Request for Letter of Map Revision

(LOMR)

For

BOCA NEGRA ARROYO

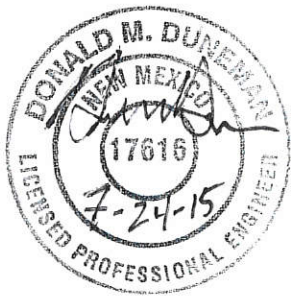
Bernalillo County, New Mexico

July 2015

SUBMITTED TO:

Federal Emergency Management Agency
(FEMA)

SUBMITTED BY:
Albuquerque Metropolitan Arroyo Flood Control Authority
(AMAFCA)



Prepared By

WILSON & COMPANY

Wilson & Company, Inc., Engineers & Architects
4900 Lang Avenue, NE
Albuquerque, NM 87109
505-348-4000

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INTRODUCTION

The purpose of this Letter of Map Revision (LOMR) is to request a revision to Flood Insurance Rate Map (FIRM) Numbers 35001C0111G and 35001C0112G within Bernalillo County, New Mexico and incorporated areas.

A portion of Zone "AE" and "AO" floodplain along the Boca Negra Arroyo has changed due to the newly constructed Boca Negra Detention Dam. A detailed study of Boca Negra Arroyo begins at the eastern edge of the North Geological Window and ends at San Ildefonso Drive crossing, approximately 4,500 ft downstream of the confluence with the South Branch of the Boca Negra Arroyo.

This document contains the required forms associated with this LOMR. Supplemental data, such as modeling output and construction as-built drawings, are provided in the appendices that follow each respective form.

PROJECT OVERVIEW

The Boca Negra Detention Dam is bounded by Unser Boulevard to the southeast, Rainbow Boulevard to the northeast, Scenic Road to the northwest and Vista Vieja Subdivision to the west. See Figure 1, Vicinity Map. The City of Albuquerque (COA) 2014 parcel shape file is included on the CD included with this submittal to provide updated Corporate Limits. This information replaces information on the current annotated FIRM for the project area which shows outdated Corporate Limits.

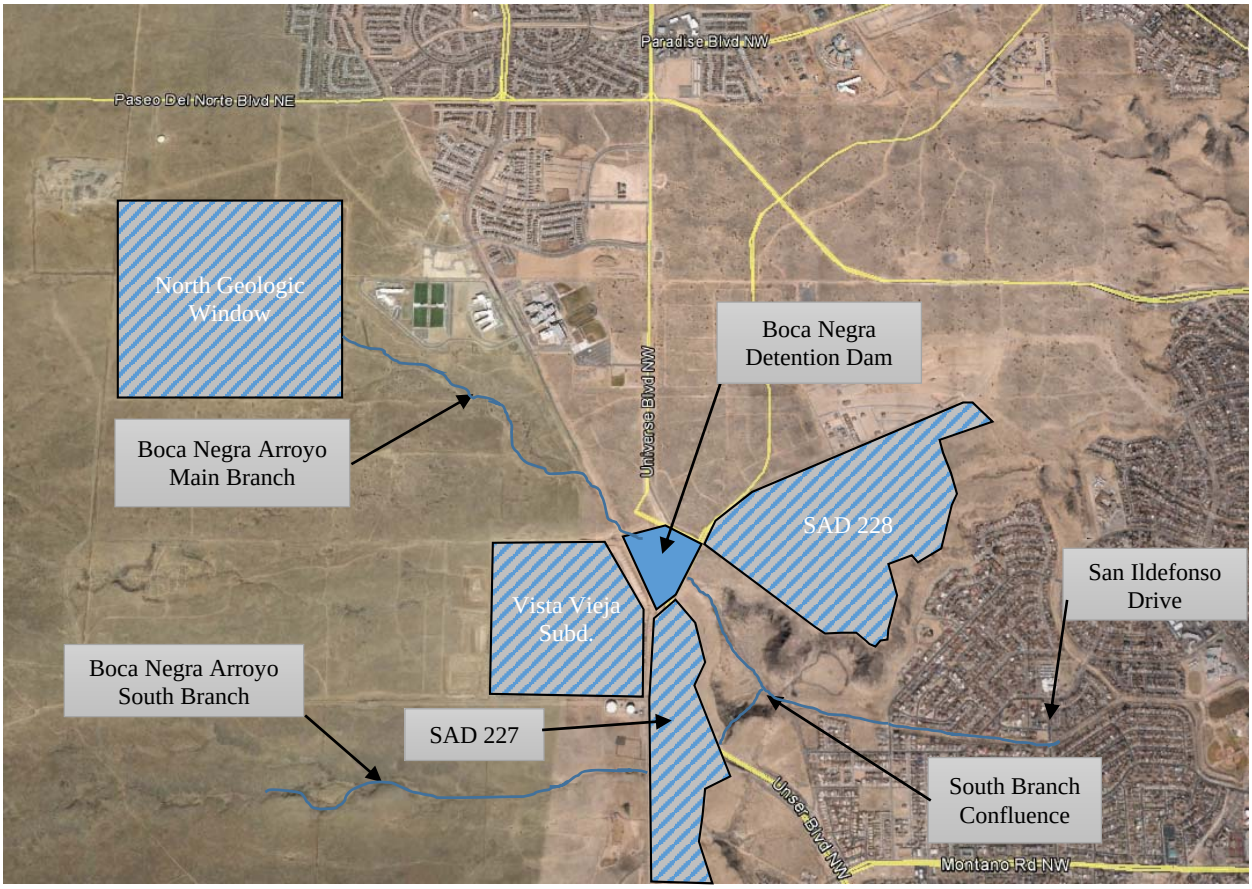

Figure 1: Vicinity Map

Calculations

LiDAR survey elevation data was used to generate a digital ground surface for the overall area of the Boca Negra Arroyo watershed. The LiDAR mapping was generated with a contour accuracy of +/- 1ft. The LiDAR mapping was supplemented with newly acquired as-built survey topography for the dam area along with cross section survey data for the segment of the Boca Negra Arroyo approximately 200ft upstream of Tesuque Drive downstream to San Ildefonso Drive. See Appendix 5 for Cross Section Survey Map. The data described above was utilized in developing the hydrologic and hydraulic models for the study area. Precipitation data dated 12-01-14 was obtained from the NOAA Atlas 14 website for use in the development of the Hydrologic models. See Appendix 1, Rainfall Data. Based on the original calculations of the dam and per agreement with Albuquerque Metropolitan Arroyo Flood Control Authority (AMAFCA), Arid-lands Hydrologic Model (AHYMO_97) distributed by Anderson-Hydro was used in the hydrologic analysis. See Appendix 1 for AHYMO files.

HEC-RAS River Analysis System V 4.1.0 by U.S. Army Corps of Engineers was used for hydraulic calculations. Electronic data was obtained from FEMA, which included the effective HEC-RAS model and cross sections in GIS format. HEC-RAS cross sections were identified at locations consistent with existing FEMA cross sections and supplemental cross sections were identified for the current conditions models. Main channel bank stations and Manning's "n" values used in the models were obtained from the effective model. The parameters for the supplementary cross sections are consistent with the effective model. The main channel throughout the arroyo varies and in some areas is not definable. Although the effective model sets channel bank stations the Manning's "n" values for the overbank area and main channel do not vary. The channel Bank stations are approximate relating to the apparent main channel but since the cross section "n " values are uniform the specified main channel bank stations do not have an impact on the water surface elevation. See Floodplain Work Map in Appendix 7 for the cross section locations. See Tables 1 and 2, HEC-RAS Flow and Output Comparison and Appendix 2 for the Summary Tables, Profile and Cross Sections.

Table 1 - HEC-RAS Flow Comparison			
River Station	Cross Section	Peak Flow (cfs)	
		Effective	Current
Upstream Model			
Reach - 1 Upper			
25374.6	Q	1493	1175
24989.3	P	1534	1175
24106.4	O	1534	1175
23000	N	1534	1175
22241.1	M	1534	1175
22027.5	L	1451	0.01*
21845.5	K	1451	0.01*
21840	16	-	612
21830	15	-	612
21820	14	-	612
21335.5	J	1451	612
21001.7	I	1451	612
Reach - 1 Split Flow			
22027.5	30	1534	1185
22000	29	-	1185
21845.5	28	1534	1185
21835	27	-	1185
21800	26	-	603
21770.8	25	-	603
21520.8	24	-	603
21335.5	23	-	603
21325	22	-	603
21315	21	-	603
21250	20	-	603
21200	19	-	603
21335.5	C	1534	-
21194.9	18	-	603
21001.7	B	1534	-
21001.7	17	-	603
20774.5	A	1534	-
Reach - 1 Lower			
20573.7	H	1534	1188
20390.6	G	1534	1188
19770.6	F	1534	1188
19290.6	13	-	1188
19175.6	12	-	1188

Table 1, Cont'd - HEC-RAS Flow Comparison			
River Station	Cross Section	Peak Flow (cfs)	
		Effective	Current
Downstream Model			
19125.5	11	-	1188
19054.6	10	-	1188
19003.57	9	-	1188
18766.3	E**	1586	-
18016.1	D**	1586	-
18022.9	8	-	695
17987.1	7	-	695
17735.62	6	-	695
17129.8	C	1586	695
17000	B	1831	695
16550	A1	1831	695
16457	A	1831	695
15976	5	-	695
15247.7	4	-	695
15100	3B	-	695
15080	3A	-	695
14886.4	3	-	1110
14300.75	2	-	1147
14200	1D	-	1147
14100.75	1C	-	1149
13900.75	1B	-	1149
13700.75	1A	-	1149
13150.55	1	-	1149
13150.54	0.995	-	1149
13150	0.99	-	1149
13149.5	0.98	-	1149
13149	0.97	-	1149
13148.5	0.96	-	1149
13148	0.95	-	1149
13145	0.94	-	1149
13144	0.93	-	1149
13143	0.92	-	1149
13140	0.91	-	1149
13135	0.9	-	1149
13130	0.8	-	1149
13120	0.7	-	1149
13110	0.6	-	1150
13100	0.53	-	1150
13095	0.52	-	1150

Table 1, Cont'd - HEC-RAS Flow Comparison			
River Station	Cross Section	Peak Flow (cfs)	
		Effective	Current
Downstream Model			
13093	0.51	-	1150
13090	0.5	-	1150
13080	0.4	-	1150
13070	0.3	-	1151
13060	0.21	-	1151
13050	0.2	-	1151
13040	0.1	-	1151

* Diverted flow at Resolana Place

** Located in the Dam

The four existing 60 in. RCP culverts upstream of the dam which were constructed with the SAD 228 project were designed with the 2008 future developed conditions model flow of 610 cfs. The current conditions flow at the culverts is 1,188 cfs which results in overtopping Scenic Road.

Table 2 - HEC-RAS Output Comparison				
River Station	Cross Section	Water Surface Elevation (ft)		
		Effective	Duplicate Effective	Current
Upstream Model				
Reach - 1 Upper				
25374.6	Q	5435.67	5434.89	5434.87
24989.3	P	5431.84	5431.11	5431.09
24106.4	O	5422.96	5422.07	5422.05
23000	N	5409.68	5408.99	5408.97
22241.1	M	5401.59	5400.83	5400.73
Reach - 1 Mid				
22027.5	L	5397.65	5396.68	5394.25
21845.5	K	5392.61	5392.03	5388.80
21840	16	-	-	5381.39
21830	15	-	-	5378.27
21820	14	-	-	5375.34
21335.5	J	5375.48	5374.61	5374.00
21001.7	I	5368.37	5367.33	5366.48
Reach - 1 Split Flow				
22027.5	30	5400.04	5399.23	5400.45
22000	29	-	-	5399.45
21845.5	28	5397.14	5396.45	5398.43
21835	27	-	-	5396.52
21800	26	-	-	5393.66
21770.8	25	-	-	5393.19

Table 2, Cont'd - HEC-RAS Output Comparison				
River Station	Cross Section	Water Surface Elevation (ft)		
		Effective	Duplicate Effective	Current
21520.8	24	-	-	5390.13
21335.5	23	-	-	5386.94
21325	22	-	-	5383.46
21315	21	-	-	5381.37
21250	20	-	-	5377.97
21200	19	-	-	5372.76
21335.5	C	5383.91	5383.09	-
21194.9	18	-	-	5365.90
21001.7	B	5372.24	5371.14	-
21001.7	17	-	-	5363.87
20774.5	A	5369.90	5368.52	-
Reach - 1 Lower				
20573.7	H	5362.96	5362.16	5362.14
20390.6	G	5360.86	5360.25	5360.22
19770.6	F	5353.24	5352.70	5352.69
19290.6	13	-	-	5347.81
19200	CULVERT			
19175.6	12	-	-	5342.63
19125.5	11	-	-	5342.15
19054.6	10	-	-	5339.93
19003.57	9	-	-	5338.67
18766.3	E*	5342.36	5334.14	5338.67
18016.1	D*	5328.99	5327.94	5338.67
Downstream Model				
18022.9	8	-	-	5326.91
17987.1	7	-	-	5326.74
17735.62	6	-	-	5322.81
17129.8	C	5316.05	5315.1	5314.43
17000	B	5275.25	5275.33	5273.82
16550	A1	-	-	5237.45
16457	A	5204.29	5203.09	5202.71
15976	5	-	-	5197.56
15247.7	4	-	-	5187.85
15100	3B	-		5187.66
15090	CULVERT			
15080	3A	-		5184.11
14886.4	3	-	-	5181.32
14300.75	2	-	-	5176.26
14200	1D	-	-	5173.99
14100.75	1C	-	-	5171.59

Table 2, Cont'd - HEC-RAS Output Comparison				
River Station	Cross Section	Water Surface Elevation (ft)		
		Effective	Duplicate Effective	Current
13900.75	1B	-	-	5169.84
13700.75	1A	-	-	5167.85
13150.55	1	-	-	5167.76
13150.54	0.995			5167.53
13150.00	0.99	-	-	5167.26
13149.50	0.98			5166.34
13149.00	0.97			5165.51
13148.50	0.96			5164.45
13148	0.95			5164.71
13146	CULVERT			
13145	0.94			5162.04
13144	0.93			5161.76
13143	0.92	-	-	5161.55
13140	0.91	-	-	5159.20
13135	0.9	-	-	5156.87
13130	0.8	-	-	5155.35
13120	0.7	-	-	5153.08
13110	0.6	-	-	5151.04
13100	0.53	-	-	5147.29
13095	0.52	-	-	5143.24
13093	0.51	-	-	5143.32
13090	0.5	-	-	5142.88
13080	0.4	-	-	5140.60
13070	0.3	-	-	5136.95
13060	0.21	-	-	5134.23
13055	BRIDGE			
13050	0.2	-	-	5133.39
13040	0.1	-	-	5130.11

* Located in the Dam

Conclusion

Due to the newly constructed Boca Negra Detention Dam and updated mapping and hydrologic data the floodplain for the Boca Negra Arroyo required revision. Updated hydrologic and hydraulic analysis of the Boca Negra Arroyo has been completed to incorporate the new topography for the flood plain. The updated models show that peak flow has been reduced resulting in reduction in water surface elevation at most sections and within 1 ft, which is the contour accuracy of the LiDAR mapping, at cross sections where the water surface elevation is above the base flood elevation from the North Geologic Window to San Ildefonso Drive bridge crossing. The analysis shows some changes from the existing floodplain boundary at the following locations: 1) Boca Negra Detention Dam facility floodplain area; 2) just south of Resolana Place, the arroyo turns south and the channel is divided into a north and south branch

with flows focused on the south branch and 3) upstream of Tesuque Drive where the arroyo depth is shallow, the floodplain widens based on the more detailed topographic mapping. The existing Zone "X" area near the split flow is included in the annotated floodplain map because there is not a certified levee to protect the area which may cause the upstream existing embankment to fail. Changes are due to updated topography, construction of the Dam and revised hydrologic analysis. The results of the analysis indicate that the floodplain widens in several areas affecting 24 vacant properties. Notification Letters have been sent to the affected property owners. See Appendix 6 for Property owner Notification Letters.

Based on the analysis, the water surface widens at two properties, 6423 Star Bright east of Atrisco Drive and 6515 Tesuque Drive at the southwest corner of intersection of Boca Negra Arroyo and Tesuque Drive. Both properties include retaining walls which may divert the floodplain along the property boundary. The retaining wall at 6423 Star Bright is a flood wall. As-built drawings are included in Appendix 5, Petroglyph Shadows Subdivision Grading & Drainage Plan sheets 4-5A. The wall at 6515 Tesuque Drive has not been certified and the maps reflect the floodplain with no wall. See Appendix 5 for photos of both properties retaining wall.

The Boca Negra Detention Dam and outfall pipe storm drain will be maintained and operated by AMAFCA. The City of Albuquerque (COA) will maintain the Boca Negra Arroyo outside of the Dam. The AMAFCA Operation and Maintenance plan Volumes 1-3 and COA Operation and Maintenance schedule are included in the CD. AMAFCA and COA have maintenance programs with crews that maintain all drainage facilities on a routine schedule to ensure facilities are operating as intended.

MT-2 (FORM 1)

OVERVIEW & CONCURRENCE FORM

U.S. DEPARTMENT OF HOMELAND SECURITY
FEDERAL EMERGENCY MANAGEMENT AGENCY

OVERVIEW & CONCURRENCE FORM

O.M.B No. 1660-0016
Expires February 28, 2014

PAPERWORK BURDEN DISCLOSURE NOTICE

Public reporting burden for this form is estimated to average 1 hours per response. The burden estimate includes the time for reviewing instructions, searching existing data sources, gathering and maintaining the needed data, and completing, reviewing, and submitting the form. You are not required to respond to this collection of information unless it displays a valid OMB control number. Send comments regarding the accuracy of the burden estimate and any suggestions for reducing this burden to: Information Collections Management, Department of Homeland Security, Federal Emergency Management Agency, 1800 South Bell Street, Arlington, VA 20958-3005, Paperwork Reduction Project (1660-0016). Submission of the form is required to obtain or retain benefits under the National Flood Insurance Program. **Please do not send your completed survey to the above address.**

PRIVACY ACT STATEMENT

AUTHORITY: The National Flood Insurance Act of 1968, Public Law 90-448, as amended by the Flood Disaster Protection Act of 1973, Public Law 93-234.

PRINCIPAL PURPOSE(S): This information is being collected for the purpose of determining an applicant's eligibility to request changes to National Flood Insurance Program (NFIP) Flood Insurance Rate Maps (FIRM).

ROUTINE USE(S): The information on this form may be disclosed as generally permitted under 5 U.S.C § 552a(b) of the Privacy Act of 1974, as amended. This includes using this information as necessary and authorized by the routine uses published in DHS/FEMA/NFIP/LOMA-1 National Flood Insurance Program (NFIP); Letter of Map Amendment (LOMA) February 15, 2006, 71 FR 7990.

DISCLOSURE: The disclosure of information on this form is voluntary; however, failure to provide the information requested may delay or prevent FEMA from processing a determination regarding a requested change to a (NFIP) Flood Insurance Rate Maps (FIRM).

A. REQUESTED RESPONSE FROM DHS-FEMA

This request is for a (check one):

☐ CLOMR: A letter from DHS-FEMA commenting on whether a proposed project, if built as proposed, would justify a map revision, or proposed hydrology changes (See 44 CFR Ch. 1, Parts 60, 65 & 72).

☒ LOMR: A letter from DHS-FEMA officially revising the current NFIP map to show the changes to floodplains, regulatory floodway or flood elevations. (See 44 CFR Ch. 1, Parts 60, 65 & 72)

B. OVERVIEW

1. The NFIP map panel(s) affected for all impacted communities is (are):

Community No.	Community Name	State	Map No.	Panel No.	Effective Date
Example: 480301 480287	City of Katy Harris County	TX TX	48473C 48201C	0005D 0220G	02/08/83 09/28/90
350001	Bernalillo County, New Mexico and Incorporated Areas	NM	35001C	0111G	09/26/08
350001	Bernalillo County, New Mexico and Incorporated Areas	NM	35001C	0112G	09/26/08

2. a. Flooding Source: Boca Negra Arroyo

   b. Types of Flooding: ☒ Riverine ☐ Coastal ☐ Shallow Flooding (e.g., Zones AO and AH)
   ☐ Alluvial fan ☐ Lakes ☐ Other (Attach Description)

3. Project Name/Identifier: Boca Negra Detention Dam

4. FEMA zone designations affected: AE (choices: A, AH, AO, A1-A30, A99, AE, AR, V, V1-V30, VE, B, C, D, X)

5. Basis for Request and Type of Revision:

   a. The basis for this revision request is (check all that apply)

   ☒ Physical Change ☐ Improved Methodology/Data ☐ Regulatory Floodway Revision ☐ Base Map Changes
   ☐ Coastal Analysis ☒ Hydraulic Analysis ☒ Hydrologic Analysis ☐ Corrections
   ☐ Weir-Dam Changes ☐ Levee Certification ☐ Alluvial Fan Analysis ☐ Natural Changes
   ☒ New Topographic Data ☐ Other (Attach Description)

   Note: A photograph and narrative description of the area of concern is not required, but is very helpful during review.

b. The area of revision encompasses the following structures (check all that apply)

Structures: ☐ Channelization ☐ Levee/Floodwall ☒ Bridge/Culvert ☒ Dam ☐ Fill ☐ Other (Attach Description)

6. ☐ Documentation of ESA compliance is submitted (required to initiate CLOMR review). Please refer to the instructions for more information.

C. REVIEW FEE

Has the review fee for the appropriate request category been included? ☒ Yes Fee amount: $7,150.00

☐ No, Attach Explanation

Please see the DHS-FEMA Web site at http://www.fema.gov/plan/prevent/fhm/frm_fees.shtm **for Fee Amounts and Exemptions.**

D. SIGNATURE

All documents submitted in support of this request are correct to the best of my knowledge. I understand that any false statement may be punishable by fine or imprisonment under Title 18 of the United States Code, Section 1001.

Name: Jerry Lovato	Company: AMAFCA	
Mailing Address: 2600 Prospect Avenue, NE Albuquerque, NM 87107	Daytime Telephone No.: 505-884-2215	Fax No.:
	E-Mail Address: jlovato@amafca.org	
Signature of Requester (required):	Date:	

: the community official responsible for floodplain management, I hereby acknowledge that we have received and reviewed this Letter of Map Revision .OMR) or conditional LOMR request. Based upon the community's review, we find the completed or proposed project meets or is designed to meet all of the community floodplain management requirements, including the requirements for when fill is placed in the regulatory floodway, and that all necessary Federal, State, and local permits have been, or in the case of a conditional LOMR, will be obtained. For Conditional LOMR requests, the applicant has documented Endangered Species Act (ESA) compliance to FEMA prior to FEMA's review of the Conditional LOMR application. For LOMR requests, I acknowledge that compliance with Sections 9 and 10 of the ESA has been achieved independently of FEMA's process. For actions authorized, funded, or being carried out by Federal or State agencies, documentation from the agency showing its compliance with Section 7(a)(2) of the ESA will be submitted. In addition, we have determined that the land and any existing or proposed structures to be removed from the SFHA are or will be reasonably safe from flooding as defined in 44CFR 65.2(c), and that we have available upon request by FEMA, all analyses and documentation used to make this determination.

Community Official's Name and Title: Curtis Cherne, Floodplain Administrator	Community Name: Bernalillo County	
Mailing Address: 600 2nd Street NW Albuquerque, NM 87102	Daytime Telephone No.: (505) 924-3986	Fax No.:
	E-Mail Address: ccherne@cabq.gov	
Community Official's Signature (required):	Date:	

CERTIFICATION BY REGISTERED PROFESSIONAL ENGINEER AND/OR LAND SURVEYOR

This certification is to be signed and sealed by a licensed land surveyor, registered professional engineer, or architect authorized by law to certify elevation information data, hydrologic and hydraulic analysis, and any other supporting information as per NFIP regulations paragraph 65.2(b) and as described in the MT-2 Forms Instructions. All documents submitted in support of this request are correct to the best of my knowledge. I understand that any false statement may be punishable by fine or imprisonment under Title 18 of the United States Code, Section 1001.

Certifier's Name: Donald Duneman	License No.: NM 17616		Expiration Date: 12-31-2016
Company Name: Wilson & Company, Inc.	Telephone No.: 505-348-4000		Fax No.: 505-348-4072
ignature:	Date: 6/18/15	E-Mail Address: donald.duneman@wilsonco.com	

b. The area of revision encompasses the following structures (check all that apply)

Structures: ☐ Channelization ☐ Levee/Floodwall ☒ Bridge/Culvert ☒ Dam ☐ Fill ☐ Other (Attach Description)

6. ☐ Documentation of ESA compliance is submitted (required to initiate CLOMR review). Please refer to the instructions for more information.

C. REVIEW FEE

Has the review fee for the appropriate request category been included? ☒ Yes Fee amount: $7,150.00 ☐ No, Attach Explanation

Please see the DHS-FEMA Web site at http://www.fema.gov/plan/prevent/fhm/frm_fees.shtm **for Fee Amounts and Exemptions.**

D. SIGNATURE

All documents submitted in support of this request are correct to the best of my knowledge. I understand that any false statement may be punishable by fine or imprisonment under Title 18 of the United States Code, Section 1001.

Name: Jerry Lovato	Company: AMAFCA	
Mailing Address: 2600 Prospect Avenue, NE Albuquerque, NM 87107	Daytime Telephone No.: 505-884-2215	Fax No.:
	E-Mail Address: jlovato@amafca.org	
Signature of Requester (required):	Date:	

As the community official responsible for floodplain management, I hereby acknowledge that we have received and reviewed this Letter of Map Revision (LOMR) or conditional LOMR request. Based upon the community's review, we find the completed or proposed project meets or is designed to meet all of the community floodplain management requirements, including the requirements for when fill is placed in the regulatory floodway, and that all necessary Federal, State, and local permits have been, or in the case of a conditional LOMR, will be obtained. For Conditional LOMR requests, the applicant has documented Endangered Species Act (ESA) compliance to FEMA prior to FEMA's review of the Conditional LOMR application. For LOMR requests, I acknowledge that compliance with Sections 9 and 10 of the ESA has been achieved independently of FEMA's process. For actions authorized, funded, or being carried out by Federal or State agencies, documentation from the agency showing its compliance with Section 7(a)(2) of the ESA will be submitted. In addition, we have determined that the land and any existing or proposed structures to be removed from the SFHA are or will be reasonably safe from flooding as defined in 44CFR 65.2(c), and that we have available upon request by FEMA, all analyses and documentation used to make this determination.

Community Official's Name and Title: ABIEL CARRILLO, Floodplain Admin	Community Name: City of Albuquerque	
Mailing Address: 600 2nd St. NW Albuquerque, NM, 87102	Daytime Telephone No.: 505 924 3986	Fax No.:
	E-Mail Address: acarrillo@cabq.gov	
Community Official's Signature (required):	Date: 5/20/16	

CERTIFICATION BY REGISTERED PROFESSIONAL ENGINEER AND/OR LAND SURVEYOR

This certification is to be signed and sealed by a licensed land surveyor, registered professional engineer, or architect authorized by law to certify elevation information data, hydrologic and hydraulic analysis, and any other supporting information as per NFIP regulations paragraph 65.2(b) and as described in the MT-2 Forms Instructions. All documents submitted in support of this request are correct to the best of my knowledge. I understand that any false statement may be punishable by fine or imprisonment under Title 18 of the United States Code, Section 1001.

Certifier's Name: Donald Duneman	License No.: NM 17616	Expiration Date: 12-31-2016
Company Name: Wilson & Company, Inc.	Telephone No.: 505-348-4000	Fax No.: 505-348-4072
Signature:	Date:	E-Mail Address: donald.duneman@wilsonco.com

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C. REVIEW FEE

Has the review fee for the appropriate request category been included? ☒ Yes Fee amount: $7,150.00 ☐ No, Attach Explanation

Please see the DHS-FEMA Web site at http://www.fema.gov/plan/prevent/fhm/frm_fees.shtm **for Fee Amounts and Exemptions.**

D. SIGNATURE

All documents submitted in support of this request are correct to the best of my knowledge. I understand that any false statement may be punishable by fine or imprisonment under Title 18 of the United States Code, Section 1001.

Name: Jerry Lovato	Company: AMAFCA	
Mailing Address: 2600 Prospect Avenue, NE Albuquerque, NM 87107	Daytime Telephone No.: 505-884-2215	Fax No.:
	E-Mail Address: jlovato@amafca.org	
Signature of Requester (required):	Date:	

As the community official responsible for floodplain management, I hereby acknowledge that we have received and reviewed this Letter of Map Revision (LOMR) or conditional LOMR request. Based upon the community's review, we find the completed or proposed project meets or is designed to meet all of the community floodplain management requirements, including the requirements for when fill is placed in the regulatory floodway, and that all necessary Federal, State, and local permits have been, or in the case of a conditional LOMR, will be obtained. For Conditional LOMR requests, the applicant has documented Endangered Species Act (ESA) compliance to FEMA prior to FEMA's review of the Conditional LOMR application. For LOMR requests, I acknowledge that compliance with Sections 9 and 10 of the ESA has been achieved independently of FEMA's process. For actions authorized, funded, or being carried out by Federal or State agencies, documentation from the agency showing its compliance with Section 7(a)(2) of the ESA will be submitted. In addition, we have determined that the land and any existing or proposed structures to be removed from the SFHA are or will be reasonably safe from flooding as defined in 44CFR 65.2(c), and that we have available upon request by FEMA, all analyses and documentation used to make this determination.

Community Official's Name and Title: Don Briggs, Floodplain Administrator	Community Name: County of Bernalillo	
Mailing Address: 2400 Broadway SE, Albuquerque, NM 87102	Daytime Telephone No.: (505) 848-1511	Fax No.: (505) 848-1510
	E-Mail Address: drbriggs@bernco.gov	
Community Official's Signature (required): Don Briggs	Date: 6/5/15	

CERTIFICATION BY REGISTERED PROFESSIONAL ENGINEER AND/OR LAND SURVEYOR

This certification is to be signed and sealed by a licensed land surveyor, registered professional engineer, or architect authorized by law to certify elevation information data, hydrologic and hydraulic analysis, and any other supporting information as per NFIP regulations paragraph 65.2(b) and as described in the MT-2 Forms Instructions. All documents submitted in support of this request are correct to the best of my knowledge. I understand that any false statement may be punishable by fine or imprisonment under Title 18 of the United States Code, Section 1001.

Certifier's Name: Donald Duneman	License No.: NM 17616	Expiration Date: 12-31-2016
Company Name: Wilson & Company, Inc.	Telephone No.: 505-348-4000	Fax No.: 505-348-4072
Signature:	Date:	E-Mail Address: donald.duneman@wilsonco.com

Ensure the forms that are appropriate to your revision request are included in your submittal.

Form Name and (Number)	Required if …
☒ Riverine Hydrology and Hydraulics Form (Form 2)	New or revised discharges or water-surface elevations
☒ Riverine Structures Form (Form 3)	Channel is modified, addition/revision of bridge/culverts, addition/revision of levee/floodwall, addition/revision of dam
☐ Coastal Analysis Form (Form 4)	New or revised coastal elevations
☐ Coastal Structures Form (Form 5)	Addition/revision of coastal structure
☐ Alluvial Fan Flooding Form (Form 6)	Flood control measures on alluvial fans

Seal (Optional)

MT-2 (FORM 2)
RIVERINE HYDROLOGY & HYDRAULICS FORM

U.S. DEPARTMENT OF HOMELAND SECURITY
FEDERAL EMERGENCY MANAGEMENT AGENCY

RIVERINE HYDROLOGY & HYDRAULICS FORM

O.M.B No. 1660-0016
Expires February 28, 2014

PAPERWORK BURDEN DISCLOSURE NOTICE

Public reporting burden for this form is estimated to average 3.5 hours per response. The burden estimate includes the time for reviewing instructions, searching existing data sources, gathering and maintaining the needed data, and completing, reviewing, and submitting the form. You are not required to respond to this collection of information unless a valid OMB control number appears in the upper right corner of this form. Send comments regarding the accuracy of the burden estimate and any suggestions for reducing this burden to: Information Collections Management, Department of Homeland Security, Federal Emergency Management Agency, 1800 South Bell Street, Arlington VA 20958-3005, Paperwork Reduction Project (1660-0016). Submission of the form is required to obtain or retain benefits under the National Flood Insurance Program. **Please do not send your completed survey to the above address.**

PRIVACY ACT STATEMENT

AUTHORITY: The National Flood Insurance Act of 1968, Public Law 90-448, as amended by the Flood Disaster Protection Act of 1973, Public Law 93-234.

PRINCIPAL PURPOSE(S): This information is being collected for the purpose of determining an applicant's eligibility to request changes to National Flood Insurance Program (NFIP) Flood Insurance Rate Maps (FIRM).

ROUTINE USE(S): The information on this form may be disclosed as generally permitted under 5 U.S.C § 552a(b) of the Privacy Act of 1974, as amended. This includes using this information as necessary and authorized by the routine uses published in DHS/FEMA/NFIP/LOMA-1 National Flood Insurance Program (NFIP); Letter of Map Amendment (LOMA) February 15, 2006, 71 FR 7990.

DISCLOSURE: The disclosure of information on this form is voluntary; however, failure to provide the information requested may delay or prevent FEMA from processing a determination regarding a requested change to a NFIP Flood Insurance Rate Maps (FIRM).

Flooding Source: Boca Negra Arroyo

Note: Fill out one form for each flooding source studied

A. HYDROLOGY

1. Reason for New Hydrologic Analysis (check all that apply)

☐ Not revised (skip to section B) ☐ No existing analysis ☒ Improved data
☐ Alternative methodology ☐ Proposed Conditions (CLOMR) ☒ Changed physical condition of watershed

2. Comparison of Representative 1%-Annual-Chance Discharges

Location	Drainage Area (Sq. Mi.)	Effective/FIS (cfs)	Revised (cfs)
West of Atrisco Drive	2.12	894	1,218
South Branch Confluence	4.38	1,653	1,208
Downstream Confluence	7.20	2,911	1,660

3. Methodology for New Hydrologic Analysis (check all that apply)

☐ Statistical Analysis of Gage Records ☒ Precipitation/Runoff Model → Specify Model: AHYMO_97
☐ Regional Regression Equations ☐ Other (please attach description)

Please enclose all relevant models in digital format, maps, computations (including computation of parameters), and documentation to support the new analysis.

4. Review/Approval of Analysis

If your community requires a regional, state, or federal agency to review the hydrologic analysis, please attach evidence of approval/review.

5. Impacts of Sediment Transport on Hydrology

Is the hydrology for the revised flooding source(s) affected by sediment transport? ☒ Yes ☐ No

If yes, then fill out Section F (Sediment Transport) of Form 3. If No, then attach your explanation..

B. HYDRAULICS

1. Reach to be Revised

	Description	Cross Section	Water-Surface Elevations (ft.) Effective	Proposed/Revised
Downstream Limit*	800 ft east of Unser Blvd	A	5204.29	5199.33
Upstream Limit*	655 ft upstream of Dam	F	5353.24	5352.71

*Proposed/Revised elevations must tie-into the Effective elevations within 0.5 foot at the downstream and upstream limits of revision.

2. Hydraulic Method/Model Used: River Analysis System HEC-RAS V 4.1.0 by USACE

3. Pre-Submittal Review of Hydraulic Models*

DHS-FEMA has developed two review programs, CHECK-2 and CHECK-RAS, to aid in the review of HEC-2 and HEC-RAS hydraulic models, respectively. We recommend that you review your HEC-2 and HEC-RAS models with CHECK-2 and CHECK-RAS.

4.

Models Submitted	Natural Run File Name:	Natural Run Plan Name:	Floodway Run File Name:	Floodway Run Plan Name:	Datum
Duplicate Effective Model*			File Name: Boca Negra Arroyo	Plan Name: Efftive Multiple	NAVD1988 _
Corrected Effective Model*			File Name: Boca Negra Arroyo	Plan Name: Duplicate Mutiple	NAVD1988
Existing or Pre-Project Conditions Model			File Name:	Plan Name:	_
Revised or Post-Project Conditions Model			File Name: BNA Prop Upst Dam	Plan Name: Proposed Upstream_	_NAVD1988_
Other - (attach description)			File Name: BNA Prop Dwn Dam_	Plan Name: ProposedDownstream	NAVD1988 _

* For details, refer to the corresponding section of the instructions.

☒ Digital Models Submitted? (Required)

C. MAPPING REQUIREMENTS

A **certified topographic work map** must be submitted showing the following information (where applicable): the boundaries of the effective, existing, and proposed conditions 1%-annual-chance floodplain (for approximate Zone A revisions) or the boundaries of the 1%- and 0.2%-annual-chance floodplains and regulatory floodway (for detailed Zone AE, AO, and AH revisions); location and alignment of all cross sections with stationing control indicated; stream, road, and other alignments (e.g., dams, levees, etc.); current community easements and boundaries; boundaries of the requester's property; certification of a registered professional engineer registered in the subject State; location and description of reference marks; and the referenced vertical datum (NGVD, NAVD, etc.).

☒ Digital Mapping (GIS/CADD) Data Submitted (preferred)

Topographic Information: Lidar, as-built survey & surveyed cross sections

Source: As-built drawings Date: November 2014

Accuracy: 1' contour interval

Note that the boundaries of the existing or proposed conditions floodplains and regulatory floodway to be shown on the revised FIRM and/or FBFM must tie-in with the effective floodplain and regulatory floodway boundaries. Please attach **a copy of the effective FIRM and/or FBFM**, at the same scale as the original, annotated to show the boundaries of the revised 1%-and 0.2%-annual-chance floodplains and regulatory floodway that tie-in with the boundaries of the effective 1%-and 0.2%-annual-chance floodplain and regulatory floodway at the upstream and downstream limits of the area on revision.

☒ Annotated FIRM and/or FBFM (Required)

D. COMMON REGULATORY REQUIREMENTS*

1. For LOMR/CLOMR requests, do Base Flood Elevations (BFEs) increase? ☒ Yes ☐ No

   a. For CLOMR requests, if either of the following is true, please submit **evidence of compliance with Section 65.12 of the NFIP regulations**:

   - The proposed project encroaches upon a regulatory floodway and would result in increases above 0.00 foot compared to pre-project conditions.
   - The proposed project encroaches upon a SFHA with or without BFEs established and would result in increases above 1.00 foot compared to pre-project conditions.

   b. Does this LOMR request cause increase in the BFE and/or SFHA compared with the effective BFEs and/or SFHA? ☒ Yes ☐ No

   If Yes, please attach **proof of property owner notification and acceptance (if available)**. Elements of and examples of property owner notifications can be found in the MT-2 Form 2 Instructions.

2. Does the request involve the placement or proposed placement of fill? ☐ Yes ☒ No

   If Yes, the community must be able to certify that the area to be removed from the special flood hazard area, to include any structures or proposed structures, meets all of the standards of the local floodplain ordinances, and is reasonably safe from flooding in accordance with the NFIP regulations set forth at 44 CFR 60.3(A)(3), 65.5(a)(4), and 65.6(a)(14). Please see the MT-2 instructions for more information.

3. For LOMR requests, is the regulatory floodway being revised? ☐ Yes ☒ No

   If Yes, attach **evidence of regulatory floodway revision notification**. As per Paragraph 65.7(b)(1) of the NFIP Regulations, notification is required for requests involving revisions to the regulatory floodway. (Not required for revisions to approximate 1%-annual-chance floodplains [studied Zone A designation] unless a regulatory floodway is being established. Elements and examples of regulatory floodway revision notification can be found in the MT-2 Form 2 Instructions.)

4. For CLOMR requests, please submit documentation to FEMA and the community to show that you have complied with Sections 9 and 10 of the Endangered Species Act (ESA).

For actions authorized, funded, or being carried out by Federal or State agencies, please submit documentation from the agency showing its compliance with Section 7(a)(2) of the ESA. Please see the MT-2 instructions for more detail.

* Not inclusive of all applicable regulatory requirements. For details, see 44 CFR parts 60 and 65.

Comments to MT-2 Form 2: Riverine Hydrology & Hydraulics Form

Section A: Hydrology

The Punch Hyd command was used to recall flows directly from the drainage studies for The Trails Subdivision, SAD 228 Ponds 4, 5 and 6 and also the South Branch of Boca Negra Arroyo. See Plate 1, Current Conditions Basin Boundary Map for pond location. SAD 228 Pond 4 is located east of Unser Boulevard and Compass Drive intersection discharging 18 cfs. SAD Pond 5 is located at the northeast corner of intersection of Compass Drive and Petirrojo Road discharging 37 cfs. Pond 6 is located on the south edge of SAD 228 contributes 51 cfs to the Boca Negra Arroyo upstream of Tesuque Drive. See Pond 4, 5 and 6 Grading Plan sheet 109A, 110R and 111R of 156 in Appendix 3. Flood zones for SAD Ponds 4, 5 and 6 are shown on the annotated FIRMs. Flood zones for the Trails Subdivision Ponds J and K are not included as directed by the City Floodplain Administrator in a letter dated July 15, 2105.

The Unser Boulevard temporary ponds A and B drain into temporary Pond C with a 30 in. RCP outlet pipe discharging a maximum of 19 cfs. This pipe ultimately ties into the existing 54 in. RCP in Unser Boulevard. Peak flows from these areas were added to the outflow from the primary principal spillway from the dam. See Atrisco Storm Drain Plan & Profile sheet 43 of 62 in Appendix 3.

A 72 in. RCP in Emerald Drive conveys 378 cfs through SAD 227 to the South Branch just east of Unser Boulevard. See SAD 227 Storm Drain & Profile Emerald Drive sheet 63A of 135. Non-contributing basins to the Boca Negra Arroyo as shown on Plate 1, Current Conditions Basin Boundary Map are either retained on site or bypassed to the San Antonio Arroyo per Boca Negra – Mariposa Arroyo Drainage Management Plan (DMP) dated April 2005. See Appendix 5, Referenced Documents Vista Vieja Current Basin Boundary Map, SAD 227 Grading and Storm Drain Plan & Profile sheets 125A to 127A of 159, SAD 227 Storm Drain Plan & Profile, Onyx Drive NW sheet 71A of 135 and Vista Vieja Phase I Paving and Storm drain Plan & Profile Vista Vieja Avenue, NW sheet 14 of 35.

A hydrologic model for the Post Project Conditions (Current Conditions) using current rainfall data for the 100 year storm event was developed. See Appendix 1 for Rainfall data and AHYMO files, and Appendix 7 for Plate 1, Current Conditions Basin Boundary Map for results. Based on the hydrologic model, total inflow to the dam is 1,287 cfs and the outflow is 1,067 cfs. The maximum water surface elevation of the dam was calculated at 5338.61 ft. The Boca Negra Detention Dam was designed in between 2005 and 2012 to detain a flood as a result of the 100 year 24 hour storm event below the crest of the emergency spillway elevation of 5338.20 using NOAA 14 rainfall data from 2005. The current conditions model indicates flows will overtop the emergency spillway due to an increase in the precipitation data for 2014. The stepped soil cement emergency spillway is 17 ft wide and 419 ft long with an emergency spillway crest elevation of 5338.20 ft. See Appendix 3, Boca Negra Detention Dam As-Built drawings. The primary principal and secondary principal spillways are 48 in. x 48 in. CBCs. The primary principal spillway is capable of conveying 372 cfs through an underground storm drain to the confluence with the South Branch. The secondary principal spillway and emergency spillway drain on the surface via a concrete lined low flow channel under the Unser Boulevard Bridge to the Boca Negra Arroyo. Accumulated flows downstream of the Dam were routed based on the existing pipe sizes. See AHYMO calculations and flowchart in

Appendix 1. The existing culvert crossings in Atrisco Vista Boulevard were not included in the AHYMO calculations since the culverts have sufficient capacity to convey the runoff with minimal to no attenuation or accumulated backwater. See Plate 1, Current Conditions Basin Boundary Map for existing culverts size and location.

The total surface flow in the Boca Negra Arroyo downstream of the dam is 695 cfs just downstream of Unser Boulevard; 1,110 cfs upstream of the confluence with the South Branch, 1,147 cfs downstream of the confluence, 1,149 cfs at Tesuque Drive; and 1,151 cfs at San Ildefonso Drive.

Section B: Hydraulics

Four HEC-RAS models were developed for the study and utilized to compare water surface elevations. The models consist of the effective model, a duplicate effective model and two proposed models. The effective model consists of existing FEMA cross sections with updated flows while the duplicate effective model utilizes updated topography. The two current conditions models include the new dam and consist of: 1) from the east boundary of the North Geologic Window to the dam including four reaches of Upper, Mid, Split Flow and Lower; and 2) from the dam to San Ildefonso Drive bridge crossing, 4,500 ft downstream of the confluence with the South Branch. The models were developed for the 1% annual chance storm event. Based on the existing topography, the main channel is diverted south just downstream of Resolana Place due to a berm that has been constructed on the main arroyo. The capacity of the arroyo is exceeded just downstream of the berm where it overflows to the north branch. The overflow was computed based on the capacity of the arroyo. Due to updated hydrologic analysis and the dam, flows were revised and water surface elevations are modified based on the more detailed data for the current conditions. See Appendix 2 for the Summary Tables, Profile and Cross Sections.

MT-2 (FORM 3)
RIVERINE STRUCTURES FORM

DEPARTMENT OF HOMELAND SECURITY
FEDERAL EMERGENCY MANAGEMENT AGENCY

RIVERINE STRUCTURES FORM

O.M.B. NO. 1660-0016
Expires February 28, 2014

PAPERWORK BURDEN DISCLOSURE NOTICE

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AUTHORITY: The National Flood Insurance Act of 1968, Public Law 90-448, as amended by the Flood Disaster Protection Act of 1973, Public Law 93-234.

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DISCLOSURE: The disclosure of information on this form is voluntary; however, failure to provide the information requested may delay or prevent FEMA from processing a determination regarding a requested change to a NFIP Flood Insurance Rate Maps (FIRM).

Flooding Source: Boca Negra Arroyo

Note**:** Fill out one form for each flooding source studied.

A. GENERAL

Complete the appropriate section(s) for each Structure listed below:

Channelization.....complete Section B
Bridge/Culvert.....complete Section C
Dam.....complete Section D
Levee/Floodwall.....complete Section E
Sediment Transport.....complete Section F (if required)

Description Of Modeled Structure

1. Name of Structure: Boca Negra Detention Dam

   Type (check one): ☐ Channelization ☐ Bridge/Culvert ☐ Levee/Floodwall ☒ Dam

   Location of Structure: Unser Blvd and Rainbow Blvd Intersection

   Downstream Limit/Cross Section: 680 ft west of Unser Blvd/C

   Upstream Limit/Cross Section: 1,880 ft east of Unser Blvd/F

2. Name of Structure: Scenic Road Culverts

   Type (check one): ☐ Channelization ☒ Bridge/Culvert ☐ Levee/Floodwall ☐ Dam

   Location of Structure: Scenic Road / Boca Negra Arroyo

   Downstream Limit/Cross Section: I2

   Upstream Limit/Cross Section: I3

3. Name of Structure: _____

   Type (check one) ☐ Channelization ☐ Bridge/Culvert ☐ Levee/Floodwall ☐ Dam

   Location of Structure: _____

   Downstream Limit/Cross Section: _____

   Upstream Limit/Cross Section: _____

NOTE: FOR MORE STRUCTURES, ATTACH ADDITIONAL PAGES AS NEEDED.

B. CHANNELIZATION

Flooding Source: _____

Name of Structure: _____

1. Hydraulic Considerations

The channel was designed to carry _____ (cfs) and/or the _____-year flood.

The design elevation in the channel is based on (check one):

☐ Subcritical flow ☐ Critical flow ☐ Supercritical flow ☐ Energy grade line

If there is the potential for a hydraulic jump at the following locations, check all that apply and attach an explanation of how the hydraulic jump is controlled without affecting the stability of the channel.

☐ Inlet to channel ☐ Outlet of channel ☐ At Drop Structures ☐ At Transitions

☐ Other locations (specify): _____

2. Channel Design Plans

Attach the plans of the channelization certified by a registered professional engineer, as described in the instructions.

3. Accessory Structures

The channelization includes (check one):

☐ Levees [Attach Section E (Levee/Floodwall)] ☐ Drop structures ☐ Superelevated sections

☐ Transitions in cross sectional geometry ☐ Debris basin/detention basin [Attach Section D (Dam/Basin)] ☐ Energy dissipator

☐ Weir ☐ Other (Describe):

4. Sediment Transport Considerations

Are the hydraulics of the channel affected by sediment transport? ☐ Yes ☐ No

If yes, then fill out Section F (Sediment Transport) of Form 3. If No, then attach your explanation for why sediment transport was not considered.

C. BRIDGE/CULVERT

Flooding Source: Boca Negra Arroyo

Name of Structure: Scenic Road Culverts

1. This revision reflects (check one):

☒ Bridge/culvert not modeled in the FIS

☐ Modified bridge/culvert previously modeled in the FIS

☐ Revised analysis of bridge/culvert previously modeled in the FIS

2. Hydraulic model used to analyze the structure (e.g., HEC-2 with special bridge routine, WSPRO, HY8): Bentley Culvert Master V3.3
If different than hydraulic analysis for the flooding source, justify why the hydraulic analysis used for the flooding source could not analyze the structures. Attach justification.

3. Attach plans of the structures certified by a registered professional engineer. The plan detail and information should include the following (check the information that has been provided):

☐ Dimensions (height, width, span, radius, length)
☒ Shape (culverts only)
☒ Material
☐ Beveling or Rounding
☐ Wing Wall Angle
☐ Skew Angle
☐ Distances Between Cross Sections
☐ Erosion Protection
☐ Low Chord Elevations – Upstream and Downstream
☒ Top of Road Elevations – Upstream and Downstream
☒ Structure Invert Elevations – Upstream and Downstream
☒ Stream Invert Elevations – Upstream and Downstream
☐ Cross-Section Locations

4. Sediment Transport Considerations

Are the hydraulics of the structure affected by sediment transport? ☒ Yes ☐ No

If Yes, then fill out Section F (Sediment Transport) of Form 3. If no, then attach an explanation.

D. DAM/BASIN

Flooding Source: Boca Negra Arroyo
Name of Structure: Boca Negra Detention Dam

1. This request is for (check one): ☐ Existing dam/basin ☒ New dam/basin ☐ Modification of existing dam/basin

2. The dam/basin was designed by (check one): ☐ Federal agency ☐ State agency ☒ Private organization ☐ Local government agency

   Name of the agency or organization: Wilson & Company, Inc.

3. The Dam was permitted as (check one): ☐ Federal Dam ☒ State Dam

   Provide the permit or identification number (ID) for the dam and the appropriate permitting agency or organization

   Permit or ID number D-695 Permitting Agency or Organization NMOSE-DSB

   a. ☒ Local Government Dam ☐ Private Dam

   Provided related drawings, specification and supporting design information.

4. Does the project involve revised hydrology? ☒ Yes ☐ No

   If Yes, complete the Riverine Hydrology & Hydraulics Form (Form 2).

   Was the dam/basin designed using critical duration storm? (must account for the maximum volume of runoff)

   ☒ Yes, provide supporting documentation with your completed Form 2.

   ☐ No, provide a written explanation and justification for not using the critical duration storm.

5. Does the submittal include debris/sediment yield analysis? ☐ Yes ☒ No

   If Yes, then fill out Section F (Sediment Transport). If No, then attach your explanation for why debris/sediment analysis was not considered?

6. Does the Base Flood Elevation behind the dam/basin or downstream of the dam/basin change? ☒ Yes ☐ No

   If Yes, complete the Riverine Hydrology & Hydraulics Form (Form 2) and complete the table below.

FREQUENCY (% annual chance)	Stillwater Elevation Behind the Dam/Basin FIS	REVISED
10-year (10%)	____	____
50-year (2%)	____	____
100-year (1%)	5353.4	5338.61
500-year (0.2%)	____	____
Normal Pool Elevation	____	____

7. Please attach a copy of the formal Operation and Maintenance Plan

E. LEVEE/FLOODWALL

The wall at 6423 Star Bright Road is treated as a floodwall based on as-built information, which is provided in appendix 5.

1. System Elements

a. This Levee/Floodwall analysis is based on (check one): ☐ upgrading of an existing levee/floodwall system ☐ a newly constructed levee/floodwall system ☐ reanalysis of an existing levee/floodwall system

b. Levee elements and locations are (check one):

☐ earthen embankment, dike, berm, etc. Station _____ to _____
☐ structural floodwall Station _____ to _____
☐ Other (describe): Station _____ to _____

c. Structural Type (check one): ☐ monolithic cast-in place reinforced concrete ☐ reinforced concrete masonry block ☐ sheet piling ☐ Other (describe): _____

d. Has this levee/floodwall system been certified by a Federal agency to provide protection from the base flood?

☐ Yes ☐ No

If Yes, by which agency? _____

e. Attach certified drawings containing the following information (indicate drawing sheet numbers):

1. Plan of the levee embankment and floodwall structures. Sheet Numbers: _____
2. A profile of the levee/floodwall system showing the Base Flood Elevation (BFE), levee and/or wall crest and foundation, and closure locations for the total levee system. Sheet Numbers: _____
3. A profile of the BFE, closure opening outlet and inlet invert elevations, type and size of opening, and kind of closure. Sheet Numbers: _____
4. A layout detail for the embankment protection measures. Sheet Numbers: _____
5. Location, layout, and size and shape of the levee embankment features, foundation treatment, Floodwall structure, closure structures, and pump stations. Sheet Numbers: _____

2. Freeboard

a. The minimum freeboard provided above the BFE is:

Riverine

3.0 feet or more at the downstream end and throughout	☐ Yes	☐ No
3.5 feet or more at the upstream end	☐ Yes	☐ No
4.0 feet within 100 feet upstream of all structures and/or constrictions	☐ Yes	☐ No

Coastal

1.0 foot above the height of the one percent wave associated with the 1%-annual-chance stillwater surge elevation or maximum wave runup (whichever is greater).	☐ Yes	☐ No
2.0 feet above the 1%-annual-chance stillwater surge elevation	☐ Yes	☐ No

Please note, occasionally exceptions are made to the minimum freeboard requirement. If an exception is requested, attach documentation addressing Paragraph 65.10(b)(1)(ii) of the NFIP Regulations.

If No is answered to any of the above, please attach an explanation.

b. Is there an indication from historical records that ice-jamming can affect the BFE? ☐ Yes ☐ No

If Yes, provide ice-jam analysis profile and evidence that the minimum freeboard discussed above still exists.

3. Closures

a. Openings through the levee system (check one): ☐ exists ☐ does not exist

If opening exists, list all closures:

Channel Station	Left or Right Bank	Opening Type	Highest Elevation for Opening Invert	Type of Closure Device

(Extend table on an added sheet as needed and reference)

Note: Geotechnical and geologic data

In addition to the required detailed analysis reports, data obtained during field and laboratory investigations and used in the design analysis for the following system features should be submitted in a tabulated summary form. (Reference U.S. Army Corps of Engineers [USACE] EM-1110-2-1906 Form 2086.)

4. Embankment Protection

a. The maximum levee slope land side is: _____

b. The maximum levee slope flood side is: _____

c. The range of velocities along the levee during the base flood is: _____ (min.) to _____ (max.)

d. Embankment material is protected by (describe what kind): _____

e. Riprap Design Parameters (check one): ☐ Velocity ☐ Tractive stress
Attach references

Reach	Sideslope	Flow Depth	Velocity	Curve or Straight	Stone Riprap			Depth of Toedown
					D_{100}	D_{50}	Thickness	
Sta to								
Sta to								
Sta to								
Sta to								
Sta to								
Sta to								

(Extend table on an added sheet as needed and reference each entry)

f. Is a bedding/filter analysis and design attached? ☐ Yes ☐ No

g. Describe the analysis used for other kinds of protection used (include copies of the design analysis):

Attach engineering analysis to support construction plans.

5. Embankment And Foundation Stability

a. Identify locations and describe the basis for selection of critical location for analysis:
_____

☐ Overall height: Sta.: _____, height _____ ft.

☐ Limiting foundation soil strength:

Strength ϕ = _____ degrees, c = _____ psf

Slope: SS = _____ (h) to _____ (v)

(Repeat as needed on an added sheet for additional locations)

b. Specify the embankment stability analysis methodology used (e.g., circular arc, sliding block, infinite slope, etc.):
_____

c. Summary of stability analysis results:

E. LEVEE/FLOODWALL (CONTINUED)

5. Embankment And Foundation Stability (continued)

Case	Loading Conditions	Critical Safety Factor	Criteria (Min.)
I	End of construction		1.3
II	Sudden drawdown		1.0
III	Critical flood stage		1.4
IV	Steady seepage at flood stage		1.4
VI	Earthquake (Case I)		1.0

(Reference: USACE EM-1110-2-1913 Table 6-1)

d. Was a seepage analysis for the embankment performed? ☐ Yes ☐ No

If Yes, describe methodology used:

e. Was a seepage analysis for the foundation performed? ☐ Yes ☐ No

f. Were uplift pressures at the embankment landside toe checked? ☐ Yes ☐ No

g. Were seepage exit gradients checked for piping potential? ☐ Yes ☐ No

h. The duration of the base flood hydrograph against the embankment is _____ hours.

Attach engineering analysis to support construction plans.

6. Floodwall And Foundation Stability

a. Describe analysis submittal based on Code (check one): ☐ UBC (1988) ☐ Other (specify): _____

b. Stability analysis submitted provides for: ☐ Overturning ☐ Sliding If not, explain: _____

c. Loading included in the analyses were: ☐ Lateral earth @ P_A = _____ psf; P_p = _____ psf

☐ Surcharge-Slope @ _____, ☐ surface _____ psf

☐ Wind @ P_w = _____ psf

☐ Seepage (Uplift); _____ ☐ Earthquake @ P_{eq} = _____ %g

☐ 1%-annual-chance significant wave height: _____ ft.

☐ 1%-annual-chance significant wave period: _____ sec.

d. Summary of Stability Analysis Results: Factors of Safety.
Itemize for each range in site layout dimension and loading condition limitation for each respective reach.

Loading Condition	Criteria (Min)		Sta	To	Sta	To
	Overturn	Sliding	Overturn	Sliding	Overturn	Sliding
Dead & Wind	1.5	1.5				
Dead & Soil	1.5	1.5				
Dead, Soil, Flood, & Impact	1.5	1.5				
Dead, Soil, & Seismic	1.3	1.3				

(Ref: FEMA 114 Sept 1986; USACE EM 1110-2-2502)
Note: (Extend table on an added sheet as needed and reference)

E. LEVEE/FLOODWALL (CONTINUED)

6. Floodwall And Foundation Stability (continued)

e. Foundation bearing strength for each soil type:

Bearing Pressure	Sustained Load (psf)	Short Term Load (psf)
Computed design maximum		
Maximum allowable		

f. Foundation scour protection ☐ is, ☐ is not provided. If provided, attach explanation and supporting documentation:

Attach engineering analysis to support construction plans.

7. Settlement

a. Has anticipated potential settlement been determined and incorporated into the specified construction elevations to maintain the established freeboard margin? ☐ Yes ☐ No

b. The computed range of settlement is _____ ft. to _____ ft.

c. Settlement of the levee crest is determined to be primarily from : ☐ Foundation consolidation ☐ Embankment compression ☐ Other (Describe): _____

d. Differential settlement of floodwalls ☐ has ☐ has not been accommodated in the structural design and construction.

Attach engineering analysis to support construction plans.

8. Interior Drainage

a. Specify size of each interior watershed:

Draining to pressure conduit: _____ acres
Draining to ponding area: _____ acres

b. Relationships Established

Ponding elevation vs. storage	☐ Yes	☐ No
Ponding elevation vs. gravity flow	☐ Yes	☐ No
Differential head vs. gravity flow	☐ Yes	☐ No

c. The river flow duration curve is enclosed: ☐ Yes ☐ No

d. Specify the discharge capacity of the head pressure conduit: _____ cfs

e. Which flooding conditions were analyzed?

• Gravity flow (Interior Watershed)	☐ Yes	☐ No
• Common storm (River Watershed)	☐ Yes	☐ No
• Historical ponding probability	☐ Yes	☐ No
• Coastal wave overtopping	☐ Yes	☐ No

If No for any of the above, attach explanation.

e. Interior drainage has been analyzed based on joint probability of interior and exterior flooding and the capacities of pumping and outlet facilities to provide the established level of flood protection. ☐ Yes ☐ No If No, attach explanation.

g. The rate of seepage through the levee system for the base flood is _____ cfs

h. The length of levee system used to drive this seepage rate in item g: _____ ft.

E. LEVEE/FLOODWALL (CONTINUED)

8. Interior Drainage (continued)

i. Will pumping plants be used for interior drainage? ☐ Yes ☐ No

If Yes, include the number of pumping plants: _____ For each pumping plant, list:

	Plant #1	Plant #2
The number of pumps		
The ponding storage capacity		
The maximum pumping rate		
The maximum pumping head		
The pumping starting elevation		
The pumping stopping elevation		
Is the discharge facility protected?		
Is there a flood warning plan?		
How much time is available between warning and flooding?		

Will the operation be automatic? ☐ Yes ☐ No

If the pumps are electric, are there backup power sources? ☐ Yes ☐ No

(Reference: USACE EM-1110-2-3101, 3102, 3103, 3104, and 3105)

Include a copy of supporting documentation of data and analysis. Provide a map showing the flooded area and maximum ponding elevations for all interior watersheds that result in flooding.

9. Other Design Criteria

a. The following items have been addressed as stated:

Liquefaction ☐ is ☐ is not a problem

Hydrocompaction ☐ is ☐ is not a problem

Heave differential movement due to soils of high shrink/swell ☐ is ☐ is not a problem

b. For each of these problems, state the basic facts and corrective action taken:

Attach supporting documentation

c. If the levee/floodwall is new or enlarged, will the structure adversely impact flood levels and/or flow velocities floodside of the structure?
☐ Yes ☐ No Attach supporting documentation

d. Sediment Transport Considerations:

Was sediment transport considered? ☐ Yes ☐ No

If Yes, then fill out Section F (Sediment Transport). If No, then attach your explanation for why sediment transport was not considered.

10. Operational Plan And Criteria

a. Are the planned/installed works in full compliance with Part 65.10 of the NFIP Regulations? ☐ Yes ☐ No

b. Does the operation plan incorporate all the provisions for closure devices as required in Paragraph 65.10(c)(1) of the NFIP regulations?
☐ Yes ☐ No

c. Does the operation plan incorporate all the provisions for interior drainage as required in Paragraph 65.10(c)(2) of the NFIP regulations?
☐ Yes ☐ No If the answer is No to any of the above, please attach supporting documentation.

E. LEVEE/FLOODWALL (CONTINUED)

11. Maintenance Plan

Please attach a copy of the fomal maintenance plan for the levee/floodwall

12. Operations and Maintenance Plan

Please attach a copy of the formal Operations and Maintenance Plan for the levee/floodwall.

CERTIFICATION OF THE LEVEE DOCUMENTION

This certification is to be signed and sealed by a licensed registered professional engineer authorized by law to certify elevation information data, hydrologic and hydraulic analysis, and any other supporting information as per NFIP regulations paragraph 65.10(e) and as described in the MT-2 Forms Instructions. All documents submitted in support of this request are correct to the best of my knowledge. I understand that any false statement may be punishable by fine or imprisonment under Title 18 of the United States Code, Section 1001.

Certifier's Name: _____ License No.: _____ Expiration Date: _____

Company Name: _____ Telephone No.: _____ Fax No.: _____

Signature: _____ Date: _____ E-Mail Address: _____

F. SEDIMENT TRANSPORT

Flooding Source: Boca Negra Arroyo

Name of Structure: Boca Negra Detention Dam

If there is any indication from historical records that sediment transport (including scour and deposition) can affect the Base Flood Elevation (BFE); and/or based on the stream morphology, vegetative cover, development of the watershed and bank conditions, there is a potential for debris and sediment transport (including scour and deposition) to affect the BFEs, then provide the following information along with the supporting documentation:

Sediment load associated with the base flood discharge: Volume 18.416 acre-feet

Debris load associated with the base flood discharge: Volume _____ acre-feet

Sediment transport rate 5% & 9% (percent concentration by volume) Based on community adopted numbers from Boca Negra-Mariposa DMP

Method used to estimate sediment transport: Bulking Factors

Most sediment transport formulas are intended for a range of hydraulic conditions and sediment sizes; attach a detailed explanation for using the selected method.

Method used to estimate scour and/or deposition: _____

Method used to revise hydraulic or hydrologic analysis (model) to account for sediment transport: Based on Boca Negra-Mariposa DMP

Please note that bulked flows are used to evaluate the performance of a structure during the base flood; however, FEMA does not map BFEs based on bulked flows.

If a sediment analysis has not been performed, an explanation as to why sediment transport (including scour and deposition) will not affect the BFEs or structures must be provided.

Comments to MT-2 Form 3: Riverine Structures Form

Section C.2: Bridge / Culverts

Bentley Culvert Master V3.3 was used only for the purpose of generating the rating curve upstream of the Scenic Road culverts. See attached calculations.

Section F: Sediment Transport

Sediment transport was addressed by adding a 5% bulking factor to areas above the escarpment and 9% to areas below the escarpment to the flows in the hydrologic model. The percentages are based on the Boca Negra – Mariposa Arroyo DMP. The DMP notes annual sediment yield using Flaxman Method to be 0.132 ac-ft/sq mi/yr for the Boca Negra Arroyo.

Culvert Calculator Report
4-60 IN AT IP3 - LOMR

Solve For: Headwater Elevation

Culvert Summary					
Allowable HW Elevation	5,346.79	ft	Headwater Depth/Height	2.08	
Computed Headwater Eleva	5,350.28	ft	Discharge	1,188.00	cfs
Inlet Control HW Elev.	5,350.28	ft	Tailwater Elevation	0.00	ft
Outlet Control HW Elev.	5,349.67	ft	Control Type	Inlet Control	

Grades					
Upstream Invert	5,339.90	ft	Downstream Invert	5,339.81	ft
Length	56.00	ft	Constructed Slope	0.001607	ft/ft

Hydraulic Profile					
Profile	CompositeM2PressureProfile		Depth, Downstream	4.66	ft
Slope Type	Mild		Normal Depth	N/A	ft
Flow Regime	Subcritical		Critical Depth	4.66	ft
Velocity Downstream	15.59	ft/s	Critical Slope	0.011246	ft/ft

Section					
Section Shape	Circular		Mannings Coefficient	0.013	
Section Material	Concrete		Span	5.00	ft
Section Size	60 inch		Rise	5.00	ft
Number Sections	4				

Outlet Control Properties					
Outlet Control HW Elev.	5,349.67	ft	Upstream Velocity Head	3.56	ft
Ke	0.20		Entrance Loss	0.71	ft

Inlet Control Properties					
Inlet Control HW Elev.	5,350.28	ft	Flow Control	N/A	
Inlet Type	Groove end w/headwall		Area Full	78.5	ft²
K	0.00180		HDS 5 Chart	1	
M	2.00000		HDS 5 Scale	2	
C	0.02920		Equation Form	1	
Y	0.74000				

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APPENDIX 1 (CD)

NOAA Atlas 14 Rainfall Data

HYDROLOGY – AHYMO Files

- **Basin Summary Table**
- **Flowchart**
- **Summary File**
- **Input File**
- **Output File**

NOAA Atlas 14, Volume 1, Version 5
Location name: Albuquerque, New Mexico, US*
Latitude: 35.1640°, Longitude: -106.7257°
Elevation: 5325ft*
* source: Google Maps

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Sarah Dietz, Sarah Heim, Lillian Hiner, Kazungu Maitaria, Deborah Martin, Sandra Pavlovic, Ishani Roy, Carl Trypaluk, Dale Unruh, Fenglin Yan, Michael Yekta, Tan Zhao, Geoffrey Bonnin, Daniel Brewer, Li-Chuan Chen, Tye Parzybok, John Yarchoan

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.160 (0.137–0.187)	0.207 (0.177–0.242)	0.279 (0.236–0.327)	0.336 (0.286–0.392)	0.413 (0.349–0.481)	0.473 (0.399–0.549)	0.538 (0.450–0.623)	0.606 (0.503–0.702)	0.698 (0.575–0.811)	0.773 (0.631–0.897)
10-min	0.243 (0.208–0.284)	0.315 (0.269–0.368)	0.424 (0.360–0.497)	0.512 (0.435–0.596)	0.629 (0.530–0.732)	0.720 (0.607–0.836)	0.818 (0.685–0.948)	0.922 (0.765–1.07)	1.06 (0.874–1.23)	1.18 (0.959–1.37)
15-min	0.301 (0.258–0.352)	0.390 (0.333–0.456)	0.525 (0.446–0.616)	0.634 (0.540–0.739)	0.780 (0.657–0.908)	0.892 (0.753–1.04)	1.01 (0.849–1.18)	1.14 (0.948–1.33)	1.32 (1.08–1.53)	1.46 (1.19–1.69)
30-min	0.405 (0.347–0.474)	0.526 (0.449–0.614)	0.707 (0.600–0.829)	0.854 (0.726–0.995)	1.05 (0.885–1.22)	1.20 (1.01–1.40)	1.37 (1.14–1.58)	1.54 (1.28–1.78)	1.77 (1.46–2.06)	1.96 (1.60–2.28)
60-min	0.501 (0.430–0.586)	0.650 (0.555–0.760)	0.876 (0.743–1.03)	1.06 (0.899–1.23)	1.30 (1.10–1.51)	1.49 (1.25–1.73)	1.69 (1.42–1.96)	1.90 (1.58–2.21)	2.20 (1.81–2.55)	2.43 (1.98–2.82)
2-hr	0.590 (0.510–0.678)	0.753 (0.649–0.868)	1.00 (0.859–1.15)	1.20 (1.03–1.37)	1.48 (1.26–1.68)	1.70 (1.44–1.93)	1.94 (1.63–2.20)	2.19 (1.83–2.48)	2.54 (2.10–2.88)	2.83 (2.31–3.21)
3-hr	0.627 (0.554–0.722)	0.800 (0.703–0.920)	1.05 (0.926–1.20)	1.26 (1.10–1.44)	1.53 (1.33–1.75)	1.76 (1.52–2.00)	2.00 (1.72–2.27)	2.26 (1.92–2.57)	2.62 (2.20–2.97)	2.91 (2.41–3.32)
6-hr	0.725 (0.641–0.823)	0.919 (0.819–1.05)	1.19 (1.06–1.35)	1.41 (1.24–1.59)	1.70 (1.49–1.92)	1.93 (1.69–2.17)	2.17 (1.89–2.45)	2.42 (2.09–2.72)	2.77 (2.37–3.12)	3.07 (2.59–3.46)
12-hr	0.808 (0.719–0.909)	1.02 (0.908–1.15)	1.30 (1.15–1.46)	1.53 (1.35–1.71)	1.82 (1.60–2.04)	2.05 (1.79–2.30)	2.29 (1.99–2.56)	2.55 (2.19–2.84)	2.88 (2.47–3.22)	3.16 (2.68–3.54)
24-hr	0.929 (0.820–1.06)	1.17 (1.03–1.32)	1.47 (1.30–1.67)	1.71 (1.51–1.93)	2.03 (1.79–2.29)	2.28 (2.00–2.57)	2.54 (2.22–2.86)	2.81 (2.44–3.15)	3.17 (2.73–3.56)	3.45 (2.95–3.87)
2-day	0.967 (0.863–1.08)	1.21 (1.09–1.36)	1.53 (1.37–1.71)	1.77 (1.58–1.98)	2.10 (1.87–2.35)	2.36 (2.09–2.63)	2.63 (2.32–2.93)	2.90 (2.55–3.23)	3.27 (2.85–3.64)	3.56 (3.09–3.97)
3-day	1.13 (1.02–1.25)	1.41 (1.28–1.56)	1.75 (1.58–1.93)	2.01 (1.82–2.22)	2.38 (2.14–2.62)	2.65 (2.38–2.92)	2.93 (2.63–3.23)	3.22 (2.87–3.54)	3.60 (3.19–3.97)	3.89 (3.44–4.30)
4-day	1.29 (1.18–1.41)	1.60 (1.47–1.76)	1.97 (1.80–2.15)	2.26 (2.06–2.46)	2.65 (2.41–2.89)	2.94 (2.67–3.21)	3.24 (2.93–3.53)	3.53 (3.19–3.86)	3.93 (3.53–4.29)	4.22 (3.78–4.62)
7-day	1.48 (1.36–1.61)	1.84 (1.68–2.00)	2.24 (2.05–2.44)	2.55 (2.34–2.77)	2.96 (2.71–3.21)	3.26 (2.98–3.55)	3.57 (3.26–3.88)	3.86 (3.52–4.20)	4.25 (3.86–4.62)	4.53 (4.10–4.93)
10-day	1.64 (1.51–1.79)	2.04 (1.87–2.22)	2.50 (2.29–2.71)	2.86 (2.62–3.09)	3.33 (3.05–3.60)	3.69 (3.37–3.99)	4.05 (3.69–4.37)	4.40 (4.00–4.76)	4.86 (4.40–5.26)	5.19 (4.69–5.63)
20-day	2.06 (1.89–2.25)	2.56 (2.35–2.79)	3.11 (2.86–3.38)	3.52 (3.23–3.83)	4.05 (3.71–4.40)	4.43 (4.06–4.81)	4.80 (4.39–5.21)	5.15 (4.70–5.58)	5.59 (5.09–6.06)	5.90 (5.36–6.41)
30-day	2.47 (2.26–2.67)	3.06 (2.81–3.31)	3.68 (3.38–3.98)	4.14 (3.80–4.47)	4.72 (4.33–5.09)	5.13 (4.69–5.53)	5.52 (5.05–5.95)	5.88 (5.37–6.34)	6.32 (5.76–6.81)	6.62 (6.03–7.15)
45-day	3.02 (2.78–3.26)	3.73 (3.44–4.04)	4.45 (4.10–4.81)	4.96 (4.57–5.35)	5.58 (5.15–6.02)	6.01 (5.54–6.47)	6.39 (5.89–6.88)	6.73 (6.20–7.25)	7.12 (6.56–7.66)	7.36 (6.78–7.92)
60-day	3.46 (3.20–3.75)	4.29 (3.96–4.64)	5.11 (4.72–5.52)	5.70 (5.26–6.16)	6.41 (5.92–6.92)	6.89 (6.36–7.44)	7.33 (6.77–7.92)	7.73 (7.14–8.34)	8.17 (7.55–8.83)	8.46 (7.83–9.14)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

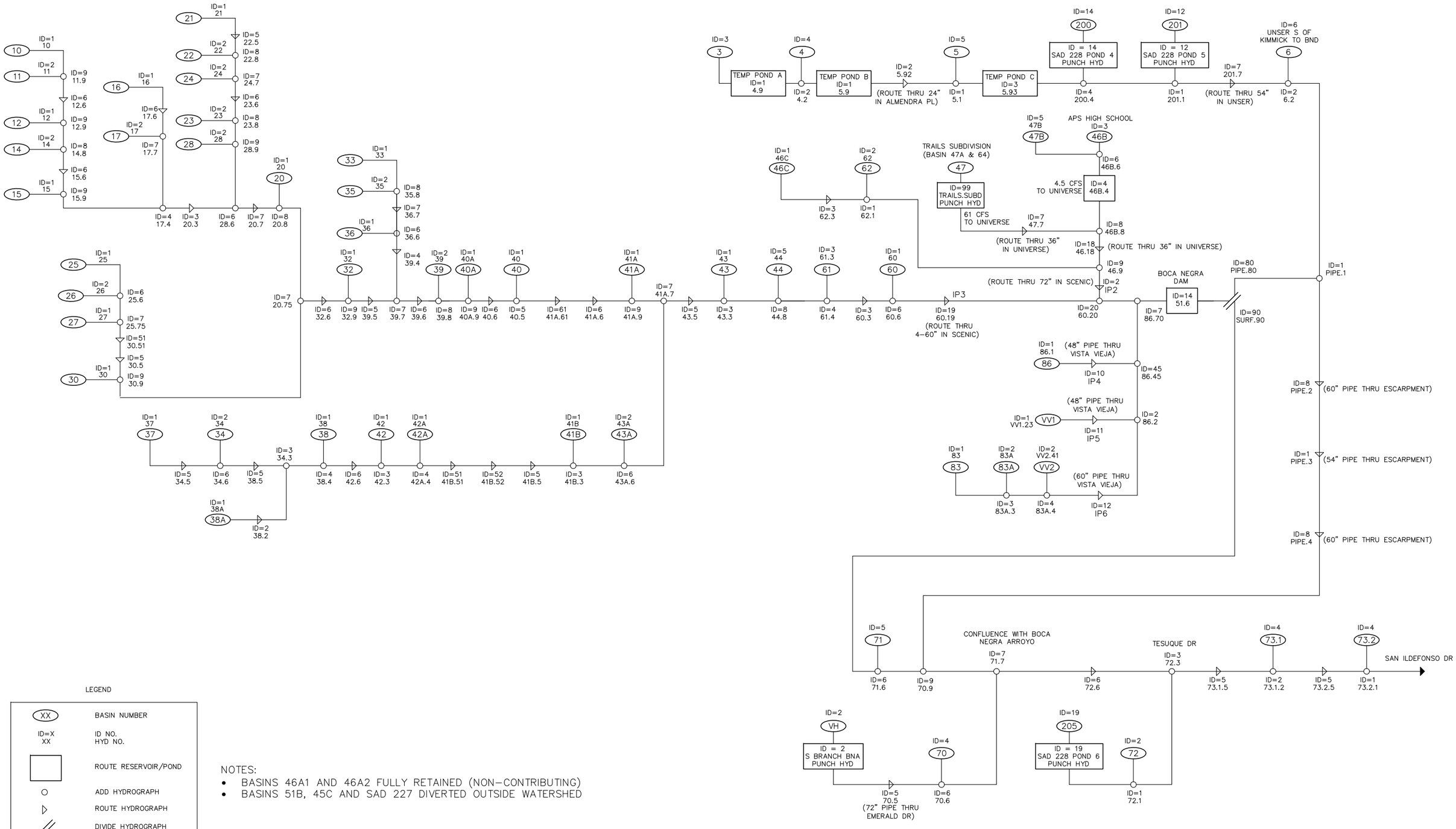
Back to Top

PF graphical

Boca Negra Arroyo - LOMR Model			
AHYMO Basin Summary			
Hydrologic Element	Area	Peak Flow	Runoff Volume
	sq mi	cfs	ac-ft
10	0.358	116.07	7.823
11	0.390	115.19	8.522
12	0.309	106.67	6.721
14	0.513	152.83	11.158
15	0.301	86.15	6.547
16	0.533	163.09	11.593
17	0.268	73.97	5.829
21	0.145	61.99	3.154
22	0.739	167.46	16.074
24	0.117	31.21	2.545
23	0.245	71.05	5.329
28	0.158	45.82	3.500
20	0.426	152.89	9.437
25	0.463	118.49	10.024
26	0.348	117.05	7.534
27	0.376	123.19	8.141
30	0.588	145.28	13.026
32	0.250	99.71	5.413
33	0.731	151.98	15.827
35	0.616	127.16	13.337
36	0.407	138.58	9.680
39	0.341	79.51	7.747
40A	0.107	46.49	2.557
40	0.356	201.31	8.506
41A	0.453	230.97	12.733
37	0.590	163.84	17.415
34	0.129	39.76	3.808
38A	0.075	32.25	1.624
38	0.131	58.62	2.889
42	0.576	269.27	13.643
42A	0.317	217.62	7.508
41B	0.137	87.53	3.851
43A	0.186	94.85	4.600
43	0.170	70.5	4.204
44	0.409	144.19	9.688
60	0.110	59.79	2.389
IP3*	12.417	1187.87	282.978
61	0.048	26.79	1.198

Boca Negra Arroyo - LOMR Model			
AHYMO Basin Summary			
Hydrologic Element	Area	Peak Flow	Runoff Volume
	sq mi	cfs	ac-ft
46C	0.003	2.11	0.059
62	0.067	35.04	1.662
47, 47A & 64 (Trails Subd.)	1.054	60.72	76.374
47B	0.031	23.57	0.722
46B	0.113	181.87	9.871
IP2*	1.267	91.83	86.977
IP4*	0.248	134.99	7.013
VV1	0.089	163.45	8.335
IP5*	0.089	162.2	8.334
83	0.538	168.06	13.317
83A	0.137	84.78	3.391
VV2	0.037	53.4	3.478
IP6*	0.712	265.02	20.191
3	0.096	39.97	2.378
4	0.028	19.54	0.671
5	0.094	38.02	2.236
200 (SAD Pond 4)	0.021	18.04	1.546
201 (SAD Pond 5)	0.149	36.97	12.287
6	0.012	21.35	1.359
71	0.077	49.24	2.055
VH (South BranchBoca Negra Arroyo)*	1.640	377.51	33.649
70	0.069	66.65	1.851
Confluence with Boca Negra Arroyo*	16.918	1147.49	463.165
205 (SAD Pond 6)	0.065	50.66	5.402
72	0.167	126.65	4.473
Tesuque Drive*	17.151	1148.83	472.813
73.1	0.129	209.07	9.91
73.2	0.051	99.73	3.928
San Ildefonso Drive	17.331	1151.04	486.629

* Routed flow



LEGEND

XX	BASIN NUMBER
ID=X XX	ID NO. HYD NO.
	ROUTE RESERVOIR/POND
	ADD HYDROGRAPH
	ROUTE HYDROGRAPH
	DIVIDE HYDROGRAPH

NOTES:

- BASINS 46A1 AND 46A2 FULLY RETAINED (NON-CONTRIBUTING)
- BASINS 51B, 45C AND SAD 227 DIVERTED OUTSIDE WATERSHED

BOCA NEGRA ARROYO LOMR AHYMO FLOW CHART

T:\Projects\x321807802\Eng\2012 Final Plans_Specifications_Estimate_Reports\2014 Final Construction Acceptance Reports\H&H\LOMR - RAS\DOCS\LOMR-AHYMO FlowChart.dwg

AHYMO PROGRAM SUMMARY TABLE (AHYMO_97) - - VERSION: 1997.02c RUN DATE (MON/DAY/YR) =05/04/2015
INPUT FILE = C:\BNDAHY~1\BOCANE~1.TXT USER NO.= AHYMO-C-9803c01UNMLIB-AH

COMMAND	HYDROGRAPH IDENTIFICATION	FROM ID NO.	TO ID NO.	AREA (SQ MI)	PEAK DISCHARGE (CFS)	RUNOFF VOLUME (AC-FT)	RUNOFF (INCHES)	TIME TO PEAK (HOURS)	CFS PER ACRE	NOTATION
*S**********										
*S BOCA NEGRA DAM										
*S LOMR MODEL - NEW RAINFALL DATA										
*S INCLUDES BASINS DOWNSTREAM OF THE DAM										
*S 100 YR 24 HR STORM EVENT										
*S DATE: APRIL 2015										
*S**********										
START										TIME= .00
LOCATION	BERNALILLO COUNTY									
*S 100 YEAR 24HR STORM										
RAINFALL TYPE= 2										RAIN24= 2.540
*S APPLY A 5% SEDIMENT BULKING FACTOR ABOVE THE ESCARPMENT AND 9% BELOW										
*S THE ESCARPMENT TO COMPUTED HYDROGRAPHS - NO SEDIMENT BULKING FACTOR										
*S WHEN USING RECALL HYD COMMAND										
SEDIMENT BULK										PK BF = 1.05
*S*** Basin Contributing to INFLOW POINT 3 (IP3) **********										
*S QUAIL RANCH BASINS										
S										
*S**** SUB-BASIN 10 ****										
COMPUTE NM HYD	10.00	-	1	.35800	116.07	7.823	.40971	1.750	.507	PER IMP= .00
*S**** SUB-BASIN 11 ****										
COMPUTE NM HYD	11.00	-	2	.39000	115.19	8.522	.40971	1.800	.461	PER IMP= .00
*S										
*S ADD IP3.10 TO IP3.11 TO GET IP3.11.9										
ADD HYD	11.90	1& 2	9	.74800	229.96	16.345	.40971	1.800	.480	
*S										
*S ROUTE 11.9 THRU IP3.12 IN NATURAL ARROYO TO 12.6										
ROUTE MCUNGE	12.60	9	6	.74800	217.63	15.941	.39959	2.550	.455	CCODE = .1
*S*** SUB-BASIN 12 ****										
COMPUTE NM HYD	12.00	-	1	.30900	106.67	6.721	.40783	1.750	.539	PER IMP= .00
*S										
ADD HYD	12.90	1& 6	9	1.05700	235.06	22.662	.40200	2.500	.347	
*S*** SUB-BASIN 14 ****										
COMPUTE NM HYD	14.00	-	2	.51300	152.83	11.158	.40783	1.800	.465	PER IMP= .00
*S										
ADD HYD	14.80	2& 9	8	1.57000	275.48	33.820	.40391	2.500	.274	
*S										
*S ROUTE 14.8 THRU 15 IN NATURAL ARROYO TO 15.6										
ROUTE MCUNGE	15.60	8	6	1.57000	255.20	33.354	.39834	3.250	.254	CCODE = .1
*S*** SUB-BASIN 15 ****										
COMPUTE NM HYD	15.00	-	1	.30100	86.15	6.547	.40783	1.800	.447	PER IMP= .00
*S										
ADD HYD	15.90	1& 6	9	1.87100	267.87	39.901	.39986	2.450	.224	
*S*** SUB-BASIN 16 ****										
COMPUTE NM HYD	16.00	-	1	.53300	163.09	11.593	.40783	1.800	.478	PER IMP= .00
*S										
*S ROUTE 16 THRU 17 IN NATURAL ARROYO TO 17.7										
ROUTE MCUNGE	17.60	1	6	.53300	158.07	11.482	.40391	2.200	.463	CCODE = .1
*S*** SUB-BASIN 17 ****										

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COMPUTE NM HYD         17.00   -     2        .26800        73.97       5.829       .40783    1.800     .431 PER IMP=    .00
*S
*S ADD 17.6 TO 17 TO GET 17.7
ADD HYD                17.70  6& 2   7        .80100       201.29      17.311       .40522    2.200     .393
*S ADD 17.7 TO 15.9 TO GET 17.4
ADD HYD                17.40  7& 9   4       2.67200       421.35      57.212       .40147    2.400     .246
*S
*S ROUTE 17.4 THRU 20 IN NATURAL ARROYO TO 28.6
ROUTE MCUNGE           20.30    4    3       2.67200       413.90      57.135       .40093    2.650     .242 CCODE =     .1
*S*** SUB-BASIN 21 ****
COMPUTE NM HYD         21.00   -     1        .14500        61.99       3.154       .40783    1.650     .668 PER IMP=    .00
*S
*S ROUTE 21 THRU 22 IN NATURAL ARROYO TO 22.8
ROUTE MCUNGE           22.50    1    5        .14500        61.54       2.964       .38331    3.550     .663 CCODE =     .2
*S*** SUB-BASIN 22 ****
COMPUTE NM HYD         22.00   -     2        .73900       167.46      16.074       .40783    1.900     .354 PER IMP=    .00
*S
*S ADD 21 AND 22 TO GET 22.8
ADD HYD                22.80  5& 2   8        .88400       167.46      19.038       .40381    1.900     .296
*S
*S*** SUB-BASIN 24 ****
COMPUTE NM HYD         24.00   -     2        .11700        31.21       2.545       .40783    1.800     .417 PER IMP=    .00
*S
*S ADD 24 AND 22.8 TO GET 24.7
ADD HYD                24.70  2& 8   7       1.00100       196.99      21.583       .40428    1.900     .307
*S
*S ROUTE 24.7 THRU 23 IN NATURAL ARROYO TO 23.8
ROUTE MCUNGE           23.60    7    6       1.00100       196.67      21.579       .40420    2.050     .307 CCODE =     .2
*S*** SUB-BASIN 23 ****
COMPUTE NM HYD         23.00   -     2        .24500        71.05       5.329       .40783    1.800     .453 PER IMP=    .00
*S
*S ADD 23 AND 23.6 TO GET 23.8
ADD HYD                23.80  2& 6   8       1.24600       252.54      26.908       .40491    2.000     .317
*S
*S*** SUB-BASIN 28 ****
COMPUTE NM HYD         28.00   -     2        .15800        45.82       3.500       .41537    1.750     .453 PER IMP=    .00
*S
*S ADD 28 AND 23.8 TO GET 28.9
ADD HYD                28.90  2& 8   9       1.40400       288.90      30.408       .40609    2.000     .322
*S
*S ADD 17.4 TO 28.9 TO GET 28.6
ADD HYD                28.60  3& 9   6       4.07600       533.05      87.543       .40271    2.650     .204
*S
*S ROUTE 28.6 THRU 20 IN NATURAL ARROYO TO 20.8
ROUTE MCUNGE           20.70    6    7       4.07600       529.55      87.503       .40252    2.750     .203 CCODE =     .1
*S*** SUB-BASIN 20 ****
COMPUTE NM HYD         20.00   -     1        .42600       152.89       9.437       .41537    1.750     .561 PER IMP=    .00
*S
ADD HYD                20.80  1& 7   8       4.50200       543.62      96.940       .40374    2.750     .189
*S*** SUB-BASIN 25 ****
COMPUTE NM HYD         25.00   -     1        .46300       118.49      10.024       .40595    1.850     .400 PER IMP=    .00
*S
*S*** SUB-BASIN 26 ****
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COMMAND	HYDROGRAPH IDENTIFICATION	FROM ID NO.	TO ID NO.	AREA (SQ MI)	PEAK DISCHARGE (CFS)	RUNOFF VOLUME (AC-FT)	RUNOFF (INCHES)	TIME TO PEAK (HOURS)	CFS PER ACRE	NOTATION


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COMPUTE NM HYD         26.00   -     2        .34800       117.05       7.534       .40595    1.750     .526 PER IMP=    .00
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*S
*S ADD 25 TO 26 TO GET 25.6
ADD HYD               25.60  1& 2   6        .81100       230.40      17.559       .40595    1.800     .444
*S*** SUB-BASIN 27 ****
COMPUTE NM HYD        27.00   -     1        .37600       123.19       8.141       .40595    1.750     .512 PER IMP=    .00
*S
*S ADD 27 TO 25.6 TO GET 25.75
ADD HYD               25.75  1& 6   7       1.18700       351.46      25.699       .40595    1.800     .463
*S
*S ROUTE 25.75 THRU UPPER 30 IN NATURAL ARROYO TO 30.91
ROUTE MCUNGE          30.51    7   51       1.18700       310.87      24.796       .39167    2.900     .409 CCODE =     .1
*S ROUTE 30.91 THRU LOWER 30 IN NATURAL ARROYO TO 30.9
ROUTE MCUNGE          30.50   51    5       1.18700       308.75      24.727       .39059    3.100     .406 CCODE =     .1
*S*** SUB-BASIN 30 ****
COMPUTE NM HYD        30.00   -     1        .58800       145.28      13.026       .41537    1.900     .386 PER IMP=    .00
*S
*S ADD 30 TO 30.5 TO GET 30.9
ADD HYD               30.90  1& 5   9       1.77500       329.34      37.753       .39880    3.100     .290
*S
*S  ***************  TOTAL FLOW OUT OF BOCA NEGRA PART OF QUAIL RANCH
*S  ADD 30.9 TO 20.8 TO GET 20.75
*S
ADD HYD               20.75  9& 8   7       6.27700       714.50     134.693       .40234    3.050     .178
*S
*S ROUTE 20.75 THRU 32 IN NATURAL ARROYO TO 32.6
ROUTE MCUNGE          32.60    7    6       6.27700       688.37     134.495       .40175    3.300     .171 CCODE =     .1
*S ADD BASIN 32************************
COMPUTE NM HYD        32.00   -     1        .25000        99.71       5.413       .40595    1.650     .623 PER IMP=    .00
*S
*S ADD 32 TO 20.75 TO GET 32.9
ADD HYD               32.90  1& 6   9       6.52700       692.78     139.907       .40191    3.300     .166
*S
*S ROUTE 32.9 THRU UPPER 39 IN NATURAL ARROYO TO 39.7
ROUTE MCUNGE          39.50    9    5       6.52700       691.70     139.908       .40191    3.400     .166 CCODE =     .2
*S*** SUB-BASIN 33 ****
COMPUTE NM HYD        33.00   -     1        .73100       151.98      15.827       .40595    1.950     .325 PER IMP=    .00
*S
*S*** SUB-BASIN 35 ****
COMPUTE NM HYD        35.00   -     2        .61600       127.16      13.337       .40595    2.000     .323 PER IMP=    .00
*S
*S  ADD 33 TO 35 TO GET 35.8
*S
ADD HYD               35.80  1& 2   8       1.34700       279.09      29.164       .40595    1.950     .324
*S
*S ROUTE 35.8 THRU UPPER 39 IN NATURAL ARROYO TO 36.6
ROUTE MCUNGE          36.70    8    7       1.34700       277.79      29.113       .40524    2.200     .322 CCODE =     .1
*S*** SUB-BASIN 36 ****
COMPUTE NM HYD        36.00   -     1        .40700       138.58       9.680       .44594    1.750     .532 PER IMP=   2.00
*S
*S  ADD 35.8 TO 36 TO GET 36.6
*S
♀
                                FROM  TO                    PEAK          RUNOFF                TIME TO    CFS       PAGE =   4
                    HYDROGRAPH    ID   ID          AREA     DISCHARGE     VOLUME      RUNOFF      PEAK      PER
COMMAND         IDENTIFICATION    NO.  NO.       (SQ MI)     (CFS)       (AC-FT)   (INCHES)   (HOURS)    ACRE      NOTATION

ADD HYD               36.60  1& 7   6       1.75400       352.26      38.792       .41468    2.100     .314
*S
*S ROUTE 36.6 THRU MID 39 IN NATURAL ARROYO TO 39.7
ROUTE MCUNGE          39.40    6    4       1.75400       351.79      38.802       .41479    2.250     .313 CCODE =     .2
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*S  ADD 32.9 TO 39.4 TO GET 39.7
*S
ADD HYD               39.70  5& 4   7       8.28100       980.06     178.709       .40464    2.350     .185
*S
*S ROUTE 39.7 THRU LOWER 39 IN NATURAL ARROYO TO 39.8
ROUTE MCUNGE          39.60    7    6       8.28100       978.30     178.716       .40465    2.400     .185 CCODE =      .2
*S*** SUB-BASIN 39 ****
COMPUTE NM HYD        39.00   -     2        .34100        79.51       7.747       .42594    1.950     .364 PER IMP=   1.00
*S
*S  ADD 39.6 TO 39 TO GET 39.8
*S
ADD HYD               39.80  2& 6   8       8.62200      1025.12     186.462       .40549    2.400     .186
*S
*S*** SUB-BASIN 40A ****
COMPUTE NM HYD          40A   -     1        .10700        46.49       2.557       .44800    1.650     .679 PER IMP=    .00
*S
*S  ADD 40A TO 39.8 TO GET 40A.9
*S
ADD HYD               40A.9  1& 8   9       8.72900      1031.81     189.019       .40601    2.400     .185
*S
*S ROUTE 40A.9 THRU 40 IN NATURAL ARROYO TO 40.5
ROUTE MCUNGE          40.60    9    6       8.72900      1029.72     189.009       .40599    2.500     .184 CCODE =      .2
*S*** SUB-BASIN 40 ****
COMPUTE NM HYD        40.00   -     1        .35600       201.31       8.506       .44800    1.600     .884 PER IMP=    .00
*S
*S  ADD 40 TO 40A.9 TO GET 40.5
*S
ADD HYD               40.50  1& 6   5       9.08500      1044.04     197.515       .40764    2.500     .180
*S
*S ROUTE 40.5 THRU UPPER 41A IN NATURAL ARROYO TO 41A.9
ROUTE MCUNGE          41A.61    5   61       9.08500      1042.92     197.468       .40754    2.700     .179 CCODE =      .1
*S ROUTE 40.5 THRU LOWER 41A IN NATURAL ARROYO TO 41A.9
ROUTE MCUNGE          41A.6    61    6       9.08500      1042.38     197.475       .40756    2.750     .179 CCODE =      .2
*S*** SUB-BASIN 41A ****
COMPUTE NM HYD          41A   -     1        .45300       230.97      12.733       .52701    1.700     .797 PER IMP=    .00
*S
*S  ADD 41A TO 40.5 TO GET 41A.9
*S
ADD HYD               41A.9  1& 6   9       9.53800      1060.60     210.208       .41323    2.750     .174
*S
*S*** SUB-BASIN 37 ****
COMPUTE NM HYD        37.00   -     1        .59000       163.84      17.415       .55343    2.000     .434 PER IMP=   7.00
*S
*S ROUTE 37 THRU 34 IN NATURAL ARROYO TO 34.6
ROUTE MCUNGE          34.50    1    5        .59000       163.84      18.049       .57360    2.350     .434 CCODE =      .2
*S*** SUB-BASIN 34 ****
COMPUTE NM HYD        34.00   -     2        .12900        39.76       3.808       .55343    1.850     .482 PER IMP=   7.00
*S
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                           FROM  TO                  PEAK         RUNOFF              TIME TO    CFS      PAGE =   5
                HYDROGRAPH   ID   ID         AREA    DISCHARGE    VOLUME     RUNOFF    PEAK     PER
COMMAND      IDENTIFICATION  NO.  NO.      (SQ MI)     (CFS)      (AC-FT)  (INCHES)  (HOURS)  ACRE     NOTATION

*S  ADD 34 TO 34.5 TO GET 34.6
*S
ADD HYD               34.60  5& 2   6        .71900       185.78      21.857       .56998    2.350     .404
*S
*S ROUTE 34.6 THRU 38 IN NATURAL ARROYO TO 34.3
ROUTE MCUNGE          38.50    6    5        .71900       183.99      21.781       .56801    2.650     .400 CCODE =      .1
*S*** SUB-BASIN 38A ****
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COMPUTE NM HYD          38A   -     1        .07500        32.25       1.624       .40595    1.600     .672 PER IMP=    .00
*S
*S ROUTE 38A THRU 38 IN NATURAL ARROYO TO 34.3
ROUTE MCUNGE          38.20    1    2        .07500        30.10       1.588       .39689    2.450     .627 CCODE =     .1
*S  ADD 38.2 TO 38.5 TO GET 34.3
*S
ADD HYD               34.30  2& 5   3        .79400       206.42      23.369       .55185    2.600     .406
*S
*S*** SUB-BASIN 38 ****
COMPUTE NM HYD        38.00   -     1        .13100        58.62       2.889       .41348    1.600     .699 PER IMP=    .00
*S
*S  ADD 38 TO 34.3 TO GET 38.4
*S
ADD HYD               38.40  1& 3   4        .92500       211.05      26.258       .53225    2.600     .357
*S
*S ROUTE 38.4 THRU 42 IN NATURAL ARROYO TO 42.3
ROUTE MCUNGE          42.60    4    6        .92500       210.37      26.234       .53178    2.950     .355 CCODE =     .1
*S*** SUB-BASIN 42 ****
COMPUTE NM HYD        42.00   -     1        .57600       269.27      13.643       .44411    1.650     .730 PER IMP=    .00
*S
*S  ADD 42 TO 38.9 TO GET 42.3
*S
ADD HYD               42.30  1& 6   3       1.50100       269.32      39.877       .49814    1.650     .280
*S
*S*** SUB-BASIN 42A ****
COMPUTE NM HYD          42A   -     1        .31700       217.62       7.508       .44411    1.550    1.073 PER IMP=    .00
*S
*S  ADD 42 TO 38.9 TO GET 42A.4
*S
ADD HYD               42A.4  1& 3   4       1.81800       465.40      47.386       .48872    1.600     .400
*S
*S ROUTE 42A.4 THRU UPPER 41B IN NATURAL ARROYO TO 41B.52
ROUTE MCUNGE        41B.51    4   51       1.81800       461.26      47.468       .48956    1.750     .396 CCODE =     .2
*S ROUTE 41B.52 THRU MID 41B IN NATURAL ARROYO TO 41B.5
ROUTE MCUNGE        41B.52   51   52       1.81800       461.26      47.468       .48956    1.750     .396 CCODE =     .0
*S ROUTE 41B.5 THRU LOWER 41B IN NATURAL ARROYO TO 41B.3
ROUTE MCUNGE         41B.5   52    5       1.81800       452.72      47.184       .48663    1.900     .389 CCODE =     .1
*S*** SUB-BASIN 41B ****
COMPUTE NM HYD          41B   -     1        .13700        87.53       3.851       .52701    1.600     .998 PER IMP=    .00
*S
*S  ADD 41B TO 42A.4 TO GET 41B.3
*S
ADD HYD               41B.3  1& 5   3       1.95500       491.33      51.034       .48946    1.900     .393
*S
*S*** SUB-BASIN 43A ****
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COMMAND	HYDROGRAPH IDENTIFICATION	FROM ID NO.	TO ID NO.	AREA (SQ MI)	PEAK DISCHARGE (CFS)	RUNOFF VOLUME (AC-FT)	RUNOFF (INCHES)	TIME TO PEAK (HOURS)	CFS PER ACRE	NOTATION
COMPUTE NM HYD	43A	-	2	.18600	94.85	4.600	.46367	1.650	.797	PER IMP= .00
*S										
*S ADD 43A TO 41B.3 TO GET 43A.6										
*S										
ADD HYD	43A.6	2& 3	6	2.14100	541.85	55.634	.48722	1.900	.395	
*S										
*S ADD 43A.6 TO 41A.9 TO GET 41A.7										
*S										
ADD HYD	41A.7	6& 9	7	11.67900	1175.63	265.842	.42679	2.750	.157	
*S										

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*S ROUTE 41A.7 THRU 43 IN NATURAL ARROYO TO 43.3
ROUTE MCUNGE          43.50    7    5      11.67900      1168.97     265.502       .42625    3.050     .156 CCODE =      .1
*S*** SUB-BASIN 43 ****
COMPUTE NM HYD        43.00    -    1        .17000        70.50       4.204       .46367    1.700     .648 PER IMP=    .00
*S
*S  ADD 43 TO 41A.7 TO GET 43.3
*S
ADD HYD               43.30  1& 5   3      11.84900      1173.65     269.706       .42679    3.050     .155
*S
*S
*S*** SUB-BASIN 44 ****
COMPUTE NM HYD        44.00    -    5        .40900       144.19       9.688       .44411    1.750     .551 PER IMP=    .00
*S
*S ADD 44 TO 61.6 TO GET 44.8
ADD HYD               44.80  5& 3   8      12.25800      1185.10     279.394       .42736    3.050     .151
*S
*S*** SUB-BASIN 61 ****
COMPUTE NM HYD        61.00    -    3        .04846        26.79       1.198       .46367    1.600     .864 PER IMP=    .00
*S ADD 61 TO 44 TO GET 61.4
ADD HYD               61.40  8& 3   4      12.30646      1186.15     280.592       .42751    3.050     .151
*S ROUTE 61.4 THRU 60 IN NATURAL ARROYO TO 60.3
ROUTE MCUNGE          60.30    4    3      12.30646      1185.85     280.589       .42750    3.100     .151 CCODE =      .2
*S*** SUB-BASIN 60 ****
COMPUTE NM HYD        60.00    -    1        .11036        59.79       2.389       .40595    1.550     .847 PER IMP=    .00
*S
*S ADD 60 TO 44.8 TO GET 60.20
*S
ADD HYD               60.60  1& 3   6      12.41682      1187.56     282.979       .42731    3.100     .149
*S
*S ROUTE THRU 4-60" PIPES IN SCENIC BLVD - IP3 *********************
*S ROUTE RESERVOIR COMMAND WAS USED TO ROUTE THRU MULTIPLE PIPES IN SCENIC
ROUTE RESERVOIR       60.19    6   19      12.41682      1187.87     282.978       .42731    3.100     .149 AC-FT=    3.178
*S*** Basin Contributing to INFLOW POINT 2 (IP2) ******************
*S*** SUB-BASIN 46C
COMPUTE NM HYD          46C    -    1        .00250         2.11        .059       .44411    1.500    1.319 PER IMP=    .00
*S ROUTE 46C THRU 62 IN NATURAL ARROYO TO 62.3
ROUTE MCUNGE          62.30    1    3        .00250         1.89        .058       .43518    2.450    1.181 CCODE =      .1
*S*** SUB-BASIN 62
COMPUTE NM HYD        62.00    -    2        .06722        35.04       1.662       .46367    1.600     .814 PER IMP=    .00
*S ADD 61.4 TO 62 TO GET 62.5
ADD HYD               62.10  2& 3   1        .06972        35.04       1.720       .46264    1.600     .785
*S
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COMMAND	HYDROGRAPH IDENTIFICATION	FROM ID NO.	TO ID NO.	AREA (SQ MI)	PEAK DISCHARGE (CFS)	RUNOFF VOLUME (AC-FT)	RUNOFF (INCHES)	TIME TO PEAK (HOURS)	CFS PER ACRE	PAGE = 7 NOTATION

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*S  APPLY NO SEDIMENT BULKING FACTOR
SEDIMENT BULK                                                                                                  PK BF =    1.00
*S THE TRAILS SUBDIVISION
*S OUTFLOW RESTRICTED TO 62 CFS AT UNIVERSE AND AVENIDA DE JAMITO
*S RECALL HYD FROM THE TRAILS SUBDIVISION
*S
RECALL HYD      BYPASS.ROUTE   -    99       1.05360        60.72       76.374      1.35915    2.800     .090
*S ROUTE 99 IN 36" PIPE IN UNIVERSE TO GET 47.19
ROUTE MCUNGE          47.70   99    7       1.05360        60.72       76.379      1.35925    2.900     .090 CCODE =      .2
*S  APPLY SEDIMENT BULKING FACTOR
SEDIMENT BULK                                                                                                  PK BF =    1.05
*S*** SUB-BASIN 47B STATE LAND PROPERTY ***
COMPUTE NM HYD          47B    -    5        .03050        23.57        .722       .44411    1.500    1.207 PER IMP=    .00
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*S*** SUB-BASIN 46B APS HIGH SCHOOL PROPERTY ***
COMPUTE NM HYD           APS    -     3        .11300       181.87       9.871      1.63785    1.600    2.515 PER IMP=  53.00
*S*** ADD 47B TO 46B TO GET 46B.6
ADD HYD               46B.6  5& 3   6        .14350       203.51      10.593      1.38413    1.550    2.216
*S*** ROUTE -46B.6 THRU APS POND TO DISCHARGE 4.5 CFS TO UNIVERSE SD
ROUTE RESERVOIR       46B.4    6    4        .14350         4.50      10.390      1.35751    3.150     .049 AC-FT=    8.119
*S ADD 46B.6 TO 46B.4 TO GET 46B.8
*S
ADD HYD               46B.8  7& 4   8       1.19710        65.22      85.306      1.33613    2.900     .085
*S ROUTE 46B.8 IN 36" PIPE IN UNIVERSE TO GET 46.18
ROUTE MCUNGE          46.18    8   18       1.19710        65.17      85.275      1.33565    3.150     .085 CCODE =      .2
*S ADD 46.18 TO 62.1 TO GET 46.9
ADD HYD               46.90 18& 1   9       1.26682        91.92      86.995      1.28761    1.600     .113
*S ROUTE 46.9 IN 72" IN SCENIC
ROUTE MCUNGE           IP2     9    2       1.26682        91.83      86.977      1.28734    1.650     .113 CCODE =      .1
*S*****************************************************************
*S ADD IP2 TO IP3 TO GET 60.20
ADD HYD               60.20  2&19  20      13.68364      1254.72     369.956       .50693    3.100     .143
*S ADD OFFSITE VISTA VIEJA (VV) SUB-BASIN - INFLOW POINT IP4
*S*** SUB-BASIN 86 - BASIN E IN VV DRAINAGE REPORT
*S*** INCLUDES 10 AC DEVELOPED VV
COMPUTE NM HYD         86.10    -     1        .24800       135.81       7.010       .52996    1.650     .856 PER IMP=   4.00
*S ROUTE THRU 48" SD - IP4
ROUTE MCUNGE             IP4    1   10        .24800       134.99       7.013       .53022    1.700     .850 CCODE =      .2
*S INFLOW POINT IP5
*S ONSITE BASINS VV1 UNITS 2 AND PART OF UNIT 3
COMPUTE NM HYD        VV1.23    -     1        .08940       163.45       8.335      1.74818    1.550    2.857 PER IMP=  60.00
*S ROUTE THRU 48" SD - IP5
ROUTE MCUNGE             IP5    1   11        .08940       162.20       8.334      1.74798    1.600    2.835 CCODE =      .2
*S ADD OFFSITE VISTA VIEJA (VV2) SUB-BASIN - INFLOW POINT IP6
*S*** SUB-BASIN 83 & 83A - BASIN E IN D DRAINAGE REPORT
*S INCLUDES PARTS OF UNIT 4 & 1
*S*** SUB-BASIN 83
COMPUTE NM HYD         83.00    -     1        .53800       168.06      13.317       .46411    1.850     .488 PER IMP=   1.00
*S*** SUB-BASIN 83A
COMPUTE NM HYD           83A    -     2        .13700        84.78       3.391       .46411    1.550     .967 PER IMP=   1.00
*S ADD 83 TO 83A TO GET 83A.3
*S
```

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COMMAND	HYDROGRAPH IDENTIFICATION	FROM ID NO.	TO ID NO.	AREA (SQ MI)	PEAK DISCHARGE (CFS)	RUNOFF VOLUME (AC-FT)	RUNOFF (INCHES)	TIME TO PEAK (HOURS)	CFS PER ACRE	NOTATION


```
ADD HYD               83A.3  1& 2   3        .67500       214.52      16.708       .46411    1.750     .497
*S
*S*** ONSITE SUB-BASIN VV2 - PARTS OF UNITS 4 & 1
COMPUTE NM HYD        VV2.41    -     2        .03730        53.40       3.478      1.74819    1.650    2.237 PER IMP=  60.00
*S ADD VV.41 TO 83A.3 TO GET 83A.4
*S
ADD HYD               83A.4  3& 2   4        .71230       265.85      20.186       .53135    1.700     .583
*S
*S ROUTE THRU 60" TO IP6
ROUTE MCUNGE             IP6    4   12        .71230       265.02      20.191       .53149    1.750     .581 CCODE =      .2
*S ADD IP5 TO IP5 AND IP6 TO GET 86.2
*S
ADD HYD               86.20 12&11   2        .80170       398.74      28.525       .66715    1.650     .777
*S
*S ADD IP4 TO 86.2 TO GET 86.45
*S
ADD HYD               86.45  2&10  45       1.04970       533.06      35.539       .63480    1.650     .793
```

```
*S
*S ADD 62.20 (IP3) TO 86.45 (IP4, 5 & 6) TO GET 86.70
*S
ADD HYD                86.70 45&20   7      14.73334      1286.69     405.494       .51604    3.100     .136
*S
*S
*S TOTAL OUTFLOW FROM BOCA NEGRA DETENTION FACILITY
ROUTE RESERVOIR        51.60    7   14      14.73334      1066.81     405.282       .51577    3.700     .113 AC-FT=   81.466
*S DIVIDE SURFACE FLOW FROM PIPE FLOW
DIVIDE HYD           PIPE.80   14   80       9.34794       372.00     257.141       .51577    1.700     .062
                     SURF.90  and   90       5.38540       694.81     148.141       .51577    3.700     .202
*S  APPLY SEDIMENT BULKING FACTOR
SEDIMENT BULK                                                                                              PK BF =    1.05
*S
*S ADD BASINS DRAINING INTO THE TEMPORARY PONDS ALONG UNSER BLVD
*S
COMPUTE NM HYD         3.00   -     3        .09570        39.97       2.378       .46593    1.650     .653 PER IMP=   3.00
*S ROUTE SUB-BASIN 3 THRU UNSER TEMP POND A
ROUTE RESERVOIR        4.90    3    1        .09570         7.92       2.378       .46592    2.350     .129 AC-FT=    1.330
COMPUTE NM HYD         4.00   -     4        .02820        19.54        .671       .44594    1.550    1.083 PER IMP=   2.00
*S ADD ROUTED FLOW FROM TEMP POND A TO SUB-BASIN 4
*S ADD SUB-BASINS 3 AND 4
ADD HYD                4.20  1& 4   2        .12390        24.60       3.049       .46137    1.550     .310
*S ROUTE THRU UNSER TEMP POND B
ROUTE RESERVOIR        5.90    2    1        .12390         7.70       2.891       .43757    3.300     .097 AC-FT=     .897
*S ROUTE THRU 24"IN ALMENDRA PL
ROUTE MCUNGE           5.92    1    2        .12390         7.70       2.891       .43757    3.300     .097 CCODE =      .0
COMPUTE NM HYD         5.00   -     5        .09400        38.02       2.236       .44594    1.650     .632 PER IMP=   2.00
*S
*S ADD ROUTED FLOW FROM TEMP POND B TO SUB-BASIN 5
ADD HYD                5.10  2& 5   1        .21790        40.11       5.127       .44118    1.700     .288
*S ROUTE THRU UNSER TEMP POND C
ROUTE RESERVOIR        5.93    1    3        .21790        18.74       5.125       .44104    2.150     .134 AC-FT=    1.178
*S  APPLY NO SEDIMENT BULKING FACTOR
SEDIMENT BULK                                                                                              PK BF =    1.00
*S RECALL HYD FROM SAD 228 POND 4
```


COMMAND	HYDROGRAPH IDENTIFICATION	FROM ID NO.	TO ID NO.	AREA (SQ MI)	PEAK DISCHARGE (CFS)	RUNOFF VOLUME (AC-FT)	RUNOFF (INCHES)	TIME TO PEAK (HOURS)	CFS PER ACRE	NOTATION
*S										
RECALL HYD	POND4A	-	14	.02050	18.04	1.546	1.41378	1.750	1.375	
*S										
*S ADD SAD 228 POND 4 OUTFLOW TO TEMP POND C OUTFLOW										
ADD HYD	200.30 3&14	4		.23840	33.45	6.671	.52468	2.000	.219	
*S RECALL HYD FROM SAD 228 POND 5										
*S										
RECALL HYD	POND5	-	12	.14890	36.97	12.287	1.54726	2.350	.388	
*S										
*S ADD SAD 228 POND 4 & 5 OUTFLOW TO TEMP POND C OUTFLOW										
ADD HYD	201.10 4&12	1		.38730	69.71	18.959	.91782	2.050	.281	
*S ROUTE 201.1 IN 54" SD IN UNSER BLVD TO GET 201.7										
ROUTE MCUNGE	102.70	1	7	.38730	69.68	18.958	.91781	2.050	.281	CCODE = .2
*S APPLY SEDIMENT BULKING FACTOR										
SEDIMENT BULK										PK BF = 1.05
*S										
*S COMPUTE UNSER BLVD RUNOFF SOUTH OF KIMMICK TO BOCA NEGRA DAM										
COMPUTE NM HYD	6.00	-	6	.01166	21.35	1.359	2.18501	1.600	2.861	PER IMP= 85.00
*S ADD TOTAL FLOWS FROM UNSER BLVD										

```
ADD HYD              6.20  7& 6   2        .39896        78.37      20.317       .95484    1.950     .307
*S ADD PIPE.80 TO 6.2 TO GET PIPE.1
ADD HYD            PIPE.1 80& 2   1       9.74690       450.37     277.459       .53374    1.950     .072
*S ROUTE PIPE.1 IN 60" SD TO GET PIPE.2
ROUTE MCUNGE       PIPE.2    1    8       9.74690       450.37     277.459       .53374    1.950     .072 CCODE =      .0
*S ROUTE PIPE.2 IN 54" SD TO GET PIPE.3
ROUTE MCUNGE       PIPE.3    8    1       9.74690       450.37     277.459       .53374    1.950     .072 CCODE =      .0
*S ROUTE PIPE.3 IN 60" SD TO GET PIPE.4
ROUTE MCUNGE       PIPE.4    1    8       9.74690       449.97     277.466       .53376    2.050     .072 CCODE =      .2
*S  APPLY SEDIMENT BULKING FACTOR
SEDIMENT BULK                                                                                            PK BF =    1.09
*S*** SUB-BASIN 71 DOWNSTREAM OF THE DAM ***
COMPUTE NM HYD       71.00   -     5        .07675        49.24       2.055       .50198    1.600    1.002 PER IMP=    .00
*S ADD SURFACE FLOW FROM DAM TO BASIN 71 TO GET 71.5
*S ADD BASIN 71 to PIPE.2 TO GET 70.9
ADD HYD              71.60  5&90   6       5.46215       695.49     150.195       .51558    3.700     .199
*S ADD 71.6 to PIPE.2 TO GET 70.9
ADD HYD              70.90  6& 8   9      15.20905      1110.38     427.662       .52723    3.700     .114
*S  APPLY NO SEDIMENT BULKING FACTOR
SEDIMENT BULK                                                                                            PK BF =    1.00
*S RECALL HYD FROM THE VOLCANO HEIGHTS MODEL (BOCA NEGRA ARROYO SOUTH BRANCH)
*S
RECALL HYD         102.00   -     2       1.64000       378.54      33.646       .38467    2.250     .361
*S ROUTE THE BOCA NEGRA ARROYO SOUTH BRANCH FLOWS THRU 72" IN EMERALD DR
ROUTE MCUNGE         70.50    2    5       1.64000       377.51      33.649       .38470    2.300     .360 CCODE =      .2
*S  APPLY SEDIMENT BULKING FACTOR
SEDIMENT BULK                                                                                            PK BF =    1.09
*S
*S*** SUB-BASIN 70 EAST OF SAD 227 ***
COMPUTE NM HYD       70.00   -     4        .06914        66.65       1.851       .50198    1.500    1.506 PER IMP=    .00
*S
*S ADD BASIN 70 to ROUTED BOCA NEGRA ARROYO SOUTH BRANCH
```



```
ADD HYD              70.60  4& 5   6       1.70914       380.70      35.500       .38945    2.250     .348
*S ADD ALL FLOWS AT THE CONFLUENCE WITH BOCA NEGRA ARROYO
ADD HYD              71.70  6& 9   7      16.91819      1147.37     463.161       .51331    3.650     .106
*S ROUTE 71.7 IN 72 TO GET 72.6
ROUTE MCUNGE         72.60    7    6      16.91819      1147.49     463.165       .51331    3.750     .106 CCODE =      .2
*S  APPLY NO SEDIMENT BULKING FACTOR
SEDIMENT BULK                                                                                            PK BF =    1.00
*S RECALL HYD FROM SAD 228 POND 6
RECALL HYD           POND6   -    19        .06540        50.66       5.402      1.54880    2.000    1.210
*S  APPLY SEDIMENT BULKING FACTOR
SEDIMENT BULK                                                                                            PK BF =    1.09
*S
*S*** SUB-BASIN 72 DOWNSTREAM OF CONFLUENCE WITH SOUTH BRANCH ***
COMPUTE NM HYD       72.00   -     2        .16708       126.65       4.473       .50198    1.550    1.184 PER IMP=    .00
*S ADD OUTFLOW FROM POND 6 TO BASIN 72
ADD HYD              72.10 19& 2   1        .23248       146.85       9.875       .79646    1.600     .987
*S ADD ALL FLOWS AT TESUQUE DR
*S ADD 72.1 TO 72.6 TO GET 72.3
ADD HYD              72.30  1& 6   3      17.15067      1151.15     473.040       .51715    3.750     .105
*S ROUTE 72.3 IN 73.1 TO GET 73.1.5
ROUTE MCUNGE         73.1.5   3    5      17.15067      1148.83     472.813       .51690    3.800     .105 CCODE =      .1
*S*** SUB-BASIN 73.1
COMPUTE NM HYD       73.10   -     4        .12879       209.07       9.910      1.44269    1.550    2.536 PER IMP=  40.00
```

```
*S ADD 72.3 TO 73.1 TO GET 73.1.2
ADD HYD              73.1.2  4& 5   2      17.27946      1150.81     482.723       .52380    3.800     .104
*S ROUTE 73.1.2 THRU 73.2 TO GET 73.2.5
ROUTE MCUNGE         73.2.5    2    5      17.27946      1150.39     482.701       .52378    3.800     .104 CCODE =      .2
*S
*S*** SUB-BASIN 73.2
COMPUTE NM HYD        73.20   -     4        .05105        99.73       3.928      1.44269    1.500    3.052 PER IMP=  40.00
*S ADD 73.2 TO 73.2.5 TO GET 73.2.1
*S TOTAL FLOWS UPSTREAM END OF SAN ILDEFONSO DR
ADD HYD              73.2.1  4& 5   1      17.33051      1151.04     486.629       .52649    3.800     .104
FINISH
```

```
*S**************************************************************************
*S BOCA NEGRA DAM
*S LOMR MODEL - NEW RAINFALL DATA
*S INCLUDES BASINS DOWNSTREAM OF THE DAM
*S 100 YR 24 HR STORM EVENT
*S DATE: APRIL 2015
*
*S**************************************************************************
START               TIME=0.0  PUNCH CODE=0 PRINT CODE=0
LOCATION            BERNALILLO COUNTY
*S 100 YEAR 24HR STORM
RAINFALL              TYPE=2  RAIN QUARTER=1.01   RAIN ONE=1.69
                    RAIN SIX=2.17  RAIN DAY=2.54  DT=0.05
*
*
**************************************************************************
*S  APPLY A 5% SEDIMENT BULKING FACTOR ABOVE THE ESCARPMENT AND 9% BELOW
*S  THE ESCARPMENT TO COMPUTED HYDROGRAPHS - NO SEDIMENT BULKING FACTOR
*S  WHEN USING RECALL HYD COMMAND
SEDIMENT BULK           CODE=1   BULKING FACTOR = 1.05
**************************************************************************
**************************************************************************
*S*** Basin Contributing to INFLOW POINT 3 (IP3) ******************
**************************************************************************
**************************************************************************
*S QUAIL RANCH BASINS
**************************************************************************
*S*
**************************************************************************
*S**** SUB-BASIN 10 ****
*
COMPUTE LT TP         LCODE=1
                      NK=3  ISLOPE=-1
                      LENGTH=400 FT   SLOPE=0.036 K=0.7
                      LENGTH=1600 FT  SLOPE=0.027 K=2.0
                      LENGTH=7708 FT  SLOPE=0.025 K=3.0
                      Kn=.033  CR=0.52
COMPUTE NM HYD        ID=1   HYD NO=10   DA= 0.358 SQ MI
                      PER A=99 PER B=0  PER C=1  PER D=0
                      TP=0.0   MASSRAIN=-1
PRINT HYD             ID=1   CODE=1
*
**************************************************************************
*S**** SUB-BASIN 11 ****
*
COMPUTE LT TP        LCODE=1
                     NK=3  ISLOPE=-1
                     LENGTH=400 FT   SLOPE=0.019 K=0.7
                     LENGTH=1600 FT  SLOPE=0.024 K=2.0
                     LENGTH=7880 FT  SLOPE=0.024 K=3.0
                     Kn=.033  CR=.64
COMPUTE NM HYD       ID=2   HYD NO=11   DA= 0.390 SQ MI
                     PER A=99 PER B=0  PER C=1  PER D=0
                     TP=0.0   MASSRAIN=-1
PRINT HYD            ID=2   CODE=1
*S
**************************************************************************
*
*S ADD IP3.10 TO IP3.11 TO GET IP3.11.9
ADD HYD              ID=9   HYD NO=11.9 ID I=1 ID II=2
PRINT HYD            ID=9   CODE=1
*S
**************************************************************************
*
*S ROUTE 11.9 THRU IP3.12 IN NATURAL ARROYO TO 12.6
*
COMPUTE RATING CURVE  CID=1   VS NO=1   NO SEGS=1
                      MIN ELEV=5896.45        MAX ELEV=5900.10
                      CH SLOPE=0.007    FP SLOPE=0.007
                      N=0.035           DIST=780
                      DIST  ELEV    DIST  ELEV
                        0       5898.04 132 5898.03
                        250     5896.63 406     5896.45
                        477     5898.02 593     5899.88
                        740     5900.10 780     5899.98


ROUTE MCUNGE         ID=6   HYD NO=12.6  INFLOW ID=9
                     DT=0.0   L=4765 FT   NS=0   SLOPE=0.007
                     MATCODE=0 REGCODE=0 CCODE=0 MM CODE=0
PRINT HYD            ID=6   CODE=1
*
**************************************************************************
*
*S*** SUB-BASIN 12 ****
*
COMPUTE LT TP        LCODE=1
                     NK=3  ISLOPE=-1
                     LENGTH=400 FT   SLOPE=0.047 K=0.7
                     LENGTH=1600 FT  SLOPE=0.026 K=2.0
                     LENGTH=6490 FT  SLOPE=0.018 K=3.0
```

```
                    Kn=.033  CR=0.50
COMPUTE NM HYD      ID=1   HYD NO=12   DA= 0.309 SQ MI
                    PER A=99 PER B=1  PER C=0  PER D=0
                    TP=0.0   MASSRAIN=-1
PRINT HYD           ID=1   CODE=1
*S
**************************************************************************
*
* ADD IP3.12 TO 12.6 TO GET 12.9
ADD HYD             ID=9   HYD NO=12.9 ID I=1 ID II=6
PRINT HYD           ID=9   CODE=1
*
**************************************************************************
*
*S*** SUB-BASIN 14 ****
*
COMPUTE LT TP       LCODE=1  UPLAND/LAG TIME TRANSITION METHOD
                    NK=3  ISLOPE=-1
                    LENGTH=400 FT   SLOPE=0.0199 K=0.7
                    LENGTH=1600 FT  SLOPE=0.033 K=2.0
                    LENGTH=8632 FT  SLOPE=0.023 K=3.0
                    Kn=.033  CR=0.50
COMPUTE NM HYD      ID=2   HYD NO=14   DA= 0.513 SQ MI
                    PER A=99 PER B=1  PER C=0  PER D=0
                    TP=0.0   MASSRAIN=-1
PRINT HYD           ID=2   CODE=1
*S
**************************************************************************
* ADD IP3.14 TO 12.9 TO GET 14.8
ADD HYD             ID=8   HYD NO=14.8 ID I=2 ID II=9
PRINT HYD           ID=8   CODE=1
*S
**************************************************************************
*S ROUTE 14.8 THRU 15 IN NATURAL ARROYO TO 15.6
COMPUTE RATING CURVE  CID=1   VS NO=1   NO SEGS=1
                      MIN ELEV=5844.46   MAX ELEV=5850.0
                      CH SLOPE=0.007    FP SLOPE=0.007
                      N=0.035           DIST=600.0
                      DIST  ELEV    DIST  ELEV
                        0   5854.38   145 5852.0
                        235     5845.95 300     5844.46
                        399     5846.0  489     5850.0
                        600     5856.87

ROUTE MCUNGE        ID=6   HYD NO=15.6  INFLOW ID=8
                    DT=0.0   L=5450 FT   NS=0   SLOPE=0.007
                    MATCODE=0 REGCODE=0 CCODE=0 MM CODE=0
PRINT HYD           ID=6   CODE=1
*

**************************************************************************
*S*** SUB-BASIN 15 ****
*
COMPUTE LT TP       LCODE=1  UPLAND/LAG TIME TRANSITION METHOD
                    NK=3  ISLOPE=-1
                    LENGTH=400 FT   SLOPE=0.005 K=0.7
                    LENGTH=1600 FT   SLOPE=0.006 K=2.0
                    LENGTH=2978 FT  SLOPE=0.011 K=3.0
                    Kn=.033  CR=0.58
COMPUTE NM HYD      ID=1   HYD NO=15   DA= 0.301 SQ MI
                    PER A=99 PER B=1  PER C=0  PER D=0
                    TP=0.0   MASSRAIN=-1
PRINT HYD           ID=1   CODE=1
*S
**************************************************************************
* ADD 15 TO 15.6 TO GET 15.9
ADD HYD             ID=9   HYD NO=15.9 ID I=1 ID II=6
PRINT HYD           ID=9   CODE=1
*
**************************************************************************
*S*** SUB-BASIN 16 ****
*
COMPUTE LT TP       LCODE=1  UPLAND/LAG TIME TRANSITION METHOD
                    NK=3  ISLOPE=-1
                    LENGTH=400 FT   SLOPE=0.014 K=0.7
                    LENGTH=1600 FT  SLOPE=0.022 K=2.0
                    LENGTH=8058 FT   SLOPE=0.025 K=3.0
                    Kn=.033  CR=0.52
COMPUTE NM HYD      ID=1   HYD NO=16   DA= 0.533 SQ MI
                    PER A=99 PER B=1  PER C=0  PER D=0
                    TP=0.0   MASSRAIN=-1
PRINT HYD           ID=1   CODE=1
*S
**************************************************************************
*S ROUTE 16 THRU 17 IN NATURAL ARROYO TO 17.7
COMPUTE RATING CURVE  CID=1   VS NO=1   NO SEGS=1
                      MIN ELEV=5849.92   MAX ELEV=5857.33
                      CH SLOPE=0.009    FP SLOPE=0.009
                      N=0.035           DIST=800.0
                      DIST  ELEV    DIST  ELEV
                        0   5854.05   148 5856.03
```

```
                        199     5857.22 274     5854.0
                        400     5849.92 484     5852.0
                        575     5856.0  800     5857.33

ROUTE MCUNGE        ID=6   HYD NO=17.6  INFLOW ID=1
                    DT=0.0   L=3385 FT   NS=0   SLOPE=0.009
                    MATCODE=0 REGCODE=0 CCODE=0 MM CODE=0
PRINT HYD           ID=6   CODE=1
*

*************************************************************************
*S*** SUB-BASIN 17 ****
*
COMPUTE LT TP       LCODE=1  UPLAND/LAG TIME TRANSITION METHOD
                    NK=3  ISLOPE=-1
                    LENGTH=400 FT   SLOPE=0.012 K=0.7
                    LENGTH=1600 FT  SLOPE=0.008 K=2.0
                    LENGTH=5130 FT  SLOPE=0.008 K=3.0
                    Kn=.033  CR=0.59
COMPUTE NM HYD      ID=2   HYD NO=17   DA= 0.268 SQ MI
                    PER A=99 PER B=1  PER C=0  PER D=0
                    TP=0.0   MASSRAIN=-1
PRINT HYD           ID=2   CODE=1
*S
*************************************************************************
*S ADD 17.6 TO 17 TO GET 17.7
ADD HYD             ID=7   HYD NO=17.7 ID I=6 ID II=2
PRINT HYD           ID=7   CODE=1
*
*************************************************************************
*S ADD 17.7 TO 15.9 TO GET 17.4
ADD HYD             ID=4   HYD NO=17.4 ID I=7 ID II=9
PRINT HYD           ID=4   CODE=5
*S
*************************************************************************
*S ROUTE 17.4 THRU 20 IN NATURAL ARROYO TO 28.6
COMPUTE RATING CURVE  CID=1   VS NO=1   NO SEGS=1
                      MIN ELEV=5812.0   MAX ELEV=5825.39
                      CH SLOPE=0.0116    FP SLOPE=0.0116
                      N=0.035           DIST=800.0
                      DIST  ELEV    DIST  ELEV
                        0   5829.74   160 5824.0
                        289     5816.16 374     5812.0
                        499     5813.98 662     5819.96
                        800     5825.39

ROUTE MCUNGE        ID=3   HYD NO=20.3  INFLOW ID=4
                    DT=0.0   L=2323 FT   NS=0   SLOPE=0.0116
                    MATCODE=0 REGCODE=0 CCODE=0 MM CODE=0
PRINT HYD           ID=3   CODE=1
*

*************************************************************************
*S*** SUB-BASIN 21 ****
*
COMPUTE LT TP       LCODE=1  UPLAND/LAG TIME TRANSITION METHOD
                    NK=3  ISLOPE=-1
                    LENGTH=400 FT   SLOPE=0.018 K=0.7
                    LENGTH=1600 FT  SLOPE=0.033 K=2.0
                    LENGTH=3667 FT   SLOPE=0.027 K=3.0
                    Kn=.033  CR=0.50
COMPUTE NM HYD      ID=1   HYD NO=21   DA= 0.145 SQ MI
                    PER A=99 PER B=1  PER C=0  PER D=0
                    TP=0.0   MASSRAIN=-1
PRINT HYD           ID=1   CODE=1
*S
*************************************************************************
*S ROUTE 21 THRU 22 IN NATURAL ARROYO TO 22.8
COMPUTE RATING CURVE  CID=1   VS NO=1   NO SEGS=1
                      MIN ELEV=5875.66   MAX ELEV=5883.82
                      CH SLOPE=0.007    FP SLOPE=0.007
                      N=0.035           DIST=1200.0
                      DIST  ELEV    DIST  ELEV
                        0   5881.59   264 5875.89
                        459     5876.12 598     5875.66
                        879     5878.0  1045    5882.96
                        1200    5883.82

ROUTE MCUNGE        ID=5   HYD NO=22.5  INFLOW ID=1
                    DT=0.0   L=7312 FT   NS=0   SLOPE=0.007
                    MATCODE=0 REGCODE=0 CCODE=0 MM CODE=0
PRINT HYD           ID=5   CODE=1
*

*************************************************************************

*S*** SUB-BASIN 22 ****
*
COMPUTE LT TP       LCODE=1  USDI BUREAU OF RECLAMATION LAG TIME EQUATION
                    NK=3  ISLOPE=-1
                    LENGTH=400 FT   SLOPE=0.015 K=0.7
```

```
                    LENGTH=1600 FT  SLOPE=0.018 K=2.0
                    LENGTH=12166 FT  SLOPE=0.017 K=3.0
                    Kn=.033  CR=.5
COMPUTE NM HYD      ID=2   HYD NO=22   DA= 0.739 SQ MI
                    PER A=99 PER B=1  PER C=0  PER D=0
                    TP=0.0   MASSRAIN=-1
PRINT HYD           ID=2   CODE=1
*S
**********************************************************************
*S ADD 21 AND 22 TO GET 22.8
ADD HYD             ID=8   HYD NO=22.8 ID I=5 ID II=2
PRINT HYD           ID=8   CODE=5
*S
**********************************************************************
*S*** SUB-BASIN 24 ****
*
COMPUTE LT TP       LCODE=1  USDI BUREAU OF RECLAMATION LAG TIME EQUATION
                    NK=3  ISLOPE=-1
                    LENGTH=400 FT   SLOPE=0.005 K=0.7
                    LENGTH=1600 FT  SLOPE=0.007 K=2.0
                    LENGTH=1338 FT  SLOPE=0.008 K=3.0

COMPUTE NM HYD      ID=2   HYD NO=24   DA= 0.117 SQ MI
                    PER A=99 PER B=1  PER C=0  PER D=0
                    TP=0.0   MASSRAIN=-1
PRINT HYD           ID=2   CODE=1
*S
**********************************************************************
*S ADD 24 AND 22.8 TO GET 24.7
ADD HYD             ID=7   HYD NO=24.7 ID I=2 ID II=8
PRINT HYD           ID=7   CODE=5
*S
**********************************************************************
*S ROUTE 24.7 THRU 23 IN NATURAL ARROYO TO 23.8
COMPUTE RATING CURVE  CID=1   VS NO=1   NO SEGS=1
                      MIN ELEV=5824.56   MAX ELEV=5840.33
                      CH SLOPE=0.014    FP SLOPE=0.014
                      N=0.035           DIST=1000.0
                      DIST  ELEV    DIST  ELEV
                        0   5839.67   207 5837.99
                        372     5829.93 498     5824.56
                        605     5827.79 729     5836.11
                        1000    5840.33

ROUTE MCUNGE        ID=6   HYD NO=23.6  INFLOW ID=7
                    DT=0.0   L=2675 FT   NS=0   SLOPE=0.014
                    MATCODE=0 REGCODE=0 CCODE=0 MM CODE=0
PRINT HYD           ID=6   CODE=1
*
**********************************************************************

*S*** SUB-BASIN 23 ****
*
COMPUTE LT TP       LCODE=1  USDI BUREAU OF RECLAMATION LAG TIME EQUATION
                    NK=3  ISLOPE=-1
                    LENGTH=400 FT   SLOPE=0.004 K=0.7
                    LENGTH=1600 FT  SLOPE=0.006 K=2.0
                    LENGTH=3613 FT  SLOPE=0.015 K=3.0
                    Kn=.033  CR=.5
COMPUTE NM HYD      ID=2   HYD NO=23   DA= 0.245 SQ MI
                    PER A=99 PER B=1  PER C=0  PER D=0
                    TP=0.0   MASSRAIN=-1
PRINT HYD           ID=2   CODE=1
*S
**********************************************************************


*S ADD 23 AND 23.6 TO GET 23.8
ADD HYD             ID=8   HYD NO=23.8 ID I=2 ID II=6
PRINT HYD           ID=8   CODE=5
*S
**********************************************************************
**********************************************************************
*S*** SUB-BASIN 28 ****
*
COMPUTE LT TP       LCODE=1  USDI BUREAU OF RECLAMATION LAG TIME EQUATION
                    NK=3  ISLOPE=-1
                    LENGTH=400 FT   SLOPE=0.019 K=0.7
                    LENGTH=1600 FT  SLOPE=0.006 K=2.0
                    LENGTH=5288 FT  SLOPE=0.012 K=3.0
                    Kn=.033  CR=.5
COMPUTE NM HYD      ID=2   HYD NO=28   DA= 0.158 SQ MI
                    PER A=95 PER B=5  PER C=0  PER D=0
                    TP=0.0   MASSRAIN=-1
PRINT HYD           ID=2   CODE=1
*S
**********************************************************************
*S ADD 28 AND 23.8 TO GET 28.9
ADD HYD             ID=9   HYD NO=28.9 ID I=2 ID II=8
PRINT HYD           ID=9   CODE=5
*S
```

```
**************************************************************************
*S ADD 17.4 TO 28.9 TO GET 28.6
ADD HYD             ID=6   HYD NO=28.6 ID I=3 ID II=9
PRINT HYD           ID=6   CODE=5
*S

**************************************************************************

*S ROUTE 28.6 THRU 20 IN NATURAL ARROYO TO 20.8
*
COMPUTE RATING CURVE  CID=1   VS NO=1   NO SEGS=1
                      MIN ELEV=5771.07   MAX ELEV=5810.76
                      CH SLOPE=0.015    FP SLOPE=0.015
                      N=0.035           DIST=850.0
                      DIST  ELEV    DIST  ELEV
                        0   5810.76   126 5801.93
                        250     5796.16 382     5779.97
                        429     5771.07 483     5775.96
                        604     5784.0  850     5792.39

ROUTE MCUNGE        ID=7   HYD NO=20.7  INFLOW ID=6
                    DT=0.0   L=2290 FT   NS=0   SLOPE=0.015
                    MATCODE=0 REGCODE=0 CCODE=0 MM CODE=0
PRINT HYD           ID=7   CODE=5
*
**************************************************************************
*S*** SUB-BASIN 20 ****
*
COMPUTE LT TP       LCODE=1  UPLAND/LAG TIME TRANSITION METHOD
                    NK=3  ISLOPE=-1
                    LENGTH=400 FT   SLOPE=0.015 K=0.7
                    LENGTH=1600 FT  SLOPE=0.015 K=2.0
                    LENGTH=5447 FT   SLOPE=0.018 K=3.0
                    Kn=.033  CR=0.50
COMPUTE NM HYD      ID=1   HYD NO=20   DA= 0.426 SQ MI
                    PER A=95 PER B=5  PER C=0  PER D=0
                    TP=0.0   MASSRAIN=-1
PRINT HYD           ID=1   CODE=1
*S
**************************************************************************
* ADD 20 TO 28.6 TO GET 20.8
ADD HYD             ID=8   HYD NO=20.8 ID I=1 ID II=7
PRINT HYD           ID=8   CODE=1
*
**************************************************************************


**************************************************************************
*S*** SUB-BASIN 25 ****
*
COMPUTE LT TP       LCODE=1  UPLAND/LAG TIME TRANSITION METHOD
                    NK=3  ISLOPE=-1
                    LENGTH=400 FT   SLOPE=0.021 K=0.7
                    LENGTH=1600 FT  SLOPE=0.04 K=2.0
                    LENGTH=10314 FT   SLOPE=0.018 K=3.0
                    Kn=.033  CR=.5
COMPUTE NM HYD      ID=1   HYD NO=25   DA= 0.463 SQ MI
                    PER A=100 PER B=0  PER C=0  PER D=0
                    TP=0.0   MASSRAIN=-1
PRINT HYD           ID=1   CODE=1
*S
**************************************************************************
*S*** SUB-BASIN 26 ****
*
COMPUTE LT TP       LCODE=1  UPLAND/LAG TIME TRANSITION METHOD
                    NK=3  ISLOPE=-1
                    LENGTH=400 FT   SLOPE=0.04 K=0.7
                    LENGTH=1600 FT  SLOPE=0.034 K=2.0
                    LENGTH=6569 FT  SLOPE=0.020 K=3.0
                    Kn=.033  CR=0.60
COMPUTE NM HYD      ID=2   HYD NO=26   DA= 0.348 SQ MI
                    PER A=100 PER B=0  PER C=0  PER D=0
                    TP=0.0   MASSRAIN=-1
PRINT HYD           ID=2   CODE=1
*S
**************************************************************************
*S ADD 25 TO 26 TO GET 25.6
ADD HYD             ID=6   HYD NO=25.6 ID I=1 ID II=2
PRINT HYD           ID=6   CODE=1
*
**************************************************************************
*S*** SUB-BASIN 27 ****
*
COMPUTE LT TP       LCODE=1  UPLAND/LAG TIME TRANSITION METHOD
                    NK=3  ISLOPE=-1
                    LENGTH=400 FT   SLOPE=0.035 K=0.7
                    LENGTH=1600 FT  SLOPE=0.029 K=2.0
                    LENGTH=7044 FT  SLOPE=0.021 K=3.0
                    Kn=.033  CR=0.55
COMPUTE NM HYD      ID=1   HYD NO=27   DA= 0.376 SQ MI
```

```
                    PER A=100 PER B=0  PER C=0  PER D=0
                    TP=0.0   MASSRAIN=-1
PRINT HYD           ID=1   CODE=1
*S
**************************************************************************
*S ADD 27 TO 25.6 TO GET 25.75
ADD HYD             ID=7   HYD NO=25.75 ID I=1 ID II=6
PRINT HYD           ID=7   CODE=1
*S
**************************************************************************
*S ROUTE 25.75 THRU UPPER 30 IN NATURAL ARROYO TO 30.91
*
COMPUTE RATING CURVE  CID=1   VS NO=1   NO SEGS=1
                      MIN ELEV=5835.82   MAX ELEV=5841.47
                      CH SLOPE=0.005    FP SLOPE=0.005
                      N=0.035           DIST=900.0
                      DIST  ELEV    DIST  ELEV
                        0   5837.78   185 5842.09
                        277     5840.10 449     5835.82
                        630     5838.02 900     5841.47


ROUTE MCUNGE        ID=51   HYD NO=30.51  INFLOW ID=7
                    DT=0.0   L=8763 FT   NS=0   SLOPE=0.005
                    MATCODE=0 REGCODE=0 CCODE=0 MM CODE=0
PRINT HYD           ID=51   CODE=5
*
**************************************************************************
*S ROUTE 30.91 THRU LOWER 30 IN NATURAL ARROYO TO 30.9
*
COMPUTE RATING CURVE  CID=1   VS NO=1   NO SEGS=1
                      MIN ELEV=5792.02   MAX ELEV=5809.13
                      CH SLOPE=0.023    FP SLOPE=0.023
                      N=0.035           DIST=700.0
                      DIST  ELEV    DIST  ELEV
                        0   5812.39   101 5806.02
                        218     5800.05 304     5795.17
                        348     5792.02 376     5793.83
                        457     5799.95 570     5807.93
                        700     5809.13

ROUTE MCUNGE        ID=5   HYD NO=30.5  INFLOW ID=51
                    DT=0.0   L=2903 FT   NS=0   SLOPE=0.023
                    MATCODE=0 REGCODE=0 CCODE=0 MM CODE=0
PRINT HYD           ID=5   CODE=5
*
**************************************************************************

*S*** SUB-BASIN 30 ****
*
COMPUTE LT TP       LCODE=1  UPLAND/LAG TIME TRANSITION METHOD
                    NK=3  ISLOPE=-1
                    LENGTH=400 FT   SLOPE=0.006 K=0.7
                    LENGTH=1600 FT  SLOPE=0.006 K=2.0
                    LENGTH=9286 FT  SLOPE=0.0111 K=3.0
                    Kn=.033  CR=0.50
COMPUTE NM HYD      ID=1   HYD NO=30   DA= 0.588 SQ MI
                    PER A=95 PER B=5  PER C=0  PER D=0
                    TP=0.0   MASSRAIN=-1
PRINT HYD           ID=1   CODE=1
*S
**************************************************************************
*S ADD 30 TO 30.5 TO GET 30.9
ADD HYD             ID=9   HYD NO=30.9 ID I=1 ID II=5
PRINT HYD           ID=9   CODE=1
*S
**************************************************************************
*S  **************  TOTAL FLOW OUT OF BOCA NEGRA PART OF QUAIL RANCH
*S  ADD 30.9 TO 20.8 TO GET 20.75
*S
ADD HYD             ID=7  HYD NO=20.75 ID I=9 ID II=8
PRINT HYD           ID=7   CODE=1
*
*S
**************************************************************************
*S ROUTE 20.75 THRU 32 IN NATURAL ARROYO TO 32.6
*
COMPUTE RATING CURVE  CID=1   VS NO=1   NO SEGS=1
                      MIN ELEV=5748.37   MAX ELEV=5771.51
                      CH SLOPE=0.009    FP SLOPE=0.009
                      N=0.035           DIST=700.0
                      DIST  ELEV    DIST  ELEV
                        0   5764.7   119 5758.15
                        227     5752.45 351     5748.37
                        476     5758.03 594     5764.93
                        700     5771.51

ROUTE MCUNGE        ID=6   HYD NO=32.6  INFLOW ID=7
                    DT=0.0   L=3180 FT   NS=0   SLOPE=0.009
                    MATCODE=0 REGCODE=0 CCODE=0 MM CODE=0
PRINT HYD           ID=6   CODE=5
```

```
*
*************************************************************************
*S ADD BASIN 32************************
*
COMPUTE LT TP       LCODE=1  UPLAND/LAG TIME TRANSITION METHOD
                    NK=3  ISLOPE=-1
                    LENGTH=400 FT   SLOPE=0.012 K=0.7
                    LENGTH=1600 FT  SLOPE=0.011 K=2.0
                    LENGTH=959 FT  SLOPE=0.010 K=3.0

COMPUTE NM HYD      ID=1   HYD NO=32   DA= 0.250 SQ MI
                    PER A=100 PER B=0  PER C=0  PER D=0
                    TP=0.0   MASSRAIN=-1
PRINT HYD           ID=1   CODE=1
*S
*************************************************************************

*S ADD 32 TO 20.75 TO GET 32.9
ADD HYD             ID=9   HYD NO=32.9 ID I=1 ID II=6
PRINT HYD           ID=9   CODE=1
*S
*************************************************************************
*
*S ROUTE 32.9 THRU UPPER 39 IN NATURAL ARROYO TO 39.7
*
COMPUTE RATING CURVE  CID=1   VS NO=1   NO SEGS=1
                      MIN ELEV=5681.92   MAX ELEV=5694.67
                      CH SLOPE=0.016    FP SLOPE=0.016
                      N=0.035           DIST=490.0
                      DIST      ELEV    DIST    ELEV
                        0       5694.40 76      5691.91
                        153     5688.85 244     5683.15
                        294     5681.92 339     5685.05
                        403     5690.03 490     5694.67

ROUTE MCUNGE        ID=5   HYD NO=39.5  INFLOW ID=9
                    DT=0.0   L=1800 FT   NS=0   SLOPE=0.016
                    MATCODE=0 REGCODE=0 CCODE=0 MM CODE=0
PRINT HYD           ID=5   CODE=1

*
*************************************************************************

*************************************************************************

*S*** SUB-BASIN 33 ****
*
COMPUTE LT TP       LCODE=1  UPLAND/LAG TIME TRANSITION METHOD
                    NK=3  ISLOPE=-1
                    LENGTH=400 FT   SLOPE=0.01 K=0.7
                    LENGTH=1600 FT  SLOPE=0.009 K=2.0
                    LENGTH=10392 FT  SLOPE=0.009 K=3.0
                    Kn=.033  CR=0.61
COMPUTE NM HYD      ID=1   HYD NO=33   DA= 0.731 SQ MI
                    PER A=100 PER B=0  PER C=0  PER D=0
                    TP=0.0   MASSRAIN=-1
PRINT HYD           ID=1   CODE=1
*S
*************************************************************************
*S*** SUB-BASIN 35 ****
*
COMPUTE LT TP       LCODE=1  UPLAND/LAG TIME TRANSITION METHOD
                    NK=3  ISLOPE=-1
                    LENGTH=400 FT   SLOPE=0.004 K=0.7
                    LENGTH=1600 FT  SLOPE=0.006 K=2.0
                    LENGTH=11265 FT  SLOPE=0.008 K=3.0
                    Kn=.033  CR=0.50
COMPUTE NM HYD      ID=2   HYD NO=35   DA= 0.616 SQ MI
                    PER A=100 PER B=0  PER C=0  PER D=0
                    TP=0.0   MASSRAIN=-1
PRINT HYD           ID=2   CODE=1
*S
*************************************************************************
*S  ADD 33 TO 35 TO GET 35.8
*S
ADD HYD             ID=8  HYD NO=35.8 ID I=1 ID II=2
PRINT HYD           ID=8   CODE=1
*
*S
*************************************************************************
*S ROUTE 35.8 THRU UPPER 39 IN NATURAL ARROYO TO 36.6
*
COMPUTE RATING CURVE  CID=1   VS NO=1   NO SEGS=1
                      MIN ELEV=5766.06   MAX ELEV=5778.83
                      CH SLOPE=0.013    FP SLOPE=0.013
                      N=0.035           DIST=700.0
                      DIST  ELEV    DIST  ELEV
                        0   5774.95   177 5770.03
                        320     5766.17 361     5766.06
                        408     5769.73 494     5778.01
                        555     5778.83 700     5775.56
```

```
ROUTE MCUNGE        ID=7   HYD NO=36.7  INFLOW ID=8
                    DT=0.0   L=2020 FT   NS=0   SLOPE=0.013
                    MATCODE=0 REGCODE=0 CCODE=0 MM CODE=0
PRINT HYD           ID=7   CODE=5
*
**************************************************************************
*S*** SUB-BASIN 36 ****
*
COMPUTE LT TP       LCODE=1  UPLAND/LAG TIME TRANSITION METHOD
                    NK=3  ISLOPE=-1
                    LENGTH=400 FT   SLOPE=0.012 K=0.7
                    LENGTH=1600 FT  SLOPE=0.008 K=2.0
                    LENGTH=5646 FT  SLOPE=0.015 K=3.0
                    Kn=.033  CR=0.50
COMPUTE NM HYD      ID=1   HYD NO=36   DA= 0.407 SQ MI
                    PER A=98 PER B=0  PER C=0  PER D=2
                    TP=0.0   MASSRAIN=-1
PRINT HYD           ID=1   CODE=1
*S
**************************************************************************
*S  ADD 35.8 TO 36 TO GET 36.6
*S
ADD HYD             ID=6  HYD NO=36.6 ID I=1 ID II=7
PRINT HYD           ID=6   CODE=1
*
*S
**************************************************************************

*S ROUTE 36.6 THRU MID 39 IN NATURAL ARROYO TO 39.7
*
COMPUTE RATING CURVE  CID=1   VS NO=1   NO SEGS=1
                      MIN ELEV=5714.17   MAX ELEV=5716.23
                      CH SLOPE=0.015    FP SLOPE=0.015
                      N=0.035           DIST=600.0
                      DIST  ELEV    DIST  ELEV
                        0   5716.58   50 5715.99
                        98      5715.76 137     5715.92
                        301     5714.17 417     5715.74
                        536     5715.06 600     5716.23

ROUTE MCUNGE        ID=4   HYD NO=39.4  INFLOW ID=6
                    DT=0.0   L=1884 FT   NS=0   SLOPE=0.015
                    MATCODE=0 REGCODE=0 CCODE=0 MM CODE=0
PRINT HYD           ID=4   CODE=1
*
**************************************************************************
*S  ADD 32.9 TO 39.4 TO GET 39.7
*S
ADD HYD             ID=7  HYD NO=39.7 ID I=5 ID II=4
PRINT HYD           ID=7   CODE=1
*
*S
**************************************************************************

*S ROUTE 39.7 THRU LOWER 39 IN NATURAL ARROYO TO 39.8
*
COMPUTE RATING CURVE  CID=1   VS NO=1   NO SEGS=1
                      MIN ELEV=5687.82   MAX ELEV=5701.09
                      CH SLOPE=0.0156    FP SLOPE=0.0156
                      N=0.035           DIST=500.0
                      DIST  ELEV    DIST  ELEV
                        0   5696.81   76 5694.05
                        174     5692.95 250     5687.82
                        339     5693.72 432     5699.97
                        500     5701.09


ROUTE MCUNGE        ID=6   HYD NO=39.6  INFLOW ID=7
                    DT=0.0   L=2583 FT   NS=0   SLOPE=0.0156
                    MATCODE=0 REGCODE=0 CCODE=0 MM CODE=0
PRINT HYD           ID=6   CODE=1
*
**************************************************************************

*S*** SUB-BASIN 39 ****
*
COMPUTE LT TP       LCODE=1  UPLAND/LAG TIME TRANSITION METHOD
                    NK=3  ISLOPE=-1
                    LENGTH=400 FT   SLOPE=0.015 K=0.7
                    LENGTH=1600 FT  SLOPE=0.015 K=2.0
                    LENGTH=5883 FT  SLOPE=0.002 K=3.0
                    Kn=.033  CR=0.50
COMPUTE NM HYD      ID=2   HYD NO=39   DA= 0.341 SQ MI
                    PER A=99 PER B=0  PER C=0  PER D=1
                    TP=0.0   MASSRAIN=-1
PRINT HYD           ID=2   CODE=1
*S
**************************************************************************
*S  ADD 39.6 TO 39 TO GET 39.8
```

```
*S
ADD HYD             ID=8  HYD NO=39.8 ID I=2 ID II=6
PRINT HYD           ID=8   CODE=1
*
*S
**********************************************************************

*S*** SUB-BASIN 40A ****
*
COMPUTE LT TP       LCODE=1  UPLAND/LAG TIME TRANSITION METHOD
                    NK=3  ISLOPE=-1
                    LENGTH=400 FT   SLOPE=0.033 K=0.7
                    LENGTH=1600 FT  SLOPE=0.013 K=2.0
                    LENGTH=2012 FT  SLOPE=0.016 K=3.0
                    Kn=.033  CR=0.50
COMPUTE NM HYD      ID=1   HYD NO=40A   DA= 0.107 SQ MI
                    PER A=88 PER B=2  PER C=10  PER D=0
                    TP=0.0   MASSRAIN=-1
PRINT HYD           ID=1   CODE=1
*S
**********************************************************************
*S  ADD 40A TO 39.8 TO GET 40A.9
*S
ADD HYD             ID=9  HYD NO=40A.9 ID I=1 ID II=8
PRINT HYD           ID=9   CODE=1
*
*S
**********************************************************************
*S ROUTE 40A.9 THRU 40 IN NATURAL ARROYO TO 40.5
*
COMPUTE RATING CURVE  CID=1   VS NO=1   NO SEGS=1
                      MIN ELEV=5636.01   MAX ELEV=5641.34
                      CH SLOPE=0.0097    FP SLOPE=0.0097
                      N=0.035           DIST=600.0
                      DIST  ELEV    DIST  ELEV
                        0   5643.37   111 5641.34
                        223     5638.84 301     5636.01
                        448     5641.12 600     5639.78


ROUTE MCUNGE        ID=6   HYD NO=40.6  INFLOW ID=9
                    DT=0.0   L=2390 FT   NS=0   SLOPE=0.0097
                    MATCODE=0 REGCODE=0 CCODE=0 MM CODE=0
PRINT HYD           ID=6   CODE=1
*
**********************************************************************

*S*** SUB-BASIN 40 ****
*
COMPUTE LT TP       LCODE=1  UPLAND/LAG TIME TRANSITION METHOD
                    NK=3  ISLOPE=-1
                    LENGTH=400 FT   SLOPE=0.052 K=0.7
                    LENGTH=1600 FT  SLOPE=0.020 K=2.0
                    LENGTH=2836 FT  SLOPE=0.026 K=3.0
                    Kn=.033  CR=0.50
COMPUTE NM HYD      ID=1   HYD NO=40   DA= 0.356 SQ MI
                    PER A=88 PER B=2  PER C=10  PER D=0
                    TP=0.0   MASSRAIN=-1
PRINT HYD           ID=1   CODE=1
*S
**********************************************************************
*S  ADD 40 TO 40A.9 TO GET 40.5
*S
ADD HYD             ID=5  HYD NO=40.5 ID I=1 ID II=6
PRINT HYD           ID=5   CODE=1
*
*S
**********************************************************************
*S ROUTE 40.5 THRU UPPER 41A IN NATURAL ARROYO TO 41A.9
*
COMPUTE RATING CURVE  CID=1   VS NO=1   NO SEGS=1
                      MIN ELEV=5518.27   MAX ELEV=5549.49
                      CH SLOPE=0.032    FP SLOPE=0.032
                      N=0.035           DIST=400.0
                      DIST  ELEV    DIST  ELEV
                        0   5546.63   70 5541.99
                        134     5529.86 200     5518.27
                        228     5519.99 260     5530.34
                        322     5545.97 400     5549.49

ROUTE MCUNGE        ID=61   HYD NO=41A.61  INFLOW ID=5
                    DT=0.0   L=4947 FT   NS=0   SLOPE=0.032
                    MATCODE=0 REGCODE=0 CCODE=0 MM CODE=0
PRINT HYD           ID=61   CODE=1
*
**********************************************************************

*S ROUTE 40.5 THRU LOWER 41A IN NATURAL ARROYO TO 41A.9
*
COMPUTE RATING CURVE  CID=1   VS NO=1   NO SEGS=1
                      MIN ELEV=5457.93   MAX ELEV=5504.28
```

```
                      CH SLOPE=0.017    FP SLOPE=0.017
                      N=0.035           DIST=400.0
                      DIST  ELEV    DIST  ELEV
                        0   5485.62   37 5499.76
                        75      5504.28 121     5489.83
                        155     5469.83 201     5457.93
                        233     5470.10 265     5490.19
                        288     5499.91 336     5502.91
                        400     5504.19

ROUTE MCUNGE        ID=6   HYD NO=41A.6  INFLOW ID=61
                    DT=0.0   L=1702 FT   NS=0   SLOPE=0.017
                    MATCODE=0 REGCODE=0 CCODE=0 MM CODE=0
PRINT HYD           ID=6   CODE=1
*
**********************************************************************

*S*** SUB-BASIN 41A ****
*
COMPUTE LT TP       LCODE=1  UPLAND/LAG TIME TRANSITION METHOD
                    NK=3  ISLOPE=-1
                    LENGTH=400 FT   SLOPE=0.022 K=0.7
                    LENGTH=1600 FT  SLOPE=0.014 K=2.0
                    LENGTH=6215 FT  SLOPE=0.036 K=3.0
                    Kn=.033  CR=0.50
COMPUTE NM HYD      ID=1   HYD NO=41A   DA= 0.453 SQ MI
                    PER A=70 PER B=0  PER C=30  PER D=0
                    TP=0.0   MASSRAIN=-1
PRINT HYD           ID=1   CODE=1
*S
**********************************************************************
*S  ADD 41A TO 40.5 TO GET 41A.9
*S
ADD HYD             ID=9  HYD NO=41A.9 ID I=1 ID II=6
PRINT HYD           ID=9   CODE=1
*
*S
**********************************************************************
**********************************************************************
*S*** SUB-BASIN 37 ****
*
COMPUTE LT TP       LCODE=1  UPLAND/LAG TIME TRANSITION METHOD
                    NK=3  ISLOPE=-1
                    LENGTH=400 FT   SLOPE=0.012 K=0.7
                    LENGTH=1600 FT  SLOPE=0.010 K=2.0
                    LENGTH=10600 FT  SLOPE=0.008 K=3.0
                    Kn=.033  CR=0.55
COMPUTE NM HYD      ID=1   HYD NO=37   DA= 0.590 SQ MI
                    PER A=91 PER B=0  PER C=2  PER D=7
                    TP=0.0   MASSRAIN=-1
PRINT HYD           ID=1   CODE=1
*S
**********************************************************************
*S ROUTE 37 THRU 34 IN NATURAL ARROYO TO 34.6
*
COMPUTE RATING CURVE  CID=1   VS NO=1   NO SEGS=1
                      MIN ELEV=5769.66   MAX ELEV=5778.71
                      CH SLOPE=0.005    FP SLOPE=0.005
                      N=0.035           DIST=500.0
                      DIST  ELEV    DIST  ELEV
                        0   5778.71   99 5771.79
                        180     5769.8  249     5769.66
                        340     5769.9  500     5775.36

ROUTE MCUNGE        ID=5   HYD NO=34.5  INFLOW ID=1
                    DT=0.0   L=4007 FT   NS=0   SLOPE=0.005
                    MATCODE=0 REGCODE=0 CCODE=0 MM CODE=0
PRINT HYD           ID=5   CODE=1
*
**********************************************************************

*S*** SUB-BASIN 34 ****
*
COMPUTE LT TP       LCODE=1  UPLAND/LAG TIME TRANSITION METHOD
                    NK=3  ISLOPE=-1
                    LENGTH=400 FT   SLOPE=0.010 K=0.7
                    LENGTH=1600 FT  SLOPE=0.003 K=2.0
                    LENGTH=1557 FT  SLOPE=0.007 K=3.0

COMPUTE NM HYD      ID=2   HYD NO=34   DA= 0.129 SQ MI
                    PER A=91 PER B=0  PER C=2  PER D=7
                    TP=0.0   MASSRAIN=-1
PRINT HYD           ID=2   CODE=1
*S
**********************************************************************
*S  ADD 34 TO 34.5 TO GET 34.6
*S
ADD HYD             ID=6  HYD NO=34.6 ID I=5 ID II=2
PRINT HYD           ID=6   CODE=1
*
*S
```

```
**********************************************************************
*S ROUTE 34.6 THRU 38 IN NATURAL ARROYO TO 34.3
*
COMPUTE RATING CURVE  CID=1   VS NO=1   NO SEGS=1
                      MIN ELEV=5749.96   MAX ELEV=5753.54
                      CH SLOPE=0.014    FP SLOPE=0.014
                      N=0.035           DIST=500.0
                      DIST  ELEV    DIST  ELEV
                         0   5750.07   77 5749.96
                       177     5753.54 211     5751.74
                       251     5750.83 287     5752.19
                       394     5753.47 500     5751.61

ROUTE MCUNGE        ID=5   HYD NO=38.5  INFLOW ID=6
                    DT=0.0   L=2678 FT   NS=0   SLOPE=0.014
                    MATCODE=0 REGCODE=0 CCODE=0 MM CODE=0
PRINT HYD           ID=5   CODE=1
*
**********************************************************************

*S*** SUB-BASIN 38A ****
*
COMPUTE LT TP       LCODE=1  UPLAND/LAG TIME TRANSITION METHOD
                    NK=2  ISLOPE=-1
                    LENGTH=400 FT   SLOPE=0.010 K=0.7
                    LENGTH=1373 FT  SLOPE=0.008 K=2.0
COMPUTE NM HYD      ID=1   HYD NO=38A   DA= 0.075 SQ MI
                    PER A=100 PER B=0  PER C=0  PER D=0
                    TP=0.0   MASSRAIN=-1
PRINT HYD           ID=1   CODE=1
*S
**********************************************************************
*S ROUTE 38A THRU 38 IN NATURAL ARROYO TO 34.3
*
COMPUTE RATING CURVE  CID=1   VS NO=1   NO SEGS=1
                     MIN ELEV=5742.94   MAX ELEV=5751.34
                      CH SLOPE=0.014    FP SLOPE=0.014
                      N=0.035           DIST=650.0
                      DIST  ELEV    DIST  ELEV
                        0   5751.34   136 5745.99
                        243     5743.74 326     5742.94
                        440     5745.94 517     5747.36
                        650     5743.89

ROUTE MCUNGE        ID=2   HYD NO=38.2  INFLOW ID=1
                    DT=0.0   L=3283 FT   NS=0   SLOPE=0.014
                    MATCODE=0 REGCODE=0 CCODE=0 MM CODE=0
PRINT HYD           ID=2   CODE=1
*
**********************************************************************


*S  ADD 38.2 TO 38.5 TO GET 34.3
*S
ADD HYD             ID=3  HYD NO=34.3 ID I=2 ID II=5
PRINT HYD           ID=3   CODE=1
*
*S
**********************************************************************
*S*** SUB-BASIN 38 ****
*
COMPUTE LT TP       LCODE=1  UPLAND/LAG TIME TRANSITION METHOD
                    NK=3  ISLOPE=-1
                    LENGTH=400 FT   SLOPE=0.012 K=0.7
                    LENGTH=1600 FT  SLOPE=0.022 K=2.0
                    LENGTH=960 FT   SLOPE=0.012 K=3.0

COMPUTE NM HYD      ID=1   HYD NO=38   DA= 0.131 SQ MI
                    PER A=96 PER B=4  PER C=0  PER D=0
                    TP=0.0   MASSRAIN=-1
PRINT HYD           ID=1   CODE=1
*S
**********************************************************************
*S  ADD 38 TO 34.3 TO GET 38.4
*S
ADD HYD             ID=4  HYD NO=38.4 ID I=1 ID II=3
PRINT HYD           ID=4   CODE=1
*
*S
**********************************************************************

*S ROUTE 38.4 THRU 42 IN NATURAL ARROYO TO 42.3
*
COMPUTE RATING CURVE  CID=1   VS NO=1   NO SEGS=1
                      MIN ELEV=5692.77   MAX ELEV=5703.76
                      CH SLOPE=0.03    FP SLOPE=0.03
                      N=0.035           DIST=500.0
                      DIST  ELEV    DIST  ELEV
                        0   5703.76   112 5700.06
                        214     5695.01 251     5692.77
                        288     5695.93 348     5700.22
```

```
                        410     5701.04 500     5702.54

ROUTE MCUNGE        ID=6   HYD NO=42.6  INFLOW ID=4
                    DT=0.0   L=4626 FT   NS=0   SLOPE=0.030
                    MATCODE=0 REGCODE=0 CCODE=0 MM CODE=0
PRINT HYD           ID=6   CODE=1
*
*****************************************************************************

*S*** SUB-BASIN 42 ****
*
COMPUTE LT TP       LCODE=1  UPLAND/LAG TIME TRANSITION METHOD
                    NK=3  ISLOPE=-1
                    LENGTH=400 FT   SLOPE=0.020 K=0.7
                    LENGTH=1600 FT  SLOPE=0.025 K=2.0
                    LENGTH=4881 FT   SLOPE=0.030 K=3.0
                    Kn=.033  CR=.5
COMPUTE NM HYD      ID=1   HYD NO=42   DA= 0.576 SQ MI
                    PER A=90 PER B=0  PER C=10  PER D=0
                    TP=0.0   MASSRAIN=-1
PRINT HYD           ID=1   CODE=1
*
*S
*****************************************************************************
*S  ADD 42 TO 38.9 TO GET 42.3
*S
ADD HYD             ID=3  HYD NO=42.3 ID I=1 ID II=6
PRINT HYD           ID=3   CODE=1
*
*S
*****************************************************************************
*S*** SUB-BASIN 42A ****
*
COMPUTE LT TP       LCODE=1  UPLAND/LAG TIME TRANSITION METHOD
                    NK=3  ISLOPE=-1
                    LENGTH=400 FT   SLOPE=0.055 K=0.7
                    LENGTH=1600 FT  SLOPE=0.040 K=2.0
                    LENGTH=2240 FT   SLOPE=0.033 K=3.0
                    Kn=.033  CR=.5
COMPUTE NM HYD      ID=1   HYD NO=42A   DA= 0.317 SQ MI
                    PER A=90 PER B=0  PER C=10  PER D=0
                    TP=0.0   MASSRAIN=-1
PRINT HYD           ID=1   CODE=1
*
*S
*****************************************************************************
*S  ADD 42 TO 38.9 TO GET 42A.4
*S
ADD HYD             ID=4  HYD NO=42A.4 ID I=1 ID II=3
PRINT HYD           ID=4   CODE=1
*
*S
*****************************************************************************
*S ROUTE 42A.4 THRU UPPER 41B IN NATURAL ARROYO TO 41B.52
*
COMPUTE RATING CURVE  CID=1   VS NO=1   NO SEGS=1
                      MIN ELEV=5556.25   MAX ELEV=5561.32
                      CH SLOPE=0.0195    FP SLOPE=0.0195
                      N=0.035           DIST=400.0
                      DIST  ELEV    DIST  ELEV
                        0   5561.13   62 5558.07
                        199     5556.25 288     5558.06
                        400     5561.32

ROUTE MCUNGE        ID=51   HYD NO=41B.51  INFLOW ID=4
                    DT=0.0   L=2296 FT   NS=0   SLOPE=0.0195
                    MATCODE=0 REGCODE=0 CCODE=0 MM CODE=0
PRINT HYD           ID=51   CODE=1

*
*****************************************************************************
*S ROUTE 41B.52 THRU MID 41B IN NATURAL ARROYO TO 41B.5
*
COMPUTE RATING CURVE  CID=1   VS NO=1   NO SEGS=1
                      MIN ELEV=5482.02   MAX ELEV=5532.32
                      CH SLOPE=0.18    FP SLOPE=0.18
                      N=0.035           DIST=400.0
                      DIST  ELEV    DIST  ELEV
                        0   5530.30   53 5531.12
                        112     5527.73 199     5482.02
                        294     5527.84 400     5532.32

ROUTE MCUNGE        ID=52   HYD NO=41B.52  INFLOW ID=51
                    DT=0.0   L=370 FT   NS=0   SLOPE=0.18
                    MATCODE=0 REGCODE=0 CCODE=0 MM CODE=0
PRINT HYD           ID=52   CODE=1

*
*****************************************************************************
*S ROUTE 41B.5 THRU LOWER 41B IN NATURAL ARROYO TO 41B.3
```

```
*
COMPUTE RATING CURVE  CID=1   VS NO=1   NO SEGS=1
                      MIN ELEV=5451.32   MAX ELEV=5462.04
                      CH SLOPE=0.016    FP SLOPE=0.016
                      N=0.035           DIST=300.0
                      DIST  ELEV    DIST  ELEV
                        0   5462.04   103 5452.05
                        150     5451.32 219     5452.73
                        300     5457.13

ROUTE MCUNGE        ID=5   HYD NO=41B.5  INFLOW ID=52
                    DT=0.0   L=1760 FT   NS=0   SLOPE=0.016
                    MATCODE=0 REGCODE=0 CCODE=0 MM CODE=0
PRINT HYD           ID=5   CODE=1

*
**********************************************************************

*S*** SUB-BASIN 41B ****
*
COMPUTE LT TP       LCODE=1  UPLAND/LAG TIME TRANSITION METHOD
                    NK=3  ISLOPE=-1
                    LENGTH=400 FT   SLOPE=0.020 K=0.7
                    LENGTH=1600 FT  SLOPE=0.020 K=2.0
                    LENGTH=2167 FT   SLOPE=0.044 K=3.0
                    Kn=.033  CR=.5
COMPUTE NM HYD      ID=1   HYD NO=41B   DA= 0.137 SQ MI
                    PER A=70 PER B=0  PER C=30  PER D=0
                    TP=0.0   MASSRAIN=-1
PRINT HYD           ID=1   CODE=1
*
*S
**********************************************************************
*S  ADD 41B TO 42A.4 TO GET 41B.3
*S
ADD HYD             ID=3  HYD NO=41B.3 ID I=1 ID II=5
PRINT HYD           ID=3   CODE=1
*
*S
**********************************************************************
*S*** SUB-BASIN 43A ****
*
COMPUTE LT TP       LCODE=1  UPLAND/LAG TIME TRANSITION METHOD
                    NK=3  ISLOPE=-1
                    LENGTH=400 FT   SLOPE=0.038 K=0.7
                    LENGTH=1600 FT  SLOPE=0.034 K=2.0
                    LENGTH=4762 FT   SLOPE=0.037 K=3.0
                    Kn=.033  CR=.5
COMPUTE NM HYD      ID=2   HYD NO=43A   DA= 0.186 SQ MI
                    PER A=80 PER B=10  PER C=10  PER D=0
                    TP=0.0   MASSRAIN=-1
PRINT HYD           ID=2   CODE=1
*
*S
**********************************************************************
*S  ADD 43A TO 41B.3 TO GET 43A.6
*S
ADD HYD             ID=6  HYD NO=43A.6 ID I=2 ID II=3
PRINT HYD           ID=6   CODE=1
*
*S
**********************************************************************
*S  ADD 43A.6 TO 41A.9 TO GET 41A.7
*S
ADD HYD             ID=7  HYD NO=41A.7 ID I=6 ID II=9
PRINT HYD           ID=7   CODE=1
*
*S
**********************************************************************
*S ROUTE 41A.7 THRU 43 IN NATURAL ARROYO TO 43.3
*
COMPUTE RATING CURVE  CID=1   VS NO=1   NO SEGS=1
                      MIN ELEV=5412.0   MAX ELEV=5437.18
                      CH SLOPE=0.009    FP SLOPE=0.009
                      N=0.035           DIST=600.0
                      DIST  ELEV    DIST  ELEV
                        0   5437.18   131 5420.64
                        248     5414.98 300     5412.0
                        362     5413.9  488     5419.34
                        600     5424.41

ROUTE MCUNGE        ID=5   HYD NO=43.5  INFLOW ID=7
                    DT=0.0   L=4200 FT   NS=0   SLOPE=0.009
                    MATCODE=0 REGCODE=0 CCODE=0 MM CODE=0
PRINT HYD           ID=5   CODE=1
*
**********************************************************************

*S*** SUB-BASIN 43 ****
*
COMPUTE LT TP       LCODE=1  USDI BUREAU OF RECLAMATION LAG TIME EQUATION
```

```
                    NK=3  ISLOPE=-1
                    LENGTH=400 FT   SLOPE=0.0204 K=0.7
                    LENGTH=1600 FT  SLOPE=0.009 K=2.0
                    LENGTH=3052 FT   SLOPE=0.017 K=3.0
                    Kn=.033  CR=.5
COMPUTE NM HYD      ID=1   HYD NO=43   DA= 0.170 SQ MI
                    PER A=80 PER B=10  PER C=10  PER D=0
                    TP=0.0   MASSRAIN=-1
PRINT HYD           ID=1   CODE=1
*
*S
*************************************************************************
*S  ADD 43 TO 41A.7 TO GET 43.3
*S
ADD HYD             ID=3  HYD NO=43.3 ID I=1 ID II=5
PRINT HYD           ID=3   CODE=1
*
*S
*************************************************************************

*S
*************************************************************************
*S*** SUB-BASIN 44 ****
*
COMPUTE LT TP       LCODE=1  UPLAND/LAG TIME TRANSITION METHOD
                    NK=3  ISLOPE=-1
                    LENGTH=400 FT   SLOPE=0.049 K=0.7
                    LENGTH=1600 FT  SLOPE=0.040 K=2.0
                    LENGTH=8103 FT   SLOPE=0.025 K=3.0
                    Kn=.033  CR=0.51
COMPUTE NM HYD      ID=5   HYD NO=44   DA= 0.409 SQ MI
                    PER A=90 PER B=0  PER C=10  PER D=0
                    TP=0.0   MASSRAIN=-1
PRINT HYD           ID=5   CODE=1
*S
*************************************************************************
*S ADD 44 TO 61.6 TO GET 44.8
*
ADD HYD             ID=8  HYD NO=44.8 ID I=5 ID II=3
PRINT HYD           ID=8   CODE=1
*
*S
*************************************************************************
*
*S*** SUB-BASIN 61 ****
*
COMPUTE LT TP       LCODE=1  USDI BUREAU OF RECLAMATION LAG TIME EQUATION
                    NK=3  ISLOPE=-1
                    LENGTH=400 FT   SLOPE=0.04 K=0.7
                    LENGTH=1600 FT  SLOPE=0.008 K=2.0
                    LENGTH=308 FT   SLOPE=0.044 K=3.0

COMPUTE NM HYD      ID=3   HYD NO=61   DA= 0.04846 SQ MI
                    PER A=80 PER B=10  PER C=10  PER D=0
                    TP=0.0   MASSRAIN=-1
PRINT HYD           ID=3   CODE=1
*
*************************************************************************
*
*S ADD 61 TO 44 TO GET 61.4
*
ADD HYD             ID=4  HYD NO=61.4 ID I=8 ID II=3
PRINT HYD           ID=4   CODE=1
*

*************************************************************************

*************************************************************************
*
*S ROUTE 61.4 THRU 60 IN NATURAL ARROYO TO 60.3
*
COMPUTE RATING CURVE  CID=1   VS NO=1   NO SEGS=1
                      MIN ELEV=5354   MAX ELEV=5360
                      CH SLOPE=0.013    FP SLOPE=0.0194
                      N=0.035           DIST=369.0
                      DIST  ELEV    DIST  ELEV
                        0       5360    45      5359
                        89      5356    105     5355
                        133     5354    150     5354
                        177     5354    210     5355
                        295     5357    349     5359
                        369     5360

ROUTE MCUNGE        ID=3   HYD NO=60.3  INFLOW ID=4
                    DT=0.0   L=1205 FT   NS=0   SLOPE=0.0194
                    MATCODE=0 REGCODE=0 CCODE=0 MM CODE=0
PRINT HYD           ID=3   CODE=1

*
*************************************************************************
*S*** SUB-BASIN 60 ****
```

```
*
COMPUTE LT TP       LCODE=1  USDI BUREAU OF RECLAMATION LAG TIME EQUATION
                    NK=3  ISLOPE=-1
                    LENGTH=400 FT   SLOPE=0.065 K=0.7
                    LENGTH=1600 FT  SLOPE=0.026 K=2.0
                    LENGTH=1310 FT   SLOPE=0.016 K=3.0

COMPUTE NM HYD      ID=1   HYD NO=60   DA= 0.11036 SQ MI
                    PER A=100 PER B=0  PER C=0  PER D=0
                    TP=0.0   MASSRAIN=-1
PRINT HYD           ID=1   CODE=1
*
*S
**********************************************************************
*
*S ADD 60 TO 44.8 TO GET 60.20
*S
ADD HYD             ID=6  HYD NO=60.6 ID I=1 ID II=3
PRINT HYD           ID=6   CODE=1
*
*S
**********************************************************************
*
*S ROUTE THRU 4-60" PIPES IN SCENIC BLVD - IP3 ********************
*S ROUTE RESERVOIR COMMAND WAS USED TO ROUTE THRU MULTIPLE PIPES IN SCENIC
*

ROUTE RESERVOIR         ID=19 HYD=60.19 INFLOW ID=6 CODE=5
                        OUTFLOW(CFS)    STORAGE(AC FT)  ELEV (FT)
                        0.0             0.000           5339.8
                        0.23            0.001           5340
                        32              0.200           5341
                        111             0.452           5342
                        229             0.775           5343
                        374             1.185           5344
                        535             1.682           5345
                        700             2.435           5346
                        1190            3.181           5346.7


PRINT HYD       ID=19   CODE=5
*
**********************************************************************
*
*S*** Basin Contributing to INFLOW POINT 2 (IP2) ******************
*
**********************************************************************
*S*** SUB-BASIN 46C
*
COMPUTE LT TP       LCODE=1  USDI BUREAU OF RECLAMATION LAG TIME EQUATION
                    NK=1  ISLOPE=-1
                    LENGTH=330 FT   SLOPE=0.023 K=1.0

COMPUTE NM HYD      ID=1   HYD NO=46C   DA= 0.0025 SQ MI
                    PER A=90 PER B=00  PER C=10  PER D=0
                    TP=0.0   MASSRAIN=-1

PRINT HYD           ID=1   CODE=1

**********************************************************************
*
*S ROUTE 46C THRU 62 IN NATURAL ARROYO TO 62.3
*
COMPUTE RATING CURVE  CID=1   VS NO=1   NO SEGS=1
                      MIN ELEV=5372.6   MAX ELEV=5375
                      CH SLOPE=0.0141    FP SLOPE=0.015
                      N=0.035           DIST=172.0
                      DIST  ELEV        DIST  ELEV
                        0       5375    73      5374
                        91      5373    109     5372.6
                        142     5373    157     5374
                        172     5375

ROUTE MCUNGE        ID=3   HYD NO=62.3  INFLOW ID=1
                    DT=0.0   L=2596 FT   NS=0   SLOPE=0.015
                    MATCODE=0 REGCODE=0 CCODE=0 MM CODE=0
PRINT HYD           ID=3   CODE=1
*
**********************************************************************
*
*S*** SUB-BASIN 62
*
COMPUTE LT TP       LCODE=1  USDI BUREAU OF RECLAMATION LAG TIME EQUATION
                    NK=3  ISLOPE=-1
                    LENGTH=400 FT   SLOPE=0.02 K=0.7
                    LENGTH=1600 FT  SLOPE=0.015 K=2.0
                    LENGTH=708 FT  SLOPE=0.009 K=3.0

COMPUTE NM HYD      ID=2   HYD NO=62   DA= 0.06722 SQ MI
                    PER A=80 PER B=10  PER C=10  PER D=0
                    TP=0.0   MASSRAIN=-1
```

```
PRINT HYD           ID=2   CODE=1
*
**********************************************************************
*
*S ADD 61.4 TO 62 TO GET 62.5
*
ADD HYD             ID=1  HYD NO=62.1 ID I=2 ID II=3
PRINT HYD           ID=1   CODE=1
*
*S
**********************************************************************
**********************************************************************
*S  APPLY NO SEDIMENT BULKING FACTOR
SEDIMENT BULK          CODE=1   BULKING FACTOR = 1.00
*
**********************************************************************
*
*S THE TRAILS SUBDIVISION
*S OUTFLOW RESTRICTED TO 62 CFS AT UNIVERSE AND AVENIDA DE JAMITO
*
**********************************************************************

*S RECALL HYD FROM THE TRAILS SUBDIVISION
*S
RECALL HYD          ID=99  HYD=BYPASS.ROUTE.K
                    DT=  .100000 HRS   DA=   1.0536 SQ MI
                    PEAK=     60.718CFS  RO= 1.3592 INCHES  NO PTS=600
                    FLOW RATES
                           .000       .000       .000       .000       .000
                           .000       .000       .000       .000       .000
                           .000      2.066     35.012     45.415     47.520
                         51.159     54.044     56.146     57.431     58.230
                         58.915     59.490     59.932     60.231     60.418
                         60.547     60.637     60.693     60.718     60.716
                         60.695     60.659     60.612     60.557     60.494
                         60.426     60.354     60.278     60.199     60.117
                         60.032     59.946     59.857     59.767     59.675
                         59.582     59.488     59.392     59.296     59.199
                         59.101     59.003     58.903     58.804     58.703
                         58.602     58.500     58.398     58.295     58.191
                         58.086     57.981     57.876     57.770     57.662
                         57.552     57.441     57.326     57.208     56.909
                         56.388     55.855     55.180     54.215     53.381
                         52.834     52.221     51.798     51.322     50.935
                         50.532     50.146     49.791     49.468     49.159
                         48.832     48.521     48.232     47.893     47.580
                         47.327     47.047     46.743     46.462     46.200
                         45.916     45.646     45.394     45.118     44.858
                         44.614     44.347     44.074     43.796     43.493
                         43.212     42.904     42.592     42.303     42.020
                         41.748     41.452     41.172     40.883     40.609
                         40.358     40.112     39.876     39.614     39.369
                         39.139     38.891     38.655     38.440     38.201
                         37.979     37.772     37.574     37.381     37.165
                         36.958     36.772     36.562     36.393     36.234
                         36.011     35.797     35.628     35.437     35.232
                         35.029     34.808     34.598     34.407     34.221
                         34.041     33.865     33.664     33.472     33.302
                         33.105     32.945     32.796     32.610     32.427
                         32.233     32.049     31.911     31.745     31.575
                         31.420     31.240     31.071     30.917     30.770
                         30.625     30.482     30.342     30.177     30.018
                         29.879     29.739     29.607     29.446     29.296
                         29.159     29.028     28.900     28.772     28.620
                         28.474     28.371     28.240     28.075     27.952
                         27.825     27.572     27.308     27.056     26.807
                         26.519     26.213     25.894     25.536     25.192
                         24.857     24.538     24.194     23.793     23.410
                         23.035     22.691     22.381     22.089     21.803
                         21.511     21.200     20.854     20.510     20.241
                         19.934     19.509     19.115     18.697     18.355
                         18.045     17.687     17.366     17.074     16.789
                         16.536     16.289     16.042     15.671     15.037
                         14.483     14.020     13.573     13.089     12.637
                         12.135     11.689     11.292     10.870     10.437
                         10.086      9.818      9.524      9.278      9.083
                          8.871      7.958      6.399      5.329      4.840
                          4.555      4.321      4.134      3.981      3.841
                          3.728      3.634      3.545      3.463      3.394
                          3.324      3.260      3.204      3.146      3.093
                          3.045      2.997      2.951      2.910      2.868
                          2.828      2.792      2.754      2.719      2.685
                          2.652      2.619      2.588      2.557      2.527
                          2.498      2.469      2.441      2.414      2.386
                          2.359      2.333      2.307      2.282      2.257
                          2.232      2.208      2.184      2.160      2.136
                          2.113      2.090      2.068      2.045      2.024
                          2.002      1.979      1.958      1.936      1.916
                          1.896      1.876      1.856      1.836      1.816
                          1.797      1.778      1.759      1.741      1.722
                          1.704      1.686      1.668      1.651      1.633
```

```
                        1.616      1.599      1.582      1.565      1.549
                        1.532      1.516      1.500      1.484      1.469
                        1.453      1.438      1.423      1.408      1.393
                        1.379      1.364      1.350      1.336      1.321
                        1.307      1.293      1.280      1.266      1.253
                        1.240      1.227      1.214      1.202      1.189
                        1.177      1.164      1.152      1.140      1.129
                        1.117      1.105      1.094      1.083      1.071
                        1.060      1.049      1.039      1.028      1.017
                        1.007       .996       .986       .976       .966
                         .956       .946       .936       .927       .917
                         .908       .899       .890       .880       .871
                         .863       .854       .845       .836       .828
                         .819       .811       .803       .795       .787
                         .779       .771       .763       .755       .748
                         .740       .732       .725       .718       .711
                         .703       .696       .689       .682       .675
                         .669       .662       .655       .649       .642
                         .636       .629       .623       .617       .611
                         .604       .598       .592       .586       .581
                         .575       .569       .563       .558       .552
                         .547       .541       .536       .531       .525
                         .520       .515       .510       .505       .500
                         .495       .490       .485       .480       .476
                         .471       .466       .462       .457       .453
                         .448       .444       .439       .435       .431
                         .426       .422       .418       .414       .410
                         .406       .402       .398       .394       .390
                         .386       .383       .379       .375       .371
                         .368       .364       .361       .357       .354
                         .350       .347       .343       .340       .337
                         .333       .330       .327       .324       .321
                         .317       .314       .311       .308       .305
                         .302       .299       .296       .294       .291
                         .288       .285       .282       .280       .277
                         .274       .272       .269       .266       .264
                         .261       .259       .256       .254       .251
                         .249       .246       .244       .242       .239
                         .237       .235       .232       .230       .228
                         .226       .224       .221       .219       .217
                         .214       .212       .210       .208       .206
                         .204       .202       .200       .198       .196
                         .194       .193       .191       .189       .187
                         .185       .184       .182       .180       .178
                         .177       .175       .173       .172       .170
                         .168       .167       .164       .163       .161
                         .159       .158       .156       .155       .154
                         .152       .151       .149       .148       .146
                         .145       .144       .142       .141       .140
                         .138       .137       .136       .134       .133
                         .132       .131       .129       .128       .127
                         .126       .124       .123       .122       .121
                         .120       .119       .118       .116       .115
                         .113       .112       .111       .110       .109
                         .108       .107       .106       .105       .104
                         .103       .102       .101       .100       .099
                         .098       .097       .096       .096       .095

**********************************************************************
*
*S ROUTE 99 IN 36" PIPE IN UNIVERSE TO GET 47.19
*
COMPUTE RATING CURVE    CID=1   VS NO=1 NO SEGS=-1  SLP=0.019
                        DIAM=3.0 FT     N=0.013

ROUTE MCUNGE    ID=7    HYD NO=47.7 INFLOW ID=99
                DT=0.0 HR       LENGTH=1532 FT
                NS=0    SLOPE=0.019  CODE=5

PRINT HYD       ID=7    CODE=5
*
**********************************************************************
*S  APPLY SEDIMENT BULKING FACTOR
SEDIMENT BULK          CODE=1   BULKING FACTOR = 1.05

*
**********************************************************************
**********************************************************************
*S*** SUB-BASIN 47B STATE LAND PROPERTY ***
*
COMPUTE LT TP       LCODE=1  UPLAND/LAG TIME TRANSITION METHOD
                    NK=2  ISLOPE=-1
                    LENGTH=400 FT   SLOPE=0.026 K=0.7
                    LENGTH=936 FT  SLOPE=0.012 K=1.0

COMPUTE NM HYD      ID=5   HYD NO=47B   DA=0.0305 SQ MI
                    PER A=90 PER B=0  PER C=10  PER D=0
                    TP=0.0   MASSRAIN=-1
PRINT HYD           ID=5   CODE=1
*
```

```
**************************************************************************
*
*S*** SUB-BASIN 46B APS HIGH SCHOOL PROPERTY ***
*
COMPUTE LT TP       LCODE=1  UPLAND/LAG TIME TRANSITION METHOD
                    NK=3  ISLOPE=-1
                    LENGTH=400 FT   SLOPE=0.02 K=0.7
                    LENGTH=1600 FT  SLOPE=0.02 K=2.0
                    LENGTH=745 FT  SLOPE=0.02 K=3.0

COMPUTE NM HYD      ID=3   HYD NO=APS   DA=0.113 SQ MI
                    PER A=0 PER B=22  PER C=25  PER D=53
                    TP=0.0   MASSRAIN=-1
PRINT HYD           ID=3   CODE=1
*
**************************************************************************
*
*S*** ADD 47B TO 46B TO GET 46B.6
*

ADD HYD             ID=6  HYD NO=46B.6 ID I=5 ID II=3
PRINT HYD           ID=6   CODE=1
*
**************************************************************************
**************************************************************************
*
*S*** ROUTE -46B.6 THRU APS POND TO DISCHARGE 4.5 CFS TO UNIVERSE SD
*
ROUTE RESERVOIR         ID=4 HYD=46B.4  INFLOW ID=6 CODE=5
                        OUTFLOW(CFS)    STORAGE(AC FT)  ELEV (FT)
                        0.01            0.0004          5375
                        0.03            0.1097          5376
                        4.45            0.4827          5377
                        4.46            1.0921          5378
                        4.47            1.9496          5379
                        4.48            3.2565          5380
                        4.49            4.9487          5381
                        4.50            8.2             5382

PRINT HYD       ID=4 CODE=5
*
**************************************************************************
*
*S ADD 46B.6 TO 46B.4 TO GET 46B.8
*S
ADD HYD             ID=8  HYD NO=46B.8 ID I=7 ID II=4
PRINT HYD           ID=8   CODE=1
*
*
**************************************************************************
*
*S ROUTE 46B.8 IN 36" PIPE IN UNIVERSE TO GET 46.18
*
COMPUTE RATING CURVE    CID=1   VS NO=1 NO SEGS=-1  SLP=0.008
                        DIAM=3.0 FT     N=0.013

ROUTE MCUNGE    ID=18   HYD NO=46.18    INFLOW ID=8
                DT=0.0 HR       LENGTH=1902 FT
                NS=0    SLOPE=0.008  CODE=5

PRINT HYD       ID=18   CODE=5
*
**************************************************************************
*
*S ADD 46.18 TO 62.1 TO GET 46.9
*
ADD HYD             ID=9  HYD NO=46.9 ID I=18 ID II=1
PRINT HYD           ID=9   CODE=1
*
*
**************************************************************************
*
*S ROUTE 46.9 IN 72" IN SCENIC
*
COMPUTE RATING CURVE    CID=1   VS NO=1 NO SEGS=-1  SLP=0.0085
                        DIAM=6.0 FT     N=0.013

ROUTE MCUNGE    ID=2    HYD NO=IP2      INFLOW ID=9
                DT=0.0 HR       LENGTH=868 FT
                NS=0    SLOPE=0.0085  CODE=5

PRINT HYD       ID=2    CODE=5
*
**************************************************************************
*
*S**************************************************************************
*S ADD IP2 TO IP3 TO GET 60.20
*
ADD HYD             ID=20  HYD NO=60.20 ID I=2 ID II=19
PRINT HYD           ID=20   CODE=1
*
```

```
*
**************************************************************************
**************************************************************************
*
*S ADD OFFSITE VISTA VIEJA (VV) SUB-BASIN - INFLOW POINT IP4
*
*S*** SUB-BASIN 86 - BASIN E IN VV DRAINAGE REPORT
*S*** INCLUDES 10 AC DEVELOPED VV
*
COMPUTE LT TP       LCODE=1  UPLAND/LAG TIME TRANSITION METHOD
                    NK=3  ISLOPE=-1
                    LENGTH=400 FT   SLOPE=0.065 K=0.7
                    LENGTH=1600 FT  SLOPE=0.038 K=2.0
                    LENGTH=4852 FT  SLOPE=0.028 K=3.0
                    Kn=.033  CR=0.51
COMPUTE NM HYD      ID=1   HYD NO=86.1   DA=0.248 SQ MI
                    PER A=84 PER B=1  PER C=11  PER D=4
                    TP=0.0   MASSRAIN=-1
PRINT HYD           ID=1   CODE=5
*
**************************************************************************
*S ROUTE THRU 48" SD - IP4
*
COMPUTE RATING CURVE    CID=1   VS NO=1 NO SEGS=-1  SLP=0.02
                        DIAM=4.0 FT     N=0.013

ROUTE MCUNGE    ID=10   HYD NO=IP4      INFLOW ID=1
                DT=0.0 HR       LENGTH=2620 FT
                NS=0    SLOPE=0.02  CODE=5

PRINT HYD       ID=10   CODE=5
*
**************************************************************************
*S INFLOW POINT IP5
*S ONSITE BASINS VV1 UNITS 2 AND PART OF UNIT 3
*
COMPUTE LT TP       LCODE=1  UPLAND/LAG TIME TRANSITION METHOD
                    NK=3  ISLOPE=-1
                    LENGTH=400 FT   SLOPE=0.02 K=0.7
                    LENGTH=1600 FT  SLOPE=0.02 K=2.0
                    LENGTH=150 FT  SLOPE=0.02 K=3.0

COMPUTE NM HYD      ID=1   HYD NO=VV1.23   DA=0.0894 SQ MI
                    PER A=0 PER B=20  PER C=20  PER D=60
                    TP=0.0   MASSRAIN=-1
PRINT HYD           ID=1   CODE=5
*
**************************************************************************
*S ROUTE THRU 48" SD - IP5
*
COMPUTE RATING CURVE    CID=1   VS NO=1 NO SEGS=-1  SLP=0.015
                        DIAM=4.0 FT     N=0.013

ROUTE MCUNGE    ID=11   HYD NO=IP5      INFLOW ID=1
                DT=0.0 HR       LENGTH=2060 FT
                NS=0    SLOPE=0.015  CODE=5

PRINT HYD       ID=11   CODE=5
*
**************************************************************************
*S ADD OFFSITE VISTA VIEJA (VV2) SUB-BASIN - INFLOW POINT IP6
*S*** SUB-BASIN 83 & 83A - BASIN E IN D DRAINAGE REPORT
*S INCLUDES PARTS OF UNIT 4 & 1
**************************************************************************
*S*** SUB-BASIN 83
*
*
COMPUTE LT TP       LCODE=1  UPLAND/LAG TIME TRANSITION METHOD
                    NK=3  ISLOPE=-1
                    LENGTH=400 FT   SLOPE=0.058 K=0.7
                    LENGTH=1600 FT  SLOPE=0.061 K=2.0
                    LENGTH=9817 FT  SLOPE=0.0326 K=3.0
                    Kn=.033  CR=0.61
COMPUTE NM HYD      ID=1   HYD NO=83   DA=0.538 SQ MI
                    PER A=89 PER B=0  PER C=10  PER D=1
                    TP=0.0   MASSRAIN=-1
PRINT HYD           ID=1   CODE=5
*
**************************************************************************
*S*** SUB-BASIN 83A
*
COMPUTE LT TP       LCODE=1  UPLAND/LAG TIME TRANSITION METHOD
                    NK=3  ISLOPE=-1
                    LENGTH=400 FT   SLOPE=0.031 K=0.7
                    LENGTH=1600 FT  SLOPE=0.043 K=2.0
                    LENGTH=2172 FT  SLOPE=0.0355 K=3.0
                    Kn=.033  CR=.5
COMPUTE NM HYD      ID=2   HYD NO=83A   DA=0.137 SQ MI
                    PER A=89 PER B=0  PER C=10  PER D=1
                    TP=0.0   MASSRAIN=-1
PRINT HYD           ID=2   CODE=5
```

```
*
*************************************************************************
*S ADD 83 TO 83A TO GET 83A.3
*S
ADD HYD             ID=3  HYD NO=83A.3 ID I=1 ID II=2
PRINT HYD           ID=3   CODE=1
*
*S
*************************************************************************
*S*** ONSITE SUB-BASIN VV2 - PARTS OF UNITS 4 & 1
*
COMPUTE LT TP       LCODE=1  UPLAND/LAG TIME TRANSITION METHOD
                    NK=3  ISLOPE=-1
                    LENGTH=400 FT   SLOPE=0.006 K=0.7
                    LENGTH=1600 FT  SLOPE=0.011 K=2.0
                    LENGTH=130 FT  SLOPE=0.013 K=3.0

COMPUTE NM HYD      ID=2   HYD NO=VV2.41   DA=0.0373 SQ MI
                    PER A=0 PER B=20  PER C=20  PER D=60
                    TP=0.0   MASSRAIN=-1
PRINT HYD           ID=2   CODE=5
*
*************************************************************************
*S ADD VV.41 TO 83A.3 TO GET 83A.4
*S
ADD HYD             ID=4  HYD NO=83A.4 ID I=3 ID II=2
PRINT HYD           ID=4   CODE=1
*
*S

*************************************************************************
*S ROUTE THRU 60" TO IP6
*
*
COMPUTE RATING CURVE    CID=1   VS NO=1 NO SEGS=-1  SLP=0.028
                        DIAM=5.0 FT     N=0.013

ROUTE MCUNGE    ID=12   HYD NO=IP6      INFLOW ID=4
                DT=0.0 HR       LENGTH=2865 FT
                NS=0    SLOPE=0.028  CODE=5

PRINT HYD       ID=12   CODE=5

*************************************************************************

*S ADD IP5 TO IP5 AND IP6 TO GET 86.2
*S
ADD HYD             ID=2  HYD NO=86.2 ID I=12 ID II=11
PRINT HYD           ID=2   CODE=1
*
*S
*************************************************************************
*S ADD IP4 TO 86.2 TO GET 86.45
*S
ADD HYD             ID=45  HYD NO=86.45 ID I=2 ID II=10
PRINT HYD           ID=45   CODE=1
*
*S
*************************************************************************
*
*S ADD 62.20 (IP3) TO 86.45 (IP4, 5 & 6) TO GET 86.70

*S
ADD HYD             ID=7  HYD NO=86.70 ID I=45 ID II=20
PRINT HYD           ID=7   CODE=1
*
*S
*************************************************************************

*
*S
*************************************************************************
*************************************************************************
** DETENTION BASIN ** AMAFCA BOCA NEGRA DAM
** ROUTE 46B.4 THROUGH DAM TO GET 51.6 OUTFLOW TO DOWN CANYON PIPE
*************************************************************************
*S TOTAL OUTFLOW FROM BOCA NEGRA DETENTION FACILITY
ROUTE RESERVOIR         ID=14 HYD=51.6  INFLOW ID=7 CODE=2
                        OUTFLOW(CFS)    STORAGE(AC FT)  ELEV (FT)
                                         0           0.0           5323
                                        18          0.86           5324
                                        31          1.78           5325
                                        40          2.99           5326
                                        62          4.51           5327
                                       106          6.46           5328
                                       226          8.97           5329
                                       430         12.16           5330
                                       479         16.37           5331
                                       513         21.62           5332
                                       545         27.74           5333
                                       574         34.67           5334
```

```
                                    602         42.83           5335
                                    629         52.31           5336
                                    655         62.75           5337
                                    679         74.19           5338
                                    684         76.49           5338.2
                                   1438         86.29           5339
                                   3699         99.27           5340
                                   6830         113.10          5341
                                  10683         127.90          5342
                                  15192         143.55          5343
                                  20320         160.17          5344
                                  26006         178.15          5345
                                  32315         197.56          5346
                                  39208         218.35          5347
                                  46624         240.56          5348
PRINT HYD           ID=14   CODE=0
*
**********************************************************************
*
*S DIVIDE SURFACE FLOW FROM PIPE FLOW
*
DIVIDE HYD      ID=14   Q=372   ID=80   HYD=PIPE.80
                        ID=90   HYD=SURF.90

PRINT HYD               ID=80   CODE=1
PRINT HYD               ID=90   CODE=1
*
**********************************************************************

**********************************************************************
**********************************************************************
*S  APPLY SEDIMENT BULKING FACTOR
SEDIMENT BULK          CODE=1   BULKING FACTOR = 1.05

*
**********************************************************************
*S
*S ADD BASINS DRAINING INTO THE TEMPORARY PONDS ALONG UNSER BLVD
*
**********************************************************************
**********************************************************************

**********************************************************************
*S
*       COMPUTE HYD FOR SUB-BASIN 3
**********************************************************************
*
COMPUTE LT TP   LCODE=1 NK=3    ISLOPE=0
                LENGTH=400      SLOPE=0.013     K=.7
                LENGTH=1600     SLOPE=0.013     K=1
                LENGTH=1250     SLOPE=0.013     K=2

COMPUTE NM HYD  ID=3    HYD NO=3        DA=0.0957 SQ MI
                PER A=97   PER B=0   PER C=0   PER D=3
                TP=0.0  MASS RAIN=-1

PRINT HYD       ID=3    CODE=5

**********************************************************************
*
*S ROUTE SUB-BASIN 3 THRU UNSER TEMP POND A
*
ROUTE RESERVOIR         ID=1 HYD=4.9 INFLOW ID=3 CODE=2
                        OUTFLOW(CFS)    STORAGE(AC FT)  ELEV (FT)
                        0.0             0.0             5337
                        4.4             0.114           5338
                        6.7             0.493           5339
                        7.6             1.086           5340
                        8.5             1.779           5341

PRINT HYD           ID=1   CODE=5
*
**********************************************************************
*
*       COMPUTE HYD FOR SUB-BASIN 4
**********************************************************************
*
COMPUTE LT TP   LCODE=1 NK=2    ISLOPE=0
                LENGTH=400      SLOPE=0.017     K=.7
                LENGTH=1053     SLOPE=0.017     K=1

COMPUTE NM HYD  ID=4    HYD NO=4        DA=0..0282 SQ MI
                PER A=98   PER B=0   PER C=0   PER D=2
                TP=0.0  MASS RAIN=-1

PRINT HYD       ID=4    CODE=5

**********************************************************************
*
*S ADD ROUTED FLOW FROM TEMP POND A TO SUB-BASIN 4
```

```
*
*S ADD SUB-BASINS 3 AND 4
*
ADD HYD             ID=2  HYD NO=4.2 ID I=1 ID II=4
PRINT HYD           ID=2   CODE=1
*
**********************************************************************
**********************************************************************
*
*S ROUTE THRU UNSER TEMP POND B
*
ROUTE RESERVOIR         ID=1 HYD=5.9 INFLOW ID=2 CODE=2
                        OUTFLOW(CFS)    STORAGE(AC FT)  ELEV (FT)
                        0.0             0.0             5333
                        0.01            0.16            5334
                        2.6             0.50            5335
                        5.1             0.71            5335.5
                        8.0             0.918           5336

PRINT HYD           ID=1   CODE=5
*
**********************************************************************
**********************************************************************
*
*S ROUTE THRU 24"IN ALMENDRA PL
*
COMPUTE RATING CURVE    CID=1   VS NO=1 NO SEGS=-1  SLP=0.011
                        DIAM=2.0 FT     N=0.013

ROUTE MCUNGE    ID=2    HYD NO=5.92     INFLOW ID=1
                DT=0.0 HR       LENGTH=48.6 FT
                NS=0    SLOPE=0.011  CODE=5

PRINT HYD           ID=2   CODE=5
*

**********************************************************************
*       COMPUTE HYD FOR SUB-BASIN 5
**********************************************************************
*
COMPUTE LT TP   LCODE=1 NK=3    ISLOPE=0
                LENGTH=400      SLOPE=0.017     K=.7
                LENGTH=1600     SLOPE=0.017     K=1
                LENGTH=2000     SLOPE=0.017     K=2

COMPUTE NM HYD  ID=5    HYD NO=5        DA=0.0940 SQ MI
                PER A=98   PER B=0   PER C=0   PER D=2
                TP=0.0  MASS RAIN=-1

PRINT HYD       ID=5    CODE=5
*
**********************************************************************
*S
*S ADD ROUTED FLOW FROM TEMP POND B TO SUB-BASIN 5

ADD HYD             ID=1  HYD NO=5.1 ID I=2 ID II=5
PRINT HYD           ID=1   CODE=1
*
**********************************************************************
*
*S ROUTE THRU UNSER TEMP POND C
*
ROUTE RESERVOIR         ID=3 HYD=5.93 INFLOW ID=1 CODE=2
                        OUTFLOW(CFS)    STORAGE(AC FT)  ELEV (FT)
                        0.0             0.0             5329
                        1.3             0.173           5330
                        5.7             0.509           5331
                        12              0.946           5332
                        19.7            1.211           5333

PRINT HYD           ID=3   CODE=5
*

**********************************************************************
*S  APPLY NO SEDIMENT BULKING FACTOR
SEDIMENT BULK          CODE=1   BULKING FACTOR = 1.00

*
**********************************************************************
*
**********************************************************************
*S RECALL HYD FROM SAD 228 POND 4
*
*S
RECALL HYD          ID=14  HYD=POND4A
                    DT=  .050000 HRS   DA=    .0205 SQ MI
                    PEAK=     18.038CFS  RO= 1.4138 INCHES  NO PTS=503
                    FLOW RATES
                           .000       .000       .000       .000       .000
                           .000       .000       .000       .000       .000
                           .000       .000       .000       .000       .001
```

.020	.091	.228	.402	.568
.709	.826	.908	.922	.917
1.110	1.922	4.102	7.064	10.145
11.550	13.447	15.337	16.809	17.708
18.038	18.026	17.734	17.205	16.542
15.798	15.014	14.211	13.388	12.542
11.685	10.840	10.027	7.066	3.940
2.143	1.856	1.674	1.516	1.375
1.250	1.138	1.040	.952	.874
.804	.740	.684	.634	.589
.550	.515	.485	.458	.433
.410	.389	.370	.352	.336
.323	.312	.302	.293	.285
.278	.272	.267	.262	.257
.253	.250	.247	.244	.241
.240	.239	.238	.236	.234
.232	.229	.228	.227	.227
.228	.229	.230	.231	.231
.231	.232	.233	.234	.236
.238	.239	.240	.241	.243
.244	.245	.246	.248	.250
.251	.253	.251	.239	.219
.198	.181	.170	.162	.157
.153	.151	.148	.147	.145
.144	.143	.143	.141	.140
.139	.138	.137	.136	.135
.135	.134	.133	.133	.132
.132	.131	.131	.131	.130
.130	.129	.128	.128	.127
.126	.126	.126	.126	.125
.125	.124	.123	.124	.123
.122	.122	.122	.122	.121
.121	.120	.120	.120	.120
.119	.118	.118	.117	.117
.117	.117	.117	.117	.116
.115	.115	.115	.115	.114
.114	.113	.113	.113	.113
.113	.112	.111	.111	.110
.110	.110	.110	.109	.109
.109	.109	.109	.108	.107
.107	.107	.106	.106	.106
.106	.106	.106	.106	.105
.104	.104	.104	.104	.103
.103	.103	.102	.102	.101
.101	.101	.101	.101	.101
.101	.101	.101	.100	.099
.099	.099	.099	.098	.098
.098	.098	.098	.097	.097
.096	.096	.096	.096	.096
.096	.095	.095	.095	.095
.095	.094	.093	.093	.093
.093	.093	.093	.093	.093
.092	.092	.092	.092	.091
.091	.091	.090	.090	.090
.090	.090	.090	.090	.090
.089	.089	.089	.088	.088
.088	.088	.088	.087	.087
.088	.087	.087	.086	.086
.085	.085	.086	.087	.087
.086	.086	.085	.084	.083
.083	.083	.084	.084	.084
.084	.084	.083	.083	.083
.083	.082	.082	.082	.082
.081	.081	.081	.081	.081
.081	.081	.080	.080	.081
.081	.081	.080	.080	.079
.079	.078	.079	.079	.079
.079	.079	.078	.078	.078
.078	.078	.078	.077	.077
.077	.077	.077	.076	.076
.076	.077	.077	.076	.075
.075	.075	.075	.074	.075
.075	.076	.076	.076	.075
.075	.074	.073	.072	.072
.073	.073	.073	.074	.074
.074	.073	.072	.072	.072
.073	.072	.072	.072	.072
.072	.071	.071	.072	.072
.071	.071	.071	.071	.071
.071	.070	.070	.069	.069
.069	.070	.070	.070	.070
.069	.069	.069	.069	.069
.069	.068	.068	.068	.068
.068	.068	.068	.068	.068
.067	.067	.067	.067	.067
.067	.067	.067	.066	.066
.067	.066	.066	.065	.066
.066	.066	.065	.065	.066
.066	.066	.065	.065	.064
.064	.064	.064	.064	.065
.065	.066	.065	.065	.064

```
                        .064       .064       .064       .064       .064
                        .064       .063       .062       .062       .062
                        .062       .062       .061       .054       .043
                        .032       .022       .016       .012       .009
                        .008       .007       .006       .005       .004
                        .004       .003       .003       .002       .002
                        .002       .001       .001


**********************************************************************
*S
*S ADD SAD 228 POND 4 OUTFLOW TO TEMP POND C OUTFLOW

ADD HYD             ID=4  HYD NO=200.3 ID I=3 ID II=14
PRINT HYD           ID=4   CODE=1
*
**********************************************************************
*
*S RECALL HYD FROM SAD 228 POND 5
*
*S
RECALL HYD          ID=12  HYD=POND5
                    DT=  .050000 HRS   DA=    .1489 SQ MI
                    PEAK=     36.968CFS  RO= 1.5473 INCHES  NO PTS=600
                    FLOW RATES
                           .000       .000       .000       .000       .000
                           .000       .000       .000       .000       .000
                           .000       .000       .000       .000       .000
                           .001       .004       .016       .042       .087
                           .155       .246       .358       .485       .621
                           .767       .948      1.234      1.765      2.740
                          4.748      9.594     15.707     21.217     25.243
                         28.978     31.229     33.174     34.808     35.892
                         36.174     36.404     36.589     36.734     36.842
                         36.915     36.956     36.968     36.957     36.926
                         36.881     36.825     36.760     36.687     36.608
                         36.524     36.436     36.344     36.248     36.149
                         36.048     35.944     35.837     35.519     35.090
                         34.659     34.228     33.796     33.364     32.934
                         32.504     32.077     31.651     31.229     30.808
                         30.391     29.977     29.567     29.160     28.736
                         28.129     27.535     26.951     26.379     25.818
                         25.269     24.730     24.203     23.686     23.180
                         22.685     22.201     21.726     21.263     20.809
                         20.366     19.932     19.508     18.867     18.173
                         17.507     16.868     16.255     15.668     15.105
                         14.565     14.047     13.551     13.076     12.620
                         12.183     11.766     11.365     10.982     10.615
                         10.263      9.927      9.605      9.296      9.001
                          8.718      8.448      8.189      7.941      7.700
                          7.466      7.236      7.010      6.789      6.573
                          6.363      6.159      5.961      5.771      5.587
                          5.411      5.241      5.078      4.921      4.770
                          4.625      4.486      4.352      4.223      4.099
                          3.990      3.934      3.879      3.825      3.772
                          3.719      3.668      3.617      3.567      3.519
                          3.471      3.424      3.378      3.332      3.288
                          3.244      3.201      3.159      3.118      3.077
                          3.037      2.998      2.960      2.922      2.885
                          2.849      2.813      2.778      2.744      2.710
                          2.677      2.644      2.613      2.581      2.551
                          2.520      2.491      2.462      2.433      2.405
                          2.378      2.350      2.324      2.298      2.272
                          2.247      2.223      2.199      2.175      2.152
                          2.129      2.106      2.084      2.062      2.041
                          2.020      1.999      1.979      1.959      1.940
                          1.921      1.902      1.883      1.865      1.847
                          1.829      1.812      1.795      1.779      1.762
                          1.746      1.730      1.715      1.700      1.684
                          1.670      1.655      1.641      1.627      1.613
                          1.600      1.586      1.573      1.560      1.548
                          1.535      1.523      1.511      1.499      1.487
                          1.476      1.464      1.453      1.442      1.431
                          1.421      1.410      1.400      1.390      1.380
                          1.371      1.361      1.352      1.342      1.333
                          1.324      1.315      1.307      1.298      1.290
                          1.281      1.273      1.265      1.257      1.249
                          1.241      1.233      1.226      1.219      1.211
                          1.204      1.197      1.190      1.183      1.177
                          1.170      1.163      1.157      1.150      1.144
                          1.138      1.132      1.126      1.120      1.114
                          1.108      1.103      1.097      1.091      1.086
                          1.080      1.075      1.070      1.065      1.060
                          1.055      1.050      1.045      1.040      1.035
                          1.030      1.026      1.021      1.016      1.012
                          1.007      1.003       .999       .994       .990
                           .986       .982       .978       .974       .970
                           .966       .962       .959       .955       .951
                           .947       .943       .940       .936       .932
                           .929       .926       .922       .919       .916
```

```
                    .912       .909       .906       .903       .899
                    .896       .893       .890       .887       .884
                    .881       .878       .875       .872       .869
                    .866       .864       .861       .858       .856
                    .853       .850       .848       .845       .842
                    .840       .837       .835       .832       .830
                    .827       .825       .823       .820       .818
                    .816       .813       .811       .809       .806
                    .804       .802       .800       .797       .795
                    .793       .791       .789       .787       .784
                    .782       .780       .778       .776       .775
                    .773       .771       .769       .767       .765
                    .763       .761       .759       .757       .755
                    .753       .752       .750       .748       .746
                    .744       .743       .741       .739       .737
                    .736       .734       .732       .730       .729
                    .727       .726       .724       .722       .721
                    .719       .718       .716       .714       .713
                    .711       .710       .708       .706       .705
                    .704       .702       .701       .699       .698
                    .696       .695       .693       .692       .690
                    .689       .687       .686       .685       .683
                    .682       .681       .679       .678       .676
                    .675       .674       .672       .671       .670
                    .668       .667       .666       .664       .663
                    .662       .660       .659       .658       .657
                    .655       .654       .653       .652       .651
                    .649       .648       .647       .645       .644
                    .643       .642       .641       .640       .639
                    .638       .637       .636       .634       .633
                    .632       .631       .630       .629       .627
                    .626       .625       .624       .622       .620
                    .617       .612       .606       .599       .591
                    .582       .573       .563       .554       .544
                    .534       .525       .515       .506       .496
                    .487       .478       .469       .460       .451
                    .442       .433       .425       .417       .408
                    .400       .392       .384       .377       .369
                    .362       .355       .347       .340       .333
                    .327       .320       .314       .307       .301
                    .295       .289       .283       .277       .271
                    .266       .260       .255       .250       .245
                    .240       .235       .230       .225       .221
                    .216       .211       .207       .203       .199
                    .195       .191       .187       .183       .179
                    .175       .172       .168       .165       .161
                    .158       .155       .151       .148       .145
                    .142       .139       .136       .134       .131
                    .128       .125       .123       .120       .118
                    .115       .113       .111       .108       .106
                    .104       .102       .100       .098       .096
                    .094       .092       .090       .088       .086
                    .084       .083       .081       .079       .078
                    .076       .074       .073       .071       .070
                    .068       .067       .066       .064       .063


**********************************************************************
*S
*S ADD SAD 228 POND 4 & 5 OUTFLOW TO TEMP POND C OUTFLOW

ADD HYD             ID=1  HYD NO=201.1 ID I=4 ID II=12
PRINT HYD           ID=1   CODE=1
*
**********************************************************************
*
*S ROUTE 201.1 IN 54" SD IN UNSER BLVD TO GET 201.7
*
COMPUTE RATING CURVE    CID=1   VS NO=1 NO SEGS=-1  SLP=0.0112
                        DIAM=4.5 FT     N=0.013

ROUTE MCUNGE    ID=7    HYD NO=102.7    INFLOW ID=1
                DT=0.0 HR       LENGTH=730 FT
                NS=0    SLOPE=0.0112  CODE=5

PRINT HYD       ID=7    CODE=5

*
**********************************************************************
*S  APPLY SEDIMENT BULKING FACTOR
SEDIMENT BULK          CODE=1   BULKING FACTOR = 1.05

*
**********************************************************************
*S
*S COMPUTE UNSER BLVD RUNOFF SOUTH OF KIMMICK TO BOCA NEGRA DAM
*
*
COMPUTE LT TP       LCODE=1  UPLAND/LAG TIME TRANSITION METHOD
                    NK=3  ISLOPE=-1
                    LENGTH=400 FT   SLOPE=0.005 K=0.7
```

```
                    LENGTH=770 FT  SLOPE=0.005 K=2.0


COMPUTE NM HYD      ID=6   HYD NO=6   DA=0.01166 SQ MI
                    PER A=0 PER B=0  PER C=15  PER D=85
                    TP=0.0   MASSRAIN=-1
PRINT HYD           ID=6   CODE=1
*
**********************************************************************
*
*S ADD TOTAL FLOWS FROM UNSER BLVD

ADD HYD             ID=2  HYD NO=6.2 ID I=7 ID II=6
PRINT HYD           ID=2   CODE=1
*
**********************************************************************
*
*S ADD PIPE.80 TO 6.2 TO GET PIPE.1
*
ADD HYD             ID=1  HYD NO=PIPE.1 ID I=80 ID II=2
PRINT HYD           ID=1   CODE=1
*
**********************************************************************
**********************************************************************
*
*S ROUTE PIPE.1 IN 60" SD TO GET PIPE.2
*
COMPUTE RATING CURVE    CID=1   VS NO=1 NO SEGS=-1  SLP=0.015
                        DIAM=5.0 FT     N=0.013

ROUTE MCUNGE    ID=8    HYD NO=PIPE.2   INFLOW ID=1
                DT=0.0 HR       LENGTH=640 FT
                NS=0    SLOPE=0.015  CODE=5

PRINT HYD       ID=8    CODE=5
*
**********************************************************************
*
*S ROUTE PIPE.2 IN 54" SD TO GET PIPE.3
*
COMPUTE RATING CURVE    CID=1   VS NO=1 NO SEGS=-1  SLP=0.0881
                        DIAM=4.5 FT     N=0.013

ROUTE MCUNGE    ID=1    HYD NO=PIPE.3   INFLOW ID=8
                DT=0.0 HR       LENGTH=1147 FT
                NS=0    SLOPE=0.0881  CODE=5

PRINT HYD       ID=1    CODE=5
*
**********************************************************************
*
*S ROUTE PIPE.3 IN 60" SD TO GET PIPE.4
*
COMPUTE RATING CURVE    CID=1   VS NO=1 NO SEGS=-1  SLP=0.02
                        DIAM=5.0 FT     N=0.013

ROUTE MCUNGE    ID=8    HYD NO=PIPE.4   INFLOW ID=1
                DT=0.0 HR       LENGTH=949 FT
                NS=0    SLOPE=0.02  CODE=5

PRINT HYD       ID=8    CODE=5
*
**********************************************************************

**********************************************************************

*S  APPLY SEDIMENT BULKING FACTOR
SEDIMENT BULK           CODE=1   BULKING FACTOR = 1.09
*
**********************************************************************
**********************************************************************

*S*** SUB-BASIN 71 DOWNSTREAM OF THE DAM ***
*
COMPUTE LT TP       LCODE=1  UPLAND/LAG TIME TRANSITION METHOD
                    NK=3  ISLOPE=-1
                    LENGTH=400 FT   SLOPE=0.02 K=0.7
                    LENGTH=1600 FT  SLOPE=0.02 K=2.0
                    LENGTH=800 FT  SLOPE=0.02 K=3.0

COMPUTE NM HYD      ID=5   HYD NO=71   DA=0.07675 SQ MI
                    PER A=80 PER B=0  PER C=20  PER D=0
                    TP=0.0   MASSRAIN=-1
PRINT HYD           ID=5   CODE=5
*
**********************************************************************
*
*S ADD SURFACE FLOW FROM DAM TO BASIN 71 TO GET 71.5
*
*S ADD BASIN 71 to PIPE.2 TO GET 70.9
*
```

```
ADD HYD             ID=6  HYD NO=71.6 ID I=5 ID II=90
PRINT HYD           ID=6   CODE=1
*
*********************************************************************
*
*S ADD 71.6 to PIPE.2 TO GET 70.9
*
ADD HYD             ID=9  HYD NO=70.9 ID I=6 ID II=8
PRINT HYD           ID=9   CODE=1
*
*********************************************************************


*********************************************************************

*S  APPLY NO SEDIMENT BULKING FACTOR
SEDIMENT BULK          CODE=1   BULKING FACTOR = 1.00
*
*********************************************************************

*
*********************************************************************
*
*S RECALL HYD FROM THE VOLCANO HEIGHTS MODEL (BOCA NEGRA ARROYO SOUTH BRANCH)
*S
RECALL HYD          ID= 2 HYD=      102.00 DT=  .050000 HRS DA=   1.6400 SQ MI
                    PEAK=    378.544CFS  RO=  .3847 INCHES  NO PTS=340
                    FLOW RATES
                          .000       .000       .000       .000       .000
                          .000       .000       .000       .000       .000
                          .000       .000       .000       .000       .000
                          .000       .000       .000       .000       .000
                          .000       .000       .000       .000       .000
                          .000       .000      1.009      9.899     32.824
                        63.396     90.963    109.803    118.751    119.115
                       113.134    103.107     91.039     81.968     97.947
                       149.940    227.995    295.915    342.675    368.910
                       378.544    375.650    363.734    345.685    323.866
                       300.290    276.692    253.626    231.248    209.969
                       190.200    172.161    155.820    141.030    127.642
                       115.523    104.556     94.638     85.701     77.771
                        70.968     65.162     59.974     55.161     50.785
                        46.796     43.156     39.835     36.850     34.361
                        32.647     31.381     30.209     29.084     28.002
                        26.961     25.961     24.998     24.073     23.182
                        22.326     21.502     20.709     19.947     19.213
                        18.507     17.828     17.174     16.545     15.940
                        15.357     14.797     14.257     13.737     13.237
                        12.756     12.292     11.846     11.417     11.003
                        10.605     10.222      9.852      9.497      9.155
                         8.825      8.507      8.201      7.907      7.623
                         7.350      7.087      6.833      6.589      6.353
                         6.127      5.908      5.698      5.495      5.299
                         5.111      4.930      4.755      4.586      4.424
                         4.267      4.116      3.971      3.831      3.696
                         3.565      3.440      3.319      3.202      3.090
                         2.981      2.877      2.776      2.679      2.585
                         2.494      2.407      2.323      2.242      2.164
                         2.088      2.016      1.946      1.878      1.813
                         1.750      1.689      1.631      1.574      1.520
                         1.467      1.416      1.367      1.320      1.274
                         1.231      1.188      1.147      1.108      1.070
                         1.033       .997       .963       .930       .898
                          .867       .838       .809       .781       .754
                          .729       .704       .680       .657       .634
                          .613       .592       .571       .552       .533
                          .515       .498       .481       .464       .449
                          .433       .419       .404       .391       .378
                          .365       .352       .340       .329       .318
                          .305       .293       .283       .274       .265
                          .256       .247       .239       .231       .223
                          .216       .209       .202       .195       .188
                          .182       .176       .170       .164       .159
                          .154       .148       .144       .139       .134
                          .130       .125       .121       .117       .113
                          .109       .106       .102       .099       .096
                          .092       .089       .086       .084       .081
                          .078       .075       .073       .070       .066
                          .062       .060       .058       .057       .055
                          .053       .051       .050       .048       .046
                          .045       .043       .042       .041       .039
                          .038       .037       .036       .034       .033
                          .032       .031       .030       .029       .028
                          .027       .026       .026       .025       .024
                          .023       .022       .022       .021       .020
                          .020       .019       .018       .018       .017
                          .017       .016       .016       .015       .015
                          .014       .014       .013       .013       .012
                          .012       .012       .011       .011       .010
```

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                          .010       .010       .009       .009       .009
                          .009       .008       .008       .008       .008
                          .007       .007       .007       .007       .006
                          .006       .006       .006       .006       .005
                          .005       .005       .005       .005       .005
                          .004       .004       .004       .004       .004
                          .002       .001       .001       .001       .001

**********************************************************************
*
*S ROUTE THE BOCA NEGRA ARROYO SOUTH BRANCH FLOWS THRU 72" IN EMERALD DR
*
*
COMPUTE RATING CURVE    CID=1   VS NO=1 NO SEGS=-1  SLP=0.021
                        DIAM=6.0 FT     N=0.013

ROUTE MCUNGE    ID=5    HYD NO=70.5     INFLOW ID=2
                DT=0.0 HR       LENGTH=1347 FT
                NS=0    SLOPE=0.021  CODE=5

PRINT HYD       ID=5    CODE=1

**********************************************************************


**********************************************************************

*S  APPLY SEDIMENT BULKING FACTOR
SEDIMENT BULK          CODE=1   BULKING FACTOR = 1.09
*
**********************************************************************
**********************************************************************
*S
*S*** SUB-BASIN 70 EAST OF SAD 227 ***
*
COMPUTE LT TP       LCODE=1  UPLAND/LAG TIME TRANSITION METHOD
                    NK=3  ISLOPE=-1
                    LENGTH=400 FT   SLOPE=0.072 K=0.7
                    LENGTH=1580 FT  SLOPE=0.072 K=2.0


COMPUTE NM HYD      ID=4   HYD NO=70   DA=0.06914 SQ MI
                    PER A=80 PER B=0  PER C=20  PER D=0
                    TP=0.0   MASSRAIN=-1
PRINT HYD           ID=4   CODE=5
*
**********************************************************************
*S
*S ADD BASIN 70 to ROUTED BOCA NEGRA ARROYO SOUTH BRANCH
*
ADD HYD             ID=6  HYD NO=70.6 ID I=4 ID II=5
PRINT HYD           ID=6   CODE=1
*
**********************************************************************
*
*S ADD ALL FLOWS AT THE CONFLUENCE WITH BOCA NEGRA ARROYO
*
ADD HYD             ID=7  HYD NO=71.7 ID I=6 ID II=9
PRINT HYD           ID=7   CODE=1
*
**********************************************************************
*
*S ROUTE 71.7 IN 72 TO GET 72.6
*
COMPUTE RATING CURVE  CID=1   VS NO=1   NO SEGS=1
                      MIN ELEV=5164.49   MAX ELEV=5167.54
                      CH SLOPE=0.008    FP SLOPE=0.008
                      N=0.035           DIST=137
                      DIST  ELEV    DIST  ELEV
                        0   5167.54     20 5165.67
                        41   5166.80    77 5165.39
                        81   5164.71    92 5164.49
                        99   5165.64    137 5166.10

ROUTE MCUNGE        ID=6   HYD NO=72.6  INFLOW ID=7
                    DT=0.0   L=1805 FT   NS=0   SLOPE=0.008
                    MATCODE=0 REGCODE=0 CCODE=0 MM CODE=0

PRINT HYD           ID=6   CODE=1


*
**********************************************************************
*S  APPLY NO SEDIMENT BULKING FACTOR
SEDIMENT BULK          CODE=1   BULKING FACTOR = 1.00

*
**********************************************************************
**********************************************************************
*
*S RECALL HYD FROM SAD 228 POND 6
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```
*
RECALL HYD          ID=19  HYD=POND6
                    DT=  .050000 HRS   DA=    .0654 SQ MI
                    PEAK=     50.659CFS  RO= 1.5488 INCHES  NO PTS=539
                    FLOW RATES
                           .000       .000       .000       .000       .000
                           .000       .000       .000       .000       .000
                           .000       .000       .000       .000       .000
                           .002       .012       .049       .137       .296
                           .533       .841      1.202      1.585      1.956
                          2.303      2.701      3.408      4.947      8.041
                         12.321     18.906     24.765     30.903     36.022
                         39.406     41.514     43.269     44.579     48.727
                         50.659     48.563     44.986     44.498     43.781
                         42.862     41.773     40.543     39.204     37.551
                         34.501     31.620     28.909     25.345     22.281
                         19.653     16.660     14.038     12.007     10.418
                          9.161      8.152      7.158      6.362      5.742
                          5.246      4.836      4.491      4.193      3.932
                          3.699      3.490      3.300      3.127      2.967
                          2.820      2.684      2.558      2.442      2.334
                          2.234      2.141      2.054      1.974      1.899
                          1.830      1.766      1.706      1.650      1.598
                          1.550      1.505      1.464      1.426      1.390
                          1.358      1.328      1.300      1.274      1.250
                          1.228      1.207      1.189      1.172      1.158
                          1.144      1.131      1.120      1.109      1.099
                          1.091      1.084      1.079      1.074      1.070
                          1.066      1.063      1.060      1.057      1.055
                          1.053      1.051      1.050      1.048      1.043
                          1.029      1.007       .975       .937       .895
                           .853       .813       .777       .745       .718
                           .696       .677       .662       .649       .639
                           .630       .622       .614       .608       .601
                           .595       .589       .584       .579       .574
                           .569       .565       .561       .557       .553
                           .548       .544       .540       .536       .533
                           .529       .526       .522       .519       .517
                           .514       .512       .510       .508       .506
                           .504       .502       .500       .498       .496
                           .495       .493       .491       .489       .488
                           .486       .485       .483       .481       .479
                           .478       .476       .474       .473       .472
                           .471       .470       .468       .467       .465
                           .464       .462       .461       .459       .458
                           .456       .455       .454       .453       .451
                           .450       .448       .446       .445       .444
                           .442       .441       .440       .439       .438
                           .437       .436       .434       .433       .431
                           .430       .429       .428       .427       .426
                           .425       .424       .423       .422       .420
                           .419       .418       .417       .416       .414
                           .413       .412       .410       .409       .408
                           .407       .406       .405       .405       .404
                           .403       .402       .401       .400       .399
                           .398       .397       .396       .395       .394
                           .393       .392       .391       .390       .388
                           .387       .386       .385       .384       .384
                           .383       .383       .382       .381       .380
                           .379       .377       .376       .375       .374
                           .374       .373       .372       .372       .371
                           .370       .369       .368       .367       .366
                           .365       .364       .363       .362       .362
                           .361       .361       .360       .359       .358
                           .357       .356       .355       .354       .353
                           .352       .352       .351       .351       .350
                           .349       .348       .347       .346       .346
                           .346       .345       .345       .345       .344
                           .343       .341       .339       .338       .337
                           .337       .337       .336       .336       .336
                           .335       .334       .333       .332       .332
                           .331       .330       .329       .328       .327
                           .327       .326       .326       .325       .325
                           .324       .324       .323       .323       .322
                           .322       .321       .320       .319       .318
                           .317       .317       .316       .316       .316
                           .315       .314       .314       .313       .313
                           .312       .311       .310       .310       .309
                           .308       .308       .307       .307       .306
                           .306       .305       .304       .303       .302
                           .301       .301       .301       .301       .301
                           .301       .301       .301       .300       .299
                           .297       .296       .295       .294       .294
                           .294       .294       .293       .293       .292
                           .292       .291       .291       .290       .289
                           .289       .288       .288       .287       .287
                           .287       .286       .286       .286       .285
                           .285       .284       .284       .283       .282
                           .281       .281       .280       .280       .279
                           .279       .279       .279       .278       .278
                           .277       .277       .276       .275       .275
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                        .274       .274       .273       .273       .273
                        .273       .272       .272       .271       .271
                        .270       .270       .269       .269       .268
                        .268       .267       .267       .266       .266
                        .265       .264       .264       .264       .263
                        .263       .263       .263       .263       .262
                        .262       .261       .260       .259       .258
                        .258       .258       .258       .259       .259
                        .259       .259       .258       .257       .257
                        .256       .256       .255       .254       .253
                        .252       .251       .250       .249       .245
                        .238       .226       .209       .188       .165
                        .143       .122       .104       .088       .075
                        .064       .055       .048       .042       .038
                        .034       .030       .028       .025       .023
                        .021       .019       .018       .016       .015
                        .014       .013       .011       .011       .010
                        .009       .008       .008       .007       .006
                        .006       .005       .005       .005       .004
                        .004       .003       .003       .003       .003
                        .002       .002       .002       .002       .002
                        .002       .001       .001       .001


**********************************************************************
*
**********************************************************************
*S  APPLY SEDIMENT BULKING FACTOR
SEDIMENT BULK          CODE=1   BULKING FACTOR = 1.09

*
**********************************************************************
*S
*S*** SUB-BASIN 72 DOWNSTREAM OF CONFLUENCE WITH SOUTH BRANCH ***
*
COMPUTE LT TP       LCODE=1  UPLAND/LAG TIME TRANSITION METHOD
                    NK=3  ISLOPE=-1
                    LENGTH=355 FT   SLOPE=0.02 K=0.7
                    LENGTH=1645 FT  SLOPE=0.02 K=2.0
                    LENGTH=260 FT  SLOPE=0.02 K=3.0

COMPUTE NM HYD      ID=2   HYD NO=72   DA=0.16708 SQ MI
                    PER A=80 PER B=0  PER C=20  PER D=0
                    TP=0.0   MASSRAIN=-1
PRINT HYD           ID=2   CODE=5
*
**********************************************************************
*
*S ADD OUTFLOW FROM POND 6 TO BASIN 72
*
ADD HYD             ID=1  HYD NO=72.1 ID I=19 ID II=2
PRINT HYD           ID=1   CODE=1
*
**********************************************************************
*
*S ADD ALL FLOWS AT TESUQUE DR
*S ADD 72.1 TO 72.6 TO GET 72.3
*
ADD HYD             ID=3  HYD NO=72.3 ID I=1 ID II=6
PRINT HYD           ID=3   CODE=1

*
**********************************************************************
*
*S ROUTE 72.3 IN 73.1 TO GET 73.1.5
*
*
COMPUTE RATING CURVE  CID=1   VS NO=1   NO SEGS=1
                      MIN ELEV=5149.46   MAX ELEV=5162.40
                      CH SLOPE=0.006    FP SLOPE=0.006
                      N=0.035           DIST=149
                      DIST  ELEV    DIST  ELEV
                        0   5162.40     17 5157.28
                        25   5156.08    35 5151.92
                        75   5149.46    112 5150.98
                        132   5156.42   149 5157.55

ROUTE MCUNGE        ID=5   HYD NO=73.1.5  INFLOW ID=3
                    DT=0.0   L=1380 FT   NS=0   SLOPE=0.006
                    MATCODE=0 REGCODE=0 CCODE=0 MM CODE=0


PRINT HYD           ID=5   CODE=1
*
**********************************************************************
*
*S*** SUB-BASIN 73.1
*
COMPUTE LT TP       LCODE=1  UPLAND/LAG TIME TRANSITION METHOD
                    NK=3  ISLOPE=-1
                    LENGTH=355 FT   SLOPE=0.02 K=0.7
```

```
                    LENGTH=1645 FT  SLOPE=0.02 K=2.0
                    LENGTH=260 FT  SLOPE=0.02 K=3.0

COMPUTE NM HYD      ID=4   HYD NO=73.1   DA=0.12879 SQ MI
                    PER A=10 PER B=20  PER C=30  PER D=40
                    TP=0.0   MASSRAIN=-1
PRINT HYD           ID=4   CODE=5
*
**********************************************************************
*
*S ADD 72.3 TO 73.1 TO GET 73.1.2

*
ADD HYD             ID=2  HYD NO=73.1.2 ID I=4 ID II=5
PRINT HYD           ID=2   CODE=1
*

**********************************************************************
*
*S ROUTE 73.1.2 THRU 73.2 TO GET 73.2.5
*
COMPUTE RATING CURVE  CID=1   VS NO=1   NO SEGS=1
                      MIN ELEV=5149.46   MAX ELEV=5162.40
                      CH SLOPE=0.004    FP SLOPE=0.004
                      N=0.035           DIST=149
                      DIST  ELEV    DIST  ELEV
                        0   5144.26     23 5143.43
                        39   5138.80    68 5137.16
                        110   5138.29   132 5144.34
                        149   5144.48

ROUTE MCUNGE        ID=5   HYD NO=73.2.5  INFLOW ID=2
                    DT=0.0   L=1060 FT   NS=0   SLOPE=0.004
                    MATCODE=0 REGCODE=0 CCODE=0 MM CODE=0


PRINT HYD           ID=5   CODE=5

*
**********************************************************************
*
*S
*S*** SUB-BASIN 73.2
*
COMPUTE LT TP       LCODE=1  UPLAND/LAG TIME TRANSITION METHOD
                    NK=2  ISLOPE=-1
                    LENGTH=400 FT   SLOPE=0.02 K=0.7
                    LENGTH=865 FT  SLOPE=0.02 K=2.0


COMPUTE NM HYD      ID=4   HYD NO=73.2   DA=0.05105 SQ MI
                    PER A=10 PER B=20  PER C=30  PER D=40
                    TP=0.0   MASSRAIN=-1
PRINT HYD           ID=4   CODE=5
*
**********************************************************************

*S ADD 73.2 TO 73.2.5 TO GET 73.2.1
*S TOTAL FLOWS UPSTREAM END OF SAN ILDEFONSO DR
*
ADD HYD             ID=1  HYD NO=73.2.1 ID I=4 ID II=5
PRINT HYD           ID=1   CODE=1
*
**********************************************************************
**********************************************************************
FINISH
**********************************************************************
```

```
    AHYMO PROGRAM (AHYMO_97) -                          - Version:  1997.02c
         RUN DATE (MON/DAY/YR) = 05/04/2015
         START TIME (HR:MIN:SEC) = 17:11:07     USER NO.= AHYMO-C-9803c01UNMLIB-AH
         INPUT FILE = C:\BNDAHY~1\BOCANE~1.TXT

*S**************************************************************************
*S BOCA NEGRA DAM
*S LOMR MODEL - NEW RAINFALL DATA
*S INCLUDES BASINS DOWNSTREAM OF THE DAM
*S 100 YR 24 HR STORM EVENT
*S DATE: APRIL 2015
*
*S**************************************************************************
START              TIME=0.0  PUNCH CODE=0 PRINT CODE=0
LOCATION           BERNALILLO COUNTY
     Bernalillo County soil infiltration values (LAND FACTORS) used for computations.
     Land Treatment     Initial Abstr.(in)    Unif. Infilt.(in/hour)
          A             0.65                  1.67
          B             0.50                  1.25
          C             0.35                  0.83
          D             0.10                  0.04

*S 100 YEAR 24HR STORM
RAINFALL              TYPE=2  RAIN QUARTER=1.01   RAIN ONE=1.69
                   RAIN SIX=2.17  RAIN DAY=2.54  DT=0.05

               COMPUTED 24-HOUR RAINFALL DISTRIBUTION BASED ON NOAA ATLAS 2 - PEAK AT 1.40 HR.
               DT =    .050000 HOURS       END TIME =    24.000000 HOURS
                  .0000   .0056   .0114   .0173   .0234   .0298   .0363
                  .0431   .0502   .0576   .0652   .0732   .0816   .0903
                  .0996   .1093   .1196   .1306   .1423   .1549   .1685
                  .1756   .1835   .2063   .2602   .3529   .4962   .7026
                  .9848  1.2074  1.3079  1.3919  1.4654  1.5312  1.5907
                 1.6451  1.6949  1.7408  1.7831  1.8223  1.8585  1.8676
                 1.8761  1.8842  1.8918  1.8991  1.9061  1.9127  1.9192
                 1.9253  1.9313  1.9371  1.9427  1.9482  1.9535  1.9587
                 1.9637  1.9686  1.9734  1.9781  1.9827  1.9872  1.9917
                 1.9960  2.0002  2.0044  2.0085  2.0126  2.0165  2.0204
                 2.0243  2.0280  2.0318  2.0354  2.0391  2.0426  2.0462
                 2.0496  2.0531  2.0565  2.0598  2.0631  2.0664  2.0696
                 2.0728  2.0760  2.0791  2.0822  2.0852  2.0883  2.0913
                 2.0942  2.0972  2.1001  2.1029  2.1058  2.1086  2.1114
                 2.1142  2.1170  2.1197  2.1224  2.1251  2.1277  2.1304
                 2.1330  2.1356  2.1382  2.1407  2.1433  2.1458  2.1483
                 2.1508  2.1532  2.1557  2.1581  2.1605  2.1629  2.1653
                 2.1677  2.1700  2.1716  2.1732  2.1748  2.1763  2.1779
                 2.1795  2.1810  2.1826  2.1841  2.1857  2.1872  2.1887
                 2.1903  2.1918  2.1933  2.1948  2.1963  2.1978  2.1993
                 2.2008  2.2023  2.2038  2.2052  2.2067  2.2082  2.2096
                 2.2111  2.2125  2.2140  2.2154  2.2169  2.2183  2.2197
                 2.2211  2.2226  2.2240  2.2254  2.2268  2.2282  2.2296
                 2.2310  2.2324  2.2337  2.2351  2.2365  2.2379  2.2392
                 2.2406  2.2419  2.2433  2.2446  2.2460  2.2473  2.2487
                 2.2500  2.2513  2.2526  2.2540  2.2553  2.2566  2.2579
                 2.2592  2.2605  2.2618  2.2631  2.2644  2.2657  2.2669
                 2.2682  2.2695  2.2708  2.2720  2.2733  2.2746  2.2758
                 2.2771  2.2783  2.2796  2.2808  2.2820  2.2833  2.2845
                 2.2857  2.2870  2.2882  2.2894  2.2906  2.2918  2.2930
                 2.2943  2.2955  2.2967  2.2978  2.2990  2.3002  2.3014
                 2.3026  2.3038  2.3050  2.3061  2.3073  2.3085  2.3096
                 2.3108  2.3120  2.3131  2.3143  2.3154  2.3166  2.3177
                 2.3188  2.3200  2.3211  2.3223  2.3234  2.3245  2.3256
                 2.3268  2.3279  2.3290  2.3301  2.3312  2.3323  2.3334
                 2.3345  2.3356  2.3367  2.3378  2.3389  2.3400  2.3411
                 2.3422  2.3433  2.3443  2.3454  2.3465  2.3476  2.3486
                 2.3497  2.3507  2.3518  2.3529  2.3539  2.3550  2.3560
                 2.3571  2.3581  2.3592  2.3602  2.3612  2.3623  2.3633
                 2.3644  2.3654  2.3664  2.3674  2.3685  2.3695  2.3705
                 2.3715  2.3725  2.3735  2.3746  2.3756  2.3766  2.3776
                 2.3786  2.3796  2.3806  2.3816  2.3825  2.3835  2.3845
                 2.3855  2.3865  2.3875  2.3885  2.3894  2.3904  2.3914
                 2.3924  2.3933  2.3943  2.3953  2.3962  2.3972  2.3981
                 2.3991  2.4000  2.4010  2.4020  2.4029  2.4038  2.4048
                 2.4057  2.4067  2.4076  2.4086  2.4095  2.4104  2.4114
                 2.4123  2.4132  2.4141  2.4151  2.4160  2.4169  2.4178
                 2.4187  2.4197  2.4206  2.4215  2.4224  2.4233  2.4242
                 2.4251  2.4260  2.4269  2.4278  2.4287  2.4296  2.4305
                 2.4314  2.4323  2.4332  2.4341  2.4350  2.4358  2.4367
                 2.4376  2.4385  2.4394  2.4402  2.4411  2.4420  2.4428
                 2.4437  2.4446  2.4455  2.4463  2.4472  2.4480  2.4489
                 2.4498  2.4506  2.4515  2.4523  2.4532  2.4540  2.4549
                 2.4557  2.4566  2.4574  2.4583  2.4591  2.4599  2.4608
                 2.4616  2.4624  2.4633  2.4641  2.4649  2.4658  2.4666
                 2.4674  2.4682  2.4691  2.4699  2.4707  2.4715  2.4724
                 2.4732  2.4740  2.4748  2.4756  2.4764  2.4772  2.4780
                 2.4788  2.4796  2.4805  2.4813  2.4821  2.4829  2.4837
                 2.4845  2.4852  2.4860  2.4868  2.4876  2.4884  2.4892
                 2.4900  2.4908  2.4916  2.4923  2.4931  2.4939  2.4947
                 2.4955  2.4962  2.4970  2.4978  2.4986  2.4993  2.5001
                 2.5009  2.5017  2.5024  2.5032  2.5040  2.5047  2.5055
```

```
                2.5062  2.5070  2.5078  2.5085  2.5093  2.5100  2.5108
                2.5115  2.5123  2.5130  2.5138  2.5145  2.5153  2.5160
                2.5168  2.5175  2.5183  2.5190  2.5197  2.5205  2.5212
                2.5219  2.5227  2.5234  2.5242  2.5249  2.5256  2.5263
                2.5271  2.5278  2.5285  2.5293  2.5300  2.5307  2.5314
                2.5321  2.5329  2.5336  2.5343  2.5350  2.5357  2.5364
                2.5372  2.5379  2.5386  2.5393  2.5400

*
*
**********************************************************************
*S  APPLY A 5% SEDIMENT BULKING FACTOR ABOVE THE ESCARPMENT AND 9% BELOW
*S  THE ESCARPMENT TO COMPUTED HYDROGRAPHS - NO SEDIMENT BULKING FACTOR
*S  WHEN USING RECALL HYD COMMAND
SEDIMENT BULK          CODE=1   BULKING FACTOR = 1.05
**********************************************************************
**********************************************************************
*S*** Basin Contributing to INFLOW POINT 3 (IP3) ******************
**********************************************************************
**********************************************************************
*S QUAIL RANCH BASINS
**********************************************************************
*S*
**********************************************************************
*S**** SUB-BASIN 10 ****
*
COMPUTE LT TP        LCODE=1
                     NK=3  ISLOPE=-1
                     LENGTH=400 FT   SLOPE=0.036 K=0.7
                     LENGTH=1600 FT  SLOPE=0.027 K=2.0
                     LENGTH=7708 FT  SLOPE=0.025 K=3.0
                     Kn=.033  CR=0.52

     Tc AND Tp COMPUTED BY UPLAND/LAG TIME PROCEDURE

     SCS UPLAND METHOD FACTORS
                               LENGTH (FT)      SLOPE (FT/FT)       COMPOSITE K
     SHEET FLOW PORTION           400.0            .036000             .7000
     SHALLOW FLOW PORTION        1600.0            .027000            2.0000
     CHANNEL FLOW PORTION        7708.0            .025000            3.0000
     TOTAL BASIN                 9708.0            .025783            2.5055


     LAG EQUATION FACTORS:     Kn=   .0330     TOTAL BASIN LENGTH (FT)=      9708.0
     TOTAL BASIN SLOPE (FT/FT)=    .025783     CENTROUD LENGTH (FT)=         5048.2


     TIME OF CONCENTRATION (HRS)=   .5818     TIME TO PEAK (HRS)=   .3879     LAG TIME (HRS)=   .4364

COMPUTE NM HYD       ID=1   HYD NO=10   DA= 0.358 SQ MI
                     PER A=99 PER B=0  PER C=1  PER D=0
                     TP=0.0   MASSRAIN=-1
     TIME TO PEAK (hrs)=   .3879

     K =   .407141HR    TP =   .387886HR    K/TP RATIO =  1.049638     SHAPE CONSTANT, N =  3.363608
     UNIT PEAK =   286.33    CFS   UNIT VOLUME =    1.000       B =   310.24      P60 = 1.6900
     AREA =      .358000 SQ MI    IA =    .64700 INCHES    INF =   1.66160 INCHES PER HOUR
     RUNOFF COMPUTED BY INITIAL ABSTRACTION/INFILTRATION NUMBER METHOD - DT =   .050000

    BULKING FACTOR APPLIED TO HYDROGRAPH.  FACTOR =  1.05000 AT PEAK FLOW.

PRINT HYD            ID=1   CODE=1

                                       OUTFLOW HYDROGRAPH REACH    10.00


    RUNOFF VOLUME =      .40971 INCHES     =       7.8227 ACRE-FEET
    PEAK DISCHARGE RATE =     116.07 CFS  AT   1.750 HOURS   BASIN AREA =   .3580 SQ. MI.



*
**********************************************************************
*S**** SUB-BASIN 11 ****
*
COMPUTE LT TP        LCODE=1
                     NK=3  ISLOPE=-1
                     LENGTH=400 FT   SLOPE=0.019 K=0.7
                     LENGTH=1600 FT  SLOPE=0.024 K=2.0
                     LENGTH=7880 FT  SLOPE=0.024 K=3.0
                     Kn=.033  CR=.64

     Tc AND Tp COMPUTED BY UPLAND/LAG TIME PROCEDURE

     SCS UPLAND METHOD FACTORS
                               LENGTH (FT)      SLOPE (FT/FT)       COMPOSITE K
     SHEET FLOW PORTION           400.0            .019000             .7000
     SHALLOW FLOW PORTION        1600.0            .024000            2.0000
     CHANNEL FLOW PORTION        7880.0            .024000            3.0000
     TOTAL BASIN                 9880.0            .023798            2.4385
```

```
     LAG EQUATION FACTORS:     Kn=   .0330     TOTAL BASIN LENGTH (FT)=      9880.0
     TOTAL BASIN SLOPE (FT/FT)=    .023798     CENTROUD LENGTH (FT)=         6323.2


     TIME OF CONCENTRATION (HRS)=   .6402     TIME TO PEAK (HRS)=   .4268     LAG TIME (HRS)=   .4802

COMPUTE NM HYD      ID=2   HYD NO=11   DA= 0.390 SQ MI
                    PER A=99 PER B=0  PER C=1  PER D=0
                    TP=0.0   MASSRAIN=-1
     TIME TO PEAK (hrs)=   .4268

     K =   .448010HR    TP =   .426823HR    K/TP RATIO =  1.049638     SHAPE CONSTANT, N =  3.363608
     UNIT PEAK =   283.47    CFS   UNIT VOLUME =    1.000       B =   310.24      P60 = 1.6900
     AREA =      .390000 SQ MI    IA =    .64700 INCHES    INF =   1.66160 INCHES PER HOUR
     RUNOFF COMPUTED BY INITIAL ABSTRACTION/INFILTRATION NUMBER METHOD - DT =   .050000

    BULKING FACTOR APPLIED TO HYDROGRAPH.  FACTOR =  1.05000 AT PEAK FLOW.

PRINT HYD           ID=2   CODE=1

                                      OUTFLOW HYDROGRAPH REACH    11.00


    RUNOFF VOLUME =      .40971 INCHES     =       8.5219 ACRE-FEET
    PEAK DISCHARGE RATE =     115.19 CFS  AT   1.800 HOURS   BASIN AREA =   .3900 SQ. MI.



*S
*************************************************************************
*
*S ADD IP3.10 TO IP3.11 TO GET IP3.11.9
ADD HYD             ID=9   HYD NO=11.9 ID I=1 ID II=2
PRINT HYD           ID=9   CODE=1

                                      OUTFLOW HYDROGRAPH REACH    11.90


    RUNOFF VOLUME =      .40971 INCHES     =      16.3446 ACRE-FEET
    PEAK DISCHARGE RATE =     229.96 CFS  AT   1.800 HOURS   BASIN AREA =   .7480 SQ. MI.



*S
*************************************************************************
*
*S ROUTE 11.9 THRU IP3.12 IN NATURAL ARROYO TO 12.6
*
COMPUTE RATING CURVE  CID=1   VS NO=1   NO SEGS=1
                      MIN ELEV=5896.45        MAX ELEV=5900.10
                      CH SLOPE=0.007    FP SLOPE=0.007
                      N=0.035           DIST=780
                      DIST  ELEV    DIST  ELEV
                        0  5898.04 132 5898.03
                                   250     5896.63 406     5896.45
                                   477     5898.02 593     5899.88
                                   740     5900.10 780     5899.98


                                    RATING CURVE VALLEY SECTION  1.0
                                       WATER       FLOW        FLOW        TOP
                                      SURFACE      AREA        RATE        WIDTH
                                       ELEV        SQ FT       CFS         FT
                                     5896.45         .00         .00         .00
                                     5896.64       16.76       12.92      165.71
                                     5896.83       50.94       75.09      190.56
                                     5897.03       89.89      178.32      215.42
                                     5897.22      133.62      320.96      240.27
                                     5897.41      182.11      503.57      265.12
                                     5897.60      235.37      727.47      289.98
                                     5897.79      293.40      994.31      314.83
                                     5897.99      356.20     1305.90      339.69
                                     5898.18      441.85     1471.31      486.81
                                     5898.37      536.41     2000.08      498.77
                                     5898.56      633.27     2596.18      510.74
                                     5898.75      732.43     3257.76      522.71
                                     5898.94      833.89     3983.49      534.68
                                     5899.14      937.64     4772.36      546.65
                                     5899.33     1043.68     5623.67      558.62
                                     5899.52     1152.03     6536.90      570.59
                                     5899.71     1262.67     7511.71      582.55
                                     5899.90     1375.79     8410.98      609.30
                                     5900.10     1507.24     8333.93      776.09
ROUTE MCUNGE        ID=6   HYD NO=12.6  INFLOW ID=9
                    DT=0.0   L=4765 FT   NS=0   SLOPE=0.007
                    MATCODE=0 REGCODE=0 CCODE=0 MM CODE=0

     INFLOW END= 274            TABLE PTS= 19
     DT=  .050000               QMED=      114.98  CKMED=      2.6500
```

WIDTH MED= 200.17 NREACH= 19 DX= 250.79

DEPTH (FT)	AREA (SQ FT)	Q (CFS)	TRAVEL TIME(HR)	WIDTH (FT)	ck (FPS)	VEL (FPS)	C	D	C1	C2	C3	Q-M (CFS)	C1-M	C2-M	C3-M
.00	.0	.0	2.535	.0	1.39	.27	1.000	.000	1.000	.000	.000	.0	1.000	.000	.000
.19	16.8	12.9	1.717	165.7	1.35	.77	.967	.033	.967	.000	.033	2.0	.995	.000	.005
.38	50.9	75.1	.898	190.6	2.30	1.47	1.653	.097	.929	.273	-.202	38.5	.943	.158	-.101
.58	89.9	178.3	.667	215.4	3.00	1.98	2.151	.157	.905	.395	-.300	122.0	.915	.340	-.254
.77	133.6	321.0	.551	240.3	3.54	2.40	2.543	.215	.886	.468	-.353	245.3	.893	.433	-.326
.96	182.1	503.6	.479	265.1	4.01	2.77	2.876	.270	.870	.518	-.387	408.1	.876	.493	-.369
1.15	235.4	727.5	.428	290.0	4.42	3.09	3.172	.323	.856	.555	-.411	611.4	.861	.536	-.398
1.34	293.4	994.3	.391	314.8	4.80	3.39	3.442	.375	.844	.585	-.429	856.9	.849	.570	-.419
1.54	356.2	1305.9	.361	339.7	3.71	3.67	2.666	.590	.723	.530	-.253	1146.1	.838	.597	-.435
1.73	441.8	1471.3	.397	486.8	3.64	3.33	2.612	.473	.768	.510	-.279	1385.3	.455	.413	.132
1.92	536.4	2000.1	.355	498.8	5.88	3.73	4.223	.388	.862	.644	-.505	1727.8	.867	.628	-.495
2.11	633.3	2596.2	.323	510.7	6.42	4.10	4.610	.451	.851	.670	-.521	2290.6	.856	.657	-.513
2.30	732.4	3257.8	.298	522.7	6.92	4.45	4.968	.513	.842	.691	-.533	2919.8	.846	.681	-.527
2.49	833.9	3983.5	.277	534.7	7.39	4.78	5.301	.575	.833	.709	-.542	3613.7	.837	.701	-.537
2.69	937.6	4772.4	.260	546.6	7.82	5.09	5.614	.636	.825	.724	-.549	4371.2	.828	.717	-.545
2.88	1043.7	5623.7	.246	558.6	8.23	5.39	5.910	.696	.817	.737	-.554	5191.5	.821	.731	-.551
3.07	1152.0	6536.9	.233	570.6	8.63	5.67	6.191	.757	.810	.748	-.558	6074.0	.813	.743	-.556
3.26	1262.7	7511.7	.222	582.6	8.42	5.95	6.046	.872	.780	.747	-.527	7018.1	.806	.753	-.559
3.45	1375.8	8411.0	.217	609.3	7.83	6.11	5.620	1.004	.737	.738	-.474	7957.4	.746	.737	-.483

MAXIMUM NO. ITERATIONS FOR SOLUTION (KKMAX) = 6 OCCURRED 2 TIMES. AVERAGE NUMBER ITERATIONS = 1.1066

DEPTH (FT)	AREA (SQ FT)	Q (CFS)	TRAVEL TIME(HR)	WIDTH (FT)	ck (FPS)	VEL (FPS)	C	D	C1	C2	C3	Q-M (CFS)	C1-M	C2-M	C3-M
.00	.0	.0	2.535	.0	1.39	.27	1.000	.000	1.000	.000	.000	.0	1.000	.000	.000
.19	16.8	12.9	1.717	165.7	1.35	.77	.967	.033	.967	.000	.033	2.0	.995	.000	.005
.38	50.9	75.1	.898	190.6	1.59	1.47	1.141	.141	.876	.124	.000	38.5	.924	.076	.000
.58	89.9	178.3	.667	215.4	1.77	1.98	1.267	.267	.789	.211	.000	122.0	.831	.169	.000
.77	133.6	321.0	.551	240.3	1.94	2.40	1.392	.392	.718	.282	.000	245.3	.751	.249	.000
.96	182.1	503.6	.479	265.1	2.11	2.77	1.513	.513	.661	.339	.000	408.1	.688	.312	.000
1.15	235.4	727.5	.428	290.0	2.27	3.09	1.629	.629	.614	.386	.000	611.4	.636	.364	.000
1.34	293.4	994.3	.391	314.8	2.43	3.39	1.741	.741	.574	.426	.000	856.9	.593	.407	.000
1.54	356.2	1305.9	.361	339.7	2.58	3.67	1.850	.850	.541	.459	.000	1146.1	.557	.443	.000
1.73	441.8	1471.3	.397	486.8	2.39	3.33	1.719	.719	.582	.418	.000	1385.3	.455	.413	.132
1.92	536.4	2000.1	.355	498.8	2.61	3.73	1.875	.875	.533	.467	.000	1727.8	.556	.444	.000
2.11	633.3	2596.2	.323	510.7	2.82	4.10	2.026	1.026	.494	.506	.000	2290.6	.513	.487	.000
2.30	732.4	3257.8	.298	522.7	3.03	4.45	2.173	1.173	.460	.540	.000	2919.8	.476	.524	.000
2.49	833.9	3983.5	.277	534.7	3.23	4.78	2.315	1.315	.432	.568	.000	3613.7	.445	.555	.000
2.69	937.6	4772.4	.260	546.6	3.42	5.09	2.454	1.454	.407	.593	.000	4371.2	.419	.581	.000
2.88	1043.7	5623.7	.246	558.6	3.61	5.39	2.589	1.589	.386	.614	.000	5191.5	.396	.604	.000
3.07	1152.0	6536.9	.233	570.6	3.79	5.67	2.721	1.721	.367	.633	.000	6074.0	.377	.623	.000
3.26	1262.7	7511.7	.222	582.6	3.97	5.95	2.850	1.850	.351	.649	.000	7018.1	.359	.641	.000
3.45	1375.8	8411.0	.217	609.3	4.08	6.11	2.928	1.928	.342	.658	.000	7957.4	.346	.654	.000

MAXIMUM NO. ITERATIONS FOR SOLUTION (KKMAX) = 4 OCCURRED 13 TIMES. AVERAGE NUMBER ITERATIONS = 1.0740

Equations solved with two passes: first using the Ponce correction to C1, second using the Fread correction to C1, C2 and C3

PRINT HYD ID=6 CODE=1

```
    RUNOFF VOLUME =      .39959 INCHES     =      15.9411 ACRE-FEET
    PEAK DISCHARGE RATE =     217.63 CFS  AT   2.550 HOURS   BASIN AREA =   .7480 SQ. MI.


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*
*S*** SUB-BASIN 12 ****
*
COMPUTE LT TP       LCODE=1
                    NK=3  ISLOPE=-1
                    LENGTH=400 FT   SLOPE=0.047 K=0.7
                    LENGTH=1600 FT  SLOPE=0.026 K=2.0
                    LENGTH=6490 FT  SLOPE=0.018 K=3.0
                    Kn=.033  CR=0.50

     Tc AND Tp COMPUTED BY UPLAND/LAG TIME PROCEDURE

     SCS UPLAND METHOD FACTORS
                               LENGTH (FT)      SLOPE (FT/FT)       COMPOSITE K
     SHEET FLOW PORTION           400.0           .047000             .7000
     SHALLOW FLOW PORTION        1600.0           .026000            2.0000
     CHANNEL FLOW PORTION        6490.0           .018000            3.0000
     TOTAL BASIN                 8490.0           .020874            2.4772


     LAG EQUATION FACTORS:     Kn=   .0330     TOTAL BASIN LENGTH (FT)=      8490.0
     TOTAL BASIN SLOPE (FT/FT)=    .020874     CENTROUD LENGTH (FT)=         4245.0


     TIME OF CONCENTRATION (HRS)=   .5404     TIME TO PEAK (HRS)=   .3603     LAG TIME (HRS)=   .4053

COMPUTE NM HYD      ID=1   HYD NO=12   DA= 0.309 SQ MI
                    PER A=99 PER B=1  PER C=0  PER D=0
                    TP=0.0   MASSRAIN=-1
     TIME TO PEAK (hrs)=   .3603

     K =   .379632HR    TP =   .360270HR    K/TP RATIO =  1.053742     SHAPE CONSTANT, N =  3.350701
     UNIT PEAK =   265.26    CFS   UNIT VOLUME =    1.000       B =   309.27      P60 = 1.6900
     AREA =      .309000 SQ MI    IA =    .64850 INCHES    INF =   1.66580 INCHES PER HOUR
     RUNOFF COMPUTED BY INITIAL ABSTRACTION/INFILTRATION NUMBER METHOD - DT =   .050000

    BULKING FACTOR APPLIED TO HYDROGRAPH.  FACTOR =  1.05000 AT PEAK FLOW.

PRINT HYD           ID=1   CODE=1

                                      OUTFLOW HYDROGRAPH REACH    12.00


    RUNOFF VOLUME =      .40783 INCHES     =       6.7210 ACRE-FEET
    PEAK DISCHARGE RATE =     106.67 CFS  AT   1.750 HOURS   BASIN AREA =   .3090 SQ. MI.


*S
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*
* ADD IP3.12 TO 12.6 TO GET 12.9
ADD HYD             ID=9   HYD NO=12.9 ID I=1 ID II=6
PRINT HYD           ID=9   CODE=1

                                      OUTFLOW HYDROGRAPH REACH    12.90


    RUNOFF VOLUME =      .40200 INCHES     =      22.6620 ACRE-FEET
    PEAK DISCHARGE RATE =     235.06 CFS  AT   2.500 HOURS   BASIN AREA =  1.0570 SQ. MI.


*
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*
*S*** SUB-BASIN 14 ****
*
COMPUTE LT TP       LCODE=1  UPLAND/LAG TIME TRANSITION METHOD
                    NK=3  ISLOPE=-1
                    LENGTH=400 FT   SLOPE=0.0199 K=0.7
                    LENGTH=1600 FT  SLOPE=0.033 K=2.0
                    LENGTH=8632 FT  SLOPE=0.023 K=3.0
                    Kn=.033  CR=0.50

     Tc AND Tp COMPUTED BY UPLAND/LAG TIME PROCEDURE

     SCS UPLAND METHOD FACTORS
                               LENGTH (FT)      SLOPE (FT/FT)       COMPOSITE K
     SHEET FLOW PORTION           400.0           .019900             .7000
     SHALLOW FLOW PORTION        1600.0           .033000            2.0000
     CHANNEL FLOW PORTION        8632.0           .023000            3.0000
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     TOTAL BASIN                 10632.0           .024388            2.4822


     LAG EQUATION FACTORS:     Kn=   .0330     TOTAL BASIN LENGTH (FT)=     10632.0
     TOTAL BASIN SLOPE (FT/FT)=    .024388     CENTROUD LENGTH (FT)=         5316.0


     TIME OF CONCENTRATION (HRS)=   .6309     TIME TO PEAK (HRS)=   .4206     LAG TIME (HRS)=   .4732

COMPUTE NM HYD      ID=2   HYD NO=14   DA= 0.513 SQ MI
                    PER A=99 PER B=1  PER C=0  PER D=0
                    TP=0.0   MASSRAIN=-1
     TIME TO PEAK (hrs)=   .4206

     K =   .441975HR    TP =   .420599HR    K/TP RATIO =  1.050822     SHAPE CONSTANT, N =  3.359877
     UNIT PEAK =   378.05    CFS   UNIT VOLUME =    1.000       B =   309.96      P60 = 1.6900
     AREA =      .513000 SQ MI    IA =    .64850 INCHES    INF =   1.66580 INCHES PER HOUR
     RUNOFF COMPUTED BY INITIAL ABSTRACTION/INFILTRATION NUMBER METHOD - DT =   .050000

    BULKING FACTOR APPLIED TO HYDROGRAPH.  FACTOR =  1.05000 AT PEAK FLOW.

PRINT HYD           ID=2   CODE=1

                                      OUTFLOW HYDROGRAPH REACH    14.00


    RUNOFF VOLUME =      .40783 INCHES     =      11.1581 ACRE-FEET
    PEAK DISCHARGE RATE =     152.83 CFS  AT   1.800 HOURS   BASIN AREA =   .5130 SQ. MI.



*S
**************************************************************************
* ADD IP3.14 TO 12.9 TO GET 14.8
ADD HYD             ID=8   HYD NO=14.8 ID I=2 ID II=9
PRINT HYD           ID=8   CODE=1

                                      OUTFLOW HYDROGRAPH REACH    14.80


    RUNOFF VOLUME =      .40391 INCHES     =      33.8201 ACRE-FEET
    PEAK DISCHARGE RATE =     275.48 CFS  AT   2.500 HOURS   BASIN AREA =  1.5700 SQ. MI.



*S
**************************************************************************
*S ROUTE 14.8 THRU 15 IN NATURAL ARROYO TO 15.6
COMPUTE RATING CURVE  CID=1   VS NO=1   NO SEGS=1
                      MIN ELEV=5844.46   MAX ELEV=5850.0
                      CH SLOPE=0.007    FP SLOPE=0.007
                      N=0.035           DIST=600.0
                      DIST  ELEV    DIST  ELEV
                        0   5854.38   145 5852.0
                                  235     5845.95 300     5844.46
                                  399     5846.0  489     5850.0
                                  600     5856.87


                                   RATING CURVE VALLEY SECTION  1.0
                                       WATER       FLOW        FLOW        TOP
                                     SURFACE       AREA        RATE        WIDTH
                                       ELEV        SQ FT       CFS         FT
                                     5844.46         .00         .00         .00
                                     5844.75        4.58        4.51       31.45
                                     5845.04       18.34       28.63       62.91
                                     5845.33       41.26       84.42       94.36
                                     5845.63       73.35      181.82      125.81
                                     5845.92      114.61      329.66      157.27
                                     5846.21      163.16      558.29      172.55
                                     5846.50      215.05      849.13      183.45
                                     5846.79      270.12     1194.70      194.34
                                     5847.08      328.36     1595.05      205.24
                                     5847.38      389.77     2050.65      216.13
                                     5847.67      454.36     2562.29      227.03
                                     5847.96      522.13     3130.91      237.92
                                     5848.25      593.08     3757.61      248.82
                                     5848.54      667.20     4443.57      259.72
                                     5848.83      744.49     5190.02      270.61
                                     5849.12      824.96     5998.23      281.51
                                     5849.42      908.61     6869.52      292.40
                                     5849.71      995.44     7805.21      303.30
                                     5850.00     1085.44     8806.66      314.19
ROUTE MCUNGE        ID=6   HYD NO=15.6  INFLOW ID=8
                    DT=0.0   L=5450 FT   NS=0   SLOPE=0.007
                    MATCODE=0 REGCODE=0 CCODE=0 MM CODE=0

     INFLOW END= 297           TABLE PTS= 20
     DT=  .050000              QMED=      137.74  CKMED=      3.0349
     WIDTH MED=      111.58    NREACH= 19         DX=      286.84
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DEPTH (FT)	AREA (SQ FT)	Q (CFS)	TRAVEL TIME(HR)	WIDTH (FT)	ck (FPS)	VEL (FPS)	C	D	C1	C2	C3	Q-M (CFS)	C1-M	C2-M	C3-M
.00	.0	.0	2.108	.0	1.59	.45	1.000	.000	1.000	.000	.000	.0	1.000	.000	.000
.29	4.6	4.5	1.539	31.5	1.52	.98	.953	.047	.953	.000	.047	.7	.993	.000	.007
.58	18.3	28.6	.970	62.9	2.17	1.56	1.363	.104	.915	.189	-.105	13.4	.922	.070	.008
.87	41.3	84.4	.740	94.4	2.79	2.05	1.749	.160	.890	.312	-.203	52.7	.895	.245	-.140
1.17	73.4	181.8	.611	125.8	3.35	2.48	2.101	.215	.870	.397	-.267	128.7	.875	.352	-.227
1.46	114.6	329.7	.526	157.3	4.07	2.88	2.553	.257	.865	.475	-.340	250.9	.858	.426	-.285
1.75	163.2	558.3	.442	172.6	5.17	3.42	3.245	.312	.863	.561	-.424	437.9	.869	.531	-.400
2.04	215.1	849.1	.383	183.4	5.96	3.95	3.743	.387	.849	.610	-.459	697.8	.857	.589	-.446
2.33	270.1	1194.7	.342	194.3	6.59	4.42	4.138	.464	.834	.643	-.477	1016.3	.841	.627	-.468
2.62	328.4	1595.0	.312	205.2	7.16	4.86	4.494	.540	.821	.669	-.489	1389.4	.827	.656	-.483
2.92	389.8	2050.7	.288	216.1	7.68	5.26	4.822	.615	.809	.689	-.498	1817.6	.814	.679	-.493
3.21	454.4	2562.3	.268	227.0	8.17	5.64	5.126	.688	.798	.706	-.504	2301.3	.803	.698	-.501
3.50	522.1	3130.9	.252	237.9	8.62	6.00	5.411	.760	.788	.721	-.509	2841.5	.792	.714	-.506
3.79	593.1	3757.6	.239	248.8	9.05	6.34	5.682	.831	.779	.734	-.513	3439.2	.783	.727	-.510
4.08	667.2	4443.6	.227	259.7	9.46	6.66	5.939	.900	.770	.745	-.515	4095.6	.774	.739	-.513
4.37	744.5	5190.0	.217	270.6	9.86	6.97	6.186	.969	.762	.755	-.517	4811.8	.766	.750	-.516
4.66	825.0	5998.2	.208	281.5	10.24	7.27	6.424	1.037	.755	.764	-.519	5589.1	.758	.759	-.517
4.96	908.6	6869.5	.200	292.4	10.60	7.56	6.654	1.103	.748	.772	-.520	6428.9	.751	.768	-.519
5.25	995.4	7805.2	.193	303.3	10.96	7.84	6.877	1.170	.741	.779	-.520	7332.4	.744	.775	-.520
5.54	1085.4	8806.7	.187	314.2	11.15	8.11	7.000	1.251	.729	.784	-.513	8300.9	.738	.782	-.520

MAXIMUM NO. ITERATIONS FOR SOLUTION (KKMAX) = 5 OCCURRED 4 TIMES. AVERAGE NUMBER ITERATIONS = 1.1914

DEPTH (FT)	AREA (SQ FT)	Q (CFS)	TRAVEL TIME(HR)	WIDTH (FT)	ck (FPS)	VEL (FPS)	C	D	C1	C2	C3	Q-M (CFS)	C1-M	C2-M	C3-M
.00	.0	.0	2.108	.0	1.59	.45	1.000	.000	1.000	.000	.000	.0	1.000	.000	.000
.29	4.6	4.5	1.539	31.5	1.52	.98	.953	.047	.953	.000	.047	.7	.993	.000	.007
.58	18.3	28.6	.970	62.9	1.79	1.56	1.126	.126	.888	.112	.000	13.4	.922	.070	.008
.87	41.3	84.4	.740	94.4	1.96	2.05	1.228	.228	.815	.185	.000	52.7	.849	.151	.000
1.17	73.4	181.8	.611	125.8	2.13	2.48	1.338	.338	.748	.252	.000	128.7	.778	.222	.000
1.46	114.6	329.7	.526	157.3	2.31	2.88	1.451	.451	.689	.311	.000	250.9	.716	.284	.000
1.75	163.2	558.3	.442	172.6	2.59	3.42	1.623	.623	.616	.384	.000	437.9	.650	.350	.000
2.04	215.1	849.1	.383	183.4	2.87	3.95	1.803	.803	.555	.445	.000	697.8	.583	.417	.000
2.33	270.1	1194.7	.342	194.3	3.14	4.42	1.974	.974	.507	.493	.000	1016.3	.529	.471	.000
2.62	328.4	1595.0	.312	205.2	3.41	4.86	2.137	1.137	.468	.532	.000	1389.4	.486	.514	.000
2.92	389.8	2050.7	.288	216.1	3.65	5.26	2.293	1.293	.436	.564	.000	1817.6	.451	.549	.000
3.21	454.4	2562.3	.268	227.0	3.89	5.64	2.444	1.444	.409	.591	.000	2301.3	.422	.578	.000
3.50	522.1	3130.9	.252	237.9	4.13	6.00	2.589	1.589	.386	.614	.000	2841.5	.397	.603	.000
3.79	593.1	3757.6	.239	248.8	4.35	6.34	2.729	1.729	.366	.634	.000	3439.2	.376	.624	.000
4.08	667.2	4443.6	.227	259.7	4.57	6.66	2.866	1.866	.349	.651	.000	4095.6	.357	.643	.000
4.37	744.5	5190.0	.217	270.6	4.78	6.97	2.999	1.999	.333	.667	.000	4811.8	.341	.659	.000
4.66	825.0	5998.2	.208	281.5	4.99	7.27	3.129	2.129	.320	.680	.000	5589.1	.326	.674	.000
4.96	908.6	6869.5	.200	292.4	5.19	7.56	3.255	2.255	.307	.693	.000	6428.9	.313	.687	.000
5.25	995.4	7805.2	.193	303.3	5.39	7.84	3.380	2.380	.296	.704	.000	7332.4	.301	.699	.000
5.54	1085.4	8806.7	.187	314.2	5.58	8.11	3.502	2.502	.286	.714	.000	8300.9	.291	.709	.000

MAXIMUM NO. ITERATIONS FOR SOLUTION (KKMAX) = 4 OCCURRED 14 TIMES. AVERAGE NUMBER ITERATIONS = 1.1608

Equations solved with two passes: first using the Ponce correction to C1, second using the Fread correction to C1, C2 and C3

PRINT HYD ID=6 CODE=1

OUTFLOW HYDROGRAPH REACH 15.60

RUNOFF VOLUME = .39834 INCHES = 33.3540 ACRE-FEET
PEAK DISCHARGE RATE = 255.20 CFS AT 3.250 HOURS BASIN AREA = 1.5700 SQ. MI.

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****
*S*** SUB-BASIN 15 ****
*
COMPUTE LT TP LCODE=1 UPLAND/LAG TIME TRANSITION METHOD
NK=3 ISLOPE=-1
LENGTH=400 FT SLOPE=0.005 K=0.7
LENGTH=1600 FT SLOPE=0.006 K=2.0
LENGTH=2978 FT SLOPE=0.011 K=3.0
Kn=.033 CR=0.58

Tc AND Tp COMPUTED BY UPLAND/LAG TIME PROCEDURE

SCS UPLAND METHOD FACTORS

	LENGTH (FT)	SLOPE (FT/FT)	COMPOSITE K
SHEET FLOW PORTION	400.0	.005000	.7000
SHALLOW FLOW PORTION	1600.0	.006000	2.0000
CHANNEL FLOW PORTION	2978.0	.011000	3.0000
TOTAL BASIN	4978.0	.008911	1.8919

LAG EQUATION FACTORS: Kn= .0330 TOTAL BASIN LENGTH (FT)= 4978.0
TOTAL BASIN SLOPE (FT/FT)= .008911 CENTROUD LENGTH (FT)= 2887.2

TIME OF CONCENTRATION (HRS)= .6525 TIME TO PEAK (HRS)= .4350 LAG TIME (HRS)= .4894

COMPUTE NM HYD ID=1 HYD NO=15 DA= 0.301 SQ MI
PER A=99 PER B=1 PER C=0 PER D=0
TP=0.0 MASSRAIN=-1
TIME TO PEAK (hrs)= .4350

K = .461282HR TP = .435001HR K/TP RATIO = 1.060418 SHAPE CONSTANT, N = 3.329977
UNIT PEAK = 212.92 CFS UNIT VOLUME = .9999 B = 307.70 P60 = 1.6900
AREA = .301000 SQ MI IA = .64850 INCHES INF = 1.66580 INCHES PER HOUR
RUNOFF COMPUTED BY INITIAL ABSTRACTION/INFILTRATION NUMBER METHOD - DT = .050000

BULKING FACTOR APPLIED TO HYDROGRAPH. FACTOR = 1.05000 AT PEAK FLOW.

PRINT HYD ID=1 CODE=1

OUTFLOW HYDROGRAPH REACH 15.00

RUNOFF VOLUME = .40783 INCHES = 6.5470 ACRE-FEET
PEAK DISCHARGE RATE = 86.15 CFS AT 1.800 HOURS BASIN AREA = .3010 SQ. MI.

*S
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* ADD 15 TO 15.6 TO GET 15.9
ADD HYD ID=9 HYD NO=15.9 ID I=1 ID II=6
PRINT HYD ID=9 CODE=1

OUTFLOW HYDROGRAPH REACH 15.90

RUNOFF VOLUME = .39986 INCHES = 39.9009 ACRE-FEET
PEAK DISCHARGE RATE = 267.87 CFS AT 2.450 HOURS BASIN AREA = 1.8710 SQ. MI.

*
****
*S*** SUB-BASIN 16 ****
*
COMPUTE LT TP LCODE=1 UPLAND/LAG TIME TRANSITION METHOD
NK=3 ISLOPE=-1
LENGTH=400 FT SLOPE=0.014 K=0.7
LENGTH=1600 FT SLOPE=0.022 K=2.0
LENGTH=8058 FT SLOPE=0.025 K=3.0
Kn=.033 CR=0.52

Tc AND Tp COMPUTED BY UPLAND/LAG TIME PROCEDURE

SCS UPLAND METHOD FACTORS

	LENGTH (FT)	SLOPE (FT/FT)	COMPOSITE K
SHEET FLOW PORTION	400.0	.014000	.7000
SHALLOW FLOW PORTION	1600.0	.022000	2.0000
CHANNEL FLOW PORTION	8058.0	.025000	3.0000

TOTAL BASIN 10058.0 .024085 2.3817

LAG EQUATION FACTORS: Kn= .0330 TOTAL BASIN LENGTH (FT)= 10058.0
TOTAL BASIN SLOPE (FT/FT)= .024085 CENTROUD LENGTH (FT)= 5230.2

TIME OF CONCENTRATION (HRS)= .6125 TIME TO PEAK (HRS)= .4084 LAG TIME (HRS)= .4594

```
COMPUTE NM HYD      ID=1   HYD NO=16   DA= 0.533 SQ MI
                    PER A=99 PER B=1  PER C=0  PER D=0
                    TP=0.0   MASSRAIN=-1
```

TIME TO PEAK (hrs)= .4084

K = .429106HR TP = .408353HR K/TP RATIO = 1.050822 SHAPE CONSTANT, N = 3.359877
UNIT PEAK = 404.57 CFS UNIT VOLUME = 1.000 B = 309.96 P60 = 1.6900
AREA = .533000 SQ MI IA = .64850 INCHES INF = 1.66580 INCHES PER HOUR
RUNOFF COMPUTED BY INITIAL ABSTRACTION/INFILTRATION NUMBER METHOD - DT = .050000

BULKING FACTOR APPLIED TO HYDROGRAPH. FACTOR = 1.05000 AT PEAK FLOW.

```
PRINT HYD           ID=1   CODE=1
```

OUTFLOW HYDROGRAPH REACH 16.00

RUNOFF VOLUME = .40783 INCHES = 11.5932 ACRE-FEET
PEAK DISCHARGE RATE = 163.09 CFS AT 1.800 HOURS BASIN AREA = .5330 SQ. MI.

```
*S
**************************************************************************
*S ROUTE 16 THRU 17 IN NATURAL ARROYO TO 17.7
COMPUTE RATING CURVE  CID=1   VS NO=1   NO SEGS=1
                      MIN ELEV=5849.92   MAX ELEV=5857.33
                      CH SLOPE=0.009    FP SLOPE=0.009
                      N=0.035           DIST=800.0
                      DIST  ELEV    DIST  ELEV
                        0   5854.05   148 5856.03
                                  199     5857.22 274     5854.0
                                  400     5849.92 484     5852.0
                                  575     5856.0  800     5857.33
```

RATING CURVE VALLEY SECTION 1.0

WATER SURFACE ELEV	FLOW AREA SQ FT	FLOW RATE CFS	TOP WIDTH FT
5849.92	.00	.00	.00
5850.31	5.42	7.35	27.80
5850.70	21.69	46.64	55.61
5851.09	48.81	137.51	83.41
5851.48	86.78	296.16	111.21
5851.87	135.59	536.97	139.02
5852.26	194.65	885.02	162.22
5852.65	262.02	1339.54	183.14
5853.04	337.55	1900.98	204.07
5853.43	421.24	2576.56	224.99
5853.82	513.10	3373.44	245.92
5854.21	613.93	4198.94	277.32
5854.60	731.32	5062.27	324.44
5854.99	867.08	6142.46	371.56
5855.38	1021.24	7451.03	418.69
5855.77	1193.77	9001.84	465.81
5856.16	1386.34	10565.12	532.45
5856.55	1611.98	12217.50	624.25
5856.94	1873.42	14324.03	716.04
5857.33	2170.27	16999.43	800.00

```
ROUTE MCUNGE        ID=6   HYD NO=17.6  INFLOW ID=1
                    DT=0.0   L=3385 FT   NS=0   SLOPE=0.009
                    MATCODE=0 REGCODE=0 CCODE=0 MM CODE=0
```

INFLOW END= 273 TABLE PTS= 20
DT= .050000 QMED= 81.54 CKMED= 3.3511
WIDTH MED= 66.28 NREACH= 11 DX= 307.73

DEPTH (FT)	AREA (SQ FT)	Q (CFS)	TRAVEL TIME(HR)	WIDTH (FT)	ck (FPS)	VEL (FPS)	C	D	C1	C2	C3	Q-M (CFS)	C1-M	C2-M	C3-M
.00	.0	.0	.951	.0	1.71	.62	1.000	.000	1.000	.000	.000	.0	1.000	.000	.000
.39	5.4	7.3	.694	27.8	1.89	1.35	1.105	.051	.953	.072	-.025	1.2	.993	.011	-.004
.78	21.7	46.6	.437	55.6	2.99	2.15	1.749	.101	.929	.298	-.227	21.9	.934	.184	-.118
1.17	48.8	137.5	.334	83.4	3.84	2.82	2.245	.155	.909	.412	-.321	85.8	.912	.349	-.261
1.56	86.8	296.2	.276	111.2	4.61	3.41	2.697	.209	.893	.488	-.381	209.7	.896	.447	-.343
1.95	135.6	537.0	.237	139.0	5.42	3.96	3.169	.257	.884	.548	-.432	408.7	.883		

```
.514  -.397
        2.34  194.6    885.0    .207  162.2     6.35   4.55    3.714   .310   .876   .602  -.478    702.1    .880
.578  -.458
        2.73  262.0   1339.5    .184  183.1     7.12   5.11    4.166   .371   .866   .639  -.505   1103.0    .870
.621  -.492
        3.12  337.5   1901.0    .167  204.1     7.78   5.63    4.550   .432   .855   .666  -.521   1610.9    .859
.652  -.511
        3.51  421.2   2576.6    .154  225.0     8.40   6.12    4.911   .492   .846   .688  -.534   2229.2    .849
.676  -.526
        3.90  513.1   3373.4    .143  245.9     8.51   6.57    4.981   .582   .823   .695  -.518   2965.2    .841
.697  -.538
        4.29  613.9   4198.9    .137  277.3     7.85   6.84    4.589   .697   .778   .682  -.460   3778.5    .797
.686  -.483
        4.68  731.3   5062.3    .136  324.4     7.68   6.92    4.490   .734   .764   .679  -.443   4623.8    .750
.669  -.419
        5.07  867.1   6142.5    .133  371.6     8.24   7.08    4.820   .724   .779   .694  -.473   5593.7    .771
.686  -.457
        5.46 1021.2   7451.0    .129  418.7     8.75   7.30    5.121   .734   .786   .708  -.494   6786.3    .781
.701  -.482
        5.85 1193.8   9001.8    .125  465.8     8.62   7.54    5.040   .810   .764   .708  -.472   8214.5    .787
.714  -.501
        6.24 1386.3  10565.1    .123  532.4     7.77   7.62    4.545   .922   .715   .691  -.406   9774.0    .731
.696  -.427
        6.63 1612.0  12217.5    .124  624.2     7.72   7.58    4.514   .916   .715   .689  -.404  11382.0    .689
.680  -.368
        7.02 1873.4  14324.0    .123  716.0     8.55   7.65    4.999   .845   .753   .708  -.461  13257.9    .731
.697  -.427
        7.41 2170.3  16999.4    .120  800.0     8.83   7.83    5.166   .869   .753   .716  -.469  15643.7    .768
.719  -.487
     MAXIMUM NO. ITERATIONS FOR SOLUTION (KKMAX) =   4 OCCURRED      21 TIMES.  AVERAGE NUMBER ITERATIONS =  1.1314
       DEPTH    AREA      Q    TRAVEL  WIDTH     ck      VEL       C       D      C1     C2     C3     Q-M      C1-M
C2-M   C3-M
        (FT)  (SQ FT)  (CFS)  TIME(HR) (FT)     (FPS)   (FPS)                                          (CFS)
         .00     .0       .0    .951     .0     1.71    .62    1.000   .000  1.000   .000   .000       .0   1.000
.000   .000
         .39    5.4      7.3    .694   27.8     1.80   1.35    1.053   .053   .950   .050   .000      1.2    .983
.017   .000
         .78   21.7     46.6    .437   55.6     1.97   2.15    1.154   .154   .867   .133   .000     21.9    .908
.092   .000
        1.17   48.8    137.5    .334   83.4     2.18   2.82    1.273   .273   .785   .215   .000     85.8    .823
.177   .000
        1.56   86.8    296.2    .276  111.2     2.40   3.41    1.401   .401   .714   .286   .000    209.7    .746
.254   .000
        1.95  135.6    537.0    .237  139.0     2.62   3.96    1.532   .532   .653   .347   .000    408.7    .681
.319   .000
        2.34  194.6    885.0    .207  162.2     2.88   4.55    1.684   .684   .594   .406   .000    702.1    .621
.379   .000
        2.73  262.0   1339.5    .184  183.1     3.15   5.11    1.840   .840   .544   .456   .000   1103.0    .567
.433   .000
        3.12  337.5   1901.0    .167  204.1     3.40   5.63    1.989   .989   .503   .497   .000   1610.9    .522
.478   .000
        3.51  421.2   2576.6    .154  225.0     3.65   6.12    2.134  1.134   .469   .531   .000   2229.2    .485
.515   .000
        3.90  513.1   3373.4    .143  245.9     3.89   6.57    2.274  1.274   .440   .560   .000   2965.2    .453
.547   .000
        4.29  613.9   4198.9    .137  277.3     4.03   6.84    2.357  1.357   .424   .576   .000   3778.5    .432
.568   .000
        4.68  731.3   5062.3    .136  324.4     4.07   6.92    2.383  1.383   .420   .580   .000   4623.8    .422
.578   .000
        5.07  867.1   6142.5    .133  371.6     4.16   7.08    2.434  1.434   .411   .589   .000   5593.7    .415
.585   .000
        5.46 1021.2   7451.0    .129  418.7     4.28   7.30    2.502  1.502   .400   .600   .000   6786.3    .405
.595   .000
        5.85 1193.8   9001.8    .125  465.8     4.41   7.54    2.581  1.581   .387   .613   .000   8214.5    .393
.607   .000
        6.24 1386.3  10565.1    .123  532.4     4.46   7.62    2.607  1.607   .384   .616   .000   9774.0    .385
.615   .000
        6.63 1612.0  12217.5    .124  624.2     4.43   7.58    2.594  1.594   .386   .614   .000  11382.0    .385
.615   .000
        7.02 1873.4  14324.0    .123  716.0     4.47   7.65    2.615  1.615   .382   .618   .000  13257.9    .384
.616   .000
        7.41 2170.3  16999.4    .120  800.0     4.58   7.83    2.677  1.677   .374   .626   .000  15643.7    .378
.622   .000
     MAXIMUM NO. ITERATIONS FOR SOLUTION (KKMAX) =   3 OCCURRED      59 TIMES.  AVERAGE NUMBER ITERATIONS =  1.1125
     Equations solved with two passes: first using the Ponce correction to C1, second using the Fread correction to C1,
C2 and C3
     PRINT HYD           ID=6   CODE=1

                                          OUTFLOW HYDROGRAPH REACH    17.60

        RUNOFF VOLUME =      .40391 INCHES     =      11.4818 ACRE-FEET
        PEAK DISCHARGE RATE =     158.07 CFS  AT   2.200 HOURS   BASIN AREA =   .5330 SQ. MI.


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     **********************************************************************
     *S*** SUB-BASIN 17 ****
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COMPUTE LT TP       LCODE=1  UPLAND/LAG TIME TRANSITION METHOD
                    NK=3  ISLOPE=-1
                    LENGTH=400 FT   SLOPE=0.012 K=0.7
                    LENGTH=1600 FT  SLOPE=0.008 K=2.0
                    LENGTH=5130 FT  SLOPE=0.008 K=3.0
                    Kn=.033  CR=0.59

     Tc AND Tp COMPUTED BY UPLAND/LAG TIME PROCEDURE

     SCS UPLAND METHOD FACTORS
                              LENGTH (FT)      SLOPE (FT/FT)       COMPOSITE K
     SHEET FLOW PORTION           400.0           .012000             .7000
     SHALLOW FLOW PORTION        1600.0           .008000            2.0000
     CHANNEL FLOW PORTION        5130.0           .008000            3.0000
     TOTAL BASIN                 7130.0           .008224            2.3625


     LAG EQUATION FACTORS:     Kn=   .0330     TOTAL BASIN LENGTH (FT)=      7130.0
     TOTAL BASIN SLOPE (FT/FT)=    .008224     CENTROUD LENGTH (FT)=         4206.7


     TIME OF CONCENTRATION (HRS)=   .6627     TIME TO PEAK (HRS)=   .4418     LAG TIME (HRS)=   .4970

COMPUTE NM HYD      ID=2   HYD NO=17   DA= 0.268 SQ MI
                    PER A=99 PER B=1  PER C=0  PER D=0
                    TP=0.0   MASSRAIN=-1
     TIME TO PEAK (hrs)=   .4418

     K =   .480672HR    TP =   .441813HR    K/TP RATIO =  1.087953     SHAPE CONSTANT, N =  3.247832
     UNIT PEAK =   182.85    CFS   UNIT VOLUME =    .9999       B =   301.44      P60 = 1.6900
     AREA =      .268000 SQ MI    IA =    .64850 INCHES    INF =   1.66580 INCHES PER HOUR
     RUNOFF COMPUTED BY INITIAL ABSTRACTION/INFILTRATION NUMBER METHOD - DT =   .050000

    BULKING FACTOR APPLIED TO HYDROGRAPH.  FACTOR =  1.05000 AT PEAK FLOW.

PRINT HYD           ID=2   CODE=1

                                        OUTFLOW HYDROGRAPH REACH    17.00


    RUNOFF VOLUME =      .40783 INCHES     =       5.8292 ACRE-FEET
    PEAK DISCHARGE RATE =      73.97 CFS  AT   1.800 HOURS   BASIN AREA =   .2680 SQ. MI.



*S
**************************************************************************
*S ADD 17.6 TO 17 TO GET 17.7
ADD HYD             ID=7   HYD NO=17.7 ID I=6 ID II=2
PRINT HYD           ID=7   CODE=1

                                        OUTFLOW HYDROGRAPH REACH    17.70


    RUNOFF VOLUME =      .40522 INCHES     =      17.3110 ACRE-FEET
    PEAK DISCHARGE RATE =     201.29 CFS  AT   2.200 HOURS   BASIN AREA =   .8010 SQ. MI.



*
**************************************************************************
*S ADD 17.7 TO 15.9 TO GET 17.4
ADD HYD             ID=4   HYD NO=17.4 ID I=7 ID II=9
PRINT HYD           ID=4   CODE=5

                                        OUTFLOW HYDROGRAPH REACH    17.40

      TIME      FLOW          TIME      FLOW          TIME      FLOW          TIME      FLOW          TIME
FLOW
       HRS       CFS           HRS       CFS           HRS       CFS           HRS       CFS           HRS
CFS
      .000        .0         3.250     290.9         6.500      11.6         9.750       1.0        13.000
  .1
      .250        .0         3.500     221.5         6.750       9.6        10.000        .8        13.250
  .1
      .500        .0         3.750     155.5         7.000       8.0        10.250        .7        13.500
  .1
      .750        .0         4.000     108.8         7.250       6.7        10.500        .5        13.750
  .0
     1.000        .0         4.250      76.3         7.500       5.5        10.750        .4        14.000
  .0
     1.250        .0         4.500      55.5         7.750       4.5        11.000        .4        14.250
  .0
     1.500       51.6        4.750      42.4         8.000       3.7        11.250        .3        14.500
  .0
     1.750      156.6        5.000      34.8         8.250       3.1        11.500        .2        14.750
  .0
     2.000      216.0        5.250      28.9         8.500       2.5        11.750        .2        15.000
  .0
     2.250      292.9        5.500      24.1         8.750       2.1        12.000        .2        15.250
  .0
```

```
        2.500     401.1          5.750      20.0          9.000       1.7         12.250        .1         15.500
.0
        2.750     272.8          6.000      16.7          9.250       1.4         12.500        .1         15.750
.0
        3.000     204.0          6.250      13.9          9.500       1.2         12.750        .1

       RUNOFF VOLUME =      .40147 INCHES     =      57.2119 ACRE-FEET
       PEAK DISCHARGE RATE =     421.35 CFS  AT   2.400 HOURS   BASIN AREA =  2.6720 SQ. MI.


    *S
    ***********************************************************************
    *S ROUTE 17.4 THRU 20 IN NATURAL ARROYO TO 28.6
    COMPUTE RATING CURVE  CID=1   VS NO=1   NO SEGS=1
                          MIN ELEV=5812.0   MAX ELEV=5825.39
                          CH SLOPE=0.0116    FP SLOPE=0.0116
                          N=0.035           DIST=800.0
                          DIST  ELEV    DIST  ELEV
                            0   5829.74   160 5824.0
                                      289     5816.16 374     5812.0
                                      499     5813.98 662     5819.96
                                      800     5825.39


                                     RATING CURVE VALLEY SECTION  1.0
                                        WATER       FLOW        FLOW        TOP
                                       SURFACE      AREA        RATE        WIDTH
                                        ELEV        SQ FT       CFS         FT
                                      5812.00         .00         .00         .00
                                      5812.70       20.74       47.30       58.88
                                      5813.41       82.97      300.34      117.76
                                      5814.11      186.36      899.32      171.84
                                      5814.82      319.27     1958.20      205.44
                                      5815.52      475.86     3442.24      239.04
                                      5816.23      656.11     5389.29      272.37
                                      5816.93      858.87     7859.91      303.17
                                      5817.64     1083.33    10850.46      333.97
                                      5818.34     1329.50    14391.48      364.77
                                      5819.05     1597.36    18513.44      395.57
                                      5819.75     1886.92    23246.49      426.37
                                      5820.46     2197.96    28653.54      456.25
                                      5821.16     2529.82    34738.90      485.75
                                      5821.86     2882.47    41514.38      515.25
                                      5822.57     3255.91    49006.30      544.75
                                      5823.27     3650.13    57240.66      574.25
                                      5823.98     4065.13    66243.14      603.75
                                      5824.68     4503.58    75496.88      641.05
                                      5825.39     4968.48    85617.45      678.59
    ROUTE MCUNGE        ID=3   HYD NO=20.3  INFLOW ID=4
                        DT=0.0   L=2323 FT   NS=0   SLOPE=0.0116
                        MATCODE=0 REGCODE=0 CCODE=0 MM CODE=0

        INFLOW END= 316            TABLE PTS= 20
        DT=  .050000               QMED=      210.67  CKMED=      4.0664
        WIDTH MED=       96.89     NREACH=  6         DX=      387.17

      DEPTH   AREA      Q    TRAVEL  WIDTH     ck      VEL      C       D      C1     C2     C3     Q-M      C1-M
C2-M  C3-M
       (FT)  (SQ FT)  (CFS)  TIME(HR) (FT)     (FPS)   (FPS)                                          (CFS)
         .00     .0       .0    .388     .0     2.15   1.05    1.000   .000  1.000   .000   .000       .0   1.000
.000   .000
         .70   20.7     47.3    .283   58.9     3.18   2.28    1.478   .056   .956   .211  -.167      7.4    .993
.033  -.026
        1.41   83.0    300.3    .178  117.8     5.09   3.62    2.368   .111   .936   .425  -.361    141.0    .938
.316  -.254
        2.11  186.4    899.3    .134  171.8     6.86   4.83    3.188   .170   .922   .541  -.463    558.9    .923
.481  -.404
        2.82  319.3   1958.2    .105  205.4     8.83   6.13    4.104   .240   .910   .626  -.536   1384.8    .916
.592  -.508
        3.52  475.9   3442.2    .089  239.0    10.21   7.23    4.748   .314   .896   .670  -.567   2656.9    .901
.648  -.549
        4.23  656.1   5389.3    .079  272.4    11.52   8.21    5.357   .382   .887   .703  -.590   4372.0    .889
.686  -.575
        4.93  858.9   7859.9    .071  303.2    12.80   9.15    5.953   .451   .878   .730  -.608   6579.4    .882
.717  -.599
        5.64 1083.3  10850.5    .064  334.0    13.90  10.02    6.461   .521   .870   .749  -.619   9309.6    .873
.739  -.612
        6.34 1329.5  14391.5    .060  364.8    14.92  10.82    6.938   .589   .862   .765  -.627  12574.8    .865
.757  -.622
        7.05 1597.4  18513.4    .056  395.6    15.90  11.59    7.392   .655   .855   .779  -.634  16405.5    .858
.772  -.630
        7.75 1886.9  23246.5    .052  426.4    16.88  12.32    7.850   .719   .850   .791  -.641  20832.2    .851
.785  -.636
        8.46 2198.0  28653.5    .049  456.3    17.88  13.04    8.315   .782   .845   .802  -.647  25900.5    .847
.797  -.644
        9.16 2529.8  34738.9    .047  485.8    18.80  13.73    8.740   .847   .840   .811  -.651  31645.6    .842
.807  -.649
        9.86 2882.5  41514.4    .045  515.3    19.66  14.40    9.140   .913   .835   .819  -.654  38075.2    .837
.815  -.652
       10.57 3255.9  49006.3    .043  544.8    20.50  15.05    9.529   .977   .830   .826  -.656  45208.0    .832
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.823  -.654
      11.27 3650.1  57240.7    .041  574.3    21.31  15.68    9.907  1.042   .826   .833  -.658  53070.3    .827
.829  -.657
      11.98 4065.1  66243.1    .040  603.8    21.51  16.30    9.999  1.136   .813   .835  -.648  61687.8    .823
.835  -.659
      12.68 4503.6  75496.9    .038  641.0    21.45  16.76    9.975  1.222   .800   .836  -.636  70823.6    .800
.833  -.633
      13.39 4968.5  85617.5    .037  678.6    21.60  17.23   10.041  1.301   .789   .838  -.627  80508.6    .798
.838  -.636
    MAXIMUM NO. ITERATIONS FOR SOLUTION (KKMAX) =   4 OCCURRED       3 TIMES.  AVERAGE NUMBER ITERATIONS =  1.2752
      DEPTH   AREA      Q    TRAVEL  WIDTH     ck       VEL      C       D      C1     C2     C3     Q-M      C1-M
C2-M   C3-M
       (FT)  (SQ FT)  (CFS)  TIME(HR) (FT)     (FPS)   (FPS)                                          (CFS)
        .00     .0       .0    .388     .0     2.15   1.05    1.000   .000  1.000   .000   .000       .0   1.000
.000   .000
        .70   20.7     47.3    .283    58.9     2.32   2.28    1.077   .077   .928   .072   .000      7.4    .975
.025   .000
       1.41   83.0    300.3    .178   117.8     2.62   3.62    1.217   .217   .822   .178   .000    141.0    .874
.126   .000
       2.11  186.4    899.3    .134   171.8     2.99   4.83    1.390   .390   .720   .280   .000    558.9    .766
.234   .000
       2.82  319.3   1958.2    .105   205.4     3.47   6.13    1.612   .612   .620   .380   .000   1384.8    .664
.336   .000
       3.52  475.9   3442.2    .089   239.0     3.91   7.23    1.819   .819   .550   .450   .000   2656.9    .582
.418   .000
       4.23  656.1   5389.3    .079   272.4     4.34   8.21    2.016  1.016   .496   .504   .000   4372.0    .520
.480   .000
       4.93  858.9   7859.9    .071   303.2     4.76   9.15    2.213  1.213   .452   .548   .000   6579.4    .472
.528   .000
       5.64 1083.3  10850.5    .064   334.0     5.16  10.02    2.401  1.401   .417   .583   .000   9309.6    .433
.567   .000
       6.34 1329.5  14391.5    .060   364.8     5.55  10.82    2.582  1.582   .387   .613   .000  12574.8    .401
.599   .000
       7.05 1597.4  18513.4    .056   395.6     5.93  11.59    2.757  1.757   .363   .637   .000  16405.5    .374
.626   .000
       7.75 1886.9  23246.5    .052   426.4     6.30  12.32    2.928  1.928   .342   .658   .000  20832.2    .352
.648   .000
       8.46 2198.0  28653.5    .049   456.3     6.66  13.04    3.098  2.098   .323   .677   .000  25900.5    .332
.668   .000
       9.16 2529.8  34738.9    .047   485.8     7.03  13.73    3.266  2.266   .306   .694   .000  31645.6    .314
.686   .000
       9.86 2882.5  41514.4    .045   515.3     7.38  14.40    3.431  2.431   .291   .709   .000  38075.2    .298
.702   .000
      10.57 3255.9  49006.3    .043   544.8     7.73  15.05    3.592  2.592   .278   .722   .000  45208.0    .285
.715   .000
      11.27 3650.1  57240.7    .041   574.3     8.07  15.68    3.751  2.751   .267   .733   .000  53070.3    .272
.728   .000
      11.98 4065.1  66243.1    .040   603.8     8.40  16.30    3.907  2.907   .256   .744   .000  61687.8    .261
.739   .000
      12.68 4503.6  75496.9    .038   641.0     8.66  16.76    4.027  3.027   .248   .752   .000  70823.6    .252
.748   .000
      13.39 4968.5  85617.5    .037   678.6     8.92  17.23    4.148  3.148   .241   .759   .000  80508.6    .245
.755   .000
    MAXIMUM NO. ITERATIONS FOR SOLUTION (KKMAX) =   3 OCCURRED      35 TIMES.  AVERAGE NUMBER ITERATIONS =  1.2039
    Equations solved with two passes: first using the Ponce correction to C1, second using the Fread correction to C1,
C2 and C3
    PRINT HYD           ID=3   CODE=1

                                        OUTFLOW HYDROGRAPH REACH    20.30


       RUNOFF VOLUME =      .40093 INCHES     =      57.1349 ACRE-FEET
       PEAK DISCHARGE RATE =     413.90 CFS  AT   2.650 HOURS   BASIN AREA =  2.6720 SQ. MI.



    *

    **********************************************************************
    *S*** SUB-BASIN 21 ****
    *
    COMPUTE LT TP       LCODE=1  UPLAND/LAG TIME TRANSITION METHOD
                        NK=3  ISLOPE=-1
                        LENGTH=400 FT   SLOPE=0.018 K=0.7
                        LENGTH=1600 FT  SLOPE=0.033 K=2.0
                        LENGTH=3667 FT   SLOPE=0.027 K=3.0
                        Kn=.033  CR=0.50

        Tc AND Tp COMPUTED BY UPLAND/LAG TIME PROCEDURE

        SCS UPLAND METHOD FACTORS
                                  LENGTH (FT)      SLOPE (FT/FT)       COMPOSITE K
        SHEET FLOW PORTION           400.0            .018000             .7000
        SHALLOW FLOW PORTION        1600.0            .033000            2.0000
        CHANNEL FLOW PORTION        3667.0            .027000            3.0000
        TOTAL BASIN                 5667.0            .028059            2.1011


        LAG EQUATION FACTORS:     Kn=   .0330     TOTAL BASIN LENGTH (FT)=      5667.0
        TOTAL BASIN SLOPE (FT/FT)=    .028059     CENTROUD LENGTH (FT)=         2833.5
```

```
     TIME OF CONCENTRATION (HRS)=   .3928     TIME TO PEAK (HRS)=   .2619     LAG TIME (HRS)=   .2946

COMPUTE NM HYD      ID=1   HYD NO=21   DA= 0.145 SQ MI
                    PER A=99 PER B=1  PER C=0  PER D=0
                    TP=0.0   MASSRAIN=-1
     TIME TO PEAK (hrs)=   .2619

     K =   .311803HR    TP =   .261891HR    K/TP RATIO =  1.190584     SHAPE CONSTANT, N =  2.982728
     UNIT PEAK =   155.25    CFS   UNIT VOLUME =    .9999       B =   280.41      P60 = 1.6900
     AREA =      .145000 SQ MI    IA =    .64850 INCHES    INF =   1.66580 INCHES PER HOUR
     RUNOFF COMPUTED BY INITIAL ABSTRACTION/INFILTRATION NUMBER METHOD - DT =   .050000

    BULKING FACTOR APPLIED TO HYDROGRAPH.  FACTOR =  1.05000 AT PEAK FLOW.

PRINT HYD           ID=1   CODE=1

                                      OUTFLOW HYDROGRAPH REACH    21.00


    RUNOFF VOLUME =      .40783 INCHES     =       3.1539 ACRE-FEET
    PEAK DISCHARGE RATE =      61.99 CFS  AT   1.650 HOURS   BASIN AREA =   .1450 SQ. MI.



*S
**********************************************************************
*S ROUTE 21 THRU 22 IN NATURAL ARROYO TO 22.8
COMPUTE RATING CURVE  CID=1   VS NO=1   NO SEGS=1
                      MIN ELEV=5875.66   MAX ELEV=5883.82
                      CH SLOPE=0.007    FP SLOPE=0.007
                      N=0.035           DIST=1200.0
                      DIST  ELEV    DIST  ELEV
                        0   5881.59   264 5875.89
                                  459     5876.12 598     5875.66
                                  879     5878.0  1045    5882.96
                                  1200    5883.82


                                    RATING CURVE VALLEY SECTION  1.0
                                       WATER       FLOW        FLOW        TOP
                                     SURFACE       AREA        RATE        WIDTH
                                       ELEV        SQ FT       CFS         FT
                                    5875.66          .00         .00         .00
                                    5876.09        56.82       58.94      360.04
                                    5876.52       241.31      552.48      466.36
                                    5876.95       457.07     1456.60      537.86
                                    5877.38       703.54     2750.33      609.37
                                    5877.81       980.74     4443.25      680.87
                                    5878.24      1286.21     6654.26      731.74
                                    5878.67      1607.99     9363.99      766.02
                                    5879.10      1944.50    12483.15      800.30
                                    5879.53      2295.75    16009.20      834.59
                                    5879.96      2661.73    19942.36      868.87
                                    5880.39      3042.43    24284.69      903.15
                                    5880.82      3437.87    29039.64      937.44
                                    5881.25      3848.04    34211.59      971.72
                                    5881.68      4272.77    39908.34     1002.02
                                    5882.11      4706.42    46441.32     1016.40
                                    5882.54      5146.24    53395.18     1030.78
                                    5882.96      5592.25    60736.71     1045.88
                                    5883.39      6058.29    66177.15     1123.34
                                    5883.82      6557.61    72264.00     1200.00
ROUTE MCUNGE        ID=5   HYD NO=22.5  INFLOW ID=1
                    DT=0.0   L=7312 FT   NS=0   SLOPE=0.007
                    MATCODE=0 REGCODE=0 CCODE=0 MM CODE=0

     INFLOW END= 188           TABLE PTS= 20
     DT=  .050000              QMED=       31.00  CKMED=      1.0373
     WIDTH MED=      189.36    NREACH= 50         DX=      146.24

      DEPTH   AREA      Q    TRAVEL  WIDTH     ck      VEL      C       D      C1     C2     C3     Q-M      C1-M
C2-M   C3-M
       (FT)  (SQ FT)  (CFS)  TIME(HR) (FT)     (FPS)   (FPS)                                          (CFS)
        .00     .0       .0   3.029     .0      .81     .30    1.000   .000  1.000   .000   .000       .0   1.000
.000   .000
        .43   56.8     58.9   1.958  360.0     1.38    1.04    1.694   .116   .917   .288  -.205      9.3    .987
.045  -.032
        .86  241.3    552.5    .887  466.4     3.60    2.29    4.434   .321   .888   .652  -.541    248.2    .909
.568  -.477
       1.29  457.1   1456.6    .637  537.9     4.80    3.19    5.904   .552   .852   .732  -.584    958.0    .865
.697  -.562
       1.72  703.5   2750.3    .520  609.4     5.73    3.91    7.054   .769   .826   .773  -.599   2060.3    .835
.754  -.589
       2.15  980.7   4443.2    .448  680.9     6.66    4.53    8.203   .957   .812   .803  -.615   3555.3    .812
.787  -.599
       2.58 1286.2   6654.3    .393  731.7     7.83    5.17    9.634  1.135   .807   .830  -.637   5504.3    .810
.818  -.628
       3.01 1608.0   9364.0    .349  766.0     8.87    5.82   10.918  1.346   .797   .849  -.646   7964.1    .804
.841  -.645
       3.44 1944.5  12483.2    .316  800.3     9.68    6.42   11.909  1.575   .783   .862  -.644  10880.6    .789
```

```
.856  -.645
      3.87 2295.8  16009.2    .291  834.6    10.41   6.97   12.815  1.800   .769   .872  -.641  14204.7    .775
.867  -.642
      4.30 2661.7  19942.4    .271  868.9    11.09   7.49   13.654  2.021   .758   .880  -.638  17935.5    .763
.876  -.639
      4.73 3042.4  24284.7    .254  903.2    11.73   7.98   14.438  2.239   .747   .887  -.634  22074.2    .751
.884  -.635
      5.16 3437.9  29039.6    .240  937.4    12.33   8.45   15.177  2.454   .737   .893  -.629  26623.6    .741
.890  -.631
      5.59 3848.0  34211.6    .228  971.7    13.01   8.89   16.017  2.643   .731   .898  -.629  31587.6    .731
.895  -.626
      6.02 4272.8  39908.3    .217 1002.0    14.17   9.34   17.444  2.745   .741   .906  -.646  37020.4    .731
.901  -.632
      6.45 4706.4  46441.3    .206 1016.4    15.45   9.87   19.013  2.890   .748   .913  -.660  43127.9    .752
.910  -.662
      6.88 5146.2  53395.2    .196 1030.8    16.15  10.38   19.873  3.134   .739   .917  -.656  49872.6    .743
.915  -.658
      7.30 5592.2  60736.7    .187 1045.9    14.36  10.86   17.670  3.952   .651   .912  -.562  57021.9    .734
.918  -.652
      7.73 6058.3  66177.1    .186 1123.3    11.94  10.92   14.702  4.818   .530   .903  -.433  63442.7    .516
.901  -.418
      8.16 6557.6  72264.0    .184 1200.0    11.96  11.02   14.721  4.919   .523   .903  -.426  69203.7    .540
.904  -.444
     MAXIMUM NO. ITERATIONS FOR SOLUTION (KKMAX) =   4 OCCURRED      97 TIMES.  AVERAGE NUMBER ITERATIONS =  1.0677
     Equations solved using the Ponce correction to C2
     PRINT HYD           ID=5   CODE=1

                                        OUTFLOW HYDROGRAPH REACH    22.50


         RUNOFF VOLUME =      .38331 INCHES     =       2.9643 ACRE-FEET
         PEAK DISCHARGE RATE =      61.54 CFS  AT   3.550 HOURS   BASIN AREA =   .1450 SQ. MI.



     *

     **********************************************************************

     *S*** SUB-BASIN 22 ****
     *
     COMPUTE LT TP       LCODE=1  USDI BUREAU OF RECLAMATION LAG TIME EQUATION
                         NK=3  ISLOPE=-1
                         LENGTH=400 FT   SLOPE=0.015 K=0.7
                         LENGTH=1600 FT  SLOPE=0.018 K=2.0
                         LENGTH=12166 FT  SLOPE=0.017 K=3.0
                         Kn=.033  CR=.5

          Tc AND Tp COMPUTED BY UPLAND/LAG TIME PROCEDURE


          LAG EQUATION FACTORS:     Kn=   .0330     TOTAL BASIN LENGTH (FT)=     14166.0
          TOTAL BASIN SLOPE (FT/FT)=    .017056     CENTROUD LENGTH (FT)=         7083.0


          TIME OF CONCENTRATION (HRS)=   .8308     TIME TO PEAK (HRS)=   .5538     LAG TIME (HRS)=   .6231

     COMPUTE NM HYD      ID=2   HYD NO=22   DA= 0.739 SQ MI
                         PER A=99 PER B=1  PER C=0  PER D=0
                         TP=0.0   MASSRAIN=-1
          TIME TO PEAK (hrs)=   .5538

          K =   .581986HR    TP =   .553839HR    K/TP RATIO =  1.050822     SHAPE CONSTANT, N =  3.359877
          UNIT PEAK =   413.58    CFS   UNIT VOLUME =    1.000       B =   309.96      P60 = 1.6900
          AREA =      .739000 SQ MI    IA =    .64850 INCHES    INF =   1.66580 INCHES PER HOUR
          RUNOFF COMPUTED BY INITIAL ABSTRACTION/INFILTRATION NUMBER METHOD - DT =   .050000

         BULKING FACTOR APPLIED TO HYDROGRAPH.  FACTOR =  1.05000 AT PEAK FLOW.

     PRINT HYD           ID=2   CODE=1

                                        OUTFLOW HYDROGRAPH REACH    22.00


         RUNOFF VOLUME =      .40783 INCHES     =      16.0738 ACRE-FEET
         PEAK DISCHARGE RATE =     167.46 CFS  AT   1.900 HOURS   BASIN AREA =   .7390 SQ. MI.



     *S
     **********************************************************************
     *S ADD 21 AND 22 TO GET 22.8
     ADD HYD             ID=8   HYD NO=22.8 ID I=5 ID II=2
     PRINT HYD           ID=8   CODE=5

                                        OUTFLOW HYDROGRAPH REACH    22.80

          TIME      FLOW           TIME      FLOW           TIME      FLOW           TIME      FLOW           TIME
FLOW
           HRS       CFS            HRS       CFS            HRS       CFS            HRS       CFS            HRS
CFS
```

.000	.0	3.750	47.9	7.500	2.0	11.250	.2	15.000	.0
.250	.0	4.000	36.0	7.750	1.7	11.500	.2	15.250	.0
.500	.0	4.250	28.3	8.000	1.4	11.750	.1	15.500	.0
.750	.0	4.500	20.5	8.250	1.2	12.000	.1	15.750	.0
1.000	.0	4.750	14.7	8.500	1.0	12.250	.1	16.000	.0
1.250	.0	5.000	11.7	8.750	.9	12.500	.1	16.250	.0
1.500	35.4	5.250	9.7	9.000	.7	12.750	.1	16.500	.0
1.750	144.7	5.500	8.1	9.250	.6	13.000	.1	16.750	.0
2.000	164.5	5.750	6.7	9.500	.5	13.250	.1	17.000	.0
2.250	125.0	6.000	5.6	9.750	.5	13.500	.1	17.250	.0
2.500	81.7	6.250	4.7	10.000	.4	13.750	.0	17.500	.0
2.750	53.2	6.500	3.9	10.250	.3	14.000	.0	17.750	.0
3.000	34.6	6.750	3.3	10.500	.3	14.250	.0		
3.250	22.5	7.000	2.8	10.750	.3	14.500	.0		
3.500	44.8	7.250	2.3	11.000	.2	14.750	.0		

RUNOFF VOLUME = .40381 INCHES = 19.0380 ACRE-FEET
PEAK DISCHARGE RATE = 167.46 CFS AT 1.900 HOURS BASIN AREA = .8840 SQ. MI.

```
*S
*********************************************************************
*S*** SUB-BASIN 24 ****
*
COMPUTE LT TP       LCODE=1  USDI BUREAU OF RECLAMATION LAG TIME EQUATION
                    NK=3  ISLOPE=-1
                    LENGTH=400 FT   SLOPE=0.005 K=0.7
                    LENGTH=1600 FT  SLOPE=0.007 K=2.0
                    LENGTH=1338 FT  SLOPE=0.008 K=3.0
```

Tc AND Tp COMPUTED BY UPLAND/LAG TIME PROCEDURE

SCS UPLAND METHOD FACTORS

	LENGTH (FT)	SLOPE (FT/FT)	COMPOSITE K
SHEET FLOW PORTION	400.0	.005000	.7000
SHALLOW FLOW PORTION	1600.0	.007000	2.0000
CHANNEL FLOW PORTION	1338.0	.008000	3.0000
TOTAL BASIN	3338.0	.007161	1.7431

TIME OF CONCENTRATION (HRS)= .6286 TIME TO PEAK (HRS)= .4191 LAG TIME (HRS)= .4714

```
COMPUTE NM HYD      ID=2   HYD NO=24   DA= 0.117 SQ MI
                    PER A=99 PER B=1  PER C=0  PER D=0
                    TP=0.0   MASSRAIN=-1
```

TIME TO PEAK (hrs)= .4191

K = .508722HR TP = .419064HR K/TP RATIO = 1.213947 SHAPE CONSTANT, N = 2.930092
UNIT PEAK = 77.077 CFS UNIT VOLUME = .9998 B = 276.07 P60 = 1.6900
AREA = .117000 SQ MI IA = .64850 INCHES INF = 1.66580 INCHES PER HOUR
RUNOFF COMPUTED BY INITIAL ABSTRACTION/INFILTRATION NUMBER METHOD - DT = .050000

BULKING FACTOR APPLIED TO HYDROGRAPH. FACTOR = 1.05000 AT PEAK FLOW.

```
PRINT HYD           ID=2   CODE=1
```

OUTFLOW HYDROGRAPH REACH 24.00

RUNOFF VOLUME = .40783 INCHES = 2.5448 ACRE-FEET
PEAK DISCHARGE RATE = 31.21 CFS AT 1.800 HOURS BASIN AREA = .1170 SQ. MI.

```
*S
*********************************************************************
*S ADD 24 AND 22.8 TO GET 24.7
ADD HYD             ID=7   HYD NO=24.7 ID I=2 ID II=8
PRINT HYD           ID=7   CODE=5
```

OUTFLOW HYDROGRAPH REACH 24.70

TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS
.000	.0	3.750	49.9	7.500	2.1	11.250	.2	15.000	

.0
.250 .0 4.000 37.7 7.750 1.8 11.500 .2 15.250
.0
.500 .0 4.250 29.7 8.000 1.5 11.750 .2 15.500
.0
.750 .0 4.500 21.8 8.250 1.3 12.000 .1 15.750
.0
1.000 .0 4.750 15.8 8.500 1.1 12.250 .1 16.000
.0
1.250 .0 5.000 12.6 8.750 .9 12.500 .1 16.250
.0
1.500 48.0 5.250 10.4 9.000 .8 12.750 .1 16.500
.0
1.750 175.7 5.500 8.7 9.250 .7 13.000 .1 16.750
.0
2.000 190.6 5.750 7.2 9.500 .6 13.250 .1 17.000
.0
2.250 141.3 6.000 6.0 9.750 .5 13.500 .1 17.250
.0
2.500 91.7 6.250 5.1 10.000 .4 13.750 .0 17.500
.0
2.750 59.3 6.500 4.2 10.250 .4 14.000 .0 17.750
.0
3.000 38.4 6.750 3.6 10.500 .3 14.250 .0
3.250 25.3 7.000 3.0 10.750 .3 14.500 .0
3.500 47.1 7.250 2.5 11.000 .2 14.750 .0

RUNOFF VOLUME = .40428 INCHES = 21.5828 ACRE-FEET
PEAK DISCHARGE RATE = 196.99 CFS AT 1.900 HOURS BASIN AREA = 1.0010 SQ. MI.

*S
****
*S ROUTE 24.7 THRU 23 IN NATURAL ARROYO TO 23.8
COMPUTE RATING CURVE CID=1 VS NO=1 NO SEGS=1
MIN ELEV=5824.56 MAX ELEV=5840.33
CH SLOPE=0.014 FP SLOPE=0.014
N=0.035 DIST=1000.0
DIST ELEV DIST ELEV
0 5839.67 207 5837.99
372 5829.93 498 5824.56
605 5827.79 729 5836.11
1000 5840.33

RATING CURVE VALLEY SECTION 1.0

WATER SURFACE ELEV	FLOW AREA SQ FT	FLOW RATE CFS	TOP WIDTH FT
5824.56	.00	.00	.00
5825.39	19.50	54.47	46.97
5826.22	77.98	345.87	93.95
5827.05	175.47	1019.75	140.92
5827.88	311.86	2208.19	186.25
5828.71	479.69	4073.36	218.10
5829.54	673.94	6555.05	249.95
5830.37	894.35	9727.32	280.48
5831.20	1139.35	13626.96	309.84
5832.03	1408.73	18271.95	339.21
5832.86	1702.49	23704.22	368.57
5833.69	2020.62	29965.41	397.93
5834.52	2363.12	37096.56	427.30
5835.35	2730.00	45138.11	456.66
5836.18	3121.38	53874.45	489.54
5837.01	3556.92	61250.50	559.84
5837.84	4050.80	70307.03	630.14
5838.67	4626.88	76752.67	770.43
5839.50	5330.98	85980.91	926.03
5840.33	6137.26	103302.80	1000.00

ROUTE MCUNGE ID=6 HYD NO=23.6 INFLOW ID=7
DT=0.0 L=2675 FT NS=0 SLOPE=0.014
MATCODE=0 REGCODE=0 CCODE=0 MM CODE=0

INFLOW END= 360 TABLE PTS= 20
DT= .050000 QMED= 98.49 CKMED= 4.9822
WIDTH MED= 54.07 NREACH= 6 DX= 445.83

DEPTH (FT)	AREA (SQ FT)	Q (CFS)	TRAVEL TIME(HR)	WIDTH (FT)	ck (FPS)	VEL (FPS)	C	D	C1	C2	C3	Q-M (CFS)	C1-M	C2-M	C3-M
.00	.0	.0	.364	.0	2.48	1.28	1.000	.000	1.000	.000	.000	.0	1.000	.000	.000
.83	19.5	54.5	.266	47.0	3.90	2.79	1.573	.048	.964	.237	-.200	8.6	.994	.037	-.032
1.66	78.0	345.9	.168	93.9	6.17	4.44	2.491	.096	.947	.442	-.389	162.4	.949	.339	-.289
2.49	175.5	1019.8	.128	140.9	7.96	5.81	3.212	.146	.933	.541	-.474	636.4	.935	.485	-.420
3.32	311.9	2208.2	.105	186.3	9.86	7.08	3.981	.193	.926	.613	-.539	1560.6	.925	.573	-.499

```
        4.15  479.7   4073.4    .088  218.1    12.04   8.49    4.862   .248   .919   .673  -.591   3081.4    .923
.649  -.572
        4.98  673.9   6555.1    .076  249.9    13.64   9.73    5.509   .308   .910   .707  -.616   5254.8    .912
.689  -.601
        5.81  894.3   9727.3    .068  280.5    15.21  10.88    6.140   .365   .903   .734  -.636   8080.1    .905
.720  -.625
        6.64 1139.4  13627.0    .062  309.8    16.63  11.96    6.715   .424   .896   .754  -.650  11614.8    .899
.744  -.643
        7.47 1408.7  18271.9    .057  339.2    17.91  12.97    7.232   .482   .889   .770  -.660  15886.3    .892
.762  -.654
        8.30 1702.5  23704.2    .053  368.6    19.13  13.92    7.722   .539   .884   .784  -.668  20923.9    .886
.777  -.663
        9.13 2020.6  29965.4    .050  397.9    20.29  14.83    8.191   .595   .878   .796  -.674  26769.5    .880
.790  -.670
        9.96 2363.1  37096.6    .047  427.3    21.40  15.70    8.641   .650   .874   .806  -.679  33464.4    .875
.801  -.676
       10.79 2730.0  45138.1    .045  456.7    22.17  16.53    8.952   .714   .866   .812  -.679  41049.4    .871
.810  -.681
       11.62 3121.4  53874.4    .043  489.5    20.01  17.26    8.079   .881   .823   .799  -.622  49442.3    .860
.814  -.673
       12.45 3556.9  61250.5    .043  559.8    17.68  17.22    7.140   .991   .783   .781  -.564  57528.9    .766
.774  -.540
       13.28 4050.8  70307.0    .043  630.1    14.95  17.36    6.034  1.196   .709   .757  -.466  65733.9    .793
.786  -.580
       14.11 4626.9  76752.7    .045  770.4    12.30  16.59    4.964  1.298   .643   .725  -.367  73500.0    .564
.713  -.277
       14.94 5331.0  85980.9    .046  926.0    17.09  16.13    6.901   .870   .802   .772  -.574  81323.3    .684
.732  -.416
       15.77 6137.3 103302.8    .044 1000.0    21.54  16.83    8.697   .768   .853   .809  -.662  94508.3    .861
.809  -.670
 MAXIMUM NO. ITERATIONS FOR SOLUTION (KKMAX) =   4 OCCURRED       9 TIMES.  AVERAGE NUMBER ITERATIONS =  1.2024
 Equations solved using the Ponce correction to C2
 PRINT HYD           ID=6   CODE=1

                                      OUTFLOW HYDROGRAPH REACH    23.60


     RUNOFF VOLUME =      .40420 INCHES     =      21.5786 ACRE-FEET
     PEAK DISCHARGE RATE =     196.67 CFS  AT   2.050 HOURS   BASIN AREA =  1.0010 SQ. MI.



 *
 **************************************************************************

 *S*** SUB-BASIN 23 ****
 *
 COMPUTE LT TP       LCODE=1  USDI BUREAU OF RECLAMATION LAG TIME EQUATION
                     NK=3  ISLOPE=-1
                     LENGTH=400 FT   SLOPE=0.004 K=0.7
                     LENGTH=1600 FT  SLOPE=0.006 K=2.0
                     LENGTH=3613 FT  SLOPE=0.015 K=3.0
                     Kn=.033  CR=.5

      Tc AND Tp COMPUTED BY UPLAND/LAG TIME PROCEDURE

      SCS UPLAND METHOD FACTORS
                                LENGTH (FT)      SLOPE (FT/FT)       COMPOSITE K
      SHEET FLOW PORTION            400.0           .004000             .7000
      SHALLOW FLOW PORTION         1600.0           .006000            2.0000
      CHANNEL FLOW PORTION         3613.0           .015000            3.0000
      TOTAL BASIN                  5613.0           .011651            1.7811


      LAG EQUATION FACTORS:     Kn=   .0330     TOTAL BASIN LENGTH (FT)=      5613.0
      TOTAL BASIN SLOPE (FT/FT)=    .011651     CENTROUD LENGTH (FT)=         2806.5


      TIME OF CONCENTRATION (HRS)=   .6213     TIME TO PEAK (HRS)=   .4142     LAG TIME (HRS)=   .4660

 COMPUTE NM HYD      ID=2   HYD NO=23   DA= 0.245 SQ MI
                     PER A=99 PER B=1  PER C=0  PER D=0
                     TP=0.0   MASSRAIN=-1
      TIME TO PEAK (hrs)=   .4142

      K =   .458572HR    TP =   .414194HR    K/TP RATIO =  1.107144     SHAPE CONSTANT, N =  3.193579
      UNIT PEAK =   175.82    CFS   UNIT VOLUME =    .9999       B =   297.24      P60 = 1.6900
      AREA =      .245000 SQ MI    IA =    .64850 INCHES    INF =   1.66580 INCHES PER HOUR
      RUNOFF COMPUTED BY INITIAL ABSTRACTION/INFILTRATION NUMBER METHOD - DT =   .050000

     BULKING FACTOR APPLIED TO HYDROGRAPH.  FACTOR =  1.05000 AT PEAK FLOW.

 PRINT HYD           ID=2   CODE=1

                                      OUTFLOW HYDROGRAPH REACH    23.00


     RUNOFF VOLUME =      .40783 INCHES     =       5.3289 ACRE-FEET
     PEAK DISCHARGE RATE =      71.05 CFS  AT   1.800 HOURS   BASIN AREA =   .2450 SQ. MI.
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*S
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*S ADD 23 AND 23.6 TO GET 23.8
ADD HYD             ID=8   HYD NO=23.8 ID I=2 ID II=6
PRINT HYD           ID=8   CODE=5
```

OUTFLOW HYDROGRAPH REACH 23.80

TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS
.000	.0	3.750	70.4	7.500	2.9	11.250	.3	15.000	.0
.250	.0	4.000	44.5	7.750	2.4	11.500	.2	15.250	.0
.500	.0	4.250	39.4	8.000	2.0	11.750	.2	15.500	.0
.750	.0	4.500	31.5	8.250	1.7	12.000	.2	15.750	.0
1.000	.0	4.750	23.7	8.500	1.5	12.250	.1	16.000	.0
1.250	.0	5.000	17.6	8.750	1.2	12.500	.1	16.250	.0
1.500	26.0	5.250	14.1	9.000	1.1	12.750	.1	16.500	.0
1.750	168.7	5.500	11.7	9.250	.9	13.000	.1	16.750	.0
2.000	252.5	5.750	9.8	9.500	.8	13.250	.1	17.000	.0
2.250	207.9	6.000	8.2	9.750	.7	13.500	.1	17.250	.0
2.500	142.1	6.250	6.8	10.000	.6	13.750	.1	17.500	.0
2.750	92.5	6.500	5.7	10.250	.5	14.000	.0	17.750	.0
3.000	60.4	6.750	4.8	10.500	.4	14.250	.0	18.000	.0
3.250	42.2	7.000	4.0	10.750	.4	14.500	.0	18.250	.0
3.500	29.8	7.250	3.4	11.000	.3	14.750	.0		

```
    RUNOFF VOLUME =      .40491 INCHES     =      26.9075 ACRE-FEET
    PEAK DISCHARGE RATE =     252.54 CFS  AT   2.000 HOURS   BASIN AREA =  1.2460 SQ. MI.


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*S*** SUB-BASIN 28 ****
*
COMPUTE LT TP       LCODE=1  USDI BUREAU OF RECLAMATION LAG TIME EQUATION
                    NK=3  ISLOPE=-1
                    LENGTH=400 FT   SLOPE=0.019 K=0.7
                    LENGTH=1600 FT  SLOPE=0.006 K=2.0
                    LENGTH=5288 FT  SLOPE=0.012 K=3.0
                    Kn=.033  CR=.5

     Tc AND Tp COMPUTED BY UPLAND/LAG TIME PROCEDURE

     SCS UPLAND METHOD FACTORS
                              LENGTH (FT)      SLOPE (FT/FT)       COMPOSITE K
     SHEET FLOW PORTION          400.0           .019000             .7000
     SHALLOW FLOW PORTION       1600.0           .006000            2.0000
     CHANNEL FLOW PORTION       5288.0           .012000            3.0000
     TOTAL BASIN                7288.0           .011067            2.2666


     LAG EQUATION FACTORS:     Kn=   .0330     TOTAL BASIN LENGTH (FT)=      7288.0
     TOTAL BASIN SLOPE (FT/FT)=    .011067     CENTROUD LENGTH (FT)=         3644.0


     TIME OF CONCENTRATION (HRS)=   .6031     TIME TO PEAK (HRS)=   .4021     LAG TIME (HRS)=   .4523

COMPUTE NM HYD      ID=2   HYD NO=28   DA= 0.158 SQ MI
                    PER A=95 PER B=5  PER C=0  PER D=0
                    TP=0.0   MASSRAIN=-1
     TIME TO PEAK (hrs)=   .4021

     K =   .471081HR    TP =   .402079HR    K/TP RATIO =  1.171611     SHAPE CONSTANT, N =  3.027397
     UNIT PEAK =   111.62    CFS   UNIT VOLUME =    .9999       B =   284.05      P60 = 1.6900
     AREA =      .158000 SQ MI    IA =    .64250 INCHES    INF =   1.64900 INCHES PER HOUR
     RUNOFF COMPUTED BY INITIAL ABSTRACTION/INFILTRATION NUMBER METHOD - DT =   .050000

    BULKING FACTOR APPLIED TO HYDROGRAPH.  FACTOR =  1.05000 AT PEAK FLOW.

PRINT HYD           ID=2   CODE=1
```

OUTFLOW HYDROGRAPH REACH 28.00

RUNOFF VOLUME = .41537 INCHES = 3.5002 ACRE-FEET
PEAK DISCHARGE RATE = 45.82 CFS AT 1.750 HOURS BASIN AREA = .1580 SQ. MI.

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*S
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*S ADD 28 AND 23.8 TO GET 28.9
ADD HYD             ID=9   HYD NO=28.9 ID I=2 ID II=8
PRINT HYD           ID=9   CODE=5
```

OUTFLOW HYDROGRAPH REACH 28.90

TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS
.000	.0	3.750	73.0	7.500	3.0	11.250	.3	15.000	.0
.250	.0	4.000	46.7	7.750	2.6	11.500	.2	15.250	.0
.500	.0	4.250	41.2	8.000	2.2	11.750	.2	15.500	.0
.750	.0	4.500	33.0	8.250	1.8	12.000	.2	15.750	.0
1.000	.0	4.750	25.0	8.500	1.6	12.250	.1	16.000	.0
1.250	.0	5.000	18.7	8.750	1.3	12.500	.1	16.250	.0
1.500	44.8	5.250	15.0	9.000	1.1	12.750	.1	16.500	.0
1.750	214.5	5.500	12.5	9.250	1.0	13.000	.1	16.750	.0
2.000	288.9	5.750	10.4	9.500	.8	13.250	.1	17.000	.0
2.250	229.6	6.000	8.7	9.750	.7	13.500	.1	17.250	.0
2.500	154.8	6.250	7.3	10.000	.6	13.750	.1	17.500	.0
2.750	100.0	6.500	6.1	10.250	.5	14.000	.0	17.750	.0
3.000	65.0	6.750	5.1	10.500	.4	14.250	.0	18.000	.0
3.250	45.9	7.000	4.3	10.750	.4	14.500	.0	18.250	.0
3.500	32.9	7.250	3.6	11.000	.3	14.750	.0		

RUNOFF VOLUME = .40609 INCHES = 30.4077 ACRE-FEET
PEAK DISCHARGE RATE = 288.90 CFS AT 2.000 HOURS BASIN AREA = 1.4040 SQ. MI.

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*S
*************************************************************************
*S ADD 17.4 TO 28.9 TO GET 28.6
ADD HYD             ID=6   HYD NO=28.6 ID I=3 ID II=9
PRINT HYD           ID=6   CODE=5
```

OUTFLOW HYDROGRAPH REACH 28.60

TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS
.000	.0	3.750	295.3	7.500	9.9	11.250	.7	15.000	.0
.250	.0	4.000	204.7	7.750	8.3	11.500	.6	15.250	.0
.500	.0	4.250	152.8	8.000	6.9	11.750	.5	15.500	.0
.750	.0	4.500	111.8	8.250	5.7	12.000	.4	15.750	.0
1.000	.0	4.750	82.3	8.500	4.7	12.250	.3	16.000	.0
1.250	.0	5.000	62.3	8.750	3.9	12.500	.3	16.250	.0
1.500	44.8	5.250	50.5	9.000	3.3	12.750	.2	16.500	.0
1.750	251.0	5.500	42.0	9.250	2.7	13.000	.2	16.750	.0
2.000	442.0	5.750	35.1	9.500	2.3	13.250	.2	17.000	.0
2.250	440.4	6.000	29.2	9.750	1.9	13.500	.1	17.250	.0
2.500	459.3	6.250	24.4	10.000	1.6	13.750	.1	17.500	.0

2.750	494.5	6.500	20.4	10.250	1.3	14.000	.1	17.750	.0
3.000	337.6	6.750	17.0	10.500	1.1	14.250	.1	18.000	.0
3.250	255.2	7.000	14.2	10.750	.9	14.500	.1	18.250	.0
3.500	320.4	7.250	11.9	11.000	.8	14.750	.0		

RUNOFF VOLUME = .40271 INCHES = 87.5425 ACRE-FEET
PEAK DISCHARGE RATE = 533.05 CFS AT 2.650 HOURS BASIN AREA = 4.0760 SQ. MI.

*S

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*S ROUTE 28.6 THRU 20 IN NATURAL ARROYO TO 20.8
*
COMPUTE RATING CURVE CID=1 VS NO=1 NO SEGS=1
MIN ELEV=5771.07 MAX ELEV=5810.76
CH SLOPE=0.015 FP SLOPE=0.015
N=0.035 DIST=850.0

DIST	ELEV	DIST	ELEV	DIST	ELEV
0	5810.76	126	5801.93		
250	5796.16	382	5779.97		
429	5771.07	483	5775.96		
604	5784.0	850	5792.39		

RATING CURVE VALLEY SECTION 1.0

WATER SURFACE ELEV	FLOW AREA SQ FT	FLOW RATE CFS	TOP WIDTH FT
5771.07	.00	.00	.00
5773.16	35.61	189.55	34.10
5775.25	142.45	1203.58	68.19
5777.34	324.31	3495.74	107.81
5779.43	593.86	7680.56	150.27
5781.51	955.54	14165.13	197.18
5783.60	1418.04	23630.47	245.64
5785.69	2002.20	35354.90	318.26
5787.78	2748.75	51802.03	396.53
5789.87	3658.81	74014.84	474.81
5791.96	4732.38	102673.60	553.09
5794.05	5929.20	144379.90	582.77
5796.14	7164.33	194134.90	599.80
5798.23	8463.46	244360.60	644.38
5800.31	9856.36	301208.00	689.27
5802.40	11342.23	366119.80	730.74
5804.49	12899.79	441774.30	760.55
5806.58	14519.62	524447.70	790.36
5808.67	16201.71	614238.90	820.17
5810.76	17946.07	711255.30	849.98

ROUTE MCUNGE ID=7 HYD NO=20.7 INFLOW ID=6
DT=0.0 L=2290 FT NS=0 SLOPE=0.015
MATCODE=0 REGCODE=0 CCODE=0 MM CODE=0

INFLOW END= 370 TABLE PTS= 20
DT= .050000 QMED= 266.53 CKMED= 9.4914
WIDTH MED= 36.69 NREACH= 3 DX= 763.33

DEPTH (FT)	AREA (SQ FT)	Q (CFS)	TRAVEL TIME(HR)	WIDTH (FT)	ck (FPS)	VEL (FPS)	C	D	C1	C2	C3	Q-M (CFS)	C1-M	C2-M	C3-M
.00	.0	.0	.164	.0	4.24	2.45	1.000	.000	1.000	.000	.000	.0	1.000	.000	.000
2.09	35.6	189.6	.120	34.1	7.42	5.32	1.750	.065	.954	.290	-.243	29.9	.967	.043	-.011
4.18	142.4	1203.6	.075	68.2	11.58	8.45	2.731	.133	.931	.482	-.414	565.0	.936	.389	-.325
6.27	324.3	3495.7	.059	107.8	14.32	10.78	3.378	.198	.914	.563	-.476	2186.3	.913	.509	-.423
8.36	593.9	7680.6	.049	150.3	17.03	12.93	4.015	.262	.901	.621	-.522	5387.4	.903	.589	-.492
10.44	955.5	14165.1	.043	197.2	19.36	14.82	4.566	.324	.890	.660	-.550	10695.2	.890	.636	-.526
12.53	1418.0	23630.5	.038	245.6	20.81	16.66	4.907	.404	.872	.683	-.555	18636.6	.883	.676	-.559
14.62	2002.2	35354.9	.036	318.3	21.16	17.66	4.990	.458	.858	.690	-.548	29229.3	.851	.674	-.524
16.71	2748.8	51802.0	.034	396.5	23.32	18.85	5.499	.489	.860	.714	-.574	43248.5	.855	.700	-.555
18.80	3658.8	74014.8	.031	474.8	25.65	20.23	6.048	.531	.860	.736	-.596	62515.3	.858	.724	-.582
20.89	4732.4	102673.6	.029	553.1	30.11	21.70	7.099	.539	.875	.768	-.644	87896.7	.857	.745	-.602
22.98	5929.2	144379.9	.026	582.8	37.54	24.35	8.852	.576	.889	.808	-.698	122840.3	.891	.796	-.687
25.07	7164.3	194134.9	.023	599.8	40.22	27.10	9.484	.703	.874	.821	-.696	168549.8	.889	.820	-.709

```
      27.16 8463.5 244360.6    .022  644.4    39.80  28.87    9.386   .832   .852   .822  -.673 218736.3    .854
.817  -.671
      29.24 9856.4 301208.0    .021  689.3    42.27  30.56    9.968   .903   .848   .832  -.679 272266.8    .848
.826  -.674
      31.3311342.2 366119.8    .020  730.7    45.96  32.28   10.838   .952   .851   .844  -.695 333112.5    .847
.837  -.684
      33.4212899.8 441774.3    .019  760.6    49.86  34.25   11.757  1.017   .852   .855  -.707 403311.8    .855
.851  -.706
      35.5114519.6 524447.7    .018  790.4    52.26  36.12   12.323  1.109   .846   .861  -.708 482485.0    .849
.858  -.707
      37.6016201.7 614238.9    .017  820.2    54.54  37.91   12.862  1.199   .841   .867  -.708 568724.4    .843
.864  -.708
      39.6917946.1 711255.3    .016  850.0    56.02  39.63   13.210  1.305   .832   .871  -.703 662133.6    .838
.870  -.708
     MAXIMUM NO. ITERATIONS FOR SOLUTION (KKMAX) =   4 OCCURRED       2 TIMES.  AVERAGE NUMBER ITERATIONS =  1.2647
       DEPTH    AREA      Q    TRAVEL  WIDTH     ck      VEL      C       D      C1     C2     C3     Q-M      C1-M
C2-M   C3-M
        (FT)  (SQ FT)  (CFS)  TIME(HR) (FT)     (FPS)   (FPS)                                          (CFS)
         .00     .0       .0    .164     .0     4.24    2.45    1.000   .000  1.000   .000   .000       .0   1.000
.000   .000
        2.09    35.6     189.6    .120    34.1     4.68    5.32    1.104   .104   .906   .094   .000     29.9    .966
.034   .000
        4.18   142.4    1203.6    .075    68.2     5.44    8.45    1.283   .283   .779   .221   .000    565.0    .840
.160   .000
        6.27   324.3    3495.7    .059   107.8     6.18   10.78    1.458   .458   .686   .314   .000   2186.3    .728
.272   .000
        8.36   593.9    7680.6    .049   150.3     6.96   12.93    1.641   .641   .609   .391   .000   5387.4    .644
.356   .000
       10.44   955.5   14165.1    .043   197.2     7.70   14.82    1.815   .815   .551   .449   .000  10695.2    .577
.423   .000
       12.53  1418.0   23630.5    .038   245.6     8.45   16.66    1.994   .994   .502   .498   .000  18636.6    .524
.476   .000
       14.62  2002.2   35354.9    .036   318.3     8.88   17.66    2.093  1.093   .478   .522   .000  29229.3    .489
.511   .000
       16.71  2748.8   51802.0    .034   396.5     9.39   18.85    2.215  1.215   .452   .548   .000  43248.5    .464
.536   .000
       18.80  3658.8   74014.8    .031   474.8    10.01   20.23    2.360  1.360   .424   .576   .000  62515.3    .437
.563   .000
       20.89  4732.4  102673.6    .029   553.1    10.68   21.70    2.518  1.518   .397   .603   .000  87896.7    .409
.591   .000
       22.98  5929.2  144379.9    .026   582.8    11.93   24.35    2.813  1.813   .355   .645   .000 122840.3    .375
.625   .000
       25.07  7164.3  194134.9    .023   599.8    13.27   27.10    3.130  2.130   .320   .680   .000 168549.8    .336
.664   .000
       27.16  8463.5  244360.6    .022   644.4    14.16   28.87    3.339  2.339   .299   .701   .000 218736.3    .309
.691   .000
       29.24  9856.4  301208.0    .021   689.3    15.02   30.56    3.541  2.541   .282   .718   .000 272266.8    .290
.710   .000
       31.3311342.2  366119.8    .020   730.7    15.91   32.28    3.751  2.751   .267   .733   .000 333112.5    .274
.726   .000
       33.4212899.8  441774.3    .019   760.6    16.94   34.25    3.995  2.995   .250   .750   .000 403311.8    .258
.742   .000
       35.5114519.6  524447.7    .018   790.4    17.94   36.12    4.230  3.230   .236   .764   .000 482485.0    .243
.757   .000
       37.6016201.7  614238.9    .017   820.2    18.91   37.91    4.459  3.459   .224   .776   .000 568724.4    .230
.770   .000
       39.6917946.1  711255.3    .016   850.0    19.85   39.63    4.681  3.681   .214   .786   .000 662133.6    .219
.781   .000
     MAXIMUM NO. ITERATIONS FOR SOLUTION (KKMAX) =   3 OCCURRED      21 TIMES.  AVERAGE NUMBER ITERATIONS =  1.2164
     Equations solved with two passes: first using the Ponce correction to C1, second using the Fread correction to C1,
C2 and C3
     PRINT HYD           ID=7   CODE=5

                                          OUTFLOW HYDROGRAPH REACH    20.70

         TIME      FLOW          TIME      FLOW          TIME      FLOW          TIME      FLOW          TIME
FLOW
          HRS       CFS           HRS       CFS           HRS       CFS           HRS       CFS           HRS
CFS
         .000        .0         3.750     290.3         7.500      11.0        11.250        .7        15.000
  .0
         .250        .0         4.000     237.8         7.750       9.2        11.500        .6        15.250
  .0
         .500        .0         4.250     186.2         8.000       7.7        11.750        .5        15.500
  .0
         .750        .0         4.500     133.2         8.250       6.4        12.000        .4        15.750
  .0
        1.000        .0         4.750      97.2         8.500       5.3        12.250        .4        16.000
  .0
        1.250        .0         5.000      72.4         8.750       4.4        12.500        .3        16.250
  .0
        1.500        .8         5.250      56.3         9.000       3.7        12.750        .3        16.500
  .0
        1.750       92.2         5.500      46.6         9.250       3.0        13.000        .2        16.750
  .0
        2.000      381.0         5.750      38.9         9.500       2.5        13.250        .2        17.000
  .0
        2.250      430.7         6.000      32.5         9.750       2.1        13.500        .1        17.250
  .0
        2.500      444.7         6.250      27.1        10.000       1.8        13.750        .1        17.500
  .0
```

```
      2.750     529.5          6.500      22.6          10.250       1.5         14.000        .1         17.750
.0
      3.000     419.4          6.750      18.9          10.500       1.2         14.250        .1         18.000
.0
      3.250     279.1          7.000      15.8          10.750       1.0         14.500        .1         18.250
.0
      3.500     299.8          7.250      13.2          11.000        .9         14.750        .1         18.500
.0

     RUNOFF VOLUME =      .40252 INCHES     =      87.5026 ACRE-FEET
     PEAK DISCHARGE RATE =     529.55 CFS  AT   2.750 HOURS   BASIN AREA =  4.0760 SQ. MI.


  *
  ***********************************************************************
  *S*** SUB-BASIN 20 ****
  *
  COMPUTE LT TP       LCODE=1  UPLAND/LAG TIME TRANSITION METHOD
                      NK=3  ISLOPE=-1
                      LENGTH=400 FT   SLOPE=0.015 K=0.7
                      LENGTH=1600 FT  SLOPE=0.015 K=2.0
                      LENGTH=5447 FT   SLOPE=0.018 K=3.0
                      Kn=.033  CR=0.50

       Tc AND Tp COMPUTED BY UPLAND/LAG TIME PROCEDURE

       SCS UPLAND METHOD FACTORS
                                LENGTH (FT)      SLOPE (FT/FT)       COMPOSITE K
       SHEET FLOW PORTION           400.0           .015000             .7000
       SHALLOW FLOW PORTION        1600.0           .015000            2.0000
       CHANNEL FLOW PORTION        5447.0           .018000            3.0000
       TOTAL BASIN                 7447.0           .017194            2.2964


       LAG EQUATION FACTORS:     Kn=   .0330     TOTAL BASIN LENGTH (FT)=      7447.0
       TOTAL BASIN SLOPE (FT/FT)=    .017194     CENTROUD LENGTH (FT)=         3723.5


       TIME OF CONCENTRATION (HRS)=   .5304     TIME TO PEAK (HRS)=   .3536     LAG TIME (HRS)=   .3978

  COMPUTE NM HYD      ID=1   HYD NO=20   DA= 0.426 SQ MI
                      PER A=95 PER B=5  PER C=0  PER D=0
                      TP=0.0   MASSRAIN=-1
       TIME TO PEAK (hrs)=   .3536

       K =   .369891HR    TP =   .353595HR    K/TP RATIO =  1.046087     SHAPE CONSTANT, N =  3.374873
       UNIT PEAK =   374.78    CFS   UNIT VOLUME =    1.000       B =   311.08       P60 = 1.6900
       AREA =      .426000 SQ MI    IA =    .64250 INCHES    INF =   1.64900 INCHES PER HOUR
       RUNOFF COMPUTED BY INITIAL ABSTRACTION/INFILTRATION NUMBER METHOD - DT =   .050000

      BULKING FACTOR APPLIED TO HYDROGRAPH.  FACTOR =  1.05000 AT PEAK FLOW.

  PRINT HYD           ID=1   CODE=1

                                        OUTFLOW HYDROGRAPH REACH    20.00


      RUNOFF VOLUME =      .41537 INCHES     =       9.4372 ACRE-FEET
      PEAK DISCHARGE RATE =     152.89 CFS  AT   1.750 HOURS   BASIN AREA =   .4260 SQ. MI.


  *S
  ***********************************************************************
  * ADD 20 TO 28.6 TO GET 20.8
  ADD HYD             ID=8   HYD NO=20.8 ID I=1 ID II=7
  PRINT HYD           ID=8   CODE=1

                                        OUTFLOW HYDROGRAPH REACH    20.80


      RUNOFF VOLUME =      .40374 INCHES     =      96.9398 ACRE-FEET
      PEAK DISCHARGE RATE =     543.62 CFS  AT   2.750 HOURS   BASIN AREA =  4.5020 SQ. MI.


  *
  ***********************************************************************


  ***********************************************************************
  *S*** SUB-BASIN 25 ****
  *
  COMPUTE LT TP       LCODE=1  UPLAND/LAG TIME TRANSITION METHOD
                      NK=3  ISLOPE=-1
                      LENGTH=400 FT   SLOPE=0.021 K=0.7
                      LENGTH=1600 FT  SLOPE=0.04 K=2.0
                      LENGTH=10314 FT   SLOPE=0.018 K=3.0
                      Kn=.033  CR=.5
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     Tc AND Tp COMPUTED BY UPLAND/LAG TIME PROCEDURE


     LAG EQUATION FACTORS:     Kn=   .0330     TOTAL BASIN LENGTH (FT)=     12314.0
     TOTAL BASIN SLOPE (FT/FT)=    .020956     CENTROUD LENGTH (FT)=         6157.0


     TIME OF CONCENTRATION (HRS)=   .7321     TIME TO PEAK (HRS)=   .4881     LAG TIME (HRS)=   .5491

COMPUTE NM HYD      ID=1   HYD NO=25   DA= 0.463 SQ MI
                    PER A=100 PER B=0  PER C=0  PER D=0
                    TP=0.0   MASSRAIN=-1
     TIME TO PEAK (hrs)=   .4881

     K =   .513437HR    TP =   .488056HR    K/TP RATIO =  1.052006     SHAPE CONSTANT, N =  3.356146
     UNIT PEAK =   293.78    CFS   UNIT VOLUME =    1.000       B =   309.68      P60 = 1.6900
     AREA =      .463000 SQ MI    IA =    .65000 INCHES    INF =   1.67000 INCHES PER HOUR
     RUNOFF COMPUTED BY INITIAL ABSTRACTION/INFILTRATION NUMBER METHOD - DT =   .050000

    BULKING FACTOR APPLIED TO HYDROGRAPH.  FACTOR =  1.05000 AT PEAK FLOW.

PRINT HYD           ID=1   CODE=1

                                      OUTFLOW HYDROGRAPH REACH    25.00


    RUNOFF VOLUME =      .40595 INCHES     =      10.0242 ACRE-FEET
    PEAK DISCHARGE RATE =     118.49 CFS  AT   1.850 HOURS   BASIN AREA =   .4630 SQ. MI.



*S
**********************************************************************
*S*** SUB-BASIN 26 ****
*
COMPUTE LT TP       LCODE=1  UPLAND/LAG TIME TRANSITION METHOD
                    NK=3  ISLOPE=-1
                    LENGTH=400 FT   SLOPE=0.04 K=0.7
                    LENGTH=1600 FT  SLOPE=0.034 K=2.0
                    LENGTH=6569 FT  SLOPE=0.020 K=3.0
                    Kn=.033  CR=0.60

     Tc AND Tp COMPUTED BY UPLAND/LAG TIME PROCEDURE

     SCS UPLAND METHOD FACTORS
                              LENGTH (FT)      SLOPE (FT/FT)       COMPOSITE K
     SHEET FLOW PORTION           400.0           .040000             .7000
     SHALLOW FLOW PORTION        1600.0           .034000            2.0000
     CHANNEL FLOW PORTION        6569.0           .020000            3.0000
     TOTAL BASIN                 8569.0           .023548            2.4622


     LAG EQUATION FACTORS:     Kn=   .0330     TOTAL BASIN LENGTH (FT)=      8569.0
     TOTAL BASIN SLOPE (FT/FT)=    .023548     CENTROUD LENGTH (FT)=         5141.4


     TIME OF CONCENTRATION (HRS)=   .5543     TIME TO PEAK (HRS)=   .3696     LAG TIME (HRS)=   .4157

COMPUTE NM HYD      ID=2   HYD NO=26   DA= 0.348 SQ MI
                    PER A=100 PER B=0  PER C=0  PER D=0
                    TP=0.0   MASSRAIN=-1
     TIME TO PEAK (hrs)=   .3696

     K =   .388772HR    TP =   .369553HR    K/TP RATIO =  1.052006     SHAPE CONSTANT, N =  3.356146
     UNIT PEAK =   291.62    CFS   UNIT VOLUME =    1.000       B =   309.68      P60 = 1.6900
     AREA =      .348000 SQ MI    IA =    .65000 INCHES    INF =   1.67000 INCHES PER HOUR
     RUNOFF COMPUTED BY INITIAL ABSTRACTION/INFILTRATION NUMBER METHOD - DT =   .050000

    BULKING FACTOR APPLIED TO HYDROGRAPH.  FACTOR =  1.05000 AT PEAK FLOW.

PRINT HYD           ID=2   CODE=1

                                      OUTFLOW HYDROGRAPH REACH    26.00


    RUNOFF VOLUME =      .40595 INCHES     =       7.5344 ACRE-FEET
    PEAK DISCHARGE RATE =     117.05 CFS  AT   1.750 HOURS   BASIN AREA =   .3480 SQ. MI.



*S
**********************************************************************
*S ADD 25 TO 26 TO GET 25.6
ADD HYD             ID=6   HYD NO=25.6 ID I=1 ID II=2
PRINT HYD           ID=6   CODE=1

                                      OUTFLOW HYDROGRAPH REACH    25.60


    RUNOFF VOLUME =      .40595 INCHES     =      17.5586 ACRE-FEET
    PEAK DISCHARGE RATE =     230.40 CFS  AT   1.800 HOURS   BASIN AREA =   .8110 SQ. MI.
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*
**********************************************************************
*S*** SUB-BASIN 27 ****
*
COMPUTE LT TP       LCODE=1  UPLAND/LAG TIME TRANSITION METHOD
                    NK=3  ISLOPE=-1
                    LENGTH=400 FT   SLOPE=0.035 K=0.7
                    LENGTH=1600 FT  SLOPE=0.029 K=2.0
                    LENGTH=7044 FT  SLOPE=0.021 K=3.0
                    Kn=.033  CR=0.55

     Tc AND Tp COMPUTED BY UPLAND/LAG TIME PROCEDURE

     SCS UPLAND METHOD FACTORS
                              LENGTH (FT)      SLOPE (FT/FT)       COMPOSITE K
     SHEET FLOW PORTION          400.0            .035000             .7000
     SHALLOW FLOW PORTION       1600.0            .029000            2.0000
     CHANNEL FLOW PORTION       7044.0            .021000            3.0000
     TOTAL BASIN                9044.0            .023034            2.4876


     LAG EQUATION FACTORS:     Kn=   .0330     TOTAL BASIN LENGTH (FT)=      9044.0
     TOTAL BASIN SLOPE (FT/FT)=    .023034     CENTROUD LENGTH (FT)=         4974.2


     TIME OF CONCENTRATION (HRS)=   .5698     TIME TO PEAK (HRS)=   .3798     LAG TIME (HRS)=   .4273

COMPUTE NM HYD      ID=1   HYD NO=27   DA= 0.376 SQ MI
                    PER A=100 PER B=0  PER C=0  PER D=0
                    TP=0.0   MASSRAIN=-1
     TIME TO PEAK (hrs)=   .3798

     K =   .399597HR    TP =   .379843HR    K/TP RATIO =  1.052006     SHAPE CONSTANT, N =  3.356146
     UNIT PEAK =   306.54    CFS   UNIT VOLUME =    1.000       B =   309.68      P60 = 1.6900
     AREA =      .376000 SQ MI    IA =    .65000 INCHES    INF =   1.67000 INCHES PER HOUR
     RUNOFF COMPUTED BY INITIAL ABSTRACTION/INFILTRATION NUMBER METHOD - DT =   .050000

    BULKING FACTOR APPLIED TO HYDROGRAPH.  FACTOR =  1.05000 AT PEAK FLOW.

PRINT HYD           ID=1   CODE=1

                                     OUTFLOW HYDROGRAPH REACH    27.00


    RUNOFF VOLUME =      .40595 INCHES     =       8.1406 ACRE-FEET
    PEAK DISCHARGE RATE =     123.19 CFS  AT   1.750 HOURS   BASIN AREA =   .3760 SQ. MI.



*S
**********************************************************************
*S ADD 27 TO 25.6 TO GET 25.75
ADD HYD             ID=7   HYD NO=25.75 ID I=1 ID II=6
PRINT HYD           ID=7   CODE=1

                                     OUTFLOW HYDROGRAPH REACH    25.75


    RUNOFF VOLUME =      .40595 INCHES     =      25.6993 ACRE-FEET
    PEAK DISCHARGE RATE =     351.46 CFS  AT   1.800 HOURS   BASIN AREA =  1.1870 SQ. MI.



*S
**********************************************************************
*S ROUTE 25.75 THRU UPPER 30 IN NATURAL ARROYO TO 30.91
*
COMPUTE RATING CURVE  CID=1   VS NO=1   NO SEGS=1
                      MIN ELEV=5835.82   MAX ELEV=5841.47
                      CH SLOPE=0.005    FP SLOPE=0.005
                      N=0.035           DIST=900.0
                      DIST  ELEV    DIST  ELEV
                        0   5837.78   185 5842.09
                                  277     5840.10 449     5835.82
                                  630     5838.02 900     5841.47


                                   RATING CURVE VALLEY SECTION  1.0
                                      WATER       FLOW        FLOW        TOP
                                     SURFACE      AREA        RATE        WIDTH
                                      ELEV        SQ FT       CFS         FT
                                    5835.82         .00         .00         .00
                                    5836.12        5.41        4.56       36.41
                                    5836.41       21.66       28.96       72.82
                                    5836.71       48.72       85.39      109.24
                                    5837.01       86.62      183.89      145.65
                                    5837.31      135.35      333.42      182.06
```

5837.60	194.90	542.17	218.47
5837.90	265.59	808.46	260.10
5838.20	350.19	1143.74	308.56
5838.50	449.08	1572.21	356.55
5838.79	562.23	2101.92	404.53
5839.09	689.66	2741.74	452.51
5839.39	831.36	3500.24	500.50
5839.69	987.32	4385.73	548.48
5839.98	1157.55	5406.27	596.46
5840.28	1342.15	6563.07	645.54
5840.58	1541.51	7867.57	695.32
5840.88	1755.68	9332.17	745.11
5841.17	1984.65	10964.47	794.89
5841.47	2228.42	12771.91	844.67

ROUTE MCUNGE ID=51 HYD NO=30.51 INFLOW ID=7
DT=0.0 L=8763 FT NS=0 SLOPE=0.005
MATCODE=0 REGCODE=0 CCODE=0 MM CODE=0

INFLOW END= 311 TABLE PTS= 20
DT= .050000 QMED= 175.73 CKMED= 2.5993
WIDTH MED= 142.63 NREACH= 32 DX= 273.84

DEPTH (FT)	AREA (SQ FT)	Q (CFS)	TRAVEL TIME(HR)	WIDTH (FT)	ck (FPS)	VEL (FPS)	C	D	C1	C2	C3	Q-M (CFS)	C1-M C2-M C3-M
.00	.0	.0	3.958	.0	1.52	.39	1.000	.000	1.000	.000	.000	.0	1.000 .000 .000
.30	5.4	4.6	2.889	36.4	1.42	.84	.936	.064	.936	.000	.064	.7	.990 .000 .010
.59	21.7	29.0	1.820	72.8	1.86	1.34	1.223	.156	.869	.159	-.028	13.6	.880 .039 .080
.89	48.7	85.4	1.389	109.2	2.39	1.75	1.569	.239	.830	.288	-.118	53.3	.838 .219 -.057
1.19	86.6	183.9	1.147	145.6	2.87	2.12	1.885	.322	.799	.376	-.176	130.2	.807 .330 -.137
1.49	135.3	333.4	.988	182.1	3.31	2.46	2.178	.404	.775	.442	-.216	253.8	.781 .408 -.189
1.78	194.9	542.2	.875	218.5	3.67	2.78	2.414	.494	.747	.488	-.235	432.5	.759 .467 -.226
2.08	265.6	808.5	.800	260.1	3.90	3.04	2.562	.583	.719	.517	-.236	670.0	.726 .500 -.226
2.38	350.2	1143.7	.745	308.6	4.16	3.27	2.736	.650	.703	.544	-.248	970.4	.702 .527 -.229
2.68	449.1	1572.2	.695	356.5	4.52	3.50	2.972	.712	.696	.573	-.269	1351.5	.697 .558 -.255
2.97	562.2	2101.9	.651	404.5	4.86	3.74	3.197	.780	.686	.598	-.285	1830.0	.688 .585 -.274
3.27	689.7	2741.7	.612	452.5	5.20	3.98	3.417	.851	.677	.620	-.297	2414.2	.679 .609 -.288
3.57	831.4	3500.2	.578	500.5	5.53	4.21	3.632	.924	.667	.640	-.307	3112.8	.670 .630 -.300
3.87	987.3	4385.7	.548	548.5	5.85	4.44	3.843	.999	.658	.658	-.316	3934.3	.661 .649 -.310
4.16	1157.6	5406.3	.521	596.5	6.14	4.67	4.038	1.078	.648	.673	-.321	4886.9	.652 .665 -.317
4.46	1342.2	6563.1	.498	645.5	6.41	4.89	4.216	1.158	.637	.686	-.323	5975.2	.640 .679 -.319
4.76	1541.5	7867.6	.477	695.3	6.70	5.10	4.403	1.234	.628	.699	-.327	7205.5	.631 .692 -.323
5.06	1755.7	9332.2	.458	745.1	6.99	5.32	4.596	1.308	.621	.710	-.331	8589.6	.623 .704 -.328
5.35	1984.6	10964.5	.441	794.9	7.28	5.52	4.784	1.384	.614	.721	-.335	10137.6	.616 .716 -.332
5.65	2228.4	12771.9	.425	844.7	7.38	5.73	4.851	1.496	.593	.728	-.320	11857.1	.609 .726 -.335

MAXIMUM NO. ITERATIONS FOR SOLUTION (KKMAX) = 6 OCCURRED 5 TIMES. AVERAGE NUMBER ITERATIONS = 1.1540

DEPTH (FT)	AREA (SQ FT)	Q (CFS)	TRAVEL TIME(HR)	WIDTH (FT)	ck (FPS)	VEL (FPS)	C	D	C1	C2	C3	Q-M (CFS)	C1-M C2-M C3-M
.00	.0	.0	3.958	.0	1.52	.39	1.000	.000	1.000	.000	.000	.0	1.000 .000 .000
.30	5.4	4.6	2.889	36.4	1.42	.84	.936	.064	.936	.000	.064	.7	.990 .000 .010
.59	21.7	29.0	1.820	72.8	1.77	1.34	1.164	.164	.859	.141	.000	13.6	.880 .039 .080
.89	48.7	85.4	1.389	109.2	1.96	1.75	1.291	.291	.775	.225	.000	53.3	.814 .186 .000
1.19	86.6	183.9	1.147	145.6	2.17	2.12	1.425	.425	.702	.298	.000	130.2	.735 .265 .000
1.49	135.3	333.4	.988	182.1	2.38	2.46	1.563	.563	.640	.360	.000	253.8	.668 .332 .000
1.78	194.9	542.2	.875	218.5	2.59	2.78	1.701	.701	.588	.412	.000	432.5	.612 .388 .000
2.08	265.6	808.5	.800	260.1	2.77	3.04	1.820	.820	.549	.451	.000	670.0	.567 .433 .000
2.38	350.2	1143.7	.745	308.6	2.93	3.27	1.925	.925	.520	.480	.000	970.4	.534 .466 .000
2.68	449.1	1572.2	.695	356.5	3.10	3.50	2.038	1.038	.491	.509	.000	1351.5	.504 .496 .000
2.97	562.2	2101.9	.651	404.5	3.28	3.74	2.157	1.157	.464	.536	.000	1830.0	.476 .524 .000

```
        3.27  689.7   2741.7    .612  452.5     3.46   3.98    2.277  1.277   .439   .561   .000   2414.2    .451
.549   .000
        3.57  831.4   3500.2    .578  500.5     3.65   4.21    2.399  1.399   .417   .583   .000   3112.8    .427
.573   .000
        3.87  987.3   4385.7    .548  548.5     3.84   4.44    2.522  1.522   .397   .603   .000   3934.3    .406
.594   .000
        4.16 1157.6   5406.3    .521  596.5     4.02   4.67    2.645  1.645   .378   .622   .000   4886.9    .387
.613   .000
        4.46 1342.2   6563.1    .498  645.5     4.21   4.89    2.765  1.765   .362   .638   .000   5975.2    .369
.631   .000
        4.76 1541.5   7867.6    .477  695.3     4.39   5.10    2.884  1.884   .347   .653   .000   7205.5    .354
.646   .000
        5.06 1755.7   9332.2    .458  745.1     4.57   5.32    3.003  2.003   .333   .667   .000   8589.6    .340
.660   .000
        5.35 1984.6  10964.5    .441  794.9     4.75   5.52    3.121  2.121   .320   .680   .000  10137.6    .326
.674   .000
        5.65 2228.4  12771.9    .425  844.7     4.93   5.73    3.240  2.240   .309   .691   .000  11857.1    .314
.686   .000
     MAXIMUM NO. ITERATIONS FOR SOLUTION (KKMAX) =   5 OCCURRED       8 TIMES.  AVERAGE NUMBER ITERATIONS =  1.1266
     Equations solved with two passes: first using the Ponce correction to C1, second using the Fread correction to C1,
C2 and C3
     PRINT HYD           ID=51   CODE=5

                                        OUTFLOW HYDROGRAPH REACH    30.51

          TIME      FLOW          TIME      FLOW          TIME      FLOW          TIME      FLOW          TIME
FLOW
           HRS       CFS           HRS       CFS           HRS       CFS           HRS       CFS           HRS
CFS
          .000        .0         3.500     137.2         7.000       5.7        10.500        .4        14.000
  .0
          .250        .0         3.750      90.0         7.250       4.7        10.750        .3        14.250
  .0
          .500        .0         4.000      58.9         7.500       3.9        11.000        .3        14.500
  .0
          .750        .0         4.250      41.0         7.750       3.2        11.250        .2        14.750
  .0
         1.000        .0         4.500      30.7         8.000       2.6        11.500        .2        15.000
  .0
         1.250        .0         4.750      25.7         8.250       2.2        11.750        .2        15.250
  .0
         1.500        .0         5.000      22.4         8.500       1.8        12.000        .1        15.500
  .0
         1.750        .0         5.250      19.4         8.750       1.5        12.250        .1        15.750
  .0
         2.000        .0         5.500      16.6         9.000       1.2        12.500        .1        16.000
  .0
         2.250        .0         5.750      14.1         9.250       1.0        12.750        .1        16.250
  .0
         2.500        .0         6.000      11.8         9.500        .9        13.000        .1        16.500
  .0
         2.750      208.5         6.250       9.9         9.750        .7        13.250        .1        16.750
  .0
         3.000      289.6         6.500       8.3        10.000        .6        13.500        .1        17.000
  .0
         3.250      206.5         6.750       6.9        10.250        .5        13.750        .0        17.250
  .0

       RUNOFF VOLUME =      .39167 INCHES     =      24.7954 ACRE-FEET
       PEAK DISCHARGE RATE =     310.87 CFS  AT   2.900 HOURS   BASIN AREA =  1.1870 SQ. MI.


     *
     ***********************************************************************
     *S ROUTE 30.91 THRU LOWER 30 IN NATURAL ARROYO TO 30.9
     *
     COMPUTE RATING CURVE  CID=1   VS NO=1   NO SEGS=1
                           MIN ELEV=5792.02   MAX ELEV=5809.13
                           CH SLOPE=0.023    FP SLOPE=0.023
                           N=0.035           DIST=700.0
                           DIST  ELEV    DIST  ELEV
                             0   5812.39   101 5806.02
                                       218     5800.05 304     5795.17
                                       348     5792.02 376     5793.83
                                       457     5799.95 570     5807.93
                                       700     5809.13

                                    RATING CURVE VALLEY SECTION  1.0
                                       WATER       FLOW        FLOW        TOP
                                      SURFACE      AREA        RATE        WIDTH
                                        ELEV       SQ FT       CFS         FT
                                      5792.02        .00         .00         .00
                                      5792.92       11.93       45.06       26.51
                                      5793.82       47.73      286.13       53.01
                                      5794.72      106.51      846.14       77.53
                                      5795.62      187.71     1792.63      103.67
                                      5796.52      293.56     3224.39      131.46
                                      5797.42      424.43     5245.53      159.24
                                      5798.32      580.32     7937.13      187.02
```

5799.22	761.22	11375.61	214.81
5800.12	967.16	15621.08	242.90
5801.02	1199.55	20675.46	273.29
5801.92	1459.31	26718.63	303.69
5802.82	1746.43	33823.13	334.08
5803.73	2060.92	42059.20	364.48
5804.63	2402.78	51494.96	394.88
5805.53	2772.00	62196.71	425.27
5806.43	3168.29	74381.91	454.15
5807.33	3589.36	88114.90	481.17
5808.23	4038.92	99808.05	536.16
5809.13	4572.03	108176.50	648.00

ROUTE MCUNGE ID=5 HYD NO=30.5 INFLOW ID=51
DT=0.0 L=2903 FT NS=0 SLOPE=0.023
MATCODE=0 REGCODE=0 CCODE=0 MM CODE=0

INFLOW END= 347 TABLE PTS= 20
DT= .050000 QMED= 155.44 CKMED= 6.7341
WIDTH MED= 38.64 NREACH= 5 DX= 580.60

DEPTH (FT)	AREA (SQ FT)	Q (CFS)	TRAVEL TIME(HR)	WIDTH (FT)	ck (FPS)	VEL (FPS)	C	D	C1	C2	C3	Q-M (CFS)	C1-M	C2-M	C3-M
.00	.0	.0	.293	.0	3.23	1.74	1.000	.000	1.000	.000	.000	.0	1.000	.000	.000
.90	11.9	45.1	.214	26.5	5.27	3.78	1.633	.024	.982	.247	-.229	7.1	.997	.039	-.036
1.80	47.7	286.1	.135	53.0	8.37	5.99	2.596	.048	.974	.451	-.425	134.3	.975	.347	-.322
2.70	106.5	846.1	.102	77.5	10.83	7.94	3.359	.075	.966	.549	-.515	528.4	.968	.499	-.466
3.60	187.7	1792.6	.084	103.7	12.75	9.55	3.954	.102	.960	.604	-.564	1277.7	.961	.571	-.532
4.50	293.6	3224.4	.073	131.5	14.60	10.98	4.527	.126	.955	.646	-.602	2461.7	.956	.622	-.578
5.40	424.4	5245.5	.065	159.2	16.45	12.36	5.101	.150	.952	.680	-.632	4183.3	.953	.662	-.614
6.30	580.3	7937.1	.059	187.0	18.22	13.68	5.649	.174	.949	.707	-.656	6535.3	.950	.693	-.642
7.20	761.2	11375.6	.054	214.8	19.89	14.94	6.166	.199	.946	.728	-.674	9596.4	.947	.717	-.664
8.10	967.2	15621.1	.050	242.9	21.30	16.15	6.604	.226	.942	.745	-.687	13435.1	.944	.737	-.680
9.00	1199.5	20675.5	.047	273.3	22.56	17.24	6.995	.251	.939	.757	-.697	18083.4	.939	.749	-.689
9.90	1459.3	26718.6	.044	303.7	24.06	18.31	7.458	.274	.937	.771	-.708	23627.7	.938	.764	-.702
10.80	1746.4	33823.1	.042	334.1	25.51	19.37	7.910	.297	.935	.783	-.718	30197.3	.936	.777	-.712
11.71	2060.9	42059.2	.040	364.5	26.94	20.41	8.352	.321	.934	.793	-.727	37863.6	.934	.788	-.722
12.61	2402.8	51495.0	.038	394.9	28.33	21.43	8.784	.345	.932	.803	-.734	46695.8	.932	.798	-.730
13.51	2772.0	62196.7	.036	425.3	29.88	22.44	9.264	.367	.931	.812	-.743	56761.0	.931	.807	-.737
14.41	3168.3	74381.9	.034	454.1	31.69	23.48	9.824	.387	.931	.822	-.753	68197.8	.931	.817	-.748
15.31	3589.4	88114.9	.033	481.2	29.61	24.55	9.179	.463	.913	.812	-.725	81150.9	.931	.826	-.757
16.21	4038.9	99808.1	.033	536.2	20.93	24.71	6.488	.666	.837	.755	-.591	93914.3	.885	.788	-.674
17.11	4572.0	108176.5	.034	648.0	14.71	23.66	4.559	.850	.735	.688	-.423	103960.2	.749	.701	-.450

MAXIMUM NO. ITERATIONS FOR SOLUTION (KKMAX) = 5 OCCURRED 3 TIMES. AVERAGE NUMBER ITERATIONS = 1.2000

DEPTH (FT)	AREA (SQ FT)	Q (CFS)	TRAVEL TIME(HR)	WIDTH (FT)	ck (FPS)	VEL (FPS)	C	D	C1	C2	C3	Q-M (CFS)	C1-M	C2-M	C3-M
.00	.0	.0	.293	.0	3.23	1.74	1.000	.000	1.000	.000	.000	.0	1.000	.000	.000
.90	11.9	45.1	.214	26.5	3.35	3.78	1.038	.038	.963	.037	.000	7.1	.988	.012	.000
1.80	47.7	286.1	.135	53.0	3.59	5.99	1.113	.113	.899	.101	.000	134.3	.932	.068	.000
2.70	106.5	846.1	.102	77.5	3.90	7.94	1.209	.209	.827	.173	.000	528.4	.861	.139	.000
3.60	187.7	1792.6	.084	103.7	4.22	9.55	1.307	.307	.765	.235	.000	1277.7	.794	.206	.000
4.50	293.6	3224.4	.073	131.5	4.53	10.98	1.405	.405	.712	.288	.000	2461.7	.736	.264	.000
5.40	424.4	5245.5	.065	159.2	4.86	12.36	1.507	.507	.663	.337	.000	4183.3	.686	.314	.000
6.30	580.3	7937.1	.059	187.0	5.20	13.68	1.611	.611	.621	.379	.000	6535.3	.640	.360	.000
7.20	761.2	11375.6	.054	214.8	5.54	14.94	1.716	.716	.583	.417	.000	9596.4	.600	.400	.000
8.10	967.2	15621.1	.050	242.9	5.87	16.15	1.820	.820	.549	.451	.000	13435.1	.565	.435	.000
9.00	1199.5	20675.5	.047	273.3	6.18	17.24	1.916	.916	.522	.478	.000	18083.4	.535	.465	.000
9.90	1459.3	26718.6	.044	303.7	6.50	18.31	2.014	1.014	.496	.504	.000	23627.7	.508	.492	.000

```
       10.80 1746.4  33823.1    .042  334.1     6.81  19.37    2.113  1.113   .473   .527   .000  30197.3    .484
.516   .000
       11.71 2060.9  42059.2    .040  364.5     7.13  20.41    2.211  1.211   .452   .548   .000  37863.6    .462
.538   .000
       12.61 2402.8  51495.0    .038  394.9     7.45  21.43    2.310  1.310   .433   .567   .000  46695.8    .442
.558   .000
       13.51 2772.0  62196.7    .036  425.3     7.77  22.44    2.409  1.409   .415   .585   .000  56761.0    .424
.576   .000
       14.41 3168.3  74381.9    .034  454.1     8.11  23.48    2.513  1.513   .398   .602   .000  68197.8    .406
.594   .000
       15.31 3589.4  88114.9    .033  481.2     8.46  24.55    2.622  1.622   .381   .619   .000  81150.9    .389
.611   .000
       16.21 4038.9  99808.1    .033  536.2     8.51  24.71    2.638  1.638   .379   .621   .000  93914.3    .380
.620   .000
       17.11 4572.0 108176.5    .034  648.0     8.16  23.66    2.531  1.531   .395   .605   .000 103960.2    .388
.612   .000
     MAXIMUM NO. ITERATIONS FOR SOLUTION (KKMAX) =   3 OCCURRED      19 TIMES.  AVERAGE NUMBER ITERATIONS =  1.1263
     Equations solved with two passes: first using the Ponce correction to C1, second using the Fread correction to C1,
C2 and C3
     PRINT HYD           ID=5   CODE=5

                                        OUTFLOW HYDROGRAPH REACH    30.50

        TIME      FLOW          TIME      FLOW          TIME      FLOW          TIME      FLOW          TIME
FLOW
         HRS       CFS           HRS       CFS           HRS       CFS           HRS       CFS           HRS
CFS
         .000        .0         3.750     133.5         7.500       4.7        11.250        .3        15.000
  .0
         .250        .0         4.000      88.0         7.750       3.9        11.500        .2        15.250
  .0
         .500        .0         4.250      57.9         8.000       3.2        11.750        .2        15.500
  .0
         .750        .0         4.500      40.6         8.250       2.6        12.000        .2        15.750
  .0
        1.000        .0         4.750      30.5         8.500       2.2        12.250        .1        16.000
  .0
        1.250        .0         5.000      25.6         8.750       1.8        12.500        .1        16.250
  .0
        1.500        .0         5.250      22.3         9.000       1.5        12.750        .1        16.500
  .0
        1.750        .0         5.500      19.3         9.250       1.2        13.000        .1        16.750
  .0
        2.000        .0         5.750      16.5         9.500       1.0        13.250        .1        17.000
  .0
        2.250        .0         6.000      14.0         9.750        .9        13.500        .1        17.250
  .0
        2.500        .0         6.250      11.8        10.000        .7        13.750        .1        17.500
  .0
        2.750        .0         6.500       9.9        10.250        .6        14.000        .0
        3.000      237.9        6.750       8.2        10.500        .5        14.250        .0
        3.250      281.6        7.000       6.9        10.750        .4        14.500        .0
        3.500      199.9        7.250       5.7        11.000        .3        14.750        .0

       RUNOFF VOLUME =      .39059 INCHES     =      24.7265 ACRE-FEET
       PEAK DISCHARGE RATE =     308.75 CFS  AT   3.100 HOURS   BASIN AREA =  1.1870 SQ. MI.


     *
     ***************************************************************************

     *S*** SUB-BASIN 30 ****
     *
     COMPUTE LT TP       LCODE=1  UPLAND/LAG TIME TRANSITION METHOD
                         NK=3  ISLOPE=-1
                         LENGTH=400 FT   SLOPE=0.006 K=0.7
                         LENGTH=1600 FT  SLOPE=0.006 K=2.0
                         LENGTH=9286 FT  SLOPE=0.0111 K=3.0
                         Kn=.033  CR=0.50

          Tc AND Tp COMPUTED BY UPLAND/LAG TIME PROCEDURE

          SCS UPLAND METHOD FACTORS
                                  LENGTH (FT)      SLOPE (FT/FT)       COMPOSITE K
          SHEET FLOW PORTION         400.0           .006000             .7000
          SHALLOW FLOW PORTION      1600.0           .006000            2.0000
          CHANNEL FLOW PORTION      9286.0           .011100            3.0000
          TOTAL BASIN              11286.0           .010196            2.3738


          LAG EQUATION FACTORS:     Kn=   .0330     TOTAL BASIN LENGTH (FT)=     11286.0
          TOTAL BASIN SLOPE (FT/FT)=    .010196     CENTROUD LENGTH (FT)=         5643.0


          TIME OF CONCENTRATION (HRS)=   .7796     TIME TO PEAK (HRS)=   .5197     LAG TIME (HRS)=   .5847

     COMPUTE NM HYD      ID=1   HYD NO=30   DA= 0.588 SQ MI
                         PER A=95 PER B=5  PER C=0  PER D=0
                         TP=0.0   MASSRAIN=-1
          TIME TO PEAK (hrs)=   .5197
```

```
     K =   .543667HR    TP =   .519715HR    K/TP RATIO =  1.046087     SHAPE CONSTANT, N =  3.374873
     UNIT PEAK =   351.95    CFS   UNIT VOLUME =    1.000       B =   311.08      P60 = 1.6900
     AREA =      .588000 SQ MI    IA =    .64250 INCHES    INF =   1.64900 INCHES PER HOUR
     RUNOFF COMPUTED BY INITIAL ABSTRACTION/INFILTRATION NUMBER METHOD - DT =   .050000

    BULKING FACTOR APPLIED TO HYDROGRAPH.  FACTOR =  1.05000 AT PEAK FLOW.

PRINT HYD           ID=1   CODE=1

                                      OUTFLOW HYDROGRAPH REACH    30.00


    RUNOFF VOLUME =      .41537 INCHES     =      13.0260 ACRE-FEET
    PEAK DISCHARGE RATE =     145.28 CFS  AT   1.900 HOURS   BASIN AREA =   .5880 SQ. MI.



*S
**********************************************************************
*S ADD 30 TO 30.5 TO GET 30.9
ADD HYD             ID=9   HYD NO=30.9 ID I=1 ID II=5
PRINT HYD           ID=9   CODE=1

                                      OUTFLOW HYDROGRAPH REACH    30.90


    RUNOFF VOLUME =      .39880 INCHES     =      37.7524 ACRE-FEET
    PEAK DISCHARGE RATE =     329.34 CFS  AT   3.100 HOURS   BASIN AREA =  1.7750 SQ. MI.



*S
**********************************************************************
*S  **************  TOTAL FLOW OUT OF BOCA NEGRA PART OF QUAIL RANCH
*S  ADD 30.9 TO 20.8 TO GET 20.75
*S
ADD HYD             ID=7  HYD NO=20.75 ID I=9 ID II=8
PRINT HYD           ID=7   CODE=1

                                      OUTFLOW HYDROGRAPH REACH    20.75


    RUNOFF VOLUME =      .40234 INCHES     =     134.6923 ACRE-FEET
    PEAK DISCHARGE RATE =     714.50 CFS  AT   3.050 HOURS   BASIN AREA =  6.2770 SQ. MI.



*
*S
**********************************************************************
*S ROUTE 20.75 THRU 32 IN NATURAL ARROYO TO 32.6
*
COMPUTE RATING CURVE  CID=1   VS NO=1   NO SEGS=1
                      MIN ELEV=5748.37   MAX ELEV=5771.51
                      CH SLOPE=0.009    FP SLOPE=0.009
                      N=0.035           DIST=700.0
                      DIST  ELEV    DIST  ELEV
                        0   5764.7   119 5758.15
                                  227     5752.45 351     5748.37
                                  476     5758.03 594     5764.93
                                  700     5771.51


                                   RATING CURVE VALLEY SECTION  1.0
                                      WATER       FLOW        FLOW        TOP
                                     SURFACE      AREA        RATE        WIDTH
                                       ELEV       SQ FT       CFS         FT
                                    5748.37         .00         .00         .00
                                    5749.59       32.13       92.89       52.77
                                    5750.81      128.52      589.82      105.54
                                    5752.02      289.17     1738.99      158.31
                                    5753.24      510.50     3811.30      202.02
                                    5754.46      780.16     6872.56      240.86
                                    5755.68     1097.12    10979.83      279.69
                                    5756.89     1461.36    16234.66      318.52
                                    5758.11     1872.91    22721.89      357.70
                                    5759.33     2334.69    30417.02      400.68
                                    5760.55     2848.77    39599.05      443.62
                                    5761.77     3415.15    50371.62      486.57
                                    5762.98     4033.84    62836.27      529.52
                                    5764.20     4704.83    77091.55      572.47
                                    5765.42     5423.30    94486.51      601.87
                                    5766.64     6168.19   114613.90      621.49
                                    5767.85     6936.98   136539.10      641.11
                                    5769.07     7729.65   160267.00      660.73
                                    5770.29     8546.22   185806.20      680.35
                                    5771.51     9386.67   213168.90      699.97
ROUTE MCUNGE        ID=6   HYD NO=32.6  INFLOW ID=7
                    DT=0.0   L=3180 FT   NS=0   SLOPE=0.009
                    MATCODE=0 REGCODE=0 CCODE=0 MM CODE=0
```

INFLOW END= 373 TABLE PTS= 20
DT= .050000 QMED= 357.25 CKMED= 5.1554
WIDTH MED= 80.84 NREACH= 7 DX= 454.29

DEPTH (FT)	AREA (SQ FT)	Q (CFS)	TRAVEL TIME(HR)	WIDTH (FT)	ck (FPS)	VEL (FPS)	C	D	C1	C2	C3	Q-M (CFS)	C1-M C2-M	C3-M
.00	.0	.0	.419	.0	2.52	1.33	1.000	.000	1.000	.000	.000	.0	1.000	.000
1.22	32.1	92.9	.306	52.8	4.03	2.89	1.597	.107	.921	.260	-.181	14.6	.945	.010
.045														
2.44	128.5	589.8	.192	105.5	6.38	4.59	2.529	.214	.886	.466	-.351	276.9	.891	.365
-.257														
3.65	289.2	1739.0	.147	158.3	8.33	6.01	3.301	.322	.860	.567	-.428	1085.3	.861	.511
-.371														
4.87	510.5	3811.3	.118	202.0	10.47	7.47	4.148	.441	.842	.642	-.484	2683.3	.848	.609
-.457														
6.09	780.2	6872.6	.100	240.9	12.25	8.81	4.855	.570	.823	.689	-.511	5246.9	.829	.667
-.496														
7.31	1097.1	10979.8	.088	279.7	13.77	10.01	5.456	.697	.805	.720	-.525	8828.6	.810	.704
-.515														
8.52	1461.4	16234.7	.080	318.5	15.16	11.11	6.007	.822	.790	.745	-.534	13506.5	.795	.732
-.527														
9.74	1872.9	22721.9	.073	357.7	16.32	12.13	6.465	.952	.774	.762	-.536	19374.5	.781	.754
-.535														
10.96	2334.7	30417.0	.068	400.7	17.31	13.03	6.858	1.073	.760	.776	-.536	26465.5	.762	.768
-.530														
12.18	2848.8	39599.0	.064	443.6	18.48	13.90	7.323	1.181	.751	.790	-.541	34898.4	.754	.783
-.536														
13.40	3415.2	50371.6	.060	486.6	19.62	14.75	7.774	1.290	.744	.801	-.545	44870.4	.746	.795
-.541														
14.61	4033.8	62836.3	.057	529.5	20.73	15.58	8.214	1.400	.736	.812	-.548	56483.9	.738	.806
-.545														
15.83	4704.8	77091.5	.054	572.5	22.63	16.39	8.965	1.456	.745	.825	-.570	69838.9	.731	.816
-.547														
17.05	5423.3	94486.5	.051	601.9	25.56	17.42	10.126	1.502	.762	.842	-.604	85630.2	.758	.835
-.592														
18.27	6168.2	114613.9	.048	621.5	27.80	18.58	11.015	1.623	.762	.853	-.615	104372.1	.767	.849
-.616														
19.48	6937.0	136539.1	.045	641.1	29.25	19.68	11.591	1.781	.752	.861	-.613	125402.7	.757	.857
-.614														
20.70	7729.7	160267.0	.043	660.7	30.63	20.73	12.136	1.937	.743	.867	-.610	148232.8	.747	.864
-.611														
21.92	8546.2	185806.2	.041	680.3	31.94	21.74	12.655	2.091	.734	.873	-.607	172869.2	.738	.870
-.608														
23.14	9386.7	213168.9	.039	700.0	32.86	22.71	13.022	2.266	.722	.877	-.599	199322.6	.730	.876
-.605														

MAXIMUM NO. ITERATIONS FOR SOLUTION (KKMAX) = 6 OCCURRED 1 TIMES. AVERAGE NUMBER ITERATIONS = 1.2678

DEPTH (FT)	AREA (SQ FT)	Q (CFS)	TRAVEL TIME(HR)	WIDTH (FT)	ck (FPS)	VEL (FPS)	C	D	C1	C2	C3	Q-M (CFS)	C1-M C2-M	C3-M
.00	.0	.0	.419	.0	2.52	1.33	1.000	.000	1.000	.000	.000	.0	1.000	.000
1.22	32.1	92.9	.306	52.8	2.90	2.89	1.149	.149	.871	.129	.000	14.6	.945	.010
.045														
2.44	128.5	589.8	.192	105.5	3.51	4.59	1.390	.390	.720	.280	.000	276.9	.789	.211
.000														
3.65	289.2	1739.0	.147	158.3	4.16	6.01	1.647	.647	.607	.393	.000	1085.3	.656	.344
.000														
4.87	510.5	3811.3	.118	202.0	4.90	7.47	1.942	.942	.515	.485	.000	2683.3	.555	.445
.000														
6.09	780.2	6872.6	.100	240.9	5.64	8.81	2.236	1.236	.447	.553	.000	5246.9	.477	.523
.000														
7.31	1097.1	10979.8	.088	279.7	6.34	10.01	2.514	1.514	.398	.602	.000	8828.6	.420	.580
.000														
8.52	1461.4	16234.7	.080	318.5	7.01	11.11	2.778	1.778	.360	.640	.000	13506.5	.377	.623
.000														
9.74	1872.9	22721.9	.073	357.7	7.65	12.13	3.031	2.031	.330	.670	.000	19374.5	.344	.656
.000														
10.96	2334.7	30417.0	.068	400.7	8.22	13.03	3.258	2.258	.307	.693	.000	26465.5	.318	.682
.000														
12.18	2848.8	39599.0	.064	443.6	8.79	13.90	3.483	2.483	.287	.713	.000	34898.4	.296	.704
.000														
13.40	3415.2	50371.6	.060	486.6	9.35	14.75	3.707	2.707	.270	.730	.000	44870.4	.278	.722
.000														
14.61	4033.8	62836.3	.057	529.5	9.91	15.58	3.928	2.928	.255	.745	.000	56483.9	.262	.738
.000														
15.83	4704.8	77091.5	.054	572.5	10.47	16.39	4.147	3.147	.241	.759	.000	69838.9	.248	.752
.000														
17.05	5423.3	94486.5	.051	601.9	11.19	17.42	4.432	3.432	.226	.774	.000	85630.2	.233	.767
.000														
18.27	6168.2	114613.9	.048	621.5	12.01	18.58	4.757	3.757	.210	.790	.000	104372.1	.218	.782
.000														
19.48	6937.0	136539.1	.045	641.1	12.80	19.68	5.070	4.070	.197	.803	.000	125402.7	.203	.797
.000														
20.70	7729.7	160267.0	.043	660.7	13.56	20.73	5.374	4.374	.186	.814	.000	148232.8	.191	.809
.000														
21.92	8546.2	185806.2	.041	680.3	14.31	21.74	5.669	4.669	.176	.824	.000	172869.2	.181	.819
.000														
23.14	9386.7	213168.9	.039	700.0	15.03	22.71	5.956	4.956	.168	.832	.000	199322.6	.172	

.828 .000

MAXIMUM NO. ITERATIONS FOR SOLUTION (KKMAX) = 4 OCCURRED 5 TIMES. AVERAGE NUMBER ITERATIONS = 1.2393
Equations solved with two passes: first using the Ponce correction to C1, second using the Fread correction to C1, C2 and C3

PRINT HYD ID=6 CODE=5

OUTFLOW HYDROGRAPH REACH 32.60

TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS
.000	.0	4.000	447.3	8.000	15.4	12.000	.9	16.000	.0
.250	.0	4.250	359.1	8.250	12.8	12.250	.7	16.250	.0
.500	.0	4.500	261.2	8.500	10.6	12.500	.6	16.500	.0
.750	.0	4.750	192.5	8.750	8.8	12.750	.5	16.750	.0
1.000	.0	5.000	143.4	9.000	7.3	13.000	.4	17.000	.0
1.250	.0	5.250	110.3	9.250	6.1	13.250	.4	17.250	.0
1.500	.0	5.500	88.7	9.500	5.1	13.500	.3	17.500	.0
1.750	13.1	5.750	75.1	9.750	4.2	13.750	.2	17.750	.0
2.000	362.8	6.000	63.8	10.000	3.5	14.000	.2	18.000	.0
2.250	604.3	6.250	54.0	10.250	2.9	14.250	.2	18.250	.0
2.500	582.2	6.500	45.4	10.500	2.5	14.500	.1	18.500	.0
2.750	534.0	6.750	38.1	10.750	2.1	14.750	.1	18.750	.0
3.000	570.0	7.000	31.8	11.000	1.7	15.000	.1		
3.250	661.2	7.250	26.6	11.250	1.4	15.250	.1		
3.500	589.7	7.500	22.2	11.500	1.2	15.500	.1		
3.750	515.9	7.750	18.5	11.750	1.0	15.750	.1		

RUNOFF VOLUME = .40175 INCHES = 134.4937 ACRE-FEET
PEAK DISCHARGE RATE = 688.37 CFS AT 3.300 HOURS BASIN AREA = 6.2770 SQ. MI.

*
****
*S ADD BASIN 32**********
*
COMPUTE LT TP LCODE=1 UPLAND/LAG TIME TRANSITION METHOD
NK=3 ISLOPE=-1
LENGTH=400 FT SLOPE=0.012 K=0.7
LENGTH=1600 FT SLOPE=0.011 K=2.0
LENGTH=959 FT SLOPE=0.010 K=3.0

Tc AND Tp COMPUTED BY UPLAND/LAG TIME PROCEDURE

SCS UPLAND METHOD FACTORS

	LENGTH (FT)	SLOPE (FT/FT)	COMPOSITE K
SHEET FLOW PORTION	400.0	.012000	.7000
SHALLOW FLOW PORTION	1600.0	.011000	2.0000
CHANNEL FLOW PORTION	959.0	.010000	3.0000
TOTAL BASIN	2959.0	.010811	1.7741

TIME OF CONCENTRATION (HRS)= .4456 TIME TO PEAK (HRS)= .2971 LAG TIME (HRS)= .3342

COMPUTE NM HYD ID=1 HYD NO=32 DA= 0.250 SQ MI
PER A=100 PER B=0 PER C=0 PER D=0
TP=0.0 MASSRAIN=-1
TIME TO PEAK (hrs)= .2971

K = .328093HR TP = .297051HR K/TP RATIO = 1.104499 SHAPE CONSTANT, N = 3.200921
UNIT PEAK = 250.64 CFS UNIT VOLUME = .9999 B = 297.81 P60 = 1.6900
AREA = .250000 SQ MI IA = .65000 INCHES INF = 1.67000 INCHES PER HOUR
RUNOFF COMPUTED BY INITIAL ABSTRACTION/INFILTRATION NUMBER METHOD - DT = .050000

BULKING FACTOR APPLIED TO HYDROGRAPH. FACTOR = 1.05000 AT PEAK FLOW.

PRINT HYD ID=1 CODE=1

OUTFLOW HYDROGRAPH REACH 32.00

RUNOFF VOLUME = .40595 INCHES = 5.4127 ACRE-FEET
PEAK DISCHARGE RATE = 99.71 CFS AT 1.650 HOURS BASIN AREA = .2500 SQ. MI.

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*S
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*S ADD 32 TO 20.75 TO GET 32.9
ADD HYD            ID=9   HYD NO=32.9 ID I=1 ID II=6
PRINT HYD          ID=9   CODE=1

                                    OUTFLOW HYDROGRAPH REACH    32.90


    RUNOFF VOLUME =      .40191 INCHES     =     139.9063 ACRE-FEET
    PEAK DISCHARGE RATE =     692.78 CFS  AT   3.300 HOURS   BASIN AREA =  6.5270 SQ. MI.



*S
**********************************************************************
*
*S ROUTE 32.9 THRU UPPER 39 IN NATURAL ARROYO TO 39.7
*
COMPUTE RATING CURVE  CID=1   VS NO=1   NO SEGS=1
                      MIN ELEV=5681.92   MAX ELEV=5694.67
                      CH SLOPE=0.016    FP SLOPE=0.016
                      N=0.035           DIST=490.0
                      DIST         ELEV    DIST    ELEV
                        0          5694.40 76      5691.91
                                   153     5688.85 244     5683.15
                                   294     5681.92 339     5685.05
                                   403     5690.03 490     5694.67


                                    RATING CURVE VALLEY SECTION  1.0
                                       WATER       FLOW        FLOW        TOP
                                      SURFACE      AREA        RATE        WIDTH
                                       ELEV        SQ FT       CFS         FT
                                     5681.92         .00         .00         .00
                                     5682.59       12.38       32.09       36.92
                                     5683.26       49.38      207.92       71.08
                                     5683.93      103.90      607.11       91.43
                                     5684.60      172.07     1230.77      111.79
                                     5685.27      253.86     2108.34      131.80
                                     5685.95      348.77     3267.32      151.14
                                     5686.62      456.65     4724.90      170.47
                                     5687.29      577.50     6504.56      189.80
                                     5687.96      711.32     8629.27      209.13
                                     5688.63      858.12    11121.39      228.47
                                     5689.30     1018.81    13870.59      251.93
                                     5689.97     1196.39    17001.34      277.44
                                     5690.64     1392.18    20479.51      306.55
                                     5691.31     1607.73    24488.67      336.01
                                     5691.98     1843.05    29054.48      365.86
                                     5692.65     2099.60    34081.44      398.92
                                     5693.33     2378.33    39783.99      431.98
                                     5694.00     2679.23    46195.91      465.04
                                     5694.67     3001.23    53908.09      489.95
ROUTE MCUNGE          ID=5   HYD NO=39.5  INFLOW ID=9
                      DT=0.0   L=1800 FT   NS=0   SLOPE=0.016
                      MATCODE=0 REGCODE=0 CCODE=0 MM CODE=0

          INFLOW END= 380            TABLE PTS= 20
          DT=  .050000               QMED=      346.39  CKMED=      7.3228
          WIDTH MED=       78.14     NREACH=  3         DX=      600.00

       DEPTH   AREA      Q    TRAVEL  WIDTH     ck      VEL      C       D      C1     C2     C3     Q-M      C1-M
C2-M   C3-M
        (FT)  (SQ FT)  (CFS)  TIME(HR) (FT)     (FPS)   (FPS)                                          (CFS)
          .00     .0       .0    .267     .0     3.33   1.15    1.000   .000  1.000   .000   .000       .0   1.000
.000   .000
          .67   12.4     32.1    .193   36.9     3.67   2.59    1.100   .025   .977   .059  -.036      5.1    .996
.009  -.006
         1.34   49.4    207.9    .119   71.1     6.08   4.21    1.825   .050   .965   .304  -.269     97.6    .968
.186  -.153
         2.01  103.9    607.1    .086   91.4     8.40   5.84    2.519   .082   .954   .445  -.399    383.5    .959
.385  -.344
         2.68  172.1   1230.8    .070  111.8    10.04   7.15    3.013   .114   .945   .515  -.460    894.9    .948
.479  -.426
         3.35  253.9   2108.3    .060  131.8    11.54   8.31    3.462   .144   .937   .566  -.503   1644.8    .940
.540  -.479
         4.03  348.8   3267.3    .053  151.1    12.93   9.37    3.878   .174   .931   .604  -.535   2662.3    .933
.585  -.518
         4.70  456.7   4724.9    .048  170.5    14.17  10.35    4.252   .204   .925   .633  -.559   3969.9    .927
.618  -.545
         5.37  577.5   6504.6    .044  189.8    15.35  11.26    4.605   .233   .920   .657  -.578   5587.8    .922
.645  -.567
         6.04  711.3   8629.3    .041  209.1    16.47  12.13    4.941   .261   .916   .678  -.593   7539.2    .917
.667  -.584
         6.71  858.1  11121.4    .039  228.5    17.15  12.96    5.146   .296   .908   .690  -.598   9846.8    .913
.686  -.599
         7.38 1018.8  13870.6    .037  251.9    17.42  13.61    5.225   .329   .900   .695  -.594  12469.6    .901
.689  -.590
         8.05 1196.4  17001.3    .035  277.4    17.79  14.21    5.337   .359   .893   .701  -.594  15408.9    .896
```

```
.698  -.594
        8.72 1392.2  20479.5    .034  306.6    18.21  14.71    5.463   .382   .888   .708  -.596  18713.8    .888
.701  -.589
        9.39 1607.7  24488.7    .033  336.0    19.03  15.23    5.709   .399   .888   .719  -.606  22454.9    .888
.713  -.600
       10.06 1843.1  29054.5    .032  365.9    19.57  15.76    5.871   .423   .884   .726  -.610  26740.1    .887
.723  -.610
       10.73 2099.6  34081.4    .031  398.9    20.05  16.23    6.015   .444   .881   .732  -.613  31536.5    .880
.726  -.606
       11.41 2378.3  39784.0    .030  432.0    20.91  16.73    6.272   .459   .881   .741  -.623  36898.3    .881
.736  -.617
       12.08 2679.2  46195.9    .029  465.0    22.58  17.24    6.773   .458   .889   .757  -.646  42952.7    .881
.745  -.626
       12.75 3001.2  53908.1    .028  489.9    24.08  17.96    7.225   .476   .891   .770  -.661  50002.1    .895
.769  -.665
     MAXIMUM NO. ITERATIONS FOR SOLUTION (KKMAX) =   4 OCCURRED       3 TIMES.  AVERAGE NUMBER ITERATIONS =  1.3322
     Equations solved using the Ponce correction to C2
     PRINT HYD           ID=5   CODE=1

                                        OUTFLOW HYDROGRAPH REACH    39.50


         RUNOFF VOLUME =      .40191 INCHES     =     139.9067 ACRE-FEET
         PEAK DISCHARGE RATE =     691.70 CFS  AT   3.400 HOURS   BASIN AREA =  6.5270 SQ. MI.



     *
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     *S*** SUB-BASIN 33 ****
     *
     COMPUTE LT TP       LCODE=1  UPLAND/LAG TIME TRANSITION METHOD
                         NK=3  ISLOPE=-1
                         LENGTH=400 FT   SLOPE=0.01 K=0.7
                         LENGTH=1600 FT  SLOPE=0.009 K=2.0
                         LENGTH=10392 FT  SLOPE=0.009 K=3.0
                         Kn=.033  CR=0.61

          Tc AND Tp COMPUTED BY UPLAND/LAG TIME PROCEDURE


          LAG EQUATION FACTORS:     Kn=   .0330     TOTAL BASIN LENGTH (FT)=     12392.0
          TOTAL BASIN SLOPE (FT/FT)=    .009032     CENTROUD LENGTH (FT)=         7559.1


          TIME OF CONCENTRATION (HRS)=   .9019     TIME TO PEAK (HRS)=   .6013     LAG TIME (HRS)=   .6765

     COMPUTE NM HYD      ID=1   HYD NO=33   DA= 0.731 SQ MI
                         PER A=100 PER B=0  PER C=0  PER D=0
                         TP=0.0   MASSRAIN=-1
          TIME TO PEAK (hrs)=   .6013

          K =   .632565HR    TP =   .601295HR    K/TP RATIO =  1.052006     SHAPE CONSTANT, N =  3.356146
          UNIT PEAK =   376.48    CFS   UNIT VOLUME =    1.000       B =   309.68      P60 = 1.6900
          AREA =      .731000 SQ MI    IA =    .65000 INCHES    INF =   1.67000 INCHES PER HOUR
          RUNOFF COMPUTED BY INITIAL ABSTRACTION/INFILTRATION NUMBER METHOD - DT =   .050000

         BULKING FACTOR APPLIED TO HYDROGRAPH.  FACTOR =  1.05000 AT PEAK FLOW.

     PRINT HYD           ID=1   CODE=1

                                        OUTFLOW HYDROGRAPH REACH    33.00


         RUNOFF VOLUME =      .40595 INCHES     =      15.8266 ACRE-FEET
         PEAK DISCHARGE RATE =     151.98 CFS  AT   1.950 HOURS   BASIN AREA =   .7310 SQ. MI.



     *S
     ************************************************************************
     *S*** SUB-BASIN 35 ****
     *
     COMPUTE LT TP       LCODE=1  UPLAND/LAG TIME TRANSITION METHOD
                         NK=3  ISLOPE=-1
                         LENGTH=400 FT   SLOPE=0.004 K=0.7
                         LENGTH=1600 FT  SLOPE=0.006 K=2.0
                         LENGTH=11265 FT  SLOPE=0.008 K=3.0
                         Kn=.033  CR=0.50

          Tc AND Tp COMPUTED BY UPLAND/LAG TIME PROCEDURE


          LAG EQUATION FACTORS:     Kn=   .0330     TOTAL BASIN LENGTH (FT)=     13265.0
          TOTAL BASIN SLOPE (FT/FT)=    .007638     CENTROUD LENGTH (FT)=         6632.5
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```
     TIME OF CONCENTRATION (HRS)=   .9083     TIME TO PEAK (HRS)=   .6055     LAG TIME (HRS)=   .6812

COMPUTE NM HYD       ID=2   HYD NO=35   DA= 0.616 SQ MI
                     PER A=100 PER B=0  PER C=0  PER D=0
                     TP=0.0   MASSRAIN=-1
     TIME TO PEAK (hrs)=   .6055

     K =   .636992HR    TP =   .605502HR    K/TP RATIO =  1.052006     SHAPE CONSTANT, N =  3.356146
     UNIT PEAK =   315.05    CFS   UNIT VOLUME =    1.000       B =   309.68      P60 = 1.6900
     AREA =      .616000 SQ MI    IA =    .65000 INCHES    INF =   1.67000 INCHES PER HOUR
     RUNOFF COMPUTED BY INITIAL ABSTRACTION/INFILTRATION NUMBER METHOD - DT =   .050000

    BULKING FACTOR APPLIED TO HYDROGRAPH.  FACTOR =  1.05000 AT PEAK FLOW.

PRINT HYD            ID=2   CODE=1

                                       OUTFLOW HYDROGRAPH REACH    35.00


    RUNOFF VOLUME =      .40595 INCHES     =      13.3368 ACRE-FEET
    PEAK DISCHARGE RATE =     127.16 CFS  AT   2.000 HOURS   BASIN AREA =   .6160 SQ. MI.



*S
**************************************************************************
*S  ADD 33 TO 35 TO GET 35.8
*S
ADD HYD              ID=8  HYD NO=35.8 ID I=1 ID II=2
PRINT HYD            ID=8   CODE=1

                                       OUTFLOW HYDROGRAPH REACH    35.80


    RUNOFF VOLUME =      .40595 INCHES     =      29.1634 ACRE-FEET
    PEAK DISCHARGE RATE =     279.09 CFS  AT   1.950 HOURS   BASIN AREA =  1.3470 SQ. MI.



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*S
**************************************************************************
*S ROUTE 35.8 THRU UPPER 39 IN NATURAL ARROYO TO 36.6
*
COMPUTE RATING CURVE  CID=1   VS NO=1   NO SEGS=1
                      MIN ELEV=5766.06   MAX ELEV=5778.83
                      CH SLOPE=0.013    FP SLOPE=0.013
                      N=0.035           DIST=700.0
                      DIST  ELEV    DIST  ELEV
                        0   5774.95   177 5770.03
                                  320     5766.17 361     5766.06
                                  408     5769.73 494     5778.01
                                  555     5778.83 700     5775.56


                                    RATING CURVE VALLEY SECTION  1.0
                                        WATER       FLOW        FLOW        TOP
                                       SURFACE      AREA        RATE        WIDTH
                                        ELEV        SQ FT       CFS         FT
                                      5766.06         .00         .00         .00
                                      5766.73       34.04      101.44       70.43
                                      5767.40       92.61      414.95      103.92
                                      5768.08      173.68      982.34      137.42
                                      5768.75      277.26     1852.05      170.91
                                      5769.42      403.35     3070.01      204.41
                                      5770.09      551.78     4689.72      236.97
                                      5770.76      721.45     6752.28      268.11
                                      5771.44      912.06     9274.84      299.26
                                      5772.11     1123.59    12291.48      330.41
                                      5772.78     1356.04    15835.27      361.56
                                      5773.45     1609.43    19938.37      392.70
                                      5774.12     1883.74    24632.06      423.85
                                      5774.79     2178.98    29946.89      455.00
                                      5775.47     2490.36    36738.55      467.58
                                      5776.14     2814.27    43063.19      500.20
                                      5776.81     3162.69    49894.73      536.97
                                      5777.48     3535.82    57491.10      573.74
                                      5778.15     3934.31    65250.65      619.72
                                      5778.83     4377.48    71915.94      699.48
ROUTE MCUNGE         ID=7   HYD NO=36.7  INFLOW ID=8
                     DT=0.0   L=2020 FT   NS=0   SLOPE=0.013
                     MATCODE=0 REGCODE=0 CCODE=0 MM CODE=0

     INFLOW END= 385            TABLE PTS= 20
     DT=  .050000               QMED=      139.54  CKMED=      5.3527
     WIDTH MED=       74.50     NREACH=  5         DX=      404.00

      DEPTH   AREA      Q    TRAVEL  WIDTH     ck      VEL      C       D      C1     C2     C3     Q-M      C1-M
C2-M   C3-M
       (FT)  (SQ FT)  (CFS)  TIME(HR) (FT)     (FPS)   (FPS)                                          (CFS)
```

.00	.0	.0	.251	.0	2.24	1.48	1.000	.000	1.000	.000	.000	.0	1.000	.000	.000
.67	34.0	101.4	.188	70.4	5.03	2.98	2.242	.055	.967	.393	-.360	16.0	.982	.240	-.222
1.34	92.6	414.9	.125	103.9	6.36	4.48	2.834	.120	.940	.494	-.434	230.8	.945	.420	-.365
2.02	173.7	982.3	.099	137.4	7.82	5.66	3.483	.174	.925	.571	-.496	669.5	.928	.529	-.458
2.69	277.3	1852.0	.084	170.9	9.12	6.68	4.062	.226	.914	.622	-.536	1386.2	.917	.594	-.511
3.36	403.3	3070.0	.074	204.4	10.35	7.61	4.610	.276	.906	.660	-.566	2428.2	.908	.639	-.547
4.03	551.8	4689.7	.066	237.0	11.58	8.50	5.159	.325	.900	.692	-.591	3844.9	.901	.675	-.577
4.70	721.5	6752.3	.060	268.1	12.75	9.36	5.679	.376	.893	.717	-.610	5684.2	.896	.704	-.600
5.38	912.1	9274.8	.055	299.3	13.79	10.17	6.145	.428	.887	.736	-.623	7975.5	.889	.726	-.615
6.05	1123.6	12291.5	.051	330.4	14.79	10.94	6.590	.479	.881	.752	-.633	10743.8	.883	.744	-.627
6.72	1356.0	15835.3	.048	361.6	15.75	11.68	7.019	.529	.876	.766	-.642	14022.7	.878	.759	-.637
7.39	1609.4	19938.4	.045	392.7	16.68	12.39	7.433	.579	.871	.778	-.649	17844.8	.873	.772	-.645
8.06	1883.7	24632.1	.043	423.9	17.58	13.08	7.835	.629	.867	.789	-.656	22241.9	.868	.783	-.652
8.73	2179.0	29946.9	.041	455.0	19.68	13.74	8.770	.637	.878	.808	-.685	27244.8	.864	.793	-.658
9.41	2490.4	36738.5	.038	467.6	21.04	14.75	9.373	.711	.872	.820	-.691	33277.4	.890	.824	-.714
10.08	2814.3	43063.2	.037	500.2	19.60	15.30	8.733	.836	.842	.811	-.653	39860.3	.846	.809	-.655
10.75	3162.7	49894.7	.036	537.0	20.00	15.78	8.912	.884	.836	.815	-.651	46439.5	.836	.811	-.647
11.42	3535.8	57491.1	.035	573.7	19.98	16.26	8.900	.955	.824	.816	-.640	53650.9	.835	.818	-.653
12.09	3934.3	65250.7	.034	619.7	17.43	16.59	7.765	1.150	.768	.798	-.566	61335.8	.810	.812	-.621
12.77	4377.5	71915.9	.034	699.5	14.42	16.43	6.423	1.358	.691	.772	-.463	68563.9	.707	.778	-.485

MAXIMUM NO. ITERATIONS FOR SOLUTION (KKMAX) = 5 OCCURRED 3 TIMES. AVERAGE NUMBER ITERATIONS = 1.2321

DEPTH (FT)	AREA (SQ FT)	Q (CFS)	TRAVEL TIME(HR)	WIDTH (FT)	ck	VEL (FPS)	C (FPS)	D	C1	C2	C3	Q-M (CFS)	C1-M	C2-M	C3-M
.00	.0	.0	.251	.0	2.24	1.48	1.000	.000	1.000	.000	.000	.0	1.000	.000	.000
.67	34.0	101.4	.188	70.4	2.49	2.98	1.110	.110	.901	.099	.000	16.0	.964	.036	.000
1.34	92.6	414.9	.125	103.9	2.84	4.48	1.267	.267	.789	.211	.000	230.8	.841	.159	.000
2.02	173.7	982.3	.099	137.4	3.20	5.66	1.425	.425	.702	.298	.000	669.5	.741	.259	.000
2.69	277.3	1852.0	.084	170.9	3.55	6.68	1.581	.581	.632	.368	.000	1386.2	.664	.336	.000
3.36	403.3	3070.0	.074	204.4	3.89	7.61	1.735	.735	.577	.423	.000	2428.2	.602	.398	.000
4.03	551.8	4689.7	.066	237.0	4.24	8.50	1.889	.889	.529	.471	.000	3844.9	.551	.449	.000
4.70	721.5	6752.3	.060	268.1	4.59	9.36	2.045	1.045	.489	.511	.000	5684.2	.508	.492	.000
5.38	912.1	9274.8	.055	299.3	4.93	10.17	2.197	1.197	.455	.545	.000	7975.5	.471	.529	.000
6.05	1123.6	12291.5	.051	330.4	5.26	10.94	2.345	1.345	.426	.574	.000	10743.8	.440	.560	.000
6.72	1356.0	15835.3	.048	361.6	5.59	11.68	2.491	1.491	.401	.599	.000	14022.7	.413	.587	.000
7.39	1609.4	19938.4	.045	392.7	5.91	12.39	2.635	1.635	.380	.620	.000	17844.8	.390	.610	.000
8.06	1883.7	24632.1	.043	423.9	6.23	13.08	2.776	1.776	.360	.640	.000	22241.9	.369	.631	.000
8.73	2179.0	29946.9	.041	455.0	6.54	13.74	2.915	1.915	.343	.657	.000	27244.8	.351	.649	.000
9.41	2490.4	36738.5	.038	467.6	7.02	14.75	3.130	2.130	.320	.680	.000	33277.4	.331	.669	.000
10.08	2814.3	43063.2	.037	500.2	7.29	15.30	3.248	2.248	.308	.692	.000	39860.3	.313	.687	.000
10.75	3162.7	49894.7	.036	537.0	7.52	15.78	3.352	2.352	.298	.702	.000	46439.5	.303	.697	.000
11.42	3535.8	57491.1	.035	573.7	7.76	16.26	3.458	2.458	.289	.711	.000	53650.9	.294	.706	.000
12.09	3934.3	65250.7	.034	619.7	7.92	16.59	3.530	2.530	.283	.717	.000	61335.8	.286	.714	.000
12.77	4377.5	71915.9	.034	699.5	7.85	16.43	3.495	2.495	.286	.714	.000	68563.9	.285	.715	.000

MAXIMUM NO. ITERATIONS FOR SOLUTION (KKMAX) = 3 OCCURRED 27 TIMES. AVERAGE NUMBER ITERATIONS = 1.1368

Equations solved with two passes: first using the Ponce correction to C1, second using the Fread correction to C1, C2 and C3

PRINT HYD ID=7 CODE=5

OUTFLOW HYDROGRAPH REACH 36.70

TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS
.000	.0	4.000	24.9	8.000	3.1	12.000	.4	16.000	.0
.250	.0	4.250	21.9	8.250	2.7	12.250	.3	16.250	.0
.500	.0	4.500	19.2	8.500	2.4	12.500	.3	16.500	.0
.750	.0	4.750	16.9	8.750	2.1	12.750	.3	16.750	.0
1.000	.0	5.000	14.8	9.000	1.8	13.000	.2	17.000	.0
1.250	.0	5.250	13.0	9.250	1.6	13.250	.2	17.250	.0
1.500	.0	5.500	11.4	9.500	1.4	13.500	.2	17.500	.0
1.750	68.5	5.750	10.0	9.750	1.2	13.750	.1	17.750	.0
2.000	241.8	6.000	8.8	10.000	1.1	14.000	.1	18.000	.0
2.250	274.4	6.250	7.7	10.250	.9	14.250	.1	18.250	.0
2.500	219.9	6.500	6.7	10.500	.8	14.500	.1	18.500	.0
2.750	152.2	6.750	5.9	10.750	.7	14.750	.1	18.750	.0
3.000	103.6	7.000	5.2	11.000	.6	15.000	.1	19.000	.0
3.250	69.9	7.250	4.5	11.250	.6	15.250	.1	19.250	.0
3.500	47.4	7.500	4.0	11.500	.5	15.500	.1	19.500	.0
3.750	32.2	7.750	3.5	11.750	.4	15.750	.1		

RUNOFF VOLUME = .40524 INCHES = 29.1125 ACRE-FEET
PEAK DISCHARGE RATE = 277.79 CFS AT 2.200 HOURS BASIN AREA = 1.3470 SQ. MI.

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*
**********************************************************************
*S*** SUB-BASIN 36 ****
*
COMPUTE LT TP       LCODE=1  UPLAND/LAG TIME TRANSITION METHOD
                    NK=3  ISLOPE=-1
                    LENGTH=400 FT   SLOPE=0.012 K=0.7
                    LENGTH=1600 FT  SLOPE=0.008 K=2.0
                    LENGTH=5646 FT  SLOPE=0.015 K=3.0
                    Kn=.033  CR=0.50
```

Tc AND Tp COMPUTED BY UPLAND/LAG TIME PROCEDURE

SCS UPLAND METHOD FACTORS

	LENGTH (FT)	SLOPE (FT/FT)	COMPOSITE K
SHEET FLOW PORTION	400.0	.012000	.7000
SHALLOW FLOW PORTION	1600.0	.008000	2.0000
CHANNEL FLOW PORTION	5646.0	.015000	3.0000
TOTAL BASIN	7646.0	.013378	2.2388

LAG EQUATION FACTORS: Kn= .0330 TOTAL BASIN LENGTH (FT)= 7646.0
TOTAL BASIN SLOPE (FT/FT)= .013378 CENTROUD LENGTH (FT)= 3823.0

TIME OF CONCENTRATION (HRS)= .5867 TIME TO PEAK (HRS)= .3912 LAG TIME (HRS)= .4401

```
COMPUTE NM HYD      ID=1   HYD NO=36   DA= 0.407 SQ MI
                    PER A=98 PER B=0  PER C=0  PER D=2
                    TP=0.0   MASSRAIN=-1
```

TIME TO PEAK (hrs)= .3912

K = .231818HR TP = .391163HR K/TP RATIO = .592638 SHAPE CONSTANT, N = 6.391015
UNIT PEAK = 10.231 CFS UNIT VOLUME = .9988 B = 491.65 P60 = 1.6900
AREA = .008140 SQ MI IA = .10000 INCHES INF = .04000 INCHES PER HOUR
RUNOFF COMPUTED BY INITIAL ABSTRACTION/INFILTRATION NUMBER METHOD - DT = .050000

K = .411506HR TP = .391163HR K/TP RATIO = 1.052006 SHAPE CONSTANT, N = 3.356146
UNIT PEAK = 315.77 CFS UNIT VOLUME = 1.000 B = 309.68 P60 = 1.6900
AREA = .398860 SQ MI IA = .65000 INCHES INF = 1.67000 INCHES PER HOUR
RUNOFF COMPUTED BY INITIAL ABSTRACTION/INFILTRATION NUMBER METHOD - DT = .050000

BULKING FACTOR APPLIED TO HYDROGRAPH. FACTOR = 1.05000 AT PEAK FLOW.

```
PRINT HYD           ID=1   CODE=1
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OUTFLOW HYDROGRAPH REACH 36.00

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    RUNOFF VOLUME =      .44594 INCHES     =       9.6798 ACRE-FEET
    PEAK DISCHARGE RATE =     138.58 CFS  AT   1.750 HOURS   BASIN AREA =   .4070 SQ. MI.


*S
*************************************************************************
*S  ADD 35.8 TO 36 TO GET 36.6
*S
ADD HYD             ID=6  HYD NO=36.6 ID I=1 ID II=7
PRINT HYD           ID=6   CODE=1

                                    OUTFLOW HYDROGRAPH REACH    36.60


    RUNOFF VOLUME =      .41468 INCHES     =      38.7921 ACRE-FEET
    PEAK DISCHARGE RATE =     352.26 CFS  AT   2.100 HOURS   BASIN AREA =  1.7540 SQ. MI.


*
*S
*************************************************************************

*S ROUTE 36.6 THRU MID 39 IN NATURAL ARROYO TO 39.7
*
COMPUTE RATING CURVE  CID=1   VS NO=1   NO SEGS=1
                      MIN ELEV=5714.17   MAX ELEV=5716.23
                      CH SLOPE=0.015    FP SLOPE=0.015
                      N=0.035           DIST=600.0
                      DIST  ELEV    DIST  ELEV
                        0   5716.58   50 5715.99
                                  98      5715.76 137     5715.92
                                  301     5714.17 417     5715.74
                                  536     5715.06 600     5716.23


                                   RATING CURVE VALLEY SECTION  1.0
                                      WATER       FLOW        FLOW        TOP
                                     SURFACE      AREA        RATE        WIDTH
                                      ELEV        SQ FT       CFS         FT
                                    5714.17         .00         .00         .00
                                    5714.28         .98         .73       18.17
                                    5714.39        3.94        4.66       36.33
                                    5714.50        8.86       13.73       54.50
                                    5714.60       15.75       29.56       72.66
                                    5714.71       24.61       53.60       90.83
                                    5714.82       35.44       87.15      109.00
                                    5714.93       48.24      131.47      127.16
                                    5715.04       63.01      187.70      145.33
                                    5715.15       80.59      242.45      183.12
                                    5715.25      102.77      315.84      226.18
                                    5715.36      129.62      414.03      269.24
                                    5715.47      161.14      539.03      312.30
                                    5715.58      197.33      693.19      355.36
                                    5715.69      238.18      878.89      398.42
                                    5715.80      283.62     1093.88      443.96
                                    5715.90      335.27     1319.69      509.02
                                    5716.01      392.49     1649.74      540.02
                                    5716.12      451.84     2048.13      555.14
                                    5716.23      512.84     2484.47      570.25
ROUTE MCUNGE          ID=4   HYD NO=39.4  INFLOW ID=6
                      DT=0.0   L=1884 FT   NS=0   SLOPE=0.015
                      MATCODE=0 REGCODE=0 CCODE=0 MM CODE=0

     INFLOW END= 531            TABLE PTS= 20
     DT=  .050000               QMED=      176.13  CKMED=      3.8075
     WIDTH MED=      141.59     NREACH=  6         DX=      314.00

  DEPTH   AREA      Q    TRAVEL  WIDTH     ck      VEL      C       D      C1     C2     C3     Q-M      C1-M
C2-M   C3-M
   (FT)  (SQ FT)  (CFS)  TIME(HR) (FT)     (FPS)   (FPS)                                          (CFS)
     .00     .0       .0    .963     .0     1.74    .34    1.000   .000  1.000   .000   .000       .0   1.000
.000   .000
     .11    1.0       .7    .703   18.2     1.74    .74     .995   .005   .995   .000   .005       .1    .999
.000   .001
     .22    3.9      4.7    .443   36.3     1.72   1.18     .984   .016   .984   .000   .016      2.2    .991
.000   .009
     .33    8.9     13.7    .338   54.5     2.11   1.55    1.210   .025   .977   .105  -.082      8.6    .979
.032  -.011
     .43   15.8     29.6    .279   72.7     2.53   1.88    1.453   .034   .973   .196  -.168     20.9    .974
.145  -.119
     .54   24.6     53.6    .240   90.8     2.93   2.18    1.679   .043   .969   .265  -.234     40.8    .970
.227  -.197
     .65   35.4     87.2    .213  109.0     3.30   2.46    1.892   .051   .965   .320  -.285     69.5    .966
.291  -.257
     .76   48.2    131.5    .192  127.2     3.65   2.73    2.093   .060   .962   .366  -.328    108.4    .963
.341  -.304
     .87   63.0    187.7    .176  145.3     3.57   2.98    2.047   .077   .951   .360  -.311    158.6    .960
.384  -.343
     .98   80.6    242.4    .174  183.1     3.23   3.01    1.851   .087   .941   .319  -.260    214.3    .936
```

```
.297  -.234
        1.08  102.8    315.8    .170  226.2     3.50   3.07    2.004   .085   .945   .353  -.298    278.2    .941
.328  -.269
        1.19  129.6    414.0    .164  269.2     3.82   3.19    2.191   .085   .948   .390  -.338    363.7    .946
.370  -.316
        1.30  161.1    539.0    .156  312.3     4.12   3.35    2.364   .089   .949   .421  -.369    475.0    .948
.404  -.352
        1.41  197.3    693.2    .149  355.4     4.41   3.51    2.529   .094   .948   .448  -.396    614.4    .948
.433  -.381
        1.52  238.2    878.9    .142  398.4     4.65   3.69    2.663   .101   .946   .469  -.415    784.1    .947
.459  -.407
        1.63  283.6   1093.9    .136  444.0     4.60   3.86    2.638   .114   .939   .467  -.406    984.4    .944
.474  -.418
        1.73  335.3   1319.7    .133  509.0     4.99   3.94    2.861   .110   .944   .496  -.441   1205.1    .932
.448  -.380
        1.84  392.5   1649.7    .125  540.0     6.20   4.20    3.555   .105   .955   .571  -.526   1481.4    .953
.549  -.502
        1.95  451.8   2048.1    .115  555.1     6.94   4.53    3.979   .113   .956   .607  -.563   1844.9    .957
.596  -.553
        2.06  512.8   2484.5    .108  570.3     7.30   4.84    4.187   .127   .952   .624  -.576   2262.4    .954
.617  -.571
     MAXIMUM NO. ITERATIONS FOR SOLUTION (KKMAX) =   5 OCCURRED       1 TIMES.  AVERAGE NUMBER ITERATIONS =  1.2085
     Equations solved using the Ponce correction to C2
     PRINT HYD           ID=4   CODE=1

                                          OUTFLOW HYDROGRAPH REACH    39.40


         RUNOFF VOLUME =      .41479 INCHES     =      38.8016 ACRE-FEET
         PEAK DISCHARGE RATE =     351.79 CFS  AT   2.250 HOURS   BASIN AREA =  1.7540 SQ. MI.



     *
     ************************************************************************
     *S  ADD 32.9 TO 39.4 TO GET 39.7
     *S
     ADD HYD             ID=7  HYD NO=39.7 ID I=5 ID II=4
     PRINT HYD           ID=7   CODE=1

                                          OUTFLOW HYDROGRAPH REACH    39.70


         RUNOFF VOLUME =      .40464 INCHES     =     178.7082 ACRE-FEET
         PEAK DISCHARGE RATE =     980.06 CFS  AT   2.350 HOURS   BASIN AREA =  8.2810 SQ. MI.



     *
     *S
     ************************************************************************

     *S ROUTE 39.7 THRU LOWER 39 IN NATURAL ARROYO TO 39.8
     *
     COMPUTE RATING CURVE  CID=1   VS NO=1   NO SEGS=1
                           MIN ELEV=5687.82   MAX ELEV=5701.09
                           CH SLOPE=0.0156    FP SLOPE=0.0156
                           N=0.035           DIST=500.0
                           DIST  ELEV    DIST  ELEV
                             0   5696.81   76 5694.05
                                       174     5692.95 250     5687.82
                                       339     5693.72 432     5699.97
                                       500     5701.09


                                      RATING CURVE VALLEY SECTION  1.0
                                         WATER       FLOW        FLOW        TOP
                                       SURFACE       AREA        RATE       WIDTH
                                         ELEV        SQ FT       CFS         FT
                                      5687.82          .00         .00         .00
                                      5688.52         7.29       19.13       20.88
                                      5689.22        29.15      121.49       41.75
                                      5689.91        65.59      358.20       62.63
                                      5690.61       116.61      771.43       83.50
                                      5691.31       182.20     1398.69      104.38
                                      5692.01       262.37     2274.43      125.25
                                      5692.71       357.12     3430.81      146.13
                                      5693.41       474.15     4452.44      200.86
                                      5694.10       639.70     6019.98      270.20
                                      5694.80       838.70     8821.59      299.82
                                      5695.50      1058.39    12208.82      329.43
                                      5696.20      1298.75    16213.98      359.05
                                      5696.90      1559.69    20953.34      386.27
                                      5697.60      1833.03    26943.03      396.66
                                      5698.29      2113.62    33577.68      407.05
                                      5698.99      2401.47    40847.31      417.44
                                      5699.69      2696.57    48745.13      427.83
                                      5700.39      3002.93    55782.66      457.39
                                      5701.09      3337.10    62694.86      499.79
     ROUTE MCUNGE        ID=6   HYD NO=39.6  INFLOW ID=7
```

DT=0.0 L=2583 FT NS=0 SLOPE=0.0156
MATCODE=0 REGCODE=0 CCODE=0 MM CODE=0

INFLOW END= 537 TABLE PTS= 20
DT= .050000 QMED= 490.03 CKMED= 8.0098
WIDTH MED= 69.29 NREACH= 4 DX= 645.75

DEPTH (FT)	AREA (SQ FT)	Q (CFS)	TRAVEL TIME(HR)	WIDTH (FT)	ck (FPS)	VEL (FPS)	C	D	C1	C2	C3	Q-M (CFS)	C1-M	C2-M	C3-M
.00	.0	.0	.374	.0	3.59	1.21	1.000	.000	1.000	.000	.000	.0	1.000	.000	.000
.70	7.3	19.1	.273	20.9	3.66	2.63	1.021	.025	.976	.022	.002	3.0	.996	.003	.000
1.40	29.2	121.5	.172	41.8	5.80	4.17	1.616	.050	.963	.250	-.212	57.0	.965	.132	-.098
2.09	65.6	358.2	.131	62.6	7.44	5.46	2.074	.076	.952	.365	-.317	223.6	.954	.300	-.253
2.79	116.6	771.4	.108	83.5	8.94	6.62	2.491	.103	.943	.443	-.386	546.3	.945	.401	-.345
3.49	182.2	1398.7	.093	104.4	10.33	7.68	2.878	.129	.936	.501	-.437	1064.6	.937	.470	-.407
4.19	262.4	2274.4	.083	125.3	11.63	8.67	3.243	.155	.930	.545	-.475	1814.4	.931	.522	-.453
4.89	357.1	3430.8	.075	146.1	10.88	9.61	3.032	.214	.899	.529	-.428	2828.9	.926	.562	-.487
5.59	474.2	4452.4	.076	200.9	9.20	9.39	2.566	.239	.874	.474	-.349	3923.6	.851	.444	-.295
6.28	639.7	6020.0	.076	270.2	11.41	9.41	3.180	.194	.911	.543	-.454	5207.4	.880	.483	-.364
6.98	838.7	8821.6	.068	299.8	14.80	10.52	4.126	.197	.926	.624	-.550	7369.5	.928	.608	-.537
7.68	1058.4	12208.8	.062	329.4	16.09	11.54	4.484	.229	.920	.650	-.570	10463.7	.922	.637	-.559
8.38	1298.8	16214.0	.057	359.0	17.44	12.48	4.860	.257	.916	.673	-.589	14159.4	.917	.660	-.577
9.08	1559.7	20953.3	.053	386.3	19.78	13.43	5.514	.272	.920	.705	-.625	18528.5	.915	.685	-.599
9.78	1833.0	26943.0	.049	396.7	22.81	14.70	6.359	.296	.923	.739	-.661	23876.5	.925	.729	-.654
10.47	2113.6	33577.7	.045	407.0	24.48	15.89	6.823	.335	.918	.755	-.673	30191.5	.920	.747	-.667
11.17	2401.5	40847.3	.042	417.4	26.03	17.01	7.257	.373	.914	.768	-.682	37146.1	.916	.762	-.677
11.87	2696.6	48745.1	.040	427.8	25.20	18.08	7.024	.449	.894	.764	-.658	44731.8	.911	.774	-.685
12.57	3002.9	55782.7	.039	457.4	21.92	18.58	6.110	.552	.856	.739	-.595	52228.7	.869	.746	-.615
13.27	3337.1	62694.9	.038	499.8	20.17	18.79	5.622	.617	.829	.724	-.553	59212.1	.838	.728	-.566

MAXIMUM NO. ITERATIONS FOR SOLUTION (KKMAX) = 4 OCCURRED 7 TIMES. AVERAGE NUMBER ITERATIONS = 1.3234
Equations solved using the Ponce correction to C2
PRINT HYD ID=6 CODE=1

OUTFLOW HYDROGRAPH REACH 39.60

RUNOFF VOLUME = .40465 INCHES = 178.7147 ACRE-FEET
PEAK DISCHARGE RATE = 978.30 CFS AT 2.400 HOURS BASIN AREA = 8.2810 SQ. MI.

*
****

*S*** SUB-BASIN 39 ****
*
COMPUTE LT TP LCODE=1 UPLAND/LAG TIME TRANSITION METHOD
NK=3 ISLOPE=-1
LENGTH=400 FT SLOPE=0.015 K=0.7
LENGTH=1600 FT SLOPE=0.015 K=2.0
LENGTH=5883 FT SLOPE=0.002 K=3.0
Kn=.033 CR=0.50

Tc AND Tp COMPUTED BY UPLAND/LAG TIME PROCEDURE

SCS UPLAND METHOD FACTORS

	LENGTH (FT)	SLOPE (FT/FT)	COMPOSITE K
SHEET FLOW PORTION	400.0	.015000	.7000
SHALLOW FLOW PORTION	1600.0	.015000	2.0000
CHANNEL FLOW PORTION	5883.0	.002000	3.0000
TOTAL BASIN	7883.0	.005298	1.9674

LAG EQUATION FACTORS: Kn= .0330 TOTAL BASIN LENGTH (FT)= 7883.0
TOTAL BASIN SLOPE (FT/FT)= .005298 CENTROUD LENGTH (FT)= 3941.5

TIME OF CONCENTRATION (HRS)= .8376 TIME TO PEAK (HRS)= .5584 LAG TIME (HRS)= .6282

COMPUTE NM HYD ID=2 HYD NO=39 DA= 0.341 SQ MI

```
                PER A=99 PER B=0  PER C=0  PER D=1
                TP=0.0   MASSRAIN=-1
     TIME TO PEAK (hrs)=   .5584

     K =   .330923HR    TP =   .558389HR    K/TP RATIO =   .592638     SHAPE CONSTANT, N =  6.391015
     UNIT PEAK =   3.0025    CFS   UNIT VOLUME =    .9958       B =   491.65      P60 = 1.6900
     AREA =      .003410 SQ MI    IA =    .10000 INCHES    INF =    .04000 INCHES PER HOUR
     RUNOFF COMPUTED BY INITIAL ABSTRACTION/INFILTRATION NUMBER METHOD - DT =   .050000


     K =   .587428HR    TP =   .558389HR    K/TP RATIO =  1.052006     SHAPE CONSTANT, N =  3.356146
     UNIT PEAK =   187.22    CFS   UNIT VOLUME =    .9999       B =   309.68      P60 = 1.6900
     AREA =      .337590 SQ MI    IA =    .65000 INCHES    INF =   1.67000 INCHES PER HOUR
     RUNOFF COMPUTED BY INITIAL ABSTRACTION/INFILTRATION NUMBER METHOD - DT =   .050000

    BULKING FACTOR APPLIED TO HYDROGRAPH.  FACTOR =  1.05000 AT PEAK FLOW.

PRINT HYD           ID=2   CODE=1

                                    OUTFLOW HYDROGRAPH REACH    39.00


    RUNOFF VOLUME =      .42594 INCHES     =       7.7465 ACRE-FEET
    PEAK DISCHARGE RATE =      79.51 CFS  AT   1.950 HOURS   BASIN AREA =   .3410 SQ. MI.



*S
**************************************************************************
*S  ADD 39.6 TO 39 TO GET 39.8
*S
ADD HYD             ID=8  HYD NO=39.8 ID I=2 ID II=6
PRINT HYD           ID=8   CODE=1

                                    OUTFLOW HYDROGRAPH REACH    39.80


    RUNOFF VOLUME =      .40549 INCHES     =     186.4611 ACRE-FEET
    PEAK DISCHARGE RATE =    1025.12 CFS  AT   2.400 HOURS   BASIN AREA =  8.6220 SQ. MI.



*
*S
**************************************************************************

*S*** SUB-BASIN 40A ****
*
COMPUTE LT TP       LCODE=1  UPLAND/LAG TIME TRANSITION METHOD
                    NK=3  ISLOPE=-1
                    LENGTH=400 FT   SLOPE=0.033 K=0.7
                    LENGTH=1600 FT  SLOPE=0.013 K=2.0
                    LENGTH=2012 FT  SLOPE=0.016 K=3.0
                    Kn=.033  CR=0.50

     Tc AND Tp COMPUTED BY UPLAND/LAG TIME PROCEDURE

     SCS UPLAND METHOD FACTORS
                              LENGTH (FT)      SLOPE (FT/FT)       COMPOSITE K
     SHEET FLOW PORTION          400.0           .033000             .7000
     SHALLOW FLOW PORTION       1600.0           .013000            2.0000
     CHANNEL FLOW PORTION       2012.0           .016000            3.0000
     TOTAL BASIN                4012.0           .016499            2.0198


     LAG EQUATION FACTORS:     Kn=   .0330     TOTAL BASIN LENGTH (FT)=      4012.0
     TOTAL BASIN SLOPE (FT/FT)=    .016499     CENTROUD LENGTH (FT)=         2006.0


     TIME OF CONCENTRATION (HRS)=   .4288     TIME TO PEAK (HRS)=   .2858     LAG TIME (HRS)=   .3216

COMPUTE NM HYD      ID=1   HYD NO=40A   DA= 0.107 SQ MI
                    PER A=88 PER B=2  PER C=10  PER D=0
                    TP=0.0   MASSRAIN=-1
     TIME TO PEAK (hrs)=   .2858

     K =   .336162HR    TP =   .285837HR    K/TP RATIO =  1.176063     SHAPE CONSTANT, N =  3.016754
     UNIT PEAK =   106.01    CFS   UNIT VOLUME =    .9998       B =   283.19      P60 = 1.6900
     AREA =      .107000 SQ MI    IA =    .61700 INCHES    INF =   1.57760 INCHES PER HOUR
     RUNOFF COMPUTED BY INITIAL ABSTRACTION/INFILTRATION NUMBER METHOD - DT =   .050000

    BULKING FACTOR APPLIED TO HYDROGRAPH.  FACTOR =  1.05000 AT PEAK FLOW.

PRINT HYD           ID=1   CODE=1

                                    HYDROGRAPH FROM AREA 40A


    RUNOFF VOLUME =      .44800 INCHES     =       2.5566 ACRE-FEET
    PEAK DISCHARGE RATE =      46.49 CFS  AT   1.650 HOURS   BASIN AREA =   .1070 SQ. MI.
```

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*S
*************************************************************************
*S  ADD 40A TO 39.8 TO GET 40A.9
*S
ADD HYD             ID=9  HYD NO=40A.9 ID I=1 ID II=8
PRINT HYD           ID=9   CODE=1

                                        HYDROGRAPH FROM AREA 40A.9


    RUNOFF VOLUME =      .40601 INCHES     =     189.0177 ACRE-FEET
    PEAK DISCHARGE RATE =    1031.81 CFS  AT   2.400 HOURS   BASIN AREA =  8.7290 SQ. MI.



*
*S
*************************************************************************
*S ROUTE 40A.9 THRU 40 IN NATURAL ARROYO TO 40.5
*
COMPUTE RATING CURVE  CID=1   VS NO=1   NO SEGS=1
                      MIN ELEV=5636.01   MAX ELEV=5641.34
                      CH SLOPE=0.0097    FP SLOPE=0.0097
                      N=0.035           DIST=600.0
                      DIST  ELEV    DIST  ELEV
                        0   5643.37   111 5641.34
                                  223     5638.84 301     5636.01
                                  448     5641.12 600     5639.78


                                     RATING CURVE VALLEY SECTION  1.0
                                        WATER       FLOW        FLOW        TOP
                                      SURFACE       AREA        RATE        WIDTH
                                       ELEV         SQ FT       CFS         FT
                                     5636.01          .00         .00         .00
                                     5636.29         2.22        2.51       15.81
                                     5636.57         8.88       15.91       31.63
                                     5636.85        19.98       46.92       47.44
                                     5637.13        35.52      101.05       63.26
                                     5637.41        55.50      183.22       79.07
                                     5637.69        79.92      297.93       94.89
                                     5637.98       108.78      449.41      110.70
                                     5638.26       142.08      641.64      126.51
                                     5638.54       179.82      878.41      142.33
                                     5638.82       222.00     1163.37      158.14
                                     5639.10       269.20     1480.25      178.41
                                     5639.38       322.19     1856.47      199.06
                                     5639.66       380.98     2298.41      219.72
                                     5639.94       447.03     2691.56      258.59
                                     5640.22       527.00     3130.66      311.08
                                     5640.50       621.71     3716.46      363.58
                                     5640.78       731.16     4451.06      416.07
                                     5641.06       855.34     5340.96      468.57
                                     5641.34       990.70     6629.10      489.24
ROUTE MCUNGE        ID=6   HYD NO=40.6  INFLOW ID=9
                    DT=0.0   L=2390 FT   NS=0   SLOPE=0.0097
                    MATCODE=0 REGCODE=0 CCODE=0 MM CODE=0

        INFLOW END= 541           TABLE PTS= 20
        DT=  .050000              QMED=      515.91  CKMED=      5.7725
        WIDTH MED=      116.17    NREACH=  5         DX=      478.00

      DEPTH   AREA      Q    TRAVEL  WIDTH     ck      VEL      C       D      C1     C2     C3     Q-M      C1-M
C2-M   C3-M
       (FT)  (SQ FT)  (CFS)  TIME(HR) (FT)     (FPS)   (FPS)                                          (CFS)
        .00     .0       .0    .806     .0     2.66     .52    1.000   .000  1.000   .000   .000       .0   1.000
.000   .000
        .28    2.2      2.5    .588   15.8     2.62    1.13     .987   .013   .987   .000   .013       .4    .998
.000   .002
        .56    8.9     15.9    .370   31.6     2.54    1.79     .957   .043   .957   .000   .043      7.5    .976
.000   .024
        .84   20.0     46.9    .283   47.4     3.20    2.35    1.205   .067   .941   .119  -.061     29.3    .945
.047   .008
       1.12   35.5    101.1    .233   63.3     3.84    2.84    1.447   .090   .929   .212  -.141     71.6    .932
.161  -.094
       1.40   55.5    183.2    .201   79.1     4.44    3.30    1.672   .113   .919   .282  -.201    139.5    .922
.244  -.166
       1.68   79.9    297.9    .178   94.9     5.00    3.73    1.884   .135   .910   .338  -.248    237.7    .913
.308  -.221
       1.97  108.8    449.4    .161  110.7     5.54    4.13    2.085   .158   .902   .383  -.286    370.6    .905
.359  -.264
       2.25  142.1    641.6    .147  126.5     6.04    4.52    2.276   .181   .895   .421  -.317    542.2    .898
.401  -.299
       2.53  179.8    878.4    .136  142.3     6.53    4.88    2.460   .204   .889   .454  -.343    756.5    .891
.437  -.328
       2.81  222.0   1163.4    .127  158.1     6.81    5.24    2.563   .233   .877   .473  -.350   1017.2    .885
.468  -.353
       3.09  269.2   1480.2    .121  178.4     6.92    5.50    2.607   .259   .866   .483  -.349   1318.4    .866
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.470  -.336
      3.37  322.2   1856.5    .115  199.1     7.32   5.76    2.757   .275   .864   .504  -.368   1664.7    .864
.492  -.356
      3.65  381.0   2298.4    .110  219.7     6.84   6.03    2.575   .330   .831   .488  -.319   2073.4    .862
.514  -.375
      3.93  447.0   2691.6    .110  258.6     5.75   6.02    2.166   .390   .780   .438  -.218   2492.5    .785
.442  -.227
      4.21  527.0   3130.7    .112  311.1     5.87   5.94    2.209   .370   .793   .441  -.235   2908.3    .768
.423  -.190
      4.49  621.7   3716.5    .111  363.6     6.47   5.98    2.435   .341   .819   .470  -.290   3419.5    .807
.456  -.264
      4.77  731.2   4451.1    .109  416.1     6.95   6.09    2.618   .332   .832   .494  -.326   4078.4    .826
.482  -.307
      5.05  855.3   5341.0    .106  468.6     8.20   6.24    3.087   .300   .863   .544  -.407   4889.5    .835
.503  -.338
      5.33  990.7   6629.1    .099  489.2     9.74   6.69    3.669   .300   .879   .598  -.477   5972.3    .885
.591  -.476
 MAXIMUM NO. ITERATIONS FOR SOLUTION (KKMAX) =   4 OCCURRED       3 TIMES.  AVERAGE NUMBER ITERATIONS =  1.3108
 Equations solved using the Ponce correction to C2
 PRINT HYD           ID=6   CODE=1

                                        OUTFLOW HYDROGRAPH REACH    40.60


     RUNOFF VOLUME =      .40599 INCHES     =     189.0080 ACRE-FEET
     PEAK DISCHARGE RATE =    1029.72 CFS  AT   2.500 HOURS   BASIN AREA =  8.7290 SQ. MI.



 *
 ************************************************************************

 *S*** SUB-BASIN 40 ****
 *
 COMPUTE LT TP       LCODE=1  UPLAND/LAG TIME TRANSITION METHOD
                     NK=3  ISLOPE=-1
                     LENGTH=400 FT   SLOPE=0.052 K=0.7
                     LENGTH=1600 FT  SLOPE=0.020 K=2.0
                     LENGTH=2836 FT  SLOPE=0.026 K=3.0
                     Kn=.033  CR=0.50

      Tc AND Tp COMPUTED BY UPLAND/LAG TIME PROCEDURE

      SCS UPLAND METHOD FACTORS
                                LENGTH (FT)      SLOPE (FT/FT)       COMPOSITE K
      SHEET FLOW PORTION           400.0           .052000             .7000
      SHALLOW FLOW PORTION        1600.0           .020000            2.0000
      CHANNEL FLOW PORTION        2836.0           .026000            3.0000
      TOTAL BASIN                 4836.0           .026165            2.1316


      LAG EQUATION FACTORS:     Kn=   .0330     TOTAL BASIN LENGTH (FT)=      4836.0
      TOTAL BASIN SLOPE (FT/FT)=    .026165     CENTROUD LENGTH (FT)=         2418.0


      TIME OF CONCENTRATION (HRS)=   .3611     TIME TO PEAK (HRS)=   .2407     LAG TIME (HRS)=   .2708

 COMPUTE NM HYD      ID=1   HYD NO=40   DA= 0.356 SQ MI
                     PER A=88 PER B=2  PER C=10  PER D=0
                     TP=0.0   MASSRAIN=-1
      TIME TO PEAK (hrs)=   .2407

      K =   .246967HR    TP =   .240717HR    K/TP RATIO =  1.025965     SHAPE CONSTANT, N =  3.440588
      UNIT PEAK =   467.29    CFS   UNIT VOLUME =    1.000       B =   315.97      P60 = 1.6900
      AREA =      .356000 SQ MI    IA =    .61700 INCHES    INF =   1.57760 INCHES PER HOUR
      RUNOFF COMPUTED BY INITIAL ABSTRACTION/INFILTRATION NUMBER METHOD - DT =   .050000

     BULKING FACTOR APPLIED TO HYDROGRAPH.  FACTOR =  1.05000 AT PEAK FLOW.

 PRINT HYD           ID=1   CODE=1

                                        OUTFLOW HYDROGRAPH REACH    40.00


     RUNOFF VOLUME =      .44800 INCHES     =       8.5060 ACRE-FEET
     PEAK DISCHARGE RATE =     201.31 CFS  AT   1.600 HOURS   BASIN AREA =   .3560 SQ. MI.



 *S
 ************************************************************************
 *S  ADD 40 TO 40A.9 TO GET 40.5
 *S
 ADD HYD             ID=5  HYD NO=40.5 ID I=1 ID II=6
 PRINT HYD           ID=5   CODE=1

                                        OUTFLOW HYDROGRAPH REACH    40.50


     RUNOFF VOLUME =      .40764 INCHES     =     197.5141 ACRE-FEET
     PEAK DISCHARGE RATE =    1044.04 CFS  AT   2.500 HOURS   BASIN AREA =  9.0850 SQ. MI.
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*
*S
*************************************************************************
*S ROUTE 40.5 THRU UPPER 41A IN NATURAL ARROYO TO 41A.9
*
COMPUTE RATING CURVE  CID=1   VS NO=1   NO SEGS=1
                      MIN ELEV=5518.27   MAX ELEV=5549.49
                      CH SLOPE=0.032    FP SLOPE=0.032
                      N=0.035           DIST=400.0
                      DIST  ELEV    DIST  ELEV
                        0   5546.63   70 5541.99
                                  134     5529.86 200     5518.27
                                  228     5519.99 260     5530.34
                                  322     5545.97 400     5549.49


                                     RATING CURVE VALLEY SECTION  1.0
                                        WATER       FLOW        FLOW        TOP
                                       SURFACE      AREA        RATE        WIDTH
                                        ELEV        SQ FT       CFS         FT
                                      5518.27         .00         .00         .00
                                      5519.91       29.66      196.88       36.10
                                      5521.56      102.47     1220.99       51.56
                                      5523.20      199.04     3124.50       65.99
                                      5524.84      319.32     6011.90       80.43
                                      5526.49      463.34    10004.45       94.87
                                      5528.13      631.07    15222.14      109.30
                                      5529.77      822.52    21781.31      123.74
                                      5531.41     1037.69    29757.30      138.47
                                      5533.06     1277.67    39263.71      153.65
                                      5534.70     1542.61    50471.71      168.84
                                      5536.34     1832.50    63491.66      184.02
                                      5537.99     2147.34    78430.69      199.21
                                      5539.63     2487.13    95392.95      214.40
                                      5541.27     2851.88   114480.00      229.58
                                      5542.92     3245.78   132907.50      253.85
                                      5544.56     3688.59   152355.30      285.16
                                      5546.20     4183.34   173934.70      320.69
                                      5547.85     4749.38   197925.00      363.55
                                      5549.49     5376.63   228588.40      399.96
ROUTE MCUNGE          ID=61   HYD NO=41A.61  INFLOW ID=5
                      DT=0.0   L=4947 FT   NS=0   SLOPE=0.032
                      MATCODE=0 REGCODE=0 CCODE=0 MM CODE=0

          INFLOW END= 546            TABLE PTS= 20
          DT=  .050000               QMED=      522.02  CKMED=     14.0657
          WIDTH MED=       41.01     NREACH=  4         DX=     1236.75

       DEPTH   AREA      Q    TRAVEL  WIDTH     ck      VEL      C       D      C1     C2     C3     Q-M      C1-M
C2-M   C3-M
        (FT)  (SQ FT)  (CFS)  TIME(HR) (FT)     (FPS)   (FPS)                                          (CFS)
         .00     .0       .0    .299     .0     6.87   2.56    1.000   .000  1.000   .000   .000       .0   1.000
.000   .000
        1.64   29.7    196.9    .207   36.1     9.60   6.64    1.397   .014   .988   .171  -.159     31.0    .998
.027  -.025
        3.29  102.5   1221.0    .115   51.6    17.58  11.92    2.559   .034   .981   .443  -.424    602.5    .984
.350  -.334
        4.93  199.0   3124.5    .088   66.0    22.23  15.70    3.236   .054   .975   .534  -.509   2070.4    .977
.487  -.464
        6.57  319.3   6011.9    .073   80.4    26.13  18.83    3.803   .072   .970   .590  -.560   4464.2    .972
.560  -.532
        8.22  463.3  10004.5    .064   94.9    29.62  21.59    4.311   .090   .967   .630  -.596   7901.1    .968
.608  -.576
        9.86  631.1  15222.1    .057  109.3    32.85  24.12    4.781   .107   .964   .660  -.624  12502.4    .965
.644  -.609
       11.50  822.5  21781.3    .052  123.7    35.81  26.48    5.212   .124   .961   .684  -.645  18386.8    .962
.672  -.634
       13.14 1037.7  29757.3    .048  138.5    38.48  28.68    5.600   .141   .958   .703  -.661  25651.2    .959
.693  -.652
       14.79 1277.7  39263.7    .045  153.7    41.06  30.73    5.977   .157   .956   .720  -.676  34388.4    .956
.711  -.667
       16.43 1542.6  50471.7    .042  168.8    43.70  32.72    6.361   .173   .954   .735  -.689  44740.3    .955
.727  -.681
       18.07 1832.5  63491.7    .040  184.0    46.27  34.65    6.734   .188   .952   .748  -.700  56849.0    .953
.741  -.694
       19.72 2147.3  78430.7    .038  199.2    48.76  36.52    7.097   .204   .951   .759  -.710  70823.5    .951
.753  -.704
       21.36 2487.1  95392.9    .036  214.4    51.20  38.35    7.451   .220   .949   .769  -.719  86769.2    .950
.764  -.714
       23.00 2851.9 114480.0    .034  229.6    50.02  40.14    7.280   .252   .941   .766  -.707 104789.0    .948
.774  -.722
       24.65 3245.8 132907.5    .034  253.9    45.54  40.95    6.628   .291   .927   .747  -.674 123589.8    .931
.751  -.681
       26.29 3688.6 152355.3    .033  285.2    43.88  41.30    6.386   .308   .920   .740  -.660 142533.5    .921
.740  -.661
       27.93 4183.3 173934.7    .033  320.7    43.32  41.58    6.306   .316   .917   .738  -.655 163042.6    .917
.737  -.655
       29.58 4749.4 197925.0    .033  363.5    45.68  41.67    6.649   .301   .924   .748  -.673 185816.9    .914
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.734  -.649
      31.22 5376.6 228588.4    .032  400.0    47.80  42.52    6.957   .302   .927   .758  -.685 213090.9    .931
.762  -.693
     MAXIMUM NO. ITERATIONS FOR SOLUTION (KKMAX) =   4 OCCURRED       6 TIMES.  AVERAGE NUMBER ITERATIONS =  1.3662
       DEPTH   AREA      Q    TRAVEL  WIDTH     ck       VEL      C       D      C1     C2     C3     Q-M      C1-M
C2-M   C3-M
        (FT)  (SQ FT)  (CFS)  TIME(HR) (FT)     (FPS)   (FPS)                                          (CFS)
         .00     .0       .0    .299     .0     6.87   2.56    1.000   .000  1.000   .000   .000       .0   1.000
.000   .000
        1.64   29.7    196.9    .207   36.1     7.01   6.64    1.020   .020   .981   .019   .000     31.0    .994
.006   .000
        3.29  102.5   1221.0    .115   51.6     7.42  11.92    1.081   .081   .925   .075   .000    602.5    .954
.046   .000
        4.93  199.0   3124.5    .088   66.0     7.91  15.70    1.151   .151   .869   .131   .000   2070.4    .896
.104   .000
        6.57  319.3   6011.9    .073   80.4     8.41  18.83    1.224   .224   .817   .183   .000   4464.2    .841
.159   .000
        8.22  463.3  10004.5    .064   94.9     8.92  21.59    1.299   .299   .770   .230   .000   7901.1    .792
.208   .000
        9.86  631.1  15222.1    .057  109.3     9.43  24.12    1.373   .373   .728   .272   .000  12502.4    .748
.252   .000
       11.50  822.5  21781.3    .052  123.7     9.94  26.48    1.447   .447   .691   .309   .000  18386.8    .709
.291   .000
       13.14 1037.7  29757.3    .048  138.5    10.44  28.68    1.520   .520   .658   .342   .000  25651.2    .674
.326   .000
       14.79 1277.7  39263.7    .045  153.7    10.93  30.73    1.591   .591   .629   .371   .000  34388.4    .643
.357   .000
       16.43 1542.6  50471.7    .042  168.8    11.42  32.72    1.662   .662   .602   .398   .000  44740.3    .615
.385   .000
       18.07 1832.5  63491.7    .040  184.0    11.90  34.65    1.732   .732   .577   .423   .000  56849.0    .589
.411   .000
       19.72 2147.3  78430.7    .038  199.2    12.39  36.52    1.803   .803   .555   .445   .000  70823.5    .565
.435   .000
       21.36 2487.1  95392.9    .036  214.4    12.87  38.35    1.873   .873   .534   .466   .000  86769.2    .544
.456   .000
       23.00 2851.9 114480.0    .034  229.6    13.35  40.14    1.944   .944   .515   .485   .000 104789.0    .524
.476   .000
       24.65 3245.8 132907.5    .034  253.9    13.57  40.95    1.975   .975   .506   .494   .000 123589.8    .510
.490   .000
       26.29 3688.6 152355.3    .033  285.2    13.66  41.30    1.988   .988   .503   .497   .000 142533.5    .505
.495   .000
       27.93 4183.3 173934.7    .033  320.7    13.73  41.58    1.998   .998   .500   .500   .000 163042.6    .502
.498   .000
       29.58 4749.4 197925.0    .033  363.5    13.75  41.67    2.001  1.001   .500   .500   .000 185816.9    .500
.500   .000
       31.22 5376.6 228588.4    .032  400.0    13.97  42.52    2.034  1.034   .492   .508   .000 213090.9    .496
.504   .000
     MAXIMUM NO. ITERATIONS FOR SOLUTION (KKMAX) =   3 OCCURRED      24 TIMES.  AVERAGE NUMBER ITERATIONS =  1.2534
     Equations solved with two passes: first using the Ponce correction to C1, second using the Fread correction to C1,
C2 and C3
     PRINT HYD           ID=61   CODE=1

                                          HYDROGRAPH FROM AREA 41A.61


        RUNOFF VOLUME =      .40754 INCHES     =     197.4664 ACRE-FEET
        PEAK DISCHARGE RATE =    1042.92 CFS  AT   2.700 HOURS   BASIN AREA =  9.0850 SQ. MI.


     *
     **********************************************************************

     *S ROUTE 40.5 THRU LOWER 41A IN NATURAL ARROYO TO 41A.9
     *
     COMPUTE RATING CURVE  CID=1   VS NO=1   NO SEGS=1
                           MIN ELEV=5457.93   MAX ELEV=5504.28
                           CH SLOPE=0.017    FP SLOPE=0.017
                           N=0.035           DIST=400.0
                           DIST  ELEV    DIST  ELEV
                             0   5485.62   37 5499.76
                                       75     5504.28 121     5489.83
                                      155     5469.83 201     5457.93
                                      233     5470.10 265     5490.19
                                      288     5499.91 336     5502.91
                                      400     5504.19


                                     RATING CURVE VALLEY SECTION  1.0
                                        WATER       FLOW        FLOW        TOP
                                       SURFACE      AREA        RATE        WIDTH
                                        ELEV        SQ FT       CFS         FT
                                      5457.93         .00         .00         .00
                                      5460.37       19.33      118.38       15.84
                                      5462.81       77.30      751.67       31.69
                                      5465.25      173.93     2216.17       47.53
                                      5467.69      309.21     4772.79       63.38
                                      5470.13      483.05     8694.58       78.55
                                      5472.57      684.46    14462.26       86.58
                                      5475.01      905.47    21604.93       94.61
                                      5477.45     1146.08    30157.85      102.65
```

5479.89	1406.28	40167.77	110.68
5482.32	1686.07	51687.35	118.71
5484.76	1985.47	64772.37	126.75
5487.20	2307.73	78117.62	138.92
5489.64	2664.21	92780.25	153.34
5492.08	3061.00	108294.30	172.56
5494.52	3506.25	126514.40	192.48
5496.96	4000.10	147812.70	212.40
5499.40	4542.54	172341.40	232.32
5501.84	5171.52	186034.50	290.61
5504.28	5994.23	194576.60	400.00

ROUTE MCUNGE ID=6 HYD NO=41A.6 INFLOW ID=61
DT=0.0 L=1702 FT NS=0 SLOPE=0.017
MATCODE=0 REGCODE=0 CCODE=0 MM CODE=0

INFLOW END= 550 TABLE PTS= 20
DT= .050000 QMED= 521.46 CKMED= 10.9231
WIDTH MED= 25.93 NREACH= 2 DX= 851.00

DEPTH (FT)	AREA (SQ FT)	Q (CFS)	TRAVEL TIME(HR)	WIDTH (FT)	ck (FPS)	VEL (FPS)	C	D	C1	C2	C3	Q-M (CFS)	C1-M	C2-M	C3-M
.00	.0	.0	.106	.0	4.73	2.82	1.000	.000	1.000	.000	.000	.0	1.000	.000	.000
2.44	19.3	118.4	.077	15.8	8.54	6.13	1.807	.060	.958	.302	-.260	18.6	.970	.057	-.028
4.88	77.3	751.7	.049	31.7	13.52	9.72	2.861	.121	.939	.498	-.437	352.8	.942	.401	-.343
7.32	173.9	2216.2	.037	47.5	17.36	12.74	3.671	.186	.924	.588	-.512	1383.1	.926	.538	-.464
9.76	309.2	4772.8	.031	63.4	20.96	15.44	4.433	.248	.913	.648	-.561	3379.7	.914	.615	-.529
12.20	483.0	8694.6	.026	78.5	25.22	18.00	5.335	.303	.909	.699	-.607	6605.6	.906	.670	-.576
14.64	684.5	14462.3	.022	86.6	30.66	21.13	6.485	.377	.904	.746	-.650	11436.3	.909	.729	-.639
17.08	905.5	21604.9	.020	94.6	34.07	23.86	7.207	.463	.893	.769	-.662	17898.3	.898	.758	-.655
19.52	1146.1	30157.9	.018	102.6	37.12	26.31	7.852	.547	.884	.787	-.671	25749.9	.887	.778	-.666
21.96	1406.3	40167.8	.017	110.7	39.92	28.56	8.443	.628	.875	.801	-.677	35033.4	.879	.794	-.673
24.39	1686.1	51687.3	.015	118.7	42.52	30.66	8.994	.708	.868	.813	-.681	45799.1	.871	.807	-.678
26.83	1985.5	64772.4	.014	126.7	42.96	32.62	9.088	.822	.849	.817	-.666	58101.6	.864	.818	-.682
29.27	2307.7	78117.6	.014	138.9	41.40	33.85	8.758	.939	.824	.813	-.637	71343.9	.830	.811	-.641
31.71	2664.2	92780.3	.014	153.3	40.46	34.82	8.558	1.034	.805	.811	-.616	85348.8	.816	.813	-.628
34.15	3061.0	108294.3	.013	172.6	40.09	35.38	8.479	1.082	.795	.811	-.606	100443.3	.788	.807	-.595
36.59	3506.3	126514.4	.013	192.5	42.09	36.08	8.903	1.079	.803	.818	-.621	117293.3	.797	.814	-.611
39.03	4000.1	147812.7	.013	212.4	44.23	36.95	9.356	1.087	.810	.825	-.635	137033.9	.806	.821	-.627
41.47	4542.5	172341.4	.012	232.3	34.09	37.94	7.210	1.504	.690	.794	-.484	159930.0	.811	.828	-.640
43.91	5171.5	186034.5	.013	290.6	15.63	35.97	3.306	2.831	.207	.720	.073	179102.8	.426	.741	-.168
46.35	5994.2	194576.6	.015	400.0	9.87	32.46	2.088	3.407	-.049	.692	.357	190096.5	.085	.707	.208

MAXIMUM NO. ITERATIONS FOR SOLUTION (KKMAX) = 5 OCCURRED 1 TIMES. AVERAGE NUMBER ITERATIONS = 1.3642
Equations solved using the Ponce correction to C2
PRINT HYD ID=6 CODE=1

HYDROGRAPH FROM AREA 41A.6

RUNOFF VOLUME = .40756 INCHES = 197.4741 ACRE-FEET
PEAK DISCHARGE RATE = 1042.38 CFS AT 2.750 HOURS BASIN AREA = 9.0850 SQ. MI.

*
****

*S*** SUB-BASIN 41A ****
*
COMPUTE LT TP LCODE=1 UPLAND/LAG TIME TRANSITION METHOD
NK=3 ISLOPE=-1
LENGTH=400 FT SLOPE=0.022 K=0.7
LENGTH=1600 FT SLOPE=0.014 K=2.0
LENGTH=6215 FT SLOPE=0.036 K=3.0
Kn=.033 CR=0.50

Tc AND Tp COMPUTED BY UPLAND/LAG TIME PROCEDURE

SCS UPLAND METHOD FACTORS

	LENGTH (FT)	SLOPE (FT/FT)	COMPOSITE K
SHEET FLOW PORTION	400.0	.022000	.7000

SHALLOW FLOW PORTION	1600.0	.014000	2.0000
CHANNEL FLOW PORTION	6215.0	.036000	3.0000
TOTAL BASIN	8215.0	.031033	2.1657

LAG EQUATION FACTORS: Kn= .0330 TOTAL BASIN LENGTH (FT)= 8215.0
TOTAL BASIN SLOPE (FT/FT)= .031033 CENTROUD LENGTH (FT)= 4107.5

TIME OF CONCENTRATION (HRS)= .4932 TIME TO PEAK (HRS)= .3288 LAG TIME (HRS)= .3699

```
COMPUTE NM HYD      ID=1   HYD NO=41A   DA= 0.453 SQ MI
                    PER A=70 PER B=0  PER C=30  PER D=0
                    TP=0.0   MASSRAIN=-1
```

TIME TO PEAK (hrs)= .3288

K = .322545HR TP = .328797HR K/TP RATIO = .980987 SHAPE CONSTANT, N = 3.599799
UNIT PEAK = 451.27 CFS UNIT VOLUME = 1.000 B = 327.54 P60 = 1.6900
AREA = .453000 SQ MI IA = .56000 INCHES INF = 1.41800 INCHES PER HOUR
RUNOFF COMPUTED BY INITIAL ABSTRACTION/INFILTRATION NUMBER METHOD - DT = .050000

BULKING FACTOR APPLIED TO HYDROGRAPH. FACTOR = 1.05000 AT PEAK FLOW.

```
PRINT HYD           ID=1   CODE=1
```

HYDROGRAPH FROM AREA 41A

RUNOFF VOLUME = .52701 INCHES = 12.7325 ACRE-FEET
PEAK DISCHARGE RATE = 230.97 CFS AT 1.700 HOURS BASIN AREA = .4530 SQ. MI.

```
*S
**************************************************************************
*S  ADD 41A TO 40.5 TO GET 41A.9
*S
ADD HYD             ID=9  HYD NO=41A.9 ID I=1 ID II=6
PRINT HYD           ID=9   CODE=1
```

HYDROGRAPH FROM AREA 41A.9

RUNOFF VOLUME = .41323 INCHES = 210.2065 ACRE-FEET
PEAK DISCHARGE RATE = 1060.60 CFS AT 2.750 HOURS BASIN AREA = 9.5380 SQ. MI.

```
*
*S
**************************************************************************
**************************************************************************
*S*** SUB-BASIN 37 ****
*
COMPUTE LT TP       LCODE=1  UPLAND/LAG TIME TRANSITION METHOD
                    NK=3  ISLOPE=-1
                    LENGTH=400 FT   SLOPE=0.012 K=0.7
                    LENGTH=1600 FT  SLOPE=0.010 K=2.0
                    LENGTH=10600 FT  SLOPE=0.008 K=3.0
                    Kn=.033  CR=0.55
```

Tc AND Tp COMPUTED BY UPLAND/LAG TIME PROCEDURE

LAG EQUATION FACTORS: Kn= .0330 TOTAL BASIN LENGTH (FT)= 12600.0
TOTAL BASIN SLOPE (FT/FT)= .008381 CENTROUD LENGTH (FT)= 6930.0

TIME OF CONCENTRATION (HRS)= .8922 TIME TO PEAK (HRS)= .5948 LAG TIME (HRS)= .6692

```
COMPUTE NM HYD      ID=1   HYD NO=37   DA= 0.590 SQ MI
                    PER A=91 PER B=0  PER C=2  PER D=7
                    TP=0.0   MASSRAIN=-1
```

TIME TO PEAK (hrs)= .5948

K = .352511HR TP = .594816HR K/TP RATIO = .592638 SHAPE CONSTANT, N = 6.391015
UNIT PEAK = 34.137 CFS UNIT VOLUME = .9996 B = 491.65 P60 = 1.6900
AREA = .041300 SQ MI IA = .10000 INCHES INF = .04000 INCHES PER HOUR
RUNOFF COMPUTED BY INITIAL ABSTRACTION/INFILTRATION NUMBER METHOD - DT = .050000

K = .622722HR TP = .594816HR K/TP RATIO = 1.046915 SHAPE CONSTANT, N = 3.372244
UNIT PEAK = 286.78 CFS UNIT VOLUME = 1.000 B = 310.88 P60 = 1.6900
AREA = .548700 SQ MI IA = .64355 INCHES INF = 1.65194 INCHES PER HOUR
RUNOFF COMPUTED BY INITIAL ABSTRACTION/INFILTRATION NUMBER METHOD - DT = .050000

BULKING FACTOR APPLIED TO HYDROGRAPH. FACTOR = 1.05000 AT PEAK FLOW.

```
PRINT HYD           ID=1   CODE=1
```

OUTFLOW HYDROGRAPH REACH 37.00

RUNOFF VOLUME = .55343 INCHES = 17.4146 ACRE-FEET
PEAK DISCHARGE RATE = 163.84 CFS AT 2.000 HOURS BASIN AREA = .5900 SQ. MI.

```
*S
**************************************************************************
*S ROUTE 37 THRU 34 IN NATURAL ARROYO TO 34.6
*
COMPUTE RATING CURVE  CID=1   VS NO=1   NO SEGS=1
                      MIN ELEV=5769.66   MAX ELEV=5778.71
                      CH SLOPE=0.005    FP SLOPE=0.005
                      N=0.035           DIST=500.0
                      DIST  ELEV    DIST  ELEV
                        0   5778.71   99 5771.79
                                  180     5769.8  249     5769.66
                                  340     5769.9  500     5775.36
```

RATING CURVE VALLEY SECTION 1.0

WATER SURFACE ELEV	FLOW AREA SQ FT	FLOW RATE CFS	TOP WIDTH FT
5769.66	.00	.00	.00
5770.14	63.57	95.13	180.62
5770.61	157.49	385.43	213.94
5771.09	267.27	845.03	247.27
5771.56	392.93	1476.32	280.60
5772.04	533.62	2314.01	307.31
5772.52	684.86	3357.71	328.07
5772.99	845.99	4583.53	348.84
5773.47	1017.01	5993.91	369.60
5773.94	1197.91	7592.27	390.36
5774.42	1388.69	9382.70	411.12
5774.90	1589.35	11369.66	431.88
5775.37	1799.90	13565.59	452.26
5775.85	2016.83	16235.71	459.07
5776.33	2237.01	19107.10	465.88
5776.80	2460.42	22176.29	472.69
5777.28	2687.08	25440.44	479.50
5777.75	2916.98	28897.18	486.32
5778.23	3150.13	32544.57	493.13
5778.71	3386.51	36381.00	499.94

```
ROUTE MCUNGE        ID=5   HYD NO=34.5  INFLOW ID=1
                    DT=0.0   L=4007 FT   NS=0   SLOPE=0.005
                    MATCODE=0 REGCODE=0 CCODE=0 MM CODE=0

      INFLOW END= 591           TABLE PTS= 20
      DT=  .050000              QMED=      81.92  CKMED=      1.4965
      WIDTH MED=      155.55    NREACH= 24         DX=      166.96
```

DEPTH (FT)	AREA (SQ FT)	Q (CFS)	TRAVEL TIME(HR)	WIDTH (FT)	ck (FPS)	VEL (FPS)	C	D	C1	C2	C3	Q-M (CFS)	C1-M	C2-M	C3-M
.00	.0	.0	1.033	.0	.93	.66	1.000	.000	1.000	.000	.000	.0	1.000	.000	.000
.48	63.6	95.1	.744	180.6	2.63	1.50	2.836	.240	.882	.509	-.392	15.0	.931	.358	-.289
.95	157.5	385.4	.455	213.9	3.73	2.45	4.025	.578	.794	.643	-.437	218.8	.819	.580	-.399
1.43	267.3	845.0	.352	247.3	4.66	3.16	5.029	.878	.746	.710	-.456	595.8	.763	.680	-.442
1.90	392.9	1476.3	.296	280.6	5.50	3.76	5.933	1.145	.716	.752	-.469	1142.2	.722	.731	-.453
2.38	533.6	2314.0	.257	307.3	6.44	4.34	6.942	1.401	.700	.786	-.486	1876.0	.707	.771	-.478
2.86	684.9	3357.7	.227	328.1	7.28	4.90	7.850	1.684	.680	.810	-.490	2816.8	.691	.800	-.491
3.33	846.0	4583.5	.205	348.8	7.95	5.42	8.571	1.980	.657	.827	-.484	3952.2	.667	.819	-.485
3.81	1017.0	5993.9	.189	369.6	8.56	5.89	9.230	2.269	.637	.840	-.477	5270.8	.645	.834	-.479
4.28	1197.9	7592.3	.176	390.4	9.13	6.34	9.840	2.553	.619	.851	-.469	6775.5	.626	.845	-.472
4.76	1388.7	9382.7	.165	411.1	9.66	6.76	10.413	2.831	.603	.860	-.462	8470.1	.609	.855	-.464
5.24	1589.4	11369.7	.156	431.9	10.18	7.15	10.973	3.098	.589	.867	-.456	10359.0	.594	.863	-.457
5.71	1799.9	13565.6	.148	452.3	11.25	7.54	12.132	3.193	.609	.877	-.486	12450.4	.582	.871	-.453
6.19	2016.8	16235.7	.138	459.1	12.68	8.05	13.675	3.340	.629	.889	-.518	14877.7	.636	.885	-.521
6.67	2237.0	19107.1	.130	465.9	13.40	8.54	14.445	3.667	.616	.895	-.512	17649.2	.622	.892	-.515
7.14	2460.4	22176.3	.123	472.7	14.08	9.01	15.177	3.992	.604	.901	-.505	20620.1	.610	.898	-.508
7.62	2687.1	25440.4	.118	479.5	14.73	9.47	15.876	4.316	.593	.906	-.498	23787.3	.598	.903	-.501
8.09	2917.0	28897.2	.112	486.3	15.35	9.91	16.546	4.638	.582	.910	-.492	27148.3	.587		

```
.908  -.495
     8.57 3150.1  32544.6    .108  493.1    15.94  10.33   17.189  4.959   .572   .914  -.485  30700.8    .576
.912  -.488
     9.05 3386.5  36381.0    .104  499.9    16.44  10.74   17.724  5.302   .559   .917  -.475  34443.1    .566
.915  -.482
 MAXIMUM NO. ITERATIONS FOR SOLUTION (KKMAX) =   7 OCCURRED       7 TIMES.  AVERAGE NUMBER ITERATIONS =  1.2202
 Equations solved using the Ponce correction to C2
 PRINT HYD           ID=5   CODE=1

                                      OUTFLOW HYDROGRAPH REACH    34.50


     RUNOFF VOLUME =      .57360 INCHES     =      18.0491 ACRE-FEET
     PEAK DISCHARGE RATE =     163.84 CFS  AT   2.350 HOURS   BASIN AREA =   .5900 SQ. MI.



 *
 ************************************************************************

 *S*** SUB-BASIN 34 ****
 *
 COMPUTE LT TP       LCODE=1  UPLAND/LAG TIME TRANSITION METHOD
                     NK=3  ISLOPE=-1
                     LENGTH=400 FT   SLOPE=0.010 K=0.7
                     LENGTH=1600 FT  SLOPE=0.003 K=2.0
                     LENGTH=1557 FT  SLOPE=0.007 K=3.0


      Tc AND Tp COMPUTED BY UPLAND/LAG TIME PROCEDURE

      SCS UPLAND METHOD FACTORS
                               LENGTH (FT)      SLOPE (FT/FT)       COMPOSITE K
      SHEET FLOW PORTION          400.0           .010000             .7000
      SHALLOW FLOW PORTION       1600.0           .003000            2.0000
      CHANNEL FLOW PORTION       1557.0           .007000            3.0000
      TOTAL BASIN                3557.0           .005538            1.8021


      TIME OF CONCENTRATION (HRS)=   .7368     TIME TO PEAK (HRS)=   .4912     LAG TIME (HRS)=   .5526

 COMPUTE NM HYD      ID=2   HYD NO=34   DA= 0.129 SQ MI
                     PER A=91 PER B=0  PER C=2  PER D=7
                     TP=0.0   MASSRAIN=-1
      TIME TO PEAK (hrs)=   .4912

      K =   .273915HR    TP =   .491175HR    K/TP RATIO =   .557672     SHAPE CONSTANT, N =  6.900863
      UNIT PEAK =   9.4963    CFS   UNIT VOLUME =    .9987       B =   516.54       P60 = 1.6900
      AREA =      .009030 SQ MI    IA =    .10000 INCHES    INF =    .04000 INCHES PER HOUR
      RUNOFF COMPUTED BY INITIAL ABSTRACTION/INFILTRATION NUMBER METHOD - DT =   .050000


      K =   .588008HR    TP =   .491175HR    K/TP RATIO =  1.197146     SHAPE CONSTANT, N =  2.967682
      UNIT PEAK =   68.189    CFS   UNIT VOLUME =    .9998       B =   279.18       P60 = 1.6900
      AREA =      .119970 SQ MI    IA =    .64355 INCHES    INF =   1.65194 INCHES PER HOUR
      RUNOFF COMPUTED BY INITIAL ABSTRACTION/INFILTRATION NUMBER METHOD - DT =   .050000

     BULKING FACTOR APPLIED TO HYDROGRAPH.  FACTOR =  1.05000 AT PEAK FLOW.

 PRINT HYD           ID=2   CODE=1

                                      OUTFLOW HYDROGRAPH REACH    34.00


     RUNOFF VOLUME =      .55343 INCHES     =       3.8076 ACRE-FEET
     PEAK DISCHARGE RATE =      39.76 CFS  AT   1.850 HOURS   BASIN AREA =   .1290 SQ. MI.



 *S
 ************************************************************************
 *S  ADD 34 TO 34.5 TO GET 34.6
 *S
 ADD HYD             ID=6  HYD NO=34.6 ID I=5 ID II=2
 PRINT HYD           ID=6   CODE=1

                                      OUTFLOW HYDROGRAPH REACH    34.60


     RUNOFF VOLUME =      .56998 INCHES     =      21.8567 ACRE-FEET
     PEAK DISCHARGE RATE =     185.78 CFS  AT   2.350 HOURS   BASIN AREA =   .7190 SQ. MI.



 *
 *S
 ************************************************************************
 *S ROUTE 34.6 THRU 38 IN NATURAL ARROYO TO 34.3
 *
 COMPUTE RATING CURVE  CID=1   VS NO=1   NO SEGS=1
                       MIN ELEV=5749.96   MAX ELEV=5753.54
```

CH SLOPE=0.014 FP SLOPE=0.014
N=0.035 DIST=500.0
DIST ELEV DIST ELEV
0 5750.07 77 5749.96
177 5753.54 211 5751.74
251 5750.83 287 5752.19
394 5753.47 500 5751.61

RATING CURVE VALLEY SECTION 1.0

WATER SURFACE ELEV	FLOW AREA SQ FT	FLOW RATE CFS	TOP WIDTH FT
5749.96	.00	.00	.00
5750.15	10.78	13.97	82.26
5750.34	26.78	61.08	87.53
5750.53	43.77	133.25	92.79
5750.71	61.76	227.94	98.06
5750.90	80.92	334.46	108.41
5751.09	103.10	450.78	126.95
5751.28	128.77	596.27	145.49
5751.47	157.94	773.56	164.02
5751.66	190.67	976.37	185.20
5751.84	228.19	1204.28	211.86
5752.03	270.44	1485.64	236.42
5752.22	317.34	1807.41	262.78
5752.41	370.20	2148.13	298.10
5752.60	429.71	2555.94	333.42
5752.79	495.88	3034.37	368.73
5752.98	568.71	3587.34	404.05
5753.16	648.19	4218.91	439.36
5753.35	734.33	4933.21	474.68
5753.54	826.77	5806.42	500.00

ROUTE MCUNGE ID=5 HYD NO=38.5 INFLOW ID=6
DT=0.0 L=2678 FT NS=0 SLOPE=0.014
MATCODE=0 REGCODE=0 CCODE=0 MM CODE=0

INFLOW END= 600 TABLE PTS= 20
DT= .050000 QMED= 92.89 CKMED= 4.2466
WIDTH MED= 89.85 NREACH= 7 DX= 382.57

DEPTH (FT)	AREA (SQ FT)	Q (CFS)	TRAVEL TIME(HR)	WIDTH (FT)	ck (FPS)	VEL (FPS)	C	D	C1	C2	C3	Q-M (CFS)	C1-M	C2-M	C3-M
.00	.0	.0	.822	.0	2.13	.51	1.000	.000	1.000	.000	.000	.0	1.000	.000	.000
.19	10.8	14.0	.574	82.3	2.24	1.30	1.054	.014	.986	.033	-.019	2.2	.998	.005	-.003
.38	26.8	61.1	.326	87.5	3.67	2.28	1.727	.036	.974	.276	-.250	34.1	.979	.172	-.151
.57	43.8	133.2	.244	92.8	4.80	3.04	2.259	.056	.966	.397	-.363	94.3	.970	.343	-.313
.75	61.8	227.9	.202	98.1	5.51	3.69	2.591	.079	.957	.455	-.412	178.0	.963	.435	-.398
.94	80.9	334.5	.180	108.4	5.50	4.13	2.586	.105	.943	.458	-.401	279.2	.950	.454	-.404
1.13	103.1	450.8	.170	126.9	5.48	4.37	2.578	.121	.935	.459	-.394	390.8	.934	.441	-.375
1.32	128.8	596.3	.161	145.5	5.89	4.63	2.773	.130	.933	.488	-.421	521.5	.933	.472	-.405
1.51	157.9	773.6	.152	164.0	6.17	4.90	2.902	.143	.929	.506	-.435	682.7	.932	.499	-.431
1.70	190.7	976.4	.145	185.2	6.19	5.12	2.913	.159	.922	.509	-.431	872.8	.925	.506	-.431
1.88	228.2	1204.3	.141	211.9	6.38	5.28	3.000	.166	.920	.520	-.440	1088.1	.916	.503	-.420
2.07	270.4	1485.6	.135	236.4	6.78	5.49	3.190	.173	.921	.542	-.462	1342.3	.922	.535	-.456
2.26	317.3	1807.4	.131	262.8	6.72	5.70	3.160	.191	.912	.540	-.452	1643.8	.918	.545	-.463
2.45	370.2	2148.1	.128	298.1	6.66	5.80	3.136	.202	.907	.539	-.446	1975.3	.903	.527	-.431
2.64	429.7	2555.9	.125	333.4	7.05	5.95	3.319	.203	.910	.558	-.468	2349.1	.908	.548	-.456
2.83	495.9	3034.4	.122	368.7	7.42	6.12	3.493	.207	.912	.574	-.486	2791.8	.911	.566	-.476
3.02	568.7	3587.3	.118	404.0	7.78	6.31	3.661	.213	.913	.590	-.502	3307.1	.912	.582	-.493
3.20	648.2	4218.9	.114	439.4	8.13	6.51	3.825	.221	.913	.604	-.516	3899.0	.912	.596	-.508
3.39	734.3	4933.2	.111	474.7	8.85	6.72	4.162	.219	.918	.628	-.547	4571.6	.912	.610	-.522
3.58	826.8	5806.4	.106	500.0	9.53	7.02	4.484	.228	.920	.650	-.570	5363.7	.924	.648	-.572

MAXIMUM NO. ITERATIONS FOR SOLUTION (KKMAX) = 4 OCCURRED 7 TIMES. AVERAGE NUMBER ITERATIONS = 1.1695

DEPTH (FT)	AREA (SQ FT)	Q (CFS)	TRAVEL TIME(HR)	WIDTH (FT)	ck (FPS)	VEL (FPS)	C	D	C1	C2	C3	Q-M (CFS)	C1-M	C2-M	C3-M
.00	.0	.0	.822	.0	2.13	.51	1.000	.000	1.000	.000	.000	.0	1.000	.000	.000
.19	10.8	14.0	.574	82.3	2.16	1.30	1.015	.015	.986	.014	.000	2.2	.995		

```
.005   .000
         .38   26.8     61.1    .326   87.5     2.25   2.28    1.058   .058   .945   .055   .000     34.1    .967
.033   .000
         .57   43.8    133.2    .244   92.8     2.37   3.04    1.113   .113   .898   .102   .000     94.3    .922
.078   .000
         .75   61.8    227.9    .202   98.1     2.50   3.69    1.174   .174   .852   .148   .000    178.0    .875
.125   .000
         .94   80.9    334.5    .180  108.4     2.60   4.13    1.222   .222   .818   .182   .000    279.2    .835
.165   .000
        1.13  103.1    450.8    .170  126.9     2.66   4.37    1.250   .250   .800   .200   .000    390.8    .809
.191   .000
        1.32  128.8    596.3    .161  145.5     2.72   4.63    1.281   .281   .781   .219   .000    521.5    .790
.210   .000
        1.51  157.9    773.6    .152  164.0     2.79   4.90    1.315   .315   .760   .240   .000    682.7    .770
.230   .000
        1.70  190.7    976.4    .145  185.2     2.86   5.12    1.344   .344   .744   .256   .000    872.8    .752
.248   .000
        1.88  228.2   1204.3    .141  211.9     2.90   5.28    1.366   .366   .732   .268   .000   1088.1    .738
.262   .000
        2.07  270.4   1485.6    .135  236.4     2.97   5.49    1.396   .396   .717   .283   .000   1342.3    .724
.276   .000
        2.26  317.3   1807.4    .131  262.8     3.03   5.70    1.424   .424   .702   .298   .000   1643.8    .709
.291   .000
        2.45  370.2   2148.1    .128  298.1     3.06   5.80    1.440   .440   .695   .305   .000   1975.3    .698
.302   .000
        2.64  429.7   2555.9    .125  333.4     3.11   5.95    1.461   .461   .684   .316   .000   2349.1    .689
.311   .000
        2.83  495.9   3034.4    .122  368.7     3.16   6.12    1.486   .486   .673   .327   .000   2791.8    .678
.322   .000
        3.02  568.7   3587.3    .118  404.0     3.22   6.31    1.515   .515   .660   .340   .000   3307.1    .666
.334   .000
        3.20  648.2   4218.9    .114  439.4     3.29   6.51    1.546   .546   .647   .353   .000   3899.0    .653
.347   .000
        3.39  734.3   4933.2    .111  474.7     3.35   6.72    1.578   .578   .634   .366   .000   4571.6    .640
.360   .000
        3.58  826.8   5806.4    .106  500.0     3.46   7.02    1.627   .627   .615   .385   .000   5363.7    .624
.376   .000
     MAXIMUM NO. ITERATIONS FOR SOLUTION (KKMAX) =   3 OCCURRED      36 TIMES.  AVERAGE NUMBER ITERATIONS =  1.1138
     Equations solved with two passes: first using the Ponce correction to C1, second using the Fread correction to C1,
C2 and C3
     PRINT HYD           ID=5   CODE=1

                                        OUTFLOW HYDROGRAPH REACH    38.50

        RUNOFF VOLUME =      .56801 INCHES     =      21.7813 ACRE-FEET
        PEAK DISCHARGE RATE =     183.99 CFS  AT   2.650 HOURS   BASIN AREA =   .7190 SQ. MI.


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     *S*** SUB-BASIN 38A ****
     *
     COMPUTE LT TP       LCODE=1  UPLAND/LAG TIME TRANSITION METHOD
                         NK=2  ISLOPE=-1
                         LENGTH=400 FT   SLOPE=0.010 K=0.7
                         LENGTH=1373 FT  SLOPE=0.008 K=2.0

          Tc AND Tp COMPUTED BY UPLAND/LAG TIME PROCEDURE

          SCS UPLAND METHOD FACTORS
                                    LENGTH (FT)      SLOPE (FT/FT)       COMPOSITE K
          SHEET FLOW PORTION            400.0           .010000            .7000
          SHALLOW FLOW PORTION         1373.0           .008000           2.0000
          CHANNEL FLOW PORTION            .0           .000000            .0000
          TOTAL BASIN                  1773.0           .008451           1.4404


          TIME OF CONCENTRATION (HRS)=   .3719     TIME TO PEAK (HRS)=   .2480     LAG TIME (HRS)=   .2789

     COMPUTE NM HYD      ID=1   HYD NO=38A   DA= 0.075 SQ MI
                         PER A=100 PER B=0  PER C=0  PER D=0
                         TP=0.0   MASSRAIN=-1
          TIME TO PEAK (hrs)=   .2480

          K =   .310311HR    TP =   .247955HR    K/TP RATIO =  1.251479     SHAPE CONSTANT, N =  2.850611
          UNIT PEAK =   81.489    CFS   UNIT VOLUME =    .9995       B =   269.41      P60 = 1.6900
          AREA =      .075000 SQ MI    IA =    .65000 INCHES    INF =   1.67000 INCHES PER HOUR
          RUNOFF COMPUTED BY INITIAL ABSTRACTION/INFILTRATION NUMBER METHOD - DT =   .050000

         BULKING FACTOR APPLIED TO HYDROGRAPH.  FACTOR =  1.05000 AT PEAK FLOW.

     PRINT HYD           ID=1   CODE=1

                                        HYDROGRAPH FROM AREA 38A


        RUNOFF VOLUME =      .40595 INCHES     =       1.6238 ACRE-FEET
        PEAK DISCHARGE RATE =      32.25 CFS  AT   1.600 HOURS   BASIN AREA =   .0750 SQ. MI.
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*S
**********************************************************************
*S ROUTE 38A THRU 38 IN NATURAL ARROYO TO 34.3
*
COMPUTE RATING CURVE  CID=1   VS NO=1   NO SEGS=1
                     MIN ELEV=5742.94   MAX ELEV=5751.34
                      CH SLOPE=0.014    FP SLOPE=0.014
                      N=0.035           DIST=650.0
                      DIST  ELEV    DIST  ELEV
                        0   5751.34   136 5745.99
                                  243     5743.74 326     5742.94
                                  440     5745.94 517     5747.36
                                  650     5743.89


                                   RATING CURVE VALLEY SECTION  1.0
                                      WATER       FLOW        FLOW        TOP
                                    SURFACE       AREA        RATE       WIDTH
                                      ELEV        SQ FT       CFS         FT
                                    5742.94         .00         .00         .00
                                    5743.38       13.84       25.40       62.62
                                    5743.82       55.15      164.47      120.55
                                    5744.27      119.48      469.33      172.75
                                    5744.71      207.91      983.48      227.50
                                    5745.15      320.54     1752.53      282.24
                                    5745.59      457.36     2815.96      336.99
                                    5746.03      618.42     4207.28      392.30
                                    5746.48      803.29     5986.73      444.43
                                    5746.92     1011.20     8159.82      496.57
                                    5747.36     1242.15    10756.41      548.70
                                    5747.80     1487.14    14323.43      560.03
                                    5748.24     1737.10    18312.47      571.26
                                    5748.68     1992.02    22710.20      582.50
                                    5749.13     2251.90    27507.32      593.73
                                    5749.57     2516.75    32696.66      604.96
                                    5750.01     2786.56    38272.65      616.20
                                    5750.45     3061.34    44230.98      627.43
                                    5750.89     3341.08    50568.35      638.67
                                    5751.34     3625.79    57282.28      649.90
ROUTE MCUNGE        ID=2   HYD NO=38.2  INFLOW ID=1
                    DT=0.0   L=3283 FT   NS=0   SLOPE=0.014
                    MATCODE=0 REGCODE=0 CCODE=0 MM CODE=0

     INFLOW END= 175           TABLE PTS= 20
     DT=  .050000              QMED=      16.13  CKMED=      1.8358
     WIDTH MED=       39.76    NREACH= 19         DX=      172.79

      DEPTH   AREA      Q    TRAVEL  WIDTH     ck      VEL      C       D      C1     C2     C3     Q-M      C1-M
C2-M   C3-M
       (FT)  (SQ FT)  (CFS)  TIME(HR) (FT)     (FPS)   (FPS)                                          (CFS)
        .00      .0       .0    .688     .0      .96     .82    1.000   .000  1.000   .000   .000       .0   1.000
.000   .000
        .44   13.8     25.4    .497   62.6     2.60   1.84    2.706   .065   .966   .470  -.435      4.0    .974
.243  -.218
        .88   55.1    164.5    .306  120.6     4.21   2.98    4.384   .134   .951   .638  -.589     77.2    .955
.564  -.519
       1.33  119.5    469.3    .232  172.8     5.37   3.93    5.596   .209   .939   .706  -.645    297.3    .940
.669  -.609
       1.77  207.9    983.5    .193  227.5     6.39   4.73    6.661   .279   .930   .748  -.678    704.3    .931
.725  -.656
       2.21  320.5   1752.5    .167  282.2     7.36   5.47    7.665   .349   .923   .778  -.701   1343.8    .924
.762  -.686
       2.65  457.4   2816.0    .148  337.0     8.26   6.16    8.600   .418   .916   .800  -.717   2258.1    .918
.789  -.706
       3.09  618.4   4207.3    .134  392.3     9.15   6.80    9.530   .485   .912   .818  -.730   3483.8    .912
.808  -.720
       3.54  803.3   5986.7    .122  444.4    10.07   7.45   10.495   .553   .908   .834  -.742   5066.8    .910
.827  -.736
       3.98 1011.2   8159.8    .113  496.6    10.88   8.07   11.333   .624   .904   .846  -.749   7041.8    .905
.840  -.745
       4.42 1242.2  10756.4    .105  548.7    12.59   8.66   13.111   .644   .913   .864  -.777   9425.4    .901
.850  -.751
       4.86 1487.1  14323.4    .095  560.0    15.28   9.63   15.921   .692   .921   .886  -.808  12490.4    .924
.881  -.805
       5.30 1737.1  18312.5    .087  571.3    16.63  10.54   17.320   .797   .917   .895  -.812  16270.8    .919
.891  -.810
       5.74 1992.0  22710.2    .080  582.5    17.87  11.40   18.619   .902   .912   .903  -.815  20466.2    .914
.899  -.813
       6.19 2251.9  27507.3    .075  593.7    19.04  12.22   19.837  1.006   .908   .908  -.816  25065.2    .910
.906  -.815
       6.63 2516.8  32696.7    .070  605.0    20.14  12.99   20.985  1.109   .904   .913  -.817  30059.9    .906
.911  -.817
       7.07 2786.6  38272.6    .066  616.2    21.19  13.73   22.073  1.212   .900   .918  -.818  35443.8    .902
.916  -.818
       7.51 3061.3  44231.0    .063  627.4    22.18  14.45   23.107  1.314   .897   .921  -.818  41212.0    .898
.920  -.818
       7.95 3341.1  50568.3    .060  638.7    23.13  15.14   24.095  1.415   .893   .925  -.818  47360.7    .895
.923  -.818
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        8.40 3625.8  57282.3    .058  649.9    23.89  15.80   24.892  1.525   .889   .927  -.816  53887.2    .892
.926  -.818
     MAXIMUM NO. ITERATIONS FOR SOLUTION (KKMAX) =   6 OCCURRED       2 TIMES.  AVERAGE NUMBER ITERATIONS =  1.0825
       DEPTH   AREA      Q    TRAVEL  WIDTH     ck      VEL      C       D      C1     C2     C3     Q-M      C1-M
C2-M   C3-M
        (FT)  (SQ FT)  (CFS)  TIME(HR) (FT)     (FPS)   (FPS)                                          (CFS)
          .00     .0       .0    .688     .0      .96    .82    1.000   .000  1.000   .000   .000       .0   1.000
.000   .000
          .44   13.8     25.4    .497   62.6     1.11   1.84    1.152   .152   .868   .132   .000      4.0    .950
.050   .000
          .88   55.1    164.5    .306  120.6     1.36   2.98    1.415   .415   .707   .293   .000     77.2    .779
.221   .000
         1.33  119.5    469.3    .232  172.8     1.62   3.93    1.692   .692   .591   .409   .000    297.3    .641
.359   .000
         1.77  207.9    983.5    .193  227.5     1.87   4.73    1.953   .953   .512   .488   .000    704.3    .547
.453   .000
         2.21  320.5   1752.5    .167  282.2     2.12   5.47    2.210  1.210   .452   .548   .000   1343.8    .479
.521   .000
         2.65  457.4   2816.0    .148  337.0     2.36   6.16    2.462  1.462   .406   .594   .000   2258.1    .427
.573   .000
         3.09  618.4   4207.3    .134  392.3     2.60   6.80    2.706  1.706   .369   .631   .000   3483.8    .386
.614   .000
         3.54  803.3   5986.7    .122  444.4     2.84   7.45    2.960  1.960   .338   .662   .000   5066.8    .352
.648   .000
         3.98 1011.2   8159.8    .113  496.6     3.08   8.07    3.207  2.207   .312   .688   .000   7041.8    .324
.676   .000
         4.42 1242.2  10756.4    .105  548.7     3.31   8.66    3.448  2.448   .290   .710   .000   9425.4    .300
.700   .000
         4.86 1487.1  14323.4    .095  560.0     3.70   9.63    3.856  2.856   .259   .741   .000  12490.4    .274
.726   .000
         5.30 1737.1  18312.5    .087  571.3     4.08  10.54    4.249  3.249   .235   .765   .000  16270.8    .247
.753   .000
         5.74 1992.0  22710.2    .080  582.5     4.44  11.40    4.628  3.628   .216   .784   .000  20466.2    .225
.775   .000
         6.19 2251.9  27507.3    .075  593.7     4.79  12.22    4.995  3.995   .200   .800   .000  25065.2    .208
.792   .000
         6.63 2516.8  32696.7    .070  605.0     5.14  12.99    5.350  4.350   .187   .813   .000  30059.9    .193
.807   .000
         7.07 2786.6  38272.6    .066  616.2     5.47  13.73    5.696  4.696   .176   .824   .000  35443.8    .181
.819   .000
         7.51 3061.3  44231.0    .063  627.4     5.79  14.45    6.032  5.032   .166   .834   .000  41212.0    .170
.830   .000
         7.95 3341.1  50568.3    .060  638.7     6.11  15.14    6.361  5.361   .157   .843   .000  47360.7    .161
.839   .000
         8.40 3625.8  57282.3    .058  649.9     6.41  15.80    6.681  5.681   .150   .850   .000  53887.2    .153
.847   .000
     MAXIMUM NO. ITERATIONS FOR SOLUTION (KKMAX) =   3 OCCURRED      33 TIMES.  AVERAGE NUMBER ITERATIONS =  1.0467
     Equations solved with two passes: first using the Ponce correction to C1, second using the Fread correction to C1,
C2 and C3
     PRINT HYD           ID=2   CODE=1

                                          OUTFLOW HYDROGRAPH REACH    38.20


         RUNOFF VOLUME =      .39689 INCHES     =       1.5875 ACRE-FEET
         PEAK DISCHARGE RATE =      30.10 CFS  AT   2.450 HOURS   BASIN AREA =   .0750 SQ. MI.


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     *S  ADD 38.2 TO 38.5 TO GET 34.3
     *S
     ADD HYD             ID=3  HYD NO=34.3 ID I=2 ID II=5
     PRINT HYD           ID=3   CODE=1

                                          OUTFLOW HYDROGRAPH REACH    34.30


         RUNOFF VOLUME =      .55185 INCHES     =      23.3688 ACRE-FEET
         PEAK DISCHARGE RATE =     206.42 CFS  AT   2.600 HOURS   BASIN AREA =   .7940 SQ. MI.


     *
     *S
     ********************************************************************************
     *S*** SUB-BASIN 38 ****
     *
     COMPUTE LT TP       LCODE=1  UPLAND/LAG TIME TRANSITION METHOD
                         NK=3  ISLOPE=-1
                         LENGTH=400 FT   SLOPE=0.012 K=0.7
                         LENGTH=1600 FT  SLOPE=0.022 K=2.0
                         LENGTH=960 FT   SLOPE=0.012 K=3.0


          Tc AND Tp COMPUTED BY UPLAND/LAG TIME PROCEDURE

          SCS UPLAND METHOD FACTORS
```

	LENGTH (FT)	SLOPE (FT/FT)	COMPOSITE K
SHEET FLOW PORTION	400.0	.012000	.7000
SHALLOW FLOW PORTION	1600.0	.022000	2.0000
CHANNEL FLOW PORTION	960.0	.012000	3.0000
TOTAL BASIN	2960.0	.017405	1.6581

TIME OF CONCENTRATION (HRS)= .3759 TIME TO PEAK (HRS)= .2506 LAG TIME (HRS)= .2819

```
COMPUTE NM HYD      ID=1   HYD NO=38   DA= 0.131 SQ MI
                    PER A=96 PER B=4  PER C=0  PER D=0
                    TP=0.0   MASSRAIN=-1
```

TIME TO PEAK (hrs)= .2506

K = .299622HR TP = .250578HR K/TP RATIO = 1.195727 SHAPE CONSTANT, N = 2.970919
UNIT PEAK = 146.09 CFS UNIT VOLUME = .9998 B = 279.44 P60 = 1.6900
AREA = .131000 SQ MI IA = .64400 INCHES INF = 1.65320 INCHES PER HOUR
RUNOFF COMPUTED BY INITIAL ABSTRACTION/INFILTRATION NUMBER METHOD - DT = .050000

BULKING FACTOR APPLIED TO HYDROGRAPH. FACTOR = 1.05000 AT PEAK FLOW.

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PRINT HYD           ID=1   CODE=1
```

OUTFLOW HYDROGRAPH REACH 38.00

RUNOFF VOLUME = .41348 INCHES = 2.8888 ACRE-FEET
PEAK DISCHARGE RATE = 58.62 CFS AT 1.600 HOURS BASIN AREA = .1310 SQ. MI.

```
*S
*************************************************************************
*S  ADD 38 TO 34.3 TO GET 38.4
*S
ADD HYD             ID=4  HYD NO=38.4 ID I=1 ID II=3
PRINT HYD           ID=4   CODE=1
```

OUTFLOW HYDROGRAPH REACH 38.40

RUNOFF VOLUME = .53225 INCHES = 26.2576 ACRE-FEET
PEAK DISCHARGE RATE = 211.05 CFS AT 2.600 HOURS BASIN AREA = .9250 SQ. MI.

```
*
*S
*************************************************************************

*S ROUTE 38.4 THRU 42 IN NATURAL ARROYO TO 42.3
*
COMPUTE RATING CURVE  CID=1   VS NO=1   NO SEGS=1
                      MIN ELEV=5692.77   MAX ELEV=5703.76
                      CH SLOPE=0.03    FP SLOPE=0.03
                      N=0.035           DIST=500.0
                      DIST  ELEV    DIST  ELEV
                        0   5703.76   112 5700.06
                                  214     5695.01 251     5692.77
                                  288     5695.93 348     5700.22
                                  410     5701.04 500     5702.54
```

RATING CURVE VALLEY SECTION 1.0

WATER SURFACE ELEV	FLOW AREA SQ FT	FLOW RATE CFS	TOP WIDTH FT
5692.77	.00	.00	.00
5693.35	4.73	15.17	16.33
5693.93	18.90	96.35	32.67
5694.51	42.53	284.07	49.00
5695.08	75.61	610.21	65.61
5695.66	118.92	1100.15	84.07
5696.24	173.01	1792.22	103.24
5696.82	238.47	2722.26	123.02
5697.40	315.37	3927.34	142.80
5697.98	403.71	5436.44	162.57
5698.56	503.50	7277.25	182.35
5699.13	614.74	9476.35	202.13
5699.71	737.42	12059.36	221.91
5700.29	871.97	14789.60	248.45
5700.87	1033.45	16951.72	309.72
5701.45	1229.08	20301.36	364.60
5702.03	1455.16	24604.75	416.84
5702.61	1711.32	29971.46	465.09
5703.19	1985.49	37460.37	482.60
5703.76	2269.80	45728.79	500.00

```
ROUTE MCUNGE        ID=6   HYD NO=42.6  INFLOW ID=4
                    DT=0.0   L=4626 FT   NS=0   SLOPE=0.030
                    MATCODE=0 REGCODE=0 CCODE=0 MM CODE=0
```

INFLOW END= 600 TABLE PTS= 20
DT= .050000 QMED= 105.52 CKMED= 7.9453
WIDTH MED= 33.46 NREACH= 7 DX= 660.86

DEPTH (FT)	AREA (SQ FT)	Q (CFS)	TRAVEL TIME(HR)	WIDTH (FT)	ck (FPS)	VEL (FPS)	C	D	C1	C2	C3	Q-M (CFS)	C1-M	C2-M	C3-M
.00	.0	.0	.548	.0	3.67	1.48	1.000	.000	1.000	.000	.000	.0	1.000	.000	.000
.58	4.7	15.2	.400	16.3	4.48	3.21	1.220	.010	.991	.103	-.094	2.4	.999	.016	-.015
1.16	18.9	96.3	.252	32.7	7.09	5.10	1.931	.021	.986	.323	-.308	45.2	.987	.209	-.196
1.74	42.5	284.1	.192	49.0	9.08	6.68	2.473	.032	.982	.429	-.411	177.3	.982	.369	-.351
2.31	75.6	610.2	.159	65.6	10.77	8.07	2.934	.044	.978	.497	-.475	432.5	.979	.460	-.439
2.89	118.9	1100.1	.139	84.1	12.17	9.25	3.315	.054	.975	.542	-.517	838.9	.976	.514	-.490
3.47	173.0	1792.2	.124	103.2	13.59	10.36	3.702	.064	.973	.580	-.553	1428.3	.973	.558	-.532
4.05	238.5	2722.3	.113	123.0	15.01	11.42	4.088	.074	.971	.613	-.584	2237.5	.971	.594	-.566
4.63	315.4	3927.3	.103	142.8	16.44	12.45	4.477	.084	.970	.640	-.610	3303.2	.970	.625	-.595
5.21	403.7	5436.4	.095	162.6	17.82	13.47	4.854	.095	.968	.664	-.632	4658.7	.969	.651	-.620
5.79	503.5	7277.3	.089	182.4	19.16	14.45	5.218	.105	.967	.684	-.650	6332.1	.967	.673	-.640
6.36	614.7	9476.3	.083	202.1	20.46	15.42	5.572	.116	.965	.701	-.666	8350.7	.966	.692	-.658
6.94	737.4	12059.4	.079	221.9	20.80	16.35	5.665	.132	.961	.706	-.667	10740.4	.965	.708	-.673
7.52	872.0	14789.6	.076	248.4	17.21	16.96	4.686	.175	.940	.659	-.599	13401.5	.957	.697	-.654
8.10	1033.5	16951.7	.078	309.7	15.36	16.40	4.182	.180	.933	.627	-.560	15855.6	.911	.587	-.499
8.68	1229.1	20301.4	.078	364.6	18.12	16.52	4.937	.155	.949	.672	-.621	18601.2	.944	.657	-.601
9.26	1455.2	24604.8	.076	416.8	20.02	16.91	5.452	.149	.955	.697	-.652	22419.1	.952	.684	-.636
9.84	1711.3	29971.5	.073	465.1	23.67	17.51	6.448	.137	.964	.736	-.700	27244.2	.957	.709	-.666
10.42	1985.5	37460.4	.068	482.6	28.23	18.87	7.690	.139	.969	.773	-.742	33638.8	.969	.767	-.736
10.99	2269.8	45728.8	.064	500.0	29.60	20.15	8.062	.156	.966	.783	-.749	41519.4	.968	.779	-.747

MAXIMUM NO. ITERATIONS FOR SOLUTION (KKMAX) = 4 OCCURRED 4 TIMES. AVERAGE NUMBER ITERATIONS = 1.2118

DEPTH (FT)	AREA (SQ FT)	Q (CFS)	TRAVEL TIME(HR)	WIDTH (FT)	ck (FPS)	VEL (FPS)	C	D	C1	C2	C3	Q-M (CFS)	C1-M	C2-M	C3-M
.00	.0	.0	.548	.0	3.67	1.48	1.000	.000	1.000	.000	.000	.0	1.000	.000	.000
.58	4.7	15.2	.400	16.3	3.72	3.21	1.013	.013	.988	.012	.000	2.4	.996	.004	.000
1.16	18.9	96.3	.252	32.7	3.81	5.10	1.039	.039	.962	.038	.000	45.2	.976	.024	.000
1.74	42.5	284.1	.192	49.0	3.94	6.68	1.074	.074	.931	.069	.000	177.3	.947	.053	.000
2.31	75.6	610.2	.159	65.6	4.09	8.07	1.115	.115	.897	.103	.000	432.5	.913	.087	.000
2.89	118.9	1100.1	.139	84.1	4.24	9.25	1.156	.156	.865	.135	.000	838.9	.881	.119	.000
3.47	173.0	1792.2	.124	103.2	4.40	10.36	1.199	.199	.834	.166	.000	1428.3	.849	.151	.000
4.05	238.5	2722.3	.113	123.0	4.57	11.42	1.244	.244	.804	.196	.000	2237.5	.818	.182	.000
4.63	315.4	3927.3	.103	142.8	4.74	12.45	1.292	.292	.774	.226	.000	3303.2	.788	.212	.000
5.21	403.7	5436.4	.095	162.6	4.93	13.47	1.342	.342	.745	.255	.000	4658.7	.759	.241	.000
5.79	503.5	7277.3	.089	182.4	5.12	14.45	1.393	.393	.718	.282	.000	6332.1	.731	.269	.000
6.36	614.7	9476.3	.083	202.1	5.31	15.42	1.446	.446	.692	.308	.000	8350.7	.704	.296	.000
6.94	737.4	12059.4	.079	221.9	5.50	16.35	1.498	.498	.667	.333	.000	10740.4	.679	.321	.000
7.52	872.0	14789.6	.076	248.4	5.63	16.96	1.533	.533	.652	.348	.000	13401.5	.659	.341	.000
8.10	1033.5	16951.7	.078	309.7	5.51	16.40	1.501	.501	.666	.334	.000	15855.6	.660	.340	.000
8.68	1229.1	20301.4	.078	364.6	5.53	16.52	1.507	.507	.663	.337	.000	18601.2	.665	.335	.000
9.26	1455.2	24604.8	.076	416.8	5.62	16.91	1.530	.530	.654	.346	.000	22419.1	.658	.342	.000
9.84	1711.3	29971.5	.073	465.1	5.75	17.51	1.566	.566	.639	.361	.000	27244.2	.646	.354	.000
10.42	1985.5	37460.4	.068	482.6	6.05	18.87	1.647	.647	.607	.393	.000	33638.8	.622	.378	.000
10.99	2269.8	45728.8	.064	500.0	6.34	20.15	1.727	.727	.579	.421	.000	41519.4	.592	.408	.000

```
     MAXIMUM NO. ITERATIONS FOR SOLUTION (KKMAX) =   3 OCCURRED      10 TIMES.  AVERAGE NUMBER ITERATIONS =  1.1175
     Equations solved with two passes: first using the Ponce correction to C1, second using the Fread correction to C1,
C2 and C3
     PRINT HYD           ID=6   CODE=1

                                        OUTFLOW HYDROGRAPH REACH    42.60


         RUNOFF VOLUME =      .53178 INCHES     =      26.2341 ACRE-FEET
         PEAK DISCHARGE RATE =     210.37 CFS  AT   2.950 HOURS   BASIN AREA =   .9250 SQ. MI.



     *
     ***********************************************************************

     *S*** SUB-BASIN 42 ****
     *
     COMPUTE LT TP       LCODE=1  UPLAND/LAG TIME TRANSITION METHOD
                         NK=3  ISLOPE=-1
                         LENGTH=400 FT   SLOPE=0.020 K=0.7
                         LENGTH=1600 FT  SLOPE=0.025 K=2.0
                         LENGTH=4881 FT   SLOPE=0.030 K=3.0
                         Kn=.033  CR=.5

          Tc AND Tp COMPUTED BY UPLAND/LAG TIME PROCEDURE

          SCS UPLAND METHOD FACTORS
                                   LENGTH (FT)      SLOPE (FT/FT)       COMPOSITE K
          SHEET FLOW PORTION          400.0           .020000             .7000
          SHALLOW FLOW PORTION       1600.0           .025000            2.0000
          CHANNEL FLOW PORTION       4881.0           .030000            3.0000
          TOTAL BASIN                6881.0           .028256            2.2135


          LAG EQUATION FACTORS:     Kn=   .0330     TOTAL BASIN LENGTH (FT)=      6881.0
          TOTAL BASIN SLOPE (FT/FT)=    .028256     CENTROUD LENGTH (FT)=         3440.5


          TIME OF CONCENTRATION (HRS)=   .4378     TIME TO PEAK (HRS)=   .2919     LAG TIME (HRS)=   .3283

     COMPUTE NM HYD      ID=1   HYD NO=42   DA= 0.576 SQ MI
                         PER A=90 PER B=0  PER C=10  PER D=0
                         TP=0.0   MASSRAIN=-1
          TIME TO PEAK (hrs)=   .2919

          K =   .300133HR    TP =   .291863HR    K/TP RATIO =  1.028333     SHAPE CONSTANT, N =  3.432684
          UNIT PEAK =   622.42    CFS   UNIT VOLUME =    1.000       B =   315.38      P60 = 1.6900
          AREA =      .576000 SQ MI    IA =    .62000 INCHES    INF =   1.58600 INCHES PER HOUR
          RUNOFF COMPUTED BY INITIAL ABSTRACTION/INFILTRATION NUMBER METHOD - DT =   .050000

         BULKING FACTOR APPLIED TO HYDROGRAPH.  FACTOR =  1.05000 AT PEAK FLOW.

     PRINT HYD           ID=1   CODE=1

                                        OUTFLOW HYDROGRAPH REACH    42.00


         RUNOFF VOLUME =      .44411 INCHES     =      13.6431 ACRE-FEET
         PEAK DISCHARGE RATE =     269.27 CFS  AT   1.650 HOURS   BASIN AREA =   .5760 SQ. MI.



     *
     *S
     ***********************************************************************
     *S  ADD 42 TO 38.9 TO GET 42.3
     *S
     ADD HYD             ID=3  HYD NO=42.3 ID I=1 ID II=6
     PRINT HYD           ID=3   CODE=1

                                        OUTFLOW HYDROGRAPH REACH    42.30


         RUNOFF VOLUME =      .49814 INCHES     =      39.8773 ACRE-FEET
         PEAK DISCHARGE RATE =     269.32 CFS  AT   1.650 HOURS   BASIN AREA =  1.5010 SQ. MI.



     *
     *S
     ***********************************************************************
     *S*** SUB-BASIN 42A ****
     *
     COMPUTE LT TP       LCODE=1  UPLAND/LAG TIME TRANSITION METHOD
                         NK=3  ISLOPE=-1
                         LENGTH=400 FT   SLOPE=0.055 K=0.7
                         LENGTH=1600 FT  SLOPE=0.040 K=2.0
                         LENGTH=2240 FT   SLOPE=0.033 K=3.0
                         Kn=.033  CR=.5
```

```
     Tc AND Tp COMPUTED BY UPLAND/LAG TIME PROCEDURE

     SCS UPLAND METHOD FACTORS
                              LENGTH (FT)      SLOPE (FT/FT)       COMPOSITE K
     SHEET FLOW PORTION           400.0           .055000             .7000
     SHALLOW FLOW PORTION        1600.0           .040000            2.0000
     CHANNEL FLOW PORTION        2240.0           .033000            3.0000
     TOTAL BASIN                 4240.0           .037717            2.0700


     LAG EQUATION FACTORS:     Kn=   .0330     TOTAL BASIN LENGTH (FT)=      4240.0
     TOTAL BASIN SLOPE (FT/FT)=    .037717     CENTROUD LENGTH (FT)=         2120.0


     TIME OF CONCENTRATION (HRS)=   .2877     TIME TO PEAK (HRS)=   .1918     LAG TIME (HRS)=   .2158

COMPUTE NM HYD      ID=1   HYD NO=42A   DA= 0.317 SQ MI
                    PER A=90 PER B=0  PER C=10  PER D=0
                    TP=0.0   MASSRAIN=-1
     TIME TO PEAK (hrs)=   .1918

     K =   .197227HR    TP =   .191793HR    K/TP RATIO =  1.028333     SHAPE CONSTANT, N =  3.432684
     UNIT PEAK =   521.27    CFS   UNIT VOLUME =    1.000       B =   315.38      P60 = 1.6900
     AREA =      .317000 SQ MI    IA =    .62000 INCHES    INF =   1.58600 INCHES PER HOUR
     RUNOFF COMPUTED BY INITIAL ABSTRACTION/INFILTRATION NUMBER METHOD - DT =   .050000

    BULKING FACTOR APPLIED TO HYDROGRAPH.  FACTOR =  1.05000 AT PEAK FLOW.

PRINT HYD           ID=1   CODE=1

                                        HYDROGRAPH FROM AREA 42A


    RUNOFF VOLUME =      .44411 INCHES     =       7.5084 ACRE-FEET
    PEAK DISCHARGE RATE =     217.62 CFS  AT   1.550 HOURS   BASIN AREA =   .3170 SQ. MI.



*
*S
************************************************************************
*S  ADD 42 TO 38.9 TO GET 42A.4
*S
ADD HYD             ID=4  HYD NO=42A.4 ID I=1 ID II=3
PRINT HYD           ID=4   CODE=1

                                        HYDROGRAPH FROM AREA 42A.4


    RUNOFF VOLUME =      .48872 INCHES     =      47.3857 ACRE-FEET
    PEAK DISCHARGE RATE =     465.40 CFS  AT   1.600 HOURS   BASIN AREA =  1.8180 SQ. MI.



*
*S
************************************************************************
*S ROUTE 42A.4 THRU UPPER 41B IN NATURAL ARROYO TO 41B.52
*
COMPUTE RATING CURVE  CID=1   VS NO=1   NO SEGS=1
                      MIN ELEV=5556.25   MAX ELEV=5561.32
                      CH SLOPE=0.0195    FP SLOPE=0.0195
                      N=0.035           DIST=400.0
                      DIST  ELEV    DIST  ELEV
                        0   5561.13   62 5558.07
                                  199     5556.25 288     5558.06
                                  400     5561.32


                                   RATING CURVE VALLEY SECTION  1.0
                                      WATER       FLOW        FLOW        TOP
                                     SURFACE      AREA        RATE        WIDTH
                                      ELEV        SQ FT       CFS         FT
                                    5556.25         .00         .00         .00
                                    5556.52        4.42        6.84       33.18
                                    5556.78       17.69       43.44       66.36
                                    5557.05       39.81      128.09       99.54
                                    5557.32       70.76      275.85      132.72
                                    5557.58      110.57      500.15      165.90
                                    5557.85      159.22      813.30      199.07
                                    5558.12      216.63     1238.07      228.87
                                    5558.38      279.59     1817.78      243.43
                                    5558.65      346.43     2499.58      257.99
                                    5558.92      417.15     3284.18      272.55
                                    5559.18      491.76     4172.95      287.12
                                    5559.45      570.25     5167.68      301.68
                                    5559.72      652.61     6270.46      316.24
                                    5559.98      738.86     7483.55      330.80
                                    5560.25      829.00     8809.37      345.36
                                    5560.52      923.01    10250.39      359.92
```

```
                                        5560.78     1020.91    11809.18      374.49
                                        5561.05     1122.69    13488.33      389.05
                                        5561.32     1228.00    15378.95      399.85
     ROUTE MCUNGE        ID=51   HYD NO=41B.51  INFLOW ID=4
                         DT=0.0   L=2296 FT   NS=0   SLOPE=0.0195
                         MATCODE=0 REGCODE=0 CCODE=0 MM CODE=0

          INFLOW END= 600            TABLE PTS= 20
          DT=  .050000               QMED=      232.70  CKMED=      4.7728
          WIDTH MED=      123.03     NREACH=  6         DX=      382.67

       DEPTH   AREA      Q    TRAVEL  WIDTH     ck      VEL      C       D      C1     C2     C3     Q-M      C1-M
C2-M   C3-M
        (FT)  (SQ FT)  (CFS)  TIME(HR) (FT)     (FPS)   (FPS)                                          (CFS)
          .00     .0       .0    .565     .0     2.13     .71    1.000   .000  1.000   .000   .000       .0   1.000
.000   .000
          .27    4.4      6.8    .412   33.2     2.16   1.55    1.015   .013   .987   .014  -.001      1.1    .998
.002   .000
          .53   17.7     43.4    .260   66.4     3.42   2.46    1.607   .026   .980   .240  -.221     20.4    .982
.122  -.104
          .80   39.8    128.1    .198   99.5     4.38   3.22    2.062   .039   .975   .355  -.330     79.9    .976
.289  -.265
         1.07   70.8    275.8    .164  132.7     5.27   3.90    2.477   .053   .970   .433  -.403    195.3    .971
.390  -.361
         1.33  110.6    500.1    .141  165.9     6.08   4.52    2.862   .066   .966   .491  -.457    380.7    .967
.460  -.427
         1.60  159.2    813.3    .125  199.1     6.94   5.11    3.266   .079   .964   .540  -.503    648.8    .964
.511  -.475
         1.87  216.6   1238.1    .112  228.9     8.19   5.72    3.851   .089   .964   .595  -.559   1016.8    .963
.564  -.526
         2.13  279.6   1817.8    .098  243.4     9.74   6.50    4.580   .103   .964   .648  -.612   1517.2    .966
.631  -.597
         2.40  346.4   2499.6    .088  258.0    10.67   7.22    5.021   .122   .960   .674  -.635   2148.4    .962
.662  -.623
         2.67  417.2   3284.2    .081  272.6    11.53   7.87    5.422   .140   .957   .695  -.653   2881.9    .959
.685  -.644
         2.93  491.8   4172.9    .075  287.1    12.31   8.49    5.792   .158   .954   .712  -.667   3718.8    .956
.704  -.659
         3.20  570.2   5167.7    .070  301.7    13.05   9.06    6.138   .176   .952   .727  -.678   4660.7    .953
.719  -.672
         3.47  652.6   6270.5    .066  316.2    13.74   9.61    6.464   .193   .950   .739  -.688   5709.6    .951
.733  -.683
         3.73  738.9   7483.6    .063  330.8    14.40  10.13    6.774   .211   .947   .750  -.697   6867.6    .948
.744  -.692
         4.00  829.0   8809.4    .060  345.4    15.03  10.63    7.071   .227   .945   .759  -.704   8137.1    .946
.754  -.700
         4.27  923.0  10250.4    .057  359.9    15.64  11.11    7.356   .244   .943   .767  -.711   9520.5    .944
.763  -.707
         4.53 1020.9  11809.2    .055  374.5    16.22  11.57    7.631   .261   .941   .775  -.716  11020.5    .942
.771  -.713
         4.80 1122.7  13488.3    .053  389.0    17.19  12.01    8.084   .270   .942   .786  -.728  12639.4    .940
.778  -.719
         5.07 1228.0  15378.9    .051  399.8    18.14  12.52    8.532   .284   .942   .796  -.738  14422.8    .944
.794  -.738
     MAXIMUM NO. ITERATIONS FOR SOLUTION (KKMAX) =   5 OCCURRED       3 TIMES.  AVERAGE NUMBER ITERATIONS =  1.2341
     Equations solved using the Ponce correction to C2
     PRINT HYD           ID=51   CODE=1

                                          HYDROGRAPH FROM AREA 41B.51

        RUNOFF VOLUME =      .48956 INCHES     =      47.4675 ACRE-FEET
        PEAK DISCHARGE RATE =     461.26 CFS  AT   1.750 HOURS   BASIN AREA =  1.8180 SQ. MI.



     *
     ************************************************************************
     *S ROUTE 41B.52 THRU MID 41B IN NATURAL ARROYO TO 41B.5
     *
     COMPUTE RATING CURVE  CID=1   VS NO=1   NO SEGS=1
                           MIN ELEV=5482.02   MAX ELEV=5532.32
                           CH SLOPE=0.18    FP SLOPE=0.18
                           N=0.035           DIST=400.0
                           DIST  ELEV    DIST  ELEV
                             0   5530.30   53 5531.12
                                       112     5527.73 199     5482.02
                                       294     5527.84 400     5532.32


                                    RATING CURVE VALLEY SECTION  1.0
                                       WATER       FLOW        FLOW        TOP
                                      SURFACE      AREA        RATE        WIDTH
                                       ELEV        SQ FT       CFS         FT
                                     5482.02         .00         .00         .00
                                     5484.67       13.94      280.70       10.53
                                     5487.31       55.74     1782.35       21.06
                                     5489.96      125.43     5254.98       31.58
                                     5492.61      222.98    11317.26       42.11
                                     5495.26      348.41    20519.57       52.64
```

5497.90	501.70	33367.11	63.17
5500.55	682.88	50331.93	73.70
5503.20	891.92	71860.30	84.22
5505.85	1128.84	98377.54	94.75
5508.49	1393.62	130291.50	105.28
5511.14	1686.29	167995.10	115.81
5513.79	2006.82	211868.50	126.34
5516.44	2355.23	262280.10	136.86
5519.08	2731.50	319588.60	147.39
5521.73	3135.66	384143.30	157.92
5524.38	3567.68	456285.50	168.45
5527.03	4027.57	536348.80	178.98
5529.67	4580.97	530426.50	259.24
5532.32	5484.07	546080.90	400.00

```
ROUTE MCUNGE        ID=52   HYD NO=41B.52  INFLOW ID=51
                    DT=0.0   L=370 FT   NS=0   SLOPE=0.18
                    MATCODE=0 REGCODE=0 CCODE=0 MM CODE=0
     ZERO VALUE HYDROGRAPH OR SHORT ROUTE - ROUTING BYPASSED
PRINT HYD           ID=52   CODE=1

                                    HYDROGRAPH FROM AREA 41B.52


    RUNOFF VOLUME =      .48956 INCHES     =      47.4675 ACRE-FEET
    PEAK DISCHARGE RATE =     461.26 CFS  AT   1.750 HOURS   BASIN AREA =  1.8180 SQ. MI.



*
**********************************************************************
*S ROUTE 41B.5 THRU LOWER 41B IN NATURAL ARROYO TO 41B.3
*
COMPUTE RATING CURVE  CID=1   VS NO=1   NO SEGS=1
                      MIN ELEV=5451.32   MAX ELEV=5462.04
                      CH SLOPE=0.016    FP SLOPE=0.016
                      N=0.035           DIST=300.0
                      DIST  ELEV    DIST  ELEV
                        0   5462.04   103 5452.05
                                  150     5451.32 219     5452.73
                                  300     5457.13
```

RATING CURVE VALLEY SECTION 1.0

WATER SURFACE ELEV	FLOW AREA SQ FT	FLOW RATE CFS	TOP WIDTH FT
5451.32	.00	.00	.00
5451.88	18.05	41.71	63.96
5452.45	67.90	270.34	106.35
5453.01	136.15	749.36	131.15
5453.58	214.75	1481.67	147.36
5454.14	302.50	2446.09	163.57
5454.71	399.40	3649.30	179.78
5455.27	505.45	5100.70	195.99
5455.84	620.65	6810.93	212.20
5456.40	745.01	8791.24	228.41
5456.96	878.51	11053.14	244.62
5457.53	1019.70	13836.65	253.49
5458.09	1164.42	17002.18	259.31
5458.66	1312.43	20448.90	265.13
5459.22	1463.73	24173.38	270.95
5459.79	1618.31	28173.12	276.77
5460.35	1776.17	32446.41	282.59
5460.92	1937.32	36992.16	288.41
5461.48	2101.76	41809.76	294.23
5462.04	2269.47	46903.77	300.00

```
ROUTE MCUNGE        ID=5   HYD NO=41B.5  INFLOW ID=52
                    DT=0.0   L=1760 FT   NS=0   SLOPE=0.016
                    MATCODE=0 REGCODE=0 CCODE=0 MM CODE=0

    INFLOW END= 600            TABLE PTS= 20
    DT=  .050000               QMED=      230.63  CKMED=      4.5862
    WIDTH MED=       98.99     NREACH=  5         DX=       352.00
```

DEPTH (FT)	AREA (SQ FT)	Q (CFS)	TRAVEL TIME(HR)	WIDTH (FT)	ck (FPS)	VEL (FPS)	C	D	C1	C2	C3	Q-M (CFS)	C1-M	C2-M	C3-M
.00	.0	.0	.300	.0	1.96	.94	1.000	.000	1.000	.000	.000	.0	1.000	.000	.000
.56	18.1	41.7	.212	64.0	3.34	2.31	1.707	.035	.975	.270	-.245	6.6	.981	.006	.012
1.13	67.9	270.3	.123	106.4	5.96	3.98	3.048	.076	.963	.515	-.478	129.3	.967	.420	-.387
1.69	136.1	749.4	.089	131.1	8.25	5.50	4.217	.123	.954	.625	-.579	482.6	.957	.578	-.536
2.26	214.7	1481.7	.071	147.4	10.25	6.90	5.242	.174	.946	.688	-.634	1089.7	.949	.662	-.611
2.82	302.5	2446.1	.060	163.6	11.78	8.09	6.022	.225	.938	.724	-.662	1939.5	.941	.707	-.647
3.39	399.4	3649.3	.054	179.8	13.11	9.14	6.703	.275	.931	.749	-.680	3024.0	.934		

```
.737  -.670
        3.95  505.5   5100.7    .048  196.0    14.31  10.09    7.319   .323   .925   .769  -.694   4351.6    .927
.759  -.686
        4.52  620.7   6810.9    .045  212.2    15.43  10.97    7.888   .369   .920   .784  -.704   5932.6    .922
.776  -.698
        5.08  745.0   8791.2    .041  228.4    16.47  11.80    8.422   .415   .916   .797  -.712   7777.8    .917
.790  -.708
        5.64  878.5  11053.1    .039  244.6    18.20  12.58    9.306   .441   .918   .814  -.732   9898.8    .913
.802  -.715
        6.21 1019.7  13836.6    .036  253.5    20.77  13.57   10.622   .467   .923   .835  -.757  12415.5    .923
.827  -.750
        6.77 1164.4  17002.2    .033  259.3    22.60  14.60   11.559   .515   .921   .847  -.768  15388.5    .923
.842  -.765
        7.34 1312.4  20448.9    .031  265.1    23.97  15.58   12.259   .571   .917   .855  -.773  18695.7    .919
.851  -.770
        7.90 1463.7  24173.4    .030  270.9    25.27  16.51   12.920   .627   .914   .863  -.776  22282.2    .915
.859  -.774
        8.47 1618.3  28173.1    .028  276.8    26.49  17.41   13.546   .682   .910   .869  -.779  26145.0    .912
.866  -.778
        9.03 1776.2  32446.4    .027  282.6    27.66  18.27   14.142   .737   .907   .874  -.781  30282.2    .909
.871  -.780
        9.60 1937.3  36992.2    .026  288.4    28.77  19.09   14.711   .792   .904   .879  -.783  34692.3    .905
.876  -.782
       10.16 2101.8  41809.8    .025  294.2    29.85  19.89   15.264   .845   .901   .883  -.784  39374.5    .902
.881  -.783
       10.72 2269.5  46903.8    .024  300.0    30.69  20.67   15.692   .905   .897   .886  -.784  44330.6    .900
.885  -.785
     MAXIMUM NO. ITERATIONS FOR SOLUTION (KKMAX) =   7 OCCURRED       1 TIMES.  AVERAGE NUMBER ITERATIONS =  1.2231
       DEPTH   AREA      Q    TRAVEL  WIDTH     ck       VEL      C       D      C1     C2     C3     Q-M      C1-M
C2-M   C3-M
        (FT)  (SQ FT)  (CFS)  TIME(HR) (FT)     (FPS)   (FPS)                                          (CFS)
         .00     .0       .0    .300     .0     1.96    .94    1.000   .000  1.000   .000   .000       .0   1.000
.000   .000
          .56   18.1     41.7    .212   64.0     2.07   2.31    1.056   .056   .947   .053   .000      6.6    .981
.006   .012
         1.13   67.9    270.3    .123  106.4     2.33   3.98    1.193   .193   .838   .162   .000    129.3    .891
.109   .000
         1.69  136.1    749.4    .089  131.1     2.69   5.50    1.377   .377   .726   .274   .000    482.6    .777
.223   .000
         2.26  214.7   1481.7    .071  147.4     3.09   6.90    1.578   .578   .634   .366   .000   1089.7    .676
.324   .000
         2.82  302.5   2446.1    .060  163.6     3.46   8.09    1.768   .768   .566   .434   .000   1939.5    .597
.403   .000
         3.39  399.4   3649.3    .054  179.8     3.81   9.14    1.947   .947   .514   .486   .000   3024.0    .538
.462   .000
         3.95  505.5   5100.7    .048  196.0     4.14  10.09    2.116  1.116   .472   .528   .000   4351.6    .492
.508   .000
         4.52  620.7   6810.9    .045  212.2     4.46  10.97    2.279  1.279   .439   .561   .000   5932.6    .455
.545   .000
         5.08  745.0   8791.2    .041  228.4     4.76  11.80    2.435  1.435   .411   .589   .000   7777.8    .424
.576   .000
         5.64  878.5  11053.1    .039  244.6     5.06  12.58    2.586  1.586   .387   .613   .000   9898.8    .398
.602   .000
         6.21 1019.7  13836.6    .036  253.5     5.44  13.57    2.782  1.782   .359   .641   .000  12415.5    .372
.628   .000
         6.77 1164.4  17002.2    .033  259.3     5.85  14.60    2.991  1.991   .334   .666   .000  15388.5    .346
.654   .000
         7.34 1312.4  20448.9    .031  265.1     6.24  15.58    3.193  2.193   .313   .687   .000  18695.7    .323
.677   .000
         7.90 1463.7  24173.4    .030  270.9     6.63  16.51    3.390  2.390   .295   .705   .000  22282.2    .304
.696   .000
         8.47 1618.3  28173.1    .028  276.8     7.00  17.41    3.581  2.581   .279   .721   .000  26145.0    .287
.713   .000
         9.03 1776.2  32446.4    .027  282.6     7.37  18.27    3.767  2.767   .265   .735   .000  30282.2    .272
.728   .000
         9.60 1937.3  36992.2    .026  288.4     7.72  19.09    3.949  2.949   .253   .747   .000  34692.3    .259
.741   .000
        10.16 2101.8  41809.8    .025  294.2     8.07  19.89    4.127  3.127   .242   .758   .000  39374.5    .248
.752   .000
        10.72 2269.5  46903.8    .024  300.0     8.41  20.67    4.301  3.301   .233   .767   .000  44330.6    .237
.763   .000
     MAXIMUM NO. ITERATIONS FOR SOLUTION (KKMAX) =   4 OCCURRED       6 TIMES.  AVERAGE NUMBER ITERATIONS =  1.1492
     Equations solved with two passes: first using the Ponce correction to C1, second using the Fread correction to C1,
C2 and C3
     PRINT HYD           ID=5   CODE=1

                                          HYDROGRAPH FROM AREA 41B.5


        RUNOFF VOLUME =      .48663 INCHES     =      47.1835 ACRE-FEET
        PEAK DISCHARGE RATE =     452.72 CFS  AT   1.900 HOURS   BASIN AREA =  1.8180 SQ. MI.



     *
     **************************************************************************

     *S*** SUB-BASIN 41B ****
     *
     COMPUTE LT TP       LCODE=1  UPLAND/LAG TIME TRANSITION METHOD
```

```
                    NK=3  ISLOPE=-1
                    LENGTH=400 FT   SLOPE=0.020 K=0.7
                    LENGTH=1600 FT  SLOPE=0.020 K=2.0
                    LENGTH=2167 FT   SLOPE=0.044 K=3.0
                    Kn=.033  CR=.5

     Tc AND Tp COMPUTED BY UPLAND/LAG TIME PROCEDURE

     SCS UPLAND METHOD FACTORS
                               LENGTH (FT)      SLOPE (FT/FT)       COMPOSITE K
     SHEET FLOW PORTION           400.0           .020000             .7000
     SHALLOW FLOW PORTION        1600.0           .020000            2.0000
     CHANNEL FLOW PORTION        2167.0           .044000            3.0000
     TOTAL BASIN                 4167.0           .032481            1.7595


     LAG EQUATION FACTORS:     Kn=   .0330     TOTAL BASIN LENGTH (FT)=      4167.0
     TOTAL BASIN SLOPE (FT/FT)=    .032481     CENTROUD LENGTH (FT)=         2083.5


     TIME OF CONCENTRATION (HRS)=   .3571     TIME TO PEAK (HRS)=   .2380     LAG TIME (HRS)=   .2678

COMPUTE NM HYD      ID=1   HYD NO=41B   DA= 0.137 SQ MI
                    PER A=70 PER B=0  PER C=30  PER D=0
                    TP=0.0   MASSRAIN=-1
     TIME TO PEAK (hrs)=   .2380

     K =   .256256HR    TP =   .238041HR    K/TP RATIO =  1.076520     SHAPE CONSTANT, N =  3.281296
     UNIT PEAK =   174.97    CFS   UNIT VOLUME =    1.000       B =   304.01      P60 = 1.6900
     AREA =      .137000 SQ MI    IA =    .56000 INCHES    INF =   1.41800 INCHES PER HOUR
     RUNOFF COMPUTED BY INITIAL ABSTRACTION/INFILTRATION NUMBER METHOD - DT =   .050000

    BULKING FACTOR APPLIED TO HYDROGRAPH.  FACTOR =  1.05000 AT PEAK FLOW.

PRINT HYD           ID=1   CODE=1

                                        HYDROGRAPH FROM AREA 41B


    RUNOFF VOLUME =      .52701 INCHES     =       3.8507 ACRE-FEET
    PEAK DISCHARGE RATE =      87.53 CFS  AT   1.600 HOURS   BASIN AREA =   .1370 SQ. MI.



*
*S
*************************************************************************
*S  ADD 41B TO 42A.4 TO GET 41B.3
*S
ADD HYD             ID=3  HYD NO=41B.3 ID I=1 ID II=5
PRINT HYD           ID=3   CODE=1

                                        HYDROGRAPH FROM AREA 41B.3


    RUNOFF VOLUME =      .48946 INCHES     =      51.0341 ACRE-FEET
    PEAK DISCHARGE RATE =     491.33 CFS  AT   1.900 HOURS   BASIN AREA =  1.9550 SQ. MI.



*
*S
*************************************************************************
*S*** SUB-BASIN 43A ****
*
COMPUTE LT TP       LCODE=1  UPLAND/LAG TIME TRANSITION METHOD
                    NK=3  ISLOPE=-1
                    LENGTH=400 FT   SLOPE=0.038 K=0.7
                    LENGTH=1600 FT  SLOPE=0.034 K=2.0
                    LENGTH=4762 FT   SLOPE=0.037 K=3.0
                    Kn=.033  CR=.5

     Tc AND Tp COMPUTED BY UPLAND/LAG TIME PROCEDURE

     SCS UPLAND METHOD FACTORS
                               LENGTH (FT)      SLOPE (FT/FT)       COMPOSITE K
     SHEET FLOW PORTION           400.0           .038000             .7000
     SHALLOW FLOW PORTION        1600.0           .034000            2.0000
     CHANNEL FLOW PORTION        4762.0           .037000            3.0000
     TOTAL BASIN                 6762.0           .036349            2.2849


     LAG EQUATION FACTORS:     Kn=   .0330     TOTAL BASIN LENGTH (FT)=      6762.0
     TOTAL BASIN SLOPE (FT/FT)=    .036349     CENTROUD LENGTH (FT)=         3381.0


     TIME OF CONCENTRATION (HRS)=   .3939     TIME TO PEAK (HRS)=   .2626     LAG TIME (HRS)=   .2954

COMPUTE NM HYD      ID=2   HYD NO=43A   DA= 0.186 SQ MI
                    PER A=80 PER B=10  PER C=10  PER D=0
                    TP=0.0   MASSRAIN=-1
```

```
     TIME TO PEAK (hrs)=   .2626

     K =   .289729HR    TP =   .262593HR    K/TP RATIO =  1.103339     SHAPE CONSTANT, N =  3.204149
     UNIT PEAK =   211.13    CFS   UNIT VOLUME =    1.000       B =   298.06      P60 = 1.6900
     AREA =      .186000 SQ MI    IA =    .60500 INCHES    INF =   1.54400 INCHES PER HOUR
     RUNOFF COMPUTED BY INITIAL ABSTRACTION/INFILTRATION NUMBER METHOD - DT =   .050000

    BULKING FACTOR APPLIED TO HYDROGRAPH.  FACTOR =  1.05000 AT PEAK FLOW.

PRINT HYD           ID=2   CODE=1

                                        HYDROGRAPH FROM AREA 43A


    RUNOFF VOLUME =      .46367 INCHES     =       4.5996 ACRE-FEET
    PEAK DISCHARGE RATE =      94.85 CFS  AT   1.650 HOURS   BASIN AREA =   .1860 SQ. MI.



*
*S
**************************************************************************
*S  ADD 43A TO 41B.3 TO GET 43A.6
*S
ADD HYD             ID=6  HYD NO=43A.6 ID I=2 ID II=3
PRINT HYD           ID=6   CODE=1

                                        HYDROGRAPH FROM AREA 43A.6


    RUNOFF VOLUME =      .48722 INCHES     =      55.6338 ACRE-FEET
    PEAK DISCHARGE RATE =     541.85 CFS  AT   1.900 HOURS   BASIN AREA =  2.1410 SQ. MI.



*
*S
**************************************************************************
*S  ADD 43A.6 TO 41A.9 TO GET 41A.7
*S
ADD HYD             ID=7  HYD NO=41A.7 ID I=6 ID II=9
PRINT HYD           ID=7   CODE=1

                                        HYDROGRAPH FROM AREA 41A.7


    RUNOFF VOLUME =      .42679 INCHES     =     265.8403 ACRE-FEET
    PEAK DISCHARGE RATE =    1175.63 CFS  AT   2.750 HOURS   BASIN AREA = 11.6790 SQ. MI.



*
*S
**************************************************************************
*S ROUTE 41A.7 THRU 43 IN NATURAL ARROYO TO 43.3
*
COMPUTE RATING CURVE  CID=1   VS NO=1   NO SEGS=1
                      MIN ELEV=5412.0   MAX ELEV=5437.18
                      CH SLOPE=0.009    FP SLOPE=0.009
                      N=0.035           DIST=600.0
                      DIST  ELEV    DIST  ELEV
                        0   5437.18   131 5420.64
                                  248     5414.98 300     5412.0
                                  362     5413.9  488     5419.34
                                  600     5424.41


                                   RATING CURVE VALLEY SECTION  1.0
                                      WATER       FLOW        FLOW        TOP
                                     SURFACE      AREA        RATE        WIDTH
                                      ELEV        SQ FT       CFS         FT
                                    5412.00         .00         .00         .00
                                    5413.33       43.98      134.55       66.37
                                    5414.65      173.24      863.91      125.63
                                    5415.98      376.98     2459.75      182.66
                                    5417.30      657.53     5171.28      240.74
                                    5418.63     1015.05     9232.20      298.83
                                    5419.95     1449.34    14866.76      356.26
                                    5421.28     1956.43    22508.80      404.82
                                    5422.60     2519.24    32224.46      444.58
                                    5423.93     3134.75    43809.27      484.35
                                    5425.25     3795.14    58548.43      505.53
                                    5426.58     4472.01    75913.80      516.02
                                    5427.90     5162.80    95153.55      526.52
                                    5429.23     5867.49   116221.90      537.01
                                    5430.55     6586.09   139083.70      547.51
                                    5431.88     7318.60   163712.00      558.01
                                    5433.20     8065.02   190086.00      568.50
                                    5434.53     8825.35   218189.80      579.00
                                    5435.85     9599.59   248011.70      589.49
                                    5437.18    10387.74   279542.90      599.99
```

ROUTE MCUNGE ID=5 HYD NO=43.5 INFLOW ID=7
DT=0.0 L=4200 FT NS=0 SLOPE=0.009
MATCODE=0 REGCODE=0 CCODE=0 MM CODE=0

INFLOW END= 600 TABLE PTS= 20
DT= .050000 QMED= 587.82 CKMED= 5.6425
WIDTH MED= 103.20 NREACH= 8 DX= 525.00

DEPTH (FT)	AREA (SQ FT)	Q (CFS)	TRAVEL TIME(HR)	WIDTH (FT)	ck (FPS)	VEL (FPS)	C	D	C1	C2	C3	Q-M (CFS)	C1-M	C2-M	C3-M
.00	.0	.0	.529	.0	2.92	1.35	1.000	.000	1.000	.000	.000	.0	1.000	.000	.000
1.33	44.0	134.5	.381	66.4	4.32	3.06	1.483	.099	.923	.225	-.149	21.2	.988	.035	-.023
2.65	173.2	863.9	.234	125.6	7.03	4.99	2.410	.207	.886	.447	-.333	407.5	.895	.350	-.245
3.98	377.0	2459.8	.179	182.7	8.91	6.52	3.056	.320	.854	.543	-.397	1557.6	.859	.491	-.350
5.30	657.5	5171.3	.148	240.7	10.63	7.86	3.646	.428	.831	.606	-.437	3698.3	.836	.573	-.408
6.63	1015.0	9232.2	.128	298.8	12.26	9.10	4.203	.533	.814	.651	-.465	7073.2	.817	.628	-.445
7.95	1449.3	14866.8	.114	356.3	14.04	10.26	4.813	.629	.805	.690	-.494	11910.3	.803	.669	-.471
9.28	1956.4	22508.8	.101	404.8	16.18	11.51	5.546	.727	.800	.725	-.525	18530.5	.802	.709	-.511
10.60	2519.2	32224.5	.091	444.6	18.10	12.79	6.207	.847	.790	.752	-.541	27199.9	.796	.740	-.536
11.93	3134.7	43809.3	.083	484.4	20.41	13.98	6.997	.938	.790	.776	-.566	37850.7	.781	.761	-.542
13.25	3795.1	58548.4	.076	505.5	23.93	15.43	8.203	1.024	.800	.804	-.604	50974.3	.799	.793	-.593
14.58	4472.0	75913.8	.069	516.0	26.79	16.98	9.185	1.162	.795	.824	-.619	67013.7	.801	.816	-.617
15.90	5162.8	95153.5	.063	526.5	28.91	18.43	9.911	1.323	.784	.837	-.620	85325.9	.789	.830	-.619
17.23	5867.5	116221.9	.059	537.0	30.88	19.81	10.589	1.483	.773	.847	-.620	105488.0	.778	.842	-.620
18.55	6586.1	139083.7	.055	547.5	32.74	21.12	11.226	1.642	.763	.856	-.619	127459.8	.768	.852	-.619
19.88	7318.6	163712.0	.052	558.0	34.50	22.37	11.829	1.800	.754	.863	-.617	151210.7	.758	.860	-.618
21.20	8065.0	190086.0	.049	568.5	36.17	23.57	12.401	1.956	.745	.870	-.615	176716.8	.749	.867	-.616
22.53	8825.4	218189.8	.047	579.0	37.76	24.72	12.946	2.112	.737	.875	-.612	203960.1	.741	.873	-.614
23.85	9599.6	248011.7	.045	589.5	39.28	25.84	13.468	2.267	.729	.880	-.610	232926.8	.733	.878	-.611
25.18	10387.7	279542.9	.043	600.0	40.49	26.91	13.883	2.435	.719	.885	-.603	263606.8	.725	.883	-.608

MAXIMUM NO. ITERATIONS FOR SOLUTION (KKMAX) = 5 OCCURRED 2 TIMES. AVERAGE NUMBER ITERATIONS = 1.3891

DEPTH (FT)	AREA (SQ FT)	Q (CFS)	TRAVEL TIME(HR)	WIDTH (FT)	ck (FPS)	VEL (FPS)	C	D	C1	C2	C3	Q-M (CFS)	C1-M	C2-M	C3-M
.00	.0	.0	.529	.0	2.92	1.35	1.000	.000	1.000	.000	.000	.0	1.000	.000	.000
1.33	44.0	134.5	.381	66.4	3.30	3.06	1.130	.130	.885	.115	.000	21.2	.958	.042	.000
2.65	173.2	863.9	.234	125.6	3.98	4.99	1.365	.365	.732	.268	.000	407.5	.802	.198	.000
3.98	377.0	2459.8	.179	182.7	4.69	6.52	1.608	.608	.622	.378	.000	1557.6	.670	.330	.000
5.30	657.5	5171.3	.148	240.7	5.38	7.86	1.845	.845	.542	.458	.000	3698.3	.577	.423	.000
6.63	1015.0	9232.2	.128	298.8	6.06	9.10	2.079	1.079	.481	.519	.000	7073.2	.508	.492	.000
7.95	1449.3	14866.8	.114	356.3	6.74	10.26	2.311	1.311	.433	.567	.000	11910.3	.455	.545	.000
9.28	1956.4	22508.8	.101	404.8	7.50	11.51	2.570	1.570	.389	.611	.000	18530.5	.409	.591	.000
10.60	2519.2	32224.5	.091	444.6	8.30	12.79	2.847	1.847	.351	.649	.000	27199.9	.369	.631	.000
11.93	3134.7	43809.3	.083	484.4	9.07	13.98	3.110	2.110	.322	.678	.000	37850.7	.335	.665	.000
13.25	3795.1	58548.4	.076	505.5	10.04	15.43	3.442	2.442	.291	.709	.000	50974.3	.305	.695	.000
14.58	4472.0	75913.8	.069	516.0	11.10	16.98	3.805	2.805	.263	.737	.000	67013.7	.276	.724	.000
15.90	5162.8	95153.5	.063	526.5	12.12	18.43	4.156	3.156	.241	.759	.000	85325.9	.251	.749	.000
17.23	5867.5	116221.9	.059	537.0	13.11	19.81	4.494	3.494	.223	.777	.000	105488.0	.231	.769	.000
18.55	6586.1	139083.7	.055	547.5	14.07	21.12	4.822	3.822	.207	.793	.000	127459.8	.215	.785	.000
19.88	7318.6	163712.0	.052	558.0	14.99	22.37	5.141	4.141	.195	.805	.000	151210.7	.201	.799	.000
21.20	8065.0	190086.0	.049	568.5	15.90	23.57	5.451	4.451	.183	.817	.000	176716.8	.189	.811	.000
22.53	8825.4	218189.8	.047	579.0	16.78	24.72	5.753	4.753	.174	.826	.000	203960.1	.178	.822	.000

```
      23.85 9599.6 248011.7    .045  589.5    17.64  25.84    6.048  5.048   .165   .835   .000 232926.8    .169
.831   .000
      25.1810387.7 279542.9    .043  600.0    18.48  26.91    6.336  5.336   .158   .842   .000 263606.8    .161
.839   .000
     MAXIMUM NO. ITERATIONS FOR SOLUTION (KKMAX) =   4 OCCURRED       2 TIMES.  AVERAGE NUMBER ITERATIONS =  1.3303
     Equations solved with two passes: first using the Ponce correction to C1, second using the Fread correction to C1,
C2 and C3
     PRINT HYD           ID=5   CODE=1

                                        OUTFLOW HYDROGRAPH REACH    43.50


         RUNOFF VOLUME =      .42625 INCHES     =     265.5005 ACRE-FEET
         PEAK DISCHARGE RATE =    1168.97 CFS  AT   3.050 HOURS   BASIN AREA = 11.6790 SQ. MI.



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     *S*** SUB-BASIN 43 ****
     *
     COMPUTE LT TP       LCODE=1  USDI BUREAU OF RECLAMATION LAG TIME EQUATION
                         NK=3  ISLOPE=-1
                         LENGTH=400 FT   SLOPE=0.0204 K=0.7
                         LENGTH=1600 FT  SLOPE=0.009 K=2.0
                         LENGTH=3052 FT   SLOPE=0.017 K=3.0
                         Kn=.033  CR=.5

          Tc AND Tp COMPUTED BY UPLAND/LAG TIME PROCEDURE

          SCS UPLAND METHOD FACTORS
                                   LENGTH (FT)      SLOPE (FT/FT)       COMPOSITE K
          SHEET FLOW PORTION          400.0            .020400             .7000
          SHALLOW FLOW PORTION       1600.0            .009000            2.0000
          CHANNEL FLOW PORTION       3052.0            .017000            3.0000
          TOTAL BASIN                5052.0            .014736            2.0566


          LAG EQUATION FACTORS:     Kn=   .0330     TOTAL BASIN LENGTH (FT)=      5052.0
          TOTAL BASIN SLOPE (FT/FT)=    .014736     CENTROUD LENGTH (FT)=         2526.0


          TIME OF CONCENTRATION (HRS)=   .4868     TIME TO PEAK (HRS)=   .3246     LAG TIME (HRS)=   .3651

     COMPUTE NM HYD      ID=1   HYD NO=43   DA= 0.170 SQ MI
                         PER A=80 PER B=10  PER C=10  PER D=0
                         TP=0.0   MASSRAIN=-1
          TIME TO PEAK (hrs)=   .3246

          K =   .361665HR    TP =   .324560HR    K/TP RATIO =  1.114323     SHAPE CONSTANT, N =  3.173880
          UNIT PEAK =   154.89    CFS   UNIT VOLUME =    .9999       B =   295.71      P60 = 1.6900
          AREA =      .170000 SQ MI    IA =    .60500 INCHES    INF =   1.54400 INCHES PER HOUR
          RUNOFF COMPUTED BY INITIAL ABSTRACTION/INFILTRATION NUMBER METHOD - DT =   .050000

         BULKING FACTOR APPLIED TO HYDROGRAPH.  FACTOR =  1.05000 AT PEAK FLOW.

     PRINT HYD           ID=1   CODE=1

                                        OUTFLOW HYDROGRAPH REACH    43.00


         RUNOFF VOLUME =      .46367 INCHES     =       4.2040 ACRE-FEET
         PEAK DISCHARGE RATE =      70.50 CFS  AT   1.700 HOURS   BASIN AREA =   .1700 SQ. MI.



     *
     *S
     **********************************************************************
     *S  ADD 43 TO 41A.7 TO GET 43.3
     *S
     ADD HYD             ID=3  HYD NO=43.3 ID I=1 ID II=5
     PRINT HYD           ID=3   CODE=1

                                        OUTFLOW HYDROGRAPH REACH    43.30


         RUNOFF VOLUME =      .42679 INCHES     =     269.7044 ACRE-FEET
         PEAK DISCHARGE RATE =    1173.65 CFS  AT   3.050 HOURS   BASIN AREA = 11.8490 SQ. MI.



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     *S*** SUB-BASIN 44 ****
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```
COMPUTE LT TP       LCODE=1  UPLAND/LAG TIME TRANSITION METHOD
                    NK=3  ISLOPE=-1
                    LENGTH=400 FT   SLOPE=0.049 K=0.7
                    LENGTH=1600 FT  SLOPE=0.040 K=2.0
                    LENGTH=8103 FT   SLOPE=0.025 K=3.0
                    Kn=.033  CR=0.51

     Tc AND Tp COMPUTED BY UPLAND/LAG TIME PROCEDURE

     SCS UPLAND METHOD FACTORS
                              LENGTH (FT)      SLOPE (FT/FT)       COMPOSITE K
     SHEET FLOW PORTION           400.0           .049000             .7000
     SHALLOW FLOW PORTION        1600.0           .040000            2.0000
     CHANNEL FLOW PORTION        8103.0           .025000            3.0000
     TOTAL BASIN                10103.0           .028326            2.5367


     LAG EQUATION FACTORS:     Kn=   .0330     TOTAL BASIN LENGTH (FT)=     10103.0
     TOTAL BASIN SLOPE (FT/FT)=    .028326     CENTROUD LENGTH (FT)=         5152.5


     TIME OF CONCENTRATION (HRS)=   .5875     TIME TO PEAK (HRS)=   .3917     LAG TIME (HRS)=   .4407

COMPUTE NM HYD      ID=5   HYD NO=44   DA= 0.409 SQ MI
                    PER A=90 PER B=0  PER C=10  PER D=0
                    TP=0.0   MASSRAIN=-1
     TIME TO PEAK (hrs)=   .3917

     K =   .402796HR    TP =   .391698HR    K/TP RATIO =  1.028333     SHAPE CONSTANT, N =  3.432684
     UNIT PEAK =   329.31    CFS   UNIT VOLUME =    1.000       B =   315.38      P60 = 1.6900
     AREA =      .409000 SQ MI    IA =    .62000 INCHES    INF =   1.58600 INCHES PER HOUR
     RUNOFF COMPUTED BY INITIAL ABSTRACTION/INFILTRATION NUMBER METHOD - DT =   .050000

    BULKING FACTOR APPLIED TO HYDROGRAPH.  FACTOR =  1.05000 AT PEAK FLOW.

PRINT HYD           ID=5   CODE=1

                                      OUTFLOW HYDROGRAPH REACH    44.00


    RUNOFF VOLUME =      .44411 INCHES     =       9.6875 ACRE-FEET
    PEAK DISCHARGE RATE =     144.19 CFS  AT   1.750 HOURS   BASIN AREA =   .4090 SQ. MI.



*S
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*S ADD 44 TO 61.6 TO GET 44.8
*
ADD HYD             ID=8  HYD NO=44.8 ID I=5 ID II=3
PRINT HYD           ID=8   CODE=1

                                      OUTFLOW HYDROGRAPH REACH    44.80


    RUNOFF VOLUME =      .42736 INCHES     =     279.3919 ACRE-FEET
    PEAK DISCHARGE RATE =    1185.10 CFS  AT   3.050 HOURS   BASIN AREA = 12.2580 SQ. MI.



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*
*S*** SUB-BASIN 61 ****
*
COMPUTE LT TP       LCODE=1  USDI BUREAU OF RECLAMATION LAG TIME EQUATION
                    NK=3  ISLOPE=-1
                    LENGTH=400 FT   SLOPE=0.04 K=0.7
                    LENGTH=1600 FT  SLOPE=0.008 K=2.0
                    LENGTH=308 FT   SLOPE=0.044 K=3.0


     Tc AND Tp COMPUTED BY UPLAND/LAG TIME PROCEDURE

     SCS UPLAND METHOD FACTORS
                              LENGTH (FT)      SLOPE (FT/FT)       COMPOSITE K
     SHEET FLOW PORTION           400.0           .040000             .7000
     SHALLOW FLOW PORTION        1600.0           .008000            2.0000
     CHANNEL FLOW PORTION         308.0           .044000            3.0000
     TOTAL BASIN                 2308.0           .018350            1.3862


     TIME OF CONCENTRATION (HRS)=   .3414     TIME TO PEAK (HRS)=   .2276     LAG TIME (HRS)=   .2561

COMPUTE NM HYD      ID=3   HYD NO=61   DA= 0.04846 SQ MI
                    PER A=80 PER B=10  PER C=10  PER D=0
                    TP=0.0   MASSRAIN=-1
     TIME TO PEAK (hrs)=   .2276

     K =   .270427HR    TP =   .227608HR    K/TP RATIO =  1.188123     SHAPE CONSTANT, N =  2.988424
```

UNIT PEAK = 59.801 CFS UNIT VOLUME = .9996 B = 280.88 P60 = 1.6900
AREA = .048460 SQ MI IA = .60500 INCHES INF = 1.54400 INCHES PER HOUR
RUNOFF COMPUTED BY INITIAL ABSTRACTION/INFILTRATION NUMBER METHOD - DT = .050000

BULKING FACTOR APPLIED TO HYDROGRAPH. FACTOR = 1.05000 AT PEAK FLOW.

```
PRINT HYD           ID=3   CODE=1
```

OUTFLOW HYDROGRAPH REACH 61.00

RUNOFF VOLUME = .46367 INCHES = 1.1984 ACRE-FEET
PEAK DISCHARGE RATE = 26.79 CFS AT 1.600 HOURS BASIN AREA = .0485 SQ. MI.

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*
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*
*S ADD 61 TO 44 TO GET 61.4
*
ADD HYD             ID=4  HYD NO=61.4 ID I=8 ID II=3
PRINT HYD           ID=4   CODE=1
```

OUTFLOW HYDROGRAPH REACH 61.40

RUNOFF VOLUME = .42751 INCHES = 280.5903 ACRE-FEET
PEAK DISCHARGE RATE = 1186.15 CFS AT 3.050 HOURS BASIN AREA = 12.3065 SQ. MI.

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*
*S ROUTE 61.4 THRU 60 IN NATURAL ARROYO TO 60.3
*
COMPUTE RATING CURVE  CID=1   VS NO=1   NO SEGS=1
                      MIN ELEV=5354   MAX ELEV=5360
                      CH SLOPE=0.013    FP SLOPE=0.0194
                      N=0.035           DIST=369.0
                      DIST  ELEV    DIST  ELEV
                        0          5360    45      5359
                                   89      5356    105     5355
                                   133     5354    150     5354
                                   177     5354    210     5355
                                   295     5357    349     5359
                                   369     5360
```

RATING CURVE VALLEY SECTION 1.0

WATER SURFACE ELEV	FLOW AREA SQ FT	FLOW RATE CFS	TOP WIDTH FT
5354.00	.00	.00	.00
5354.32	16.94	41.63	63.27
5354.63	39.98	145.77	82.54
5354.95	69.10	315.50	101.81
5355.26	104.22	559.56	120.42
5355.58	145.18	883.98	138.91
5355.90	191.98	1295.74	157.39
5356.21	244.60	1803.57	175.59
5356.53	302.92	2413.10	193.65
5356.84	366.95	3130.03	211.71
5357.16	436.49	3986.33	227.30
5357.48	510.37	4982.63	240.46
5357.79	588.42	6095.60	253.63
5358.11	670.62	7328.43	266.79
5358.42	756.99	8684.42	279.95
5358.74	847.51	10166.92	293.12
5359.05	942.22	11747.49	307.55
5359.37	1042.63	13320.75	328.09
5359.69	1149.52	15052.23	348.62
5360.00	1262.90	16952.94	369.00

```
ROUTE MCUNGE        ID=3   HYD NO=60.3  INFLOW ID=4
                    DT=0.0   L=1205 FT   NS=0   SLOPE=0.0194
                    MATCODE=0 REGCODE=0 CCODE=0 MM CODE=0
```

INFLOW END= 600 TABLE PTS= 20
DT= .050000 QMED= 593.08 CKMED= 7.9197
WIDTH MED= 122.33 NREACH= 2 DX= 602.50

DEPTH (FT)	AREA (SQ FT)	Q (CFS)	TRAVEL TIME(HR)	WIDTH (FT)	ck (FPS)	VEL (FPS)	C	D	C1	C2	C3	Q-M (CFS)	C1-M	C2-M	C3-M
.00	.0	.0	.181	.0	3.35	1.25	1.000	.000	1.000	.000	.000	.0	1.000	.000	.000
.32	16.9	41.6	.136	63.3	4.58	2.46	1.369	.012	.990	.160	-.150	6.6	.995		

```
.025  -.020
        .63   40.0    145.8    .092   82.5     5.31   3.65    1.586   .028   .978   .235  -.213     86.2    .981
.154  -.135
         .95   69.1    315.5    .073  101.8     6.46   4.57    1.931   .041   .972   .327  -.300    223.2    .974
.278  -.252
        1.26  104.2    559.6    .062  120.4     7.50   5.37    2.240   .053   .968   .393  -.360    430.0    .969
.359  -.328
        1.58  145.2    884.0    .055  138.9     8.41   6.09    2.512   .065   .964   .441  -.405    714.1    .965
.415  -.380
        1.90  192.0   1295.7    .050  157.4     9.26   6.75    2.767   .076   .960   .480  -.440   1082.0    .961
.459  -.420
        2.21  244.6   1803.6    .045  175.6    10.09   7.37    3.013   .087   .958   .512  -.470   1541.5    .959
.495  -.454
        2.53  302.9   2413.1    .042  193.6    10.85   7.97    3.243   .098   .955   .539  -.494   2099.9    .956
.525  -.481
        2.84  366.9   3130.0    .039  211.7    11.75   8.53    3.511   .108   .953   .567  -.520   2763.0    .953
.550  -.503
        3.16  436.5   3986.3    .037  227.3    12.90   9.13    3.853   .116   .953   .598  -.551   3548.7    .953
.583  -.537
        3.48  510.4   4982.6    .034  240.5    13.89   9.76    4.151   .128   .952   .621  -.573   4474.4    .953
.612  -.564
        3.79  588.4   6095.6    .032  253.6    14.65  10.36    4.377   .140   .949   .637  -.587   5529.1    .950
.629  -.579
        4.11  670.6   7328.4    .031  266.8    15.37  10.93    4.591   .153   .947   .652  -.599   6702.0    .948
.644  -.592
        4.42  757.0   8684.4    .029  280.0    16.06  11.47    4.797   .165   .945   .665  -.609   7996.4    .945
.658  -.604
        4.74  847.5  10166.9    .028  293.1    16.56  12.00    4.947   .179   .942   .674  -.615   9415.6    .943
.670  -.613
        5.05  942.2  11747.5    .027  307.6    16.28  12.47    4.865   .201   .934   .670  -.604  10947.7    .939
.675  -.615
        5.37 1042.6  13320.8    .026  328.1    15.95  12.78    4.764   .218   .927   .666  -.593  12526.7    .927
.661  -.588
        5.69 1149.5  15052.2    .026  348.6    16.49  13.09    4.928   .224   .927   .675  -.602  14178.5    .927
.670  -.597
        6.00 1262.9  16952.9    .025  369.0    16.62  13.42    4.964   .237   .924   .677  -.601  15994.1    .927
.679  -.606
     MAXIMUM NO. ITERATIONS FOR SOLUTION (KKMAX) =   4 OCCURRED       2 TIMES.  AVERAGE NUMBER ITERATIONS =  1.4354
     Equations solved using the Ponce correction to C2
     PRINT HYD           ID=3   CODE=1

                                        OUTFLOW HYDROGRAPH REACH    60.30

        RUNOFF VOLUME =      .42750 INCHES     =     280.5875 ACRE-FEET
        PEAK DISCHARGE RATE =    1185.85 CFS  AT   3.100 HOURS   BASIN AREA = 12.3065 SQ. MI.



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     *S*** SUB-BASIN 60 ****
     *
     COMPUTE LT TP       LCODE=1  USDI BUREAU OF RECLAMATION LAG TIME EQUATION
                         NK=3  ISLOPE=-1
                         LENGTH=400 FT   SLOPE=0.065 K=0.7
                         LENGTH=1600 FT  SLOPE=0.026 K=2.0
                         LENGTH=1310 FT   SLOPE=0.016 K=3.0


          Tc AND Tp COMPUTED BY UPLAND/LAG TIME PROCEDURE

          SCS UPLAND METHOD FACTORS
                                    LENGTH (FT)      SLOPE (FT/FT)       COMPOSITE K
          SHEET FLOW PORTION           400.0            .065000             .7000
          SHALLOW FLOW PORTION        1600.0            .026000            2.0000
          CHANNEL FLOW PORTION        1310.0            .016000            3.0000
          TOTAL BASIN                 3310.0            .026755            1.8992


          TIME OF CONCENTRATION (HRS)=   .2960     TIME TO PEAK (HRS)=   .1973     LAG TIME (HRS)=   .2220

     COMPUTE NM HYD      ID=1   HYD NO=60   DA= 0.11036 SQ MI
                         PER A=100 PER B=0  PER C=0  PER D=0
                         TP=0.0   MASSRAIN=-1
          TIME TO PEAK (hrs)=   .1973

          K =   .241072HR    TP =   .197312HR    K/TP RATIO =  1.221780     SHAPE CONSTANT, N =  2.913005
          UNIT PEAK =   153.62    CFS   UNIT VOLUME =    .9996       B =   274.65      P60 = 1.6900
          AREA =      .110360 SQ MI    IA =    .65000 INCHES    INF =   1.67000 INCHES PER HOUR
          RUNOFF COMPUTED BY INITIAL ABSTRACTION/INFILTRATION NUMBER METHOD - DT =   .050000

         BULKING FACTOR APPLIED TO HYDROGRAPH.  FACTOR =  1.05000 AT PEAK FLOW.

     PRINT HYD           ID=1   CODE=1

                                        OUTFLOW HYDROGRAPH REACH    60.00


         RUNOFF VOLUME =      .40595 INCHES     =       2.3894 ACRE-FEET
```

PEAK DISCHARGE RATE = 59.79 CFS AT 1.550 HOURS BASIN AREA = .1104 SQ. MI.

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*S
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*
*S ADD 60 TO 44.8 TO GET 60.20
*S
ADD HYD             ID=6  HYD NO=60.6 ID I=1 ID II=3
PRINT HYD           ID=6   CODE=1
```

OUTFLOW HYDROGRAPH REACH 60.60

RUNOFF VOLUME = .42731 INCHES = 282.9768 ACRE-FEET
PEAK DISCHARGE RATE = 1187.56 CFS AT 3.100 HOURS BASIN AREA = 12.4168 SQ. MI.

```
*
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*
*S ROUTE THRU 4-60" PIPES IN SCENIC BLVD - IP3 ********************
*S ROUTE RESERVOIR COMMAND WAS USED TO ROUTE THRU MULTIPLE PIPES IN SCENIC
*
ROUTE RESERVOIR         ID=19 HYD=60.19    INFLOW ID=6 CODE=5
                        OUTFLOW(CFS)    STORAGE(AC FT)  ELEV (FT)
                                  0.0             0.000           5339.8
                                 0.23             0.001           5340
                                   32             0.200           5341
                                  111             0.452           5342
                                  229             0.775           5343
                                  374             1.185           5344
                                  535             1.682           5345
                                  700             2.435           5346
                                 1190             3.181           5346.7
```

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TIME (HRS)	INFLOW (CFS)	ELEV (FEET)	VOLUME (AC-FT)	OUTFLOW (CFS)
.00	.00	5339.80	.000	.00
.25	.00	5339.80	.000	.00
.50	.00	5339.80	.000	.00
.75	.00	5339.80	.000	.00
1.00	.00	5339.80	.000	.00
1.25	.00	5339.80	.000	.00
1.50	85.85	5341.12	.231	41.81
1.75	274.44	5343.26	.881	266.49
2.00	590.41	5345.08	1.743	548.30
2.25	953.17	5346.34	2.796	937.21
2.50	744.13	5346.08	2.516	753.30
2.75	952.98	5346.32	2.777	924.55
3.00	1176.46	5346.67	3.149	1168.83
3.25	1163.04	5346.67	3.147	1167.77
3.50	1044.79	5346.50	2.970	1051.43
3.75	961.14	5346.38	2.839	965.39
4.00	920.56	5346.31	2.771	920.53
4.25	833.82	5346.21	2.664	850.48
4.50	664.75	5345.90	2.358	683.11
4.75	593.53	5345.46	2.031	611.37
5.00	489.85	5344.81	1.590	505.20
5.25	392.61	5344.21	1.290	408.04
5.50	306.47	5343.61	1.024	317.22
5.75	240.64	5343.14	.831	248.92
6.00	191.31	5342.73	.688	197.13
6.25	154.96	5342.41	.584	159.26
6.50	128.54	5342.17	.508	131.63
6.75	110.16	5342.01	.456	112.29
7.00	95.75	5341.83	.410	97.88
7.25	83.09	5341.67	.369	84.96
7.50	71.88	5341.53	.333	73.54
7.75	61.98	5341.40	.300	63.44
8.00	53.37	5341.29	.272	54.63
8.25	46.05	5341.19	.248	47.13
8.50	39.70	5341.11	.227	40.62
8.75	34.26	5341.04	.210	35.06
9.00	29.54	5340.96	.192	30.73
9.25	25.38	5340.83	.166	26.60
9.50	21.71	5340.71	.142	22.79
9.75	18.52	5340.61	.121	19.46
10.00	15.81	5340.52	.104	16.60
10.25	13.54	5340.44	.089	14.21
10.50	11.64	5340.38	.076	12.20

10.75	10.03	5340.32	.065	10.50
11.00	8.68	5340.28	.056	9.08
11.25	7.53	5340.24	.049	7.87
11.50	6.56	5340.21	.042	6.84
11.75	5.74	5340.18	.037	5.98
12.00	5.03	5340.16	.032	5.24
12.25	4.44	5340.14	.028	4.61
12.50	3.94	5340.12	.025	4.08
12.75	3.50	5340.11	.022	3.63
13.00	3.14	5340.09	.020	3.24
13.25	2.82	5340.08	.018	2.92
13.50	2.55	5340.08	.016	2.63
13.75	2.32	5340.07	.015	2.39

TIME (HRS)	INFLOW (CFS)	ELEV (FEET)	VOLUME (AC-FT)	OUTFLOW (CFS)
14.00	2.12	5340.06	.013	2.18
14.25	1.95	5340.06	.012	2.00
14.50	1.80	5340.05	.011	1.84
14.75	1.67	5340.05	.010	1.71
15.00	1.55	5340.04	.009	1.58
15.25	1.45	5340.04	.009	1.48
15.50	1.37	5340.04	.008	1.39
15.75	1.29	5340.03	.008	1.31
16.00	1.23	5340.03	.007	1.25
16.25	1.17	5340.03	.007	1.18
16.50	1.12	5340.03	.007	1.13
16.75	1.07	5340.03	.006	1.08
17.00	1.03	5340.03	.006	1.04
17.25	1.00	5340.02	.006	1.01
17.50	.97	5340.02	.006	.98
17.75	.94	5340.02	.006	.95
18.00	.91	5340.02	.005	.92
18.25	.89	5340.02	.005	.90
18.50	.87	5340.02	.005	.88
18.75	.86	5340.02	.005	.86
19.00	.84	5340.02	.005	.84
19.25	.82	5340.02	.005	.83
19.50	.81	5340.02	.005	.81
19.75	.80	5340.02	.005	.80
20.00	.79	5340.02	.005	.79
20.25	.77	5340.02	.004	.78
20.50	.76	5340.02	.004	.77
20.75	.75	5340.02	.004	.76
21.00	.74	5340.02	.004	.74
21.25	.73	5340.02	.004	.73
21.50	.72	5340.02	.004	.72
21.75	.71	5340.02	.004	.72
22.00	.71	5340.02	.004	.71
22.25	.70	5340.01	.004	.70
22.50	.69	5340.01	.004	.70
22.75	.69	5340.01	.004	.69
23.00	.68	5340.01	.004	.68
23.25	.68	5340.01	.004	.68
23.50	.67	5340.01	.004	.67
23.75	.66	5340.01	.004	.67
24.00	.66	5340.01	.004	.66
24.25	.65	5340.01	.004	.66
24.50	.65	5340.01	.004	.65
24.75	.64	5340.01	.004	.65
25.00	.64	5340.01	.004	.64
25.25	.63	5340.01	.004	.63
25.50	.62	5340.01	.003	.62
25.75	.60	5340.01	.003	.61
26.00	.55	5340.01	.003	.57
26.25	.49	5340.01	.003	.51
26.50	.45	5340.01	.002	.46
26.75	.44	5340.01	.002	.44
27.00	.42	5340.01	.002	.43
27.25	.39	5340.01	.002	.41
27.50	.28	5340.00	.002	.32
27.75	.17	5339.97	.001	.19

TIME (HRS)	INFLOW (CFS)	ELEV (FEET)	VOLUME (AC-FT)	OUTFLOW (CFS)
28.00	.10	5339.90	.000	.11
28.25	.07	5339.86	.000	.07
28.50	.05	5339.85	.000	.05
28.75	.04	5339.84	.000	.04
29.00	.03	5339.83	.000	.03
29.25	.02	5339.82	.000	.03
29.50	.02	5339.82	.000	.02
29.75	.02	5339.81	.000	.02

PEAK DISCHARGE = 1187.870 CFS - PEAK OCCURS AT HOUR 3.10
MAXIMUM WATER SURFACE ELEVATION = 5346.697
MAXIMUM STORAGE = 3.1778 AC-FT INCREMENTAL TIME= .050000HRS

PRINT HYD ID=19 CODE=5

OUTFLOW HYDROGRAPH REACH 60.19

TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS
.000	.0	6.000	197.1	12.000	5.2	18.000	.9	24.000	.7
.250	.0	6.250	159.3	12.250	4.6	18.250	.9	24.250	.7
.500	.0	6.500	131.6	12.500	4.1	18.500	.9	24.500	.7
.750	.0	6.750	112.3	12.750	3.6	18.750	.9	24.750	.6
1.000	.0	7.000	97.9	13.000	3.2	19.000	.8	25.000	.6
1.250	.0	7.250	85.0	13.250	2.9	19.250	.8	25.250	.6
1.500	41.8	7.500	73.5	13.500	2.6	19.500	.8	25.500	.6
1.750	266.5	7.750	63.4	13.750	2.4	19.750	.8	25.750	.6
2.000	548.3	8.000	54.6	14.000	2.2	20.000	.8	26.000	.6
2.250	937.2	8.250	47.1	14.250	2.0	20.250	.8	26.250	.5
2.500	753.3	8.500	40.6	14.500	1.8	20.500	.8	26.500	.5
2.750	924.6	8.750	35.1	14.750	1.7	20.750	.8	26.750	.4
3.000	1168.8	9.000	30.7	15.000	1.6	21.000	.7	27.000	.4
3.250	1167.8	9.250	26.6	15.250	1.5	21.250	.7	27.250	.4
3.500	1051.4	9.500	22.8	15.500	1.4	21.500	.7	27.500	.3
3.750	965.4	9.750	19.5	15.750	1.3	21.750	.7	27.750	.2
4.000	920.5	10.000	16.6	16.000	1.2	22.000	.7	28.000	.1
4.250	850.5	10.250	14.2	16.250	1.2	22.250	.7	28.250	.1
4.500	683.1	10.500	12.2	16.500	1.1	22.500	.7	28.500	.1
4.750	611.4	10.750	10.5	16.750	1.1	22.750	.7	28.750	.0
5.000	505.2	11.000	9.1	17.000	1.0	23.000	.7	29.000	.0
5.250	408.0	11.250	7.9	17.250	1.0	23.250	.7	29.250	.0
5.500	317.2	11.500	6.8	17.500	1.0	23.500	.7	29.500	.0
5.750	248.9	11.750	6.0	17.750	1.0	23.750	.7	29.750	.0

RUNOFF VOLUME = .42731 INCHES = 282.9765 ACRE-FEET
PEAK DISCHARGE RATE = 1187.87 CFS AT 3.100 HOURS BASIN AREA = 12.4168 SQ. MI.

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*
*S*** Basin Contributing to INFLOW POINT 2 (IP2) ******************
*
**********************************************************************
*S*** SUB-BASIN 46C
*
COMPUTE LT TP       LCODE=1  USDI BUREAU OF RECLAMATION LAG TIME EQUATION
                    NK=1  ISLOPE=-1
                    LENGTH=330 FT   SLOPE=0.023 K=1.0
```

Tc AND Tp COMPUTED BY UPLAND/LAG TIME PROCEDURE

SCS UPLAND METHOD FACTORS

	LENGTH (FT)	SLOPE (FT/FT)	COMPOSITE K
SHEET FLOW PORTION	330.0	.023000	1.0000
SHALLOW FLOW PORTION	.0	.000000	.0000
CHANNEL FLOW PORTION	.0	.000000	.0000
TOTAL BASIN	330.0	.023000	1.0000

TIME OF CONCENTRATION (HRS)= .0604 TIME TO PEAK (HRS)= .0403 LAG TIME (HRS)= .0453

TIME TO PEAK COMPUTED TO BE LESS THAN 0.133333 HOUR MINIMUM VALUE.
REVISED VALUES: TIME OF CONCENTRATION (HRS)= .2000 TIME TO PEAK (HRS)= .1333 LAG TIME (HRS)= .1500

```
COMPUTE NM HYD      ID=1   HYD NO=46C   DA= 0.0025 SQ MI
                    PER A=90 PER B=00  PER C=10  PER D=0
                    TP=0.0   MASSRAIN=-1

     TIME TO PEAK (hrs)=   .1333

     K =   .161823HR    TP =   .133333HR    K/TP RATIO =  1.213676     SHAPE CONSTANT, N =  2.930686
     UNIT PEAK =   5.1773    CFS   UNIT VOLUME =    .9956       B =   276.12       P60 = 1.6900
     AREA =      .002500 SQ MI    IA =    .62000 INCHES    INF =   1.58600 INCHES PER HOUR
     RUNOFF COMPUTED BY INITIAL ABSTRACTION/INFILTRATION NUMBER METHOD - DT =   .050000

    BULKING FACTOR APPLIED TO HYDROGRAPH.  FACTOR =  1.05000 AT PEAK FLOW.

PRINT HYD           ID=1   CODE=1

                                        HYDROGRAPH FROM AREA 46C


    RUNOFF VOLUME =      .44411 INCHES     =        .0592 ACRE-FEET
    PEAK DISCHARGE RATE =       2.11 CFS  AT   1.500 HOURS   BASIN AREA =   .0025 SQ. MI.



**********************************************************************
*
*S ROUTE 46C THRU 62 IN NATURAL ARROYO TO 62.3
*
COMPUTE RATING CURVE  CID=1   VS NO=1   NO SEGS=1
                      MIN ELEV=5372.6   MAX ELEV=5375
                      CH SLOPE=0.0141    FP SLOPE=0.015
                      N=0.035           DIST=172.0
                      DIST  ELEV          DIST  ELEV
                        0          5375    73      5374
                                   91      5373    109     5372.6
                                   142     5373    157     5374
                                   172     5375


                                    RATING CURVE VALLEY SECTION  1.0
                                       WATER       FLOW        FLOW        TOP
                                     SURFACE       AREA        RATE        WIDTH
                                       ELEV        SQ FT       CFS         FT
                                    5372.60          .00         .00         .00
                                    5372.73         1.02         .84       16.13
                                    5372.85         4.08        5.34       32.26
                                    5372.98         9.18       15.76       48.38
                                    5373.11       15.79        35.93       54.50
                                    5373.23       22.94        63.78       58.67
                                    5373.36       30.63        98.59       62.84
                                    5373.49       38.84       140.32       67.02
                                    5373.61       47.58       189.03       71.19
                                    5373.74       56.84       244.81       75.36
                                    5373.86       66.64       307.80       79.54
                                    5373.99       76.96       378.17       83.71
                                    5374.12       88.19       438.17       94.36
                                    5374.24      100.83       508.50      105.48
                                    5374.37      114.87       591.08      116.61
                                    5374.50      130.32       686.45      127.74
                                    5374.62      147.18       795.21      138.87
                                    5374.75      165.45       918.01      150.00
                                    5374.88      185.12      1055.49      161.13
                                    5375.00      206.20      1209.53      172.00
ROUTE MCUNGE        ID=3   HYD NO=62.3  INFLOW ID=1
                    DT=0.0   L=2596 FT   NS=0   SLOPE=0.015
                    MATCODE=0 REGCODE=0 CCODE=0 MM CODE=0

     INFLOW END=  78           TABLE PTS= 20
     DT=  .050000              QMED=        1.05  CKMED=      1.4716
     WIDTH MED=       16.89    NREACH= 20         DX=      129.80

  DEPTH   AREA      Q    TRAVEL  WIDTH     ck      VEL      C       D      C1     C2     C3     Q-M      C1-M
C2-M   C3-M
   (FT)  (SQ FT)  (CFS)  TIME(HR) (FT)     (FPS)   (FPS)                                          (CFS)
     .00     .0       .0   1.197     .0      .72     .38    1.000   .000  1.000   .000   .000       .0   1.000
.000   .000
     .13    1.0       .8    .874   16.1     1.15     .83    1.596   .023   .982   .236  -.219       .1    .997
.037  -.034
     .25    4.1      5.3    .550   32.3     1.82    1.31    2.527   .047   .974   .440  -.414      2.5    .975
.337  -.312
     .38    9.2     15.8    .420   48.4     2.47    1.72    3.425   .068   .970   .555  -.525      9.8    .968
.482  -.450
     .51   15.8     35.9    .317   54.5     3.51    2.28    4.861   .097   .968   .664  -.632     25.0    .970
.628  -.598
     .63   22.9     63.8    .259   58.7     4.24    2.78    5.878   .132   .962   .715  -.677     49.1    .965
.693  -.658
     .76   30.6     98.6    .224   62.8     4.83    3.22    6.695   .167   .958   .746  -.703     80.4    .960
.731  -.690
     .89   38.8    140.3    .200   67.0     5.34    3.61    7.412   .201   .953   .768  -.721    118.7    .955
.757  -.712
    1.01   47.6    189.0    .181   71.2     5.81    3.97    8.057   .235   .949   .785  -.734    164.0    .951
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.776  -.727
        1.14   56.8    244.8    .167   75.4     6.24   4.31    8.650   .267   .946   .798  -.744    216.2    .947
.792  -.739
        1.26   66.6    307.8    .156   79.5     6.64   4.62    9.201   .300   .943   .810  -.752    275.6    .944
.804  -.748
        1.39   77.0    378.2    .147   83.7     6.22   4.91    8.631   .373   .925   .800  -.726    342.3    .941
.814  -.756
        1.52   88.2    438.2    .145   94.4     5.47   4.97    7.579   .436   .903   .778  -.681    407.8    .900
.773  -.673
        1.64  100.8    508.5    .143  105.5     5.73   5.04    7.950   .432   .908   .787  -.695    472.9    .904
.781  -.686
        1.77  114.9    591.1    .140  116.6     6.04   5.15    8.369   .431   .912   .796  -.708    549.3    .910
.791  -.701
        1.90  130.3    686.4    .137  127.7     6.32   5.27    8.764   .437   .914   .804  -.718    638.2    .913
.800  -.713
        2.02  147.2    795.2    .133  138.9     6.59   5.40    9.145   .446   .916   .811  -.727    740.2    .915
.807  -.722
        2.15  165.4    918.0    .130  150.0     6.86   5.55    9.517   .458   .917   .818  -.734    855.9    .916
.814  -.730
        2.28  185.1   1055.5    .126  161.1     7.15   5.70    9.920   .470   .917   .824  -.742    986.0    .916
.821  -.737
        2.40  206.2   1209.5    .123  172.0     7.24   5.87   10.040   .499   .914   .827  -.740   1131.7    .918
.828  -.746
     MAXIMUM NO. ITERATIONS FOR SOLUTION (KKMAX) =   3 OCCURRED      38 TIMES.  AVERAGE NUMBER ITERATIONS =  1.0252
       DEPTH    AREA      Q    TRAVEL  WIDTH     ck      VEL      C       D      C1     C2     C3     Q-M      C1-M
C2-M   C3-M
        (FT)  (SQ FT)  (CFS)  TIME(HR) (FT)     (FPS)   (FPS)                                          (CFS)
          .00     .0       .0   1.197     .0      .72     .38    1.000   .000  1.000   .000   .000       .0   1.000
.000   .000
          .13    1.0       .8    .874   16.1      .75     .83    1.036   .036   .965   .035   .000       .1    .989
.011   .000
          .25    4.1      5.3    .550   32.3      .80    1.31    1.107   .107   .904   .096   .000      2.5    .935
.065   .000
          .38    9.2     15.8    .420   48.4      .86    1.72    1.194   .194   .837   .163   .000      9.8    .869
.131   .000
          .51   15.8     35.9    .317   54.5      .97    2.28    1.348   .348   .742   .258   .000     25.0    .786
.214   .000
          .63   22.9     63.8    .259   58.7     1.09    2.78    1.512   .512   .661   .339   .000     49.1    .699
.301   .000
          .76   30.6     98.6    .224   62.8     1.20    3.22    1.669   .669   .599   .401   .000     80.4    .628
.372   .000
          .89   38.8    140.3    .200   67.0     1.31    3.61    1.820   .820   .550   .450   .000    118.7    .573
.427   .000
         1.01   47.6    189.0    .181   71.2     1.42    3.97    1.963   .963   .509   .491   .000    164.0    .528
.472   .000
         1.14   56.8    244.8    .167   75.4     1.52    4.31    2.101  1.101   .476   .524   .000    216.2    .492
.508   .000
         1.26   66.6    307.8    .156   79.5     1.61    4.62    2.234  1.234   .448   .552   .000    275.6    .461
.539   .000
         1.39   77.0    378.2    .147   83.7     1.70    4.91    2.362  1.362   .423   .577   .000    342.3    .435
.565   .000
         1.52   88.2    438.2    .145   94.4     1.72    4.97    2.386  1.386   .419   .581   .000    407.8    .421
.579   .000
         1.64  100.8    508.5    .143  105.5     1.74    5.04    2.419  1.419   .413   .587   .000    472.9    .416
.584   .000
         1.77  114.9    591.1    .140  116.6     1.78    5.15    2.465  1.465   .406   .594   .000    549.3    .409
.591   .000
         1.90  130.3    686.4    .137  127.7     1.82    5.27    2.519  1.519   .397   .603   .000    638.2    .401
.599   .000
         2.02  147.2    795.2    .133  138.9     1.86    5.40    2.581  1.581   .388   .612   .000    740.2    .392
.608   .000
         2.15  165.4    918.0    .130  150.0     1.91    5.55    2.647  1.647   .378   .622   .000    855.9    .382
.618   .000
         2.28  185.1   1055.5    .126  161.1     1.96    5.70    2.717  1.717   .368   .632   .000    986.0    .373
.627   .000
         2.40  206.2   1209.5    .123  172.0     2.01    5.87    2.793  1.793   .358   .642   .000   1131.7    .363
.637   .000
     MAXIMUM NO. ITERATIONS FOR SOLUTION (KKMAX) =   2 OCCURRED     259 TIMES.  AVERAGE NUMBER ITERATIONS =  1.0226
     Equations solved with two passes: first using the Ponce correction to C1, second using the Fread correction to C1,
C2 and C3
     PRINT HYD           ID=3   CODE=1

                                          OUTFLOW HYDROGRAPH REACH    62.30


         RUNOFF VOLUME =      .43518 INCHES     =        .0580 ACRE-FEET
         PEAK DISCHARGE RATE =       1.89 CFS  AT   2.450 HOURS   BASIN AREA =   .0025 SQ. MI.



     *
     **********************************************************************
     *
     *S*** SUB-BASIN 62
     *
     COMPUTE LT TP       LCODE=1  USDI BUREAU OF RECLAMATION LAG TIME EQUATION
                         NK=3  ISLOPE=-1
                         LENGTH=400 FT   SLOPE=0.02 K=0.7
                         LENGTH=1600 FT  SLOPE=0.015 K=2.0
                         LENGTH=708 FT  SLOPE=0.009 K=3.0
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     Tc AND Tp COMPUTED BY UPLAND/LAG TIME PROCEDURE

     SCS UPLAND METHOD FACTORS
                              LENGTH (FT)      SLOPE (FT/FT)       COMPOSITE K
     SHEET FLOW PORTION          400.0           .020000             .7000
     SHALLOW FLOW PORTION       1600.0           .015000            2.0000
     CHANNEL FLOW PORTION        708.0           .009000            3.0000
     TOTAL BASIN                2708.0           .014170            1.7419


     TIME OF CONCENTRATION (HRS)=   .3628     TIME TO PEAK (HRS)=   .2419     LAG TIME (HRS)=   .2721

COMPUTE NM HYD       ID=2   HYD NO=62   DA= 0.06722 SQ MI
                     PER A=80 PER B=10  PER C=10  PER D=0
                     TP=0.0   MASSRAIN=-1
     TIME TO PEAK (hrs)=   .2419

     K =   .286571HR    TP =   .241856HR    K/TP RATIO =  1.184883     SHAPE CONSTANT, N =  2.995963
     UNIT PEAK =   78.236    CFS   UNIT VOLUME =    .9997       B =   281.49      P60 = 1.6900
     AREA =      .067220 SQ MI    IA =    .60500 INCHES    INF =   1.54400 INCHES PER HOUR
     RUNOFF COMPUTED BY INITIAL ABSTRACTION/INFILTRATION NUMBER METHOD - DT =   .050000

    BULKING FACTOR APPLIED TO HYDROGRAPH.  FACTOR =  1.05000 AT PEAK FLOW.

PRINT HYD            ID=2   CODE=1

                                      OUTFLOW HYDROGRAPH REACH    62.00


    RUNOFF VOLUME =      .46367 INCHES     =       1.6623 ACRE-FEET
    PEAK DISCHARGE RATE =      35.04 CFS  AT   1.600 HOURS   BASIN AREA =   .0672 SQ. MI.



*
**********************************************************************
*
*S ADD 61.4 TO 62 TO GET 62.5
*
ADD HYD              ID=1  HYD NO=62.1 ID I=2 ID II=3
PRINT HYD            ID=1   CODE=1

                                      OUTFLOW HYDROGRAPH REACH    62.10


    RUNOFF VOLUME =      .46264 INCHES     =       1.7203 ACRE-FEET
    PEAK DISCHARGE RATE =      35.04 CFS  AT   1.600 HOURS   BASIN AREA =   .0697 SQ. MI.



*
*S
**************************************************************************
**************************************************************************
*S  APPLY NO SEDIMENT BULKING FACTOR
SEDIMENT BULK          CODE=1   BULKING FACTOR = 1.00
*
**************************************************************************
*
*S THE TRAILS SUBDIVISION
*S OUTFLOW RESTRICTED TO 62 CFS AT UNIVERSE AND AVENIDA DE JAMITO
*
**************************************************************************

*S RECALL HYD FROM THE TRAILS SUBDIVISION
*S
RECALL HYD           ID=99  HYD=BYPASS.ROUTE.K
                     DT=  .100000 HRS   DA=   1.0536 SQ MI
                     PEAK=     60.718CFS  RO= 1.3592 INCHES  NO PTS=600
                     FLOW RATES
                           .000       .000       .000       .000       .000
                           .000       .000       .000       .000       .000
                           .000      2.066     35.012     45.415     47.520
                         51.159     54.044     56.146     57.431     58.230
                         58.915     59.490     59.932     60.231     60.418
                         60.547     60.637     60.693     60.718     60.716
                         60.695     60.659     60.612     60.557     60.494
                         60.426     60.354     60.278     60.199     60.117
                         60.032     59.946     59.857     59.767     59.675
                         59.582     59.488     59.392     59.296     59.199
                         59.101     59.003     58.903     58.804     58.703
                         58.602     58.500     58.398     58.295     58.191
                         58.086     57.981     57.876     57.770     57.662
                         57.552     57.441     57.326     57.208     56.909
                         56.388     55.855     55.180     54.215     53.381
                         52.834     52.221     51.798     51.322     50.935
                         50.532     50.146     49.791     49.468     49.159
                         48.832     48.521     48.232     47.893     47.580
                         47.327     47.047     46.743     46.462     46.200
                         45.916     45.646     45.394     45.118     44.858
```

44.614	44.347	44.074	43.796	43.493
43.212	42.904	42.592	42.303	42.020
41.748	41.452	41.172	40.883	40.609
40.358	40.112	39.876	39.614	39.369
39.139	38.891	38.655	38.440	38.201
37.979	37.772	37.574	37.381	37.165
36.958	36.772	36.562	36.393	36.234
36.011	35.797	35.628	35.437	35.232
35.029	34.808	34.598	34.407	34.221
34.041	33.865	33.664	33.472	33.302
33.105	32.945	32.796	32.610	32.427
32.233	32.049	31.911	31.745	31.575
31.420	31.240	31.071	30.917	30.770
30.625	30.482	30.342	30.177	30.018
29.879	29.739	29.607	29.446	29.296
29.159	29.028	28.900	28.772	28.620
28.474	28.371	28.240	28.075	27.952
27.825	27.572	27.308	27.056	26.807
26.519	26.213	25.894	25.536	25.192
24.857	24.538	24.194	23.793	23.410
23.035	22.691	22.381	22.089	21.803
21.511	21.200	20.854	20.510	20.241
19.934	19.509	19.115	18.697	18.355
18.045	17.687	17.366	17.074	16.789
16.536	16.289	16.042	15.671	15.037
14.483	14.020	13.573	13.089	12.637
12.135	11.689	11.292	10.870	10.437
10.086	9.818	9.524	9.278	9.083
8.871	7.958	6.399	5.329	4.840
4.555	4.321	4.134	3.981	3.841
3.728	3.634	3.545	3.463	3.394
3.324	3.260	3.204	3.146	3.093
3.045	2.997	2.951	2.910	2.868
2.828	2.792	2.754	2.719	2.685
2.652	2.619	2.588	2.557	2.527
2.498	2.469	2.441	2.414	2.386
2.359	2.333	2.307	2.282	2.257
2.232	2.208	2.184	2.160	2.136
2.113	2.090	2.068	2.045	2.024
2.002	1.979	1.958	1.936	1.916
1.896	1.876	1.856	1.836	1.816
1.797	1.778	1.759	1.741	1.722
1.704	1.686	1.668	1.651	1.633
1.616	1.599	1.582	1.565	1.549
1.532	1.516	1.500	1.484	1.469
1.453	1.438	1.423	1.408	1.393
1.379	1.364	1.350	1.336	1.321
1.307	1.293	1.280	1.266	1.253
1.240	1.227	1.214	1.202	1.189
1.177	1.164	1.152	1.140	1.129
1.117	1.105	1.094	1.083	1.071
1.060	1.049	1.039	1.028	1.017
1.007	.996	.986	.976	.966
.956	.946	.936	.927	.917
.908	.899	.890	.880	.871
.863	.854	.845	.836	.828
.819	.811	.803	.795	.787
.779	.771	.763	.755	.748
.740	.732	.725	.718	.711
.703	.696	.689	.682	.675
.669	.662	.655	.649	.642
.636	.629	.623	.617	.611
.604	.598	.592	.586	.581
.575	.569	.563	.558	.552
.547	.541	.536	.531	.525
.520	.515	.510	.505	.500
.495	.490	.485	.480	.476
.471	.466	.462	.457	.453
.448	.444	.439	.435	.431
.426	.422	.418	.414	.410
.406	.402	.398	.394	.390
.386	.383	.379	.375	.371
.368	.364	.361	.357	.354
.350	.347	.343	.340	.337
.333	.330	.327	.324	.321
.317	.314	.311	.308	.305
.302	.299	.296	.294	.291
.288	.285	.282	.280	.277
.274	.272	.269	.266	.264
.261	.259	.256	.254	.251
.249	.246	.244	.242	.239
.237	.235	.232	.230	.228
.226	.224	.221	.219	.217
.214	.212	.210	.208	.206
.204	.202	.200	.198	.196
.194	.193	.191	.189	.187
.185	.184	.182	.180	.178
.177	.175	.173	.172	.170
.168	.167	.164	.163	.161
.159	.158	.156	.155	.154
.152	.151	.149	.148	.146

.145	.144	.142	.141	.140
.138	.137	.136	.134	.133
.132	.131	.129	.128	.127
.126	.124	.123	.122	.121
.120	.119	.118	.116	.115
.113	.112	.111	.110	.109
.108	.107	.106	.105	.104
.103	.102	.101	.100	.099
.098	.097	.096	.096	.095

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**********************************************************************
*
*S ROUTE 99 IN 36" PIPE IN UNIVERSE TO GET 47.19
*
COMPUTE RATING CURVE       CID=1   VS NO=1 NO SEGS=-1  SLP=0.019
                                   DIAM=3.0 FT     N=0.013
```

RATING CURVE PIPE SECTION 1.0

WATER SURFACE ELEV	FLOW AREA SQ FT	FLOW RATE CFS	MAX WIDTH FT
.00	.00	.00	.00
.16	.14	.48	1.33
.31	.39	2.09	1.83
.47	.71	4.87	2.18
.63	1.07	8.75	2.44
.78	1.46	13.67	2.63
.94	1.89	19.50	2.78
1.09	2.33	26.13	2.89
1.25	2.79	33.40	2.96
1.41	3.26	41.18	2.99
1.56	3.72	49.28	3.00
1.72	4.19	57.53	3.00
1.88	4.65	65.74	3.00
2.03	5.10	73.68	3.00
2.19	5.53	81.11	3.00
2.35	5.93	87.77	3.00
2.50	6.30	93.31	3.00
2.66	6.62	97.27	3.00
2.81	6.89	98.90	3.00
3.00	7.07	98.90	3.00

```
ROUTE MCUNGE        ID=7   HYD NO=47.7 INFLOW ID=99
                           DT=0.0 HR       LENGTH=1532 FT
                           NS=0    SLOPE=0.019  CODE=5

     INFLOW END= 600            TABLE PTS= 19
     DT=  .100000               QMED=       30.36  CKMED=     15.9074
     WIDTH MED=        2.93     NREACH=  1         DX=     1532.00
```

DEPTH (FT)	AREA (SQ FT)	Q (CFS)	TRAVEL TIME(HR)	WIDTH (FT)	ck (FPS)	VEL (FPS)	C	D	C1	C2	C3	Q-M (CFS)	C1-M	C2-M	C3-M
.00	.0	.0	.169	.0	4.26	1.62	1.000	.000	1.000	.000	.000	.0	1.000	.000	.000
.16	.1	.5	.124	1.3	5.65	3.43	1.327	.002	.998	.141	-.139	.1	1.000	.022	-.022
.31	.4	2.1	.079	1.8	7.79	5.36	1.831	.005	.996	.295	-.291	1.2	.997	.207	-.204
.47	.7	4.9	.062	2.2	9.87	6.89	2.319	.008	.995	.399	-.394	3.4	.996	.351	-.346
.63	1.1	8.8	.052	2.4	11.62	8.20	2.730	.011	.994	.465	-.460	6.7	.995	.435	-.430
.78	1.5	13.7	.046	2.6	13.10	9.33	3.079	.014	.993	.511	-.505	11.1	.994	.490	-.484
.94	1.9	19.5	.041	2.8	14.37	10.33	3.377	.017	.992	.545	-.537	16.5	.993	.530	-.523
1.09	2.3	26.1	.038	2.9	15.43	11.20	3.627	.020	.991	.570	-.561	22.7	.992	.559	-.551
1.25	2.8	33.4	.036	3.0	16.31	11.97	3.832	.024	.990	.588	-.578	29.7	.991	.580	-.571
1.41	3.3	41.2	.034	3.0	16.99	12.65	3.993	.028	.989	.602	-.591	37.2	.990	.596	-.586
1.56	3.7	49.3	.032	3.0	17.47	13.23	4.105	.032	.987	.611	-.598	45.2	.988	.607	-.596
1.72	4.2	57.5	.031	3.0	17.58	13.73	4.131	.037	.985	.613	-.599	53.4	.987	.613	-.600
1.88	4.7	65.7	.030	3.0	17.25	14.14	4.054	.044	.983	.608	-.591	61.6	.984	.612	-.596
2.03	5.1	73.7	.029	3.0	16.43	14.45	3.862	.051	.979	.593	-.572	69.7	.981	.602	-.583
2.19	5.5	81.1	.029	3.0	15.06	14.68	3.540	.062	.973	.565	-.539	77.4	.977	.582	-.558
2.35	5.9	87.8	.029	3.0	13.03	14.81	3.062	.077	.963	.517	-.480	84.4	.969	.546	-.515
2.50	6.3	93.3	.029	3.0	10.15	14.82	2.385	.105	.940	.427	-.367	90.5	.955	.482	-.437
2.66	6.6	97.3	.029	3.0	5.94	14.69	1.397	.187	.855	.226	-.081	95.3	.917	.358	-.275
2.81	6.9	98.9	.030	3.0	3.39	14.36	.796	.334	.686	.061	.253	98.1	.697		

.065 .238

MAXIMUM NO. ITERATIONS FOR SOLUTION (KKMAX) = 4 OCCURRED 1 TIMES. AVERAGE NUMBER ITERATIONS = 1.4482
Equations solved using the Ponce correction to C2
PRINT HYD ID=7 CODE=5

OUTFLOW HYDROGRAPH REACH 47.70

TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS
.000	.0	12.000	39.2	24.000	9.0	36.000	1.0	48.000	.3
.500	.0	12.500	38.0	24.500	4.7	36.500	1.0	48.500	.3
1.000	.0	13.000	37.0	25.000	3.8	37.000	.9	49.000	.3
1.500	51.9	13.500	36.1	25.500	3.4	37.500	.9	49.500	.3
2.000	58.6	14.000	35.1	26.000	3.1	38.000	.8	50.000	.3
2.500	60.5	14.500	34.1	26.500	2.8	38.500	.8	50.500	.2
3.000	60.7	15.000	33.2	27.000	2.7	39.000	.7	51.000	.2
3.500	60.4	15.500	32.3	27.500	2.5	39.500	.7	51.500	.2
4.000	60.1	16.000	31.5	28.000	2.4	40.000	.7	52.000	.2
4.500	59.6	16.500	30.7	28.500	2.2	40.500	.6	52.500	.2
5.000	59.1	17.000	29.9	29.000	2.1	41.000	.6	53.000	.2
5.500	58.6	17.500	29.2	29.500	2.0	41.500	.6	53.500	.2
6.000	58.1	18.000	28.5	30.000	1.9	42.000	.6	54.000	.2
6.500	57.6	18.500	27.9	30.500	1.8	42.500	.5	54.500	.2
7.000	56.5	19.000	26.6	31.000	1.7	43.000	.5	55.000	.2
7.500	52.9	19.500	25.0	31.500	1.6	43.500	.5	55.500	.1
8.000	50.7	20.000	23.1	32.000	1.5	44.000	.5	56.000	.1
8.500	48.9	20.500	21.6	32.500	1.5	44.500	.4	56.500	.1
9.000	47.4	21.000	20.0	33.000	1.4	45.000	.4	57.000	.1
9.500	46.0	21.500	18.1	33.500	1.3	45.500	.4	57.500	.1
10.000	44.7	22.000	16.6	34.000	1.2	46.000	.4	58.000	.1
10.500	43.3	22.500	14.6	34.500	1.2	46.500	.4	58.500	.1
11.000	41.8	23.000	12.3	35.000	1.1	47.000	.3	59.000	.1
11.500	40.4	23.500	10.2	35.500	1.1	47.500	.3	59.500	.1

RUNOFF VOLUME = 1.35925 INCHES = 76.3787 ACRE-FEET
PEAK DISCHARGE RATE = 60.72 CFS AT 2.900 HOURS BASIN AREA = 1.0536 SQ. MI.

*
****
*S APPLY SEDIMENT BULKING FACTOR
SEDIMENT BULK CODE=1 BULKING FACTOR = 1.05

*
****
****
*S*** SUB-BASIN 47B STATE LAND PROPERTY ***
*
COMPUTE LT TP LCODE=1 UPLAND/LAG TIME TRANSITION METHOD
NK=2 ISLOPE=-1
LENGTH=400 FT SLOPE=0.026 K=0.7
LENGTH=936 FT SLOPE=0.012 K=1.0

Tc AND Tp COMPUTED BY UPLAND/LAG TIME PROCEDURE

SCS UPLAND METHOD FACTORS
NOTE: Upland factor input values have been adjusted to meet Upland/Lag Time requirements.

	LENGTH (FT)	SLOPE (FT/FT)	COMPOSITE K
SHEET FLOW PORTION	400.0	.026000	.7000
SHALLOW FLOW PORTION	936.0	.012000	2.0000
CHANNEL FLOW PORTION	.0	.000000	.0000
TOTAL BASIN	1336.0	.016192	1.3433

```
     TIME OF CONCENTRATION (HRS)=   .2171     TIME TO PEAK (HRS)=   .1447     LAG TIME (HRS)=   .1628

COMPUTE NM HYD      ID=5   HYD NO=47B   DA=0.0305 SQ MI
                    PER A=90 PER B=0  PER C=10  PER D=0
                    TP=0.0   MASSRAIN=-1
     TIME TO PEAK (hrs)=   .1447

     K =   .175670HR    TP =   .144742HR    K/TP RATIO =  1.213676     SHAPE CONSTANT, N =  2.930686
     UNIT PEAK =   58.184    CFS   UNIT VOLUME =    .9985       B =   276.12      P60 = 1.6900
     AREA =      .030500 SQ MI    IA =    .62000 INCHES    INF =   1.58600 INCHES PER HOUR
     RUNOFF COMPUTED BY INITIAL ABSTRACTION/INFILTRATION NUMBER METHOD - DT =   .050000

    BULKING FACTOR APPLIED TO HYDROGRAPH.  FACTOR =  1.05000 AT PEAK FLOW.

PRINT HYD           ID=5   CODE=1

                                        HYDROGRAPH FROM AREA 47B


    RUNOFF VOLUME =      .44411 INCHES     =        .7224 ACRE-FEET
    PEAK DISCHARGE RATE =      23.57 CFS  AT   1.500 HOURS   BASIN AREA =   .0305 SQ. MI.



*

**********************************************************************
*
*S*** SUB-BASIN 46B APS HIGH SCHOOL PROPERTY ***
*
COMPUTE LT TP       LCODE=1  UPLAND/LAG TIME TRANSITION METHOD
                    NK=3  ISLOPE=-1
                    LENGTH=400 FT   SLOPE=0.02 K=0.7
                    LENGTH=1600 FT  SLOPE=0.02 K=2.0
                    LENGTH=745 FT  SLOPE=0.02 K=3.0


     Tc AND Tp COMPUTED BY UPLAND/LAG TIME PROCEDURE

     SCS UPLAND METHOD FACTORS
                              LENGTH (FT)      SLOPE (FT/FT)       COMPOSITE K
     SHEET FLOW PORTION          400.0           .020000             .7000
     SHALLOW FLOW PORTION       1600.0           .020000            2.0000
     CHANNEL FLOW PORTION        745.0           .020000            3.0000
     TOTAL BASIN                2745.0           .020000            1.6947


     TIME OF CONCENTRATION (HRS)=   .3182     TIME TO PEAK (HRS)=   .2121     LAG TIME (HRS)=   .2386

COMPUTE NM HYD      ID=3   HYD NO=APS   DA=0.113 SQ MI
                    PER A=0 PER B=22  PER C=25  PER D=53
                    TP=0.0   MASSRAIN=-1
     TIME TO PEAK (hrs)=   .2121

     K =   .117636HR    TP =   .212101HR    K/TP RATIO =   .554623     SHAPE CONSTANT, N =  6.949226
     UNIT PEAK =   146.50    CFS   UNIT VOLUME =    1.000       B =   518.84      P60 = 1.6900
     AREA =      .059890 SQ MI    IA =    .10000 INCHES    INF =    .04000 INCHES PER HOUR
     RUNOFF COMPUTED BY INITIAL ABSTRACTION/INFILTRATION NUMBER METHOD - DT =   .050000


     K =   .187171HR    TP =   .212101HR    K/TP RATIO =   .882464     SHAPE CONSTANT, N =  4.021449
     UNIT PEAK =   89.292    CFS   UNIT VOLUME =    1.000       B =   356.60      P60 = 1.6900
     AREA =      .053110 SQ MI    IA =    .42021 INCHES    INF =   1.02660 INCHES PER HOUR
     RUNOFF COMPUTED BY INITIAL ABSTRACTION/INFILTRATION NUMBER METHOD - DT =   .050000

    BULKING FACTOR APPLIED TO HYDROGRAPH.  FACTOR =  1.05000 AT PEAK FLOW.

PRINT HYD           ID=3   CODE=1

                                        HYDROGRAPH FROM AREA APS


    RUNOFF VOLUME =     1.63785 INCHES     =       9.8707 ACRE-FEET
    PEAK DISCHARGE RATE =     181.87 CFS  AT   1.600 HOURS   BASIN AREA =   .1130 SQ. MI.



*
**********************************************************************
*
*S*** ADD 47B TO 46B TO GET 46B.6
*

ADD HYD             ID=6  HYD NO=46B.6 ID I=5 ID II=3
PRINT HYD           ID=6   CODE=1

                                        HYDROGRAPH FROM AREA 46B.6


    RUNOFF VOLUME =     1.38413 INCHES     =      10.5931 ACRE-FEET
```

PEAK DISCHARGE RATE = 203.51 CFS AT 1.550 HOURS BASIN AREA = .1435 SQ. MI.

*
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****
*
*S*** ROUTE -46B.6 THRU APS POND TO DISCHARGE 4.5 CFS TO UNIVERSE SD
*
ROUTE RESERVOIR ID=4 HYD=46B.4 INFLOW ID=6 CODE=5

OUTFLOW(CFS)	STORAGE(AC FT)	ELEV (FT)
0.01	0.0004	5375
0.03	0.1097	5376
4.45	0.4827	5377
4.46	1.0921	5378
4.47	1.9496	5379
4.48	3.2565	5380
4.49	4.9487	5381
4.50	8.2	5382

* * * * * * * * * * * * * * * * * *

TIME (HRS)	INFLOW (CFS)	ELEV (FEET)	VOLUME (AC-FT)	OUTFLOW (CFS)
.00	.00	5374.50	-.054	.00
.25	.00	5375.00	.000	.01
.50	.00	5375.00	.000	.01
.75	.02	5375.00	.000	.01
1.00	4.85	5375.38	.042	.02
1.25	9.14	5376.16	.170	.74
1.50	175.80	5378.50	1.519	4.46
1.75	126.98	5381.05	5.098	4.49
2.00	59.70	5381.57	6.800	4.50
2.25	27.86	5381.82	7.616	4.50
2.50	13.89	5381.91	7.923	4.50
2.75	8.69	5381.96	8.058	4.50
3.00	5.70	5381.97	8.111	4.50
3.25	4.00	5381.97	8.117	4.50
3.50	3.02	5381.97	8.095	4.50
3.75	2.44	5381.96	8.058	4.50
4.00	2.10	5381.94	8.012	4.50
4.25	1.90	5381.93	7.960	4.50
4.50	1.78	5381.91	7.905	4.50
4.75	1.73	5381.89	7.849	4.50
5.00	1.72	5381.87	7.791	4.50
5.25	1.73	5381.86	7.734	4.50
5.50	1.76	5381.84	7.677	4.50
5.75	1.81	5381.82	7.621	4.50
6.00	1.86	5381.81	7.566	4.50
6.25	1.55	5381.79	7.509	4.50
6.50	1.34	5381.77	7.446	4.50
6.75	1.29	5381.75	7.380	4.50
7.00	1.25	5381.73	7.313	4.50
7.25	1.22	5381.71	7.246	4.50
7.50	1.19	5381.69	7.178	4.50
7.75	1.17	5381.66	7.109	4.50
8.00	1.16	5381.64	7.041	4.50
8.25	1.13	5381.62	6.971	4.50
8.50	1.11	5381.60	6.902	4.50
8.75	1.10	5381.58	6.832	4.50
9.00	1.08	5381.56	6.761	4.50
9.25	1.06	5381.54	6.691	4.50
9.50	1.05	5381.51	6.620	4.50
9.75	1.04	5381.49	6.548	4.49
10.00	1.02	5381.47	6.477	4.49
10.25	1.01	5381.45	6.405	4.49
10.50	.99	5381.43	6.333	4.49
10.75	.98	5381.40	6.260	4.49
11.00	.97	5381.38	6.187	4.49
11.25	.95	5381.36	6.114	4.49
11.50	.94	5381.34	6.041	4.49
11.75	.93	5381.31	5.967	4.49
12.00	.92	5381.29	5.894	4.49
12.25	.90	5381.27	5.820	4.49
12.50	.90	5381.25	5.745	4.49
12.75	.89	5381.22	5.671	4.49
13.00	.87	5381.20	5.597	4.49
13.25	.87	5381.18	5.522	4.49
13.50	.86	5381.15	5.447	4.49
13.75	.85	5381.13	5.371	4.49

TIME (HRS)	INFLOW (CFS)	ELEV (FEET)	VOLUME (AC-FT)	OUTFLOW (CFS)
14.00	.84	5381.11	5.296	4.49
14.25	.83	5381.08	5.220	4.49
14.50	.82	5381.06	5.145	4.49

14.75	.80	5381.04	5.068	4.49
15.00	.80	5381.01	4.992	4.49
15.25	.79	5380.98	4.916	4.49
15.50	.78	5380.94	4.839	4.49
15.75	.77	5380.89	4.763	4.49
16.00	.77	5380.84	4.686	4.49
16.25	.76	5380.80	4.609	4.49
16.50	.75	5380.75	4.532	4.49
16.75	.74	5380.71	4.454	4.49
17.00	.73	5380.66	4.377	4.49
17.25	.73	5380.62	4.299	4.49
17.50	.72	5380.57	4.222	4.49
17.75	.71	5380.52	4.144	4.49
18.00	.71	5380.48	4.066	4.48
18.25	.70	5380.43	3.988	4.48
18.50	.69	5380.39	3.910	4.48
18.75	.69	5380.34	3.831	4.48
19.00	.68	5380.29	3.753	4.48
19.25	.68	5380.25	3.674	4.48
19.50	.67	5380.20	3.595	4.48
19.75	.67	5380.15	3.517	4.48
20.00	.65	5380.11	3.438	4.48
20.25	.66	5380.06	3.359	4.48
20.50	.64	5380.01	3.280	4.48
20.75	.65	5379.96	3.200	4.48
21.00	.63	5379.90	3.121	4.48
21.25	.63	5379.84	3.042	4.48
21.50	.63	5379.77	2.962	4.48
21.75	.62	5379.71	2.883	4.48
22.00	.62	5379.65	2.803	4.48
22.25	.61	5379.59	2.723	4.48
22.50	.61	5379.53	2.643	4.48
22.75	.60	5379.47	2.563	4.47
23.00	.60	5379.41	2.483	4.47
23.25	.59	5379.35	2.403	4.47
23.50	.58	5379.29	2.323	4.47
23.75	.58	5379.22	2.243	4.47
24.00	.58	5379.16	2.162	4.47
24.25	.26	5379.10	2.080	4.47
24.50	.07	5379.03	1.990	4.47
24.75	.04	5378.94	1.899	4.47
25.00	.02	5378.83	1.807	4.47
25.25	.01	5378.73	1.715	4.47
25.50	.00	5378.62	1.623	4.47
25.75	.00	5378.51	1.531	4.47
26.00	.00	5378.40	1.438	4.46
26.25	.00	5378.30	1.346	4.46
26.50	.00	5378.19	1.254	4.46
26.75	.00	5378.08	1.162	4.46
27.00	.00	5377.96	1.070	4.46
27.25	.00	5377.81	.977	4.46
27.50	.00	5377.66	.885	4.46
27.75	.00	5377.51	.793	4.46

TIME (HRS)	INFLOW (CFS)	ELEV (FEET)	VOLUME (AC-FT)	OUTFLOW (CFS)
28.00	.00	5377.36	.701	4.45
28.25	.00	5377.21	.609	4.45
28.50	.00	5377.06	.517	4.45
28.75	.00	5376.86	.430	3.82
29.00	.00	5376.67	.360	2.99
29.25	.00	5376.52	.305	2.34
29.50	.00	5376.41	.262	1.83
29.75	.00	5376.32	.228	1.43

PEAK DISCHARGE = 4.500 CFS - PEAK OCCURS AT HOUR 3.15
MAXIMUM WATER SURFACE ELEVATION = 5381.975
MAXIMUM STORAGE = 8.1186 AC-FT INCREMENTAL TIME= .050000HRS

PRINT HYD ID=4 CODE=5

HYDROGRAPH FROM AREA 46B.4

TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS
.000	.0	6.000	4.5	12.000	4.5	18.000	4.5	24.000	4.5
.250	.0	6.250	4.5	12.250	4.5	18.250	4.5	24.250	4.5
.500	.0	6.500	4.5	12.500	4.5	18.500	4.5	24.500	4.5
.750	.0	6.750	4.5	12.750	4.5	18.750	4.5	24.750	4.5
1.000	.0	7.000	4.5	13.000	4.5	19.000	4.5	25.000	4.5
1.250	.7	7.250	4.5	13.250	4.5	19.250	4.5	25.250	4.5
1.500	4.5	7.500	4.5	13.500	4.5	19.500	4.5	25.500	4.5

1.750	4.5	7.750	4.5	13.750	4.5	19.750	4.5	25.750	4.5
2.000	4.5	8.000	4.5	14.000	4.5	20.000	4.5	26.000	4.5
2.250	4.5	8.250	4.5	14.250	4.5	20.250	4.5	26.250	4.5
2.500	4.5	8.500	4.5	14.500	4.5	20.500	4.5	26.500	4.5
2.750	4.5	8.750	4.5	14.750	4.5	20.750	4.5	26.750	4.5
3.000	4.5	9.000	4.5	15.000	4.5	21.000	4.5	27.000	4.5
3.250	4.5	9.250	4.5	15.250	4.5	21.250	4.5	27.250	4.5
3.500	4.5	9.500	4.5	15.500	4.5	21.500	4.5	27.500	4.5
3.750	4.5	9.750	4.5	15.750	4.5	21.750	4.5	27.750	4.5
4.000	4.5	10.000	4.5	16.000	4.5	22.000	4.5	28.000	4.5
4.250	4.5	10.250	4.5	16.250	4.5	22.250	4.5	28.250	4.5
4.500	4.5	10.500	4.5	16.500	4.5	22.500	4.5	28.500	4.5
4.750	4.5	10.750	4.5	16.750	4.5	22.750	4.5	28.750	3.8
5.000	4.5	11.000	4.5	17.000	4.5	23.000	4.5	29.000	3.0
5.250	4.5	11.250	4.5	17.250	4.5	23.250	4.5	29.250	2.3
5.500	4.5	11.500	4.5	17.500	4.5	23.500	4.5	29.500	1.8
5.750	4.5	11.750	4.5	17.750	4.5	23.750	4.5	29.750	1.4

RUNOFF VOLUME = 1.35751 INCHES = 10.3894 ACRE-FEET
PEAK DISCHARGE RATE = 4.50 CFS AT 3.150 HOURS BASIN AREA = .1435 SQ. MI.

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*
*S ADD 46B.6 TO 46B.4 TO GET 46B.8
*S
ADD HYD             ID=8  HYD NO=46B.8 ID I=7 ID II=4
PRINT HYD           ID=8   CODE=1
```

HYDROGRAPH FROM AREA 46B.8

RUNOFF VOLUME = 1.33613 INCHES = 85.3052 ACRE-FEET
PEAK DISCHARGE RATE = 65.22 CFS AT 2.900 HOURS BASIN AREA = 1.1971 SQ. MI.

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*
*S ROUTE 46B.8 IN 36" PIPE IN UNIVERSE TO GET 46.18
*
COMPUTE RATING CURVE       CID=1   VS NO=1 NO SEGS=-1  SLP=0.008
                                   DIAM=3.0 FT     N=0.013
```

RATING CURVE PIPE SECTION 1.0

WATER SURFACE ELEV	FLOW AREA SQ FT	FLOW RATE CFS	MAX WIDTH FT
.00	.00	.00	.00
.16	.14	.31	1.33
.31	.39	1.36	1.83
.47	.71	3.16	2.18
.63	1.07	5.68	2.44
.78	1.46	8.87	2.63
.94	1.89	12.65	2.78
1.09	2.33	16.95	2.89
1.25	2.79	21.67	2.96
1.41	3.26	26.72	2.99
1.56	3.72	31.98	3.00
1.72	4.19	37.33	3.00
1.88	4.65	42.66	3.00
2.03	5.10	47.81	3.00
2.19	5.53	52.63	3.00
2.35	5.93	56.95	3.00
2.50	6.30	60.55	3.00
2.66	6.62	63.12	3.00
2.81	6.89	64.17	3.00
3.00	7.07	64.17	3.00

```
ROUTE MCUNGE        ID=18  HYD NO=46.18    INFLOW ID=8
```

DT=0.0 HR LENGTH=1902 FT
NS=0 SLOPE=0.008 CODE=5

INFLOW END= 600 TABLE PTS= 19
DT= .050000 QMED= 32.61 CKMED= 11.4738
WIDTH MED= 3.00 NREACH= 2 DX= 951.00

DEPTH (FT)	AREA (SQ FT)	Q (CFS)	TRAVEL TIME(HR)	WIDTH (FT)	ck (FPS)	VEL (FPS)	C	D	C1	C2	C3	Q-M (CFS)	C1-M	C2-M	C3-M
.00	.0	.0	.322	.0	5.28	1.05	1.000	.000	1.000	.000	.000	.0	1.000	.000	.000
.16	.1	.3	.237	1.3	5.25	2.23	.994	.006	.994	.000	.006	.0	.999	.000	.001
.31	.4	1.4	.152	1.8	5.18	3.48	.981	.019	.981	.000	.019	.7	.989	.000	.011
.47	.7	3.2	.118	2.2	6.40	4.47	1.212	.030	.973	.108	-.081	2.2	.976	.052	-.028
.63	1.1	5.7	.099	2.4	7.54	5.32	1.427	.041	.967	.189	-.156	4.3	.970	.152	-.121
.78	1.5	8.9	.087	2.6	8.50	6.05	1.610	.052	.961	.249	-.209	7.2	.964	.221	-.185
.94	1.9	12.7	.079	2.8	9.32	6.70	1.765	.064	.955	.293	-.248	10.7	.958	.273	-.231
1.09	2.3	17.0	.073	2.9	10.01	7.27	1.896	.077	.948	.327	-.275	14.8	.951	.312	-.263
1.25	2.8	21.7	.068	3.0	10.58	7.77	2.003	.091	.941	.354	-.295	19.3	.945	.342	-.287
1.41	3.3	26.7	.064	3.0	11.03	8.21	2.087	.106	.933	.374	-.307	24.2	.938	.365	-.303
1.56	3.7	32.0	.062	3.0	11.33	8.59	2.145	.124	.924	.388	-.313	29.3	.929	.383	-.312
1.72	4.2	37.3	.059	3.0	11.41	8.91	2.159	.143	.913	.394	-.308	34.6	.919	.393	-.312
1.88	4.7	42.7	.058	3.0	11.19	9.17	2.119	.167	.898	.391	-.290	40.0	.907	.394	-.301
2.03	5.1	47.8	.056	3.0	10.66	9.38	2.018	.196	.878	.378	-.256	45.2	.889	.386	-.276
2.19	5.5	52.6	.055	3.0	9.77	9.53	1.850	.236	.847	.352	-.199	50.2	.865	.367	-.232
2.35	5.9	57.0	.055	3.0	8.46	9.61	1.601	.295	.796	.309	-.106	54.8	.826	.334	-.161
2.50	6.3	60.5	.055	3.0	6.58	9.61	1.246	.403	.696	.245	.059	58.8	.759	.282	-.041
2.66	6.6	63.1	.055	3.0	3.86	9.53	.730	.717	.414	.183	.403	61.8	.610	.210	.180
2.81	6.9	64.2	.057	3.0	2.20	9.32	.416	1.279	.051	.258	.691	63.7	.070	.249	.680

MAXIMUM NO. ITERATIONS FOR SOLUTION (KKMAX) = 4 OCCURRED 2 TIMES. AVERAGE NUMBER ITERATIONS = 1.8164
Equations solved using the Ponce correction to C2
PRINT HYD ID=18 CODE=5

OUTFLOW HYDROGRAPH REACH 46.18

TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS
.000	.0	6.000	62.7	12.000	43.8	18.000	33.1	24.000	13.5
.250	.0	6.250	62.5	12.250	43.2	18.250	32.8	24.250	11.6
.500	.0	6.500	62.2	12.500	42.6	18.500	32.4	24.500	9.3
.750	.0	6.750	61.9	12.750	42.1	18.750	31.8	24.750	8.7
1.000	.0	7.000	61.4	13.000	41.6	19.000	31.2	25.000	8.3
1.250	22.4	7.250	60.0	13.250	41.1	19.250	30.5	25.250	8.1
1.500	51.8	7.500	57.8	13.500	40.7	19.500	29.6	25.500	7.9
1.750	59.8	7.750	56.4	13.750	40.2	19.750	28.8	25.750	7.7
2.000	62.5	8.000	55.3	14.000	39.7	20.000	27.8	26.000	7.6
2.250	63.6	8.250	54.4	14.250	39.1	20.250	26.9	26.250	7.4
2.500	64.4	8.500	53.6	14.500	38.7	20.500	26.2	26.500	7.3
2.750	64.9	8.750	52.8	14.750	38.2	20.750	25.4	26.750	7.2
3.000	65.1	9.000	52.0	15.000	37.7	21.000	24.6	27.000	7.2
3.250	65.2	9.250	51.3	15.250	37.3	21.250	23.7	27.250	7.1
3.500	65.1	9.500	50.6	15.500	36.9	21.500	22.8	27.500	7.0
3.750	64.9	9.750	50.0	15.750	36.4	21.750	21.9	27.750	6.9

4.000	64.7	10.000	49.3	16.000	36.0	22.000	21.2	28.000	6.8
4.250	64.5	10.250	48.6	16.250	35.6	22.250	20.6	28.250	6.8
4.500	64.3	10.500	47.9	16.500	35.2	22.500	19.4	28.500	6.7
4.750	64.1	10.750	47.2	16.750	34.9	22.750	18.2	28.750	6.3
5.000	63.9	11.000	46.4	17.000	34.5	23.000	17.0	29.000	5.3
5.250	63.6	11.250	45.7	17.250	34.1	23.250	15.9	29.250	4.6
5.500	63.3	11.500	45.0	17.500	33.7	23.500	14.9	29.500	4.0
5.750	63.0	11.750	44.4	17.750	33.4	23.750	14.1	29.750	3.5

RUNOFF VOLUME = 1.33565 INCHES = 85.2746 ACRE-FEET
PEAK DISCHARGE RATE = 65.17 CFS AT 3.150 HOURS BASIN AREA = 1.1971 SQ. MI.

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*
*S ADD 46.18 TO 62.1 TO GET 46.9
*
ADD HYD             ID=9  HYD NO=46.9 ID I=18 ID II=1
PRINT HYD           ID=9   CODE=1
```

OUTFLOW HYDROGRAPH REACH 46.90

RUNOFF VOLUME = 1.28761 INCHES = 86.9949 ACRE-FEET
PEAK DISCHARGE RATE = 91.92 CFS AT 1.600 HOURS BASIN AREA = 1.2668 SQ. MI.

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*
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*
*S ROUTE 46.9 IN 72" IN SCENIC
*
COMPUTE RATING CURVE       CID=1   VS NO=1 NO SEGS=-1  SLP=0.0085
                                   DIAM=6.0 FT     N=0.013
```

RATING CURVE PIPE SECTION 1.0

WATER SURFACE ELEV	FLOW AREA SQ FT	FLOW RATE CFS	MAX WIDTH FT
.00	.00	.00	.00
.31	.56	2.05	2.67
.63	1.56	8.89	3.67
.94	2.82	20.67	4.36
1.25	4.27	37.17	4.87
1.56	5.86	58.04	5.27
1.88	7.55	82.82	5.56
2.19	9.33	110.95	5.78
2.50	11.16	141.86	5.92
2.81	13.02	174.87	5.99
3.13	14.90	209.29	6.00
3.44	16.76	244.34	6.00
3.75	18.60	279.18	6.00
4.06	20.39	312.91	6.00
4.38	22.10	344.49	6.00
4.69	23.71	372.76	6.00
5.00	25.19	396.27	6.00
5.32	26.49	413.10	6.00
5.63	27.55	420.02	6.00
6.00	28.27	420.02	6.00

```
ROUTE MCUNGE        ID=2   HYD NO=IP2      INFLOW ID=9
                           DT=0.0 HR       LENGTH=868 FT
                           NS=0    SLOPE=0.0085  CODE=5
```

INFLOW END= 600 TABLE PTS= 19
DT= .050000 QMED= 45.96 CKMED= 13.1397
WIDTH MED= 5.04 NREACH= 1 DX= 868.00

DEPTH (FT)	AREA (SQ FT)	Q (CFS)	TRAVEL TIME(HR)	WIDTH (FT)	ck (FPS)	VEL (FPS)	C	D	C1	C2	C3	Q-M (CFS)	C1-M	C2-M	C3-M
.00	.0	.0	.090	.0	4.82	1.72	1.000	.000	1.000	.000	.000	.0	1.000	.000	.000
.31	.6	2.0	.066	2.7	6.00	3.64	1.243	.017	.985	.115	-.100	.3	.998	.018	-.016
.63	1.6	8.9	.042	3.7	8.28	5.69	1.716	.040	.971	.274	-.245	4.9	.975	.185	-.160
.94	2.8	20.7	.033	4.4	10.48	7.32	2.173	.061	.962	.382	-.344	14.3	.966		

```
.332  -.298
        1.25    4.3     37.2    .028    4.9    12.33   8.70    2.558   .084   .954   .451  -.405     28.5    .958
.419  -.377
        1.56    5.9     58.0    .024    5.3    13.91   9.91    2.885   .107   .946   .499  -.445     47.2    .950
.477  -.427
        1.88    7.6     82.8    .022    5.6    15.26  10.96    3.164   .132   .938   .534  -.473     70.1    .942
.519  -.461
        2.19    9.3    111.0    .020    5.8    16.39  11.89    3.398   .159   .930   .561  -.491     96.6    .934
.549  -.484
        2.50   11.2    141.9    .019    5.9    17.31  12.71    3.590   .188   .921   .581  -.503    126.1    .926
.573  -.499
        2.81   13.0    174.9    .018    6.0    18.04  13.43    3.741   .219   .912   .597  -.508    158.1    .917
.590  -.507
        3.13   14.9    209.3    .017    6.0    18.55  14.05    3.846   .255   .900   .608  -.508    191.9    .906
.604  -.510
        3.44   16.8    244.3    .017    6.0    18.66  14.58    3.871   .296   .886   .613  -.498    226.7    .894
.612  -.505
        3.75   18.6    279.2    .016    6.0    18.32  15.01    3.798   .344   .866   .611  -.477    261.6    .877
.613  -.490
        4.06   20.4    312.9    .016    6.0    17.45  15.35    3.618   .405   .839   .602  -.441    296.0    .854
.608  -.462
        4.38   22.1    344.5    .015    6.0    15.99  15.59    3.317   .487   .797   .584  -.381    328.7    .821
.595  -.416
        4.69   23.7    372.8    .015    6.0    13.84  15.72    2.869   .609   .728   .553  -.282    358.6    .769
.571  -.340
        5.00   25.2    396.3    .015    6.0    10.77  15.73    2.234   .831   .591   .508  -.099    384.6    .677
.534  -.211
        5.32   26.5    413.1    .015    6.0     6.31  15.60    1.309  1.479   .219   .472   .309    404.8    .474
.484   .041
        5.63   27.5    420.0    .016    6.0     3.60  15.25     .746  2.638  -.203   .544   .660    416.6    .005
.508   .487
     MAXIMUM NO. ITERATIONS FOR SOLUTION (KKMAX) =   3 OCCURRED       7 TIMES.  AVERAGE NUMBER ITERATIONS =  1.8664
       DEPTH   AREA      Q    TRAVEL  WIDTH     ck      VEL      C       D      C1     C2     C3     Q-M     C1-M
C2-M   C3-M
        (FT)  (SQ FT)  (CFS)  TIME(HR) (FT)     (FPS)   (FPS)                                          (CFS)
         .00     .0       .0    .090     .0     4.82    1.72    1.000   .000  1.000   .000   .000       .0    1.000
.000   .000
         .31     .6      2.0    .066    2.7     4.92    3.64    1.021   .021   .979   .021   .000       .3    .993
.007   .000
         .63    1.6      8.9    .042    3.7     5.13    5.69    1.064   .064   .940   .060   .000      4.9    .960
.040   .000
         .94    2.8     20.7    .033    4.4     5.40    7.32    1.119   .119   .894   .106   .000     14.3    .916
.084   .000
        1.25    4.3     37.2    .028    4.9     5.70    8.70    1.181   .181   .846   .154   .000     28.5    .869
.131   .000
        1.56    5.9     58.0    .024    5.3     6.02    9.91    1.248   .248   .801   .199   .000     47.2    .823
.177   .000
        1.88    7.6     82.8    .022    5.6     6.35   10.96    1.318   .318   .759   .241   .000     70.1    .779
.221   .000
        2.19    9.3    111.0    .020    5.8     6.70   11.89    1.389   .389   .720   .280   .000     96.6    .739
.261   .000
        2.50   11.2    141.9    .019    5.9     7.05   12.71    1.461   .461   .684   .316   .000    126.1    .702
.298   .000
        2.81   13.0    174.9    .018    6.0     7.40   13.43    1.535   .535   .652   .348   .000    158.1    .667
.333   .000
        3.13   14.9    209.3    .017    6.0     7.76   14.05    1.609   .609   .621   .379   .000    191.9    .636
.364   .000
        3.44   16.8    244.3    .017    6.0     8.11   14.58    1.681   .681   .595   .405   .000    226.7    .608
.392   .000
        3.75   18.6    279.2    .016    6.0     8.43   15.01    1.748   .748   .572   .428   .000    261.6    .583
.417   .000
        4.06   20.4    312.9    .016    6.0     8.73   15.35    1.810   .810   .553   .447   .000    296.0    .562
.438   .000
        4.38   22.1    344.5    .015    6.0     8.99   15.59    1.865   .865   .536   .464   .000    328.7    .544
.456   .000
        4.69   23.7    372.8    .015    6.0     9.22   15.72    1.913   .913   .523   .477   .000    358.6    .529
.471   .000
        5.00   25.2    396.3    .015    6.0     9.41   15.73    1.951   .951   .512   .488   .000    384.6    .518
.482   .000
        5.32   26.5    413.1    .015    6.0     6.31   15.60    1.309  1.479   .219   .472   .309    404.8    .474
.484   .041
        5.63   27.5    420.0    .016    6.0     4.77   15.25     .989  1.989   .000   .497   .503    416.6    .108
.485   .407
     MAXIMUM NO. ITERATIONS FOR SOLUTION (KKMAX) =   3 OCCURRED       4 TIMES.  AVERAGE NUMBER ITERATIONS =  1.5292
     Equations solved with two passes: first using the Ponce correction to C1, second using the Fread correction to C1,
C2 and C3
     PRINT HYD           ID=2   CODE=5

                                        HYDROGRAPH FROM AREA IP2

          TIME      FLOW          TIME      FLOW          TIME      FLOW          TIME      FLOW          TIME
FLOW
           HRS       CFS           HRS       CFS           HRS       CFS           HRS       CFS           HRS
CFS
          .000        .0         6.000      62.8        12.000      43.9        18.000      33.1        24.000
13.6
          .250        .0         6.250      62.5        12.250      43.3        18.250      32.8        24.250
12.3
          .500        .0         6.500      62.3        12.500      42.7        18.500      32.5        24.500
 9.6
          .750        .0         6.750      62.0        12.750      42.2        18.750      32.0        24.750
```

8.8
1.000 .0 7.000 61.6 13.000 41.7 19.000 31.3 25.000
8.4
1.250 5.0 7.250 60.3 13.250 41.2 19.250 30.6 25.250
8.1
1.500 67.0 7.500 58.1 13.500 40.7 19.500 29.7 25.500
7.9
1.750 89.6 7.750 56.6 13.750 40.2 19.750 28.9 25.750
7.7
2.000 76.0 8.000 55.5 14.000 39.8 20.000 28.0 26.000
7.6
2.250 69.2 8.250 54.5 14.250 39.2 20.250 27.1 26.250
7.5
2.500 69.3 8.500 53.7 14.500 38.7 20.500 26.3 26.500
7.4
2.750 67.9 8.750 52.9 14.750 38.3 20.750 25.6 26.750
7.3
3.000 67.0 9.000 52.1 15.000 37.8 21.000 24.8 27.000
7.2
3.250 66.6 9.250 51.4 15.250 37.4 21.250 23.9 27.250
7.1
3.500 66.1 9.500 50.7 15.500 36.9 21.500 22.9 27.500
7.0
3.750 65.7 9.750 50.1 15.750 36.5 21.750 22.1 27.750
6.9
4.000 65.3 10.000 49.4 16.000 36.1 22.000 21.3 28.000
6.9
4.250 65.0 10.250 48.7 16.250 35.7 22.250 20.7 28.250
6.8
4.500 64.7 10.500 48.0 16.500 35.3 22.500 19.7 28.500
6.7
4.750 64.4 10.750 47.3 16.750 34.9 22.750 18.4 28.750
6.5
5.000 64.1 11.000 46.6 17.000 34.5 23.000 17.2 29.000
5.5
5.250 63.8 11.250 45.8 17.250 34.2 23.250 16.1 29.250
4.7
5.500 63.4 11.500 45.1 17.500 33.8 23.500 15.1 29.500
4.1
5.750 63.1 11.750 44.5 17.750 33.5 23.750 14.2 29.750
3.6

RUNOFF VOLUME = 1.28734 INCHES = 86.9766 ACRE-FEET
PEAK DISCHARGE RATE = 91.83 CFS AT 1.650 HOURS BASIN AREA = 1.2668 SQ. MI.

```
*
*********************************************************************
*
*S*******************************************************************
*S ADD IP2 TO IP3 TO GET 60.20
*
ADD HYD             ID=20  HYD NO=60.20 ID I=2 ID II=19
PRINT HYD           ID=20   CODE=1
```

OUTFLOW HYDROGRAPH REACH 60.20

RUNOFF VOLUME = .50693 INCHES = 369.9536 ACRE-FEET
PEAK DISCHARGE RATE = 1254.72 CFS AT 3.100 HOURS BASIN AREA = 13.6836 SQ. MI.

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*
*
*********************************************************************
*********************************************************************
*
*S ADD OFFSITE VISTA VIEJA (VV) SUB-BASIN - INFLOW POINT IP4
*
*S*** SUB-BASIN 86 - BASIN E IN VV DRAINAGE REPORT
*S*** INCLUDES 10 AC DEVELOPED VV
*
COMPUTE LT TP       LCODE=1  UPLAND/LAG TIME TRANSITION METHOD
                    NK=3  ISLOPE=-1
                    LENGTH=400 FT   SLOPE=0.065 K=0.7
                    LENGTH=1600 FT  SLOPE=0.038 K=2.0
                    LENGTH=4852 FT  SLOPE=0.028 K=3.0
                    Kn=.033  CR=0.51
```

Tc AND Tp COMPUTED BY UPLAND/LAG TIME PROCEDURE

SCS UPLAND METHOD FACTORS

	LENGTH (FT)	SLOPE (FT/FT)	COMPOSITE K
SHEET FLOW PORTION	400.0	.065000	.7000
SHALLOW FLOW PORTION	1600.0	.038000	2.0000
CHANNEL FLOW PORTION	4852.0	.028000	3.0000
TOTAL BASIN	6852.0	.032495	2.3741

LAG EQUATION FACTORS: Kn= .0330 TOTAL BASIN LENGTH (FT)= 6852.0
TOTAL BASIN SLOPE (FT/FT)= .032495 CENTROUD LENGTH (FT)= 3494.5

TIME OF CONCENTRATION (HRS)= .4073 TIME TO PEAK (HRS)= .2715 LAG TIME (HRS)= .3055

COMPUTE NM HYD ID=1 HYD NO=86.1 DA=0.248 SQ MI
PER A=84 PER B=1 PER C=11 PER D=4
TP=0.0 MASSRAIN=-1
TIME TO PEAK (hrs)= .2715

K = .157581HR TP = .271529HR K/TP RATIO = .580348 SHAPE CONSTANT, N = 6.561513
UNIT PEAK = 18.270 CFS UNIT VOLUME = .9991 B = 500.09 P60 = 1.6900
AREA = .009920 SQ MI IA = .10000 INCHES INF = .04000 INCHES PER HOUR
RUNOFF COMPUTED BY INITIAL ABSTRACTION/INFILTRATION NUMBER METHOD - DT = .050000

K = .290582HR TP = .271529HR K/TP RATIO = 1.070171 SHAPE CONSTANT, N = 3.300278
UNIT PEAK = 267.83 CFS UNIT VOLUME = 1.000 B = 305.45 P60 = 1.6900
AREA = .238080 SQ MI IA = .61406 INCHES INF = 1.56937 INCHES PER HOUR
RUNOFF COMPUTED BY INITIAL ABSTRACTION/INFILTRATION NUMBER METHOD - DT = .050000

BULKING FACTOR APPLIED TO HYDROGRAPH. FACTOR = 1.05000 AT PEAK FLOW.

PRINT HYD ID=1 CODE=5

OUTFLOW HYDROGRAPH REACH 86.10

TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS
.000	.0	5.250	.7	10.500	.2	15.750	.1	21.000	.1
.250	.0	5.500	.6	10.750	.2	16.000	.1	21.250	.1
.500	.0	5.750	.5	11.000	.2	16.250	.1	21.500	.1
.750	.0	6.000	.5	11.250	.2	16.500	.1	21.750	.1
1.000	.5	6.250	.4	11.500	.2	16.750	.1	22.000	.1
1.250	1.2	6.500	.3	11.750	.2	17.000	.1	22.250	.1
1.500	84.9	6.750	.3	12.000	.2	17.250	.1	22.500	.1
1.750	118.3	7.000	.3	12.250	.2	17.500	.1	22.750	.1
2.000	54.5	7.250	.2	12.500	.1	17.750	.1	23.000	.1
2.250	24.2	7.500	.2	12.750	.1	18.000	.1	23.250	.1
2.500	12.5	7.750	.2	13.000	.1	18.250	.1	23.500	.1
2.750	9.1	8.000	.2	13.250	.1	18.500	.1	23.750	.1
3.000	6.7	8.250	.2	13.500	.1	18.750	.1	24.000	.1
3.250	5.0	8.500	.2	13.750	.1	19.000	.1	24.250	.1
3.500	3.8	8.750	.2	14.000	.1	19.250	.1	24.500	.0
3.750	2.9	9.000	.2	14.250	.1	19.500	.1	24.750	.0
4.000	2.2	9.250	.2	14.500	.1	19.750	.1	25.000	.0
4.250	1.7	9.500	.2	14.750	.1	20.000	.1	25.250	.0
4.500	1.3	9.750	.2	15.000	.1	20.250	.1	25.500	.0
4.750	1.1	10.000	.2	15.250	.1	20.500	.1	25.750	.0
5.000	.9	10.250	.2	15.500	.1	20.750	.1		

RUNOFF VOLUME = .52996 INCHES = 7.0095 ACRE-FEET
PEAK DISCHARGE RATE = 135.81 CFS AT 1.650 HOURS BASIN AREA = .2480 SQ. MI.

*
****
*S ROUTE THRU 48" SD - IP4
*
COMPUTE RATING CURVE CID=1 VS NO=1 NO SEGS=-1 SLP=0.02
DIAM=4.0 FT N=0.013

RATING CURVE PIPE SECTION 1.0

WATER SURFACE ELEV	FLOW AREA SQ FT	FLOW RATE CFS	MAX WIDTH FT

OUT.WPD

.00	.00	.00	.00
.21	.25	1.07	1.78
.42	.69	4.63	2.44
.63	1.25	10.75	2.91
.83	1.90	19.34	3.25
1.04	2.60	30.20	3.51
1.25	3.36	43.09	3.71
1.46	4.15	57.73	3.85
1.67	4.96	73.80	3.94
1.88	5.79	90.98	3.99
2.08	6.62	108.89	4.00
2.29	7.45	127.12	4.00
2.50	8.27	145.25	4.00
2.71	9.06	162.80	4.00
2.92	9.82	179.23	4.00
3.13	10.54	193.93	4.00
3.34	11.20	206.17	4.00
3.54	11.77	214.92	4.00
3.75	12.24	218.52	4.00
4.00	12.57	218.52	4.00

ROUTE MCUNGE ID=10 HYD NO=IP4 INFLOW ID=1
DT=0.0 HR LENGTH=2620 FT
NS=0 SLOPE=0.02 CODE=5

INFLOW END= 517 TABLE PTS= 19
DT= .050000 QMED= 67.90 CKMED= 19.7710
WIDTH MED= 3.91 NREACH= 2 DX= 1310.00

DEPTH (FT)	AREA (SQ FT)	Q (CFS)	TRAVEL TIME(HR)	WIDTH (FT)	ck (FPS)	VEL (FPS)	C	D	C1	C2	C3	Q-M (CFS)	C1-M	C2-M	C3-M
.00	.0	.0	.232	.0	7.28	2.01	1.000	.000	1.000	.000	.000	.0	1.000	.000	.000
.21	.2	1.1	.171	1.8	7.25	4.27	.997	.003	.997	.000	.003	.2	1.000	.000	.000
.42	.7	4.6	.109	2.4	9.69	6.66	1.331	.007	.994	.145	-.138	2.5	.995	.052	-.047
.63	1.3	10.8	.085	2.9	12.26	8.57	1.685	.012	.991	.258	-.250	7.4	.992	.205	-.198
.83	1.9	19.3	.071	3.2	14.44	10.19	1.984	.016	.990	.333	-.323	14.8	.990	.299	-.289
1.04	2.6	30.2	.063	3.5	16.29	11.60	2.238	.020	.988	.386	-.374	24.6	.989	.362	-.350
1.25	3.4	43.1	.057	3.7	17.86	12.83	2.454	.025	.986	.425	-.411	36.5	.987	.408	-.394
1.46	4.1	57.7	.052	3.9	19.18	13.92	2.636	.030	.984	.454	-.438	50.2	.985	.441	-.426
1.67	5.0	73.8	.049	3.9	20.27	14.88	2.785	.035	.982	.476	-.458	65.6	.983	.467	-.450
1.88	5.8	91.0	.046	4.0	21.12	15.72	2.902	.041	.979	.493	-.472	82.3	.980	.486	-.467
2.08	6.6	108.9	.044	4.0	21.71	16.45	2.983	.048	.976	.504	-.480	99.8	.978	.500	-.478
2.29	7.5	127.1	.043	4.0	21.85	17.06	3.002	.056	.973	.507	-.480	117.9	.975	.507	-.482
2.50	8.3	145.2	.041	4.0	21.44	17.57	2.946	.065	.968	.501	-.469	136.1	.970	.506	-.476
2.71	9.1	162.8	.041	4.0	20.43	17.97	2.807	.076	.961	.485	-.446	154.0	.965	.495	-.460
2.92	9.8	179.2	.040	4.0	18.72	18.25	2.573	.091	.950	.454	-.404	171.0	.956	.472	-.429
3.13	10.5	193.9	.040	4.0	16.20	18.40	2.226	.114	.932	.401	-.333	186.6	.943	.433	-.375
3.34	11.2	206.2	.040	4.0	12.61	18.42	1.733	.156	.892	.308	-.200	200.1	.917	.364	-.282
3.54	11.8	214.9	.040	4.0	7.39	18.26	1.015	.278	.758	.128	.115	210.6	.855	.241	-.095
3.75	12.2	218.5	.041	4.0	4.21	17.85	.579	.495	.522	.036	.442	216.7	.537	.035	.428

MAXIMUM NO. ITERATIONS FOR SOLUTION (KKMAX) = 4 OCCURRED 3 TIMES. AVERAGE NUMBER ITERATIONS = 1.1291
Equations solved using the Ponce correction to C2
PRINT HYD ID=10 CODE=5

HYDROGRAPH FROM AREA IP4

TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS
.000	.0	5.250	.8	10.500	.2	15.750	.1	21.000	.1
.250	.0	5.500	.7	10.750	.2	16.000	.1	21.250	.1
.500	.0	5.750	.6	11.000	.2	16.250	.1	21.500	.1
.750	.0	6.000	.5	11.250	.2	16.500	.1	21.750	.1
1.000	.2	6.250	.5	11.500	.2	16.750	.1	22.000	.1
1.250	.9	6.500	.4	11.750	.2	17.000	.1	22.250	

.1	1.500	57.0	6.750	.3	12.000	.2	17.250	.1	22.500
.1	1.750	126.9	7.000	.3	12.250	.2	17.500	.1	22.750
.1	2.000	61.5	7.250	.3	12.500	.1	17.750	.1	23.000
.1	2.250	28.3	7.500	.2	12.750	.1	18.000	.1	23.250
.1	2.500	13.6	7.750	.2	13.000	.1	18.250	.1	23.500
.1	2.750	9.8	8.000	.2	13.250	.1	18.500	.1	23.750
.1	3.000	7.3	8.250	.2	13.500	.1	18.750	.1	24.000
.1	3.250	5.5	8.500	.2	13.750	.1	19.000	.1	24.250
.1	3.500	4.1	8.750	.2	14.000	.1	19.250	.1	24.500
.0	3.750	3.2	9.000	.2	14.250	.1	19.500	.1	24.750
.0	4.000	2.4	9.250	.2	14.500	.1	19.750	.1	25.000
.0	4.250	1.9	9.500	.2	14.750	.1	20.000	.1	25.250
.0	4.500	1.5	9.750	.2	15.000	.1	20.250	.1	25.500
.0	4.750	1.2	10.000	.2	15.250	.1	20.500	.1	25.750
.0	5.000	.9	10.250	.2	15.500	.1	20.750	.1	

RUNOFF VOLUME = .53022 INCHES = 7.0131 ACRE-FEET
PEAK DISCHARGE RATE = 134.99 CFS AT 1.700 HOURS BASIN AREA = .2480 SQ. MI.

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*
**********************************************************************
*S INFLOW POINT IP5
*S ONSITE BASINS VV1 UNITS 2 AND PART OF UNIT 3
*
COMPUTE LT TP       LCODE=1  UPLAND/LAG TIME TRANSITION METHOD
                    NK=3  ISLOPE=-1
                    LENGTH=400 FT   SLOPE=0.02 K=0.7
                    LENGTH=1600 FT  SLOPE=0.02 K=2.0
                    LENGTH=150 FT  SLOPE=0.02 K=3.0


     Tc AND Tp COMPUTED BY UPLAND/LAG TIME PROCEDURE

     SCS UPLAND METHOD FACTORS
                              LENGTH (FT)      SLOPE (FT/FT)       COMPOSITE K
     SHEET FLOW PORTION          400.0           .020000             .7000
     SHALLOW FLOW PORTION       1600.0           .020000            2.0000
     CHANNEL FLOW PORTION        150.0           .020000            3.0000
     TOTAL BASIN                2150.0           .020000            1.5126


     TIME OF CONCENTRATION (HRS)=   .2792     TIME TO PEAK (HRS)=   .1861     LAG TIME (HRS)=   .2094

COMPUTE NM HYD      ID=1   HYD NO=VV1.23   DA=0.0894 SQ MI
                    PER A=0 PER B=20  PER C=20  PER D=60
                    TP=0.0   MASSRAIN=-1
     TIME TO PEAK (hrs)=   .1861

     K =   .102395HR    TP =   .186130HR    K/TP RATIO =   .550126     SHAPE CONSTANT, N =  7.021823
     UNIT PEAK =   150.52    CFS   UNIT VOLUME =    1.000       B =   522.29      P60 = 1.6900
     AREA =      .053640 SQ MI    IA =    .10000 INCHES    INF =    .04000 INCHES PER HOUR
     RUNOFF COMPUTED BY INITIAL ABSTRACTION/INFILTRATION NUMBER METHOD - DT =   .050000


     K =   .165794HR    TP =   .186130HR    K/TP RATIO =   .890743     SHAPE CONSTANT, N =  3.981464
     UNIT PEAK =   67.999    CFS   UNIT VOLUME =    1.000       B =   353.93      P60 = 1.6900
     AREA =      .035760 SQ MI    IA =    .42500 INCHES    INF =   1.04000 INCHES PER HOUR
     RUNOFF COMPUTED BY INITIAL ABSTRACTION/INFILTRATION NUMBER METHOD - DT =   .050000

    BULKING FACTOR APPLIED TO HYDROGRAPH.  FACTOR =  1.05000 AT PEAK FLOW.

PRINT HYD           ID=1   CODE=5
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HYDROGRAPH FROM AREA VV1.23

TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS
.000	.0	5.250	1.5	10.500	.9	15.750	.7	21.000	.6
.250	.0	5.500	1.6	10.750	.9	16.000	.7	21.250	.6
.500	.0	5.750	1.6	11.000	.9	16.250	.7	21.500	

.6	.750	.0	6.000	1.7	11.250	.9	16.500	.7	21.750
.6	1.000	5.0	6.250	1.3	11.500	.8	16.750	.7	22.000
.6	1.250	9.9	6.500	1.2	11.750	.8	17.000	.7	22.250
.5	1.500	148.7	6.750	1.1	12.000	.8	17.250	.7	22.500
.5	1.750	88.3	7.000	1.1	12.250	.8	17.500	.6	22.750
.5	2.000	45.4	7.250	1.1	12.500	.8	17.750	.6	23.000
.5	2.250	19.0	7.500	1.1	12.750	.8	18.000	.6	23.250
.5	2.500	9.4	7.750	1.0	13.000	.8	18.250	.6	23.500
.5	2.750	5.7	8.000	1.0	13.250	.8	18.500	.6	23.750
.5	3.000	3.8	8.250	1.0	13.500	.8	18.750	.6	24.000
.5	3.250	2.7	8.500	1.0	13.750	.8	19.000	.6	24.250
.2	3.500	2.2	8.750	1.0	14.000	.7	19.250	.6	24.500
.1	3.750	1.8	9.000	1.0	14.250	.7	19.500	.6	24.750
.0	4.000	1.7	9.250	1.0	14.500	.7	19.750	.6	25.000
.0	4.250	1.6	9.500	.9	14.750	.7	20.000	.6	25.250
.0	4.500	1.5	9.750	.9	15.000	.7	20.250	.6	25.500
.0	4.750	1.5	10.000	.9	15.250	.7	20.500	.6	
	5.000	1.5	10.250	.9	15.500	.7	20.750	.6	

RUNOFF VOLUME = 1.74818 INCHES = 8.3353 ACRE-FEET
PEAK DISCHARGE RATE = 163.45 CFS AT 1.550 HOURS BASIN AREA = .0894 SQ. MI.

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*
**********************************************************************
*S ROUTE THRU 48" SD - IP5
*
COMPUTE RATING CURVE       CID=1   VS NO=1 NO SEGS=-1  SLP=0.015
                                   DIAM=4.0 FT     N=0.013
```

RATING CURVE PIPE SECTION 1.0

WATER SURFACE ELEV	FLOW AREA SQ FT	FLOW RATE CFS	MAX WIDTH FT
.00	.00	.00	.00
.21	.25	.92	1.78
.42	.69	4.01	2.44
.63	1.25	9.31	2.91
.83	1.90	16.75	3.25
1.04	2.60	26.15	3.51
1.25	3.36	37.31	3.71
1.46	4.15	49.99	3.85
1.67	4.96	63.92	3.94
1.88	5.79	78.79	3.99
2.08	6.62	94.30	4.00
2.29	7.45	110.09	4.00
2.50	8.27	125.79	4.00
2.71	9.06	140.99	4.00
2.92	9.82	155.22	4.00
3.13	10.54	167.95	4.00
3.34	11.20	178.55	4.00
3.54	11.77	186.13	4.00
3.75	12.24	189.24	4.00
4.00	12.57	189.25	4.00

```
ROUTE MCUNGE        ID=11  HYD NO=IP5      INFLOW ID=1
                           DT=0.0 HR       LENGTH=2060 FT
                           NS=0    SLOPE=0.015  CODE=5
```

INFLOW END= 515 TABLE PTS= 19
DT= .050000 QMED= 81.73 CKMED= 18.6076
WIDTH MED= 3.99 NREACH= 2 DX= 1030.00

DEPTH (FT)	AREA (SQ FT)	Q (CFS)	TRAVEL TIME(HR)	WIDTH (FT)	ck (FPS)	VEL (FPS)	C	D	C1	C2	C3	Q-M (CFS)	C1-M	C2-M	C3-M
.00	.0	.0	.211	.0	5.72	1.74	1.000	.000	1.000	.000	.000	.0	1.000	.000	.000
.21	.2	.9	.155	1.8	6.08	3.69	1.062	.006	.995	.033	-.027	.1	.999	.005	-.004
.42	.7	4.0	.099	2.4	8.39	5.76	1.466	.013	.990	.193	-.183	2.2	.991	.101	-.093

.63	1.3	9.3	.077	2.9	10.62	7.42	1.856	.020	.986	.304	-.291	6.4	.988
.253	-.240												
.83	1.9	16.7	.065	3.2	12.50	8.82	2.185	.027	.983	.377	-.361	12.8	.985
.344	-.328												
1.04	2.6	26.2	.057	3.5	14.11	10.04	2.465	.034	.980	.428	-.409	21.3	.982
.405	-.387												
1.25	3.4	37.3	.051	3.7	15.47	11.11	2.703	.042	.978	.466	-.443	31.6	.979
.449	-.428												
1.46	4.1	50.0	.047	3.9	16.61	12.06	2.903	.051	.974	.494	-.469	43.5	.976
.482	-.458												
1.67	5.0	63.9	.044	3.9	17.55	12.89	3.067	.060	.971	.515	-.486	56.8	.973
.506	-.479												
1.88	5.8	78.8	.042	4.0	18.29	13.61	3.196	.070	.967	.531	-.498	71.2	.969
.525	-.494												
2.08	6.6	94.3	.040	4.0	18.80	14.24	3.286	.081	.963	.542	-.505	86.5	.965
.538	-.503												
2.29	7.5	110.1	.039	4.0	18.92	14.78	3.307	.094	.957	.546	-.503	102.1	.960
.545	-.506												
2.50	8.3	125.8	.038	4.0	18.57	15.22	3.245	.110	.950	.541	-.490	117.9	.954
.545	-.499												
2.71	9.1	141.0	.037	4.0	17.69	15.56	3.091	.129	.939	.526	-.465	133.4	.945
.535	-.480												
2.92	9.8	155.2	.036	4.0	16.21	15.80	2.834	.155	.922	.499	-.421	148.1	.932
.515	-.447												
3.13	10.5	168.0	.036	4.0	14.03	15.94	2.451	.194	.894	.451	-.345	161.6	.911
.479	-.390												
3.34	11.2	178.5	.036	4.0	10.92	15.95	1.909	.265	.833	.370	-.203	173.3	.872
.419	-.291												
3.54	11.8	186.1	.036	4.0	6.40	15.81	1.118	.471	.636	.227	.136	182.4	.777
.314	-.091												
3.75	12.2	189.2	.037	4.0	3.65	15.46	.637	.840	.322	.193	.486	187.7	.341
.189	.471												

MAXIMUM NO. ITERATIONS FOR SOLUTION (KKMAX) = 3 OCCURRED 33 TIMES. AVERAGE NUMBER ITERATIONS = 1.1385
Equations solved using the Ponce correction to C2
PRINT HYD ID=11 CODE=5

HYDROGRAPH FROM AREA IP5

TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS
.000	.0	5.250	1.5	10.500	.9	15.750	.7	21.000	.6
.250	.0	5.500	1.6	10.750	.9	16.000	.7	21.250	.6
.500	.0	5.750	1.6	11.000	.9	16.250	.7	21.500	.6
.750	.0	6.000	1.7	11.250	.9	16.500	.7	21.750	.6
1.000	3.6	6.250	1.5	11.500	.8	16.750	.7	22.000	.6
1.250	6.1	6.500	1.2	11.750	.8	17.000	.7	22.250	.5
1.500	126.1	6.750	1.2	12.000	.8	17.250	.7	22.500	.5
1.750	98.7	7.000	1.1	12.250	.8	17.500	.7	22.750	.5
2.000	48.8	7.250	1.1	12.500	.8	17.750	.6	23.000	.5
2.250	22.9	7.500	1.1	12.750	.8	18.000	.6	23.250	.5
2.500	10.5	7.750	1.1	13.000	.8	18.250	.6	23.500	.5
2.750	6.4	8.000	1.0	13.250	.8	18.500	.6	23.750	.5
3.000	4.2	8.250	1.0	13.500	.8	18.750	.6	24.000	.5
3.250	3.0	8.500	1.0	13.750	.8	19.000	.6	24.250	.4
3.500	2.3	8.750	1.0	14.000	.7	19.250	.6	24.500	.1
3.750	1.9	9.000	1.0	14.250	.7	19.500	.6	24.750	.0
4.000	1.7	9.250	1.0	14.500	.7	19.750	.6	25.000	.0
4.250	1.6	9.500	.9	14.750	.7	20.000	.6	25.250	.0
4.500	1.5	9.750	.9	15.000	.7	20.250	.6	25.500	.0
4.750	1.5	10.000	.9	15.250	.7	20.500	.6	25.750	.0
5.000	1.5	10.250	.9	15.500	.7	20.750	.6		

RUNOFF VOLUME = 1.74798 INCHES = 8.3343 ACRE-FEET
PEAK DISCHARGE RATE = 162.20 CFS AT 1.600 HOURS BASIN AREA = .0894 SQ. MI.

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*S ADD OFFSITE VISTA VIEJA (VV2) SUB-BASIN - INFLOW POINT IP6
*S*** SUB-BASIN 83 & 83A - BASIN E IN D DRAINAGE REPORT
*S INCLUDES PARTS OF UNIT 4 & 1
**********************************************************************
*S*** SUB-BASIN 83
*
*
COMPUTE LT TP       LCODE=1  UPLAND/LAG TIME TRANSITION METHOD
                    NK=3  ISLOPE=-1
                    LENGTH=400 FT   SLOPE=0.058 K=0.7
                    LENGTH=1600 FT  SLOPE=0.061 K=2.0
                    LENGTH=9817 FT  SLOPE=0.0326 K=3.0
                    Kn=.033  CR=0.61

     Tc AND Tp COMPUTED BY UPLAND/LAG TIME PROCEDURE

     SCS UPLAND METHOD FACTORS
                              LENGTH (FT)      SLOPE (FT/FT)       COMPOSITE K
     SHEET FLOW PORTION           400.0           .058000             .7000
     SHALLOW FLOW PORTION        1600.0           .061000            2.0000
     CHANNEL FLOW PORTION        9817.0           .032600            3.0000
     TOTAL BASIN                11817.0           .037305            2.5776


     LAG EQUATION FACTORS:     Kn=   .0330     TOTAL BASIN LENGTH (FT)=     11817.0
     TOTAL BASIN SLOPE (FT/FT)=    .037305     CENTROUD LENGTH (FT)=         7208.4


     TIME OF CONCENTRATION (HRS)=   .6879     TIME TO PEAK (HRS)=   .4586     LAG TIME (HRS)=   .5159

COMPUTE NM HYD      ID=1   HYD NO=83   DA=0.538 SQ MI
                    PER A=89 PER B=0  PER C=10  PER D=1
                    TP=0.0   MASSRAIN=-1
     TIME TO PEAK (hrs)=   .4586

     K =   .271774HR    TP =   .458584HR    K/TP RATIO =   .592638     SHAPE CONSTANT, N =  6.391029
     UNIT PEAK =   5.7680    CFS   UNIT VOLUME =    .9977       B =   491.65      P60 = 1.6900
     AREA =      .005380 SQ MI    IA =    .10000 INCHES    INF =    .04000 INCHES PER HOUR
     RUNOFF COMPUTED BY INITIAL ABSTRACTION/INFILTRATION NUMBER METHOD - DT =   .050000


     K =   .471467HR    TP =   .458584HR    K/TP RATIO =  1.028094     SHAPE CONSTANT, N =  3.433486
     UNIT PEAK =   366.37    CFS   UNIT VOLUME =    1.000       B =   315.44      P60 = 1.6900
     AREA =      .532620 SQ MI    IA =    .61970 INCHES    INF =   1.58515 INCHES PER HOUR
     RUNOFF COMPUTED BY INITIAL ABSTRACTION/INFILTRATION NUMBER METHOD - DT =   .050000

    BULKING FACTOR APPLIED TO HYDROGRAPH.  FACTOR =  1.05000 AT PEAK FLOW.

PRINT HYD           ID=1   CODE=5

                                        OUTFLOW HYDROGRAPH REACH    83.00

      TIME      FLOW          TIME      FLOW          TIME      FLOW          TIME      FLOW          TIME      FLOW
       HRS       CFS           HRS       CFS           HRS       CFS           HRS       CFS           HRS       CFS
      .000        .0         5.500       2.9        11.000        .1        16.500        .1        22.000        .1
      .250        .0         5.750       2.5        11.250        .1        16.750        .1        22.250        .1
      .500        .0         6.000       2.1        11.500        .1        17.000        .1        22.500        .1
      .750        .0         6.250       1.8        11.750        .1        17.250        .1        22.750        .1
     1.000        .1         6.500       1.5        12.000        .1        17.500        .1        23.000        .1
     1.250        .3         6.750       1.3        12.250        .1        17.750        .1        23.250        .1
     1.500      48.1         7.000       1.1        12.500        .1        18.000        .1        23.500        .1
     1.750     161.4         7.250        .9        12.750        .1        18.250        .1        23.750        .1
     2.000     147.4         7.500        .8        13.000        .1        18.500        .1        24.000        .1
     2.250      91.3         7.750        .7        13.250        .1        18.750        .1        24.250        .0
     2.500      53.5         8.000        .6        13.500        .1        19.000        .1        24.500        .0
     2.750      31.5         8.250        .5        13.750        .1        19.250        .1        24.750        .0
     3.000      18.6         8.500        .4        14.000        .1        19.500        .1        25.000        .0
     3.250      14.2         8.750        .4        14.250        .1        19.750        .1        25.250        .0
     3.500      11.9         9.000        .3        14.500        .1        20.000        .1        25.500        .0
     3.750       9.9         9.250        .3        14.750        .1        20.250        .1        25.750        .0
     4.000       8.3         9.500        .3        15.000        .1        20.500        .1        26.000        .0
     4.250       7.0         9.750        .2        15.250        .1        20.750        .1        26.250
```

.0

	4.500	5.9	10.000	.2	15.500	.1	21.000	.1	26.500

.0

4.750	4.9	10.250	.2	15.750	.1	21.250	.1	
5.000	4.1	10.500	.2	16.000	.1	21.500	.1	
5.250	3.5	10.750	.2	16.250	.1	21.750	.1	

RUNOFF VOLUME = .46411 INCHES = 13.3169 ACRE-FEET
PEAK DISCHARGE RATE = 168.06 CFS AT 1.850 HOURS BASIN AREA = .5380 SQ. MI.

*
****
*S*** SUB-BASIN 83A
*
COMPUTE LT TP LCODE=1 UPLAND/LAG TIME TRANSITION METHOD
NK=3 ISLOPE=-1
LENGTH=400 FT SLOPE=0.031 K=0.7
LENGTH=1600 FT SLOPE=0.043 K=2.0
LENGTH=2172 FT SLOPE=0.0355 K=3.0
Kn=.033 CR=.5

Tc AND Tp COMPUTED BY UPLAND/LAG TIME PROCEDURE

SCS UPLAND METHOD FACTORS

	LENGTH (FT)	SLOPE (FT/FT)	COMPOSITE K
SHEET FLOW PORTION	400.0	.031000	.7000
SHALLOW FLOW PORTION	1600.0	.043000	2.0000
CHANNEL FLOW PORTION	2172.0	.035500	3.0000
TOTAL BASIN	4172.0	.037945	1.9566

LAG EQUATION FACTORS: Kn= .0330 TOTAL BASIN LENGTH (FT)= 4172.0
TOTAL BASIN SLOPE (FT/FT)= .037945 CENTROUD LENGTH (FT)= 2086.0

TIME OF CONCENTRATION (HRS)= .2993 TIME TO PEAK (HRS)= .1995 LAG TIME (HRS)= .2245

COMPUTE NM HYD ID=2 HYD NO=83A DA=0.137 SQ MI
PER A=89 PER B=0 PER C=10 PER D=1
TP=0.0 MASSRAIN=-1
TIME TO PEAK (hrs)= .1995

K = .111572HR TP = .199522HR K/TP RATIO = .559196 SHAPE CONSTANT, N = 6.876949
UNIT PEAK = 3.5389 CFS UNIT VOLUME = .9964 B = 515.39 P60 = 1.6900
AREA = .001370 SQ MI IA = .10000 INCHES INF = .04000 INCHES PER HOUR
RUNOFF COMPUTED BY INITIAL ABSTRACTION/INFILTRATION NUMBER METHOD - DT = .050000

K = .231052HR TP = .199522HR K/TP RATIO = 1.158030 SHAPE CONSTANT, N = 3.060499
UNIT PEAK = 194.90 CFS UNIT VOLUME = .9997 B = 286.72 P60 = 1.6900
AREA = .135630 SQ MI IA = .61970 INCHES INF = 1.58515 INCHES PER HOUR
RUNOFF COMPUTED BY INITIAL ABSTRACTION/INFILTRATION NUMBER METHOD - DT = .050000

BULKING FACTOR APPLIED TO HYDROGRAPH. FACTOR = 1.05000 AT PEAK FLOW.

PRINT HYD ID=2 CODE=5

HYDROGRAPH FROM AREA 83A

TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS
.000	.0	5.000	.2	10.000	.0	15.000	.0	20.000	.0
.250	.0	5.250	.1	10.250	.0	15.250	.0	20.250	.0
.500	.0	5.500	.1	10.500	.0	15.500	.0	20.500	.0
.750	.0	5.750	.1	10.750	.0	15.750	.0	20.750	.0
1.000	.1	6.000	.1	11.000	.0	16.000	.0	21.000	.0
1.250	.2	6.250	.1	11.250	.0	16.250	.0	21.250	.0
1.500	72.5	6.500	.0	11.500	.0	16.500	.0	21.500	.0
1.750	53.1	6.750	.0	11.750	.0	16.750	.0	21.750	.0
2.000	18.5	7.000	.0	12.000	.0	17.000	.0	22.000	.0
2.250	7.9	7.250	.0	12.250	.0	17.250	.0	22.250	.0
2.500	5.4	7.500	.0	12.500	.0	17.500	.0	22.500	.0
2.750	3.7	7.750	.0	12.750	.0	17.750	.0	22.750	.0
3.000	2.6	8.000	.0	13.000	.0	18.000	.0	23.000	.0

3.250	1.8	8.250	.0	13.250	.0	18.250	.0	23.250	.0						
3.500	1.3	8.500	.0	13.500	.0	18.500	.0	23.500	.0						
3.750	.9	8.750	.0	13.750	.0	18.750	.0	23.750	.0						
4.000	.6	9.000	.0	14.000	.0	19.000	.0	24.000	.0						
4.250	.5	9.250	.0	14.250	.0	19.250	.0	24.250	.0						
4.500	.3	9.500	.0	14.500	.0	19.500	.0	24.500	.0						
4.750	.2	9.750	.0	14.750	.0	19.750	.0								

RUNOFF VOLUME = .46411 INCHES = 3.3911 ACRE-FEET
PEAK DISCHARGE RATE = 84.78 CFS AT 1.550 HOURS BASIN AREA = .1370 SQ. MI.

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*
**********************************************************************
*S ADD 83 TO 83A TO GET 83A.3
*S
ADD HYD             ID=3  HYD NO=83A.3 ID I=1 ID II=2
PRINT HYD           ID=3   CODE=1
```

HYDROGRAPH FROM AREA 83A.3

RUNOFF VOLUME = .46411 INCHES = 16.7079 ACRE-FEET
PEAK DISCHARGE RATE = 214.52 CFS AT 1.750 HOURS BASIN AREA = .6750 SQ. MI.

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*
*S
**********************************************************************
*S*** ONSITE SUB-BASIN VV2 - PARTS OF UNITS 4 & 1
*
COMPUTE LT TP       LCODE=1  UPLAND/LAG TIME TRANSITION METHOD
                    NK=3  ISLOPE=-1
                    LENGTH=400 FT   SLOPE=0.006 K=0.7
                    LENGTH=1600 FT  SLOPE=0.011 K=2.0
                    LENGTH=130 FT  SLOPE=0.013 K=3.0
```

Tc AND Tp COMPUTED BY UPLAND/LAG TIME PROCEDURE

SCS UPLAND METHOD FACTORS

	LENGTH (FT)	SLOPE (FT/FT)	COMPOSITE K
SHEET FLOW PORTION	400.0	.006000	.7000
SHALLOW FLOW PORTION	1600.0	.011000	2.0000
CHANNEL FLOW PORTION	130.0	.013000	3.0000
TOTAL BASIN	2130.0	.010183	1.3720

TIME OF CONCENTRATION (HRS)= .4274 TIME TO PEAK (HRS)= .2849 LAG TIME (HRS)= .3205

```
COMPUTE NM HYD      ID=2   HYD NO=VV2.41   DA=0.0373 SQ MI
                    PER A=0 PER B=20  PER C=20  PER D=60
                    TP=0.0   MASSRAIN=-1
```

TIME TO PEAK (hrs)= .2849

K = .155273HR TP = .284905HR K/TP RATIO = .545000 SHAPE CONSTANT, N = 7.106420
UNIT PEAK = 41.340 CFS UNIT VOLUME = .9998 B = 526.28 P60 = 1.6900
AREA = .022380 SQ MI IA = .10000 INCHES INF = .04000 INCHES PER HOUR
RUNOFF COMPUTED BY INITIAL ABSTRACTION/INFILTRATION NUMBER METHOD - DT = .050000

K = .254337HR TP = .284905HR K/TP RATIO = .892706 SHAPE CONSTANT, N = 3.972111
UNIT PEAK = 18.502 CFS UNIT VOLUME = .9993 B = 353.31 P60 = 1.6900
AREA = .014920 SQ MI IA = .42500 INCHES INF = 1.04000 INCHES PER HOUR
RUNOFF COMPUTED BY INITIAL ABSTRACTION/INFILTRATION NUMBER METHOD - DT = .050000

BULKING FACTOR APPLIED TO HYDROGRAPH. FACTOR = 1.05000 AT PEAK FLOW.

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PRINT HYD           ID=2   CODE=5
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HYDROGRAPH FROM AREA VV2.41

TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS
.000	.0	5.250	.7	10.500	.4	15.750	.3	21.000	.2
.250	.0	5.500	.7	10.750	.4	16.000	.3	21.250	.2
.500	.0	5.750	.7	11.000	.4	16.250	.3	21.500	.2
.750	.0	6.000	.7	11.250	.4	16.500	.3	21.750	

.2
1.000 1.1 6.250 .6 11.500 .4 16.750 .3 22.000
.2
1.250 2.5 6.500 .5 11.750 .3 17.000 .3 22.250
.2
1.500 31.6 6.750 .5 12.000 .3 17.250 .3 22.500
.2
1.750 47.3 7.000 .5 12.250 .3 17.500 .3 22.750
.2
2.000 24.8 7.250 .5 12.500 .3 17.750 .3 23.000
.2
2.250 13.2 7.500 .5 12.750 .3 18.000 .3 23.250
.2
2.500 6.2 7.750 .4 13.000 .3 18.250 .3 23.500
.2
2.750 3.9 8.000 .4 13.250 .3 18.500 .3 23.750
.2
3.000 2.7 8.250 .4 13.500 .3 18.750 .3 24.000
.2
3.250 1.9 8.500 .4 13.750 .3 19.000 .3 24.250
.2
3.500 1.5 8.750 .4 14.000 .3 19.250 .3 24.500
.0
3.750 1.2 9.000 .4 14.250 .3 19.500 .3 24.750
.0
4.000 1.0 9.250 .4 14.500 .3 19.750 .3 25.000
.0
4.250 .8 9.500 .4 14.750 .3 20.000 .2 25.250
.0
4.500 .8 9.750 .4 15.000 .3 20.250 .2 25.500
.0
4.750 .7 10.000 .4 15.250 .3 20.500 .2 25.750
.0
5.000 .7 10.250 .4 15.500 .3 20.750 .2 26.000
.0

RUNOFF VOLUME = 1.74819 INCHES = 3.4777 ACRE-FEET
PEAK DISCHARGE RATE = 53.40 CFS AT 1.650 HOURS BASIN AREA = .0373 SQ. MI.

*
****
*S ADD VV.41 TO 83A.3 TO GET 83A.4
*S
ADD HYD ID=4 HYD NO=83A.4 ID I=3 ID II=2
PRINT HYD ID=4 CODE=1

HYDROGRAPH FROM AREA 83A.4

RUNOFF VOLUME = .53135 INCHES = 20.1856 ACRE-FEET
PEAK DISCHARGE RATE = 265.85 CFS AT 1.700 HOURS BASIN AREA = .7123 SQ. MI.

*
*S

****
*S ROUTE THRU 60" TO IP6
*
*
COMPUTE RATING CURVE CID=1 VS NO=1 NO SEGS=-1 SLP=0.028
DIAM=5.0 FT N=0.013

RATING CURVE PIPE SECTION 1.0

WATER SURFACE ELEV	FLOW AREA SQ FT	FLOW RATE CFS	MAX WIDTH FT
.00	.00	.00	.00
.26	.39	2.29	2.22
.52	1.09	9.92	3.06
.78	1.96	23.07	3.63
1.04	2.97	41.49	4.06
1.30	4.07	64.79	4.39
1.56	5.25	92.43	4.64
1.82	6.48	123.84	4.81
2.08	7.75	158.33	4.93
2.35	9.04	195.19	4.99
2.61	10.35	233.60	5.00
2.87	11.64	272.72	5.00
3.13	12.92	311.61	5.00
3.39	14.16	349.25	5.00
3.65	15.35	384.50	5.00
3.91	16.47	416.05	5.00
4.17	17.49	442.30	5.00
4.43	18.39	461.08	5.00
4.69	19.13	468.80	5.00
5.00	19.63	468.80	5.00

ROUTE MCUNGE ID=12 HYD NO=IP6 INFLOW ID=4
DT=0.0 HR LENGTH=2865 FT
NS=0 SLOPE=0.028 CODE=5

INFLOW END= 533 TABLE PTS= 19
DT= .050000 QMED= 132.92 CKMED= 27.1456
WIDTH MED= 4.84 NREACH= 2 DX= 1432.50

DEPTH (FT)	AREA (SQ FT)	Q (CFS)	TRAVEL TIME(HR)	WIDTH (FT)	ck (FPS)	VEL (FPS)	C	D	C1	C2	C3	Q-M (CFS)	C1-M	C2-M	C3-M
.00	.0	.0	.185	.0	7.96	2.76	1.000	.000	1.000	.000	.000	.0	1.000	.000	.000
.26	.4	2.3	.136	2.2	9.64	5.86	1.211	.003	.998	.097	-.094	.4	1.000	.015	-.015
.52	1.1	9.9	.087	3.1	13.30	9.14	1.671	.006	.995	.253	-.248	5.5	.996	.163	-.160
.78	2.0	23.1	.068	3.6	16.84	11.76	2.116	.009	.994	.360	-.354	15.9	.995	.310	-.305
1.04	3.0	41.5	.057	4.1	19.82	13.99	2.491	.013	.993	.429	-.422	31.8	.993	.397	-.391
1.30	4.1	64.8	.050	4.4	22.36	15.92	2.810	.016	.991	.477	-.469	52.7	.992	.455	-.447
1.56	5.2	92.4	.045	4.6	24.52	17.62	3.081	.020	.990	.512	-.503	78.2	.991	.497	-.487
1.82	6.5	123.8	.042	4.8	26.34	19.12	3.309	.024	.989	.539	-.527	107.8	.989	.527	-.516
2.08	7.7	158.3	.039	4.9	27.83	20.43	3.497	.029	.987	.558	-.545	140.8	.988	.550	-.538
2.35	9.0	195.2	.037	5.0	29.00	21.58	3.643	.034	.986	.572	-.558	176.5	.987	.567	-.553
2.61	10.3	233.6	.035	5.0	29.81	22.58	3.745	.039	.984	.582	-.566	214.2	.985	.579	-.563
2.87	11.6	272.7	.034	5.0	30.00	23.43	3.769	.045	.981	.585	-.566	253.0	.983	.585	-.567
3.13	12.9	311.6	.033	5.0	29.44	24.12	3.699	.053	.978	.579	-.557	292.0	.980	.583	-.563
3.39	14.2	349.2	.032	5.0	28.05	24.67	3.524	.062	.973	.564	-.537	330.3	.976	.573	-.549
3.65	15.3	384.5	.032	5.0	25.71	25.05	3.230	.075	.965	.535	-.501	366.8	.970	.552	-.522
3.91	16.5	416.1	.031	5.0	22.24	25.27	2.795	.093	.952	.486	-.438	400.3	.960	.515	-.475
4.17	17.5	442.3	.031	5.0	17.32	25.29	2.176	.127	.923	.395	-.317	429.2	.942	.450	-.392
4.43	18.4	461.1	.032	5.0	10.14	25.07	1.274	.227	.819	.200	-.019	451.8	.895	.326	-.221
4.69	19.1	468.8	.032	5.0	5.78	24.51	.726	.404	.620	.061	.318	465.0	.633	.064	.303

MAXIMUM NO. ITERATIONS FOR SOLUTION (KKMAX) = 4 OCCURRED 4 TIMES. AVERAGE NUMBER ITERATIONS = 1.2179
Equations solved using the Ponce correction to C2
PRINT HYD ID=12 CODE=5

HYDROGRAPH FROM AREA IP6

TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS
.000	.0	5.500	3.9	11.000	.5	16.500	.4	22.000	.3
.250	.0	5.750	3.4	11.250	.5	16.750	.4	22.250	.3
.500	.0	6.000	3.0	11.500	.5	17.000	.4	22.500	.3
.750	.0	6.250	2.6	11.750	.5	17.250	.4	22.750	.3
1.000	.5	6.500	2.2	12.000	.5	17.500	.4	23.000	.3
1.250	2.5	6.750	1.9	12.250	.5	17.750	.4	23.250	.3
1.500	114.4	7.000	1.7	12.500	.5	18.000	.3	23.500	.3
1.750	265.0	7.250	1.5	12.750	.5	18.250	.3	23.750	.3
2.000	200.2	7.500	1.3	13.000	.4	18.500	.3	24.000	.3
2.250	120.1	7.750	1.2	13.250	.4	18.750	.3	24.250	.3
2.500	70.0	8.000	1.1	13.500	.4	19.000	.3	24.500	.1
2.750	42.4	8.250	1.0	13.750	.4	19.250	.3	24.750	.0
3.000	26.2	8.500	.9	14.000	.4	19.500	.3	25.000	.0
3.250	18.8	8.750	.8	14.250	.4	19.750	.3	25.250	.0
3.500	15.3	9.000	.8	14.500	.4	20.000	.3	25.500	.0
3.750	12.5	9.250	.7	14.750	.4	20.250	.3	25.750	

```
.0
      4.000      10.4          9.500        .7         15.000        .4         20.500        .3         26.000
.0
      4.250       8.6          9.750        .7         15.250        .4         20.750        .3         26.250
.0
      4.500       7.3         10.000        .6         15.500        .4         21.000        .3         26.500
.0
      4.750       6.1         10.250        .6         15.750        .4         21.250        .3
      5.000       5.2         10.500        .6         16.000        .4         21.500        .3
      5.250       4.5         10.750        .6         16.250        .4         21.750        .3

     RUNOFF VOLUME =      .53149 INCHES     =      20.1910 ACRE-FEET
     PEAK DISCHARGE RATE =     265.02 CFS  AT   1.750 HOURS   BASIN AREA =   .7123 SQ. MI.



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 *S ADD IP5 TO IP5 AND IP6 TO GET 86.2
 *S
 ADD HYD             ID=2  HYD NO=86.2 ID I=12 ID II=11
 PRINT HYD           ID=2   CODE=1

                                      OUTFLOW HYDROGRAPH REACH    86.20


     RUNOFF VOLUME =      .66715 INCHES     =      28.5252 ACRE-FEET
     PEAK DISCHARGE RATE =     398.74 CFS  AT   1.650 HOURS   BASIN AREA =   .8017 SQ. MI.



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 *S ADD IP4 TO 86.2 TO GET 86.45
 *S
 ADD HYD             ID=45  HYD NO=86.45 ID I=2 ID II=10
 PRINT HYD           ID=45   CODE=1

                                      OUTFLOW HYDROGRAPH REACH    86.45


     RUNOFF VOLUME =      .63480 INCHES     =      35.5383 ACRE-FEET
     PEAK DISCHARGE RATE =     533.06 CFS  AT   1.650 HOURS   BASIN AREA =  1.0497 SQ. MI.



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 *S ADD 62.20 (IP3) TO 86.45 (IP4, 5 & 6) TO GET 86.70

 *S
 ADD HYD             ID=7  HYD NO=86.70 ID I=45 ID II=20
 PRINT HYD           ID=7   CODE=1

                                      OUTFLOW HYDROGRAPH REACH    86.70


     RUNOFF VOLUME =      .51604 INCHES     =     405.4915 ACRE-FEET
     PEAK DISCHARGE RATE =    1286.69 CFS  AT   3.100 HOURS   BASIN AREA = 14.7333 SQ. MI.



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 ** DETENTION BASIN ** AMAFCA BOCA NEGRA DAM
 ** ROUTE 46B.4 THROUGH DAM TO GET 51.6 OUTFLOW TO DOWN CANYON PIPE

 ***************************************************************************
 *S TOTAL OUTFLOW FROM BOCA NEGRA DETENTION FACILITY
 ROUTE RESERVOIR         ID=14 HYD=51.6  INFLOW ID=7 CODE=2
                         OUTFLOW(CFS)    STORAGE(AC FT)  ELEV (FT)
                                          0           0.0          5323
                                         18          0.86          5324
                                         31          1.78          5325
                                         40          2.99          5326
                                         62          4.51          5327
                                        106          6.46          5328
                                        226          8.97          5329
                                        430         12.16          5330
                                        479         16.37          5331
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513	21.62	5332	
545	27.74	5333	
574	34.67	5334	
602	42.83	5335	
629	52.31	5336	
655	62.75	5337	
679	74.19	5338	
	684	76.49	5338.2
1438	86.29	5339	
3699	99.27	5340	
6830	113.10	5341	
10683	127.90	5342	
15192	143.55	5343	
20320	160.17	5344	
26006	178.15	5345	
32315	197.56	5346	
39208	218.35	5347	
46624	240.56	5348	

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TIME (HRS)	INFLOW (CFS)	ELEV (FEET)	VOLUME (AC-FT)	OUTFLOW (CFS)
.00	.00	5323.00	.000	.00
.10	.00	5323.00	.000	.00
.20	.01	5323.00	.000	.00
.30	.01	5323.00	.000	.00
.40	.01	5323.00	.000	.00
.50	.01	5323.00	.000	.00
.60	.01	5323.00	.000	.01
.70	.01	5323.00	.000	.01
.80	.01	5323.00	.000	.01
.90	.63	5323.00	.002	.04
1.00	4.30	5323.02	.020	.41
1.10	7.49	5323.07	.062	1.30
1.20	9.24	5323.14	.117	2.44
1.30	37.37	5323.28	.244	5.11
1.40	115.44	5323.87	.749	15.68
1.50	406.31	5325.62	2.536	36.62
1.60	758.89	5328.16	6.865	125.38
1.70	859.50	5329.81	11.570	392.27
1.80	825.05	5330.66	14.948	462.45
1.90	868.34	5331.30	17.929	489.10
2.00	934.68	5331.94	21.288	510.85
2.10	954.30	5332.52	24.772	529.48
2.20	1139.03	5333.15	28.762	549.28
2.30	1163.26	5333.87	33.760	570.19
2.40	1027.94	5334.42	38.059	585.63
2.50	916.70	5334.80	41.170	596.30
2.60	909.46	5335.09	43.692	604.46
2.70	988.13	5335.38	46.475	612.38
2.80	1123.13	5335.76	50.078	622.64
2.90	1225.47	5336.22	54.631	634.78
3.00	1273.52	5336.71	59.673	647.34
3.10	1286.69	5337.19	64.872	659.45
3.20	1273.26	5337.63	69.962	670.13
3.30	1242.84	5338.05	74.793	680.31
3.40	1186.59	5338.38	78.688	853.14
3.50	1139.26	5338.53	80.575	998.30
3.60	1100.55	5338.59	81.315	1055.21
3.70	1062.92	5338.61	81.466	1066.81
3.80	1037.12	5338.60	81.352	1058.07
3.90	1014.03	5338.58	81.147	1042.30
4.00	1000.36	5338.56	80.919	1024.76
4.10	1002.77	5338.55	80.778	1013.90
4.20	967.72	5338.54	80.618	1001.62
4.30	881.06	5338.50	80.132	964.18
4.40	799.01	5338.43	79.337	903.04
4.50	758.03	5338.37	78.541	841.82
4.60	726.19	5338.32	77.918	793.84
4.70	699.61	5338.28	77.413	755.00
4.80	666.59	5338.24	76.967	720.68
4.90	624.55	5338.20	76.496	684.48
5.00	576.93	5338.14	75.818	682.54
5.10	538.74	5338.05	74.794	680.31
5.20	499.43	5337.94	73.475	677.50
5.30	458.24	5337.79	71.846	674.08
5.40	420.21	5337.63	69.920	670.04
5.50	386.76	5337.44	67.734	665.46

TIME (HRS)	INFLOW (CFS)	ELEV (FEET)	VOLUME (AC-FT)	OUTFLOW (CFS)
5.60	357.13	5337.23	65.327	660.41
5.70	330.25	5337.00	62.731	654.95
5.80	305.83	5336.73	59.973	648.08
5.90	284.30	5336.46	57.084	640.89
6.00	265.11	5336.17	54.087	633.43
6.10	248.42	5335.86	51.006	625.29
6.20	233.39	5335.53	47.865	616.34

6.30	219.85	5335.20	44.681	607.27
6.40	207.96	5334.83	41.468	597.33
6.50	197.65	5334.44	38.253	586.29
6.60	188.70	5334.05	35.049	575.30
6.70	181.06	5333.60	31.875	562.30
6.80	174.50	5333.15	28.750	549.23
6.90	168.46	5332.66	25.688	534.27
7.00	162.51	5332.18	22.705	518.67
7.10	156.62	5331.65	19.807	501.26
7.20	150.88	5331.12	17.010	483.14
7.30	145.30	5330.52	14.349	455.48
7.40	139.72	5329.92	11.909	413.95
7.50	134.31	5329.36	10.122	299.67
7.60	129.38	5329.02	9.039	230.39
7.70	124.76	5328.75	8.336	195.71
7.80	120.40	5328.55	7.835	171.73
7.90	116.34	5328.40	7.469	154.23
8.00	112.47	5328.29	7.195	141.16
8.10	108.91	5328.21	6.986	131.15
8.20	105.50	5328.14	6.822	123.29
8.30	102.30	5328.09	6.688	116.91
8.40	99.27	5328.05	6.577	111.61
8.50	96.45	5328.01	6.483	107.08
8.60	93.76	5327.97	6.395	104.54
8.70	91.22	5327.92	6.304	102.48
8.80	88.82	5327.87	6.210	100.35
8.90	86.52	5327.82	6.114	98.19
9.00	84.80	5327.77	6.019	96.06
9.10	82.87	5327.73	5.927	93.97
9.20	80.91	5327.68	5.836	91.91
9.30	78.96	5327.63	5.745	89.87
9.40	77.10	5327.59	5.656	87.85
9.50	75.35	5327.54	5.568	85.87
9.60	73.65	5327.50	5.482	83.93
9.70	72.05	5327.46	5.398	82.04
9.80	70.53	5327.41	5.317	80.20
9.90	69.09	5327.37	5.238	78.43
10.00	67.71	5327.33	5.162	76.72
10.10	66.44	5327.30	5.089	75.07
10.20	65.21	5327.26	5.020	73.50
10.30	64.05	5327.23	4.953	71.98
10.40	62.94	5327.19	4.888	70.54
10.50	61.87	5327.16	4.827	69.15
10.60	60.84	5327.13	4.768	67.82
10.70	59.88	5327.10	4.712	66.55
10.80	58.93	5327.08	4.658	65.33
10.90	58.03	5327.05	4.606	64.16
11.00	57.20	5327.02	4.556	63.04
11.10	56.41	5327.00	4.509	61.99

TIME (HRS)	INFLOW (CFS)	ELEV (FEET)	VOLUME (AC-FT)	OUTFLOW (CFS)
11.20	55.63	5326.97	4.463	61.31
11.30	54.88	5326.94	4.415	60.63
11.40	54.18	5326.91	4.368	59.94
11.50	53.50	5326.88	4.320	59.25
11.60	52.87	5326.84	4.273	58.57
11.70	52.27	5326.81	4.226	57.89
11.80	51.70	5326.78	4.180	57.22
11.90	51.14	5326.75	4.135	56.57
12.00	50.59	5326.72	4.090	55.92
12.10	50.09	5326.70	4.047	55.29
12.20	49.59	5326.67	4.004	54.68
12.30	49.11	5326.64	3.963	54.08
12.40	48.66	5326.61	3.922	53.49
12.50	48.23	5326.59	3.883	52.92
12.60	47.80	5326.56	3.845	52.37
12.70	47.42	5326.54	3.807	51.83
12.80	47.04	5326.51	3.772	51.31
12.90	46.67	5326.49	3.737	50.81
13.00	46.31	5326.47	3.703	50.32
13.10	45.95	5326.45	3.671	49.85
13.20	45.62	5326.43	3.639	49.39
13.30	45.30	5326.41	3.608	48.95
13.40	44.99	5326.39	3.579	48.52
13.50	44.72	5326.37	3.550	48.10
13.60	44.40	5326.35	3.522	47.70
13.70	44.07	5326.33	3.495	47.31
13.80	43.81	5326.31	3.469	46.93
13.90	43.53	5326.30	3.444	46.56
14.00	43.23	5326.28	3.419	46.21
14.10	42.95	5326.27	3.395	45.85
14.20	42.65	5326.25	3.371	45.51
14.30	42.37	5326.23	3.347	45.17
14.40	42.12	5326.22	3.324	44.84
14.50	41.86	5326.21	3.302	44.52
14.60	41.62	5326.19	3.281	44.21
14.70	41.37	5326.18	3.259	43.90
14.80	41.11	5326.16	3.239	43.60
14.90	40.87	5326.15	3.218	43.30

15.00	40.65	5326.14	3.198	43.02
15.10	40.41	5326.12	3.179	42.74
15.20	40.19	5326.11	3.160	42.46
15.30	40.00	5326.10	3.142	42.19
15.40	39.78	5326.09	3.124	41.93
15.50	39.55	5326.08	3.106	41.68
15.60	39.32	5326.06	3.088	41.43
15.70	39.10	5326.05	3.071	41.17
15.80	38.92	5326.04	3.054	40.93
15.90	38.73	5326.03	3.038	40.69
16.00	38.53	5326.02	3.022	40.46
16.10	38.34	5326.01	3.006	40.23
16.20	38.14	5326.00	2.990	40.01
16.30	37.93	5325.99	2.975	39.89
16.40	37.75	5325.97	2.958	39.76
16.50	37.58	5325.96	2.941	39.64
16.60	37.40	5325.95	2.924	39.51
16.70	37.25	5325.93	2.907	39.38

TIME (HRS)	INFLOW (CFS)	ELEV (FEET)	VOLUME (AC-FT)	OUTFLOW (CFS)
16.80	37.08	5325.92	2.889	39.25
16.90	36.90	5325.90	2.871	39.11
17.00	36.71	5325.89	2.852	38.98
17.10	36.55	5325.87	2.833	38.84
17.20	36.40	5325.85	2.814	38.69
17.30	36.24	5325.84	2.795	38.55
17.40	36.08	5325.82	2.776	38.41
17.50	35.91	5325.81	2.757	38.27
17.60	35.75	5325.79	2.737	38.12
17.70	35.60	5325.77	2.718	37.98
17.80	35.46	5325.76	2.698	37.83
17.90	35.31	5325.74	2.679	37.68
18.00	35.15	5325.73	2.659	37.54
18.10	35.00	5325.71	2.639	37.39
18.20	34.87	5325.69	2.619	37.24
18.30	34.73	5325.68	2.600	37.10
18.40	34.56	5325.66	2.580	36.95
18.50	34.41	5325.65	2.560	36.81
18.60	34.27	5325.63	2.541	36.66
18.70	34.04	5325.61	2.521	36.51
18.80	33.76	5325.59	2.500	36.35
18.90	33.50	5325.58	2.478	36.19
19.00	33.23	5325.56	2.455	36.02
19.10	32.95	5325.54	2.432	35.85
19.20	32.63	5325.52	2.407	35.67
19.30	32.31	5325.50	2.382	35.48
19.40	31.95	5325.48	2.355	35.28
19.50	31.59	5325.45	2.327	35.07
19.60	31.25	5325.43	2.298	34.85
19.70	30.92	5325.40	2.267	34.62
19.80	30.58	5325.38	2.236	34.39
19.90	30.18	5325.35	2.204	34.15
20.00	29.77	5325.32	2.171	33.90
20.10	29.39	5325.29	2.136	33.65
20.20	29.04	5325.26	2.100	33.38
20.30	28.73	5325.23	2.064	33.11
20.40	28.42	5325.20	2.028	32.84
20.50	28.12	5325.17	1.991	32.57
20.60	27.80	5325.14	1.954	32.30
20.70	27.50	5325.11	1.917	32.02
20.80	27.16	5325.08	1.879	31.74
20.90	26.82	5325.05	1.841	31.46
21.00	26.50	5325.02	1.803	31.17
21.10	26.21	5324.98	1.764	30.78
21.20	25.81	5324.94	1.727	30.25
21.30	25.38	5324.90	1.691	29.74
21.40	24.99	5324.86	1.655	29.24
21.50	24.60	5324.83	1.621	28.75
21.60	24.30	5324.79	1.587	28.27
21.70	23.94	5324.75	1.555	27.82
21.80	23.60	5324.72	1.523	27.37
21.90	23.30	5324.69	1.492	26.94
22.00	23.01	5324.66	1.463	26.52
22.10	22.74	5324.62	1.434	26.12
22.20	22.48	5324.59	1.407	25.73
22.30	22.22	5324.57	1.381	25.36

TIME (HRS)	INFLOW (CFS)	ELEV (FEET)	VOLUME (AC-FT)	OUTFLOW (CFS)
22.40	21.89	5324.54	1.355	24.99
22.50	21.34	5324.51	1.329	24.62
22.60	20.73	5324.48	1.301	24.23
22.70	20.27	5324.45	1.272	23.82
22.80	19.80	5324.42	1.242	23.40
22.90	19.33	5324.38	1.212	22.97
23.00	18.85	5324.35	1.182	22.55
23.10	18.39	5324.32	1.151	22.11
23.20	17.90	5324.28	1.120	21.68

23.30	17.50	5324.25	1.089	21.24
23.40	17.08	5324.22	1.058	20.80
23.50	16.66	5324.18	1.027	20.37
23.60	16.26	5324.15	.997	19.93
23.70	15.96	5324.12	.967	19.51
23.80	15.68	5324.08	.938	19.10
23.90	15.40	5324.05	.910	18.71
24.00	15.19	5324.03	.884	18.33
24.10	14.97	5324.00	.858	17.96
24.20	14.33	5323.97	.833	17.44
24.30	12.79	5323.94	.804	16.83
24.40	11.26	5323.89	.768	16.07
24.50	10.42	5323.85	.727	15.22
24.60	9.98	5323.80	.689	14.42
24.70	9.67	5323.76	.654	13.69
24.80	9.43	5323.72	.622	13.03
24.90	9.24	5323.69	.594	12.44
25.00	9.08	5323.66	.569	11.92
25.10	8.94	5323.64	.547	11.45
25.20	8.82	5323.61	.528	11.04
25.30	8.72	5323.59	.510	10.68
25.40	8.63	5323.58	.495	10.36
25.50	8.54	5323.56	.482	10.08
25.60	8.46	5323.55	.470	9.83
25.70	8.39	5323.53	.459	9.61
25.80	8.32	5323.52	.449	9.41
25.90	8.24	5323.51	.441	9.23
26.00	8.16	5323.50	.433	9.06
26.10	8.09	5323.50	.426	8.91
26.20	8.02	5323.49	.419	8.78
26.30	7.94	5323.48	.413	8.65
26.40	7.88	5323.47	.408	8.53
26.50	7.82	5323.47	.403	8.42
26.60	7.77	5323.46	.398	8.32
26.70	7.72	5323.46	.393	8.23
26.80	7.68	5323.45	.389	8.15
26.90	7.63	5323.45	.386	8.07
27.00	7.59	5323.44	.382	8.00
27.10	7.56	5323.44	.379	7.93
27.20	7.51	5323.44	.376	7.87
27.30	7.46	5323.43	.373	7.81
27.40	7.40	5323.43	.370	7.75
27.50	7.32	5323.43	.367	7.69
27.60	7.24	5323.42	.364	7.62
27.70	7.17	5323.42	.361	7.56
27.80	7.09	5323.42	.358	7.49
27.90	7.03	5323.41	.354	7.42

TIME (HRS)	INFLOW (CFS)	ELEV (FEET)	VOLUME (AC-FT)	OUTFLOW (CFS)
28.00	6.97	5323.41	.351	7.35
28.10	6.93	5323.40	.348	7.29
28.20	6.88	5323.40	.345	7.23
28.30	6.85	5323.40	.342	7.17
28.40	6.81	5323.40	.340	7.11
28.50	6.78	5323.39	.337	7.06
28.60	6.75	5323.39	.335	7.02
28.70	6.69	5323.39	.333	6.97
28.80	6.31	5323.38	.330	6.90
28.90	5.91	5323.38	.324	6.77
29.00	5.54	5323.37	.316	6.61
29.10	5.21	5323.36	.306	6.41
29.20	4.90	5323.34	.296	6.19
29.30	4.62	5323.33	.285	5.97
29.40	4.37	5323.32	.274	5.73
29.50	4.13	5323.31	.263	5.50
29.60	3.92	5323.29	.251	5.26
29.70	3.72	5323.28	.240	5.03
29.80	3.54	5323.27	.230	4.81
29.90	3.37	5323.26	.219	4.59

PEAK DISCHARGE = 1066.813 CFS - PEAK OCCURS AT HOUR 3.70
MAXIMUM WATER SURFACE ELEVATION = 5338.606
MAXIMUM STORAGE = 81.4655 AC-FT INCREMENTAL TIME= .050000HRS

PRINT HYD ID=14 CODE=0

OUTFLOW HYDROGRAPH REACH 51.60

TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS
.000	.0	6.000	633.4	12.000	55.9	18.000	37.5	24.000	18.3
.050	.0	6.050	629.6	12.050	55.6	18.050	37.5	24.050	18.2
.100	.0	6.100	625.3	12.100	55.3	18.100	37.4	24.100	18.0
.150	.0	6.150	620.8	12.150	55.0	18.150	37.3	24.150	17.7

.200	.0	6.200	616.3	12.200	54.7	18.200	37.2	24.200
17.4								
.250	.0	6.250	611.8	12.250	54.4	18.250	37.2	24.250
17.2								
.300	.0	6.300	607.3	12.300	54.1	18.300	37.1	24.300
16.8								
.350	.0	6.350	602.7	12.350	53.8	18.350	37.0	24.350
16.5								
.400	.0	6.400	597.3	12.400	53.5	18.400	37.0	24.400
16.1								
.450	.0	6.450	591.8	12.450	53.2	18.450	36.9	24.450
15.6								
.500	.0	6.500	586.3	12.500	52.9	18.500	36.8	24.500
15.2								
.550	.0	6.550	580.8	12.550	52.6	18.550	36.7	24.550
14.8								
.600	.0	6.600	575.3	12.600	52.4	18.600	36.7	24.600
14.4								
.650	.0	6.650	568.9	12.650	52.1	18.650	36.6	24.650
14.0								
.700	.0	6.700	562.3	12.700	51.8	18.700	36.5	24.700
13.7								
.750	.0	6.750	555.7	12.750	51.6	18.750	36.4	24.750
13.3								
.800	.0	6.800	549.2	12.800	51.3	18.800	36.4	24.800
13.0								
.850	.0	6.850	542.2	12.850	51.1	18.850	36.3	24.850
12.7								
.900	.0	6.900	534.3	12.900	50.8	18.900	36.2	24.900
12.4								
.950	.2	6.950	526.4	12.950	50.6	18.950	36.1	24.950
12.2								
1.000	.4	7.000	518.7	13.000	50.3	19.000	36.0	25.000
11.9								
1.050	.8	7.050	510.6	13.050	50.1	19.050	35.9	25.050
11.7								
1.100	1.3	7.100	501.3	13.100	49.8	19.100	35.8	25.100
11.5								
1.150	1.9	7.150	492.1	13.150	49.6	19.150	35.8	25.150
11.2								
1.200	2.4	7.200	483.1	13.200	49.4	19.200	35.7	25.200
11.0								
1.250	3.2	7.250	470.7	13.250	49.2	19.250	35.6	25.250
10.9								
1.300	5.1	7.300	455.5	13.300	48.9	19.300	35.5	25.300
10.7								
1.350	8.9	7.350	440.8	13.350	48.7	19.350	35.4	25.350
10.5								
1.400	15.7	7.400	413.9	13.400	48.5	19.400	35.3	25.400
10.4								
1.450	25.1	7.450	349.6	13.450	48.3	19.450	35.2	25.450
10.2								
1.500	36.6	7.500	299.7	13.500	48.1	19.500	35.1	25.500
10.1								
1.550	60.8	7.550	260.8	13.550	47.9	19.550	35.0	25.550
10.0								
1.600	125.4	7.600	230.4	13.600	47.7	19.600	34.8	25.600
9.8								
1.650	252.8	7.650	211.0	13.650	47.5	19.650	34.7	25.650
9.7								
1.700	392.3	7.700	195.7	13.700	47.3	19.700	34.6	25.700
9.6								
1.750	444.1	7.750	182.8	13.750	47.1	19.750	34.5	25.750
9.5								
1.800	462.5	7.800	171.7	13.800	46.9	19.800	34.4	25.800
9.4								
1.850	479.3	7.850	162.3	13.850	46.7	19.850	34.3	25.850
9.3								
1.900	489.1	7.900	154.2	13.900	46.6	19.900	34.2	25.900
9.2								
1.950	499.7	7.950	147.2	13.950	46.4	19.950	34.0	25.950
9.1								
2.000	510.9	8.000	141.2	14.000	46.2	20.000	33.9	26.000
9.1								
2.050	520.4	8.050	135.8	14.050	46.0	20.050	33.8	26.050
9.0								
2.100	529.5	8.100	131.2	14.100	45.9	20.100	33.6	26.100
8.9								
2.150	539.0	8.150	127.0	14.150	45.7	20.150	33.5	26.150
8.8								
2.200	549.3	8.200	123.3	14.200	45.5	20.200	33.4	26.200
8.8								
2.250	559.7	8.250	119.9	14.250	45.3	20.250	33.2	26.250
8.7								
2.300	570.2	8.300	116.9	14.300	45.2	20.300	33.1	26.300
8.7								
2.350	578.8	8.350	114.1	14.350	45.0	20.350	33.0	26.350
8.6								
2.400	585.6	8.400	111.6	14.400	44.8	20.400	32.8	26.400
8.5								
2.450	591.4	8.450	109.3	14.450	44.7	20.450	32.7	26.450

2.500	596.3	8.500	107.1	14.500	44.5	20.500	32.6	26.500
2.550	600.7	8.550	105.5	14.550	44.4	20.550	32.4	26.550
2.600	604.5	8.600	104.5	14.600	44.2	20.600	32.3	26.600
2.650	608.2	8.650	103.5	14.650	44.1	20.650	32.2	26.650
2.700	612.4	8.700	102.5	14.700	43.9	20.700	32.0	26.700
2.750	617.1	8.750	101.4	14.750	43.7	20.750	31.9	26.750
2.800	622.6	8.800	100.4	14.800	43.6	20.800	31.7	26.800
2.850	628.9	8.850	99.3	14.850	43.5	20.850	31.6	26.850
2.900	634.8	8.900	98.2	14.900	43.3	20.900	31.5	26.900
2.950	641.0	8.950	97.1	14.950	43.2	20.950	31.3	26.950
3.000	647.3	9.000	96.1	15.000	43.0	21.000	31.2	27.000
3.050	653.8	9.050	95.0	15.050	42.9	21.050	31.0	27.050
3.100	659.5	9.100	94.0	15.100	42.7	21.100	30.8	27.100
3.150	664.8	9.150	92.9	15.150	42.6	21.150	30.5	27.150
3.200	670.1	9.200	91.9	15.200	42.5	21.200	30.3	27.200
3.250	675.3	9.250	90.9	15.250	42.3	21.250	30.0	27.250
3.300	680.3	9.300	89.9	15.300	42.2	21.300	29.7	27.300
3.350	721.5	9.350	88.9	15.350	42.1	21.350	29.5	27.350
3.400	853.1	9.400	87.8	15.400	41.9	21.400	29.2	27.400
3.450	941.0	9.450	86.9	15.450	41.8	21.450	29.0	27.450
3.500	998.3	9.500	85.9	15.500	41.7	21.500	28.7	27.500
3.550	1034.4	9.550	84.9	15.550	41.6	21.550	28.5	27.550
3.600	1055.2	9.600	83.9	15.600	41.4	21.600	28.3	27.600
3.650	1064.9	9.650	83.0	15.650	41.3	21.650	28.0	27.650
3.700	1066.8	9.700	82.0	15.700	41.2	21.700	27.8	27.700
3.750	1063.8	9.750	81.1	15.750	41.1	21.750	27.6	27.750
3.800	1058.1	9.800	80.2	15.800	40.9	21.800	27.4	27.800
3.850	1050.8	9.850	79.3	15.850	40.8	21.850	27.2	27.850
3.900	1042.3	9.900	78.4	15.900	40.7	21.900	26.9	27.900
3.950	1033.2	9.950	77.6	15.950	40.6	21.950	26.7	27.950
4.000	1024.8	10.000	76.7	16.000	40.5	22.000	26.5	28.000
4.050	1018.3	10.050	75.9	16.050	40.3	22.050	26.3	28.050
4.100	1013.9	10.100	75.1	16.100	40.2	22.100	26.1	28.100
4.150	1009.6	10.150	74.3	16.150	40.1	22.150	25.9	28.150
4.200	1001.6	10.200	73.5	16.200	40.0	22.200	25.7	28.200
4.250	986.8	10.250	72.7	16.250	39.9	22.250	25.5	28.250
4.300	964.2	10.300	72.0	16.300	39.9	22.300	25.4	28.300
4.350	935.3	10.350	71.3	16.350	39.8	22.350	25.2	28.350
4.400	903.0	10.400	70.5	16.400	39.8	22.400	25.0	28.400
4.450	870.8	10.450	69.8	16.450	39.7	22.450	24.8	28.450
4.500	841.8	10.500	69.2	16.500	39.6	22.500	24.6	28.500
4.550	816.5	10.550	68.5	16.550	39.6	22.550	24.4	28.550
4.600	793.8	10.600	67.8	16.600	39.5	22.600	24.2	28.600
4.650	773.4	10.650	67.2	16.650	39.4	22.650	24.0	28.650
4.700	755.0	10.700	66.5	16.700	39.4	22.700	23.8	28.700

4.750	737.7	10.750	65.9	16.750	39.3	22.750	23.6	28.750
6.9								
4.800	720.7	10.800	65.3	16.800	39.2	22.800	23.4	28.800
6.9								
4.850	703.0	10.850	64.7	16.850	39.2	22.850	23.2	28.850
6.8								
4.900	684.5	10.900	64.2	16.900	39.1	22.900	23.0	28.900
6.8								
4.950	683.4	10.950	63.6	16.950	39.0	22.950	22.8	28.950
6.7								
5.000	682.5	11.000	63.0	17.000	39.0	23.000	22.5	29.000
6.6								
5.050	681.5	11.050	62.5	17.050	38.9	23.050	22.3	29.050
6.5								
5.100	680.3	11.100	62.0	17.100	38.8	23.100	22.1	29.100
6.4								
5.150	679.0	11.150	61.7	17.150	38.8	23.150	21.9	29.150
6.3								
5.200	677.5	11.200	61.3	17.200	38.7	23.200	21.7	29.200
6.2								
5.250	675.9	11.250	61.0	17.250	38.6	23.250	21.5	29.250
6.1								
5.300	674.1	11.300	60.6	17.300	38.6	23.300	21.2	29.300
6.0								
5.350	672.1	11.350	60.3	17.350	38.5	23.350	21.0	29.350
5.8								
5.400	670.0	11.400	59.9	17.400	38.4	23.400	20.8	29.400
5.7								
5.450	667.8	11.450	59.6	17.450	38.3	23.450	20.6	29.450
5.6								
5.500	665.5	11.500	59.3	17.500	38.3	23.500	20.4	29.500
5.5								
5.550	663.0	11.550	58.9	17.550	38.2	23.550	20.2	29.550
5.4								
5.600	660.4	11.600	58.6	17.600	38.1	23.600	19.9	29.600
5.3								
5.650	657.7	11.650	58.2	17.650	38.0	23.650	19.7	29.650
5.1								
5.700	655.0	11.700	57.9	17.700	38.0	23.700	19.5	29.700
5.0								
5.750	651.6	11.750	57.6	17.750	37.9	23.750	19.3	29.750
4.9								
5.800	648.1	11.800	57.2	17.800	37.8	23.800	19.1	29.800
4.8								
5.850	644.5	11.850	56.9	17.850	37.8	23.850	18.9	29.850
4.7								
5.900	640.9	11.900	56.6	17.900	37.7	23.900	18.7	29.900
4.6								
5.950	637.2	11.950	56.2	17.950	37.6	23.950	18.5	29.950
4.5								

RUNOFF VOLUME = .51577 INCHES = 405.2797 ACRE-FEET
PEAK DISCHARGE RATE = 1066.81 CFS AT 3.700 HOURS BASIN AREA = 14.7333 SQ. MI.

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*
*S DIVIDE SURFACE FLOW FROM PIPE FLOW
*
DIVIDE HYD          ID=14  Q=372   ID=80   HYD=PIPE.80
                                   ID=90   HYD=SURF.90

PRINT HYD                  ID=80   CODE=1

                                        HYDROGRAPH FROM AREA PIPE.80
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RUNOFF VOLUME = .51577 INCHES = 257.1398 ACRE-FEET
PEAK DISCHARGE RATE = 372.00 CFS AT 1.700 HOURS BASIN AREA = 9.3479 SQ. MI.

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PRINT HYD                  ID=90   CODE=1

                                        HYDROGRAPH FROM AREA SURF.90
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RUNOFF VOLUME = .51577 INCHES = 148.1398 ACRE-FEET
PEAK DISCHARGE RATE = 694.81 CFS AT 3.700 HOURS BASIN AREA = 5.3854 SQ. MI.

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*S  APPLY SEDIMENT BULKING FACTOR
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SEDIMENT BULK          CODE=1   BULKING FACTOR = 1.05

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*S
*S ADD BASINS DRAINING INTO THE TEMPORARY PONDS ALONG UNSER BLVD
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*S
*                   COMPUTE HYD FOR SUB-BASIN 3
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*
COMPUTE LT TP       LCODE=1        NK=3    ISLOPE=0
                          LENGTH=400      SLOPE=0.013     K=.7
                          LENGTH=1600     SLOPE=0.013     K=1
                          LENGTH=1250     SLOPE=0.013     K=2


     Tc AND Tp COMPUTED BY UPLAND/LAG TIME PROCEDURE

     SCS UPLAND METHOD FACTORS
          NOTE: Upland factor input values have been adjusted to meet Upland/Lag Time requirements.
                                LENGTH (FT)      SLOPE (FT/FT)       COMPOSITE K
     SHEET FLOW PORTION            400.0           .013000             .7000
     SHALLOW FLOW PORTION         1600.0           .013000            2.0000
     CHANNEL FLOW PORTION         1250.0           .013000            3.0000
     TOTAL BASIN                  3250.0           .013000            1.8176


     TIME OF CONCENTRATION (HRS)=   .4356     TIME TO PEAK (HRS)=   .2904     LAG TIME (HRS)=   .3267

COMPUTE NM HYD      ID=3   HYD NO=3        DA=0.0957 SQ MI
                           PER A=97   PER B=0   PER C=0   PER D=3
                           TP=0.0  MASS RAIN=-1

     TIME TO PEAK (hrs)=   .2904

     K =   .160116HR    TP =   .290419HR    K/TP RATIO =   .551326     SHAPE CONSTANT, N =  7.002282
     UNIT PEAK =   5.1540    CFS   UNIT VOLUME =    .9978       B =   521.36      P60 = 1.6900
     AREA =      .002871 SQ MI    IA =    .10000 INCHES    INF =    .04000 INCHES PER HOUR
     RUNOFF COMPUTED BY INITIAL ABSTRACTION/INFILTRATION NUMBER METHOD - DT =   .050000


     K =   .358404HR    TP =   .290419HR    K/TP RATIO =  1.234093     SHAPE CONSTANT, N =  2.886688
     UNIT PEAK =   87.085    CFS   UNIT VOLUME =    .9998       B =   272.45      P60 = 1.6900
     AREA =      .092829 SQ MI    IA =    .65000 INCHES    INF =   1.67000 INCHES PER HOUR
     RUNOFF COMPUTED BY INITIAL ABSTRACTION/INFILTRATION NUMBER METHOD - DT =   .050000

    BULKING FACTOR APPLIED TO HYDROGRAPH.  FACTOR =  1.05000 AT PEAK FLOW.

PRINT HYD           ID=3   CODE=5

                                    OUTFLOW HYDROGRAPH REACH     3.00

      TIME      FLOW          TIME      FLOW          TIME      FLOW          TIME      FLOW          TIME
FLOW
       HRS       CFS           HRS       CFS           HRS       CFS           HRS       CFS           HRS
CFS
      .000        .0         5.250        .4        10.500        .0        15.750        .0        21.000
  .0
      .250        .0         5.500        .3        10.750        .0        16.000        .0        21.250
  .0
      .500        .0         5.750        .3        11.000        .0        16.250        .0        21.500
  .0
      .750        .0         6.000        .2        11.250        .0        16.500        .0        21.750
  .0
     1.000        .1         6.250        .2        11.500        .0        16.750        .0        22.000
  .0
     1.250        .3         6.500        .2        11.750        .0        17.000        .0        22.250
  .0
     1.500      24.7         6.750        .1        12.000        .0        17.250        .0        22.500
  .0
     1.750      37.1         7.000        .1        12.250        .0        17.500        .0        22.750
  .0
     2.000      20.2         7.250        .1        12.500        .0        17.750        .0        23.000
  .0
     2.250      10.2         7.500        .1        12.750        .0        18.000        .0        23.250
  .0
     2.500       5.0         7.750        .1        13.000        .0        18.250        .0        23.500
  .0
     2.750       3.3         8.000        .1        13.250        .0        18.500        .0        23.750
  .0
     3.000       2.6         8.250        .1        13.500        .0        18.750        .0        24.000
  .0
     3.250       2.0         8.500        .1        13.750        .0        19.000        .0        24.250
  .0
     3.500       1.6         8.750        .1        14.000        .0        19.250        .0        24.500
  .0
```

3.750	1.3	9.000	.1	14.250	.0	19.500	.0	24.750
.0								
4.000	1.0	9.250	.1	14.500	.0	19.750	.0	25.000
.0								
4.250	.8	9.500	.1	14.750	.0	20.000	.0	25.250
.0								
4.500	.7	9.750	.1	15.000	.0	20.250	.0	
4.750	.5	10.000	.0	15.250	.0	20.500	.0	
5.000	.4	10.250	.0	15.500	.0	20.750	.0	

RUNOFF VOLUME = .46593 INCHES = 2.3781 ACRE-FEET
PEAK DISCHARGE RATE = 39.97 CFS AT 1.650 HOURS BASIN AREA = .0957 SQ. MI.

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*
*S ROUTE SUB-BASIN 3 THRU UNSER TEMP POND A
*
ROUTE RESERVOIR         ID=1 HYD=4.9 INFLOW ID=3 CODE=2
                        OUTFLOW(CFS)    STORAGE(AC FT)  ELEV (FT)
                                  0.0             0.0            5337
                                  4.4             0.114          5338
                                  6.7             0.493          5339
                                  7.6             1.086          5340
                                  8.5             1.779          5341

  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *

    TIME      INFLOW    ELEV      VOLUME    OUTFLOW
    (HRS)     (CFS)     (FEET)    (AC-FT)   (CFS)

      .00        .00   5337.00       .000       .00
      .10        .00   5337.00       .000       .00
      .20        .00   5337.00       .000       .00
      .30        .00   5337.00       .000       .00
      .40        .00   5337.00       .000       .00
      .50        .00   5337.00       .000       .00
      .60        .00   5337.00       .000       .00
      .70        .00   5337.00       .000       .00
      .80        .00   5337.00       .000       .00
      .90        .05   5337.00       .000       .01
     1.00        .14   5337.01       .001       .03
     1.10        .23   5337.02       .002       .07
     1.20        .28   5337.03       .003       .12
     1.30        .44   5337.04       .005       .18
     1.40       5.67   5337.17       .019       .75
     1.50      24.70   5338.02       .123      4.45
     1.60      37.98   5338.61       .346      5.81
     1.70      39.42   5339.21       .618      6.89
     1.80      33.85   5339.63       .864      7.26
     1.90      26.44   5339.94      1.052      7.55
     2.00      20.16   5340.14      1.180      7.72
     2.10      15.43   5340.25      1.262      7.83
     2.20      11.77   5340.32      1.309      7.89
     2.30       8.86   5340.35      1.329      7.92
     2.40       6.65   5340.35      1.327      7.91
     2.50       5.03   5340.32      1.310      7.89
     2.60       3.97   5340.28      1.282      7.85
     2.70       3.52   5340.23      1.248      7.81
     2.80       3.18   5340.18      1.211      7.76
     2.90       2.88   5340.12      1.172      7.71
     3.00       2.61   5340.07      1.131      7.66
     3.10       2.36   5340.00      1.089      7.60
     3.20       2.14   5339.93      1.045      7.54
     3.30       1.95   5339.85      1.000      7.47
     3.40       1.77   5339.78       .954      7.40
     3.50       1.61   5339.70       .907      7.33
     3.60       1.47   5339.62       .859      7.26
     3.70       1.34   5339.54       .811      7.18
     3.80       1.22   5339.45       .763      7.11
     3.90       1.11   5339.37       .714      7.04
     4.00       1.01   5339.29       .665      6.96
     4.10        .93   5339.21       .615      6.89
     4.20        .85   5339.12       .566      6.81
     4.30        .78   5339.04       .517      6.74
     4.40        .71   5338.93       .468      6.55
     4.50        .66   5338.81       .421      6.26
     4.60        .60   5338.69       .375      5.99
     4.70        .56   5338.57       .332      5.72
     4.80        .51   5338.46       .290      5.47
     4.90        .48   5338.36       .250      5.22
     5.00        .44   5338.26       .211      4.99
     5.10        .41   5338.16       .175      4.77
     5.20        .38   5338.07       .139      4.55
     5.30        .35   5337.93       .106      4.10
     5.40        .33   5337.70       .080      3.07
     5.50        .31   5337.53       .060      2.32
```

TIME (HRS)	INFLOW (CFS)	ELEV (FEET)	VOLUME (AC-FT)	OUTFLOW (CFS)
5.60	.29	5337.40	.046	1.77
5.70	.27	5337.31	.035	1.36
5.80	.26	5337.24	.027	1.06
5.90	.24	5337.19	.022	.84
6.00	.23	5337.15	.017	.67
6.10	.22	5337.13	.014	.55
6.20	.20	5337.10	.012	.46
6.30	.19	5337.09	.010	.39
6.40	.17	5337.07	.009	.33
6.50	.16	5337.06	.007	.28
6.60	.15	5337.06	.006	.25
6.70	.14	5337.05	.006	.22
6.80	.13	5337.04	.005	.20
6.90	.12	5337.04	.005	.18
7.00	.12	5337.04	.004	.16
7.10	.11	5337.03	.004	.15
7.20	.11	5337.03	.004	.14
7.30	.10	5337.03	.003	.13
7.40	.10	5337.03	.003	.12
7.50	.09	5337.03	.003	.11
7.60	.09	5337.02	.003	.11
7.70	.09	5337.02	.003	.10
7.80	.08	5337.02	.003	.10
7.90	.08	5337.02	.002	.09
8.00	.08	5337.02	.002	.09
8.10	.08	5337.02	.002	.09
8.20	.07	5337.02	.002	.08
8.30	.07	5337.02	.002	.08
8.40	.07	5337.02	.002	.08
8.50	.07	5337.02	.002	.07
8.60	.07	5337.02	.002	.07
8.70	.06	5337.02	.002	.07
8.80	.06	5337.02	.002	.07
8.90	.06	5337.02	.002	.07
9.00	.06	5337.02	.002	.07
9.10	.06	5337.01	.002	.06
9.20	.06	5337.01	.002	.06
9.30	.06	5337.01	.002	.06
9.40	.06	5337.01	.002	.06
9.50	.06	5337.01	.002	.06
9.60	.06	5337.01	.002	.06
9.70	.05	5337.01	.001	.06
9.80	.05	5337.01	.001	.06
9.90	.05	5337.01	.001	.06
10.00	.05	5337.01	.001	.05
10.10	.05	5337.01	.001	.05
10.20	.05	5337.01	.001	.05
10.30	.05	5337.01	.001	.05
10.40	.05	5337.01	.001	.05
10.50	.05	5337.01	.001	.05
10.60	.05	5337.01	.001	.05
10.70	.05	5337.01	.001	.05
10.80	.05	5337.01	.001	.05
10.90	.05	5337.01	.001	.05
11.00	.05	5337.01	.001	.05
11.10	.05	5337.01	.001	.05

TIME (HRS)	INFLOW (CFS)	ELEV (FEET)	VOLUME (AC-FT)	OUTFLOW (CFS)
11.20	.05	5337.01	.001	.05
11.30	.05	5337.01	.001	.05
11.40	.05	5337.01	.001	.05
11.50	.05	5337.01	.001	.05
11.60	.05	5337.01	.001	.05
11.70	.04	5337.01	.001	.05
11.80	.04	5337.01	.001	.05
11.90	.04	5337.01	.001	.05
12.00	.04	5337.01	.001	.05
12.10	.04	5337.01	.001	.04
12.20	.04	5337.01	.001	.04
12.30	.04	5337.01	.001	.04
12.40	.04	5337.01	.001	.04
12.50	.04	5337.01	.001	.04
12.60	.04	5337.01	.001	.04
12.70	.04	5337.01	.001	.04
12.80	.04	5337.01	.001	.04
12.90	.04	5337.01	.001	.04
13.00	.04	5337.01	.001	.04
13.10	.04	5337.01	.001	.04
13.20	.04	5337.01	.001	.04
13.30	.04	5337.01	.001	.04
13.40	.04	5337.01	.001	.04
13.50	.04	5337.01	.001	.04
13.60	.04	5337.01	.001	.04
13.70	.04	5337.01	.001	.04
13.80	.04	5337.01	.001	.04
13.90	.04	5337.01	.001	.04

14.00	.04	5337.01	.001	.04
14.10	.04	5337.01	.001	.04
14.20	.04	5337.01	.001	.04
14.30	.04	5337.01	.001	.04
14.40	.04	5337.01	.001	.04
14.50	.04	5337.01	.001	.04
14.60	.04	5337.01	.001	.04
14.70	.04	5337.01	.001	.04
14.80	.04	5337.01	.001	.04
14.90	.04	5337.01	.001	.04
15.00	.04	5337.01	.001	.04
15.10	.04	5337.01	.001	.04
15.20	.04	5337.01	.001	.04
15.30	.04	5337.01	.001	.04
15.40	.04	5337.01	.001	.04
15.50	.04	5337.01	.001	.04
15.60	.04	5337.01	.001	.04
15.70	.04	5337.01	.001	.04
15.80	.04	5337.01	.001	.04
15.90	.04	5337.01	.001	.04
16.00	.04	5337.01	.001	.04
16.10	.04	5337.01	.001	.04
16.20	.04	5337.01	.001	.04
16.30	.04	5337.01	.001	.04
16.40	.04	5337.01	.001	.04
16.50	.04	5337.01	.001	.04
16.60	.04	5337.01	.001	.04
16.70	.04	5337.01	.001	.04

TIME (HRS)	INFLOW (CFS)	ELEV (FEET)	VOLUME (AC-FT)	OUTFLOW (CFS)
16.80	.04	5337.01	.001	.04
16.90	.04	5337.01	.001	.04
17.00	.04	5337.01	.001	.04
17.10	.04	5337.01	.001	.04
17.20	.04	5337.01	.001	.04
17.30	.04	5337.01	.001	.04
17.40	.04	5337.01	.001	.04
17.50	.03	5337.01	.001	.04
17.60	.03	5337.01	.001	.04
17.70	.03	5337.01	.001	.03
17.80	.03	5337.01	.001	.03
17.90	.03	5337.01	.001	.03
18.00	.03	5337.01	.001	.03
18.10	.03	5337.01	.001	.03
18.20	.03	5337.01	.001	.03
18.30	.03	5337.01	.001	.03
18.40	.03	5337.01	.001	.03
18.50	.03	5337.01	.001	.03
18.60	.03	5337.01	.001	.03
18.70	.03	5337.01	.001	.03
18.80	.03	5337.01	.001	.03
18.90	.03	5337.01	.001	.03
19.00	.03	5337.01	.001	.03
19.10	.03	5337.01	.001	.03
19.20	.03	5337.01	.001	.03
19.30	.03	5337.01	.001	.03
19.40	.03	5337.01	.001	.03
19.50	.03	5337.01	.001	.03
19.60	.03	5337.01	.001	.03
19.70	.03	5337.01	.001	.03
19.80	.03	5337.01	.001	.03
19.90	.03	5337.01	.001	.03
20.00	.03	5337.01	.001	.03
20.10	.03	5337.01	.001	.03
20.20	.03	5337.01	.001	.03
20.30	.03	5337.01	.001	.03
20.40	.03	5337.01	.001	.03
20.50	.03	5337.01	.001	.03
20.60	.03	5337.01	.001	.03
20.70	.03	5337.01	.001	.03
20.80	.03	5337.01	.001	.03
20.90	.03	5337.01	.001	.03
21.00	.03	5337.01	.001	.03
21.10	.03	5337.01	.001	.03
21.20	.03	5337.01	.001	.03
21.30	.03	5337.01	.001	.03
21.40	.03	5337.01	.001	.03
21.50	.03	5337.01	.001	.03
21.60	.03	5337.01	.001	.03
21.70	.03	5337.01	.001	.03
21.80	.03	5337.01	.001	.03
21.90	.03	5337.01	.001	.03
22.00	.03	5337.01	.001	.03
22.10	.03	5337.01	.001	.03
22.20	.03	5337.01	.001	.03
22.30	.03	5337.01	.001	.03

TIME (HRS)	INFLOW (CFS)	ELEV (FEET)	VOLUME (AC-FT)	OUTFLOW (CFS)

22.40	.03	5337.01	.001	.03
22.50	.03	5337.01	.001	.03
22.60	.03	5337.01	.001	.03
22.70	.03	5337.01	.001	.03
22.80	.03	5337.01	.001	.03
22.90	.03	5337.01	.001	.03
23.00	.03	5337.01	.001	.03
23.10	.03	5337.01	.001	.03
23.20	.03	5337.01	.001	.03
23.30	.03	5337.01	.001	.03
23.40	.03	5337.01	.001	.03
23.50	.03	5337.01	.001	.03
23.60	.03	5337.01	.001	.03
23.70	.03	5337.01	.001	.03
23.80	.03	5337.01	.001	.03
23.90	.03	5337.01	.001	.03
24.00	.03	5337.01	.001	.03
24.10	.03	5337.01	.001	.03
24.20	.02	5337.01	.001	.03
24.30	.02	5337.01	.001	.03
24.40	.01	5337.00	.001	.02
24.50	.01	5337.00	.000	.02
24.60	.00	5337.00	.000	.01
24.70	.00	5337.00	.000	.01
24.80	.00	5337.00	.000	.01
24.90	.00	5337.00	.000	.01
25.00	.00	5337.00	.000	.01
25.10	.00	5337.00	.000	.00

PEAK DISCHARGE = 7.917 CFS - PEAK OCCURS AT HOUR 2.35
MAXIMUM WATER SURFACE ELEVATION = 5340.353
MAXIMUM STORAGE = 1.3304 AC-FT INCREMENTAL TIME= .050000HRS

PRINT HYD ID=1 CODE=5

OUTFLOW HYDROGRAPH REACH 4.90

TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS
.000	.0	5.250	4.5	10.500	.0	15.750	.0	21.000	.0
.250	.0	5.500	2.3	10.750	.0	16.000	.0	21.250	.0
.500	.0	5.750	1.2	11.000	.0	16.250	.0	21.500	.0
.750	.0	6.000	.7	11.250	.0	16.500	.0	21.750	.0
1.000	.0	6.250	.4	11.500	.0	16.750	.0	22.000	.0
1.250	.1	6.500	.3	11.750	.0	17.000	.0	22.250	.0
1.500	4.5	6.750	.2	12.000	.0	17.250	.0	22.500	.0
1.750	7.1	7.000	.2	12.250	.0	17.500	.0	22.750	.0
2.000	7.7	7.250	.1	12.500	.0	17.750	.0	23.000	.0
2.250	7.9	7.500	.1	12.750	.0	18.000	.0	23.250	.0
2.500	7.9	7.750	.1	13.000	.0	18.250	.0	23.500	.0
2.750	7.8	8.000	.1	13.250	.0	18.500	.0	23.750	.0
3.000	7.7	8.250	.1	13.500	.0	18.750	.0	24.000	.0
3.250	7.5	8.500	.1	13.750	.0	19.000	.0	24.250	.0
3.500	7.3	8.750	.1	14.000	.0	19.250	.0	24.500	.0
3.750	7.1	9.000	.1	14.250	.0	19.500	.0	24.750	.0
4.000	7.0	9.250	.1	14.500	.0	19.750	.0	25.000	.0
4.250	6.8	9.500	.1	14.750	.0	20.000	.0	25.250	.0
4.500	6.3	9.750	.1	15.000	.0	20.250	.0	25.500	.0
4.750	5.6	10.000	.1	15.250	.0	20.500	.0		
5.000	5.0	10.250	.1	15.500	.0	20.750	.0		

RUNOFF VOLUME = .46592 INCHES = 2.3781 ACRE-FEET
PEAK DISCHARGE RATE = 7.92 CFS AT 2.350 HOURS BASIN AREA = .0957 SQ. MI.

*
****
*
* COMPUTE HYD FOR SUB-BASIN 4

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**************************************************************************
*
COMPUTE LT TP       LCODE=1        NK=2    ISLOPE=0
                          LENGTH=400      SLOPE=0.017     K=.7
                          LENGTH=1053     SLOPE=0.017     K=1


     Tc AND Tp COMPUTED BY UPLAND/LAG TIME PROCEDURE

     SCS UPLAND METHOD FACTORS
          NOTE: Upland factor input values have been adjusted to meet Upland/Lag Time requirements.
                                LENGTH (FT)      SLOPE (FT/FT)       COMPOSITE K
     SHEET FLOW PORTION            400.0            .017000             .7000
     SHALLOW FLOW PORTION         1053.0            .017000            2.0000
     CHANNEL FLOW PORTION            .0             .000000             .0000
     TOTAL BASIN                  1453.0            .017000            1.3234


     TIME OF CONCENTRATION (HRS)=   .2339     TIME TO PEAK (HRS)=   .1559     LAG TIME (HRS)=   .1754

COMPUTE NM HYD      ID=4   HYD NO=4        DA=0..0282 SQ MI
                           PER A=98   PER B=0   PER C=0   PER D=2
                           TP=0.0  MASS RAIN=-1

     TIME TO PEAK (hrs)=   .1559

     K =   .084987HR    TP =   .155939HR    K/TP RATIO =   .545000     SHAPE CONSTANT, N =  7.106420
     UNIT PEAK =   1.9034    CFS   UNIT VOLUME =    .9945       B =   526.28      P60 = 1.6900
     AREA =      .000564 SQ MI    IA =    .10000 INCHES    INF =    .04000 INCHES PER HOUR
     RUNOFF COMPUTED BY INITIAL ABSTRACTION/INFILTRATION NUMBER METHOD - DT =   .050000


     K =   .196792HR    TP =   .155939HR    K/TP RATIO =  1.261977     SHAPE CONSTANT, N =  2.829424
     UNIT PEAK =   47.426    CFS   UNIT VOLUME =    .9986       B =   267.61      P60 = 1.6900
     AREA =      .027636 SQ MI    IA =    .65000 INCHES    INF =   1.67000 INCHES PER HOUR
     RUNOFF COMPUTED BY INITIAL ABSTRACTION/INFILTRATION NUMBER METHOD - DT =   .050000

    BULKING FACTOR APPLIED TO HYDROGRAPH.  FACTOR =  1.05000 AT PEAK FLOW.

PRINT HYD           ID=4   CODE=5

                                    OUTFLOW HYDROGRAPH REACH     4.00

      TIME      FLOW          TIME      FLOW          TIME      FLOW          TIME      FLOW          TIME
FLOW
       HRS       CFS           HRS       CFS           HRS       CFS           HRS       CFS           HRS
CFS
      .000        .0         5.000        .0        10.000        .0        15.000        .0        20.000
  .0
      .250        .0         5.250        .0        10.250        .0        15.250        .0        20.250
  .0
      .500        .0         5.500        .0        10.500        .0        15.500        .0        20.500
  .0
      .750        .0         5.750        .0        10.750        .0        15.750        .0        20.750
  .0
     1.000        .1         6.000        .0        11.000        .0        16.000        .0        21.000
  .0
     1.250        .1         6.250        .0        11.250        .0        16.250        .0        21.250
  .0
     1.500      19.0         6.500        .0        11.500        .0        16.500        .0        21.500
  .0
     1.750       8.6         6.750        .0        11.750        .0        16.750        .0        21.750
  .0
     2.000       2.6         7.000        .0        12.000        .0        17.000        .0        22.000
  .0
     2.250       1.4         7.250        .0        12.250        .0        17.250        .0        22.250
  .0
     2.500        .9         7.500        .0        12.500        .0        17.500        .0        22.500
  .0
     2.750        .6         7.750        .0        12.750        .0        17.750        .0        22.750
  .0
     3.000        .4         8.000        .0        13.000        .0        18.000        .0        23.000
  .0
     3.250        .3         8.250        .0        13.250        .0        18.250        .0        23.250
  .0
     3.500        .2         8.500        .0        13.500        .0        18.500        .0        23.500
  .0
     3.750        .1         8.750        .0        13.750        .0        18.750        .0        23.750
  .0
     4.000        .1         9.000        .0        14.000        .0        19.000        .0        24.000
  .0
     4.250        .1         9.250        .0        14.250        .0        19.250        .0        24.250
  .0
     4.500        .0         9.500        .0        14.500        .0        19.500        .0
     4.750        .0         9.750        .0        14.750        .0        19.750        .0

    RUNOFF VOLUME =      .44594 INCHES     =        .6707 ACRE-FEET
    PEAK DISCHARGE RATE =      19.54 CFS  AT   1.550 HOURS   BASIN AREA =   .0282 SQ. MI.
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*******************************************************************************
*
*S ADD ROUTED FLOW FROM TEMP POND A TO SUB-BASIN 4
*
*S ADD SUB-BASINS 3 AND 4
*
ADD HYD             ID=2  HYD NO=4.2 ID I=1 ID II=4
PRINT HYD           ID=2   CODE=1

                                      OUTFLOW HYDROGRAPH REACH     4.20


    RUNOFF VOLUME =      .46137 INCHES     =       3.0487 ACRE-FEET
    PEAK DISCHARGE RATE =      24.60 CFS  AT   1.550 HOURS   BASIN AREA =   .1239 SQ. MI.



*
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*
*S ROUTE THRU UNSER TEMP POND B
*
ROUTE RESERVOIR         ID=1 HYD=5.9 INFLOW ID=2 CODE=2
                        OUTFLOW(CFS)    STORAGE(AC FT)  ELEV (FT)
                                  0.0             0.0             5333
                                 0.01            0.16             5334
                                  2.6             0.50             5335
                                  5.1             0.71           5335.5
                                  8.0            0.918             5336


  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *

    TIME      INFLOW    ELEV      VOLUME    OUTFLOW
    (HRS)     (CFS)     (FEET)    (AC-FT)   (CFS)

      .00        .00   5333.00       .000       .00
      .10        .00   5333.00       .000       .00
      .20        .00   5333.00       .000       .00
      .30        .00   5333.00       .000       .00
      .40        .00   5333.00       .000       .00
      .50        .00   5333.00       .000       .00
      .60        .00   5333.00       .000       .00
      .70        .00   5333.00       .000       .00
      .80        .01   5333.00       .000       .00
      .90        .05   5333.00       .000       .00
     1.00        .09   5333.00       .001       .00
     1.10        .14   5333.01       .002       .00
     1.20        .20   5333.02       .003       .00
     1.30        .46   5333.04       .006       .00
     1.40       7.14   5333.17       .027       .00
     1.50      23.49   5333.99       .158       .01
     1.60      23.06   5334.56       .350      1.46
     1.70      17.87   5335.01       .502      2.63
     1.80      14.00   5335.25       .606      3.86
     1.90      11.73   5335.42       .676      4.70
     2.00      10.36   5335.54       .726      5.32
     2.10       9.79   5335.63       .762      5.83
     2.20       9.46   5335.70       .792      6.24
     2.30       9.21   5335.76       .816      6.58
     2.40       8.99   5335.80       .836      6.85
     2.50       8.80   5335.84       .852      7.08
     2.60       8.61   5335.87       .864      7.25
     2.70       8.45   5335.90       .874      7.39
     2.80       8.30   5335.91       .882      7.50
     2.90       8.17   5335.93       .888      7.58
     3.00       8.05   5335.94       .892      7.64
     3.10       7.93   5335.94       .895      7.67
     3.20       7.82   5335.95       .896      7.70
     3.30       7.71   5335.95       .897      7.70
     3.40       7.60   5335.95       .896      7.70
     3.50       7.50   5335.95       .895      7.68
     3.60       7.40   5335.94       .893      7.66
     3.70       7.31   5335.94       .891      7.62
     3.80       7.22   5335.93       .888      7.58
     3.90       7.13   5335.92       .885      7.54
     4.00       7.04   5335.91       .881      7.49
     4.10       6.96   5335.90       .878      7.44
     4.20       6.87   5335.89       .874      7.38
     4.30       6.79   5335.88       .869      7.32
     4.40       6.60   5335.87       .865      7.26
     4.50       6.31   5335.86       .858      7.17
     4.60       6.03   5335.84       .850      7.06
     4.70       5.76   5335.82       .841      6.93
     4.80       5.50   5335.79       .831      6.79
     4.90       5.25   5335.76       .820      6.63
     5.00       5.02   5335.74       .808      6.47
     5.10       4.79   5335.71       .796      6.30
     5.20       4.58   5335.68       .784      6.12
```

5.30	4.12	5335.64	.770	5.94
5.40	3.09	5335.60	.752	5.68
5.50	2.34	5335.54	.728	5.36

TIME (HRS)	INFLOW (CFS)	ELEV (FEET)	VOLUME (AC-FT)	OUTFLOW (CFS)
5.60	1.79	5335.48	.703	5.01
5.70	1.38	5335.42	.675	4.69
5.80	1.08	5335.35	.648	4.36
5.90	.86	5335.29	.621	4.04
6.00	.69	5335.23	.596	3.74
6.10	.57	5335.17	.571	3.45
6.20	.47	5335.11	.548	3.17
6.30	.40	5335.06	.526	2.91
6.40	.34	5335.02	.506	2.68
6.50	.30	5334.96	.488	2.51
6.60	.26	5334.91	.470	2.37
6.70	.23	5334.86	.453	2.24
6.80	.21	5334.81	.437	2.12
6.90	.19	5334.77	.421	2.00
7.00	.17	5334.73	.407	1.89
7.10	.16	5334.68	.393	1.78
7.20	.15	5334.65	.380	1.68
7.30	.14	5334.61	.367	1.59
7.40	.13	5334.58	.356	1.50
7.50	.12	5334.54	.345	1.42
7.60	.12	5334.51	.334	1.34
7.70	.11	5334.48	.325	1.26
7.80	.11	5334.46	.315	1.19
7.90	.10	5334.43	.307	1.13
8.00	.10	5334.41	.298	1.06
8.10	.10	5334.38	.291	1.01
8.20	.09	5334.36	.283	.95
8.30	.09	5334.34	.277	.90
8.40	.09	5334.32	.270	.85
8.50	.09	5334.31	.264	.80
8.60	.08	5334.29	.258	.76
8.70	.08	5334.27	.253	.72
8.80	.08	5334.26	.248	.68
8.90	.08	5334.24	.243	.64
9.00	.08	5334.23	.238	.61
9.10	.07	5334.22	.234	.57
9.20	.07	5334.21	.230	.54
9.30	.07	5334.19	.226	.52
9.40	.07	5334.18	.223	.49
9.50	.07	5334.17	.219	.46
9.60	.07	5334.17	.216	.44
9.70	.07	5334.16	.213	.42
9.80	.07	5334.15	.210	.39
9.90	.07	5334.14	.208	.37
10.00	.06	5334.13	.205	.36
10.10	.06	5334.13	.203	.34
10.20	.06	5334.12	.201	.32
10.30	.06	5334.11	.199	.31
10.40	.06	5334.11	.197	.29
10.50	.06	5334.10	.195	.28
10.60	.06	5334.10	.193	.26
10.70	.06	5334.09	.192	.25
10.80	.06	5334.09	.190	.24
10.90	.06	5334.08	.189	.23
11.00	.06	5334.08	.187	.22
11.10	.06	5334.08	.186	.21

TIME (HRS)	INFLOW (CFS)	ELEV (FEET)	VOLUME (AC-FT)	OUTFLOW (CFS)
11.20	.06	5334.07	.185	.20
11.30	.06	5334.07	.184	.19
11.40	.06	5334.07	.182	.18
11.50	.06	5334.06	.181	.17
11.60	.05	5334.06	.181	.17
11.70	.05	5334.06	.180	.16
11.80	.05	5334.06	.179	.15
11.90	.05	5334.05	.178	.15
12.00	.05	5334.05	.177	.14
12.10	.05	5334.05	.177	.14
12.20	.05	5334.05	.176	.13
12.30	.05	5334.04	.175	.13
12.40	.05	5334.04	.175	.12
12.50	.05	5334.04	.174	.12
12.60	.05	5334.04	.174	.11
12.70	.05	5334.04	.173	.11
12.80	.05	5334.04	.173	.11
12.90	.05	5334.04	.172	.10
13.00	.05	5334.03	.172	.10
13.10	.05	5334.03	.171	.10
13.20	.05	5334.03	.171	.09
13.30	.05	5334.03	.171	.09
13.40	.05	5334.03	.170	.09
13.50	.05	5334.03	.170	.09

13.60	.05	5334.03	.170	.08
13.70	.05	5334.03	.169	.08
13.80	.05	5334.03	.169	.08
13.90	.05	5334.03	.169	.08
14.00	.05	5334.03	.169	.08
14.10	.05	5334.02	.168	.07
14.20	.05	5334.02	.168	.07
14.30	.05	5334.02	.168	.07
14.40	.05	5334.02	.168	.07
14.50	.05	5334.02	.168	.07
14.60	.05	5334.02	.168	.07
14.70	.05	5334.02	.167	.07
14.80	.05	5334.02	.167	.06
14.90	.05	5334.02	.167	.06
15.00	.05	5334.02	.167	.06
15.10	.05	5334.02	.167	.06
15.20	.05	5334.02	.167	.06
15.30	.05	5334.02	.167	.06
15.40	.05	5334.02	.166	.06
15.50	.05	5334.02	.166	.06
15.60	.05	5334.02	.166	.06
15.70	.05	5334.02	.166	.06
15.80	.04	5334.02	.166	.06
15.90	.04	5334.02	.166	.06
16.00	.04	5334.02	.166	.05
16.10	.04	5334.02	.166	.05
16.20	.04	5334.02	.166	.05
16.30	.04	5334.02	.166	.05
16.40	.04	5334.02	.166	.05
16.50	.04	5334.02	.165	.05
16.60	.04	5334.02	.165	.05
16.70	.04	5334.02	.165	.05

TIME (HRS)	INFLOW (CFS)	ELEV (FEET)	VOLUME (AC-FT)	OUTFLOW (CFS)
16.80	.04	5334.02	.165	.05
16.90	.04	5334.02	.165	.05
17.00	.04	5334.02	.165	.05
17.10	.04	5334.02	.165	.05
17.20	.04	5334.02	.165	.05
17.30	.04	5334.01	.165	.05
17.40	.04	5334.01	.165	.05
17.50	.04	5334.01	.165	.05
17.60	.04	5334.01	.165	.05
17.70	.04	5334.01	.165	.05
17.80	.04	5334.01	.165	.05
17.90	.04	5334.01	.165	.05
18.00	.04	5334.01	.165	.05
18.10	.04	5334.01	.165	.05
18.20	.04	5334.01	.165	.05
18.30	.04	5334.01	.165	.05
18.40	.04	5334.01	.165	.04
18.50	.04	5334.01	.165	.04
18.60	.04	5334.01	.165	.04
18.70	.04	5334.01	.164	.04
18.80	.04	5334.01	.164	.04
18.90	.04	5334.01	.164	.04
19.00	.04	5334.01	.164	.04
19.10	.04	5334.01	.164	.04
19.20	.04	5334.01	.164	.04
19.30	.04	5334.01	.164	.04
19.40	.04	5334.01	.164	.04
19.50	.04	5334.01	.164	.04
19.60	.04	5334.01	.164	.04
19.70	.04	5334.01	.164	.04
19.80	.04	5334.01	.164	.04
19.90	.04	5334.01	.164	.04
20.00	.04	5334.01	.164	.04
20.10	.04	5334.01	.164	.04
20.20	.04	5334.01	.164	.04
20.30	.04	5334.01	.164	.04
20.40	.04	5334.01	.164	.04
20.50	.04	5334.01	.164	.04
20.60	.04	5334.01	.164	.04
20.70	.04	5334.01	.164	.04
20.80	.04	5334.01	.164	.04
20.90	.04	5334.01	.164	.04
21.00	.04	5334.01	.164	.04
21.10	.04	5334.01	.164	.04
21.20	.04	5334.01	.164	.04
21.30	.04	5334.01	.164	.04
21.40	.04	5334.01	.164	.04
21.50	.04	5334.01	.164	.04
21.60	.04	5334.01	.164	.04
21.70	.04	5334.01	.164	.04
21.80	.04	5334.01	.164	.04
21.90	.04	5334.01	.164	.04
22.00	.04	5334.01	.164	.04
22.10	.04	5334.01	.164	.04
22.20	.04	5334.01	.164	.04

22.30	.04	5334.01	.164	.04

TIME (HRS)	INFLOW (CFS)	ELEV (FEET)	VOLUME (AC-FT)	OUTFLOW (CFS)
22.40	.04	5334.01	.164	.04
22.50	.04	5334.01	.164	.04
22.60	.04	5334.01	.164	.04
22.70	.03	5334.01	.164	.04
22.80	.03	5334.01	.164	.04
22.90	.03	5334.01	.164	.04
23.00	.03	5334.01	.164	.04
23.10	.03	5334.01	.163	.04
23.20	.03	5334.01	.163	.04
23.30	.03	5334.01	.163	.04
23.40	.03	5334.01	.163	.04
23.50	.03	5334.01	.163	.04
23.60	.03	5334.01	.163	.04
23.70	.03	5334.01	.163	.04
23.80	.03	5334.01	.163	.04
23.90	.03	5334.01	.163	.04
24.00	.03	5334.01	.163	.04
24.10	.03	5334.01	.163	.04
24.20	.03	5334.01	.163	.04
24.30	.03	5334.01	.163	.03
24.40	.02	5334.01	.163	.03
24.50	.02	5334.01	.163	.03
24.60	.01	5334.01	.163	.03
24.70	.01	5334.01	.163	.03
24.80	.01	5334.01	.163	.03
24.90	.01	5334.01	.162	.03
25.00	.01	5334.01	.162	.03
25.10	.00	5334.01	.162	.03
25.20	.00	5334.01	.162	.02
25.30	.00	5334.00	.162	.02
25.40	.00	5334.00	.162	.02
25.50	.00	5334.00	.161	.02
25.60	.00	5334.00	.161	.02
25.70	.00	5334.00	.161	.02
25.80	.00	5334.00	.161	.02
25.90	.00	5334.00	.161	.02
26.00	.00	5334.00	.161	.02
26.10	.00	5334.00	.161	.01
26.20	.00	5334.00	.160	.01
26.30	.00	5334.00	.160	.01
26.40	.00	5334.00	.160	.01
26.50	.00	5334.00	.160	.01
26.60	.00	5334.00	.160	.01
26.70	.00	5334.00	.160	.01
26.80	.00	5334.00	.160	.01
26.90	.00	5334.00	.160	.01
27.00	.00	5334.00	.160	.01
27.10	.00	5334.00	.160	.01
27.20	.00	5334.00	.160	.01
27.30	.00	5334.00	.159	.01
27.40	.00	5334.00	.159	.01
27.50	.00	5334.00	.159	.01
27.60	.00	5334.00	.159	.01
27.70	.00	5333.99	.159	.01
27.80	.00	5333.99	.159	.01
27.90	.00	5333.99	.159	.01

TIME (HRS)	INFLOW (CFS)	ELEV (FEET)	VOLUME (AC-FT)	OUTFLOW (CFS)
28.00	.00	5333.99	.159	.01
28.10	.00	5333.99	.159	.01
28.20	.00	5333.99	.159	.01
28.30	.00	5333.99	.159	.01
28.40	.00	5333.99	.159	.01
28.50	.00	5333.99	.158	.01
28.60	.00	5333.99	.158	.01
28.70	.00	5333.99	.158	.01
28.80	.00	5333.99	.158	.01
28.90	.00	5333.99	.158	.01
29.00	.00	5333.99	.158	.01
29.10	.00	5333.99	.158	.01
29.20	.00	5333.99	.158	.01
29.30	.00	5333.99	.158	.01
29.40	.00	5333.99	.158	.01
29.50	.00	5333.99	.158	.01
29.60	.00	5333.98	.158	.01
29.70	.00	5333.98	.158	.01
29.80	.00	5333.98	.157	.01
29.90	.00	5333.98	.157	.01

PEAK DISCHARGE = 7.703 CFS - PEAK OCCURS AT HOUR 3.30
MAXIMUM WATER SURFACE ELEVATION = 5335.949
MAXIMUM STORAGE = .8967 AC-FT INCREMENTAL TIME= .050000HRS

PRINT HYD ID=1 CODE=5

OUTFLOW HYDROGRAPH REACH 5.90

TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS
.000	.0	6.000	3.7	12.000	.1	18.000	.0	24.000	.0
.250	.0	6.250	3.0	12.250	.1	18.250	.0	24.250	.0
.500	.0	6.500	2.5	12.500	.1	18.500	.0	24.500	.0
.750	.0	6.750	2.2	12.750	.1	18.750	.0	24.750	.0
1.000	.0	7.000	1.9	13.000	.1	19.000	.0	25.000	.0
1.250	.0	7.250	1.6	13.250	.1	19.250	.0	25.250	.0
1.500	.0	7.500	1.4	13.500	.1	19.500	.0	25.500	.0
1.750	3.3	7.750	1.2	13.750	.1	19.750	.0	25.750	.0
2.000	5.3	8.000	1.1	14.000	.1	20.000	.0	26.000	.0
2.250	6.4	8.250	.9	14.250	.1	20.250	.0	26.250	.0
2.500	7.1	8.500	.8	14.500	.1	20.500	.0	26.500	.0
2.750	7.4	8.750	.7	14.750	.1	20.750	.0	26.750	.0
3.000	7.6	9.000	.6	15.000	.1	21.000	.0	27.000	.0
3.250	7.7	9.250	.5	15.250	.1	21.250	.0	27.250	.0
3.500	7.7	9.500	.5	15.500	.1	21.500	.0	27.500	.0
3.750	7.6	9.750	.4	15.750	.1	21.750	.0	27.750	.0
4.000	7.5	10.000	.4	16.000	.1	22.000	.0	28.000	.0
4.250	7.4	10.250	.3	16.250	.1	22.250	.0	28.250	.0
4.500	7.2	10.500	.3	16.500	.1	22.500	.0	28.500	.0
4.750	6.9	10.750	.2	16.750	.1	22.750	.0	28.750	.0
5.000	6.5	11.000	.2	17.000	.0	23.000	.0	29.000	.0
5.250	6.0	11.250	.2	17.250	.0	23.250	.0	29.250	.0
5.500	5.4	11.500	.2	17.500	.0	23.500	.0	29.500	.0
5.750	4.5	11.750	.2	17.750	.0	23.750	.0	29.750	.0

RUNOFF VOLUME = .43757 INCHES = 2.8914 ACRE-FEET
PEAK DISCHARGE RATE = 7.70 CFS AT 3.300 HOURS BASIN AREA = .1239 SQ. MI.

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*
*S ROUTE THRU 24"IN ALMENDRA PL
*
COMPUTE RATING CURVE       CID=1   VS NO=1 NO SEGS=-1  SLP=0.011
                                   DIAM=2.0 FT     N=0.013
```

RATING CURVE PIPE SECTION 1.0

WATER SURFACE ELEV	FLOW AREA SQ FT	FLOW RATE CFS	MAX WIDTH FT
.00	.00	.00	.00
.10	.06	.12	.89
.21	.17	.54	1.22
.31	.31	1.26	1.45
.42	.47	2.26	1.62
.52	.65	3.53	1.76
.63	.84	5.03	1.85
.73	1.04	6.74	1.93
.83	1.24	8.62	1.97
.94	1.45	10.63	2.00
1.04	1.66	12.72	2.00
1.15	1.86	14.85	2.00
1.25	2.07	16.96	2.00
1.35	2.27	19.01	2.00
1.46	2.46	20.93	2.00
1.56	2.63	22.65	2.00
1.67	2.80	24.08	2.00

1.77	2.94	25.10	2.00
1.88	3.06	25.52	2.00
2.00	3.14	25.52	2.00

ROUTE MCUNGE ID=2 HYD NO=5.92 INFLOW ID=1
DT=0.0 HR LENGTH=48.6 FT
NS=0 SLOPE=0.011 CODE=5

ZERO VALUE HYDROGRAPH OR SHORT ROUTE - ROUTING BYPASSED
PRINT HYD ID=2 CODE=5

OUTFLOW HYDROGRAPH REACH 5.92

TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS
.000	.0	6.000	3.7	12.000	.1	18.000	.0	24.000	.0
.250	.0	6.250	3.0	12.250	.1	18.250	.0	24.250	.0
.500	.0	6.500	2.5	12.500	.1	18.500	.0	24.500	.0
.750	.0	6.750	2.2	12.750	.1	18.750	.0	24.750	.0
1.000	.0	7.000	1.9	13.000	.1	19.000	.0	25.000	.0
1.250	.0	7.250	1.6	13.250	.1	19.250	.0	25.250	.0
1.500	.0	7.500	1.4	13.500	.1	19.500	.0	25.500	.0
1.750	3.3	7.750	1.2	13.750	.1	19.750	.0	25.750	.0
2.000	5.3	8.000	1.1	14.000	.1	20.000	.0	26.000	.0
2.250	6.4	8.250	.9	14.250	.1	20.250	.0	26.250	.0
2.500	7.1	8.500	.8	14.500	.1	20.500	.0	26.500	.0
2.750	7.4	8.750	.7	14.750	.1	20.750	.0	26.750	.0
3.000	7.6	9.000	.6	15.000	.1	21.000	.0	27.000	.0
3.250	7.7	9.250	.5	15.250	.1	21.250	.0	27.250	.0
3.500	7.7	9.500	.5	15.500	.1	21.500	.0	27.500	.0
3.750	7.6	9.750	.4	15.750	.1	21.750	.0	27.750	.0
4.000	7.5	10.000	.4	16.000	.1	22.000	.0	28.000	.0
4.250	7.4	10.250	.3	16.250	.1	22.250	.0	28.250	.0
4.500	7.2	10.500	.3	16.500	.1	22.500	.0	28.500	.0
4.750	6.9	10.750	.2	16.750	.1	22.750	.0	28.750	.0
5.000	6.5	11.000	.2	17.000	.0	23.000	.0	29.000	.0
5.250	6.0	11.250	.2	17.250	.0	23.250	.0	29.250	.0
5.500	5.4	11.500	.2	17.500	.0	23.500	.0	29.500	.0
5.750	4.5	11.750	.2	17.750	.0	23.750	.0	29.750	.0

RUNOFF VOLUME = .43757 INCHES = 2.8914 ACRE-FEET
PEAK DISCHARGE RATE = 7.70 CFS AT 3.300 HOURS BASIN AREA = .1239 SQ. MI.

*

****
* COMPUTE HYD FOR SUB-BASIN 5
****
*
COMPUTE LT TP LCODE=1 NK=3 ISLOPE=0
LENGTH=400 SLOPE=0.017 K=.7
LENGTH=1600 SLOPE=0.017 K=1
LENGTH=2000 SLOPE=0.017 K=2

Tc AND Tp COMPUTED BY UPLAND/LAG TIME PROCEDURE

SCS UPLAND METHOD FACTORS
NOTE: Upland factor input values have been adjusted to meet Upland/Lag Time requirements.

	LENGTH (FT)	SLOPE (FT/FT)	COMPOSITE K
SHEET FLOW PORTION	400.0	.017000	.7000
SHALLOW FLOW PORTION	1600.0	.017000	2.0000
CHANNEL FLOW PORTION	2000.0	.017000	3.0000
TOTAL BASIN	4000.0	.017000	1.9626

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     TIME OF CONCENTRATION (HRS)=   .4342     TIME TO PEAK (HRS)=   .2895     LAG TIME (HRS)=   .3257

 COMPUTE NM HYD      ID=5   HYD NO=5        DA=0.0940 SQ MI
                            PER A=98   PER B=0   PER C=0   PER D=2
                            TP=0.0  MASS RAIN=-1

     TIME TO PEAK (hrs)=   .2895

     K =   .159500HR    TP =   .289472HR    K/TP RATIO =   .551002     SHAPE CONSTANT, N =  7.007543
     UNIT PEAK =   3.3877    CFS   UNIT VOLUME =    .9967       B =   521.61      P60 = 1.6900
     AREA =      .001880 SQ MI    IA =    .10000 INCHES    INF =    .04000 INCHES PER HOUR
     RUNOFF COMPUTED BY INITIAL ABSTRACTION/INFILTRATION NUMBER METHOD - DT =   .050000


     K =   .357648HR    TP =   .289472HR    K/TP RATIO =  1.235521     SHAPE CONSTANT, N =  2.883674
     UNIT PEAK =   86.622    CFS   UNIT VOLUME =    .9997       B =   272.20      P60 = 1.6900
     AREA =      .092120 SQ MI    IA =    .65000 INCHES    INF =   1.67000 INCHES PER HOUR
     RUNOFF COMPUTED BY INITIAL ABSTRACTION/INFILTRATION NUMBER METHOD - DT =   .050000

    BULKING FACTOR APPLIED TO HYDROGRAPH.  FACTOR =  1.05000 AT PEAK FLOW.

 PRINT HYD           ID=5   CODE=5

                                      OUTFLOW HYDROGRAPH REACH     5.00

      TIME      FLOW          TIME      FLOW          TIME      FLOW          TIME      FLOW          TIME
FLOW
       HRS       CFS           HRS       CFS           HRS       CFS           HRS       CFS           HRS
CFS
      .000        .0         5.250        .3        10.500        .0        15.750        .0        21.000
  .0
      .250        .0         5.500        .3        10.750        .0        16.000        .0        21.250
  .0
      .500        .0         5.750        .2        11.000        .0        16.250        .0        21.500
  .0
      .750        .0         6.000        .2        11.250        .0        16.500        .0        21.750
  .0
     1.000        .1         6.250        .2        11.500        .0        16.750        .0        22.000
  .0
     1.250        .2         6.500        .1        11.750        .0        17.000        .0        22.250
  .0
     1.500      23.6         6.750        .1        12.000        .0        17.250        .0        22.500
  .0
     1.750      35.3         7.000        .1        12.250        .0        17.500        .0        22.750
  .0
     2.000      19.1         7.250        .1        12.500        .0        17.750        .0        23.000
  .0
     2.250       9.6         7.500        .1        12.750        .0        18.000        .0        23.250
  .0
     2.500       4.7         7.750        .1        13.000        .0        18.250        .0        23.500
  .0
     2.750       3.2         8.000        .1        13.250        .0        18.500        .0        23.750
  .0
     3.000       2.5         8.250        .1        13.500        .0        18.750        .0        24.000
  .0
     3.250       2.0         8.500        .0        13.750        .0        19.000        .0        24.250
  .0
     3.500       1.5         8.750        .0        14.000        .0        19.250        .0        24.500
  .0
     3.750       1.2         9.000        .0        14.250        .0        19.500        .0        24.750
  .0
     4.000       1.0         9.250        .0        14.500        .0        19.750        .0        25.000
  .0
     4.250        .8         9.500        .0        14.750        .0        20.000        .0
     4.500        .6         9.750        .0        15.000        .0        20.250        .0
     4.750        .5        10.000        .0        15.250        .0        20.500        .0
     5.000        .4        10.250        .0        15.500        .0        20.750        .0

     RUNOFF VOLUME =      .44594 INCHES     =       2.2356 ACRE-FEET
     PEAK DISCHARGE RATE =      38.02 CFS  AT   1.650 HOURS   BASIN AREA =   .0940 SQ. MI.


 *
 ************************************************************************
 *S
 *S ADD ROUTED FLOW FROM TEMP POND B TO SUB-BASIN 5

 ADD HYD             ID=1  HYD NO=5.1 ID I=2 ID II=5
 PRINT HYD           ID=1   CODE=1

                                      OUTFLOW HYDROGRAPH REACH     5.10


     RUNOFF VOLUME =      .44118 INCHES     =       5.1270 ACRE-FEET
     PEAK DISCHARGE RATE =      40.11 CFS  AT   1.700 HOURS   BASIN AREA =   .2179 SQ. MI.
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*
*S ROUTE THRU UNSER TEMP POND C
*
ROUTE RESERVOIR         ID=3 HYD=5.93 INFLOW ID=1 CODE=2
                        OUTFLOW(CFS)    STORAGE(AC FT)  ELEV (FT)
                                  0.0             0.0            5329
                                  1.3             0.173          5330
                                  5.7             0.509          5331
                                  12              0.946          5332
                                  19.7            1.211          5333


  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *  *

    TIME      INFLOW    ELEV      VOLUME    OUTFLOW
    (HRS)     (CFS)     (FEET)    (AC-FT)   (CFS)

      .00        .00   5329.00       .000       .00
      .10        .00   5329.00       .000       .00
      .20        .00   5329.00       .000       .00
      .30        .00   5329.00       .000       .00
      .40        .00   5329.00       .000       .00
      .50        .00   5329.00       .000       .00
      .60        .00   5329.00       .000       .00
      .70        .00   5329.00       .000       .00
      .80        .00   5329.00       .000       .00
      .90        .03   5329.00       .000       .00
     1.00        .09   5329.00       .001       .00
     1.10        .15   5329.01       .002       .01
     1.20        .18   5329.02       .003       .02
     1.30        .29   5329.03       .004       .03
     1.40       5.27   5329.11       .019       .15
     1.50      23.66   5329.77       .133      1.00
     1.60      37.65   5330.60       .373      3.92
     1.70      40.11   5331.33       .651      7.75
     1.80      36.05   5331.87       .890     11.19
     1.90      29.81   5332.41      1.054     15.13
     2.00      24.41   5332.73      1.140     17.65
     2.10      20.39   5332.86      1.174     18.64
     2.20      17.31   5332.87      1.175     18.66
     2.30      14.92   5332.79      1.156     18.10
     2.40      13.12   5332.68      1.126     17.22
     2.50      11.82   5332.54      1.090     16.19
     2.60      11.00   5332.41      1.055     15.16
     2.70      10.73   5332.29      1.023     14.24
     2.80      10.52   5332.19       .996     13.46
     2.90      10.32   5332.11       .974     12.81
     3.00      10.12   5332.03       .955     12.26
     3.10       9.93   5331.98       .938     11.89
     3.20       9.75   5331.95       .922     11.66
     3.30       9.57   5331.91       .907     11.43
     3.40       9.39   5331.88       .891     11.21
     3.50       9.22   5331.84       .877     11.00
     3.60       9.06   5331.81       .862     10.79
     3.70       8.90   5331.78       .848     10.59
     3.80       8.75   5331.74       .834     10.39
     3.90       8.60   5331.71       .821     10.20
     4.00       8.46   5331.68       .808     10.01
     4.10       8.32   5331.65       .795      9.83
     4.20       8.19   5331.63       .783      9.65
     4.30       8.06   5331.60       .771      9.48
     4.40       7.93   5331.57       .759      9.31
     4.50       7.79   5331.55       .748      9.15
     4.60       7.63   5331.52       .737      8.99
     4.70       7.45   5331.50       .726      8.82
     4.80       7.27   5331.47       .714      8.66
     4.90       7.08   5331.44       .703      8.49
     5.00       6.88   5331.42       .691      8.32
     5.10       6.68   5331.39       .679      8.15
     5.20       6.47   5331.36       .667      7.97
     5.30       6.26   5331.33       .654      7.79
     5.40       5.98   5331.30       .641      7.60
     5.50       5.63   5331.27       .627      7.40

    TIME      INFLOW    ELEV      VOLUME    OUTFLOW
    (HRS)     (CFS)     (FEET)    (AC-FT)   (CFS)

     5.60       5.27   5331.24       .612      7.18
     5.70       4.93   5331.20       .596      6.95
     5.80       4.59   5331.16       .579      6.70
     5.90       4.26   5331.12       .561      6.45
     6.00       3.94   5331.08       .542      6.18
     6.10       3.63   5331.03       .524      5.91
     6.20       3.34   5330.99       .505      5.64
     6.30       3.07   5330.93       .486      5.39
     6.40       2.82   5330.87       .466      5.14
     6.50       2.64   5330.82       .447      4.89
     6.60       2.49   5330.76       .429      4.65
     6.70       2.36   5330.71       .412      4.43
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6.80	2.22	5330.66	.395	4.21
6.90	2.10	5330.61	.379	4.00
7.00	1.98	5330.57	.364	3.80
7.10	1.87	5330.52	.349	3.60
7.20	1.77	5330.48	.335	3.42
7.30	1.67	5330.44	.322	3.25
7.40	1.58	5330.40	.309	3.08
7.50	1.49	5330.37	.297	2.92
7.60	1.41	5330.33	.285	2.77
7.70	1.33	5330.30	.274	2.63
7.80	1.26	5330.27	.264	2.49
7.90	1.19	5330.24	.254	2.36
8.00	1.12	5330.21	.244	2.24
8.10	1.06	5330.19	.236	2.12
8.20	1.00	5330.16	.227	2.01
8.30	.95	5330.14	.219	1.90
8.40	.90	5330.11	.211	1.80
8.50	.85	5330.09	.204	1.71
8.60	.81	5330.07	.197	1.62
8.70	.76	5330.05	.191	1.53
8.80	.72	5330.03	.184	1.45
8.90	.69	5330.02	.179	1.37
9.00	.65	5330.00	.173	1.30
9.10	.62	5329.97	.168	1.26
9.20	.58	5329.94	.162	1.22
9.30	.56	5329.91	.157	1.18
9.40	.53	5329.88	.152	1.14
9.50	.50	5329.85	.147	1.10
9.60	.48	5329.82	.142	1.07
9.70	.45	5329.79	.137	1.03
9.80	.43	5329.77	.133	1.00
9.90	.41	5329.74	.128	.96
10.00	.39	5329.71	.123	.93
10.10	.37	5329.69	.119	.89
10.20	.35	5329.66	.115	.86
10.30	.34	5329.64	.111	.83
10.40	.32	5329.62	.107	.80
10.50	.31	5329.59	.103	.77
10.60	.29	5329.57	.099	.74
10.70	.28	5329.55	.095	.72
10.80	.27	5329.53	.092	.69
10.90	.26	5329.51	.088	.66
11.00	.25	5329.49	.085	.64
11.10	.24	5329.47	.082	.61

TIME (HRS)	INFLOW (CFS)	ELEV (FEET)	VOLUME (AC-FT)	OUTFLOW (CFS)
11.20	.23	5329.46	.079	.59
11.30	.22	5329.44	.076	.57
11.40	.21	5329.42	.073	.55
11.50	.20	5329.41	.070	.53
11.60	.20	5329.39	.068	.51
11.70	.19	5329.38	.065	.49
11.80	.18	5329.36	.063	.47
11.90	.18	5329.35	.060	.45
12.00	.17	5329.34	.058	.44
12.10	.16	5329.32	.056	.42
12.20	.16	5329.31	.054	.40
12.30	.15	5329.30	.052	.39
12.40	.15	5329.29	.050	.38
12.50	.15	5329.28	.048	.36
12.60	.14	5329.27	.046	.35
12.70	.14	5329.26	.045	.34
12.80	.13	5329.25	.043	.32
12.90	.13	5329.24	.042	.31
13.00	.13	5329.23	.040	.30
13.10	.12	5329.22	.039	.29
13.20	.12	5329.22	.037	.28
13.30	.12	5329.21	.036	.27
13.40	.12	5329.20	.035	.26
13.50	.11	5329.19	.034	.25
13.60	.11	5329.19	.033	.24
13.70	.11	5329.18	.031	.24
13.80	.11	5329.18	.030	.23
13.90	.10	5329.17	.029	.22
14.00	.10	5329.16	.028	.21
14.10	.10	5329.16	.028	.21
14.20	.10	5329.15	.027	.20
14.30	.10	5329.15	.026	.19
14.40	.10	5329.15	.025	.19
14.50	.09	5329.14	.024	.18
14.60	.09	5329.14	.024	.18
14.70	.09	5329.13	.023	.17
14.80	.09	5329.13	.022	.17
14.90	.09	5329.13	.022	.16
15.00	.09	5329.12	.021	.16
15.10	.09	5329.12	.021	.15
15.20	.09	5329.12	.020	.15
15.30	.08	5329.11	.019	.15
15.40	.08	5329.11	.019	.14

15.50	.08	5329.11	.018	.14
15.60	.08	5329.10	.018	.14
15.70	.08	5329.10	.018	.13
15.80	.08	5329.10	.017	.13
15.90	.08	5329.10	.017	.13
16.00	.08	5329.09	.016	.12
16.10	.08	5329.09	.016	.12
16.20	.08	5329.09	.016	.12
16.30	.08	5329.09	.015	.12
16.40	.08	5329.09	.015	.11
16.50	.08	5329.09	.015	.11
16.60	.07	5329.08	.014	.11
16.70	.07	5329.08	.014	.11

TIME (HRS)	INFLOW (CFS)	ELEV (FEET)	VOLUME (AC-FT)	OUTFLOW (CFS)
16.80	.07	5329.08	.014	.10
16.90	.07	5329.08	.014	.10
17.00	.07	5329.08	.013	.10
17.10	.07	5329.08	.013	.10
17.20	.07	5329.08	.013	.10
17.30	.07	5329.07	.013	.10
17.40	.07	5329.07	.013	.09
17.50	.07	5329.07	.012	.09
17.60	.07	5329.07	.012	.09
17.70	.07	5329.07	.012	.09
17.80	.07	5329.07	.012	.09
17.90	.07	5329.07	.012	.09
18.00	.07	5329.07	.012	.09
18.10	.07	5329.07	.011	.09
18.20	.07	5329.06	.011	.08
18.30	.07	5329.06	.011	.08
18.40	.07	5329.06	.011	.08
18.50	.07	5329.06	.011	.08
18.60	.07	5329.06	.011	.08
18.70	.07	5329.06	.011	.08
18.80	.07	5329.06	.011	.08
18.90	.07	5329.06	.010	.08
19.00	.06	5329.06	.010	.08
19.10	.06	5329.06	.010	.08
19.20	.06	5329.06	.010	.08
19.30	.06	5329.06	.010	.08
19.40	.06	5329.06	.010	.07
19.50	.06	5329.06	.010	.07
19.60	.06	5329.06	.010	.07
19.70	.06	5329.06	.010	.07
19.80	.06	5329.06	.010	.07
19.90	.06	5329.05	.009	.07
20.00	.06	5329.05	.009	.07
20.10	.06	5329.05	.009	.07
20.20	.06	5329.05	.009	.07
20.30	.06	5329.05	.009	.07
20.40	.06	5329.05	.009	.07
20.50	.06	5329.05	.009	.07
20.60	.06	5329.05	.009	.07
20.70	.06	5329.05	.009	.07
20.80	.06	5329.05	.009	.07
20.90	.06	5329.05	.009	.07
21.00	.06	5329.05	.009	.07
21.10	.06	5329.05	.009	.07
21.20	.06	5329.05	.009	.07
21.30	.06	5329.05	.009	.06
21.40	.06	5329.05	.009	.06
21.50	.06	5329.05	.009	.06
21.60	.06	5329.05	.008	.06
21.70	.06	5329.05	.008	.06
21.80	.06	5329.05	.008	.06
21.90	.06	5329.05	.008	.06
22.00	.06	5329.05	.008	.06
22.10	.06	5329.05	.008	.06
22.20	.06	5329.05	.008	.06
22.30	.06	5329.05	.008	.06

TIME (HRS)	INFLOW (CFS)	ELEV (FEET)	VOLUME (AC-FT)	OUTFLOW (CFS)
22.40	.06	5329.05	.008	.06
22.50	.06	5329.05	.008	.06
22.60	.06	5329.05	.008	.06
22.70	.06	5329.05	.008	.06
22.80	.06	5329.05	.008	.06
22.90	.06	5329.05	.008	.06
23.00	.06	5329.05	.008	.06
23.10	.06	5329.05	.008	.06
23.20	.06	5329.05	.008	.06
23.30	.05	5329.05	.008	.06
23.40	.05	5329.04	.008	.06
23.50	.05	5329.04	.008	.06
23.60	.05	5329.04	.008	.06
23.70	.05	5329.04	.008	.06

23.80	.05	5329.04	.008	.06
23.90	.05	5329.04	.008	.06
24.00	.05	5329.04	.008	.06
24.10	.05	5329.04	.008	.06
24.20	.05	5329.04	.008	.06
24.30	.04	5329.04	.007	.06
24.40	.04	5329.04	.007	.06
24.50	.04	5329.04	.007	.05
24.60	.03	5329.04	.007	.05
24.70	.03	5329.04	.007	.05
24.80	.03	5329.04	.007	.05
24.90	.03	5329.04	.007	.05
25.00	.03	5329.04	.006	.05
25.10	.03	5329.04	.006	.05
25.20	.02	5329.04	.006	.05
25.30	.02	5329.03	.006	.04
25.40	.02	5329.03	.006	.04
25.50	.02	5329.03	.006	.04
25.60	.02	5329.03	.005	.04
25.70	.02	5329.03	.005	.04
25.80	.02	5329.03	.005	.04
25.90	.02	5329.03	.005	.04
26.00	.02	5329.03	.005	.04
26.10	.01	5329.03	.005	.03
26.20	.01	5329.03	.004	.03
26.30	.01	5329.02	.004	.03
26.40	.01	5329.02	.004	.03
26.50	.01	5329.02	.004	.03
26.60	.01	5329.02	.004	.03
26.70	.01	5329.02	.004	.03
26.80	.01	5329.02	.003	.03
26.90	.01	5329.02	.003	.03
27.00	.01	5329.02	.003	.02
27.10	.01	5329.02	.003	.02
27.20	.01	5329.02	.003	.02
27.30	.01	5329.02	.003	.02
27.40	.01	5329.02	.003	.02
27.50	.01	5329.02	.003	.02
27.60	.01	5329.02	.003	.02
27.70	.01	5329.01	.003	.02
27.80	.01	5329.01	.002	.02
27.90	.01	5329.01	.002	.02

TIME (HRS)	INFLOW (CFS)	ELEV (FEET)	VOLUME (AC-FT)	OUTFLOW (CFS)
28.00	.01	5329.01	.002	.02
28.10	.01	5329.01	.002	.02
28.20	.01	5329.01	.002	.02
28.30	.01	5329.01	.002	.02
28.40	.01	5329.01	.002	.02
28.50	.01	5329.01	.002	.02
28.60	.01	5329.01	.002	.02
28.70	.01	5329.01	.002	.01
28.80	.01	5329.01	.002	.01
28.90	.01	5329.01	.002	.01
29.00	.01	5329.01	.002	.01
29.10	.01	5329.01	.002	.01
29.20	.01	5329.01	.002	.01
29.30	.01	5329.01	.002	.01
29.40	.01	5329.01	.002	.01
29.50	.01	5329.01	.002	.01
29.60	.01	5329.01	.002	.01
29.70	.01	5329.01	.002	.01
29.80	.01	5329.01	.002	.01
29.90	.01	5329.01	.002	.01

PEAK DISCHARGE = 18.742 CFS - PEAK OCCURS AT HOUR 2.15
MAXIMUM WATER SURFACE ELEVATION = 5332.875
MAXIMUM STORAGE = 1.1780 AC-FT INCREMENTAL TIME= .050000HRS

PRINT HYD ID=3 CODE=5

OUTFLOW HYDROGRAPH REACH 5.93

TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS
.000	.0	6.000	6.2	12.000	.4	18.000	.1	24.000	.1
.250	.0	6.250	5.5	12.250	.4	18.250	.1	24.250	.1
.500	.0	6.500	4.9	12.500	.4	18.500	.1	24.500	.1
.750	.0	6.750	4.3	12.750	.3	18.750	.1	24.750	.1
1.000	.0	7.000	3.8	13.000	.3	19.000	.1	25.000	.0
1.250	.0	7.250	3.3	13.250	.3	19.250	.1	25.250	.0
1.500	1.0	7.500	2.9	13.500	.3	19.500	.1	25.500	

.0

1.750	9.6	7.750	2.6	13.750	.2	19.750	.1	25.750

.0

2.000	17.6	8.000	2.2	14.000	.2	20.000	.1	26.000

.0

2.250	18.4	8.250	2.0	14.250	.2	20.250	.1	26.250

.0

2.500	16.2	8.500	1.7	14.500	.2	20.500	.1	26.500

.0

2.750	13.8	8.750	1.5	14.750	.2	20.750	.1	26.750

.0

3.000	12.3	9.000	1.3	15.000	.2	21.000	.1	27.000

.0

3.250	11.5	9.250	1.2	15.250	.1	21.250	.1	27.250

.0

3.500	11.0	9.500	1.1	15.500	.1	21.500	.1	27.500

.0

3.750	10.5	9.750	1.0	15.750	.1	21.750	.1	27.750

.0

4.000	10.0	10.000	.9	16.000	.1	22.000	.1	28.000

.0

4.250	9.6	10.250	.8	16.250	.1	22.250	.1	28.250

.0

4.500	9.1	10.500	.8	16.500	.1	22.500	.1	28.500

.0

4.750	8.7	10.750	.7	16.750	.1	22.750	.1	28.750

.0

5.000	8.3	11.000	.6	17.000	.1	23.000	.1	29.000

.0

5.250	7.9	11.250	.6	17.250	.1	23.250	.1	29.250

.0

5.500	7.4	11.500	.5	17.500	.1	23.500	.1	29.500

.0

5.750	6.8	11.750	.5	17.750	.1	23.750	.1	29.750

.0

RUNOFF VOLUME = .44104 INCHES = 5.1254 ACRE-FEET
PEAK DISCHARGE RATE = 18.74 CFS AT 2.150 HOURS BASIN AREA = .2179 SQ. MI.

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*S APPLY NO SEDIMENT BULKING FACTOR
SEDIMENT BULK CODE=1 BULKING FACTOR = 1.00

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*S RECALL HYD FROM SAD 228 POND 4
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*S
RECALL HYD ID=14 HYD=POND4A
DT= .050000 HRS DA= .0205 SQ MI
PEAK= 18.038CFS RO= 1.4138 INCHES NO PTS=503
FLOW RATES

.000	.000	.000	.000	.000
.000	.000	.000	.000	.000
.000	.000	.000	.000	.001
.020	.091	.228	.402	.568
.709	.826	.908	.922	.917
1.110	1.922	4.102	7.064	10.145
11.550	13.447	15.337	16.809	17.708
18.038	18.026	17.734	17.205	16.542
15.798	15.014	14.211	13.388	12.542
11.685	10.840	10.027	7.066	3.940
2.143	1.856	1.674	1.516	1.375
1.250	1.138	1.040	.952	.874
.804	.740	.684	.634	.589
.550	.515	.485	.458	.433
.410	.389	.370	.352	.336
.323	.312	.302	.293	.285
.278	.272	.267	.262	.257
.253	.250	.247	.244	.241
.240	.239	.238	.236	.234
.232	.229	.228	.227	.227
.228	.229	.230	.231	.231
.231	.232	.233	.234	.236
.238	.239	.240	.241	.243
.244	.245	.246	.248	.250
.251	.253	.251	.239	.219
.198	.181	.170	.162	.157
.153	.151	.148	.147	.145
.144	.143	.143	.141	.140
.139	.138	.137	.136	.135
.135	.134	.133	.133	.132
.132	.131	.131	.131	.130
.130	.129	.128	.128	.127
.126	.126	.126	.126	.125

.125	.124	.123	.124	.123
.122	.122	.122	.122	.121
.121	.120	.120	.120	.120
.119	.118	.118	.117	.117
.117	.117	.117	.117	.116
.115	.115	.115	.115	.114
.114	.113	.113	.113	.113
.113	.112	.111	.111	.110
.110	.110	.110	.109	.109
.109	.109	.109	.108	.107
.107	.107	.106	.106	.106
.106	.106	.106	.106	.105
.104	.104	.104	.104	.103
.103	.103	.102	.102	.101
.101	.101	.101	.101	.101
.101	.101	.101	.100	.099
.099	.099	.099	.098	.098
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.096	.095	.095	.095	.095
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.091	.091	.090	.090	.090
.090	.090	.090	.090	.090
.089	.089	.089	.088	.088
.088	.088	.088	.087	.087
.088	.087	.087	.086	.086
.085	.085	.086	.087	.087
.086	.086	.085	.084	.083
.083	.083	.084	.084	.084
.084	.084	.083	.083	.083
.083	.082	.082	.082	.082
.081	.081	.081	.081	.081
.081	.081	.080	.080	.081
.081	.081	.080	.080	.079
.079	.078	.079	.079	.079
.079	.079	.078	.078	.078
.078	.078	.078	.077	.077
.077	.077	.077	.076	.076
.076	.077	.077	.076	.075
.075	.075	.075	.074	.075
.075	.076	.076	.076	.075
.075	.074	.073	.072	.072
.073	.073	.073	.074	.074
.074	.073	.072	.072	.072
.073	.072	.072	.072	.072
.072	.071	.071	.072	.072
.071	.071	.071	.071	.071
.071	.070	.070	.069	.069
.069	.070	.070	.070	.070
.069	.069	.069	.069	.069
.069	.068	.068	.068	.068
.068	.068	.068	.068	.068
.067	.067	.067	.067	.067
.067	.067	.067	.066	.066
.067	.066	.066	.065	.066
.066	.066	.065	.065	.066
.066	.066	.065	.065	.064
.064	.064	.064	.064	.065
.065	.066	.065	.065	.064
.064	.064	.064	.064	.064
.064	.063	.062	.062	.062
.062	.062	.061	.054	.043
.032	.022	.016	.012	.009
.008	.007	.006	.005	.004
.004	.003	.003	.002	.002
.002	.001	.001		

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*S
*S ADD SAD 228 POND 4 OUTFLOW TO TEMP POND C OUTFLOW

ADD HYD             ID=4  HYD NO=200.3 ID I=3 ID II=14
PRINT HYD           ID=4   CODE=1

                                PARTIAL HYDROGRAPH   200.30


    RUNOFF VOLUME =      .52468 INCHES     =       6.6711 ACRE-FEET
    PEAK DISCHARGE RATE =      33.45 CFS  AT   2.000 HOURS   BASIN AREA =   .2384 SQ. MI.


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*S RECALL HYD FROM SAD 228 POND 5
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*S
RECALL HYD          ID=12  HYD=POND5
                    DT=  .050000 HRS   DA=    .1489 SQ MI
                    PEAK=     36.968CFS  RO= 1.5473 INCHES  NO PTS=600
                    FLOW RATES
                          .000       .000       .000       .000       .000
                          .000       .000       .000       .000       .000
                          .000       .000       .000       .000       .000
                          .001       .004       .016       .042       .087
                          .155       .246       .358       .485       .621
                          .767       .948      1.234      1.765      2.740
                         4.748      9.594     15.707     21.217     25.243
                        28.978     31.229     33.174     34.808     35.892
                        36.174     36.404     36.589     36.734     36.842
                        36.915     36.956     36.968     36.957     36.926
                        36.881     36.825     36.760     36.687     36.608
                        36.524     36.436     36.344     36.248     36.149
                        36.048     35.944     35.837     35.519     35.090
                        34.659     34.228     33.796     33.364     32.934
                        32.504     32.077     31.651     31.229     30.808
                        30.391     29.977     29.567     29.160     28.736
                        28.129     27.535     26.951     26.379     25.818
                        25.269     24.730     24.203     23.686     23.180
                        22.685     22.201     21.726     21.263     20.809
                        20.366     19.932     19.508     18.867     18.173
                        17.507     16.868     16.255     15.668     15.105
                        14.565     14.047     13.551     13.076     12.620
                        12.183     11.766     11.365     10.982     10.615
                        10.263      9.927      9.605      9.296      9.001
                         8.718      8.448      8.189      7.941      7.700
                         7.466      7.236      7.010      6.789      6.573
                         6.363      6.159      5.961      5.771      5.587
                         5.411      5.241      5.078      4.921      4.770
                         4.625      4.486      4.352      4.223      4.099
                         3.990      3.934      3.879      3.825      3.772
                         3.719      3.668      3.617      3.567      3.519
                         3.471      3.424      3.378      3.332      3.288
                         3.244      3.201      3.159      3.118      3.077
                         3.037      2.998      2.960      2.922      2.885
                         2.849      2.813      2.778      2.744      2.710
                         2.677      2.644      2.613      2.581      2.551
                         2.520      2.491      2.462      2.433      2.405
                         2.378      2.350      2.324      2.298      2.272
                         2.247      2.223      2.199      2.175      2.152
                         2.129      2.106      2.084      2.062      2.041
                         2.020      1.999      1.979      1.959      1.940
                         1.921      1.902      1.883      1.865      1.847
                         1.829      1.812      1.795      1.779      1.762
                         1.746      1.730      1.715      1.700      1.684
                         1.670      1.655      1.641      1.627      1.613
                         1.600      1.586      1.573      1.560      1.548
                         1.535      1.523      1.511      1.499      1.487
                         1.476      1.464      1.453      1.442      1.431
                         1.421      1.410      1.400      1.390      1.380
                         1.371      1.361      1.352      1.342      1.333
                         1.324      1.315      1.307      1.298      1.290
                         1.281      1.273      1.265      1.257      1.249
                         1.241      1.233      1.226      1.219      1.211
                         1.204      1.197      1.190      1.183      1.177
                         1.170      1.163      1.157      1.150      1.144
                         1.138      1.132      1.126      1.120      1.114
                         1.108      1.103      1.097      1.091      1.086
                         1.080      1.075      1.070      1.065      1.060
                         1.055      1.050      1.045      1.040      1.035
                         1.030      1.026      1.021      1.016      1.012
                         1.007      1.003       .999       .994       .990
                          .986       .982       .978       .974       .970
                          .966       .962       .959       .955       .951
                          .947       .943       .940       .936       .932
                          .929       .926       .922       .919       .916
                          .912       .909       .906       .903       .899
                          .896       .893       .890       .887       .884
                          .881       .878       .875       .872       .869
                          .866       .864       .861       .858       .856
                          .853       .850       .848       .845       .842
                          .840       .837       .835       .832       .830
                          .827       .825       .823       .820       .818
                          .816       .813       .811       .809       .806
                          .804       .802       .800       .797       .795
                          .793       .791       .789       .787       .784
                          .782       .780       .778       .776       .775
                          .773       .771       .769       .767       .765
                          .763       .761       .759       .757       .755
                          .753       .752       .750       .748       .746
                          .744       .743       .741       .739       .737
                          .736       .734       .732       .730       .729
                          .727       .726       .724       .722       .721
                          .719       .718       .716       .714       .713
                          .711       .710       .708       .706       .705
                          .704       .702       .701       .699       .698
                          .696       .695       .693       .692       .690
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.689	.687	.686	.685	.683
.682	.681	.679	.678	.676
.675	.674	.672	.671	.670
.668	.667	.666	.664	.663
.662	.660	.659	.658	.657
.655	.654	.653	.652	.651
.649	.648	.647	.645	.644
.643	.642	.641	.640	.639
.638	.637	.636	.634	.633
.632	.631	.630	.629	.627
.626	.625	.624	.622	.620
.617	.612	.606	.599	.591
.582	.573	.563	.554	.544
.534	.525	.515	.506	.496
.487	.478	.469	.460	.451
.442	.433	.425	.417	.408
.400	.392	.384	.377	.369
.362	.355	.347	.340	.333
.327	.320	.314	.307	.301
.295	.289	.283	.277	.271
.266	.260	.255	.250	.245
.240	.235	.230	.225	.221
.216	.211	.207	.203	.199
.195	.191	.187	.183	.179
.175	.172	.168	.165	.161
.158	.155	.151	.148	.145
.142	.139	.136	.134	.131
.128	.125	.123	.120	.118
.115	.113	.111	.108	.106
.104	.102	.100	.098	.096
.094	.092	.090	.088	.086
.084	.083	.081	.079	.078
.076	.074	.073	.071	.070
.068	.067	.066	.064	.063

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*S
*S ADD SAD 228 POND 4 & 5 OUTFLOW TO TEMP POND C OUTFLOW

ADD HYD             ID=1  HYD NO=201.1 ID I=4 ID II=12
PRINT HYD           ID=1   CODE=1

                                  PARTIAL HYDROGRAPH   201.10


    RUNOFF VOLUME =      .91782 INCHES     =      18.9584 ACRE-FEET
    PEAK DISCHARGE RATE =      69.71 CFS  AT   2.050 HOURS   BASIN AREA =   .3873 SQ. MI.


*
**********************************************************************
*
*S ROUTE 201.1 IN 54" SD IN UNSER BLVD TO GET 201.7
*
COMPUTE RATING CURVE       CID=1   VS NO=1 NO SEGS=-1  SLP=0.0112
                                   DIAM=4.5 FT     N=0.013


                                   RATING CURVE PIPE SECTION  1.0
                                      WATER       FLOW        FLOW        MAX
                                     SURFACE      AREA        RATE        WIDTH
                                      ELEV        SQ FT       CFS         FT
                                        .00         .00         .00         .00
                                        .23         .32        1.09        2.00
                                        .47         .88        4.74        2.75
                                        .70        1.59       11.02        3.27
                                        .94        2.40       19.81        3.66
                                       1.17        3.30       30.94        3.95
                                       1.41        4.25       44.14        4.17
                                       1.64        5.25       59.14        4.33
                                       1.88        6.28       75.61        4.44
                                       2.11        7.32       93.21        4.49
                                       2.35        8.38      111.55        4.50
                                       2.58        9.43      130.23        4.50
                                       2.81       10.46      148.80        4.50
                                       3.05       11.47      166.78        4.50
                                       3.28       12.43      183.61        4.50
                                       3.52       13.34      198.68        4.50
                                       3.75       14.17      211.21        4.50
                                       3.99       14.90      220.18        4.50
                                       4.22       15.50      223.87        4.50
                                       4.50       15.90      223.87        4.50
ROUTE MCUNGE        ID=7   HYD NO=102.7    INFLOW ID=1
                           DT=0.0 HR       LENGTH=730 FT
                           NS=0    SLOPE=0.0112  CODE=5


     INFLOW END= 600            TABLE PTS= 19
     DT=  .050000               QMED=       34.86  CKMED=     13.8449
```

WIDTH MED= 4.02 NREACH= 1 DX= 730.00

DEPTH (FT)	AREA (SQ FT)	Q (CFS)	TRAVEL TIME(HR)	WIDTH (FT)	ck (FPS)	VEL (FPS)	C	D	C1	C2	C3	Q-M (CFS)	C1-M	C2-M	C3-M
.00	.0	.0	.080	.0	4.06	1.63	1.000	.000	1.000	.000	.000	.0	1.000	.000	.000
.23	.3	1.1	.059	2.0	5.68	3.45	1.401	.012	.990	.171	-.161	.2	.998	.027	-.025
.47	.9	4.7	.038	2.7	7.84	5.39	1.933	.027	.982	.324	-.306	2.6	.984	.238	-.222
.70	1.6	11.0	.029	3.3	9.93	6.94	2.448	.042	.976	.427	-.403	7.6	.978	.380	-.358
.94	2.4	19.8	.025	3.7	11.69	8.25	2.882	.057	.971	.492	-.463	15.2	.973	.462	-.436
1.17	3.3	30.9	.022	4.0	13.18	9.39	3.251	.073	.966	.537	-.504	25.2	.969	.517	-.486
1.41	4.2	44.1	.020	4.2	14.46	10.39	3.565	.090	.962	.570	-.532	37.3	.964	.556	-.519
1.64	5.2	59.1	.018	4.3	15.53	11.27	3.829	.108	.956	.595	-.551	51.5	.959	.584	-.543
1.88	6.3	75.6	.017	4.4	16.41	12.05	4.045	.127	.951	.613	-.564	67.2	.954	.605	-.559
2.11	7.3	93.2	.016	4.5	17.09	12.73	4.215	.148	.945	.627	-.572	84.3	.948	.621	-.569
2.35	8.4	111.6	.015	4.5	17.57	13.31	4.333	.173	.937	.637	-.574	102.3	.941	.633	-.574
2.58	9.4	130.2	.015	4.5	17.69	13.81	4.361	.200	.928	.640	-.568	120.8	.933	.640	-.573
2.81	10.5	148.8	.014	4.5	17.36	14.22	4.279	.233	.915	.637	-.553	139.5	.922	.640	-.562
3.05	11.5	166.8	.014	4.5	16.53	14.54	4.077	.274	.898	.626	-.524	157.8	.908	.633	-.541
3.28	12.4	183.6	.014	4.5	15.15	14.77	3.737	.329	.870	.605	-.475	175.2	.886	.618	-.504
3.52	13.3	198.7	.014	4.5	13.11	14.90	3.233	.412	.823	.569	-.392	191.2	.851	.591	-.442
3.75	14.2	211.2	.014	4.5	10.21	14.91	2.517	.562	.724	.510	-.234	205.0	.787	.545	-.332
3.99	14.9	220.2	.014	4.5	5.98	14.78	1.474	1.001	.424	.425	.151	215.7	.635	.472	-.107
4.22	15.5	223.9	.014	4.5	3.41	14.45	.840	1.785	.015	.448	.536	222.1	.037	.443	.520

MAXIMUM NO. ITERATIONS FOR SOLUTION (KKMAX) = 3 OCCURRED 7 TIMES. AVERAGE NUMBER ITERATIONS = 1.3276
Equations solved using the Ponce correction to C2
PRINT HYD ID=7 CODE=5

PARTIAL HYDROGRAPH 102.70

TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS
.000	.0	6.000	15.3	12.000	2.0	18.000	1.0	24.000	.7
.250	.0	6.250	13.3	12.250	1.9	18.250	1.0	24.250	.7
.500	.0	6.500	11.5	12.500	1.8	18.500	1.0	24.500	.7
.750	.0	6.750	10.0	12.750	1.7	18.750	.9	24.750	.6
1.000	.7	7.000	8.7	13.000	1.6	19.000	.9	25.000	.5
1.250	1.6	7.250	7.5	13.250	1.6	19.250	.9	25.250	.5
1.500	15.9	7.500	6.8	13.500	1.5	19.500	.9	25.500	.4
1.750	55.1	7.750	6.2	13.750	1.5	19.750	.9	25.750	.4
2.000	69.6	8.000	5.7	14.000	1.4	20.000	.9	26.000	.4
2.250	67.3	8.250	5.2	14.250	1.4	20.250	.9	26.250	.3
2.500	55.7	8.500	4.7	14.500	1.3	20.500	.9	26.500	.3
2.750	51.8	8.750	4.3	14.750	1.3	20.750	.8	26.750	.3
3.000	49.2	9.000	4.0	15.000	1.3	21.000	.8	27.000	.2
3.250	46.9	9.250	3.7	15.250	1.2	21.250	.8	27.250	.2
3.500	44.1	9.500	3.5	15.500	1.2	21.500	.8	27.500	.2
3.750	41.4	9.750	3.3	15.750	1.2	21.750	.8	27.750	.2
4.000	38.6	10.000	3.1	16.000	1.1	22.000	.8	28.000	.2
4.250	35.3	10.250	2.9	16.250	1.1	22.250	.8	28.250	.1
4.500	32.2	10.500	2.7	16.500	1.1	22.500	.8	28.500	.1

```
      4.750      29.5         10.750       2.6         16.750       1.1         22.750        .8         28.750
.1
      5.000      26.3         11.000       2.4         17.000       1.1         23.000        .8         29.000
.1
      5.250      22.9         11.250       2.3         17.250       1.0         23.250        .8         29.250
.1
      5.500      20.0         11.500       2.2         17.500       1.0         23.500        .8         29.500
.1
      5.750      17.5         11.750       2.1         17.750       1.0         23.750        .8         29.750
.1

     RUNOFF VOLUME =      .91781 INCHES     =      18.9581 ACRE-FEET
     PEAK DISCHARGE RATE =      69.68 CFS  AT   2.050 HOURS   BASIN AREA =   .3873 SQ. MI.



*
**********************************************************************
*S  APPLY SEDIMENT BULKING FACTOR
SEDIMENT BULK          CODE=1   BULKING FACTOR = 1.05

*
**********************************************************************
*S
*S COMPUTE UNSER BLVD RUNOFF SOUTH OF KIMMICK TO BOCA NEGRA DAM
*
*
COMPUTE LT TP       LCODE=1  UPLAND/LAG TIME TRANSITION METHOD
                    NK=3  ISLOPE=-1
                    LENGTH=400 FT   SLOPE=0.005 K=0.7
                    LENGTH=770 FT  SLOPE=0.005 K=2.0



     Tc AND Tp COMPUTED BY UPLAND/LAG TIME PROCEDURE

     SCS UPLAND METHOD FACTORS
          NOTE: Upland factor input values have been adjusted to meet Upland/Lag Time requirements.
                              LENGTH (FT)      SLOPE (FT/FT)       COMPOSITE K
     SHEET FLOW PORTION           400.0           .005000             .7000
     SHALLOW FLOW PORTION         770.0           .005000            2.0000
     CHANNEL FLOW PORTION            .0           .000000             .0000
     TOTAL BASIN                1170.0           .005000            1.2233


     TIME OF CONCENTRATION (HRS)=   .3757     TIME TO PEAK (HRS)=   .2505     LAG TIME (HRS)=   .2818

COMPUTE NM HYD      ID=6   HYD NO=6   DA=0.01166 SQ MI
                    PER A=0 PER B=0  PER C=15  PER D=85
                    TP=0.0   MASSRAIN=-1
     TIME TO PEAK (hrs)=   .2505

     K =   .136512HR    TP =   .250481HR    K/TP RATIO =   .545000     SHAPE CONSTANT, N =  7.106420
     UNIT PEAK =   20.824    CFS   UNIT VOLUME =    .9997       B =   526.28      P60 = 1.6900
     AREA =      .009911 SQ MI    IA =    .10000 INCHES    INF =    .04000 INCHES PER HOUR
     RUNOFF COMPUTED BY INITIAL ABSTRACTION/INFILTRATION NUMBER METHOD - DT =   .050000


     K =   .195117HR    TP =   .250481HR    K/TP RATIO =   .778968     SHAPE CONSTANT, N =  4.614413
     UNIT PEAK =   2.7528    CFS   UNIT VOLUME =    .9954       B =   394.24      P60 = 1.6900
     AREA =      .001749 SQ MI    IA =    .35000 INCHES    INF =    .83000 INCHES PER HOUR
     RUNOFF COMPUTED BY INITIAL ABSTRACTION/INFILTRATION NUMBER METHOD - DT =   .050000

    BULKING FACTOR APPLIED TO HYDROGRAPH.  FACTOR =  1.05000 AT PEAK FLOW.

PRINT HYD           ID=6   CODE=1

                                      OUTFLOW HYDROGRAPH REACH     6.00


    RUNOFF VOLUME =     2.18501 INCHES     =       1.3588 ACRE-FEET
    PEAK DISCHARGE RATE =      21.35 CFS  AT   1.600 HOURS   BASIN AREA =   .0117 SQ. MI.



*
**********************************************************************
*
*S ADD TOTAL FLOWS FROM UNSER BLVD

ADD HYD             ID=2  HYD NO=6.2 ID I=7 ID II=6
PRINT HYD           ID=2   CODE=1

                                      OUTFLOW HYDROGRAPH REACH     6.20


    RUNOFF VOLUME =      .95484 INCHES     =      20.3169 ACRE-FEET
    PEAK DISCHARGE RATE =      78.37 CFS  AT   1.950 HOURS   BASIN AREA =   .3990 SQ. MI.
```

```
*
**********************************************************************
*
*S ADD PIPE.80 TO 6.2 TO GET PIPE.1
*
ADD HYD             ID=1  HYD NO=PIPE.1 ID I=80 ID II=2
PRINT HYD           ID=1   CODE=1
```

HYDROGRAPH FROM AREA PIPE.1

RUNOFF VOLUME = .53374 INCHES = 277.4568 ACRE-FEET
PEAK DISCHARGE RATE = 450.37 CFS AT 1.950 HOURS BASIN AREA = 9.7469 SQ. MI.

```
*
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**********************************************************************
*
*S ROUTE PIPE.1 IN 60" SD TO GET PIPE.2
*
COMPUTE RATING CURVE       CID=1   VS NO=1 NO SEGS=-1  SLP=0.015
                                   DIAM=5.0 FT     N=0.013
```

RATING CURVE PIPE SECTION 1.0

WATER SURFACE ELEV	FLOW AREA SQ FT	FLOW RATE CFS	MAX WIDTH FT
.00	.00	.00	.00
.26	.39	1.67	2.22
.52	1.09	7.26	3.06
.78	1.96	16.89	3.63
1.04	2.97	30.37	4.06
1.30	4.07	47.42	4.39
1.56	5.25	67.65	4.64
1.82	6.48	90.64	4.81
2.08	7.75	115.89	4.93
2.35	9.04	142.86	4.99
2.61	10.35	170.98	5.00
2.87	11.64	199.61	5.00
3.13	12.92	228.07	5.00
3.39	14.16	255.62	5.00
3.65	15.35	281.43	5.00
3.91	16.47	304.52	5.00
4.17	17.49	323.73	5.00
4.43	18.39	337.48	5.00
4.69	19.13	343.12	5.00
5.00	19.63	343.12	5.00

```
ROUTE MCUNGE        ID=8   HYD NO=PIPE.2   INFLOW ID=1
                           DT=0.0 HR       LENGTH=640 FT
                           NS=0    SLOPE=0.015  CODE=5
```

ZERO VALUE HYDROGRAPH OR SHORT ROUTE - ROUTING BYPASSED

```
PRINT HYD           ID=8   CODE=5
```

HYDROGRAPH FROM AREA PIPE.2

TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS
.000	.0	6.000	387.6	12.000	58.0	18.000	38.6	24.000	19.2
.250	.0	6.250	385.6	12.250	56.4	18.250	38.3	24.250	17.9
.500	.0	6.500	383.8	12.500	54.9	18.500	37.9	24.500	15.9
.750	.0	6.750	382.2	12.750	53.4	18.750	37.5	24.750	14.0
1.000	1.7	7.000	380.9	13.000	52.1	19.000	37.1	25.000	12.5
1.250	6.1	7.250	379.7	13.250	50.9	19.250	36.6	25.250	11.4
1.500	67.7	7.500	306.7	13.500	49.8	19.500	36.1	25.500	10.5
1.750	443.6	7.750	189.2	13.750	48.7	19.750	35.5	25.750	9.9
2.000	450.3	8.000	147.0	14.000	47.8	20.000	34.9	26.000	9.4
2.250	443.9	8.250	125.3	14.250	46.9	20.250	34.2	26.250	9.0
2.500	429.8	8.500	112.0	14.500	46.0	20.500	33.5	26.500	8.7
2.750	425.1	8.750	105.9	14.750	45.2	20.750	32.8	26.750	8.5
3.000	422.1	9.000	100.2	15.000	44.4	21.000	32.1	27.000	8.2
3.250	419.5	9.250	94.8	15.250	43.7	21.250	30.9	27.250	

3.500	416.5	9.500	89.5	15.500	43.0	21.500	29.7	27.500
8.1								
3.750	413.7	9.750	84.6	15.750	42.3	21.750	28.5	27.750
7.9								
4.000	411.0	10.000	80.0	16.000	41.7	22.000	27.4	28.000
7.7								
4.250	407.6	10.250	75.8	16.250	41.2	22.250	26.4	28.250
7.5								
4.500	404.5	10.500	72.0	16.500	40.9	22.500	25.5	28.500
7.3								
4.750	401.8	10.750	68.7	16.750	40.5	22.750	24.5	28.750
7.2								
5.000	398.6	11.000	65.6	17.000	40.1	23.000	23.4	29.000
7.1								
5.250	395.2	11.250	63.4	17.250	39.8	23.250	22.3	29.250
6.7								
5.500	392.3	11.500	61.6	17.500	39.4	23.500	21.2	29.500
6.2								
5.750	389.8	11.750	59.8	17.750	39.0	23.750	20.2	29.750
5.6								
5.0								

RUNOFF VOLUME = .53374 INCHES = 277.4568 ACRE-FEET
PEAK DISCHARGE RATE = 450.37 CFS AT 1.950 HOURS BASIN AREA = 9.7469 SQ. MI.

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*
**********************************************************************
*
*S ROUTE PIPE.2 IN 54" SD TO GET PIPE.3
*
COMPUTE RATING CURVE       CID=1   VS NO=1 NO SEGS=-1  SLP=0.0881
                                   DIAM=4.5 FT     N=0.013
```

RATING CURVE PIPE SECTION 1.0

WATER SURFACE ELEV	FLOW AREA SQ FT	FLOW RATE CFS	MAX WIDTH FT
.00	.00	.00	.00
.23	.32	3.06	2.00
.47	.88	13.29	2.75
.70	1.59	30.90	3.27
.94	2.40	55.57	3.66
1.17	3.30	86.77	3.95
1.41	4.25	123.80	4.17
1.64	5.25	165.86	4.33
1.88	6.28	212.06	4.44
2.11	7.32	261.42	4.49
2.35	8.38	312.87	4.50
2.58	9.43	365.26	4.50
2.81	10.46	417.34	4.50
3.05	11.47	467.76	4.50
3.28	12.43	514.97	4.50
3.52	13.34	557.23	4.50
3.75	14.17	592.38	4.50
3.99	14.90	617.54	4.50
4.22	15.50	627.88	4.50
4.50	15.90	627.88	4.50

```
ROUTE MCUNGE        ID=1   HYD NO=PIPE.3   INFLOW ID=8
                           DT=0.0 HR       LENGTH=1147 FT
                           NS=0    SLOPE=0.0881  CODE=5

     ZERO VALUE HYDROGRAPH OR SHORT ROUTE - ROUTING BYPASSED
PRINT HYD           ID=1   CODE=5
```

HYDROGRAPH FROM AREA PIPE.3

TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS
.000	.0	6.000	387.6	12.000	58.0	18.000	38.6	24.000	19.2
.250	.0	6.250	385.6	12.250	56.4	18.250	38.3	24.250	17.9
.500	.0	6.500	383.8	12.500	54.9	18.500	37.9	24.500	15.9
.750	.0	6.750	382.2	12.750	53.4	18.750	37.5	24.750	14.0
1.000	1.7	7.000	380.9	13.000	52.1	19.000	37.1	25.000	12.5
1.250	6.1	7.250	379.7	13.250	50.9	19.250	36.6	25.250	11.4
1.500	67.7	7.500	306.7	13.500	49.8	19.500	36.1	25.500	10.5
1.750	443.6	7.750	189.2	13.750	48.7	19.750	35.5	25.750	9.9
2.000	450.3	8.000	147.0	14.000	47.8	20.000	34.9	26.000	9.4

2.250	443.9	8.250	125.3	14.250	46.9	20.250	34.2	26.250
9.0								
2.500	429.8	8.500	112.0	14.500	46.0	20.500	33.5	26.500
8.7								
2.750	425.1	8.750	105.9	14.750	45.2	20.750	32.8	26.750
8.5								
3.000	422.1	9.000	100.2	15.000	44.4	21.000	32.1	27.000
8.2								
3.250	419.5	9.250	94.8	15.250	43.7	21.250	30.9	27.250
8.1								
3.500	416.5	9.500	89.5	15.500	43.0	21.500	29.7	27.500
7.9								
3.750	413.7	9.750	84.6	15.750	42.3	21.750	28.5	27.750
7.7								
4.000	411.0	10.000	80.0	16.000	41.7	22.000	27.4	28.000
7.5								
4.250	407.6	10.250	75.8	16.250	41.2	22.250	26.4	28.250
7.3								
4.500	404.5	10.500	72.0	16.500	40.9	22.500	25.5	28.500
7.2								
4.750	401.8	10.750	68.7	16.750	40.5	22.750	24.5	28.750
7.1								
5.000	398.6	11.000	65.6	17.000	40.1	23.000	23.4	29.000
6.7								
5.250	395.2	11.250	63.4	17.250	39.8	23.250	22.3	29.250
6.2								
5.500	392.3	11.500	61.6	17.500	39.4	23.500	21.2	29.500
5.6								
5.750	389.8	11.750	59.8	17.750	39.0	23.750	20.2	29.750
5.0								

RUNOFF VOLUME = .53374 INCHES = 277.4568 ACRE-FEET
PEAK DISCHARGE RATE = 450.37 CFS AT 1.950 HOURS BASIN AREA = 9.7469 SQ. MI.

*
****
*
*S ROUTE PIPE.3 IN 60" SD TO GET PIPE.4
*
COMPUTE RATING CURVE CID=1 VS NO=1 NO SEGS=-1 SLP=0.02
DIAM=5.0 FT N=0.013

RATING CURVE PIPE SECTION 1.0

WATER SURFACE ELEV	FLOW AREA SQ FT	FLOW RATE CFS	MAX WIDTH FT
.00	.00	.00	.00
.26	.39	1.93	2.22
.52	1.09	8.39	3.06
.78	1.96	19.50	3.63
1.04	2.97	35.07	4.06
1.30	4.07	54.75	4.39
1.56	5.25	78.12	4.64
1.82	6.48	104.66	4.81
2.08	7.75	133.82	4.93
2.35	9.04	164.96	4.99
2.61	10.35	197.43	5.00
2.87	11.64	230.49	5.00
3.13	12.92	263.36	5.00
3.39	14.16	295.17	5.00
3.65	15.35	324.96	5.00
3.91	16.47	351.63	5.00
4.17	17.49	373.81	5.00
4.43	18.39	389.68	5.00
4.69	19.13	396.21	5.00
5.00	19.63	396.21	5.00

ROUTE MCUNGE ID=8 HYD NO=PIPE.4 INFLOW ID=1
DT=0.0 HR LENGTH=949 FT
NS=0 SLOPE=0.02 CODE=5

INFLOW END= 600 TABLE PTS= 19
DT= .050000 QMED= 225.19 CKMED= 25.5022
WIDTH MED= 5.00 NREACH= 1 DX= 949.00

DEPTH (FT)	AREA (SQ FT)	Q (CFS)	TRAVEL TIME(HR)	WIDTH (FT)	ck (FPS)	VEL (FPS)	C	D	C1	C2	C3	Q-M (CFS)	C1-M	C2-M	C3-M
.00	.0	.0	.072	.0	5.27	2.33	1.000	.000	1.000	.000	.000	.0	1.000	.000	.000
.26	.4	1.9	.053	2.2	8.15	4.95	1.545	.006	.996	.216	-.211	.3	.998	.033	-.030
.52	1.1	8.4	.034	3.1	11.24	7.72	2.132	.013	.992	.364	-.356	4.6	.993	.280	-.273
.78	2.0	19.5	.027	3.6	14.23	9.94	2.699	.020	.989	.462	-.452	13.5	.990	.417	-.407
1.04	3.0	35.1	.022	4.1	16.75	11.82	3.178	.027	.987	.524	-.511	26.9	.988	.496	-.484

1.30	4.1	54.8	.020	4.4	18.90	13.46	3.585	.035	.985	.567	-.552	44.5	.986
.548	-.534												
1.56	5.2	78.1	.018	4.6	20.73	14.89	3.931	.043	.983	.598	-.581	66.1	.984
.584	-.568												
1.82	6.5	104.7	.016	4.8	22.26	16.16	4.222	.051	.980	.621	-.601	91.1	.982
.611	-.592												
2.08	7.7	133.8	.015	4.9	23.52	17.27	4.461	.061	.978	.638	-.616	119.0	.979
.630	-.610												
2.35	9.0	165.0	.014	5.0	24.51	18.24	4.648	.071	.975	.650	-.625	149.2	.977
.645	-.622												
2.61	10.3	197.4	.014	5.0	25.19	19.08	4.778	.083	.972	.659	-.631	181.0	.974
.656	-.629												
2.87	11.6	230.5	.013	5.0	25.35	19.80	4.809	.096	.968	.661	-.629	213.8	.970
.661	-.631												
3.13	12.9	263.4	.013	5.0	24.88	20.39	4.719	.112	.962	.657	-.619	246.8	.965
.660	-.625												
3.39	14.2	295.2	.013	5.0	23.70	20.85	4.496	.131	.953	.645	-.598	279.2	.958
.652	-.610												
3.65	15.3	325.0	.012	5.0	21.73	21.17	4.121	.158	.940	.621	-.561	310.0	.948
.635	-.583												
3.91	16.5	351.6	.012	5.0	18.80	21.35	3.565	.197	.917	.580	-.497	338.3	.931
.604	-.536												
4.17	17.5	373.8	.012	5.0	14.64	21.37	2.776	.269	.867	.506	-.372	362.8	.899
.551	-.450												
4.43	18.4	389.7	.012	5.0	8.57	21.18	1.626	.479	.691	.356	-.047	381.8	.819
.451	-.269												
4.69	19.1	396.2	.013	5.0	4.89	20.71	.927	.855	.385	.281	.334	393.0	.404
.280	.316												

MAXIMUM NO. ITERATIONS FOR SOLUTION (KKMAX) = 6 OCCURRED 1 TIMES. AVERAGE NUMBER ITERATIONS = 1.9883
Equations solved using the Ponce correction to C2
PRINT HYD ID=8 CODE=5

HYDROGRAPH FROM AREA PIPE.4

TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS
.000	.0	6.000	387.8	12.000	58.1	18.000	38.7	24.000	19.2
.250	.0	6.250	385.8	12.250	56.5	18.250	38.3	24.250	18.1
.500	.0	6.500	383.9	12.500	54.9	18.500	37.9	24.500	16.1
.750	.0	6.750	382.3	12.750	53.5	18.750	37.5	24.750	14.1
1.000	1.2	7.000	381.0	13.000	52.2	19.000	37.1	25.000	12.6
1.250	5.4	7.250	379.8	13.250	51.0	19.250	36.6	25.250	11.4
1.500	61.8	7.500	320.7	13.500	49.8	19.500	36.1	25.500	10.6
1.750	427.8	7.750	191.2	13.750	48.8	19.750	35.5	25.750	10.0
2.000	449.8	8.000	148.3	14.000	47.8	20.000	34.9	26.000	9.5
2.250	445.8	8.250	126.0	14.250	46.9	20.250	34.3	26.250	9.1
2.500	433.3	8.500	112.5	14.500	46.0	20.500	33.6	26.500	8.8
2.750	425.9	8.750	106.2	14.750	45.2	20.750	32.9	26.750	8.5
3.000	422.7	9.000	100.5	15.000	44.5	21.000	32.2	27.000	8.3
3.250	420.2	9.250	95.0	15.250	43.7	21.250	31.0	27.250	8.1
3.500	417.2	9.500	89.8	15.500	43.0	21.500	29.8	27.500	7.9
3.750	414.3	9.750	84.8	15.750	42.4	21.750	28.6	27.750	7.7
4.000	411.6	10.000	80.2	16.000	41.8	22.000	27.5	28.000	7.5
4.250	408.3	10.250	76.0	16.250	41.2	22.250	26.5	28.250	7.4
4.500	405.2	10.500	72.2	16.500	40.9	22.500	25.6	28.500	7.2
4.750	402.4	10.750	68.8	16.750	40.5	22.750	24.6	28.750	7.1
5.000	399.4	11.000	65.8	17.000	40.2	23.000	23.5	29.000	6.8
5.250	395.9	11.250	63.5	17.250	39.8	23.250	22.4	29.250	6.2
5.500	392.9	11.500	61.7	17.500	39.4	23.500	21.3	29.500	5.7
5.750	390.1	11.750	59.9	17.750	39.0	23.750	20.2	29.750	5.1

RUNOFF VOLUME = .53376 INCHES = 277.4647 ACRE-FEET
PEAK DISCHARGE RATE = 449.97 CFS AT 2.050 HOURS BASIN AREA = 9.7469 SQ. MI.

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*S  APPLY SEDIMENT BULKING FACTOR
SEDIMENT BULK          CODE=1   BULKING FACTOR = 1.09
*
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*S*** SUB-BASIN 71 DOWNSTREAM OF THE DAM ***
*
COMPUTE LT TP       LCODE=1  UPLAND/LAG TIME TRANSITION METHOD
                    NK=3  ISLOPE=-1
                    LENGTH=400 FT   SLOPE=0.02 K=0.7
                    LENGTH=1600 FT  SLOPE=0.02 K=2.0
                    LENGTH=800 FT  SLOPE=0.02 K=3.0


     Tc AND Tp COMPUTED BY UPLAND/LAG TIME PROCEDURE

     SCS UPLAND METHOD FACTORS
                              LENGTH (FT)      SLOPE (FT/FT)       COMPOSITE K
     SHEET FLOW PORTION          400.0           .020000             .7000
     SHALLOW FLOW PORTION       1600.0           .020000            2.0000
     CHANNEL FLOW PORTION        800.0           .020000            3.0000
     TOTAL BASIN                2800.0           .020000            1.7093


     TIME OF CONCENTRATION (HRS)=   .3218     TIME TO PEAK (HRS)=   .2145     LAG TIME (HRS)=   .2413

COMPUTE NM HYD      ID=5   HYD NO=71   DA=0.07675 SQ MI
                    PER A=80 PER B=0  PER C=20  PER D=0
                    TP=0.0   MASSRAIN=-1
     TIME TO PEAK (hrs)=   .2145

     K =   .248010HR    TP =   .214502HR    K/TP RATIO =  1.156214     SHAPE CONSTANT, N =  3.064995
     UNIT PEAK =   102.72    CFS   UNIT VOLUME =    .9998       B =   287.08      P60 = 1.6900
     AREA =      .076750 SQ MI    IA =    .59000 INCHES    INF =   1.50200 INCHES PER HOUR
     RUNOFF COMPUTED BY INITIAL ABSTRACTION/INFILTRATION NUMBER METHOD - DT =   .050000

    BULKING FACTOR APPLIED TO HYDROGRAPH.  FACTOR =  1.09000 AT PEAK FLOW.

PRINT HYD           ID=5   CODE=5

                                       OUTFLOW HYDROGRAPH REACH    71.00

     TIME      FLOW          TIME      FLOW          TIME      FLOW          TIME      FLOW          TIME
FLOW
      HRS       CFS           HRS       CFS           HRS       CFS           HRS       CFS           HRS
CFS
      .000        .0         1.500      39.6         3.000       1.7         4.500        .2         6.000
  .0
      .250        .0         1.750      34.0         3.250       1.2         4.750        .2         6.250
  .0
      .500        .0         2.000      12.5         3.500        .9         5.000        .1         6.500
  .0
      .750        .0         2.250       4.9         3.750        .6         5.250        .1         6.750
  .0
     1.000        .0         2.500       3.4         4.000        .5         5.500        .1         7.000
  .0
     1.250        .0         2.750       2.4         4.250        .3         5.750        .0         7.250
  .0

     RUNOFF VOLUME =      .50198 INCHES     =       2.0547 ACRE-FEET
     PEAK DISCHARGE RATE =      49.24 CFS  AT   1.600 HOURS   BASIN AREA =   .0768 SQ. MI.


*
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*
*S ADD SURFACE FLOW FROM DAM TO BASIN 71 TO GET 71.5
*
*S ADD BASIN 71 to PIPE.2 TO GET 70.9
*
ADD HYD             ID=6  HYD NO=71.6 ID I=5 ID II=90
PRINT HYD           ID=6   CODE=1

                                       OUTFLOW HYDROGRAPH REACH    71.60


     RUNOFF VOLUME =      .51558 INCHES     =     150.1944 ACRE-FEET
     PEAK DISCHARGE RATE =     695.49 CFS  AT   3.700 HOURS   BASIN AREA =  5.4622 SQ. MI.


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*
*S ADD 71.6 to PIPE.2 TO GET 70.9
*
ADD HYD             ID=9  HYD NO=70.9 ID I=6 ID II=8
PRINT HYD           ID=9   CODE=1

                                    OUTFLOW HYDROGRAPH REACH    70.90


    RUNOFF VOLUME =      .52723 INCHES     =     427.6592 ACRE-FEET
    PEAK DISCHARGE RATE =    1110.38 CFS  AT   3.700 HOURS   BASIN AREA = 15.2091 SQ. MI.



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*S  APPLY NO SEDIMENT BULKING FACTOR
SEDIMENT BULK          CODE=1   BULKING FACTOR = 1.00
*
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*
*S RECALL HYD FROM THE VOLCANO HEIGHTS MODEL (BOCA NEGRA ARROYO SOUTH BRANCH)
*S
RECALL HYD          ID= 2 HYD=      102.00 DT=  .050000 HRS DA=   1.6400 SQ MI
                    PEAK=    378.544CFS  RO=  .3847 INCHES  NO PTS=340
                    FLOW RATES
                          .000       .000       .000       .000       .000
                          .000       .000       .000       .000       .000
                          .000       .000       .000       .000       .000
                          .000       .000       .000       .000       .000
                          .000       .000       .000       .000       .000
                          .000       .000      1.009      9.899     32.824
                        63.396     90.963    109.803    118.751    119.115
                       113.134    103.107     91.039     81.968     97.947
                       149.940    227.995    295.915    342.675    368.910
                       378.544    375.650    363.734    345.685    323.866
                       300.290    276.692    253.626    231.248    209.969
                       190.200    172.161    155.820    141.030    127.642
                       115.523    104.556     94.638     85.701     77.771
                        70.968     65.162     59.974     55.161     50.785
                        46.796     43.156     39.835     36.850     34.361
                        32.647     31.381     30.209     29.084     28.002
                        26.961     25.961     24.998     24.073     23.182
                        22.326     21.502     20.709     19.947     19.213
                        18.507     17.828     17.174     16.545     15.940
                        15.357     14.797     14.257     13.737     13.237
                        12.756     12.292     11.846     11.417     11.003
                        10.605     10.222      9.852      9.497      9.155
                         8.825      8.507      8.201      7.907      7.623
                         7.350      7.087      6.833      6.589      6.353
                         6.127      5.908      5.698      5.495      5.299
                         5.111      4.930      4.755      4.586      4.424
                         4.267      4.116      3.971      3.831      3.696
                         3.565      3.440      3.319      3.202      3.090
                         2.981      2.877      2.776      2.679      2.585
                         2.494      2.407      2.323      2.242      2.164
                         2.088      2.016      1.946      1.878      1.813
                         1.750      1.689      1.631      1.574      1.520
                         1.467      1.416      1.367      1.320      1.274
                         1.231      1.188      1.147      1.108      1.070
                         1.033       .997       .963       .930       .898
                          .867       .838       .809       .781       .754
                          .729       .704       .680       .657       .634
                          .613       .592       .571       .552       .533
                          .515       .498       .481       .464       .449
                          .433       .419       .404       .391       .378
                          .365       .352       .340       .329       .318
                          .305       .293       .283       .274       .265
                          .256       .247       .239       .231       .223
                          .216       .209       .202       .195       .188
                          .182       .176       .170       .164       .159
                          .154       .148       .144       .139       .134
                          .130       .125       .121       .117       .113
                          .109       .106       .102       .099       .096
                          .092       .089       .086       .084       .081
                          .078       .075       .073       .070       .066
                          .062       .060       .058       .057       .055
                          .053       .051       .050       .048       .046
                          .045       .043       .042       .041       .039
                          .038       .037       .036       .034       .033
                          .032       .031       .030       .029       .028
                          .027       .026       .026       .025       .024
```

.023	.022	.022	.021	.020
.020	.019	.018	.018	.017
.017	.016	.016	.015	.015
.014	.014	.013	.013	.012
.012	.012	.011	.011	.010
.010	.010	.009	.009	.009
.009	.008	.008	.008	.008
.007	.007	.007	.007	.006
.006	.006	.006	.006	.005
.005	.005	.005	.005	.005
.004	.004	.004	.004	.004
.002	.001	.001	.001	.001

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*
*S ROUTE THE BOCA NEGRA ARROYO SOUTH BRANCH FLOWS THRU 72" IN EMERALD DR
*
*
COMPUTE RATING CURVE       CID=1   VS NO=1 NO SEGS=-1  SLP=0.021
                                   DIAM=6.0 FT     N=0.013
```

RATING CURVE PIPE SECTION 1.0

WATER SURFACE ELEV	FLOW AREA SQ FT	FLOW RATE CFS	MAX WIDTH FT
.00	.00	.00	.00
.31	.56	3.22	2.67
.63	1.56	13.98	3.67
.94	2.82	32.49	4.36
1.25	4.27	58.43	4.87
1.56	5.86	91.23	5.27
1.88	7.55	130.17	5.56
2.19	9.33	174.40	5.78
2.50	11.16	222.98	5.92
2.81	13.02	274.87	5.99
3.13	14.90	328.97	6.00
3.44	16.76	384.05	6.00
3.75	18.60	438.82	6.00
4.06	20.39	491.83	6.00
4.38	22.10	541.47	6.00
4.69	23.71	585.90	6.00
5.00	25.19	622.87	6.00
5.32	26.49	649.32	6.00
5.63	27.55	660.18	6.00
6.00	28.27	660.18	6.00

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ROUTE MCUNGE        ID=5   HYD NO=70.5     INFLOW ID=2
                           DT=0.0 HR       LENGTH=1347 FT
                           NS=0    SLOPE=0.021  CODE=5

     INFLOW END= 340            TABLE PTS= 19
     DT=  .050000               QMED=      189.27  CKMED=     26.5472
     WIDTH MED=        5.82     NREACH=  1         DX=     1347.00
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DEPTH (FT)	AREA (SQ FT)	Q (CFS)	TRAVEL TIME(HR)	WIDTH (FT)	ck (FPS)	VEL (FPS)	C	D	C1	C2	C3	Q-M (CFS)	C1-M	C2-M	C3-M
.00	.0	.0	.089	.0	7.48	2.70	1.000	.000	1.000	.000	.000	.0	1.000	.000	.000
.31	.6	3.2	.065	2.7	9.42	5.73	1.259	.005	.996	.117	-.113	.5	.999	.018	-.018
.63	1.6	14.0	.042	3.7	13.01	8.94	1.738	.010	.992	.272	-.265	7.7	.993	.184	-.177
.94	2.8	32.5	.033	4.4	16.47	11.51	2.201	.016	.990	.378	-.368	22.4	.991	.329	-.320
1.25	4.3	58.4	.027	4.9	19.39	13.68	2.591	.022	.988	.446	-.434	44.7	.989	.415	-.404
1.56	5.9	91.2	.024	5.3	21.87	15.57	2.923	.028	.986	.494	-.480	74.2	.987	.472	-.459
1.88	7.6	130.2	.022	5.6	23.98	17.23	3.205	.034	.984	.528	-.512	110.1	.985	.513	-.497
2.19	9.3	174.4	.020	5.8	25.76	18.69	3.442	.041	.982	.554	-.535	151.8	.983	.543	-.525
2.50	11.2	223.0	.019	5.9	27.21	19.98	3.637	.049	.979	.573	-.552	198.3	.980	.565	-.545
2.81	13.0	274.9	.018	6.0	28.36	21.11	3.789	.057	.976	.587	-.564	248.6	.978	.582	-.559
3.13	14.9	329.0	.017	6.0	29.15	22.08	3.895	.066	.973	.597	-.570	301.6	.975	.593	-.568
3.44	16.8	384.1	.016	6.0	29.34	22.91	3.920	.077	.969	.600	-.569	356.3	.971	.600	-.571
3.75	18.6	438.8	.016	6.0	28.79	23.59	3.847	.090	.964	.595	-.559	411.3	.967	.599	-.565
4.06	20.4	491.8	.016	6.0	27.43	24.12	3.665	.106	.956	.581	-.536	465.2	.960	.590	-.550
4.38	22.1	541.5	.015	6.0	25.14	24.50	3.359	.127	.943	.554	-.498	516.6	.951	.570	-.521
4.69	23.7	585.9	.015	6.0	21.75	24.71	2.906	.159	.922	.508	-.430	563.7	.935	.535	-.470
5.00	25.2	622.9	.015	6.0	16.93	24.73	2.263	.217	.875	.425	-.301	604.5	.905		

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.476  -.381
     5.32   26.5    649.3    .015    6.0     9.92  24.51    1.325   .386   .715   .262   .022    636.2    .831
.365  -.196
     5.63   27.5    660.2    .016    6.0     5.65  23.97     .755   .688   .437   .182   .382    654.8    .454
.180   .366
 MAXIMUM NO. ITERATIONS FOR SOLUTION (KKMAX) =   4 OCCURRED       2 TIMES.  AVERAGE NUMBER ITERATIONS =  1.2618
 Equations solved using the Ponce correction to C2
 PRINT HYD           ID=5   CODE=1

                                        OUTFLOW HYDROGRAPH REACH    70.50


     RUNOFF VOLUME =      .38470 INCHES     =      33.6484 ACRE-FEET
     PEAK DISCHARGE RATE =     377.51 CFS  AT   2.300 HOURS   BASIN AREA =  1.6400 SQ. MI.



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 *S  APPLY SEDIMENT BULKING FACTOR
 SEDIMENT BULK          CODE=1   BULKING FACTOR = 1.09
 *
 **************************************************************************
 **************************************************************************
 *S
 *S*** SUB-BASIN 70 EAST OF SAD 227 ***
 *
 COMPUTE LT TP       LCODE=1  UPLAND/LAG TIME TRANSITION METHOD
                     NK=3  ISLOPE=-1
                     LENGTH=400 FT   SLOPE=0.072 K=0.7
                     LENGTH=1580 FT  SLOPE=0.072 K=2.0


      Tc AND Tp COMPUTED BY UPLAND/LAG TIME PROCEDURE

      SCS UPLAND METHOD FACTORS
           NOTE: Upland factor input values have been adjusted to meet Upland/Lag Time requirements.
                               LENGTH (FT)      SLOPE (FT/FT)       COMPOSITE K
      SHEET FLOW PORTION           400.0           .072000             .7000
      SHALLOW FLOW PORTION        1580.0           .072000            2.0000
      CHANNEL FLOW PORTION           .0            .000000             .0000
      TOTAL BASIN                 1980.0           .072000            1.4544


      TIME OF CONCENTRATION (HRS)=   .1409     TIME TO PEAK (HRS)=   .0940     LAG TIME (HRS)=   .1057



      TIME TO PEAK COMPUTED TO BE LESS THAN 0.133333 HOUR MINIMUM VALUE.
      REVISED VALUES: TIME OF CONCENTRATION (HRS)=   .2000     TIME TO PEAK (HRS)=   .1333     LAG TIME (HRS)=
.1500

 COMPUTE NM HYD      ID=4   HYD NO=70   DA=0.06914 SQ MI
                     PER A=80 PER B=0  PER C=20  PER D=0
                     TP=0.0   MASSRAIN=-1
      TIME TO PEAK (hrs)=   .1333

      K =   .154814HR    TP =   .133333HR    K/TP RATIO =  1.161107     SHAPE CONSTANT, N =  3.052911
      UNIT PEAK =   148.36    CFS   UNIT VOLUME =    .9992       B =   286.11      P60 = 1.6900
      AREA =      .069140 SQ MI    IA =    .59000 INCHES    INF =   1.50200 INCHES PER HOUR
      RUNOFF COMPUTED BY INITIAL ABSTRACTION/INFILTRATION NUMBER METHOD - DT =   .050000

     BULKING FACTOR APPLIED TO HYDROGRAPH.  FACTOR =  1.09000 AT PEAK FLOW.

 PRINT HYD           ID=4   CODE=5

                                        OUTFLOW HYDROGRAPH REACH    70.00

      TIME      FLOW          TIME      FLOW          TIME      FLOW          TIME      FLOW          TIME
FLOW
       HRS       CFS           HRS       CFS           HRS       CFS           HRS       CFS           HRS
CFS
       .000        .0         1.250        .0         2.500       2.0         3.750        .1         5.000
  .0
       .250        .0         1.500      66.6         2.750       1.2         4.000        .1         5.250
  .0
       .500        .0         1.750      19.9         3.000        .7         4.250        .0
       .750        .0         2.000       5.8         3.250        .4         4.500        .0
      1.000        .0         2.250       3.4         3.500        .2         4.750        .0

     RUNOFF VOLUME =      .50198 INCHES     =       1.8510 ACRE-FEET
     PEAK DISCHARGE RATE =      66.65 CFS  AT   1.500 HOURS   BASIN AREA =   .0691 SQ. MI.



 *
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**********************************************************************
*S
*S ADD BASIN 70 to ROUTED BOCA NEGRA ARROYO SOUTH BRANCH
*
ADD HYD             ID=6  HYD NO=70.6 ID I=4 ID II=5
PRINT HYD           ID=6   CODE=1

                                    OUTFLOW HYDROGRAPH REACH    70.60


    RUNOFF VOLUME =      .38945 INCHES     =      35.4994 ACRE-FEET
    PEAK DISCHARGE RATE =     380.70 CFS  AT   2.250 HOURS   BASIN AREA =  1.7091 SQ. MI.



*
**********************************************************************
*
*S ADD ALL FLOWS AT THE CONFLUENCE WITH BOCA NEGRA ARROYO
*
ADD HYD             ID=7  HYD NO=71.7 ID I=6 ID II=9
PRINT HYD           ID=7   CODE=1

                                    OUTFLOW HYDROGRAPH REACH    71.70


    RUNOFF VOLUME =      .51331 INCHES     =     463.1585 ACRE-FEET
    PEAK DISCHARGE RATE =    1147.37 CFS  AT   3.650 HOURS   BASIN AREA = 16.9182 SQ. MI.



*
**********************************************************************
*
*S ROUTE 71.7 IN 72 TO GET 72.6
*
COMPUTE RATING CURVE  CID=1   VS NO=1   NO SEGS=1
                      MIN ELEV=5164.49   MAX ELEV=5167.54
                      CH SLOPE=0.008    FP SLOPE=0.008
                      N=0.035           DIST=137
                      DIST  ELEV    DIST  ELEV
                        0   5167.54        20 5165.67
                                   41   5166.80    77 5165.39
                                   81   5164.71    92 5164.49
                                   99   5165.64    137 5166.10


                                  RATING CURVE VALLEY SECTION  1.0
                                      WATER       FLOW        FLOW        TOP
                                     SURFACE      AREA        RATE        WIDTH
                                      ELEV        SQ FT       CFS         FT
                                    5164.49         .00         .00         .00
                                    5164.65         .72         .51        9.02
                                    5164.81        2.67        3.43       13.55
                                    5164.97        5.00        8.92       15.48
                                    5165.13        7.64       16.71       17.40
                                    5165.29       10.59       26.83       19.32
                                    5165.45       13.89       38.08       22.50
                                    5165.61       17.91       50.82       27.58
                                    5165.78       23.61       57.27       46.10
                                    5165.94       32.79       76.31       68.18
                                    5166.10       45.52      109.36       90.26
                                    5166.26       60.77      166.06       99.35
                                    5166.42       77.44      235.02      108.15
                                    5166.58       95.52      316.48      116.96
                                    5166.74      115.02      410.94      125.76
                                    5166.90      135.71      529.15      130.15
                                    5167.06      156.75      667.01      131.87
                                    5167.22      178.07      817.89      133.59
                                    5167.38      199.67      981.41      135.31
                                    5167.54      221.55     1157.42      137.00
ROUTE MCUNGE        ID=6   HYD NO=72.6  INFLOW ID=7
                    DT=0.0   L=1805 FT   NS=0   SLOPE=0.008
                    MATCODE=0 REGCODE=0 CCODE=0 MM CODE=0

      INFLOW END= 600           TABLE PTS= 20
      DT=  .050000              QMED=      573.69  CKMED=      6.5504
      WIDTH MED=      130.71    NREACH=  3         DX=      601.67

      DEPTH   AREA      Q    TRAVEL  WIDTH     ck      VEL      C       D      C1     C2     C3     Q-M      C1-M
C2-M   C3-M
       (FT)  (SQ FT)  (CFS)  TIME(HR) (FT)     (FPS)   (FPS)                                          (CFS)
         .00     .0       .0   1.029     .0     3.34    .27    1.000   .000  1.000   .000   .000       .0   1.000
.000   .000
         .16     .7       .5    .710    9.0     3.33    .71     .996   .004   .996   .000   .004       .1    .999
.000   .001
         .32    2.7      3.4    .391   13.6     3.29   1.28     .984   .016   .984   .000   .016      1.6    .992
.000   .008
         .48    5.0      8.9    .281   15.5     3.22   1.78     .963   .037   .963   .000   .037      5.9    .974
.000   .026
         .64    7.6     16.7    .229   17.4     3.22   2.19     .963   .062   .939   .012   .049     12.6    .952
```

```
.006   .043
         .80   10.6     26.8    .198   19.3     3.48   2.53    1.042   .083   .922   .059   .019     21.5    .932
.046   .022
          .96   13.9     38.1    .183   22.5     3.34   2.74     .999   .105   .900   .049   .051     32.3    .908
.046   .046
         1.12   17.9     50.8    .177   27.6     2.90   2.84     .868   .132   .868   .000   .132     44.3    .887
.029   .084
         1.29   23.6     57.3    .207   46.1     3.06   2.43     .916   .084   .916   .000   .084     53.7    .889
.000   .111
         1.45   32.8     76.3    .215   68.2     3.09   2.33     .925   .075   .925   .000   .075     66.3    .920
.000   .080
         1.61   45.5    109.4    .209   90.3     3.07   2.40     .918   .082   .918   .000   .082     92.1    .922
.000   .078
         1.77   60.8    166.1    .183   99.3     3.94   2.73    1.180   .088   .922   .118  -.040    136.6    .927
.088  -.015
         1.93   77.4    235.0    .165  108.2     4.34   3.03    1.297   .104   .913   .167  -.080    199.4    .917
.143  -.060
         2.09   95.5    316.5    .151  117.0     4.69   3.31    1.402   .120   .905   .207  -.112    274.6    .908
.187  -.095
         2.25  115.0    410.9    .140  125.8     5.24   3.57    1.567   .130   .904   .258  -.162    362.6    .901
.224  -.124
         2.41  135.7    529.2    .129  130.2     6.11   3.90    1.828   .138   .907   .326  -.233    468.6    .907
.299  -.206
         2.57  156.8    667.0    .118  131.9     6.82   4.26    2.040   .154   .904   .374  -.277    596.5    .907
.356  -.263
         2.73  178.1    817.9    .109  133.6     7.33   4.59    2.193   .174   .897   .406  -.303    741.0    .900
.390  -.290
         2.89  199.7    981.4    .102  135.3     7.81   4.92    2.338   .193   .891   .434  -.324    898.2    .894
.420  -.314
         3.05  221.5   1157.4    .096  137.0     8.24   5.22    2.465   .213   .884   .456  -.340   1068.0    .888
.446  -.334
     MAXIMUM NO. ITERATIONS FOR SOLUTION (KKMAX) =   4 OCCURRED      10 TIMES.  AVERAGE NUMBER ITERATIONS =  1.5299
     Equations solved using the Ponce correction to C2

     PRINT HYD           ID=6   CODE=1

                                        OUTFLOW HYDROGRAPH REACH    72.60


         RUNOFF VOLUME =      .51331 INCHES     =     463.1622 ACRE-FEET
         PEAK DISCHARGE RATE =    1147.49 CFS  AT   3.750 HOURS   BASIN AREA = 16.9182 SQ. MI.



     *
     ************************************************************************
     *S  APPLY NO SEDIMENT BULKING FACTOR
     SEDIMENT BULK          CODE=1   BULKING FACTOR = 1.00

     *
     ************************************************************************
     ************************************************************************
     *
     *S RECALL HYD FROM SAD 228 POND 6
     *
     RECALL HYD          ID=19  HYD=POND6
                         DT=  .050000 HRS   DA=    .0654 SQ MI
                         PEAK=     50.659CFS  RO= 1.5488 INCHES  NO PTS=539
                         FLOW RATES
                                .000       .000       .000       .000       .000
                                .000       .000       .000       .000       .000
                                .000       .000       .000       .000       .000
                                .002       .012       .049       .137       .296
                                .533       .841      1.202      1.585      1.956
                               2.303      2.701      3.408      4.947      8.041
                              12.321     18.906     24.765     30.903     36.022
                              39.406     41.514     43.269     44.579     48.727
                              50.659     48.563     44.986     44.498     43.781
                              42.862     41.773     40.543     39.204     37.551
                              34.501     31.620     28.909     25.345     22.281
                              19.653     16.660     14.038     12.007     10.418
                               9.161      8.152      7.158      6.362      5.742
                               5.246      4.836      4.491      4.193      3.932
                               3.699      3.490      3.300      3.127      2.967
                               2.820      2.684      2.558      2.442      2.334
                               2.234      2.141      2.054      1.974      1.899
                               1.830      1.766      1.706      1.650      1.598
                               1.550      1.505      1.464      1.426      1.390
                               1.358      1.328      1.300      1.274      1.250
                               1.228      1.207      1.189      1.172      1.158
                               1.144      1.131      1.120      1.109      1.099
                               1.091      1.084      1.079      1.074      1.070
                               1.066      1.063      1.060      1.057      1.055
                               1.053      1.051      1.050      1.048      1.043
                               1.029      1.007       .975       .937       .895
                                .853       .813       .777       .745       .718
                                .696       .677       .662       .649       .639
                                .630       .622       .614       .608       .601
                                .595       .589       .584       .579       .574
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.569	.565	.561	.557	.553
.548	.544	.540	.536	.533
.529	.526	.522	.519	.517
.514	.512	.510	.508	.506
.504	.502	.500	.498	.496
.495	.493	.491	.489	.488
.486	.485	.483	.481	.479
.478	.476	.474	.473	.472
.471	.470	.468	.467	.465
.464	.462	.461	.459	.458
.456	.455	.454	.453	.451
.450	.448	.446	.445	.444
.442	.441	.440	.439	.438
.437	.436	.434	.433	.431
.430	.429	.428	.427	.426
.425	.424	.423	.422	.420
.419	.418	.417	.416	.414
.413	.412	.410	.409	.408
.407	.406	.405	.405	.404
.403	.402	.401	.400	.399
.398	.397	.396	.395	.394
.393	.392	.391	.390	.388
.387	.386	.385	.384	.384
.383	.383	.382	.381	.380
.379	.377	.376	.375	.374
.374	.373	.372	.372	.371
.370	.369	.368	.367	.366
.365	.364	.363	.362	.362
.361	.361	.360	.359	.358
.357	.356	.355	.354	.353
.352	.352	.351	.351	.350
.349	.348	.347	.346	.346
.346	.345	.345	.345	.344
.343	.341	.339	.338	.337
.337	.337	.336	.336	.336
.335	.334	.333	.332	.332
.331	.330	.329	.328	.327
.327	.326	.326	.325	.325
.324	.324	.323	.323	.322
.322	.321	.320	.319	.318
.317	.317	.316	.316	.316
.315	.314	.314	.313	.313
.312	.311	.310	.310	.309
.308	.308	.307	.307	.306
.306	.305	.304	.303	.302
.301	.301	.301	.301	.301
.301	.301	.301	.300	.299
.297	.296	.295	.294	.294
.294	.294	.293	.293	.292
.292	.291	.291	.290	.289
.289	.288	.288	.287	.287
.287	.286	.286	.286	.285
.285	.284	.284	.283	.282
.281	.281	.280	.280	.279
.279	.279	.279	.278	.278
.277	.277	.276	.275	.275
.274	.274	.273	.273	.273
.273	.272	.272	.271	.271
.270	.270	.269	.269	.268
.268	.267	.267	.266	.266
.265	.264	.264	.264	.263
.263	.263	.263	.263	.262
.262	.261	.260	.259	.258
.258	.258	.258	.259	.259
.259	.259	.258	.257	.257
.256	.256	.255	.254	.253
.252	.251	.250	.249	.245
.238	.226	.209	.188	.165
.143	.122	.104	.088	.075
.064	.055	.048	.042	.038
.034	.030	.028	.025	.023
.021	.019	.018	.016	.015
.014	.013	.011	.011	.010
.009	.008	.008	.007	.006
.006	.005	.005	.005	.004
.004	.003	.003	.003	.003
.002	.002	.002	.002	.002
.002	.001	.001	.001	

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*
**********************************************************************
*S  APPLY SEDIMENT BULKING FACTOR
SEDIMENT BULK          CODE=1   BULKING FACTOR = 1.09

*
**********************************************************************
*S
*S*** SUB-BASIN 72 DOWNSTREAM OF CONFLUENCE WITH SOUTH BRANCH ***
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COMPUTE LT TP       LCODE=1  UPLAND/LAG TIME TRANSITION METHOD
                    NK=3  ISLOPE=-1
                    LENGTH=355 FT   SLOPE=0.02 K=0.7
                    LENGTH=1645 FT  SLOPE=0.02 K=2.0
                    LENGTH=260 FT  SLOPE=0.02 K=3.0


     Tc AND Tp COMPUTED BY UPLAND/LAG TIME PROCEDURE

     SCS UPLAND METHOD FACTORS
                              LENGTH (FT)      SLOPE (FT/FT)       COMPOSITE K
     SHEET FLOW PORTION           355.0           .020000             .7000
     SHALLOW FLOW PORTION        1645.0           .020000            2.0000
     CHANNEL FLOW PORTION         260.0           .020000            3.0000
     TOTAL BASIN                 2260.0           .020000            1.5957


     TIME OF CONCENTRATION (HRS)=   .2782     TIME TO PEAK (HRS)=   .1855     LAG TIME (HRS)=   .2086

COMPUTE NM HYD      ID=2   HYD NO=72   DA=0.16708 SQ MI
                    PER A=80 PER B=0  PER C=20  PER D=0
                    TP=0.0   MASSRAIN=-1
     TIME TO PEAK (hrs)=   .1855

     K =   .203662HR    TP =   .185460HR    K/TP RATIO =  1.098145     SHAPE CONSTANT, N =  3.218722
     UNIT PEAK =   269.54    CFS   UNIT VOLUME =    1.000       B =   299.19      P60 = 1.6900
     AREA =      .167080 SQ MI    IA =    .59000 INCHES    INF =   1.50200 INCHES PER HOUR
     RUNOFF COMPUTED BY INITIAL ABSTRACTION/INFILTRATION NUMBER METHOD - DT =   .050000

    BULKING FACTOR APPLIED TO HYDROGRAPH.  FACTOR =  1.09000 AT PEAK FLOW.

PRINT HYD           ID=2   CODE=5

                                       OUTFLOW HYDROGRAPH REACH    72.00

     TIME      FLOW           TIME      FLOW           TIME      FLOW           TIME      FLOW           TIME
FLOW
      HRS       CFS            HRS       CFS            HRS       CFS            HRS       CFS            HRS
CFS
      .000        .0          1.500     111.6          3.000       2.9          4.500        .2          6.000
  .0
      .250        .0          1.750      68.0          3.250       1.9          4.750        .2          6.250
  .0
      .500        .0          2.000      20.0          3.500       1.3          5.000        .1          6.500
  .0
      .750        .0          2.250       9.9          3.750        .8          5.250        .1          6.750
  .0
     1.000        .0          2.500       6.5          4.000        .6          5.500        .0
     1.250        .0          2.750       4.3          4.250        .4          5.750        .0

    RUNOFF VOLUME =      .50198 INCHES     =       4.4731 ACRE-FEET
    PEAK DISCHARGE RATE =     126.65 CFS  AT   1.550 HOURS   BASIN AREA =   .1671 SQ. MI.


*
**********************************************************************
*
*S ADD OUTFLOW FROM POND 6 TO BASIN 72
*
ADD HYD             ID=1  HYD NO=72.1 ID I=19 ID II=2
PRINT HYD           ID=1   CODE=1

                                       OUTFLOW HYDROGRAPH REACH    72.10


    RUNOFF VOLUME =      .79646 INCHES     =       9.8752 ACRE-FEET
    PEAK DISCHARGE RATE =     146.85 CFS  AT   1.600 HOURS   BASIN AREA =   .2325 SQ. MI.


*
**********************************************************************
*
*S ADD ALL FLOWS AT TESUQUE DR
*S ADD 72.1 TO 72.6 TO GET 72.3
*
ADD HYD             ID=3  HYD NO=72.3 ID I=1 ID II=6
PRINT HYD           ID=3   CODE=1

                                       OUTFLOW HYDROGRAPH REACH    72.30


    RUNOFF VOLUME =      .51715 INCHES     =     473.0370 ACRE-FEET
    PEAK DISCHARGE RATE =    1151.15 CFS  AT   3.750 HOURS   BASIN AREA = 17.1507 SQ. MI.



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*
*S ROUTE 72.3 IN 73.1 TO GET 73.1.5
*
*
COMPUTE RATING CURVE  CID=1   VS NO=1   NO SEGS=1
                      MIN ELEV=5149.46   MAX ELEV=5162.40
                      CH SLOPE=0.006    FP SLOPE=0.006
                      N=0.035           DIST=149
                      DIST  ELEV    DIST  ELEV
                        0   5162.40        17 5157.28
                                   25   5156.08    35 5151.92
                                   75   5149.46    112 5150.98
                                   132   5156.42   149 5157.55


                                    RATING CURVE VALLEY SECTION  1.0
                                        WATER       FLOW        FLOW        TOP
                                       SURFACE      AREA        RATE        WIDTH
                                        ELEV        SQ FT       CFS         FT
                                      5149.46         .00         .00         .00
                                      5150.14        9.42       15.09       27.66
                                      5150.82       37.68       95.84       55.31
                                      5151.50       81.94      292.89       72.15
                                      5152.18      135.23      618.82       82.06
                                      5152.87      192.54     1077.35       86.21
                                      5153.55      252.67     1640.05       90.35
                                      5154.23      315.62     2303.15       94.49
                                      5154.91      381.39     3064.67       98.63
                                      5155.59      449.98     3923.72      102.77
                                      5156.27      521.48     4857.76      107.73
                                      5156.95      598.87     5670.68      120.83
                                      5157.63      685.95     6666.85      133.18
                                      5158.31      777.43     8119.27      135.44
                                      5159.00      870.46     9691.45      137.70
                                      5159.68      965.02    11381.12      139.96
                                      5160.36     1061.13    13186.48      142.22
                                      5161.04     1158.77    15106.07      144.48
                                      5161.72     1257.96    17138.70      146.74
                                      5162.40     1358.68    19283.99      149.00
ROUTE MCUNGE        ID=5   HYD NO=73.1.5  INFLOW ID=3
                    DT=0.0   L=1380 FT   NS=0   SLOPE=0.006
                    MATCODE=0 REGCODE=0 CCODE=0 MM CODE=0

     INFLOW END= 600           TABLE PTS= 20
     DT=  .050000              QMED=      575.58  CKMED=      6.1166
     WIDTH MED=       80.75    NREACH=  3         DX=      460.00

      DEPTH   AREA      Q    TRAVEL  WIDTH     ck      VEL      C       D      C1     C2     C3     Q-M      C1-M
C2-M   C3-M
       (FT)  (SQ FT)  (CFS)  TIME(HR) (FT)     (FPS)   (FPS)                                          (CFS)
        .00     .0       .0    .328     .0     2.56     .74    1.000   .000  1.000   .000   .000       .0   1.000
.000   .000
        .68    9.4     15.1    .239   27.7     2.34   1.60     .915   .085   .915   .000   .085      2.4    .987
.000   .013
       1.36   37.7     95.8    .151   55.3     3.66   2.54    1.432   .172   .868   .232  -.100     45.0    .873
.101   .026
       2.04   81.9    292.9    .107   72.2     5.34   3.57    2.088   .276   .836   .405  -.241    181.8    .847
.333  -.180
       2.72  135.2    618.8    .084   82.1     7.03   4.58    2.750   .389   .812   .517  -.329    443.1    .821
.468  -.290
       3.41  192.5   1077.3    .069   86.2     8.73   5.60    3.415   .519   .790   .595  -.384    835.5    .804
.563  -.367
       4.09  252.7   1640.0    .059   90.3     9.98   6.49    3.907   .659   .763   .641  -.404   1347.2    .775
.619  -.394
       4.77  315.6   2303.1    .053   94.5    11.09   7.30    4.338   .797   .740   .674  -.414   1960.8    .751
.658  -.409
       5.45  381.4   3064.7    .048   98.6    12.08   8.04    4.726   .932   .720   .700  -.420   2673.6    .729
.687  -.416
       6.13  450.0   3923.7    .044  102.8    12.84   8.72    5.023  1.078   .696   .718  -.415   3484.3    .710
.710  -.420
       6.81  521.5   4857.8    .041  107.7    12.03   9.32    4.706  1.358   .615   .717  -.332   4381.7    .681
.724  -.405
       7.49  598.9   5670.7    .040  120.8    10.98   9.47    4.296  1.549   .547   .708  -.255   5259.2    .521
.701  -.222
       8.17  686.0   6666.8    .039  133.2    13.36   9.72    5.227  1.358   .642   .736  -.378   6162.2    .565
.715  -.281
       8.85  777.4   8119.3    .037  135.4    16.40  10.44    6.418  1.324   .697   .771  -.468   7379.4    .704
.764  -.468
       9.54  870.5   9691.4    .034  137.7    17.40  11.13    6.808  1.466   .684   .784  -.468   8892.2    .690
.778  -.468
      10.22  965.0  11381.1    .033  140.0    18.34  11.79    7.176  1.607   .672   .796  -.467  10523.6    .677
.790  -.467
      10.90 1061.1  13186.5    .031  142.2    19.23  12.43    7.526  1.747   .660   .805  -.465  12271.4    .665
.801  -.466
      11.58 1158.8  15106.1    .029  144.5    20.09  13.04    7.860  1.886   .649   .814  -.463  14134.2    .654
.810  -.464
      12.26 1258.0  17138.7    .028  146.7    20.90  13.62    8.180  2.024   .639   .821  -.460  16110.6    .644
.818  -.461
      12.94 1358.7  19284.0    .027  149.0    21.58  14.19    8.444  2.173   .626   .828  -.454  18199.8    .634
.825  -.459
MAXIMUM NO. ITERATIONS FOR SOLUTION (KKMAX) =   4 OCCURRED       9 TIMES.  AVERAGE NUMBER ITERATIONS =  1.5713
```

DEPTH (FT)	AREA (SQ FT)	Q (CFS)	TRAVEL TIME(HR)	WIDTH (FT)	ck (FPS)	VEL (FPS)	C	D	C1	C2	C3	Q-M (CFS)	C1-M	C2-M	C3-M
.00	.0	.0	.328	.0	2.56	.74	1.000	.000	1.000	.000	.000	.0	1.000	.000	.000
.68	9.4	15.1	.239	27.7	2.34	1.60	.915	.085	.915	.000	.085	2.4	.987	.000	.013
1.36	37.7	95.8	.151	55.3	3.08	2.54	1.204	.204	.831	.169	.000	45.0	.873	.101	.026
2.04	81.9	292.9	.107	72.2	3.60	3.57	1.409	.409	.710	.290	.000	181.8	.764	.236	.000
2.72	135.2	618.8	.084	82.1	4.21	4.58	1.649	.649	.607	.393	.000	443.1	.653	.347	.000
3.41	192.5	1077.3	.069	86.2	4.91	5.60	1.922	.922	.520	.480	.000	835.5	.559	.441	.000
4.09	252.7	1640.0	.059	90.3	5.57	6.49	2.180	1.180	.459	.541	.000	1347.2	.487	.513	.000
4.77	315.6	2303.1	.053	94.5	6.20	7.30	2.425	1.425	.412	.588	.000	1960.8	.434	.566	.000
5.45	381.4	3064.7	.048	98.6	6.79	8.04	2.658	1.658	.376	.624	.000	2673.6	.393	.607	.000
6.13	450.0	3923.7	.044	102.8	7.36	8.72	2.880	1.880	.347	.653	.000	3484.3	.361	.639	.000
6.81	521.5	4857.8	.041	107.7	7.86	9.32	3.077	2.077	.325	.675	.000	4381.7	.336	.664	.000
7.49	598.9	5670.7	.040	120.8	7.99	9.47	3.127	2.127	.320	.680	.000	5259.2	.322	.678	.000
8.17	686.0	6666.8	.039	133.2	8.20	9.72	3.211	2.211	.311	.689	.000	6162.2	.315	.685	.000
8.85	777.4	8119.3	.037	135.4	8.84	10.44	3.458	2.458	.289	.711	.000	7379.4	.300	.700	.000
9.54	870.5	9691.4	.034	137.7	9.45	11.13	3.698	2.698	.270	.730	.000	8892.2	.279	.721	.000
10.22	965.0	11381.1	.033	140.0	10.05	11.79	3.932	2.932	.254	.746	.000	10523.6	.262	.738	.000
10.90	1061.1	13186.5	.031	142.2	10.63	12.43	4.160	3.160	.240	.760	.000	12271.4	.247	.753	.000
11.58	1158.8	15106.1	.029	144.5	11.20	13.04	4.382	3.382	.228	.772	.000	14134.2	.234	.766	.000
12.26	1258.0	17138.7	.028	146.7	11.76	13.62	4.600	3.600	.217	.783	.000	16110.6	.223	.777	.000
12.94	1358.7	19284.0	.027	149.0	12.30	14.19	4.813	3.813	.208	.792	.000	18199.8	.212	.788	.000

MAXIMUM NO. ITERATIONS FOR SOLUTION (KKMAX) = 4 OCCURRED 2 TIMES. AVERAGE NUMBER ITERATIONS = 1.5466
Equations solved with two passes: first using the Ponce correction to C1, second using the Fread correction to C1, C2 and C3

PRINT HYD ID=5 CODE=1

HYDROGRAPH FROM AREA 73.1.5

RUNOFF VOLUME = .51690 INCHES = 472.8104 ACRE-FEET
PEAK DISCHARGE RATE = 1148.83 CFS AT 3.800 HOURS BASIN AREA = 17.1507 SQ. MI.

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*
*S*** SUB-BASIN 73.1
*
COMPUTE LT TP LCODE=1 UPLAND/LAG TIME TRANSITION METHOD
NK=3 ISLOPE=-1
LENGTH=355 FT SLOPE=0.02 K=0.7
LENGTH=1645 FT SLOPE=0.02 K=2.0
LENGTH=260 FT SLOPE=0.02 K=3.0

Tc AND Tp COMPUTED BY UPLAND/LAG TIME PROCEDURE

SCS UPLAND METHOD FACTORS

	LENGTH (FT)	SLOPE (FT/FT)	COMPOSITE K
SHEET FLOW PORTION	355.0	.020000	.7000
SHALLOW FLOW PORTION	1645.0	.020000	2.0000
CHANNEL FLOW PORTION	260.0	.020000	3.0000
TOTAL BASIN	2260.0	.020000	1.5957

TIME OF CONCENTRATION (HRS)= .2782 TIME TO PEAK (HRS)= .1855 LAG TIME (HRS)= .2086

COMPUTE NM HYD ID=4 HYD NO=73.1 DA=0.12879 SQ MI
PER A=10 PER B=20 PER C=30 PER D=40
TP=0.0 MASSRAIN=-1
TIME TO PEAK (hrs)= .1855

K = .103418HR TP = .185460HR K/TP RATIO = .557632 SHAPE CONSTANT, N = 6.901476
UNIT PEAK = 143.49 CFS UNIT VOLUME = 1.000 B = 516.57 P60 = 1.6900
AREA = .051516 SQ MI IA = .10000 INCHES INF = .04000 INCHES PER HOUR
RUNOFF COMPUTED BY INITIAL ABSTRACTION/INFILTRATION NUMBER METHOD - DT = .050000

K = .171438HR TP = .185460HR K/TP RATIO = .924395 SHAPE CONSTANT, N = 3.828155
UNIT PEAK = 143.14 CFS UNIT VOLUME = 1.000 B = 343.54 P60 = 1.6900
AREA = .077274 SQ MI IA = .45000 INCHES INF = 1.11000 INCHES PER HOUR
RUNOFF COMPUTED BY INITIAL ABSTRACTION/INFILTRATION NUMBER METHOD - DT = .050000

BULKING FACTOR APPLIED TO HYDROGRAPH. FACTOR = 1.09000 AT PEAK FLOW.

PRINT HYD ID=4 CODE=5

OUTFLOW HYDROGRAPH REACH 73.10

TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS	TIME HRS	FLOW CFS
.000	.0	5.250	1.5	10.500	.9	15.750	.7	21.000	.6
.250	.0	5.500	1.6	10.750	.9	16.000	.7	21.250	.6
.500	.0	5.750	1.6	11.000	.9	16.250	.7	21.500	.6
.750	.0	6.000	1.7	11.250	.8	16.500	.7	21.750	.6
1.000	4.9	6.250	1.3	11.500	.8	16.750	.7	22.000	.5
1.250	10.0	6.500	1.2	11.750	.8	17.000	.7	22.250	.5
1.500	189.5	6.750	1.1	12.000	.8	17.250	.7	22.500	.5
1.750	112.8	7.000	1.1	12.250	.8	17.500	.6	22.750	.5
2.000	51.6	7.250	1.1	12.500	.8	17.750	.6	23.000	.5
2.250	22.4	7.500	1.1	12.750	.8	18.000	.6	23.250	.5
2.500	11.5	7.750	1.0	13.000	.8	18.250	.6	23.500	.5
2.750	7.1	8.000	1.0	13.250	.8	18.500	.6	23.750	.5
3.000	4.6	8.250	1.0	13.500	.8	18.750	.6	24.000	.5
3.250	3.2	8.500	1.0	13.750	.8	19.000	.6	24.250	.2
3.500	2.5	8.750	1.0	14.000	.7	19.250	.6	24.500	.1
3.750	2.0	9.000	1.0	14.250	.7	19.500	.6	24.750	.0
4.000	1.8	9.250	.9	14.500	.7	19.750	.6	25.000	.0
4.250	1.6	9.500	.9	14.750	.7	20.000	.6	25.250	.0
4.500	1.6	9.750	.9	15.000	.7	20.250	.6	25.500	.0
4.750	1.5	10.000	.9	15.250	.7	20.500	.6		
5.000	1.5	10.250	.9	15.500	.7	20.750	.6		

RUNOFF VOLUME = 1.44269 INCHES = 9.9095 ACRE-FEET
PEAK DISCHARGE RATE = 209.07 CFS AT 1.550 HOURS BASIN AREA = .1288 SQ. MI.

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*S ADD 72.3 TO 73.1 TO GET 73.1.2

*
ADD HYD ID=2 HYD NO=73.1.2 ID I=4 ID II=5
PRINT HYD ID=2 CODE=1

HYDROGRAPH FROM AREA 73.1.2

RUNOFF VOLUME = .52380 INCHES = 482.7200 ACRE-FEET
PEAK DISCHARGE RATE = 1150.81 CFS AT 3.800 HOURS BASIN AREA = 17.2795 SQ. MI.

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*
*S ROUTE 73.1.2 THRU 73.2 TO GET 73.2.5
*
COMPUTE RATING CURVE CID=1 VS NO=1 NO SEGS=1
MIN ELEV=5149.46 MAX ELEV=5162.40
CH SLOPE=0.004 FP SLOPE=0.004
N=0.035 DIST=149
DIST ELEV DIST ELEV

```
0   5144.26        23 5143.43
          39   5138.80    68 5137.16
          110   5138.29   132 5144.34
          149   5144.48


                                    RATING CURVE VALLEY SECTION  1.0
                                       WATER        FLOW        FLOW        TOP
                                     SURFACE       AREA        RATE       WIDTH
                                       ELEV        SQ FT       CFS         FT
                                     5149.46          .00         .00      149.00
                                     5150.14     1454.98    17726.59      149.00
                                     5150.82     1556.47    19835.01      149.00
                                     5151.50     1657.96    22037.14      149.00
                                     5152.18     1759.46    24331.04      149.00
                                     5152.87     1860.95    26714.91      149.00
                                     5153.55     1962.44    29187.08      149.00
                                     5154.23     2063.93    31745.99      149.00
                                     5154.91     2165.42    34390.21      149.00
                                     5155.59     2266.91    37118.38      149.00
                                     5156.27     2368.41    39929.21      149.00
                                     5156.95     2469.90    42821.54      149.00
                                     5157.63     2571.39    45794.19      149.00
                                     5158.31     2672.88    48846.13      149.00
                                     5159.00     2774.37    51976.31      149.00
                                     5159.68     2875.86    55183.79      149.00
                                     5160.36     2977.36    58467.63      149.00
                                     5161.04     3078.85    61826.96      149.00
                                     5161.72     3180.34    65260.96      149.00
                                     5162.40     3281.83    68768.80      149.00
     ROUTE MCUNGE        ID=5   HYD NO=73.2.5  INFLOW ID=2
                         DT=0.0   L=1060 FT   NS=0   SLOPE=0.004
                         MATCODE=0 REGCODE=0 CCODE=0 MM CODE=0

         INFLOW END= 600            TABLE PTS= 20
         DT=  .050000               QMED=      575.41  CKMED=     12.1834
         WIDTH MED=      149.00     NREACH=  1         DX=     1060.00

       DEPTH   AREA      Q    TRAVEL  WIDTH     ck      VEL      C       D       C1      C2      C3     Q-M      C1-M
C2-M   C3-M
        (FT)  (SQ FT)  (CFS)  TIME(HR) (FT)     (FPS)   (FPS)                                                (CFS)
          .00     .0       .0    .025  149.0     5.89  11.16    1.000   .000  1.000   .000   .000       .0   1.000
.000   .000
          .68 1455.0  17726.6    .024  149.0   275.19  12.18   46.731   .102   .996   .958  -.954   1973.8    .998
.908  -.905
         1.36 1556.5  19835.0    .023  149.0    21.24  12.74    3.607  1.478   .514   .671  -.185  18769.0    .520
.664  -.184
         2.04 1658.0  22037.1    .022  149.0    22.15  13.29    3.762  1.575   .503   .684  -.187  20924.5    .508
.678  -.186
         2.72 1759.5  24331.0    .021  149.0    23.05  13.83    3.914  1.671   .492   .696  -.189  23172.7    .498
.690  -.188
         3.41 1860.9  26714.9    .021  149.0    23.93  14.36    4.063  1.767   .482   .707  -.190  25511.8    .487
.702  -.189
         4.09 1962.4  29187.1    .020  149.0    24.79  14.87    4.209  1.864   .473   .717  -.190  27940.1    .478
.712  -.190
         4.77 2063.9  31746.0    .019  149.0    25.64  15.38    4.353  1.960   .464   .727  -.190  30455.8    .468
.722  -.190
         5.45 2165.4  34390.2    .019  149.0    26.47  15.88    4.495  2.057   .455   .735  -.190  33057.5    .460
.731  -.191
         6.13 2266.9  37118.4    .018  149.0    27.29  16.37    4.634  2.153   .447   .743  -.190  35743.9    .451
.739  -.190
         6.81 2368.4  39929.2    .017  149.0    28.10  16.86    4.771  2.249   .439   .751  -.190  38513.5    .443
.747  -.190
         7.49 2469.9  42821.5    .017  149.0    28.90  17.34    4.907  2.346   .432   .758  -.189  41365.3    .435
.754  -.189
         8.17 2571.4  45794.2    .017  149.0    29.68  17.81    5.040  2.442   .424   .764  -.188  44297.9    .428
.761  -.189
         8.85 2672.9  48846.1    .016  149.0    30.46  18.27    5.172  2.538   .417   .770  -.188  47310.3    .421
.767  -.188
         9.54 2774.4  51976.3    .016  149.0    31.22  18.73    5.302  2.635   .410   .776  -.187  50401.5    .414
.773  -.187
        10.22 2875.9  55183.8    .015  149.0    31.98  19.19    5.431  2.731   .404   .782  -.185  53570.4    .407
.779  -.186
        10.90 2977.4  58467.6    .015  149.0    32.73  19.64    5.558  2.828   .397   .787  -.184  56816.2    .401
.784  -.185
        11.58 3078.8  61827.0    .015  149.0    33.47  20.08    5.683  2.924   .391   .792  -.183  60137.9    .394
.789  -.184
        12.26 3180.3  65261.0    .014  149.0    34.20  20.52    5.808  3.020   .385   .797  -.182  63534.7    .388
.794  -.182
        12.94 3281.8  68768.8    .014  149.0    34.91  20.95    5.927  3.118   .379   .801  -.180  67005.7    .382
.799  -.181
     MAXIMUM NO. ITERATIONS FOR SOLUTION (KKMAX) =   4 OCCURRED       1 TIMES.  AVERAGE NUMBER ITERATIONS =  1.5465
     Equations solved using the Ponce correction to C2


     PRINT HYD           ID=5   CODE=5

                                          HYDROGRAPH FROM AREA 73.2.5

          TIME      FLOW          TIME      FLOW          TIME      FLOW          TIME      FLOW          TIME
FLOW
```

HRS	CFS	HRS	CFS	HRS	CFS	HRS	CFS	HRS	CFS
.000	.0	6.000	674.7	12.000	61.9	18.000	40.1	24.000	21.5
.250	.0	6.250	652.4	12.250	60.1	18.250	39.7	24.250	20.2
.500	.0	6.500	627.0	12.500	58.4	18.500	39.3	24.500	19.0
.750	.0	6.750	597.9	12.750	56.8	18.750	39.0	24.750	17.2
1.000	4.1	7.000	564.3	13.000	55.3	19.000	38.6	25.000	15.0
1.250	7.3	7.250	524.6	13.250	53.9	19.250	38.2	25.250	13.3
1.500	153.4	7.500	471.4	13.500	52.6	19.500	37.7	25.500	12.0
1.750	465.4	7.750	323.1	13.750	51.5	19.750	37.2	25.750	11.0
2.000	814.1	8.000	202.0	14.000	50.4	20.000	36.6	26.000	10.2
2.250	943.6	8.250	156.4	14.250	49.3	20.250	36.1	26.250	9.7
2.500	1079.3	8.500	132.7	14.500	48.4	20.500	35.4	26.500	9.3
2.750	969.8	8.750	118.4	14.750	47.5	20.750	34.7	26.750	8.9
3.000	870.6	9.000	110.4	15.000	46.6	21.000	34.0	27.000	8.6
3.250	823.8	9.250	104.6	15.250	45.8	21.250	33.3	27.250	8.4
3.500	845.5	9.500	98.9	15.500	45.0	21.500	32.4	27.500	8.2
3.750	1142.4	9.750	93.5	15.750	44.3	21.750	31.1	27.750	8.0
4.000	1128.5	10.000	88.3	16.000	43.7	22.000	29.8	28.000	7.8
4.250	1082.7	10.250	83.4	16.250	43.0	22.250	28.7	28.250	7.6
4.500	1000.8	10.500	79.0	16.500	42.4	22.500	27.7	28.500	7.4
4.750	857.5	10.750	75.1	16.750	42.0	22.750	26.7	28.750	7.3
5.000	761.1	11.000	71.5	17.000	41.6	23.000	25.8	29.000	7.1
5.250	723.0	11.250	68.3	17.250	41.3	23.250	24.7	29.250	6.9
5.500	709.7	11.500	65.6	17.500	40.9	23.500	23.6	29.500	6.5
5.750	693.8	11.750	63.7	17.750	40.5	23.750	22.5	29.750	5.9

RUNOFF VOLUME = .52378 INCHES = 482.6983 ACRE-FEET
PEAK DISCHARGE RATE = 1150.39 CFS AT 3.800 HOURS BASIN AREA = 17.2795 SQ. MI.

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*S
*S*** SUB-BASIN 73.2
*
COMPUTE LT TP       LCODE=1  UPLAND/LAG TIME TRANSITION METHOD
                    NK=2  ISLOPE=-1
                    LENGTH=400 FT   SLOPE=0.02 K=0.7
                    LENGTH=865 FT  SLOPE=0.02 K=2.0
```

Tc AND Tp COMPUTED BY UPLAND/LAG TIME PROCEDURE

SCS UPLAND METHOD FACTORS

	LENGTH (FT)	SLOPE (FT/FT)	COMPOSITE K
SHEET FLOW PORTION	400.0	.020000	.7000
SHALLOW FLOW PORTION	865.0	.020000	2.0000
CHANNEL FLOW PORTION	.0	.000000	.0000
TOTAL BASIN	1265.0	.020000	1.2600

TIME OF CONCENTRATION (HRS)= .1972 TIME TO PEAK (HRS)= .1315 LAG TIME (HRS)= .1479

TIME TO PEAK COMPUTED TO BE LESS THAN 0.133333 HOUR MINIMUM VALUE.
REVISED VALUES: TIME OF CONCENTRATION (HRS)= .2000 TIME TO PEAK (HRS)= .1333 LAG TIME (HRS)= .1500

```
COMPUTE NM HYD      ID=4   HYD NO=73.2   DA=0.05105 SQ MI
                    PER A=10 PER B=20  PER C=30  PER D=40
                    TP=0.0   MASSRAIN=-1
```

```
 TIME TO PEAK (hrs)=   .1333

 K =   .072666HR    TP =   .133333HR    K/TP RATIO =   .545000     SHAPE CONSTANT, N =  7.106420
 UNIT PEAK =   80.599    CFS   UNIT VOLUME =    .9990       B =   526.28      P60 = 1.6900
 AREA =      .020420 SQ MI    IA =    .10000 INCHES    INF =    .04000 INCHES PER HOUR
 RUNOFF COMPUTED BY INITIAL ABSTRACTION/INFILTRATION NUMBER METHOD - DT =   .050000


 K =   .124706HR    TP =   .133333HR    K/TP RATIO =   .935295     SHAPE CONSTANT, N =  3.781454
 UNIT PEAK =   78.182    CFS   UNIT VOLUME =    1.001       B =   340.33      P60 = 1.6900
 AREA =      .030630 SQ MI    IA =    .45000 INCHES    INF =   1.11000 INCHES PER HOUR
 RUNOFF COMPUTED BY INITIAL ABSTRACTION/INFILTRATION NUMBER METHOD - DT =   .050000

BULKING FACTOR APPLIED TO HYDROGRAPH.  FACTOR =  1.09000 AT PEAK FLOW.

PRINT HYD           ID=4   CODE=5

                                    OUTFLOW HYDROGRAPH REACH    73.20

      TIME      FLOW          TIME      FLOW          TIME      FLOW          TIME      FLOW          TIME      FLOW
       HRS       CFS           HRS       CFS           HRS       CFS           HRS       CFS           HRS       CFS
      .000        .0         5.250        .6        10.500        .3        15.750        .3        21.000        .2
      .250        .0         5.500        .6        10.750        .3        16.000        .3        21.250        .2
      .500        .0         5.750        .6        11.000        .3        16.250        .3        21.500        .2
      .750        .1         6.000        .7        11.250        .3        16.500        .3        21.750        .2
     1.000       2.4         6.250        .5        11.500        .3        16.750        .3        22.000        .2
     1.250       7.1         6.500        .5        11.750        .3        17.000        .3        22.250        .2
     1.500      99.7         6.750        .4        12.000        .3        17.250        .3        22.500        .2
     1.750      34.8         7.000        .4        12.250        .3        17.500        .2        22.750        .2
     2.000      17.4         7.250        .4        12.500        .3        17.750        .2        23.000        .2
     2.250       5.8         7.500        .4        12.750        .3        18.000        .3        23.250        .2
     2.500       3.0         7.750        .4        13.000        .3        18.250        .3        23.500        .2
     2.750       1.8         8.000        .4        13.250        .3        18.500        .2        23.750        .2
     3.000       1.2         8.250        .4        13.500        .3        18.750        .2        24.000        .2
     3.250        .9         8.500        .4        13.750        .3        19.000        .2        24.250        .0
     3.500        .7         8.750        .4        14.000        .3        19.250        .2        24.500        .0
     3.750        .7         9.000        .4        14.250        .3        19.500        .2        24.750        .0
     4.000        .6         9.250        .4        14.500        .3        19.750        .2        25.000        .0
     4.250        .6         9.500        .4        14.750        .3        20.000        .2
     4.500        .6         9.750        .4        15.000        .3        20.250        .2
     4.750        .6        10.000        .4        15.250        .3        20.500        .2
     5.000        .6        10.250        .4        15.500        .3        20.750        .2

 RUNOFF VOLUME =     1.44269 INCHES     =       3.9280 ACRE-FEET
 PEAK DISCHARGE RATE =      99.73 CFS  AT   1.500 HOURS   BASIN AREA =   .0511 SQ. MI.


*
**********************************************************************

*S ADD 73.2 TO 73.2.5 TO GET 73.2.1
*S TOTAL FLOWS UPSTREAM END OF SAN ILDEFONSO DR
*
ADD HYD             ID=1  HYD NO=73.2.1 ID I=4 ID II=5
PRINT HYD           ID=1   CODE=1

                                    HYDROGRAPH FROM AREA 73.2.1


 RUNOFF VOLUME =      .52649 INCHES     =     486.6263 ACRE-FEET
 PEAK DISCHARGE RATE =    1151.04 CFS  AT   3.800 HOURS   BASIN AREA = 17.3305 SQ. MI.


*
**********************************************************************
**********************************************************************
FINISH

 NORMAL PROGRAM FINISH          END TIME (HR:MIN:SEC) = 17:11:09
```

APPENDIX 2 (CD)

HYDRAULICS – HEC-RAS Files

- **Effective Model**
- **Duplicate Effective Model**
- **Current Upstream Model**
- **Current Downstream Model**

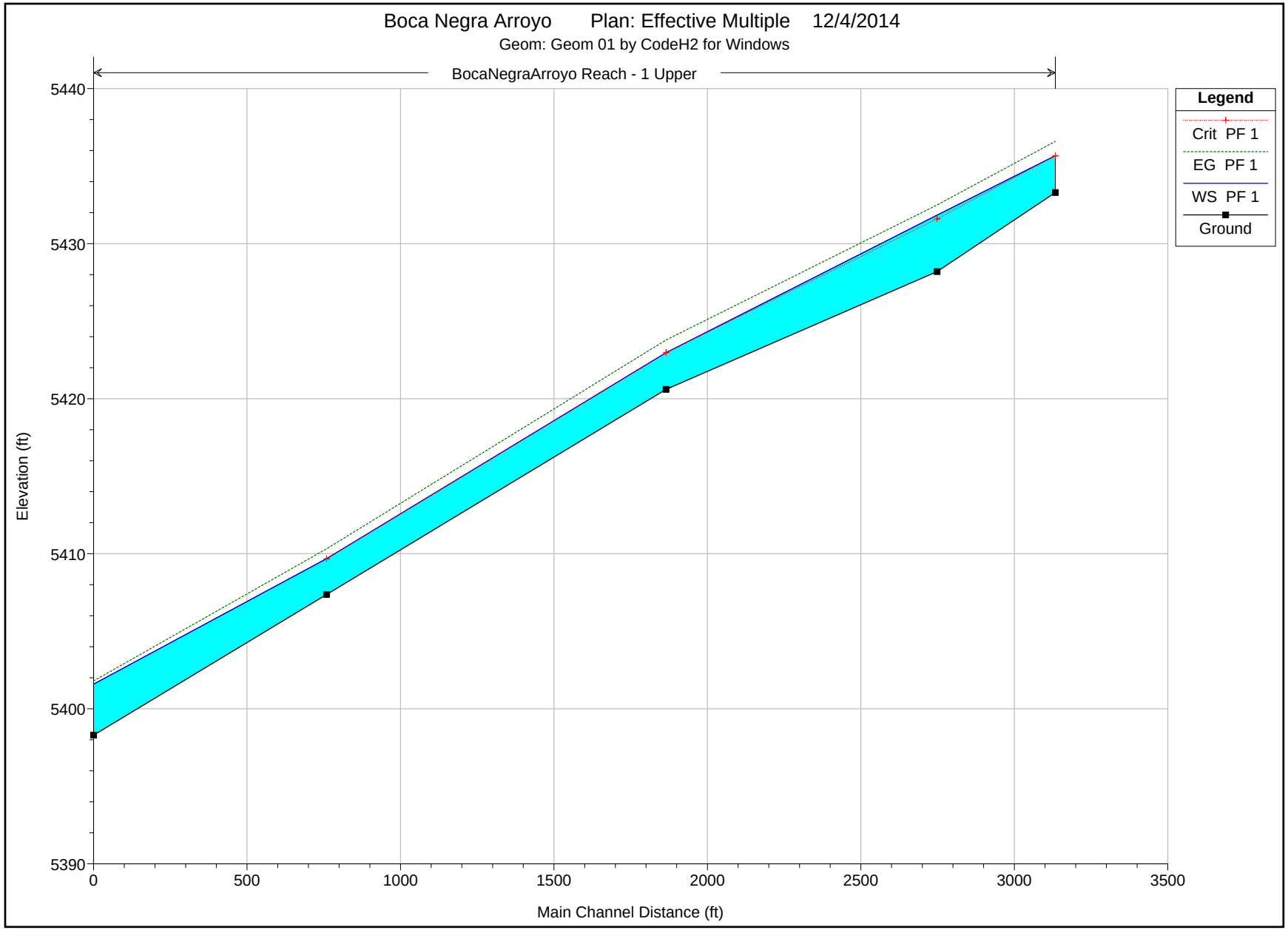
Effective Model

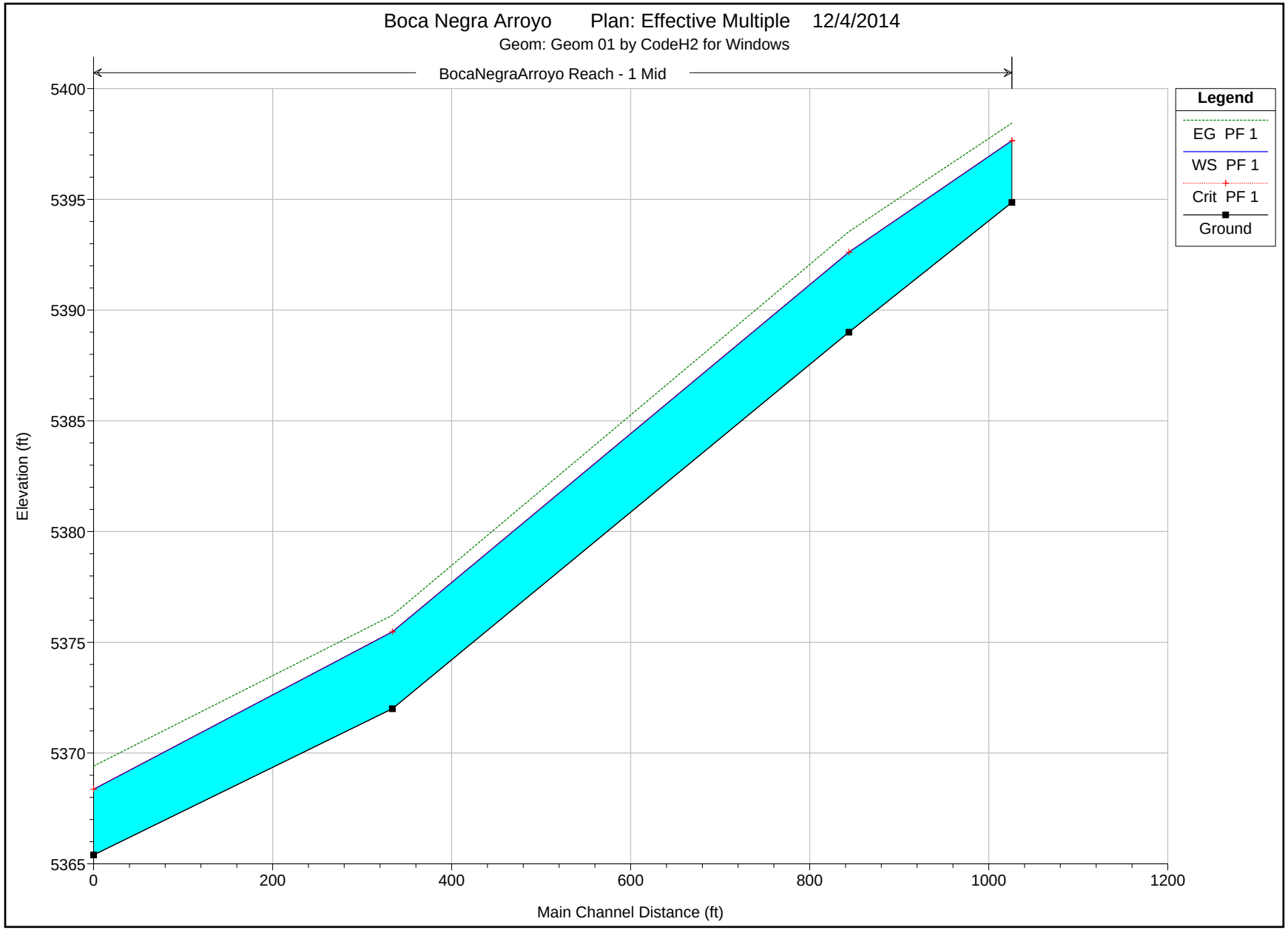
Summary
Profile
Cross Sections

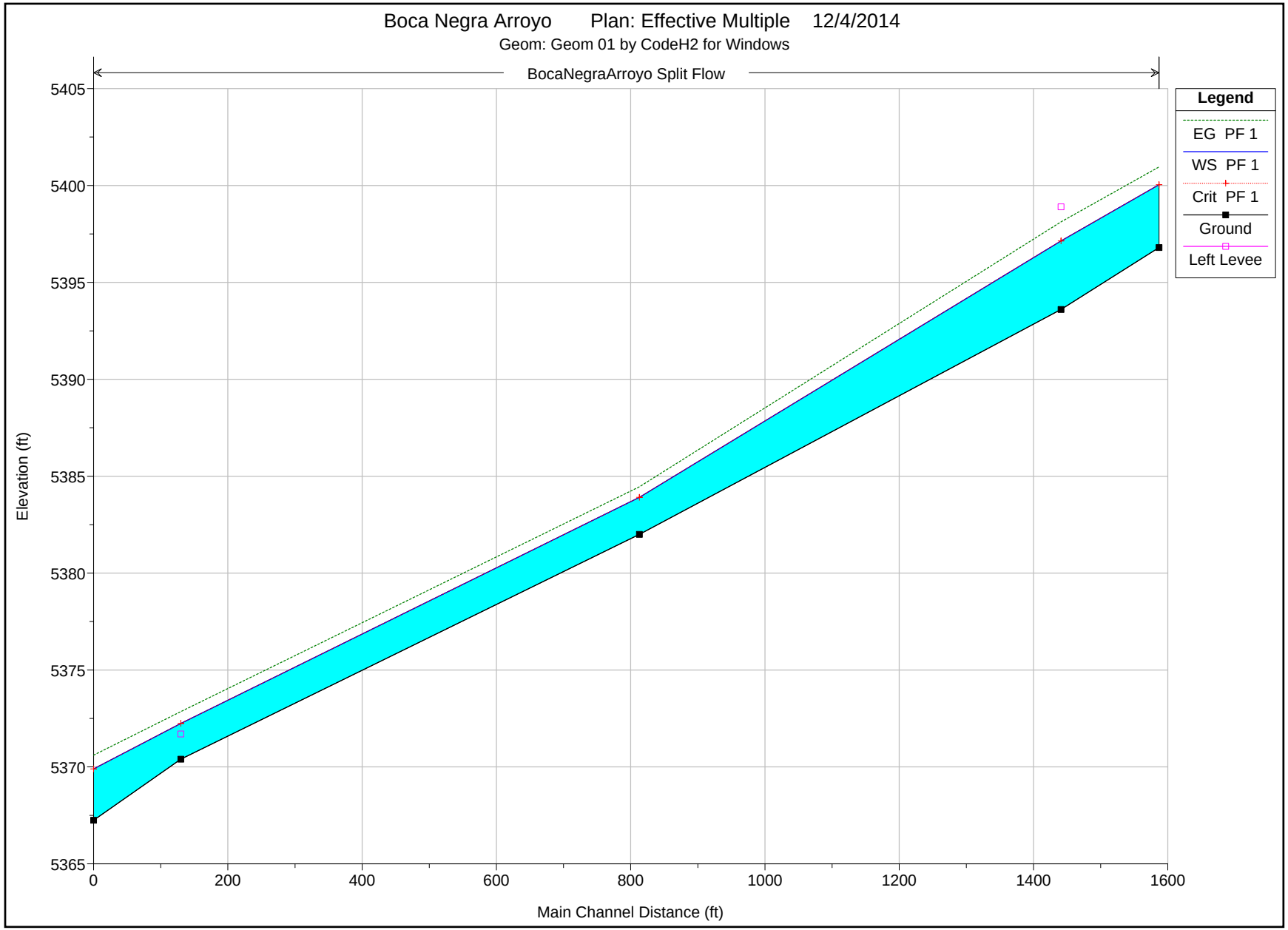
Hydraulics Model – HEC-RAS Analysis (CD)
FEMA Effective Files

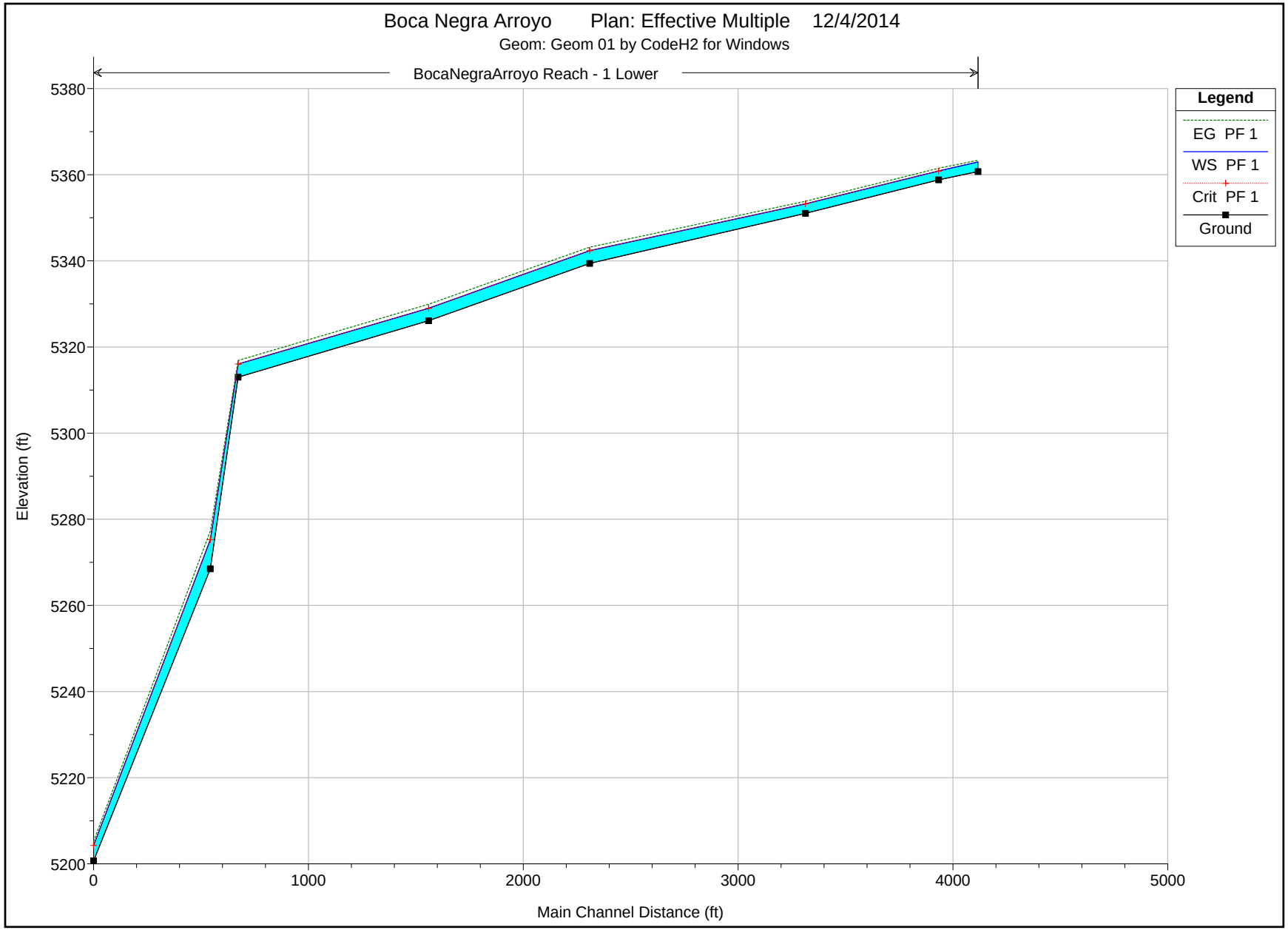
i.Project:	Boca Negra Arroyo	Boca Negra Arroyo.prj
ii.Plan:	Effective Multiple	Boca Negra Arroyo.p08
iii.Geometry:	Geom 01 by CodeH2 for windows	Boca Negra Arroyo.g01
iv.Flow:	Updated 2014 – Effective	Boca Negra Arroyo.f06

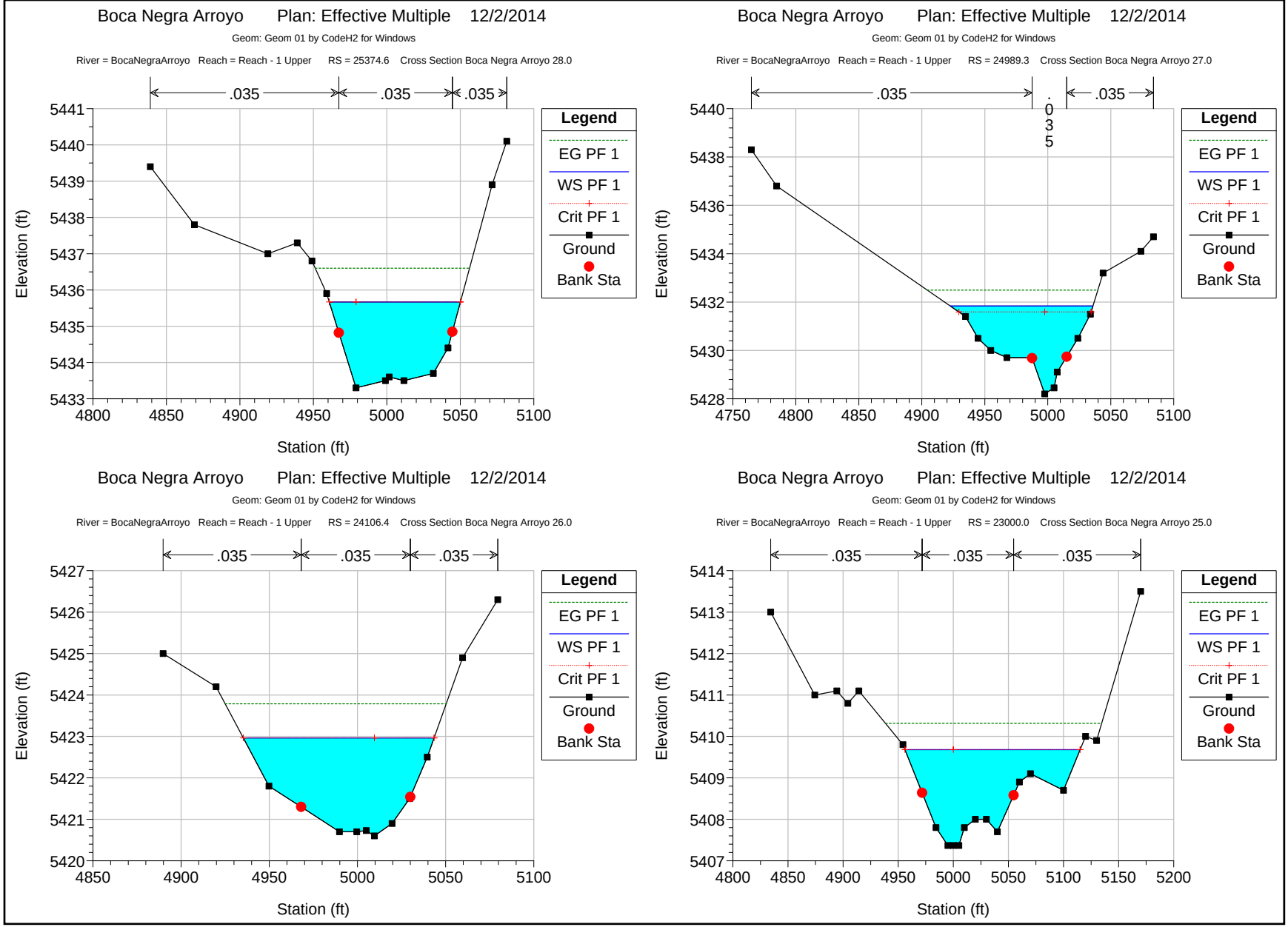
Boca Negra Arroyo - Effective Model													
Reach	River Sta	Cross Section	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach - 1 Upper	25374.6	Q	PF 1	1193	5433.3	5435.67	5435.67	5436.6	0.01371	7.78	156.61	89.28	0.98
Reach - 1 Upper	24989.3	P	PF 1	1193	5428.2	5431.84	5431.59	5432.49	0.007919	7.73	200.77	113.39	0.79
Reach - 1 Upper	24106.4	O	PF 1	1193	5420.6	5422.96	5422.96	5423.79	0.012566	7.72	172.12	108.2	0.95
Reach - 1 Upper	23000	N	PF 1	1193	5407.37	5409.68	5409.68	5410.31	0.011587	6.77	200.55	158.97	0.89
Reach - 1 Upper	22241.1	M	PF 1	1193	5398.3	5401.59		5401.79	0.002084	3.98	350.09	170.34	0.41
Reach - 1 Mid	22027.5	L	PF 1	1215	5394.86	5397.65	5397.65	5398.44	0.010509	7.45	184.24	122.42	0.88
Reach - 1 Mid	21845.5	K	PF 1	1215	5389	5392.61	5392.61	5393.54	0.010443	8.54	171.71	96.51	0.9
Reach - 1 Mid	21335.5	I	PF 1	1215	5372	5375.48	5375.48	5376.23	0.015719	6.95	174.76	116.8	1
Reach - 1 Mid	21001.7	J	PF 1	1215	5365.4	5368.37	5368.37	5369.42	0.011901	8.27	151.26	136.36	0.94
Split Flow	22027.5	E	PF 1	1215	5396.8	5400.04	5400.04	5400.96	0.014571	7.66	158.77	88.58	1
Split Flow	21845.5	D	PF 1	1215	5393.6	5397.14	5397.14	5398.12	0.014942	7.96	152.98	82.93	1.02
Split Flow	21335.5	C	PF 1	1215	5382	5383.91	5383.91	5384.45	0.017685	5.9	205.91	192.67	1.01
Split Flow	21001.7	B	PF 1	1215	5370.4	5372.24	5372.24	5372.85	0.015923	6.23	194.8	158.8	0.98
Split Flow	20774.5	A	PF 1	1215	5367.25	5369.9	5369.9	5370.61	0.01638	6.78	179.27	128.58	1.01
Reach - 1 Lower	20573.7	H	PF 1	1218	5360.73	5362.96		5363.33	0.00766	5.87	270.75	223.02	0.73
Reach - 1 Lower	20390.6	G	PF 1	1218	5358.8	5360.86	5360.85	5361.49	0.013323	7.5	200.59	153.68	0.96
Reach - 1 Lower	19770.6	F	PF 1	1218	5351.03	5353.24	5353.24	5353.84	0.011458	6.84	212.73	173.76	0.89
Reach - 1 Lower	18766.3	E	PF 1	1218	5339.4	5342.36	5342.36	5343.16	0.009778	7.57	188.44	130.91	0.86
Reach - 1 Lower	18016.1	D	PF 1	1218	5326.1	5328.99	5328.99	5329.93	0.01495	7.8	156.16	86.45	1.01
Reach - 1 Lower	17129.8	C	PF 1	1298	5313	5316.05	5316.05	5316.86	0.009499	8.1	199.89	120.13	0.86
Reach - 1 Lower	17000	B	PF 1	1298	5268.48	5275.25	5275.25	5277.25	0.022363	11.42	118.37	34.25	0.9
Reach - 1 Lower	16457	A	PF 1	1298	5200.7	5204.29	5204.29	5205.23	0.013801	7.82	167.29	90.37	0.98

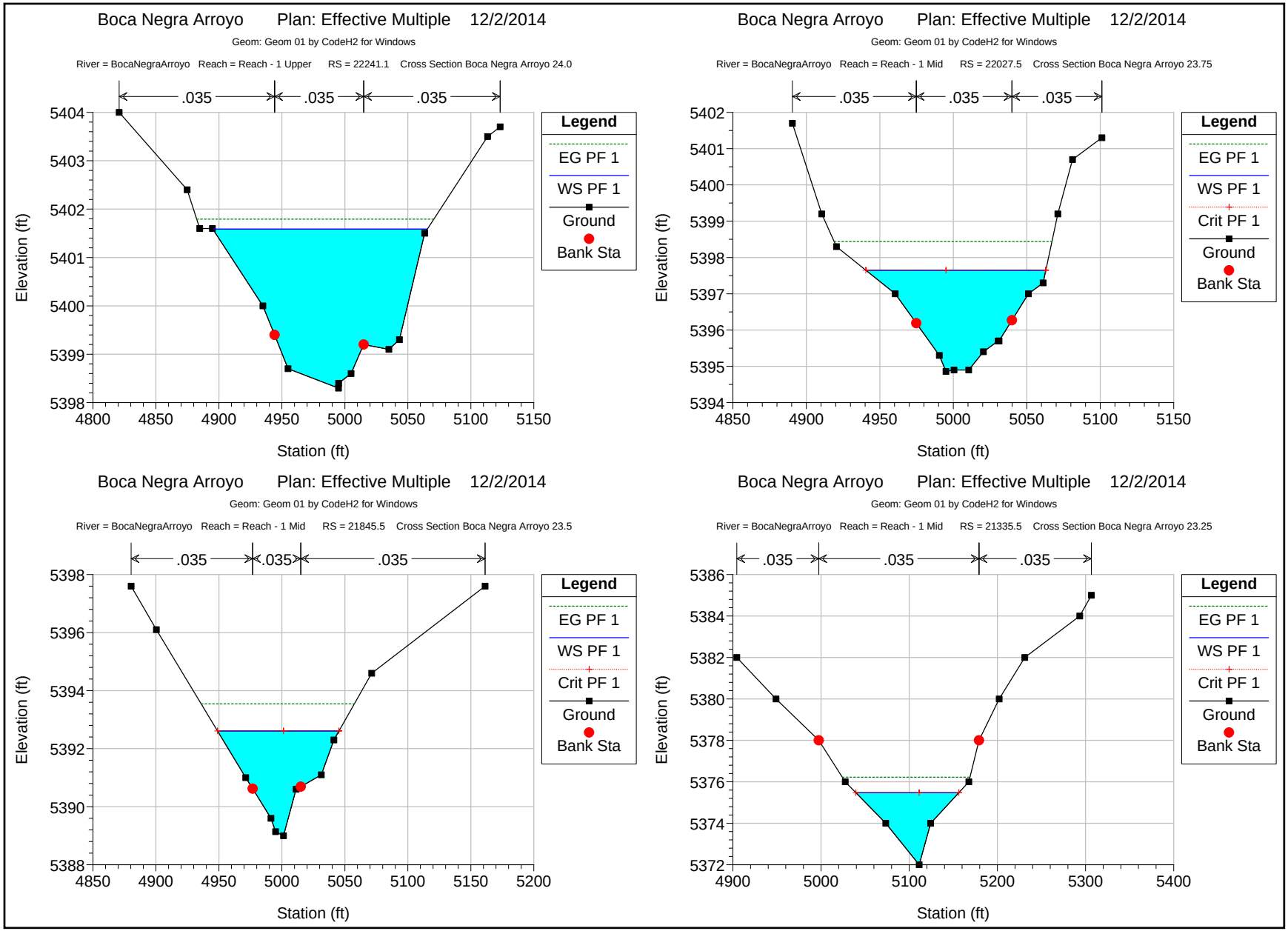

Boca Negra Arroyo Plan: Effective Multiple 12/4/2014
Geom: Geom 01 by CodeH2 for Windows
BocaNegraArroyo Reach - 1 Upper
Legend
Crit PF 1
EG PF 1
WS PF 1
Ground
Elevation (ft)
5440
5430
5420
5410
5400
5390
0
500
1000
1500
2000
2500
3000
3500
Main Channel Distance (ft)

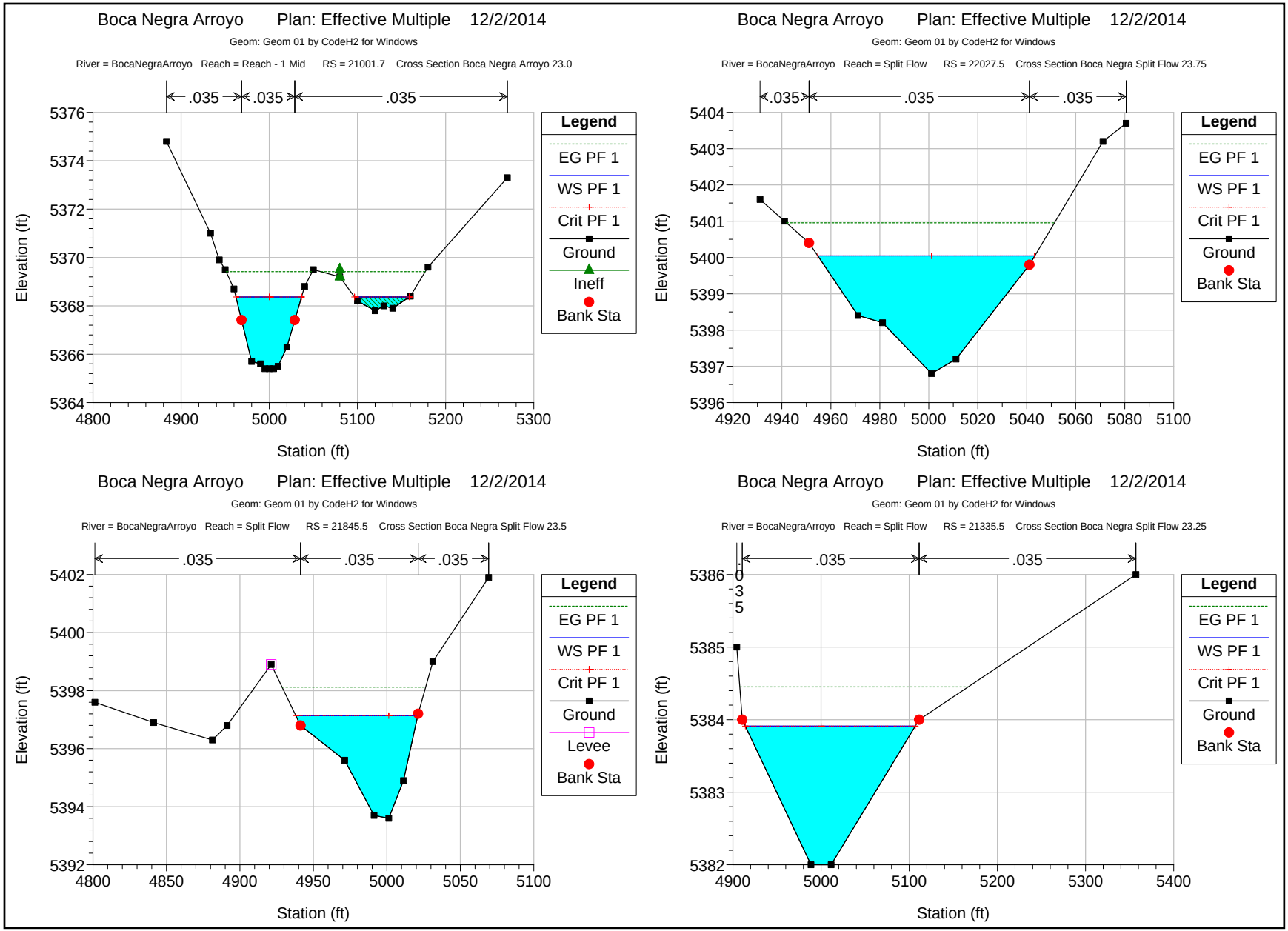

Boca Negra Arroyo Plan: Effective Multiple 12/4/2014
Geom: Geom 01 by CodeH2 for Windows
BocaNegraArroyo Reach - 1 Mid
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Elevation (ft)
5400
5395
5390
5385
5380
5375
5370
5365
0
200
400
600
800
1000
1200
Main Channel Distance (ft)

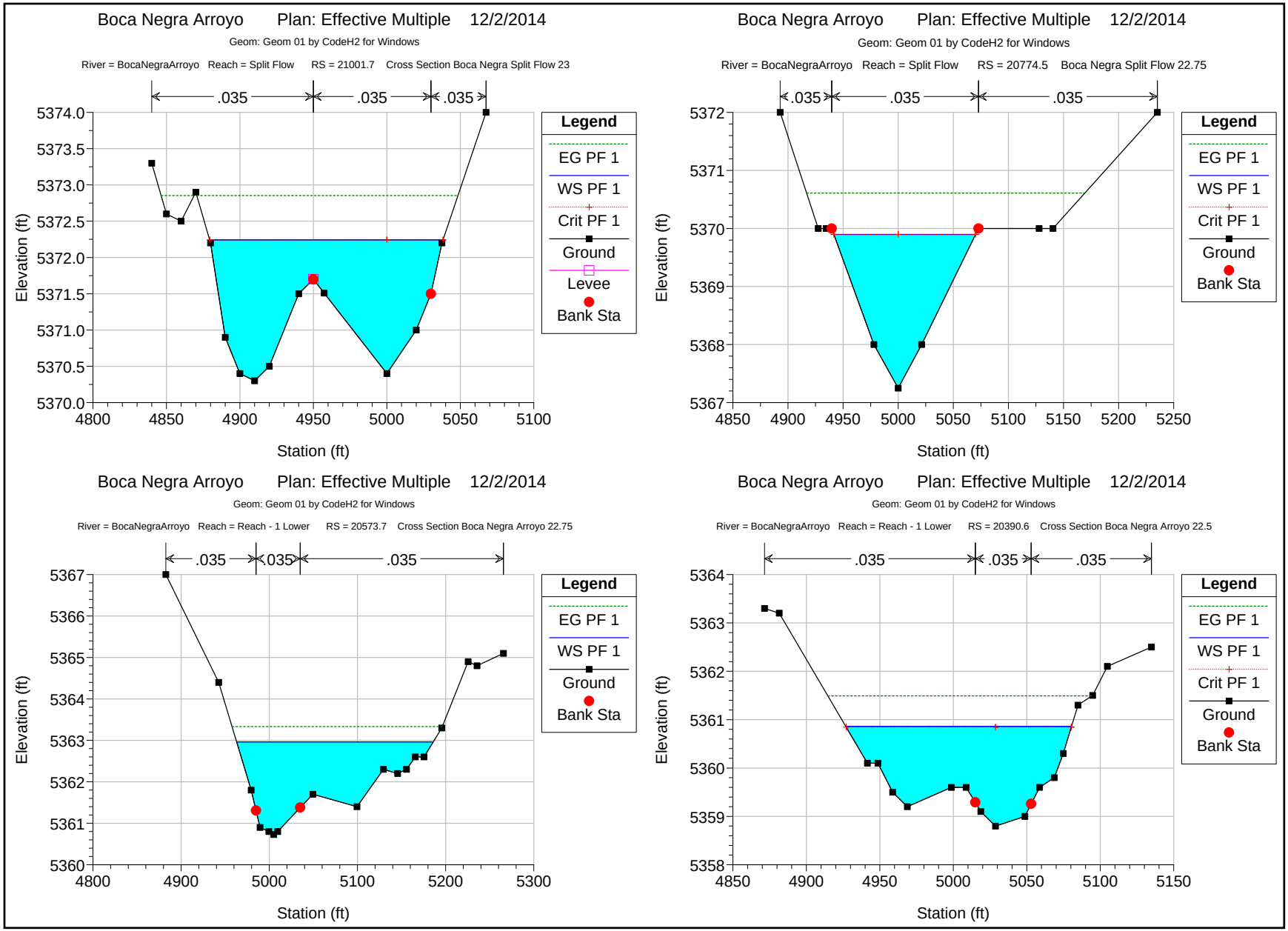

Boca Negra Arroyo Plan: Effective Multiple 12/4/2014
Geom: Geom 01 by CodeH2 for Windows
BocaNegraArroyo Split Flow
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Left Levee
Elevation (ft)
5405
5400
5395
5390
5385
5380
5375
5370
5365
0
200
400
600
800
1000
1200
1400
1600
Main Channel Distance (ft)

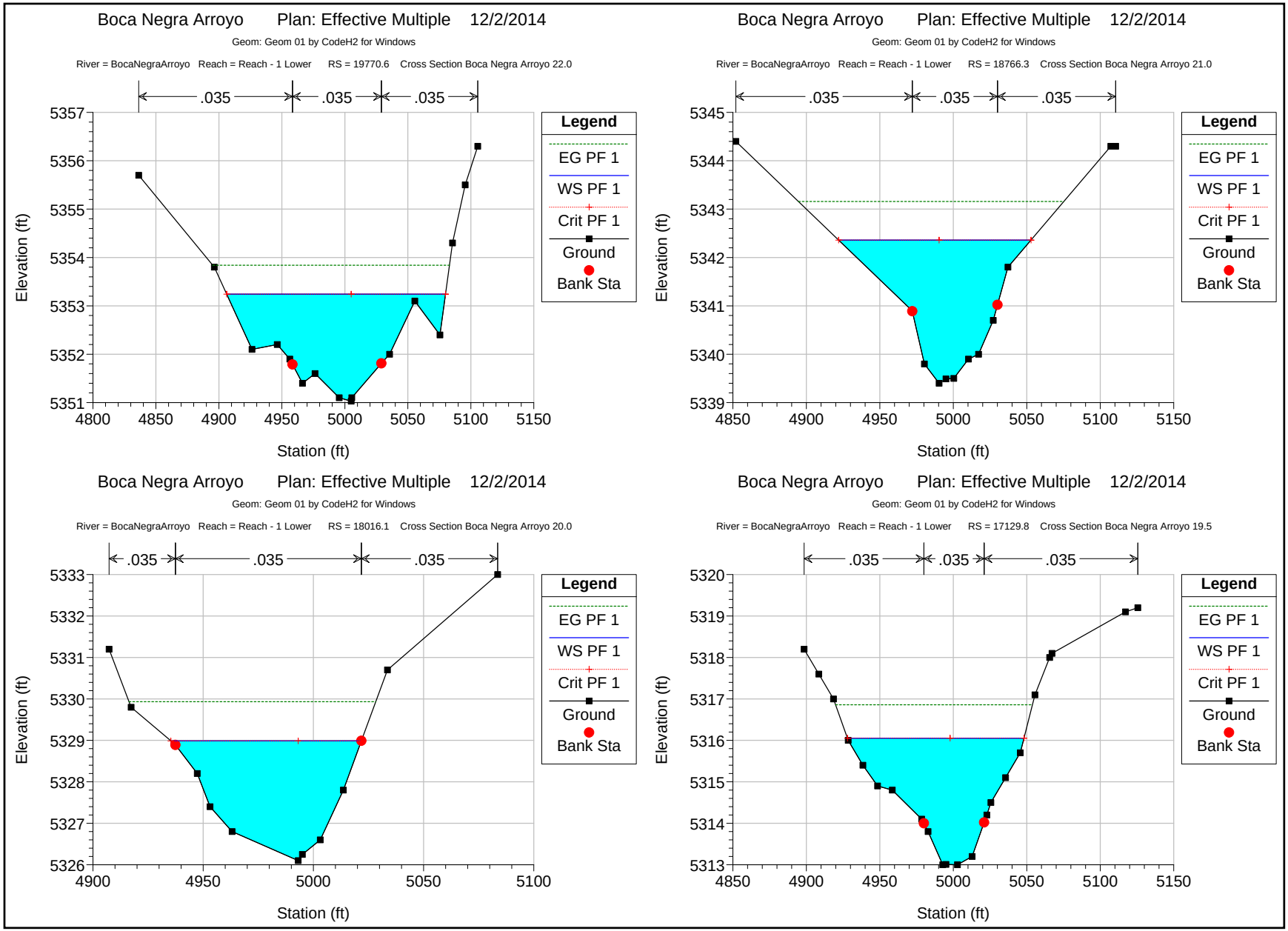

Boca Negra Arroyo Plan: Effective Multiple 12/4/2014
Geom: Geom 01 by CodeH2 for Windows
BocaNegraArroyo Reach - 1 Lower
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Elevation (ft)
5380
5360
5340
5320
5300
5280
5260
5240
5220
5200
0
1000
2000
3000
4000
5000
Main Channel Distance (ft)

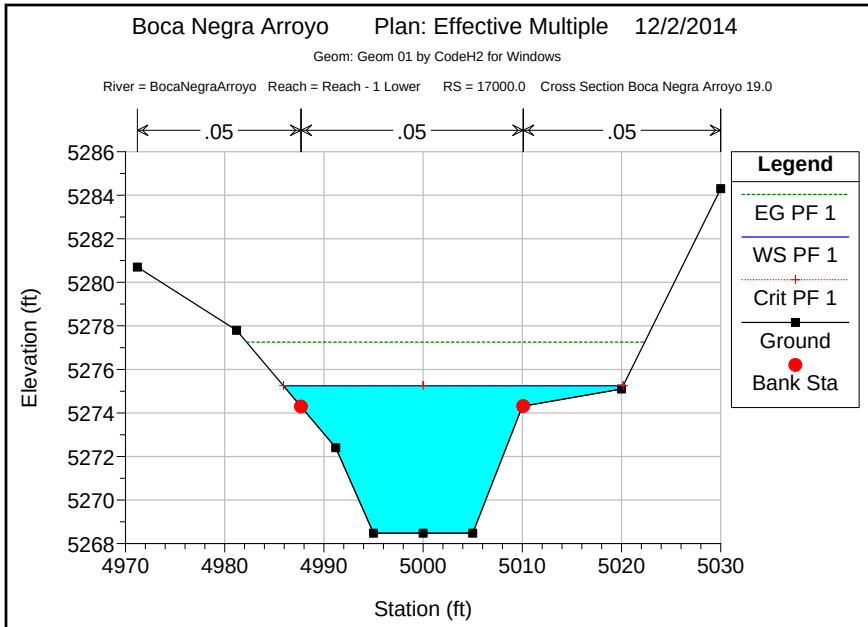

Boca Negra Arroyo Plan: Effective Multiple 12/2/2014
Geom: Geom 01 by CodeH2 for Windows
River = BocaNegraArroyo Reach = Reach - 1 Upper RS = 25374.6 Cross Section Boca Negra Arroyo 28.0
.035
.035
.035
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)
Boca Negra Arroyo Plan: Effective Multiple 12/2/2014
Geom: Geom 01 by CodeH2 for Windows
River = BocaNegraArroyo Reach = Reach - 1 Upper RS = 24989.3 Cross Section Boca Negra Arroyo 27.0
.035
.035
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)
Boca Negra Arroyo Plan: Effective Multiple 12/2/2014
Geom: Geom 01 by CodeH2 for Windows
River = BocaNegraArroyo Reach = Reach - 1 Upper RS = 24106.4 Cross Section Boca Negra Arroyo 26.0
.035
.035
.035
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)
Boca Negra Arroyo Plan: Effective Multiple 12/2/2014
Geom: Geom 01 by CodeH2 for Windows
River = BocaNegraArroyo Reach = Reach - 1 Upper RS = 23000.0 Cross Section Boca Negra Arroyo 25.0
.035
.035
.035
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)

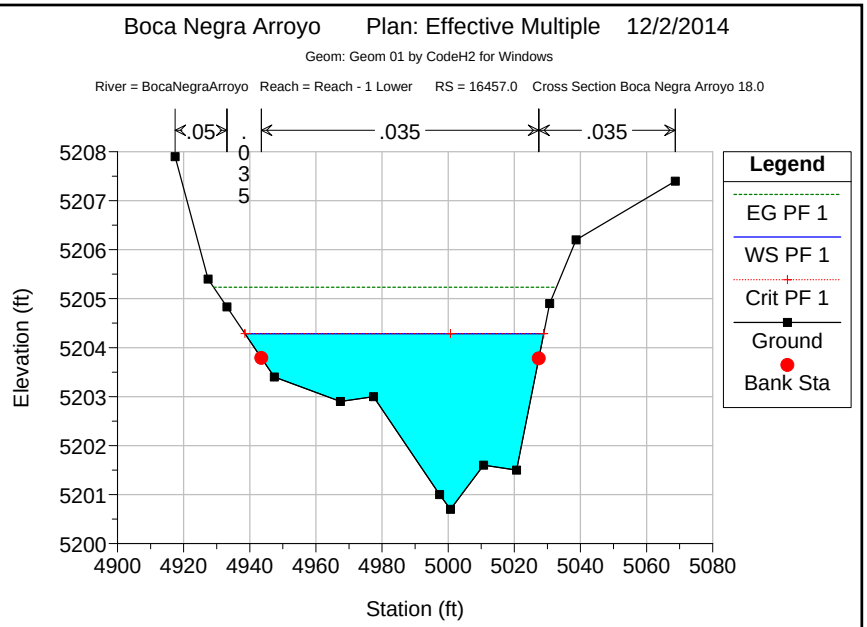

Boca Negra Arroyo Plan: Effective Multiple 12/2/2014
Geom: Geom 01 by CodeH2 for Windows
River = BocaNegraArroyo Reach = Reach - 1 Upper RS = 22241.1 Cross Section Boca Negra Arroyo 24.0
.035
.035
.035
Legend
EG PF 1
WS PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)
Boca Negra Arroyo Plan: Effective Multiple 12/2/2014
Geom: Geom 01 by CodeH2 for Windows
River = BocaNegraArroyo Reach = Reach - 1 Mid RS = 22027.5 Cross Section Boca Negra Arroyo 23.75
.035
.035
.035
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)
Boca Negra Arroyo Plan: Effective Multiple 12/2/2014
Geom: Geom 01 by CodeH2 for Windows
River = BocaNegraArroyo Reach = Reach - 1 Mid RS = 21845.5 Cross Section Boca Negra Arroyo 23.5
.035
.035
.035
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)
Boca Negra Arroyo Plan: Effective Multiple 12/2/2014
Geom: Geom 01 by CodeH2 for Windows
River = BocaNegraArroyo Reach = Reach - 1 Mid RS = 21335.5 Cross Section Boca Negra Arroyo 23.25
.035
.035
.035
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)


Boca Negra Arroyo Plan: Effective Multiple 12/2/2014
Geom: Geom 01 by CodeH2 for Windows
River = BocaNegraArroyo Reach = Reach - 1 Mid RS = 21001.7 Cross Section Boca Negra Arroyo 23.0
.035
.035
.035
Elevation (ft)
Station (ft)
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Ineff
Bank Sta
Boca Negra Arroyo Plan: Effective Multiple 12/2/2014
Geom: Geom 01 by CodeH2 for Windows
River = BocaNegraArroyo Reach = Split Flow RS = 22027.5 Cross Section Boca Negra Split Flow 23.75
.035
.035
.035
Elevation (ft)
Station (ft)
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Boca Negra Arroyo Plan: Effective Multiple 12/2/2014
Geom: Geom 01 by CodeH2 for Windows
River = BocaNegraArroyo Reach = Split Flow RS = 21845.5 Cross Section Boca Negra Split Flow 23.5
.035
.035
.035
Elevation (ft)
Station (ft)
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Levee
Bank Sta
Boca Negra Arroyo Plan: Effective Multiple 12/2/2014
Geom: Geom 01 by CodeH2 for Windows
River = BocaNegraArroyo Reach = Split Flow RS = 21335.5 Cross Section Boca Negra Split Flow 23.25
.035
.035
Elevation (ft)
Station (ft)
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta


Boca Negra Arroyo Plan: Effective Multiple 12/2/2014
Geom: Geom 01 by CodeH2 for Windows
River = BocaNegraArroyo Reach = Split Flow RS = 21001.7 Cross Section Boca Negra Split Flow 23
.035
.035
.035
Elevation (ft)
Station (ft)
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Levee
Bank Sta
Boca Negra Arroyo Plan: Effective Multiple 12/2/2014
Geom: Geom 01 by CodeH2 for Windows
River = BocaNegraArroyo Reach = Split Flow RS = 20774.5 Boca Negra Split Flow 22.75
.035
.035
.035
Elevation (ft)
Station (ft)
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Boca Negra Arroyo Plan: Effective Multiple 12/2/2014
Geom: Geom 01 by CodeH2 for Windows
River = BocaNegraArroyo Reach = Reach - 1 Lower RS = 20573.7 Cross Section Boca Negra Arroyo 22.75
.035
.035
.035
Elevation (ft)
Station (ft)
Legend
EG PF 1
WS PF 1
Ground
Bank Sta
Boca Negra Arroyo Plan: Effective Multiple 12/2/2014
Geom: Geom 01 by CodeH2 for Windows
River = BocaNegraArroyo Reach = Reach - 1 Lower RS = 20390.6 Cross Section Boca Negra Arroyo 22.5
.035
.035
.035
Elevation (ft)
Station (ft)
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta


Boca Negra Arroyo Plan: Effective Multiple 12/2/2014
Geom: Geom 01 by CodeH2 for Windows
River = BocaNegraArroyo Reach = Reach - 1 Lower RS = 19770.6 Cross Section Boca Negra Arroyo 22.0
.035
.035
.035
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)
Boca Negra Arroyo Plan: Effective Multiple 12/2/2014
Geom: Geom 01 by CodeH2 for Windows
River = BocaNegraArroyo Reach = Reach - 1 Lower RS = 18766.3 Cross Section Boca Negra Arroyo 21.0
.035
.035
.035
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)
Boca Negra Arroyo Plan: Effective Multiple 12/2/2014
Geom: Geom 01 by CodeH2 for Windows
River = BocaNegraArroyo Reach = Reach - 1 Lower RS = 18016.1 Cross Section Boca Negra Arroyo 20.0
.035
.035
.035
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)
Boca Negra Arroyo Plan: Effective Multiple 12/2/2014
Geom: Geom 01 by CodeH2 for Windows
River = BocaNegraArroyo Reach = Reach - 1 Lower RS = 17129.8 Cross Section Boca Negra Arroyo 19.5
.035
.035
.035
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)


Boca Negra Arroyo Plan: Effective Multiple 12/2/2014
Geom: Geom 01 by CodeH2 for Windows
River = BocaNegraArroyo Reach = Reach - 1 Lower RS = 17000.0 Cross Section Boca Negra Arroyo 19.0
.05
.05
.05
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)
5286
5284
5282
5280
5278
5276
5274
5272
5270
5268
4970
4980
4990
5000
5010
5020
5030


Boca Negra Arroyo Plan: Effective Multiple 12/2/2014
Geom: Geom 01 by CodeH2 for Windows
River = BocaNegraArroyo Reach = Reach - 1 Lower RS = 16457.0 Cross Section Boca Negra Arroyo 18.0
.05
.035
.035
.035
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)
5208
5207
5206
5205
5204
5203
5202
5201
5200
4900
4920
4940
4960
4980
5000
5020
5040
5060
5080

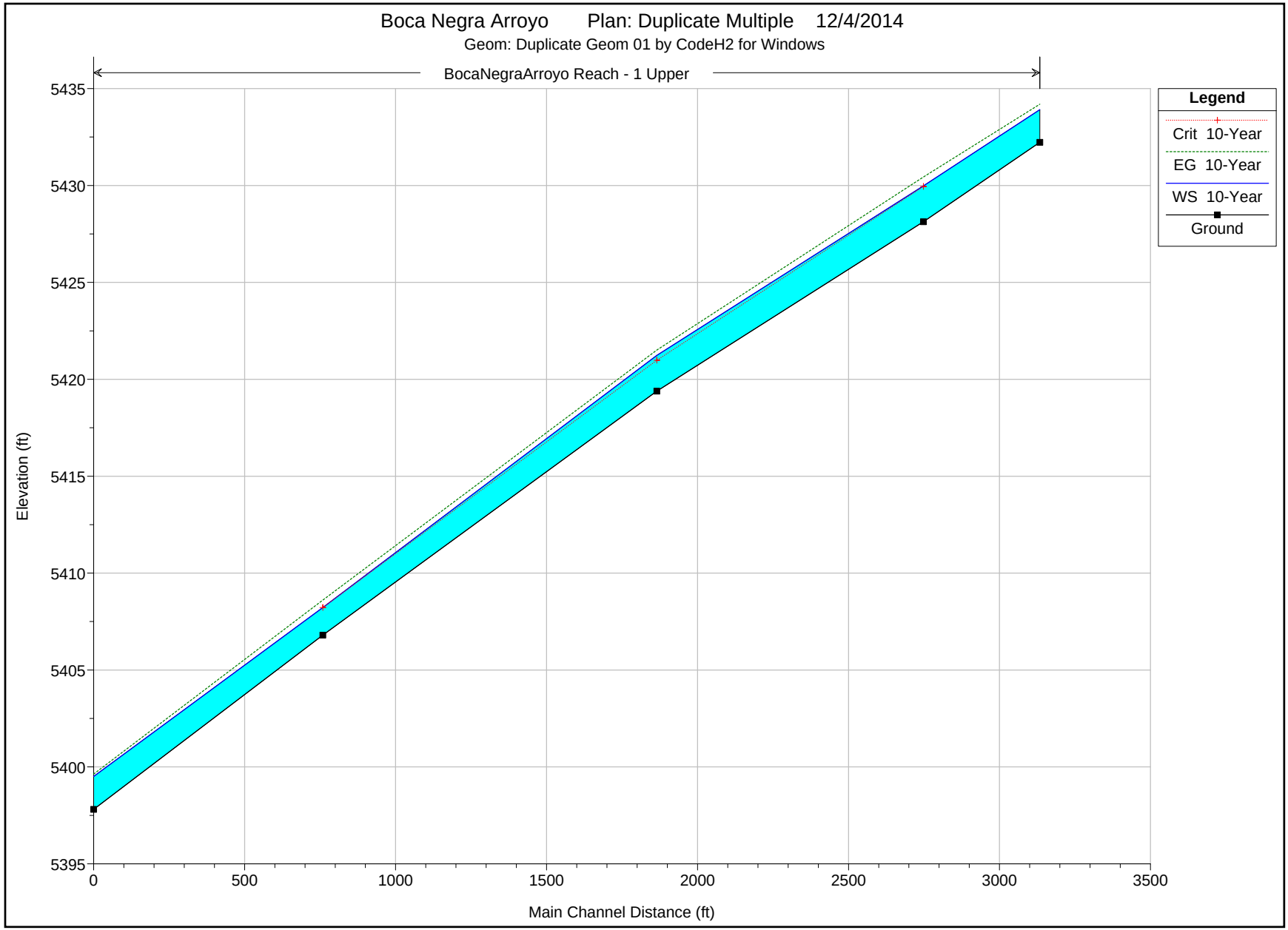
Duplicate Effective Model

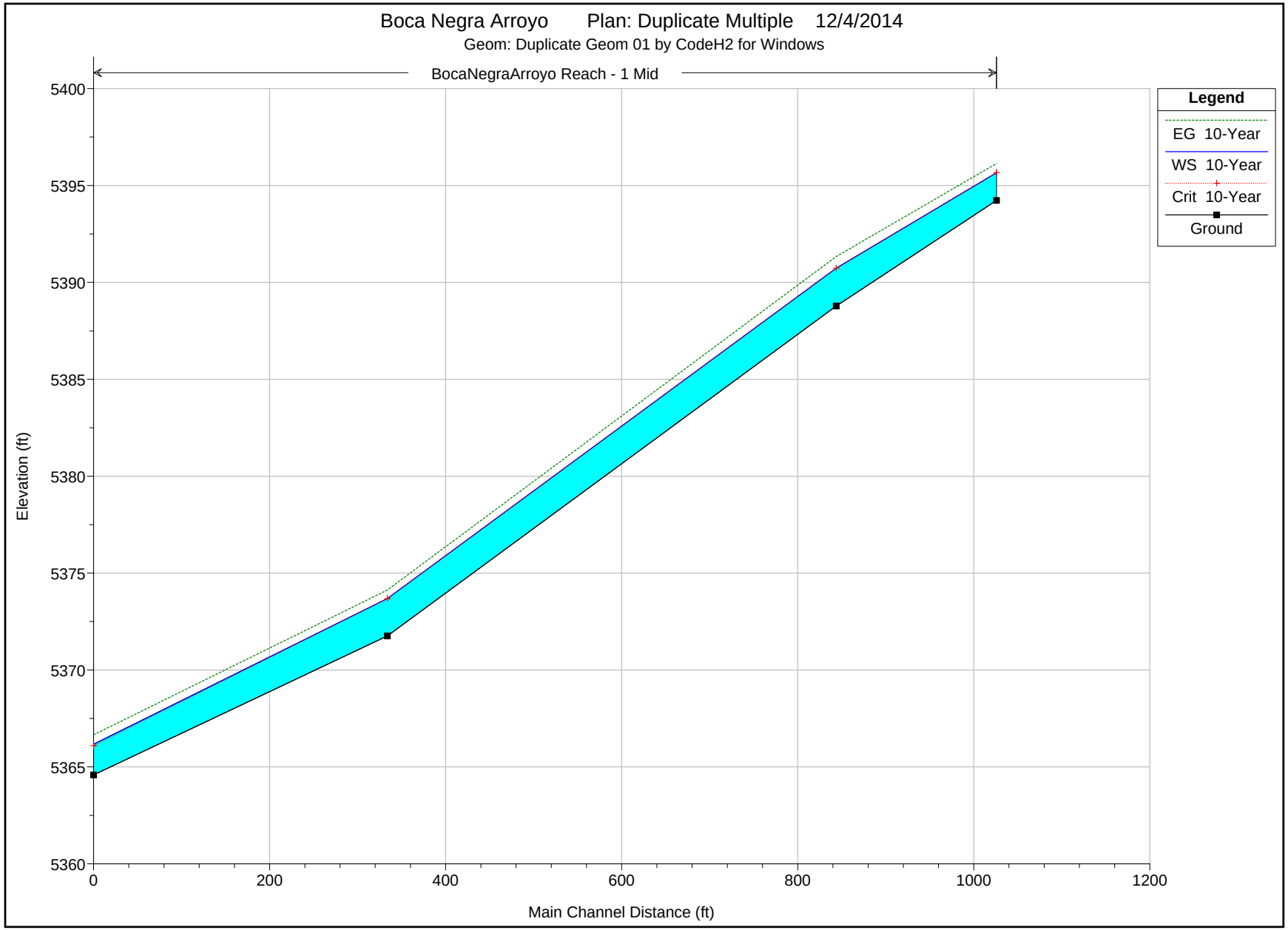
Summary
Profile
Cross Sections

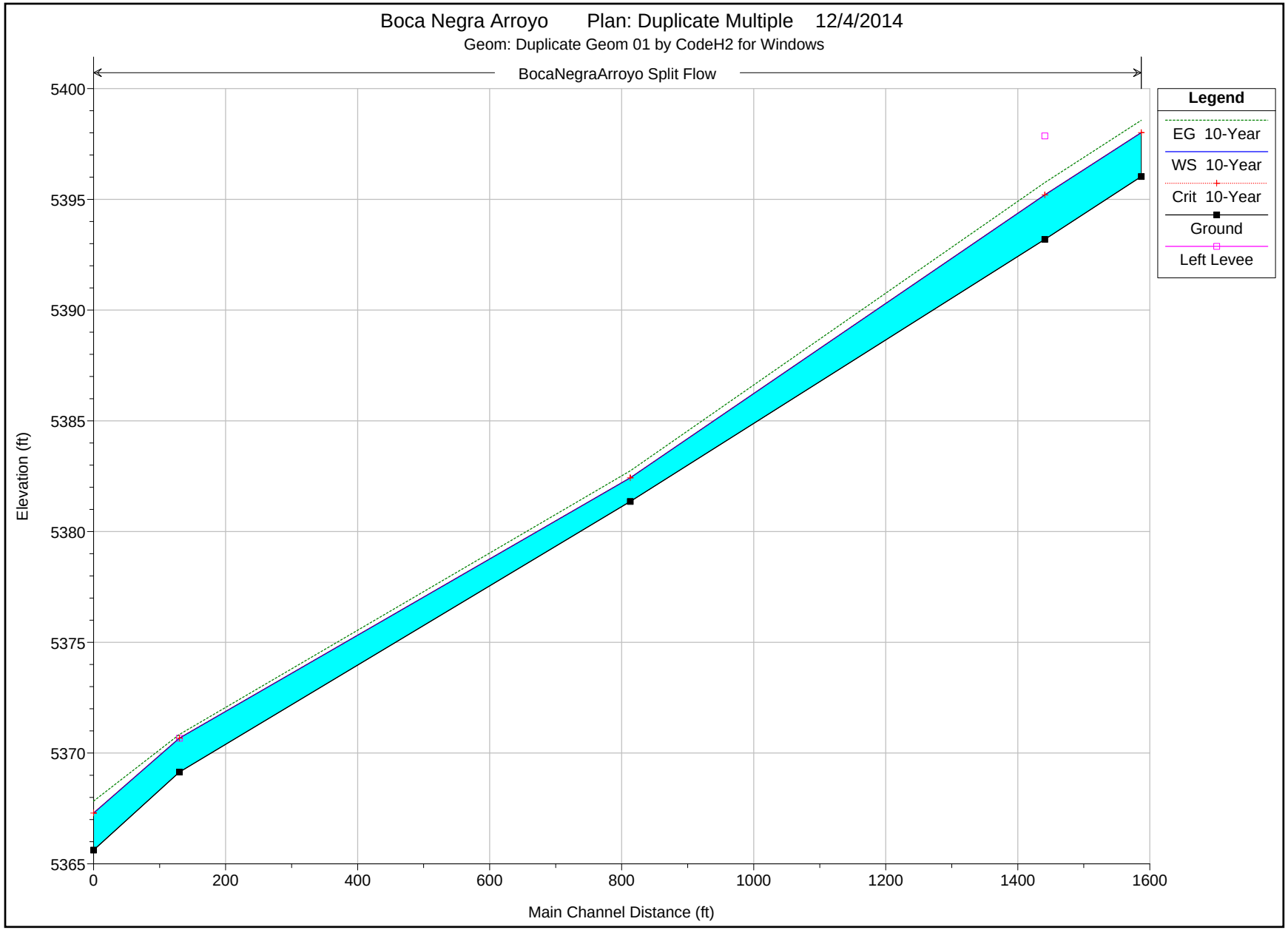
Hydraulics Model – HEC-RAS Analysis (CD)
FEMA Duplicate Effective Files

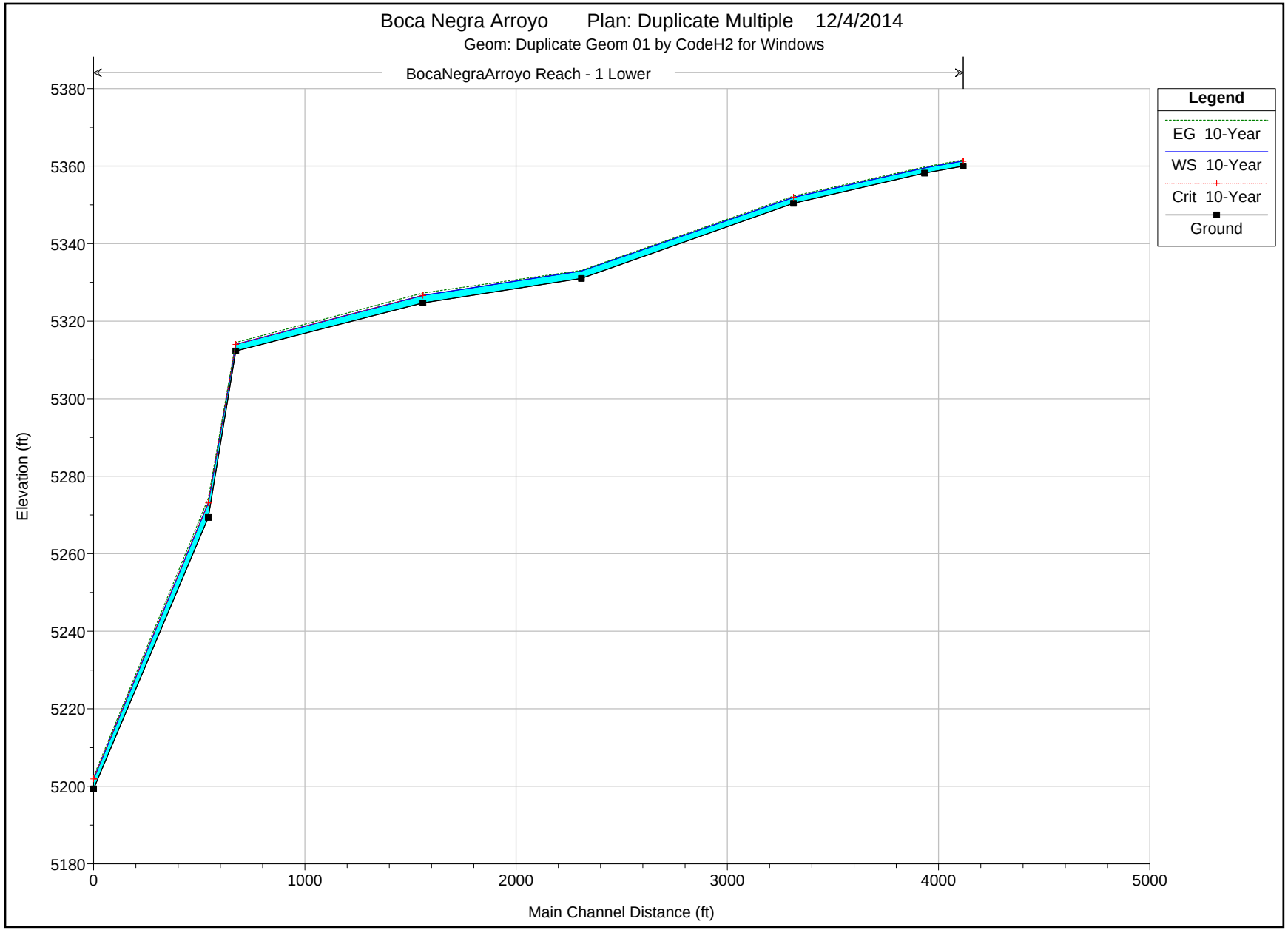
i.Project:	Boca Negra Arroyo	Boca Negra Arroyo.prj
ii.Plan:	Multiple Updated Flow	Boca Negra Arroyo.p05
iii.Geometry:	Duplicate Geom 01 by CodeH2 for windows	Boca Negra Arroyo.g04
iv.Flow:	Updated 2014	Boca Negra Arroyo.f01

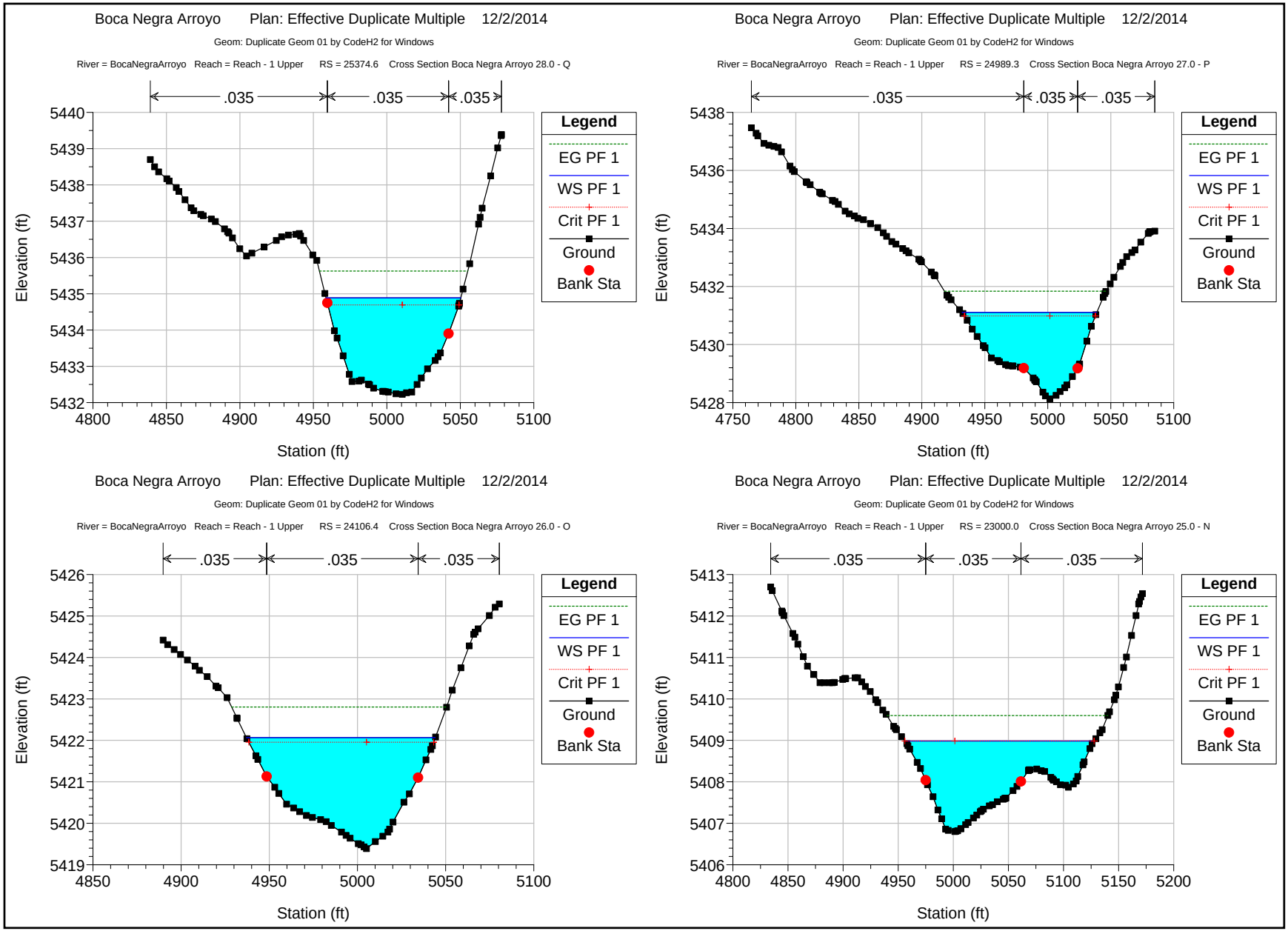
Boca Negra Arroyo - Duplicate Effective Model													
Reach	River Sta	Cross Section	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach - 1 Upper	25374.6	Q	PF 1	1193	5432.23	5434.89	5434.69	5435.63	0.010156	6.93	174.84	91.71	0.85
Reach - 1 Upper	24989.3	P	PF 1	1193	5428.13	5431.11	5430.99	5431.84	0.009544	7.64	185.62	106.99	0.85
Reach - 1 Upper	24106.4	O	PF 1	1193	5419.39	5422.07	5421.96	5422.8	0.011023	6.95	177.79	107.19	0.88
Reach - 1 Upper	23000	N	PF 1	1193	5406.8	5408.99	5408.99	5409.6	0.012888	6.73	202.56	171.81	0.92
Reach - 1 Upper	22241.1	M	PF 1	1193	5397.81	5400.83		5401.06	0.00231	3.94	326.78	162.42	0.42
Reach - 1 Mid	22027.5	L	PF 1	1215	5394.23	5396.68	5396.68	5397.48	0.013755	7.23	172.91	117.31	0.96
Reach - 1 Mid	21845.5	K	PF 1	1215	5388.78	5392.03	5392.03	5392.98	0.010556	8.25	168.19	93.65	0.9
Reach - 1 Mid	21335.5	I	PF 1	1215	5371.76	5374.61	5374.61	5375.32	0.016031	6.77	179.56	126.88	1
Reach - 1 Mid	21001.7	J	PF 1	1215	5364.59	5367.33	5367.33	5368.34	0.014032	8.07	150.72	126.52	1
Split Flow	22027.5	E	PF 1	1215	5396.03	5399.23	5399.23	5400.21	0.012136	8.06	159.99	92.1	0.94
Split Flow	21845.5	D	PF 1	1215	5393.19	5396.45	5396.45	5397.4	0.014147	7.85	154.88	79.6	0.99
Split Flow	21335.5	C	PF 1	1215	5381.36	5383.09	5383.09	5383.65	0.017527	5.99	202.97	184.61	1.01
Split Flow	21001.7	B	PF 1	1215	5369.14	5371.14	5371.14	5371.74	0.016072	6.42	195.91	162.66	0.99
Split Flow	20774.5	A	PF 1	1215	5365.62	5368.52	5368.52	5369.29	0.015836	7.06	172.17	113.22	1.01
Reach - 1 Lower	20573.7	H	PF 1	1218	5359.99	5362.16	5362.07	5362.59	0.008864	6.21	254.61	221.76	0.79
Reach - 1 Lower	20390.6	G	PF 1	1218	5358.19	5360.25	5360.14	5360.77	0.011134	6.72	217.67	163	0.87
Reach - 1 Lower	19770.6	F	PF 1	1218	5350.42	5352.7	5352.7	5353.31	0.013025	6.91	207.2	173.39	0.93
Reach - 1 Lower	18766.3	E	PF 1	1218	5331.02	5334.14		5334.51	0.004476	4.88	249.52	110.36	0.57
Reach - 1 Lower	18016.1	D	PF 1	1218	5324.69	5327.94	5327.94	5328.89	0.014637	7.82	155.74	82.59	1
Reach - 1 Lower	17129.8	C	PF 1	1298	5312.3	5315.1	5315.1	5315.91	0.010453	7.91	192.9	117.09	0.89
Reach - 1 Lower	17000	B	PF 1	1298	5269.36	5275.33	5275.33	5277.13	0.026371	10.78	120.4	33.72	1.01
Reach - 1 Lower	16457	A	PF 1	1298	5199.33	5203.09	5203.09	5203.95	0.015134	7.45	174.23	101.64	1

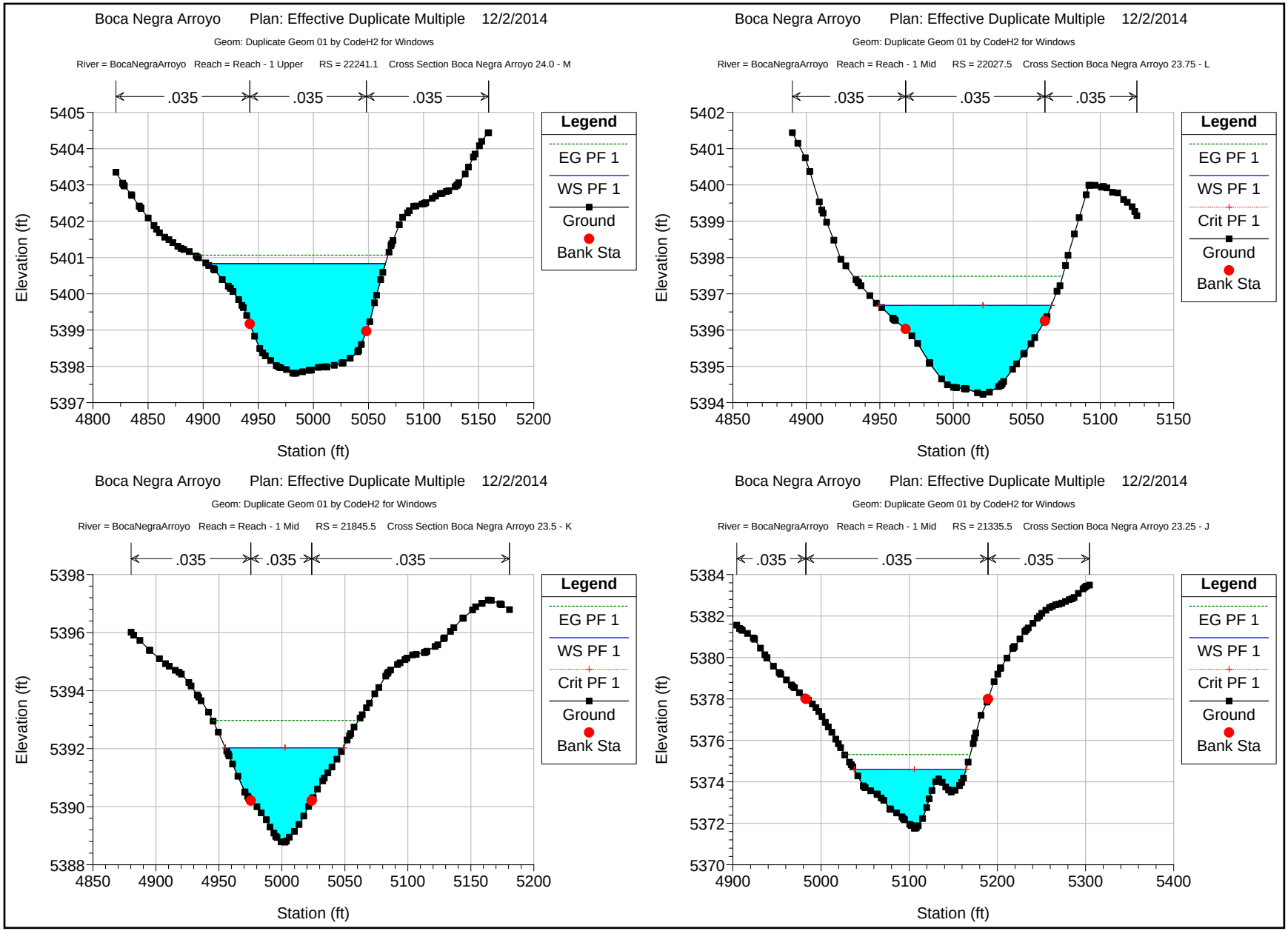

Boca Negra Arroyo Plan: Duplicate Multiple 12/4/2014
Geom: Duplicate Geom 01 by CodeH2 for Windows
BocaNegraArroyo Reach - 1 Upper
Legend
Crit 10-Year
EG 10-Year
WS 10-Year
Ground
Elevation (ft)
5435
5430
5425
5420
5415
5410
5405
5400
5395
0
500
1000
1500
2000
2500
3000
3500
Main Channel Distance (ft)

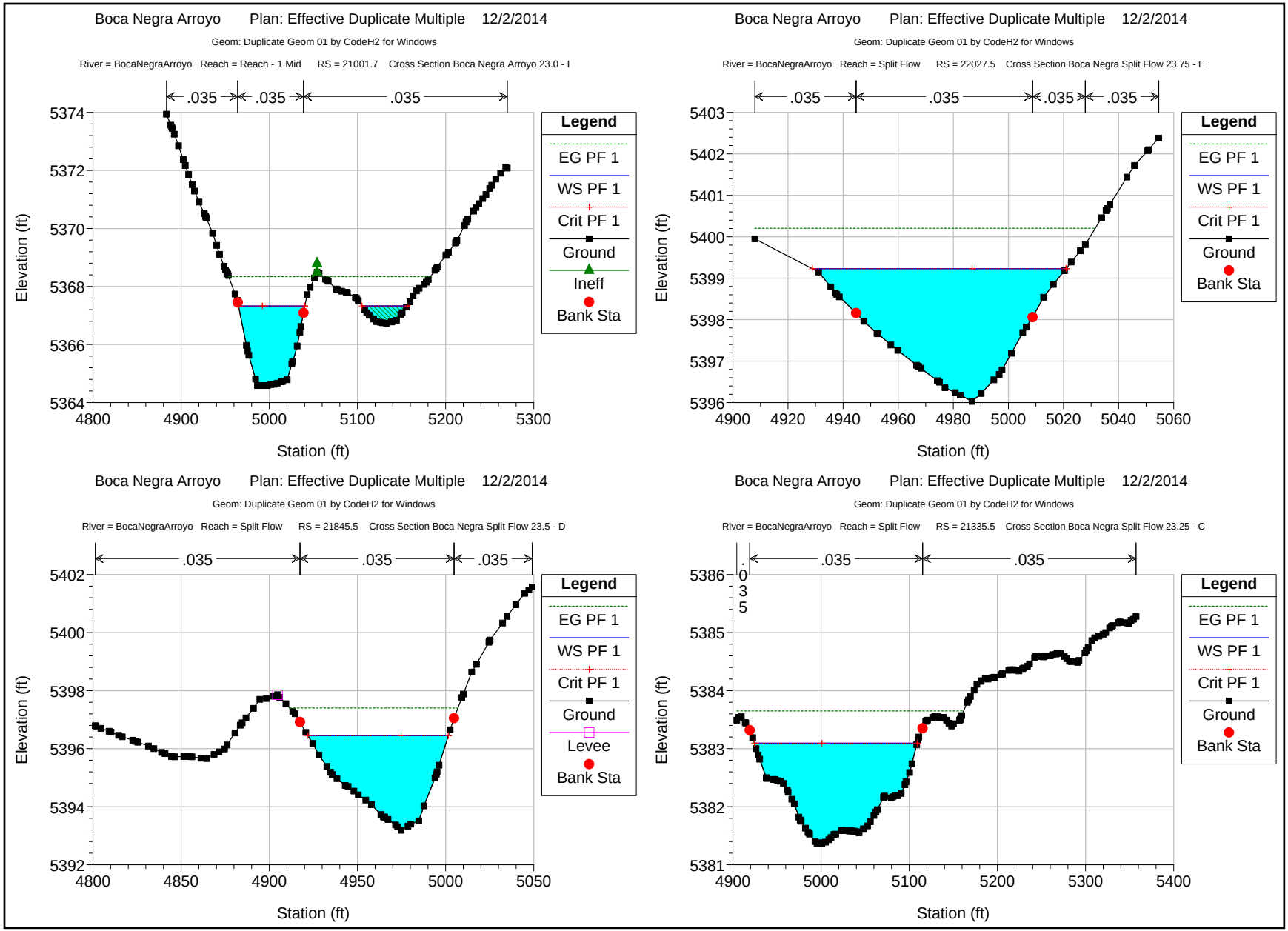

Boca Negra Arroyo Plan: Duplicate Multiple 12/4/2014
Geom: Duplicate Geom 01 by CodeH2 for Windows
BocaNegraArroyo Reach - 1 Mid
Legend
EG 10-Year
WS 10-Year
Crit 10-Year
Ground
Elevation (ft)
5400
5395
5390
5385
5380
5375
5370
5365
5360
0
200
400
600
800
1000
1200
Main Channel Distance (ft)

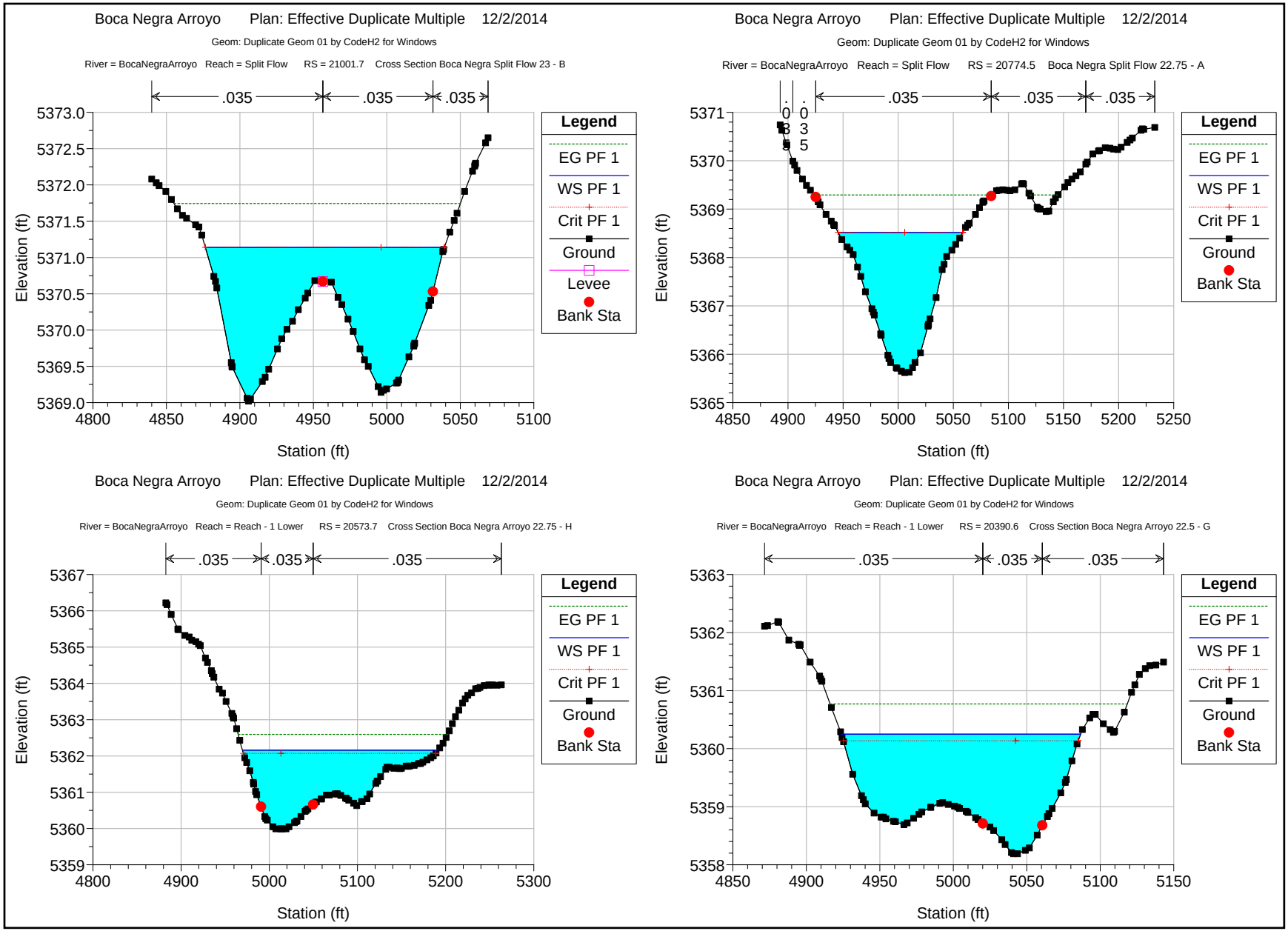

Boca Negra Arroyo Plan: Duplicate Multiple 12/4/2014
Geom: Duplicate Geom 01 by CodeH2 for Windows
BocaNegraArroyo Split Flow
Legend
EG 10-Year
WS 10-Year
Crit 10-Year
Ground
Left Levee
Elevation (ft)
5400
5395
5390
5385
5380
5375
5370
5365
0
200
400
600
800
1000
1200
1400
1600
Main Channel Distance (ft)

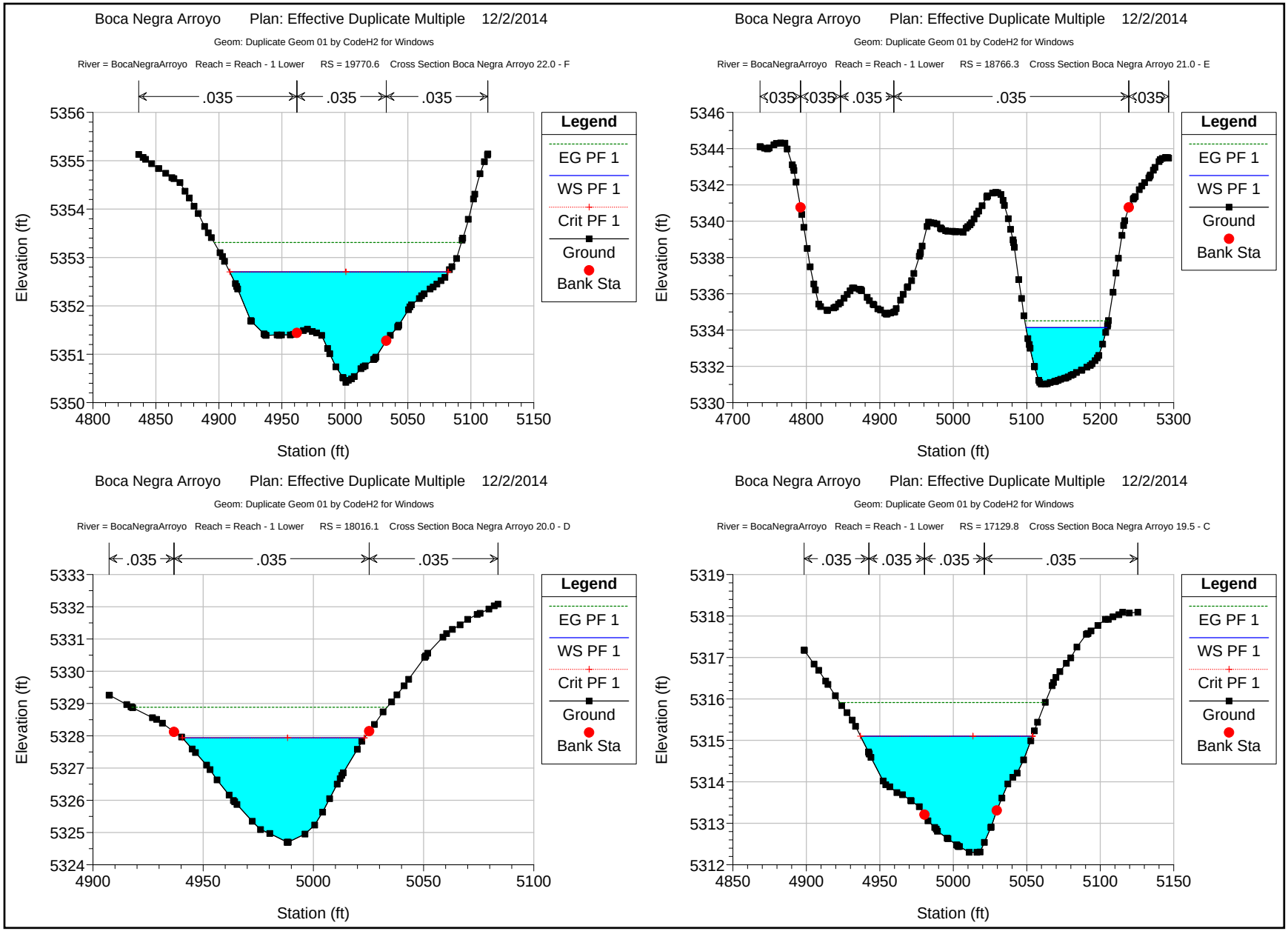

Boca Negra Arroyo Plan: Duplicate Multiple 12/4/2014
Geom: Duplicate Geom 01 by CodeH2 for Windows
BocaNegraArroyo Reach - 1 Lower
Legend
EG 10-Year
WS 10-Year
Crit 10-Year
Ground
Elevation (ft)
5380
5360
5340
5320
5300
5280
5260
5240
5220
5200
5180
0
1000
2000
3000
4000
5000
Main Channel Distance (ft)

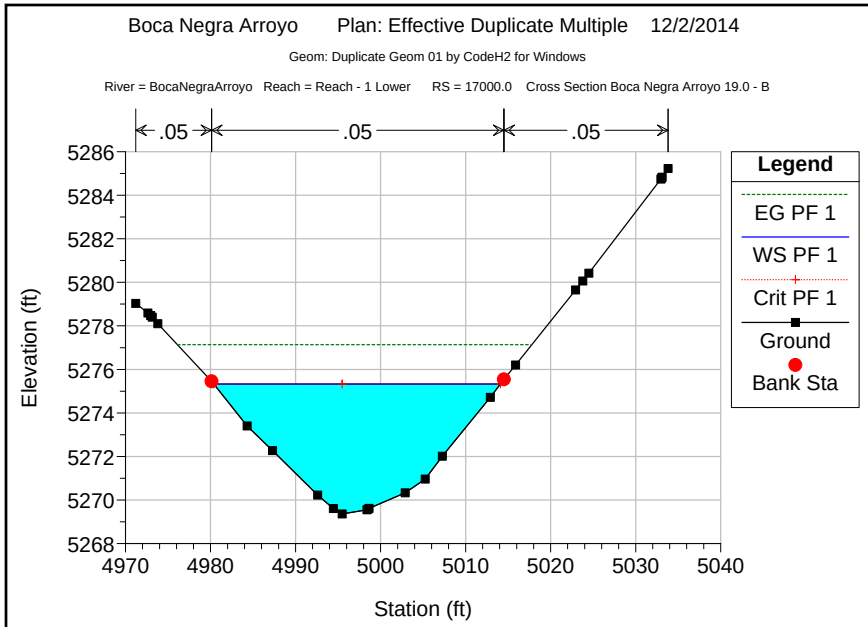

Boca Negra Arroyo Plan: Effective Duplicate Multiple 12/2/2014
Geom: Duplicate Geom 01 by CodeH2 for Windows
River = BocaNegraArroyo Reach = Reach - 1 Upper RS = 25374.6 Cross Section Boca Negra Arroyo 28.0 - Q
.035
.035
.035
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)
Boca Negra Arroyo Plan: Effective Duplicate Multiple 12/2/2014
Geom: Duplicate Geom 01 by CodeH2 for Windows
River = BocaNegraArroyo Reach = Reach - 1 Upper RS = 24989.3 Cross Section Boca Negra Arroyo 27.0 - P
.035
.035
.035
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)
Boca Negra Arroyo Plan: Effective Duplicate Multiple 12/2/2014
Geom: Duplicate Geom 01 by CodeH2 for Windows
River = BocaNegraArroyo Reach = Reach - 1 Upper RS = 24106.4 Cross Section Boca Negra Arroyo 26.0 - O
.035
.035
.035
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)
Boca Negra Arroyo Plan: Effective Duplicate Multiple 12/2/2014
Geom: Duplicate Geom 01 by CodeH2 for Windows
River = BocaNegraArroyo Reach = Reach - 1 Upper RS = 23000.0 Cross Section Boca Negra Arroyo 25.0 - N
.035
.035
.035
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)

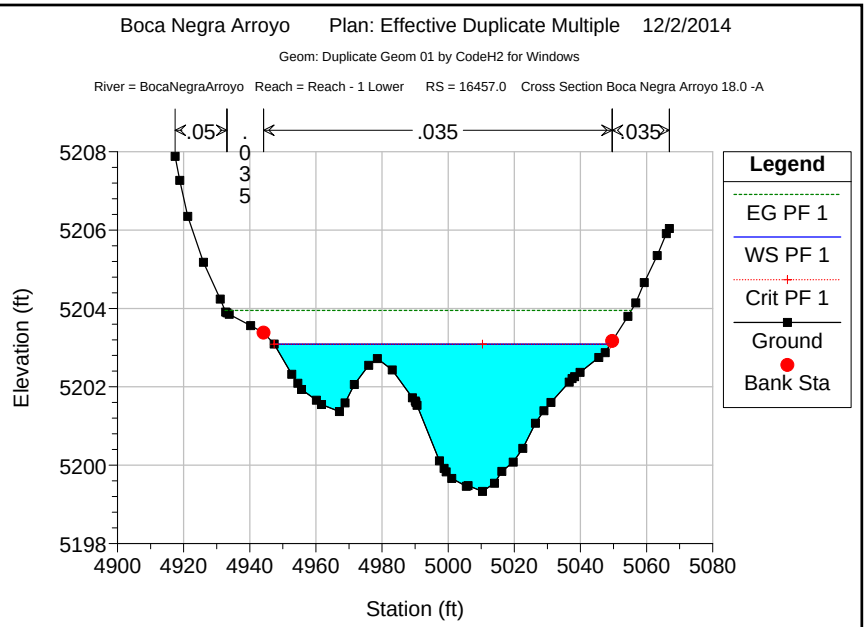

Boca Negra Arroyo Plan: Effective Duplicate Multiple 12/2/2014
Geom: Duplicate Geom 01 by CodeH2 for Windows
River = BocaNegraArroyo Reach = Reach - 1 Upper RS = 22241.1 Cross Section Boca Negra Arroyo 24.0 - M
.035 .035 .035
Elevation (ft)
Station (ft)
Legend
EG PF 1
WS PF 1
Ground
Bank Sta
Boca Negra Arroyo Plan: Effective Duplicate Multiple 12/2/2014
Geom: Duplicate Geom 01 by CodeH2 for Windows
River = BocaNegraArroyo Reach = Reach - 1 Mid RS = 22027.5 Cross Section Boca Negra Arroyo 23.75 - L
.035 .035 .035
Elevation (ft)
Station (ft)
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Boca Negra Arroyo Plan: Effective Duplicate Multiple 12/2/2014
Geom: Duplicate Geom 01 by CodeH2 for Windows
River = BocaNegraArroyo Reach = Reach - 1 Mid RS = 21845.5 Cross Section Boca Negra Arroyo 23.5 - K
.035 .035 .035
Elevation (ft)
Station (ft)
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Boca Negra Arroyo Plan: Effective Duplicate Multiple 12/2/2014
Geom: Duplicate Geom 01 by CodeH2 for Windows
River = BocaNegraArroyo Reach = Reach - 1 Mid RS = 21335.5 Cross Section Boca Negra Arroyo 23.25 - J
.035 .035 .035
Elevation (ft)
Station (ft)
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta


Boca Negra Arroyo Plan: Effective Duplicate Multiple 12/2/2014
Geom: Duplicate Geom 01 by CodeH2 for Windows
River = BocaNegraArroyo Reach = Reach - 1 Mid RS = 21001.7 Cross Section Boca Negra Arroyo 23.0 - I
.035 .035 .035
Elevation (ft)
Station (ft)
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Ineff
Bank Sta
Boca Negra Arroyo Plan: Effective Duplicate Multiple 12/2/2014
Geom: Duplicate Geom 01 by CodeH2 for Windows
River = BocaNegraArroyo Reach = Split Flow RS = 22027.5 Cross Section Boca Negra Split Flow 23.75 - E
.035 .035 .035 .035
Elevation (ft)
Station (ft)
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Boca Negra Arroyo Plan: Effective Duplicate Multiple 12/2/2014
Geom: Duplicate Geom 01 by CodeH2 for Windows
River = BocaNegraArroyo Reach = Split Flow RS = 21845.5 Cross Section Boca Negra Split Flow 23.5 - D
.035 .035 .035
Elevation (ft)
Station (ft)
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Levee
Bank Sta
Boca Negra Arroyo Plan: Effective Duplicate Multiple 12/2/2014
Geom: Duplicate Geom 01 by CodeH2 for Windows
River = BocaNegraArroyo Reach = Split Flow RS = 21335.5 Cross Section Boca Negra Split Flow 23.25 - C
.035 .035
Elevation (ft)
Station (ft)
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta


Boca Negra Arroyo Plan: Effective Duplicate Multiple 12/2/2014
Geom: Duplicate Geom 01 by CodeH2 for Windows
River = BocaNegraArroyo Reach = Split Flow RS = 21001.7 Cross Section Boca Negra Split Flow 23 - B
.035
.035
.035
Elevation (ft)
Station (ft)
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Levee
Bank Sta
Boca Negra Arroyo Plan: Effective Duplicate Multiple 12/2/2014
Geom: Duplicate Geom 01 by CodeH2 for Windows
River = BocaNegraArroyo Reach = Split Flow RS = 20774.5 Boca Negra Split Flow 22.75 - A
.035
.035
.035
Elevation (ft)
Station (ft)
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Boca Negra Arroyo Plan: Effective Duplicate Multiple 12/2/2014
Geom: Duplicate Geom 01 by CodeH2 for Windows
River = BocaNegraArroyo Reach = Reach - 1 Lower RS = 20573.7 Cross Section Boca Negra Arroyo 22.75 - H
.035
.035
.035
Elevation (ft)
Station (ft)
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Boca Negra Arroyo Plan: Effective Duplicate Multiple 12/2/2014
Geom: Duplicate Geom 01 by CodeH2 for Windows
River = BocaNegraArroyo Reach = Reach - 1 Lower RS = 20390.6 Cross Section Boca Negra Arroyo 22.5 - G
.035
.035
.035
Elevation (ft)
Station (ft)
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta


Boca Negra Arroyo Plan: Effective Duplicate Multiple 12/2/2014
Geom: Duplicate Geom 01 by CodeH2 for Windows
River = BocaNegraArroyo Reach = Reach - 1 Lower RS = 19770.6 Cross Section Boca Negra Arroyo 22.0 - F
.035
.035
.035
Elevation (ft)
Station (ft)
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Boca Negra Arroyo Plan: Effective Duplicate Multiple 12/2/2014
Geom: Duplicate Geom 01 by CodeH2 for Windows
River = BocaNegraArroyo Reach = Reach - 1 Lower RS = 18766.3 Cross Section Boca Negra Arroyo 21.0 - E
.035
.035
.035
.035
.035
Elevation (ft)
Station (ft)
Legend
EG PF 1
WS PF 1
Ground
Bank Sta
Boca Negra Arroyo Plan: Effective Duplicate Multiple 12/2/2014
Geom: Duplicate Geom 01 by CodeH2 for Windows
River = BocaNegraArroyo Reach = Reach - 1 Lower RS = 18016.1 Cross Section Boca Negra Arroyo 20.0 - D
.035
.035
.035
Elevation (ft)
Station (ft)
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Boca Negra Arroyo Plan: Effective Duplicate Multiple 12/2/2014
Geom: Duplicate Geom 01 by CodeH2 for Windows
River = BocaNegraArroyo Reach = Reach - 1 Lower RS = 17129.8 Cross Section Boca Negra Arroyo 19.5 - C
.035
.035
.035
.035
Elevation (ft)
Station (ft)
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta


Boca Negra Arroyo Plan: Effective Duplicate Multiple 12/2/2014
Geom: Duplicate Geom 01 by CodeH2 for Windows
River = BocaNegraArroyo Reach = Reach - 1 Lower RS = 17000.0 Cross Section Boca Negra Arroyo 19.0 - B
.05
.05
.05
Elevation (ft)
Station (ft)
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta

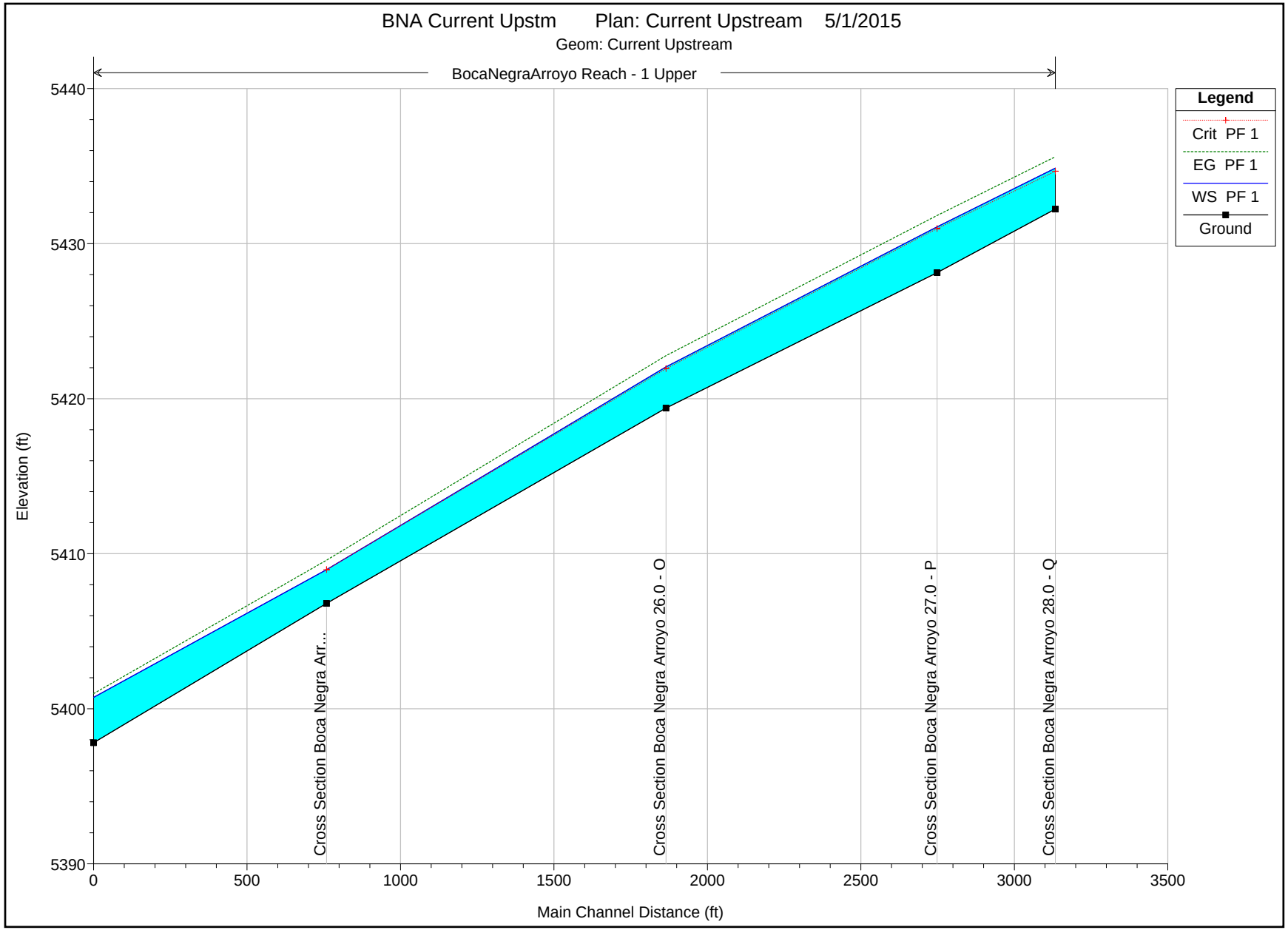

Boca Negra Arroyo Plan: Effective Duplicate Multiple 12/2/2014
Geom: Duplicate Geom 01 by CodeH2 for Windows
River = BocaNegraArroyo Reach = Reach - 1 Lower RS = 16457.0 Cross Section Boca Negra Arroyo 18.0 -A
.05
.035
.035
Elevation (ft)
Station (ft)
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta

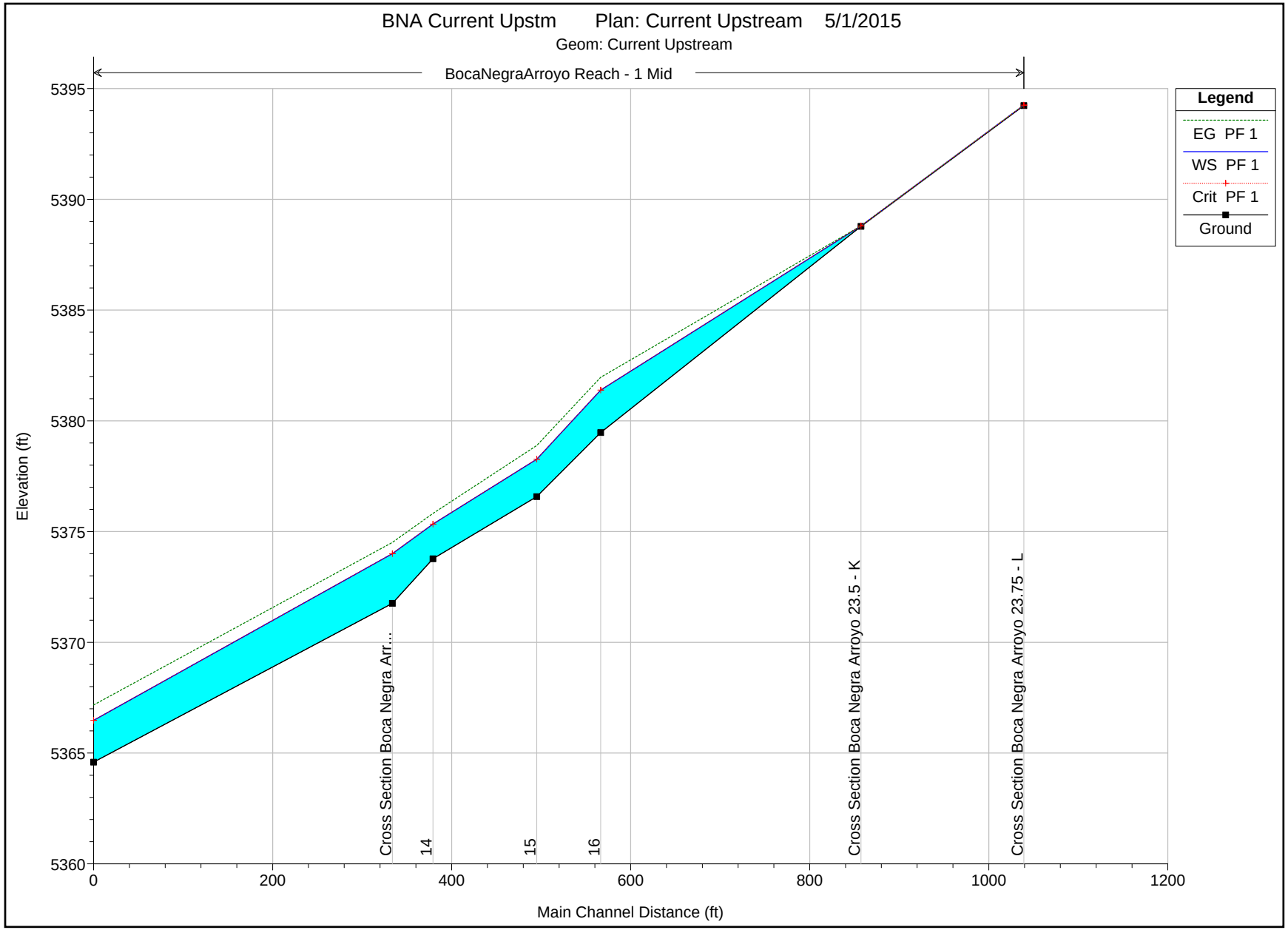
Current Upstream Model

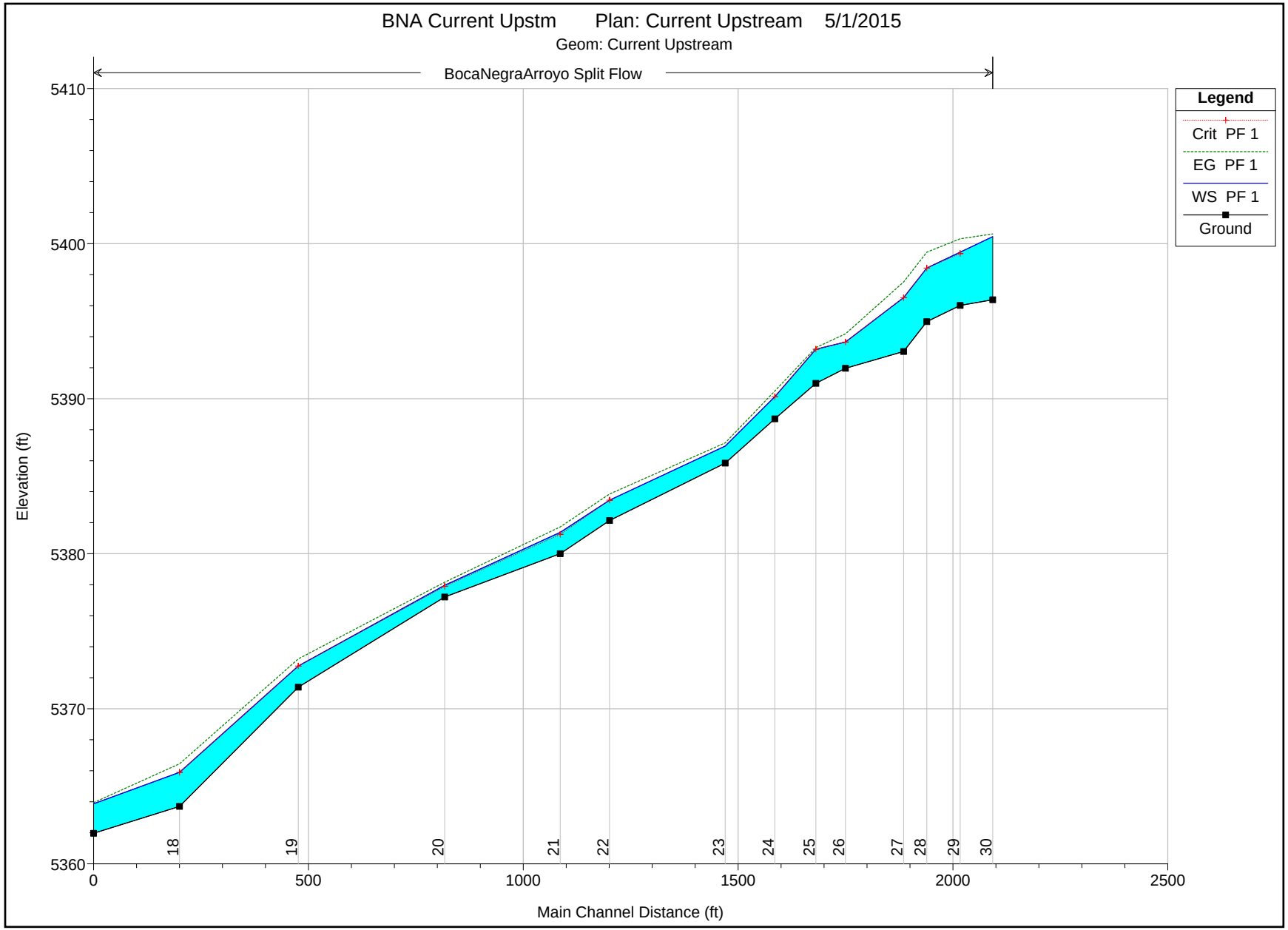
Summary
Profile
Cross Sections
Hydraulics Model – HEC-RAS Analysis (CD)
Current Upstream Files

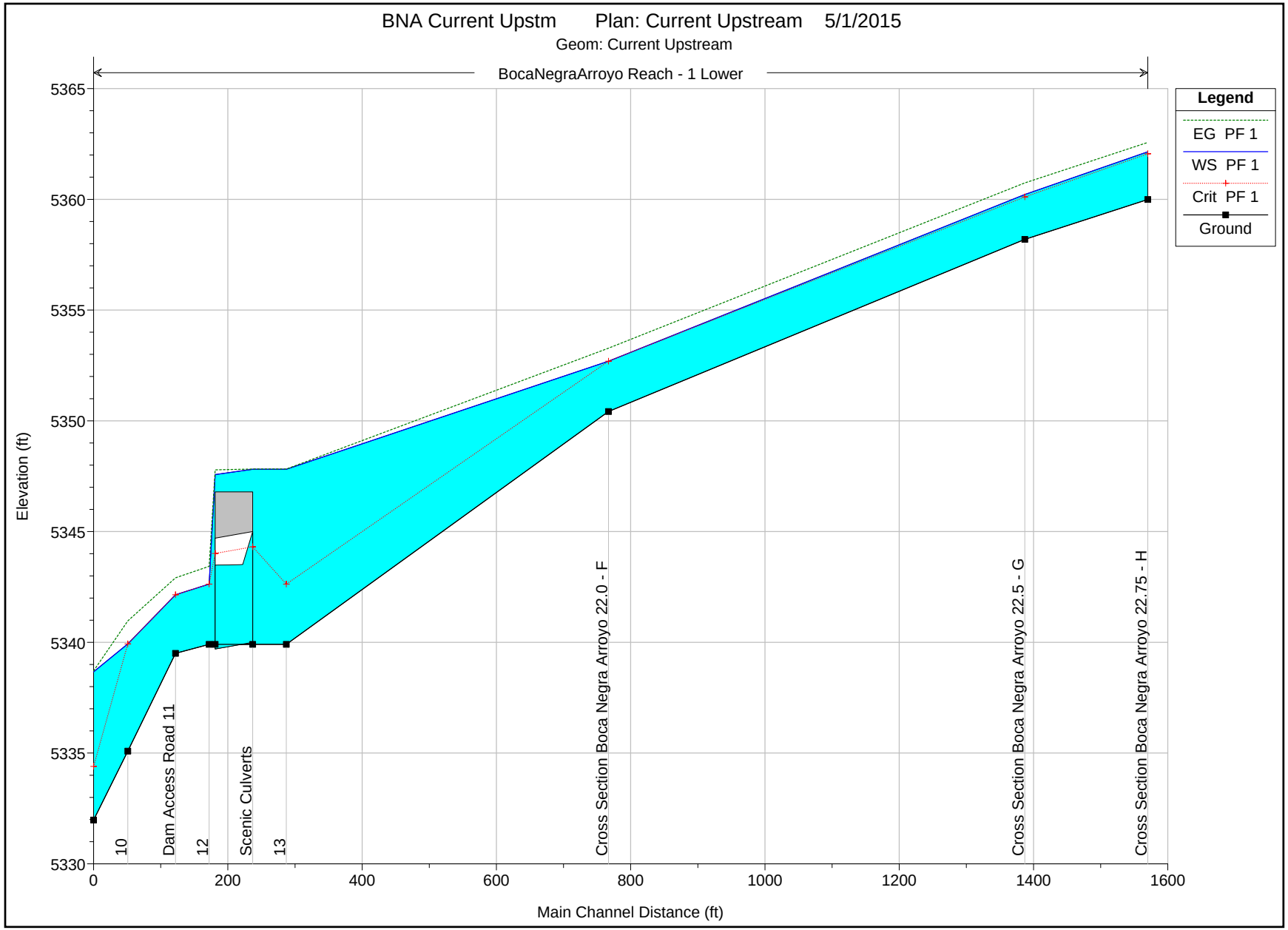
i.Project:	BNA Current Upstm BNACurrentUpstm.prj	
ii.Plan:	Current Upstream	BNACurrentUpstm.p06
iii.Geometry:	Current Upstream	BNACurrentUpstm.g05
iv.Flow:	Updated 2014	BNACurrentUpstm.f01

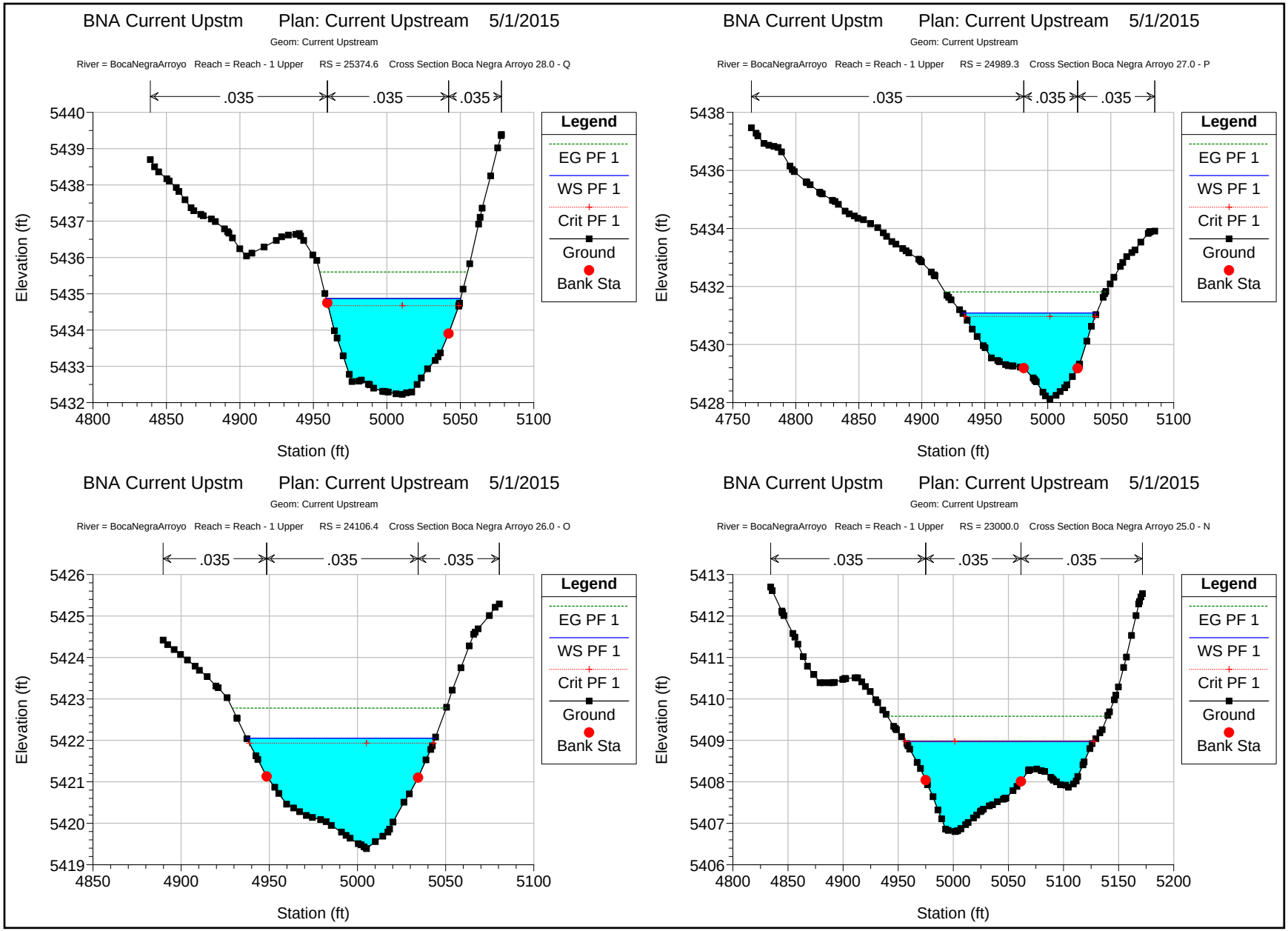
Boca Negra Arroyo - Current Upstream Model													
Reach	River Sta	Cross Section	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Reach - 1 Upper	25374.6	Q	PF 1	1175	5432.23	5434.87	5434.67	5435.60	0.010152	6.89	173.18	91.48	0.85
Reach - 1 Upper	24989.3	P	PF 1	1175	5428.13	5431.09	5430.97	5431.81	0.009555	7.6	183.48	106.39	0.85
Reach - 1 Upper	24106.4	O	PF 1	1175	5419.39	5422.05	5421.93	5422.78	0.011	6.91	176.12	106.88	0.88
Reach - 1 Upper	23000	N	PF 1	1175	5406.80	5408.97	5408.97	5409.58	0.012903	6.7	200.3	171.05	0.92
Reach - 1 Upper	22241.1	M	PF 1	1175	5397.81	5400.73		5400.98	0.002578	4.06	310.55	157.02	0.44
Reach - 1 Mid	22027.5	L	PF 1	0.01	5394.23	5394.25	5394.25	5394.25	0.008922	0.21	0.05	3.99	0.34
Reach - 1 Mid	21845.5	K	PF 1	0.01	5388.78	5388.80	5388.80	5388.80	0.005878	0.19	0.05	3.93	0.28
Reach - 1 Mid	21840	16	PF 1	612	5379.47	5381.39	5381.39	5381.97	0.015824	6.42	102.84	93.67	0.98
Reach - 1 Mid	21830	15	PF 1	612	5376.58	5378.27	5378.27	5378.89	0.014829	6.42	99.46	83.88	0.96
Reach - 1 Mid	21820	14	PF 1	612	5373.77	5375.34	5375.34	5375.82	0.015709	6.01	114.49	121.51	0.97
Reach - 1 Mid	21335.5	J	PF 1	612	5371.76	5374.00	5374.00	5374.51	0.018407	5.73	106.74	107.29	1.01
Reach - 1 Mid	21001.7	I	PF 1	612	5364.59	5366.48	5366.48	5367.17	0.015681	6.7	91.29	64.25	0.99
Split Flow	22027.5	30	PF 1	1185	5396.38	5400.45		5400.63	0.001476	3.41	352.96	140.41	0.35
Split Flow	22000	29	PF 1	1185	5396.01	5399.45	5399.36	5400.31	0.011929	7.46	160.62	89.37	0.92
Split Flow	21845.5	28	PF 1	1185	5394.97	5398.43	5398.43	5399.45	0.009996	8.4	157.06	82.34	0.89
Split Flow	21835	27	PF 1	1185	5393.04	5396.52	5396.52	5397.53	0.014438	8.05	147.26	74.97	1
Split Flow	21800	26	PF 1	603	5391.96	5393.66	5393.66	5394.18	0.018357	5.6	103.5	100.47	1
Split Flow	21770.8	25	PF 1	603	5390.99	5393.19	5393.19	5393.30	0.003057	2.73	227.62	189.16	0.43
Split Flow	21520.8	24	PF 1	603	5388.70	5390.13	5390.13	5390.49	0.020402	4.6	124.06	172.48	1
Split Flow	21335.5	23	PF 1	603	5385.84	5386.94		5387.15	0.010839	3.57	165.77	236.96	0.74
Split Flow	21325	22	PF 1	603	5382.14	5383.46	5383.46	5383.85	0.013895	5.21	127.71	177.88	0.89
Split Flow	21315	21	PF 1	603	5380.00	5381.37	5381.25	5381.73	0.012718	4.78	126.25	126.63	0.84
Split Flow	21250	20	PF 1	603	5377.21	5377.97	5377.90	5378.17	0.013486	3.07	171.42	293.61	0.77
Split Flow	21200	19	PF 1	603	5371.39	5372.76	5372.76	5373.22	0.015498	4.59	112.4	112.52	0.9
Split Flow	21194.9	18	PF 1	603	5363.70	5365.90	5365.90	5366.46	0.017547	5.97	100.96	92.13	1.01
Split Flow	21001.7	17	PF 1	603	5361.97	5363.87		5363.94	0.001612	1.56	285.58	219.73	0.29
Reach - 1 Lower	20573.7	H	PF 1	1188	5359.99	5362.14	5362.06	5362.57	0.008756	6.14	251.26	221.14	0.78
Reach - 1 Lower	20390.6	G	PF 1	1188	5358.19	5360.22	5360.11	5360.74	0.011394	6.72	212.5	162.22	0.88
Reach - 1 Lower	19770.6	F	PF 1	1188	5350.42	5352.69	5352.69	5353.28	0.012714	6.8	205.34	172.94	0.92
Reach - 1 Lower	19290.6	13	PF 1	1188	5339.91	5347.81	5342.63	5347.82	0.000048	1.09	1541.12	433.22	0.07
Reach - 1 Lower	19200			Culvert									
Reach - 1 Lower	19175.6	12	PF 1	1188	5339.91	5342.63	5342.63	5343.43	0.011745	7.38	175.52	121.26	0.91
Reach - 1 Lower	19125.5	11	PF 1	1188	5339.50	5342.15	5342.15	5342.91	0.001821	6.99	169.86	113.51	1.01
Reach - 1 Lower	19054.6	10	PF 1	1188	5335.09	5339.93	5339.93	5340.97	0.010152	8.47	156.31	81.35	0.88
Reach - 1 Lower	19003.57	9	PF 1	1188	5331.98	5338.67	5334.40	5338.71	0.000176	1.61	739.07	151.76	0.13

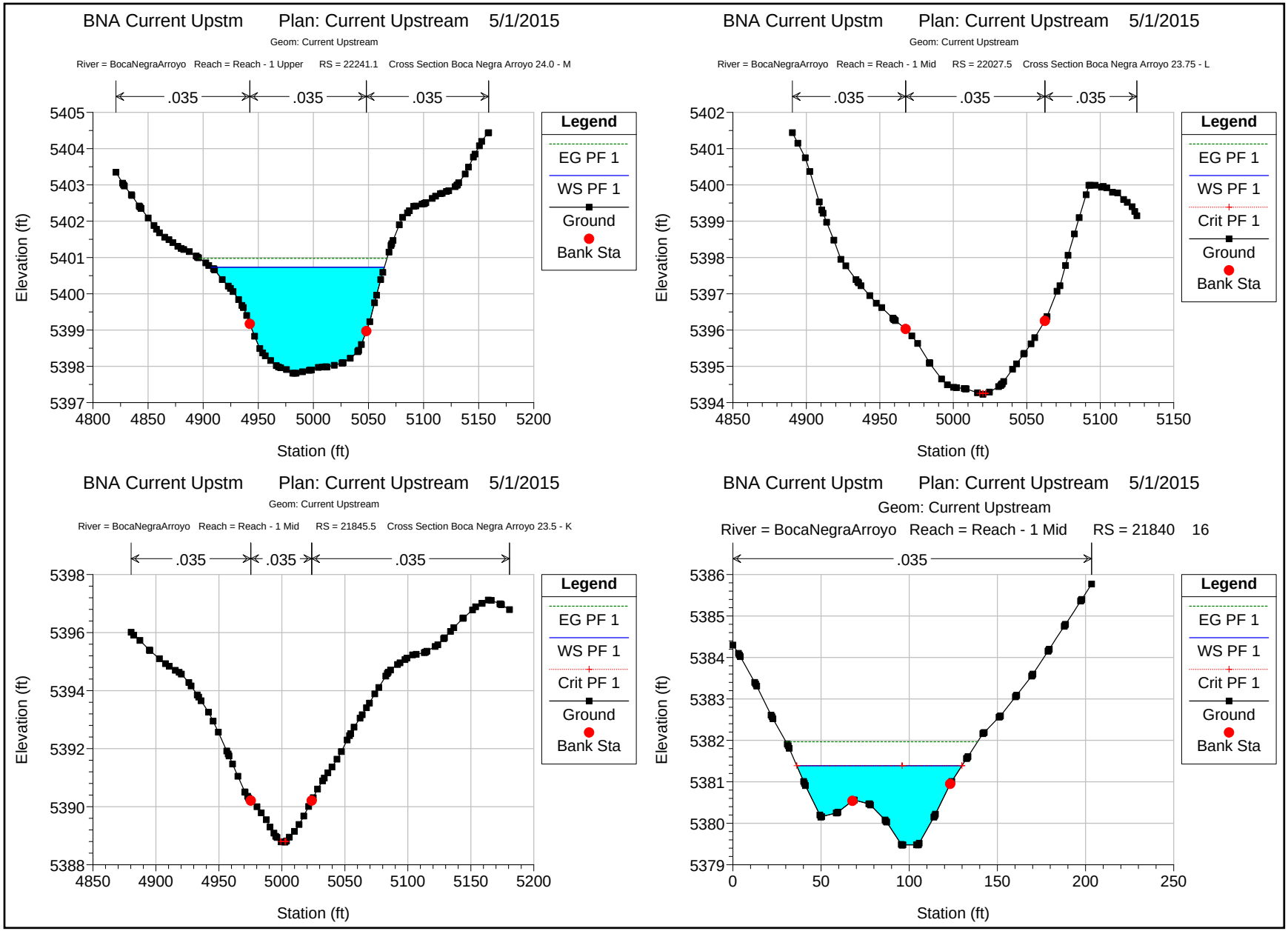

BNA Current Upstm Plan: Current Upstream 5/1/2015
Geom: Current Upstream
BocaNegraArroyo Reach - 1 Upper
Legend
Crit PF 1
EG PF 1
WS PF 1
Ground
Elevation (ft)
5440
5430
5420
5410
5400
5390
0
500
1000
1500
2000
2500
3000
3500
Main Channel Distance (ft)
Cross Section Boca Negra Arr...
Cross Section Boca Negra Arroyo 26.0 - O
Cross Section Boca Negra Arroyo 27.0 - P
Cross Section Boca Negra Arroyo 28.0 - Q

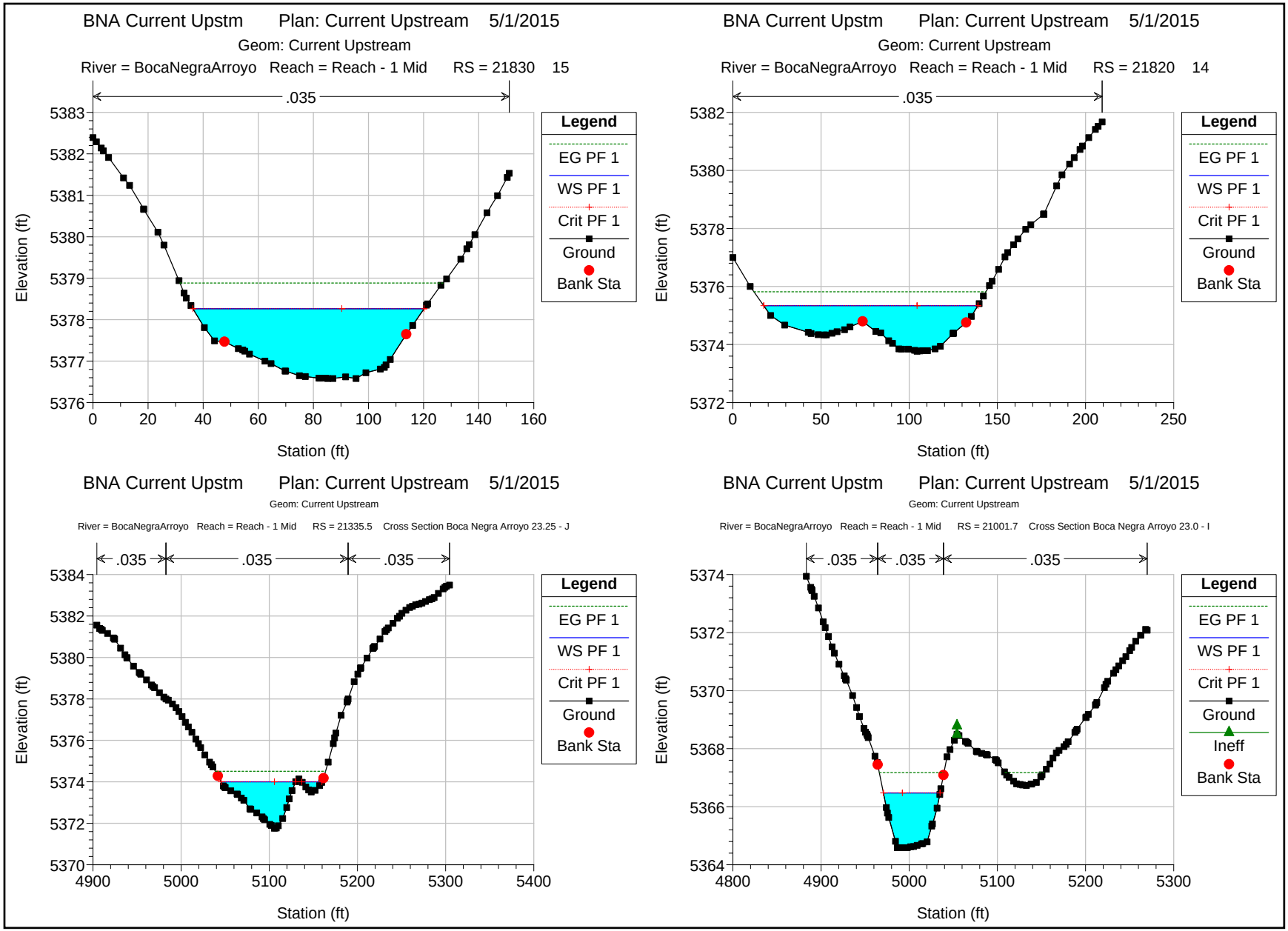

BNA Current Upstm Plan: Current Upstream 5/1/2015
Geom: Current Upstream
BocaNegraArroyo Reach - 1 Mid
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Elevation (ft)
5395
5390
5385
5380
5375
5370
5365
5360
0
200
400
600
800
1000
1200
Main Channel Distance (ft)
Cross Section Boca Negra Arr...
14
15
16
Cross Section Boca Negra Arroyo 23.5 - K
Cross Section Boca Negra Arroyo 23.75 - L

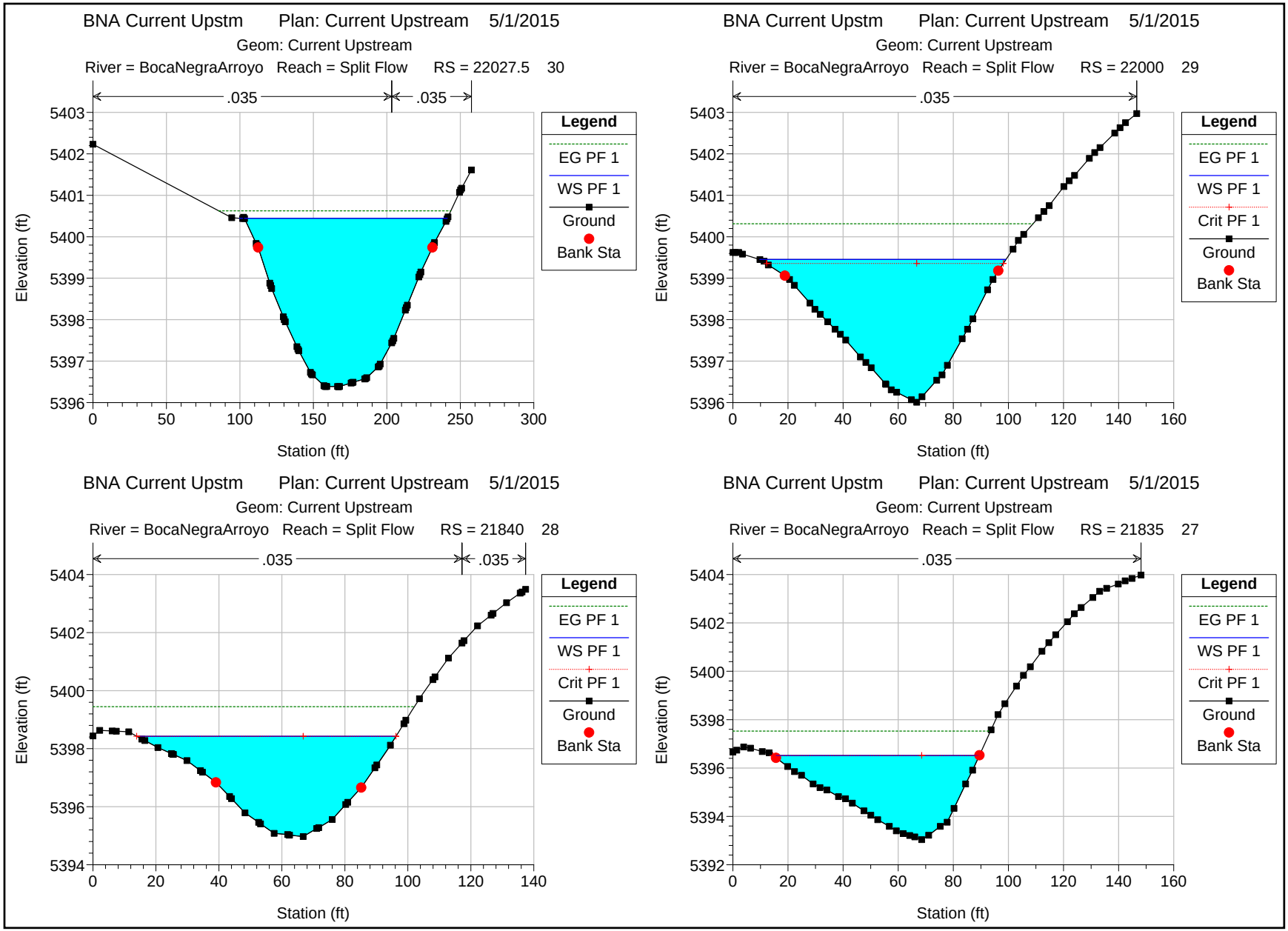

BNA Current Upstm Plan: Current Upstream 5/1/2015
Geom: Current Upstream
BocaNegraArroyo Split Flow
Legend
Crit PF 1
EG PF 1
WS PF 1
Ground
Elevation (ft)
5410
5400
5390
5380
5370
5360
0
500
1000
1500
2000
2500
Main Channel Distance (ft)
18
19
20
21
22
23
24
25
26
27
28
29
30

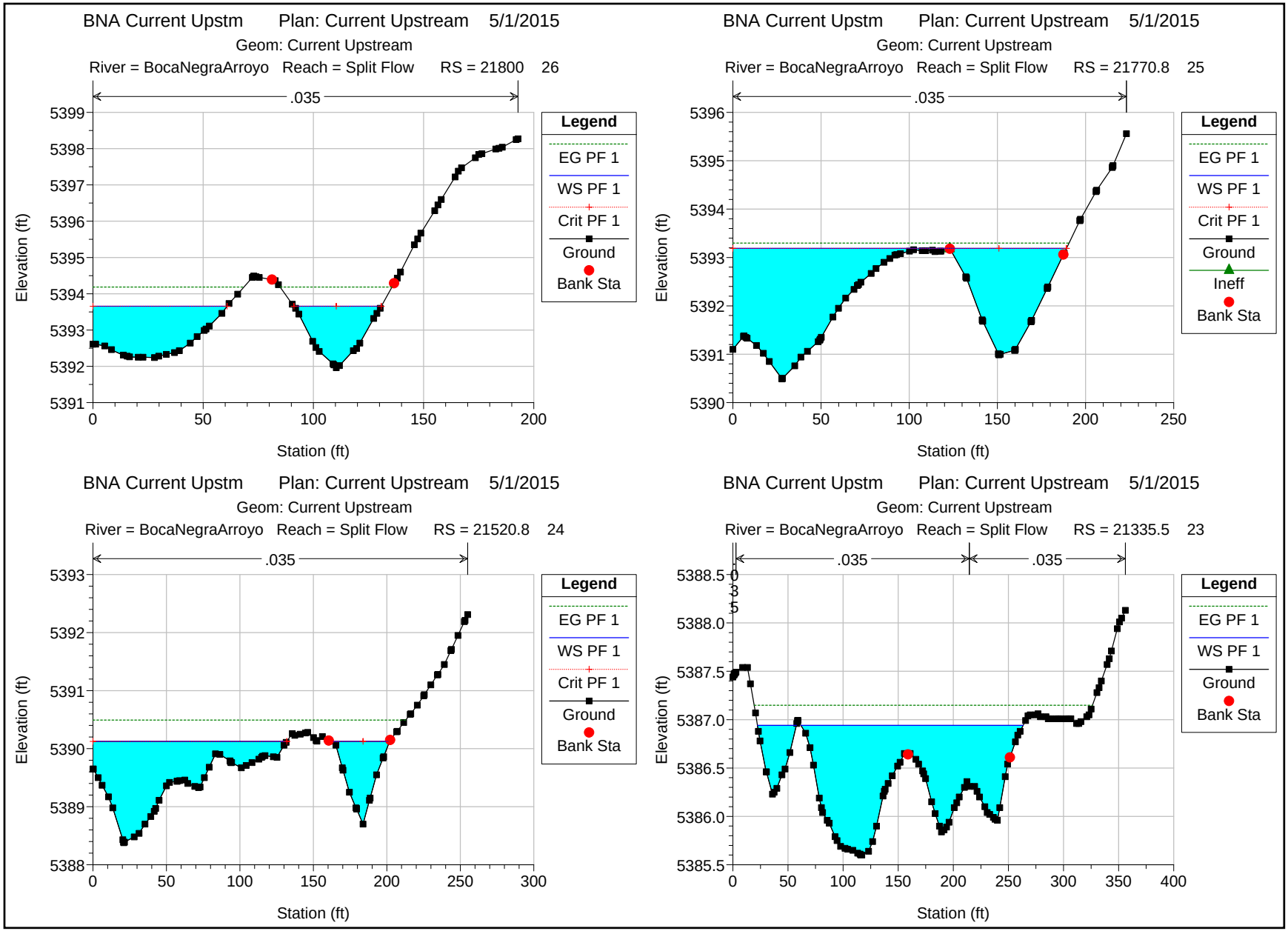

BNA Current Upstm Plan: Current Upstream 5/1/2015
Geom: Current Upstream
BocaNegraArroyo Reach - 1 Lower
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Elevation (ft)
Main Channel Distance (ft)
5365
5360
5355
5350
5345
5340
5335
5330
0
200
400
600
800
1000
1200
1400
1600
10
Dam Access Road 11
12
Scenic Culverts
13
Cross Section Boca Negra Arroyo 22.0 - F
Cross Section Boca Negra Arroyo 22.5 - G
Cross Section Boca Negra Arroyo 22.75 - H

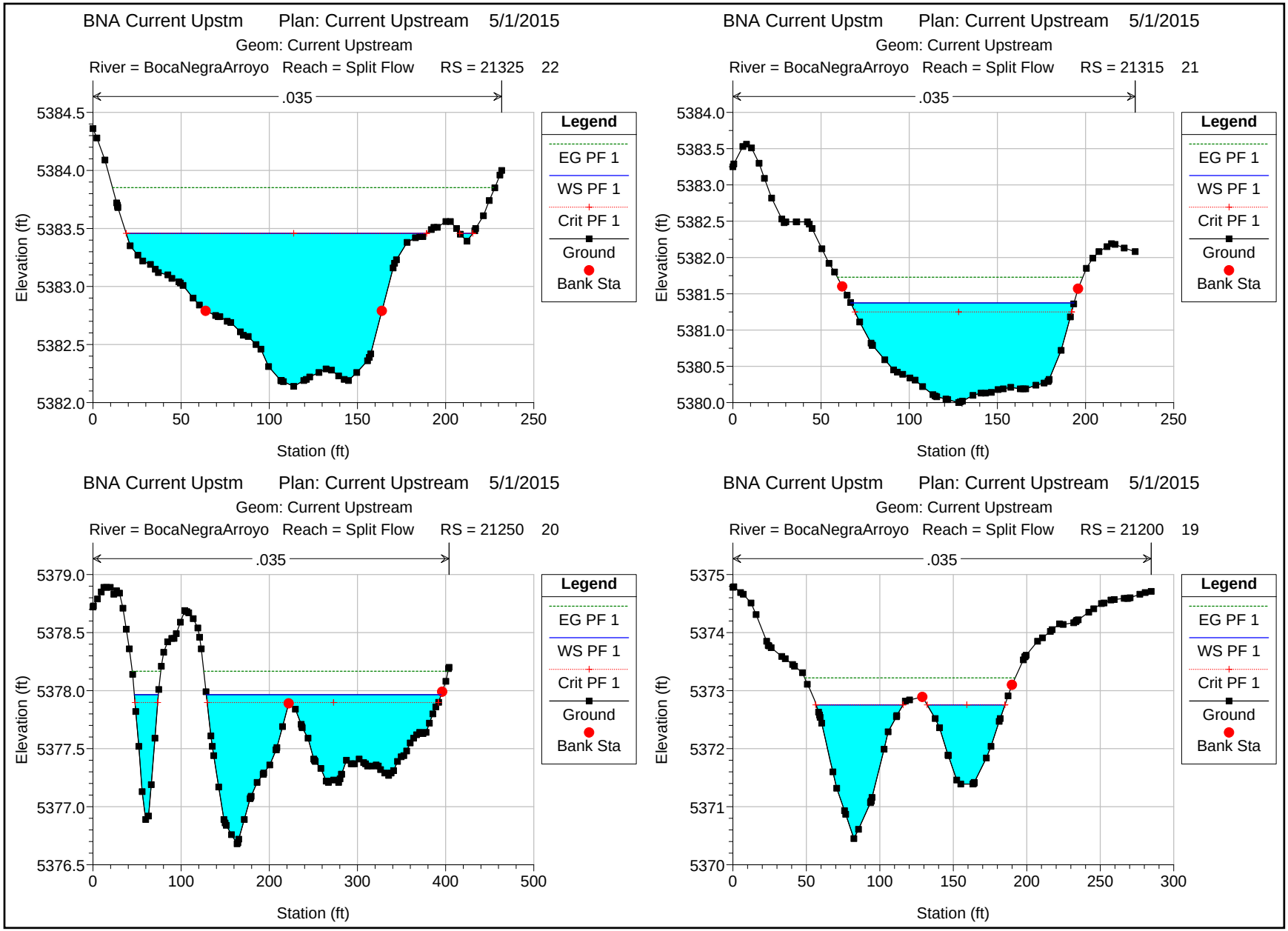

BNA Current Upstm Plan: Current Upstream 5/1/2015
Geom: Current Upstream
River = BocaNegraArroyo Reach = Reach - 1 Upper RS = 25374.6 Cross Section Boca Negra Arroyo 28.0 - Q
.035
.035
.035
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)
BNA Current Upstm Plan: Current Upstream 5/1/2015
Geom: Current Upstream
River = BocaNegraArroyo Reach = Reach - 1 Upper RS = 24989.3 Cross Section Boca Negra Arroyo 27.0 - P
BNA Current Upstm Plan: Current Upstream 5/1/2015
Geom: Current Upstream
River = BocaNegraArroyo Reach = Reach - 1 Upper RS = 24106.4 Cross Section Boca Negra Arroyo 26.0 - O
BNA Current Upstm Plan: Current Upstream 5/1/2015
Geom: Current Upstream
River = BocaNegraArroyo Reach = Reach - 1 Upper RS = 23000.0 Cross Section Boca Negra Arroyo 25.0 - N

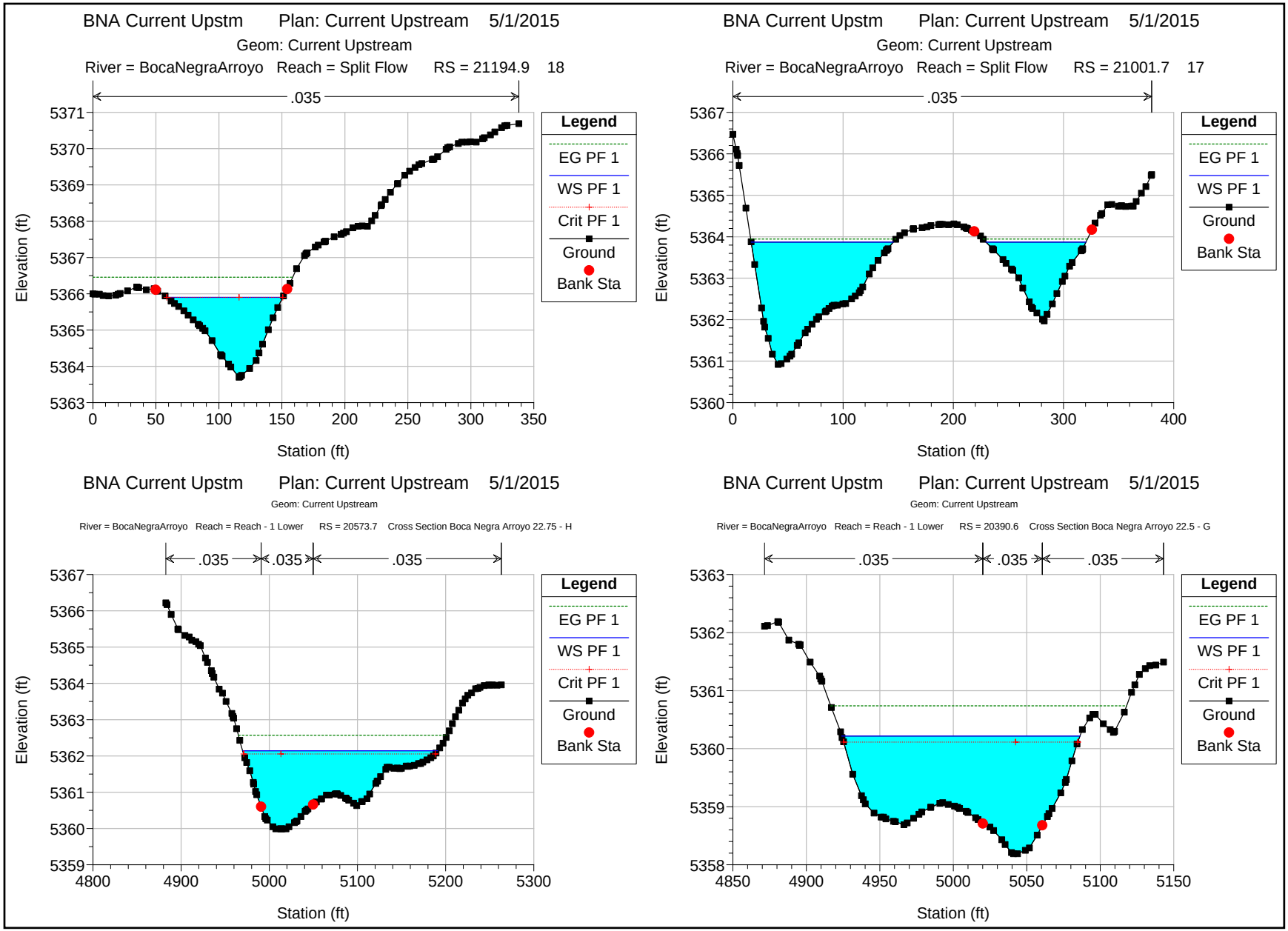

BNA Current Upstm Plan: Current Upstream 5/1/2015
Geom: Current Upstream
River = BocaNegraArroyo Reach = Reach - 1 Upper RS = 22241.1 Cross Section Boca Negra Arroyo 24.0 - M
.035
.035
.035
Legend
EG PF 1
WS PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)
BNA Current Upstm Plan: Current Upstream 5/1/2015
Geom: Current Upstream
River = BocaNegraArroyo Reach = Reach - 1 Mid RS = 22027.5 Cross Section Boca Negra Arroyo 23.75 - L
.035
.035
.035
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)
BNA Current Upstm Plan: Current Upstream 5/1/2015
Geom: Current Upstream
River = BocaNegraArroyo Reach = Reach - 1 Mid RS = 21845.5 Cross Section Boca Negra Arroyo 23.5 - K
.035
.035
.035
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)
BNA Current Upstm Plan: Current Upstream 5/1/2015
Geom: Current Upstream
River = BocaNegraArroyo Reach = Reach - 1 Mid RS = 21840 16
.035
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)

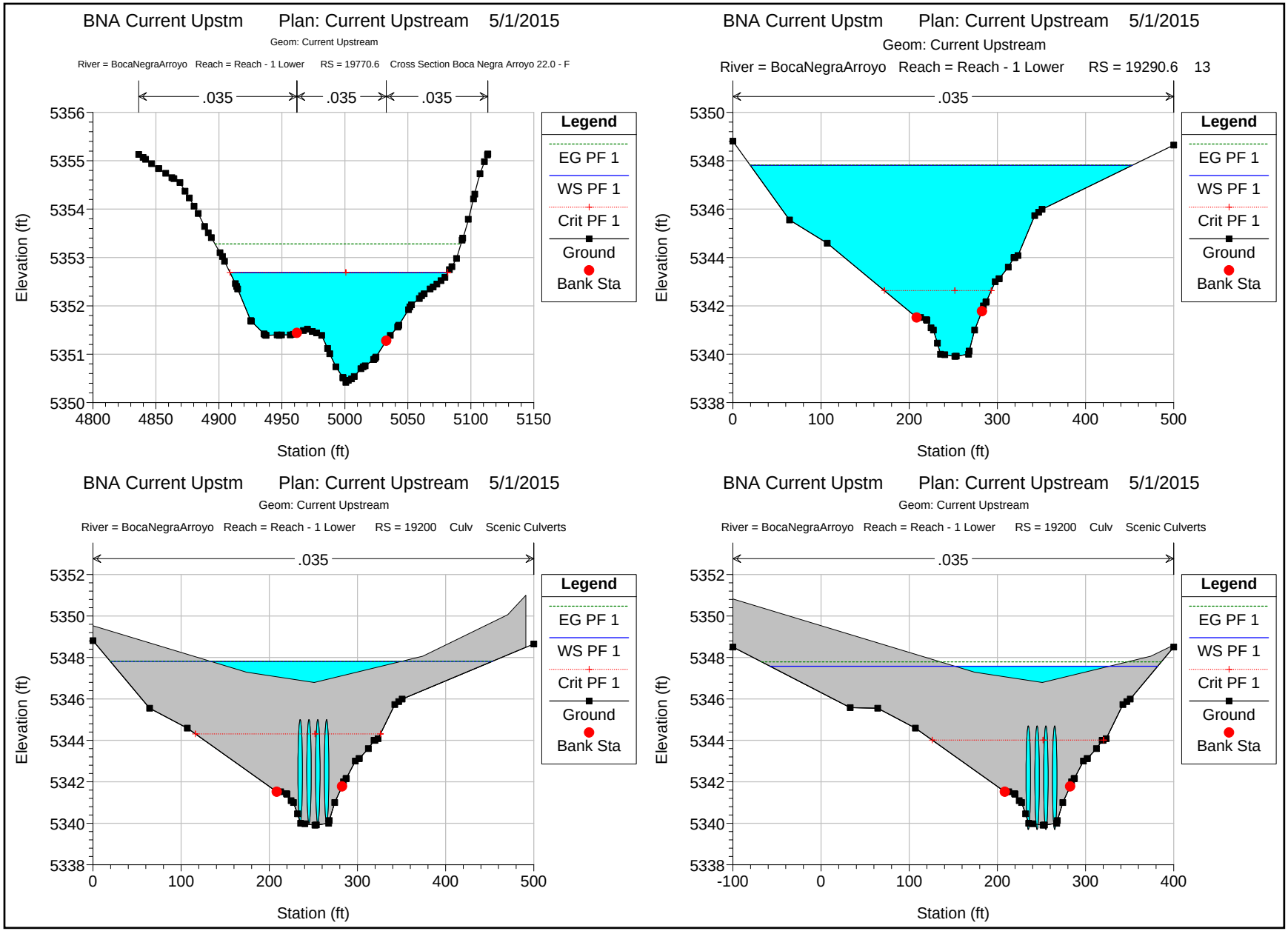

BNA Current Upstm Plan: Current Upstream 5/1/2015
Geom: Current Upstream
River = BocaNegraArroyo Reach = Reach - 1 Mid RS = 21830 15
.035
Elevation (ft)
Station (ft)
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
BNA Current Upstm Plan: Current Upstream 5/1/2015
Geom: Current Upstream
River = BocaNegraArroyo Reach = Reach - 1 Mid RS = 21820 14
.035
Elevation (ft)
Station (ft)
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
BNA Current Upstm Plan: Current Upstream 5/1/2015
Geom: Current Upstream
River = BocaNegraArroyo Reach = Reach - 1 Mid RS = 21335.5 Cross Section Boca Negra Arroyo 23.25 - J
.035
.035
.035
Elevation (ft)
Station (ft)
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
BNA Current Upstm Plan: Current Upstream 5/1/2015
Geom: Current Upstream
River = BocaNegraArroyo Reach = Reach - 1 Mid RS = 21001.7 Cross Section Boca Negra Arroyo 23.0 - I
.035
.035
.035
Elevation (ft)
Station (ft)
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Ineff
Bank Sta

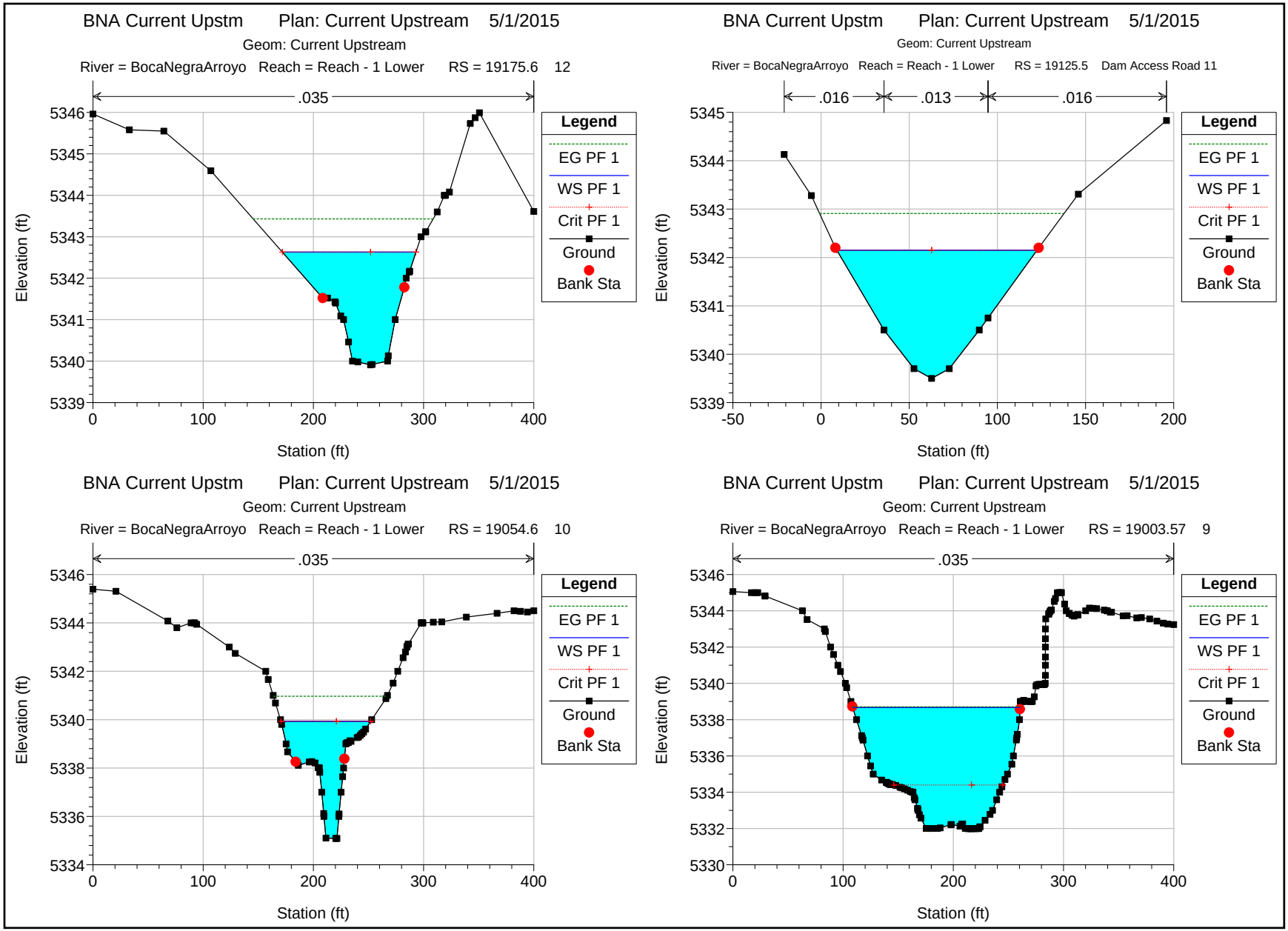

BNA Current Upstm Plan: Current Upstream 5/1/2015
Geom: Current Upstream
River = BocaNegraArroyo Reach = Split Flow RS = 22027.5 30
.035
.035
Elevation (ft)
Station (ft)
Legend
EG PF 1
WS PF 1
Ground
Bank Sta
BNA Current Upstm Plan: Current Upstream 5/1/2015
Geom: Current Upstream
River = BocaNegraArroyo Reach = Split Flow RS = 22000 29
.035
Elevation (ft)
Station (ft)
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
BNA Current Upstm Plan: Current Upstream 5/1/2015
Geom: Current Upstream
River = BocaNegraArroyo Reach = Split Flow RS = 21840 28
.035
.035
Elevation (ft)
Station (ft)
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
BNA Current Upstm Plan: Current Upstream 5/1/2015
Geom: Current Upstream
River = BocaNegraArroyo Reach = Split Flow RS = 21835 27
.035
Elevation (ft)
Station (ft)
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta


BNA Current Upstm Plan: Current Upstream 5/1/2015
Geom: Current Upstream
River = BocaNegraArroyo Reach = Split Flow RS = 21800 26
.035
Elevation (ft)
Station (ft)
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
BNA Current Upstm Plan: Current Upstream 5/1/2015
Geom: Current Upstream
River = BocaNegraArroyo Reach = Split Flow RS = 21770.8 25
.035
Elevation (ft)
Station (ft)
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Ineff
Bank Sta
BNA Current Upstm Plan: Current Upstream 5/1/2015
Geom: Current Upstream
River = BocaNegraArroyo Reach = Split Flow RS = 21520.8 24
.035
Elevation (ft)
Station (ft)
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
BNA Current Upstm Plan: Current Upstream 5/1/2015
Geom: Current Upstream
River = BocaNegraArroyo Reach = Split Flow RS = 21335.5 23
.035
.035
Elevation (ft)
Station (ft)
Legend
EG PF 1
WS PF 1
Ground
Bank Sta


BNA Current Upstm Plan: Current Upstream 5/1/2015
Geom: Current Upstream
River = BocaNegraArroyo Reach = Split Flow RS = 21325 22
.035
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)
BNA Current Upstm Plan: Current Upstream 5/1/2015
Geom: Current Upstream
River = BocaNegraArroyo Reach = Split Flow RS = 21315 21
.035
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)
BNA Current Upstm Plan: Current Upstream 5/1/2015
Geom: Current Upstream
River = BocaNegraArroyo Reach = Split Flow RS = 21250 20
.035
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)
BNA Current Upstm Plan: Current Upstream 5/1/2015
Geom: Current Upstream
River = BocaNegraArroyo Reach = Split Flow RS = 21200 19
.035
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)


BNA Current Upstm Plan: Current Upstream 5/1/2015
Geom: Current Upstream
River = BocaNegraArroyo Reach = Split Flow RS = 21194.9 18
.035
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)
BNA Current Upstm Plan: Current Upstream 5/1/2015
Geom: Current Upstream
River = BocaNegraArroyo Reach = Split Flow RS = 21001.7 17
.035
Legend
EG PF 1
WS PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)
BNA Current Upstm Plan: Current Upstream 5/1/2015
Geom: Current Upstream
River = BocaNegraArroyo Reach = Reach - 1 Lower RS = 20573.7 Cross Section Boca Negra Arroyo 22.75 - H
.035
.035
.035
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)
BNA Current Upstm Plan: Current Upstream 5/1/2015
Geom: Current Upstream
River = BocaNegraArroyo Reach = Reach - 1 Lower RS = 20390.6 Cross Section Boca Negra Arroyo 22.5 - G
.035
.035
.035
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)


BNA Current Upstm Plan: Current Upstream 5/1/2015
Geom: Current Upstream
River = BocaNegraArroyo Reach = Reach - 1 Lower RS = 19770.6 Cross Section Boca Negra Arroyo 22.0 - F
.035
.035
.035
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)
BNA Current Upstm Plan: Current Upstream 5/1/2015
Geom: Current Upstream
River = BocaNegraArroyo Reach = Reach - 1 Lower RS = 19290.6 13
.035
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)
BNA Current Upstm Plan: Current Upstream 5/1/2015
Geom: Current Upstream
River = BocaNegraArroyo Reach = Reach - 1 Lower RS = 19200 Culv Scenic Culverts
.035
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)
BNA Current Upstm Plan: Current Upstream 5/1/2015
Geom: Current Upstream
River = BocaNegraArroyo Reach = Reach - 1 Lower RS = 19200 Culv Scenic Culverts
.035
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)

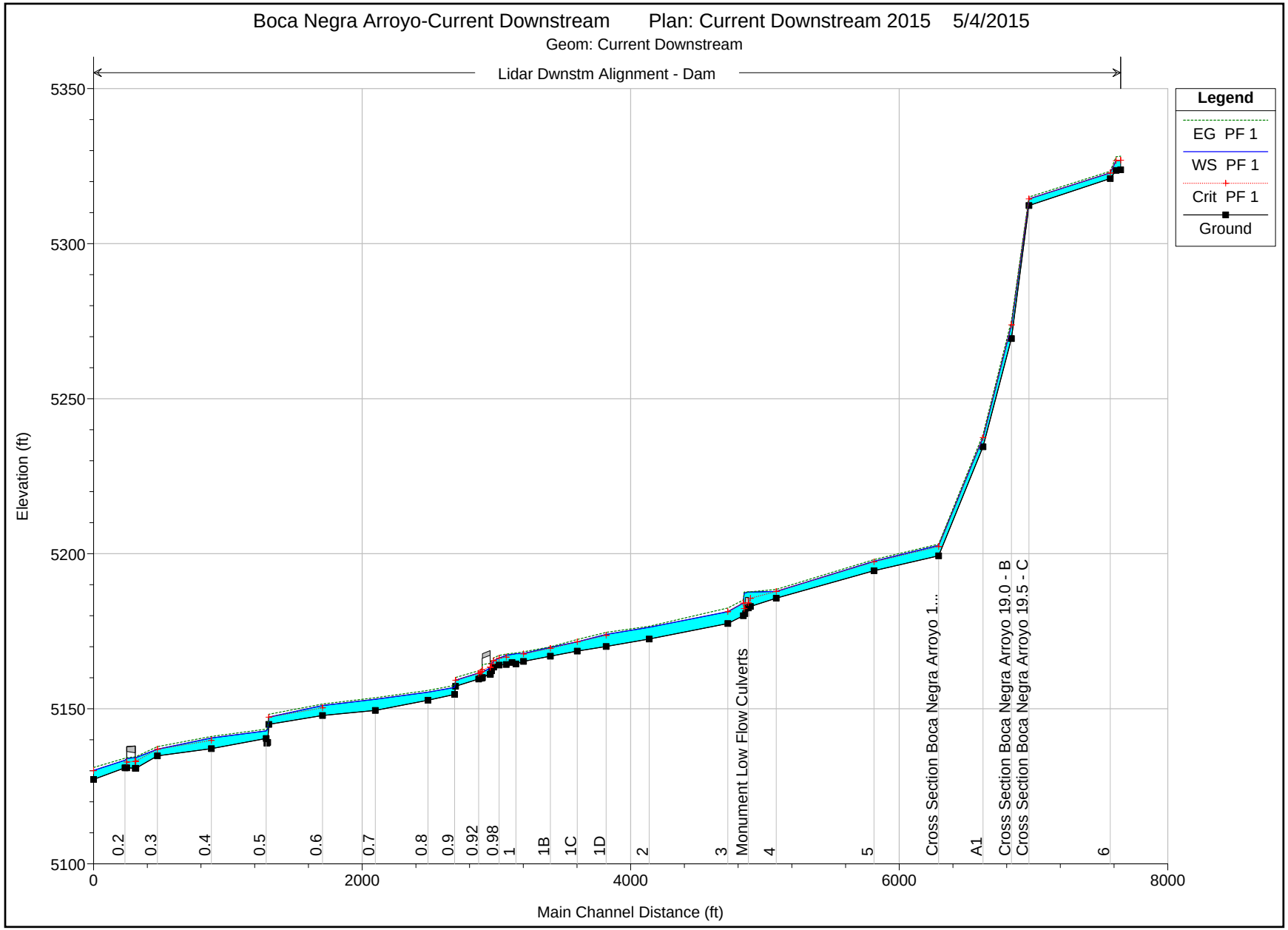

BNA Current Upstm Plan: Current Upstream 5/1/2015
Geom: Current Upstream
River = BocaNegraArroyo Reach = Reach - 1 Lower RS = 19175.6 12
.035
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)
BNA Current Upstm Plan: Current Upstream 5/1/2015
Geom: Current Upstream
River = BocaNegraArroyo Reach = Reach - 1 Lower RS = 19125.5 Dam Access Road 11
.016
.013
.016
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)
BNA Current Upstm Plan: Current Upstream 5/1/2015
Geom: Current Upstream
River = BocaNegraArroyo Reach = Reach - 1 Lower RS = 19054.6 10
.035
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)
BNA Current Upstm Plan: Current Upstream 5/1/2015
Geom: Current Upstream
River = BocaNegraArroyo Reach = Reach - 1 Lower RS = 19003.57 9
.035
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)

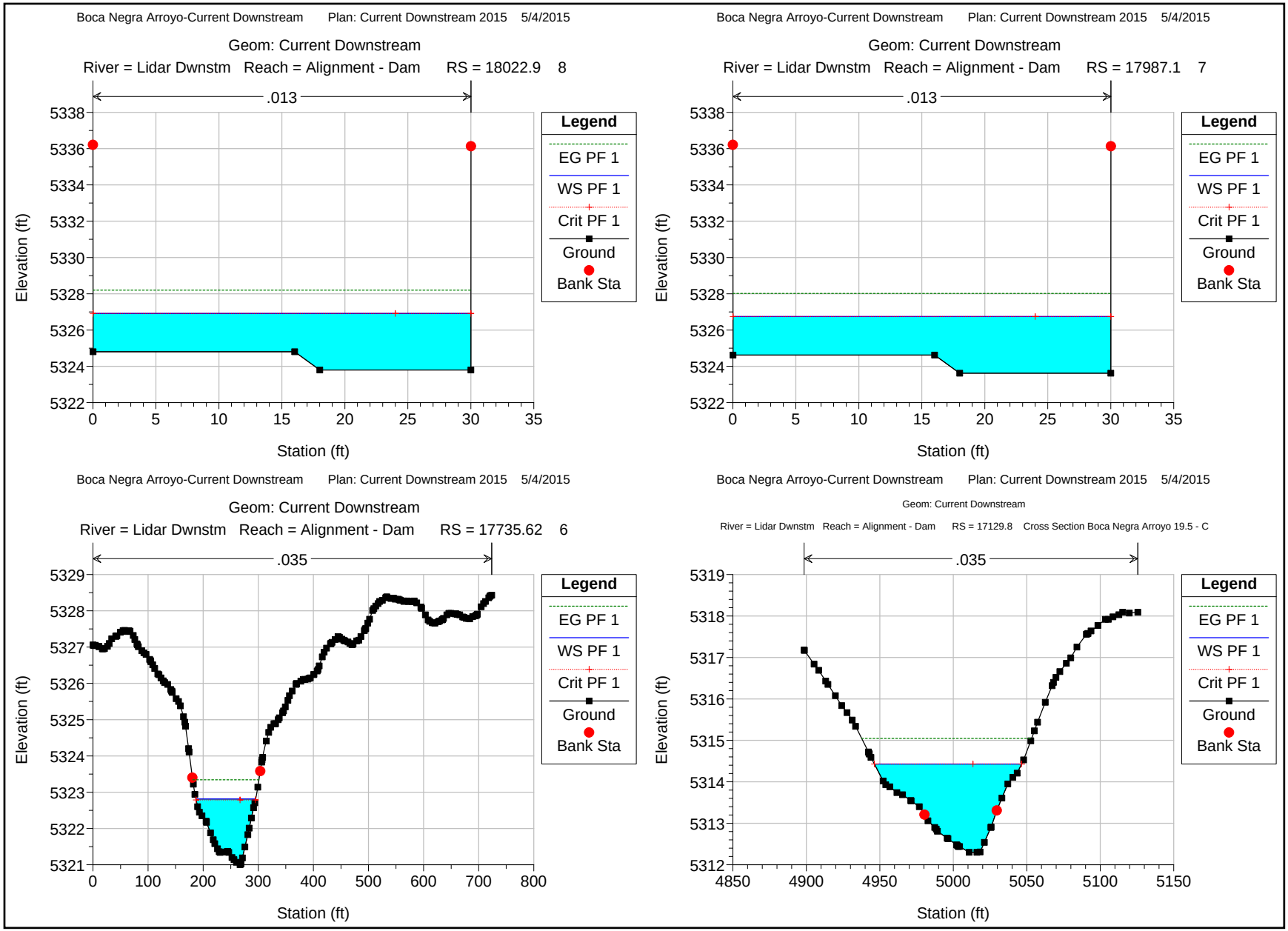
Current Downstream Model

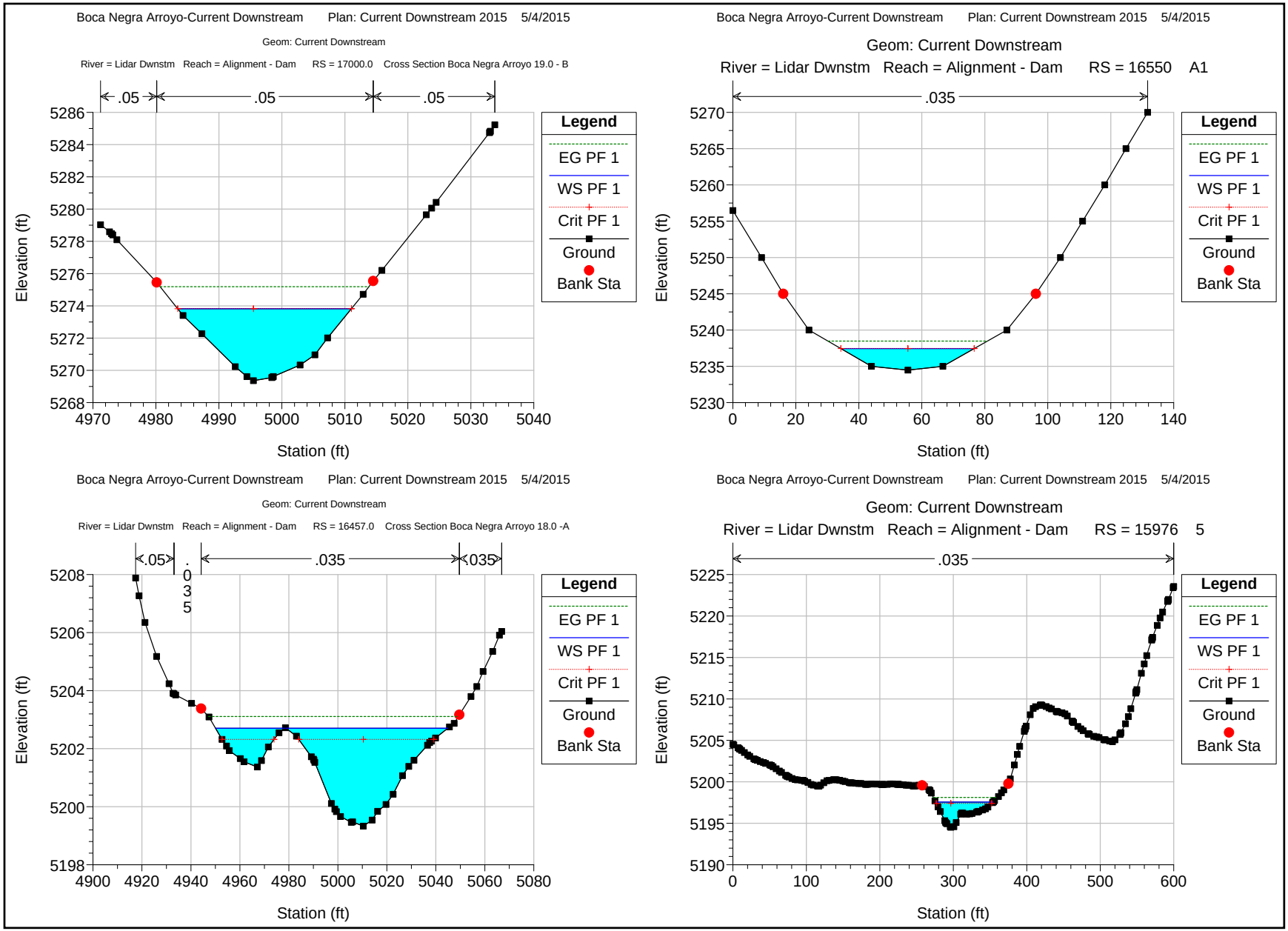
Summary
Profile
Cross Sections
Hydraulics Model – HEC-RAS Analysis (CD)
Current Downstream Files

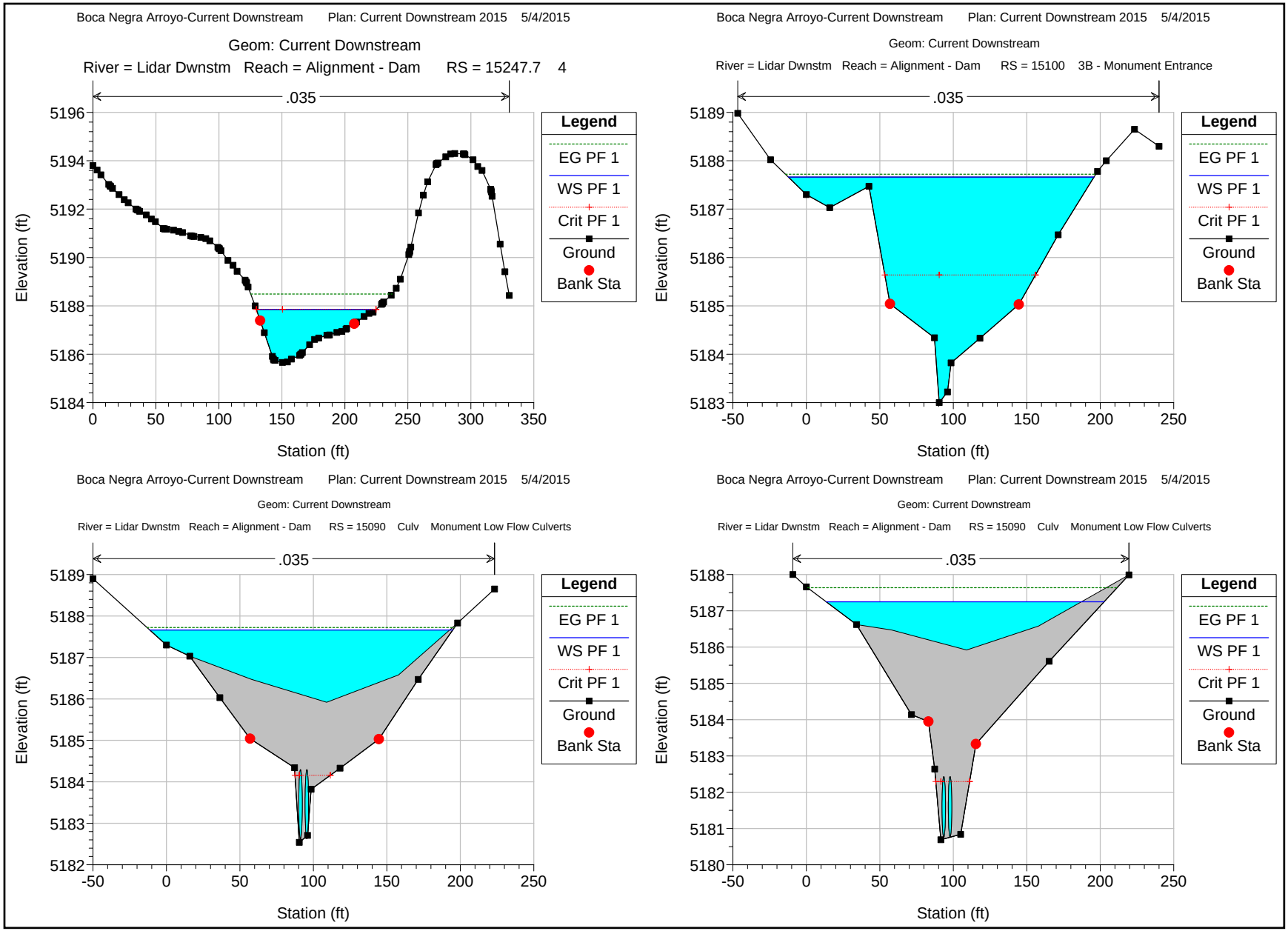
i.Project:	Boca Negra Arroyo– Current Downstream BNADwstn-.prj	
ii.Plan:	Current Downstream 2015	BNADwstn-.p10
iii.Geometry:	Current Downstream 2015	BNADwstn-.g07
iv.Flow:	Updated 2015 - Downstream	BNADwstn-.f07

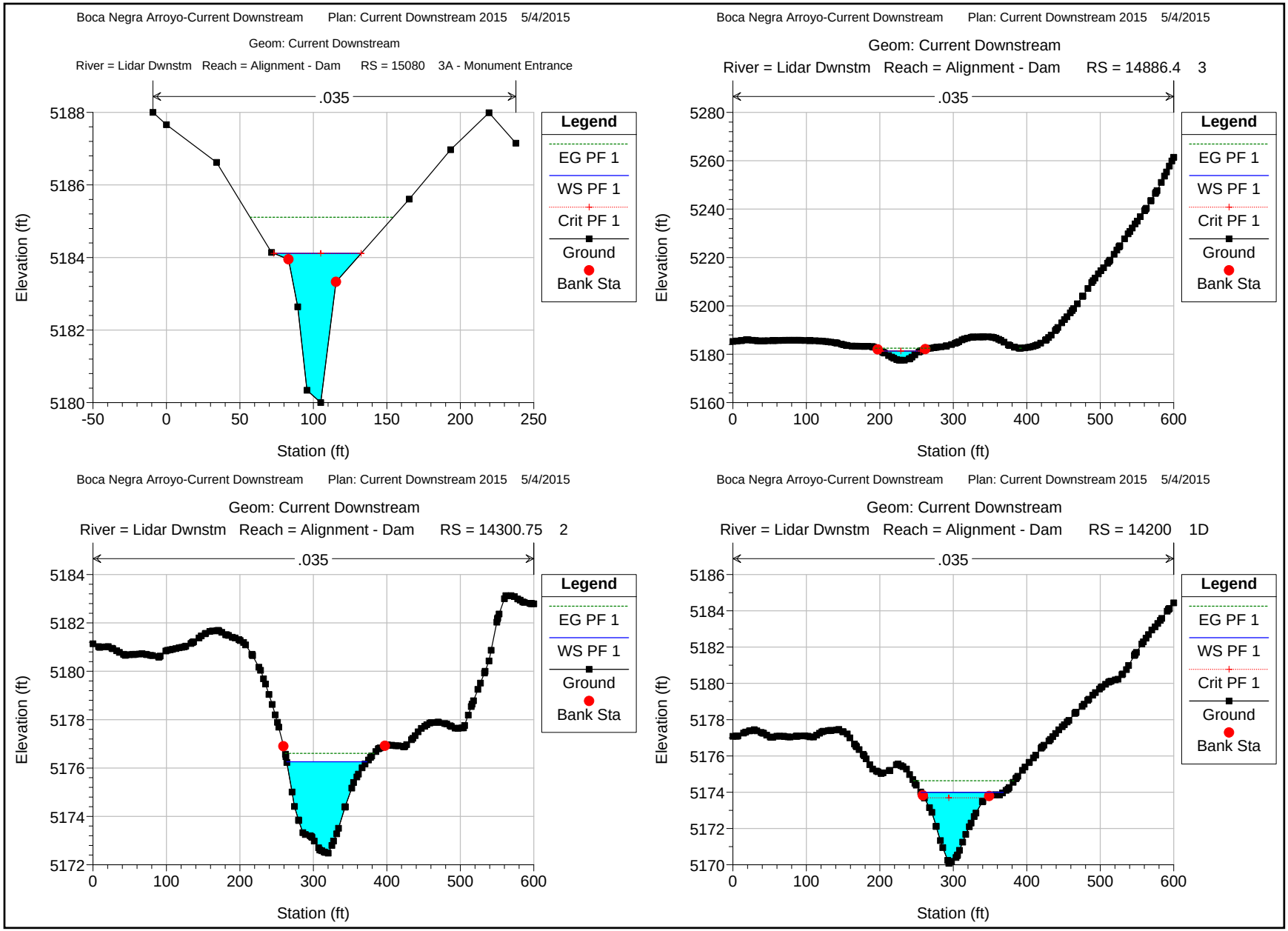
Boca Negra Arroyo - Current Downstream Model													
Reach	River Sta	Cross Section	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Alignment - Dam	18022.9	8	PF 1	695	5323.80	5326.91	5326.91	5328.20	0.002278	9.10	76.37	29.99	1.00
Alignment - Dam	17987.1	7	PF 1	695	5323.62	5326.74	5326.74	5328.02	0.002254	9.07	76.64	29.99	1.00
Alignment - Dam	17735.62	6	PF 1	695	5321.00	5322.81	5322.79	5323.34	0.016567	5.83	119.27	108.22	0.98
Alignment - Dam	17129.8	C	PF 1	695	5312.30	5314.43	5314.43	5315.05	0.011505	6.70	119.60	100.14	0.88
Alignment - Dam	17000	B	PF 1	695	5269.36	5273.82	5273.82	5275.19	0.02867	9.36	74.22	27.59	1.01
Alignment - Dam	16550	A1	PF 1	695	5234.48	5237.45	5237.45	5238.48	0.014622	8.12	85.55	42.35	1.01
Alignment - Dam	16457	A	PF 1	695	5199.33	5202.71	5202.32	5203.11	0.0089	5.10	136.33	94.36	0.75
Alignment - Dam	15976	5	PF 1	695	5194.51	5197.56	5197.40	5198.12	0.012124	6.03	115.21	78.18	0.88
Alignment - Dam	15247.7	4	PF 1	695	5185.66	5187.85	5187.85	5188.49	0.014488	6.44	111.57	95.01	0.95
Alignment - Dam	15100	3B	PF 1	695	5183.00	5187.66	5185.64	5187.72	0.000487	2.07	395.10	207.98	0.20
Alignment - Dam	15090			Culvert									
Alignment - Dam	15080	3A	PF 1	695	5180.00	5184.11	5184.11	5185.11	0.010626	8.09	91.42	59.42	0.88
Alignment - Dam	14886.4	3	PF 1	1110	5177.49	5181.32	5181.32	5182.51	0.013818	8.74	127.00	54.13	1.01
Alignment - Dam	14300.75	2	PF 1	1147	5172.48	5176.26		5176.61	0.004246	4.71	243.50	109.21	0.56
Alignment - Dam	14200	1D	PF 1	1147	5170.08	5173.99	5173.69	5174.63	0.009301	6.42	180.80	112.12	0.81
Alignment - Dam	14100.75	1C	PF 1	1149	5168.60	5171.59	5171.59	5172.33	0.01233	6.96	171.35	183.18	0.91
Alignment - Dam	13900.75	1B	PF 1	1149	5166.95	5169.84	5169.49	5169.98	0.005603	3.07	374.57	394.73	0.55
Alignment - Dam	13700.75	1A	PF 1	1149	5165.29	5167.85	5167.70	5168.39	0.011479	5.89	195.11	132.31	0.85
Alignment - Dam	13150.55	1	PF 1	1149	5164.49	5167.76		5167.98	0.003175	4.89	332.41	202.42	0.50
Alignment - Dam	13150.54	0.995	PF 1	1149	5164.94	5167.53		5167.86	0.004375	4.71	264.19	162.93	0.56
Alignment - Dam	13150	0.99	PF 1	1149	5164.30	5167.26	5166.66	5167.65	0.004857	5.70	248.10	156.53	0.61
Alignment - Dam	13149.5	0.98	PF 1	1149	5164.10	5166.34	5166.34	5167.18	0.015442	7.37	155.85	94.06	1.01
Alignment - Dam	13149	0.97	PF 1	1149	5163.46	5165.51	5165.51	5166.46	0.002074	7.83	146.83	78.74	1.01
Alignment - Dam	13148.5	0.96	PF 1	1149	5162.28	5164.45	5164.45	5165.42	0.002043	7.89	145.63	76.19	1.01
Alignment - Dam	13148	0.95	PF 1	1149	5161.09	5164.71	5163.32	5165.08	0.000392	4.86	236.28	69.06	0.46
Alignment - Dam	13146			Culvert									
Alignment - Dam	13145	0.94	PF 1	1149	5159.94	5162.04	5162.04	5163.04	0.002115	8.01	143.36	72.47	1.00
Alignment - Dam	13144	0.93	PF 1	1149	5159.86	5161.76	5161.76	5162.66	0.013428	7.64	150.40	84.08	1.01
Alignment - Dam	13143	0.92	PF 1	1149	5159.58	5161.55	5161.39	5162.26	0.010417	6.77	169.81	92.87	0.88
Alignment - Dam	13140	0.91	PF 1	1149	5157.25	5159.20	5159.20	5160.09	0.015214	7.59	151.42	85.86	1.01
Alignment - Dam	13135	0.9	PF 1	1149	5154.62	5156.87		5157.53	0.009152	6.52	176.14	84.92	0.80
Alignment - Dam	13130	0.8	PF 1	1149	5152.76	5155.35		5155.92	0.006995	6.05	189.82	84.40	0.71
Alignment - Dam	13120	0.7	PF 1	1149	5149.46	5153.08		5153.55	0.005177	5.50	208.74	85.59	0.62
Alignment - Dam	13110	0.6	PF 1	1150	5147.82	5151.04	5150.30	5151.52	0.005113	5.57	206.65	82.32	0.62
Alignment - Dam	13100	0.53	PF 1	1150	5144.96	5147.29	5147.29	5148.20	0.015146	7.64	150.53	84.64	1.01
Alignment - Dam	13095	0.52	PF 1	1150	5139.15	5143.24		5143.55	0.002315	4.47	257.19	77.67	0.43
Alignment - Dam	13093	0.51	PF 1	1150	5138.89	5143.32		5143.50	0.00112	3.45	333.73	85.64	0.31
Alignment - Dam	13090	0.5	PF 1	1150	5140.41	5142.88		5143.45	0.006877	6.06	189.69	82.43	0.70
Alignment - Dam	13080	0.4	PF 1	1150	5137.16	5140.60	5139.82	5141.06	0.004903	5.47	210.07	83.28	0.61
Alignment - Dam	13070	0.3	PF 1	1151	5134.83	5136.95	5136.95	5137.81	0.015264	7.45	154.42	90.61	1.01
Alignment - Dam	13060	0.21	PF 1	1151	5130.80	5134.23	5133.09	5134.53	0.003762	4.42	260.22	95.17	0.47
Alignment - Dam	13055			Bridge									
Alignment - Dam	13050	0.2	PF 1	1151	5130.97	5133.39		5134.05	0.012033	6.54	176.12	85.99	0.80
Alignment - Dam	13040	0.1	PF 1	1151	5127.23	5130.11	5130.03	5131.09	0.013003	7.95	144.84	68.16	0.96

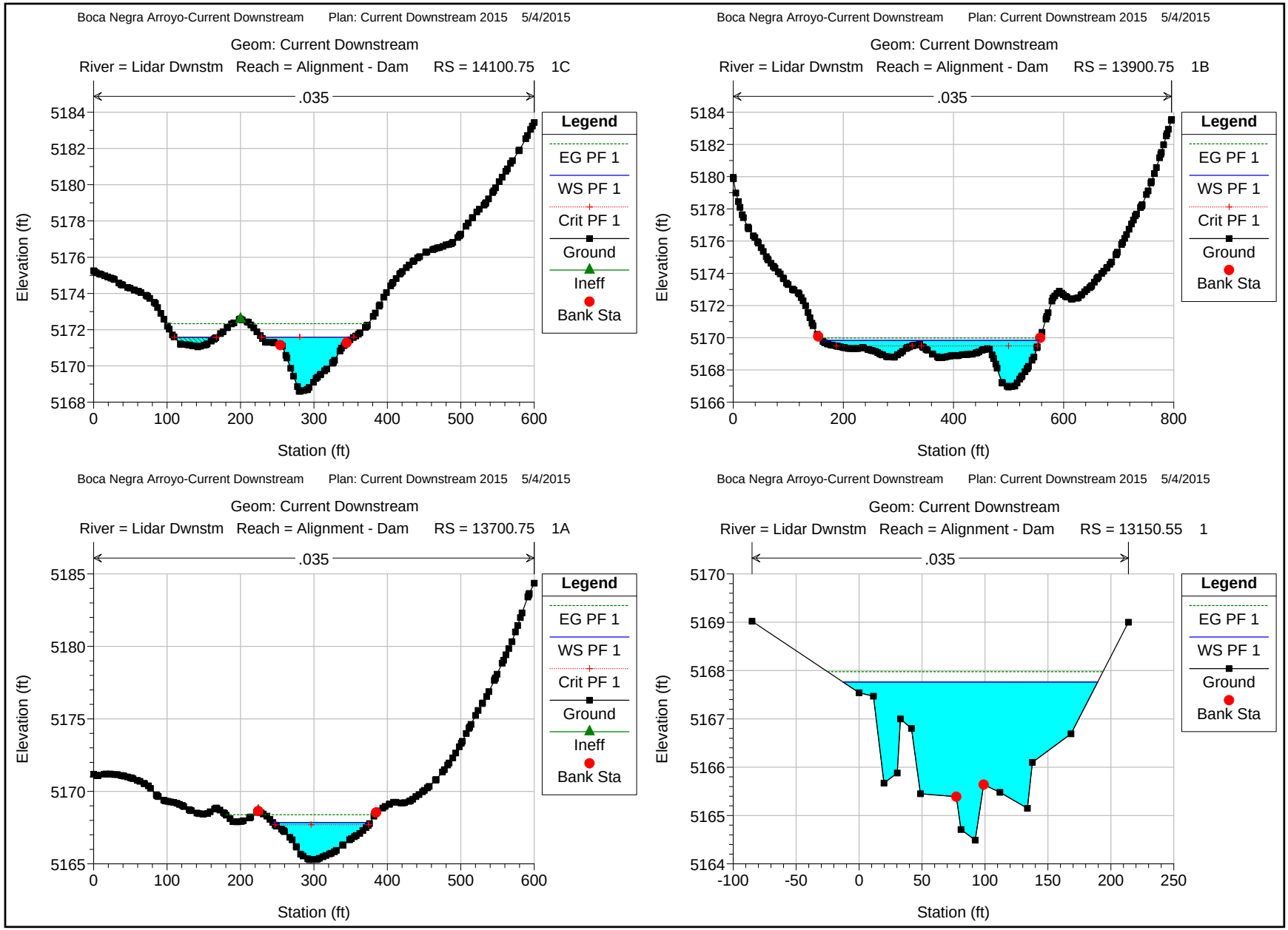

Boca Negra Arroyo-Current Downstream Plan: Current Downstream 2015 5/4/2015
Geom: Current Downstream
Lidar Dwnstm Alignment - Dam
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Elevation (ft)
5350
5300
5250
5200
5150
5100
0
2000
4000
6000
8000
Main Channel Distance (ft)
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
0.92
0.98
1
1B
1C
1D
2
3
Monument Low Flow Culverts
4
5
Cross Section Boca Negra Arroyo 1...
A1
Cross Section Boca Negra Arroyo 19.0 - B
Cross Section Boca Negra Arroyo 19.5 - C
6

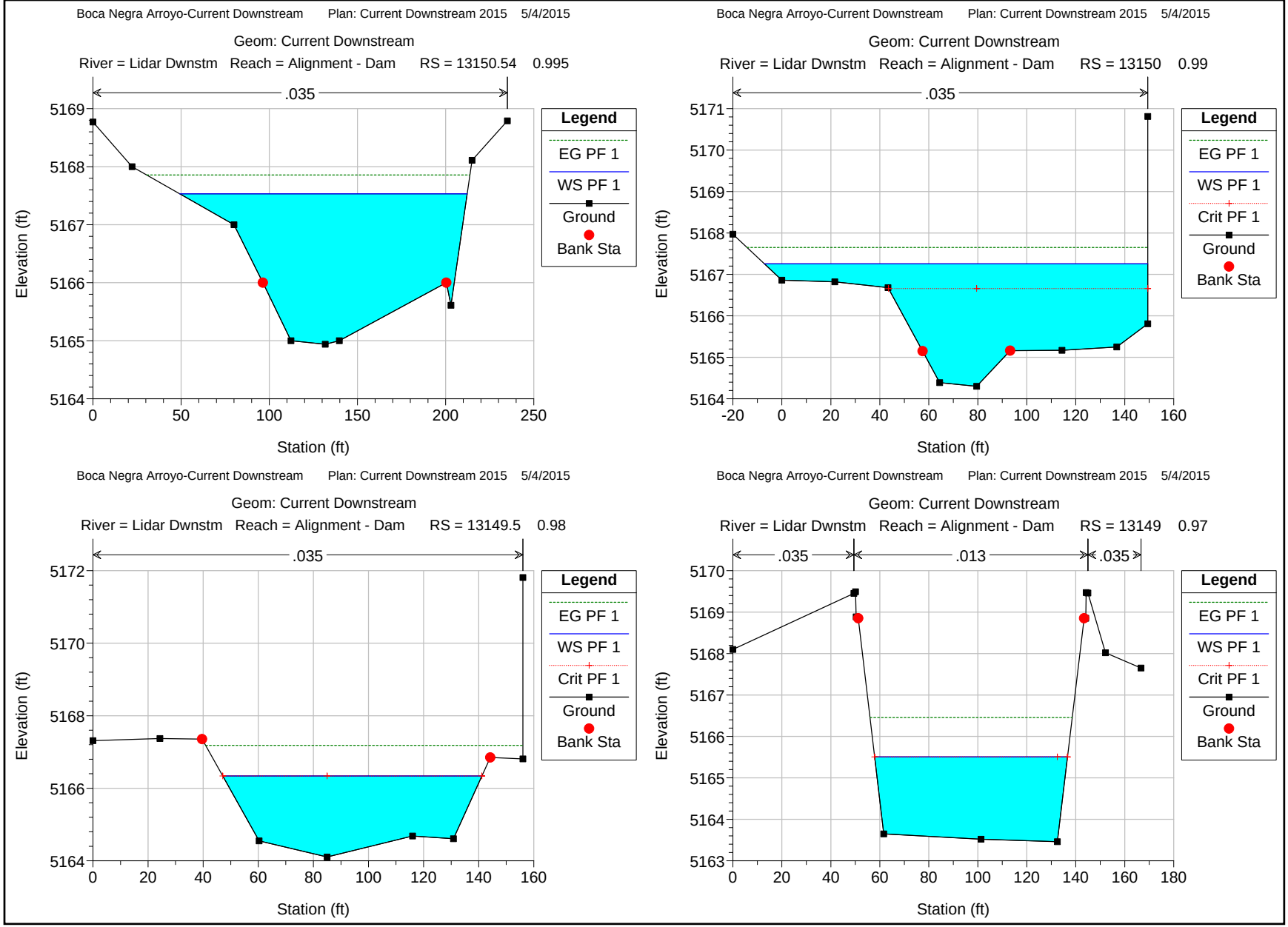

Boca Negra Arroyo-Current Downstream Plan: Current Downstream 2015 5/4/2015
Geom: Current Downstream
River = Lidar Dwnstm Reach = Alignment - Dam RS = 18022.9 8
.013
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)
Boca Negra Arroyo-Current Downstream Plan: Current Downstream 2015 5/4/2015
Geom: Current Downstream
River = Lidar Dwnstm Reach = Alignment - Dam RS = 17987.1 7
.013
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)
Boca Negra Arroyo-Current Downstream Plan: Current Downstream 2015 5/4/2015
Geom: Current Downstream
River = Lidar Dwnstm Reach = Alignment - Dam RS = 17735.62 6
.035
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)
Boca Negra Arroyo-Current Downstream Plan: Current Downstream 2015 5/4/2015
Geom: Current Downstream
River = Lidar Dwnstm Reach = Alignment - Dam RS = 17129.8 Cross Section Boca Negra Arroyo 19.5 - C
.035
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)

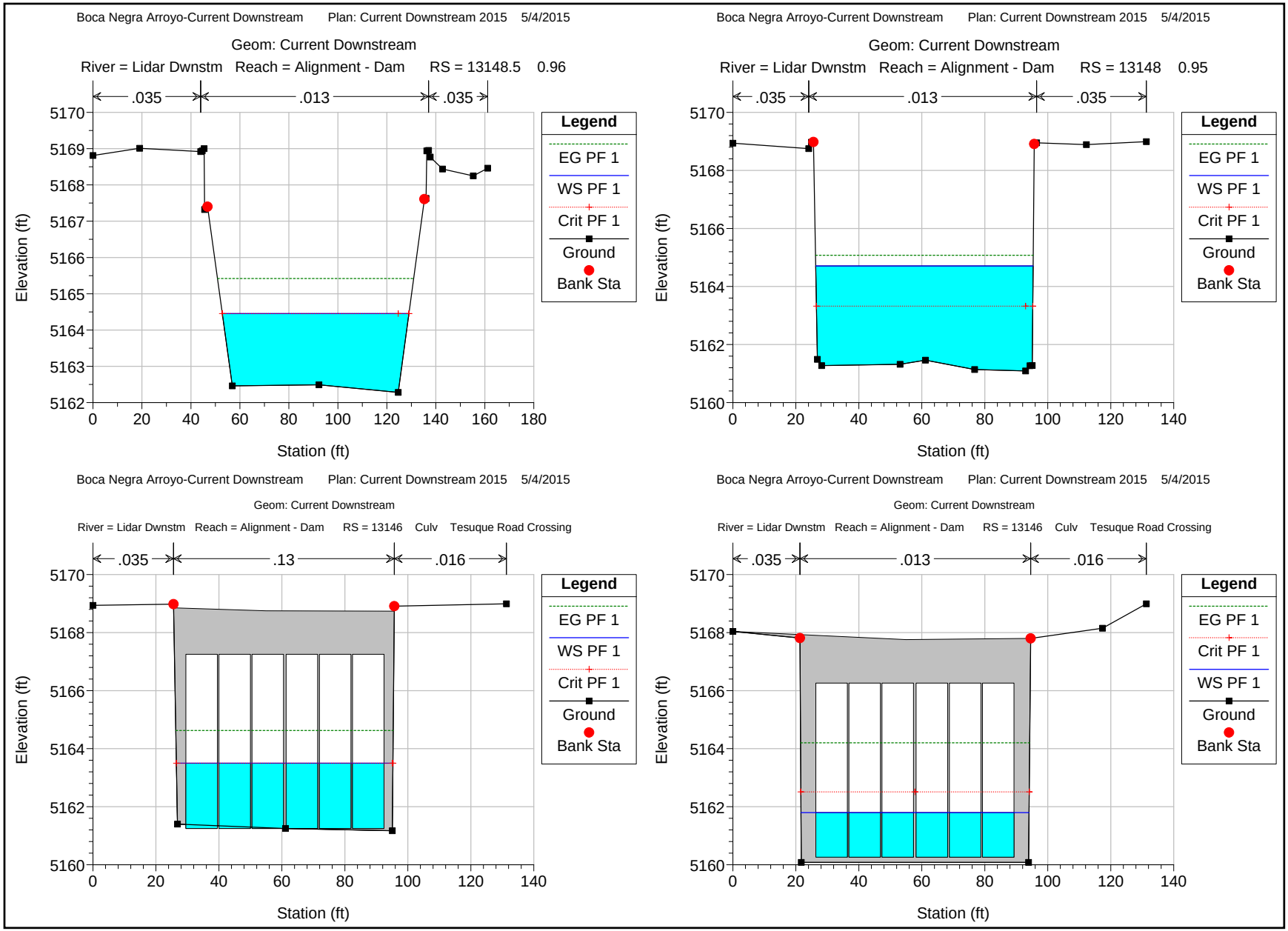

Boca Negra Arroyo-Current Downstream Plan: Current Downstream 2015 5/4/2015
Geom: Current Downstream
River = Lidar Dwnstm Reach = Alignment - Dam RS = 17000.0 Cross Section Boca Negra Arroyo 19.0 - B
.05
.05
.05
Elevation (ft)
Station (ft)
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Boca Negra Arroyo-Current Downstream Plan: Current Downstream 2015 5/4/2015
Geom: Current Downstream
River = Lidar Dwnstm Reach = Alignment - Dam RS = 16550 A1
.035
Elevation (ft)
Station (ft)
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Boca Negra Arroyo-Current Downstream Plan: Current Downstream 2015 5/4/2015
Geom: Current Downstream
River = Lidar Dwnstm Reach = Alignment - Dam RS = 16457.0 Cross Section Boca Negra Arroyo 18.0 -A
.05
.035
.035
Elevation (ft)
Station (ft)
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Boca Negra Arroyo-Current Downstream Plan: Current Downstream 2015 5/4/2015
Geom: Current Downstream
River = Lidar Dwnstm Reach = Alignment - Dam RS = 15976 5
.035
Elevation (ft)
Station (ft)
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta

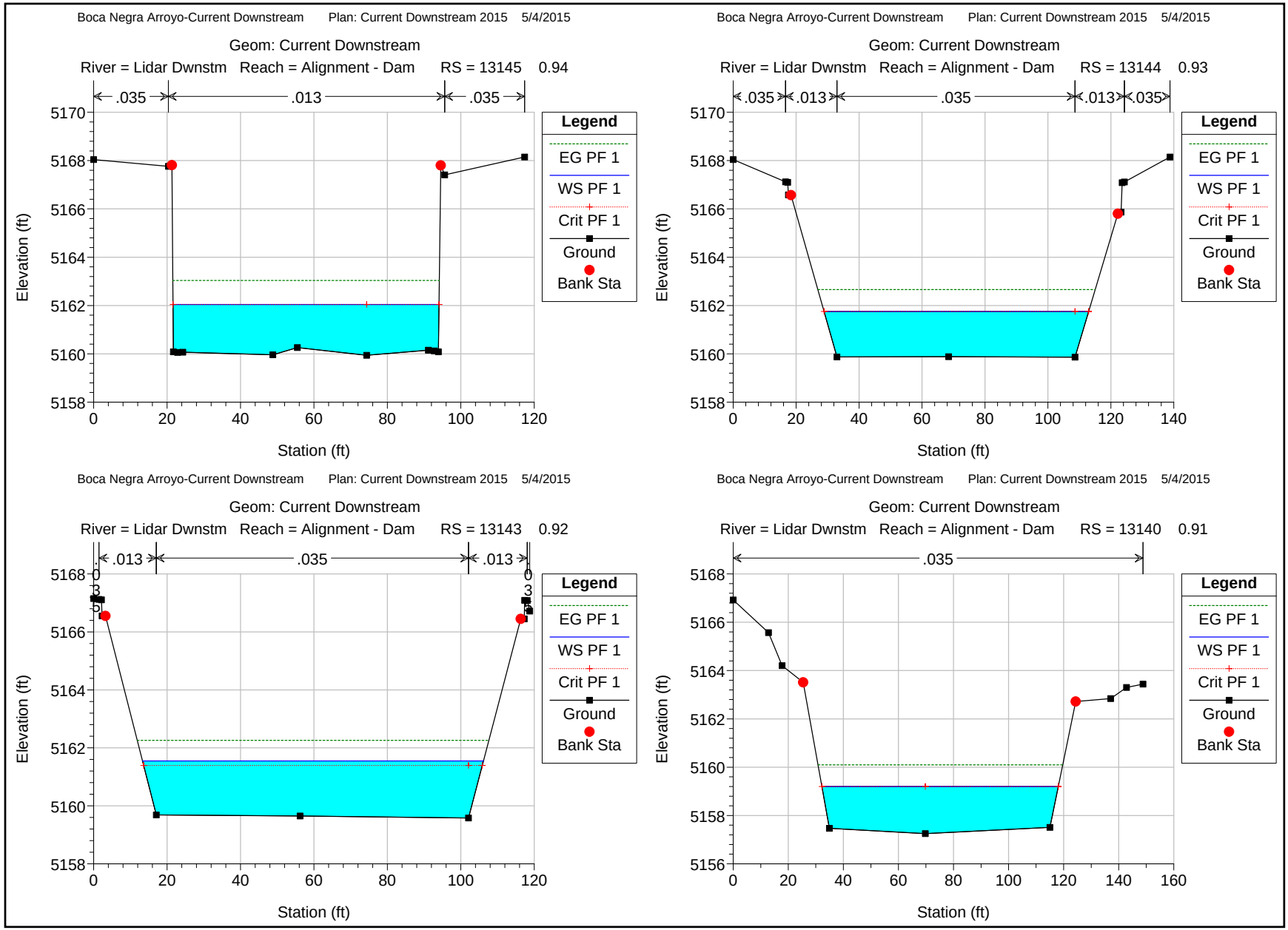

Boca Negra Arroyo-Current Downstream Plan: Current Downstream 2015 5/4/2015
Geom: Current Downstream
River = Lidar Dwnstm Reach = Alignment - Dam RS = 15247.7 4
.035
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)
Boca Negra Arroyo-Current Downstream Plan: Current Downstream 2015 5/4/2015
Geom: Current Downstream
River = Lidar Dwnstm Reach = Alignment - Dam RS = 15100 3B - Monument Entrance
.035
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)
Boca Negra Arroyo-Current Downstream Plan: Current Downstream 2015 5/4/2015
Geom: Current Downstream
River = Lidar Dwnstm Reach = Alignment - Dam RS = 15090 Culv Monument Low Flow Culverts
.035
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)
Boca Negra Arroyo-Current Downstream Plan: Current Downstream 2015 5/4/2015
Geom: Current Downstream
River = Lidar Dwnstm Reach = Alignment - Dam RS = 15090 Culv Monument Low Flow Culverts
.035
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)


Boca Negra Arroyo-Current Downstream Plan: Current Downstream 2015 5/4/2015
Geom: Current Downstream
River = Lidar Dwnstm Reach = Alignment - Dam RS = 15080 3A - Monument Entrance
.035
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)
Boca Negra Arroyo-Current Downstream Plan: Current Downstream 2015 5/4/2015
Geom: Current Downstream
River = Lidar Dwnstm Reach = Alignment - Dam RS = 14886.4 3
.035
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)
Boca Negra Arroyo-Current Downstream Plan: Current Downstream 2015 5/4/2015
Geom: Current Downstream
River = Lidar Dwnstm Reach = Alignment - Dam RS = 14300.75 2
.035
Legend
EG PF 1
WS PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)
Boca Negra Arroyo-Current Downstream Plan: Current Downstream 2015 5/4/2015
Geom: Current Downstream
River = Lidar Dwnstm Reach = Alignment - Dam RS = 14200 1D
.035
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)


Boca Negra Arroyo-Current Downstream Plan: Current Downstream 2015 5/4/2015
Geom: Current Downstream
River = Lidar Dwnstm Reach = Alignment - Dam RS = 14100.75 1C
.035
Elevation (ft)
Station (ft)
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Ineff
Bank Sta
Boca Negra Arroyo-Current Downstream Plan: Current Downstream 2015 5/4/2015
Geom: Current Downstream
River = Lidar Dwnstm Reach = Alignment - Dam RS = 13900.75 1B
.035
Elevation (ft)
Station (ft)
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Boca Negra Arroyo-Current Downstream Plan: Current Downstream 2015 5/4/2015
Geom: Current Downstream
River = Lidar Dwnstm Reach = Alignment - Dam RS = 13700.75 1A
.035
Elevation (ft)
Station (ft)
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Ineff
Bank Sta
Boca Negra Arroyo-Current Downstream Plan: Current Downstream 2015 5/4/2015
Geom: Current Downstream
River = Lidar Dwnstm Reach = Alignment - Dam RS = 13150.55 1
.035
Elevation (ft)
Station (ft)
Legend
EG PF 1
WS PF 1
Ground
Bank Sta


Boca Negra Arroyo-Current Downstream Plan: Current Downstream 2015 5/4/2015
Geom: Current Downstream
River = Lidar Dwnstm Reach = Alignment - Dam RS = 13150.54 0.995
.035
Legend
EG PF 1
WS PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)
Boca Negra Arroyo-Current Downstream Plan: Current Downstream 2015 5/4/2015
Geom: Current Downstream
River = Lidar Dwnstm Reach = Alignment - Dam RS = 13150 0.99
.035
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)
Boca Negra Arroyo-Current Downstream Plan: Current Downstream 2015 5/4/2015
Geom: Current Downstream
River = Lidar Dwnstm Reach = Alignment - Dam RS = 13149.5 0.98
.035
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)
Boca Negra Arroyo-Current Downstream Plan: Current Downstream 2015 5/4/2015
Geom: Current Downstream
River = Lidar Dwnstm Reach = Alignment - Dam RS = 13149 0.97
.035
.013
.035
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)

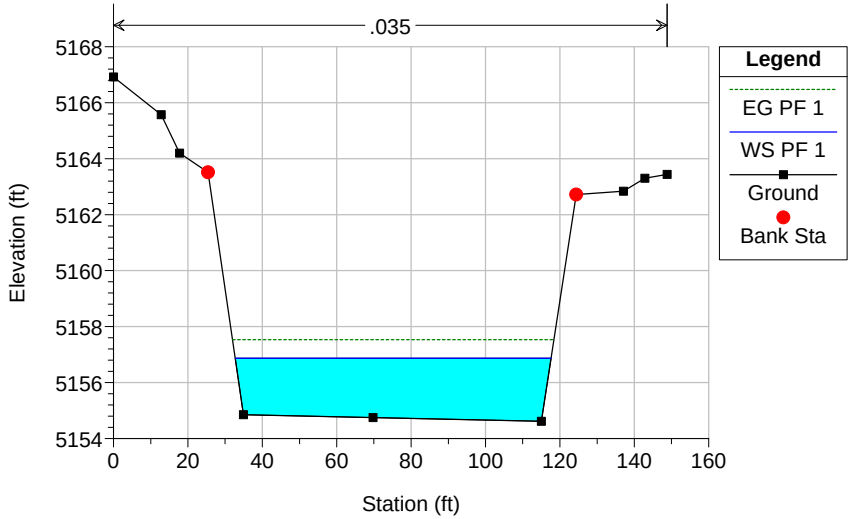

Boca Negra Arroyo-Current Downstream Plan: Current Downstream 2015 5/4/2015
Geom: Current Downstream
River = Lidar Dwnstm Reach = Alignment - Dam RS = 13148.5 0.96
.035
.013
.035
Elevation (ft)
Station (ft)
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Boca Negra Arroyo-Current Downstream Plan: Current Downstream 2015 5/4/2015
Geom: Current Downstream
River = Lidar Dwnstm Reach = Alignment - Dam RS = 13148 0.95
.035
.013
.035
Elevation (ft)
Station (ft)
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Boca Negra Arroyo-Current Downstream Plan: Current Downstream 2015 5/4/2015
Geom: Current Downstream
River = Lidar Dwnstm Reach = Alignment - Dam RS = 13146 Culv Tesuque Road Crossing
.035
.13
.016
Elevation (ft)
Station (ft)
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Boca Negra Arroyo-Current Downstream Plan: Current Downstream 2015 5/4/2015
Geom: Current Downstream
River = Lidar Dwnstm Reach = Alignment - Dam RS = 13146 Culv Tesuque Road Crossing
.035
.013
.016
Elevation (ft)
Station (ft)
Legend
EG PF 1
Crit PF 1
WS PF 1
Ground
Bank Sta


Boca Negra Arroyo-Current Downstream Plan: Current Downstream 2015 5/4/2015
Geom: Current Downstream
River = Lidar Dwnstm Reach = Alignment - Dam RS = 13145 0.94
.035
.013
.035
Elevation (ft)
Station (ft)
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Boca Negra Arroyo-Current Downstream Plan: Current Downstream 2015 5/4/2015
Geom: Current Downstream
River = Lidar Dwnstm Reach = Alignment - Dam RS = 13144 0.93
.035
.013
.035
.013
.035
Elevation (ft)
Station (ft)
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Boca Negra Arroyo-Current Downstream Plan: Current Downstream 2015 5/4/2015
Geom: Current Downstream
River = Lidar Dwnstm Reach = Alignment - Dam RS = 13143 0.92
.013
.035
.013
Elevation (ft)
Station (ft)
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Boca Negra Arroyo-Current Downstream Plan: Current Downstream 2015 5/4/2015
Geom: Current Downstream
River = Lidar Dwnstm Reach = Alignment - Dam RS = 13140 0.91
.035
Elevation (ft)
Station (ft)
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta

Boca Negra Arroyo-Current Downstream Plan: Current Downstream 2015 5/4/2015

Geom: Current Downstream

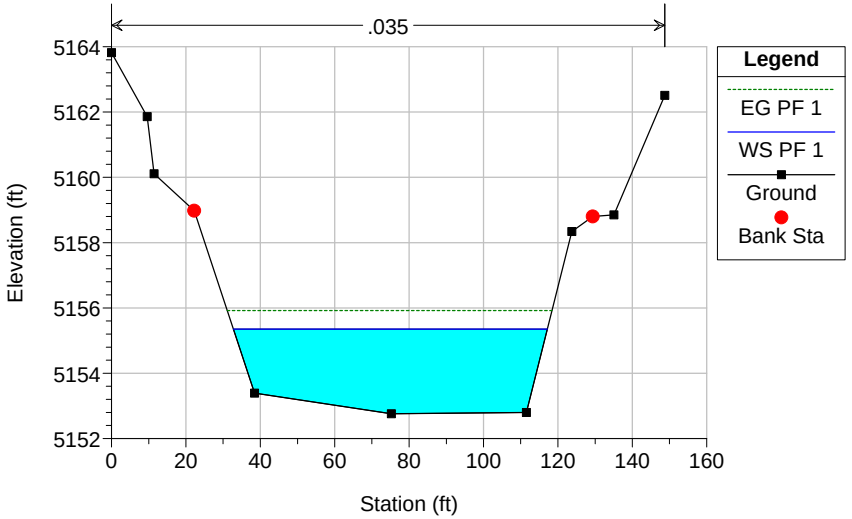
River = Lidar Dwnstm Reach = Alignment - Dam RS = 13135 0.9



Boca Negra Arroyo-Current Downstream Plan: Current Downstream 2015 5/4/2015

Geom: Current Downstream

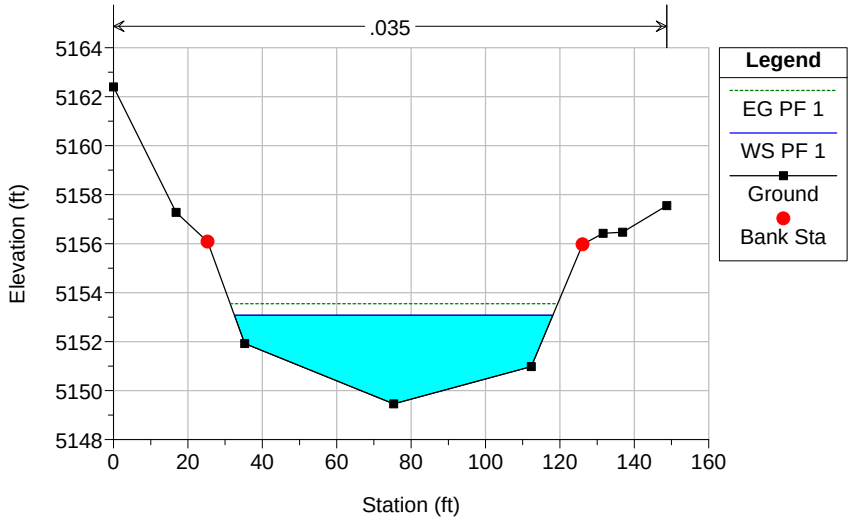
River = Lidar Dwnstm Reach = Alignment - Dam RS = 13130 0.8



Boca Negra Arroyo-Current Downstream Plan: Current Downstream 2015 5/4/2015

Geom: Current Downstream

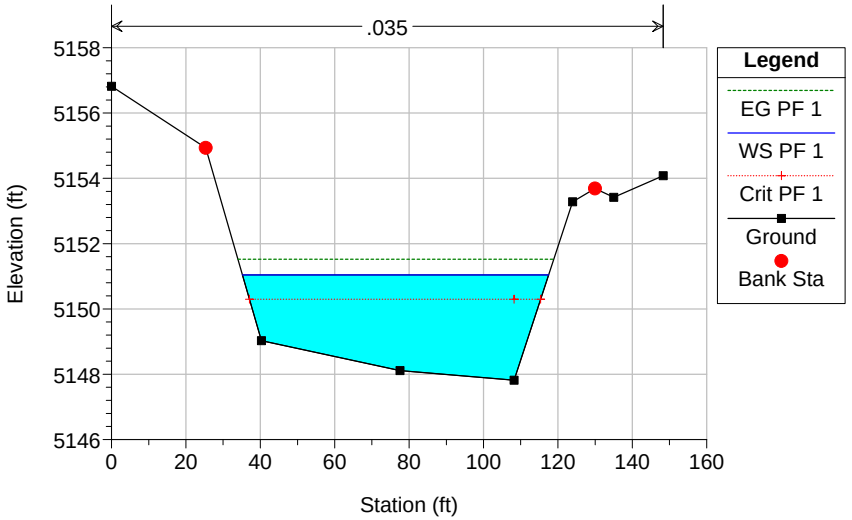
River = Lidar Dwnstm Reach = Alignment - Dam RS = 13120 0.7

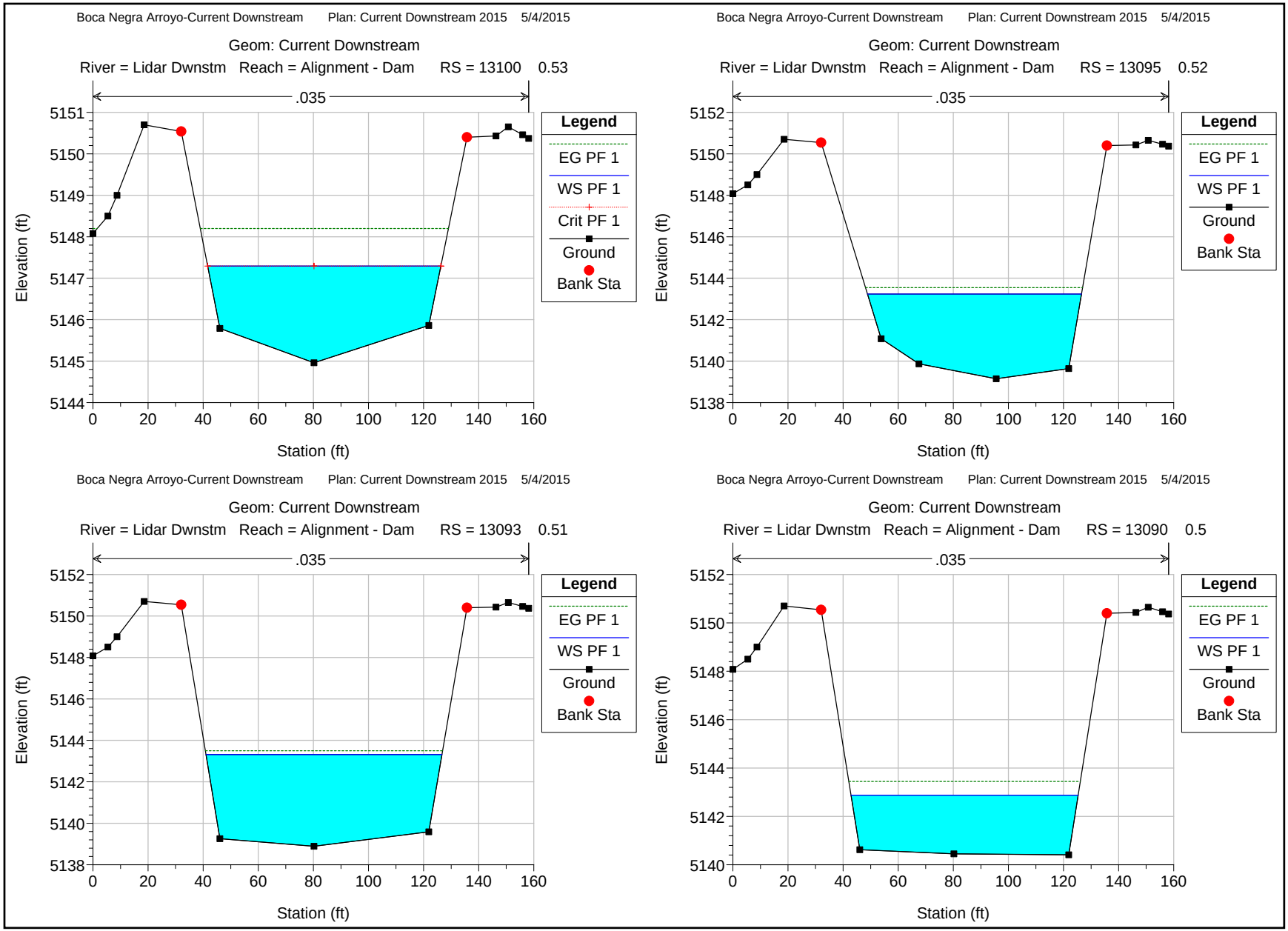


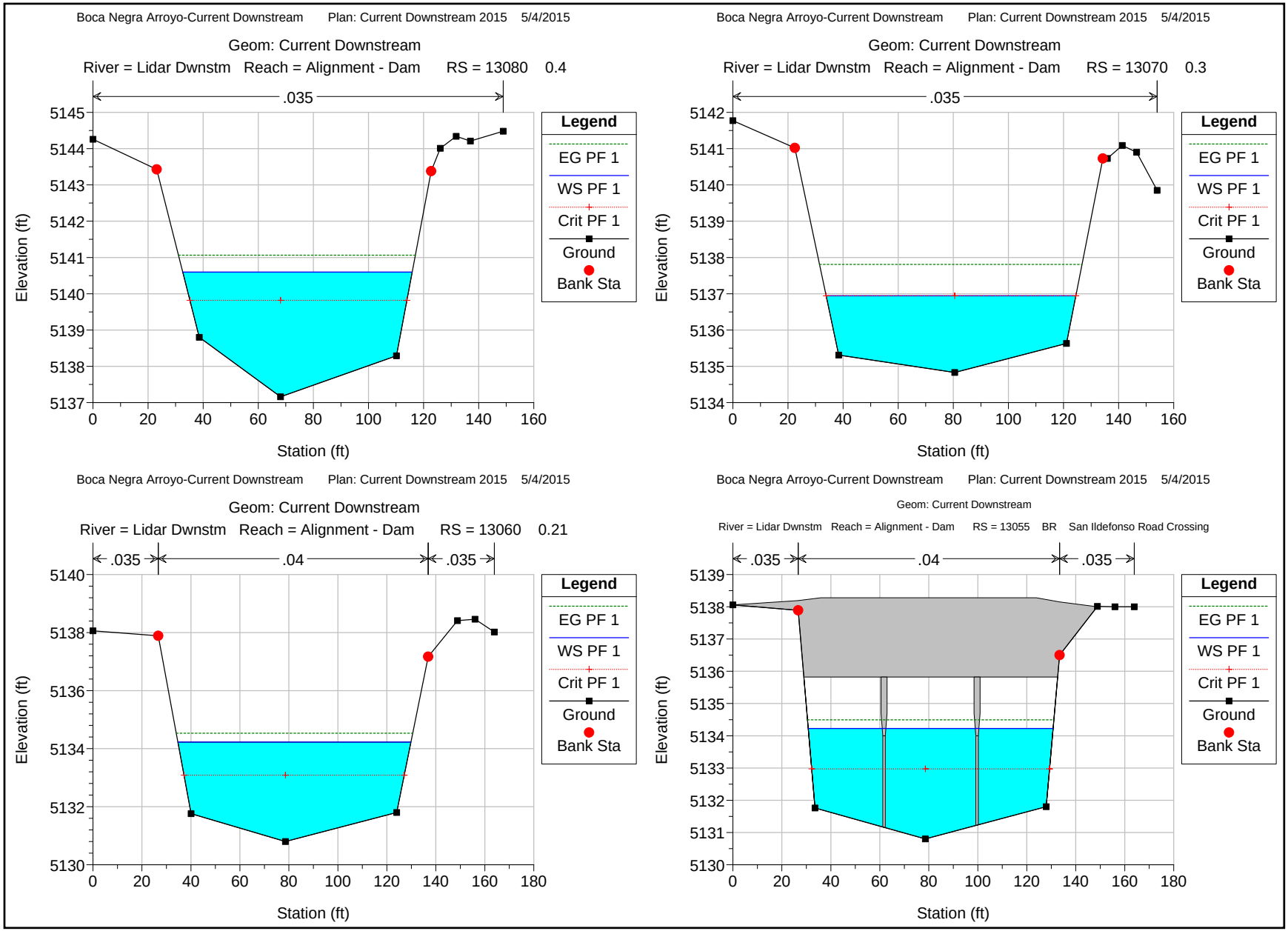
Boca Negra Arroyo-Current Downstream Plan: Current Downstream 2015 5/4/2015

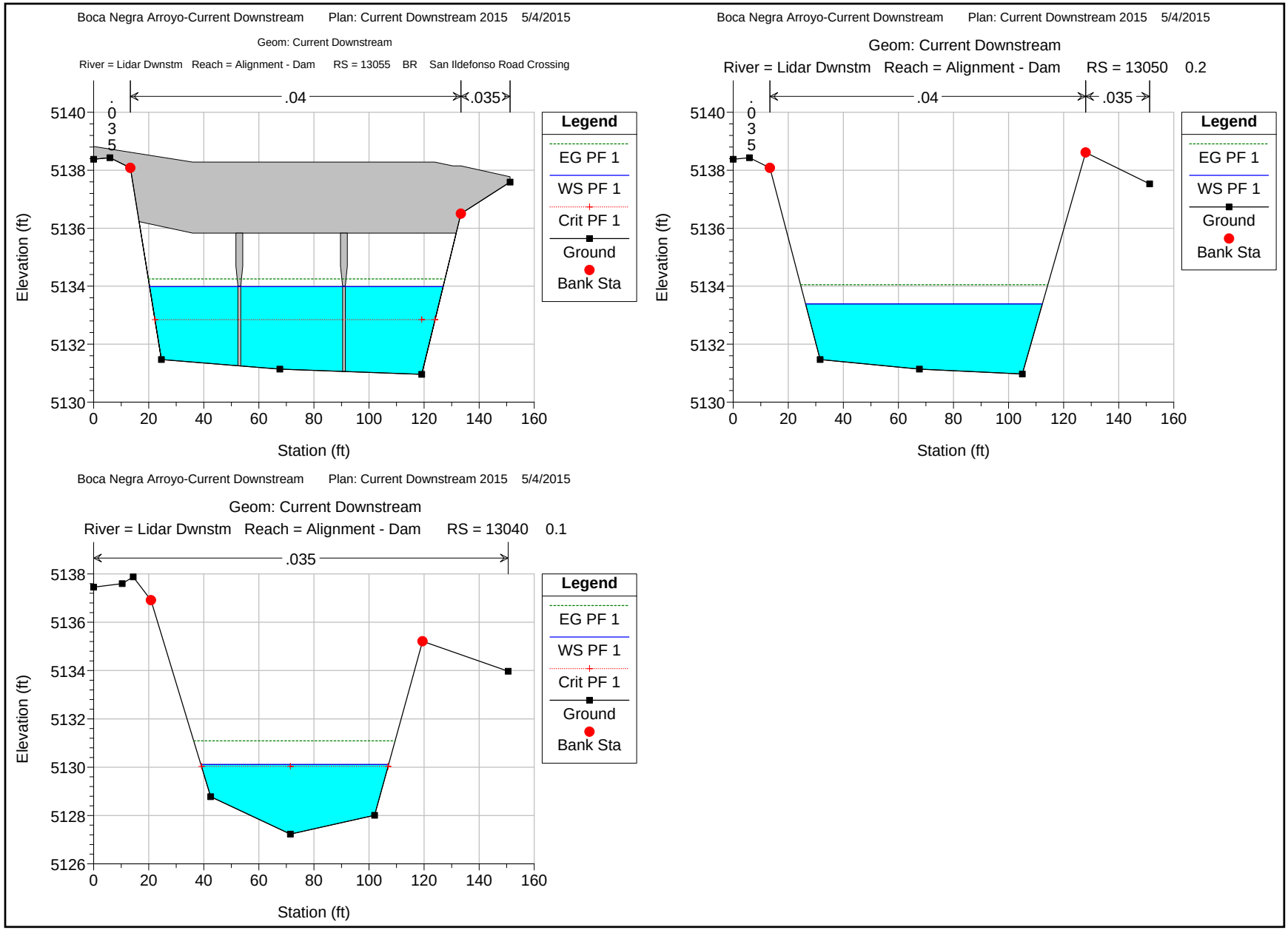
Geom: Current Downstream

River = Lidar Dwnstm Reach = Alignment - Dam RS = 13110 0.6




Boca Negra Arroyo-Current Downstream Plan: Current Downstream 2015 5/4/2015
Geom: Current Downstream
River = Lidar Dwnstm Reach = Alignment - Dam RS = 13100 0.53
.035
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)
Boca Negra Arroyo-Current Downstream Plan: Current Downstream 2015 5/4/2015
Geom: Current Downstream
River = Lidar Dwnstm Reach = Alignment - Dam RS = 13095 0.52
.035
Legend
EG PF 1
WS PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)
Boca Negra Arroyo-Current Downstream Plan: Current Downstream 2015 5/4/2015
Geom: Current Downstream
River = Lidar Dwnstm Reach = Alignment - Dam RS = 13093 0.51
.035
Legend
EG PF 1
WS PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)
Boca Negra Arroyo-Current Downstream Plan: Current Downstream 2015 5/4/2015
Geom: Current Downstream
River = Lidar Dwnstm Reach = Alignment - Dam RS = 13090 0.5
.035
Legend
EG PF 1
WS PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)


Boca Negra Arroyo-Current Downstream Plan: Current Downstream 2015 5/4/2015
Geom: Current Downstream
River = Lidar Dwnstm Reach = Alignment - Dam RS = 13080 0.4
.035
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)
Boca Negra Arroyo-Current Downstream Plan: Current Downstream 2015 5/4/2015
Geom: Current Downstream
River = Lidar Dwnstm Reach = Alignment - Dam RS = 13070 0.3
.035
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)
Boca Negra Arroyo-Current Downstream Plan: Current Downstream 2015 5/4/2015
Geom: Current Downstream
River = Lidar Dwnstm Reach = Alignment - Dam RS = 13060 0.21
.035
.04
.035
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)
Boca Negra Arroyo-Current Downstream Plan: Current Downstream 2015 5/4/2015
Geom: Current Downstream
River = Lidar Dwnstm Reach = Alignment - Dam RS = 13055 BR San Ildefonso Road Crossing
.035
.04
.035
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)

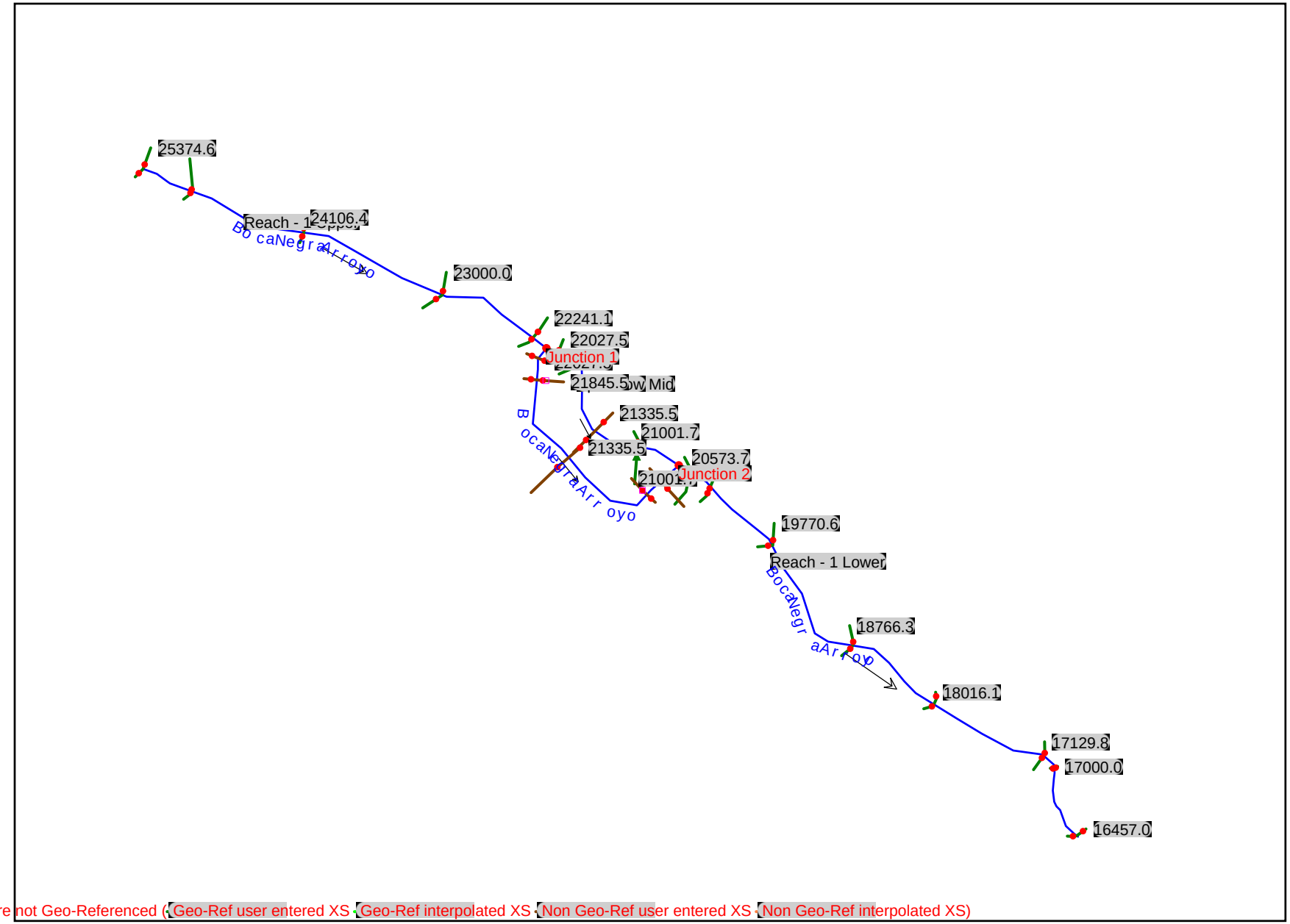

Boca Negra Arroyo-Current Downstream Plan: Current Downstream 2015 5/4/2015
Geom: Current Downstream
River = Lidar Dwnstm Reach = Alignment - Dam RS = 13055 BR San Ildefonso Road Crossing
.035
.04
.035
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)
Boca Negra Arroyo-Current Downstream Plan: Current Downstream 2015 5/4/2015
Geom: Current Downstream
River = Lidar Dwnstm Reach = Alignment - Dam RS = 13050 0.2
.035
.04
.035
Legend
EG PF 1
WS PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)
Boca Negra Arroyo-Current Downstream Plan: Current Downstream 2015 5/4/2015
Geom: Current Downstream
River = Lidar Dwnstm Reach = Alignment - Dam RS = 13040 0.1
.035
Legend
EG PF 1
WS PF 1
Crit PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)

Effective Floodway Model

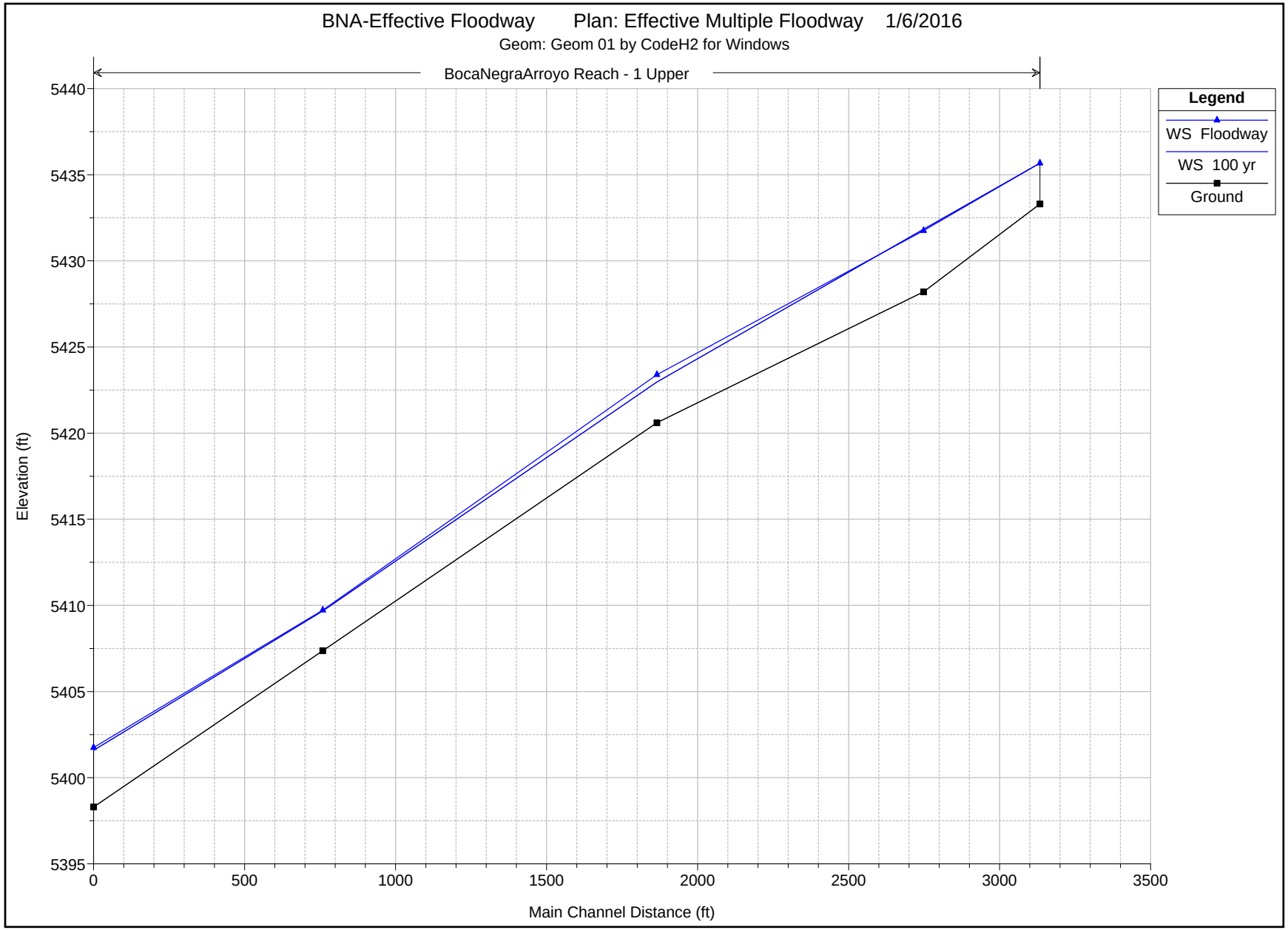
Plan
Profile
Summary
Cross Sections
Input/output Report

Hydraulics Model – HEC-RAS Analysis (CD)
FEMA Duplicate Effective Floodway Files

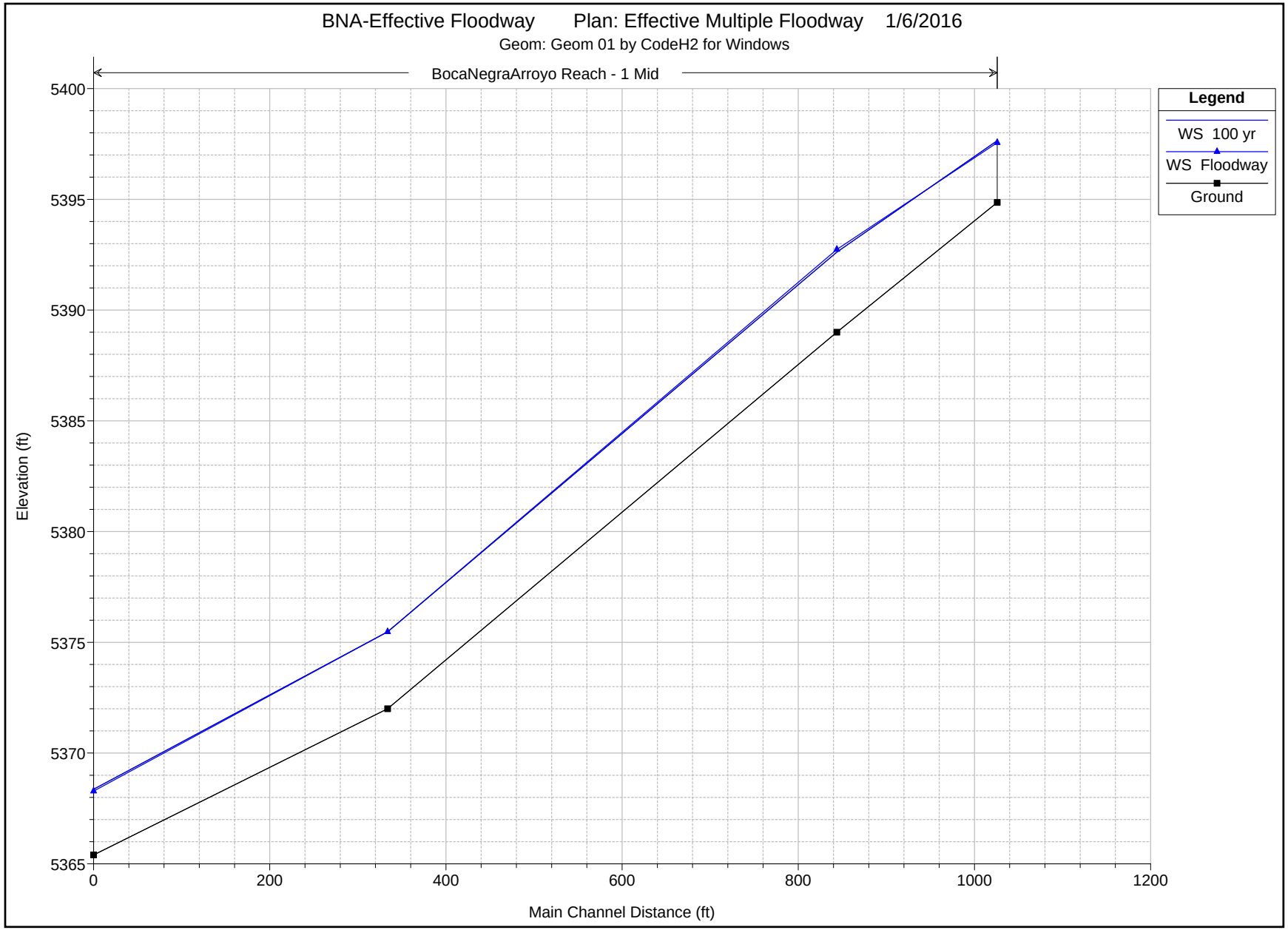
i.Project:	BNA- Eff Floodway	BNA-EffFloodway.prj
ii.Plan:	Effective Multiple Floodway	BNA-EffFloodway.p09
iii.Geometry:	Geom 01 by CodeH2 for windows	BNA-EffFloodway.g01
iv.Flow:	Updated 2014 - Effective	BNA-EffFloodway.f06

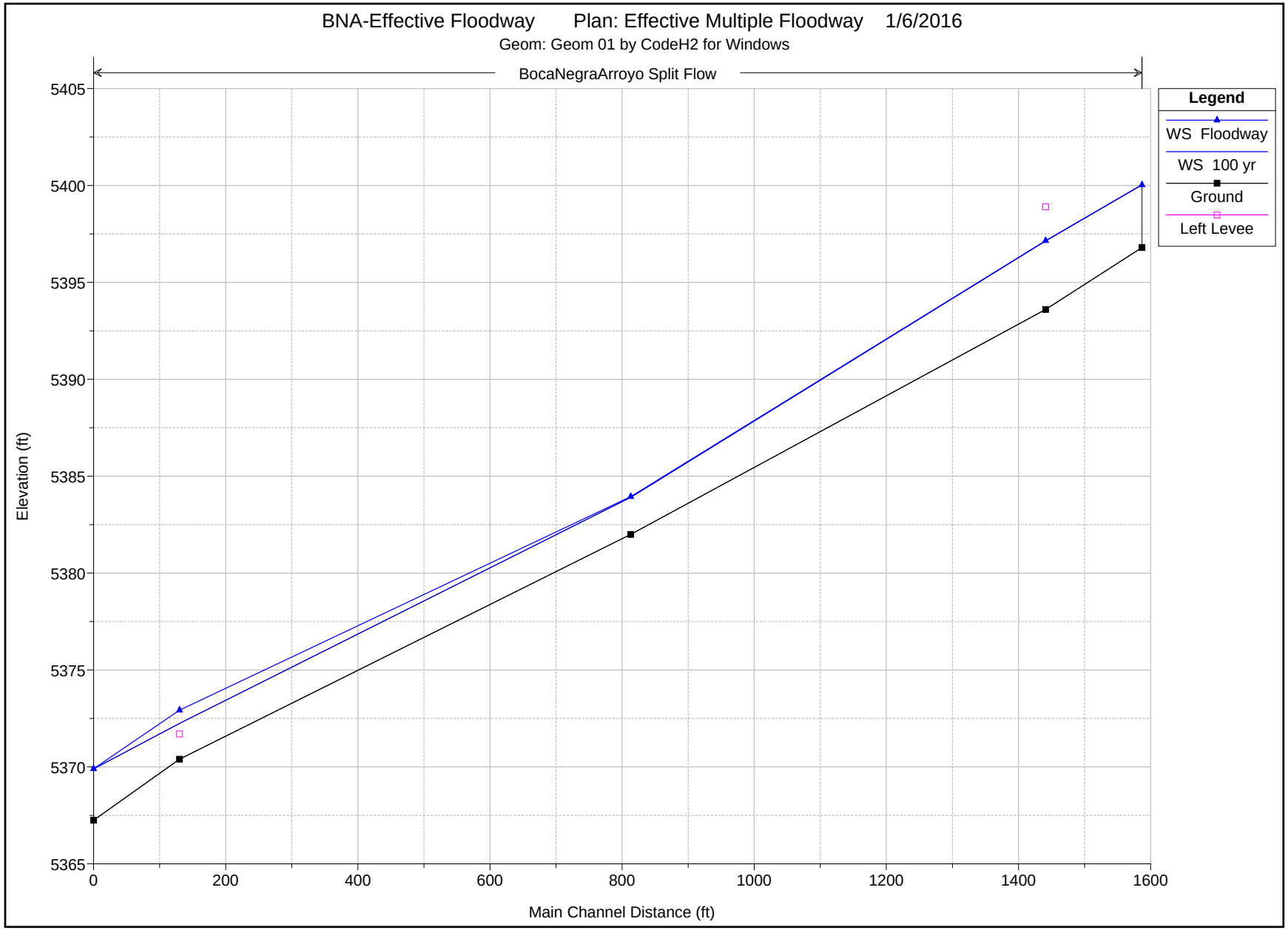


BNA Effective Floodway Model

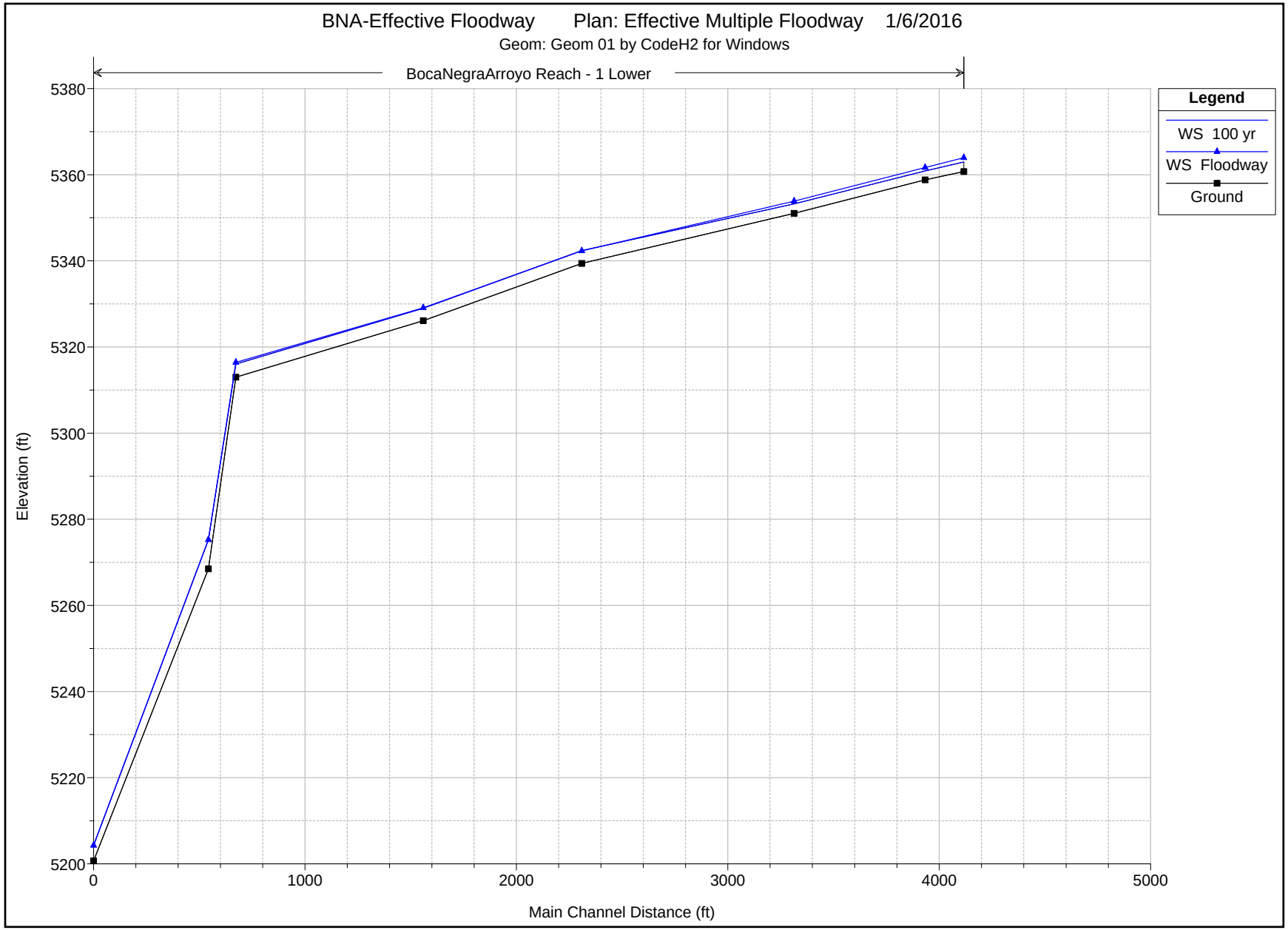


BNA Effective Floodway Model


BNA-Effective Floodway Plan: Effective Multiple Floodway 1/6/2016
Geom: Geom 01 by CodeH2 for Windows
BocaNegraArroyo Reach - 1 Mid
Legend
WS 100 yr
WS Floodway
Ground
Elevation (ft)
5400
5395
5390
5385
5380
5375
5370
5365
0
200
400
600
800
1000
1200
Main Channel Distance (ft)



BNA Effective Floodway Model



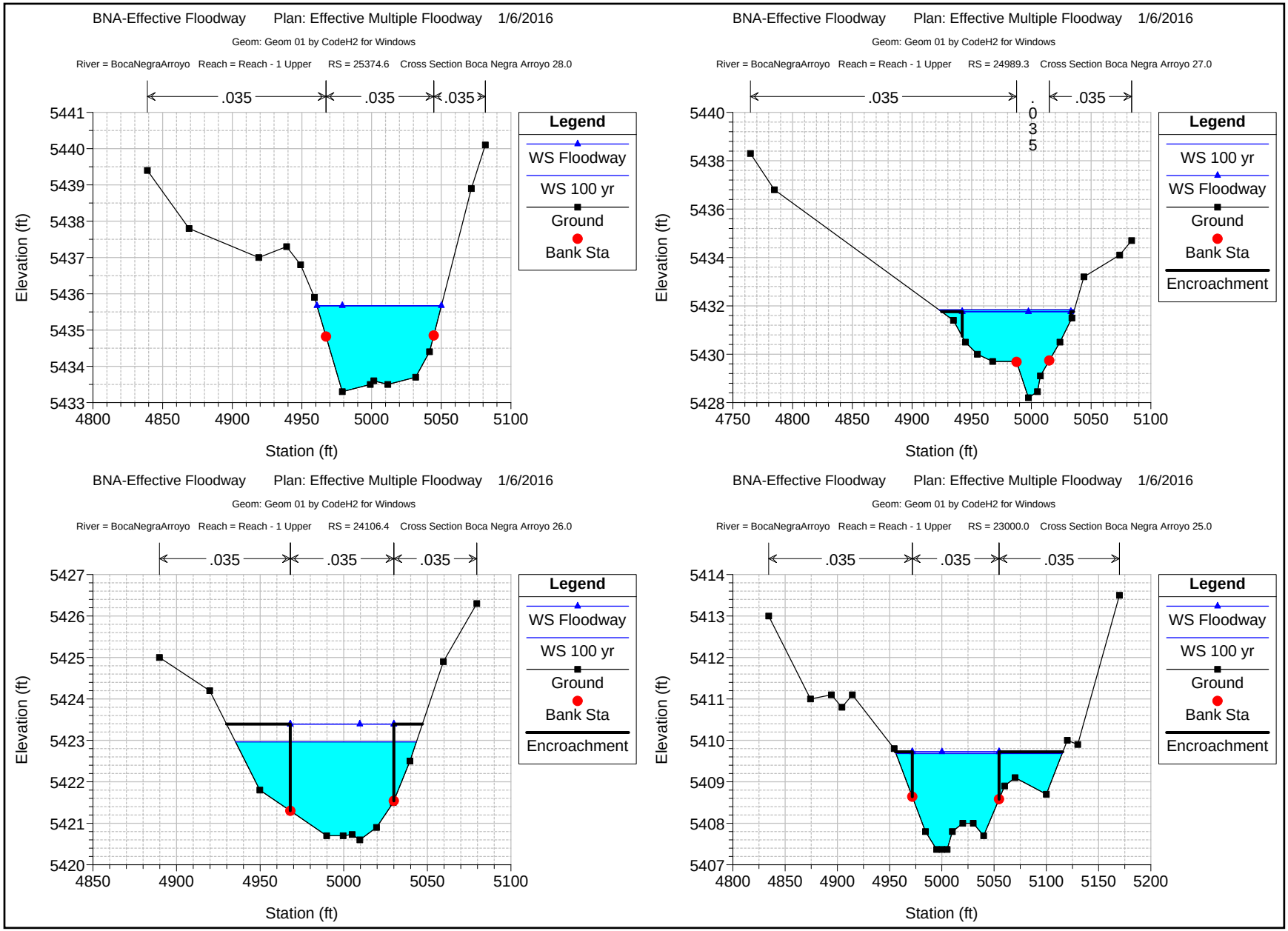
BNA Effective Floodway Model

HEC-RAS Plan: Eff Fldwy

Reach	River Sta	Profile	W.S. Elev	Prof Delta WS	E.G. Elev	Top Wdth Act	Q Left	Q Channel	Q Right	Enc Sta L	Ch Sta L	Ch Sta R	Enc Sta R
			(ft)	(ft)	(ft)	(ft)	(cfs)	(cfs)	(cfs)	(ft)	(ft)	(ft)	(ft)
Reach - 1 Upper	25374.6	100 yr	5435.67		5436.60	89.28	7.74	1179.18	6.08		4967.30	5044.60	
Reach - 1 Upper	25374.6	Floodway	5435.67	0.00	5436.60	89.33	7.79	1179.09	6.12	4958.00	4967.30	5044.60	5052.00
Reach - 1 Upper	24989.3	100 yr	5431.84		5432.49	113.39	468.77	624.97	99.26		4987.60	5015.00	
Reach - 1 Upper	24989.3	Floodway	5431.76	-0.08	5432.48	91.00	483.01	614.57	95.42	4942.00	4987.60	5015.00	5033.00
Reach - 1 Upper	24106.4	100 yr	5422.96		5423.79	108.20	168.09	986.34	38.57		4968.10	5030.00	
Reach - 1 Upper	24106.4	Floodway	5423.39	0.43	5424.32	62.00	0.19	1192.81		4968.00	4968.10	5030.00	5030.00
Reach - 1 Upper	23000.0	100 yr	5409.68		5410.31	158.97	23.92	1015.19	153.89		4971.70	5054.70	
Reach - 1 Upper	23000.0	Floodway	5409.72	0.04	5410.66	83.00		1193.00		4971.70	4971.70	5054.70	5054.70
Reach - 1 Upper	22241.1	100 yr	5401.59		5401.79	170.34	95.16	830.38	267.47		4944.20	5015.00	
Reach - 1 Upper	22241.1	Floodway	5401.75	0.16	5402.21	70.80		1193.00		4944.20	4944.20	5015.00	5015.00
Reach - 1 Mid	22027.5	100 yr	5397.65		5398.44	122.42	68.87	1087.72	58.42		4974.80	5039.90	
Reach - 1 Mid	22027.5	Floodway	5397.56	-0.09	5398.55	80.00	29.01	1141.68	44.31	4970.00	4974.80	5039.90	5050.00
Reach - 1 Mid	21845.5	100 yr	5392.61		5393.54	96.51	121.40	904.73	188.87		4976.80	5015.00	
Reach - 1 Mid	21845.5	Floodway	5392.74	0.12	5394.10	50.00	80.64	1074.05	60.32	4970.00	4976.80	5015.00	5020.00
Reach - 1 Mid	21335.5	100 yr	5375.48		5376.23	116.80		1215.00			4997.39	5179.10	
Reach - 1 Mid	21335.5	Floodway	5375.48	0.00	5376.23	116.84		1215.00		4904.44	4997.39	5179.10	5306.53
Reach - 1 Mid	21001.7	100 yr	5368.37		5369.42	74.32	8.59	1196.10	10.31		4968.60	5028.90	
Reach - 1 Mid	21001.7	Floodway	5368.28	-0.09	5369.46	60.30		1215.00		4968.60	4968.60	5028.90	5028.90
Split Flow	22027.5	100 yr	5400.04		5400.96	88.58		1214.67	0.33		4951.10	5041.10	
Split Flow	22027.5	Floodway	5400.03	-0.02	5400.96	86.25		1215.00		4951.10	4951.10	5041.10	5041.10
Split Flow	21845.5	100 yr	5397.14		5398.12	82.93	0.85	1214.15			4941.30	5021.30	
Split Flow	21845.5	Floodway	5397.15	0.02	5398.12	79.80		1215.00		4941.30	4941.30	5021.30	5021.30
Split Flow	21335.5	100 yr	5383.91		5384.45	192.67		1215.00			4910.65	5111.26	
Split Flow	21335.5	Floodway	5383.95	0.04	5384.45	195.88		1215.00		4910.65	4910.65	5111.26	5111.26
Split Flow	21001.7	100 yr	5372.24		5372.85	158.80	581.65	625.35	8.00		4950.00	5030.00	
Split Flow	21001.7	Floodway	5372.93	0.68	5373.88	80.00		1215.00		4950.00	4950.00	5030.00	5030.00
Split Flow	20774.5	100 yr	5369.90		5370.61	128.58		1215.00			4939.64	5072.87	
Split Flow	20774.5	Floodway	5369.90	0.01	5370.61	128.86		1215.00		4939.64	4939.64	5072.87	5072.87
Reach - 1 Lower	20573.7	100 yr	5362.96		5363.33	223.02	54.97	583.63	579.41		4985.00	5035.10	
Reach - 1 Lower	20573.7	Floodway	5363.96	1.00	5364.75	60.00	73.80	1097.26	46.94	4979.00	4985.00	5035.10	5039.00
Reach - 1 Lower	20390.6	100 yr	5360.86		5361.49	153.68	552.70	539.95	125.36		5015.00	5053.00	

HEC-RAS Plan: Eff Fldwy (Continued)

Reach	River Sta	Profile	W.S. Elev	Prof Delta WS	E.G. Elev	Top Wdth Act	Q Left	Q Channel	Q Right	Enc Sta L	Ch Sta L	Ch Sta R	Enc Sta R
			(ft)	(ft)	(ft)	(ft)	(cfs)	(cfs)	(cfs)	(ft)	(ft)	(ft)	(ft)
Reach - 1 Lower	20390.6	Floodway	5361.67	0.81	5362.97	53.00	92.65	984.36	140.99	5009.00	5015.00	5053.00	5062.00
Reach - 1 Lower	19770.6	100 yr	5353.24		5353.84	173.76	207.02	892.15	118.83		4958.40	5029.00	
Reach - 1 Lower	19770.6	Floodway	5353.87	0.63	5354.63	70.60		1218.00		4958.40	4958.40	5029.00	5029.00
Reach - 1 Lower	18766.3	100 yr	5342.36		5343.16	130.91	124.88	1064.19	28.93		4972.10	5030.10	
Reach - 1 Lower	18766.3	Floodway	5342.31	-0.05	5343.52	58.00		1218.00		4972.10	4972.10	5030.10	5030.10
Reach - 1 Lower	18016.1	100 yr	5328.99		5329.93	86.45	0.06	1217.94			4937.40	5021.80	
Reach - 1 Lower	18016.1	Floodway	5329.10	0.11	5329.94	84.40		1218.00		4937.40	4937.40	5021.80	5021.80
Reach - 1 Lower	17129.8	100 yr	5316.05		5316.86	120.13	269.92	911.82	116.26		4980.00	5021.00	
Reach - 1 Lower	17129.8	Floodway	5316.44	0.39	5318.03	41.00		1298.00		4980.00	4980.00	5021.00	5021.00
Reach - 1 Lower	17000.0	100 yr	5275.25		5277.25	34.25	2.15	1279.97	15.88		4987.70	5010.10	
Reach - 1 Lower	17000.0	Floodway	5275.25	0.00	5277.25	34.08	2.15	1279.89	15.96	4985.00	4987.70	5010.10	5020.00
Reach - 1 Lower	16457.0	100 yr	5204.29		5205.23	90.37	2.43	1294.84	0.73		4943.50	5027.40	
Reach - 1 Lower	16457.0	Floodway	5204.29	0.00	5205.23	88.89	2.56	1294.71	0.73	4940.00	4943.50	5027.40	5030.00


BNA-Effective Floodway Plan: Effective Multiple Floodway 1/6/2016
Geom: Geom 01 by CodeH2 for Windows
River = BocaNegraArroyo Reach = Reach - 1 Upper RS = 25374.6 Cross Section Boca Negra Arroyo 28.0
.035
.035
.035
Legend
WS Floodway
WS 100 yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
BNA-Effective Floodway Plan: Effective Multiple Floodway 1/6/2016
Geom: Geom 01 by CodeH2 for Windows
River = BocaNegraArroyo Reach = Reach - 1 Upper RS = 24989.3 Cross Section Boca Negra Arroyo 27.0
.035
.035
Legend
WS 100 yr
WS Floodway
Ground
Bank Sta
Encroachment
Elevation (ft)
Station (ft)
BNA-Effective Floodway Plan: Effective Multiple Floodway 1/6/2016
Geom: Geom 01 by CodeH2 for Windows
River = BocaNegraArroyo Reach = Reach - 1 Upper RS = 24106.4 Cross Section Boca Negra Arroyo 26.0
.035
.035
.035
Legend
WS Floodway
WS 100 yr
Ground
Bank Sta
Encroachment
Elevation (ft)
Station (ft)
BNA-Effective Floodway Plan: Effective Multiple Floodway 1/6/2016
Geom: Geom 01 by CodeH2 for Windows
River = BocaNegraArroyo Reach = Reach - 1 Upper RS = 23000.0 Cross Section Boca Negra Arroyo 25.0
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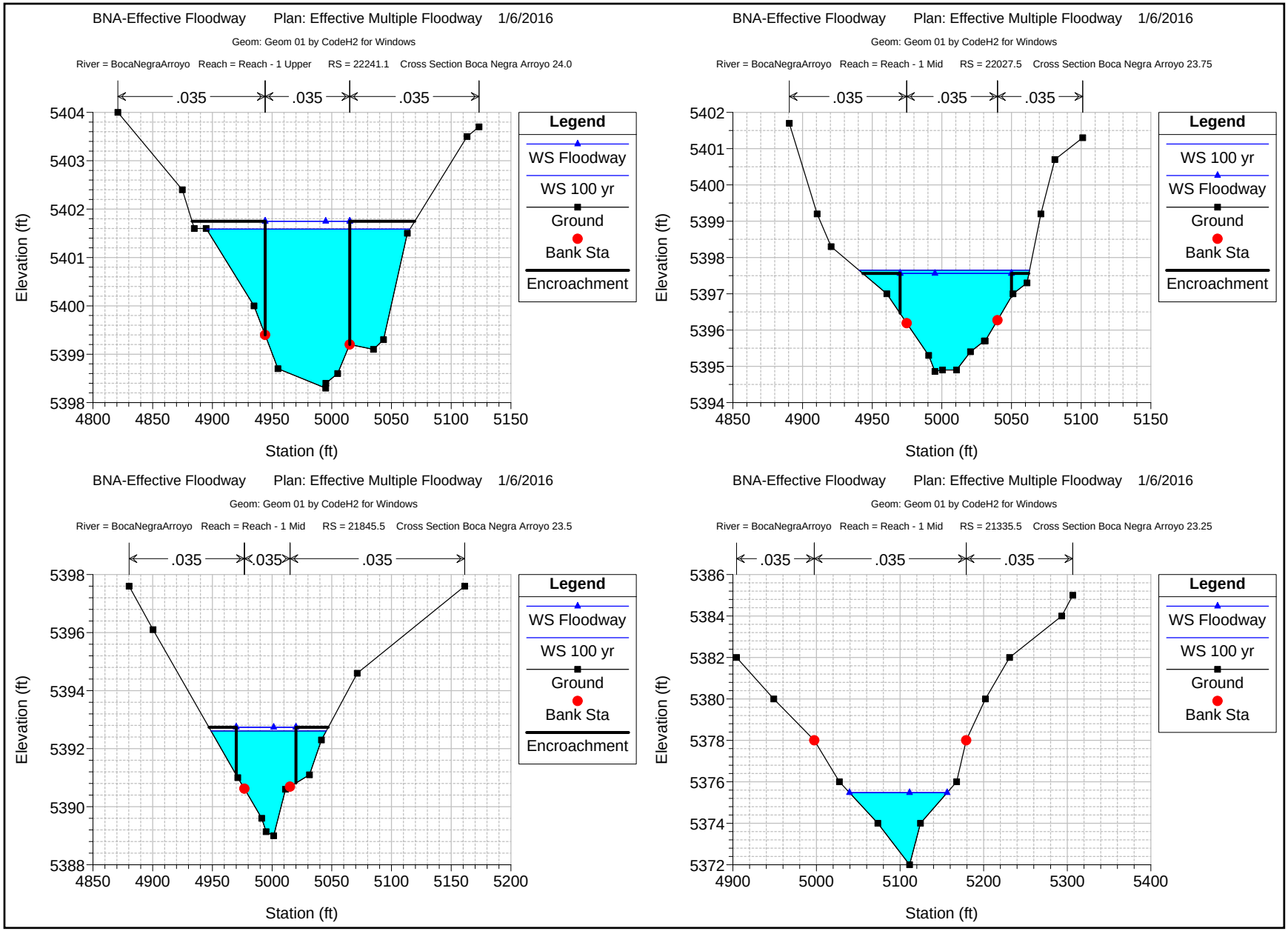
.035
.035
Legend
WS Floodway
WS 100 yr
Ground
Bank Sta
Encroachment
Elevation (ft)
Station (ft)


BNA-Effective Floodway Plan: Effective Multiple Floodway 1/6/2016
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River = BocaNegraArroyo Reach = Reach - 1 Upper RS = 22241.1 Cross Section Boca Negra Arroyo 24.0
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.035
.035
Elevation (ft)
Station (ft)
Legend
WS Floodway
WS 100 yr
Ground
Bank Sta
Encroachment
BNA-Effective Floodway Plan: Effective Multiple Floodway 1/6/2016
Geom: Geom 01 by CodeH2 for Windows
River = BocaNegraArroyo Reach = Reach - 1 Mid RS = 22027.5 Cross Section Boca Negra Arroyo 23.75
.035
.035
.035
Elevation (ft)
Station (ft)
Legend
WS 100 yr
WS Floodway
Ground
Bank Sta
Encroachment
BNA-Effective Floodway Plan: Effective Multiple Floodway 1/6/2016
Geom: Geom 01 by CodeH2 for Windows
River = BocaNegraArroyo Reach = Reach - 1 Mid RS = 21845.5 Cross Section Boca Negra Arroyo 23.5
.035
.035
.035
Elevation (ft)
Station (ft)
Legend
WS Floodway
WS 100 yr
Ground
Bank Sta
Encroachment
BNA-Effective Floodway Plan: Effective Multiple Floodway 1/6/2016
Geom: Geom 01 by CodeH2 for Windows
River = BocaNegraArroyo Reach = Reach - 1 Mid RS = 21335.5 Cross Section Boca Negra Arroyo 23.25
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.035
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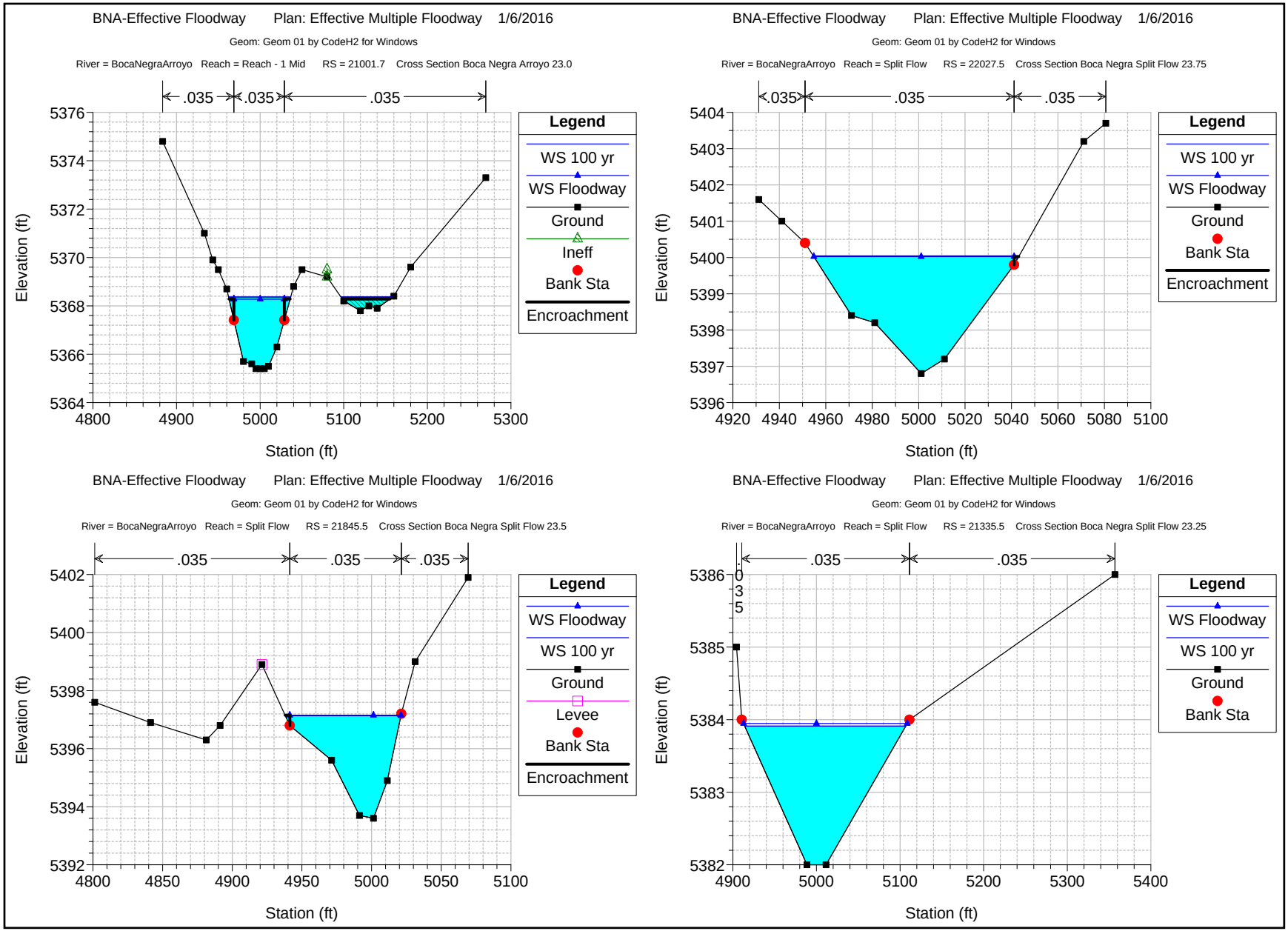
Elevation (ft)
Station (ft)
Legend
WS Floodway
WS 100 yr
Ground
Bank Sta


BNA-Effective Floodway Plan: Effective Multiple Floodway 1/6/2016
Geom: Geom 01 by CodeH2 for Windows
River = BocaNegraArroyo Reach = Reach - 1 Mid RS = 21001.7 Cross Section Boca Negra Arroyo 23.0
.035
.035
.035
Elevation (ft)
Station (ft)
Legend
WS 100 yr
WS Floodway
Ground
Ineff
Bank Sta
Encroachment
BNA-Effective Floodway Plan: Effective Multiple Floodway 1/6/2016
Geom: Geom 01 by CodeH2 for Windows
River = BocaNegraArroyo Reach = Split Flow RS = 22027.5 Cross Section Boca Negra Split Flow 23.75
.035
.035
.035
Elevation (ft)
Station (ft)
Legend
WS 100 yr
WS Floodway
Ground
Bank Sta
Encroachment
BNA-Effective Floodway Plan: Effective Multiple Floodway 1/6/2016
Geom: Geom 01 by CodeH2 for Windows
River = BocaNegraArroyo Reach = Split Flow RS = 21845.5 Cross Section Boca Negra Split Flow 23.5
.035
.035
.035
Elevation (ft)
Station (ft)
Legend
WS Floodway
WS 100 yr
Ground
Levee
Bank Sta
Encroachment
BNA-Effective Floodway Plan: Effective Multiple Floodway 1/6/2016
Geom: Geom 01 by CodeH2 for Windows
River = BocaNegraArroyo Reach = Split Flow RS = 21335.5 Cross Section Boca Negra Split Flow 23.25
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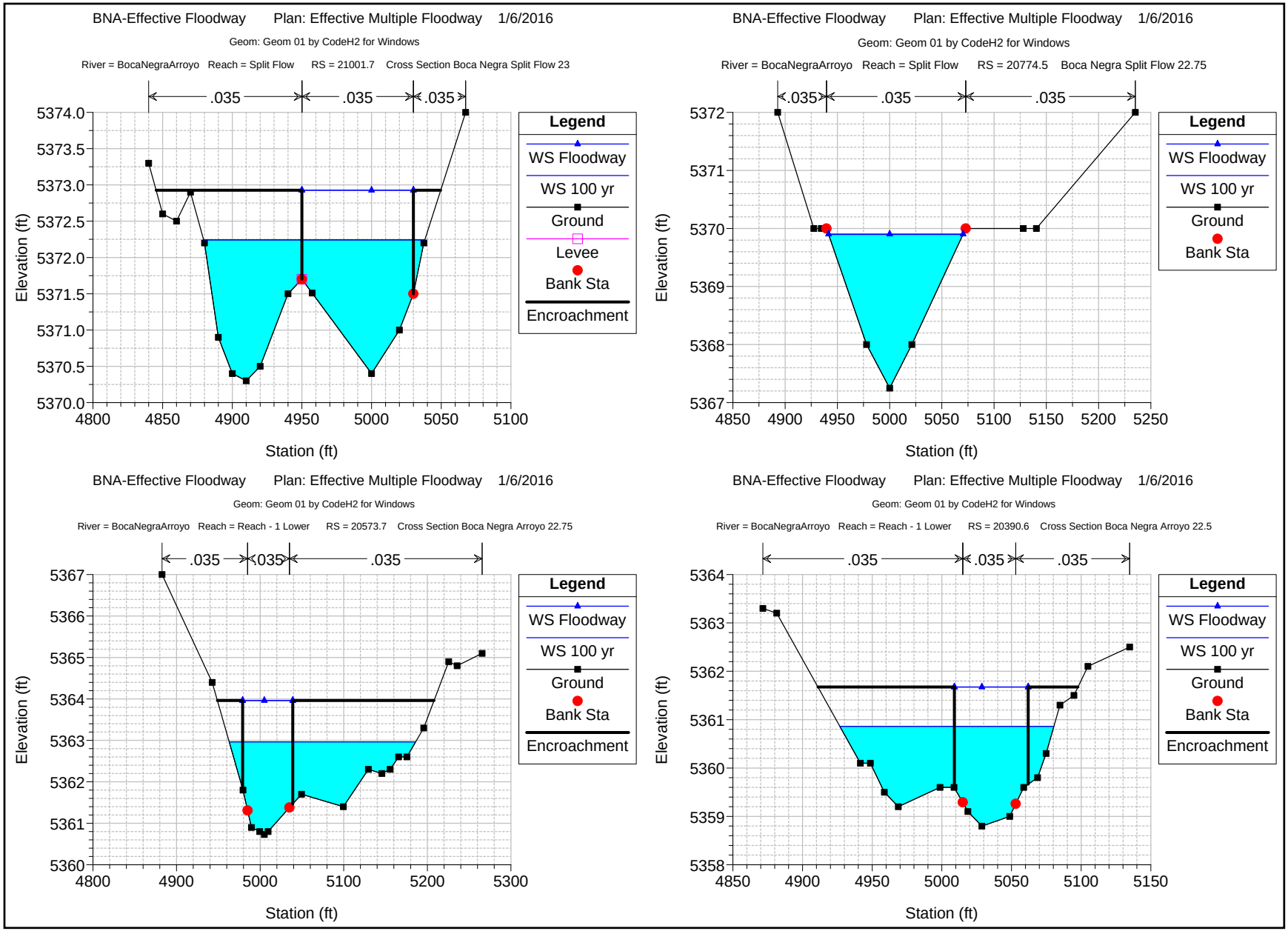
.035
Elevation (ft)
Station (ft)
Legend
WS Floodway
WS 100 yr
Ground
Bank Sta


BNA-Effective Floodway Plan: Effective Multiple Floodway 1/6/2016
Geom: Geom 01 by CodeH2 for Windows
River = BocaNegraArroyo Reach = Split Flow RS = 21001.7 Cross Section Boca Negra Split Flow 23
.035
.035
.035
Elevation (ft)
Station (ft)
Legend
WS Floodway
WS 100 yr
Ground
Levee
Bank Sta
Encroachment
BNA-Effective Floodway Plan: Effective Multiple Floodway 1/6/2016
Geom: Geom 01 by CodeH2 for Windows
River = BocaNegraArroyo Reach = Split Flow RS = 20774.5 Boca Negra Split Flow 22.75
.035
.035
.035
Elevation (ft)
Station (ft)
Legend
WS Floodway
WS 100 yr
Ground
Bank Sta
BNA-Effective Floodway Plan: Effective Multiple Floodway 1/6/2016
Geom: Geom 01 by CodeH2 for Windows
River = BocaNegraArroyo Reach = Reach - 1 Lower RS = 20573.7 Cross Section Boca Negra Arroyo 22.75
.035
.035
.035
Elevation (ft)
Station (ft)
Legend
WS Floodway
WS 100 yr
Ground
Bank Sta
Encroachment
BNA-Effective Floodway Plan: Effective Multiple Floodway 1/6/2016
Geom: Geom 01 by CodeH2 for Windows
River = BocaNegraArroyo Reach = Reach - 1 Lower RS = 20390.6 Cross Section Boca Negra Arroyo 22.5
.035
.035
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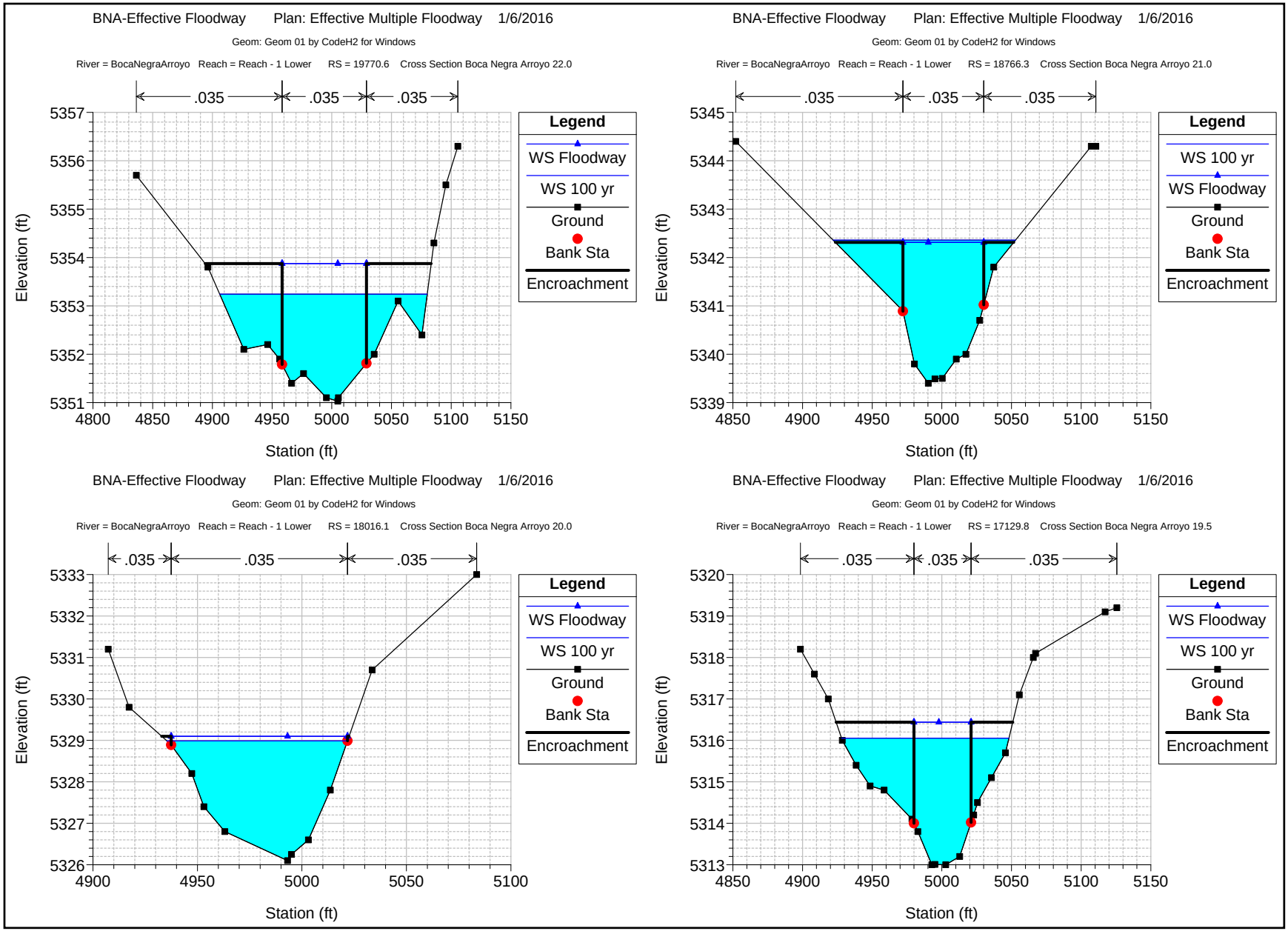
Elevation (ft)
Station (ft)
Legend
WS Floodway
WS 100 yr
Ground
Bank Sta
Encroachment


BNA-Effective Floodway Plan: Effective Multiple Floodway 1/6/2016
Geom: Geom 01 by CodeH2 for Windows
River = BocaNegraArroyo Reach = Reach - 1 Lower RS = 19770.6 Cross Section Boca Negra Arroyo 22.0
.035
.035
.035
Elevation (ft)
Station (ft)
Legend
WS Floodway
WS 100 yr
Ground
Bank Sta
Encroachment
BNA-Effective Floodway Plan: Effective Multiple Floodway 1/6/2016
Geom: Geom 01 by CodeH2 for Windows
River = BocaNegraArroyo Reach = Reach - 1 Lower RS = 18766.3 Cross Section Boca Negra Arroyo 21.0
.035
.035
.035
Elevation (ft)
Station (ft)
Legend
WS 100 yr
WS Floodway
Ground
Bank Sta
Encroachment
BNA-Effective Floodway Plan: Effective Multiple Floodway 1/6/2016
Geom: Geom 01 by CodeH2 for Windows
River = BocaNegraArroyo Reach = Reach - 1 Lower RS = 18016.1 Cross Section Boca Negra Arroyo 20.0
.035
.035
.035
Elevation (ft)
Station (ft)
Legend
WS Floodway
WS 100 yr
Ground
Bank Sta
Encroachment
BNA-Effective Floodway Plan: Effective Multiple Floodway 1/6/2016
Geom: Geom 01 by CodeH2 for Windows
River = BocaNegraArroyo Reach = Reach - 1 Lower RS = 17129.8 Cross Section Boca Negra Arroyo 19.5
.035
.035
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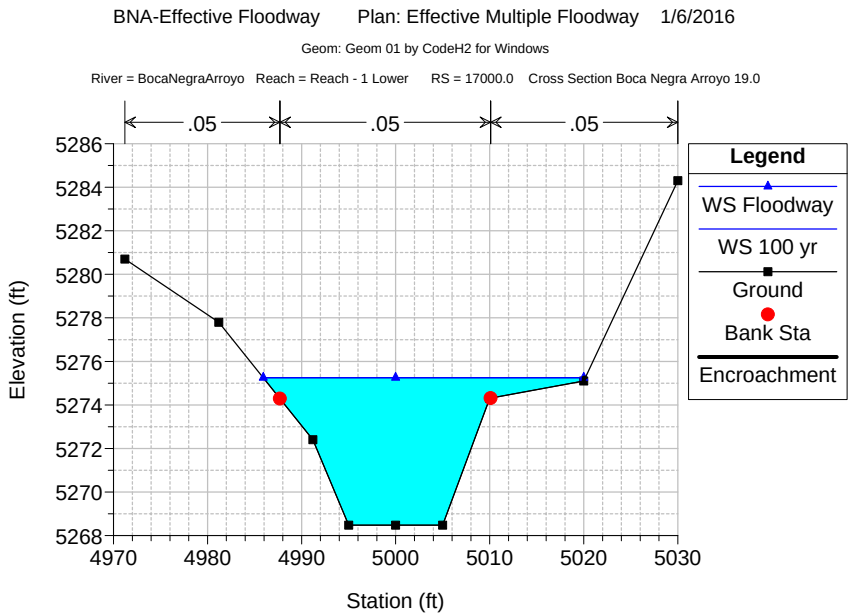
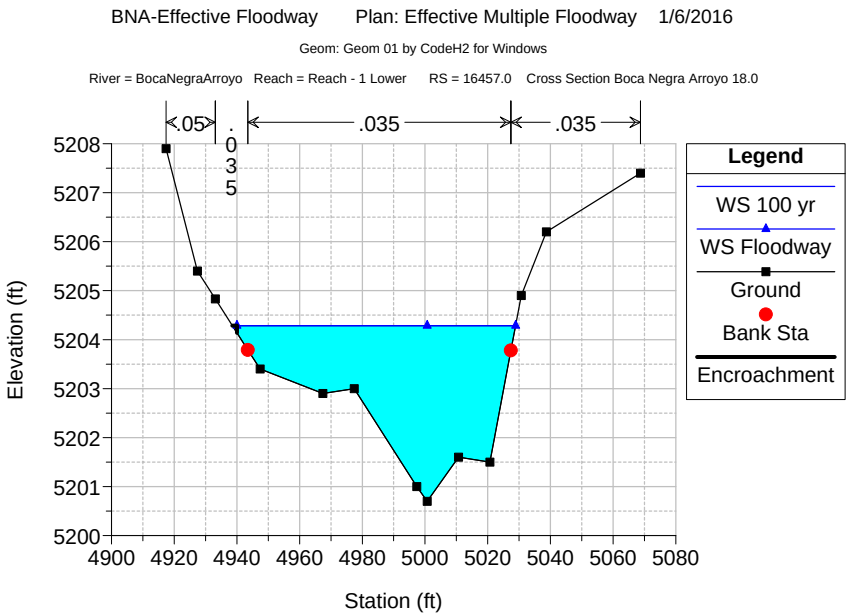
Elevation (ft)
Station (ft)
Legend
WS Floodway
WS 100 yr
Ground
Bank Sta
Encroachment


BNA-Effective Floodway Plan: Effective Multiple Floodway 1/6/2016
Geom: Geom 01 by CodeH2 for Windows
River = BocaNegraArroyo Reach = Reach - 1 Lower RS = 17000.0 Cross Section Boca Negra Arroyo 19.0
.05
.05
.05
Elevation (ft)
5286
5284
5282
5280
5278
5276
5274
5272
5270
5268
4970
4980
4990
5000
5010
5020
5030
Station (ft)
Legend
WS Floodway
WS 100 yr
Ground
Bank Sta
Encroachment


BNA-Effective Floodway Plan: Effective Multiple Floodway 1/6/2016
Geom: Geom 01 by CodeH2 for Windows
River = BocaNegraArroyo Reach = Reach - 1 Lower RS = 16457.0 Cross Section Boca Negra Arroyo 18.0
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.035
.035
Elevation (ft)
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5207
5206
5205
5204
5203
5202
5201
5200
4900
4920
4940
4960
4980
5000
5020
5040
5060
5080
Station (ft)
Legend
WS 100 yr
WS Floodway
Ground
Bank Sta
Encroachment

HEC-RAS Version 4.1.0 Jan 2010
U.S. Army Corps of Engineers
Hydrologic Engineering Center
609 Second Street
Davis, California

```
X     X  XXXXXX    XXXX        XXXX       XX      XXXX
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X     X  X        X            X  X     X    X        X
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PROJECT DATA
Project Title: BNA-Effective Floodway
Project File : BNA-EffectFloodway.prj
Run Date and Time: 1/6/2016 8:39:43 AM

Project in English units

PLAN DATA

Plan Title: Effective Multiple Floodway
Plan File : t:\Projects\x321807802\Eng\2012 Final Plans_Specifications_Estimate_Reports\2014 Final Construction Acceptance Reports\H&H\LOMR - RAS\BNA RAS FLOODWAY\BNA-EffectFloodway.p09

Geometry Title: Geom 01 by CodeH2 for Windows
Geometry File : t:\Projects\x321807802\Eng\2012 Final Plans_Specifications_Estimate_Reports\2014 Final Construction Acceptance Reports\H&H\LOMR - RAS\BNA RAS FLOODWAY\BNA-EffectFloodway.g01

Flow Title : Updated 2014 - Effective
Flow File : t:\Projects\x321807802\Eng\2012 Final Plans_Specifications_Estimate_Reports\2014 Final Construction Acceptance Reports\H&H\LOMR - RAS\BNA RAS FLOODWAY\BNA-EffectFloodway.f06

Plan Summary Information:
Number of: Cross Sections = 22 Multiple Openings = 0
Culverts = 0 Inline Structures = 0
Bridges = 0 Lateral Structures = 0

Computational Information
Water surface calculation tolerance = 0.01
Critical depth calculation tolerance = 0.01
Maximum number of iterations = 20
Maximum difference tolerance = 0.3
Flow tolerance factor = 0.001

Computation Options
Critical depth computed only where necessary
Conveyance Calculation Method: At breaks in n values only
Friction Slope Method: Average Conveyance
Computational Flow Regime: Subcritical Flow

Encroachment Data
Equal Conveyance = False
Left Offset = 0
Right Offset = 0

River = BocaNegraArroyo Reach = Reach - 1 Upper

RS	Profile	Method	Value1	Value2
25374.6	Floodway	1	4958	5052
24989.3	Floodway	1	4942	5033
24106.4	Floodway	1	4968	5030
23000.0	Floodway	1	4971.7	5054.7
22241.1	Floodway	1	4944.2	5015

River = BocaNegraArroyo Reach = Reach - 1 Mid

RS	Profile	Method	Value1	Value2
22027.5	Floodway	1	4970	5050
21845.5	Floodway	1	4970	5020
21335.5	Floodway	1	4904.44	5306.53
21001.7	Floodway	1	4968.6	5028.9

River = BocaNegraArroyo Reach = Split Flow

RS	Profile	Method	Value1	Value2
22027.5	Floodway	1	4951.1	5041.1
21845.5	Floodway	1	4941.3	5021.3
21335.5	Floodway	1	4910.65	5111.26
21001.7	Floodway	1	4950	5030
20774.5	Floodway	1	4939.64	5072.87

River = BocaNegraArroyo Reach = Reach - 1 Lower

RS	Profile	Method	Value1	Value2
20573.7	Floodway	1	4979	5039

```
20390.6 Floodway              1    5009    5062
19770.6 Floodway              1  4958.4    5029
18766.3 Floodway              1  4972.1  5030.1
18016.1 Floodway              1  4937.4  5021.8
17129.8 Floodway              1    4980    5021
17000.0 Floodway              1    4985    5020
16457.0 Floodway              1    4940    5030
```

FLOW DATA

Flow Title: Updated 2014 - Effective
Flow File : t:\Projects\x321807802\Eng\2012 Final Plans_Specifications_Estimate_Reports\2014 Final Construction Acceptance Reports\H&H\LOMR - RAS\BNA RAS FLOODWAY\BNA-EffectFloodway.f06

Flow Data (cfs)

River	Reach	RS	100 yr	Floodway
BocaNegraArroyo	Reach - 1 Upper	25374.6	1193	1193
BocaNegraArroyo	Reach - 1 Mid	22027.5	1215	1215
BocaNegraArroyo	Split Flow	22027.5	1215	1215
BocaNegraArroyo	Reach - 1 Lower	20573.7	1218	1218
BocaNegraArroyo	Reach - 1 Lower	17129.8	1298	1298

Boundary Conditions

River	Reach	Profile	Upstream	Downstream
BocaNegraArroyo	Reach - 1 Lower	100 yr		Normal S = 0.0283

GEOMETRY DATA

Geometry Title: Geom 01 by CodeH2 for Windows
Geometry File : t:\Projects\x321807802\Eng\2012 Final Plans_Specifications_Estimate_Reports\2014 Final Construction Acceptance Reports\H&H\LOMR - RAS\BNA RAS FLOODWAY\BNA-EffectFloodway.g01

Reach Connection Table

River	Reach	Upstream Boundary	Downstream Boundary
BocaNegraArroyo	Reach - 1 Upper		Junction 1
BocaNegraArroyo	Reach - 1 Mid	Junction 1	Junction 2
BocaNegraArroyo	Split Flow	Junction 1	Junction 2
BocaNegraArroyo	Reach - 1 Lower	Junction 2	

JUNCTION INFORMATION

Name: Junction 1
Description:
Energy computation Method

Length across Junction River	Reach		Tributary River	Reach	Length	Angle
BocaNegraArroyo	Reach - 1 Upper	to BocaNegraArroyo	Reach - 1 Mid		213.6	
BocaNegraArroyo	Reach - 1 Upper	to BocaNegraArroyo	Split Flow		173	

Name: Junction 2
Description:
Energy computation Method

Length across Junction River	Reach		Tributary River	Reach	Length	Angle
BocaNegraArroyo	Reach - 1 Mid	to BocaNegraArroyo	Reach - 1 Lower		428	
BocaNegraArroyo	Split Flow	to BocaNegraArroyo	Reach - 1 Lower		321	

CROSS SECTION

RIVER: BocaNegraArroyo
REACH: Reach - 1 Upper RS: 25374.6

INPUT
Description: Cross Section Boca Negra Arroyo 28.0
Station Elevation Data num= 16

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
4839	5439.4	4869	5437.8	4919	5437	4939	5437.3	4949	5436.8
4959	5435.9	4967.3	5434.82	4979	5433.3	4999	5433.5	5001.6	5433.6
5011.6	5433.5	5031.6	5433.7	5041.6	5434.4	5044.6	5434.85	5071.6	5438.9
5081.6	5440.1								

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
4839	.035	4967.3	.035	5044.6	.035

Bank Sta: Left Right Lengths: Left Channel Right Coeff Contr. Expan.
4967.3 5044.6 385.3 385.3 385.3 .1 .3

CROSS SECTION

RIVER: BocaNegraArroyo
REACH: Reach - 1 Upper RS: 24989.3

INPUT
Description: Cross Section Boca Negra Arroyo 27.0
Station Elevation Data num= 17

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
4764.7	5438.3	4784.7	5436.8	4934.7	5431.4	4944.7	5430.5	4954.7	5430
4967.5	5429.7	4987.5	5429.7	4987.6	5429.68	4997.5	5428.2	5005	5428.45
5007.5	5429.1	5015	5429.74	5023.9	5430.5	5033.9	5431.5	5043.9	5433.2
5073.9	5434.1	5083.9	5434.7						

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
4764.7	.035	4987.6	.035	5015	.035

Bank Sta: Left Right Lengths: Left Channel Right Coeff Contr. Expan.
4987.6 5015 882.9 882.9 882.9 .1 .3

CROSS SECTION

RIVER: BocaNegraArroyo
REACH: Reach - 1 Upper RS: 24106.4

INPUT
Description: Cross Section Boca Negra Arroyo 26.0
Station Elevation Data num= 14

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
4889.8	5425	4919.8	5424.2	4949.8	5421.8	4968.1	5421.3	4989.8	5420.7
4999.6	5420.7	5005	5420.73	5009.6	5420.6	5019.6	5420.9	5029.6	5421.5
5030	5421.54	5039.6	5422.5	5059.6	5424.9	5079.6	5426.3		

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
4889.8	.035	4968.1	.035	5030	.035

Bank Sta: Left Right Lengths: Left Channel Right Coeff Contr. Expan.
4968.1 5030 1106.4 1106.4 1106.4 .1 .3

CROSS SECTION

RIVER: BocaNegraArroyo
REACH: Reach - 1 Upper RS: 23000.0

INPUT
Description: Cross Section Boca Negra Arroyo 25.0
Station Elevation Data num= 22

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
4834.3	5413	4874.3	5411	4894.3	5411.1	4904.3	5410.8	4914.3	5411.1
4954.3	5409.8	4971.7	5408.64	4984.3	5407.8	4995	5407.37	5000	5407.37
5005	5407.37	5010	5407.8	5020	5408	5030	5408	5040	5407.7
5054.7	5408.58	5060	5408.9	5070	5409.1	5100	5408.7	5120	5410
5130	5409.9	5170	5413.5						

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
4834.3	.035	4971.7	.035	5054.7	.035

Bank Sta: Left Right Lengths: Left Channel Right Coeff Contr. Expan.
4971.7 5054.7 758.9 758.9 758.9 .1 .3

CROSS SECTION

RIVER: BocaNegraArroyo
REACH: Reach - 1 Upper RS: 22241.1

INPUT
Description: Cross Section Boca Negra Arroyo 24.0
Station Elevation Data num= 17

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
4820.81	5404	4874.8	5402.4	4884.8	5401.6	4894.8	5401.6	4934.9	5400
4944.2	5399.4	4954.9	5398.7	4994.9	5398.3	4995	5398.4	5004.9	5398.6
5014.9	5399.2	5015	5399.2	5034.9	5399.1	5043.3	5399.3	5063.3	5401.5
5113.3	5403.5	5123.3	5403.7						

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
4820.81	.035	4944.2	.035	5015	.035

Bank Sta: Left Right Lengths: Left Channel Right Coeff Contr. Expan.
4944.2 5015 0 0 0 .1 .3

CROSS SECTION

RIVER: BocaNegraArroyo
REACH: Reach - 1 Mid RS: 22027.5

INPUT
Description: Cross Section Boca Negra Arroyo 23.75
Station Elevation Data num= 18

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
4890.5	5401.7	4910.5	5399.2	4920.5	5398.3	4960.5	5397	4974.8	5396.19
4990.5	5395.3	4995	5394.86	5000.5	5394.9	5010.5	5394.9	5020.5	5395.4
5030.5	5395.7	5031.1	5395.7	5039.9	5396.27	5051.1	5397	5061.1	5397.3
5071.1	5399.2	5081.1	5400.7	5101.1	5401.3				

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
4890.5	.035	4974.8	.035	5039.9	.035

Bank Sta: Left	Right	Lengths: Left Channel	Channel	Right	Coeff Contr.	Expan.
4974.8	5039.9	182	182	182	.1	.3

CROSS SECTION

RIVER: BocaNegraArroyo
REACH: Reach - 1 Mid RS: 21845.5

INPUT
Description: Cross Section Boca Negra Arroyo 23.5
Station Elevation Data num= 13

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
4880.3	5397.6	4900.3	5396.1	4971.3	5391	4976.8	5390.62	4991.3	5389.6
4995	5389.14	5001.3	5389	5011.3	5390.6	5015	5390.69	5031.3	5391.1
5041.3	5392.3	5071.3	5394.6	5161.3	5397.6				

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
4880.3	.035	4976.8	.035	5015	.035

Bank Sta: Left	Right	Lengths: Left Channel	Channel	Right	Coeff Contr.	Expan.
4976.8	5015	510	510	510	.1	.3

CROSS SECTION

RIVER: BocaNegraArroyo
REACH: Reach - 1 Mid RS: 21335.5

INPUT
Description: Cross Section Boca Negra Arroyo 23.25
Station Elevation Data num= 13

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
4904.44	5382	4948.86	5380	4997.39	5378	5027.42	5376	5073.36	5374
5111.31	5372	5124.36	5374	5167.63	5376	5179.1	5378	5202.04	5380
5231.06	5382	5293.41	5384	5306.53	5385				

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
4904.44	.035	4997.39	.035	5179.1	.035

Bank Sta: Left	Right	Lengths: Left Channel	Channel	Right	Coeff Contr.	Expan.
4997.39	5179.1	333.8	333.8	333.8	.1	.3

CROSS SECTION

RIVER: BocaNegraArroyo
REACH: Reach - 1 Mid RS: 21001.7

INPUT
Description: Cross Section Boca Negra Arroyo 23.0
Station Elevation Data num= 24

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
4883.3	5374.8	4933.3	5371	4943.3	5369.9	4950	5369.5	4960	5368.7
4968.6	5367.41	4980	5365.7	4990	5365.6	4995	5365.4	5000	5365.4
5005	5365.4	5010	5365.5	5020	5366.3	5028.9	5367.41	5040	5368.8
5050	5369.5	5080	5369.2	5100	5368.2	5120	5367.8	5130	5368
5140	5367.9	5160	5368.4	5180	5369.6	5270	5373.3		

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
4883.3	.035	4968.6	.035	5028.9	.035

Bank Sta: Left	Right	Lengths: Left Channel	Channel	Right	Coeff Contr.	Expan.
4968.6	5028.9	0	0	0	.1	.3

Ineffective Flow num= 1

Sta L	Sta R	Elev	Permanent
5080	5270	5369.5	F

CROSS SECTION

```
RIVER: BocaNegraArroyo
REACH: Split Flow         RS: 22027.5

INPUT
Description: Cross Section Boca Negra Split Flow 23.75
Station Elevation Data    num=      10
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
  4931.1  5401.6  4941.1    5401  4951.1  5400.4  4971.1  5398.4  4981.1  5398.2
  5001.1  5396.8  5011.1  5397.2  5041.1  5399.8  5071.1  5403.2  5080.6  5403.7

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
  4931.1    .035  4951.1    .035  5041.1    .035

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
        4951.1  5041.1              146     146     146             .1       .3

CROSS SECTION


RIVER: BocaNegraArroyo
REACH: Split Flow         RS: 21845.5

INPUT
Description: Cross Section Boca Negra Split Flow 23.5
Station Elevation Data    num=      13
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
  4801.3  5397.6  4841.3  5396.9  4881.3  5396.3  4891.3  5396.8  4921.3  5398.9
  4941.3  5396.8  4971.3  5395.6  4991.3  5393.7  5001.3  5393.6  5011.3  5394.9
  5021.3  5397.2  5031.3    5399  5069.3  5401.9

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
  4801.3    .035  4941.3    .035  5021.3    .035

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
        4941.3  5021.3              628     628     628             .1       .3
Left Levee      Station=  4921.3      Elevation=  5398.9

CROSS SECTION


RIVER: BocaNegraArroyo
REACH: Split Flow         RS: 21335.5

INPUT
Description: Cross Section Boca Negra Split Flow 23.25
Station Elevation Data    num=       6
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
 4904.44    5385 4910.65    5384 4988.57    5382 5011.44    5382 5111.26    5384
 5357.11    5386

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
 4904.44    .035 4910.65    .035 5111.26    .035

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
       4910.65 5111.26              683     683     683             .1       .3

CROSS SECTION


RIVER: BocaNegraArroyo
REACH: Split Flow         RS: 21001.7

INPUT
Description: Cross Section Boca Negra Split Flow 23
Station Elevation Data    num=      17
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
    4840  5373.3    4850  5372.6    4860  5372.5    4870  5372.9    4880  5372.2
    4890  5370.9    4900  5370.4    4910  5370.3    4920  5370.5    4940  5371.5
    4950  5371.7 4957.32 5371.51    5000  5370.4    5020    5371    5030  5371.5
  5037.5  5372.2  5067.5    5374

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
    4840    .035    4950    .035    5030    .035

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
         4950    5030              130     130     130             .1       .3
Left Levee      Station=    4950      Elevation=  5371.7

CROSS SECTION


RIVER: BocaNegraArroyo
REACH: Split Flow         RS: 20774.5

INPUT
```

```
Description: Boca Negra Split Flow 22.75
Station Elevation Data    num=      11
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
 4892.85    5372 4927.47    5370 4934.65    5370 4939.64    5370 4977.96    5368
    5000 5367.25  5021.3    5368 5072.87    5370  5127.9    5370 5140.39    5370
 5235.19    5372

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
 4892.85    .035 4939.64    .035 5072.87    .035

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
       4939.64 5072.87                0       0       0             .1      .3

CROSS SECTION


RIVER: BocaNegraArroyo
REACH: Reach - 1 Lower    RS: 20573.7

INPUT
Description: Cross Section Boca Negra Arroyo 22.75
Station Elevation Data    num=      20
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
  4882.6    5367  4942.6  5364.4  4979.5  5361.8    4985 5361.31  4989.5  5360.9
  4999.5  5360.8    5005 5360.73  5009.5  5360.8  5035.1 5361.38  5049.5  5361.7
  5099.5  5361.4  5129.5  5362.3  5145.6  5362.2  5155.6  5362.3  5165.6  5362.6
  5175.6  5362.6  5195.6  5363.3  5225.6  5364.9  5235.6  5364.8  5265.6  5365.1

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
  4882.6    .035    4985    .035  5035.1    .035

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
          4985  5035.1            183.1   183.1   183.1             .1      .3

CROSS SECTION


RIVER: BocaNegraArroyo
REACH: Reach - 1 Lower    RS: 20390.6

INPUT
Description: Cross Section Boca Negra Arroyo 22.5
Station Elevation Data    num=      20
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
  4871.5  5363.3  4881.5  5363.2  4941.5  5360.1  4948.7  5360.1  4958.7  5359.5
  4968.7  5359.2  4998.7  5359.6  5008.7  5359.6    5015 5359.29  5018.7  5359.1
  5028.7  5358.8  5048.7    5359    5053 5359.26  5058.7  5359.6  5068.7  5359.8
  5074.8  5360.3  5084.8  5361.3  5094.8  5361.5  5104.8  5362.1  5134.8  5362.5

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
  4871.5    .035    5015    .035    5053    .035

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
          5015    5053             620     620     620             .1      .3

CROSS SECTION


RIVER: BocaNegraArroyo
REACH: Reach - 1 Lower    RS: 19770.6

INPUT
Description: Cross Section Boca Negra Arroyo 22.0
Station Elevation Data    num=      18
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
  4836.3  5355.7  4896.3  5353.8  4926.3  5352.1  4946.3  5352.2  4956.3  5351.9
  4958.4 5351.79  4966.3  5351.4  4976.3  5351.6  4995.5  5351.1    5005 5351.03
  5005.5  5351.1    5029 5351.81  5035.5    5352  5055.5  5353.1  5075.5  5352.4
  5085.5  5354.3  5095.5  5355.5  5105.5  5356.3

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
  4836.3    .035  4958.4    .035    5029    .035

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
        4958.4    5029           1004.3  1004.3  1004.3             .1      .3

CROSS SECTION


RIVER: BocaNegraArroyo
REACH: Reach - 1 Lower    RS: 18766.3

INPUT
Description: Cross Section Boca Negra Arroyo 21.0
Station Elevation Data    num=      14
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
    4852  5344.4    4972  5340.9  4972.1 5340.89  4980.3  5339.8  4990.3  5339.4
```

```
    4995 5339.49  5000.3  5339.5  5010.3  5339.9  5017.2    5340  5027.2  5340.7
  5030.1 5341.02  5037.2  5341.8  5107.2  5344.3  5110.5  5344.3

Manning's n Values        num=       4
     Sta   n Val     Sta   n Val     Sta   n Val     Sta   n Val
    4852    .035  4972.1    .035  5030.1    .035  5110.5      .2

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
        4972.1  5030.1            750.2   750.2   750.2             .1       .3

CROSS SECTION


RIVER: BocaNegraArroyo
REACH: Reach - 1 Lower    RS: 18016.1

INPUT
Description: Cross Section Boca Negra Arroyo 20.0
Station Elevation Data    num=      14
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
  4907.3  5331.2  4917.3  5329.8  4937.3  5328.9  4937.4 5328.89  4947.3  5328.2
  4953.1  5327.4  4963.1  5326.8  4993.1  5326.1    4995 5326.25  5003.1  5326.6
  5013.6  5327.8  5021.8 5328.99  5033.6  5330.7  5083.6    5333

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
  4907.3    .035  4937.4    .035  5021.8    .035

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
        4937.4  5021.8            886.3   886.3   886.3             .1       .3

CROSS SECTION


RIVER: BocaNegraArroyo
REACH: Reach - 1 Lower    RS: 17129.8

INPUT
Description: Cross Section Boca Negra Arroyo 19.5
Station Elevation Data    num=      24
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
  4898.5  5318.2  4908.5  5317.6  4918.5    5317  4928.5    5316  4938.5  5315.4
  4948.5  5314.9  4958.5  5314.8  4978.5  5314.1    4980    5314  4982.8  5313.8
  4992.8    5313    4995 5313.01  5002.8    5313  5012.8  5313.2    5021 5314.02
  5022.8  5314.2  5025.6  5314.5  5035.6  5315.1  5045.6  5315.7  5055.6  5317.1
  5065.6    5318  5067.2  5318.1  5117.2  5319.1  5125.6  5319.2

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
  4898.5    .035    4980    .035    5021    .035

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
          4980    5021            129.8   129.8   129.8             .1       .3

CROSS SECTION


RIVER: BocaNegraArroyo
REACH: Reach - 1 Lower    RS: 17000.0

INPUT
Description: Cross Section Boca Negra Arroyo 19.0
Station Elevation Data    num=      11
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
  4971.2  5280.7  4981.2  5277.8  4987.7 5274.29  4991.2  5272.4    4995 5268.48
    5000 5268.48    5005 5268.48    5010  5274.3  5010.1 5274.31    5020  5275.1
    5030  5284.3

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
  4971.2     .05  4987.7     .05  5010.1     .05

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
        4987.7  5010.1              543     543     543             .1       .3

CROSS SECTION


RIVER: BocaNegraArroyo
REACH: Reach - 1 Lower    RS: 16457.0

INPUT
Description: Cross Section Boca Negra Arroyo 18.0
Station Elevation Data    num=      15
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
  4917.4  5207.9  4927.4  5205.4  4933.1 5204.83  4943.5 5203.79  4947.4  5203.4
  4967.4  5202.9  4977.4    5203  4997.4    5201  5000.7  5200.7  5010.7  5201.6
  5020.7  5201.5  5027.4 5203.78  5030.7  5204.9  5038.7  5206.2  5068.7  5207.4

Manning's n Values        num=       4
     Sta   n Val     Sta   n Val     Sta   n Val     Sta   n Val
```

4917.4	.05	4933.1	.035	4943.5	.035	5027.4	.035

Bank Sta: Left	Right	Lengths: Left Channel	Right	Coeff Contr.	Expan.
4943.5	5027.4	0	0	.1	.3

SUMMARY OF MANNING'S N VALUES

River:BocaNegraArroyo

Reach	River Sta.	n1	n2	n3	n4
Reach - 1 Upper	25374.6	.035	.035	.035	
Reach - 1 Upper	24989.3	.035	.035	.035	
Reach - 1 Upper	24106.4	.035	.035	.035	
Reach - 1 Upper	23000.0	.035	.035	.035	
Reach - 1 Upper	22241.1	.035	.035	.035	
Reach - 1 Mid	22027.5	.035	.035	.035	
Reach - 1 Mid	21845.5	.035	.035	.035	
Reach - 1 Mid	21335.5	.035	.035	.035	
Reach - 1 Mid	21001.7	.035	.035	.035	
Split Flow	22027.5	.035	.035	.035	
Split Flow	21845.5	.035	.035	.035	
Split Flow	21335.5	.035	.035	.035	
Split Flow	21001.7	.035	.035	.035	
Split Flow	20774.5	.035	.035	.035	
Reach - 1 Lower	20573.7	.035	.035	.035	
Reach - 1 Lower	20390.6	.035	.035	.035	
Reach - 1 Lower	19770.6	.035	.035	.035	
Reach - 1 Lower	18766.3	.035	.035	.035	.2
Reach - 1 Lower	18016.1	.035	.035	.035	
Reach - 1 Lower	17129.8	.035	.035	.035	
Reach - 1 Lower	17000.0	.05	.05	.05	
Reach - 1 Lower	16457.0	.05	.035	.035	.035

SUMMARY OF REACH LENGTHS

River: BocaNegraArroyo

Reach	River Sta.	Left	Channel	Right
Reach - 1 Upper	25374.6	385.3	385.3	385.3
Reach - 1 Upper	24989.3	882.9	882.9	882.9
Reach - 1 Upper	24106.4	1106.4	1106.4	1106.4
Reach - 1 Upper	23000.0	758.9	758.9	758.9
Reach - 1 Upper	22241.1	0	0	0
Reach - 1 Mid	22027.5	182	182	182
Reach - 1 Mid	21845.5	510	510	510
Reach - 1 Mid	21335.5	333.8	333.8	333.8
Reach - 1 Mid	21001.7	0	0	0
Split Flow	22027.5	146	146	146
Split Flow	21845.5	628	628	628
Split Flow	21335.5	683	683	683
Split Flow	21001.7	130	130	130
Split Flow	20774.5	0	0	0
Reach - 1 Lower	20573.7	183.1	183.1	183.1
Reach - 1 Lower	20390.6	620	620	620
Reach - 1 Lower	19770.6	1004.3	1004.3	1004.3
Reach - 1 Lower	18766.3	750.2	750.2	750.2
Reach - 1 Lower	18016.1	886.3	886.3	886.3
Reach - 1 Lower	17129.8	129.8	129.8	129.8
Reach - 1 Lower	17000.0	543	543	543
Reach - 1 Lower	16457.0	0	0	0

SUMMARY OF CONTRACTION AND EXPANSION COEFFICIENTS
River: BocaNegraArroyo

Reach	River Sta.	Contr.	Expan.
Reach - 1 Upper	25374.6	.1	.3
Reach - 1 Upper	24989.3	.1	.3
Reach - 1 Upper	24106.4	.1	.3
Reach - 1 Upper	23000.0	.1	.3
Reach - 1 Upper	22241.1	.1	.3
Reach - 1 Mid	22027.5	.1	.3
Reach - 1 Mid	21845.5	.1	.3
Reach - 1 Mid	21335.5	.1	.3
Reach - 1 Mid	21001.7	.1	.3
Split Flow	22027.5	.1	.3
Split Flow	21845.5	.1	.3
Split Flow	21335.5	.1	.3
Split Flow	21001.7	.1	.3
Split Flow	20774.5	.1	.3

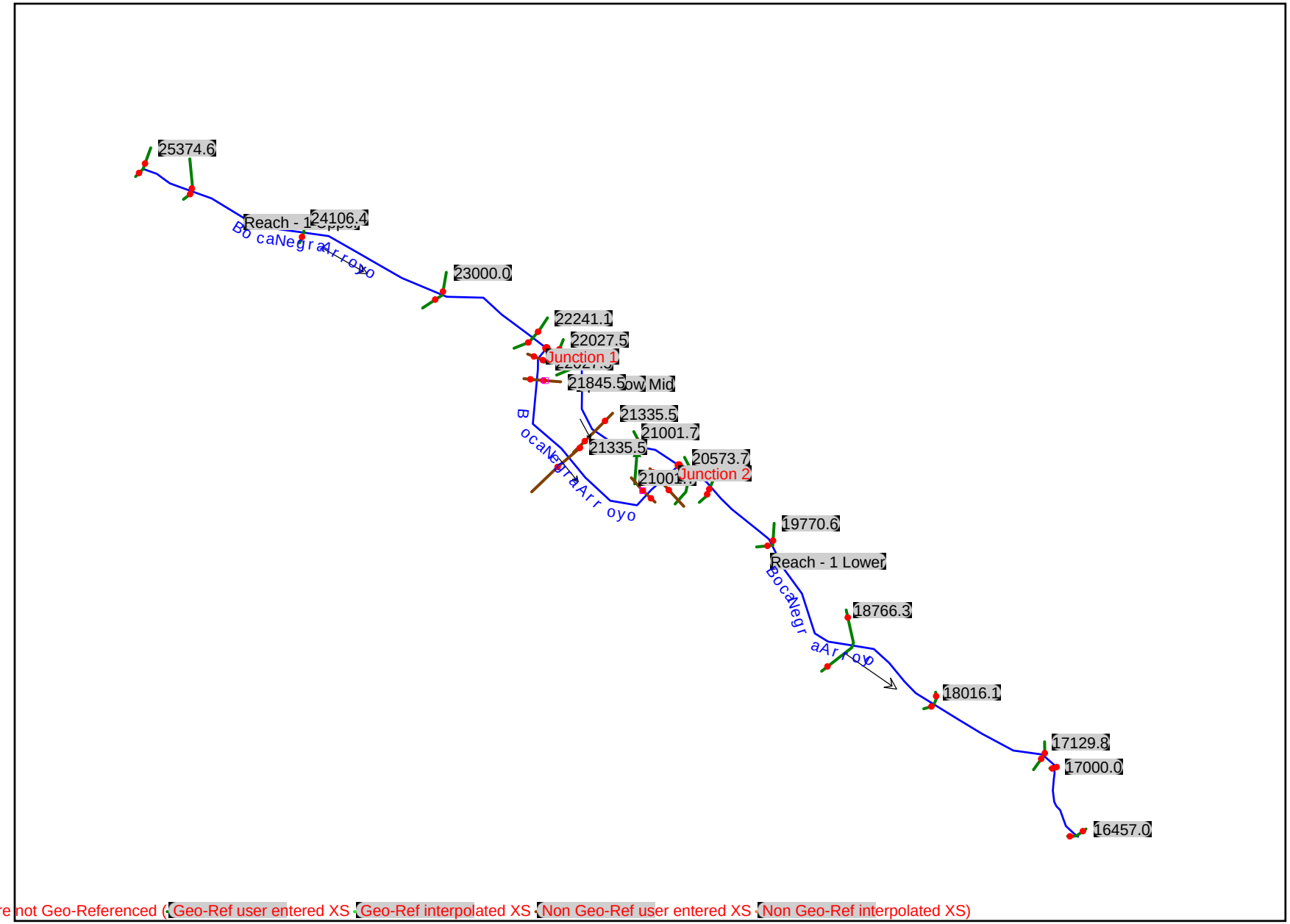
Reach - 1 Lower	20573.7	.1	.3
Reach - 1 Lower	20390.6	.1	.3
Reach - 1 Lower	19770.6	.1	.3
Reach - 1 Lower	18766.3	.1	.3
Reach - 1 Lower	18016.1	.1	.3
Reach - 1 Lower	17129.8	.1	.3
Reach - 1 Lower	17000.0	.1	.3
Reach - 1 Lower	16457.0	.1	.3

Duplicate Effective Floodway Model

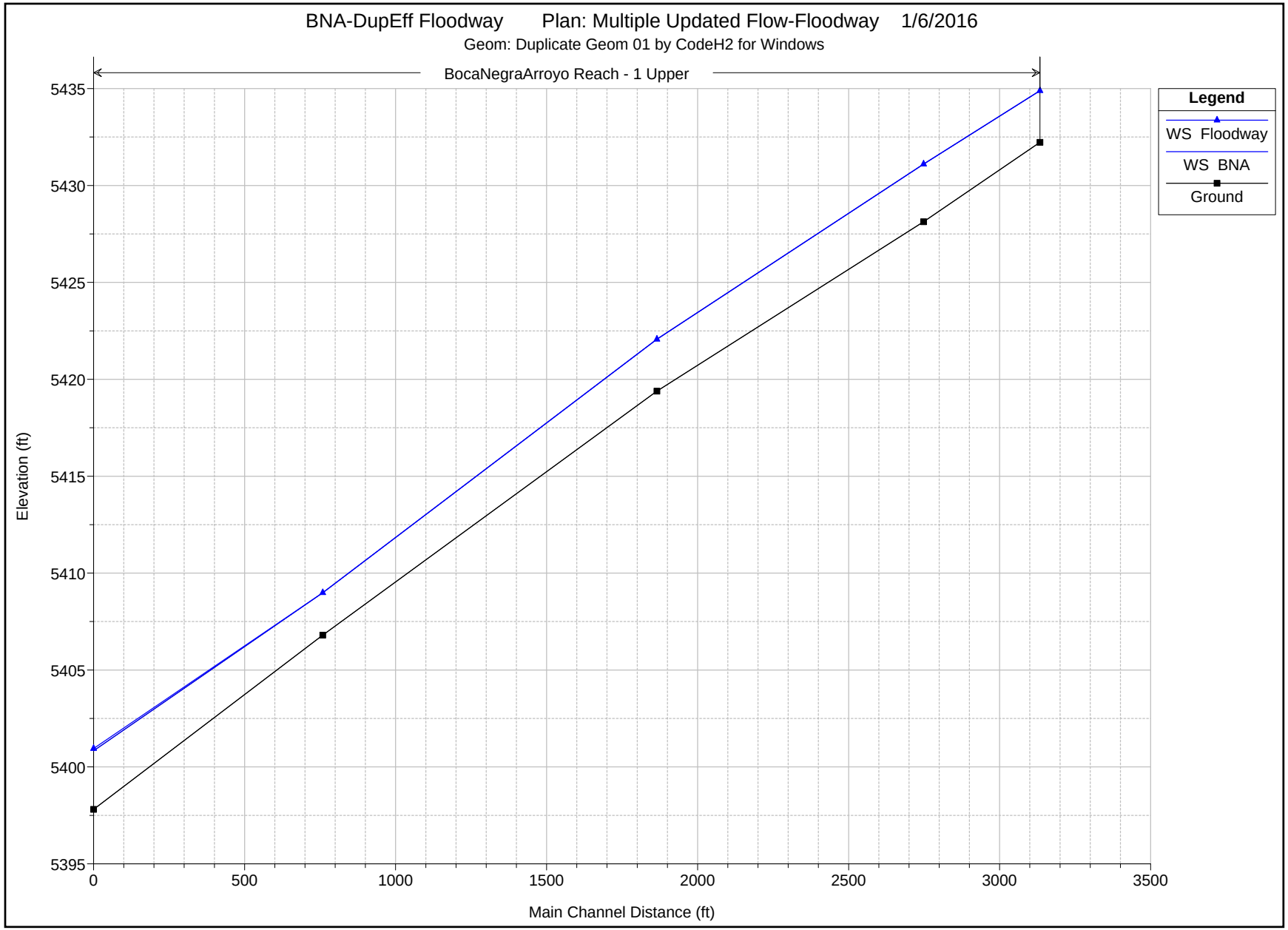
Plan
Profile
Summary
Cross Sections
Input/output Report

Hydraulics Model – HEC-RAS Analysis (CD)
FEMA Duplicate Effective Floodway Files

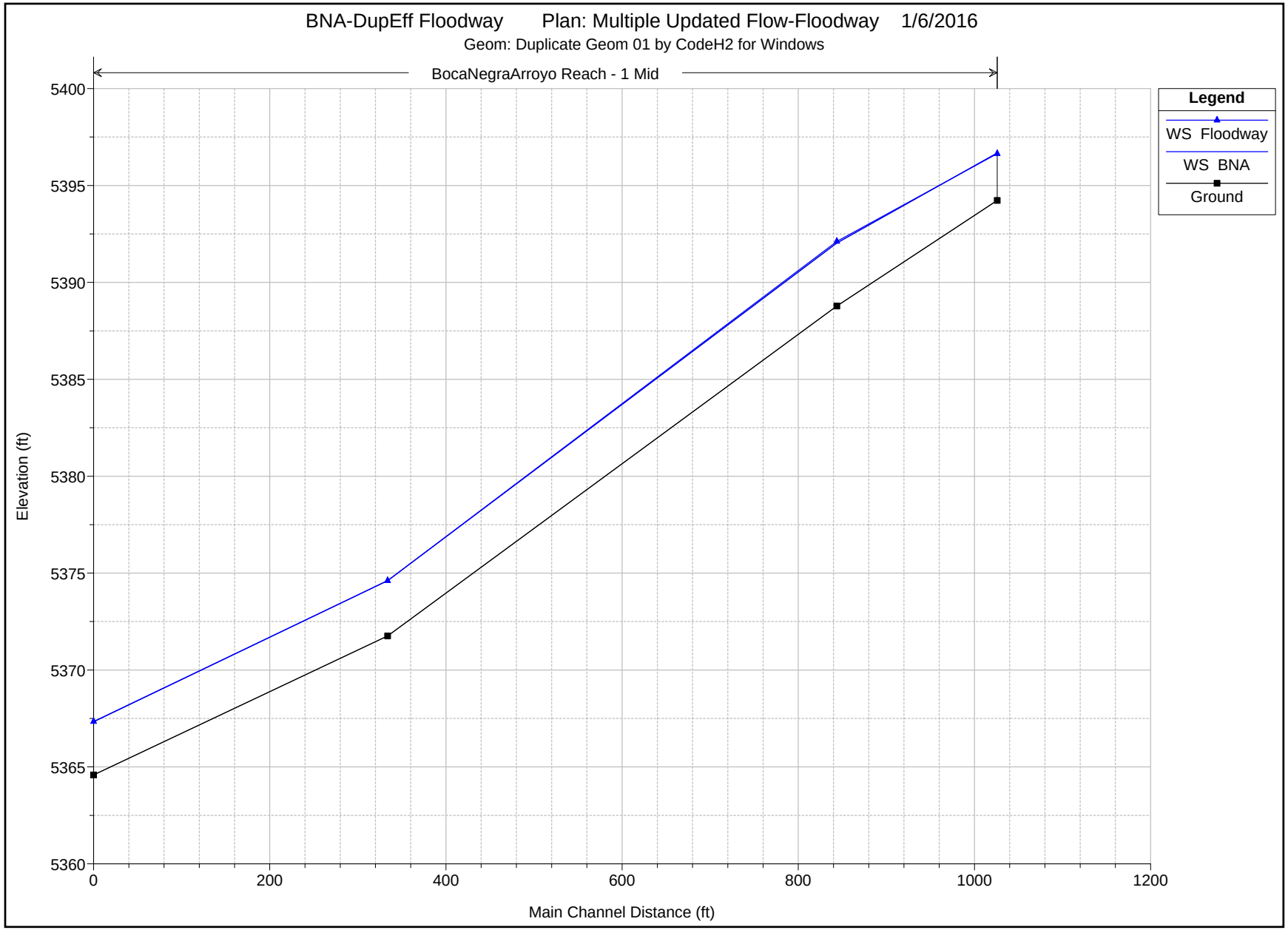
i.Project:	BNA- DupEff Floodway	DupEffFloodway.prj
ii.Plan:	Multiple Updated Flow-Floodway	DupEffFloodway.p09
iii.Geometry:	Duplicate Geom 01 by CodeH2 for windows	DupEffFloodway.g04
iv.Flow:	Updated 2014	DupEffFloodway.f01



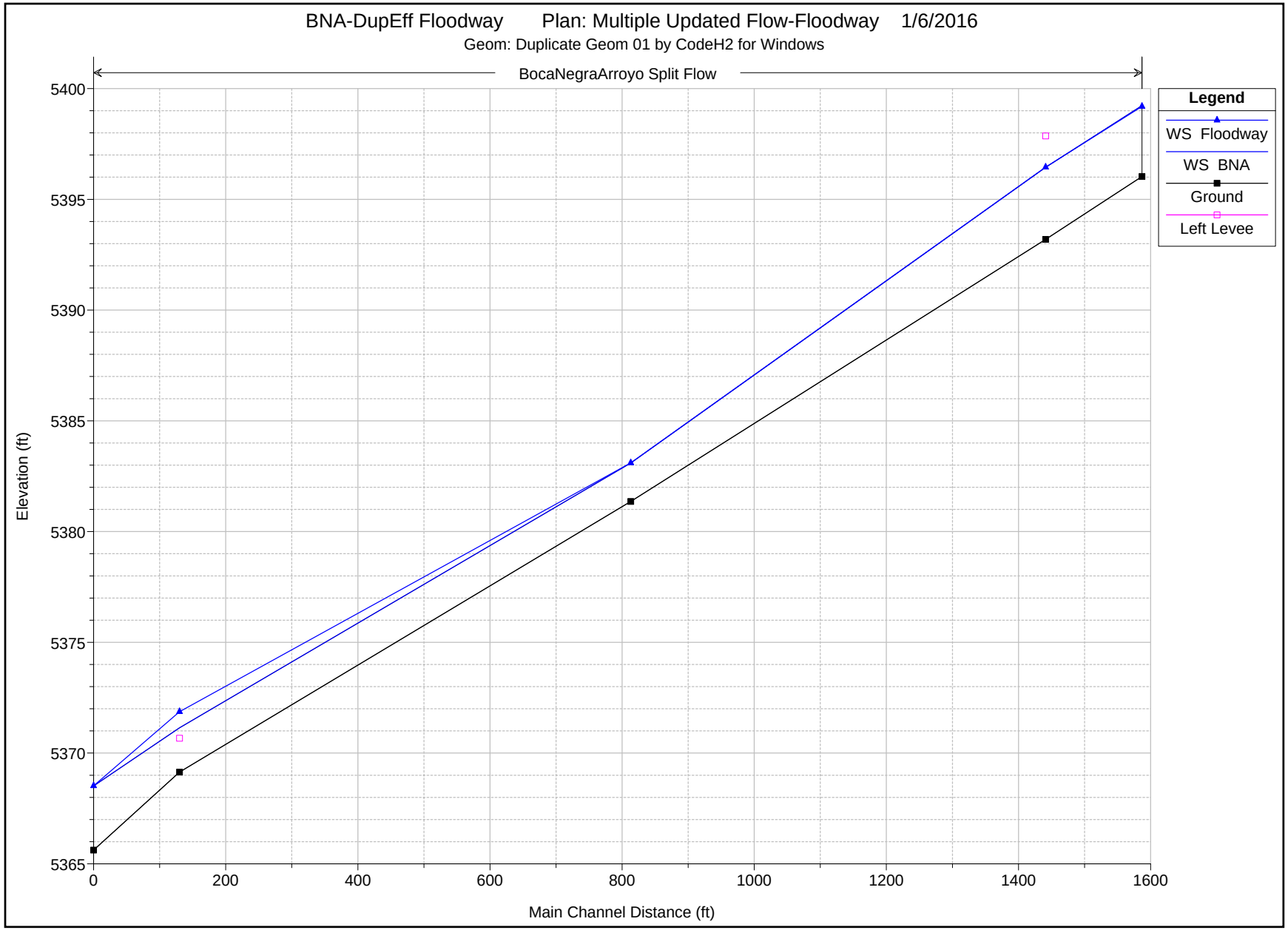
Duplicate Effective Floodway



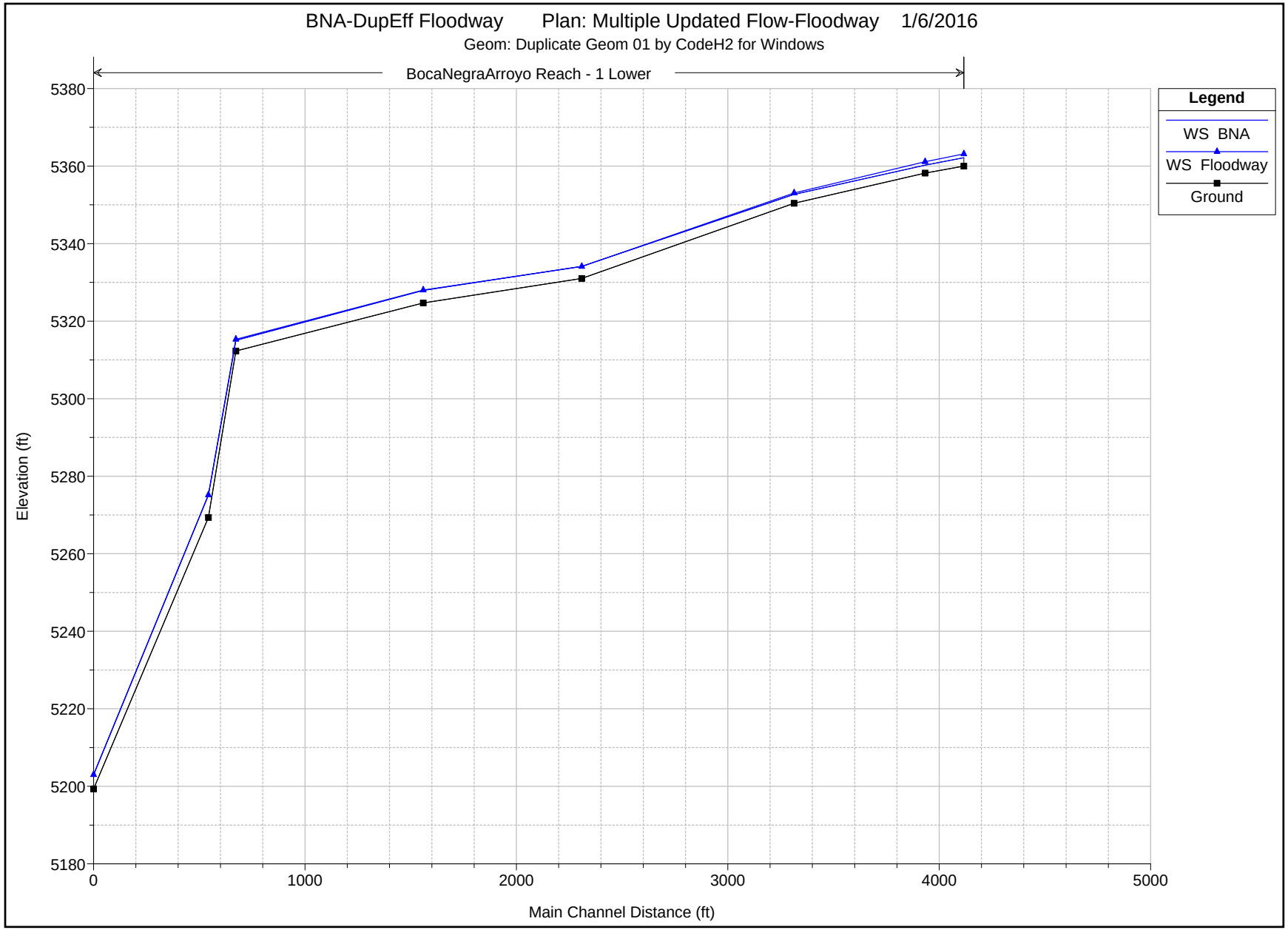
Duplicate Effective Floodway



Duplicate Effective Floodway



Duplicate Effective Floodway



Duplicate Effective Floodway

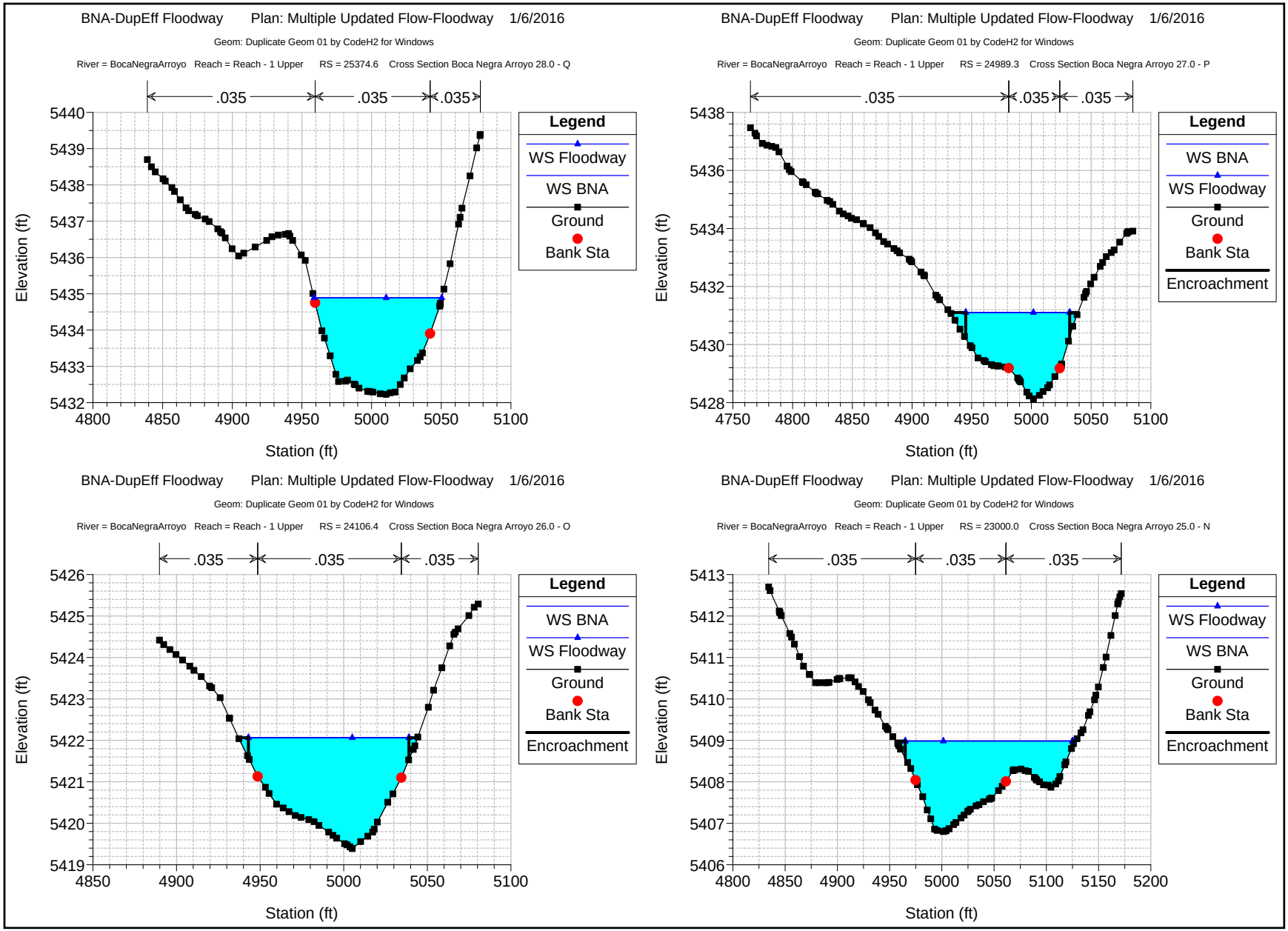
HEC-RAS Plan: FW

Reach	River Sta	Profile	W.S. Elev	Prof Delta WS	E.G. Elev	Top Wdth Act	Q Left	Q Channel	Q Right	Enc Sta L	Ch Sta L	Ch Sta R	Enc Sta R
			(ft)	(ft)	(ft)	(ft)	(cfs)	(cfs)	(cfs)	(ft)	(ft)	(ft)	(ft)
Reach - 1 Upper	25374.6	BNA	5434.89		5435.63	91.71	0.04	1181.01	11.95		4959.52	5042.01	
Reach - 1 Upper	25374.6	Floodway	5434.89	0.00	5435.63	91.72	0.04	1180.99	11.96	4955.00	4959.52	5042.01	5052.00
Reach - 1 Upper	24989.3	BNA	5431.11		5431.84	106.99	318.41	816.44	58.15		4980.99	5023.67	
Reach - 1 Upper	24989.3	Floodway	5431.10	0.00	5431.86	87.00	325.58	810.19	57.23	4945.00	4980.99	5023.67	5032.00
Reach - 1 Upper	24106.4	BNA	5422.07		5422.80	107.19	14.56	1164.83	13.61		4948.54	5034.40	
Reach - 1 Upper	24106.4	Floodway	5422.07	0.00	5422.81	96.00	13.25	1168.07	11.68	4943.00	4948.54	5034.40	5039.00
Reach - 1 Upper	23000.0	BNA	5408.99		5409.60	171.81	23.36	960.16	209.48		4974.92	5061.35	
Reach - 1 Upper	23000.0	Floodway	5408.99	0.00	5409.60	160.00	23.36	956.16	213.48	4965.00	4974.92	5061.35	5125.00
Reach - 1 Upper	22241.1	BNA	5400.83		5401.06	162.42	41.14	1119.64	32.22		4942.34	5048.02	
Reach - 1 Upper	22241.1	Floodway	5400.95	0.12	5401.18	115.00	7.75	1157.05	28.19	4940.00	4942.34	5048.02	5055.00
Reach - 1 Mid	22027.5	BNA	5396.68		5397.48	117.31	14.37	1198.77	1.86		4967.55	5062.32	
Reach - 1 Mid	22027.5	Floodway	5396.64	-0.04	5397.51	94.77		1215.00		4967.55	4967.55	5062.32	5062.32
Reach - 1 Mid	21845.5	BNA	5392.03		5392.98	93.65	83.97	1040.44	90.59		4975.28	5023.67	
Reach - 1 Mid	21845.5	Floodway	5392.12	0.09	5393.47	48.39		1215.00		4975.28	4975.28	5023.67	5023.67
Reach - 1 Mid	21335.5	BNA	5374.61		5375.32	126.88		1215.00			4982.78	5189.42	
Reach - 1 Mid	21335.5	Floodway	5374.61	0.00	5375.32	126.94		1215.00		4982.78	4982.78	5189.42	5189.42
Reach - 1 Mid	21001.7	BNA	5367.33		5368.34	75.26		1214.78	0.22		4964.29	5038.83	
Reach - 1 Mid	21001.7	Floodway	5367.34	0.01	5368.34	73.82		1215.00		4964.29	4964.29	5038.83	5038.83
Split Flow	22027.5	BNA	5399.23		5400.21	92.10	25.38	1169.72	19.90		4944.75	5008.76	
Split Flow	22027.5	Floodway	5399.20	-0.03	5400.32	64.01		1215.00		4944.75	4944.75	5008.76	5008.76
Split Flow	21845.5	BNA	5396.45		5397.40	79.60		1215.00			4917.38	5004.75	
Split Flow	21845.5	Floodway	5396.45	0.01	5397.40	79.69		1215.00		4917.38	4917.38	5004.75	5004.75
Split Flow	21335.5	BNA	5383.09		5383.65	184.61		1215.00			4919.15	5115.19	
Split Flow	21335.5	Floodway	5383.10	0.00	5383.65	184.79		1215.00		4919.15	4919.15	5115.19	5115.19
Split Flow	21001.7	BNA	5371.14		5371.74	162.66	582.86	626.76	5.37		4956.44	5031.38	
Split Flow	21001.7	Floodway	5371.87	0.73	5372.86	74.94		1215.00		4956.44	4956.44	5031.38	5031.38
Split Flow	20774.5	BNA	5368.52		5369.29	113.22		1215.00			4925.19	5084.41	
Split Flow	20774.5	Floodway	5368.52	0.00	5369.29	113.26		1215.00		4925.19	4925.19	5084.41	5084.41
Reach - 1 Lower	20573.7	BNA	5362.16		5362.59	221.76	56.15	710.02	451.83		4990.78	5049.79	
Reach - 1 Lower	20573.7	Floodway	5363.16	1.00	5363.93	59.01		1218.00		4990.78	4990.78	5049.79	5049.79
Reach - 1 Lower	20390.6	BNA	5360.25		5360.77	163.00	621.49	499.69	96.82		5020.10	5060.56	

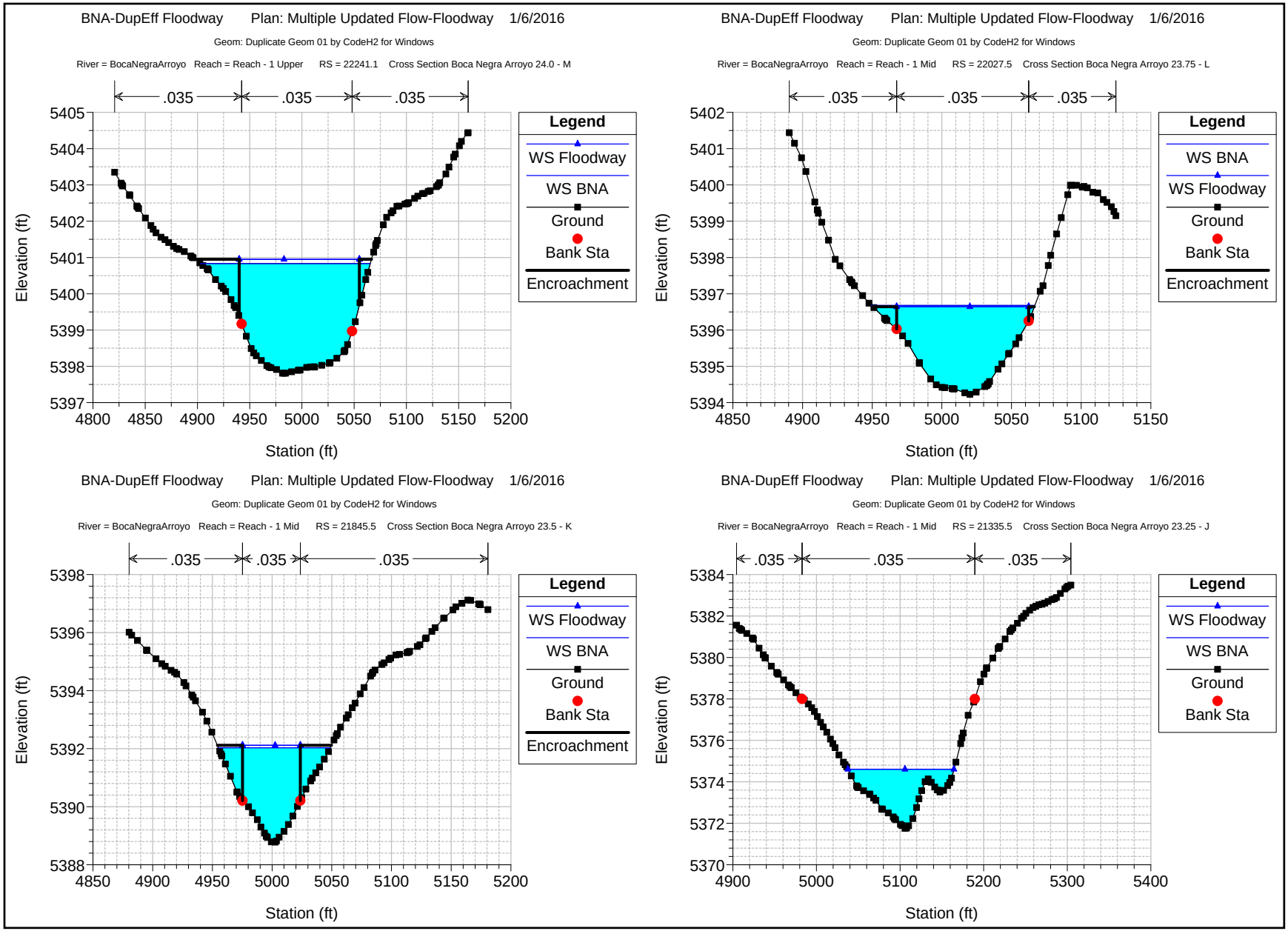
Duplicate Effective Floodway

HEC-RAS Plan: FW (Continued)

Reach	River Sta	Profile	W.S. Elev	Prof Delta WS	E.G. Elev	Top Wdth Act	Q Left	Q Channel	Q Right	Enc Sta L	Ch Sta L	Ch Sta R	Enc Sta R
			(ft)	(ft)	(ft)	(ft)	(cfs)	(cfs)	(cfs)	(ft)	(ft)	(ft)	(ft)
Reach - 1 Lower	20390.6	Floodway	5361.14	0.89	5362.25	56.00	146.33	974.26	97.41	5011.00	5020.10	5060.56	5067.00
Reach - 1 Lower	19770.6	BNA	5352.70		5353.31	173.39	264.71	836.04	117.26		4961.90	5032.84	
Reach - 1 Lower	19770.6	Floodway	5353.07	0.37	5354.13	70.94		1218.00		4961.90	4961.90	5032.84	5032.84
Reach - 1 Lower	18766.3	BNA	5334.14		5334.51	110.37		1218.00			4792.08	5238.87	
Reach - 1 Lower	18766.3	Floodway	5334.10	-0.04	5334.48	109.94		1218.00		4792.08	4792.08	5238.87	5238.87
Reach - 1 Lower	18016.1	BNA	5327.94		5328.89	82.57		1218.00			4936.76	5025.30	
Reach - 1 Lower	18016.1	Floodway	5328.02	0.08	5328.89	84.95		1218.00		4936.76	4936.76	5025.30	5025.30
Reach - 1 Lower	17129.8	BNA	5315.03		5315.81	115.42	225.08	910.26	82.66		4980.40	5029.57	
Reach - 1 Lower	17129.8	Floodway	5315.30	0.27	5316.65	49.17		1218.00		4980.40	4980.40	5029.57	5029.57
Reach - 1 Lower	17000.0	BNA	5275.17		5276.91	33.08		1218.00			4980.13	5014.51	
Reach - 1 Lower	17000.0	Floodway	5275.17	0.00	5276.91	33.08		1218.00		4980.13	4980.13	5014.51	5014.51
Reach - 1 Lower	16457.0	BNA	5203.01		5203.84	100.51		1218.00			4944.16	5049.59	
Reach - 1 Lower	16457.0	Floodway	5203.01	0.00	5203.84	100.51		1218.00		4944.16	4944.16	5049.59	5049.59



Duplicate Effective Floodway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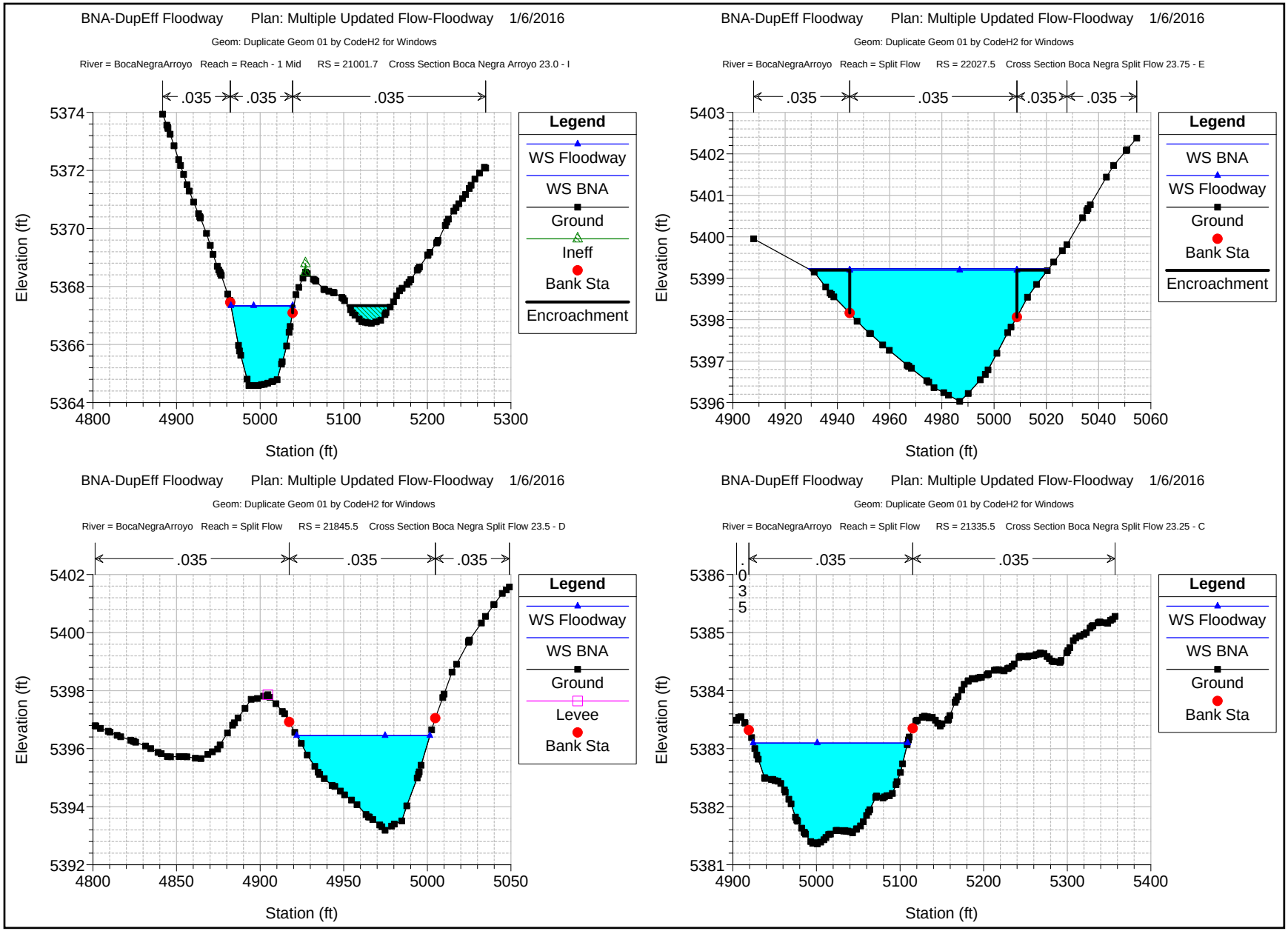
Geom: Duplicate Geom 01 by CodeH2 for Windows
River = BocaNegraArroyo Reach = Reach - 1 Upper RS = 22241.1 Cross Section Boca Negra Arroyo 24.0 - M
.035 .035 .035
Elevation (ft)
Station (ft)
Legend
WS Floodway
WS BNA
Ground
Bank Sta
Encroachment
BNA-DupEff Floodway Plan: Multiple Updated Flow-Floodway 1/6/2016
Geom: Duplicate Geom 01 by CodeH2 for Windows
River = BocaNegraArroyo Reach = Reach - 1 Mid RS = 22027.5 Cross Section Boca Negra Arroyo 23.75 - L
.035 .035 .035
Elevation (ft)
Station (ft)
Legend
WS BNA
WS Floodway
Ground
Bank Sta
Encroachment
BNA-DupEff Floodway Plan: Multiple Updated Flow-Floodway 1/6/2016
Geom: Duplicate Geom 01 by CodeH2 for Windows
River = BocaNegraArroyo Reach = Reach - 1 Mid RS = 21845.5 Cross Section Boca Negra Arroyo 23.5 - K
.035 .035 .035
Elevation (ft)
Station (ft)
Legend
WS Floodway
WS BNA
Ground
Bank Sta
Encroachment
BNA-DupEff Floodway Plan: Multiple Updated Flow-Floodway 1/6/2016
Geom: Duplicate Geom 01 by CodeH2 for Windows
River = BocaNegraArroyo Reach = Reach - 1 Mid RS = 21335.5 Cross Section Boca Negra Arroyo 23.25 - J
.035 .035 .035
Elevation (ft)
Station (ft)
Legend
WS Floodway
WS BNA
Ground
Bank Sta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Geom: Duplicate Geom 01 by CodeH2 for Windows
River = BocaNegraArroyo Reach = Reach - 1 Mid RS = 21001.7 Cross Section Boca Negra Arroyo 23.0 - I
.035 .035 .035
Elevation (ft)
Station (ft)
Legend
WS Floodway
WS BNA
Ground
Ineff
Bank Sta
Encroachment
BNA-DupEff Floodway Plan: Multiple Updated Flow-Floodway 1/6/2016
Geom: Duplicate Geom 01 by CodeH2 for Windows
River = BocaNegraArroyo Reach = Split Flow RS = 22027.5 Cross Section Boca Negra Split Flow 23.75 - E
.035 .035 .035 .035
Elevation (ft)
Station (ft)
Legend
WS BNA
WS Floodway
Ground
Bank Sta
Encroachment
BNA-DupEff Floodway Plan: Multiple Updated Flow-Floodway 1/6/2016
Geom: Duplicate Geom 01 by CodeH2 for Windows
River = BocaNegraArroyo Reach = Split Flow RS = 21845.5 Cross Section Boca Negra Split Flow 23.5 - D
.035 .035 .035
Elevation (ft)
Station (ft)
Legend
WS Floodway
WS BNA
Ground
Levee
Bank Sta
BNA-DupEff Floodway Plan: Multiple Updated Flow-Floodway 1/6/2016
Geom: Duplicate Geom 01 by CodeH2 for Windows
River = BocaNegraArroyo Reach = Split Flow RS = 21335.5 Cross Section Boca Negra Split Flow 23.25 - C
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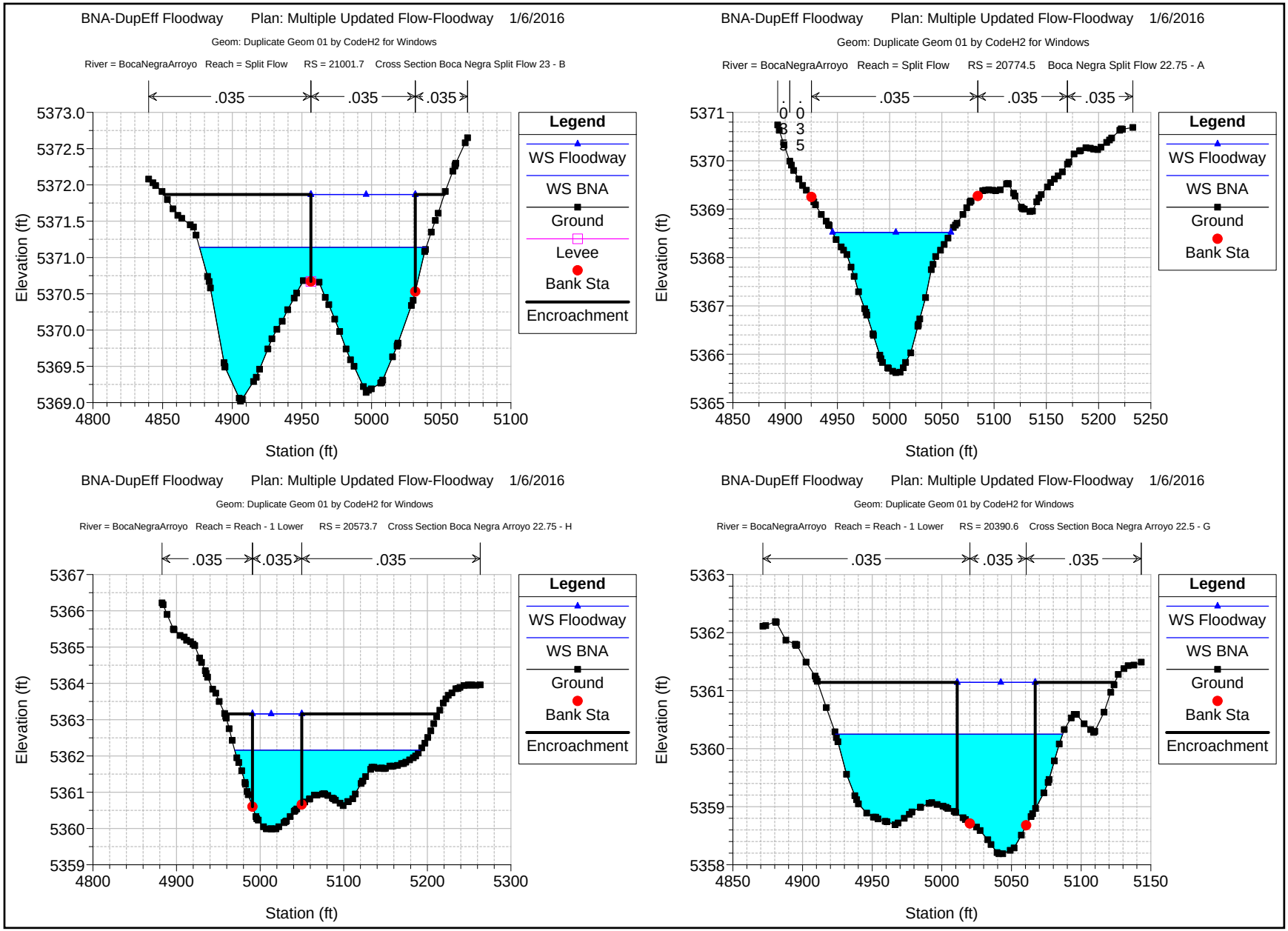
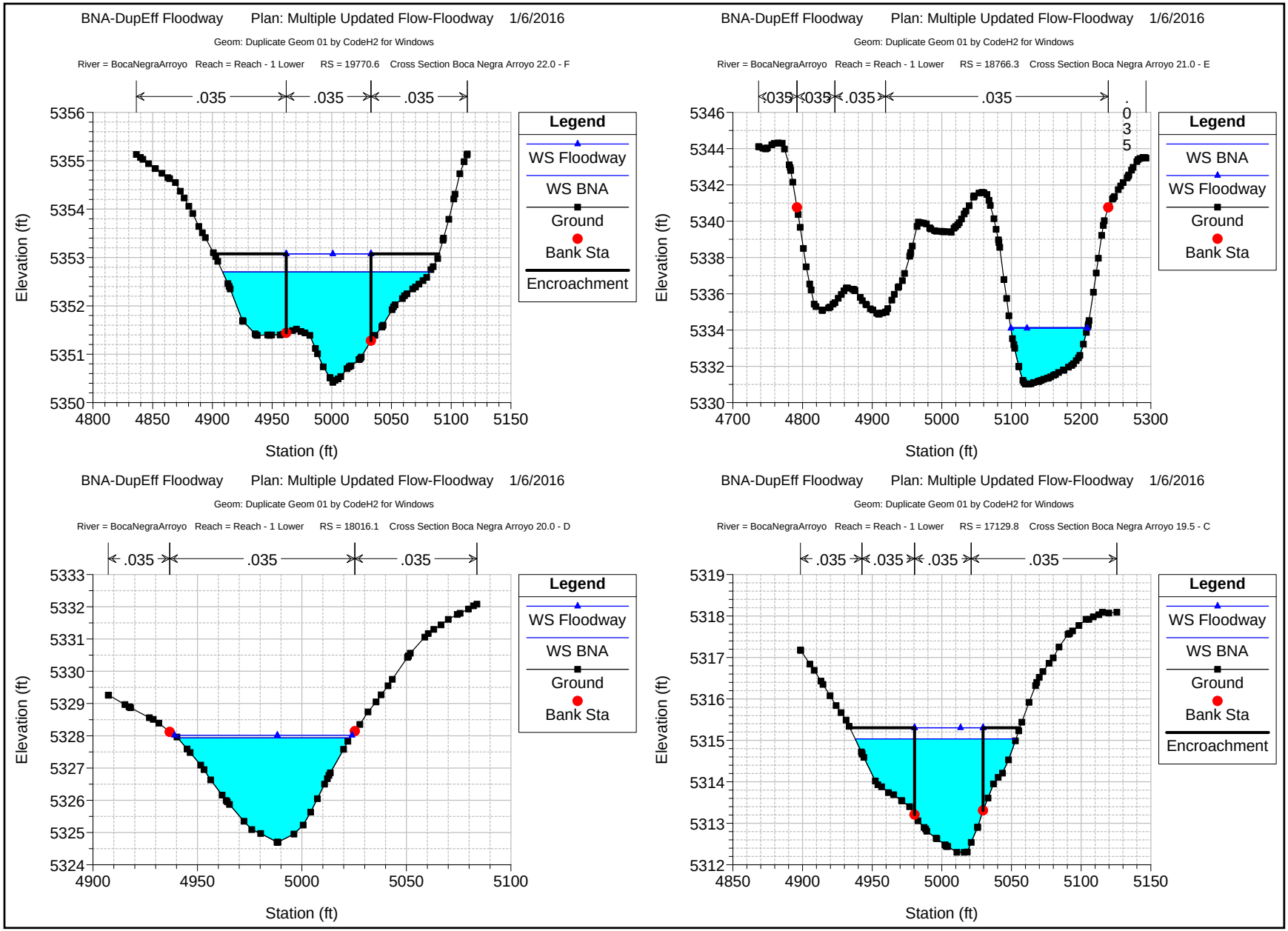
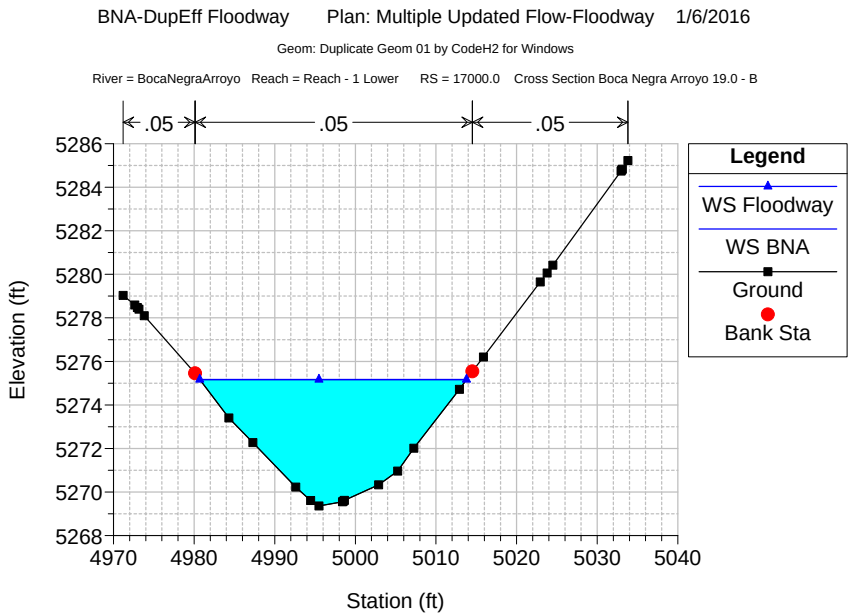
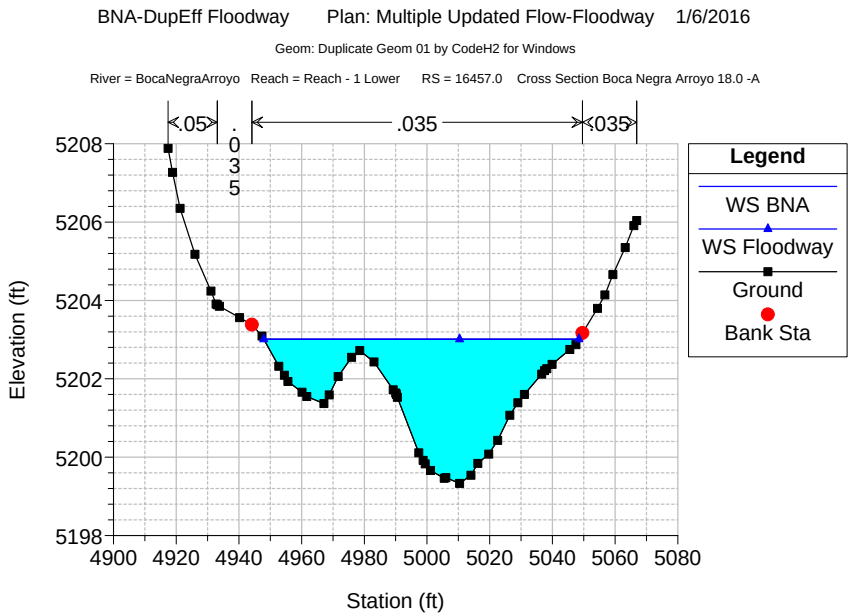
Elevation (ft)
Station (ft)
Legend
WS Floodway
WS BNA
Ground
Bank Sta


BNA-DupEff Floodway Plan: Multiple Updated Flow-Floodway 1/6/2016
Geom: Duplicate Geom 01 by CodeH2 for Windows
River = BocaNegraArroyo Reach = Split Flow RS = 21001.7 Cross Section Boca Negra Split Flow 23 - B
.035
.035
.035
Elevation (ft)
Station (ft)
Legend
WS Floodway
WS BNA
Ground
Levee
Bank Sta
Encroachment
BNA-DupEff Floodway Plan: Multiple Updated Flow-Floodway 1/6/2016
Geom: Duplicate Geom 01 by CodeH2 for Windows
River = BocaNegraArroyo Reach = Split Flow RS = 20774.5 Boca Negra Split Flow 22.75 - A
.035
.035
.035
Elevation (ft)
Station (ft)
Legend
WS Floodway
WS BNA
Ground
Bank Sta
BNA-DupEff Floodway Plan: Multiple Updated Flow-Floodway 1/6/2016
Geom: Duplicate Geom 01 by CodeH2 for Windows
River = BocaNegraArroyo Reach = Reach - 1 Lower RS = 20573.7 Cross Section Boca Negra Arroyo 22.75 - H
.035
.035
.035
Elevation (ft)
Station (ft)
Legend
WS Floodway
WS BNA
Ground
Bank Sta
Encroachment
BNA-DupEff Floodway Plan: Multiple Updated Flow-Floodway 1/6/2016
Geom: Duplicate Geom 01 by CodeH2 for Windows
River = BocaNegraArroyo Reach = Reach - 1 Lower RS = 20390.6 Cross Section Boca Negra Arroyo 22.5 - G
.035
.035
.035
Elevation (ft)
Station (ft)
Legend
WS Floodway
WS BNA
Ground
Bank Sta
Encroachment



Duplicate Effective Floodway


BNA-DupEff Floodway Plan: Multiple Updated Flow-Floodway 1/6/2016
Geom: Duplicate Geom 01 by CodeH2 for Windows
River = BocaNegraArroyo Reach = Reach - 1 Lower RS = 17000.0 Cross Section Boca Negra Arroyo 19.0 - B
.05
.05
.05
Elevation (ft)
Station (ft)
Legend
WS Floodway
WS BNA
Ground
Bank Sta


BNA-DupEff Floodway Plan: Multiple Updated Flow-Floodway 1/6/2016
Geom: Duplicate Geom 01 by CodeH2 for Windows
River = BocaNegraArroyo Reach = Reach - 1 Lower RS = 16457.0 Cross Section Boca Negra Arroyo 18.0 -A
.05
.035
.035
Elevation (ft)
Station (ft)
Legend
WS BNA
WS Floodway
Ground
Bank Sta

HEC-RAS Version 4.1.0 Jan 2010
U.S. Army Corps of Engineers
Hydrologic Engineering Center
609 Second Street
Davis, California

```
X     X  XXXXXX    XXXX        XXXX       XX      XXXX
X     X  X        X    X       X   X     X  X    X
X     X  X        X            X   X    X    X   X
XXXXXXX  XXXX     X       XXX  XXXX     XXXXXX    XXXX
X     X  X        X            X  X     X    X        X
X     X  X        X    X       X   X    X    X        X
X     X  XXXXXX    XXXX        X    X   X    X   XXXXX
```

PROJECT DATA
Project Title: BNA-DupEff Floodway
Project File : DupEffFloodway.prj
Run Date and Time: 1/6/2016 9:14:08 AM

Project in English units

PLAN DATA

Plan Title: Multiple Updated Flow-Floodway
Plan File : t:\Projects\x321807802\Eng\2012 Final Plans_Specifications_Estimate_Reports\2014 Final Construction Acceptance Reports\H&H\LOMR - RAS\BNA RAS FLOODWAY\DupEffFloodway.p09

Geometry Title: Duplicate Geom 01 by CodeH2 for Windows
Geometry File : t:\Projects\x321807802\Eng\2012 Final Plans_Specifications_Estimate_Reports\2014 Final Construction Acceptance Reports\H&H\LOMR - RAS\BNA RAS FLOODWAY\DupEffFloodway.g04

Flow Title : Updated 2014
Flow File : t:\Projects\x321807802\Eng\2012 Final Plans_Specifications_Estimate_Reports\2014 Final Construction Acceptance Reports\H&H\LOMR - RAS\BNA RAS FLOODWAY\DupEffFloodway.f01

Plan Summary Information:
Number of: Cross Sections = 22 Multiple Openings = 0
Culverts = 0 Inline Structures = 0
Bridges = 0 Lateral Structures = 0

Computational Information
Water surface calculation tolerance = 0.01
Critical depth calculation tolerance = 0.01
Maximum number of iterations = 20
Maximum difference tolerance = 0.3
Flow tolerance factor = 0.001

Computation Options
Critical depth computed only where necessary
Conveyance Calculation Method: At breaks in n values only
Friction Slope Method: Average Conveyance
Computational Flow Regime: Subcritical Flow

Encroachment Data
Equal Conveyance = False
Left Offset = 0
Right Offset = 0

River = BocaNegraArroyo Reach = Reach - 1 Upper

RS	Profile	Method	Value1	Value2
25374.6	Floodway	1	4955	5052
24989.3	Floodway	1	4945	5032
24106.4	Floodway	1	4943	5039
23000.0	Floodway	1	4965	5125
22241.1	Floodway	1	4940	5055

River = BocaNegraArroyo Reach = Reach - 1 Mid

RS	Profile	Method	Value1	Value2
22027.5	Floodway	1	4967.55	5062.32
21845.5	Floodway	1	4975.28	5023.67
21335.5	Floodway	1	4982.78	5189.42
21001.7	Floodway	1	4964.29	5038.83

River = BocaNegraArroyo Reach = Split Flow

RS	Profile	Method	Value1	Value2
22027.5	Floodway	1	4944.75	5008.76
21845.5	Floodway	1	4917.38	5004.75
21335.5	Floodway	1	4919.15	5115.19
21001.7	Floodway	1	4956.44	5031.38
20774.5	Floodway	1	4925.19	5084.41

River = BocaNegraArroyo Reach = Reach - 1 Lower

RS	Profile	Method	Value1	Value2
20573.7	Floodway	1	4990.78	5049.79

```
20390.6 Floodway              1    5011    5067
19770.6 Floodway              1  4961.9 5032.84
18766.3 Floodway              1 4792.08 5238.87
18016.1 Floodway              1 4936.76  5025.3
17129.8 Floodway              1  4980.4 5029.57
17000.0 Floodway              1 4980.13 5014.51
16457.0 Floodway              1 4944.16 5049.59
```

FLOW DATA

Flow Title: Updated 2014
Flow File : t:\Projects\x321807802\Eng\2012 Final Plans_Specifications_Estimate_Reports\2014 Final Construction Acceptance Reports\H&H\LOMR - RAS\BNA RAS FLOODWAY\DupEffFloodway.f01

Flow Data (cfs)

River	Reach	RS	BNA	Floodway
BocaNegraArroyo	Reach - 1 Upper	25374.6	1193	1193
BocaNegraArroyo	Reach - 1 Mid	22027.5	1215	1215
BocaNegraArroyo	Split Flow	22027.5	1215	1215
BocaNegraArroyo	Reach - 1 Lower	20573.7	1218	1218

Boundary Conditions

River	Reach	Profile	Upstream	Downstream
BocaNegraArroyo	Reach - 1 Lower	BNA		Normal S = 0.0283

GEOMETRY DATA

Geometry Title: Duplicate Geom 01 by CodeH2 for Windows
Geometry File : t:\Projects\x321807802\Eng\2012 Final Plans_Specifications_Estimate_Reports\2014 Final Construction Acceptance Reports\H&H\LOMR - RAS\BNA RAS FLOODWAY\DupEffFloodway.g04

Reach Connection Table

River	Reach	Upstream Boundary	Downstream Boundary
BocaNegraArroyo	Reach - 1 Upper		Junction 1
BocaNegraArroyo	Reach - 1 Mid	Junction 1	Junction 2
BocaNegraArroyo	Split Flow	Junction 1	Junction 2
BocaNegraArroyo	Reach - 1 Lower	Junction 2	

JUNCTION INFORMATION

Name: Junction 1
Description:
Energy computation Method

Length across Junction River	Reach	Tributary River	Reach	Length	Angle
BocaNegraArroyo	Reach - 1 Upper	to BocaNegraArroyo	Reach - 1 Mid	213.6	
BocaNegraArroyo	Reach - 1 Upper	to BocaNegraArroyo	Split Flow	173	

Name: Junction 2
Description:
Energy computation Method

Length across Junction River	Reach	Tributary River	Reach	Length	Angle
BocaNegraArroyo	Reach - 1 Mid	to BocaNegraArroyo	Reach - 1 Lower	428	
BocaNegraArroyo	Split Flow	to BocaNegraArroyo	Reach - 1 Lower	321	

CROSS SECTION

RIVER: BocaNegraArroyo
REACH: Reach - 1 Upper RS: 25374.6

INPUT
Description: Cross Section Boca Negra Arroyo 28.0 - Q
Station Elevation Data num= 71

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
4839	5438.7	4841.95	5438.5	4844.7	5438.36	4850.23	5438.17	4851.86	5438.11
4856.66	5437.93	4858.5	5437.82	4862.65	5437.59	4866.78	5437.37	4868.62	5437.29
4873.39	5437.19	4875.06	5437.15	4880.58	5437.06	4883.34	5436.99	4889.55	5436.79
4891.62	5436.71	4892.54	5436.67	4894.92	5436.54	4899.9	5436.24	4904.5	5436.04
4908.18	5436.12	4916.45	5436.29	4916.46	5436.29	4924.73	5436.47	4928.41	5436.57
4933.01	5436.62	4937.99	5436.64	4940.37	5436.66	4941.29	5436.59	4943.35	5436.47
4949.57	5436.07	4952.33	5435.92	4957.85	5435.01	4959.52	5434.75	4964.29	5433.98
4966.13	5433.78	4970.25	5433.29	4974.4	5432.78	4976.25	5432.58	4981.05	5432.59
4982.68	5432.62	4987.45	5432.51	4988.21	5432.49	4990.96	5432.4	4997.15	5432.31
4997.8	5432.31	4999.05	5432.3	5000.96	5432.29	5006.21	5432.24	5010.47	5432.23

5013.37 5432.27 5016.93 5432.29 5020.53 5432.5 5023.46 5432.68 5027.69 5432.93
5032.9 5433.16 5034.85 5433.26 5036.44 5433.37 5042.01 5433.9 5048.87 5434.66
5049.18 5434.7 5049.43 5434.74 5051.87 5435.13 5056.34 5435.83 5062.41 5436.92
5063.5 5437.11 5064.84 5437.36 5070.66 5438.25 5075.4 5439.02 5077.82 5439.36
5078.02 5439.39

Manning's n Values num= 3
Sta n Val Sta n Val Sta n Val
4839 .035 4959.52 .035 5042.01 .035

Bank Sta: Left Right Lengths: Left Channel Right Coeff Contr. Expan.
4959.52 5042.01 385.3 385.3 385.3 .1 .3

CROSS SECTION

RIVER: BocaNegraArroyo
REACH: Reach - 1 Upper RS: 24989.3

INPUT
Description: Cross Section Boca Negra Arroyo 27.0 - P
Station Elevation Data num= 96
Sta Elev Sta Elev Sta Elev Sta Elev Sta Elev
4764.7 5437.47 4768.41 5437.28 4769.76 5437.19 4774.65 5436.93 4778.51 5436.87
4782.55 5436.83 4785.93 5436.79 4788.61 5436.64 4795.33 5436.15 4797.22 5436.03
4798.71 5435.96 4808.12 5435.61 4808.5 5435.59 4808.8 5435.58 4811.38 5435.51
4818.9 5435.25 4819.79 5435.21 4820.91 5435.19 4829 5434.97 4831.07 5434.93
4833.69 5434.83 4839.1 5434.6 4842.36 5434.5 4846.48 5434.43 4849.2 5434.35
4853.64 5434.3 4859.27 5434.17 4859.3 5434.16 4864.93 5434.03 4869.4 5433.85
4872.06 5433.73 4876.21 5433.55 4879.5 5433.46 4884.84 5433.31 4887.5 5433.23
4889.6 5433.16 4897.63 5432.94 4898.78 5432.9 4899.7 5432.85 4907.47 5432.5
4909.8 5432.4 4910.07 5432.38 4910.42 5432.37 4919.9 5431.7 4921.36 5431.63
4923.2 5431.54 4929.99 5431.2 4932.64 5431.07 4935.99 5430.84 4940.09 5430.53
4943.93 5430.28 4948.78 5429.96 4950.19 5429.89 4955.21 5429.54 4960.29 5429.45
4961.56 5429.41 4966.5 5429.31 4968.63 5429.27 4971.93 5429.26 4972.45 5429.26
4978.17 5429.22 4980.99 5429.19 4988.45 5428.85 4989.52 5428.79 4989.93 5428.76
4990.83 5428.72 4996.15 5428.36 4998.06 5428.23 5001.69 5428.13 5006.6 5428.25
5009.73 5428.38 5013.45 5428.51 5015.13 5428.61 5019.59 5428.9 5023.67 5429.18
5025.04 5429.3 5025.31 5429.33 5031.03 5430.12 5034.57 5430.63 5038.17 5431.03
5044 5431.63 5045.31 5431.76 5046.12 5431.83 5049.54 5432.09 5052.45 5432.32
5057.67 5432.69 5059.58 5432.83 5062.69 5433.03 5066.72 5433.17 5069.22 5433.26
5073.86 5433.53 5079.78 5433.83 5080.76 5433.88 5081 5433.89 5081.37 5433.89
5084.93 5433.91

Manning's n Values num= 3
Sta n Val Sta n Val Sta n Val
4764.7 .035 4980.99 .035 5023.67 .035

Bank Sta: Left Right Lengths: Left Channel Right Coeff Contr. Expan.
4980.99 5023.67 882.9 882.9 882.9 .1 .3

CROSS SECTION

RIVER: BocaNegraArroyo
REACH: Reach - 1 Upper RS: 24106.4

INPUT
Description: Cross Section Boca Negra Arroyo 26.0 - O
Station Elevation Data num= 56
Sta Elev Sta Elev Sta Elev Sta Elev Sta Elev
4889.8 5424.42 4892.33 5424.31 4896.03 5424.19 4899.68 5424.07 4903.57 5423.94
4907.9 5423.79 4910.36 5423.69 4914.81 5423.54 4919.76 5423.31 4921.04 5423.27
4926.06 5423.03 4931.62 5422.54 4931.73 5422.53 4937.3 5422.04 4942.41 5421.63
4943.49 5421.54 4948.54 5421.13 4953.1 5420.87 4955.35 5420.72 4959.79 5420.46
4963.78 5420.37 4967.22 5420.28 4971.03 5420.19 4974.47 5420.14 4979.08 5420.09
4982.27 5420.04 4985.15 5419.95 4990.95 5419.79 4993.52 5419.71 4995.83 5419.64
5000.47 5419.51 5002.06 5419.48 5003.76 5419.43 5005.11 5419.39 5010.15 5419.56
5014.35 5419.69 5017.27 5419.79 5018.23 5419.86 5020.14 5420.03 5026.32 5420.51
5029.43 5420.71 5034.4 5421.1 5038.86 5421.53 5041.58 5421.78 5042.48 5421.87
5044.27 5422.08 5050.57 5422.8 5053.74 5423.21 5058.65 5423.75 5063.36 5424.28
5065.9 5424.56 5066.74 5424.61 5068.4 5424.69 5074.82 5425.01 5078.06 5425.21
5080.45 5425.29

Manning's n Values num= 3
Sta n Val Sta n Val Sta n Val
4889.8 .035 4948.54 .035 5034.4 .035

Bank Sta: Left Right Lengths: Left Channel Right Coeff Contr. Expan.
4948.54 5034.4 1106.4 1106.4 1106.4 .1 .3

CROSS SECTION

RIVER: BocaNegraArroyo
REACH: Reach - 1 Upper RS: 23000.0

INPUT
Description: Cross Section Boca Negra Arroyo 25.0 - N
Station Elevation Data num= 106
Sta Elev Sta Elev Sta Elev Sta Elev Sta Elev

```
  4834.3  5412.7 4835.65 5412.61 4844.38 5412.12 4844.78 5412.09 4845.05 5412.08
 4846.28 5412.01 4854.44 5411.58 4856.19 5411.49 4858.88 5411.32 4863.84 5411.02
 4867.59 5410.79 4873.24 5410.59 4873.39 5410.59    4879 5410.39 4882.63 5410.39
 4887.89 5410.39  4890.4 5410.39 4892.03  5410.4 4899.65 5410.47 4901.43 5410.49
 4901.81 5410.49  4902.4 5410.49 4910.82 5410.51 4913.21 5410.51  4916.9 5410.41
 4920.22  5410.3 4924.62 5410.18 4929.62 5409.98  4931.4 5409.91 4936.02 5409.73
 4939.01 5409.63 4945.91 5409.34 4947.43 5409.29 4948.41 5409.26 4953.01 5409.09
 4957.81 5408.92 4958.83 5408.87 4960.41 5408.79  4967.2 5408.47 4970.24 5408.32
 4974.92 5408.04  4976.6 5407.93 4981.64 5407.64    4986 5407.32 4989.42 5407.11
 4993.05 5406.86 4995.39 5406.83  5001.4  5406.8 5002.43 5406.81 5003.99 5406.82
 5006.86 5406.87 5006.89 5406.87 5011.16 5406.97 5013.48 5407.02 5018.33 5407.13
 5021.29  5407.2 5024.54 5407.28  5025.5  5407.3 5027.28 5407.34 5032.67 5407.42
 5035.59 5407.45 5039.84 5407.52 5045.38 5407.58 5046.64  5407.6 5047.01  5407.6
  5047.7 5407.61 5054.18 5407.79 5057.69 5407.89 5061.35 5408.01 5068.12 5408.27
 5068.52 5408.29 5068.74 5408.29 5069.47 5408.29  5075.7 5408.31 5079.79 5408.27
 5082.87 5408.25 5088.54 5408.11 5090.04 5408.07 5090.84 5408.04 5093.55    5408
 5097.21 5407.93 5101.89 5407.92 5104.38 5407.87 5108.97 5407.95 5111.55 5408.02
 5112.95 5408.13 5117.64 5408.41 5118.72 5408.48    5124  5408.8 5125.89 5408.92
 5129.39 5409.04 5133.06 5409.18 5135.05 5409.26 5140.23  5409.6 5141.73 5409.69
  5146.1 5409.98  5147.4 5410.09 5149.81 5410.29 5154.57 5410.76 5157.15 5411.01
 5161.74 5411.53 5165.81 5412.01  5168.2 5412.29 5168.91 5412.35 5170.23 5412.46
 5171.65 5412.54

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
  4834.3    .035 4974.92    .035 5061.35    .035

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
       4974.92 5061.35             758.9   758.9   758.9             .1       .3

CROSS SECTION


RIVER: BocaNegraArroyo
REACH: Reach - 1 Upper    RS: 22241.1

INPUT
Description: Cross Section Boca Negra Arroyo 24.0 - M
Station Elevation Data    num=     106
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
 4820.81 5403.35 4826.92 5403.05 4827.77    5403 4828.45 5402.97 4834.88 5402.73
 4835.23 5402.71 4841.93 5402.42 4842.68 5402.39 4843.61 5402.35 4850.14 5402.09
 4855.42 5401.88  4857.6 5401.78  4860.3 5401.68 4865.05 5401.56  4868.9 5401.49
 4872.51 5401.41 4876.98 5401.31 4879.97 5401.25 4882.38 5401.22 4887.43 5401.16
 4893.67 5401.04 4894.88 5401.01 4895.86 5400.99 4902.34 5400.85 4905.09 5400.78
 4909.35 5400.69  4909.8 5400.68 4910.36 5400.66 4917.26 5400.39 4922.83 5400.21
 4924.71 5400.15 4927.05 5400.06 4932.17 5399.84 4935.12 5399.68 4936.44 5399.62
 4939.49  5399.4 4942.34 5399.17 4946.71 5398.83  4951.4 5398.49 4953.94 5398.37
 4956.32 5398.29 4961.17 5398.16 4966.35 5398.02 4968.39 5397.98  4970.3 5397.96
 4975.62 5397.91 4981.31 5397.81 4982.84 5397.81 4984.28 5397.81 4990.07 5397.85
 4996.26 5397.89 4997.29  5397.9 4998.26  5397.9 5004.52 5397.97 5008.04 5397.98
 5011.21 5397.99 5011.74 5397.98 5012.24 5397.98 5018.97 5398.03 5026.17 5398.09
  5026.2 5398.09 5026.22 5398.09 5026.99  5398.1 5033.42 5398.22  5040.2  5398.4
 5040.65 5398.42 5041.12 5398.44 5043.57  5398.6 5048.02 5398.97 5051.13 5399.23
 5055.49 5399.75 5057.32 5399.96 5061.08 5400.39 5062.97 5400.59 5068.64 5401.15
 5070.44 5401.33 5071.04 5401.38 5072.22 5401.47 5077.91  5401.9 5080.99 5402.11
 5085.39 5402.23 5087.12 5402.29 5090.94 5402.41 5092.86 5402.42 5098.63 5402.47
 5100.33 5402.48  5100.9 5402.49 5102.02 5402.51  5107.8 5402.63 5110.85 5402.69
 5115.28 5402.76 5116.92 5402.77  5120.8 5402.82 5122.75 5402.84 5128.61 5402.95
 5130.22 5402.99 5130.76    5403 5131.82 5403.06  5137.7  5403.3 5140.71 5403.49
 5145.17 5403.77 5146.72 5403.85 5150.67 5404.08 5152.64  5404.2  5158.6 5404.43
 5159.07 5404.44

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
 4820.81    .035 4942.34    .035 5048.02    .035

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
       4942.34 5048.02               0       0       0             .1       .3

CROSS SECTION


RIVER: BocaNegraArroyo
REACH: Reach - 1 Mid      RS: 22027.5

INPUT
Description: Cross Section Boca Negra Arroyo 23.75 - L
Station Elevation Data    num=      76
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
  4890.5 5401.44 4894.23 5401.15 4899.28 5400.75 4902.37 5400.37 4908.78 5399.53
 4910.52 5399.31 4911.36 5399.22 4913.78 5398.97 4918.67 5398.48 4923.45 5397.95
 4926.82 5397.77 4933.78 5397.39 4934.96 5397.33 4935.54  5397.3 4937.18 5397.22
 4943.11 5396.95 4947.62 5396.74 4951.26 5396.62 4958.78 5396.33 4959.41  5396.3
 4959.71 5396.29 4960.59 5396.26 4967.55 5396.03  4971.8 5395.84  4975.7 5395.63
 4983.78  5395.1 4983.85 5395.09 4983.89 5395.09 4983.99 5395.08    4992 5394.65
 4995.97 5394.49 5000.14 5394.42 5002.14 5394.41 5007.39 5394.39 5008.06 5394.38
 5008.29 5394.38 5008.77 5394.38 5016.44 5394.27 5020.15 5394.23 5024.59 5394.29
  5030.8 5394.44 5032.23 5394.47 5032.73  5394.5 5032.96 5394.51 5033.28 5394.52
 5034.26 5394.58 5040.31 5394.92  5043.1 5395.07 5047.87 5395.34 5048.29 5395.36
 5052.93 5395.62 5055.43 5395.79 5062.32 5396.25 5062.75 5396.27 5062.99  5396.3
```

```
 5063.77 5396.37 5070.54 5397.07 5072.58 5397.22 5076.34 5397.78  5078.1 5398.06
  5082.4 5398.65 5085.66  5399.1 5090.37 5399.73 5092.22 5399.99 5093.22 5399.99
 5096.55 5399.99 5100.78 5399.94 5102.05 5399.96  5104.4 5399.92 5108.34  5399.8
 5111.87 5399.78  5115.9  5399.6 5118.42 5399.52 5121.69  5399.4 5123.46 5399.27
 5124.92 5399.15

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
  4890.5    .035 4967.55    .035 5062.32    .035

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
       4967.55 5062.32              182     182     182             .1       .3

CROSS SECTION


RIVER: BocaNegraArroyo
REACH: Reach - 1 Mid      RS: 21845.5

INPUT
Description: Cross Section Boca Negra Arroyo 23.5 - K
Station Elevation Data    num=      99
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
  4880.3 5396.01 4882.41 5395.91 4887.22 5395.73 4894.99 5395.39    4895 5395.39
 4895.01 5395.39 4902.79  5395.1  4907.6 5394.93 4910.58 5394.84 4915.41  5394.7
 4918.37 5394.63 4920.19 5394.57 4926.16 5394.28 4927.91 5394.16 4932.79 5393.85
 4933.94 5393.78 4935.81 5393.65 4941.73 5393.26 4945.38 5392.95 4949.52 5392.57
 4956.21 5391.92 4957.31 5391.82 4957.98 5391.75 4960.83 5391.47 4965.09 5391.05
 4970.58 5390.51  4970.7  5390.5 4972.78 5390.36  4973.6  5390.3 4975.28 5390.21
 4980.22    5390 4983.61 5389.79 4987.66 5389.55 4990.59  5389.3 4993.63 5389.09
  4995.1 5388.98 4996.09 5388.94 4999.37 5388.79 5002.54 5388.78 5003.64 5388.82
  5005.9 5388.95 5009.98 5389.15 5013.66 5389.39 5017.42 5389.68 5021.21 5390.01
 5023.67 5390.21 5024.86 5390.31 5028.32 5390.61  5032.3 5390.89 5033.68 5390.99
 5036.52 5391.17 5039.74 5391.37  5043.7 5391.64 5047.18  5391.9 5051.83  5392.3
 5053.71 5392.45 5054.62 5392.52 5057.26 5392.74 5062.06 5393.05 5063.72 5393.17
 5067.14 5393.41  5069.5 5393.57 5073.74 5393.89 5076.94 5394.11 5082.45  5394.5
 5083.75 5394.59 5084.38 5394.63 5086.21 5394.71 5091.82  5394.9 5093.77 5394.96
 5097.76 5395.07 5099.26 5395.12 5103.78 5395.23  5106.7 5395.25 5113.07 5395.31
 5113.79 5395.32 5114.14 5395.33 5115.16 5395.36 5121.58 5395.52 5123.81 5395.58
 5128.38 5395.79 5129.02 5395.82 5133.82 5396.04 5136.46 5396.17 5143.69 5396.49
 5143.83  5396.5  5143.9  5396.5  5144.1  5396.5 5151.34 5396.78 5153.85 5396.89
 5158.78 5397.01    5159 5397.01 5163.86 5397.12 5166.22 5397.11 5173.05 5396.99
 5173.66 5396.98 5173.88 5396.98 5174.31 5396.96 5180.71 5396.79

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
  4880.3    .035 4975.28    .035 5023.67    .035

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
       4975.28 5023.67              510     510     510             .1       .3

CROSS SECTION


RIVER: BocaNegraArroyo
REACH: Reach - 1 Mid      RS: 21335.5

INPUT
Description: Cross Section Boca Negra Arroyo 23.25 - J
Station Elevation Data    num=     115
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
 4904.44 5381.56 4907.59  5381.4 4909.19 5381.36 4910.62 5381.31 4916.55 5381.16
 4923.18 5380.94 4923.91 5380.92 4924.56 5380.88 4931.27 5380.45 4936.31 5380.13
  4938.5 5379.99 4938.63 5379.98 4938.76 5379.97 4945.98 5379.58 4952.44 5379.28
 4953.34 5379.24 4954.35 5379.19  4960.7 5378.92 4966.38 5378.67 4968.06  5378.6
 4969.93 5378.54 4975.42  5378.3 4980.32 5378.09 4982.78    5378 4985.52 5377.94
 4990.13 5377.76 4994.26 5377.58 4997.49 5377.39  5001.1 5377.15 5004.85 5376.87
  5008.2 5376.65 5012.21 5376.39 5016.69 5376.06 5019.57 5375.84 5022.14 5375.65
 5026.93  5375.3 5032.27 5374.95 5034.28 5374.83 5036.08 5374.72 5041.64 5374.29
 5047.86 5373.81    5049 5373.75 5050.02 5373.72 5056.36 5373.57 5063.45 5373.41
 5063.72  5373.4 5063.96 5373.39 5068.34 5373.22 5071.08 5373.11  5077.9  5372.7
 5078.44 5372.68 5079.03 5372.67 5085.79  5372.5 5091.84 5372.31 5093.15 5372.23
 5094.62 5372.17 5100.51 5371.95 5102.29 5371.89 5105.78 5371.76 5107.87 5371.77
  5110.2 5371.88 5115.23 5372.23 5119.72 5372.76 5122.59 5373.18 5125.79 5373.58
 5129.94 5374.01 5133.66 5374.14  5137.3 5373.98 5141.37 5373.75 5144.66 5373.61
  5147.6 5373.51 5152.02 5373.59 5156.96 5373.82 5159.38 5373.97 5161.54 5374.18
 5166.74 5374.95 5172.54 5375.84 5174.09 5376.12 5175.48 5376.35 5181.45 5377.21
 5188.13 5377.85 5188.81 5377.93 5189.42    5378 5196.17 5378.83 5200.37  5379.2
 5203.36 5379.47 5203.53 5379.49 5203.71  5379.5 5210.89 5379.97  5217.3 5380.43
 5218.24 5380.48  5219.3 5380.53  5225.6 5380.89 5231.24 5381.25 5232.96 5381.33
 5234.89 5381.42 5240.32 5381.65 5245.18 5381.89 5247.68 5381.99 5250.47 5382.13
 5255.04 5382.28 5259.12 5382.41  5262.4 5382.47 5266.06 5382.54 5269.75 5382.57
 5273.06 5382.62 5277.11  5382.7 5281.64 5382.79 5284.47 5382.83    5287 5382.89
 5291.83 5383.09 5297.23 5383.31 5299.19 5383.38 5300.94 5383.44 5304.37 5383.49

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
 4904.44    .035 4982.78    .035 5189.42    .035

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
       4982.78 5189.42            333.8   333.8   333.8             .1       .3
```

CROSS SECTION

RIVER: BocaNegraArroyo
REACH: Reach - 1 Mid RS: 21001.7

INPUT
Description: Cross Section Boca Negra Arroyo 23.0 - I
Station Elevation Data num= 112

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
4883.3	5373.94	4888.36	5373.56	4889.24	5373.49	4889.79	5373.45	4892.23	5373.25
4897	5372.85	4902.44	5372.37	4904.76	5372.17	4908.46	5371.86	4912.53	5371.51
4915.08	5371.29	4920.29	5370.91	4926.29	5370.51	4927.72	5370.41	4928.05	5370.39
4928.57	5370.36	4935.81	5369.83	4940.37	5369.42	4943.57	5369.11	4948.67	5368.7
4950.46	5368.57	4951.86	5368.5	4952.73	5368.44	4953.46	5368.38	4961.22	5367.74
4963.76	5367.52	4964	5367.49	4964.29	5367.45	4974.07	5365.97	4975.27	5365.78
4976.71	5365.63	4984.37	5364.81	4986.53	5364.59	4989.13	5364.59	4994.68	5364.59
4997.8	5364.59	5001.56	5364.62	5004.99	5364.63	5009.06	5364.67	5013.98	5364.72
5015.29	5364.73	5020.33	5364.79	5025.6	5365.33	5026.4	5365.41	5031.6	5365.95
5034.62	5366.42	5035.9	5366.62	5038.83	5367.09	5042.86	5367.72	5046.21	5367.97
5051.25	5368.29	5054.13	5368.49	5056.51	5368.45	5063.67	5368.25	5065.39	5368.22
5066.82	5368.18	5076.1	5367.91	5076.66	5367.9	5077.13	5367.89	5082.12	5367.84
5087.43	5367.8	5087.93	5367.79	5088.52	5367.78	5097.74	5367.62	5099.19	5367.59
5100.95	5367.51	5108.04	5367.2	5110.46	5367.09	5113.37	5367.01	5118.35	5366.88
5121.72	5366.79	5125.79	5366.77	5128.65	5366.75	5132.99	5366.73	5138.22	5366.78
5138.96	5366.78	5144.26	5366.84	5149.26	5367.03	5150.64	5367.1	5155.52	5367.29
5159.57	5367.47	5163.06	5367.68	5166.79	5367.85	5169.88	5367.94	5175.49	5368.07
5178.05	5368.15	5180.18	5368.24	5187.91	5368.56	5189.32	5368.62	5190.49	5368.67
5200.33	5369.07	5200.58	5369.08	5200.79	5369.09	5203.03	5369.18	5211.1	5369.5
5211.85	5369.53	5212.76	5369.59	5221.4	5370.1	5223.12	5370.22	5225.18	5370.32
5231.71	5370.6	5234.38	5370.72	5237.6	5370.85	5242.02	5371.03	5245.65	5371.17
5250.03	5371.38	5252.32	5371.49	5256.91	5371.7	5262.45	5371.91	5262.63	5371.91
5268.18	5372.11	5269.85	5372.08						

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
4883.3	.035	4964.29	.035	5038.83	.035

Bank Sta: Left	Right	Lengths: Left Channel	Right	Coeff Contr.	Expan.
4964.29	5038.83	0	0	0 .1	.3

Ineffective Flow num= 1

Sta L	Sta R	Elev	Permanent
5054.13	5269.85	5368.79	F

CROSS SECTION

RIVER: BocaNegraArroyo
REACH: Split Flow RS: 22027.5

INPUT
Description: Cross Section Boca Negra Split Flow 23.75 - E
Station Elevation Data num= 45

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
4907.94	5399.95	4931.1	5399.15	4935.51	5398.79	4937.19	5398.64	4937.69	5398.61
4938.63	5398.55	4944.75	5398.16	4947.52	5397.96	4952.31	5397.67	4952.65	5397.66
4957.34	5397.39	4959.87	5397.26	4966.68	5396.9	4967.16	5396.88	4967.43	5396.87
4968.3	5396.83	4974.21	5396.53	4974.98	5396.49	4976.99	5396.36	4980.7	5396.24
4982.54	5396.18	4986.81	5396.03	4990.1	5396.22	4994.73	5396.55	4996.63	5396.68
4997.66	5396.79	5001.08	5397.19	5005.22	5397.69	5006.46	5397.82	5008.76	5398.06
5012.78	5398.54	5016.28	5398.85	5020.34	5399.18	5022.78	5399.39	5026.11	5399.66
5027.9	5399.81	5033.87	5400.46	5035.45	5400.63	5035.93	5400.68	5036.81	5400.77
5043.01	5401.44	5045.75	5401.72	5050.57	5402.08	5050.84	5402.1	5054.58	5402.38

Manning's n Values num= 4

Sta	n Val	Sta	n Val	Sta	n Val	Sta	n Val
4907.94	.035	4944.75	.035	5008.76	.035	5027.9	.035

Bank Sta: Left	Right	Lengths: Left Channel	Right	Coeff Contr.	Expan.
4944.75	5008.76	146	146	146 .1	.3

CROSS SECTION

RIVER: BocaNegraArroyo
REACH: Split Flow RS: 21845.5

INPUT
Description: Cross Section Boca Negra Split Flow 23.5 - D
Station Elevation Data num= 86

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
4801.3	5396.79	4801.69	5396.78	4804.48	5396.7	4809.13	5396.6	4810.21	5396.57
4814.49	5396.46	4816.57	5396.41	4822.58	5396.29	4824.01	5396.26	4824.5	5396.25
4825.52	5396.22	4831.45	5396.09	4834.52	5396	4838.89	5395.87	4840.83	5395.83
4844.53	5395.73	4846.33	5395.72	4851.53	5395.73	4853.77	5395.73	4854.55	5395.73
4856.14	5395.72	4861.21	5395.67	4864.56	5395.66	4868.65	5395.8	4871.45	5395.89
4874.57	5395.99	4876.09	5396.13	4880.48	5396.54	4883.53	5396.81	4884.59	5396.89
4886.76	5397.06	4890.97	5397.39	4894.6	5397.7	4898.41	5397.73	4902.07	5397.81
4904.61	5397.86	4905.85	5397.77	4909.43	5397.55	4913.29	5397.28	4914.63	5397.2
4917.38	5396.92	4920.73	5396.56	4924.64	5396.18	4928.17	5395.78	4932.69	5395.39

```
 4934.66 5395.19 4935.61 5395.11 4938.37 5394.97 4943.05 5394.73 4944.67  5394.7
    4948 5394.54 4950.49 5394.41 4954.68 5394.23 4957.93 5394.07 4963.31 5393.73
  4964.7 5393.65 4965.37 5393.64 4967.32 5393.56 4971.56 5393.37 4972.81 5393.31
 4974.71 5393.19 4978.62 5393.33 4980.25  5393.4 4984.72 5393.51 4987.69 5394.03
 4993.93 5394.99 4994.74 5395.12 4995.13  5395.2 4996.27 5395.43 5002.57 5396.65
 5004.75 5397.05 5009.24 5397.76 5010.01 5397.88 5014.77 5398.64 5017.45 5398.91
 5024.55 5399.67 5024.78  5399.7 5024.89 5399.71 5025.21 5399.74 5032.33 5400.33
 5034.79 5400.56 5039.77 5400.96 5039.86 5400.97 5044.81 5401.35 5047.21 5401.47
 5049.08 5401.57

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
  4801.3    .035 4917.38    .035 5004.75    .035

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
       4917.38 5004.75              628     628     628             .1       .3
Left Levee      Station= 4904.61      Elevation= 5397.86

CROSS SECTION


RIVER: BocaNegraArroyo
REACH: Split Flow         RS: 21335.5

INPUT
Description: Cross Section Boca Negra Split Flow 23.25 - C
Station Elevation Data    num=     155
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
 4904.44 5383.49 4906.76 5383.54 4909.61 5383.55 4914.01 5383.45 4914.61 5383.44
 4919.15 5383.32 4922.46 5383.19 4926.17    5383 4928.69 5382.89 4930.31 5382.82
 4937.86  5382.5 4938.16 5382.49 4938.23 5382.49 4938.33 5382.49 4946.01 5382.47
 4947.77 5382.47 4950.48 5382.45 4953.86 5382.44 4957.31  5382.4 4961.72 5382.29
 4962.64 5382.25 4966.85 5382.13 4969.57 5382.05  4974.8 5381.82 4976.39 5381.77
 4977.42 5381.75  4982.2 5381.63 4985.27 5381.56 4985.93 5381.55 4986.95 5381.53
 4993.12  5381.4 4995.47 5381.37 4999.11 5381.38 5000.97 5381.36 5005.01 5381.39
 5008.82 5381.43 5011.26 5381.47 5014.55 5381.52 5016.67 5381.53 5023.42 5381.59
 5024.09 5381.59 5024.52 5381.59 5026.53 5381.59 5032.37 5381.58 5033.63 5381.59
 5035.58 5381.58 5037.71 5381.58 5040.22 5381.57 5043.17 5381.55 5047.73 5381.61
 5048.07 5381.62 5052.71 5381.67 5055.93 5381.74 5059.89 5381.85 5062.25 5381.91
 5063.78 5381.95 5070.86 5382.16 5071.63 5382.18 5071.79 5382.18 5072.05 5382.18
 5079.48 5382.15 5081.33 5382.17  5084.2 5382.19 5087.33 5382.19 5090.87 5382.23
 5095.18 5382.38 5096.36 5382.43 5100.41 5382.59 5103.03 5382.74 5108.52 5383.07
 5109.95 5383.15 5110.88  5383.2 5115.19 5383.35 5118.73 5383.47 5119.49 5383.48
 5120.67 5383.49 5126.58 5383.54 5129.03 5383.56 5132.83 5383.55 5134.43 5383.53
 5138.57 5383.54 5142.28 5383.49 5144.99 5383.44 5148.11 5383.39 5150.14 5383.43
 5157.14 5383.49 5157.65  5383.5 5157.99 5383.51 5159.53 5383.57 5165.84  5383.8
  5167.2 5383.84  5169.3  5383.9 5173.69 5384.01 5176.74 5384.11 5181.45 5384.16
 5181.54 5384.17 5186.28 5384.21 5189.39  5384.2 5193.61 5384.22 5195.82 5384.23
 5197.24 5384.23 5203.86 5384.27 5205.09 5384.28 5205.36 5384.29 5205.77 5384.29
 5212.94 5384.35  5214.9 5384.36 5217.92 5384.36 5220.79 5384.35 5224.44 5384.34
 5228.64 5384.38 5230.08 5384.39 5233.98 5384.42 5236.49 5384.46 5242.24 5384.57
 5243.52 5384.59 5244.35 5384.59 5248.19 5384.59  5252.2 5384.58 5253.06 5384.59
 5254.39  5384.6 5260.05  5384.6  5262.6 5384.62 5266.55 5384.63  5267.9 5384.65
 5272.14 5384.64 5275.75 5384.59 5278.71 5384.55 5281.68 5384.51  5283.6  5384.5
 5290.86 5384.49 5291.22 5384.49 5291.45 5384.49 5292.52 5384.52  5299.3 5384.65
 5300.76 5384.69 5303.02 5384.74 5307.15 5384.86  5310.3 5384.91    5315 5384.94
 5315.18 5384.94 5319.84 5384.97 5322.85    5385 5327.33 5385.08 5329.38 5385.11
 5330.71 5385.12 5336.86 5385.17 5338.56 5385.18 5338.92 5385.18 5339.49 5385.18
 5346.41 5385.17 5348.46 5385.16 5351.64 5385.21 5354.26 5385.23 5357.21 5385.28

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
 4904.44    .035 4919.15    .035 5115.19    .035

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
       4919.15 5115.19              683     683     683             .1       .3

CROSS SECTION


RIVER: BocaNegraArroyo
REACH: Split Flow         RS: 21001.7

INPUT
Description: Cross Section Boca Negra Split Flow 23 - B
Station Elevation Data    num=      68
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
    4840 5372.08 4843.08 5372.03 4845.02 5371.99  4849.6 5371.91 4853.39  5371.8
 4857.45 5371.67 4860.86 5371.58 4863.69 5371.54 4869.87 5371.45 4872.13 5371.42
    4874 5371.31 4882.29 5370.74 4883.39 5370.67  4884.3 5370.58 4894.09 5369.55
 4894.61  5369.5 4894.66 5369.49 4894.72 5369.49 4904.92 5369.06 4905.92 5369.02
 4907.14 5369.05 4915.22 5369.29 4917.19 5369.35 4919.56 5369.46 4925.53 5369.74
 4928.46 5369.88 4931.99 5370.01 4935.83 5370.12 4939.72 5370.28 4944.41 5370.44
 4946.14 5370.51 4950.99 5370.68 4956.44 5370.67 4956.84 5370.67 4962.25 5370.66
 4966.75 5370.45 4969.26 5370.35 4973.52 5370.15 4977.06 5369.98 4981.68 5369.74
 4984.79 5369.59 4987.36  5369.5 4994.11 5369.22 4996.05 5369.14 4997.67 5369.17
  4999.8 5369.19 5006.53 5369.27 5007.32 5369.28 5007.97 5369.31 5014.99 5369.63
 5018.28 5369.78 5018.58  5369.8 5018.95 5369.82 5028.58 5370.34 5029.85 5370.41
 5031.38 5370.53 5038.08 5371.08 5038.64 5371.11 5042.83 5371.35 5045.77 5371.51
 5047.77 5371.61  5052.9 5371.91  5058.3 5372.19 5059.76 5372.26 5060.03 5372.28
 5060.44  5372.3 5067.16 5372.58 5068.85 5372.65
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Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
    4840    .035 4956.44    .035 5031.38    .035

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
       4956.44 5031.38             130     130     130             .1       .3
Left Levee      Station= 4956.44      Elevation= 5370.67

CROSS SECTION


RIVER: BocaNegraArroyo
REACH: Split Flow         RS: 20774.5

INPUT
Description: Boca Negra Split Flow 22.75 - A
Station Elevation Data    num=     101
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
 4892.85 5370.74 4894.39 5370.63 4898.88 5370.33 4904.42 5369.99 4906.02 5369.91
 4908.22  5369.8 4913.15 5369.62 4916.73 5369.49 4920.29 5369.39 4925.19 5369.25
 4927.43 5369.15 4929.05 5369.09 4934.56 5368.89 4939.22 5368.75 4941.36 5368.68
  4941.7 5368.67 4942.16 5368.66 4948.83 5368.37 4953.67 5368.22 4955.97 5368.15
 4959.14 5368.06  4963.1  5367.8 4965.98 5367.61 4970.24 5367.29 4976.11 5366.94
 4977.37 5366.87 4978.29 5366.81 4984.06 5366.42 4984.51 5366.39  4990.6 5365.98
 4991.64 5365.91 4993.08 5365.83 4998.12 5365.72 4998.78 5365.71 5002.91 5365.65
 5005.92 5365.62 5010.05 5365.63 5013.05 5365.72 5015.23 5365.83 5020.19 5366.03
 5027.03 5366.58 5027.32  5366.6 5027.54 5366.62 5028.89 5366.73 5034.46 5367.17
 5039.85 5367.75 5041.59 5367.86    5044 5368.02 5048.73 5368.15 5052.16 5368.27
 5055.86  5368.4 5060.97 5368.62    5063 5368.67 5064.47 5368.71 5070.13 5368.89
 5073.72 5369.03 5076.78 5369.14 5077.27 5369.16 5077.94 5369.17 5084.41 5369.27
 5089.09 5369.38 5091.54 5369.39 5094.91  5369.4 5098.68 5369.39 5101.41 5369.38
 5105.81  5369.4 5111.89 5369.52 5112.95 5369.53 5113.72 5369.52 5118.55 5369.33
 5120.08 5369.27 5126.03 5369.04 5127.22 5369.01 5128.86    5369 5134.35 5368.95
 5136.65 5368.96 5140.78 5369.15 5142.74 5369.23 5145.14  5369.3 5151.03 5369.46
 5154.02 5369.55 5157.66 5369.62 5161.28 5369.69 5165.29 5369.77 5170.19 5369.93
 5171.52 5369.97 5176.56 5370.14 5181.77  5370.2 5182.71 5370.21 5187.83 5370.27
 5192.02 5370.26 5195.23 5370.24  5199.1 5370.23 5202.27 5370.28 5207.75 5370.38
 5210.37 5370.43 5212.51 5370.47 5220.27 5370.63 5221.64 5370.66 5222.76 5370.65
 5232.77 5370.69

Manning's n Values        num=       5
     Sta   n Val     Sta   n Val     Sta   n Val     Sta   n Val     Sta   n Val
 4892.85    .035 4904.42    .035 4925.19    .035 5084.41    .035 5170.19    .035

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
       4925.19 5084.41               0       0       0             .1       .3

CROSS SECTION


RIVER: BocaNegraArroyo
REACH: Reach - 1 Lower    RS: 20573.7

INPUT
Description: Cross Section Boca Negra Arroyo 22.75 - H
Station Elevation Data    num=     112
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
  4882.6 5366.22 4883.94 5366.17 4888.67  5365.9 4896.32  5365.5 4896.46 5365.49
 4896.54 5365.49  4896.9 5365.48 4904.24 5365.32 4909.14 5365.28 4912.03 5365.19
 4916.71 5365.15 4919.82 5365.08 4921.74 5365.04  4927.6  5364.7 4929.87 5364.58
 4934.33 5364.35 4935.39 5364.27 4937.09 5364.17 4943.17 5363.84 4946.93 5363.73
 4950.96  5363.5 4957.48 5363.17 4958.75 5363.09 4959.53 5363.04 4962.85 5362.75
 4966.53 5362.43 4972.13 5361.95 4974.32 5361.82 4977.87 5361.59 4981.89 5361.27
 4982.32 5361.22 4984.47 5361.02 4985.75 5360.93 4990.78  5360.6  4994.9 5360.33
 4995.95 5360.27 4997.71 5360.23 5004.05 5360.05 5007.42 5359.99  5013.1 5359.99
  5013.2 5359.99  5014.7 5359.99  5018.9 5359.99 5022.35 5360.05 5028.49 5360.16
 5030.38 5360.19  5031.5 5360.21  5035.9 5360.33 5040.65 5360.47 5041.85  5360.5
 5043.88 5360.54 5049.79 5360.66 5053.33 5360.73 5058.94 5360.81 5059.27 5360.82
  5064.8 5360.92 5068.09 5360.92 5074.66 5360.95 5076.28 5360.96 5077.24 5360.95
 5081.02 5360.91 5086.39 5360.84 5087.75 5360.82 5090.05 5360.78 5095.54  5360.7
 5099.23 5360.63 5104.69 5360.74 5105.44 5360.74 5110.71 5360.82 5113.84 5360.95
 5120.83 5361.24 5122.18  5361.3 5122.99 5361.31 5126.15 5361.43 5132.13 5361.63
 5133.66 5361.69 5136.22 5361.69 5141.28 5361.66 5145.13 5361.67 5147.97 5361.65
 5149.91 5361.66 5155.18 5361.72 5157.14 5361.71 5159.23 5361.72 5164.36 5361.74
 5169.16 5361.79 5171.59 5361.79 5174.19 5361.83 5178.81 5361.89 5183.14 5361.95
 5186.04    5362 5189.15 5362.08 5193.27 5362.22 5197.11 5362.35 5200.49 5362.51
  5204.1 5362.69 5207.72 5362.89 5211.09 5363.08 5214.94 5363.26 5219.06 5363.46
 5222.17 5363.57 5225.07 5363.67 5229.39 5363.74 5234.02 5363.85 5236.62 5363.86
 5239.04 5363.89 5243.84 5363.94 5248.98 5363.96 5251.07 5363.95 5253.02 5363.96
 5258.29 5363.95 5263.23 5363.96

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
  4882.6    .035 4990.78    .035 5049.79    .035

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
       4990.78 5049.79            183.1   183.1   183.1             .1       .3

CROSS SECTION
```

RIVER: BocaNegraArroyo
REACH: Reach - 1 Lower RS: 20390.6

INPUT
Description: Cross Section Boca Negra Arroyo 22.5 - G
Station Elevation Data num= 81

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
4871.5	5362.11	4873.57	5362.12	4880.55	5362.19	4880.81	5362.18	4881.09	5362.18
4888.06	5361.87	4894.79	5361.8	4895.3	5361.78	4895.84	5361.79	4902.55	5361.49
4909.03	5361.25	4909.79	5361.2	4910.59	5361.16	4917.04	5360.71	4923.27	5360.29
4924.29	5360.19	4925.33	5360.12	4931.53	5359.56	4937.52	5359.19	4938.78	5359.12
4940.08	5359.05	4946.02	5358.89	4950.87	5358.82	4952.52	5358.82	4954.15	5358.79
4959.26	5358.75	4960.57	5358.74	4966.36	5358.69	4968.61	5358.72	4972.96	5358.8
4976.65	5358.87	4978.56	5358.91	4984.59	5358.99	4984.69	5358.99	4990.77	5359.06
4992.74	5359.07	4996.53	5359.04	5000.78	5359.01	5002.98	5358.99	5004.29	5358.97
5008.82	5358.92	5009.91	5358.9	5015.19	5358.81	5016.86	5358.78	5020.1	5358.71
5024.91	5358.65	5027.39	5358.59	5032.95	5358.43	5035.23	5358.35	5039.6	5358.21
5040.99	5358.19	5043.67	5358.19	5049.03	5358.25	5051.81	5358.29	5057.07	5358.51
5060.56	5358.68	5064.02	5358.83	5065.12	5358.88	5067.24	5358.97	5073.16	5359.24
5076.23	5359.42	5076.96	5359.47	5080.72	5359.79	5084.22	5360.08	5087.86	5360.33
5092.83	5360.53	5095	5360.59	5096.58	5360.59	5102.13	5360.43	5106.79	5360.33
5108.94	5360.28	5109.27	5360.29	5109.73	5360.3	5116.41	5360.63	5121.29	5360.97
5123.54	5361.1	5126.62	5361.28	5130.68	5361.38	5133.65	5361.43	5137.82	5361.44
5143.07	5361.49								

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
4871.5	.035	5020.1	.035	5060.56	.035

Bank Sta: Left	Right	Lengths: Left Channel	Right	Coeff Contr.	Expan.
5020.1	5060.56	620	620	.1	.3

CROSS SECTION

RIVER: BocaNegraArroyo
REACH: Reach - 1 Lower RS: 19770.6

INPUT
Description: Cross Section Boca Negra Arroyo 22.0 - F
Station Elevation Data num= 86

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
4836.3	5355.13	4839.83	5355.07	4841.82	5355.03	4846.53	5354.94	4852.04	5354.84
4852.26	5354.84	4857.78	5354.74	4862.7	5354.65	4864.24	5354.63	4869.04	5354.55
4873.14	5354.37	4876.45	5354.23	4880.3	5354.06	4883.59	5353.91	4888.66	5353.64
4891.55	5353.51	4894.03	5353.41	4900.86	5353.1	4902.81	5353.02	4904.47	5352.92
4913.07	5352.46	4914.06	5352.4	4914.91	5352.35	4925.28	5351.69	4925.32	5351.69
4925.36	5351.69	4925.82	5351.68	4935.8	5351.42	4936.58	5351.4	4937.49	5351.39
4946.24	5351.4	4947.83	5351.39	4949.69	5351.4	4956.68	5351.4	4959.09	5351.41
4961.9	5351.44	4967.13	5351.49	4970.34	5351.52	4974.11	5351.47	4977.57	5351.44
4981.6	5351.39	4986.31	5351.12	4988.01	5351.01	4992.86	5350.74	4998.46	5350.52
4998.52	5350.51	5000.82	5350.42	5002.71	5350.46	5005.28	5350.49	5007.48	5350.54
5012.75	5350.7	5014.55	5350.74	5016.08	5350.76	5022.79	5350.89	5023.82	5350.91
5024.69	5350.94	5032.84	5351.28	5033.08	5351.29	5033.3	5351.3	5036.05	5351.39
5041.9	5351.56	5042.35	5351.58	5042.88	5351.6	5050.51	5351.92	5051.62	5351.98
5052.92	5352.02	5059.12	5352.15	5060.89	5352.21	5062.97	5352.25	5067.72	5352.35
5070.16	5352.39	5073.01	5352.45	5076.33	5352.52	5079.43	5352.59	5083.05	5352.75
5084.94	5352.81	5088.7	5352.98	5093.1	5353.36	5093.54	5353.4	5097.97	5353.79
5102.15	5354.21	5103.14	5354.31	5107.24	5354.73	5110.76	5354.98	5113.18	5355.12
5113.51	5355.14								

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
4836.3	.035	4961.9	.035	5032.84	.035

Bank Sta: Left	Right	Lengths: Left Channel	Right	Coeff Contr.	Expan.
4961.9	5032.84	1004.3	1004.3	.1	.3

CROSS SECTION

RIVER: BocaNegraArroyo
REACH: Reach - 1 Lower RS: 18766.3

INPUT
Description: Cross Section Boca Negra Arroyo 21.0 - E
Station Elevation Data num= 170

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
4737	5344.11	4737.65	5344.1	4743	5344.03	4746.73	5343.99	4747.73	5344
4749.46	5344.04	4755.8	5344.21	4759.23	5344.29	4764.87	5344.31	4765.17	5344.31
4770.73	5344.3	4773.94	5343.98	4780.88	5343.11	4782.23	5342.96	4783.01	5342.8
4785.92	5342.15	4792.08	5340.76	4793.73	5340.37	4796.6	5339.66	4801.15	5338.5
4805.24	5337.49	4810.22	5336.54	4812.31	5336.21	4816.74	5335.43	4819.3	5335.29
4828.02	5335.1	4828.24	5335.09	4828.37	5335.09	4828.84	5335.09	4837.44	5335.22
4839.74	5335.27	4843.74	5335.43	4846.51	5335.51	4851.24	5335.75	4855.58	5335.96
4859.45	5336.16	4862.75	5336.32	4864.65	5336.32	4871.76	5336.25	4873.72	5336.23
4874.25	5336.22	4875.16	5336.17	4882.79	5335.8	4885.75	5335.62	4890.88	5335.42
4891.86	5335.39	4897.25	5335.17	4900.94	5335.1	4906.59	5334.93	4908.76	5334.88
4910.01	5334.88	4914.67	5334.94	4919.08	5334.99	4920.26	5335	4922.3	5335.18
4928.15	5335.65	4931.76	5335.97	4937.22	5336.35	4938.01	5336.39	4943.26	5336.72

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 4946.29 5337.12 4953.73 5338.07 4954.76  5338.2 4955.36 5338.28 4957.59 5338.63
 4964.43 5339.71 4966.27 5339.95 4969.44 5339.92  4973.5  5339.9 4977.77 5339.85
 4982.58 5339.63 4982.85 5339.61 4984.07 5339.57  4989.5 5339.48  4992.4 5339.45
 4999.16 5339.45 5000.74 5339.43 5001.41 5339.43 5002.87 5339.43 5003.11 5339.42
 5009.07 5339.42 5013.32 5339.39  5017.4 5339.62 5019.73  5339.7 5022.75  5339.8
 5024.87 5339.91 5028.19 5340.12    5032  5340.4 5034.44 5340.56 5039.14 5340.85
  5045.5 5341.33 5046.13 5341.38 5046.27 5341.38 5046.49  5341.4  5053.4 5341.55
 5057.82 5341.59 5060.54 5341.57 5064.78 5341.47 5067.67 5341.15 5069.52 5340.87
  5074.8 5340.14 5077.89 5339.55 5081.21 5338.97 5081.94 5338.82 5083.08 5338.56
 5089.07 5336.78  5092.9 5335.74  5096.2 5334.79 5101.38 5333.53 5103.34  5333.2
 5104.59    5333 5110.28    5332 5110.47 5331.97 5116.28 5331.23  5117.6 5331.12
 5119.67 5331.02 5124.74 5331.02 5127.97 5331.04 5131.87 5331.11 5137.97 5331.16
    5139 5331.17 5139.67 5331.18 5142.67 5331.23 5146.14 5331.29 5151.36 5331.34
 5153.27 5331.36 5156.27 5331.42  5160.4  5331.5 5163.05 5331.55 5167.54 5331.66
 5174.56 5331.79 5174.67 5331.79 5174.74 5331.79 5175.06  5331.8 5181.81 5331.95
 5186.43 5332.05 5188.94 5332.14 5192.86 5332.31 5196.07 5332.47 5198.13  5332.6
 5203.21 5333.22 5207.45 5333.87 5209.82 5334.22 5210.34 5334.32 5211.16 5334.52
 5217.47 5336.08 5221.51 5337.14 5224.61 5337.96 5229.45 5339.22 5231.74 5339.77
  5233.2 5340.03 5238.87 5340.76 5239.84 5340.82 5244.89 5341.22 5246.01 5341.28
 5247.75 5341.36 5253.14 5341.74 5256.59 5341.94 5260.27 5342.13 5266.05 5342.39
 5267.41 5342.48 5268.28 5342.55 5272.23 5342.81 5274.54 5342.97 5279.97 5343.29
 5281.67 5343.39 5284.34 5343.46 5288.81 5343.52 5291.66 5343.51 5293.03 5343.48

Manning's n Values        num=       5
     Sta   n Val     Sta   n Val     Sta   n Val     Sta   n Val     Sta   n Val
    4737    .035 4792.08    .035 4846.51    .035 4919.08    .035 5238.87    .035

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
       4792.08 5238.87             750.2   750.2   750.2             .1       .3

CROSS SECTION


RIVER: BocaNegraArroyo
REACH: Reach - 1 Lower    RS: 18016.1

INPUT
Description: Cross Section Boca Negra Arroyo 20.0 - D
Station Elevation Data    num=      58
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
  4907.3 5329.26 4907.49 5329.26  4915.3 5328.97 4917.24  5328.9 4917.56 5328.89
 4917.99 5328.87    4927 5328.56 4928.89 5328.51  4931.5 5328.39 4936.76 5328.12
 4940.22 5327.96 4945.01 5327.59 4946.52 5327.48 4951.55 5327.09 4953.11 5326.95
  4956.3 5326.63  4961.8 5326.16 4963.71 5325.99 4964.28 5325.95 4965.33 5325.87
 4972.26 5325.35    4976 5325.09 4980.23 5324.97 4988.06  5324.7 4988.21 5324.69
  4988.3 5324.69 4988.58  5324.7 4996.19 5324.95 5000.59 5325.23 5004.17 5325.63
 5007.38 5326.05 5010.78  5326.5 5012.14 5326.67 5012.88 5326.77 5013.56 5326.85
 5019.95 5327.58 5021.99 5327.83  5025.3 5328.14 5027.71 5328.35 5031.59 5328.74
 5035.48 5329.05 5037.89 5329.27  5041.2 5329.55 5043.24 5329.75 5050.48 5330.43
  5050.8 5330.46 5051.01 5330.48 5051.86 5330.56 5058.77 5331.06 5060.41 5331.17
 5063.06  5331.3 5066.54 5331.44 5070.01 5331.61  5074.3 5331.76 5075.65  5331.8
 5079.62 5331.93 5082.07 5332.03 5083.74 5332.08

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
  4907.3    .035 4936.76    .035  5025.3    .035

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
       4936.76  5025.3             886.3   886.3   886.3             .1       .3

CROSS SECTION


RIVER: BocaNegraArroyo
REACH: Reach - 1 Lower    RS: 17129.8

INPUT
Description: Cross Section Boca Negra Arroyo 19.5 - C
Station Elevation Data    num=      69
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
  4898.5 5317.18 4898.64 5317.17 4905.28 5316.84 4908.38 5316.69 4913.17 5316.43
 4914.67 5316.35 4919.79 5316.08 4924.06 5315.84  4927.7 5315.67 4931.19 5315.49
 4933.45 5315.34 4942.22 5314.72  4942.6 5314.69 4942.84 5314.67 4943.98 5314.59
 4952.23 5314.02 4954.01 5313.93 4956.75 5313.88 4961.62 5313.74 4965.41 5313.69
 4971.01 5313.55 4971.27 5313.54 4976.82  5313.4  4980.4 5313.21 4982.77 5313.06
 4987.32  5312.9 4988.36 5312.86 4989.19 5312.81 4995.84 5312.64 4996.39 5312.63
 5002.14 5312.48  5002.6 5312.47 5003.31 5312.44 5004.21 5312.44 5010.79  5312.3
 5016.02  5312.3 5018.26 5312.31 5021.09 5312.54 5025.58  5312.9 5025.73 5312.91
 5029.57 5313.31  5033.1 5313.61 5037.08 5313.95 5040.47 5314.11 5043.47 5314.21
 5047.83 5314.53 5052.75 5314.99  5055.2 5315.23 5057.37 5315.44 5062.56 5315.92
 5067.22 5316.32 5068.12  5316.4 5069.84 5316.52 5072.49 5316.66 5076.97 5316.86
  5079.9 5316.99 5084.11 5317.25 5090.57 5317.56 5091.24 5317.57 5091.67 5317.58
 5093.74 5317.64 5098.37 5317.77 5103.45 5317.92  5105.5 5317.92 5108.65 5317.98
 5112.63 5318.03 5115.23 5318.09 5119.77 5318.07  5125.6 5318.09

Manning's n Values        num=       4
     Sta   n Val     Sta   n Val     Sta   n Val     Sta   n Val
  4898.5    .035  4942.6    .035  4980.4    .035 5021.09    .035

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
       4980.4 5029.57             129.8   129.8   129.8             .1       .3
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CROSS SECTION

RIVER: BocaNegraArroyo
REACH: Reach - 1 Lower RS: 17000.0

INPUT
Description: Cross Section Boca Negra Arroyo 19.0 - B
Station Elevation Data num= 27

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
4971.2	5279.03	4972.63	5278.59	4972.96	5278.47	4973.15	5278.4	4973.81	5278.1
4980.13	5275.45	4984.31	5273.4	4987.29	5272.27	4992.6	5270.23	4994.45	5269.61
4995.48	5269.36	4998.4	5269.55	4998.52	5269.58	4998.64	5269.62	5002.89	5270.33
5005.24	5270.96	5007.26	5272.01	5012.91	5274.72	5014.51	5275.54	5015.88	5276.2
5022.93	5279.65	5023.78	5280.06	5024.5	5280.42	5032.96	5284.74	5033.04	5284.79
5033.12	5284.83	5033.8	5285.23						

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
4971.2	.05	4980.13	.05	5014.51	.05

Bank Sta: Left	Right	Lengths: Left Channel	Right	Coeff Contr.	Expan.
4980.13	5014.51	543	543	.1	.3

CROSS SECTION

RIVER: BocaNegraArroyo
REACH: Reach - 1 Lower RS: 16457.0

INPUT
Description: Cross Section Boca Negra Arroyo 18.0 -A
Station Elevation Data num= 53

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
4917.4	5207.88	4918.82	5207.27	4921.23	5206.35	4925.96	5205.18	4931.06	5204.24
4932.7	5203.91	4933.1	5203.89	4933.77	5203.85	4940.24	5203.56	4944.16	5203.38
4947.38	5203.09	4952.7	5202.32	4954.52	5202.09	4955.63	5201.93	4960.13	5201.66
4961.67	5201.55	4967.1	5201.37	4968.81	5201.59	4971.63	5202.06	4975.95	5202.55
4978.56	5202.72	4983.09	5202.43	4989.2	5201.72	4990.03	5201.64	4990.23	5201.6
4990.56	5201.53	4997.37	5200.11	4998.74	5199.92	4999.41	5199.83	5001.09	5199.66
5005.5	5199.46	5006.02	5199.48	5010.38	5199.33	5014.02	5199.54	5016.21	5199.84
5019.66	5200.08	5022.55	5200.43	5026.39	5201.07	5028.94	5201.39	5031.08	5201.6
5036.58	5202.12	5037.48	5202.21	5038.22	5202.26	5039.89	5202.37	5045.53	5202.75
5047.47	5202.87	5049.59	5203.17	5054.36	5203.8	5056.71	5204.14	5059.29	5204.66
5063.19	5205.35	5065.96	5205.91	5066.87	5206.04				

Manning's n Values num= 4

Sta	n Val	Sta	n Val	Sta	n Val	Sta	n Val
4917.4	.05	4933.1	.035	4944.16	.035	5049.59	.035

Bank Sta: Left	Right	Lengths: Left Channel	Right	Coeff Contr.	Expan.
4944.16	5049.59	0	0	.1	.3

SUMMARY OF MANNING'S N VALUES

River:BocaNegraArroyo

Reach	River Sta.	n1	n2	n3	n4	n5
Reach - 1 Upper	25374.6	.035	.035	.035		
Reach - 1 Upper	24989.3	.035	.035	.035		
Reach - 1 Upper	24106.4	.035	.035	.035		
Reach - 1 Upper	23000.0	.035	.035	.035		
Reach - 1 Upper	22241.1	.035	.035	.035		
Reach - 1 Mid	22027.5	.035	.035	.035		
Reach - 1 Mid	21845.5	.035	.035	.035		
Reach - 1 Mid	21335.5	.035	.035	.035		
Reach - 1 Mid	21001.7	.035	.035	.035		
Split Flow	22027.5	.035	.035	.035	.035	
Split Flow	21845.5	.035	.035	.035		
Split Flow	21335.5	.035	.035	.035		
Split Flow	21001.7	.035	.035	.035		
Split Flow	20774.5	.035	.035	.035	.035	.035
Reach - 1 Lower	20573.7	.035	.035	.035		
Reach - 1 Lower	20390.6	.035	.035	.035		
Reach - 1 Lower	19770.6	.035	.035	.035		
Reach - 1 Lower	18766.3	.035	.035	.035	.035	.035
Reach - 1 Lower	18016.1	.035	.035	.035		
Reach - 1 Lower	17129.8	.035	.035	.035	.035	
Reach - 1 Lower	17000.0	.05	.05	.05		
Reach - 1 Lower	16457.0	.05	.035	.035	.035	

SUMMARY OF REACH LENGTHS

River: BocaNegraArroyo

Reach	River Sta.	Left	Channel	Right
Reach - 1 Upper	25374.6	385.3	385.3	385.3
Reach - 1 Upper	24989.3	882.9	882.9	882.9
Reach - 1 Upper	24106.4	1106.4	1106.4	1106.4
Reach - 1 Upper	23000.0	758.9	758.9	758.9
Reach - 1 Upper	22241.1	0	0	0
Reach - 1 Mid	22027.5	182	182	182
Reach - 1 Mid	21845.5	510	510	510
Reach - 1 Mid	21335.5	333.8	333.8	333.8
Reach - 1 Mid	21001.7	0	0	0
Split Flow	22027.5	146	146	146
Split Flow	21845.5	628	628	628
Split Flow	21335.5	683	683	683
Split Flow	21001.7	130	130	130
Split Flow	20774.5	0	0	0
Reach - 1 Lower	20573.7	183.1	183.1	183.1
Reach - 1 Lower	20390.6	620	620	620
Reach - 1 Lower	19770.6	1004.3	1004.3	1004.3
Reach - 1 Lower	18766.3	750.2	750.2	750.2
Reach - 1 Lower	18016.1	886.3	886.3	886.3
Reach - 1 Lower	17129.8	129.8	129.8	129.8
Reach - 1 Lower	17000.0	543	543	543
Reach - 1 Lower	16457.0	0	0	0

SUMMARY OF CONTRACTION AND EXPANSION COEFFICIENTS
River: BocaNegraArroyo

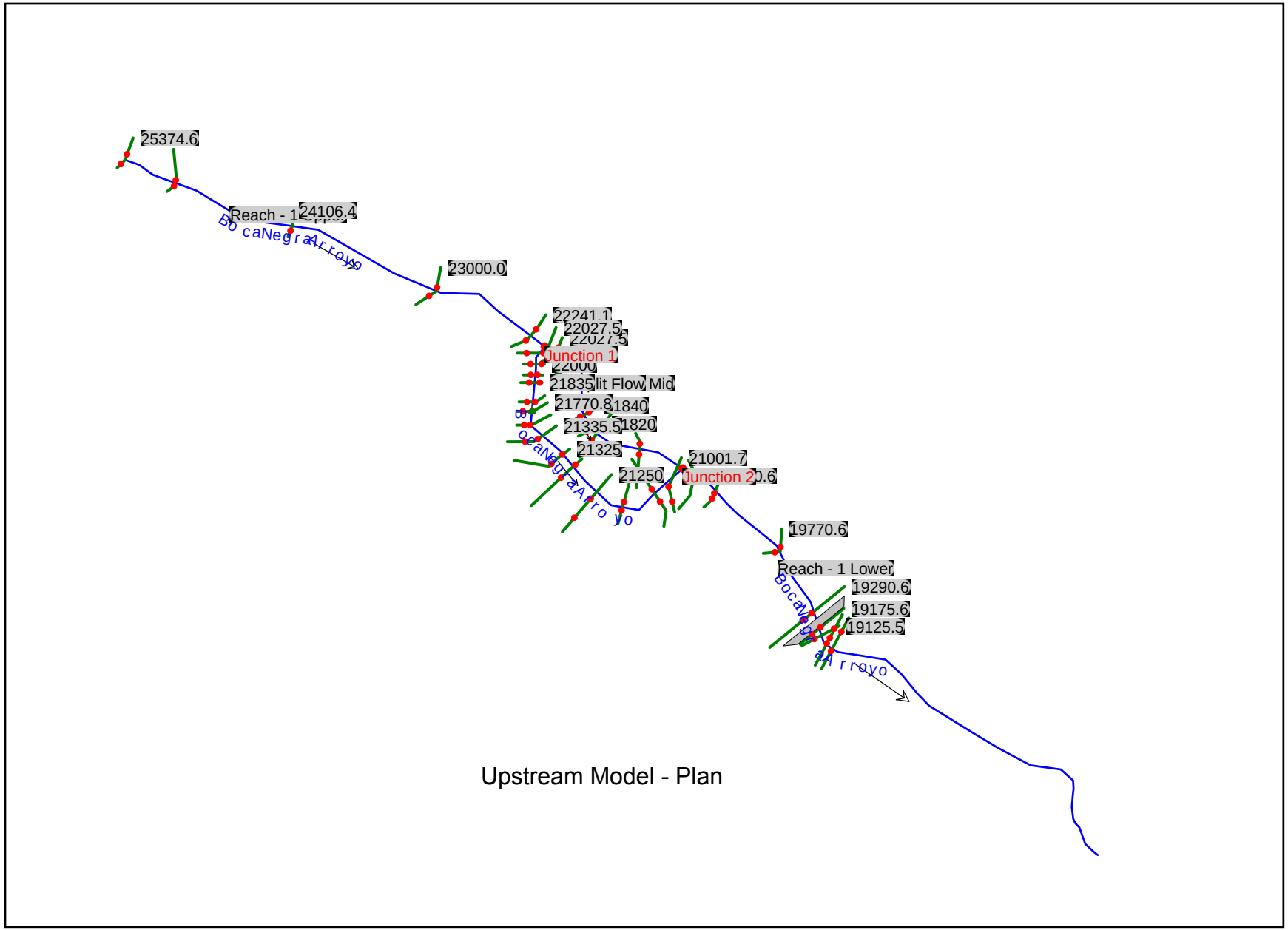
Reach	River Sta.	Contr.	Expan.
Reach - 1 Upper	25374.6	.1	.3
Reach - 1 Upper	24989.3	.1	.3
Reach - 1 Upper	24106.4	.1	.3
Reach - 1 Upper	23000.0	.1	.3
Reach - 1 Upper	22241.1	.1	.3
Reach - 1 Mid	22027.5	.1	.3
Reach - 1 Mid	21845.5	.1	.3
Reach - 1 Mid	21335.5	.1	.3
Reach - 1 Mid	21001.7	.1	.3
Split Flow	22027.5	.1	.3
Split Flow	21845.5	.1	.3
Split Flow	21335.5	.1	.3
Split Flow	21001.7	.1	.3
Split Flow	20774.5	.1	.3
Reach - 1 Lower	20573.7	.1	.3
Reach - 1 Lower	20390.6	.1	.3
Reach - 1 Lower	19770.6	.1	.3
Reach - 1 Lower	18766.3	.1	.3
Reach - 1 Lower	18016.1	.1	.3
Reach - 1 Lower	17129.8	.1	.3
Reach - 1 Lower	17000.0	.1	.3
Reach - 1 Lower	16457.0	.1	.3

Current Upstream Floodway Model

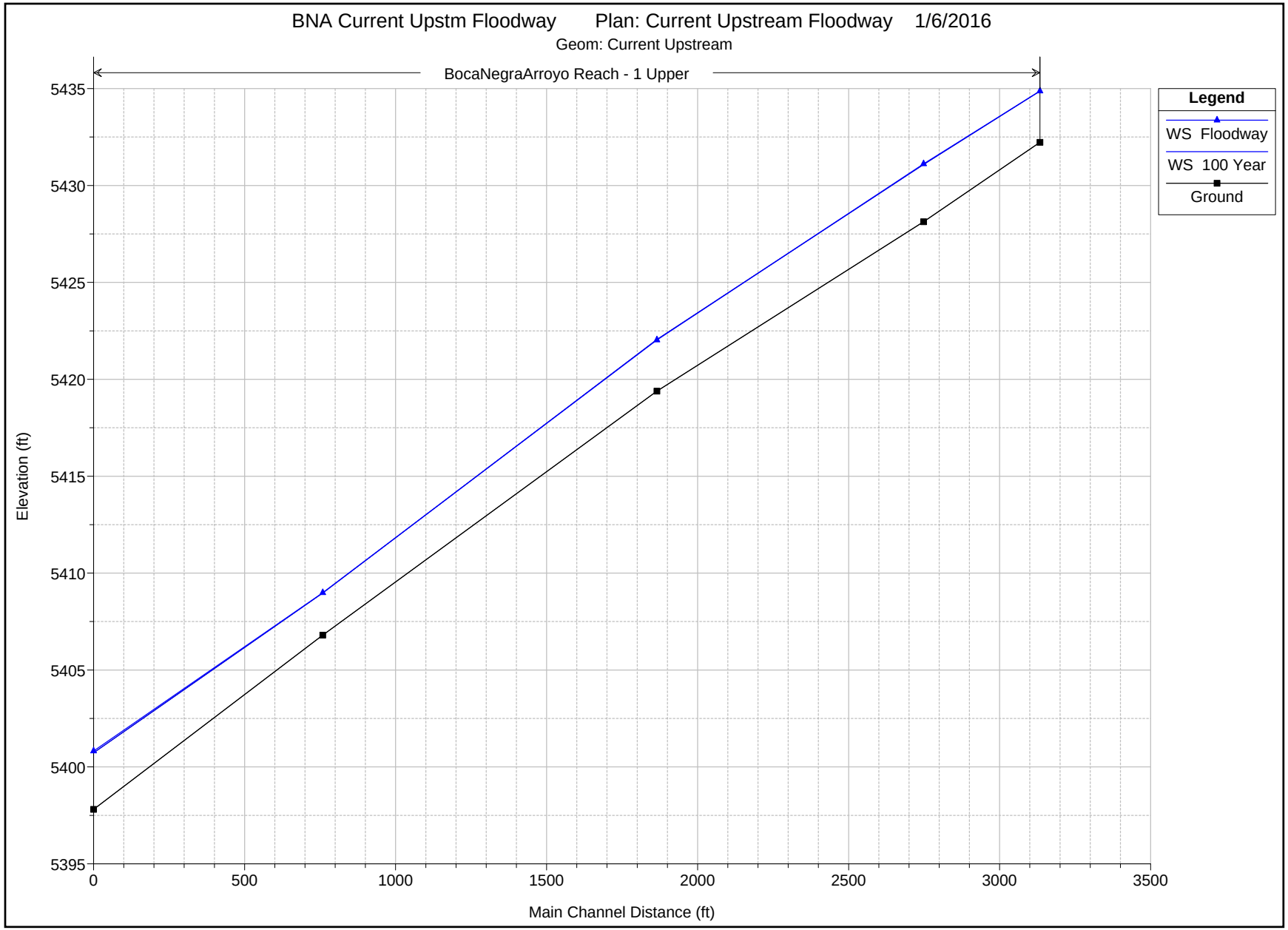
Plan
Profile
Summary
Cross Sections
Input/output Report

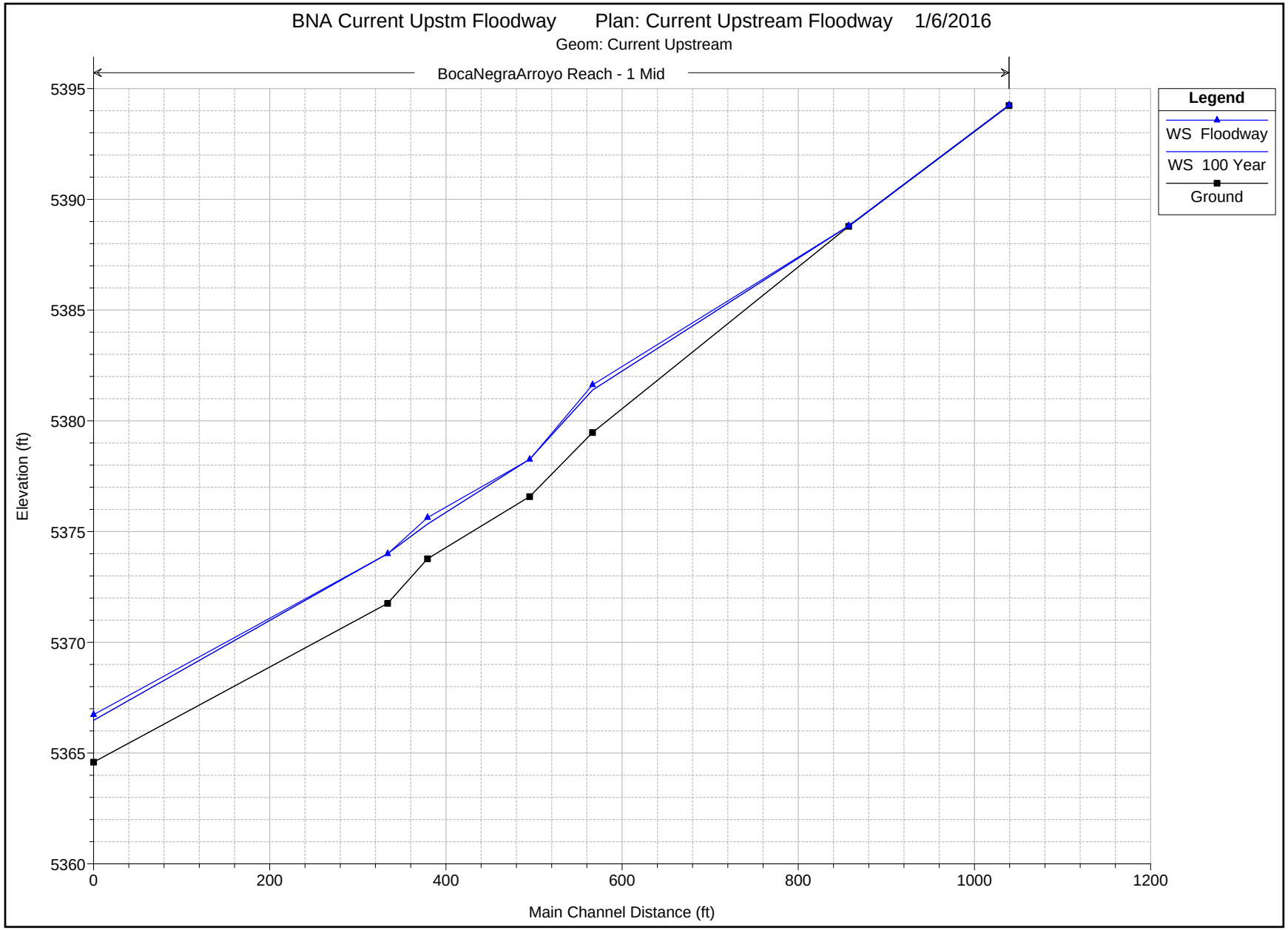
Hydraulics Model – HEC-RAS Analysis (CD)
Current Upstream Floodway Files

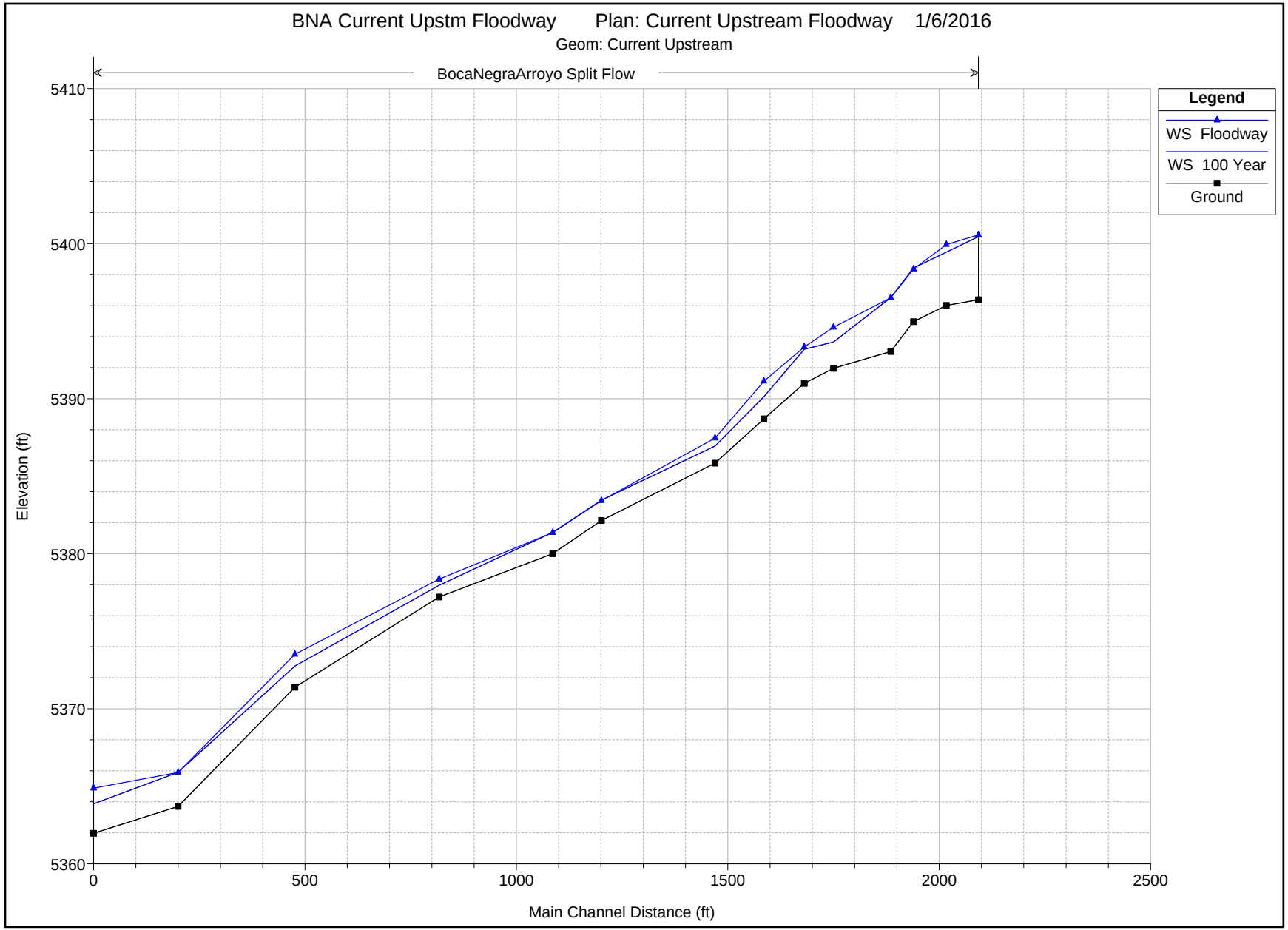
i.Project:	BNA Current Upstm Floodway CurrentUpstm Floodway.prj	
ii.Plan:	Current Upstream Floodway	CurrentUpstm Floodway.p08
iii.Geometry:	Current Upstream	CurrentUpstm Floodway.g05
iv.Flow:	Updated 2014	CurrentUpstm Floodway.f01

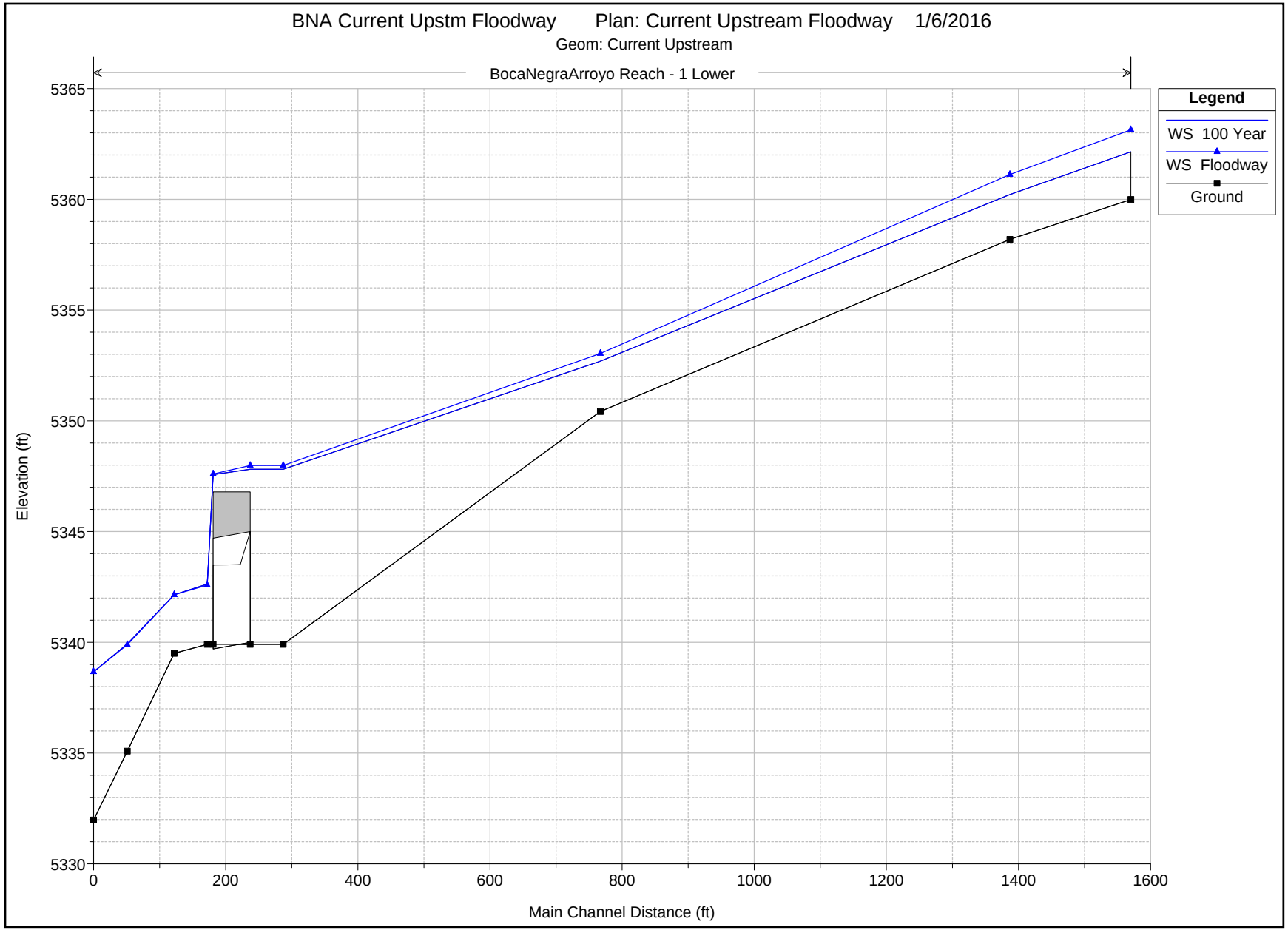


Upstream Floodway Model


BNA Current Upstm Floodway Plan: Current Upstream Floodway 1/6/2016
Geom: Current Upstream
BocaNegraArroyo Reach - 1 Upper
Legend
WS Floodway
WS 100 Year
Ground
Elevation (ft)
5435
5430
5425
5420
5415
5410
5405
5400
5395
0
500
1000
1500
2000
2500
3000
3500
Main Channel Distance (ft)


BNA Current Upstm Floodway Plan: Current Upstream Floodway 1/6/2016
Geom: Current Upstream
BocaNegraArroyo Reach - 1 Mid
Legend
WS Floodway
WS 100 Year
Ground
Elevation (ft)
5395
5390
5385
5380
5375
5370
5365
5360
0
200
400
600
800
1000
1200
Main Channel Distance (ft)


BNA Current Upstm Floodway Plan: Current Upstream Floodway 1/6/2016
Geom: Current Upstream
BocaNegraArroyo Split Flow
Legend
WS Floodway
WS 100 Year
Ground
Elevation (ft)
5410
5400
5390
5380
5370
5360
0
500
1000
1500
2000
2500
Main Channel Distance (ft)



Upstream Floodway Model

HEC-RAS Plan: 2

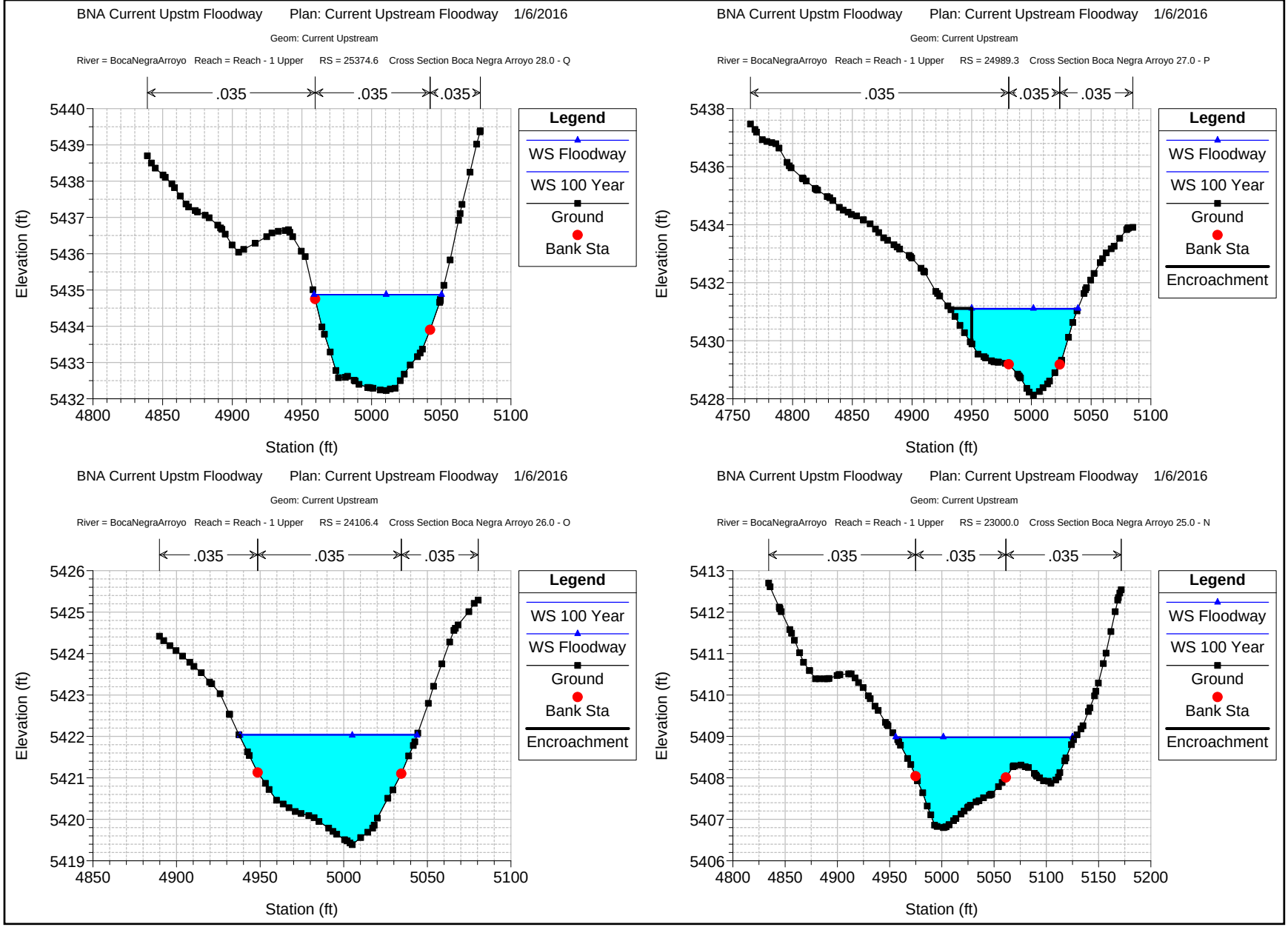
Reach	River Sta	Profile	W.S. Elev	Prof Delta WS	E.G. Elev	Top Wdth Act	Q Left	Q Channel	Q Right	Enc Sta L	Ch Sta L	Ch Sta R	Enc Sta R
			(ft)	(ft)	(ft)	(ft)	(cfs)	(cfs)	(cfs)	(ft)	(ft)	(ft)	(ft)
Reach - 1 Upper	25374.6	100 Year	5434.87		5435.60	91.48	0.03	1163.60	11.37		4959.52	5042.01	
Reach - 1 Upper	25374.6	Floodway	5434.87	0.00	5435.60	91.53	0.03	1163.51	11.46	4950.00	4959.52	5042.01	5051.00
Reach - 1 Upper	24989.3	100 Year	5431.09		5431.81	106.39	312.28	806.07	56.66		4980.99	5023.67	
Reach - 1 Upper	24989.3	Floodway	5431.12	0.03	5431.87	89.00	305.86	811.01	58.13	4950.00	4980.99	5023.67	5125.00
Reach - 1 Upper	24106.4	100 Year	5422.05		5422.78	106.88	13.89	1148.09	13.02		4948.54	5034.40	
Reach - 1 Upper	24106.4	Floodway	5422.03	-0.02	5422.78	105.83	13.58	1149.01	12.41	4938.00	4948.54	5034.40	5044.00
Reach - 1 Upper	23000.0	100 Year	5408.97		5409.58	171.05	22.52	947.97	204.50		4974.92	5061.35	
Reach - 1 Upper	23000.0	Floodway	5408.99	0.02	5409.58	169.12	23.03	941.19	210.78	4955.00	4974.92	5061.35	5125.00
Reach - 1 Upper	22241.1	100 Year	5400.73		5400.98	157.02	36.31	1109.19	29.50		4942.34	5048.02	
Reach - 1 Upper	22241.1	Floodway	5400.82	0.09	5401.04	160.00	40.81	1102.46	31.72	4905.00	4942.34	5048.02	5065.00
Reach - 1 Mid	22027.5	100 Year	5394.25		5394.25	3.99		0.01			4967.55	5062.32	
Reach - 1 Mid	22027.5	Floodway	5394.26	0.00	5394.26	4.31		0.01		4967.55	4967.55	5062.32	5062.32
Reach - 1 Mid	21845.5	100 Year	5388.80		5388.80	3.93		0.01			4975.28	5023.67	
Reach - 1 Mid	21845.5	Floodway	5388.80	0.00	5388.80	3.93		0.01		4975.28	4975.28	5023.67	5023.67
Reach - 1 Mid	21840	100 Year	5381.39		5381.97	93.67	139.80	469.41	2.79		67.81	123.25	
Reach - 1 Mid	21840	Floodway	5381.62	0.23	5382.41	55.44		612.00		67.81	67.81	123.25	123.25
Reach - 1 Mid	21830	100 Year	5378.27		5378.89	83.88	20.45	586.75	4.80		47.75	113.71	
Reach - 1 Mid	21830	Floodway	5378.26	-0.01	5378.96	65.96		612.00		47.75	47.75	113.71	113.71
Reach - 1 Mid	21820	100 Year	5375.34		5375.82	121.51	183.48	423.44	5.07		73.59	132.32	
Reach - 1 Mid	21820	Floodway	5375.63	0.29	5376.39	58.73		612.00		73.59	73.59	132.32	132.32
Reach - 1 Mid	21335.5	100 Year	5374.00		5374.51	107.29		612.00			5041.64	5161.54	
Reach - 1 Mid	21335.5	Floodway	5374.00	0.00	5374.51	107.18		612.00		5041.64	5041.64	5161.54	5161.54
Reach - 1 Mid	21001.7	100 Year	5366.48		5367.17	64.25		612.00			4964.29	5038.83	
Reach - 1 Mid	21001.7	Floodway	5366.74	0.26	5367.23	67.61		612.00		4964.29	4964.29	5038.83	5038.83
Split Flow	22027.5	100 Year	5400.45		5400.63	140.41	2.67	1179.49	2.84		112.42	231.02	
Split Flow	22027.5	Floodway	5400.56	0.12	5400.73	118.60		1185.00		112.42	112.42	231.02	231.02
Split Flow	22000	100 Year	5399.45		5400.31	89.37	2.67	1181.87	0.46		18.89	96.33	
Split Flow	22000	Floodway	5399.94	0.49	5400.51	77.44		1185.00		18.89	18.89	96.33	96.33
Split Flow	21840	100 Year	5398.43		5399.45	82.34	61.88	1084.65	38.47		39.07	85.22	
Split Flow	21840	Floodway	5398.35	-0.07	5399.74	46.15		1185.00		39.07	39.07	85.22	85.22
Split Flow	21835	100 Year	5396.52		5397.53	74.97	0.04	1184.96			15.66	89.49	

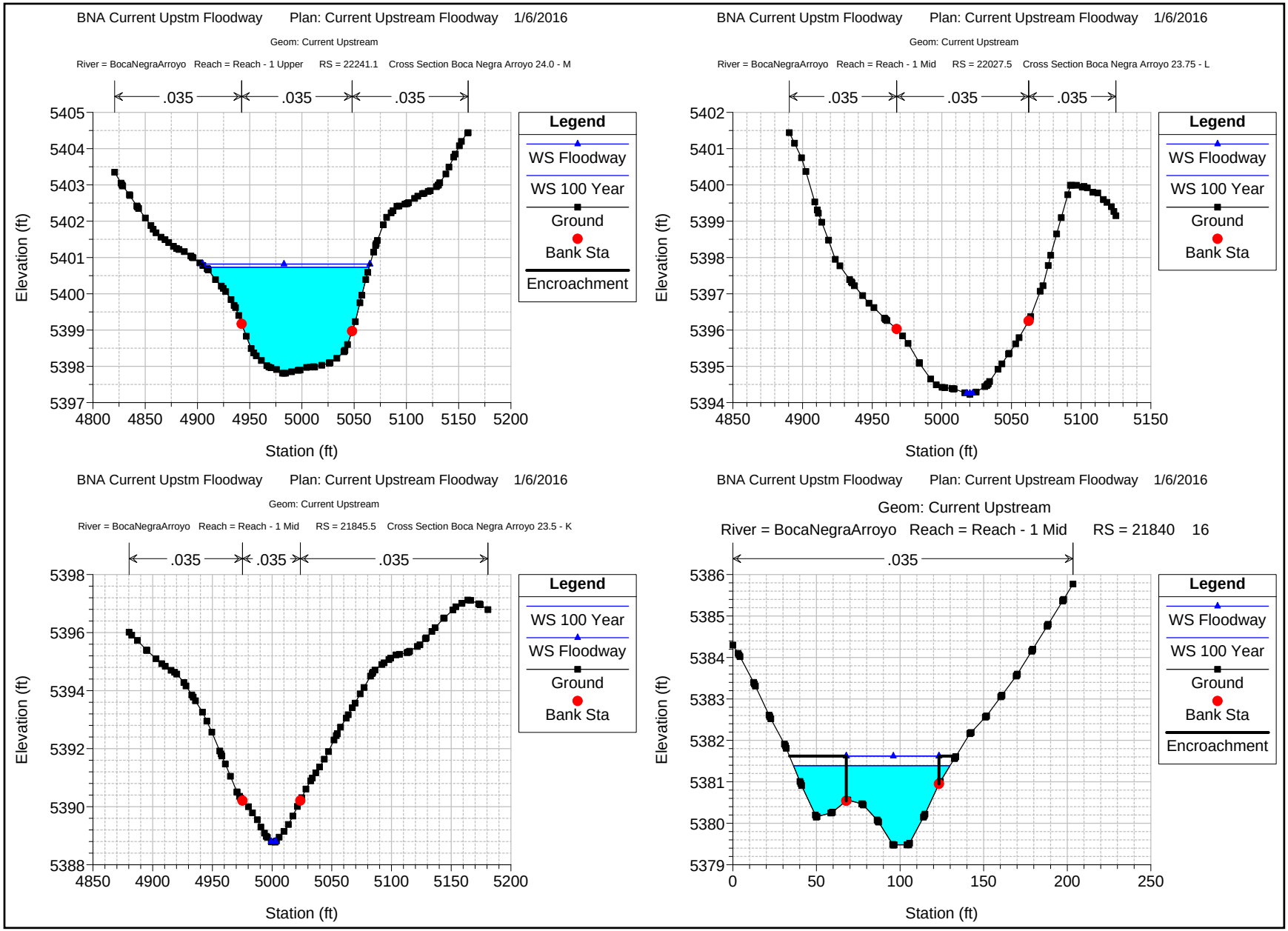
HEC-RAS Plan: 2 (Continued)

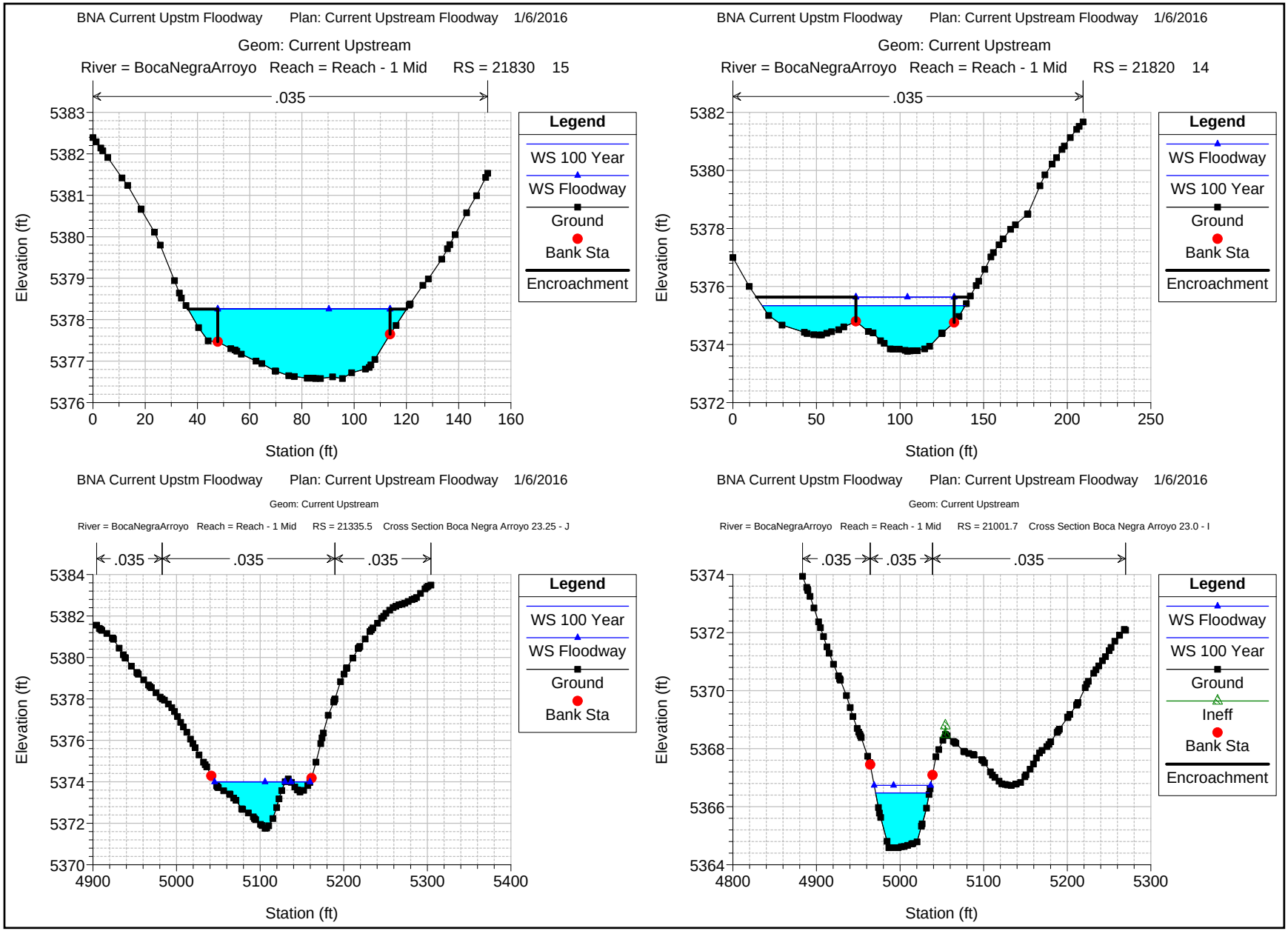
Reach	River Sta	Profile	W.S. Elev	Prof Delta WS	E.G. Elev	Top Wdth Act	Q Left	Q Channel	Q Right	Enc Sta L	Ch Sta L	Ch Sta R	Enc Sta R
			(ft)	(ft)	(ft)	(ft)	(cfs)	(cfs)	(cfs)	(ft)	(ft)	(ft)	(ft)
Split Flow	21835	Floodway	5396.51	-0.01	5397.53	73.74		1185.00		15.66	15.66	89.49	89.49
Split Flow	21800	100 Year	5393.66		5394.18	100.47	389.27	213.73			81.22	136.60	
Split Flow	21800	Floodway	5394.61	0.95	5395.21	82.60	53.41	549.59		54.00	81.22	136.60	136.60
Split Flow	21770.8	100 Year	5393.19		5393.30	189.16	382.35	220.61	0.04		123.06	187.45	
Split Flow	21770.8	Floodway	5393.33	0.14	5394.03	64.39		603.00		123.06	123.06	187.45	187.45
Split Flow	21520.8	100 Year	5390.13		5390.49	172.48	479.61	123.39			160.48	202.23	
Split Flow	21520.8	Floodway	5391.13	1.00	5391.74	76.00	121.37	464.13	17.50	131.00	160.48	202.23	207.00
Split Flow	21335.5	100 Year	5386.94		5387.15	236.96	360.79	239.99	2.22		158.88	251.40	
Split Flow	21335.5	Floodway	5387.46	0.52	5387.88	92.52		603.00		158.88	158.88	251.40	251.40
Split Flow	21325	100 Year	5383.46		5383.85	177.88	41.77	552.81	8.42		63.90	163.82	
Split Flow	21325	Floodway	5383.43	-0.03	5383.96	99.92		603.00		63.90	63.90	163.82	163.82
Split Flow	21315	100 Year	5381.37		5381.73	126.63		603.00			62.02	195.78	
Split Flow	21315	Floodway	5381.36	-0.01	5381.73	126.24		603.00		62.02	62.02	195.78	195.78
Split Flow	21250	100 Year	5377.97		5378.17	293.61	342.29	260.71			222.00	396.05	
Split Flow	21250	Floodway	5378.36	0.40	5378.60	174.05		603.00		222.00	222.00	396.05	396.05
Split Flow	21200	100 Year	5372.76		5373.22	112.52	405.77	197.23			128.95	189.91	
Split Flow	21200	Floodway	5373.51	0.76	5374.24	60.96		603.00		128.95	128.95	189.91	189.91
Split Flow	21194.9	100 Year	5365.90		5366.46	92.13		603.00			49.81	154.17	
Split Flow	21194.9	Floodway	5365.89	-0.01	5366.46	91.80		603.00		49.81	49.81	154.17	154.17
Split Flow	21001.7	100 Year	5363.87		5363.94	219.73	478.34	124.66			219.00	325.79	
Split Flow	21001.7	Floodway	5364.88	1.00	5364.93	231.79	228.71	374.29		94.00	219.00	325.79	325.79
Reach - 1 Lower	20573.7	100 Year	5362.14		5362.57	221.14	54.34	696.54	437.12		4990.78	5049.79	
Reach - 1 Lower	20573.7	Floodway	5363.14	0.99	5363.88	59.01		1188.00		4990.78	4990.78	5049.79	5049.79
Reach - 1 Lower	20390.6	100 Year	5360.22		5360.74	162.22	603.60	491.03	93.37		5020.10	5060.56	
Reach - 1 Lower	20390.6	Floodway	5361.12	0.90	5362.23	55.00	127.41	964.25	96.34	5012.00	5020.10	5060.56	5067.00
Reach - 1 Lower	19770.6	100 Year	5352.69		5353.28	172.94	257.59	817.34	113.07		4961.90	5032.84	
Reach - 1 Lower	19770.6	Floodway	5353.04	0.35	5354.08	70.94		1188.00		4961.90	4961.90	5032.84	5032.84
Reach - 1 Lower	19290.6	100 Year	5347.81		5347.82	433.22	433.80	583.88	170.33		208.45	282.53	
Reach - 1 Lower	19290.6	Floodway	5347.98	0.17	5348.06	74.08		1188.00		208.45	208.45	282.53	282.53
Reach - 1 Lower	19200		Culvert										

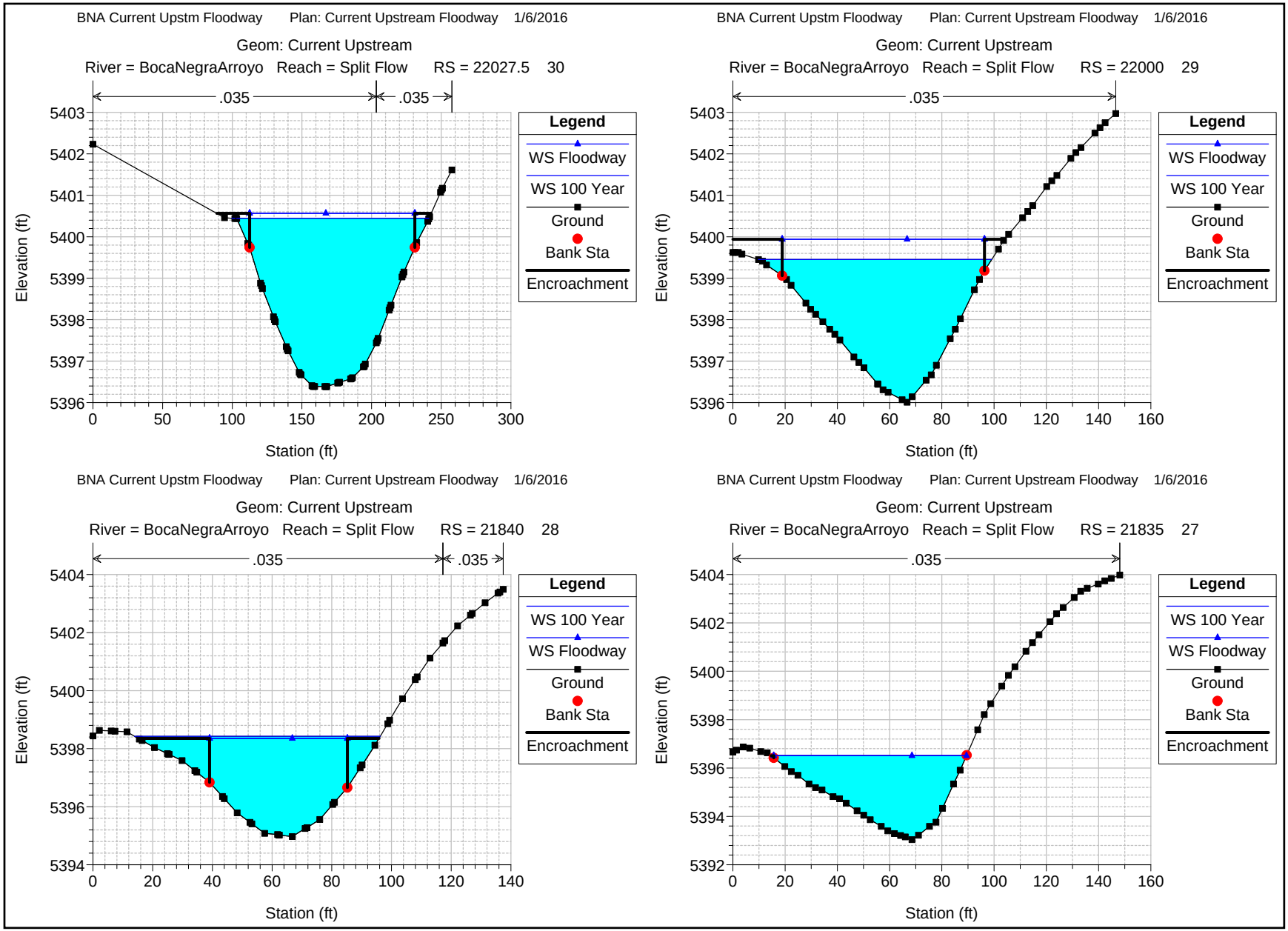
HEC-RAS Plan: 2 (Continued)

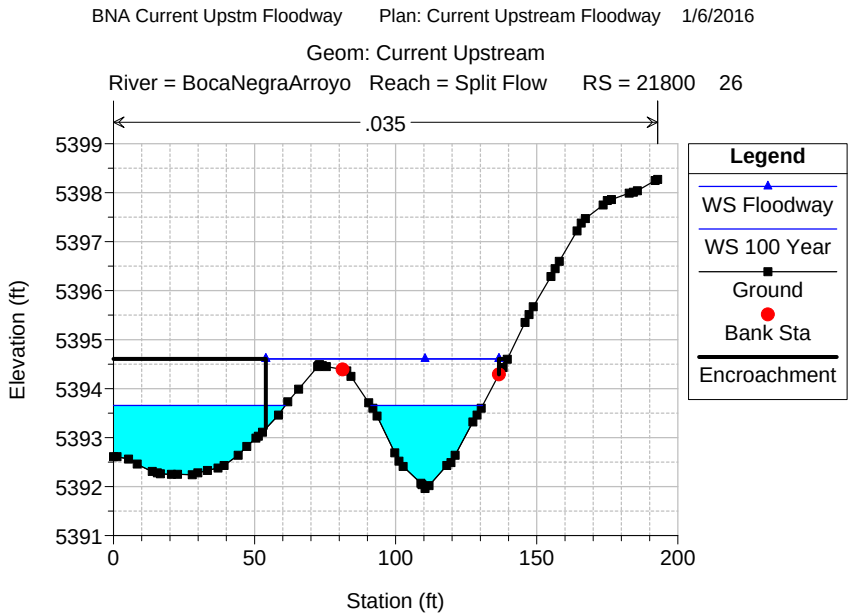
Reach	River Sta	Profile	W.S. Elev	Prof Delta WS	E.G. Elev	Top Wdth Act	Q Left	Q Channel	Q Right	Enc Sta L	Ch Sta L	Ch Sta R	Enc Sta R
			(ft)	(ft)	(ft)	(ft)	(cfs)	(cfs)	(cfs)	(ft)	(ft)	(ft)	(ft)
Reach - 1 Lower	19175.6	100 Year	5342.63		5343.43	121.26	63.08	1114.21	10.72		208.45	282.53	
Reach - 1 Lower	19175.6	Floodway	5342.58	-0.05	5343.59	74.08		1188.00		208.45	208.45	282.53	282.53
Reach - 1 Lower	19125.5	100 Year	5342.15		5342.91	113.51		1188.00			8.12	123.44	
Reach - 1 Lower	19125.5	Floodway	5342.15	0.00	5342.91	113.37		1188.00		8.12	8.12	123.44	123.44
Reach - 1 Lower	19054.6	100 Year	5339.93		5340.97	81.35	64.44	1078.95	44.62		183.95	228.20	
Reach - 1 Lower	19054.6	Floodway	5339.89	-0.04	5341.28	44.25		1188.00		183.95	183.95	228.20	228.20
Reach - 1 Lower	19003.57	100 Year	5338.67		5338.71	151.76		1188.00	0.00		108.43	260.42	
Reach - 1 Lower	19003.57	Floodway	5338.67	0.00	5338.71	151.69		1188.00		108.43	108.43	260.42	260.42

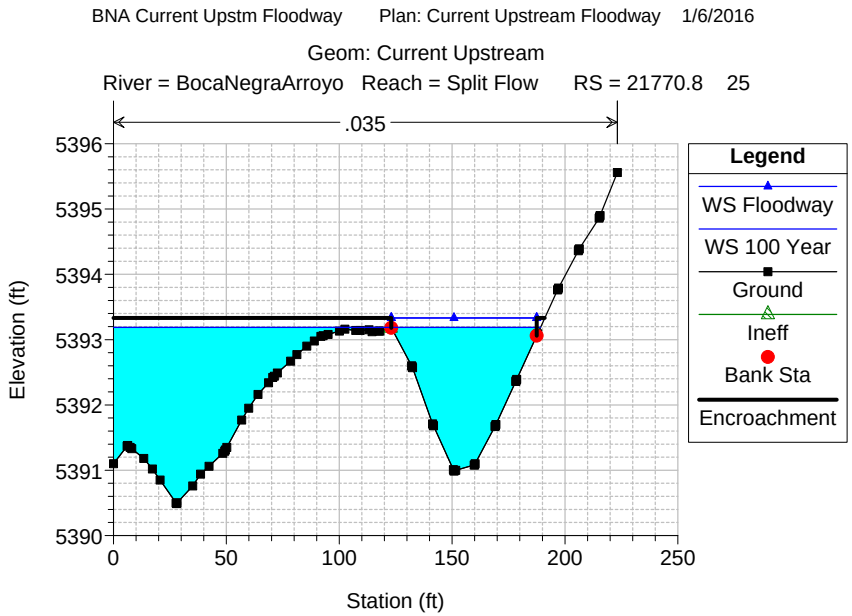

BNA Current Upstm Floodway Plan: Current Upstream Floodway 1/6/2016
Geom: Current Upstream
River = BocaNegraArroyo Reach = Reach - 1 Upper RS = 25374.6 Cross Section Boca Negra Arroyo 28.0 - Q
.035
.035
.035
Elevation (ft)
Station (ft)
Legend
WS Floodway
WS 100 Year
Ground
Bank Sta
BNA Current Upstm Floodway Plan: Current Upstream Floodway 1/6/2016
Geom: Current Upstream
River = BocaNegraArroyo Reach = Reach - 1 Upper RS = 24989.3 Cross Section Boca Negra Arroyo 27.0 - P
.035
.035
.035
Elevation (ft)
Station (ft)
Legend
WS Floodway
WS 100 Year
Ground
Bank Sta
Encroachment
BNA Current Upstm Floodway Plan: Current Upstream Floodway 1/6/2016
Geom: Current Upstream
River = BocaNegraArroyo Reach = Reach - 1 Upper RS = 24106.4 Cross Section Boca Negra Arroyo 26.0 - O
.035
.035
.035
Elevation (ft)
Station (ft)
Legend
WS 100 Year
WS Floodway
Ground
Bank Sta
Encroachment
BNA Current Upstm Floodway Plan: Current Upstream Floodway 1/6/2016
Geom: Current Upstream
River = BocaNegraArroyo Reach = Reach - 1 Upper RS = 23000.0 Cross Section Boca Negra Arroyo 25.0 - N
.035
.035
.035
Elevation (ft)
Station (ft)
Legend
WS Floodway
WS 100 Year
Ground
Bank Sta
Encroachment

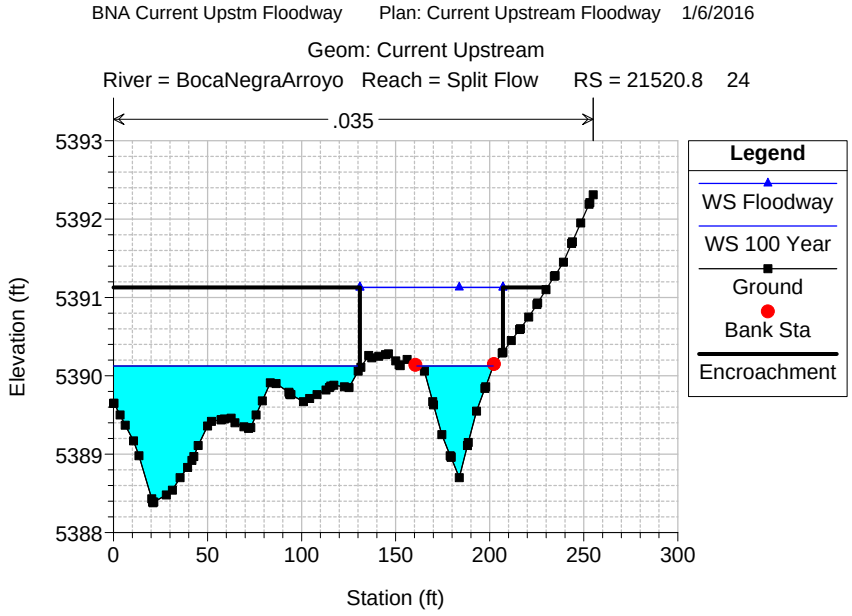

BNA Current Upstm Floodway Plan: Current Upstream Floodway 1/6/2016
Geom: Current Upstream
River = BocaNegraArroyo Reach = Reach - 1 Upper RS = 22241.1 Cross Section Boca Negra Arroyo 24.0 - M
.035
.035
.035
Elevation (ft)
Station (ft)
Legend
WS Floodway
WS 100 Year
Ground
Bank Sta
Encroachment
BNA Current Upstm Floodway Plan: Current Upstream Floodway 1/6/2016
Geom: Current Upstream
River = BocaNegraArroyo Reach = Reach - 1 Mid RS = 22027.5 Cross Section Boca Negra Arroyo 23.75 - L
.035
.035
.035
Elevation (ft)
Station (ft)
Legend
WS Floodway
WS 100 Year
Ground
Bank Sta
BNA Current Upstm Floodway Plan: Current Upstream Floodway 1/6/2016
Geom: Current Upstream
River = BocaNegraArroyo Reach = Reach - 1 Mid RS = 21845.5 Cross Section Boca Negra Arroyo 23.5 - K
.035
.035
.035
Elevation (ft)
Station (ft)
Legend
WS 100 Year
WS Floodway
Ground
Bank Sta
BNA Current Upstm Floodway Plan: Current Upstream Floodway 1/6/2016
Geom: Current Upstream
River = BocaNegraArroyo Reach = Reach - 1 Mid RS = 21840 16
.035
Elevation (ft)
Station (ft)
Legend
WS Floodway
WS 100 Year
Ground
Bank Sta
Encroachment

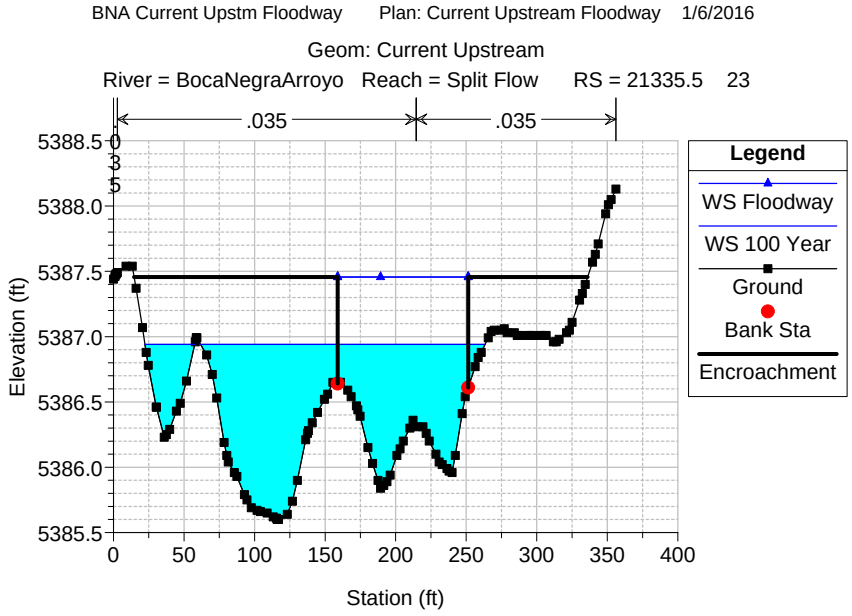

BNA Current Upstm Floodway Plan: Current Upstream Floodway 1/6/2016
Geom: Current Upstream
River = BocaNegraArroyo Reach = Reach - 1 Mid RS = 21830 15
.035
Elevation (ft)
Station (ft)
Legend
WS 100 Year
WS Floodway
Ground
Bank Sta
Encroachment
BNA Current Upstm Floodway Plan: Current Upstream Floodway 1/6/2016
Geom: Current Upstream
River = BocaNegraArroyo Reach = Reach - 1 Mid RS = 21820 14
.035
Elevation (ft)
Station (ft)
Legend
WS Floodway
WS 100 Year
Ground
Bank Sta
Encroachment
BNA Current Upstm Floodway Plan: Current Upstream Floodway 1/6/2016
Geom: Current Upstream
River = BocaNegraArroyo Reach = Reach - 1 Mid RS = 21335.5 Cross Section Boca Negra Arroyo 23.25 - J
.035
.035
.035
Elevation (ft)
Station (ft)
Legend
WS 100 Year
WS Floodway
Ground
Bank Sta
BNA Current Upstm Floodway Plan: Current Upstream Floodway 1/6/2016
Geom: Current Upstream
River = BocaNegraArroyo Reach = Reach - 1 Mid RS = 21001.7 Cross Section Boca Negra Arroyo 23.0 - I
.035
.035
.035
Elevation (ft)
Station (ft)
Legend
WS Floodway
WS 100 Year
Ground
Ineff
Bank Sta
Encroachment

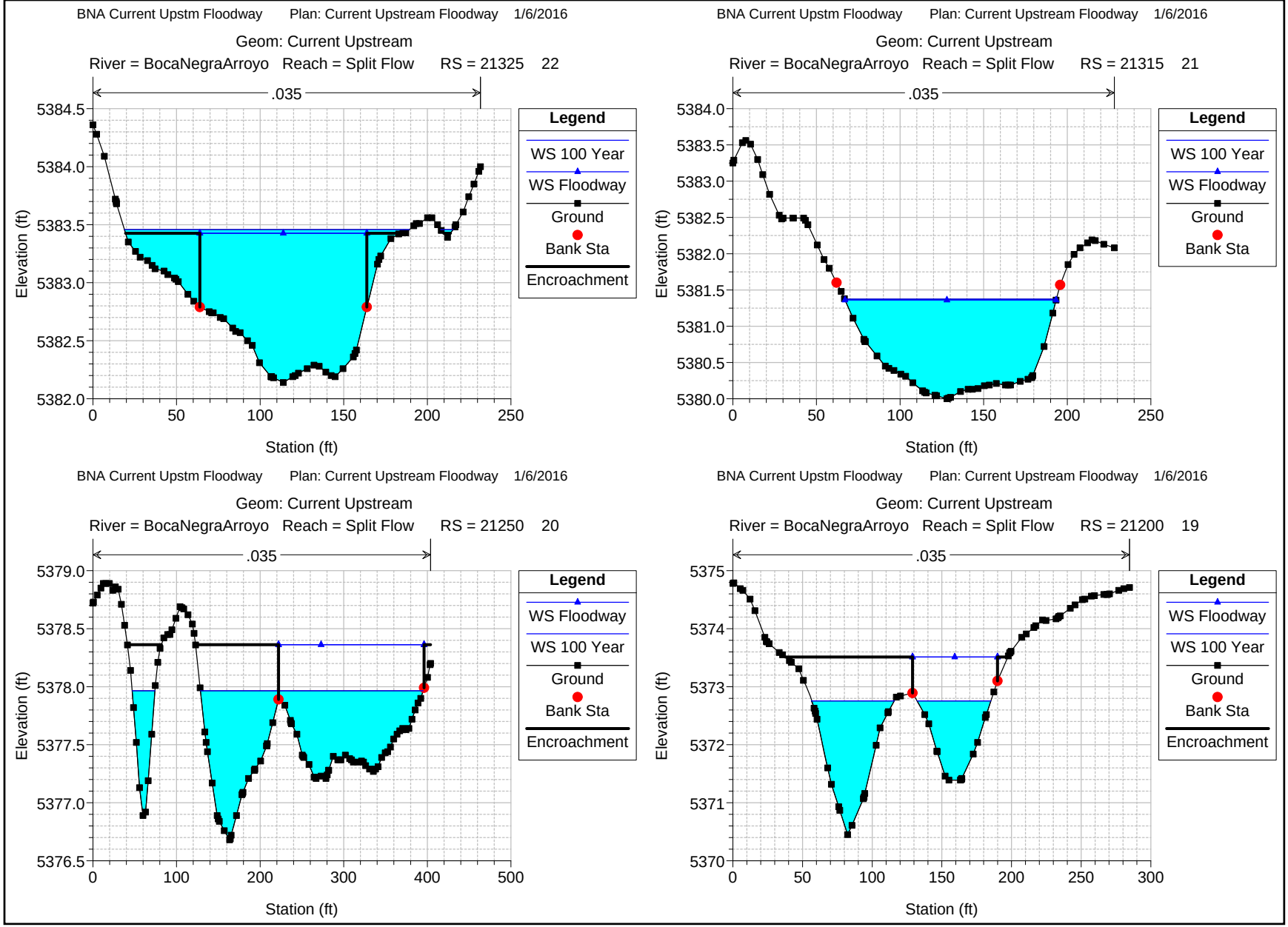

BNA Current Upstm Floodway Plan: Current Upstream Floodway 1/6/2016
Geom: Current Upstream
River = BocaNegraArroyo Reach = Split Flow RS = 22027.5 30
.035
.035
Legend
WS Floodway
WS 100 Year
Ground
Bank Sta
Encroachment
Elevation (ft)
Station (ft)
BNA Current Upstm Floodway Plan: Current Upstream Floodway 1/6/2016
Geom: Current Upstream
River = BocaNegraArroyo Reach = Split Flow RS = 22000 29
.035
Legend
WS Floodway
WS 100 Year
Ground
Bank Sta
Encroachment
Elevation (ft)
Station (ft)
BNA Current Upstm Floodway Plan: Current Upstream Floodway 1/6/2016
Geom: Current Upstream
River = BocaNegraArroyo Reach = Split Flow RS = 21840 28
.035
.035
Legend
WS 100 Year
WS Floodway
Ground
Bank Sta
Encroachment
Elevation (ft)
Station (ft)
BNA Current Upstm Floodway Plan: Current Upstream Floodway 1/6/2016
Geom: Current Upstream
River = BocaNegraArroyo Reach = Split Flow RS = 21835 27
.035
Legend
WS 100 Year
WS Floodway
Ground
Bank Sta
Encroachment
Elevation (ft)
Station (ft)

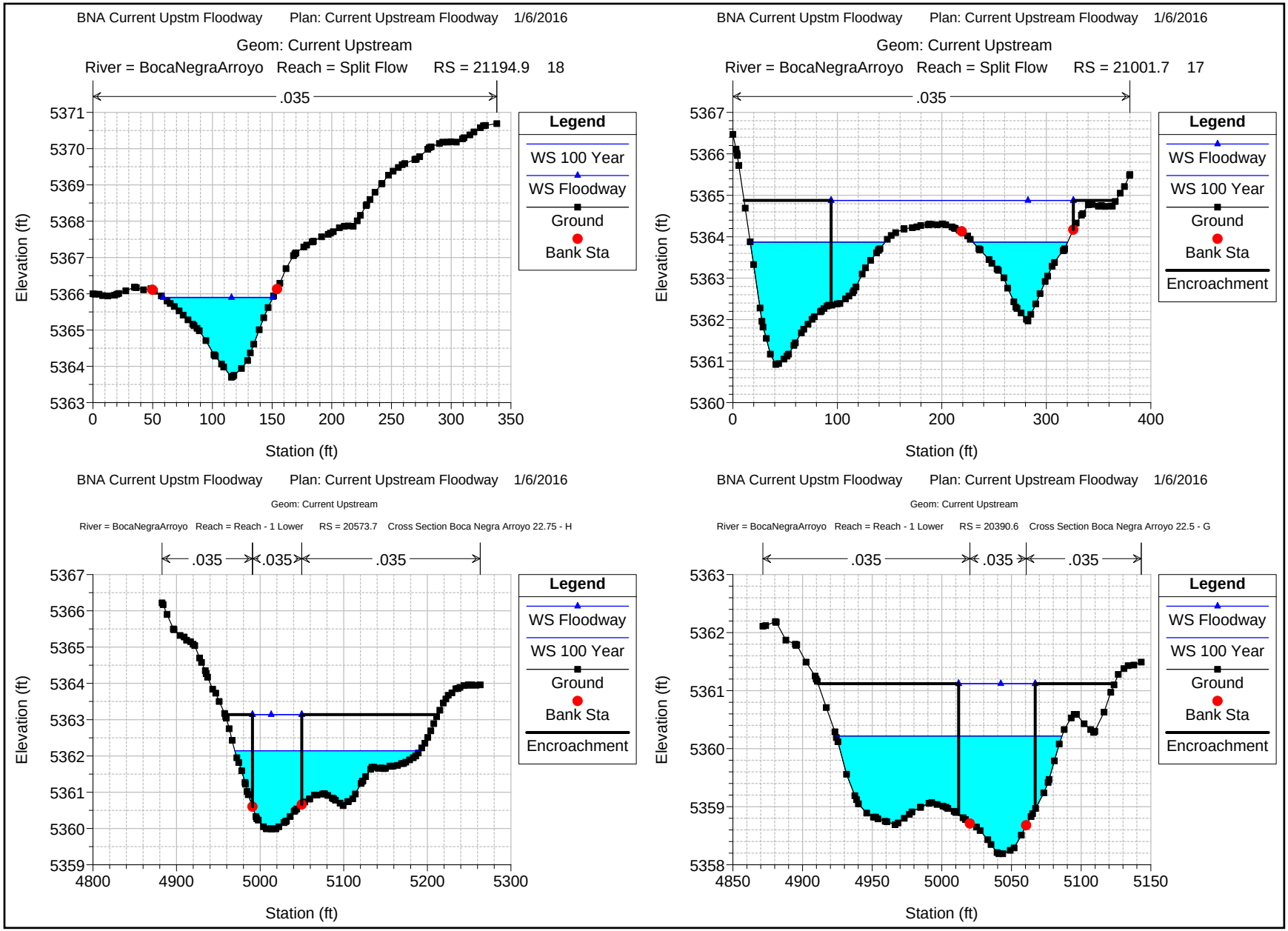

BNA Current Upstm Floodway Plan: Current Upstream Floodway 1/6/2016
Geom: Current Upstream
River = BocaNegraArroyo Reach = Split Flow RS = 21800 26
.035
Elevation (ft)
Station (ft)
Legend
WS Floodway
WS 100 Year
Ground
Bank Sta
Encroachment

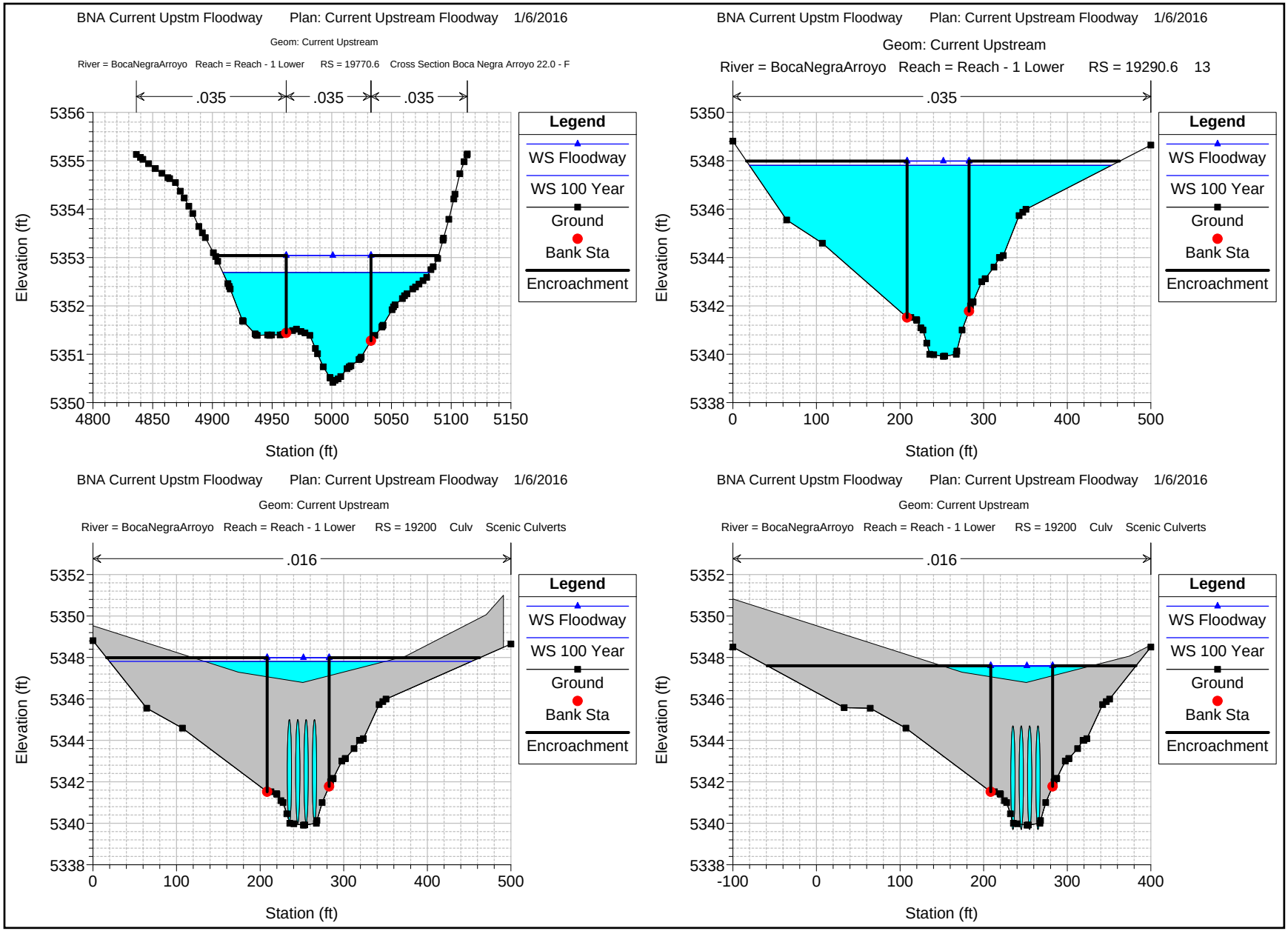

BNA Current Upstm Floodway Plan: Current Upstream Floodway 1/6/2016
Geom: Current Upstream
River = BocaNegraArroyo Reach = Split Flow RS = 21770.8 25
.035
Elevation (ft)
Station (ft)
Legend
WS Floodway
WS 100 Year
Ground
Ineff
Bank Sta
Encroachment

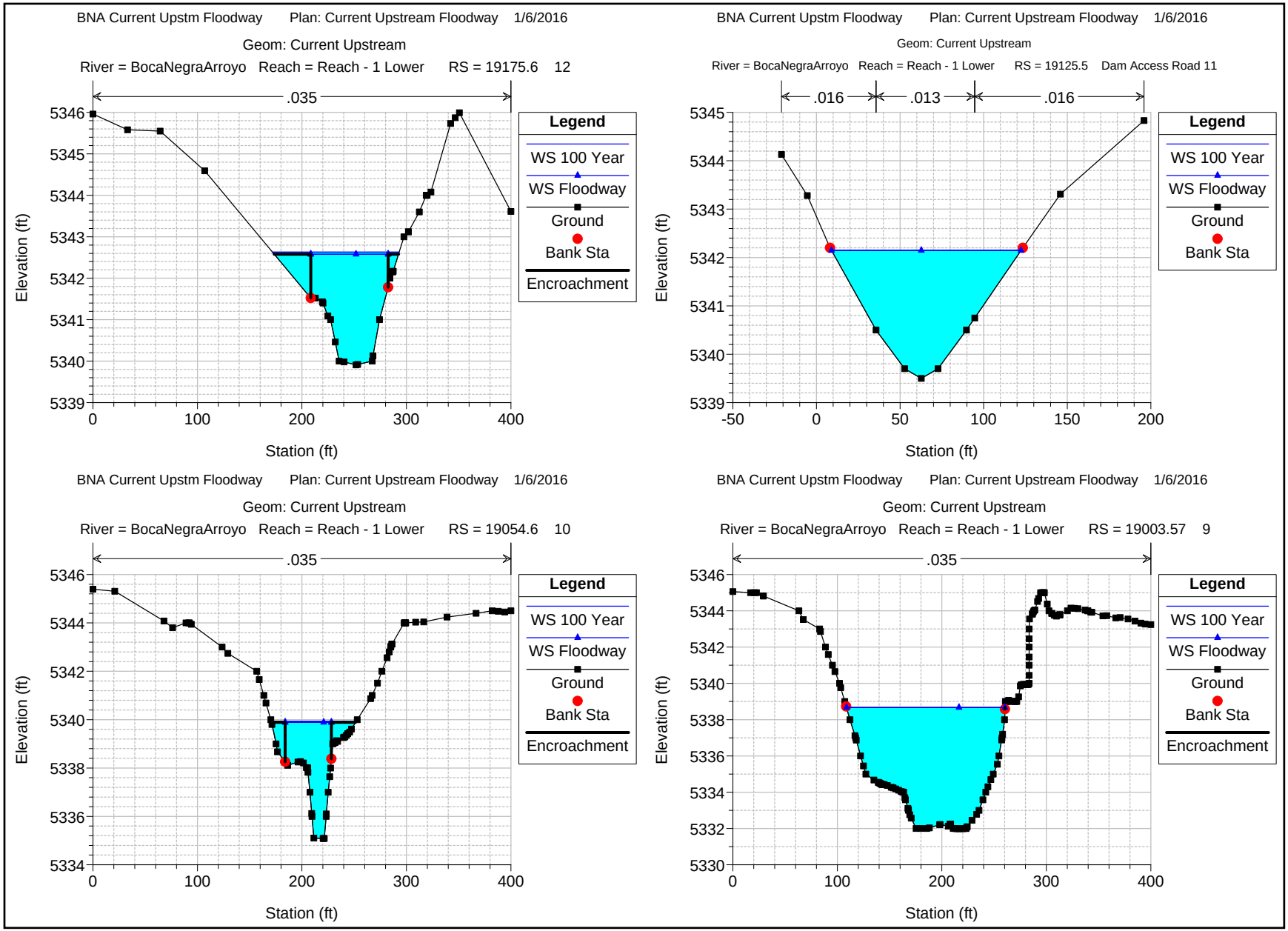

BNA Current Upstm Floodway Plan: Current Upstream Floodway 1/6/2016
Geom: Current Upstream
River = BocaNegraArroyo Reach = Split Flow RS = 21520.8 24
.035
Elevation (ft)
Station (ft)
Legend
WS Floodway
WS 100 Year
Ground
Bank Sta
Encroachment


BNA Current Upstm Floodway Plan: Current Upstream Floodway 1/6/2016
Geom: Current Upstream
River = BocaNegraArroyo Reach = Split Flow RS = 21335.5 23
.035
.035
Elevation (ft)
Station (ft)
Legend
WS Floodway
WS 100 Year
Ground
Bank Sta
Encroachment


BNA Current Upstm Floodway Plan: Current Upstream Floodway 1/6/2016
Geom: Current Upstream
River = BocaNegraArroyo Reach = Split Flow RS = 21325 22
.035
Elevation (ft)
Station (ft)
Legend
WS 100 Year
WS Floodway
Ground
Bank Sta
Encroachment
BNA Current Upstm Floodway Plan: Current Upstream Floodway 1/6/2016
Geom: Current Upstream
River = BocaNegraArroyo Reach = Split Flow RS = 21315 21
.035
Elevation (ft)
Station (ft)
Legend
WS 100 Year
WS Floodway
Ground
Bank Sta
BNA Current Upstm Floodway Plan: Current Upstream Floodway 1/6/2016
Geom: Current Upstream
River = BocaNegraArroyo Reach = Split Flow RS = 21250 20
.035
Elevation (ft)
Station (ft)
Legend
WS Floodway
WS 100 Year
Ground
Bank Sta
Encroachment
BNA Current Upstm Floodway Plan: Current Upstream Floodway 1/6/2016
Geom: Current Upstream
River = BocaNegraArroyo Reach = Split Flow RS = 21200 19
.035
Elevation (ft)
Station (ft)
Legend
WS Floodway
WS 100 Year
Ground
Bank Sta
Encroachment


BNA Current Upstm Floodway Plan: Current Upstream Floodway 1/6/2016
Geom: Current Upstream
River = BocaNegraArroyo Reach = Split Flow RS = 21194.9 18
.035
Elevation (ft)
Station (ft)
Legend
WS 100 Year
WS Floodway
Ground
Bank Sta
BNA Current Upstm Floodway Plan: Current Upstream Floodway 1/6/2016
Geom: Current Upstream
River = BocaNegraArroyo Reach = Split Flow RS = 21001.7 17
.035
Elevation (ft)
Station (ft)
Legend
WS Floodway
WS 100 Year
Ground
Bank Sta
Encroachment
BNA Current Upstm Floodway Plan: Current Upstream Floodway 1/6/2016
Geom: Current Upstream
River = BocaNegraArroyo Reach = Reach - 1 Lower RS = 20573.7 Cross Section Boca Negra Arroyo 22.75 - H
.035
.035
.035
Elevation (ft)
Station (ft)
Legend
WS Floodway
WS 100 Year
Ground
Bank Sta
Encroachment
BNA Current Upstm Floodway Plan: Current Upstream Floodway 1/6/2016
Geom: Current Upstream
River = BocaNegraArroyo Reach = Reach - 1 Lower RS = 20390.6 Cross Section Boca Negra Arroyo 22.5 - G
.035
.035
.035
Elevation (ft)
Station (ft)
Legend
WS Floodway
WS 100 Year
Ground
Bank Sta
Encroachment


BNA Current Upstm Floodway Plan: Current Upstream Floodway 1/6/2016
Geom: Current Upstream
River = BocaNegraArroyo Reach = Reach - 1 Lower RS = 19770.6 Cross Section Boca Negra Arroyo 22.0 - F
.035
.035
.035
Elevation (ft)
Station (ft)
Legend
WS Floodway
WS 100 Year
Ground
Bank Sta
Encroachment
BNA Current Upstm Floodway Plan: Current Upstream Floodway 1/6/2016
Geom: Current Upstream
River = BocaNegraArroyo Reach = Reach - 1 Lower RS = 19290.6 13
.035
Elevation (ft)
Station (ft)
Legend
WS Floodway
WS 100 Year
Ground
Bank Sta
Encroachment
BNA Current Upstm Floodway Plan: Current Upstream Floodway 1/6/2016
Geom: Current Upstream
River = BocaNegraArroyo Reach = Reach - 1 Lower RS = 19200 Culv Scenic Culverts
.016
Elevation (ft)
Station (ft)
Legend
WS Floodway
WS 100 Year
Ground
Bank Sta
Encroachment
BNA Current Upstm Floodway Plan: Current Upstream Floodway 1/6/2016
Geom: Current Upstream
River = BocaNegraArroyo Reach = Reach - 1 Lower RS = 19200 Culv Scenic Culverts
.016
Elevation (ft)
Station (ft)
Legend
WS Floodway
WS 100 Year
Ground
Bank Sta
Encroachment


BNA Current Upstm Floodway Plan: Current Upstream Floodway 1/6/2016
Geom: Current Upstream
River = BocaNegraArroyo Reach = Reach - 1 Lower RS = 19175.6 12
.035
Elevation (ft)
Station (ft)
Legend
WS 100 Year
WS Floodway
Ground
Bank Sta
Encroachment
BNA Current Upstm Floodway Plan: Current Upstream Floodway 1/6/2016
Geom: Current Upstream
River = BocaNegraArroyo Reach = Reach - 1 Lower RS = 19125.5 Dam Access Road 11
.016
.013
.016
Elevation (ft)
Station (ft)
Legend
WS 100 Year
WS Floodway
Ground
Bank Sta
BNA Current Upstm Floodway Plan: Current Upstream Floodway 1/6/2016
Geom: Current Upstream
River = BocaNegraArroyo Reach = Reach - 1 Lower RS = 19054.6 10
.035
Elevation (ft)
Station (ft)
Legend
WS 100 Year
WS Floodway
Ground
Bank Sta
Encroachment
BNA Current Upstm Floodway Plan: Current Upstream Floodway 1/6/2016
Geom: Current Upstream
River = BocaNegraArroyo Reach = Reach - 1 Lower RS = 19003.57 9
.035
Elevation (ft)
Station (ft)
Legend
WS 100 Year
WS Floodway
Ground
Bank Sta
Encroachment

HEC-RAS Version 4.1.0 Jan 2010
U.S. Army Corps of Engineers
Hydrologic Engineering Center
609 Second Street
Davis, California

```
X     X  XXXXXX    XXXX        XXXX       XX      XXXX
X     X  X        X    X       X   X     X  X    X
X     X  X        X            X   X    X    X   X
XXXXXXX  XXXX     X       XXX  XXXX     XXXXXX    XXXX
X     X  X        X            X  X     X    X        X
X     X  X        X    X       X   X    X    X        X
X     X  XXXXXX    XXXX        X    X   X    X   XXXXX
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PROJECT DATA
Project Title: BNA Current Upstm Floodway
Project File : CurrentUpstmFloodway.prj
Run Date and Time: 1/6/2016 10:27:44 AM

Project in English units

PLAN DATA

Plan Title: Current Upstream Floodway
Plan File : t:\Projects\x321807802\Eng\2012 Final Plans_Specifications_Estimate_Reports\2014 Final Construction Acceptance Reports\H&H\LOMR - RAS\BNA RAS FLOODWAY\CurrentUpstmFloodway.p08

Geometry Title: Current Upstream
Geometry File : t:\Projects\x321807802\Eng\2012 Final Plans_Specifications_Estimate_Reports\2014 Final Construction Acceptance Reports\H&H\LOMR - RAS\BNA RAS FLOODWAY\CurrentUpstmFloodway.g05

Flow Title : Updated 2014
Flow File : t:\Projects\x321807802\Eng\2012 Final Plans_Specifications_Estimate_Reports\2014 Final Construction Acceptance Reports\H&H\LOMR - RAS\BNA RAS FLOODWAY\CurrentUpstmFloodway.f01

Plan Summary Information:
Number of: Cross Sections = 34 Multiple Openings = 0
Culverts = 1 Inline Structures = 0
Bridges = 0 Lateral Structures = 0

Computational Information
Water surface calculation tolerance = 0.01
Critical depth calculation tolerance = 0.01
Maximum number of iterations = 20
Maximum difference tolerance = 0.3
Flow tolerance factor = 0.001

Computation Options
Critical depth computed only where necessary
Conveyance Calculation Method: At breaks in n values only
Friction Slope Method: Average Conveyance
Computational Flow Regime: Subcritical Flow

Encroachment Data
Equal Conveyance = False
Left Offset = 0
Right Offset = 0

River = BocaNegraArroyo Reach = Reach - 1 Upper

RS	Profile	Method	Value1	Value2
25374.6	Floodway	1	4950	5051
24989.3	Floodway	1	4950	5125
24106.4	Floodway	1	4938	5044
23000.0	Floodway	1	4955	5125
22241.1	Floodway	1	4905	5065

River = BocaNegraArroyo Reach = Reach - 1 Mid

RS	Profile	Method	Value1	Value2
22027.5	Floodway	1	4967.55	5062.32
21845.5	Floodway	1	4975.28	5023.67
21840	Floodway	1	67.81	123.25
21830	Floodway		147.75001	113.71
21820	Floodway	1	73.59	132.32
21335.5	Floodway	1	5041.64	5161.54
21001.7	Floodway	1	4964.29	5038.83

River = BocaNegraArroyo Reach = Split Flow

RS	Profile	Method	Value1	Value2
22027.5	Floodway	1	112.42	231.02
22000	Floodway	1	18.89	96.33
21840	Floodway		139.07001	85.22
21835	Floodway	1	15.66	89.49
21800	Floodway	1	54	136.6
21770.8	Floodway	1	123.06	187.45

21520.8	Floodway	1	131	207
21335.5	Floodway	1	158.88	251.4
21325	Floodway	1	63.9	163.82
21315	Floodway	1	62.02	195.78
21250	Floodway	1	222	396.05
21200	Floodway	1	128.95	189.91
21194.9	Floodway	1	49.81	154.17
21001.7	Floodway	1	94	325.79

River = BocaNegraArroyo Reach = Reach - 1 Lower

RS	Profile	Method	Value1	Value2
20573.7	Floodway	1	4990.78	5049.79
20390.6	Floodway	1	5012	5067
19770.6	Floodway	1	4961.9	5032.84
19290.6	Floodway	1	208.45	282.53
19175.6	Floodway	1	208.45	282.53
19125.5	Floodway	1	8.12	123.44
19054.6	Floodway	1	183.95	228.2
19003.57	Floodway	1	108.43	260.42

FLOW DATA

Flow Title: Updated 2014
Flow File : t:\Projects\x321807802\Eng\2012 Final Plans_Specifications_Estimate_Reports\2014 Final Construction Acceptance Reports\H&H\LOMR - RAS\BNA RAS FLOODWAY\CurrentUpstmFloodway.f01

Flow Data (cfs)

River	Reach	RS	100 Year	Floodway
BocaNegraArroyo	Reach - 1 Upper	25374.6	1175	1175
BocaNegraArroyo	Reach - 1 Mid	22027.5	.01	.01
BocaNegraArroyo	Reach - 1 Mid	21840	612	612
BocaNegraArroyo	Split Flow	22027.5	1185	1185
BocaNegraArroyo	Split Flow	21800	603	603
BocaNegraArroyo	Reach - 1 Lower	20573.7	1188	1188

Boundary Conditions

River	Reach	Profile	Upstream	Downstream
BocaNegraArroyo	Reach - 1 Lower	100 Year		Known WS = 5338.67

GEOMETRY DATA

Geometry Title: Current Upstream
Geometry File : t:\Projects\x321807802\Eng\2012 Final Plans_Specifications_Estimate_Reports\2014 Final Construction Acceptance Reports\H&H\LOMR - RAS\BNA RAS FLOODWAY\CurrentUpstmFloodway.g05

Reach Connection Table

River	Reach	Upstream Boundary	Downstream Boundary
BocaNegraArroyo	Reach - 1 Upper		Junction 1
BocaNegraArroyo	Reach - 1 Mid	Junction 1	Junction 2
BocaNegraArroyo	Split Flow	Junction 1	Junction 2
BocaNegraArroyo	Reach - 1 Lower	Junction 2	

JUNCTION INFORMATION

Name: Junction 1
Description:
Energy computation Method

Length across Junction River	Reach		Tributary River	Reach	Length	Angle
BocaNegraArroyo	Reach - 1 Upper	to BocaNegraArroyo	Reach - 1 Mid		213.6	
BocaNegraArroyo	Reach - 1 Upper	to BocaNegraArroyo	Split Flow		173	

Name: Junction 2
Description:
Energy computation Method

Length across Junction River	Reach		Tributary River	Reach	Length	Angle
BocaNegraArroyo	Reach - 1 Mid	to BocaNegraArroyo	Reach - 1 Lower		428	
BocaNegraArroyo	Split Flow	to BocaNegraArroyo	Reach - 1 Lower		321	

CROSS SECTION

RIVER: BocaNegraArroyo
REACH: Reach - 1 Upper RS: 25374.6

```
INPUT
Description: Cross Section Boca Negra Arroyo 28.0 - Q
Station Elevation Data    num=      71
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
    4839  5438.7 4841.95  5438.5  4844.7 5438.36 4850.23 5438.17 4851.86 5438.11
 4856.66 5437.93  4858.5 5437.82 4862.65 5437.59 4866.78 5437.37 4868.62 5437.29
 4873.39 5437.19 4875.06 5437.15 4880.58 5437.06 4883.34 5436.99 4889.55 5436.79
 4891.62 5436.71 4892.54 5436.67 4894.92 5436.54  4899.9 5436.24  4904.5 5436.04
 4908.18 5436.12 4916.45 5436.29 4916.46 5436.29 4924.73 5436.47 4928.41 5436.57
 4933.01 5436.62 4937.99 5436.64 4940.37 5436.66 4941.29 5436.59 4943.35 5436.47
 4949.57 5436.07 4952.33 5435.92 4957.85 5435.01 4959.52 5434.75 4964.29 5433.98
 4966.13 5433.78 4970.25 5433.29  4974.4 5432.78 4976.25 5432.58 4981.05 5432.59
 4982.68 5432.62 4987.45 5432.51 4988.21 5432.49 4990.96  5432.4 4997.15 5432.31
  4997.8 5432.31 4999.05  5432.3 5000.96 5432.29 5006.21 5432.24 5010.47 5432.23
 5013.37 5432.27 5016.93 5432.29 5020.53  5432.5 5023.46 5432.68 5027.69 5432.93
  5032.9 5433.16 5034.85 5433.26 5036.44 5433.37 5042.01  5433.9 5048.87 5434.66
 5049.18  5434.7 5049.43 5434.74 5051.87 5435.13 5056.34 5435.83 5062.41 5436.92
  5063.5 5437.11 5064.84 5437.36 5070.66 5438.25  5075.4 5439.02 5077.82 5439.36
 5078.02 5439.39

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
    4839    .035 4959.52    .035 5042.01    .035

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
       4959.52 5042.01             385.3   385.3   385.3             .1       .3

CROSS SECTION


RIVER: BocaNegraArroyo
REACH: Reach - 1 Upper    RS: 24989.3

INPUT
Description: Cross Section Boca Negra Arroyo 27.0 - P
Station Elevation Data    num=      96
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
  4764.7 5437.47 4768.41 5437.28 4769.76 5437.19 4774.65 5436.93 4778.51 5436.87
 4782.55 5436.83 4785.93 5436.79 4788.61 5436.64 4795.33 5436.15 4797.22 5436.03
 4798.71 5435.96 4808.12 5435.61  4808.5 5435.59  4808.8 5435.58 4811.38 5435.51
  4818.9 5435.25 4819.79 5435.21 4820.91 5435.19    4829 5434.97 4831.07 5434.93
 4833.69 5434.83  4839.1  5434.6 4842.36  5434.5 4846.48 5434.43  4849.2 5434.35
 4853.64  5434.3 4859.27 5434.17  4859.3 5434.16 4864.93 5434.03  4869.4 5433.85
 4872.06 5433.73 4876.21 5433.55  4879.5 5433.46 4884.84 5433.31  4887.5 5433.23
  4889.6 5433.16 4897.63 5432.94 4898.78  5432.9  4899.7 5432.85 4907.47  5432.5
  4909.8  5432.4 4910.07 5432.38 4910.42 5432.37  4919.9  5431.7 4921.36 5431.63
  4923.2 5431.54 4929.99  5431.2 4932.64 5431.07 4935.99 5430.84 4940.09 5430.53
 4943.93 5430.28 4948.78 5429.96 4950.19 5429.89 4955.21 5429.54 4960.29 5429.45
 4961.56 5429.41  4966.5 5429.31 4968.63 5429.27 4971.93 5429.26 4972.45 5429.26
 4978.17 5429.22 4980.99 5429.19 4988.45 5428.85 4989.52 5428.79 4989.93 5428.76
 4990.83 5428.72 4996.15 5428.36 4998.06 5428.23 5001.69 5428.13  5006.6 5428.25
 5009.73 5428.38 5013.45 5428.51 5015.13 5428.61 5019.59  5428.9 5023.67 5429.18
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    5044 5431.63 5045.31 5431.76 5046.12 5431.83 5049.54 5432.09 5052.45 5432.32
 5057.67 5432.69 5059.58 5432.83 5062.69 5433.03 5066.72 5433.17 5069.22 5433.26
 5073.86 5433.53 5079.78 5433.83 5080.76 5433.88    5081 5433.89 5081.37 5433.89
 5084.93 5433.91

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
  4764.7    .035 4980.99    .035 5023.67    .035

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
       4980.99 5023.67             882.9   882.9   882.9             .1       .3

CROSS SECTION


RIVER: BocaNegraArroyo
REACH: Reach - 1 Upper    RS: 24106.4

INPUT
Description: Cross Section Boca Negra Arroyo 26.0 - O
Station Elevation Data    num=      56
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
  4889.8 5424.42 4892.33 5424.31 4896.03 5424.19 4899.68 5424.07 4903.57 5423.94
  4907.9 5423.79 4910.36 5423.69 4914.81 5423.54 4919.76 5423.31 4921.04 5423.27
 4926.06 5423.03 4931.62 5422.54 4931.73 5422.53  4937.3 5422.04 4942.41 5421.63
 4943.49 5421.54 4948.54 5421.13  4953.1 5420.87 4955.35 5420.72 4959.79 5420.46
 4963.78 5420.37 4967.22 5420.28 4971.03 5420.19 4974.47 5420.14 4979.08 5420.09
 4982.27 5420.04 4985.15 5419.95 4990.95 5419.79 4993.52 5419.71 4995.83 5419.64
 5000.47 5419.51 5002.06 5419.48 5003.76 5419.43 5005.11 5419.39 5010.15 5419.56
 5014.35 5419.69 5017.27 5419.79 5018.23 5419.86 5020.14 5420.03 5026.32 5420.51
 5029.43 5420.71  5034.4  5421.1 5038.86 5421.53 5041.58 5421.78 5042.48 5421.87
 5044.27 5422.08 5050.57  5422.8 5053.74 5423.21 5058.65 5423.75 5063.36 5424.28
  5065.9 5424.56 5066.74 5424.61  5068.4 5424.69 5074.82 5425.01 5078.06 5425.21
 5080.45 5425.29

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
  4889.8    .035 4948.54    .035  5034.4    .035
```

```
Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
       4948.54  5034.4           1106.4  1106.4  1106.4             .1       .3

CROSS SECTION


RIVER: BocaNegraArroyo
REACH: Reach - 1 Upper    RS: 23000.0

INPUT
Description: Cross Section Boca Negra Arroyo 25.0 - N
Station Elevation Data    num=     106
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
  4834.3  5412.7 4835.65 5412.61 4844.38 5412.12 4844.78 5412.09 4845.05 5412.08
 4846.28 5412.01 4854.44 5411.58 4856.19 5411.49 4858.88 5411.32 4863.84 5411.02
 4867.59 5410.79 4873.24 5410.59 4873.39 5410.59    4879 5410.39 4882.63 5410.39
 4887.89 5410.39  4890.4 5410.39 4892.03  5410.4 4899.65 5410.47 4901.43 5410.49
 4901.81 5410.49  4902.4 5410.49 4910.82 5410.51 4913.21 5410.51  4916.9 5410.41
 4920.22  5410.3 4924.62 5410.18 4929.62 5409.98  4931.4 5409.91 4936.02 5409.73
 4939.01 5409.63 4945.91 5409.34 4947.43 5409.29 4948.41 5409.26 4953.01 5409.09
 4957.81 5408.92 4958.83 5408.87 4960.41 5408.79  4967.2 5408.47 4970.24 5408.32
 4974.92 5408.04  4976.6 5407.93 4981.64 5407.64    4986 5407.32 4989.42 5407.11
 4993.05 5406.86 4995.39 5406.83  5001.4  5406.8 5002.43 5406.81 5003.99 5406.82
 5006.86 5406.87 5006.89 5406.87 5011.16 5406.97 5013.48 5407.02 5018.33 5407.13
 5021.29  5407.2 5024.54 5407.28  5025.5  5407.3 5027.28 5407.34 5032.67 5407.42
 5035.59 5407.45 5039.84 5407.52 5045.38 5407.58 5046.64  5407.6 5047.01  5407.6
  5047.7 5407.61 5054.18 5407.79 5057.69 5407.89 5061.35 5408.01 5068.12 5408.27
 5068.52 5408.29 5068.74 5408.29 5069.47 5408.29  5075.7 5408.31 5079.79 5408.27
 5082.87 5408.25 5088.54 5408.11 5090.04 5408.07 5090.84 5408.04 5093.55    5408
 5097.21 5407.93 5101.89 5407.92 5104.38 5407.87 5108.97 5407.95 5111.55 5408.02
 5112.95 5408.13 5117.64 5408.41 5118.72 5408.48    5124  5408.8 5125.89 5408.92
 5129.39 5409.04 5133.06 5409.18 5135.05 5409.26 5140.23  5409.6 5141.73 5409.69
  5146.1 5409.98  5147.4 5410.09 5149.81 5410.29 5154.57 5410.76 5157.15 5411.01
 5161.74 5411.53 5165.81 5412.01  5168.2 5412.29 5168.91 5412.35 5170.23 5412.46
 5171.65 5412.54

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
  4834.3    .035 4974.92    .035 5061.35    .035

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
       4974.92 5061.35            758.9   758.9   758.9             .1       .3

CROSS SECTION


RIVER: BocaNegraArroyo
REACH: Reach - 1 Upper    RS: 22241.1

INPUT
Description: Cross Section Boca Negra Arroyo 24.0 - M
Station Elevation Data    num=     106
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
 4820.81 5403.35 4826.92 5403.05 4827.77    5403 4828.45 5402.97 4834.88 5402.73
 4835.23 5402.71 4841.93 5402.42 4842.68 5402.39 4843.61 5402.35 4850.14 5402.09
 4855.42 5401.88  4857.6 5401.78  4860.3 5401.68 4865.05 5401.56  4868.9 5401.49
 4872.51 5401.41 4876.98 5401.31 4879.97 5401.25 4882.38 5401.22 4887.43 5401.16
 4893.67 5401.04 4894.88 5401.01 4895.86 5400.99 4902.34 5400.85 4905.09 5400.78
 4909.35 5400.69  4909.8 5400.68 4910.36 5400.66 4917.26 5400.39 4922.83 5400.21
 4924.71 5400.15 4927.05 5400.06 4932.17 5399.84 4935.12 5399.68 4936.44 5399.62
 4939.49  5399.4 4942.34 5399.17 4946.71 5398.83  4951.4 5398.49 4953.94 5398.37
 4956.32 5398.29 4961.17 5398.16 4966.35 5398.02 4968.39 5397.98  4970.3 5397.96
 4975.62 5397.91 4981.31 5397.81 4982.84 5397.81 4984.28 5397.81 4990.07 5397.85
 4996.26 5397.89 4997.29  5397.9 4998.26  5397.9 5004.52 5397.97 5008.04 5397.98
 5011.21 5397.99 5011.74 5397.98 5012.24 5397.98 5018.97 5398.03 5026.17 5398.09
  5026.2 5398.09 5026.22 5398.09 5026.99  5398.1 5033.42 5398.22  5040.2  5398.4
 5040.65 5398.42 5041.12 5398.44 5043.57  5398.6 5048.02 5398.97 5051.13 5399.23
 5055.49 5399.75 5057.32 5399.96 5061.08 5400.39 5062.97 5400.59 5068.64 5401.15
 5070.44 5401.33 5071.04 5401.38 5072.22 5401.47 5077.91  5401.9 5080.99 5402.11
 5085.39 5402.23 5087.12 5402.29 5090.94 5402.41 5092.86 5402.42 5098.63 5402.47
 5100.33 5402.48  5100.9 5402.49 5102.02 5402.51  5107.8 5402.63 5110.85 5402.69
 5115.28 5402.76 5116.92 5402.77  5120.8 5402.82 5122.75 5402.84 5128.61 5402.95
 5130.22 5402.99 5130.76    5403 5131.82 5403.06  5137.7  5403.3 5140.71 5403.49
 5145.17 5403.77 5146.72 5403.85 5150.67 5404.08 5152.64  5404.2  5158.6 5404.43
 5159.07 5404.44

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
 4820.81    .035 4942.34    .035 5048.02    .035

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
       4942.34 5048.02               0       0       0             .1       .3

CROSS SECTION


RIVER: BocaNegraArroyo
REACH: Reach - 1 Mid      RS: 22027.5

INPUT
```

Description: Cross Section Boca Negra Arroyo 23.75 - L
Station Elevation Data num= 76

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
4890.5	5401.44	4894.23	5401.15	4899.28	5400.75	4902.37	5400.37	4908.78	5399.53
4910.52	5399.31	4911.36	5399.22	4913.78	5398.97	4918.67	5398.48	4923.45	5397.95
4926.82	5397.77	4933.78	5397.39	4934.96	5397.33	4935.54	5397.3	4937.18	5397.22
4943.11	5396.95	4947.62	5396.74	4951.26	5396.62	4958.78	5396.33	4959.41	5396.3
4959.71	5396.29	4960.59	5396.26	4967.55	5396.03	4971.8	5395.84	4975.7	5395.63
4983.78	5395.1	4983.85	5395.09	4983.89	5395.09	4983.99	5395.08	4992	5394.65
4995.97	5394.49	5000.14	5394.42	5002.14	5394.41	5007.39	5394.39	5008.06	5394.38
5008.29	5394.38	5008.77	5394.38	5016.44	5394.27	5020.15	5394.23	5024.59	5394.29
5030.8	5394.44	5032.23	5394.47	5032.73	5394.5	5032.96	5394.51	5033.28	5394.52
5034.26	5394.58	5040.31	5394.92	5043.1	5395.07	5047.87	5395.34	5048.29	5395.36
5052.93	5395.62	5055.43	5395.79	5062.32	5396.25	5062.75	5396.27	5062.99	5396.3
5063.77	5396.37	5070.54	5397.07	5072.58	5397.22	5076.34	5397.78	5078.1	5398.06
5082.4	5398.65	5085.66	5399.1	5090.37	5399.73	5092.22	5399.99	5093.22	5399.99
5096.55	5399.99	5100.78	5399.94	5102.05	5399.96	5104.4	5399.92	5108.34	5399.8
5111.87	5399.78	5115.9	5399.6	5118.42	5399.52	5121.69	5399.4	5123.46	5399.27
5124.92	5399.15								

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
4890.5	.035	4967.55	.035	5062.32	.035

Bank Sta: Left	Right	Lengths: Left Channel	Right	Coeff Contr.	Expan.
4967.55	5062.32	182	182	.1	.3

CROSS SECTION

RIVER: BocaNegraArroyo
REACH: Reach - 1 Mid RS: 21845.5

INPUT
Description: Cross Section Boca Negra Arroyo 23.5 - K
Station Elevation Data num= 99

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
4880.3	5396.01	4882.41	5395.91	4887.22	5395.73	4894.99	5395.39	4895	5395.39
4895.01	5395.39	4902.79	5395.1	4907.6	5394.93	4910.58	5394.84	4915.41	5394.7
4918.37	5394.63	4920.19	5394.57	4926.16	5394.28	4927.91	5394.16	4932.79	5393.85
4933.94	5393.78	4935.81	5393.65	4941.73	5393.26	4945.38	5392.95	4949.52	5392.57
4956.21	5391.92	4957.31	5391.82	4957.98	5391.75	4960.83	5391.47	4965.09	5391.05
4970.58	5390.51	4970.7	5390.5	4972.78	5390.36	4973.6	5390.3	4975.28	5390.21
4980.22	5390	4983.61	5389.79	4987.66	5389.55	4990.59	5389.3	4993.63	5389.09
4995.1	5388.98	4996.09	5388.94	4999.37	5388.79	5002.54	5388.78	5003.64	5388.82
5005.9	5388.95	5009.98	5389.15	5013.66	5389.39	5017.42	5389.68	5021.21	5390.01
5023.67	5390.21	5024.86	5390.31	5028.32	5390.61	5032.3	5390.89	5033.68	5390.99
5036.52	5391.17	5039.74	5391.37	5043.7	5391.64	5047.18	5391.9	5051.83	5392.3
5053.71	5392.45	5054.62	5392.52	5057.26	5392.74	5062.06	5393.05	5063.72	5393.17
5067.14	5393.41	5069.5	5393.57	5073.74	5393.89	5076.94	5394.11	5082.45	5394.5
5083.75	5394.59	5084.38	5394.63	5086.21	5394.71	5091.82	5394.9	5093.77	5394.96
5097.76	5395.07	5099.26	5395.12	5103.78	5395.23	5106.7	5395.25	5113.07	5395.31
5113.79	5395.32	5114.14	5395.33	5115.16	5395.36	5121.58	5395.52	5123.81	5395.58
5128.38	5395.79	5129.02	5395.82	5133.82	5396.04	5136.46	5396.17	5143.69	5396.49
5143.83	5396.5	5143.9	5396.5	5144.1	5396.5	5151.34	5396.78	5153.85	5396.89
5158.78	5397.01	5159	5397.01	5163.86	5397.12	5166.22	5397.11	5173.05	5396.99
5173.66	5396.98	5173.88	5396.98	5174.31	5396.96	5180.71	5396.79		

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
4880.3	.035	4975.28	.035	5023.67	.035

Bank Sta: Left	Right	Lengths: Left Channel	Right	Coeff Contr.	Expan.
4975.28	5023.67	290.81	290.81	.1	.3

CROSS SECTION

RIVER: BocaNegraArroyo
REACH: Reach - 1 Mid RS: 21840

INPUT
Description: 16
Station Elevation Data num= 69

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	5384.3	3.12999	5384.13	.699997	5384.06	4.259995	5384.02	12.37	5383.4
12.92	5383.36	13.48	5383.31	21.61	5382.61	22.14999	5382.57	22.69	5382.52
30.84999	5381.91	31.37999	5381.87	31.91	5381.81	40.09	5381.01	40.61	5380.96
41.12999	5380.91	49.33	5380.2	49.84	5380.15	50.34999	5380.16	58.56999	5380.25
59.06999	5380.25	59.56999	5380.27	67.81	5380.54	68.3	5380.56	68.78999	5380.56
77.05	5380.47	77.53	5380.47	78.00999	5380.44	86.28999	5380.08	86.75999	5380.05
87.21999	5380.03	95.53	5379.49	95.99	5379.47	96.43999	5379.48	104.12	5379.48
104.77	5379.48	105.21	5379.48	105.66	5379.52	114.01	5380.15	114.44	5380.18
114.88	5380.22	123.25	5380.95	123.67	5380.98	124.1	5381.01	132.48	5381.56
132.9	5381.58	133.32	5381.61	141.72	5382.16	142.13	5382.18	142.54	5382.19
150.96	5382.56	151.36	5382.57	151.75	5382.59	160.2	5383.05	160.59	5383.07
160.97	5383.09	169.44	5383.55	169.82	5383.57	170.19	5383.6	178.68	5384.15
179.05	5384.17	179.41	5384.2	187.92	5384.75	188.28	5384.78	188.63	5384.8
197.16	5385.36	197.5	5385.38	197.85	5385.4	203.45	5385.77		

Manning's n Values num= 1

```
     Sta   n Val
       0    .035

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
         67.81  123.25             71.4    71.4    71.4             .1       .3

CROSS SECTION


RIVER: BocaNegraArroyo
REACH: Reach - 1 Mid      RS: 21830

INPUT
Description: 15
Station Elevation Data    num=      54
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0 5382.391.240005 5382.29 3.01001 5382.143.770004 5382.075.660004 5381.91
11.10001 5381.4213.29001 5381.24   18.41 5380.6718.43001 5380.6623.56001 5380.11
25.76001  5379.8   31.23 5378.94   33.09 5378.64   33.84 5378.52   35.59 5378.34
40.42001 5377.8144.11001 5377.4947.75001 5377.4752.76001  5377.3   54.38 5377.27
55.08001 5377.24    56.8 5377.1762.40001    5377   64.66 5376.94   69.73 5376.76
   69.94 5376.7674.93001 5376.6577.06001 5376.6382.01001 5376.5982.36001 5376.59
84.39001 5376.59    85.2 5376.58   87.11 5376.58   91.72 5376.6295.48001 5376.58
   99.05 5376.72  104.29 5376.81  105.75 5376.85  106.38 5376.91  107.93 5377.04
  113.71 5377.65  116.03 5377.86  121.03 5378.35  121.46 5378.38   126.3 5378.83
  128.36 5378.98   133.5 5379.46  135.69 5379.71  136.57 5379.81  138.64 5380.05
  143.02 5380.58  146.85 5380.99  150.35 5381.43   151.1 5381.53

Manning's n Values        num=       1
     Sta   n Val
       0    .035

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
      47.75001  113.71           115.95  115.95  115.95             .1       .3

CROSS SECTION


RIVER: BocaNegraArroyo
REACH: Reach - 1 Mid      RS: 21820

INPUT
Description: 14
Station Elevation Data    num=      62
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0    5377     9.8    5376    21.4    5375   29.39 5374.67   42.77 5374.42
   44.38 5374.38   48.39 5374.34   51.71 5374.33   53.04 5374.33   56.17 5374.39
   59.04 5374.44   63.32 5374.51   66.37 5374.61   73.34 5374.79   73.59  5374.8
   73.69 5374.79   73.95 5374.78   81.02 5374.45   83.86  5374.4   88.35 5374.13
   90.52 5374.04   94.14 5373.85   95.68 5373.84   99.52 5373.84  103.01  5373.8
  104.41 5373.77  106.14 5373.78   107.7 5373.79  110.34 5373.79  114.68 5373.85
  117.67 5373.94  124.87 5374.38  124.96 5374.39     125 5374.39  125.09 5374.39
  132.32 5374.76  135.23 5374.97  139.65 5375.41  142.05 5375.67  145.51 5376.03
  146.98 5376.18  150.66 5376.59  154.31 5377.02  155.78 5377.17  159.22 5377.44
  161.64 5377.64  166.05 5377.97  168.97 5378.13  176.22 5378.49   176.3 5378.49
  176.33 5378.49   176.4  5378.5  183.63 5379.47   186.6 5379.85  190.95 5380.22
  193.57 5380.44  196.87 5380.72  198.28 5380.84  201.79 5381.13  205.61 5381.41
  207.15 5381.52  209.44 5381.67

Manning's n Values        num=       1
     Sta   n Val
       0    .035

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
         73.59  132.32             45.3    45.3    45.3             .1       .3

CROSS SECTION


RIVER: BocaNegraArroyo
REACH: Reach - 1 Mid      RS: 21335.5

INPUT
Description: Cross Section Boca Negra Arroyo 23.25 - J
Station Elevation Data    num=     115
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
 4904.44 5381.56 4907.59  5381.4 4909.19 5381.36 4910.62 5381.31 4916.55 5381.16
 4923.18 5380.94 4923.91 5380.92 4924.56 5380.88 4931.27 5380.45 4936.31 5380.13
  4938.5 5379.99 4938.63 5379.98 4938.76 5379.97 4945.98 5379.58 4952.44 5379.28
 4953.34 5379.24 4954.35 5379.19  4960.7 5378.92 4966.38 5378.67 4968.06  5378.6
 4969.93 5378.54 4975.42  5378.3 4980.32 5378.09 4982.78    5378 4985.52 5377.94
 4990.13 5377.76 4994.26 5377.58 4997.49 5377.39  5001.1 5377.15 5004.85 5376.87
  5008.2 5376.65 5012.21 5376.39 5016.69 5376.06 5019.57 5375.84 5022.14 5375.65
 5026.93  5375.3 5032.27 5374.95 5034.28 5374.83 5036.08 5374.72 5041.64 5374.29
 5047.86 5373.81    5049 5373.75 5050.02 5373.72 5056.36 5373.57 5063.45 5373.41
 5063.72  5373.4 5063.96 5373.39 5068.34 5373.22 5071.08 5373.11  5077.9  5372.7
 5078.44 5372.68 5079.03 5372.67 5085.79  5372.5 5091.84 5372.31 5093.15 5372.23
 5094.62 5372.17 5100.51 5371.95 5102.29 5371.89 5105.78 5371.76 5107.87 5371.77
  5110.2 5371.88 5115.23 5372.23 5119.72 5372.76 5122.59 5373.18 5125.79 5373.58
 5129.94 5374.01 5133.66 5374.14  5137.3 5373.98 5141.37 5373.75 5144.66 5373.61
  5147.6 5373.51 5152.02 5373.59 5156.96 5373.82 5159.38 5373.97 5161.54 5374.18
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 5166.74 5374.95 5172.54 5375.84 5174.09 5376.12 5175.48 5376.35 5181.45 5377.21
 5188.13 5377.85 5188.81 5377.93 5189.42    5378 5196.17 5378.83 5200.37  5379.2
 5203.36 5379.47 5203.53 5379.49 5203.71  5379.5 5210.89 5379.97  5217.3 5380.43
 5218.24 5380.48  5219.3 5380.53  5225.6 5380.89 5231.24 5381.25 5232.96 5381.33
 5234.89 5381.42 5240.32 5381.65 5245.18 5381.89 5247.68 5381.99 5250.47 5382.13
 5255.04 5382.28 5259.12 5382.41  5262.4 5382.47 5266.06 5382.54 5269.75 5382.57
 5273.06 5382.62 5277.11  5382.7 5281.64 5382.79 5284.47 5382.83    5287 5382.89
 5291.83 5383.09 5297.23 5383.31 5299.19 5383.38 5300.94 5383.44 5304.37 5383.49

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
 4904.44    .035 4982.78    .035 5189.42    .035

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
       5041.64 5161.54            333.8   333.8   333.8             .1       .3

CROSS SECTION


RIVER: BocaNegraArroyo
REACH: Reach - 1 Mid      RS: 21001.7

INPUT
Description: Cross Section Boca Negra Arroyo 23.0 - I
Station Elevation Data    num=     112
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
  4883.3 5373.94 4888.36 5373.56 4889.24 5373.49 4889.79 5373.45 4892.23 5373.25
    4897 5372.85 4902.44 5372.37 4904.76 5372.17 4908.46 5371.86 4912.53 5371.51
 4915.08 5371.29 4920.29 5370.91 4926.29 5370.51 4927.72 5370.41 4928.05 5370.39
 4928.57 5370.36 4935.81 5369.83 4940.37 5369.42 4943.57 5369.11 4948.67  5368.7
 4950.46 5368.57 4951.86  5368.5 4952.73 5368.44 4953.46 5368.38 4961.22 5367.74
 4963.76 5367.52    4964 5367.49 4964.29 5367.45 4974.07 5365.97 4975.27 5365.78
 4976.71 5365.63 4984.37 5364.81 4986.53 5364.59 4989.13 5364.59 4994.68 5364.59
  4997.8 5364.59 5001.56 5364.62 5004.99 5364.63 5009.06 5364.67 5013.98 5364.72
 5015.29 5364.73 5020.33 5364.79  5025.6 5365.33  5026.4 5365.41  5031.6 5365.95
 5034.62 5366.42  5035.9 5366.62 5038.83 5367.09 5042.86 5367.72 5046.21 5367.97
 5051.25 5368.29 5054.13 5368.49 5056.51 5368.45 5063.67 5368.25 5065.39 5368.22
 5066.82 5368.18  5076.1 5367.91 5076.66  5367.9 5077.13 5367.89 5082.12 5367.84
 5087.43  5367.8 5087.93 5367.79 5088.52 5367.78 5097.74 5367.62 5099.19 5367.59
 5100.95 5367.51 5108.04  5367.2 5110.46 5367.09 5113.37 5367.01 5118.35 5366.88
 5121.72 5366.79 5125.79 5366.77 5128.65 5366.75 5132.99 5366.73 5138.22 5366.78
 5138.96 5366.78 5144.26 5366.84 5149.26 5367.03 5150.64  5367.1 5155.52 5367.29
 5159.57 5367.47 5163.06 5367.68 5166.79 5367.85 5169.88 5367.94 5175.49 5368.07
 5178.05 5368.15 5180.18 5368.24 5187.91 5368.56 5189.32 5368.62 5190.49 5368.67
 5200.33 5369.07 5200.58 5369.08 5200.79 5369.09 5203.03 5369.18  5211.1  5369.5
 5211.85 5369.53 5212.76 5369.59  5221.4  5370.1 5223.12 5370.22 5225.18 5370.32
 5231.71  5370.6 5234.38 5370.72  5237.6 5370.85 5242.02 5371.03 5245.65 5371.17
 5250.03 5371.38 5252.32 5371.49 5256.91  5371.7 5262.45 5371.91 5262.63 5371.91
 5268.18 5372.11 5269.85 5372.08

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
  4883.3    .035 4964.29    .035 5038.83    .035

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
       4964.29 5038.83               0       0       0             .1       .3
Ineffective Flow     num=       1
   Sta L   Sta R    Elev  Permanent
 5054.13 5269.85 5368.79       F

CROSS SECTION


RIVER: BocaNegraArroyo
REACH: Split Flow         RS: 22027.5

INPUT
Description: 30
Station Elevation Data    num=      55
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0 5402.23   94.42 5400.46  101.84 5400.44  102.51 5400.47  103.18 5400.44
  111.07 5399.84  111.74  5399.8  112.42 5399.74  120.29 5398.88  120.97 5398.82
  121.64 5398.75  129.52 5398.07   130.2    5398  130.87 5397.95  138.75 5397.35
  139.42 5397.29   140.1 5397.25  147.98 5396.73  148.65 5396.69  149.33 5396.67
   157.2 5396.41  157.88 5396.39  158.56 5396.39  159.11 5396.39  166.43 5396.39
  167.11 5396.38  167.79 5396.39  175.66 5396.47  176.34 5396.48  177.03 5396.49
  184.88 5396.57  185.57 5396.58  186.26  5396.6  194.11 5396.86   194.8 5396.88
  195.49 5396.93  203.34 5397.44  204.03 5397.49  204.72 5397.55  212.56 5398.23
  213.26 5398.29  213.95 5398.35  221.79 5399.03  222.49 5399.09  223.18 5399.15
  231.02 5399.74  231.72  5399.8  232.41 5399.86  240.25 5400.37  240.94 5400.43
  241.64 5400.48  249.47 5401.07  250.17 5401.13  250.87 5401.17  257.62 5401.61

Manning's n Values        num=       2
     Sta   n Val     Sta   n Val
       0    .035  203.34    .035

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
        112.42  231.02             75.7    75.7    75.7             .1       .3

CROSS SECTION
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RIVER: BocaNegraArroyo
REACH: Split Flow         RS: 22000

INPUT
Description: 29
Station Elevation Data    num=      52
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0 5399.62.7599945 5399.622.089996 5399.623.470001 5399.589.820007 5399.45
11.32001 5399.41   12.87 5399.32   18.89 5399.06   20.55 5398.97   22.28 5398.83
   27.96  5398.4   29.78 5398.25   31.68 5398.13   34.42 5397.95   37.07 5397.77
   39.01 5397.65   40.96 5397.51    46.3  5397.148.24001 5396.97   50.19 5396.84
    55.4 5396.45   55.53 5396.44   57.47 5396.31   59.42 5396.25   64.76 5396.07
    66.7 5396.01   68.64 5396.1473.99001 5396.54   75.93 5396.67   77.87  5396.9
83.21001 5397.54   85.16 5397.7787.10001 5398.02   92.44 5398.72   94.39 5398.97
   96.33 5399.18  101.67  5399.7  103.62 5399.91  105.56 5400.06   110.9 5400.46
  112.85 5400.61  114.79 5400.75  120.13 5401.21  122.07 5401.35  124.02 5401.48
  129.36 5401.89   131.3 5402.03  133.25 5402.15  138.59  5402.5  140.53 5402.63
  142.48 5402.75  146.58 5402.97

Manning's n Values        num=       1
     Sta   n Val
       0    .035

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
         18.89   96.33            77.63   77.63   77.63             .1       .3

CROSS SECTION


RIVER: BocaNegraArroyo
REACH: Split Flow         RS: 21840

INPUT
Description: 28
Station Elevation Data    num=      49
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0 5398.442.150009 5398.636.110001 5398.617.400009  5398.6   11.38 5398.58
   15.51 5398.33   16.47 5398.28   20.61 5398.04   24.91 5397.83   25.25 5397.81
   25.54  5397.8   29.84 5397.59   34.15 5397.24   34.77 5397.1939.07001 5396.84
   43.38 5396.35      44 5396.28    48.3 5395.79   52.61 5395.46   53.23 5395.41
57.53001 5395.08   61.84 5395.04   62.29 5395.02   62.45 5395.02   66.76 5394.97
71.07001 5395.25   71.68 5395.2875.99001 5395.5680.29001 5396.08   80.91 5396.15
   85.22 5396.66   89.52 5397.34   90.14 5397.44   94.45 5398.12   98.75 5398.86
   99.37 5398.98  103.68 5399.72  107.98 5400.38   108.6 5400.47   112.9 5401.12
  117.21 5401.64  117.83 5401.72  122.13 5402.23  126.44  5402.6  127.06 5402.66
  131.36 5403.03  135.67 5403.36  136.29  5403.4  137.41 5403.49

Manning's n Values        num=       2
     Sta   n Val     Sta   n Val
       0    .035  117.21    .035

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
      39.07001   85.22            54.1    54.1    54.1             .1       .3

CROSS SECTION


RIVER: BocaNegraArroyo
REACH: Split Flow         RS: 21835

INPUT
Description: 27
Station Elevation Data    num=      51
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0 5396.661.419998 5396.743.929993 5396.876.429993 5396.8210.64999 5396.68
13.15999 5396.63   15.66 5396.4219.87999 5396.06   22.38 5395.8524.88999  5395.7
29.10999 5395.3431.60999 5395.19   34.12 5395.09   38.34 5394.82   40.84 5394.73
   43.35 5394.55   47.56 5394.2350.06999 5394.0552.57999 5393.8656.78999 5393.59
    59.3  5393.4   61.81 5393.2964.17999 5393.21   66.02 5393.15   68.53 5393.04
71.03999 5393.2275.24999 5393.5977.75999 5393.7680.25999 5394.33   84.48 5395.34
86.98999 5395.91   89.49 5396.5393.70999 5397.5896.21999 5398.2198.71999 5398.66
  102.94 5399.39  105.45 5399.83  107.95 5400.19  112.17 5400.83  114.67 5401.18
  117.18 5401.51   121.4 5402.05   123.9 5402.38  126.41 5402.64  130.63 5403.05
  133.13 5403.31  135.64 5403.43  139.85 5403.61  142.36 5403.74  144.87 5403.84
  148.12 5403.98

Manning's n Values        num=       1
     Sta   n Val
       0    .035

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
         15.66   89.49           135.23  135.23  135.23             .1       .3

CROSS SECTION


RIVER: BocaNegraArroyo
REACH: Split Flow         RS: 21800

INPUT
```

```
Description: 26
Station Elevation Data    num=      66
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0 5392.611.259995 5392.615.330002 5392.568.410004 5392.4613.74001 5392.31
   15.56 5392.28   16.61 5392.26   20.53 5392.2522.71001 5392.25   27.89 5392.24
   29.86 5392.28   33.27 5392.3337.00999 5392.38   39.17 5392.43   44.16 5392.64
   47.25 5392.8250.46001 5392.99   51.31 5393.03    52.8 5393.11   58.47 5393.46
61.74001 5393.73   65.62 5393.99   72.33 5394.45   72.77 5394.48   73.02 5394.49
   73.98 5394.47   75.43 5394.45   81.22 5394.39   82.69 5394.36   84.16 5394.25
   90.45 5393.71   91.92  5393.6   93.39 5393.44   99.68 5392.69  101.15 5392.52
  102.61 5392.41  108.91 5392.07  109.32 5392.04  110.38 5391.96  111.84 5392.02
  118.14 5392.43  119.61 5392.49  121.07 5392.64  127.37 5393.32  128.83 5393.46
   130.3  5393.6   136.6 5394.29  138.06 5394.43  139.53  5394.6  145.83 5395.35
  147.29 5395.51  148.76 5395.67  155.05 5396.29  156.52 5396.45  157.99  5396.6
  164.28 5397.22  165.75 5397.38  167.22 5397.47  173.51 5397.75  174.98 5397.84
  176.45 5397.86  182.74 5397.99  184.21 5398.01  185.68 5398.04  191.97 5398.25
  192.86 5398.27

Manning's n Values        num=       1
     Sta   n Val
       0    .035

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
         81.22   136.6             68.96   68.96   68.96             .1       .3

CROSS SECTION


RIVER: BocaNegraArroyo
REACH: Split Flow         RS: 21770.8

INPUT
Description: 25
Station Elevation Data    num=      77
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0  5391.16.020004 5391.376.179993 5391.386.300003 5391.387.349991 5391.35
8.050003 5391.33   13.39 5391.18   17.25 5391.02   20.61 5390.85   27.69  5390.5
   27.84 5390.49   27.91 5390.49   28.11  5390.535.06999 5390.7638.56999 5390.94
    42.3 5391.0648.39999 5391.26   49.23 5391.29   49.53 5391.3150.14999 5391.35
   56.75 5391.77   59.89 5391.95   63.98 5392.16   68.69 5392.34   70.55 5392.42
71.20999 5392.4472.59999 5392.49   78.44 5392.6781.20999 5392.77   85.66  5392.9
88.98999 5392.98   91.87 5393.05   92.89 5393.06   95.05 5393.08  100.12 5393.13
  102.52 5393.16  107.35 5393.14  109.28 5393.14  113.18 5393.15  114.57 5393.12
   117.5 5393.13  118.02 5393.13  122.85 5393.18  123.06 5393.18  123.27 5393.17
  132.08  5392.6  132.29 5392.59   132.5 5392.57  141.31 5391.71  141.52 5391.69
  141.73 5391.68  150.54 5391.01  150.75 5390.99  150.96 5390.99  151.64    5391
  159.76 5391.08  159.98 5391.08  160.19  5391.1  168.99 5391.67  169.21 5391.68
  169.42  5391.7  178.22 5392.36  178.44 5392.38  178.65 5392.39  187.45 5393.06
  187.66 5393.08  187.88 5393.09  196.68 5393.76  196.89 5393.77  197.11 5393.79
  205.91 5394.36  206.12 5394.38  206.34 5394.39  215.14 5394.86  215.35 5394.88
  215.56  5394.9   223.2 5395.56

Manning's n Values        num=       1
     Sta   n Val
       0    .035

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
        123.06  187.45            95.48   95.48   95.48             .1       .3
Ineffective Flow     num=       1
   Sta L   Sta R    Elev  Permanent
       0  122.85 5393.18       F

CROSS SECTION


RIVER: BocaNegraArroyo
REACH: Split Flow         RS: 21520.8

INPUT
Description: 24
Station Elevation Data    num=      89
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0 5389.65 .230011 5389.653.520004  5389.56.190002 5389.3710.60001 5389.17
13.49001 5388.9820.34001 5388.4320.79001 5388.39   20.97 5388.3821.43001 5388.39
28.09001 5388.4831.34001 5388.54   35.38  5388.739.35001 5388.83   41.72 5388.92
42.68001 5388.97   44.97 5389.1149.98001 5389.3652.09001 5389.4257.26001 5389.44
   57.28 5389.44   58.97 5389.4562.49001 5389.46   64.55  5389.469.29001 5389.35
   71.83 5389.33   72.94 5389.34   75.77  5389.579.10001 5389.68   83.39 5389.91
   86.38  5389.993.20001 5389.7993.65001 5389.7793.85001 5389.7694.35001 5389.76
  100.93 5389.67   104.3 5389.71   108.2 5389.76  112.92 5389.82  114.76 5389.85
  115.47 5389.87  117.12 5389.88  122.75 5389.86  125.21 5389.85  130.02 5390.06
  131.49 5390.11  135.66 5390.26   137.3 5390.23  141.04 5390.25  144.57 5390.27
  146.12 5390.28  150.06 5390.19  151.85 5390.14  152.43 5390.13  156.09 5390.21
  160.48 5390.14  160.92 5390.13  165.31 5390.06  169.71 5389.67  170.15 5389.63
  174.54 5389.25  178.94 5388.98  179.38 5388.97  179.45 5388.96  183.77  5388.7
  188.17 5389.11   188.6 5389.15     193 5389.55   197.4 5389.84  197.83 5389.86
  202.23 5390.15  206.63 5390.29  207.06  5390.3  211.46 5390.45  215.86 5390.59
  216.29  5390.6  220.69 5390.75  225.09 5390.91  225.52 5390.93  229.92  5391.1
  234.32 5391.27  234.75 5391.28  239.15 5391.45  243.54 5391.69  243.98 5391.71
  248.38 5391.95  252.77 5392.19  253.21 5392.21  254.99 5392.31
```

Manning's n Values num= 1

Sta	n Val
0	.035

Bank Sta: Left Right Lengths: Left Channel Right Coeff Contr. Expan.

160.48	202.23		115.6	115.6	115.6	.1	.3

CROSS SECTION

RIVER: BocaNegraArroyo
REACH: Split Flow RS: 21335.5

INPUT
Description: 23
Station Elevation Data num= 120

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	5387.44.9900208	5387.46	1.27002	5387.471.660004		5387.481.890015		5387.48	
2.77002	5387.498.800018	5387.54	13.24002	5387.5415.95001		5387.3720.55002		5387.07	
23.10001	5386.8824.60001	5386.78	30.24002	5386.4630.39001		5386.4635.95001		5386.23	
37.39001	5386.25	39.84	5386.2944.54001	5386.4347.30002		5386.4951.67999		5386.66	
58	5386.96	58.66	5386.9958.83002	5386.99	59.12	5386.9965.98001		5386.86	
70.01001	5386.71	73.12	5386.5378.39999	5386.1980.27002		5386.09	81.37	5386.04	
85.62	5385.9687.42001	5385.93	92.72	5385.79	94.56	5385.75	97.69	5385.69	
101.71	5385.67	104.08	5385.66	108.85	5385.65	113.23	5385.62	115.43	5385.61
116	5385.6	116.97	5385.6	123.15	5385.64	126.79	5385.74	130.29	5385.9
136.25	5386.21	137.44	5386.26	138.14	5386.28	140.84	5386.34	144.59	5386.42
149.49	5386.52	151.73	5386.56	155.54	5386.65	158.88	5386.64	160.85	5386.65
166.03	5386.59	168.46	5386.54	172.2	5386.47	173.17	5386.44	174.82	5386.39
180.32	5386.15	183.56	5386.03	187.47	5385.9	189.3	5385.84	191.57	5385.86
193.86	5385.89	196.14	5385.94	200.82	5386.09	203.09	5386.14	205.35	5386.2
210.07	5386.3	212.32	5386.36	214.56	5386.31	219.32	5386.31	221.55	5386.26
223.77	5386.2	228.57	5386.1	230.78	5386.04	232.98	5386.02	236.3	5385.99
237.82	5385.97	240.01	5385.96	242.19	5386.09	247.07	5386.41	249.24	5386.54
251.4	5386.61	256.32	5386.77	258.47	5386.84	260.61	5386.88	265.57	5386.99
267.7	5387.04	269.82	5387.05	274.82	5387.05	276.92	5387.06	279.02	5387.03
284.06	5387.03	286.15	5387.01	288.23	5387.01	293.31	5387.01	295.38	5387.01
297.44	5387.01	302.56	5387.01	304.61	5387.01	306.65	5387.01	311.81	5386.96
313.84	5386.96	315.86	5386.98	321.06	5387.03	323.07	5387.05	325.07	5387.11
330.31	5387.28	332.3	5387.33	334.28	5387.4	339.56	5387.57	341.53	5387.63
343.49	5387.71	348.81	5387.94	350.76	5388.01	352.7	5388.05	356.1	5388.13

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.035	2.77002	.035	214.56	.035

Bank Sta: Left Right Lengths: Left Channel Right Coeff Contr. Expan.

158.88	251.4		268.96	268.96	268.96	.1	.3

CROSS SECTION

RIVER: BocaNegraArroyo
REACH: Split Flow RS: 21325

INPUT
Description: 22
Station Elevation Data num= 75

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	5384.362.229996	5384.28	6.819992	5384.0913.42999		5383.72	13.86	5383.7	
13.95999	5383.69	14.11	5383.68	21.09	5383.35	25.48	5383.27	28.23	5383.22
32.59	5383.19	35.36	5383.15	37.11	5383.12	42.5	5383.144.76999		5383.07	
48.73	5383.0449.62999	5383.03		51.06	5383.0156.76999		5382.960.34999		5382.84	
63.9	5382.7969.53999	5382.75	71.03999	5382.74	71.98	5382.74	76.12	5382.7		
78.17	5382.6983.59999	5382.61		85.31	5382.5888.01999		5382.5792.43999		5382.5	
95.23	5382.46	99.58	5382.31	106.49	5382.19	106.71	5382.19	106.75	5382.19	
106.86	5382.19	108.02	5382.18	113.86	5382.14	119.53	5382.19	121.01	5382.2	
122.91	5382.22	128.15	5382.26	132.2	5382.29	135.3	5382.28	139.31	5382.23	
142.45	5382.2	144.87	5382.19	149.59	5382.26	155.7	5382.36	156.74	5382.39	
157.54	5382.42	163.82	5382.79	163.89	5382.79	170.22	5383.16	171.03	5383.2	
172.09	5383.23	178.18	5383.38	182.89	5383.42	185.33	5383.43	187.1	5383.43	
191.89	5383.49	193.35	5383.51	195.28	5383.51	200.11	5383.56	202.71	5383.56	
206.15	5383.5	208.32	5383.45	212.07	5383.39	216.54	5383.48	217.02	5383.5	
221.43	5383.61	224.76	5383.74	227.9	5383.85	230.79	5383.96	231.76	5384	

Manning's n Values num= 1

Sta	n Val
0	.035

Bank Sta: Left Right Lengths: Left Channel Right Coeff Contr. Expan.

63.9	163.82		114.8	114.8	114.8	.1	.3

CROSS SECTION

RIVER: BocaNegraArroyo
REACH: Split Flow RS: 21315

INPUT
Description: 21
Station Elevation Data num= 70

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	5383.25.5599976	5383.295.639999		5383.537.699997		5383.56	10.58	5383.51	
14.83	5383.3	17.86	5383.09	21.97	5382.8227.73001		5382.5329.10001		5382.48
30.07001	5382.49	35.89	5382.4936.23001		5382.4942.29001		5382.4943.37001		5382.46
44.88	5382.4	50.5	5382.1254.51001		5381.92	57.63	5381.8	62.02	5381.6
64.77	5381.48	66.72	5381.3871.90001		5381.1178.35001		5380.82	78.94	5380.79
79.03	5380.79	79.17	5380.79	86.17	5380.5991.15001		5380.45	93.3	5380.42
96.32001	5380.39	100.43	5380.34	103.37	5380.31	107.57	5380.22	113.46	5380.11
114.7	5380.09	115.58	5380.08	120.82	5380.05	121.3	5380.04	121.83	5380.04
128.04	5380	128.98	5380.01	130.2	5380.02	136.13	5380.1	140.71	5380.13
143.28	5380.13	146.6	5380.14	150.42	5380.18	153.38	5380.19	157.57	5380.21
162.99	5380.19	164.72	5380.19	166.05	5380.19	171.86	5380.24	176.48	5380.27
178.72	5380.29	179.01	5380.3	179.38	5380.32	186.16	5380.72	191.39	5381.18
193.3	5381.36	195.78	5381.57	200.45	5381.85	204.07	5381.99	207.6	5382.08
212.17	5382.15	214.75	5382.19	216.74	5382.18	221.89	5382.13	228.16	5382.08

Manning's n Values num= 1

Sta	n Val
0	.035

Bank Sta: Left	Right	Lengths: Left Channel	Right	Coeff Contr.	Expan.
62.02	195.78	268.94	268.94	.1	.3

CROSS SECTION

RIVER: BocaNegraArroyo
REACH: Split Flow RS: 21250

INPUT
Description: 20
Station Elevation Data num= 116

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	5378.72.5499878	5378.735.089996		5378.799.440002		5378.8512.32999		5378.89	
15.35999	5378.8919.57001	5378.8923.60999		5378.83	26.81	5378.86	30.16	5378.84	
34.04999	5378.71	37.78	5378.5341.29001		5378.3644.95999		5378.14	48.53	5377.82
51.94998	5377.5255.76999	5377.1359.76999		5376.8963.01001		5376.92	66.12	5377.19	
70.25	5377.5974.57001	5378.0177.48999		5378.2180.29001		5378.3384.72998		5378.42	
89.37	5378.45	91.97	5378.45	94.47	5378.4999.20999		5378.59	104.17	5378.69
106.45	5378.68	108.64	5378.67	113.69	5378.62	118.98	5378.54	120.93	5378.46
122.81	5378.36	128.17	5377.99	133.78	5377.61	135.41	5377.52	136.98	5377.44
142.65	5377.17	148.58	5376.89	149.89	5376.86	151.15	5376.84	157.13	5376.76
163.39	5376.68	164.37	5376.69	165.32	5376.72	171.61	5376.89	178.19	5377.07
178.85	5377.08	179.49	5377.09	186.09	5377.21	192.99	5377.28	193.33	5377.28
193.66	5377.29	200.57	5377.36	207.8	5377.49	207.81	5377.49	207.83	5377.49
208.59	5377.51	215.05	5377.69	222	5377.89	222.29	5377.89	222.6	5377.89
229.53	5377.84	236.17	5377.71	236.77	5377.69	237.4	5377.68	244.01	5377.59
250.34	5377.41	251.25	5377.4	252.21	5377.39	258.49	5377.33	264.51	5377.22
265.73	5377.22	267.01	5377.21	272.97	5377.23	278.68	5377.21	280.21	5377.24
281.81	5377.28	281.95	5377.28	287.45	5377.4	292.85	5377.37	294.69	5377.37
296.61	5377.37	301.93	5377.41	307.02	5377.38	309.17	5377.37	311.42	5377.35
316.41	5377.35	321.19	5377.36	323.65	5377.35	326.22	5377.32	330.89	5377.29
335.37	5377.27	338.13	5377.29	341.02	5377.31	345.37	5377.39	349.54	5377.43
352.61	5377.44	355.83	5377.48	359.85	5377.55	363.71	5377.59	367.09	5377.62
370.63	5377.64	374.33	5377.63	377.88	5377.64	381.57	5377.72	385.43	5377.8
388.81	5377.86	392.05	5377.9	396.05	5377.99	400.23	5378.08	403.29	5378.19
403.87	5378.2								

Manning's n Values num= 1

Sta	n Val
0	.035

Bank Sta: Left	Right	Lengths: Left Channel	Right	Coeff Contr.	Expan.
222	396.05	340.84	340.84	.1	.3

CROSS SECTION

RIVER: BocaNegraArroyo
REACH: Split Flow RS: 21200

INPUT
Description: 19
Station Elevation Data num= 84

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	5374.78.6799927	5374.795.279999		5374.697.119995		5374.66	12.34	5374.51	
15.82001	5374.3122.94998	5373.85	24	5373.78	24.53	5373.77	26.06	5373.74	
33.23	5373.59	35.67	5373.5540.60999		5373.4541.92999		5373.4247.32999		5373.31
50.64	5373.11	58.28	5372.6358.98999		5372.58	59.34	5372.54	60.37	5372.44
68.04999	5371.670.65999	5371.32	75.95	5370.93	76.75	5370.8782.31999		5370.45	
85.45999	5370.61	93.62	5371.07	93.98	5371.0994.15999		5371.194.68999		5371.16
102.87	5371.99	105.64	5372.29	111.28	5372.55	111.57	5372.57	117.31	5372.82
120.27	5372.84	128.95	5372.89	128.97	5372.89	128.98	5372.89	129	5372.89
137.68	5372.52	140.63	5372.36	146.39	5371.89	146.62	5371.88	152.3	5371.46
155.09	5371.39	163.32	5371.39	163.8	5371.4	163.96	5371.4	164.17	5371.41
164.29	5371.42	172.5	5371.84	175.62	5372.04	181.21	5372.47	181.95	5372.52
187.28	5372.91	189.91	5373.1	197.64	5373.53	198.61	5373.58	198.95	5373.59
199.62	5373.61	207.32	5373.85	210.61	5373.91	216.02	5374.02	217.29	5374.05
222.27	5374.15	224.73	5374.14	231.95	5374.17	233.43	5374.19	233.94	5374.21
234.96	5374.22	242.14	5374.35	245.6	5374.41	250.84	5374.5	252.62	5374.51
257.26	5374.56	259.54	5374.57	266.27	5374.59	268.25	5374.59	268.92	5374.59

  270.29 5374.6 276.95 5374.66 280.59 5374.69 284.68 5374.71

Manning's n Values   num=   1
     Sta   n Val
       0   .035

Bank Sta: Left   Right   Lengths: Left Channel   Right   Coeff Contr.   Expan.
        128.95 189.91   276.3   276.3   276.3   .1   .3

CROSS SECTION

RIVER: BocaNegraArroyo
REACH: Split Flow   RS: 21194.9

INPUT
Description: 18
Station Elevation Data   num=   97
     Sta   Elev   Sta   Elev   Sta   Elev   Sta   Elev   Sta   Elev
       0   53661.440002 5365.995.089996 5365.998.049988 5365.9512.54001 5365.94
   18.09 5365.96   20 5365.9921.54001 5366.0127.44998 5366.0834.73999 5366.18
34.89999 5366.1835.04001 5366.1836.35001 5366.1742.35999 5366.1148.54001 5366.14
   49.81 5366.11   51.38 5366.0757.26999 5365.94   62.03 5365.8   64.72 5365.73
   68.03 5365.6572.16998 5365.53   75.53 5365.41   79.63 5365.2883.54999 5365.16
84.67999 5365.1287.07999 5365.05   89.03 5364.9894.53999 5364.71 101.33 5364.32
  101.99 5364.3 102.52 5364.28 107.62 5364.06 109.44 5363.98 116.02 5363.7
   116.9 5363.72 117.98 5363.75 124.35 5363.94 129.52 5364.16 131.81 5364.37
  134.63 5364.61 139.26 5365.01 143.01 5365.34 146.71 5365.62 151.28 5365.94
  154.17 5366.13 156.51 5366.29 161.62 5366.69 167.93 5367.05 169.08 5367.1
     170 5367.13 176.53 5367.29 178.89 5367.34   183.5 5367.43 183.98 5367.43
  184.58 5367.45 191.44 5367.57   197 5367.64 198.89 5367.67 201.23 5367.71
  206.35 5367.82 210.49 5367.86   213.8 5367.87 217.88 5367.86 221.25 5368.01
  223.99 5368.16 228.71 5368.43 229.21 5368.46 232.05 5368.6 236.17 5368.8
  241.71 5369.03 242.02 5369.04 247.51 5369.27 251.38 5369.38 255.76 5369.48
  258.86 5369.56 261.05 5369.59 269.49 5369.7 270.21 5369.71 270.71 5369.71
   273.6 5369.78 280.38 5369.98 281.56 5370.03 283.23 5370.05 290.04 5370.14
   292.9 5370.18 296.97 5370.18 299.71 5370.19 304.25 5370.18 309.38 5370.27
   310.7 5370.3   315.6 5370.38 319.04 5370.46 324.44 5370.58 326.95 5370.63
  328.71 5370.64 338.15 5370.69

Manning's n Values   num=   1
     Sta   n Val
       0   .035

Bank Sta: Left   Right   Lengths: Left Channel   Right   Coeff Contr.   Expan.
         49.81 154.17   200   200   200   .1   .3

CROSS SECTION

RIVER: BocaNegraArroyo
REACH: Split Flow   RS: 21001.7

INPUT
Description: 17
Station Elevation Data   num=   114
     Sta   Elev   Sta   Elev   Sta   Elev   Sta   Elev   Sta   Elev
       0 5366.47 3.02002 5366.113.820007 5366.01   4.25 5365.965.660004 5365.72
   11.82 5364.6916.52002 5363.88   19.81 5363.33   25.97 5362.28   27.81 5361.96
28.79001 5361.8232.02002 5361.5535.80002 5361.17   41.06 5360.9243.80002 5360.94
48.93002 5361.0551.79001 5361.1253.32001 5361.1758.37003 5361.3859.79001 5361.44
65.59003 5361.68   67.78 5361.77   71.88 5361.89   75.78 5362.0177.86002 5362.07
83.77002 5362.19   84.72 5362.21   87.22 5362.27   90.13 5362.3391.77002 5362.35
94.84003 5362.3599.76001 5362.38   102.4 5362.39 107.76 5362.5 111.07 5362.57
  114.67 5362.65 115.76 5362.7   117.8 5362.79 123.75 5363.1 126.93 5363.25
  131.75 5363.43 137.42 5363.61   139.2 5363.67 139.74 5363.69 140.75 5363.71
  147.74 5363.94 151.47 5364.03 155.73 5364.1 163.71 5364.19 163.73 5364.19
  163.74 5364.19 163.78 5364.19 171.72 5364.22 176.01 5364.24 179.72 5364.27
  186.66 5364.29 187.71 5364.3 188.27 5364.3 190.13 5364.3 195.71 5364.29
  200.54 5364.31   203.7 5364.29 209.62 5364.24   211.7 5364.21 212.81 5364.2
  216.48 5364.16   219 5364.13 220.41 5364.1 224.72 5364.02 227.11 5363.94
  235.47 5363.71 236.08 5363.69 236.26 5363.69 236.58 5363.68 245.05 5363.45
   247.8 5363.36 252.75 5363.22 254.02 5363.19 259.34 5363.01 262.99 5362.76
  268.91 5362.43 270.88 5362.3 271.97 5362.27 275.77 5362.16 280.94 5362.01
  282.42 5361.97 285.08 5362.13 289.91 5362.38 293.96 5362.63 298.88 5362.92
  301.25 5363.05   305.5 5363.29 307.85 5363.38 316.07 5363.66 316.82 5363.68
  317.04 5363.68 317.42 5363.71 325.79 5364.17 328.58 5364.33 333.59 5364.52
  334.76 5364.56 340.12 5364.77 343.73 5364.78 349.76 5364.74 351.66 5364.74
  352.71 5364.75 356.38 5364.73 361.68 5364.74 363.19 5364.74 365.93 5364.85
  370.65 5365.05 374.73 5365.21 379.62 5365.48 379.95 5365.5

Manning's n Values   num=   1
     Sta   n Val
       0   .035

Bank Sta: Left   Right   Lengths: Left Channel   Right   Coeff Contr.   Expan.
          219 325.79   130   130   130   .1   .3

CROSS SECTION

RIVER: BocaNegraArroyo
REACH: Reach - 1 Lower RS: 20573.7

INPUT
Description: Cross Section Boca Negra Arroyo 22.75 - H
Station Elevation Data num= 112

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
4882.6	5366.22	4883.94	5366.17	4888.67	5365.9	4896.32	5365.5	4896.46	5365.49
4896.54	5365.49	4896.9	5365.48	4904.24	5365.32	4909.14	5365.28	4912.03	5365.19
4916.71	5365.15	4919.82	5365.08	4921.74	5365.04	4927.6	5364.7	4929.87	5364.58
4934.33	5364.35	4935.39	5364.27	4937.09	5364.17	4943.17	5363.84	4946.93	5363.73
4950.96	5363.5	4957.48	5363.17	4958.75	5363.09	4959.53	5363.04	4962.85	5362.75
4966.53	5362.43	4972.13	5361.95	4974.32	5361.82	4977.87	5361.59	4981.89	5361.27
4982.32	5361.22	4984.47	5361.02	4985.75	5360.93	4990.78	5360.6	4994.9	5360.33
4995.95	5360.27	4997.71	5360.23	5004.05	5360.05	5007.42	5359.99	5013.1	5359.99
5013.2	5359.99	5014.7	5359.99	5018.9	5359.99	5022.35	5360.05	5028.49	5360.16
5030.38	5360.19	5031.5	5360.21	5035.9	5360.33	5040.65	5360.47	5041.85	5360.5
5043.88	5360.54	5049.79	5360.66	5053.33	5360.73	5058.94	5360.81	5059.27	5360.82
5064.8	5360.92	5068.09	5360.92	5074.66	5360.95	5076.28	5360.96	5077.24	5360.95
5081.02	5360.91	5086.39	5360.84	5087.75	5360.82	5090.05	5360.78	5095.54	5360.7
5099.23	5360.63	5104.69	5360.74	5105.44	5360.74	5110.71	5360.82	5113.84	5360.95
5120.83	5361.24	5122.18	5361.3	5122.99	5361.31	5126.15	5361.43	5132.13	5361.63
5133.66	5361.69	5136.22	5361.69	5141.28	5361.66	5145.13	5361.67	5147.97	5361.65
5149.91	5361.66	5155.18	5361.72	5157.14	5361.71	5159.23	5361.72	5164.36	5361.74
5169.16	5361.79	5171.59	5361.79	5174.19	5361.83	5178.81	5361.89	5183.14	5361.95
5186.04	5362	5189.15	5362.08	5193.27	5362.22	5197.11	5362.35	5200.49	5362.51
5204.1	5362.69	5207.72	5362.89	5211.09	5363.08	5214.94	5363.26	5219.06	5363.46
5222.17	5363.57	5225.07	5363.67	5229.39	5363.74	5234.02	5363.85	5236.62	5363.86
5239.04	5363.89	5243.84	5363.94	5248.98	5363.96	5251.07	5363.95	5253.02	5363.96
5258.29	5363.95	5263.23	5363.96						

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
4882.6	.035	4990.78	.035	5049.79	.035

Bank Sta: Left	Right	Lengths: Left Channel	Right	Coeff Contr.	Expan.
4990.78	5049.79	183.1	183.1	183.1	.1	.3

CROSS SECTION

RIVER: BocaNegraArroyo
REACH: Reach - 1 Lower RS: 20390.6

INPUT
Description: Cross Section Boca Negra Arroyo 22.5 - G
Station Elevation Data num= 81

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
4871.5	5362.11	4873.57	5362.12	4880.55	5362.19	4880.81	5362.18	4881.09	5362.18
4888.06	5361.87	4894.79	5361.8	4895.3	5361.78	4895.84	5361.79	4902.55	5361.49
4909.03	5361.25	4909.79	5361.2	4910.59	5361.16	4917.04	5360.71	4923.27	5360.29
4924.29	5360.19	4925.33	5360.12	4931.53	5359.56	4937.52	5359.19	4938.78	5359.12
4940.08	5359.05	4946.02	5358.89	4950.87	5358.82	4952.52	5358.82	4954.15	5358.79
4959.26	5358.75	4960.57	5358.74	4966.36	5358.69	4968.61	5358.72	4972.96	5358.8
4976.65	5358.87	4978.56	5358.91	4984.59	5358.99	4984.69	5358.99	4990.77	5359.06
4992.74	5359.07	4996.53	5359.04	5000.78	5359.01	5002.98	5358.99	5004.29	5358.97
5008.82	5358.92	5009.91	5358.9	5015.19	5358.81	5016.86	5358.78	5020.1	5358.71
5024.91	5358.65	5027.39	5358.59	5032.95	5358.43	5035.23	5358.35	5039.6	5358.21
5040.99	5358.19	5043.67	5358.19	5049.03	5358.25	5051.81	5358.29	5057.07	5358.51
5060.56	5358.68	5064.02	5358.83	5065.12	5358.88	5067.24	5358.97	5073.16	5359.24
5076.23	5359.42	5076.96	5359.47	5080.72	5359.79	5084.22	5360.08	5087.86	5360.33
5092.83	5360.53	5095	5360.59	5096.58	5360.59	5102.13	5360.43	5106.79	5360.33
5108.94	5360.28	5109.27	5360.29	5109.73	5360.3	5116.41	5360.63	5121.29	5360.97
5123.54	5361.1	5126.62	5361.28	5130.68	5361.38	5133.65	5361.43	5137.82	5361.44
5143.07	5361.49								

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
4871.5	.035	5020.1	.035	5060.56	.035

Bank Sta: Left	Right	Lengths: Left Channel	Right	Coeff Contr.	Expan.
5020.1	5060.56	620	620	620	.1	.3

CROSS SECTION

RIVER: BocaNegraArroyo
REACH: Reach - 1 Lower RS: 19770.6

INPUT
Description: Cross Section Boca Negra Arroyo 22.0 - F
Station Elevation Data num= 86

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
4836.3	5355.13	4839.83	5355.07	4841.82	5355.03	4846.53	5354.94	4852.04	5354.84
4852.26	5354.84	4857.78	5354.74	4862.7	5354.65	4864.24	5354.63	4869.04	5354.55
4873.14	5354.37	4876.45	5354.23	4880.3	5354.06	4883.59	5353.91	4888.66	5353.64
4891.55	5353.51	4894.03	5353.41	4900.86	5353.1	4902.81	5353.02	4904.47	5352.92
4913.07	5352.46	4914.06	5352.4	4914.91	5352.35	4925.28	5351.69	4925.32	5351.69
4925.36	5351.69	4925.82	5351.68	4935.8	5351.42	4936.58	5351.4	4937.49	5351.39
4946.24	5351.4	4947.83	5351.39	4949.69	5351.4	4956.68	5351.4	4959.09	5351.41
4961.9	5351.44	4967.13	5351.49	4970.34	5351.52	4974.11	5351.47	4977.57	5351.44

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  4981.6 5351.39 4986.31 5351.12 4988.01 5351.01 4992.86 5350.74 4998.46 5350.52
 4998.52 5350.51 5000.82 5350.42 5002.71 5350.46 5005.28 5350.49 5007.48 5350.54
 5012.75  5350.7 5014.55 5350.74 5016.08 5350.76 5022.79 5350.89 5023.82 5350.91
 5024.69 5350.94 5032.84 5351.28 5033.08 5351.29  5033.3  5351.3 5036.05 5351.39
  5041.9 5351.56 5042.35 5351.58 5042.88  5351.6 5050.51 5351.92 5051.62 5351.98
 5052.92 5352.02 5059.12 5352.15 5060.89 5352.21 5062.97 5352.25 5067.72 5352.35
 5070.16 5352.39 5073.01 5352.45 5076.33 5352.52 5079.43 5352.59 5083.05 5352.75
 5084.94 5352.81  5088.7 5352.98  5093.1 5353.36 5093.54  5353.4 5097.97 5353.79
 5102.15 5354.21 5103.14 5354.31 5107.24 5354.73 5110.76 5354.98 5113.18 5355.12
 5113.51 5355.14

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
  4836.3    .035  4961.9    .035 5032.84    .035

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
        4961.9 5032.84              480     480     480             .1       .3

CROSS SECTION


RIVER: BocaNegraArroyo
REACH: Reach - 1 Lower    RS: 19290.6

INPUT
Description: 13
Station Elevation Data    num=      33
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0 5348.8164.29999 5345.55  106.99 5344.59  208.45 5341.52  212.88 5341.52
  219.55 5341.43  220.08  5341.4  224.79 5341.09  227.42    5341  231.98 5340.46
  235.53    5340  240.35 5339.98  251.78 5339.91  253.38 5339.92  267.29    5340
  267.99 5340.13  274.23    5341  282.53 5341.78  284.17    5342  286.98 5342.15
   287.4 5342.17  297.64    5343  301.86 5343.12  301.95 5343.12  312.36  5343.6
  318.87    5344  319.07    5344  319.86    5344  323.45 5344.08  342.32 5345.73
  346.74 5345.87  350.63 5345.99     500 5348.65

Manning's n Values        num=       1
     Sta   n Val
       0    .035

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
        208.45  282.53              115     115     115             .3       .5

CULVERT


RIVER: BocaNegraArroyo
REACH: Reach - 1 Lower    RS: 19200

INPUT
Description: Scenic Culverts
Distance from Upstream XS =      50
Deck/Roadway Width        =      56
Weir Coefficient          =     2.6
Upstream  Deck/Roadway Coordinates
    num=       6
     Sta Hi Cord Lo Cord     Sta Hi Cord Lo Cord     Sta Hi Cord Lo Cord
    -176  5351.8             174 5347.29             251 5346.79
     374 5348.06           470.4 5350.06             491    5351

Upstream Bridge Cross Section Data
Station Elevation Data    num=      33
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0 5348.81    64.3 5345.55  106.99 5344.59  208.45 5341.52  212.88 5341.52
  219.55 5341.43  220.08  5341.4  224.79 5341.09  227.42    5341  231.98 5340.46
  235.53    5340  240.35 5339.98  251.78 5339.91  253.38 5339.92  267.29    5340
  267.99 5340.13  274.23    5341  282.53 5341.78  284.17    5342  286.98 5342.15
   287.4 5342.17  297.64    5343  301.86 5343.12  301.95 5343.12  312.36  5343.6
  318.87    5344  319.07    5344  319.86    5344  323.45 5344.08  342.32 5345.73
  346.74 5345.87  350.63 5345.99     500 5348.65

Manning's n Values        num=       1
     Sta   n Val
       0    .016

Bank Sta: Left   Right    Coeff Contr.   Expan.
        208.45  282.53             .3       .5

Downstream  Deck/Roadway Coordinates
    num=       6
     Sta Hi Cord Lo Cord     Sta Hi Cord Lo Cord     Sta Hi Cord Lo Cord
    -176  5351.8             174 5347.29             251 5346.79
     374 5348.06           470.4 5350.06             491    5351

Downstream Bridge Cross Section Data
Station Elevation Data    num=      34
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
    -100  5348.5   33.06 5345.58    64.3 5345.55  106.99 5344.59  208.45 5341.52
  212.88 5341.52  219.55 5341.43  220.08  5341.4  224.79 5341.09  227.42    5341
  231.98 5340.46  235.53    5340  240.35 5339.98  251.78 5339.91  253.38 5339.92
  267.29    5340  267.99 5340.13  274.23    5341  282.53 5341.78  284.17    5342
```

```
  286.98 5342.15   287.4 5342.17  297.64    5343  301.86 5343.12  301.95 5343.12
  312.36  5343.6  318.87    5344  319.07    5344  319.86    5344  323.45 5344.08
  342.32 5345.73  346.74 5345.87  350.63 5345.99     400  5348.5

Manning's n Values        num=       1
     Sta   n Val
    -100    .016

Bank Sta: Left   Right    Coeff Contr.   Expan.
        208.45  282.53            .1       .3

Upstream Embankment side slope             =       0 horiz. to 1.0 vertical
Downstream Embankment side slope           =       0 horiz. to 1.0 vertical
Maximum allowable submergence for weir flow =     .98
Elevation at which weir flow begins        =
Energy head used in spillway design        =
Spillway height used in design             =
Weir crest shape                           = Broad Crested

Number of Culverts =  1

Culvert Name     Shape      Rise    Span
Culvert #1      Circular       5
FHWA Chart # 1 - Concrete Pipe Culvert
FHWA Scale # 2 - Groove end entrance with headwall
Solution Criteria = Highest U.S. EG
Culvert Upstrm Dist  Length    Top n  Bottom n  Depth Blocked  Entrance Loss Coef   Exit Loss Coef
                 50      56     .013     .013        0                  .2                1
Number of Barrels =  4
Upstream   Elevation =  5340
Centerline Stations
    Sta.    Sta.    Sta.    Sta.
     235     245     255     265
Downstream Elevation =  5339.7
Centerline Stations
    Sta.    Sta.    Sta.    Sta.
     235     245     255     265

CROSS SECTION


RIVER: BocaNegraArroyo
REACH: Reach - 1 Lower    RS: 19175.6

INPUT
Description: 12
Station Elevation Data    num=      34
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0 5345.96   33.06 5345.5864.29999 5345.55  106.99 5344.59  208.45 5341.52
  212.88 5341.52  219.55 5341.43  220.08  5341.4  224.79 5341.09  227.42    5341
  231.98 5340.46  235.53    5340  240.35 5339.98  251.78 5339.91  253.38 5339.92
  267.29    5340  267.99 5340.13  274.23    5341  282.53 5341.78  284.17    5342
  286.98 5342.15   287.4 5342.17  297.64    5343  301.86 5343.12  301.95 5343.12
  312.36  5343.6  318.87    5344  319.07    5344  319.86    5344  323.45 5344.08
  342.32 5345.73  346.74 5345.87  350.63 5345.99     400 5343.61

Manning's n Values        num=       1
     Sta   n Val
       0    .035

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
        208.45  282.53             50.1    50.1    50.1             .1       .3

CROSS SECTION


RIVER: BocaNegraArroyo
REACH: Reach - 1 Lower    RS: 19125.5

INPUT
Description: Dam Access Road 11
Station Elevation Data    num=      12
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
  -20.92 5344.13    -5.5 5343.28    8.12  5342.2   35.66  5340.5    52.7  5339.7
    62.7  5339.5    72.7  5339.7    89.7  5340.5    94.7 5340.75  123.44  5342.2
   145.9 5343.31   195.9 5344.83

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
  -20.92    .016   35.66    .013    94.7    .016

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
          8.12  123.44            70.95   70.95   70.95             .1       .3

CROSS SECTION


RIVER: BocaNegraArroyo
REACH: Reach - 1 Lower    RS: 19054.6

INPUT
```

```
Description: 10
Station Elevation Data    num=      81
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0 5345.39   20.88 5345.31   67.91 5344.08   76.16  5343.889.01999    5344
91.64001    534492.35999    534494.07999 5343.94  123.61    5343  129.09 5342.74
  156.79    5342  159.07 5341.66  163.51    5341  165.57 5340.69  170.22    5340
  171.22  5339.8  175.26    5339   176.6 5338.67  183.95 5338.26  186.39 5338.11
  196.19 5338.25  198.61 5338.27  201.46 5338.21  204.28 5338.02  205.25 5338.01
  205.36    5338  205.77 5337.82  207.66    5337  209.38 5336.12  209.61    5336
  211.36  5335.1  220.29 5335.09  220.45 5335.09  221.37 5335.09  223.15    5336
  223.35  5336.1  225.12    5337  226.59 5337.64  227.44    5338   228.2 5338.38
  229.46    5339  230.01 5339.03   230.9 5339.05  231.41 5339.05  231.69 5339.05
  233.21 5339.13  234.16  5339.1   239.7 5339.26  240.93 5339.28  242.58 5339.35
  243.83 5339.42  243.84 5339.42  245.64 5339.49  247.38 5339.61   252.9    5340
  265.77 5340.87  267.16    5341  272.35 5341.51  276.53    5342  281.45 5342.56
  283.53  5342.8  284.87    5343  285.07 5343.03  285.93 5343.12  286.23 5343.13
  297.83    5344  298.23    5344  298.39    5344  298.42    5344  298.83    5344
  298.91    5344  299.13    5344  299.31    5344  308.85 5344.03   316.5 5344.04
  338.87 5344.24  366.69  5344.4  382.08  5344.5  387.83 5344.48  394.15 5344.45
     400  5344.5

Manning's n Values        num=       1
     Sta   n Val
       0    .035

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
        183.95   228.2             50.98   50.98   50.98             .1       .3

CROSS SECTION


RIVER: BocaNegraArroyo
REACH: Reach - 1 Lower    RS: 19003.57

INPUT
Description: 9
Station Elevation Data    num=     158
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0 5345.0616.92999    534520.54001    534522.60999    534529.14999 5344.82
29.17999 5344.82   63.16    5344   67.31 5343.5283.04999    534383.85001 5342.86
   88.59    5342   91.34 5341.59   95.31    5341   97.63 5340.65  102.03    5340
  103.21 5339.76  107.06    5339  108.43 5338.73   112.1    5338  116.81 5337.12
  117.45    5337  118.07 5336.87  122.18    5336  124.93 5335.45  127.27    5335
  134.93 5334.67  139.13 5334.55  139.52 5334.53  140.24 5334.51  141.05 5334.48
  141.71 5334.45  142.33 5334.44  142.98 5334.42  143.89 5334.42  144.81 5334.42
   147.8 5334.37  151.56 5334.27  153.33 5334.24  155.72 5334.18  158.53 5334.11
  161.01 5334.04  162.54 5334.01  163.09    5334  163.39    5334  164.53  5333.7
  165.13 5333.58  167.54 5333.11  167.88 5333.04  168.03    5333  169.25 5332.76
  170.64 5332.57  175.33    5332  179.91    5332  185.56    5332  188.03 5332.03
  197.88 5332.21  198.19 5332.22  206.03 5332.13  207.66 5332.24  208.49 5332.25
  210.85    5332   213.6 5331.99  213.83 5331.99   216.4 5331.98  219.51 5331.99
  220.17 5331.99  222.85    5332  222.87    5332  222.89    5332  223.07 5332.01
  223.97 5332.08  224.28  5332.1  228.83 5332.45  233.31 5332.78   235.6    5333
  239.35 5333.58  242.07    5334  244.04  5334.3  246.93  5334.7  249.17    5335
  253.16 5335.54  254.56    5336   257.2 5336.88  257.54    5337  258.11 5337.19
  259.98    5338  260.42 5338.58  260.74    5339  262.19    5339  262.92    5339
  263.87 5339.07  265.26    5339   269.3    5339  270.14    5339  270.55    5339
   271.7    5339  273.47 5339.26  275.09 5339.86  275.78 5339.92   277.3 5339.94
  277.86 5339.94  278.15 5339.94  278.88 5339.94  280.47 5339.93  280.73 5339.93
  280.92 5339.93  282.27 5339.94  282.89 5339.96  282.94 5339.96  283.49    5340
   283.5 5340.44  283.52    5341  283.53 5341.45  283.55    5342  283.56 5342.46
  283.58    5343  283.91 5343.55   286.6 5343.81   286.7 5343.85  287.49 5343.94
  288.04    5344  289.01 5344.05  291.58 5344.52  292.65 5344.68  294.51 5344.99
  294.59    5345  295.97    5345   296.6    5345  297.86    5345  298.09    5345
  300.92 5344.37  302.52    5344  305.14 5343.86  305.15 5343.86  307.59 5343.76
  309.62 5343.71  312.64 5343.78  312.78 5343.78   312.9 5343.78  313.01 5343.78
  320.13    5344  323.56 5344.15   326.8 5344.14  330.15 5344.12  337.01 5344.04
  339.57    5344  339.74    5344  342.46 5343.92  343.52 5343.92  354.06 5343.72
  357.77 5343.73  366.48 5343.61  370.63 5343.63  378.13 5343.55  384.76 5343.43
  390.49 5343.32  394.58 5343.27     400 5343.24

Manning's n Values        num=       1
     Sta   n Val
       0    .035

Bank Sta: Left   Right    Coeff Contr.   Expan.
        108.43  260.42             .1       .3


SUMMARY OF MANNING'S N VALUES

River:BocaNegraArroyo

      Reach          River Sta.       n1        n2        n3

 Reach - 1 Upper      25374.6           .035      .035      .035
 Reach - 1 Upper      24989.3           .035      .035      .035
 Reach - 1 Upper      24106.4           .035      .035      .035
 Reach - 1 Upper      23000.0           .035      .035      .035
 Reach - 1 Upper      22241.1           .035      .035      .035
```

Reach - 1 Mid	22027.5	.035	.035	.035
Reach - 1 Mid	21845.5	.035	.035	.035
Reach - 1 Mid	21840	.035		
Reach - 1 Mid	21830	.035		
Reach - 1 Mid	21820	.035		
Reach - 1 Mid	21335.5	.035	.035	.035
Reach - 1 Mid	21001.7	.035	.035	.035
Split Flow	22027.5	.035	.035	
Split Flow	22000	.035		
Split Flow	21840	.035	.035	
Split Flow	21835	.035		
Split Flow	21800	.035		
Split Flow	21770.8	.035		
Split Flow	21520.8	.035		
Split Flow	21335.5	.035	.035	.035
Split Flow	21325	.035		
Split Flow	21315	.035		
Split Flow	21250	.035		
Split Flow	21200	.035		
Split Flow	21194.9	.035		
Split Flow	21001.7	.035		
Reach - 1 Lower	20573.7	.035	.035	.035
Reach - 1 Lower	20390.6	.035	.035	.035
Reach - 1 Lower	19770.6	.035	.035	.035
Reach - 1 Lower	19290.6	.035		
Reach - 1 Lower	19200	Culvert		
Reach - 1 Lower	19175.6	.035		
Reach - 1 Lower	19125.5	.016	.013	.016
Reach - 1 Lower	19054.6	.035		
Reach - 1 Lower	19003.57	.035		

SUMMARY OF REACH LENGTHS

River: BocaNegraArroyo

Reach	River Sta.	Left	Channel	Right
Reach - 1 Upper	25374.6	385.3	385.3	385.3
Reach - 1 Upper	24989.3	882.9	882.9	882.9
Reach - 1 Upper	24106.4	1106.4	1106.4	1106.4
Reach - 1 Upper	23000.0	758.9	758.9	758.9
Reach - 1 Upper	22241.1	0	0	0
Reach - 1 Mid	22027.5	182	182	182
Reach - 1 Mid	21845.5	290.81	290.81	290.81
Reach - 1 Mid	21840	71.4	71.4	71.4
Reach - 1 Mid	21830	115.95	115.95	115.95
Reach - 1 Mid	21820	45.3	45.3	45.3
Reach - 1 Mid	21335.5	333.8	333.8	333.8
Reach - 1 Mid	21001.7	0	0	0
Split Flow	22027.5	75.7	75.7	75.7
Split Flow	22000	77.63	77.63	77.63
Split Flow	21840	54.1	54.1	54.1
Split Flow	21835	135.23	135.23	135.23
Split Flow	21800	68.96	68.96	68.96
Split Flow	21770.8	95.48	95.48	95.48
Split Flow	21520.8	115.6	115.6	115.6
Split Flow	21335.5	268.96	268.96	268.96
Split Flow	21325	114.8	114.8	114.8
Split Flow	21315	268.94	268.94	268.94
Split Flow	21250	340.84	340.84	340.84
Split Flow	21200	276.3	276.3	276.3
Split Flow	21194.9	200	200	200
Split Flow	21001.7	130	130	130
Reach - 1 Lower	20573.7	183.1	183.1	183.1
Reach - 1 Lower	20390.6	620	620	620
Reach - 1 Lower	19770.6	480	480	480
Reach - 1 Lower	19290.6	115	115	115
Reach - 1 Lower	19200	Culvert		
Reach - 1 Lower	19175.6	50.1	50.1	50.1
Reach - 1 Lower	19125.5	70.95	70.95	70.95
Reach - 1 Lower	19054.6	50.98	50.98	50.98
Reach - 1 Lower	19003.57			

SUMMARY OF CONTRACTION AND EXPANSION COEFFICIENTS
River: BocaNegraArroyo

Reach	River Sta.	Contr.	Expan.
Reach - 1 Upper	25374.6	.1	.3
Reach - 1 Upper	24989.3	.1	.3
Reach - 1 Upper	24106.4	.1	.3
Reach - 1 Upper	23000.0	.1	.3
Reach - 1 Upper	22241.1	.1	.3
Reach - 1 Mid	22027.5	.1	.3

CurrentUpstmFloodway.rep

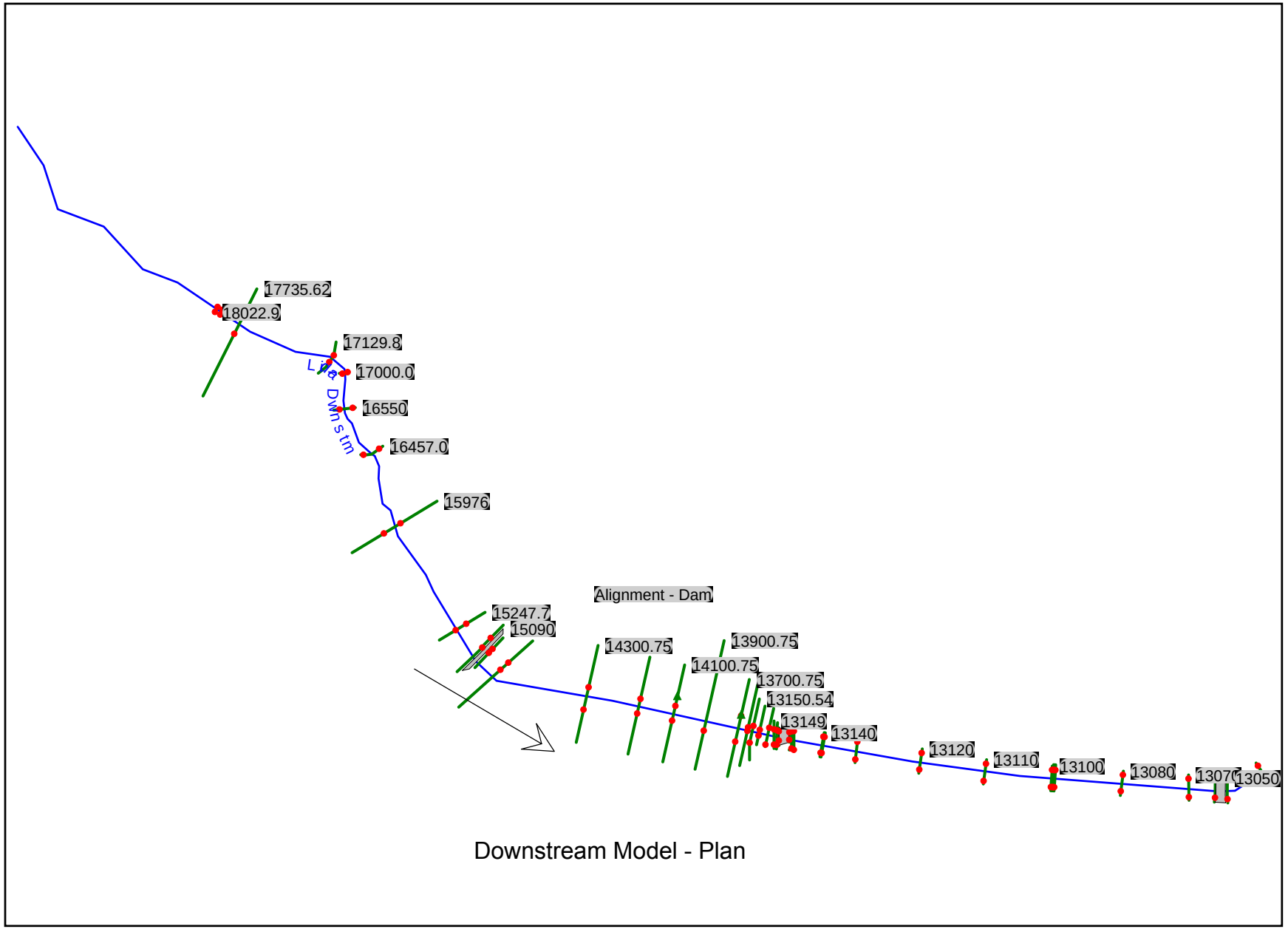
Reach - 1 Mid	21845.5		.1	.3
Reach - 1 Mid	21840		.1	.3
Reach - 1 Mid	21830		.1	.3
Reach - 1 Mid	21820		.1	.3
Reach - 1 Mid	21335.5		.1	.3
Reach - 1 Mid	21001.7		.1	.3
Split Flow	22027.5		.1	.3
Split Flow	22000		.1	.3
Split Flow	21840		.1	.3
Split Flow	21835		.1	.3
Split Flow	21800		.1	.3
Split Flow	21770.8		.1	.3
Split Flow	21520.8		.1	.3
Split Flow	21335.5		.1	.3
Split Flow	21325		.1	.3
Split Flow	21315		.1	.3
Split Flow	21250		.1	.3
Split Flow	21200		.1	.3
Split Flow	21194.9		.1	.3
Split Flow	21001.7		.1	.3
Reach - 1 Lower	20573.7		.1	.3
Reach - 1 Lower	20390.6		.1	.3
Reach - 1 Lower	19770.6		.1	.3
Reach - 1 Lower	19290.6		.3	.5
Reach - 1 Lower	19200	Culvert		
Reach - 1 Lower	19175.6		.1	.3
Reach - 1 Lower	19125.5		.1	.3
Reach - 1 Lower	19054.6		.1	.3
Reach - 1 Lower	19003.57		.1	.3

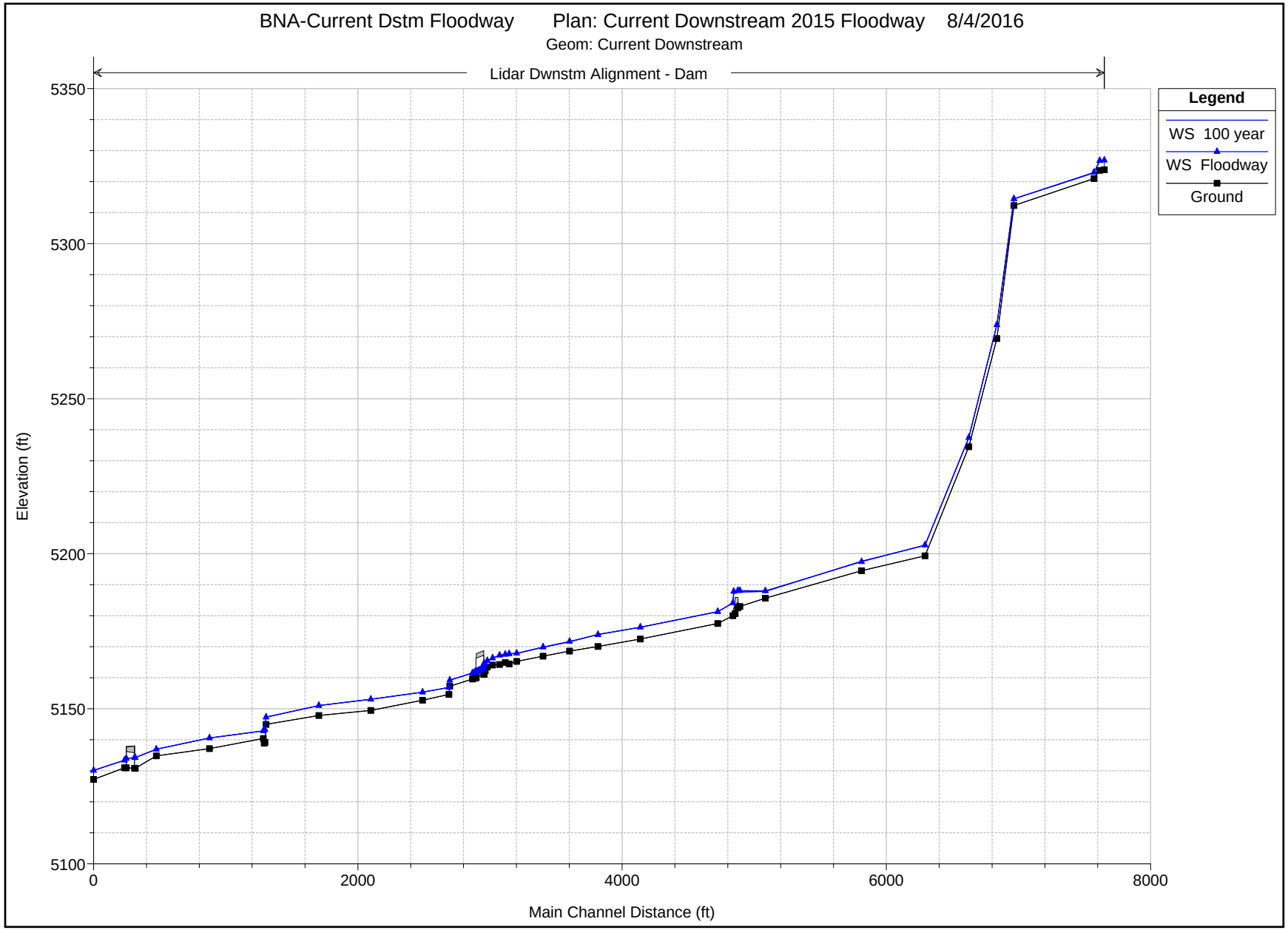
Current Downstream Floodway Model

Plan
Profile
Summary
Cross Sections
Input/output Report

Hydraulics Model – HEC-RAS Analysis (CD)
Current Downstream Floodway Files

i.Project:	BNA-Current Dstm Floodway	CurrentDownFloodway.prj
ii.Plan:	Current Downstream 2015 Floodway CurrentDownFloodway.p01	
iii.Geometry:	Current Downstream	CurrentDownFloodway.g07
iv.Flow:	Updated 2015 - Downstream	CurrentDownFloodway.f07


17735.62
18022.9
17129.8
17000.0
16550
16457.0
15976
Alignment - Dam
15247.7
15090
14300.75
13900.75
14100.75
13700.75
13150.54
13149
13140
13120
13110
13100
13080
13070
13050
Downstream Model - Plan


BNA-Current Dstm Floodway
Plan: Current Downstream 2015 Floodway
8/4/2016
Geom: Current Downstream
Lidar Dwnstm Alignment - Dam
Legend
WS 100 year
WS Floodway
Ground
Elevation (ft)
5350
5300
5250
5200
5150
5100
0
2000
4000
6000
8000
Main Channel Distance (ft)

HEC-RAS Plan: Down Floodway River: Lidar Dwnstm Reach: Alignment - Dam

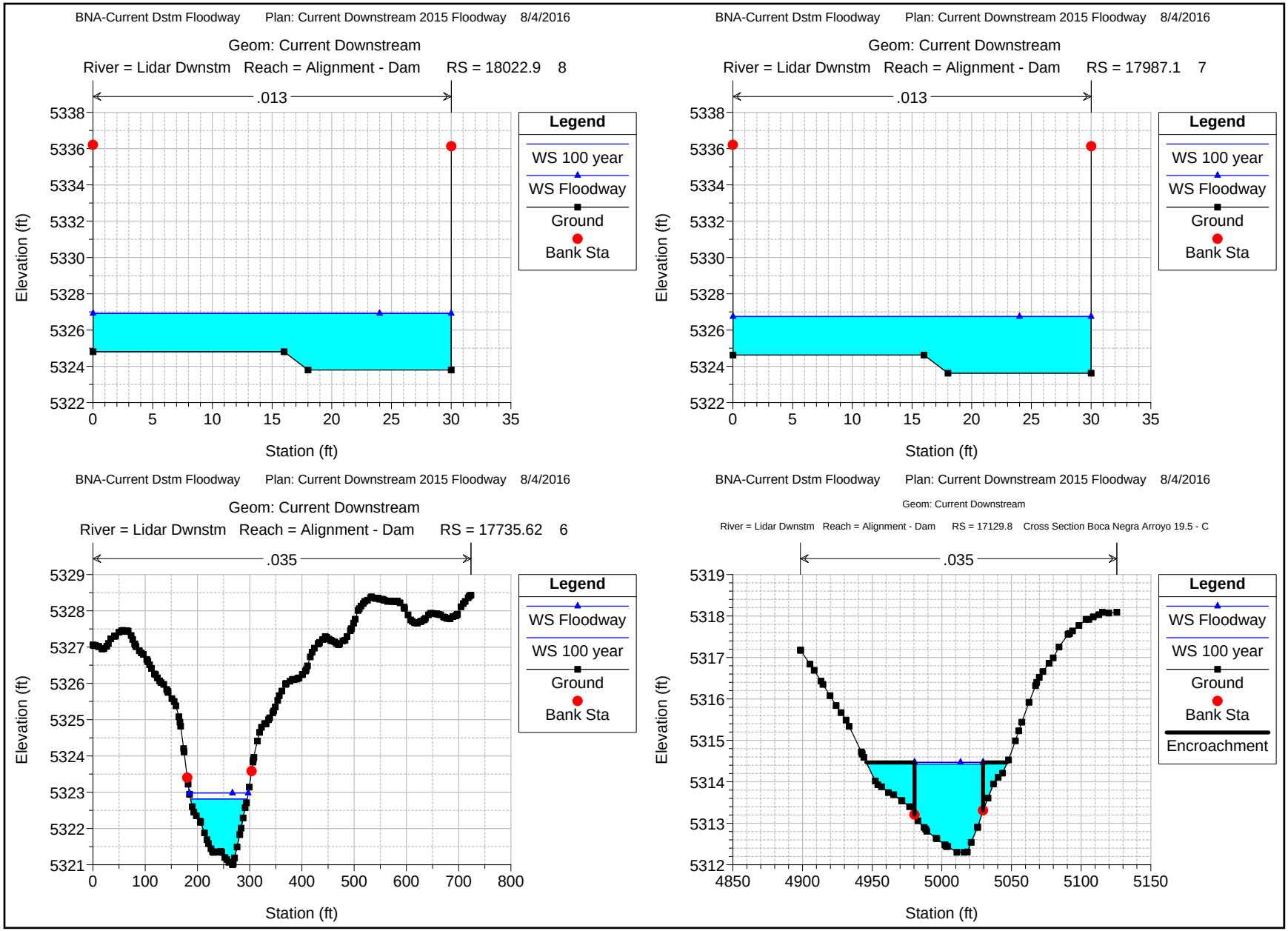
Reach	River Sta	Profile	W.S. Elev	Prof Delta WS	E.G. Elev	Top Wdth Act	Q Left	Q Channel	Q Right	Enc Sta L	Ch Sta L	Ch Sta R	Enc Sta R
			(ft)	(ft)	(ft)	(ft)	(cfs)	(cfs)	(cfs)	(ft)	(ft)	(ft)	(ft)
Alignment - Dam	18022.9	100 year	5326.91		5328.20	29.99		695.00			0.00	30.01	
Alignment - Dam	18022.9	Floodway	5326.91	0.00	5328.20	29.99		695.00		0.00	0.00	30.01	30.01
Alignment - Dam	17987.1	100 year	5326.74		5328.02	29.99		695.00			0.00	30.01	
Alignment - Dam	17987.1	Floodway	5326.74	0.00	5328.02	29.99		695.00		0.00	0.00	30.01	30.01
Alignment - Dam	17735.62	100 year	5322.81		5323.34	108.22		695.00			180.50	303.61	
Alignment - Dam	17735.62	Floodway	5322.98	0.16	5323.37	112.48		695.00		180.50	180.50	303.61	303.61
Alignment - Dam	17129.8	100 year	5314.43		5315.05	100.14	82.13	588.48	24.39		4980.40	5029.57	
Alignment - Dam	17129.8	Floodway	5314.47	0.04	5315.40	49.17		695.00		4980.40	4980.40	5029.57	5029.57
Alignment - Dam	17000.0	100 year	5273.82		5275.19	27.59		695.00			4980.13	5014.51	
Alignment - Dam	17000.0	Floodway	5273.82	0.00	5275.19	27.59		695.00		4980.13	4980.13	5014.51	5014.51
Alignment - Dam	16550	100 year	5237.45		5238.48	42.35		695.00			16.00	96.23	
Alignment - Dam	16550	Floodway	5237.45	0.00	5238.48	42.34		695.00		16.00	16.00	96.23	96.23
Alignment - Dam	16457.0	100 year	5202.71		5203.11	94.36		695.00			4944.16	5049.59	
Alignment - Dam	16457.0	Floodway	5202.82	0.11	5203.17	97.38		695.00		4944.16	4944.16	5049.59	5049.59
Alignment - Dam	15976	100 year	5197.56		5198.12	78.18		695.00			257.57	375.02	
Alignment - Dam	15976	Floodway	5197.40	-0.15	5198.10	75.55		695.00		257.57	257.57	375.02	375.02
Alignment - Dam	15247.7	100 year	5187.85		5188.49	95.01	1.34	682.75	10.92		132.79	207.43	
Alignment - Dam	15247.7	Floodway	5188.03	0.18	5188.56	74.64		695.00		132.79	132.79	207.43	207.43
Alignment - Dam	15100	100 year	5187.66		5187.72	207.98	27.41	594.84	72.75		56.90	144.58	
Alignment - Dam	15100	Floodway	5188.10	0.44	5188.17	87.68		695.00		56.90	56.90	144.58	144.58
Alignment - Dam	15090		Culvert										
Alignment - Dam	15080	100 year	5184.11		5185.11	59.42	0.67	678.59	15.74		83.06	115.37	
Alignment - Dam	15080	Floodway	5184.12	0.00	5185.11	46.94		678.02	16.98	83.06	83.06	115.37	130.00
Alignment - Dam	14886.4	100 year	5181.32		5182.51	54.13		1110.00			197.15	261.93	
Alignment - Dam	14886.4	Floodway	5181.32	0.00	5182.51	54.13		1110.00		197.15	197.15	261.93	261.93
Alignment - Dam	14300.75	100 year	5176.26		5176.61	109.21		1147.00			259.21	397.40	
Alignment - Dam	14300.75	Floodway	5176.30	0.04	5176.63	110.59		1147.00		260.00	259.21	397.40	395.00
Alignment - Dam	14200	100 year	5173.99		5174.63	112.12	0.16	1144.37	2.47		258.53	348.88	
Alignment - Dam	14200	Floodway	5173.92	-0.07	5174.61	108.54	0.04	1146.11	0.86	235.00	258.53	348.88	375.00
Alignment - Dam	14100.75	100 year	5171.59		5172.33	125.76	15.06	1132.07	1.88		254.13	344.48	
Alignment - Dam	14100.75	Floodway	5171.71	0.13	5172.39	104.19		1144.61	4.39	255.00	254.13	344.48	360.00

HEC-RAS Plan: Down Floodway River: Lidar Dwnstm Reach: Alignment - Dam (Continued)

Reach	River Sta	Profile	W.S. Elev	Prof Delta WS	E.G. Elev	Top Wdth Act	Q Left	Q Channel	Q Right	Enc Sta L	Ch Sta L	Ch Sta R	Enc Sta R
			(ft)	(ft)	(ft)	(ft)	(cfs)	(cfs)	(cfs)	(ft)	(ft)	(ft)	(ft)
Alignment - Dam	13900.75	100 year	5169.84		5169.98	394.73		1149.00			154.43	557.47	
Alignment - Dam	13900.75	Floodway	5169.88	0.05	5170.38	126.41		1149.00		430.00	154.43	557.47	557.47
Alignment - Dam	13700.75	100 year	5167.85		5168.39	132.31		1149.00			224.22	384.62	
Alignment - Dam	13700.75	Floodway	5167.90	0.05	5168.40	131.82		1149.00		225.00	224.22	384.62	375.00
Alignment - Dam	13150.55	100 year	5167.76		5167.98	202.42	369.06	312.35	467.59		77.26	98.97	
Alignment - Dam	13150.55	Floodway	5167.72	-0.05	5168.01	130.00	323.82	326.20	498.97	40.00	77.26	98.97	170.00
Alignment - Dam	13150.54	100 year	5167.53		5167.86	162.93	46.21	1062.66	40.13		96.40	200.40	
Alignment - Dam	13150.54	Floodway	5167.52	-0.02	5167.88	125.00	51.48	1097.53		75.00	96.40	200.40	200.00
Alignment - Dam	13150	100 year	5167.26		5167.65	156.53	87.16	547.14	514.70		57.45	93.24	
Alignment - Dam	13150	Floodway	5167.25	-0.01	5167.66	124.39	76.04	553.41	519.56	25.00	57.45	93.24	156.00
Alignment - Dam	13149.5	100 year	5166.34		5167.18	94.06		1149.00			39.62	144.23	
Alignment - Dam	13149.5	Floodway	5166.34	0.00	5167.18	94.06		1149.00		39.62	39.62	144.23	144.23
Alignment - Dam	13149	100 year	5165.51		5166.46	78.74		1149.00			51.17	143.40	
Alignment - Dam	13149	Floodway	5165.51	0.00	5166.46	78.74		1149.00		51.17	51.17	143.40	143.40
Alignment - Dam	13148.5	100 year	5164.45		5165.42	76.19		1149.00			46.79	135.36	
Alignment - Dam	13148.5	Floodway	5164.45	0.00	5165.42	76.19		1149.00		46.79	46.79	135.36	135.36
Alignment - Dam	13148	100 year	5164.71		5165.08	69.06		1149.00			25.58	95.72	
Alignment - Dam	13148	Floodway	5164.71	0.00	5165.08	69.06		1149.00		25.58	25.58	95.72	95.72
Alignment - Dam	13146		Culvert										
Alignment - Dam	13145	100 year	5162.04		5163.04	72.47		1149.00			21.31	94.56	
Alignment - Dam	13145	Floodway	5162.04	0.00	5163.04	72.47		1149.00		21.31	21.31	94.56	94.56
Alignment - Dam	13144	100 year	5161.76		5162.66	84.08		1149.00			18.37	122.23	
Alignment - Dam	13144	Floodway	5161.76	0.00	5162.66	84.08		1149.00		18.37	18.37	122.23	122.23
Alignment - Dam	13143	100 year	5161.55		5162.26	92.87		1149.00			3.24	116.32	
Alignment - Dam	13143	Floodway	5161.55	0.00	5162.26	92.87		1149.00		3.24	3.24	116.32	116.32
Alignment - Dam	13140	100 year	5159.20		5160.09	85.86		1149.00			25.43	124.40	
Alignment - Dam	13140	Floodway	5159.20	0.00	5160.09	85.86		1149.00		25.43	25.43	124.40	124.40
Alignment - Dam	13135	100 year	5156.87		5157.53	84.92		1149.00			25.43	124.40	
Alignment - Dam	13135	Floodway	5156.87	0.00	5157.53	84.92		1149.00		25.43	25.43	124.40	124.40
Alignment - Dam	13130	100 year	5155.35		5155.92	84.40		1149.00			22.22	129.39	
Alignment - Dam	13130	Floodway	5155.35	0.00	5155.92	84.40		1149.00		22.22	22.22	129.39	129.39

HEC-RAS Plan: Down Floodway River: Lidar Dwnstm Reach: Alignment - Dam (Continued)

Reach	River Sta	Profile	W.S. Elev	Prof Delta WS	E.G. Elev	Top Wdth Act	Q Left	Q Channel	Q Right	Enc Sta L	Ch Sta L	Ch Sta R	Enc Sta R
			(ft)	(ft)	(ft)	(ft)	(cfs)	(cfs)	(cfs)	(ft)	(ft)	(ft)	(ft)
Alignment - Dam	13120	100 year	5153.08		5153.55	85.59		1149.00			25.27	126.10	
Alignment - Dam	13120	Floodway	5153.08	0.00	5153.55	85.59		1149.00		25.27	25.27	126.10	126.10
Alignment - Dam	13110	100 year	5151.04		5151.52	82.32		1150.00			25.32	129.96	
Alignment - Dam	13110	Floodway	5151.04	0.00	5151.52	82.32		1150.00		25.32	25.32	129.96	129.96
Alignment - Dam	13100	100 year	5147.29		5148.20	84.64		1150.00			32.06	135.74	
Alignment - Dam	13100	Floodway	5147.29	0.00	5148.20	84.64		1150.00		32.06	32.06	135.74	135.74
Alignment - Dam	13095	100 year	5143.24		5143.55	77.67		1150.00			32.06	135.74	
Alignment - Dam	13095	Floodway	5143.24	0.00	5143.55	77.67		1150.00		32.06	32.06	135.74	135.74
Alignment - Dam	13093	100 year	5143.32		5143.50	85.64		1150.00			32.06	135.74	
Alignment - Dam	13093	Floodway	5143.32	0.00	5143.50	85.64		1150.00		32.06	32.06	135.74	135.74
Alignment - Dam	13090	100 year	5142.88		5143.45	82.43		1150.00			32.06	135.74	
Alignment - Dam	13090	Floodway	5142.88	0.00	5143.45	82.43		1150.00		32.06	32.06	135.74	135.74
Alignment - Dam	13080	100 year	5140.60		5141.06	83.28		1150.00			23.15	122.75	
Alignment - Dam	13080	Floodway	5140.60	0.00	5141.06	83.28		1150.00		23.15	23.15	122.75	122.75
Alignment - Dam	13070	100 year	5136.95		5137.81	90.61		1151.00			22.48	134.28	
Alignment - Dam	13070	Floodway	5136.95	0.00	5137.81	90.61		1151.00		22.48	22.48	134.28	134.28
Alignment - Dam	13060	100 year	5134.23		5134.53	95.17		1151.00			26.64	136.90	
Alignment - Dam	13060	Floodway	5134.23	0.00	5134.53	95.17		1151.00		26.64	26.64	136.90	136.90
Alignment - Dam	13055 BR U	100 year	5134.23		5134.49	97.03		1151.00			26.64	133.38	
Alignment - Dam	13055 BR U	Floodway	5134.23	0.00	5134.49	97.03		1151.00		26.64	26.64	133.38	136.90
Alignment - Dam	13055 BR D	100 year	5133.99		5134.25	104.60		1151.00			13.34	133.38	
Alignment - Dam	13055 BR D	Floodway	5133.99	0.00	5134.25	104.60		1151.00		13.34	13.34	133.38	127.98
Alignment - Dam	13050	100 year	5133.39		5134.05	85.99		1151.00			13.34	127.98	
Alignment - Dam	13050	Floodway	5133.39	0.00	5134.05	85.99		1151.00		13.34	13.34	127.98	127.98
Alignment - Dam	13040	100 year	5130.11		5131.09	68.16		1151.00			20.80	119.45	
Alignment - Dam	13040	Floodway	5130.11	0.00	5131.09	68.16		1151.00		20.80	20.80	119.45	119.45


BNA-Current Dstm Floodway Plan: Current Downstream 2015 Floodway 8/4/2016
Geom: Current Downstream
River = Lidar Dwnstm Reach = Alignment - Dam RS = 18022.9 8
.013
Elevation (ft)
Station (ft)
Legend
WS 100 year
WS Floodway
Ground
Bank Sta
BNA-Current Dstm Floodway Plan: Current Downstream 2015 Floodway 8/4/2016
Geom: Current Downstream
River = Lidar Dwnstm Reach = Alignment - Dam RS = 17987.1 7
.013
Elevation (ft)
Station (ft)
Legend
WS 100 year
WS Floodway
Ground
Bank Sta
BNA-Current Dstm Floodway Plan: Current Downstream 2015 Floodway 8/4/2016
Geom: Current Downstream
River = Lidar Dwnstm Reach = Alignment - Dam RS = 17735.62 6
.035
Elevation (ft)
Station (ft)
Legend
WS Floodway
WS 100 year
Ground
Bank Sta
BNA-Current Dstm Floodway Plan: Current Downstream 2015 Floodway 8/4/2016
Geom: Current Downstream
River = Lidar Dwnstm Reach = Alignment - Dam RS = 17129.8 Cross Section Boca Negra Arroyo 19.5 - C
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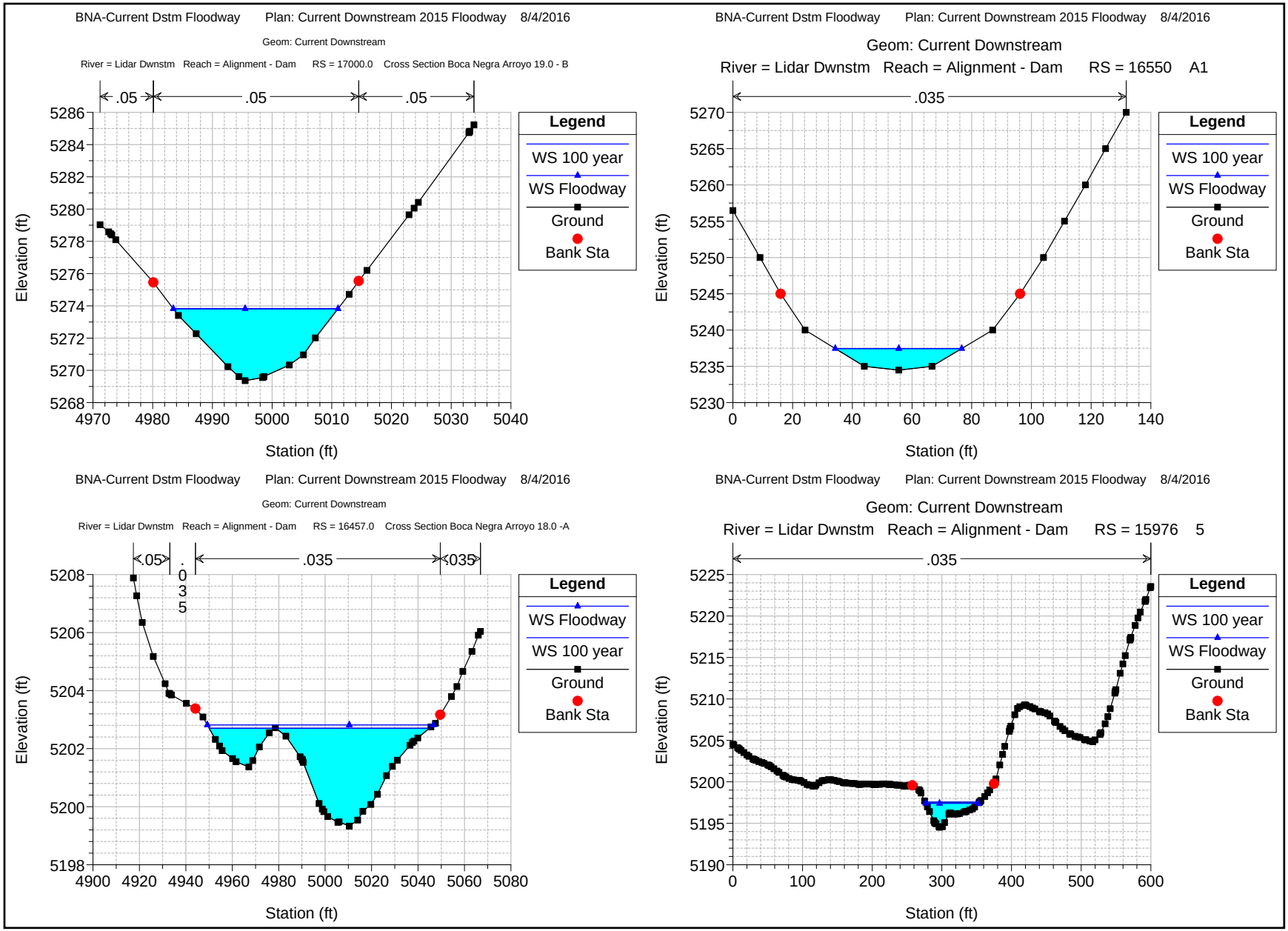
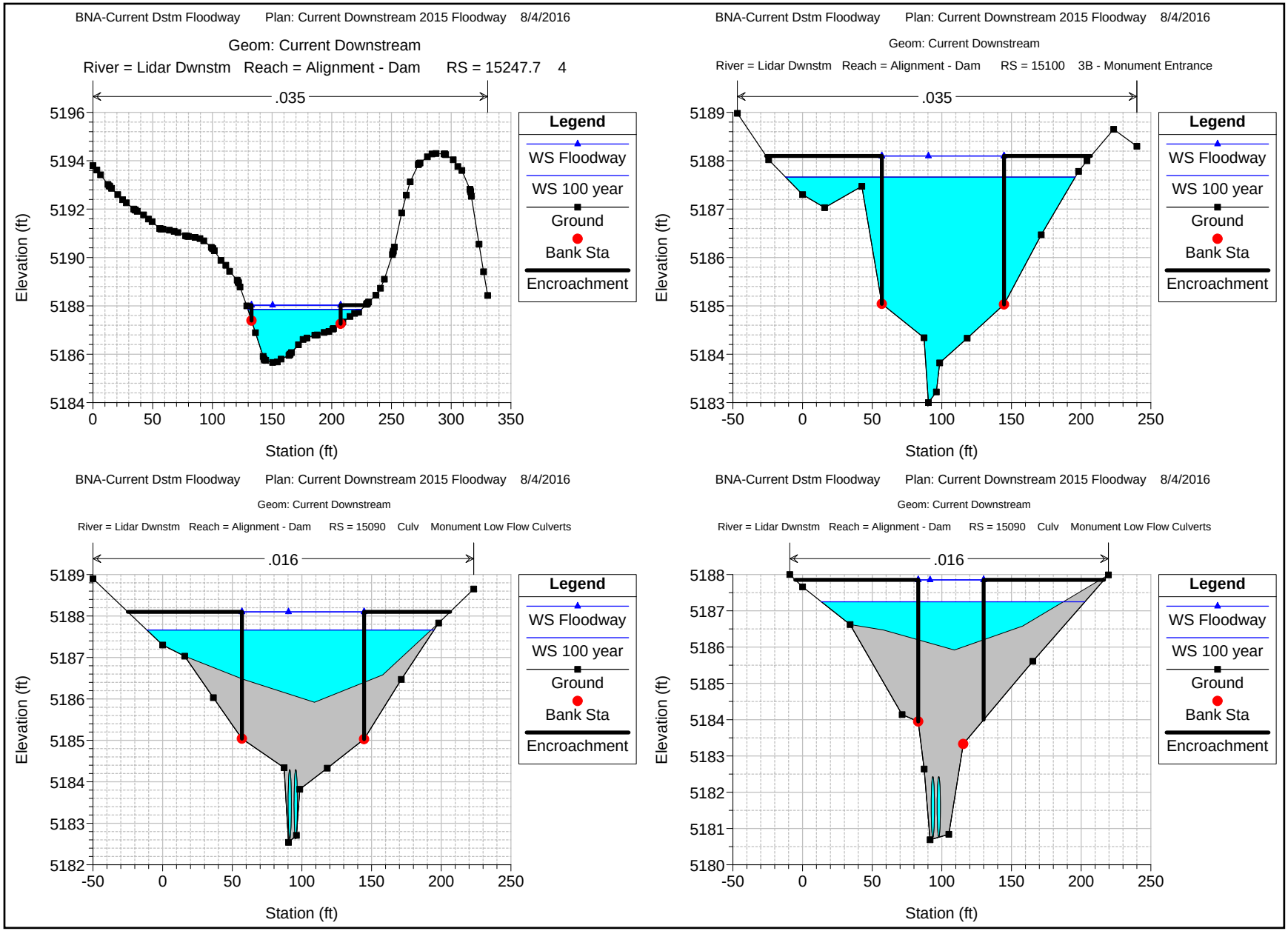
Elevation (ft)
Station (ft)
Legend
WS Floodway
WS 100 year
Ground
Bank Sta
Encroachment


BNA-Current Dstm Floodway Plan: Current Downstream 2015 Floodway 8/4/2016
Geom: Current Downstream
River = Lidar Dwnstm Reach = Alignment - Dam RS = 17000.0 Cross Section Boca Negra Arroyo 19.0 - B
.05
.05
.05
Elevation (ft)
Station (ft)
Legend
WS 100 year
WS Floodway
Ground
Bank Sta
BNA-Current Dstm Floodway Plan: Current Downstream 2015 Floodway 8/4/2016
Geom: Current Downstream
River = Lidar Dwnstm Reach = Alignment - Dam RS = 16550 A1
.035
Elevation (ft)
Station (ft)
Legend
WS 100 year
WS Floodway
Ground
Bank Sta
BNA-Current Dstm Floodway Plan: Current Downstream 2015 Floodway 8/4/2016
Geom: Current Downstream
River = Lidar Dwnstm Reach = Alignment - Dam RS = 16457.0 Cross Section Boca Negra Arroyo 18.0 -A
.05
.035
.035
Elevation (ft)
Station (ft)
Legend
WS Floodway
WS 100 year
Ground
Bank Sta
BNA-Current Dstm Floodway Plan: Current Downstream 2015 Floodway 8/4/2016
Geom: Current Downstream
River = Lidar Dwnstm Reach = Alignment - Dam RS = 15976 5
.035
Elevation (ft)
Station (ft)
Legend
WS 100 year
WS Floodway
Ground
Bank Sta


BNA-Current Dstm Floodway Plan: Current Downstream 2015 Floodway 8/4/2016
Geom: Current Downstream
River = Lidar Dwnstm Reach = Alignment - Dam RS = 15247.7 4
.035
Elevation (ft)
Station (ft)
Legend
WS Floodway
WS 100 year
Ground
Bank Sta
Encroachment
BNA-Current Dstm Floodway Plan: Current Downstream 2015 Floodway 8/4/2016
Geom: Current Downstream
River = Lidar Dwnstm Reach = Alignment - Dam RS = 15100 3B - Monument Entrance
.035
Elevation (ft)
Station (ft)
Legend
WS Floodway
WS 100 year
Ground
Bank Sta
Encroachment
BNA-Current Dstm Floodway Plan: Current Downstream 2015 Floodway 8/4/2016
Geom: Current Downstream
River = Lidar Dwnstm Reach = Alignment - Dam RS = 15090 Culv Monument Low Flow Culverts
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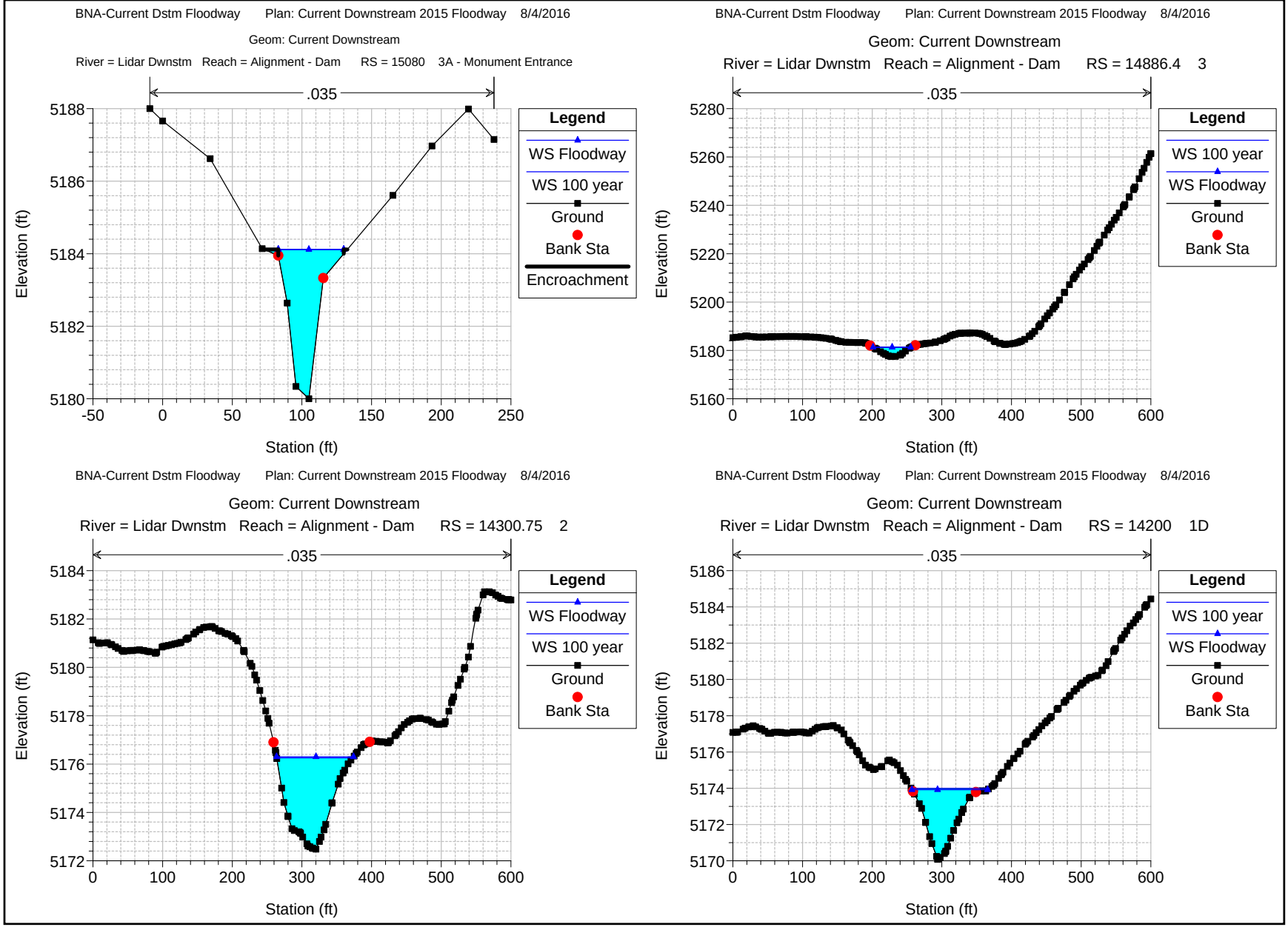
Elevation (ft)
Station (ft)
Legend
WS Floodway
WS 100 year
Ground
Bank Sta
Encroachment
BNA-Current Dstm Floodway Plan: Current Downstream 2015 Floodway 8/4/2016
Geom: Current Downstream
River = Lidar Dwnstm Reach = Alignment - Dam RS = 15090 Culv Monument Low Flow Culverts
.016
Elevation (ft)
Station (ft)
Legend
WS Floodway
WS 100 year
Ground
Bank Sta
Encroachment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Geom: Current Downstream
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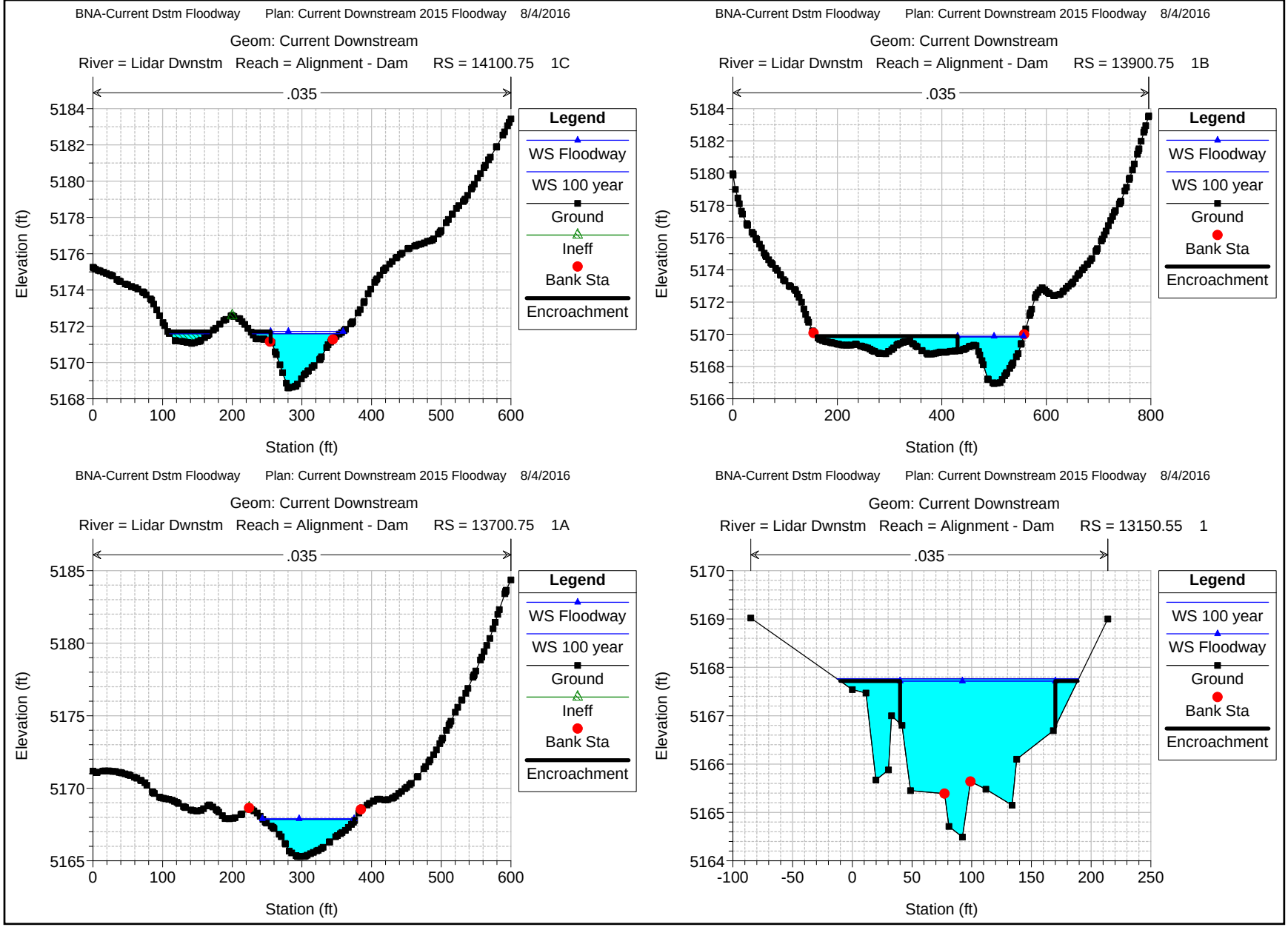
.035
Elevation (ft)
Station (ft)
Legend
WS Floodway
WS 100 year
Ground
Bank Sta
Encroachment
BNA-Current Dstm Floodway Plan: Current Downstream 2015 Floodway 8/4/2016
Geom: Current Downstream
River = Lidar Dwnstm Reach = Alignment - Dam RS = 14886.4 3
.035
Elevation (ft)
Station (ft)
Legend
WS 100 year
WS Floodway
Ground
Bank Sta
BNA-Current Dstm Floodway Plan: Current Downstream 2015 Floodway 8/4/2016
Geom: Current Downstream
River = Lidar Dwnstm Reach = Alignment - Dam RS = 14300.75 2
.035
Elevation (ft)
Station (ft)
Legend
WS Floodway
WS 100 year
Ground
Bank Sta
BNA-Current Dstm Floodway Plan: Current Downstream 2015 Floodway 8/4/2016
Geom: Current Downstream
River = Lidar Dwnstm Reach = Alignment - Dam RS = 14200 1D
.035
Elevation (ft)
Station (ft)
Legend
WS 100 year
WS Floodway
Ground
Bank Sta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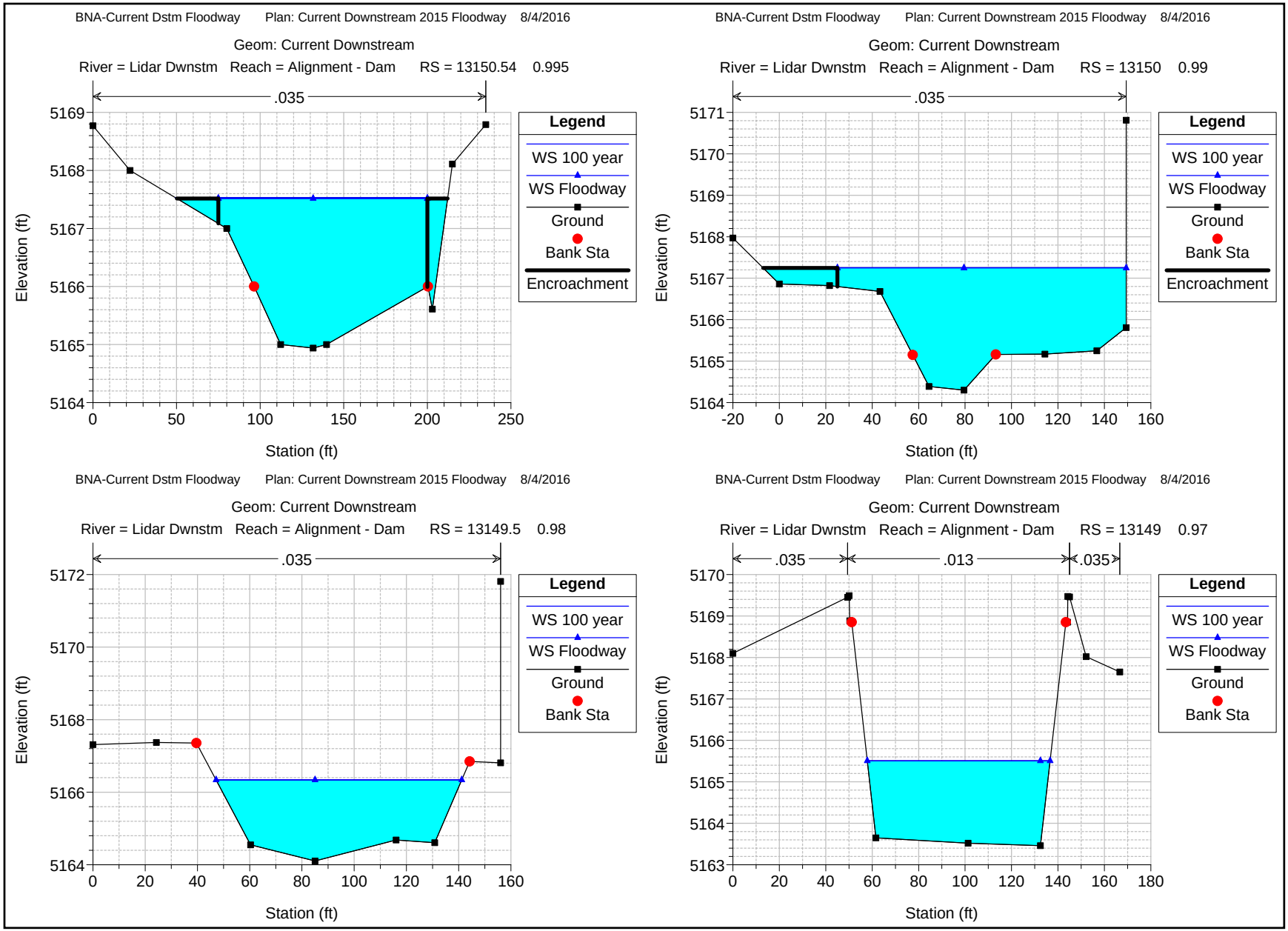
Geom: Current Downstream
River = Lidar Dwnstm Reach = Alignment - Dam RS = 14100.75 1C
.035
Elevation (ft)
Station (ft)
Legend
WS Floodway
WS 100 year
Ground
Ineff
Bank Sta
Encroachment
BNA-Current Dstm Floodway Plan: Current Downstream 2015 Floodway 8/4/2016
Geom: Current Downstream
River = Lidar Dwnstm Reach = Alignment - Dam RS = 13900.75 1B
.035
Elevation (ft)
Station (ft)
Legend
WS Floodway
WS 100 year
Ground
Bank Sta
Encroachment
BNA-Current Dstm Floodway Plan: Current Downstream 2015 Floodway 8/4/2016
Geom: Current Downstream
River = Lidar Dwnstm Reach = Alignment - Dam RS = 13700.75 1A
.035
Elevation (ft)
Station (ft)
Legend
WS Floodway
WS 100 year
Ground
Ineff
Bank Sta
Encroachment
BNA-Current Dstm Floodway Plan: Current Downstream 2015 Floodway 8/4/2016
Geom: Current Downstream
River = Lidar Dwnstm Reach = Alignment - Dam RS = 13150.55 1
.035
Elevation (ft)
Station (ft)
Legend
WS 100 year
WS Floodway
Ground
Bank Sta
Encroachment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Geom: Current Downstream
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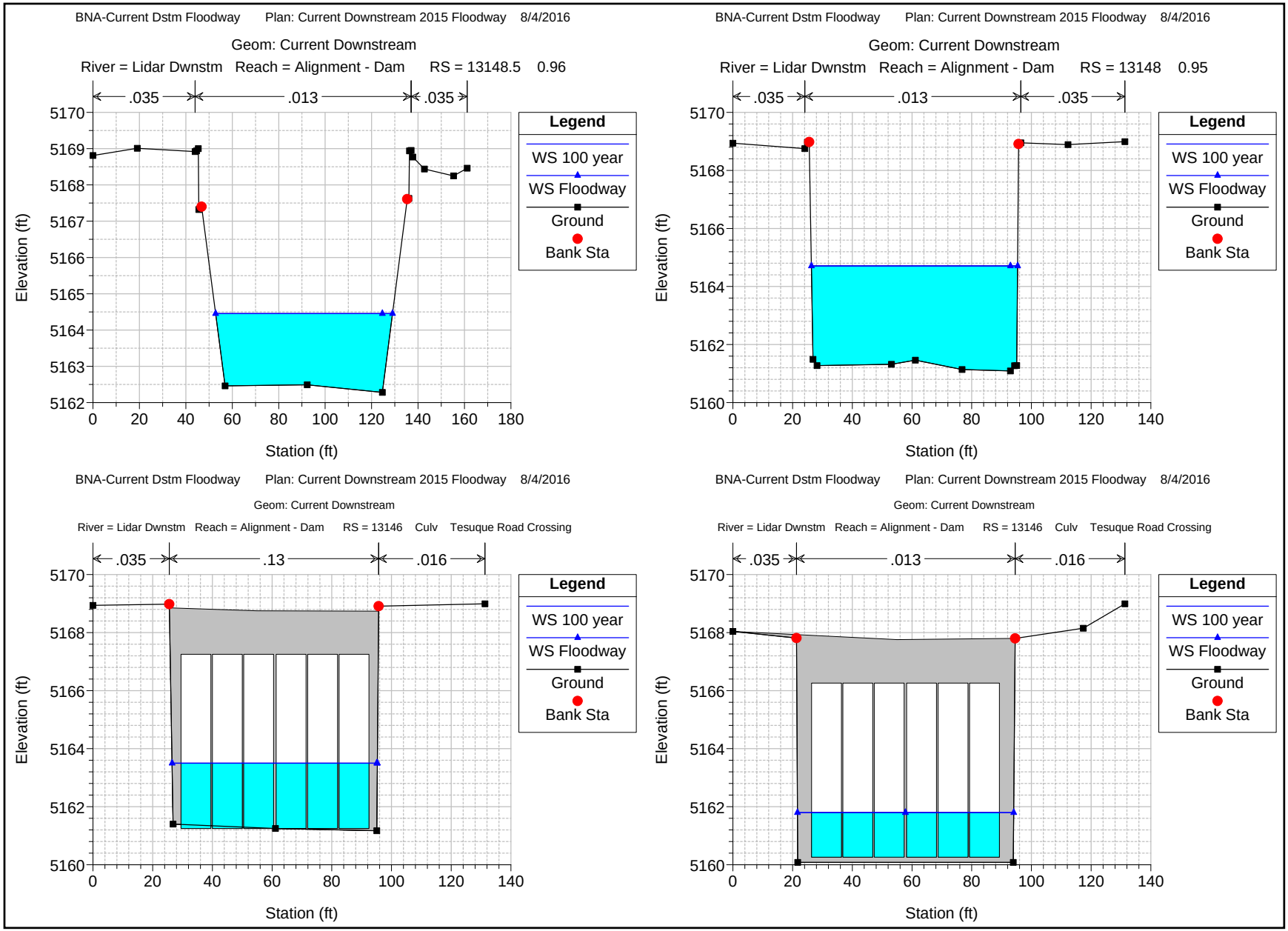
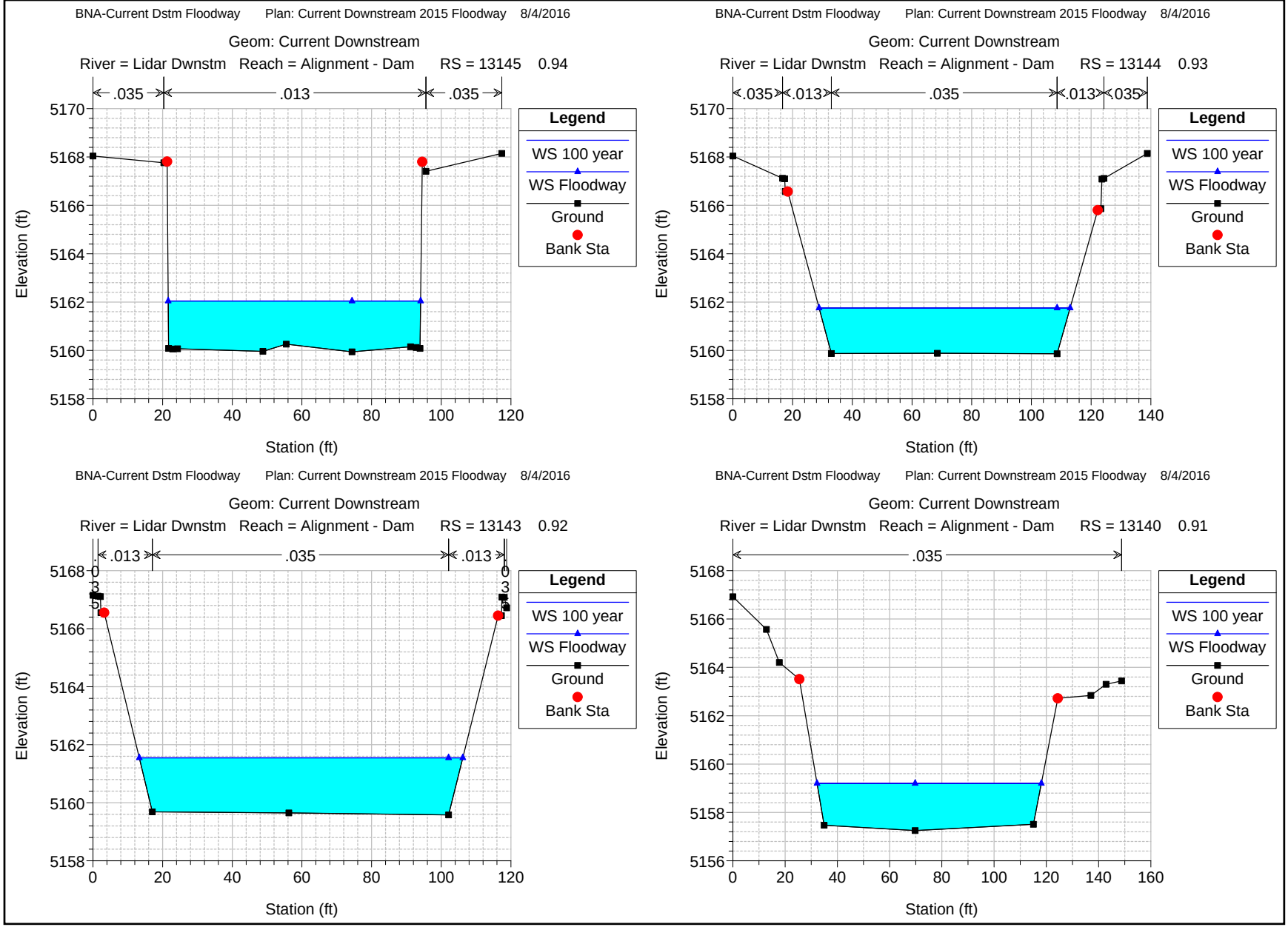
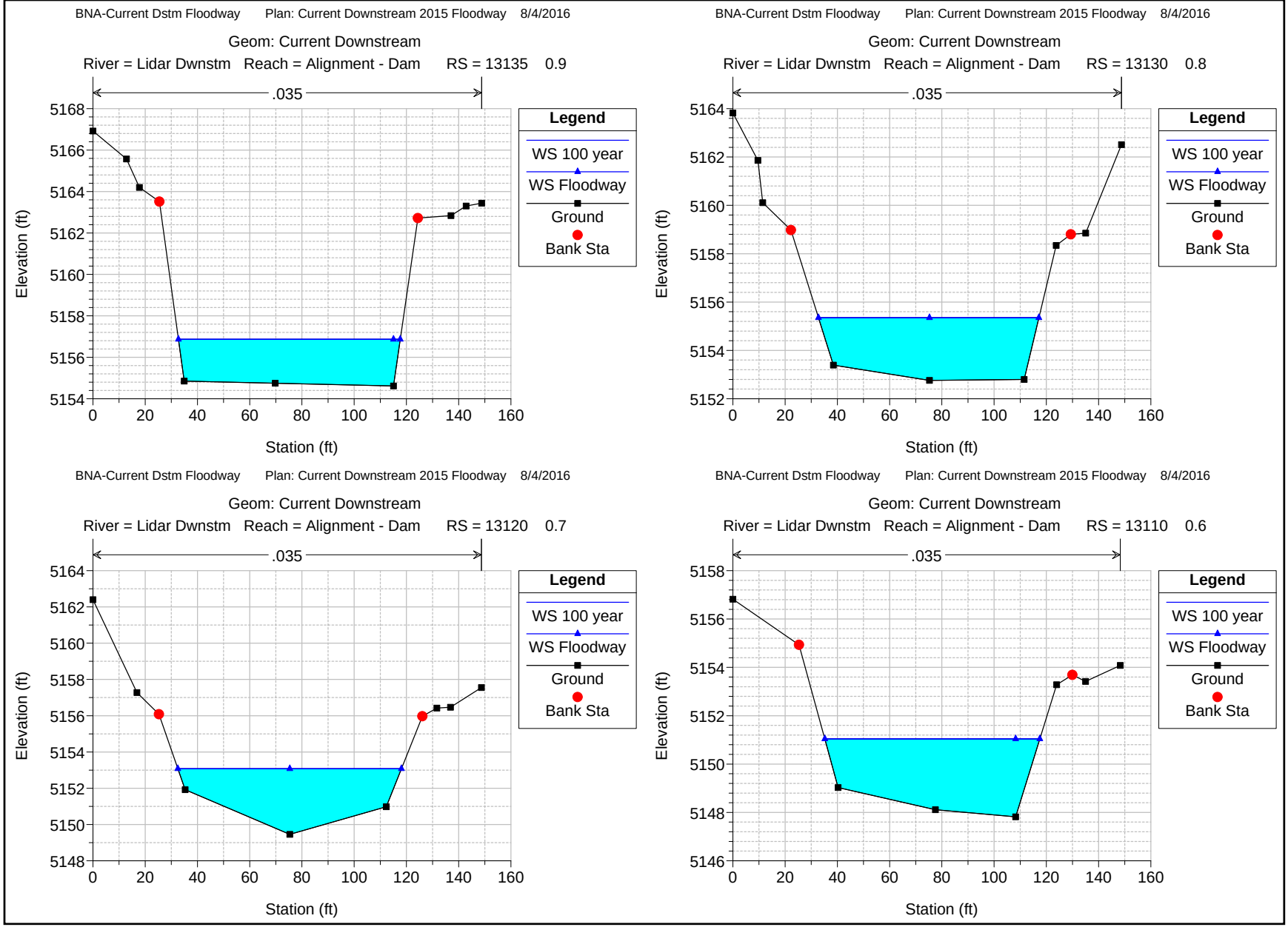
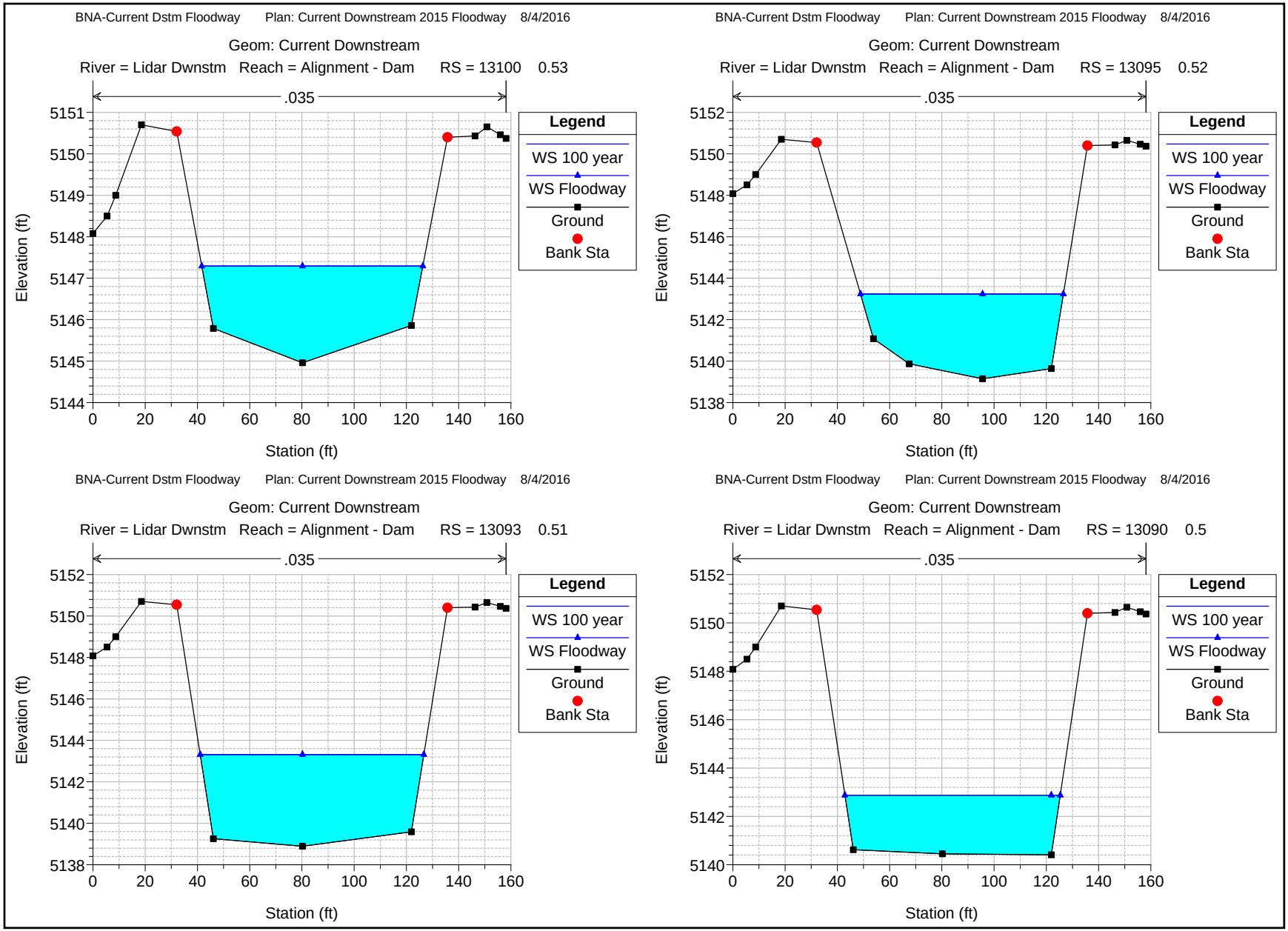
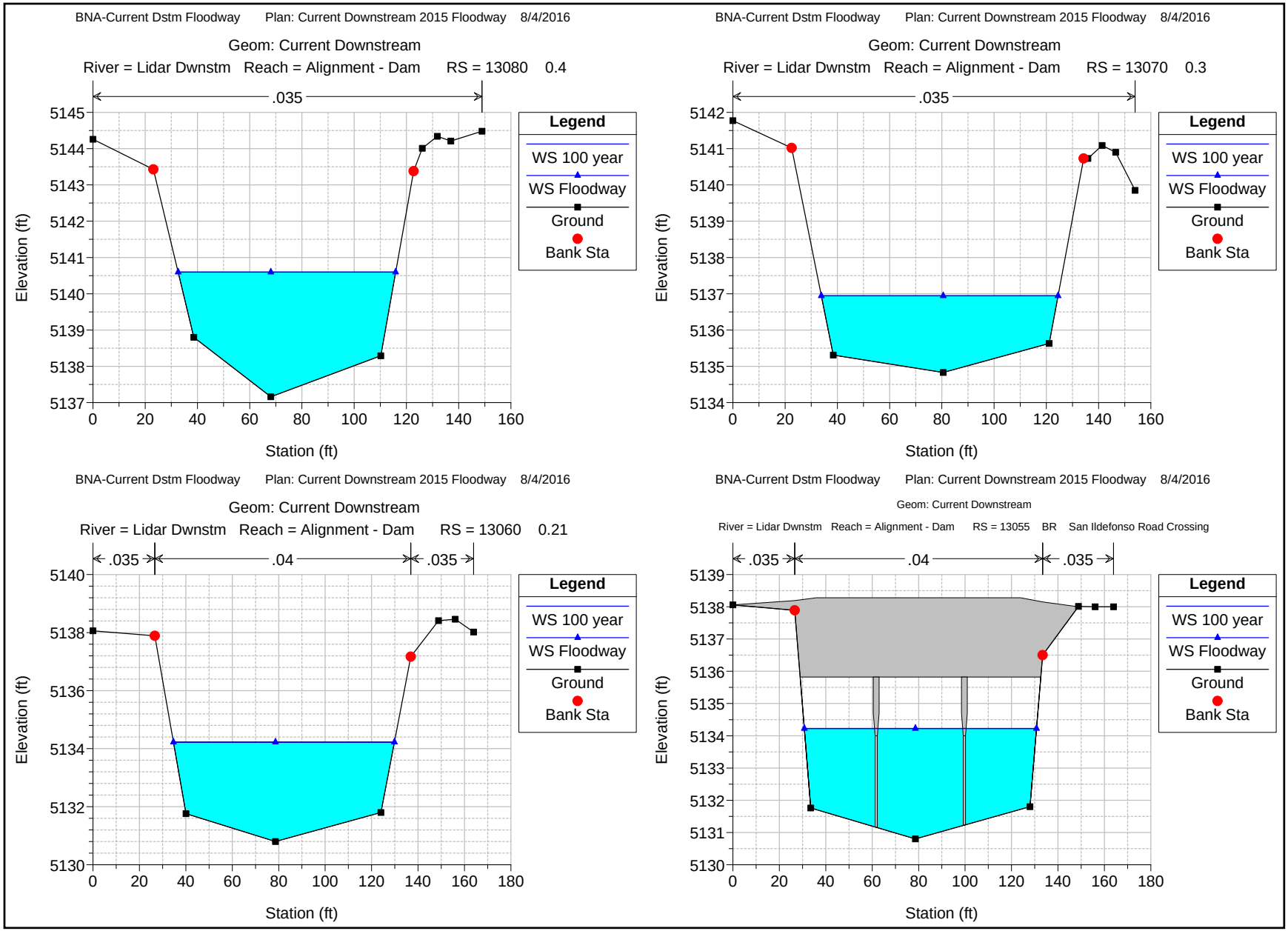
.035
Elevation (ft)
Station (ft)
Legend
WS 100 year
WS Floodway
Ground
Bank Sta
Encroachment
BNA-Current Dstm Floodway Plan: Current Downstream 2015 Floodway 8/4/2016
Geom: Current Downstream
River = Lidar Dwnstm Reach = Alignment - Dam RS = 13150 0.99
.035
Elevation (ft)
Station (ft)
Legend
WS 100 year
WS Floodway
Ground
Bank Sta
Encroachment
BNA-Current Dstm Floodway Plan: Current Downstream 2015 Floodway 8/4/2016
Geom: Current Downstream
River = Lidar Dwnstm Reach = Alignment - Dam RS = 13149.5 0.98
.035
Elevation (ft)
Station (ft)
Legend
WS 100 year
WS Floodway
Ground
Bank Sta
BNA-Current Dstm Floodway Plan: Current Downstream 2015 Floodway 8/4/2016
Geom: Current Downstream
River = Lidar Dwnstm Reach = Alignment - Dam RS = 13149 0.97
.035
.013
.035
Elevation (ft)
Station (ft)
Legend
WS 100 year
WS Floodway
Ground
Bank Sta

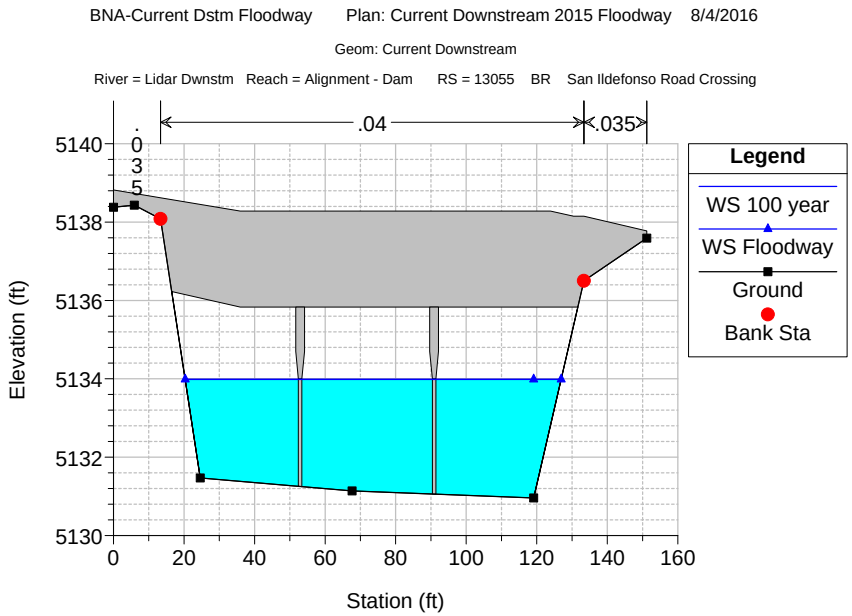

BNA-Current Dstm Floodway Plan: Current Downstream 2015 Floodway 8/4/2016
Geom: Current Downstream
River = Lidar Dwnstm Reach = Alignment - Dam RS = 13148.5 0.96
.035
.013
.035
Elevation (ft)
Station (ft)
Legend
WS 100 year
WS Floodway
Ground
Bank Sta
BNA-Current Dstm Floodway Plan: Current Downstream 2015 Floodway 8/4/2016
Geom: Current Downstream
River = Lidar Dwnstm Reach = Alignment - Dam RS = 13148 0.95
.035
.013
.035
Elevation (ft)
Station (ft)
Legend
WS 100 year
WS Floodway
Ground
Bank Sta
BNA-Current Dstm Floodway Plan: Current Downstream 2015 Floodway 8/4/2016
Geom: Current Downstream
River = Lidar Dwnstm Reach = Alignment - Dam RS = 13146 Culv Tesuque Road Crossing
.035
.13
.016
Elevation (ft)
Station (ft)
Legend
WS 100 year
WS Floodway
Ground
Bank Sta
BNA-Current Dstm Floodway Plan: Current Downstream 2015 Floodway 8/4/2016
Geom: Current Downstream
River = Lidar Dwnstm Reach = Alignment - Dam RS = 13146 Culv Tesuque Road Crossing
.035
.013
.016
Elevation (ft)
Station (ft)
Legend
WS 100 year
WS Floodway
Ground
Bank Sta

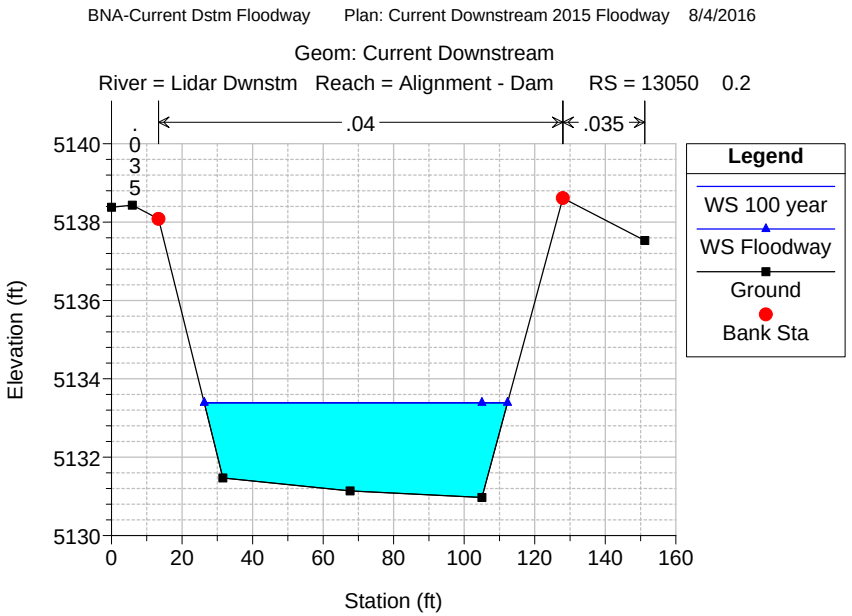

BNA-Current Dstm Floodway Plan: Current Downstream 2015 Floodway 8/4/2016
Geom: Current Downstream
River = Lidar Dwnstm Reach = Alignment - Dam RS = 13145 0.94
.035
.013
.035
Legend
WS 100 year
WS Floodway
Ground
Bank Sta
Elevation (ft)
Station (ft)
BNA-Current Dstm Floodway Plan: Current Downstream 2015 Floodway 8/4/2016
Geom: Current Downstream
River = Lidar Dwnstm Reach = Alignment - Dam RS = 13144 0.93
.035
.013
.035
.013
.035
Legend
WS 100 year
WS Floodway
Ground
Bank Sta
Elevation (ft)
Station (ft)
BNA-Current Dstm Floodway Plan: Current Downstream 2015 Floodway 8/4/2016
Geom: Current Downstream
River = Lidar Dwnstm Reach = Alignment - Dam RS = 13143 0.92
.013
.035
.013
Legend
WS 100 year
WS Floodway
Ground
Bank Sta
Elevation (ft)
Station (ft)
BNA-Current Dstm Floodway Plan: Current Downstream 2015 Floodway 8/4/2016
Geom: Current Downstream
River = Lidar Dwnstm Reach = Alignment - Dam RS = 13140 0.91
.035
Legend
WS 100 year
WS Floodway
Ground
Bank Sta
Elevation (ft)
Station (ft)

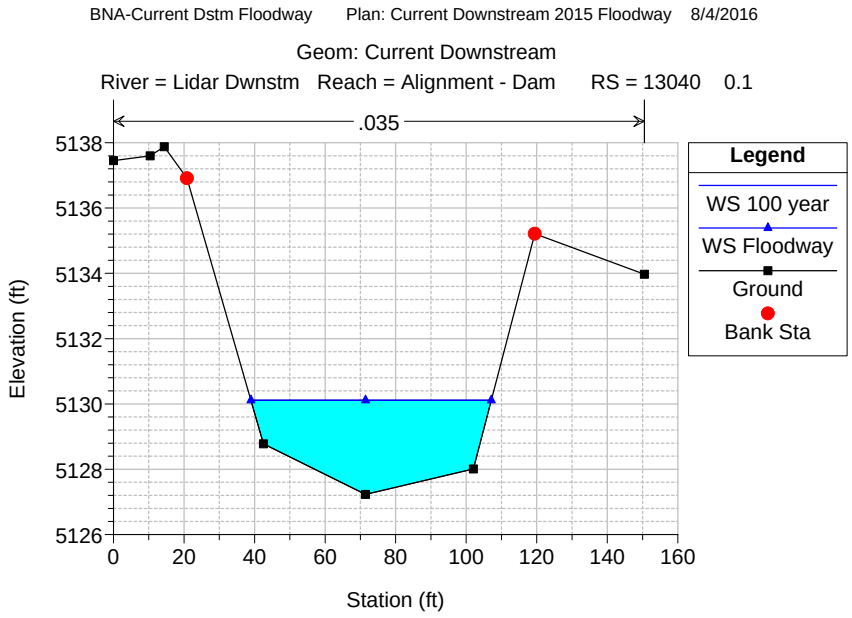

BNA-Current Dstm Floodway Plan: Current Downstream 2015 Floodway 8/4/2016
Geom: Current Downstream
River = Lidar Dwnstm Reach = Alignment - Dam RS = 13135 0.9
.035
Legend
WS 100 year
WS Floodway
Ground
Bank Sta
Elevation (ft)
Station (ft)
BNA-Current Dstm Floodway Plan: Current Downstream 2015 Floodway 8/4/2016
Geom: Current Downstream
River = Lidar Dwnstm Reach = Alignment - Dam RS = 13130 0.8
.035
Legend
WS 100 year
WS Floodway
Ground
Bank Sta
Elevation (ft)
Station (ft)
BNA-Current Dstm Floodway Plan: Current Downstream 2015 Floodway 8/4/2016
Geom: Current Downstream
River = Lidar Dwnstm Reach = Alignment - Dam RS = 13120 0.7
.035
Legend
WS 100 year
WS Floodway
Ground
Bank Sta
Elevation (ft)
Station (ft)
BNA-Current Dstm Floodway Plan: Current Downstream 2015 Floodway 8/4/2016
Geom: Current Downstream
River = Lidar Dwnstm Reach = Alignment - Dam RS = 13110 0.6
.035
Legend
WS 100 year
WS Floodway
Ground
Bank Sta
Elevation (ft)
Station (ft)


BNA-Current Dstm Floodway Plan: Current Downstream 2015 Floodway 8/4/2016
Geom: Current Downstream
River = Lidar Dwnstm Reach = Alignment - Dam RS = 13100 0.53
.035
Elevation (ft)
Station (ft)
Legend
WS 100 year
WS Floodway
Ground
Bank Sta
BNA-Current Dstm Floodway Plan: Current Downstream 2015 Floodway 8/4/2016
Geom: Current Downstream
River = Lidar Dwnstm Reach = Alignment - Dam RS = 13095 0.52
.035
Elevation (ft)
Station (ft)
Legend
WS 100 year
WS Floodway
Ground
Bank Sta
BNA-Current Dstm Floodway Plan: Current Downstream 2015 Floodway 8/4/2016
Geom: Current Downstream
River = Lidar Dwnstm Reach = Alignment - Dam RS = 13093 0.51
.035
Elevation (ft)
Station (ft)
Legend
WS 100 year
WS Floodway
Ground
Bank Sta
BNA-Current Dstm Floodway Plan: Current Downstream 2015 Floodway 8/4/2016
Geom: Current Downstream
River = Lidar Dwnstm Reach = Alignment - Dam RS = 13090 0.5
.035
Elevation (ft)
Station (ft)
Legend
WS 100 year
WS Floodway
Ground
Bank Sta


BNA-Current Dstm Floodway Plan: Current Downstream 2015 Floodway 8/4/2016
Geom: Current Downstream
River = Lidar Dwnstm Reach = Alignment - Dam RS = 13080 0.4
.035
Legend
WS 100 year
WS Floodway
Ground
Bank Sta
Elevation (ft)
Station (ft)
BNA-Current Dstm Floodway Plan: Current Downstream 2015 Floodway 8/4/2016
Geom: Current Downstream
River = Lidar Dwnstm Reach = Alignment - Dam RS = 13070 0.3
.035
Legend
WS 100 year
WS Floodway
Ground
Bank Sta
Elevation (ft)
Station (ft)
BNA-Current Dstm Floodway Plan: Current Downstream 2015 Floodway 8/4/2016
Geom: Current Downstream
River = Lidar Dwnstm Reach = Alignment - Dam RS = 13060 0.21
.035
.04
.035
Legend
WS 100 year
WS Floodway
Ground
Bank Sta
Elevation (ft)
Station (ft)
BNA-Current Dstm Floodway Plan: Current Downstream 2015 Floodway 8/4/2016
Geom: Current Downstream
River = Lidar Dwnstm Reach = Alignment - Dam RS = 13055 BR San Ildefonso Road Crossing
.035
.04
.035
Legend
WS 100 year
WS Floodway
Ground
Bank Sta
Elevation (ft)
Station (ft)


BNA-Current Dstm Floodway Plan: Current Downstream 2015 Floodway 8/4/2016
Geom: Current Downstream
River = Lidar Dwnstm Reach = Alignment - Dam RS = 13055 BR San Ildefonso Road Crossing
.04
.035
.035
Legend
WS 100 year
WS Floodway
Ground
Bank Sta
Elevation (ft)
Station (ft)
5140
5138
5136
5134
5132
5130
0
20
40
60
80
100
120
140
160


BNA-Current Dstm Floodway Plan: Current Downstream 2015 Floodway 8/4/2016
Geom: Current Downstream
River = Lidar Dwnstm Reach = Alignment - Dam RS = 13050 0.2
.04
.035
.035
Legend
WS 100 year
WS Floodway
Ground
Bank Sta
Elevation (ft)
Station (ft)
5140
5138
5136
5134
5132
5130
0
20
40
60
80
100
120
140
160


BNA-Current Dstm Floodway Plan: Current Downstream 2015 Floodway 8/4/2016
Geom: Current Downstream
River = Lidar Dwnstm Reach = Alignment - Dam RS = 13040 0.1
.035
Legend
WS 100 year
WS Floodway
Ground
Bank Sta
Elevation (ft)
Station (ft)
5138
5136
5134
5132
5130
5128
5126
0
20
40
60
80
100
120
140
160

HEC-RAS Version 4.1.0 Jan 2010
U.S. Army Corps of Engineers
Hydrologic Engineering Center
609 Second Street
Davis, California

```
X     X  XXXXXX    XXXX        XXXX       XX      XXXX
X     X  X        X    X       X   X     X  X    X
X     X  X        X            X   X    X    X   X
XXXXXXX  XXXX     X       XXX  XXXX     XXXXXX    XXXX
X     X  X        X            X  X     X    X        X
X     X  X        X    X       X   X    X    X        X
X     X  XXXXXX    XXXX        X    X   X    X   XXXXX
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PROJECT DATA
Project Title: BNA-Current Dstm Floodway
Project File : CurrentDownFloodway.prj
Run Date and Time: 8/4/2016 1:55:40 PM

Project in English units

PLAN DATA

Plan Title: Current Downstream 2015 Floodway
Plan File : t:\Projects\x321807802\Eng\2012 Final Plans_Specifications_Estimate_Reports\2014 Final Construction Acceptance Reports\H&H\LOMR - RAS\BNA RAS FLOODWAY\CurrentDownFloodway.p01

Geometry Title: Current Downstream
Geometry File : t:\Projects\x321807802\Eng\2012 Final Plans_Specifications_Estimate_Reports\2014 Final Construction Acceptance Reports\H&H\LOMR - RAS\BNA RAS FLOODWAY\CurrentDownFloodway.g07

Flow Title : Updated 2015 - Downstream
Flow File : t:\Projects\x321807802\Eng\2012 Final Plans_Specifications_Estimate_Reports\2014 Final Construction Acceptance Reports\H&H\LOMR - RAS\BNA RAS FLOODWAY\CurrentDownFloodway.f07

Plan Summary Information:
Number of: Cross Sections = 41 Multiple Openings = 0
Culverts = 2 Inline Structures = 0
Bridges = 1 Lateral Structures = 0

Computational Information
Water surface calculation tolerance = 0.01
Critical depth calculation tolerance = 0.01
Maximum number of iterations = 20
Maximum difference tolerance = 0.3
Flow tolerance factor = 0.001

Computation Options
Critical depth computed only where necessary
Conveyance Calculation Method: At breaks in n values only
Friction Slope Method: Average Conveyance
Computational Flow Regime: Subcritical Flow

Encroachment Data
Equal Conveyance = False
Left Offset = 0
Right Offset = 0

River = Lidar Dwnstm Reach = Alignment - Dam

RS	Profile	Method	Value1	Value2
18022.9	Floodway	1	0	30.01
17987.1	Floodway	1	0	30.01
17735.62	Floodway	1	180.5	303.61
17129.8	Floodway	1	4980.4	5029.57
17000.0	Floodway	1	4980.13	5014.51
16550	Floodway	1	16	96.23
16457.0	Floodway	1	4944.16	5049.59
15976	Floodway	1	257.57	375.02
15247.7	Floodway	1	132.79	207.43
15100	Floodway	1	56.9	144.58

15080	Floodway	1	83.06	130
14886.4	Floodway	1	197.15	261.93
14300.75	Floodway	1	260	395
14200	Floodway	1	235	375
14100.75	Floodway	1	255	360
13900.75	Floodway	1	430	557.47
13700.75	Floodway	1	225	375
13150.55	Floodway	1	40	170
13150.54	Floodway	1	75	200
13150	Floodway	1	25	156
13149.5	Floodway	1	39.62	144.23
13149	Floodway	1	51.17	143.4
13148.5	Floodway	1	46.785	135.357
13148	Floodway	1	25.58	95.72
13145	Floodway	1	21.31	94.56
13144	Floodway	1	18.37	122.23
13143	Floodway	1	3.24	116.32
13140	Floodway	1	25.43	124.4
13135	Floodway	1	25.43	124.4
13130	Floodway	1	22.22	129.39
13120	Floodway	1	25.27	126.1
13110	Floodway	1	25.32	129.96
13100	Floodway	1	32.06	135.74
13095	Floodway	1	32.06	135.74
13093	Floodway	1	32.06	135.74
13090	Floodway	1	32.06	135.74
13080	Floodway	1	23.15	122.75
13070	Floodway	1	22.48	134.28
13060	Floodway	1	26.64	136.9
13050	Floodway	1	13.34	127.98
13040	Floodway	1	20.8	119.45

FLOW DATA

Flow Title: Updated 2015 - Downstream
Flow File : t:\Projects\x321807802\Eng\2012 Final Plans_Specifications_Estimate_Reports\2014 Final Construction Acceptance Reports\H&H\LOMR - RAS\BNA RAS FLOODWAY\CurrentDownFloodway.f07

Flow Data (cfs)

River	Reach	RS	100 year	Floodway
Lidar Dwnstm	Alignment - Dam	18022.9	695	695
Lidar Dwnstm	Alignment - Dam	14886.4	1110	1110
Lidar Dwnstm	Alignment - Dam	14300.75	1147	1147
Lidar Dwnstm	Alignment - Dam	14100.75	1149	1149
Lidar Dwnstm	Alignment - Dam	13110	1150	1150
Lidar Dwnstm	Alignment - Dam	13070	1151	1151

Boundary Conditions

River	Reach	Profile	Upstream	Downstream
Lidar Dwnstm	Alignment - Dam	100 year		Normal S = 0.013

GEOMETRY DATA

Geometry Title: Current Downstream
Geometry File : t:\Projects\x321807802\Eng\2012 Final Plans_Specifications_Estimate_Reports\2014 Final Construction Acceptance Reports\H&H\LOMR - RAS\BNA RAS FLOODWAY\CurrentDownFloodway.g07

CROSS SECTION

RIVER: Lidar Dwnstm
REACH: Alignment - Dam RS: 18022.9

INPUT
Description: 8
Station Elevation Data num= 6

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	5336.21	.01	5324.8	16.01	5324.8	18.01	5323.8	30	5323.8
30.01	5336.13								

Manning's n Values num= 1

Sta	n Val
0	.013

Bank Sta: Left	Right	Lengths: Left Channel	Right	Coeff Contr.	Expan.
0	30.01	35	35	35	.1	.3

CROSS SECTION

RIVER: Lidar Dwnstm
REACH: Alignment - Dam RS: 17987.1

INPUT
Description: 7
Station Elevation Data num= 6

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	5336.21	.01	5324.62	16.01	5324.62	18.01	5323.62	30	5323.62
30.01	5336.13								

Manning's n Values num= 1

Sta	n Val
0	.013

Bank Sta: Left	Right	Lengths: Left Channel	Right	Coeff Contr.	Expan.
0	30.01	43	43	43	.1	.3

CROSS SECTION

RIVER: Lidar Dwnstm
REACH: Alignment - Dam RS: 17735.62

INPUT
Description: 6
Station Elevation Data num= 212

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	5327.06.3200073	5327.052.849976		5327.044.400024		5327.0510.65002		5327.02	
10.88	5327.0116.97998	5326.9518.45001		5326.9520.83002		5326.9626.23999		5327.02	
29.56	5327.134.03998	5327.2341.33997		5327.341.83997		5327.342.14001		5327.3	
43.40002	5327.31	49.63	5327.4154.71997	5327.4557.42999		5327.4661.84998		5327.43	
65.22998	5327.4567.29999	5327.4473.02002		5327.3275.92999		5327.21	79.88	5327.09	
80.82001	5327.0682.35999	5327.01	88.62	5326.992.45001		5326.8496.40997		5326.8	
102.87	5326.66	104.21	5326.63	105.03	5326.6	108.45	5326.51	112.01	5326.41
117.61	5326.26	119.81	5326.24	123.38	5326.15	127.6	5326.07	130.19	5326.02
135.4	5325.97	140.98	5325.83	142.77	5325.79	143.2	5325.78	143.89	5325.75
150.99	5325.58	155.35	5325.5	158.79	5325.38	164.4	5325.08	166.59	5324.93
167.92	5324.82	173.51	5324.2	174.38	5324.11	180.5	5323.4	182.18	5323.22
184.91	5322.94	189.98	5322.6	193.08	5322.45	197.77	5322.35	205.43	5322.2
205.57	5322.19	205.66	5322.19	206.03	5322.17	213.37	5321.88	218.24	5321.69
221.16	5321.58	225.94	5321.44	228.96	5321.36	230.82	5321.34	236.76	5321.35
238.51	5321.35	238.56	5321.35	243.39	5321.36	244.55	5321.37	246.45	5321.34
252.35	5321.2	255.97	5321.14	260.15	5321.07	266.96	5321	267.94	5321.02
268.55	5321.03	271.08	5321.19	275.74	5321.49	281.13	5321.83	283.54	5322.01
287.47	5322.29	291.34	5322.57	293.71	5322.71	299.13	5323.14	303.61	5323.58
306.29	5323.83	306.93	5323.89	307.98	5323.96	314.73	5324.41	318.87	5324.65
322.52	5324.79	328.49	5324.89	330.32	5324.88	331.44	5324.89	336.13	5325
338.12	5325.05	344.02	5325.19	345.91	5325.24	349	5325.35	353.71	5325.53
356.6	5325.66	361.51	5325.79	368.66	5325.97	369.18	5325.99	369.3	5325.99
369.51	5325.99	377.1	5326.06	381.76	5326.11	384.9	5326.11	390.02	5326.12
392.69	5326.14	394.34	5326.15	400.49	5326.24	401.18	5326.25	406.91	5326.34
408.29	5326.38	410.53	5326.48	416.08	5326.73	419.49	5326.86	423.88	5326.97
431.04	5327.09	431.68	5327.1	432.07	5327.1	433.71	5327.13	439.48	5327.21
444.65	5327.29	447.27	5327.27	451.55	5327.22	455.07	5327.19	457.23	5327.17
462.87	5327.14	466.24	5327.1	469.81	5327.07	470.66	5327.07	472.06	5327.09
478.46	5327.17	482.38	5327.19	486.26	5327.29	492.57	5327.45	494.05	5327.5
494.96	5327.51	498.76	5327.66	501.85	5327.77	507.54	5328.01	509.65	5328.06
513.08	5328.13	517.44	5328.2	520.12	5328.26	525.24	5328.29	531.29	5328.36
532.7	5328.38	533.04	5328.38	533.59	5328.38	540.83	5328.34	545.28	5328.35
548.63	5328.32	554.1	5328.32	556.43	5328.3	557.86	5328.29	563.81	5328.27
564.22	5328.26	570.43	5328.27	572.02	5328.26	574.61	5328.26	579.82	5328.25
583.01	5328.27	587.61	5328.22	595.12	5328.1	595.41	5328.1	595.59	5328.09
596.34	5328.07	603.21	5327.89	608.17	5327.75	611.01	5327.71	615.63	5327.67
618.8	5327.67	620.75	5327.66	626.6	5327.7	628.86	5327.72	633.33	5327.75
634.4	5327.76	636.14	5327.79	642.19	5327.89	645.9	5327.93	649.99	5327.93
656.65	5327.92	657.79	5327.92	658.48	5327.92	661.39	5327.9	665.58	5327.89
671.06	5327.83	673.38	5327.82	677.16	5327.79	681.18	5327.79	683.64	5327.78
688.97	5327.84	693.92	5327.86	696.22	5327.88	696.77	5327.89	697.67	5327.91

```
  704.57 5328.11   708.8  5328.2  712.36 5328.26  718.18 5328.36  720.16  5328.4
  721.38 5328.42  723.62 5328.43

Manning's n Values        num=       1
     Sta   n Val
       0    .035

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
         180.5  303.61           605.82  605.82  605.82             .1       .3

CROSS SECTION


RIVER: Lidar Dwnstm
REACH: Alignment - Dam    RS: 17129.8

INPUT
Description: Cross Section Boca Negra Arroyo 19.5 - C
Station Elevation Data    num=      69
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
  4898.5 5317.18 4898.64 5317.17 4905.28 5316.84 4908.38 5316.69 4913.17 5316.43
 4914.67 5316.35 4919.79 5316.08 4924.06 5315.84  4927.7 5315.67 4931.19 5315.49
 4933.45 5315.34 4942.22 5314.72  4942.6 5314.69 4942.84 5314.67 4943.98 5314.59
 4952.23 5314.02 4954.01 5313.93 4956.75 5313.88 4961.62 5313.74 4965.41 5313.69
 4971.01 5313.55 4971.27 5313.54 4976.82  5313.4  4980.4 5313.21 4982.77 5313.06
 4987.32  5312.9 4988.36 5312.86 4989.19 5312.81 4995.84 5312.64 4996.39 5312.63
 5002.14 5312.48  5002.6 5312.47 5003.31 5312.44 5004.21 5312.44 5010.79  5312.3
 5016.02  5312.3 5018.26 5312.31 5021.09 5312.54 5025.58  5312.9 5025.73 5312.91
 5029.57 5313.31  5033.1 5313.61 5037.08 5313.95 5040.47 5314.11 5043.47 5314.21
 5047.83 5314.53 5052.75 5314.99  5055.2 5315.23 5057.37 5315.44 5062.56 5315.92
 5067.22 5316.32 5068.12  5316.4 5069.84 5316.52 5072.49 5316.66 5076.97 5316.86
  5079.9 5316.99 5084.11 5317.25 5090.57 5317.56 5091.24 5317.57 5091.67 5317.58
 5093.74 5317.64 5098.37 5317.77 5103.45 5317.92  5105.5 5317.92 5108.65 5317.98
 5112.63 5318.03 5115.23 5318.09 5119.77 5318.07  5125.6 5318.09

Manning's n Values        num=       1
     Sta   n Val
  4898.5    .035

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
        4980.4 5029.57            129.8   129.8   129.8             .1       .3

CROSS SECTION


RIVER: Lidar Dwnstm
REACH: Alignment - Dam    RS: 17000.0

INPUT
Description: Cross Section Boca Negra Arroyo 19.0 - B
Station Elevation Data    num=      27
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
  4971.2 5279.03 4972.63 5278.59 4972.96 5278.47 4973.15  5278.4 4973.81  5278.1
 4980.13 5275.45 4984.31  5273.4 4987.29 5272.27  4992.6 5270.23 4994.45 5269.61
 4995.48 5269.36  4998.4 5269.55 4998.52 5269.58 4998.64 5269.62 5002.89 5270.33
 5005.24 5270.96 5007.26 5272.01 5012.91 5274.72 5014.51 5275.54 5015.88  5276.2
 5022.93 5279.65 5023.78 5280.06  5024.5 5280.42 5032.96 5284.74 5033.04 5284.79
 5033.12 5284.83  5033.8 5285.23

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
  4971.2     .05 4980.13     .05 5014.51     .05

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
       4980.13 5014.51              212     212     212             .1       .3

CROSS SECTION


RIVER: Lidar Dwnstm
REACH: Alignment - Dam    RS: 16550

INPUT
Description: A1
Station Elevation Data    num=      14
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0 5256.48     9.1    5250      16    5245   24.17    5240   44.01    5235
   55.58 5234.48   66.69    5235      87    5240   96.23    5245  104.03    5250
  111.06    5255   118.1    5260  124.84    5265  131.73    5270
```

```
Manning's n Values        num=       1
     Sta   n Val
       0    .035

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
            16   96.23              331     331     331             .1       .3

CROSS SECTION


RIVER: Lidar Dwnstm
REACH: Alignment - Dam    RS: 16457.0

INPUT
Description: Cross Section Boca Negra Arroyo 18.0 -A
Station Elevation Data    num=      53
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
  4917.4 5207.88 4918.82 5207.27 4921.23 5206.35 4925.96 5205.18 4931.06 5204.24
  4932.7 5203.91  4933.1 5203.89 4933.77 5203.85 4940.24 5203.56 4944.16 5203.38
 4947.38 5203.09  4952.7 5202.32 4954.52 5202.09 4955.63 5201.93 4960.13 5201.66
 4961.67 5201.55  4967.1 5201.37 4968.81 5201.59 4971.63 5202.06 4975.95 5202.55
 4978.56 5202.72 4983.09 5202.43  4989.2 5201.72 4990.03 5201.64 4990.23  5201.6
 4990.56 5201.53 4997.37 5200.11 4998.74 5199.92 4999.41 5199.83 5001.09 5199.66
  5005.5 5199.46 5006.02 5199.48 5010.38 5199.33 5014.02 5199.54 5016.21 5199.84
 5019.66 5200.08 5022.55 5200.43 5026.39 5201.07 5028.94 5201.39 5031.08  5201.6
 5036.58 5202.12 5037.48 5202.21 5038.22 5202.26 5039.89 5202.37 5045.53 5202.75
 5047.47 5202.87 5049.59 5203.17 5054.36  5203.8 5056.71 5204.14 5059.29 5204.66
 5063.19 5205.35 5065.96 5205.91 5066.87 5206.04

Manning's n Values        num=       4
     Sta   n Val     Sta   n Val     Sta   n Val     Sta   n Val
  4917.4     .05  4933.1    .035 4944.16    .035 5049.59    .035

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
       4944.16 5049.59             481     481     481             .1       .3

CROSS SECTION


RIVER: Lidar Dwnstm
REACH: Alignment - Dam    RS: 15976

INPUT
Description: 5
Station Elevation Data    num=     198
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0 5204.531.280029 5204.456.869995 5204.12 8.48999    52049.289978 5203.94
11.70001 5203.79   15.69 5203.5320.09003 5203.2522.90002 5203.0828.53003 5202.78
30.09998  5202.7   30.88 5202.6733.22998 5202.5937.29999 5202.4541.67999 5202.33
44.51001 5202.2250.17999 5202.0551.71002 5201.9852.46997 5201.96   54.75 5201.82
58.91998 5201.5763.27002 5201.31   66.12 5201.1471.84003 5200.7973.32001  5200.7
   74.06 5200.6676.27002 5200.5880.53003 5200.4184.85999 5200.2787.72998 5200.23
93.48999 5200.1994.92999 5200.1895.64999 5200.1797.79999 5200.08  102.14 5199.93
  106.45 5199.69  109.34  5199.6  115.15 5199.49  116.55 5199.48  117.24 5199.49
  119.32 5199.61  123.75 5199.89  128.04 5200.13  130.95 5200.18  136.81 5200.25
  138.16 5200.27  138.83 5200.27  140.84 5200.24  145.36 5200.19  149.63 5200.11
  152.57 5200.03  158.46 5199.91  159.77 5199.89  160.42 5199.89  162.37 5199.87
  166.97 5199.83  171.22 5199.79  174.18  5199.8  180.12 5199.71  181.38  5199.7
  182.01  5199.7  183.89 5199.71  188.58 5199.75   192.8 5199.73  195.79 5199.73
  201.78 5199.69  202.99 5199.68   203.6 5199.68  205.41 5199.69   210.2 5199.69
  214.39 5199.75   217.4 5199.75  223.43 5199.71   224.6 5199.69  225.19  5199.7
  226.94 5199.68  231.81 5199.65  235.98 5199.59  239.01 5199.59  245.09 5199.51
  246.22 5199.51  246.78  5199.5  248.46 5199.51  253.42 5199.59  257.57 5199.57
  260.62 5199.43  266.74 5199.06  267.83 5198.98  268.37 5198.93  269.98 5198.64
  275.03 5197.71  279.16 5196.99  282.24 5196.42   288.4 5195.32  289.44 5195.11
  289.96 5195.03   291.5 5194.95  295.77 5194.59  296.64 5194.51  300.75 5194.59
  303.85 5195.09  310.06  5196.1  311.05 5196.22  311.55 5196.25  313.03 5196.23
  318.25  5196.1  322.34 5196.13  325.46 5196.19  331.71 5196.35  332.66 5196.37
  333.14 5196.39  334.55 5196.44  339.87  5196.6  343.93 5196.75  347.07 5196.96
  353.37 5197.49  354.27 5197.57  354.73 5197.61  356.07 5197.75  361.48 5198.23
  365.52 5198.68  368.68 5199.03  375.02 5199.78  375.89 5199.88  376.32 5199.95
   377.6 5200.35  383.09 5202.04  387.11  5203.3  390.29 5204.28  396.68 5206.09
   397.5 5206.34   397.9 5206.45  399.12 5206.72   404.7  5208.1   408.7 5208.85
  411.91 5209.07  418.34 5209.25  419.11 5209.27  419.49 5209.27  420.64 5209.24
  426.31 5209.08  430.29 5208.91  433.52 5208.79  439.99 5208.51  440.72 5208.47
  441.08 5208.46  442.17 5208.43  447.92 5208.34  451.88  5208.2  455.13 5207.94
  461.65 5207.34  462.33 5207.27  462.67 5207.23  463.69 5207.15  469.54 5206.68
  473.47 5206.39  476.74 5206.16  483.31  5205.8  483.94 5205.77  484.26 5205.75
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  485.21 5205.72  491.15 5205.49  495.06 5205.42  498.35 5205.33  504.96  5205.1
  505.56 5205.08  505.85 5205.08  506.74 5205.06  512.76 5204.92  516.65 5204.83
  519.96 5205.06  526.62 5205.71  527.17 5205.75  527.44 5205.78  528.26 5205.94
  534.37    5207  538.24 5207.86  541.58 5208.82  548.27 5210.69  548.78 5210.83
  549.03 5210.89  549.78 5211.12  555.98 5213.09  559.83 5214.23  563.19 5215.23
  569.93 5217.09  570.39 5217.21  570.62 5217.27  571.31 5217.43  577.59 5218.87
  581.42 5219.77   584.8 5220.49  591.59 5221.75     592 5221.83  592.21 5221.87
  592.83    5222  599.21 5223.42     600 5223.56

Manning's n Values        num=       1
     Sta   n Val
       0    .035

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
        257.57  375.02           728.26  728.26  728.26             .1       .3

CROSS SECTION


RIVER: Lidar Dwnstm
REACH: Alignment - Dam    RS: 15247.7

INPUT
Description: 4
Station Elevation Data    num=     109
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0  5193.8    3.25 5193.626.339996 5193.4212.51999 5193.0213.54001 5192.96
14.04999 5192.94   15.56 5192.8620.73999  5192.6   24.84 5192.3927.95001 5192.26
34.17999    519235.14999 5191.9735.64001 5191.9637.07999 5191.9142.35999 5191.76
46.42999 5191.59   49.56 5191.48   55.84  5191.256.76001 5191.1857.23001 5191.18
58.60999 5191.17   63.97 5191.1368.01999 5191.0871.17001 5191.0377.48999  5190.9
   78.37 5190.89   78.81 5190.88   80.13 5190.8785.57999 5190.8389.60999 5190.78
   92.78 5190.6999.14999 5190.4299.98999 5190.38   100.4 5190.36  101.65 5190.28
  107.19 5189.88   111.2 5189.68  114.39 5189.43   120.8 5189.06   121.6 5188.99
  121.99 5188.95  123.18 5188.78   128.8    5188  132.79 5187.39  136.01 5186.89
  142.46 5185.91  143.21 5185.81  143.58 5185.76   144.7 5185.75  150.41 5185.66
  154.38 5185.68  157.62  5185.8  164.12 5185.95  164.82 5185.99  165.17 5186.01
  166.22 5186.07  172.03 5186.39  175.97 5186.61  179.23 5186.67  185.77 5186.79
  186.43 5186.79  186.76 5186.79  187.75  5186.8  193.64  5186.9  197.56 5186.94
  200.84 5187.04  201.44 5187.06  207.43 5187.26  208.04 5187.28  208.35 5187.29
  209.27 5187.33  215.25 5187.56  219.15 5187.69  222.45 5187.74  229.08 5188.06
  229.66 5188.09  229.94 5188.11  230.79 5188.16  236.86 5188.44  240.74 5188.73
  244.06  5189.1  250.74 5190.12  251.27 5190.21  251.53 5190.26  252.32 5190.43
  258.47 5191.84  262.33 5192.58  265.68 5193.13   272.4 5193.84  272.88 5193.88
  273.12 5193.89  273.84 5193.91  280.08 5194.16  283.91 5194.28  287.29  5194.3
  294.05 5194.28  294.49 5194.28  294.71 5194.28  295.36 5194.25   301.7 5194.04
   305.5 5193.76   308.9  5193.6  315.71 5192.82   316.1 5192.76   316.3 5192.71
  316.88 5192.53  323.31 5190.55  327.09 5189.41  330.51 5188.43

Manning's n Values        num=       1
     Sta   n Val
       0    .035

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
        132.79  207.43             139     192     259             .1       .3

CROSS SECTION


RIVER: Lidar Dwnstm
REACH: Alignment - Dam    RS: 15100

INPUT
Description: 3B - Monument Entrance
Station Elevation Data    num=      17
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
  -46.73 5188.98  -24.33 5188.02       0  5187.3   15.86 5187.03   42.56 5187.47
    56.9 5185.04   87.21 5184.34   90.38    5183   96.07 5183.22   98.45 5183.82
  118.18 5184.33  144.58 5185.03  171.35 5186.47  198.12 5187.78  204.13    5188
  223.32 5188.65     240  5188.3

Manning's n Values        num=       1
     Sta   n Val
  -46.73    .035

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
          56.9  144.58              53      53      53             .3       .5

CULVERT
```

```
RIVER: Lidar Dwnstm
REACH: Alignment - Dam    RS: 15090

INPUT
Description: Monument Low Flow Culverts
Distance from Upstream XS =    15.3
Deck/Roadway Width        =      21
Weir Coefficient          =     2.6
Upstream  Deck/Roadway Coordinates
    num=       5
     Sta Hi Cord Lo Cord     Sta Hi Cord Lo Cord     Sta Hi Cord Lo Cord
   15.86 5187.03 5187.03      58 5186.47             109 5185.92
     158 5186.58          198.12 5187.83

Upstream Bridge Cross Section Data
Station Elevation Data    num=      14
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
     -50  5188.9       0  5187.3   15.86 5187.03   36.38 5186.03    56.9 5185.04
   87.21 5184.34   90.38 5182.54   96.07 5182.71   98.45 5183.82  118.18 5184.33
  144.58 5185.03  171.35 5186.47  198.12 5187.83  223.32 5188.65

Manning's n Values        num=       1
     Sta   n Val
     -50    .016

Bank Sta: Left   Right    Coeff Contr.   Expan.
          56.9  144.58             .3       .5

Downstream  Deck/Roadway Coordinates
    num=       5
     Sta Hi Cord Lo Cord     Sta Hi Cord Lo Cord     Sta Hi Cord Lo Cord
   34.09 5186.62 5186.62      58 5186.47             109 5185.92
     158 5186.58          219.55 5187.99

Downstream Bridge Cross Section Data
Station Elevation Data    num=      11
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
    -9.2    5188       0 5187.66   34.09 5186.62    71.5 5184.14   83.06 5183.95
    87.3 5182.64    91.5 5180.69     105 5180.84  115.37 5183.33  165.26 5185.61
  219.55 5187.99

Manning's n Values        num=       1
     Sta   n Val
    -9.2    .016

Bank Sta: Left   Right    Coeff Contr.   Expan.
         83.06  115.37             .1       .3

Upstream Embankment side slope              =       2 horiz. to 1.0 vertical
Downstream Embankment side slope            =       2 horiz. to 1.0 vertical
Maximum allowable submergence for weir flow =     .98
Elevation at which weir flow begins         =
Energy head used in spillway design         =
Spillway height used in design              =
Weir crest shape                            = Broad Crested

Number of Culverts =  1

Culvert Name     Shape      Rise    Span
Culvert #1       Ellipse    1.67    2.33
FHWA Chart # 29- Horizontal Ellipse; Concrete
FHWA Scale # 1 - Square edge with headwall
Solution Criteria = Highest U.S. EG
Culvert Upstrm Dist  Length    Top n  Bottom n  Depth Blocked  Entrance Loss Coef   Exit Loss Coef
               15.3    31.8     .024     .024        0                  .9               1
Number of Barrels =  2
Upstream   Elevation =  5182.625
Centerline Stations
    Sta.    Sta.
   91.23   95.55
Downstream Elevation =  5180.76
Centerline Stations
    Sta.    Sta.
   93.52    97.8

CROSS SECTION
```

RIVER: Lidar Dwnstm
REACH: Alignment - Dam RS: 15080

INPUT
Description: 3A - Monument Entrance
Station Elevation Data num= 13

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
-9.2	5188	0	5187.66	34.09	5186.62	71.5	5184.14	83.06	5183.95
89.37	5182.64	95.67	5180.34	105	5180	115.37	5183.33	165.26	5185.61
193.38	5186.97	219.55	5187.99	237.86	5187.15				

Manning's n Values num= 1

Sta	n Val
-9.2	.035

Bank Sta: Left	Right	Lengths: Left Channel	Right	Coeff Contr.	Expan.
83.06	115.37	115	115	.1	.3

CROSS SECTION

RIVER: Lidar Dwnstm
REACH: Alignment - Dam RS: 14886.4

INPUT
Description: 3
Station Elevation Data num= 184

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	5185.27	3.880005	5185.43	5	5185.45	5.820007	5185.47	11.16998	5185.64
12.14001	5185.67	18.20001	5185.97	19.28003	5185.97	20.75	5185.97	26.40997	5185.75
30.57001	5185.63	3.54999	5185.54	37.60999	5185.49	40.69	5185.54	2.95001	5185.52
47.82001	5185.59	54.46997	5185.68	54.96002	5185.68	55.32001	5185.68	57.66998	5185.69
62.09998	5185.76	7.70001	5185.71	69.23999	5185.73	71.33002	5185.75	76.37	5185.79
80.07001	5185.79	83.51001	5185.77	88.20001	5185.76	90.64999	5185.75	92.45001	5185.74
97.78	5185.7	104.16	5185.69	104.82	5185.69	104.92	5185.69	105.06	5185.69
112.06	5185.56	117.19	5185.47	119.19	5185.43	121.92	5185.39	126.33	5185.26
129.57	5185.12	133.47	5184.98	138.78	5184.79	140.61	5184.71	141.94	5184.62
147.74	5184.15	150.65	5183.93	154.32	5183.65	154.88	5183.61	155.65	5183.57
162.02	5183.39	166.69	5183.32	169.15	5183.31	172.51	5183.29	176.29	5183.28
179.07	5183.25	183.43	5183.28	189.37	5183.19	190.56	5183.04	191.44	5182.91
197.15	5181.99	197.7	5181.9	203.82	5180.92	204.84	5180.73	206.23	5180.47
211.98	5179.46	216.19	5178.81	219.11	5178.33	223.1	5177.77	226.25	5177.55
228.56	5177.49	233.39	5177.54	239.96	5178.03	240.52	5178.11	240.94	5178.18
243.64	5178.81	247.66	5179.76	253.31	5180.94	254.8	5181.23	256.82	5181.53
261.93	5182.1	265.69	5182.39	269.07	5182.51	273.68	5182.71	276.21	5182.81
278.06	5182.92	283.35	5183.1	290.14	5183.38	290.44	5183.39	290.48	5183.39
290.55	5183.4	297.62	5184.03	302.81	5184.57	304.76	5184.81	307.41	5185.2
311.89	5185.92	315.19	5186.3	319.03	5186.68	324.27	5187.01	326.17	5187.07
326.59	5187.08	327.56	5187.09	333.31	5187.14	336.63	5187.16	339.93	5187.19
340.44	5187.19	341.13	5187.2	347.58	5187.21	352.31	5187.09	354.72	5186.97
358	5186.67	361.85	5186.18	364.68	5185.73	368.99	5184.99	374.86	5183.9
376.13	5183.69	377.06	5183.57	383.12	5182.95	383.26	5182.94	389.43	5182.53
390.4	5182.49	391.72	5182.47	397.54	5182.65	401.81	5182.81	404.68	5182.97
408.58	5183.25	411.81	5183.57	414.18	5183.85	418.95	5184.58	425.45	5185.79
426.09	5185.92	426.56	5186.02	429.62	5186.92	433.22	5187.95	438.93	5189.79
440.36	5190.3	442.31	5191.08	447.5	5192.97	451.3	5194.36	454.63	5195.48
459.17	5197.11	461.77	5198.07	463.68	5198.84	468.91	5200.87	476.03	5203.98
476.05	5203.99	476.11	5204.02	483.18	5207.17	488.43	5209.65	490.32	5210.4
492.9	5211.48	497.46	5213.23	500.8	5214.52	504.59	5215.78	509.76	5217.6
511.73	5218.31	513.18	5218.88	518.87	5221.33	522.6	5223.05	525.55	5224.39
526	5224.59	526.62	5224.85	533.14	5227.71	537.93	5229.77	540.28	5230.78
543.48	5232.2	547.42	5233.87	550.3	5235.01	554.55	5236.87	560.35	5239.31
561.69	5239.94	562.68	5240.37	568.83	5243.4	569.1	5243.53	575.05	5246.46
575.96	5246.95	577.21	5247.65	583.1	5251.06	587.42	5253.62	590.24	5255.37
594.07	5257.78	597.37	5259.9	599.8	5261.32	600	5261.45		

Manning's n Values num= 1

Sta	n Val
0	.035

Bank Sta: Left	Right	Lengths: Left Channel	Right	Coeff Contr.	Expan.
197.15	261.93	585.65	585.65	.1	.3

CROSS SECTION

RIVER: Lidar Dwnstm
REACH: Alignment - Dam RS: 14300.75

```
INPUT
Description: 2
Station Elevation Data    num=     174
      Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
        0 5181.147.580017 5181.028.909973    5181 9.27002 5180.999.909973    5181
    17.94 5181.0120.78998 5181.0225.78998 5180.9526.97998 5180.9332.29999 5180.85
36.01001 5180.7841.65997  5180.743.82001 5180.6645.04999 5180.6749.52002 5180.69
54.08002  5180.755.33002 5180.6957.53003  5180.763.10999 5180.7166.84998 5180.73
72.15002  5180.773.40997 5180.6978.35999 5180.6681.17999 5180.65   89.28 5180.59
   89.88 5180.59   90.22  5180.691.45999 5180.63   99.25 5180.84  101.39 5180.87
  105.16 5180.89  108.29 5180.91  112.91 5180.94  117.32 5180.97  121.03 5180.99
  124.43 5181.01  126.36 5181.04  133.39 5181.15  135.39 5181.19  135.94  5181.2
   136.9 5181.22  144.43 5181.38  147.46 5181.46  152.78 5181.55  153.46 5181.57
  158.97 5181.65   162.5 5181.67  168.65 5181.68  170.49 5181.69  171.53 5181.67
  175.33 5181.61  180.57 5181.51     182 5181.51  184.53 5181.48   189.6 5181.41
  193.52 5181.38  198.63 5181.31   200.4 5181.27  205.03 5181.19  207.67 5181.09
  216.27  5180.7  216.55 5180.69   216.7 5180.68  217.27 5180.65  225.74 5180.17
  228.06 5180.04  232.15 5179.69  234.77 5179.47  239.58 5179.04  243.81 5178.63
  248.02  5178.2  251.09 5177.89  252.84 5177.69  259.21  5176.9  261.88 5176.57
  262.61 5176.47   263.9 5176.23  270.91 5175.01  274.12 5174.41  279.77 5173.85
  279.95 5173.83  285.64 5173.33  288.98 5173.25  295.64  5173.2  297.16 5173.17
  298.02 5173.13  301.15 5172.98  307.05  5172.7  308.67 5172.61  311.52 5172.58
  314.63 5172.53  316.09 5172.51  320.19 5172.48  325.12  5172.8  327.39 5172.98
   331.7 5173.28  334.15 5173.51  343.09 5174.38  343.19 5174.39  343.22 5174.39
  343.27  5174.4  352.22 5175.17  354.73  5175.4  359.14 5175.63  361.26 5175.75
  366.25 5176.01  370.29 5176.17  375.01 5176.33  377.76 5176.44  379.33  5176.5
  385.03 5176.68  388.36 5176.79  389.28 5176.81  390.89 5176.83   397.4 5176.92
  400.79 5176.96  406.43 5176.94  406.76 5176.94  412.31 5176.92  415.47 5176.92
  422.64 5176.88  423.82 5176.88   424.5  5176.9  426.96 5176.97  433.54 5177.17
  435.34 5177.23  438.51 5177.34  442.57  5177.5  446.86 5177.64  451.61 5177.73
  454.38 5177.79  458.37 5177.86  460.64 5177.88   468.9 5177.89  469.67 5177.89
  469.89 5177.89  470.26 5177.89  478.71 5177.84   481.4 5177.82  486.13 5177.75
  487.74 5177.72  492.92 5177.65  496.78 5177.64  502.01 5177.66  504.43 5177.66
  505.81 5177.76  510.84 5178.19  514.85 5178.54  515.95 5178.64  517.88 5178.78
  523.88 5179.25  527.46 5179.51  532.92 5179.93  533.75    5180  538.98 5180.43
  541.95 5180.87  549.63 5182.03  550.49 5182.16  550.99 5182.21  552.78 5182.37
  560.02    5183  562.01 5183.13   565.5 5183.12  569.06 5183.13  573.52 5183.09
  578.09 5182.99  581.38 5182.94  585.04 5182.87  587.12 5182.85  594.72 5182.81
  596.16  5182.8  596.56  5182.8  597.25  5182.8     600 5182.79

Manning's n Values        num=       1
     Sta   n Val
       0    .035

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
        259.21   397.4              321     321     321             .1       .3

CROSS SECTION


RIVER: Lidar Dwnstm
REACH: Alignment - Dam    RS: 14200

INPUT
Description: 1D
Station Elevation Data    num=     174
      Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
        0 5177.084.030029 5177.095.559998  5177.1 5.97998 5177.096.719971 5177.11
14.59003 5177.2617.48999 5177.3222.59003 5177.38   23.63 5177.3929.01001 5177.45
32.65997 5177.3838.46002  5177.340.52002 5177.2641.70001 5177.2545.96997 5177.15
50.72998 5177.0452.03998 5177.0254.34003 5177.0359.77002 5177.0963.54999 5177.09
68.79999 5177.0970.21002 5177.0775.07001 5177.0577.84003 5177.0486.09003 5177.09
86.59003 5177.09   86.87 5177.0987.90997 5177.0995.89999  5177.198.10001 5177.11
  101.96 5177.09  104.94 5177.05  109.62 5177.04  113.97 5177.15  117.83 5177.25
  121.13 5177.33  123.01 5177.36  129.84 5177.39  132.04  5177.4  132.65  5177.4
  133.71  5177.4  141.08 5177.43  144.16 5177.46  149.58 5177.34  150.11 5177.33
  155.68 5177.21  159.15    5177  165.46 5176.66  167.19 5176.56  168.18 5176.51
  171.78 5176.35  177.22 5176.09  178.71 5176.01  181.33 5175.84  186.25 5175.52
  190.22 5175.28  195.29 5175.17   197.2 5175.13  201.74 5175.03  204.32 5175.07
  213.08 5175.19  213.25 5175.19  213.36 5175.19  213.72 5175.21  222.39 5175.51
  224.77 5175.56  228.95 5175.46  231.42 5175.41  236.29 5175.28  240.46 5174.97
  244.83  5174.7   247.8 5174.49  249.49 5174.39  255.66 5174.01  258.53 5173.83
  259.32 5173.79   260.7 5173.68  267.56 5173.15  270.83 5172.89  276.57 5172.12
   276.6 5172.11  282.35 5171.33  285.63 5170.95  292.45 5170.24  293.86 5170.08
  294.67 5170.09   297.6 5170.19   303.7  5170.4  305.38  5170.5  305.75 5170.54
  308.32  5170.8  312.74 5171.25  316.89 5171.67  321.77  5172.1   324.2  5172.3
  328.41 5172.66  330.81 5172.85  339.54 5173.47  339.84 5173.49  339.92 5173.49
  340.07  5173.5  348.88 5173.79  351.44 5173.85  355.94 5173.85  357.91 5173.86
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362.95	5173.85	366.94	5173.96	371.82	5174.1	374.47	5174.17	375.98	5174.26
381.48	5174.55	385.01	5174.74	385.99	5174.79	387.69	5174.88	394.05	5175.21
397.5	5175.39	403.08	5175.63	403.57	5175.65	409.02	5175.89	412.12	5176.04
419.44	5176.43	420.53	5176.48	421.15	5176.51	423.41	5176.59	430.19	5176.83
432.05	5176.91	435.31	5177.06	439.22	5177.24	443.56	5177.44	448.26	5177.61
451.19	5177.72	455.08	5177.87	457.29	5177.96	465.35	5178.34	466.33	5178.38
466.59	5178.39	467.06	5178.41	475.36	5178.73	478.11	5178.85	482.94	5179.06
484.39	5179.13	489.62	5179.35	493.43	5179.49	498.81	5179.69	501.14	5179.78
502.46	5179.81	507.29	5179.95	511.5	5180.07	512.65	5180.1	514.68	5180.12
520.53	5180.19	524.17	5180.23	529.57	5180.48	530.56	5180.52	535.69	5180.76
538.6	5180.99	546.43	5181.54	547.2	5181.59	547.64	5181.62	549.23	5181.71
556.67	5182.17	558.72	5182.29	562.31	5182.49	565.71	5182.69	570.23	5182.94
574.74	5183.12	578.18	5183.3	581.75	5183.47	583.78	5183.58	591.17	5183.98
592.81	5184.07	593.26	5184.09	594.05	5184.13	600	5184.44		

Manning's n Values num= 1

Sta	n Val
0	.035

Bank Sta: Left	Right	Lengths: Left Channel	Right	Coeff Contr.	Expan.
258.53	348.88	215	215	215	.1	.3

CROSS SECTION

RIVER: Lidar Dwnstm
REACH: Alignment - Dam RS: 14100.75

INPUT
Description: 1C
Station Elevation Data num= 174

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	5175.25	1.159973	5175.21	3.539978	5175.14	7.719971	5175.08	10.19	5175.05
15.04999	5174.98	19.22998	5174.91	23.59003	5174.85	26.57001	5174.81	28.26001	5174.77
34.42999	5174.58	37.29999	5174.5	38.08002	5174.48	39.46002	5174.46	46.33002	5174.33
49.59998	5174.29	55.34003	5174.19	55.37	5174.19	61.10999	5174.12	64.40002	5174.05
71.21002	5173.9	72.63	5173.87	73.44	5173.84	76.37	5173.73	82.46997	5173.51
84.15002	5173.45	87.09003	5173.22	91.51001	5172.9	95.66	5172.58	100.54	5172.2
102.96	5172.03	107.18	5171.71	109.57	5171.6	118.31	5171.21	118.61	5171.2
118.69	5171.19	118.83	5171.19	127.64	5171.17	130.21	5171.15	134.71	5171.11
136.68	5171.1	141.72	5171.05	145.71	5171.09	150.58	5171.14	153.24	5171.17
154.75	5171.22	160.25	5171.37	163.78	5171.47	164.75	5171.5	166.46	5171.56
172.82	5171.78	176.27	5171.89	181.85	5172.11	182.33	5172.12	187.78	5172.32
190.89	5172.38	198.2	5172.57	199.3	5172.59	199.92	5172.58	202.19	5172.54
208.96	5172.43	210.81	5172.41	214.08	5172.26	217.99	5172.1	222.33	5171.89
227.03	5171.67	229.95	5171.51	233.84	5171.31	236.06	5171.3	244.13	5171.29
245.09	5171.29	245.36	5171.29	245.83	5171.28	254.13	5171.15	256.88	5171.09
261.7	5170.59	263.16	5170.44	268.39	5169.87	272.2	5169.44	277.57	5168.86
279.91	5168.6	281.23	5168.6	286.07	5168.64	290.27	5168.68	291.42	5168.7
293.45	5168.81	299.3	5169.1	302.94	5169.31	304.86	5169.38	308.34	5169.51
309.32	5169.54	314.45	5169.73	317.37	5169.83	325.2	5170.15	325.97	5170.18
326.41	5170.2	328	5170.31	335.44	5170.82	337.48	5170.98	341.07	5171.12
344.48	5171.27	349	5171.44	353.51	5171.57	356.95	5171.65	360.51	5171.75
362.55	5171.83	369.94	5172.12	371.58	5172.19	372.03	5172.2	372.82	5172.25
380.61	5172.73	383.54	5172.92	388.69	5173.3	389.65	5173.37	395.06	5173.79
398.68	5174.05	404.57	5174.42	406.58	5174.55	407.72	5174.61	411.88	5174.82
416.75	5175.07	418.09	5175.12	420.44	5175.21	425.79	5175.42	429.61	5175.57
434.82	5175.76	436.32	5175.8	441.12	5175.96	443.86	5176.03	452.19	5176.27
452.64	5176.28	452.89	5176.29	453.82	5176.3	461.93	5176.42	464.15	5176.46
468.06	5176.51	470.96	5176.53	475.67	5176.6	480	5176.68	483.94	5176.71
487.18	5176.75	489.03	5176.82	495.76	5177.09	498.06	5177.18	498.7	5177.21
499.81	5177.28	507.1	5177.71	510.21	5177.89	515.69	5178.17	516.13	5178.19
521.73	5178.5	525.17	5178.65	531.56	5178.88	533.24	5178.95	534.2	5179.01
537.7	5179.22	543.24	5179.57	544.76	5179.66	547.43	5179.83	552.27	5180.17
556.28	5180.42	561.31	5180.74	563.31	5180.88	567.79	5181.18	570.34	5181.33
579.18	5181.88	579.31	5181.89	579.38	5181.89	579.64	5181.91	588.41	5182.54
590.82	5182.72	595.06	5183.05	597.45	5183.24	600	5183.43		

Manning's n Values num= 1

Sta	n Val
0	.035

Bank Sta: Left	Right	Lengths: Left Channel	Right	Coeff Contr.	Expan.
254.13	344.48	200	200	200	.1	.3

Ineffective Flow num= 1

Sta L	Sta R	Elev	Permanent
0	199.92	5172.58	F

CROSS SECTION

RIVER: Lidar Dwnstm
REACH: Alignment - Dam RS: 13900.75

INPUT
Description: 1B
Station Elevation Data num= 230

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	5179.96	.4100342	5179.87	4.72998	5178.99	9.440002	5178.46	12.32001	5178.1
16.23999	5177.64	18.47998	5177.46	26.60004	5176.87	27.51001	5176.81	27.76001	5176.79
28.20001	5176.77	36.54999	5176.33	39.28003	5176.22	44.07001	5175.96	45.58002	5175.88
50.79004	5175.59	54.62	5175.36	59.95001	5175.03	62.31	5174.89	63.65002	5174.83
68.54004	5174.62	72.67999	5174.44	73.82001	5174.47	5.82001	5174.33	81.72003	5174.09
85.34003	5173.97	90.75	5173.71	91.69	5173.66	96.85004	5173.39	99.79004	5173.3
107.57	5173.02	108.37	5172.99	108.82	5172.99	110.48	5172.95	117.86	5172.79
119.88	5172.72	123.44	5172.5	126.89	5172.29	131.4	5171.99	135.93	5171.57
139.32	5171.24	142.91	5170.9	144.96	5170.75	152.42	5170.21	154	5170.11
154.43	5170.08	155.19	5170.06	163.03	5169.77	165.94	5169.69	171.06	5169.62
172.07	5169.61	177.46	5169.55	181.1	5169.53	186.94	5169.49	188.98	5169.48
190.14	5169.47	194.36	5169.44	199.17	5169.4	200.49	5169.39	202.81	5169.38
208.2	5169.34	212.01	5169.33	217.24	5169.32	218.69	5169.33	223.52	5169.33
226.27	5169.33	234.56	5169.38	235.04	5169.38	235.31	5169.38	236.3	5169.37
244.34	5169.28	246.55	5169.26	250.43	5169.22	253.38	5169.19	258.07	5169.15
262.41	5169.08	266.31	5169	269.58	5168.95	271.45	5168.93	278.24	5168.84
280.48	5168.82	281.1	5168.81	282.18	5168.81	289.52	5168.8	292.61	5168.79
298.06	5168.93	298.55	5168.94	304.13	5169.05	307.59	5169.15	313.93	5169.33
315.64	5169.38	316.62	5169.39	320.17	5169.43	325.65	5169.5	327.16	5169.52
329.8	5169.54	334.69	5169.56	338.68	5169.58	343.72	5169.43	345.68	5169.39
350.19	5169.28	352.76	5169.23	361.55	5168.99	361.71	5168.99	361.79	5168.99
362.11	5168.98	370.83	5168.82	373.22	5168.76	377.43	5168.77	379.86	5168.77
384.74	5168.79	388.9	5168.83	393.3	5168.86	396.25	5168.89	397.93	5168.9
404.05	5168.89	406.97	5168.89	407.77	5168.89	409.17	5168.9	416	5168.95
419.28	5168.95	425.04	5168.96	425.05	5168.96	430.8	5168.99	434.07	5168.98
440.92	5169.06	442.31	5169.06	443.11	5169.08	445.99	5169.12	452.14	5169.23
453.83	5169.26	456.8	5169.27	461.17	5169.33	465.34	5169.29	470.21	5168.93
472.67	5168.71	476.86	5168.37	479.24	5168.11	487.93	5167.23	488.28	5167.2
488.38	5167.19	488.54	5167.19	497.31	5166.99	499.89	5166.95	500.03	5166.95
504.42	5166.97	506.35	5166.98	511.41	5167	515.38	5167.19	520.29	5167.43
522.92	5167.56	524.42	5167.63	529.87	5167.89	533.45	5168.07	534.44	5168.12
536.17	5168.23	542.49	5168.6	545.95	5168.8	551.52	5169.38	552.04	5169.43
557.47	5169.99	560.56	5170.34	567.91	5171.16	568.98	5171.28	569.59	5171.33
571.8	5171.56	578.63	5172.28	580.5	5172.47	583.79	5172.59	587.66	5172.75
592.01	5172.89	596.69	5172.77	599.66	5172.67	603.53	5172.57	605.73	5172.53
613.74	5172.41	614.76	5172.4	615.04	5172.4	615.54	5172.4	623.8	5172.45
626.56	5172.48	631.41	5172.64	632.83	5172.69	638.07	5172.86	641.87	5172.99
647.28	5173.11	649.59	5173.18	650.9	5173.24	655.68	5173.45	659.94	5173.65
661.11	5173.7	663.16	5173.78	668.97	5173.99	672.62	5174.13	678.01	5174.33
679.03	5174.37	684.14	5174.56	687.04	5174.7	694.91	5175.14	695.65	5175.18
696.08	5175.21	697.62	5175.31	705.11	5175.79	707.17	5175.91	710.78	5176.17
714.15	5176.41	718.68	5176.74	723.18	5177.06	726.65	5177.31	730.2	5177.57
732.21	5177.68	739.56	5178.08	741.25	5178.17	741.71	5178.19	742.53	5178.26
750.28	5178.89	753.23	5179.12	758.4	5179.61	759.32	5179.7	764.74	5180.19
768.35	5180.57	774.28	5181.18	776.26	5181.39	777.39	5181.51	781.5	5181.98
786.42	5182.53	787.77	5182.67	790.15	5182.94	795.46	5183.49	796.01	5183.55

Manning's n Values num= 1

Sta	n Val
0	.035

Bank Sta: Left	Right	Lengths: Left Channel	Right	Coeff Contr.	Expan.
154.43	557.47	200	200	200	.1	.3

CROSS SECTION

RIVER: Lidar Dwnstm
REACH: Alignment - Dam RS: 13700.75

INPUT
Description: 1A
Station Elevation Data num= 174

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	5171.18	4.200012	5171.15	.159973	5171.09	5.419983	5171.08	5.890015	5171.09
14.20001	5171.18	16.94	5171.22	1.76001	5171.19	23.22998	5171.19	28.45001	5171.16
32.26001	5171.16	37.64001	5171.09	39.96997	5171.08	41.29999	5171.05	46.14001	5170.99
50.33002	5170.94	51.48999	5170.93	53.51001	5170.88	59.37	5170.76	63	5170.69
68.40002	5170.55	69.38	5170.52	74.52002	5170.38	77.44	5170.28	5.26001	5169.76
86.03003	5169.71	86.46997	5169.69	88.07999	5169.64	95.51001	5169.39	97.54999	5169.34

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  101.13 5169.31  104.54 5169.27  109.06 5169.24  113.58 5169.17  117.01  5169.1
  120.58 5169.03  122.61 5168.95  130.02 5168.74  131.65 5168.69  132.09 5168.68
  132.88 5168.67  140.68  5168.5  143.61 5168.46  148.75 5168.44  149.72 5168.43
  155.12 5168.47  158.75 5168.59  164.63 5168.78  166.64 5168.85  167.78 5168.84
  171.95 5168.71  176.82 5168.54  178.15 5168.48   180.5 5168.36  185.85 5168.11
  189.67 5167.91  194.89  5167.9  196.38 5167.91  201.19 5167.92  203.92 5167.97
  212.25 5168.18   212.7 5168.19  212.96 5168.19  213.89 5168.23  221.99 5168.55
  224.22 5168.64  228.12 5168.52  231.03 5168.44  235.73 5168.29  240.06 5168.07
     244 5167.85  247.25 5167.67   249.1  5167.6  255.83 5167.39  258.13 5167.31
  258.76 5167.28  259.87 5167.22  267.17 5166.83  270.28 5166.66  275.75 5166.19
   276.2 5166.15  281.79 5165.67  285.23 5165.54  291.62 5165.36  293.31  5165.3
  294.27 5165.29  297.77 5165.29  303.19  5165.3   303.3  5165.3  304.82 5165.32
  307.49 5165.38  312.34 5165.49  316.34 5165.58  321.37 5165.69  323.37 5165.73
  327.85 5165.83  330.41 5165.93  339.24 5166.28  339.37 5166.29  339.44 5166.29
  339.71  5166.3  348.48 5166.66  350.89 5166.74  355.12 5166.87  357.51 5166.95
   362.4  5167.1  366.55  5167.3  370.99 5167.51  373.92 5167.65  375.58 5167.78
  381.65 5168.29  384.62 5168.54  385.43  5168.6  386.86 5168.65  393.65 5168.85
  396.95 5168.96  402.69 5169.11  402.74 5169.12  408.46 5169.25  411.72 5169.25
  418.61  5169.2  419.98 5169.19  420.75 5169.19  423.59 5169.22  429.79 5169.31
  431.49 5169.35  434.49 5169.46  438.82 5169.64  443.01 5169.78  447.86 5169.97
  450.36 5170.07  454.52 5170.24  456.89 5170.34  465.52 5170.77  465.93 5170.79
  466.04 5170.79  466.23 5170.81  474.96 5171.34  477.55  5171.5  482.11 5171.82
     484 5171.96  489.07 5172.31  493.03 5172.64  497.98 5173.08  500.58 5173.31
  502.07 5173.45  507.46 5173.99   511.1 5174.35   512.1 5174.44  513.86 5174.62
  520.14 5175.24  523.62 5175.58  529.17 5176.06  529.73  5176.1  535.13 5176.55
  538.21 5176.88   545.6 5177.65  546.65 5177.76  547.24 5177.83   549.4 5178.08
  556.27 5178.84  558.16 5179.05  561.48 5179.42  565.31 5179.85  569.68 5180.33
  574.34    5181  577.35 5181.44  581.19 5181.99  583.38 5182.31  591.34 5183.41
  592.41 5183.55  592.71 5183.59  593.23 5183.65     600 5184.36

Manning's n Values        num=       1
     Sta   n Val
       0    .035

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
        224.22  384.62              57      57      57             .1       .3
Ineffective Flow     num=       1
   Sta L   Sta R    Elev  Permanent
       0  224.22 5168.64       F

CROSS SECTION


RIVER: Lidar Dwnstm
REACH: Alignment - Dam    RS: 13150.55

INPUT
Description: 1
Station Elevation Data    num=      17
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
     -85 5169.02       0 5167.54   11.41 5167.47   19.81 5165.67   30.27 5165.88
   32.83    5167   41.57  5166.8   48.77 5165.45   77.26 5165.39   80.94 5164.71
   92.23 5164.49   98.97 5165.64  111.85 5165.48  133.75 5165.15  137.68  5166.1
  168.37 5166.69  213.99    5169

Manning's n Values        num=       1
     Sta   n Val
     -85    .035

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
         77.26   98.97              29      29      29             .1       .3

CROSS SECTION


RIVER: Lidar Dwnstm
REACH: Alignment - Dam    RS: 13150.54

INPUT
Description: 0.995
Station Elevation Data    num=      11
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0 5168.77    22.2    5168      80    5167    96.4    5166   112.3    5165
   131.7 5164.94   139.7    5165   200.4    5166     203 5165.61     215 5168.11
     235 5168.79

Manning's n Values        num=       1
     Sta   n Val
       0    .035
```

```
Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
          96.4   200.4               43      43      43             .1       .3

CROSS SECTION


RIVER: Lidar Dwnstm
REACH: Alignment - Dam    RS: 13150

INPUT
Description: 0.99
Station Elevation Data    num=      12
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
     -20 5167.97       0 5166.86   21.63 5166.82   43.34 5166.68   57.455165.149
   64.44 5164.39   79.51  5164.3   93.24 5165.16  114.39 5165.17  136.73 5165.25
  149.39 5165.81  149.39 5170.81

Manning's n Values        num=       1
     Sta   n Val
     -20    .035

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
         57.45   93.24               53      53      53             .1       .3

CROSS SECTION


RIVER: Lidar Dwnstm
REACH: Alignment - Dam    RS: 13149.5

INPUT
Description: 0.98
Station Elevation Data    num=      10
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       05167.313   24.295167.371   39.625167.354   60.325164.549   85.015164.104
  116.025164.682  130.835164.608  144.235166.849  156.055166.808  156.06 5171.81

Manning's n Values        num=       1
     Sta   n Val
       0    .035

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
         39.62  144.23               40      40      40             .1       .3

CROSS SECTION


RIVER: Lidar Dwnstm
REACH: Alignment - Dam    RS: 13149

INPUT
Description: 0.97
Station Elevation Data    num=      14
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0  5168.1    49.4 5169.45   50.07 5169.49    50.35168.885   51.17 5168.85
   61.59 5163.65  101.31 5163.52  132.46 5163.46   143.4 5168.85  144.12 5168.85
  144.23 5169.47  144.98 5169.46  152.11 5168.02  166.64 5167.65

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0    .035    49.4    .013  144.98    .035

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
         51.17   143.4               16      16      16             .1       .3

CROSS SECTION


RIVER: Lidar Dwnstm
REACH: Alignment - Dam    RS: 13148.5

INPUT
Description: 0.96
Station Elevation Data    num=      18
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0 5168.81  19.065 5169.01  43.977 5168.92   44.59 5168.94   45.38    5169
  45.595 5167.32  46.785  5167.4  56.8855162.462  92.275 5162.49  124.64 5162.28
 135.357 5167.61  136.04 5167.63  136.31 5168.94  137.01 5168.95 137.718 5168.77
```

```
 142.765 5168.44  155.28 5168.25  161.19 5168.46

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0    .035  43.977    .013  137.01    .035

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
        46.785 135.357                9       9       9             .3       .5

CROSS SECTION


RIVER: Lidar Dwnstm
REACH: Alignment - Dam    RS: 13148

INPUT
Description: 0.95
Station Elevation Data    num=      16
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0 5168.94   24.08 5168.75   24.97 5168.97   25.58 5168.98   26.85 5161.49
    28.25161.275    53.1 5161.32   61.14 5161.46   76.77 5161.14   92.95 5161.09
   94.34 5161.27   95.08 5161.28   95.72 5168.91   96.47 5168.95  112.27 5168.89
   131.3 5168.99

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0    .035   24.08    .013   96.47    .035

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
         25.58   95.72                65      63      62             .3       .5

CULVERT


RIVER: Lidar Dwnstm
REACH: Alignment - Dam    RS: 13146

INPUT
Description: Tesuque Road Crossing
Distance from Upstream XS =       2
Deck/Roadway Width        =      57
Weir Coefficient          =     2.6
Upstream  Deck/Roadway Coordinates
    num=       4
     Sta Hi Cord Lo Cord     Sta Hi Cord Lo Cord     Sta Hi Cord Lo Cord
       0 5168.94 5167.17   54.97 5168.75             119 5168.73
  182.49 5168.87

Upstream Bridge Cross Section Data
Station Elevation Data    num=       7
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0 5168.94   25.58 5168.98   26.85  5161.4   61.14 5161.25   95.08 5161.17
   95.72 5168.91   131.3 5168.99

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0    .035   25.58     .13   95.72    .016

Bank Sta: Left   Right    Coeff Contr.   Expan.
         25.58   95.72             .3       .5

Downstream  Deck/Roadway Coordinates
    num=       5
     Sta Hi Cord Lo Cord     Sta Hi Cord Lo Cord     Sta Hi Cord Lo Cord
       0 5168.04 5166.66   54.97 5167.76              94  5167.8
     119  5167.6           182.49 5168.53

Downstream Bridge Cross Section Data
Station Elevation Data    num=       7
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0 5168.04   21.31 5167.81    21.7 5160.08   93.91 5160.08   94.56  5167.8
 117.375 5168.15   131.3 5168.99

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0    .035   21.31    .013   94.56    .016

Bank Sta: Left   Right    Coeff Contr.   Expan.
         21.31   94.56             .1       .3
```

```
Upstream Embankment side slope              =       0 horiz. to 1.0 vertical
Downstream Embankment side slope            =       0 horiz. to 1.0 vertical
Maximum allowable submergence for weir flow =     .98
Elevation at which weir flow begins         =
Energy head used in spillway design         =
Spillway height used in design              =
Weir crest shape                            = Broad Crested

Number of Culverts =  1

Culvert Name     Shape      Rise    Span
Culvert #1           Box       6      10
FHWA Chart # 8 - flared wingwalls
FHWA Scale # 1 - Wingwall flared 30 to 75 deg.
Solution Criteria = Highest U.S. EG
Culvert Upstrm Dist  Length    Top n  Bottom n  Depth Blocked  Entrance Loss Coef   Exit Loss Coef
                 2      59     .013     .013        0                  .4               1
Number of Barrels =  6
Upstream   Elevation =  5161.25
Centerline Stations
    Sta.    Sta.    Sta.    Sta.    Sta.    Sta.
   34.51   45.01   55.51   66.36   76.93   87.43
Downstream Elevation =  5160.26
Centerline Stations
    Sta.    Sta.    Sta.    Sta.    Sta.    Sta.
   31.34   41.84   52.34   63.19   73.76   84.26

CROSS SECTION


RIVER: Lidar Dwnstm
REACH: Alignment - Dam    RS: 13145

INPUT
Description: 0.94
Station Elevation Data    num=      15
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0 5168.04   20.36 5167.76   21.31 5167.81    21.7 5160.08   22.86 5160.06
    24.3 5160.07    48.8 5159.96   55.49 5160.26   74.36 5159.94   91.17 5160.15
   92.78 5160.12   93.91 5160.08   94.56  5167.8    95.6 5167.41 117.375 5168.15

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0    .035   20.36    .013    95.6    .035

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
         21.31   94.56                9       9       9             .1       .3

CROSS SECTION


RIVER: Lidar Dwnstm
REACH: Alignment - Dam    RS: 13144

INPUT
Description: 0.93
Station Elevation Data    num=      13
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0 5168.04   16.65 5167.12   17.33  5167.1   17.53 5166.58   18.37 5166.57
   32.98 5159.87   68.47 5159.88   108.6 5159.86  122.23  5165.8  123.255165.865
  123.615167.085   124.35167.116  138.79 5168.15

Manning's n Values        num=       5
     Sta   n Val     Sta   n Val     Sta   n Val     Sta   n Val     Sta   n Val
       0    .035   16.65    .013   32.98    .035   108.6    .013   124.3    .035

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
         18.37  122.23                15      15      15             .1       .3

CROSS SECTION


RIVER: Lidar Dwnstm
REACH: Alignment - Dam    RS: 13143

INPUT
Description: 0.92
Station Elevation Data    num=      13
```

```
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0 5167.15   1.453 5167.12    2.135167.105    2.29 5166.55    3.24 5166.55
   17.055159.686   56.23 5159.65   102.1 5159.58  116.32 5166.45  117.28 5166.45
   117.4 5167.09 118.106 5167.08  118.775166.717

Manning's n Values        num=       5
     Sta   n Val     Sta   n Val     Sta   n Val     Sta   n Val     Sta   n Val
       0    .035   1.453    .013   17.05    .035   102.1    .013 118.106    .035

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
          3.24  116.32              183     172     162             .1       .3

CROSS SECTION


RIVER: Lidar Dwnstm
REACH: Alignment - Dam    RS: 13140

INPUT
Description: 0.91
Station Elevation Data    num=      11
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0 5166.92   12.82 5165.57   17.77  5164.2   25.43 5163.51   34.93 5157.47
   69.78 5157.25  115.03 5157.51   124.4 5162.72  137.06 5162.84  142.85  5163.3
  148.81 5163.44

Manning's n Values        num=       1
     Sta   n Val
       0    .035

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
         25.43   124.4                7       7       7             .1       .3

CROSS SECTION


RIVER: Lidar Dwnstm
REACH: Alignment - Dam    RS: 13135

INPUT
Description: 0.9
Station Elevation Data    num=      11
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0 5166.92   12.82 5165.57   17.77  5164.2   25.43 5163.51   34.93 5154.85
   69.78 5154.75  115.03 5154.62   124.4 5162.72  137.06 5162.84  142.85  5163.3
  148.81 5163.44

Manning's n Values        num=       1
     Sta   n Val
       0    .035

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
         25.43   124.4              199     199     199             .1       .3

CROSS SECTION


RIVER: Lidar Dwnstm
REACH: Alignment - Dam    RS: 13130

INPUT
Description: 0.8
Station Elevation Data    num=      11
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0 5163.82    9.59 5161.86   11.43 5160.11   22.22 5158.98   38.45 5153.39
   75.24 5152.76  111.51  5152.8  123.76 5158.34  129.39  5158.8  135.05 5158.85
  148.75 5162.51

Manning's n Values        num=       1
     Sta   n Val
       0    .035

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
         22.22  129.39              394     392     390             .1       .3

CROSS SECTION


RIVER: Lidar Dwnstm
```

REACH: Alignment - Dam RS: 13120

INPUT
Description: 0.7
Station Elevation Data num= 10

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	5162.4	16.83	5157.28	25.27	5156.08	35.28	5151.92	75.33	5149.46
112.29	5150.98	126.1	5155.97	131.63	5156.42	136.88	5156.47	148.72	5157.55

Manning's n Values num= 1

Sta	n Val
0	.035

Bank Sta: Left	Right	Lengths: Left Channel	Right	Coeff Contr.	Expan.
25.27	126.1	393	393	393	.1	.3

CROSS SECTION

RIVER: Lidar Dwnstm
REACH: Alignment - Dam RS: 13110

INPUT
Description: 0.6
Station Elevation Data num= 9

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	5156.82	25.32	5154.93	40.3	5149.03	77.54	5148.11	108.22	5147.82
123.95	5153.28	129.96	5153.69	135.02	5153.42	148.3	5154.08		

Manning's n Values num= 1

Sta	n Val
0	.035

Bank Sta: Left	Right	Lengths: Left Channel	Right	Coeff Contr.	Expan.
25.32	129.96	398	400	409	.1	.3

CROSS SECTION

RIVER: Lidar Dwnstm
REACH: Alignment - Dam RS: 13100

INPUT
Description: 0.53
Station Elevation Data num= 13

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	5148.08	5.4	5148.5	8.71	5149	18.57	5150.7	32.06	5150.54
46.08	5145.79	80.21	5144.96	121.91	5145.86	135.74	5150.4	146.26	5150.43
150.77	5150.65	155.95	5150.46	158.16	5150.37				

Manning's n Values num= 1

Sta	n Val
0	.035

Bank Sta: Left	Right	Lengths: Left Channel	Right	Coeff Contr.	Expan.
32.06	135.74	8	8	8	.1	.3

CROSS SECTION

RIVER: Lidar Dwnstm
REACH: Alignment - Dam RS: 13095

INPUT
Description: 0.52
Station Elevation Data num= 14

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	5148.08	5.4	5148.5	8.71	5149	18.57	5150.7	32.06	5150.54
53.82	5141.08	67.52	5139.87	95.57	5139.15	121.91	5139.64	135.74	5150.4
146.26	5150.43	150.77	5150.65	155.95	5150.46	158.16	5150.37		

Manning's n Values num= 1

Sta	n Val
0	.035

Bank Sta: Left	Right	Lengths: Left Channel	Right	Coeff Contr.	Expan.
32.06	135.74	6	6	6	.1	.3

CROSS SECTION

```
RIVER: Lidar Dwnstm
REACH: Alignment - Dam    RS: 13093

INPUT
Description: 0.51
Station Elevation Data    num=      13
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0 5148.08     5.4  5148.5    8.71    5149   18.57  5150.7   32.06 5150.54
   46.08 5139.26   80.21 5138.89  121.91 5139.59  135.74  5150.4  146.26 5150.43
  150.77 5150.65  155.95 5150.46  158.16 5150.37

Manning's n Values        num=       1
     Sta   n Val
       0    .035

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
         32.06  135.74                6       6       6             .1       .3

CROSS SECTION


RIVER: Lidar Dwnstm
REACH: Alignment - Dam    RS: 13090

INPUT
Description: 0.5
Station Elevation Data    num=      13
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0 5148.08     5.4  5148.5    8.71    5149   18.57  5150.7   32.06 5150.54
   46.08 5140.62   80.21 5140.45  121.91 5140.41  135.74  5150.4  146.26 5150.43
  150.77 5150.65  155.95 5150.46  158.16 5150.37

Manning's n Values        num=       1
     Sta   n Val
       0    .035

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
         32.06  135.74              410     408     401             .1       .3

CROSS SECTION


RIVER: Lidar Dwnstm
REACH: Alignment - Dam    RS: 13080

INPUT
Description: 0.4
Station Elevation Data    num=      10
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0 5144.26   23.15 5143.43   38.59  5138.8    68.1 5137.16  110.17 5138.29
  122.75 5143.38  126.08 5144.01  131.81 5144.34  137.01 5144.21  148.91 5144.48

Manning's n Values        num=       1
     Sta   n Val
       0    .035

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
         23.15  122.75              394     402     416             .1       .3

CROSS SECTION


RIVER: Lidar Dwnstm
REACH: Alignment - Dam    RS: 13070

INPUT
Description: 0.3
Station Elevation Data    num=      10
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0 5141.77   22.48 5141.02   38.43 5135.31   80.51 5134.83  121.07 5135.63
  134.28 5140.73   135.9 5140.73  141.35 5141.09  146.52  5140.9  153.97 5139.85

Manning's n Values        num=       1
     Sta   n Val
       0    .035

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
```

```
        22.48  134.28              160     160     160             .1       .3

CROSS SECTION


RIVER: Lidar Dwnstm
REACH: Alignment - Dam    RS: 13060

INPUT
Description: 0.21
Station Elevation Data    num=       9
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0 5138.06   26.64 5137.89   40.08 5131.76    78.6  5130.8  124.02  5131.8
   136.9 5137.17  148.83 5138.41  156.01 5138.46  163.91 5138.02

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0    .035   26.64     .04   136.9    .035

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
         26.64   136.9               81      81      81             .3       .5

BRIDGE


RIVER: Lidar Dwnstm
REACH: Alignment - Dam    RS: 13055

INPUT
Description: San Ildefonso Road Crossing
Distance from Upstream XS =       5
Deck/Roadway Width        =      63
Weir Coefficient          =     2.6
Upstream  Deck/Roadway Coordinates
    num=       6
     Sta Hi Cord Lo Cord     Sta Hi Cord Lo Cord     Sta Hi Cord Lo Cord
       0 5138.06 5137.82   26.54 5138.19 5135.82   35.95 5138.28 5135.82
  123.89 5138.28 5135.82  133.38 5138.15 5135.82   191.4 5137.59

Upstream Bridge Cross Section Data
Station Elevation Data    num=       9
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0 5138.06   26.64 5137.89   33.52 5131.76    78.6  5130.8  127.95  5131.8
  133.38  5136.5  148.83 5138.01  156.01    5138  163.91    5138

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0    .035   26.64     .04  133.38    .035

Bank Sta: Left   Right    Coeff Contr.   Expan.
         26.64  133.38             .3       .5

Downstream  Deck/Roadway Coordinates
    num=       6
     Sta Hi Cord Lo Cord     Sta Hi Cord Lo Cord     Sta Hi Cord Lo Cord
       0 5138.82 5136.56   35.95 5138.28 5135.83  123.89 5138.28 5135.83
   130.4 5138.15 5135.83  133.38 5138.15 5135.83     160 5137.59

Downstream Bridge Cross Section Data
Station Elevation Data    num=       8
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0 5138.38    5.88 5138.43   13.34 5138.08    24.6 5131.47   67.63 5131.14
  119.12 5130.96  133.38  5136.5  151.22 5137.59

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0    .035   13.34     .04  133.38    .035

Bank Sta: Left   Right    Coeff Contr.   Expan.
         13.34  133.38             .1       .3

Upstream Embankment side slope              =       0 horiz. to 1.0 vertical
Downstream Embankment side slope            =       0 horiz. to 1.0 vertical
Maximum allowable submergence for weir flow =     .98
Elevation at which weir flow begins         =
Energy head used in spillway design         =
Spillway height used in design              =
Weir crest shape                            = Broad Crested
```

```
Number of Piers =  2

Pier Data
Pier Station     Upstream=   61.72    Downstream=    52.9
Upstream     num=       4
    Width   Elev    Width   Elev    Width   Elev    Width   Elev
       1  5131.5       1    5134     2.5  5134.7     2.5  5136.5
Downstream     num=       4
    Width   Elev    Width   Elev    Width   Elev    Width   Elev
       1  5131.5       1    5134     2.5  5134.7     2.5  5136.5

Pier Data
Pier Station     Upstream=    99.7    Downstream=    90.9
Upstream     num=       4
    Width   Elev    Width   Elev    Width   Elev    Width   Elev
       1  5131.5       1    5134     2.5  5134.7     2.5  5136.5
Downstream     num=       4
    Width   Elev    Width   Elev    Width   Elev    Width   Elev
       1  5131.5       1    5134     2.5  5134.7     2.5  5136.5

Number of Bridge Coefficient Sets =  1

Low Flow Methods and Data
       Energy
Selected Low Flow Methods = Highest Energy Answer

High Flow Method
       Energy Only

Additional Bridge Parameters
       Add Friction component to Momentum
       Do not add Weight component to Momentum
       Class B flow critical depth computations use critical depth
           inside the bridge at the upstream end
       Criteria to check for pressure flow = Upstream energy grade line

CROSS SECTION


RIVER: Lidar Dwnstm
REACH: Alignment - Dam    RS: 13050

INPUT
Description: 0.2
Station Elevation Data    num=       8
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0 5138.38    5.88 5138.43   13.34 5138.08   31.58 5131.47   67.63 5131.14
  105.01 5130.97  127.98 5138.61  151.22 5137.53

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0    .035   13.34     .04  127.98    .035

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
         13.34  127.98              193     234     277              .1       .3

CROSS SECTION


RIVER: Lidar Dwnstm
REACH: Alignment - Dam    RS: 13040

INPUT
Description: 0.1
Station Elevation Data    num=       9
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0 5137.45   10.38  5137.6   14.36 5137.88    20.8 5136.91   42.51 5128.78
   71.46 5127.23  102.04 5128.01  119.45 5135.21  150.52 5133.97

Manning's n Values        num=       1
     Sta   n Val
       0    .035

Bank Sta: Left   Right    Coeff Contr.   Expan.
          20.8  119.45             .1       .3


SUMMARY OF MANNING'S N VALUES
```

River:Lidar Dwnstm

Reach	River Sta.	n1	n2	n3	n4	n5
Alignment - Dam	18022.9	.013				
Alignment - Dam	17987.1	.013				
Alignment - Dam	17735.62	.035				
Alignment - Dam	17129.8	.035				
Alignment - Dam	17000.0	.05	.05	.05		
Alignment - Dam	16550	.035				
Alignment - Dam	16457.0	.05	.035	.035	.035	
Alignment - Dam	15976	.035				
Alignment - Dam	15247.7	.035				
Alignment - Dam	15100	.035				
Alignment - Dam	15090	Culvert				
Alignment - Dam	15080	.035				
Alignment - Dam	14886.4	.035				
Alignment - Dam	14300.75	.035				
Alignment - Dam	14200	.035				
Alignment - Dam	14100.75	.035				
Alignment - Dam	13900.75	.035				
Alignment - Dam	13700.75	.035				
Alignment - Dam	13150.55	.035				
Alignment - Dam	13150.54	.035				
Alignment - Dam	13150	.035				
Alignment - Dam	13149.5	.035				
Alignment - Dam	13149	.035	.013	.035		
Alignment - Dam	13148.5	.035	.013	.035		
Alignment - Dam	13148	.035	.013	.035		
Alignment - Dam	13146	Culvert				
Alignment - Dam	13145	.035	.013	.035		
Alignment - Dam	13144	.035	.013	.035	.013	.035
Alignment - Dam	13143	.035	.013	.035	.013	.035
Alignment - Dam	13140	.035				
Alignment - Dam	13135	.035				
Alignment - Dam	13130	.035				
Alignment - Dam	13120	.035				
Alignment - Dam	13110	.035				
Alignment - Dam	13100	.035				
Alignment - Dam	13095	.035				
Alignment - Dam	13093	.035				
Alignment - Dam	13090	.035				
Alignment - Dam	13080	.035				
Alignment - Dam	13070	.035				
Alignment - Dam	13060	.035	.04	.035		
Alignment - Dam	13055	Bridge				
Alignment - Dam	13050	.035	.04	.035		
Alignment - Dam	13040	.035				

SUMMARY OF REACH LENGTHS

River: Lidar Dwnstm

Reach	River Sta.	Left	Channel	Right
Alignment - Dam	18022.9	35	35	35
Alignment - Dam	17987.1	43	43	43
Alignment - Dam	17735.62	605.82	605.82	605.82
Alignment - Dam	17129.8	129.8	129.8	129.8
Alignment - Dam	17000.0	212	212	212
Alignment - Dam	16550	331	331	331
Alignment - Dam	16457.0	481	481	481
Alignment - Dam	15976	728.26	728.26	728.26
Alignment - Dam	15247.7	139	192	259
Alignment - Dam	15100	53	53	53
Alignment - Dam	15090	Culvert		
Alignment - Dam	15080	115	115	115
Alignment - Dam	14886.4	585.65	585.65	585.65
Alignment - Dam	14300.75	321	321	321
Alignment - Dam	14200	215	215	215
Alignment - Dam	14100.75	200	200	200
Alignment - Dam	13900.75	200	200	200
Alignment - Dam	13700.75	57	57	57
Alignment - Dam	13150.55	29	29	29
Alignment - Dam	13150.54	43	43	43

Alignment - Dam	13150		53	53	53
Alignment - Dam	13149.5		40	40	40
Alignment - Dam	13149		16	16	16
Alignment - Dam	13148.5		9	9	9
Alignment - Dam	13148		65	63	62
Alignment - Dam	13146	Culvert			
Alignment - Dam	13145		9	9	9
Alignment - Dam	13144		15	15	15
Alignment - Dam	13143		183	172	162
Alignment - Dam	13140		7	7	7
Alignment - Dam	13135		199	199	199
Alignment - Dam	13130		394	392	390
Alignment - Dam	13120		393	393	393
Alignment - Dam	13110		398	400	409
Alignment - Dam	13100		8	8	8
Alignment - Dam	13095		6	6	6
Alignment - Dam	13093		6	6	6
Alignment - Dam	13090		410	408	401
Alignment - Dam	13080		394	402	416
Alignment - Dam	13070		160	160	160
Alignment - Dam	13060		81	81	81
Alignment - Dam	13055	Bridge			
Alignment - Dam	13050		193	234	277
Alignment - Dam	13040				

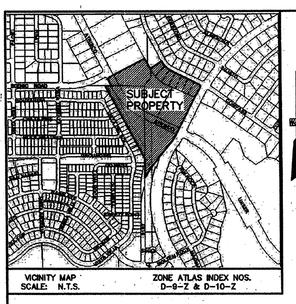
SUMMARY OF CONTRACTION AND EXPANSION COEFFICIENTS
River: Lidar Dwnstm

Reach	River Sta.		Contr.	Expan.
Alignment - Dam	18022.9		.1	.3
Alignment - Dam	17987.1		.1	.3
Alignment - Dam	17735.62		.1	.3
Alignment - Dam	17129.8		.1	.3
Alignment - Dam	17000.0		.1	.3
Alignment - Dam	16550		.1	.3
Alignment - Dam	16457.0		.1	.3
Alignment - Dam	15976		.1	.3
Alignment - Dam	15247.7		.1	.3
Alignment - Dam	15100		.3	.5
Alignment - Dam	15090	Culvert		
Alignment - Dam	15080		.1	.3
Alignment - Dam	14886.4		.1	.3
Alignment - Dam	14300.75		.1	.3
Alignment - Dam	14200		.1	.3
Alignment - Dam	14100.75		.1	.3
Alignment - Dam	13900.75		.1	.3
Alignment - Dam	13700.75		.1	.3
Alignment - Dam	13150.55		.1	.3
Alignment - Dam	13150.54		.1	.3
Alignment - Dam	13150		.1	.3
Alignment - Dam	13149.5		.1	.3
Alignment - Dam	13149		.1	.3
Alignment - Dam	13148.5		.3	.5
Alignment - Dam	13148		.3	.5
Alignment - Dam	13146	Culvert		
Alignment - Dam	13145		.1	.3
Alignment - Dam	13144		.1	.3
Alignment - Dam	13143		.1	.3
Alignment - Dam	13140		.1	.3
Alignment - Dam	13135		.1	.3
Alignment - Dam	13130		.1	.3
Alignment - Dam	13120		.1	.3
Alignment - Dam	13110		.1	.3
Alignment - Dam	13100		.1	.3
Alignment - Dam	13095		.1	.3
Alignment - Dam	13093		.1	.3
Alignment - Dam	13090		.1	.3
Alignment - Dam	13080		.1	.3
Alignment - Dam	13070		.1	.3
Alignment - Dam	13060		.3	.5
Alignment - Dam	13055	Bridge		
Alignment - Dam	13050		.1	.3
Alignment - Dam	13040		.1	.3

APPENDIX 3 (CD)

BOCA NEGRA DETENTION DAM PLAT

BOCA NEGRA DETENTION DAM AS-BUILT DRAWINGS



DOCH 2012031891
03/30/2012 10:45 AM Page: 1 of 4
PLAT R:350 M:81 2012C-27
Owen N. Toulouse Olivare, Bernalillo Cou

PLAT OF TRACT 1
BOCA NEGRA DETENTION DAM

WITHIN SECTIONS 21 and 22,
TOWNSHIP 11 NORTH, RANGE 2 EAST
NEW MEXICO PRINCIPAL MERIDIAN
CITY OF ALBUQUERQUE
BERNALILLO COUNTY, NEW MEXICO
AUGUST 2011

PROJECT NUMBER: 1004540

APPLICATION NUMBERS: 11DRB - 70256 to 11DRB-70259

"NOTICE OF SUBDIVISION PLAT CONDITIONS" (BOCA NEGRA DETENTION DAM)

A VARIANCE OR WAIVER FROM CERTAIN SUBDIVISION REQUIREMENTS HAS BEEN GRANTED BY THE CITY AND THE ALBUQUERQUE METROPOLITAN ARROYO FLOOD CONTROL AUTHORITY IN CONNECTION WITH THIS PLAT.

FUTURE SUBDIVISION OF LANDS WITHIN THIS PLAT, ZONING SITE DEVELOPMENT PLAN APPROVALS, AND DEVELOPMENT PERMITS MAY BE CONDITIONED UPON DEDICATION OF RIGHTS-OF-WAY AND EASEMENTS, AND/OR UPON INFRASTRUCTURE IMPROVEMENTS BY THE OWNER FOR WATER, SANITARY SEWER, STREETS, DRAINAGE, GRADING AND PARKS IN ACCORDANCE WITH CURRENT RESOLUTIONS, ORDINANCES AND POLICIES IN EFFECT AT THE TIME FOR ANY SPECIFIC PROPOSAL.

THE CITY (AND AMAFCA WITH REFERENCE TO DRAINAGE) MAY REQUIRE AND/OR PERMIT EASEMENTS TO BE ADDED, MODIFIED OR REMOVED WHEN FUTURE PLATS OR SITE DEVELOPMENT PLANS ARE APPROVED.

BY ITS APPROVAL THE CITY MAKES NO REPRESENTATION OR WARRANTIES AS TO AVAILABILITY OF UTILITIES, OR FINAL APPROVAL OF ALL REQUIREMENTS INCLUDING (BUT NOT LIMITED TO) THE FOLLOWING ITEMS: WATER AND SANITARY SEWER AVAILABILITY; FUTURE STREET DEDICATIONS AND/OR IMPROVEMENTS; PARK AND OPEN SPACE REQUIREMENTS; DRAINAGE REQUIREMENTS AND/OR IMPROVEMENTS; AND EXCAVATION, FILLING OR GRADING REQUIREMENTS. ANY PERSON INTENDING DEVELOPMENT OF LANDS WITHIN THIS SUBDIVISION IS CAUTIONED TO INVESTIGATE THE STATUS OF THESE ITEMS.

IT IS UNDERSTOOD THAT A SEPARATE NOTICE OF THESE CONDITIONS IS TO BE RECORDED WITH THE COUNTY CLERK AT THE TIME OF FINAL PLAT RECORDING.

FREE CONSENT AND DEDICATION:

THE PARCEL SHOWN HEREON IS WITH THE FREE CONSENT AND IN ACCORDANCE WITH THE DESIRES OF THE UNDERSIGNED OWNER(S). SAID OWNER(S) DO HEREBY DEDICATE ADDITIONAL PUBLIC RIGHT-OF-WAY FOR UNSER BOULEVARD N.W. AND RAINBOW BOULEVARD N.W. AS SHOWN HEREON TO THE CITY OF ALBUQUERQUE IN FEE SIMPLE AND DO HEREBY GRANT: ALL ACCESS, UTILITY AND DRAINAGE EASEMENTS SHOWN HEREON INCLUDING THE RIGHT TO CONSTRUCT, OPERATE, INSPECT AND MAINTAIN FACILITIES THEREIN; ALL PUBLIC UTILITY EASEMENTS SHOWN HEREON FOR THE COMMON AND JOINT USE OF GAS, ELECTRICAL POWER AND COMMUNICATION SERVICES FOR OVERHEAD AND/OR BURIED DISTRIBUTION LINES, CONDUITS, AND PIPES FOR UNDERGROUND AND/OR OVERHEAD UTILITIES WHERE SHOWN OR INDICATED, AND INCLUDING THE RIGHT OF INGRESS AND EGRESS FOR CONSTRUCTION AND MAINTENANCE AND THE RIGHT TO TRIM INTERFERING TREES AND SHRUBS; SAID OWNER(S) DO HEREBY CONSENT TO ALL OF THE FOREGOING AND DO HEREBY CERTIFY THAT THIS SUBDIVISION IS THEIR FREE ACT AND DEED.

PROPERTY OWNER SIGNATURE:

ALBUQUERQUE METROPOLITAN ARROYO FLOOD CONTROL AUTHORITY OWNER OF:
LOTS 4, 5 AND 6, BLOCK 2, LOT 1, BLOCK 5, VOLCANO CLIFFS SUBDIVISION, UNIT 25 AND COMMON AREA TRACT "D" OF VISTA VEJA SUBDIVISION, UNIT 2

JERRY M. LOVATO, P.E., EXECUTIVE ENGINEER — DATE 8/29/2011
FOR: AMAFCA, A POLITICAL SUBDIVISION OF STATE OF NEW MEXICO

STATE OF NEW MEXICO)
) ss.
COUNTY OF BERNALILLO)

THIS INSTRUMENT WAS ACKNOWLEDGED BEFORE ME ON THIS 29th DAY OF August, 2011, BY JERRY M. LOVATO, P.E., AS EXECUTIVE ENGINEER OF AMAFCA. A POLITICAL SUBDIVISION OF STATE OF NEW MEXICO

NOTARY PUBLIC: Loren J. Hines
MY COMMISSION EXPIRES: July 25, 2015

OFFICIAL SEAL
LOREN J. HINES
Notary Public
State of New Mexico
My Commission Expires 7-25-15

CITY OF ALBUQUERQUE OWNER OF:
LOTS 12 THRU 18, BLOCK 2, VOLCANO CLIFFS SUBDIVISION, UNIT 14

Robert J. Perry, CHIEF ADMINISTRATIVE OFFICER — DATE 8/31/11
FOR: CITY OF ALBUQUERQUE, A NEW MEXICO MUNICIPAL CORPORATION

STATE OF NEW MEXICO)
) ss.
COUNTY OF BERNALILLO)

THIS INSTRUMENT WAS ACKNOWLEDGED BEFORE ME ON THIS 31st DAY OF August, 2011, BY ROBERT J. PERRY, CHIEF ADMINISTRATIVE OFFICER FOR CITY OF ALBUQUERQUE, A NEW MEXICO MUNICIPAL CORPORATION

NOTARY PUBLIC: Mary E. Chavez
MY COMMISSION EXPIRES: 2/17/13

SUBDIVISION DATA:

TOTAL NO. OF LOTS EXISTING:	TWELVE
TOTAL NO. OF TRACTS CREATED:	ONE
GROSS SUBDIVISION ACREAGE:	26.9937 ACRES
TOTAL MILES OF STREETS CREATED:	±0.2121
ZONE ATLAS INDEX NO:	D-9-Z & D-10-Z
DATE OF SURVEY:	APRIL 2011
CURRENT ZONING:	R-1 and R-D

DISCLOSURE STATEMENT:

THE PURPOSE OF THIS PLAT IS TO REPLAT ELEVEN EXISTING LOTS INCLUDING LOTS 12-18, BLOCK 2, UNIT 14, AND LOTS 4, 5, AND 6, BLOCK 2, UNIT 25, AND LOT 1, BLOCK 5, UNIT 25 OF VOLCANO CLIFFS SUBDIVISION; AND ONE COMMON AREA TRACT D, VISTA VEJA SUBDIVISION, UNIT 2, INTO ONE TRACT, VACATE A PORTION OF ATRISCO DRIVE NW, VACATE AND GRANT EASEMENTS AND DEDICATE ADDITIONAL RIGHT OF WAY.
TRACT 1, CREATED BY THIS PLAT, IS LIMITED TO DRAINAGE, RECREATION AND UTILITY PURPOSES ONLY.

GENERAL NOTES:

1. FIELD SURVEY WAS PERFORMED IN SEPTEMBER 2010.
2. BEARINGS SHOWN ARE NEW MEXICO STATE PLANE GRID BEARINGS (CENTRAL ZONE NAD 83). BASED ON A LINE FROM "G_C10" TO "I_C11" BEARING = S 80°39'02"E.
3. ALL DISTANCES ARE GROUND DISTANCES.
4. BEARINGS AND DISTANCES SHOWN IN PARENTHESES ARE RECORD BEARINGS AND DISTANCES.
5. CORNERS SHOWN AS ⊙ ARE 5/8" REBAR WITH CAP STAMPED "CROSHAW 14733", UNLESS OTHERWISE INDICATED.
6. LOTS 5 AND 6, BLOCK 2, VOLCANO CLIFFS UNIT 25 WERE CONVEYED AS PARCEL 5 AND 6 ON WARRANTY DEED RECORDED ON 06-08-2011, DOC. #2011053296.

THIS IS TO CERTIFY THAT TAXES ARE CURRENT AND PAID ON

UNIFORM PROPERTY CODE #: 1-009-083-515-277-10734, 1-009-083-513-227-40350, 1-010-083-018-253-30801, 1-010-083-047-235-30810, 1-010-083-021-181-30710
PROPERTY OWNER OF RECORD: A.M.A.F.C.A.

UNIFORM PROPERTY CODE #: 1-010-083-070-252-20201, 1-010-083-060-254-20202, 1-010-083-051-264-20203, 1-010-083-044-267-20204, 1-010-083-035-269-20205, 1-010-083-026-278-20206, 1-010-083-018-284-20207
PROPERTY OWNER OF RECORD: CITY OF ALBUQUERQUE

BERNALILLO COUNTY TREASURER'S OFFICE: DATE: 3-26-12

INDEXING INFORMATION FOR COUNTY CLERK

OWNER(S): A.M.A.F.C.A. AND CITY OF ALBUQUERQUE
SECTIONS 21 AND 22, T.11 N., R.2 E., N.M.P.M.
SUBDIVISION: Tract 1, Boca Negra Detention Dam

PROJECT APPROVAL

UTILITY APPROVALS: PUBLIC UTILITY EASEMENTS SHOWN ON THIS PLAT ARE NOT EXCLUSIVE AND ARE GRANTED FOR THE COMMON AND JOINT USE OF THE UTILITIES DESIGNATED ON THIS PLAT, THEIR SUCCESSORS AND ASSIGNS, AND FOR THE USE OF ANY OTHER PUBLIC UTILITIES WHOSE USE OF SAID EASEMENT IS DEEDED TO BE IN THE PUBLIC INTEREST. DISCLAIMER: IN APPROVING THIS PLAT, PUBLIC SERVICE COMPANY OF NEW MEXICO (PNM) AND NEW MEXICO GAS COMPANY (NMGC) DID NOT CONDUCT A TITLE SEARCH OF THE PROPERTIES SHOWN HEREON, CONSEQUENTLY, PNM AND NMGC DO NOT WAIVE NOR RELEASE ANY EASEMENT OR EASEMENT RIGHTS WHICH MAY HAVE BEEN GRANTED BY PRIOR PLAT, REPLAT OR OTHER DOCUMENT, WHICH ARE NOT SHOWN ON THIS PLAT.

NEW MEXICO GAS COMPANY — DATE 12/21/2011
PNM ELECTRIC SERVICES — DATE 9-29-11
QWEST TELECOMMUNICATIONS — DATE 09/26/11
COMCAST — DATE 09-27-11

CITY APPROVALS:

CITY SURVEYOR — DATE 8-30-11
REAL PROPERTY DIVISION — DATE 11-08-11
ENVIRONMENTAL HEALTH DEPARTMENT — DATE
TRAFFIC ENGINEERING, TRANSPORTATION DIVISION — DATE 10-26-11
ABCWUA — DATE 10/26/11
PARKS AND RECREATION DEPARTMENT — DATE 11-7-11
A.M.A.F.C.A. — DATE 10-26-11
CITY ENGINEER — DATE 10-26-11
DRB CHAIRPERSON, PLANNING DEPARTMENT — DATE 3-28-12

SURVEYOR'S CERTIFICATION:

I, CHRISTOPHER S. CROSHAW, A DULY REGISTERED LAND SURVEYOR UNDER THE LAWS OF THE STATE OF NEW MEXICO, DO HEREBY CERTIFY THAT THIS PLAT WAS PREPARED BY ME OR UNDER MY DIRECT SUPERVISION, MEETS THE MINIMUM REQUIREMENTS FOR MONUMENTATION AND SURVEYS OF THE ALBUQUERQUE SUBDIVISION ORDINANCE, SHOWS ALL EASEMENTS MADE KNOWN TO ME BY THE OWNER(S), UTILITY COMPANIES, OR OTHER PARTIES EXPRESSING AN INTEREST, IS CORRECT AND TRUE TO THE BEST OF MY BELIEF AND KNOWLEDGE AND THAT THIS SURVEY AND PLAT MEET THE MINIMUM STANDARDS FOR SURVEYING IN NEW MEXICO AS ADOPTED BY THE NEW MEXICO BOARD OF REGISTRATION FOR PROFESSIONAL ENGINEERS AND SURVEYORS EFFECTIVE MAY 1, 2007.

CHRISTOPHER S. CROSHAW
N.M.P.L.S. #14733
23 AUGUST 2011
DATE

NEW MEXICO — CHRISTOPHER S. CROSHAW — 14733 — REGISTERED PROFESSIONAL SURVEYOR

WILSON & COMPANY
4900 LANG AVENUE N.E.
ALBUQUERQUE, NEW MEXICO
87109
(505) 348-4000

Drawing Name:X3218078Z-Dam Final Plat.dwg
NETWORK ADDRESS: X:\Public\Projects\X3218078-02\S\Plat | Plot By: SH

DOCH 2012031891
03/30/2012 10:45 AM Page: 2 of 4
PLAT R:350 M:81 2012C-27
Owen N. Toulouse Olivare, Bernalillo Cou

PLAT OF TRACT 1
BOCA NEGRA DETENTION DAM

WITHIN SECTIONS 21 and 22,
TOWNSHIP 11 NORTH, RANGE 2 EAST
NEW MEXICO PRINCIPAL MERIDIAN
CITY OF ALBUQUERQUE
BERNALILLO COUNTY, NEW MEXICO
AUGUST 2011

FLOOD NOTE:

PORTIONS OF THIS PROPERTY ARE WITHIN A 100 YEAR FLOOD PLAIN AS SHOWN ON THE NATIONAL FLOOD INSURANCE PROGRAM'S "FLOOD INSURANCE RATE MAP". ANY DEVELOPMENT OF THIS PROPERTY MUST CONFORM TO THE BERNALILLO COUNTY FLOOD DAMAGE PREVENTION ORDINANCE. THE PROPERTY MAY BE SUBJECT TO THE FLOOD INSURANCE REQUIREMENTS OF THE FEDERAL EMERGENCY MANAGEMENT AGENCY (FEMA). FLOOD INSURANCE IS LIKELY TO BE REQUIRED FOR DEVELOPMENT OF THESE PROPERTIES." SAID PORTIONS ARE SUBJECT TO PENDING LOMR.

SOLAR NOTE:

SUBDIVISION ORDINANCE SECTION 14-14-4-7. PROHIBITION ON PRIVATE RESTRICTIONS ON THE INSTALLATION OF SOLAR COLLECTORS ON PROPERTY WITHIN AN AREA FOR WHICH DRB APPROVAL IS SOUGHT. NO PROPERTY WITHIN THE AREA OF REQUESTED FINAL ACTION SHALL AT ANY TIME BE SUBJECT TO A DEED RESTRICTION, COVENANT, OR BINDING AGREEMENT PROHIBITING SOLAR COLLECTORS FROM BEING INSTALLED ON BUILDINGS OR ERECTED ON THE LOTS OR PARCELS WITHIN THE AREA OF PROPOSED PLAT. THE FOREGOING REQUIREMENT SHALL BE A CONDITION TO APPROVAL OF THIS PLAT OR SITE DEVELOPMENT PLAN FOR SUBDIVISION.

A.M.A.F.C.A. DRAINAGE EASEMENT DEDICATION LANGUAGE:

DEDICATION TO THE ALBUQUERQUE METROPOLITAN ARROYO FLOOD CONTROL AUTHORITY, GRANTEE, ITS SUCCESSORS AND ASSIGNS, OF LANDS, RIGHTS OF WAY, AND EASEMENTS DESIGNATED HEREIN AS "FLOOD PLAIN EASEMENT" OR "DRAINAGE EASEMENT" IS WITH THE FULL AND FREE CONSENT AND IN ACCORDANCE WITH THE DESIRE OF THE UNDERSIGNED OWNER, GRANTOR. THIS DEDICATION IS FOR DRAINAGE, FLOOD CONTROL, CONVEYANCE AND STORAGE OF STORM WATER, AND THE CONSTRUCTION, MAINTENANCE, RECONSTRUCTION OR REPLACEMENT OF, AND ACCESS TO, SUCH FACILITIES. EXCEPT BY THE WRITTEN APPROVAL OF GRANTEE, NO FENCE, WALL, BUILDING OR OTHER OBSTRUCTION MAY BE PLACED OR MAINTAINED ON ANY PROPERTY DEDICATED TO GRANTEE HEREBY, AND THERE SHALL BE NO ALTERATION OF THE GRADES OR CONTOURS IN SUCH PROPERTY. THIS DEDICATION SHALL NOT OBLIGATE GRANTEE TO MAINTAIN NATURAL ARROYOS, DRAINAGE CHANNELS OR OTHER FACILITIES THAT DO NOT MEET THE STANDARDS OF THE GRANTEE FOR DESIGN AND CONSTRUCTION, NOR SHALL THIS GRANTING REQUIRE THE PROTECTION OF PROPERTY LYING OUTSIDE OF THE AREA DEDICATED. GRANTEE SHALL ONLY MAINTAIN PROPERTY AND/OR IMPROVEMENTS THAT IT SPECIFICALLY AGREES, IN WRITING, TO MAINTAIN. ABSENT A WRITTEN MAINTENANCE AGREEMENT, SUCH RESPONSIBILITY SHALL REMAIN WITH THE GRANTOR, ITS SUCCESSORS AND ASSIGNS. LANDSCAPING OR MAINTENANCE WORK BY THE GRANTOR WITHIN THE PROPERTY HEREBY DEDICATED SHALL NOT ALTER THE PRESENT FLOWLINE, CAPACITY OR PERMEABILITY OF THE PRESENT FLOOD WAY AREA EXCEPT IN AN EMERGENCY. IF EMERGENCY WORK IS PERFORMED, GRANTOR SHALL NOTIFY GRANTEE AS SOON AS PRACTICAL THEREAFTER. GRANTEE WILL THEN DETERMINE IF THE EMERGENCY WORK CAN REMAIN OR MUST BE MODIFIED. SAFE LOCATIONS FOR STRUCTURES BUILT ON LANDS ADJACENT TO THE PROPERTY DEDICATED HEREBY MAY BE SUBSTANTIALLY OUTSIDE OF THE AREA DESCRIBED. GRANTOR COVENANTS AND WARRANTS THAT IT IS THE OWNER IN FEE SIMPLE OF THE PROPERTY AND THAT IT HAS A GOOD AND LAWFUL RIGHT TO DEDICATE THE RIGHT OF WAY OR EASEMENT INTERESTS DESCRIBED HEREIN. ANY PORTION OF ANY LAND, RIGHT OF WAY OR EASEMENTS GRANTED HEREIN SHALL REVERT TO THE GRANTOR, ITS SUCCESSORS OR ASSIGNS, AS AND TO THE EXTENT SAID PORTION IS DECLARED UNNECESSARY FOR FLOOD CONTROL OR DRAINAGE BY THE BOARD OF DIRECTORS OF THE ALBUQUERQUE METROPOLITAN ARROYO FLOOD CONTROL AUTHORITY. ANY REVERSION SHALL BE CONVEYED BY QUITCLAIM DEED, VACATION APPROVAL CONSISTENT WITH THE CITY OF ALBUQUERQUE OR BERNALILLO COUNTY SUBDIVISION ORDINANCES WILL ALSO BE REQUIRED.

PUBLIC UTILITY EASEMENTS:

PUBLIC UTILITY EASEMENTS SHOWN ON THIS PLAT ARE GRANTED FOR THE COMMON AND JOINT USE OF:

A. PUBLIC SERVICE COMPANY OF NEW MEXICO ("PNM"), A NEW MEXICO CORPORATION, (PNM ELECTRIC) FOR INSTALLATION, MAINTENANCE, AND SERVICE OF OVERHEAD AND UNDERGROUND ELECTRICAL LINES, TRANSFORMERS, AND OTHER EQUIPMENT AND RELATED FACILITIES REASONABLY NECESSARY TO PROVIDE ELECTRICAL SERVICES.

B. NEW MEXICO GAS COMPANY FOR INSTALLATION, MAINTENANCE, AND SERVICE OF NATURAL GAS LINES, VALVES AND OTHER EQUIPMENT AND FACILITIES REASONABLY NECESSARY TO PROVIDE NATURAL GAS SERVICES.

C. QWEST FOR THE INSTALLATION, MAINTENANCE, AND SERVICE OF SUCH LINES, CABLE, AND OTHER RELATED EQUIPMENT AND FACILITIES REASONABLY NECESSARY TO PROVIDE COMMUNICATION SERVICES.

D. CABLE TV FOR THE INSTALLATION, MAINTENANCE, AND SERVICE OF SUCH LINES, CABLE, AND OTHER RELATED EQUIPMENT AND FACILITIES REASONABLY NECESSARY TO PROVIDE CABLE SERVICES.

INCLUDED, IS THE RIGHT TO BUILD, REBUILD, CONSTRUCT, RECONSTRUCT, LOCATE, RELOCATE, CHANGE, REMOVE, REPLACE, MODIFY, RENEW, OPERATE AND MAINTAIN FACILITIES FOR THE PURPOSES DESCRIBED ABOVE. TOGETHER WITH FREE ACCESS TO, FROM, AND OVER SAID EASEMENTS, WITH THE RIGHT AND PRIVILEGE OF GOING UPON, OVER AND ACROSS ADJOINING LANDS OF GRANTOR FOR THE PURPOSES SET FORTH HEREIN AND WITH THE RIGHT TO UTILIZE THE RIGHT OF WAY AND EASEMENT TO EXTEND SERVICES TO CUSTOMERS OF GRANTEE, INCLUDING SUFFICIENT WORKING AREA SPACE FOR ELECTRIC TRANSFORMERS, WITH THE RIGHT AND PRIVILEGE TO TRIM AND REMOVE TREES, SHRUBS OR BUSHES WHICH INTERFERE WITH THE PURPOSES SET FORTH HEREIN. NO BUILDING, SIGN, POOL (ABOVEGROUND OR SUBSURFACE), HOT TUB, CONCRETE OR WOOD POOL DECKING, OR OTHER STRUCTURE SHALL BE ERECTED OR CONSTRUCTED ON SAID EASEMENTS, NOR SHALL ANY WELL BE DRILLED OR OPERATED THEREON. PROPERTY OWNERS SHALL BE SOLELY RESPONSIBLE FOR CORRECTING ANY VIOLATIONS OF NATIONAL ELECTRICAL SAFETY CODE BY CONSTRUCTION OF POOLS, DECKING, OR ANY STRUCTURES ADJACENT TO OR NEAR EASEMENTS SHOWN ON THIS PLAT.

EASEMENTS FOR ELECTRIC TRANSFORMER/SWITCHGEARS, AS INSTALLED, SHALL EXTEND TEN (10) FEET IN FRONT OF TRANSFORMER/SWITCHGEAR DOORS AND FIVE (5) FEET ON EACH SIDE.

DISCLAIMER

IN APPROVING THIS PLAT, PUBLIC SERVICE COMPANY OF NEW MEXICO (PNM) AND NEW MEXICO GAS COMPANY (NMGC) DID NOT CONDUCT A TITLE SEARCH OF THE PROPERTIES SHOWN HEREON. CONSEQUENTLY, PNM AND NMGC DO NOT WAIVE OR RELEASE ANY EASEMENT OR EASEMENT RIGHTS WHICH MAY HAVE BEEN GRANTED BY PRIOR PLAT, REPLAT OR OTHER DOCUMENT AND WHICH ARE NOT SHOWN ON THIS PLAT.

RECORD DRAWING
DATE 10/4

LEGAL DESCRIPTION:

A CERTAIN TRACT OF LAND BEING COMPRISED OF LOTS 12 THRU 18, BLOCK 2, VOLCANO CLIFFS SUBDIVISION, UNIT 14, AS THE SAME IS SHOWN AND DESIGNATED ON SAID PLAT THEREOF, FILED ON JULY 29, 1970, IN VOLUME: D4, FOLIO: 80;

TOGETHER WITH, LOTS 4, 5 AND 6, BLOCK 2; LOT 1, BLOCK 5; AND A PORTION OF ATRISCO DRIVE N.W., WITHIN VOLCANO CLIFFS SUBDIVISION, UNIT 25, AS THE SAME IS SHOWN AND DESIGNATED ON SAID PLAT THEREOF, FILED ON DECEMBER 15, 1970, IN VOLUME: D4, FOLIO: 100;

TOGETHER WITH, COMMON AREA TRACT "D" OF VISTA VEJA SUBDIVISION, UNIT 2, AS THE SAME IS SHOWN AND DESIGNATED ON SAID PLAT THEREOF, FILED ON OCTOBER 3, 2006, IN BOOK: 2006C, PAGE: 298; SAID COMPRISED TRACT LYING WITHIN SECTIONS 21 AND 22, TOWNSHIP 11 NORTH, RANGE 2 EAST OF THE NEW MEXICO PRINCIPAL MERIDIAN, BERNALILLO COUNTY, NEW MEXICO;

BEING MORE PARTICULARLY DESCRIBED AS FOLLOWS:

BEGINNING AT A POINT ON A CURVE ON THE WESTERLY PRESENT (2011) RIGHT OF WAY LINE OF 81ST STREET N.W.; WHENCE, THE ALBUQUERQUE CONTROL SURVEY MONUMENT IDENTIFIED AS "I_C11", A STANDARD A.C.S. BRASS CAP MONUMENT IN PLACE BEARS N.69°59'29"E., 8409.25 FEET DISTANT; THENCE,

FROM SAID POINT OF BEGINNING, ALONG SAID WESTERLY RIGHT OF WAY LINE SOUTHWESTERLY 52.94 FEET ALONG THE ARC OF A CURVE TO THE LEFT, HAVING A CENTRAL ANGLE OF 01°06'04", A RADIUS OF 2754.70 FEET AND A CHORD OF: 52.94 FEET WHICH BEARS S 26°47'59" W TO A POINT; THENCE,

S 26°18'41" W ALONG SAID WESTERLY RIGHT OF WAY A DISTANCE OF 558.76 FEET TO A POINT OF CURVATURE TO THE RIGHT; THENCE,

104.64 FEET ALONG THE ARC OF SAID CURVE AND SAID WESTERLY RIGHT OF WAY LINE WITH A CENTRAL ANGLE OF 12°37'46", A RADIUS OF 474.67 FEET, AND A CHORD OF 104.42 FEET WHICH BEARS S 32°38'35" W TO A POINT OF TANGENCY; THENCE,

S 38°54'29" W A DISTANCE OF 439.78 FEET TO A POINT OF CURVATURE TO THE LEFT; THENCE,

223.64 FEET ALONG THE ARC OF SAID CURVE HAVING A CENTRAL ANGLE OF 12°25'45", A RADIUS OF 1030.93 FEET AND A CHORD OF 223.20 FEET WHICH BEARS S 32°41'37" W TO A POINT ON THE EASTERLY LINE OF COMMON AREA TRACT "C" AS THE SAME IS SHOWN IN RECORDED PLAT OF VISTA VEJA UNIT I, FILED ON OCTOBER 06, 2005, BOOK 2005C, PAGE 326 ; THENCE,

N 00°18'56" E ALONG SAID EASTERLY LINE A DISTANCE OF 270.25 FEET TO THE MOST SOUTHERLY CORNER OF TRACT D, VISTA VEJA UNIT 2 AS SHOWN IN PLAT FILED ON OCTOBER 3, 2006, BOOK: 2006C, PAGE: 298; THENCE,

N 27°43'30" W ALONG THE WESTERLY LINE OF SAID TRACT D A DISTANCE OF 1201.53 FEET TO A POINT ON THE SOUTHERLY LINE OF LOT 1, BLOCK 6, VOLCANO CLIFFS SUBDIVISION, UNIT 25; THENCE,

S 89°53'36" E ALONG SAID SOUTH LINE A DISTANCE OF 90.46 FEET TO THE SOUTHEAST CORNER OF SAID LOT 1, BLOCK 6; THENCE,

N 27°43'30" W ALONG THE EAST LINE OF SAID LOT 1 A DISTANCE OF 116.21 FEET TO A POINT ON A CURVE TO THE LEFT; THENCE,

12.21 FEET ALONG THE ARC OF SAID CURVE HAVING A CENTRAL ANGLE OF 23°19'22", A RADIUS OF 30.00 FEET AND A CHORD OF 12.13 FEET WHICH BEARS N 39°23'11" W TO A POINT ON A NON-TANGENTIAL LINE; THENCE,

N 62°15'04" E A DISTANCE OF 609.11 FEET TO THE SOUTHEAST CORNER OF LOT 3, BLOCK 2 WITHIN VOLCANO CLIFFS SUBDIVISION, UNIT 25; THENCE,

S 27°23'18" E A DISTANCE OF 178.36 FEET TO A POINT; THENCE,

N 58°46'14" E A DISTANCE OF 201.15 FEET TO A POINT ON A NON-TANGENTIAL CURVE TO THE LEFT AND THE EASTERLY CORNER OF LOT 18, BLOCK 2 WITHIN VOLCANO CLIFFS SUBDIVISION, UNIT 14 AND ALSO BEING THE WESTERLY PRESENT (2011) RIGHT OF WAY LINE OF COMPASS DRIVE N.W.; THENCE,

190.74 FEET ALONG THE ARC OF SAID CURVE AND SAID WESTERLY RIGHT OF WAY LINE WITH A CENTRAL ANGLE OF 32°42'45", A RADIUS OF 337.04 FEET AND A CHORD OF 188.20 FEET WHICH BEARS S 47°30'04" E TO A POINT; THENCE,

S 63°41'22" E A DISTANCE OF 435.56 FEET TO A POINT ON A CURVE TO THE RIGHT AND ALSO BEING THE NORTHEASTERLY CORNER OF HEREIN DESCRIBED TRACT; THENCE,

49.55 FEET ALONG THE ARC OF SAID CURVE HAVING A CENTRAL ANGLE OF 94°38'30", A RADIUS OF 30.00 FEET AND A CHORD OF 44.11 FEET WHICH BEARS S 16°28'47" E TO A POINT OF REVERSE CURVATURE AND ALSO BEING THE WESTERLY PRESENT (2011) RIGHT OF WAY LINE OF 81ST STREET N.W.; THENCE,

167.86 FEET ALONG THE ARC OF SAID CURVE HAVING A CENTRAL ANGLE OF 04°59'36", A RADIUS OF 1926.14 FEET AND A CHORD OF 167.81 FEET WHICH BEARS S 29°05'45" W TO THE POINT OF BEGINNING; SAID TRACT CONTAINS 26.9937 ACRES (1,175,846 SQUARE FEET) MORE OR LESS.

WILSON & COMPANY
4900 LANG AVENUE N.E.
ALBUQUERQUE, NEW MEXICO
87109
(505) 348-4000

Drawing Name:X3218078Z-Dam Final Plat.dwg
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I:\Projects\X321807802\SHEETS\05-837802PLAT02.dwg 2/10/2012 11:06:48 AM MST

EASEMENTS TO REMAIN KEY:

(H) EXISTING 30' CITY OF ALBUQUERQUE PUBLIC WATER UTILITY EASEMENT (VISTA VEJA SUBDIVISION PLAT, UNIT TWO DOC#: 2006150317 FILED: 10/03/06 BOOK: 2006C, PAGE: 298 SUBJECT TO LICENSE AGREEMENT BETWEEN AMAFCA, COA AND ABCWUA DOC#: 2009012724 FILED: 02-09-2009

(I) EXISTING 100' OVERHEAD POWERLINE EASEMENT PER UNIT NO. 25, VOLCANO CLIFFS PLAT FILED: 12-15-1970, VOL. 04, FOL. 100 SUBJECT TO ENCROACHMENT AGREEMENT BETWEEN AMAFCA AND PNM DOC#: 2011068115 FILED: 07-26-2011 .

(J) EXISTING 25' PUBLIC WATER AND SANITARY SEWER EASEMENT GRANTED BY SEPARATE INSTRUMENT DOC# :2006124199 FILED: 08/17/06 BOOK: A122, PAGE: 3861

(K) EXISTING 10' PNM EASEMENT DOC#'s: 2010084462-2010084466 & 2010084468 & 2010084469 FILED: 8-23-2010

(L) EXISTING 50' SOUTHERN UNION GAS EASEMENT FILED: 02-20-1957 VOL. D377, FOL. 588

(M) EXISTING PNM EASEMENT FILED:08-23-2010 DOC#: 2010084467

(N) EXISTING PNM EASEMENTS FILED:06-24-2011 DOC#: 2011058352-2011058353

(O) EXISTING 50' SOUTHERN UNION GAS EASEMENT FILED: 03-29-1956 VOL. 346, FOL. 363

EASEMENTS TO BE GRANTED KEY:

(Q) 16' PNM EASEMENT GRANTED BY THE FILING OF THIS PLAT

(R) 50' ACCESS AND UTILITY EASEMENT TO BE MAINTAINED BY PNM GRANTED BY THE FILING OF THIS PLAT FOR THE BENEFIT OF PNM SUBSTATION

(S) BLANKET DRAINAGE EASEMENT ON TRACT 1, EXCEPTING THE AREAS COVERED BY NMGC'S EXISTING EASEMENTS AS IDENTIFIED IN KEY NOTES (C) AND (G), GRANTED BY THE FILING OF THIS PLAT FOR THE BENEFIT OF ALBUQUERQUE METROPOLITAN ARROYO FLOOD CONTROL AUTHORITY SEE AMAFCA DRAINAGE EASEMENT DEDICATION LANGUAGE ON FIRST PAGE

(T) PUBLIC ROADWAY EASEMENT GRANTED BY THE FILING OF THIS PLAT FOR THE BENEFIT OF COA

(U) 10' PNM EASEMENT GRANTED BY THE FILING OF THIS PLAT

PLAT OF TRACT 1
BOCA NEGRA DETENTION DAM

WITHIN SECTIONS 21 and 22,
TOWNSHIP 11 NORTH, RANGE 2 EAST
NEW MEXICO PRINCIPAL MERIDIAN
CITY OF ALBUQUERQUE
BERNALILLO COUNTY, NEW MEXICO
AUGUST 2011

GRAPHIC SCALE
100 0 50 100 200
(IN FEET)
1 inch = 100 ft.

TRACT 1
AMAFCA
1,063,932 S.F.
24.4245 AC.

FLOOD ZONE "AE"

RAINBOW BLVD. ROW DEDICATED TO CITY OF ALBUQUERQUE BY THE FILING OF THIS PLAT 6,744 S.F. (0.1548 AC.)

TRACT "A" VISTA VEJA SUBDIVISION UNIT ONE FILED: 10-31-2005 BK. 2005C, PG. 326

TRACT "B" VISTA VEJA SUBDIVISION UNIT TWO FILED: 10-03-2006 BK. 2006C, PG. 298

TRACT "C" VISTA VEJA SUBDIVISION UNIT TWO FILED: 10-03-2006 BK. 2006C, PG. 298

PNM SUBSTATION EASEMENT FILED: 10-15-2007 DOC# 2007144825

LINE TABLE		
LINE	LENGTH	BEARING
L1	90.46'	S89°53'38"E (S89°46'26"E)
L2	116.21'	N27°43'30"W (N27°43'30"W)
L3	178.36'	S27°43'18"E (S27°43'30"E)
L4	201.15'	N58°56'14"E
L5	82.34'	S27°21'32"W
L6	75.96'	S63°41'22"E
L7	54.84'	N63°41'10"W
L8	169.08'	S38°34'29"W
L9	42.52'	S27°33'18"E
L10	29.92'	N58°46'14"E

CURVE TABLE						
CURVE	LENGTH	RADIUS	DELTA	TANGENT	CHORD	CHORD DIRECTION
C1	52.94' (53.01')	2754.70'	01°06'04" (01°06'09")	26.47	52.94' (53.01')	S28°47'59"W
C2	104.64'	474.67'	12°37'48"	52.53	104.42'	S32°35'35"W
C3	223.64' (223.83')	1030.93'	12°25'45" (12°26'23")	112.26	223.20' (223.39')	S32°41'37"W
C4	12.21'	30.00'	23°19'22"	6.19'	12.13'	N39°23'11"W
C5	190.74'	337.04'	32°42'45"	98.00'	188.20'	S47°30'24"E
C6	49.55'	30.00'	94°38'30"	32.53'	44.11'	S16°28'47"E
C7	187.88'	1926.14'	04°59'36"	93.98'	187.81'	S29°05'45"W
C8	480.09'	5601.86'	04°54'37"	240.19'	479.94'	S24°35'22"W
C9	39.72'	25.00'	91°02'54"	25.46'	35.68'	S18°09'55"E
C10	47.11'	30.00'	89°58'34"	29.99'	42.42'	N71°15'09"E

ACS CONTROL STATION "1_C11, 1986" DATA:
3-1/4" ALUMINUM CAP SET FLUSH IN THE LAVA OUTCROP
NEW MEXICO STATE PLANE GRID COORDINATES (CENTRAL ZONE)
X= 1,506,287.794 Y= 1,519,187.726
ELEV.=5275.136 (NAVD 1988)
GROUND TO GRID FACTOR = 0.999672216
DELTA ALPHA = (-)00°15'30.84", NAD 1983

ACS CONTROL STATION "8_C10":
3-1/4" ALUMINUM CAP SET FLUSH IN THE LAVA OUTCROP
NEW MEXICO STATE PLANE GRID COORDINATES (CENTRAL ZONE)
X= 1,502,106.697 Y= 1,521,538.710
ELEV.=5392.936 (NAVD 1988)
GROUND TO GRID FACTOR = 0.999667901
DELTA ALPHA = (-)00°16'00.09", NAD 1983

LEGEND:
- FOUND REBAR
- SET 5/8" REBAR WITH CAP STAMPED "CROSHAW 14733".
- INFLOW DESIGN FLOOD (IDF) LIMITS
- FLOOD ZONE "A" LIMITS

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4900 LANG AVENUE N.E.
ALBUQUERQUE, NEW MEXICO
87109
(505) 348-4000

SHEET 3 OF 4

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NETWORK ADDRESS: X:\Public\Projects\X321807802-01\S\Plot

GAS LINE WORK AREA AS DEFINED BY ENCROACHMENT AGREEMENT DATED 3-22-12 SEE SHEET 60.

EASEMENTS TO BE VACATED KEY:

(A) EXISTING 7' PUBLIC UTILITY EASEMENT PER VOLCANO CLIFFS SUBDIVISION, UNIT 25 FILED: 12-15-1970 VOL. D4, FOL. 100 VACATED BY THE FILING OF THIS PLAT

(B) EXISTING 106' PUBLIC ROADWAY EASEMENT PER BULK LAND PLAT OF VISTA VEJA SUBDIVISION FILED: 04-21-2005, BK. 2005C, PG. 122 VACATED BY THE FILING OF THIS PLAT

(C) EXISTING 15' PUBLIC UTILITY EASEMENT (INCLUDING 15'X20' SWITCH GEAR) PER BULK LAND PLAT OF VISTA VEJA SUBDIVISION FILED: 04-21-2005, BK. 2005C, PG. 122 VACATED BY THE FILING OF THIS PLAT

(D) EXISTING 50' DRAINAGE AND UTILITY EASEMENT PER VOLCANO CLIFFS SUBDIVISION, UNIT 25 FILED: 12-15-1970 VOL. D4, FOL. 100 VACATED BY THE FILING OF THIS PLAT

(E) EXISTING 50' DRAINAGE AND UTILITY EASEMENT PER VOLCANO CLIFFS SUBDIVISION, UNIT 14 FILED: 08-12-1970 VOL. D4, FOL. 88 VACATED BY THE FILING OF THIS PLAT

GRAPHIC SCALE
100 0 50 100 200
(IN FEET)
1 inch = 100 ft.

106' RIGHT OF WAY VACATED BY THE FILING OF THIS PLAT

100' RIGHT OF WAY VACATED BY THE FILING OF THIS PLAT

EXISTING LOT LINES TO BE ELIMINATED BY THE FILING OF THIS PLAT

EXISTING LOT LINE TO BE ELIMINATED BY THE FILING OF THIS PLAT

EXISTING LOT LINE TO BE ELIMINATED BY THE FILING OF THIS PLAT

LOT 5 CONVEYED AS PARCEL 6 BLOCK 2 VOLCANO CLIFFS SUBDIVISION – UNIT 25 FILED: DECEMBER 15, 1970 VOLUME D4, FOLIO 100

LOT 6 CONVEYED AS PARCEL 5 BLOCK 2 VOLCANO CLIFFS SUBDIVISION – UNIT 25 FILED: DECEMBER 15, 1970 VOLUME D4, FOLIO 100

EASEMENTS TO REMAIN KEY:

(H) EXISTING 30' CITY OF ALBUQUERQUE PUBLIC WATER UTILITY EASEMENT (VISTA VEJA SUBDIVISION PLAT, UNIT TWO DOC#: 2006150317 FILED: 10/03/06 BOOK: 2006C, PAGE: 298 SUBJECT TO LICENSE AGREEMENT BETWEEN AMAFCA, COA AND ABCWUA DOC#: 2009012724 FILED: 02-09-2009

(I) EXISTING 100' OVERHEAD POWERLINE EASEMENT PER UNIT NO. 25, VOLCANO CLIFFS PLAT FILED: 12-15-1970, VOL. D4, FOL. 100 SUBJECT TO ENCROACHMENT AGREEMENT BETWEEN AMAFCA AND PNM DOC#: 2011068115 FILED: 07-26-2011

(J) EXISTING 25' PUBLIC WATER AND SANITARY SEWER EASEMENT GRANTED BY SEPARATE INSTRUMENT DOC# :2006124199 FILED: 08/17/06 BOOK: A122, PAGE: 3861

(K) EXISTING 10' PNM EASEMENT 2010084462-2010084466 & 2010084468 & 2010084469 FILED: 8-23-2010

(L) EXISTING 50' SOUTHERN UNION GAS EASEMENT FILED: 02-20-1957 VOL. D377, FOL. 588

(M) EXISTING PNM EASEMENT FILED:08-23-2010 DOC#: 2010084467

(N) EXISTING PNM EASEMENTS FILED:06-24-2011 DOC#: 2011058352-2011058353

(O) EXISTING 50' SOUTHERN UNION GAS EASEMENT FILED: 03-29-1956 VOL. 346, FOL. 363

LEGEND:
- FOUND REBAR
- SET 5/8" REBAR WITH CAP STAMPED "CROSHAW 14733"
- EXISTING LOT LINE TO BE ELIMINATED BY THIS PLAT
- EXISTING EASEMENT LINE TO BE ELIMINATED BY THIS PLAT

VACATION EXHIBIT

DOC# 2012031891
02/28/2012 10:45:00AM Page: 4 of 4
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SHEET 4 OF 4

Drawing Name:X321807802-Dam Final Plat.dwg
NETWORK ADDRESS: X:\Public\Projects\X321807802-02\S\Plot

RECORD DRAWING
DATE: 10/11

ALBUQUERQUE METROPOLITAN ARROYO FLOOD CONTROL AUTHORITY

CONSTRUCTION PLANS FOR

BOCA NEGRA DETENTION DAM

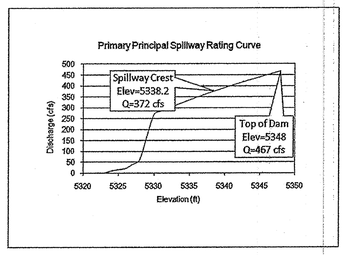
REFERENCES:

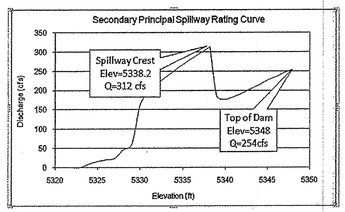
BOCA NEGRA MARIPOSA DMP	RTI	APRIL 2005
DESIGN REPORT	WCI	DECEMBER 2011
GEOTECH REPORT	GEOTEST	OCTOBER 2011
DOUBLE EAGLE II AIRPORT DRAINAGE MANAGEMENT	MCI	APRIL 2005
HYDROLOGIC & HYDRAULIC ANALYSIS REPORT	WCI	SEPTEMBER 2011

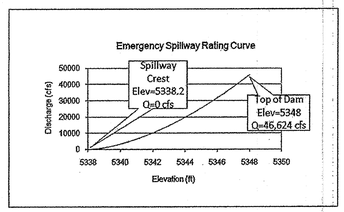
MARCH 2015

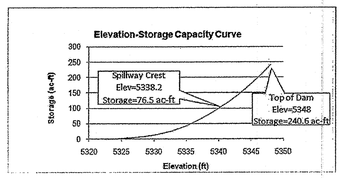
TAKEN FROM ORIGINAL

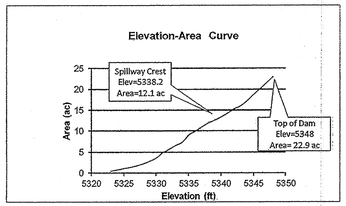
NAME OF DAM		BOCA NEGRA DETENTION DAM
TYPE OF DAM (MATERIAL)		HOMOGENEOUS EARTH EMBANKMENT
HAZARD POTENTIAL CLASSIFICATION		HIGH
MAX. HEIGHT ABOVE DOWNSTREAM TOE (FT)		26
MAX. LENGTH (FT)		3560
CREST WIDTH (FT)		17
SLOPE OF UPSTREAM FACE xH:1V		3 TO 1
SLOPE OF DOWNSTREAM FACE xH:1V		2.5 TO 1 & 3 TO 1
ELEVATION OF DAM CREST (FT)		5348
ELEVATION OF EMERGENCY SPILLWAY CREST (FT)		5338.2
EMERGENCY SPILLWAY WIDTH (FT)		419
1. PRIMARY PRINCIPAL SPILLWAY CONDUIT LENGTH (FT)		143
2. SECONDARY PRINCIPAL SPILLWAY CONDUIT LENGTH (FT)		145
1. UPSTREAM INVERT PRIMARY PRINCIPAL SPILLWAY (FT)		5318
2. UPSTREAM INVERT SECONDARY PRINCIPAL SPILLWAY (FT)		5328
1. DOWNSTREAM INVERT PRIMARY PRINCIPAL SPILLWAY (FT)		5311.9
2. DOWNSTREAM INVERT SECONDARY PRINCIPAL SPILLWAY (FT)		5321.8
FREEBOARD (FT)		10
RESIDUAL FREEBOARD (FT)		1.1
MAX EMERGENCY SPILLWAY DISCHARGE AT TOP OF DAM (CFS)		45903
1. PRIMARY PRINCIPAL SPILLWAY MATERIAL AND SIZE		48" x 48" CBC
2. SECONDARY PRINCIPAL SPILLWAY MATERIAL AND SIZE		48" x 48" CBC
1. MAX PRIMARY PRINCIPAL SPILLWAY DISCHARGE AT TOP OF DAM (CFS)		467
2. MAX SECONDARY PRINCIPAL SPILLWAY DISCHARGE AT TOP OF DAM (CFS)		254
1. LOCATION OF PRIMARY PRINCIPAL SPILLWAY		31.03722°N 107.66167°W
2. LOCATION OF SECONDARY PRINCIPAL SPILLWAY		31.03778°N 107.66167°W











BOCA NEGRA DETENTION DAM CHARACTERISTICS

ELEVATION (ft)	DISCHARGE (CFS)	STORAGE (AC-FT)	SURFACE AREA (ACRES)
5318=4' X 4' CBC (PRIMARY) SPILLWAY INV			
5319	0	0	0
5320	0	0	0
5321	0	0	0
5322	0	0	0
5323=4' X 4' CBC (SECONDARY) SPILLWAY INV	0	0	0.5
5324	18	0.9	0.8
5325	31	1.8	1.1
5326	40	3.0	1.3
5327	62	4.5	1.7
5328	106	6.5	2.2
5329	226	9.0	2.8
5330	430	12.2	3.6
5331	479	16.4	4.8
5332	513	21.6	5.7
5333	545	27.7	6.6
5334	574	34.7	7.3
5335	602	42.8	9.0
5336	629	52.3	9.9
5337	655	62.8	10.9
5337.94 = 100 YR FUTURE CONDITION	677	73.5	11.6
5337.98 = 100 YR INTERIM CONDITION	678	74.0	11.9
5338	679	74.2	11.9
5338.2=EMERGENCY SPILLWAY CREST ELEVATION	684	76.5	12.1
5339	1,438	86.3	12.6
5340	3,699	99.3	13.4
5341	6,830	113.1	14.3
5342	10,683	127.9	15.3
5343	15,192	143.6	16.0
5344	20,320	160.2	17.2
5345	26,006	178.2	18.7
5346	32,315	197.6	20.1
5347	39,208	218.4	21.5
5348=TOP OF DAM	46,624	240.6	22.9

⚠ REVISED TABLES AND GRAPHS

I, Daniel S. Aguirre, P.E., state that I am a qualified professional engineer licensed in the State of New Mexico, that I have supervised the construction of Boca Negra Detention Dam and appurtenant structures and find them to be completed in accordance with the record construction drawings and specifications and are now in a satisfactory condition for acceptance.

Daniel S. Aguirre, P.E. NM 11955 — Date 3/20/15

DANIEL S. AGUIRRE NEW MEXICO 11955 REGISTERED PROFESSIONAL ENGINEER

CERTIFICATE OF SUBSTANTIAL COMPLIANCE OF PLANS

I, Christopher Perea of the firm Wilson & Company, a Registered Professional Engineer in the State of New Mexico, do hereby certify, to the best of my knowledge and belief, that the infrastructure installed as part of this project has been inspected by me or by a qualified person under my direct supervision and has been constructed in accordance with the plans and specifications. The original design intent of the approved plans has been met, except as noted by me on the as-built construction drawing. This certification is based on site inspection by me or personnel under my direction.

Christopher Perea, P.E. NM 13686 — Date 3/20/15

CHRISTOPHER A. PEREA NEW MEXICO 13686 REGISTERED PROFESSIONAL ENGINEER

State of New Mexico } ss.
County of Santa Fe }

I hereby certify that the accompanying Construction Drawings for Boca Negra Detention Dam and appurtenant structures has been duly examined by me and were duly accepted for filing on the _____ day of _____, 20 ____.

State Engineer — Date

State of New Mexico } ss.
County of Bernalillo }

I, Jerry M. Lewis, P.E., being first duly sworn, upon my oath, state that I am the Executive Engineer of the Albuquerque Metropolitan Arroyo Flood Control Authority, a governmental entity duly organized under the laws of the state of New Mexico, that the accompanying Construction Drawings, consisting of 55 sheets, for Boca Negra Detention Dam, were made under authority of the Board of Directors of said governmental entity and that, in their behalf, I have read and examined the statements and representations and all that is shown herein is done with their free consent and in accordance with their wishes and state that the same are true and correct to the best of my knowledge and belief.

Jerry M. Lewis, P.E., Executive Engineer — Date 2/9/2012

Subscribed and sworn to before me this 9th day of February 20 12.

Notary public
My commission expires 10-07-2012

State of New Mexico } ss.
County of Bernalillo }

I, Daniel S. Aguirre, P.E., CFM, state that I am a qualified professional engineer licensed in the state of New Mexico, qualified in CFM engineering; that the accompanying Construction Drawings consisting of 55 sheets, was prepared by me or under my supervision; that the accompanying Construction Drawings consisting of 55 sheets, is in compliance with the Dam Design, Construction and Dam Safety Regulations (19.25.12 NMAC) and that the same are true and correct to the best of my knowledge and belief.

Daniel S. Aguirre, P.E., CFM — License No. 11955

Date submitted 2/9/12

Subscribed and sworn to before me this 9th day of February 20 12.

Notary public
My commission expires 10-07-12

REV	SHEETS	CITY ENGINEER	DATE	USER DEPARTMENT	DATE	USER DEPARTMENT	DATE
2			03-13-15	CERTIFICATION TAKEN FROM SHEET 1 OF 62			
1			11-11-14	REVISED TABLES AND GRAPHS			

DRB# 1002962

RECORD DRAWING
DATE 03/15

WILSON & COMPANY
4900 LANG AVENUE, NE
SUITE 100
ALBUQUERQUE, NEW MEXICO
87109
(505) 348-4000

ENGINEERS STAMP & SIGNATURE

DANIEL S. AGUIRRE NEW MEXICO 11955 REGISTERED PROFESSIONAL ENGINEER

APPROVALS	ENGINEER	DATE
DRC Chairman		
Transportation		
Water/Wastewater		
Hydrology		
AMAFCA		

APPROVED FOR CONSTRUCTION

City Engineer — Date

AMAFCA Project No.
City Project No. 781181

Sheet 1R OF 62

T:\Projects\x321807802\M\SHEETS\01-837802dfil.dwg 1/19/2012 4:54:38 PM MST

MONUMENT TABLE			
	NORTHING	EASTING	ELEVATION
M1	16843.9804	58073.1456	5347.60'
M2	16658.59317	58001.0931	5348.14'
M3	16342.53087	57886.6212	5337.99'
M4	16089.20695	57713.7805	5348.08'
M5	15943.1996	57580.6665	5348.08'
M6	16509.37269	57883.7862	5323.10'
M7	16371.67192	57813.3017	5323.12'
M8	16441.60207	58022.2353	5326.58'
M9	16311.14961	57940.2296	5333.02'
M10	16479.60195	57956.8297	5338.14'

LEGEND:

- LIMITS OF 100 YR EVENT
- LIMITS – HIGH WATER LINE ELEV = 5348.00
- AS–BUILT MONUMENT LOCATION

96"RCP STORM DRAIN / 8'x8' CBC STUBOUT
MONUMENT M1
CLASS 'D' RIPRAP
MONUMENT M2
MONUMENT M10
EXISTING 12' MONUMENT ACCESS ROAD
MONUMENT M8
20' MAINTENANCE ROAD
15' MAINTENANCE ROAD
ATRISCO STORM DRAIN
ATRISCO DR.
EXISTING BRIDGE (COA PROJ #705004)
EXISTING STORM DRAIN (COA PROJ #705004)
MONUMENT M9
MONUMENT M3
PLUNGE POOL
CLASS 'D' RIPRAP
MONUMENT M4
EXISTING 24" WATERLINE
UNSER BLVD.
MULTI-USE TRAIL
NE DAM ACCESS ROAD
RAINBOW BLVD
ACCESS TO RAINBOW BLVD
SCENIC RD.
EXISTING UNDERGROUND ELECTRIC
NW DAM ACCESS ROAD
PNM ACCESS ROAD
PNM SUB-STATION
EMERGENCY SPILLWAY
SECONDARY PRINCIPAL SPILLWAY
MONUMENT M6
BOCA NEGRA DETENTION DAM
EXISTING OVERHEAD POWER
MONUMENT M7
PRIMARY PRINCIPAL SPILLWAY
EXISTING 14" WATERLINE
FUTURE UNDERGROUND ELECTRICAL LOCATION
BOCA NEGRA ARROYO INLET STRUCTURE
PARK ACCESS ROAD
DAM CENTERLINE
CLASS 'D' RIPRAP
SOIL GROUTING
MONUMENT M5
EXISTING UNSER BLVD.
VOLCANO CLIFFS WELL NO. 3
SCENIC RD.
12" WELL WASH LINE
PROPOSED 16" WELL COLLECTOR WATERLINE
VISTA VIEJA SUBDIVISION (UNIT 2)
WORK AREA AS DEFINED IN ENCROACHMENT AGREEMENT DATED 3-22-14. SEE SHEET 60.
VISTA DEL SOL DRIVE N.W.
EXISTING RETAINING WALL
EXISTING 48" & 60" STORM DRAIN
EXISTING GAS LINES
GAS LINE WORK AREA AS DEFINED BY ENCROACHMENT AGREEMENT DATED 3-22-14. SEE SHEET 60.
DAM PROPERTY BOUNDARY
4 STRAND BARBLESS WIRE FENCE
EXISTING 48" RCP
DAM ACCESS & MAINTENANCE ROAD

GRAPHIC SCALE
100 0 50 100 200 400
(IN FEET)
1 inch = 100 ft.

WCEA #X321807802
APRIL 2011

RECORD DRAWING
DATE 10-14

AS–BUILT INFORMATION
CONTRACTOR: JAUS BROTHER
STAKED BY: VARIOUS DATE: 10/14
INSPECTED BY: VCI DATE: 10/14
FIELD VERIFICATION BY: VCI DATE: 10/14
DRAWING BY: VCI DATE: 10/14
COMPILED BY: VCI MICRO-FILM INFORMATION
RECORDED BY: DATE:
NO.:

BENCH MARKS
THE STATION IS A 3 1/2" ALUMINIUM CAP SET FLUSH IN THE LAVA OUTCROP, AND IS STAMPED "ACS 8-C10, 1986". (NAD 1927).
E= 361860.83, N= 1521476.37
LAT 35° 10' 51.940" LONG 106° 42' 44.230"
TRUNCATED: E=-300,000, N=-1,500,000
COMBINED GROUND TO GRID = 0.999664705
ELEVATION = 5392.936 FT. (NAVD 88)

SURVEY INFORMATION
FIELD NOTES

NO.	BY	DATE

ENGINEER'S SEAL
DANIEL S. AGUIRRE NEW MEXICO 11955 REGISTERED PROFESSIONAL ENGINEER

NO.	BY	DATE	GRADING REVISION REMARKS
1			

REVISIONS
WILSON & COMPANY, ENGINEERS & ARCHITECTS
DESIGNED BY JSD DATE APRIL 2011
DRAWN BY STAFF DATE APRIL 2011
CHECKED BY DSA DATE APRIL 2011

ALBUQUERQUE METROPOLITAN ARROYO FLOOD CONTROL AUTHORITY
DAM BID LOT
OVERALL LAYOUT PLAN

Design Review Committee	City Engineer Approval	Last Design Update	Mo./Day/Yr.	Mo./Day/Yr.

City Project No. 781181
Zone Map No. D– 9/10
Sheet 8R OF ~~56~~ 62

WILSON & COMPANY

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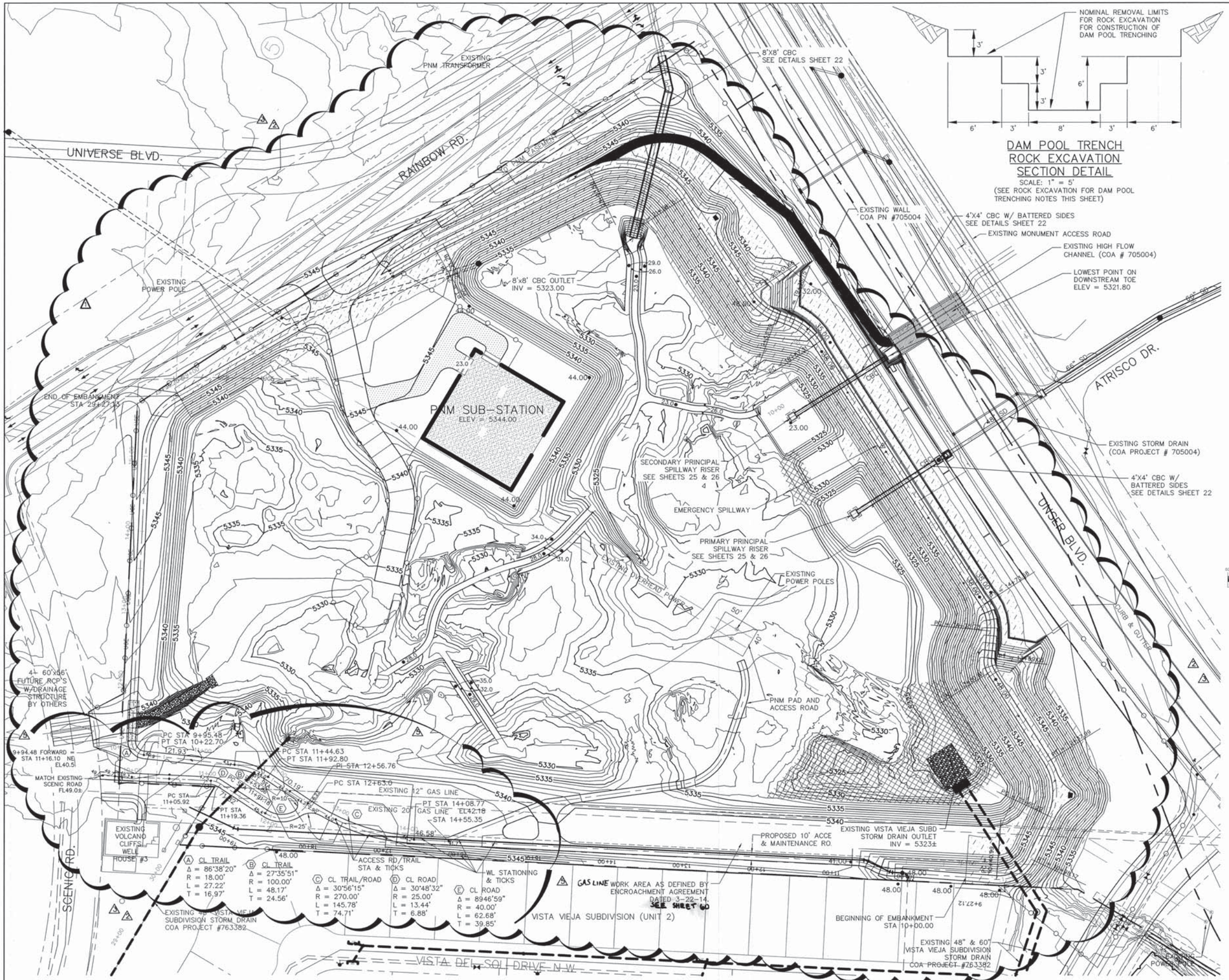

DAM POOL TRENCH ROCK EXCAVATION SECTION DETAIL

SCALE: 1" = 5'

(SEE ROCK EXCAVATION FOR DAM POOL TRENCHING NOTES THIS SHEET)

NOTE:

1) THE UPPER 12" OF THE ENTIRE DAM FOUNDATION SHALL BE COMPACTED TO 95% MIN DENSITY PER ASTMD-1557.
2) CONTRACTOR SHALL OVEREXCAVATE AND RECOMPACT THE MATERIAL WITHIN 100 FEET OF THE UPSTREAM TOE OF THE EMBANKMENT TO A DEPTH OF 2 FEET. IF ROCK IS ENCOUNTERED, THE CONSTRACTOR SHALL STOP AND IS NOT REQUIRED TO EXCAVATE BELOW THE ROCK SURFACE.
3) CONTRACTOR SHALL NOT PERFORM ROCK EXCAVATION WITHIN 50' H.P. GAS LINE EASEMENT. NO VIBRATORY COMPACTION WILL BE ALLOWED AND NO LOADS GREATER THAN HS-20 ALLOWED OVER H.P. GAS LINES. CONTRACTOR SHALL COORDINATE WITH NM GAS PRIOR TO ANY OPERATIONS WITHIN EASEMENT.

FOUNDATION TREATMENT AREA

OVER EXCAVATION AREA

ROCK EXCAVATION FOR DAM POOL TRENCHING NOTES:

1) CONTRACTOR SHALL ATTEMPT TO REMOVE ROCK TO MEET THE LINES AND GRADES OF THE NOMINAL REMOVAL LIMITS AS SHOWN IN THE 'DAM POOL TRENCH ROCK EXCAVATION SECTION DETAIL', THIS SHEET. PAYMENT WILL BE MADE FOR ACTUAL ROCK REMOVAL AS APPROVED BY THE PROJECT MANAGER. IT IS UNDERSTOOD THAT THE ACTUAL SURFACE MAY VARY DUE TO THE ROCK FRACTURING. THE ALIGNMENT OF THE TRENCHES AND THE TRENCH CROSS-SECTION MAY BE MODIFIED IN THE FIELD BY DIRECTION OF THE PROJECT MANAGER.
2) LOOSE ROCKS IN THE AREAS OUTSIDE OF THE NOMINAL REMOVAL LIMITS MAY BE LEFT IN PLACE IF THEY ARE LOWER THAN FINISHED GRADE AND ARE LEFT IN A STABLE CONDITION. ALL ROCK OVERHANG SHALL BE REMOVED AS DIRECTED BY THE PROJECT MANAGER. THE DAM POOL TRENCHES DO NOT REQUIRE WASHING OF THE ROCK SURFACE OR GROUTING OF CRACKS AND IRREGULARITIES.
3) DAM POOL TRENCHES REQUIRING ROCK EXCAVATION SHALL BE PAID AS:

ROCK EXCAVATION - TRENCHING.

GRAPHIC SCALE

60 0 30 60 120 240

(IN FEET)
1 inch = 60 ft.

RECORD DRAWING
DATE 10/14

AS-BUILT INFORMATION
CONTRACTOR: SALLS BROTHERS
WORK INSPECTED BY: WAYDHN — DATE: 10/14
INSPECTIONS BY FIELD: WCI — DATE: 10/14
VERIFICATION BY FIELD: WCI — DATE: 10/14
CORRECTED BY: WCI — DATE: 10/14
MICRO-FILM INFORMATION
RECORDED BY — DATE
NO.

BENCH MARKS

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E= 361860.83, N= 1521476.37
LAT 35° 10' 51.940" LONG 106° 42' 44.230"
TRUNCATED: E=-300,000, N=-1,500,000
COMBINED GROUND TO GRID = 0.999664705
ELEVATION = 5392.936 FT. (NAVD 88)

SURVEY INFORMATION
FIELD NOTES

NO.	BY	DATE

ENGINEER'S SEAL

DANIEL S. AGUIRRE — NEW MEXICO — 11955 — REGISTERED PROFESSIONAL ENGINEER

NO.	DATE	REVISIONS / REMARKS	BY
6	11-20-14	OVER EXCAVATION AREA REVISED	TDS
5	01-7-14	ACCESS/MAINTENANCE ROAD REV	DSA
4	06-24-13	ROCK TRENCH DETAIL/NOTES REV	DSA
3	06-11-13	GRADING REVISIONS	DSA
2	01-28-13	GRADING REVISIONS	DSA
1	11/27/12	OVEREX/FOUND. TREATMENT LIMITS	DMD

WILSON & COMPANY, ENGINEERS & ARCHITECTS
DESIGNED BY JSD — DATE APRIL 2011
DRAWN BY STAFF — DATE APRIL 2011
CHECKED BY DSA — DATE APRIL 2011

ALBUQUERQUE METROPOLITAN ARROYO FLOOD CONTROL AUTHORITY
DAM BID LOT
GRADING PLAN

Design Review Committee	City Engineer Approval	Last Design Update	Mo./Day/Yr.	Mo./Day/Yr.

City Project No. 781181 | Zone Map No. D- 9/10 | Sheet 9R OF ~~55~~ 67

WCEA #X321807802
APRIL 2011

WILSON & COMPANY

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UNIVERSE BLVD.

RAINBOW BLVD

RAINBOW BLVD PROJECT # 705004

12' MULTI-USE TRAIL SEE SHEET 31

MATCH EXISTING PAVEMENT

END OF EMBANKMENT STA 29+28.80

PNM SUB-STATION ELEV = 5344.00

EXISTING UNDERGROUND ELECTRIC

10' PAVED ACCESS ROAD SEE SHEET 31 FOR TYPICAL SECTION

8'x8' CBC OUTLET INV = 5323.00

8'x8' CBC SEE DETAIL SHEET 22

INSTALL MONUMENT PER DETAIL SHEET 34

INSTALL BENCH THOMAS STEELE PRODUCT GRB-6-VS OR APPROVED EQUAL

INSTALL MONUMENT PER DETAIL SHEET 34

EXISTING WALL COA PROJECT 705004

4' X 4' CBC W/BATTERED SIDES, SEE SHEET 22

EXISTING MONUMENT ACCESS ROAD

INSTALL MONUMENT PER DETAIL SHEET 34

LOWEST POINT ON DOWNSTREAM TOE ELEV = 5321.80

INSTALL MONUMENT PER DETAIL SHEET 34

UNSER BLVD.

ATRISCO DR.

EX. 24" W.L.

EX. 21" SAS

GRADE SLAB

SECONDARY PRINCIPAL SPILLWAY RISER SEE SHEET 25

INSTALL MONUMENT PER DETAIL SHEET 34

EMERGENCY SPILLWAY

PRIMARY PRINCIPAL SPILLWAY RISER W/ ORIFICE SEE SHEET 25

GRADE SLAB

EXISTING STORM DRAIN (COA PROJECT # 705004)

INSTALL MONUMENT PER DETAIL SHEET 34

JUNCTION BOX

4' X 4' CBC W/BATTERED SIDES, SEE SHEET 22

INSTALL MONUMENT PER DETAIL SHEET 34

INSTALL MONUMENT PER DETAIL SHEET 34

INSTALL MONUMENT PER DETAIL SHEET 34

EXISTING POWER POLES

EXISTING OVERHEAD POWER

REMOVE & DISPOSE EXISTING 10" WELL WASH LINE

WATER DRAIN FEATURE

REMOVE & DISPOSE EXISTING 14" WL BACKFILL WITH STRUCTURAL DAM EMBANKMENT PER SPECIFICATION SECTION 203

REMOVE & DISPOSE 1240±LF EXISTING 14" WL

CURB & GUTTER

BOCA NEGRA DAM CENTERLINE SEE SHEET 11 FOR PROFILE

INSTALL BENCH THOMAS STEELE PRODUCT GRB-6-VS OR APPROVED EQUAL

2- 6'x10' FUTURE CBC BY OTHERS

6" R/W

BOCA NEGRA ARROYO INLET STRUCTURE SEE SHEET 21

GAS LINE

WORK AREA AS DEFINED BY ENCROACHMENT AGREEMENT DATED 3-22-14. SEE SHEET 60

EXISTING VISTA VIEJA SUBDIVISION STORM DRAIN OUTLET

EXISTING 12" GAS LINE

EXISTING 20" GAS LINE

FUTURE SAS

EXISTING VOLCANO CLIFFS WELL HOUSE #3

SCENIC RD.

PROPOSED 10' ACCESS & MAINTENANCE ROAD

10' ACCESS AND MAINTENANCE ROAD SEE SHEET 31 FOR TYPICAL SECTION

ACCESS & MAINTENANCE ROAD SEE SHEET 28

EXISTING 30' PUBLIC WATER UTILITY EASEMENT

EXISTING 50' SOUTHERN UNION GAS EASEMENT

16" WL SEE SHEET 51

EXISTING WALL

STA 9+75 BEGIN SOIL GROUTING

BEGINNING OF EMBANKMENT STA 10+00.00

EXISTING 16" WL COA PROJECT #763382

EXISTING 48" & 60" VISTA VIEJA SUBDIVISION STORM DRAIN COA PROJECT #763382

INSTALL MONUMENT PER DETAIL SHEET 34

EXISTING 48" VISTA VIEJA SUBDIVISION STORM DRAIN COA PROJECT #763382

VISTA VIEJA SUBDIVISION (UNIT 2)

VISTA DEL SOL DRIVE N.W.

MAINTENANCE ROAD PAVING SCHEDULE

- 34' ACCESS & MAINTENANCE ROAD SEE ROADWAY TYPICAL SECTIONS SHEET 31
- 12' TRAIL SEE MULTI-USE TRAIL SHEET 31
- 10' MAINTENANCE ROAD SEE ROADWAY TYPICAL SECTIONS SHEET 31
- 16' BASE COURSE ENTRANCE ROAD
- SOIL CEMENT

CL CURVE DATA FOR DAM CENTERLINE

SEE SHEET 1-11 FOR PROFILE

(1) Δ =68°45'58" R =47.64' T =32.60' L =57.17'	(2) Δ =57°29'44" R =77.50' T =42.51' L =77.77'
(3) Δ =38°00'09" R =27.50' T =9.47' L =18.24'	(4) Δ =38°28'48" R =56.50' T =19.72' L =37.95'
(5) Δ =37°00'24" R =75.00' T =25.10' L =48.44'	(6) Δ =36°34'20" R =75.00' T =24.78' L =47.87'
(7) Δ =83°17'36" R =100.00' T =88.93' L =145.37'	(8) Δ =3°04'33" R =200.00' T =6.45' L =12.89'

NOTE:
1) MONUMENTS TO BE INSTALLED ACCORDING TO AMAFCA STANDARD DETAIL AND SPECIFICATION SHEET 34.
2) ~~NM GAS CO REPRESENTATIVE MUST BE PRESENT DURING CHEMICAL GROUTING OPERATIONS.~~
3) CARSONITE MARKERS TO BE INSTALLED ALONG EACH H.P. GAS LINE EVERY 500 FT. MARKER TO BE FURNISHED BY NM GAS. (MIN. 12 MARKERS)

NOTE:
SEE SHEET 32 "FENCING & REVEGETATION PLAN FOR FENCING, GATE AND BOLLARD INFORMATION.

RECORD DRAWING
DATE 10/14

GRAPHIC SCALE
(IN FEET)
1 inch = 60 ft.

AS-BUILT INFORMATION
CONTRACTOR SALLS BROTHERS
NEW/ADDED BY WAYBUM DATE 10/14
PROTECTED BY WCI DATE 10/14
FIELD ENTRANCE BY WCI DATE 10/14
VERIFICATION BY WCI DATE 10/14
CORRECTED BY WCI DATE 10/14
MICRO-FILM INFORMATION
RECORDED BY DATE
NO.

BENCH MARKS
THE STATION IS A 3 1/2" ALUMINUM CAP SET FLUSH IN THE LAVA OUTCROP, AND IS STAMPED "ACS 8-C10, 1986". (NAD 1927).
E= 361860.83, N= 1521476.37
LAT 35° 10' 51.940" LONG 106° 42' 44.230"
TRUNCATED: E=-300,000, N=-1,500,000
COMBINED GROUND TO GRID = 0.9996647O5
ELEVATION = 5392.936 Ft. (NAVD 88)

SURVEY INFORMATION
FIELD NOTES
NO. BY DATE

ENGINEER'S SEAL
DANIEL S. AGUIRRE NEW MEXICO 11955 REGISTERED PROFESSIONAL ENGINEER

NO.	DATE	REMARKS	BY
1	01-26-13	GRADING REVISIONS	DSA
2	3-2-12	UPDATE NOTE	

REVISIONS

WILSON & COMPANY, ENGINEERS & ARCHITECTS

DESIGNED BY	JSD	DATE APRIL 2011
DRAWN BY	STAFF	DATE APRIL 2011
CHECKED BY	DSA	DATE APRIL 2011

ALBUQUERQUE METROPOLITAN ARROYO FLOOD CONTROL AUTHORITY

DAM BID LOT

SITE PLAN

Design Review Committee	City Engineer Approval	Last Design Update	Mo./Day/Yr.	Mo./Day/Yr.

City Project No.	Zone Map No.	Sheet
781181	D- 9/10	10R OF 56 62

WCEA #X321807802
APRIL 2011

WILSON & COMPANY

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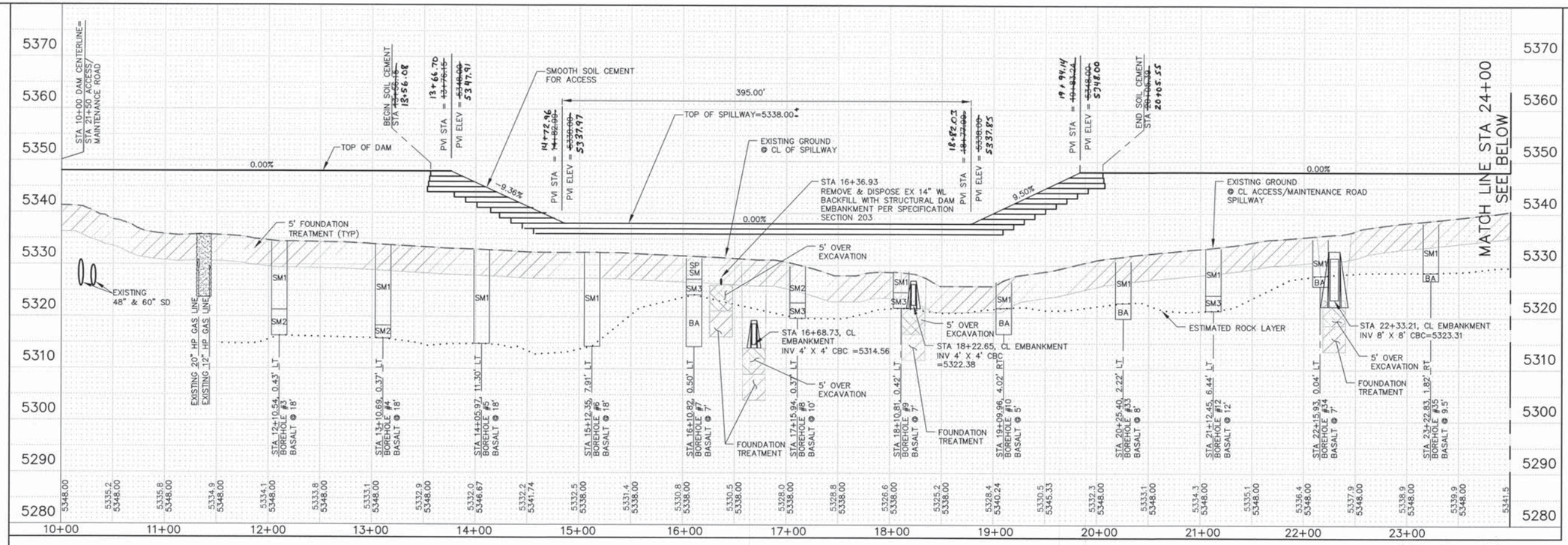
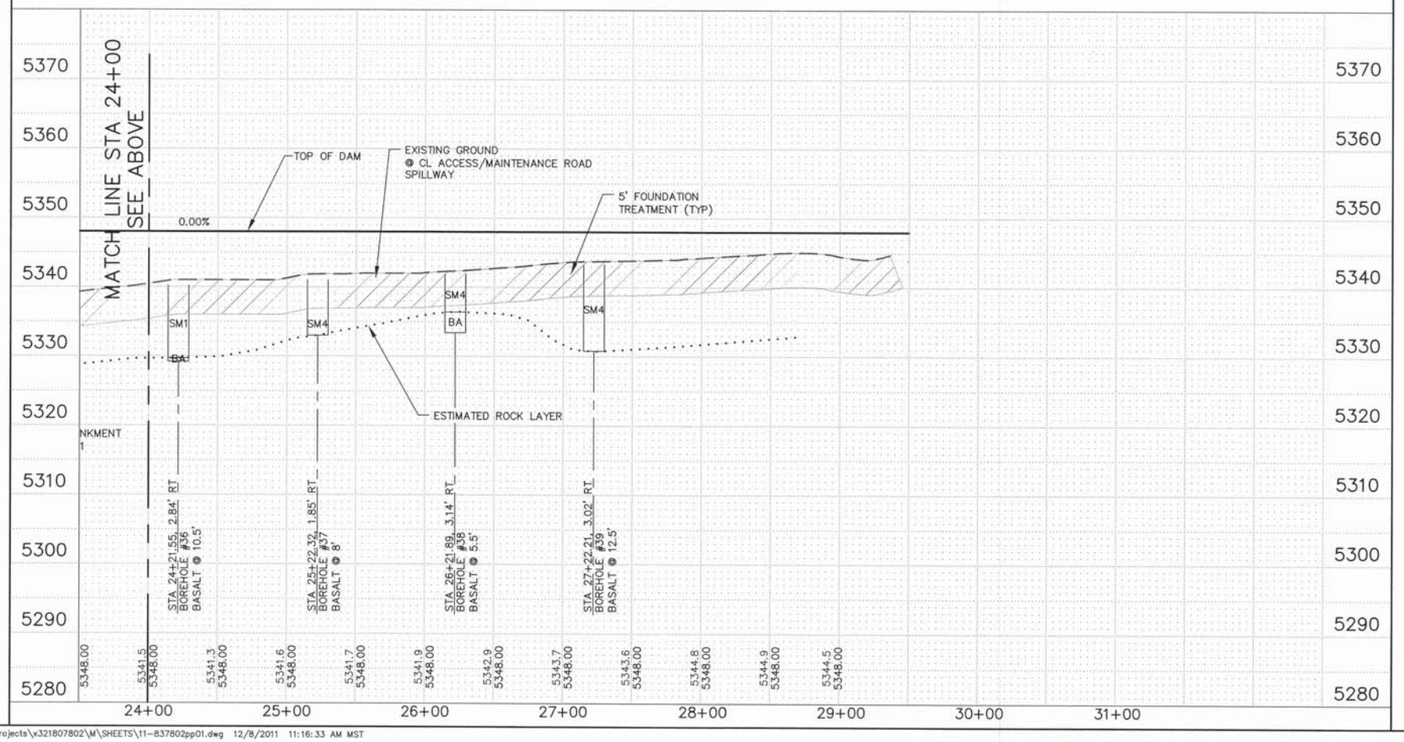


HORIZ: 1" = 50'
VERT: 1" = 10'



HORIZ: 1" = 50'
VERT: 1" = 10'

SOIL TYPE LEGEND – FOR CLARIFICATION

BA	BASALT
SM1	SILTY SAND
SM2	SILTY SAND AND GRAVEL
SM3	SILTY SAND WITH GRAVEL AND COBBLES
SM4	SLIGHTLY SILTY SAND
SP SM	SAND

REFERENCE

GEO–TEST, INC. GEOTECHNICAL ENGINEERING ANALYSIS REPORT FOR BOCA NEGRA DETENTION DAM. ALBUQUERQUE, NM: GEO–TEST, INC., 2011.

SEE SHEET 10 FOR PLAN

RECORD DRAWING
DATE 10/14

AS–BUILT INFORMATION
CONTRACTOR SAUS BROTHERS
WORK ACCEPTED BY WAYSMAN DATE 10/14
PROJECT ACCEPTANCE BY W/C1 DATE 10/14
FIELD VERIFICATION BY W/C1 DATE 10/14
DRAWINGS CHANGED BY W/C1 DATE 10/14
MICRO–FILM INFORMATION
RECORDED BY DATE

BENCH MARKS
THE STATION IS A 3 1/2" ALUMINIUM CAP SET FLUSH IN THE LAVA OUTCROP, AND IS STAMPED "ACS 8–C10, 1986". (NAD 1927).
X= 361860.83, Y= 1521476.37
ELEVATION = 5390.130 FT. (SLD 1929)

SURVEY INFORMATION
FIELD NOTES

NO.	BY	DATE

ENGINEER'S SEAL
JAMES D. AGUIRRE
NEW MEXICO
11955
REGISTERED PROFESSIONAL ENGINEER
10/14

NO.	DATE	REMARKS	BY
		REVISIONS	

WILSON & COMPANY, ENGINEERS & ARCHITECTS

DESIGNED BY	JSD	DATE	APRIL 2011
DRAWN BY	STAFF	DATE	APRIL 2011
CHECKED BY	DSA	DATE	APRIL 2011

ALBUQUERQUE METROPOLITAN
ARROYO FLOOD CONTROL
AUTHORITY
DAM BID LOT
DAM CENTERLINE
PROFILE

Design Review Committee	City Engineer Approval	Last Design Update	Mo./Day/Yr.	Mo./Day/Yr.
APPROVED FEB 10 2012 DESIGN REVIEW COMMITTEE	APPROVED FEB 10 2012 CITY ENGINEER			

City Project No.	Zone Map No.	Sheet	Of
781181	D– 9/10	11	55 62

WCEA #X321807802
APRIL 2011

WILSON & COMPANY

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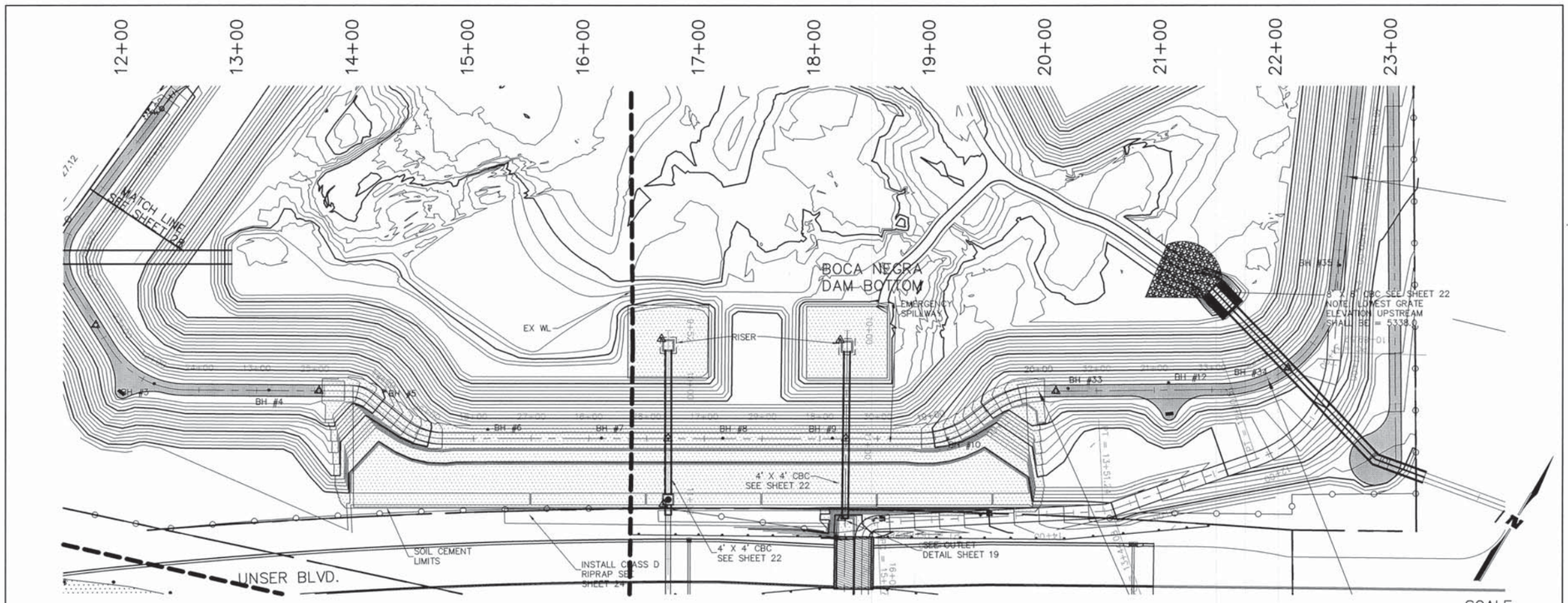


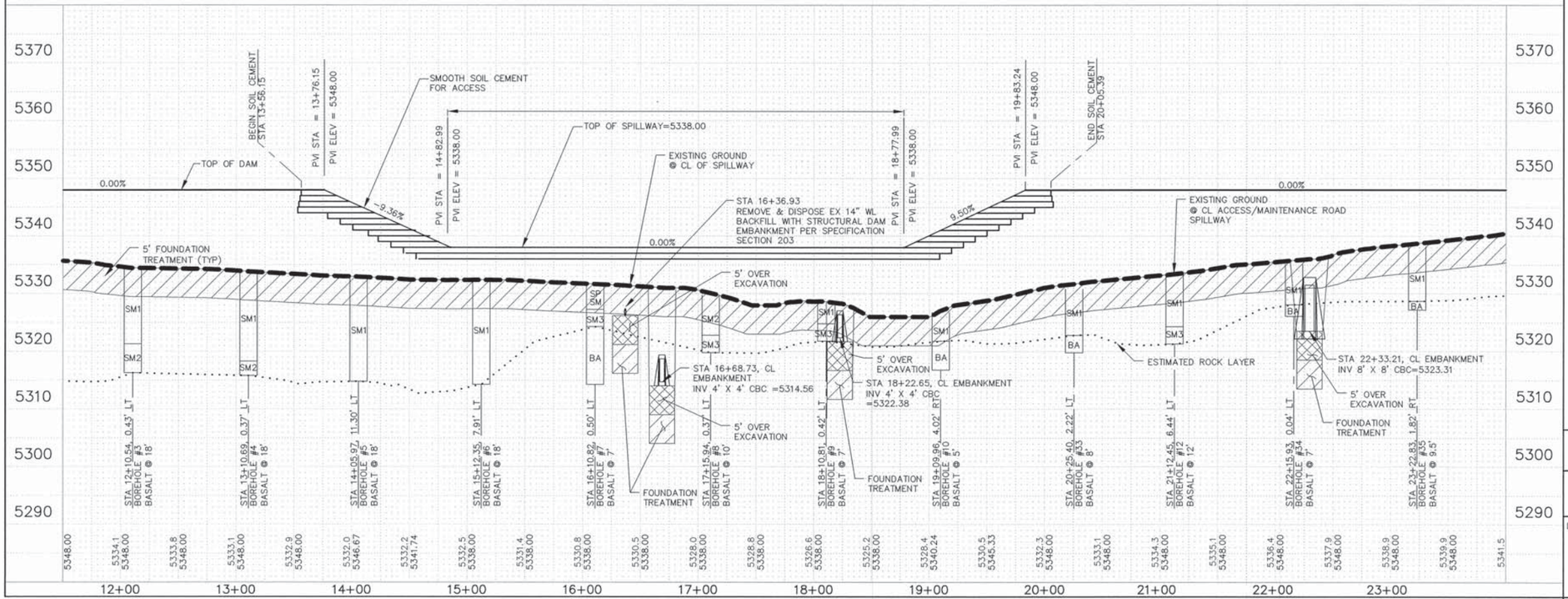
NOTES:

1. SEE SHEETS 25 & 26 FOR RISER DETAILS.
2. EMERGENCY SPILLWAY LIFTS SEE SHEETS 14 THRU 16.

SOIL TYPE LEGEND (FOR CLARIFICATION)

BA	BASALT
SM1	SILTY SAND
SM2	SILTY SAND AND GRAVEL
SM3	SILTY SAND WITH GRAVEL AND COBBLES
SM4	SLIGHTLY SILTY SAND
SP SM	SAND

REF: GEOTECHNICAL ENGINEERING ANALYSIS REPORT FOR BOCA NEGRA DETENTION DAM – APRIL 2011



RECORD DRAWING
DATE 10/14

WCI #X321807802
APRIL 2011

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AS-BUILT INFORMATION
CONTRACTOR SALLS BROTHERS
MAPPED BY JAYSON 10/14 DATE
STAKED BY WCI 10/14 DATE
ACCEPTANCE BY WCI 10/14 DATE
FIELD VERIFICATION BY WCI 10/14 DATE
DRAWINGS CORRECTED BY WCI 10/14 DATE
MICRO-FILM INFORMATION
RECORDED BY DATE
NO.

BENCH MARKS
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ELEVATION = 5392.936 FT. (NAVD 88)

SURVEY INFORMATION
FIELD NOTES
NO. BY DATE

ENGINEER'S SEAL
DONALD M. DUNEMAN
NEW MEXICO
17616
LICENSED PROFESSIONAL ENGINEER

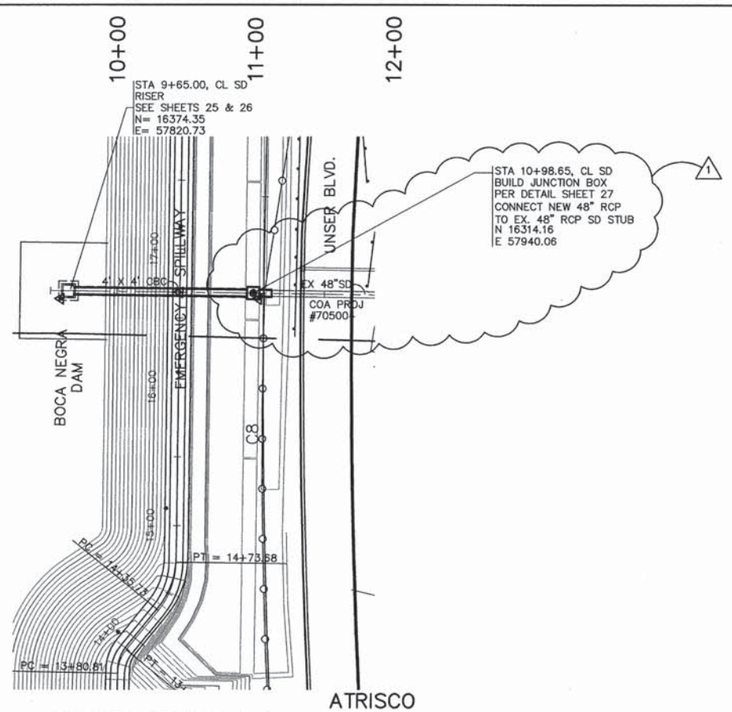
NO.	DATE	REMARKS / REVISIONS	BY
		WILSON & COMPANY, ENGINEERS & ARCHITECTS	
		DESIGNED BY RSD DATE APRIL 2011	
		DRAWN BY STAFF DATE APRIL 2011	
		CHECKED BY DSA DATE APRIL 2011	

ALBUQUERQUE METROPOLITAN ARROYO FLOOD CONTROL AUTHORITY
DAM BID LOT
EMERGENCY SPILLWAY
PLAN & PROFILE

Design Review Committee	City Engineer Approval	Last Design Update	Mo./Day/Yr.	Mo./Day/Yr.

City Project No. 781181 | Zone Map No. D- 9/10 | Sheet 12R OF ~~59~~ 62

WILSON & COMPANY



PRIMARY PRINCIPAL SPILLWAY

SCALE:
HORIZ: 1" = 50'
VERT: 1" = 10'

WCI #X321807802
APRIL 2011

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AS-BUILT INFORMATION

CONTRACTOR SAUS BROTHERS

WORK STAKED BY	WCI	DATE 10/14
WORK INSPECTED FOR ACCEPTANCE BY	WCI	DATE 10/14
FIELD VERIFICATION BY	WCI	DATE 10/14
DRAWINGS CORRECTED BY	WCI	DATE 10/14

MICRO-FILM INFORMATION

RECORDED BY DATE

NO.

BENCH MARKS

THE STATION IS A 3 1/2" ALUMINIUM CAP SET FLUSH IN THE LAVA OUTCROP, AND IS STAMPED "ACS 8-C10, 1986". (NAD 1927).
E= 361860.83, N= 1521476.37

TRUNCATED: E=-300,000, N=-1,500,000

COMBINED GROUND TO GRID = 0.999664705

ELEVATION = 5392.936 FT. (NAVD 88)

SURVEY INFORMATION

FIELD NOTES

NO.	BY	DATE

ENGINEER'S SEAL

RECORD DRAWING
DATE 10/14

NO.	DATE	REMARKS	BY
1	1/11/13	MOVED MH UPSTREAM	DSA

REVISIONS

WILSON & COMPANY, ENGINEERS & ARCHITECTS

DESIGNED BY	JSD	DATE APRIL 2011
DRAWN BY	STAFF	DATE APRIL 2011
CHECKED BY	DSA	DATE APRIL 2011

ALBUQUERQUE METROPOLITAN ARROYO FLOOD CONTROL AUTHORITY

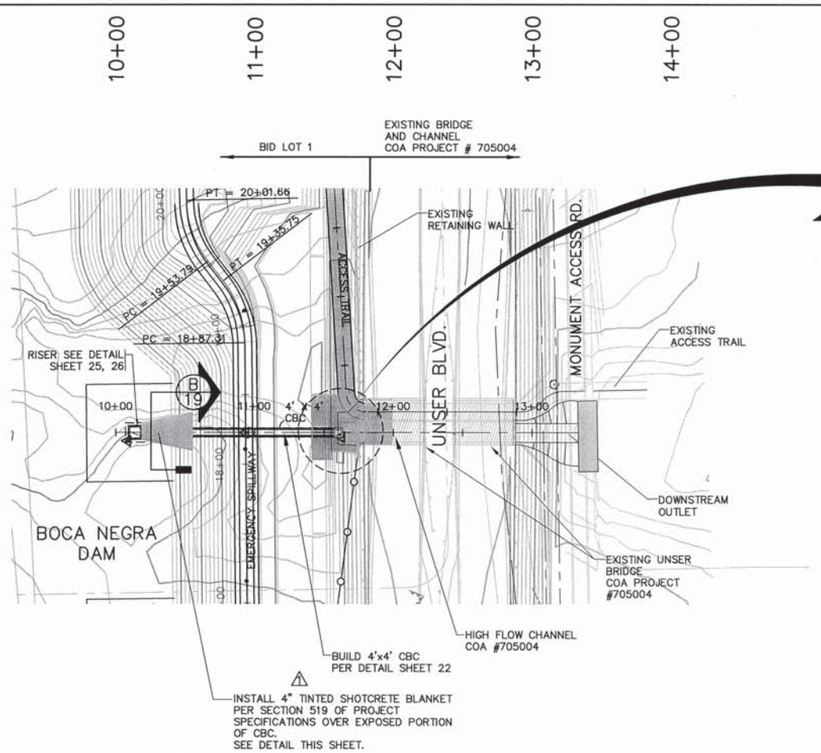
DAM BID LOT

PRIMARY PRINCIPAL SPILLWAY PLAN & PROFILE STA. 10+00.00 TO STA. 11+11.88

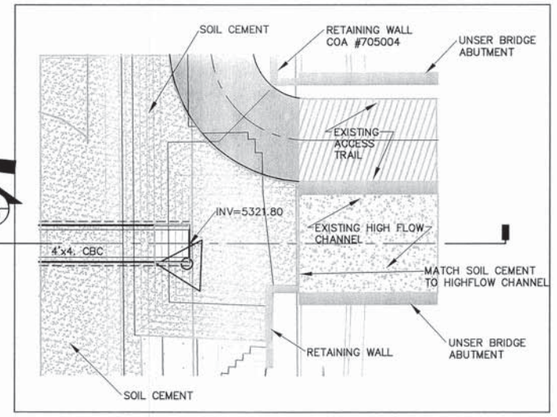
Design Review Committee	City Engineer Approval	Last Design Update	Mo./Day/Yr.	Mo./Day/Yr.

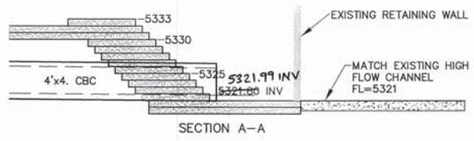
City Project No.	Zone Map No.	Sheet
781181	D- 9/10	18ROF 5562

WILSON & COMPANY



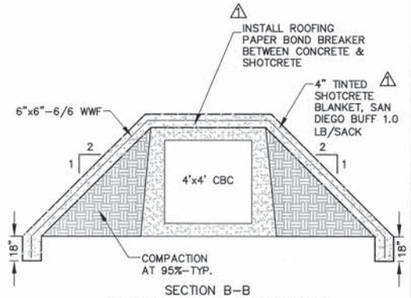
4' X 4' CBC SECONDARY PRINCIPAL SPILLWAY





SECTION A–A

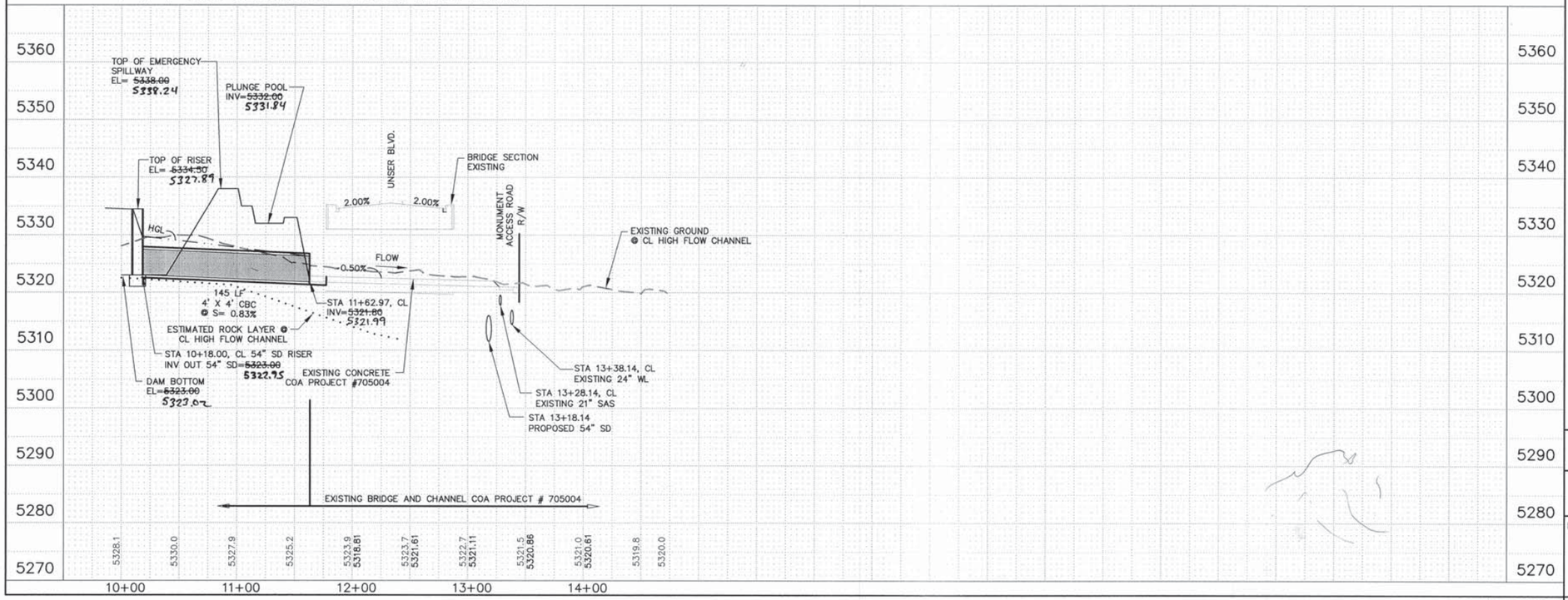
SECONDARY PRINCIPAL SPILLWAY OUTLET DETAIL



SECTION B–B

SHOTCRETE BLANKET

SCALE:
HORIZ: 1" = 50'
VERT: 1" = 10'



WCI #X321807802
APRIL 2011

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AS-BUILT INFORMATION
CONTRACTOR SALLS & BETHKE
WORK STARTED BY WAYTOHN DATE 10/14
WORK ACCEPTANCE BY WCI DATE 10/14
FIELD VERIFICATION BY WCI DATE 10/14
DRAWINGS EDITED BY WCI DATE 10/14
MICRO-FILM INFORMATION
RECORDED BY DATE
NO.

BENCH MARKS
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TRUNCATED: E=-300,000, N=-1,500,000
COMBINED GROUND TO GRID = 0.999664705
ELEVATION = 5392.936 FT. (NAVD 88)

SURVEY INFORMATION
FIELD NOTES
NO. BY DATE

ENGINEER'S SEAL
DANIEL S. HOSTETTER 17555 REGISTERED PROFESSIONAL ENGINEER

NO.	DATE	REVISIONS / REMARKS	BY
1	3-2-12	ADDED NOTE	

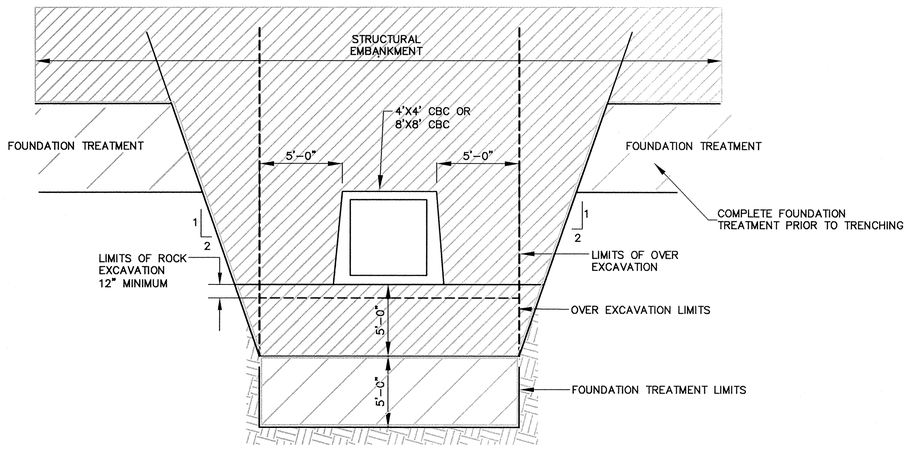
WILSON & COMPANY, ENGINEERS & ARCHITECTS
DESIGNED BY JSD DATE APRIL 2011
DRAWN BY STAFF DATE APRIL 2011
CHECKED BY DSA DATE APRIL 2011

RECORD DRAWING
DATE 10/14

ALBUQUERQUE METROPOLITAN ARROYO FLOOD CONTROL AUTHORITY
DAM BID LOT
SECONDARY PRINCIPAL SPILLWAY
PLAN & PROFILE

Design Review Committee: APPROVED OCT 26 2012 DESIGN REVIEW COMMITTEE
City Engineer Approval: APPROVED OCT 26 2012 CITY ENGINEER
Last Design Update: Mo./Day/Yr.
City Project No. 781181
Zone Map No. D- 9/10
Sheet 19 OF 55 62

WILSON & COMPANY



PRINCIPAL SPILLWAY & INLET PIPES TRENCHING DETAIL

SCALE 1" = 5'

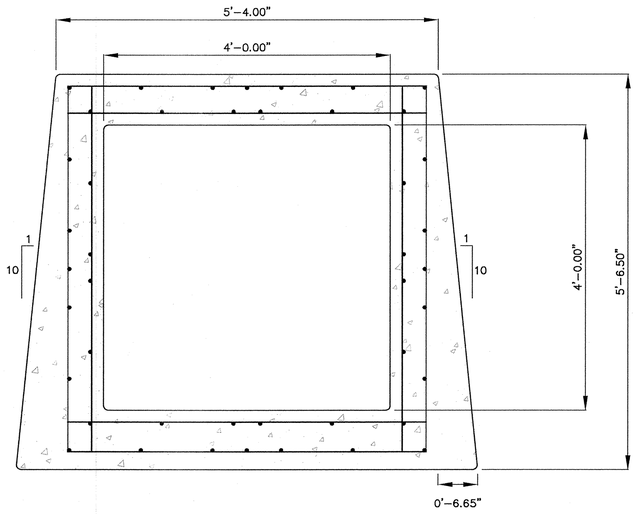
4' X 4' CBC STA 9+65 TO STA 11+12

4' X 4' CBC STA 10+18 TO STA 11+63

8' X 8' STA 10+00 TO STA 11+93

NOTES:

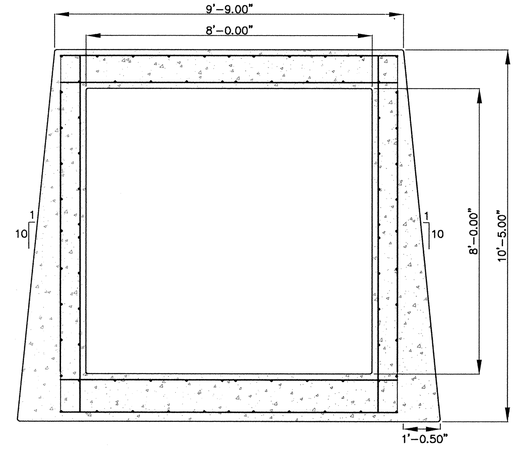
1. IF BASALT BEDROCK IN ENCOUNTERED IN EXCAVATION, OVEREX 12" MIN BELOW THE BOTTOM OF BOX. NO COMPACTION OF BASALT SURFACE IS REQUIRED.
2. IN THE ZONE WITHIN 5' OF THE BATTERED SIDES OF THE CULVERTS, FILL SHOULD BE PLACED USING MANUALLY CONTROLLED WALK BEHIND ROLLING COMPACTORS, VIBRATORY PLATE COMPACTORS, OR JUMPING JACKS CAPABLE OF COMPACTING THE SOIL IMMEDIATELY ADJACENT TO THE CULVERTS.
3. BACKFILL LAYERS SHALL BE COMPACTED TO A MINIMUM OF 95% OF MODIFIED PROCTOR PER ASTM D-1557 MEASURED BY ASTM D-1556 OR D-2922.
4. IF BASALT BEDROCK IS ENCOUNTERED IN EXCAVATION AND CONTAINS DEFECTS, REMOVE AND REPLACE AS DIRECTED BY THE GEOTECHNICAL ENGINEER.
5. TRENCHING & BACKFILL FOR ALL CBC INSTALLATION SHALL BE INCIDENTAL TO UNCLASSIFIED EXCAVATION AND FOUNDATION TREATMENT BID ITEMS.



4'X4' CAST-IN-PLACE CBC W/BATTERED SIDES DETAIL

SCALE: 1" = 1'

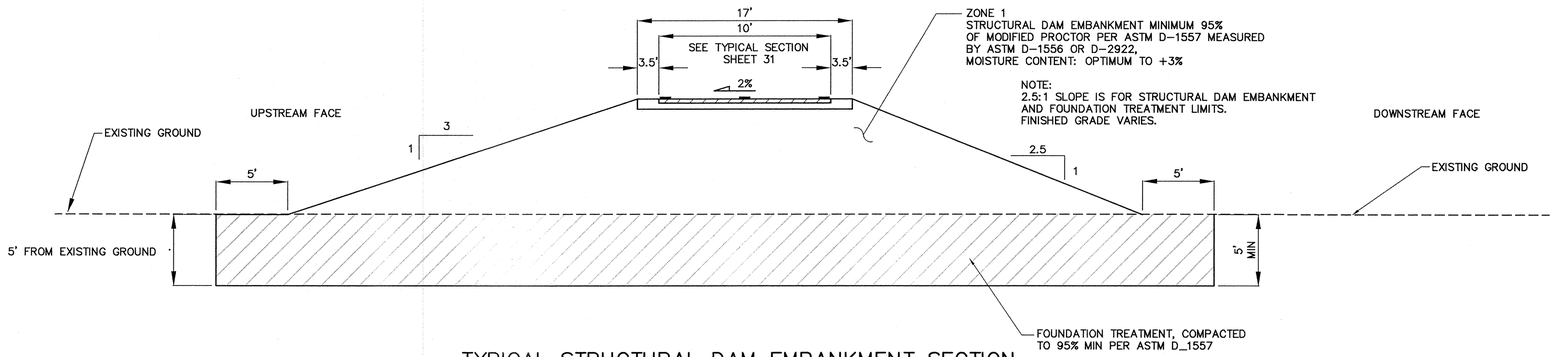
FOR STEEL DETAIL SEE SHEET 23 FOR NMDOT STD. DTL. FOR CBC DESIGN FILL "D"



8'X8' CAST-IN-PLACE CBC W/BATTERED SIDES DETAIL

SCALE: 1" = 2'

FOR STEEL DETAIL SEE SHEET 23 FOR NMDOT STD. DTL. FOR CBC DESIGN FILL "D"



TYPICAL STRUCTURAL DAM EMBANKMENT SECTION

NTS

STA. 9+14.83 TO STA. 29+27.13
SEE SHEET 9 OF 55

RECORD DRAWING
DATE 10/14

AS-BUILT INFORMATION
CONTRACTOR SALLS BROTHERS DATE 10/14
WORK INSPECTED BY WAYTOHN DATE 10/14
INSPECTOR'S ACCEPTANCE BY W.C.I. DATE 10/14
AS-BUILT VERIFICATION BY W.C.I. DATE 10/14
AS-BUILT CORRECTED BY W.C.I. DATE 10/14
MICRO-FILM INFORMATION
RECORDED BY DATE
NO.

BENCH MARKS
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E= 361860.83, N= 1521476.37
LAT 35° 10' 51.940" LONG 106° 42' 44.230"
TRUNCATED: E=-300,000, N=-1,500,000
COMBINED GROUND TO GRID = 0.999664705
ELEVATION = 5392.936 FT. (NAVD 88)

SURVEY INFORMATION
FIELD NOTES
NO. | BY | DATE

ENGINEER'S SEAL
DANIEL S. ANAYA NEW MEXICO 11955 REGISTERED PROFESSIONAL ENGINEER

NO.	DATE	BY
1	3-2-12	ADDED NOTE

REVISIONS
WILSON & COMPANY, ENGINEERS & ARCHITECTS
DESIGNED BY JSD DATE APRIL 2011
DRAWN BY STAFF DATE APRIL 2011
CHECKED BY DSA DATE APRIL 2011

ALBUQUERQUE METROPOLITAN ARROYO FLOOD CONTROL AUTHORITY
DAM BID LOT
PRINCIPAL SPILLWAY DETAILS

Design Review Committee: APPROVED OCT 26 2012 DESIGN REVIEW COMMITTEE
City Engineer Approval: APPROVED OCT 26 2012 CITY ENGINEER
Last Design Update: Mo./Day/Yr. | Mo./Day/Yr.

City Project No. 781181
Zone Map No. D- 9/10
Sheet 22 OF ~~55~~ 62

WCEA #X321807802
APRIL 2011

WILSON & COMPANY

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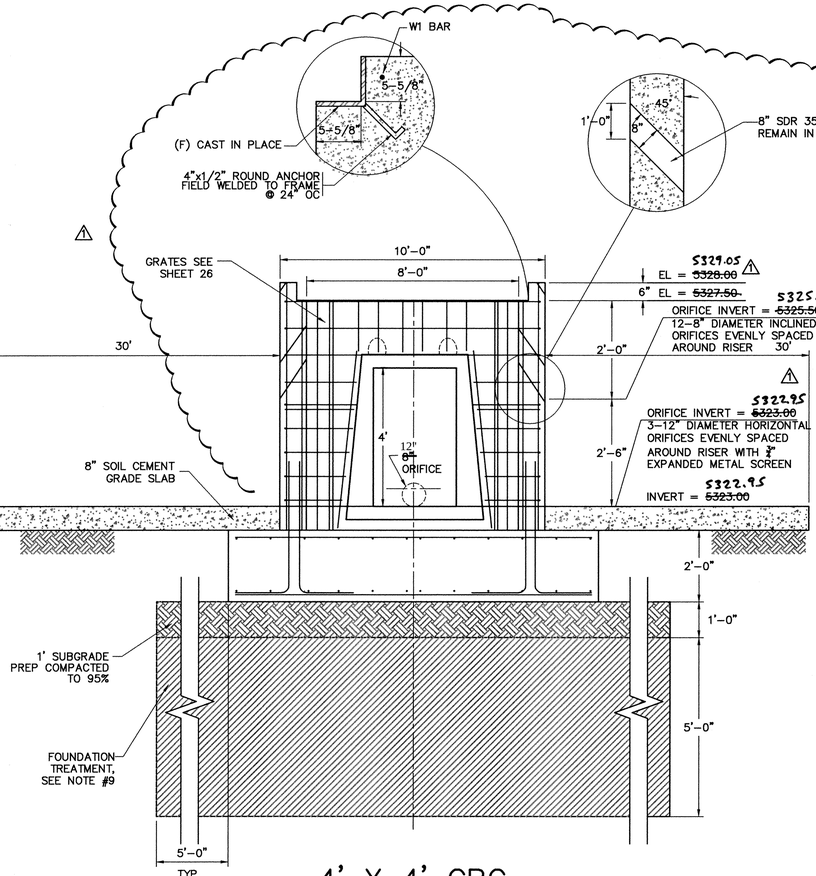
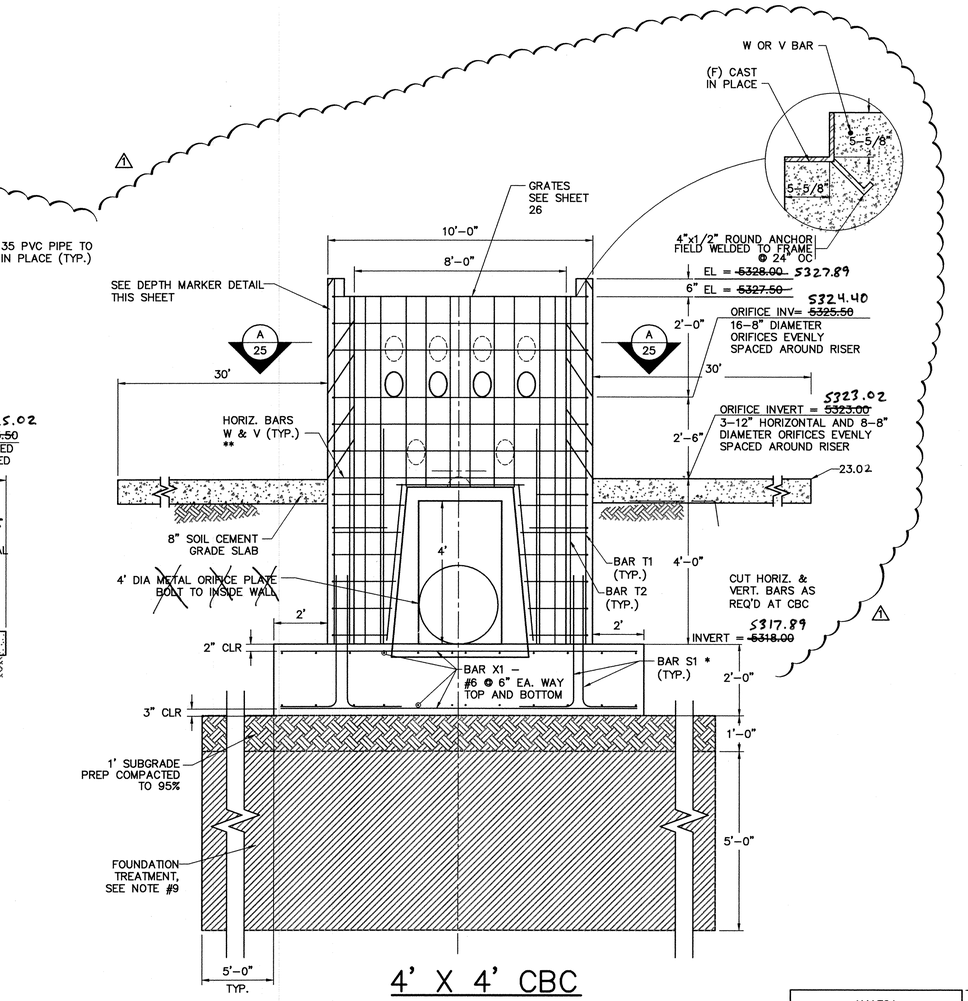


4' X 4' CBC SECONDARY SPILLWAY RISER

NTS

SEE PRIMARY SPILLWAY RISER FOR REINFORCING DETAILS NOT SHOWN



4' X 4' CBC PRIMARY SPILLWAY RISER

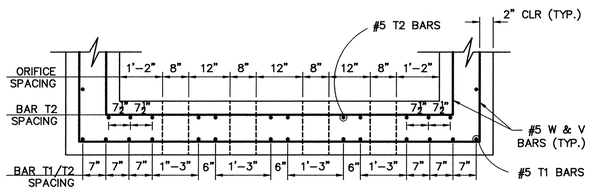
NTS

* BARS S1 - MATCH VERTICAL WALL BAR SIZE AND SPACING

** SPACE HORIZ. BARS AT 8" MAX. O.C., EXCEPT BTN ORIFICES PLACE 3 EQUAL SPACED BARS AS SHOWN

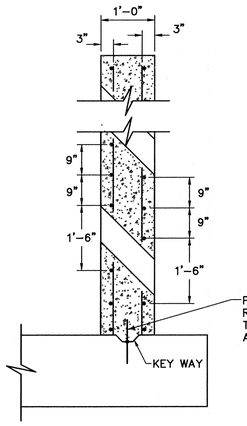
SEE SHEET 26 FOR REINFORCING DETAILS

COVER 12" HORIZONTAL ORIFICES WITH 1/4" EXPANDED METAL SCREEN.



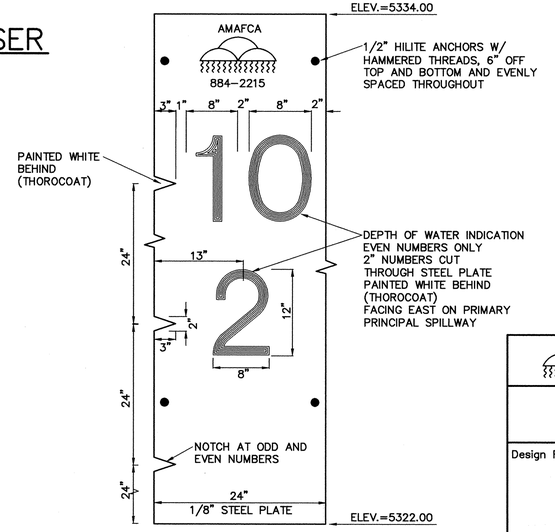
A RISER SECTION

NTS



WALL DETAIL

NTS



DEPTH MARKER DETAIL

GENERAL STRUCTURAL NOTES

1. SPECIFICATIONS FOR CONSTRUCTION: SPECIFICATION FOR BOCA NEGRA DETENTION DAM, 2011.
2. CONCRETE: PROVIDE 4000 PSI CONCRETE PER SECTION 509 AND APPLICABLE TECHNICAL SPECIFICATIONS. CHAMFER ALL EXPOSED EDGES OF STRUCTURES 3/4" UNLESS OTHERWISE NOTED.
3. FINISHING CONCRETE SURFACES: PAINT ALL EXPOSED CONCRETE SURFACES WITH TEXTURED THOROCOAT OR APPROVED EQUAL. OBTAIN ENGINEER'S APPROVAL OF COLOR PRIOR TO APPLICATION.
4. REINFORCING BARS: ASTM A615, GRADE 60. DIMENSIONS SHOWN REFER TO THE CENTERLINE OF BARS UNLESS OTHERWISE NOTED.

   UNLESS OTHERWISE INDICATED, USE THE FOLLOWING MINIMUM LAP LENGTHS:

#4 BARS	1'-9"
#5 BARS	2'-2"
#6 BARS	2'-7"

5. STRUCTURAL STEEL:
   STEEL SECTIONS AND BARS: ASTM A 36
   BOLTS, NUTS, & WASHERS: ASTM A 307
   PLATES: ASTM A 283
   RODS: ASTM A 36
6. WELDING: CONFORM TO AWS D1.1 WITH ELECTRODES CONFORMING TO AWS A5.1, E-70 SERIES. PROVIDE CERTIFIED WELDERS FOR ALL WELDING.
7. SPILLWAY RISER ORIFICES: SCHEDULE 40 PVC PIPE.
8. JUNCTION BOX SAFETY LADDER: PROVIDE LADDER USING GALVANIZED ASTM A36 STEEL AND CONFORMING TO OSHA REQUIREMENTS.
9. RISER FOUNDATION PREPARATION: OVER-EXCAVATE FOUNDATION TO A DEPTH OF 5 FEET AND FOR A DISTANCE OF 5 FEET LATERALLY BEYOND THE FOOTING PERIMETER AND DENSIFY THE EXPOSED SURFACES OF THE NATIVE SOILS. REPLACE OVER-EXCAVATED VOLUME WITH STRUCTURAL FILL IN ACCORDANCE WITH THE SPECIFICATIONS.
   IF BASALT IS ENCOUNTERED WITHIN 12 INCHES OF BOTTOM OF FOUNDATION, ROCK REMOVAL IS REQUIRED.
10. SPECIAL INSPECTIONS: PROVIDE ACCESS FOR OWNER OR OWNER'S REPRESENTATIVE TO MAKE SPECIAL INSPECTIONS OF CONCRETE AND REINFORCEMENT PLACEMENT, FIELD WELDING, AND EARTHWORK IN ACCORDANCE WITH SECTION 17 OF THE BUILDING CODE.
11. ALL 8" AND 12" ORIFICES SHALL BE FORMED USING SDR 35 PVC PIPE.

DESIGN DATA

DESIGN SPECIFICATIONS: 2003 STATE OF NEW MEXICO COMMERCIAL BUILDING CODE (2003 INTERNATIONAL BUILDING CODE AS AMENDED).

LIVE LOAD: 10,000 LB VEHICLE LOAD.

WIND: BASIC WIND SPEED = 90 MPH, Iw = 1.00, BLDG CATEGORY II, EXPOSURE C, DESIGN WIND PRES. = 18 PSF.

SEISMIC: Ie = 1.00, SEISMIC USE GROUP I, Ss = 0.60, S1 = 0.15, SITE CLASS D, Sds = 0.53, Sd1 = 0.22, SEISMIC DESIGN CATEGORY D.

DESIGN STRESSES:
REINFORCED CONCRETE: f'c = 4000 PSI (28 DAYS)
REINFORCING STEEL: fy = 60000 PSI

ALLOWABLE SOIL BEARING PRESSURE: 1500 PSF (DL + LL)
2000 PSF (DL + LAT LOAD)

NOTE:
STEEL DETAILS:
SEE SHEET 26 FOR
REINFORCING DETAILS

RECORD DRAWING
DATE 10/14

AS-BUILT INFORMATION
CONTRACTOR SALC Brothers
WORK STAKED BY WATSON DATE 10/14
WORK INSPECTED FOR ACCEPTANCE BY WCI DATE 10/14
FIELD VERIFICATION BY WCI DATE 10/14
DRAWINGS CORRECTED BY WCI DATE 10/14
BENCH MARKS
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LAT 35° 10' 51.940" LONG 106° 42' 44.230"
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COMBINED GROUND TO GRID = 0.999664705
ELEVATION = 5392.936 FT. (NAVD 88)
MICRO-FILM INFORMATION
RECORDED BY DATE
NO.

SURVEY INFORMATION
FIELD NOTES
NO. BY DATE

ENGINEER'S SEAL
DANIEL J. GUTIERREZ NEW MEXICO 19965 REGISTERED PROFESSIONAL ENGINEER

NO.	DATE	REMARKS	BY
1	01-26-13	SPILLWAY REVISIONS	DSA

REVISIONS

WILSON & COMPANY, ENGINEERS & ARCHITECTS
DESIGNED BY JSD DATE APRIL 2011
DRAWN BY STAFF DATE APRIL 2011
CHECKED BY DSA DATE APRIL 2011

ALBUQUERQUE METROPOLITAN ARROYO FLOOD CONTROL AUTHORITY
DAM BID LOT
RISER DETAILS

Design Review Committee	City Engineer Approval	Last Design Update	Mo./Day/Yr.	Mo./Day/Yr.

City Project No. 781181
Zone Map No. D- 9/10
Sheet 25R OF ~~56~~ 57

WCEA #X321807802
APRIL 2011

WILSON & COMPANY

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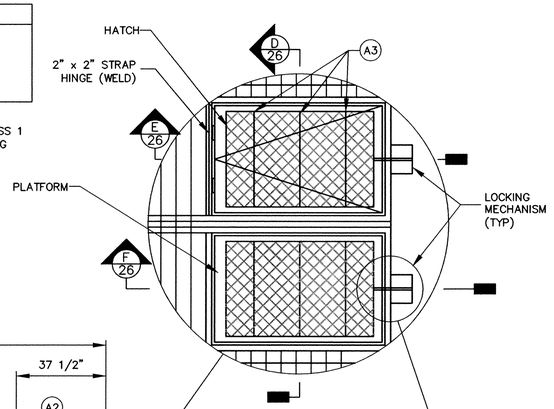
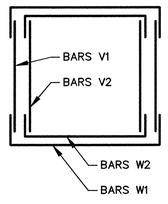
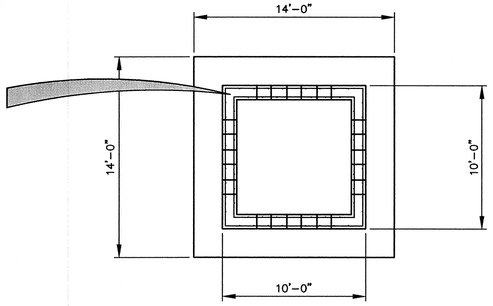
KEY TABLE	
A	1/2" x 1/2" STEEL BARS
B	L 4 x 4 x 3/8
C	C 3 x 6
D	C 3 x 6
E	L 3 x 3 x 3/8
F	L 5 x 5 x 3/8

* EXPANDED METAL DECKING
MIL-M-1719D TYPE 1 CLASS 1
NORMAL .92" x 2" OPENING
1.8#/SF (MIN) OVERALL
THICKNESS .312"

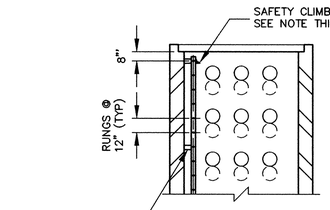




RISER REBAR
NTS

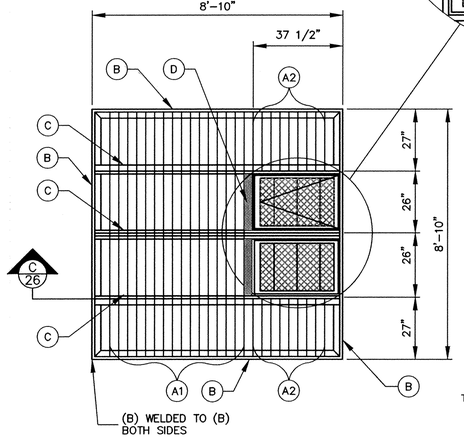


RISER PLAN VIEW
SCALE: 1" = 5'

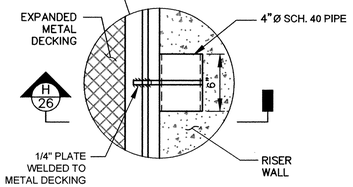


NOTE:
3/4" ø STAINLESS STEEL WEDGE ANCHOR 3" MIN EMBEDMENT (REDHEAD, HILTI OR APPROVED EQUAL)

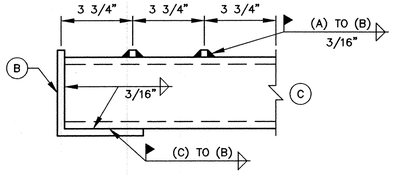
G SECTION
SCALE: 1" = 5'



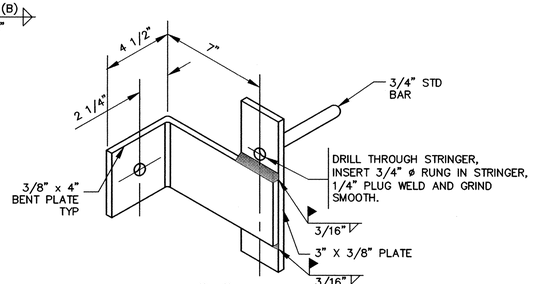
RISER GRATE-PLAN
NTS



LOCKING MECHANISM
NTS

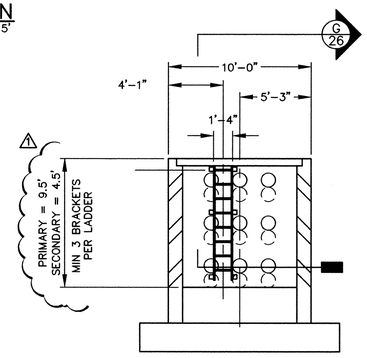


C SECTION
NTS



DETAIL "B"

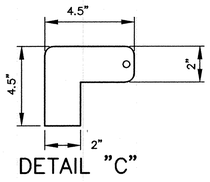
LADDER BRACKET DETAIL
NTS



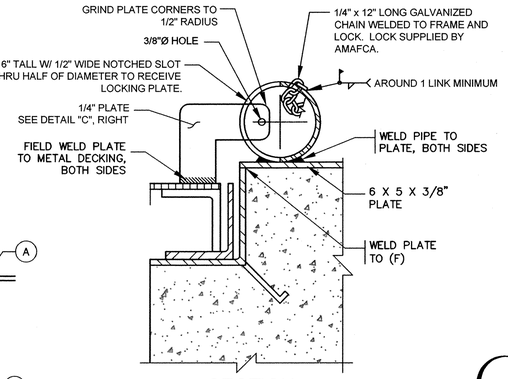
RISER LADDER ELEVATION
SCALE: 1" = 5'

SAFETY LADDER NOTES:

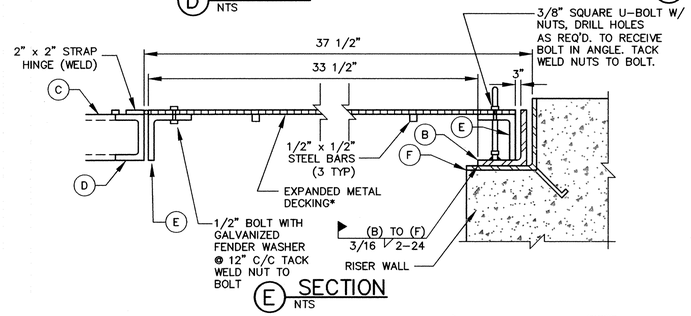
1. SAFETY LADDER SHALL BE GALVANIZED A-36 STEEL AND SHALL MEET ALL REQUIREMENTS OF OSHA REGARDLESS OF DETAILS SHOWN.



DETAIL "C"

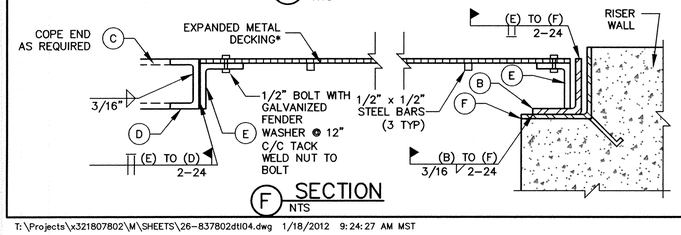


H SECTION
NTS

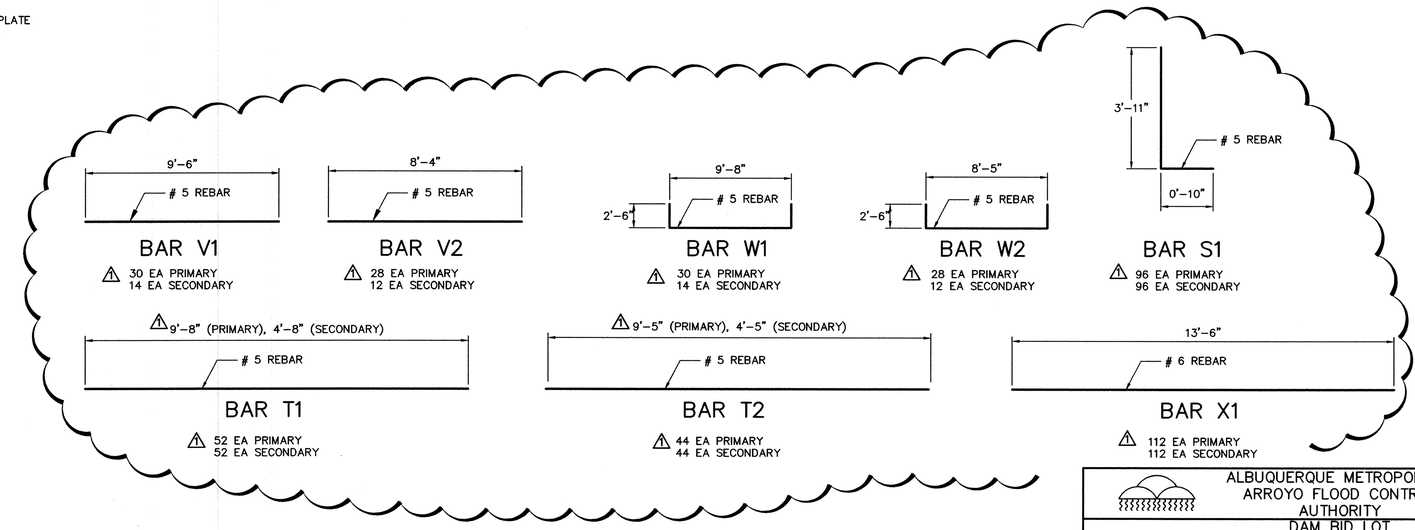


D SECTION
NTS

E SECTION
NTS



F SECTION
NTS



AS-BUILT INFORMATION
CONTRACTOR SALLS BROTHERS

WORK STAKED BY	WAYDAN	DATE 10/14
WORK INSPECTED/ ACCEPTANCE BY	WCI	DATE 10/14
FIELD VERIFICATION BY	WCI	DATE 10/14
DRAWINGS COMPILED BY	WCI	DATE 10/14

MICRO-FILM INFORMATION
RECORDED BY — DATE
NO.

BENCH MARKS

THE STATION IS A 3 1/2" ALUMINIUM CAP SET FLUSH IN THE LAVA OUTCROP, AND IS STAMPED "ACS 8-C10, 1986". (NAD 1927).
E= 361860.83, N= 1521476.37
LAT 35° 10' 51.940" LONG 106° 42' 44.230"
TRUNCATED: E=-300,000, N=-1,500,000
COMBINED GROUND TO GRID = 0.999664705
ELEVATION = 5392.936 FT. (NAVD 88)

SURVEY INFORMATION
FIELD NOTES

NO.	BY	DATE

ENGINEER'S SEAL
DANIEL S. GUTIERREZ 15955 REGISTERED PROFESSIONAL ENGINEER

NO.	DATE	REVISIONS / REMARKS	BY	DSA
1	01-26-13	REBAR QUANTITY REVISIONS		

WILSON & COMPANY, ENGINEERS & ARCHITECTS
DESIGNED BY JSD DATE APRIL 2011
DRAWN BY STAFF DATE APRIL 2011
CHECKED BY DSA DATE APRIL 2011

RECORD DRAWING
DATE 10/14

WCEA #X321807802
APRIL 2011

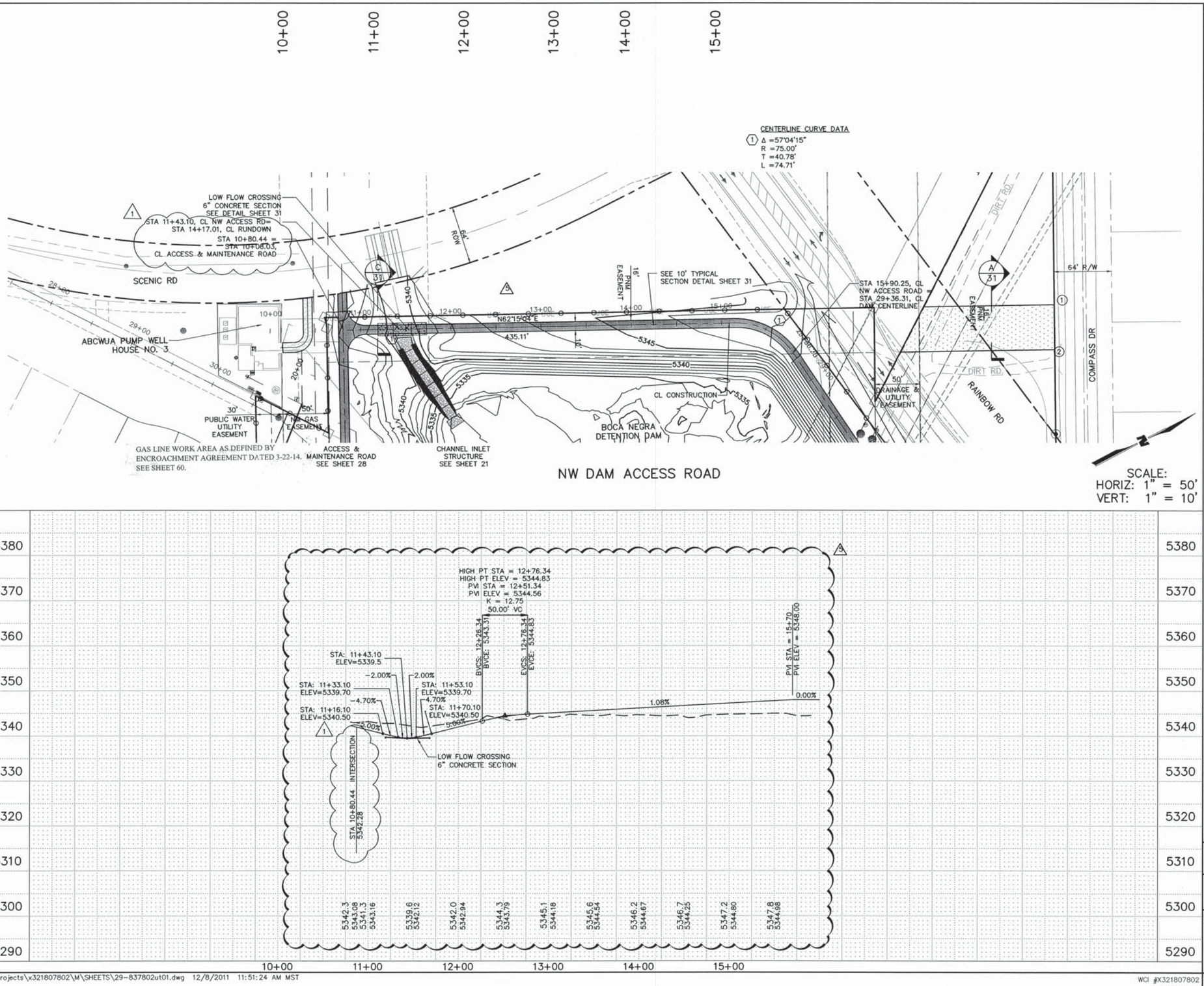
ALBUQUERQUE METROPOLITAN ARROYO FLOOD CONTROL AUTHORITY
DAM BID LOT
RISER DETAILS

Design Review Committee	City Engineer Approval	Last Design Update	Mo./Day/Yr.	Mo./Day/Yr.

City Project No.	Zone Map No.	Sheet
781181	D- 9/10	26R OF 56 62

WILSON & COMPANY

T:\Projects\x321807802\M\SHEETS\26-837802dtl04.dwg 1/18/2012 9:24:27 AM MST



LEGEND:

- 10' WIDE ASPHALT ACCESS ROAD SEE SHEET 31
- 10' WIDE CONCRETE ACCESS ROAD SEE SHEET 31
- PNM ACCESS ROAD

AS-BUILT INFORMATION

CONTRACTOR: SALLS BROTHERS

WORK STAKED BY:	WARD NW	DATE 10/14
INSPECTOR'S ACCEPTANCE BY:	WCI	DATE 10/14
FIELD VERIFICATION BY:	WCI	DATE 10/14
DRAWING CORRECTED BY:	WCI	DATE 10/14

MICRO-FILM INFORMATION

RECORDED BY: DATE

NO.

BENCH MARKS

THE STATION IS A 3 1/2" ALUMINUM CAP SET FLUSH IN THE LAVA OUTCROP, AND IS STAMPED "ACS 8-C10, 1986". (NAD 1927).
E= 361860.83, N= 1521476.37
TRUNCATED: E=-300,000, N=-1,500,000
COMBINED GROUND TO GRID = 0.9996664705
ELEVATION = 5392.936 FT. (NAVD 88)

SURVEY INFORMATION

FIELD NOTES

NO.	BY	DATE

ENGINEER'S SEAL

DANIEL S. AGUIRRE
NEW MEXICO
(11955)
REGISTERED PROFESSIONAL ENGINEER

NO.	DATE	REMARKS	BY
1	10-9-13	REVISED PROFILE	DMD
2	3-6-13	REVISE TYPO	PAS

REVISIONS

WILSON & COMPANY, ENGINEERS & ARCHITECTS

DESIGNED BY	JSD	DATE APRIL 2011
DRAWN BY	STAFF	DATE APRIL 2011
CHECKED BY	OSA	DATE APRIL 2011

RECORD DRAWING
DATE 10/14

ALBUQUERQUE METROPOLITAN ARROYO FLOOD CONTROL AUTHORITY

DAM BID LOT

NW DAM ACCESS ROAD PLAN & PROFILE

Design Review Committee	City Engineer Approval	Last Design Update	Mo./Day/Yr.	Mo./Day/Yr.

City Project No.	Zone Map No.	Sheet
781181	D- 9/10	29R OF 5562

T:\Projects\x321807802\M\SHEETS\29-837802ut01.dwg 12/8/2011 11:51:24 AM MST

WCI #X321807802
APRIL 2011

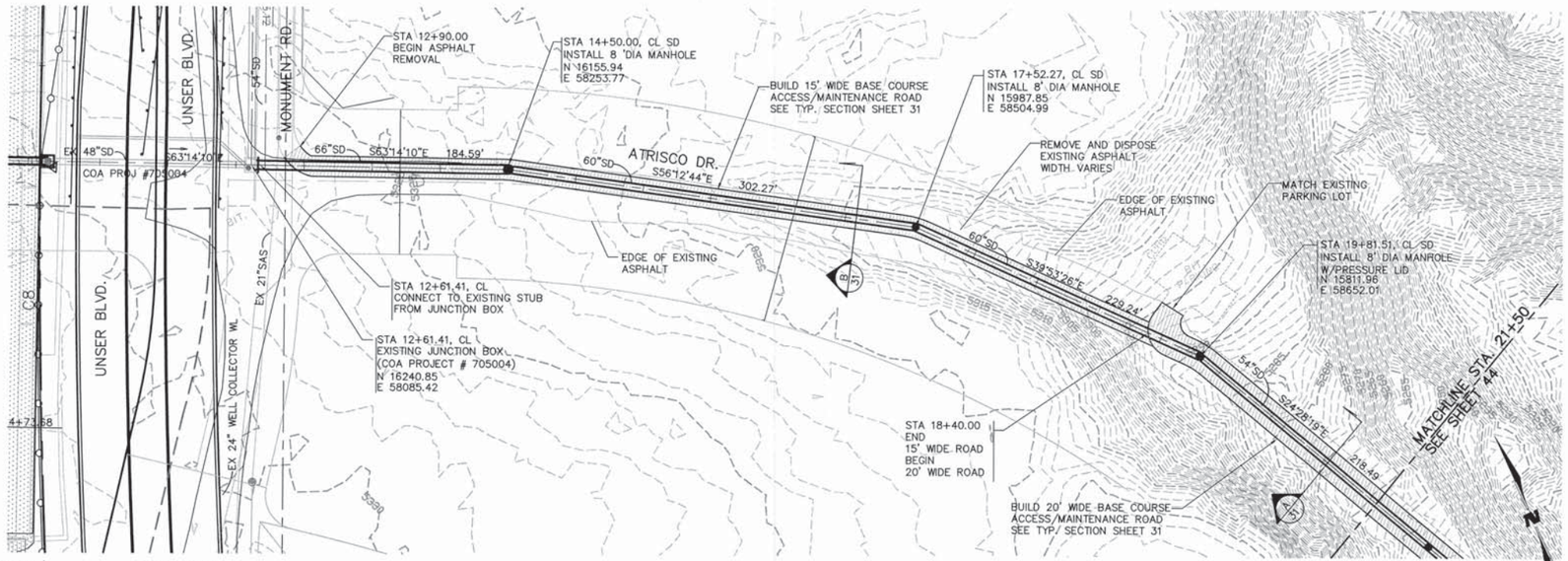
WILSON & COMPANY

NOTE:
PRESSURE LID AT STA. 19+81.51 IS INCIDENTAL TO MANHOLE BID ITEM

NOTE:
CONTRACTOR TO REMAIN WITHIN RIGHT OF WAY AND DRAINAGE EASEMENT AT ALL TIMES.

LEGEND

ATRISCO DR. BASECOURSE TRAIL

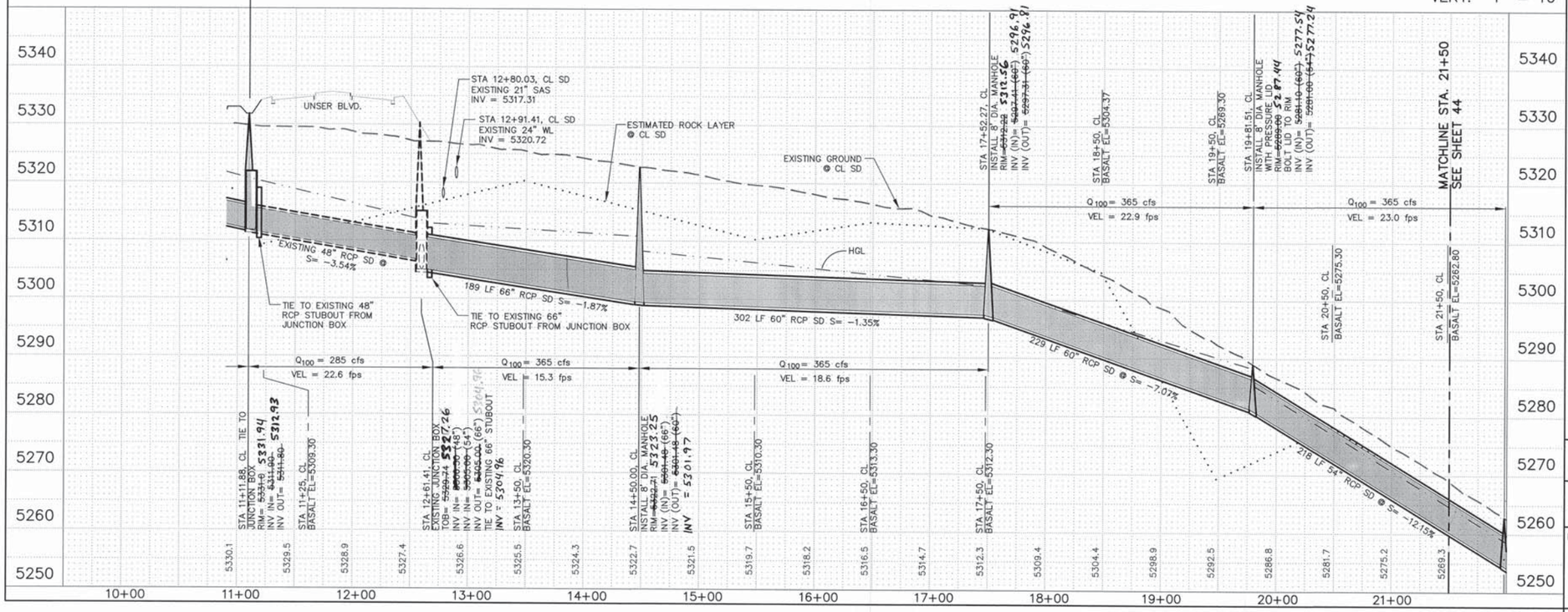


PRIMARY PRINCIPAL SPILLWAY SEE SHEET 18

ATRISCO STORM DRAIN

ATRISCO STORM DRAIN

SCALE:
HORIZ: 1" = 50'
VERT: 1" = 10'



WCI #X321807802
APRIL 2011

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AS-BUILT INFORMATION
CONTRACTOR SALLS BROTHERS
WORK STAKED BY WAYNE HW DATE 10/14
ACCEPTANCE BY WCI DATE 10/14
FIELD INSPECTION BY WCI DATE 10/14
DRAWINGS REVISED BY WCI DATE 10/14
MICRO-FILM INFORMATION
RECORDED BY DATE
NO.

BENCH MARKS
THE STATION IS A 3 1/2" ALUMINIUM CAP SET FLUSH IN THE LAVA OUTCROP, AND IS STAMPED "ACS 8-C10, 1986". (NAD 1927).
E= 361860.83, N= 1521476.37
TRUNCATED: E=-300,000, N=-1,500,000
COMBINED GROUND TO GRID = 0.999664705
ELEVATION = 5392.936 FT. (NAVD 88)

SURVEY INFORMATION
FIELD NOTES
NO. BY DATE

ENGINEER'S SEAL
NEW MEXICO 15955 REGISTERED PROFESSIONAL ENGINEER

NO. DATE REMARKS BY
REVISIONS
WILSON & COMPANY, ENGINEERS & ARCHITECTS
DESIGNED BY JSD DATE APRIL 2011
DRAWN BY STAFF DATE APRIL 2011
CHECKED BY DSA DATE APRIL 2011

RECORD DRAWING
DATE 10/14

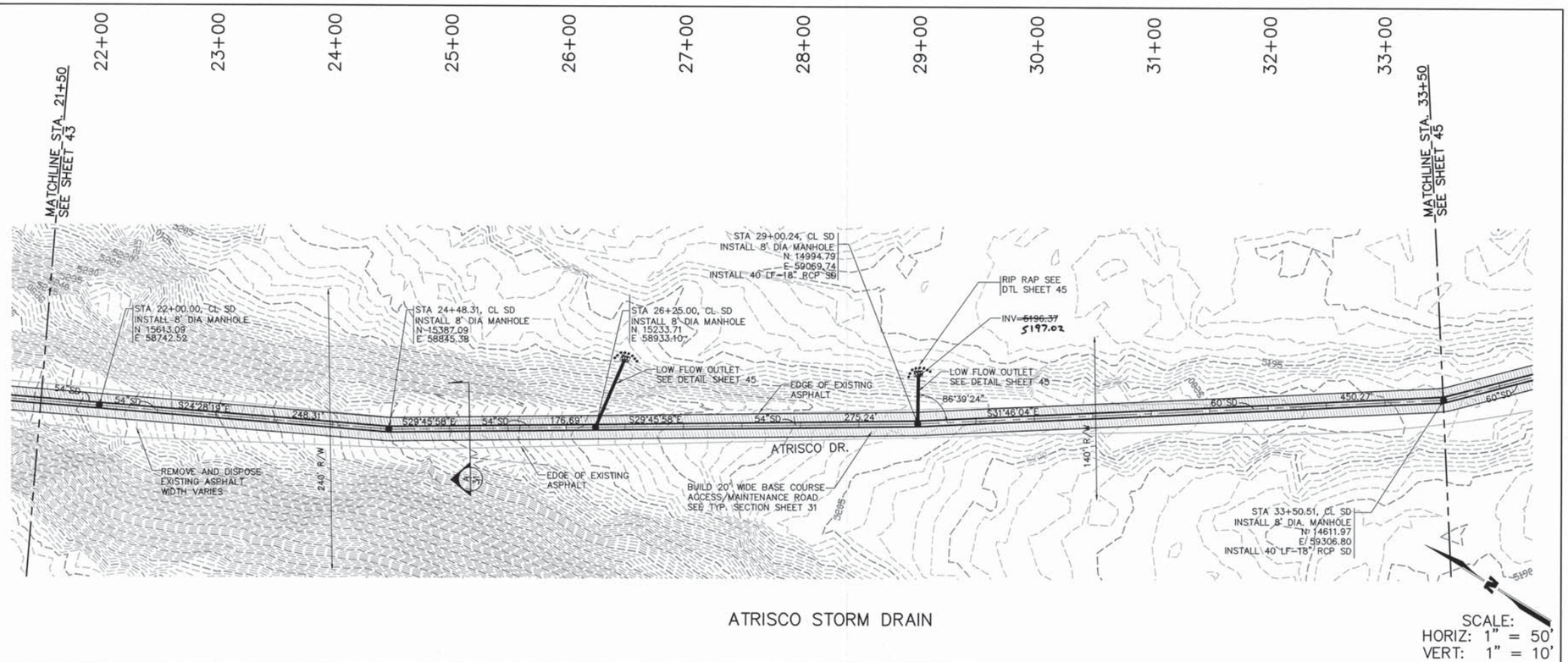
ALBUQUERQUE METROPOLITAN ARROYO FLOOD CONTROL AUTHORITY
DAM BID LOT

ATRISCO STORM DRAIN PLAN & PROFILE STA. 11+11.88 TO STA. 21+50.00

Design Review Committee: APPROVED FEB 10 2012 DESIGN REVIEW COMMITTEE
City Engineer Approval: APPROVED FEB 10 2012 CITY ENGINEER
Last Design Update: Mo./Day/Yr.

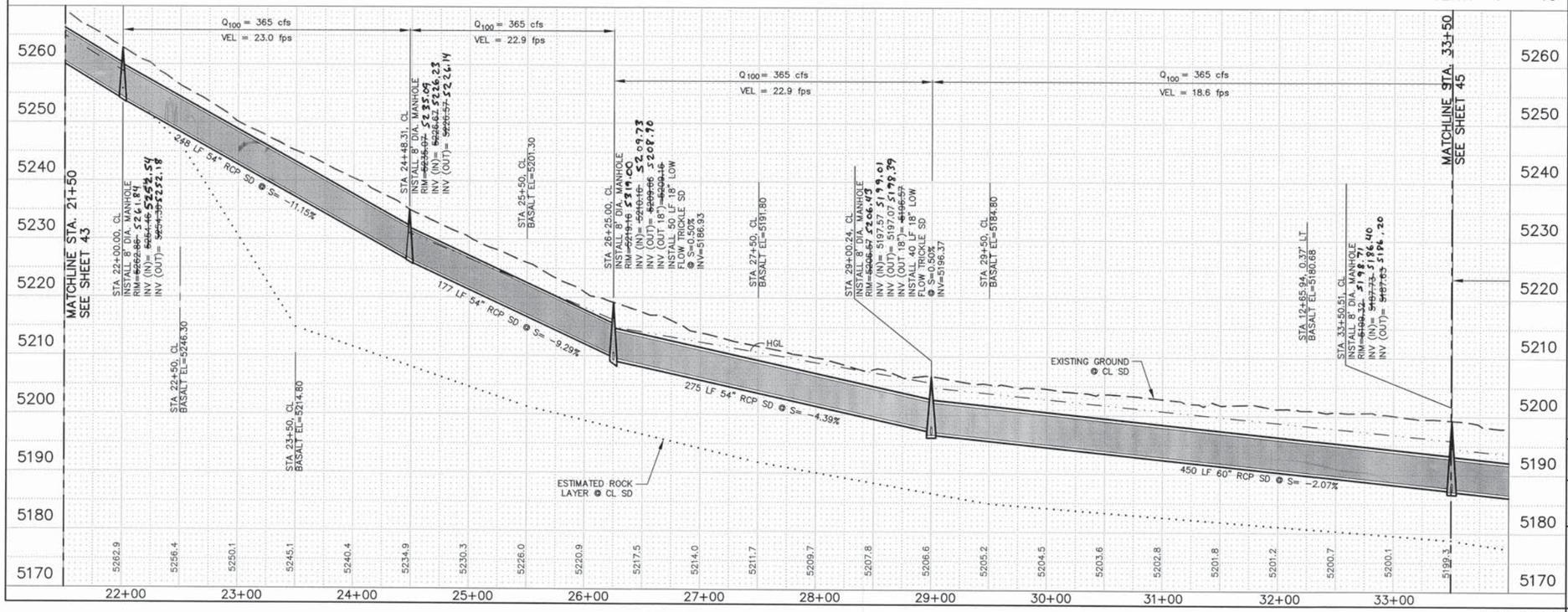
City Project No. 781181
Zone Map No. D- 9/10
Sheet 43 OF 55 62

WILSON & COMPANY



ATRISCO STORM DRAIN

SCALE:
HORIZ: 1" = 50'
VERT: 1" = 10'



NOTE:
CONTRACTOR TO REMAIN WITHIN RIGHT OF WAY AND DRAINAGE EASEMENT AT ALL TIMES.

LEGEND

ATRISCO DR. BASECOURSE TRAIL

AS-BUILT INFORMATION
CONTRACTOR SALLS BROTHERS
WORK STAKED BY: VANDAM DATE 10/14
ACCEPTANCE BY: WCI DATE 10/14
FIELD VERIFICATION BY: WCI DATE 10/14
DRAWINGS CORRECTED BY: WCI DATE 10/14
TRUNCATED: E=-300,000, N=-1,500,000 MICRO-FILM INFORMATION
COMBINED GROUND TO GRID = 0.999664705 RECORDED BY DATE
ELEVATION = 5392.936 FT. (NAVD 88) NO.

BENCH MARKS
THE STATION IS A 3 1/2" ALUMINUM CAP SET FLUSH IN THE LAVA OUTCROP, AND IS STAMPED "ACS 8-C10, 1986". (NAD 1927).
E= 361860.83, N= 1521476.37

SURVEY INFORMATION
FIELD NOTES

NO.	BY	DATE

ENGINEER'S SEAL
JAMES S. AGUILAR 15955 REGISTERED PROFESSIONAL ENGINEER

NO.	DATE	REMARKS	BY
		REVISIONS	

WILSON & COMPANY, ENGINEERS & ARCHITECTS
DESIGNED BY JSD DATE APRIL 2011
DRAWN BY STAFF DATE APRIL 2011
CHECKED BY DSA DATE APRIL 2011

RECORD DRAWING
DATE 10/14

ALBUQUERQUE METROPOLITAN
ARROYO FLOOD CONTROL
AUTHORITY
DAM BID LOT

ATRISCO STORM DRAIN PLAN & PROFILE
STA. 21+50.00 TO STA. 33+50.00

Design Review Committee	City Engineer Approval	Last Design Update	Mo./Day/Yr.	Mo./Day/Yr.
APPROVED FEB 10 2012 DESIGN REVIEW COMMITTEE	APPROVED FEB 10 2012 CITY ENGINEER			

City Project No. 781181 | Zone Map No. D- 9/10 | Sheet 44 OF ~~55~~ 62

WCI #X321807802
APRIL 2011

WILSON & COMPANY

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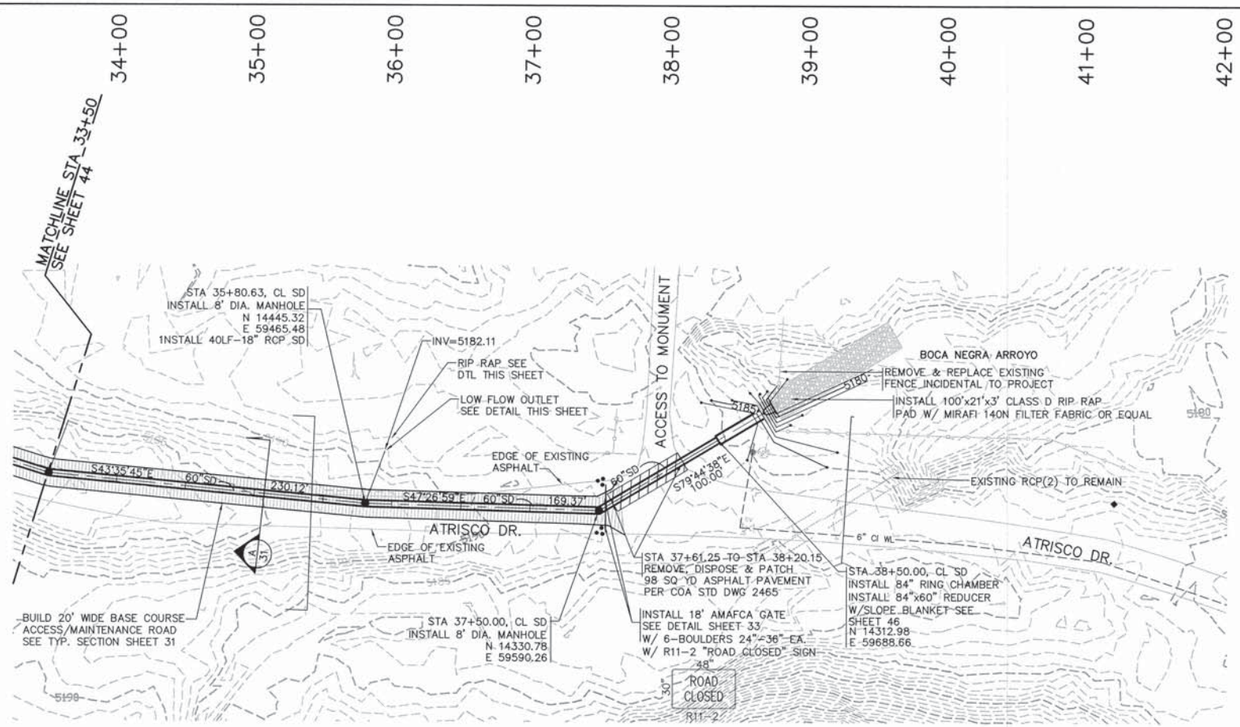
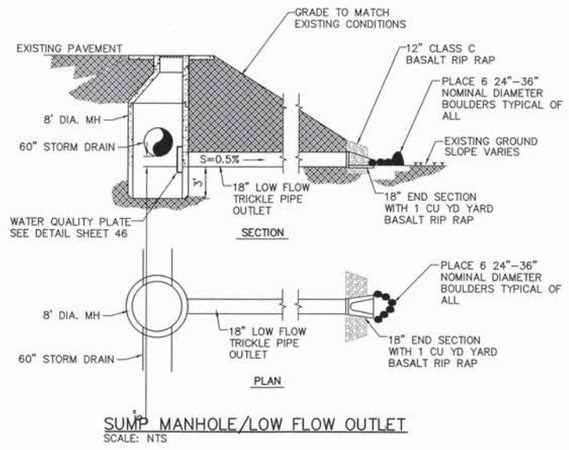


ATRISCO STORM DRAIN



SUMP MANHOLE/LOW FLOW OUTLET
SCALE: NTS

NOTE:

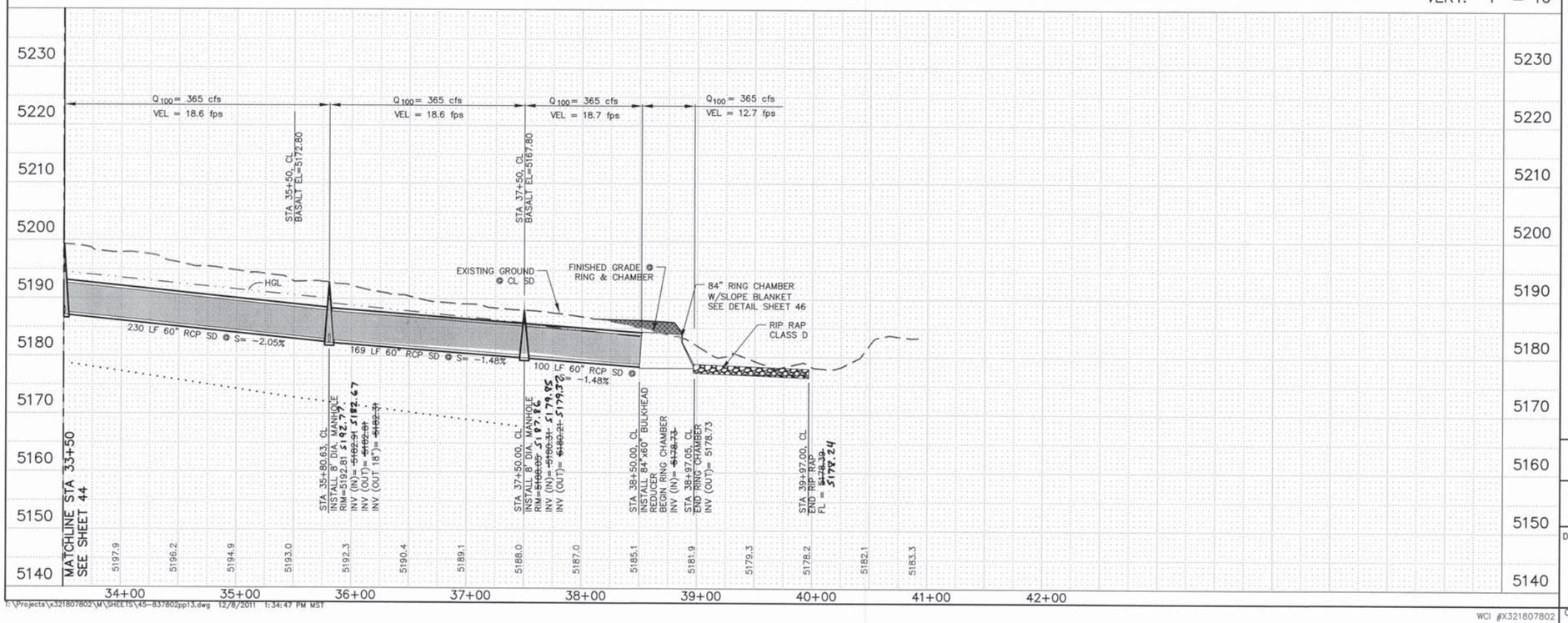
1. CONTRACTOR SHALL COORDINATE WITH THE NATIONAL PARK SERVICE TO CLOSE ENTRANCE ROAD FOR STORM DRAIN CONSTRUCTION DURING NON PARK HOURS.

NOTE:
CONTRACTOR TO REMAIN WITHIN RIGHT OF WAY AND DRAINAGE EASEMENT AT ALL TIMES.

LEGEND

ATRISCO DR. BASECOURSE TRAIL

SCALE:
HORIZ: 1" = 50'
VERT: 1" = 10'



RECORD DRAWING
DATE 10/19

NO.	DATE	BENCH MARKS	SURVEY INFORMATION
		THE STATION IS A 3 1/2" ALUMINIUM CAP SET FLUSH IN THE LAVA OUTCROP, AND IS STAMPED "ACS 8-C10, 1986". (NAD 1927). E= 361860.83, N= 1521476.37 TRUNCATED: E=-300,000, N=-1,500,000 COMBINED GROUND TO GRID = 0.999664705 ELEVATION = 5392.936 FT. (NAVD 88)	FIELD NOTES BY

AS-BUILT INFORMATION		
CONTRACTOR	SALLS BROTHERS	DATE 10/14
STAKED BY	VARGAS	DATE 10/14
INSPECTORS	VCI	DATE 10/14
FIELD REVISIONS BY	VCI	DATE 10/14
DRAWINGS CORRECTED BY	VCI	DATE 10/14
MICRO-FILM INFORMATION		
RECORDED BY		DATE
NO.		

ENGINEER'S SEAL

NO.	DATE	REMARKS / REVISIONS	BY

WILSON & COMPANY, ENGINEERS & ARCHITECTS

DESIGNED BY	JSD	DATE APRIL 2011
DRAWN BY	STAFF	DATE APRIL 2011
CHECKED BY	DSA	DATE APRIL 2011

ALBUQUERQUE METROPOLITAN ARROYO FLOOD CONTROL AUTHORITY
DAM BID LOT
ATRISCO STORM DRAIN PLAN & PROFILE
STA. 33+50.00 TO STA. 40+00.00

Design Review Committee	City Engineer Approval	Last Design Update	Mo./Day/Yr.	Mo./Day/Yr.
APPROVED FEB 10 2012 DESIGN REVIEW COMMITTEE	APPROVED FEB 10 2012 CITY ENGINEER			

City Project No.	Zone Map No.	Sheet
781181	D- 9/10	45 OF 5562

WCI #X321807802
APRIL 2011

WILSON & COMPANY

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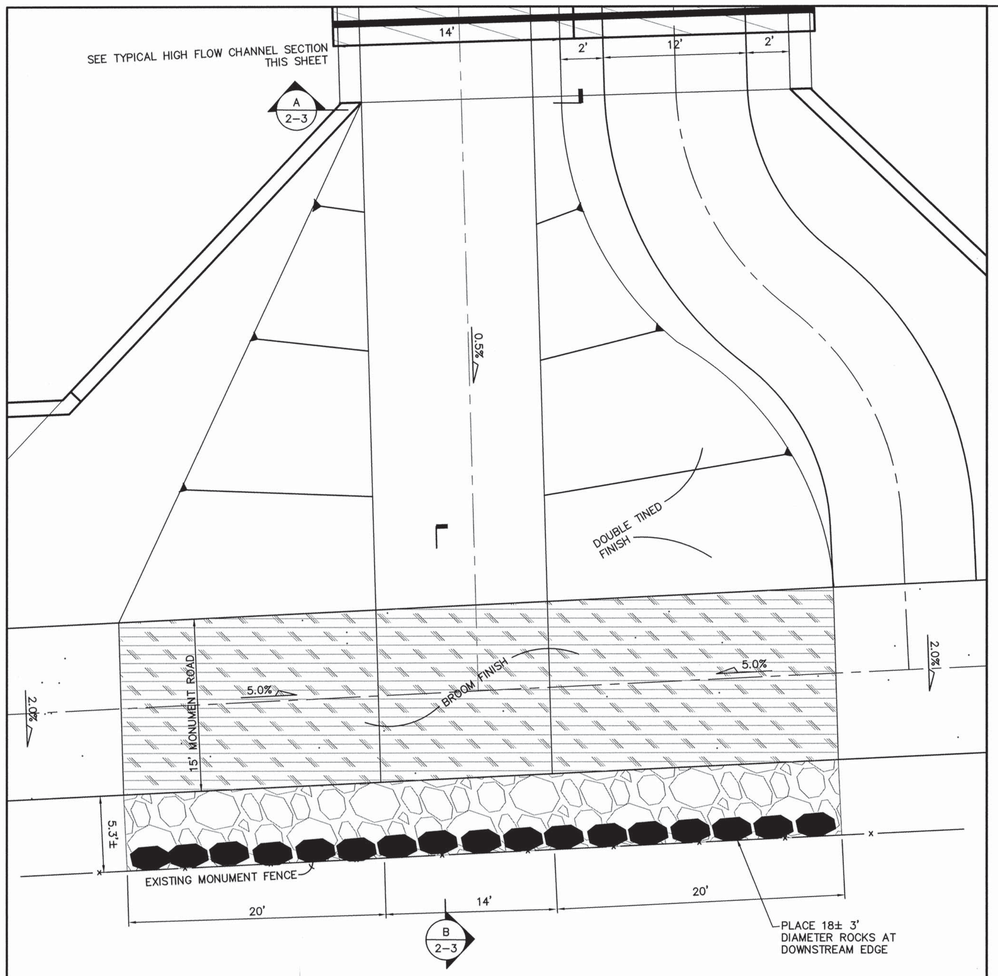
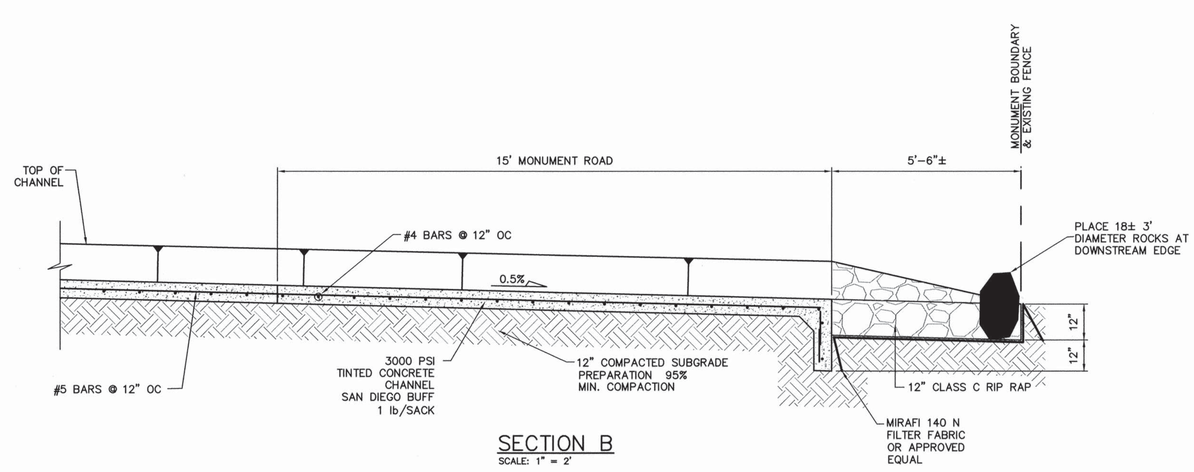


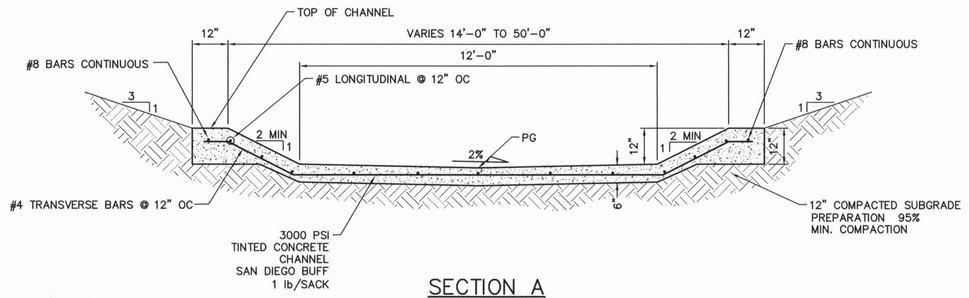
HIGH FLOW CHANNEL PLAN VIEW

SCALE: 1" = 5'



SECTION B

SCALE: 1" = 2'



SECTION A

TYPICAL HIGH FLOW CHANNEL

SCALE: 1" = 2'

AS-BUILT INFORMATION

CONTRACTOR

WORK STAKED BY — DATE

INSPECTANCE BY — DATE

FIELD VERIFICATION BY — DATE

DRAWINGS CORRECTED BY — DATE

MICRO-FILM INFORMATION

RECORDED BY — DATE

NO.

BENCH MARKS

THE STATION IS A 3 1/2" ALUMINIUM CAP SET FLUSH IN THE LAVA OUTCROP, AND IS STAMPED "ACS 8-C10, 1986". (NAD 1927).

X= 361860.83, Y= 1521476.37

ELEVATION = 5390.130 FT. (SLD 1929)

SURVEY INFORMATION

FIELD NOTES

NO.	DATE	BY

ENGINEER'S SEAL

NEW MEXICO — 11955 — REGISTERED PROFESSIONAL ENGINEER

11/9/06

NO.	DATE	REMARKS	BY

REVISIONS

WILSON & COMPANY, ENGINEERS & ARCHITECTS

DESIGNED BY — JSD — DATE OCT. 06

DRAWN BY — STAFF — DATE OCT. 06

CHECKED BY — DSA — DATE OCT. 06

ALBUQUERQUE METROPOLITAN ARROYO FLOOD CONTROL AUTHORITY

TRAIL / OUTLET BID LOT

HIGH FLOW DETAILS

Design Review Committee	City Engineer Approval	Last Design Update	Mo./Day/Yr.	Mo./Day/Yr.

City Project No.	Zone Map No.	Sheet	Of
781181	D- 9/10	2 - 3	

WCEA #X321807802
OCT. 2006

WILSON & COMPANY

47 OF 89

T:\Projects\x321807802\M\SHEETS\BID LOT 2\837802dt022.dwg 1/3/2006 7:38:00 AM MST

62+00

63+00

64+00

12+00

13+00

℄ ABUT. NO. 1
STA. 62+67.19
ELEV. 5333.33

℄ ABUT. NO. 2
STA. 62+98.69
ELEV. 5333.41

℄ UNSER STA. 62+74.94 =
℄ CHANNEL STA. 12+33.33

STA. 62+66.44
BACK OF ABUTMENT

STA. 62+99.44
BACK OF ABUTMENT

PROFILE GRADE

N 27° 49' 32.76" E

1'-6"
5'-0"
8'-0"
12'-0"
12'-0"
4'-0"
9'-6"
9'-6"
1'-6"
12'-0"
12'-0"
8'-0"
5'-0"
1'-6"

COLORED CONCRETE,
SEE GENERAL NOTE 4,
SHEET 2-7

℄ MULTI-USE TRAIL

℄ HIGH FLOW CHANNEL

RETAINING WALL,
SEE ROADWAY PLANS

RETAINING WALL,
SEE ROADWAY PLANS

STRUCTURE PLAN
SCALE 1" = 10'

AS-BUILT INFORMATION

CONTRACTOR
WORK STAKED BY — DATE
WORK INSPECTED BY — DATE
FIELD ACCEPTANCE BY — DATE
FIELD VERIFICATION BY — DATE
DRAWINGS CORRECTED BY — DATE
MICRO-FILM INFORMATION
RECORDED BY — DATE
NO.

BENCH MARKS

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X= 361860.83, Y= 1521476.37

ELEVATION = 5390.130 FT. (SLD 1929)

SURVEY INFORMATION
FIELD NOTES

NO.	BY	DATE

ENGINEER'S SEAL

GARY W. KINCHEN
NEW MEXICO
14366
REGISTERED PROFESSIONAL ENGINEER
OCTOBER 17, 2006

NO.	DATE	REMARKS	BY
		REVISIONS	

WILSON & COMPANY, ENGINEERS & ARCHITECTS

DESIGNED BY	GWK	DATE OCT 2006
DRAWN BY	CRH	DATE OCT 2006
CHECKED BY	RSM	DATE OCT 2006

ALBUQUERQUE METROPOLITAN
ARROYO FLOOD CONTROL
AUTHORITY

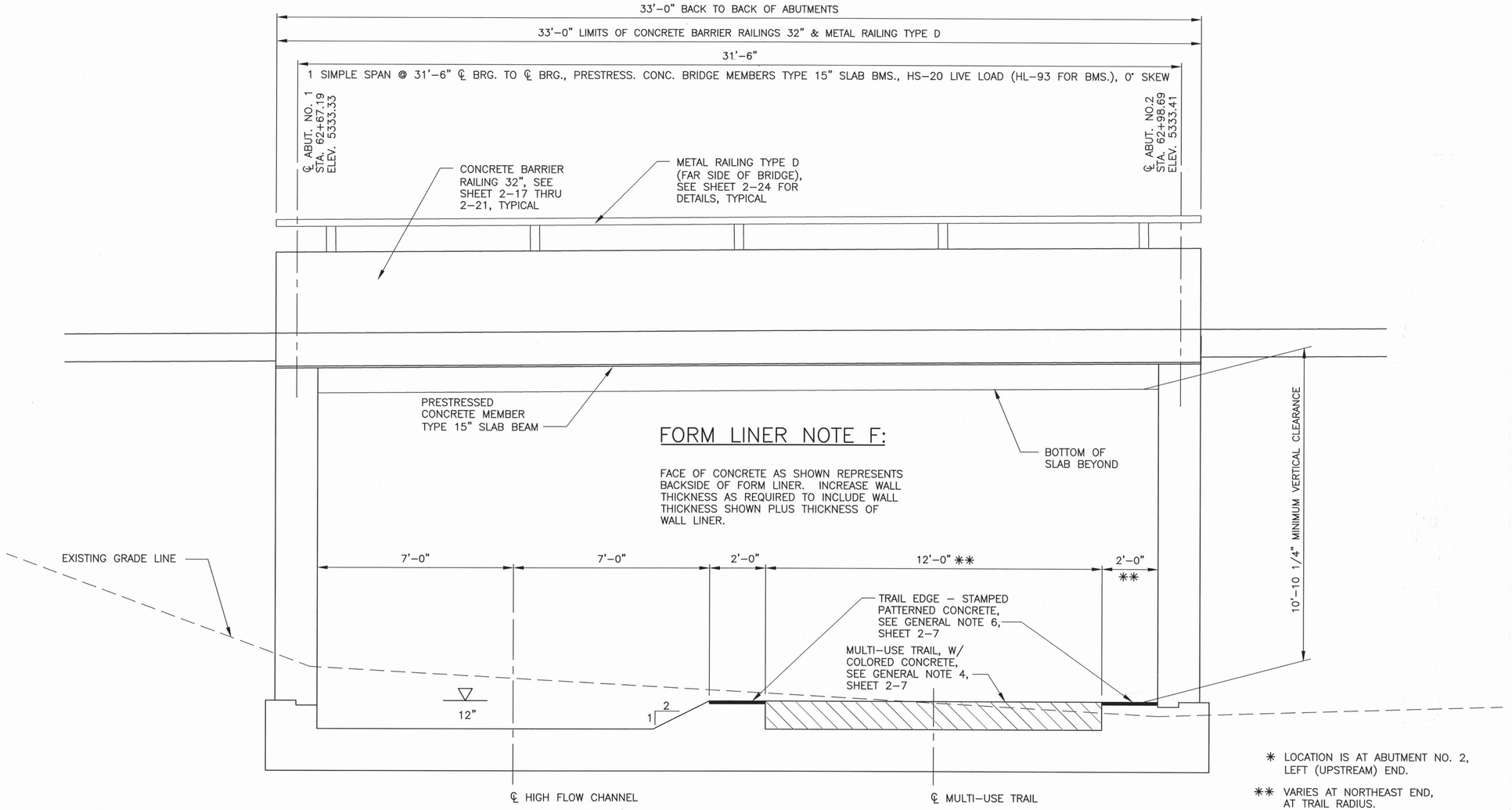
BOCA NEGRA DETENTION DAM
UNSER BLVD. OVER HIGH FLOW CHANNEL
STRUCTURE PLAN

Design Review Committee	City Engineer Approval	Last Design Update	Mo./Day/Yr.	Mo./Day/Yr.

City Project No.	Zone Map No.	Sheet	Of
781181	D- 9/10	2 - 8	

WCEA #X321807802
JULY 2006

WILSON & COMPANY



* LOCATION IS AT ABUTMENT NO. 2, LEFT (UPSTREAM) END.

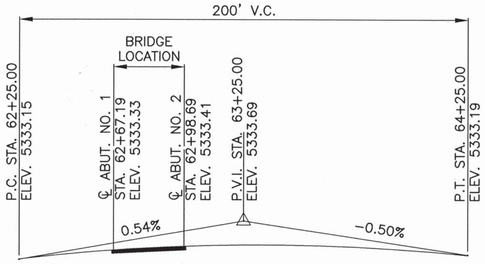
** VARIES AT NORTHEAST END, AT TRAIL RADIUS.

ELEVATION ALONG CENTERLINE OF PROFILE GRADE LINE

SCALE 1/2" = 1'-0"

FOUNDATION PREPARATION NOTES

1. OVER-EXCAVATE TO A DEPTH OF FIVE FEET BELOW BOTTOMS OF FOUNDATIONS AND FOR A DISTANCE OF FIVE FEET LATERALLY BEYOND PERIMETER OF FOUNDATIONS, AND REPLACE WITH STRUCTURAL FILL.
2. SCARIFY EXISTING SURFACE OF NATIVE SOILS TO A DEPTH OF 12", MOISTURE CONDITION TO NEAR OPTIMUM MOISTURE CONTENT (+ 3%), AND COMPACT TO 95% MAXIMUM DENSITY AS DETERMINED BY ASTM D-1557. WHERE BASALT IS ENCOUNTERED PRIOR TO ACHIEVING FIVE FEET OF OVER-EXCAVATION, NO ADDITIONAL OVER-EXCAVATION IS REQUIRED AND NO COMPACTION OF NATIVE SOILS IS REQUIRED.
3. STRUCTURAL FILL: SEE PROJECT SPECIFICATIONS FOR STRUCTURAL FILL AND PLACEMENT REQUIREMENTS.



PROFILE GRADE LINE - UNSER BLVD.

NOT TO SCALE

AS-BUILT INFORMATION
CONTRACTOR
WORK STAKED BY / INSPECTION ACCEPTANCE BY / FIELD LOCATION BY / DRAWINGS CORRECTED BY — DATE

BENCH MARKS
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X= 361860.83, Y= 1521476.37
ELEVATION = 5390.130 FT. (SLD 1929)

MICRO-FILM INFORMATION
RECORDED BY — DATE
NO.

SURVEY INFORMATION
FIELD NOTES
NO. | BY | DATE

ENGINEER'S SEAL
GARY W. KINCHEN
NEW MEXICO
14366
REGISTERED PROFESSIONAL ENGINEER
OCTOBER 17, 2006

REVISIONS
NO. | DATE | REMARKS | BY

WILSON & COMPANY, ENGINEERS & ARCHITECTS
DESIGNED BY GWK DATE OCT 2006
DRAWN BY CRH DATE OCT 2006
CHECKED BY RSM DATE OCT 2006

ALBUQUERQUE METROPOLITAN ARROYO FLOOD CONTROL AUTHORITY

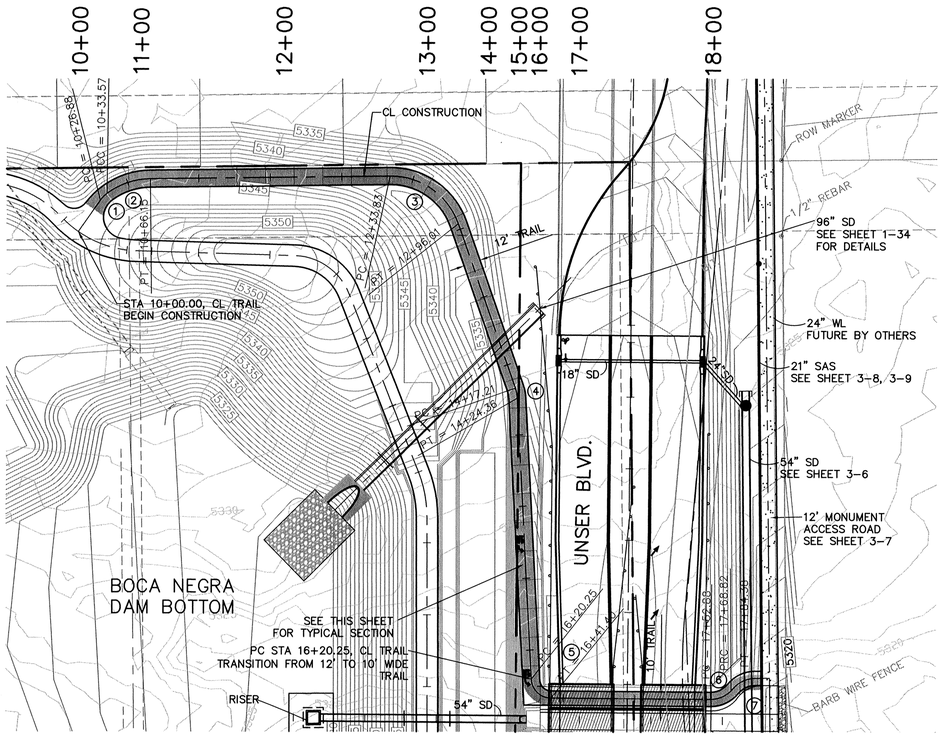
BOCA NEGRA DETENTION DAM
UNSER BLVD. OVER HIGH FLOW CHANNEL
STRUCTURE PROFILE

Design Review Committee	City Engineer Approval	Last Design Update	Mo./Day/Yr.	Mo./Day/Yr.

City Project No.	Zone Map No.	Sheet	Of
781181	D- 9/10	2 - 9	

WCEA #X321807802
JULY 2006
WILSON & COMPANY

51 OF 89



MULTI-USE TRAIL

PLAN

CL CURVE DATA
① Δ =18°15'26"
R =21.00'
T =3.37'
L =6.69'

CL CURVE DATA
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R =51.50'
T =16.85'
L =32.58'

CL CURVE DATA
③ Δ =71°14'58"
R =50.00'
T =35.85'
L =62.18'

CL CURVE DATA
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T =3.60'
L =7.15'

CL CURVE DATA
⑤ Δ =86°33'38"
R =14.00'
T =13.18'
L =21.15'

CL CURVE DATA
⑥ Δ =45°39'56"
R =20.00'
T =8.42'
L =15.94'

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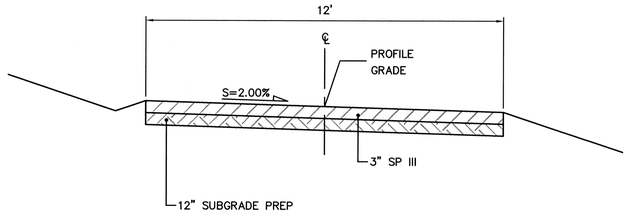


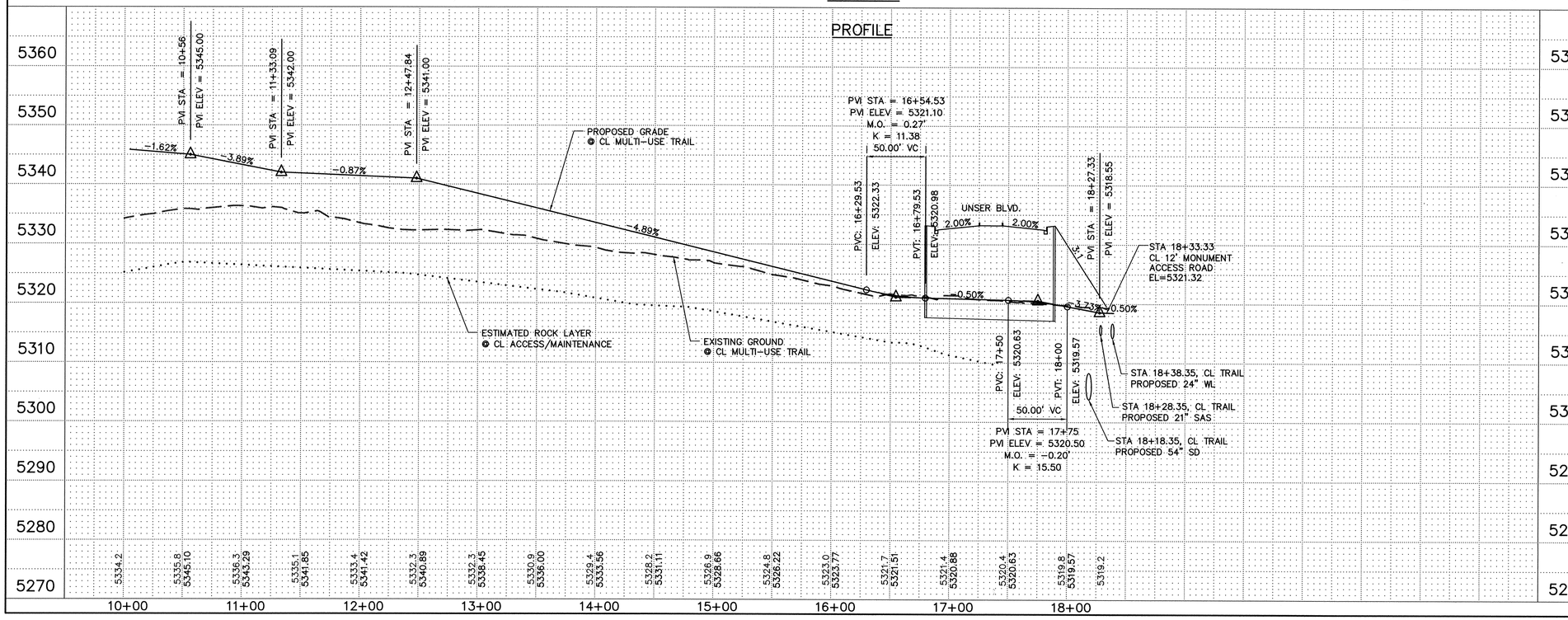
TYPICAL SECTION
12' MULTI-USE TRAIL
N.T.S.

NOTE:

1. SEE SHEET 3-19 FOR SIGNING STRIPING

SCALE:
HORIZ: 1" = 50'
VERT: 1" = 10'

PROFILE



WCEA #X321807802
OCT. 2006

T:\Projects\x321807802\M\SHEETS\BID LOT 2\837802pp02.dwg 10/23/2006 9:52:04 AM MST

AS-BUILT INFORMATION
CONTRACTOR
WORK STAKED BY — DATE
INSPECTIONS BY — DATE
FIELD REVISIONS BY — DATE
DRAWINGS CORRECTED BY — DATE
MICRO-FILM INFORMATION
RECORDED BY — DATE
NO.

BENCH MARKS
THE STATION IS A 3 1/2" ALUMINIUM CAP SET FLUSH IN THE LAVA OUTCROP, AND IS STAMPED "ACS 8-C10, 1986". (NAD 1927).
X= 361860.83, Y= 1521476.37
ELEVATION = 5390.130 FT. (SLD 1929)

SURVEY INFORMATION
FIELD NOTES
NO. | BY | DATE

ENGINEER'S SEAL
JOHN S. KELLY NEW MEXICO 11955 REGISTERED PROFESSIONAL ENGINEER

NO.	DATE	REMARKS	BY
		REVISIONS	

WILSON & COMPANY, ENGINEERS & ARCHITECTS
DESIGNED BY — JSD — DATE OCT. 06
DRAWN BY — STAFF — DATE OCT. 06
CHECKED BY — RSM — DATE OCT. 06

ALBUQUERQUE METROPOLITAN ARROYO FLOOD CONTROL AUTHORITY

TRAIL / OUTLET BID LOT
MULTI-USE TRAIL
PLAN & PROFILE

Design Review Committee	City Engineer Approval	Last Design Update	Mo./Day/Yr.	Mo./Day/Yr.

City Project No. 781181 | Zone Map No. D- 9/10 | Sheet 2 Of 2

WILSON & COMPANY

APPENDIX 4 (CD)

OPERATION & MAINTENANCE PLAN

CITY OF ALBUQUERQUE

AMAFCA - Volumes 1-3

MAINTENANCE RESPONSIBILITIES

The Boca Negra Detention Dam and outfall pipe storm drain will be maintained and operated by AMAFCA. The City of Albuquerque (COA) will maintain the Boca Negra Arroyo outside of the Dam. AMAFCA and COA have maintenance programs with crews that maintain all drainage facilities on a routine schedule to ensure facilities are operating as intended.

The City of Albuquerque, Public Works Department, Storm Drainage Maintenance Division is responsible for the operation and maintenance of storm drainage systems in the City. Storm drainage maintenance schedule is included on the CD provided with the LOMR document.

AMAFCA has prepared an Operation and Maintenance Manual for AMAFCA Flood Control Dams (O&M Manual), which is included on the CD provided with the LOMR document. The manual describes the general plan of operation, inspection, and maintenance for AMAFCA owned and operated flood control dams in the greater Albuquerque area. The intent of this manual is to give all operation, inspection, and maintenance personnel uniform guidance and procedures to ensure proper operations and maintenance for all AMAFCA's flood control dams. In addition, this document provides a unified and consistent process for communications and coordination with other flood control agencies in the area. This manual was prepared in conformance with the Rules and Regulations of the New Mexico Office of the State Engineer Dam Safety Bureau (NMOSE-DSB). Information, data or modifications pertinent to NMOSE-DSB jurisdictional dams will be coordinated through the NMOSE-DSB. The O&M Manual consists of three volumes:

- Volume 1: General Information: consisting of general information and appendices concerning inspection and maintenance for all AMAFCA dams. A glossary of terms is provided in Appendix A of the O&M Manual to familiarize staff with terms relating to dams. Inspection guidance is included in Appendix B of the O&M Manual and a blank inspection form is provided in Appendix C of the O&M Manual. The inspection / maintenance forms are designed for easy revision.
- Volume 2: Individual Dam Characteristics: containing individual sections with specific information and dam modification history concerning each dam. Complete as-built plans are located on a disk included in Volume 2 and are on file at AMAFCA.
- Volume 3: Publications: with supporting publications.

CITY OF ALBUQUERQUE

Department of Municipal Development

Wilfred A. Gallegos, Director

Richard J. Berry, Mayor

July 1, 2015

Federal Emergency Management Agency
LOMC Clearinghouse
847 South Pickett Street
Alexandria, VA 22304-4605

Re: Community: City of Albuquerque, New Mexico - Community No.: 350002

To whom it may concern:

The City of Albuquerque, Public Works Department, Storm Drainage Maintenance Division, is responsible for the operation and maintenance of storm drainage systems in the City. The Storm Drainage Maintenance Division has 14 full-time employees, and is equipped to perform maintenance operations for all types of storm drainage facilities. Maintenance operations include sediment removal, pipe cleaning and flushing, pipeline, manhole, inlet repair and construction, concrete channel repair, and vegetation control.

Storm drainage maintenance activities are on-going throughout the year. Drainage system components are maintained per the following schedule:

PO Box 1293

Albuquerque

New Mexico 87103

www.cabq.gov

System Component	Inspection	Maintenance
Pipes, Manholes, Inlets	Biannual-concentrating on valley areas, problem spots, and complaints	Cleaning done as part of inspection, with repairs and renovation as needed
Channels, Arroyos	Annual	Annual-as required
Detention Basins	Annual-and following complaints	Annual-Mowing Sediment Removal as required

The Storm Drainage Maintenance Division is managed by Phillip A. Romo, PE.

Sincerely,

Wilfred A Gallegos, P.E., Director

cc: Philip Romo, PE, Manager, Street/Storm Maintenance
Kevin Daggett, PE/PS, Storm Drain Design Section

OPERATION AND MAINTENANCE MANUAL
for
AMAFCA FLOOD CONTROL DAMS

located in
Bernalillo County, New Mexico

Revision 0
May 2011

Prepared by:
Albuquerque Metropolitan Arroyo Flood Control Authority
2600 Prospect Avenue NE
Albuquerque, NM 87107
(505) 884-2215

In Conjunction with:
URS Corporation
6501 Americas Parkway NE
Suite 900
Albuquerque NM 87110
(505)855-7500

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g) Inspection/Maintenance Log

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g) Inspection/Maintenance Log

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f) Dam Performance History
g) Inspection/Maintenance Log

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APPENDIX F: FEMA 534 Technical manual for Dam Owners: Impacts of Plants on Earthen Dams
APPENDIX G: US Bureau of Reclamation – Guide to Concrete Repair

* Volume 3 is furnished on CD only to Office of the State Engineer, Dam Safety Bureau

I. INTRODUCTION AND DEFINITION OF GENERAL RESPONSIBILITIES

A. Introduction

This manual describes the general plan of operation, inspection, and maintenance, for Albuquerque Metropolitan Arroyo Flood Control Authority (AMAFCA) owned and operated flood control dams in the greater Albuquerque area. The intent of this manual is to give all operation, inspection, and maintenance personnel uniform guidance and procedures to ensure proper operations and maintenance for all AMAFCA's flood control dams. In addition, this document provides a unified and consistent process for communications and coordination with other flood control agencies in the area. This manual was prepared in conformance with the Rules and Regulations of the New Mexico Office of the State Engineer Dam Safety Bureau (NMOSE-DSB). Information, data or modifications pertinent to NMOSE-DSB jurisdictional dams will be coordinated through the NMOSE-DSB.

The manual is divided into three parts:

- Volume 1: General Information: consisting of general information and appendices concerning inspection and maintenance for all AMAFCA dams. A glossary of terms is provided in Appendix A to familiarize staff with terms relating to dams. Inspection guidance is included in Appendix B and a blank inspection form is provided in Appendix C. The inspection and maintenance forms are designed for easy revision. Complete as-built plans are located on a disk included in Volume 1 and are on file at AMAFCA.

- Volume 2: Individual Dam Characteristics: containing individual sections with specific information and dam modification history concerning each dam.

- Volume 3: Publications: with supporting publications.

B. Purpose and Intent

All AMAFCA dams are intended for flood control and the normal condition is dry with no permanently impounded water. Any storage allocations are temporary and are designed for downstream system capacity limitations. Proper operation and maintenance is essential for the continued viability and safety of each dam and its associated structures. Improper operation of any dam may result in increased risk to the dam and public and even dam failure. Poor maintenance can result in deterioration of the dam and its appurtenances, reduced life expectancy, and increased risk of dam failure. The following is included with AMAFCA's operation and maintenance program:

- Standard operating procedures
- Operating and maintenance procedures under emergency conditions
- Inspection guidelines and frequency
- Recordkeeping

This document is a living document and will be updated and changed as standards, technology, and regulations change, or if modifications are made to the dams. New or

revised pages will be inserted and the date of revision will be listed on the bottom of the page. The existing page(s) will be marked with an X and left in the document in order to track the changes made. All revised pages in Volume I will be furnished to the NMOSE-DSB. Revisions to Volume II will be furnished to the NMOSE-DSB only on NMOSE-DSB jurisdictional dams.

C. Description of Flood Control Facilities

Flood control dams in the greater Albuquerque area are designed to control a 1% chance flood (100 year event), and emergency spillways are designed to pass the spillway design flood. Figure 1 is a Vicinity Map showing the location of all AMAFCA dams. Table 1 is an index keying all the dams to the Vicinity Map and to the Volume 2 tab numbers.

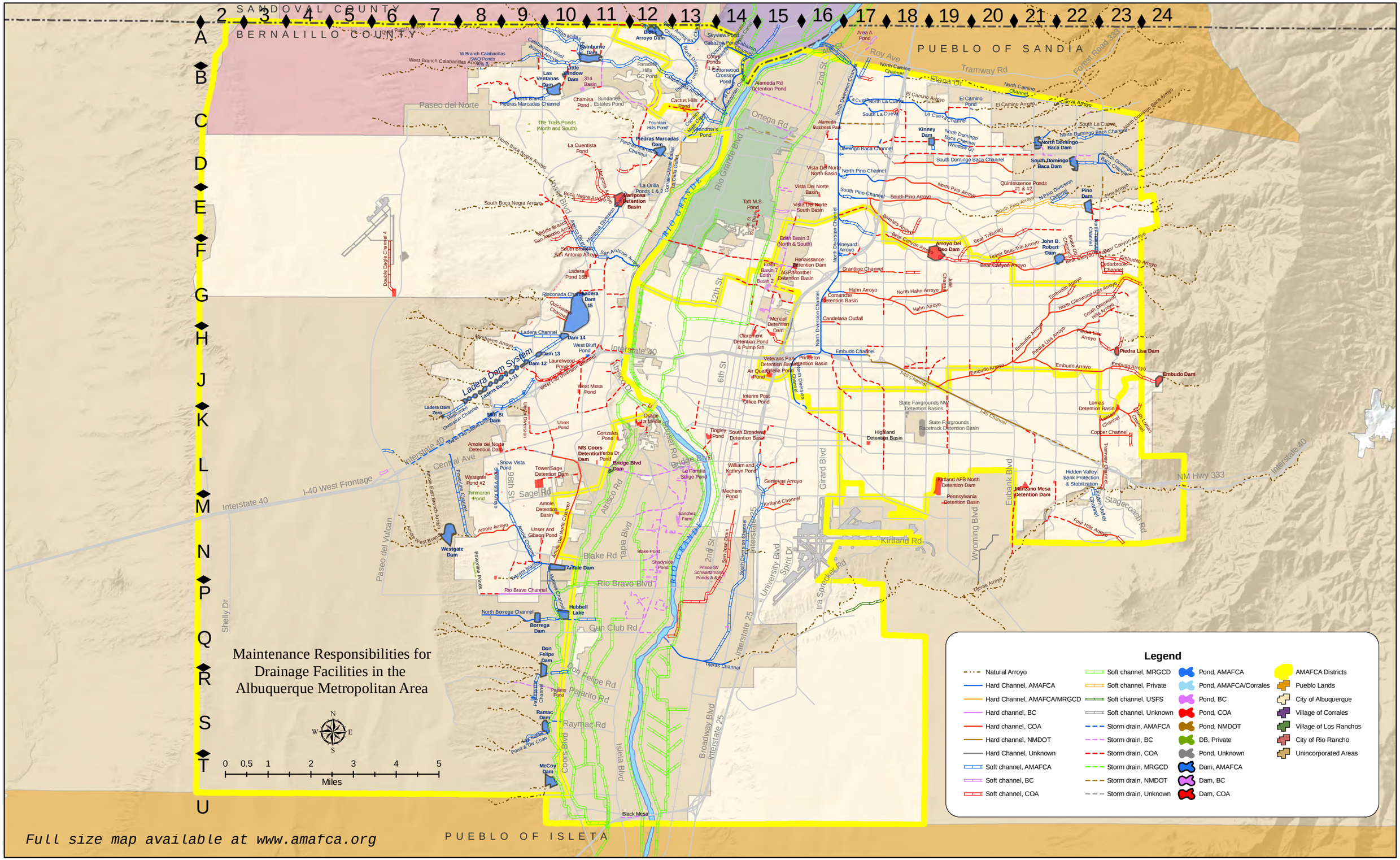
Table 1: AMAFCA Dam Index

Total Number of Dams	*Facility Name*	*Zone Atlas Page*	*Volume 2 Tab No.*
1	98th St Surge Pond Dam	K8	14*
2	Amole Arroyo SWQ Pond A	N9	15*
3	Amole Detention Basin	N10	6
4	Amole Sediment Basin #1	N9	16*
5	Amole Sediment Basin #2	N9	17*
6	Amole Sediment Basin #3	N9	18*
7	Black Arroyo Detention Dam	A12	19*
8	Borrega Dam	P9-P10	4
9	Cottonwood Crossings Pond	B14	20*
10	Don Felipe Dam	Q10-R10	3
11	El Camino Pond	B19-B20	21*
12	Fountain Hills Pond	C12	22*
13	Grandma's Pond	C13	23*
14	Hubbell Lake Detention Basin	P10	5
15	John B. Robert Dam	F21-F22	13
16	La Orilla Pond 1	D12	24*
17	La Orilla Pond 2	D12	25*
18	Ladera Dam 0	K7	26*
19	Ladera Dam 1	J8	27*
20	Ladera Dam 2	J8	28*
21	Ladera Dam 3	J8	29*
22	Ladera Dam 4	J8	30*
23	Ladera Dam 5	J8	31*
24	Ladera Dam 6	J8	32*
25	Ladera Dam 7	J8-J9	33*
26	Ladera Dam 8	J9	34*

Table 1: AMAFCA Dam Index

Total Number of Dams	*Facility Name*	*Zone Atlas Page*	*Volume 2 Tab No.*
27	Ladera Dam 9	J9	*35**
28	*Ladera Dam 10*	*J9*	*36**
29	*Ladera Dam 11*	*J9-H9*	*37**
30	*Ladera Dam 12*	*H9*	*38**
31	*Ladera Dam 13*	*H9-H10*	*39**
32	*Ladera Dam 14*	*H10*	*40**
33	*Ladera Golf Course - Dam 15*	*G10,G11,H10,H11*	*41**
34	*Las Ventanas Dam*	*B10*	*42**
35	*Little Window Dam*	*B10*	*43**
36	*Los Indios Pond*	*S9*	*44**
37	*Kinney Dam*	*C19*	*9*
38	McCoy Dam	T10	1
39	North Domingo Baca Dam	C21	10
40	North Pino Diversion Sediment Basin	D22	*45**
41	Octopus Pond	A14	*46**
42	Pajarito Diversion Sediment Basin	R9	*47**
43	Piedras Marcadas Dam	C12-D12	7
44	Pino Dam	E22	12
45	Raymac Dam	S10	2
46	Skyview Acres Pond	A14	*48**
47	Snow Vista Pond	L9	*49**
48	South Domingo Baca Dam	D22	11
49	Swinburne Dam	A10-A11	*50**
50	W Branch Calabacillas SWQ Pond A	B8	*51**
51	W Branch Calabacillas SWQ Pond B	B8	*52**
52	West Bluff Pond	H11	*53**
53	Westgate Dam	M7,M8,N7,N8	8

** To be added at a later date*


SANDOVAL COUNTY
BERNALILLO COUNTY
PUEBLO OF SANDIA
PUEBLO OF ISLETA
Maintenance Responsibilities for Drainage Facilities in the Albuquerque Metropolitan Area
0 0.5 1 2 3 4 5
Miles
Legend
Natural Arroyo
Hard Channel, AMAFCA
Hard Channel, AMAFCA/MRGCD
Hard channel, BC
Hard channel, COA
Hard channel, NMDOT
Hard Channel, Unknown
Soft channel, AMAFCA
Soft channel, BC
Soft channel, COA
Soft channel, MRGCD
Soft channel, Private
Soft channel, USFS
Soft channel, Unknown
Storm drain, AMAFCA
Storm drain, BC
Storm drain, COA
Storm drain, MRGCD
Storm drain, NMDOT
Storm drain, Unknown
Pond, AMAFCA
Pond, AMAFCA/Corrales
Pond, BC
Pond, COA
Pond, NMDOT
DB, Private
Pond, Unknown
Dam, AMAFCA
Dam, BC
Dam, COA
AMAFCA Districts
Pueblo Lands
City of Albuquerque
Village of Corrales
Village of Los Ranchos
City of Rio Rancho
Unincorporated Areas
Full size map available at www.amafca.org

D. Access to Dams

Access to the dams for inspections and standard operations and maintenance is generally shown on the Zone Atlas pages in Volume 2. The AMAFCA maintenance crew is trained as to where to access the dams for standard operations and maintenance and given keys to the gates. If they have any questions as to where to access the dams they are instructed to ask the Maintenance Superintendent, Field Engineer, Real Estate Manager or GIS Technician. Access can also be seen on the AMAFCA Maintenance Map on the AMAFCA website at www.amafca.org.

In the event of an intense storm which denies access through normal means, the Emergency Action Plan will be invoked.

E. Key Personnel and Their Responsibilities

AMAFCA is responsible for routine and preventative maintenance, inspections, and operation of AMAFCA owned dams. Operations and maintenance actions along with the responsible personnel are shown in Table 2 below.

Specific duties for operation, inspection, maintenance and emergency operation or maintenance will be assigned according to the AMAFCA organization chart included in the AMAFCA Personnel Manual.

Only trained AMAFCA staff or crew, as shown in the Action/Responsibility Matrix in Table 2, may operate any of AMAFCA's dams. These people are collectively referred to in this document as the Operator. They are responsible for routine and annual inspections. More thorough inspections are required after intense storm events and, if possible, during the storm event. The dam operator is also responsible for monitoring conditions during high flow conditions. The operator will notify adjacent upstream and downstream operators about changes to the gate levels (where applicable) and may be required to change gate-operating levels. The dam operator will coordinate changes with owners of adjacent drainage facilities. The adjacent dam owners and their contact information are included in Table 5, in Section II.F. Adjacent drainage facility owners are shown on the map entitled *Drainage Facilities in the Albuquerque Metropolitan Area* available to all AMAFCA staff and crew. AMAFCA staff and crew that operate or maintain dams know the adjacent facility owners and are trained on possible impacts to adjacent facilities. If they have questions as to ownership they are instructed to ask the Maintenance Superintendent, Field Engineer, Real Estate Manager or GIS Technician. Adjacent ownership can also be found on the AMAFCA Maintenance Map at www.amafca.org.

Table 2: Action / Responsibility Matrix

	AMAFCA Personnel							Contractors		
Action	Board of Directors	Executive Engineer	Field Engineer	Maintenance Superintendent	Maintenance Crew	Drainage Development Storm Water Quality Engineers	Office Staff	Engineers	Surveyors	Maintenance
Maintenance Funding	P	S								
Inspection Funding	P	S								
Emergency Funding	S	P								
Emergency Procurement		P	S	S			P			
Media Communications	S	P	S	S		S	S			
Annual Inspections		S	P			S		S		
Quarterly Inspections		S	S	P	S	S	S			
Emergency Inspections		S	P	P	S	S	S	S		S
Post Operation Inspections		S	P	P	S	S	S			
5 Year Inspections		S	P			S		S		
5 Year Survey			P						S	
Level 1, 2 & 3 Maintenance			S	P	S					S
Level 4 & 5 Maintenance Design			P	S		S		S		
Level 4 & 5 Maintenance			P	S						S
Emergency Maintenance		S	P	P	P	S	S	S		S
Emergency Contacts		S	P	P	S	S	S			
Dam Operation		S	P	P	S	S				

P = Primary Responsibility, S = Secondary Responsibility

F. Documentation

All as-built drawings, construction documentation, inspection, maintenance, dam modifications, and any other documents relating to AMAFCA dams are kept in an Operations and Maintenance file kept for each individual dam in the AMAFCA office. An Inspection/Maintenance Log, a Dam Modification History, Dam Performance History and a copy of the latest inspection report are kept in Volume 2 for each dam in the applicable section.

II. OPERATION, INSPECTION, AND MAINTENANCE

Operation, inspection, and maintenance procedures are needed to ensure the public safety. Regular inspection is a requirement of proper maintenance. The operator can only reasonably maintain the dam in good working order with the support of an active inspection program. The following sections will be used to guide routine operation, inspection, maintenance, and emergency action.

A. Operational Procedures

1. General

All AMAFCA dams are operated for flood control. In early spring each year, gates will be serviced and operated. Dams with gates are noted in the individual dam sections in Volume 2 and any special instructions are noted on the Special Conditions Sheet also included in Volume 2. The maintenance crew is trained on proper operation and maintenance procedures on the gates.

None of the dams has yet achieved full capacity (first filling). When any dam is observed to approach its full capacity, the dam condition and water levels shall be closely monitored. All dams, upon their first filling, shall be closely monitored for seepage leaks around the conduit, in the downstream toe, and in the abutments. Upon first filling the Emergency Action Plan will be invoked.

2. Standard Operating Procedures

Gated Dams:
Gates on AMAFCA dam outlet structures are normally closed. In the event of rainfall, the AMAFCA Maintenance Supervisor or Field Engineer will notify downstream adjacent drainage facility owners. If there is no immediate need to open the gate they may agree to delay the opening to allow the downstream owner time to prepare for the flows. All downstream facilities are designed to take full flows from a fully opened gate. In the event the operator deems it necessary, gates will be fully opened prior to contacting the downstream owner. Gate operation wheels are located in the AMAFCA shop. Crew members are trained in their use. Crew and Staff are given keys to AMAFCA access control gates.

Non-gated Dams:
Non-gated AMACA dams are designed to meter the flow out of the dam with no specific operation necessary. The operator of the dam will monitor the outlet structure to ensure it is working properly. If the outlet structure is not working properly or in the event of potential flow through the emergency spillway, the Emergency Action Plan will be invoked.

3. General Surveillance Provisions

AMAFCA Field Engineer and Maintenance Supervisor have primary responsibility for surveillance of AMAFCA dams. Other crew, engineers, and staff may be used for surveillance depending on need. If the need arises, the adjacent drainage facilities can

be found on the Vicinity Map and on the AMAFCA Maintenance Map found at www.amafca.org. Administrative and Emergency contact information is shown on Table 5 in Section II.F.

Early Warning System:

Currently, AMAFCA dams have no early warning systems. High water levels or increasing floodwater levels are not remotely monitored at this time. Doppler radar information is available for the greater Albuquerque area on time-delayed basis.

During a flood event the Dam Operator is responsible for initiating and maintaining constant communication with support staff assigned to dam locations. Communication will be by two way radio or cell phone. Changes (and anticipated changes) such as The rate of rise of the water level in the reservoir and changes in the inflow to the dam shall be noted and time stamped and immediately communicated to the AMAFCA Field Engineer. The AMAFCA Field Engineer will approve all dam operation changes throughout the event. Support personnel shall not change the operation of a flood control dam without approval of the AMAFCA Field Engineer, except in an emergency situation when communication is out and immediate action is required.

4. Response During Periods of Darkness

AMAFCA dams are not equipped with lights. Lights adjacent to dams and street lights may partially illuminate the dam and its appurtenances. AMAFCA has spotlight-equipped vehicles and inspectors are equipped with handheld flashlights.

5. Identification of Emergency

AMAFCA dams do not have automated flood warning systems. Seasonal weather conditions are monitored to help identify potential or developing floodwater conditions and to anticipate dam operations. Flood conditions are characterized by significant amounts of rain falling over relatively short periods of time. Reports of precipitation events in excess of 2-inches per hour are carefully evaluated and the affected facilities monitored. During flood events or high water events, AMAFCA personnel are trained and assigned to evaluate dam performance and report any and all abnormal conditions. In the event of an intense storm (as defined in the glossary) or other unusual event, each affected dam must be inspected for surface cracks, signs of movement, settlement, seepage, or erosion. If damage to the dam has, or is, occurring or the flood event is deemed an emergency, the Emergency Action Plan will be invoked. All dams when filling for the first time are to be monitored closely for any water flowing from around or in the vicinity of the conduit, the abutments, and the downstream toe. Performance of the spillway will also be monitored.

6. Emergency Repair Supplies and Resources

AMAFCA dam repair materials including sandbags, earth fill, and riprap are stockpiled at some dam locations for emergencies. Heavy equipment is available from AMAFCA or local area contractors. Other repair materials, such as concrete, flowable fill, etc., can be obtained from nearby commercial sources. Major repairs will be coordinated through the NMOSE-DSB as the situation and time allow.

7. Coordination or Floodwater Flows

Upstream flows may be regulated from the adjacent dams or drainage features. If a gate needs to be opened or an adjustment to flow made, the owner of the adjacent drainage facility must be notified. Adverse weather conditions may create rising water conditions. The Dam Operator is responsible for coordinating high water flows with the adjacent downstream dam operators.

B. Inspection

1. Inspection Frequency

Inspection is a necessary part of operation since early detection of gradual changes can reduce maintenance costs and identify minor problems before they become large, potentially dangerous and expensive repairs. Routine inspections provide a way to monitor the dams' performance. Only properly trained staff perform inspections. Inspection guidance is presented in Appendix B and AMAFCA Dam Inspection Report is shown in Appendix C. Table 3 summarizes inspection items and the frequency these inspections must be performed. The most recent Inspection and Maintenance Log can be found in Volume 2.

2. Inspection Safety

All Occupational Safety and Health Administration (OSHA) safety rules and regulations will be followed during inspections. Personal protective equipment will be used in accordance with OSHA rules and regulations and in accordance with the AMAFCA Safety and Health Policy and Job Hazard Analysis found on file at AMAFCA. Confined space entry will be performed only by individuals who are trained to do so.

Table 3: Dam Inspections

Items to Inspect	Frequency	Personnel
General Condition - after reservoir operations	Post Operation	AMAFCA
Embankment Seepage	Post Operation/Quarterly	AMAFCA
Reservoir Level	Post Operation/Quarterly	AMAFCA
Slides	Post Operation/Quarterly	AMAFCA
Spillway Cracks	Post Operation/Quarterly	AMAFCA
Debris in Primary Spillway	Post Operation/Quarterly	AMAFCA
Debris in Intake Structure	Post Operation/Quarterly	AMAFCA
Animal Burrows	Post Operation/Quarterly	AMAFCA
Woody Vegetation	Post Operation/Annual	AMAFCA
Riprap Protection	Post Operation/Annual	AMAFCA
Slope Erosion	Post Operation/Annual	AMAFCA
Vegetative Cover	Post Operation/Annual	AMAFCA
Embankment Condition	Post Operation/Annual	AMAFCA
Spillway Condition	Post Operation/Annual	AMAFCA
Gates	Post Operation/Annual	AMAFCA
Outlet Conduit	5 Years	AMAFCA
Dam Crest Surveys	5 Years	NM Professional Surveyor
Formal Engineering Inspection	5 Years	NM Professional Engineer

Quarterly inspections require little time to perform and provide insight on how the dam has performed under recent weather conditions. Annual inspections are designed to evaluate how the dam performed throughout the year and its current condition, covering items listed on the AMAFCA Dam Inspection Report, located in Appendix C. This inspection also evaluates and documents how the dam has changed from its original as-built condition. Detailed photo documentation provides a permanent record of the dam over time and allows for monitoring of any changing conditions. Repair and maintenance items are identified for correction. Annual inspections are normally performed in the late fall after the summer and fall rainy seasons. Annual inspections and good record keeping also allow for budgeting for any unusual or unexpected maintenance issues.

Maintenance identified as a result of any inspection is documented and performed using the following procedure. Maintenance issues are logged on the AMAFCA Inspection /Maintenance Report Form, found on page 6 of 6 on the AMAFCA Dam Inspection Form. A photograph is taken of each task required and annotated with a photo number and a brief description of the work to be accomplished. Once the photograph is printed, the location and nature of the work are noted on it as well. The AMAFCA Inspection /Maintenance Report Form, Page 6, is then given to the Maintenance Superintendent. Once a task is completed, the date of completion is noted after the appropriate

annotation, and once all tasks are completed the form is signed by the Maintenance Superintendent and filed in the AMAFCA O & M File. A copy is not sent to the NMOSE-DSB unless Level 4 or 5 tasks, described in Section II.D and in the Glossary, are included.

Quarterly inspections are not documented in writing. In the event the quarterly inspection identifies the need for maintenance, the items will be documented using the annual inspection process. In addition if the quarterly inspection identifies something out of the ordinary, a formal written inspection will be done. Annual inspections are documented on the AMAFCA Dam Inspection/Maintenance Report form, located in Appendix C, and a copy is sent to the NMOSE-DSB on jurisdictional dams. Prior to performing an annual inspection, the inspector will review the AMAFCA O & M file and the most recent inspection report.

A five-year inspection by a New Mexico Professional Engineer is required by State Rules and Regulations. The AMAFCA Dam Inspection Report, located in Appendix C will be used to document the inspection. This inspection is coordinated through the NMOSE-DSB and includes the following items:

- Reviews of the most recent inspection and the pertinent information shown in Volume 2 specific to the dam
- Structure Integrity (concrete, up / downstream conditions)
- Dam Equipment Operation (gate operators, etc.)
- Outlet Conduits
- Emergency Spillway
- Earth Fill: slope, riprap, and abutment stability, seepage
- Vegetation

Post reservoir operation inspections must be made as soon as floodwater conditions have subsided. Dams are susceptible to damage during high flow conditions and during rapid drawdown of the floodwaters from the reservoir. Listed below are key elements to be inspected after storm flows have subsided:

- Vegetation: high flow damage
- Earthen Fill: slope, riprap, and abutment stability
- Cut or fill slopes within the reservoir area
- Erosion in the reservoir area and embankment slopes
- Seepage
- Gate Openings: deposited debris
- Plugging of Outlet Structures
- Deposition of Sediment
- Spillway and Emergency Spillway Condition
- Inlet and Outlet Channels

Repair and maintenance items will be identified during the inspection and will be logged on the AMAFCA Dam Inspection/Maintenance Report, located in Appendix C

Some conduit inspections and dam elevation surveys are performed as a separate inspection as funding and scheduling allow. Copies of those inspections will be kept in the AMAFCA O & M files and noted on the Inspection/Maintenance Log in Volume 2. The NMOSE-DSB will be furnished a copy of these inspections on jurisdictional dams.

3. Inspection Equipment

The Dam Owner / Operator and qualified inspection personnel must be adequately equipped for inspection. The following are recommended inspection related equipment items:

- Copy of site map and drawings of dam appurtenances, as needed
- Camera
- Hand pick
- Measuring tape
- Knives for prying cracks and removing materials
- Mirror
- Gloves
- Hard hat, when required
- Flashlight
- Hand Level
- Confined space entry equipment, when required
- Other personal protective equipment (PPE), where required
- Any other safety equipment required by OSHA or in the AMAFCA Safety and Health Policy or identified on AMAFCA Job Hazard Analysis Forms, found on file at AMAFCA.

C. Monitoring

Some of the dams are equipped with monitoring apparatus as shown in the individual sections describing each dam in Volume 2. Water surface elevations and rates of rise and fall can be measured by depth gages located as shown on the as-built plans. AMAFCA is in the process of installing depth gages on dams that do not have them, as funding and scheduling allow. Monuments to measure settlement are generally located on each dam, as shown in the as-built plans. Settlement monuments will be surveyed every 5 years. Surveys will be conducted to 0.01 foot accuracy. Settlements of over 0.2 feet are of concern and further investigation is warranted.

D. Maintenance

1. General

Flood control dams are built with earthen embankments, a principal spillway, and an emergency spillway. Specific information and selected as-built drawings for each dam can be found in Volume 2 in the section for that particular dam. Routine, annual, and post storm inspection results will dictate how often and to what degree maintenance, in addition to regular periodic maintenance, is required.

Repair work is separated into five maintenance levels depending on the severity of the work. Routine maintenance, Levels 1-3, will be performed by AMAFCA and the NMOSE-DSB will not be notified. Levels 4 or 5 which entail larger scale repairs or construction will be coordinated through the NMOSE-DSB, who will determine if a permit is required. The NMOSE-DSB will be notified by phone and in writing when Level 4 or 5 maintenance is being done. Level 5 work always requires NMOSE-DSB approval prior to commencement of work. Level 4 emergency work will not be delayed if the NMOSE-DSB cannot be reached. Level 4 work may invoke the EAP if necessary. AMAFCA will obtain a permit and adhere to all NMOSE-DSB conditions of approval. Records of all levels of maintenance are stored in AMAFCA's O & M file and can be accessed there.

Work corresponding to each level is shown below.

- **Level 1** – fencing, access control, trash and debris removal, grading of maintenance roads, encroachments
- **Level 2** – minor sealant repairs to concrete or minor concrete repairs
- **Level 3** – erosion less than 3 feet deep, rodent removal and repair of the remaining burrow, woody vegetation removal, adding or maintaining riprap, conduit inspection and cleaning, sediment removal
- **Level 4** – erosion 3 feet deep or greater, seepage repair, structural defects
- **Level 5** – major work requiring engineering investigation and possibly preparation of construction plans, modifications to the dam

AMAFCA personnel can repair most items, including all Level 1-3 items and possibly Levels 4 and 5. If larger repairs or specialized work are needed (Levels 4 and 5) then a qualified contractor will be hired. The owner's New Mexico licensed engineer will inspect all Level 4 and 5 repairs.

The following reference materials (current version) are used by AMAFCA in the maintenance and repair of their dams. These documents are available at the AMAFCA office.

- Current AMAFCA standards and details
- US Army Corps of Engineers Design Guidelines
- New Mexico Department of Transportation Standard Specifications for Highway and Bridges Construction
- City of Albuquerque Standard Specifications and Details
- N.M. Office of the State Engineer Dam Safety Bureau, Guidelines for Woody Vegetation Removal on Dams (Appendix D)
- FEMA 473 – Technical Manual for Dam Owners: Impacts of Animals on Earthen Dams (Appendix E)
- FEMA 534 – Technical Manual for Dam Owners: Impacts of Plants on Earthen Dams (Appendix F)
- US Bureau of Reclamation – Guide to Concrete Repair (Appendix G)
- Most recent NMOSE-DSB inspection report

2. Maintenance Frequency

Maintenance will be routinely performed. Periodic maintenance items are listed in Table 4 with the frequency shown. Frequency shown as "As Needed" may be a result of an inspection as called for in Section II.B, Inspection.

Table 4: Maintenance Items and Frequency

Item	Frequency
Exterminate or Remove Rodents	Quarterly or As Needed
Eliminate Rodent Burrows	Quarterly or As Needed
Remove Vegetation on dam slopes and along toes*	Annually or As Needed
Repair Erosion	Quarterly or As Needed
Clean Trash Rack or Outlet Structures	Quarterly or As Needed
Trash and Debris Removal	Quarterly or After Storm Events
Sediment Removal	Annually or As Needed
Repair Concrete	Quarterly or As Needed
Repair Mechanical Equipment	Quarterly or As Needed
Instrumentation	Quarterly or As Needed
Lubricate & Operate Gates and Valves	Annually, early Spring
Other Mechanical Equipment	Annually
Road Maintenance & Grading	Annually
Maintain Outlet Works Pertinent Features Free of Corrosion	Quarterly or As Needed
Riprap Maintenance	Annually

** Woody vegetation will be removed in accordance with the NMOSE-DSB Guidelines for Woody Vegetation Removal on Dams, found in Volume 3.*

3. Maintenance Safety

All OSHA safety rules and regulations will be followed during any maintenance activities. Personal protective equipment will be used in accordance with OSHA rules and regulations and in accordance with the AMAFCA Safety and Health Policy and Job Hazard Analysis found on file at AMAFCA. Confined space entry will be performed only by individuals who are trained to do so.

4. Maintenance Procedures and Documentation

All maintenance activities will be recorded along with the observations made by personnel. Routine observations provide the information needed to identify trends that could indicate that serious problems are developing. Identifying problems before they become serious is an important part of preventive maintenance. Maintenance activities

that occur as a result of annual inspections will be documented on the AMAFCA Dam Inspection Report form, located in Appendix C. All maintenance records are kept in the AMAFCA O & M files.

All maintenance personnel shall be trained to recognize maintenance concerns and in the proper operation and maintenance of all aspects of dams under the control of AMAFCA. If any maintenance personnel are unclear as to proper maintenance and/or operation procedures or methods, they are to contact the Maintenance Superintendent or Field Engineer for proper instructions prior to the performance of any operation or maintenance function. Reference documents in Volume 3 will be used by the Maintenance Superintendent or the Field Engineer to determine correct procedures for maintenance or repair activities. In the event of more serious or uncommon repairs the Field Engineer will notify the Executive Engineer a contract engineer could be engaged for consultation or design.

5. Budget Considerations

Expendable items such as fencing, paint, lubrication, riprap materials, etc. will be used in the course of both preventive and routine maintenance. Riprap, geotextile fabric, and embankment fill materials will be stockpiled for both emergency and routine use. Other expendable items will be budgeted based on manufacturer's recommendations and owner's experience. Funds will be allocated for larger maintenance items and repairs, even though they may not always be predicted. AMAFCA maintains a Contingency Fund which reserves funds for unexpected, non-routine, and/or emergency maintenance and repairs. The Maintenance Superintendent and Field Engineer are authorized to commit the maintenance crew and equipment to perform routine and emergency operations. The Executive Engineer is authorized to commit up to $20,000 for labor, equipment, and materials. All amounts above that require approval of AMAFCA's Board of Directors.

E. As-Built Plans and Photo Documentation

As-built plans, photographs, detail construction dimensions, materials, and installed conditions must be monitored. Photos of selected features document how key features are being maintained.

F. Emergency Action Plan

Emergency Action Plans (EAPs) are being prepared in compliance with NMOSE-DSB Rules and Regulations for jurisdictional dams and, at a later date, for non-jurisdictional dams. AMAFCA has an ongoing process of preparing and updating EAPs for their dams. The purpose of the EAP is to provide the State, County, and City Emergency Managers and designated officials with specific guidelines and evacuation maps for emergency action in the event of a dam related emergency. The intent of this plan is primarily to protect the lives of citizens and secondarily to reduce property damage. Once an emergency condition is observed, AMAFCA will notify the appropriate Emergency Response Agencies as described in the notification flowcharts contained in the EAP and take action as described in the EAP.

Appropriate action/response is described in the EAP and will depend on whether Condition A or B exists, as noted below:

- Condition A: Failure of a dam is imminent or has occurred.
- Condition B: A potentially hazardous situation is developing at the dam.

Table 5 contains contact information for adjacent drainage facility owners and emergency response agencies.

Table 5: Adjacent Dam Owners & Emergency Response Agencies

Agency	Daytime Phone	After Hours Phone
Albuquerque Metropolitan Arroyo Flood Control Authority (AMAFCA)	(505) 884-2215	(505) 362-1272 Kurt Wagener (505) 362-1268 Larry Trujillo (505) 362-0020 Jerry Lovato
City of Albuquerque o Police Department Dispatch o Fire Department o Emergency Management o City of Albuquerque Dept. of Municipal Development - Storm Drainage Design	 (505) 242-2677 (505) 833-7300 (505) 833-7381 (505) 768-2654	 911
New Mexico Office of the State Engineer - Dam Safety Bureau	(505) 827-6122	(505) 476-9635 NMOEC 24-hour Duty Officer
Albuquerque Bernalillo County Water Utility Authority (ABCWUA)	(505) 842-9287	(505) 857-8250 - dispatch
Middle Rio Grande Conservancy District (MRGCD)	(505) 247-0234	(505) 247-0234 and receive directions
Bernalillo County o Sheriff's Office o Fire Department o Emergency Management o Public Works	 (505) 468-7100 (505) 468-1310 (505) 468-1307 (505) 848-1500	 911 For all others see City/County Emergency Operations Plan
State of New Mexico o Department of Public Safety o Division of Emergency Management o New Mexico Department of Transportation	 (505) 827-3361 (505) 476-9600 (505) 827-5100	 911
National Weather Service	(505) 243-0702	(888) 386-7637

III. SIGNS OF ABNORMAL CONDITIONS

As routine inspections are carried out, AMAFCA staff monitors the dams for any unusual or abnormal conditions. Upon notification by maintenance staff, AMAFCA Field Engineer, or other designated professional engineer, will determine if the following conditions exist. Abnormal conditions fall under Maintenance Levels 4 or 5, as defined in Section II.B.1 and in the Glossary. Detailed descriptions of the following abnormal conditions can be found in Appendix B in the Guidelines for Inspection of Existing Dams.

1. Excessive or Concentrated Seepage
1. Movements or Cracks in the Dams
2. Slumping, Sloughing, or Loss of Grade
3. Excessive Beaching or Erosion
4. Abnormal Instrument Readings
5. Concrete Problems
    a. Cracking
    b. Erosion and Cavitation
    c. Corrosion
    d. Movements
6. Abnormal Conditions in the Structural Steel / Reinforcing Steel
7. Abnormal Conditions with Mechanical Equipment
8. Landslides
9. Other Abnormal Conditions

APPENDIX A

GLOSSARY OF TERMS

ABUTMENT - That part of the natural ground against which the dam is constructed. The left and right abutments of dams are defined with the observer looking downstream.

ACRE-FOOT - A unit of volumetric measure that covers one acre to a depth of one foot. One acre-foot is equal to 43,560 cubic feet or 325,850 gallons.

AMAFCA – Albuquerque Metropolitan Arroyo Flood Control Authority.

APPURTENANT STRUCTURE - Ancillary features of a dam such as inlet structures, conduits, outlets, spillway, sluice gate, etc.

BERM - A nearly horizontal step (bench) in the sloping face of the dam.

BOIL - A disruption of the soil surface due to water discharging from below the surface. Eroded soil may be deposited in the form of a ring (miniature volcano) around the disruption.

BREACH - An opening through the dam that allows draining of the reservoir. A controlled breach is an intentionally constructed opening. An uncontrolled breach is an unintended failure of the dam.

CAVITATION – The rapid formation and collapse of pockets of vapor in a flowing liquid in regions of low pressure. Cavitation can occur in reservoir inlet or outlet works when high velocity water flow encounters discontinuities on the flow surface, causing the water to be lifted from the concrete surface, thus creating a negative pressure zone which may result in bubbles of water vapor. When the bubbles collapse against a concrete surface, a high pressure impact occurs and small particles of concrete may be removed. This forms another discontinuity, which can lead to cavitation damage. (US Bureau of Reclamation)

COLLECTOR DRAINS – A drainage system installed in the dam embankment to convey seepage flow safely away from the embankment.

CONDUIT - A closed channel (round pipe or rectangular box) that conveys water through, around, or under the dam.

CONTROL SECTION - A usually level segment in the profile of an open channel spillway above which water in the reservoir discharges through the spillway.

CREST OF DAM - See “top of dam”.

CROSS SECTION - A slice through the dam showing elevation vertically and direction of natural water flow horizontally from left to right. Or it may be a slice through a spillway showing elevation vertically and left and right sides of the spillway typically looking downstream.

DAM - A man-made barrier built across a watercourse or off-channel for the purpose of storage, control or diversion of water.

DAM FAILURE - The uncontrolled release of a dam’s impounded water.

DISCHARGE – Flow rate, typically measured in cubic feet per second or cubic meters per second.

DRAIN, TOE or FOUNDATION or BLANKET - A water collection system of sand and gravel and typically pipes along the downstream portion of the dam to collect seepage and convey it to a safe outlet.

DRAINAGE AREA (WATERSHED) - That geographic area on which all runoff flows into the dam. This may vary depending upon storm frequency.

DRAWDOWN - The lowering or releasing of the water level in a reservoir over time or the volume lowered or released over a particular period of time.

EMBANKMENT – A slope constructed of fill material, usually earth or rock, that is longer than it is high or the sloping side of a dam.

EMERGENCY - A condition that develops unexpectedly, endangers the structural integrity of the dam and/or downstream human life and property, and requires immediate action.

EMERGENCY ACTION PLAN (EAP) - A formal document identifying potential emergency conditions that may occur at the dam and specifying preplanned actions to minimize potential failure of the dam and to minimize failure consequences including loss of life, property damage, and environmental damages. The EAP includes an Evacuation Map.

EVACUATION MAP - A map showing the geographic area downstream of a dam to be evacuated if it is threatened by flooding caused by a breach of the dam or other large discharge. This map may also show planned evacuation routes.

FATIGUE STRESS – Progressive and localized stress that occurs when a material is subjected to repeated loading and unloading.

FEMA - Federal Emergency Management Agency, U.S. Department of Homeland Security.

FILTER - Layers of sand and gravel or a geotextile in a drain that allow seepage through an embankment to discharge into the drain without eroding the embankment soil.

FIRST FILLING – The initial filling of a dam with water to a specified design level, typically with flood control dams, this is up to or near the spillway crest.

FREEBOARD - The vertical distance between a design water surface elevation and the lowest point of the dam crest not including camber.

GATE, SLIDE or SLUICE or REGULATING - An operable, watertight valve to manage the discharge of water from the dam.

GROIN - The area along the intersection of the face of a dam and the abutment.

HAZARD - A situation that creates the potential for adverse consequences such as loss of life, property damage and environmental damages.

HEIGHT, DAM - The vertical distance as measured from the lowest natural ground surface elevation at the downstream toe of the structural fill of the dam to the crest of the dam.

HOMOGENEOUS EARTHFILL DAM - An embankment dam constructed of similar earth material throughout.

HYDROGRAPH, INFLOW or OUTFLOW or BREACH - A graphical representation of either the flow rate or flow depth at a specific point above or below the dam over time for a specific flood occurrence.

INSTRUMENTATION - An arrangement of devices installed into or near dams that provide measurements to evaluate the structural behavior and other performance parameters of the dam and appurtenant structures.

INTENSE STORM - A storm in which precipitation is greater than 2 inches per hour.

INUNDATION AREA or MAP - The geographic area downstream of the dam that would probably be flooded by a breach of the dam or other large discharge. The inundation map is used to develop the evacuation map.

LENGTH OF DAM - The length along the top of the dam between the abutments.

MAINTENANCE LEVEL 1 - Work consisting of fencing, access control, trash and debris removal, grading of maintenance, roads, encroachments. NMOSE-DSB notification is not required.

MAINTENANCE LEVEL 2 - Work consisting of minor sealant repairs to concrete or minor concrete repairs. NMOSE-DSB notification is not required.

MAINTENANCE LEVEL 3 - Work consisting of erosion less than 3-feet deep, rodent removal and repair of the remaining burrow, woody vegetation removal, adding or maintaining riprap, conduit inspection and cleaning, sediment removal. NMOSE-DSB notification is not required.

MAINTENANCE LEVEL 4 - Work consisting of erosion 3 feet deep or greater, seepage repair, structural defects. NMOSE-DSB coordination is required.

MAINTENANCE LEVEL 5 - Major work requiring engineering investigation and possibly preparation of construction plans and modifications to the dam. NMOSE-DSB coordination is required.

MRGCD – Middle Rio Grande Conservancy District.

NMOSE-DSB – New Mexico Office of the State Engineer Dam Safety Bureau.

NORMAL WATER LEVEL - For AMAFCA flood control dams, the normal condition is empty, therefore there is no normal water level.

NOTIFICATION - To immediately inform appropriate individuals, organizations, or agencies about a potentially emergency situation so they can initiate appropriate actions.

OPERATOR - The person or position in a company or organization, who is responsible for a dam's operation and surveillance.

OSHA – Occupational Safety and Health Administration.

OUTLET WORKS (PRINCIPAL SPILLWAY) - An appurtenant structure (gated or non-gated) that provides for controlled passage and release of water from the dam.

OVERSTRESS – Stresses greater than those allowed by the governing code.

OVERTOPPING – The rising of water to a level such that it would flow over the top of the dam or spillway.

PIPING - The progressive development of internal erosion by seepage flows, appearing downstream as a hole or seam discharging water that contains soil particles.

PROBABLE MAXIMUM PRECIPITATION (PMP) or FLOOD (PMF) - The theoretically greatest precipitation or resulting flood that is meteorologically feasible for a given duration over a specific drainage area at a particular geographical location.

RESERVOIR - The body of water impounded or potentially impounded by the dam.

RIPRAP - A layer of large stones, broken rock, precast blocks, or other suitable material, placed on an embankment, on a reservoir shore, or along a watercourse as protection against wave action, erosion, or scour. Very large riprap is sometimes referred to as armoring. Riprap may be dumped, wire-tied, or grouted.

RISK - A measure of the likelihood and severity of an adverse consequence.

ROTATIONAL SLIDE – A landslide in which the surface of the rupture is curved concavely upward and the slide movement is roughly rotational about an axis that is parallel to the ground surface and transverse across the slide (source - http://www.nationalatlas.gov/articles/geology/a_landslide.html)

SEEPAGE - The internal movement of water through the embankment, foundation, or abutments of the dam.

SLIDE - The disrupted movement of a mass of earth down a slope on the embankment or abutment of the dam or in the reservoir area.

SOIL CEMENT – A mix of native soil, portland cement, and water, compacted to a high density. It is commonly used for grade control structures and erosion control.

SPALLING – Spalling occurs when flakes of material are broken off a larger solid body. Typically with dam applications, it refers to concrete spalling and may have

several causes including freeze/thaw cycles, poor finishing methods, or dissolved salts in water.

SPILLWAY (PRINCIPAL or EMERGENCY) - The appurtenant structure (gated or ungated) that provides the controlled conveyance of excess water through, over, or around the dam. The principal spillway conveys normal design flows (typically 100-year or less) from the reservoir and the emergency spillway conveys flow from the reservoir in excess of the design storm.

SPILLWAY CAPACITY - The maximum discharge the spillway can safely convey with the reservoir at the maximum design elevation.

SPILLWAY CREST - The lowest level at which reservoir water can flow into the spillway.

TAILWATER - The body of water immediately downstream of the outlet works and/or spillway at a specific point in time.

TOE OF DAM - The junction of the upstream or downstream slope (structural fill) of an embankment with the natural ground surface.

TOP OF DAM (CREST OF DAM) - The elevation of the uppermost surface of an embankment (structural fill), which can safely impound water behind the dam.

TRANSLATIONAL SLIDING – A landslide in which the landmass moves along a roughly planar surface with little rotation or backward tilting. (source - http://www.nationalatlas.gov/articles/geology/a_landslide.html)

WOODY VEGETATION – Plants that develop woody trunks, rootballs, and root systems that are not as large as trees but can cause undesirable root penetration in dams. (FEMA 534)

APPENDIX B:

GUIDELINES

FOR

INSPECTION OF EXISTING AMAFCA DAMS

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I. GUIDELINES FOR THE INSPECTION AND PREPARATION OF A REPORT ON THE CONDITION OF A DAM

The objective of the Dam Safety Program is to protect lives and property from the consequences of a dam failure or the improper release of impounded water. A primary means of achieving this goal is through the maintenance and periodic inspection of in-service dams.

The inspection program is intended to identify conditions that may adversely affect the safety and functionality of a dam and its appurtenant structures; to note the extent of deterioration as a basis for long term planning, periodic maintenance or immediate repair; to evaluate conformity with current design and construction practices; and to determine the appropriateness of the existing hazard classification. The professional engineer performing the inspection should, where appropriate, recommend subsequent investigations required to resolve uncertain conditions and corrective measures to enable the dam to continue to perform its intended functions.

A. Inspection Guidelines

The inspection guidelines are designed to assist AMAFCA Inspection Staff to better understand the requirements, responsibilities, and duties inherent with dam ownership and to assist the professional engineer by providing a consistent approach to dam inspection and in-service evaluation.

Several different types of dam inspections can be performed. Dams and appurtenances should be inspected regularly to identify conditions that may adversely affect the safety of a dam and its ability to perform intended functions. An inspection may include the periodic evaluation of the as-built dam elevations to determine if any settlement of the dam appurtenances has occurred.

II. SIGNS OF ABNORMAL CONDITIONS

Abnormal conditions fall under Maintenance Levels 4 or 5, as defined in Section II.D and in the Glossary. If these conditions are identified, the Maintenance Superintendent and Field Engineer will review the reference materials in Volume 3 to aid them in determining a course of action. Outside engineers and other resources may also be engaged to determine the course of action required for Level 4 and 5 maintenance or repair. The NMOSE-DSB will be notified as detailed in Section II.D on NMOSE-DSB jurisdictional dams.

A. Excessive or Concentrated Seepage

Seepage through the embankment under prolonged storage conditions is expected to be negligible in comparison to seepage through the foundation due to more permeable material, except at first fill along conduit and in abutments. Periodic visual inspections are required to detect any abnormal conditions such as excessive or concentrated seepage. Field personnel must visually inspect the area around the outlet conduit connection to outlet works, the downstream embankment toe, and abutment areas daily

for seepage during periods of reservoir filling and on a 24-hour basis during flood stage. Areas of concentrated seepage must be critically observed for surface indications of sediment transport (piping) or erosion, change in quantity or concentration, and turbidity, or cloudiness of the water. The extent of saturated areas or ponding areas associated with concentrated seepage should be monitored.

A sign of abnormal seepage is when water emerges from a small area or single point. In this instance, evidence of sediment transport in the seepage areas is of particular concern. Emerging seepage must be inspected closely to determine if it is clear and free of any soil particles. The most critical sign of abnormal seepage is when water emerges from a small or single point with a build-up of soil particles forming a concentric mound called a sand boil. Chemical analysis of the seepage water and reservoir water may be required to determine whether piping or leaching is occurring. Sand boils must be observed, recorded and evaluated periodically for any change or trend that might indicate a worsening condition or long-term deterioration.

Some of the more apparent signs of abnormal seepage are whirlpools or vortices along the dam, or sinkhole or bog conditions on the downstream portion of the dam and toe. It is generally agreed that the properties of the water may be more significant than the absolute amount of water. Good records and proper analysis of these records are essential to the evaluation of the seepage along with the time line of significant occurrences, including precipitation data and pool elevations. It is important to gather as much information as possible about the seepage conditions in terms of location, extent, changes with time, seepage quantities, and characteristics (i.e., sediment transport, boils, loss of grade, etc.). Photographs will be used to document the conditions and provide a basis for evaluating changes.

B. Movements or Cracks in the Dams

Field personnel must observe and periodically inspect the embankment crest and slopes for movements or cracks in the dams. Specific inspections must be made after earthquakes and during periods of rapid pool filling or drawdown. Anticipated vertical movements are gradual. Abnormal conditions would be indicated by abrupt changes in the crest profile. Following an earthquake occurring at the project or sudden filling or drawdown, the crest should be inspected for cracks and displacement. Unusual movements may be detected through observation of the alignments of the crest station markers. Significant misalignment, tilting or displacement can be observed readily.

C. Slumping, Sloughing or Loss of Grade

As in the case of movements or cracks, specific inspections for slumping, sloughing or loss of grade must be made after an earthquake and during periods of rapid pool filling or drawdown. In addition, specific inspections should be made after severe or violent storms. Significant movement would appear in the form of bulges, depressions, or breaks in the embankment outer slopes. The top of the embankment may be the most vulnerable part during a strong earthquake.

D. Excessive Beaching or Erosion

Accepted methods and procedures for dumped rock placement may still result in varied in-place gradations and occasional reaches of smaller stone on the embankment slope.

These reaches are not distinguishable because slope dressing sometimes results in smaller rock on the surface only. During reservoir operations, waves can hit against areas of smaller sized stone, resulting in step-like benches. Smaller size stones move downslope to form a berm referred to as beaching, also known as segregation. The damage is usually minor (unless the wave action is severe and duration significant) and can be detected and corrected before serious damage develops.

Areas of concentrated surface flow not considered in design and construction but apparent during operations should be brought to the immediate attention of AMAFCA's Engineer for evaluation of corrective action. During a single violent storm, deep gullies can be eroded where flows tend to concentrate. Progressive caving at the head of such gullies (headward erosion or headcutting) can result in damaged slopes that are difficult and costly to repair. Headward erosion is of particular concern if it cuts into the crest of the dam.

E. Response to Abnormal Instrument Readings

A settlement of 0.2 feet will be considered an abnormal settlement of a dam survey monument. When an abnormal instrument reading is observed, it should first be verified. A check of any equipment used in making the original measurement should he performed. Once the condition is verified, determine if it is localized. Take other measurements in the general area noting changes in previous values or trends. Visually observe the area for signs of distress, wet or damp spots, loss of grade or bulging. Gather as much technical information as possible about the condition to aid in its analysis.

F. Concrete and Soil Cement

Distress in concrete and soil cement is manifested in a number of ways, including cracking, cavitation, scaling, erosion, disintegration, corrosion or chemical attack, distortion and misalignment. The seriousness of each of these depends upon how advanced the distress has become.

1. Cracking

Cracking is the process of breaking or splitting, usually without complete separation of the structure. Some cracking is expected, but sudden new cracks, a large number of cracks, significant seepage through the cracks, or cracking much wider than hairline ($1/64^{th}$ inch) are obvious indicators of distress in concrete. Cracking has many forms: pattern, random diagonal, longitudinal, and transverse. The causes of cracking are many, but usually can be related to structure overloading, expansion, shrinkage, and alkali-silica reactivity or other chemical reaction. The following is a list of various types of cracking and the possible causes.

- Pattern cracking begins as fine openings on concrete surfaces in a pattern. Pattern cracking with a whitish gel or other secretion in the cracks is the typical result of alkali-silica chemical reaction. Alkali-silica reactivity occurs between the aggregate and the alkali in the cement and can produce severe expansive forces in the concrete.
- Shrinkage cracking usually occurs in random fashion and is very common. It happens when the concrete is restrained, allowing tensile stress to build up and

exceed the tensile strength of the concrete. Shrinkage cracking usually takes place at regular intervals between joints in walls and slabs on-grade.

- Thermal expansive forces in concrete can result in cracking in areas of wide temperature variation, where movement of the concrete is completely restrained. This can result in buckling of the concrete.
- Cracking can occur due to overloading of a structure and will take place in areas where restraint and stresses are highest. Cracking due to overloading is frequently wider than the other types and occurs suddenly, causing more immediate concern. Examples may be found at the intersection of two walls, at an increases in size of a tunnel, at discontinuities (holes or penetrations), or at abrupt changes in slab or wall thickness.

Shrinkage, alkali-silica reaction, or other expansion cracking is generally either an inactive or slowly progressing problem and allows ample time for analysis.

Cracking of any type may lead to other serious problems, such as corrosion of steel reinforcement, water leakage in hydraulic structures, and even loss of structural integrity. Therefore, a cracking survey, monitors, or gages may be helpful in locating, marking, and identifying the cracks, and possibly identifying their cause. This survey also aids in determining if the cracking is progressive and in evaluating the future serviceability of the structure.

2. Erosion and Cavitation of Concrete

Erosion and cavitation of concrete due to the flow of water, or solids in water, is common in hydraulic structures. It is not expected anywhere except at the outlet conduit just downstream of the gate (where applicable). The seriousness of the problem depends upon the flow rate, particle load of the flow, and durability of the concrete.

- Moderate erosion is usually defined as the removal of the surface mortar of the concrete, exposing some coarse aggregate. Moderate erosion requires no action beyond monitoring.
- Serious erosion is defined as the actual removal of concrete well below the original surface, possibly exposing steel reinforcement. Because deterioration of this type is usually progressive, repairs should be done immediately.
- Cavitation causes erosion. Once a failure has started, depressions in the surface accelerate the damage to the concrete. Damage from cavitation is not common at water velocities below about 40 feet per second.

3. Corrosion

Chemical attack of concrete can occur from a number of agents and the effects are usually very obvious although the cause may not be. This type of distress is typically marked by simple disintegration of the concrete. It can occur in the presence of any number of chemicals in high concentration; for example, an odor of sulfur (hydrogen sulfide gas) in the conduit may be an indicator of sulfuric acid attack.

4. Movements

Deflection, distortion, or settlement of concrete structures, walls, beams, etc., beyond the small amounts expected after initial loading is considered serious and significant if on the order of 1/4 inch or more. Indications of these conditions are: leakage, separation, cracking, bulging, spalling, and/or misaligned joints (obvious vertical movement at the joint between a building and exterior walls).

The condition of joint filler material and the existence of vegetation or debris in the joint should also be checked. All of these conditions can be readily identified by a visual inspection.

In hydraulic structures, if the downstream side of a joint is higher than the upstream side, it can be particularly destructive during high-velocity flow. This condition can be detected by sliding a foot across the joint to determine if a small difference in elevation exists.

G. Structural Steel and Reinforcing Steel

Overloading from the gate and valve maintenance operations or missing bolts at the supports could cause distress in the control structures hangar beams. Distress can be detected by observing the beams and girders for misalignment, paint peeling, movement cracking, or missing bolts.

Corrosion of steel reinforcement can occur due to a number of agents. Typically, corrosion results from simple exposure to air and moisture. It can become serious if not repaired or is allowed to expand beyond small areas. Exposed rusted steel, concrete marked by reddish or dark gray stains, and bulging or spalling of the concrete in lines parallel to the reinforcement indicates corrosion of reinforcement.

Steel can also be subject to corrosion and deterioration where it is subjected to chemical action of water, bird droppings, human, or animal waste concentrations. Concentration of stress might be produced in areas where there is an abrupt change in the metal size or configuration. Fatigue stress can occur when members are subjected to vibration or movement. Overstress can be evidenced by excessive deflection under passage of heavy loads. Bracing members should be securely fastened.

Cavitation at the gates, valves and steel liners can occur under certain conditions. Just as in concrete, irregularities in the steel or high heads can cause bubbles in low-pressure areas to collapse with great impacting force as they enter areas of high pressure. Holes and/or pits formed in the surface of the steel indicate cavitation while a smooth, worn appearance points to abrasion.

H. Mechanical Equipment

Malfunctioning of mechanical equipment may result from displacement of supporting structural elements, corroded or loose parts, misalignment of parts, binding due to infrequent operation, insufficient lubrication, or improper operation. Unusual noises from conduit air vents should be noted, as this could indicate irregular flows caused by a damaged gate or conduit.

The capability of lowering the reservoir, should structural distress dictate, depends upon the outlet works and operable mechanical equipment. Procedures have been developed for avoiding abnormal conditions and problems with mechanical equipment to ensure operability of the outlet works. Effective defenses against problems with mechanical equipment include:

- regular examinations
- preventive maintenance on a regular schedule and including lubrication
- repair of deficiencies
- prominently posted, clear and concise operating instructions
- periodic exercising or testing of equipment
- a reliable alternate power source

During each pre-flood, post operation and periodic inspection, all equipment such as gates and valves, emergency power generator, and ancillary equipment must be inspected and operated to ensure that they are in good operating condition.

Cavitation of the gates, valves and steel conduits can occur under certain conditions. Just as in concrete, irregularities in the steel or high heads can cause bubbles that are formed in the areas of low pressure. Cavitation is recognized from the holes or pits formed in the surface of the steel.

I. Landslides

The cut slopes along the backslopes of reservoirs should be free of sloughs, slides and debris. Slide problems usually occur during periods of excessive precipitation and surface runoff and or rapid drawdown of the reservoir. Shallow translational slides typically occur in granular material with little or no cohesion and deep rotational slides typically occur in cohesive material. Deep rotational slides engage more material and therefore have the highest potential for creating significant damage. Surface slides do not result in significant mass movement, however with time these slides have the potential of progressively engaging more material and becoming larger. Consequently, surface slides require remedial actions to prevent progressive movement.

Natural or constructed fill or cut slopes should be examined for the presence of cracking, slumping, or other signs of movement. Cracks are usually symptoms of distress. Cracks in shotcrete surfaces that are not random in pattern (non-shrinkage cracking) indicate movement of the slope. Water can enter the slope through cracks and increase the driving force on the slope and reduce the resisting strength of the soil. Therefore, to minimize the potential for slides, ensure that slopes drain properly so that water cannot collect in them or cause erosional gullies. Ensure that all drainage devices such as horizontal drains and ditches are unobstructed and not damaged. If practical, cracks should be covered or sealed to prevent water from entering. Emergency or short-term remedial actions would consist of covering the cracks with anchored (i.e., sand bags, etc.) plastic sheeting.

In maintaining roads, care should be taken not to alter drainage or undercut slopes. Cracks in roads due to slope movement should be sealed to prevent water from entering

the slope. Keep plastic sheeting and sandbags readily available. If possible, also keep a stockpile of clayey soil readily available.

The perimeter of the reservoirs should be checked for slides following periods of heavy precipitation and large volumes of runoff, extreme reservoir water level fluctuations, and earthquakes. Close surveillance should be maintained until there is assurance that potential landslides do not present a problem to any reservoir operation. Landslides can often be detected by the bare surface between the top of the slide (head) and the original ground surface (crown), bulges at the toe, or leaning trees.

J. Other Abnormal Conditions

The trash rack, outlet conduit, spillway channel and exit structures should be checked regularly and after storm events to keep them free from sediment and debris. Debris can cause restriction of the flow and erosion of the concrete surfaces. Slope protection should be examined to determine if it is performing satisfactorily. Collector drains and slope drain holes should be checked to determine that they are open and free of obstructions that may impair their function. A change of flow rate may be an indication of a developing problem. Water seeping through joints may indicate defective collector drains. Collector drain discharge should be examined routinely to ensure the discharge water is not carrying material. Drain hole efficiency may decrease with time due to biological growth, leaching, and the formation of chemical deposits. When obstructed, drain holes should be cleaned or new drain holes installed.

Pre-flood season inspections should include an inspection of the upstream conveyance system for the purpose of identifying any significant trash or debris accumulations that have been deposited in a location from which they can be washed into the reservoir and cause a blockage of the spillways.

APPENDIX C:

AMAFCA DAM INSPECTION REPORT

AMAFCA DAM INSPECTION REPORT

Project _____

Date _____ **Inspector(s)** _____

AMAFCA O&M File # _____ **OSE File #** _____

PROJECT CONDITION:

A. General – Will project operate as intended during a heavy storm? Yes _____ No _____

If in doubt, explain:

_____

B. Embankment and Abutments

1. Surface Cracks_____
2. Movement or cracking at or beyond toe_____
3. Soughing of slopes_____
4. Vertical alignment of crest (settlement)_____
5. Horizontal alignment of crest (movement)_____
6. Junction of embankment and abutment_____
7. Junction of spillway and dam_____
8. Seepage_____
9. Condition of gutters, internal drains_____
10. Traffic damage_____
11. Erosion _____
12. Drains, Erosion control devices_____
13. Vegetation_____

14. Animal Burrows_____

15. Ant activities_____

C. Reservoir Area

1. Adequate capacity (free of sediment)_____

2. Free of large debris_____

3. Incoming arroyo/channel condition_____

D. Principal Spillway

1. Intake structure

General condition_____

Clear of debris?_____

2. Conduit

General condition_____

Junction with intake structure_____

Debris_____

Sediment_____

Condition of joints_____

Alignment (horizontal)_____

(vertical)_____

Circularity_____

Junction with outlet structure_____

Seepage_____

3. Gates and Valves

General condition_____

Operable?_____

4. Outlet Structure

General condition_____

Debris_____

5. Outlet Channel

General Condition_____

Wire enclosed riprap

Transition from outlet structure_____

Condition of wire_____

Condition of tie wires_____

Condition of riprap_____

Evidence of undermining_____

Erosion control structures

Type_____

Condition_____

Head cutting

Distance from structure_____

Description (depth, width, etc.)_____

6. Emergency Spillway

General condition_____

Grade control/erosion checks_____

Erosion_____

Debris/Blockages_____

Condition of concrete, riprap, gabions, wire-enclosed rock _____

_____

_____

_____

_____

7. Other_____

E. Project Safety

Guard Rail_____

Delineators _____

Fence and Gates_____

Warning Signs_____

Barriers/Barricades_____

Manhole Covers_____

F. Right Of Way

Unauthorized use of project lands_____

Property Signs:

Missing _____

Damaged_____

Monuments_____

Maintenance Roads_____

Encroachments_____

AMAFCA Dam Inspection/Maintenance Report Form

Facility _____ Date _____

Inspector's initials _____ AMAFCA O&M File # _____

Required Maintenance/Repairs

Urgent (Level 4 or 5)

Picture Number	*Work to be Accomplished*	*Date Completed*

Routine (Level 1, 2, or 3)

Picture Number	*Work to be Accomplished*	*Date Completed*

_____ _____

Date Items Completed Signature

Boca Negra Detention Dam

Operation, Maintenance, Repair, Replacement, & Rehabilitation Manual

Volume 2 – Book 2, Tab 56

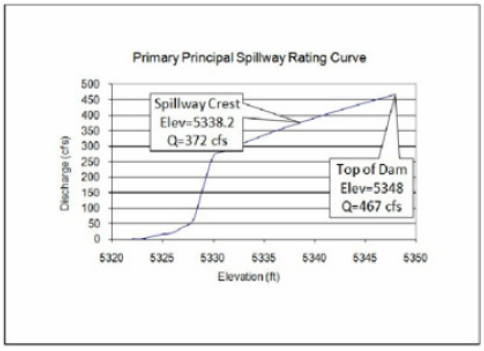
AMAFCA

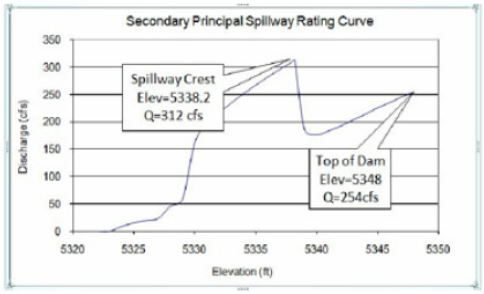
WILSON & COMPANY

BOCA NEGRA DETENTION DAM CHARACTERISTICS

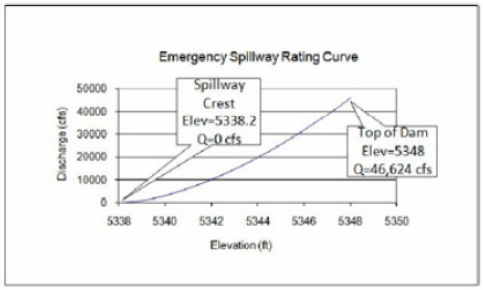
OSE File Number D-695 | National Dam ID Number NM00695

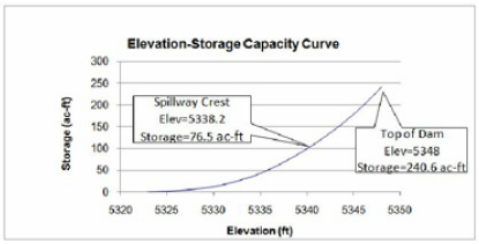
NAME OF DAM		BOCA NEGRA DETENTION DAM
TYPE OF DAM (MATERIAL)		HOMOGENEOUS EARTH EMBANKMENT
HAZARD POTENTIAL CLASSIFICATION		HIGH
MAX. HEIGHT ABOVE DOWNSTREAM TOE (FT)		26
MAX. LENGTH (FT)		3560
CREST WIDTH (FT)		17
SLOPE OF UPSTREAM FACE xH:1V		3 TO 1
SLOPE OF DOWNSTREAM FACE xH:1V		2.5 TO 1 & 3 TO 1
ELEVATION OF DAM CREST (FT)		5348
ELEVATION OF EMERGENCY SPILLWAY CREST (FT)		5338.2
EMERGENCY SPILLWAY WIDTH (FT)		419
1. PRIMARY PRINCIPAL SPILLWAY CONDUIT LENGTH (FT)		143
2. SECONDARY PRINCIPAL SPILLWAY CONDUIT LENGTH (FT)		145
1. UPSTREAM INVERT PRIMARY PRINCIPAL SPILLWAY (FT)		5318
2. UPSTREAM INVERT SECONDARY PRINCIPAL SPILLWAY (FT)		5323
1. DOWNSTREAM INVERT PRIMARY PRINCIPAL SPILLWAY (FT)		5311.9
2. DOWNSTREAM INVERT SECONDARY PRINCIPAL SPILLWAY (FT)		5321.8
FREEBOARD (FT)		10
RESIDUAL FREEBOARD (FT)		1.1
MAX EMERGENCY SPILLWAY DISCHARGE AT TOP OF DAM (CFS)		45903
1. PRIMARY PRINCIPAL SPILLWAY MATERIAL AND SIZE		48" x 48" CBC
2. SECONDARY PRINCIPAL SPILLWAY MATERIAL AND SIZE		48" x 48" CBC
1. MAX PRIMARY PRINCIPAL SPILLWAY DISCHARGE AT TOP OF DAM (CFS)		467
2. MAX SECONDARY PRINCIPAL SPILLWAY DISCHARGE AT TOP OF DAM (CFS)		254
1. LOCATION OF PRIMARY PRINCIPAL SPILLWAY		31.03722°N 107.66167°W
2. LOCATION OF SECONDARY PRINCIPAL SPILLWAY		31.03778°N 107.66167°W

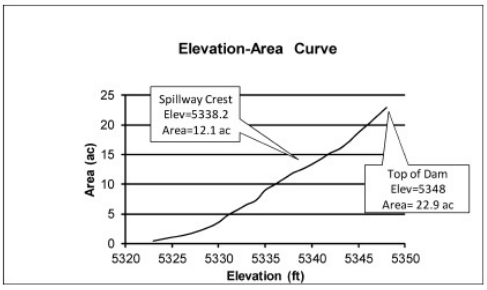




BOCA NEGRA DETENTION DAM CHARACTERISTICS			
ELEVATION (ft)	DISCHARGE (CFS)	STORAGE (AC-FT)	SURFACE AREA (ACRES)
5318=4' X 4' CBC (PRIMARY) SPILLWAY INV			
5319	0	0	0
5320	0	0	0
5321	0	0	0
5322	0	0	0
5323=4' X 4' CBC (SECONDARY) SPILLWAY INV	0	0	0.5
5324	18	0.9	0.8
5325	31	1.8	1.1
5326	40	3.0	1.3
5327	62	4.5	1.7
5328	106	6.5	2.2
5329	226	9.0	2.8
5330	430	12.2	3.6
5331	479	16.4	4.8
5332	513	21.6	5.7
5333	545	27.7	6.6
5334	574	34.7	7.3
5335	602	42.8	9.0
5336	629	52.3	9.9
5337	655	62.8	10.9
5337.94 = 100 YR FUTURE CONDITION	677	73.5	11.6
5337.98 = 100 YR INTERIM CONDITION	678	74.0	11.9
5338	679	74.2	11.9
5338.2=EMERGENCY SPILLWAY CREST ELEVATION	684	76.5	12.1
5339	1,438	86.3	12.6
5340	3,699	99.3	13.4
5341	6,830	113.1	14.3
5342	10,683	127.9	15.3
5343	15,192	143.6	16.0
5344	20,320	160.2	17.2
5345	26,006	178.2	18.7
5346	32,315	197.6	20.1
5347	39,208	218.4	21.5
5348=TOP OF DAM	46,624	240.6	22.9

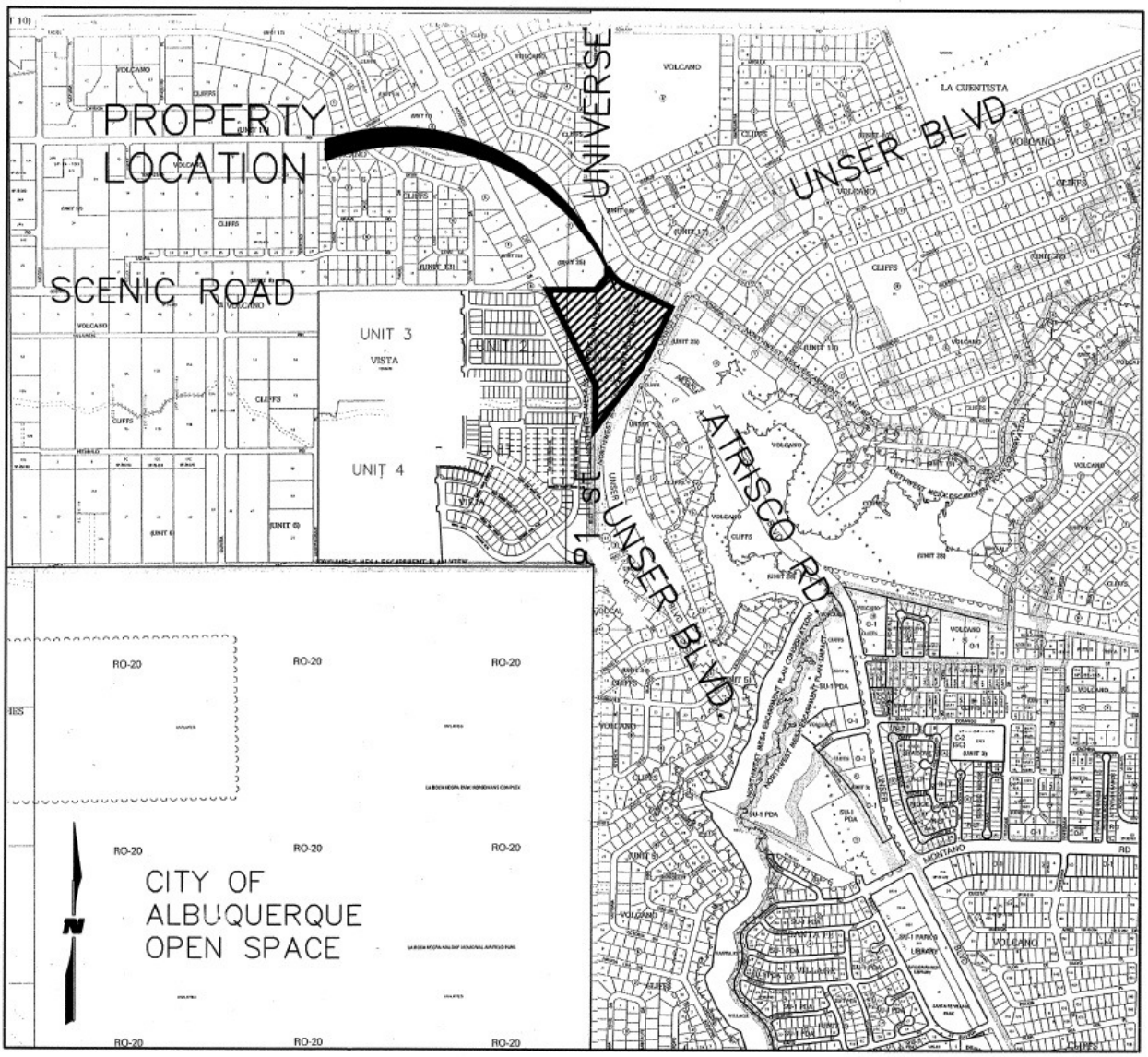






BOCA NEGRA DETENTION DAM

BOCA NEGRA
DETENTION DAM
ZONE ATLAS MAP



VICINITY MAP

ZONE ATLAS MAP NO. D– 9/10

Boca Negra Detention Dam

Special Conditions

1. City of Albuquerque Parks and Recreation maintains the shared use path, 3ft adjacent to trail.
2. Two existing gas lines exist along the south side of the dam (20” &12”). They are covered under a reciprocal encroachment agreement.
3. Overhead and underground electrical lines, as well as a substation, exist in the dam. They are covered by a reciprocal encroachment agreement.
4. There are two water lines in the dam (16” & 12”). They are covered by a reciprocal encroachment agreement.

BOCA NEGRA DETENTION DAM
PRIMARY ACCESS MAP

Boca Negra Detention Dam Modification History

Date	Modification	Entry Made By	Comments / Notes

Boca Negra Detention Dam Performance History

Date	Water Depth	Formal Inspection Required?		Action Required	Entry Made By	Comments / Notes
		Y	N			

Boca Negra Detention Dam

Inspection/Maintenance Log

Date of Inspection	Is Maintenance Required?	Maintenance Level	Comment

GUIDELINES FOR WOODY VEGETATION REMOVAL ON DAMS[1]

The guidelines for woody vegetation removal on dams are general guidelines and proper evaluation of the dam's geometry, woody vegetation species and other field conditions may be required before implementing these guidelines.

STORAGE DAMS

ZONE	DESCRIPTION	TRUNK DIAMETER (Inches)	TREATMENT
1*	Upstream slope	All	A
2	Crest	< 12	B
		≥ 12	A
3	Upper third of the downstream slope	< 8	B
		≥ 8	A
4*	Middle third of the downstream slope	< 6	B
		≥ 6	A & C
5*	Lower third of the downstream slope and downstream area for a distance of half the dam height	< 4	B
		≥ 4	A & C

* Lower the reservoir to a safe level, as determined by a professional engineer, before the repairs begin.

Treatment A:

1. Cut the woody vegetation approximately two feet above ground level leaving a prominent stump for use in the rootball extraction process;
2. Remove the stump and rootball by pulling the stump or extracting with a backhoe after loosening the rootball by pulling on the stump from different locations;
3. Clean the rootball cavity to remove loose soil and the remaining root system (root systems > ½ inch) by excavating the rootball cavity with maximum 1:1 (horizontal to vertical) side slopes and a horizontal bottom; and
4. Backfill the excavation with well-compacted soil placed in relatively thin lifts not greater than about 8 inches in loose lift thickness. Compaction typically requires the use of manually operated compaction equipment or compaction equipment attached to a backhoe. Backfill should consist of appropriate fill material and should be compacted to a minimum of 95% of the maximum dry density of the fill soil as determined by the Standard Proctor compaction test (ASTM D-698); and
5. For upstream slopes include a slope protection system to reduce the potential for wave and surface runoff erosion. For downstream slopes all disturbed areas shall be protected by seeding or mulching.

Treatment B:

1. Cut the woody vegetation stump flush with the ground;
2. Regularly treat the stump with a protective coating similar to polyurethane that will prolong the decay process.

Treatment C:

If water is encountered in the rootball cavity consultation with a professional engineer regarding the need for a filter drain system is required. A professional engineer must supervise the construction repair. Office of the State Engineer Dam Safety Bureau approval of the filter drain system design and installation is required.

DETENTION DAMS

For dams with no permanent storage, implement Storage Dams Zone 1 guidelines for the upstream slope and Zone 2 guidelines for the crest and entire downstream slope. Also implement Zone 2 guidelines for a distance 20 feet from the toe for dams < 40 feet in height and for a distance 25 feet from the toe for dams $\geq$ 40 feet in height.

MISCELLANEOUS AREAS OF DAMS[2]

Maintain 25-foot clearance zone beyond groins and adjacent to all concrete structures.

Maintain 15-foot clearance zone on each side of open channels, pipe conveyance systems and drains (especially perforated pipes).

1 Adapted from Marks, Dan B.; Tschantz, Bruce A. and Woodward, David K. *Plant and Animal Penetrations of Earthen Dams.* 2001 ASDSO Technical Seminar

2 Bureau of Reclamation (USBR). *Water Operation and Maintenance.* Bulletin No. 150, 1989.

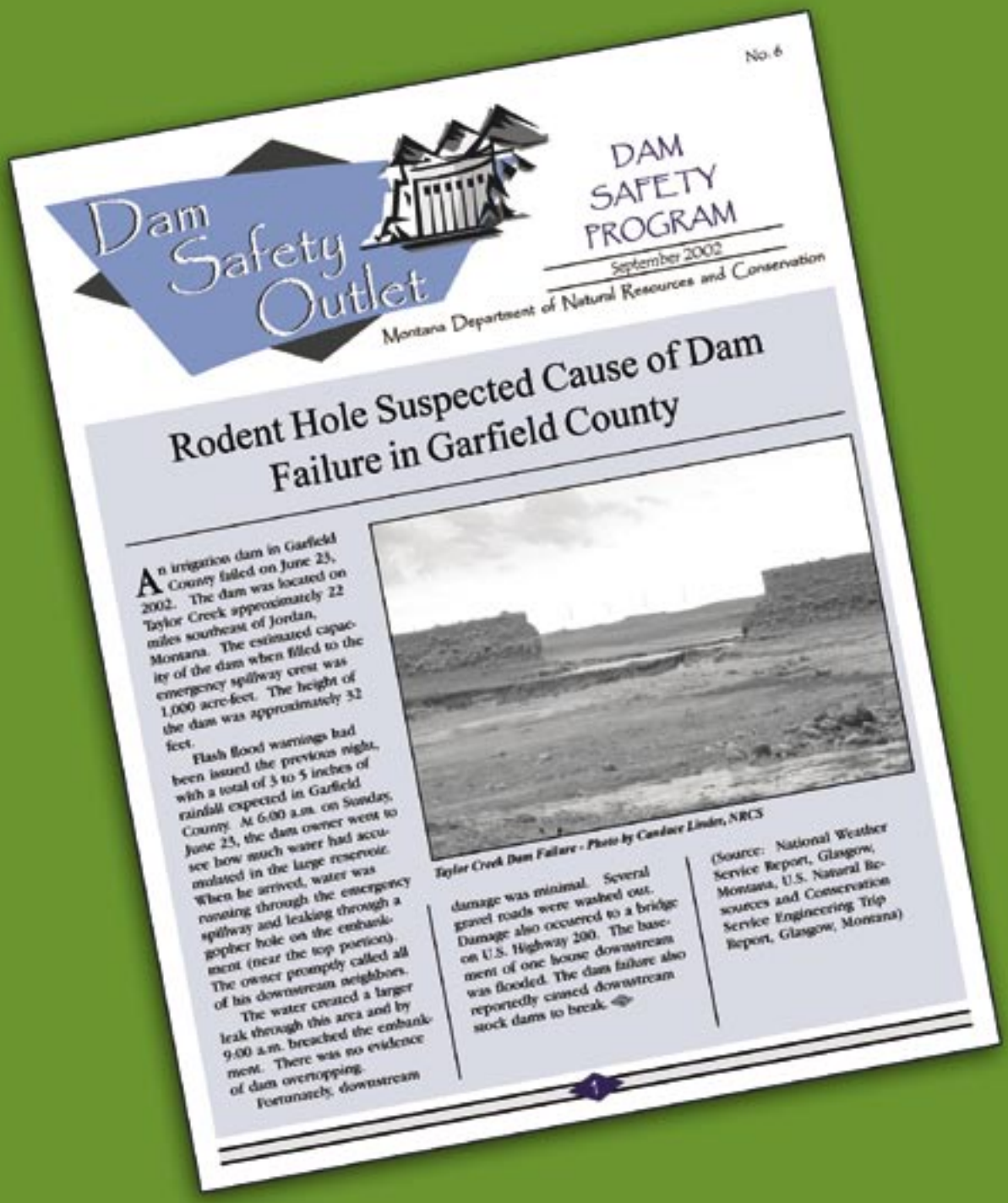
Technical Manual for Dam Owners

Impacts of Animals on Earthen Dams

FEMA 473 / September 2005

FEMA

Twenty-five states across the U.S. can write headlines of dam failure caused by nuisance wildlife intrusions, and many dam owners find the struggle to adequately manage nuisance wildlife at their dams a never-ending story. The Federal Emergency Management Agency (FEMA) has funded the development of this manual with the understanding that safe dam operation includes comprehensive, state-of-practice guidance on timely inspection and observation of wildlife damages, accurate wildlife identification and mitigation, and appropriate dam design, repair, and preventive measures. It is hoped that the information and methods contained in this manual will compose the core of dam management routines practiced by dam specialists across the country. Armed with education and diligence, dam specialists can prevent animal intrusion dam failure from becoming headline news.



No. 6

Dam Safety Outlet

DAM SAFETY PROGRAM

September 2002

Montana Department of Natural Resources and Conservation

Rodent Hole Suspected Cause of Dam Failure in Garfield County

An irrigation dam in Garfield County failed on June 25, 2002. The dam was located on Taylor Creek approximately 22 miles southeast of Jordan, Montana. The estimated capacity of the dam when filled to the emergency spillway crest was 1,000 acre-feet. The height of the dam was approximately 32 feet.

Flash flood warnings had been issued the previous night, with a total of 3 to 5 inches of rainfall expected in Garfield County. At 6:00 a.m. on Sunday, June 25, the dam owner went to see how much water had accumulated in the large reservoir. When he arrived, water was running through the emergency spillway and leaking through a gopher hole on the embankment (near the top portion). The owner promptly called all of his downstream neighbors.

The water created a larger leak through this area and by 9:00 a.m. breached the embankment. There was no evidence of dam overtopping.

Fortunately, downstream damage was minimal. Several gravel roads were washed out. Damage also occured to a bridge on U.S. Highway 200. The basement of one house downstream was flooded. The dam failure also reportedly caused downstream stock dams to break.

Taylor Creek Dam Failure - Photo by Candace Linder, NRCS

(Source: National Weather Service Report, Glasgow, Montana, U.S. Natural Resources and Conservation Service Engineering Trip Report, Glasgow, Montana)

1

Technical Manual for Dam Owners

Impacts of Animals on Earthen Dams

FEMA

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1.0 Introduction and Purpose of Manual

1.1 Background

In 1999, the Federal Emergency Management Agency (FEMA) and the Association of State Dam Safety Officials (ASDSO) jointly conducted research and a workshop to shed light on the national problem of animal intrusion damage to earthen dams and the resulting safety issues. The FEMA/ASDSO survey and workshop united dam owners, engineers, state and federal regulators, wildlife managers, foresters, and academia to form an educated and experienced front against the growing problem of earthen dam damage and failures due to animal intrusion. The information generated by roundtable discussions and survey answers indicates that while most states recognize animal intrusion as a problem, only a handful know of guidance on dams and wildlife management practices available to the dam professionals and owners. Based on input from the dam communities, FEMA/ASDSO's mission to develop a guidance manual on the proper management of nuisance wildlife in the earthen dam environment became clear.

To determine the information needs of the dam community—and therefore the most appropriate focus of this manual—FEMA/ASDSO issued a survey in 1999 and used the survey input from the 48 state dam safety officials representatives and 11 federal agencies representing the Interagency Committee on Dam Safety (ICODS). Additionally, a second survey was issued in 2003 to identify the current needs of each state, determine what nuisance wildlife and damages the states encounter, and understand which mitigation methods are being used with success or failure. Four main ideas emerged from the two survey efforts; these ideas consequently steered the direction of this manual:

- Cumulatively, the states indicated a range of problems caused by numerous wildlife species relative to the operation of dams. This manual discusses 23 species with regard to their habitat, behavior, threat to dams, food habits, identifying characteristics, and management options: Muskrat, Beaver, Mountain Beaver, Groundhog, Pocket Gopher, North American Badger, Nutria, Prairie Dog, Ground Squirrel, Armadillo, Livestock (cow, sheep, horse, pig and wild pig), Crayfish, Coyote, Moles and Voles, River Otter, Gopher Tortoise, Red Fox and Gray Fox, Canada Goose, American Alligator, and Ants.

- While the states are fully aware of the potential adverse impacts wildlife activity can have on earthen dams (such as failure), private dam owners and local dam operators are often not aware of potential problems, and thus may

25: number of states that indicate animal activity has caused or contributed to unsafe dam operation or outright failure within the state.

9: number of states aware of information or guidance on the effects of animal activity on dams.

not conduct inspections with wildlife damage in mind. Local dam owners may not typically mitigate existing wildlife intrusion problems or prevent them in the future.

- States want to know how other states are successfully mitigating wildlife damages. Further, mitigation and prevention guidance should be developed and conveyed to the dam communities.

- Guidance booklets for local dam owners are needed to assist dam inspectors in identifying and mitigating animal intrusion issues.

Out of 48 states that responded to FEMA and ASDSO surveys, 25 document nuisance animals as the cause of dam failures or unsafe dam operations in their states. The U.S. Bureau of Reclamation, the National Park Service, and the U.S. Department of Agriculture document several similar cases at the federal level. State dam safety officials and federal agencies agree that animal burrows within dams can cause substantial and costly damage if left unmitigated and are consequently a major concern.

1.2 Target Audience, Purpose, and Application of This Manual

This manual provides technical guidance to dam specialists (including dam owners, operators, inspectors, state dam officials, and consulting engineers) in areas of focus identified through the two survey efforts and workshop. The purposes of this manual are to:

- Assist dam specialists in understanding the impacts wildlife can have on earthen dams.

- Provide dam specialists with basic information on habitat, range, description, and behavior of common nuisance wildlife to aid in their proper identification at the dam.

- Describe state-of-practice methods to prevent and mitigate adverse wildlife impacts on earthen dams.

- Provide state-of-practice design guidance for repair and preventive design associated with nuisance wildlife intrusion.

It is envisioned that the entire dam specialist community will use this manual to augment their routine duties in earthen dam management. This manual is presented as a process toward dam inspection and management that includes wildlife damage identification and control. This manual provides technical information and guidance on:

- How wildlife damage adversely affects the safe operation of earthen dams; specifically, hydraulic alteration, internal and external erosion, and structural integrity losses (Chapter 2.0).

- Dam inspections that incorporate a biological component to sensitize dam specialists to the aspects of their dams that attract wildlife and to understand where nuisance wildlife are likely to occur on the dam (Chapter 3.0).

- Biological data for specific nuisance wildlife to assist the dam specialist in identifying which nuisance wildlife inhabits the dam. Biological data will also assist in controlling nuisance wildlife (e.g., listed food sources can be removed to encourage the animal to leave the area) (Chapter 4.0).

- Dam design specifications and methods that can be incorporated into repair of existing dams or new dam designs to prevent wildlife intrusions (Chapter 5.0).

- Guidelines to determine when wildlife management should occur at a dam (beyond dam repair and prevention actions) and wildlife management methods that can be implemented when control of specific nuisance wildlife populations is deemed necessary. Specific methods discussed include habitat modification, use of toxicants and fumigants, trapping, and shooting (Chapter 6.0).

- The fiscal issues related to appropriate and timely wildlife management at earthen dams (Chapter 7.0).

1.3 Technical Resources Cited

The technical information provided in this manual represents the most current practices in the areas of wildlife data and management and engineering inspection and repair, as they relate to nuisance wildlife and their effects on safe dam operations. While numerous technical sources are cited throughout the document, three main sources form the backbone of this manual's technical understanding and recommendations. The first source is a manual titled *Prevention and Control of Wildlife Damage* (University of Nebraska, 1994). The data contained in the 1994 manual are considered the industry standard for pest control, and the manual is used as the handbook for those testing for licensure as pest control managers. It should be noted that the 1994 manual is under revision and a revised version will be completed February 2005. Until the release of the revised manual, the 1994 edition remains the leading guidance literature in this field and is accepted as the most current practice in nuisance wildlife management (Smith, Pers. comm., 2003; 2004). The second source is a booklet called *Prevention and Control of Animal Damage to Hydraulic Structures* (USDA, 1991). The 1991 booklet adapts some of the 1994 manual data for application to the dam environment. The last source is technical data on remedial dam repair design by Dr. B. Dan Marks, as presented in the 2001 ASDSO West Region Seminar on Plant and Animal Penetrations for Earthen Dams (ASDSO, 2001). Many other sources are also used throughout this manual to provide a cross-reference of data as well as a broad spectrum of information.

2.0 Impacts of Wildlife on Earthen Dams

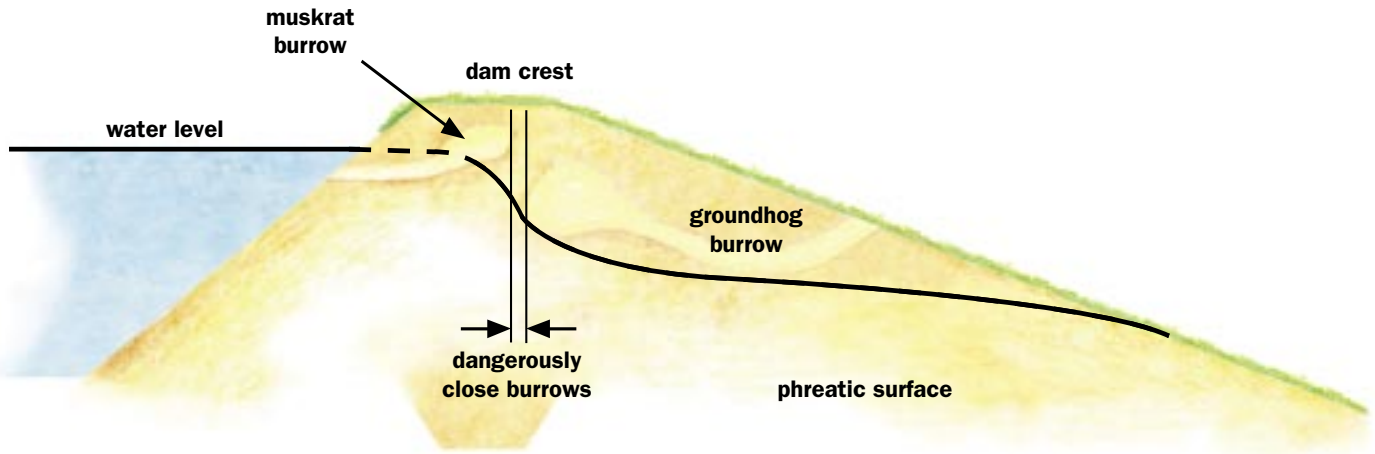


Figure 2-1. Upstream and downstream burrows can become dangerously close, causing internal erosion that may lead to dam failure.

Earthen embankment dams are used by private landowners and state and federal agencies to store farm water supplies, city water supplies, recreational waters, flood waters, and wastewater lagoons. Earthen dams rely on a thick placement of compacted soils to withstand the water pressure of the pool contained behind the embankment. Often constructed outside of developed areas, the earthen dam environment is usually near a water source and can contain a variety of vegetation; given these characteristics, earthen dam environments can be naturally conducive to use by wildlife. Wildlife inhabiting the dam can alter the dam environment through habitat establishment and use—beaver build dams, muskrat excavate dens, livestock feed on stabilizing vegetation. The natural instincts of wildlife to adapt and use their environment toward their survival can compromise the balance of engineered functions that maintain the viability of an earthen dam.

The first step in fortifying a dam against unsafe operations caused by wildlife damage is to understand what could go wrong if wildlife damage is left unchecked. While a dam owner may observe a few small burrows on the upstream and downstream slopes, it is important to understand that potential problems, like those burrows, often run deep below the surface. As such, the purpose of this Chapter is to discuss adverse engineering effects stemming from nuisance wildlife activity. Adverse effects caused by specific wildlife (as well as their identification and mitigation) are discussed in Chapters 4.0, 5.0, and 6.0.

2.1 Background

Embankment dams are vulnerable to damage from wildlife intrusions. Twenty-five states indicate that animal activity has caused or contributed to unsafe operation or outright failure of an embankment dam. Several animal species excavate burrows, tunnels, and den entrances for shelter, while other predatory animals will enlarge these structures via digging in search of prey. Similarly, herbivorous species will forage on vegetation growing on embankment dams. All of these occurrences create open areas in the embankment fill which are detrimental to the safety and performance of embankment dams. Some of these effects can be easily identified, such as surface erosion; other effects such as internal erosion may not become visible until dam safety is jeopardized.

Homogeneous and zoned embankment dams are equally susceptible to damage from animal intrusions. The ultimate consequence from the intrusions depends on the specific engineering and biological characteristics of an individual dam.

Embankment dams can be generally categorized as either homogeneous (containing one material) or zoned (containing multiple materials). Zoned embankment dams usually contain a central core designed to produce a lower phreatic surface (static water level within a dam embankment) within the downstream slope than the theoretical surface often assumed for homogeneous embankments. Due to the variability of zoned embankments, this manual discusses only homogeneous embankments.

2.2 Hydraulic Alteration

The most significant and often least obvious impact of wildlife intrusions on embankment dams is hydraulic alteration. Hydraulic alteration and its effects can manifest in different ways depending on the type and location of intrusion, including flownet distortion and physical barriers to flow.

A distorted flownet may not be a visible problem but it can have the most dramatic impact. Flownet is a term referring to the theoretical description of water flow through and under an embankment dam. The phreatic surface, equal potential lines and flow lines associated with a flownet are defined by the physical dimensions of the dam, classification of soils in the dam, and variability of the reservoir normal pool. As such, each dam has a unique flownet. The presence of animal burrows, either on the upstream or downstream slope, can distort the established phreatic surface and impact the flownet. As illustrated on Figure 2-2, upstream burrows can allow the normal pool elevation to extend into the dam embankment, forcing the phreatic surface further into the embankment. Likewise, downstream intrusions can allow the phreatic surface to day-light higher on the downstream slope. The overall effect can be a significant alteration to the phreatic surface. Dramatic changes to the phreatic surface can shorten seepage paths, increase seepage volumes, decrease the factor of safety against slope failure, and cause internal erosion of embankment materials (piping).

Of these impacts, piping is most often cited as the greatest concern among dam safety professionals because it is progressive and can rapidly lead to failure of the dam. Piping is the uncontrolled movement of soil particles caused by flowing water. As shown on Figure 2-3, piping will often start in a burrow on the downstream slope. Flowing water moves soil particles from the embankment to the burrow, leaving a void that is quickly filled with soil particles from deeper within the embankment. Because water pressure and flow generally increase further into the dam embankment, the rate of movement of soil particles will also increase. A pipe is rapidly formed extending from the downstream slope to the upstream slope. A dam breach is almost certain to develop in these instances.

External problems can also arise from wildlife activity around an embankment dam. Though hydraulic barriers can result from the activities of several species, beaver cause perhaps the largest array of adverse effects. To create deep waters in which to hide from predators, beavers compact felled tree trunks, limbs, and other materials into a mound to restrict the natural flow of a water source. As a result, the hydraulic function of the dam is altered in several ways. First, beaver mounds may block principal and emergency spillways and riser outlets, resulting in increased normal pool levels and reduced spillway discharge capacity. Second, sudden high discharges from the dam could occur if the beaver dam fails. Third, beaver dams located upstream of the embankment dam can clog water control structures as debris from the beaver dam floats downstream. Finally, erosion of the downstream toe of the dam can occur as a result of elevated tailwater caused by beaver activity.

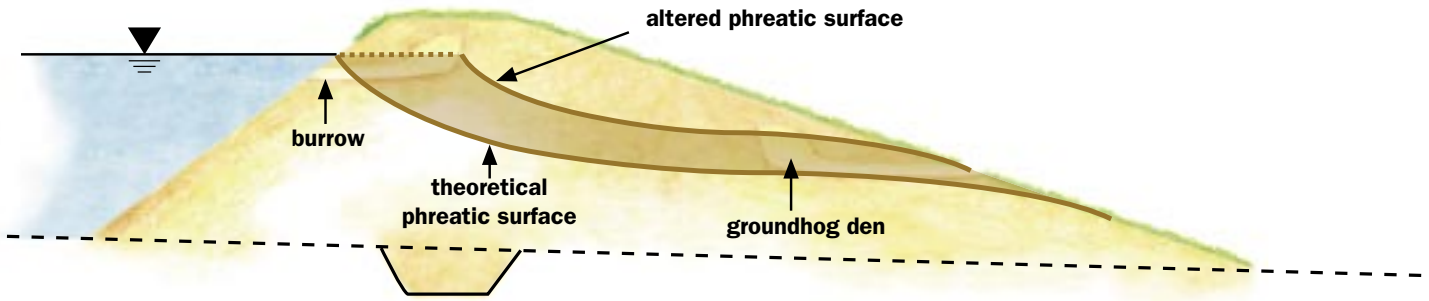


Figure 2-2. Burrows can alter dam hydraulics by shortening seepage paths.

2.3 Structural Integrity Losses

Wildlife excavate dens, burrows, and tunnels within embankment dams, causing large voids that weaken the structural integrity of the dam. Typical voids can range from the size of a bowling ball to a beach ball and much larger. Heavy rain and snow melt loosen soils surrounding a burrow, causing a localized collapse inside the burrow. In addition, a burrowing animal may encounter loose zones in the embankment (due to variability of constructed embankments) during burrow excavation, leading to a localized collapse. Animal dens also erode and collapse under the load of heavy equipment and other vehicles that use the crest of the dam as a throughway.

The collapsing soils will progressively lead to sinkholes or depressions appearing on the embankment surface. Because burrows can be under several feet of soil, the deformation or sinkhole visible at the surface could be several times the size of the original burrow. As illustrated on Figure 2-4, the collapsed soils can represent a significant portion of the dam embankment. Under the right circumstances, localized slope instability can result from a collapsed animal burrow. Depending on the location and number of collapsed burrows, dam safety or operation could be jeopardized. If portions of the crest are affected, a loss of freeboard can result, thus endangering the dam during storm events. Downstream slope failures, regardless of their extent, weaken embankment soils and reduce confinement of surrounding soils, thereby resulting in further weakening of embankment soils. Depending upon site and weather conditions, the process can progress slowly or rapidly, potentially leading to massive slope instability.

2.4 Surface Erosion

The foraging behavior of some animals on open area vegetation associated with dam embankments can reduce or eliminate vegetative cover on a dam. This increased feeding pressure on the dam's vegetative groundcover can lead to erosion paths and decreased soil retention on the dam's crest and slope. In addition, dams that are grazed by live-

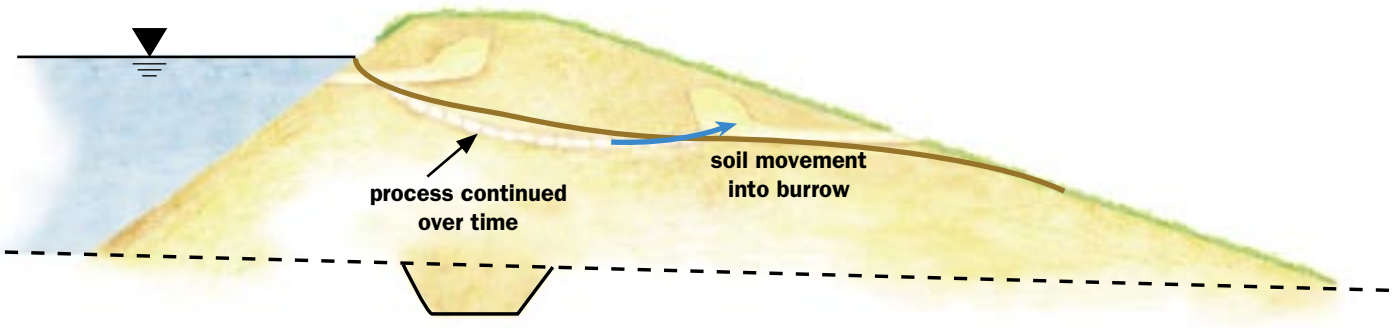


Figure 2-3. Burrows can lead to piping within an embankment.

stock often show increased rates of soil erosion because of the lack of stabilizing vegetation from grazing and trafficking, which can lead to irregular surface erosion and the formation of rills and gullies.

With continued neglect, these areas will require more than simple maintenance. In fact, given enough time, external erosion can lead to a reduction in freeboard and loss of cross section. In turn, these impacts can increase the dam's vulnerability to damage from high water during large storm events.

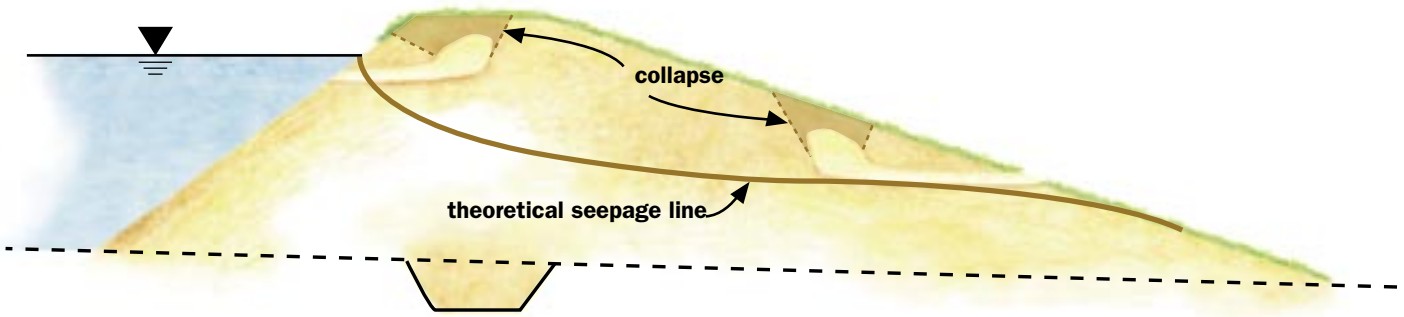


Figure 2-4. Burrows can collapse, leading to formation of sinkholes and loss of structural integrity.

3.0 Dam Inspection From Two Perspectives: Engineering Function and Biological Potential

The second step toward fortifying a dam against the effects of nuisance wildlife damage is the observation of clues left by wildlife in the dam environment. As such, regular inspection of the dam that incorporates wildlife activity recognition must be conducted by the dam owner, who is the first line of defense in protecting earthen dams. While the dam inspection is focused primarily on seepage, deformation, and structural deficiencies, the inspectors must also perceive wildlife clues left behind by dam inhabitants whose presence could cause trouble down the road. Toward this goal, this Chapter details an inspection procedure that pairs engineering inspection with key biological considerations to assist the dam specialist in viewing the dam from both perspectives (this methodology should be applied using the specific wildlife clues data presented in Chapter 4.0 of this manual).

3.1 Wildlife And The Earthen Dam

Through their natural desire to create dens, search for food, or escape predators, wildlife can cause a host of adverse impacts to an earthen dam which can lead to dam failure (refer to Chapter 2.0 of this manual for detail on the adverse impacts of wildlife activities). Though earthen dams are manmade, wildlife interacts with the earthen dam environment as if it were natural field or forest. To protect their dams, dam owners should know the biological potential of their dams—can wildlife find a suitable environment at the dam, and if so, which kind of wildlife will inhabit which locations of the dam? In answering these questions, it is helpful to know the characteristics that compose favorable habitat, and to realize that dams with diverse vegetation and site features often support a wide variety of wildlife. In assessing the dam for its biological potential, review the following relative to the dam area and surrounding areas (adapted from Benyus, 1989):

- **Vegetation Vitality:** Do the dam and adjacent areas contain dense vegetation at all levels (e.g., grass, shrub, and tree)? In general, greater variety of dense vegetation at levels ranging from groundcover to understory to canopy (regardless of vegetation type) allows for a greater variety of wildlife to inhabit the area. Small mammals, such as those discussed in this manual, prefer sites with adequate vegetation cover to hide from predators (see Chapter 5.2 for a discussion on appropriate vegetation at a dam).

- **Mini-habitats:** Do the dam and surrounding area offer vegetative diversity? Different landscapes such as prairie and forest? Sun and shade? Deep and shallow water? An environment with a mosaic landscape provides several habitat types in one area, which can support a wider variety of wildlife.

- **Transition Zones:** Is there a clear edge between one habitat type and another? At the dam environment, the dam area (a lake/pond environment) may be surrounded by a grassy field environment, a shrub edge, or a forested environment. The junction where two environments meet is called an edge, and edges are the most heavily trafficked areas in an environment (a good place to view the wildlife in and around the dam area) because they provide safe travel corridors between the two habitat types and create a more diverse habitat than either of the two habitat types.

- **Size:** Does the dam environment provide a large land area that allows wildlife to meander without having to cross roadways or come into contact with people? Most species of wildlife prefer large parcels of land that provide habitat variety without human influence.

- **Unique Characteristics:** Does the dam contain unique land features? By its very nature, the dam environment is unique because it contains a water source. Wildlife prefers a constant water source, so dams with a permanent pool will be preferable to those with a fluctuating pool, such as those used for flood control or irrigation. However, any water source will attract wildlife to some degree.

3.2 Two-Perspective Dam Inspection Methodology

The typical dam safety inspection checklist requires observation of every dam feature. The checklist is developed by an individual state's dam safety program or federal organization such as the U.S. Bureau of Reclamation, U.S. Army Corps of Engineers, U.S. Fish and Wildlife Service, or the Federal Energy Regulatory Commission. All inspections focus on distinct physical regions, although the inspection checklists vary in length, listed inspection items, and required observations. Generally, the features are divided into clear components including:

- Upstream Slope
- Downstream Slope
- Crest
- Embankment-Abutment Contact (Groin)
- Principal Spillway
- Emergency Spillway
- Lake Drain or Outlet Works

Although inspection for animal intrusions is a facet of most if not all state inspection checklists, it is certainly not a major part of the inspection. Specific guidance on identifying animal intrusions or the typical intrusion locations of specific animals is not provided on the checklists. An inspector lacking this information may be unable to adequately inspect their dam for animal intrusions, much less adequately identify and mitigate the nuisance animal. As such, this manual presents an inspection methodology that combines engineering and biological considerations, which when viewed together, allow a dam specialist to view the dam comprehensively.

For the purposes of this manual, the dam is divided into six zones: Upstream Slope, Dam Crest, Upper Downstream Slope, Lower Downstream Slope, Downstream Toe, and Spillway, Outlets, and General Areas (Figure 3-1). The risk posed by animal intrusions is greater in some zones than in others. As such, the zones are overlapped to emphasize the critical nature of the area and to require inspection of the area twice to ensure that biological clues are sighted (ASDSO, 2001). Further discussion of the six zones relative to risk, restoration, and repair of animal intrusions is provided in Chapters 5.3 and 5.4.

When considering animal intrusions, inspection of each zone should consider not only physical evidence of an animal presence (e.g., burrow entrance), but also the habitat and biological factors that attract wildlife to the dam and sustain them once they have become established (Figure 3-2). Understanding both the engineering and biological aspects of animal intrusions into embankment dams is critical in eliminating or at least controlling the intrusions.

3.2.1 Zone 1: Upstream Slope Area

Engineering Perspective: The goal of inspecting the upstream slope of the earthen dam is to see the entire surface clearly. To ensure the inspector views the entire slope surface, the inspector must walk back and forth across the slope utilizing one of two patterns: zig-zag or parallel. In general, the zig-zag method is best for small dams and mild slopes (Figure 3-3, shown on page 17). It may prove difficult to move in a zig-zag pattern on large dams and steeper slopes, and in these cases the parallel pattern is suggested (Figure 3-4, shown on page 17).

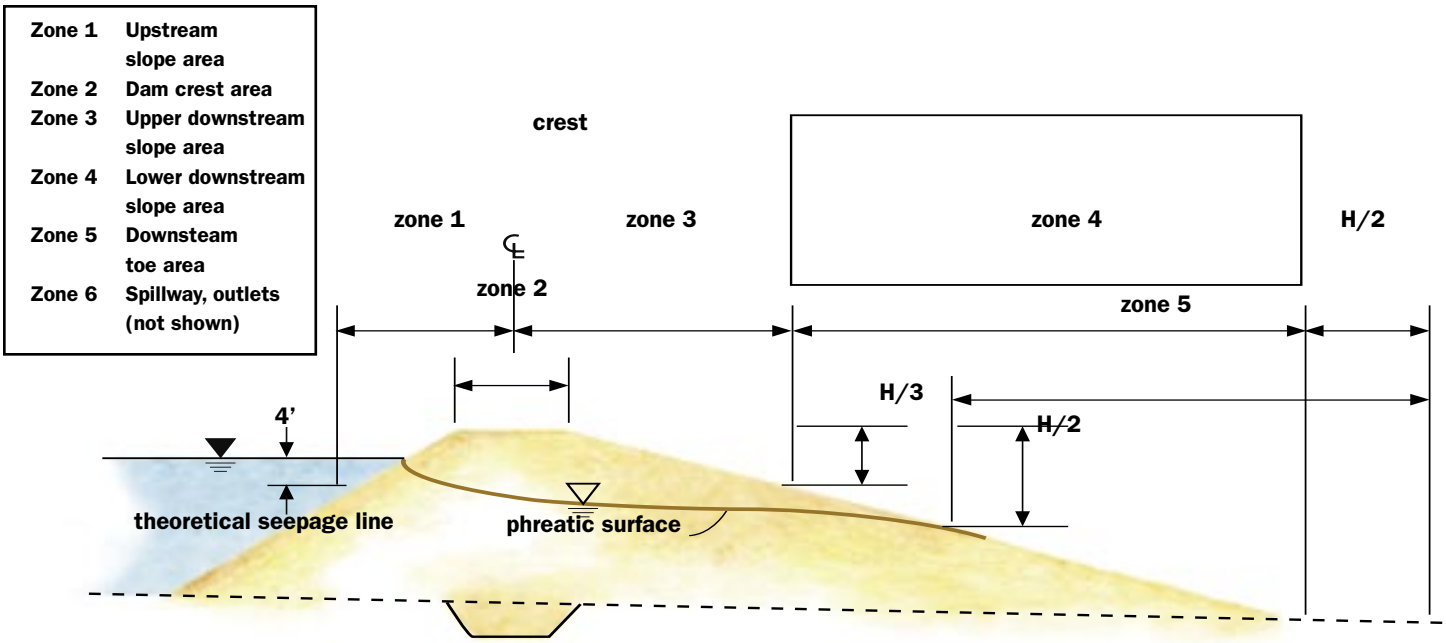


Figure 3-1. Dam Inspection Zones.

While walking the slope, the inspectors should routinely stop and view the alignment of the surface by turning their gaze a full 360 degrees. Checking the slope frequently and from many viewpoints and distances can reveal deficiencies and distortions (such as surface distortions or vegetation changes) that might otherwise go undetected. The inspectors should observe berms on the upstream slope by centering their eyes on the line being viewed and moving their body from side to side to view the line from several angles. This approach will help the inspector identify misalignments.

A typical dam safety inspection report should comment on vegetation, slope protection, erosion, instabilities, and animal burrows observed in Zone 1. When specifically considering animal burrows and other deficiencies resulting from animal activity, the inspector should look for the following: animal burrow entrances, mounds of excavated soil, debris (evidence of beaver activity), cracks, depressions, erosion, sinkholes, paths and ruts, sloughs, slides, and scarps. These conditions often indicate damaging animal activity. The inspection report should note whether the deficiencies warrant monitoring, repair, or further investigation.

Biological Perspective: This zone is primary habitat for aquatic burrowers such as muskrat and beaver, which generally burrow from 6 inches to 4 feet below the water line upward toward the crest. Nutria prefer to dig dens in the zone where land and water meet, which could be dominated by aquatic vegetation. River otters are often found living in abandoned muskrat, beaver, and nutria burrows, and can construct slides on slopes and bare areas where they repeatedly enter and exit the water. Livestock often traverse the upstream slope area—look for hoof tracks, rills, and eroded pathways. Canada geese and livestock feed on embankment slopes causing eroded areas and ruts. Crayfish and alligator may inhabit the banks and shallows of the upstream slope area. Ants may dig tunnels in the slope, loosening existing cracks. Mountain beaver or armadillo may be found along the wet edge of the pond, especially if a forest fringe or wooded area is nearby. Moles may hunt in the moist soils near the reservoir.

3.2.2 Zone 2: Dam Crest Area

Engineering Perspective: Similar to inspecting the upstream slope, the crest can be viewed using either a zig-zag or parallel pattern, with the primary goal being to view the

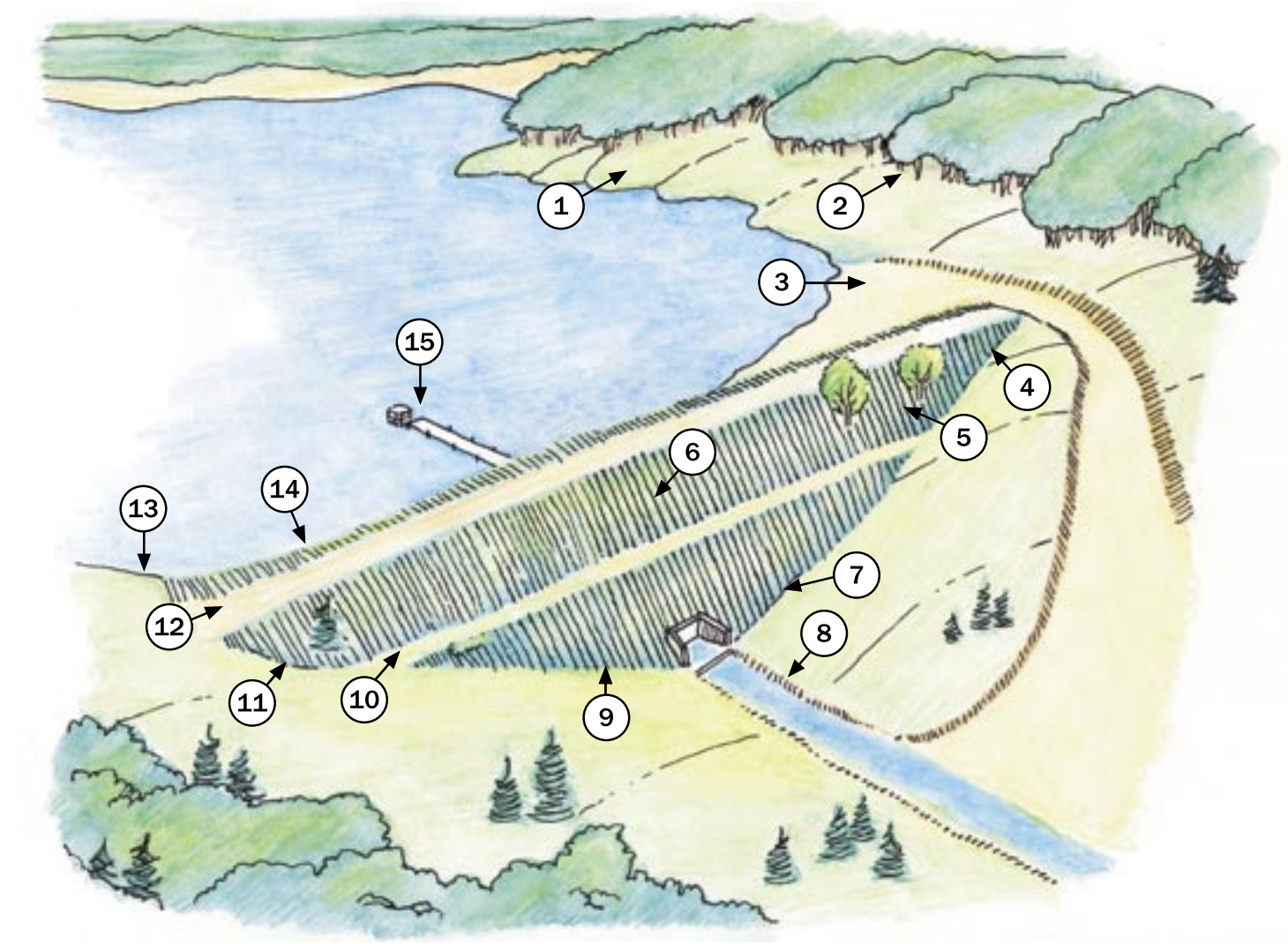


Figure 3-2. The Earthen Dam from Biological and Engineering Perspectives.

1. **Upland Areas.** Many species live in the upland areas, away from the water. Even the downstream slope, abutments, and groin areas of the dam can be considered upland in terms of habitat.
2. **Forest Fringe.** The zone between two environments (the edge) is the best place to observe those species living at and around the dam. The more habitat types at the dam, the greater number of species likely to inhabit the dam. Mountain beaver or armadillo prefer forested/wooded areas.
3. **Emergency Spillway.** Beaver often dam the spillway, causing the pond water levels to rise.
4. **Left Abutment contact.**
5. **Inappropriate Vegetation on Embankment.** Many dams contain vegetation other than mowed grass. Improper vegetation provides cover and food supply, which encourage animals to inhabit the dam.
6. **Downstream Slope.** This area is often the location where groundhogs, coyote, and fox excavate burrows. Canada geese will feed on the downstream slope, which could cause loss of protective vegetative cover and associated erosion. Species that prefer upland areas could be found in this area.
7. **Left Groin.**
8. **Discharge Conduit and Outlet Channel.** Beaver can dam the outlet structure. Aquatic species may inhabit this area depending on water flow and availability of vegetation.
9. **Toe of Embankment and right groin.**
10. **Erosion Pathways on the Embankment.** Livestock traverse the embankment creating erosion pathways.
11. **Right abutment contact.**
12. **Crest.** Livestock traverse the crest which creates ruts. The ceilings of beaver and muskrat burrows in the upstream slope are often just below the dam crest.
13. **Aquatic Fringe.** The zone where the bank meets the pond usually contains aquatic vegetation preferred by many animals such as nutria.
14. **Upstream Slope.** Beaver, muskrat, and nutria prefer the upstream slope for burrow excavation. Alligators, otters, and turtles usually live in the shallow waters near the upstream slope.
15. **Principal Spillway (with riser and trash rack).** Beavers can block principal spillways by constructing dams.

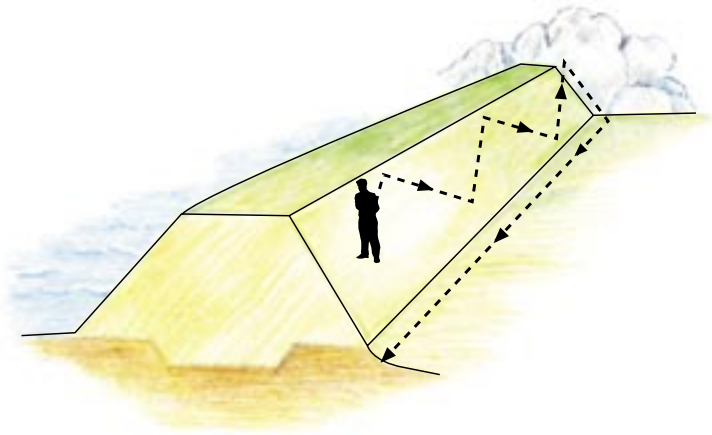


Figure 3-3. The zig-zag method of inspection is best used on small dams and mild slopes.

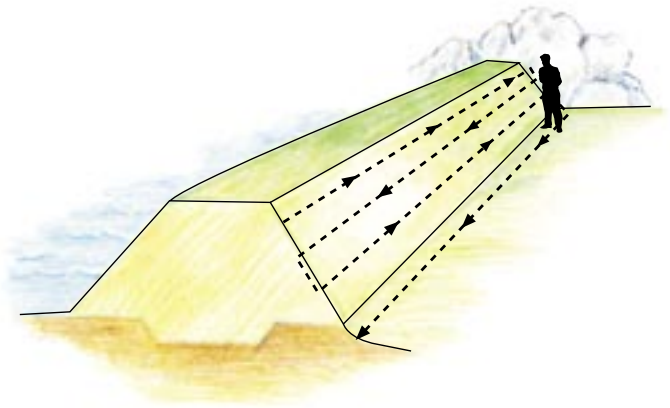


Figure 3-4. The parallel method of inspection is best used for dams with steep slopes.

entire crest from several perspectives and distances. Similar to the upstream slope inspection, the inspectors should center their eyes on the crest line, moving their body from side to side to view the line from several angles. Fixed features that can mark horizontal and vertical points along a dam can be used as reference lines; guardrails, a row of posts, or parapet walls are good reference lines (use caution when using man-made reference lines which can be moved). The reference line must be viewed from several different perspectives; first, the inspectors should sight directly on the reference line and then move their body to either side. This method will assist the inspector in detecting a change in the uniformity of the crest. Zone 2 overlaps Zone 1 on one-half of the crest width. This is intentional, and is meant to emphasize the critical nature of the area by requiring inspection of the area twice (ASDSO, 2001).

A typical dam safety inspection report should comment on width, alignment, vegetation, erosion, instabilities, and animal burrows observed in Zone 2. When specifically considering animal burrows and other deficiencies resulting from animal activity, the inspector should observe the following: animal burrow entrances, mounds of excavated soil, cracks, depressions, erosion, sinkholes, paths and ruts, sloughs, slides, and scarps. As with Zone 1, these issues can indicate animal activity. The inspection report should note whether the deficiencies warrant monitoring, repair, or further investigation.

Biological Perspective: Dens of beaver and muskrat are typically located just below the crest (look for depressions in the crest since the burrow entrance is typically underwater), and livestock often traverse the crest (look for hoof tracks, rills, gullies, and eroded pathways). Terrestrial wildlife such as groundhogs, ground squirrels, pocket gophers, foxes, coyote, and badgers may inhabit or hunt in the crest area. Moles may dig burrows in the dry, upland area of the upper upstream slope/crest that lead to their hunting grounds in the cool, moist soils near the reservoir pool. Vehicular traffic on crests may discourage wildlife establishment. Additionally, the crest is often constructed of well-compacted material, which is not attractive to most burrowing wildlife. Ants may dig tunnels in the crest, loosening existing cracks.

3.2.3 Zone 3: Upper Downstream Slope Area

Engineering Perspective: Inspecting the downstream slope is similar in method to inspecting the upstream slope. It is suggested that the downstream slope be viewed from a distance at a time of day when the angle of the sun is low so that wet areas, which will reflect sunlight, are seen more easily. Zone 2 overlaps Zone 3 on one-half of the crest in order to draw additional attention to the crest area.

A typical dam safety inspection report should comment on alignment, vegetation, erosion, instabilities, and animal burrows observed in Zone 3. When specifically considering animal burrows and other deficiencies resulting from animal activity, the inspector should observe the following: animal burrow entrances, mounds of excavated soil, cracks, depressions, erosion, sinkholes, paths and ruts, sloughs, slides, and scarps. As with the previous zones, these issues can indicate animal activity. The inspection report should

note whether the deficiencies warrant monitoring, repair, or further investigation.

Biological Perspective: This zone is the most attractive for terrestrial animal activity and is preferred by groundhog, fox, and coyote for burrow and den sites. Prairie dog, pocket gopher, ground squirrel, and groundhog may inhabit the downstream slope area; if they do, predators such as badger, coyote, and foxes may choose this zone as a hunting ground. Gopher tortoises, which are strictly terrestrial, would prefer this zone as it is dry and located well-above the phreatic surface. Look for large dens, burrows, and piles of dirt outside of small burrows. Ants may dig tunnels in the slope, loosening existing cracks. Livestock and Canada geese may graze on the stabilizing vegetation. Moles may inhabit this area and dig burrows from the slope area to an adjacent outlet or spillway for the moist soils they prefer as a hunting ground. Armadillo, mountain beaver, or voles may inhabit this area if the dam is improperly vegetated with trees, shrubs, or a thick understory.

3.2.4 Zone 4: Lower Downstream Slope Area

Engineering Perspective: Inspection of this zone is similar to inspecting the upstream and upper downstream slopes, but the inspector should give greater scrutiny to the downstream slope below the pool elevation. In most embankment dams, the potential for seepage through the embankment materials day-lighting on the downstream slope increases dramatically further down the downstream slope. As shown on Figure 3-1, the theoretical phreatic surface typical for homogeneous embankment dams intersects the downstream slope. Therefore, the presence of an animal burrow in this area could shorten seepage paths, increase hydraulic gradients, and ultimately cause internal erosion of the embankment materials. A more detailed description of the potential impacts from animal intrusions is provided in Chapter 2.0.

A typical dam safety inspection report should comment on vegetation, erosion, instabilities, seepage, and animal burrows. The potential for uncontrolled seepage through animal burrows in Zone 4 is significantly greater than in the three previous zones. Therefore, seepage observations are important in Zone 4. When specifically considering animal burrows and other deficiencies resulting from animal activity, the inspector should scrutinize the following: animal burrow entrances, mounds of excavated soil, concentrated seeps, wet/spongy areas, cracks, depressions, erosion, sinkholes, paths and ruts, sloughs, slides, and scarps. As with previous zones, these issues can indicate animal activity. The inspection report should note whether the deficiencies warrant monitoring, repair, or further investigation

Biological Perspective: This zone would also likely support terrestrial wildlife as described under Zone 3. Burrows constructed in lower Zone 4 (where it overlaps with Zone 5) will become saturated depending on depth, which is not preferred by most burrowing animals; therefore, burrows of terrestrial animals (i.e., gopher tortoise, fox, coyote, and groundhog) will occur in upper Zone 4. If a resident beaver constructs a dam that retains water, then muskrat, beaver, and otter will occupy inundated downstream slopes and outlet areas. Moles may hunt in the downstream slope if soils are moist, and the mountain beaver or armadillo may inhabit this area if the vegetation includes trees, shrubs, and a thick understory. Ants may dig tunnels in the slope, loosening existing cracks. Livestock and Canada geese may graze on stabilizing vegetation.

3.2.5 Zone 5: Downstream Toe Area

Engineering Perspective: Inspection of this zone is similar to inspecting the upstream slope and upper/lower downstream slopes, but Zone 5 is the most critical area because of the potential proximity of the phreatic surface to the downstream slope in this zone. Therefore, as in Zone 4, the presence of animal burrows in this area could shorten seepage paths, increase hydraulic gradients, and ultimately cause internal erosion of the embankment materials.

A typical dam safety inspection report should comment on vegetation, erosion, instabilities, seepage and animal burrows in Zone 5. The potential for uncontrolled seepage through animal burrows in Zone 5 is significantly greater than in Zones 1 through 3, and somewhat greater than in Zone 4. Therefore, seepage observations are critical in Zone 5. When specifically considering animal burrows and other deficiencies resulting from animal activity, the inspectors should observe the following: animal burrow entrances, mounds of excavated soil, concentrated seeps, wet/spongy areas, cracks, depressions, erosion, sinkholes, paths and ruts, sloughs, slides, and scarps. As with previous zones, these issues can indicate animal activity. The inspection report should note whether the deficiencies warrant monitoring, repair, or further investigation.

Biological Perspective: Burrows constructed in Zone 5 will become saturated depending on depth, which is not preferred by burrowing terrestrial animals (i.e., armadillo,

mountain beaver, vole, mole, gopher tortoise, fox, coyote, and groundhog). If a resident beaver builds a dam that retains water, then muskrat, beaver, nutria, and otter will occupy inundated downstream slopes and outlet areas, if appropriate vegetation has become established. Ants may dig tunnels in the slope, loosening existing cracks. Livestock and Canada geese may graze on stabilizing vegetation.

3.2.6 Zone 6: Spillway, Outlets, and General Areas

Engineering Perspective: The best approach to inspecting spillways and outlets is to view all surface and internal areas by walking closely along or within the structure, observing confined space entry requirements. The inspector should enter the conduit and view the internal structure using a flashlight, providing the conduit is of the appropriate size and in safe repair. The inspector should use binoculars or a camera/video camera with the appropriate lens to document the conduit condition if the conduit is not accessible (e.g., located in the water separated from the shoreline or embankment). Underwater features can be viewed via use of boats or underwater divers. Shorelines and upstream areas should be inspected by walking or using vehicles to traverse the inspection areas. Other appurtenant works should be inspected up-close.

Biological Perspective: Beaver will construct dams at the spillway locations to capture and reroute water flow. Look for gnaw marks in a circular pattern on tree trunks, beaver dams, and otters playing in the beaver dam waters. Aquatic animals such as muskrat and nutria may be found at these locations if the beaver dam retains water, and if sufficient aquatic vegetation has become established. Armadillo or mountain beaver may inhabit the area if a forest fringe or wooded area is adjacent to the water source.

4.0 Overview and Identification of Nuisance Wildlife

The FEMA/ASDSO workshop and 2003 dam safety specialist surveys indicate that several species damage earthen dams across the nation. This Chapter discusses 23 animals identified by the states as presenting the greatest threats to safe dam operations. Tracks, photographs, and range maps are provided for each animal, as well as a description of the specific threats each animal poses to the earthen dam environment, its preferred habitat, food habits, behavior, and field-identifying tips specific to each animal. It should be noted that some information is difficult to present depending on the animal (e.g., crayfish tracks) and in these cases, such information is omitted.

In a general sense, it is envisioned that a dam specialist will use this information to gain a better understanding of the wildlife that inhabits a dam. To a greater degree, it is hoped that this information will go hand in hand with overall dam management to assist a dam specialist in knowing where to look for wildlife damage (e.g., burrow sites), indicate which animals caused the damage via specific descriptors, and lead the dam specialist toward appropriate damage repair, prevention, and wildlife management (see Chapters 5.0 and 6.0 for dam repair, damage prevention, and wildlife management methods).

4.1 The Importance of Accurate Wildlife Identification

During the regular dam inspection detailed in Chapter 3.0 of this manual, the dam specialist will have viewed the dam from both engineering and biological perspectives. In doing so, the specialist may have identified burrows just below the water-line, observed floating rafts of vegetation on the water, trails from the water to the bank, and noted an abundance of aquatic vegetation along the shoreline. Application of the information in this chapter will assist the dam specialist in putting the above clues together to determine which animal is damaging the embankment.

Given the dynamic nature of wildlife and its desire to avoid human interaction, a dam owner will seldom witness wildlife causing damage to dams. However, proper identification of nuisance wildlife is critical so that dam repair and wildlife management methods can be appropriately and lawfully applied to mitigate specific species and their impacts to the earthen dam.

A dam environment that has high biological potential (refer to Chapter 3.1 for discussion of biological potential) will most likely support several nuisance species; however, not all

species living at the dam are necessarily in need of management. To apply mitigation that blankets all animals seen at the dam may be a waste of time and money, not to mention unnecessarily damaging to the environment. For this reason it is important to carefully evaluate the biological evidence at the dam to accurately identify the species responsible for the damage. For example, beaver and otters often live in the same environment, and otters often opt to use beaver dens instead of creating their own. In this case, the otter may be seen living in the den, but the beaver is the species actually responsible for the burrowing activity. Therefore, mitigation should be geared toward the beaver, and not necessarily the otter, which will live in hollow logs and rock crevices just as comfortably. On the other hand, several species may be responsible for compromising activities at the dam, and dam repair, prevention action, and wildlife mitigation will need to be geared toward several species. In essence, application of the information provided in this Chapter will assist in accurate identification of the problematic species, which will help the dam specialist appropriately manage the dam without spending unnecessary energy or funds.

Misidentification of a wildlife species may result in inadequate mitigation, which could allow damage to continue, perhaps leading to dam failure. As wildlife identification can be difficult, a dam owner may benefit from using a wildlife specialist or professional trapper to positively identify the species so that proper wildlife mitigation can be developed. Appendix A contains state wildlife contacts, and state trapper information can be obtained at www.nationaltrappers.com.

4.2 Identifying Nuisance Wildlife

4.2.1 Muskrat Overview

Muskrat(Ondatra zibethicus) are semi-aquatic rodents with brownish-black fur and with a body 10-14 inches long and a tail 8-11 inches long. Muskrats have large, partially-webbed hind feet and a vertically flattened tail, which they use to propel themselves through water.

Threat to Dams: Muskrats dig fairly large burrows that can lead to internal erosion and structural integrity losses in the earthen dam. Muskrats will continue to dig upward into the embankment as the phreatic surface rises; internal burrows can become extensive.

Habitat and Home (Figure 4-1): Muskrat inhabit freshwater and saltwater marshes, lakes, ponds, rivers, and other water-courses, where water is calm or very slowly moving. Muskrats prefer water courses that are about 3-4 feet deep that don't freeze completely in the winter and contain abundant cattails or aquatic vegetation. Muskrats typically burrow

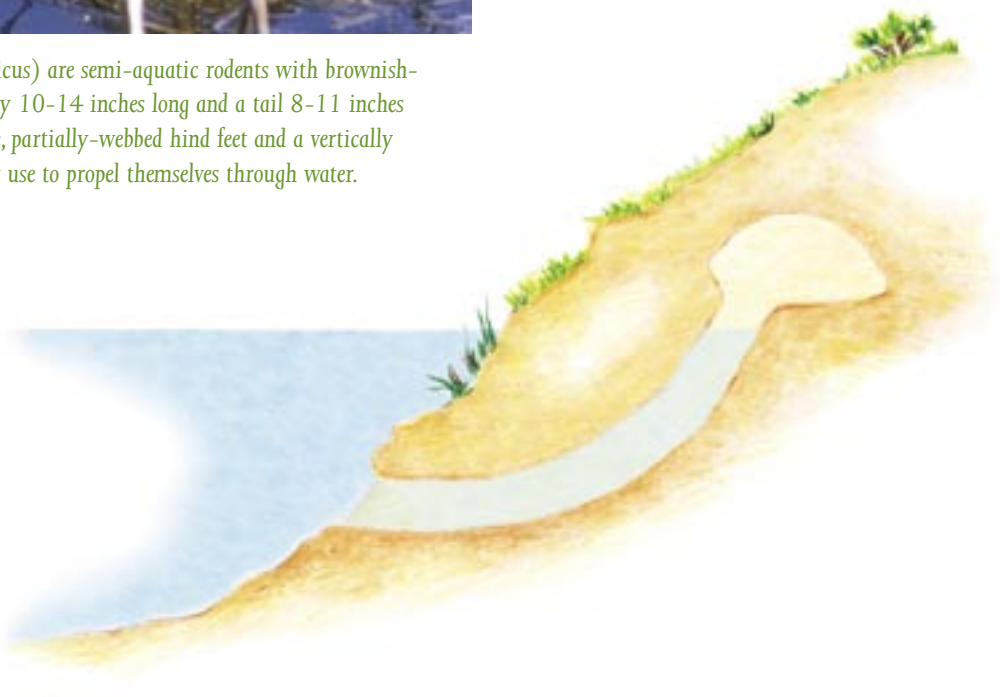
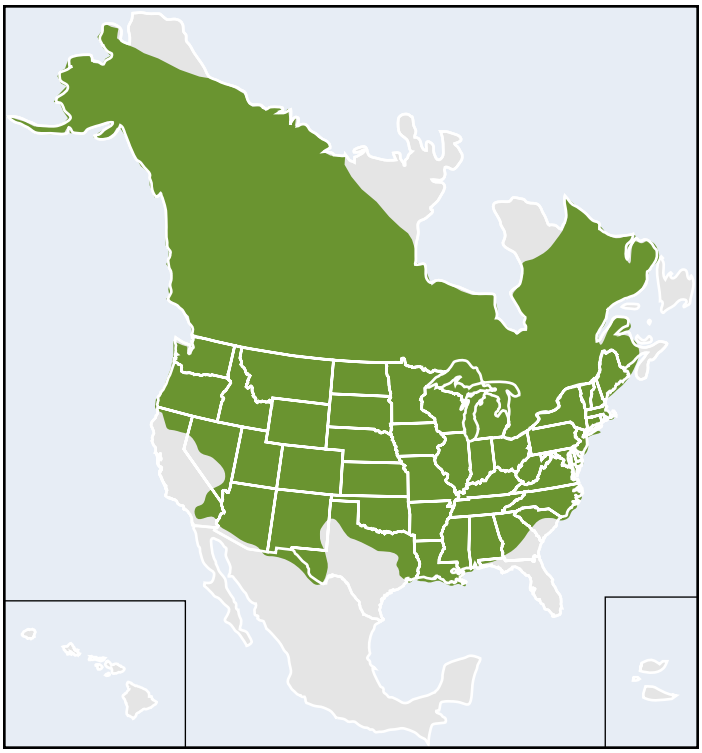


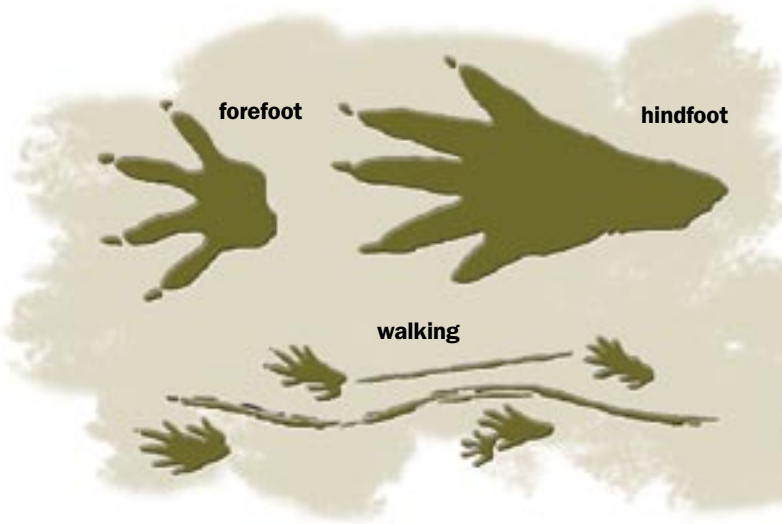
Figure 4-1. Muskrat dig dens in the upstream slope, with the entrance tunnel beginning about 6-18 inches below the water line.



Range of the muskrat in North America.

into a dam's upstream face. Their burrows begin from 6 to 18 inches below the water surface, and breather holes and escape holes can be observed above the water line. If the water level rises, the muskrat will excavate a dry chamber by digging higher into the embankment at an upward slant. Muskrats also build conical houses out of marsh vegetation, but usually excavate and use burrows when inhabiting earthen dams and other hydraulic structures (USDA, 1991). Detection of muskrat can be difficult if slopes of the dam are improperly vegetated, as their burrows may be covered over (see Chapter 5.2 for a discussion on improper vegetation at an earthen dam).

Muskrats are considered a significant dam safety issue in 71% of the surveyed states.



In very clear tracks, a small fifth toe can be seen on the outside of the front foot pad. All toes, except the nubbin, will show claw prints. The muskrat's vertically flattened, bare tail will create a drag mark in the center of the prints.

Food Habits: Muskrats are primarily herbivores and prefer to feed on cattails, grasses, smartweed, duck potato, water lily, sedges, and other aquatic plants. When vegetation is scarce, muskrat will feed on bivalves, crustaceans, insects, and sometimes fish (University of Nebraska, 1994).

Behavior: Muskrats can often be seen swimming at any hour of the day however they are most active at twilight. Muskrats often construct roofs over floating rafts of vegetation so that they have a covered place to eat. These huts can be found floating on the water and are especially important to the muskrat in winter when cooler weather can chill the animal's naked tail and feet (USDA, 1991; Benyus, 1989).

Field Tip: Listen for a loud splash when nearing the water. Muskrats plop into the water when approached to alert other muskrat of human activity. Muskrats sometimes hold their tails out of the water as they swim (Benyus, 1989).

4.2.2 Beaver Overview

The Beaver (Castor canadensis) is the largest rodent in North America weighing 45-60 pounds, with a body measuring 25-30 inches and a tail measuring 9-10 inches. Beavers are typically aquatic mammals, with webbed feet that are adapted for swimming and a flattened tail. Beavers vary in color but the most common body fur is reddish-brown and the belly fur is usually gray (USDA, 1991).

Threat to Dams: Beaver can cause extensive damage to earthen dams by excavating bank burrows, which can cause internal erosion or structural integrity losses. Beaver dams constructed across spillways can cause adverse hydraulic effects and result in flooding or failure of the spillway or the earthen dam itself. Beavers often clog the intake and outlet structures with their cuttings.

Habitat and Home: (Figures 4-2, 4-3, 4-3A and 4-4): Beaver can be found throughout the continental United States wherever there is a year-round source of water. However, beaver will avoid an aquatic site that does not contain preferred foods or have adequate sites for lodges, dens, or dams (University of Nebraska, 1994). Beaver lodges are easy to identify; they are dome-shaped, built of limbs and

Beavers are considered a significant dam safety issue in 67% of the surveyed states.

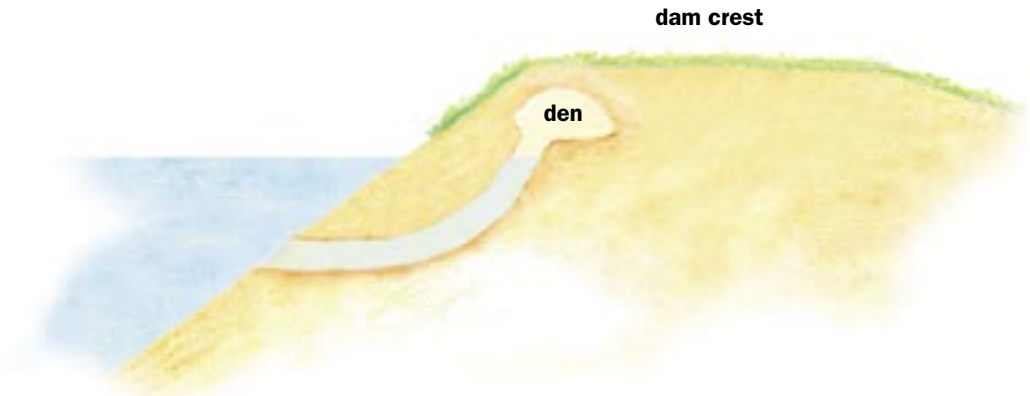
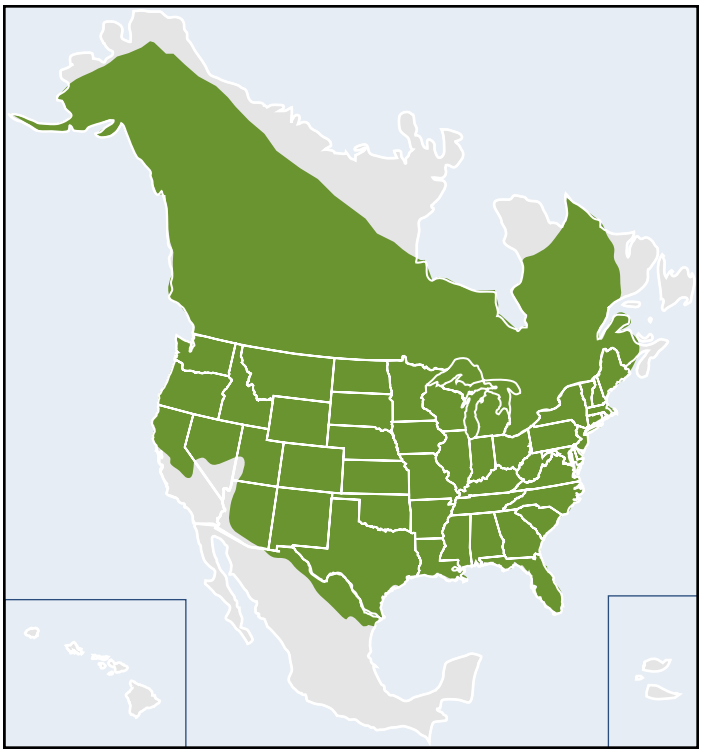


Figure 4-2. The ceiling of a beaver den is often just below the crest of the dam.



Range of the beaver in the North America.

logs, may reach 5-6 feet above the water line, and be 12-14 feet wide (Benyus, 1989). Beavers have also been known to create tunnels and dens. Beaver tunnel entrances have been observed 1-4 feet below the water level. Beavers burrow into the dam from below the water line upwards toward the crest, where the beaver will excavate their den. The entrance to the lodge or bank den is typically under water, with the interior den being several inches above the water surface. All lodges and bank dens have at least two entrances, and perhaps four or more (University of Nebraska, 1994).

Beaver dens are often excavated just below the dam crest within the dam. A den roof collapse at this location can create voids in the crest and upstream slope.

Beaver tracks are not a reliable way to identify their presence due to their walking pattern. The beaver's hind foot is placed on top of the front foot's track and the wide tail, which drags along the ground, smears both to a point where identification becomes nearly impossible.

Food Habits: Beaver prefer to eat tree species such as aspen, willow, poplar, cottonwood, sweetgum, blackgum, and pine, although beaver will also eat most woody plants that grow near water, as well as herbaceous and aquatic plants. Beavers will travel 100 yards or more from their water habitat to cut down crops or trees growing in adjacent habitats and drag them back to their pond home. Beaver use whatever vegetation they don't eat for dam construction (University of Nebraska, 1994).

Figures 4-3 and 4-3A. Beaver dams can block emergency spillways causing water levels behind the dam to rise.

Figure 4-4. A lodge can reach 5-6 feet above the waterline.

The ranges for beaver, nutria and muskrat overlap, and their damages can appear similar. Careful examination of the damage, burrows, and proper use of the field tips listed in this manual will assist in accurate species identification and management.

Behavior: Beavers construct dams to create a depth of water suitable for them to hide from predators as they travel to their shore feeding grounds. Beaver use a variety of materials to construct these dams—the use of wood, fiber, metal, wire, and rocks is not uncommon. Beavers leave their lodge at dusk and spend most of the night working (removing shoreline trees, constructing dams, gathering food). However, in the fall season it is not uncommon to see a beaver working in the daytime as they gather food for the winter (Benyus, 1989).

Field Tip: Perhaps the best indication of beaver is their dams. Dams are typically a few feet long, but can be up to several hundreds of feet long. A second indication is the presence of canals, which beaver build in the water to help them transport the trees they fell to construct the dams. Gnaw marks in a circular pattern on tree trunks are also good indicators of beaver, and trees cut by beavers show a distinctive tapered cone at the end of the trunk. An audible sign of beaver is the loud slap of their horizontally flattened tail on the surface of the water to alert other beaver to the presence of predators (Benyus, 1989).

4.2.3 Mountain Beaver Overview

Mountain Beaver (Aplondontia rufa) is typically found in Washington, Oregon, and portions of California. Mountain beaver neither prefer mountainous habitat nor are true beavers. These rodents have short, heavy bodies and are dark brown above and lighter brown below; they resemble a tailless muskrat. Mountain beavers have long, strong claws, which they use to create burrows up to 19 inches in diameter in wet soil near dense water-side vegetation.

Threat to Dams: Mountain beavers divert waterflow by blocking water with vegetation. The shallow location of the extensive burrows will often cause the ground to cave in. The mountain beaver's activities could result in hydraulic alteration and structural losses.

Habitat and Home: Mountain beavers prefer habitats in forested areas where the canopy is open enough to allow dense understory vegetation. If a dam is covered with trees and thick understory, then a mountain beaver will likely find a comfortable habitat. Within this area, mountain beaver prefer moist gullies, and vegetated hillsides or flat areas that are not prone to flooding. Habitats dominated by red alder, salmonberry, huckleberry, and bracken and sword ferns are preferred by the mountain beaver. Mountain beavers dig extensive burrows that can cover a quarter-acre, are usually located near vegetative cover, and are generally 1-6 feet deep with 10-30 open entrances. The burrows contain deep (1-9 feet) nesting and food chambers usually located about 3 feet below ground surface; the chambers can be large, usually measuring 2 feet in height and 2 feet in diameter. Mountain beavers do not like their burrows to be wet and will leave a burrow once it is flooded (University of Nebraska, 1994) (Figure 4-5).

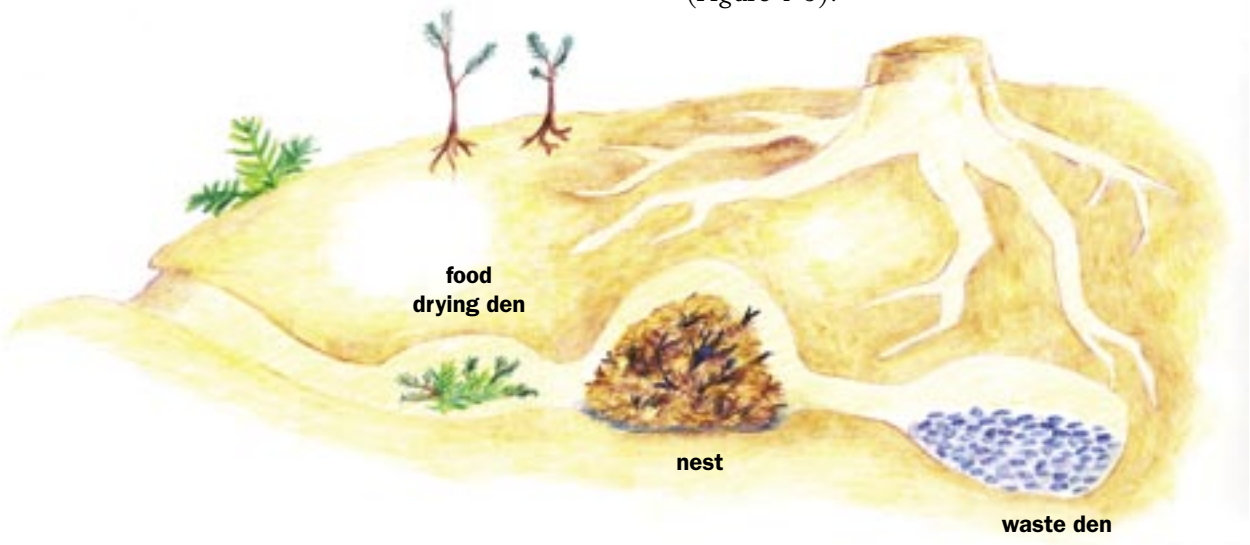
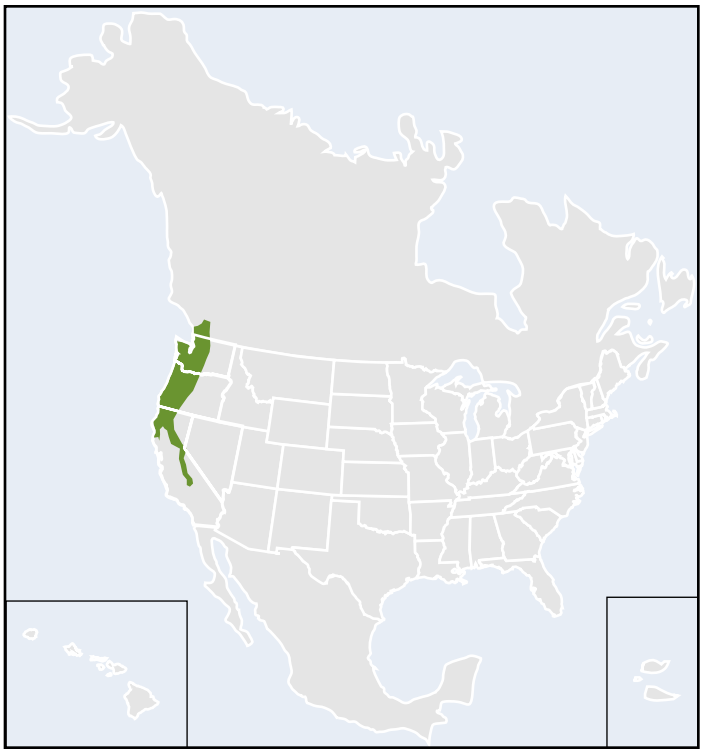
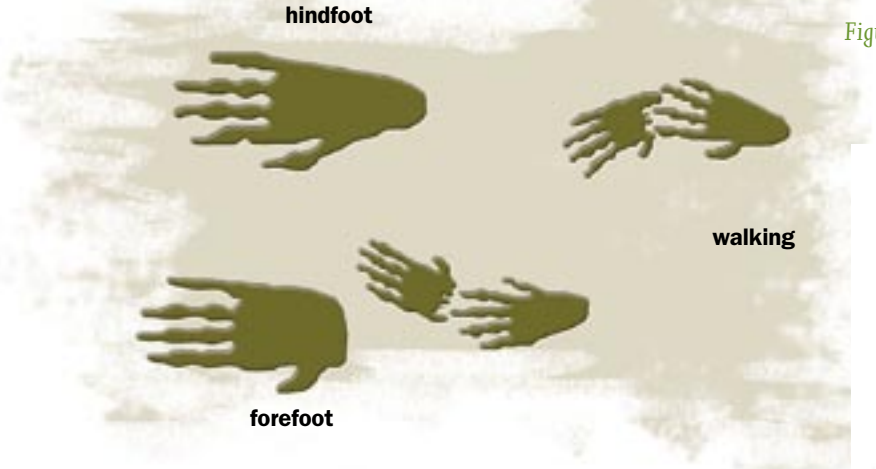


Figure 4-5. The mountain beaver only leaves its den to forage or create new dens.



Range of the mountain beaver in North America.



The identifying characteristic of a mountain beaver track is a front foot print that has a square heel and a hind print that displays a tapered heel.

Food Habits: Mountain beavers are herbivores and eat any type of succulent vegetation, with sword fern and bracken fern being favorites (University of Nebraska, 1994). Mountain beavers will also girdle the base of trees and feed on small stems (Figure 4-6). Plants that are gathered by the mountain beaver are often dried near the burrow and are probably used for storage or nesting material. Mountain beavers dry their food by stacking vegetation on a nearby log or rock, which is termed "haystacking" (Figure 4-7). Mountain beaver usually feed on plants located within 50 feet of their burrows (University of Nebraska, 1994).

Figure 4-6. Mountain beavers girdle trees and feed on small stems.

Figure 4-7. Mountain beavers dry their vegetation on logs, known as "haystacking," before moving it into their burrows. Haystacks can be up to 2 feet high.

Figure 4-8. Ferns and Douglas fir branches placed in a burrow is a reliable field sign of mountain beaver.

Behavior: Mountain beavers are nocturnal animals. They are superb diggers and spend much of the night digging and maintaining their labyrinth of burrows. Mountain beavers often stack cut vegetation in a burrow entrance, presumably to lower the vegetation's moisture content before storing it in the burrow (University of Nebraska, 1994).

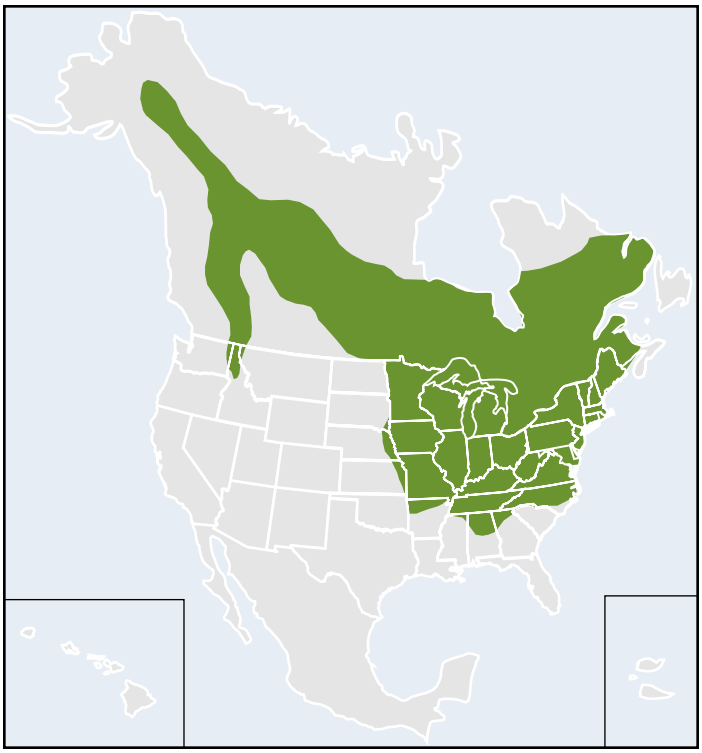
Field Tip: Stem and branch cutting within the vicinity of the dam may be a positive sign of mountain beavers. Signs of mountain beaver include freshly dug soil and chewed vegetation in proximity to a 6 to 8-inch diameter hole. Look for haystacks near the burrow entrance and vegetation piled in the burrow entrance (Figure 4-8).

4.2.4 Groundhog Overview

Groundhog (Marmota monax) (also known as Woodchuck or Rockchuck) are large burrowing rodents that weigh an average of 5 to 10 pounds and have an average body length of 16-20 inches. Groundhogs are usually grizzled brownish gray, although white and black individuals may occasionally be found. The groundhog's forefeet have long, curved claws that are well adapted to digging burrows (University of Nebraska, 1994).

Threat to Dams: Groundhog burrows in earthen dams can weaken the embankment and act as a pathway for seepage.

Habitat and Home: The groundhog generally prefers open farmland and woody or brushy areas adjacent to open land. Groundhog burrows are usually located in fields or near grassy pastures or meadows, along fence rows, stone walls, roadsides, and near building foundations or the bases of trees (University of Nebraska, 1994) (Figure 4-9, shown on page 31). Groundhogs will burrow into earthen dams, generally on the downstream side of the dam, as this environment can be similar to their preferred habitat (Michigan State University Extension, 1998). Their burrows can be distinguished by the large mound of excavated earth deposited by the main entrance. Two or more entrances generally exist for each burrow system. Burrows are often well-hidden and may be difficult to locate.

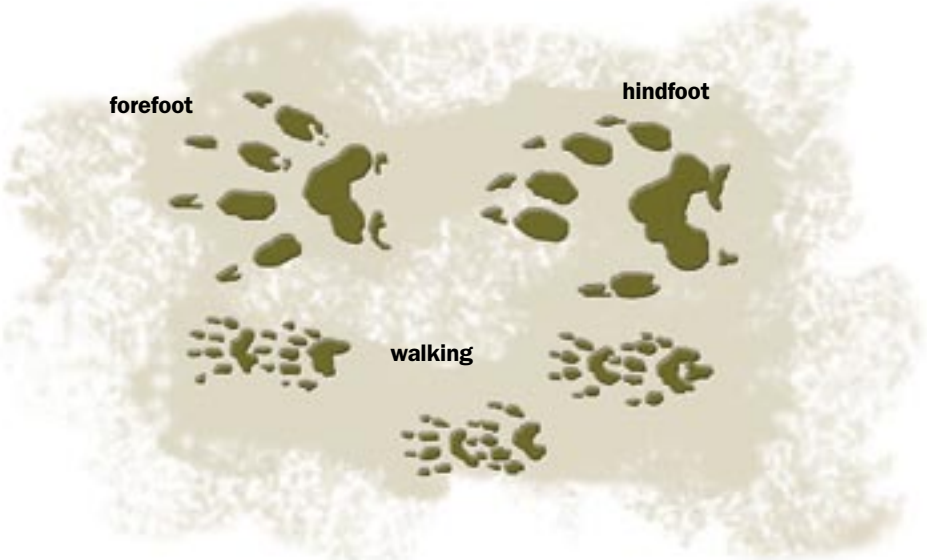


Range of the groundhog in the North America.

Food Habits: Groundhogs are strict herbivores. They feed on a variety of vegetables, grasses, and legumes, including beans, peas, carrot tops, alfalfa, and clover. Groundhogs prefer to feed in the early morning and evening hours (University of Nebraska, 1994).

Behavior: Groundhogs are usually only active during the day. During warm periods, they can often be found basking in the sun near their burrows. Groundhogs are one of the few mammals that enter a true hibernation period. Hibernation generally occurs from late October or early November to late February or March, although the exact timing depends on the latitude (University of Nebraska, 1994). New burrow construction occurs in late summer (USFS, 1994).

Field Tip: When approached or startled, a groundhog will often emit a shrill whistle followed by a low, rapid warble (University of Nebraska, 1994). An indicative sign of a groundhog burrow is the spring cleaning performed by the groundhog, which results in a mound of fresh dirt outside the burrow entrance. Adjacent trees may be girdled or clawed (Indiana Department of Natural Resources, 2003). Look for burrow construction in the late summer months.



It may be difficult to tell the front and back tracks apart because when a groundhog walks, it puts its hind foot in the track of its front foot.

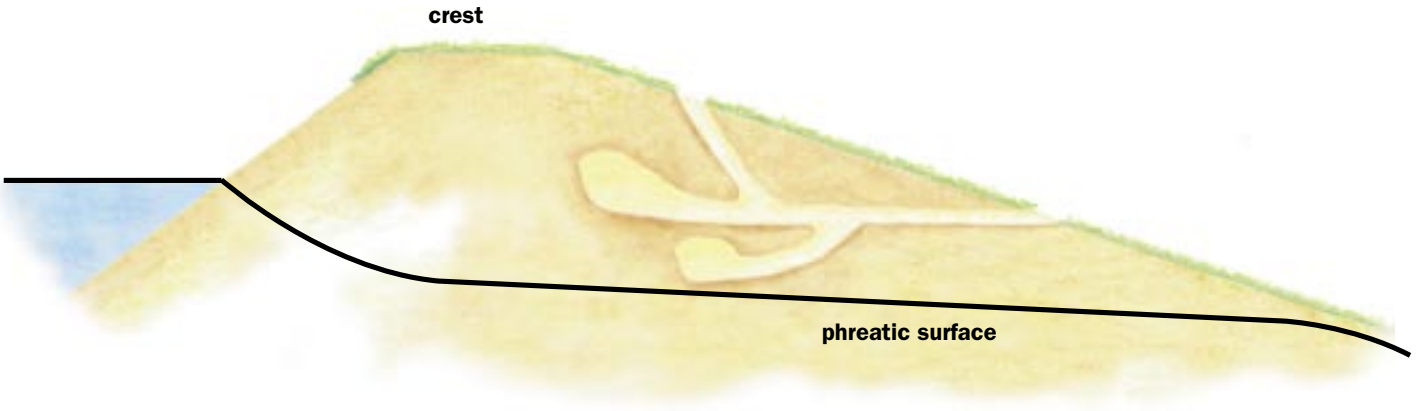


Figure 4-9. Groundhog burrows are extensive and irregular in pattern.

4.2.5 Pocket Gopher Overview

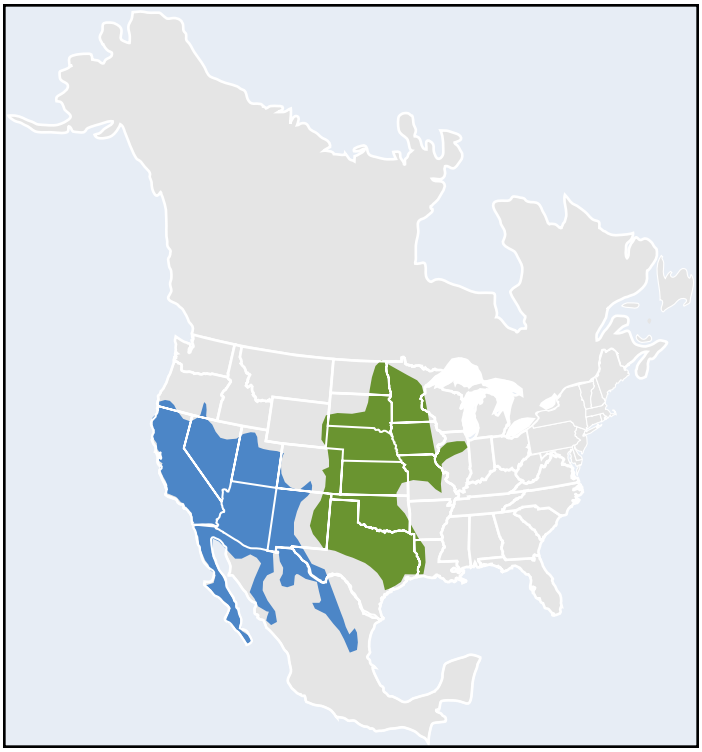
Pocket Gopher (Geomys spp., Thomomys spp., and Pappogeomys castanops) are medium-sized burrowing rodents that weigh an average of 3 to 20 ounces and have an average body length of 5 to 14 inches. Their fine fur is highly variable in color, ranging from nearly black to pale brown to almost white. Pocket gophers have fur-lined pouches outside of the mouth that are used for carrying food. They have yellowish-colored incisor teeth that are always exposed, even when the mouth is closed.

Pocket gophers are considered a significant dam safety issue in 23% of the surveyed states.

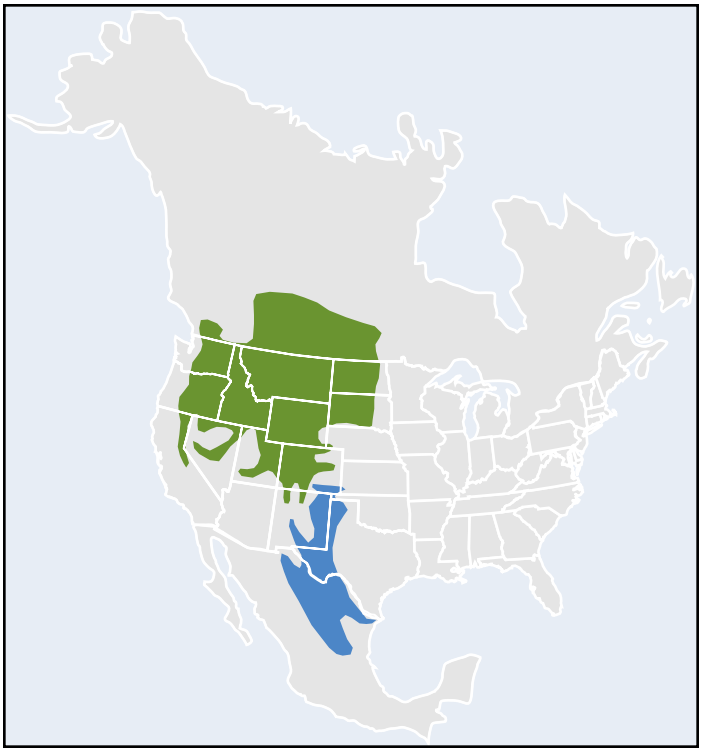
Threat to Dams: Pocket gophers are generally only a threat to small earthen dams. They dig burrows that can lead to internal erosion and structural integrity losses in the dam. The presence of pocket gophers also increases the likelihood of badger activity. Badgers are one of the primary predators of pocket gophers. Badgers will attempt to dig gophers out of their burrows, which can be very destructive to earthen dams (See Chapter 4.2.6 for a discussion on badgers). Pocket gophers can also damage underground utilities, such as irrigation pipes or electric cables (USDA, 1991).

Habitat and Home: There are 10 species of pocket gopher with substantial populations in the United States, but only one species is typically found in an area (USFS, 1994). They can occupy a wide range of habitats, from low coastal areas

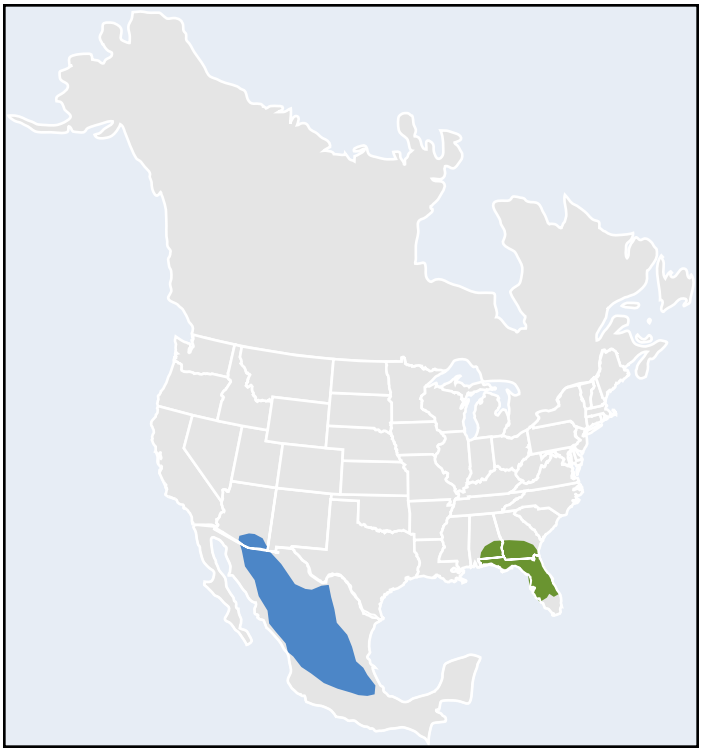
Range of the pocket gopher in North America.



Plains (*Geomys bursarius*), and Botta (*Thomomys botta*) Pocket Gophers



Northern (*Thomomys talpoides*), and Yellow-Faced (*Pappogeomys castanops*) Pocket Gophers

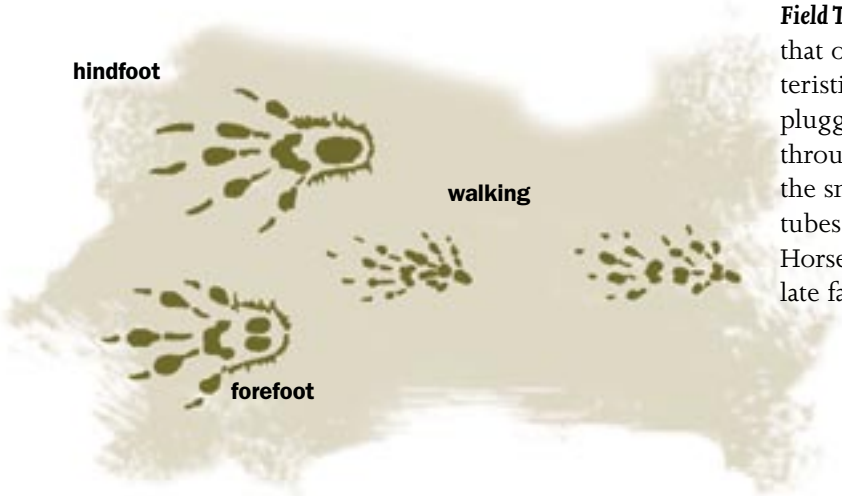


Southeastern (*Geomys pinetis*), and Southern (*Thomomys umbrinus*) Pocket Gophers

to mountains (USDA, 1991). Horseshoe-, fan- or kidney-shaped mounds of soil are characteristic evidence of pocket gopher burrows. Their burrows are nearly always kept closed with an earthen plug (University of Nebraska, 1994) (Figure 4-10).

Food Habits: Pocket gophers are strict herbivores, eating all types of forbs, grasses, shrubs, and trees. Roots are the major food source, although during the growing season, pocket gophers will also eat the above-ground portions of plants (University of Nebraska, 1994).

Behavior: Pocket gophers are solitary animals that spend much of their time underground. There is typically only one gopher per burrow, except during breeding season (USDA, 1991).



Pocket gopher tracks will show five toes on the hindfoot and four toes on the slightly smaller forefoot. Claw marks are usually well-defined.

Field Tip: Pocket gopher activity can be distinguished from that of other burrowing animals by their burrow characteristics, particularly the fan-shaped mounds of soil and plugged burrow entrances. Pocket gophers will tunnel through the snow, pushing soil from below ground into the snow tunnels. When the snow melts, the soil "casts" or tubes can be found on the ground surface (USFS, 1994). Horseshoe-shaped mounds of soil are created in summer or late fall.

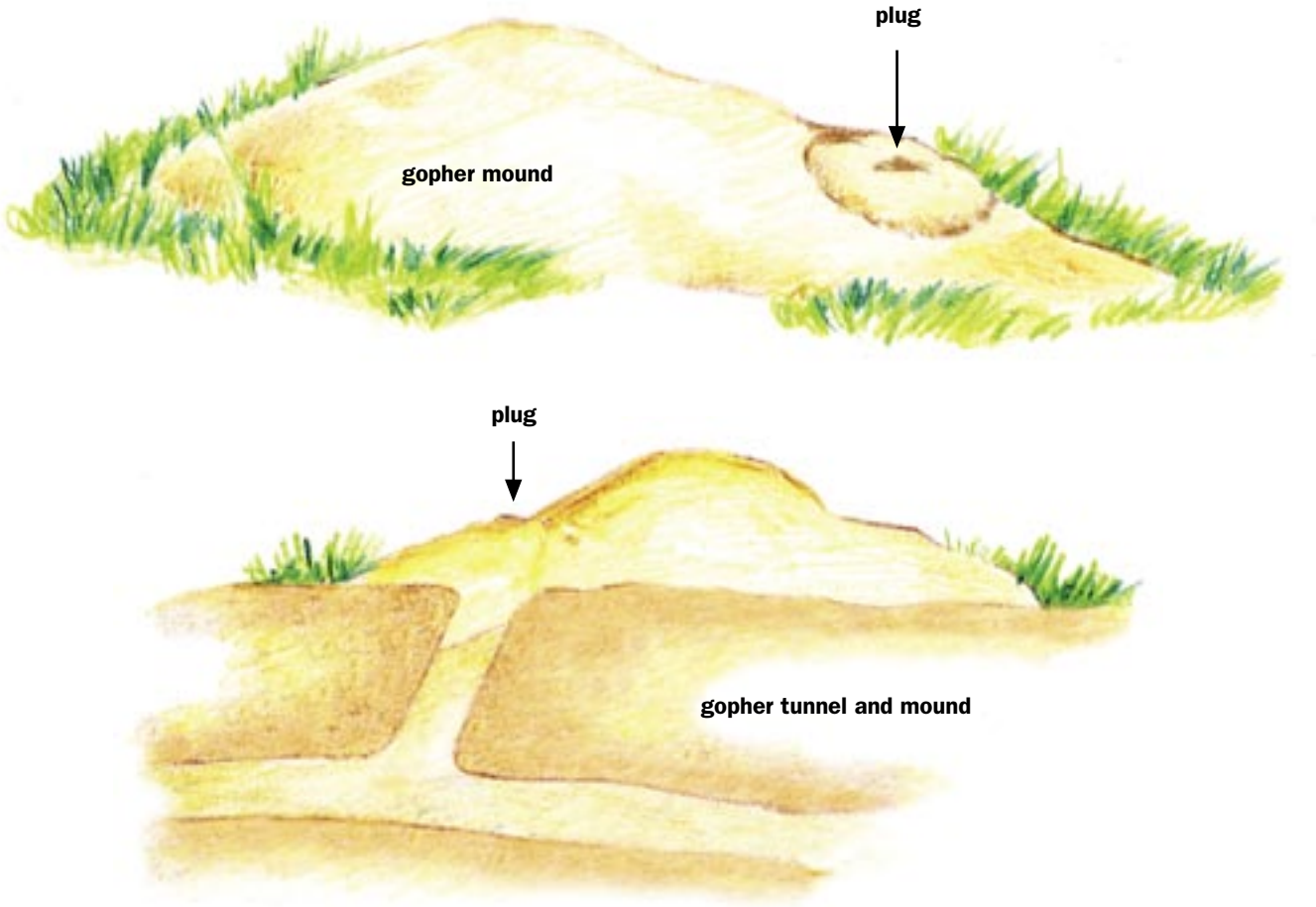


Figure 4-10. Lateral burrows of the pocket gopher end in a soil mound or a soil plug.

4.2.6 North American Badger Overview

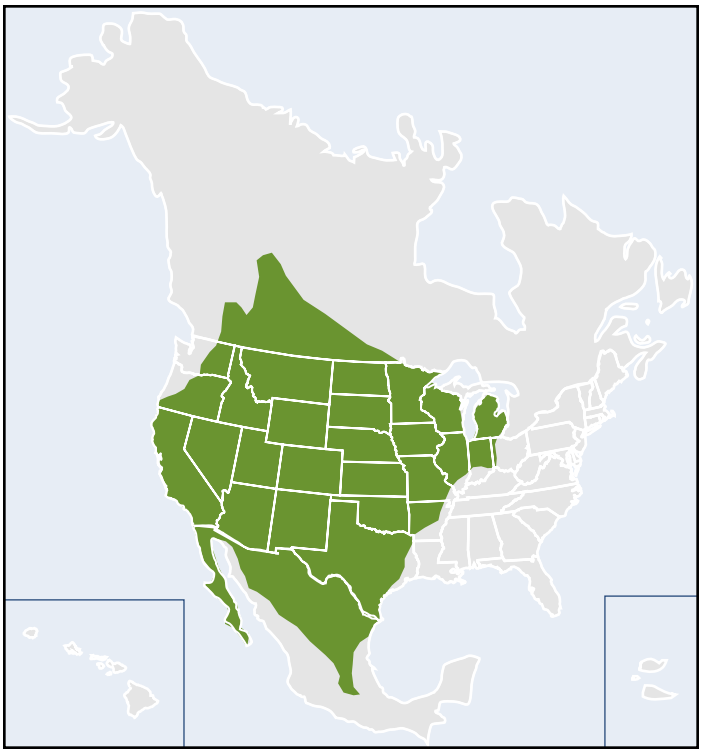
The North American Badger (Taxidea taxus) is a stocky animal that can grow up to 30 inches long. It has grayish yellow fur with pale underparts, long claws, a short, bushy tail, and black feet. Badgers can weigh from 19 to 30 pounds and can be identified by a white stripe that runs from its nose to the back of its head (University of Nebraska, 1994).

Threat to Dams: Badgers are especially adapted for digging and dig in pursuit of prey and to construct dens for shelter. Badgers can cause severe damage to hydraulic structures. Badgers can exacerbate internal and external erosion in an earthen dam by enlarging existing burrows of prairie dog, pocket gopher, or ground squirrels, all of which can inhabit an earthen dam and are a preferred food of the badger. Badger dens create large voids in the earthen dam, compromising structural integrity.

Badgers are considered a significant dam safety issue in 17% of the surveyed states.

Habitat and Home: Badgers prefer pastures or rangelands with light to moderate cover and few trees. Habitats with sandy or porous soils are preferred. Female badgers dig large burrows (5-30 feet long) with a large chamber 2-3 feet below the ground surface for birthing. Dens have one entrance that is usually elliptical in shape (University of Nebraska, 1994).

Food Habits: North American badgers are opportunist omnivores that feed on earthworms, mammals, birds, reptiles, grains, and fruits. Prairie dog, pocket gopher, and ground squirrels are common in badger diets.



Range of the badger in North America.

Badger tracks are similar to coyote tracks, but are distinct in the long claw marks on the front feet and the presence of five toes. Badger tracks are typically turned inward toward each other, and the hindprints are narrower than the foreprints.

Behavior: Badgers are adept at pursuit and capture of ground-dwelling prey. A typical burrow dug in pursuit of prey is shallow and about 1 foot in diameter (University of Nebraska, 1994). Badgers are mostly nocturnal but will be active during the day if the area is quiet. Badgers are usually solitary.

Field Tip: Large piles of dirt and rock left near animal burrows can indicate badger hunting activity. Badgers maintain the condition of their claws by sharpening them on trees or fence posts; claw marks can indicate badger presence (University of Nebraska, 1994).

Badger tunnels and dirt mounds resulting from prey pursuit can cover an area the size of a car.

4.2.7 Nutria Overview

Nutria (Myocastor coypus) With an average weight of 8 pounds and a body length of 24 inches (tail is an additional 16 inches long), nutria are larger than muskrat, but much smaller than beaver. With a preferred habitat that includes permanent water, nutria are excellent swimmers with webbed hind feet, but move awkwardly on land.

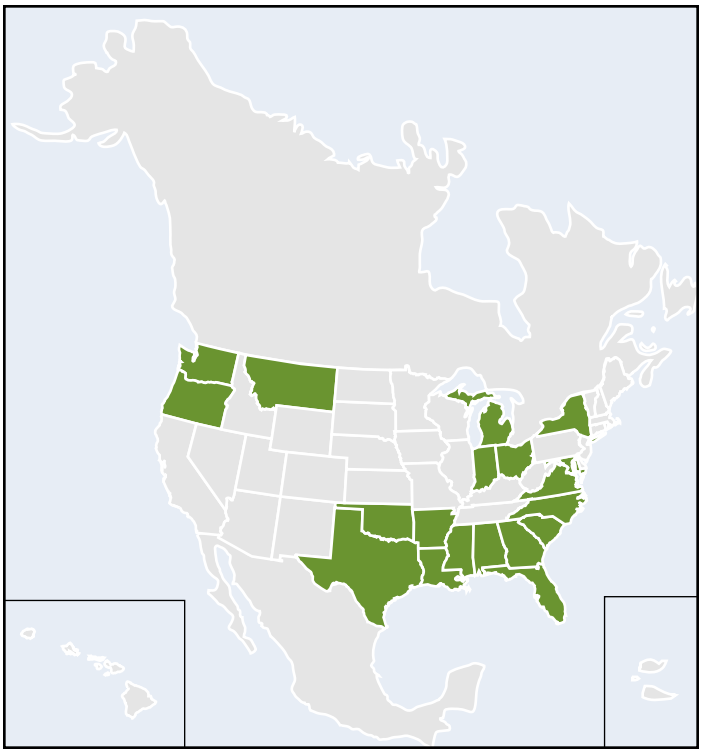
Threat to Dams: Nutria construct extensive burrows as shelter in the upstream slope. Burrows can weaken an earthen dam to the point of collapse when soil becomes saturated by precipitation or high water, or when heavy vehicles cross the crest. Nutria are notorious for breaking through water-retaining levees in Louisiana and Texas (University of Nebraska, 1994).

In some cases, nutria tunnels have been so extensive that water flowed unobstructed through the embankment necessitating its complete reconstruction.

Habitat and Home: Nutria can adapt to a variety of habitats, but prefer a semi-aquatic environment and particularly, the zone between land and permanent water. This zone is preferred for its abundance of aquatic vegetation. For the most part, any substantial nutria populations in the United States occur in freshwater marshes of coastal areas (University of Nebraska, 1994). Nutria are ground-dwellers during the summer, preferring to live in dense vegetation. The rest of the year nutria live in burrows they have dug, or that have been abandoned by armadillos, muskrat, or beaver. Nutria construct burrow entrances in vegetated banks of dams and waterways; a bank that has a slope greater than 45 degrees is a preferred location (University of Nebraska, 1994). Nutria burrows can be simple or complex; a complex burrow may have several tunnels and entrances at different levels in the bank. A burrow system will contain compartments (ranging from 1-3 feet across) for resting, feeding, and shelter from the weather and predators. Tunnels can be 4-6 feet in length.

Look closely! Nutria are aquatic rodents often misidentified as either a muskrat or beaver.

Nutria are considered a significant dam safety issue in 4% of the surveyed states.

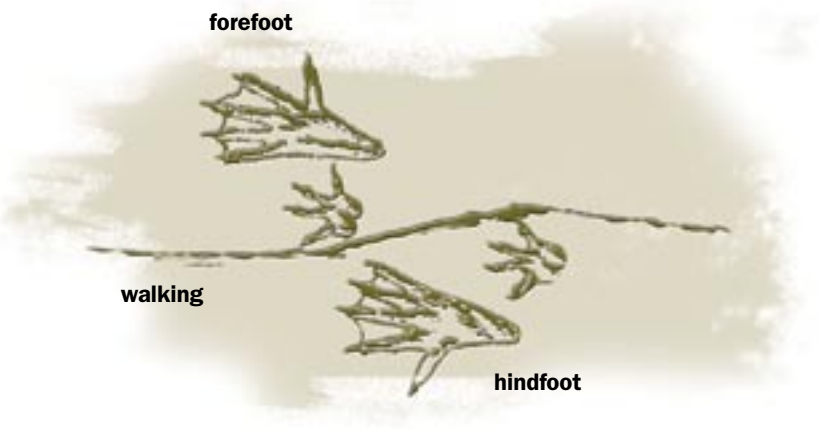


Range of the nutria in North America.

Food Habits: Nutria prefer aquatic plants such as sedges, rushes, cattails, and arrowheads, however the bark of black willow and bald-cypress may be eaten in the winter. Nutria eat food in a number of places including feeding platforms on the water (floating mats of vegetation or even on top of beaver and muskrat houses), in the water itself, or on land.

Behavior: Nutria feed at night when food is plentiful, but will feed during the day if food is limited. Nutria can scratch or bite aggressively if captured or cornered.

Field Tip: Unlike muskrat or beaver, a nutria's tail is round with scant hair, the whiskers are long (around 4 inches) and whitish, and nutria have prominent red-orange incisors. Trees girdled by nutria will show no teeth marks.



Tracks left by nutria may also have tail drag marks, or sometimes chest marks, as a nutria may drag its chest when on land.

Nutria construct platforms of floating vegetation used for loafing, grooming, birthing, and escape, which are often mistaken for muskrat houses.

4.2.8 Prairie Dog Overview

Prairie Dogs (Cynomys spp.) are squirrel-like, burrowing rodents with squat, muscular bodies and short tails and ears. Their fur is sandy brown to cinnamon in color with grizzled black and buff-colored tips. Adult prairie dogs grow to a length of 13 to 17 inches and weigh approximately 2 to 4 pounds (USDA, 1991).

Prairie dogs are considered a significant dam safety issue in 8% of the surveyed states.

Threat to Dams: Prairie dogs dig burrows that can lead to internal erosion and structural integrity losses in earthen dams.

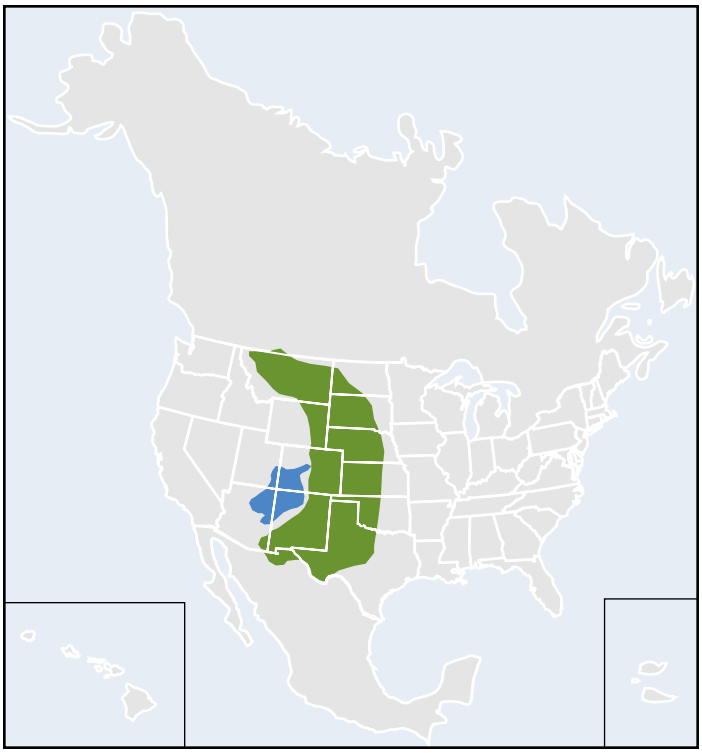
Habitat and Home: Prairie dogs prefer grassland or short shrubland habitats. They often establish colonies near intermittent streams or water impoundments (USDA, 1991). Prairie dog burrows are found in open areas with low vegetation. Their burrows are distinguished by relatively large holes and cone-shaped mounds. Prairie dogs remove the vegetation from around their burrows and use it for food or nesting material (USDA, 1991). Other animals often make their homes in prairie dog burrows, including the federally protected black-footed ferret and burrowing owl.

Food Habits: Prairie dogs eat mostly grass, although they will also eat flowers, seeds, shoots, roots, and insects when available (University of Nebraska, 1994).

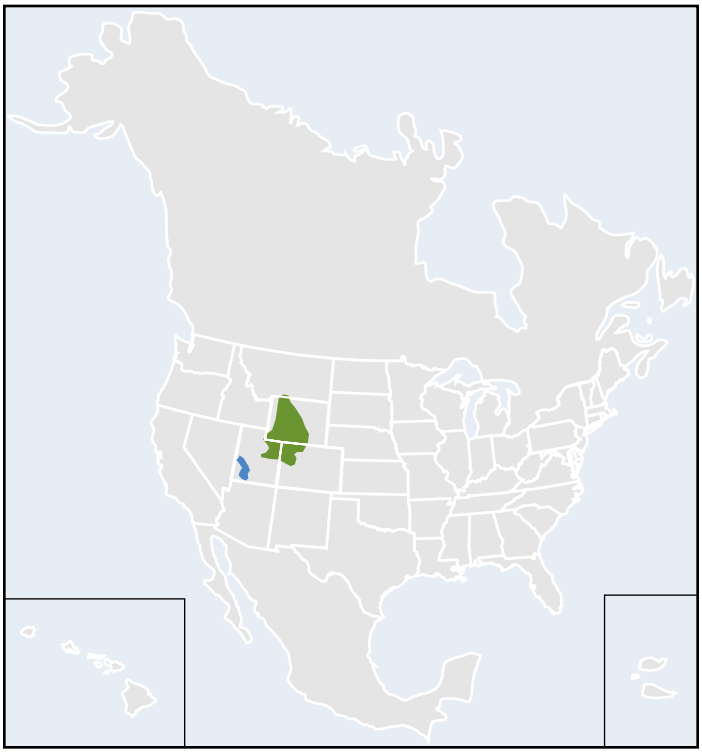
Behavior: Prairie dogs live in large colonies known as "towns." Each town is made up of a complex series of tunnels and may have as many as 20 to 50 burrow entrances. Prairie dogs are social animals that are most active during the day (University of Nebraska, 1994).

Field Tip: Look for mounds of earth about 1 to 2 feet high that resemble miniature volcanoes.

Range of the prairie dog in North America.



Black-Tailed (Cynomys ludovicianus), and Gunnison (Cynomys gnnisoni) prairie dogs



White-Tailed (Cynomys leucurus), and Mexican (Cynomys mexicanus) prairie dogs

Prairie dog tracks will show five toes on the hindfoot and four toes on the slightly smaller forefoot.

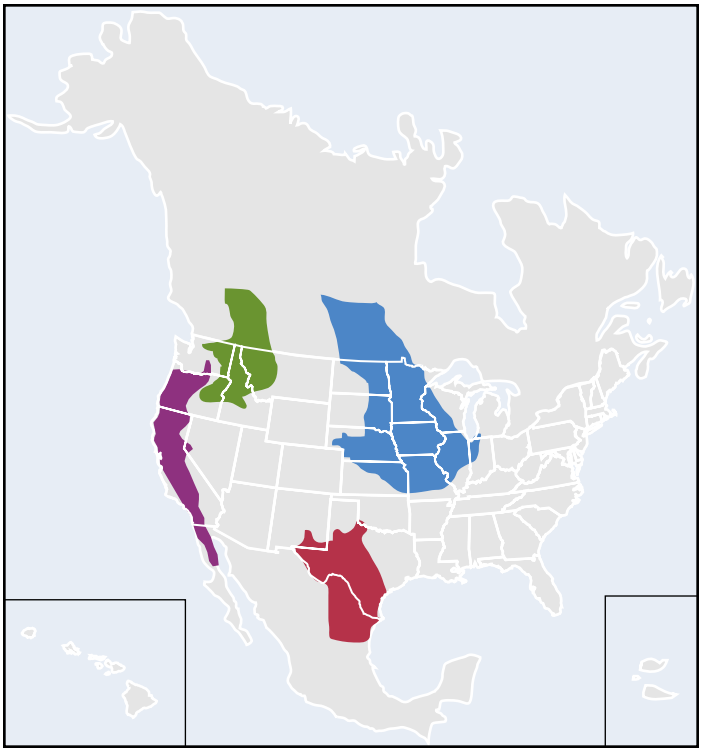
4.2.9 Ground Squirrel Overview

Ground Squirrel (Spermophilus spp.) are small to medium-sized burrowing rodents. Twenty-three species of ground squirrels live in the United States (University of Nebraska, 1994). They vary is size, with lengths ranging from 6 to 20 inches and weight ranging from 0.25 to 2.5 pounds. They also vary in color, ranging from brown to reddish brown to gray. Some species have markings, such as spots or stripes. Some species have long bushy tails, while others have short tails with short hair (USDA, 1991).

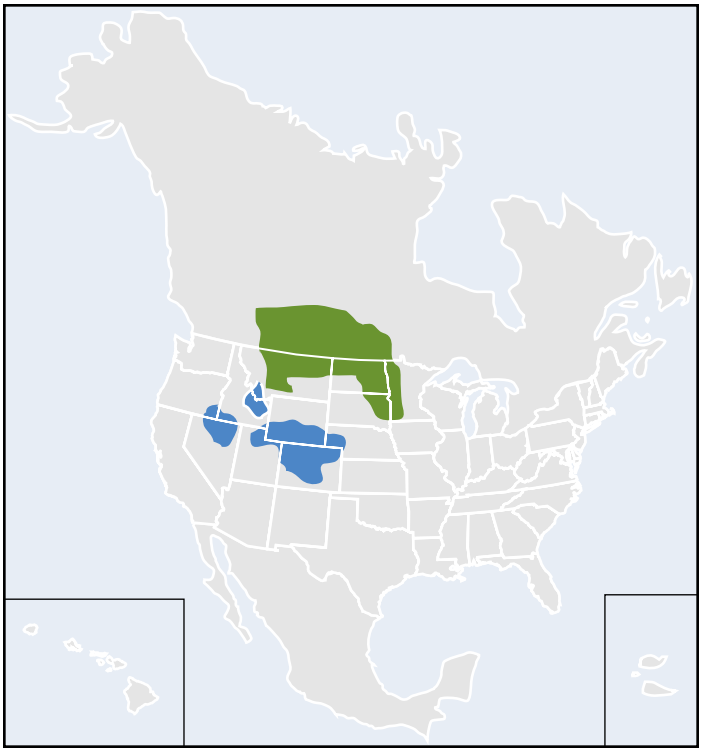
Threat to Dam: Ground squirrels dig burrows that can lead to internal erosion and structural integrity losses in earthen dams. The presence of ground squirrels also increases the likelihood of badger activity. Badgers will pursue ground squirrels into their burrows, which can be very destructive to earthen dams (USDA, 1991).

Habitat and Home: Ground squirrels can be found in at least 27 states west of Ohio. They occupy a wide range of habitats from low coastal areas to mountains. Ground squirrels keep their burrows unplugged. Specific burrow design varies with species, soil type, habitat and climate. Some species of ground squirrels are colonial, which means that several individuals live in the same burrow system. These systems consist of clustered, above-ground mounds that resemble prairie dog burrows. They are generally easier to spot than the burrows of solitary ground squirrel species, which tend to be scattered and inconspicuous (USDA, 1991).

Range of the ground squirrel in North America.

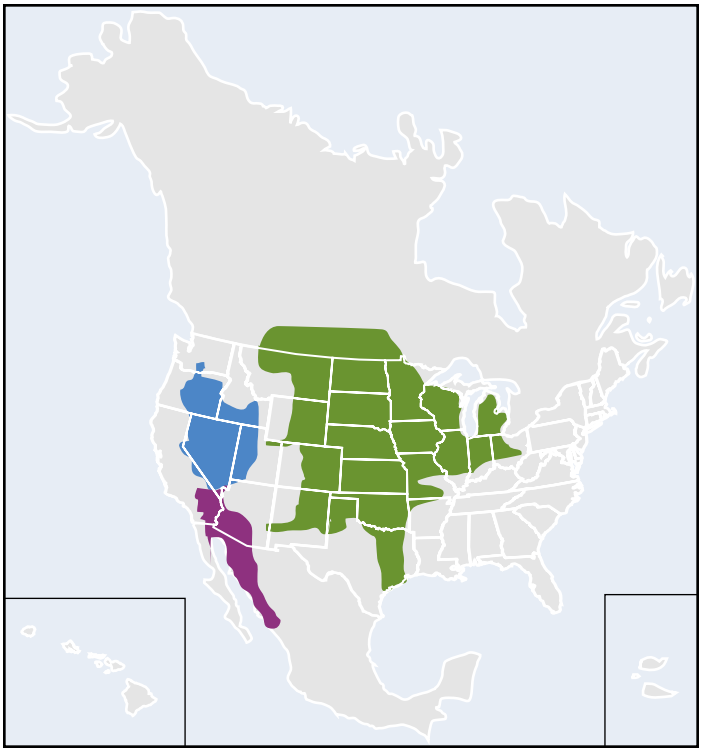


Columbian (Spermophilus columbianus), Franklin (Spermophilus franklinii), California (Spermophilus beecheyi), and Mexican (Spermophilus mexicanus), ground squirrels

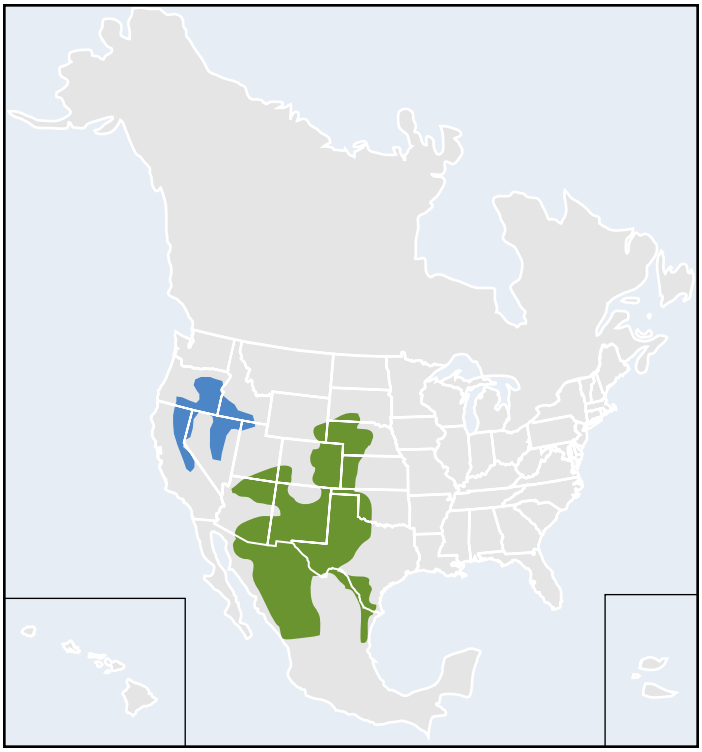


Richardson (Spermophilus richardson), and Wyoming (Spermophilus elegans) ground squirrels

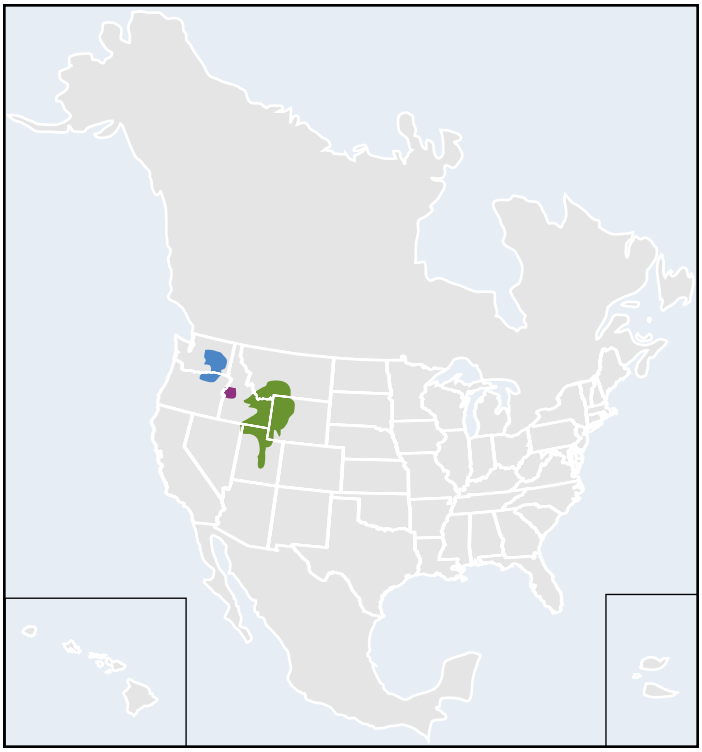
Range of the ground squirrel in North America (continued).



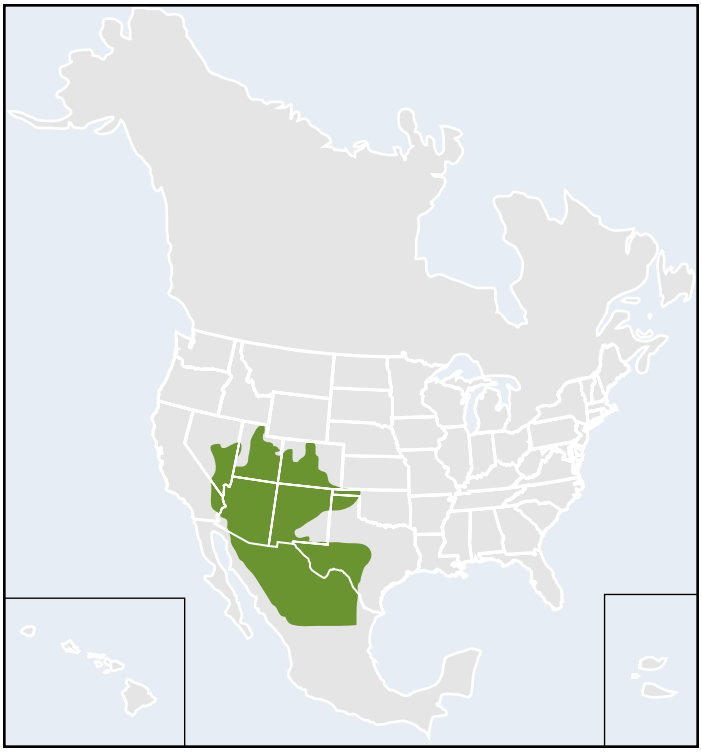
Townsend (Spermophilus townsendi), Thirteen-lined (Spermophilus tridecemlineatus), and Round-tailed (Spermophilus tereticaudus) ground squirrels



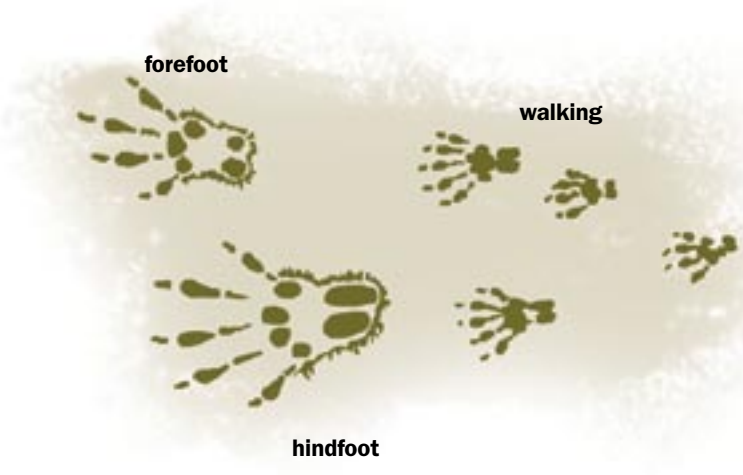
Belding (Spermophilus beldingi) and Spotted (Spermophilus spilosoma) ground squirrels



Washington (Spermophilus washingtoni), Idaho (Spermophilus brunneus), and Uinta (Spermophilus armatus) ground squirrels



Rock (Spermophilus variegatus) ground squirrels



Although ground squirrel tracks will vary in size, they generally show five toes on the hindfoot and four toes on the smaller and rounder forefoot.

Food Habits: Ground squirrels mostly eat plant material, although some species may also eat insects, eggs, carrion, and other animal material (USDA, 1991).

Behavior: Ground squirrels are only active during the day, and they are most active during mid-morning and late afternoon. They hibernate in the winter, and most species estivate in summer as well (USDA, 1991).

Field Tip: During warm months, ground squirrels are quite active during the day and can be easily spotted. Unplugged burrows are a distinctive characteristic of ground squirrel inhabitation (USDA, 1991).

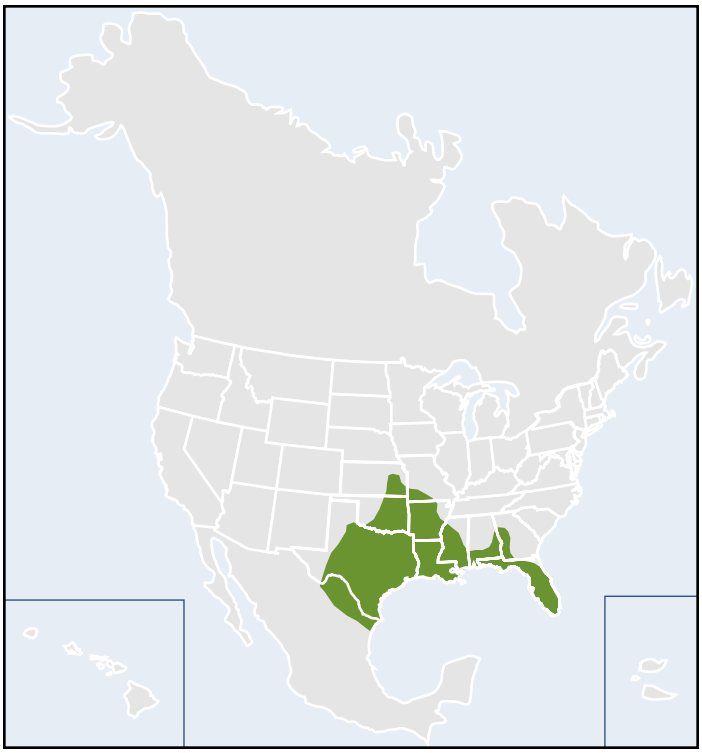
Ground squirrels are considered a significant dam safety issue in 15% of the surveyed states.

4.2.10 Armadillo Overview

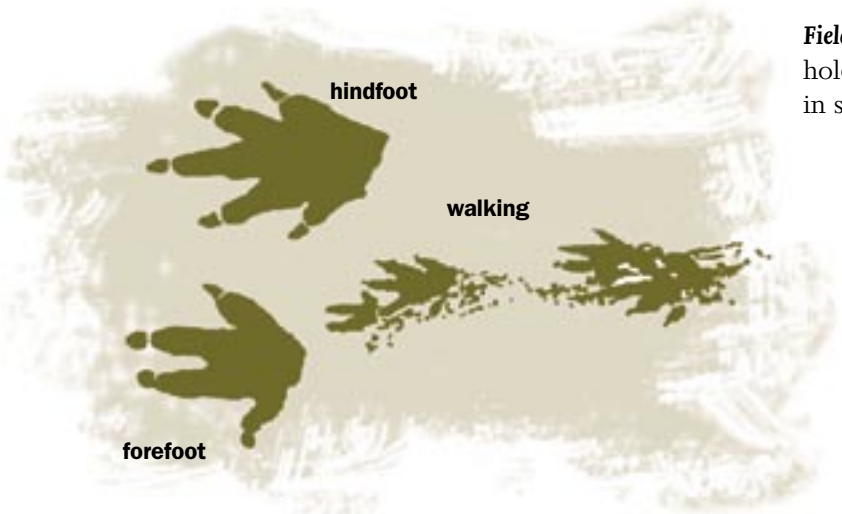
The Armadillo (Dasypus novemcinctus) is a medium-sized animal, about 8 to 17 pounds, with a protective, armor-like shell on its head, body, and tail. It has nine movable bands across its back, and the tail is covered with a series of overlapping rings. The armadillo has a small head with a long, narrow, piglike snout (University of Nebraska, 1994).

Threat to Dams: Armadillos dig burrows that can result in internal erosion and structural integrity losses in dams.

Habitat and Home: It prefers forest, woodland and brush habitat, as well as areas near creeks and rivers. The armadillo will also inhabit areas with rocks, cracks, and crevices that are suitable for burrows (University of Nebraska, 1994). Armadillos generally dig burrows 7 to 8 inches in diameter and up to 15 feet in length. They can be found in rock piles, around stumps, brush piles, or terraces around brush or dense woodlands. Armadillos usually have more than one den in an area (University of Nebraska, 1994).



Range of the armadillo in North America.



Armadillos have four toes on their forefeet and five toes on their hindfeet, although not all toes may show up in their tracks. Sharp claw marks are often visible.

Food Habits: The armadillo primarily eats insects and their larvae. They also feed on spiders, earthworms, scorpions, and other invertebrates. To a lesser extent, they may eat some fruit and vegetable matter (University of Nebraska, 1994).

Armadillos are considered a significant dam safety issue in 4% of the surveyed states.

Behavior: During the summer, the armadillo is active from twilight through early morning hours, but in the winter, it is usually only active during the day. The armadillo has poor eyesight, but a keen sense of smell. It can run fast when in danger and is also a good swimmer (USDA, 1991).

Field Tip: Characteristic signs of armadillo activity are shallow holes, about 1 to 3 inches deep and 3 to 5 inches wide, dug in search of food (University of Nebraska, 1994).

4.2.11 Livestock Overview

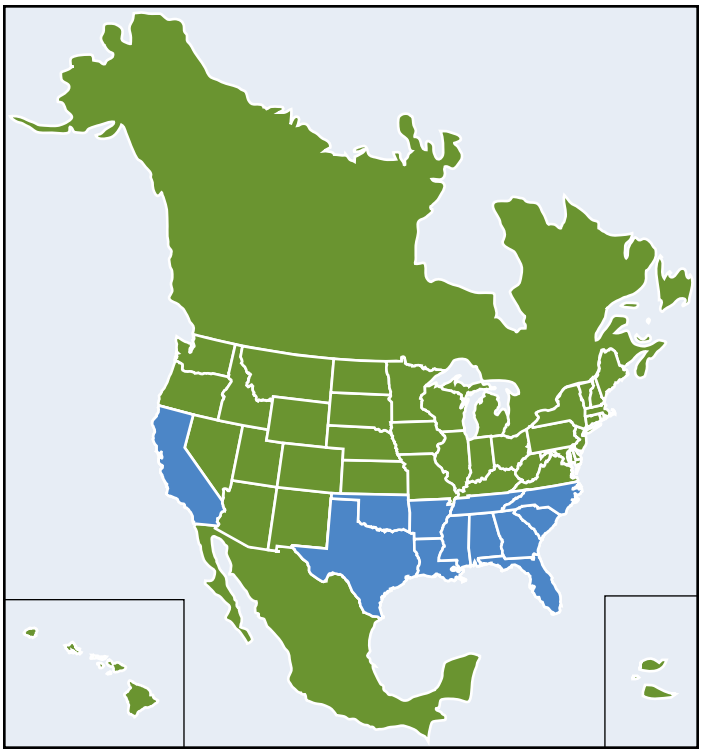
Livestock can include cattle, horses, sheep, goats, and pigs of all varieties, domesticated and wild. Livestock exist widely across the United States and utilize earthen dams and farm ponds for grazing and drinking.

Threat to Dams: Livestock can damage an earthen dam by removing stabilizing vegetation through grazing, trampling, and rooting. External erosion can occur without vegetative cover, and erosion pathways can be created as livestock traverse the embankment (Figures 4-11 and 4-12). Damages are most severe in arid regions, and damage is often not noted until the wet season when precipitation collects in holes and along erosion pathways. Livestock carcasses could alter or block water flow if located at control structures. Wild pigs commonly damage farm ponds and can cause substantial damage to a grassy area in a single night (University of Nebraska, 1994).

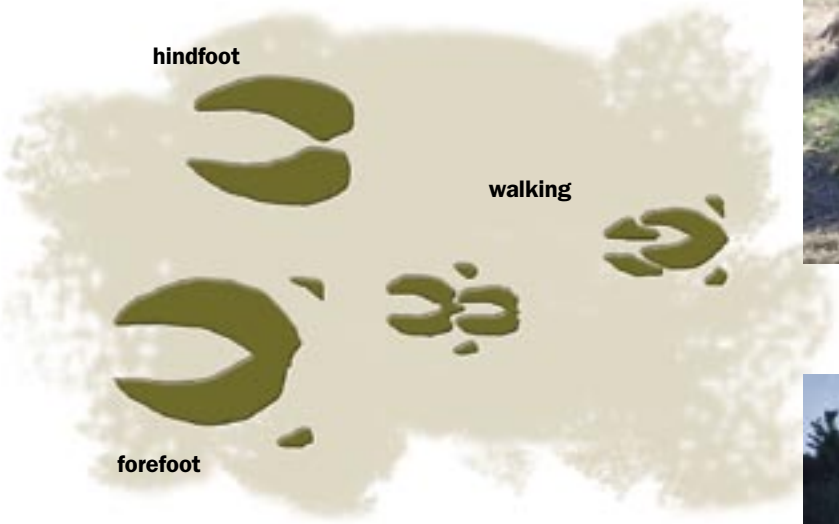
Livestock are considered a significant dam safety issue in 25% of the surveyed states.

Habitat and Home: Livestock can occur anywhere in the United States. In some cases, several livestock species will graze in one area. Wild pigs can exist in a variety of habitats but prefer dense brush or marsh vegetation as cover. Wild pigs are often found inhabiting livestock-producing areas (University of Nebraska, 1994).

Food Habits: Most livestock, including cows, sheep, goats, and horses, are grazers. Pigs, however, generally root for underground vegetation, in addition to feeding on acorns and



Range of livestock, and wild pigs in North America.



Tracks can be used to identify wild pigs. Tracks are generally not needed to identify other types of livestock since they are often intentionally grazed on lands near farm dams.

One milk-producing Jersey cow can drink up to 12 gallons of water a day. Herds of dairy cows typically include 50 to 100 animals. That's a lot of hoof-traffic at an earthen dam!

other mast. Livestock disturb soil and vegetation through their feeding methods.

Behavior: Location to a water source is considered the primary influence on livestock's activity within a given grazing area, followed by desirable forage and topography of the grazing area. In hot weather, pigs will wallow in ponds, springs, or streams that contain or are near vegetative cover.

Field Tip: Livestock are easily identified as they are often intentionally grazed on lands near farm dams. Wild pigs are obvious if observed, otherwise look for wallows.

Figure 4-11. Livestock can cause external erosion by creating ruts and erosion paths via hoof traffic.

Figure 4-12. Livestock can remove stabilizing vegetation through grazing and hoof traffic.

4.2.12 Crayfish Overview

Crayfish (Cambarus spp.) resemble miniature lobsters. There are over 300 species of various sizes, shapes, and colors in the United States (University of Nebraska, 1994).

Threat to Dams: Crayfish burrow into earthen dam embankments; extensive burrowing may cause internal erosion and structural integrity losses.

Habitat and Home: Crayfish are found in a variety of fresh water habitats, including streams, rivers, ponds, lakes, swamps, and wet meadows (Peckarsky et al, 1990). Crayfish burrows are usually located along the shoreline close to the water's edge. They may be anywhere from a few inches to three feet deep. The opening is generally about ¼ to 2 inches in diameter with a cone-shaped mound, known as a "chimney," plugging the burrow (Virginia Cooperative Extension, 2001a) (Figure 4-13).

Food Habits: Crayfish eat both living and dead plant and animal material. Almost half of their diet consists of bottom-dwelling worms and insects. The rest of their diet consists of

Crayfish are considered a significant dam safety issue in 4% of the surveyed states.

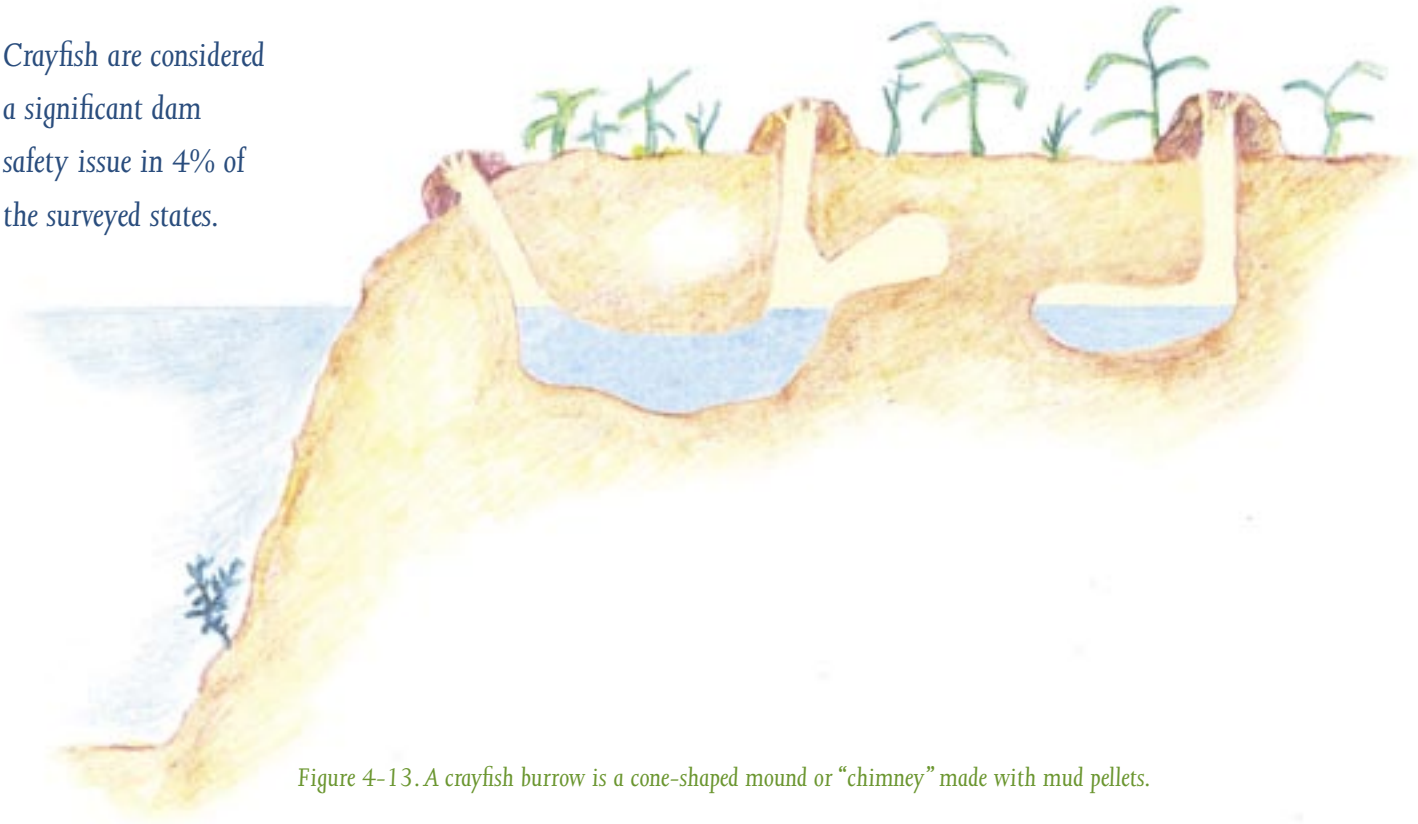


Figure 4-13. A crayfish burrow is a cone-shaped mound or "chimney" made with mud pellets.

Range of the crayfish in North America.

living and decaying aquatic vegetation (Virginia Cooperative Extension, 2001a).

Behavior: A crayfish will molt several times in its short lifespan. They can be quite aggressive towards each other and toward anything they perceive as a threat (Peckarsky et al, 1990). Most crayfish dig burrows to use as a refuge from predators and as a resting place during molting and inactive periods (Virginia Cooperative Extension, 2001a).

Field Tip: Crayfish stay in their burrows or in mud bottoms during cold weather. They will emerge, and be easier to spot, once the water warms up (Virginia Cooperative Extension, 2001a).

4.2.13 Coyote Overview

The Coyote (Canis latrans) is a member of the dog family, and in size and shape, it resembles a small German shepherd, with erect pointed ears, slender muzzle, and a bushy tail. Coyotes are generally brownish-gray with a lighter colored belly, although this varies widely across local populations. In the west, adult males typically weigh 25 to 45 pounds and adult females typically weigh 22 to 35 pounds. Coyotes in the east are usually larger, with adult males weighing about 45 pounds and adult females weighing about 30 pounds (University of Nebraska, 1994).

Threat to Dams: Although coyotes do not pose a large threat to earthen dams, den construction or enlargement, and digging out prey that live at the dam can cause structural integrity losses.

Coyote are considered a significant dam safety issue in 4% of the surveyed states.

Habitat and Home: Coyotes exist in virtually any type of habitat, arctic to tropic. High densities of coyotes even appear in the suburbs of major western cities such as Los Angeles and Phoenix. Their dens are often found in steep banks, rock crevices, sinkholes, and underbrush, as well as open areas. Dens are usually located close to water. Coyotes will often dig out and enlarge burrows of other animals. Size of coyote dens varies from a few feet to 50 feet, and each den often has several openings (University of Nebraska, 1994).

Range of the coyote in North America.

Badger tracks are often confused with coyote tracks, but note that coyotes only have four toes on each foot, while badgers have five toes.

Food Habits: Coyotes eat a variety of animals, insects, fruits, and vegetables (University of Nebraska, 1994).

Behavior: During hot summer months, coyotes are most active at night and during the early morning hours. During cooler weather, and in areas with minimal human activity, coyotes may be active throughout the day. Coyotes have good eyesight and hearing and a keen sense of smell. Their adaptable behavior and social system allows them to survive, and even flourish, in the presence of humans (University of Nebraska, 1994).

Field Tip: Coyotes can often be identified by their tracks, although it should be noted that regular dog tracks are often mistaken for coyote tracks. Coyote dens are often located in the downstream slope.

4.2.14 Moles and Voles Overview

Moles (Scapanus spp.) are small insectivores that are often confused with voles, shrews, and pocket gophers. Moles, however, can be distinguished by their hairless, pointed snout, small eyes, and webbed forefeet. There are seven different species of moles living in the United States. Adult males grow to a length of about 7 inches and weigh about 4 ounces; adult females are slightly smaller (University of Nebraska, 1994).

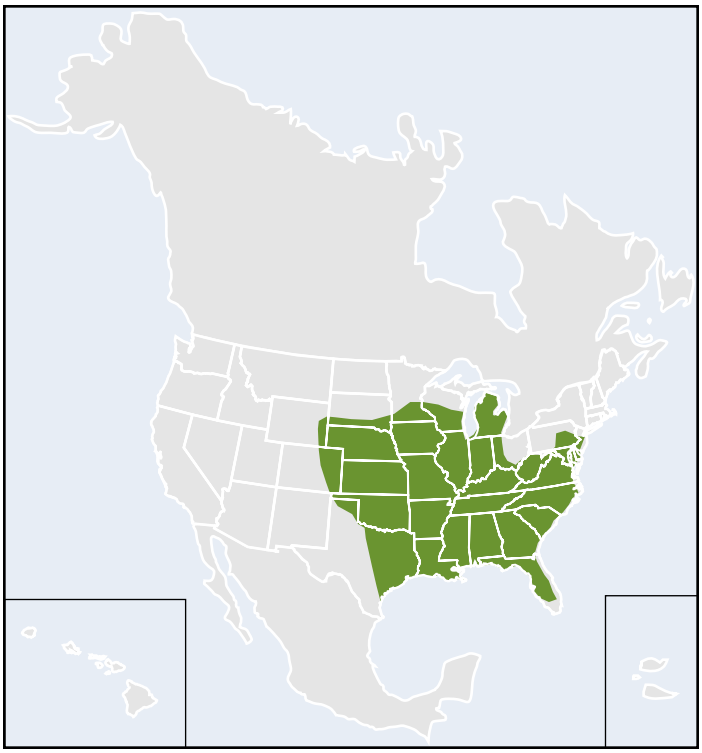
Voles (Microtus spp.) also known as meadow mice or field mice, are compact rodents with short legs and short tails. There are 23 species of voles in the United States. Most are gray or brown, and about 4 to 8 inches long; although both size and coloration varies across species.

Threat to Dams: Earthen dams may provide good hunting grounds for moles. Although they usually make their home burrows in dry, upland areas, they prefer to hunt in areas that are cool and moist. They construct tunnels from their dens to their hunting grounds. If located in an earthen dam, these tunnels may cause internal erosion and structural integrity losses. When present in large numbers, voles may also cause damage to earthen dams. They dig extensive burrow systems that could lead to internal erosion and structural integrity losses in the dam (University of Nebraska, 1994).

Moles and voles are considered a significant dam safety issue in 10% of the surveyed states.

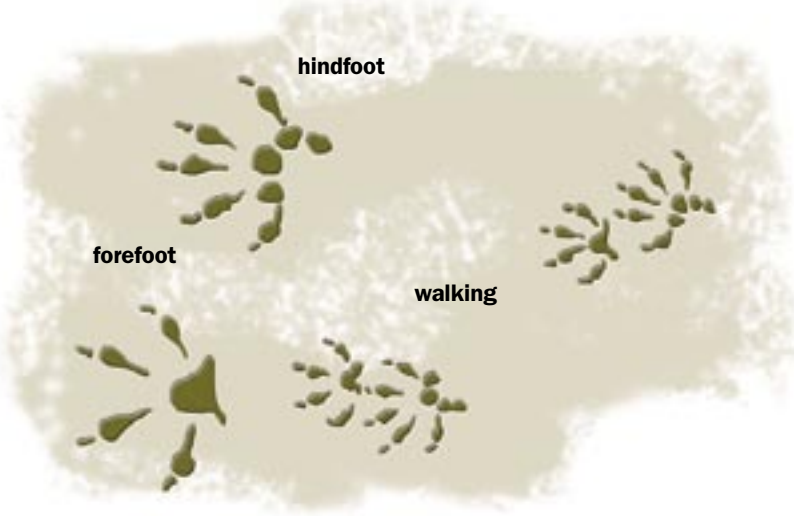
Habitat and Home: Moles can be found across most of the United States. As mentioned above, they generally construct their burrows in dry, upland areas. Deep runways connect their dens to their hunting grounds (University of Nebraska, 1994) (Figures 4-14 and 4-15, shown on page 51). Voles can also be found across most of the United States. They prefer areas of heavy ground cover, although they can survive in a wide variety of habitats. Burrow systems consist of a series of tunnels and surface runways, and often have several entrances (University of Nebraska, 1994) (Figure 4-16, shown on page 51).

Food Habits: Moles primarily eat insects, grubs, and worms. Voles are mostly herbivorous, primarily eating grasses and forbs. Voles will also occasionally eat snails, insects, or animal remains (University of Nebraska, 1994).



Range of the mole in North America.

Range of the vole in North America.



Vole tracks.

Behavior: Moles are solitary animals, and they spend most of their time underground. They are active through all seasons of the year. Voles are also active throughout the year, both day and night. They are excellent swimmers and often try to escape from predators through the water (University of Nebraska, 1994).

Field Tip: Moles push up volcano-shaped mounds of soil when they are building tunnels. The mounds may be anywhere from 2 to 24 inches tall. Surface tunnels or ridges are also an indication of mole activity. Voles can be identified by their extensive surface runway systems. These runways are generally 1 to 2 inches in width.

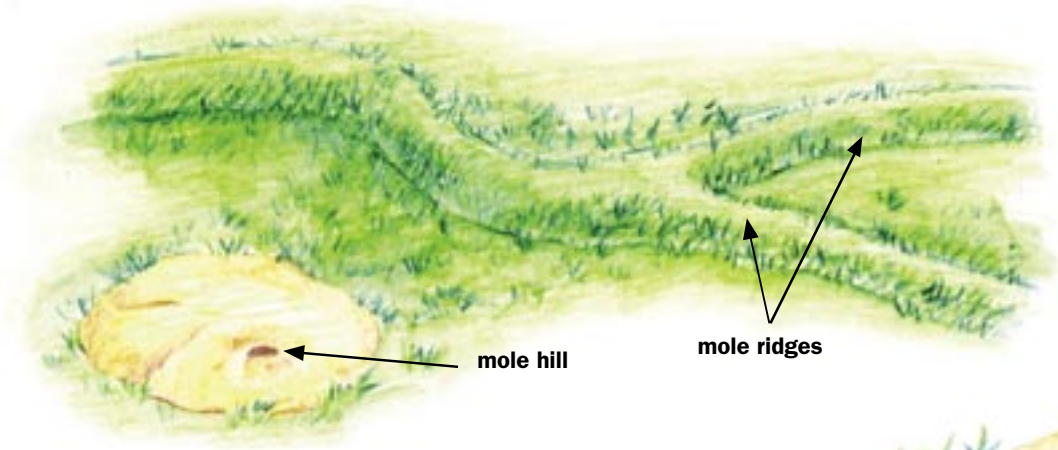


Figure 4-14. Mole burrows form ridges visible from the surface.

Figure 4-15. Moles push dirt vertically to the surface, which forms a mound.

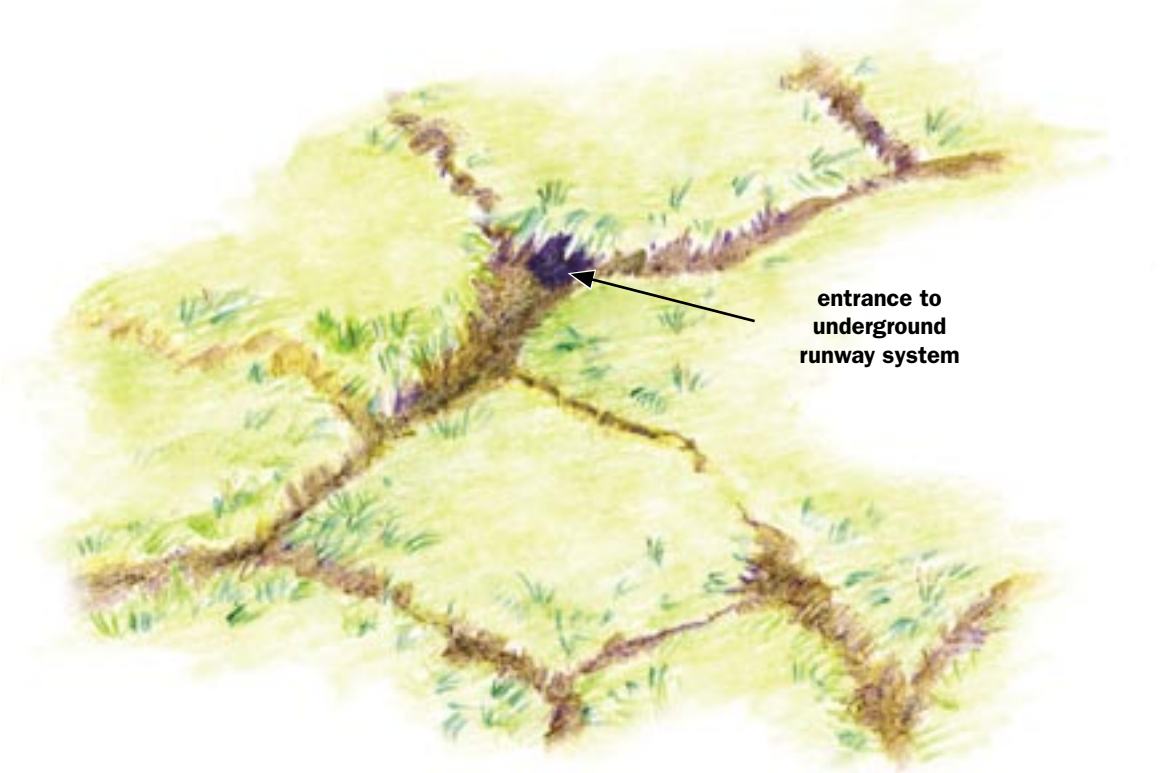


Figure 4-16.Voles are most easily identified by an extensive surface runway system with many burrows.

4.2.15 River Otter Overview

The River Otter's (Lutra canadensis) sleek body, short legs, webbed toes, and tapered tail help it thrive in its aquatic environment. Otter fur is thick and shaded from brown to near black on most of the body, with a lighter brown to beige on the belly, chin, throat, cheeks, and chest (University of Nebraska, 1994).

Threat to Dams: Otters sometimes dig bank dens for shelter with an underwater entrance for use in the winter and an above-water entrance for use in the summer (Benyus, 1989). Dens can cause large voids in the dam embankment, and underwater entrances provide pathways for internal erosion and wave action if water levels rise into the embankment den.

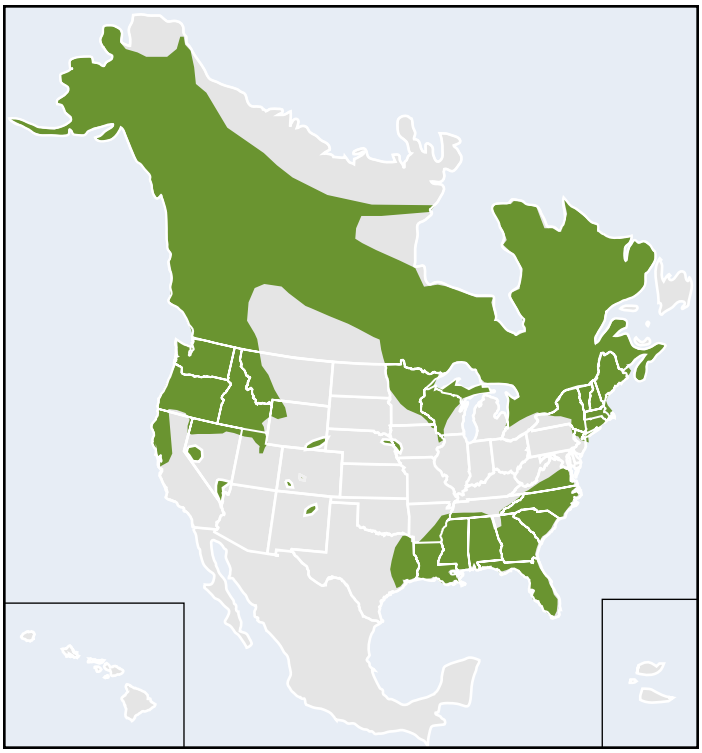
Habitat and Home: Otters are associated almost invariably with water environments no matter the water type: fresh, brackish, or salt. Water quality, available fish forage, and available den sites are the most important factors in determining otter habitat. Otters can be found in lakes, rivers, streams, bays, estuaries and associated riparian habitat. Otters most often utilize existing bank dens and lodges constructed by beaver, muskrat, and nutria. Otherwise, otters use hollow logs and rock crevices as their shelter and construct natal dens on small streams that lead to major drainages (University of Nebraska, 1994).

Food Habits: Otters prefer fish of several varieties, but also feed on shellfish, crayfish, reptiles, and amphibians.

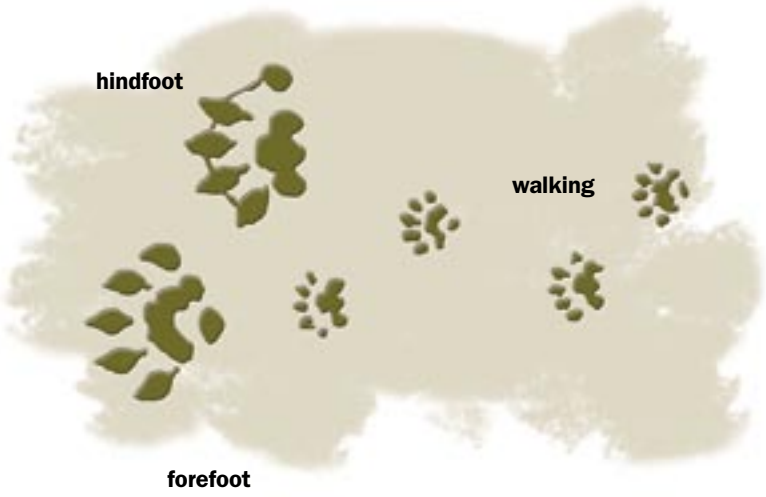
River otters are considered a significant dam safety issue in 4% of the surveyed states.

Behavior: Otters spend most of the day feeding and participating in group play. Otters are superb swimmers and very alert.

Field Tip: Look for slides into the water or snowbank (in winter) where otters play. Look for "haul-outs," worn areas along the bank where otters consistently pull themselves out of the water. If this area is indeed a haul-out, there will be a trail leading away from the haul-out to a patch of trampled vegetation where otters roll around to dry themselves after a swim or to leave their scent (Benyus, 1989). Listen for the blow and sniff sounds of a surfacing otter.



Range of the river otter in North America.



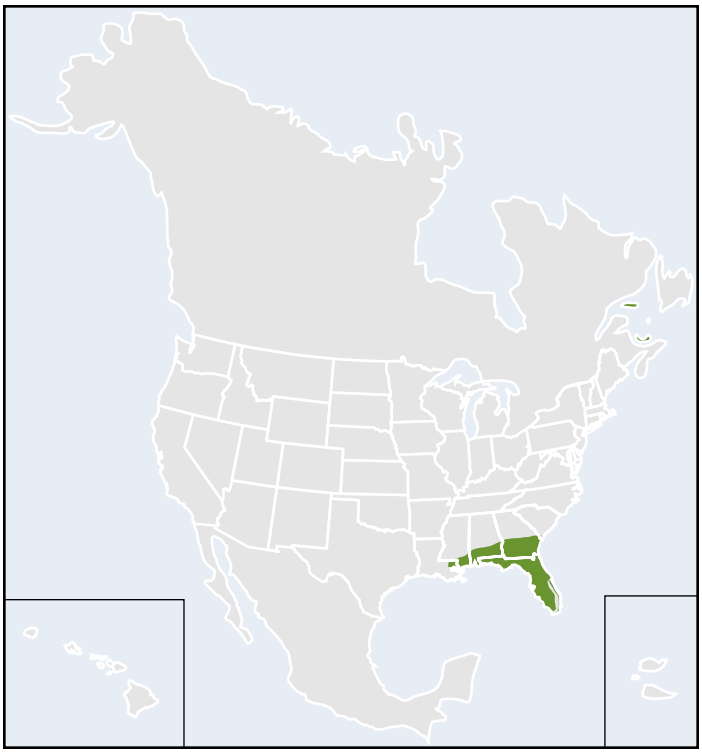
The inner toe of the otter's hind paw juts out to the side.

4.2.16 Gopher Tortoise Overview

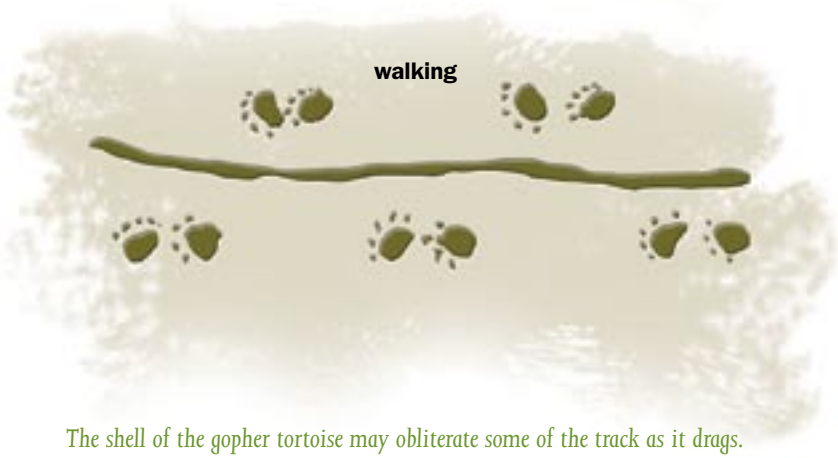
Gopher Tortoise (Gopherus polyphemus) are large, terrestrial tortoises with a shell length of 10 to 15 inches that weigh about 9 pounds. The gopher tortoise is a protected species and a permit is always required to possess, study, remove, or relocate a specimen (Gopher Tortoise Council, 2001). The burrows of the gopher tortoise are also protected by law. Over 360 animal species have been documented inhabiting a gopher tortoise burrow so use caution when investigating a burrow. Many of the species which coexist in or use gopher tortoise burrows are also protected by state and federal laws, such as the burrowing owl and indigo snake.

Threat to Dams: The gopher tortoise's strong claws make it an effective burrower. Burrows can be 40 feet long and 10 feet deep and will include a spacious chamber used to cool off during the heat of the day (Gopher Tortoise Council, 2001). Gopher tortoise burrows can cause structural integrity losses.

Tortoises are considered a significant dam safety issue in 4% of the surveyed states.



Range of the gopher tortoise in the United States.



The shell of the gopher tortoise may obliterate some of the track as it drags.

Habitat and Home: Gopher tortoises prefer to dig their burrows in dry, upland habitats especially where saw-palmetto is present in the understory and sandy soils dominate. Gopher tortoises can live in grassy areas, pastures, and old fields as long as there are well-drained sandy soils, herbaceous plants, and sunny, open areas for nesting and basking (Gopher Tortoise Council, 2001). Look for burrows on the southeastern side of sandy hills (such as old dunes that are covered in vegetation) at a 30-degree angle from the surface (Benyus, 1989; Enchanted Forest Nature Sanctuary, 2003). The burrow entrance, or "apron," will be marked by a characteristic mound of loose sand. The downstream slope and toe of a dam may be suitable for gopher tortoises, as might a forest fringe in a dam area.

Note: In some cases, snapping turtles may hibernate or lay eggs in an existing muskrat den and as such, are often identified as the responsible burrowing animal. In truth, turtles are more correctly simply associated with burrowing animals, rather than responsible for burrows. Depending on its size, the snapping turtle may enlarge an existing muskrat den.

An east-central Florida study indicates that a male gopher tortoise constructs and uses an average of 17 burrows. Some males construct and use as many as 35 burrows.

Food Habits: Primary food sources of the gopher tortoise include low-growing grasses, herbs, and berries.

Behavior: Gopher tortoises emerge from their burrows in the morning to feed and return to the burrows if temperatures get too hot or cold.

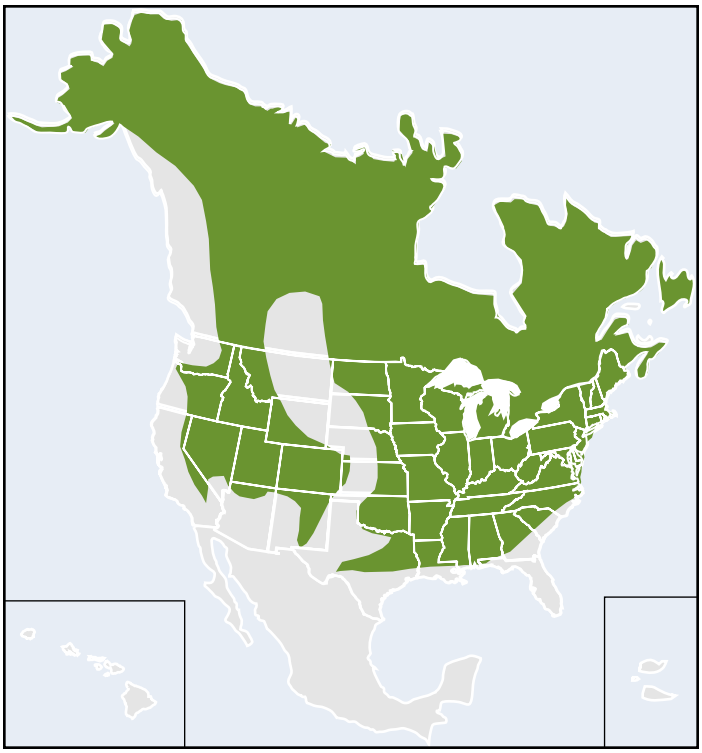
Field Tip: Look for large mounds of loose sand created as the gopher tortoise digs its burrow.

4.2.17 Red Fox and Gray Fox Overview

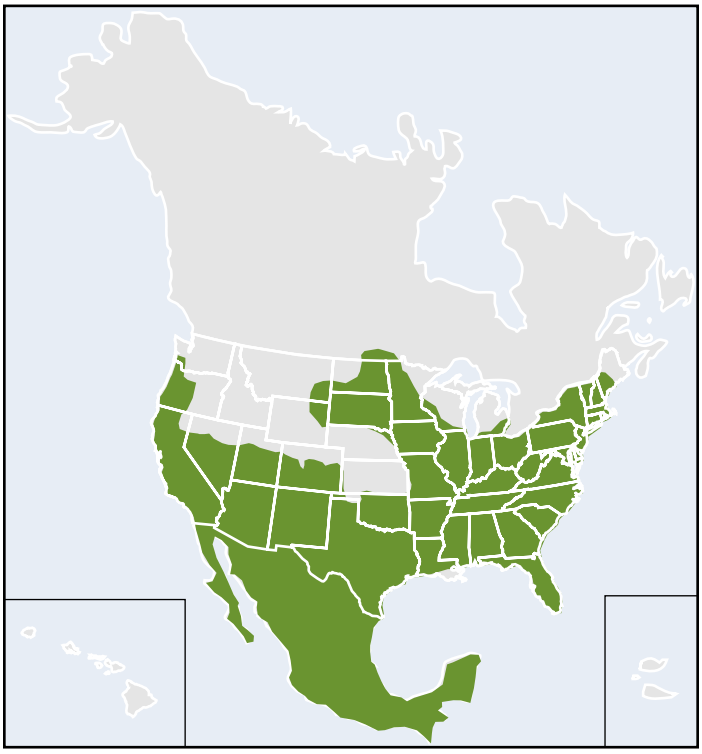
The Red Fox (Vulpes vulpes) is dog-like in appearance with large pointed ears and an elongated pointed muzzle. It typically has a light orange-red coat with lighter colored underfur, black legs, and a white-tipped tail. Coat coloration can vary from red to gray to black, but the tail tip is always white. Adult red foxes can weigh anywhere from 7.7 to 15.4 pounds; males are about 2.2 pounds heavier than females (University of Nebraska, 1994).

The Gray Fox (Urocyon cinereoargenteus) has a long, bushy tail with a black tip. It is salt-and-pepper gray over most of its body, with some rusty yellow spots on the sides of the neck, back of the ears, legs and feet. Adult gray foxes weigh about 7 to 13 pounds, and measure about 32 to 45 inches from nose to tip of tail (University of Nebraska, 1994).

Fox are considered a significant dam safety issue in 4% of the surveyed states.



Range of the red fox in the North America.



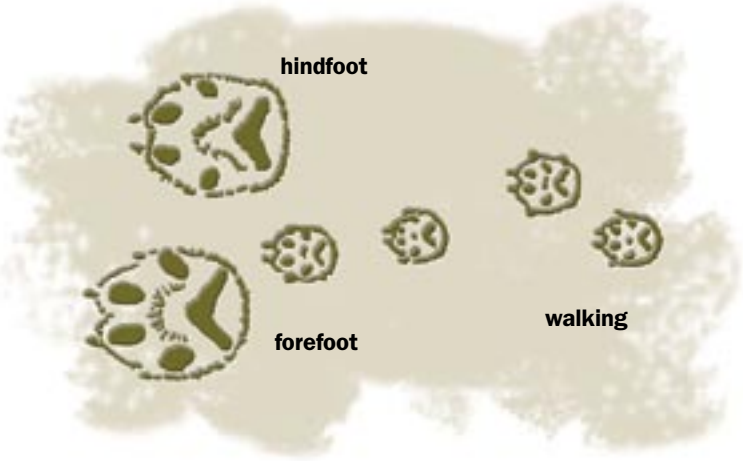
Range of the gray fox in North America.

Threat to Dams: Foxes do not pose a great threat to earthen dams. It is possible that they could cause damage by digging out burrowing animals for food. This type of damage may be prevented with good rodent control and vegetative management.

Habitat and Home: The red fox prefers open country with moderate cover, although it is generally adaptable to any habitat within its range. Red foxes are commonly found in urban areas. They may either dig their own dens or use abandoned groundhog or badger burrows. The gray fox prefers areas of dense cover such as swamp land or thickets. Gray foxes can also be found in urban areas. They commonly use wood piles, rocky outcrops, or hollow trees as den sites (University of Nebraska, 1994).

Food Habits: Foxes mostly eat rabbits, mice, bird eggs, insects, and fruit (University of Nebraska, 1994).

Behavior: Foxes are solitary animals that are most active during twilight and early morning hours. They have a variety of calls that sound like barks, screams, howls, yaps, growls, and hiccups (University of Nebraska, 1994).



Tracks of red fox.

Field Tip: Fox dens may be identified by several 10-inch wide entrance holes, with sandy aprons of soil spilling from them (Benyus, 1989).

Tracks of gray fox.

4.2.18 Canada Goose Overview

The Canada Goose (Branta canadensis) is a large bird that grows to a height of 2 to 3 feet and weighs approximately 10 to 12 pounds. It has a grayish-brown body and wings; black feet, bill and neck; a white underside; and a white patch on each cheek (USDA, 2003). There are 11 subspecies that live in the United States (Virginia Cooperative Extension, 2001b).

Threat to Dam: Canada geese build their nests near water. If they choose to nest on or near an earthen dam, their nesting and feeding activities could cause external erosion.

Canada geese can cause erosion from over-grazing similar to that caused by livestock.

Habitat and Home: Canada geese are found across the United States. Many Canada geese spend their summers in Canada and migrate south to the United States during the winter. Some geese, known as resident Canada geese, spend most of the year in the same general area and fly only far enough to find food or open water (Virginia Cooperative Extension, 2001b). Canada geese nest in areas near open water, such as swamps, marshes, meadows and lakes. Nests are typi-

Range of the Canada goose in North America.

Tracks of the Canada goose.

cally made from weeds, twigs, grass, moss, and pine needles (University of Michigan Museum of Zoology, 2002).

Food Habits: Canada geese eat a variety of grasses and aquatic plants. They will also eat crops such as corn, soybeans, and wheat. Young Canada geese require more protein, and will consequently eat insects, small crustaceans, and mollusks (Virginia Cooperative Extension, 2001b).

Behavior: Canada geese are social animals that communicate to each other through a series of calls. They tend to be aggressive birds, particularly the males. They will vigorously defend their territory, nests, and eggs from intruders (University of Michigan Museum of Zoology, 2002).

Field Tip: Canada geese can be easily identified by the white patches on their cheeks. In absence of the birds themselves, Canada geese can be identified by their long, black, cylindrical droppings.

4.2.19 American Alligator Overview

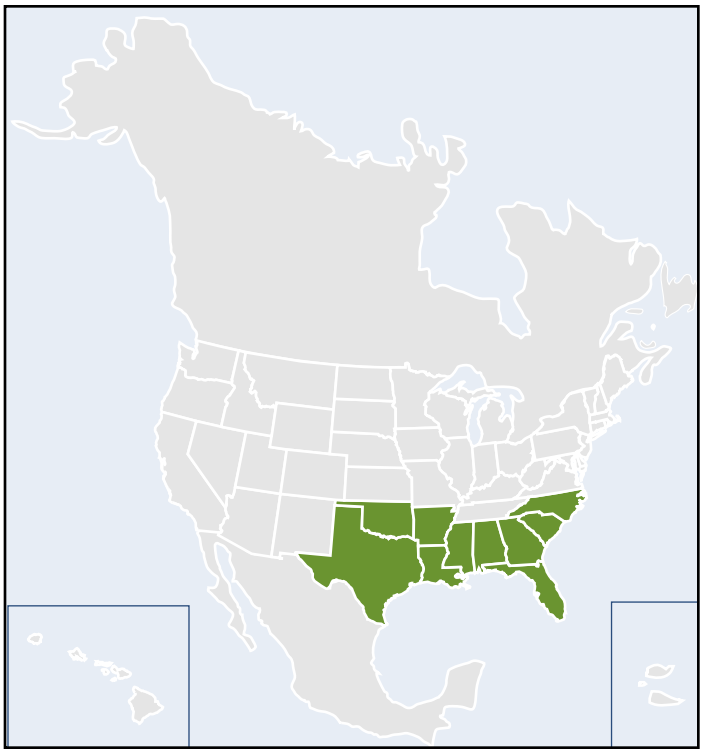
The American Alligator (Alligator mississippiensis) is one of the largest animals in North America. Adult males can grow to a length of 14 feet and weight up to 1,000 pounds. Adult females can grow to a length of 10 feet and weigh up to 250 pounds. They have a rounded snout and black and yellow-white coloration (University of Nebraska, 1994). Alligator hunting is allowed in several states under strict quota or licence guidelines.

Threat to Dam: Alligators sometimes dig burrows or dens for refuge from cold temperatures, drought, and predators. These burrows can cause internal erosion and structural integrity losses in earthen dams (University of Nebraska, 1994).

Habitat and Home: Alligators can be found in almost any type of fresh water, including wetlands, lakes, canals, and streams. They will occasionally inhabit brackish or salt water environments (University of Nebraska, 1994).

Alligators are considered a significant dam safety issue in 2% of the surveyed states.

Food Habits: Alligators will prey upon whatever creatures are most available, including fish, turtles, birds, mammals, and other alligators. Alligators are opportunistic feeders and will eat carrion if it is available and they are sufficiently hungry. If they are near human environments, they may also eat pets and livestock (University of Nebraska, 1994).



Range of the American alligator in North America.

Behavior: Because they are cold-blooded, alligators are most active when the temperature is warm. When the temperature drops below 70°F, alligators will stop feeding, and when the temperature drops below 55°F, they become dormant. Alligators are not typically aggressive toward humans, but they can and will attack if provoked (University of Nebraska, 1994).

Field Tip: Alligators are large animals, but they blend into their surroundings. It is important to be vigilant and cautious around any water body in the alligator's range.

4.2.20 Ants Overview

Ants (Formicidae spp.) are small insects that live in large colonies. The body of an ant is clearly divided into three sections. Many different species of ants live in the United States. Color and size varies widely across species (University of Florida Cooperative Extension Service, 2002).

Threat to Dam: Ants often build their homes underground. Their colonies consist of a complex series of tunnels that excacerbate existing cracks and can "soften" the embankment, threatening the structural integrity of an earthen dam.

Habitat and Home: Ants can be found across the United States in a variety of habitats. Most ants live in the soil, although some also live in wood or in the cavities of plants (University of Arizona, 1997).

Ants are considered a significant dam safety issue in 4% of the surveyed states.

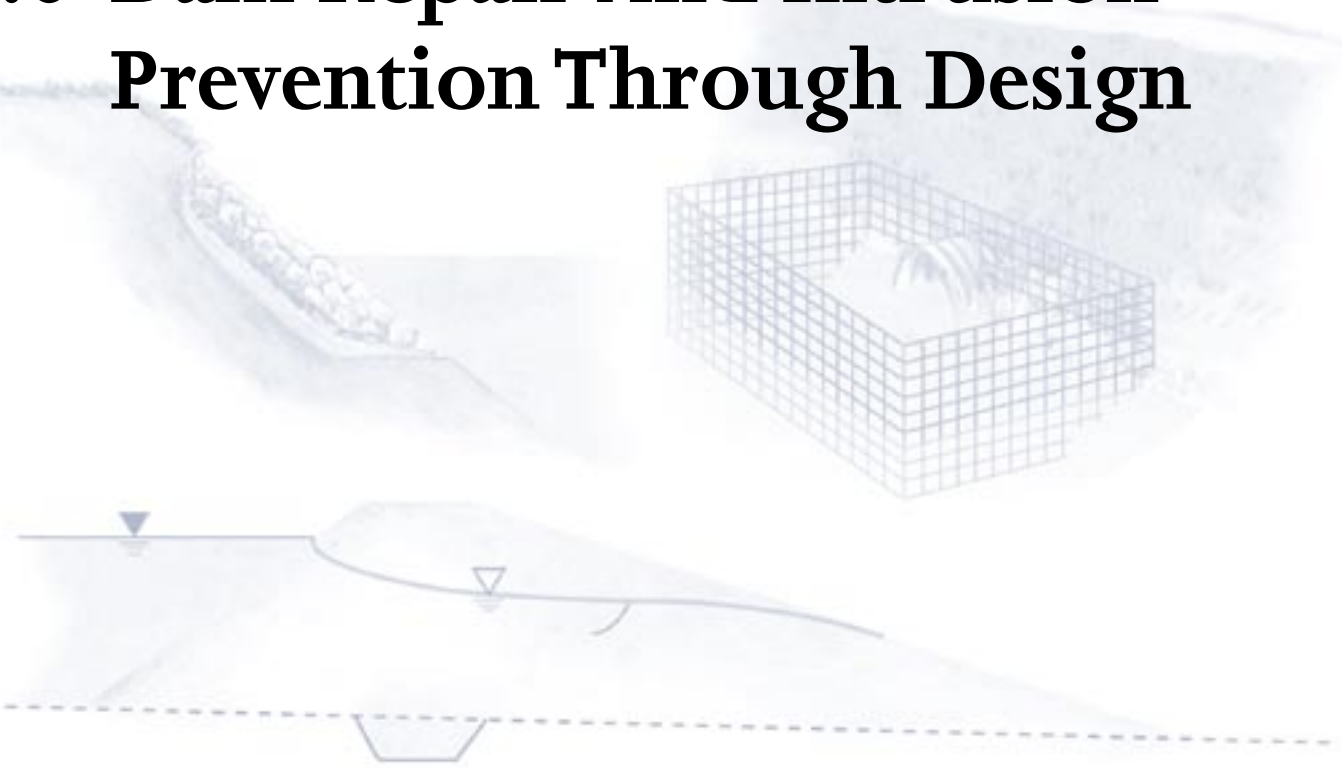
Range of the ant in North America.

Food Habits: Ants eat a variety of foods, including plants, sugars, seeds, and small insects (University of Florida Cooperative Extension Service, 2002).

Behavior: Ants are social animals. They live in colonies comprised of one or a few queens and many workers. Some ants have a potent sting (University of Arizona, 1997).

Field Tip: Small mounds of soil are often indicative of ant inhabitation.

5.0 Dam Repair And Intrusion Prevention Through Design



Once the inspection is completed according to the guidelines (refer to Chapter 3.0) and considering the biological perspectives presented in Chapter 4.0, the dam specialist will need to take action relative to damages found at the dam. Specifically, the dam owner will need to repair burrow or beaver dam damage, and determine the appropriate level and type of prevention action (e.g., reinforced concrete wall and slab system on upstream slope to prevent muskrat burrows). This Chapter first outlines burrow repair procedures, followed by a discussion of each earthen dam zone (which corresponds to the zones described in Chapter 3.3 of this manual) with regard to the relative priority of prevention action for each zone. Lastly, design options to mitigate and prevent future animal intrusions are presented for each wildlife species. The prevention methods in this chapter relate to modification of the dam or its structures; a discussion of prevention through animal control methods (e.g., trapping) is presented in Chapter 6.0.

The majority of the prevention action design criteria of this Chapter are meant to be incorporated when major features of the dam can be easily altered such as during new dam construction or dam repair construction, when the majority of the dam or a large portion of the dam will be reworked. The input of a professional engineer is required to ensure proper design and construction of prevention actions.

5.1 Conformity to the Clean Water Act of 1972

The Clean Water Act of 1972 (CWA) is the primary guidance for protecting surface water quality in the United States. The goals of the CWA are to restore and maintain the chemical, physical, and biological integrity of the nation's waters so that they can support "the protection and propagation of fish, shellfish, and wildlife and recreation in and on the water." Towards these goals, the CWA sets water quality standards for waterbodies, which are upheld by antidegradation policies and programs, ambient monitoring, and pollutant load reduction strategies as necessary.

In the dam environment, extensive vegetation removal, burrow excavation and repair, and dam restoration measures could trigger the CWA if dredged or fill materials could be deposited into wetlands or Waters of the United States. As such, all remediation activities must be completed in accordance with the CWA and its provisions, and coordination with the State Dam Safety Official and the State Water Resources Agency is required.

5.2 The Role of Vegetation Management

Proper vegetation management is a cornerstone of effective wildlife intrusion management. In most cases, wildlife will not inhabit an earthen dam that does not provide vegetation for food supply, protective cover, or shelter. If a variety of vegetation exists at the dam, then wildlife will choose to inhabit the earthen dam environment over other areas lacking in vegetation or without a water supply. Ideally, the earthen dam environment will contain appropriate grass species maintained such that dam inspections can be conducted easily without visual obstruction of the embankment and other appurtenant structures. Vegetation such as dense groundcover and thick, woody trees and shrubs not only hinder dam inspections, but can also obscure indicators of potential performance problems such as animal burrows, settlement, depressions, cracks, and similar issues. If vegetation is too thick, animal burrows can go undiscovered and proper animal intrusion mitigation may not occur.

In general, it is advised to limit vegetation at the earthen dam to low-growing native grass that is mowed regularly, and to keep the embankment and spillway inlet and outlets free of vegetation. Vegetated emergency spillways should be maintained in a similar fashion as the dam embankment. Maintained grass will accommodate thorough inspections and limit the number of wildlife species that can easily inhabit the dam. If a dam contains vegetation other than appropriate grasses, then the dam owner should complete mitigation and management as outlined in the FEMA document, *A Technical Manual on the Effects of Tree and Woody Vegetation Root Penetrations on the Safety of Earthen Dams* (FEMA, 2002) and the FEMA brochure, *Dam Owner's Guide to Plant Intrusion of Earthen Dams* (FEMA, 2003).

5.3 Burrow Repair Procedures

Repair actions can be separated into two categories: restoration measures and preventive measures. As the names imply, restoration measures address repairing a deficiency, whereas preventive measures prevent or avert future damage in the area. Specific restoration and preventive measures applicable for various locations in the dam are discussed below.

5.3.1 Restoration Measures

Damage from animal intrusions can occur throughout the dam. The damage can include removal of surface vegetation, rutting, and burrowing. Regardless of the damage location, applicable restoration options depend upon the judged severity of the damage.

Filling Ruts and Near Surface Deformation

Ruts, near surface deformation, and loss of vegetation can be the result of frequent animal crossings, most likely by livestock. Repair of these deficiencies is generally considered not critical. However, if left unattended for a sufficiently long period of time, these deficiencies can result in a progressive loss of vegetation and surface soils due to erosion. In extreme cases, the damage can lead to increasing amounts of erosion in localized areas, jeopardizing performance and requiring significant maintenance. Timely repair of ruts and vegetation loss can save considerable effort and expense later.

The repair methodology for ruts, surface deformation, and vegetation loss includes the following steps:

1. Fill the rut with soil of a similar type to that of the dam embankment. Overfill the rut slightly to account for compaction of the fill material.

2. Compact the soil using hand held or walk behind equipment. In order to achieve reasonable compaction, the fill material should not contain particle sizes greater than 1 inch in diameter. For larger ruts, and ruts created by vehicles, larger diameter material may be acceptable. The compacted surface should be smooth and level with the surrounding ground.

3. Revegetate the area with grass species appropriate for the region (see Chapter 5.2).

Filling Burrows

Methods for repairing or filling an animal burrow are essentially limited to two basic types. The first method considers filling the burrow without excavation while the second method considers excavating the burrow and backfilling the area. Details for each method are discussed below.

Observed burrows without signs of embankment distress (e.g., cracking, slumping) in the area may simply require filling with an impervious material or cementious grout. To fill the entire burrow, a process often referred to as "mud-packing" can be applied. This method consists of placing one or two lengths of metal stove or vent pipe vertically into the burrow. When the pipe is properly sealed, a slurry of 90% earth and 10% concrete, plus an appropriate amount of water to make the slurry flow, is placed in the pipe and allowed to flow into the burrow (Virginia Dam

Safety Program, 2003). The last 6 inches is filled with dirt that will support grass growth.

On the other hand, signs of embankment stress surrounding a burrow may indicate massive soil movement into the burrow. In these cases and at the owner's discretion, complete removal of the burrow is preferred. Shovels or backhoes could be necessary during excavation depending upon the burrow location, size, and depth. Excavation limits will be defined by the burrow size and location as well as the density and type of embankment material. Prior to excavation, dam safety professionals and dam owners should examine potential consequences of soil removal, including slope instability and increased hydraulic gradient. The completed excavation should be thoroughly inspected for adequate removal of the animal burrow. Voids remaining from an animal burrow can develop into potential internal erosion pathways or sinkholes.

Once excavation is complete, the resulting hole must be properly backfilled in a timely manner. Acceptable backfill

A local dam safety professional should be notified prior to any excavation activities in an embankment dam.

material should consist of soil types (e.g., sand, clay, etc.) similar to that of the surrounding embankment. If desired, laboratory index testing such as grain size and Atterberg Limits of the backfill and embankment materials may be performed. To achieve adequate compaction of the backfill materials, necessary laboratory testing of backfill materials should include a maximum dry density determination by either the Standard or Modified Proctor test (ASTM D-698 or ASTM D-1557). Backfill material should be compacted to a minimum of 95% of the maximum dry density and within +/- 2% of the optimum moisture content, as determined by ASTM D-698. The completed backfilled surface should be smooth and approximately level with the surrounding ground surface. Backfill should be placed and compacted in lifts of no more than 8 inches thick. A 2 to 4-inch gap can be left between the top of the completed backfill surface and surrounding ground surface to accommodate topsoil.

The final step is to revegetate the disturbed area. Native grass species appropriate for embankment dam slopes should be provided (see Chapter 5.2).

5.3.2 Preventive Measures

For a specific animal intrusion or animal related deficiency, appropriate preventive measures are highly dependent on the affected area's location on the dam. Therefore, common preventive measures are discussed in the context of the Repair Zone in the following section. The use and effectiveness of preventive measures should be assessed by the dam owner in conjunction with a dam safety professional. It may not be cost effective to employ these measures for treatment of animal intrusions alone; however, coincident benefits such as protection against wave erosion and plant intrusion may make the measure more fiscally viable.

5.4 Dam Repair Zones

As discussed in this manual, a variety of animals can damage an embankment dam. The damage can be surfical with minor impact to dam safety or performance, or the damage can directly threaten the integrity of the dam, potentially leading to failure. However, all animal impacts should be considered undesirable and must be repaired. Dam regulators, owners, and engineers should develop an understanding of the potential impact of an animal intrusion to properly evaluate its impact on the safety and performance of the dam (refer to chapter 2.0 for a discussion on animal intrusion impacts).

Prioritization of necessary repairs is critical to maintain a proactive approach to repair and maintenance of a dam. With limited available capital, many dam owners may delay or avoid necessary dam repairs. In addition, routine safety inspections by either regulatory personnel or consulting engineers tend to overwhelm dam owners by listing all observed deficiencies without a clear indication of the relative importance or seriousness of each deficiency. The relative importance and criticality of a specific deficiency depends on the size and nature of the observation (length, width, depth, area, etc.) as well as its location.

Developing a well-defined methodology for evaluating observed deficiencies will permit dam safety professionals to accurately communicate repair prioritization to dam owners. Chapter 3.0 describes an inspection process that considers both engineering and biological perspectives for a dam divided into five distinct zones. These dam zones cor-

respond to specific physical areas of the dam as illustrated on Figure 5-1 (ASDSO, 2001). The intent of the zones is to differentiate and prioritize animal intrusion damages based on their potential impact to dam safety or performance. Depending on the type of animal intrusion or deficiency observed, one or more zones may be considered critical and require near term or immediate repair. However, these critical zones will vary with the dam as well as the dam inspection. Therefore, the zones are not ordered by their importance; rather they are simply ordered from upstream to downstream.

The following sections provide a description of each repair zone, potential damage from animal intrusion, and suggested preventive measures. These descriptions are limited to animal intrusions and their impact to embankment dams. However, other deficiencies such as plant intrusion and erosion can occur within each repair zone. Where appropriate, restoration and preventive measures should consider all observed deficiencies in the area.

5.4.1 Dam Repair Zone 1

Zone 1 begins on the upstream slope at a point approximately 4 vertical feet below the normal pool elevation and extends to the center of the crest. A 4-foot vertical distance was recommended by Marks, et.al. (ASDSO, 2001) to account for average fluctuations in the normal pool and typical underwater animal burrows. The size of Zone 1 can vary significantly from dam to dam because it depends upon the distance between the crest elevation and the normal pool elevation. This distance is often referred to as freeboard.

The relative importance of Zone 1 depends upon the crest width and freeboard. For a dam with a wide crest and large freeboard, animal intrusion within Zone 1 becomes less critical. However, as the crest narrows and freeboard lessens, the importance of repairing deficiencies in Zone 1 increases rapidly.

The most common animal intrusions within Zone 1 are muskrat burrows in which the burrow entrance is underwater as shown on Figure 5-2. However, other intrusions are possible depending upon the specific characteristics of the

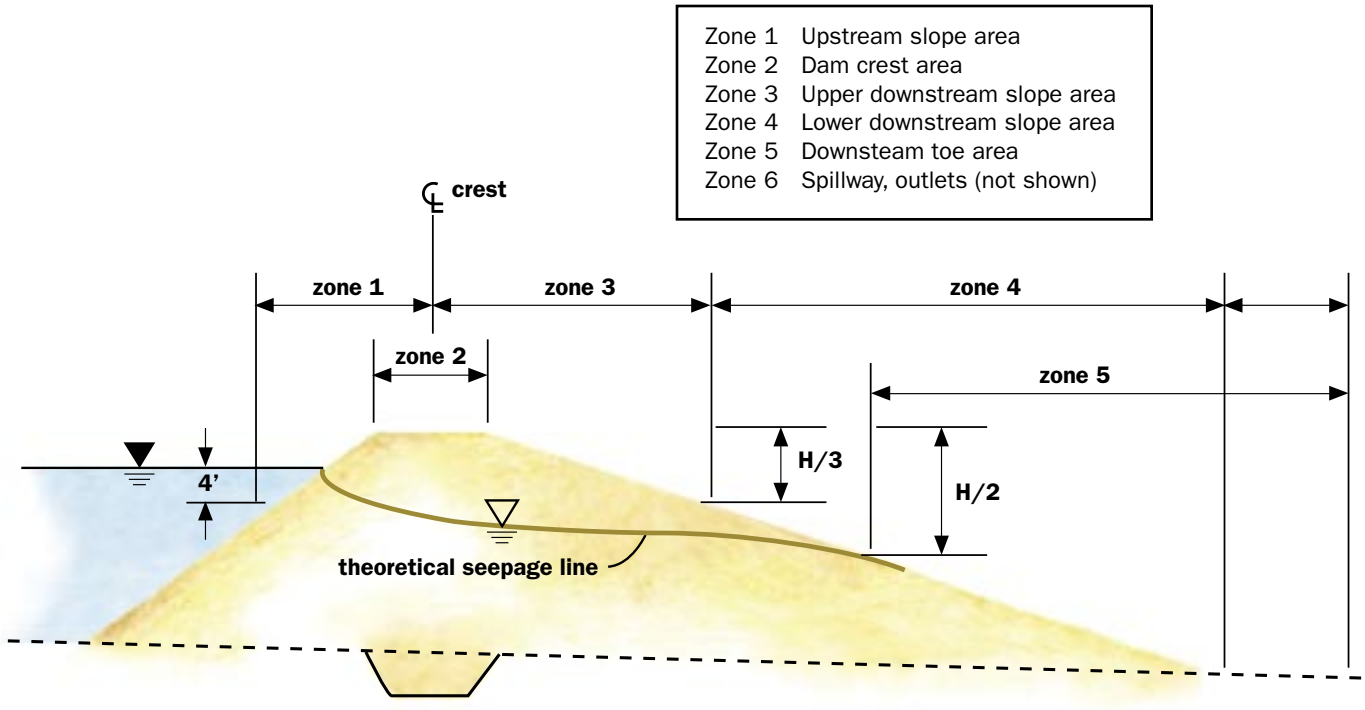


Figure 5-1. Remedial dam repair zones.

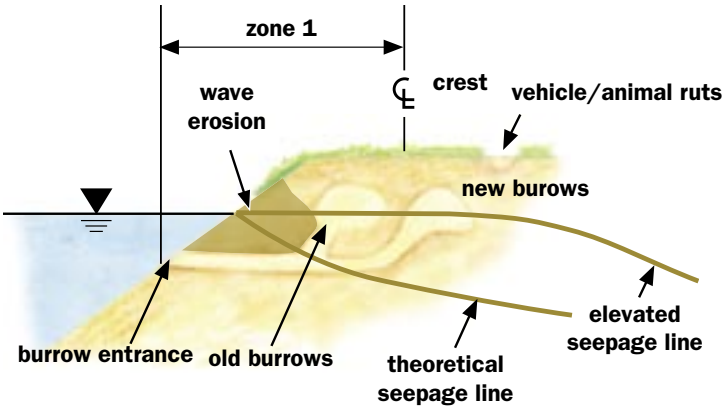


Figure 5-2. Zone 1 Pentration Problems.

dam and reservoir that include geographic location of the dam, proximate vegetation, and prevailing weather patterns. Zone 1 is also susceptible to other forms of deterioration including wave erosion, vehicle access, surface water erosion, and plant intrusion.

To effectively repair animal intrusions in Zone 1, the reservoir pool must be lowered as far below the observed deficiencies as necessary to allow proper access during construction. If the dam owner is unable or unwilling to lower the reservoir pool, then the repair costs will likely increase dramatically to account for necessary water management and diversion.

Preventive measures acceptable for use along the upstream slope generally consist of hardened or structural features. The intent is to provide a physical barrier to the animal, thus making the area much less attractive as a burrow site. These features include riprap, concrete facing, revetment mats, gabions, large gauge wire mesh, and mechanically stabilized earth walls among others. With proper design and installation procedures, each of the methods can be successful. Two of the more common measures are riprap and concrete facing because they are relatively simple to design and provide protection from wave action and plant intrusion as well as animal intrusion.

- A typical cross section of riprap, shown on Figure 5-3 (Ohio DNR, 1999) should consist of a layer of rock riprap overlying bedding material and filter material or a geotextile separator. Limits of the protection should extend at least 4 feet below the normal pool elevation and several feet above depending on estimated wave heights and average reservoir fluctuation. Rock size and layer thickness will vary significantly from dam to dam depending on the reservoir size, prevailing winds and other physical characteristics of the area. Therefore, material (e.g. riprap, bedding and filter) sizes and layer thickness, must be based on the anticipated wave action, ice thickness, and compatibility with neighboring materials. A number of guidelines including Technical Release No. 69 developed by USDA, Natural Resources Conservation Service can assist dam safety professionals in detailed design for riprap slope protection.

- A typical cross section of concrete facing as shown on Figure 5-4 (Ohio DNR, 1999) will resemble riprap in that the concrete will overlie a filter material. As with riprap, the concrete facing limits should extend at least

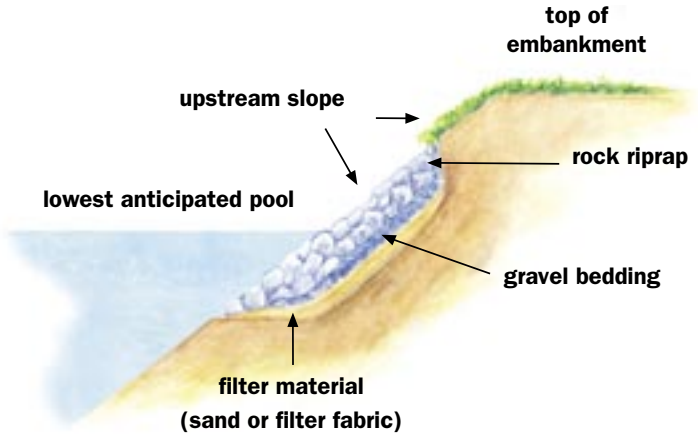


Figure 5-3. Riprap Repair in Zone 1.

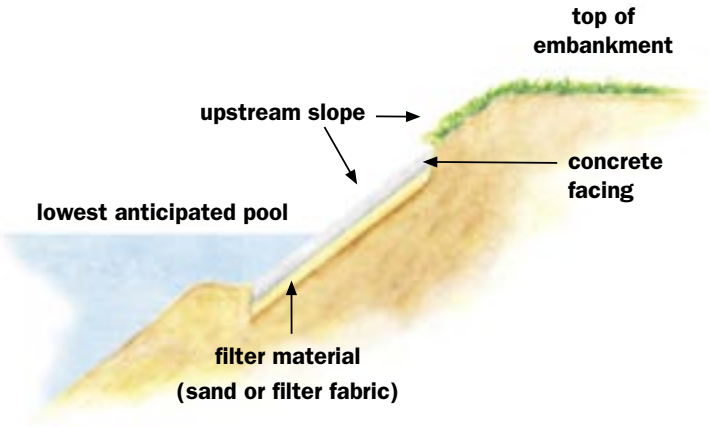


Figure 5-4. Concrete Facing in Zone 1.

4 feet below the normal pool elevation and several feet above, depending on estimated wave heights and average reservoir fluctuation. Concrete thickness, compressive strength, and reinforcing depend on wave action, freeze/thaw cycles and other factors.

Regardless of the measure selected, proper implementation requires specific design recommendations from a qualified dam safety professional.

5.4.2 Dam Repair Zone 2

Repair Zone 2 corresponds to the limits of the dam crest and, therefore, overlaps with Zone 1 by one-half of the crest width. Overlapping a portion of Zone 1 with Zone 2 emphasizes the importance and critical nature of both zones. This overlap essentially suggests that both zones be inspected twice during a dam safety inspection.

As with Zone 1, the relative importance of Zone 2 depends upon the crest width and freeboard. For a dam with a wide crest and large freeboard, animal intrusion within Zone 2 becomes less critical. However, as the crest narrows and freeboard lessens, the importance of repairing deficiencies increases rapidly. These intrusions may include terrestrial animal burrows such those made by groundhog, but most typically include ruts and other minor deformations. Zone 2 is also susceptible to other forms of deterioration including vehicle access, surface water erosion, and plant intrusion.

Restoration of animal penetrations within Zone 2 should follow the guidelines presented in Chapter 5.3. Any excavation activities within a dam embankment should be coordinated with a dam safety professional.

Applicable preventive measures for Zone 2 include hardening the crest surface with stone, concrete, or asphalt. These measures tend to prevent rutting from animal and vehicular traffic. Design of these measures depends upon the specific characteristics of the dam and expected loading conditions.

5.4.3 Dam Repair Zone 3

Repair Zone 3 begins at the crest centerline and extends to a point on the downstream slope equivalent to one-third the structural height of the dam below the dam crest elevation. As with Zone 2, Zone 3 overlaps Zone 2 by one-half of the crest width to emphasize the importance of the dam crest area. However, the remaining portion of Zone 3 is typically considered the least critical dam repair zone relative to dam safety issues (ASDSO, 2001). The phreatic surface and zone of saturation within the embankment are generally below the depths of average animal burrows and should not interfere with restoration activities.

Zone 3 is the most attractive area for burrows of terrestrial animal, including groundhog, fox, and coyote. Similar to all other zones, Zone 3 is also susceptible to other forms of deterioration including vehicle access, surface water erosion, and plant intrusion.

Restoration of animal penetrations within Zone 3 should follow the guidelines presented in Chapter 5.3.1 and as shown on Figure 5-5. Any excavation activities within a dam embankment should be coordinated with a dam safety professional.

Applicable preventive measures for Zone 3 (beyond the limits of Zone 2) are limited. Use of hardening materials such as stone, riprap, or concrete is generally discouraged by dam safety professionals because they obscure the surface and prevent detailed inspection. Installation of wire mesh or fencing (e.g., chain link fencing) directly on the ground surface can effectively deter to burrowing animals. With properly sized openings, the wire mesh deters animal intruders and accommodates inspection of the area. However, these materials can represent an obstacle to routine maintenance activities such as mowing and be viewed as a tripping hazard.

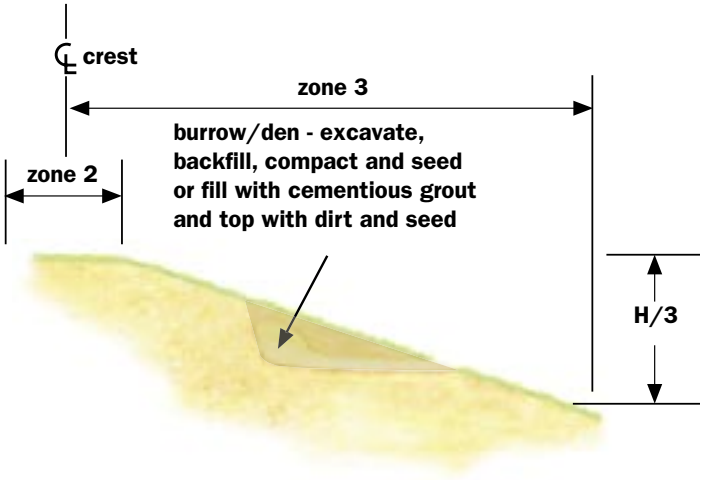


Figure 5-5. Zone 2 and 3 Repair Procedures.

5.4.4 Dam Repair Zone 4

Repair Zone 4 extends from the point on the downstream slope that is one-third the dams' structural height below the crest to the toe of the downstream slope. Zone 4 is one of the two most critical dam repair zones relative to dam safety issues because of the proximity of the phreatic surface and zone of saturation to the embankment slope.

Animal and plant intrusions within this repair zone should be of major concern to dam owners and dam safety professionals. Any animal intrusion or dam penetration should be thoroughly evaluated for potential impact to dam safety and for the required repair.

Restoration of animal burrows within Zone 4 should follow procedures presented in Chapter 5.3. However, due to the proximity of the phreatic surface to the animal burrow, the increased potential of soil migration and, therefore controlling water in the restored burrow must be considered. As shown in Figure 5-6, the use of filter materials within the backfilled burrow can control internal erosion, and with small diameter plastic piping, can manage the flow of water in the area.

Similar to Zone 3, use of hardening materials such as stone, riprap, or concrete is generally discouraged by dam safety professionals because they obscure the surface and prevent detailed inspection. The use of wire mesh or fencing as discussed for Zone 3 is also applicable to Zone 4. It is essential that restoration and preventive measures in Zone 4 undergo review from a dam safety professional prior to implementation.

5.4.5 Dam Repair Zone 5

Repair Zone 5 begins at the mid-height of the downstream slope and extends to a distance of one-half of the dam's structural height horizontally beyond the downstream toe. Zone 5 overlaps a large portion of Zone 4 to emphasize the most critical portions of both zones and heighten scrutiny during inspection. Zone 5 is typically considered the most critical zone relative to dam safety issues (ASDSO, 2001) because the interception of the phreatic surface and downstream slope is typically located in this zone for homogeneous dams.

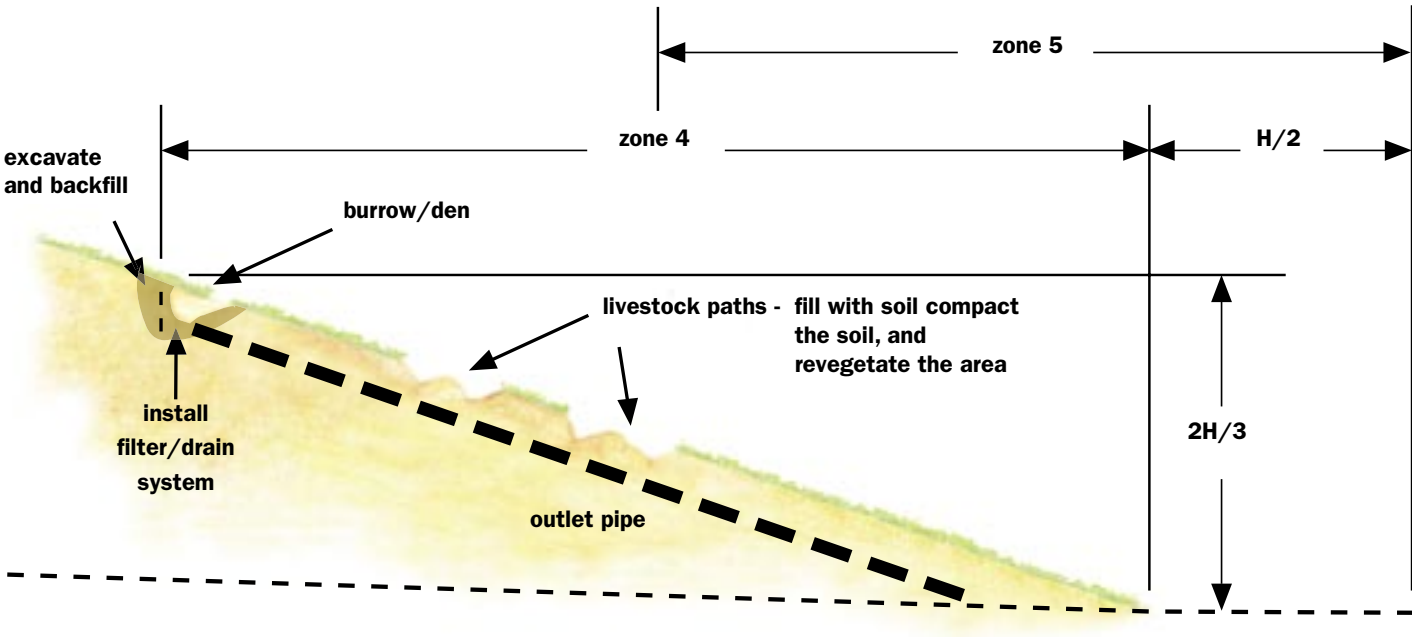


Figure 5-6. Zone 4 and 5 Repair Procedures.

Animal and plant intrusions in this zone often develop into serious conditions involving seepage and piping that are progressive and can lead to dam failure if left untreated. The installation of filter and drain systems to control soil migration and manage seepage must be considered in Zone 5. Similar to Zone 3 and 4, the use of wire mesh of fencing to deter animal intruders can also be considered in Zone 5. It is essential that restoration and preventive measures in Zone 5 undergo review from a dam safety professional prior to implementation.

5.5 Professional Dam Safety Review

Construction or repair activities on an embankment dam should be reviewed by a dam safety professional prior to initiation. Due to the complexity of interaction among animal penetrations, the phreatic surface, slope stability, and other deficiencies, the impact of excavation activities on a dam can be unpredictable without thorough review by a qualified professional. This review should include the following elements at a minimum:

- Evaluation of the existing dam relative to the position of the phreatic surface and slope stability through review of pre-existing inspection reports, design drawings, design memoranda, and owner observations.
- Assessment of the impact of excavation given the phreatic surface position and physical characteristics of embankment materials (material type, density, plasticity, etc.).
- Evaluation of the restoration and preventive scheme proposed.

5.6 Sequenced Repair Program

Currently, dam safety inspections provide a comprehensive list of deficiencies observed at the time of the inspection. The list is generally separated into physical areas of the dam including the upstream slope, crest, downstream slope, emergency spillway, and principal spillway. However, in most cases, the list is not prioritized for the dam owner. Consequently, the dam owner is left with a long list of deficiencies with little guidance on immediate, near-term, and long-term repair items.

Considering that most dam owners do not have the financial means to address all deficiencies quickly, a prioritization methodology should be established for dam repair. The following sequence is one that provides the owner, regulator, and dam safety engineer with a reasonable opportunity to effectively evaluate the condition of an earthen dam (ASDSO, 2001). It must be noted that the following sequence is intended for general guidance only. Specific dam inspections may substantially deviate from the following sequence based on the needs and requirements of the individual dam.

- **Year 1.** (from date of last inspection) Repair animal penetrations that exhibit seepage, soil migration, or have caused slope instability in Zones 1, 4, or 5. Preventive measures should be installed where appropriate.
- **Year 2.** Repair penetrations in Zones 2 and 3. If deemed necessary, initiate investigation, analysis, and preliminary design of major repair activities.
- **Year 3.** Complete design and begin construction of major repair activities.
- **Year 4.** Complete construction of major repair activities and establish an operation and maintenance program that will manage animal intrusions and penetrations on a frequent and regular basis.

If dam failure is judged imminent or if dam safety or operation has greatly diminished, the above sequence may not be applicable. In these cases, a dam safety professional must be advised of the situation to develop a revised schedule.

5.7 Mitigation Through Design

5.7.1 Muskrat

Some of these design criteria are referred to as "overbuilding" however, they are generally effective at preventing serious muskrat burrow damages. The design measures are adapted from the following references: University of Nebraska, 1994; University of Missouri Extension, 1999; ASDSO, 2001; Connecticut DEP, 1999; USDA, 1991; and South Carolina DNR, 2003.

- Construct the upstream slope of the dam to a 3H to 1V slope. Muskrats favor steep slopes so gentle slopes will be less attractive (Figure 5-7).
- Construct the downstream slope of the dam at a 2H to 1V slope with a crest width of not less than 8 feet, preferably 10 to 12 feet.

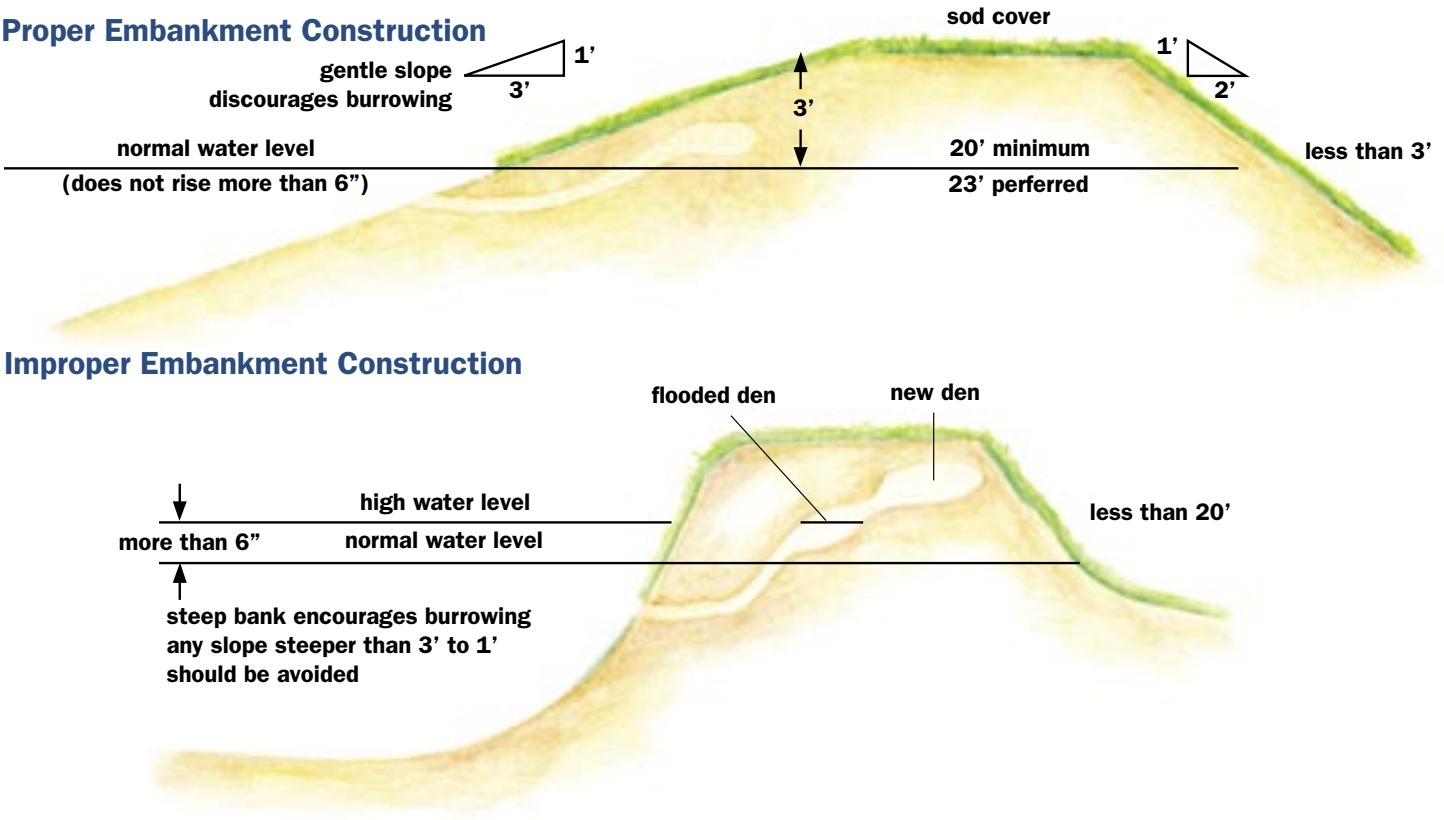


Figure 5-7. Proper dam construction can reduce muskrat damage.

- The normal water level in the pond should be at least 3 feet below the top of the dam and the spillway should be wide enough that relatively frequent storms (less than the 10 year storm event) will not increase the level of the water for any length of time.
- Design for a minimum width of 20 feet at normal water level.
- Bind soil adequately by sodding well.
- Protect the crest from muskrat by applying compacted dense-graded aggregate base course 4 to 6 inches thick.
- Construct a 10-foot-wide shelf projecting from the face of the dam into the reservoir at the water line. This shelf will act as a muskrat barrier and also reduce wave action erosion.
- Place stone rip-rap underlain by fine filter stone and geotextile (high strength, non-woven) extending from 3 to 4 feet below the water line to 1 foot above the water line. Riprap size and thickness will depend upon specific reservoir characteristics. The riprap will prevent muskrat from burrowing into the dam.
- Use an appropriate gabion wall system and/or enlarged reinforced concrete outlet works structures to act as exclusion systems at the toe of the downstream slope.
- Embed 1 to 2-inch welded wire or chain link fencing into the dam upstream face. Mesh wire should extend from 3 to 4 feet below the water line to 1 foot above the water line. Lay the wire flat against the banks and fasten it down every few feet to secure the wire. It is likely that portions of the mesh below the water surface will corrode over time and require replacement.
- Using a narrow trenching machine, cut a vertical trench extending the full length of the embankment in the centerline of the earth fill. The trench should extend from 3 to 4 feet below the water line to 1 foot above the water line. Fill the trench with concrete to create a core that will prevent muskrat from digging through the embankment.

The South Carolina Dam Safety Office indicates that using siphons and other "non-trickle" principal spillway systems may be effective against beaver, but their success is not documented.

- Design water control structures with a concrete apron to prevent muskrat burrows from damaging these facilities.

Several of the above design components indicate placement of the barrier 3 to 4 feet below the water line of the normal pool. It should be noted that if the barriers are not placed at least 3 feet (and preferably 4 feet) below the water line, then the muskrat will burrow underneath the barrier and penetrate the embankment; failure of the slope protection system and embankment damages will result.

5.7.2 Beaver

Structures or techniques to prevent beaver damage can often be included in initial engineering plans or added during dam upgrades and repairs. The following techniques have been adapted from the following references: University of Nebraska, 1994; North Carolina State University, 1994; Wilson, 2001; New York State DEC, 2002; Porter, 2003; Barnes, 1991; Virginia Cooperative Extension, 2000; and FEMA, 2000.

- Gently slope the embankment (3H to 1V or flatter) to discourage burrowing and minimize the probability of beaver dam construction.

- Install spillway risers so that they open upstream instead of toward the dam.

- Place riser structures far from the face of the dam in the deepest water possible.

- Protect large risers from clogging by installing mesh bars (at least 5 inches square) or hog pen panel (4 x 4 inches). This will prevent beaver from entering the trash rack.

- Protect intakes with a deep water cage or fence to prevent plugging.

- Replace the standard manhole cover on top of the riser tower with a "beehive" grate. This cast iron dome allows drainage during high water events, even if the lower orifices are blocked.

- Install a single strand, high-tensile electric wire across active beaver paths or around the shoreline just above the slope where beavers would exit the water. The electric wire should be staked about 3 to 4 inches above the soil surface and can be powered by a direct 110-volt charger or a rechargeable battery pack. After repeated shocks, the beaver will usually relocate to another area. Public safety issues and concerns must be addressed when considering this option.

- Install fencing around outlets to prevent plugging. Secure the fence to the reservoir bottom with metal posts. Fencing should be about 5 feet high, made of heavy-gauge woven wire with no larger than 6-inch openings. It should extend 10 to 20 feet out from the outlet. Before installing the fence, debris should be removed from the outlet (Figure 5-8).

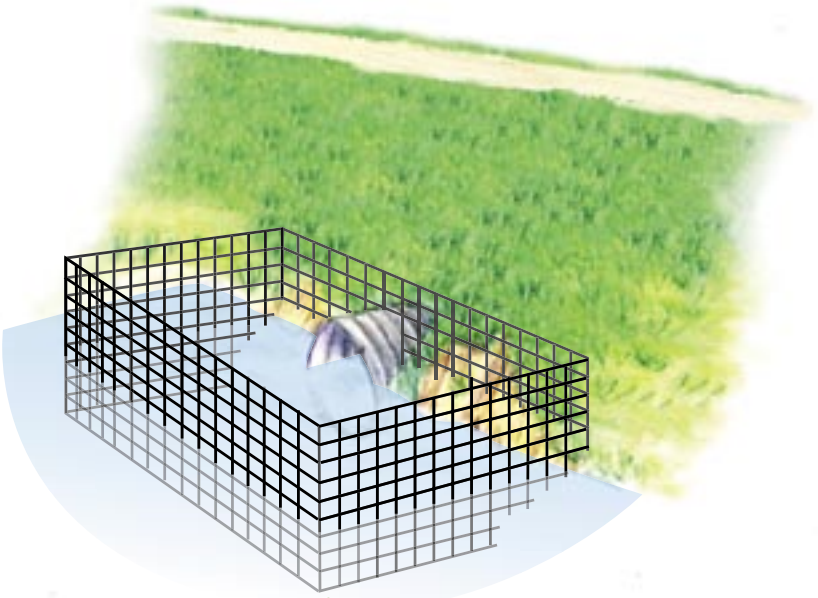


Figure 5-8. Install fencing around culverts and outlets to prevent beavers from blocking flow.

Avoid These Water Level Control Devices at Dams

Because these devices require partial obstruction of spillways or outlet pipes, their use at a dam should be strictly prohibited. Obstruction of spillways or outlets can cause reservoir levels to rise resulting in overtopping of the dam, erosion of earthen spillways and other detrimental impacts.

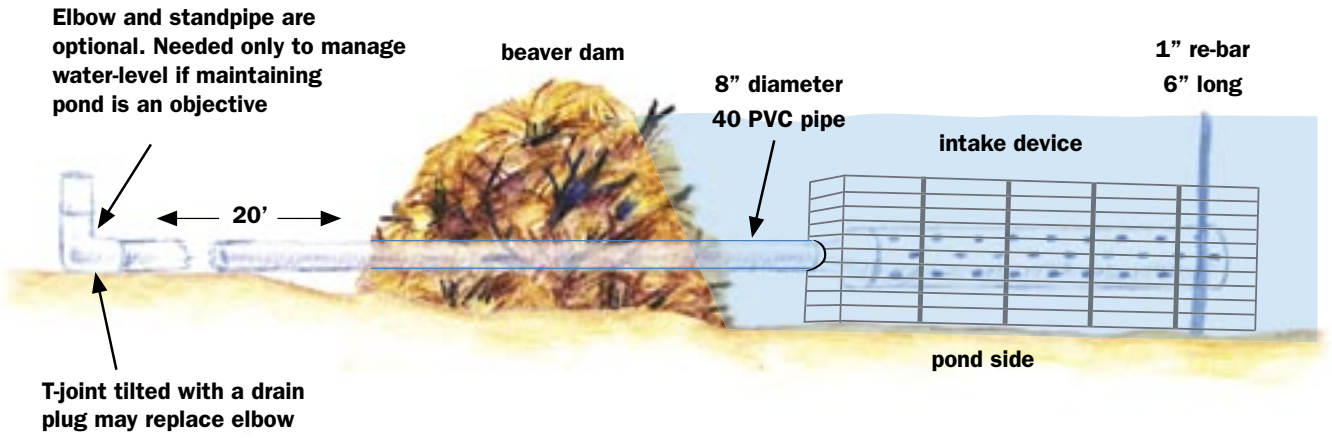


Figure 5-9. The Clemson Beaver Pond Leveler is a passive but effective means to control water levels through a beaver dam.

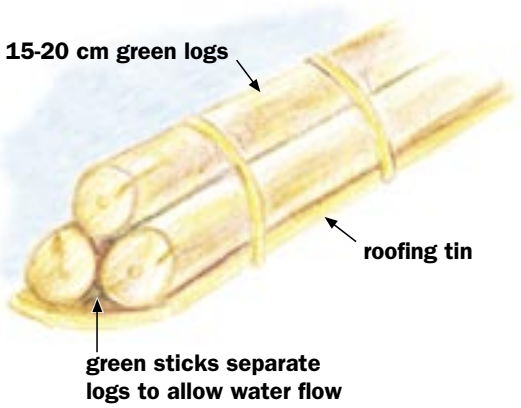


Figure 5-10. A 3-log drain manipulates water levels through a beaver dam.

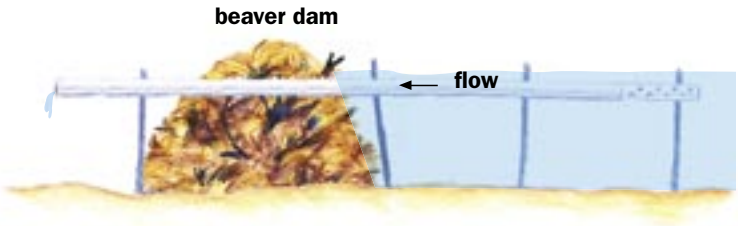


Figure 5-11. PVC Beaver Drain Pipe

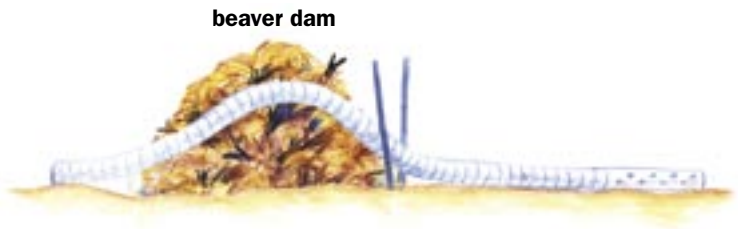


Figure 5-12. Massachusetts Beaver Pond Leveler

- Install a layer of riprap on the upstream side of the embankment to prevent burrowing. The riprap should extend from 4 feet below to 2 feet above normal water levels.

5.7.3 Mountain Beaver

It may be possible to exclude mountain beavers from a dam by installing a rabbit-proof fence (chain-link, chicken wire, etc.) around the embankment. The bottom of the fence must be tight against the ground or, for better protection, buried about 1 to 2 feet (Pehling, 2003).

5.7.4 Groundhog

It is possible to discourage groundhogs from burrowing in an earthen dam by armoring the structure with rock or other hard materials (Michigan State University Extension, 1998).

It is also possible to exclude groundhogs from an earthen dam by installing a fence around the area of concern. Groundhogs are good climbers so the fence should be at least 3 feet high and made of heavy poultry wire or 2-inch mesh woven wire. To prevent burrowing underneath the fence, it should be buried 10 to 12 inches into the ground or bent into an L-shaped angle (pointing away from the excluded area) buried 1 to 2 inches into the ground. For added protection, an electric wire placed 4 to 5 inches off the ground and 4 to 5 inches away from the fence may be installed (University of Nebraska, 1994). Public safety issues and concerns must be addressed when considering this option.

5.7.5 Pocket Gopher

Fencing is of limited use for protecting earthen dams from pocket gophers; the method is expensive and generally not practical because pocket gophers burrow so deeply underground. However, if fencing is used to exclude pocket gophers from the dam, it should be buried at least 20 inches into the ground and extend 6 to 8 inches above the ground (USDA, 1991).

5.7.6 North American Badger

Fencing may be used to exclude badgers from an earthen dam. The fence should be made of mesh wire and it should be buried to a depth of 12 to 18 inches to prevent badgers from burrowing underneath. This control method may not be practical for protecting large areas because installation can be costly and time consuming (University of Nebraska, 1994).

5.7.7 Nutria

There are several design measures that can be implemented to reduce nutria damage.

- Install fencing around the dam embankment. Fences should be about 4 feet high with at least 6 inches of fencing buried underground.

- Armor the embankment with riprap to discourage burrowing.

- Contour embankment slopes to an angle less than 45° to discourage burrowing.

5.7.8 Prairie Dog

The use of fencing to exclude prairie dogs from a dam is a potential management tool, although it is rarely practical because prairie dogs burrow so deeply underground. If fencing is chosen as a control method, a tight-mesh, heavy-gauge, galvanized wire fence should be used, with 2 feet buried in the ground and 3 feet remaining above ground (University of Nebraska, 1994).

Visual barriers may also discourage prairie dogs from inhabiting an area. Prairie dogs prefer areas of low vegetation to provide a clear view of their surroundings and to improve their ability to detect predators. Objects such as fences or hay bales that are strategically placed to block prairie dog views may reduce suitability of the habitat. High construction and maintenance costs generally reduce the viability of this option (University of Nebraska, 1994).

5.7.9 Ground Squirrel

Fencing is not usually a practical method of control for ground squirrels because they are able to climb over or burrow under most exclusion structures. Routine weed control and vegetative management may limit some damage, but the effectiveness of this method is usually limited as well (USDA, 1991).

5.7.10 Armadillo

It is possible to exclude armadillos from an earthen dam by installing a fence or barrier around areas of concern. Armadillos can both climb and burrow so the fence should be slanted outward at a 40° angle with a portion buried underground sufficient to maintain the fence's pitch.

5.7.11 Livestock

Fencing is a highly effective method of protecting earthen dams from domestic livestock and is moderately effective with free-ranging or wild grazing animals (USDA, 1991). Heavy wire fences, wooden post fences, or electric fences may be used (University of Nebraska, 1994).

5.7.12 Crayfish

No design techniques are effective at discouraging crayfish inhabitation.

5.7.13 Coyote

Fencing can be used to exclude coyotes from a dam. Both wire and electric fences will work, and a combination of the two will probably be most effective. Net wire fences should be about 5 feet high with barbed wire at ground level or a buried wire apron. Horizontal spacing of the mesh should be less than 6 inches and vertical spacing should be less than 4 inches. Electric fences usually consist of strands of smooth, high-tensile wire stretched to a tension of 200 to 300 pounds. Studies have shown that 13 strands of charged wire effectively protected pastures from coyote predation (University of Nebraska, 1994).

Studies have shown that 13 strands of charged wire effectively protected pastures from coyote predation.

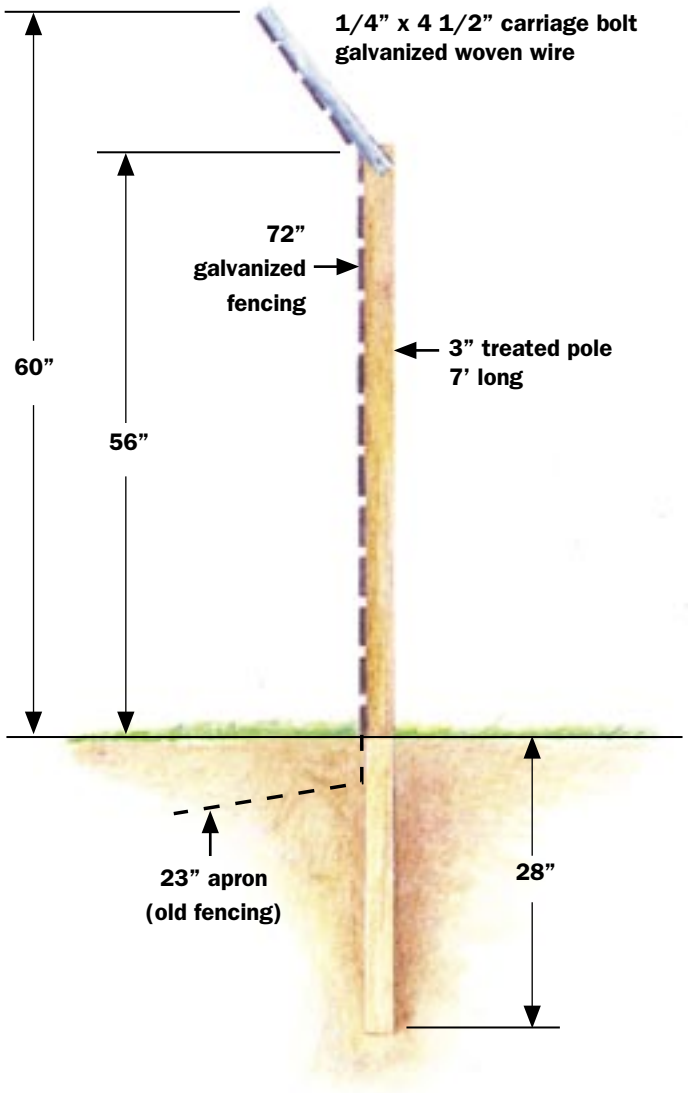


Figure 5-13. Installation of a net fence with wire overhang and buried apron is an effective coyote exclusion method.

5.7.14 Mole and Vole

Fencing may be useful for mole control in small dams. The fence should be made of rolled sheet metal or hardware cloth, with at least 12 inches buried underground and 12 inches extending aboveground. It is also possible to discourage moles from burrowing in an earthen dam by packing the soil with a roller to reduce soil moisture. This will reduce the habitat's attractiveness to moles (University of Nebraska, 1994).

Fencing of large-scale areas is generally not a cost-effective method of vole control (University of Nebraska, 1994).

5.7.15 River Otter

Fencing may be used to exclude river otters from an earthen dam. The fence should be constructed of mesh wire (3 x 3-inch or smaller) or hog-wire. Dam owners should regularly check the fence to ensure that it has not been spread apart

or raised to allow otters to enter (University of Nebraska, 1994).

5.7.16 Gopher Tortoise

Fencing the dam embankment may be practical for protecting small areas from gopher tortoise damage (University of Nebraska, 1994).

5.7.17 Red and Gray Fox

Fencing can be used to exclude foxes from an area of concern. Both wire and electric fences will work, and a combination of the two will probably be most effective. Net wire fences should be constructed so that all openings are less than 3 inches. The bottom should be buried 1 to 2 feet into the ground with at least 1 foot above ground. For an effective electric fence, there should be at least three charged wires spaced 6 inches, 12 inches, and 18 inches above the ground (University of Nebraska, 1994).

5.7.18 Canada Goose

It is often possible to discourage Canada goose inhabitation by installing fencing, rock barriers, or vegetative barriers around shorelines. Fencing can be constructed out of a variety of materials including mylar tape, metal mesh, plastic or synthetic mesh, electric wires, or wood. Fences should be at least 25 inches tall and should not contain openings greater than 3 inches (Virginia Cooperative Extension, 2001b).

5.7.19 American Alligator

Fencing may be used to exclude alligators from earthen dams. The fence should be at least 5 feet high with the top edge angled outward (University of Nebraska, 1994).

5.7.20 Ants

There are no exclusion methods or design measures effective against ant inhabitation

5.8 Monitoring

Once a dam specialist identifies the burrow and the species creating or occupying it, the burrow(s) would be filled and a prevention technique implemented as appropriate. The next step to maintaining safe dam operation is to monitor the effectiveness of the remedial action (e.g., has the riprap effectively deterred muskrat activity?). In many cases, regular dam inspections and swift burrow mitigation (and preventive actions when needed) will adequately preserve safe dam operations. However, it is possible for a dam to become overrun by nuisance animals, or for several species to cumulatively compromise safe dam operations. In these cases, repair actions are only partial solutions. Monitoring can help the dam owner determine whether additional mitigation is necessary.

In general, it is recommended that the dam owner inspect the dam once every 3 months after first finding and repairing animal damage. The frequency is aimed at confirming the animal has not returned to the dam once the burrow is removed. Once burrows are identified, the owner should consider implementing a preventive action if a burrow occurred in one of the critical dam zones (see Chapter 5.4 for a discussion on animal burrows in critical dam zones). Understanding the potential fiscal limitations of dam owners, the most realistic approach is to use the fewest actions needed to ensure dam safety. As a guideline, if the dam owner finds new animal burrows in the dam on two consecutive inspections following repair and preventive actions, then implementing a wildlife control strategy is probably necessary to maintain safe dam operations (see Chapter 6.0 for a discussion on wildlife control).

6.0 Mitigating Damaging Wildlife

This chapter of the manual details methods for managing wildlife populations. General wildlife management information is provided first, followed by specific management information for the 23 species considered in this manual. The application of this data in the dam environment can be beneficial and at times necessary to protect human populations from the disastrous effects of dam failure. However, applied indiscriminately, these methods can adversely affect the dam environment, protected wildlife species, and even human populations. For this reason, nuisance wildlife management practices should be implemented only with coordination and input from state and federal wildlife agencies and the county agent responsible for toxicant and fumigant registration and application (Appendix A contains state wildlife contacts).

6.1 Compliance with State and Federal Regulations

6.1.1 Conformity to Federal Regulations

As the vast majority of surveyed states indicate, the dam owner is responsible for the identification and mitigation of nuisance wildlife at dams. Although the dam owner is empowered by the state dam safety official to manage a dam toward safe operation, the dam owner must abide by applicable federal and state regulations when implementing nuisance wildlife management measures. The Endangered Species Act of 1973 (ESA), the Migratory Bird Treaty Act of 1918 (MBTA), and the Federal Insecticide, Fungicide, and Rodenticide Act of 1996 (FIFRA) are three federal laws that must be complied with during application of wildlife management methods. The ESA protects species of plants and animals that are in danger of extinction. Under the ESA, it is illegal for anyone to "take" a species listed as threatened or endangered.

The ESA defines "take" as, "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect or attempt to engage in any such conduct" (USFWS, 2002a). The MBTA was established to conserve migratory bird species in the United States and prohibits the hunting, trapping, possession, and transfer of listed species except under the terms of a valid permit or during authorized hunting seasons (USFWS, 2002b).

Species that are discussed in this manual and protected under the ESA and the MBTA include:

- Gopher Tortoise (*Gopherus polyphemus*). This species is listed as Threatened under the ESA throughout its range of Mississippi, Louisiana, and portions of Alabama, and is protected by state laws in Alabama, Georgia, Florida, and South Carolina.

- The American Alligator (*Alligator mississippiensis*). This species is listed as "Threatened by Similarity of Appearance to a Threatened Taxon" under the ESA throughout its range of Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, North Carolina, Oklahoma, South Carolina, and Texas. This designation means that the American Alligator is protected under the ESA because of its similarity in appearance to the American Crocodile (*Crocodylus acutus*). The American Crocodile is classified as Endangered under the ESA. The USFWS determined that in order to adequately protect the American Crocodile, which is often mistaken for the American Alligator, the USFWS must also protect the American Alligator. Therefore, though populations of the American Alligator are healthy throughout its range, it is afforded full protection under the ESA.

- Point Arena Mountain Beaver (*Aplodontia rufa nigra*). This subspecies is listed as Endangered throughout its range of California.

- Utah Prairie Dog (*Cynomys parvidens*). This species is listed as Threatened throughout its range of Utah.

- Northern Idaho Ground Squirrel (*Spermophilus brunneus brunneus*). This subspecies is listed as Threatened throughout its range of Idaho.

- Canada Goose (*Branta canadensis*). This species is protected under the MBTA throughout its range of the United States.

If dam owners suspect that one of these species is damaging the earthen dam, then the dam owner must contact the USFWS and the state wildlife agency to discuss management options. While it is often possible to relocate these animals with permits and guidance from the USFWS and the state wildlife agency, the permitting agency must be consulted prior to taking any action. It should be noted that the list of protected species can and does change, and regular contact with an agency is required to ensure that no protected species are adversely affected.

While difficult to predict each potential circumstance, there may be cases when management of a species not protected by the ESA or MBTA may result in the illegal taking of a protected species that is associated with the targeted nuisance species. For example, the endangered black-footed ferret (*Mustela nigripes*) depends on the burrows of prairie dog colonies for survival. Mitigation against the prairie dog may impact the ferret. Similarly, the eastern indigo snake (*Drymarchon corais couperi*) is afforded refuge by gopher tortoise burrows; thus, managing a dam for the tortoise could have secondary effects on the indigo snake. As some species show interdependencies on others, it is recommended that coordination with state and federal wildlife agencies be conducted before management of any species, protected or not, occurs.

Last, FIFRA divides pesticides, including toxicants and fumigants, into two categories: General Use Pesticides and Restricted Use Pesticides. General Use Pesticides will not ordinarily cause unreasonable adverse effects on the user or the environment when used as directed and as such, they are commercially available to the public. Restricted Use Pesticides, however, could cause adverse effects to the user or the environment even when used correctly. Restricted Use Pesticides can only be purchased by a certified pesticide applicator and applied by or under the supervision of a certified pesticide applicator, in accordance with FIFRA. Appropriate disposal of pesticide containers is also required.

6.1.2 Conformity to State Regulations

Certain wildlife species are protected by the state even though they are not listed as Federally threatened or endangered; each state determines its own regulations with regard to protected species. Furthermore, hunting and trapping regulations in regard to furbearer, game, and nongame species vary from state to state. For these reasons, it is recommended that a dam owner contact the appropriate state wildlife agency for information about mitigation of wildlife species, and hunting and trapping seasons, licenses, and permits before attempting to remove an animal from the dam environment or before any wildlife management actions are taken. As with federal laws, the list of protected species can change from year to year and regular contact with an agency is required to ensure that no protected species are adversely affected.

Finally, legal use of specific toxicants and fumigants varies from state to state; one state may allow a toxicant that is banned in another. As such, it is recommended that coor-

dination with the state wildlife agency or county agent be conducted to determine which substances are allowed for use in each state. If toxicants or fumigants are selected as the management option, it is recommended that:

- The substance is used according to direction and precaution;
- The substance is stored securely in original containers away from children, animals, food, and feed;
- The substance is applied so as not to endanger humans, livestock, crops, beneficial wildlife, or water supply, or leave illegal residues;
- Excess substance is not dumped, and associated equipment is not cleaned near ponds, streams, or wells; and
- Substance containers are disposed of properly at an appropriate landfill facility.

6.2 Muskrat Management Methods

6.2.1 Muskrat Control Through Habitat Modification (South Carolina DNR, 2003; University of Nebraska, 1994; Michigan State University Extension, 1998; USDA, 1991)

Mow regularly to remove food supply. Specifically, remove cattails, arrowhead, and other plants that grow on the fringe of the reservoir.

Implement an aquatic vegetation control program to reduce aquatic vegetation preferred by the muskrat for food and cover. Muskrat populations can be effectively managed by eliminating food sources. The vegetation control program can be achieved through several management approaches:

- ***Herbicides*** are widely used to control aquatic vegetation. Out of the 200 herbicides registered with the U.S. Environmental Protection Agency, only 8 are available for aquatic uses, and only 6 of those 8 are widely used (2 herbicides are limited to use in 17 western States' irrigation systems under Bureau of Reclamation control). Coordination with the state agency responsible for aquatic plant management is required to ensure that the appropriate herbicide is selected based on management goals and that herbicides are lawfully applied.
- ***Hand Removal*** of preferred muskrat vegetation can be implemented; however this method is labor-intensive and needs to be repeated frequently to keep vegetation, especially perennial plants, under adequate control. Hand removal can be combined with herbicide application.
- ***Mechanical Removal*** utilizes small and large weed harvesters to remove vegetation around the shoreline. This method achieves immediate vegetation control in small dams and does not carry water-use restrictions after treatment, unlike herbicide application. However, weed harvesters cannot be used in all environments—for example, obstructions may preclude harvester use. This method is usually higher in cost, slower, and less efficient than other available methods.

Manipulate water levels in the reservoir to create an undesirable habitat for the muskrat. A 2-foot drawdown in the reservoir during the winter months can be an effective muskrat management tool. Drawdown allows a dam specialist to identify and repair muskrat holes in the upstream slope (refer to Chapter 5.3.1 for burrow repair discussion), and may drive away resident muskrats, which need adequate water levels. It is recommended that muskrats be trapped and removed during the drawdown; however, trapping and relocation should be coordinated with the appropriate state agency, since a permit may be required.

A secondary benefit of water level manipulation is the potential drying and freezing of aquatic plants—the muskrat's primary food supply—as the plants are exposed to air. It should be noted that some aquatic plants are tolerant of drawdown and may actually increase after a drawdown; therefore, drawdown as a primary aquatic plant management method is not recommended.

6.2.2 Muskrat Control Through Trapping (University of Nebraska, 1994; South Carolina DNR, 2003)

The most effective types of traps for muskrat include the Conibear® traps No. 110 and 120, and leghold traps like the long spring No. 1, 1½ or 2, and similar coil spring traps (Figure 6-1 and 6-2). The Conibear® traps are preferred because they are effective in shallow and deep water settings, easy to set up, and kill the muskrat quickly, preventing escapes. The Conibear® and leghold traps are most effective when set close to the den entrance in the "runs" or trails carved into the reservoir bottom by the muskrat's hind feet. Runs can be easily seen in clear water, or can be felt with

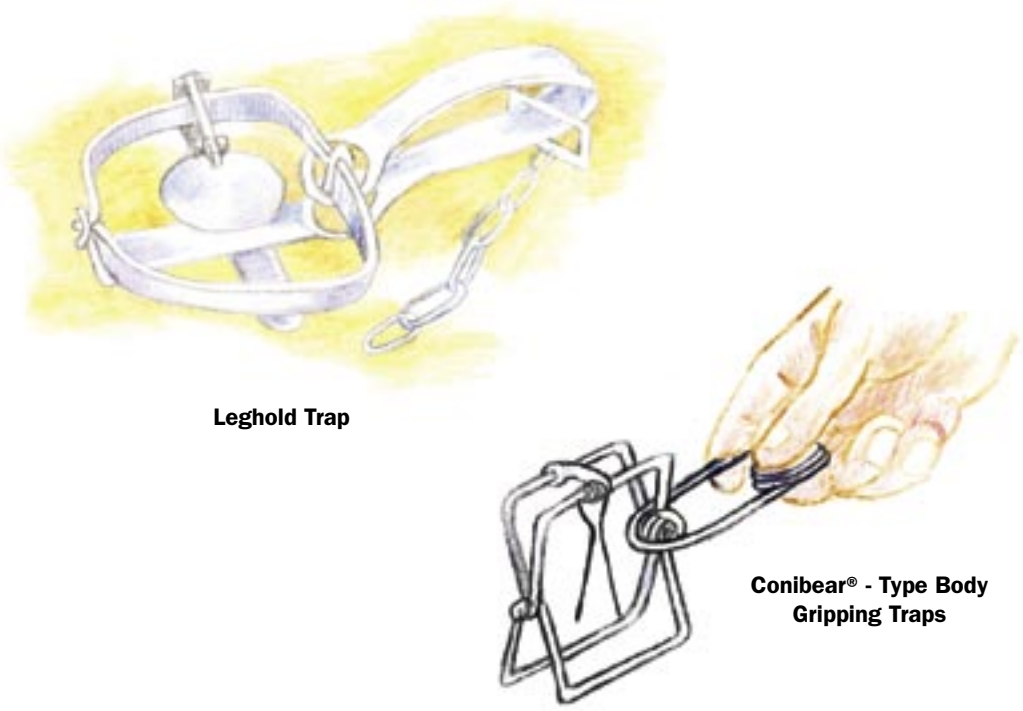


Figure 6-1. To capture muskrats, leghold traps should be set along runways, den openings, or natural resting areas. Conibear No. 110 traps should be set in the water.

Field testing in a 100-acre rice field (36 Conibear® 110 traps were set) and a 60-acre minnow pond (24 1½ leghold traps were set) yielded an effective muskrat removal rate of 93.3% and 87.5% for the Conibear® and leghold traps, respectively. All tripped traps were 100% effective.

Figure 6-2. Muskrat traps can be effectively set in four locations. Bait traps with carrots, potatoes, sweet potatoes, or apples.

the hands or feet in murky or deep water. Poles can be used to anchor the trap in front of the den (Figure 6-3).

Where legal, homemade stovepipe traps can also be effective. This type of trap is cheap, simple, and easy to make, but it requires more time and effort to set. A trap can be constructed by forming sheet metal into a 6 x 6-inch rectangular box, 30 to 36 inches long with heavy-gauge hardware cloth or welded wire doors. The doors should be hinged at the top to allow entry from either end, but no escape out of the box. The trap should be set right up against the primary den entrance to be most effective.

6.2.3 Muskrat Control Through Fumigants (University of Nebraska, 1994)

No fumigants are registered for muskrat control.

6.2.4 Muskrat Control Through Toxicants (University of Nebraska, 1994)

Zinc phosphide (63% concentration) is the only toxicant Federally registered for muskrat control. To make a bait, vegetable oil is applied to cubes of apples, sweet potatoes, or carrots; the zinc phosphide is sprinkled on top; and the ingredients are mixed together thoroughly. The bait is then placed at the burrow entrance, on floating platforms (Figure 6-4), or on feeding houses. Zinc phosphide is a Restricted Use Pesticide and may therefore, only be purchased and applied by a certified pesticide applicator. Zinc phosphide should always be used as directed. Dam owners should contact the appropriate state wildlife agency regarding legality of toxicant use in their state.

Anticoagulants such as pivalyl, warfarin, diphacinone, and chlorophacinone have also been registered for muskrat control in some states. These anticoagulants come in the form of a "lollipop" made of grain, pesticide, and melted paraffin. As with zinc phosphide, anticoagulant baits can

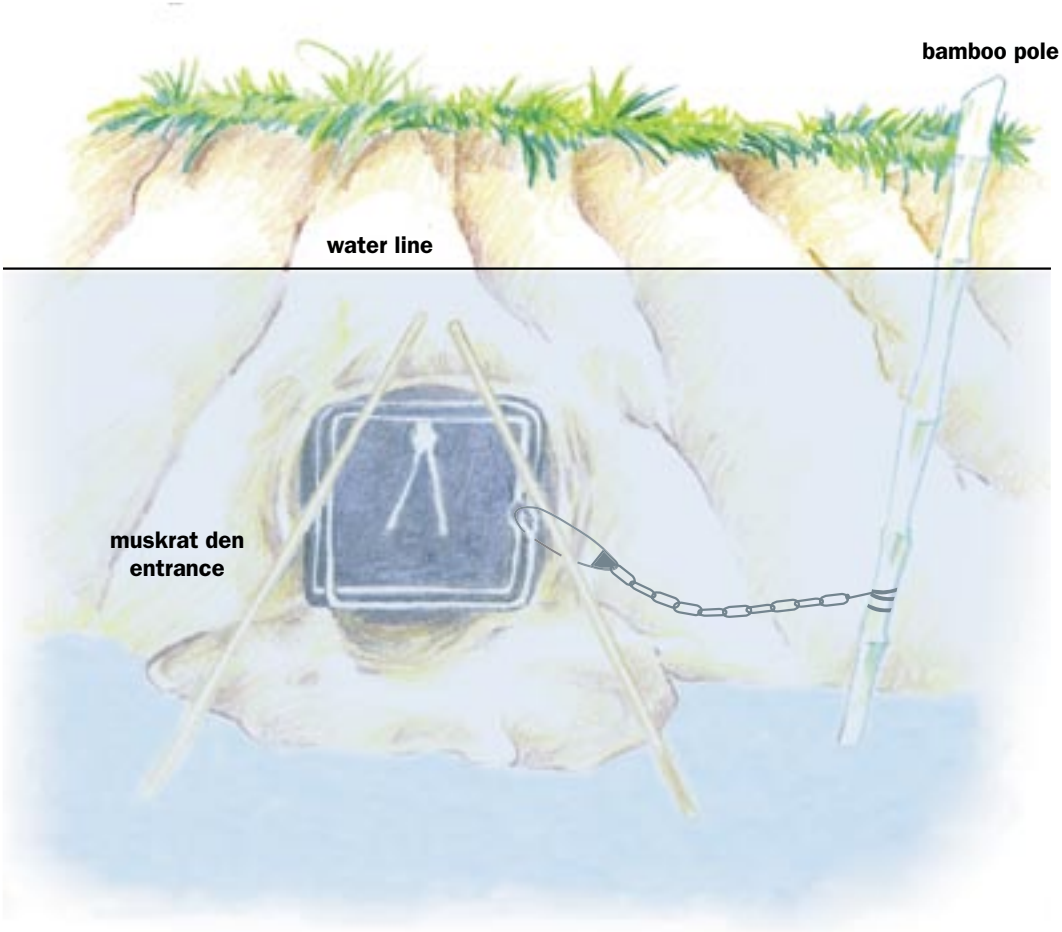


Figure 6-3. Pole set at muskrat den.

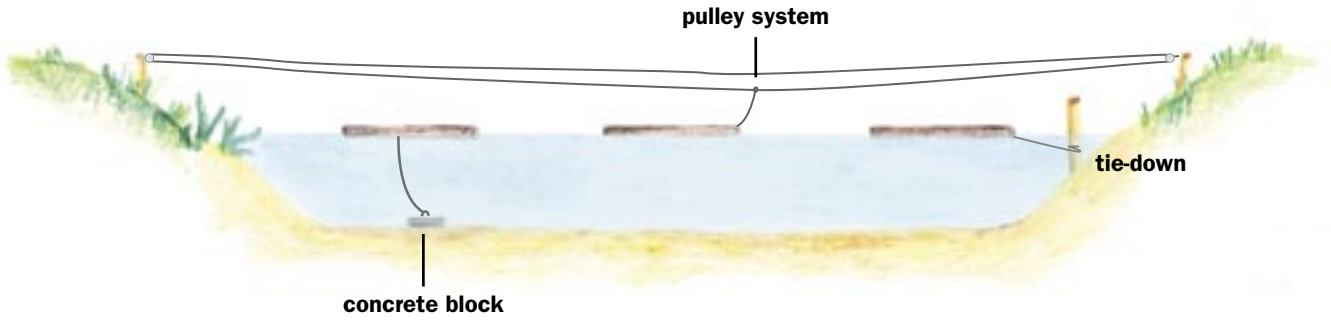


Figure 6-4. Toxicant bait platforms.

be placed at burrow entrances, on floating platforms, or on feeding houses. Dam owners should contact their state wildlife agency to see which, if any, anticoagulants are registered in their state.

6.2.5 Muskrat Control Though Frightening (University of Nebraska, 1994)

Frightening is not an effective method of muskrat control.

6.2.6 Muskrat Control Through Repellents (University of Nebraska, 1994)

No repellents are registered for muskrat control.

6.2.7 Muskrat Control Through Shooting (University of Nebraska, 1994)

Shooting can be an effective method of eliminating a few individual muskrats. Hunting efforts are most successful at dawn and dusk. Dam owners should contact their state wildlife agency for information on hunting regulations and restrictions.

6.3 Beaver Management Methods

6.3.1 Beaver Control Through Habitat Modification (University of Nebraska, 1994; University of New Hampshire Cooperative Extension, 1997; USDA, 1994)

Clearing trees and shrubs near the reservoir will reduce potential food sources and habitat and may discourage beaver inhabitation of a dam. Daily destruction of existing dams and removal of dam construction material will sometimes cause existing beaver colonies or individuals to relocate.

Researchers in Louisiana found that deep water beaver dams could be removed more effectively than shallow water beaver dams, and that it was more effective to remove beaver dams in later summer rather than early or midsummer.

6.3.2 Beaver Control Through Trapping (University of Nebraska, 1994)

In most situations, trapping is the most effective and economical method of controlling beaver damage. Various types of traps can be used, but the Conibear® No. 330 is generally considered the most effective (refer to Figure 6-1 for trap types). It is designed primarily for water use, and works equally well in deep and shallow areas. Conibear®-type traps should be set on dry, solid ground to prevent injury to the person setting the trap. Once the trap is set, it can be

moved to the water and anchored down with stakes. Traps can be effectively set in front of lodge entrances, in front of a hole in the beaver dam, or on underwater beaver trails.

Leghold traps (No. 3 double spring or larger) are also commonly used to capture beavers. This type of trap should be used with a drowning set attachment so that the captured beaver cannot escape. Proper placement is very important with leghold traps. They should be set just at the water's edge, slightly underwater, with the pan, jaws, and springs covered lightly with leaves or debris. There must be a cavity under the pan for the trap to properly trigger. Leghold traps are most effective when they are set slightly off-center on an underwater beaver trail.

Snares can also be used to capture beavers. The equipment costs less than trapping equipment, and snares can be set so that the beaver is caught alive and can then be relocated. Snares are frequently set under logs, near bank dens, and next to castor mounds.

Dam owners should contact their state wildlife agency regarding trapping regulations and seasons and regulations regarding live trapping and relocation.

6.3.3 Beaver Control Through Fumigants (University of Nebraska, 1994)

No fumigants are registered for beaver control.

6.3.4 Beaver Control Through Toxicants (University of Nebraska, 1994)

No toxicants are registered for beaver control.

6.3.5 Beaver Control Through Frightening (University of Nebraska, 1994)

Frightening is not an effective method of beaver control.

6.3.6 Beaver Control Through Repellents (University of Nebraska, 1994)

No repellents are Federally registered for beaver control.

6.3.7 Beaver Control Through Shooting

Shooting may also be used to remove small populations of beavers. If permitted by law, night shooting is most effective; however, hunting in the early evening and early morning hours can also be effective. Dam owners should contact their state wildlife agency for information on hunting regulations and restrictions.

6.4 Mountain Beaver Management Methods

The Point Arena mountain beaver is a Federally listed endangered subspecies and therefore subject to the provisions of the Endangered Species Act. This subspecies is found only in California. Dam owners in California who suspect that they have a mountain beaver problem should contact the USFWS and the California Department of Fish and Game for definitive species identification and management guidance.

6.4.1 Mountain Beaver Control Through Habitat Modification (University of Nebraska, 1994)

Removal of plants such as sword fern, bracken fern, or salal may reduce the attractiveness of a site to mountain beavers.

6.4.2 Mountain Beaver Control Through Trapping (University of Nebraska, 1994)

Trapping is an effective method of controlling mountain beavers. The Conibear® No. 110 is most commonly used (refer to Figure 6-1). The trap should be set in the main burrow entrance, anchored with three stakes. Trapping is most effective in warm months when mountain beaver are most active.

Live trapping is also possible using double-door wire mesh traps such as the Tomahawk. This method of trapping is recommended in areas where pets or livestock could accidentally be captured. The trap should be placed in the main burrow entrance with vegetation arranged along the inside and outside of the trap. The trap should be wrapped with black plastic and covered with soil to protect the captured mountain beavers from the weather. Captured animals should be placed in a dry burlap sack and euthanized or relocated to an appropriate location.

Dam owners should contact their state wildlife agency regarding trapping regulations and seasons and requirements for euthanasia or relocation.

6.4.3 Mountain Beaver Control Through Fumigants (University of Nebraska, 1994)

No fumigants are registered for mountain beaver control.

6.4.4 Mountain Beaver Control Through Toxicants (University of Nebraska, 1994)

No toxicants are Federally registered for mountain beaver control. Some toxicants may be registered in certain states, though, so dam owners should contact their state wildlife agency regarding this option.

6.4.5 Mountain Beaver Control Through Frightening (University of Nebraska, 1994)

Frightening is not an effective method of controlling mountain beaver.

6.4.6 Mountain Beaver Control Through Repellents (University of Nebraska, 1994)

Repellents are effective for controlling mountain beaver that are causing damage to trees/seedlings, but this method is not practical for preventing damage to earthen dams.

6.4.7 Mountain Beaver Control Through Shooting (University of Nebraska, 1994)

Mountain beavers are nocturnal animals that spend most of their time below ground; therefore, shooting is not a practical method of mountain beaver control.

6.5 Groundhog Management Methods

6.5.1 Groundhog Control Through Habitat Modification (Michigan State University Extension, 1998)

It is possible to discourage groundhog inhabitation by mowing vegetated areas of the earthen dam to remove cover.

6.5.2 Groundhog Control Through Trapping (USDA, 1991; University of Nebraska, 1994)

Trapping is an effective method of controlling limited populations of groundhogs. Steel leghold traps (No. 2) (refer to Figure 6-1) and live traps are both commonly used. Traps should be set at the main burrow entrance or on major travel lanes. Live traps, which can be purchased commercially or home-built, require bait such as apple slices, carrots, or lettuce. Groundhogs captured in live traps should be euthanized or relocated to a suitable habitat where they will not cause further damage.

Conibear® traps (110, 160, or 220) may also be used in certain situations (refer to Figure 6-1). They should not be used where they could capture domestic animals or livestock. Conibear® traps should be set in major travelways or at the main entrance of a burrow system. No bait is necessary.

Dam owners should consult with their state wildlife agency regarding specific trapping regulations and requirements for euthanasia or relocation.

6.5.3 Groundhog Control Through Fumigants (University of Nebraska, 1994)

Use of the commercial gas cartridge is the most common method of groundhog control. The cartridge is ignited and placed in the burrow with all other entrances sealed. As the cartridge burns, it produces carbon monoxide and other gases lethal to the groundhog. Gas cartridges are General Use Pesticides that can usually be purchased at local farm supply stores or pesticide dealers. They should be used with caution and in accordance with the directions on the label.

Aluminum phosphide is a Restricted Use Pesticide that may be applied by a certified pesticide applicator to control groundhogs. The legal application of aluminum phosphide may vary from state to state, so dam owners should consult with their state wildlife agency or state pesticide registration board before implementing this control method. Aluminum phosphide comes in tablet form. Two to four tablets should be inserted into the main burrow and then all burrow entrances must be tightly sealed. Aluminum phosphide should always be used as directed on the label.

Dam owners should consult with their state wildlife agency for information on state and local regulations regarding the use of fumigants to control groundhogs.

6.5.4 Groundhog Control Through Toxicants (University of Nebraska, 1994)

No toxicants are registered for groundhog control.

6.5.5 Groundhog Control Though Frightening (University of Nebraska, 1994)

Scarecrows or other effigies may be installed on or around the earthen dam to frighten groundhogs. This method of control works best if the scarecrows are moved regularly and if there is a high level of human activity around the dam.

6.5.6 Groundhog Control Through Repellents (University of Nebraska, 1994)

No repellents are registered for groundhog control.

6.5.7 Groundhog Control Through Shooting (University of Nebraska, 1994)

Shooting is most effective if used as a follow-up to other control measures. Groundhogs are considered game animals in most states; therefore a hunting license may be required. Dam owners should consult with their state wildlife agency regarding specific hunting regulations and requirements.

6.6 Pocket Gopher Management Methods

6.6.1 Pocket Gopher Control Through Habitat Modification (Colorado State University Cooperative Extension, 2003)

Removal of forbs, through either chemical or mechanical treatment, may control some pocket gopher damage. This technique is generally effective only for individuals of the genera *Thomomys*, because they prefer the underground storage structure of forbs. Other species easily survive on grass and therefore will not likely be deterred by this technique.

6.6.2 Pocket Gopher Control Through Trapping (USDA, 1994; University of Nebraska, 1994)

Trapping can be extremely effective for pocket gopher control in small areas or when used in conjunction with toxicants. There are many types of traps available for pocket gopher control. The Macabee® gopher trap is the most popular, but other traps are also commonly used, including the Victor® Gopher Getter, the Death-Klutch 1 gopher and mole trap, and the Guardian gopher trap (Figures 6-5 through 6-8). Traps may be set in either the main tunnel or in one of the lateral tunnels (Figure 6-9). Trapping is most effective in the spring and fall, when gophers are pushing up new mounds, although it can be done year-round. Dam owners should consult with their state wildlife agency regarding specific trapping regulations.

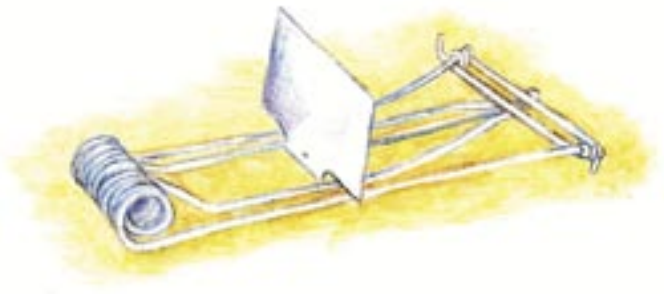


Figure 6-5. Macabee® gopher trap.

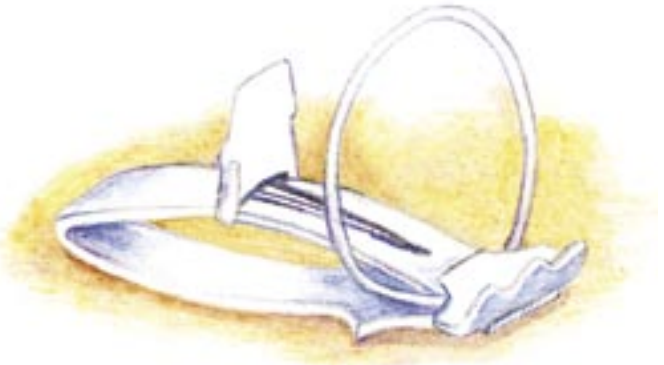


Figure 6-6.Victor® Gopher Getter.

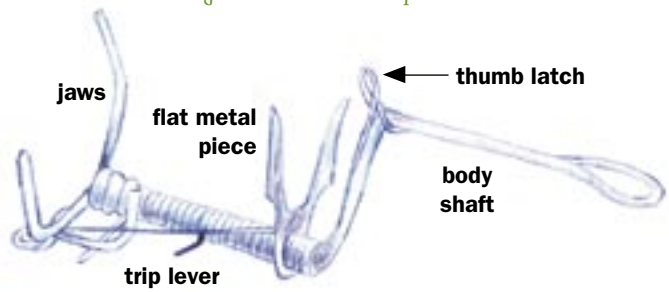


Figure 6-7. Death-Klutch 1 gopher and mole trap.

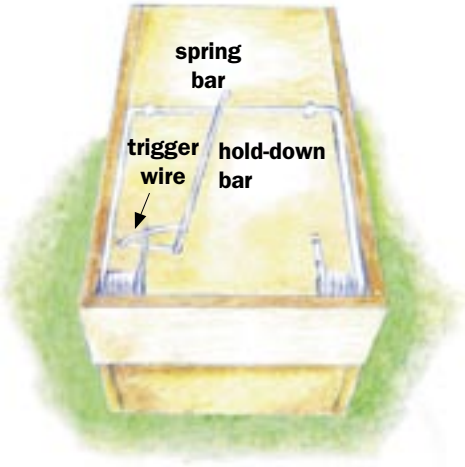


Figure 6-8. Guardian (California box-type) gopher trap.

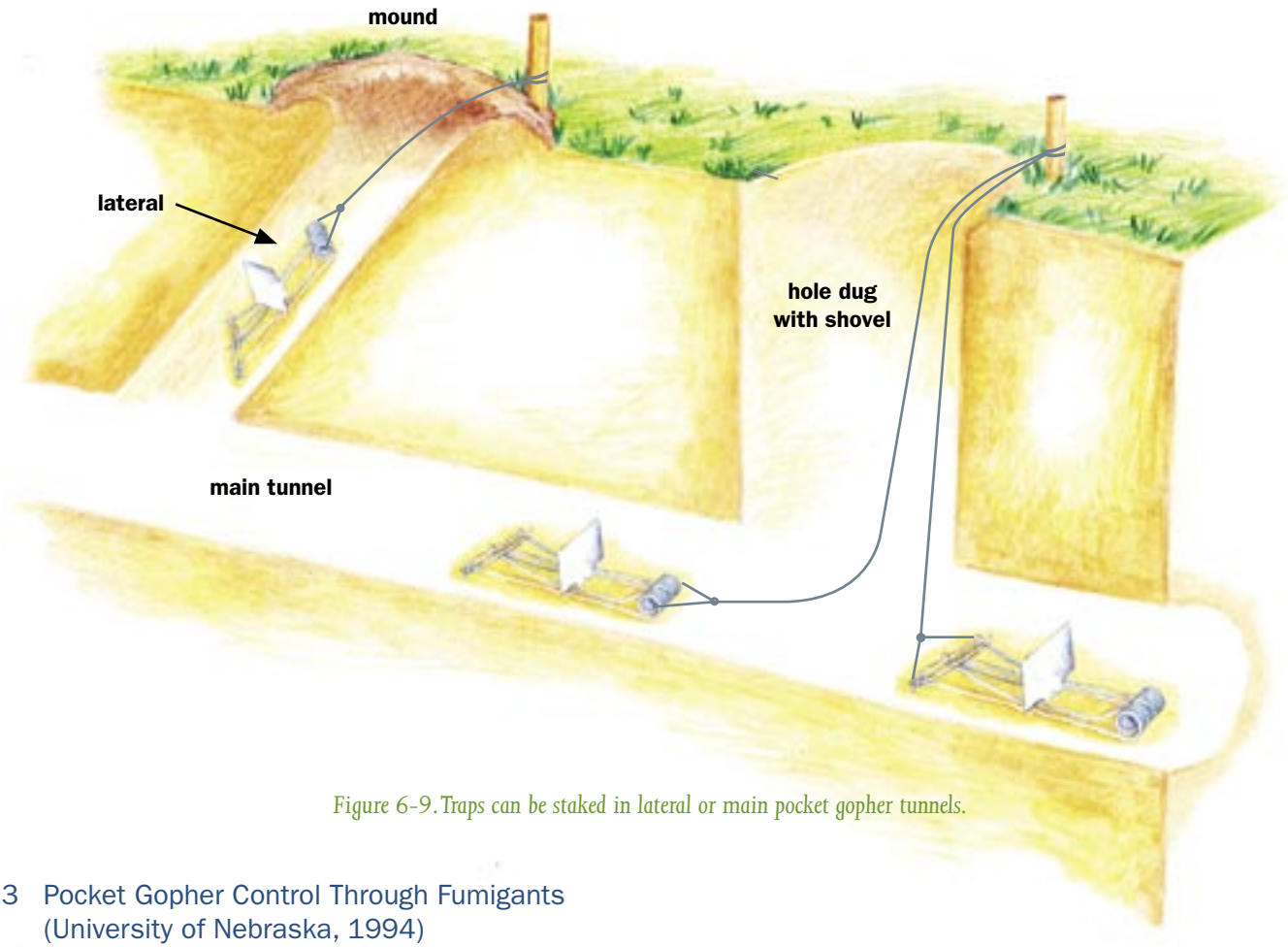


Figure 6-9. Traps can be staked in lateral or main pocket gopher tunnels.

6.6.3 Pocket Gopher Control Through Fumigants (University of Nebraska, 1994)

Aluminum phosphide and gas cartridges are both Federally registered for pocket gopher control. They are generally not effective though because the gas moves slowly through the tunnel system, allowing the fumigant to diffuse through the soil and escape to the surface. Carbon monoxide from automobile exhaust has proven more effective because of its greater volume and pressure. To implement this method of control, connect a hose or pipe to the engine exhaust and place it in a burrow opening near a fresh soil mound. Tightly pack soil around the hose or pipe and allow the engine to run for at least 3 minutes. This method is generally 90% effective and requires no federal registration. Dam owners should consult with their state wildlife agency for information on state and local regulations regarding fumigants.

Carbon monoxide is generally 90% effective for pocket gopher control and requires no Federal registration.

6.6.4 Pocket Gopher Control Through Toxicants (University of Nebraska, 1994)

Several rodenticides are currently registered for pocket gopher control. Strychnine alkaloid (0.3 to 0.5% active ingredient) on grain baits is the most widely used. It is classified as a Restricted Use Pesticide and can only be sold to and used by a certified pesticide applicator. Applying 1 to 2 pounds per acre of 0.3 to 0.5% strychnine alkaloid grain with a burrow builder should provide an 85% to 95% reduction in the pocket gopher population. Zinc phosphide (2%) is also a registered toxicant for pocket gopher control, though it is less effective than strychnine. Additionally,

two anticoagulants (chlorophacinine and diphacinone) are registered for pocket gopher control. Bait can be placed in a pocket gopher burrow system by hand, using a special hand-operated bait dispenser probe or with a mechanical burrow builder (Figures 6-10 and 6-11).

The first step to hand baiting with the bait dispenser is finding the main burrow, which is generally located 12 to 18 inches away from a plugged mound. Once the main burrow is located, place the probe over the burrow and push down until there is decreased resistance on the probe. Then push the button on the bait dispenser to release a metered dose of bait. For best results, each burrow should be baited in two or three locations.

Properly applied, strychnine alkaloid can provide an 85% to 95% reduction in a pocket gopher population.

Figure 6-10. Effective baiting with a bait dispenser requires accurately finding the pocket gopher burrow. Use the probe to detect the main burrow, which is usually on the plug-side of the mound, 8-18 inches away from the plug (USDA, 1994).

The burrow builder is a tractor-drawn device that mechanically delivers bait underground. As the burrow builder moves along, it makes an artificial burrow, dispenses the bait into the newly formed burrow, and then closes up the hole. Artificial burrows should be constructed at depths similar to those constructed by pocket gophers in the area.

All toxicant products should be used as directed on the label. Dam owners should consult with their state wildlife agency regarding legality of toxicant use in their state before implementing any control measures.

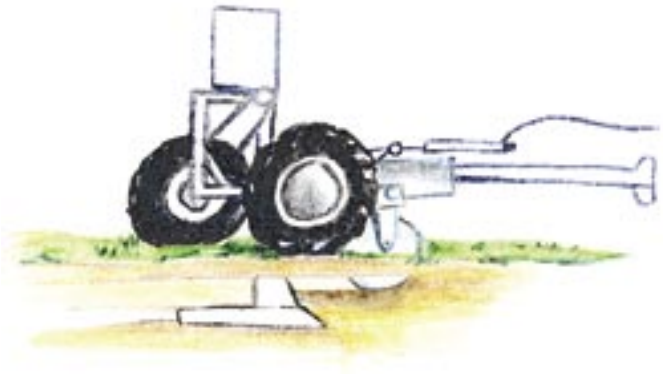


Figure 6-11. A burrow builder mechanically dispenses bait into constructed burrows. Adequate soil moisture is needed to form effective burrows. Adequate soil can be compressed in the hand and rolled gently without crumbling (USDA, 1994).

6.6.5 Pocket Gopher Control Through Frightening

No frightening methods are effective for pocket gopher control.

6.6.6 Pocket Gopher Control Through Repellents (University of Nebraska, 1994; Witmer et al., 1995)

Repellents may be used to discourage pocket gopher inhabitation, although the effectiveness of this method is still in question. Initial testing has shown that some predator odors, such as coyote or bobcat urine, may effectively repel

pocket gophers. Additionally, the mole plant (*Euphoriba lathyrus*), also known as the caper spurge or gopher purge, and the castor-oil plant (*Ricinus lathyrus*) have both been promoted as gopher repellents, although there is no scientific evidence to support this claim. Use of these plants is not recommended because they are poisonious to humans and pets, and can grow thickly, obscuring the dam.

6.6.7 Pocket Gopher Control Through Shooting (University of Nebraska, 1994)

Shooting pocket gophers is usually not a practical option because they spend most of their time below ground.

6.7 North American Badger Management Methods

6.7.1 North American Badger Control Through Habitat Modification (University of Nebraska, 1994; Texas Wildlife Damage Management Service, 1998)

Rodent control will alleviate most problems associated with badger damage. Badgers commonly prey on ground squirrels, pocket gophers, and prairie dogs. If this food source is eliminated, then damage from badger predation will be reduced and the badger will often move elsewhere in search of food. Dam owners should refer to sections of this manual pertaining to management of ground squirrels, pocket gophers, and prairie dogs for rodent control guidance.

6.7.2 North American Badger Control Through Trapping (University of Nebraska, 1994; Texas Wildlife Damage Management Service, 1998)

Badgers can often be removed from an area through the use of cage traps, leghold traps, or snares placed near the entrance of an active den. Cage traps require bait, such as a dead chicken or large rodent. After a badger is caught alive, it should be euthanized or relocated to an area where it will not cause further damage.

Leghold traps (No. 3 or 4) are most effective if attached to a drag such as a strong limb or fence post. If leghold traps are staked into the ground, it is likely that the badger will dig out the trap and escape.

Snaring involves setting a steel-cable loop in an animal's path to capture it by the neck, body, or leg. Snares are lightweight, compact, easy to set, low-cost, and they offer a high degree of human safety. Ready-made snares and snare components may be purchased from trapping suppliers. They must be attached to a solid object so the captured animal cannot escape. Snares should not be set where they could capture pets or livestock.

Dam owners should contact their state wildlife agency regarding trapping regulations.

6.7.3 North American Badger Control Through Fumigants (University of Nebraska, 1994)

No fumigants are registered for badger control.

6.7.4 North American Badger Control Through Toxicants (University of Nebraska, 1994)

No toxicants are registered for badger control.

6.7.5 North American Badger Control Through Frightening (University of Nebraska, 1994)

Badgers may be discouraged from inhabiting an area if high-intensity lights are installed and used at night.

6.7.6 North American Badger Control Through Repellents (University of Nebraska, 1994)

No repellents are registered for badger control.

6.7.7 North American Badger Control Through Shooting (University of Nebraska, 1994)

Shooting can be an effective method of controlling small populations of badgers. Early morning, late evening, and after dark are the best times for hunting. Where legal, spotlights can be an effective tool for hunting at night. Dam owners should contact their state wildlife agency regarding hunting regulations and restrictions.

6.8 Nutria Management Methods

6.8.1 Nutria Control Through Habitat Modification (University of Nebraska, 1994; USDA, 1991)

Nutria can be discouraged from inhabiting an area by eliminating brush, trees, thickets, and weeds, which provide food and cover. Cleared vegetation should be burned or removed.

In certain situations, water level manipulation may be another damage control option. Dropping water levels in

the summer and raising water levels in the winter will cause stress to nutria populations and may encourage them to relocate. The viability of this option is dependent upon reservoir useage (e.g., water spray, recreation, etc.) and owner willingness. In addition, lowering the water level has not yet been proven effective by researchers, but it is a tool to consider as part of a comprehensive nutria management strategy.

6.8.2 Nutria Control Through Trapping (University of Nebraska, 1994)

Trapping is a very effective method of controlling nutria. Leghold traps are most commonly used. Most trappers prefer double longspring traps (No. 11 or 2), but the No. 1 ½ coilspring, No. 3 double longspring, and soft-catch fox traps are also effective. Traps should be set just under the water where an active nutria trail enters the reservoir. The trap should be staked to the ground just off to the side of the trail and covered with leaves or other debris. To increase effectiveness, traps should be baited with chunks of apples, carrots, sweet potatoes, or watermelon rinds. In deep water, a drowning set should be used. If a nutria is captured alive in shallow water, then it should be disposed of humanely.

Single- or double-door live traps may be used to capture nutria. The cage should be at least 9 x 9 x 32 inches in size. Place the trap along active trails and bait with sweet potatoes or carrots. Captured nutria should be humanely destroyed.

Conibear® traps (No. 220-2, 160-2, and 330-2) are also commonly used to reduce nutria populations. These traps should be set on trails, at den entrances, in culverts, or in narrow waterways. They should not be used in areas frequented by children, domestic pets, or desirable wildlife species.

Snaring is another option for capturing nutria. Snaring involves setting a steel-cable loop in an animal's path to capture it by the neck, body, or leg. Snares constructed with 3/32-inch flexible stainless steel wire or galvanized aircraft cable are suitable for catching nutria. They should be set along trails, travel routes, feeding lanes, or bank slides.

Dam owners should contact their state wildlife agency regarding trapping regulations.

6.8.3 Nutria Control Through Fumigants (University of Nebraska, 1994)

No fumigants are registered for nutria control.

6.8.4 Nutria Control Through Toxicants (University of Nebraska, 1994)

Zinc phosphide is the only toxicant registered for nutria control. It is a Restricted Use Pesticide that must be purchased and applied by a certified pesticide applicator. The zinc phosphide is mixed with bait, such as apples, carrots, or sweet potatoes, and then the bait is placed in waterways, ponds, and ditches where permanent standing water and recent signs of nutria activity are found. Do not place bait directly in the water, but rather on floating rafts (anchored to the bottom or tied to the shore as depicted on figure 6-4), small islands, floating logs, or exposed tree stumps. Ground baiting is not recommended because humans and nontarget animals may be exposed to the toxicant.

Prebaiting increases the effectiveness of this control method. Apply corn oil to chunks of apples, carrots, or sweet potatoes and place the prebait at the designated baiting station. The station should be prebaited for several nights. Observe the station to ensure that nutria, rather than nontarget animals, are taking the bait. Once the nutria are accustomed to eating the prebait, the zinc-phosphide treated bait can be applied. The toxic bait should be applied until no more bait is being taken. Dead nutria that have been exposed to zinc phosphide should be collected and disposed of by deep burial or burning to prevent zinc phosphide exposure to domestic and wild scavengers.

6.8.5 Nutria Control Through Frightening (University of Nebraska, 1994)

Harassment may temporarily deter nutria from inhabiting an area. Loud noises and high-pressure water sprays have worked in some cases. As a long-term control method, however, frightening is not an effective or practical option.

6.8.6 Nutria Control Through Repellents (University of Nebraska, 1994)

No repellents are registered for nutria control.

In certain areas, legal hunting with a shotgun or small caliber rifle has reduced nutria populations by 80%.

6.8.7 Nutria Control Through Shooting (University of Nebraska, 1994)

Shooting is an effective method of controlling nutria. This method is most effective at night with a spotlight, although it should be noted that this technique is not legal in all states. Shooting can be effective when carried out at bait stations, from boats, or from the bank. Dam owners should contact their state wildlife agency for information on hunting regulations and restrictions.

6.9 Prairie Dog Management Methods

Because other animals frequently inhabit prairie dog towns, including the Federally protected burrowing owl and black-footed ferret, dam owners need to be particularly cautious when taking action to control prairie dogs. In regions and habitats where burrowing owls and black-footed ferrets are known to live, dam owners should coordinate with their state wildlife agency and the USFWS to determine whether either of these species is present; field surveys by qualified biologists may be required. Burrows that have feathers or white droppings at the mouth probably contain burrowing owls. Black-footed ferrets are secretive animals, and since it can be very difficult to verify their existence in a particular burrow system, it is best to contact the USFWS and the state wildlife agency for guidance on completing a black-footed ferret survey (University of Nebraska, 1994). If either of these species is present, the dam owner must contact the USFWS and their state wildlife agency for management guidance.

It is also important to remember that the Utah prairie dog, one of the four prairie dog species found in the United States, is listed as a Federally threatened species and is therefore subject to the provisions of the Endangered Species Act. As the name implies, the Utah prairie dog is found only in Utah. Dam owners in Utah who suspect that they have a prairie dog problem should contact the USFWS and the Utah Division of Wildlife Resources for species identification and management guidance.

6.9.1 Prairie Dog Control Through Habitat Modification (University of Nebraska, 1994)

Installation of visual barriers may discourage prairie dogs from inhabiting an area. Prairie dogs prefer areas of low vegetation to provide a clear view of their surroundings and to improve their ability to detect predators. Objects such as fences or hay bales that are strategically placed to block prairie dog views may reduce suitability of the habitat.

6.9.2 Prairie Dog Control Through Trapping (USDA, 1991)

Trapping may be used to control prairie dogs, but it is quite labor intensive and therefore only practical for removing small populations. Cage traps for live capture, Conibear® traps (No. 110), and leg-hold traps are often used. Cage traps are most effective in early spring. They should be baited with oats flavored with corn or anise oil. Dam owners should consult with their state wildlife agency for guidance on releasing captured prairie dogs. Conibear® and leg-hold traps should be set in burrow entrances. They do not require bait. Dam owners should consult with their state wildlife agency regarding specific trapping regulations.

6.9.3 Prairie Dog Control Through Fumigants (University of Nebraska, 1994)

Fumigants can be used to control prairie dogs in some situations, however this method is often costly, time-consuming, and particularly hazardous to other wildlife. Fumigation is most effective as a follow-up to toxic baits. It should not be used in burrows where nontarget species are thought to be present.

Aluminum phosphide can reduce prairie dog populations by 85% to 95%.

Aluminum phosphide is a registered fumigant for control of burrowing rodents, including prairie dogs. It is a Restricted Use Pesticide and therefore must be purchased and ap-

plied by a certified pesticide applicator. Aluminum phosphide comes in tablet form. One tablet should be inserted into each burrow and then the burrow entrance should be tightly plugged with soil. When used correctly, aluminum phosphide typically provides an 85% to 95% reduction in prairie dog populations. The legal application of aluminum phosphide may vary from state to state so dam owners should consult with their state wildlife agency or state pesticide registration board before implementing this control method.

Gas cartridges may also be used to control prairie dogs. Gas cartridges are General Use Pesticides that can usually be purchased at local farm supply stores or pesticide dealers. When ignited, a gas cartridge will produce carbon monoxide, carbon dioxide, and other gases that are toxic to the prairie dog. The cartridge should be lit before it is placed in the burrow. Once it has been inserted, the burrow should be immediately plugged with soil. Gas cartridges should be used with caution and in accordance with the directions on the label. When used correctly, gas cartridges can provide a 95% reduction in prairie dog populations.

Gas cartridges can provide a 95% reduction in prairie dog populations.

Dam owners should consult with their state wildlife agency for information on state and local regulations regarding gas cartridges and the use of fumigants.

6.9.4 Prairie Dog Control Through Toxicants (University of Nebraska, 1994)

Baiting with a toxicant is generally the most economical and effective method of controlling prairie dogs. Zinc phosphide bait is currently the only registered and legal toxicant available for prairie dog control. It is available in 2% zinc phosphide-treated grain bait and pellet formulations. It is a Restricted Use Pesticide, which means that it is only available for sale to and use by certified pesticide applicators. Zinc phosphide baits can be applied from July 1 through January 31, though it is best to apply the baits in late summer and fall when prairie dogs are most active and there is no green forage available.

Zinc phosphide can be 75% to 85% successful in controlling prairie dogs when used correctly.

A prebait must be applied to the burrows before the toxic bait. The prairie dogs will become accustomed to eating the non-toxic grains, which will increase the effectiveness of the toxic bait. The prebait and the toxic bait may be applied by hand or by a mechanical bait dispenser attached to an all-terrain vehicle, motorcycle, or horse.

6.9.5 Prairie Dog Control Through Frightening (University of Nebraska, 1994)

Frightening is not an effective method of control for prairie dogs.

6.9.6 Prairie Dog Control Though Repellents (University of Nebraska, 1994)

No repellents are Federally registered for prairie dog control.

6.9.7 Prairie Dog Control Through Shooting (University of Nebraska, 1994)

Continuous shooting of prairie dogs can remove about 65% of the population annually, but it is generally not a practical or cost-effective method of control. Shooting is most effective in spring because it can disrupt breeding. Dam owners should consult with their state wildlife agency regarding specific hunting regulations and requirements.

6.10 Ground Squirrel Management Methods

The northern Idaho ground squirrel, one of 23 ground squirrel species in the United States, is Federally listed as a threatened species and is therefore subject to the provisions of the Endangered Species Act. The northern Idaho ground squirrel is found in limited distribution in the northwest. Dam owners in that region who experience problems with ground squirrels should contact the USFWS and their state wildlife agency for species identification and management guidance.

The New Mexico and Nebraska Dam Safety Offices have set up roosts in the dam environment to support raptors such as red-tailed hawks to provide predator control of small rodents.

6.10.1 Ground Squirrel Control Through Habitat Modification (USDA, 1991)

Routine weed control and vegetative management may limit some ground squirrel damage, but the effectiveness of this method is usually limited.

6.10.2 Ground Squirrel Control Through Trapping (University of Nebraska, 1994)

Trapping is a labor-intensive control method, and therefore it is generally only useful for removing small populations of ground squirrels. Jaw traps (No. 1 or No. 0), box or cage traps, and Conibear® traps (No. 110 or No. 110-2) may be used (refer to Figure 6-1). Generally, one trap is needed for every 10 to 15 squirrels present. Traps should be set on trails or near burrow entrances. Box or cage traps require bait, such as fruit, vegetables, peanut butter, or grain; baiting is not necessary with jaw traps or Conibear® traps. Dam owners should contact their state wildlife agency for information on state and local trapping regulations.

6.10.3 Ground Squirrel Control Through Fumigants (University of Nebraska, 1994)

Aluminum phosphide and gas cartridges are both registered fumigants for ground squirrel control. Fumigants work best for light squirrel infestations limited to a few acres. This method is most effective in the spring, when ground squirrels have just emerged from hibernation.

Aluminum phosphide is a Restricted Use Pesticide that comes in tablet form. This fumigant can only be purchased and applied by a certified pesticide applicator. One tablet should be placed in each burrow entrance and then the burrow should be plugged with soil to form an air-tight seal. The legal application of aluminum phosphide may vary from state to state so dam owners should consult with their state wildlife agency or state pesticide registration board before implementing this control method.

Gas cartridges are General Use Pesticides that can usually be purchased at local farm supply stores or pesticide dealers. When ignited, a gas cartridge will produce carbon monoxide, carbon dioxide, and other gases that are toxic to ground squirrels. The cartridge should be lit before it is placed in the burrow. Once it has been inserted, the burrow should be immediately plugged with soil. Gas cartridges should be used with caution and in accordance with the directions on the label. Dam owners should consult with their state wildlife agency for information on state and local regulations regarding gas cartridges and the use of fumigants.

6.10.4 Ground Squirrel Control Through Toxicants (University of Nebraska, 1994)

Zinc phosphide and two anticoagulants, chlorophacinone and diphacinone, are currently registered for ground squirrel control.

When used correctly, zinc phosphide can result in an 85% to 95% reduction in ground squirrel population.

Zinc phosphide is a Restricted Use Pesticide, which means that it can only be purchased and applied by a certified pesticide applicator. It is a single-dose toxicant delivered on oat baits. The ground squirrels should be exposed to an untreated prebait several days before using the toxic grain. Bait can be delivered by hand or mechanically dispensed.

Chlorophacinone and diphacinone are two anticoagulant baits that are registered in some states under various trade names. A continuous supply of bait must be applied for 4 to 9 days for the toxicant to be effective. The bait is usually delivered in a bait box, which can be made of rubber tires or metal, plastic, or wood containers. The commonly used PVC Inverted-T anticoagulant bait station consists of 4-inch sections of plastic irrigation pipe formed into an inverted "T" configuration (Figure 6-12). Dam owners should contact

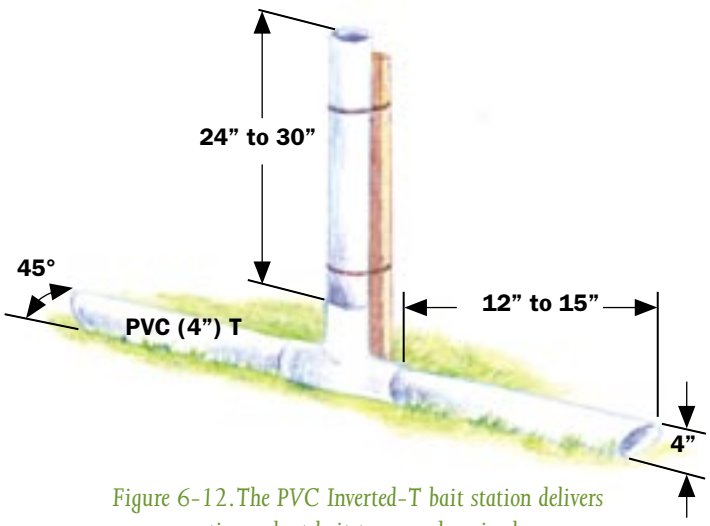


Figure 6-12. The PVC Inverted-T bait station delivers anticoagulant bait to ground squirrels.

their state wildlife agency for information on anticoagulants that may be available for use.

All products should be used as directed. Dam owners should consult with their state wildlife agency regarding legality of toxicant use in their state.

6.10.5 Ground Squirrel Control Through Frightening (University of Nebraska, 1994)

Frightening is not an effective method of control for ground squirrels.

6.10.6 Ground Squirrel Control Through Repellents (University of Nebraska, 1994)

No repellents are registered for ground squirrel control.

6.10.7 Ground Squirrel Control Through Shooting (University of Nebraska, 1994)

Shooting may be used to remove small populations of ground squirrels, although it is an expensive and time-consuming method of control. Dam owners should consult with their state wildlife agency regarding specific hunting regulations and requirements

6.11 Armadillo Management Methods

6.11.1 Armadillo Control Through Habitat Modification (University of Nebraska, 1994)

It is possible to discourage armadillos from burrowing in an earthen dam by implementing the following habitat mitigation techniques:

- Remove brush or other cover to reduce the amount of suitable habitat.
- Apply soil insecticides to remove insects and other invertebrates that make up the majority of the armadillo’s diet.

6.11.2 Armadillo Control Through Trapping (University of Nebraska, 1994)

Trapping can be an effective method of managing armadillos. Live or box traps (10 x 12 x 32-inch), such as the Havahart or Tomahawk, work best. A trap’s effectiveness can be enhanced by adding “wings” (1 x 4-inch or 1 x 6-inch boards about 6 feet long) to funnel the animal into the trap (Figure 6-13). The best locations to set traps are along pathways to burrows and along fences or other barriers where armadillos may travel. Conibear® (No. 220) or leghold traps (No. 1 or 2) may also be used (refer to Figure 6-1). These types of traps should be placed at the entrance of a burrow.

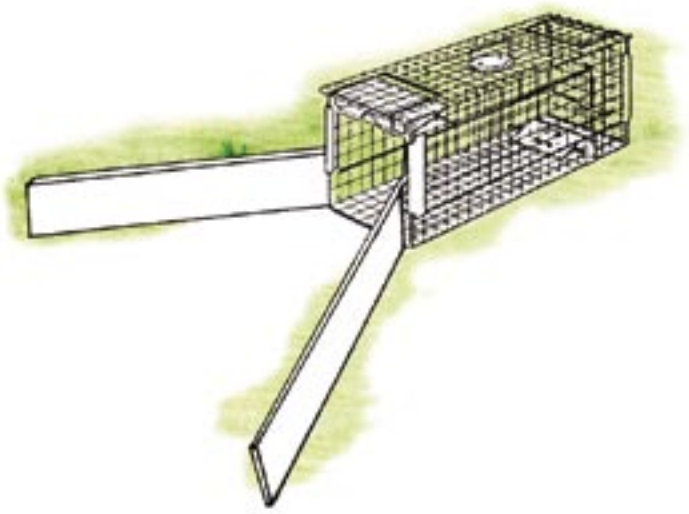


Figure 6-13. The effectiveness of cage traps can be enhanced by adding “wings” to funnel the armadillo into the trap.

6.11.3 Armadillo Control Through Fumigants (University of Nebraska, 1994)

No fumigants are Federally registered for armadillo control. However, there are some fumigants that are effective and that may be legal in certain states. Dam owners should consult their state wildlife agency regarding fumigants that may be legal in their area.

6.11.4 Armadillo Control Through Toxicants (University of Nebraska, 1994)

No toxicants are registered for armadillo control.

6.11.5 Armadillo Control Through Frightening

Frightening is not an effective method of armadillo control.

6.11.6 Armadillo Control Through Repellents (University of Nebraska, 1994)

No repellents are registered for armadillo control.

6.11.7 Armadillo Control Through Shooting (University of Nebraska, 1994)

Shooting is an effective method of controlling armadillos. The best time to shoot is during twilight hours or at night when armadillos are most active. Dam owners should consult with their state wildlife agency regarding specific hunting regulations and requirements.

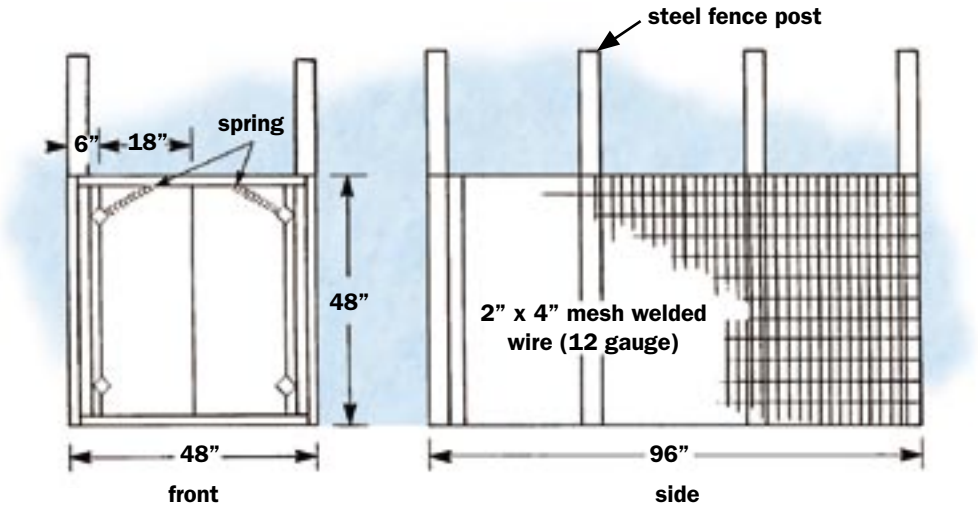
6.12 Livestock (Cow, Sheep, Horse, Pig, and Wild Pig) Management Methods

6.12.1 Livestock Control Through Habitat Modification (USDA, 1991)

Providing a water source away from the earthen dam may help reduce livestock damage near the dam, since livestock are often at the dam in search of drinking water.

6.12.2 Livestock Control Through Trapping (USDA, 1991; University of Nebraska, 1994)

Trapping is quite effective for wild pigs. Stationary corral-type traps and box traps are commonly used (Figure 6-14). They are most effective in summer when acorns and other



2" x 4" x 24' wood		8	6" steel fence posts
36" x 48" x 3/4" plywood		4 lbs	16-penny nails
36' x 2" x 4" mesh welded wire		1 lbs	12-penny nails
4	6" strap hinges	2 lbs	1 1/2" staples
2	12" screen door springs	1	100 12-gauge wire

Figure 6-14. Stationary hog trap.

preferred natural foods are not available. Traps should be baited with grains, fruits, or vegetables. The traps may be placed anywhere that wild pigs concentrate.

6.12.3 Livestock Control Through Fumigants (USDA, 1991)

Fumigants are not suitable for livestock control.

6.12.4 Livestock Control Through Toxicants (USDA, 1991)

Toxicants are not suitable for livestock control.

6.12.5 Livestock Control Through Frightening (USDA, 1991)

Frightening devices such as animated scarecrows or firecrackers may temporarily deter livestock from inhabiting an area, but these techniques generally do not provide a long-term solution to livestock damage.

6.12.6 Livestock Control Through Repellents (USDA, 1991)

Repellents are not suitable for livestock control.

6.12.7 Livestock Control Through Shooting (USDA, 1991)

Shooting may be an effective method of removing a small population of nuisance livestock; however, hunting is generally only permitted for wild animals such as pigs. Dam owners should contact their state wildlife agency regarding hunting regulations and restrictions.

6.13 Crayfish Management Methods

6.13.1 Crayfish Control Through Habitat Modification (Virginia Cooperative Extension, 2001a).

Damage may be prevented by stocking the reservoir with natural enemies of crayfish, such as trout, bass, catfish, and large bluegills. These species will eat the crayfish, which will reduce the overall crayfish population and decrease the number of burrows.

6.13.2 Crayfish Control Through Trapping (University of Nebraska, 1994)

Wire cage traps baited with fish or meat can be used to catch crayfish.

6.13.3 Crayfish Control Through Fumigants (University of Nebraska, 1994)

No fumigants are Federally registered for crayfish control.

6.13.4 Crayfish Control Through Toxicants (University of Nebraska, 1994)

No toxicants are Federally registered for crayfish control. Some states, however, have regulations that allow application of certain insecticides for crayfish burrow treatment. Dam owners should consult with their state wildlife agency regarding the legality of toxicants in their state.

6.13.5 Crayfish Control Through Frightening

Frightening is not an effective method of controlling crayfish.

6.13.6 Crayfish Control Through Repellents (University of Nebraska, 1994)

No repellents are registered for crayfish control.

6.13.7 Crayfish Control Through Shooting

Shooting is not a suitable method of controlling crayfish.

6.14 Coyote Management Methods

6.14.1 Coyote Control Through Habitat Modification (USDA, 1991)

Proper vegetative management (mowing and brush removal) and rodent control will often discourage coyotes from digging in earthen dams.

6.14.2 Coyote Control Through Trapping (University of Nebraska, 1994)

Steel leg-hold traps (No. 3 and 4) are often used for coyote removal. Effective use of these traps for coyote control generally requires a great deal of experience and training.

Dam owners should contact their state wildlife agency for guidance on trapping nuisance coyotes.

Snaring is another method of removing coyotes. Snaring involves setting a steel-cable loop in an animal's path to capture it by the neck, body, or leg. Snares are light-weight, compact, easy to set, low-cost, and they offer a high degree of human safety. In one study, they were proven to be more effective than leg-hold traps for coyote control. Snares are usually made of a 2.5- to 10-foot long piece of galvanized aircraft cable with a slide lock that forms a loop. Snares should be set along known coyote trails. They must be attached to a solid object so that the captured animal cannot escape. Snares should not be set where they could capture pets or livestock. Snares are not legal in all states so dam owners should consult with their state wildlife agency before choosing this control method. Once caught, coyotes should be humanely destroyed.

6.14.3 Coyote Control Through Fumigants (University of Nebraska, 1994)

Gas cartridges are the only registered fumigant for coyote control. Gas cartridges are General Use Pesticides that can usually be purchased at local farm supply stores or pesticide dealers. When ignited and placed in the den, a gas cartridge will produce carbon monoxide, carbon dioxide, and other gases that are toxic to the coyote. Gas cartridges should be used with caution and in accordance with the directions on the label. Dam owners should consult with their state wildlife agency regarding state and local regulations on gas cartridges and the use of fumigants.

6.14.4 Coyote Control Through Toxicants (University of Nebraska, 1994)

The only toxicant registered for coyote control is sodium cyanide used in an M-44 ejector device. The M-44 is a spring-activated device that expels a sodium cyanide capsule into the animal's mouth. The M-44 device should be set along the sides of trails or paths used by coyotes. This control method is most effective during cooler months. The M-44 sodium cyanide device is classified as a Restricted Use Pesticide and may only be used by USDA Animal Damage Control personnel and, in some states, certified pesticide applicators. The M-44 is not registered for use in all states so dam owners must consult their state wildlife agency before implementing this control measure.

6.14.5 Coyote Control Through Frightening (USDA, 1991)

Several types of frightening devices are available for coyote control, but these devices were designed for livestock protection and are not practical for protection of earthen dams.

6.14.6 Coyote Control Through Repellents (University of Nebraska, 1994)

No repellents have proven effective for coyote control.

6.14.7 Coyote Control Through Shooting (USDA, 1991)

Coyote hunting is often an effective method of control for livestock protection, but it is generally not practical for protecting earthen dams. If a dam owner decides to pursue this method of control, they must contact the state wildlife agency for information on hunting regulations.

6.15 Mole and Vole Management Methods

6.15.1 Mole and Vole Control Through Habitat Modification (University of Nebraska, 1994; USDA, 1991)

It is possible to discourage moles from burrowing in an earthen dam by implementing the following habitat modification techniques:

- Compact the soil with a roller to reduce soil moisture. This will reduce the habitat's attractiveness to moles.
- Apply insecticides to reduce food supply. Legal insecticides may vary by state so dam owners should contact their state wildlife agency for specific guidance.

6.15.2 Mole and Vole Control Through Trapping (University of Nebraska, 1994)

Trapping is the most effective method of reducing mole populations. Several traps are specifically designed for moles, including the Victor mole trap, Out O' Sight, and Nash (choker loop) mole trap. If used properly, any of these traps can be effective. Traps should be set in the surface runway where there is evidence of recent mole activity.

Trapping is generally not an effective method of reducing large vole populations because of prohibitive time and

labor costs. Mouse snap traps may be used for control of a few individual voles. Traps should be set perpendicular to a runway with the trigger end in the runway. Voles are easiest to trap in the fall and late winter.

6.15.3 Mole and Vole Control Through Fumigants (University of Nebraska, 1994)

Both aluminum phosphide and gas cartridges are Federally registered for mole control. Aluminum phosphide is a Restricted Use Pesticide that comes in tablet form. One tablet should be placed in each burrow entrance and then the burrow should be plugged with soil to form an air-tight seal. The legal application of aluminum phosphide may vary from state to state so dam owners should consult with their state wildlife agency or state pesticide registration board before implementing this control method.

Gas cartridges are General Use Pesticides that can usually be purchased at local farm supply stores or pesticide dealers. When ignited, a gas cartridge will produce carbon monoxide, carbon dioxide, and other toxic gases. The cartridge should be lit before it is placed in the burrow. Once it has been inserted, the burrow should be immediately plugged with soil. Gas cartridges should be used with caution and in accordance with the directions on the label. Dam owners should consult with their state wildlife agency for information on state and local regulations regarding gas cartridges and the use of fumigants.

Fumigants are generally not effective for vole control. The vole burrow system is so complex and shallow that the fumigant easily escapes to the surface.

6.15.4 Mole and Vole Control Through Toxicants (University of Nebraska, 1994)

Strychnine alkaloid and chlorophacinone are both Federally registered for mole control. Strychnine alkaloid is a Restricted Use Pesticide that can only be purchased and applied by a certified pesticide applicator. However, since moles do not normally consume grain, strychnine alkaloid grain baits are seldom effective. Chlorophacinone is commercially available in pellet form under the name Orco Mole Bait. Researchers have found that this is a highly effective and easy to apply mole control technique. Dam owners should be aware, though, that two or more successive treatments are often required. If a dam owner chooses either of these methods of control, they should contact the state wildlife agency regarding the legality of toxicant use in their state.

Zinc phosphide is often used for vole control. Zinc phosphide is a single-dose toxicant available in pellet or grain bait formulas. Pellets or grain bait can be delivered to burrows by hand or mechanically dispensed. Zinc phosphide is a Restricted Use Pesticide, which must be purchased and applied by a certified pesticide applicator. Anticoagulant baits can also be used to reduce vole populations. Anticoagulants generally require several feedings and can take anywhere from 5 to 15 days to be effective. Bait can be delivered by hand, mechanically dispensed, or placed in various types of bait containers. Registration for anticoagulants varies by state.

All products should be used as directed. Dam owners should consult with their state wildlife agency regarding legality of toxicant use in their state.

6.15.5 Mole and Vole Control Through Frightening (University of Nebraska, 1994)

Frightening is not an effective method of control for moles or voles.

6.15.6 Mole and Vole Control Through Repellents (University of Nebraska, 1994)

No repellents are registered for mole control.

Several repellents using thiram or capsaicin as the active ingredient are registered for vole control, but there is no evidence that these repellents are actually effective. Dam owners should contact their state wildlife agency or pesticide regulatory agency for information on available repellents in their state.

6.15.7 Mole and Vole Control Through Shooting (University of Nebraska, 1994)

Shooting is not an effective method of control for moles or voles.

6.16 River Otter Management Methods

6.16.1 River Otter Control Through Habitat Modification (University of Nebraska, 1994)

Habitat modification is generally not an effective method of control for river otters. Otters often share their environment with beavers, whose burrowing activity is detrimental to the earthen dam environment. Otters will often live in

beaver burrows and dens and do not often dig their own dens. Before mitigating for the river otter, evaluate whether the damaging actions are caused by beaver so that the appropriate species is managed and proper preventive actions are implemented (as discussed in Chapters 4.0 and 5.0 of this manual).

6.16.2 River Otter Control Through Trapping (University of Nebraska, 1994)

Both Conibear (No. 220 and 330) and leghold (modified No. 1 ½ soft-catch and No. 11 double coilspring) traps have been successfully used to catch river otters. Traps should be placed underwater along river otter trails or on "pull-outs" where otters leave the water. Leghold traps can also be used out of the water along trails and peninsula crossings. River otter trapping is illegal in many states so dam owners should contact their state wildlife agency before initiating a trapping program.

6.16.3 River Otter Control Through Fumigants (University of Nebraska, 1994)

No fumigants are registered for river otter control.

6.16.4 River Otter Control Through Toxicants (University of Nebraska, 1994)

No toxicants are registered for river otter control.

6.16.5 River Otter Control Through Frightening (University of Nebraska, 1994)

Frightening has not proven to be an effective method of river otter control.

6.16.6 River Otter Control Through Repellents (University of Nebraska, 1994)

No repellents are registered for river otter control.

6.16.7 River Otter Control Through Shooting (University of Nebraska, 1994)

Shooting is generally only effective for removing small populations of river otters. Dam owners should contact their state wildlife agency for information on hunting regulations and requirements.

6.17 Gopher Tortoise Management Methods

The gopher tortoise is a Federally listed threatened species and therefore subject to the provisions of the Endangered Species Act. The historic range of the gopher tortoise includes Alabama, Florida, Georgia, Louisiana, Mississippi, and South Carolina. Dam owners in those states who suspect that they have a gopher tortoise problem should contact the USFWS and their state wildlife agency for management guidance.

6.17.1 Gopher Tortoise Control Through Habitat Modification (University of Nebraska, 1994)

Habitat modification is generally not an effective method of gopher tortoise control.

6.17.2 Gopher Tortoise Control Through Trapping

Since the gopher tortoise is Federally listed as a threatened species, dam owners should contact the USFWS or their state wildlife agency for management guidance.

6.17.3 Gopher Tortoise Control Through Fumigants (University of Nebraska, 1994)

No fumigants are registered for gopher tortoise control.

6.17.4 Gopher Tortoise Control Through Toxicants (University of Nebraska, 1994)

No toxicants are registered for gopher tortoise control.

6.17.5 Gopher Tortoise Control Through Frightening

Frightening has not proven to be an effective method of gopher tortoise control and would be prohibited under the Endangered Species Act.

6.17.6 Gopher Tortoise Control Through Repellents (University of Nebraska, 1994)

No repellents are registered for gopher tortoise control.

6.17.7 Gopher Tortoise Control Through Shooting (University of Nebraska, 1994)

Gopher tortoises are protected under the Endangered Species Act and therefore, cannot be shot. Dam owners should

contact the USFWS or their state wildlife agency for management guidance.

6.18 Red Fox and Gray Fox Management Methods

6.18.1 Red Fox and Gray Fox Control Through Habitat Modification

Proper vegetative management (mowing and brush removal) and rodent control will often discourage foxes from digging in earthen dams by reducing their primary food source.

6.18.2 Red Fox and Gray Fox Control Through Trapping (University of Nebraska, 1994)

Trapping is a very effective method of controlling foxes, however it requires a great deal of expertise and training. Steel leg-hold traps (No. 1 ½, 1 ¾, and 2 doublespring coil traps; and No. 2 and 3 double longspring trap) are suitable for both red and gray foxes. Cage traps may be used for juvenile red foxes. Traps set along trails, at entrances to fields, and near bait carcasses are most effective.

Snares may also be used to capture foxes. Snaring involves setting a steel-cable loop in an animal's path to capture it by the neck, body, or leg. Snares should be made from 1/16-inch, 5/64-inch or 3/32-inch cable to capture red or gray foxes. The snare should have a 6-inch loop that is placed 10 to 12 inches off the ground. Snares should be set on trails or in crawl holes that are frequented by foxes.

Traps and snares are not legal in all states. Dam owners should contact their state wildlife agency for specific information on trapping regulations.

6.18.3 Red Fox and Gray Fox Control Through Fumigants (University of Nebraska, 1994)

Gas cartridges are the only registered fumigant for red and gray fox control. Gas cartridges are General Use Pesticides that can usually be purchased at local farm supply stores or pesticide dealers. When ignited and place in the den, a gas cartridge will produce carbon monoxide, carbon dioxide, and other gases that are toxic to the fox. Gas cartridges should be used with caution and in accordance with the directions on the label. Dam owners should consult with their state wildlife agency for information on state and local regulations regarding gas cartridges and the use of fumigants.

6.18.4 Red Fox and Gray Fox Control Through Toxicants (University of Nebraska, 1994)

The only toxicant registered for red and gray fox control is sodium cyanide used in an M-44 ejector device. The M-44 is a spring-activated device that expels a sodium cyanide capsule into the animal's mouth. It should be set along trails and at crossings regularly used by foxes. This is a Restricted Use Pesticide and may only be used by USDA Animal Damage Control personnel and, in some states, certified pesticide applicators. The M-44 is not registered in all states so dam owners must consult their state wildlife agency before implementing this control measure.

6.18.5 Red Fox and Gray Fox Control Through Frightening (University of Nebraska, 1994)

Noise-making devices such as radios, amplifiers, or propane exploders may temporarily deter foxes from inhabiting an area, but they do not provide a long-term solution.

6.18.6 Red Fox and Gray Fox Control Through Repellents (University of Nebraska, 1994)

No repellants are registered for red or gray fox control.

6.18.7 Red Fox and Gray Fox Control Through Shooting

Shooting is another method of managing both red and gray foxes. Hunting regulations and seasons vary by state. Dam owners should contact their state wildlife agency for specific information on hunting foxes.

6.19 Canada Goose Management Methods

6.19.1 Canada Goose Control Through Habitat Modification (Virginia Cooperative Extension, 2001b; University of Nebraska, 1994)

The following habitat modification techniques can be implemented to reduce Canada goose damage:

- Minimize the amount of forage plants that exists near the water body by mowing or hand removal.
- Construct a wire grid of stainless steel spring wire or monofilament line above the surface of the water. This will prevent Canada geese and other waterfowl from using the water and discourage them from nesting in that

area. The individual lines should be staked to the ground about 12 inches above the water's surface.

6.19.2 Canada Goose Control Through Trapping (University of Nebraska, 1994; Virginia Cooperative Extension, 2001b)

Live trapping may be effective for small populations of Canada geese. Several types of traps are effective including walk-in funnel traps, rocket or cannon nets, and spring-powered nets. A federal permit is required before trapping may be initiated. In addition, all relevant state and federal agencies must agree on what will happen to the geese after capture. Dam owners should contact the USFWS and their state wildlife agency for guidance.

Walk-in funnel traps are most effective in late June or early July. These types of traps can be constructed using poultry wire, woven wire fencing, steel fence posts, and netting (Figure 6-15). The trap should be set immediately next to the affected waterbody and then the geese should be herded into the trap. The herders must surround the geese on three sides, forcing them into the trap. Once the geese are secured in the trap, they may be transported to a designated location.

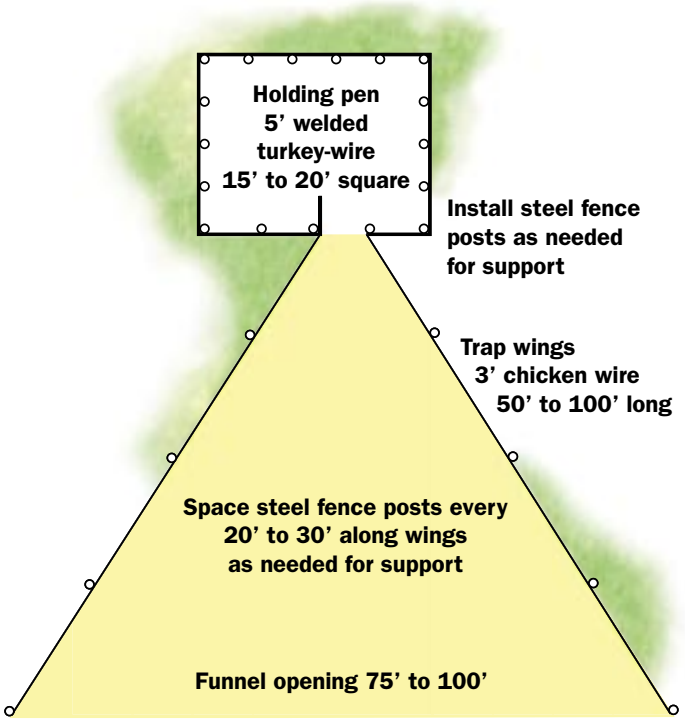


Figure 6-15. Canada goose funnel trap.

Net traps may also be used to capture Canada geese. Rocket or cannon nets with 2- to 2.5-inch mesh work well for large geese. The net should be placed at a location near the water and a second site should be repetitively baited with corn or other suitable bait until the bait is well accepted. Once the geese are trained to feed at the bait site, the area should be re-baited in preparation for capture. When the geese are concentrated at the site, the rocket or cannon net should be fired at the location so the birds are trapped underneath. The Canada geese can then be transported to a designated location. Spring-powered nets work in a similar fashion, though they are smaller than standard rocket or cannon nets. The net is triggered mechanically or electronically, and because it does not create as much noise as the rocket or cannon net, it may be more effective even though it is smaller.

A final method of capturing Canada geese is through the use of an immobilizing agent, Alpha-chloralose. Alpha-chloralose is a non-lethal chemical that is applied to bait and then fed to the geese. Approximately 20 to 90 minutes after ingestion, the geese will be unable to fly or escape and can be captured by hand. Alpha-chloralose may only be used by USDA Animal Damage Control (ADC) staff or biologists of other certified state or federal wildlife management agencies. Dam owners should contact USDA ADC staff, the USFWS, or their state wildlife agency for more information about this option

6.19.3 Canada Goose Control Through Fumigants

Fumigants are not a practical method of control for Canada geese.

6.19.4 Canada Goose Control Through Toxicants (University of Nebraska, 1994)

No toxicants are registered for Canada goose control.

6.19.5 Canada Goose Control Through Frightening (Virginia Cooperative Extension, 2001b)

Auditory and visual scare devices may be used to deter Canada geese from inhabiting an area. Auditory scare devices make loud noises that will frighten geese away. Commonly used devices include propane cannons, pyrotechnics, and pre-recorded tapes of Canada goose distress calls. Visual scare devices installed on or around an earthen dam are also effective. They are usually inexpensive and easy to install, but they work best in conjunction with another deterrent.

Examples of visual scare devices include strobe lights, scarecrows, owl effigies, mylar reflective tape, flags, and balloons.

Harassment or hazing of Canada geese is generally more effective than visual or auditory deterrents, but it can be labor intensive and expensive. Examples of common hazing programs include use of radio-controlled toys (boats or airplanes), trained dogs, or high-power water spray devices. These deterrent activities must be persistent and repeated to remain effective.

6.19.6 Canada Goose Control Through Repellents (Virginia Cooperative Extension, 2001b)

Methyl anthranilate has been registered as a goose repellant under the name ReJeX-iT. This repellant is non-toxic and does not harm the geese. Re-JeX-iT is applied directly to the grass of an affected area. It may have to be reapplied frequently to remain effective. Repellents should always be used as directed.

6.19.7 Canada Goose Control Through Shooting (University of Nebraska, 1994)

Hunting is another effective method of reducing Canada goose populations. Since Canada geese are listed as migratory birds under the Migratory Bird Treaty Act, a federal permit is required. In many areas, state permits are also required for hunting Canada geese. Dam owners should contact the USFWS and their state wildlife agency for specific hunting regulations and requirements.

6.19.8 Other Methods of Canada Goose Control

It is also possible to reduce resident Canada goose populations by oiling, shaking, or puncturing their eggs. This requires a federal permit; dam owners should contact USFWS and their state wildlife agency for more information.

6.20 American Alligator Management Methods

The American Alligator is Federally listed as a threatened species "due to similarity of appearance" to the federally endangered American crocodile. This listing grants the American Alligator protection under the Endangered Species Act. Dam owners who experience problems with nuisance alligators should contact the USFWS and their state wildlife agency for management guidance.

6.20.1 American Alligator Control Through Habitat Modification (University of Nebraska, 1994)

Removal of emergent wetland vegetation may reduce alligator densities by reducing cover. There are strict laws however, regarding human modifications to wetlands so dam owners must consult with appropriate state environmental agencies before disturbing any wetland vegetation.

6.20.2 American Alligator Control Through Trapping (University of Nebraska, 1994)

Trapping is an effective method of eliminating alligators from an area. A baited hook is the simplest and most effective method. This involves rigging a large fish hook (12/0 forged) with bait (e.g., fish, beef, chicken, or nutria) and suspending it via rope from a tree or pole about 2 feet above the water. When the alligator swallows the bait, the hook is lodged in its stomach and the alligator is retrieved using the attached rope. This method almost always kills or injures the alligator.

Trip-snare traps and wire box traps may also be used. They are not quite as effective as the baited hook, but they do not kill or injure the alligator, which then must be relocated. Dam owners must contact the USFWS and their state wildlife agency for information on trapping regulations, the Endangered Species Act, and permit requirements.

6.20.3 American Alligator Control Through Fumigants (University of Nebraska, 1994)

No fumigants are registered for alligator control.

6.20.4 American Alligator Control Through Toxicants (University of Nebraska, 1994)

No toxicants are registered for alligator control.

6.20.5 American Alligator Control Through Frightening (University of Nebraska, 1994)

Under the Endangered Species Act, no actions to harass or frighten a protected species are allowed.

6.20.6 American Alligator Control Through Repellents (University of Nebraska, 1994)

No repellents are registered for alligator control.

6.20.7 American Alligator Control Through Shooting (University of Nebraska, 1994)

Shooting is an effective method of eliminating alligators. A sufficiently powerful rifle (.243 caliber or larger) should be used for a humane kill. Dam owners must contact the USFWS and their state wildlife agency for information on hunting regulations, compliance with the Endangered Species Act, and permit requirements.

6.21 Ant Management Methods

6.21.1 Ant Control Through Habitat Modification (University of Georgia Cooperative Extension Service, 2000)

It may be possible to reduce ant populations by physically destroying visible ant mounds. This can be accomplished by simply knocking down or disturbing mounds with a stick or shovel. Another option is to pour very hot (almost boiling) water directly on each mound.

Pouring very hot water on each ant mound will eliminate about 60% of mounds.

6.21.2 Ant Control Through Trapping

Ant traps are commercially available, but they are not effective for large, outdoor ant infestations.

6.21.3 Ant Control Through Fumigants (University of Georgia, 1993; University of Georgia Cooperative Extension Service, 2000)

Fumigants may help control some type of ant species. Earthfire® (vaporized resmethrin) and Brom-O-Gas (methyl bromide) are two examples of fumigants that have proven effective against fire ants. Both are Restricted Use Pesticides that must be purchased and applied by a certified pesticide applicator. These fumigants may not necessarily be effective for all ant species. Dam owners should contact a professional pest removal company for information on fumigants that may be effective for their particular ant infestation.

6.21.4 Ant Control Through Toxicants (University of Florida Cooperative Extension Service, 2002)

Ants can usually be controlled with baits or chemical treatments. Many of these products are available commercially at hardware stores, home and garden suppliers, and other retail outlets. These treatments come in various forms, including granules, liquids, gels, and ready-to-use tamper resistant containers. Treatment should be tailored to the type of ant species present and the extent of infestation. Dam owners should contact their local cooperative extension agency or a professional pest control company for assistance. Professional pest control companies may also be able to provide stronger treatment options if damage is significant and the use of commercially available products is not effective.

Insecticides can contaminate both ground and surface waters so dam owners need to be particularly cautious when applying baits or chemical treatments near a reservoir. Insecticide use must occur in accordance with Federal law (FIFRA of 1996).

6.21.5 Ant Control Through Frightening

Frightening is not an effective or practical method of ant control.

6.21.6 Ant Control Through Repellents

Large, outdoor ant infestations cannot be effectively controlled through the use of repellents.

6.21.7 Ant Control Through Shooting

Shooting is not a practical method of ant control.

7.0 Fiscal Considerations for Managing Animal Damage on Earthen Dams

"There is no free lunch. Either we make the investments required to keep our nation's dams safe, or we will pay the price in dam failures."

Martin McCann, consulting professor of civil and environmental engineering at Stanford University and director of the National Performance of Dams Program (NPDP).

Almost everyone in the dam community agrees that the funds spent preserving a dam's integrity and safe operation will almost always be less than those spent repairing an unsafe dam or worse, recovering from a dam failure. The economics behind this understanding are self-explanatory and probably need no quantitative explanation; yet across the nation, dams deteriorate from animal intrusion damages and dam owners struggle with the financial responsibility of repairing their unsafe dams, or removing them altogether when the repair costs become too great. Clearly then, the economic considerations related to appropriate dam management go beyond the economic efficiency and long-term benefit of such repairs; the considerations involve acknowledgement of animal damages as a problem, human motivation factors, and the availability of funding mechanisms at the federal and state level.

7.1 Fiscal Considerations for the Reluctant Dam Owner

As indicated in the FEMA/ASDSO workshops, inspectors, engineers, and regulators can find it difficult to convince dam owners that animal burrows and erosion can have serious detrimental effects on their dams. Even though dam failures are becoming all too common—partially a product of America's aging dams—some dam owners put too much confidence in the integrity of their dams, even when visible evidence of animal burrows and inappropriate vegetation are present on their dams. For these dam owners, animal damage management is not likely to become a budget line item until an understanding is developed of how adverse animal intrusion effects can cascade, resulting in extensive repair/replacement costs, as well as the associated liabilities, that follow a dam failure.

7.2 Fiscal Considerations of the Willing Dam Owner

Other dam owners are aware of the dangers inherent to animal damages at an earthen dam, but overlook routine owner actions that are relatively affordable and can save hundreds of thousands of dollars in the long-term, not to mention reduce the public safety hazard for those located downstream of the dam. Inspections and repair actions are indeed overlooked, as documented by the states in the 2003 surveys and in the 2002 workshop where "financial limitations by owners" is listed as the most common impediment to timely and adequate dam upkeep. Considering that over 50% of the dams in this country are privately owned (AS-

DSO, 2003), financial limitations to upkeep pose a daunting threat to public safety.

Still other dam owners know the inherent problems of animal damage, and vigilantly conduct inspections, mow twice annually, and fill burrows in a timely manner. However, some dams because of their size, location, and biological attractiveness continue to have animal damage problems despite owner vigilance. In these cases, the dam owner pays continuously to correct animal damages and routine owner actions become an expensive proposition in terms of both time and money.

7.3 Overcoming the Economic Hurdles

The current and persisting economic issues with regard to animal damage management at earthen dams is twofold: first, reluctant owners need to be educated on the dangers of animal damages and motivated by economic examples; and second, funding sources for all owners need to be identified to assist funding of needed repairs. To begin to address the first consideration, a simple estimate of routine dam maintenance as it relates to vegetation and animal management (one influences the other) is given below:

Table 7.1

Vegetation Management (mowing twice per year)	$500 to $1000 annually*
Owner Inspection (one to two times per year)	No cost for dam owner inspection; inspection once every 2 to 5 years by a Professional Engineer can cost between $3,500 and $7,500
Filling animal burrows (per burrow)	$100 to $300 depending upon burrow size and repair method (grout or excavate and replace)

*for most dams, as indicated in FEMA, 2002.
This estimate assumes the dam is in good condition and that the owner is providing upkeep of an already stable operation

As the table indicates, the cost of routinely maintaining a dam is estimated at greater than $500.00 dollars per year. For many private dam owners, such as businesses and citizens, the outlay of these funds, though relatively low, is prohibitive. Even those dam owners with substantial financial resources are often overwhelmed by the costs of dam maintenance and repairs (WaterWebster, 2003). In these cases, it is important for dam owners to consider that neglect will eventually lead to greater costs on many levels; in short, dam owners can't afford to save money when it comes to the upkeep of their dams. Economic impacts of a failed dam can include:

Liability Costs of Loss of Life and Property Damage. Liability may be imposed on a dam owner if maintenance, repair, or operations were conducted in an unsafe or improper manner. Liability could apply to the dam owner as well as the company who possesses the dam and the individual who or company which operates and maintains the dam. The dam owner must take actions to ensure the dam functions properly so that injuries to people or property are avoided. This applies to foreseeable conditions or circumstances that can be predicted with reasonable certainty. If an inspection identifies problems at the dam, then an owner should correct them (Pennsylvania DEP, 1995).

Clean-up Costs. The costs associated with clean-up from a dam failure can be tremendous, depending on the size of the reservoir and the amount of downstream development. Debris removal, sediment clean-up, and reconstruction of damaged infrastructure could be required.

Loss of Dam Infrastructure and Its Revenue. Over 30% of the dams in the United States are used primarily for recreation (ASDSO, 2003). The benefit of dams to recreational income to the community can be in the millions of dollars each year, depending on the reservoir size and recreational opportunities available.

Environmental Losses. Many reservoirs provide wildlife habitat and associated ecotourism revenue, which generates $59 billion annually in the United States. Communities often benefit from the "wilderness" which dams and their reservoirs provide.

Economic Effect on Community. A community that depends on the dam for several uses (e.g., flood control, irrigation, water supply) will have to locate other facilities to serve these purposes should the dam fail or be removed. Alternative sources could be costly or may not be available as quickly as needed, resulting in an adverse social and economic impact on the community.

In essence, a neglected dam can cause a cascade of adverse effects at the community level as well as result in liability issues for the dam owner. Attaching a reasonable dollar figure to each of the considerations above would illustrate that this considerable investment per year in maintenance is like paying an insurance premium that covers the dam owner and their community.

Lessons Learned:

- Maintenance of animal burrows is critical. Burrows should be backfilled and animals removed as soon as possible.

- Owners should inspect their dams in a regular and thorough manner.

- Pond levels should be monitored and safety precautions such as spillways and freeboard should be factored into design.

The second consideration presents the most current and widespread dilemma facing the entire dam community. Many dam owners conduct inspections and typical maintenance as required, but preventive measures and wildlife mitigation actions may also be required. It would seem that vigilant dam owners would ensure the required actions were forthcoming; however, this is not always the case. According to the workshop (FEMA, 2001) and the state surveys (FEMA, 2003), and as echoed in the document The Cost of Rehabilitating Our Nation's Dams (ASDSO, 2003), owners of dams in need of repair are often not able to finance the required actions due largely to a lack of funding mechanisms at the state and federal levels; dams become neglected and deteriorate to the point of being hazardous. Currently, there are only a handful of states that provide financial assistance in the form of loans or grants to repair unsafe dams, as presented in Table 7-2.

Animal Burrows Contribute to $5 Million Dam Breach

Wallula, Iowa

The Iowa Beef Processor's (IBP) Waste Pond was constructed in 1971 to store wastewater from the IBP Plant. When full, the pond had a surface area of 37 acres and a maximum storage capacity of 270 acre-feet. The pond was located on a natural drainage course and was impounded behind a 15-foot-high, 1000-foot-long earthen dam. State inspections in 1981 and 1985 discovered that the embankment was riddled with animal burrows. It was recommended that the burrows be filled and the animals removed from the site. Repairs were not made quickly enough, and the rapid melting of record snow pack coupled with higher than normal pond levels filled the waste pond and overtopped a portion of the west end of the dam (the dam had no emergency spillway). High pond levels allowed water to exit through animal burrows that were normally above the pond elevation. Uncontrolled leakage and seepage through the animal borrows exiting on the downstream face likely resulted in erosion that backcut rapidly toward the upstream face, eventually breaching the dam.

The estimated cost of the failure was $5 million, which included the cost of the five locomotives that were derailed downstream, environmental cleanup, and repair to the rail line. The cost to construct a new facility was several million more dollars.

Table 7-2 Summary of State Dam Funding Programs

State	Program Name and Type	Eligibility	Loan/Grant Amount
Arizona	Dam Repair (loan or grant)	State engineer determines dam to be dangerous to life, non-emergency	Loan – Cost of project
Maryland	Maryland Environmental Service (loan and planning assistance)	Counties, utilities, and private groups; must have established service district for water supply, resource reclamation, dredging or stormwater	
Massachusetts	No name given (grants)	Local communities for repair or removal	75% of the project; local share can be in-kind contributions
New Jersey	Dam Restoration and Clean Water Trust Fund (revolving loan fund; new grant fund for municipally-owned dams)	Local units of governments; private owners can be co-applicants	Loan – Cost of project Grants – Up to 100%
New York	Clean Water/Clean Air Bond Act (grants)	Municipalities for dam safety projects	75% of eligible project with 25% local match; $300,000 cap per project
Ohio	Ohio Water Development Authority (revolving loan fund)	Owner must be under mandate from ODNR **Dam Safety Loan Program** – Local units of government, state, districts **Dam Safety Linked Deposit Program** – private owners/organizations	Cost of project
Pennsylvania	Pennvest (revolving loan fund)	Projects associated with wastewater, water supply, or stormwater	Up to cost of project
Utah	Utah Board of Water Resources (loans or grants)	High hazard dam owners; mandated repairs	80-95% grant for irrigation or water supply dams; loans or grants for other owners
Wisconsin	DNR Municipal Dam Grant Program (grants)	Local units of government and lake districts	50-50 grants; $200,000 maximum

Similarly, the federal government extends dam rehabilitation assistance through only a few programs. The combination of existing state and federal assistance does not approach the estimated $36.2 billion needed nationwide to support needed dam repair and rehabilitation related to wildlife damages and other structural integrity issues.

Table 7-3. Summary of Potential Federal Programs for Dam Management

Agency	Program	Description
Natural Resources Conservation Service, Department of Agriculture	10.916 Watershed Rehabilitation Program	Provides grants to rehabilitate dams originally built with assistance from USDA Watershed Programs. Rehabilitation must extend the life of the dam and meet applicable performance and safety requirements. Priority is given to high hazard dams.
Natural Resources Conservation Service, Department of Agriculture	10.904 Watershed Protection and Flood Prevention	Provides grants and technical assistance to carry out watershed improvement projects that protect, develop, and utilize the land and water resources in small watersheds.
Bureau of Indian Affairs, Department of the Interior	15.065 Safety of Dams on Indian Lands	Provides direct payments to federally recognized Indian tribal governments and Native American organization to improve the structural integrity of dams on Indian lands.
Federal Emergency Management Agency, Department of Homeland Security	97.047 Pre-Disaster Mitigation (PDM)	Provides grants to states and communities for cost-effective hazard mitigation activities that are part of a comprehensive mitigation program, and that reduce injuries, loss of life, and damage and destruction of property. Dam repair and rehabilitation projects may be eligible for PDM funding if: • The project has a high benefit-cost ratio; • There is a high risk of dam failure or dam failure would result in significant damages; and • The project is consistent with State funding priorities.
Federal Emergency Management Agency, Department of Homeland Security	P.L. 107-310 National Dam Safety and Security Act of 2002	Funds are granted each year to state dam safety programs.
Federal Insurance and Mitigation Administration, Federal Emergency Management Agency	83.550 National Dam Safety Program (Dam Safety State Assistance Program)	Funds are distributed each year (in the form of project grants) to state dam safety programs.

In conclusion, the dam community is composed of owners in need of education and economic understanding of the consequences associated with neglected dams, as well as those owners who are diligent in dam upkeep, but perhaps unable to fund the necessary repair and preventive actions. Even if federal, state, and local agencies can educate the reluctant dam owners such that they become vigilant in the upkeep of their dams, our nation's dams will likely continue to degrade without adequate funding to implement the sometimes perpetual animal damage repair and management needed.

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Appendix A
State Wildlife Agency Contacts

Alabama Department of Conservation and Natural Resources
Division of Wildlife and Freshwater Fisheries
64 N. Union Street
Montgomery, Alabama 36130
(334) 242-3469

Alaska Department of Fish and Game
PO Box 25526
Juneau, Alaska 99802-5526
(907) 465-4100

Arizona Game and Fish Department
2221 W. Greenway Road
Phoenix, Arizona 85023-4399
(602) 942-3000

Arkansas Game and Fish Commission
Natural Resources Drive
Little Rock, Arkansas 72205
(501) 223-6359

California Department of Fish and Game
1416 Ninth Street
Sacramento, California 95814
(916) 445-0411

Colorado Department of Natural Resources
Division of Wildlife
6060 Broadway
Denver, Colorado 80216
(303) 297-1192

Connecticut Department of Environmental Protection
Bureau of Natural Resources, Wildlife Division
79 Elm Street
Hartford, Connecticut 06106-5127
(860) 424-3011

Delaware Department of Natural Resources and
Environmental Control
Division of Fish and Wildlife
89 Kings Highway
Dover, Delaware 19901
(302) 739-5297

Florida Fish and Wildlife Conservation Commission
620 South Meridian Street
Tallahassee, Florida 32399-1600
(850) 921-5990

Georgia Department of Natural Resources
Wildlife Resources Division
2070 U.S. Highway 278, S.E.
Social Circle, Georgia 30025
(770) 918-6400

Hawaii Department of Land and Natural Resources
Division of Forestry and Wildlife
1151 Punchbowl Street, Room 325
Honolulu, Hawaii 96813
(808) 587-0166

Idaho Department of Fish and Game
600 S. Walnut, PO Box 25
Boise, Idaho 83707
(208) 334-3700

Illinois Department of Natural Resources
1 Natural Resources Way
Springfield, Illinois 62702-1271
(217) 782-6302

Indiana Department of Natural Resources
Division of Fish and Wildlife
402 W. Washington Street, Room W273
Indianapolis, Indiana 46204
(317) 232-4080

Iowa Department of Natural Resources
Wildlife Bureau
Henry A. Wallace Building
502 E. 9th Street
Des Moines, Iowa 50319-0034
(515) 281-5918

Kansas Department of Wildlife and Parks
14639 W. 95th
Lenexa, Kansas 66215
(913) 894-9113

Kentucky Department of Fish and Wildlife
1 Game Farm Road
Frankfort, Kentucky 40601
(800) 858-1549

Louisiana Department of Wildlife and Fisheries
2000 Quail Drive
Baton Rouge, Louisiana.70808
(225) 763-3557

Maine Department of Inland Fisheries and Wildlife
284 State Street
41 State House Station
Augusta, Maine 04333-0041
(207) 287-8000

Maryland Department of Natural Resources
Wildlife and Heritage Service
Tawes State Office Building, E-1
580 Taylor Avenue
Annapolis, Maryland 21401
(410) 260-8540

Massachusetts Department of Fisheries, Wildlife and
Environmental Law Enforcement
Division of Fisheries & Wildlife
251 Causeway Street, Suite 400
Boston, Massachusetts 02114-2152
(617) 626-1590

Michigan Department of Natural Resources
Wildlife Division
Mason Building, Fourth Floor
PO Box 30444
Lansing, Michigan 48909-7944
(517) 373-1263

Minnesota Department of Natural Resources
500 Lafayette Road
St. Paul, Minnesota 55155-4040
(651) 296-6157

Mississippi Department of Wildlife, Fisheries and Parks
1505 Eastover Drive
Jackson, Mississippi 39211-6374
(601) 432-2400

Missouri Department of Conservation
2901 W. Truman Boulevard
Jefferson City, Missouri 65109
(573) 751-4115

Montana Fish, Wildlife & Parks
1420 East Sixth Avenue
Helena, Montana 59620-0701
(406) 444-2535

Nebraska Game and Parks Commission
2200 North 33rd Street
Lincoln, Nebraska 68503
(402) 471-0641

Nevada Department of Wildlife
1100 Valley Road
Reno, Nevada 89512
(775) 688-1500

New Hampshire Fish and Game Department
Wildlife Division
11 Hazen Drive
Concord, New Hampshire 03301
(603) 271-2461

New Jersey Department of Environmental Protection
Division of Fish and Wildlife
PO Box 400
Trenton, New Jersey 08625-0400
(609) 292-2965

New Mexico Department of Game and Fish
PO Box 25112
Santa Fe, New Mexico 87507
(800) 862-9310

New York State Department of Environmental Conservation
Division of Fish, Wildlife and Marine Resources
625 Broadway
Albany, New York 12233-4750
(518) 402-8919

North Carolina Wildlife Resources Commission
Archdale Building
512 N. Salisbury Street
Raleigh, North Carolina 27604-1188
(919) 733-7191

North Dakota Game and Fish Department
100 N. Bismarck Expressway
Bismarck, North Dakota 58501-5095
(701) 328-6300

Ohio Department of Natural Resources
Division of Wildlife
1840 Belcher Drive
Columbus, Ohio 43224-1300
(800) 945-3543

Oklahoma Department of Wildlife Conservation
1801 N. Lincoln
Oklahoma City, Oklahoma 73105
(405) 521-3851

Oregon Department of Fish and Wildlife
3406 Cherry Avenue N.E.
Salem, Oregon 97303-4924
(503) 947-6000

Pennsylvania Game Commission
2001 Elmerton Avenue
Harrisburg, Pennsylvania 17110-9797
(717) 787-4250

Rhode Island Department of Environmental Management
Division of Fish and Wildlife
4808 Tower Hill Road
Wakefield, Rhode Island 02879
(401) 789-3094

South Carolina Department of Natural Resources
Wildlife and Freshwater Fisheries Division
PO Box 167
Columbia, South Carolina 29202
(803) 734-3886

South Dakota Department of Game, Fish, and Parks
Wildlife Division
523 East Capitol Avenue
Pierre, South Dakota 57501-3182
(605) 773-3381

Tennessee Wildlife Resources Agency
Wildlife Division
Ellington Agricultural Center
PO Box 40747
Nashville, Tennessee 37204
(615) 781-6610

Texas Parks and Wildlife Department
4200 Smith School Road
Austin, Texas 78744
(800) 792-1112

Utah Department of Natural Resources
Division of Wildlife Resources
1594 W. North Temple
Salt Lake City, Utah 84114
(801) 538-4700

Vermont Agency of Natural Resources
Fish and Wildlife Department
103 South Main Street
Waterbury, Vermont 05671-0501
(802) 241-3700

Virginia Department of Game and Inland Fisheries
4010 West Broad Street
Richmond, Virginia 23230
(804) 367-1000

Washington Department of Fish and Wildlife
Natural Resources Building
1111 Washington Street, SE
Olympia, Washington 98501
(360) 902-2200

West Virginia Division of Natural Resources
Wildlife Resources
State Capitol Building 3, Room 812
Charleston, West Virginia 25305
(304) 558-2771
Wisconsin Department of Natural Resources
101 South Webster Street
Madison, Wisconsin 53703
(608) 266-2621

Wyoming Game and Fish Department
5400 Bishop Boulevard
Cheyenne, Wyoming 82006-0001
(307) 777-4600

Appendix B
Association of State Dam Safety Officials Contact Information

Association of State Dam Safety Officials
450 Old Vine Street, 2nd Floor
Lexington, KY 40507-1544
Phone: 859-257-5140
Fax: 859-323-1958
E-Mail: info@damsafety.org
Web: www.damsafety.org

Lori Spragens, Executive Director lspragens@damsafety.org

Susan Sorrell, Meetings & Membership Director
sasorrell@damsafety.org

Sarah Mayfield, Information Specialist smayfield@damsafety.org

Maureen Hogle, Administrative Database Specialist
mhogle@damsafety.org

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Technical Manual for Dam Owners

Impacts of Plants on Earthen Dams

FEMA 534 / September 2005

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PREFACE

Damage to earthen dams and dam safety issues associated with tree and woody vegetation penetrations of earthen dams is all too often believed to be a routine maintenance situation by many dam owners, dam safety regulators, and engineers. Contrary to this belief, tree and woody vegetation penetrations of earthen dams and their appurtenances have been demonstrated to be causes of serious structural deterioration and distress that can result in failure of earthen dams. For the first time in the history of dam safety, a Research Needs Workshop on Plant and Animal Impacts on Earthen Dams (Workshop) was convened through the joint efforts of the Federal Emergency Management Agency (FEMA) and the Association of State Dam Safety Officials (ASDSO) in November 1999 to bring together technical resources of dam owners, engineers, state and federal regulators, wildlife managers, foresters, and members of academia with expertise in these areas. The Workshop highlighted the realization that damage to earthen dams resulting from plant and animal penetrations was indeed a significant dam safety issue in the United States. The purpose of this *Technical Manual for Dam Owners, Impacts of Plants on Earthen Dams* is to convey technology assembled through the Workshop by successful completion of four objectives. These objectives are as follows:

1. Advance awareness of the characteristics and seriousness of dam safety problems associated with tree and woody vegetation growth impacts on earthen dams;

2. Provide a higher level of understanding of dam safety issues associated with tree and woody vegetation growth impacts on earthen dams by reviewing current damage control policies;

3. Provide state-of-practice guidance for remediation design considerations associated with damages associated with tree and woody vegetation growth on earthen dams; and

4. Provide rationale and state-of-practice techniques and procedures for management of desirable and undesirable vegetation on earthen dams.

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Appreciation and sincere gratitude are extended to the members, and especially to the full-time staff, of the Association of State Dam Safety Officials (ASDSO) for their support and coordination of the federally-funded project that culminated with convening of the Research Needs Workshop on Plant and Animal Impacts on Earthen Dams at the University of Tennessee in Knoxville, Tennessee, on November 30-December 2, 1999. The editors of this Manual are especially appreciative of the continued support, patience, and dedication of Susan Sorrell and Sarah Mayfield of the ASDSO staff.

The Steering Committee of the Workshop was comprised of the following individuals who contributed significantly and diligently to making the Workshop a truly historical dam safety technological event:

Dr. B. Dan Marks, P.E. (Chairman)
Dr. Bruce A. Tschantz, UT Knoxville
David K. Woodward, NCSU
Charles Clevenger, MS (Deceased)
William L. Bouley, USBR
Sarah M. Mayfield, ASDSO
Susan A. Sorrell, ASDSO (Project Coordinator)

Participants in the Workshop brought together diverse technologies, experiences, and scientific developments to create a significant contribution to dam safety in the United States. The editors of this Manual acknowledge the valuable contributions of the following Workshop participants:

Matthew A. Barner, Wright State Univ.
William L. Bouley, USBR
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Edward Fiegle, GA Dam Safety
James K. Leumas, NC Dam Safety
Dr. B. Dan Marks, Marks Enterprises
Sarah M. Mayfield, ASDSO
Dr. Marty McCann, NPDP-Stanford
Douglas E. McClelland, USDA Forest Service
Dr. James E. Miller, USDA-CSREES/NRE
Dr. Dale L. Nolte, USDA-APHIS/WS/NWRC
Richard D. Owens, USDA-APHIS/WS
Tom Renckly, Maricopa County, AZ
Dr. David Sisneros, USBR
Boris Slogar, OH Dam Safety
Susan A. Sorrell, ASDSO
Dr. Bruce A Tschantz, UT Knoxville
David K. Woodward, NCSU

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James K. Leumas, City of Raleigh, NC
Lori Spragens, ASDSO Executive Director (Project Coordinator)

Because of the efforts of the many individuals previously mentioned, the editors are confident that users of this Manual will develop a better understanding and gain a greater appreciation of the seriousness and magnitude of problems associated with the effects of tree and woody vegetation root penetrations on the safety of earthen dams and their appurtenances.

GLOSSARY

This glossary provides the definitions of some of the basic terms used in this ***Manual*** and is not intended to be a comprehensive glossary of terms associated with dam safety. A more extensive resource of dam safety terms and definitions is available through the many references provided at the end of each chapter of the ***Manual***.

Absorption - the process of being taken into a mass or body, as water being taken in by plant roots.

Abutments - the interface between the sides of a valley containing a dam and the dam embankment. Right and left abutments are referenced by viewing the dam while facing downstream.

Adsorption – the adhesion of an extremely thin layer of molecules to the surface of solid bodies or liquids with which they are in contact.

Appurtenances – structures associated with dams such as spillways, gates, outlet works, ramps, docks, etc. that are built to allow proper operation of dams.

Berm – a horizontal step or bench in the embankment slope of an earthen dam.

Biological Barrier – an herbicidal releasing system, device, or material designed to exclude root growth and/or penetration of plants into a protected underground zone (such as a dam embankment).

Boil – a typically circular feature created by the upward movement of soil particles by seepage flowing under a pressure slightly greater than the submerged unit weight of the soil through which seepage is occurring.

Breach – a break, gap, or opening in a dam that typically allows uncontrolled release of impounded water.

Capillary Rise – the rise of water in the voids of a soil mass as a result of the surface tension forces of water.

Clearing – the removal of trees and woody vegetation by cutting without removal of stumps, rootballs, and root systems.

Crest – the near horizontal top surface of an earthen dam, or the control elevation of a spillway system.

Diameter at Breast Height (dbh) – the diameter of a tree measured at about four feet (breast height of average person) above the ground surface.

Drainage System – graded and/or protected pervious aggregates in a dam designed to collect, filter, and discharge seepage through the embankment, abutments, or foundation.

Earthen Dam – a dam constructed of compacted natural soil fill materials selected to minimize embankment seepage while maximizing workability and performance.

Embankment – an earthen or rockfilled structure having sloping sides constructed of select compacted fill materials.

Failure – a (dam) incident that results in the uncontrolled release of water from the impoundment of a dam.

Freeboard – the vertical distance from the normal operating water level of an impoundment to the crest (top) of the dam.

Grubbing – the removal of stumps, rootballs, and lateral root system of trees and woody vegetation. A construction operation that is typically done following the clearing operation.

Herbicide – a chemical substance or mixture designed to kill or maintain undesirable Plants that may include herbaceous plants, vines, brush, and trees.

Hydraulic Height (of a Dam) – the vertical distance from the normal operating water level of the impoundment to the invert of the outlet works or downstream outlet channel.

Hydro-seeding – the technique of applying grass seeds, fertilizer, agricultural lime, and seedbed mulch to seeded area in a pressurized aqueous mixture.

Lateral Root System – roots of trees and woody plants that extend laterally from the tap root and/or rootball to provide lateral support and nutrient uptake for the plant.

Line of Saturation – the leading boundary of the progression of saturation of soil in an embankment exposed to an increasing head (source) of water (impoundment).

Line of Wetting – the leading boundary of the progression of wetting (partial saturation) of soil in an embankment exposed to an increasing head (source) of water (impoundment).

Maintenance – routine upkeep necessary for efficient inspection, and safe operation and performance of dam and their appurtenances. Labor and materials are required; however, maintenance should never be considered to comprise dam remediation.

Mowing – the cutting of grass, weeds, and small-diameter woody vegetation by mechanical devices such as mowers, bush hogs, and other vegetation cutting machinery.

Mulching – the application of protective material such as straw, fiber matting, and shredded paper to newly seeded areas.

Operation (of a dam) – activity by a dam owner for the necessary and safe use and performance of a dam, the appurtenances of a dam, and the impoundment.

Owner – any person or organization that owns, leases, controls, operates, maintains, or manages a dam and/or impoundment.

Phreatic Surface – the upper boundary (surface) of seepage (water flow) zone in an embankment.

Piping – the progressive downstream to upstream development of internal erosion of soil as a result of excessive seepage that is typically observed downstream as a hole, or boil, that discharges water containing soil particles.

Remediation – restoration of a dam to a safe and intended design condition.

Revegetation – restoration of desirable ground cover vegetation (i.e. grasses) to disturbed areas designed to prevent embankment surface erosion.

Rootball – the root and soil mass portion of a tree or woody plant that is located directly beneath the trunk or body of the tree that provides the primary vertical support for the tree or woody plant.

Root Penetration – intrusion of plant roots into a dam embankment so as to interfere with the safe hydraulic or structural operation of the dam.

Root System – roots contained in the rootball and the lateral root system collectively comprise the root system of trees and woody plans and provide both lateral and vertical support for the plant as well as providing water and nutrient uptake for the plant.

Seeding – application of a seeding mixture to a prepared seedbed or disturbed area.

Seepage – the flow of water from an impoundment through the embankment, abutments, or foundation of a dam.

Seepage Line – the uppermost boundary of a flow net, or the upper surface (boundary) of water flow through an embankment (see Phreatic Surface).

Slump – a portion of soil mass on an earthen dam that has or is moved downslope, sometimes suddenly, often characterized by a head scarp and tension cracks on the crest and embankment slope.

Spillway Systems – control structures over or through which flows are discharged from the impoundment. Spillway systems include Primary or Principal Spillways through which normal flows and small storm water flows are discharged and Auxiliary or Emergency Spillways through which storm water flows (floods) are discharged.

Stripping – the removal of topsoil, organic laden materials, and shallow root systems by excavating the ground surface (surficial soil stratum) after grubbing an area.

Structural Height (of a Dam) – the vertical distance from the crest (top) of the dam to the lowest point at the toe of the downstream embankment slope, or downstream toe outlet channel.

Stump – that portion of the trunk or body of a tree or woody plant left after removal by cutting during timber harvesting and/or clearing of trees and woody plants.

Stump Diameter – the diameter of a tree or woody plant at the ground surface.

Tap Root – the primary vertical root in the rootball that is the origin of development for the rootball and lateral root system growth.

Toe of Embankment – the point of intersection of the embankment slope of a dam with the natural ground surface.

Weeds – shallow-rooted, non-woody plants that grow sufficiently high as to hinder dam safety inspections and do not provide desirable embankment slope protection against surface runoff.

Woody Vegetation – plants that develop woody trunks, rootballs, and root systems that are not as large as trees but cause undesirable root penetration in dams.

Zone of Aeration – the partially saturated zone of a soil mass above the zone of saturation (above the height of capillary rise of water in a soil mass).

Zone of Saturation – the saturated zone of a soil mass above the phreatic surface defined by the height of capillary rise.

Chapter 1
Introduction

At the time Joyce Kilmer dedicated his famous poem "**Trees**" to Mrs. Henry Mills Alden, he was undoubtedly inspired by the beauty of a healthy living tree, and rightly so. For those that do not remember, the first verse of this famous poem is as follows: "***I think that I shall never see / A poem lovely as a tree.***" Most people are inspired and impressed by the splendor of trees; however, dam owners, operators, inspectors, dam safety regulators, engineers, and consultants might find the following verse more nearly appropriate. "***I think that I shall never see / A sight so wonderful as a tree / Removed from an earthen dam / Whose future safety we wish to see.***" This paraphrased verse is not intended to debase the great works of Joyce Kilmer; but rather, is intended to draw attention to the fact that trees and woody vegetation growth have no place on the embankment of an earthen dam.

Dam safety regulators and inspectors, engineers, and consultants are frequently confronted with grass roots resistance in the issue of removal of trees and woody vegetation from earthen dams. This resistance is often associated with sentimental, cultural, ecological, legal, and financial issues. A fundamental understanding and technical knowledge of potential detrimental impacts of trees and woody vegetation growth on the safety of earthen dams is necessary in order to address these issues.

Purpose

The purpose of this ***Manual*** is to provide the dam owner, operator, inspector, dam safety regulator, engineer, and consultant with the fundamental understanding and technical knowledge associated with the potential detrimental impacts of tree and woody vegetation growth on the safety of earthen dams. In addition to objectives related to raising the knowledge level of detrimental effects of trees and woody vegetation growth on the safety of earthen dams, the contents will provide the user of this ***Manual*** with an

understanding of the methods, procedures, and benefits of maintaining a growth of desirable ground covering vegetation on the embankments of earthen dams.

Scope

The editors of this ***Manual*** have organized the contents in a sequential manner in order that the reader and user of this ***Manual*** can develop the desired fundamental understanding and gain the technical knowledge associated with the detrimental impacts of tree and woody vegetation growth on earthen dams. Chapter 2 deals with the problems associated with tree and woody vegetation growth on earthen dams. Chapter 3 presents some common misconceptions about tree growth and tree root development. These misconceptions are contrasted with factual data about tree growth and tree root development.

Chapter 4 presents a recommended earthen dam inspection protocol and procedures for determination of potential impacts of tree and woody vegetation growth on earthen dams. Chapter 5 begins the presentation of proper vegetation management on earthen dams. The user of this ***Manual*** is presented with methods and procedures for maintaining desirable vegetation growth, while also controlling tree and woody vegetation growth.

Chapter 6 presents a number of remediation design considerations associated with the removal of trees and woody vegetation from the embankments of earthen dams. This chapter also presents a recommended phased-remediation procedure for removal of undesirable vegetation (trees and woody vegetation) from earthen dam embankments. Chapter 7 is a succinct factual presentation of costs associated with either continual proper vegetative maintenance or long-term dam remediation construction after tree and woody vegetation removal. The contents of this chapter should make every dam owner cognizant of the need for proper operation and maintenance relative to vegetative growth on earthen dams.

Implementation

While this ***Manual*** may not be considered highly technical relative to the presentation of complex engineering calculations for the solution of potentially serious earthen dam safety problems, this ***Manual*** does present a combined sixty-five years of research and practice in dam safety engineering associated with tree and woody vegetation growth impacts on earthen dams. This ***Manual*** is presented in a manner to be beneficial to the entire dam safety community (dam owners, dam operators, dam safety inspectors, dam safety regulators, dam safety engineers and consultants). Dam safety engineers and consultants can utilize this ***Manual*** as a reference for recommendations for proper maintenance of desirable vegetation growth, control of undesirable vegetation growth, and remediation dam design associated with the removal and control of trees and woody vegetation growth on earthen dams. Dam safety regulators and dam safety inspectors can utilize this ***Manual*** as a guideline for the inspection of earthen dams relative to tree and vegetation growth dam safety issues and for the direction of dam owners and operators in the proper method and procedures for maintaining earthen dams without detrimental vegetative growth. Dam owners and operators can utilize this ***Manual*** to establish proper operation and maintenance programs to promote the growth of desirable vegetative growth on earthen dams and/or remove and control the undesirable tree and woody vegetation growth on earthen dams.

The last verse in the famous poem **Trees** by Joyce Kilmer is as follows: **"Poems are made by fools like me / But only God can make a tree."** Again, the author will paraphrase this last verse, not to debase the great works of Joyce Kilmer, but to make a distinct point. **"Only God can make a tree / But not removing trees from dams / Is done by fools like me."**

There is yet much research and study to be done relative to the growth of proper vegetative cover on earthen dams. However, there is no doubt that trees and woody vegetation have no place on the embankment slopes of an earthen dam. The authors of this ***Manual*** intend to continue technological development in the area of controlling tree and woody vegetation growth on earthen dams. The authors would appreciate documentation of unusual cases of tree and woody vegetation growth related to safety issues associated with earthen dams. Documentation of these issues can be communicated through ASDSO and/or directly to the authors of this ***Manual***.

Chapter 2
Problems with Tree and Woody Vegetation Growth

According to the 1998-99 National Inventory of Dams (NID) data, there are approximately 76,700 dams of significant size[1] and hazard category in the 50 states (USCOE, 1999). Most of these dams are regulated by the jurisdictional states, but many are not because of specific exemption clauses or different size or hazard restrictions. Because some states have lower size definitions for their dams than used for the NID count, the actual number of state-regulated dams is much higher (about 94,000). In Tennessee over 40 percent of the approximately 1000 inventoried dams ***not*** subject to regulation because of statutorily named county exclusions or agricultural use exemptions. Most of these unregulated dams and some of the regulated dams in Tennessee have troublesome trees and brush growing on their faces and crests. Some states estimate that as many as 95 percent of their regulated dams have trees. Figure 1 illustrates the general magnitude and range of the tree growth on regulated dams in 48 states where this information is reported (ASDSO, 2000). About half of the state-regulated dams are estimated to have excessive tree growth.

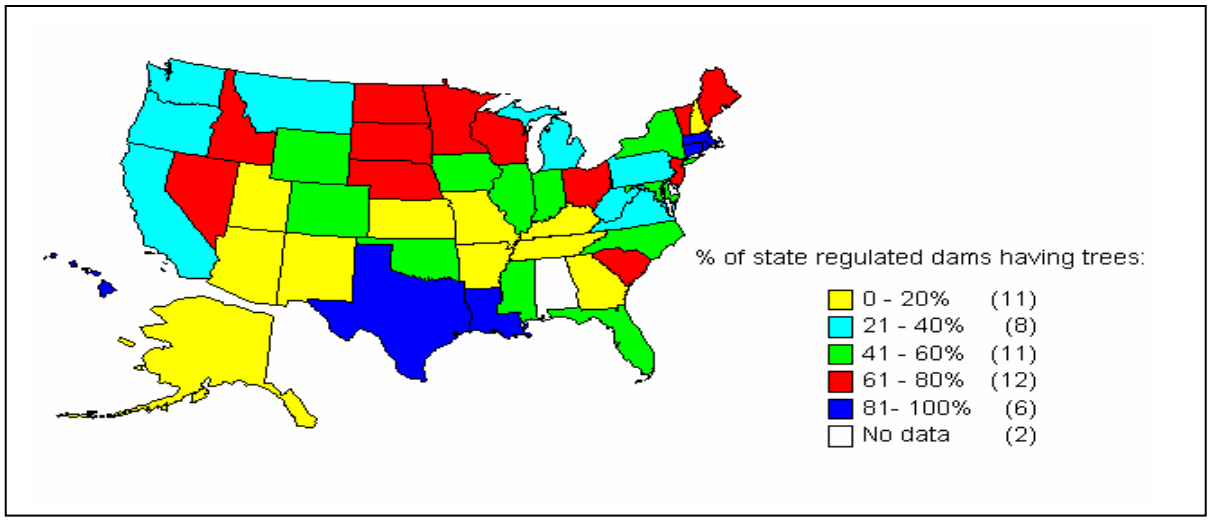

Figure 1. Estimated percentages of state-regulated dams having trees.

[1] Inclusion in the National Inventory has been defined under P.L. 99-662 and P.L. 92-367 to include dams that are at least 25 ft. high or 50 acre-feet of storage (excluding low hazard dams less than 6 ft. high or 15 acre feet of storage) and dams that due to location may pose a significant threat to human life or property in event of failure.

Most dam safety engineers, including state and federal officials, consultants, and other experts involved with dam safety, agree that when trees and woody plants are allowed to grow on earthen dams, they can hinder safety inspections, can interfere with safe operation, or can even cause dam failure. In the past, engineers and dam safety experts have not always been in agreement about the best way to prevent or control tree growth, remove trees, or repair safety-related damages caused by trees and woody vegetation. However, all dam engineers agree that a healthy, dense stand of low-growing grass on earthen dams is a desirable condition and should be encouraged.

From November 30 - December 2, 1999, a joint ASDSO/FEMA-sponsored workshop was held in Knoxville, Tennessee, for the purpose of inviting a panel of experts to discuss various problems, policies, and practices associated with plant and animal penetrations of earthen dams. Much of this manual follows up the work and recommendations produced by the workshop participants for engineers and owners to use in managing problems associated with both plant and animal intrusions. This chapter will discuss the consensus of current attitudes, issues, and policies involving woody vegetation penetrations of earthen dams, by state and federal officials, researchers, and practitioners active in dam safety.

Attitudes Toward Woody Plant Growth on Dams

The Association of State Dam Safety Officials (ASDSO) sent out survey questionnaires to dam safety officials in all 50 states and to federal representatives to the Interagency Committee on Dam Safety (ICODS) to determine state and federal agency attitudes about the effects of trees and woody plant growth on dams under their jurisdiction (ASDSO, 1999).

In this survey the state and federal agency representatives were asked (1) if they considered vegetative growth to be a problem on dams, (2) if they had specific policies or operating procedures for removing unwanted vegetation and trees on dams and if they didn't, how did they handle such problems, (3) what legal, financial, environmental or other constraints did

they have in dealing with unwanted vegetation problems, (4) to provide documented evidence and examples where vegetation has negatively affected the safe operation or has contributed to the failure of dams, (5) to provide references to current or past research regarding the effects of plants and trees on dam safety, and (6) to provide example cost and other information related to rehabilitation and remediation of dams having problem woody plant growth. This chapter summarizes the collective state and federal attitude, and practice toward woody plant growth on dams.

Problems Caused by Trees and Woody Plants

Of the 48 states that responded to the above seven questions (Alabama and Delaware did not reply), all state dam safety officials indicated that they consider trees and plant growth on dams to be a safety problem. One eastern state dam safety engineer goes so far to say that trees are probably the major problem that he has to deal with. He notes further that most of the trouble occurs because owners (and some engineers) do not recognize trees as problems and become complacent as trees slowly grow into serious problems. Both state and federal officials agree that trees have no place on dams. Federal agencies like the Corps of Engineers, U. S. Bureau of Reclamation, and TVA, which own, operate and maintain their own dams, do not allow trees to grow on their structures. Figure 2 shows a problem dam in Nebraska where tree roots have been reported to penetrate the chimney drain and thus affect the operation of the dam.

Figure 2. Example dam with problematic trees in Nebraska.

Figure 3. Example dam with inspection-hindering trees in Tennessee.

The problem most commonly noted by state officials is that trees, woody vegetation, briars, and vines interfere with effective safety inspections. Figure 3 illustrates this problem for a dam located in Tennessee.

Figure 4 gives a breakdown of the percentage ranges of regulated dams where the 48 reporting state dam safety officials shown in Figure 1 estimate that trees and brush hinder safety inspections in their respective states (ASDSO, 1999). While half the states report having only 20 percent or fewer dams with significant trees and woody vegetation that hinder inspections, vegetation on an estimated 30,000 or nearly a third of the collective state-regulated dams, is reported to obstruct effective dam safety inspections.

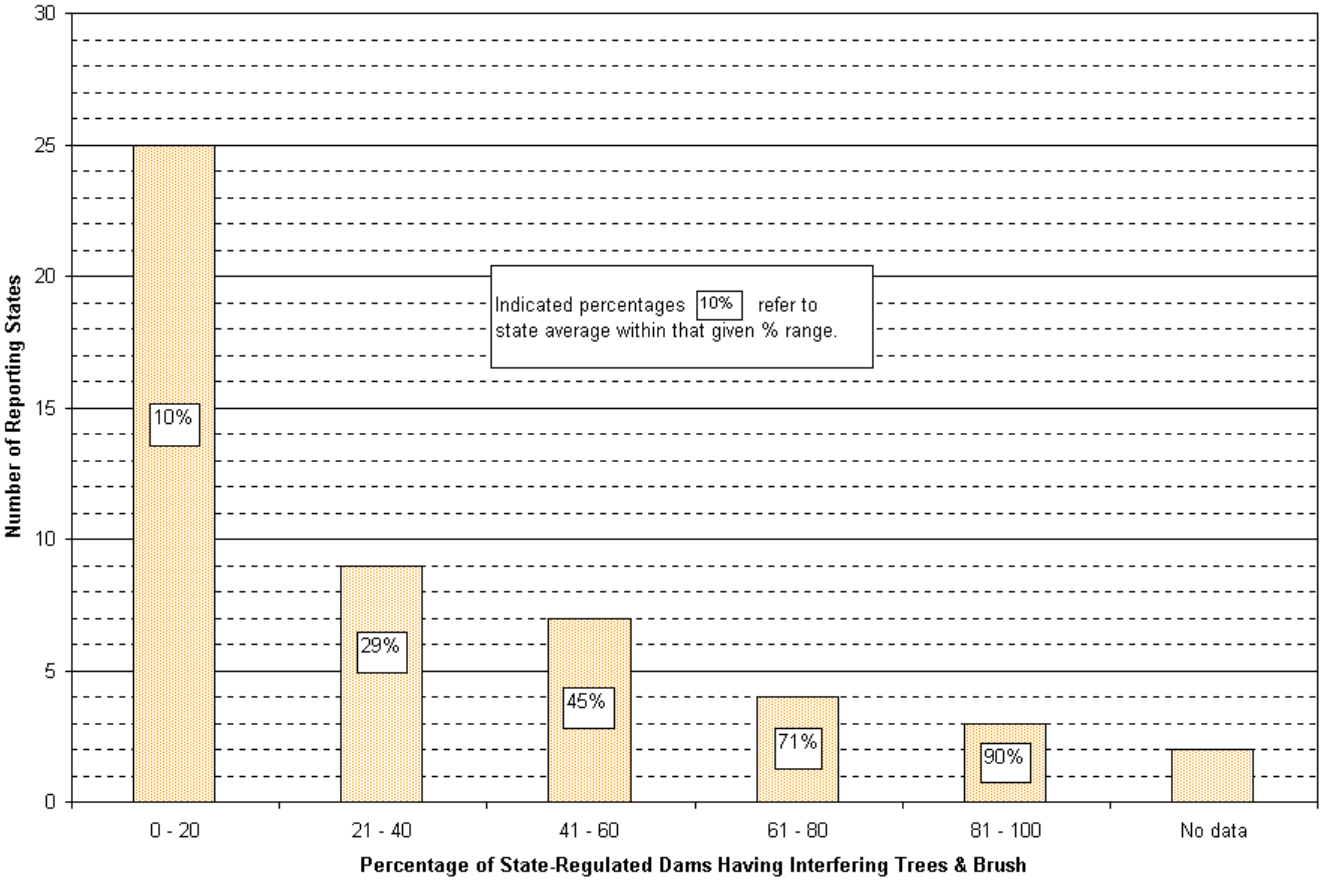

Figure 4. Estimated percentages of state-regulated dams where trees and brush are considered a deterrent to effective safety inspections.

Other dam safety problems caused by woody vegetation growth are:

- Uprooted trees that produce large voids and reduced freeboard; and/or reduced x-section for maintaining stability as shown in Figure 5.
- Decaying roots that create seepage paths and internal erosion problems.
- Interfering with effective dam safety monitoring, inspection and maintenance for seepage, cracking, sinkholes, slumping, settlement, deflection, and other signs of stress

Figure 5. Serious damage by uprooted tree to embankment stability at a dam in Oregon.

- Hindering desirable vegetative cover and causing embankment erosion
- Obstructing emergency spillway capacity
- Falling trees causing possible damage to spillways and outlet facilities
- Clogging embankment underdrain systems
- Cracking, uplifting or displacing concrete structures and other facilities
- Inducing local turbulence and scouring around trees in emergency spillways and during overtopping as shown in Figure 6.

Figure 6. Tree root induced scouring on crest and downstream face of Coffey dam in Kansas.

- Providing cover for burrowing animals
- Loosening compacted soil
- Allowing roots to wedge into open joints and cracks in foundation rock along abutment groins and toe of embankment, thus increasing piping and leakage potential.
- Root penetration of conduit joints and joints in concrete structures

Current Policies and Procedures

Twenty-four of the 48 responding states noted that they had formal policies and/or operating procedures for addressing tree and woody plant growth issues. These policies usually include one, or some combination, of the following:

- Trees are not allowed to grow on dams or near toe and abutment
- All trees and stumps must be removed, but roots may be left
- All trees, stumps, and roots must be removed
- All trees must be removed, but root systems of "small" trees may be left; root systems of "large" trees must be removed
- Dams are treated on a case-by-case basis -- usually under the direction of a qualified professional engineer.

For those states that choose to distinguish between "small" and "large" trees, the definition basis ranges from two to eight inches in diameter; most use a size of four or six inches in carrying out their policies.

Of the remaining 24 states indicating that they have no formal policies or procedures, the range of recommended procedures to dam owners varies widely. Some states evaluate dams on a case-by-case basis, while other states require owners either to maintain their dams, to remove vegetation for inspection, or to use other means for dealing with plant problems such as requiring a qualified engineer to be retained, depending on the dam hazard classification.

In summary, states follow several schools of thought and considerations in dealing with trees and vegetation on existing and new dams:

Existing Dams:

- Distinguish between "small" trees and "large" trees
- Remove all trees, stumps, and roots from dam embankment
- Cut trees to ground level, but leave stumps and roots
- Cut trees, remove stumps, but leave roots
- Consider case-by-case basis
- Breach, remove, or decommission dam
- Require retention of a qualified engineer by owner
- Do nothing.

Chapter 4: Dam Remediation Design Considerations presents recommended procedures for removal of trees and dealing with tree and woody vegetation related problems.

Figure 6. Trees cut prior to removing stumps and roots from dam.

Figure 7. Completed remediation job after removing stumps, seeding, fertilizing & mulching.

Figures 6 and 7 illustrate extensive efforts necessary to restore a heavily wooded earthen dam to a desirable vegetated and maintained condition.

New Dams:

- Establish effective ground cover and hope for the best in continual maintenance
- Use vegetative barriers such as bio-barriers, or use silvicides/herbicides/chemical treatment.

Constraints to Removing Trees and Plants

Several state and federal dam safety officials reported constraints to removing and/or controlling unwanted trees and other vegetation. Constraint categories explicitly cited by state dam safety officials (number of states in parentheses) are given below:

- Financial limitations by owners (13 states)
- Environmental regulations and/or permits (10 states)
- Legal issues (6 states)
- Aesthetics (5 states)
- Threatened/endangered species issues (2 states)
- Media (1 state)
- Sentimental reasons (several).

States indicated that the greatest constraint to removing unwanted trees and plants and repairing a structure infested with roots is limited financial capability by the owner. States such as Kentucky try to work with the owner to minimize the financial burden without threatening public safety. Ohio has recently established two low-cost loan programs to assist qualified public and private dam owners in funding safety-related improvements to their dams, including repairs mandated by the state dam safety program.

Environmental constraints range from limitation of the use of certain herbicides or chemicals for controlling vegetation and for treating stumps and/or roots near water bodies; to prohibition of, or air quality concern for, burning cleared vegetation. Unless exempted, vegetation removal and maintenance around dams may conflict with wetland protection regulations. In Washington, environmental issues can pose a major hurdle to removing trees, but ultimately, public safety takes precedence over environmental concerns. In Arizona, problems with time-consuming environmental permit requirements for larger plant removal projects are sometimes encountered.

Some states have limited legal power to force owners to remove trees and vegetation from dams. This lack of authority may cause delays and expensive and time-consuming litigation to obtain an order. Other states, like Maine, do not have specific laws that force owners to remove vegetation from their dams, and removal orders have yet to be tested. One state, South Carolina, notes that if the owner will not voluntarily cut or remove unwanted vegetation, the only course is to start legal action against the owner. Because legal help is limited, such help is normally requested for the "most extreme cases." This means that only a few owners can be forced to do something about their vegetation. In New Hampshire, legal assistance is sometimes necessary to perform enforcement functions. In Oregon, if there is a problem with a recalcitrant owner, a Proposed Order can be initiated by the Oregon Dam Safety Program to correct the situation if it is determined to be an immediate threat to the integrity of the structure. However, this process can be rather lengthy and expensive when staff time, materials, and attorney fees are included in the costs of preparing for a contested case hearing. In the end, most dam owners have the right to contest state directives to remove trees and other plants through administrative and legal processes and judicial appeals.

In some states, concerns have arisen when dams are located in parks or environmentally sensitive areas, especially when endangered or threatened species habitat is involved, in turn creating legal constraints.

Aesthetics and sentimental reasons are often used by dam owners and their neighbors to resist removing trees and undesirable vegetation. This is particularly true if owners have intentionally planted ornamental trees and shrubs on their dams to provide shade or fruit, or to improve looks. Some owners believe that the more woody vegetation on a structure, the better -- thus making it very difficult for state dam safety officials to request its removal.

The power of the press has had major influence on tree removal programs in some cases, especially where the target dam is owned by a poor or downtrodden citizen or insolvent municipality. Heated controversy between public safety interests and private owners or

interest groups was generated through various newspaper stories and letters to the editor in 1990 over the removal of 500 mature cottonwood trees on two dams owned by an 85-year-old widowed rancher who at the time was suffering from serious illness. The news stories, which cast the owner as being targeted because she was vulnerable, influenced the owner's neighbors to encourage her to take a stand against further removal of 500 remaining trees because they felt that enforcement of the state dam safety act "would cause more harm than good."

While these constraints affect the ability of many states to enforce their regulations, some states such as Arkansas, Georgia, Colorado, Iowa, Maryland, Montana, New Jersey, North Carolina, and Tennessee report no major constraints to enforcement and consider the safety of dams to be of primary importance.

Federal agencies appear to have fewer constraints than states relative to mandating the upkeep and maintenance of jurisdictional dams. However, some federal agencies noted that they must make sure that they comply with the National Environmental Policy Act and the Endangered Species Act prior to initiating tree and plant control and management. Isolated constraints at the National Park Service involving funding priorities, historic preservation, and disruption of visitor services may override safe operation and maintenance needs at some dams. Local watershed districts that are often poorly funded are responsible for the operation and maintenance of many of the USDA/NRCS flood control dam projects.

Vegetation-Caused Problems and Failures

Twenty-nine states indicated documented evidence where vegetation on dams has either caused dam failure or negatively affected their safe operation. Sixteen states had no documented evidence and five states had no response. Several states provided photos (Figure 8) and information on tree caused failures or dam

Figure 8. Exposed tree roots in overtopped dam.

safety problems. The most recent documented dam failure due to tree root penetration occurred in May 1999 at an unnamed Air Force Academy dam near Colorado Springs. Here, an approximately 13-ft. high dam with a pond capacity of less than 5 acre-feet of horse stable waste water failed, releasing its contents and injuring a horse in a stable located about 100 yards downstream. The failure occurred after more than 7 inches of rain had fallen in the previous 72 hours. The dam had several pine trees on its crest and faces, and the breach opening exposed an extensive, deep root system. Roots up to 4 inches in diameter were found in the breach area. Figure 9 shows an example of a large root exposed in the bottom of the channel at the breach. The dam had not overtopped, and the failure was attributed to internal erosion of the decomposed granite embankment material along the roots. A tree had been located directly over the breach.

Figure 9. Large pine tree root located in the channel of the breach opening of a failed Air Force Academy waste lagoon pond dam (David Eyre, Senior Civil Engineer, Air Force Academy, Colorado, 1999).

At the Federal level, USDA/NRCS referred to documented cases where dam failure has been determined to be caused solely by trees, and noted that trees have also masked other more serious seepage problems, which went undetected.

Past and Current Research

Other than a few references to the University of Tennessee Tree Growth Report (Tschantz, 1988), only one or two other citations for tree or woody plant-related research were identified by the state dam safety officials (USDA/SCS, 1981). The surveyed Federal agencies had relatively little to offer in the way of references to current or past research regarding the effects of tree and plant growth on dam safety. The Corps of Engineers referred to geotechnical and other related program research conducted at the Waterways Experiment Station, published as a technical report series, Repair- Evaluation-Maintenance-Rehabilitation (REMR). One recent study for the St. Paul District showed that a hole formed by a blown-down tree in the downstream toe area can produce a potentially dangerous increase in hydraulic seepage gradient and internal erosion or piping problems in dikes (Duncan, 1999). The USDA/NRCS referred to the 1950's research work done at the ARS Hydraulics Laboratory in Stillwater, Oklahoma, on Flow in Vegetative Channels, which could have application to some emergency spillways.

A recent literature review, sponsored by ASDSO/FEMA and conducted for the Steering Committee on Plant and Animal Penetration of Earthen Dams, researched available material on the effects of woody plants on dam safety (Tschantz et al, 1999). All types of sources and searches were inventoried, including ASDSO conference and workshop proceedings, ASCE technical journals and articles, USCOLD, direct e-mail and telephone contacts of selected federal and state agency officials, universities, research laboratories and other data bases accessible through the National Technical Information Service (NTIS) and National Performance of Dams Program (NPDP). While only a few references were found on recent or

current research of tree and plant effects on dam safety, several references on federal and state practices, policies, and procedures for dealing with trees and vegetation were cited in such topical areas as:

- woody plant physiology
- documented examples of woody plant-caused dam failures, operation, and maintenance problems
- case histories related to tree-caused dam failures
- current and past federal, international, and other research activities
- federal, state, international, and other organizations' policies, procedures and practices for preventing and remediating woody plant problems, and
- federal, state or private cost documentation for removing or controlling trees and woody plants.

Costs of Removing Trees and Tree Related Remediation

Limited cost information for removing trees and brush or for repairing damages caused by vegetation at dams was available from the states or federal agencies. Most state dam safety officials indicated either that they did not have the data or that the owner or his consultant would have that information. Virginia reported that, while costs can be nominal, in extensive tree growth situations where grubbing is required, $10,000 to $20,000 per dam is common and that at one dam; the tree-clearing cost was about $40,000. Missouri reported that such costs could range from $1,000 to $10,000 depending on how badly the dam is overgrown with trees. A prominent North Carolina geotechnical engineering firm stated that ten different contractors, working in North Carolina, South Carolina, and Georgia, reported recent bid prices ranging from about $1500 to $3000 per acre for cutting trees at ground level, removing stumps and root balls, and grubbing the area to remove perimeter roots. Contractors were advised that clearing

and grubbing would be done on embankment slopes ranging from 1.5:1 (Horizontal to Vertical) to 4:1 (Horizontal to Vertical), within possible wet areas in the lower 1/3 to 1/2 of the downstream slopes, and on earthen dams ranging in height from 25 to 50 feet. Table 1 compares cost experiences reported by state dam safety officials in different regions of the country for clearing and grubbing trees from dams.

Reporting State	Number of Dams	*Cost per acre	Survey Comments
Georgia	More than 25	$1,000 to $5,000	Based on consultants' feedback; cost varies depending on dam face conditions such as slope steepness, degree of wetness and tree density.
Oklahoma	1 1	$900 $1,150	2 acres of d/s slope over 2-1/2 day period 3-1/2 acres, current proposal estimate.
South Dakota	Several	$100 to $200/Acre	Usually 10 - 20 trees per dam
Nevada	1	$532	Based on 3 hourly laborers working for 2 weeks on 3.25 acres of willow & mesquite removal on d/s dam face (~1995)
Michigan	General DNR construction cost experience	$3,500 $6,000 $12,000	Light clear/grub (diam.<6") Medium clear/grub (diam.<12") Heavy clear/grub (diam<24")
Tennessee	7	$1,540 (Ave.) (approx. range = $1030 to $3290)	Total clearing, grubbing & reseeding cost for 7 dams = $16,705 @ ~1.5 acres per dam. Jobs included range of tree sizes & heavy brush. (1995-98)
Texas	1	$5,500	Part of overall site clearing and grubbing contract for new dam in East Texas (1995)
Ohio	1	$10,000	Cost included clearing, grubbing, mulching and seeding. Heavily wooded; hundreds of trees removed from d/s slope (1999)
Minnesota	Current estimates from Minnesota consultant Small Projects	$1350 $2800 $4475 $4225 $6775 $960	Clearing brush with brush saw - no grubbing Clearing brush by hand - no grubbing Clear and grub brush, incl. stumps Cut & chip up to 6" trees; grub/remove stumps Cut & chip up to 12" trees; grub/remove stumps 16 m-hrs @ $60/hr to clear and grub small trees (diam. < 6") for less than one acre projects

*Reported costs not indexed

Table 1. Cost Comparisons for Clearing, Grubbing and Removing Trees from Dams.

While the range of remedial costs varies widely, depending on several factors, it appears that about $1,000 - $5,000/acre may be a reasonable baseline to use for rough estimating purposes, with the lower figure applicable to small and low-density tree growth and the larger figure appropriate to mature, very dense tree stands.

A typical 25-foot high by 750-foot long earthen dam having 3:1 (Horizontal to Vertical) embankment slopes, a 15-foot crest width, and a freeboard of 10 feet above normal pool has approximately two acres of exposed crest and face area for potential tree growth. Total costs for clearing and grubbing trees for such a dam would be in the range of $2000 to $10,000 depending upon the local site conditions.

Several site-specific factors can influence tree removal costs. These include size and type of trees, growth density, total job size (number of acres), location of growth (crest and/or both faces), embankment slope steepness, slope condition (such as degree of wetness or surface texture), degree and type of required surface treatment (backfilling, use of herbicides or bio-barriers, mulching, seeding, fertilizing, etc.), and regional labor and construction indices.

The U. S. Bureau of Reclamation reported detailed cost data using three herbicidal application methods (aerial, cut-stump, and ground-based foliar-application) in its 1987-93 program to control salt cedar along waterways in seven states of the Upper Colorado Region. Application costs ranged from about $60/acre for aerial spraying to about $1000/acre for cut-stump and spray methods (Sisneros, 1994). The National Park Service indicated that it has done tree removal with the assistance of the U. S. Bureau of Reclamation, but cost information is not readily available.

Summary

Trees appear to be a major dam safety issue for many states. Based on recent survey responses from 48 states, it is estimated that about one half of the state-regulated dams have trees growing on them. The same reporting states estimate that an average of nearly a third of the dams that they regulate have sufficient trees, brush and other growth to hinder effective safety inspections.

Current state and federal policies, procedures, and practices relating to tree and woody plant removal, control, and management for dam safety are generally fragmented and inconsistent among state and federal dam safety agencies**.** ***However, all state and federal agency dam safety officials and experts agree that trees have no place on dams and need to be managed and controlled on both existing and new dams for at least three important reasons:*** (1) trees and dense vegetation hinder effective dam inspections; (2) tree roots can cause serious structural instability or hydraulic problems, which could lead to dam failure and possible loss of life; and (3) trees and brush attract burrowing animals, which can in turn cause serious structural or hydraulic problems.

The fragmentation among state and federal agencies applies only to procedures about ***how*** and ***to what extent*** the trees and their roots should be removed and resulting cavities remediated to ensure a hydraulically and structurally safe dam. Other chapters in this ***Manual*** present methods and practices for controlling trees and woody plants and for remediating damage caused by trees and other woody plants.

While limited information is available, a sampling of state dam safety officials and other experts report that the cost of removing trees and brush from the face of a dam can broadly range from about $1,000 to $10,000 per acre, depending on several factors. Typically, the cost of clearing and grubbing trees from dams falls into the $1,000 - $5,000 per acre range. The

broad range of costs is not surprising as most dam safety engineers agree that tree removal costs are very much site specific. Controlling vegetation annually is relatively inexpensive, but removing trees on and repairing damage to neglected dams may cost owners several thousand dollars.

Most dam safety experts agree that research needs to be done on determining the relationship of plant and tree species to root penetration of artificial environments such as embankment dams; the interaction between root systems and the phreatic zone and surface; and development and understanding of various types of physical, biological, and chemical treatment and barriers for controlling root growth. Because many existing dams exhibit dense growths of trees and woody vegetation with deep-penetrating root systems, engineering methods need to be developed for understanding, predicting, and stabilizing the effects of these root penetrations to minimize internal erosion and failure. Dam safety experts agree that both technical and non-technical pamphlets and brochures, practice manuals, web-based documents, workshops, and guidance materials need to be developed for educating dam owners about the problems caused by trees and woody vegetation. Engineers, dam safety officials and inspectors, developers, and contractors must be provided technical training and information relative to the control and/or safe removal of trees and other undesirable woody vegetation from earthen dams.

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Chapter 3
Tree Growth and Tree Root Development Requirements

The purpose of this chapter is to provide the reader and user of this ***Manual*** with a basic understanding of plant physiology related to fundamental processes of tree growth and tree root development. It is not the intent of this chapter to delve into a detailed biological study of trees and woody vegetation, but to provide the reader with a fundamental understanding of the requirements for tree growth and tree root development while attempting to dispel some of the misconceptions and myths associated with tree and woody vegetation growth, particularly as related to tree root development.

Common Myths and Misconceptions

There are many misconceptions and common myths relating to trees and woody vegetation that have been accepted by many people without a scientific basis. Many of these common myths and misconceptions relative to plant physiology have originated from uneducated interpretations of observations associated with tree growth and tree root development. Some of these myths and misconceptions associated with trees and woody vegetation affect correct interpretation and understanding of the impact of such growth on the safety of earthen dams. The more common myths and misconceptions must be dispelled so that a new level of understanding about the impacts of trees and woody vegetation on earthen dams can be properly developed. Trees and woody vegetation, like all living things, must have oxygen, nutrients, and water (moisture) to survive. Without these requirements, tree roots cannot continue development and tree growth cannot continue. The root system of trees and woody vegetation is in simplified terms comprised of two major components that are the root ball, typically directly below the trunk of the tree, and the lateral or perimeter transport root system that typically extends beyond the ‘drip line’ or vertical projection of the canopy of the tree.

Tree Tap Roots are thought by many to be the primary root system for all ages and types of trees and woody vegetation. In fact, the taproot is the first root to develop from the seed or reproductive source. This central root is an extension of the stem and differs from the stem only in that the root contains nodes for development of additional roots. Once the taproot has stabilized the young plant (tree), the root ball begins to develop and the taproot becomes less important than other roots that grow laterally from the taproot. The developing root ball provides vertical support for the tree as well as providing nutrients and water (moisture) to the tree. Roots extending laterally from the root ball increase the stability of the tree while functioning to collect and store nutrients, oxygen, and water for the tree. While it is true that some trees have more clearly defined taproots, taproots of most trees do not extend significantly far below the massive root ball of healthy trees. However, taproots are more predominant in locations where trees grow in deep deposits of loose dry soils.

Tree Root Soil Stabilization is likely the most common misconception associated with tree growth and tree root development. How many times has the reader heard, or perhaps mistakenly said, **"If it were not for those trees and tree roots this slope would really be eroded or unstable – those tree roots are really 'holding' that soil slope"**. Many otherwise knowledgeable and educated individuals believe the myth that tree roots actually stabilize soil masses by 'holding' the soil together. This misconception leads many people to believe that heavy tree and woody vegetation growth is actually beneficial for steep embankment slopes. Tree root development that is necessary to provide nutrients for tree growth and stabilize the tree actually loosens the soil mass. Laterally extending tree roots could be thought of as being nature's original application of the geotechnical engineering design concept of soil nailing. ***Root penetration stabilizes the tree and loosens the soil mass within which the tree roots are developing; the converse is a myth and certainly not true.***

Groundwater Penetration by tree root systems is another common myth and misconception believed by many otherwise knowledgeable individuals. Although Cypress, Tulip Poplar, some Willow and Water Birch tree species appear to have root systems that are submerged, nutrient root systems of trees cannot survive beneath the water table or the phreatic surface (seepage line) in an earthen dam. Trees and woody vegetation depend upon their transport root systems to provide the major portion of the oxygen demand for continual tree growth and tree root development. Most species of trees and woody vegetation quickly die of suffocation once the lateral transport root system and root ball are inundated. This phenomenon can be visually observed in many areas of Arkansas, Mississippi, and Louisiana where large tracts of timber have been artificially flooded for duck hunting. If these flooded tracts of timber are not drained seasonally, the timber (trees) die as a result of suffocation. Similarly, beaver activity causes significant losses in the timber industry every year as a result of inundation of harvestable timber. Tree roots do not penetrate the water table or the zone of saturation where oxygen demands of the tree cannot be met. If the zone of saturation or water table is raised above the level of tree roots for an extended period, the tree will die as a result of suffocation. Tree root development and tree growth cannot occur when moisture contents in the soil mass are greater than about forty percent.

Soil Moisture Uptake of many species of trees far exceeds that which most individuals would estimate as a normal requirement of water for continual tree growth and tree root development. It is not uncommon for most species of healthy mature trees to absorb 200 to 300 gallons of water per day if this amount of water is available to the lateral transport root system. Reduced availability of soil moisture will curtail continual tree root development until such time that the soil mass is replenished with sufficient moisture to allow resumption of tree root development. Tree root development and tree growth cannot occur in soil masses having moisture contents less than about twelve percent for extended periods.

Woody Vegetation Control Versus Dam Performance is an issue that is clearly misunderstood by many dam owners, operators, inspectors, dam safety regulators, engineers, and consultants. Tree and woody vegetation root penetration is not a beneficial effect on the performance of earthen dams. As indicated previously, tree root penetration does not stabilize a soil mass, particularly an embankment slope. Quite the contrary, tree root penetration loosens the soil of an embankment slope and creates a condition more conducive to surface water penetration and slope failure. Earthen dams are not unlike other engineered structures in that they must be properly maintained in order to perform as perceived in the original design of the structure.

When does routine vegetation maintenance and control become a dam safety and/or dam performance issue? The author is of the opinion that vegetation maintenance and control on an earthen dam ends, and the need for an ***engineered*** earthen dam rehabilitation plan begins, when effects of an improper vegetation maintenance and control program create conditions that are ***detrimental to the structural integrity*** of the earthen dam. For example, an earthen dam that exhibits a dense growth of grasses and weeds that are waist high, but is free of significant woody vegetation growth, is an earthen dam that is in need of proper vegetation maintenance and control to allow proper inspection of the dam. However, waist-high grasses and weeds would not typically affect the structural integrity of the earthen dam. Conversely, an earthen dam that supports a dense growth of four to eight inch diameter trees that preclude proper access for inspection is a dam safety and performance issue. Dense growths of trees and woody vegetation not only present a hindrance to proper dam safety inspection, but also are detrimental to the structural integrity of the earthen dam. Proper removal of trees and woody vegetation from earthen dams is a dam safety and performance issue that must be conducted in accordance with properly designed dam remediation plans and specifications.

Tree Root Characteristics and Requirements

As previously indicated, root systems of trees and woody vegetation consist of two primary components that are the root ball and the lateral transport root system. While all tree and woody vegetation roots have a primary function of providing oxygen, nutrients, and water to the plant, they also provide stability for the plant. The root ball that is typically directly below the trunk of the tree provides vertical support while the lateral transport roots provide lateral support for the tree. Root systems of trees and woody vegetation growing on dam embankment slopes will typically be asymmetrical as a result of the need for the tree to be stabilized in the sloping embankment soil mass. The lateral transport roots will typically be better developed on the uphill side of the tree than on the downhill side of the tree. Dr. Kim D. Coder at the University of Georgia has conducted extensive studies and research on tree growth and tree root development requirements and characteristics. He has developed data from these studies and research programs that relate tree trunk size to root ball diameter and lateral transport root system diameter. These data are presented in Table 1 below.

Table 1: Typical Rootball and Root System Sizes for Various Tree Sizes

Tree Diameter, inches	Rootball Diameter, feet	Root System Diameter, feet
4 to 5	6	10 to 12
6 to 7	8	16 to 18
8 to 9	10	20 to22
10 to 11	12	26 to 28
12 to 14	14	30 to 32
15 to 18	16	38 to 46
19 to 23	18	48 to 58
24 to 36	20	60 to 90
37 to 45	22	92 to 112

During the presentation of common myths and misconceptions about tree growth and tree root development, requirements of trees and woody vegetation for continual growth and root development were discussed. Based upon research and studies conducted by Dr. Kim Coder, requirements for tree and woody vegetation growth and root development are tabulated in Table 2.

Table 2: Root Growth Resource Requirements

Requirement	Minimum Value	Maximum Value
Soil Oxygen Content	**2.5%**	**21.0%**
Soil Air Voids	**12.0%**	**N/A**
Soil Bulk Density (Clays)	**N/A**	**87 pcf**
Soil Bulk Density (Sands)	**N/A**	**112 pcf**
Water Content of Soil	**12.0%**	**40.0%**
Limiting Soil Temperatures	**40ºF**	**94ºF**
Soil pH Values	**3.5**	**8.2**

Soil air void content is one of the most critical factors for continual tree root development. This factor is critical since both soil density and soil oxygen content are dependent upon the amount of air voids present in a soil mass. Because of the importance of soil air void content, Dr. Coder conducted extensive research to determine limiting air void contents for various soil types required for continual tree root growth (See Table 3).

Table 3: Limiting Soil Air Voids for Root Growth in Various Soil Types/Textures

Soil Type/Texture	Air Voids, %
Sand	**24**
Fine Sand	**21**
Sandy Loam	**19**
Fine Sandy Loam	**15**
Loam	**14**
Silt Loam	**17**
Clay Loam	**11**
Clay	**13**

Utilizing weight-volume relationships for various soil types and textures, Dr. Coder was able to determine the limiting (maximum) dry density of soil that would allow continual tree root development. Results of these correlations between minimum soil air void content and maximum soil dry densities required for continual tree root development are presented in Table 4 below.

Table 4: Limiting Soil Dry Density for Root Growth in Various Soil Types/Textures

Soil Type/Texture	Dry Density, pcf
Sand	112.3
Fine Sand	109.2
Sandy Loam	106.1
Fine Sandy Loam	103.0
Loam	96.7
Silt Loam	90.5
Clay Loam	93.6
Clay	87.4

In an attempt to relate the research data developed by Dr. Coder to geotechnical engineering data developed from over 200 earthen dam projects, the author has compiled a comparative list of soil properties for various soils that have been found in earthen dam embankments. The ranges given in the data presented in Table 5 below are associated with soil in a loose condition and soil in a compacted state that might be required in the construction or remediation of an earthen dam. ***The user of this Manual must be aware that these soil parameters are typical values and should not be relied upon for design of new earthen dams or design of remediation plans for existing dams.***

Table 5: Summary of Typical Soil Parameters

Soil Type	Specific Gravity	Void Ratio	Porosity, %	Dry Density, pcf	Permeability, cm/sec
Sand	**2.62 to 2.66**	**0.40 to 0.90**	**30 to 45**	**90 to 115**	**0.01 to 0.0001**
Silt	**2.60 to 2.68**	**0.50 to 1.20**	**35 to 55**	**75 to 110**	**0.001 to 0.00001**
Clay	**2.66 to 2.72**	**0.60 to 1.40**	**40 to 60**	**70 to 105**	**0.0001 to 0.0000001**

As one can see from the tabulated summary of typical soil parameters, continual tree root development cannot occur in soils that are well compacted. One of the best methods of controlling tree and woody vegetation growth on new earthen dams and existing earthen dams where remediation requires placement of additional embankment fill soil is to compact the embankment fill soils to a high degree of compaction. Increased compaction of embankment fill soils reduces the air void content and limits the amount of surface water that can infiltrate into the embankment slope. However, a good ground cover of grasses can be established in well-compacted soils since the depth of grass root penetration is minimal and the surficial soils will typically sustain the shallow grass root penetration.

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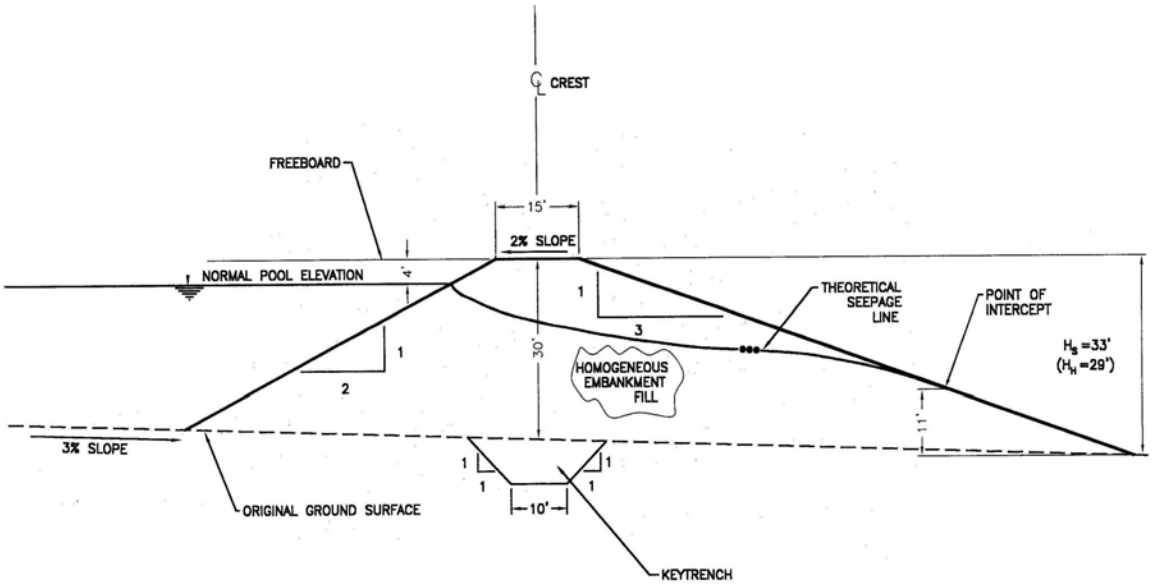
Chapter 4
Earthen Dam Safety Inspection and Evaluation Methodology

The purpose of this chapter is to illustrate dam behavior during the initial years of design life and to present a suggested inspection and evaluation methodology. An example earthen dam configuration will be presented in order to illustrate earthen dam behavior and to develop the suggested inspection methodology.

Example Earthen Dam Configuration

The example earthen dam is assumed to be a high-hazard dam having a structural height of about 33 feet and impounding a lake area of about three acres at normal pool elevation. The contributing watershed of the lake is about 320 acres (0.5 square mile) with a base flow of about one-half (0.5) cubic feet per second (cfs).

The configuration of the example earthen dam consists of an upstream slope of 2:1 (horizontal to vertical), a crest width of fifteen feet, and a 3:1 (horizontal to vertical) downstream slope. The dam has a freeboard of four feet making the hydraulic height of the dam about 29 feet. The dam is founded on relatively impervious (compared to the embankment fill soil) material with a down gradient slope of about three percent. The example earthen dam section has a key trench directly below the centerline of the dam crest that has a bottom width of ten feet and side slopes of 1:1 (horizontal to vertical). The dam crest has a two-percent slope toward the impounded lake and the upstream slope has no protection system against tree and woody vegetation growth or wave erosion. The embankment of the example earthen dam is assumed to be homogeneous. Figure 1 is a representation of the example earthen dam configuration with the theoretical seepage line intercepting the downstream slope at about one-third the hydraulic height of the dam. **Rule-of-Thumb:** ***The phreatic surface intercepts the downstream slope of a homogeneous earthen dam at a vertical distance of about one-third the hydraulic height above the toe of the downstream slope, provided there is no internal drainage system in the dam embankment.***



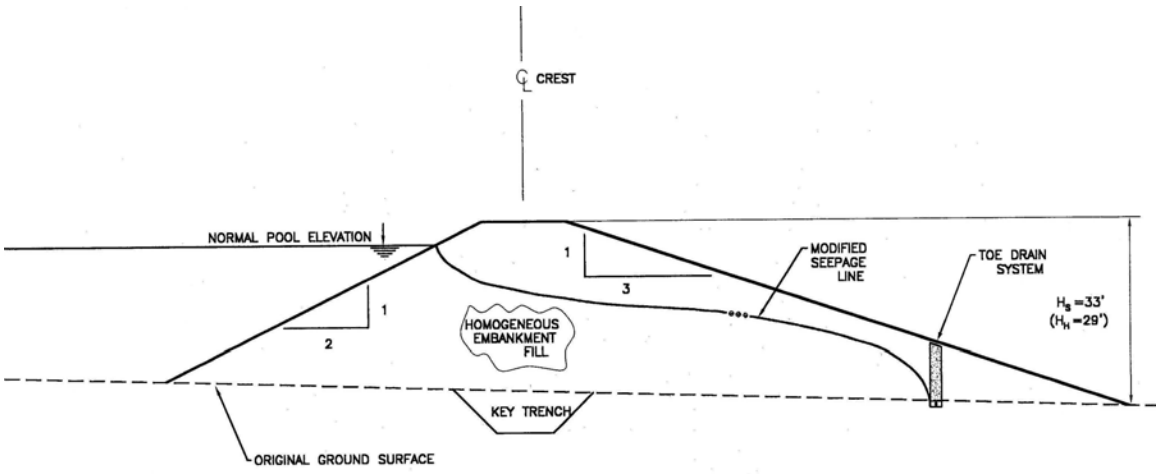
TYPICAL EMBANKMENT SECTION
WITHOUT TOE DRAIN SYSTEM

Figure 1

Based upon data provided for the example earthen dam, this dam would be listed on the National Inventory of Dams (NID). In addition, the example earthen dam would be classified as a small-size, high-hazard dam by most state dam safety regulations**.**

Figure 2 illustrates the example earthen dam with an embankment subdrain system located within the downstream embankment slope. The subdrain or embankment drain system is located at about the point of interception of the seepage line with the downstream slope if there was no embankment toe drain system within the downstream slope. As a result of the presence of the embankment subdrain system, the seepage line through the dam embankment has been modified (lowered) from the location of the theoretical seepage line for a homogeneous earthen dam embankment. The seepage line within an earthen dam is often mistakenly considered to have a permanent location.

However, the location of the seepage line is continually changing as a result of many influential factors. Fluctuations in the pool elevation, seasonal and long-term climatological conditions, and the growth of trees and woody vegetation in close proximity to the seepage line are some of the factors that influence changes in the location of the phreatic surface within an earthen dam embankment.



TYPICAL EMBANKMENT SECTION
WITH TOE DRAIN SYSTEM

Figure 2

Important moisture regimes other than the steady-state seepage line (phreatic surface) are often not given proper consideration in the evaluation of the performance of earthen dams. The ***zone of saturation*** is located immediately above the phreatic surface or seepage line where embankment fill soils have become saturated as a result of capillary rise caused by capillary forces in the soil voids. Figure 3 illustrates the presence of zones of saturation associated with that of a theoretical seepage line location without an embankment subdrain system as well as that of a modified seepage line location with an embankment toe drain system. The height of capillary rise (thickness of the zone of saturation) is directly dependent upon the effective mean diameter of soil voids within the earthen dam embankment. The effective mean diameter of compacted soil is dependent upon the ***effective particle size*** (De) of the compacted embankment fill soil. Soil within

the zone of saturation is completely saturated; however, there is no flow or gravity induced movement of water unless some external force disturbs the soil. This phenomenon is often observable during the inspection of downstream slopes of earthen

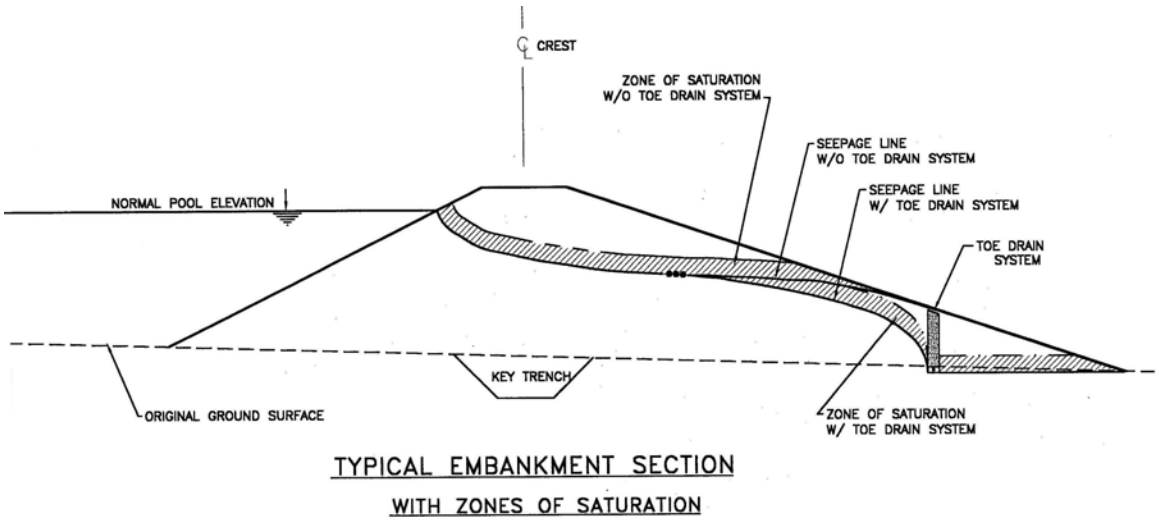


Figure 3

dams. Seepage and free flowing water can be seen on the downstream slope of an older dam below the point of interception of the seepage line if no embankment subdrain is present. Above the point of interception of the seepage line with the downstream slope, the soil is saturated and the Zone of Saturation can be observed for a significant distance above the seepage line intercept in some cases. In the Zone of Saturation, pore water may be observed to fill tracks made in the water-softened embankment soil. However, once the tracks are filled by pore water released from the disturbed soil there will be no continued flow or seepage from the embankment. This condition is often confused with the presence of embankment seepage. Installation of a subdrain location in this situation may lower the phreatic surface relatively quickly; however, months or even years may be required to drain the zone of saturation because of tensile forces or negative pore pressures in the embankment fill soils.

Embankment Wetting, Saturation, and Seepage

Prior to presentation of the behavior and performance of an earthen dam embankment during the initial years of the design life, one must have an understanding of relationships between various velocities of moisture movement and water flow through compacted embankment soils. First, consider the relationship between the optimum compaction moisture content of an embankment soil and other moisture content properties.

Rule-of-Thumb: ***The optimum compaction moisture content as determined by ASTM D-698 (standard Proctor compaction test) is approximately two to four percent below the Plastic Limit (PL) of most soils and about three to five percent below the saturation moisture content of the same soils.***

Compacted soils will typically increase in moisture content from the compaction moisture content to about the PL of the soil relatively quickly after construction of an earthen embankment. The rate of wetting is much greater in soils compacted dry of optimum moisture content than in soils compacted wet of optimum moisture content. Although compacted soils may undergo wetting or increase in moisture content relatively quickly when exposed to a source of water, the rate of saturation is much slower because air trapped in discontinuous soil voids must be dissolved in soil pore water during the saturation process. Embankment wetting and saturation are not associated with seepage or the flow of water through a homogeneous earthen dam; however, relative velocities of wetting and saturation can be related to values of steady-state seepage velocity, permeability, or hydraulic conductivity of compacted embankment soils.

Figure 4 is an illustration of the example earthen dam with relationships between various soil water flow velocities and permeabilities. First, consider the relationship between the vertical and horizontal permeability of a compacted homogeneous embankment soil.

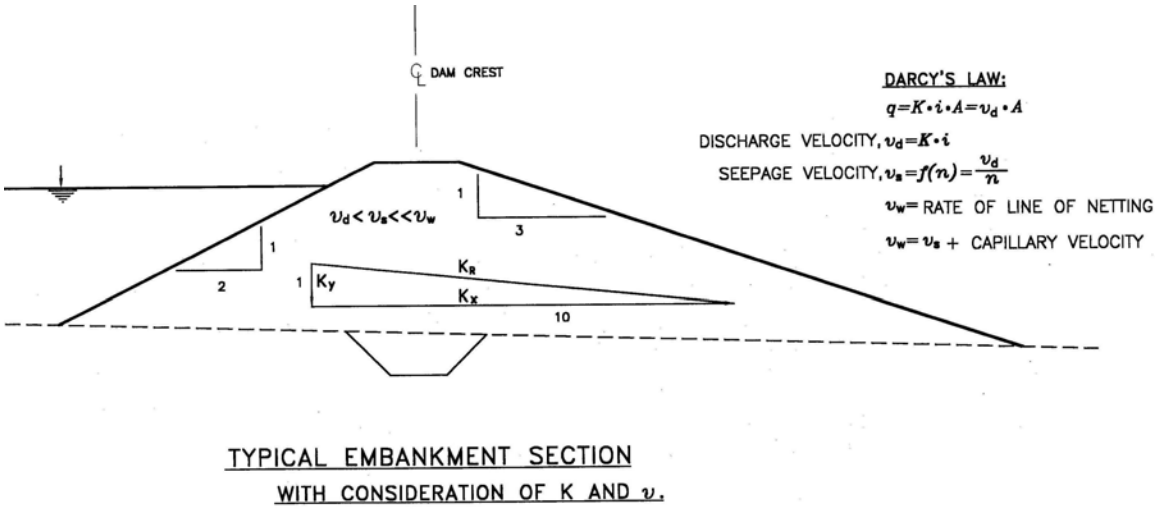


Figure 4

Rule-of-Thumb: ***The horizontal permeability of a compacted homogeneous embankment soils are typically about nine times to ten times (one order of magnitude) greater than the vertical permeability.***

Variation between the horizontal permeability and vertical permeability is the result of the internal structure of compacted soils. This variation does not account for poorly compacted lifts since the embankment is assumed to be homogeneous. Consequently, if laboratory permeability tests indicate that a compacted embankment soil exhibits a hydraulic conductivity value of about 0.000004 centimeters per second (cm/sec) then the horizontal permeability of this compacted embankment soil will be about 0.000036 to 0.00004 cm/sec. Second, consider Darcy's Law that is the basis for all theories and analyses associated with the flow of water through soil masses. Darcy did not account for soil voids relative to soil solids in derivation of his equation. As a result, the area of discharge is the total cross-sectional area through which flow is occurring. If one assumes that the hydraulic gradient producing flow through a soil mass is equal to one (unity), then the ***discharge velocity*** (Darcy's flow velocity) is equal to the permeability value of

the soil. The actual flow velocity in the voids of the soil is often identified as the ***seepage velocity*** and is approximately equal to the discharge velocity divided by the porosity value (expressed as a decimal) of the soil. Assuming that the compacted embankment soil in the example earthen dam has a porosity of forty (40) percent (0.40), the seepage velocity of the soil would be about 2.5 times greater than the discharge velocity. Third, consider the wetting velocity or the velocity of the ***line of wetting***. The wetting velocity is the rate at which soil increases in moisture content up to about the PL when exposed to a free water source. The line of wetting can often be observed as it progresses through soil masses, particularly soils that are dry of optimum moisture content. The wetting velocity is the sum of the seepage velocity and the capillary velocity or the velocity of wetting attributable to capillary forces in the soil.

Rule-of-Thumb: ***The wetting velocity or the velocity of the line of wetting through compacted soil is about one order of magnitude (ten times) greater than the seepage velocity.***

Applying this factor to the previous comparison between seepage velocity and discharge velocity, one finds that the wetting velocity is about 25 times greater than the discharge velocity. Based upon the foregoing discussion of earthen dam embankment wetting, saturation, and steady-state seepage velocities, consider the illustration in Figure 5. This figure illustrates embankment wetting, saturation, and steady-state seepage during the early years of the design life of an earthen dam. Assume that laboratory testing indicates that embankment soils of the example dam embankment have a permeability or hydraulic conductivity value of 0.02 foot per day. The discharge velocity would be about 0.008 foot per day with a hydraulic gradient of about 0.4 resulting in a horizontal discharge velocity of about 0.08 foot per day. The associated seepage velocity would be about 0.02 foot per day with a soil porosity of about 40 percent and the horizontal seepage velocity would be about 0.2 foot per day. The velocity of the line of wetting or the wetting velocity would be about 2.0 feet per day.

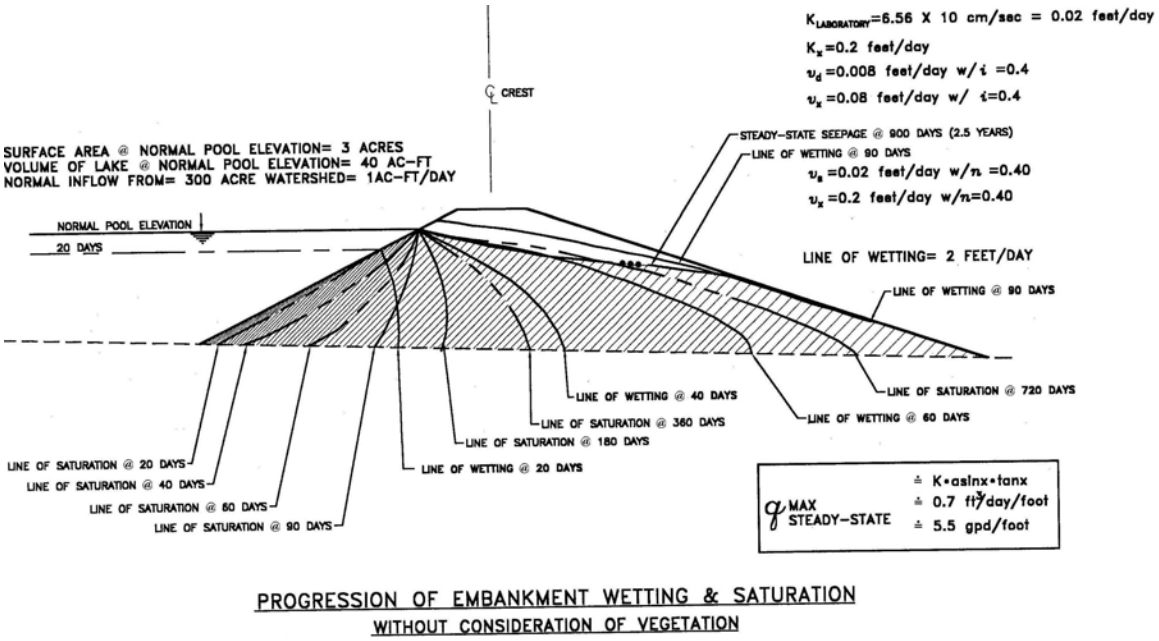


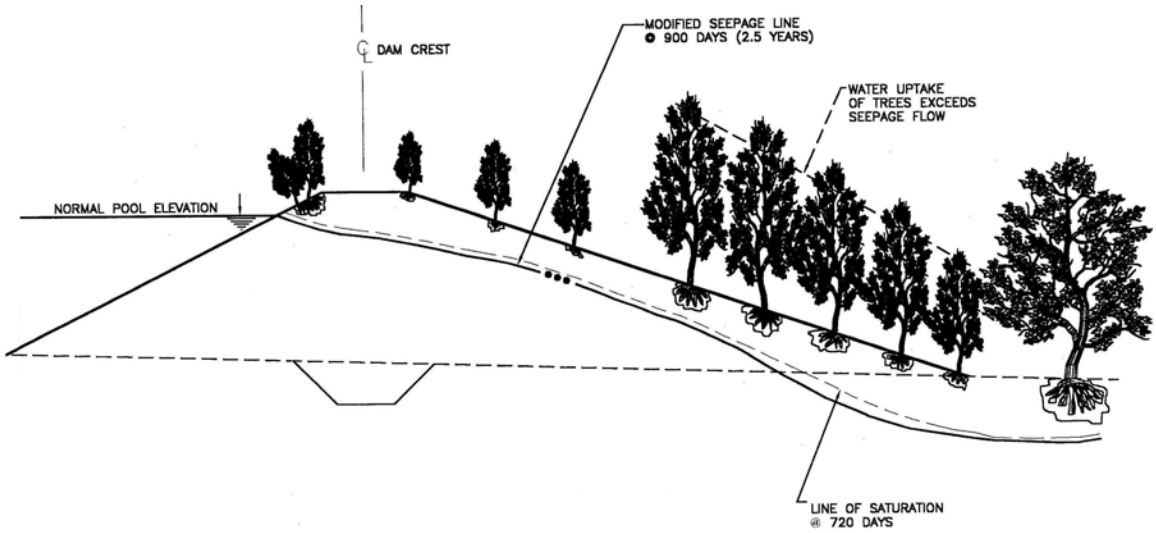
Figure 5

Based upon the estimated normal inflow from the contributing watershed, the lake retained by the example dam should reach about fifty percent volume in approximately twenty days and reach normal pool elevation in about forty days. Solid lines in Figure 5 illustrate the location of the line of wetting at various time intervals. The line of wetting should reach the downstream slope in about ninety days. ***Note: The compacted embankment soils remain partially saturated after passage of the line of wetting.*** Dashed lines in Figure 5 illustrate the line of saturation at various time intervals. The line of saturation moves at the seepage velocity that is about one-tenth the value of the wetting velocity. When the line of wetting has reached the downstream slope in about ninety days, the line of saturation is still at about the vertical from the intercept of the normal pool with the upstream slope. Based upon this rate of progression, the line of saturation will not reach the surface of the downstream slope and steady-state seepage will not be initiated for about 900 days (about 2.5 years), ***provided that no external influences affect the rate of wetting and saturation***.

The estimated maximum steady-state seepage rate for the example dam will be about 5.5 gallons per day per foot of dam. Before leaving Figure 5, imagine that the example dam contains an embankment subdrain system as indicated in Figures 2 and 3. The rate of progression of the line of wetting and the line of saturation will both be affected by the presence of the subdrain system.

Even without the presence of an embankment subdrain system, the time required for the line of wetting could encompass an entire growing season depending upon the time of year that the dam was completed. More importantly, the time that is required for the line of saturation to intercept the downstream slope might encompass two or three entire growing seasons. Tree and woody vegetation growth can become quite dense and relatively large within the initial two to three growing seasons if not properly controlled.

The initiation of tree and woody vegetation growth on the downstream slope begins the soil moisture uptake cycle so that the line of saturation and the seepage line may never completely develop and intercept the downstream slope. The condition represented by Figure 6 might initially be considered to be beneficial to the stability of the dam embankment. However, one must understand that as the tree and woody vegetation growth continues compacted soils of the dam embankment are continually loosened by the penetration of major tree and woody vegetation root systems. Furthermore, trees that might appear healthy to an untrained inspector may be an unhealthy specimen and have a premature death leaving penetrating root systems to rot inside the dam embankment. Additionally, soil nutrients in the compacted soil embankment of an earthen dam may not be sufficient for development of growth beyond which the tree cannot be properly sustained without premature death. Regardless of the cause, trees and woody vegetation do die and cease to uptake soil moisture that they previously used. This change in soil moisture uptake will affect the zone of aeration, zone of saturation, and the location of the seepage line in the vicinity of the unhealthy or dead trees and woody vegetation.



MODIFICATION OF SEEPAGE LINE
WITH TREES & WOODY VEGETATION

Figure 6

The Mid-Life Crisis of an Aging Earthen Dam

Once an earthen dam embankment has become impregnated with numerous trees and woody vegetation penetrations, routine and even major maintenance activities will likely not be sufficient to regain the original design life of the dam. At this time in the life of an earthen dam, previously identifiable maintenance problems have become serious dam performance and dam safety issues. Restoration through an ***engineered*** dam remediation design and remediation construction is typically required to bring the dam to acceptable standards relative to dam safety requirements.

Figure 7 illustrates some of the problems and dam safety issues that can be created by uncontrolled or non-maintained tree and woody vegetation growth in what has been termed by the author as the ***'Mid-Life Crisis'*** of an earthen dam. Seepage flow may be emerging from rootball cavities of blowdowns (uprooted trees) because they are no longer using soil moisture and the seepage line has adjusted upward toward the surface of

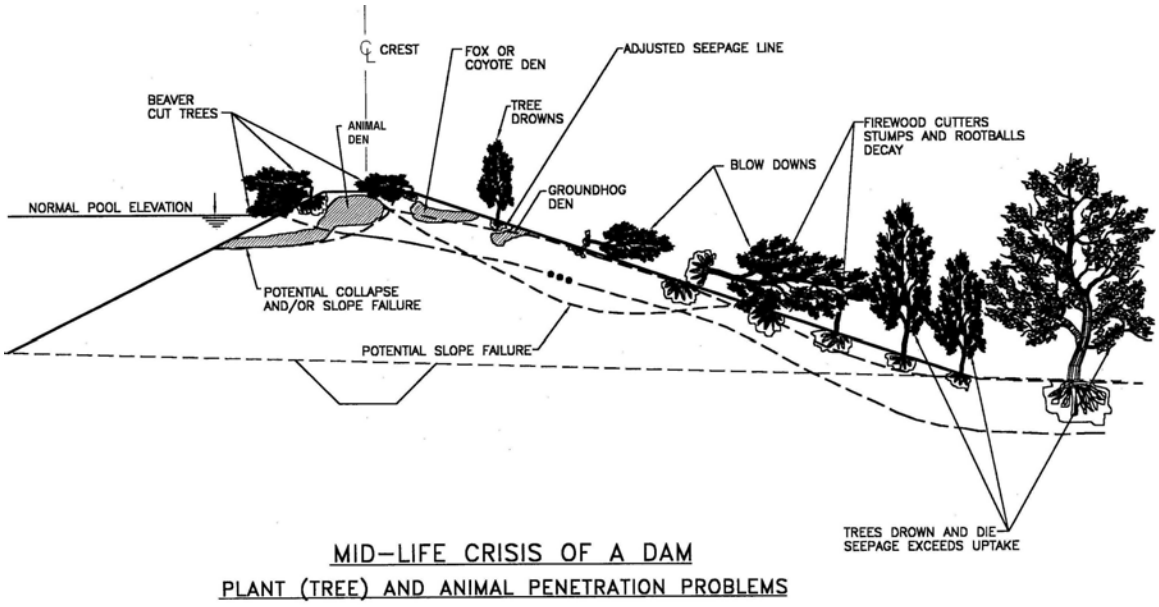


Figure 7

the slope. Removal of mature trees by woodcutters deletes the soil moisture uptake of the removed trees thus further modifying the location of the seepage line closer to the surface of the downstream slope. Rootballs and root systems of otherwise healthy trees located at and beyond the toe of the downstream embankment slope become inundated by the adjusted seepage line. Since trees cannot live through prolonged submergence of their major root systems, these trees will become unhealthy and die leaving decaying rootballs and root systems as serious penetrations in the earthen dam. Rootball cavities remaining from blowdowns (uprooted trees) and their relationship to the seepage line create conditions susceptible to potential slope failure of the downstream embankment slope. Restoration of the example earthen dam illustrated in Figure 7 to a safe condition cannot be brought about through routine maintenance activities. An ***engineered*** dam remediation design and remediation construction will be required to restore this dam to a safe condition and original design life.

Inspection and Evaluation Methodology

The effectiveness, economics, and constructability of dam remediation designs for earthen dams begin and end with proper evaluations of the characteristics and seriousness of deficiencies as related to dam safety issues. ***All tree and woody vegetation growth on earthen dams is undesirable and has some level of detrimental impact upon operation, performance, and safety of an earthen dam***. However, not all tree and woody vegetation growth on earthen dams imposes the same level of impact on operation, performance, and dam safety. Dam owners, regulators, inspectors, and engineers must develop an understanding of the impact of tree and woody vegetation growth relative to location on the dam configuration. Proper evaluation of the seriousness of dam safety issues related to tree and woody vegetation growth on earthen dams is typically associated with the location of the undesirable plant growth on the dam embankment.

A few examples of the variability of seriousness of plant penetrations are presented herein to begin the learning process. The presence of a twelve-inch diameter tree on the downstream side of the crest of an earthen dam typically does not pose the same degree of impact on potential dam safety as a twelve-inch diameter tree located in the lower portion of the downstream slope. Conversely, a twelve-inch diameter tree in the upper portion of the downstream slope does not typically create the same level of seriousness as an unhealthy twelve-inch diameter tree on the upstream slope or front crest of a dam having a narrow crest width. Ornamental shrubs having shallow root systems along a wide roadway crossing the crest of an earthen dam will not impose the same level of seriousness as similar shallow rooted woody vegetation growing on the lower portion of the downstream slope.

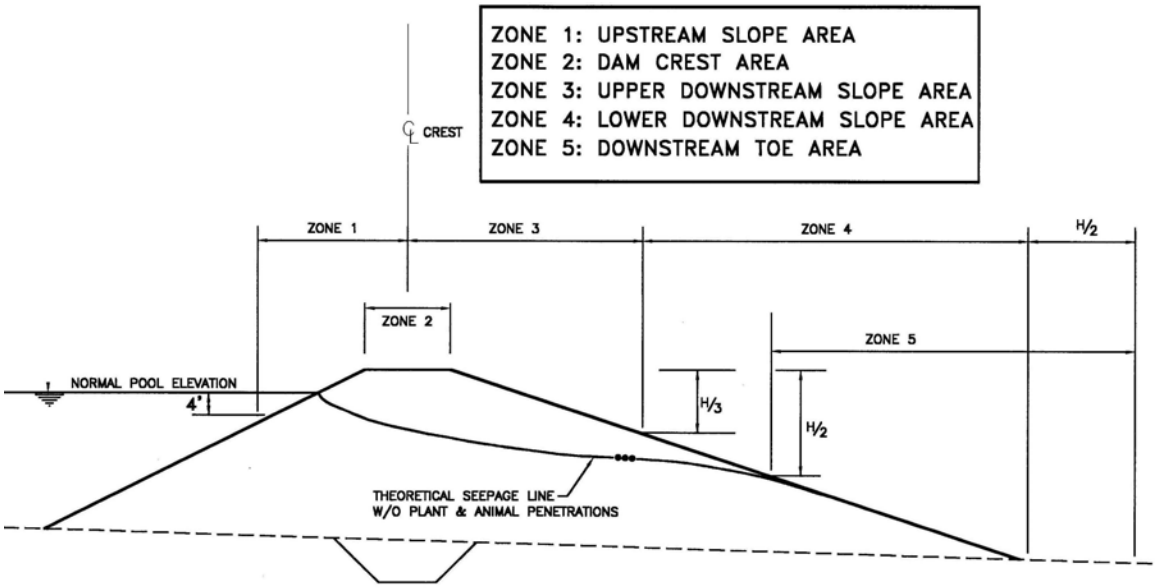
The purpose of developing a well-defined inspection and evaluation methodology is to allow the establishment of dam remediation design priorities. Most anyone having a basic understanding of the seriousness of tree and woody vegetation growth to the safety of

earthen dams can inspect an earthen dam and recommend removal of all trees, stumps, and root systems. However, inspectors and dam engineers must develop a definitive inspection and evaluation methodology in order to prioritize the seriousness of various locations of tree and woody vegetation growth on earthen dams.

Many individual dam owners do not have economic resources to undertake extensive dam remediation projects to bring an earthen dam into safe operation and performance conditions if the dam exists in a severely deteriorated condition. These owners often have to budget dam remediation projects over a scheduled maintenance and remediation construction period. Dam safety regulators, inspectors, and engineers that have developed and utilized a well-defined dam safety inspection and evaluation methodology can communicate priorities to dam owners so that the needed dam remediation design components can be completed in a prioritized manner. All too often dam safety regulators and engineers overwhelm dam owners with dam deficiencies without consideration of prioritization of deficiencies on dam safety, performance, and operation.

Dam Safety Inspection and Evaluation Zones

Five dam safety inspection and evaluation zones have been identified within the geometric configuration of a typical earthen dam. The delineated zones, illustrated in Figure 8, are not numbered in any implied order of seriousness relative to the impact of tree and woody vegetation growth, but have simply been numbered from upstream to downstream. The seriousness and potential impacts of tree and woody vegetation growth within each inspection and evaluation zone will be discussed during the description and identification of the delineated dam safety inspection and evaluation zones.



REMEDIAL DAM REPAIR ZONES

Figure 8

Inspection and Evaluation Zone 1 begins on the upstream slope of the earthen dam embankment at about four feet below normal pool elevation. Zone 1 extends laterally to the centerline of the crest of the dam. Tree and woody vegetation growth in Zone 1 is more critical relative to dam safety in the case of dams having a narrow crest width than those having a wide crest width. Zone 1 also includes the area subject to damage resulting from wave erosion and frequently recurring rapid drawdown events.

Inspection and Evaluation Zone 2 includes the entire width of the crest of the dam. Zone 2 overlaps Zone 1 by one-half the crest width. Overlapping a portion of Zone 1 with a portion of Zone 2 was done to emphasize the critical portions of both zones. Zone 2 is typically considered to be one of the least critical zones relative to dam safety issues associated with tree and woody vegetation growth. However, careful inspection of Zone 2 often reveals evidence of serious dam safety issues such as tension cracks, slope failure scarps, and erosion features that may or may not be related to tree and woody vegetation growth originating in other dam safety inspection and evaluation zones.

Inspection and Evaluation Zone 3 extends from the centerline of the crest of the dam to a point on the downstream embankment slope that is about one-third of the structural height below the crest of the dam. Zone 3 overlaps Zone 2 by one-half the crest width and is typically considered the least critical zone relative to dam safety issues associated with tree and woody vegetation growth. The seepage line and zone of saturation in this portion of an earthen dam embankment are typically sufficiently far below the surface to allow excavation of tree rootballs on the downstream slope of the dam without installation of a drain or filter system. A portion of Zone 2 has been overlapped by Zone 3 to draw attention to the most critical portion of Zone 3 that is the downstream portion of the crest of an earthen dam.

Inspection and Evaluation Zone 4 extends from a point on the downstream embankment slope that is about one-third the structural height of the embankment to the toe of the downstream embankment slope. Zone 4 is one of the two most critical zones relative to dam safety issues associated with tree and woody vegetation growth as well as other potential dam safety issues. This zone typically contains the interceptions of both the zone of saturation and the seepage line with the downstream slope. The close proximity of the zone of saturation and seepage line to the surface of the downstream embankment slope in this zone is a critical factor relative to dam safety issues associated with tree and woody vegetation growth. ***Tree and woody vegetation growth in this Zone 4 must be of major concern to everyone associated with the safety of an earthen dam and must be evaluated carefully relative to prioritization of dam remediation requirements.***

Inspection and Evaluation Zone 5 extends from the mid-height of the downstream embankment slope to a distance of one-half the structural height beyond the toe of the downstream embankment slope. This zone typically contains the interception of the seepage line with the downstream embankment slope and potential boiling (soil piping)

action beyond the toe of the downstream embankment slope. As such, this zone is critical relative to long-term, steady-state seepage stability considerations for an earthen dam. Tree and woody vegetation growth in this zone rapidly develops into serious conditions that directly affect the safety of an earthen dam. Zone 5 overlaps Zone 4 to draw attention to the more critical portions of both Zone 4 and Zone 5. As in the case of Zone 4, Zone 5 is typically considered to be one of the two most critical zones relative to dam safety issues associated with tree and woody vegetation growth. Tree and woody vegetation growth in Zone 5 must be a concern to all involved in the safety of an earthen dam. ***Maintenance and/or engineered dam remediation must be undertaken immediately in the event that tree and woody vegetation growth is significant within Zone 5.*** Control of tree and woody vegetation growth well beyond the toe of the downstream embankment slope cannot be over-emphasized. This area of an earthen dam is critical to overall stability and potential dam safety issues associated with embankment and foundation seepage.

The dam safety inspection and evaluation methodology set forth herein can be easily modified and/or extended to meet the needs of specific dam owners, dam safety regulators and inspectors, and engineers. This proposed methodology for dam safety inspections and evaluations should provide a basic plan that will allow the reader to customize and/or improve existing dam safety inspection and evaluation programs.

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Chapter 5
Controlling Trees and Woody Vegetation on Earthen Dams

The establishment and control of proper vegetation on an earthen dam are essential to maintaining a *safe* dam. Effective, shallow-rooted, vegetative cover is necessary to reduce and prevent embankment slope erosion. Trees and other undesirable deep-rooted vegetation should be prevented from being established for the following reasons:

- Permit effective inspection and monitoring of embankment crest and faces
- Allow for adequate access to dam for normal and emergency operation
- Prevent structural damage from embankment piping and internal erosion, unstable slopes from toppled trees, concrete wall/slab joint cracking/displacement, and other problems
- Reduce possibility of root-blocked drains
- Prevent blockage of spillway channel
- Discourage rodent and other animal activity by eliminating food source and habitat
- Eliminate expensive tree and brush removal and remediation costs
- Reduce impression of owner neglect

Consequently, dam owners should observe these four important rules:

1. Existing trees should be removed and not be allowed to mature on earthen dams, abutment groins, or around water conveyance structures
2. Trees or shrubbery should never be planted on or around new or existing dams
3. Existing trees should be watched closely until they are removed
4. Grasses and shallow-rooted native vegetation are the most desirable surface covering for an earthen dam.

Dam owners should be especially aware of dangerous or potentially hazardous tree conditions such as decaying or dead branches; lightening-caused splits; stripping or breakage; leaning, uprooted or blown-down trees; and seepage around exposed tree roots located along embankment slopes, especially in vulnerable downstream toe or abutment areas. Outward leaning trees may result from a slumping embankment condition that can be an indicator of slope instability. Any of these conditions warrants immediate attention by the owner and a qualified engineer.

Woody vegetation and tree growth creating undesirable root penetrations in earthen dams can be controlled or prevented by proper management of root growth into new dams and dams that have previously been cleared of trees by proper removal procedures. In this manual, some of the characteristics of woody vegetation and tree growth are presented relative to the aging of an earthen dam. Remedial dam repair design procedures and construction techniques are presented for proper removal of trees of various sizes in various areas of the geometric configuration of an earthen dam. Proper management and control of woody vegetation on new and previously repaired dams (tree removal projects) are based upon an understanding of soil conditions that limit root growth, factors that affect or promote root growth, and various procedures and techniques that can be used to stop, redirect, and/or reduce the rate of root elongation.

The purpose of this chapter is to provide a basic understanding of requirements for healthy root elongation, and to provide an introduction to some techniques and procedures that can be utilized to manage and control undesirable woody vegetation and tree growth on earthen dams. Development of a basic level of tree-literacy combines basic understanding of soil properties and characteristics with basic understanding of requirements and characteristics of healthy tree root elongation and tree growth into a single conceptual understanding of management and control.

Healthy Tree Growth Requirements

The primary requirement for healthy tree growth is an environment for continual elongation of tree roots. Continual elongation of tree roots is essential to healthy tree growth for the following reasons: 1) respiration that requires a continual flow of oxygen to root tissue through soil pores; 2) soil moisture uptake that requires continual availability of soil pore water that can be captured by root tissue; 3) nutrition that requires root systems to make continuously renewed soil/root surface contact to provide needed elements and nutrients for healthy tree growth; and 4) support and stabilization that requires soil-to-root surface contact to resist externally applied loads.

Managed tree root growth control is required to prevent or minimize dangerous impacts on dams. To constrain root growth, identification of soil attributes and it's supporting environment that promote or limit growth is required. By understanding what soil conditions limit growth, various tools and techniques can be used to stop, redirect, or inhibit tree root growth and elongation. The following discussion on root growth requirements, limitations and mechanics is based on a series of publications authored and furnished by Dr. Kim Coder of the University of Georgia Cooperative Extension Services (Coder, FOR98-9, -10, -11, & -13, 1998). The reader is referred to these well-referenced publications for further and more detailed information.

Trees are not much different from all living organisms, relative to biological needs. Trees must have (1) oxygen gained through respiration, (2) water gained through adsorption and absorption, and (3) nutrition gained through adsorption and absorption, and (4) a stable foundation to withstand external forces. General root growth resource requirements are summarized in Table 1. Roots utilize soil spaces for access to water and essential element resources, and soil mass to provide structural support. Soil minerals surround the water-filled and air-filled voids or pores. These pores are continually filling and draining with water and air, depending upon the availability of water, water uptake, and atmospheric air. Root growth follows pathways of interconnected soil voids. Such voids result because of space between soil particles, between soil structural units (i.e., blocks, plates, aggregated soil, etc.); along soil fracture lines, lenses, joints, and various interstitial interfaces; and through paths of biological origins such as decayed or shrunken roots, animal burrows, etc. Better means of controlling growth can be developed by understanding resource levels that encourage and limit root growth (Coder, FOR98-9, 1998).

Root Resource	Requirements	
	Minimal	Maximum
Oxygen in soil atmosphere	2.5%	21%
Air pore space in soil (for root growth)	12%	-
Soil bulk density restricting root growth	-	1.4 g/cc (clay) (note: 1 g/cc = 62.4 pcf)
	-	1.8 g/cc (sand)
Penetration strength (water content dependent)	0.01 kPa (note: 1 kPa = 1kN/m^2 = 10 mbar = 0.145 psi)	3 MPa
Water content in soil	12%	21%
Root initiation (O_2% in soil atmosphere)	12%	21%
Root growth (O_2% in soil atmosphere)	5%	21%
Progressive loss of element absorption in roots (O_2% in soil atmosphere)	15%	21%
Temperature limits for root growth	40^{o}F/4^{o}C	94^{o}F/34^{o}C
PH of soil (wet test)	pH 3.5 (acidic soils)	pH 8.2 (alk. soils)

Table 1. General list of tree root growth resource requirements (After Coder, FOR98-9, 1998).

Roots survive and proliferate where adequate water is available, temperatures are warm, oxygen is present and other essential resources are concentrated. They generally tend to be shallow, limited by available oxygen and water saturation in deeper soil. However, near the base of the tree, deep-growing roots can be found, but are aerated by soil fissures and cracks and around roots where mechanical forces exerted by wind loads on the tree loosen the soil.

The ability of primary root tips to enter soil pores, open soil pores and elongate through pores is dependent upon the force generated by the root and the soil penetration resistance. As the diameter and length of an expanding root increase, its strength to resist

structural failure and its expansive force it can generate both increase. The chance for structural failure increases with longer and smaller diameter roots, while short and thick roots generate significant force but minimize structural failure. Radial expansion of the root structure immediately behind the tip also helps to fracture or reduce penetration resistance in the soil ahead of the elongating root tip.

Roots use the mass of the tissues behind the tip, including root hairs, lateral root formation, and microbial entanglements to minimize the length over which root elongation force (or pressure) is expressed, thus reducing structural failure potential. As the root elongates, only root tissue within about six root diameters behind the tip is involved with force generation. Root tissue further back will act as an anchor and support base against the soil. Root tip pressure can be enormous and can range up to 9-15 MPa (9,000-15,000 mbars, 130-215 psi, or 18,700 – 31,000 psf)), with 1MPa or about 15 psi being most cited. Thus a typical root tip diameter of one millimeter is capable of generating up to about a 0.25-pound force. While tree roots cannot produce enough pressure to penetrate concrete, pipes, and most plastics or metals, they do take advantage of cracks, holes, joints and faults already in materials and exacerbate cracks and faults by growing root mass within, beneath, or around materials. When water supply is short, or when temperatures increase, diameter of roots are sacrificed to facilitate more elongation. Roots can lose more than one-third of their diameter under dry conditions, leaving roots thinner and elongating at a slower rate. Such conditions can generate passageways and set up the possibility for piping and internal erosion conditions in an earthen dam. Additionally, the loss of root contact with the soil and potential for mechanical failure of the elongating root system can lead to poor tree support, thus making a tree vulnerable to wind forces and possible upending. Tree roots are opportunistic in the colonization and control of resource space. The attributes that make a root an ideal resource gatherer for the tree conspire to make roots soil matrix explorers and fault exploiters. To prevent, control or eliminate roots from the soil infrastructure, dam owners and dam design engineers need an understanding of environmental conditions that limit and promote root

growth. The foregoing discussion is summarized in terms of the four main requirements and conditions for tree growth and tree root development as follows:

Trees need to breathe. Oxygen is required for healthy tree growth through continual root elongation. In order for proper root respiration to occur, oxygen must continually move through soil pore spaces to the root tissue. Tree roots are not the only living things in the soil pore system that is competing for oxygen. As oxygen flows toward an otherwise healthy root system, enormous numbers of aerobic organisms can utilize portions, and perhaps all, of the available soil pore space oxygen before it can be utilized by root systems. If all of the oxygen is used before reaching the root system, changes must occur in the characteristics and growth rate of the root system. Trees have the ability to generate energy for short periods using carbohydrates in low or non-oxygen environments. However, this process is taxing on tree growth, and is approximately twenty times more inefficient than under normal oxygen availability and respiration conditions (Rendig & Taylor, 1989; Coder, FOR98-10,1998). Air-filled voids in soil must be of sufficient size and continuity to allow carbon dioxide to move away from the root system and oxygen to move to the root system in order to sustain healthy root elongation and tree growth. Water-filled voids resulting from saturated soils around roots inhibit this process at a rate 10,000 times less than air-filled voids (Rendig & Taylor, 1989; Coder, FOR98-10, 1998). When oxygen drops below two to five percent of atmospheric content, root growth and the root's ability to generate elongation force significantly declines (Souty & Stepniewshi, 1988). Table 2 summarizes air void content requirements of various soil texture and types that limit root elongation. The table data shows that, for most embankment soils, trees need at least 10-25% air-filled voids in order to promote healthy growth. In summary, ***Roots that cannot breath die, resulting in unhealthy, unstable, and/or dead trees.***

Soil Texture	Root-limiting % pores normally filled with air
Sand	24%
Fine sand	21
Sandy loam	19
Fine sandy loam	15
Loam	14
Silt loam	17
Clay loam	11
Clay	13

Table 2. Root growth limiting air-pore space values by soil texture (After Coder, FOR98-10, 1998)

Trees need to drink. Second behind the need for oxygen is a tree's requirement for water. Water uptake of trees occurs both by adsorption and absorption. In the same manner as that described for oxygen supply, tree root systems depend upon the flow of soil pore water to the root system to continually uptake sufficient water to sustain healthy root elongation and tree growth. Soil voids that are sufficiently small to prevent continual flow of pore water can limit the amount of water that elongating roots can use within the soil matrix. Often, the moisture uptake is typically lower than that required for root elongation and healthy tree growth. As noted in Table 1, root elongation and healthy tree growth cannot be sustained where average soil moisture contents are less than about 12 percent nor greater than about 40 percent. ***Soils that restrict free moisture movement preclude healthy root elongation (penetration) and healthy tree growth. Compacted soils limit pore space and therefore tend to limit supplies of both oxygen and usable water to trees.***

Trees need nourishment. Third, roots systems must provide nutrition for healthy root elongation and tree growth. Root elongation is required to encounter needed minerals, nutrients, and companion microorganisms in the soil mass. Root elongation must be continuous since replenishment of nutrients in soil is a long-term process that will not meet the requirements of stationary root systems and trees. Elongating or growing root systems continually encounter soil pores of various sizes. Soil pores that are larger than root tips create little resistance to root elongation; however, as soil pore sizes approach the size of root tips and/or become smaller than root tips resistance to root elongation increases significantly. Soil pores that are much smaller than root tips may be deformed in weak or soft soils; however, these small soil voids will reject root penetration in dense or strong soil masses. Roots cannot 'squeeze' into small, rigid soil pores within soil masses where soil strength and density preclude soil deformation and, therefore, growth is inhibited. ***High strength, dense soil masses containing limited required nutrients for healthy root elongation will not sustain healthy tree growth.***

Trees need foundation support. Tree stabilization and support is provided by both components of the tree root system. The root plate (root ball) provides vertical support for the weight of the tree much the same as a shallow foundation system provides support for a building column. However, tree root systems must also resist laterally applied external loads (i.e., wind loads). Lateral root systems provide required lateral support capacity against horizontal forces through development of soil-to-root frictional forces (nature's own application of "soil nailing"). Inadequate root elongation results in reduction of base and lateral support, resulting in an unstable tree that becomes unhealthy and/or subject to failure under laterally applied loads. ***Dense, compacted soil masses preclude proper lateral root elongation thus creating unstable, unhealthy trees that are subject to premature failure.***

In summary, whether in design of new dams or in maintenance of older existing dams, engineers and dam owners need to appreciate the forces, conditions and resources that control and affect the health and stability of trees so as to prevent or discourage trees from growing on new or re-constructed dams or to understand why/how trees respond to given and changing conditions on existing earthen dams.

Tree Root Elongation Management and Control

There are at least eight well-documented methods and tools available to control and limit tree (root) growth through the application of tree root elongation processes, resource availabilities, and soil preparation characteristics. These methods take advantage of depriving the tree roots of ideal resource needs for healthy growth discussed above. While these methods have been primarily used in urban or agricultural applications and settings, some methods are directly applicable to use on earthen dams and include the following methods described by Coder (FOR98-11):

1. **Intelligent designs** and applications that include techniques and materials based upon knowledge of tree growth and root development requirements. Here, minimizing available soil material faults or interfaces and tree root spaces are the preferred means for controlling and discouraging tree growth with the philosophy 'Build it correctly and they will not come!'

2. **Root kill zones** utilizing cultivation methods, sawing and cutting, trenching, vibratory plows, and chemicals to control, discourage, and remove root structure. However, these methods often result in damaging or killing the tree that, perhaps, should have been removed in the first place.

3. **Root exclusion zones** utilizing soil structure changes, soil compaction, water/aeration, stress, anaerobic conditions, soil injections and slurries, soil additives, and chemicals to prevent roots from colonizing the soil structure areas due to applied physical or chemical changes to the soil. Changing the soil structure, pore space volume or drainage/aeration matrices can generate a soil environment that roots cannot effectively grow and sustain. A variety of physical- or chemical-based soil altering materials (i.e., soil injected clay slurry or cement solutions) can be effective, at least over the short term if adequate soil volume is treated. Compacting soils appear to be a very good way to prevent root colonization. High density soils increase the resisting strength of these soils to root penetration and deprive the roots from needed oxygen and available water. Certain types of clay soils, freeze-thaw cycles, biological activity, and poor soil compaction can, over time, produce root-accessible pore space. Soil or infrastructure building material additives that neutralize or sterilize the available minerals and nutrients such as nitrogen gas, sulphur, sodium, zinc, borate, salts, or herbicides may produce serious environmental consequences, short-lived results, and non-targeted damage potential. Other methods or additives may be cost-prohibitive. See Figure 6 at end of chapter for root clearance zones.

4. **Air gap systems** designed to provide temporary and permanent air spaces for root pruning and lack of root support by use of large cobble stone barriers and drain systems. One of the more effective means of controlling tree root growth is providing stone matrices that dry quickly, create large air gaps, have poor water-holding ability, and are impermeable to systematic root penetration. Gravel layers or areas having at least 3/4 inch stone size or clean, graded, medium-sized rubble (crushed brick remnants or recycled paving and other materials), provided it is not covered or filled in with sand, are reported to produce large enough air gaps to discourage root growth.

5. **Barrier systems** using commercial root traps, root deflectors, containment devices, metals, screens, plastics, paints, and inhibitors. One of the easiest and most available materials used to control root growth are various types of 2D-type screens and barriers. While some barriers are not completely effective, many types have been shown to be effective. A list of mechanical, biological and chemical tree root growth control barriers, products and systems is shown in Table 3.

a. Copper sulfate-soaked, synthetic, non-woven fabric
b. Copper screen
c. Cupric Carbonate ($CuCO_3$) in latex paint
d. Fiberglass and plastic panels
e. Fiber-welded geosynthetic fabric/mesh
f. Galvanized metal screen
g. Ground-contact preserved plywood
h. *Geomembranes and heavy rigid plastics
i. Infrastructure aprons and footings
j. Metal roofing sheets
k. Multiple layers of thin plastic sheets
l. Nylon fabric/screen
m. Permeable woven geosynthetics
n. Rock-impregnated tar paper/felt
o. *Slow-release chemical barriers
p. Thin layered bitumen & herbicide mixtures
q. Woven and non-woven slit-film plastic sheets

*Common commercial tree growth control products available

Table 3. Selected list of tree root growth control barriers (after Coder, FOR98-11, 1998)

The costs of these products will likely continue to decrease as the demand for these products increases in the future. Of the barriers shown in the list, three types are most commonly used: traps (root engaging and constricting), deflectors (walls), and inhibitors (chemical constraints). Combined features of the barrier, the site, and barrier installation and maintenance are critical to their effectiveness, but no barrier should be assumed to stop all roots under all conditions. Most types of mechanical and chemical barriers have limited effectiveness lives and this should be factored into any long-term cost analysis. The reader is directed to the Table 3 reference source and other related publications for details on commercially-available root barriers.

6. **Directed growth systems** to concentrate roots in desired directions, guide root growth along channels, allow root survival in desired areas, and create root culverts or layers. As noted earlier, roots are opportunistic and grow and proliferate where there are good supplies of resources. Understanding root elongation, colonization, and survival processes allows growth-favoring soil layers, corridors, and areas to be designed for directing or deflecting roots away from infrastructures where tree roots can be harmful. Several methods or systems are used to attract, deflect, channel or lead roots in a direction or area as needed. One attraction method used is called "baiting" and involves providing ideal essential soil condition resources in a direction away from an infrastructure. The net result is a much higher survival and growth rate in that part of the root system as opposed near infrastructures where root damage can occur. Water, growth nourishment elements, and oxygen should be limited and compaction should be maximum near infrastructures.

   Another method is to "shepherd" roots to desirable locations using trenches, channels, layers, raceways, tunnels, and other devices that are surrounded by root control obstacles, barriers, or resource constraints. Growth channels filled with rich, well-aerated, ecologically healthy growth medium will encourage root colonization and survival in areas away from sensitive infrastructure targets.

7. **Selection of desired species** of trees that require lower soil oxygen environments, have improved root morphology, and are more effective species for long-term solutions. This method focuses on choosing and planting available tree species that can survive under rather limited or harsh environmental conditions. Several tree species are available that are small in size, have shallow and less aggressive rooting, and are slower growing. Dam owners, however, should be reminded again that trees in general are not a good plant option and have no place on dams; instead, more desirable, native grasses should be planted and maintained.

8. **Creating avoidance zones** to separate tree growth from earthen dam embankments and dam appurtenances where root damage may be critical thus establishing biological-free zones that reduce potential problems. This method simply recognizes that there are places where trees are acceptable and other places, namely dams, where they are not (see Figure 6).

The most practicable of these methods for use on earthen dams are those associated with intelligent design development, exclusion zones, kill zones, and barriers. Within this group of suitable methods the combination of intelligent design development and exclusion zones are the most effective. With an understanding of the previous meshing of soil properties with healthy tree root elongation, it is not difficult to develop an intelligent design scheme for new dams and the remedial repair of existing dams. An intelligent design philosophy associated with dam embankment design and construction would involve proper embankment soil compaction as the means of exclusion of root elongation.

In summary, there are many tools, methods and options for minimizing or preventing tree root-caused damage to earthen dams. The most important management (and design) concept to understand is how tree roots are invited to be associated with interstitial elements and colonize soil matrices and discontinuities, and resource availability areas. Our responsibilities as owners and dam design engineers must lie with creating and using any or a combination of the numerous root growth control tools and techniques that are tree-literate so that trees do not have the opportunity to become a safety problem to embankment dams and their appurtenances in the first place.

Exclusion by Embankment Compaction

Design and construction practices of using optimum compaction of embankment soils reduce potential settlement of embankments, increases shear strength of the embankment soils, decreases the permeability of the embankment soils, and minimizes long-term changes in the physical and engineering properties of soils. When embankment soil compaction results in the attainment of desirable objectives from a geotechnical engineering behavior perspective of earthen slopes, compaction of embankment soils also precludes tree root growth and elongation as a result of exclusion of most of the requirements for healthy root elongation and tree growth. As has been previously noted, densely compacted soils discourage root elongation through increased resistance, lowered oxygen levels, and reduced available water. Traditional embankment soil compaction specifications require that the soil be compacted to about 95 to 98 percent of the standard Proctor maximum dry density as determined by ASTM D-698. Furthermore, most properly written soil compaction specifications generally require that compaction moisture contents be maintained about two percent below to three percent above optimum moisture content. At these degrees of compaction and at these moisture contents, soil oxygen content, water content, and soil pore size are not available for healthy root elongation and tree growth. Even if there is sufficient moisture content in the soil to otherwise sustain healthy root elongation, the soil pore sizes are so small that

available pore water cannot be effectively moved to the root system. Consequently, the compacted dam embankment fill soil produces an exclusion system that mechanically impedes healthy root elongation and tree growth. Table 2 provides a summary of minimum air voids for various soil types required to impede root elongation for healthy root and tree growth.

Maintenance Mowing and Kill Zones

The second most effective method of controlling woody vegetation and tree growth on dam embankments is through the use of native grass or ground cover with maintenance mowing, and using kill zones where necessary around critical structures to control trees and other undesirable nuisance-types of vegetative growth. Maintenance mowing should be done ***at least*** twice per year with one mowing scheduled for spring after initiation of new spring growth and the second mowing scheduled for late fall immediately prior to the first killing frost or freeze (See Chapter 7). The spring mowing should be a very close cutting of all vegetation to allow maximum sunlight to penetrate to desirable grass cover species. The fall cutting should not be as close as the spring cutting to provide maximum resistance to surface runoff erosion and to provide cover for desired wildlife species (quail, rabbit, grouse, songbirds, etc.).

In areas where regular maintenance mowing is not practical to control woody vegetation and tree growth, the selective use of herbicides might become necessary to control small woody vegetation and tree growth. There are many commercially available herbicides that are environmentally safe to use in most applications. However, one must always be careful in the use, or overuse of herbicides, because they are design to kill and/or impede (slow) plant growth. Overuse of herbicides may contaminate areas of the dam embankment to such an extent that desirable grass cover cannot be effectively grown. One must always follow manufacturers recommendations when using herbicides, or better yet, solicit the advice of the nearest USDA/NRCS agent prior to using herbicides to control woody vegetation and tree growth on earthen dams.

Chemical Barrier Systems to Inhibit Root Growth

Commercially available barrier systems are effective in controlling root elongation and growth; however, many of these barrier systems are relatively expensive and cannot be justified for placement over the entire earthen dam embankment. These barrier systems are often economical for placement on portions of earthen dams where accessibility is difficult after construction and/or where particularly problematic and nuisance woody vegetation and tree growth is likely to occur.

One typical biocide product, called "Biobarrier©" is marketed and promoted, among other applications such as sidewalk and landfill cap protection, to prevent tree and plant roots from penetrating dams. The product consists of long-term, slow release nodules containing Trifluralin herbicide, that are bonded to a geotextile fabric as shown in Figure1.

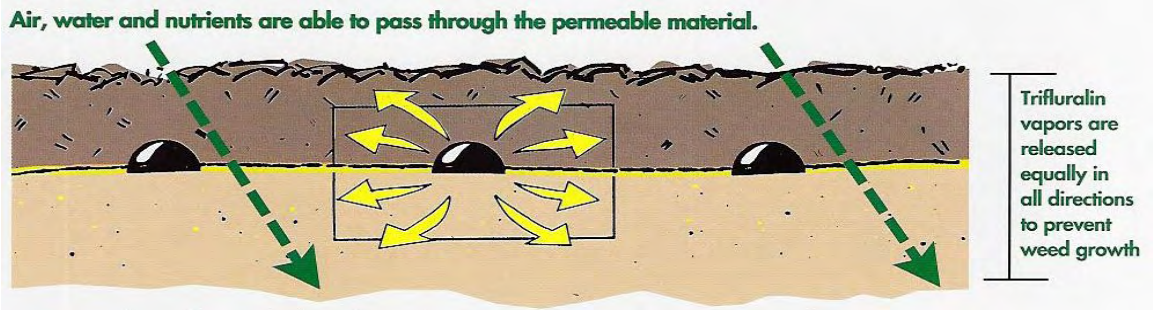

Figure 1. Chemical biocide barrier installation showing slow-releasing biocide nodules attached in a woven fabric matrix and installed under a cover of soil, mulch, gravel or stone (Biobarrier©).

This particular barrier is environmentally acceptable to EPA and indicated to be effective against all types of roots around pipes, hardscapes, and dams and levees. While the product is guaranteed for 15 years, its life is inversely proportional to environmental temperature conditions.

For example, its effectiveness is expected to be about 40 years at 20°C (68°F) and about 100 years at 15°C (60°F). For deep soil cover, it is expected to last 100 years; for near soil-surface weed control installations, where temperatures are higher and cycle daily, the projected life is expected to exceed the guaranteed 15-year life. Figures 2 and 3 show an application of this product on a 25-foot high and 350-foot long earthen dam to prevent deep penetration of deep-rooting native trees and woody vegetation such as willows, sagebrush, and chokecherries.

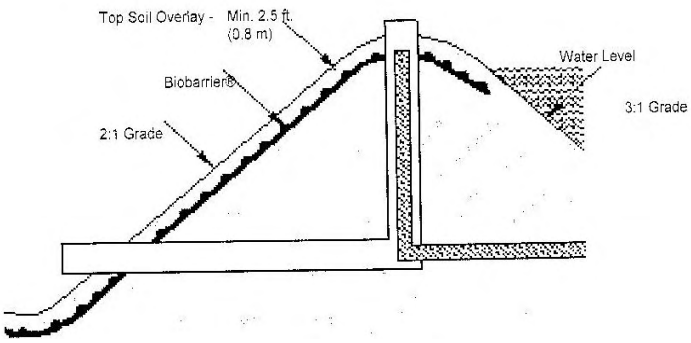

Figure 2. Earth dam installation of chemical

Figure 3. Installed chemical barrier on a dam in Montana (Kershner, 1992)

Herbicidal Applications

Herbicidal delivery to control undesirable vegetation depends on several considerations which include (a) types of plants and weeds (herbaceous, vines, trees, brush, phreatophytes, etc.), (b) site conditions (geology/sinkholes/karst), topography, (c) proximity to water bodies, (d) riparian land use, (e) sensitive environmental factors (Federal, state & local regulations; potential off-site wind drift over water or land), and (f) application factors (dosage, placement, retention time, plant growth stage, physiological factors, and method of application). A very important consideration is for the user to follow the herbicide manufacturer's warnings and instructions. The user is

also encouraged to consult with a local county extension office or agent to obtain advice on the best and safest herbicide to use and on what recommended application technique to use. While there are several herbicidal delivery methods available, the most common techniques are shown below in Figure 4.

- Foliage spraying
- Tree injection
- Frill or girdle treatment (slash through bark then spray or paint)
- Basal bark spraying
- Cutting tree and poisoning stump
- Soil treatment
- Other

Figure 4. Herbicide delivery application methods

Some of these techniques and herbicides used are illustrated in Figures 5a – 5f. The U. S. Department of Agriculture (SCS, now NRCS) published a useful methods, treatment points, and time of treatment guidelines for controlling trees and brush on dams, including some of the applications listed in Figure 4 (USDA, 1988). Table 4 summarizes the USDA recommendations. With the exception of Krenite, which is applied to the foliage, 2,4-D is the only approved herbicide for poisoning trees on dams. 2, 4-D is manufactured by several companies and is sold under several trade names. In all cases, the user is cautioned again to follow the manufacturer's instructions and should consider the manufacturer's label instructions to supercede recommended instructions in the USDA table.

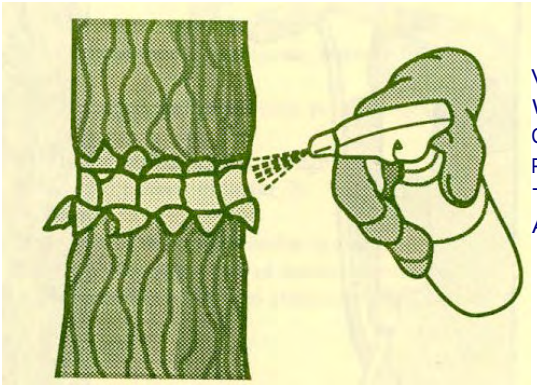

Figure 5a. Frill cut application.

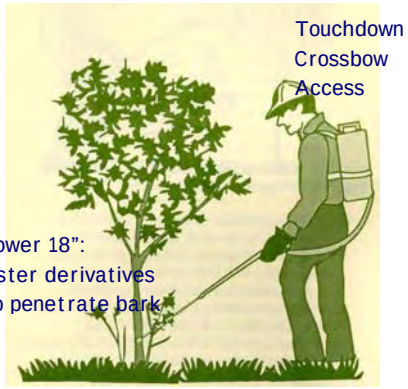

Figure 5b. Basal bark spraying.

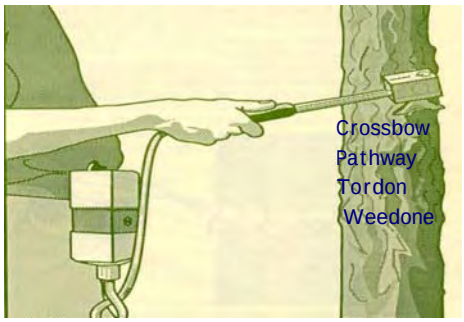

Figure 5c. Hypohachet application.

Figure 5d. Cut-stump application.

Figure 5e. Backpack foliar application on dam.

Figure 5. Applications and techniques for different herbicidal deliveries to trees and brush, with example commercially-available herbicides listed.

Figure 5f. Tractor spraying application on dam.

Method of Application	Recommended Time
• Cutting trees and poisoning stumps • Injection • Foliage spraying • Frill treatment (trees larger than 4" dbh) • Basal spraying (trees smaller than 6" dbh) • Prescribed burning (trees smaller than 2" dbh)	• Growing season • Anytime • Last two (2) months of growing season • Anytime • Growing season • See technical specifications

Table 4. Recommended methods and time of herbicide treatment application (USDA, 1988).

USDA recommends that trees killed by herbicide should be removed within the year following treatment to prevent front slope from falling into the reservoir and plugging the spillway. Downed trees on the back slope should also be removed to prevent potential problems of seepage, erosion, burrowing animals, etc.

The reader is referred to the USDA guideline for detailed discussion on each of the six treatment methods listed in the above table. These methods can be applied to establish tree and woody plant clearance or avoidance zones on and around dams as illustrated in Figure 6.

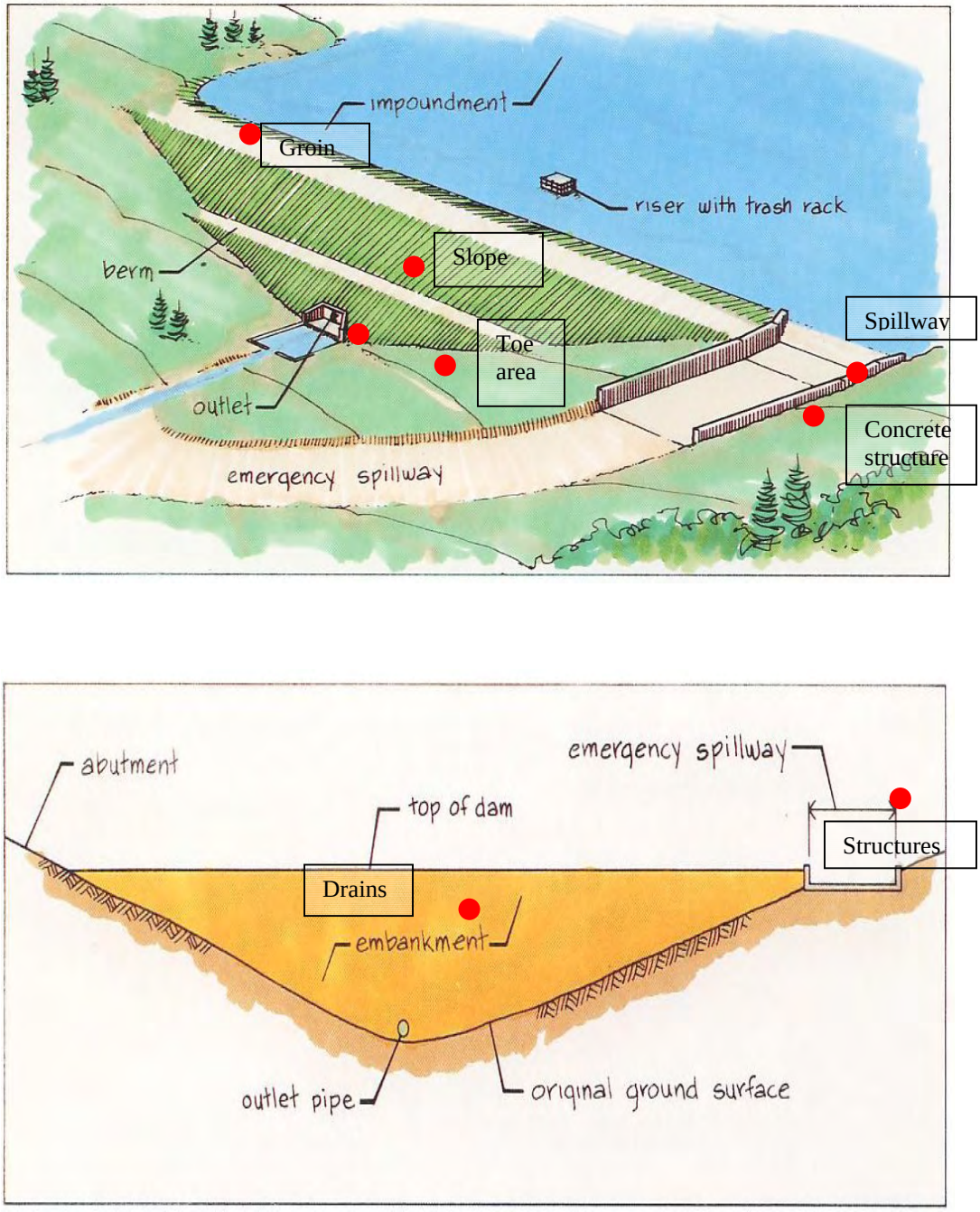

Figure 6. Tree clearance zones for embankment dams and dikes.

Desert Plants

Deep-rooted desert plants, when left unchecked, can propagate rapidly on earthen dams located in arid and semi-arid regions of the U. S. Some of these deep-rooted plants include Desert Broom shown in Figure 7, Salt Cedar, Mesquite, Cypress, Cottonwood and Paloverde. All of these species require considerable effort to control and should not be allowed to become established anywhere on dams. Palm trees can be a problem in that they are shallow-rooted, but develop a large root ball that can produce large cavities when toppled during high winds. Upstream and downstream access roads, in place at many dams, should be utilized to create a buffer zone between these species and the toe of dams.

Figure 7. Deep-rooting Desert Broom Plant

The Maricopa County, Arizona, Flood Control District (MCFCD) recommends, in cases where deep-rooted plants are two feet in height or less, that they be controlled with a 3-5% solution of Roundup® Pro (Renckly and Drake, 1999). If the plants are over two feet in height they should be hand cut to ground level. The stumps should be treated within the first five minutes by an almost straight mix of either Roundup Pro® or Garlon 3A-Garlon 4®, depending on the temperature conditions. MCFCD recommends that when

treating Salt Cedar near waterways that Rodeo be sprayed at a 3-5% solution with six ounces of Siltwet® per acre added. This is sprayed on plants two feet in height and under. Plants over two feet are hand cut and the stump treated with an almost straight solution of Rodeo® within five minutes of cutting the plant.

Revegetation on earthen dams is recommended to minimize erosion on the embankment slopes and to provide natural landscaping for earthen dams. MCFCD recommends hydro-seeding over labor-intensive hand-seeding to revegetate dam embankments. Figure 8 illustrates hydro-seeding operations on a floodway dam. Seed, water, tack material and a wood fiber or paper mulch are mixed in a hydro-seeder and sprayed directed onto the slopes. The seeds are encapsulated in the mulch and tack material until enough moisture is present to begin the germination process.

Figure 8. Hydro-seeding operations on a floodway dam in Maricopa County, Arizona (Renckly & Drake, 1999).

MCFCD has found that it takes 2 to 3 years before "significant" vegetative cover results are achieved because of the arid climate and high degree of embankment compaction. MCFCD determines the desirable seed mix by first laying out a test acre on the dam embankment and a plant count is then taken of all the different plant species that are native to the area and placed on the test acre. This plant count is converted by the seed supplier into the amount of seed needed to germinate the desired amount of the species per acre. The amount of pure live seed (PLS) applied for individual plant species also varies by availability from the local seed supplier. Table 4 shows a seeding mixture specified for one of the District's dams and is typical of specified hydro-seeding mixes. No deep-rooted species are allowed in the seed mix.

MCFCD has found that revegetation efforts have successfully reduced erosion problems, but has attracted both desirable and undesirable animals.

SEEDING MIXTURE

Common name	Scientific Name	Pounds of Seed Per Acre
Purple three-awn	Aristida purpurea	4
Indian Wheat	Plantago insularis	3
Needle Grama	Bouteloua arstiodoides	1
Desert Marigold	Baileya multiradiata	1
Mexican Gold Poppy	Eschschotzia mexicana	1
Creosote	Larrea tridentata	8
Brittle Bush	Encelia farinosa	2.5
Bursage	Ambrosia deltoidea	2

** **Note:** **Apply 1500 pounds of wood fiber mulch in Hydro-seed mix, plus 150 – 200 pounds tack material per acre.**

Table 4. Typical seed list specified for a flood control dam managed by the Maricopa County, Arizona, Flood Control District (Renckly & Drake, 1999)

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20. STS Consultants Ltd., ASDSO Working Group, Dam Safety Guidebook, 1985.

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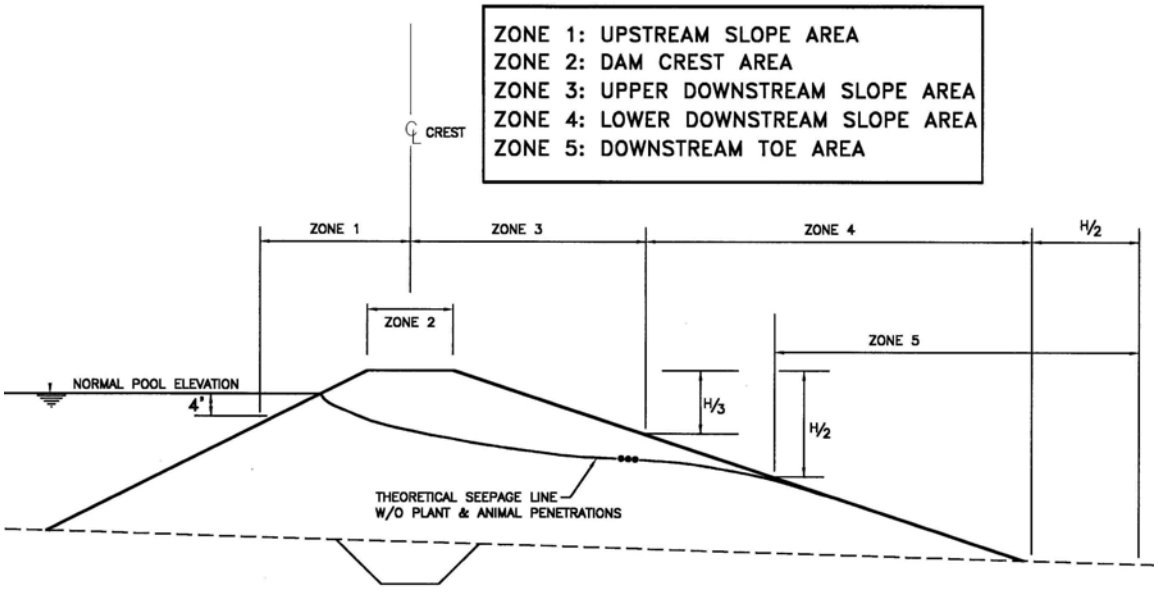
Chapter 6
Dam Remediation Design Considerations

Specific dam remediation design considerations, procedures, and techniques will be considered for each of the previously identified dam safety inspection and evaluation zones. Figure 1 presents these zones as a review prior to discussion of potential dam remediation design considerations for each zone. Dam remediation design alternatives presented herein should be considered examples. These remediation design examples should not be considered the only alternatives for use in dam remediation design to correct deficiencies associated with tree and woody vegetation growth on earthen dams. Some additional dam remediation design alternatives presented for correction of tree and woody vegetation growth related deficiencies also provide positive correction of other deficiencies and protection against other types of earthen dam deterioration.



REMEDIAL DAM REPAIR ZONES

Figure 1

Inspection and Evaluation Zone 1

Figure 2 illustrates potential problems that can occur in Zone 1 with respect to tree and woody vegetation growth on earthen dams. This illustration also depicts the occurrence of wave erosion, vehicle access, and surface runoff erosion. Potential problems illustrated include instability of relatively large trees on the upstream slope and dam crest, and alteration of the seepage line as a result of wave erosion.

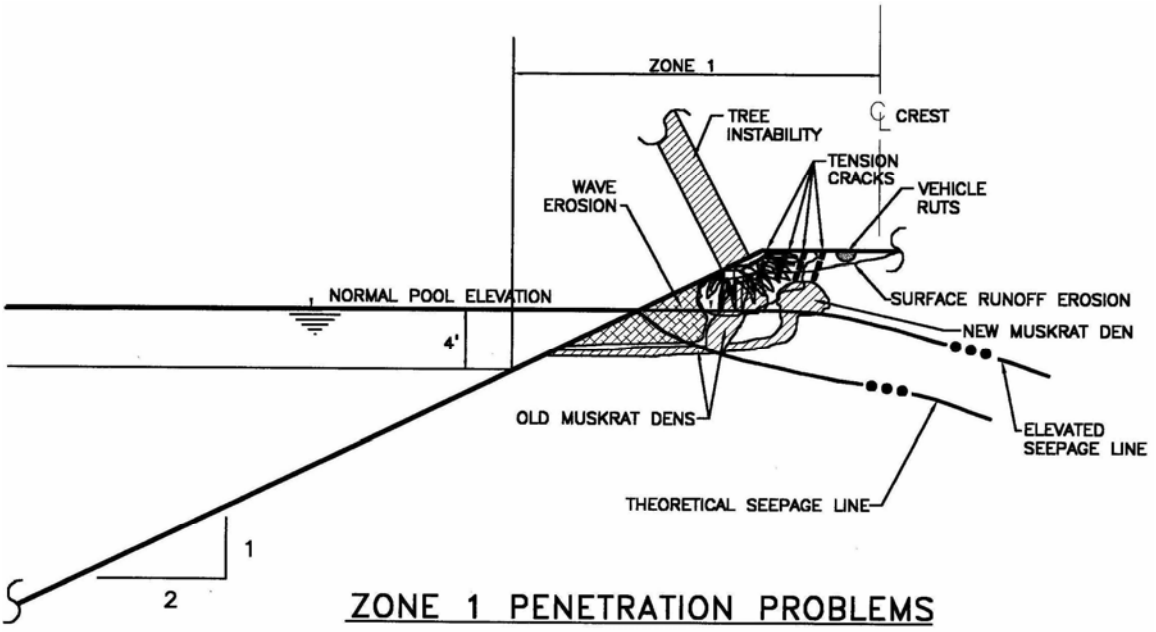


Figure 2

Dam remediation design techniques necessary to address potential problems illustrated in Figure 2 are illustrated in Figures 3 and 4. Dam remediation construction typically requires lowering of the normal pool elevation and/or complete drawdown of the retained reservoir. This is particularly true for dam remediation construction in Zone 1. The normal pool elevation should be lowered as far ahead of the scheduled dam remediation construction as practicable.

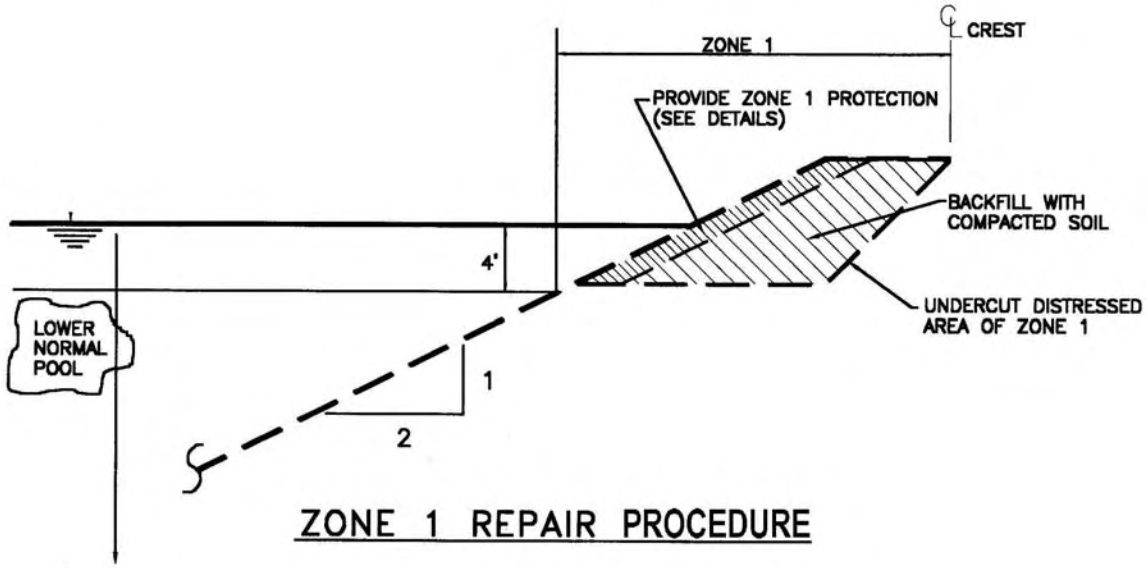


Figure 3

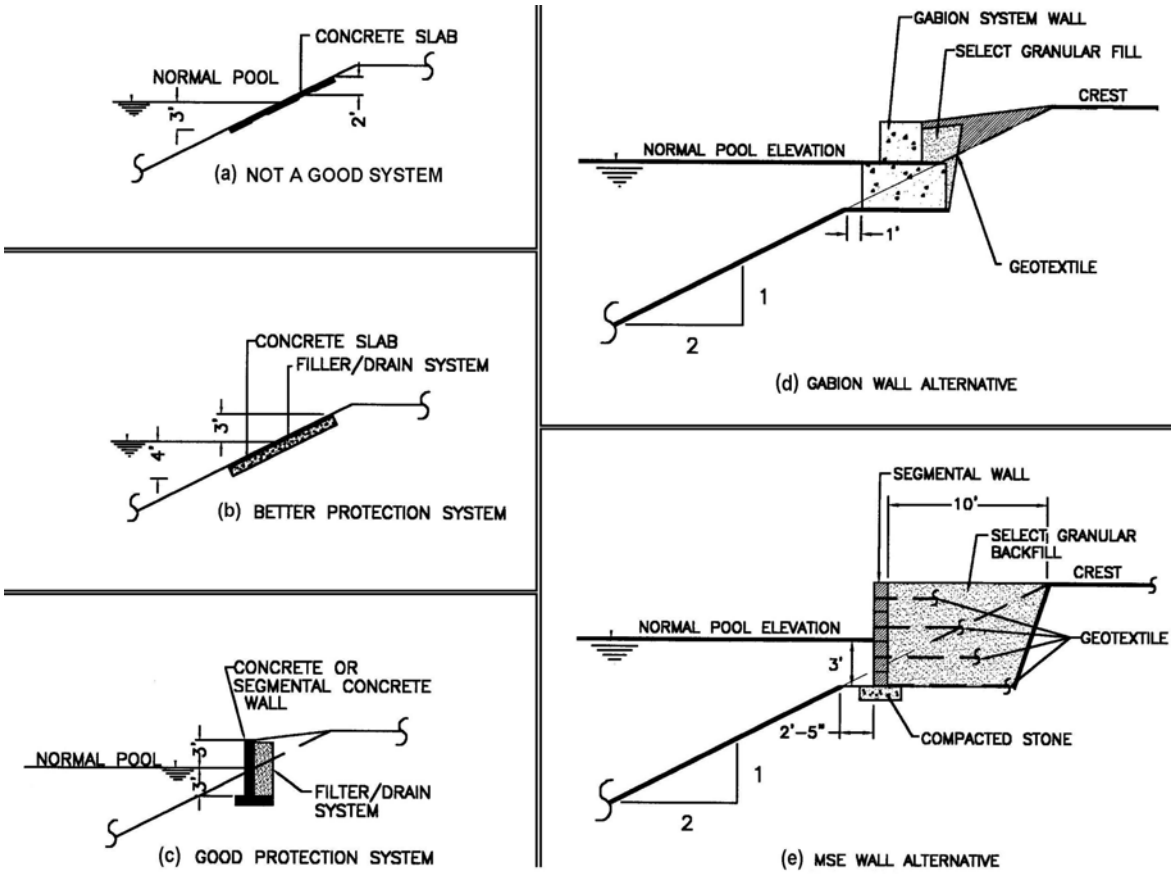


Figure 4

Tree and woody vegetation growth in Zone 1 must be undercut to remove all stumps, rootballs, and root systems developed by tree penetrations as illustrated in Figure 3. The required depth of undercutting typically extends to near the limits of Zone 1, which is about four feet below normal pool elevation. In the case of earthen dams with narrow crest widths, the backslope of the undercut area will typically extend to near the centerline of the dam crest or the downstream limits of Zone 1. Subsequent to undercutting affected areas of Zone 1, the undercut area must be thoroughly inspected to confirm that all major root systems (greater than about one-half inch in diameter) have been removed during the undercutting operation. Following inspection and approval of the undercut area by the engineer, suitable backfill should be placed in the excavation and properly compacted to the dam remediation design limits. Backfill should consist of approved embankment fill material and should be compacted to a minimum of 95 percent of the maximum dry density of the fill soil as determined by the standard Proctor compaction test (ASTM D-698). In conjunction with the undercutting and backfilling, the dam remediation design should include a slope protection system to deter future tree and woody vegetation growth and reduce the potential for wave and surface runoff erosion.

Figures 4(a) through 4(c) illustrate various configurations of rigid (concrete) upstream embankment slope protection systems. Figure 4(a) illustrates a concrete slab being placed directly on the upstream slope from about three feet below to about two feet above normal pool elevation. While this system is somewhat limited relative to the area of protection, the most critical aspect of this system is that it provides no filtration and/or drainage system beneath the concrete slab. Continual wave action and the buildup of hydrostatic pressures beneath the concrete slab will eventually result in downward movement of the slab. Figure 4(b) illustrates a better dam remediation design utilizing a concrete slab slope protection system. This slope protection system has been improved over the original system by covering a larger area of the upstream slope and by providing a filter system beneath the concrete slab protection system. The author is of the opinion

that the dam remediation protection system shown in Figure 4(c) is the most desirable and cost effective design for use of reinforced concrete for a protection system. The reinforced concrete wall provides a gentle slope to flat backfill area that can easily be maintained by mowing to preclude tree and woody vegetation growth. In addition, this dam remediation design alternative can be used to provide a wider effective dam crest and provides excellent protection against wave erosion.

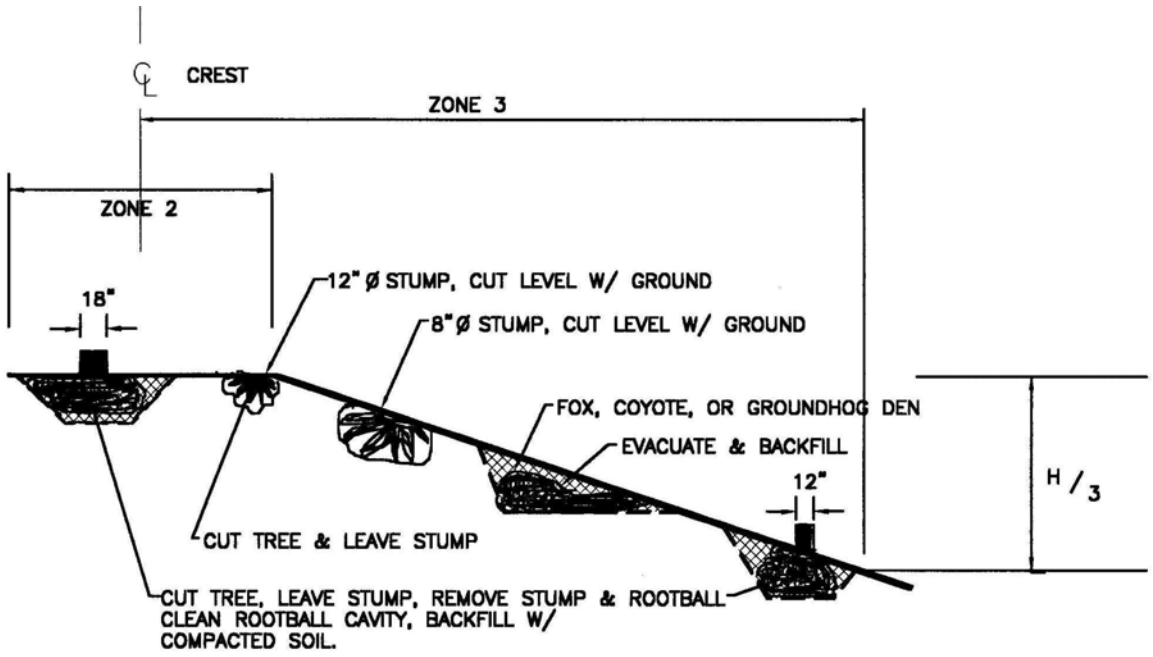
NOTE: Reinforced concrete wall and slab systems constructed on the upstream slope must always be provided with filtration/drainage systems to reduce the potential for development of excessive hydrostatic pressures and internal erosion and scour of soil from beneath the structures. The referenced figures are presented for illustrative purposes and should not be used for actual dam remediation design without proper design analyses to confirm any indicated dimensions of the drawings.

Alternative flexible upstream slope protection system designs for use in Zone 1 are shown in Figures 4(d) and 4(e). The author has utilized both of these flexible slope protection systems effectively to reduce potential tree and woody vegetation growth on upstream slopes and to provide resistance to wave and surface erosion. Figure 4(d) illustrates a typical gabion wall system while Figure 4(e) illustrates the use of a Mechanically Stabilized Earth (MSE) wall system for protection of the upstream slope of an earthen dam.

NOTE: Granular backfill material used in design and construction of these flexible wall systems must be protected against soil contamination and internal erosion of retained soil by an effective geotextile filter/drainage material and/or a graded aggregate filter. These figures are presented herein for illustrative purposes and should not be used for actual design without proper design analyses to confirm any indicated dimensions of the drawings.

Inspection and Evaluation Zones 2 and 3

Potential problems associated with tree and woody vegetation growth on earthen dams in identified Zones 2 and 3 are illustrated with dam remediation design procedures in Figure 5. Potential problems illustrated for Zone 2 include the growth of mature trees having stump diameters greater than twelve inches. Mature trees having stump diameters greater than eight inches are illustrated at various locations throughout Zone 3 and in the overlap area of Zones 2 and 3.



ZONE 2 & 3 REPAIR PROCEDURES

Figure 5

Two dam remediation design procedures are illustrated in Figure 5 for removal of trees of various sizes. This illustration implies that trees located in the overlap area of Zones 2 and 3 having stump diameters less than about twelve inches could be cut flush with the ground and left in place for future treatment of the decayed stump and rootball system. However, removal of all stumps, rootballs and root systems is always the better and more conservative approach to removal of mature trees. Subsequent to cutting of trees having stump diameter less than about twelve inches in the overlap area of Zones 2 and 3, the surface of the stump can be treated with a protective coating similar to polyurethane that will prolong the decaying process. Conversely, the referenced illustration indicates that any trees in Zone 2 upstream of the overlap area of Zones 2 and 3 having stump diameters of twelve inches or greater should be treated by total removal of the tree, stump, rootball, and root system. The suggested dam remediation design and construction procedure suggested for complete removal of trees, stumps, rootballs, and root systems in Zones 2 and 3 consists of the following activities:

1. **Cut** the tree approximately two feet above ground leaving a well-defined stump that can be used in the rootball removal process;

2. **Remove** the stump and rootball by pulling the stump, or by using a track-mounted backhoe to first loosen the rootball by pulling on the stump and then extracting the stump and rootball all together (this is much the same procedure a dentist would use in extracting a tooth);

3. **Remove** the remaining root system and loose soil from the rootball cavity by excavating the sides of the cavity to slopes no steeper than 1:1 (horizontal to vertical) and the bottom of the cavity approximately horizontal; and

4. **Backfill** the excavation with well-compacted soil placed in relatively thin lifts not greater than about eight inches in loose lift thickness. Compaction of backfilled soils in these tree stump and rootball excavations typically requires the use of manually operated compaction equipment or compaction equipment attached to a backhoe.

NOTE: All disturbed areas must be protected by seeding and mulching.

Figure 5 further illustrates that trees located in Zone 3 that have stump diameters greater than about eight inches should be treated by total removal. The removal procedure should be the same as previously described for larger trees in Zone 2. Trees having stump diameter of less than about eight inches could be cut flush with the ground and treated with a waterproofing sealant similar to polyurethane to prolong the stump and rootball decaying process. Again, complete removal of the stumps, rootballs, and root systems of all mature trees is a better and more conservative method of remediation.

Inspection and Evaluation Zone 4

Figure 6 illustrates potential problems associated with tree and woody vegetation growth in Zone 4 of an earthen dam with suggested dam remediation design and construction procedures.

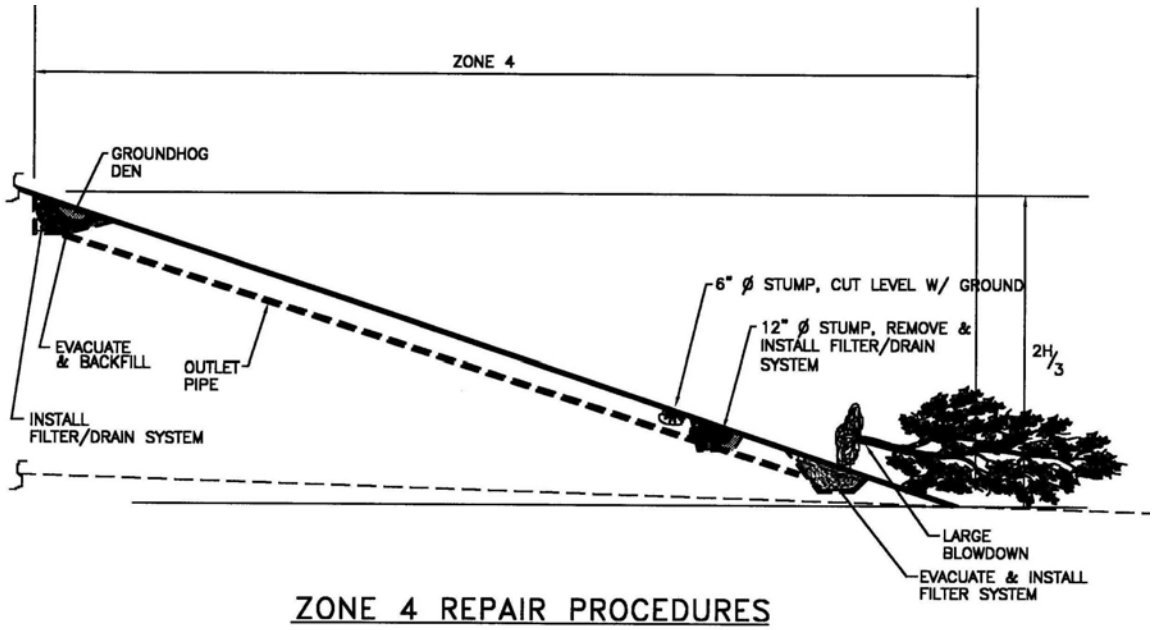


Figure 6

Young immature trees having stump diameters less than about six inches can be removed by cutting flush with the ground and treating the stump with a wood preservative and/or sealant to prolong the decaying process. This procedure is based upon the fact that immature trees of this size typically have not developed a rootball and/or root system that will significantly impact the zone of saturation or the seepage line in Zone 4.

Trees having stump diameters greater than about six inches must be treated by complete removal; however, the dam remediation design and construction procedure for total removal of trees in Zone 4 is somewhat more complicated than total removal of trees in previously discussed zones. Treatment of mature tree penetrations in Zone 4 involves the following activities:

1. **Cut** the tree approximately two feet above ground level leaving a prominent stump for use in the rootball extraction process;

2. **Remove** the stump and rootball by pulling the stump or extracting with a track-mounted backhoe after loosening the rootball by pulling on the stump from different directions;

3. **Clean** the rootball cavity to remove loose soil and the remaining root system by excavating the rootball cavity with maximum 1:1 (horizontal to vertical) side slopes and a horizontal bottom; and

4. **Install** a subdrain and/or filter system in the tree penetration excavation and backfill with compacted soil placed in maximum loose lifts of eight inches.

Note: Backfill placed in all tree removal excavations must be compacted to a minimum of 95 percent of the maximum dry density as determined by ASTM D-698.

Note: Subdrain and/or filter systems installed in tree removal excavations in Zone 4 may be incorporated into major subdrain systems to be installed in the overlap area of Zones 4 and 5.

Inspection and Evaluation Zone 5

The author identified Zone 5 as one of the two most critical zones for tree and woody vegetation growth on an earthen dam. Figure 7 illustrates some of the problems that can occur with tree and woody vegetation growth in Zone 5. The major adverse feature in Zone 5 is typically the interception of the downstream embankment slope by the seepage line. The author is a strong advocate of the installation of embankment subdrain systems during dam remediation design and construction even though the earthen dam may have been provided with an embankment subdrain system during original design and construction.

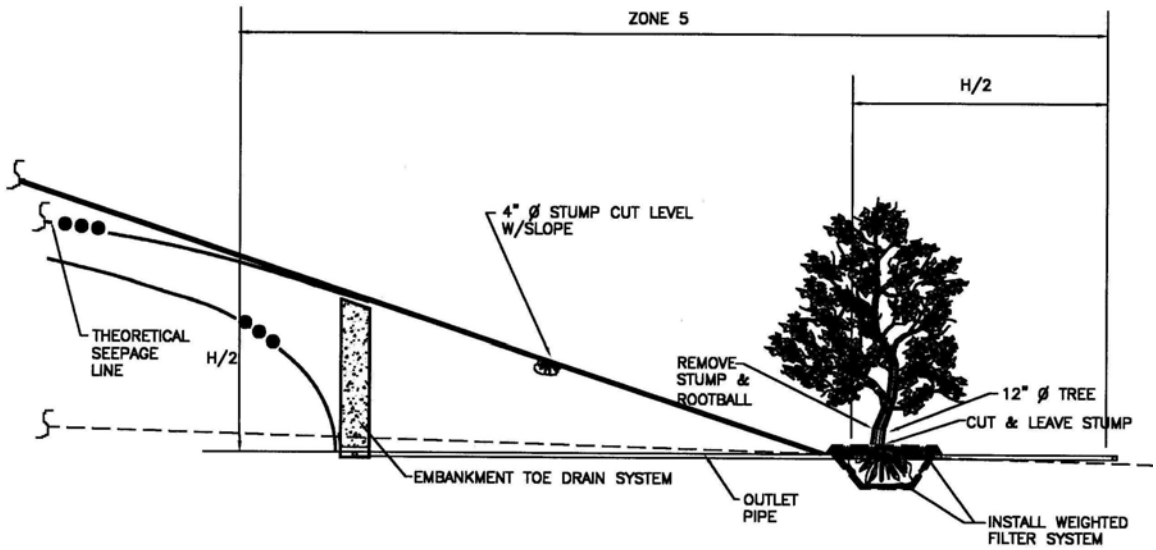


Figure 7

One must understand the impact of tree removal in Zone 5 on the seepage line and the quantity of seepage that will occur subsequent to dam remediation in this zone. As indicated by Figure 7, trees in Zone 5 having stump diameters less than about four inches can be cut flush with the ground and the stump treated with a waterproof sealant to

prolong stump and rootball decay. Trees having stump diameters greater than about four inches must be removed completely. If the embankment toe drain or subdrain system is installed in advance of tree removal in Zone 5, the rootball cavity can be backfilled with compacted soil, provided seepage does not emerge from the excavation and/or the tree is located beyond the toe of the embankment slope. Tree rootball cavities existing beyond the toe of the downstream embankment slope generally require the installation of a filter system and in some cases a weighted filter system as indicated in Figure 7. The weighted filter system may be converted to a weighted drain system by installing a drain and outlet pipes connected to the outlet pipe of the embankment subdrain system.

Summary of Dam Remediation Design Considerations

A summary of dam remediation design considerations for treatment of tree and woody vegetation on earthen dams is presented below. Dam remediation design procedures and techniques are presented for treatment of various size trees in the identified dam safety inspection and evaluation zones.

Remedial Repair Zone	**Procedures and Techniques**
Zone 1	Remove all trees, stumps, rootballs, and root system; clean rootball cavity; and backfill with properly placed and compacted soil backfill. Install tree and woody vegetation and wave erosion protection system on the upstream slope from about four feet below normal pool elevation to about three feet above normal pool elevation.
Zone 2	Cut trees in overlap area of Zone 2 and Zone 3 having stump diameters of twelve inches or less flush with the ground and treat the stump with a waterproof sealant to prolong stump decay.

Completely remove trees having stump diameters of about twelve inches and greater, and backfill rootball cavity with properly compacted backfill soil.

Zone 3

Cut trees having stump diameters of about eight inches and less level with the ground and treat the stump with a waterproof sealant to prolong stump and rootball decay.

Completely remove all trees having stump diameters greater than about eight inches and backfill the cleaned rootball cavity with compacted backfill soil.

Zone 4

Cut all trees having stump diameters of six inches or less flush with the ground and treat the stump with a waterproof sealant to prolong stump and rootball decay.

Remove all trees having stump diameters greater than about six inches, install subdrain and/or filter systems, and backfill with properly compacted soil around the filter/drain system.

Zone 5

Cut all trees having stump diameters of about four inches and smaller flush with the ground and treat the stump to prolong stump and rootball decay.

Install a major embankment toe drain or subdrain system to lower the phreatic surface, filter, collect, and discharge embankment seepage. Incorporate major subdrain with tree rootball and stump removal where possible.

Remove all trees located beyond the toe of the downstream slope having stump diameters greater than about four inches. Install weighted filters and/drain systems in rootball cavities where seepage boiling and soil piping is likely to occur.

Tree and Woody Vegetation Growth Control Program

Many individual dam owners and small dam owner organizations are not financially capable of undertaking comprehensive dam remediation projects in one major construction contract. Therefore, they must undertake dam remediation programs in a sequential manner. The following sequential dam remediation program for controlling tree and woody vegetation growth provides the owner, regulator, and engineer with a reasonable opportunity to effectively evaluate the condition of an earthen dam and to prioritize dam remediation relative to observed dam safety issues.

1. **First Year**: Cut all tall grasses, weeds, underbrush, and trees and woody vegetation having stump diameters of four inches or less flush with the ground and treat all cut stumps with a waterproof preservative to prolong rootball and stump decay.

2. **Second Year**: Cut all trees in Zones 1 through 4 having stump diameters of six inches or less flush with the ground and treat the stumps to prolong stump and rootball decay. Keep all zones mowed and/or maintained to preclude renewed growth of previously cut woody vegetation. Repair most severe animal penetrations that exhibit seepage flows and/or cause unstable slope conditions on Zones 1, 4, and 5.

3. **Third Year**: Initiate comprehensive remedial dam repair investigations, analyses, and preliminary design. Remove all trees from Zones 1 through 3 having stump diameters less than about eight inches by cutting flush with the ground and treating the stump with a preservative to prolong stump and rootball decay.

4. **Fourth Year**: Finalize remedial dam repair design and begin construction of remedial repairs for all plant and animal penetrations that require special remedial dam repair design considerations.

5. **<u>Fifth Year</u>**: Finalize remedial dam repair construction and begin an operation and maintenance program that will preclude the need for future remedial dam repair associated with plant and animal penetrations of earthen dams.

<u>NOTE:</u> **Earthen dams that exhibit severe dam safety deficiencies and dam safety issues that cannot be prolonged as a result of potential imminent dam failure <u>are not</u> subject to the use of this type of sequential dam remediation program!!!**

Chapter 7
Economics of Proper Vegetation Maintenance

Regular maintenance on a dam, especially attention to trees and brush, is known to be critical to dam safety for several reasons (Tschantz, 2000):

- Overturning or uprooting trees causing large voids and reduced freeboard; and/or reduced cross-section for maintaining stability
- Decaying roots of dead trees causing potential seepage paths and piping problems
- Interfering with effective dam safety monitoring, inspection and maintenance for seepage, cracking, sinkholes, slumping, settlement, deflection, and other signs of stress
- Hindering desirable vegetative cover and causing embankment erosion
- Obstructing emergency spillway capacity
- Falling trees causing possible damage to spillways and outlet facilities
- Clogging embankment underdrain systems
- Cracking, uplifting or displacing concrete structures and other facilities
- Inducing local turbulence and scouring around trees in emergency spillways and during overtopping
- Providing cover for burrowing animals
- Loosening compacted soil
- Allowing roots to wedge into open joints and cracks in foundation rock along abutment groins and toe of embankment, thus increasing piping and leakage potential.

State and federal dam safety officials and other dam safety experts agree that trees have no place on dams. Federal agencies and some states do not allow trees to grow on dams. However, it is estimated that about a third of the nation's 77,000 inventoried dams have sufficient woody vegetation to hinder effective dam safety inspections (ASDSO, 2000; Tschantz, 2000). Most states require dam owners to remove trees and undesirable vegetation, but the cost of clearing and grubbing trees and restoring the dam embankment slopes and crest is often cost prohibitive for many dam owners, usually running into thousands of dollars. It would seem that regular control of woody vegetation and maintaining the surface on an earthen is relatively inexpensive, compared to removing trees on and repairing damage from neglected dams such as shown in Figure 1.

Figure 1. Restored Downstream Slope on Fishing Creek Dam, Maryland (1991-92)

Likewise, it is important that owners maintain *desirable* vegetation on their dams on a regular schedule to avoid the expense of periodically removing undesirable heavy brush and mature trees. Early control is generally viewed to be the most cost-effective means of avoiding potential adverse effects on these structures from their continued growth (USBR, 1989). The bulk of maintaining a dam usually involves keeping the grass mowed and brush trimmed. An important question arises, ***"How much is a dam owner justified in spending to maintain a dam on a regular or annual basis to avoid having to bear the heavy cost of removing trees?"*** A correlative question then follows, ***"How often should a dam be mowed to control undesirable woody growth?"***

This chapter attempts to answer these questions, but there are many variables and site-specific factors which need to be considered. Some assumptions also need to be made.

Tree Removal Costs

The cost of clearing and grubbing a dam depends on the size and type of trees, growth density, total job size (i.e., number of acres of trees), location of growth (crest and/or both faces?), embankment face steepness, slope condition (such as degree of wetness or surface texture), degree and type of required surface treatment (backfilling, use of herbicides or bio-barriers, mulching, seeding, fertilizing, etc.), and regional labor and construction differences.

The reader is referred to Table 1 in Chapter 2 and Figure 2 below for unit area tree removal cost comparison experiences reported in a survey by eight state dam safety officials in different regions of the country. The survey data shows that the cost of clearing and grubbing trees and other woody vegetation varies widely within and among states, but generally ranges from about $1000 to $5000 per acre, depending on site-specific conditions (Tschantz, 2000).

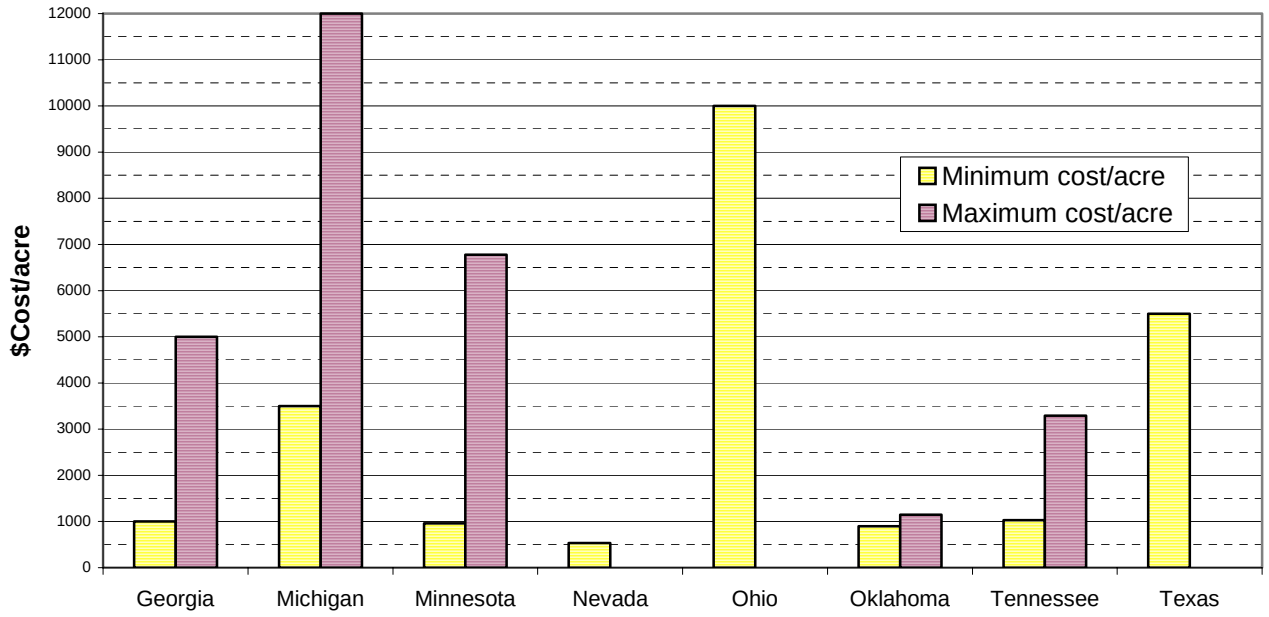


Figure 2. Comparison of tree removal costs per acre of dam surface area reported by 8 states.

These data compare favorably with the $1500 - $3000 bid price data for three Southeastern states discussed earlier in Chapter 2 for cutting trees, removing stumps and rootballs, and grubbing the area to remove roots for different dam conditions. While not included in the above Figure 2 chart data, Massachusetts' dam safety personnel reported in 2000 that, based on its own in-house experience, some local consultants and other sources, "broad area" tree removal costs ranged from $5000 and $6000 per acre or from about $800 to $1000 for individual 18-24 inch trees in their region. One dam safety official, from Tennessee, provided detailed cost data for clearing trees from seven dams in that state from 1995-1999. The cost for clearing and grubbing trees and for reseeding for one typical dam in 1998 is described for the reader in Table 1.

Dam Height	22.3 ft.
Length of Dam	830 ft.
Freeboard above Normal Pool	8 ft.
Density of trees ≤ 6 inches diameter primarily on downstream face	"Moderate"
Approximate surface area of downstream face	≅1.3 acres
Approximate dam face slopes	3H:1V
Amount of brush cutting	"Moderate"
Stumps grubbed out	Yes
Amount of hand work	"Considerable"
Total job cost for clearing, grubbing & reseeding	$4275
Unit area job cost	$3290/acre
Year job completed	1998

Table 1. Tree clearing/grubbing and reseeding cost for a "typical" dam located in Fayette Co., Tennessee (Bentley, 2000)

For comparison purposes, general sitework cost information is available from various construction cost books. General cost data for cutting and clearing out individual trees and for clearing wooded area is shown in Table 2 from one source (BNi, 2001). Indices are normally provided for factoring in regional cost differences. Other cost book sources provide detailed material, labor and equipment requirements for estimating site clearing costs (Means, 2001).

Clear small size wooded area:	
• Light density	$3,607/acre
• Medium density	$4,900/acre
• Heavy density	$5,880/acre
Cut trees & clear out stumps:	
• 9 to 12 inches diameter	$290 per tree
• To 24 inches diameter	$370 per tree
• 24 inches and up	$490 per tree

Table 2. General tree cutting and clearing construction cost data (Bni, 2001).

Similar general tree clearing and grubbing, chipping, seeding, mulching and fertilizing data for estimating construction costs in various regions of the country are also available from other sources (Means, 2001; AC&E, 2002). For example, 2001 Means cost data gives tree cutting, chipping,

clearing, and grubbing costs for trees 6-inches or less to be $2975/acre and stump removal to be $1425/acre for a total unit cost of $4400/acre. For trees up to 12 inches the cost is $6925/acre, and for trees up to 24 inches the cost is $15,250/acre (Means, 2001). If burning is allowed, the cut and chip costs can be significantly reduced. Hydro or air seeding, including seed & fertilizer is estimated to be 35¢/square yard (about $1700/acre) (Means, 2001). Mulching would add to this cost.

Maintenance Costs

For most dams, maintenance means keeping the crest and dam embankment slopes mowed and trimmed. The cost of mowing a dam depends on many factors, including geographical location, accessibility, condition of slopes as discussed above, degree of public use and desired aesthetics, type of vegetation and frequency of mowing. Cost also depends on whether the work is done directly by private owners, subcontracted commercially, or done by in-house state or federal maintenance crews. Table 3 summarizes these factors. The availability of slope mowers as illustrated in

Table 3. Factors Affecting Dam Maintenance Cost

• Region of country	• Embankment slope steepness
• Type of ground cover & vegetation	• Mowing frequency
• Accessibility to dam	• Local labor costs
• Surface condition	• Type of maintenance provider
• Size of job (surface area)	• Degree of public use; aesthetics

Figure 3 illustrates the use of a slope mower for easing the burden of maintenance for state and federal agencies and for other multiple or large dam owners.

Figure 3. Example of slope mower (Terratrac© photo used with permission from AEBI North America, Inc.)

Most public works dams usually get mowed at least twice a year, in the early fall and late spring. Many subdivisions, homeowner associations, and/or residential developments typically mow dams, located in high-visibility areas, about once a month to every six weeks. One geotechnical consultant, who specializes in embankment dam rehabilitation, uses a "rule of thumb" mowing estimate of about $100 per acre with a minimum fee of $200 to $250 per mowing job (Marks, 2000). 1998 bid prices for mowing general right-of-way areas along East Tennessee highways averaged about $32 per acre, with a range of about $28 to $38 per acre for four jobs (TDOT-Region 1, 2000).

The U. S. Corps of Engineers, Nashville District, furnished recent annual mowing costs for three District dams, including some proximate recreation zones, having total mowing areas ranging from 8 to 27 acres. The average mowing cost for these three dams was about $55/acre and ranged from $43.42 to $78.24/acre (Corps, 2000).

The Tennessee Valley Authority furnished similar estimated in-house annual mowing cost data associated with general dam safety grounds maintenance activities for its dams. However, TVA's annual cost data included labor, supervision, slope mower fuel, parts, equipment, etc. and averaged slightly over $600/acre for 31 saddle and main embankment dams with a cost range from about $45 to $2000/acre (TVA, 2000).

A dam owner is advised that, in addition to mowing cost, the total annual maintenance expenditure should also include the expenses of dam inspection(s), minor repairs and rehabilitation of various structural components, removal of obstructions from emergency and service spillways, and other safety or operational costs associated with maintaining a dam.

Example maintenance cost analysis

The following example illustrates a rational procedure for answering the two earlier questions: 1) how much should a dam owner spend yearly to maintain a typical earthen dam to control trees and woody vegetation growth while avoiding bearing the cost of removing mature trees at a later date?

and 2) how often should an earthen dam be mowed to maintain acceptable ground covering vegetation? Maintenance expense in this example is for mowing only. Assumptions for this example are as follows:

1. **Dam Description:**
   - Length = 900 feet
   - Crest width = 15 feet
   - Embankment slopes (upstream and downstream) = 3:1 (horizontal to vertical)
   - Height = 35 feet
   - Normal pool = 10 feet below crest
   - Nearly vertical end abutments
2. **Economic Analysis Assumptions:**
   - 30-year project analysis period
   - Annual rates of return rates = 4, 6, 8, 10, and 15%
   - Zero annual inflation on recurring costs
3. **Maintenance Assumptions:**
   - Assume that 10-year old brush and trees are mature enough to significantly hinder effective inspection. Trees of this age can reach in size from 6 to 8 inches in diameter, depending upon species, tree density and other environmental conditions
   - Mowing costs = $100 per acre (with a minimum fee of $250 per mowing)
   - Trees can grow on all exposed upstream and downstream embankment slopes and the crest of the dam
   - Assume tree removal, including clearing and grubbing, costs = $2500/acre
   - Seeding & mulch not included in surface restoration costs.

Economic Analysis Calculations

Charts have been prepared and attached at the end of this chapter as a tool in helping to estimate mowing areas (or tree stand estimates) for different dam configurations. Chart 1 can be used to determine dam embankment slope area in acres for four slopes ranging from 1.5:1 to 3:1 (horizontal to vertical) and for dam lengths of 200 and 500 feet. Linear interpolations and ratio extrapolations can be made for other slope configurations and dam embankment lengths, respectively. Note that when determining the area of an upstream embankment slope, the equivalent dam height entered into the chart is the vertical distance between normal pool and crest elevation. Chart 2 is used to estimate dam crest area for three convenient lengths; crest areas for other actual dam crest lengths can be calculated from direct ratios. A self-guiding Chart 3 is provided to allow for small abutment area reduction corrections to be estimated and applied to slope area determined from Chart 1.

For the assumed example dam given above, make the following computations:

1. Use the attached charts to estimate total mowable and potential tree-covered dam area:

   (a) Downstream Embankment Slope (35 ft. high, 3:1 slope, 900 ft. length):
   A_1 = 1.28 acres x 900/500 = 2.3 acres (Use Chart 1; no abutment area reduction correction∗)

   (b) Crest (15 ft. wide, 900 ft. length)
   A_2 = 0.17 x 900/500 = 0.31 acres (Use Chart 2)

   (c) Upstream Embankment Slope (10 ft. high exposure, 3:1 slope, 900 ft. length):
   A_3 = 0.37 x 900/500 = 0.67 acres (Use Chart 1)

   (d) Estimated total dam area to be restored ≈ 2.3 + 0.3 + 0.7 = 3.3 acres

2. Estimated 10-year cycle clearing and grubbing job costs, over a 30-year analysis period, starting with end of 10th year:

   Total Estimated Cost = 3.3 acres x $2500 per acre = $8250

∗ For this example, the abutment slopes are assumed vertical or 0^o, but total slope area reduction for a 30^o abutment would be only ≈ 0.25 acres (see Chart 3).

3. Find the annual break-even cost balance between mowing and recurring clearing and grubbing, using the sinking fund factor (SFF), assuming 4, 6, 8, 10, and 15% discount rates for a 30-year period. A sinking fund is an equivalent annual amount to be set aside and left to grow at a certain interest rate into a specified amount at the end of a predetermined time period.

It is assumed in this example that mowing and clearing and grubbing costs do not change over the 30-year analysis period and that the dam safety inspections are not hindered for up to 10-year tree growth. By assuming a zero inflation rate for these costs, the results of this exercise are not dependent on the selected period of analysis; therefore, the annual values are valid for a 50- or 100-year period as well as for a 30-year period.

- Annualized clearing and grubbing cost = \$8250 x (SFF, i, N years)

  where the SFF = $i/[(1 + i)^N - 1]$

  and i = discount rate (expressed as fraction)
  N = time period, in years, between tree clearing and grubbing

- Mowing job cost = 3.3 acres x \$100/acre = \$330

- Equivalent number of mowings per year = (Annualized clearing & grubbing costs)/(\$330 per mowing)

The following Table 4 shows that the annualized clearing and grubbing costs and equivalent number of annual mowings varies somewhat with the discount rate. For this example, at a 6% discount rate, this dam owner would be able to justify about two mowings per year at \$330 per mowing to avoid having to shell out \$8250 every 10 years for clearing the dam of trees and woody vegetation. The owner could afford to mow once or twice a year, even at a relatively high 10%

Assumed discount rate, i	Annualized 10-yr frequency clearing and grubbing cost	Equivalent number of mowings per year
4%	$687	2.1
6%	$626	1.9
8%	$569	1.7
10%	$518	1.6
15%	$406	1.3

Table 4. Annualized Cost Comparison for Assumed $2500 per acre for a 10-Year Cycle Clearing and Grubbing Payout.

discount rate. By mowing on a regular basis, the owner would also realize side benefits of a more aesthetically pleasing dam -- one that would be viewed more as a community asset than a liability, be accessible and inspection friendly, and be less attractive to unwanted burrowing animals.

If $5000 per acre or $16,500 for 3.3 acres, rather than the $2500 per acre and $8,250 per job, had been assumed for tree clearing costs over the 10-year cycle control period, the justifiable annual costs for mowing would double for the same discount rates. For this higher restoration cost, the owner would be justified to mow 3 or 4 times per year, depending on the cost of money. The following Table 5 illustrates this assumption.

Assumed discount rate, i	Annualized 10-yr frequency clearing and grubbing cost	Equivalent number of mowings per year
4%	$1374	4.2
6%	$1252	3.8
8%	$1138	3.4
10%	$1036	3.1
15	$ 813	2.5

Table 5. Annualized Cost Comparison for Assumed $5000 per acre for a 10-Year Cycle Clearing and Grubbing Payout.

For a more conservative 5-year tree growth cycle and a $2500 clearing and grubbing cost assumption, the annualized clearing and grubbing costs would be $1523, $1464, $1406, $1351, and $1224 for the same discount rates, respectively. The corresponding justifiable mowings would be 4.6, 4.4, 4.3, 4.1, and 3.7 per year. Similarly, justifiable mowings for an assumed $5000 clearing and grubbing cost would double the justifiable mowings to 9.2, 8.9, 8.6, 8.2, and 7.4 per year. Figure 4 compares 5 and 10-year annualized costs for $2500/acre clearing and grubbing payouts.

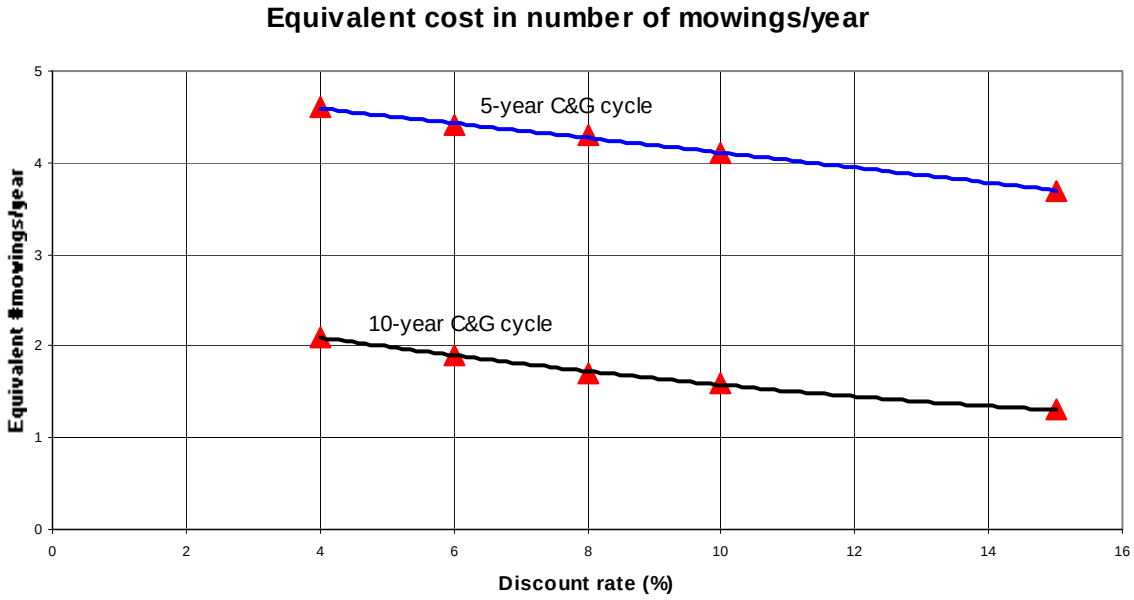


Figure 4. Comparison of Annual Tree Clearing and Grubbing Costs for 5 and 10-Year $2500/acre payouts.

Realistically, unit area costs would likely be reduced substantially for more frequent clearing and grubbing or bush hogging of smaller growth. Obviously, the above values will be different if the costs are assumed to escalate each year. For example, assuming a modest 3% annual inflation factor results in an increase in the clearing and grubbing cost from $8250 to $14,900 for a 30-year analysis period.

Summary

Cost data obtained from the private, state and federal sectors show that dam maintenance and tree removal and dam restoration costs can vary widely, depending on several factors.

It has been demonstrated, by way of example and reasonable cost assumptions, that dam owners can economically justify mowing their embankments 2 to 8 times a year, depending on local factors and costs, to prevent trees and other woody vegetation from maturing to a point that could compromise dam safety and require major capital outlays. It appears extremely economically efficient for dam owners to control woody growth on at least an annual basis, to avoid the large cost of removing mature brush and trees every 5 to 10 years and to comply with state inspection requirements.

So, how much should a dam owner spend on maintaining his dam? At least enough to keep it mowed and trimmed a couple times a year – probably something in the neighborhood of $500 to a $1000 annually for most dams, if contracted. Keeping a dam mowed a minimum of twice a year does not appear to be an unreasonable financial burden for most small dam owners. A dam owner must understand that spending a few dollars on annual vegetative maintenance and upkeep, such as mowing, will pay dividends over the long run for an asset (and potential liability) such as a dam.

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Chart 1. Dam face area for different geometries

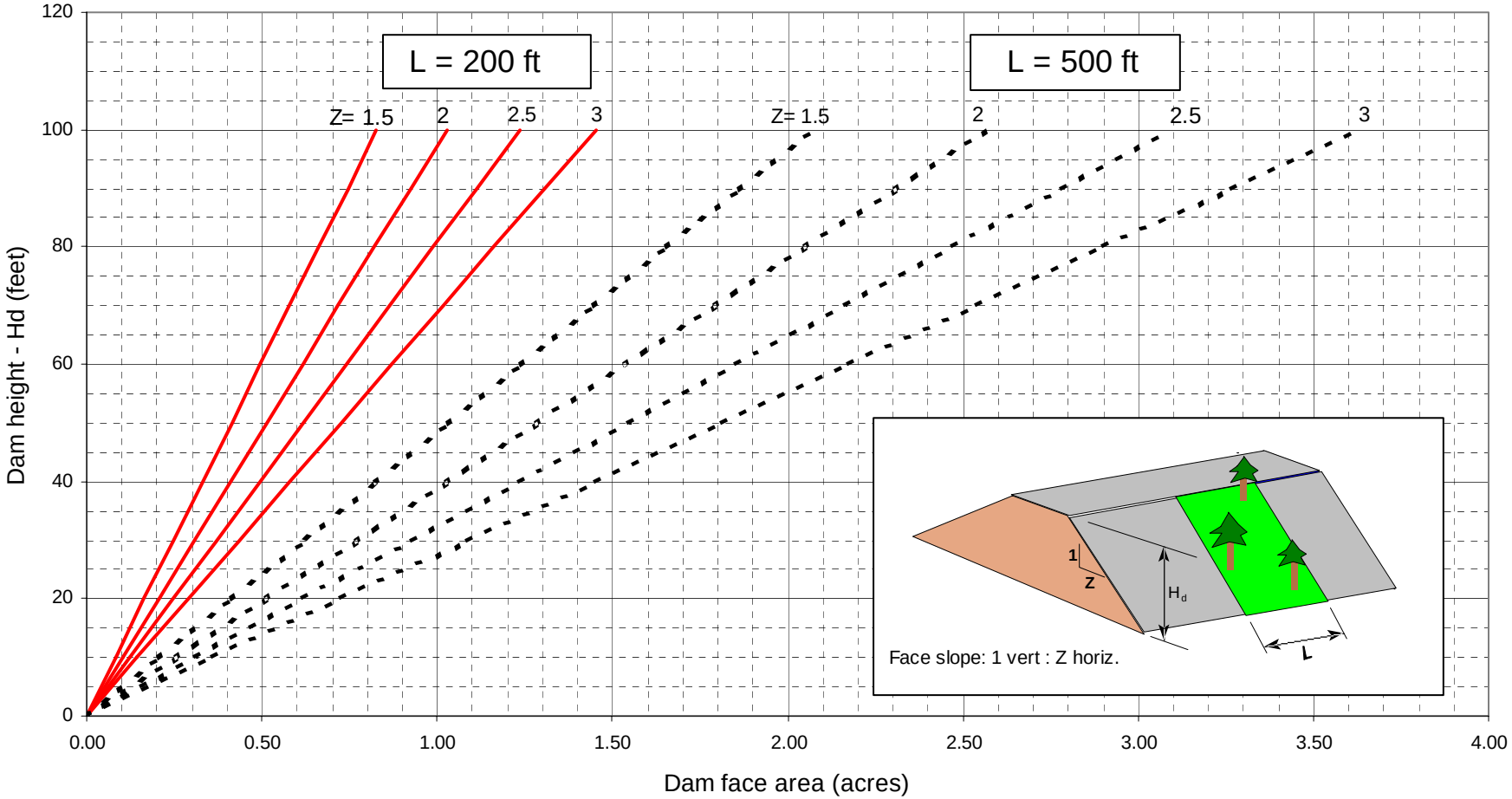


Chart 2. Dam crest area by width and length

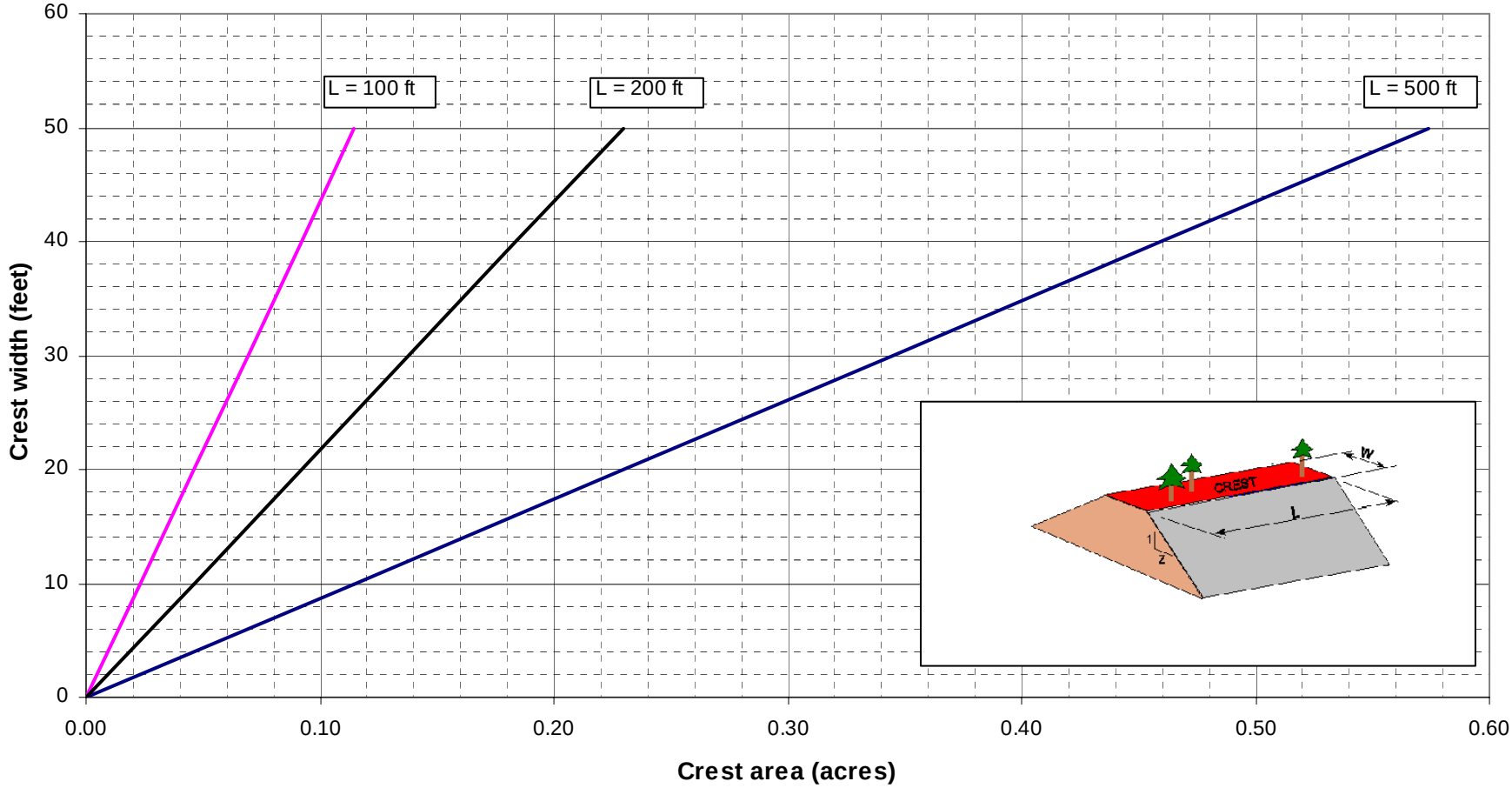
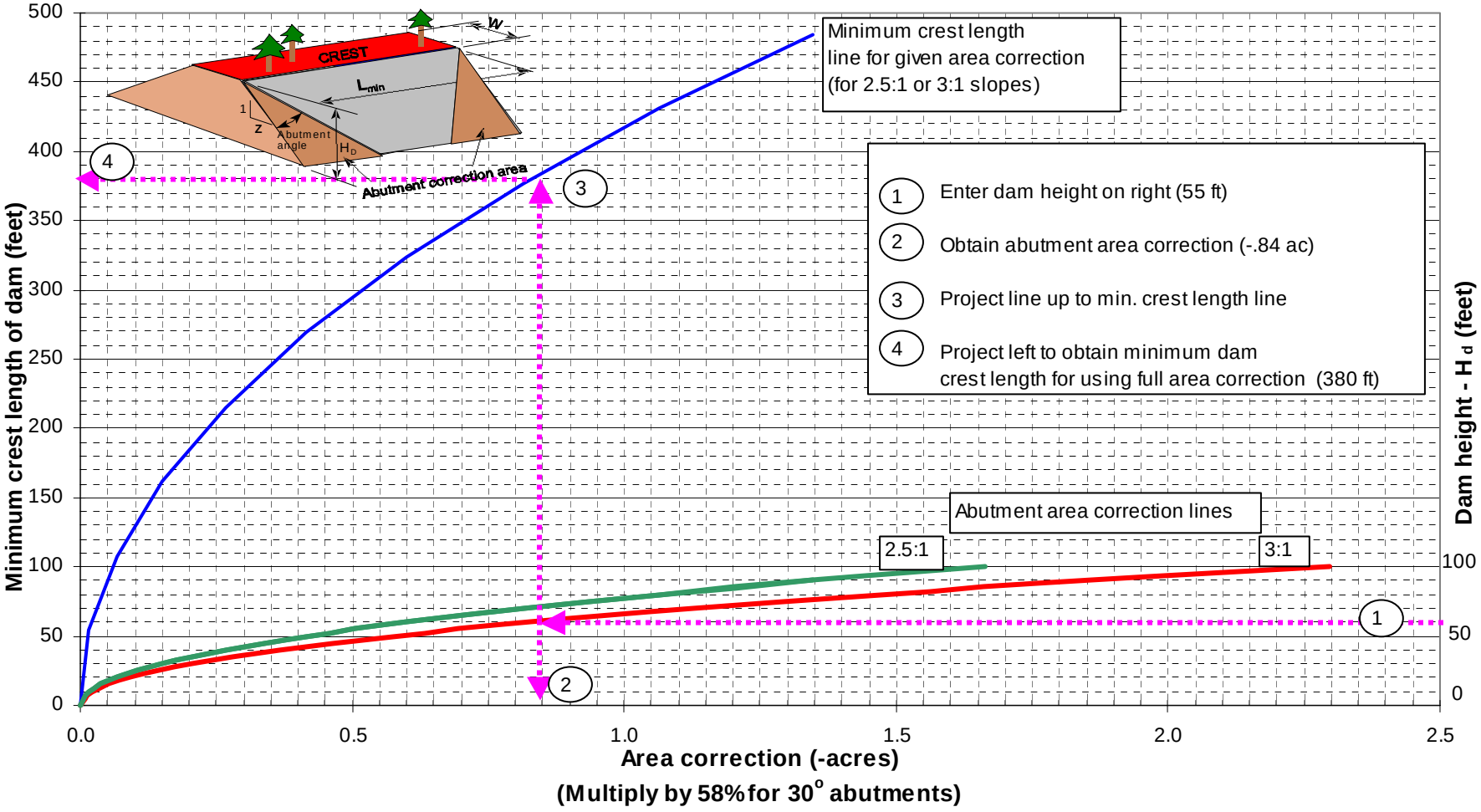


Chart 3. Abutment area corrections vs. dam height for 2.5H:1V & 3H:1V side slopes, with 45° abutment angle and corresponding minimum dam crest length



Guide to Concrete Repair

United States Department of the Interior
Bureau of Reclamation
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Preface

This guide contains the expertise of numerous individuals who have directly assisted the author on many concrete repair projects or freely shared their concrete repair knowledge whenever requested. Their substantial contributions to the preparation of this guide are acknowledged and appreciated. Some of the material in this guide originated in the various editions of Reclamation's *Concrete Manual*. The author edited, revised, or updated this information for inclusion herein.

Individuals who have been especially helpful to the author include James E. Backstrom, former Reclamation engineer, mentor, and friend, deceased; Edward M. Harboe, Reclamation engineer, retired; U. Marlin Cash, Reclamation technician, deceased; Dennis O. Arney, Reclamation technician, retired; G.W. DePuy, Reclamation engineer, former supervisor and friend, retired; and Kurt D. Mitchell, Reclamation technician. Dr. Dave Harris, Manager, Materials Engineering and Research Laboratory, obtained much of the funding to prepare this guide; Kurt F. Von Fay, Civil Engineer, Materials Engineering and Research Laboratories, performed the peer review; James E. McDonald, Structures Laboratory, Waterways Experiment Station, U.S. Army Corps of Engineers, provided editorial reviews of selected information and many useful sug-gestions and participated with the author in several cooperative Reclamation—U.S. Corps of Engineers concrete repair programs. The assistance of these and numerous other engineers and technicians is gratefully acknowledged.

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Chapter I

Repair of Concrete

1. Introduction.—For many years, the Bureau of Reclamation (Reclamation) has published the *Concrete Manual*, the first edition dated July 1938, and more recently, the *Standard Specifications For Repair of Concrete, M-47*, the first edition dated November 1970. The subsequent revisions of these two documents (Bureau of Reclamation, 1975 and 1996), particularly chapter 7 of the *Concrete Manual*, have formed the basis for nearly all concrete repair performed on Reclamation projects during the past 25 years.

Reclamation operates and maintains a water resources infrastructure, located primarily in the harsh climatic zones of the Western United States, valued at over $17 billion. It has become apparent that there is need for modernization and expansion of the information on the methods, materials, and procedures of concrete repair originally found in chapter 7 of the *Concrete Manual*. This *Guide to Concrete Repair* results from recognition of that need. It is designed to serve as a companion document to the "Standard Specifications for Repair of Concrete" included in appendix A of this guide.

This guide first discusses Reclamation's methodology for concrete repair. It then addresses the more common causes of damage to Reclamation concrete, including suggestions of the types of repair methods and materials most likely to be successful in repairing concrete damage resulting from those causes. Finally, the guide contains a detailed description of the uses, limitations, materials, and procedures of each of the standard repair methods/materials included in the "Standard Specifications for Repair of Concrete."

2. Maintenance of Concrete.—Modern concrete is a very durable construction material and, if properly proportioned and placed, will give very long service under normal conditions. Many Reclamation concrete structures, however, were constructed using early concrete technology, and they have already provided well over 50 years of service under harsh conditions. Such concrete must be inspected regularly to ensure that it is receiving the maintenance necessary to retain serviceability. Managers and foremen of operation and maintenance crews must understand that, with respect to concrete, there is no such thing as economical deferred maintenance. Failure to promptly provide the proper necessary maintenance will simply result in very expensive repairs or replacement of otherwise useful structures. Figures 1 and 2 demonstrate the folly of inadequate or inappropriate maintenance. These two structures now require replacement at a cost tens of times greater than that of the preventive maintenance that could have extended their serviceability indefinitely.

Experience has shown that there are certain portions of exposed concrete structures more vulnerable than others to deterioration from weathering in freezing climates. These are exposed surfaces of the top 2 feet of walls, piers, posts, handrails, and parapets; all of curbs, sills, ledges, copings, cornices, and corners; and surfaces in contact with spray or water at frequently changing levels during freezing weather. The durability of these surfaces can be considerably improved and serviceability greatly prolonged by preventive maintenance such as weatherproofing treatment with concrete sealing compounds (sections 35 and 38).

Figure 1.—Lack of maintenance has resulted in near loss of this irrigation structure.

Figure 2.—Deferred maintenance has allowed freezing and thawing deterioration to seriously damage this structure.

Selecting the most satisfactory protective treatment depends to a considerable extent upon correctly assessing the exposure environment. Concrete sealing compounds and coatings that provide good protection from weathering in an essentially dry environment may perform poorly in the presence of an abundance of water such as on some bridge curbs and railings, stilling basin walls, and piers. Freezing and thawing tests of concrete specimens protected by a variety of concrete sealing compounds and coatings, including linseed oil, fluosilicates, epoxy and latex paints, chlorinated rubber, and water-proofing and penetrating sealers, have been performed in Reclamation laboratories. These tests indicate that proprietary epoxy formulations, siloxane and silane formulations, and the high molecular weight methacrylate formulations (section 35) clearly excel in resisting deterioration caused by repeated freezing and thawing in the presence of water. None of these formulations, however, will totally "waterproof" concrete. That is, they will not prevent treated concrete from absorbing water and becoming saturated under conditions of complete and long-term submergence.

The performance of new concrete sealing compounds is continually being evaluated by the Materials Engineering and Research Laboratory, Code D-8180, located in Denver, Colorado. If use of these materials is being considered, the project should contact the Denver Office for the latest recommendations on materials, methods of mixing, application, curing, and precautions to be exercised during placement.

Except for hand-placed mortar restorations of deteriorated concrete (section 25), concrete sealing compounds are ordinarily not applied on new concrete construction. The treatments are most commonly used on older surfaces when the earliest visible evidence of weather-ing appears. That is, the treatment is best used before deterioration advances to a stage where it cannot be arrested. Such early evidence consists primarily of fine surface cracking, close and parallel to edges and corners. The need for protection also may be indicated by pattern cracking, surface scaling or spalling, and shrinkage cracking. By treatment of these vulnerable surfaces in the early stages of deterioration, later repairs may be avoided or at least postponed for a long time.

Linseed oil-turpentine-paint preparations have been widely used in the past by Reclamation to retard concrete deterioration caused by weathering. These preparations, when applied correctly, have been effective. The terminology "linseed oil treatment," however, has caused many users to believe that a simple coating of boiled linseed oil would protect concrete from weathering. Such is not the case. The treatment recommended by Reclamation consisted of a number of steps including acid washing surface preparation, 48-hour drying, and application of two or more coats of a hot linseed oil-turpentine mixture followed by two or more coats of white lead paint, the first of which was thinned with linseed oil and turpentine. The modern concrete sealing compounds are much simpler to apply and provide superior protection to the concrete. The use of the linseed oil-turpentine-oil paint system is no longer recommended.

3. General Requirements for Quality Repair.—The term "concrete repair" refers to any replacing, restoring, or renewing of concrete or concrete surfaces after initial placement. The need for repairs can vary from such minor imperfections as she-bolt holes, snap-tie holes, or normal weathering to major damages resulting from water energy or structural failure. Although the procedures described may initially appear to be unnecessarily detailed, experience has repeatedly demonstrated that no step in a repair operation can be omitted or carelessly performed without detriment to the serviceability of the work. Inadequate workmanship, procedures, or materials will result in inferior repairs which will ultimately fail at significant cost.

(a) Workmanship.—It is the obligation of the construction contractor or operation and maintenance crew to repair imperfections or damage in concrete so that repairs will be

serviceable and of a quality and durability comparable to the adjacent portions of the structure. Repair personnel are responsible for making repairs that are inconspicuous, durable, and well bonded to existing surfaces. Since most repair procedures involve predominantly manual operations, it is particularly important that both foremen and workmen be fully instructed concerning procedural details of repairing concrete and the reasons for the procedures. Workmen should also be apprized of the more critical aspects of repairing concrete. Constant vigilance must be exercised by the contractor's and/or the Government's forces to ensure maintenance of the necessary standards of workmanship. Employment of dependable and capable workmen is essential. Well trained, competent workmen are particularly essential when epoxy, polyurethane, or other resinous materials are used in repair of concrete.

(b) Procedures.—Serviceable concrete repairs can result only if correct methods are chosen and techniques are carefully performed. Wrong or ineffective repair or construction procedures, coupled with poor workmanship, lead to inferior repairs. Many proven procedures for making high quality repairs are detailed in this guide; however, not all procedures used in repair or maintenance are discussed. Therefore, it is incumbent upon the craftsmen doing the work to use procedures that have been successful or that have a proven high reliability factor.

Repairs made on new or old concrete should be made as soon as possible after such need is realized and evaluated. On new work, the repairs that will develop the best bond and, thus, are the most likely to be as durable and permanent as the original work are those that are made immediately after stripping of the forms while the concrete is quite green. For this reason, repairs to newly constructed concrete should be completed within 24 hours after the forms have been removed.

Before repairs are commenced, the method and materials proposed for use should be approved by an authorized inspector. Routine curing should be interrupted only in the area of repair operations.

Effective repair of deteriorated portions of concrete structures cannot be ensured unless there is complete removal of all deteriorated or possibly affected concrete, careful replacement in strict accordance with a standard or approved procedure, and assurance of secure anchorage and effective drainage when needed. Consequently, work of this type should not be undertaken unless or until ample time, personnel, and facilities are available. Only as much of this work should be undertaken as can be completed correctly; otherwise, the work should be postponed, but not so long as to allow further deterioration. Repairs should be made at the earliest possible date.

(c) Materials.—Materials to be used in concrete repair must be high quality, relatively fresh, and capable of meeting specifications requirements for the particular application or intended use. Mill reports or testing laboratory reports should be required of the supplier or manufacturer as an indication of quality and suitability. Short of this requirement, certifications stating that the materials meet certain specifications should be required of the supplier. Due to the high cost associated with the subsequent removal and replacement of new, unknown, or unproven materials if they prove unsuitable for the job, such materials should never be used in concrete repair unless (1) the standard repair materials have been determined unsuitable and (2) the owners and all other parties to the repair have been informed of the need to use nonstandard materials and the associated risk.

Materials selected for repair application must be used in accordance with manufacturers' recommendations or other approved methods. Mixing, proportioning, and handling must be in accordance with the highest standards of workmanship.

Chapter II

A Concrete Repair System

Concrete repairs have occurred on Reclamation projects since the first construction concrete was placed in 1903. Unfortunately, even though the best available materials were used, many repair failures have occurred during the 90 years since that first concrete construction. In evaluating the causes of these failures, it was learned that it is essential to consistently use a systematic approach to concrete repair. There are several such repair approaches or systems currently in use. The U.S. Army Corps of Engineers lists an excellent system in the first chapter of its manual, *Evaluation and Repair of Concrete Structures* (U.S. Army Corps of Engineers, 1995). Other organizations, such as the American Concrete Institute, the Portland Cement Association, the International Concrete Repair Institute, and private authors (Emmons, 1994) have also published excellent methodologies for concrete repair. This guide will not attempt to discuss or evaluate these systems for any particular set of field conditions. Rather, the following seven-step repair system, which has been developed, used, and evaluated by Reclamation over an extended period of time, is presented. This methodology has been found suitable for repairing construction defects in newly constructed concrete as well as old concrete that has been damaged by long exposure and service under field conditions.

This system will be found most useful if followed in a numerically sequential, or step wise manner. Quite often, the first questions asked when the existence of deteriorated or damaged concrete becomes apparent are: "What should be used to repair this?" and "How much is this going to cost?". These are not improper questions. However, they are questions asked at an improper time. Ultimately, these questions must be answered, but pursuing answers to these questions too early in the repair process will lead to incorrect and, therefore, extremely costly solutions. If a systematic approach to repair is used, such questions will be asked when sufficient information has been developed to provide correct and economical answers.

Reclamation's Concrete Repair System

1. Determine the cause(s) of damage
2. Evaluate the extent of damage
3. Evaluate the need to repair
4. Select the repair method
5. Prepare the old concrete for repair
6. Apply the repair method
7. Cure the repair properly

4. Determine the Cause(s) of Damage.— The first and often most important step of repairing damaged or deteriorated concrete is to correctly determine the cause of the damage. If the cause of the original damage to concrete is not determined and eliminated, or if an incorrect determination is made, whatever damaged the original concrete will likely also damage the repaired concrete. Money and effort spent for such repairs is, thus, totally wasted. Additionally, larger and even more costly replacement repairs will then be required.

If the original damage is the result of a one- time event, such as a river barge hitting a bridge pier, an earthquake, or structural overload, remediation of the cause of damage need not be addressed. It is unlikely that such an event will occur again. If, however, the cause of damage is of a continuing or recurring nature, remediation must be addressed, or the repair method and materials must in some manner be made resistant to predictable future damage. The more common causes of damage to Reclamation concrete are discussed in chapter III. A quick review of these common causes of damage reveals that the majority of them are of a continuing or recurring nature.

It is important to differentiate between causes of damage and symptoms of damage. In the above case of the river barge hitting the bridge pier, the cause of damage is the impact to the concrete. The resultant cracking is a symptom of that impact. In the event of freezing and thawing deterioration to modern concrete, the cause of the damage may well lie with the use of low quality or dirty fine or coarse aggregate in the concrete mix. The resultant scaling and cracking is a symptom of low durability concrete. The application of high cost repairs to low quality concrete is usually economically questionable.

It is somewhat common to find that multiple causes of damage exist (section 23). Improper design, low quality materials, or poor construction practices reduce the durability of concrete and increase its susceptibility to deterioration from other causes. Similarly, sulfate and alkali-silica deterioration cause cracks in the exterior surfaces of concrete that allow accelerated deterioration from cycles of freezing and thawing. The deterioration resulting from the lowered resistance to cyclic freezing and thawing might mask the original cause of the damage.

Finally, it is important to fully understand the original design intent and concepts of a damaged structure before attempting repair. Low quality local aggregate may have intentionally been used in the concrete mix because the costs associated with hauling higher quality aggregate great distances may have made it more economical to repair the structure when required at some future date. A classic example of misunderstanding the intent of design recently occurred on a project in Nebraska. A concrete sluiceway that would experience great quantities of waterborne sand was designed with an abrasion-resistant protective overlay of silica fume concrete. This overlay was intentionally designed so that it would not bond to the base concrete, making replacement easier when required by the anticipated abrasion-erosion damage. This design concept, however, was not communicated to construction personnel who became deeply concerned when the silica fume overlay was found to be "disbonded" shortly after placement and curing was completed. Some difficulty was experienced in preventing field personnel from requiring the construction contractor to repair a perfectly serviceable overlay that was performing exactly as intended.

5. Evaluate the Extent of Damage.—The next step of the repair process is to evaluate the extent and severity of damage. The intent of this step is to determine how much concrete has been damaged and how this damage will affect serviceability of the structure (how long, how wide, how deep, and how much of the structure is involved). This activity includes prediction of how quickly the damage is occurring and what progression of the damage is likely.

The importance of determining the severity of the damage should be understood. Damage resulting from cyclic freezing and thawing, sulfate exposure, and alkali-aggregate reaction appears quite similar. The damage caused by alkali-aggregate reaction and sulfates is far more severe than that caused by freeze-thaw, although all three of these causes can result in destruction of the concrete and loss of the affected structure. The main difference in severity lies in the fact that proper maintenance can reduce or eliminate damage caused by freeze-thaw. There is no proven method of reducing damage caused by alkali-aggregate reaction or sulfate exposure.

The most common technique used to determine the extent of damage is sounding the damaged and surrounding undamaged concrete with a hammer. If performed by experienced personnel, this simple technique, when combined with a close visual inspection, will provide the needed information in many instances of concrete damage. In sounding suspected delaminated or disbonded concrete, it should be remembered that deep delaminations or delaminations that contain only minute separation may not always sound drummy or hollow. The presence of such delaminations can be detected by placing a hand close to the location of hammer blows or by closely observing sand particles on the surface

close to the hammer blows. If the hand feels vibration in the concrete, or if the sand particles are seen to bounce however slightly due to the hammer blows, the concrete is delaminated.

An indication of the strength of concrete can also be determined by hammer blows. High strength concrete develops a distinct ring from a hammer blow and the hammer rebounds smartly. Low strength concrete resounds with a dull thud and little rebound of the hammer. More detailed information can be obtained by using commercially available rebound hammers, such as the Schmidt Rebound Hammer.

Cores taken from the damaged areas can be used to detect subsurface deterioration, to determine strength properties through laboratory testing, and to determine petrography. Petrographic examination of concrete obtained by coring can also be very useful in determining some causes of deterioration.

There are a number of nondestructive testing methods that can be used to evaluate the extent of damage (Poston et al., 1995). The above-mentioned Schmidt Rebound Hammer is perhaps the cheapest and simplest to use. Ultrasonic pulse velocity and acoustic pulse echo devices measure the time required for an electronically generated sound wave to either travel through a concrete section or to travel to the far side of a concrete section and rebound. Damaged or low quality concrete deflects or attenuates such sound waves and can be detected by comparison of the resulting travel time with that of sound concrete. Acoustic emission devices detect the elastic waves that are generated when materials are stressed or strained beyond their elastic limits. With such devices, it is possible to "hear" the impulses from development of microcracks in overly stressed concrete. Acoustic emission equipment has been used to "hear" the occurrence of prestressing strand failure in large diameter prestressed concrete pipe. With computer assistance, several acoustic emission devices have been used not only to detect the occurrence of strand failure(s), but through triangulation, they were able to determine the location of the failure(s) (Travers, 1994).

The areas of deteriorated or damaged concrete discovered by these methods should be mapped or marked on drawings of the affected structure to provide information needed in subsequent calculations of the area and volume of concrete to be repaired and for preparation of repair specifications. Even though care is taken in these investigations, it is common to find during preparation of the concrete for repair that the actual area and volume of deteriorated concrete exceeds the original estimate. For this reason, it is usually a good idea to increase the computed quantity estimates by 15 to 25 percent to cover anticipated overruns.

6. Evaluate the Need to Repair.—Not all damaged concrete requires immediate repair. Many factors need consideration before the decision to perform repairs can be made. Obviously, repair is required if the damage affects the safety or safe operation of the structure. Similarly, repairs should be performed if the deterioration has reached a state, or is progressing at a rate, such that future serviceability of the structure will be reduced. Most concrete damage, however, progresses slowly, and several options are usually available if the deterioration is detected early. With early detection, it may be possible to arrest the rate of deterioration using maintenance procedures. Even if repair is required, early detection of damage will allow orderly budgeting of funds to pay the costs of repair.

Some types of concrete deterioration can simply be ignored. Cracking due to drying shrinkage and freezing and thawing deterioration is common on the downstream face of many older western dams. These types of damage are unsightly, but repair can seldom be justified for other than cosmetic purposes. It should be anticipated that such repairs might be more unsightly and of lower durability than the existing concrete. Conversely, structural cracks due to foundation settlement and freezing and thawing deterioration to the walls or floor of a

spillway will usually require repair, if not immediately, at some point in the future. Figure 3 shows freezing and thawing damage to the face of a dam that does not require repair for safe operation of the structure. Figure 4 shows similar damage that should have been repaired long ago. Damage caused by absorptive aggregate popouts is common on bridge deck, canal, and dam concrete (figure 5). Unless such concrete is exposed to high velocity waterflows, where the offsets caused by popouts can result in cavitation damage, repair can be ignored. Figure 6 shows damage to a spillway that appears quite serious, and repair is obviously required. This spillway, however, is constructed with a very thick slab and does not experience high velocity water flow. The repairs can be scheduled at some future date to allow an orderly process of budgeting to obtain the required funding. It should be noted, however, that proper maintenance might have eliminated the need to repair this spillway.

Selecting or scheduling the most optimum time to perform needed concrete repair should be part of the process of determining the need to repair. Except in emergencies, many irrigation structures cannot be removed from service during the water delivery season. The expense or loss of income involved with the inopportune release of reservoir water in order to lower water surface elevations to accomplish repairs may exceed the costs of the repairs by many times. If such costs exceed the value of the benefits expected from performing repairs, it might be prudent to postpone or even cancel performance of the repairs. Figure 7 shows damage on a spillway floor. This damage was initially judged to be of a nonserious nature. Closer evaluation, however, revealed that foundation material had been removed from a very large area beneath this floor slab and that immediate repair was required. Had this spillway been operated without repair during periods of high spring runoff or floodflows, extensive additional damage might have resulted.

These first steps—determining the cause of damage, evaluating the extent of damage, and evaluating the need to repair—form the basis of what is known as a condition survey. If the damage is not extensive or if only a small part of a structure is involved, the condition survey could be simply a mental exercise. If major repair or rehabilitation is required, a detailed condition survey should be performed and documented. Such a survey will consist of review of the plans, specifications, and operating parameters for the structure; determination of concrete properties; and any additional field surveys, engineering studies, or structural analysis required to fully evaluate the present and desired conditions of the structure (American Concrete Institute, 1993). The final feature of a condition survey, completed only after the above-listed items have been completed, is a list of the recommended repair methods and materials.

7. Select the Repair Method.—There is a tendency to attempt selection of repair methods/materials too early in the repair process. This should be guarded against. With insufficient information, it is very difficult to make proper, economical, and successful selections. Once the above three steps of the repair process have been completed, or upon completion of a detailed condition survey, the selection of proper repair methods and materials usually becomes very easy. These steps define the types of conditions the repair must resist, the available repair construction time period, and when repairs must be accomplished. This information, in combination with data on the volume and area of concrete to be repaired, will usually determine which of the 15 standard repair materials should be used. Also, this information will determine when the standard repair materials cannot be expected to perform well and when nonstandard materials should be considered (see chapter V). Chapter IV contains a detailed discussion of each of the standard repair materials.

8. Prepare the Old Concrete for Repair.— Preparation of the old concrete for application of the repair material is of primary importance in the accomplishment of durable repairs. The

Figure 3.—Freezing and thawing deterioration to the downstream face of this dam does not require repair for safe operation of the structure.

Figure 4.—This freezing and thawing deterioration should have been repaired before it advanced to the point that wall replacement or removal is the only option.

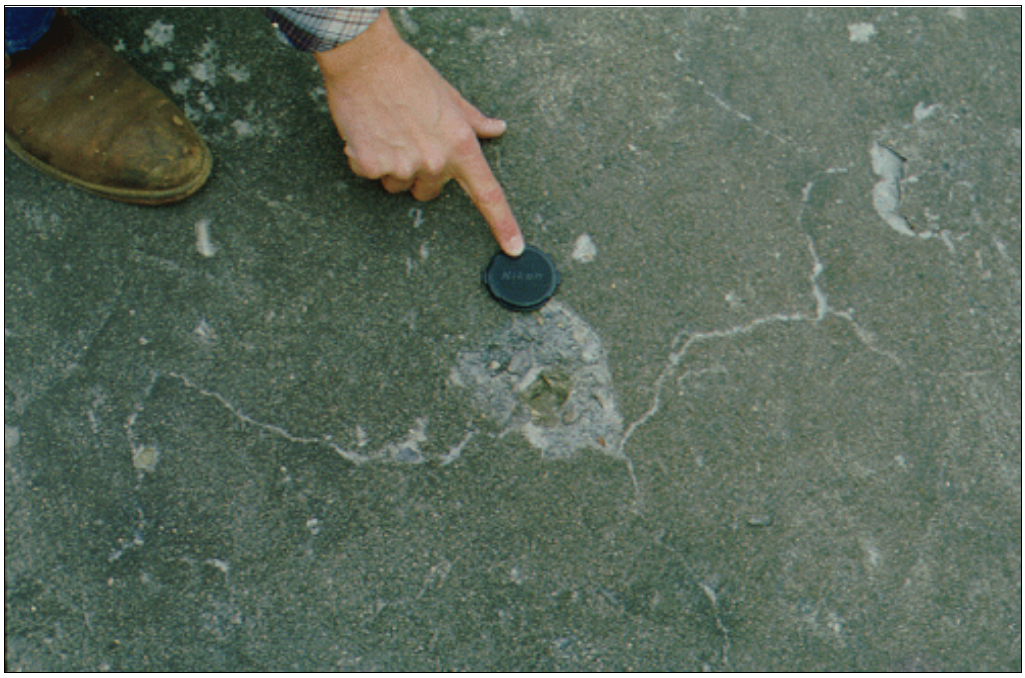

Figure 5.—Absorptive aggregate popout on spillway floor.

Figure 6.—Spillway damage requiring repairs at some future date.

Figure 7.—This concrete damage was found to be a serious threat to the structural integrity of this spillway.

very best of repair materials will give unsatisfactory performance if applied to weakened or deteriorated old concrete. The repair material must able to bond to sound concrete. It is essential that all of the unsound or deteriorated concrete be removed before new repair materials are applied.

Saw Cut Perimeters. The first step in preparing the old concrete for repair is to saw cut the perimeter of the repair area to a depth of 1 to 1.5 inches. The purpose of the saw cuts is to provide a retaining boundary against which the repair material can be compacted and consolidated. The perimeters of repairs are the locations most exposed to the effects of shrinkage, deterioration, and bond failure. Only poor compaction of repair material can be accomplished at feather edge perimeters. Such repair zones will fail quickly. For this reason feather edge perimeters to repair areas are not permitted by Reclamation's M-47 specifications. It is unnecessary to cut to the full depth of the repair, although to do so is not harmful. The saw cuts should be perpendicular to the concrete surface or tilted inward 2 to 3 degrees to provide retaining keyways that mechanically lock the repair material into the area. Tilting the saw inward more than 3 degrees may result in weak top corners in the old concrete and should be avoided. The saw cuts should never be beveled outward.

It is usually false economy to try to closely follow the shape of the repair area with a multitude of short saw cuts as seen at the bottom of figure 8. The cost of sawing such a shape most likely will exceed the cost of

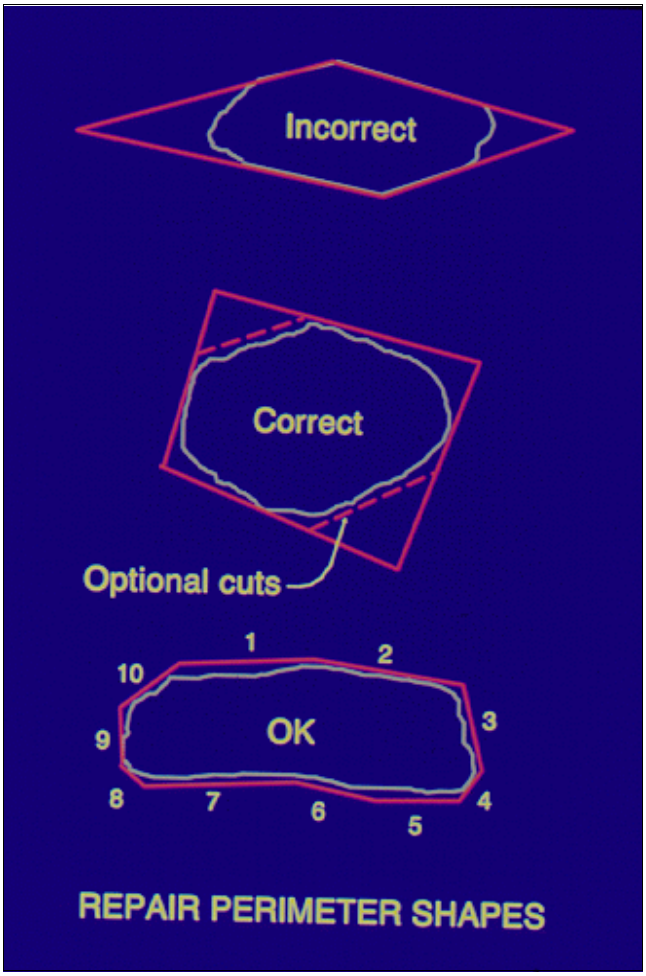

Figure 8.—Saw cut patterns for the perimeters of repair areas.

increased repair area, and the resulting repair may be less attractive than those having simple rectangular shapes. Saw cuts should not meet in acute angles as shown at the top of figure 8. It is very difficult to compact repair material into such sharp corners. The saw cut perimeters should have rounded corners, as seen in figure 9, whenever reasonable. Rounded corners cannot be cut with a circular concrete saw, but the cuts can be stopped short of the intersection and rounded using a jackhammer or bush hammer carefully held in a vertical orientation. It should be noted that intersections cannot be cut with a circular saw without the cuts extending outside the intersection. These cut extensions often serve as sources of cracking in some repair materials. Once the perimeters have been cut, the deteriorated concrete is removed using methods discussed in following paragraphs.

Concrete Removal. All deteriorated or damaged concrete must be removed from the repair area to provide sound concrete for the repair material to bond to. It is always false economy to attempt to save time or money by shortchanging the removal of deteriorated concrete. Whenever possible, the first choice of concrete removal technique should be high pressure (8,000 to 15,000 pounds per square inch [psi]) hydroblasting or hydrodemolition. These techniques have the advantage of removing the unsound concrete while leaving high quality concrete in place. They have a further advantage in that they do not leave microfractured surfaces on the old concrete. Impact removal techniques, such as bush-hammering, scrabbling, or jackhammering, can leave surfaces containing a multitude of microfractures which seriously reduce the bond of the repair material to the existing

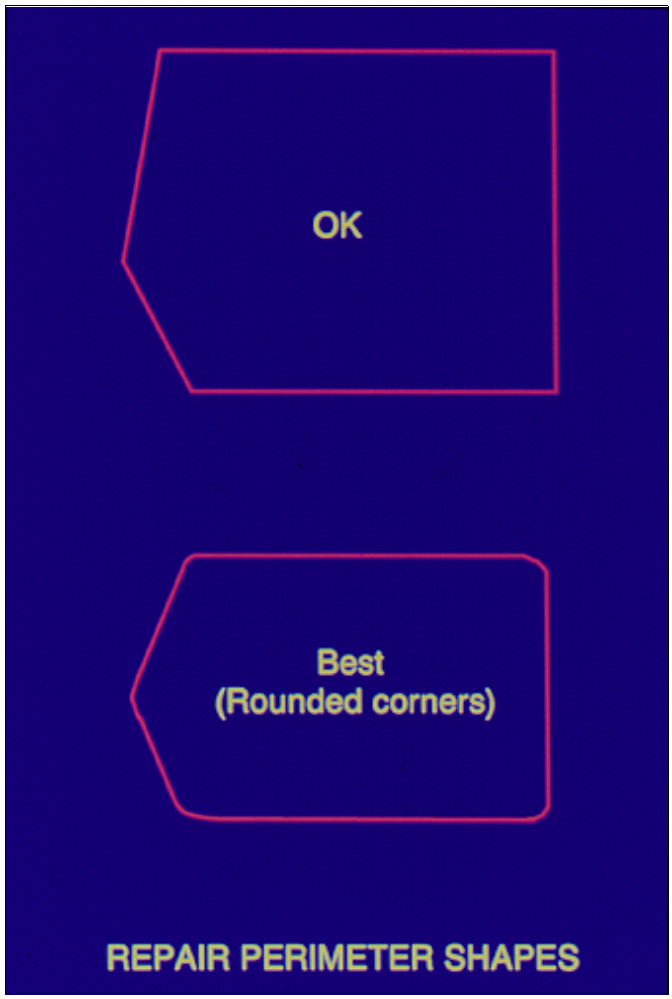

Figure 9.—Corners of repair areas should be rounded whenever possible.

concrete. Subsequent removal of the micro-fractured surface by hydroblasting, shot blasting, or by wet or dry sandblasting is required by Reclamation's M-47 specifications if impact removal techniques are used. A disadvantage of the high pressure water blasting techniques is that the waste water and debris must be handled in an environmentally acceptable manner as prescribed by local regulations.

Impact concrete removal techniques, such as jackhammering for large jobs and bush-hammering for smaller areas, have been used for many years. These removal procedures are quick and economical, but it should be kept in mind that the costs of subsequent removal of the microfractured surfaces resulting from these techniques must be included when comparing the costs of these techniques to the costs of high pressure water blasting. The maximum size of jackhammers should usually be limited to 60 pounds. The larger jackhammers remove concrete at a high rate but are more likely to damage surrounding sound concrete. The larger hammers can impact and loosen the bond of concrete to reinforcing steel for quite some distance away from the point of impact. Pointed hammer bits, which are more likely to break the concrete cleanly rather than to pulverize it, should be used to reduce the occurrence of surface microfracturing.

Shallow surface deterioration (usually less than 1/2 inch deep) is best removed with shot blasting (figure 10) or dry or wet sand-blasting. Shot blasting equipment is highly efficient and usually includes some type of vacuum pickup of

Figure 10 – Shot blasting equipment used to remove shallow concrete deterioration

the resulting dust and debris. The use of such equipment is much more environmentally acceptable than dry sand blasting. The need for removal of such shallow depths of deteriorated concrete is seldom encountered in Reclamation repairs other than for removal of microfractured surfaces or for cosmetic surface cleaning. Shallow deterioration to concrete surfaces can also be removed with tools known as scrabblers (figure 11). These tools usually have multiple bits (figure 12) which pound and pulverize the concrete surfaces in the removal process. Their use greatly multiplies the micro fractures in the remaining concrete surfaces. Extensive high pressure water, sand, or shot blasting efforts are then needed to remove the resulting damaged surfaces. Such efforts are seldom attained under field conditions. For this reason, Reclamation's M-47 specifications prohibit use of scrabblers for concrete removal.

Reinforcing Steel Preparation. Reinforcing steel exposed during concrete removal requires special treatment. As a minimum, all scale, rust, corrosion, and bonded concrete must be removed by wire brushing or high pressure water or sand blasting. It is not necessary to clean the steel to white metal condition, just to remove all the loose or poorly bonded debris that would affect bond between the repair material and the reinforcing steel. If corrosion has reduced the cross section of the steel to less than 75 per- cent of its original diameter, the affected bars should be removed and replaced in accordance with section 12.14 of American Concrete Institute (ACI) 318 (ACI, 1992). Steel exposed more than one-third of its perimeter circumference should be sufficiently exposed to provide a 1-inch minimum clearance between the steel and the concrete. Figure 13 shows the correct concrete removal and preparation for repairing a delamination occurring at the top mat of reinforcing steel of a concrete slab. Figure 14 shows correct preparation of a concrete defect that extends entirely through a wall. Figure 15 shows a properly prepared shallow repair area on a highway bridge deck.

Maintenance of Prepared Area. After the repair area has been prepared, it must be maintained in a clean condition and protected

Figure 11.—Scrabbler equipment used to remove shallow concrete deterioration.

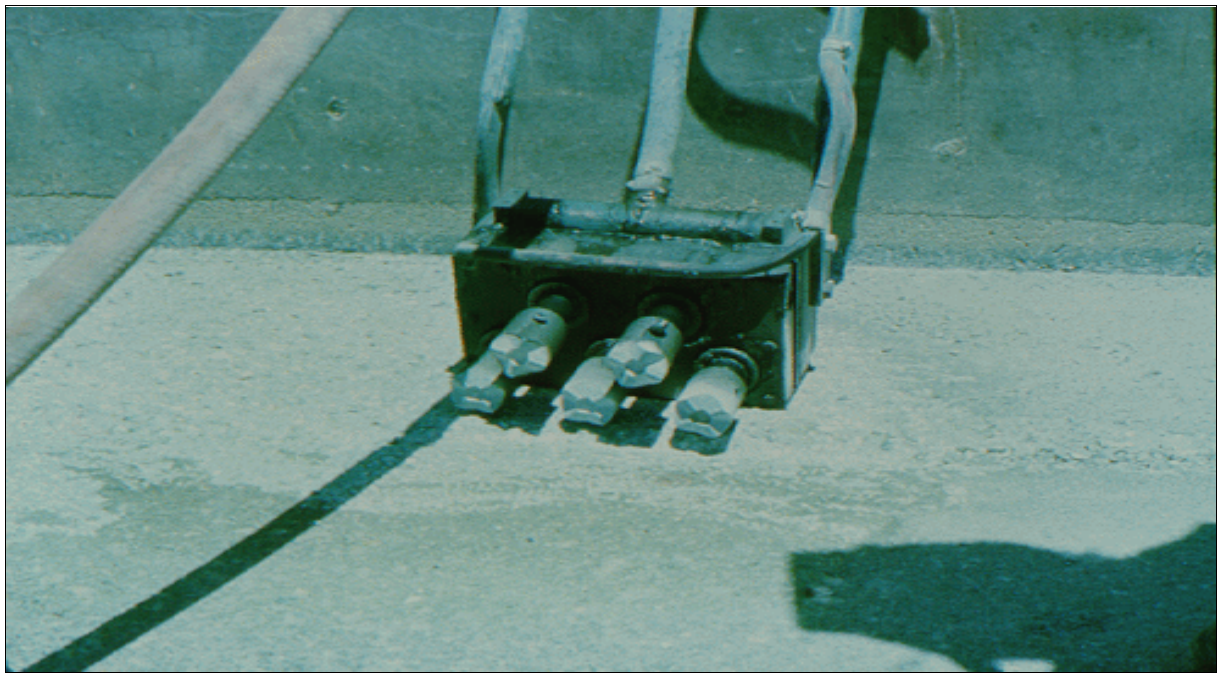

Figure 12.—Multiple bits on the head of a scrabbler pound and pulverize the concrete surface during the removal process.

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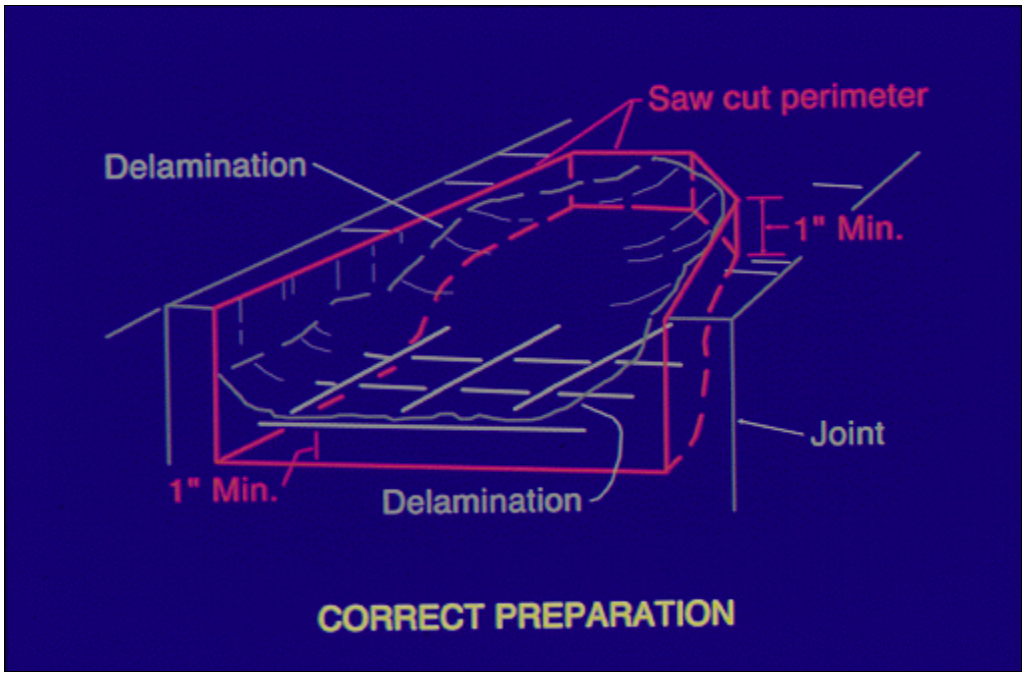

Figure 13.—Correct preparation of a concrete delamination. Perimeter has been saw cut to a minimum depth of 1 inch, and concrete has been removed to at least 1 inch beneath exposed reinforcing steel.

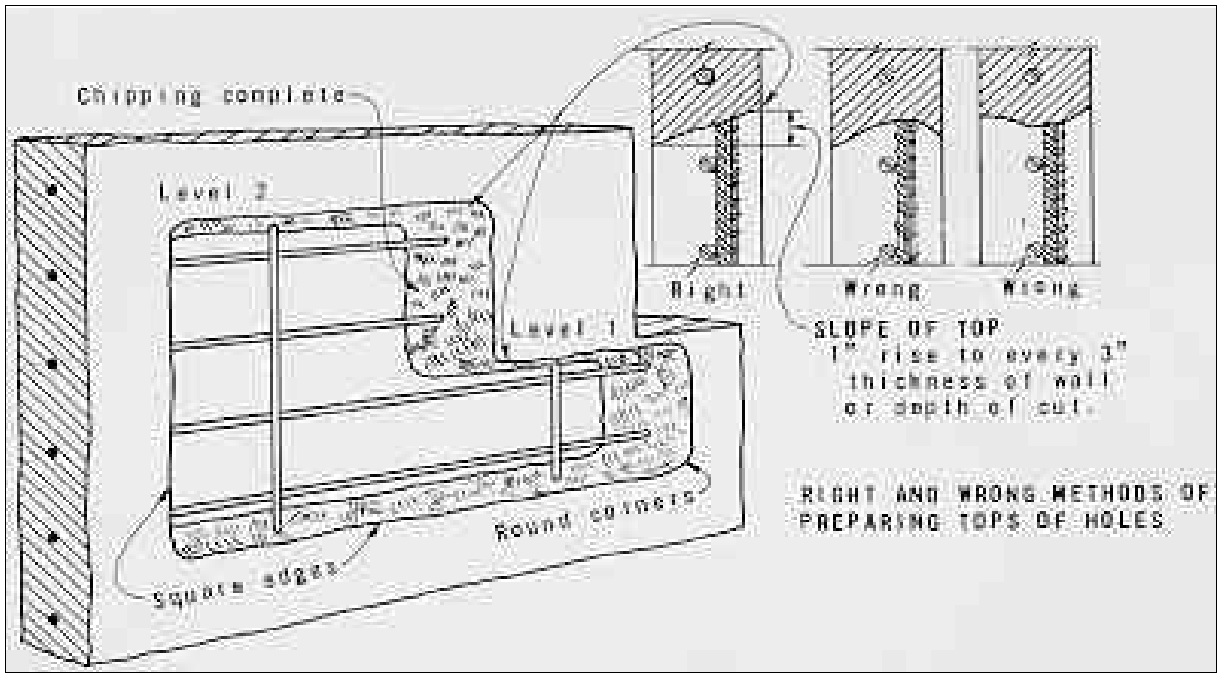

Figure 14.—Preparation of a concrete deterioration that extends completely through a concrete wall.

Figure 15.—Preparation of a shallow defect on a highway bridge deck.

from damage until the repair materials can be placed and cured. In hot climates, this might involve providing shade to keep the concrete cool, thereby reducing rapid hydration or hardening. If winter conditions exist, steps need to be taken to provide sufficient insulation and/or heat to prevent the repair area from being covered with snow, ice, or snowmelt water. It should be remembered that repair activities can also contaminate or damage a properly prepared site. Workmen placing repair materials in one area of a repair often track mud, debris, cement dust, or concrete into an adjacent repair area. Once deposited on a prepared surface, this material will serve as a bond breaker if not cleaned up before the new repair material is placed. Repair contractors should be required to repeat preparation if a repair area is allowed to become damaged or contaminated. The prepared concrete should be kept wet or dry, depending upon the repair material to be used. Surfaces that will receive polymer concrete or epoxy-bonded materials should be kept as dry as possible. Some epoxies will bond to wet concrete, but they always bond better to dry concrete. Surfaces that will be repaired with cementitious material should be in a saturated surface dry (SSD) condition immediately prior to material application. This condition is achieved by soaking the surfaces with water for 2 to 24 hours just before repair application. Immediately before material application, the repair surfaces should be blown free of water, using compressed air. The SSD condition prevents the old concrete from absorbing mix water from the repair material and promotes development of adequate bond strength in the repair material. The presence of free water on the repair surfaces during application of the repair material must be avoided whenever practicable.

9. Apply the Repair Method.—There are 15 different standard concrete repair methods/materials in Reclamation's M-47 specification. Each of these materials has uniquely different requirements for successful application. These requirements and application procedures are discussed at length in chapter IV of this guide.

10. Cure the Repair Properly.—All of the standard repair materials, with the exception of some of the resinous systems, require proper curing procedures. Curing is usually the final step of the repair process, followed only by cleanup and demobilization, and it is somewhat common to find that the curing step has been shortened, performed haphazardly, or eliminated entirely as a result of rushing to leave the job or for the sake of perceived economies. It should be understood that proper curing does not represent unnecessary costs. Rather, it represents a sound investment in long-term insurance. Inadequate or improper curing can result in significant loss of money. At best, improper curing will reduce the service life of the repairs. More likely, inadequate or improper curing will result in the necessity to remove and replace the repairs. The costs of the original repair are, thus, completely lost, and the costs of the replacement repair will be greater because the replacement repairs will be larger and must include the costs of removal of the failed repair material. The curing requirements for each of the 15 standard repair materials are discussed in chapter IV.

Chapter III

Causes of Damage to Concrete

The more common causes of damage to Reclamation concrete are discussed in this chapter. The discussion for each cause of damage consists of (1) a description of the cause and how it damages concrete and (2) a discussion and/or listing of appropriate methods/materials to repair that particular type of concrete damage. The format for the text of this chapter was chosen in recognition of the importance of first determining the cause(s) of damage to concrete before trying to select the repair method. It is expected that the full discussion of the selected repair method, as found in chapter IV, will be consulted prior to performance of the work.

11. Excess Concrete Mix Water.—The use of excessive water in concrete mixtures is the single most common cause of damage to concrete. Excessive water reduces strength, increases curing and drying shrinkage, increases porosity, increases creep, and reduces the abrasion resistance of concrete. Figure 16 shows the cumulative effects of water-cement ratio on the durability of concrete. In this figure, high durability is associated with low water-cement ratio and the use of entrained air.

Damage caused by excessive mix water can be difficult to correctly diagnose because it is usually masked by damage from other causes. Freezing and thawing cracking, abrasion erosion deterioration, or drying shrinkage cracking, for example, is often blamed for damage to concrete when, in reality, excessive mix water caused the low durability that allowed these other causes to attack the concrete. During petrographic examination, extreme cases of excessive mix water in hardened concrete can sometimes be detected by the presence of bleed water channels or water pockets under large aggregate. More commonly, examination of the batch sheets, mix records, and field inspection reports will provide confirmation of the use of excessive mix water in damaged concrete. It should be recognized, however, that water added to transit truck mixes at the construction site or applied to concrete surfaces during finishing operations often goes undocumented.

The only permanent repair of concrete damaged by excessive mix water is removal and replacement. However, depending on the extent and nature of damage, a number of maintenance or repair methods can be useful in extending the service life of such concrete. If the damage is detected early and is shallow (less than 1.5 inches deep), application of concrete sealing compounds, such as the high solids content (greater than 15 percent) oligomeric alkyl-alkoxy siloxane or silane systems (section 38) or the high molecular weight methacrylic monomer system (section 35), will reduce water penetration and improve resistance to freeze-thaw spalling and deterioration. Such systems require reap-plication at 5- to 10-year intervals. Epoxy- bonded replacement concrete (section 31) can be used to repair damage that extends between 1.5 and 6 inches into the concrete, and replacement concrete (section 29) can be used to repair damage 6 inches deep or deeper.

12. Faulty Design.—Design faults can create many types of concrete damage. Discussion of all the types of damage that can result from faulty design is beyond the scope of this guide. However, one type of design fault that is somewhat common is positioning em-bedded metal such as electrical conduits or outlet boxes too near the exterior surfaces of concrete structures. Cracks form in the concrete over and around such metal features and allow accelerated freeze-thaw deterioration to occur. Bases of handrails or guardrails

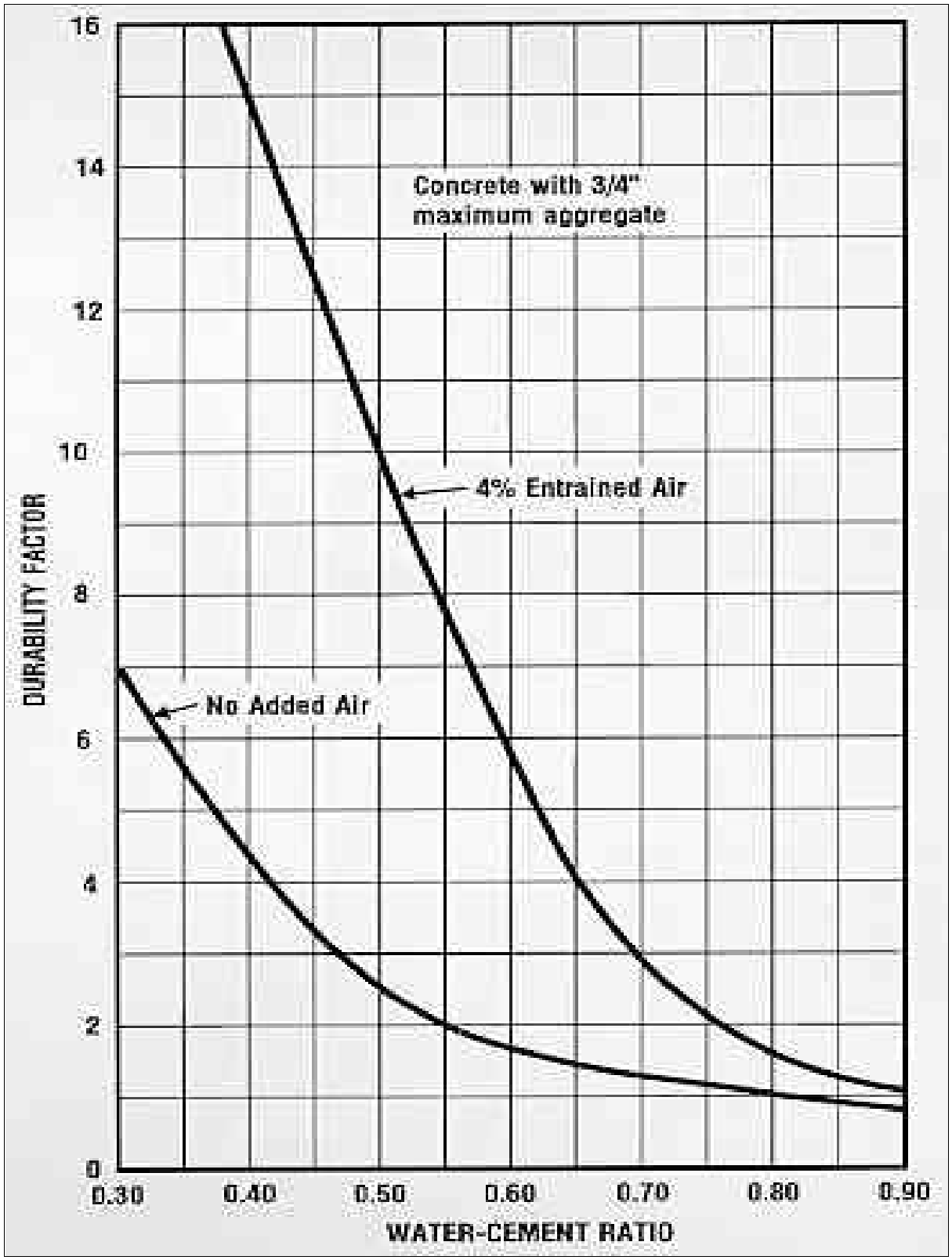

Figure 16.—Relation between durability and water-cement ratio for air entrained and nonair entrained concrete.

are placed too near the exterior corners of walls, walkways, and parapets with similar results. These bases or intrusions into the concrete expand and contract with temperature changes at a rate different from the concrete. Tensile stresses, created in the concrete by expanding metal, cause cracking and subsequent freeze-thaw damage. Long guardrails or handrails can create another problem. The pipe used for such rails also undergoes thermal expansion and contraction. If sufficient slip joints are not provided in the rails, the expansion and contraction cause cracking at the points where the rail attachment bases enter the concrete. This cracking also allows accelerated damage to the concrete from freezing and thawing.

Insufficient concrete cover over reinforcing steel is a common cause of damage to highway bridge structures. This can also be a problem in hydroelectric and irrigation structures. Reclamation usually requires a minimum of 3 inches of concrete cover over reinforcing steel, but in corrosive environments, this can be insufficient. Concrete exposed to the corrosive effects of sulfates, acids, or chlorides should have a minimum of 4 inches of cover to protect the reinforcing steel. Insufficient cover allows corrosion of the reinforcing steel to begin. The iron oxide byproducts of this corrosion require more space in the concrete than the reinforcing steel and result in cracking and delaminating in the concrete.

Failure to provide adequate contraction joints or failure to make expansion joints wide enough to accommodate temperature expansion in concrete slabs will result in damage. Concrete with inadequate contraction joints will crack and make a joint wherever a joint was needed but not pro-vided. Unfortunately, such cracks will not be as visually attractive as a formed or sawed joint. Formation of the cracks relieves the tensile stresses and, though unsightly, seldom requires repair. Concrete slabs constructed with insufficient or too narrow expansion joints can cause serious damage to bridge deck surfaces, dam roadways, and the floors of long, steeply sloping, south facing spillways. Such concrete experiences large daily and seasonal temperature changes resulting from solar radiation. The resulting concrete expansion is greater in the top surfaces of the slabs, where the concrete temperatures are higher, and less in the cooler bottom edges. Such expansion can cause the upper portions of concrete in adjacent slabs to butt against one another at the joints between the slabs. The only possible direction of relief movement in such slabs is upward, which causes delaminations to form in the concrete, starting at the joints and extending an inch or two back into the slab. These delaminations are commonly located at the top mat of reinforcing steel. In temperate climates, the formation of delaminations relieves the expansion strains, and further damage will usually cease. In cold climates, however, water can enter the delaminations where it undergoes a daily cycle of freezing and thawing. This causes the delaminations to grow and extend as much as 3 to 5 feet away from the joint. Figure 17 is an exaggerated example of such damage.

Repair of damage caused by faulty design is futile until the design faults have been mitigated. Embedded metal features can be removed, handrails can be provided with slip joints, and guardrail attachment bases can be moved to locations with sufficient concrete to withstand the tensile forces. Mitigation of insufficient concrete cover over reinforcing steel is very difficult, but repair materials resistant to those particular types of corrosion can be selected for the repair. Repairs can also be protected by concrete sealing compounds or coatings to reduce water penetration. Slabs containing inadequate expansion joints can be saw cut to increase the number of joints and/or to widen the joints to provide sufficient room for the expected thermal expansion.

Damage caused by design faults can most likely be repaired using replacement concrete (section 29), epoxy-bonded replacement concrete (section 31), or epoxy-bonded epoxy mortar (section 30).

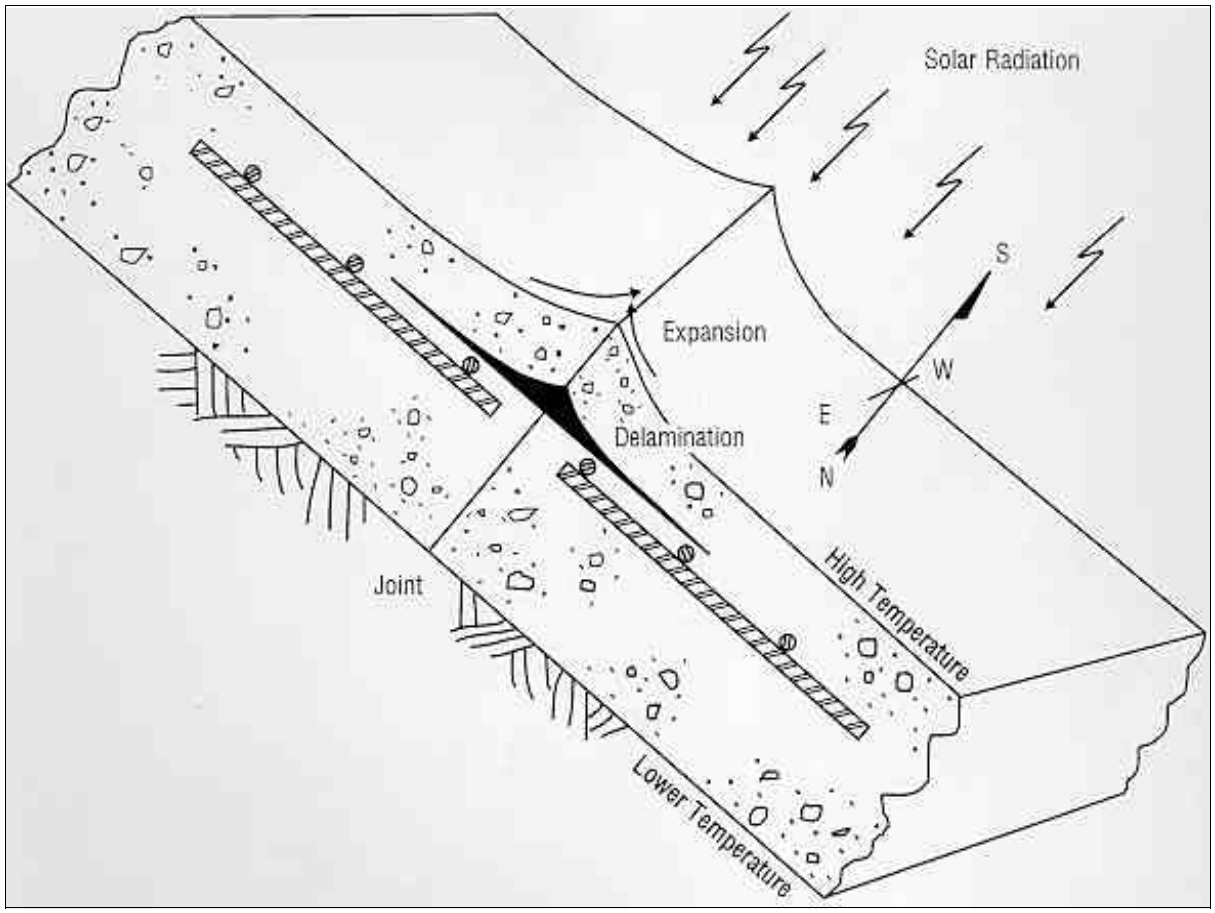

Figure 17.—Delamination caused by solar expansion.

13. Construction Defects.—Some of the more common types of damage to concrete caused by construction defects are rock pockets and honeycombing, form failures, dimensional errors, and finishing defects.

Honeycomb and rock pockets are areas of concrete where voids are left due to failure of the cement mortar to fill the spaces around and among coarse aggregate particles. These defects, if minor, can be repaired with cement mortar (section 25) if less than 24 hours has passed since form removal. If repair is delayed longer than 24 hours after form removal, or if the rock pocket is extensive, the area must be prepared and the defective concrete must be removed and replaced with dry pack (section 26), epoxy-bonded replacement concrete (section 31), or replacement concrete (section 29). Some minor defects resulting from form movement or failure can be repaired with surface grinding (section 24). More likely, the resulting defect is either simply accepted by the owner, or the contractor is required to remove the defective concrete and reconstruct that portion of the structure.

There are many opportunities to create dimensional errors in concrete construction. Whenever possible, it usually is best to accept the resulting deficiency rather than attempt to repair it. If the nature of the deficiency is such that it cannot be accepted, then complete removal and reconstruction is probably the best course of action. Occasionally, dimensional errors can be corrected by removing the defective concrete and replacing it with epoxy-bonded concrete or replacement

concrete.

Finishing defects usually involve overfinishing or the addition of water and/or cement to the surface during the finishing procedures. In each instance, the resulting surface is porous and permeable and has low durability. Poorly finished surfaces exhibit surface spalling early in their service life. Repair of surface spalling involves removal of the weakened concrete and replacement with epoxy-bonded concrete (section 31). If the deterioration is detected early, the service life of the surface can be extended through the use of concrete sealing compounds (sections 35 and 38).

14. Sulfate Deterioration.—Sodium, magnesium, and calcium sulfates are salts commonly found in the alkali soils and groundwaters of the Western United States. These sulfates react chemically with the hydrated lime and hydrated aluminate in cement paste and form calcium sulfate and calcium sulfoaluminate. The volume of these reaction byproducts is greater than the volume of the cement paste from which they are formed, causing disruption of the concrete from expansion. Type V portland cement, which has a low calcium aluminate content, is highly resistant to sulfate reaction and attack and should be specified when it is recognized that concrete must be exposed to soil and groundwater sulfates. See table 2 of the *Concrete Manual* (Bureau of Reclamation, 1975) for guidance on materials and mixture proportions for concretes exposed to sulfate environments.

Concrete that is undergoing active deterioration and damage due to sulfate exposure can sometimes be helped by application of a thin polymer concrete overlay (section 33) or concrete sealing compounds (sections 35 and 38). Alternate wetting and drying cycles accelerate sulfate deterioration, and some slowing of the rate of deterioration can be accomplished by interrupting the cyclic wetting and drying. Procedures for eliminating or removing waterborne sulfates are also helpful if this is the source of the sulfates. Otherwise, the deteriorating concrete should be monitored for removal and replacement with concrete constructed of type V cement, when appropriate.

15. Alkali-Aggregate Reaction.—Certain types of sand and aggregate, such as opal, chert, and flint, or volcanics with high silica content, are reactive with the calcium, sodium, and potassium hydroxide alkalies in portland cement concrete. These reactions, though observed and studied for more than 50 years (Bureau of Reclamation, 1942), remain poorly defined and little understood. Some concrete containing alkali reactive aggregate shows immediate evidence of destructive expansion and deterioration. Other concrete might remain undisturbed for many years. Petrographic examination of reactive concrete shows that a gel is formed around the reactive aggregate. This gel undergoes extensive expansion in the presence of water or water vapor (a relative humidity of 80 to 85 percent is all the water required), creating tension cracks around the aggregate and expansion of the concrete (figure 18). If unconfined, the expansion within the concrete is first apparent by pattern cracking on the surface. Usually, some type of whitish exudation will be evident in and around the cracked concrete. In extreme instances, these cracks have opened 1.5 to 2 inches (figure 19). It is common for such expansion to cause significant offsets in the concrete and binding or seizure of control gates on dams. In large concrete structures, alkali-aggregate reaction may occur only in certain areas of the structure. Until it is recognized that multiple aggregate sources are commonly used to construct large concrete structures, this might be confusing. Only portions of the structure constructed with concrete containing alkali reactive sand and/or aggregate will exhibit expansion due to alkali-aggregate reaction. This situation presently exists at Minidoka Dam (Stark and DePuy, 1995), Stewart Mountain Dam, Coolidge Dam, Friant Dam, and Seminoe Dam.

In new construction, low alkali portland cements and fly ash pozzolan can be used to

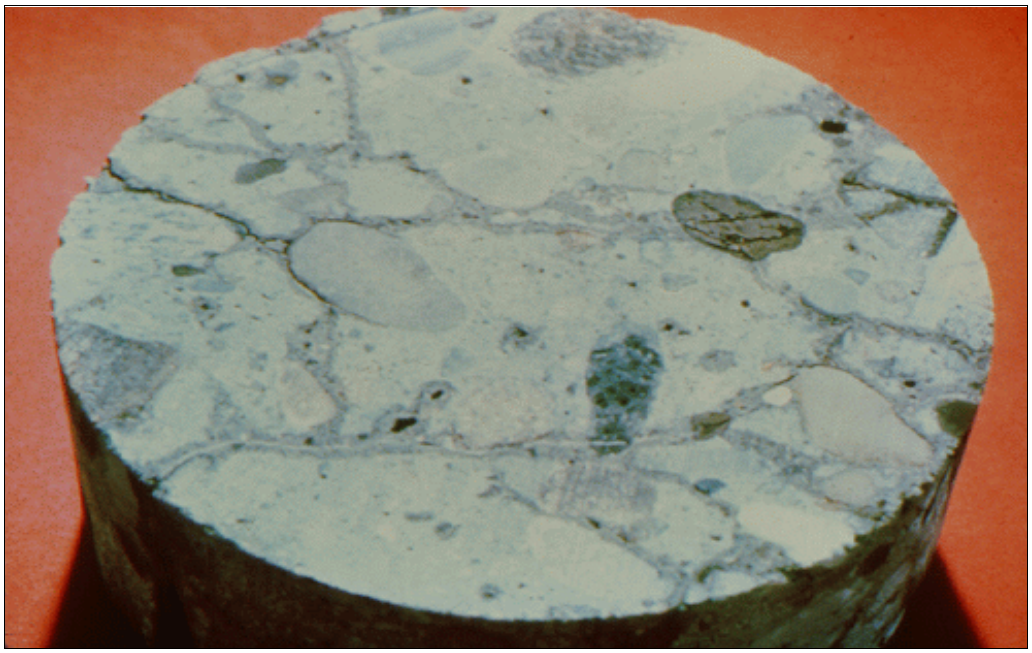

Figure 18.—Gel resulting from alkali-aggregate reaction causes expansion and tension cracks in a concrete core.

eliminate or greatly reduce the deterioration of reactive aggregates. In existing concrete structures, deterioration due to reactive aggregate is virtually impossible to mediate. There are no proven methods of eliminating the deterioration of alkali-aggregate reaction, although the rate of expansion can sometimes be reduced by taking steps to maintain the concrete in as dry a condition as possible. It is usually futile to attempt repair of concrete actively undergoing alkali-aggregate reaction. The continuing expansion within the concrete will simply disrupt and destroy the repair material. Structures undergoing active deterioration should be monitored for rate of expansion and movement, and only the repairs necessary to maintain safe operation of the facility should be made. The binding gates of several dams have been relieved and returned to operation by using wire saws to make expansion relief cuts in the concrete on either side of the binding gates. The cuts were subsequently sealed to water leakage using polyurethane resin injection techniques (section 34). With continuing expansion of the concrete, such relief cuts may have to be repeated several times. In many structures, the expansion and movement associated with reactive aggregate slows down and ceases when all the alkali components are consumed by the reactions. Once the expansion ceases, repairs can be performed to rehabilitate and restore the structure to full operation and serviceability. However, it should be anticipated that, ultimately, it may be necessary to replace structures undergoing alkali-aggregate deterioration. Such was the case with the 1975 replacement of Reclamation's American Falls Dam in Idaho. This dam was constructed in 1927 and replaced after extensive studies conducted by Reclamation's Denver concrete laboratories revealed that it had been severely damaged by alkali-aggregate reaction.

16. Deterioration Caused by Cyclic Freezing and Thawing.—Freeze-thaw deterioration is a common cause of damage to concrete constructed in the colder climates. For freeze-thaw damage to occur, the following conditions must exist:

a. The concrete must undergo cyclic freezing and thawing.

Figure 19.—Severe cracking caused by alkali-aggregate reaction.

b. The pores in the concrete, during freezing, must be nearly saturated with water (more than 90 percent of saturation).

Water experiences about 15 percent volumetric expansion during freezing. If the pores and capillaries in concrete are nearly saturated during freezing, the expansion exerts tensile forces that fracture the cement mortar matrix. This deterioration occurs from the outer surfaces inward in almost a layering manner. The rate of progression of freeze-thaw deterioration depends on the number of cycles of freezing and thawing, the degree of saturation during freezing, the porosity of the concrete, and the exposure conditions. The tops of walls exposed to snowmelt or water spray, horizontal slabs exposed to water, and vertical walls at the water line are the locations most commonly damaged by freeze-thaw deterioration. If such concrete has a southern exposure, it will experience daily cycles of freezing during the night and thawing during the morning. Conversely, concrete with a northern exposure may only experience one cycle of freezing and thawing each winter, a far less damaging condition. Figures 20 and 21 show typical examples of freeze-thaw deterioration.

Another type of deterioration caused by cycles of freezing and thawing is known as D-cracking. In this instance, the expansion occurs in low quality, absorptive, coarse aggregate instead of in the cement mortar matrix. D-cracking is most commonly seen at the exposed corners of walls or slabs formed by joints. A series of roughly parallel cracks exuding calcite usually cuts across the corners of such damage (figure 22).

In 1942, Reclamation began specifying the use of air entraining admixtures (AEA) in concrete to protect concrete from freezing and thawing damage. Concrete structures built prior to that date did not contain AEA. Angostura Dam, started in 1946, was the first Reclamation Dam constructed with specifications requiring the use of AEA (Price, 1981). This type of admixture produces small air bubbles in the concrete matrix that provide space for water expansion during freezing. If the proper AEA, at the correct concentration, is properly mixed into high quality fresh concrete, there should be very little damage resulting from cyclic freezing and thawing except in very severe climates. Accordingly, if freezing and thawing damage is suspected in modern concrete, investigations should be performed to determine why the AEA was not effective. Except in cases of extremely cold and wet exposure, modern concrete exhibiting freeze-thaw damage has most likely suffered low durability from some other cause (see section 23).

Damage caused by cyclic freezing and thawing of concrete occurs only when the concrete is nearly saturated. Successful mitigation of freeze-thaw deterioration, therefore, involves reducing or eliminating the cycles of freezing and thawing or reducing absorption of water into the concrete. It usually is not practical to protect or insulate concrete from cycles of freezing and thawing temperatures, but concrete sealing compounds (sections 35 and 38) can be applied to exposed concrete surfaces to prevent or reduce water absorption. The sealing compounds are not effective in protecting inundated concrete, but they can provide protection to concrete exposed to rain, windblown spray, or snow melt water.

Repair of concrete damaged by freeze-thaw deterioration is most often accomplished with replacement concrete (section 29) if the damage is 6 inches or deeper, or with epoxy- bonded replacement concrete (section 31) or polymer concrete (section 32) if the damage is between 1.5 and 6 inches deep. The replacement concretes must, of course, contain AEA. Attempted repair of spalls or shallow freeze-thaw deterioration less than 1.5 inches deep is discouraged. To date, no generic or proprietary repair material tested in the Denver laboratories has been found fully suitable for such shallow repairs.

17. Abrasion-Erosion Damage.—Concrete structures that transport water containing silt,

Figure 20.—Freezing and thawing deterioration on small irrigation gate structure.

Figure 21.—Freezing and thawing deterioration on spillway concrete.

Figure 22.—D-cracking type of freezing and thawing deterioration.

sand, and rock or water at high velocities are subject to abrasion damage. Dam stilling basins experience abrasion damage if the flows do not sweep debris from the basins. Some stilling basins have faulty flow patterns that cause downstream sand and rock to be pulled upstream into the basins. This material is retained in the basins where it produces significant damage during periods of high flow (figure 23). Abrasion damage results from the grinding action of silt, sand, and rock. Concrete surfaces damaged in this way usually have a polished appearance (figure 24). The coarse aggregate often is exposed and somewhat polished due to the action of the silt and sand on the cement mortar matrix. Figure 25 shows an early stage of abrasion or, possibly, erosion damage to a stilling basin wall. The extent of abrasion-erosion damage is a function of so many variables—duration of exposure, shape of the concrete surfaces, flow velocity and pattern, flow direction, and aggregate loading—that it is difficult to develop general theories to predict concrete performance under these conditions. Consequently, hydraulic model studies are often required to define the flow conditions and patterns that exist in damaged basins and to evaluate required modifications. If the conditions that caused abrasion-erosion damage are not addressed, the best repair materials will suffer damage and short service life.

It is generally understood that high quality concrete is far more resistant to abrasion damage than low quality concrete, and a number of studies (Smoak, 1991) clearly indicate that the resistance of concrete increases as the compressive strength of the concrete increases.

Abrasion damage is best repaired with silica fume concrete (section 37) or polymer concrete (section 32). These materials have shown the highest resistance to abrasion damage in laboratory and field tests. If the damage does not extend behind reinforcing steel or at least 6 inches into the concrete, the silica fume concrete should be placed over a fresh epoxy bond coat. Figure 26 shows the application of silica fume concrete to an area of abrasion, erosion, and freeze-thaw damage on the floor of

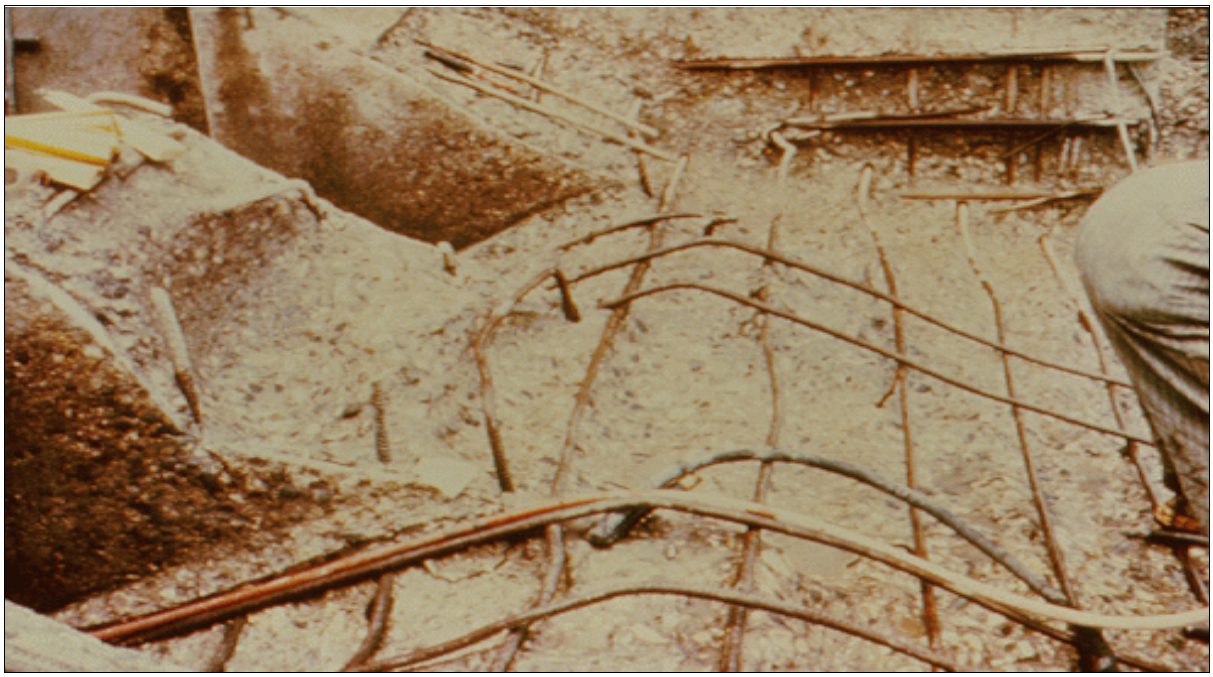

Figure 23.—Abrasion-erosion damage in a concrete stilling basin.

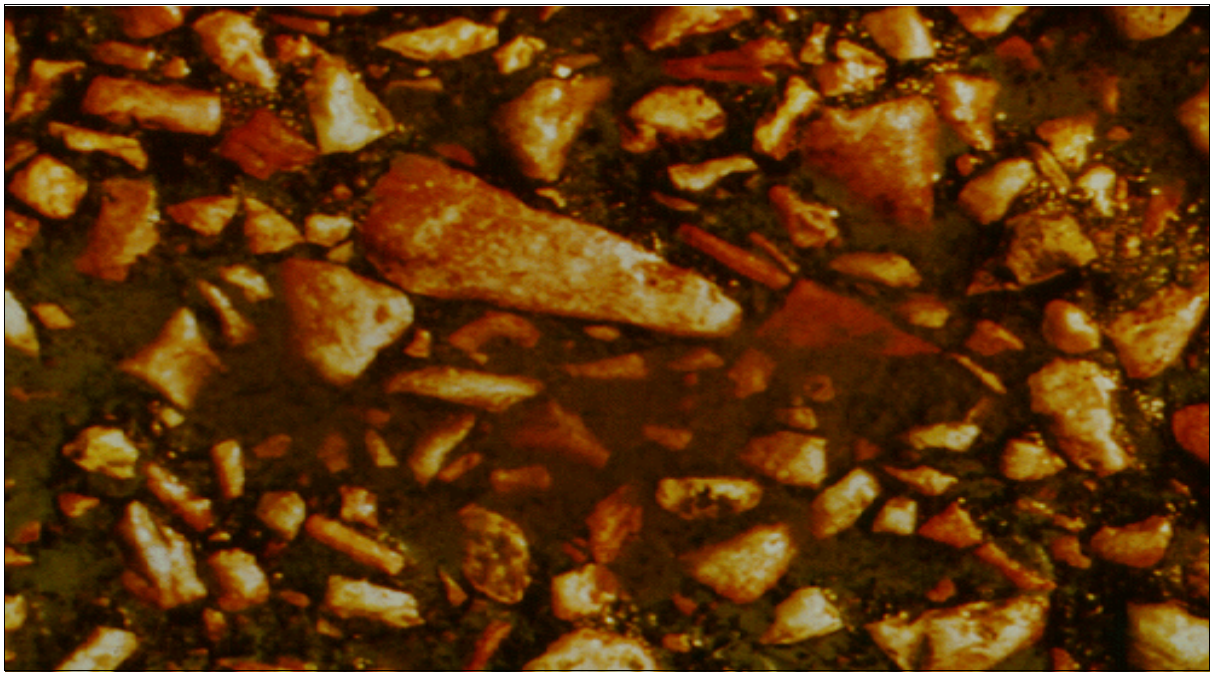

Figure 24.—Abrasion-erosion damage caused by sand or silt.

Figure 25.—Early stages of abrasion-erosion damage.

the Vallecito Dam spillway.

18. Cavitation Damage.—Cavitation damage occurs when high velocity waterflows encounter discontinuities on the flow surface. Discontinuities in the flow path cause the water to lift off the flow surface, creating negative pressure zones and resulting bubbles of water vapor. These bubbles travel downstream and collapse. If the bubbles collapse against a concrete surface, a zone of very high pressure impact occurs over an infinitely small area of the surface. Such high impacts can remove particles of concrete, forming another discontinuity which then can create more extensive cavitation damage. Figure 27 shows the classic "Christmas tree" pattern of cavitation damage that occurred in a large concrete-lined tunnel at Glen Canyon Dam during the flood releases of 1982. In this instance, cavitation damage extended entirely through the concrete tunnel lining and some 40 feet into foundation rock (figure 28).

Cavitation damage is common on and around water control gates and gate frames. Very high velocity flows occur when control gates are first being opened or at small gate openings. Such flows cause cavitation damage just downstream from the gates or gate frames.

The cavitation resistance of many different repair materials has been tested by the laboratories of Reclamation, the U.S. Army Corps of Engineers, and others. To date, no material, including stainless steel and cast iron, has been found capable of withstanding fully developed instances of cavitation. Successful repairs must first include mediation of the causes of cavitation.

A standard rule of thumb is that cavitation damage will not occur at flow velocities less than about 40 feet per second at ambient pressures. As flow velocities approach this threshold, it becomes necessary to ensure that there are no offsets or discontinuities on the surfaces in the flow path. Reclamation's specifications for finishing the surfaces of concrete structures that will experience high velocity flows are very strict. Repairs to newly constructed concrete that fail to meet these

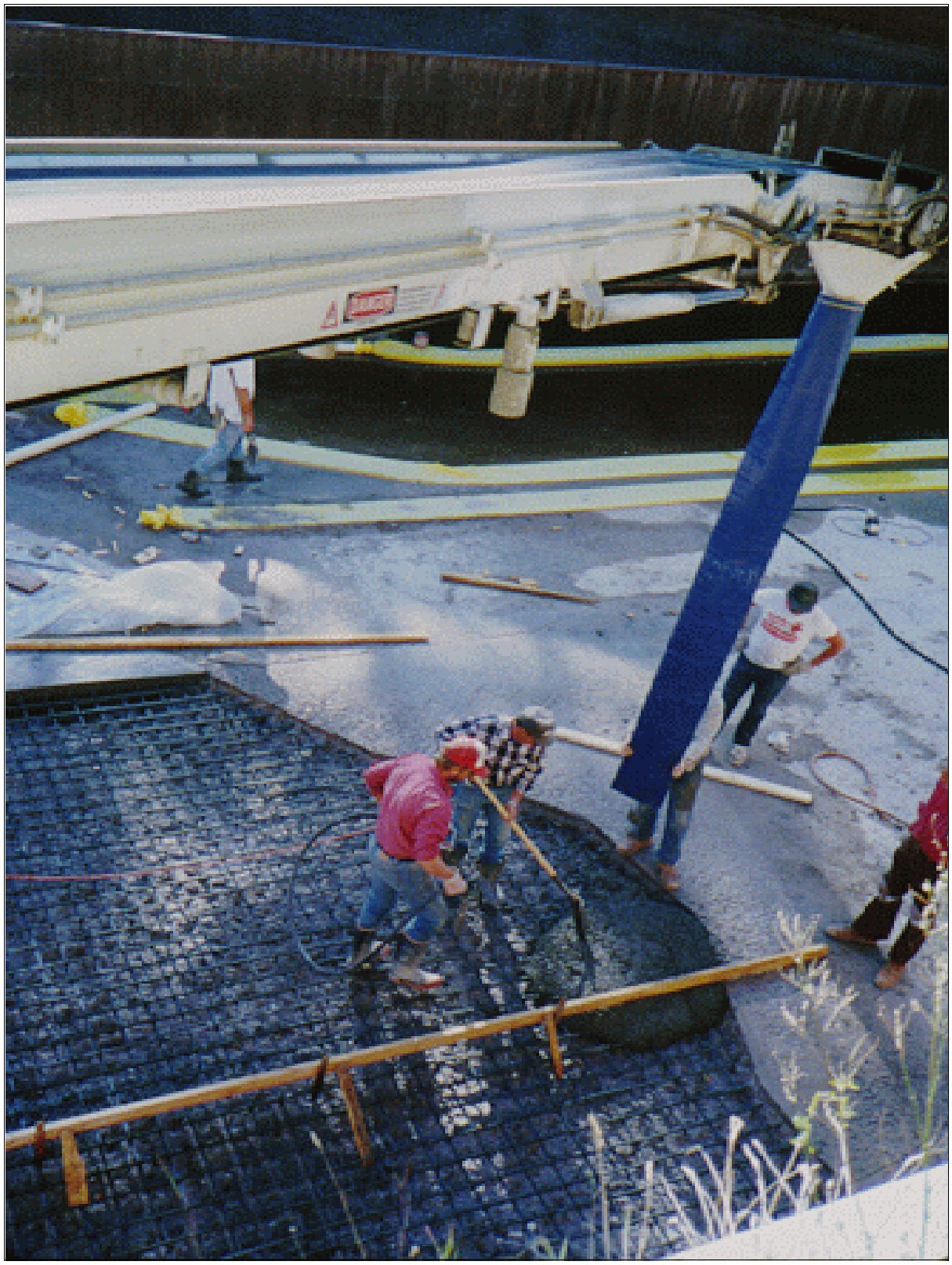

Figure 26.—Placing silica fume concrete to repair a spillway floor damaged by cyclic freezing and thawing and abrasion-erosion.

Figure 27.—Typical Christmas tree pattern of progressive cavitation damage.

Figure 28.—Extensive cavitation damage to Glen Canyon Dam.

requirements can sometimes be accomplished by surface grinding (section 24). More likely, however, the concrete that does not meet surface specifications must be removed and replaced with replacement concrete (section 29) or epoxy-bonded replacement concrete (section 31).

Cavitation damage at, or adjacent to, control gates can usually be repaired with epoxy-bonded epoxy mortar (section 30), polymer concrete (section 32), or epoxy-bonded replacement concrete (section 31). Such damage is usually not very extensive in nature. That is, it is usually discovered before major repairs become necessary. After performing such repairs, it might be a good idea to apply a 100-percent solids epoxy coating to the concrete, beginning at the gate frame and extending downstream 5 to 10 feet. The glass-like surfaces of epoxy coatings may help prevent cavitation damage to the concrete. It should be understood, however, that epoxy coatings will not resist fully developed instances of cavitation damage.

Successful repair of cavitation damage to spillway, outlet works, or stilling basin concrete almost always requires making major modifications to the damaged structure to prevent recurrence of damage. Performance of hydraulic model studies should be considered to ensure correctness of the design of such repair and facility modification. One modification technique, the installation of air slots in spillways and tunnels, has been very successful in eliminating or significantly reducing cavitation damage. Replacement concrete is usually used for construction of such features and the repair of the cavitation damage.

19. Corrosion of Reinforcing Steel.— Corrosion of reinforcing steel is usually a symptom of damage to concrete rather than a cause of damage. That is, some other cause weakens the concrete and allows steel corrosion to occur. However, corroded reinforcing steel is so commonly found in damaged concrete that the purposes of this guide will best be served by discussing it as if it were a cause of damage.

The alkalinity of the portland cement used in concrete normally creates a passive, basic environment (pH of about 12) around the reinforcing steel which protects it from corrosion. When that passivity is lost or destroyed, or when the concrete is cracked or delaminated sufficiently to allow free entrance of water, corrosion can occur. The iron oxides formed during steel corrosion require more space in the concrete than the original reinforcing steel. This creates tensile stresses within the concrete and results in additional cracking and/or delamination which accelerate the corrosion process.

Some of the more common causes of corrosion of reinforcing steel are cracking associated with freeze-thaw deterioration, sulfate exposure, and alkali-aggregate reaction, acid exposure, loss of alkalinity due to carbonation, lack of sufficient depth of concrete cover, and exposure to chlorides.

Exposure to chlorides greatly accelerates the rates of corrosion and can occur in several manners. The application of deicing salts (sodium chloride) to concrete to accelerate thawing of snow and ice is a common source of chlorides. Chlorides can also occur in the sand, aggregate, and mixing water used to prepare concrete mixtures. Some irrigation structures located in the Western States transport waters that have high chloride contents (figure 29). Concrete structures located in marine environments experience chloride exposure from the sea water or from windblown spray. Finally, it was once a somewhat common practice to use concrete admixtures containing chlorides to accelerate the hydration of concrete placed during winter conditions.

The occurrence of corroding reinforcing steel can usually, but not always, be detected by the presence of rust stains on the exterior surfaces and by the hollow or drummy sounds that result from tapping the affected concrete with a hammer. It can also be detected by measuring the half cell potentials of the affected concrete using special electronic devices manufactured specifically for this purpose. When the

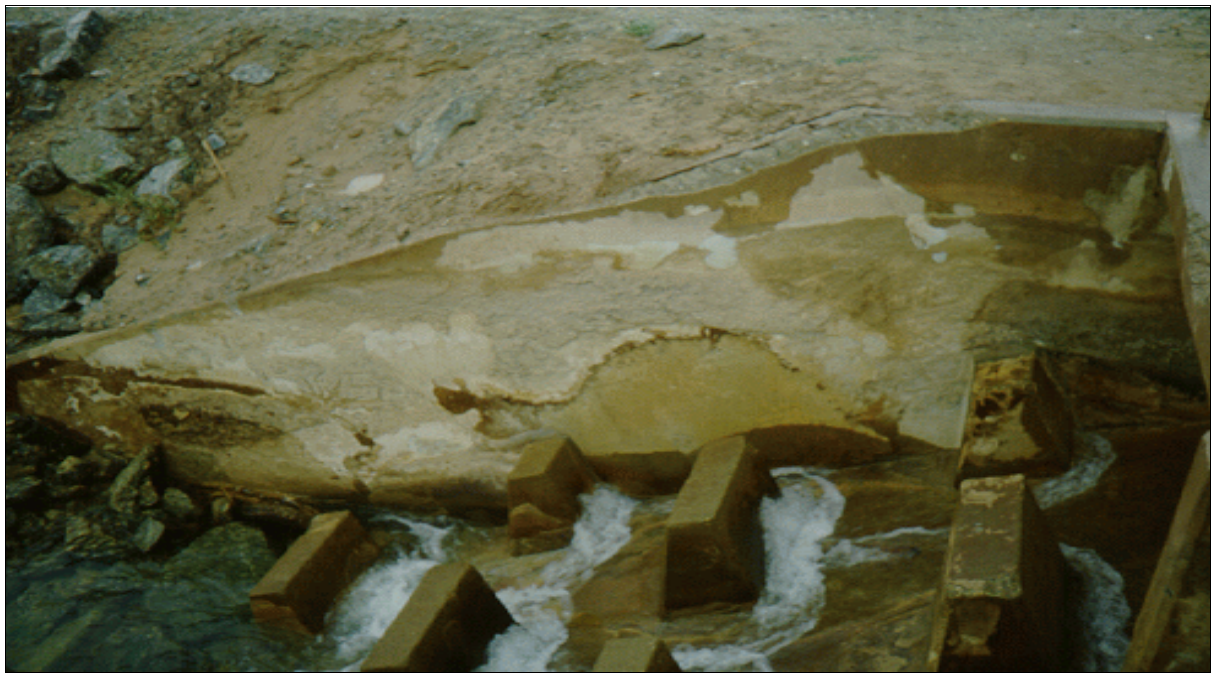

Figure 29.—Concrete damage caused by chloride-induced corrosion of reinforcing steel. The waters contained within this flume had high chloride content.

presence of corroding steel has been confirmed, it is important to define what actually caused the corrosion because the cause(s) of corrosion will usually determine which repair procedure should be used. Further discussion of such repair procedures can be found elsewhere in this guide. Once the cause of damage has been defined and mitigated, if necessary, proper preparation of the corroded steel exposed during removal of the deteriorated concrete becomes important. Steel that has been reduced to less than half its original cross section by the corrosion process should be removed and replaced. The remaining steel must then be cleaned to remove all loose rust, scale, and corrosion byproducts that would interfere with the bond to the repair material. Corroded reinforcing steel may extend from areas of obviously deteriorated concrete well into areas of apparently sound concrete. Care must be taken to remove sufficient concrete to include all the corroded steel.

20. Acid Exposure.—The more common sources of acidic exposure involving concrete structures occur in the vicinity of under-ground mines. Drainage waters exiting from such mines can contain acids of sometimes unexpectedly low pH value. A pH value of 7 is defined as neutral. Values higher than 7 are defined as basic, while pH values lower than 7 are acidic. A 15- to 20-percent solution of sulfuric acid will have a pH value of about 1. Such a solution will damage concrete very rapidly. Acidic waters having pH values of 5 to 6 will also damage concrete, but only after long exposure.

Concrete damaged by acids is very easy to detect. The acid reacts with the portland cement mortar matrix of concrete and converts the cement into calcium salts that slough off or are washed away by flowing waters. The coarse aggregate is usually undamaged but left exposed. The appearance of acid-damaged concrete is somewhat like that of abrasion damage, but the exposure of the coarse aggregate is more pronounced and does not appear polished. Figures 30 and 31 show the typical appearance of concrete that has been damaged by acid exposure. Acid damage begins, and is most pronounced, on the exposed

Figure 30.—Concrete deterioration caused by acidic water.

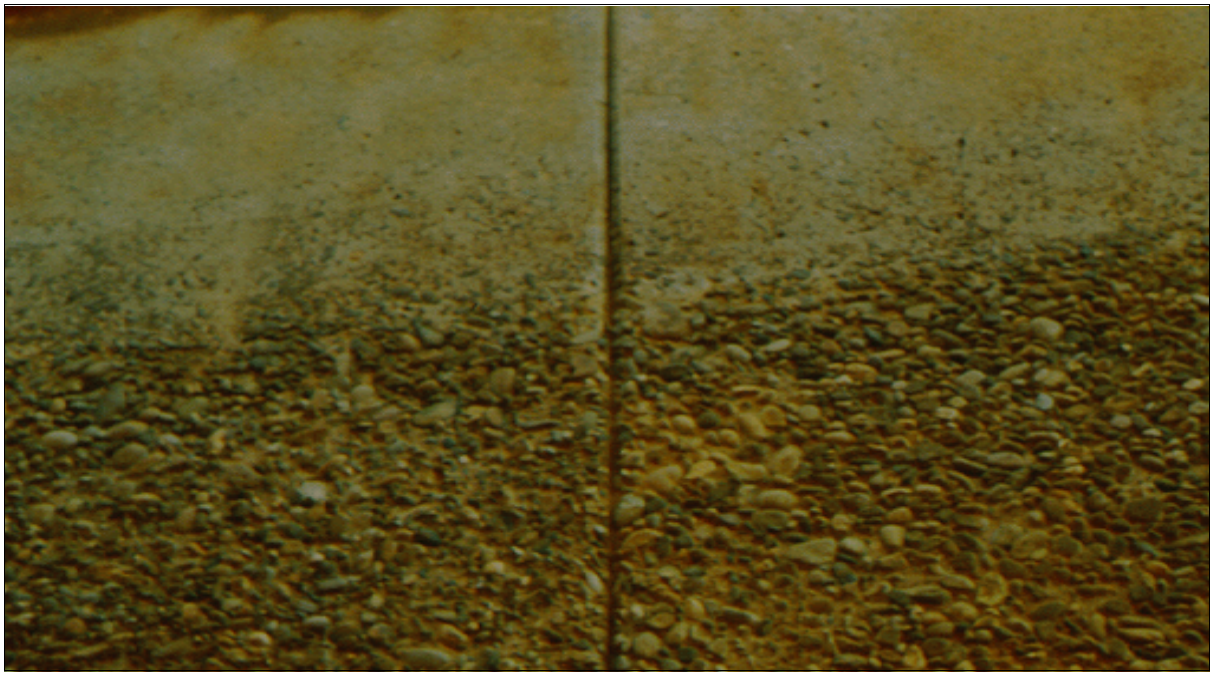

Figure 31.—The depth of acidic water on this concrete wall is very apparent.

surface of concrete but always extends, to a diminishing extent, into the core of the structure. The acid is most concentrated at the surface. As it penetrates into the concrete, it is neutralized by reaction with the portland cement. The cement at depth inside the structure, however, is weakened by the reaction. Preparation of acid-damaged concrete, therefore, always involves removal of more concrete than would otherwise be expected. Failure to remove all the concrete affected and weakened by the acid will result in bond failure of the repair material. Acid washes were once permitted as a method of cleaning concrete surfaces in preparation for repairs. It has been learned, however, that bond failures would occur unless extensive efforts were expended to remove all traces of acid from the concrete. Reclamation specifications no longer permit the use of acid washes to prepare concrete for repair or to clean cracks subject to resin injection repairs.

As with all causes of damage to concrete, it is generally necessary to remove the source of damage prior to repair. The most common technique used with acid damage is to dilute the acid with water. Low pH acid solutions can be converted to higher pH solutions having far less potential for damage in this manner. Alternately, if the pH of the acid solution is relatively high, coatings such as the thin polymer concrete coating system, section 33, can be applied over repair materials to prevent the acid from redamaging the surfaces. Laboratory tests have revealed very few economical coatings capable of protecting repair materials from low pH solutions.

Repairs to acid-damaged concrete can be made using epoxy-bonded replacement concrete (section 31), replacement concrete (section 29), polymer concrete (section 32), and, in some instances, epoxy-bonded epoxy mortar (section 30). Polymer concrete and epoxy mortar, which do not contain portland cement, offer the most resistance to acid exposure conditions.

21. Cracking.—Cracking, like corrosion of reinforcing steel, is not commonly a cause of damage to concrete. Instead, cracking is a symptom of damage created by some other cause.

All portland cement concrete undergoes some degree of shrinkage during hydration. This shrinkage produces multidirectional drying shrinkage and curing shrinkage cracking having a somewhat circular pattern (figure 32). Such cracks seldom extend very deeply into the concrete and can generally be ignored.

Plastic shrinkage cracking occurs when the fresh concrete is exposed to high rates of evaporative water loss which causes shrinkage while the concrete is still plastic (figure 33). Plastic shrinkage cracks are usually somewhat deeper than drying or curing shrinkage cracks and may exhibit a parallel orientation that is visually unattractive.

Thermal cracking is caused by the normal expansion and contraction of concrete during changes of ambient temperature. Concrete has a linear coefficient of thermal expansion of about 5.5 millionths inch per inch per degree Fahrenheit (°F). This can cause concrete to undergo length changes of about 0.5 inch per 100 linear feet for an 80 °F temperature change. If sufficient joints are not provided by the design of the structure to accommodate this length change, the concrete will simply crack and provide the joints where needed. This type of cracking will normally extend entirely through the member and create a source of leakage in water retaining structures. Thermal cracking can also be caused by using portland cements developing high heats of hydration during curing. Such concrete develops exothermic heat and hardens while at elevated temperatures. Subsequent contraction upon cooling develops internal tensile stresses and resulting cracks at or across points of restraint.

Inadequate foundation support is another common cause of cracking in concrete structures. The tensile strength of concrete is usually only about 200 to 300 psi. Foundation settlement can easily create displacement conditions where the tensile strength of concrete

Figure 32.—Typical appearance of drying shrinkage cracking.

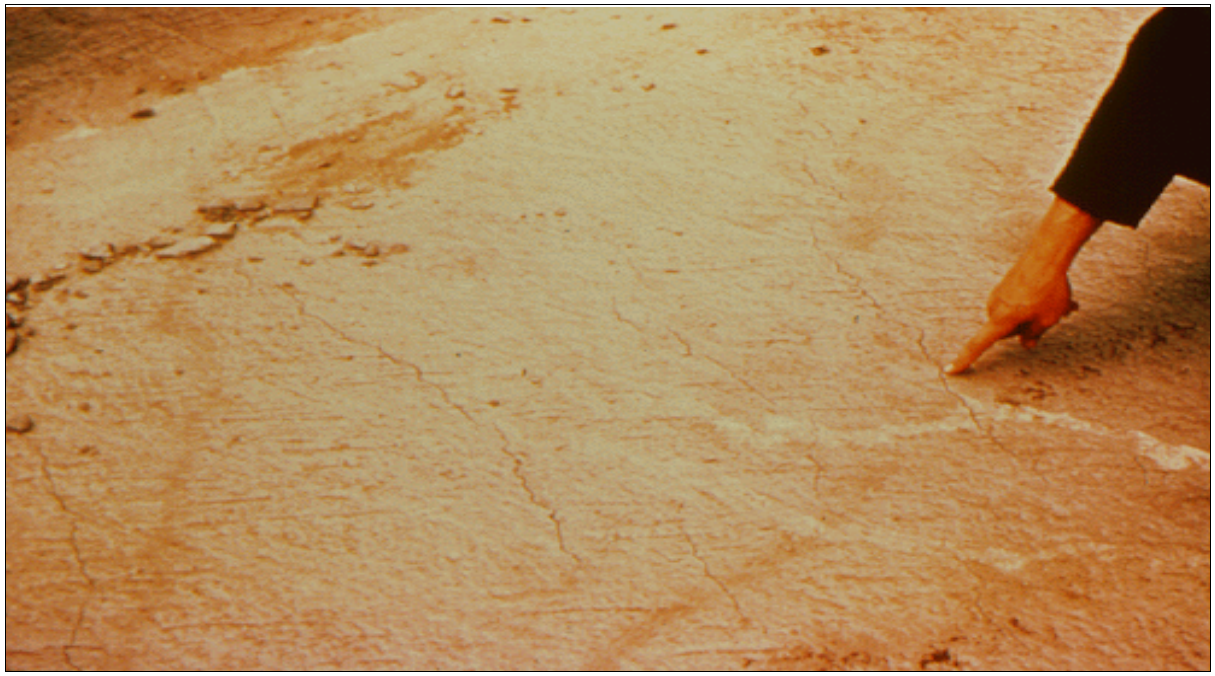

Figure 33.—Plastic shrinkage cracking caused by high evaporative water loss while the concrete was still in a plastic state.

is exceeded with resulting cracking.

Cracking is also caused by alkali-aggregate reaction, sulfate exposure, and exposure to cyclic freeze-thaw conditions, as has been discussed in previous sections, and by structural overloads as discussed in the following section.

Successful repair of cracking is often very difficult to attain. It is better to leave most types of concrete cracking unrepaired than to attempt inadequate or improper repairs (figure 34 and 35). The selection of methods for repairing cracked concrete depends on the cause of the cracking. First, it is necessary to determine if the cracks are "live" or "dead." If the cracks are cyclicly opening and closing, or progressively widening, structural repair becomes very complicated and is often futile. Such cracking will simply reestablish in the repair material or adjacent concrete. For this reason, it is normal procedure to install crack gages across the cracks to monitor their movement prior to attempting repair (figure 36). The gages should be monitored for extended periods to determine if the cracks are simply opening and closing as a result of daily or seasonal temperature changes or if there is a continued or progressive widening of the cracks resulting from foundation or

load conditions. Repairs should be attempted only after the cause and behavior of the cracking is understood.

If it is determined that the cracks are "dead" or static, epoxy resin injection (section 34) can be used to structurally rebond the concrete. If the objective of the repair is to seal water leakage rather than to accomplish structural rebonding, the cracks should be injected with polyurethane resin. Epoxy resin injection can sometimes be used to seal low volume water leakage and structurally rebond cracked concrete members. Epoxy resins cure to form hard, brittle materials that will not withstand movement of the injected cracks. Poly-urethane resins cure to a flexible, low tensile strength, closed cell foam that is effective in sealing water leakage but cannot normally be used for structural rebonding. (Some two component polyurethane resin systems cure to form flexible solids that may be

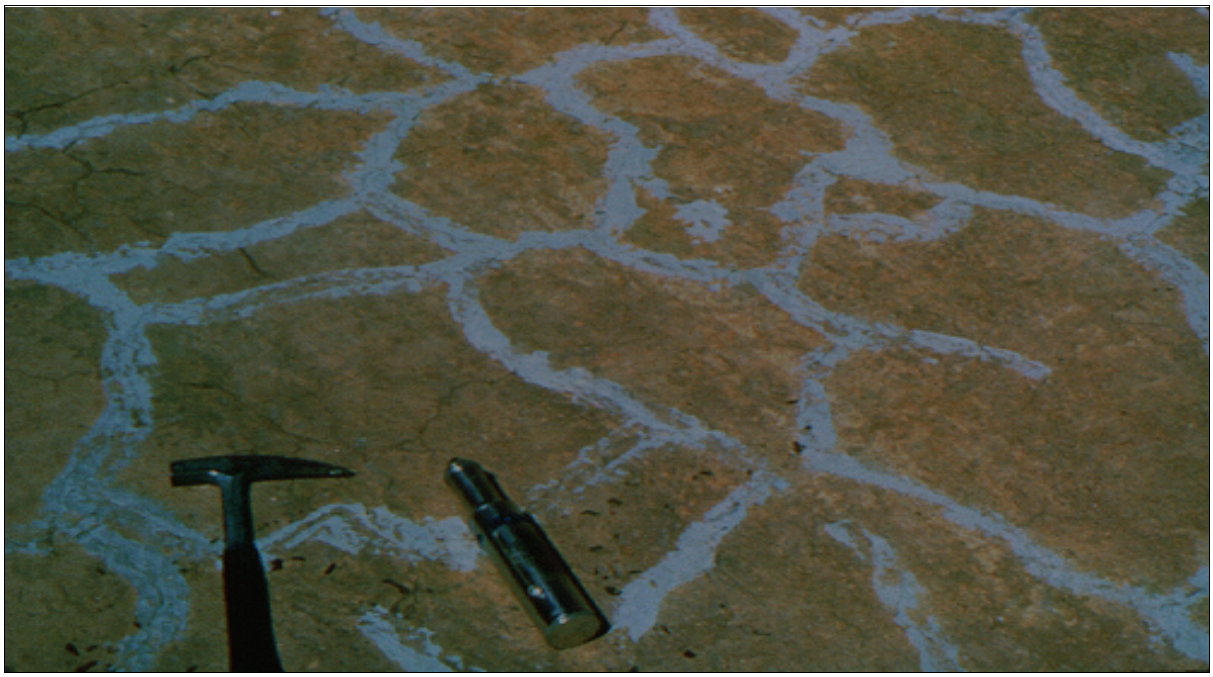

Figure 34.—Inadequate crack repair techniques often result in poor appearance upon completion.

Figure 35.—Improper crack repair techniques often result in short service life.

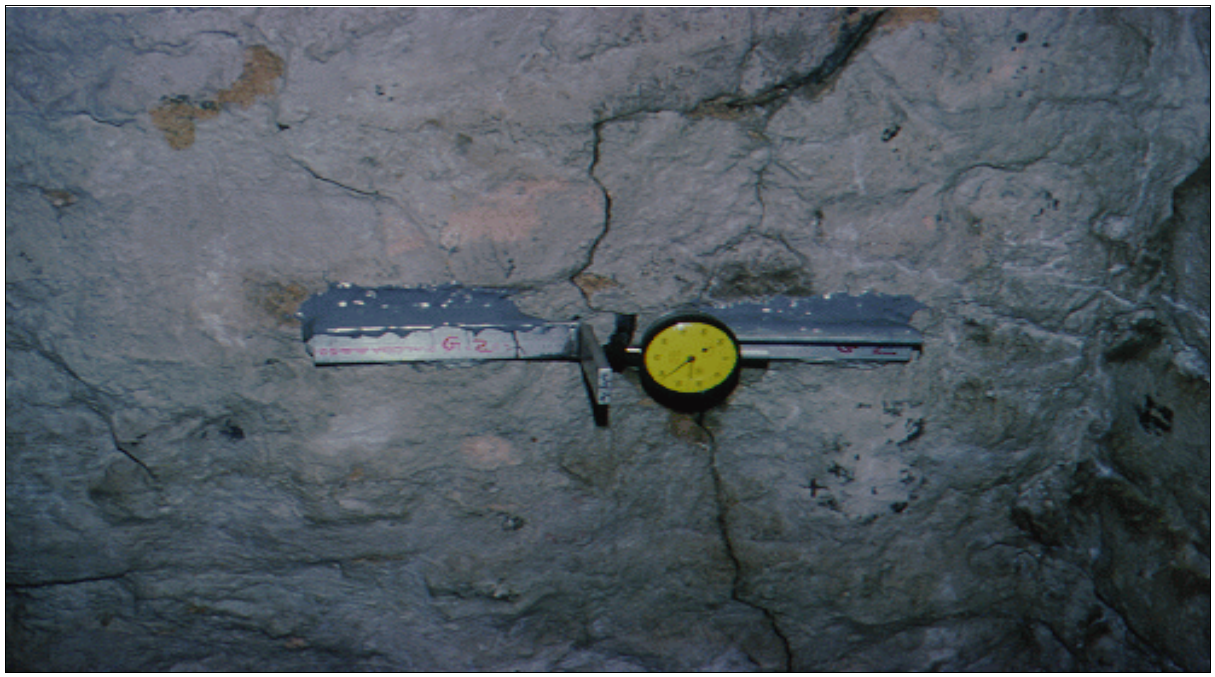

Figure 36.—Crack gage installed across a crack will allow determination of progressive widening or movement of the crack. It may be necessary to monitor such gages for periods up to a year to predict future crack behavior.

useful for structural rebonding.) These flexible foams can experience 300- to 400-percent elongation due to crack movement. It is not uncommon to find that damaged concrete contains cracking not related to the cause of the primary damage (see section 23). If the depth of removal of the damaged or deteriorated concrete does not extend below the depth and extent of the existing cracks, it should be expected that the cracking will ultimately reflect through the new repair materials. Such reflective cracking is common in bonded overlay repairs to bridge decks, spillways, and canal linings (figure 37). If reflective cracking is intolerable, the repairs must be designed as separate structural members not bonded to the old existing concrete.

22. Structural Overloads.—Concrete damage caused by structural overloading is usually very obvious and easy to detect. Frequently, the event causing overloading has been noted and is a matter of record. The stresses created by overloads result in distinctive patterns of cracking that indicate the source and cause of excessive loading and the point(s) of load application. Normally, structural overloads are one time events and, once defined, the resulting damage can be repaired with the expectation that the cause of the damage will not reoccur to create damage in the repaired concrete.

It should be expected that the assistance of a knowledgeable structural engineer will be required to perform the structural analysis needed to fully define and evaluate the cause and resulting damage of most structural overloads and to assist in determining the extent of repair required. This analysis should include determination of the loads the structure was designed to carry and the extent the overload exceeded design capacity. A thorough inspection of the damaged concrete must be performed to determine the entire effect of the overload on the structure. Displacements must be discovered and the secondary damage, if any, located. Care should be taken to ensure that some other cause of damage did not first

Figure 37.—A large reflective crack has formed in a concrete overlay which also exhibits circular drying shrinkage cracking.

weaken the concrete and make it incapable of carrying the design loads. The repair of damage caused by overloading can, most likely, best be performed with conventional replacement concrete (section 29). The need for repair and/or replacement of damaged reinforcing steel should be anticipated and included in the repair procedures.

23. Multiple Causes of Damage.—Multiple causes of the damage should be suspected whenever damage or deterioration is discovered in modern concrete. Modern concrete (concrete constructed since about 1950) has the benefit of the use of various admixtures and advanced concrete materials technology. Such concrete should not be damaged by many of the causes listed in this chapter. If deterioration or damage has occurred, it is likely that a combination of causes are in effect. Failure to recognize and mitigate all the causes of damage will most likely result in poor repair serviceability. Figure 38 shows the results of multiple cause damage. This concrete is suffering from alkali-aggregate reaction cracking that has also accelerated freeze-thaw deterioration of the surface. It is also being damaged by faulty design or construction techniques that located the electrical conduits too close to the exterior surface of the concrete.

The proper use of air entraining admixtures in modern concrete has greatly increased the resistance of the concrete to freeze-thaw deterioration. Except in unusually severe exposures, freeze-thaw deterioration should not occur. This notwithstanding, freeze-thaw deterioration is often still blamed as the cause of damage to modern concrete. Before blaming freezing and thawing conditions, it is better to first determine why the air entraining admixture did not provide effective protection. Mix records and aggregate quality test results may indicate that the concrete was poorly proportioned or that the available aggregate was of low quality. Construction inspection records may indicate that placing and finishing techniques were inadequate. Petrographic examination of the affected concrete may reveal that alkali-aggregate reaction, sulfate exposure, or induced chlorides have weakened the concrete and allowed freeze-thaw damage to occur. All such findings might indicate that the problem is far more extensive than at first thought and requires more extensive preventative or corrective action than the simple replacement of the presently deteriorated concrete.

The use of excessive mix water, the improper type of portland cement, poor construction practices, improper mixture proportioning, dirty or low quality aggregate, and inadequate curing all contribute to low durability in concrete. Such concrete may have low resistance to normal weathering or to other hazards.

Selection of the proper methods and materials for repair of concrete damaged by multiple causes depends on determining which is the weakening cause and which is the accelerated cause. Once the weakening cause is fully understood, it is commonly necessary to take preventative measures to protect the re-maining original concrete from additional damage. The application of concrete sealing compounds (sections 35 and 38) or the thin polymer concrete overlay (section 32) may prove useful in this respect. If no such preventative measures are judged useable, repair of the damaged concrete can be made as discussed in previous sections, but short repair service life and the occurrence of future damage should be anticipated.

Figure 38.—Multiple causes of damage are apparent in this photograph. Poor design or construction practices placed the electrical conduit too near the surface. A combination of freezing and thawing deterioration and alkali-aggregate reaction is responsible for the cracking and surface spalling on the parapet wall.

Chapter IV

Standard Methods of Concrete Repair

Proven methods of repairing concrete are described in this chapter. Sections 24 through 38 contain detailed discussions of each of the proven repair methods. Construction specifications for these methods/materials of repair are contained in the latest revision of Reclamation's *Standard Specifications for the Repair of Concrete, M-47,* Appendix A. It is essential that the provisions of these specifications be closely followed during repair of Reclamation concrete. It should be recognized, however, that these "standard" methods and specifications cannot apply to unusual or nonstandard concrete repair situations. Assistance with unusual or special repair problems can readily be obtained by contacting personnel of the Materials Engineering and Research Laboratories, Code D-8180.

24. Surface Grinding.—Surface grinding can be used to repair some bulges, offsets, and other irregularities that exceed the desired surface tolerances. Excessive surface grinding, however, may result in weakening of the concrete surface, exposure of easily removed aggregate particles, or unsightly appearance. For these reasons, surface grinding should be performed subject to the following limitations:

a. Grinding of surfaces subject to cavitation erosion (hydraulic surfaces subject to flow velocities exceeding 40 feet per second) should be limited in depth so that no aggregate particles more than 1/16 inch in cross section are exposed at the finished surface.

b. Grinding of surfaces exposed to public view should be limited in depth so that no aggregate particles more than 1/4 inch in cross section are exposed at the finished surface.

c. In no event should surface grinding result in exposure of aggregate of more than one-half the diameter of the maximum size aggregate.

Where surface grinding has caused or will cause exposure of aggregate particles greater than the limits of subparagraph 24.a. or b., the concrete must then be repaired by excavating and replacing the concrete in accordance with sections 29, 30, 31, or 32.

25. Portland Cement Mortar.—Portland cement mortar may be used for repairing defects on surfaces not prominently exposed, where the defects are too wide for dry pack filling or where the defects are too shallow for concrete filling and no deeper than the far side of the reinforcement that is nearest the surface. Repairs may be made either by use of shotcrete or by hand application methods. Replacement mortar can be used to make shallow, small size repairs to new or green concrete, provided that *the repairs are performed within 24 hours of removing the concrete forms.*

The use of replacement mortar to repair old or deteriorated concrete has been permitted on Reclamation projects in the past. It is now recognized, however, that accomplishing successful mortar repairs to old concrete without the use of a bonding resin is unlikely or extremely difficult. Evaporative loss of water from the surface of the repair mortar, combined with capillary water loss to the old concrete, results in unhydrated or poorly hydrated cement in the mortar. Additionally, repair mortar bond strength development proceeds at a slower rate than compressive strength development. This causes workers to mistakenly abandon curing procedures prematurely, when the mortar

"seems strong." Once the mortar dries, bond strength development stops, and bond failure of the mortar patch results.

For these reasons, using cement mortar without a resin bond coat to repair old concrete is discouraged and is not allowed under Reclamation's *Standard Specifications for the Repair of Concrete, M-47*.

A portland cement mortar patch is usually darker than the surrounding concrete unless precautions are taken to match colors (figure 39). A leaner mix will usually produce a lighter color patch. Also, white cement can be used to produce a patch that will blend with the surrounding concrete. The quantity of white cement to use must be determined by trial.

(a) Preparation.—Concrete to be repaired with replacement mortar should be prepared in accordance with the provisions of section 8. After preparation, the areas should be cleaned, roughened, if necessary (preferably by wet sandblasting), and surface dried to a saturated surface condition. The mortar should be applied immediately thereafter.

(b) Materials.—Replacement mortar contains water, portland cement, and sand. The cement should be same type as used in the concrete being repaired. The water and sand should be suitable for use in concrete, and the sand should pass a No. 16 sieve. The cement to sand ratio should be between 1:2 to 1:4, depending on application technique. Only enough water should be added to the cement-sand mixture to permit placing.

(c) Application.—Best results with replacement mortar are obtained when the material is pneumatically applied using a small gun. Equipment commonly used for shotcreting is too large to be satisfactory for the ordinarily small size mortar repairs of new concrete. With shotcreting equipment, neat work is difficult in the usual small areas, and cleanup costs are high because cleanup is seldom done promptly. However, small size equipment such as shown in figure 40 has been satisfactory for small scale repair work when the mortar was premixed, including water, to a consistency of dry-pack material. No initial application of cement, cement grout, or wet mortar should be made. If repairs are more than 1 inch deep, the mortar should be applied in layers not more than 3/4 of an inch thick to avoid sagging and loss of bond. After completion of each layer, there should be a lapse of 30 minutes or more before the next layer is placed. Scratching or otherwise preparing the surface of a layer prior to addition of the next layer is unnecessary, but the mortar must not be allowed to dry.

In completing the repair, the hole should be filled slightly more than level full. After the material has partially hardened but can still be trimmed off with the edge of a steel trowel, excess material should be shaved off, working from the center toward the edges. Extreme care must be used to avoid impairment of bond. Neither the trowel nor water should be used in finishing. A satisfactory finish may be obtained by lightly rubbing the surface with a soft rag.

For minor restorations, satisfactory mortar replacement may be performed by hand. The success of this method depends on complete removal of all defective and affected concrete, good bonding of the mortar to the concrete, elimination of shrinkage of the patch after placement, and thorough curing.

Replacement mortar repairs can be made using an epoxy bonding agent as described in section 26. This technique, while not required by Reclamation's M-47 specifications, is highly recommended.

(d) Curing.—Failure to cure properly is the most common cause of failure of replacement mortar. It is essential that mortar repairs receive a thorough water cure starting immediately after initial set and continuing for 14 days. In no event should the mortar be allowed to become dry during the 14-day period following placement. Following the 14-day water cure and while the mortar is still saturated, the surface of the mortar should

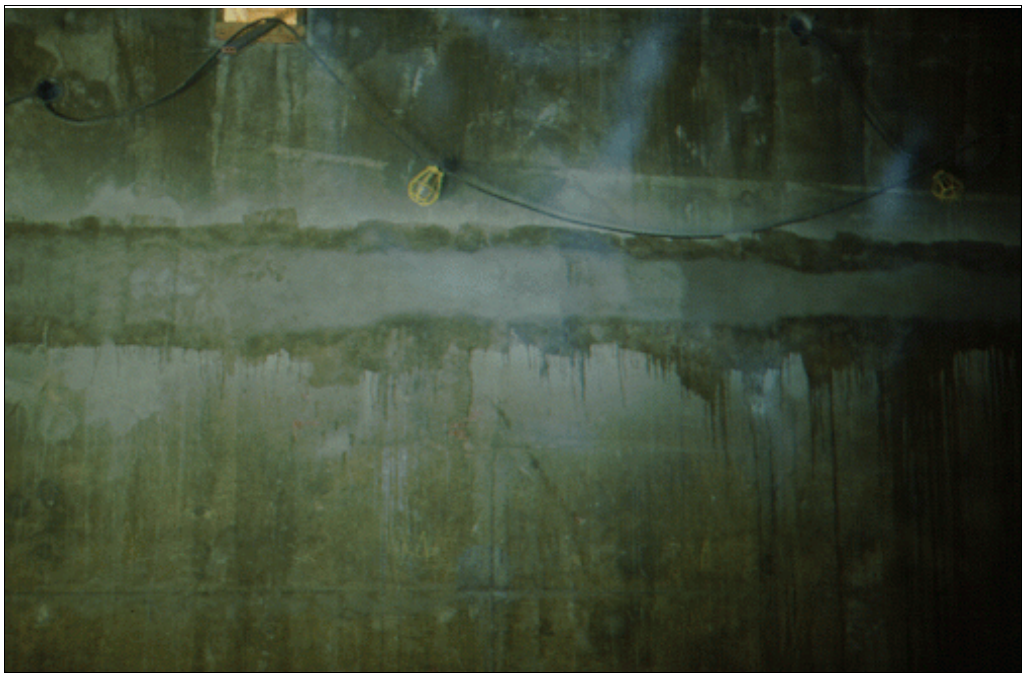

Figure 39.—A portland cement mortar patch seldom matches the color of the original concrete unless special efforts are taken to blend white cement with normal portland cement.

Figure 40.—A small size pneumatic gun can be used to apply portland cement mortar. Regular shotcreting equipment would be too large for this application.

be coated with two coats of a wax-base or water-emulsified resin base curing compound meeting Reclamation specifications. If this curing procedure cannot be followed or if conditions at the job are such that this curing procedure will not be followed, money would be saved by using another repair material.

26. Dry Pack and Epoxy-Bonded Dry Pack.—Dry pack is a combination of portland cement and sand passing a No. 16 sieve mixed with just enough water to hydrate the cement. Dry pack should be used for filling holes having a depth equal to, or greater than, the least surface dimension of the repair area; for cone bolt, she bolt, core holes, and grout-insert holes; for holes left by the removal of form ties; and for narrow slots cut for repair of cracks. Dry pack should not be used for relatively shallow depressions where lateral restraint cannot be obtained, for filling behind reinforcement, or for filling holes that extend completely through a concrete section.

For the dry pack method of concrete repair, holes should be sharp and square at the surface edges, but corners within the holes should be rounded, especially when water tightness is required. The interior surfaces of holes left by cone bolts and she bolts should be roughened to develop an effective bond; this can be done with a rough stub of 7/8-inch steel-wire rope, a notched tapered reamer, or a star drill. Other holes should be undercut slightly in several places around the perimeter, as shown in figure 41. Holes for dry pack should have a minimum depth of 1 inch.

(a) Preparation.—Application of dry pack mortar should be preceded by a careful inspection to see that the hole is thoroughly cleaned and free from mechanically held loose pieces of aggregate. One of the three following methods should be used to ensure good bond of the dry pack repair.

The first method is the application of a stiff mortar or grout bond coat immediately before applying the dry pack mortar. The mix for the bonding grout is 1:1 cement and fine sand mixed with water to a fluid paste consistency. All surfaces of the hole are thoroughly brushed with the grout, and dry packing is done quickly before the bonding grout can dry. Under no circumstances should the bonding coat be so wet or applied so heavily that the dry pack material becomes more than slightly rubbery. When a grout bond coat is used, the hole to be repaired can be dry. Presoaking the hole overnight with wet rags or burlap prior to dry packing may sometimes give better results by reducing the loss of hydration water, but there must be no free surface water in the hole when the bonding grout is applied.

The second method of ensuring good bond starts with presoaking the hole overnight with wet rags or burlap. The hole is left slightly wet with a small amount of free water on the inside surfaces. The surfaces are then dusted lightly and slowly with cement using a small dry brush until all surfaces have been covered and the free water absorbed. Any dry cement in the hole should be removed using a jet of air before packing begins. The hole should not be painted with neat cement grout because it could make the dry pack material too wet and because high shrinkage would prevent development of the bond that is essential to a good repair.

A third method of ensuring good bond is the use of an epoxy bonding resin. The epoxy bonding resin should meet the requirements of ASTM C-881 for a type II, grade 2, class B or C resin, depending on the job site ambient temperatures. Epoxies bond best to dry concrete. It may be necessary to dry the hole immediately prior to dry packing using hot air, a propane torch, or other appropriate method. The concrete temperature, however, should not be high enough to cause instant setting of the epoxy or to burn the epoxy when it is applied. After being mixed, the epoxy is thoroughly brushed to cover all surfaces, but any excess epoxy is removed. Dry pack mortar is then applied immediately, before the epoxy starts to harden. The epoxy must be either fluid or tacky when dry packing takes place. If it appears that the epoxy may become hard before dry packing is

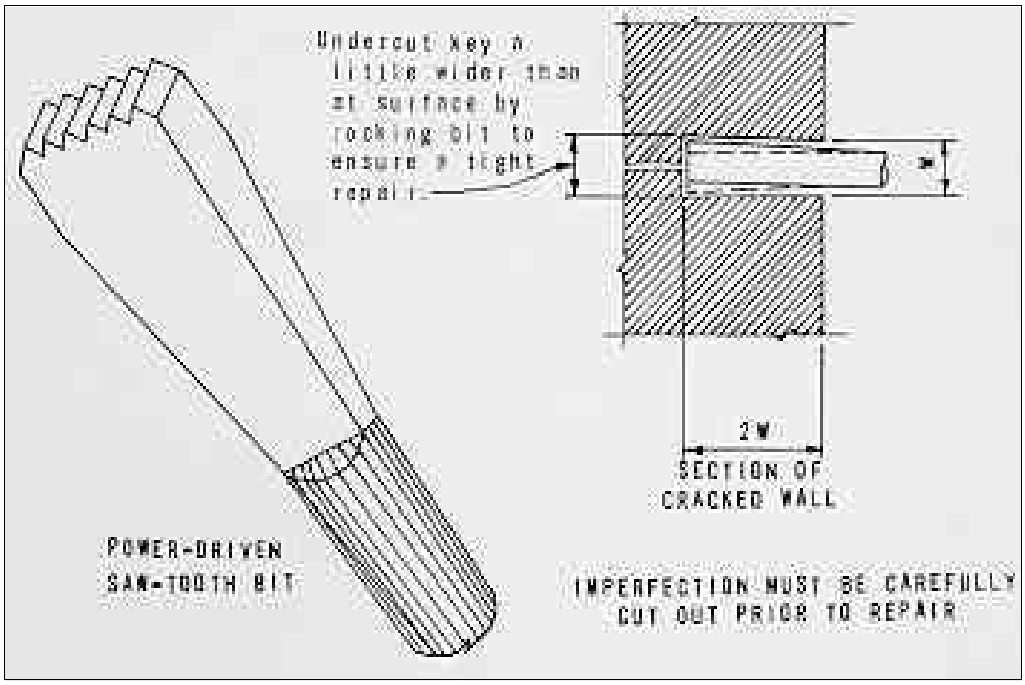

Figure 41.—Saw-tooth bit used to cut slot for dry packing.

complete, fresh fluid epoxy can be brushed over epoxy that has become tacky. If the epoxy becomes hard, it must be removed before a new coat is applied. The epoxy ensures a good bond between the dry pack repair and the old concrete. It also reduces the loss of hydration water from the repair to the surrounding concrete, thus assisting in good curing; however, the epoxy-bonded dry pack still requires curing as discussed below. Where appearance is not important, epoxy has sometimes been used on the surface in place of a curing compound. This procedure is not recommended and is not allowed on Reclamation jobs.

(b) Materials.—Dry pack mortar is usually a mixture (by dry volume or weight) of 1 part cement to 2-1/2 parts sand that will pass a No. 16 screen. While the mixture is rich in cement, the low water content prevents excessive shrinkage and gives high strengths. A dry pack repair is usually darker than the surrounding concrete unless special precautions are taken to match the colors. Where uniform color is important, white cement may be used in sufficient amount (as determined by trial) to produce uniform appearance. For packing cone bolt holes, a leaner mix of 1:3 or 1:3-1/2 will be sufficiently strong and will blend better with the color of the wall. Sufficient water should be used to produce a mortar that will just stick together while being molded into a ball with the hands and will not exude water but will leave the hands damp. The proper amount of water will produce a mix at the point of becoming rubbery when solidly packed. Any less water will not make a sound, solid pack; any more will result in excessive shrinkage and a loose repair.

(c) Application.—Dry pack mortar should be placed and packed in layers having a compacted thickness of about three-eighths of an inch. Thicker layers will not be well compacted at the bottom. The surface of each layer should be scratched to facilitate bonding with the next layer. One layer may be placed immediately after another unless an appreciable rubbery quality develops; if this occurs, work on the repair should be delayed 30 to 40 minutes. Under no circumstances should alternate layers of wet and dry materials be used.

Each layer should be solidly compacted over the entire surface by striking a hardwood dowel or stick with a hammer. These sticks are usually 8 to 12 inches long and not over 1 inch in diameter and are used on fresh mortar like a caulking tool. Hardwood sticks are used in preference to metal bars because the latter tend to polish the surface of each layer and, thus, make bonding less certain and filling less uniform. Much of the tamping should be directed at a slight angle and toward the sides of the hole to ensure maximum compaction in these areas. The holes should not be overfilled; finishing may usually be completed at once by laying the flat side of a hardwood piece against the fill and striking it several good blows with a hammer. If necessary later, a few light strokes with a rag may improve appearance. Steel finishing tools should not be used, and water must not be used to facilitate finishing.

(d) Curing and Protection.—Procedures for curing and protection of dry pack are essentially the same as those for concrete and are described in section 25. Additionally, the dry pack repair area should be protected and not exposed to freezing temperatures for at least 3 days after application of the curing compound.

27. Preplaced Aggregate Concrete.— Preplaced aggregate concrete is an excellent repair material that has not been used much in recent years. Preplaced aggregate concrete is made by injecting portland cement grout, with or without sand, into the voids of a formed, compacted mass of clean, graded, coarse aggregate. The preplaced aggregated is washed and screened to remove fines before placing into the forms. As the grout is injected or pumped into the forms, it displaces any included air or water and fills the voids around the aggregate, thus creating a dense concrete having a high aggregate content.

Because the coarse aggregate has point contact prior to grout injection, preplaced aggregate concrete undergoes very little settlement, curing, or drying shrinkage during hydration. Drying shrinkage of preplaced aggregate concrete containing 1-1/2 inch maximum size aggregate is about 200 to 400 millionths, while conventional concrete drying shrinkage containing the same size maximum aggregate is about 400 to 600 millionths.

Another advantage of preplaced aggregate concrete is the ease with which it can be placed in certain situations where placement of conventional concrete would be extremely difficult or impossible. Preplaced aggregate concrete is especially useful in underwater repair construction. It has been used in a variety of large concrete and masonry repairs, including bridge piers and the resurfacing of dams. It has been used to construct atomic reactor shielding and plugs for outlet works and tunnels in mine workings, and it has been used to embed penstocks and turbine scrollcases (American Concrete Institute, 1992). Figure 42 shows the upstream face of Barker Dam near Boulder, Colorado, which was resurfaced with prepacked aggregate concrete.

Although preplaced aggregated is adaptable to many special repair applications, it is essential that the work be undertaken by well qualified personnel who are willing to follow exactly the construction procedures required for this repair material. Form work for preplaced aggregate concrete requires special attention to prevent grout loss. The construction of forms should be with workmanship better than that normally encountered with conventional concrete. Leaking forms can cause significant problems and should, by careful construction, be avoided whenever possible. The injected grout is more flowable than plastic concrete and takes slightly longer to set. Forms, therefore, must be constructed to take more lateral pressure than would be necessary with conventional concrete. Form bolts should fit tightly through the sheathing, and all possible points of grout leakage should be caulked.

(a) Preparation The preparation of concrete to be repaired by preplaced aggregate concrete is identical to the preparation required for replacement concrete (section 29) if the development of bond is required.

Figure 42.—The downstream face of Barker Dam, near Boulder, Colorado, was resurfaced with prepacked aggregate.

(b) Materials .—Grout for preplaced aggregate concrete may be mixed with sand either of the gradation specified for conventional concrete or with fine sand, pozzolanic or fly ash fillers, water reducing admixtures, and pumping admixtures as dictated by the minimum size of the coarse aggregate. With 1-1/2-inch minimum size coarse aggregate, the sand gradation is that specified for conventional concrete. The portland cement, water, and sand are mixed using high speed centrifugal grout mixers that produce well mixed grouts of a creamy consistency. For use with 1/2-inch minimum size coarse aggregate, a grout mixture is prepared containing fine sand passing a No. 8 screen and with at least 95 percent passing a No. 16 screen. Best pumping characteristics will be obtained with fineness modulus between 1.2 and 2 and with the rounded shape of natural sands as opposed to crushed sands.

Addition of fly ash and water reducing admixture improves the flowability of the grout and the ultimate strength. Proprietary pumping admixtures are commonly used to increase the penetration and pumpability of the final grout. The consistency of grout for preplaced aggregated should be uniform from batch to batch and should be such that it can be readily pumped into the voids at relatively low pressure. Consistency is affected by water content, sand grading, filler type and content, cement type, and admixture type. For each mix, there are optimum proportions that produce best grout pumpability or consistency, and tests are necessary for each job to determine these optimum proportions.

The maximum size coarse aggregate used with both types of grout is the largest available, provided that the aggregate can be easily handled and placed. Coarse aggregate should meet all the requirements of coarse aggregate for conventional concrete. It is essential that the coarse aggregated be clean. The aggregate should be well graded from minimum size (1/2-inch minimum or 1-1/2-inch minimum) up to the

maximum size, and when compacted into the forms, should have a void content of 35 to 40 percent. If grout containing sand of concrete grading is used, the minimum coarse aggregate size should be 1-1/2 inches.

(c) Application.—The grout piping system used with preplaced aggregate concrete must be designed to serve at least 3 purposes—to deliver and inject grout, to provide means for determining grout level in the forms, and to serve as vents in enclosed forms for escape or air and water. Proper design and location of the grout piping system is essential for successful placement.

The grout delivery pipeline should be a recirculating system. That is, the grout delivery pipeline should extend from the grout agitator or holding tank to the grout pump, then to the injection manifold, and return to the grout agitator tank. With this type of pipeline, the grout can be kept moving and circulating in the delivery pipeline even when no grout is being injected into the aggregate. Such a system prevents stoppages and clogging of the delivery line. Noncirculating or deadheaded grout delivery lines are not allowed on Reclamation projects. The delivery line should be kept as short as practicable, and the pipe size should be such that normal grout flow velocities range between 2 and 4 feet per second. For most applications, a 1-inch ID grout line will suffice. All valves used in the grout piping system should be quick opening ball valves which can be readily cleaned.

The simplest piping system is a single recirculating delivery line attached via a manifold and valves to a single injection line. The injection line should extend to the lowest point in the form. Multiple injection lines are used for larger projects. Spacing of the injection lines is variable, depending on the form configuration, aggregate gradation, and other factors, but spacings of 4 to 6 feet are common. In preparing the layout of the grout delivery system, it is normally assumed that the slope of the grout face will be 4:1 for work in the dry and 6:1 for underwater work. Much flatter slopes are common with actual grout surfaces.

Sounding wells constructed from 2-inch-diameter slotted pipe are installed to allow determination of the level of grout during injection. Similarly, clear plastic windows can be installed in the forms to allow visual determination of grout levels. The number and location of sounding wells are determined by the size and configuration of the aggregate mass. The ratio of sounding wells to injection pipes should be from 1:4 to about 1:8.

Grout injection should begin at the lowest point of the form and continue uniformly until the entire form is filled. After sufficient grout has been pumped to raise the level of grout in the form about 18 inches above the bottom outlet of the injection line, the injection line can be progressively raised, maintaining about 12 inches of embedment below the level of the grout at all times. A great deal of thought and planning is required if multiple injection lines are used. The objective is to entirely fill the form without trapping air or water. Vents must be located where needed and the injection sequence designed to promote complete filling. It is not possible to use internal vibrators to consolidate preplaced aggregate concrete. External vibrators, however, can be attached to the forms and used advantageously. External vibration will eliminate the splotchy appearance that can occur where coarse aggregate particles contact the forms. Underwater applications of preplaced aggregate concrete require additional considerations. During injection, grout pumping must continue until an undiluted flow of grout emerges from the top of the form. Formwork is usually closed at the top to prevent washout or dilution of the grout after placement if flowing water is encountered. Anti-washout admixtures might prove useful for underwater applications of preplaced aggregate concrete. Care must be taken, however, when using several different types of admixtures (e.g., anti-washout, pumping aids, or high range water reducers) that undesirable combinations are avoided. It is known for example, that some anti-washout admixtures can significantly reduce the

pumpability benefits of some high range water reducers. Such problems should be detected during the mixture proportioning tests previously recommended in paragraph (b).

The minimum volume of the grout mixer tank and the grout agitator tank should be 17 cubic feet. The grout should be mixed using a high speed centrifugal mixer operating at a minimum of 1,500 rotations per minute. The grout pump should be of the helical screw, rotor-type (commonly known as a "Moyno" grout pump), capable of pumping at least 20 gallons of grout per minute at the specified injection pressure.

Quality control of preplaced aggregate concrete lies with proper compaction of the aggregate into the forms and maintenance of proper grout consistency throughout the job. Compaction requirements must be satisfied by visual inspection during placement and before grout is introduced into the forms. Grout consistency can be determined by using a Baroid Model 140 Mud Balance to measure grout density. Some practitioners promote using a flow cone to time the rate of flow of a known volume of grout through the cone as a measure of consistency. Recent laboratory tests (Smoak, 1993), however, have proven that the flow cone is useless for measuring the consistency of grout containing high range water reducing admixture.

(d) Curing.—The curing requirements for preplaced aggregate concrete are the same as for replacement concrete (section 29). Preplaced aggregate concrete placed during underwater applications will normally receive excellent curing without further effort.

28. Shotcrete.—Shotcrete is defined as "mortar or concrete pneumatically projected at high speed onto a surface" (American Concrete Institute, 1990). There are two basic types of shotcrete—dry mix and wet mix. In dry mix shotcrete, the dry cement, sand, and coarse aggregate, if used, are premixed with only sufficient water to reduce dusting. This mixture is then forced through the delivery line to the nozzle by compressed air (figure 43). At the nozzle, sufficient water is added to the moving stream to meet the requirements of cement hydration. Figure 44 shows the nozzle and water ring of a dry mix shotcrete nozzle. For wet mix shotcrete, the cement, sand, and coarse aggregate are first conventionally mixed with water (figure 45), and the resulting concrete is then pumped to the nozzle where compressed air propels the wet mixture onto the desired surface (figure 46). The two types of shotcrete produce mixes with different water contents and different application characteristics as a result of the distinctly different mixing processes. Dry mix shotcrete suffers high dust generation and rebound losses varying from about 15 percent to up to 50 percent. Wet mix shotcrete must contain enough water to permit pumping through the delivery line. Wet mix shotcrete, as a result, may experience significantly more cracking problems due to the excess water and drying shrinkage. Advances in the development of the high range water reducing admixtures, pumping aids, and concrete pumping equipment since about 1960 have greatly reduced these problems, and wet mix shotcrete is now being used more frequently in repair construction.

Shotcrete is a very versatile construction material that can be readily placed and successfully used for a variety of concrete repair applications. The necessity of form work can be eliminated in many repair applications by use of shotcrete. Shotcrete has been used to repair canal and spillway linings and walls, the faces of dams, tunnel linings, highway bridges and tunnels, deteriorating natural rock walls and earthen slopes, and to thicken and strengthen existing concrete structures. Provided the proper materials, equipment, and procedures are employed, such shotcrete repairs can be accomplished quickly and economically. This apparent ease of application should not cause one to believe that shotcrete repair is a simple procedure or one that can be haphazardly or improperly applied

Figure 43.—Dry mix shotcrete equipment being used in the Denver concrete laboratories.

Figure 44.—Dry mix shotcrete equipment showing the nozzle and water injection ring.

Figure 45.—Wet mix shotcrete equipment. The premixed shotcrete is delivered to the shotcrete pump by a transit truck.

Figure 46.—Wet mix shotcrete is propelled by compressed air.

with impunity. The following two paragraphs contain a very descriptive warning of such practices:

> "Regardless of the considerable ad-vantages of the shotcrete process and its ability to provide finished work of the highest quality, a large amount of poor and sometimes unacceptable work has unfortunately occurred in the past, with the result that many design and construction professionals are hesitant to employ the process. As with all construction methods, failure to employ proper procedures will result in inferior work. In the case of shotcrete the deficiencies can be severe, requiring complete removal and replacement.
>
> "Deficiencies in shotcrete applications usually fall into one of four categories: failure to bond to the receiving substrate, delamination at construction joints or faces of the application layers, incomplete filing of the material behind the reinforcing, and embedment of rebound or other unsatisfactory material." (Warner, 1995).

Each of the above-listed deficiencies has occurred on Reclamation repair projects. Perhaps more important with shotcrete than with any other standard concrete repair method, if highly qualified, well trained, and competent workmen cannot be employed, it is advisable to consider using some other repair procedure. The quality of shotcrete closely depends upon the skill and experience of one person, the nozzleman. Reclamation specifications require employment of only formally certified nozzlemen for shotcrete repairs. The on-the-job training necessary to develop the experience and skill needed to achieve such certification for Reclamation work should occur prior to the nozzleman's arrival at the job.

(a) Preparation.—Concrete to be repaired with shotcrete should be prepared in a manner identical to the preparation required for replacement concrete, section 29.(a). Experience indicates, however, that surface preparation for shotcrete repair is more critical than for replacement concrete. It is essential with shotcrete repairs that the shotcrete have a clean, sound concrete base for bond.

(b) Materials.—Cement used for shotcrete should meet the same requirements as cement used for replacement concrete, section 29.(b). If sulfate exposure conditions exist, type V portland cement should be specified. Normally, however, type I-II, low alkali cement is adequate. Water, sand, and coarse aggregate used in shotcrete should also meet the requirements for replacement concrete, except that the maximum size coarse aggregate should not exceed 3/8 of an inch.

Additives for shotcrete should meet the requirements of ASTM designation C 494, Chemical Admixtures for Concrete. It is normally not possible to accomplish air entrainment with dry mix shotcrete. Lack of air entrainment may lead to dry mix shotcrete having lower than desired freeze-thaw resistance. Wet mix shotcrete should be proportioned to contain 6 to 8 percent entrained air.

It is sometimes desirable to use accelerating admixtures in shotcrete where rapid setting or rapid strength development is required. Calcium chloride accelerators have long been used, but there are now sufficient non-chloride containing accelerators in the market- place to make the use of calcium chloride inadvisable. The use of calcium chloride accelerators is particularly unadvisable in shotcrete applications containing reinforcing steel or steel fibers.

Fiber reinforcement has been used in shotcrete since the early 1970s, and the M-47 specifications in appendix A contain specifications for steel fiber reinforcement. The American Concrete Institute has published a state of the art report on fiber reinforced shotcrete (American Concrete Institute, 1984), and this document should be consulted if the use of fiber reinforced shotcrete is being considered. It should be recognized that

application of fiber reinforced shotcrete is more difficult and requires more experienced nozzlemen.

(c) Application.—The detailed discussion of shotcrete application techniques and technology is beyond the scope of this guide. The American Concrete Institute has published a recommended practice and a specification for materials, proportioning, and application of shotcrete (American Concrete Institute, 1966; 1977). These documents should be studied before attempting shotcrete repairs.

(d) Curing.—Proper curing of shotcrete is essential if high strength properties, durability, and long service life are to be obtained. The M-47 specifications permit water curing or curing of shotcrete by application of curing compounds. It is important to begin curing by applying approved curing compounds or water spray before there has been evaporative water loss from the shotcrete, particularly during periods of high temperatures, low humidity, or high wind conditions. Improvements in bond strength will be obtained by continuing curing for periods of up to a month.

29. Replacement Concrete.—Concrete repairs made by bonding new concrete to repair areas without use of an epoxy bonding agent or mortar grout applied on the prepared surface should be made when the area exceeds 1 square foot and has a depth greater than 6 inches and when the repair will be of appreciable continuous area. Replacement concrete repairs should also be used for:

- Holes extending entirely through concrete sections
- Holes in which no reinforcement is encountered, or in which the depth extends 1 inch below or behind the backside of the reinforcing steel and which are greater in area than 1 square foot and deeper than 4 inches, except where epoxy- bonded concrete replacement is required or permitted as an alternative to concrete replacement
- Holes in reinforced concrete greater than one-half square foot and extending beyond reinforcement

Replacement concrete is the most common concrete repair material and will meet the needs of a majority of all concrete repairs. Replacement concrete repairs are made by bonding new concrete to the repair areas without the use of a bonding agent or portland cement grout. The combination of a deep repair and good curing practices ensures adequate hydration water will remain at the bonding surface zone for at least 28 days, allowing the cement hydration process to develop good bond. Because the defective concrete is being replaced with high quality concrete very similar to the surrounding concrete, the repair is compatible in thermal expansion and in other physical and chemical properties with the old concrete. For this reason, in many cases, the best repair method is the use of replacement concrete. Only when an unusual increase in durability is needed, or when placing conditions or dimensions dictate otherwise, should other materials be considered.

(a) Preparation.—To obtain satisfactory results with the replacement concrete method, preparation should be as follows:

- Reinforcement bars should not be left partially embedded; concrete should be removed to provide a clearance of at least an inch around each bar exposed more than one-third its circumference.
- The perimeter of the hole at the face should be saw cut to a minimum depth of 1 inch. If the shape of the defect makes it advisable, the remainder of the concrete removal may be chipped below the vertical saw cut and continued until a horizontal surface is obtained. The top of the hole, if on a vertical wall, should be cut on a 1:3 upward slope from the back toward the face from which the concrete will be placed (see figure 14). This is essential to permit vibration of the concrete without

leaving air pockets at the top of the repair. In some instances, where a hole extends through a wall or beam, it may be necessary to fill the hole from both sides; the slope of the top of the cut should be modified accordingly.

- The bottom and sides of the hole should be cut sharply and approximately square with the face of the wall. When the hole extends through the concrete section, spalling and feather edges must be avoided by having perimeter saw cuts from both faces. All interior corners should be rounded to a minimum radius of 1 inch.

- For repairs on surfaces subject to destructive water action and for other repairs on exposed surfaces, the outlines of areas to be repaired should be saw cut as directed to a depth of 1-1/2 inches before the defective concrete is excavated. The new concrete should be secured by keying methods. Figure 47 shows a vertical wall being prepared for replacement concrete repairs.

The construction and setting of forms are important steps in the procedure for satisfactory concrete replacement where the concrete must be placed from the side of the structure. Form details for walls are shown in figure 48. To obtain a tight and acceptable repair, the following requirements must be observed:

- Front forms for wall repairs more than 18 inches high should be constructed in horizontal sections so the concrete can be conveniently placed in lifts not more than 12 inches deep. The back form may be built in one piece. Sections to be set as concreting progresses should be fitted before placement is started.

- To exert pressure on the largest area of form sheathing, tie bolts should pass through wooden blocks fitted snugly between the walers and the sheathing.

- For irregularly shaped holes, chimneys may be required at more than one level; when beam connections are required, a chimney may be necessary on both sides of the wall or beam. For such construction, the chimney should extend the full width of the hole.

- Forms should be substantially constructed so that pressure may be applied to the chimney cap at the proper time.

- Forms must be mortar tight at all joints between adjacent sections, between the forms and concrete, and at tie bolt holes to prevent the loss of mortar when pressure is applied during the final stages of placement. Twisted or stranded caulking cotton, folded canvas strips, or similar material should be used as the forms are assembled.

Surfaces of old concrete to which new concrete is to be bonded must be clean, rough, and in a saturated surface dry condition. Extraneous material on the joint resulting from form construction must be removed prior to placement.

(b) Materials.—Concrete for repair should have the same water-cement ratio as used for similar new structures but should not exceed 0.47, by weight. Aggregate of as large a maximum size and slump as low as is consistent with proper placing and thorough vibration should be used to minimize water content and consequent shrinkage. The concrete should contain 3 to 5 percent entrained air. Where surface color is important, the cement should be carefully selected or blended with white cement to obtain the desired results. To minimize shrinkage, the concrete should be as cool as practicable when placed, preferably at about 70 °F or lower. Materials should, therefore, be kept in shaded areas during warm weather. Use of ice in mixing water may sometimes be necessary. Batching of materials should be by weight; but batch boxes, if of the exact size needed, may be used. Since batches for this class of work will be small, the uniformity of the materials is important and should receive proper attention.

Figure 47.—Preparation of a wall for placement of replacement concrete repairs.

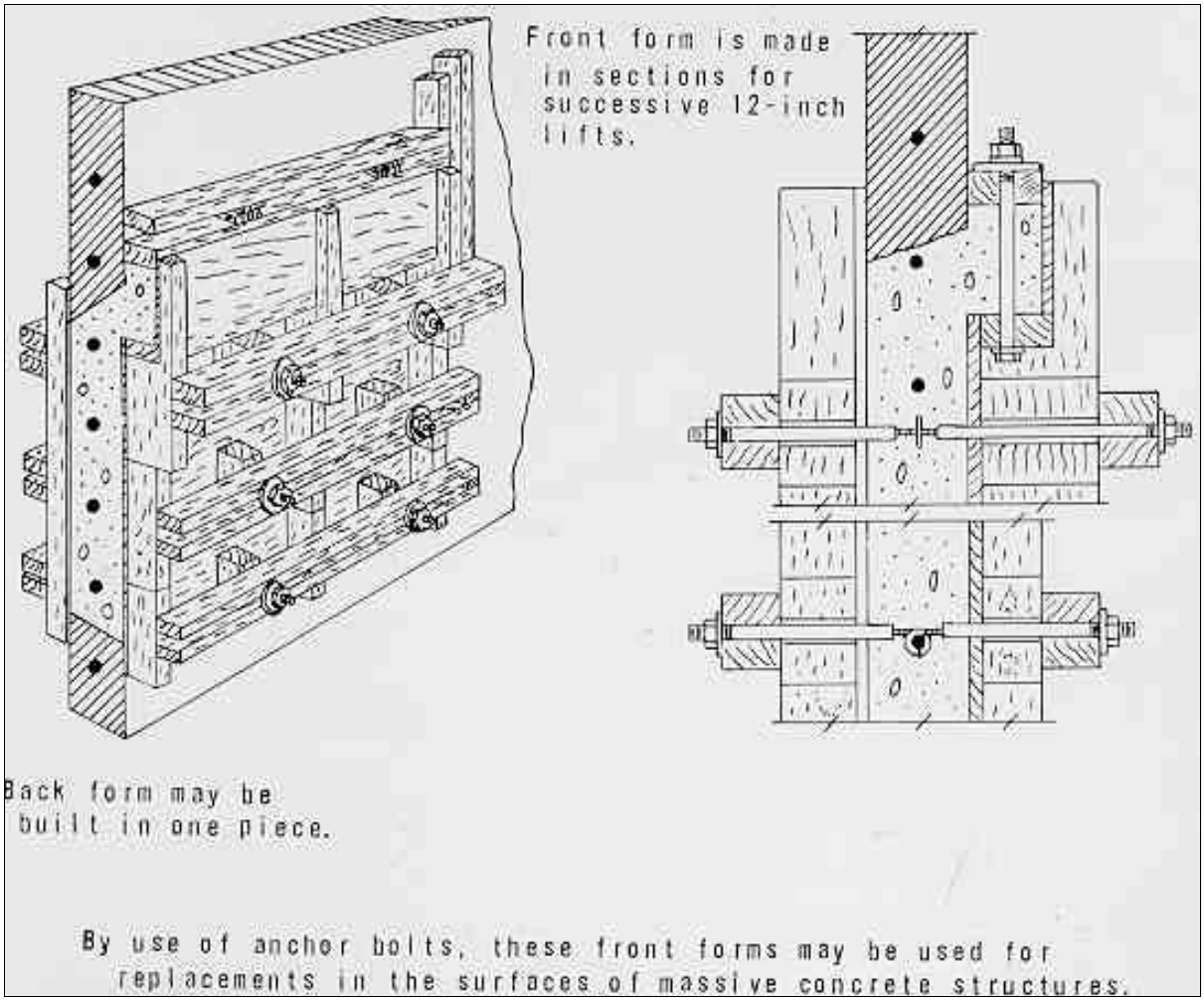

Figure 48.—Detail of forms for concrete replacement in walls.

Best repairs are obtained when the lowest practicable slump is used. This is about 3 inches for the first lift in an ordinary large form. Subsequent lifts can be drier, and the top few inches of concrete in the hole and that in the chimney should be placed at almost zero slump. It is usually best to mix enough concrete at the start for the entire hole. Thus, the concrete will be up to 1-1/2 hours old when the successive lifts are placed. Such premixed concrete, provided it can be vibrated satisfactorily, will have less settlement, less shrinkage, and greater strength than freshly mixed concrete.

Structural concrete placements should be started with an oversanded mix containing about a 3/4-inch-maximum size aggregate; a maximum water-cement ratio of 0.47, by weight; 6 percent total air, by volume of concrete; and having a maximum slump of 4 inches. This special mix should be placed several inches deep on the joint at the bottom of the placement. A mortar layer should not be used on the construction joints.

(c) Application.—When placing concrete in lifts, placement should not be continuous; a minimum of 30 minutes should elapse between lifts. When chimneys are required at more than one level, the lower chimney should be filled and allowed to remain for 30 minutes between lifts. When chimneys are required on both faces of a wall or beam, concrete should be placed in only one of the chimneys until it flows to the

other. Attempted placement in both chimneys will result in air entrapment and/or voids in the structure.

The quality of a repair depends not only on use of low-slump concrete, but also on the thoroughness of the vibration during and after depositing the concrete. There is little danger of overvibration. Immersion-type vibrators should be used if accessibility permits. If not, this type of vibrator can be used very effectively on the forms from the outside. Form vibrators can be used to good advantage on forms for large inaccessible repairs, especially on a one-piece back form, or attached to large metal fittings such as hinge-base castings. Immediately after the hole has been completely filled, pressure should be applied to the fill and the form vibrated. This operation should be repeated at 30-minute intervals until the concrete hardens and no longer responds to vibration. Pressure is applied by wedging or by tightening the bolts extending through the pressure cap (figure 48). In filling the top of the form, concrete to a depth of only 2 or 3 inches should be left in the chimney under the pressure cap. A greater depth tends to dissipate the pressure. After the hole has been filled and the pressure cap placed, the concrete should not be vibrated without a simultaneous application of pressure. To do so may pro-duce a film of water at the top of the repair that will prevent bonding.

Addition of aluminum powder to concrete causes the latter to expand as described in section 182 of the *Concrete Manual* (Bureau of Reclamation, 1975). Under favorable conditions, this procedure has been successfully used to secure tight, well-bonded repairs in locations where the replacement material had to be introduced from the side. Forms similar to those shown in figure 48 should be used. Time should not be allowed for settlement between lifts. When the top lift and the chimney are filled, no pressure need be applied, but the pressure cap should be secured in position so expanding concrete will be confined to and completely fill the hole undergoing repair. There should be no subsequent revibration.

Concrete replacement in open-top forms, as used for reconstruction of the tops of walls, piers, parapets, and curbs, is a comparatively simple operation. Only such materials as will make concrete of proved durability should be used. The water-cement ratio should not exceed 0.47, by weight. For the best durability, the maximum size of aggregate should be the largest practicable and the percentage of sand the minimum practicable. No special features are required in the forms, but they should be mortar tight when vibrated and should give the new concrete a finish similar to the adjacent areas. The slump should be as low as practicable, and dosage of air entraining agent should be increased as necessary to secure the maximum permissible percentage of entrained air, despite the low slump. Top surfaces should be sloped to provide rapid drainage. Manipulation in finishing should be held to a minimum, and a wood-float finish is preferable to a steel-trowel finish. Edges and corners should be tooled or chamfered. Use of water for finishing is prohibited.

Forms for concrete replacement repairs usually may be removed the day after casting unless form removal would damage the green concrete, in which event stripping should be postponed another day or two. The projections left by the chimneys normally should be removed the second day. If the trimming is done earlier, the concrete tends to break back into the repair. These projections should always be removed by working up from the bottom because working down from the top tends to break concrete out of the repair. The rough area resulting from trimming should be filled and stoned to produce a surface comparable to that of surrounding areas. Plastering of these surfaces should never be permitted.

Some replacement concrete does not require forms. Replacement of damaged or deteriorated paving or canal lining slabs, wherein the full depth of the slab is replaced, involves procedures no different from those required for best results in original construction. Contact edges at the perimeter should be saw cut clean and square with the surface.

Special repair techniques are required for restoration of damaged or eroded surfaces of spillway or outlet works tunnel inverts and stilling basins. In addition to the usual forces of deterioration, such repairs often must withstand enormous dynamic and abrasive forces from fast-flowing water and sometimes from suspended solids. Silica fume concrete (section 37) is the repair material of choice for these types of repair. Whenever practicable, low slump silica fume concrete should be used. Slump of the concrete should not exceed 2 inches for slabs that are horizontal or nearly horizontal and 3 inches for all other concrete. (Note: This is 1 inch less slump than that permitted in the M-47 specifications for conventional applications of silica fume concrete.) The net water-cementitious ratio (exclusive of water absorbed by the aggregates) should not exceed 0.35 by weight. An air-entraining agent and a high range water reducing admixture should be used. Set- retarding admixtures should be used only when the interval between mixing and placing is quite long. (These recommendations are repeated in section 37.)

If, however, needed repairs are too small for the replacement concrete method (including silica fume concrete), they should be made using the dry pack procedure (section 26), the epoxy-bonded epoxy mortar method, (section 30) or the epoxy-bonded replacement concrete method (section 31).

(d) Curing and Protection.—The importance of curing replacement concrete repairs cannot be overemphasized. Complete failure of repairs has been attributed to inadequate or improper curing. There is no known condition short of flooding the repaired structure (which in itself is an excellent curing method) that does not require curing of cementitious repairs. Because of the relatively small volume of most repairs and the tendency of old concrete to absorb moisture from new material, water curing is a highly desirable procedure, at least during the first 24 hours. When forms are used for repair, they can be removed and then reset to hold a few layers of wet burlap in contact with new concrete. One of the best methods of water curing is a soil- soaker hose laid beneath a plastic membrane covering the repair area.

When curing compound is used, the best curing combination is an initial water-curing period of 7 days (never less than 24 hours) followed, while the surface is still damp, by a uniform coat of the compound. It is always essential that repairs, even dry packed cone bolt holes, receive some water curing and be thoroughly damp before the curing compound is applied. If nothing better can be devised for the initial water curing of the dry pack in cone bolt holes and similar repairs, a reliable workman should be detailed to make the rounds with water and a large brush or a spraying device to keep the repaired surfaces wet for 24 hours prior to application of a curing compound. White curing compound may be used only where its color does not create objectionable contrast in appearance.

30. Epoxy-Bonded Epoxy Mortar.— Epoxy-bonded epoxy mortar should be used where the depth of repair is less than 1-1/2 inches and the exposure conditions are such that *relatively constant temperatures* can be expected. Epoxy mortars have thermal coefficients of expansion that may be significantly different from conventional concrete. If such mortars are used under conditions of wide and frequent temperature fluctuations, they will cause failure just below the bond surface in the base concrete. *For this reason, current Reclamation practice precludes the use of epoxy mortars under conditions of frequent or large temperature fluctuations.*

The application of epoxy mortar to repair areas of concrete deterioration caused by corroding reinforcing steel is also not recommended. The epoxy bond coat and epoxy mortar create zones of electrical potential that are different from the electrical potential in the surrounding concrete. This difference in potential can result in the formation of a galvanic corrosion cell with accelerated corrosion at the repair perimeters.

Epoxy mortar is properly used to make thin repairs (1/2-inch to 1-1/2-inch thickness) to concrete under relatively constant temperature exposure conditions. Such applications could include tunnel linings, indoor or interior concrete, the underside of concrete structures such as bridge decks, continuously inundated concrete such as stilling basin floors, canal linings below water line, or concrete pipe. Applications to concrete exposed to the daily temperature fluctuations caused by exposure to direct sunlight *are not appropriate for epoxy mortar repair*.

Properly applied epoxy mortar repairs have a long history of successful performance on Reclamation concrete when used under appropriate conditions. A 1991 inspection of the epoxy mortar repairs made at Yellowtail Dam in 1968 showed that less than 2 percent of the repairs had suffered failure in over 20 years of service. This is considered outstanding performance for a repair material.

(a) Preparation.—Concrete to be repaired with epoxy mortar should be prepared in accordance with section 8. Prior to application of the epoxy mortar, the concrete should be heated in sufficient depth, when necessary, so that the surface temperature (as measured by a surface temperature gage) does not drop below 40 EF during the first 4 hours after placement of an epoxy bond coat. This may require several hours of preheating with radiant heaters or other approved means (figures 49 and 50). If existing conditions prohibit meeting these temperature requirements, suitable modifications should be adopted upon the approval of the inspector or other responsible official. The concrete temperature during preheating should never exceed 200 EF, and the final surface temperature at the time of placing epoxy materials should never be greater than 100 EF.

(b) Materials.—Epoxy resins used to prepare epoxy mortar for use in concrete repair should be two-component, 100-percent solids type meeting the requirements of specification ASTM C-881 for type III, grade 2, class B or C. Class B epoxy is used between 40 and 60 EF. Class C epoxy is used above 60 EF up to the highest temperature defined by the epoxy manufacturer. The sand used in epoxy mortar must be clean, dry, well graded, and composed of sound particles. For most applications, sand passing a No. 16 screen and conforming to the following limits should be used:

Screen number	Individual percent, by mass, retained on screen
30	26 to 36
50	18 to 28
100	11 to 21
Pan	25 to 35

Range shown is applicable when 60 to 100 percent of pan is retained on No. 200 screen. When 41 to 100 percent of pan passes the No. 200 screen, the percent pan should be within the range of 10 to 20 percent, and the individual percentages retained on the Nos. 30, 50, and 100 screens should be adjusted accordingly.

Sand processed for use in concrete rarely contains the required quantity of pan size sand. As a result, problems often arise in obtaining additional pan size material to supplement sand available on the jobsite. A source of silica pan size material may be obtained by contacting the Materials Engineering and Research Laboratory, Code D-8180, Bureau of Reclamation, Denver Federal Center, Denver, Colorado 80225. A sand graded as shown above and properly mixed with an epoxy meeting ASTM C-881 specifications will provide a dense, high strength, workable epoxy mortar.

Figure 49.—A gas-fired forced air heater is being used to heat concrete prior to application of epoxy mortar.

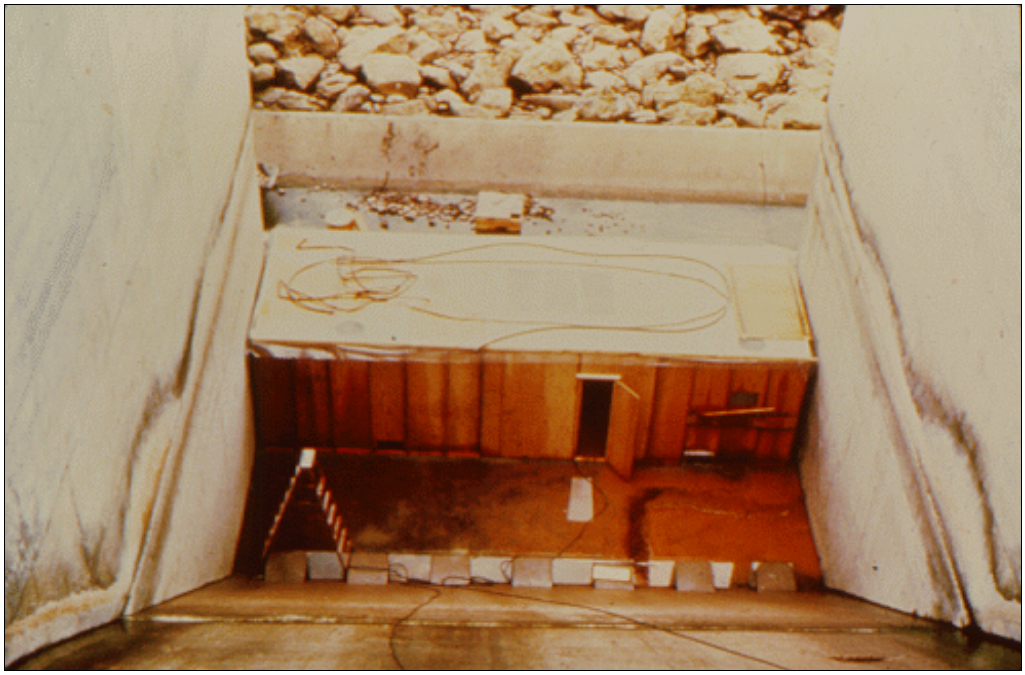

Figure 50.—An enclosure has been constructed over an area to be repaired with epoxy mortar to keep the concrete warm.

The sand should be maintained in a dry area at not less than 70 EF for 24 hours immediately prior to the time of use. Filler materials other than sand, such as portland cement, can be used. However, for general applications, a natural sand is recommended.

It is also acceptable to obtain and use brand name prepackaged epoxy mortar repair systems that contain resin and sand, *provided that the resin systems meet the ASTM C-881 specifications previously listed*. Such mortar systems are manufactured specifically for concrete repair and must be used in exact accordance with the manufacturer's recommendations.

On critical repair jobs such as areas of high velocity flow or on repairs requiring a considerable quantity of materials, the contractor should be required to submit samples of epoxy resin and graded sand to the Materials Engineering and Research Laboratory, Denver, for use in mix design determinations. The samples should consist of 1 gallon total quantity of epoxy components and a minimum of 50 pounds of graded sand. Samples should be submitted at least 30 days prior to use in the work and be labeled or otherwise identified with the specifications number under which the material is to be used.

(c) Mixing.—Preparation of epoxy mortar involves premixing proper quantities of epoxy resin and hardener and then mixing the resin system with sand to make the epoxy mortar.

The epoxy resin used for mortar preparation is a two-component (part A and part B) material which requires accurate combination of components and mixing prior to use. Once mixed, the material has a limited pot life and must be used immediately. (Pot life refers to the period of time elapsing between mixing of ingredients and their stiffening to the point where satisfactory use cannot be achieved.) The repair resin should be prepared by adding the required quantity of hardener (normally, part B) to the resin (normally part A) in proportions recommended by the manufacturer, followed by thorough mixing. Since the pot life of the mixture depends on the temperature (longer at low temperature, much shorter at high temperature), the quantity to be mixed at one time should be that quantity that can be applied within approximately 30 minutes. The addition of nonreactive thinners or diluents to the resin mixture is not permitted since it weakens the epoxy.

The epoxy mortar is composed of sand and epoxy resin suitably blended to provide a stiff, workable mix. Mix proportions should be established, batched, and reported on a weight basis, although the dry sand and mixed epoxy may be batched by volume using suitable measuring containers that have been calibrated on a weight basis. Epoxy meeting ASTM specification C-881 will require approximately 5-1/2 to 6 parts of graded sand to 1 part epoxy, by weight. This is equivalent to a ratio of approximately 4 to 4-1/2 parts sand to 1 part epoxy, by volume. If equivalent volume proportions are being used, care must be taken to prevent confusing them with weight proportions. It will be necessary to adjust the mix proportions for the particular epoxy and sand being used. The epoxy mortar should be thoroughly mixed with a slow-speed mechanical device. The mortar should be mixed in small size batches so that each batch can be completely mixed and placed within approximately 30 minutes. Figure 51 shows a simple bucket mixer that is adequate to mix epoxy mortar for small repairs.

(d) Application.—Application of epoxy mortar repairs first requires application of a resin bond coat followed by application and finishing of the epoxy mortar. Surfaces of existing concrete to which epoxy mortar is to be bonded should be prepared as discussed in section 8. Steel to be embedded in epoxy mortar should be prepared, cleaned, and dried in the same manner as the concrete being repaired. The exposed steel should be completely coated with epoxy bonding agent when the agent is applied to the surfaces of the repair area.

A resin bond coat consisting of the same type epoxy resin used to mix the epoxy mortar is applied to the prepared concrete surface immediately before placing the epoxy mortar. After the bond coat resin is mixed, it must be uniformly applied to the prepared, dry, existing concrete at a coverage of not more than 80 square feet per gallon, depending on surface conditions. The area of coverage per gallon of resin depends on the roughness of the surface to be covered and may be considerably less than the maximum specified. The epoxy bonding agent may be applied by any convenient, safe method such as

Figure 51.—A bucket mixer can be used to mix epoxy mortar for small repair areas.

squeegee, brushes, or rollers which will yield an effective coverage. Spraying of the material is permitted if an efficient airless spray is used and if the concrete surfaces to receive the agent are at a temperature of 70 EF or some-what warmer. Before approving spraying, it should be demonstrated that spraying will provide an adequate job with minimum overspray. If spray application is used, the operator must wear a compressed air-fed hood, and no other personnel should be closer than 100 feet if downwind of the operator.

During application of the epoxy bond coat, care must be exercised to confine the material to the area being bonded and to avoid contamination of adjacent surfaces. However, the bond coat should extend slightly beyond the edges of the repair area.

The applied epoxy bonding resin must be in a fluid condition when the epoxy mortar is placed. If the resin cures beyond this fluid state but is still tacky, a second bond coat should be applied over the first coat. If any bond coat has cured beyond the tacky state, it must be completely removed by sandblasting, the concrete properly cleaned, and a new bond coat applied.

Special care must be taken to prevent the bond coat from being spread over concrete surfaces not properly cleaned and prepared.

Appropriate solvents may be used to clean tools and spray guns, but in no case should the solvents be incorporated in any bonding agent. All tools must be completely dried before reuse.

The prepared epoxy mortar should be tamped, flattened, and smoothed into place (figure 52) in all areas while the bonding resin is still in a fluid condition, except that on steep slopes, the bond coat can be allowed to stiffen to a very tacky condition to assist in holding the mortar in place. Special care must be taken to thoroughly compact the epoxy mortar against the bond coat. The mortar should be worked to grade and given a steel trowel finish (figure 53). Special care must be taken at the edges of the area being repaired to assure complete filling and leveling and to prevent the mortar from being spread over surfaces not having the epoxy bond coat application. Steel troweling should best suit prevailing conditions; in general, it should be performed by applying slow, even strokes. Trowels may be heated to facilitate the finishing, but the use of thinner, diluents, water, or other lubricants on placing or finishing tools is not permitted. After leveling the epoxy mortar to the finished grade where precision surfaces are required on sloping, vertical, or overhead surfaces, the mortar should be covered with plywood panels smoothly lined with polyethylene sheeting and weighted with sandbags or otherwise braced by suitable means until the possibility of slumping has passed. When polyethylene sheeting is used, no attempt should be made to remove it from the epoxy mortar repair before final hardening.

Surfaces of all epoxy mortar repairs should be finished to the plane of surfaces adjoining the repair areas. The final finished surfaces should have the same smoothness and texture of surfaces adjoining the repair areas.

(e) Curing.—Epoxy mortar repairs should be cured immediately after completion at not less than the temperature range prescribed by the class of the epoxy until the mortar is hard. Postcuring, if required by the specifications, can then be initiated at elevated temperatures by heating in depth the epoxy mortar and the concrete beneath the repair. Postcuring should continue for a minimum of 4 hours at a surface temperature generally not less than 90 EF nor more than 110 EF. The heat could be supplied by use of portable propane-fired heaters, infrared lamp heaters, or other approved sources positioned to attain the required surface temperatures (figure 54).

In no case should epoxy-bonded epoxy mortar be subjected to moisture until after the specified postcuring has been completed.

Epoxy mortars generally produce patches that are darker than the surrounding concrete.

Figure 52.—Epoxy mortar is consolidated and compacted by hand tamping.

Figure 53.—Applying the steel trowel finish required by epoxy mortar repairs.

Figure 54.—Postcuring heating enclosure installed over an epoxy mortar repair area.

Some available epoxies produce a gray- colored mortar resembling concrete. However, these materials will rarely produce an exact color match. Grinding hardened epoxy mortar may lighten its color to about that of the surfaces adjoining the repair areas. Epoxy mortars can be colored by the addition of such materials as iron oxide red, chromium oxide green, lampblack and titanium dioxide white for gray, and ocher yellow; although Reclamation rarely uses any materials to color the epoxy other than the sand for the mortar. Use of white silica sand in the mortar will produce a white-looking patch; most natural riverborne sands will produce darker colored mortars. Whenever epoxy mortar repair materials must be colored to match adjacent concrete, laboratory mixes should be made to ascertain the proper quantities of coloring constituents.

(f) Safety.—All personnel must be carefully instructed to take every precaution in pre-venting epoxy resins and their components from contacting the skin and in preventing the breathing of epoxy fumes or vapors. Protec-tive clothing must be worn, including gloves and goggles, and protective creams for other exposed skin areas should be provided when handling epoxies, as severe allergic reactions and possible permanent health damage can result when these materials are allowed to con-tact and remain upon the skin. Any deposits acquired through accidental contact of these materials with unprotected skin must be removed immediately by washing with soap and water, never with solvents. Solvents, such as toluene and xylene, may be used only for cleaning epoxy from tools and equipment. Care must also be exercised to avoid contact of cleaning solvents with the skin and to provide adequate ventilation for mixing, placing, and cleanup operations. All safety equipment used must conform to the requirements of the Occupational Safety and Health Standards of the Occupational Safety and Health Administration.

31. Epoxy-Bonded Replacement Concrete.— Epoxy-bonded concrete is used for repairs to concrete that are between 1.5 and 6 inches thick. Shallow replacement concrete repairs, less than 6 inches thick, are subject to poor curing conditions as a result of moisture loss to evaporation and to capillary absorption by the old base concrete. Such repairs seldom develop acceptable bond strength to the old concrete.

The epoxy bonding resin is used to ensure a strong, durable bond between the old concrete and the replacement concrete.

As with epoxy-bonded epoxy mortar, care should be exercised if epoxy-bonded concrete is to be used to repair shallow deterioration resulting from corroding reinforcement. The epoxy bond coat may create electrical potentials sufficiently different from potentials in the surrounding concrete to result in accelerated corrosion at repair perimeters.

(a) Preparation.—Concrete to be repaired with epoxy-bonded concrete must be prepared as described in section 8.

(b) Materials.—The materials used in epoxy-bonded concrete repairs consist of conventional portland cement concrete and epoxy resin bonding agent.

The concrete used for epoxy-bonded repairs is the same as that used for replacement concrete repairs (section 29) except that the slump of the concrete when placed should not exceed 1-1/2 inches.

A number of proprietary epoxy formulations prepared for bonding new concrete to old concrete are now available. Many of these materials are excellent high quality products and can be used with reasonable certainty as to the results. However, some of the resins available are unsuitable or untested for such repair applications, and care should be taken to use only the epoxy bonding resins meeting the requirements of specification ASTM C-881 for a type II, grade 2, class B or C epoxy system. Class B epoxy should be used when the temperatures are above 40 EF but less than 60 EF. Class C epoxy should be used when concrete temperatures are from 60 EF up to the maximum temperature recommended by the epoxy manufacturer.

The epoxy resin used for epoxy-bonded concrete is a two component, 100-percent solids resin system requiring accurate proportioning and thorough mixing prior to use. The procedures described in section 30 should be followed during preparation and application of the resin. Conventional concrete mixing procedures as described in section 29 should be followed to mix the concrete.

(c) Application.—Use of epoxy-bonded concrete in repairs requiring forming, such as on steeply sloped or vertical surfaces, can be permitted only when sufficient time has been allowed to place concrete against the epoxy bonding resin while it is still fluid. If the resin cures before placement of the concrete, no bond will develop between the old and new concrete. It is a good idea to practice install such forms at least once before actually applying the epoxy bond coat (figure 55).

Immediately after application of the epoxy resin bonding agent and while the epoxy is still fluid, unformed epoxy-bonded concrete should be spread evenly to a level slightly above grade and compacted thoroughly by vibrating or tamping (figure 56). Tampers should be sufficiently heavy for thorough compaction. After being compacted and screeded, the concrete should be given a wood-float or steel-trowel finish as required. Water, cement, or a mixture of dry cement and sand should never be sprinkled on the surface. Troweling, if required, should be performed at the proper time and with heavy pressure to produce a smooth, dense finish free of defects and blemishes. As the concrete continues to harden, the surface should be given additional trowelings.

The final troweling should be performed after the surface has hardened so that no cement paste will adhere to the edge of the trowel, but excessive troweling cannot be permitted.

(d) Curing.—Even though an epoxy bond coat is used, it still remains essential to properly cure epoxy-bonded concrete. As soon as the epoxy-bonded concrete has hardened sufficiently to prevent damage, the surface should be cured by spraying lightly with water and then covering with sheet poly-ethylene or by coating with an approved curing compound.

Figure 55.—If forms are required for epoxy-bonded concrete repairs, they should be installed at least once prior to application of the epoxy bond coat to ensure that they fit as planned and that they can be installed and filled before the bond coat hardens.

Figure 56.—The placement techniques for epoxy-bonded concrete are essentially the same as for conventional concrete.

Curing compound should be used whenever there is any possibility that freezing temperatures will prevail during the curing period. Sheet polyethylene must be an airtight, nonstaining, waterproof covering that will effectively prevent evaporation. Edges of the polyethylene should be lapped and sealed. The waterproof covering should be left in place for at least 2 weeks. If a waterproof covering is used and the concrete is subjected to any usage during the curing period that might rupture or otherwise damage the covering, the covering must be protected by a suitable layer of clean, wet sand or other cushioning material that will not stain concrete. Application of curing compound must be in accordance with appropriate standard procedures as contained in the *Concrete Manual* (Bureau of Reclamation, 1975).

(e) Safety.—All personnel must be carefully instructed to take every precaution in preventing epoxy resins and their components from contacting the skin and in preventing the breathing of epoxy fumes or vapors. Protective clothing must be worn, including gloves and goggles, and protective creams for other exposed skin areas should be provided when handling epoxies, as severe allergic reactions and possible permanent health damage can result when these materials are allowed to contact and remain upon the skin. Any deposits acquired through accidental contact of these materials with unprotected skin must be removed immediately by washing with soap and water, never with solvents. Solvents, such as toluene and xylene, may be used only for cleaning epoxy from tools and equipment. Care must also be exercised to avoid contact of cleaning solvents with the skin and to provide adequate ventilation for mixing, placing, and cleanup operations. All safety equipment used must conform to the requirements of the Occupational Safety and Health Standards of the Occupational Safety and Health Administration.

32. Polymer Concrete.—Polymer concrete (PC) is a concrete system composed of a polymeric resin binder and fine and coarse aggregate. Water is not used to mix polymer concrete. Instead, the liquid resin, known as a

monomer, is caused to cure or harden by a chemical reaction known as polymerization. During polymerization, the monomer molecules are chemically linked and cross linked to form a hard, glassy plastic known as a polymer. The polymers used in PC are formulated to provide the special properties needed for high performance repair materials. These systems can be cured very quickly and are most useful in performing repairs to structures that must be immediately returned to service. As an example, PC is commonly used to repair potholes in concrete highway bridge decks, thereby eliminating the necessity of long and costly road closures or detours. It is also useful for repairs to structures, such as tunnel linings, that can be maintained in a dry condition for only short periods of time and for cold weather repairs down to temperatures as low as 15 EF. PC repairs can be accomplished in thicknesses varying from about 1/2 inch to several feet if appropriate precautions are taken.

PC develops strength and durability properties very quickly due to its rapid polymerization characteristics and is useful where rapid repairs to concrete are required. PC can be mixed, placed, polymerized, and put into service in only a matter of hours. PC also develops enhanced durability properties. This feature makes it useful as protective overlays on conventional concrete exposed to corrosive or severe environments. Since PC does not contain mix water, it can be used at much lower temperatures (down to 15 EF) than portland cement concrete.

Most polymer concretes experience some volumetric shrinkage during polymerization and also have problems associated with the coefficient of thermal expansion similar to those experienced with epoxy mortars. These problems with PC, though generally less severe than similar problems with epoxy mortar, can limit the materials use on concrete exposed to wide temperature variations. Potential users of PC should be aware of these problems. The Materials Engineering and Research Laboratory at Denver, D-8180, can provide guidance and recommendations for the application of these very useful materials.

(a) Preparation.—Concrete preparation for PC repairs should be in accordance with section 8. Although some manufacturers indicate that PC may be used for feather edge repairs, Reclamation experience is otherwise. Saw cut repair perimeters are required if high quality repairs are to be achieved. Special care should be taken to ensure the base concrete is dry prior to application of the repair material. Once the PC is in place, this requirement can be relaxed. However, flowing water may remove the fresh polymer concrete if allowed on the concrete prior to development of initial set.

(b) Materials.—A number of manufacturers have developed prepackaged PC systems. Most of the systems consist of acrylic or vinyl ester monomers, appropriate polymerization initiators and catalysts, and fine aggregate and fillers. It is common for the user to extend the polymer concrete, particularly when used to fill depressions deeper than 1 inch, by supplying and adding coarse aggregate to the prepackaged PC system during mixing. The prepackaged polymer concretes also contain monomer bond coat systems that must be mixed and applied to the base concrete prior to application of the polymer concrete mixture.

(c) Application.—Each manufacturer of prepackaged PC provides detailed instructions for proportioning, mixing, and applying its product. These instructions must be closely followed to obtain a satisfactory repair.

A bond coat monomer system is mixed and applied to the prepared concrete prior to application of the PC. Care must be taken to proportion and mix the bond coat components properly. Some manufacturers specify that the bond coat be applied and cured prior to placing the polymer concrete. Others specify that the polymer concrete be applied while the bond coat is still in the liquid state. It is important to follow the procedures recommended by the manufacturer of the product actually being used.

Polymer concrete can be mixed in paddle-type, rotary drum-type, or other types of power equipment suitable for mixing conventional concrete. Very small quantities of PC can even be mixed in the original shipping containers. Three minutes of mixing time should be adequate for all the prepackaged systems. It is common practice to first add the dry powder and aggregate components to the mixer and then add the liquid resin. With some systems, the liquid component may require a separate premixing step to combine the monomer with the catalyst or initiators needed for polymerization. Other manufacturers include the initiators in the powder-fine aggregate component, thereby eliminating the premixing requirement.

The mixed PC is placed just like conventional concrete, using the same tools and procedures (figure 57). Most PC mixtures will be almost self-leveling and require only a minimum finishing operation. Light mechanical vibration should be provided to consolidate placements thicker than 2 to 3 inches (figure 58). Once the PC has been placed and consolidated, it should be screeded to proper grade and quickly finished with a wood or steel trowel. The top surface of the repair forms a "skin" soon after being placed. If repeated toweling is attempted, this skin will tear and cause an unsightly surface.

Polymer concrete develops a strong bond to most materials. If forms are used, they must be leakproof and provided with some method of bond breaker or release agent. Wrapping the forms with polyethylene film has proven a very effective method of preventing bond between the form and the PC.

(d) Curing.—Polymer concretes polymerize and harden very quickly under most ambient conditions and will develop nearly full strength within a 1- to 2-hour period. During this time, the fresh concrete must be protected from water and not disturbed (figure 59). If temperatures are lower than about 40 EF, the polymerization reaction will occur at a slower rate unless increased concentrations of initiator are used or the repair is heated to 70E to 80 EF. Conversely, polymerization can occur too quickly, with insufficient finishing time, if the ambient temperature exceeds 90E to 100 EF. A reduction of initiator concentration can reduce this problem. Alternately, the repairs can be made during the cooler parts of the day or at night.

(e) Safety.—All workers, supervisors, and inspectors involved with the project must be made aware of the procedures required for safe use of PC. The manufacturers of PC provide recommendations for safe storage, handling, and use. These recommendations must be known and followed by users of the materials. The following *minimum* safety requirements must be followed on Reclamation projects:

Storage.—Polymer concrete monomer and initiators are heat sensitive and flammable. These materials should be stored away from the direct rays of sunlight, in the original shipping containers, in well-ventilated areas away from sources of ignition. The storage temperature should not exceed 80 EF. Storage periods should not exceed manufacturer's recommendations.

Mixing and Handling.—Smoking, flame, or other sources of ignition must not be permitted during mixing and application. Electrical equipment in contact with polymer concrete should be grounded for safe discharge of static electricity. Type B or type ABC fire extinguishers must be provided at the storage, mixing, and application locations.

Personal Protective Equipment.—Workers using polymer concrete must be provided rubber boots and required to use disposable protective clothing. Splash-type safety goggles and impervious gloves must be provided to workers using polymer concrete, and the workers must be required to wear these items. In some instances where ventilation is poor or inadequate, workers may be required to wear organic vapor respirators. The mixing and application site should be provided with portable eyewash equipment capable of

Figure 57.—Placing polymer concrete in a repair area. Sandbags and polyethylene sheeting were used to prevent water from entering the repair area.

Figure 58.—Small stinger vibrators can be used to consolidate shallow depths of polymer concrete.

Figure 59.—Polymer concrete must be protected from water and not disturbed during the 1- to 2-hour curing period. No other curing procedures are required unless ambient temperatures are very low.

sustaining a 15-minute stream of clean, room temperature water.

33. Thin Polymer Concrete Overlay.—The thin PC overlay is a hard, glassy concrete coating, 25 to 50 mils thick, consisting of a vinyl ester resin system, silica flour filler, and appropriate coloring pigments. This membrane-forming overlay partially penetrates the immediate top surface of the concrete and provides very good protection to concrete exposed to adverse chemical or weathering conditions. It can also provide cosmetic treatment to concrete exposed to public view. The normal three-coat application of this material (one primer coat plus two filler coats) should result in a total overlay thickness of about 50 mils.

The overlay is applied to protect the concrete from water penetration and resulting freeze-thaw damage; to protect the concrete from chemical corrosive elements such as acids, chlorides, or sulfates; and/or to improve the cosmetic appearance of the concrete. The overlay provides complete opaque coverage of the concrete surface and flows into and seals narrow cracks in the surface. The thin PC overlay is a standard repair material specified in the *Standard Specifications for the Repair of Concrete, M-47* of appendix A. There is currently no known commercial manufacturer of the thin polymer concrete overlay. Contractors or users of the overlay system can have the material prepared by custom resin blenders or can blend and mix the material themselves using the formulas listed below.

(a) Preparation.—Concrete to receive the thin polymer concrete overlay must be cleaned and prepared using light hydroblasting or wet sandblasting in accordance with the requirements of section 8. The prepared concrete surfaces must then be maintained in a clean, dry condition until the placement of the thin overlay is completed. The dryness of the concrete can be checked by taping a clear polyethylene sheet onto the surface of the concrete in a sunlight exposure. If no moisture collects under the polyethylene sheet after an hour or two of sunlight, the surface is sufficiently dry.

(b) Materials.—The thin overlay is prepared with vinyl ester resin, polymerization initiator and promoter, silicon flour filler, and pigments.

Vinyl Ester.—The vinyl ester resin is Dow Derakane 8084, manufactured by Dow Chemical Co., 2800 Mitchell Drive, Walnut Creek, California 94596.

Initiator.—The initiator is cumene hydroperoxide-78 percent, manufactured by Lucidol Division, Penwalt Corp., 1740 Military Road, Buffalo, New York 14240, or equal.

Promoter.—The promoter is cobalt napthenate-6 percent, available from fiber-glass materials suppliers.

Filler.—The filler is ground silica, minus 45 micrometers (No. 355) sieve size, manufactured by Ottawa Silica Co., Ottawa, Illinois; or Silco Seal 395 Ground Silica, manufactured by VWR Scientific, PO Box 3200, San Francisco, California 94119.

Pigment.—Two pigments are required to obtain a concrete gray color.

Titanium dioxide powder, manufactured by VWR Scientific

Carbon lamp black or bone black powder (do not use activated carbon)

Mixing Proportions.—

Primer	5.0	gallons vinyl ester resin
	0.60	pounds initiator
	0.25	pounds promoter
Pigmented topcoats	5.0	gallons vinyl ester resin
	1.35	pounds initiator
	0.27	pounds promoter
	40.0	pounds filler
	4.00	pounds titanium dioxide pigment
	0.02	pounds carbon black pigment

Mixing Sequence.—The vinyl ester resin, filler, and pigments should be premixed and set aside for several hours to wet out before use. Immediately prior to application, the initiator is added and thoroughly mixed with the resin. Then, the promoter is added to the resin and thoroughly mixed. *Never directly mix initiator and promoter, or an extremely violent and explosive reaction will occur.*

(c) Application.—The thin polymer concrete overlay consists of one primer coat and one or two sealant coats applied at a coverage rate of 1.3 to 2.0 gallons of material per 100 square feet of surface per coat, depending on surface texture of the concrete. The material may be applied with brooms, brushes, or paint rollers (figure 60).

The primer must uniformly and completely cover the surface and should be scrubbed into the surface of the concrete, eliminating discontinuities and puddles. The pigmented topcoat(s) must be applied to the primed surface not less than 4 hours nor more than 24 hours after application of the primer or of a succeeding to coat. It is not desired that the primer or topcoat cure to a hard final finish before application of the succeeding topcoat. A somewhat tacky finish is more desirable. However, full bond between coats will be obtained by following the above-listed timeframe for application.

Caution must be exercised to prevent application of primer or topcoats not containing initiator, promoter, or both. A simple technique of reducing the possibility of this is to place containers of preweighed resin, initiator, and promoter at appropriate locations along the application route before the application begins. After the containers are preplaced, one workman can quickly check that all needed components are at each location. Then, as applicators need a resupply of the primer or topcoating system, they need only to mix all the containers at the next location.

Application of the thin PC overlay system proceeds quite quickly. By proper pre-planning, two men were able to prime and topcoat the power house roof shown in figure 61 in 2 days.

(d) Curing and Protection.—The coated surfaces must be protected until the resin has completely cured to a hard finish. Such condition will normally be obtained within about 30 hours of application of the final topcoat. Low ambient temperatures and/or high relative humidity may lengthen the hardening process.

(e) Safety.—All workers, supervisors, and inspectors involved with the project must be made aware of the procedures required for safe use of the thin polymer concrete coating. The manufacturers of vinyl ester resin and the initiators and promoters provide recommendations for safe storage, handling, and use. These recommendations must be known and followed by users of the materials. The following *minimum* safety requirements must be followed on Reclamation projects:

Storage.—Vinyl ester resin and initiators are heat sensitive and flammable. These materials should be stored away from direct sunlight, in the original shipping containers, in well-ventilated areas away from sources of ignition. The storage temperature should not exceed 80 EF. Storage periods should not exceed manufacturer's recommendations.

Mixing and Handling.—Smoking, flame, or other sources of ignition must not be permitted during mixing and application. Electrical equipment in contact with polymer concrete should be grounded for safe discharge of static electricity. Type B or type ABC fire extinguishers must be provided at the storage, mixing, and application locations. *Never directly mix initiator and promoter, or an extremely violent and explosive reaction will occur.*

Personal Protective Equipment.—Workers using thin polymer concrete overlays must be provided rubber boots and required to use disposable protective clothing. Splash-type

Figure 60.—The thin PC overlay system may be applied with push brooms, squeegees, or heavy industrial grade paint rollers.

Figure 61.—The thin PC overlay system can be applied very quickly. Two workmen completed application to this powerplant roof in 2 days.

safety goggles and impervious gloves must be provided to workers using polymer concrete, and the workers must be required to wear these items. In some instances where ventilation is poor or inadequate, workers may be required to wear organic vapor respirators. The mixing and application site should be provided with portable eyewash equipment capable of sustaining a 15-minute stream of clean, room temperature water.

34. Resin Injection.—Resin injection is used to repair concrete that is cracked or delaminated and to seal cracks in concrete to water leakage. Two basic types of resin and injection techniques are used to repair Reclamation concrete.

(a) Epoxy Resins – Epoxy resins cure to form solids with high strength and relatively high moduli of elasticity. These materials bond readily to concrete and are capable, when properly applied, of restoring the original structural strength to cracked concrete. The high modulus of elasticity causes epoxy resin systems to be unsuitable for rebonding cracked concrete that will undergo subsequent movement. Epoxy resin has been used to seal cracks in concrete to waterflow. The epoxies, however, do not cure very quickly, partic-ularly at low temperatures, and using them to stop large flows of water may not be practical. Cracks to be injected with epoxy resins should be between 0.005 inch and 0.25 inch in width. It is difficult or impossible to inject resin into cracks less than 0.005 inch in width, while it is very difficult to retain injected epoxy resin in cracks greater than 0.25 inch in width, although high viscosity epoxies have been used with some success. Epoxy resins cure to form relatively brittle materials with bond strengths exceeding the shear or tensile strength of the concrete. If these materials are used to rebond cracked concrete that is subsequently exposed to loads exceeding the tensile or shear strength of the concrete, it should be expected that the cracks will recur adjacent to the epoxy bond line. In other words, epoxy resin should not be used to rebond "working" cracks.

Epoxy resins will bond with varying degrees of success to wet concrete, and there are a number of special techniques that have been developed and used to rebond and seal water leaking cracks with epoxy resins. These special techniques and procedures are highly technical and, in most cases,

are proprietary in nature. They may have application on Reclamation projects, but only after a thorough analysis has been performed to ensure that the more standard repair procedures will not be successful or cost effective.

(b) Polyurethane Resins.—Polyurethane resins are used to seal and eliminate or reduce water leakage from concrete cracks and joints. They can also be injected into cracks that experience some small degree of movement. Such systems, with the exception of the two-part solid polyurethanes, have relatively low strengths and should not be used to structurally rebond cracked concrete. Cracks to be injected with polyurethane resin should not be less than 0.005 inch in width. No upper limit on crack width has been established for the polyurethane resins at the time this is being written. Polyurethane resins are available with substantial variation in their physical properties. Some of the polyurethanes cure into flexible foams. Other polyurethane systems cure to semiflexible, high density solids that can be used to rebond concrete cracks subject to movement. Most of the foaming polyurethane resins require some form of water to initiate the curing reaction and are, thus, a natural selection for use in repairing concrete exposed to water or in wet environments. At the time this is written, there are no standard specifications for polyurethane resins equivalent to the Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete, ASTM Designation C-881. This current lack of standards, combined with the wide variations possible in polyurethane physical properties, creates the necessity that great care be exercised in selecting these resins for concrete repair. "Cookbook" type application of these resins will not be successful. The Materials Engineering and Research Laboratory (D-8180) of the Denver Technical Services Center is currently testing and evaluating these very useful resin systems. They will provide advice and guidance for field applications if requested.

Because of the high costs (generally about $200.00 per linear foot of injected crack), resin injection is not normally used to repair shallow, drying shrinkage, or pattern cracking.

The *Standard Specifications for Repair of Concrete, M-47* in appendix A contains current materials and procedures specifications for epoxy and polyurethane injection resins.

(a) Preparation.—Cracks, joints, or lift lines to be injected with resin should be cleaned to remove all the contained debris and organic matter possible. Several techniques have been used, with varying degrees of success, for cleaning such cracks. Once injection holes have been drilled, repeated cycles of alternately injecting compressed air followed by water have been very useful in flushing and cleaning cracks subject to water leakage. The successful use of soaps in the flushing water has been reported by some practitioners. Complete removal of such materials once injected into cracks is troublesome and may create more problems than it is worth. The use of acids to flush and clean cracks is not allowed by Reclamation. Cracks subject to epoxy injection for purposes of structural rebonding should not normally be injected with water. The epoxy resins will bond to wet concrete, but they develop higher bond strength when bonding to dry concrete.

(b) Materials.—Epoxy resin used for crack injection should be a 100-percent solids resin meeting the requirements of specification ASTM C-881 for type I or IV, grade 1, class B or C. If the purpose of injection is to restore the concrete to its original design load bearing capabilities, a type IV epoxy should be specified and used. If the purpose does not involve restoration of load bearing capabilities, a type I epoxy is sufficient. No solvents or unreactive diluents should be permitted in the resin.

Polyurethane resin used for crack injection should be a two-part system composed of 100-percent polyurethane resin as one part and water as the second part. The polyurethane resin, when mixed with water, should be capable of forming either a closed cell flexible foam or a cured gel, dependent on the water to resin mixing ratio. However, the resin should be such that, with appropriate water to resin mixing ratios, the resulting cured resin foam can attain at least 20-psi tensile strength with a bond

to concrete of at least 20 psi and a minimum elongation at tensile failure of 400 percent. The manufacturer's certification that his product meets these minimum requirements should be required before the injection resins are accepted for use on the job.

(c) Injection Equipment.—Resins can be injected with several types of equipment. Small repair jobs employing epoxy resin can use any system that will successfully deposit the epoxy in the required zones. Such systems could use a prebatch arrangement in which the two components of the epoxy are batched together prior to initiating the injection phase with equipment such as small paint pressure pots. The relatively short pot life of the epoxy makes this technique rather critical as far as timing is concerned.

Large epoxy injection jobs generally require a single-stage injection technique in which the two epoxy components are pumped independently of one another from the reservoir to the mixing nozzle. At the mixing nozzle, located adjacent to the crack being repaired, the two epoxy components are brought together for mixing and injecting. The epoxy used in this injection technique must have a low initial viscosity and a closely controlled set time. Several private companies have proprietary epoxy injection systems (figure 62). These organizations have developed epoxies and techniques which allow them to make satisfactory repairs under the most adverse conditions. One or more of these companies should be contacted regarding any major repairs requiring the epoxy injection technique. Names and addresses of these companies can be obtained from the Materials Engineering and Research Laboratory, Code D-8180, Denver, Colorado.

Polyurethane resins have a very short pot life after mixing and are always prepared and injected with *multiple component*, single stage proprietary equipment similar to that used for large scale epoxy repairs. Reclamation specifications do not permit single component injection of 100-percent pure resin. In every instance, multiple component water-resin mixtures or resin (part A) -resin (part B) mixtures must be used. This equipment mixes the resin system components just prior to the point of crack injection. The size of polyurethane injection equipment varies from small, hand operated, pumps to full size commercial equipment capable of discharging many cubic feet of resin per hour (figures 63 and 64). The pumping pressure required of polyurethane injection equipment may exceed 3,000 psi. There are a number of manufacturers of high quality polyurethane resin injection equipment, and there is seldom any cause to attempt polyurethane injection on a Reclamation project with equipment designed for, or adapted from, other operations. Such adaptation is usually indicative of an inexperienced contractor and is highly discouraged.

(d) Application.—The success of resin injection repair projects is directly related to the experience and knowledge of the injection contractor. Reclamation requires that an injection contractor have a minimum of 3 years' experience in performing injection work similar to that being contracted for and that a minimum of five projects be included in that experience. Reclamation may also accept an injection contractor not having the required experience provided that the work is per-formed under the full-time, direct technical supervision of the injection resin manufacturer, provided the manufacturer has a minimum of 5 years' experience providing resins for applications similar to those specified.

(1) Application of Epoxy Resin by Pressure Injection.—The objective of epoxy resin injection is to completely fill the crack or delamination being injected and retain the resin in the filled voids until cure is complete. The first step in the resin injection process is to thoroughly clean the concrete surface in the vicinity of the cracks of all loose or deteriorated concrete and debris. The area of injection is then inspected and the injection port location pattern established. Several different types of injection patterns can be used:

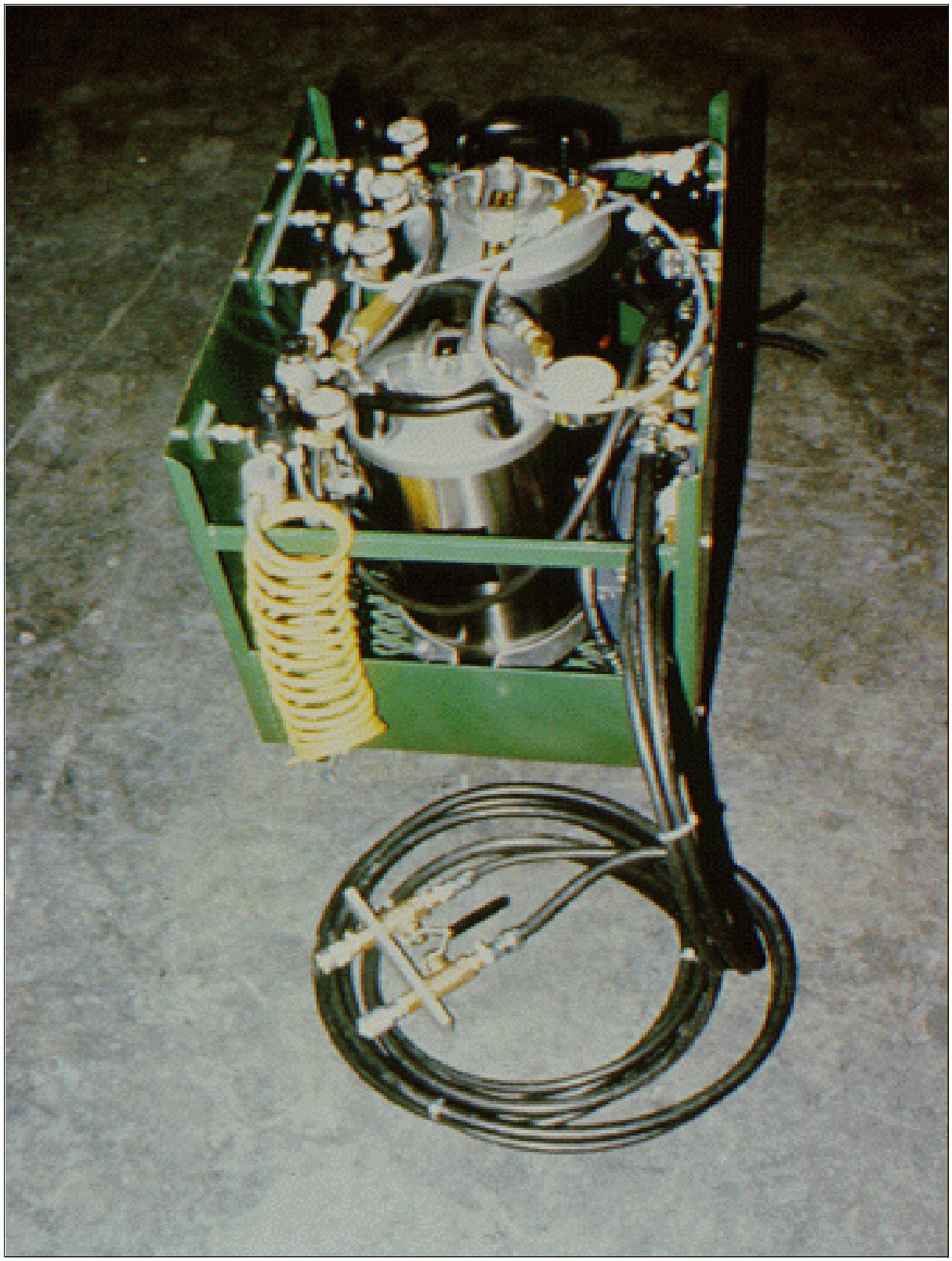

Figure 62.—Proprietary epoxy injection equipment. Such equipment does not mix resin components until the point of injection.

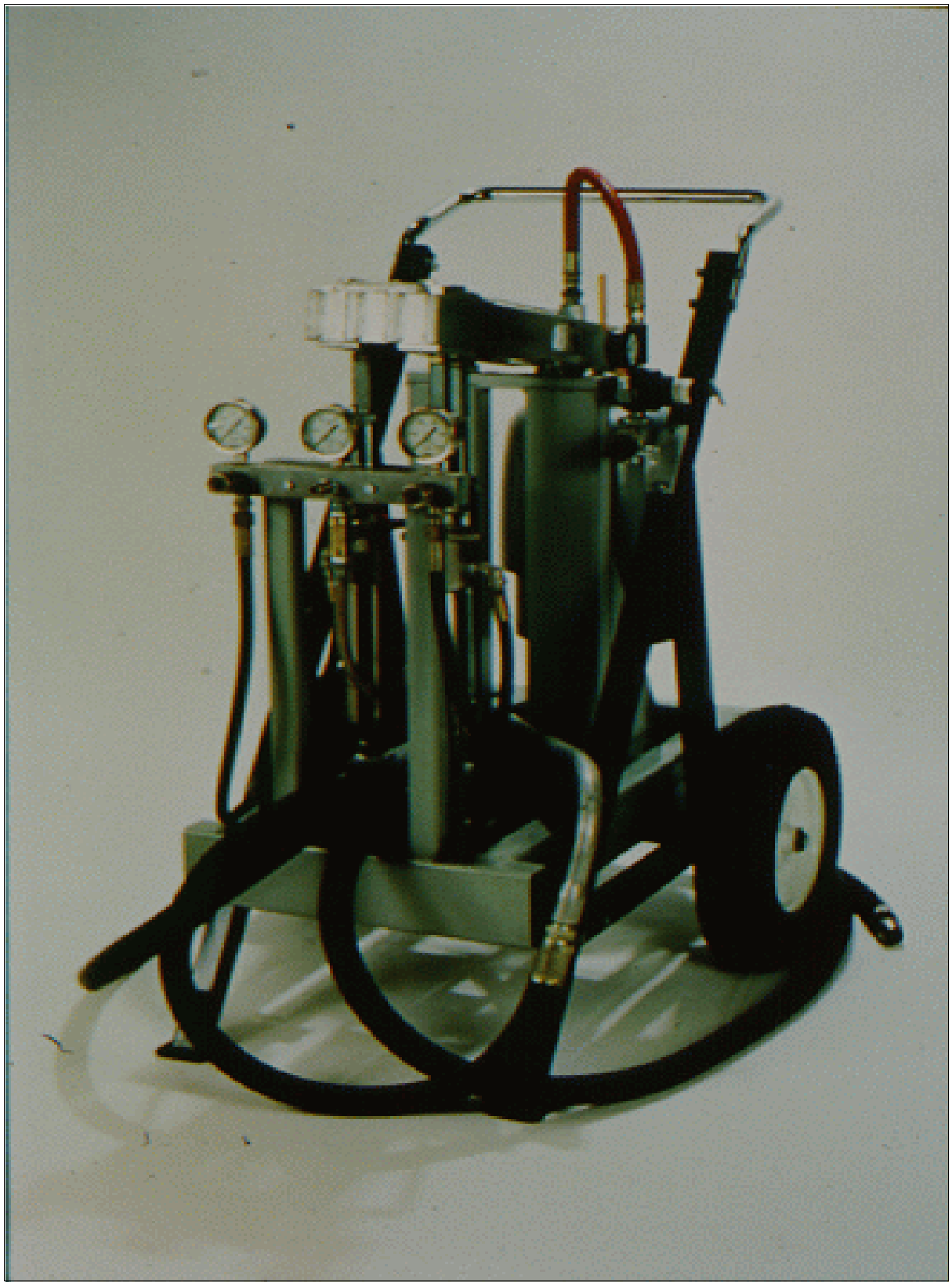

Figure 63.—Commercial polyurethane injection pump.

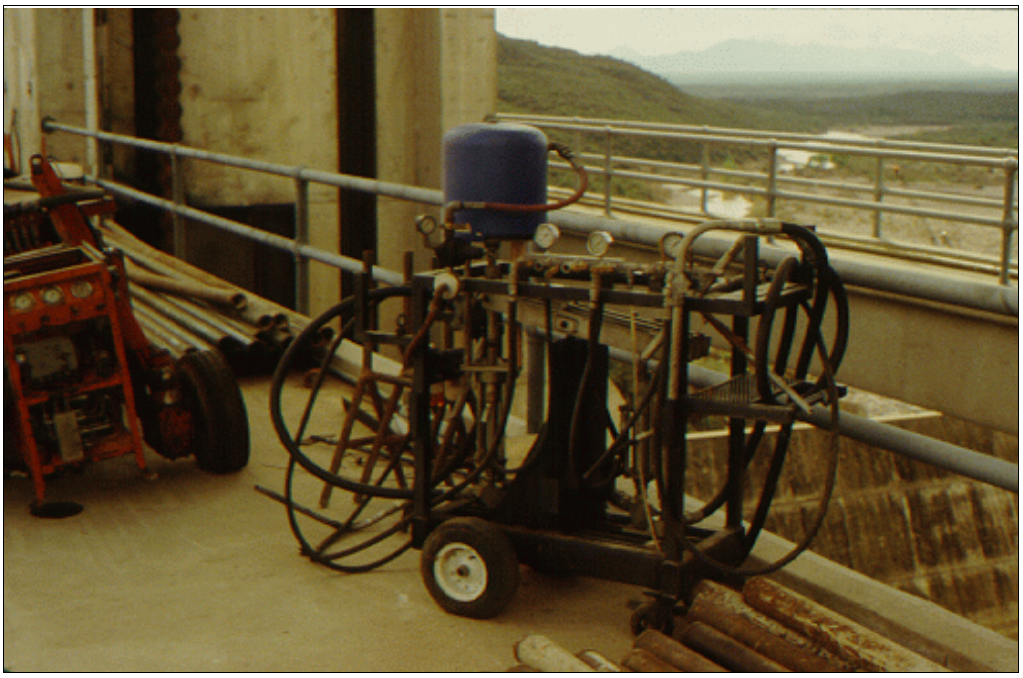

Figure 64.—This is an air-powered pump system used for large scale polyurethane resin injection.

- If the cracks are clearly visible and relatively open, injection ports can be installed at appropriate intervals by drilling directly into the crack surface. Care should be taken in drilling the ports to prevent drilling debris and dust from blocking or sealing the openings. Special vacuum drill chucks are available for this work. The surface of the crack between ports is then sealed with epoxy paste and the paste is allowed to cure. Epoxy injection begins at the lowest elevation port and proceeds along and up the crack to the uppermost port.

- A more positive method is to drill holes on alternate sides of the crack, angled to intersect the crack plane at some depth below the surface. This method ensures that the crack will be intersected even if it strikes or dips in unexpected directions. The top surface of the crack is then sealed with epoxy paste, and injection is accomplished as described above.

Low to moderate epoxy injection pressures should be used and patience should be exercised to permit the resin to flow and completely fill the voids existing in the concrete. The use of high injection pressures can result in flow blockage and incomplete filling and, generally, is an indication of an inexperienced contractor.

The best method of ensuring quality epoxy injection work is to require the contractor to prepare and submit for approval his overall, detailed injection plan and then to obtain small diameter proof cores from the injected concrete. If more than 90 percent of the voids in the cores are filled with hardened epoxy, the injection can be considered complete. If injection is not complete, the contractor should be required to reinject the concrete and obtain additional cores at no additional cost to the Government.

(2) Application of Polyurethane Resin by Pressure Injection.—The basic procedure for polyurethane injection consists of first gaining control of the leaking water, followed by pressure injecting resin to seal the cracks. In most instances, the polyurethane injection procedure is almost identical to the processes

followed for cementitious grouting.

To gain control of the waterflow, holes are drilled to intercept the waterflow paths as far as possible from the concrete surface. Valved drains known as "wall spears" (figure 65) are installed in the drilled holes, opened, and used to relieve water pressure in the cracks near the surface. The cracks are then temporarily sealed with wood wedges, lead wool, or resin soaked jute rope to prevent excessive loss of injection resin.

Additional resin injection holes are then drilled on alternate sides of the crack at a maximum spacing of 24 inches. These holes are angled to intercept the crack at a depth of 8 to 24 inches (as concrete thickness allows, these holes should extend as deeply as possible). Injection ports of various design (figure 66) or additional valved wall spears may be installed in the drilled holes, depending on the injection plan and the presence of flowing water.

Polyurethane resin injection should occur according to a preplanned sequence. A system of split spacing similar to cementitious grouting is often successful. In such a system, the primary holes are injected first, followed by drilling and injection of secondary holes located between the primary holes. Similarly, tertiary holes, located between the secondary holes and primary holes are then drilled and injected. Injection pressures should be the minimum pressures necessary to accomplish resin travel and filling. Even so, pressures of 1,500 to 2,000 psi are common in this work. Closure of each injection hole should be accomplished by holding injection pressure for a period of 10 to 15 minutes after injection flow has ceased. This technique of "closure to absolute refusal" ensures that the resin attains maximum density in the crack and becomes a permanent repair. It is usually a mistake to stop injection as soon as the water leakage is stopped. If such a procedure is followed, the partially cured, low density resin can be pushed out of the crack system by hydrostatic pressure, and repeat injection will be required to seal the resulting leakage.

It is also common practice to intermittently inject resin into a port in order to accomplish sealing of large waterflows. With this technique, a preselected quantity of resin is slowly injected into a port, followed by a 15-minute to 2-hour waiting period before repeat injection. Several such cycles of injection may be necessary to control and seal large waterflows. It is still necessary that closure to absolute refusal be accomplished with the final injection cycle.

Polyurethane resin injection is accomplished with varying water to resin ratios. In cases of high waterflows, it may be desirable to inject water to resin ratios as low as 0.5:1. Alternatively, the water and resin may be introduced and mixed in a "residence tube" 1 to 5 feet before the point of injection so the foaming reaction may be well underway upon entering the crack network. Special downhole packers can be utilized to inject resin at points deep within a structure. If resin components are mixed and injected at the surface of such deep holes, the reaction will occur within the drill hole before reaching the desired point of injection into the cracks. These special packers (figure 67) allow separation of the resin components until they reach the downhole point of crack injection.

The necessity of using experienced injection contractors or technical advisors for work of this nature cannot be overemphasized.

(3) Cleanup.—At the completion of resin injection, all injection ports, excess resin, and crack surface sealer should be removed from surfaces that are visible to the public. This can be accomplished by scraping, high pressure water blasting, or grinding. The use of dry pack or other replacement repair material necessary to fill injection holes should be anticipated and provided by the specifications.

35. High Molecular Weight Methacrylic Sealing Compound.—Concrete sealing compounds (see also section 38) are applied to cured, dry concrete as a maintenance procedure to reduce or prevent penetration of water, aggressive

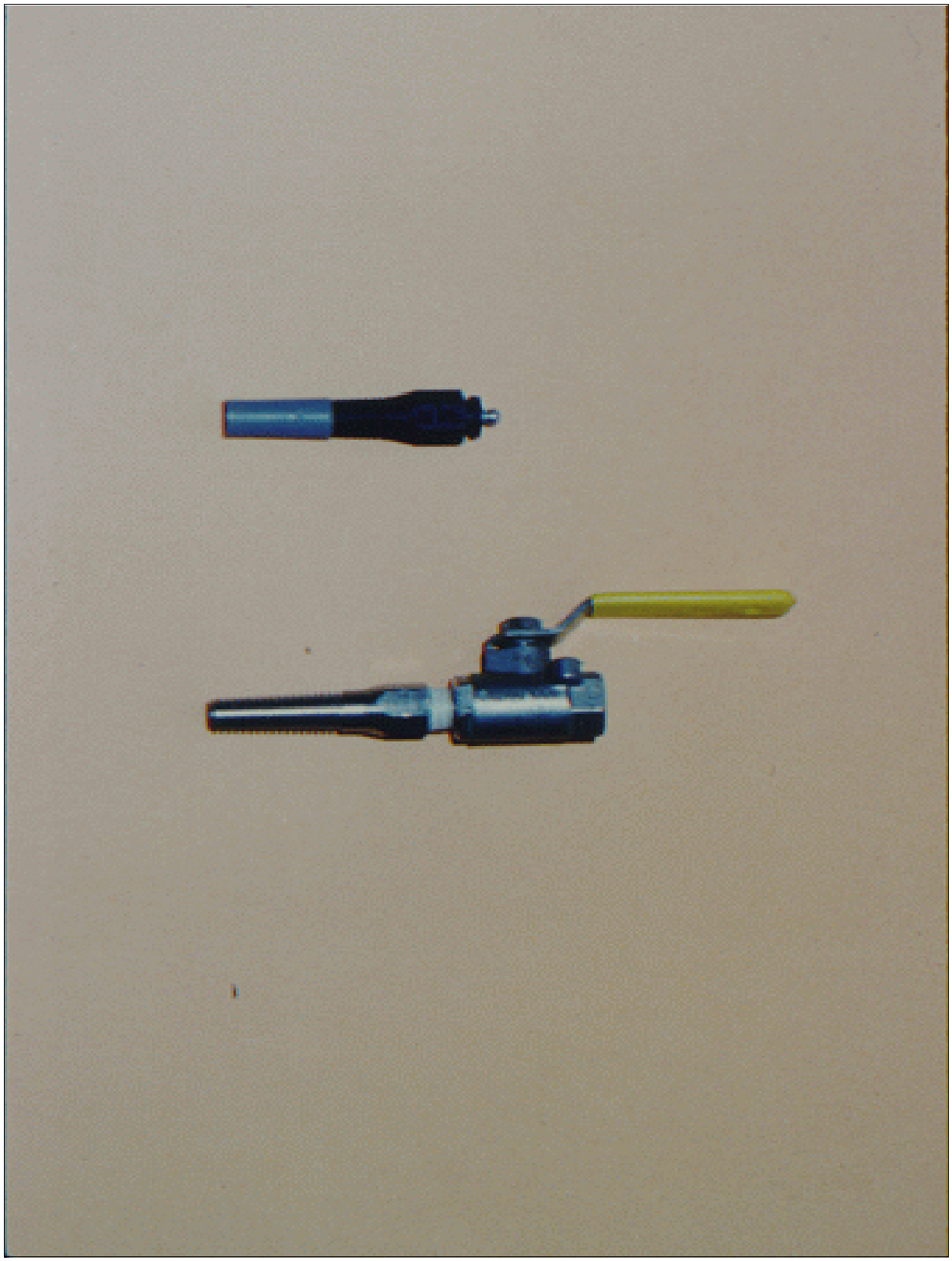

Figure 65.—An injection port with zirc fitting and a valved wall spear are shown in this photograph. The wall spear can be used to relieve water pressure and to inject resin.

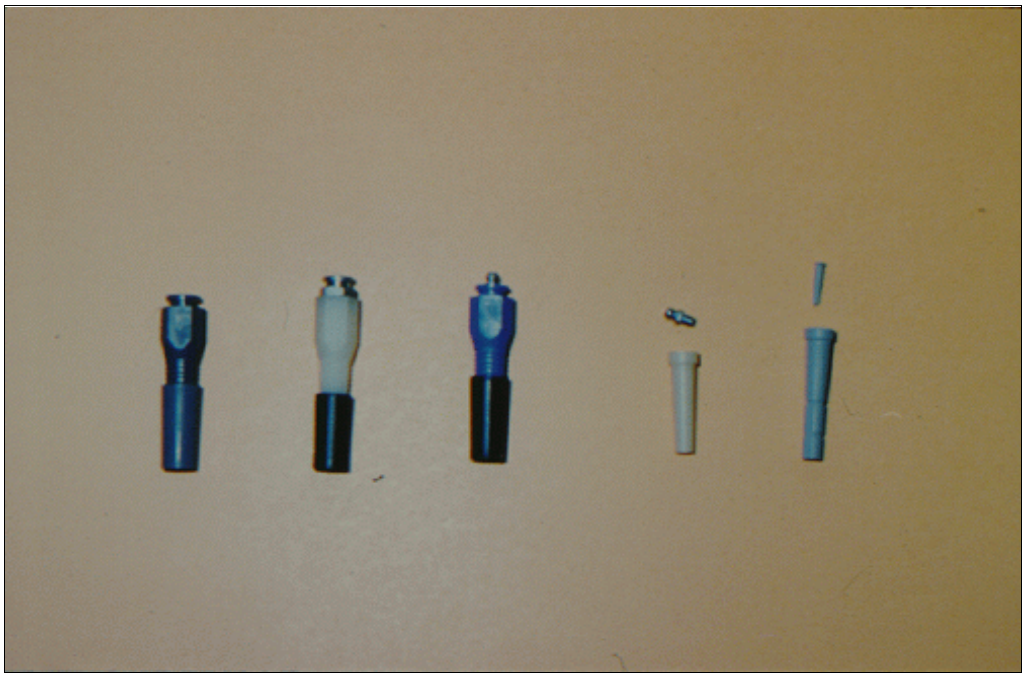

Figure 66.—Several different types of injection ports are shown in this photograph.

solutions, or gaseous media and the associated deterioration, such as freeze-thaw, carbonation, or sulfate damage. These materials replace the linseed oil based treatment, which was generally misunderstood and is no longer recommended for use on Reclamation concrete.

A variety of different membrane forming (similar to paints or coatings) and surface penetrating chemicals are manufactured and sold as sealing compounds for concrete surfaces. Some of these materials provide very good protection to the concrete for discrete periods of time. Other commercially available sealing materials, however, may be little more than mineral spirits and linseed oil. Such systems will, at best, do little harm to the concrete. Their application may, however, prevent subsequent treatment with the sealing compounds that have been proven effective. For this reason, only products that have proven effective in standardized laboratory evaluations should be used on Reclamation concrete. The Materials Engineering and Research Laboratory, D-8180, maintains a current listing of concrete sealing compounds that have been found effective for Reclamation applications.

One type of sealing compound that has proven effective in Reclamation laboratory tests and field applications and has been designated a Standard Repair Material is known as a high molecular weight methacrylic monomer system. This sealing compound is composed of a methacrylic monomer and appropriate polymerization "catalysts" very similar to the monomer system used in polymer concrete (section 32). It is a water thin, amber colored liquid that is easily spread over horizontal and vertical concrete surfaces with brooms or squeegees. The liquid penetrates the concrete surface to a depth of about 1/16 inch *but is most effective in penetrating and sealing cracks in the concrete surface.* This sealer will act like a membrane forming system if excess monomer is applied or if two or more applications are made. The appearance of the concrete following application will be somewhat like a varnished or water wet surface and may be splotchy in areas of high and low absorption. Cured sealer left on the surface of the concrete will be deteriorated by solar radiation within 1 to

Figure 67.—A proprietary downhole packer allows separation of the resin components untilthey reach the downhole point of injection.

2 years and will disappear. The loss of this surface material is of no consequence since the objective of the application is to penetrate and seal cracks where the sealer is protected from solar radiation deterioration. The expected service life of properly applied methacrylic sealing compound under typical Western State climatic conditions is 10 to 15 years. Reapplication is then necessary. Figure 68 shows application of a high molecular weight methacrylic sealing compound to the crest of Kortes Dam.

(a) Preparation.—Concrete to receive methacrylic sealing compound must be dry, clean, and physically sound. The cracks and porosity of wet or damp concrete will be completely or partially filled with water that will prevent the desired penetration of the sealing compound. The concrete is suitably dry if no moisture appears under a sheet of transparent polyethylene taped to the concrete surface during a minimum 2-hour exposure to full sunlight.

Power sweeping or hand brooming followed by blowing with high pressure compressed air should be used to remove all debris from the surface. Very small areas of paint, asphalt, rubber, or similar type coatings can usually be ignored. It should be expected, however, that the methacrylic monomer system will attack and deteriorate most markings or coatings intentionally placed on the concrete. Deteriorated or unsound concrete should be removed following the methods described in section 8. After proper preparation, the concrete must be protected from construction traffic and wetting.

(b) Materials.—The high molecular weight methacrylic sealing compound is usually obtained from the manufacturer as a three-component system:

(1) A water thin liquid methacrylic monomer

(2) Cuemene hydroperoxide initiator (or catalyst)

(3) Cobalt napthenate promoter

Each manufacturer will specify the proper proportions for mixing these materials, and these recommendations must be closely followed. As a general rule, it can be expected that the initiator will be added to the monomer at about 4 to 6 percent, by weight and the promoter at about 1 to 3 percent, by weight. *The initiator and promoter must never be directly mixed with each other, as this will produce an extremely violent and explosive chemical reaction.* Rather, the initiator is first thoroughly mixed with the monomer and then the promoter is added and mixed with the monomer-initiator mixture.

Some manufacturers supply a two-part monomer system already containing the proper proportion of promoter. With such systems, it is necessary to add only the proper quantity of initiator. Once all the components are mixed, the sealing compound system will have a definite and short pot life that cannot be extended under normal conditions.

For this reason, if the project is of sufficient size to require more than 5 gallons of sealing compound, it is usually best to premeasure the required quantity of monomer into separate 5-gallon volumes which are not mixed but are placed at appropriate locations along the application path; each location consists of 5 gallons of monomer, the appropriate quantity of initiator, and the separate and appropriate quantity of promoter (if not already added to the monomer by the manufacturer). During application, as one 5-gallon volume of sealing compound is nearly used up, an additional 5 gallons can then be mixed for use. Since all the 5-gallon materials quantities are premeasured and located along the application path, this system also helps ensure that all necessary components are added and mixed for each volume of sealing compound. Otherwise, it is some-what common to discover that either the initiator or the promoter has been omitted from sealing compound already applied to the concrete, thereby creating a bothersome situation.

(c) Application.—As the mixed monomer system has a distinctly short pot life at normal ambient temperatures, it is important not to mix more material than can be easily applied prior to the system becoming too thick— normally within 15 to 20 minutes. If the material is being applied by two workmen and the application path is clear and easily attained, it would be common to mix up to 5-gallon quantities of material unless the ambient temperatures exceed 85 EF. The sealant should be applied immediately after mixing. Application of the sealant system to concrete in direct sunlight should be avoided. Solar radiation greatly shortens the working pot life of the mixed sealant. Workmen can use squeegees, industrial size paint rollers, push brooms, brushes, or airless powered spray systems to apply the sealant system. What is desired is to flood the concrete with a heavy uniform coverage without leaving puddles of excess material. Application rates will normally vary from 75 to 100 square feet per gallon, depending on surface roughness and absorption. Vertical surfaces should receive two or more brushed, sprayed, or rolled applications. Repeat applications should be made immediately, without waiting for the sealant to cure.

If a skid-resistant surface is required for foot or vehicle traffic, sand must be broadcast over the liquid sealant system within 15 to 20 min-utes of application. The sand gradation is contained in the appendix A specifications. The sand application rate should be about 1/4 to 1/2 pound per square yard of surface

(d) Curing and Protection.—After application, the treated surfaces should be protected for a minimum of 24 hours. Protection should be provided for 48 to 72 hours if ambient temperatures are lower than 50 EF to permit the sealant to fully cure. Sealant applied during the night will be quickly cured by solar radiation the following morning. Night applications allow the maximum penetration into cracked surfaces and should be pursued whenever practicable.

(e) Safety.—The safety provisions of section 33.(e) should be followed when using high molecular weight methacrylic sealants. Storage of initiator and promoter in the same room is prohibited. Storage of initiator under refrigerated conditions is desirable. Every precaution should be taken to prevent mixing or direct contact of initiator and promoter.

36. Polymer Surface Impregnation.—The polymer surface impregnation process was developed by Reclamation for the Federal Highway Administration to prevent chloride deicing salt penetration and subsequent corrosion of reinforcing steel in existing concrete highway bridge decks. The process has provided in excess of 20 years of highly successful protection to many highway bridge decks and was applied to the entire roadway surface over Reclamation's Grand Coulee Dam.

In this process, the concrete to be treated is first covered with a bed of sand and dried with heat to remove moisture from the zone to be impregnated. A low viscosity methyl methacrylic monomer system is applied to the sandbed under a heavy polyethylene sheet and allowed to soak into the concrete surface for about 6 hours. The polyethylene retards evaporation of the highly volatile monomer system, and the sand acts as a reservoir, retaining the monomer system on the concrete until it soaks into the surface. The polyethylene covered sand and treated surface is then reheated to initiate in-situ polymerization of the methyl methacrylate monomer system within the structure of the concrete. Concrete so treated will be virtually impervious to water absorption and freeze-thaw deterioration.

Detailed materials and performance specifications for the polymer surface impregnation process are contained in section 3.13 of appendix A. Users considering application of this procedure should carefully appraise the current costs and associated safety issues. The costs of energy to properly dry and reheat areas of concrete may preclude large scale use of this very effective preventative maintenance process.

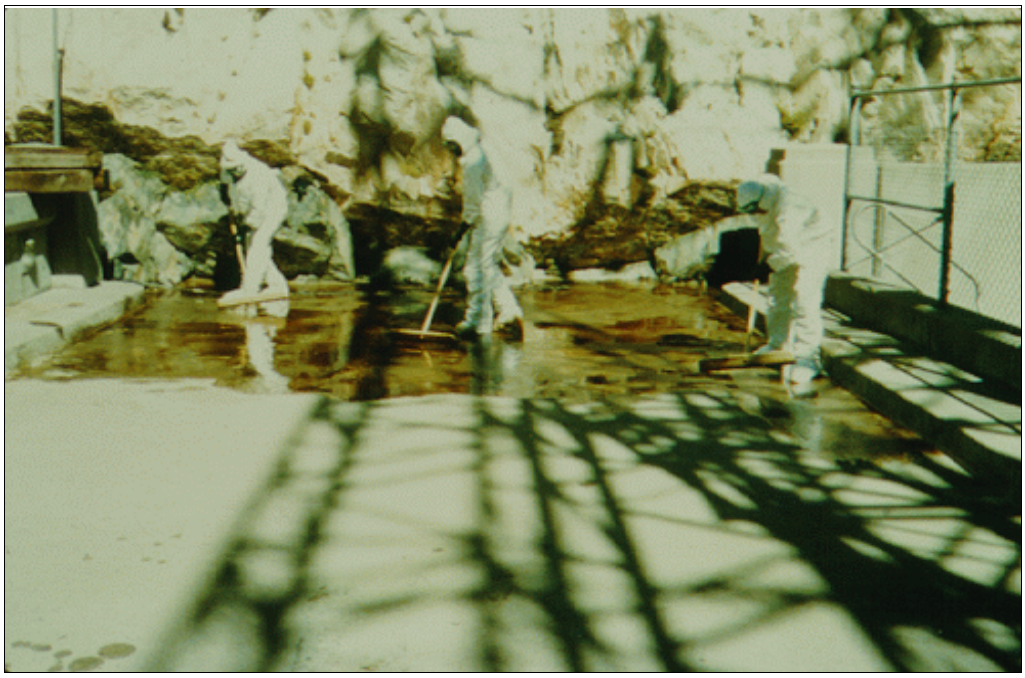

Figure 68.—High molecular weight methacrylic sealing compound is being applied tothe crest of Kortes Dam, near Casper, Wyoming.

37. Silica Fume Concrete.—Silica fume concrete is conventional portland cement concrete containing admixtures of silica fume. Silica fume is a finely divided powder by-product resulting from the use of electric arc furnaces. When mixed with portland cement concrete, silica fume acts as a "super pozzolan." Concrete containing 5 to 15 per-cent silica fume by mass of cement commonly can develop 10,000- to 15,000-psi compressive strengths, reduced tendency to segregate, very low permeabilities, and enhanced freeze-thaw and abrasion-erosion resistance. Reclamation use of silica fume is primarily for the purpose of enhancing or improving concrete durability with less emphasis on strength improvement.

Silica fume concrete is the repair material of choice for applications requiring enhanced abrasion-erosion resistance and/or reduced permeability. Silica fume concrete requires a very thorough curing procedure, however, and should not be used unless such a procedure can be accomplished. Otherwise, this repair material is used in accordance with the provisions for conventional replacement concrete.

The silica fume admixture can be obtained in at least three forms for use in concrete:

(1) Silica fume powder

(2) Densified silica fume powder with or without a high range water reducing admixture (HRWRA) and other dry admixtures

(3) Silica fume-water slurry with HRWRA and other admixtures

The dry silica fume powder is difficult to use because of its extremely small particle size. The fine powder drifts and spreads in any draft or air movement and can create silicate respiratory problems to workers. The water slurry form is easy to use, creates no dust problems, but does involve an additional mixing step as the slurry settles during storage and shipment and must be stirred and remixed prior to use. The water in the slurry must be accounted during mix design. Transportation costs of the slurry must also be considered. The

densified powder form is currently the most convenient form to ship and use. In this form, the silica fume powder is compacted and densified and does not produce nearly the quantity of dust that occurs with the powdered form. It is a dry material and does not create additional shipping costs. Because it has been compacted into clumps, it should be expected that additional time would be required during mixing to fully break up and disperse the densified silica fume admixture in the concrete mixture.

Because of these various forms, it is essential that trial mixtures be prepared and tested during mix design to ensure development of the desired concrete properties.

The addition of silica fume admixture to concrete will increase the water requirement due to the high surface area of the very fine silica fume particles. The use of HRWRA is thus necessary to obtain the maximum strength and durability with silica fume concrete. Provisions should be made during proportioning, however, to accommodate the slump gain commonly associated with concrete containing HRWRA. Silica fume increases the cohesion or "stickiness" of the concrete and can result in workability and finishing problems for those inexperienced in the proper finishing techniques. It is of primary importance to place and finish silica fume quickly, before excessive mix water evaporation and stiffening occurs. The slump gain from the HRWRA commonly offsets some of the "stickiness" of silica fume concretes. Reclamation requirements include 4-6 percent entrained air in silica fume concrete. This addition of air entraining admixture also improves the workability of the concrete.

Special repair techniques are required for restoration of damaged or eroded surfaces of spillway or outlet works tunnel inverts and stilling basins. In addition to the usual forces of deterioration, such repairs often must withstand enormous dynamic and abrasive forces from fast-flowing water and sometimes from suspended solids. The enhanced abrasion-erosion resistance and high strength of silica fume concrete makes it the repair material of choice for these types of repair. It should be recognized, however, that the cause(s) of the original damage in such repairs must be mitigated if a permanent repair is to be accomplished.

Whenever practicable, low slump silica fume concrete should be used for these types of repair. Slump of the concrete should not exceed 2 inches for slabs that are horizontal or nearly horizontal and 3 inches for all other concrete. (This is 1 inch less slump than required in the M-47 specifications for conventional applications of silica fume concrete.) The net water-cementitious ratio (exclusive of water absorbed by the aggregates) should not exceed 0.35, by weight. An air-entraining agent should be used, and a high range water reducing admixture should be used. Set-retarding admixtures should be used only when the interval between mixing and placing is quite long.

(a) Preparation.—Concrete to be repaired with silica fume concrete should be prepared in accordance with the requirements of section 8.

(b) Materials.—There are currently no ASTM specifications for the silica fume admixture. Reclamation has been approving silica fume meeting the requirements of the Standard Specification for Microsilica for Use in Concrete and Mortar, AASHTO Designation: M 307-90.

All other materials, including the requirement for 4- to 6-percent entrained air, should be in accordance with the provisions of section 29.

(c) Application.—Silica fume concrete must be mixed, transported, and placed in accordance with the highest quality procedures for conventional concrete technology and with the provisions of section 29.

The following silica fume concrete mix design is included as a reference or starting point only. Proper proportioning of silica fume concrete requires trial mixes:

Material	
Portland cement	679.3 lb/yd^3
Coarse aggregate (3/4-in. MSA)	1,910.9 lb/yd^3
Sand	1,036.2 lb/yd^3
Water	169.0 lb/yd^3
Silica fume slurry[1] = 13.3 percent by mass of cement	200.6 lb/yd^3
Total	3,996.0 lb/yd^3
HRWRA	300 cc

$$\text{w/c ratio} = \frac{\text{Water} + 0.51(\text{slurry}) = 239.2}{\text{Cement} + 0.45(\text{slurry}) = 769.5} = 0.35$$

[1] Silica fume slurry contains 51 percent water, 45 percent cementitious silica fume, and 4 percent admixtures, all by mass. The admixtures consist of HRWRA and air entraining admixture. In this instance, additional HRWRA was required to produce a workable concrete.

Silica fume concrete is placed and finished using conventional equipment and procedures. As previously discussed, placement should be done quickly to allow finishing before stiffening occurs. Consolidation and compaction should be accomplished with internal vibrators. Vibrating screeds can be used for larger placements and, usually, a single pass of multirow screeds will provide an adequate surface finish. Small repair areas can be hand screeded (figure 69). Bull floats can be used after screeding, but floating must be done immediately after screed passage (figure 70). Hand troweling silica fume concrete is usually not too effective, except for small repairs, because it takes too long. There is very little bleed water development after placing silica fume concrete. This can result in plastic and drying shrinkage cracking under conditions of elevated temperatures, low humidity, and high wind conditions which cause rapid water evaporation from the concrete surface (see section (d) below). The use of a long chain cetyl alcohol evaporation retarding finishing aid is highly recommended under such conditions.

(d) Curing.—Silica fume concrete must be properly cured if a successful repair is to result. Fresh silica fume concrete has very low or no bleed water development. This is due to the affinity silica fume has for water and to the low water-cement ratio of the mix. If the rate of evaporative water loss from the surface of freshly placed silica fume concrete exceeds the rate of bleed water development, plastic shrinkage cracking of the surface will result. Evaporative water loss must be prevented by such measures as immediate application of curing compound, covering the fresh concrete with plastic membrane, water fogging or flooding, use of an evaporation retarding finishing admixture, and by immediate curing. The common practice (with conventional concrete) of allowing the development and evaporation of bleed water from the surface prior to beginning curing will always result in cracking of silica fume concrete. It is best to begin the curing of silica fume concrete immediately after finishing. Very successful curing of stilling basin repairs has resulted from flooding the repair area with water immediately after the silica fume concrete has attained initial set. Even so, water evaporation from the concrete surface must be prevented prior to flooding. The spillway repairs shown in figures 69 and 70 were cured by applying curing compound and covering with polyethylene immediately after floating, even while placing operations were continuing (figure 71). Water trickler hoses were placed under the polyethylene as soon as the concrete attained initial set, and water was applied continuously for 14 days. This thin, 4- to 6-inch deep, repair has experienced virtually no shrinkage cracking.

(e) Safety The same safety provisions should be followed as with the use of any portland cement product, except that additional precautions must be taken to prevent inhalation of silica fume dust. The high silica content of silica fume dust can lead to development of silicosis if proper respirators are not used by workmen participating in or downwind of mixing operations.

38. Alkyl-Alkoxy Siloxane Sealing Compound This sealing compound is effective in reducing water penetration into treated concrete, provided that the sealing compound contains in excess of 15-percent siloxane solids. These solids are suspended in a carrier such as alcohol or mineral spirits that evaporates from the concrete following application. Use of this type of sealing compound does not cause a

Figure 69.—This workman is hand screeding a small silica fume concrete repair.

Figure 70.—Using a bull float on a silica fume repair. Finishing must be done immediately after screeding.

Figure 71.—Curing compound and polyethylene sheeting should be applied to cure silica fumeconcrete as soon as finishing is completed if drying shrinkage cracking is to be prevented.

change in the appearance of the treated concrete, except that the darkening normally associated with water wetting of concrete does not occur. It is common to see water bead on treated concrete surfaces. Siloxane sealing compounds will not provide protection to concrete that is completely inundated in water except for short periods. They should not be used under conditions that involve prolonged inundation such as occurs with stilling basins, canal floors, or spillway floors unless there are significantly long dry periods between inundations and it is acceptable to reapply the sealing compound following inundation. Siloxane sealing compound is best used to protect concrete from rain, snowmelt, and water splash zones.

These materials have a relatively limited service life, and reapplication should be scheduled about every 5 to 7 years for optimum protection. Application of these materials, however, proceeds very quickly on horizontal and vertical concrete surfaces. Two workmen can be expected to treat 10,000 to 15,000 square feet of horizontal surface in a day. Cost of siloxane sealing compound and application average about $0.50 to $0.70 per square foot.

(a) Preparation.—Concrete surfaces to be treated with siloxane sealing compound should be dry, clean, and sound. All deteriorated concrete should be removed (section 8), and all needed repairs should be accomplished prior to application. As a general rule, power sweeping and, in some instances, high pressure (less than 8,000 psi) water washing of the surfaces will be suf-ficient. The concrete should be allowed to dry for 24 to 48 hours following wetting. Cracks in the concrete should be cleaned and blown out with compressed air to remove any debris. Once preparation (including drying if needed) is completed, the sealing compound should be applied within 24 hours.

(b) Materials.—Siloxane sealing compound should be a one-part, ready to apply, oligo-meric alkyl-alkoxy siloxane containing no less than 20 percent active solids, by mass, in a clear organic carrier. Siloxane sealing compounds

Figure 72.—A paint roller application of siloxane sealing compound to the downstream face of Nambe Falls Dam, near Santa Fe, New Mexico.

containing less than 20 percent active solids do not provide sufficient protection to the concrete and are not allowed by section 3.15.d of the M-47 specifications in appendix A. The material should be supplied in 5-gallon pails or 55-gallon drums. No additional mixing or blending should be necessary prior to application. No additional solvents or diluents should be added to the supplied sealing compound.

(c) Application.—The sealing compound should be applied to the concrete using squeegees, push brooms, paint rollers (figure 72) or low pressure airless spray equipment. Adjacent glass, metal, and painted surfaces must be protected from the sealing compound. Overspray protection must be provided if spray application equipment is utilized. Fine spray mists can travel extensively and damage downwind structures, equipment, and automobiles.

The application rate should be 1 gallon per 80 to 120 square feet of concrete surface. Horizontal and vertical surfaces should receive two wet to wet coatings, 5 or so minutes apart, flooding the surface each time. Excess sealant should be broomed out until it is absorbed by the concrete. Low density areas of the concrete surface need the most protection, and these areas are the most absorptive.

(d) Curing.—Siloxane treated concrete must be protected from foot and vehicular traffic and water wetting for 24 hours following application. Should the concrete experience rain or heavy water splashing during this period, the drying step of preparation should be repeated and reapplication made.

(e) Safety.—Siloxane sealing compounds are formulated with organic solvents such as alcohol or mineral spirits. Materials Safety Data Sheets should be consulted concerning flammability and toxicity. Applicators should wear protective coveralls, rubber boots, eye protection, and approved respirators.

Chapter V

Nonstandard Methods of Repair

39. Use of Nonstandard Repair Methods.— The standard concrete repair methods/ materials discussed in chapter IV will meet nearly all concrete repair needs. There will be occasions, however, resulting from unusual causes of damage and exposure conditions or special repair needs, when the standard repair methods may not meet the performance needs. In these infrequent instances, non-standard repair methods may be required.

Repair materials are considered to be non-standard if they have not been thoroughly tested and evaluated for Reclamation applications. The use of such materials involves a certain element of risk because the performance properties of these materials are unknown or not fully defined. The application of nonstandard materials can be justified only when it has been determined that no standard repair material will serve, and if all parties associated with or responsible for accomplishing the repairs are made to understand the risks and agree to accept the uncertainties and possible consequences.

An example of such a situation would be the need to repair concrete damage on the crest of a dam that is less than 1-1/2 inches deep. There is no standard repair material suitable for such shallow repairs when exposed to sunlight temperature variation conditions. (These conditions eliminate the use of epoxy mortars.) The current standard repair material for depths between 1-1/2 inches and 6 inches is epoxy-bonded replacement concrete. If the deterioration is not at least 1-1/2 inches deep, sufficient concrete must be removed to accomplish a 1-1/2- inch depth. If, for some reason, it was undesirable or impossible to remove the required depth of concrete, it might be appropriate to select one of the proprietary thin repair products. These materials have been only partially evaluated (Smoak and Husbands, 1996) and the long- term field performance has not yet been fully determined. In this example, the people responsible for the dam must be contacted, and the risks of using an unproven repair material must be made known to them. These responsible personnel, with this knowledge, can then determine if the benefits of performing the shallower repairs would outweigh the uncertainties associated with unproven performance.

(a) Preparation.—Concrete preparation for repair with nonstandard materials should be in accordance with section 8 unless required otherwise by the materials manufacturer. The recommendations of the manufacturer should be closely followed.

(b) Materials.—Nonstandard repair materials will be proprietary or commercial products in most instances. Manufacturer's technical representatives should be contacted and made fully aware of the nature of the problem and the causes for selecting nonstandard repair materials. They must be informed of any secondary considerations, such as the need to accomplish repairs on an emergency basis or the inability of taking the structure to be repaired out of service except at certain times. Copies of materials warranties should be obtained if available. Technical representatives should be questioned closely about the conditions under which their materials *would not be suitable* for use or when the materials *warranties would not apply*. The manufacturer should be able to supply case studies or project histories of use of their materials to repair similar damage.

(c) Application.—Application of nonstandard repair materials must be made in exact conformance to the manufacturer's recommendations. Failure to apply the

materials properly will void any warranties and is a commonly cited reason for proprietary material failure. Construction inspection reports should closely note any contractor variance from the manufacturer's recommended application procedures.

(d) Curing.—Curing of nonstandard repair materials must be performed exactly as recommended by the materials manufacturer.

(e) Safety.—Nonstandard repair materials could contain compounds not commonly encountered during repair construction. Copies of the Materials Safety Data Sheets must accompany the shipment of materials to the jobsite. They should be consulted and appropriate safety provisions developed.

Appendix A

Standard Specifications for the Repair of Concrete
M-47, 08-96

M-47

(M0470000.896)

STANDARD SPECIFICATIONS

FOR

REPAIR OF CONCRETE

August 1996

United States
Department of the Interior
Bureau of Reclamation
Technical Service Center
Denver Federal Center
Denver, Colorado 80225-0007

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HOW TO USE THIS MANUAL

This manual is divided into 3 sections. The general requirements contained in section 1 and the concrete preparation requirements contained in section 2 always apply to each and every Reclamation concrete repair project. Section 3 consists of a number of paragraphs containing the special requirements of the various repair materials and techniques. Once a repair material/technique has been properly selected from section 3 (see "Step 4. Choose An Appropriate System" below) it should be sufficient in preparing a job specific specification to simply require that the repairs be performed in accordance with the provisions of section 1, section 2, and section 3.X of this manual.
Assistance in using this manual or with any other phase of concrete repair of Reclamation structures can be obtained by contacting:

Glenn Smoak or Kurt von Fay
Materials Engineering and Research Laboratory
Code D-8180
Technical Service Center
P.O. Box 25007
Denver, Co 80225
phone 303-236-3730.

The standard concrete repair materials and techniques described in this manual have been developed and evaluated by the Bureau of Reclamation over a period of some 90 years. Unfortunately, during this time many repair failures have occurred on Reclamation concrete structures even though very durable repair materials were specified and used. In evaluating the causes of these failures it has been learned that it is essential to consistently use a systematic approach to repairing concrete. Many such such repair systems exist and this manual will not attempt to discuss or evaluate which of these systems is best for any set of field conditions. Rather, the following repair system has been used by Reclamation over a long period of time and has been found to result in successful concrete repairs. This system, known as "The Seven Steps of Concrete Repair", is suitable for repairing both construction defects in new concrete as well as old concrete damaged by long exposure to field conditions. In using this system it is necessary to take the steps in numerical order. Quite often the first questions asked when damaged concrete is detected is "What should be used to repair this?" or "How much will the repair cost?". These are not wrong questions. Rather they are asked at the wrong time. With a systematic approach these questions are asked only when sufficient information is available to provide correct answers.

The Seven Steps of Concrete Repair

1. Determine the cause of damage
2. Evaluate the extent of damage
3. Determine the need to repair
4. Choose an appropriate repair system
5. Prepare the old concrete
6. Apply the repair system

7. Cure the repair properly

Step 1. Determine the cause of damage - It is essential to correctly determine the causes(s) of the damage to the concrete. If this is not done, or if the determination is incorrect, the cause of damage will most likely attack and deteriorate the repair. The money spent for such repairs is, thus, totally lost and larger replacement repairs become necessary at much higher cost.

Step 2. Evaluate the extent of damage - The objective of this step is to determine how much of the structure is damaged and how extensive the damage is.

Step 3. Determine the need to repair - Not all damage to concrete requires repair. Repairs should be undertaken only if they will result in longer or more economical service life, a safer structure, or necessary cosmetic improvements in the structure. This step also includes determination of when the structure can be taken out of service for repairs, an estimate of how long the repairs will take, and how to budget the costs of the repairs.

These first 3 steps are the major components of a condition survey. Only after they have properly been performed should one proceed with selecting and installing the repair materials.

Step 4. Choose an appropriate repair system - Upon completion of the first 3 steps, an appropriate repair system can be selected that takes into consideration the many factors essential to a successful repair. In a majority of the repair situations, the standard materials and methods in this specification will fully meet all repair needs. It should be recognized, however, that service conditions or special repair situations will occur where these "standard materials" will not meet the special requirements and it will be necessary to resort to "non-standard" repair materials or methods. Such materials are continually being tested and evaluated by Reclamation laboratory and field offices. They include materials that may have performed quite well in laboratory tests but have not yet been applied in the field, materials not yet having long or sufficient field service to determine service life expectancy, or newly developed commercial materials not yet tested or evaluated by Reclamation. It is appropriate to use such repair materials and techniques only when it has been determined that none of the standard repair materials will properly serve, and when it is fully understood and agreed by all involved parties that the risks associated with the use of unproven materials are justified by the expected benefits of repair success and are acceptable.

Step 5. Prepare the old concrete - The most common cause of repair failure is improper or inadequate preparation of the old concrete prior to application of the repair material. Even the best of repair materials will give poor service life if bonded to weakened or deteriorated old concrete. The provisions of section 2 of this manual provide only the minimum preparation requirements. It should be noted that each of the standard repair materials has special preparation requirements and that these requirements are listed under paragraphs f of section 3. That is, for example, the special preparation requirements for replacement concrete will be listed under paragraphs 3.6.f while those of epoxy bonded concrete will be listed under paragraphs 3.8.f.

Step 6. Apply the repair system - Each standard and non-standard repair material has application procedures specific for that material. For

example, the procedures used with replacement concrete are vastly different from those necessary for polymer concrete or epoxy bonded concrete. It is essential that proper application techniques as listed in the section 3 paragraphs g for each material be followed exactly.

Step 7. Cure the repair properly - The second most common cause of repair failures is improper or inadequate curing. Each repair material has specific curing requirements. As an example, replacement concrete benefits from long periods of water curing while latex modified concrete, currently a non-standard material, requires 24 hours water curing followed by drying to allow formation of the latex film. Polymer concrete has essentially no curing requirements while those of silica fume concrete are are exceedingly exact. Failure to achieve proper cure for the proper duration, as listed in section 3 paragraphs f, will result in loss of the repair at the final step of the process.

SECTION 1 - GENERAL REQUIREMENTS

1.1 GENERAL

Concrete that is damaged from any cause; structural concrete that has cracked; concrete that is honeycombed, fractured, or otherwise defective; and concrete that, because of excessive surface depressions, must be excavated and built up to bring the surfaces to the prescribed lines, shall be repaired or replaced in accordance with these specifications and contract requirements.

The method of repair or replacement (procedure) shall be as determined and directed by the Contracting Officer.

Contract, as used herein, shall mean the contract which, by reference, these specifications are included in and made a part. Contracting Officer, as used herein, shall mean the person executing the contract on behalf of the Government, and shall include duly authorized representatives. Contractor, as used herein, shall mean the party entering into the contract with the Government, and shall include subcontractors, suppliers, manufacturers, and agents at all tiers.

1.2 DESIGNS

Concrete mixture proportions, compressive strengths, and other design requirements shall be as specified in these specifications. Designs by the Contractor shall be subject to the approval of the Contracting Officer.

1.3 SUBMITTALS

Submittals shall be in accordance with these specifications and the contract requirements entitled "Submittal Requirements." The Contractor shall submit MSDS (Material Safety Data Sheets), approval drawings and data, repair plans, certifications, material samples, test data and samples, and other submittals as required in these specifications. The Contractor shall be responsible for the accuracy of all submittals.

Unless specified otherwise submittals shall include the original and 2 copies.

1.4 QUALITY ASSURANCE

Quality assurance shall be in accordance with the requirements of the contract entitled "Quality Assurance," and with the requirements of these specifications.

All concrete shall be repaired as necessary to produce surfaces conforming to the specified tolerances and finish requirements of the contract in which these specifications are incorporated by reference and as outlined in section 3.

If, in the opinion of the Contracting Officer, the results of concrete repair indicate that proper quality control procedures are not being consistently utilized, further repair work may be suspended in whole or in part at the discretion of the Contracting Officer. Such suspension will be effective until the Contractor demonstrates substantial improvement in quality control procedures and repair results.

a. Contractor's quality control. - In accordance with the clause in the contract entitled "Inspection of Construction," the Contractor shall be responsible for providing quality control measures to ensure compliance of the repair with these specifications. The Contractor shall implement necessary and appropriate quality control procedures to ensure that all concrete repairs conform to the requirements of these specifications.

b. Government inspection and tests. - Government inspection and tests will be in accordance with the clause in the contract entitled "Inspection of Construction," and with these specifications.

Not less than 24 hours in advance of any concrete repair, the Contractor shall inform the Contracting Officer when the concrete repairs will be performed and, unless inspection is specifically waived, the repairs shall be performed only in the presence of an authorized representative of the Contracting Officer.

c. Testing. - Except as specified in paragraphs 3.5 and 3.12 of the specifications the Contractor shall perform all tests. The Contractor shall provide all materials, equipment, and labor necessary for performing the tests at no additional cost to the Government.

d. Approval. - Approval of the repairs will be based on the inspection and testing requirements of these specifications.

e. Rejection. - Repairs that fail to meet the requirements of these specifications will be rejected.

1.5 MATERIALS AND WORKMANSHIP

a. Materials. - The Contractor shall furnish all materials for repair or maintenance of concrete and shall furnish all materials for forming, curing, and protection of the repairs, as required. All materials shall meet materials specifications as specified in section 3, and all equipment used and methods of operation for the repair or maintenance of concrete shall be subject to approval of the Contracting Officer.

The references to materials in the specifications, wherein manufacturer's products or brands are specified by "brand name or equal" purchase descriptions, are made as standards of comparison only as to type, design, character, or quality of the article required, and do not restrict the Contractor to the manufacturer's products or to the specific brands named. It shall be the responsibility of the Contractor to prove equality of materials and products to those referenced and to provide all descriptive information, test results, and other evidence as may be necessary to prove the equality of materials or products which the Contractor offers as being equal to those referenced.

b. Workmanship. - Concrete shall be repaired by skilled workmen as outlined in section 3.

1.6 SAFETY

All work shall be performed in accordance with the applicable safety and health standards, the requirements of Reclamation's "Health and Safety Standards," the contract, and these specifications. Certain additional safety precautions shall be employed to prevent skin and eye contact with chemicals, resins, or monomeric materials. Protective glasses and clothing, including rubber or plastic gloves shall be worn by all persons handling monomeric materials. All exposed skin areas shall be protected with a protective barrier cream formulated for that purpose. Barrier cream for skin protection shall be specified for the materials used and approved by a physician. Adequate ventilation shall be provided and maintained at all times during use of monomeric materials and solvents. Fans used for ventilating shall be explosion proof. If necessary, respirators that filter organic fumes and mists shall be worn. All contaminated materials such as wipes, empty containers, and waste material shall be continually deposited in containers that are protected from spillage. Spillage shall be immediately and thoroughly cleaned up and disposed of in accordance with applicable regulations.

Federal Standard No. 313, as amended, for the preparation and submission of material safety data sheets is hereby incorporated and made a part of these specifications.

In accordance with the clause in the contract entitled "Hazardous Material Identification and Material Safety Data," the Contractor shall submit a completed MSDS (Material Safety Data Sheet), Department of Labor Form OSHA-174, or GSA-approved Alternate Form A for each hazardous material as required by Federal Standard No. 313, as amended. The information in this MSDS shall be followed to assure safe use, handling, storage, and an environmentally acceptable disposal of the commodity used on the job site.

The Contractor shall submit to the Contracting Officer, not less than 30 days prior to job site delivery of each hazardous material, completed MSDS and identification and certification for the material.

1.7 REPAIR PROCEDURES

All repair or maintenance procedures shall be performed in accordance with the applicable specifications of section 3, including surface preparation, forming, finishing, and curing.

SECTION 2 - CONCRETE PREPARATION FOR REPAIR

Concrete to be repaired shall be prepared in accordance with the requirements of this paragraph and with the special requirements of section 3.

2.1 REMOVAL AND CLEANING

All damaged, deteriorated, loosened, or unbonded portions of existing concrete shall first be removed by water blasting, bush hammering, jack hammering, or any other approved method, with approved equipment, after which the surfaces of existing concrete shall be prepared by contained shotblasting, wet sandblasting, or water blasting to remove any microfractured surfaces resulting from the initial removal process. The surfaces shall then be cleaned and allowed to dry thoroughly, unless the specific repair technique requires application of materials to a saturated surface. Concrete removal processes involving the use of jack hammers in excess of 30 pounds, dry sandblasting, or scrabblers shall not be used without approval by the Contracting Officer. The use of acids for cleaning or preparing concrete surfaces for repair will not be permitted.

2.2 SAW CUT EDGES

The perimeters of repairs to concrete that involve concrete removal and subsequent materials replacement shall be saw cut perpendicular to the repair surface to a minimum depth of 1 inch. Featheredge repairs to concrete shall not be used.

2.3 REINFORCING STEEL

All loose scale, rust, corrosion by products, or concrete shall be removed from exposed reinforcing steel. Reinforcing steel exposed for more than one-third of its perimeter circumference shall be completely exposed to provide 1-inch minimum clearance between the steel and the concrete. Damaged or deteriorated reinforcing steel shall be removed and replaced as directed by the Contracting Officer.

2.4 MAINTENANCE OF PREPARED SURFACES

After the concrete has been prepared and cleaned, it shall be kept in a clean, dry condition until the repair has been completed. Any contamination, including oil, solvent, dirt accumulation, or foreign material shall be removed by additional wet sandblasting and air-water jet cleanup followed by drying.

SECTION 3 - SPECIFICATIONS FOR REPAIRING CONCRETE

3.1 SURFACE GRINDING

Where bulges, offsets, and other irregularities exceed the specified tolerances, the protrusions shall be repaired so that the surfaces are within the specified limits. Surface grinding techniques may be used for this purpose subject to the following limitations:

a. Grinding of surfaces subject to cavitation erosion (hydraulic surfaces subject to flow velocities exceeding 40 feet per second) shall be limited in depth so that no aggregate particles are exposed more than 1/16 inch in cross section at the finished surface.

b. Grinding of surfaces exposed to public view shall be limited in depth so that no aggregate particles are exposed more than 1/4 inch in cross section at the finished surface.

c. Grinding of all other surfaces shall be as directed by the Contracting Officer. In no event shall surface grinding result in exposure of more than one-half the diameter of the maximum-size aggregate.

d. Where surface grinding has caused or will cause exposure of aggregate particles greater than the limits of subparagraph 3.1.a. or b., the concrete shall be repaired by excavating and replacing the concrete in accordance with paragraph 3.6 or 3.8. as directed by the Contracting Officer.

3.2 PORTLAND CEMENT MORTAR

a. General. - Repairs with portland cement mortar shall be made only if specifically approved by the Contracting Officer. Approval for hand-applied cement mortar repairs will be given only for very small repair areas not associated with critical performance of the structure. When approved, portland cement mortar may be used for repairing defects on exposed, new concrete surfaces if the defects are small and are too wide for dry pack and too shallow for concrete replacement and only if the repairs can be completed within 24 hours of removing the forms. Portland cement mortar shall not be used for repairs to old or existing concrete or for repairs that extend to or below the first layer of reinforcing steel.

b. Submittals. - Before beginning any repair work, the Contractor shall submit a detailed list of the equipment, procedures, and materials the Contractor proposes to use for cement mortar repair to the Contracting Officer for approval.

c. Quality assurance. - Quality assurance shall be in accordance with paragraph 1.4.

d. Materials. - Portland cement mortar shall consist of type I or type II portland cement, clean water, and clean, well-graded sand passing a 1.18-mm (No. 16) sieve. All mortar materials, including curing compound shall meet the requirements of subparagraph 3.6.d.

e. Safety. - All work shall be performed in accordance with the requirements of paragraph 1.6.

f. Concrete preparation. - After damaged or defective concrete has been removed as specified in section 2, the surface on which mortar is to be placed shall be prepared by being thoroughly cleaned of all micro fractured, loose, or deteriorated materials and surface-dried.

g. Application and Mixture Proportioning. - Portland cement mortar shall be composed of portland cement, sand, and water, all well mixed and brought to proper consistency. Mortar mixtures and application techniques shall be in accordance with the requirements for mortar replacement method as described in Reclamation's "Concrete Manual", Eighth Edition, revised, chapter VII. Cement mortar shall not be applied until approval of all submittals has been received from the Contracting Officer.

h. Curing. - All cement mortar repairs shall be water cured for 7 days following application. At no time during this initial curing period shall the mortar be allowed to dry. If drying occurs, the repair shall be removed and replaced. If the repair is removed and the original concrete is older than the maximum specified in subparagraph 3.2.a., another repair method shall be used in accordance with these specifications. Following the 7-day curing period and while the repair is still saturated, the surface of the repair shall receive two coats of wax-base (type I) or water-emulsified resin base (type II) curing compound meeting the requirements of subparagraph 3.6.d.

3.3 DRY PACK AND EPOXY BONDED DRY PACK

a. General. - The dry pack concrete repair technique shall be limited to areas that are small in width and relatively deep, such as core holes, holes left by the removal of form ties, cone-bolt and she-bolt holes, and narrow slots cut for repair of cracks. Epoxy bonded dry pack shall be used for critical repairs or for repairs expected to be exposed to severe service conditions. Dry pack shall not be used for shallow depressions where lateral restraint cannot be obtained, nor for filling behind steel reinforcement.

b. Submittals. - Before beginning any repair work, the Contractor shall submit to the Contracting Officer for approval, data for the mortar materials and as provided by paragraph 3.8.b.(2).

c. Quality assurance. - Quality assurance shall be in accordance with paragraph 1.4.

d. Materials. - Dry pack mortar shall consist of type I or II portland cement, clean sand that will pass a 1.18-mm (No. 16) sieve, and clean water. All dry pack materials, including curing compound, shall meet the requirements of subparagraph 3.6.d. Epoxy bonding resin shall meet the requirements of paragraph 3.8.d.(2).

e. Safety. - All work shall be performed in accordance with the requirements of paragraph 1.6.

f. Concrete preparation. - Holes for dry pack shall have a minimum depth of 1 inch and shall be square at the surface edge. A careful inspection shall be made to ensure that the hole is thoroughly clean and is in sound concrete. The interior surfaces of the hole shall be presoaked prior to application of the dry pack. If epoxy bonded dry pack is to be used presoaking the repair area prior to application of the dry pack shall not be performed.

g. Application. - A mortar bond coat or epoxy resin bond coat shall be applied to the concrete hole surface prior to placing dry pack. The mortar bond coat shall consist of 1 part portland cement to 1 part sand mixed with water to give a fluid paste consistency. The mortar bond coat shall be thoroughly brushed onto the hole surfaces. The epoxy resin bond

coat shall consist of materials and be applied in accordance with the provisions of paragraph 3.8.g.(3). Dry pack mortar shall consist of 1 part portland cement to 2.5 parts sand (by weight) and shall be mixed with just enough water so that the mortar will stick together when molded by hand and not exude water when squeezed.

The dry-pack mortar shall be immediately packed into place in 3/8-inch compacted layers before the bond coat has dried or cured.

Each layer shall be compacted over the entire surface by tamping with a hardwood dowel and hammer. Hardwood dowels are used in preference to metal bars because the bars tend to polish the surface of each layer. The final layer shall be finished immediately after compaction by laying the flat side of a hardwood board against the fill and striking the board firmly with a hammer.

h. Curing. - Proper curing is essential for a successful dry-pack repair. The surface of the repair area shall be protected from drying and shall be kept continuously moist for 7 days. The surface of the repair shall be protected from surface drying by using burlap kept wet, wet sand, or plastic sheeting over a water soaker hose, or other methods approved by the Contracting Officer. After 7 days and while the surface is still damp, two coats of curing compound shall be applied to prevent moisture loss. The dry-pack repair area shall not be exposed to freezing temperatures for 3 days after application of the curing compound.

3.4 PREPLACED AGGREGATE CONCRETE

a. General. -

(1) Preplaced aggregate concrete (PAC) is concrete that has been made by forcing a grout into the voids of a mass of clean, graded, coarse aggregate. As a repair method, PAC is used where placing conventional concrete is extremely difficult, such as in underwater repairs, concrete and masonry repairs, or where shrinkage of concrete must be kept to a minimum. In underwater repairs, injection of grout at the bottom of the PAC displaces water, leaving a homogeneous mass of concrete with a minimum of paste washout.

For the purpose of this repair method, grout is defined as a mixture of water, cementitious materials, sand, and admixtures.

(2) Reference standards and specifications for PAC. - Reference standards and specifications for materials, testing, and proportioning PAC shall be the standards listed below. Standards and specifications for testing concrete and concrete materials shall be in accordance with applicable ASTM and ACI standards.

(a) ASTM C 937 - Standard Specification for Grout Fluidifier for Preplaced-Aggregate Concrete.

(b) ASTM C 938 - Standard Practice for Proportioning Grout Mixtures for Preplaced-Aggregate Concrete.

(c) ASTM C 939 - Standard Test Method for Flow of Grout for Preplaced-Aggregate Concrete (Flow Cone Method).

(d) ASTM C 940 - Standard Test Method for Expansion and Bleeding of Freshly Mixed Grouts for Preplaced-Aggregate Concrete in the Laboratory.

(e) ASTM C 941 - Standard Test Method for Water Retentivity of Grout Mixtures for Preplaced-Aggregate Concrete in the Laboratory.

(f) ASTM C 942 - Standard Test Method for Compressive Strength of Grouts for Preplaced-Aggregate Concrete in the Laboratory.

(g) ASTM C 943 - Standard Practice for Making Test Cylinders and Prisms for Determining Strength and Density of Preplaced-Aggregate Concrete in the Laboratory.

(h) ASTM C 953 - Standard Test Method for Time of Setting of Grouts for Preplaced-Aggregate Concrete in the Laboratory.

(i) American Concrete Institute Standard (ACI-304), Recommended Practice for Measuring, Mixing, Transporting, and Placing Concrete.

b. Submittals. -

(1) At least 60 days prior to beginning repair work, the Contractor shall submit for approval a repair plan for PAC construction. The repair plan shall include detailed drawings of formwork construction, the grout injection system including sequence of injecting grout into insert pipes, location and spacing of injection tubes, sounding wells, and pipes; a description of all equipment including pumps, sizes and diameters of pipes, hoses, and connections; the planned operating procedures and pumping rates for grout; methods of placing coarse aggregate; methods of consolidating aggregates and PAC during grouting; and communication facilities between the grout mixing and pumping plant and PAC placement.

The proportions of grout mixtures and fresh properties of grout shall be submitted with the repair plan. Included with the grout proportions, shall be the voids content and compacted density of aggregates before injection of grout, the density of hardened PAC, and the compressive strengths of PAC at 7 and 28 days' age.

(2) The Contractor shall submit for approval to the Contracting Officer's representative a proposed specific operating procedure including a hazard analysis for all preplaced aggregate concreting and grout injecting operations. The specific operating procedure shall include such things as engineering controls, protective clothing, eye protection, respiratory protection, and air sampling as necessary to check the effectiveness of the control program.

(3) Pump rating curves and complete mixer details, including photographs or drawings of the proposed mixing equipment, shall be submitted to the Contracting Officer for approval 30 days prior to use. The Contracting Officer shall have the right to require the Contractor to make changes in the equipment which the Contracting Officer determines necessary to make the equipment perform satisfactorily during the grouting operations without additional cost to the Government

(4) The Contractor shall submit test results from testing of cylinders in accordance with the requirements of subparagraph c. below.

c. Quality assurance. - Quality assurance shall be in accordance with paragraph 1.4 and these specifications. Unless otherwise directed, grout mixtures shall be proportioned in accordance with ASTM C 938.

For normal structural work, the ratio of cementitious materials (cement plus pozzolan) to sand shall be 1:1. If leaner mixes are required (generally for low heat generation), the ratio may be adjusted, but shall not exceed 1:2.

The ratio of cement to pozzolan, by weight, shall be between 2:1 and 4:1 as directed by the Contracting Officer.

The ratio of water to cementitious materials

$$\frac{W}{P+C}$$

where:
W = weight of water
P = weight of pozzolan
C = weight of concrete

shall not exceed 0.50 by weight. For severe exposure conditions, the W/P+C ratio shall be in accordance with Reclamation's "Concrete Manual," Eighth Edition, revised, chapter III, table 15.

The pumpability of grout containing fine sand (grading 1, table 2 of ASTM C 637) shall be controlled by the consistency test using the flow cone in accordance with ASTM C 939. The flow time shall be between 20 and 30 seconds unless it can be demonstrated that grout can be effectively pumped at a different flow time.

Compressive strength cylinders shall be cast in accordance with ASTM C 943 and tested at 7 and 28 days' age with a minimum of two cylinders tested for each age. The design compressive strength of PAC shall be 4,000 pounds per square inch at 28 days' age. The required average strength for PAC is that which will ensure that 80 percent of all test cylinders exceed the design strength.

The quality of the top of formed PAC placements shall be ensured by venting air, water, and low-quality grout from the uppermost location in the placement.

For unformed surfaces where a screeded or troweled finish is required, the grout level shall flood the top surface above any aggregate, and any diluted grout shall be removed by brooming. A thin layer of pea gravel having a maximum-size aggregate (MSA) of 3/8 inch shall be worked into the surface by raking and tamping or internal vibration. The surface shall be finished in accordance with conventional concrete procedures to resemble the finish of the surrounding concrete. Care shall be taken when topping off the unformed surface to avoid lifting or loosening of the surface aggregate.

d. Materials. - Materials for PAC shall be in accordance with the requirements of ASTM C 938 and the following additional requirements:

(1) Pozzolan. - Pozzolan shall meet the requirements of ASTM C 618 for class F pozzolan.

(2) Admixtures. -

(a) Air-entraining admixture. - Air-entraining admixture (AEA) shall meet the requirements of ASTM C 260.

The amount of AEA used for injecting mortar shall be that amount necessary to effect a total air content in the mortar, prior to injection, of 9 percent, plus or minus 1 percent, by volume of mortar.

(b) Grout fluidifier. - Grout fluidifier shall meet the requirements of ASTM C 937.

(c) Chemical admixtures. - Chemical admixtures, if permitted, shall meet the requirements of ASTM C 494 for types A, D, F, or G admixtures. Chemical admixtures shall not be used without prior approval from the Contracting Officer.

(3) Sand. - Sand shall consist of natural particles which may be supplemented by limited quantities of crushed sand to make up for deficiencies in the natural materials. Natural sand is required due to its favorable particle shape for pumping grout. Sand for PAC differs from sand used for conventional concrete, primarily in its finer grading.

Sand shall meet the quality requirements of subparagraph 3.6.d.; and the grading requirements of ASTM C 938.

(4) Coarse aggregate . - Coarse aggregate shall be clean and well-graded. Unless otherwise directed, the MSA shall be 1-1/2 inches, and after compaction in the forms, shall have a voids content from 35 to 45 percent.

Coarse aggregate shall meet the quality requirements of subparagraph 3.6.d.; and, the grading requirements of ASTM C 637, table 2, grading 1 for coarse aggregate.

For larger placements, the largest size aggregate that can economically be placed shall be used. The MSA and grading of coarse aggregate for these placements should follow the guidelines of ACI 304.

e. Safety. - All work shall be performed in accordance with requirements of paragraph 1.6 and these specifications.

The Contractor shall comply with Reclamation's "Construction Safety Standards" as well as all other applicable safety and health standards and regulations. In the event of conflict, the more stringent standard shall apply.

f. Concrete preparation. - The Contractor shall prepare all concrete surfaces and foundations for PAC application. Concrete surface preparation shall be in accordance with subparagraph 3.6.f.

For underwater repairs, high-pressure water jetting shall be the normal method for concrete removal and surface scarification. Low-pressure water jetting will be allowed for cleanup immediately before placing PAC.

In underwater construction where contamination is known or suspected to exist, the water shall be sampled and tested to determine the degree of contamination and its possible influence on the quality of concrete. Where moderate contamination is present, concrete surfaces shall be cleaned within 2 days prior to placing aggregate and grouting. If contaminants are present in such quantity or are of such character that

harmful effects cannot be eliminated or controlled, preplaced aggregate concrete shall not be used.

All loose, fine material shall be removed from the placement insofar as possible before placement of coarse aggregate to prevent subsequent coating of the aggregate or filling of voids.

g. Application. -

(1) General. - Application of PAC shall include construction and placement of formwork and the grout injection system, placement of aggregate, injection of grout, finishing, and curing of PAC.

(2) Equipment. - The grout mixing, pumping, and injection system shall be furnished by the Contractor.

The grout injection system shall be designed to deliver and inject grout into the preplaced aggregate, to provide a means for determining the grout elevations within the aggregate mass, and to provide vents in enclosed forms for water and air to escape. The injection system shall have a bypass for returning grout to an agitating tank.

Pumps shall be of a positive displacement type and be equipped with a pressure gauge on the outlet line to indicate any incipient line blockage. At least one extra pump shall be on standby to maintain continuous pumping operations. The pumps shall have quick-disconnecting fittings to the grout supply line.

Mixing and agitating equipment shall be sized to maintain a continuous, uninterrupted flow of grouting mortar for the duration of the PAC placement. The mixing plant shall be a high-speed centrifugal type and shall be equipped with an accurate water meter, reading cubic feet to tenths of a cubic foot. In addition to the grout mixer, a holdover mechanical agitator tank of similar volume as the mixer shall be provided. Suitable provisions shall be made for passing the grout through a U.S. Standard 2.36-mm (No. 8) sieve as it is discharged from the mixer.

The batching and mixing plant equipment shall accurately measure the amounts of cement, pozzolan, sand, admixtures, and water batched for grout. Inaccuracies in feeding and measuring during operation shall not exceed by individual weight plus or minus 1 percent for water; plus or minus 2 percent for cement, pozzolan, or sand; and plus or minus 3 percent for admixtures.

The length of delivery line shall be kept to a practicable minimum. Pipe sizes shall be designed so that during operation, the grout velocity ranges between 2 and 4 feet per second for delivery lines up to 300 feet, or at a pumping rate of about 1 cubic foot of grout per minute through a 1-inch-diameter pipe. Pipe sizes shall be approximately 1 inch in diameter, but may need to be increased in size for delivery lines longer than 300 feet to reduce pressures.

Grout insert pipes shall have a diameter of 3/4 to 1 inch and shall be placed vertically, horizontally, or at angles to inject grout at the proper location. Grout insert pipes shall be in sections about 5-1/2 feet in length for ease of withdrawal. For depths greater than 15 feet, grout insert pipes shall be flushed coupled. For depths less than 15 feet, standard pipe couplings may be used.

Connections between grout delivery lines and insert pipes shall have quick-disconnect fittings. Quick-disconnect fittings which reduce the cross section of the flow area shall not be used. Each insert pipe, or the end of the delivery line where it attaches to the insert pipe, shall be equipped with an individual valve to control or stop the flow of grout. Valves shall be of a quick-opening, plug type which can readily be cleaned.

For vertical and angled injection tube placements, sounding wells shall be used to determine the level of grout in the placement. Sounding wells shall consist of slotted pipe with a diameter of about 2 inches. A 1-inch-diameter float, weighted so that it will float on grout and sink in water (for underwater placements), shall be attached to a sounding line and float freely in the sounding well.

(3) Formwork. - Forms for PAC may be of wood, steel, or other materials suitable for conventional concrete. Wood forms or other materials which may swell or become damaged by submergence in water shall not be used for underwater repairs.

Joints and any entry holes for bolts, reinforcement, injection ports, vents, or injection wells shall be caulked to eliminate grout leakage.

Forms shall be designed to resist the lateral pressure exerted by aggregates during and after placing, and to resist full hydraulic pressure of the concrete throughout placing until initial setting has begun.

Form vibrators for consolidation shall be mounted so that vibration does not loosen bolts and joints which may lead to grout leakage or failure. Form vibrators shall be mounted on ribs or stiffeners attached to the sheathing to effectively transmit vibration to the concrete.

All forms shall be coated with a suitable bond breaker for ease of removal without damaging concrete. For underwater repairs, the bond breaker shall be selected so that it does not wash off the forms during submergence. Formwork, injection tubing, inspection wells, and other equipment shall be protected from damage by aggregates during placing.

Reinforcing steel shall be installed during construction of formwork and securely held in place during placement of aggregate and injection of grout.

(4) Grout pipe system. - The grout pipe system shall be furnished by the Contractor and shall consist of a series of regularly spaced injection tubes with outlets beginning at the bottom and continuing to the top of the compacted aggregates. Observation wells shall be spaced at regular intervals between the injection tubes. Vent pipes shall be used in forms that contain restricted or irregular spaces where water or air may be entrapped by the rising grout surface, such as blockouts or embedment work.

The grout pipe system shall be designed to inject grout beginning at the lowest point in the PAC placement and continue to raise the grout level within the mass by selectively withdrawing the pipes and switching to other pipes to maintain the grout at a gently sloping to nearly horizontal level. The grout pipe system shall be coded to

clearly identify the location of the outlet of the pipe supplying grout and the order of supplying grout to the pipes.

The spacing of grout insert pipes shall be between 4 and 12 feet and should average approximately 6 feet. The outlet of grout insert pipes shall begin not more than 6 inches above the bottom of the aggregate mass. Rows of horizontal pipes should be not more than 6 inches above the next lower row of pipes.

As a guide for layout of insert pipes, it can be assumed that the grout surface will have a 1:4 (vertical to horizontal) slope in the dry and a l:6 slope under water.

For vertical and inclined injection systems, sounding wells shall be spaced to observe the level of grout. The ratio of number of sounding wells to insert pipes shall be between 1:4 and not less than 1:10. Sounding wells shall be placed vertically or near vertically.

The delivery line shall consist of a single pipeline extending from the pump to the insert pipe equipped with a valve, or to a wye branching to two insert pipes equipped with valves at the beginning of the wye and at both outlets. A manifold system in which more than one grout insert is operative at the same time shall not be used.

(5) Aggregate preparation and placement. - Coarse aggregate shall be washed and screened immediately before placing in the forms. If more than one size of coarse aggregate is used, the aggregate shall be batched and mixed in the proper proportions or discharged at proportional rates onto a vibrating deck or revolving wash screens.

Coarse aggregate shall be transported to the forms by buckets, conveyors, or other approved methods. Coarse aggregates shall be dumped as close as possible to their final location. A flexible rubber elephant trunk (tremie) shall be used to limit free fall to less than 5 feet to minimize segregation and breakage of aggregate. For large placements, a gated pipe with a diameter at least four times the MSA shall be used. The pipe shall be gradually filled and lowered toward the point of placement, and after the pipe is completely filled at the upper end, aggregate shall be discharged from the lower gate. Aggregate shall not be discharged through an unfilled or partially filled pipe.

Coarse aggregate shall be dumped and spread in nearly horizontal lifts, each lift not to exceed 1 foot in height. Around closely spaced embedded items, such as reinforcing steel, conduits, and blockouts, and in more difficult placements where high density and exceptional homogeneity of concrete are desired, the lift height shall be limited to no more than 4 inches and may have to be placed by hand. Vehicular traffic shall not be permitted on top of preplaced coarse aggregate, with the exception of small skips or loaders and only with approval of the Contracting Officer. This equipment shall have rubber tires and be cleaned of any loose debris or substances that may contaminate aggregates or interfere with grout travel during injection.

Although coarse aggregate shall be completely washed prior to placing it shall not be flushed with water in the forms for the purpose of washing.

If water is used for the purpose of precooling aggregate or to provide lubrication for grout, the water shall be injected through the preplaced grout insert pipes rather than on top of the aggregates.

(6) Grout injection. - Injection shall begin at the lowest insert pipe point within the form and continue to raise the level of grout evenly to the top of the mass of aggregate. The injection process shall raise the level of grout approximately 18 to 24 inches above the outlet of the insert pipe before withdrawing of that pipe begins. Thereafter, the level of grout shall remain a minimum of 12 inches above the outlet of the insert pipe until the injection is completed.

Grouting shall proceed at only one insert pipe at a time. If a wye or manifold system is used, the system shall be equipped with individual valves to control the flow to each insert pipe.

Before the insert pipe is withdrawn, the valve at the pipe inlet shall be shut off. The delivery pipe may then be disconnected to inject at other locations.

When injection insert pipes are placed horizontally, the process shall begin at the lowest insert pipe. Adjacent insert pipes shall have valves opened both alongside and above the pipe being injected. When grout begins to flow out of these pipes, they shall be shut off and grouting continued so that the adjacent pipes are completely submerged. The initial pipe shall then be shut and the process shall be repeated, traveling in a horizontal direction before proceeding to the upper row.

Grout shall not be allowed to set up in the insert pipes between injections. If the injection process is expected to continue for an extended period, a suitable retarding admixture shall be used in the grout. Vertical insert pipes may be rodded to remove grout prior to reinjection; however, insert pipes shall not be cleaned by injecting water through them.

The rate of grout rise and rate of grout injection shall be controlled within the form so that excessive form pressures are not created and so that grout does not cascade within the mass. This is particularly important when grouting under water to avoid sand streaks and honeycombing within the mass.

When grouting around embedded items and particularly under flat surfaces or recessed areas, the grout shall be injected until good quality grout is forced from vent pipes. Good quality grout shall be grout that is not diluted and free from sand, silt, trash, and other items. The rate of flow of grout and grout injection pressures shall be closely monitored in enclosed locations to avoid form failure.

Form vibration shall be used to consolidate grout and remove entrapped air pockets adjacent to form surfaces. Excessive form vibration which causes sand streaking shall not be done. Internal vibration shall not be used for consolidation of the aggregate-grout mixture, but may be used for topping off unformed surfaces.

Unplanned construction joints shall not be used without approval from the Contracting Officer. If a breakdown occurs that stops placement, the grout insert tubes shall be withdrawn, and the grout surface shall be considered a cold joint. Cold joints shall be treated by first removing coarse aggregate down to the joint surface, removing

aggregate and poor-quality mortar, and then cleaning the joint surface by approved methods, taking care not to undercut exposed aggregates.

h. Curing. - Curing and protection of PAC shall be in accordance with subparagraph 3.6.h.

3.5 SHOTCRETE

a. General. - Shotcrete is defined as pneumatically applied concrete or mortar placed directly onto a surface. The shotcrete shall be composed of water, cementitious materials, sand, coarse aggregate, steel fibers (if specified), and admixtures, and shall be placed by either the dry-mix or wet-mix process as specified herein.

The dry-mix process shall consist of thoroughly mixing the solid materials; feeding these materials into a mechanical feeder or gun; carrying the materials by compressed air through a hose to a special nozzle; introducing the water and intimately mixing it with the other ingredients at the nozzle; and then jetting the mixture from the nozzle at high velocity onto the surface to receive the shotcrete.

The wet-mix process shall consist of thoroughly mixing all the ingredients with the exception of the accelerating admixture, if used; feeding the mixture into the delivery equipment; delivering the mixture by positive displacement or compressed air to the nozzle; and then jetting the mixture from the nozzle at high velocity onto the surface to receive the shotcrete.

The equipment used by the Contractor for mixing and applying shotcrete shall be capable of handling and applying shotcrete containing the specified maximum-size coarse aggregate. All equipment, including mixers, hoses, nozzles, nozzle liners, air- and water-pressure gauges, and gaskets, shall be maintained in clean and proper operating condition satisfactory to the Contracting Officer.

b. Submittals. - The Contractor shall submit for approval to the Contracting Officer a proposed specific operating procedure including a hazard analysis for all shotcrete operations. The specific operating procedure shall include such things as engineering controls, protective clothing, eye protection, respiratory protection, and air sampling as necessary to check the effectiveness of the control program.

The Contractor shall submit the specimens extracted from panels fabricated for preapplication testing.

The Contractor shall submit test specimens of fresh and hardened concrete from locations directed by the Contracting Officer.

c. Quality assurance. - Quality assurance shall be in accordance with paragraph 1.4 and these specifications. The Government will perform all testing of fresh and hardened shotcrete. The Contractor shall obtain specimens from locations specified by the Government. The compressive strength of the shotcrete will be determined through the medium of tests of 3- by 3-inch cores or 3-inch cubes. The average compressive strength of specimens taken from a shotcrete application shall be not less than:

(1) Four thousand pounds per square inch at 28 days' age.

(2) Six hundred pounds per square inch at 8 hours' age. This will be determined from 3-inch cubes extracted from test panels.

Adjustments shall be made as directed by the Contracting Officer to obtain shotcrete having suitable impermeability, strength, density, and durability. Suitable strength is that which will ensure that 80 percent of all test specimens exceed or equal the average strength as specified above.

(3) Preapplication testing of shotcrete and nozzlemen. - No shotcrete shall be applied to the work until preapplication testing indicates that the nozzleman is qualified and the proposed shotcrete mixture meets the specified compressive strength. The Contractor shall allow adequate lead time for fabricating of test panels and testing shotcrete specimens. Furthermore, the Contractor is encouraged to fabricate panels for several mixtures since failure of a single mixture to meet specified strength requirements could delay accomplishment of other work.

(a) Shotcrete mixture. - At least 30 days prior to application of shotcrete to the work, the Contractor shall fabricate two test panels for each mixture to be used for vertical and overhead positions of application.

Application of shotcrete to test panels may be accomplished at locations other than the construction site provided:

(aa) Equipment used for fabricating test panels is identical to that to be used in application.

(bb) The materials used in fabricating test panels are from the same sources as those to be used in application and meet all specifications requirements.

(cc) Application is made in the presence of the Contracting Officer by a nozzleman who will later apply the shotcrete to the work.

Test panels shall be fabricated by applying shotcrete in one application not less than 4 inches thick to a panel form made of plywood or other suitable material.

The panel form to be used for vertical and overhead applications shall be either of two types as follows:

(dd) Open ended on at least two sides with 90E edges on enclosed sides. The minimum size of this open-ended panel shall be 18 inches square.

(ee) Enclosed on all four sides with members that taper outward in a manner that prevents the accumulation of rebound at edges and corners while allowing a shotcrete thickness of not less than 4 inches over the entire flat area of the panel. The minimum size of the center flat area of panels enclosed by tapered edges shall be 15 inches square.

Panels should be stiffened and weighted sufficiently to provide rigid surfaces against which the shotcrete can be applied. The panels shall contain the same type of reinforcement as to be used in construction to indicate whether sound shotcrete is obtained without shadowing behind the reinforcement.

After fabrication, the panel shall, except when test specimens are being obtained, be covered and sealed with polyethylene sheeting or shall be cured by any other approved method that will prevent loss of moisture.

The Contractor shall provide all necessary equipment and shall obtain 3-inch cubes from the test panels for testing the compressive strength at 8 hours' age and shall obtain 3-inch cubes or 3-inch-diameter cores from test panels for testing the compressive strength at 28 days' age.

All core drilling and saw cutting of cubes shall be performed in a workmanlike manner by competent and experienced workmen. Test specimens shall be extracted at the latest time, satisfactory to the Contracting Officer, that the specimens can be delivered by the Contractor to the Government for testing at the specified age. At least five specimens shall be obtained from each of the panels for each mixture being verified. Extreme care shall be taken in drilling cores or cutting cubes to obtain specimens satisfactory to the Contracting Officer.

Cores shall be 3 inches in diameter, drilled the full depth of the shotcrete; they shall be straight, sound, of uniform diameter, and of sufficient length for subsequent trimming by the Contractor to produce a right cylinder with an L/D ratio of 1.0 plus or minus 0.03.

Cubes shall be cut full depth of the shotcrete, shall be sound, and shall have six uniform square sides of 3-inch length plus or minus 0.05 inch.

Immediately after extraction, test specimens shall be individually wrapped and sealed in polyethylene bags or covered and sealed by any other approved means to prevent loss of moisture. Each test specimen shall be properly marked for identification.

Each set of test specimens shall be delivered without delay to the project laboratory, or other location approved by the Contracting Officer, for testing at the specified age.

(b) Shotcrete nozzleman. - The nozzleman who applies shotcrete shall be certified with the materials and equipment to be used for the work. Certification shall be in accordance with ACI 506.3R with the following limitations:

(aa) The certification examination will be conducted by authorized representative of the Contracting Officer.

(bb) The examination will consist of an oral test and a field workmanship demonstration test.

(cc) The test panels shall be a minimum of 18 inches square and 4 inches deep. The sides may have beveled edge forms (45E angle out to reduce the entrapment of rebound in the corners).

(dd) Test specimens shall be of the size and shape specified for quality control in these specifications.

d. Materials. -

(1) Portland cement. - The cementitious materials in shotcrete shall comply with subparagraph 3.6.d.(1), with the exception that type III cement may be approved for use if sulfate conditions do not exist.

(2) Water. - Water shall be in accordance with subparagraph 3.6.d.(4).

(3) Sand and coarse aggregate. - Except as hereinafter provided for coarse aggregate grading, the sand and coarse aggregate shall be in accordance with subparagraph 3.6.d.(5).

The maximum-size coarse aggregate shall be no larger than 3/8 inch. No material retained on the 3/8-inch sieve shall be permitted. Only 3 percent significant undersize aggregate material that will pass a 4.75-mm (No. 4) U.S. Standard sieve will be permitted.

(4) Admixtures. - Admixtures shall be in accordance with subparagraph 3.6.d.(3).

(a) Accelerator. - The Contractor may use an accelerating admixture in shotcrete.

(b) Air-entraining admixture. - The amount of air-entraining admixture used for the wet-mix process shall be that amount necessary to effect a total air content in the shotcrete, prior to application, of 7 percent plus or minus 1 percent by volume of shotcrete.

(5) Steel fibers. - Where directed by the Contracting Officer, the Contractor shall furnish steel fibers for reinforcement. The amount of steel fibers used shall be 90 pounds of fiber per cubic yard of shotcrete.

Steel fibers shall be carbon steel deformed type I (cold drawn wire) or type II (cut sheet) to conform to the requirements of ASTM A 820. Length of steel fiber shall be 3/4-inch minimum to 1-1/4-inch maximum. The length divided by diameter (or equivalent diameter), or aspect ratio, shall be 45 minimum and 100 maximum. The steel fiber shall have a minimum average tensile strength of 50,000 pound-force per square inch.

(6) Curing compounds. - Curing compounds shall meet the applicable requirements of subparagraph 3.6.d.(6).

e. Safety. - All work shall be performed in accordance with the requirements of paragraph 1.6.

f. Concrete preparation. - Concrete to be repaired with shotcrete shall be prepared in accordance with section 2.

g. Application. -

(1) Mixture proportions. - The proportions of water, cementitious materials, sand, coarse aggregate, and admixture and fibers, if used, shall be determined by the Contractor subject to approval by the Contracting Officer to obtain the specified compressive strength and bond. The shotcrete shall have a minimum cementitious materials content of 658 pounds per cubic yard, as discharged from the nozzle. Furthermore, the amount of cementitious materials will be increased by

the Contracting Officer as necessary to obtain the specified compressive strengths and bond.

(2) Consistency. - The consistency of the dry-mix process shotcrete shall be regulated by the amount of water introduced at the nozzle and shall be adjusted so that the in-place shotcrete is adequately compacted and neither sags nor shows excessive rebound.

The consistency of the wet-mix process shotcrete at the delivery point shall not exceed a 3-inch slump.

(3) Batching. - Batching for the dry-mix process shall be as specified in this paragraph. Water, cementitious materials, sand, coarse aggregate, admixture, and fibers shall be volume proportioned by controlled, calibrated, screw conveyor, or other methods of feed, provided uniform proportions are obtained. The equipment shall be capable of controlling the delivery of material so that inaccuracies do not exceed 1 percent for water; 1-1/2 percent for cementitious materials; 2 percent for sand and coarse aggregate; and 3 percent for admixture and fibers. If these limits cannot be consistently met, then batching shall be by direct weighing.

To ensure accurate, consistent proportioning of aggregate, augers used in dry-mix process shotcrete delivery equipment shall be constructed of abrasion-resistant material to prevent rapid and excessive wear. Auger feed shall be recalibrated as necessary to keep them within the prescribed batching accuracy percent.

The percentage of surface moisture in the sand (ASTM C 566) shall be 3 to 6 percent, by weight, and shall be controlled within this range as may be necessary to maintain uniform feed and to avoid choking the delivery equipment.

Shotcrete batches containing cementitious materials that have been in contact with damp aggregate or other moisture for more than 2 hours shall be wasted at the Contractor's expense.

Batching for the wet-mix process shall be in accordance with the requirements for concrete batching under subparagraph 3.6.g.

When batching with fibers the Contractor shall obtain a good blend of fibers throughout the shotcrete. The Contractor shall furnish appropriate equipment or develop a suitable technique for dispersing the fibers in the mixer free of fiber clumps. A suggested guide is ACI 544.3R.

(4) Mixing. - Mixing for the wet-mix and the dry-mix process shall be as specified in this paragraph. Cementitious materials, sand, coarse aggregate, admixtures, and steel fibers shall be uniformly added and thoroughly mixed by machine before being fed into the delivery equipment.

Mixers used to mix dry ingredients shall discharge the batch without segregation. Mixers shall be tested for uniformity of coarse aggregate content from front to back of the mixer. The maximum permissible difference in percentage of coarse aggregate by weight of sample shall not exceed 6 percent within a batch.

The discharge nozzle for the dry-mix process shall be equipped with a manually operated water injection system of sufficient pressure to

provide an even distribution of water into the dry shotcrete mixture at the nozzle. The water valve shall be capable of ready adjustment to vary the quantity of water and shall be convenient to the nozzleman.

(5) Placing. - Placing shotcrete shall be performed only by a nozzleman certified in accordance with subparagraph 3.5.c.(3) during preapplication testing.

An air compressor with ample capacity to provide clean, dry air and maintain a uniform nozzle velocity shall be used for applying shotcrete.

The shotcrete shall be applied by pneumatic pressure from a discharge nozzle held about 2 to 5 feet from the surface and in a stream as nearly normal as possible to the surface being covered. The nozzle shall also be rapidly gyrated while applying the shotcrete.

The shotcrete shall be applied in layers having a thickness that will ensure complete adherence of the shotcrete to the surface. Any shotcrete that shows evidence of sloughing or separation shall be removed and replaced by and at the expense of the Contractor and to the satisfaction of the Contracting Officer.

Care shall be taken to prevent the formation of sand pockets in the shotcrete. Any sand pockets formed shall be removed immediately and replaced with suitable shotcrete at the expense of the Contractor.

Use of rebound as shotcrete aggregate is not permitted, and rebound accumulations shall be removed and disposed of at the expense of the Contractor as approved by the Contracting Officer.

The temperature of shotcrete, as placed, shall be between 50 and 90 EF. Shotcrete shall not be applied to frozen surfaces. The applied shotcrete shall be kept at a temperature of at least 50 EF for a minimum of 3 days immediately following application. When cold weather conditions prevail at the job site and the temperature of aggregates and water is below 50 EF, it may be necessary to heat the aggregate and/or water prior to use in the shotcrete to obtain shotcrete meeting the specified 28-day compressive strength.

The Contractor shall provide and maintain sufficient standby equipment to assure continuous production and application of shotcrete.

If, in the Contracting Officer's opinion, the shotcreting system selected by the Contractor fails to provide satisfactory in-place shotcrete in accordance with these specifications, the Contractor shall change to another system of either of the two processes, provide a redemonstration of the nozzleman's proficiency, or provide a new qualified nozzleman.

If, in the Contracting Officer's opinion, the projection of steel fibers (when used) on the face of the finished shotcrete creates a hazard to personnel, a sacrificial coating of no less than 1/2-inch thickness of shotcrete without the steel fibers shall be applied.

h. Curing. - Shotcrete that is applied where the ambient relative humidity is 85 percent or above will not require measures to control the evaporation of water during curing. However, the Contractor shall substantiate that the relative humidity level in the area of application

is above 85 percent by furnishing, installing, and maintaining equipment capable of continuously recording relative humidity.

When the relative humidity is less than 85 percent, the Contractor shall initiate an approved curing method immediately after application of the shotcrete.

Curing shall be accomplished by either:

(1) Raising and maintaining the ambient relative humidity above 85 percent, or

(2) Applying a membrane curing compound as specified in subparagraph 3.6.d.(6).

Water curing. - Shotcrete cured with water shall meet the applicable requirements of subparagraph 3.6.h. except the 14-day requirement may be reduced to 7 days.

3.6 CONCRETE REPLACEMENT

a. General. - Concrete replacement shall be used on areas of damaged or unacceptable concrete greater than 1 square foot having a depth greater than 6 inches or a depth extending 1 inch below or behind the backside of reinforcement. Concrete replacement shall also be used for holes extending entirely through concrete sections and for large areas of repair greater than 4 inches in depth when the concrete to be repaired is less than 7 days old. Epoxy bonding agents, latex bonding agents, dry neat cement, cement paste, or cement and sand mortar shall not be used to bond fresh concrete to concrete being repaired by this method.

b. Submittals. - The Contractor shall submit certification of compliance for materials in accordance with subparagraph d. below.

c. Quality assurance. - Quality assurance shall be in accordance with paragraph 1.4.

d. Materials. - All concrete materials shall be obtained from previously tested and approved sources. Materials will be accepted on certificate of compliance with the following ASTM Standards:

(1) Portland cement. - Portland cement shall meet the requirements of ASTM C 150 for type I, II, or V cement. The specific cement type shall be as directed by the Contracting Officer and determined by the environment in which the repair is conducted.

(2) Pozzolan. - Pozzolan shall meet the requirements of ASTM C 618 for class F pozzolan.

(3) Admixtures. - The Contractor shall furnish air-entraining and chemical admixtures for use in concrete.

(a) Air-entraining admixture shall be used in all concrete and shall conform to ASTM C 260.

(b) Chemical admixtures. - The Contractor may use type A, D, F, or G chemical admixtures. If used, they shall conform to ASTM C 494.

(4) Water. - The water used in making and curing concrete shall be free from objectionable quantities of silt, organic matter, salts, and other impurities.

(5) Aggregate. - The term "sand" is used to designate aggregate in which the maximum size particle will pass a 4.75-mm (No. 4) sieve. The term "coarse aggregate" is used to designate all aggregate which can be retained on a 4.75-mm (No. 4) sieve. Sand and coarse aggregate meeting the requirements of ASTM C 33 shall be used in all concrete.

(6) Curing compound. - Wax-base (type I) and water-emulsified resin-base (type II) curing compounds shall conform to the requirements of Reclamation's "Specifications for Concrete Curing Compound" (M-30) dated October 1, 1980.

e. Safety. - All work shall be performed in accordance with paragraph 1.6.

f. Concrete preparation. - After damaged or unacceptable concrete has been removed as specified in section 2. the surface on which the replacement concrete will be placed shall be prepared. An acceptable surface shall have the appearance of freshly broken, properly cured concrete. The surface shall be free of any deleterious materials such as free moisture, ice, petroleum products, mud, dust, carbonation, and rust. The perimeters of the repair shall be saw cut to a minimum depth of 1 inch.

The clean surface is not ready to receive repair concrete until it has been brought to a saturated, surface-dry condition. This condition is attained by saturating the surface to a depth that no concrete mixture water may be absorbed from the fresh concrete. Then, just prior to placing concrete against the surface, all free moisture (moisture capable of reflecting light) shall be removed from the prepared surface.

g. Application. - Replacement concrete shall be composed of cement, coarse aggregate, sand, water, and approved admixtures, all well mixed and brought to the proper consistency. Concrete mixtures shall be proportioned in accordance with Reclamation's "Concrete Manual", Eighth Edition, revised, chapter III. The water-cement ratio of the concrete (exclusive of water absorbed by the aggregates) shall not exceed 0.47 by weight. Slump of the concrete, when placed, shall not exceed 2 inches for concrete in slabs that are horizontal or nearly horizontal and 3 inches for all other concrete. Concrete with less slump should be used when it is practicable to do so. The concrete ingredients shall be thoroughly mixed in a batch mixer. The concrete, as discharged from the mixer, shall be uniform in composition and consistency from batch to batch.

(1) Forms. - Forms shall be used for concrete whenever necessary to confine the concrete and shape it to the required lines. The forms shall be clean and free from encrustations of mortar, grout, or other foreign material. Before concrete is placed, the surfaces of the forms shall be coated with a form oil that will effectively prevent sticking and will not soften or stain the concrete surfaces or cause the surfaces to become chalky or dust producing.

(2) Placing. - Placing of concrete shall be performed only in the presence of an authorized representative of the Contracting Officer. Placement shall not begin until all preparations are complete and the authorized representative of the Contracting Officer has approved the

preparations. Concrete shall not be placed in standing or running water unless, as determined by the Contracting Officer, the structure under repair cannot be economically dewatered. If underwater concrete placement is required, special placing procedures shall be required. A suggested guide is ACI 394R.

When appropriate, concrete shall be placed in layers not greater than 20 inches thick. Each layer, regardless of the thickness, shall be adequately consolidated using immersion-type vibrators or form vibrators when approved. Adequate consolidation of concrete is obtained when all undesirable air voids, including the air voids trapped against forms and construction joints, have been removed from the concrete.

(3) Finishing. - The class of finish required shall be a finish closely resembling the finish of the surrounding concrete.

h. Curing and protection. - Concrete repairs shall be cured either by water curing or by use of wax-base (type I) or water-emulsified resin-base (type II) curing compound meeting the requirements of subparagraph 3.6.d.(6). Daily inspection by the Contractor shall be performed to ensure the maintenance of a continuous, water-retaining film over the repaired area. The water-retaining film shall be maintained for 28 days after the concrete has been placed.

Water curing shall commence when the concrete has attained sufficient set to prevent detrimental effects to the concrete surface. The concrete surface shall be kept continuously wet for 14 days.

The Contractor shall protect all concrete against damage until acceptance by the Government. Whenever freezing temperatures are imminent, the Contractor shall maintain the newly placed repair concrete at a temperature of not less than 50 EF for 72 hours. Water-cured concrete shall be protected from freezing for the duration of the curing cycle and an additional 72 hours after the water is removed.

3.7 EPOXY-BONDED EPOXY MORTAR

a. General. - Epoxy-bonded epoxy mortar is defined as freshly mixed epoxy mortar (sand with epoxy binder) that is placed over an epoxy resin bond coat on hardened existing concrete. Epoxy-bonded epoxy mortar repair may be used when the depth of repair is 1-1/2 inches or less. This method may also be used for repair of areas with a depth greater than 1-1/2 inches when those areas are small (less than 1 square foot) and few in number, and where it is impractical to use epoxy-bonded concrete.

Epoxy-bonded epoxy mortar may be used only when:

(1) Moisture in the structure will not collect behind the bond coat and cause damage upon freezing, and

(2) The repair will not be subjected to extremes of temperatures such as those caused by exposure to direct sunlight, extremes of climate, or extremes in water temperature.

All epoxy-bonded epoxy mortar repairs to new construction shall be performed after 7 days from the original placement.

b. Submittals. -

(1) When directed by the Contracting Officer, the Contractor shall submit samples of the epoxy-resin bonding system. The samples shall be submitted at least 30 days prior to use in the work to the Bureau of Reclamation, Attn D-8180, Building 56, Denver Federal Center, West Sixth Avenue and Kipling Street, Denver CO 80225.

(2) Certification of epoxy-bonding agent. - The Contractor shall furnish the Contracting Officer the manufacturer's certification of conformance of the epoxy-resin bonding system with these specifications. The certification shall identify the Reclamation solicitation/ specifications number(s) under which the epoxy is to be used and shall include the quantity represented, the batch numbers of the resin and curing agent, and the manufacturer's results of tests performed on the particular combination of resin and curing agent.

c. Quality assurance. - Quality assurance shall be in accordance with paragraph 1.4.

d. Materials. -

(1) Epoxy resin. - The same epoxy resin system shall be used for both the bond coat and the epoxy mortar. The epoxy resin shall meet the requirements of specifications ASTM C 881 for a type I , grade 2, class B or C or a type III, grade 2, class B or C epoxy system. In addition, it shall be a 100-percent solids system, and no unreactive diluents, wetting agents, or volatile solvents shall be incorporated.

(2) Sand. - The sand for epoxy mortar shall be clean, dry, well-graded sand composed of sound particles passing a 1.18-mm (No. 16) sieve and conform to the following limits:

Sieve	Individual percent, by weight, retained on sieve
600 µm (No. 30)	26 to 36
300 µm (No. 50)	18 to 28
150 µm (No. 100)	11 to 21
pan	[1]25 to 35

[1]Range shown is applicable when 60 to 100 percent of pan is retained on the 75 µm (No. 200) sieve. When 0 to 59 percent of pan is retained on the 75 µm (No. 200) sieve, the percent pan shall be within the range of 10 to 20 percent, and the individual percentages retained on the 600 µm, 300 µm, and 150 µm (Nos. 30, 50, and 100) sieves shall be increased proportionately.

Sand of this grading is not usually commercially available and may have to be produced by the Contractor. Starting with a concrete sand, the oversized particles shall be removed with a 1.18-mm (No. 16) sieve. Individual sieve sizes of sand can be purchased to mix with the remaining sand to meet the required grading. Most sands require at least the addition of more pan material to meet the required grading.

When directed, minor adjustments in sand grading shall be made to provide a suitable epoxy mortar. Other fillers or commercially available sand gradings prepared specifically for epoxy mortars may be used in epoxy mortar on approval by the Contracting Officer.

The sand shall be maintained in a dry area at no less than 60 EF temperature for 24 hours immediately prior to time of use.

e. Safety. - All work shall be performed in accordance with paragraph 1.6 of these specifications. Certain additional safety precautions shall be employed when using uncured epoxy materials. Skin contact with uncured epoxy shall be avoided. Protective clothing, including rubber or plastic gloves, shall be worn by all persons handling epoxy materials. All exposed skin areas that may come in contact with the material shall be protected with a protective barrier cream formulated for that purpose. Adequate ventilation shall be provided and maintained at all times during use of epoxy and epoxy solvents. Fans used for ventilating shall be explosion proof. If necessary, respirators that filter organic fumes and mists shall be worn. If spray application is used, the operator shall wear a compressed air-fed hood, and no other personnel shall be closer than 100 feet if downwind of the operator when spraying is being performed. All epoxy-contaminated materials such as wipes, empty containers, and waste material shall be continually disposed of in containers which are protected from spillage. Epoxy spillage shall be immediately and thoroughly cleaned up. Appropriate solvents may be used to clean tools and spray guns, but in no case shall the solvents be incorporated in any epoxy resin or in the placing operation. Solvents shall not be used to remove epoxy materials from skin. Only soap, water, and rags shall be used for this purpose.

All tools shall be completely dried after cleaning and before reuse. All materials, tools, and containers contaminated with epoxy resin or epoxy curing agent shall be removed from the site for disposal in accordance with appropriate local or Federal regulations.

f. Concrete preparation. - Surface preparation and needed removal of existing concrete shall be as in section 2, except that the saw cut shall be 1 inch or equal to the depth of the repair, whichever is less. For repairs less than 1 square foot in area, the required vertical edge may be accomplished with a pneumatic tool or hydrodemolition equipment in lieu of saw cutting. For minor cosmetic repairs of surface defects less than 2 inches in diameter, surface preparation may be limited to cleaning with a small wire brush, removing dust, and heating in depth. Epoxy paste meeting the requirements of ASTM C 881, grade 3, may be used without a bond coat for minor cosmetic repairs of surface defects less than 2 inches in diameter in lieu of epoxy-bonded epoxy mortar when all of the conditions for use of epoxy mortar are met. Any overfilling of minor surface defects shall be removed by grinding after hardening is complete. Where repairs are exposed to public view, color matching of the repair material to the existing concrete shall be done.

The surfaces of the existing concrete to which epoxy mortar is to be epoxy bonded shall be prepared and maintained in a clean and dry condition. Unless epoxy mortar application to wet concrete surfaces is approved by the Contracting Officer. The existing concrete shall be preheated in depth. Preheating shall be sufficient to drive internal moisture from the repair surface and prevent its return until the bond coat is in place. Preheating shall not cause damage to or instant setting of the bond coat.

g. Application. -

(1) Forms. - Forms shall be used as necessary to prevent slumping or sagging of finished epoxy-bonded epoxy mortar. Such forms shall be covered with polyethylene film, and form oil shall not be used.

(2) Preparation of epoxy resin for bond coat. - The epoxy resin is a two-component material which requires combination of components and mixing prior to use. Once mixed, the material has a limited pot life and must be used immediately. The bonding system shall be prepared by adding the curing component to the resin component in the proportions recommended by the manufacturer, followed by thorough mixing. Since the working life of the mixture depends on the temperature (longer at lower temperature, much shorter at higher temperature), the quantity to be mixed at one time shall be applied and topped within approximately 30 minutes. The addition of thinners or diluents to the resin mixture shall not be done. Both components of class C epoxy shall be stored above 60 EF prior to use.

(3) Application of epoxy resin bond coat for epoxy-bonded epoxy mortar. - Immediately after the epoxy resin is mixed, it shall be applied to the prepared, dry existing concrete at a coverage of not more than 80 square feet per gallon, depending on surface conditions. The area of coverage per gallon of agent depends on the roughness of the surface to be covered and may be considerably less than the maximum specified. The epoxy resin may be applied by any convenient, safe method such as squeegee, brushes, or rollers, which will yield an effective coverage, except that spraying of the materials will be permitted only if an efficient airless spray is used and when the concrete surfaces to receive the agent are 70 EF or warmer, which spray shall be demonstrated as providing an adequate job with minimum overspray prior to approval of its use.

Care shall be exercised to confine the epoxy resin to the area being bonded and to avoid contamination of adjacent surfaces. However, the epoxy bond coat shall extend slightly beyond the edges of the repair area.

Steel to be embedded in epoxy mortar shall be coated with epoxy resin. The steel shall be prepared in accordance with the requirements of section 2 and by removing all loose rust either with a wire brush or by wet sandblasting. The exposed steel shall be completely coated with epoxy resin at the time it is being applied to the concrete surfaces of the repair area.

The applied epoxy resin film shall be in a fluid condition at the time the epoxy mortar is placed. The epoxy resin may be allowed to stiffen to a very tacky condition rather than a fluid condition before epoxy mortar is placed on steep sloping or vertical surfaces, in which case special care shall be taken to thoroughly compact the epoxy mortar against the stiffening bond coat. In the event the bond coat is curing too quickly to meet the placement requirements, a second bond coat shall be applied over the first while the first bond coat is still tacky. If any bond coat has cured beyond the tacky state, it shall be completely removed by sandblasting, and proper cleanup, heating, and drying shall be accomplished and a new bond coat applied.

(4) Placing and finishing. - The epoxy mortar shall be composed of sand and epoxy resin suitably blended to provide a stiff, workable mixture. The epoxy components shall be mixed thoroughly prior to the

application of the bond coat and prior to the addition of the sand. The mixture proportions shall be established, batched, and reported on a weight basis, provided that the dry sand and mixed epoxy may be batched by volume using suitable measuring containers that have been calibrated on a weight basis. If equivalent volume proportions are being used, care shall be taken to prevent confusing them with weight proportions. Epoxy mortar will require approximately 5-1/2 to 6 parts of graded sand to 1 part epoxy, by weight. The Contracting Officer will determine, and adjust where necessary, the mix proportions for the particular epoxy and sand being used. The epoxy mortar shall be thoroughly mixed with a slow-speed mechanical stirrer or other equipment producing equivalent results. The mortar shall be mixed in small-sized batches so that each batch will be completely mixed and placed within approximately 30 minutes from the time the two components for the epoxy resin are combined. The addition of thinners or diluents to the mortar mixture will not be permitted.

The prepared epoxy mortar shall be tamped, flattened, and smoothed into place in all areas while the epoxy bond coat is still in a fluid condition. The mortar shall be worked to grade and given a steel trowel finish. Special care shall be taken at the edges of the area being repaired to ensure complete filling and leveling and to prevent the mortar from being spread over surfaces not having the epoxy bond coat application. Steel troweling shall be performed in a manner to best suit the prevailing conditions but, in general, shall be performed by applying slow, even strokes. Trowels may be heated to facilitate the finishing. The use of thinner, diluents, water, or other lubricant on placing or finishing tools will not be permitted, except for final cleanup of tools. After leveling of the epoxy mortar to the finished grade where precision surfaces are required, the mortar shall be covered with plywood panels smoothly lined with polyethylene sheeting and weighted with sandbags or otherwise braced, or by other means acceptable to the Contracting Officer, until danger from slumping has passed. When polyethylene sheeting is used, no attempt shall be made to remove it from the epoxy mortar repair before final hardening.

Epoxy-bonded epoxy mortar repairs shall be finished to the plane of the surfaces adjoining the repair areas. The final finished surfaces shall match the texture of the surfaces adjoining the repair areas.

h. Curing and protection. - Epoxy-mortar repairs shall be cured immediately after completion of each repair area at not less than 60 EF until the mortar is hard. Post curing shall then be initiated at elevated temperatures by heating, in depth, the epoxy mortar and the concrete beneath the repair. Post curing shall continue for a minimum of 4 hours at a surface temperature not less than 90 EF nor more than 110 EF, or for a minimum of 24 hours at a surface temperature not less than 60 EF nor more than 110 EF. The heat shall be supplied by using portable propane-fired heaters, infrared heat lamps, or other approved methods capable of producing the required temperature and positioned so that the required surface temperatures are obtained.

In no case shall epoxy-bonded epoxy mortar be subjected to moisture until after the specified post curing has been completed.

3.8 EPOXY-BONDED CONCRETE

a. General - Epoxy-bonded concrete is defined as freshly mixed portland cement concrete that is placed over a fluid epoxy resin bond coat on hardened existing concrete. Epoxy-bonded concrete repair may be used when the depth of repair is 1-1/2 inches or greater.

b. Submittals. -

(1) When directed by the Contracting Officer, the Contractor shall submit samples of the epoxy-resin bonding system. The samples shall be submitted at least 30 days prior to use in the work to the Bureau of Reclamation, Attn D-3731, Building 56, Denver Federal Center, West Sixth Avenue and Kipling Street, Denver CO 80225.

(2) Certification of epoxy-bonding agent. - The Contractor shall furnish the Contracting Officer the manufacturer's certification of conformance of the epoxy-resin bonding system with these specifications. The certification shall identify the Reclamation solicitation/ specifications number(s) under which the epoxy is to be used and shall include the quantity represented, the batch numbers of the resin and curing agent, and the manufacturer's results of tests performed on the particular combination of resin and curing agent.

c. Quality assurance. - Quality assurance shall be in accordance with paragraph 1.4.

d. Materials. -

(1) Concrete materials. - The materials and procedures used to prepare and mix concrete for epoxy-bonded concrete repair shall be as specified in subparagraph 3.6.d. except that slump of concrete, when placed, shall not exceed 1-1/2 inches.

(2) Epoxy resin. - The epoxy-resin bonding system shall meet the requirements of specification, ASTM C 881 for a type II, grade 2, class B or C epoxy system. In addition, it shall be a 100-percent solids system and shall not contain unreactive diluents or wetting agents. Volatile solvents shall not be incorporated into the epoxy system.

e. Safety. - All work shall be performed in accordance with paragraph 1.6 and these specifications. Certain additional safety precautions shall be employed when using uncured epoxy materials. Skin contact with uncured epoxy shall be avoided. Protective clothing, including rubber or plastic gloves, shall be worn by all persons handling epoxy materials. All exposed skin areas that may come in contact with the material shall be protected with a protective barrier cream formulated for that purpose. Adequate ventilation shall be provided and maintained at all times during use of epoxy and epoxy solvents. Fans used for ventilating shall be explosion proof. If necessary, respirators that filter organic fumes and mists shall be worn. All epoxy-contaminated materials such as wipes, empty containers, and waste material shall be continually disposed of in containers which are protected from spillage. Epoxy spillage shall be immediately and thoroughly cleaned up. Appropriate solvents may be used to clean tools and spray guns, but in no case shall the solvents be incorporated in any epoxy resin or in the placing operation. Solvents shall not be used to remove epoxy materials from skin. Only soap, water, and rags shall be used for this purpose.

All tools shall be completely dried after cleaning and before reuse.

All materials, tools, and containers contaminated with epoxy resin or epoxy curing agent shall be removed from the site for disposal in accordance with appropriate local or Federal regulations.

f. Concrete preparation. - Concrete to be repaired by epoxy-bonded concrete shall be prepared in accordance with the provisions of section 2, except that the perimeters of the repair shall be saw cut to a minimum depth of 1 inch. Epoxy-bonded concrete shall not be applied to concrete surfaces at a surface temperature less than 60 EF nor greater than 90 EF.

g. Application of epoxy-bonded concrete. -

(1) Forms. - Forms shall be used for epoxy-bonded concrete whenever necessary to confine the concrete and shape it to the required lines. The forms shall have sufficient strength to withstand the pressure resulting from placing operations, shall be maintained rigidly in position, and shall be sufficiently tight to prevent loss of mortar from the concrete.

(2) Preparation of epoxy resin. - The epoxy resin is a two-component material which requires combination of components and mixing prior to use. Once mixed, the material has a limited pot life and must be used immediately. The bonding system shall be prepared by adding the curing component to the resin component in the proportions recommended by the manufacturer, followed by thorough mixing. Since the working life of the mixture depends on the temperature (longer at lower temperature, much shorter at higher temperature), the quantity to be mixed at one time shall be applied and topped within approximately 30 minutes. The addition of thinners or diluents to the resin mixture will not be permitted. Both components of class C epoxy shall be at 60 EF prior to use.

(3) Application of epoxy resin bond coat for surface repairs. - Immediately after the epoxy resin is mixed, it shall be applied to the prepared, dry existing concrete at a coverage of not more than 80 square feet per gallon, depending on surface conditions. The area of coverage per gallon of agent depends on the roughness of the surface to be covered and may be considerably less than the maximum specified. The epoxy resin may be applied by any convenient, safe method such as squeegee, brushes, or rollers, which will yield an effective coverage, except that spraying of the materials will be permitted only if an efficient airless spray is used and when the concrete surfaces to receive the agent are 70 EF or warmer, which spray shall be demonstrated as providing an adequate job with minimum overspray prior to approval of its use. If spray application is used, the operator shall wear a compressed air-fed hood, and no other personnel shall be closer than 100 feet if downwind of the operator when spraying is being performed.

Care shall be exercised to confine the epoxy resin to the area being bonded and to avoid contamination of adjacent surfaces. However, the epoxy bond coat shall extend slightly beyond the edges of the repair area.

Steel to be embedded in epoxy-bonded concrete shall be coated with epoxy resin. The steel shall be prepared in accordance with the requirements of section 2 and in the same manner required for preparation of the concrete being repaired. The exposed steel shall

be completely coated with epoxy resin at the time it is being applied to the concrete surfaces of the repair area.

The applied epoxy resin film shall be in a fluid condition at the time the concrete is placed, provided that the epoxy resin may be allowed to stiffen to a very tacky condition rather than a fluid condition before concrete is placed on steep sloping or vertical surfaces, in which case special care shall be taken to thoroughly compact the concrete against the stiffening bond coat. In the event that an applied film cures beyond the fluid condition, or a very tacky condition where permitted, before the concrete is placed, a second bond coat shall be applied while the first bond coat is still tacky. If any bond coat has cured beyond the tacky state, it shall be completely removed by sandblasting, and proper cleanup, heating, and drying shall be accomplished, and a new bond coat applied.

(4) Placing and finishing. - Use of epoxy-bonded concrete in repairs requiring forming, such as on steeply sloped or vertical surfaces, will be permitted only when the forming required is such that the bond coat can be applied and the concrete properly placed within the time period necessary to ensure that the applied bond coat will still be fluid, or tacky where permitted.

Immediately after application of the epoxy bond coat, while the epoxy is still fluid, concrete shall be spread evenly to a level slightly above grade and compacted thoroughly by vibrating, tamping, or both. Vibrators shall not be permitted to penetrate through the fresh concrete to the level of the fluid epoxy bond coat. Such vibration can emulsify the epoxy and reduce the bond. Tampers shall be sufficiently heavy for thorough compaction. After being compacted and screeded, the concrete shall be given a wood float or steel trowel finish, as directed. Troweling, if required, shall result in a smooth, dense finish that is free from defects and blemishes. As the concrete continues to harden, the surface shall be given successive trowelings. The final troweling shall be performed after the surface has hardened to such an extent that no cement paste will adhere to the edge of the trowel. The number of trowelings and time at which trowelings are performed shall be subject to approval of the Contracting Officer.

The surfaces of epoxy-bonded concrete repairs shall be finished to the plane of the surfaces adjoining the repair areas. The final finished surfaces shall match the texture of the surfaces adjoining the repair areas.

h. Curing and protection. - The Contractor shall cure and protect all repairs from damage until acceptance by the Government. Concrete shall be protected against freezing for not less than 6 days from time of placement.

As soon as the epoxy-bonded concrete has hardened sufficiently to prevent damage, the surface shall be moistened by spraying lightly with water and then covering with sheet polyethylene, or by applying an approved curing compound, provided that curing compound shall be used for curing concrete whenever there is any possibility that freezing temperatures will prevail during the curing period. Sheet polyethylene, if used, shall be an airtight, nonstaining, waterproof covering which will effectively prevent loss of moisture from the concrete by evaporation. Edges of the polyethylene shall be lapped and sealed. The waterproof covering shall be left in place for not less than 14 days.

If a waterproof covering is used and the concrete is to be subjected to any use that might rupture or otherwise damage the covering during the curing period, the covering shall be protected by a suitable layer of clean wet sand or other cushioning material that will not stain concrete, as approved by the Contracting Officer. Application of curing compound, if used, shall be in accordance with Reclamation's "Specifications for Concrete Curing Compound, M-30." After the curing has been accomplished, the covering, except curing compound if used, and all foreign material shall be removed and disposed of as directed.

3.9 POLYMER CONCRETE SYSTEMS

a. General. - Polymer concrete repair systems for concrete may be either of two types: a methacrylate monomer system, or a vinyl ester resin system. These materials may be used for patches, overlays, grout pads, and embedment of sills, gates, and similar structures in concrete members. Prior approval of the Contracting Officer is required for applications where the repair is exposed to the direct rays of the sun or subjected to rapid temperature changes in excess of 10 EF per hour for more than a 3-hour period. The materials may be supplied as a prepackaged system or as components for a system designed for use as polymer concrete.

The polymer concrete system shall consist of a 100-percent reactive monomer or resin system (no nonreactive diluents or solvents are permitted); an initiator for polymerization of the resin or monomer system, a promoter to activate the initiator; aggregate; and a primer system to be applied to the surface of the concrete to be repaired. The system shall be supplied with or without pigments to approximate the color of concrete, as directed by the Contracting Officer.

b. Submittals. - Before starting work, the Contractor shall submit to the Contracting Officer for approval the following documents:

(1) A safety plan.

(2) A statement of technical qualifications, training, and past experience in handling and applying polymer concrete materials.

(3) A manufacturer's affidavit that states the chemical constituents and proportions of the material, a Materials Data Safety Sheet for each component, the use for which the material is designed, instructions on storage and use of the materials, and typical mechanical and physical properties of the final product.

c. Quality assurance. - Quality assurance shall be in accordance with paragraph 1.4.

d. Materials. -

(1) Monomer and resin systems. -

(a) Methacrylate monomer systems. - The monomer system may be based on either methyl methacrylate monomer or on high molecular weight methacrylate monomer systems. The monomer system shall consist of 100-percent reactive components, and no nonreactive diluents or solvents shall be permitted. The initiator shall be an organic peroxide. The promoter shall be either a cobalt salt or an organic amine compound. Materials shall be used in the proportions recommended by the manufacturer for the temperature

conditions at the job site to meet the pot life and curing time requirements of these specifications.

(b) Vinyl ester resin systems. - The vinyl ester resin shall be an elastomer-modified dimethacrylate diglycidyl ether of bisphenol A and shall be Dow Chemical Company Derakane 8084; or equal having the following salient characteristics:

Liquid Resin Properties	
Styrene content	45 percent by weight
Viscosity, Brookfield (cps), 77 EF	1,200
Flash point, cc, (EF)	82
Clear Casting Properties	
Tensile strength, (lb/in^2)	10,000
Tensile modulus (lb/in^2)	430,000
Elongation, percent	10
Flexural strength, (lb/in^2)	16,000
Flexural modulus, (lb/in^2)	420,000
Heat distortion temperature (EF)	170

The initiator shall be an organic peroxide and the promoter shall be cobalt napthenate or cobalt octoate. Materials shall be used in the proportions recommended by the manufacturer for the temperature conditions at the job site to meet the pot life and curing time requirements of these specifications.

(2) Aggregates. -

(a) Prepackaged systems. - Prepackaged systems normally contain a preblended fine aggregate. The use of additional fine aggregate shall not be permitted in these systems unless specifically authorized by the manufacturer. Prepackaged systems that do not contain a preblended fine aggregate shall use a fine aggregate meeting the requirements of subparagraph 3.9.d.(2)(b). Prepackaged polymer concrete systems may be extended by the addition of coarse aggregate. The maximum size of the coarse aggregate shall not exceed the lesser of either one-third of the depth of the repair or 1-1/2 inches. The coarse aggregate shall be composed of hard, dense, clean durable, well-graded rock particles.

(b) Separate component polymer concrete systems. - The aggregate shall be composed of hard, dense, clean, durable, well-graded rock particles. Not more than 2 percent by weight of the fine aggregate shall pass the 75 µm (No. 200) sieve, and the maximum aggregate size shall not be greater than one-third the depth of the repair. The grading shall be based on the following guide:

Nominal size fraction	Aggregate grading percent retained by weight					
9.5 - 19.0 mm (3/8 - 3/4 inch)	--	--	--	--	--	29
4.75 - 9.5 mm (No. 4 - 3/8 inch)	--	--	--	--	29	20
2.36 - 4.75 mm (No. 8 - No. 4)	--	--	--	29	21	16

1.18 - 2.36 mm (No. 16 - No. 8)	--	--	31	21	16	10
600 µm - 1.18 mm (No. 30 - No. 16)	--	31	22	15	10	7
300 - 600 µm (No. 50 - No. 30)	50	23	16	10	7	5
150 - 300 µm (No. 100 - No. 50)	30	16	10	8	4	
*Pan	20	30	21	17	13	9

*NOTE: Pan material shall consist of:
1. Minus 75 µm (No. 200) sieve size ground silica, or
2. Minus 75 µm (No. 200) sieve size crushed hard, dense, durable, clean rock washed free of clay and organic impurities, or
3. A mixture of 1 or 2 above with 50% fly ash.

(3) Coupling agent. - The coupling agent incorporated into the monomer or resin system shall be an organosilane compound, Union Carbide A-174, or equal.

(4) Primer. - The polymer concrete shall be applied to a prepared and primed concrete surface. The primer shall consist of either a methyl methacrylate monomer system, a high molecular weight methacrylate monomer system, or an elastomer-modified vinyl ester resin system (Dow Chemical Company Derakane 8084, or equal). The same monomer or resin system used in the polymer concrete is acceptable as a primer. The polymer concrete shall be applied to a primed surface while the primer is still tacky and has not completely cured to a hard and dry finish, with the exception of methyl methacrylate polymer concrete systems applied to a methyl methacrylate primer system which does not contain cross-linking comonomers which may be applied to a cured and dry primed surface. The primer system shall be formulated according to the manufacturer's instructions to give adequate pot life for the job site temperature conditions for proper application of the polymer concrete.

(5) Polymer concrete properties. - The polymer concrete shall have the following properties:

(a) Curing time of 1 to 3 hours at ambient temperature (substrate and air) of 32 to 100 EF.

(b) Pot life of 15 to 30 minutes at ambient temperatures of 32 to 100 EF.

(c) Compressive strength of at least 7,000 lb/in^2. (ASTM C 39).

(d) Splitting tensile strength of at least 1,000 lb/in^2. (ASTM C 496).

(e) Linear shrinkage, less than 0.05%.

(f) Bond strength to concrete - at least equal to the splitting tensile strength of the base concrete.

e. Safety. - All work shall be performed in accordance with requirements of paragraph 1.6 and these specifications. The Contractor shall also:

(1) Hold a safety meeting at the job site conducted by an industrial hygienist or by a technically qualified professional staff member to acquaint and instruct all workers and supervisors on the job in the proper care and handling of the polymer concrete materials as specified by the manufacturer of the polymer concrete, safety precautions to be observed, personal protective gear, and protection of the environment.

(2) Require all workers, supervisors, inspectors, visitors, and other people at the job site to wear personal protective gear as directed by the Contracting Officer.

(3) Ensure that the polymer concrete materials are stored, handled, and applied in the manner specified by the manufacturer. In addition:

(a) Storage. - polymer concrete materials shall be stored in the shipping containers in a well-ventilated area and out of the direct rays of the sun. The storage temperature shall not exceed 80 EF (27 EC). Materials shall not be stored longer than 3 months.

(b) Mixing and application. - No smoking, flame, or other ignition sources shall be permitted during mixing and application. Type B or type ABC fire extinguishers shall be provided at the mixing and application sites. Electrical equipment in contact with the polymer concrete should be grounded for safe discharge of static electricity.

(c) Handling. - Workers shall be provided and required to wear rubber boots, disposable protective clothing, splash-type safety goggles, rubber gloves, and organic vapor respirators as directed by the Contracting Officer. A heated eye wash capable of sustaining a 15-minute stream of clean, room temperature water shall be provided at the mixer and at the application site. Materials coming into direct contact with the skin shall be immediately removed using soap and water.

(4) Prevent the contamination of soil or water at the job site by liquid components.

(5) Dispose of liquid components and excess materials at the job site by combining the materials in the same manner and procedure used for mixing polymer concrete, placing the mixed materials in an open container, and allowing the material to harden. Hardened polymer concrete is nonpolluting and may be disposed of as a solid nonhazardous waste.

f. Concrete preparation. - In addition to the requirements of section 2, the concrete surface shall be dry and primed with an approved primer.

The primer and the polymer concrete shall not be applied until the surface preparation meets the approval of the Contracting Officer. The dryness of the surface shall be determined by taping a sheet of transparent polyethylene sheeting to the surface and exposing it to the full rays of the sun for at least 4 hours and observing the interior surface of the polyethylene sheeting for the occurrence of condensed moisture. As an alternative method, a calibrated moisture meter which meets the approval of the Contracting Officer may be used to determine the dryness of the surface.

g. Preparation and application requirements. -

(1) Initiator and promoter. - The initiator and promoter shall be prebatched and packaged separately from each other in a manner so that the two components cannot be combined until the time of the concrete mixing operation. The promoter shall be combined with the monomer or resin system prior to the addition of the initiator. UNDER NO CIRCUMSTANCES SHALL THE INITIATOR BE ADDED TO OR DIRECTLY CONTACT THE PROMOTER. THE DIRECT COMBINATION OF PROMOTER AND INITIATOR WILL RESULT IN AN EXTREMELY VIOLENT AND EXPLOSIVE REACTION.

(2) Sequence of addition and combination of materials at the mixer. - The polymer concrete materials shall be combined in the sequence and manner specified by the manufacturer.

(3) Mixing of polymer concrete. - The polymer concrete shall be mixed in a paddle-type power mixer, a rotating drum-type power mixer, or other type of power equipment approved by the Contracting Officer. Polymer concrete materials shall be mixed according to the recommendations of the manufacturer of the polymer concrete materials for at least 3 minutes.

(4) Removal of polymer concrete from the mixer. - The polymer concrete shall be removed from the mixer immediately after mixing.

(5) Appropriate forms shall be used for polymer concrete whenever necessary to confine the polymer concrete and shape it to required lines. The surfaces of the forms shall be coated with a release agent that will effectively prevent sticking without damage to the polymer concrete surfaces.

3.10 THIN POLYMER CONCRETE OVERLAY

a. General. - Thin polymer concrete overlay shall consist of one coat of primer and one or more coats of sealant as directed by the Contracting Officer.

The coat of primer shall consist of vinyl ester resin, initiator, and promoter. Each coat of sealant shall consist of the same materials as in the primer, but with the addition of silica filler, titanium dioxide pigment, and carbon black pigment.

b. Submittals. - The Contractor shall, before starting work, provide a manufacturer's affidavit which indicates the chemical constituents of the material by proportion. The chemical constituents shall correspond to the requirement of subparagraph 3.10.d.

c. Quality assurance. - Quality assurance shall be in accordance with paragraph 1.4 and these specifications.

The vinyl ester resin shall be stored in the shipping containers and kept in the shade, well ventilated, and out of direct sunlight. The recommended storage temperature is 50 to 75 EF. Resin shall not reach 80 EF or higher, as it will start to gel. The resin has a storage life of about 3 months. During storage, the resin shall not come in contact with copper, brass, zinc, or rust, as discoloration, polymerization, or interference with normal cure conditions can occur. Resin shall also not contact rubber, as resin is a solvent for rubber.

Styrene monomer, which is a component of vinyl ester resin, is flammable and forms explosive mixtures in the air; however, it is not sufficiently flammable to be listed as a "flammable liquid" under Interstate Commerce Commission definitions (flash point at or below 80 EF). The explosive limits are 1.1 to 6.1 percent volume in air.

The Contracting Officer will not allow the use of vinyl ester resin if it has already polymerized, gelled, discolored, or will not cure under normal conditions. Substandard materials shall be replaced at the expense of the Contractor.

d. Materials. -

(1) Vinyl ester. - The vinyl ester resin material shall be Dow Derakane 8084 elastomer-modified vinyl ester resin, manufactured by Dow Chemical Co., 2800 Mitchell Drive, Walnut Creek CA 94596; or equal. It shall meet the requirements of 3.9.d.(1)(b).

(2) Initiator. - The initiator shall be cuemene hydroperoxide - 78 percent as manufactured by: Lucidol Division, Penwalt Corp., 1740 Military Road, Buffalo NY 14240; Reichold Chemicals, Inc., 107 South Motor Avenue, Azusa CA 91706; Witco Chemicals, U.S. Peroxygen Division, 850 Morton Avenue, Richmond CA 94804; or equal.

(3) Promoter. - The promoter shall be cobalt napthenate; 6 percent.

(4) Filler. - The filler shall be ground silica, minus 45 µm (No. 355) sieve size as manufactured by: Ottawa Silica Co., Ottawa, Illinois; VWR Scientific (Silco Seal 395 Ground Silica), PO Box 3200, San Francisco CA 94119; or equal.

(5) Pigment for opaqueness. - Two pigments shall be used and they shall be:

(a) Titanium dioxide powder as manufactured by: VWR Scientific, PO Box 3200, San Francisco CA 94119; MCB Manufacturing Chemist, Inc., 470 Valley Drive, Brisband CA 94005; or equal.

(b) Carbon lamp black or bone black powder. - (Do <u>not</u> use activated carbon)

e. Safety. - All work shall be performed in accordance with paragraph 1.6 and these specifications. No smoking, flame, or other ignition source shall be present during mixing and the application procedures. Fire extinguishers (types B or ABC) shall be provided. Equipment contacting resins shall be grounded for safe discharge of static electricity. Tools used shall be the non-sparking, special alloy type.

Workers shall be provided with rubber boots, rubber gloves, protective clothing, safety goggles or face shields, and organic vapor respirators. It is important to avoid inhalation of vapors and direct eye or skin

contact. Eyewash facility shall be available which will provide a clean, room temperature flushing stream for a minimum of 15 minutes. Contaminated clothing shall be discarded immediately. Proper tools and facilities to quickly remove spills shall be at the worksite.

Personnel shall follow manufacturer's recommendations for safe handling of vinyl ester resin and all additives.

CUEMENE HYDROPEROXIDE INITIATOR SHALL NEVER BE ADDED DIRECTLY TO COBALT NAPTHENATE PROMOTER OR AN EXTREMELY VIOLENT AND EXPLOSIVE REACTION WILL OCCUR.

f. Concrete preparation. - Concrete surfaces designated to receive the thin polymer concrete overlay shall be prepared in accordance with section 2. The minimum preparation shall consist of wet sandblasting or water blasting the concrete to a clean, sound surface condition followed by drying.

g. Application of the thin polymer concrete overlay. -

(1) Coverage. - An average coverage rate of 50 to 75 square feet per gallon of applied material per coat over the entire surface is anticipated for this work. The surface texture of the concrete may affect this coverage rate.

(2) Mixing proportion. -

(a) Primer: 5.0 gallons vinyl ester resin
0.60 pound initiator
0.25 pound promoter

(b) Sealant: 5.0 gallons vinyl ester resin
1.35 pounds initiator
0.27 pounds promoter
40.0 pounds filler
4.0 pounds titanium dioxide pigment
0.02 pound carbon lamp black pigment

(3) Variations. - The proportions of cobalt napthenate promoter and cuemene hydroperoxide initiator were selected to give a 2- to 4-hour pot life at a temperature of about 70 EF. The rate of the polymerization reaction also depends on temperature - in colder weather the reaction will be slower, and in hot weather or in sunshine, the reaction will proceed faster. The temperature effects can be compensated for, to a certain extent, by increasing the total amount of initiator plus promoter in cold weather and decreasing the amount in hot weather.

Great care shall be exercised in proportioning the titanium dioxide and the carbon black to ensure exact color between batches of sealant layer.

The Contracting Officer may require variations from the proportions and quantities specified above and trial mixtures.

At no additional cost to the Government the Contracting Officer may require two trial mixtures utilizing a total of 5 gallons of vinyl ester resin with a proportional amount of other materials as indicated in subparagraph 3.10.g.(2). The Contractor shall supply, mix, and apply the trial polymer overlay where directed and in a manner as

indicated by these specifications. The Contracting Officer shall be given 12 hours' notice before a trial mix is applied.

(4) Mixing. - The filler, pigments, and cobalt napthenate promoter shall be mixed with vinyl ester resin in a paddle-type or rotating drum power mixer in advance of the application. Mixtures shall be prepared in maximum volumes of 5 gallons of resin per mixed batch.

The Contractor shall mix the required constituents, with the exception of the cuemene hydroperoxide, to the satisfaction of the Contracting Officer. The sealant material will then be required to set for 45 to 90 minutes for the filler and pigment to become thoroughly wetted by the vinyl ester resin. Just prior to use, the cuemene hydroperoxide initiator shall then be added and the sealant mixture mixed again to the Contracting Officer's satisfaction. CUEMENE HYDROPEROXIDE INITIATOR AND COBALT NAPTHENATE PROMOTOR SHALL NEVER BE ADDED TOGETHER DIRECTLY, OR AN INSTANTANEOUS AND VIOLENTLY EXPLOSIVE REACTION COULD OCCUR. For the primer, the setting period may be omitted, but the initiator must still be added after the first mixing of the promoter, then mixed again.

(5) Application. - The primer shall uniformly and completely cover the surface by being spread and scrubbed into the concrete surface with a paint roller, brush, or push broom. Discontinuities and puddles shall be eliminated by vigorous scrubbing action. The application rate of primer is expected to be 1 gallon per 50 to 75 square feet of surface area, but may vary due to texture of the prepared surface.

The pigmented sealant layers of the overlay material shall be applied not less than 4 and no greater than 24 hours after the application of the primer or succeeding sealant layer. The primer layer may not have completely cured during this time period. The sealant shall be applied to dry, primed surfaces, and provisions shall be taken to prevent wetting of the surfaces from rain or leakage and seepage of water. The sealant layers shall also be applied with a paint roller, brush, or push broom. The application rate of the sealant is expected to be 1 gallon per 50 to 75 square feet of surface area.

The primer and sealant layers shall be spread evenly and uniformly over the surface.

3.11 RESIN INJECTION

a. General. - When hardened concrete is cracked in depth or when hollow plane delaminations or open joints exist in hardened concrete and when structural integrity or watertightness must be restored for the structure to be serviceable, resin injection shall be used for repair, as directed.

However, since not all cracked, delaminated, or jointed concrete can be restored to serviceable condition by resin injection, resin injection repairs shall be made only as directed by the Contracting Officer.

Two basic types of injection resin are used to repair concrete:

(1) Epoxy resins are used to rebond cracked concrete and to restore structural soundness. Epoxy resins may also be used to eliminate water leakage from concrete cracks or joints, provided that cracks to be injected with epoxy resin are stationary. Cracks that are actively leaking water and that cannot be protected from uncontrolled water

inflow shall not be injected with epoxy resin. Cracks to be injected with epoxy resin shall be between 0.005 inch and 0.25 inch in width.

(2) Hydrophilic polyurethane resin is used to eliminate or reduce water leakage from concrete cracks and joints and can be used to inject cracks subject to some degree of movement. Hydrophilic polyurethane resin shall not be used to inject concrete cracks or joints when restoration of structural bond is desired. Cracks to be injected with polyurethane resin shall be 0.005 inch in width or greater.

Other types of injection resin are available for nonstandard or specialized repair applications. Use of these materials shall require specific approval of the Contracting Officer.

b. Submittals. - The Contractor shall provide the Contracting Officer with evidence that the Contractor is qualified to perform resin injection repairs. The data shall show that the Contractor has a minimum of 3 years of experience in performing resin injection work similar to that detailed in the drawings and specifications.

The Contractor shall submit a list of 5 projects in which resin injection was successfully completed. The list shall contain the following information for each project:

(1) Project name and location.

(2) Owner of project.

(3) Brief description of work.

(4) Date of completion of resin injection work.

If the repair work is performed by the Contractor's personnel under the supervision of the manufacturer's representative, the data shall show that the resin manufacturer has a minimum of 5 years' experience providing resin materials similar to those specified.

Manufacturer's brochures, technical data sheets, Material Safety Data Sheets, and any other information describing the polyurethane resin, the proper formulation to achieve the required tensile strength, bond strength, and elongation of the cured resin mixture, and recommended injection procedures shall be submitted to the Contracting Officer for approval at least 30 days prior to commencement of crack repairing operations.

The Contractor shall furnish the Contracting Officer a manufacturer's certification of conformance of the epoxy or polyurethane resin system with these specifications. The certification shall identify the Reclamation solicitation/specifications number(s) under which the resin is to be used and shall include the quantity represented, the batch numbers of the resin, and the manufacturer's results of tests performed on the resin system.

The Contractor shall submit a detailed proposal for epoxy injection repair to the Contracting Officer for approval. The approval will be based on the degree of conformance of the proposal with procedures contained in Reclamation's Concrete Manual, chapter 7, Eighth Edition, revised reprint, and the report of ACI Committee 503, section 7.2.5, "Use of Epoxy Compounds with Concrete."

The Contractor shall submit a detailed proposal for polyurethane resin injection repair to the Contracting Officer for approval. The approval will be based on the degree of conformance to the basic steps of polyurethane resin injection and on the Contracting Officer's judgment of the technical feasibility of the Contractor's proposal.

c. Quality assurance. - Quality assurance shall be in accordance with paragraph 1.4 and these specifications. The repair work may be performed by the Contractor or by the Contractor's personnel under the supervision of the resin manufacturer's representative. If the Contractor performs the repair work, the Contractor shall provide a full-time, onsite supervisor throughout the duration of the resin injection work.

If the repair work is performed by the Contractor's personnel under the supervision of the resin manufacturer's representative the Contractor shall have the resin manufacturer provide a representative who will train the Contractor's personnel on the proper techniques of injecting resin with an injection system approved by the manufacturer. Also, the Contractor shall provide a full-time, onsite, manufacturer-certified injection supervisor throughout the duration of the resin injection work.

d. Materials. -

(1) Epoxy resin. - Epoxy resin for injection shall meet the requirements of specification ASTM C-881 for a type I, grade 1 epoxy system. The class of the system shall be appropriate for the temperature of the application.

(2) Polyurethane resin. - The polyurethane resin system for injection into cracked concrete shall be a two-part system composed of 100 percent hydrophilic polyurethane resin and water. The polyurethane resin, when mixed with water, shall be capable of forming either a flexible closed-cell foam or a cured gel dependent upon the water-to-resin mixing ratio. The amount of water mixed with the polyurethane resin shall be such that the cured material meets the following physical properties:

(a) Minimum tensile strength -- 20 pounds per square inch.

(b) Bond to concrete (wet) -- greater than 20 pounds per square inch.

(c) Minimum elongation -- 400 percent.

The injection of pure polyurethane resin, not mixed with water, shall not be allowed.

e. Safety. - All work shall be performed in accordance with paragraph 1.6 and these specifications.

(1) Epoxy resins. - Certain additional safety precautions shall be employed when using uncured epoxy materials. Skin contact with uncured epoxy shall be avoided. Protective clothing, including rubber or plastic gloves, shall be worn by all persons handling epoxy materials. All exposed skin areas that may come in contact with the material shall be protected with a protective barrier cream formulated for that purpose. Adequate ventilation shall be provided and maintained at all times during use of epoxy and epoxy solvents. Fans used for ventilating shall be explosion proof. If necessary, respirators that filter organic fumes and mists shall be worn. All

epoxy-contaminated materials such as wipes, empty containers, and waste material shall be continually disposed of in containers which are protected from spillage. Epoxy spillage shall be immediately and thoroughly cleaned up. Appropriate solvents may be used to clean tools and spray guns, but in no case shall the solvents be incorporated in any epoxy resin or in the placing operation. Solvents shall not be used to remove epoxy materials from skin. Only soap, water, and rags shall be used for this purpose.

All tools shall be completely dried after cleaning and before reuse.

(2) Polyurethane resins. - Polyurethane injection resin systems contain either toluene diisocyanate or methylene dephenyl diisocyanate. Both isocyanates can create risks if safe handling procedures are not followed. The principal hazards arise from isocyanate vapor, which will irritate the membranes of the nose, throat, lungs, and eyes. Adequate ventilation is required to prevent vapor concentrations from approaching the Threshold Limit Value (TLV). Protective clothing, including rubber or plastic gloves and protective glasses, shall be worn by all persons handling polyurethane resins. If necessary, respirators that filter isocyanate vapors and mists shall also be worn. Monomeric urethane resins react with water to produce polyurethane and carbon dioxide gas. If this reaction occurs inside a closed container, excessive pressures can develop that may rupture the container. Care must be taken to prevent contamination of monomeric urethane resin with water.

Polyurethane resin spillage shall be immediately and thoroughly cleaned up. Spilled polyurethane resin can be absorbed in sand and removed for burial.

(3) Cleanup and disposal of injection resin. - All materials, tools, and containers contaminated with injection resin, surface sealers, or other contaminants shall be removed from the site for disposal in accordance with appropriate local or Federal regulations.

f. Concrete preparation. - The concrete surface to be repaired by resin injection shall be thoroughly cleaned of all deteriorated concrete, efflorescence, and all other loose material. The area to be injected shall then be thoroughly inspected and an injection port drilling and pumping pattern established.

Upon completion of resin injection, all excess material shall be removed from the exterior surfaces of the concrete. The final finished surfaces shall match the texture of the surfaces adjoining the repair areas.

g. Application of resin injection repairs to concrete. -

(1) Epoxy resin injection repair. - The process used for epoxy injection shall fill the entire crack or hollow plane delamination with liquid epoxy resin system and shall contain the resin system in the crack until it has hardened. The Contractor shall be responsible for drilling and removing three, a minimum of 2-inch-diameter cores from the injected concrete at locations determined by the Contracting Officer to determine the completeness of the injection repair. Injection shall be considered complete if more than 90 percent of the void is filled with hardened epoxy. If injection is not complete, reinjection and additional cores may be required at the direction of the Contracting Officer at no additional cost to the Government.

Epoxy injection repair methods shall be in accordance with the approved detailed proposal for epoxy injection repair and shall be adjusted to fit the repair situations encountered.

(2) Hydrophilic polyurethane resin injection repairs. - The process used for polyurethane injection of cracks or joints to reduce water leakage shall consist of the following basic steps:

(a) Intercept the water flow paths with valved drains installed into the concrete to control the leakage.

(b) Install injection ports by drilling holes designed to intersect the cracks at depth below the concrete surface. The maximum spacing of injection ports shall not exceed 60 inches, and closer spacing of ports may be required.

(c) All injection holes shall be flushed with clean water to remove drilling dust and loose debris and to clean the intersected crack line. Each drill hole shall be water tested at the resin injection pressure to determine if the crack intersection is open. Polyurethane resin shall not be pumped into a drill hole that refuses to take water at the resin injection pressure.

(d) Inject polyurethane resin system into cracks or joints at the minimum pressure required to obtain the desired travel, filling, and sealing. The mix water to resin ratio shall be 1:1 unless otherwise approved by the Contracting Officer. The Contractor should anticipate the necessity to provide a surface seal for the crack or joint to contain the injection resin. It may also be necessary to inject the crack or joint in an intermittent manner to achieve filling and sealing. Injection shall be by the method of split spacing unless otherwise approved by the Contracting Officer. Primary holes shall be drilled and injected on centers not exceeding 10 feet. Secondary holes, half way between the primary holes, will then be drilled and injected. If resin take occurs in the secondary holes, a series of tertiary holes, half way between the secondary and primary holes, shall then be drilled and injected. All holes shall be injected to absolute refusal.

(e) Remove drains, injection ports, and excess polyurethane upon completion of resin cure.

This process shall entirely stop the water leakage to a dust dry condition or as directed by the Contracting Officer.

The pump used to inject the polyurethane resin system shall be a two-component positive-displacement-type pump with static mixing head and pressure regulation necessary to control injection pressures while pumping low volumes. The equipment will be subject to approval by the Contracting Officer. The use of single component pumps and/or the injection of pure water followed by injection of pure resin will not be approved.

Polyurethane resin injection methods shall be in accordance with the approved, detailed proposal for injection repair and shall be adjusted to fit the repair situations encountered.

3.12 HIGH MOLUCULAR WEIGHT METHACRYLIC SEALING COMPOUND

a. General. - A concrete sealing compound is defined as a liquid that is applied to the surface of hardened concrete to prevent or decrease the penetration of liquid or gaseous media, such as water, aggressive solutions, and carbon dioxide, during the service exposure, preferably after initial drying to facilitate its absorption into voids and cracks.

The sealing of concrete surfaces with a high molecular weight methacrylic monomer-catalyst system and sand shall be in accordance with these specifications. Other types of concrete sealing compounds may be used by the Contractor only when approved by the Contracting Officer.

The high molecular weight methacrylic sealing compound shall not be used to seal concrete subject to frequent or permanent immersion in water; nor shall it be used on concrete surfaces exposed to high abrasion forces.

b. Submittals. - The Contractor shall provide the Contracting Officer a table showing preparation of initiator and promoter to be added to the monomer to achieve the cure time requirements based on concrete surface temperature. The temperature of the surface to be treated shall range from 45 to 100 EF. If it is desired to work outside these temperature ranges, approval of the Contracting Officer is required, and the monomer manufacturer should be consulted for technical advice.

A MSDS shall be furnished to the Contracting Officer prior to shipment of material with information pertaining to the safe practices for storage, handling and disposal of the materials and their explosive and flammable characteristics, health hazards, and the manufacturer's recommended fire fighting techniques. The MSDS shall be posted at all storage areas and at the job site.

The Contractor shall furnish, for approval, a detailed written description of the methods the Contractor plans to use for clean up of all spills and residue in open containers. See subparagraph 3.12.g.(4).

c. Quality assurance. - Quality assurance shall be in accordance with paragraph 1.4.

d. Materials. -

(1) High molecular weight methacrylic monomer. - The monomer shall be a high molecular weight or substituted methacrylate that conforms to the following properties:

(a)	Vapor pressure	Less than 1.0 mm HG @ 77 EF (ASTM D 323)
(b)	Flash point	Greater than 200 EF (Pensky-Martens CC)
(c)	Density	Greater than 8.4 lb/gal at 77 EF (ASTM D 2849)
(d)	Viscosity	12 ± 4 cps (Brookfield No. 1 Spindle 60 rpm, at 73 EF)
(e)	Index of refraction	1.470 ± 0.002
(f)	Boiling point @ 1 mm Hg, degrees F	158

(g) Shrinkage on cure -less than- 11%

(h) Glass transition temperature (DSC), degrees F. 135 EF (ASTM D 3418)

(i) Curing time (100 g mass) Greater than 40 minutes at 77 EF, with 4% cuemene hydroperoxide (ASTM D 2471)

(j) Bond strength greater than 1,500 lb/in^2 (ASTM C 882)

(k) No unreactive solvents or diluents shall be permitted in the monomer system.

(2) Initiator-promoter system. -

(a) Initiator Cuemene hydro peroxide - 78 percent

(b) Promoter Cobalt Napthenate - 6 percent

The initiator/promoter system shall be capable of providing a surface cure time of not less than 40 minutes nor more than 3 hours at the surface temperature of the concrete during application. The initiator/promoter system shall be such that the gel time may be adjusted to compensate for changes in temperature that may occur throughout the treatment application.

(3) Sand. - The sand shall be clean, dry, and free of organic materials, silt, and clay. Except as otherwise approved by the Contracting Officer, the sand shall conform to the following grading:

U.S. standard sieve size	Percent passing
4.75 mm (No. 4)	100
2.36 mm (No. 8)	90-10
850 µm (No. 20)	5-10
300 µm (No. 50)	0-10

This grading is intended to allow the use of commercially available silica sands of No. 8/20 or No. 10/20.

e. Safety. - All work shall be performed in accordance with the requirements of paragraph 1.6 and these specifications. The materials shall be stored, handled, and applied in accordance with the manufacturer's recommendations. Storage of all materials shall be in the original shipping containers and as specified in this paragraph.

INITIATORS AND PROMOTERS SHALL BE STORED SEPARATELY SINCE COMBINATION CAN RESULT IN A VIOLENT REACTION OR EXPLOSION.

Personnel exposed to monomer, initiator, or promoter, or their vapors shall use minimum protective equipment as follows: safety eye glasses, impervious gloves and aprons, and rubber boots as required. As determined by the Contracting Officer, personnel may be required to use full-face protective shields, self-contained respiratory equipment, or both. All personnel handling the monomer or catalysts shall be thoroughly trained in their safe use in accordance with the manufacturer's recommendations.

Unsafe handling practices will be sufficient cause to discontinue work until the hazardous procedures are corrected. The handling and use of

the monomer and catalysts shall in all cases comply with the requirements of applicable Federal, State, and local safety requirements and ordinances.

The Contractor shall provide an eye wash and water washing facility for use in the event of accidental splashing of the monomer or catalysts on the workers. Eyewash facility shall be capable of providing a clean, room temperature flushing stream for a minimum of 15 minutes. All sources of sparks or flame must be removed from areas used for storage and handling. In these areas storage and mixing vessels shall be provided with electrical grounds to prevent static sparks.

Mixing and transfer equipment shall be explosion proof, and sufficient ventilation shall be provided to prevent the formation of explosive sealant/air mixtures. In accordance with applicable safety regulations, warning signs, such as "No Smoking" signs, shall be posted. In public areas, care shall be taken to eliminate sources of sparks or flame when the monomer system is present. Particular attention should be given to removal of welding operations, posting of "No Smoking" signs, and to traffic control to eliminate accidental fires from these sources. Visitors at the job site should be warned of the potential hazards and provided with applicable safety equipment. The Contractor shall also place an adequate number of 4-A:60B:C fire extinguishers on the job, so that no portion of the monomer system application is conducted farther than 100 feet from the nearest fire extinguisher.

f. Concrete preparation. - The concrete surfaces to be treated shall be clean, dry, and physically sound. All deteriorated concrete shall be removed in accordance with paragraph 2.1 to obtain a physically sound surface for treatment. The Contractor shall perform all work required to bring the surfaces to this condition.

Concrete surfaces shall then be prepared by power sweeping and by blowing with high-pressure air to remove all dirt and foreign material from the surface and from all cracks. Contaminants, such as asphalt and heavy oil and rubber stains, shall be removed, at the discretion of the Contracting Officer, by scraping and cleaning with solvents. Well-bonded surface contaminants and existing painted surfaces shall be removed by wet sandblasting. High-pressure water blasting will be permitted only if it can be demonstrated to the satisfaction of the Contracting Officer that the concrete surface and cracks can be completely dried prior to the application of the polymer treatment.

g. Application. - The methacrylic concrete sealing compound shall be mixed, applied to the prepared concrete surface, and cured in accordance with these specifications.

(1) Mixing of materials. - The monomer shall be mixed with initiator and promoter in the following proportions (proportions may be adjusted by the Contracting Officer to give a satisfactory pot life based on concrete surface temperatures and recommendations of the monomer system manufacturer):

		Parts by weight
(a)	Substituted Methacrylate Monomer	100
(b)	Cuemene Hydroperoxide (78%)	4.0

(c) Cobalt Napthenate (6%) 2.0

DO NOT MIX COBALT NAPTHENATE DIRECTLY WITH CUEMENE HYDROPEROXIDE AS THIS WILL PRODUCE AN EXTREMELY VIOLENT AND EXPLOSIVE CHEMICAL REACTION.

The cobalt napthenate and cuemene hydroperoxide shall be mixed with the substituted methacrylate monomer in separate steps; i.e., first add and mix cobalt napthenate with the substituted methacrylate monomer, and then add and mix the cuemene hydroperoxide with the cobalt napthenate/ methacrylate monomer mixture.

The materials shall not be premixed. The monomer system shall be applied to the concrete surface within 5 minutes after mixing the cuemene hydroperoxide with the cobalt napthenate/substituted methacrylate monomer mixture.

For manual application, the quantity of monomer system mixed shall be limited to 5 gallons at a time. A significant increase in viscosity or change in gel time prior to application shall be cause for rejection.

Machine mixing and application of the methacrylic sealing compound may also be performed by using a two-part monomer system utilizing a promoted monomer for one part and an initiated monomer for the other part. Adequate mixing shall be done to achieve a uniform blend of the two parts.

The use of machine mixing and application requires approval by the Contracting Officer and treatment of a 10- by 50-foot test site to demonstrate that the equipment is working properly and capable of providing a uniform monomer mixture.

(2) Application of sealing compound. - Prepared surfaces shall be protected from rain and moisture. Surfaces shall be treated with sealing compound within 24 hours after surface preparation is completed. The surface shall be allowed to dry thoroughly for a minimum of 48 hours before treatment. At the discretion of the Contracting Officer, the following test shall be made to determine if the concrete surface is sufficiently dry to proceed with the polymer treatment. A 2-foot-square piece of clear polyethylene sheeting shall be taped to the surface of the concrete and allowed to remain there for a minimum of 2 hours exposed to sunlight. Moisture condensation on the inside surface of the polyethylene sheeting shall be considered as evidence that the concrete surface is not sufficiently dry, and an additional period for drying will be required before proceeding with the polymer treatment. Additional tests may be required, at the discretion of the Contracting Officer.

The monomer system shall be applied to the concrete surfaces during nighttime and early morning hours as directed by the Contracting Officer and with concrete temperatures between 45 and 85 EF. Monomer application will not be permitted in the direct rays of the sun as this may cause a premature curing of the system.

The concrete surfaces shall be treated with monomer at an application rate of 75 to 100 square feet per gallon. The concrete surfaces shall be flooded with the monomer mixture, allowing full penetration of the concrete and filling all cracks, and brushed with a stiff bristle broom. Puddles of excess monomer shall be removed by the Contractor.

The sealing compound may also be spray-applied by machine using a two-part mixing procedure described in subparagraph 3.12.g.(1). The pressure at the spray nozzle shall not be great enough to cause monomer mist to drift more than 2 feet beyond the nozzle. Compressed air shall not be used to produce the spray.

(3) Application of sand and curing. - Within 15 to 20 minutes after application of the methacrylic sealing compound, and before significant gelling has occurred, the entire treated area of concrete shall be covered by sand broadcast to achieve a uniform coverage of 0.25 to 0.50 pound per square yard. This sand shall be left on the concrete surface until the sealing compound has cured to a tack-free condition. Any excess sand, not bonded to the concrete, shall then be removed by the Contractor. Sand shall not be applied to vertical surfaces that have been treated with methacrylic sealing compound.

Treated areas shall be protected and not put back into service for 24 hours after treatment to allow the sealing compound to fully cure.

(4) Cleanup. - The Contractor shall keep the mixing equipment and tools clean during the course of the treatment, using a suitable solvent such as acetone or methyl ketone (both flammable), or 1,1,1,-trichloroethane (nonflammable). Soap and water are also satisfactory for cleanup of fresh monomer from the tools. The Contractor shall quickly clean up all spills by a method previously approved by the Contracting Officer.

After the repair work is completed, the residue in the open containers of cuemene hydroperoxide and cobalt napthenate shall be safely destroyed by using some of the excess monomer resin to wash out the catalyst containers and then allow it to cure before disposal or by other methods recommended by the manufacturers and approved by the Contracting Officer.

3.13 SURFACE IMPREGNATION

a. General. - These specifications present the requirements for impregnating concrete with a methyl methacrylate based monomer-catalyst system followed by in situ polymerization of the monomer by heat.

b. Submittals. -

(1) The Contractor shall provide the Contracting Officer with the manufacturer's certifications that the monomers and catalyst meet these specifications. Representative samples of the monomer system components, or of the combined monomer system if purchased premixed, shall be delivered to the Contracting Officer at least 30 days prior to use. At the Contracting Officer's option, these samples will be tested to determine specifications compliance.

(2) At least 30 days prior to beginning the concrete impregnation process, the Contractor shall deliver to the Contracting Officer a written report describing the Contractor's planned treatment procedures. Included in this report shall be a detailed description of the drying, impregnation, monomer mixing and storage, polymerization and quality control procedures, facilities, and equipment the Contractor intends to use to treat the concrete. The Contracting Officer will review this report and approve or disapprove the plan within 30 days of the date of receipt. In no event shall the Contractor proceed with the surface impregnation treatment until

approval of the Contractor's procedures, materials, and equipment has been received.

(3) During the drying, cooling, impregnation, and polymerization cycles, the Contractor shall obtain and supply to the Contracting Officer concrete temperature data accurate to ±5 EF from at least nine points uniformly spaced on the surface of each treatment area and from at least one point 1 inch below the concrete surface at the approximate center of each treated area.

These data shall be in the form of a continuous record or periodic readings recorded at 1-hour intervals. The technique and equipment used to obtain the temperature data required in subparagraph 3.13.g.(1) shall be described in the written procedures report required above and subject to the Contracting Officer's approval.

(4) The Contractor shall maintain and supply to the Contracting Officer monomer and catalyst records listing the dates of manufacture, storage temperatures, date of use and application rates, and quantities as applied to the concrete.

c. Quality assurance. - Quality assurance shall be in accordance with paragraph 1.4 and these specifications. Representative material samples submitted by the Contractor, as specified in subparagraph 3.13.b.(1) will be tested, at the Contracting Officer's option.

d. Materials. -

(1) Monomer system. - The monomer system shall be composed of 95 percent by weight methyl methacrylate (MMA) and 5 percent by weight trimethlolpropane trimethacrylate (TMPTMA). A polymerization catalyst, 2,2-azobis-(2,4-dimethylvaleronitrile), shall be added to this monomer system at the rate of 1 part catalyst to 200 parts monomer by weight, or as directed by the Contracting Officer.

(a) MMA. - MMA shall meet the following requirements:

Formula	$CH_2=C(CH_3)C00CH_3$
Inhibitor	25 parts per million hydroquinone (HQ)
Molecular weight	100
Assay (Gas Chromatography) %	99.8 min
Density	7.83 lb/gal (0.938 kg/L)
Boiling	212 EF (100 EC)
Flash point (Tag, ASTM D 1310)	55 EF (13 EC)

(b) TMPTMA. - TMPTMA shall meet the following requirements:

Formula	$(CH_2=CH_3\ COOCH_2)_3CCH_2CH_3$
Inhibitor	100 parts per million hydroquinone (HQ)

Assay, %	95.0 min
Density	8.82 lb/gal (1.058 kg/L)
Flash point	Greater than 300 EF (149 EC)

(c) The polymerization catalyst shall be 2,2-azobis-(2,4-dimethyl-valeronitrile). Empirical formula: $C_{14}H_{24}N_4$.

Monomer system components shall be used within 6 months after manufacture.

(2) Sand. - The impregnation sand shall be composed of clean, hard, dense, low-absorptive particles that will pass a 1.18-mm (No. 16) sieve, but with not more than 5 percent passing a 150 µm (No. 100) sieve.

e. Safety. - All work shall be performed in accordance with paragraph 1.6 and these specifications. Because of the hazards associated with improper use and handling of the monomer and catalyst, the following additional safety requirements shall be adhered to during the surface impregnation process.

Personnel working with the monomers or catalyst shall be provided with and use safety eyeglasses or goggles, impervious gloves, aprons, and boots. Normally, in an outdoor monomer application, respiratory equipment will not be necessary. In storage and mixing operations, however, accidental spills or equipment failures may result in hazardous vapor concentrations requiring self-contained respiratory equipment for personnel protection. The Contractor shall provide a field eye wash and water washing facility for use in the event of an accidental splash of monomer on the workers. Eye wash facility shall be capable of providing a clean, room temperature flushing stream for a minimum of 15 minutes.

All sources of sparks or flame shall be removed from areas for monomer storage and handling. In these areas monomer storage and mixing vessels shall be provided with electrical grounds to prevent static sparks. Mixing and transfer equipment and motors shall be explosion proof, and sufficient ventilation shall be provided to prevent the formation of explosive monomer vapor-air mixtures. In accordance with applicable safety regulations, warning signs such as "No Smoking" regulations shall be posted. At the construction site, care shall be taken to eliminate sources of sparks or flame when monomer is present. Particular attention shall be given to removal of welding operations, posting of "No Smoking" signs, and to traffic control to eliminate accidental fires from these sources. Visitors at the job site shall be warned of the potential hazards and provided with applicable safety equipment.

Catalyzed monomer not used within 4 hours of catalyst addition shall be stored in an explosion proof storage facility at a maximum storage temperature of 0 EF until it can be used or destroyed as approved by the Contracting Officer. Storage of catalyzed monomer for periods longer than 2 days will not be permitted.

Monomer and catalyst storage and handling. - The monomers, MMA and TMPTMA, or the premixed monomer system shall be stored in their original shipping containers or in other clean containers as approved by the Contracting Officer. Maximum monomer storage temperature shall not exceed 90 EF. The storage area shall be selected to provide protection from direct sunlight, fire hazard, and oxidizing chemicals. Sufficient

ventilation shall be maintained in the storage area to prevent the hazardous buildup of monomer vapor concentrations in the storage air space. The polymerization catalyst shall be stored in accordance with the manufacturer's recommendations, but in no event shall the catalyst storage temperature be allowed to exceed 35 EF. Personnel exposed to monomer or monomer vapor shall use minimum protective equipment as follows: safety eyeglasses, impervious gloves and aprons, and rubber boots as required. As determined by the Contracting Officer, personnel may be required to use full face protective shields, self-contained respiratory equipment, or both. All personnel handling the monomers or catalyst shall be thoroughly trained in their safe use in accordance with manufacturer's recommendations.

Unsafe handling practices will be sufficient cause to discontinue work until the hazardous procedures are corrected. The handling and use of monomer shall in all cases comply with the requirements of applicable Federal, State, and local safety requirements and ordinances.

During the polymerization cycle, the heating enclosure shall be provided with a means of positive ventilation to prevent hazardous concentrations of monomer vapor within the enclosure. Open flame heat sources will not be approved for use during polymerization.

The monomer mixing area shall be free of sources of ignition and shall be well ventilated. Spilled monomer shall be contained with absorptive materials such as vermiculite or dry sawdust and removed with non-sparking equipment.

f. Concrete preparation. - Deteriorated concrete shall be removed from the surface by wet sandblasting or other suitable means. Concrete containing surface contaminants such as oil, paint, or protective coatings shall be cleaned by wet sandblasting or by other approved means to remove these materials. After the removal of these materials, the concrete surface shall be swept and air-blown to remove sand, leaves, trash, gravel, or other miscellaneous loose materials to the satisfaction of the Contracting Officer.

The Contractor shall install a temporary dike along the high side of the area to be impregnated to divert possible rainwater around the area to be impregnated. The Contractor shall also install a temporary dike along the low side of the area to be impregnated to act as a barrier to prevent monomer from accidentally escaping due to an accidental spill or excess application.

g. Application of the surface impregnation process. -

(1) Drying. - After the concrete surface area to be treated has been cleaned in accordance with subparagraph 3.13.f., it shall be uniformly covered with a 1/4- to 1/2-inch thick layer of sand meeting the requirements of subparagraph 3.13.d.(2) and dried to permit polymer penetration. The equipment used to accomplish drying shall consist of a weatherproof enclosure with either an electric infrared, or hot-air heat system, or other technique as approved by the Contracting Officer. Exposed flame infrared heat systems, if selected for drying, shall not be used for polymerization.

Drying shall be accomplished by raising the concrete surface temperature at a rate not exceeding 100 EF per hour to between 250 and 275 EF, and maintaining that surface temperature range for 8 hours. If a higher maximum temperature is desired, approval by the

Contracting Officer shall be obtained. During the drying period, sufficient airflow shall be maintained over the concrete surface to ventilate the water vapor removed from the concrete and to provide uniform concrete surface temperature. During the drying cycle, the Contractor shall obtain continuous or periodic surface temperature measurements, as specified in subparagraph 3.13.b.(3), at a sufficient number of locations over the heated concrete surface [normally one location per 100 square feet] to ensure temperature uniformity. The maximum temperature variation over the heated concrete surface shall not exceed ±20 EF of mean concrete surface temperature at the time measurements are taken.

(2) Cooling. - After the concrete has been dried, it shall be cooled prior to monomer application. The cooling rate for concrete surface temperature shall not exceed 100 EF per hour. Cooling shall continue until the maximum temperature at a depth of 1 inch below the surface of the concrete is 100 EF or less.

During the cooling and impregnation cycles, the dried concrete shall be protected to prevent moisture from reentering the concrete. It may be necessary, if determined by the Contracting Officer, to repeat the drying and cooling cycles prior to monomer application should moisture reenter the concrete.

(3) Monomer mixing. - The monomer MMA and TMPTMA may be premixed in the specified ratio and stored prior to use. Storage of premixed monomer shall be as required in subparagraph 3.13.e. All monomer mixing and transfer equipment shall be as required in subparagraph 3.13.e. All monomer mixing and transfer equipment shall be of explosion proof design and shall be provided with electrical ground cables. Monomer transfer shall be from bottom to bottom of the vessels or through dip pipes in the vessels to prevent the buildup of static charge during transfer. Pipe fittings, valves, pump impellers, or other equipment which will come into contact with monomer shall not be made of copper or brass or certain plastics attacked by the monomer.

(4) Catalyst-monomer mixing. - The polymerization catalyst shall be mixed with the monomer system immediately prior to use. Monomer system temperature at the time of catalyst addition shall not exceed 90 EF. Mixing shall be accomplished with explosion proof equipment in electrically grounded containers in a well-ventilated area.

(5) Impregnation. - Following the drying and cooling cycles, the sand on the concrete surface to be impregnated shall be uniformly leveled if necessary.

The temperature on the surface of the concrete shall not exceed 100 EF at the time of monomer application nor at any time during the impregnation cycle.

Monomer application shall be made at a rate sufficient to uniformly saturate the sand layer to a slight excess without applying so much monomer that it would drain away from the impregnated area. The monomer application rate should be 0.8 pound of monomer per square foot of concrete surface. This is approximately 0.9 gallon per square yard of surface area. However, sand layer thickness, sand particle size, and slope may necessitate application rate adjustment to achieve the described saturation. Following application, the monomer shall be allowed to soak into the concrete for approximately 6 hours. If at

any time during the soak cycle the sand should become dry, additional monomer shall be applied as directed by the Contracting Officer.

In order to protect the monomer-saturated sand from the polymerizing effects of direct and indirect solar radiation, monomer application and subsequent soaking shall occur during the time period sunset to sunrise unless the Contractor provides shielding, as approved by the Contracting Officer, to prevent solar radiation from reaching the area being impregnated. Immediately following monomer application, a continuous mylar membrane a minimum of 6 mils thick shall be placed over the monomer-saturated surface to reduce monomer evaporation. This membrane shall remain in place, except for the short periods of monomer application or surface inspection, throughout the impregnation cycle and until the polymerization cycle is complete.

(6) Polymerization. - Polymerization of the monomer impregnated into the concrete shall be accomplished by uniformly heating the treated concrete to a surface temperature of at least 165 EF and not exceeding 185 EF and maintaining it for a minimum of 5 hours. The rate of temperature increase and allowable surface temperature variation shall be as required in subparagraph 3.13.g.(1).

The equipment and procedures used to accomplish heating of the concrete for polymerization shall be of the type described in subparagraph 3.13.g.(1) as approved by the Contracting Officer. See subparagraph 3.13.b.

(7) Cleanup. - Following completion of the surface impregnation treatment process, the Contractor shall remove the sand from the concrete surface and dispose of the sand at the site as directed by the Contracting Officer.

3.14 SILICA FUME CONCRETE

a. General. - Silica fume concrete shall be used to repair concrete damaged by abrasion-erosion action. Silica fume concrete may also be used in the infrequent occasions where a high strength (compressive strength in excess of 10,000 lbs per square inch) repair concrete is required. Silica fume concrete shall be used on areas of damaged concrete greater than 1 square foot having a depth greater than 6 inches or a depth extending 1 inch below or behind the backside of reinforcement. If the depth of repair is at least 2 inches but less than 6 inches, epoxy bonding agent shall be used in accordance with the provisions of paragraph 3.8, to bond fresh silica fume concrete to concrete being repaired. Silica fume concrete shall not be used for repairs that are less than 2 inches in depth.

b. Submittals. - The Contractor shall submit certification of compliance for materials in accordance with subparagraph d. below.

c. Quality assurance. - Quality assurance shall be in accordance with paragraph 1.4.

d. Materials. - All concrete materials shall be obtained from previously tested and approved sources. Materials will be accepted on certificate of compliance with the following ASTM Standards:

(1) Portland cement. - Portland cement shall meet the requirements of ASTM C 150 for type I, II, or V cement. The specific cement type

shall be as directed by the Contracting Officer and determined by the environment in which the repair is conducted.

(2) Silica fume. - The silica fume mineral admixture shall be obtained as a byproduct from the manufacture of solely silicon metal in electric blast furnaces. The condensed silica fume shall be processed and sized to a fineness of approximately 200,000 cm^2 per gm (20,000 m^2/kg) at a porosity (t) of 0.500 when tested in accordance with ASTM C 204 and have an amorphous silica ($Si0_2$) content of not less than 85 percent of the total fume. When tested in accordance with ASTM C 311, the silica fume shall have a moisture content of less than 3 percent and a loss on ignition of not greater than 6 percent. A manufacturer's certificate of compliance with these requirements and applicable provisions of ASTM C 618 is required. The silica fume shall be supplied, proportioned and combined with other admixtures, as necessary, from a supplier regularly engaged in the sale of this combination product as a concrete admixture. This combination admixture shall be batched with the concrete in either of two forms or types.

(a) The wet type shall consist of water slurry containing approximately 45 percent silica fume solids with a water-reducing admixture meeting all requirements specified.

(b) The dry form shall be a densified powder blended with a dry water reducing admixture. Both types shall be compatible with a water reducing admixture that could be added at the concrete plant or at the placement site.

(3) Admixtures. - The Contractor shall furnish air-entraining and chemical admixtures for use in concrete.

(a) Air-entraining admixture shall be used in all silica fume concrete and shall conform to ASTM C 260.

(b) Chemical admixtures. - The Contractor may use type A, D, F, or G chemical admixtures. If used, they shall conform to ASTM C 494.

(c) Use of other admixtures must be approved by the Contracting Officer.

(4) Water. - The water used in making and curing silica fume concrete shall be free from objectionable quantities of silt, organic matter, salts, and other impurities.

(5) Aggregate. - The term "sand" is used to designate aggregate in which the maximum size particle will pass a 4.75-mm (No. 4) sieve. The term "coarse aggregate" is used to designate all aggregate which can be retained on a 4.75-mm (No. 4) sieve. Sand and coarse aggregate meeting the requirements of ASTM C 33 shall be used in all concrete.

(6) Curing compound. - Wax-base (type I) and water-emulsified resin-base (type II) curing compounds shall conform to the requirements of Reclamation's "Specifications for Concrete Curing Compound" (M-30) dated October 1, 1980.

(7) Evaporation retarder. - Monomolecular membrane evaporation retardant formulated for use with silica fume concrete requirements shall be equal to "Confilm", manufactured by Master Builders, Lee at Mayfield, Cleveland, OH 44118.

e. Safety. - All work shall be performed in accordance with paragraph 1.6.

f. Concrete preparation. - After damaged or unacceptable concrete has been removed as specified in section 2. the surface on which the silica fume concrete will be placed shall be prepared. An acceptable surface shall have the appearance of freshly broken, properly cured concrete. The surface shall be free of any deleterious materials such as free moisture, ice, petroleum products, mud, dust, carbonation, and rust. The perimeters of the repair shall be saw cut to a minimum depth of 1 inch.

The clean surface is not ready to receive repair silica fume concrete until it has been brought to a saturated, surface-dry condition. This condition is attained by saturating the surface to a depth that no concrete mixture water may be absorbed from the fresh concrete. Then, just prior to placing concrete against the surface, all free moisture (moisture capable of reflecting light) shall be removed from the prepared surface.

g. Application. - Silica fume concrete shall be composed of cement, silica fume, coarse aggregate, sand, water, and approved admixtures, all well mixed and brought to the proper consistency. Silica fume concrete mixtures shall be proportioned in accordance with Reclamation's "Concrete Manual", Eighth Edition, revised, chapter III, except that silica fume shall be added to the mixture at a ratio of 7 to 12 percent by mass of the portland cement as directed by the Contracting Officer. The water-cementitious ratio of the concrete (exclusive of water absorbed by the aggregates) shall not exceed 0.35 by weight. Slump of the silica fume concrete, when placed, shall not exceed 3 inches for concrete in slabs that are horizontal or nearly horizontal and 4 inches for all other concrete. Silica fume concrete with less slump should be used when it is practicable to do so. The concrete ingredients shall be thoroughly mixed in a batch mixer. The concrete, as discharged from the mixer, shall be uniform in composition and consistency from batch to batch.

(1) Forms. - Forms shall be used for silica fume concrete whenever necessary to confine the concrete and shape it to the required lines. The forms shall be clean and free from encrustations of mortar, grout, or other foreign material. Before silica fume concrete is placed, the surfaces of the forms shall be coated with a form oil that will effectively prevent sticking and will not soften or stain the concrete surfaces or cause the surfaces to become chalky or dust producing.

(2) Placing. - Placing of silica fume concrete shall be performed only in the presence of an authorized representative of the Contracting Officer. Placement shall not begin until all preparations are complete and the authorized representative of the Contracting Officer has approved the preparations. Silica fume concrete shall not be placed in standing or running water unless, as determined by the Contracting Officer, the structure under repair cannot be economically dewatered. If underwater silica fume concrete placement is required, special placing procedures shall be required. A suggested guide is ACI 394R.

When appropriate, silica fume concrete shall be placed in layers not greater than 20 inches thick. Each layer, regardless of the thickness, shall be adequately consolidated using immersion-type vibrators or form vibrators when approved. Adequate consolidation of silica fume concrete is obtained when all undesirable air voids,

including the air voids trapped against forms and construction joints, have been removed from the concrete.

(3) Finishing. - The class of finish required shall be a finish closely resembling the finish of the surrounding concrete. Silica fume concrete does not normally develop bleed water and special finishing procedures may thus be required. The ambient temperature of surfaces being finished shall be not less than 50E F. Immediately following placement of silica fume concrete to finished grade, the surface shall be screeded to bring the surface to finished level with no coarse aggregate visible. No cement or mortar shall be added to the finishing operation.

A monomolecular membrane evaporation retarder shall be applied to the surfaces of the silica fume concrete, in accordance with manufacturer's recommendations, immediately after the screening operation.

Floating, if necessary to achieve the specified finish, shall be performed immediately following the application of evaporation retarder.

h. Curing and protection. - Proper curing of silica fume concrete is essential if bond failure and shrinkage cracking are to be eliminated. Silica fume concrete repairs shall be cured, preferably by water curing, or alternately, by application of a uniform and continuous membrane of wax-base (type I) or water-emulsified resin-base (type II) curing compound meeting the requirements of subparagraph 3.6.d.(6). and as approved by the Contracting Officer. If the use of curing compound is approved, daily inspection by the Contractor shall be performed to ensure the maintenance of a continuous, water-retaining film over the repaired area. The water-retaining film shall be maintained for 28 days after the concrete has been placed.

Silica fume concrete surfaces to which curing compound has been applied shall be adequately protected during the entire curing period from pedestrian and vehicular traffic and from any other possible damage to the continuity of the curing compound membrane. Areas where curing compound is damaged by subsequent construction operation within the curing period shall be resprayed.

Water curing shall commence immediately after the concrete has attained sufficient set to prevent detrimental effects to the concrete surface. The concrete surface shall be kept continuously wet for a minimum of 14 days. Whenever possible, silica fume concrete shall be water cured by complete and continuous inundation for a minimum period of 14 days.

The Contractor shall protect all silica fume concrete against damage until acceptance by the Government. Whenever freezing temperatures are imminent, the Contractor shall maintain the newly placed repair concrete at a temperature of not less than 50 EF for 72 hours. Water-cured silica fume concrete shall be protected from freezing for the duration of the curing cycle and an additional 72 hours after the water is removed.

3.15 ALKYL-ALKOXY SILOXANE SEALING COMPOUND

a. General. - A concrete sealing compound is defined as a liquid that is applied to the surface of hardened concrete to prevent or decrease the penetration of liquid or gaseous media, such as water, aggressive

solutions, and carbon dioxide, during the service exposure, preferably after initial drying to facilitate its absorption into voids and cracks. An alkyl-alkoxy siloxane sealing compound, herein after referred to as siloxane, shall be applied to concrete surfaces when it is desired that application of a sealing compound cause no change in the appearance of the sealed surfaces.

The sealing of concrete surfaces with siloxane shall be in accordance with these specifications.

Siloxane sealing compound shall not be used to seal concrete subject to frequent or permanent immersion in water; nor shall it be used on concrete surfaces exposed to high abrasion forces.

b. Submittals. - The Contractor shall, before starting work, shall submit to the Contracting Officer manufactures data and certification that the concrete cleaner and siloxane sealing compound furnished by the Contractor meets the requirements of this specifications. The chemical constituents shall correspond to the requirement of subparagraph 3.15.d.

A MSDS shall be furnished to the Contracting Officer prior to shipment of material with information pertaining to the safe practices for storage, handling and disposal of the materials and their explosive and flammable characteristics, health hazards, and the manufacturer's recommended fire fighting techniques. The MSDS shall be posted at all storage areas and at the job site.

The Contractor shall furnish, for approval, a detailed written description of the methods the Contractor plans to use to apply the siloxane and for clean up of all spills and residue in open containers.

c. Quality assurance. - Quality assurance shall be in accordance with paragraph 1.4.

d. Materials. - The siloxane sealing compound shall be a clear, ready to use sealer based on oligomeric alkyl-alkoxy siloxane containing not less than 20 percent active siloxane solids by mass.) The compound when properly applied to concrete shall conform to the following performance standard:

Chloride screening	91% (minimum)	(NCHRP 224, Series I)
Reduction of Chlorine Penetration vs untreated concrete	92.4(minimum)	(NCHRP 224, Series IV)
Moisture Vapor Transmission	97.5%(minimum)	(ASTM E-96)
Water Repellency Rating	92%(minimum)	(ASTM C-140, ASTM C-67)
Water Absorption	1.40%(maximum)	(ASTM C-67, ASTM C-140)
Scaling Resistance to Deicers	Excellent	(ASTM C-672)
Resistance to Chlorine Penetration	0.07 lbs/cu.yd. (maximum)	(AASHTO T-259/260)
Surface Friction Reduction	0	(ASTM E-303)
Penetration (1 application)	1/8" - 1/4"	

The compound shall have a high flash solvent carrier with a strong chloride screen and shall exhibit alkaline stability and form a chemical bond with the treated concrete.

The concrete sealing compound shall be Consolideck SX as manufactured by ProSoCo Inc., P.O. Box 1578, Kansas City, KS 66117, (913) 281-2700, or approved equal.

e. Safety. - The Contractor shall take the necessary precautions to avoid wind drift onto auto and pedestrian traffic. The materials shall be stored, handled, and applied in accordance with the manufacturer's or supplier's recommendations. Storage of all materials may be in the original shipping containers. The material should be stored in sealed containers and kept away from extreme heat. The sealant contains blended solvents and should be handled accordingly. Do not use near fire or extreme heat and provide good ventilation to avoid buildup of solvent fumes. Personnel applying the concrete sealant shall wear NIOSH/MSHA approved respirators, goggles, rubber gloves, and plastic or rubber suits to avoid splash to skin and eyes. Clothing that becomes contaminated with the concrete sealant shall be changed as quickly as possible.

Unsafe handling practices will be sufficient cause to discontinue work until the hazardous procedures are corrected. The handling and use of the concrete sealant shall in all cases comply with the requirements of applicable federal, state, and local safety requirements and ordinances.

f. Concrete preparation. - The concrete surfaces to be treated shall be clean and physically sound. Unsound or deteriorated surfaces shall be removed in accordance with the requirements of section 2. All needed repair work shall be adequately cured prior to application of the siloxane.

Concrete surfaces shall be prepared by power sweeping and blowing with high pressure air to remove all dirt and foreign material from the surface and from all cracks. Contaminants, such as asphalt and heavy oil and rubber stains, shall be removed at the discretion of the Contracting Officer by scraping and cleaning with solvents. Well bonded surface contaminants and existing painted surfaces shall be removed by high pressure water blasting or wet sand blasting. The concrete surface and all cracks shall be completely dried prior to the application of the siloxane.

g. Application. - If the concrete sealant is a product other than Consolodeck SX, a test application of the concrete sealant shall be made to an area selected by the Contracting Officer using the same equipment and procedures proposed for the project. The test procedure is to insure compatibility of the product, to determine the waterproofing results and to check for surface discoloration from the procedure. The Contractor shall not proceed with the remainder of the work until the Contracting Officer approves the results of the test application. If the results of the test application are deemed unsatisfactory by the Contracting Officer, the Contractor shall modify his sealant materials, procedure, and/or equipment as directed by the Contracting Officer and the test application shall be repeated.

The siloxane sealant shall not be applied at surface and air temperatures below 40 degrees F, or above 100 degrees F. Surfaces shall be treated within 24 hours after the surface preparation is completed. The prepared surfaces shall be maintained in a dry condition and protected to prevent contamination prior to the siloxane application. If the prepared surface becomes contaminated, it shall be recleaned in accordance with paragraph 3.15.f. The Contracting Officer shall determine if the surface is dry enough to receive sealant. If the Contracting Officer determines that the surface is too damp for application of the sealant, application of the sealant shall not commence without approval of the Contracting Officer.

The sealant shall be applied with low pressure (20) psi airless spray equipment fitted with solvent resistant hoses and gaskets. Heavily

saturated brush or roller may be used in isolated incidents if the Contracting Officer determines that brush or roller application is the most effective means.

Adjoining glass, metal and painted surfaces shall be protected from overspray and splash of the siloxane sealant. Any accidental or unintentional overspray or splash on adjoining glass, metal or painted surfaces shall be removed using mineral spirits before the solution has dried on the surface.

When applying to exteriors of occupied areas, all exterior air conditioning and ventilation vents shall be covered during application and air handling equipment shall be turned off during application to avoid solvent odors within the occupied areas.

The concrete surfaces shall be given a full and complete application of the siloxane sealant at the following application rate of 80-120 sq.ft./gal.

(1) Horizontal surfaces. - When applying the siloxane to flat horizontal concrete surfaces, the siloxane shall be applied in two "wet-on-wet" coats. Flood the surface and broom or squeegee the material around for even distribution. Allow the surface to absorb the siloxane and follow immediately with a second application before the surface dries. Puddles of excess siloxane sealant shall be broomed out thoroughly until they completely penetrate into the surface.

(2) Vertical surfaces. - When applying the siloxane to vertical surfaces, the siloxane shall be applied in two "wet-on-wet" applications. Apply the siloxane in a flooding application, from the bottom up with sufficient material applied to produce a 6" to 8" rundown below the contact point of the spray pattern with the concrete surface. Allow the first application to penetrate the surface (approximately three to five minutes) and reapply in the same saturating manner. If the siloxane sealant is applied to surfaces of extremely dense, mirror finish concrete the Contracting Officer may direct that the siloxane be applied in one saturating application to prevent surface darkening.

h. Curing. - The treated areas shall be protected from rain and foot traffic for six hours after application. Vehicular traffic will not be allowed on the treated area until after 24 hours after the application of the siloxane.

i. Measurement for Payment. -

(1) Measurement for payment of surface preparation of the concrete surfaces will be made of the actual surface area prepared. Payment for surface preparation will be made at the unit price per square foot bid therefor in the schedule, which unit price shall include all costs of preparing the concrete surfaces for the siloxane as specified in paragraph 3.15.f.

(2) Payment for seal coating of the concrete surfaces will utilize the same area as measured for the surface preparation. Payment for seal coating of concrete surfaces will be made at the unit price per square foot bid therefor in the schedule, which unit price shall include all costs for storing and handling materials, of applying the siloxane system, of cleanup, and of providing all the necessary safety equipment, and any other work required under these specifications to properly complete the job.

Notes

APPENDIX 5 (CD)

REFERENCED DOCUMENTS

- Isaacson & Arfman, P.A. (2002), Petroglyph Shadows Subdivision
  - Grading & Drainage Plan sheets 4 to 5A

- Wilson & Company, Inc (2003), SAD 227
  - Storm drain Plan & Profile Sheets, Emerald Drive Sheets 63A and 63 of 135, 128A of 159
  - Storm Drain Plan & Profile, Onyx Drive NW sheet 71A of 135

- Wilson & Company, Inc (2004), Vista Vieja Current Basin Boundary Map

- Wilson & Company, Inc (2004), SAD 227
  - Grading and Storm Drain Plan & Profile sheets 125A to 127A of 159

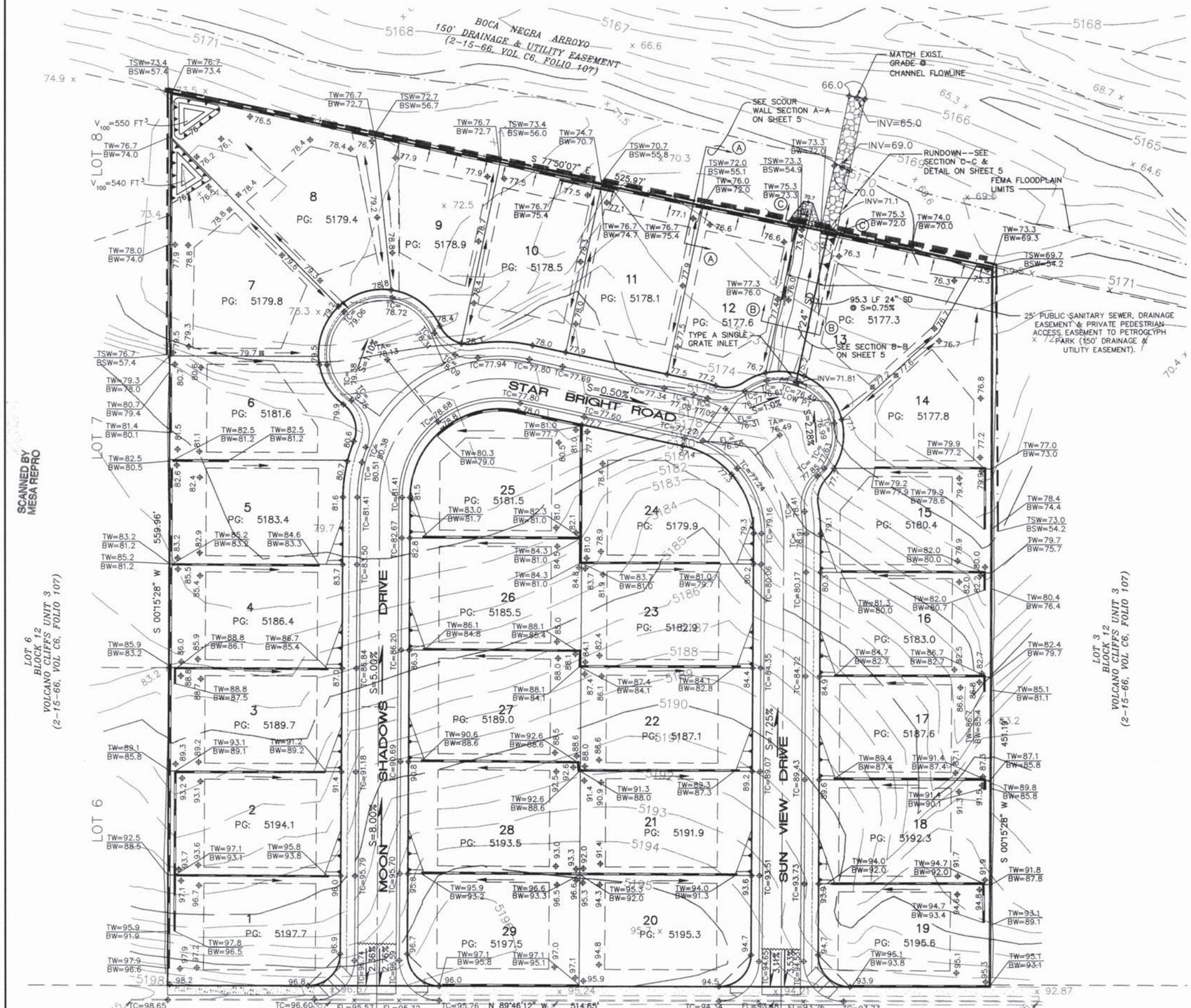
- Wilson & Company, Inc (2005), SAD 227
  - Vista Vieja Phase I Paving and Storm drain Plan & Profile Vista Vieja Avenue, NW sheet 14 of 35

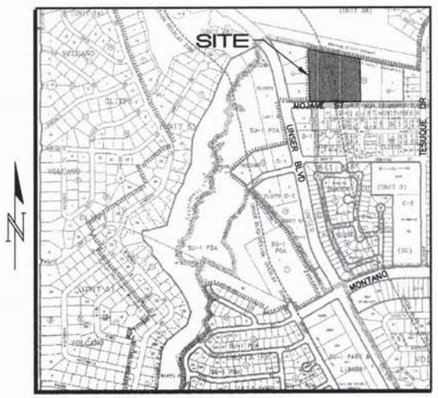
- Wilson & Company, Inc (2014), SAD 228,
  - Volume 2 - Paving/storm Drain Plan & Profile Sheets 15 and 29 of 29
  - Volume 1 - Pond 4 Grading Plan Sheet 109A of 156
  - Volume 1 - Pond 5 Grading Plan Sheet 110R of 156
  - Volume 1 - Pond 6 Grading Plan Sheet 111R of 156

- Photos of Properties with Existing Retaining Wall

- Cross Section Survey Map

SCANNED BY
MESA REPRO





VICINITY MAP

SCALE: 1"=30'

30 20 10 0 30 60 FEET

NOTE:

ROOF DRAINS ON LOTS 7-14 SHALL BE DIRECTED TOWARD THE FRONT OF THE LOTS.

LEGEND

5180	EXISTING CONTOUR
78.3	PROPOSED SPOT ELEVATION
	FLOW ARROW
PG=5177.2	PAD GRADE ELEVATION
TC=81.95 / FL=81.45	TOP OF CURB / FLOWLINE ELEVATION
INV=70.7	INVERT ELEVATION
	RETAINING WALL
	SCOUR WALL
	EROSION CONTROL BERM
	WATER BAR
TSW=74.9 / BSW=63.7	TOP OF SCOUR WALL / BOTTOM OF SCOUR WALL ELEVATION
TW=86.8 / BW=83.5	TOP OF RETAINING WALL / BOTTOM OF RETAINING WALL ELEVATION

AS-BUILT INFORMATION
CONTRACTOR: SAIS
WORK STAKED BY: AIS DATE 11/02
CONSTRUCTION ACCEPTANCE BY: [illegible] DATE 11/02
FIELD REVISIONS BY: AIS DATE 3/2
DRAWINGS CORRECTED BY: AIS DATE 3/12
MICRO-FILM INFORMATION
RECORDED BY: DATE
NO.

BENCH MARKS
ALBUQUERQUE CONTROL STATION "13-E10"
AN "X" CUT CHISELED ON A BONNET BOLT OF A FIRE HYDRANT
IN THE NW QUADRANT OF ATRISCO RD. & SANTO DOMINGO ST. NW
ELEV=5204.85 NGVD 1929, IN FEET

SURVEY INFORMATION
FIELD NOTES
1. ALDRICH LAND SURVEYING 10/01

ENGINEER'S SEAL
FRED C. ARFMAN NEW MEXICO 7322 REGISTERED PROFESSIONAL ENGINEER
4-22-02

NO.	DATE	REMARKS	BY
		REVISIONS	
		DESIGN	
	2/02	DESIGNED BY ANW	
	2/02	DRAWN BY ANW	
	2/02	CHECKED BY FCA	

ISAACSON & ARFMAN, P.A.
Consulting Engineering Associates
128 Monroe Street N.E.
Albuquerque New Mexico
183GRD.DWGnav 03/06/02

CITY OF ALBUQUERQUE
PUBLIC WORKS DEPARTMENT
ENGINEERING GROUP

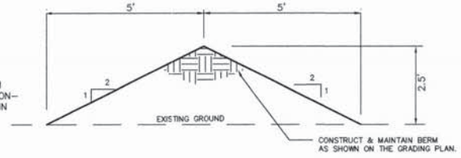
TITLE: PETROGLYPH SHADOWS SUBDIVISION
GRADING & DRAINAGE PLAN

Design Review Committee	City Engineer Approval	Last Design Update	Mo./Day/Yr.	Mo./Day/Yr.
For Information Only				

City Project No.	Zone Map No.	Sheet	Of
684381	E-10	4	16

EROSION CONTROL

1. THE CONTRACTOR SHALL ENSURE THAT NO SOIL ERODES FROM THE SITE INTO THE PUBLIC RIGHT-OF-WAY OR ONTO PRIVATE PROPERTY. THIS CAN BE ACHIEVED BY CONSTRUCTING EROSION CONTROL BERMS (AS DETAILED AT RIGHT) AS SHOWN ON THE PLAN AND WETTING THE SOIL TO KEEP IT FROM BLOWING.
2. THE CONTRACTOR SHALL SECURE "TOPSOIL DISTURBANCE PERMIT" FROM THE CITY ENVIRONMENTAL HEALTH DEPARTMENT PRIOR TO BEGINNING CONSTRUCTION. AN EXCAVATION PERMIT IS REQUIRED FOR ALL WORK WITHIN PUBLIC RIGHT-OF-WAY.
3. SEE GRADING NOTES.

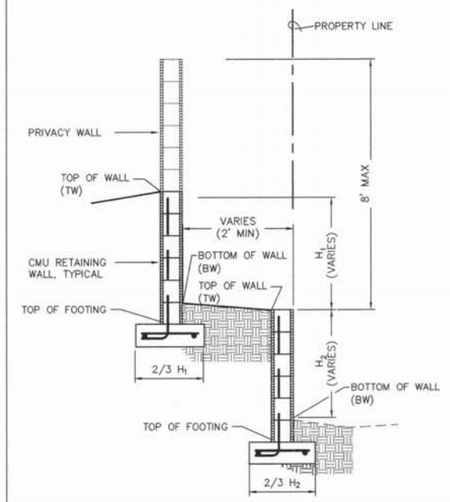


EROSION CONTROL BERM
NTS

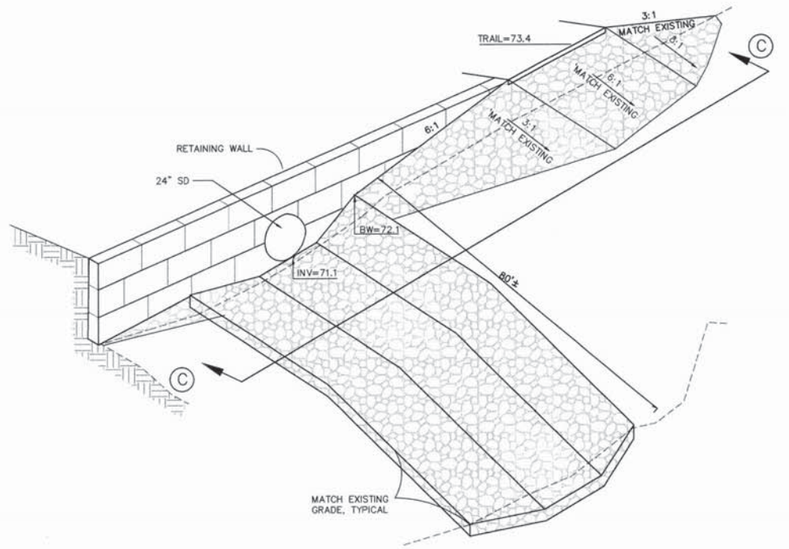
GRADING NOTES:

1. ALL TRASH, DEBRIS, & SURFACE VEGETATION SHALL BE CLEARED AND LEGALLY DISPOSED OFFSITE.
2. ALL SUBGRADE AND FILL SHALL BE COMPACTED TO A MINIMUM OF 90% ASTM D-1557.
3. EXCAVATION IS UNCLASSIFIED AND INCLUDES EXCAVATION TO SUBGRADE ELEVATIONS INDICATED, REGARDLESS OF CHARACTER OF MATERIALS ENCOUNTERED.
4. CONFORM TO ELEVATIONS AND DIMENSIONS SHOWN ON PLANS WITHIN A TOLERANCE OF 0.3± FEET.
5. SCARIFY AND COMPACT SUBGRADE FOR FILLS. PLACE FILL MATERIALS IN LAYERS NOT MORE THAN 8" IN LOOSE DEPTH. MOISTEN AS NECESSARY TO PROVIDE OPTIMUM MOISTURE (±2%) CONTENT.
6. UNIFORMLY GRADE AREAS WITHIN LIMITS OF GRADING AS SHOWN ON PLAN. SMOOTH FINISHED SURFACE WITHIN SPECIFIED TOLERANCE, COMPACT WITH UNIFORM SLOPES BETWEEN POINTS WHERE ELEVATIONS ARE INDICATED.
7. MAXIMUM SLOPES SHALL BE 3:1 MINIMUM SLOPES SHALL BE 1%.
8. TWO (2) WORKING DAYS PRIOR TO ANY EXCAVATION, CONTRACTOR MUST CONTACT NEW MEXICO ONE CALL SYSTEM, 260-1990, FOR LOCATION OF EXISTING UTILITIES.
9. IF ANY UTILITY LINES, PIPELINES, OR UNDERGROUND UTILITY LINES ARE SHOWN ON THESE DRAWINGS, THEY ARE SHOWN IN AN APPROXIMATE MANNER ONLY, AND SUCH LINES MAY EXIST WHERE NONE ARE SHOWN. IF ANY SUCH EXISTING LINES ARE SHOWN, THE LOCATION IS BASED UPON INFORMATION PROVIDED BY THE OWNER OF SAID UTILITY, AND THE INFORMATION MAY BE INCOMPLETE, OR MAY BE OBSOLETE BY THE TIME CONSTRUCTION COMMENCES. THE ENGINEER HAS CONDUCTED ONLY PRELIMINARY INVESTIGATION OF THE LOCATION, DEPTH, SIZE OR TYPE OF EXISTING UTILITY LINES, PIPELINES, OR UNDERGROUND UTILITY LINES. THIS INVESTIGATIONS IS NOT CONCLUSIVE, AND MAY NOT BE COMPLETE, THEREFORE, MAKES NO REPRESENTATION PERTAINING THERETO, AND ASSUMES NO RESPONSIBILITY OR LIABILITY THEREFORE. THE CONTRACTOR SHALL INFORM ITSELF OF THE LOCATION OF ANY UTILITY LINE, PIPELINE, OR UNDERGROUND UTILITY LINE IN OR NEAR THE AREA OF THE WORK IN ADVANCE OF AND DURING EXCAVATION WORK. THE CONTRACTOR IS FULLY RESPONSIBLE FOR ANY AND ALL DAMAGE CAUSED BY ITS FAILURE TO LOCATE, IDENTIFY AND PRESERVE ANY AND ALL EXISTING UTILITIES, PIPELINES, AND UNDERGROUND UTILITY LINES. IN PLANNING AND CONDUCTING EXCAVATION, THE CONTRACTOR SHALL COMPLY WITH STATE STATUES, MUNICIPAL AND LOCAL ORDINANCES, RULES AND REGULATIONS, IF ANY, PERTAINING TO THE LOCATION OF THESE LINES AND FACILITIES.
10. THE CONTRACTOR SHALL PROMPTLY CLEAN UP ANY MATERIAL EXCAVATED WITHIN THE PUBLIC RIGHT-OF-WAY SO THAT THE EXCAVATED MATERIAL IS NOT ERODED AND WASHED DOWN THE STREET.
11. OWNER WILL PROVIDE SOIL TESTING AND INSPECTION SERVICES DURING EARTHWORK OPERATIONS. ALLOW TESTING SERVICE TO INSPECT AND APPROVE COMPACTED SUBGRADES AND FILL LAYERS BEFORE FURTHER CONSTRUCTION WORK IS DONE. SHALL COMPACTION TESTS INDICATE INADEQUATE DENSITY, CONTRACTOR SHALL PROVIDE ADDITIONAL COMPACTION AND TESTING AT NO ADDITIONAL EXPENSE.
12. OWNER HAS ESTABLISHED SUBDIVISION BOUNDARY CORNERS. CONTRACTOR SHALL PROVIDE ALL OTHER CONSTRUCTION STAKING INCLUDING TRACT CORNERS. CONTRACTOR SHALL LOCATE AND PRESERVE ALL BOUNDARY CORNERS AND REPLACE ANY LOST OR DISTURBED CORNERS.

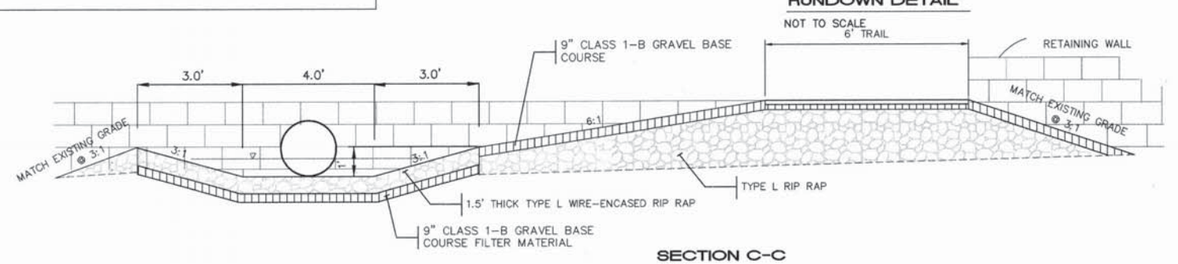
SCANNED BY MESA REPRO



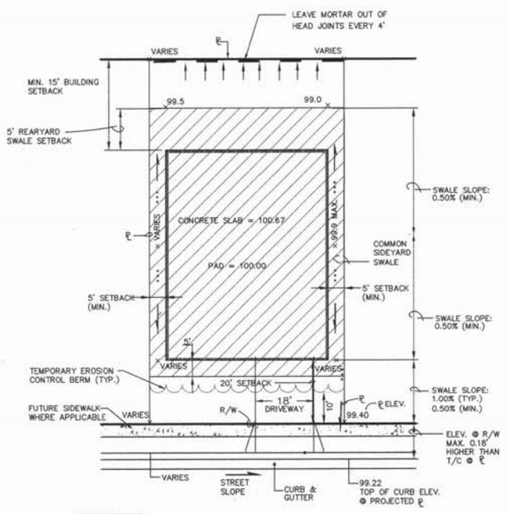
TWO-TIER RETAINING WALL
NTS



RUNDOWN DETAIL
NOT TO SCALE

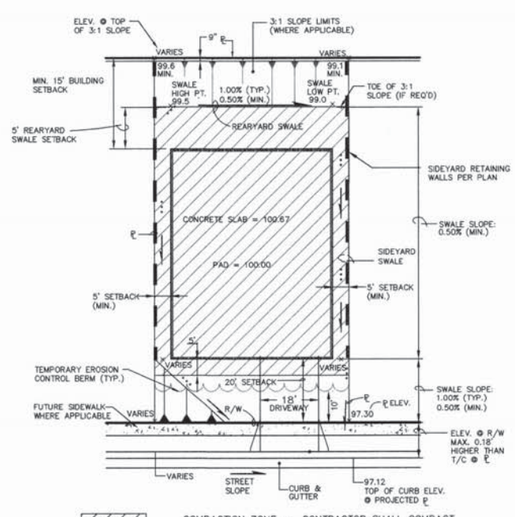


SECTION C-C
NTS



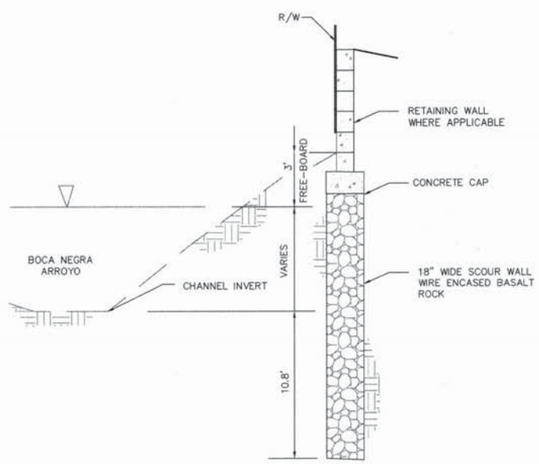
COMPACTION ZONE – CONTRACTOR SHALL COMPACT SOILS IN THIS AREA TO A MINIMUM OF 95% COMPACTION PER ASTM D698, FOR A DEPTH OF 12 INCHES.

TYPICAL LOT GRADING SHOWING COMPACTION ZONE LOTS DRAINING TO THE BACK
NTS

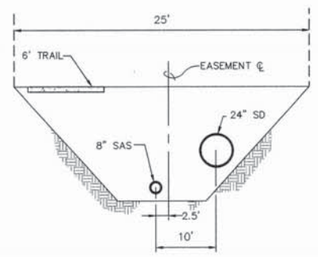


COMPACTION ZONE – CONTRACTOR SHALL COMPACT SOILS IN THIS AREA TO A MINIMUM OF 95% COMPACTION PER ASTM D698, FOR A DEPTH OF 12 INCHES.

TYPICAL LOT GRADING SHOWING COMPACTION ZONE LOTS DRAINING TO STREET
NTS



SECTION A-A SCOUR WALL
NTS



SECTION B-B DRAINAGE, SAS AND PEDESTRIAN ACCESS EASEMENT
NTS

SURVEY INFORMATION
FIELD NOTES
1. ALDRICH LAND SURVEYING 10/01

BENCH MARKS
1. ALBUQUERQUE CONTROL STATION "13-E10" AN "X" CUT CHISELED ON A BONNET BOLT OF A FIRE HYDRANT IN THE NW QUADRANT OF ATRISCO RD. & SANTO DOMINGO ST. N.W.
ELEV=5204.85 NGVD 1929, IN FEET

AS-BUILT INFORMATION
CONTRACTOR — STAKED BY — DATE
INSPECTOR'S INITIALS — FIELD DEVIATIONS — DATE
MICRO-FILM INFORMATION
CORRECTED BY — RECORDED BY — DATE

ENGINEER'S SEAL
FRED C. ARFMAN NEW MEXICO 7322 REGISTERED PROFESSIONAL ENGINEER
04-02-02

NO.	DATE	REMARKS	BY
		REVISIONS	
		DESIGN	
DESIGNED BY ANW	DATE 2/02		
DRAWN BY ANW	DATE 2/02		
CHECKED BY FCA	DATE 2/02		

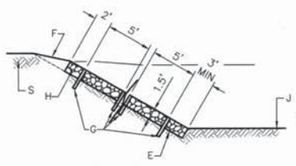
ISAACSON & ARFMAN, P.A.
Consulting Engineering Associates
128 Monroe Street N.E.
Albuquerque New Mexico
183GRD.DWGanw 2/11/02

CITY OF ALBUQUERQUE
PUBLIC WORKS DEPARTMENT
ENGINEERING GROUP

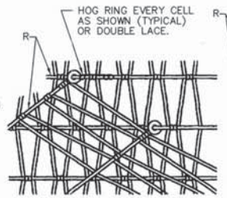
TITLE: PETROGLYPH SHADOWS SUBDIVISION
GRADING DETAILS

Design Review Committee: APPROVED APR 2 1 2002 DESIGN REVIEW COMMITTEE
City Engineer Approval: APPROVED JUL 22 2002 CITY ENGINEER
Last Design Update: Mo./Day/Yr.

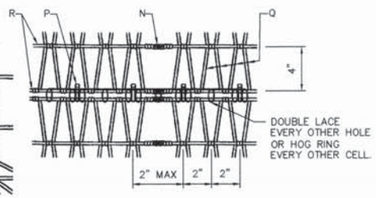
City Project No. 684381 | Zone Map No. E-10 | Sheet 5 Of 16



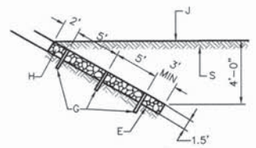
TYPICAL RIPRAP SECTION



DETAIL OF SPLICE AT SKEWED INTERSECTIONS



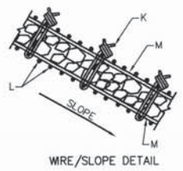
DETAIL OF WIRE FABRIC AND NORMAL SPLICE



TOE PROTECTION SECTION

WIRE-TIED RIPRAP DETAILS & SECTIONS

N.T.S.



WIRE/SLOPE DETAIL

CONSTRUCTION NOTES:

E. FILTER MATERIAL, 6" MIN. DEPTH AS SHOWN ON PLANS.

F. FILL & COMPACT AT 90% ASTM 1557 AFTER PLACEMENT OF RIPRAP.

G. STEEL STAKES MAY BE RAILROAD RAILS NOT LESS THAN 30 LBS. PER FT., 4" O.D. STANDARD STRENGTH GALV. ST. PIPE OR 4x4x3/8 STEEL ANGLES. STEEL STAKES SHALL BE 5' LONG AND 8' O.C. AND SHALL BE RECESSED TO A MAX. OF 3" BELOW TOP OF RIPRAP.

H. WIRE ENCLOSED RIPRAP.

J. FINISHED GROUND LINE.

K. No. 9 GAGE GALV. WIRE TIES APPROX. 2' O.C. LONGITUDINALLY & TRANSVERSELY.

L. MAIN WIRES TO BE PLACED PERPENDICULAR TO SLOPE.

M. WIRE FABRIC.

N. TRANSVERSE SPLICE.

P. LONGITUDINAL SPLICE, No. 9 GALV. WIRE TIES (TWO WRAPS ALTERNATE SPACES).

Q. CROSS WIRES: 12-1/2 GAGE WIRES SPACED AT 2" WITH NOT LESS THAN TWO TURNS AROUND MAIN WIRES.

R. MAIN WIRES: TWO No. 12-1/2 GAGE STRANDED WIRES SPACED AT 4".

S. ALL SUBGRADE, BACKFILL & EMBANKMENT SHALL BE COMPACTED TO 95% (MODIFIED PROCTOR) WITHIN THE AMAFCA R/W. TESTING REPORTS SHALL BE PROVIDED TO AMAFCA FIELD ENGINEER.

GENERAL NOTES:

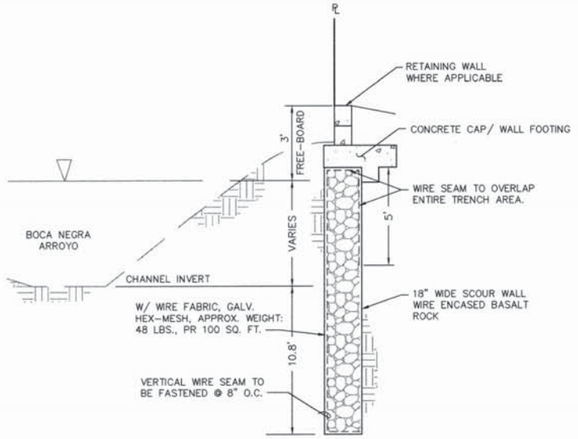
1. WIRE FABRIC IS TO BE GALV. HEX-MESH, APPROX. WEIGHT: 48 LBS. PR 100 SQ. FT.

2. STEEL STAKES ARE CONSIDERED INCIDENTAL TO THE COMPLETION OF THE WORK & NO DIRECT MEASUREMENT OR PAYMENT WILL BE MADE THEREFOR.

3. IF LENGTH OF SLOPE IS 15' OR LESS ONLY ONE ROW OF STEEL STAKES 2' FROM THE TOP EDGE OF THE RIPRAP WILL BE REQUIRED UNLESS OTHERWISE NOTED ON PLANS.

4. CONTRACTOR SHALL DOUBLE LACE EVERY OTHER HOLE (OR HOG RING EVERY OTHER CELL) HORIZONTALLY AND VERTICALLY WHEN TYING EXISTING WIRE-TIED RIPRAP TO PROPOSED WIRE-TIED RIPRAP.

5. HEXAGONAL MESH, MEETING SAME SPECIFICATION FOR V MESH MAY BE APPROVED SUBJECT TO SUBMITTAL TO PROJECT MANAGER.



SCOUR WALL W/ WIRE-TIED RIPRAP DETAIL

N.T.S.

SURVEY INFORMATION
FIELD NOTES
1. ALDRICH LAND SURVEYING 10/01

BENCH MARKS
ALBUQUERQUE CONTROL STATION "13-E10"
AN "X" CUT CHISELED ON A BONNET BOLT OF A FIRE HYDRANT
IN THE NW QUADRANT OF ATRISCO RD. & SANTO DOMINGO ST NW
ELEV=5204.85 NGVD 1929, IN FEET

AS-BUILT INFORMATION
CONTRACTOR SAIS
STAKED BY SAIS DATE 11/01
INSPECTOR'S NOTIFICATION BY ZA DATE 11/01
FIELD VERIFICATION BY AIS DATE 9/02
DRAWING CORRECTED BY AIS DATE 10/2
MICRO-FILM INFORMATION
RECORDED BY DATE
NO.

ENGINEER'S SEAL
FRED C. ARFMAN NEW MEXICO 7322 LICENSED PROFESSIONAL ENGINEER
04-02-02

NO.	DATE	REMARKS	BY
		REVISIONS	
		DESIGN	
		DESIGNED BY ANW	DATE 2/02
		DRAWN BY ANW	DATE 2/02
		CHECKED BY FCA	DATE 2/02

ISAACSON & ARFMAN, P.A.
Consulting Engineering Associates
128 Monroe Street N.E.
Albuquerque New Mexico
183GRD.DWGanw 3/12/02

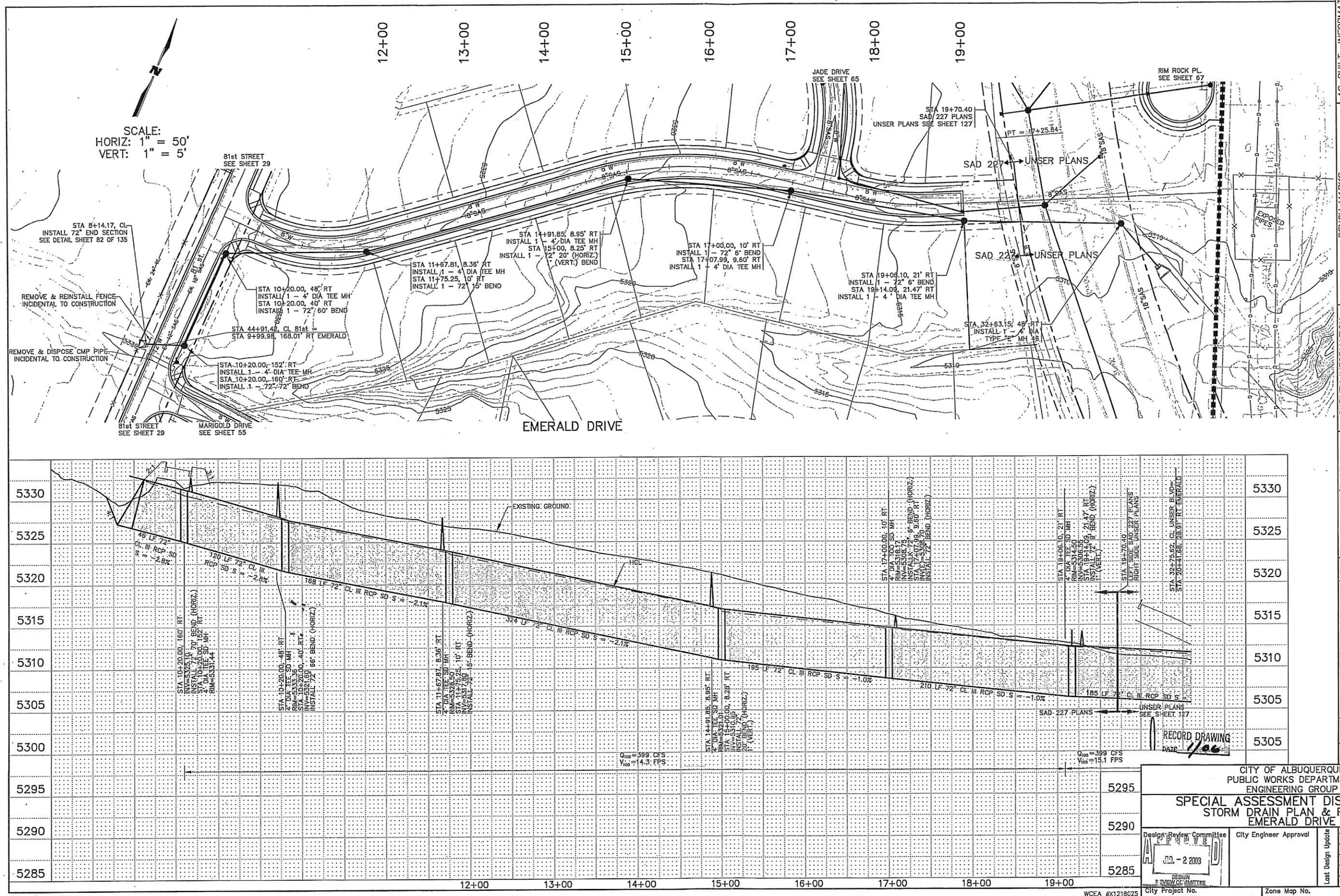
CITY OF ALBUQUERQUE
PUBLIC WORKS DEPARTMENT
ENGINEERING GROUP

TITLE: PETROGLYPH SHADOWS SUBDIVISION
WIRE-TIED RIPRAP DETAILS

Design Review Committee: APPROVED APR 2 4 2002 DESIGN REVIEW COMMITTEE
City Engineer Approval: APPROVED MAY 22 2002 CITY ENGINEER
Last Design Update: Mo./Day/Yr.

City Project No. 684381 | Zone Map No. E-10 | Sheet 5A Of 16

SCANNED BY MESA REPRO



AS-BUILT INFORMATION

	CONTRACTOR	WORK INSPECTED BY	FIELD CHANGES BY	DRAWINGS CORRECTED BY	RECORDED BY
	SALLS BROTHERS	WILSON & CO.	WILSON & CO.	WILSON & CO.	MIL
	DATE 7/03	DATE 11/05	DATE 11/05	DATE 01/06	DATE

BENCH MARKS

ACS BRASS CAP, STAMPED "3-E10 1969"
SET IN TOP OF CONCRETE POST PROJECTING
0.30 FT. ABOVE GROUND, LOCATED
APPROX. 178' SE OF THE INTERSECTION OF
RIM ROCK DR. NW AND MARIGOLD DR. NW
(NAD 1927), X 358813.84, Y 1512565.54

ELEVATION = 5316.12 FT. (SLD 1929)

SURVEY INFORMATION

FIELD NOTES

NO.	BY	DATE
	WILSON & CO.	6/03
	THRU	
	WILSON & CO.	11/05

ENGINEER'S SEAL

ROBERT S. MACLAKE
NEW MEXICO
15986
REGISTERED PROFESSIONAL ENGINEER
6-30-03

NO.	DATE	REMARKS	BY
		REVISIONS	

WILSON & COMPANY, ENGINEERS & ARCHITECTS

DESIGNED BY	SJM	MAY 03
DRAWN BY	STAFF	MAY 03
CHECKED BY	SJM	MAY 03

CITY OF ALBUQUERQUE
PUBLIC WORKS DEPARTMENT
ENGINEERING GROUP

SPECIAL ASSESSMENT DISTRICT 227
STORM DRAIN PLAN & PROFILE
EMERALD DRIVE

Design Review Committee	City Engineer Approval	Last Design Update	Mo./Day/Yr.	Mo./Day/Yr.
APPROVED JUL - 2 2003 DESIGN REVIEW COMMITTEE				

City Project No.	Zone Map No.	Sheet	Of
707391	D–10, E–10	63A	135

WCEA #X1218025
MAY 2003

WILSON & COMPANY

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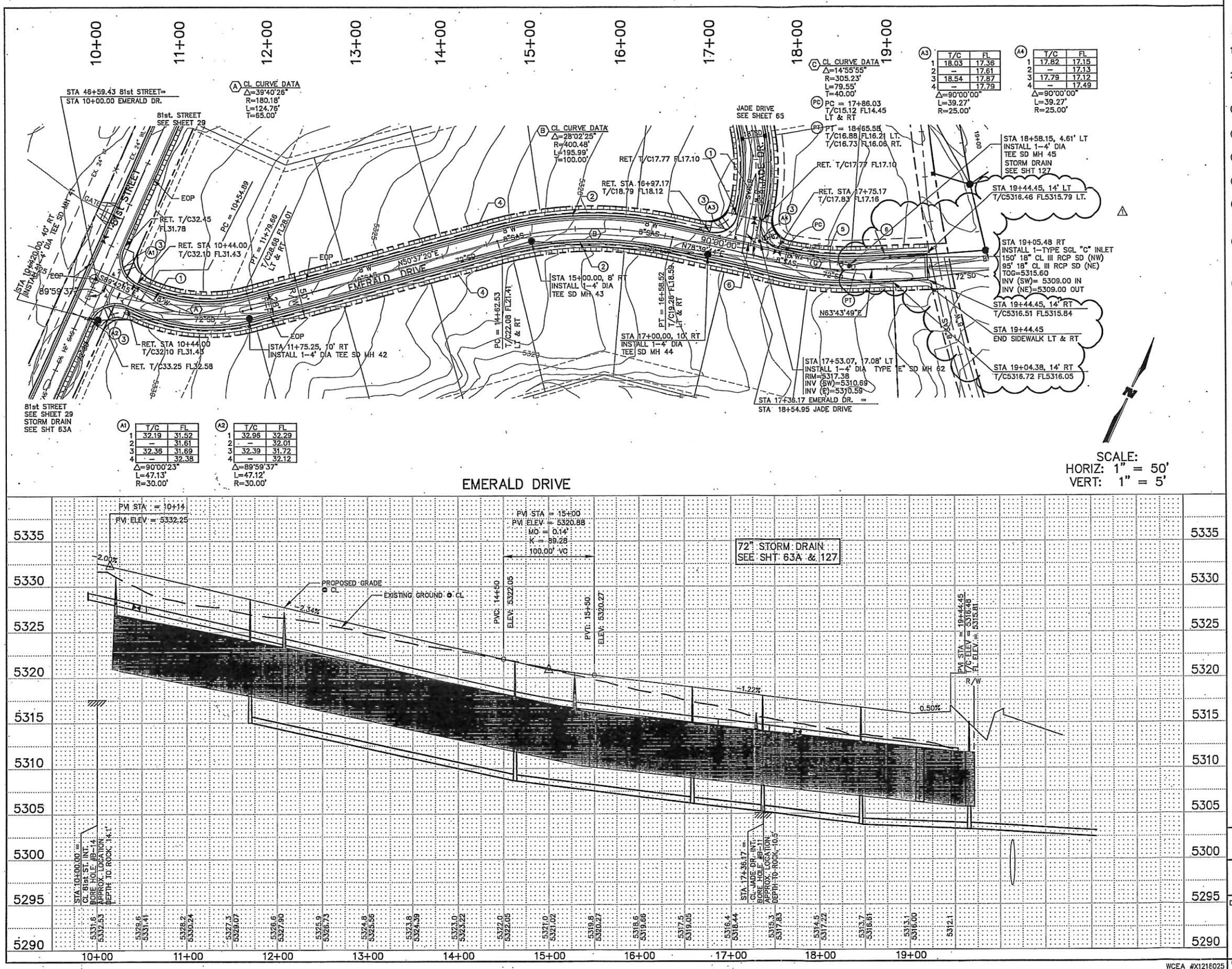


NOTES

1. SEE 50' R/W TYPICAL ROADWAY SECTION, SEE SHT. 7
2. FOR STORM DRAIN INFORMATION SEE SHEET 63A.

(1) 50' CROWN REDUCTION PER STD DWG 2401.

(2) CONSTRUCT STANDARD TYPE CURB PER STD DWG 2415.

(3) CONSTRUCT WHEEL CHAIR RAMP PER STD DWG 2440, 2441.

(4) CONSTRUCT 4' OFFSET TYPE SIDEWALK PER STD DWG 2430.

(5) STA 18+00.00 TO STA 19+00.00 TRANSITION ROADWAY CROSS SLOPE FROM –2.00% TO 0.20% LEFT SIDE ONLY

(6) STA 18+95.00 LT TO STA 19+00.00 LT TRANSITION FROM STD TYPE CURB TO DEPRESSED GUTTER TYPE CURB, B=0.04' PER STD DWG 2415

(7) CONSTRUCT CONC. VALLEY GUTTER PER STD DWG 2420

AS–BUILT INFORMATION

CONTRACTOR SALLS BROTHERS

MARKS BY:	WILSON & CO.	DATE 7/03
SUPERVISORS FIELD FENCE BY:	WILSON & CO.	DATE 11/05
VERIFICATION BY:	WILSON & CO.	DATE 11/05
CORRECTED BY:	WILSON & CO.	DATE 01/06

MICRO–FILM INFORMATION

RECORDED BY DATE

NO.

BENCH MARKS

ACS BRASS CAP, STAMPED "3–E10 1969" SET IN TOP OF CONCRETE POST PROJECTING 0.30 FT. ABOVE GROUND, LOCATED APPROX. 178' SE. OF THE INTERSECTION OF RIM ROCK DR. NW AND MARIGOLD DR. NW (NAD 1927), X 358813.84, Y 1512565.54

ELEVATION = 5316.12 FT. (SLD 1929)

SURVEY INFORMATION

FIELD NOTES

NO.	BY	DATE
	WILSON & CO.	THRU
	WILSON & CO.	

ENGINEER'S SEAL

REGISTERED PROFESSIONAL ENGINEER ROBERT S. MCLANE NEW MEXICO 15269

NO.	DATE	REMARKS	BY
		EXTENDED PAVING AND SIDEWALK	WC
2/05		REVISIONS	BY

WILSON & COMPANY, ENGINEERS & ARCHITECTS

DESIGNED BY:	ESC	DATE JUNE 03
DRAWN BY:	STAFF	DATE JUNE 03
CHECKED BY:	RSM	DATE JUNE 03

RECORD DRAWING DATE 1/06

CITY OF ALBUQUERQUE
PUBLIC WORKS DEPARTMENT
ENGINEERING GROUP

SPECIAL ASSESSMENT DISTRICT 227
PAVING PLAN & PROFILE
EMERALD DRIVE N.W.

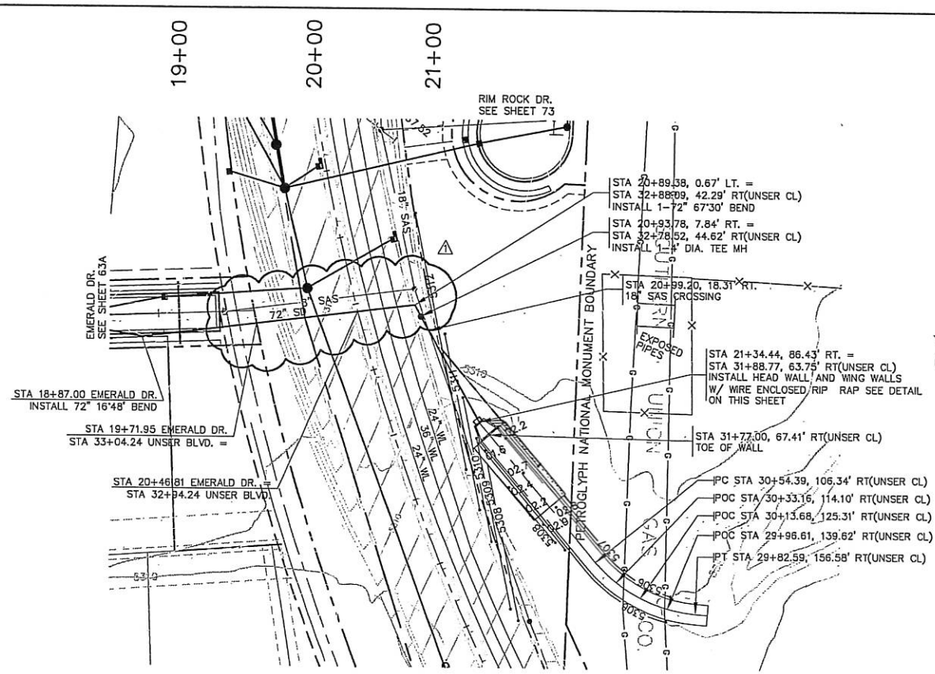
Design Review Committee	City Engineer Approval	Last Design Update	Mo./Day/Yr.	Mo./Day/Yr.

City Project No.	Zone Map No.	Sheet	Of
707391	D–10, E–10	63	135

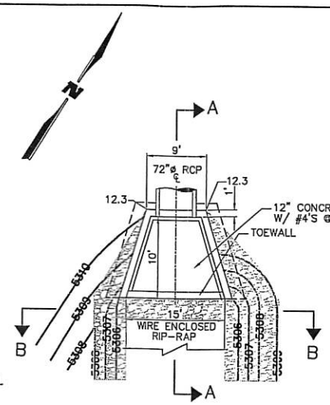
WCEA #X1218025 JUNE 03

WILSON & COMPANY

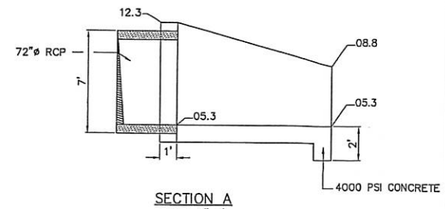
X:\Public\PROJECTS\X1218025\M\SHEETS\Pnp\8125pnp21.dwg 6/13/2003 10:54:45 AM MDT



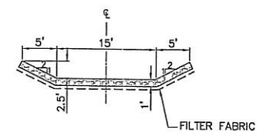
ALL STATIONING IS EMERALD DR. STATIONING



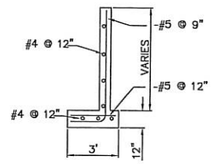
CONCRETE APRON
SCALE: 5"–1'



SECTION A
SCALE: 2"–1'



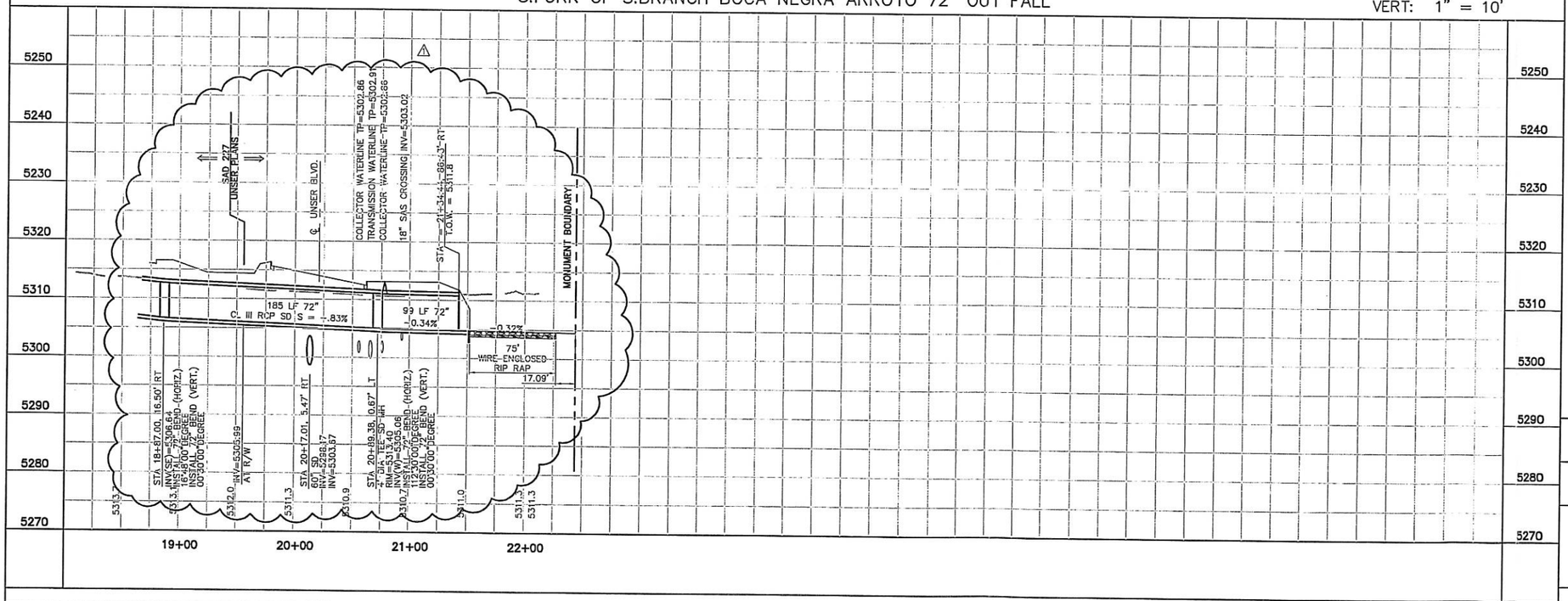
CHANNEL SECTION B
SCALE: 5"–1'



WINGWALL SECTION
SCALE: 2"–1'

S.FORK OF S.BRANCH BOCA NEGRA ARROYO 72" OUT FALL

SCALE:
HORIZ: 1" = 50'
VERT: 1" = 10'



PLANS PREPARED BY WILSON & CO.
TO BE INCLUDED IN THE UNSER
BOULEVARD–MIDDLE SECTION PLANS

CITY OF ALBUQUERQUE
PUBLIC WORKS DEPARTMENT
ENGINEERING DEVELOPMENT GROUP

TITLE: PUBLIC UTILITY & STORM DRAIN IMPROVEMENTS
S. FORK OF S. BRANCH
BOCA NEGRA ARROYO 72" OUTFALL

Design Review Committee	City Engineer Approval	Last Design Update	Mo./Day/Yr.	Mo./Day/Yr.

City Project No. 707392 | Zone Map No. D10,E10 | Sheet 128A | Of 159

SURVEY INFORMATION
FIELD NOTES

NO.	DATE	
	6/03	WILSON & CO.
		THRU
	11/05	WILSON & CO.

BENCH MARKS

DATE	
6/03	BENCHMARK: CITY OF ALBUQUERQUE STANDARD BRASS CAP STAMPED 3-E10 1969, SET IN TOP OF CONCRETE POST PROJECTING 0.30' ABOVE GROUND. LOCATED 45° NORTHEAST OF THE CENTERLINE OF MARIGOLD DR. AND RIM ROCK RD. EL=5316.12 – NGVD 29

AS BUILT INFORMATION

CONTRACTOR SALLS BROTHERS

STAKED BY	WILSON & CO.	7/03
INSPECTED BY	WILSON & CO.	11/05
FIELD CHANGE	WILSON & CO.	11/05
FINAL INSPECTION	WILSON & CO.	01/06
CORRECTED BY	WILSON & CO.	01/06

MICRO–FILM INFORMATION
RECORDED BY DATE
NO.

ENGINEERS SEAL
S. AGUIRRE OMNITEC NEW MEXICO (11959) REGISTERED PROFESSIONAL ENGINEER

NO.	DATE	WC
2	2/05	STORM DRAIN CROSSING

REVISIONS

DESIGN	DATE	JUNE 03
DESIGNED BY	RSM	
DRAWN BY	STAFF	DATE JUNE 03
CHECKED BY	SJM	DATE JUNE 03

REMARKS

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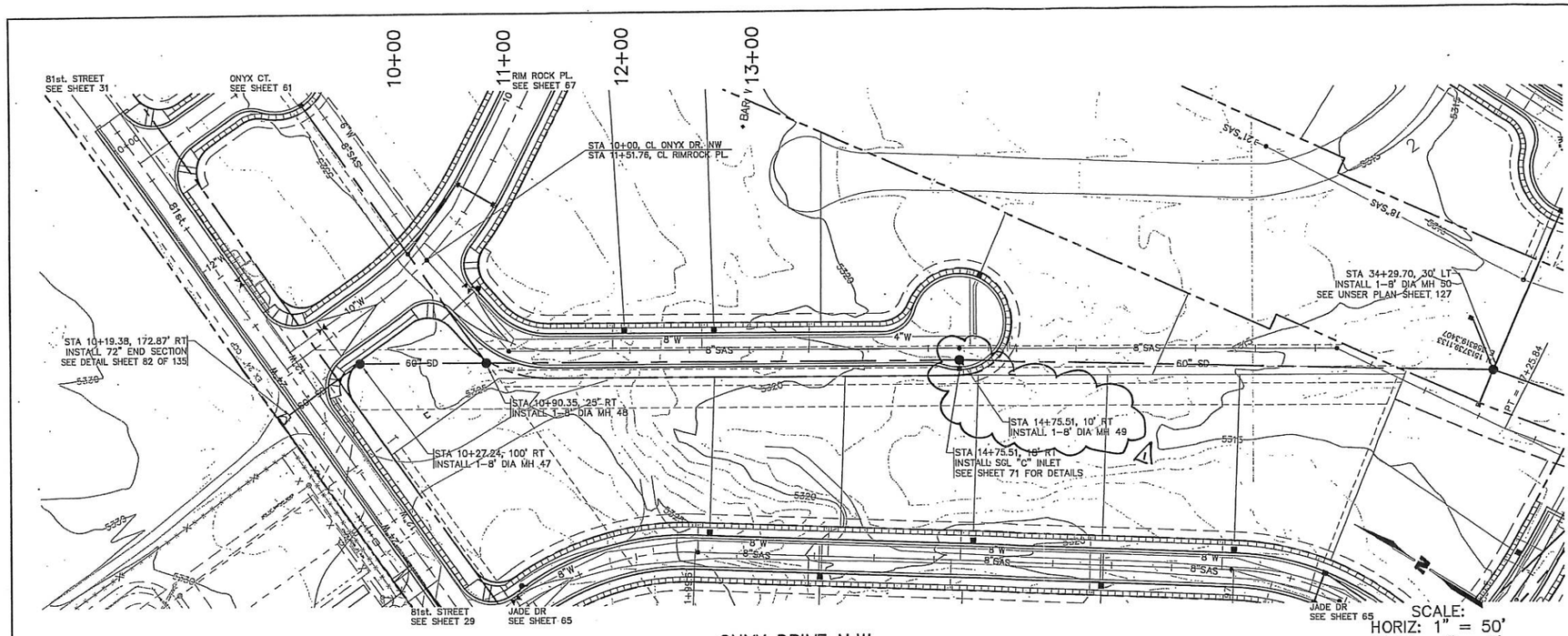

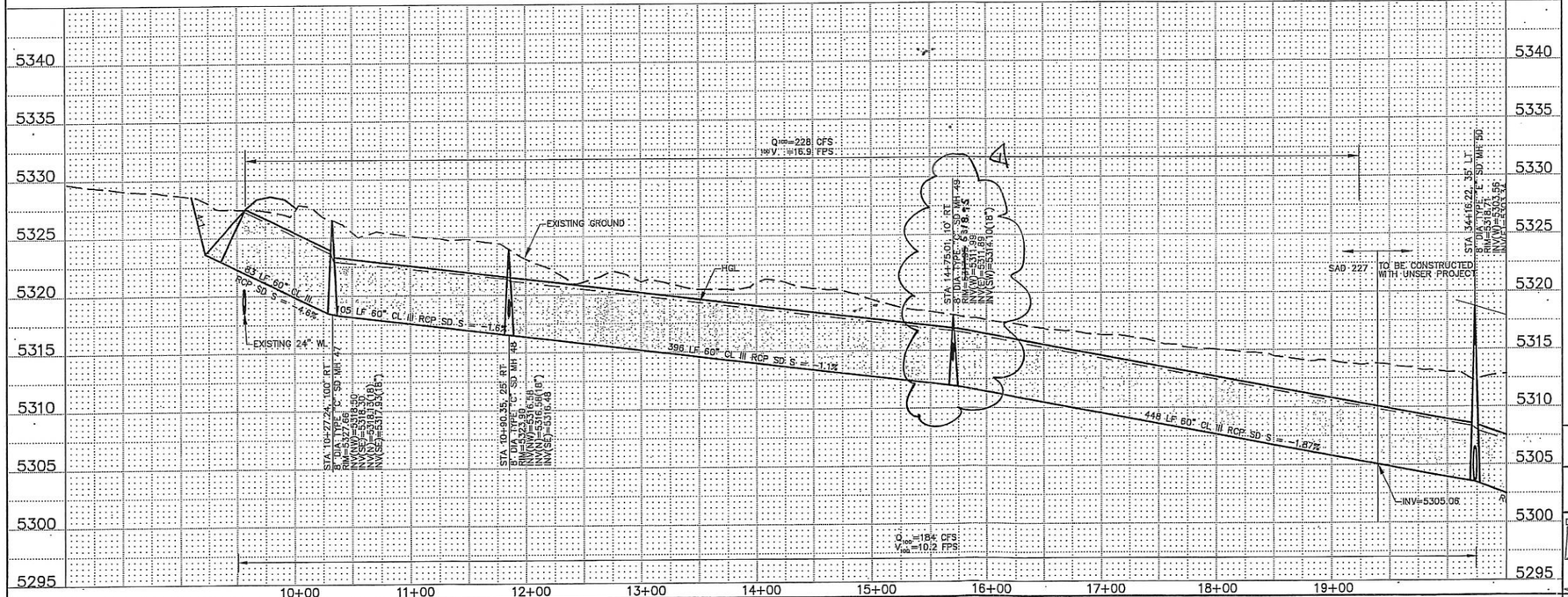

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WCEA #X1218025
APRIL 2003

WILSON & COMPANY

AS-BUILT INFORMATION

BENCH MARKS
ACS BRASS CAP, STAMPED "3-E10 1969"
SET IN TOP OF CONCRETE POST PROJECTING 0.30 FT. ABOVE GROUND, LOCATED APPROX. 178' SE OF THE INTERSECTION OF RIM ROCK DR. NW AND MARIGOLD DR. NW
(NAD 1927), X 356813.84, Y 1512565.54
ELEVATION = 5316.12 FT. (SLD 1929)

CONTRACTOR — DATE
WORK STAKED BY — DATE
INSPECTION BY — DATE
FIELD VERIFICATION BY — DATE
DRAWINGS BY — DATE
CORRECTED BY — DATE
RECORDED BY — DATE
NO.

SURVEY INFORMATION

FIELD NOTES
NO. | BY | DATE

ENGINEER'S SEAL
ROBERT S. MACLAKE
NEW MEXICO
15985
REGISTERED PROFESSIONAL ENGINEER
LICENSED

NO.	DATE	REVISIONS	BY
1	1/05	Revised Rim SD MH 49	
		REMARKS	

WILSON & COMPANY, ENGINEERS & ARCHITECTS
DESIGNED BY SJM DATE MAY 03
DRAWN BY STAFF DATE MAY 03
CHECKED BY SJM DATE MAY 03

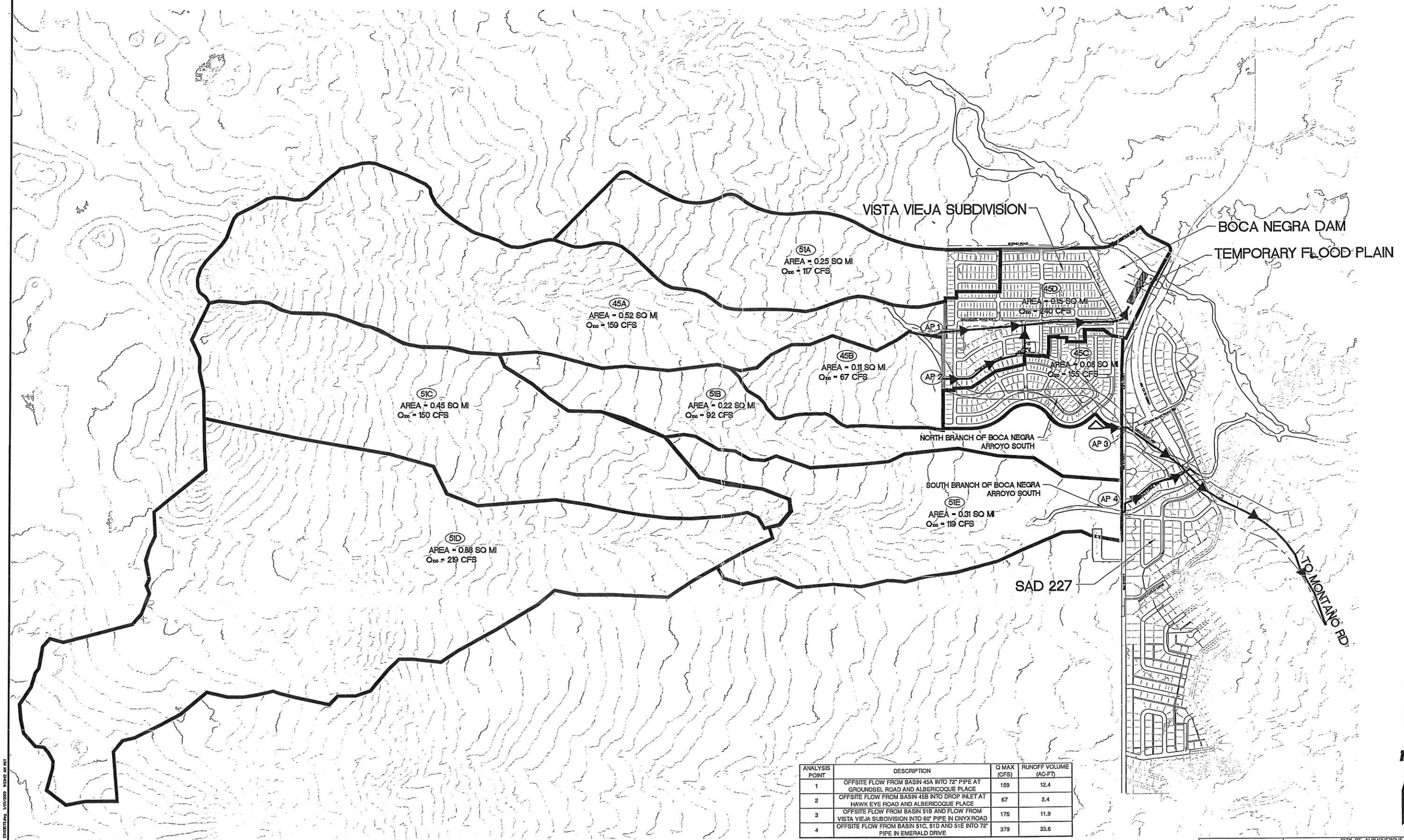
RECORD DRAWING
DATE 1/06

CITY OF ALBUQUERQUE
PUBLIC WORKS DEPARTMENT
ENGINEERING GROUP

SPECIAL ASSESSMENT DISTRICT 227
STORM DRAIN PLAN & PROFILE
ONYX DRIVE N.W.

Design Review Committee — APPROVED — JUL - 2 2003 — DESIGN REVIEW COMMITTEE
City Engineer Approval
Last Design Update — Mo./Day/Yr. — Mo./Day/Yr.

City Project No.	Zone Map No.	Sheet	Of
707391	D-10, E-10	71A	135



ANALYSIS POINT	DESCRIPTION	Q MAX (CFS)	RUNOFF VOLUME (AC-FT)
1	OFFSITE FLOW FROM BASIN 45A INTO 72" PIPE AT GROUNDSEL ROAD AND ALBERICOQUE PLACE	159	12.4
2	OFFSITE FLOW FROM BASIN 45B INTO DROP INLET AT HAWK EYE ROAD AND ALBERICOQUE PLACE	67	2.4
3	OFFSITE FLOW FROM BASIN 51B AND FLOW FROM VISTA VIEJA SUBDIVISION INTO 60" PIPE IN ONYX ROAD	175	11.9
4	OFFSITE FLOW FROM BASIN 51C, 51D AND 51E INTO 72" PIPE IN EMERALD DRIVE	379	33.6

NOTE:
1. TEMPORARY FLOOD PLAIN WILL BE REMOVED AFTER CONSTRUCTION OF THE BOCA NEGRA DAM.

LEGEND

- 5070 / 5071 — EXISTING INTERMEDIATE CONTOUR / EXISTING INDEX CONTOUR
- BASIN BOUNDARY
- (51A) BASIN ID
- (APX) ANALYSIS POINT
- EFFECTIVE FLOOD PLAIN (FIRM)

GRAPHIC SCALE

800 0 300 600 1200 2400

(IN FEET)
1 inch = 600 ft.

WILSON & COMPANY
4900 LANG AVENUE, NE
ALBUQUERQUE, NEW MEXICO
87109
(505) 348-4000

CITY OF ALBUQUERQUE
PUBLIC WORKS DEPARTMENT
ENGINEERING GROUP

VISTA VIEJA
CURRENT BASIN BOUNDARY MAP

Design Review Committee | City Engineer Approval

DATE SEPT 2009 | DESIGN RBM | DRAWN JLB
FILE NO. XXXXXXXX
City Project No. 763381,2,3,4
Zone Map No. D-9-Z

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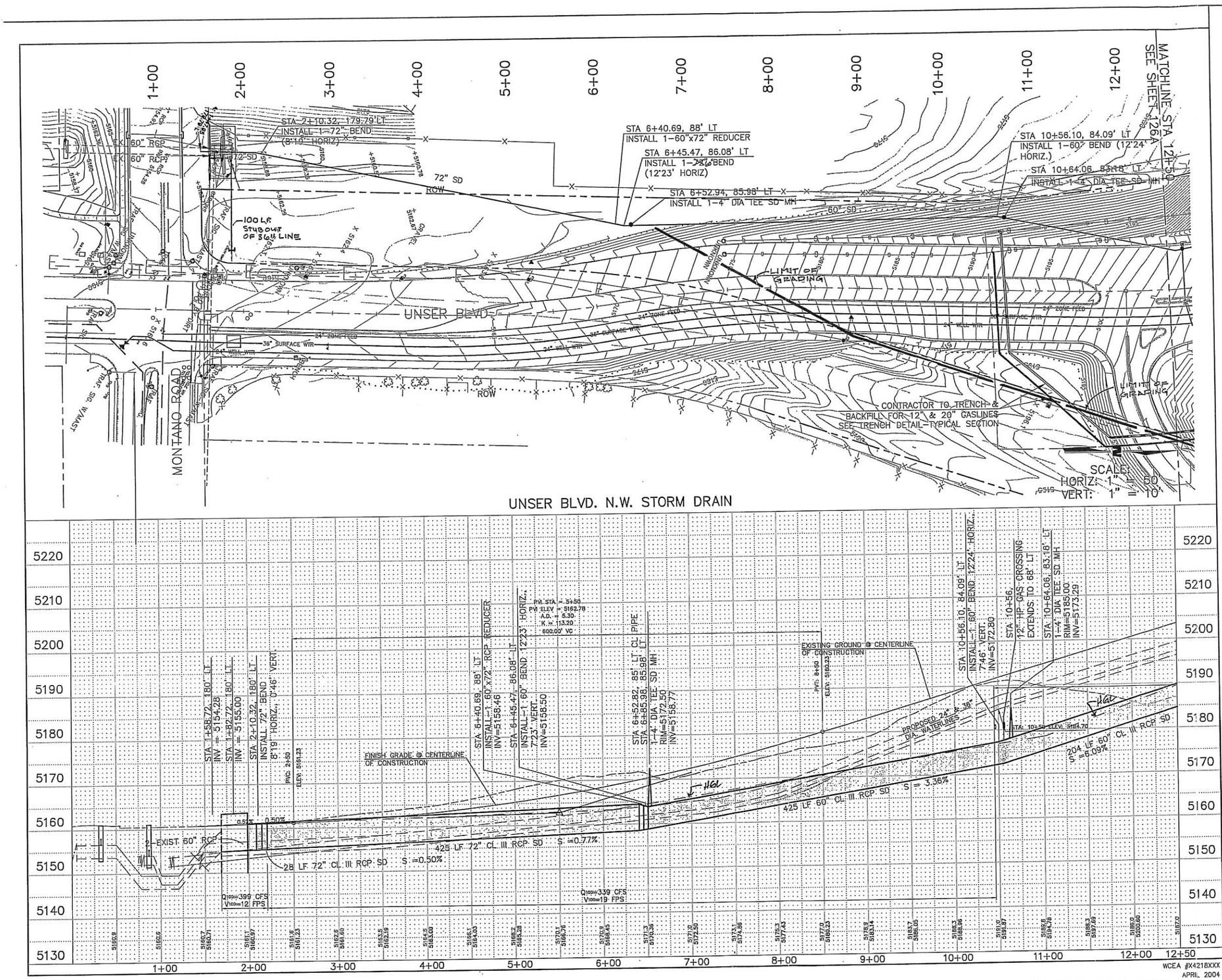

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BENCH MARKS

ACS BRASS CAP, STAMPED "3-E10 1969"
SET IN TOP OF CONCRETE POST PROJECTING
0.30 FT. ABOVE GROUND. LOCATED
APPROX. 178' SE. OF THE INTERSECTION OF
RIM ROCK DR. NW AND MARIGOLD DR. NW
(NAD 1927), X 358813.84, Y 1512565.54

ELEVATION = 5316.12 FT. (SLD 1929)

AS-BUILT INFORMATION

CONTRACTOR: SALLS BROTHERS

	WORK BY:	DATE: 7/03
INSPECTOR'S FIELD NOTATIONS BY:	WILSON & CO.	DATE 11/05
FIELD VERIFICATIONS BY:	WILSON & CO.	DATE 11/05
DRAWINGS CORRECTED BY:	WILSON & CO.	DATE 01/06

MICRO-FILM INFORMATION

RECORDED BY: HGL DATE:

SURVEY INFORMATION

FIELD NOTES

NO.	BY	DATE
	WILSON & CO.	6/03
	THRU	
	WILSON & CO.	11/05

ENGINEER'S SEAL

REGISTERED PROFESSIONAL ENGINEER
STATE OF NEW MEXICO
12177
8/5/04

NO.	DATE	REMARKS	BY
		REVISIONS	
		WILSON & COMPANY, ENGINEERS & ARCHITECTS	
		DESIGNED BY RSM	DATE APRIL 04
		DRAWN BY STAFF	DATE APRIL 04
		CHECKED BY RSM	DATE APRIL 04

RECORD DRAWING
DATE 1.0.6.

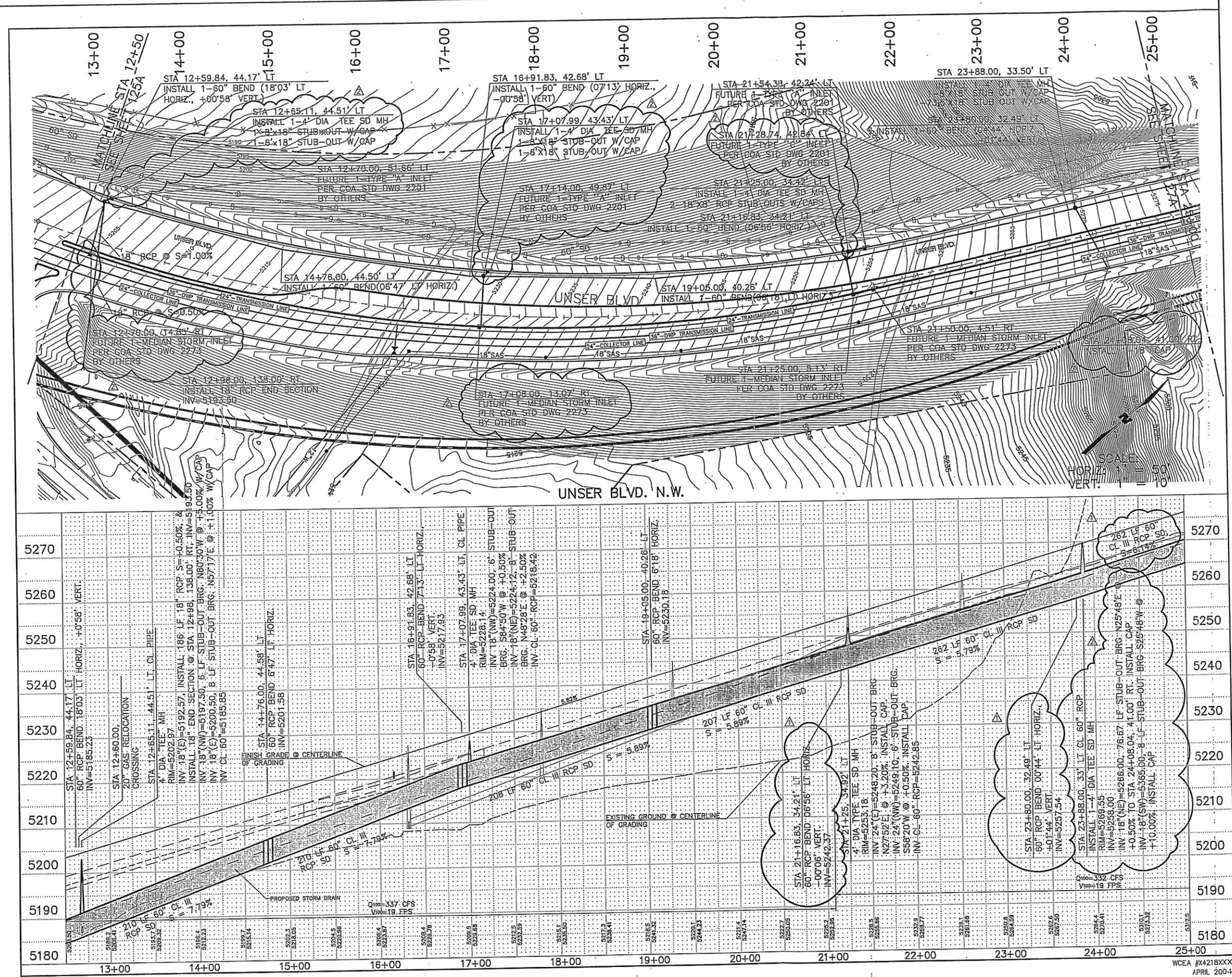
CITY OF ALBUQUERQUE
PUBLIC WORKS DEPARTMENT
ENGINEERING GROUP

SPECIAL ASSESSMENT DISTRICT 227
GRADING AND STORM DRAIN PLAN & PROFILE
PUBLIC UTILITY & STORM DRAIN IMPROVEMENTS

Design Review Committee	City Engineer Approval	Last Design Update	Mo./Day/Yr.	Mo./Day/Yr.
AUG - 9 2004	AUG - 9 2004			

City Project No.	Zone Map No.	Sheet	Of
707391	D-10, E-10	125A	159

WILSON & COMPANY



AS-BUILT INFORMATION		
CONTRACTOR	SALLS BROTHERS	DATE
DRAWN BY	WILSON & CO.	DATE 7/03
REVISED BY	WILSON & CO.	DATE 11/05
REVISED BY	WILSON & CO.	DATE 11/05
FIELD CHECKED BY	WILSON & CO.	DATE 01/06
CORRECTED BY	WILSON & CO.	DATE
RECORDED BY		DATE
NO.		

MICRO-FILM INFORMATION

BENCH MARKS

ACS BRASS CAP, STAMPED "3-E10 1969"
SET IN TOP OF CONCRETE POST PROJECTING 0.30 FT. ABOVE GROUND, LOCATED APPROX. 178' SEC. OF THE INTERSECTION OF RIM ROCK DR. NW AND MARIGOLD DR. NW
(NAD 1927). X 358813.84, Y 1512565.54

ELEVATION = 5316.12 FT. (SLD 1929)

SURVEY INFORMATION

NO.	FIELD NOTES BY	DATE
	WILSON & CO.	6/03
	THRU	
	WILSON & CO.	11/05

ENGINEER'S SEAL

DONALD S. AGUIRRE, NEW MEXICO, 9455, REGISTERED PROFESSIONAL ENGINEER

REVISIONS	NO.	DATE	BY
REVISED STORM DRAIN INLETS	2	04/05	WC
REVISED STORM DRAIN	1	03/05	WC
REMARKS	NO.	DATE	BY

WILSON & COMPANY, ENGINEERS & ARCHITECTS

DESIGNED BY	RSM	DATE APRIL 04
DRAWN BY	STAFF	DATE APRIL 04
CHECKED BY	RSM	DATE APRIL 04

RECORD DRAWING
DATE 6/06

CITY OF ALBUQUERQUE
PUBLIC WORKS DEPARTMENT
ENGINEERING GROUP

SPECIAL ASSESSMENT DISTRICT 227
GRADING AND STORM DRAIN PLAN & PROFILE
PUBLIC UTILITY & STORM DRAIN IMPROVEMENTS

Design Review Committee	City Engineer Approval	Last Design Update	Mo./Day/Yr.	Mo./Day/Yr.

City Project No.	Zone Map No.	Sheet	Of
707391	D-10, E-10	126A	159

WCEA #X4218XXX
APRIL 2004

WILSON & COMPANY

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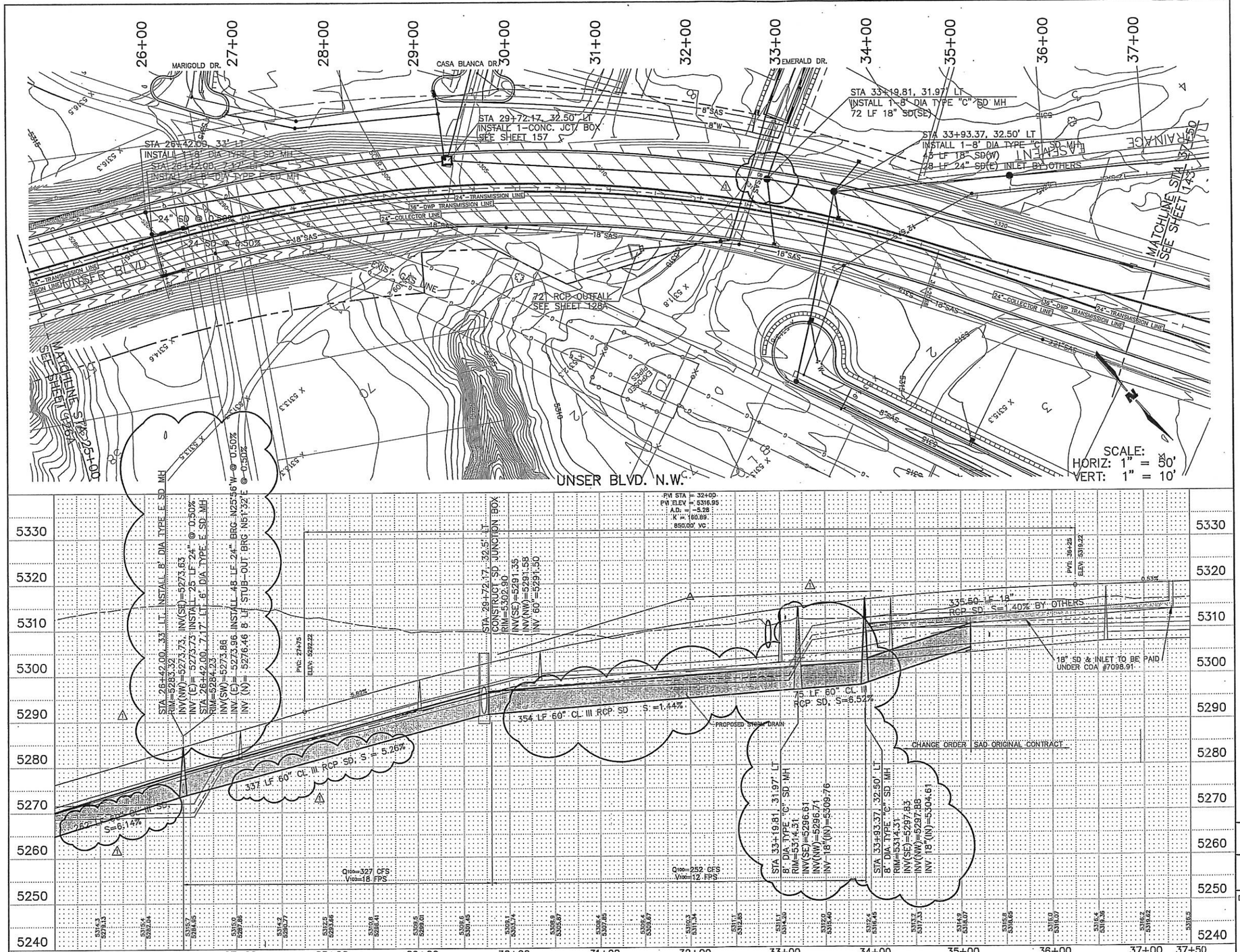

WCEA #X4218XXX
APRIL 2004

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AS-BUILT INFORMATION

BENCH MARKS

ACS BRASS CAP, STAMPED "3-E10 1969"
SET IN TOP OF CONCRETE POST PROJECTING 0.30 FT. ABOVE GROUND, LOCATED APPROX. 178' SE. OF THE INTERSECTION OF RIM ROCK DR. NW AND MARIGOLD DR. NW
(NAD 1927), X 358813.84, Y 1512565.54

ELEVATION = 5316.12 FT. (SLD 1929)

CONTRACTOR	SALLS BROTHERS	
WORK PERFORMED BY	WILSON & CO.	DATE 7/03
INSPECTION & ACCEPTANCE BY	WILSON & CO.	DATE 11/05
VERIFICATION BY	WILSON & CO.	DATE 11/05
CORRECTED BY	WILSON & CO.	DATE 01/06
RECORDED BY		DATE
NO.		

SURVEY INFORMATION

FIELD NOTES

NO.	BY	DATE
	WILSON & CO.	6/03
	THRU	
	WILSON & CO.	11/05

ENGINEER'S SEAL

DANIEL R. AGUILERA
NEW MEXICO
14955
REGISTERED PROFESSIONAL ENGINEER

NO.	DATE	REMARKS	BY
1	3/05	REVISED STORM DRAIN	WC

REVISIONS

WILSON & COMPANY, ENGINEERS & ARCHITECTS

DESIGNED BY	RSM	DATE APRIL 04
DRAWN BY	STAFF	DATE APRIL 04
CHECKED BY	RSM	DATE APRIL 04

RECORD DRAWING
DATE 1/06

CITY OF ALBUQUERQUE
PUBLIC WORKS DEPARTMENT
ENGINEERING GROUP

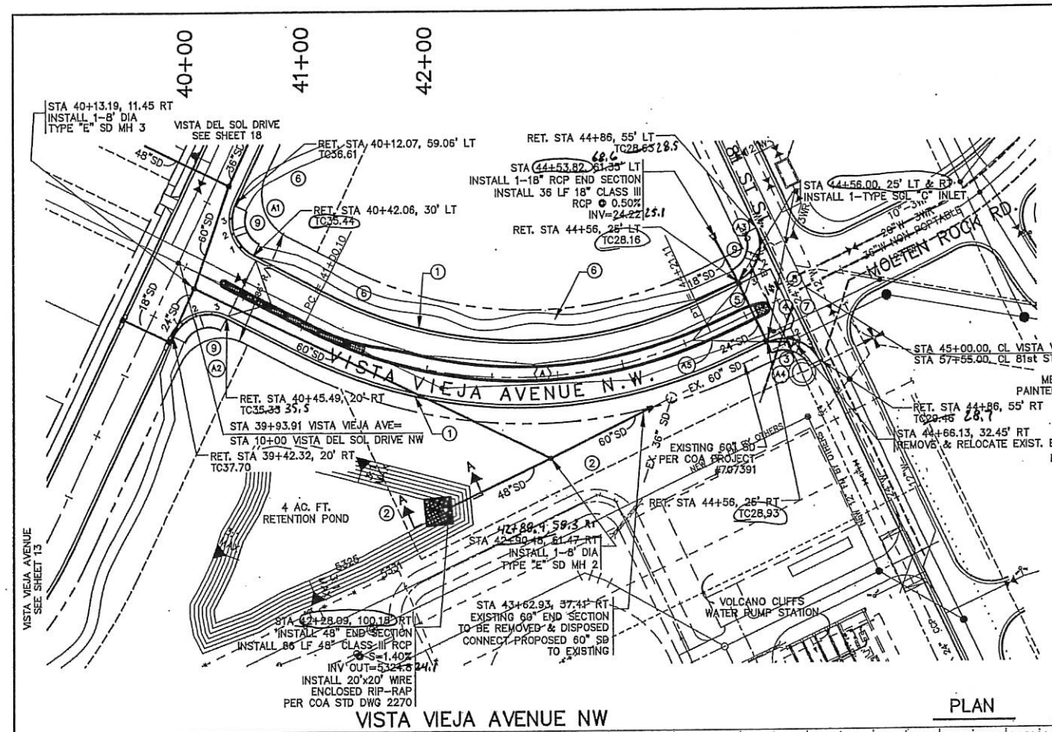
SPECIAL ASSESSMENT DISTRICT 227
GRADING AND STORM DRAIN PLAN & PROFILE
PUBLIC UTILITY & STORM DRAIN IMPROVEMENTS

Design Review Committee	City Engineer Approval	Last Design Update	Mo./Day/Yr.	Mo./Day/Yr.

City Project No.	Zone Map No.	Sheet	Of
707391	D-10, E-10	127A	159

WILSON & COMPANY

RECORD DRAWINGS



PLAN

VISTA VIEJA AVENUE NW

SCALE:
HORIZ: 1" = 50'
VERT: 1" = 5'

A3	T/C	FL
1	28.51	27.84
2	–	27.72
3	28.27	27.60
4	–	28.11

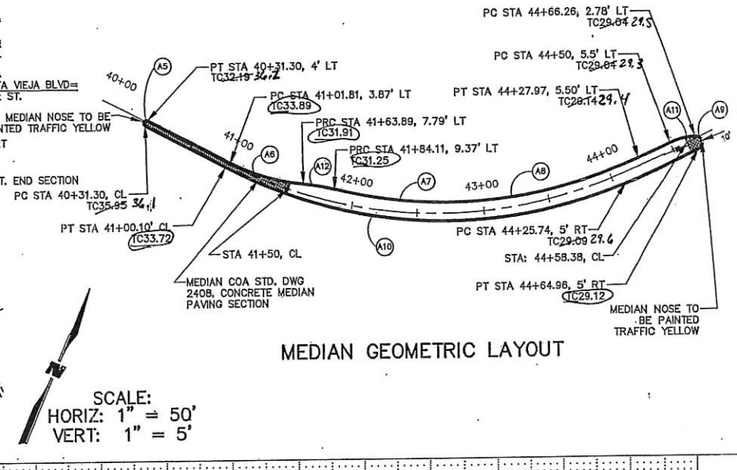
Δ=90°00'00"
L=47.12'
R=30.00'

A4	T/C	FL
1	29.06	28.39
2	–	28.52
3	28.80	28.13
4	–	28.36

Δ=90°00'00"
L=47.12'
R=30.00'

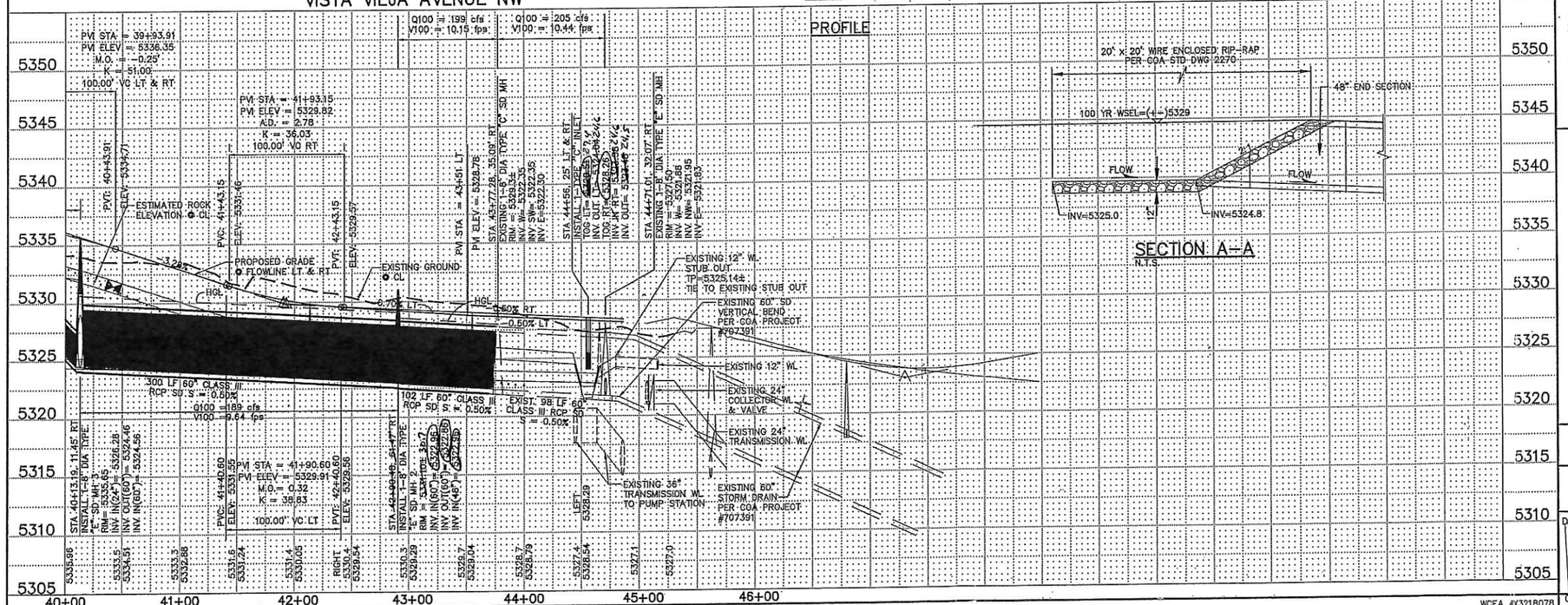
A CL CURVE DATA
Δ=52°32'59"
R=350.00
L=321.01
T=172.79

A5 Δ=180°00'00" L=6.28' R=2.00'
A6 Δ=20°27'25" L=53.56' R=150.00'
A7 Δ=39°50'22" L=238.81' R=150.00'
A8 NOT USED
A9 Δ=161°01'25" L=11.24' R=4.00'
A10 Δ=53°02'58" L=327.72' R=353.95'
A11 Δ=18°58'35" L=16.56' R=50.00'
A12 Δ=07°33'43" L=19.80' R=150.00'



MEDIAN GEOMETRIC LAYOUT

PROFILE



SECTION A-A
N.T.S.

NOTES

SEE TYPICAL ROADWAY SECTION. D
SEE SHEET 10

1. CONSTRUCT STANDARD CURB & GUTTER PER STD DWG 2415A
2. BLANKET STORM DRAIN EASEMENT
3. CONSTRUCT WHEELCHAIR RAMP PER STD DWG 2441 CASE II
4. CONSTRUCT 6' VALLEY GUTTER PER STD DWG 2420
5. 50' CROWN REDUCTION PER STD DWG 2401
6. CONSTRUCT 8' WIDE TRAIL -- ALIGNMENT TO REMAIN WITHIN 25' OF ROW AND BE DETERMINED IN FIELD BY LANDSCAPE ARCHITECT
7. STA 44+89, 55' LT TO STA 44+89, 55' RT REMOVE 110' LF EXISTING CURB & GUTTER. SAW AT EXISTING PAVEMENT.
8. SAW CUT EXISTING 81 ST. STREET PAVEMENT 1". PER COA DWG #2465
9. BIKE TRAIL RAMP SEE SHEET #10

SURVEY INFORMATION
FIELD NOTES

NO.	BY	DATE
	Coronado Surveying, Inc.	

AS-BUILT INFORMATION
CONTRACTOR AGUILA PAVING CO., INC.
WORK INSPECTED BY: CORONADO SURVEYING, INC.
INSPECTOR'S CERTIFIED FIELD REPRESENTATIVE: [illegible]
CONVERTED BY: CORONADO SURVEYING, INC.
RECORDED BY: [illegible]

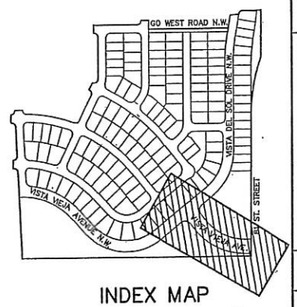
BENCH MARKS
THE STATION IS A 3 1/2" ALUMINUM CAP SET FLUSH IN THE LAVA OUTCROP, AND IS STAMPED "ACS 8-C10, 1986". (NAD 1927).
X= 361860.83, Y= 1521476.37
ELEVATION = 5390.130 FT. (SLD 1929)

MICRO-FILM INFORMATION

NO.	DATE

ENGINEER'S SEAL
ROBERT S. MACLAIRE
NEW MEXICO
15585
REGISTERED PROFESSIONAL ENGINEER
5-24-06

Certification
THE CHANGES SHOWN HEREON ARE BASED UPON A FIELD SURVEY CONDUCTED BY ME OR UNDER MY SUPERVISION AND REFLECT THE LOCATIONS (VERTICALLY AND HORIZONTALLY) TO THE BEST OF MY KNOWLEDGE AND BELIEF.



INDEX MAP

NO.	DATE	REMARKS	BY
		REVISIONS	
		WILSON & COMPANY, ENGINEERS & ARCHITECTS	
		DESIGNED BY RSM	DATE AUGUST 05
		DRAWN BY ST/JFF	DATE AUGUST 05
		CHECKED BY DSA	DATE AUGUST 05

CITY OF ALBUQUERQUE
PUBLIC WORKS DEPARTMENT
ENGINEERING GROUP

VISTA VIEJA PHASE I
PAVING AND STORM DRAIN PLAN &PROFILE
VISTA VIEJA AVENUE N.W.

Design Review Committee: APPROVED DEC 08 2005 DESIGN REVIEW COMMITTEE
City Engineer Approval: APPROVED JAN 27 2006 CITY ENGINEER

Last Design Update	Mo./Day/Yr.	Mo./Day/Yr.

City Project No. 7633.81 | Zone Map No. D-9 | Sheet 14 Of 35

WCEA #X3218078
AUGUST 2005

WILSON & COMPANY

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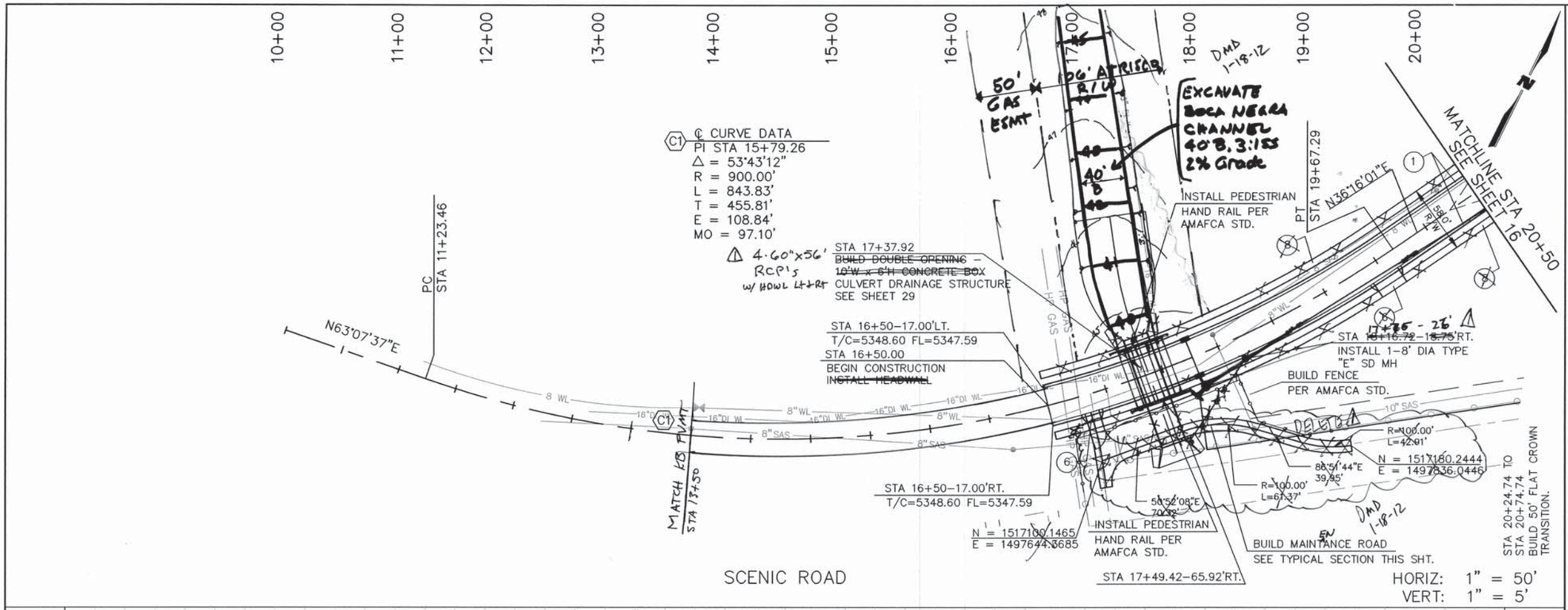
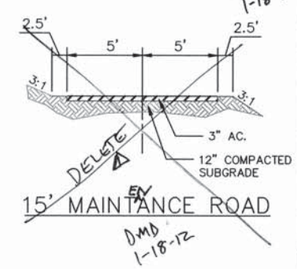
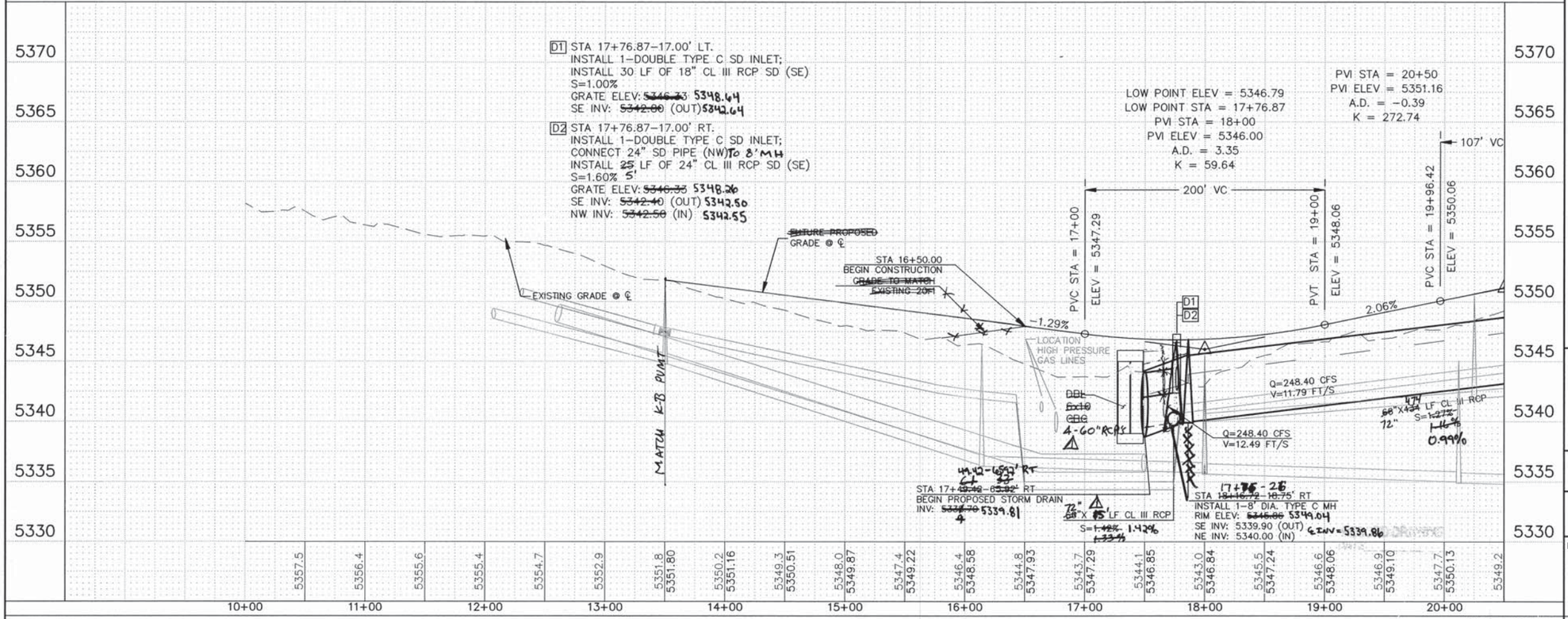


KEYED NOTES:

1. BUILD STANDARD CURB & GUTTER AS PER COA STD DWG 2415A
2. BUILD PINNED CURB TYPE III AS PER COA STD DWG 2415B.
3. BUILD MEDIAN NOSE PATTERNED PCC SEE NOTE (10) SHT. 4 OF ~~28~~.
4. BUILD 6' WIDE VALLEY GUTTER AS PER COA STD DWG 2420
6. BUILD DRIVEPAD AS PER COA STD DWG 2425.
7. BUILD ADA RAMP (DIRECTIONAL) WITH DETECTABLE WARNING SURFACE AS PER COA STD DWG 2426 AND SHEET 28 OF ~~28~~.
8. ~~BUILD 6' WIDE SIDEWALK AS PER PER STD DWG 2430 AND SIDEWALK TABLE THIS SHEET.~~
9. BUILD ADA RAMP WITH DETECTABLE WARNING SURFACE AS PER COA STD DWG 2441 CASE I AND DETAIL ON SHEET 28 OF ~~28~~.
10. BUILD 10' WIDE WALKING TRAIL PER TYPICAL SECTION ON SHT 4 OF ~~28~~.
11. BUILD 6' HIGH CMU WALL PER DETAIL ON SHT 28 OF ~~26~~.





RECORD DRAWING
DATE 07/14

0 50 75 100
HORIZONTAL SCALE

0 5 7.5 10
VERTICAL SCALE

11"x17" SCALE: HORIZ: 1"=100' VERT: 1"=10'
22"x34" SCALE: HORIZ: 1"=50' VERT: 1"=5'

WILSON & COMPANY
4900 LANG AVE NE
ALBUQUERQUE, NEW MEXICO 87109
PH (505) 348-4000
FAX (505) 348-4072
www.wilsonco.com

AS-BUILT INFORMATION
CONTRACTOR: AUI
WORK INSPECTED BY: AUI DATE 07/14
INSPECTOR'S ACCEPTANCE BY: W.C.I. DATE 07/14
FIELD VERIFICATION BY: W.C.I. DATE 07/14
DRAWING CORRECTED BY: W.C.I. DATE 07/14
MICRO-FILM INFORMATION
RECORDED BY: DATE
NO.

BENCH MARKS
ACS BRASS CAP, STAMPED "3-E10"
SET IN TOP OF CONCRETE POST PROJECTING 0.30 FT. ABOVE GROUND, LOCATED APPROX. 225' E OF THE INTERSECTION OF RIM ROCK DR. NW AND MARIGOLD DR. NW
(NAD 1983), X 1499059.808, Y 1512627.946
ELEVATION = 5318.89 FT. (NAVD 1988)

SURVEY INFORMATION
FIELD NOTES
NO. BY DATE

ENGINEER'S SEAL
DONALD M. DUNCAN NEW MEXICO 17616 REGISTERED PROFESSIONAL ENGINEER
1-11-12

NO.	DATE	REMARKS	BY
1	7.2.12	REVISIONS AS-BUILT	STA

WILSON & COMPANY, ENGINEERS & ARCHITECTS

DESIGNED BY	DAS	DATE	JUNE 11
DRAWN BY	STAFF	DATE	JUNE 11
CHECKED BY	SJM	DATE	JUNE 11

CITY OF ALBUQUERQUE
DEPARTMENT OF MUNICIPAL DEVELOPMENT
ENGINEERING DIVISION

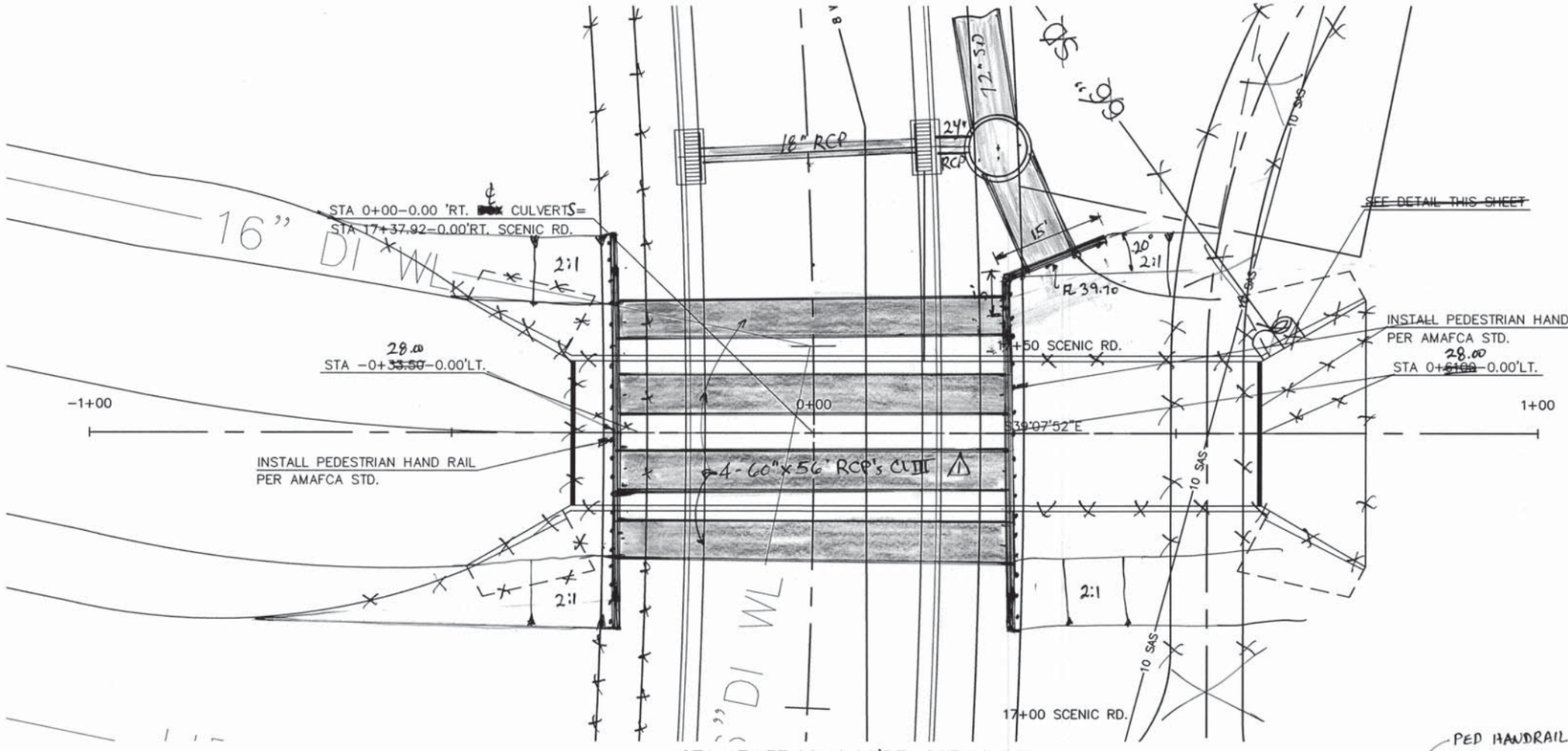
SPECIAL ASSESSMENT DISTRICT 228-VOL 2
PAVING/STORM DRAIN PLAN & PROFILE
SCENIC ROAD

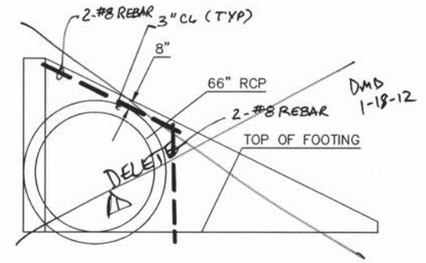
Design Review Committee	City Engineer Approval	Last Design Update	Mo./Day/Yr.	Mo./Day/Yr.
APPROVED JAN 23 2012 DESIGN REVIEW COMMITTEE	APPROVED JAN 23 2012 CITY ENGINEER			

City Project No.	Zone Map No.	Sheet
693391	D-9, D-10	15 Of 29

J:\RR\08-400-104-00\CADD\SHEETS\UNITS 14-25\PNP Road\PNP_Scenic Dr_UNIVERSE BLVD.dwg 1/4/2012 10:24:31 AM MST

WCEA #08400100400
DECEMBER 2011





~~SCENIC RD. BOX CULVERT~~
~~WING WALL WITH 66" RCP~~

STA 17+37.92-0.00'RT. SCENIC RD.

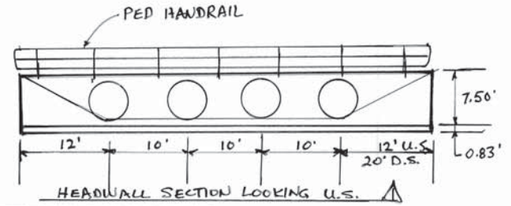
BUILD ~~DOUBLE OPENING [illegible] X 6'H X 95' C.B.C.'S~~ 4-60"x56'RCP's

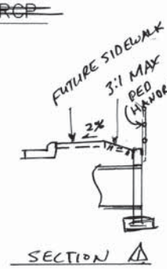
NORMAL IN PLACE

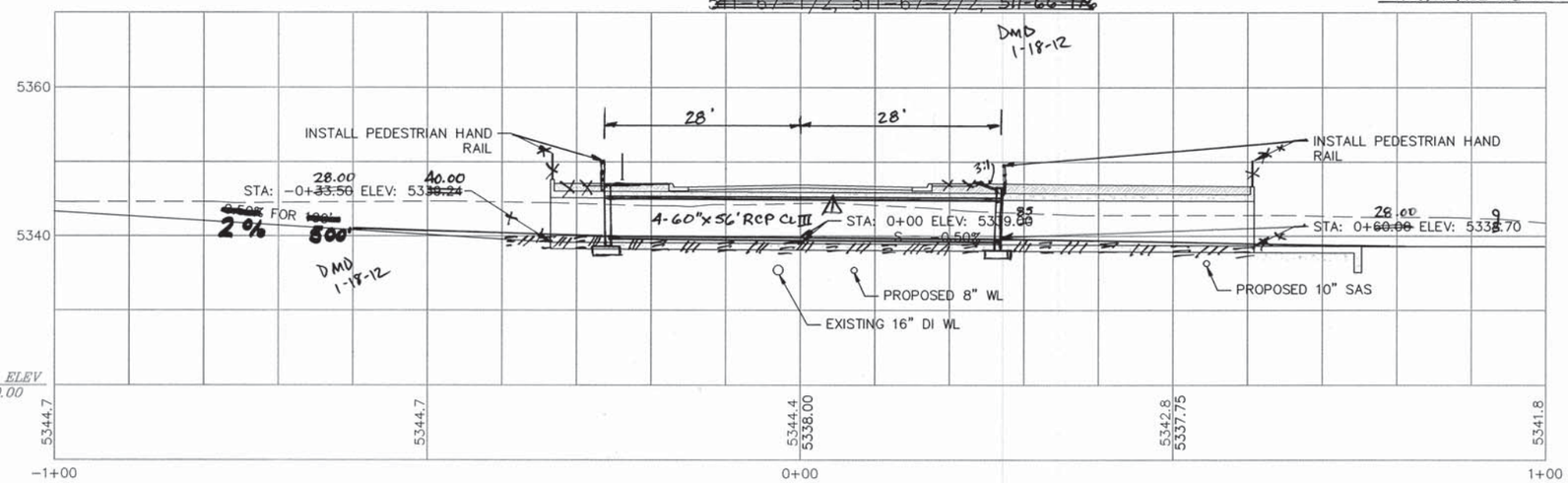
BUILD ~~HEADWALLS~~ ~~WINGWALLS~~ LT. & RT:

~~BUILD EROSION CONTROL PAD RT. L =18.75'~~

PER NMDOT STD. DWGS 511-~~65 1/2~~ 03-1/4, ~~511-65 2/2~~,
~~511-66 1/2~~, ~~511-66 2/2~~, ~~511-66 5/8~~,
~~511-67 1/2~~, ~~511-67 2/2~~, ~~511-69 1/6~~







0 10 15 20
HORIZONTAL SCALE

0 10 15 20
VERTICAL SCALE

11"x17" SCALE: HORIZ: 1"=20' VERT: 1"=10'
22"x34" SCALE: HORIZ: 1"=10' VERT: 1"=10'

WILSON &COMPANY
4900 LANG AVE NE
ALBUQUERQUE, NEW MEXICO 87109
PH (505) 348-4000
FAX (505) 348-4072
www.wilsonco.com

RECORD DRAWING
DATE 07/14

CITY OF ALBUQUERQUE
DEPARTMENT OF MUNICIPAL DEVELOPMENT
ENGINEERING DIVISION

SPECIAL ASSESSMENT DISTRICT 228 – VOL. 2
BOX CULVERT DETAILS

Design Review Committee	City Engineer Approval	Last Design Update	Mo./Day/Yr.	Mo./Day/Yr.
APPROVED JAN 23 2012 DESIGN REVIEW COMMITTEE	APPROVED JAN 23 2012 CITY ENGINEER			

WCEA #0840010400
DECEMBER 2011

City Project No. 693391 | Zone Map No. D-9, D-10 | Sheet 29 Of 29

AS-BUILT INFORMATION

	CONTRACTOR	DATE
WORK STAKED BY	AUT	07/14
ACCEPTANCE BY	WCE	07/14
VERIFICATION BY	WCE	07/14
DRAWINGS REVISED BY	WCE	07/14

BENCH MARKS

ACS BRASS CAP, STAMPED "3-E10"
SET IN TOP OF CONCRETE POST PROJECTING 0.30 FT. ABOVE GROUND. LOCATED APPROX. 225' E OF THE INTERSECTION OF RIM ROCK DR. NW AND MARIGOLD DR. NW
(NAD 1983), X 1499059.808, Y 1512627.946

MICRO-FILM INFORMATION

RECORDED BY
DATE
NO.

ELEVATION = 5318.89 FT. (NAVD 1988)

SURVEY INFORMATION
FIELD NOTES

NO.	BY	DATE

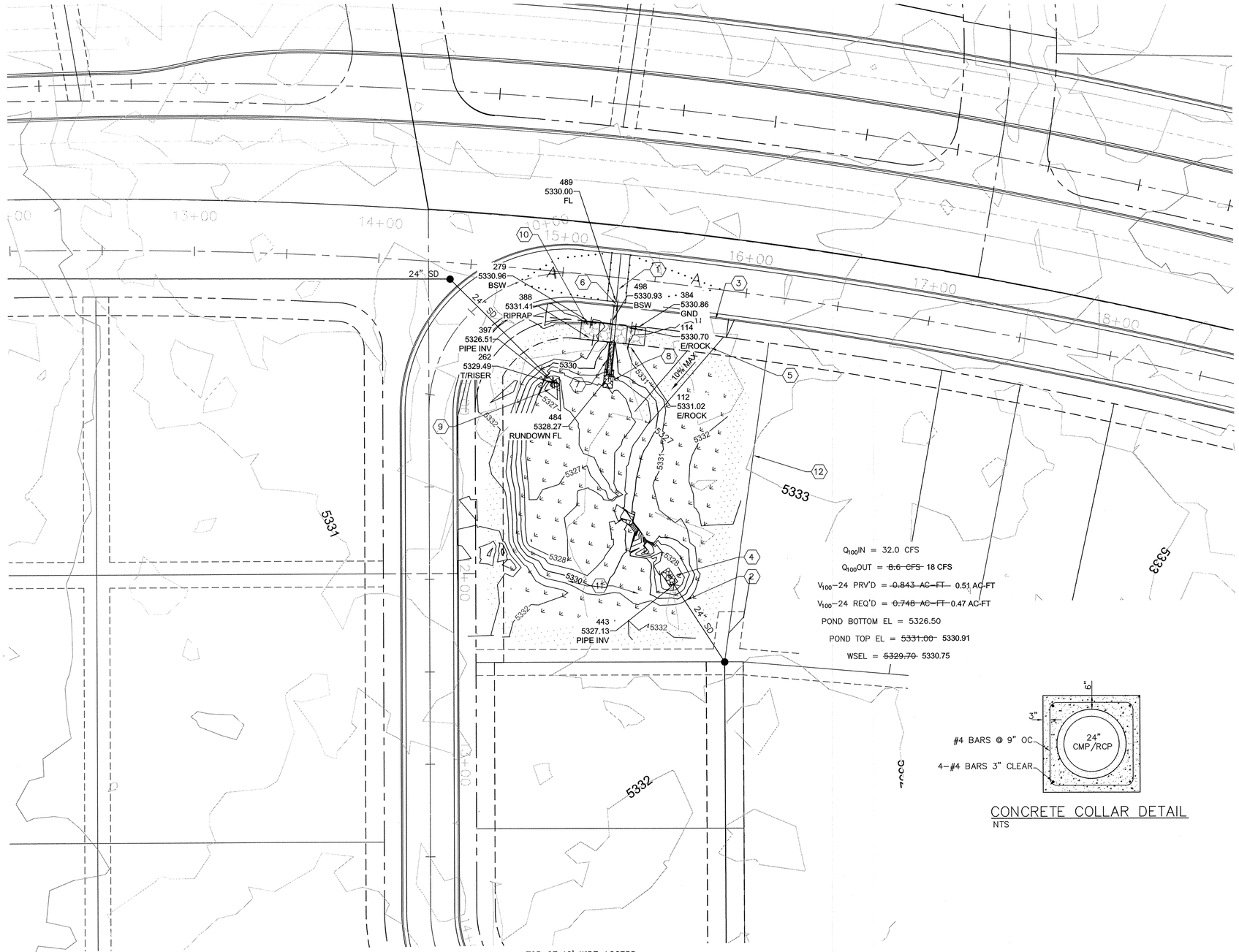
ENGINEER'S SEAL

DOUGLAS M. GUTIERREZ — NEW MEXICO — 17078 — REGISTERED PROFESSIONAL ENGINEER — 1-17-12

NO.	DATE	REMARKS / REVISIONS	BY
1	1-2-12	EXH A Revisions	SJM

WILSON & COMPANY, ENGINEERS & ARCHITECTS

DESIGNED BY	TGO/ELO	DATE	2011
DRAWN BY	ELO	DATE	2011
CHECKED BY	SJM	DATE	2011



$Q_{100}IN$ = 32.0 CFS

$Q_{100}OUT$ = ~~8.6 CFS~~ 18 CFS

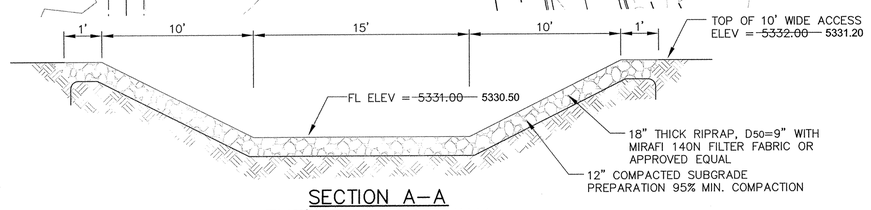
V_{100}-24 PRV'D = ~~0.843 AC-FT~~ 0.51 AC-FT

V_{100}-24 REQ'D = ~~0.748 AC-FT~~ 0.47 AC-FT

POND BOTTOM EL = 5326.50

POND TOP EL = ~~5331.00~~ 5330.91

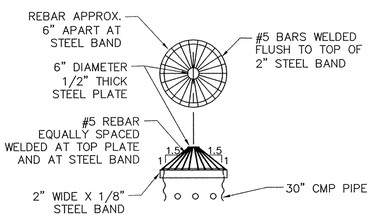
WSEL = ~~5329.70~~ 5330.75



SECTION A-A
EMERGENCY SPILLWAY
NTS

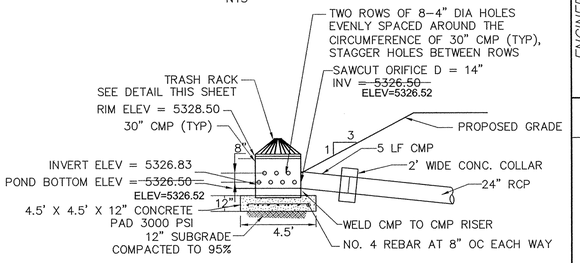
POND 4
SHALL BE MAINTAINED BY
PRIVATE (VCPOA)

CONCRETE COLLAR DETAIL
NTS



NOTE: ALL EXPOSED METAL SHALL BE "HOT DIP" GALVANIZED

TRASH RACK DETAIL
NTS



CMP RISER DETAIL
NTS

GENERAL SHEET NOTES

1. NO ROCK EXCAVATION ALLOWED PER V.C.S.P.

SHEET KEYNOTES

1. STA 15+30.3, INSTALL 10' WIDE SPECIAL CONCRETE VALLEY GUTTER PER COA STD DWG 2422.
2. INSTALL 50 LF 24" PIPE @ 0.94%, INV = ~~5327.00~~, 1-24" POND INLET STRUCTURE. INV=5327.13
3. STA 15+84, 15' RT INSTALL 15' WIDE DRIVEPAD PER COA STD DWG 2425
4. INSTALL 5'W X 9'L X 18" D, D_{50}=9" RIPRAP BLANKET WITH MIRAFI 140N FILTER FABRIC OR APPROVED EQUAL.
5. INSTALL 10' WIDE GRAVEL MAINTENANCE ACCESS. 6" AGGREGATE BASE COURSE, 95% MIN COMPACTION, S_{MAX}=10%.
6. STA 15+30.3, 15' RT, INSTALL 1-24" WIDE DOUBLE SIDEWALK CULVERT PER COA STD DWG 2236. FL = ~~5330.01~~ FL=5330.00
7. INSTALL 18 LF 2' WIDE, 6" DEEP CONCRETE RUNDOWN, S_{MAX}=3:1.
8. INSTALL 5'W X 10'L X 18" D TYPE 'L' RIPRAP BLANKET WITH MIRAFI 140N FILTER FABRIC OR APPROVED EQUAL.
9. INSTALL 30" RISER, 2 ROWS OF 8-4" DIA HOLES, W/14" ORIFICE PLATE. SEE DETAIL THIS SHEET.
10. INSTALL 10'W X 15'L EMERGENCY SPILLWAY. SEE DETAIL THIS SHEET.
11. INSTALL NATIVE SEED AND MULCH OVER 1' TOP SOIL, PI>10.
12. APPROXIMATELY 350 LF OF 5' CMU WALL TO BE INSTALLED AROUND POND AS APPROVED BY ENGINEER. PAID FOR PER LF CMU WALL BID ITEM.

GRAPHIC SCALE

30 0 15 30 60 120

(IN FEET)
1 inch = 30 ft.

RECORD DRAWING
DATE 10/7/14

WCEA # 0840010400
DECEMBER 2011

AS-BUILT INFORMATION

CONTRACTOR	AUI	
WORK STAKED BY:	AUI	DATE 07/14
INSPECTOR'S ACCEPTANCE BY:	WCI	DATE 10/14
AS-BUILT VERIFICATION BY	WCI	DATE 10/14
DRAWINGS CORRECTED BY:	WCI	DATE 10/14

MICRO-FILM INFORMATION

RECORDED BY
DATE
NO.

BENCH MARKS

ACS BRASS CAP, STAMPED "3-E10"
SET IN TOP OF CONCRETE POST PROJECTING 0.30 FT. ABOVE GROUND. LOCATED APPROX. 225' E OF THE INTERSECTION OF RIM ROCK DR. NW AND MARIGOLD DR. NW
(NAD 1983), X 1499059.808, Y 1512627.946

ELEVATION = 5318.89 FT. (NAVD 1988)

SURVEY INFORMATION

FIELD NOTES

NO.	BY	DATE

ENGINEER'S SEAL

DONALD M. DUNEMAN
NEW MEXICO
17616
REGISTERED PROFESSIONAL ENGINEER

NO.	DATE	REMARKS
		REVISIONS

WILSON & COMPANY, ENGINEERS & ARCHITECTS

DESIGNED BY	STAFF	DATE JAN. 2012
DRAWN BY	STAFF	DATE JAN. 2012
CHECKED BY	SJM	DATE JAN. 2012

WILSON & COMPANY
4900 LANG AVE. NE
ALBUQUERQUE, NEW MEXICO 87109
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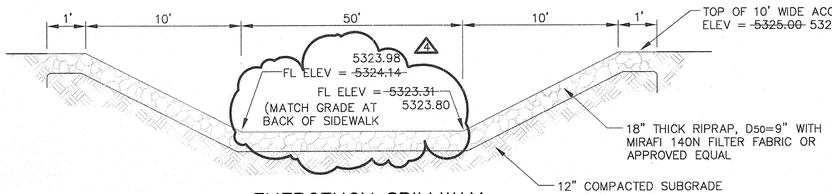
CITY OF ALBUQUERQUE
DEPARTMENT OF MUNICIPAL DEVELOPMENT
ENGINEERING DIVISION

SPECIAL ASSESSMENT DISTRICT 228-VOL. 1
POND 4 GRADING PLAN

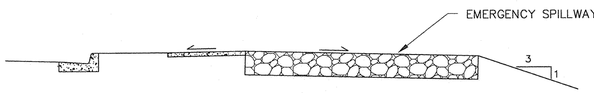
Design Review Committee	City Engineer Approval	Last Design Update	Mo./Day/Yr.	Mo./Day/Yr.

City Project No.	Zone Map No.	Sheet	Of
693391	D-10, D-11	109A	156

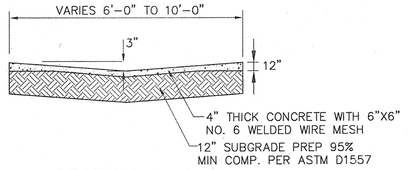
M:\RR\08-400-104-00\CADD\SHEETS\UNITS 18-19-22\0109 POND 4 GRADING.dwg 1/12/2012 2:50:13 PM MST



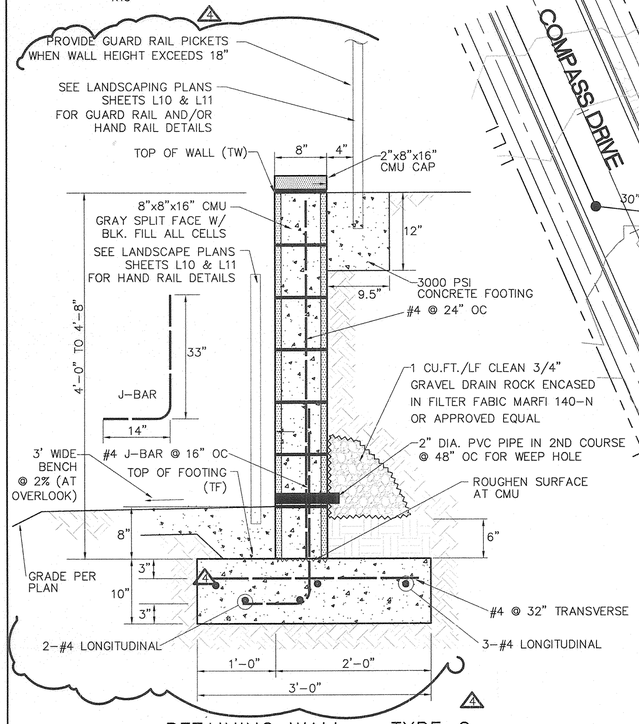
EMERGENCY SPILLWAY
NTS



SECTION B–B
NTS

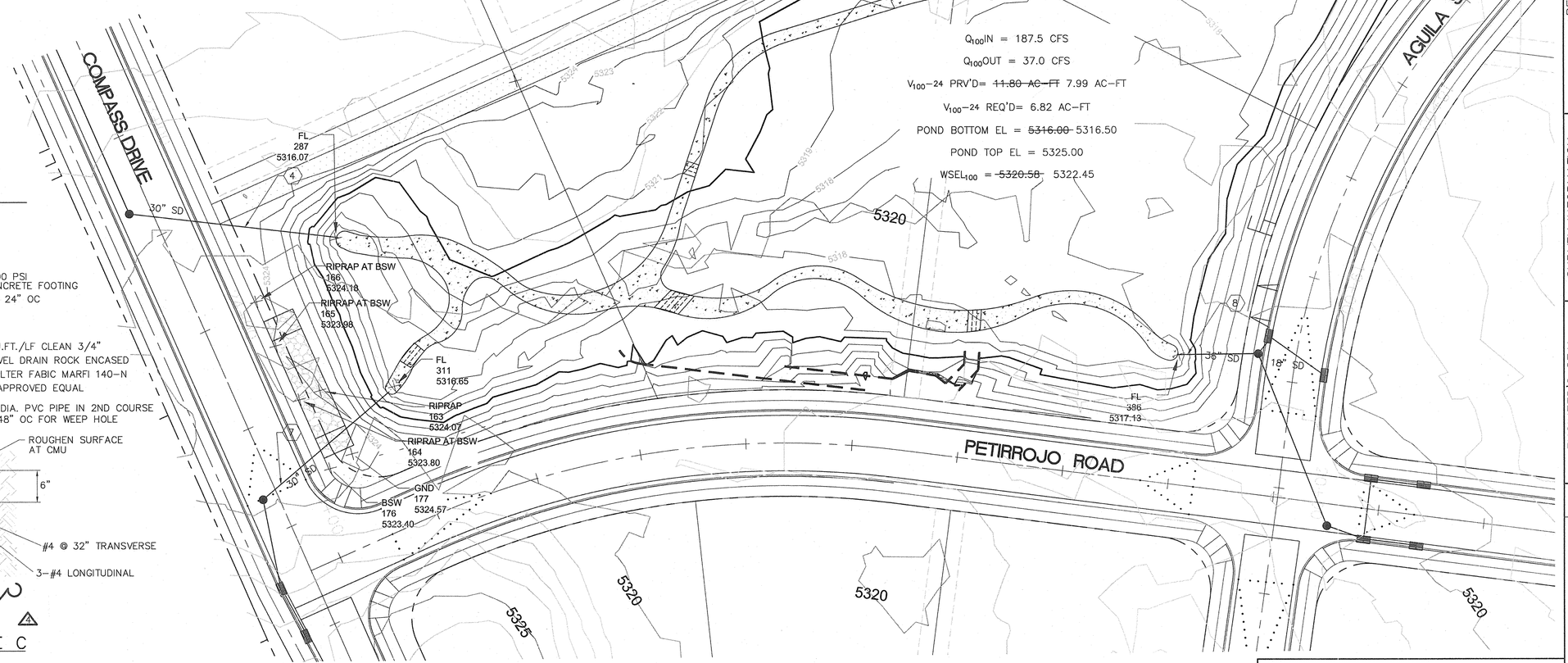


SECTION A–A
LOW FLOW CHANNEL
NTS



RETAINING WALL – TYPE C
2'–0" TO 4'–8"

NOTE:
FINISHED GRADE SHALL BE LEVEL WITH OR BELOW TOP OF RETAINING PORTION OF WALL, AND NO ADDITIONAL SURFACE LOADS SHALL BE PLACED WITHIN AN AREA FROM FACE OF WALL TO A DISTANCE EQUAL TO THE RETAINED EARTH HEIGHT.



SHEET KEYNOTES

1. INSTALL 10' WIDE GRAVEL MAINTENANCE ACCESS, S_{MAX}=10%, 6" AGGREGATE BASE COURSE, 95% MIN COMPACTION. SEE SHEET 124 FOR DETAIL.
2. NOT USED.
3. FLATTEN CHANNEL BOTTOM FROM 3" TO 0".
4. INSTALL 30" POND OUTLET STRUCTURE, ~~INV =5315.75.~~ INV=5316.07 SEE SHEET 124 FOR DETAIL.
5. STA 19+17, 15' RT, INSTALL 15' WIDE DRIVEPAD PER COA STD DWG 2425.
6. INSTALL 48 LF 60" SD PIPE @ 0.35%, ~~INV = 5317.24~~, INV=5317.51 1– 60" POND INLET STRUCTURE. SEE SHEET 124 FOR DETAIL.
7. INSTALL 81.5 LF 24" PIPE @ 0.12%, ~~INV = 5316.20~~ INV=5316.65, 1–24" POND INLET STRUCTURE.
8. INSTALL 34 LF 36" PIPE @ 0.50%, ~~INV = 5317.00,~~ INV=5317.13 1–36" INLET STRUCTURE. SEE SHEET 124 FOR DETAIL.
9. INSTALL LOW FLOW CHANNEL. SEE DETAIL THIS SHEET.
10. NOT USED.
11. INSTALL 10'W X 50'L EMERGENCY SPILLWAY. SEE DETAIL THIS SHEET.
12. INSTALL 10' WIDE MAINTENANCE ACCESS. SEE SHEET 124 FOR DETAIL.
13. INSTALL 3–24" SIDEWALK CULVERT PER COA STD DWG 2236. SKEW ANGLE = 0° AND 13°
14. INSTALL RETAINING WALL PER DETAIL THIS SHEET. COST WILL BE INCIDENTAL PER LANDSCAPE LUMP SUM BID ITEM.
15. INSTALL 5–24" SIDEWALK CULVERT PER COA STD DWG 2236. SKEW ANGLE = 26°

GENERAL SHEET NOTES

1. NO ROCK EXCAVATION ALLOWED PER V.C.S.P.
2. SEE LANDSCAPE PLANS FOR PROPOSED SURFACE TREATMENTS
3. SEE LANDSCAPE PLANS FOR PROPOSED POND FEATURES.

POND 5
CITY PARK MAINTAINED BY PARKS & REC EXCEPT FOR INLET/OUTLET STRUCTURES AND LOW FLOW CHANNEL (ITEMS 4, 6, 7, 8, AND 9) WHICH WILL BE MAINTAINED BY COA STORM DRAIN MAINTENANCE.

N

RECORD DRAWING
DATE 11/3/14

GRAPHIC SCALE
30 0 15 30 60 120
(IN FEET)
1 inch = 30 ft.

WCEA # 0840010400
DECEMBER 2011

AS-BUILT INFORMATION

CONTRACTOR	AUI	DATE 07/14
WORK INSPECTOR'S DESIGN	AUI	DATE 10/14
INSPECTOR'S ACCEPTANCE	WCI	DATE 10/14
AS-BUILT VERIFICATION	WCI	DATE 10/14
DRAWINGS CHECKED	WCI	DATE 10/14
MICRO-FILM INFORMATION		RECORDED BY
		DATE

BENCH MARKS
ACS BRASS CAP, STAMPED "3–E10"
SET IN TOP OF CONCRETE POST PROJECTING 0.30 FT. ABOVE GROUND. LOCATED APPROX. 225' E OF THE INTERSECTION OF RIM ROCK DR. NW AND MARIGOLD DR. NW
(NAD 1983), X 1499059.808, Y 1512627.946
ELEVATION = 5318.89 FT. (NAVD 1988)

SURVEY INFORMATION
FIELD NOTES

NO.	BY	DATE

ENGINEER'S SEAL
DONALD M. DUNCAN NEW MEXICO 17616 LICENSED PROFESSIONAL ENGINEER

REVISIONS

NO.	DATE	REMARKS	BY
1	06-12-13	MISC GRADING CLAIRIFICATIONS	KJS
2	07-12-12	EXHIBIT A REVISION	DMD

WILSON & COMPANY, ENGINEERS & ARCHITECTS
DESIGNED BY STAFF DATE JAN. 2012
DRAWN BY STAFF DATE JAN. 2012
CHECKED BY S.M. DATE JAN. 2012

WILSON &COMPANY
4900 LANG AVE NE
ALBUQUERQUE, NEW MEXICO 87109
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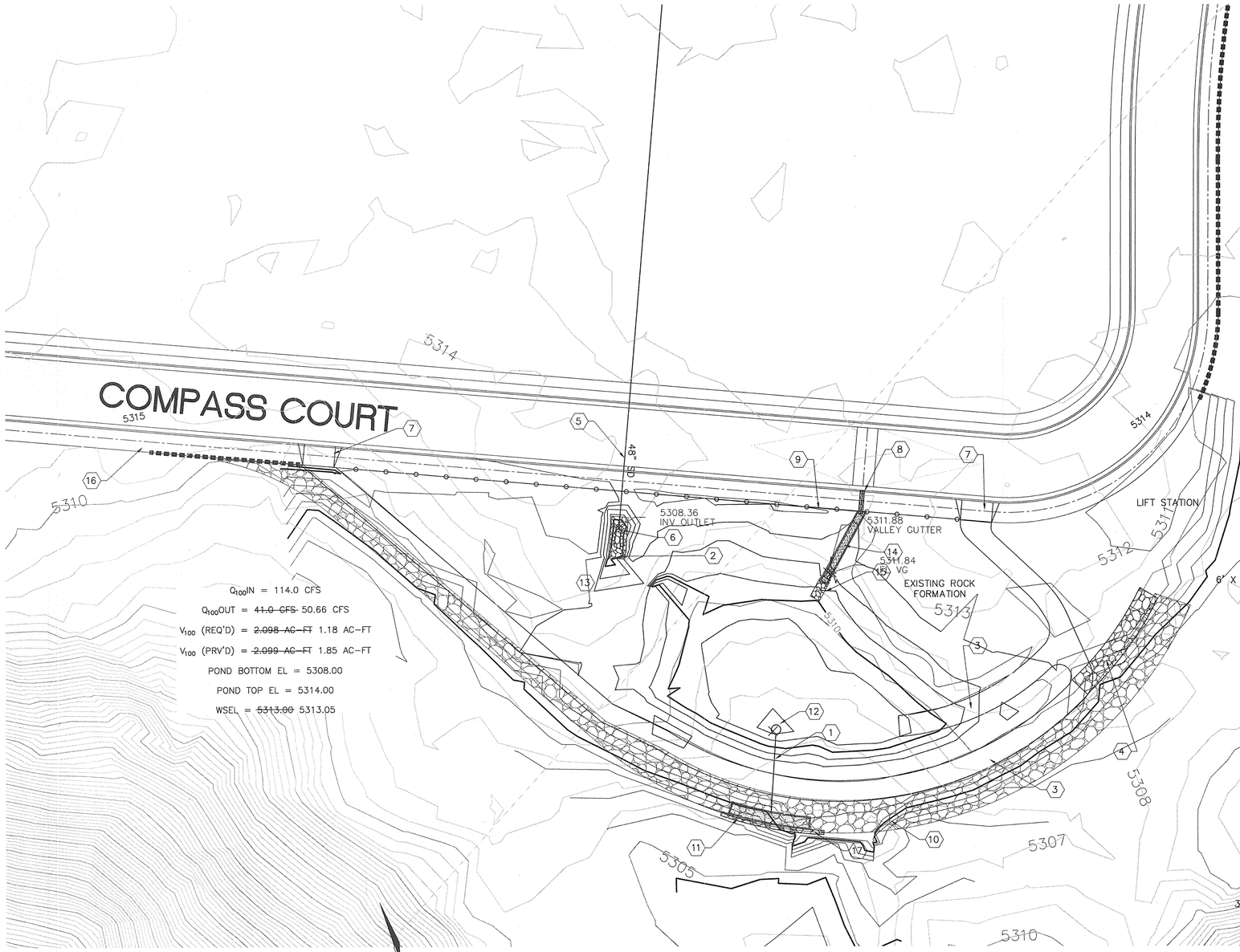
CITY OF ALBUQUERQUE
DEPARTMENT OF MUNICIPAL DEVELOPMENT
ENGINEERING DIVISION

SPECIAL ASSESSMENT DISTRICT 228–VOL. 1
POND 5 GRADING & DRAINAGE PLAN

Design Review Committee	City Engineer Approval	Last Design Update	Mo./Day/Yr.	Mo./Day/Yr.

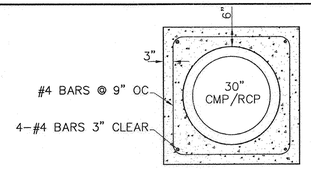
City Project No.	Zone Map No.	Sheet	Of
693391	D–10, D–11	110P	156



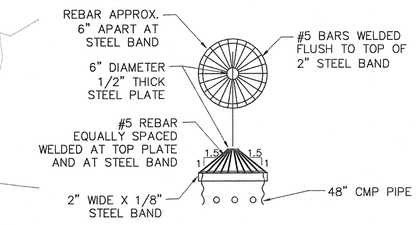
GRAPHIC SCALE

30 0 15 30 60 120

(IN FEET)
1 inch = 30 ft.

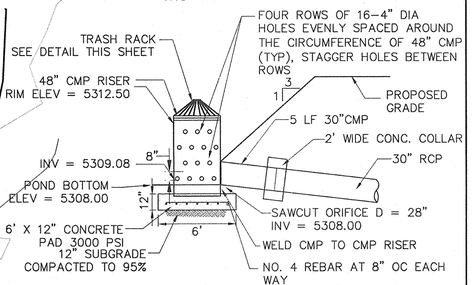


CONCRETE COLLAR DETAIL
NTS

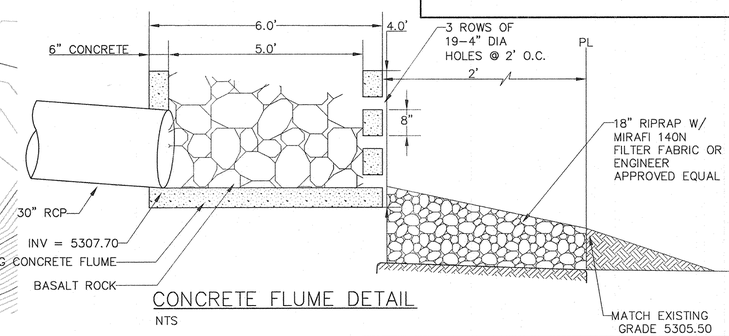


NOTE: ALL EXPOSED METAL SHALL BE "HOT DIP" GALVANIZED

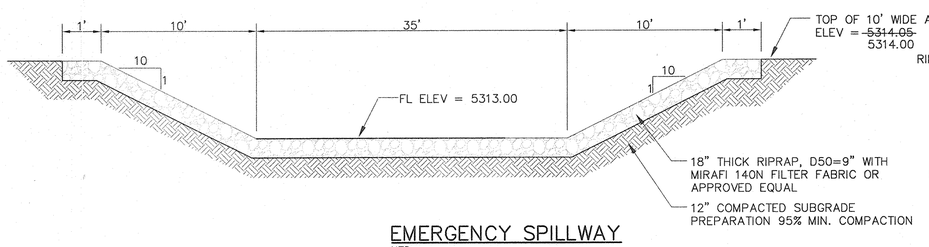
TRASH RACK DETAIL
NTS



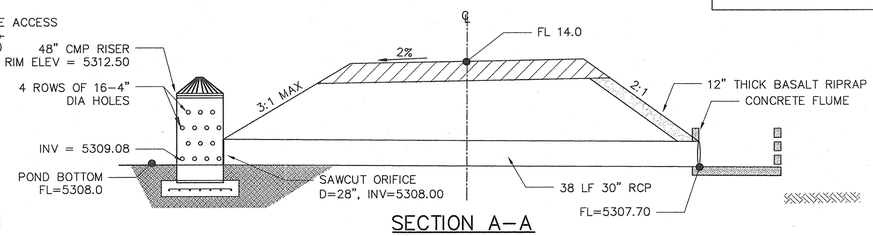
CMP RISER DETAIL
NTS



CONCRETE FLUME DETAIL
NTS



EMERGENCY SPILLWAY
NTS



SECTION A-A
NTS

POND 6
SHALL BE MAINTAINED BY COA OPEN SPACE EXCEPT FOR INLET/OUTLET STRUCTURES (ITEMS 1, 2, 6, 12,) WHICH WILL BE MAINTAINED BY COA STORM DRAIN MAINTENANCE.

RECORD DRAWING
DATE 11/3/14

WCEA # 0840010400
DECEMBER 2011

GENERAL SHEET NOTES

1. NO ROCK EXCAVATION ALLOWED PER V.C.S.P.
2. SEE LANDSCAPING PLAN FOR PLANTING AND IRRIGATION DETAILS.

SHEET KEYNOTES

1. INSTALL 42 LF 30" RCP SD, S = 0.70%, INV UP = 5308.00, INV DOWN = 5307.70
2. INSTALL 8'W X 17'L X 12"D, D50=6" RIPRAP BLANKET W/ MIRAFI 140N FILTER FABRIC OR APPROVED EQUAL.
3. INSTALL 10' WIDE, GRAVEL MAINTENANCE ACCESS. 6" AGGREGATE BASE COURSE, 95% MIN COMPACTION.
4. INSTALL EMERGENCY SPILLWAY. SEE DETAIL THIS SHEET.
5. INSTALL 342 LF 48" SD PIPE @ 0.22%, INV = 5308.20.
6. INSTALL 1-48" SD POND INLET STRUCTURE.
7. STA 12+78, 15' RT & STA 16+15, 15' RT, INSTALL 15' WIDE DRIVE PAD PER COA STD DWG 2425.
8. STA 15+40, 15' RT, INSTALL 2-24" WIDE SIDEWALK CULVERT PER COA STD DWG 2236.
9. INSTALL OPEN SPACE FENCE.
10. INSTALL 12" THICK BASALT RIPRAP, D50=6", W/ MIRAFI 140N FILTER FABRIC OR APPROVED EQUAL.
11. INSTALL 2'W X 50'L X 18" D, D50=6" RIPRAP BLANKET W/ MIRAFI 140N FILTER FABRIC OR APPROVED EQUAL.
12. INSTALL 48" RISER W/ 28" ORIFICE PLATE, 4 ROWS OF 15-4" DIA STAGGERED HOLES. SEE DETAIL THIS SHEET.
13. NATIVE GRASS SEED AND MULCH OVER 1' TOP SOIL PI>10
14. INSTALL 5' WIDE, 6" DEEP CONCRETE RUNDOWN, SMAX = 3:1. SEE DETAIL SHEET 124.
15. INSTALL 5'W X8'L X 18" D, D50=6" RIPRAP BLANKET WITH MIRAFI 140N FILTER FABRIC OR APPROVED EQUAL.
16. 10' WIDE PEDESTRIAN TRAIL.
17. INSTALL 38' LONG, 5' WIDE CONCRETE FLUME. SEE DETAIL THIS SHEET.

AS-BUILT INFORMATION
CONTRACTOR AUI
WORK STAKED BY AUI DATE 07/14
AS-BUILT SURVEY ACCEPTANCE BY WCI DATE 10/14
AS-BUILT SURVEY VERIFICATION BY WCI DATE 10/14
DRAWINGS CORRECTED BY WCI DATE 10/14
MICRO-FILM INFORMATION
RECORDED BY DATE
NO.

BENCH MARKS
ACS BRASS CAP, STAMPED "3-E10"
SET IN TOP OF CONCRETE POST PROJECTING 0.30 FT. ABOVE GROUND. LOCATED APPROX. 225' E OF THE INTERSECTION OF RIM ROCK DR. NW AND MARIGOLD DR. NW
(NAD 1983), X 1499059.808, Y 1512627.946
ELEVATION = 5318.89 FT (NAVD 1988)

SURVEY INFORMATION
FIELD NOTES
NO. BY DATE

ENGINEER'S SEAL
DONALD M. DUNEMAN NEW MEXICO 17616 LICENSED PROFESSIONAL ENGINEER

REMARKS
REVISIONS
NO. BY DATE

WILSON & COMPANY, ENGINEERS & ARCHITECTS
DESIGNED BY STAFF DATE JAN. 2012
DRAWN BY STAFF DATE JAN. 2012
CHECKED BY STAFF DATE JAN. 2012

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4900 LANG AVE NE
ALBUQUERQUE, NEW MEXICO 87109
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FAX (505) 348-4072
www.wilsonco.com

CITY OF ALBUQUERQUE
DEPARTMENT OF MUNICIPAL DEVELOPMENT
ENGINEERING DIVISION

SPECIAL ASSESSMENT DISTRICT 228-VOL.
POND 6 GRADING PLAN

Design Review Committee	City Engineer Approval	Last Design Update	Mo./Day/Yr.	Mo./Day/Yr.

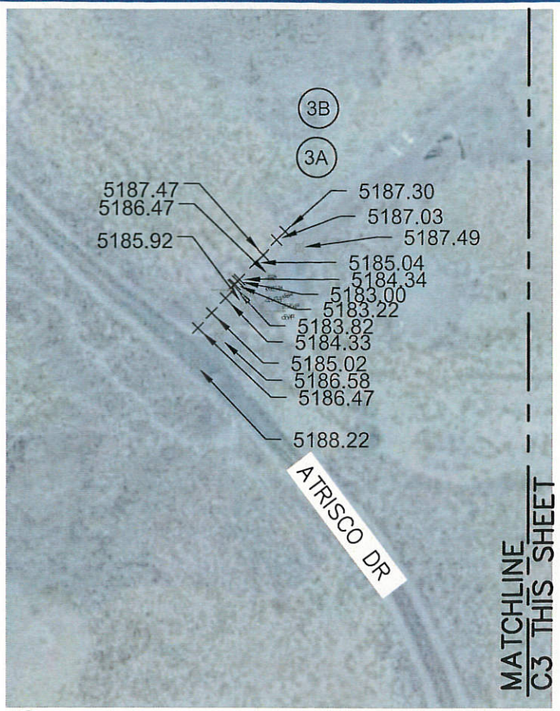
City Project No. 693391 | Zone Map No. D-10, D-11 | Sheet 111R Of 156

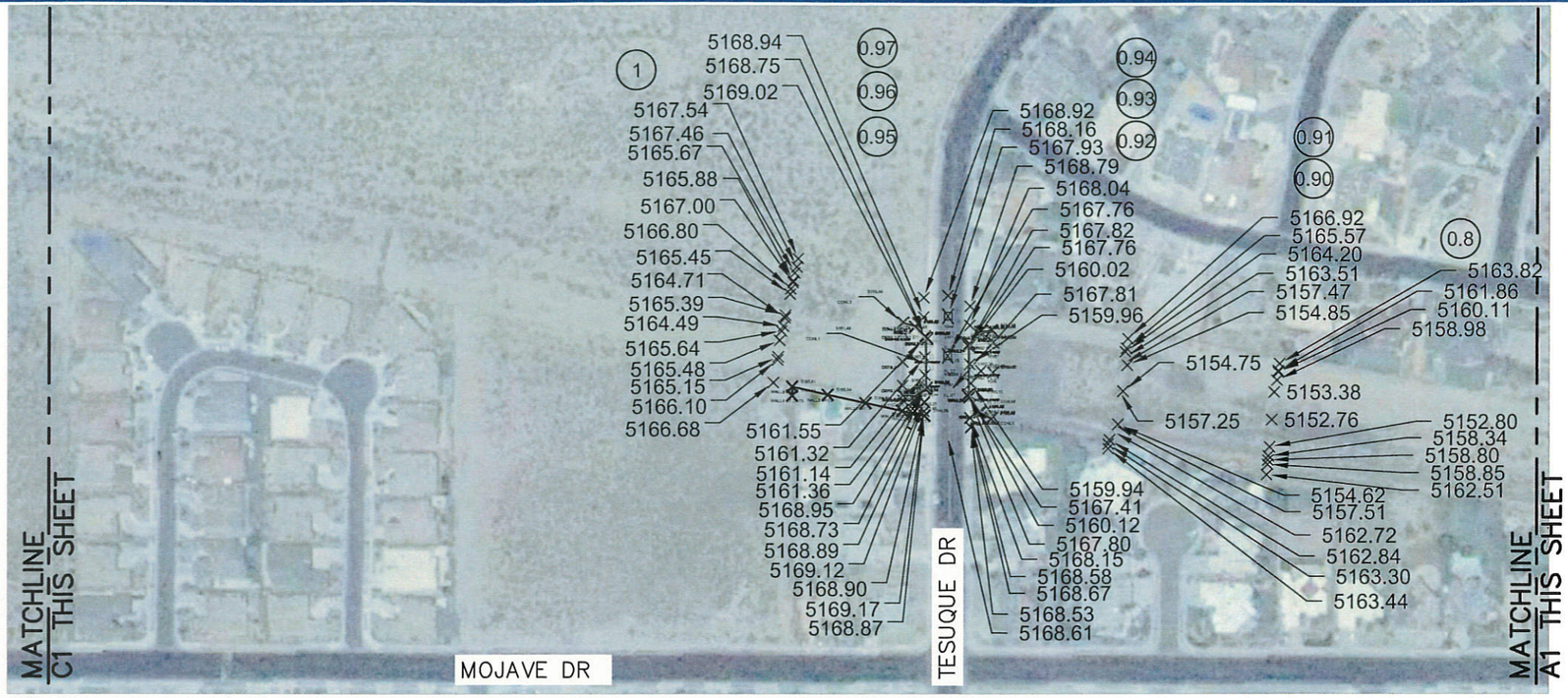
M:\RR\08-400-104-00\CADD\SHEETS\UNITS 18-19-22\0111 POND 6 GRADING.dwg 1/12/2012 2:48:58 PM MST

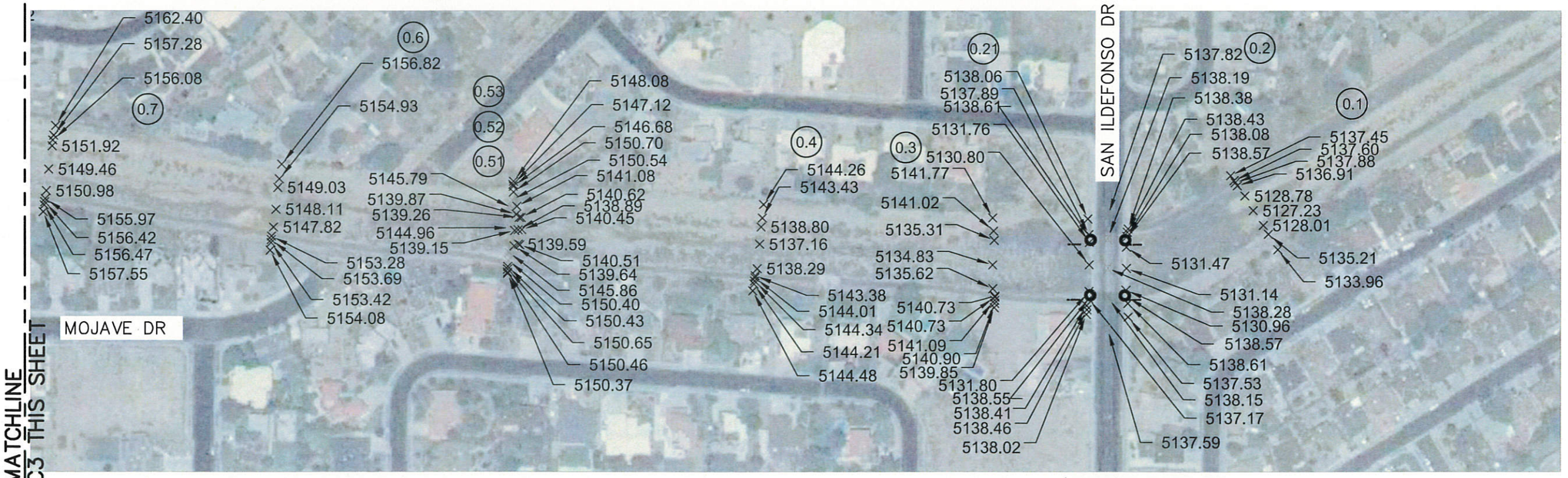
6423Star Bright Road

*Recognized floodwall per Petroglyph Shadows Subdivision as-built drawings April 2002

6515 Tesuque Drive







C1 C3 A1

N

SCALE: 1"= 200'

LEGEND

SECTION ID (0.4)

CROSS SECTION SURVEY MAP

WILSON & COMPANY
4900 LANG AVE., N.E.
ALBUQUERQUE, NEW MEXICO
87109
PH (505) 348-4000
FAX (505) 348-4072
www.wilsonco.com

U:\PROJ\2400\086\00\CADD\EXHIBITS\BOCA NEGRA XSEC.DWG 6/10/2016 2:32 PM

APPENDIX 6 (CD)

PROPERTY OWNER NOTIFICATION LETTERS
PROPERTY OWNERSHIP TABLE
FLOODPLAIN EXHIBIT
ANNOTATED FIRM

Bruce M. Thomson, P.E., Chair
Cynthia D. Borrego, Vice Chair
Ronald D. Brown, Secretary-Treasurer
Deborah L. Stover, Assistant Secretary-Treasurer
Tim Eichenberg, Director

Jerry M. Lovato, P.E.
Executive Engineer

Albuquerque Metropolitan Arroyo Flood Control Authority
2600 Prospect N.E., Albuquerque, NM 87107
Phone: (505) 884-2215 Fax: (505) 884-0214
Website: www.amafca.org

June 29, 2016

Attn: LOMC Manager
LOMC Clearinghouse
847 South Pickett Street
Alexandria, VA 22304-4605

Re: Boca Negra Arroyo Letter of Map Revision (LOMR) – Additional information
Case No: 16-06-0422P
Community: City of Albuquerque, NM
Community No.: 350001
316-AD

Dear LOMC Manager:

Please find included the updated Work Map, property owner notification letters certified by the engineer, the MT-2 Form with City of Albuquerque signature, and a CD containing that information for the above referenced LOMR.

I can be contacted at 505-884-2215 or by e-mail at bbingham@amafca.org if you have any questions or need additional information.

Sincerely,
AMAFCA

Bradley L. Bingham

Brad Bingham, P.E.
Drainage Engineer

cc AMAFCA Construction File 400 118000
Ms. Melissa Lozoya, P.E. – mlozoya@cabq.com w/o attachments
Ms. Tiffany Tillison - tiffany.tillison@aecom.com w/o attachments
Mr. Don Briggs – Bernalillo County
Mr. Abiel Carrillo – City of Albuquerque

ATTACHMENT 1

BOCA NEGRA ARROYO LOMR

NO.	UPC	LEGAL DESCRIPTION	OWNER	OWNER ADDRESS	SITUS ADDRESS
1	100906329046411104	4 002VOLCANO CLIFFS SUBD UNIT 13	STROUD JOHN M & MELISSA J	8019 VICTORIA NW, ALBUQUERQUE NM 87120	N/A, ALBUQUERQUE NM 87120
2	100906329545511105	5 002VOLCANO CLIFFS SUBD UNIT 13	BREWER MARK ALEXANDER & ERIK CHRISTOPHER BREWER	CMR 480 BOX 703, APO AE 09128	N/A, ALBUQUERQUE NM 87120
3	100906329744611106	6 002VOLCANO CLIFFS SUBD UNIT 13	MERWIN GLADYS M C/O VIRGINIA M STEELE	3523 TIMBER LN, SLATINGTON PA 18080	N/A, ALBUQUERQUE NM 87120
4	100906330043811107	7 002VOLCANO CLIFFS SUBD UNIT 13	KRAMER DENNIS K 1 FOX HILLS LANE	PO BOX 970, SANDIA PARK NM 87047-0970	N/A, ALBUQUERQUE NM 87120
5	100906330342911108	8 002VOLCANO CLIFFS SUBD UNIT 13	KRAMER JULIA B	10005 CARDINAL NW, ALBUQUERQUE NM 87114	N/A, ALBUQUERQUE NM 87120
6	100906328342120164	001TRACT 6 VOLCANO CLIFFS SUBD UNIT 13	LE KHANH TRAN & THONG NGUYEN	15522 ASHLEY AVE, WESTMINSTER CA 92683	FACIEL RD NW, ALBUQUERQUE NM 87120
7	100906326043220165	TRACT 23 VOLCANO CLIFFS SUBD UNIT 12	RALPH DALE L & TAZMIN	5816 MIMOSA PL NE, ALBUQUERQUE NM 87111	ROSA PARKS RD NW, ALBUQUERQUE NM 87120
8	100906328940110534	3 008VOLCANO CLIFFS SUBD UNIT 13	SOLID GOLD CLASSIC LTD	5319 MENAUL BLVD NE, ALBUQUERQUE NM 87110-3113	N/A, ALBUQUERQUE NM 87120
9	100906329738310520	17 008VOLCANO CLIFFS SUBD UNIT 13	KASSAM LAND ACQUISITIONS 5 LLC % LEGACY HOSPITALITY LLC	6500 EAGLE ROCK AVE NE B5, ALBUQUERQUE NM 87113	N/A, ALBUQUERQUE NM 87120
10	100906330738510521	16 008VOLCANO CLIFFS SUBD UNIT 13	KASSAM LAND ACQUISITIONS 5 LLC % LEGACY HOSPITALITY LLC	6501 EAGLE ROCK AVE NE B5, ALBUQUERQUE NM 87113	N/A, ALBUQUERQUE NM 87120
11	100906331736910523	14 008VOLCANO CLIFFS SUBD UNIT 13	KASSAM LAND ACQUISITIONS 5 LLC % LEGACY HOSPITALITY LLC	6501 EAGLE ROCK AVE NE B5, ALBUQUERQUE NM 87113	N/A, ALBUQUERQUE NM 87120
12	100906331735610524	13 008VOLCANO CLIFFS SUBD UNIT 13	FRYE EUGENE R &RUTH E	5201 ROMA NE APT 336, ALBUQUERQUE NM 87108	N/A, ALBUQUERQUE NM 87120
13	100906332240710614	2 005UNIT 13 VOLCANO CLIFFS SUBD	DIEKE LOUIS H & BETTY D	8772 E FARM RD 2, FAIR GROVE MO 65648	N/A, ALBUQUERQUE NM 87120
14	100906333040410613	3 005VOLCANO CLIFFS SUBD UNIT 13	DIEKE LOUIS H & BETTY D	8772 E FARM RD 2, FAIR GROVE MO 65648	N/A, ALBUQUERQUE NM 87120
15	100906333939910612	4 005VOLCANO CLIFFS SUBD UNIT 13	DIEKE LOUIS H & BETTY D	8772 E FARM RD 2, FAIR GROVE MO 65648	FACIEL RD NW, ALBUQUERQUE NM 87120
16	100906334939010611	5 005VOLCANO CLIFFS SUBD UNIT 13	DIEKE LOUIS H & BETTY D	8772 E FARM RD 2, FAIR GROVE MO 65648	N/A, ALBUQUERQUE NM 87120
17	100906344430510622	003 001VOLCANO CLIFFS UNIT 25	DENTON GORDON E & NANCY J TR OF DENTON LIVING TRUST	4030 PEPPER POST AVE, LAS CRUCES NM 88011	N/A, ALBUQUERQUE NM 87120
18	100906345029410623	004 001VOLCANO CLIFFS UNIT 25	BARZ RICHARD K	PO BOX 82, ACT 2616 AUSTRALIA	N/A, ALBUQUERQUE NM 87120
19	100906345728210624	005 001VOLCANO CLIFFS UNIT 25	BALDRIDGE FAMILY LIMITED PARTNERSHIP II LP	110 CYPRESS LN, COUSHATTA LA 71019	N/A, ALBUQUERQUE NM 87120
20	100906348131011301	LT 2-A BLK 2 PLAT OF LTS 1-A THRU 3-A BLK 2 UNIT 25VOLCANO CLIFFS SUBD CONT 1.4483 AC	VP UNIT #25 LLC & ETAL	2806 LYNDALE LN, BILLINGS MT 59102	7501 RAINBOW BLVD NW, ALBUQUERQUE NM 87120
21	101006301023230801	TR 1 PLAT OF TR 1 BOCA NEGRA DETENTION DAM CONT 24.4245 AC	AMAFCA	2600 PROSPECT NE, ALBUQUERQUE NM 87107	UNSER BLVD NW, ALBUQUERQUE NM 87120
22	101006326006030920	TR A UNIT 28 VOLCANO CLIFFS SUBDIVISION CONT 56.9670 AC	CITY OF ALBUQUERQUE	PO BOX 2248, ALBUQUERQUE NM 87103-2248	, ALBUQUERQUE NM 87120
23	101006225850810906	008 012VOLCANO CLIFFS SUB UNIT 3 11N 2E SEC 27	STATE OF NEW MEXICO STATE LAND OFFICE, FACILITY MANAGEMENT DIVISION	PO BOX 6850, SANTA FE NM 87502	ATRISCO RD NW, ALBUQUERQUE NM 87120
24	101006229449510928	LT 8 PLAT FOR PETROGLYPH SHADOWS SUBDIVISION BEING AREPLAT OF LOTS 4 & 5 BLOCK 12 UNIT 3 VOLCANO CLIFFSSUBDIVISION CONT	KAMM CHRISTINA L	6423 STAR BRIGHT RD NW ALBUQUERQUE NM 87120	6423 STAR BRIGHT RD NW ALBUQUERQUE NM 87120
25	101006236247410914	LT 2 BLK 12 VOLCANO CLIFFS SUBD UNIT 3 CONT 1.9945 AC	PIANO JASPER & EMILY E TRUSTEES PIANO FAMILY TRUST	200 S BURKE DR, GALLUP NM 87301	MOJAVE ST NW, ALBUQUERQUE NM 87120
26	101006238548310920	LOT 1-A BLOCK 12 REPLAT OF LOT 1 BLOCK 12 VOLCANO CLIFFSUNIT 3 CONT	CHAVEZ JOE V & VIRGINIA B	6515 TESUQUE DR NW ALBUQUERQUE NM 87120	6515 TESUQUE NW ALBUQUERQUE NM 87120

ATTACHMENT 2

BOCA NEGRA ARROYO LOMR

NO.	UPC	LEGAL DESCRIPTION	OWNER	OWNER ADDRESS	SITUS ADDRESS
22	101006326006030920	TR A UNIT 28 VOLCANO CLIFFS SUBDIVISION CONT 56.9670 AC	CITY OF ALBUQUERQUE	PO BOX 1293 ALBUQUERQUE NM 87103	ALBUQUERQUE NM 87120
23	101006225850810906	008 012VOLCANO CLIFFS SUB UNIT 3 11N 2E SEC 27	STATE OF NEW MEXICO STATE LAND OFFICE, FACILITY MANAGEMENT DIVISION	PO BOX 6850, SANTA FE NM 87502	ATRISCO RD NW, ALBUQUERQUE NM 87120
24	101006229449510928	LT 8 PLAT FOR PETROGLYPH SHADOWS SUBDIVISION BEING AREPLAT OF LOTS 4 & 5 BLOCK 12 UNIT 3 VOLCANO CLIFFSSUBDIVISION CONT	KAMM CHRISTINA L	6423 STAR BRIGHT RD NW ALBUQUERQUE NM 87120	6423 STAR BRIGHT RD NW ALBUQUERQUE NM 87120
25	101006236247410914	LT 2 BLK 12 VOLCANO CLIFFS SUBD UNIT 3 CONT 1.9945 AC	PIANO JASPER & EMILY E TRUSTEES PIANO FAMILY TRUST	200 S BURKE DR, GALLUP NM 87301	MOJAVE ST NW, ALBUQUERQUE NM 87120
26	101006238548310920	LOT 1-A BLOCK 12 REPLAT OF LOT 1 BLOCK 12 VOLCANO CLIFFSUNIT 3 CONT	CHAVEZ JOE V & VIRGINIA B	6515 TESUQUE DR NW ALBUQUERQUE NM 87120	6515 TESUQUE NW ALBUQUERQUE NM 87120

Ronald D. Brown, Chair
Bruce M. Thomson, P.E., Vice Chair
Tim Eichenberg, Secretary-Treasurer
Cynthia D. Borrego, Assistant Secretary-Treasurer
Deborah L. Stover, Director

Jerry M. Lovato, P.E.
Executive Engineer

Albuquerque
Metropolitan
Arroyo
Flood
Control
Authority
2600 Prospect N.E., Albuquerque, NM 87107
Phone: (505) 884-2215 Fax: (505) 884-0214
Website: www.amafca.org

October 30, 2015

VP Unit #25 LLC & ETAL
2806 Lyndale Ln.
Billings, MT 59102

RE: Notification of Revision of 1% (100-year) Annual Chance Floodplain along the North Branch of Boca Negra Arroyo

Dear Property Owner,

Federal Emergency Management Agency (FEMA) provides Flood Risk Products to help community officials and the public view and understand their local flood risk. The Flood Insurance Rate Map (FIRM) for a community depicts land which has been determined to be subject to a 1% (100-year) or greater chance of flooding in any given year. The FIRM is used to delineate flood insurance zones for insurance companies to use to set rates and to help the community with floodplain management.

The construction of the Boca Negra Detention Dam Facility was completed in 2014. As a result, the floodplain for the Boca Negra Arroyo has changed.

The Albuquerque Metropolitan Arroyo Flood Control Authority (AMAFCA) is applying for a Letter of Map Revision (LOMR) from the Federal Emergency Management Agency (DHS-FEMA) to revise FIRM #35001C0111G and 35001C0112G, (effective date September 26, 2008) for Bernalillo County, New Mexico along the Boca Negra Arroyo (See attached Floodplain Exhibit and Annotated FIRMs).

The current hydrological / hydraulic study of the Boca Negra Arroyo confirms a narrower floodplain than the floodplain reflected in the effective (2008) FIRM during the 1% (100-year) event in most areas. The study also identified extensions of floodplains were necessary at various locations within the limits of the study area.

The Letter of Map Revision will result in:

1. Revision of Base (1% annual chance) Flood Elevations (BFEs), and of 1% annual chance floodplain.
2. Inclusion of the Boca Negra Detention Dam Facility floodplain.
3. Widening and narrowing of existing 1% annual chance floodplains.

The floodplain study area analyzed along Boca Negra Arroyo begins at the eastern edge of the North Geological Window and ends at the San Ildefonso Drive bridge crossing.

This letter is to inform you of the establishment of Base Flood Elevations and revision of the 1% annual chance floodplain on affected properties. Attached are the Floodplain Exhibit and Annotated FIRMs showing the revised floodplain.

A paper copy of the proposed maps showing the affected areas is also available for viewing at:

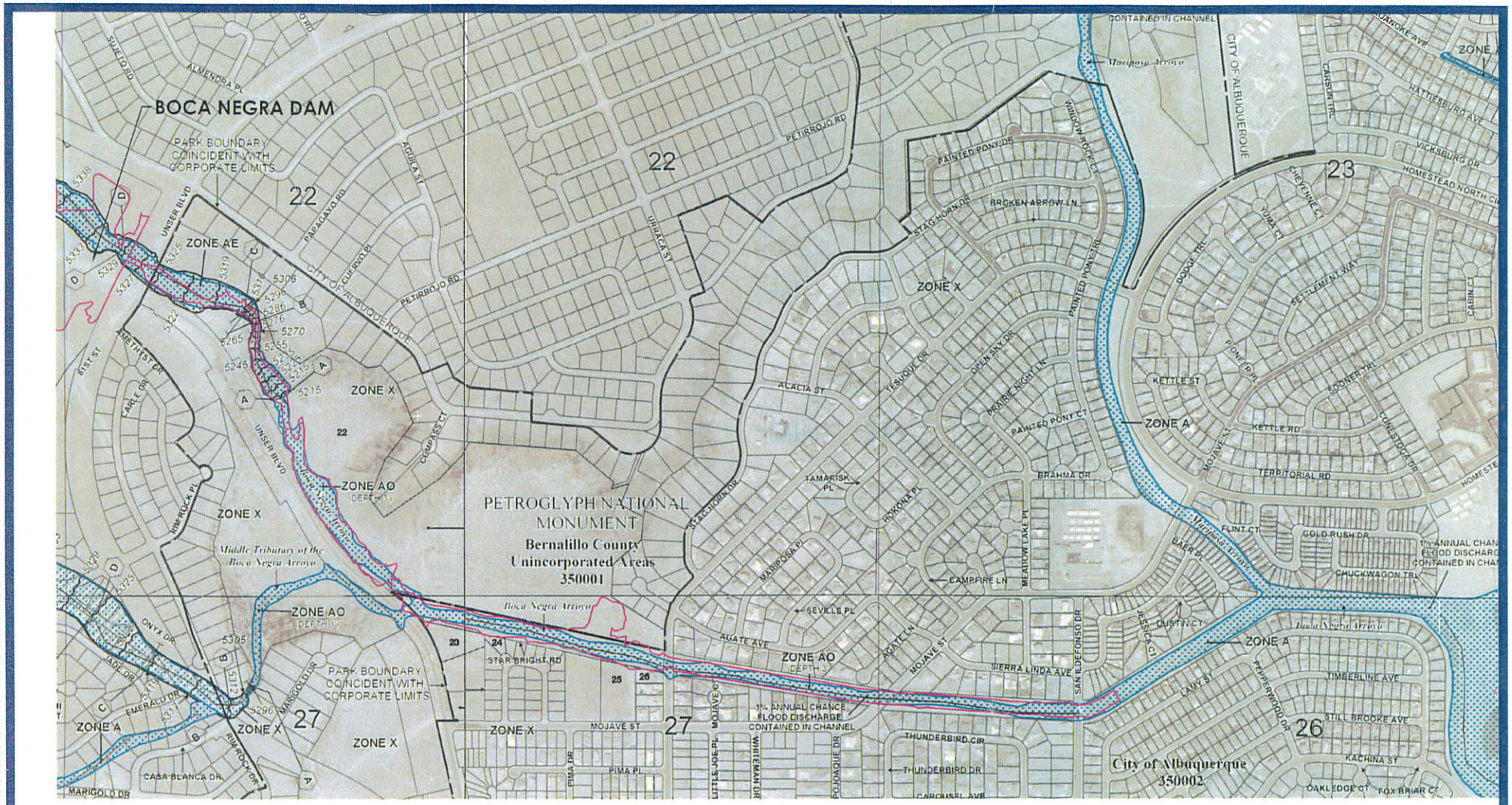
AMAFCA
2600 Prospect Avenue, NE
Albuquerque, NM 87107

Once revised FIRM maps are published by FEMA and become effective, residents will be responsible for coordinating insurance policy changes with their respective lenders. Neither AMAFCA nor FEMA have the authority to change terms of individual policies.

If you have any questions or concerns about the proposed changes to the FIRMs or its effect on your property, you may contact Brad Bingham, P.E., Drainage Engineer, for the Albuquerque Metropolitan Arroyo Flood Control Authority's Office, at (505) 884-2215.

Sincerely,
AMAFCA

Jerry M. Lovato, P.E.
Executive Engineer



LEGEND

EXISTING FLOODPLAIN

PROPOSED FLOODPLAIN

25 AFFECTED PROPERTY NUMBER

N

SCALE: 1 inch = 600 ft

FLOODPLAIN EXHIBIT

WILSON & COMPANY
4900 LANG AVE. N.E.
ALBUQUERQUE, NEW MEXICO 87109
PH (505) 348-4000
FAX (505) 348-4055
www.wilsonco.com

NOTES TO USERS

This map is for use in administering the National Flood Insurance Program. It does not necessarily identify all areas subject to flooding, particularly from local drainage sources of small size. The **community map repository** should be consulted for possible updated or additional flood hazard information.

To obtain more detailed information in areas where **Base Flood Elevations** (BFEs) and/or **floodways** have been determined, users are encouraged to consult the Flood Profiles and Floodway Data and/or Summary of Stillwater Elevations tables contained within the Flood Insurance Study (FIS) report that accompanies this FIRM. Users should be aware that BFEs shown on the FIRM represent rounded whole-foot elevations. These BFEs are intended for flood insurance rating purposes only and should not be used as the sole source of flood elevation information. Accordingly, flood elevation data presented in the FIS report should be utilized in conjunction with the FIRM for purposes of construction and/or floodplain management.

Coastal Base Flood Elevations shown on this map apply only landward of 0.0' North American Vertical Datum of 1988 (NAVD 88). Users of this FIRM should be aware that coastal flood elevations are also provided in the Summary of Stillwater Elevations table in the Flood Insurance Study Report for this jurisdiction. Elevations shown in the Summary of Stillwater Elevations table should be used for construction and/or floodplain management purposes when they are higher than the elevations shown on this FIRM.

Boundaries of the **floodways** were computed at cross-sections and interpolated between cross-sections. The floodways were based on hydraulic considerations with regard to requirements of the National Flood Insurance Program. Floodway widths and other pertinent floodway data are provided in the Flood Insurance Study report for this jurisdiction.

Certain areas not in Special Flood Hazard Areas may be protected by **flood control structures**. Refer to Section 2.4 "Flood Protection Measures" of the Flood Insurance Study report for information on flood control structures in this jurisdiction.

The **projection** used in the preparation of this map was New Mexico State Plane Central Zone. The **horizontal datum** was NAD 83, GRS80 spheroid. Differences in datum, spheroid, projection or UTM zones used in the production of FIRMs for adjacent jurisdictions may result in slight positional differences in map features across jurisdiction boundaries. These differences do not affect the accuracy of this FIRM.

Flood elevations on this map are referenced to the North American Vertical Datum of 1988. These flood elevations must be compared to structure and ground elevations referenced to the same **vertical datum**. For information regarding conversion between the National Geodetic Vertical Datum of 1929 and the North American Vertical Datum of 1988, visit the National Geodetic Survey website at http://www.ngs.noaa.gov or contact the National Geodetic Survey at the following address:

NGS Information Services
NOAA, N/NGS12
National Geodetic Survey, SSMC-3, #9202
1315 East-West Highway
Silver Spring, Maryland 20910-3282
(301) 713-3242

To obtain current elevation, description, and/or location information for **bench marks** shown on this map, please contact the Information Services Branch of the National Geodetic Survey at (301) 713-3242 or visit their website at http://www.ngs.noaa.gov.

Base map information shown on this FIRM was provided in digital format by Bernalillo County, produced at a scale of 1:12,000 from photography dated 1995 or later.

Based on updated topographic information, this map reflects more detailed and up-to-date **stream channel configurations and floodplain delineations** than those shown on the previous FIRM for this jurisdiction. As a result, the Flood Profiles and Floodway Data tables for the Flood Insurance Study report may reflect stream channel distances that differ from what is shown on the map. Also, the road to floodplain relationships for unnamed streams may differ from what is shown on previous maps.

Corporate limits shown on this map are based on the best data available at the time of publication. Because changes due to annexations or de-annexations may have occurred after this map was published, map users should contact appropriate community officials to verify current corporate limit locations.

Please refer to the separately printed **Map Index** for an overview map of the county showing the layout of map panels; community map repository addresses; and a Listing of Communities table containing National Flood Insurance Program dates for each community as well as a listing of the panels on which each community is located.

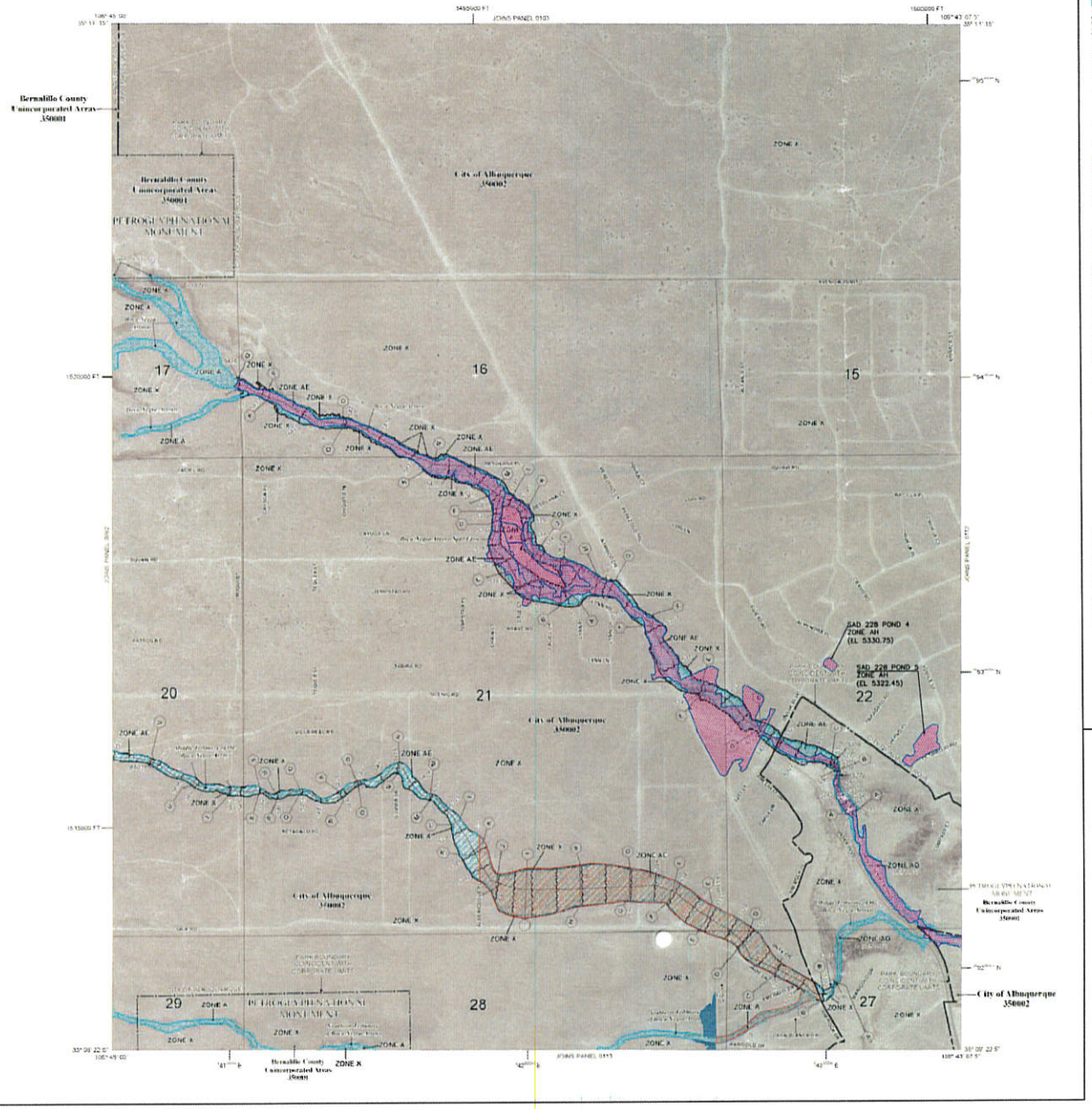
Contact the **FEMA Map Service Center** at 1-800-358-9616 for information on available products associated with this FIRM. Available products may include previously issued Letters of Map Change, a Flood Insurance Study report, and/or digital versions of this map. The FEMA Map Service Center may also be reached by Fax at 1-800-358-9620 and their website at http://www.msc.fema.gov.

If you have **questions about this map** or questions concerning the National Flood Insurance Program in general, please call **1-877-FEMA MAP** (1-877-336-2627) or visit the FEMA website at http://www.fema.gov/business/nfip.

LEGEND

- PROPOSED 100YR FLOODPLAIN
- REMOVED FLOODPLAIN PER LOMR CASE NUMBER 09-06-2899P, MARCH 25, 2010
- CREATED FLOODPLAIN PERLOMR CASE NUMBER 09-06-2899P, MARCH 25, 2010

NOTE: PONDS 4 & 5 WATER SURFACE ELEVATION PER SAD 228 DRAINAGE REPORT DATED JANUARY 2012



LEGEND

SPECIAL FLOOD HAZARD AREAS (SFHAs) SUBJECT TO INUNDATION BY THE 1% ANNUAL CHANCE FLOOD

The 1% annual chance flood (100-year flood), also known as the base flood, is the flood that has a 1% chance of being equaled or exceeded in any given year. The Special Flood Hazard Area is the area subject to flooding by the 1% annual chance flood. Areas of Special Flood Hazard include Zones A, AE, AH, AO, AG, A99, and VE. The Base Flood Elevation is the water surface elevation of the 1% annual chance flood.

- ZONE A — No Base Flood Elevations determined.
- ZONE AE — Base Flood Elevations determined.
- ZONE AH — Flood depths of 1 to 3 feet (usually areas of ponding); Base Flood Elevations determined.
- ZONE AO — Flood depths of 1 to 3 feet (usually sheet flow on sloping terrain); average depths determined. For areas of alluvial fan flooding, velocities also determined.
- ZONE AR — Special Flood Hazard Area formerly protected from the 1% annual chance flood by a flood control system that was subsequently decertified. Zone AR indicates that the former flood control system is being restored to provide protection from the 1% annual chance or greater flood.
- ZONE A99 — Area to be protected from 1% annual chance flood by a federal flood protection system under construction; no Base Flood Elevations determined.
- ZONE VE — Coastal flood zone with velocity hazard (wave action); Base Flood Elevations determined.

FLOODWAY AREAS IN ZONE AE

The floodway is the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment so that the 1% annual chance flood can be carried without substantial increases in flood heights.

OTHER FLOOD AREAS

- ZONE X — Areas of 0.2% annual chance flood; areas of 1% annual chance flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 1% annual chance flood.

OTHER AREAS

- ZONE X — Areas determined to be outside the 0.2% annual chance floodplain.
- ZONE D — Areas in which flood hazards are undetermined, but possible.

COASTAL BARRIER RESOURCES SYSTEM (CBRS) AREAS

OTHERWISE PROTECTED AREAS (OPAs)

CBRS areas and OPAs are normally located within or adjacent to Special Flood Hazard Areas.

- 1% annual chance floodplain boundary
- 0.2% annual chance floodplain boundary
- Floodway boundary
- Zone D boundary
- CBRS and OPA boundary
- Boundary dividing Special Flood Hazard Areas of different Base Flood Elevations, flood depths or flood velocities.
- 513 — Base Flood Elevation line and value; elevation in feet*
- 513 — Base Flood Elevation value where uniform within zone; elevation in feet*

*Referenced to the North American Vertical Datum of 1988

- 23 — Cross section line
- 23 97° 07' 30" 32° 22' 30" — Geographic coordinates referenced to the North American Datum of 1983 (NAD 83), western hemisphere
- 1000-meter Universal Transverse Mercator grid values, zone 13
- 5000-foot grid ticks: New Mexico State Plane coordinate system (Central zone) (FIPSZONE 3002), Transverse Mercator
- Bench mark (see explanation in Publication Publication section of this FIRM panel)
- River Mile

MAP REPOSITORIES

Refer to Map Repositories list on Map Index

EFFECTIVE DATE OF COUNTYWIDE FLOOD INSURANCE RATE MAP PANEL

SEPTEMBER 26, 2008

EFFECTIVE DATE(S) OF REVISION(S) TO THIS PANEL

March 1992: to update corporate limits, to change Base Flood Elevations and Special Flood Hazard Areas, to add roads, and to reflect updated topographic information.

November 19, 2002: to update corporate limits and to incorporate previously issued Letters of Map Revision.

September 26, 2008: to update corporate limits, to change Special Flood Hazard Areas, to add roads and road names, to incorporate previously issued Letters of Map Revision, to reflect updated topographic information, to change Base Flood Elevations, and Base Flood Elevations.

For community map revision history prior to countywide mapping, refer to the Community Map History table located in the Flood Insurance Study report for this jurisdiction.

To determine if flood insurance is available in this community, contact your insurance agent or call the National Flood Insurance Program at 1-800-638-6620.

MAP SCALE 1" = 500'

PANEL 0111G

FIRM

FLOOD INSURANCE RATE MAP

BERNALILLO COUNTY, NEW MEXICO AND INCORPORATED AREAS

PANEL 111 OF 825

SEE MAP INDEX FOR FIRM PANEL LAYOUT

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
BERNALILLO COUNTY, UNINCORPORATED AREAS	350001	0111	G
ALBUQUERQUE, CITY OF	350002	0111	G

ANNOTATED FIRM

MAP NUMBER
35001C0111G

MAP REVISED
SEPTEMBER 26, 2008

Federal Emergency Management Agency

NATIONAL FLOOD INSURANCE PROGRAM

NOTES TO USERS

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NGS Information Services
NOAA, N/NGS12
National Geodetic Survey, SSMC-3, #9202
1315 East-West Highway
Silver Spring, Maryland 20910-3282
(301) 713-3242

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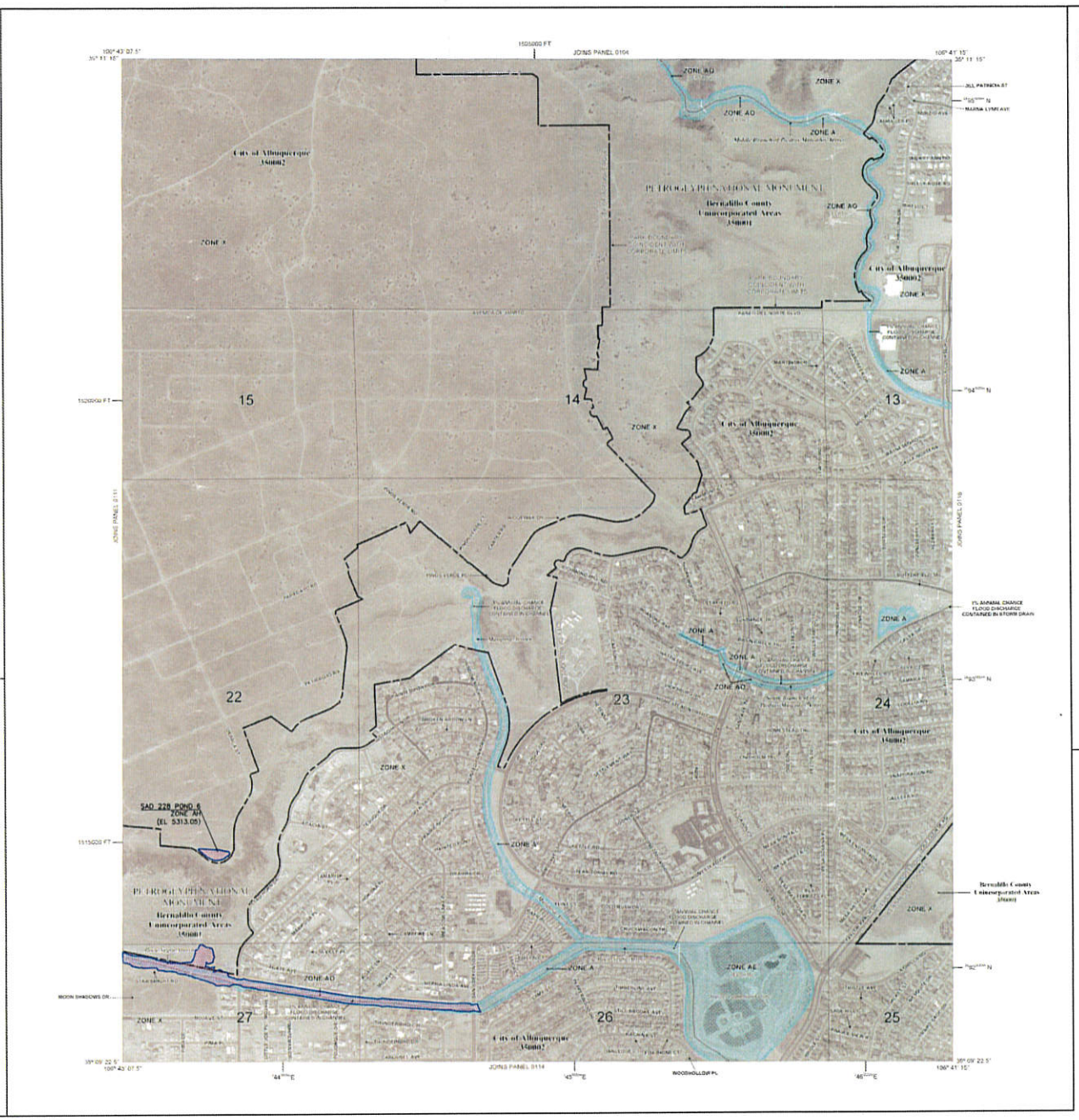
LEGEND

PROPOSED 100YR FLOODPLAIN

NOTES: POND 6 WATER SURFACE ELEVATION PER SAD 228 DRAINAGE REPORT DATED JANUARY 2012



LEGEND

SPECIAL FLOOD HAZARD AREAS (SFHAs) SUBJECT TO INUNDATION BY THE 1% ANNUAL CHANCE FLOOD

The 1% annual chance flood (100-year flood), also known as the base flood, is the flood that has a 1% chance of being equaled or exceeded in any given year. The Special Flood Hazard Area is the area subject to flooding by the 1% annual chance flood. Areas of Special Flood Hazard include Zones A, AE, AH, AO, AR, A99, and VE. The Base Flood Elevation is the water surface elevation of the 1% annual chance flood.

ZONE A — No Base Flood Elevations determined.
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ZONE AR — Special Flood Hazard Area formerly protected from the 1% annual chance flood by a flood control system that was subsequently decertified. Zone AR indicates that the former flood control system is being restored to provide protection from the 1% annual chance or greater flood.
ZONE A99 — Area to be protected from 1% annual chance flood by a Federal flood protection system under construction; no Base Flood Elevations determined.
ZONE VE — Coastal flood zone with velocity hazard (wave action); Base Flood Elevations determined.

FLOODWAY AREAS IN ZONE AE

The floodway is the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment so that the 1% annual chance flood can be carried without substantial increases in flood heights.

OTHER FLOOD AREAS

ZONE X — Areas of 0.2% annual chance flood; areas of 1% annual chance flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 1% annual chance flood.

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COASTAL BARRIER RESOURCES SYSTEM (CBRS) AREAS

OTHERWISE PROTECTED AREAS (OPAs)

CBRS areas and OPAs are normally adjacent within or adjacent to Special Flood Hazard Areas.

1% annual chance floodplain boundary
0.2% annual chance floodplain boundary
Floodway boundary
Zone D boundary
CBRS and OPA boundary
Boundary dividing Special Flood Hazard Areas of different Base Flood Elevations, flood depths or flood velocities.
Base Flood Elevation line and value; elevation in feet*
Base Flood Elevation value where uniform within zone; elevation in feet*
*Referenced to the North American Vertical Datum of 1988
Cross section line
Transect line
Geographic coordinates referenced to the North American Datum of 1983 (NAD 83), western hemisphere
1000-meter Universal Transverse Mercator grid values, zone 13
5000-foot ticks: New Mexico State Plane coordinate system, Central zone (FIPSZONE 3002), Transverse Mercator
Bench mark (see explanation in Notes to Users section of this FIRM panel)
River Mile

MAP REPOSITORIES
Refer to Map Repositories list on Map Index

EFFECTIVE DATE OF COUNTYWIDE FLOOD INSURANCE RATE MAP PANEL
SEPTEMBER 26, 2008

EFFECTIVE DATE(S) OF REVISION(S) TO THIS PANEL
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MAP SCALE 1" = 500'

250 0 250 500 FEET
75 0 75 150 METERS

NFIP NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0112G

FIRM

FLOOD INSURANCE RATE MAP

BERNALILLO COUNTY, NEW MEXICO AND INCORPORATED AREAS

PANEL 112 OF 825

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINING:

COMMUNITY	NUMBER	PANEL	SUFFIX
ALBUQUERQUE, CITY OF	[illegible]	[illegible]	[illegible]
BERNALILLO COUNTY	[illegible]	[illegible]	[illegible]

ANNOTATED FIRM

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MAP NUMBER
35001C0112G

MAP REVISED
SEPTEMBER 26, 2008

Federal Emergency Management Agency

Bruce M. Thomson, P.E., Chair
Cynthia D. Borrego, Vice Chair
Ronald D. Brown, Secretary-Treasurer
Deborah L. Stover, Assistant Secretary-Treasurer
Tim Eichenberg, Director

Jerry M. Lovato, P.E.
Executive Engineer

Albuquerque
Metropolitan
Arroyo
Flood
Control
Authority
2600 Prospect N.E., Albuquerque, NM 87107
Phone: (505) 884-2215 Fax: (505) 884-0214
Website: www.amafca.org

June 20, 2016

City of Albuquerque
PO Box 1293
Albuquerque, NM 87103

RE: Notification of Revision of 1% (100-year) Annual Chance Floodplain and floodway along the North Branch of Boca Negra Arroyo

Dear City of Albuquerque,

The Federal Emergency Management Agency (FEMA) provides Flood Risk Products to help community officials and the public view and understand their local flood risk. The Flood Insurance Rate Map (FIRM) for a community depicts land which has been determined to be subject to a 1% (100-year) or greater chance of flooding in any given year. The FIRM is used to delineate flood insurance zones that insurance companies use to set policy rates. It is also used by the community to manage the floodplain. The floodway is the portion of the floodplain that needs to be reserved to discharge the base flood without a significant increase in water surface elevation when other parts of the floodplain are encroached.

The construction of the Boca Negra Detention Dam Facility was completed in 2014. As a result, the floodplain for the Boca Negra Arroyo has changed.

The Albuquerque Metropolitan Arroyo Flood Control Authority (AMAFCA) is applying for a Letter of Map Revision (LOMR) from the Federal Emergency Management Agency (DHS-FEMA) to revise FIRM #35001C0111G and 35001C0112G, (effective date September 26, 2008) for Bernalillo County, New Mexico along the Boca Negra Arroyo (See attached Floodplain Exhibit and Annotated FIRMs).

The Albuquerque Metropolitan Arroyo Flood Control Authority (AMAFCA), in accordance with National Flood Insurance Program regulation 65.7(b)(1), hereby gives notice of the City of Albuquerque and Bernalillo County intent to establish the 1% annual chance (100-year) floodway, generally located between Unser Boulevard and San Ildefonso Drive. Specifically, the floodway shall be established from a point 1,350 ft downstream of Unser Boulevard to upstream of San Ildefonso Drive. As a result of the LOMR, the floodway shall be established within the area of revision.

The floodplain study area analyzed along the Boca Negra Arroyo begins at the eastern edge of the North Geological Window and ends at the San Ildefonso Drive bridge crossing. In most areas, it confirmed a narrower floodplain than what is reflected in the effective FIRM (2008) during the 1% (100-year). In other areas, the floodplain has been extended. In some cases, the extension is a result of more accurate field information.

The Letter of Map Revision will result in:

1. Revision of Base (1% annual chance) Flood Elevations (BFEs), and of 1% annual chance floodplain.
2. Inclusion of the Boca Negra Detention Dam Facility floodplain.
3. Widening and narrowing of existing 1% annual chance floodplains.
4. Change of floodplain map zone designation of "AO-3" to "AE" from 1,350 ft downstream of Unser Boulevard to San Ildefonso Drive.

This letter is to inform you of the establishment of Base Flood Elevations and the revision of the 1% annual chance floodplain on affected properties. Attached are the Floodplain Exhibit and Annotated FIRMs showing the revised floodplain.

A paper copy of the proposed maps showing the affected areas is also available for viewing at:

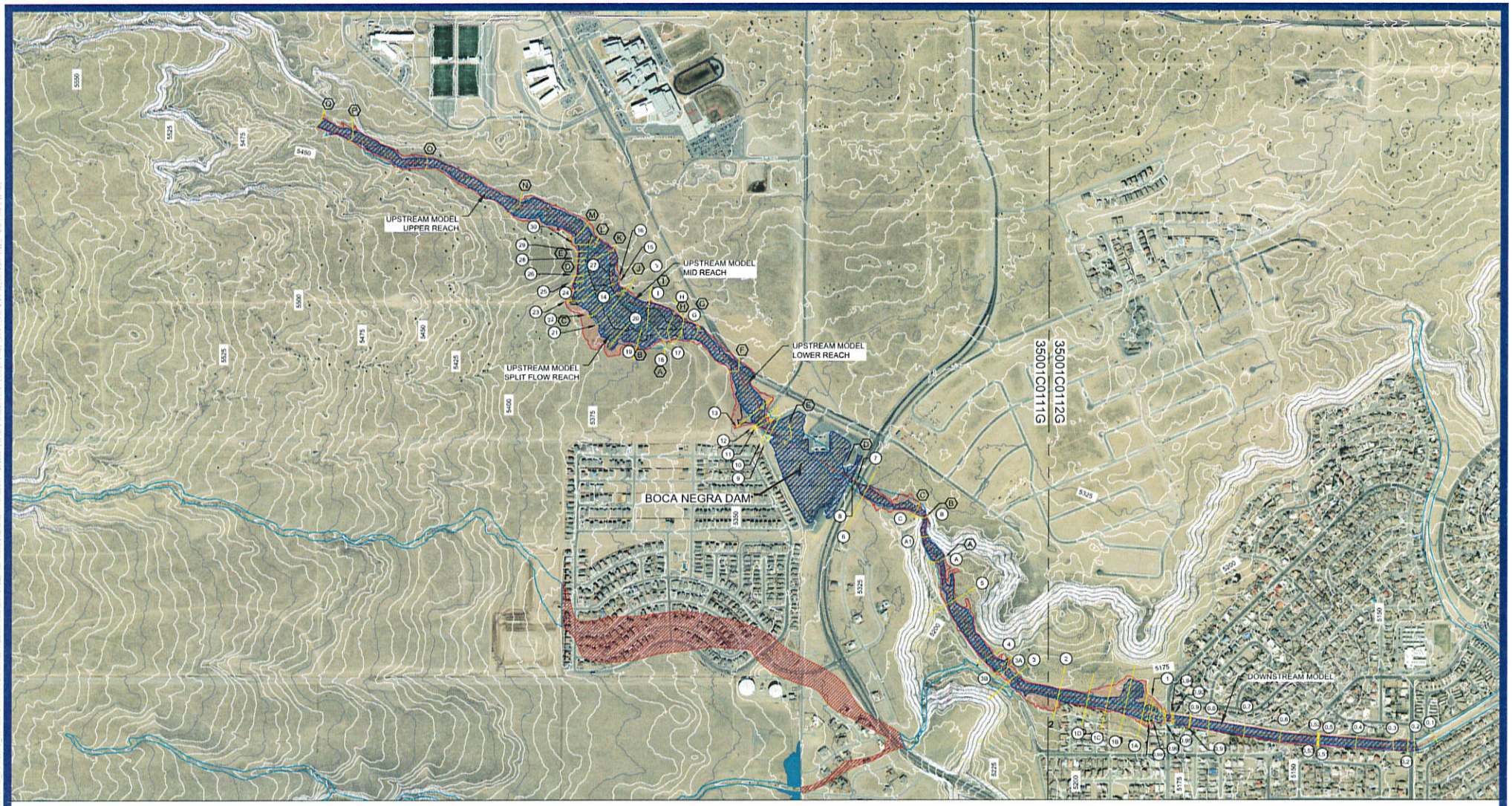
AMAFCA
2600 Prospect Avenue, NE
Albuquerque, NM 87107

Once the revised FIRM maps are published by FEMA and become effective, residents will be responsible for coordinating insurance policy changes with their respective lenders. Neither AMAFCA nor FEMA have the authority to change terms of individual policies.

If you have any questions or concerns about the proposed changes to the FIRMs or its effect on your property, you may contact Brad Bingham, P.E., Drainage Engineer, for the Albuquerque Metropolitan Arroyo Flood Control Authority's Office, at (505) 884-2215.

Sincerely,
AMAFCA

Jerry M. Lovato, P.E.
Executive Engineer



SUPPLEMENTAL FLOODPLAIN WORK MAP

LEGEND

- PROPOSED 100 YR FLOODPLAIN
- PROPOSED 100 YR FLOODWAY
- PROPOSED 500 YR FLOODPLAIN
- EFFECTIVE FLOODPLAIN
- REMOVED FLOODPLAIN PER LOMR CASE NUMBER 09-06-2899P, MARCH 25, 2010
- CREATED FLOODPLAIN LOMR PER CASE NUMBER 09-06-2899P, MARCH 25, 2010
- CURRENT CROSS SECTION LABEL
- PROPOSED CROSS SECTION NUMBER
- BASELINE ALIGNMENT
- CROSS SECTION LINE

GRAPHIC SCALE

(IN FEET)
1 inch = 500 ft.

DATUM NOTE:
US SURVEY FEET
NM STATE PLANE CENTRAL ZONE
NAD 83
NAVD 88
COMBINED GRID-TO-GROUND FACTOR = 1.0003278455
SCALED TO GROUND AROUND (0,0)

WILSON & COMPANY
4900 LANG AVE., N.E.
SUITE 200
ALBUQUERQUE, NEW MEXICO
87109
PH (505) 348-4000
FAX (505) 348-4072
www.wilsonco.com

NOTES TO USERS

This map is for use in administering the National Flood Insurance Program. It does not necessarily identify all areas subject to flooding, particularly from local drainage sources of small size. The **community map repository** should be consulted for possible updated or additional flood hazard information.

To obtain more detailed information in areas where **Base Flood Elevations** (BFEs) and/or **floodways** have been determined, users are encouraged to consult the Flood Profiles and Floodway Data and/or Summary of Stillwater Elevations tables contained within the Flood Insurance Study (FIS) report that accompanies this FIRM. Users should be aware that BFEs shown on the FIRM represent rounded whole-foot elevations. These BFEs are intended for flood insurance rating purposes only and should not be used as the sole source of flood elevation information. Accordingly, flood elevation data presented in the FIS report should be utilized in conjunction with the FIRM for purposes of construction and/or floodplain management.

Coastal Base Flood Elevations shown on this map apply only landward of 0.0° North American Vertical Datum of 1988 (NAVD 88). Users of this FIRM should be aware that coastal flood elevations are also provided in the summary of Stillwater Elevations table in the Flood Insurance Study Report for this jurisdiction. Elevations shown in the Summary of Stillwater Elevations table should be used for construction and/or floodplain management purposes when they are higher than the elevations shown on this FIRM.

Boundaries of the **floodways** were computed at cross sections and interpolated between cross sections. The floodways were based on hydraulic considerations with regard to requirements of the National Flood Insurance Program. Floodway widths and other pertinent floodway data are provided in the Flood Insurance Study report for this jurisdiction.

Certain areas not in Special Flood Hazard Areas may be protected by **flood control structures**. Refer to Section 2.4 "Flood Protection Measures" of the Flood Insurance Study report for information on flood control structures in this jurisdiction.

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NGS Information Services
NOAA, N/NGS12
National Geodetic Survey, SSMC-3, #3202
1315 East-West Highway
Silver Spring, Maryland 20910-3282
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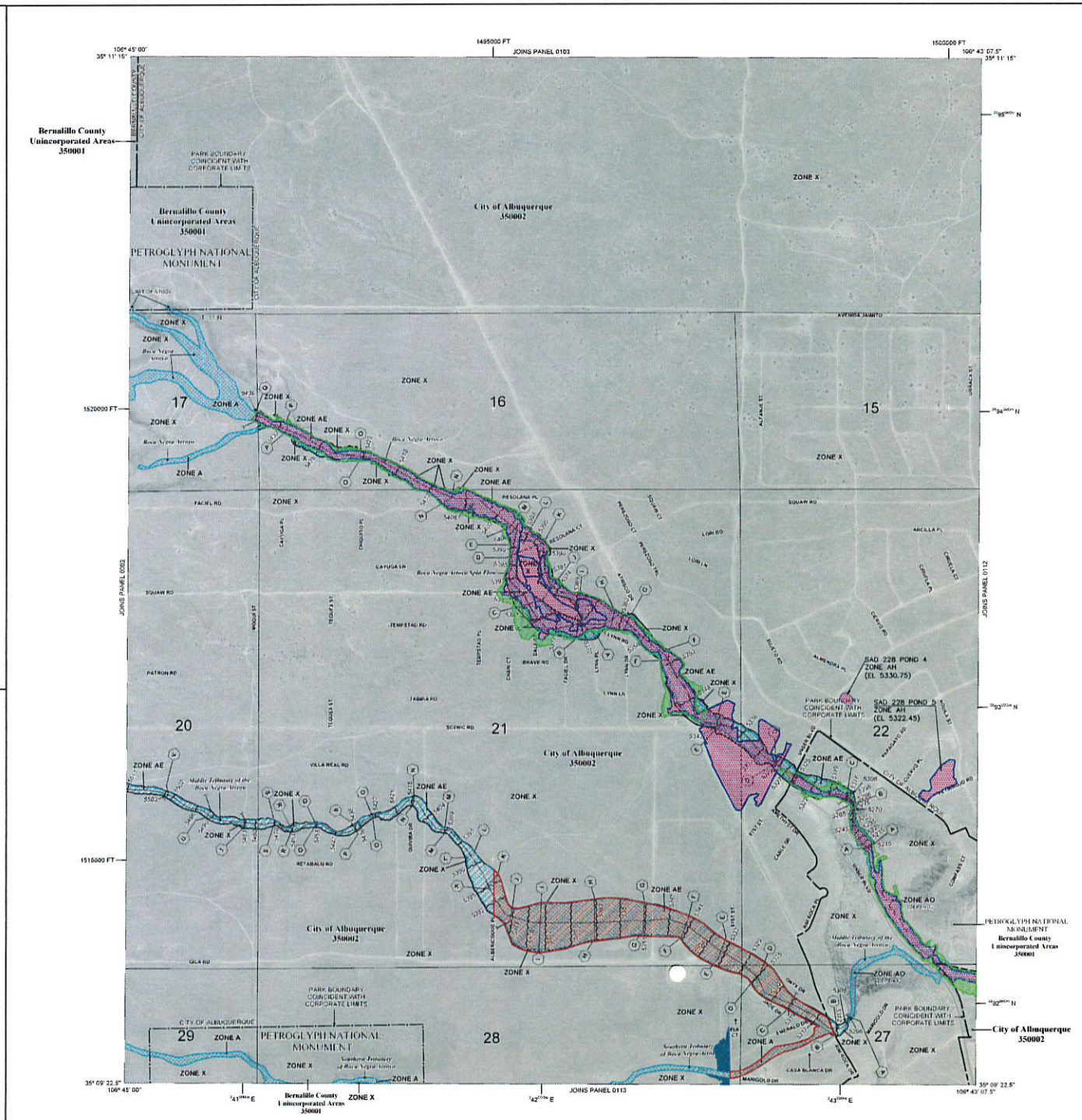
LEGEND

- PROPOSED 100YR FLOODPLAIN
- PROPOSED 500YR FLOODPLAIN
- REMOVED FLOODPLAIN PER LOMR CASE NUMBER 09-06-2899P, MARCH 25, 2010
- CREATED FLOODPLAIN PERLOMR CASE NUMBER 09-06-2899P, MARCH 25, 2010

NOTE: PONDS 4 & 5 WATER SURFACE ELEVATION PER SAD 228 DRAINAGE REPORT DATED JANUARY 2012



LEGEND

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OTHER FLOOD AREAS

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OTHER AREAS

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OTHERWISE PROTECTED AREAS (OPAs)

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- 1% annual chance floodplain boundary
- 0.2% annual chance floodplain boundary
- Floodway boundary
- Zone D boundary
- CBRS and OPA Boundary
- Boundary dividing Special Flood Hazard Areas of different Base Flood Elevations, flood depths or flood velocities
- 513 — Base Flood Elevation line and value; elevation in feet*
- (EL 987) — Base Flood Elevation value where uniform within zone; elevation in feet*

*Referenced to the North American Vertical Datum of 1988

- A — A — Cross section line
- 23 — 23 — Transect line
- 97° 07' 30", 32° 22' 30" — Geographic coordinates referenced to the North American Datum of 1983 (NAD 83), Western Hemisphere
- 4276000 mE — 1000-meter Universal Transverse Mercator grid values, zone 13
- 600000 FT — 1000-foot grid ticks: New Mexico State Plane coordinate system, Central zone (FIPSZONE 3002), Transverse Mercator
- DX5510 — Bench mark (see explanation in Notes to Users section of this FIRM panel)
- M1.5 — River Mile

MAP REPOSITORIES
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EFFECTIVE DATE OF COUNTYWIDE FLOOD INSURANCE RATE MAP PANEL
SEPTEMBER 26, 2008

EFFECTIVE DATE(S) OF REVISION(S) TO THIS PANEL

April 2, 2002 - to update corporate limits, to change Base Flood Elevations and Special Flood Hazard Areas, to add roads and road names, to reflect updated topographic information, and to incorporate previously issued Letters of Map Revision.

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250 0 500 1000 FEET
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NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0111G

FIRM

FLOOD INSURANCE RATE MAP

BERNALILLO COUNTY, NEW MEXICO AND INCORPORATED AREAS

PANEL 111 OF 825

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
ALBUQUERQUE, CITY OF	350002	0111	G
BERNALILLO COUNTY UNINCORPORATED AREAS	350001	0111	G

ANNOTATED FIRM

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35001C0111G

MAP REVISED
SEPTEMBER 26, 2008

Federal Emergency Management Agency

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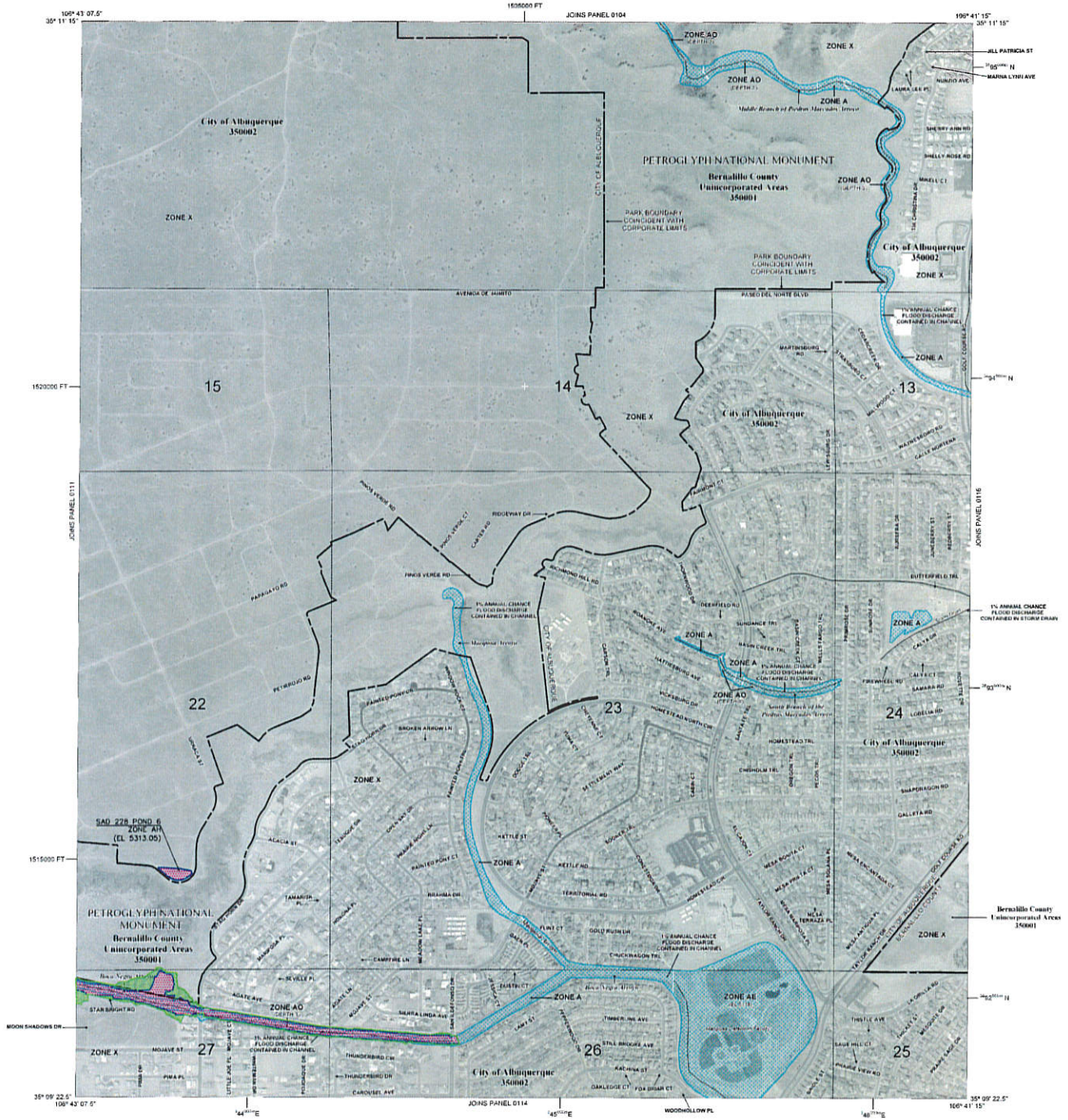
LEGEND

PROPOSED 100YR FLOODPLAIN

PROPOSED 500YR FLOODPLAIN

NOTES: POND 6 WATER SURFACE ELEVATION PER SAD 228 DRAINAGE REPORT DATED JANUARY 2012



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The floodway is the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment so that the 1% annual chance flood can be carried without substantial increases in flood heights.

OTHER FLOOD AREAS

- ZONE X — Areas of 0.2% annual chance flood; areas of 1% annual chance flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 1% annual chance flood.

OTHER AREAS

- ZONE X — Areas determined to be outside the 0.2% annual chance floodplain.
- ZONE D — Areas in which flood hazards are undetermined, but possible.

COASTAL BARRIER RESOURCES SYSTEM (CBRS) AREAS

OTHERWISE PROTECTED AREAS (OPAs)

CBRS areas and OPAs are normally located within or adjacent to Special Flood Hazard Areas.

- 1% annual chance floodplain boundary
- 0.2% annual chance floodplain boundary
- Floodway boundary
- Zone D boundary
- CBRS and OPA boundary
- Boundary dividing Special Flood Hazard Areas of different Base Flood Elevations, flood depths or flood velocities.
- 513 (EL 987) — Base Flood Elevation line and value; elevation in feet*
- (EL 987) — Base Flood Elevation value where uniform within zone; elevation in feet*

*Referenced to the North American Vertical Datum of 1988

- A — A — Cross section line
- 23 — 23 — Transect line
- 97° 07' 30", 32° 22' 30" — Geographic coordinates referenced to the North American Datum of 1983 (NAD 83), Western Hemisphere
- 76 mE — 1000-meter Universal Transverse Mercator grid values, zone 13
- 600000 FT — 5000-foot grid ticks: New Mexico State Plane coordinate system, Central zone (FIPSZONE 3002), Transverse Mercator
- DX5510 — Bench mark (see explanation in Notes to Users section of this FIRM panel)
- MLS — River mile

MAP REPOSITORIES
Refer to Map Repositories list on Map Index.

EFFECTIVE DATE OF COUNTYWIDE FLOOD INSURANCE RATE MAP PANEL

SEPTEMBER 26, 1996

EFFECTIVE DATE(S) OF REVISION(S) TO THIS PANEL

April 2, 2002 - to update corporate limits, to change Base Flood Elevations and Special Flood Hazard Areas, to add roads and road names, to reflect updated topographic information, and to incorporate previously issued Letters of Map Revision.

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MAP SCALE 1" = 500'

250 0 500 1000 FEET
150 0 150 300 METERS

NFIP NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0112G

FIRM

FLOOD INSURANCE RATE MAP

BERNALILLO COUNTY, NEW MEXICO AND INCORPORATED AREAS

PANEL 112 OF 825

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
ALBUQUERQUE, CITY OF	350002	0112	G
BERNALILLO, COUNTY OF			
UNINCORPORATED AREAS	350001	0112	G

ANNOTATED FIRM

Notice to User: The Map Number shown below should be used when placing map orders; the Community Number shown above should be used on insurance applications for the subject community.

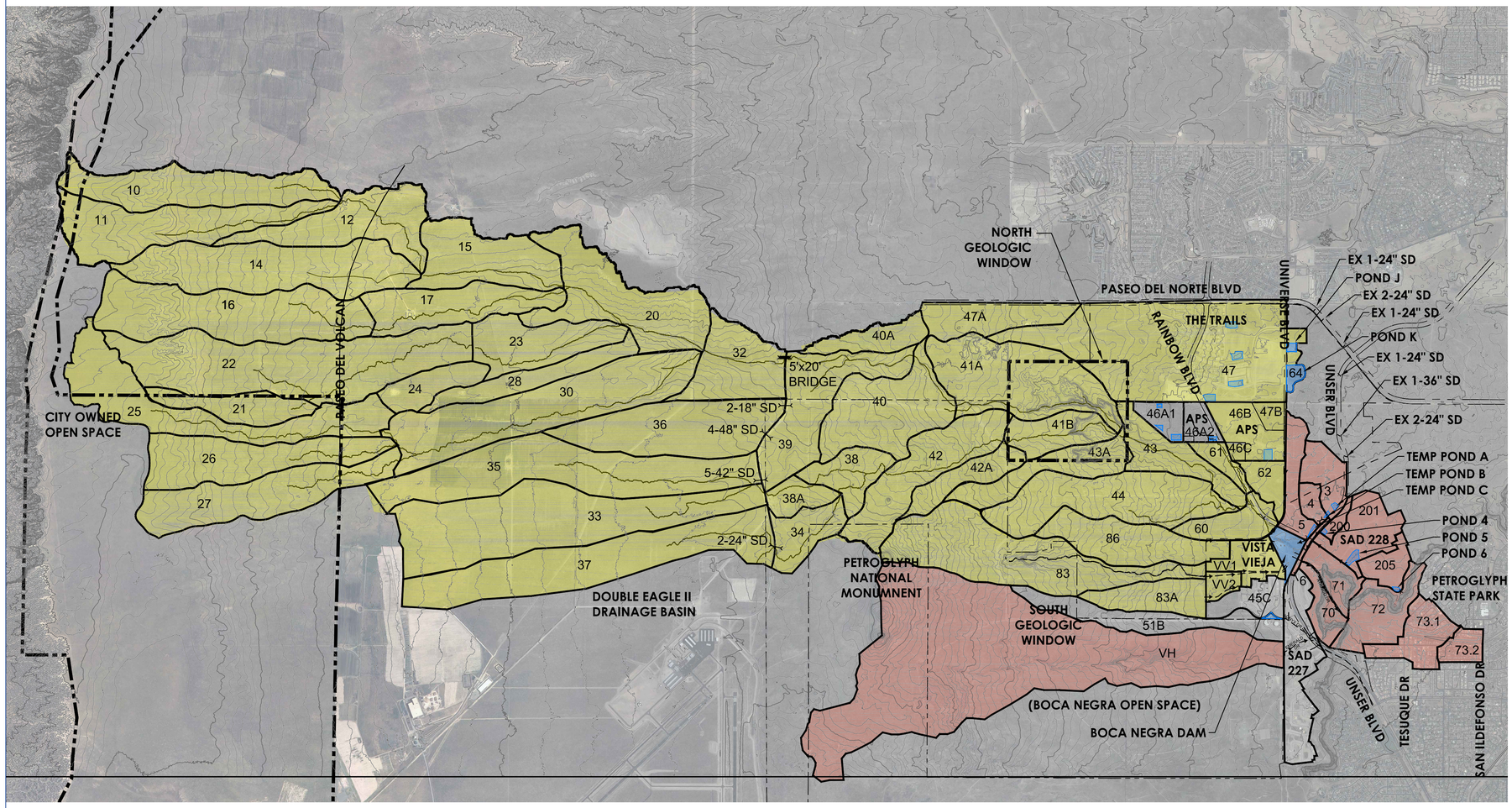
MAP NUMBER
35001C0112G

MAP REVISED
SEPTEMBER 26, 2008

Federal Emergency Management Agency

APPENDIX 7

PLATE 1 – CURRENT CONDITIONS BASIN BOUNDARY MAP (LOMR)
FLOODPLAIN WORK MAP
SUPPLEMENTAL FLOODPLAIN WORK MAP
ANNOTATED FIRM



LEGEND

- EXISTING 10' CONTOUR
- MAJOR ROADWAY
- FLOW PATH
- BASIN BOUNDARY
- UNDEVELOPED AREA BOUNDARY
- 38 BASIN ID
- EXISTING POND
- EXISTING CULVERT
- DAM WATERSHED
- ARROYO WATERSHED
- NON-CONTRIBUTING WATERSHED

DATUM NOTE:
US SURVEY FEET
NM STATE PLANE CENTRAL ZONE
NAD 83
NAVD 88
COMBINED GRID-TO-GROUND FACTOR = 1.0003278455
SCALED TO GROUND AROUND (0,0)

N

GRAPHIC SCALE

2000 0 1000 2000 4000 8000

(IN FEET)
1 inch = 2000ft.

WCEA #1260008003
MAY 2015

ALBUQUERQUE METROPOLITAN
ARROYO FLOOD CONTROL AUTHORITY
DAM BID LOT

PLATE 1:
CURRENT CONDITIONS BASIN BOUNDARY MAP
(L O M R)

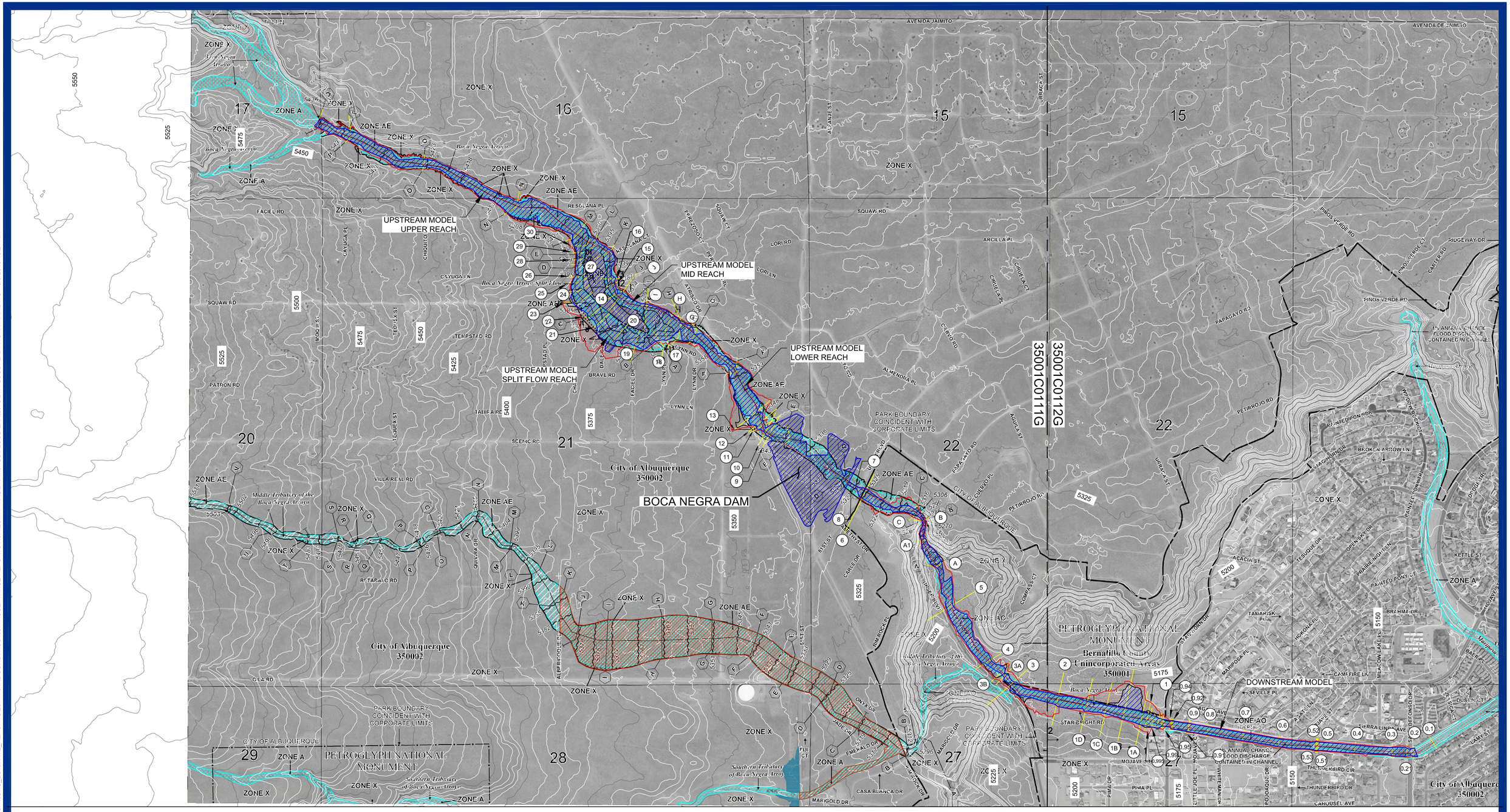
Design Review Committee	City Engineer Approval	Last Design Update	Mo./Day/Yr.	Mo./Day/Yr.

City Project No.	Zone Map No.	Sheet	Of

WILSON & COMPANY

6/9/15 M:\IFS\12-600-080-03\CADD\EXHIBITS\BND EXIST BASINS_LOMR PLATE 1.DWG

T:\PROJECTS\X32180780\2\ENG\2012 FINAL PLANS_SPECIFICATIONS_ESTIMATE_REPORTS\2014 FINAL CONSTRUCTION ACCEPTANCE REPORTS\H&HLOMR - RAS\DRAWINGS\FLOOD EXHIBIT\SIN FLOODPLAIN WORK MAP.DWG 6/9/2016 10:24 AM



FLOODPLAIN WORK MAP

LEGEND

- PROPOSED 100YR FLOODPLAIN
- PROPOSED 100YR FLOODWAY
- PROPOSED 500 YR FLOODPLAIN
- EFFECTIVE FLOODPLAIN
- REMOVED FLOODPLAIN PER LOMR CASE NUMBER 09-06-2899P, MARCH 25, 2010
- CREATED FLOODPLAIN LOMR PER CASE NUMBER 09-06-2899P, MARCH 25, 2010
- CURRENT CROSS SECTION LABEL
- PROPOSED CROSS SECTION NUMBER
- BASELINE ALIGNMENT
- CROSS SECTION LINE

GRAPHIC SCALE

500 0 250 500 1000 2000

(IN FEET)

1 inch = 500 ft.

DATUM NOTE:
US SURVEY FEET
NM STATE PLANE CENTRAL ZONE
NAD 83
NAVD 88
COMBINED GRID-TO-GROUND FACTOR = 1.0003278455
SCALED TO GROUND AROUND (0,0)

RONALD M. DUNLAVY NEW MEXICO 15174 PROFESSIONAL ENGINEER

WILSON &COMPANY
4900 LANG AVE., N.E.
SUITE 200
ALBUQUERQUE, NEW MEXICO
87109
PH (505) 348-4000
FAX (505) 348-4072
www.wilsonco.com

T:\PROJECTS\V3218078\02\ENG\2012 FINAL PLANS_SPECIFICATIONS_ESTIMATE_REPORTS\2014 FINAL CONSTRUCTION ACCEPTANCE REPORTS\H&H\LOMR - RAS\DRAWINGS\FLOOD EXHIBIT\SBN FLOODPLAIN SUPPLEMENTAL WORK MAP.DWG 8/5/2016 10:00 AM

UPSTREAM MODEL UPPER REACH

UPSTREAM MODEL MID REACH

UPSTREAM MODEL SPLIT FLOW REACH

UPSTREAM MODEL LOWER REACH

BOCA NEGRA DAM

DOWNSTREAM MODEL

35001C0111G

35001C0112G

SUPPLEMENTAL FLOODPLAIN WORK MAP

LEGEND

- PROPOSED 100 YR FLOODPLAIN
- PROPOSED 100 YR FLOODWAY
- PROPOSED 500 YR FLOODPLAIN
- EFFECTIVE FLOODPLAIN
- REMOVED FLOODPLAIN PER LOMR CASE NUMBER 09-06-2899P, MARCH 25, 2010
- CREATED FLOODPLAIN LOMR PER CASE NUMBER 09-06-2899P, MARCH 25, 2010
- (X) CURRENT CROSS SECTION LABEL
- (0) PROPOSED CROSS SECTION NUMBER
- BASELINE ALIGNMENT
- CROSS SECTION LINE

N

GRAPHIC SCALE

500 0 250 500 1000 2000

(IN FEET)
1 inch = 500 ft.

DATUM NOTE:
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NEW MEXICO M. DUNN 15/14/16 PROFESSIONAL ENGINEER

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4900 LANG AVE., N.E.
SUITE 200
ALBUQUERQUE, NEW MEXICO
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NOTES TO USERS

This map is for use in administering the National Flood Insurance Program. It does not necessarily identify all areas subject to flooding, particularly from local drainage sources of small size. The **community map repository** should be consulted for possible updated or additional flood hazard information.

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Coastal Base Flood Elevations shown on this map apply only landward of 0.0' North American Vertical Datum of 1988 (NAVD 88). Users of this FIRM should be aware that coastal flood elevations are also provided in the summary of Stillwater Elevations table in the Flood Insurance Study Report for this jurisdiction. Elevations shown in the Summary of Stillwater Elevations table should be used for construction and/or floodplain management purposes when they are higher than the elevations shown on this FIRM.

Boundaries of the **floodways** were computed at cross sections and interpolated between cross sections. The floodways were based on hydraulic considerations with regard to requirements of the National Flood Insurance Program. Floodway widths and other pertinent floodway data are provided in the Flood Insurance Study report for this jurisdiction.

Certain areas not in Special Flood Hazard Areas may be protected by **flood control structures**. Refer to Section 2.4 "Flood Protection Measures" of the Flood Insurance Study report for information on flood control structures in this jurisdiction.

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NGS Information Services
NOAA, N/NGS12
National Geodetic Survey, SSMC-3, #9202
1315 East-West Highway
Silver Spring, Maryland 20910-3282
(301) 713-3242

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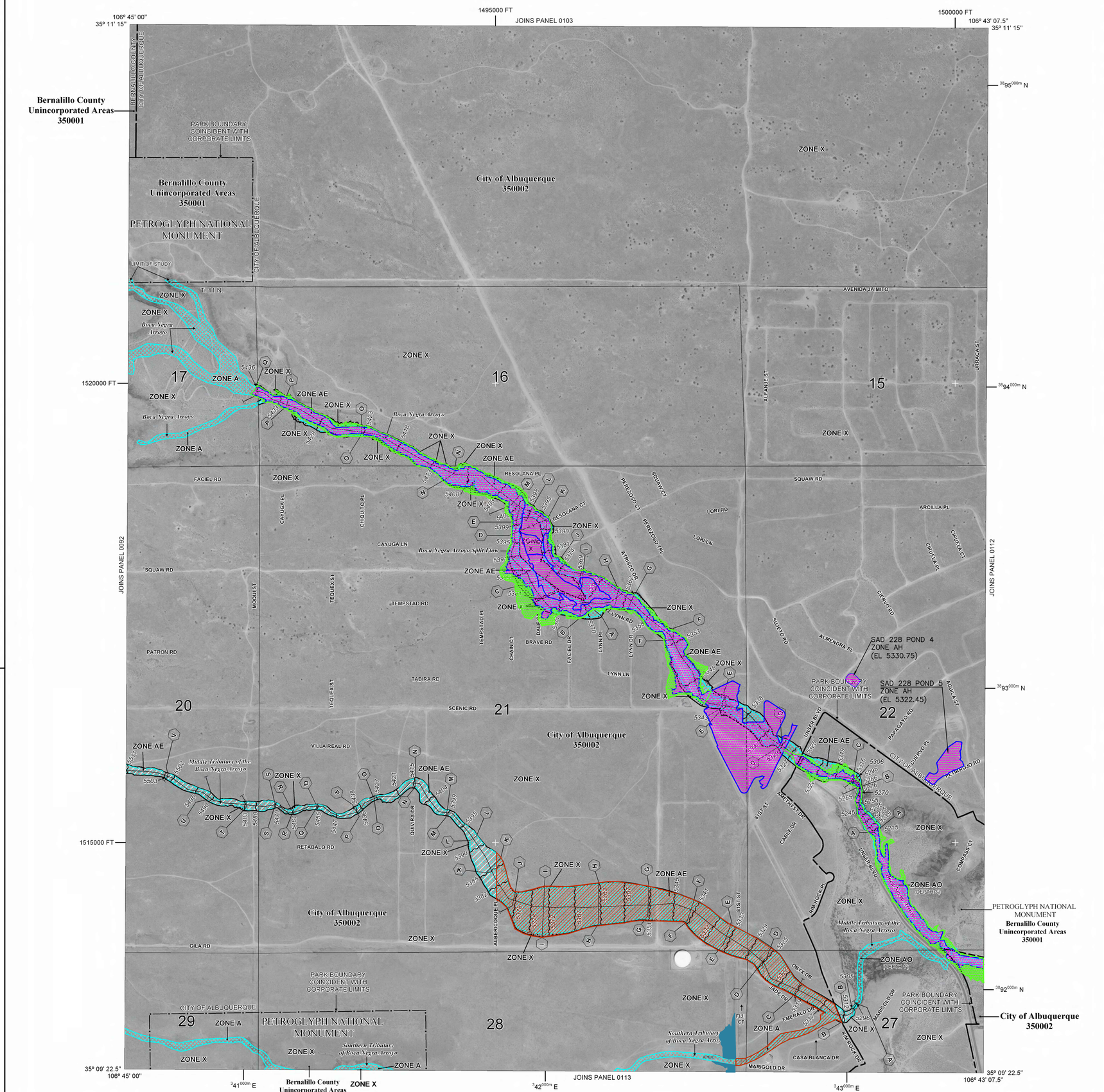
Contact the **FEMA Map Service Center** at 1-800-358-9616 for information on available products associated with this FIRM. Available products may include previously issued Letters of Map Change, a Flood Insurance Study report, and/or digital versions of this map. The FEMA Map Service Center may also be reached by Fax at 1-800-358-9620 and their website at http://www.msc.fema.gov.

If you have **questions about this map** or questions concerning the National Flood Insurance Program in general, please call **1- 877- FEMA MAP** (1-877-336-2627) or visit the FEMA website at http://www.fema.gov/business/nfip.

LEGEND

- PROPOSED 100YR FLOODPLAIN
- PROPOSED 500YR FLOODPLAIN
- REMOVED FLOODPLAIN PER LOMR CASE NUMBER 09-06-2899P, MARCH 25, 2010
- CREATED FLOODPLAIN PERLOMR CASE NUMBER 09-06-2899P, MARCH 25, 2010

NOTE: PONDS 4 & 5 WATER SURFACE ELEVATION PER SAD 228 DRAINAGE REPORT DATED JANUARY 2012



LEGEND

SPECIAL FLOOD HAZARD AREAS (SFHAs) SUBJECT TO INUNDATION BY THE 1% ANNUAL CHANCE FLOOD

The 1% annual chance flood (100-year flood), also known as the base flood, is the flood that has a 1% chance of being equaled or exceeded in any given year. The Special Flood Hazard Area is the area subject to flooding by the 1% annual chance flood. Areas of Special Flood Hazard include Zones A, AE, AH, AO, AR, A99, V, and VE. The Base Flood Elevation is the water-surface elevation of the 1% annual chance flood.

ZONE A	No Base Flood Elevations determined.
ZONE AE	Base Flood Elevations determined.
ZONE AH	Flood depths of 1 to 3 feet (usually areas of ponding); Base Flood Elevations determined.
ZONE AO	Flood depths of 1 to 3 feet (usually sheet flow on sloping terrain); average depths determined. For areas of alluvial fan flooding, velocities also determined.
ZONE AR	Special Flood Hazard Area formerly protected from the 1% annual chance flood by a flood control system that was subsequently decertified. Zone AR indicates that the former flood control system is being restored to provide protection from the 1% annual chance or greater flood.
ZONE A99	Area to be protected from 1% annual chance flood by a Federal flood protection system under construction; no Base Flood Elevations determined.
ZONE VE	Coastal flood zone with velocity hazard (wave action); Base Flood Elevations determined.

FLOODWAY AREAS IN ZONE AE

The floodway is the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment so that the 1% annual chance flood can be carried without substantial increases in flood heights.

OTHER FLOOD AREAS

ZONE X — Areas of 0.2% annual chance flood; areas of 1% annual chance flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 1% annual chance flood.

OTHER AREAS

ZONE X / ZONE D — Areas determined to be outside the 0.2% annual chance floodplain. Areas in which flood hazards are undetermined, but possible.

COASTAL BARRIER RESOURCES SYSTEM (CBRS) AREAS

OTHERWISE PROTECTED AREAS (OPAs)

CBRS areas and OPAs are normally located within or adjacent to Special Flood Hazard Areas.

- 1% annual chance floodplain boundary
- 0.2% annual chance floodplain boundary
- Floodway boundary
- Zone D Boundary
- CBRS and OPA Boundary
- Boundary dividing Special Flood Hazard Areas of different Base Flood Elevations, flood depths or flood velocities.
- 513 (EL 987) — Base Flood Elevation line and value; elevation in feet* / Base Flood Elevation value where uniform within zone; elevation in feet*

*Referenced to the North American Vertical Datum of 1988

- A — A: Cross section line
- 23 — 23: Transect line
- 97° 07' 30", 32° 22' 30": Geographic coordinates referenced to the North American Datum of 1983 (NAD 83), Western Hemisphere
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- 600000 FT: 5000-foot grid ticks: New Mexico State Plane coordinate system, Central zone (FIPSZONE 3002), Transverse Mercator
- DX5510: Bench mark (see explanation in Notes to Users section of this FIRM panel)
- M1.5: River Mile

MAP REPOSITORIES
Refer to Map Repositories list on Map Index.

EFFECTIVE DATE OF COUNTYWIDE FLOOD INSURANCE RATE MAP PANEL

SEPTEMBER 20, 1996

EFFECTIVE DATE(S) OF REVISION(S) TO THIS PANEL

April 2, 2002 - to update corporate limits, to change Base Flood Elevations and Special Flood Hazard Areas, to add roads and road names, to reflect updated topographic information, and to incorporate previously issued Letters of Map Revision.

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MAP SCALE 1" = 500'

250 0 500 1000 FEET
150 0 150 300 METERS

NFIP NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0111G

FIRM

FLOOD INSURANCE RATE MAP

BERNALILLO COUNTY, NEW MEXICO AND INCORPORATED AREAS

PANEL 111 OF 825

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
ALBUQUERQUE, CITY OF	350002	0111	G
BERNALILLO COUNTY UNINCORPORATED AREAS	350001	0111	G

ANNOTATED FIRM

Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

MAP NUMBER
35001C0111G

MAP REVISED
SEPTEMBER 26, 2008

Federal Emergency Management Agency

NOTES TO USERS

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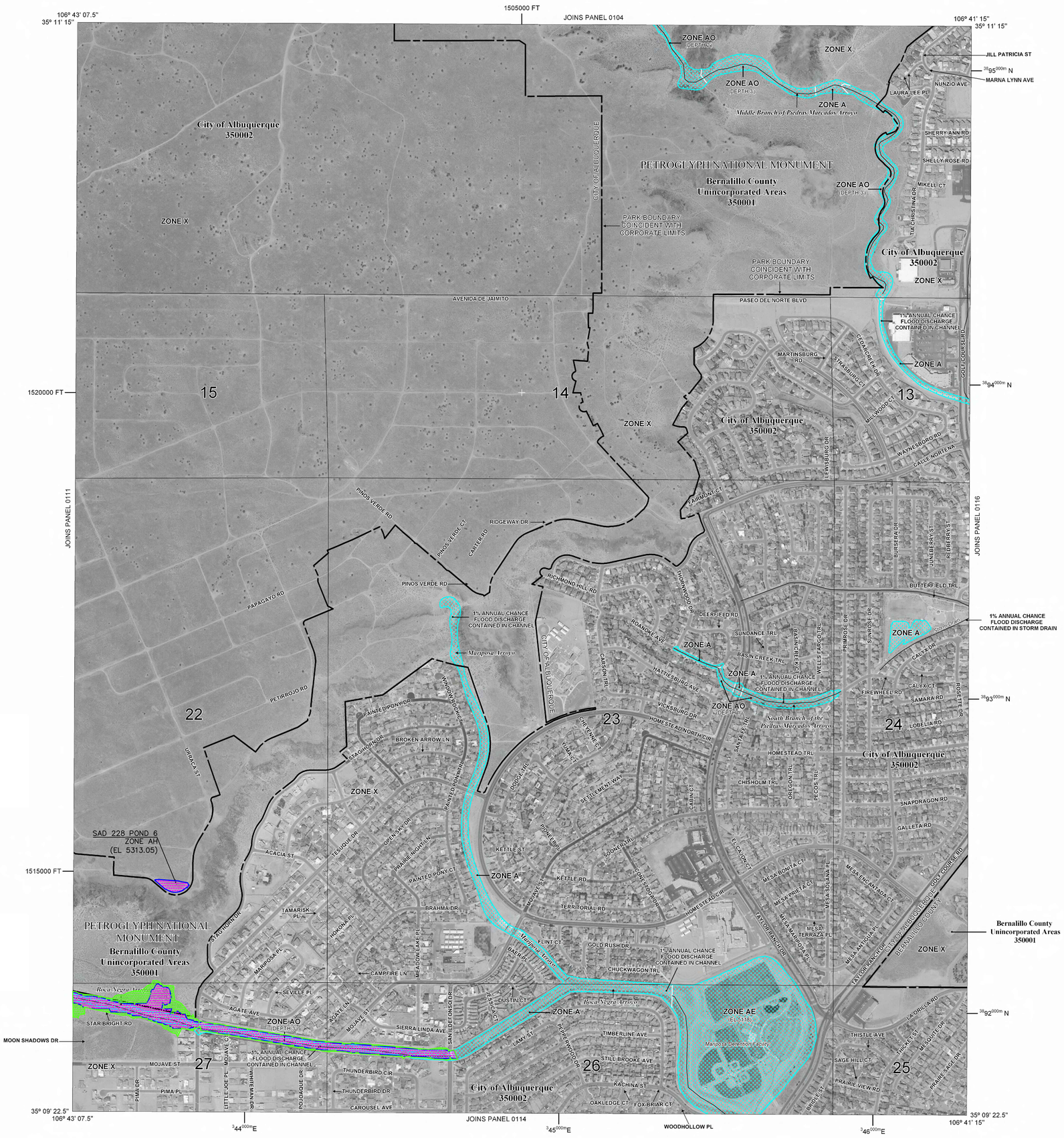
LEGEND

PROPOSED 100YR FLOODPLAIN

PROPOSED 500YR FLOODPLAIN

NOTES: POND 6 WATER SURFACE ELEVATION PER SAD 228 DRAINAGE REPORT DATED JANUARY 2012



LEGEND

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SEPTEMBER 20, 1996

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150 0 150 300 METERS

NFIP

NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0112G

FIRM

FLOOD INSURANCE RATE MAP

BERNALILLO COUNTY, NEW MEXICO
AND INCORPORATED AREAS

PANEL 112 OF 825

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
ALBUQUERQUE, CITY OF	350002	0112	G
BERNALILLO COUNTY UNINCORPORATED AREAS	350001	0112	G

ANNOTATED FIRM

Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

MAP NUMBER
35001C0112G

MAP REVISED
SEPTEMBER 26, 2008

Federal Emergency Management Agency