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WEST I-40 DMP

VOLUME I

DRAINAGE MANAGEMENT PLAN

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PREPARED FOR:

**ALBUQUERQUE METROPOLITAN ARROYO
FLOOD CONTROL AUTHORITY
2600 PROSPECT NE
ALBUQUERQUE, NM 87107**

VOLUME I – Drainage Management Plan



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Draft Working Hydrology
Preliminary Options Summary
Sediment Reconnaissance
Analysis of Existing Conditions Sediment Yields and Detention Dam Trap Efficiencies
Sediment Erosion Analysis Within Petroglyph National Monument
Public Meeting Minutes and Survey Results
Cultural Resource Survey

EXECUTIVE SUMMARY


I. Introduction

The west side of Albuquerque is the last remaining area of the City that has an excess of developable land to meet the City's growth needs well into the 21st Century. Several issues must be resolved before responsible development can occur. One major issue, which is the subject of this study, is drainage management.

The West Interstate 40 Diversion Drainage Management Plan (West I-40 DMP), authorized by the Albuquerque Metropolitan Arroyo Flood Control Authority (AMAFCA), provides the framework for safe and orderly planning and implementation of drainage improvements. This DMP, and supporting documents, provide a comprehensive drainage management plan for the DMP study area, which covers approximately 40 square miles of the west side. The DMP boundaries are: the Rio Puerco escarpment on the west, Double Eagle II Airport and Vulcan Volcano on the north, Coors Boulevard and the Rio Grande Bluff on the east, and Bluewater Road and I-40 on the south.

The West I-40 DMP is named for the proposed West I-40 Diversion Channel. This drainage diversion structure is proposed to run north of, and parallel to, I-40 from the East Amole Arroyo to the West Bluff Outfall to the Rio Grande. The **Amole-Westgate Dam Drainage Management Plan** (Amole-Westgate DMP), Debra Vaughan-Cleff, P.E., June, 1994, adopted by AMAFCA in 1994, recommended the diversion of flows from the Amole watershed into the West I-40 Diversion. The function of the West I-40 Diversion is to; divert a portion of the Amole watershed flows to relieve capacity problems of existing facilities, accept diverted flows from the parallel Ladera System, and intercept flows from the West Mesa north of I-40.

The **West Interstate 40 Diversion Drainage Management Plan Working Draft Hydrology Report (Volume IV)**, Bohannon Huston, Inc, June 1996, showed that the *existing* 100-year flows can be accommodated by the existing drainage facilities, but *developed* 100-year flow rates will exceed the capacity of many of the existing facilities. Some of the West I-40 DMP's critical drainage facilities are: proposed West I-40 Diversion Channel, Amole East Dam, and Dam 12 Diversion to the West I-40 Diversion Channel; and the existing West Bluff Outfall, Ladera Dam 12, and Mirehaven Arroyo.



A total of fourteen options to eliminate flooding and provide an overall drainage management plan for the project area, plus a "Take No Action" option, have been studied. The options have been investigated and presented to the AMAFCA Board and the West I-40 Technical Team. The Tech Team, comprised of Landowners, City and County staff, Neighborhood Association and National Park Service representatives, and AMAFCA staff and their consultants, narrowed the selection to two preferred options. At the direction of the AMAFCA Board, a final recommended Option was developed considering the two preferred options. A brief summary of the options is provided below. Additional information on the preferred and recommended options is discussed in detail in the DMP (Volume I), while the rejected preliminary options are provided in the Preliminary Options Summary (Volume IV).

II. PREFERRED OPTIONS

The two preferred options are similar in cost but present two philosophically different approaches to drainage management within the upper portion of the West I-40 DMP study area. One option (Option 2D) proposes diverting developed flows around the Petroglyph National Monument with a series of detention dams and buried storm drains. The other option (Option 3C.1) proposes carrying flows through the Monument via Mirehaven Arroyos B and C with a series of detention dams and buried storm drains that follow the natural path of the existing arroyos.

A. Option 2D – Divert Mirehaven Arroyos In Pipe to New D5 Dam and Build Dam 5 Diversion (Estimated Project Cost: \$44,760,000)

The National Park Service, one of the major landowners in the area, prefers Option 2 in general, and Option 2D in particular. Option 2D proposes diversion of flows west of the Monument via a combination of detention dams and buried storm drains, known as the Petroglyph Diversion, to a new dam at the top of the Dam 5 Arroyo. Flow is then conveyed to Ladera Dam 5 by a storm drain or open channel. To avoid exceeding the capacity of the existing Ladera System, the increased flow at Dam 5 is diverted to the I-40 Diversion Channel at 98th Street. Runoff from developed areas between the Petroglyph Diversion and the West Monument Boundary will enter the Monument at historic levels (for the 100-year event). Flows will pass through the Monument through the existing Mirehaven A, B, and C arroyos in drainage easements retained by Westland Development Corporation.

B. Option 3C.1– Divert Mirehaven Arroyos “A” to “B” with Detention at “C” and Through Monument (Estimated Project Cost: \$46,040,000)

Westland Development Corporation, the second major landowner in the area, prefers Option 3 in general, and Option 3C.1 specifically. Under Option 3C.1, a portion of the Petroglyph Diversion is constructed to divert runoff from Mirehaven A to B upstream of the Monument. Two detention dams along the Mirehaven A2 and C Arroyos attenuate the peak flow rates to enable economic conveyance through the Monument along both the Mirehaven B and C Arroyo alignments via storm drains.

III. RECOMMENDED OPTION

While the Tech Team successfully reduced the number of options to two, a consensus recommending a single preferred option could not be reached. The two majority landowners within the study area indicated support for one option or the other; with neither party able to accept the ramifications of the other option. Consequently, at the direction of the AMAFCA Board, a modified version of an earlier option became the recommended option. This recommended option, referred to as Option 6A, is a variation of option 6, which assumed phased growth to the base of the Atrisco Terrace. Facilities under this option would be sized for the worst case (highest) flow rate and volume from either option 2D or 3C.1. By sizing drainage facilities in this manner, either option 2D or 3C.1 could be implemented in the future without costly retrofitting or expansion of what would then be existing facilities. It should be noted that, with the multiple detention facilities in the upper portion of the watershed in both Options 2D and 3C.1, the flow rates for each option in the lower portion of the watershed are nearly identical. Further, due to upstream detention proposed with both Options 2D and 3C.1, the flow rates used to size conveyances for arroyos, such as the Mirehaven, between the Monument/Atrisco Terrace, and the Ladera Dams are only slightly larger than existing conditions flow rates, plus sediment. This increase is due to the increase in runoff from development of the area between the Monument/Atrisco Terrace and the Ladera Dams.

Option 6A addresses the immediate needs in the downstream portion of the watershed and puts in place the trunk of the drainage system. This option also defers the decision of whether or not to divert flows around the Monument, allowing the two majority landowners time to reach an agreement. The estimated cost for Option 6A is \$27,870,000, with a deferred cost of \$16,500,000

or \$18,710,000, depending on the future selection of Option 2D or 3C.1. For these reasons, option 6A is the recommended option.

Projects Common to 2D, 3C.1 and 6A

Project Description	Est. Cost	Est. Completion
I-40 Diversion From West Bluff Outfall to West Mesa Diversion Channel	-	In place
I-40 Diversion From West Mesa Diversion Channel to and including Unser Blvd Pond	\$3,310,000	by 2002
Parkway Storm Drain (Dam 12 Diversion)	\$730,000	by 2002
West Mesa Diversion Channel Including West Mesa Pond*	\$3,410,000	by 2003
I-40 Diversion From Unser Blvd Pond to and including 98 th Street Pond	\$2,560,000	by 2005
I-40 Diversion From 98 th Street Pond to East Amole Dam	\$4,320,000	2005 to 2010
Amole Diversion From East Amole Dam to West Amole Dam	\$2,750,000	after 2010
Mirehaven Channel from Monument Boundary to Dam 12	\$2,320,000	2005 to 2010

*Currently under design by the City of Albuquerque

Projects Common to 2D, and 3C.1


Project Description	Est. Cost	Est. Completion
Arroyo Stabilization in Atrisco Terrace and Upsizing Dams 1 and 3 of Ladera System	\$3,600,000	after 2010
Paseo Del Volcan Dam	\$3,540,000	after 2010
West Amole Dam	\$3,460,000	after 2010
Petroglyph Diversion from PDV Dam to A2 Dam	\$1,220,000	after 2010
A2 Dam	\$440,000	after 2010
Dam 5 Arroyo	\$3,710,000	2005 to 2010
East Amole Dam	\$3,520,000	2005 to 2010

Projects Specific to Option 2D

Project Description	Est. Cost	Est. Completion
Petroglyph Diversion from A2 Dam to C dam	\$1,000,000	after 2010
C dam	\$880,000	after 2010
Petroglyph Diversion from C dam to D5 Dam	\$270,000	after 2010
D5 Dam	\$1,810,000	after 2010
C1 and C2 Storm Drains	\$710,000	after 2010
Arroyo Stabilization Inside Petroglyph National Monument	\$490,000	after 2010
Relocate Ladera Training dike	\$100,000	after 2010
Enlarge Ladera Dam 5	\$70,000	after 2010
Dam 5 Diversion	\$540,000	after 2010

Projects Specific to Option 3c.1

Project Description	Est. Cost	Est. Completion
Paseo Del Volcan Mirehaven "B" Pipe from A2 Dam to Confluence w/ C	\$1,910,000	after 2010
C1 and C2 Storm Drains	\$1,540,000	after 2010
Mirehaven "C" Dam	\$1,030,000	after 2010
Mirehaven Diversion from "C" Dam to Confluence w/ Mirehaven "B"	\$590,000	after 2010
Pipe from Confluence to Boundary	\$1,810,000	after 2010
Upsize Dams 5 and 11	\$270,000	by 2005

Projects Specific to 6A

Project Description	Est. Cost	Est. Completion
Dam 5 Diversion	\$540,000	2010
Arroyo Stabilization in Atrisco Terrace (Dam 1 Arroyo)	\$760,000	After 2010
Dam 5 Arroyo	\$2,440,000	2005 to 2010
East Amole Dam	\$1,330,000	2005 to 2010
West Amole Dam	\$2,860,000	after 2010
Upsize Dams 5 and 11	\$270,000	By 2005

SUMMARY OF KEY FLOW RATES

Description	Option 2D			Option 3C.1			Option 6A		
	Pipe/ Channel	Dam		Pipe/ Channel	Dam		Pipe/ Channel	Dam	
		In (cfs)	Out (cfs)		In (cfs)	Out (cfs)		In (cfs)	Out (cfs)
West Amole Dam	-	3880	250	-	3880	250	-	3880	250
Amole Diversion - West Amole Dam to Paseo del Volcan	665	-	-	665	-	-	665	-	-
Amole Diversion - Paseo del Volcan to East Amole Dam	1715	-	-	1715	-	-	1715	-	-
East Amole Dam	-	2650	300	-	2650	300	-	2650	300
Paseo del Volcan Dam	-	2060	300	-	2060	300	-	-	-
Petroglyph Diversion - Paseo del Volcan to A2 Dam	510	-	-	510	-	-	-	-	-
Mirehaven A2 Dam	-	510	265	-	510	265	-	-	-
Petroglyph Diversion - A2 Dam to C Dam	265	-	-	-	-	-	-	-	-
C Dam	-	1125	335	-	1290	260	-	-	-
Petroglyph Diversion C Dam to D5 Dam	340	-	-	-	-	-	-	-	-
D5 Dam	-	340	270	-	-	-	-	-	-
C1 and C2 Storm Drains	190 ea.	-	-	645 ea.	-	-	-	-	-
Dam 5 Arroyo	1135	-	-	1135	-	-	1135	-	-
Dam 1 Arroyo	745	-	-	745	-	-	745	-	-
Dam 0 Arroyo	460	-	-	460	-	-	460	-	-
A2 Dam Outfall - A2 Dam to Training Dike	-	-	-	450	-	-	-	-	-
Mirehaven Pipe from C Dam to Confluence	-	-	-	255	-	-	-	-	-
Mirehaven Channel from Confluence to National Monument Boundary	-	-	-	1325	-	-	-	-	-
Mirehaven Channel - Petroglyph National Monument to 98 th Street	1405	-	-	1495	-	-	1495	-	-
Mirehaven Channel - 98 th Street to Dam 12	1655	-	-	1650	-	-	1655	-	-
Ladera Dam 5 (Enlarge)	-	1145	320	-	1105	220	-	1145	320
Dam 5 Diversion from Ladera Dam 5 to I-40 Diversion	255	-	-	-	-	-	255	-	-
Ladera Dam 11 (Enlarge for 3C.1 and 6A)	-	-	-	-	290	45	-	290	45
Dam 12 Diversion from Ladera Dam 12	-	-	300	-	-	300	-	-	300
Parkway Storm Drain (Dam 12 Diversion)	555	-	-	615	-	-	615	-	-
I-40 Diversion: East Amole to 98 th Street	1805	-	-	1805	-	-	1805	-	-
I-40 Pond at 98 th Street	-	2120	765	-	2120	765	-	2120	765
I-40 Diversion Channel - 98 th Street to Unser Boulevard	1090	-	-	1090	-	-	1090	-	-
I-40 Pond at Unser Boulevard	-	1565	1170	-	1565	1170	-	1565	1170
I-40 Diversion Channel - Unser Boulevard to West Mesa Diversion	1350	-	-	1360	-	-	1360	-	-
Laurelwood Pond	-	440	100	-	440	100	-	440	100
West Mesa Diversion Pond	-	530	420	-	530	420	-	530	420
West Mesa Diversion Channel	255	-	-	255	-	-	255	-	-
West Mesa Diversion Channel Concrete Box Culvert	790	-	-	790	-	-	790	-	-
Confluence of I-40 and West Mesa Diversion Channel	2030			2060			2060		
West Bluff Outfall	2545			2585			2585		

SUMMARY OF PROPOSED DAM SITES

Description	Option 2D				Option 3C.1				Option 6A			
	Flow In (cfs)	Flow Out (cfs)	100 Yr. Water Surface Area	100 Yr. Storage Volume (ac-ft)	Flow In (cfs)	Flow Out (cfs)	100 Yr. Water Surface Area	100 Yr. Storage Volume (ac-ft)	Flow In (cfs)	Flow Out (cfs)	100 Yr. Water Surface Area	100 Yr. Storage Volume (ac-ft)
West Amole Dam	3880	250	-	600	3880	250	-	600	3880	250	-	136*
East Amole Dam	2650	300	-	270	2650	300	-	270	2650	300	-	60*
Paseo del Volcan Dam	2060	300	30	198.3	2060	300	30	198.3	-	-	-	-
Mirehaven A2 Dam	510	265	-	21.8	510	265	-	21.8	-	-	-	-
Mirehaven C Dam	925	335	-	42.5	1285	255	-	54	-	-	-	-
D5 Dam	340	270	-	102	-	-	-	-	-	-	-	-
Ladera Dam 1	1110	265	-	41 (was 30)	1110	265	-	41	1110	265	-	41
Ladera Dam 3	180	45	-	45.4 (was 29.7)	180	45	-	45.4	180	45	-	45.4
Ladera Dam 5 (Enlarge for All Options)	1145	320	-	37.8 (was 31.5)	1105	220	-	35.8	1145	320	-	37.8
Ladera Dam 11 (Enlarge for 3C.1 and 6A)	565	55	-	36.2 (was 29)	290	45	-	45.5	290	45	-	45.5
I-40 Pond at 98 th Street	2120	765	8	49	2120	745	8	49	2120	765	8	49
I-40 Pond at Unser Boulevard	1555	1170	6	44.4	1565	1165	6	44.4	1565	1170	6	44.4
West Mesa Diversion Pond	530	425	1	6.5	530	425	1	6.5	530	425	1	6.5

*Sized for existing conditions flows.

IV. REJECTED OPTIONS

A. Take No Action

The option to take no action is not acceptable for a number of reasons. Existing drainage problems, both north and south of I-40, will remain if no action is taken. The **Amole-Hubbell DMP** is based on the assumption that all runoff north and south of I-40 will be diverted to the West Bluff Outfall at I-40. If no action is taken, the **Amole-Hubbell DMP** cannot be implemented.

B. Option 1

Option 1 proposes to allow fully developed flow from above the Petroglyph National Monument to flow through the Monument, with detention of developed flows either in the Monument, just below the Monument, or at Ladera Dam 12. Additionally, some expansion to the other existing Ladera Dams, and diversion of flows from Ladera Dam 12 to the I-40 Channel, is required under Option 1. Four sub options of Option 1 are summarized as follows:

1. Option 1A – Expand Dam 12 (Estimated Project Cost: \$49,310,000)

To accommodate increased runoff from development of the watershed, this sub option proposes a nearly 400 percent expansion of Ladera Dam 12, and the diversion of over 1,300 cfs from the Ladera system to the I-40 Diversion Channel. Concerns over extensive construction activity within the Monument to convey developed flows through the Monument, and the requirement to meet National Environment Preservation Act (NEPA) guidelines, ultimately led to the elimination of this option.

2. Option 1B – Build Mirehaven Dam (Estimated Project Cost: \$51,080,000)

Option 1B is similar to Option 1A, with one major exception. Rather than expanding Ladera Dam 12, a new dam (Mirehaven Dam) would be constructed just downstream (east) of the Monument, below the confluence of the Mirehaven A, B and C Arroyos. The cost of Option 1B is approximately 2.0 million more than 1A, causing its elimination in favor of 1A.

3. Option 1C – Build Lower Ladera West Dam (Estimated Project Cost: \$50,410,000)

The primary difference between Option 1C and Option 1B is the location of the new detention dam (Ladera West Dam). Option 1C proposes to construct this Dam approximately 2500' further west, placing it within the Monument.

The Tech Team concluded that expansion of Dam 12 was preferred to the construction of a new dam within the Monument, as land adjacent to Dam 12 is already encumbered with power lines and a blanket drainage easement. Consequently, this option was not given further consideration

4. Option 1D – Build Upper Ladera West Dam and Expand Dam 12 (Estimated Project Cost: \$50,870,000)

Similar to Option 1C, this option also proposes the construction of a detention facility within the Monument. However, with Option 1D, the dam is located further upstream at the confluence of the Mirehaven Arroyos B and C and is smaller,

requiring expansion of Dam 12. Due to the requirement for a new dam as well as expansion of Dam 12, Option 1D is more costly than Option 1A and 1C. As a result Option 1D was eliminated.

C. OPTION 2

Option 2 proposes to divert developed flows around the Petroglyph National Monument with the construction of a new diversion facility, referred to as the Petroglyph Diversion. With the diversion in place, discharge to the Monument under developed conditions will remain equal to or less than historic peak rates for the 100-year event. This option minimizes the impact on the Monument. Three sub options to Option 2 are summarized as follows:

1. Option 2A – Divert Mirehaven Arroyos to New D5 Dam (Estimated Project Cost: \$46,250,000)

Option 2A proposes diversion of flows west of the Monument via a combination pipe and open channel system running north to south to a new dam at the top of the Dam 5 Arroyo. Flow is then conveyed to Ladera Dam 5 and, ultimately, Ladera Dam 12. This option requires upsizing the principal spillways for Ladera Dams 5 through 11 to convey the additional runoff reaching Dam 5 to Dam 12. This option was rejected primarily based on the requirement to breach Ladera Dams 5 through 11.

2. Option 2B – Divert Mirehaven Arroyos to New D5 Dam and Build Dam 5 Diversion (Estimated Project Cost: \$45,890,000)

Option 2B is identical to Option 2A except flow is diverted from Ladera Dam 5 to the I-40 Diversion Channel, rather than modifying the principal spillways of Ladera Dams 6 through 11. This option formed the basis for Option 2D that later emerged as one of two preferred options and was hence rejected in favor of Option 2D.

3. Option 2C – Divert Mirehaven Arroyos to New Mirehaven “C” Dam (Estimated Project Cost: \$46,050,000)

Option 2C is similar to Options 2A and 2B. Under Option 2C flows are diverted to a dam at the head of the Mirehaven C Arroyo, rather than the Dam 5 Arroyo. Runoff is then released at historic levels (for the 100-year event) and allowed to flow through the Monument in the existing arroyo with drop structures constructed as necessary to control arroyo erosion. This Option was rejected because it is more expensive than Options 2A and 2B, and has a greater number of adverse impacts on the Monument.

D. OPTION 3

Option 3 represents a hybrid between Options 1 and 2 originally proposed in the AMAFCA West I-40 DMP. These options were developed as part of an analysis completed for Westland Development Corporation and the National Park Service in an attempt to develop an option that is acceptable to both parties. Three sub options evolved and are referred to as Options 3, 3C and 3C.1.

1. Option 3 – Detention Above Petroglyph National Monument (Estimated Project Cost: \$44,090,000)

Option 3 proposes construction of the Paseo del Volcan Dam and detention dams along the Mirehaven A2 and C Arroyos just upstream (west) of the Monument. Flows attenuated to historic flow rates for the 100-year event will then discharge from these dams and flow through the Monument to Ladera Dam 12. Some stabilization of the arroyo in the form of drop structures, or other means will be required. Option 3 was refined to create Option 3C and rejected in favor of Option 3C.

2. Option 3C – Divert Mirehaven Arroyos “A” and “B” to “C” Through Monument (Estimated Project Cost: \$45,830,000)

Option 3C is a slight variation of Option 3 in that runoff from upstream areas will be diverted to Mirehaven C Arroyo and conveyed through the Monument in a storm drain, rather than allowing flows to cross the Monument in the existing

arroyos. Developed flows cross the Monument in only one location and in a pipe, rather than the existing unlined arroyo. Consequently, only very minimal arroyo stabilization within the Monument is anticipated with Option 3C. Option 3C was modified slightly to create Option 3C.1 and rejected in favor of Option 3C.1.

E. OPTION 4 – Unrestrained Flow (Estimated Project Cost: \$60,950,000)

Option 4 is an unrestrained flow option, in which the capacity of the West Bluff Outfall would be increased and the two Amole Dams would be the only additional detention facilities constructed. This option requires construction of a culvert, equal in size and parallel to the existing West Bluff Outfall, from Coors to the Rio Grande to convey the developed condition flow rate of over 5,000 cfs. In addition the crossing structures at Unser Boulevard and 98th Street must be upsized.


This option presents many problems, including a cost of over 8 million dollars more than the next most costly option. In addition to the cost are some very difficult construction operations and potential traffic control problems associated with the construction of a CBC parallel to the existing outfall along I-40 and the construction of additional culverts at Unser Boulevard and 98th Street. Based on these considerations, this option is not feasible.

F. OPTION 5 - Ladera Dam 15 (Estimated Project Cost: \$52,460,000)

Option 5 proposes diversion of all developed runoff from the Ladera Watershed to the Ladera Golf Course (Dam 15). This option attempts to utilize some of the extra capacity that exists in Dam 15. Major modifications to the existing Ladera System are required, including reconstruction of both Ladera Dams 12 and 14 to enlarge their principal spillways, and the removal of Dam 13. Additionally, reconstruction of portions of Unser Boulevard and Ouray Boulevard are required which will be very disruptive, expensive, and create substantial delays to the traveling public. For these reasons, Option 5 was rejected.

G. OPTION 6 Phased Growth (Estimated Project Cost: \$27,030,000)

Option 6 assumes phased growth to the base of the Atrisco Terrace, without provisions for future expansion. While runoff volumes and flow rates would reflect development only to the Atrisco Terrace, the two Amole Dams and the Amole Diversion would be included so that



the **Amole-Hubbell DMP** could be implemented. The two dams would, however, only be constructed at this time to accommodate existing undeveloped conditions runoff. Under this option, the necessary improvements to the watershed are reduced substantially. Option 6 was revised to create Option 6A, which incorporates provisions for future expansion. Option 6 was rejected in favor of Option 6A.

I. INTRODUCTION

The West Interstate 40 Diversion Drainage Management Plan (West I-40 DMP) study area is located on the west side of Albuquerque and is composed of the Upper Amole, Ladera, and West Bluff watersheds. The Albuquerque Metropolitan Arroyo Flood Control Authority (AMAFCA) contracted with Bohannon Huston, Inc. (BHI) to provide a comprehensive drainage management plan of the region. The project area encompasses approximately 40 square miles (see Vicinity Map, Figure 1). The general limits of the project are: the Rio Puerco escarpment on the west, Double Eagle II Airport and Vulcan Volcano on the north, Coors Boulevard and the Rio Grande Bluff on the east, and Bluewater Road and I-40 on the south.

The project area has three outfalls to the Rio Grande: the West Bluff Outfall to the Rio Grande, the Ladera Dam 15 outfall pipe to the San Antonio Arroyo, and the Westgate Dam outfall pipe to the Amole-Hubbell detention facilities. Each of the outfalls has deficiencies as summarized below:

- The West Bluff Outfall has a capacity of 2,585 cubic feet per second (cfs), but, due to the lack of additional drainage infrastructure, upstream flows cannot reach the facility.
- The 60" outfall pipe from Ladera Dam 15 is at capacity.
- The Westgate Dam and the downstream Amole-Hubbell System do not have the capacity for fully developed conditions flows. This situation resulted in the adoption of the **Amole Arroyo – Westgate Dam Drainage Management Plan** (Amole-Westgate DMP), Debra Vaughan-Cleff, P.E., June, 1994. The primary recommendation of this DMP was to detain and divert all runoff from the Amole-Hubbell Watershed north of I-40 to the West Bluff Outfall.

The **Amole–Westgate DMP**, adopted by the AMAFCA Board via Resolution 1994-4, April 28, 1994, served as the starting point for the development of the West I-40 DMP. Significant capacity and flooding problems exist south of I-40.

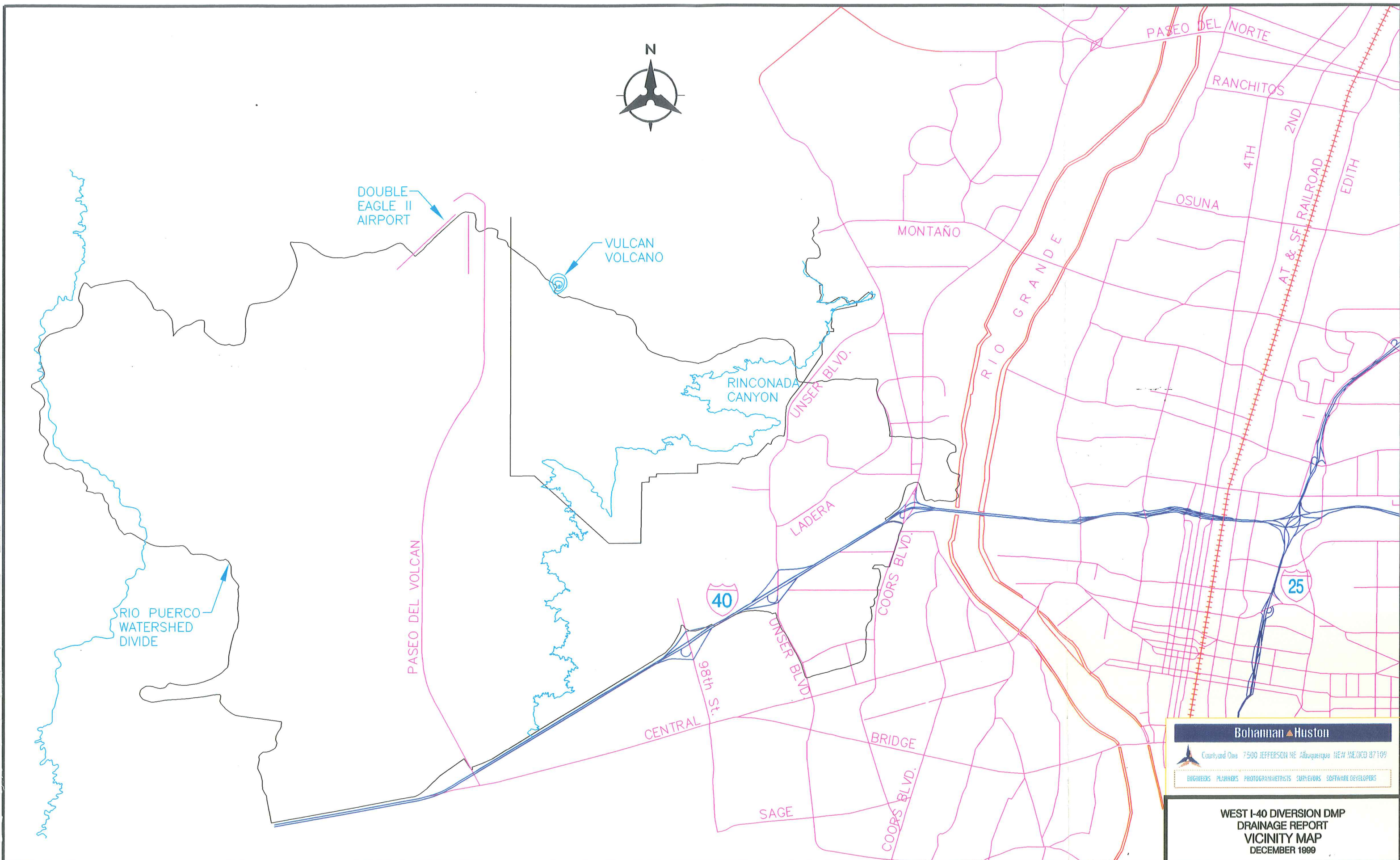



FIGURE 1



The **Amole–Westgate DMP** proposed several measures, including the East and West Amole Detention Dams north of I-40 and I-40 Diversion, as a means of diverting runoff to the river north of I-40. Diverting runoff north of I-40 makes use of the existing West Bluff Outfall while reducing the need to use Middle Rio Grande Conservancy District (MRGCD) irrigation canals and drains as storm water outfalls. In addition, the Amole Detention Dams and West I-40 Diversion:

- diverts a substantial portion of the existing watershed that causes flooding in the southwest valley;
- reduces flows impacting the area from I-40 all the way south to the Hubbell Lake outfall; an area which currently lacks an outfall to the Rio Grande;
- eliminates capacity problems at the Westgate Dam, and;
- eliminates over 110 acres of existing floodplain.

The drainage management options presented in this DMP consider the limited outfalls to the river both north and south of I-40 and thus build on the **Amole–Westgate DMP** premise of diverting runoff north of I-40 to the West Bluff Outfall. As part of the DMP, six (6) options with several sub options, and a "Take no Action" option, for a total of fifteen options, were developed. The rejected options and earlier versions of the preferred options are included in the Preliminary Options Summary as part of Volume IV. The West I-40 Tech Team narrowed the selection to Options 2D and 3C.1. A third preferred option, Option 6A, was then added because the Tech Team was unable to reach a consensus supporting as either Option 2D or Option 3C.1. Option 6A, the recommended option, is discussed in more detail along with options 2D and 3C.1 in the Facilities Planning section of the DMP.

This DMP considers previous drainage analyses within the study area. A summary of the analyses and reports that preceded this DMP is provided in the document, **West I-40 Diversion Drainage Management Plan Literature Review** (West I-40 DMP Literature Review), Bohannon Huston Inc., December 1995 w/Addendum No. 1 June, 2000. (See Volume IV.)

II. HYDROLOGY

A. METHODOLOGY

Hydrologic modeling for this project was performed using the Albuquerque Metropolitan Arroyo Flood Control Authority Hydrologic Model, January 1994 (AHYMO) computer program, in accordance with the City of Albuquerque Development Process Manual Section 22.2, January 1993.

1. Land Treatments

AHYMO uses an input parameter called treatment type to describe infiltration and initial abstractions. There are four treatment types: A, B, C, and D. Type A is the most pervious, and Type D is the least pervious. Type A is typically used for undisturbed land, and Type D is used for impervious areas such as paved areas or rooftops, which allow most of the rainfall to run off.

The treatment types of the Ladera and West Bluff basins were examined for this study. For existing conditions, the land usage distributions among the treatment type categories A through D were calculated based on the level of development shown on the project orthophoto maps, which were photographed in October 1995. The Amole watershed uses the treatments from the **Amole-Westgate DMP** model.

2. Routing

The Flood routing method used for this DMP was the Muskingum-Cunge method. The Muskingum-Cunge method is becoming the community standard for calculating flood routing in AHYMO. It generally attenuates flows to a lesser degree than the variable storage coefficient method (previously used in the AHYMO model).

3. Basin Delineation

To establish basin boundaries, topo maps with 2 foot interval contours were used. For the DMP, a new set of 14 – 24" x 36" orthophoto maps at scale 1" = 500' was produced. These are bound as part of the Supplemental Maps (Volume III)

The basin boundaries were delineated using the new orthophoto maps, and verified by as-built drawings and field visits. The boundaries were digitized into a computer graph file from basin boundaries depicted on the orthophoto maps (Figure 2).

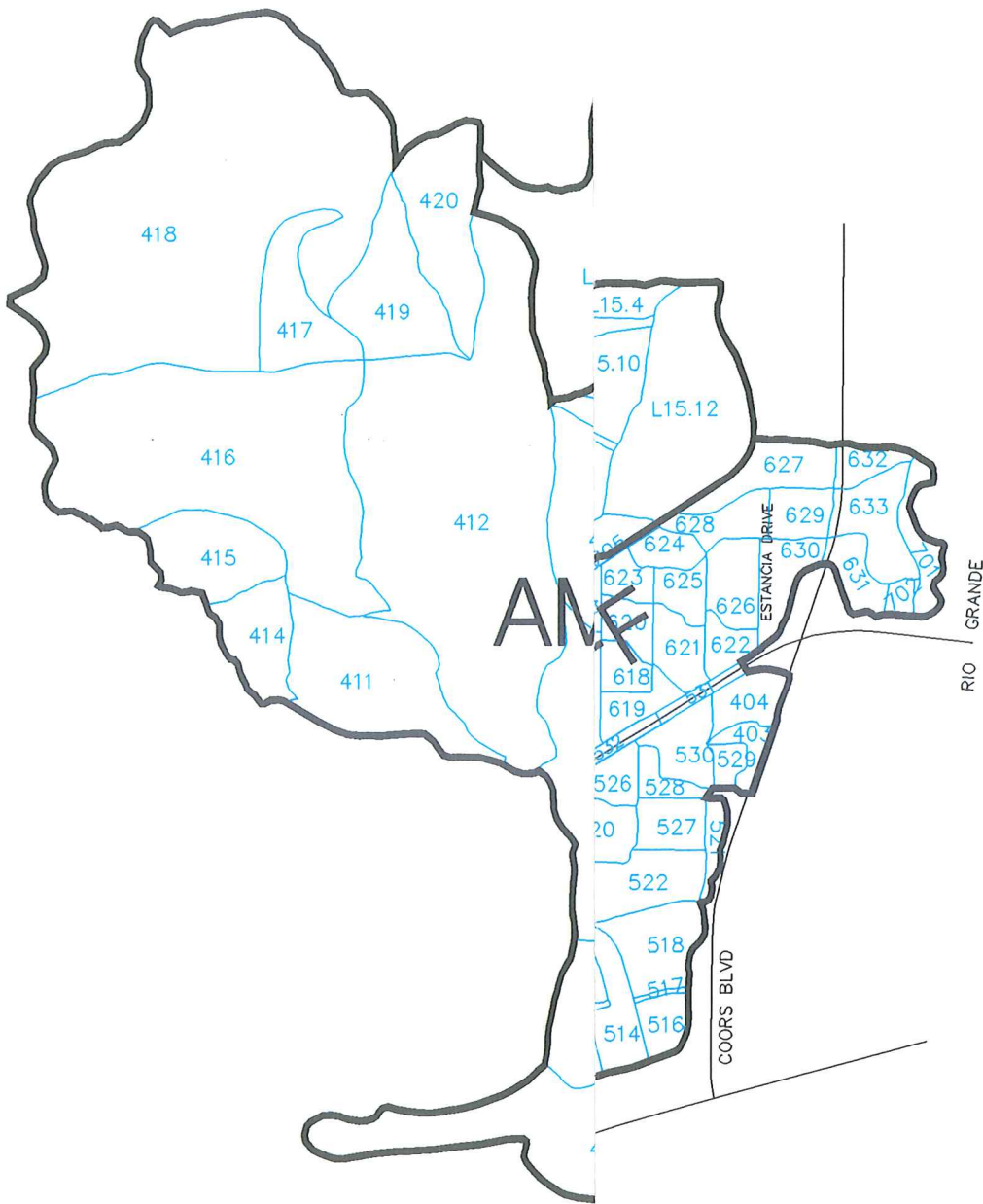
The Ladera watershed basin I.D.'s reflect the delineation of basin runoff within the Ladera Dam system. For example, basins with the L12 prefix discharge to Ladera Dam 12.

A basin size of approximately one half to one square mile was used wherever possible in the creation of the hydrology model for the DMP. This size of basin allows sufficient detail to obtain flow rates at key locations in the watershed. This size of basin also allows for adequate representation of channel routing affects.

4. Precipitation

For the Amole basins, the rainfall parameters are the same as the **Amole-Westgate DMP**. The Amole study was approved by AMAFCA and did not use area reduction for the watershed. Consequently, area reduction was not applied to the Amole Watershed in this study.

For the Ladera and West Bluff watersheds, the rainfall from the Ladera Dam No. 15 Safety Report, Bohannon Huston Inc., January 1993, was used. The Dam 15 report used the area reduction method for large watersheds, as provided in Part C, Section 22.2, Hydrology 1993, of the Albuquerque Development Process Manual. Table 1 describes the rainfall values used.



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DRAINAGE REPORT
BASIN MAP
MAY 1996

FIGURE 2

TABLE 1
Rainfall Depths for Design Storm Events

	AMOLE WATERSHED				LADERA WATERSHED ABOVE DAM 12				LADERA WATERSHED DAM; AND WEST BLUFF			
	2yr	10yr	100yr	PMP	2yr	10yr	100yr	PMP	2yr	10yr	100yr	PMP
15 min.	-	-	-	8.06	-	-	-	5.811	-	-	-	6.851
1hr.	.73	1.24	1.87	11.85	.683	1.16	1.763	9.693	.763	1.25	1.9	10.784
6 hr.	.95	1.47	2.2	16	.93	1.429	2.143	14.064	.955	1.467	2.2	15.12
24 hr.	1.15	1.77	2.66	-	1.129	1.736	2.602	-	1.15	1.768	2.65	-

5. Time of Concentration

Time of concentration (T_c), is the time it takes runoff to travel from the hydraulically most distant point of the watershed to the watershed outlet. The T_c was calculated based on the procedure in the DPM. The time to peak (T_p) is equal to $2/3 T_c$. T_p , rather than T_c , is used by the AHYMO model. A table of T_c 's can be found in the **West I-40 Drainage Management Plan Working Draft Hydrology Report**, Bohannon Huston Inc., June 1996 (Volume IV).

6. Sediment Bulking

A sediment analysis of the Ladera watershed system was performed as part of this DMP. This study was completed by Mussetter Engineering, Inc. (MEI) with findings compiled in their report **Analysis of Existing conditions Sediment Yields and Detention Dam Trap Efficiencies**, April 1996 (Volume IV). Two additional reports prepared by MEI that are used in this DMP study (see Volume IV) are **Sediment Reconnaissance for West I-40 Drainage Management Plan**, November 1995, and **Sediment and Erosion Analysis within Petroglyph National Monument**, December 1996. (See section 4 of this report, *Sediment Transport Analysis*, for a summary of sediment yield, sediment trapping, bulking, and Petroglyph National Monument Stabilization.)

B. HYDROLOGY MODEL

1. General

'Existing' refers to the watershed as it appeared in 1996, with 1996 development levels and drainage improvements, as shown in Figure 3. 'Developed' conditions refer to the watershed with full development and the following, approved, future drainage facilities in place:

- West Amole Dam, Amole Diversion and East Amole Dam (as recommended in the adopted **Amole-Westgate DMP**, and **Amole-Hubbell DMP**, Leedshill-Herkenhoff, July 1999)
- I-40 Diversion (recommended in the adopted **Amole-Westgate DMP**, and **Amole-Hubbell DMP**)
- West Mesa Diversion (City of Albuquerque facility recommended in **West Bluff Drainage Plan**, Andrews, Asbury & Robert, Inc., 1987, and **Amole-Hubbell DMP**)

2. Existing Conditions Description

The drainage facilities in the existing model are described proceeding upstream from the West Bluff Outfall. This structure was built from the Rio Grande west to Estancia Drive. At the time the hydrology model was completed (1996), flows from the Coors area north of I-40 constituted the only runoff draining into the West Bluff Outfall. South of I-40, the basins discharged to the east and southeast, leaving the study area.

The Ladera System collects the flows that discharge from the Ladera watershed, located north of I-40. The Ladera watershed flows are routed in the series of dams numbered from Zero to 15 (Dam 15 is the Ladera Golf Course). The Ladera Channel conveys flows from the developed neighborhoods west of Unser Blvd. to Dam 14. The neighborhoods along Ladera Drive just south of Dam 13 and southwest of Dam 14 discharge in a storm drain to Dam 14. The Rinconada Channel conveys flows from Unser to the north end of Dam 15. The

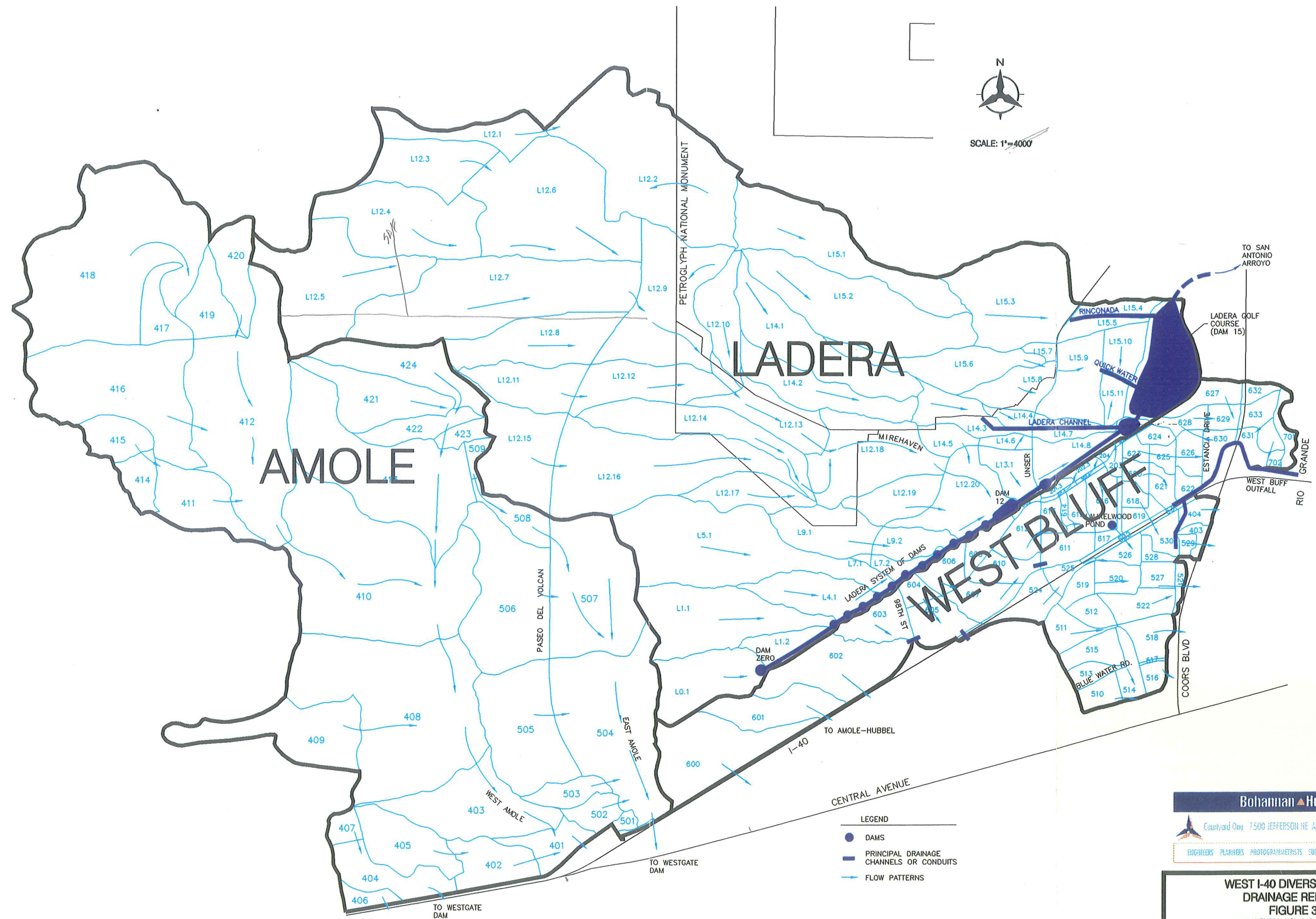


FIGURE 3

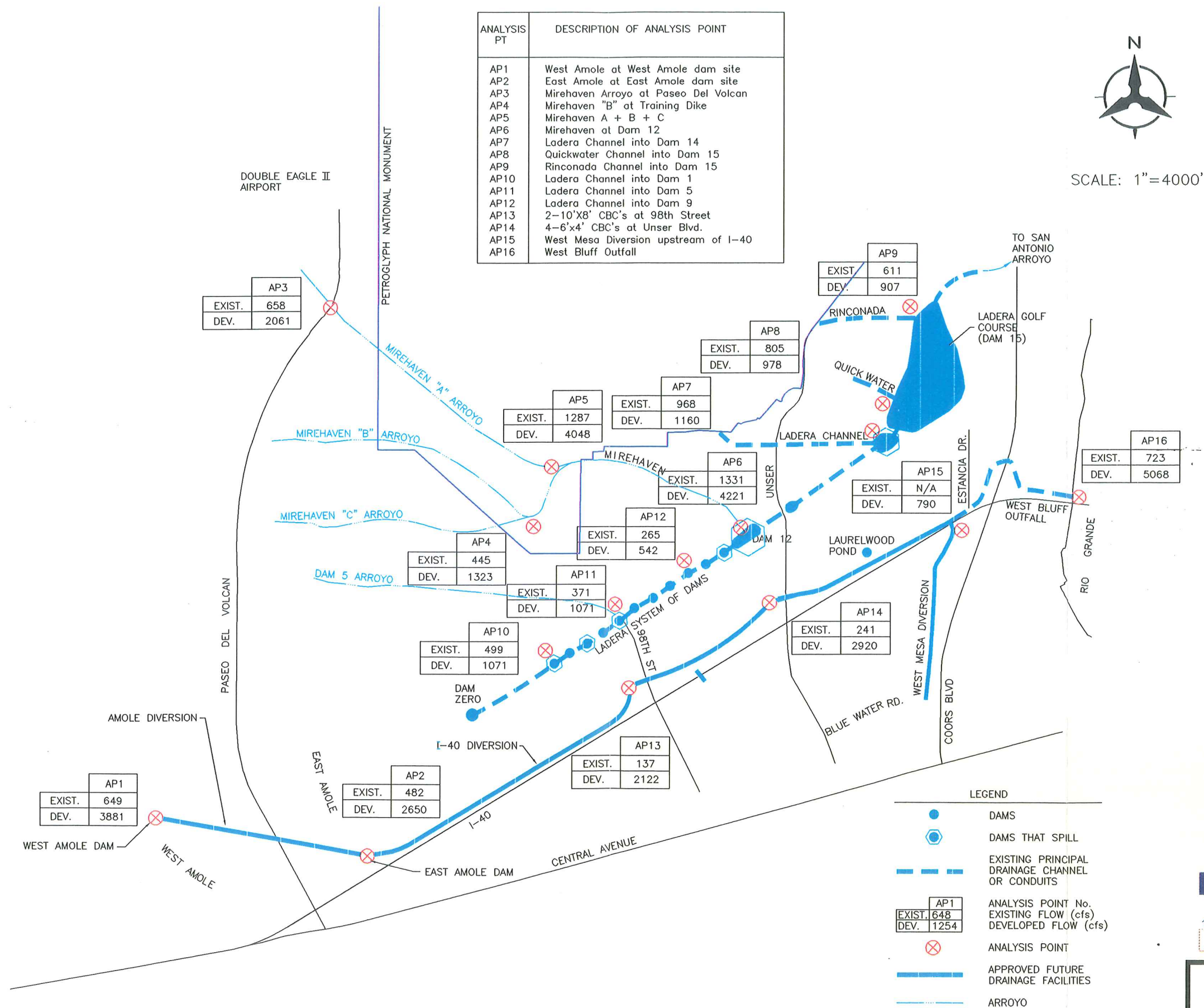
Quickwater Channel conveys flows to Dam 15 from the neighborhoods directly west of Dam 15. Dam 15 outfalls in a storm drain to the San Antonio Arroyo, outside of the study area 1-mile to the northeast of the golf course (see Figure 6).

The Mirehaven Arroyos A, B, and C convey flows from the upper Ladera basins through the Petroglyph National Monument. These three arroyos converge at the base of the escarpment within the Petroglyph National Monument. Below this point, the Mirehaven Arroyo discharges to Dam 12. The Mirehaven Arroyo is unlined except for a 1,300' long soil cement scour wall along its northeastern bank, just north of Dam 12.

Flows from the Amole watershed go south, under I-40, to Westgate Dam. This facility is located outside of the study area, 1.5 miles southeast of the intersection of Paseo del Volcan and I-40.

The major drainage structures or arroyos in the existing model are:

- West Bluff Outfall from the Rio Grande to Estancia Drive
- Ladera Dams Zero through 15
- Mirehaven Diversion Channel from Dam Zero to Dam 1
- Mirehaven Diversion Channel between Dams 13 and 14
- Ladera Channel to Dam 14
- Laurelwood Pond
- Rinconada Channel to Dam 15
- Quickwater Channel to Dam 15
- Undeveloped Mirehaven Arroyos discharging to Dam 12
- Undeveloped Amole Arroyos north of I-40



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 DRAINAGE REPORT
 EXISTING & DEVELOPED
 KEY 100-YEAR FLOWS
 JANUARY 1997

FIGURE 6

3. Existing Floodplains

There are numerous floodplains both within and beyond the limits of the DMP study area that are created by runoff from within the study area. Much of the floodplain north of I-40 is located in undeveloped areas and hence the need to remove the floodplain is not urgent. However, there are also over 110 acres south of I-40, in mostly developed areas, that are encumbered by floodplain due to runoff from the I-40 DMP study area. Figure 3A, based on the Federal Emergency Management Agency (FEMA) Flood Insurance Rate Maps (FIRM), shows the flood plain below I-40 that would be removed with the construction of the proposed I-40 Diversion. The details of the I-40 Diversion are discussed in later sections of the DMP.

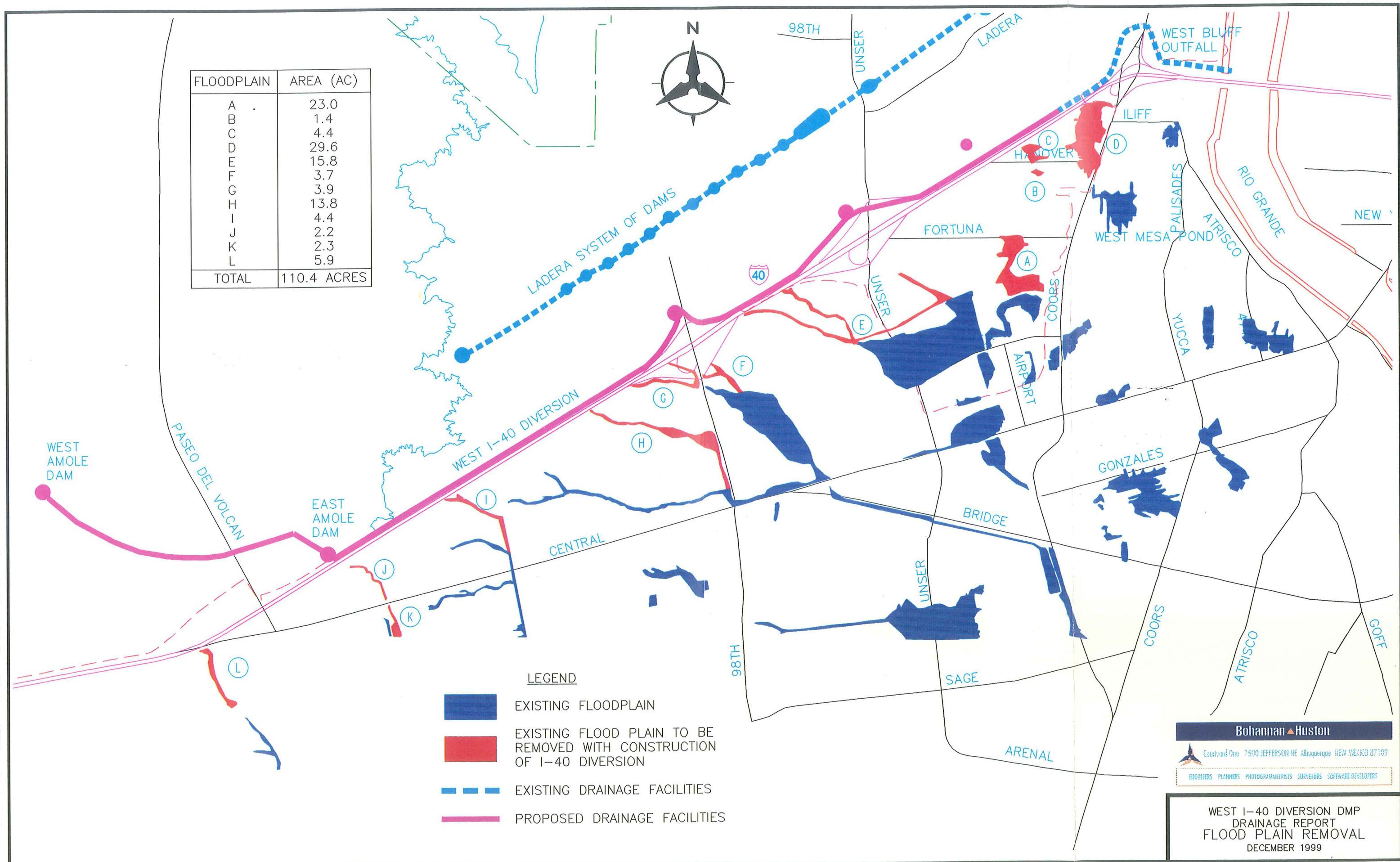
4. Developed Conditions Description

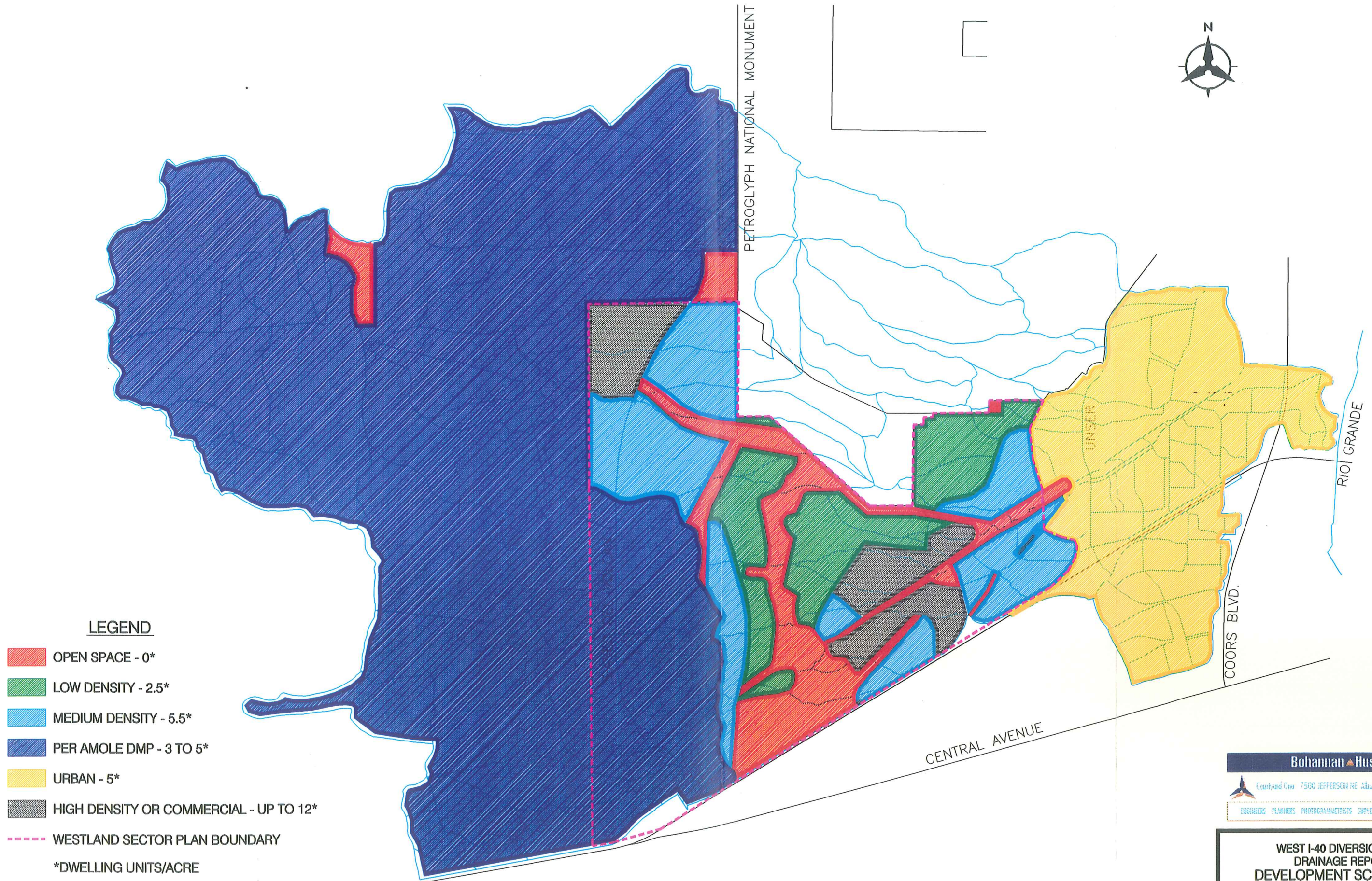
Two developed conditions were analyzed for this DMP. The first condition, Development Scenario 1, is guided by the 1991 Comprehensive Plan. The second condition, Development Scenario 2, on the Westland Sector Development Plan and the adopted **Amole-Westgate DMP** as guides. For maps of the two development scenarios, see Figures 4 and 5.

There are two basic differences between the two developed models:

- Development Scenario 1 has a larger amount of open space south of the Petroglyph National Monument
- Development Scenario 2 has a smaller open space and a higher density of development within the area included in the Westland Sector Development Plan.

At the time the hydrology was completed the City had not yet approved the Westland Sector Development Plan. Nonetheless, the second development scenario was recommended for use in the development of drainage management options in the "Draft Hydrology Report", June 1996, because it was believed to be the more realistic development scenario. This proved to be the correct assumption as the City and County approved the Westland Sector Development Plan on June 14, 2000. **Unless otherwise stated, all flow rates reported in this study are based on Development Scenario 2.**

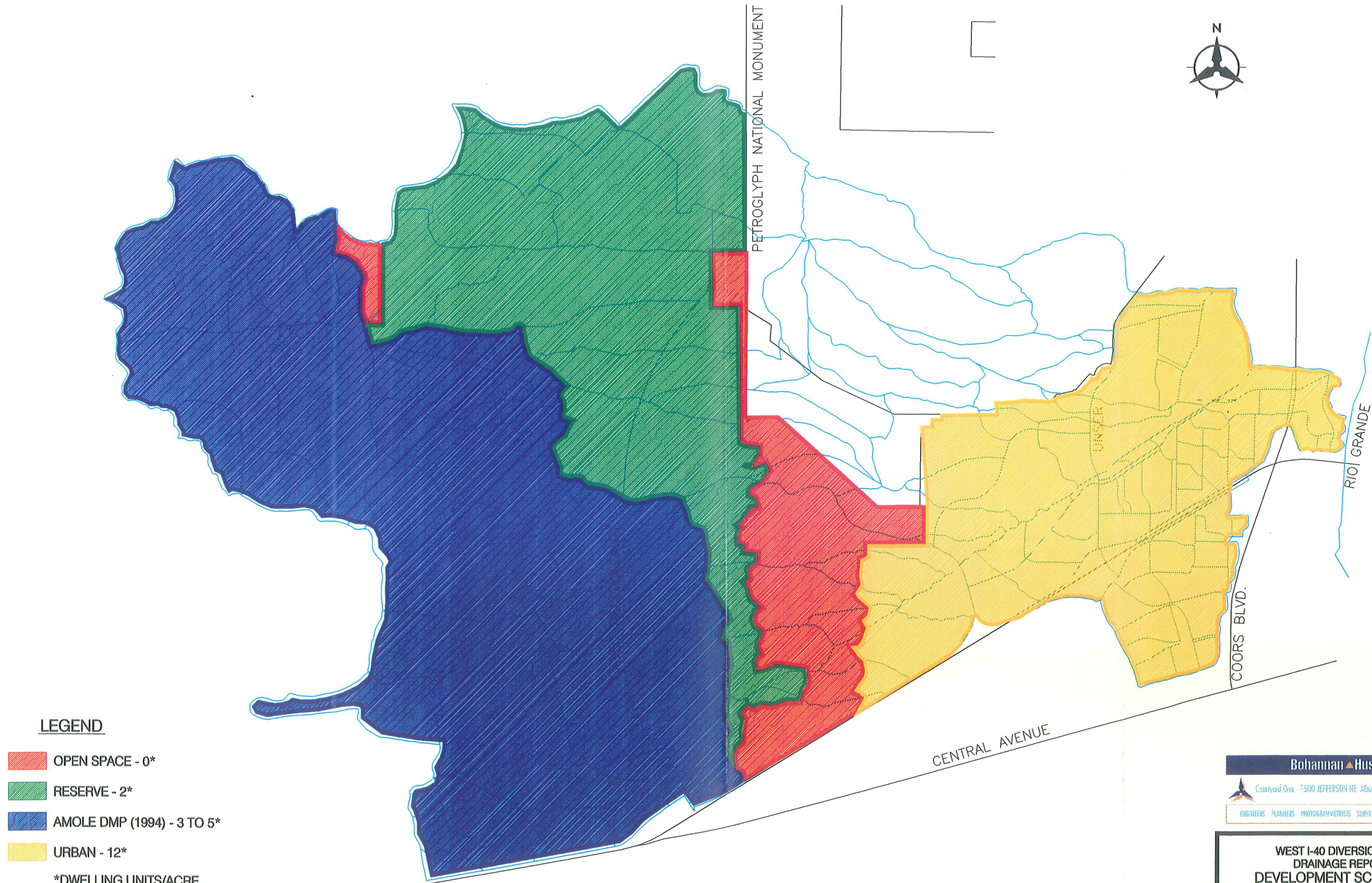




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**WEST I-40 DIVERSION DMP
 DRAINAGE REPORT
 DEVELOPMENT SCENARIO 2
 MAY 1996**

FIGURE 5



LEGEND

- OPEN SPACE - 0*
- RESERVE - 2*
- AMOLE DMP (1994) - 3 TO 5*
- URBAN - 12*

*DWELLING UNITS/ACRE

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WEST I-40 DIVERSION DMP
DRAINAGE REPORT
DEVELOPMENT SCENARIO 1
MAY 1996

FIGURE 4

C. SEDIMENT TRANSPORT ANALYSIS

1. Sediment Yield (from MEI report)




Analyses have been performed to determine existing conditions sediment yields for the Ladera Drainage System above Dam No. 12. The sediment yield analyses were performed using the Modified Universal Soil Loss Equation (MUSLE) to estimate fine sediment yields and sediment transport calculations using the MPM-Woo relationship as presented in the **AMAFCA Sediment and Erosion Design Guide** to estimate bed material sediment yields. Average annual bed material sediment yields ranged from negligible for runoff into Dam No. 7 to 1.68 tons/ac/yr for Dam No. 0, with a watershed average of about 1.1 tons/ac/yr. Total average annual sediment yields ranged from negligible for runoff into Dam No. 7 to 2.15 tons/ac/yr for Dam No. 0, with an average watershed yield of about 1.3 tons/ac/yr. Examination of the results for the entire watershed above Dam No. 12 shows an average annual sediment yield based on the sediment removal data of 1.7 tons/ac/yr compared with the lower value of 1.0 tons/ac/yr based on the simulated bed material yields. Over excavation of the ponds, erosion and recycling of removed material that is stockpiled next to the ponds, degradation of the arroyos immediately upstream from the ponds, and overestimation of the amounts of material actually hauled from the dams may result in overestimation of the watershed sediment yield using the silt removal data. Based on this and the general opinion that the MUSLE and MPM-Woo relationships tend to produce conservative results, the computed sediment yields are believed to be reasonable.

2. Sediment Trapping

Ladera Dams 0, 1, 4, 5, 9, and 12 were analyzed by MEI for sediment trap efficiencies. The trap efficiencies for all the other Ladera Dams were projected for the computed trap efficiencies and in consultation with MEI. The efficiencies were applied in the AHYMO models for the 100-year Existing and the 100-year Development Scenario 2 conditions. The trap efficiencies range from 42.2% at Dam 0 to 91.1% at Dam 9. Dam 12 trap efficiency is 82.5%. A list of the sediment

trap efficiencies is included in Appendix E of the **West I-40 Diversion Drainage Management Plan Draft Hydrology Report**, Bohannon Huston, Inc., June 1996.



The sediment trapping was accomplished in AHYMO using the DIVIDE HYD command twice. First the command is used to separate the clean water from the sediment. Then the command is applied again to the "sediment hydrograph" to account for the dam's trap efficiency. The sediment hydrograph that is not trapped is then added to the clean water hydrograph to produce a dam outflow hydrograph accounting for the dam's trap efficiency.

At each dam, the percent flow removed to account for the MEI sediment trap efficiency was calculated. This percentage varied at each dam depending on the percentage of sediment entering the dam and the trap efficiency of each dam. These calculations are provided in Appendix E of the **West I-40 Diversion Drainage Management Plan Draft Hydrology Report**, Bohannon Huston, Inc., June 1996.

3. Bulking Factors

The sediment bulking factor varies throughout the study area. The **Amole-Westgate DMP** assumed 2.5% bulking for undeveloped and developed conditions. The basins in the far northwest Ladera watershed lie directly north of the **Amole-Westgate DMP** and have similar size, vegetation, and flat slopes. Therefore, the 2.5% bulking factor for the 100-year storm was used in the Ladera basins west of Paseo del Volcan.

East of Paseo del Volcan, the terrain becomes more sloped and irregular, and the arroyos are more defined. The bulking factors established in the Mussetter analysis (**Analysis of Existing Condition Sediment Yields and Detention Dam Trap Efficiencies**, April 1996) were used in this region.

Sediment at Ladera Dams 13, 14, and 15 and the region south of the Ladera Dams was not analyzed by MEI. A conservative 100-year sediment bulking factor of 8% was applied for the undeveloped regions of the Ladera watershed east of Paseo del Volcan outside of the MEI study limits. A list of the sediment bulking factors for the 2-, 10-, and 100-year events used in the West I-40 DMP are in Table 2 below.

TABLE 2
Sediment Bulking Factors

	% SEDIMENT BULKING		
	2-YEAR	10-YEAR	100-YEAR
DEVELOPED REGIONS:	0	1	2.5
UNDEVELOPED REGIONS:			
AMOLE WATERSHED	0	1	2.5
LADERA WEST OF PASEO DEL VOLCAN	0	1	2.5
LADERA EAST OF PASEO DEL VOLCAN:			
BASINS DISCHARGING TO: DAM 0	0	12	23
DAM 1	0	3	7
DAM 2	0	3	5
DAM 3	0	3	5
DAM 4	0	3	5
DAM 5	0	6	12
DAM 6	0	1	2.5
DAM 7	0	1	2.5
DAM 8	0	1	2.5
DAM 9	0	4	10
DAM 10	0	3.5	8
DAM 11	0	3.5	8
DAM 12	0	3	7
DAM 13	0	3.5	8
DAM 14	0	3.5	8
DAM 15	0	3.5	8
WEST BLUFF WATERSHED 600-611 BASIN	0	3.5	8

Some of the basins will see only partial development under developed conditions. This assumption is based on the fact that much of the north-central Ladera watershed is within the National Monument, which was assumed to have no development. A weighted sediment bulking factor was calculated for each

basin containing areas both inside and outside the National Monument based on the fractions of undeveloped land.

4. Petroglyph National Monument Stabilization

Following the presentation at the August 1996 AMAFCA Board meeting, the National Park Service requested that an evaluation of partial stabilization within the Petroglyph National Monument be conducted. In December 1996 Mussetter Engineering Inc. (MEI) completed a draft report entitled **Sediment and Erosion Analysis within the Petroglyph National Monument**, addressing stabilization within the park.


The MEI report used sediment yield and transport equations from the **AMAFCA Sediment and Erosion Design Guide** to determine the amount of sediment that would be delivered to the bottom of the Petroglyph National Monument over a thirty year period. The analysis assumed the following conditions:

1. Diversion of a large portion of the upland drainage area by the Petroglyph Diversion
2. No stabilization of the arroyos within the Monument boundaries
3. Relocation of the existing Ladera Training Dike to the south approximately 400 feet to the existing saddle in the hillside

Considering these assumptions, the analysis determined that, under developed conditions on an average basis, the following would occur:

1. Sediment yields from the watershed would be less than existing due to decreased drainage area and increased impervious surfaces
2. Sediment yields from the arroyos themselves would increase
3. With the relocation of the Ladera Training Dike the sediment leaving the Monument would actually decrease from current yearly levels. Relocating the training dike to the south allows the flow to spread out thus reducing

the velocity of the flow. This in turn allows the sediment being carried in the runoff to settle or drop out in the arroyo before it reaches the Monument Boundary.



Considering the findings of this study, stabilization of the arroyos within the Petroglyph National Monument under Option 2, as described in section 7 *Facilities Planning*, would still be required at critical locations, such as just upstream of the Monument and in particularly steep reaches. However, the MEI study showed that the overall amount of required stabilization could be reduced substantially.

Besides the reduction of arroyo stabilization, Option 2, as described in section 7 *Facilities Planning*, was also modified to include relocation of the Ladera Training Dike. It should be noted that the previous analysis by MEI concluded that the Ladera Training Dike does not divert flow, but merely ensures it follows in its historic path (**Sediment and Erosion Analysis within the Petroglyph National Monument**, December 1996).

5. Reconnaissance

A field reconnaissance of the area encompassed by the DMP was conducted on October 10 and 11, 1995 by employees of AMAFCA, MEI, and BHI. The primary objective of the field reconnaissance was to:

- familiarize the project team members with the area,
- obtain soil samples from the major arroyos,
- identify major geologic formations,
- assess existing vegetative ground cover,
- clarify or assign names to existing arroyos,
- develop recommendations for subsequent sediment and erosion analysis and
- obtain photographs of the major arroyos and existing facilities.

MEI completed a report entitled **Sediment Reconnaissance for West I-40 Drainage Management Plan**, November 1995 that summarizes the site visit and the aforementioned objectives

D. HYDRAULIC ANALYSIS OF EXISTING DRAINAGE FACILITIES

1. General

The project area encompasses nearly 40 square miles within 3 watersheds; the Amole, Ladera and West Bluff watersheds (see Figure 2). Across the project area, the land slopes generally to the southeast. The western one-third of the project area is on a relatively flat plateau called the Ceja Mesa, which divides the Rio Puerco and Rio Grande basins. The Atrisco Terrace forms the eastern border of the mesa. This landform runs generally north to south and is the geomorphic extension of the escarpment without the basalt outcrop. The southern portion of the Petroglyph National Monument extends into the north central project area.

Mostly undeveloped land compromises the western half of the project area, while approximately half of the eastern half of the project area has seen rapid development in the past 14 years. The most heavily developed area is a corridor of commercial development along Coors Boulevard and residential development along Unser Boulevard.

The vegetation on the mesa consists of low grasses and shrubs and scattered juniper. Overgrazing on both the mesa and the undeveloped expanses of land east of the mesa is widely evident. Due to the flat slopes, the mesa lacks defined gullies and arroyos. Additionally, the delivery to downstream facilities takes longer than in the more steeply sloped areas of the watershed. The northernmost portion of the mesa is particularly subject to wind erosion, as is the region just north of I-40. While the vegetation in much of the watershed has been overgrazed these areas are still hydrologically modeled as land treatment A in accordance with Section 22.2 Hydrology of the City DPM, January 1993.

2. Amole Watershed Drainage Facilities

The West and East Amole Arroyos convey flows from north to south. These arroyos cross under I-40 through culverts. The West Amole Arroyo crosses I-40 2,000 feet west of Paseo del Volcan through three 48" reinforced concrete pipes (RCP's). The East Amole Arroyo crosses I-40, 2,000 feet east of Paseo del Volcan through two 10' x 4' Concrete Box Culverts (CBC's), see Figure 6 and Table 3.

TABLE 3
Key 100yr Flows - Amole Watershed

Analysis PT	Description of Analysis Point	Existing Flow at Analysis PT (cfs)	Developed Flow at Analysis PT (cfs)	Capacity of Existing Structure* (cfs)
AP1	West Amole at West Amole Dam Site	649	3881	435
AP2	East Amole at East Amole Dam Site	482	2650	700


* Structure under I-40

3. Ladera Watershed Drainage Facilities

a) Ladera System of Dams

The Ladera System, completed in 1977, consists of a series of sixteen dams. Dam Zero is the first dam, and the Ladera Golf Course (Dam 15) is the last in the series. The system was designed to divert 100-year undeveloped flows (based on the criteria in effect at the time) from the Ladera Watershed to the Ladera Golf Course and ultimately to the Rio Grande via the San Antonio Arroyo (see Figure 6 and Table 4).

The connection between Dam Zero and Dam 1 is the earthen channel stabilized with gabion drop structures and riprap. Mirehaven Diversion Channel. The connection from Dam 12 and Dam 13 is an earthen channel stabilized with gabion drop structures. The Mirehaven Diversion Channel connects Dam 13 and Dam 14 and is an earthen channel with gabion drop structures. All other dams in the system are connected by one or more RCP's.



Dam 14 is the only Ladera dam designed with a 100-year water surface elevation above the emergency spillway. Overflow from Dam 14 is designed to spill north into Dam 15, the Ladera Golf Course. The direction of spill from Dam 14 is unique in the Ladera system because it is not designed to spill towards the natural drainage course, generally to the south towards I-40. Flow that overtops the spillway of Dam 14 is either conveyed under Ouray Boulevard to Dam 15 or flows over Ouray Boulevard to Dam 15 and Ladera Drive. The existing culverts in Ouray Boulevard are undersized and during the 100-year event some flow in and over Ouray Boulevard is anticipated. Determination of the flow path and limits of this flooding from Dam 14 is beyond the scope of the DMP.

The Ladera Diversion to West Bluff Outfall Drainage Study, Bohannon Huston, Inc., July 1989, identified the need to divert runoff from Ladera Dam 12 to the West Bluff Outfall to prevent potential overtopping of the emergency spillway. However, under existing conditions, the DMP has found that Dam 12 has sufficient capacity. This apparent discrepancy is resolved by reviewing the new mapping for the DMP, which revealed that approximately 1.4 square miles of land, once thought to contribute to Dam 12, is contained by a large (70 ac-ft) playa on top of the escarpment, near the Double Eagle II Airport. This playa is assumed to remain under developed conditions. If this playa is filled in at the time of development, the lost storage volume could be offset by expanding the Paseo del Volcan Detention Dam.

The Mirehaven Diversion Channel and the Ladera Channel discharge into Dam 14, and the Rinconada and Quickwater Channels discharge into Dam 15. The limited outfall for Dam 15 is through a 7,560-foot long 60" RCP with a capacity of 124 cfs, that ultimately discharges to the San Antonio Arroyo downstream of Coors Boulevard. A summary of both the

existing and developed flows and volumes for each of the Ladera Dams is provided in Table 4.

TABLE 4
Ladera Dams Hydrology Summary

Dam No.	Flows				Dam				Results
	Existing 100yr Q (cfs)	Existing Volume Into Dam (ac-ft)	Developed 100yr Q (ln) (cfs)	Developed Volume Into Dam (ac-ft)	Principal Spillway Desc. (RCP)	Principal Spillway Capacity (cfs)	Existing 100yr Volume (ac-ft)	Flow Out (cfs)	Developed Flow Over Emergency Spillway*
0	248	11.6	459	22.6	3 - 48"	425	3.2	380	
1	499	29.6	1108	71.3	3 - 30"	200	29.9	609	YES
2	150	32	243	69.2	2 - 24"	105	29.8	100	
3	69	34.5	181	77.4	1 - 24"	54	28.4	62	YES
4	67	36.6	175	78.7	1 - 24"	45	19.0	40	
5	371	65	1106	137.6	3 - 36"	222	31.5	456	YES
6	142	64.9	229	131.9	3 - 30"	162	25.1	143	
7	72	64.9	143	130.9	3 - 30"	180	16.8	130	
8	72	64.8	130	130.3	2 - 24"	90	36.2	77	
9	265	72	559	147.8	2 - 24"	100	21.8	82	
10	48	70.8	82	142.6	1 - 24"	63	51.6	55	
11	223	70.1	567	133.8	1 - 24"	47	28.9	57	YES
12	1331	258.3	4221	682.7	8 - 42"	1175	55.4	4220	YES
13	1002	266.3	1108	473.8	7 - 42"	1070	34.2	1046	
14	969	317	1168	549.2	6 - 36"	594	93.6	1069	YES
15	1281	427.5	1744	698.3	1 - 60"	124	1128.4	107	


* In some instances, the developed flow into the dam is greater than the dam's 100yr volume, but because some of the flow is leaving the dam through the principal spillway, there is not necessarily flow over the emergency spillway. AHYMO was used to model each dam and determine whether the flow overtops the dam.

The results showed that, without additional drainage improvements, under developed conditions, the existing facilities will receive more runoff than they were designed to accommodate. Because of this, dams 1, 3, 5, 11, 12, and 14 will overtop and potentially cause downstream flooding. Ladera Dams 1, 3, 5, 11, 12, and 14 will spill. Determining the actual depth and extent of the resulting flooding requires a water surface profile analysis, which is beyond the scope of this project.

b) Mirehaven Arroyo

Tributaries to the Mirehaven Arroyo originate southeast of the Double Eagle II Airport, traverses the southern part of the Petroglyph National Monument, and outfalls to Dam 12 of the Ladera System. This arroyo has three principal branches that were given informal names Mirehaven A, B,

and C at the start of the sediment reconnaissance study, in October 1985 (see Figure 6 and Table 5).



The Mirehaven A Arroyo begins just upstream, at Paseo del Volcan. It enters the Petroglyph National Monument and runs east to the escarpment, where it cascades down the face of the escarpment. Mirehaven B and C parallel Mirehaven A, which lies to the north. Mirehaven B and C pass through the Atrisco Terrace and converge upstream of the Ladera Training Dike, continuing as Mirehaven BC. The Ladera Training Dike is a riprap armored levee located at the foot of Mesa Prieta, which maintains the historical course of the Mirehaven B.

Mirehaven BC (combination of Mirehaven B and C Arroyos) turns sharply north after the Training Dike and parallels the escarpment, travelling another 2,500 feet before it converges with the Mirehaven A.

The Mirehaven Main Arroyo shows significant lateral migration below the escarpment. A prudent line study completed in 1994 resulted in the construction of 1,300 feet of soil cement scour wall on the east bank of the arroyo to provide erosion protection for the Las Lomitas Subdivision. The Training Dike and the scour wall are the only improvements made on the Mirehaven Main Arroyo. As part of the Crossings Subdivision project, Westland Development Corporation financially guaranteed improvements to the Mirehaven Arroyo from Dam 12 to the planned intersection with future 98th Street.

TABLE 5
Key 100yr Flows – Ladera Watershed

Analysis PT	Description of Analysis Point	Existing Flow into (cfs)	Developed Flow into (cfs)
AP3	Mirehaven Arroyo at Paseo Del Volcan	658	2061
AP4	Mirehaven "B" at Training Dike	445	1323
AP5	Mirehaven A + B + C	1287	4048
AP6	Mirehaven at Dam 12	1331	4221

c) Ladera and Rinconada Arroyos; Quickwater Channel

The Ladera and Rinconada Arroyos convey flows from the eastern slopes of the volcanoes eastward to Ladera Dam 14 and Dam 15, respectively. These arroyos originate in the Petroglyph National Monument, traverse the escarpment, and remain in undeveloped condition until they enter the developed regions below the escarpment (see Figure 6). The Ladera Arroyo is concrete-lined from downstream of the Petroglyph National Monument to Unser Boulevard. From Unser Boulevard to its outfall to Ladera Dam 14, the arroyo is an improved earth-lined channel stabilized with gabion drop structures. See Figure 6 and Table 6.

The Quickwater Channel is a 1,200-foot riprap and grass-lined channel with concrete drop structures that collects flows from the residential areas west of Dam 15 and discharge into the west side of Dam 15. See Figure 6 and Table 6.

TABLE 6
Key 100yr Flows – Ladera, Quickwater and Rinconada Channels

Analysis PT	Description of Analysis Point	Existing Flow into (cfs)	Developed Flow into (cfs)
AP7	Ladera Channel into Dam 14	968	1160
AP8	Quickwater Channel into Dam 15	805	978
AP9	Rinconada Channel into Dam 15	611	907

d) Dam 1, Dam 5, and Dam 9 Arroyos

Three arroyos take their names from the Ladera Dams to which they connect. Dam 1 and Dam 5 Arroyos are called Mirehaven Arroyo "C" and Mirehaven Arroyo "B" respectively, on the Bernalillo County FEMA Floodway Maps, but were renamed for the I-40 DMP. Dam 9 Arroyo is likely a man-made ditch that was probably dug to intercept runoff, for stock watering purposes, from the newly named Mirehaven BC Arroyo, where it rounds the bend at Mesa Prieta, below the location of the Ladera Training Dike (see Figure 6 and Table 7).

TABLE 7
Key 100yr Flows – Dams 1, 5 and 9

Analysis PT	Description of Analysis Point	Existing Flow into (cfs)	Developed Flow into (cfs)
AP10	Ladera Channel into Dam 1	499	1071
AP11	Ladera Channel into Dam 5	371	1071
AP12	Ladera Channel into Dam 9	265	542

4. West Bluff Watershed Drainage Facilities

a) Drainage from North to South of I-40

The region between I-40 and the Ladera system is considered to be in the West Bluff watershed even though existing flows from this region either discharge south under I-40 through numerous culverts, or are held

in temporary retention ponds located along the north side of I-40. This runoff goes southeast to the Amole del Norte Diversion channel, which discharges to the Hubbell Lake detention area. (see Figure 6)

Under developed conditions, the flows from the region between I-40 and the Ladera system will be intercepted by the proposed West I-40 Diversion. The West I-40 Diversion will discharge flows through the West Bluff Outfall, thereby reducing flow going to the Amole-Hubbell Watershed. North of I-40 under 98th Street and Unser Boulevard are existing culverts which convey runoff from west to east. The structure under 98th Street is a pair of 10' x 8' concrete box culverts (CBC's) and the structure under Unser consists of four 6' x 4' CBC's. These CBC's will be incorporated into the proposed West I-40 Diversion to convey flows to the West Bluff Outfall. (see Figure 6 and Table 8)

TABLE 8
Key 100yr Flows – CBCs at 98th Street and at Unser Boulevard

Analysis PT	Description of Analysis Point	CBC Capacity (cfs)	Existing Flow into (cfs)	Developed Flow into (cfs)
AP13	2 – 10' x 8' CBCs at 98 th Street	2000	137	2122
AP14	4 – 6' x 4' CBCs at Unser Boulevard	800	241	2920

b) West Mesa Diversion

The West Mesa Diversion, a portion of which was recently constructed by the City, discharges to the West Bluff Outfall through the existing pair of 10' x 12' CBC's, buried under I-40 just west of Estancia Drive. The West Mesa Diversion ties into the West Bluff Outfall at this point (see Figure 6 and Table 9). Hydraulic constraints limit the West Mesa Diversion to a maximum flow of approximately 800 cfs. In a 1988 report by BHI, the West Mesa Diversion was found to be the critical upstream system for the West Bluff Outfall/I-40 Channel/Coors Storm

Drain drainage network. Discharge from the West Mesa Diversion is also limited to 800 cfs by a 1996 agreement between the City and AMAFCA.

TABLE 9
Key 100yr Flows – West Mesa Diversion

Analysis PT	Description of Analysis Point	Existing Flow into (cfs)	Developed Flow into (cfs)
AP15	West Mesa Diversion Upstream of I-40	N/A	790

c) West Bluff Outfall

The West Bluff Outfall currently begins as an open channel inlet leading to a 14' x 14' CBC just west of Estancia Drive. The 14' x 14' CBC then ties to two of the 4 CBC's running east under Coors Boulevard. East of Coors Boulevard, the box increases in slope and transitions from a 14' x 14' CBC to a 12' x 12' CBC. At the downstream end, near the Rio Grande, the CBC dimensions are 10' x 10'. The design flow rate is 2,585 cfs. (see Figure 6 and Table 10).

TABLE 10
Key 100yr Flows – CBC at West Bluff Outfall

Analysis PT	Description of Analysis Point	Existing Flow into (cfs)	Developed Flow into (cfs)	Design Capacity (cfs)
AP16	West Bluff Outfall	723	5068	2585

III. FACILITIES PLANNING

A. GENERAL

Fifteen options, and numerous suboptions, to eliminate flooding and provide an overall drainage management plan for the 40 square mile project area have been studied. Initially, two primary options with multiple suboptions were developed (Option 1 which allows fully

developed flow from above Petroglyph National Monument, and Option 2 which diverts flow around the Monument) and presented to the AMAFCA Board between August 1996 and March 1997. At the Board's direction, additional options were developed. The additional options include:

- Option 3 - a hybrid of options 1 and 2 (this option has 2 additional sub options)
- Option 4 - unrestrained flow
- Option 5 - diverts all developed runoff from the Ladera Watershed to the Ladera Golf Course
- Option 6 - phased growth to the base of the Atrisco Terrace.
- Take no action option

The options were evaluated considering: construction costs, concerns over extensive construction activity within the Monument, the requirement to meet National Environment Preservation Act (NEPA) guidelines, constructibility issues, traffic control concerns, and or social costs.

Based on these considerations, the Tech Team narrowed the list of viable options to two. However, the Tech Team was unable to decide between the two options, which differ philosophically, particularly with respect to the management of flows impacting the Monument. Consequently, at the direction of the AMAFCA Board, a third preferred Option 6A is also included in this study. Option 6A is the recommendation Option being adopted within the West I-40 DMP.

The three preferred options, options 2D, and 3C.1, and 6A are discussed in detail in the next section. A summary, along with an explanation of why each of the remaining options were not chosen, can be found in the draft working DMP in Volume IV.

B. TRUNK FACILITIES

All of the options being considered as part of the DMP, with the exception of the "Take No Action Option," include key drainage facilities, referred to as trunk facilities. These trunk facilities are required regardless of the selected option. Many of these facilities were deemed

necessary and recommended in other approved drainage reports, including the **Amole-Westgate DMP** and the recently adopted **Amole-Hubbell DMP**. These trunk facilities vary in size slightly between options depending upon the routing and detention of runoff in the upstream watershed (above the Ladera Dams). However, regardless of the final selection of a drainage management plan option for the upstream watershed, a minimum number of trunk facilities are required to accommodate existing development between I-40 and the Ladera Dams, divert flows along I-40 to prevent downstream flooding, and allow the **Amole-Hubbell DMP** to be implemented. Table 11 summarizes these trunk facilities.

TABLE 11
Trunk Facility Sizes

DESCRIPTION	Pipe			Channel			Dam		100yr Water Surface Area	100yr Storage Volume (ac-ft)
	Dia.	Length (ft)	Flow (cfs)	Depth (ft)	Length (ft)	Flow (cfs)	Flow in (cfs)	Flow Out (cfs)		
Dam 0 Arroyo	54"	3800	460	-	-	-	-	-	-	-
Dam 1 Arroyo	48"	9300	300	4	2900	745	-	-	-	-
Dam 5 Arroyo*	48"	7400	270	5	6900	1135	-	-	-	-
Dam 5 Arroyo (Option 6A)	-	-	-	5	6900	1135	-	-	-	-
West Amole Dam*	-	-	-	-	-	-	3880	250	-	600
West Amole Dam (Option 6A)	-	-	-	-	-	-	840	255	-	136
Amole Diversion – West Amole Dam to Paseo del Volcan	66"	3000	250	5	3900	665	-	-	-	-
Amole Diversion – Paseo del Volcan to East Amole Dam	-	-	-	7	1500	1715	-	-	-	-
East Amole Dam*	-	-	-	-	-	-	2650	300	-	270
East Amole Dam (Option 6A)	-	-	-	-	-	-	725	320	-	60
I-40 Diversion: East Amole to 98 th Street	54"–90"	8500	300–810	5–7	3800	805–1805	-	-	-	-
I-40 Pond at 98 th Street	-	-	-	-	-	-	2120	765	8	49
I-40 Diversion Channel – 98 th Street to Unser Boulevard	-	-	-	5	5500	1090	-	-	-	-
I-40 Pond at Unser Boulevard	-	-	-	-	-	-	1565	1170	6	44.4
I-40 Diversion Channel – Unser Boulevard to West Mesa Diversion	-	-	-	6	6850	1360	-	-	-	-
West Mesa Diversion Pond	-	-	-	-	-	-	530	420	1	6.5
West Mesa Diversion Channel	90"	2000	255	-	-	-	-	-	-	-
West Mesa Diversion Channel Concrete Box Culvert	10' cbc	5800	790	-	-	-	-	-	-	-

*Option 2D or 3C.1

For routing purposes, either concrete pipes or ten-foot wide channels were assumed for developed conditions. This does not, however, imply that the DMP is requiring all runoff to be conveyed in this manner. Rather, by assuming such conveyances, detention facilities can be designed for the largest peak flows and volumes. Channel treatments such as soil cement and other more naturalistic linings will be considered with the design of the facilities.

Trunk Facilities Cost Summary:

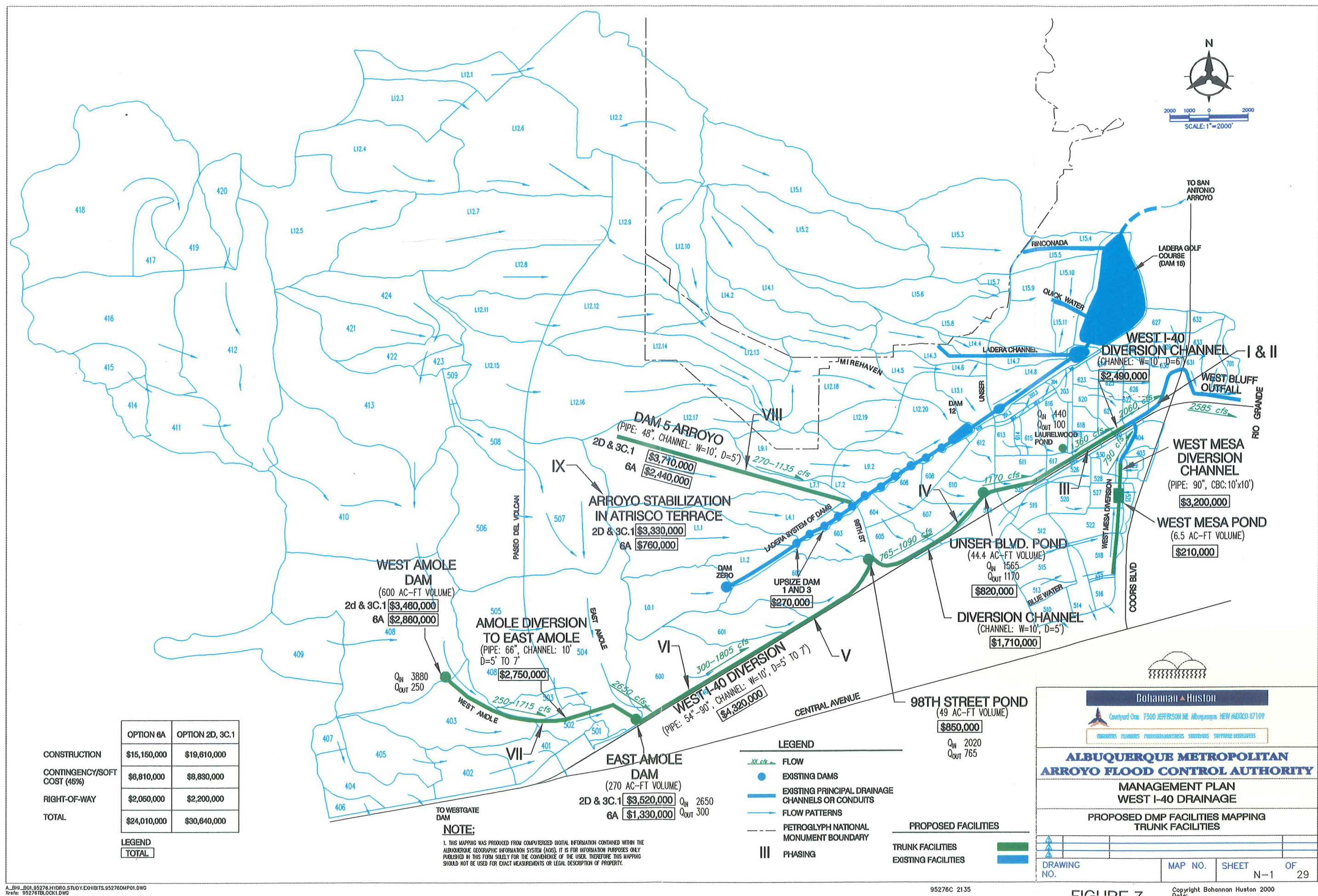
	Option 2d or 3c.1	Option 6A
Total Construction Cost:	\$ 19,610,000	\$ 15,150,000
Contingency/Soft Cost	\$ 8,830,000	\$ 6,810,000
Construction Subtotal	\$ 28,440,000	\$ 21,960,000
Total Right-of-Way Cost:	\$ 2,200,000	\$ 2,050,000
Total:	\$ 30,640,000	\$ 24,010,000

In addition to the new facilities shown in Table 11, the storage volumes at Ladera Dam 1 and 3 need to be increased. Presently, Dam 1 has a 100-year storage volume of 30 ac-ft. This needs to be increased from 11 ac-ft to 41 ac-ft. Similarly, for Dam 3, an increase of 15.7 ac-ft from 29.7 ac-ft to 45.4 ac-ft is required.

Figure 7 illustrates the trunk facilities along with the estimated costs. Table 12 accompanies Figure 7 suggesting possible timing of construction and estimated project costs for the various phases.

TABLE 12
Construction Phases and Costs Associated with Trunk Facilities

Project Description	Phase	Timing of Construction	Opt. 2D & 3C.1 Total Cost	Opt. 6A Total Cost
West I-40 Diversion From West Bluff Outfall to West Mesa Diversion Channel	I and II	Existing	N/A	N/A
West I-40 Diversion From West Mesa Diversion Channel to (and including) Unser Blvd Pond	III	By 2002	\$3,310,000	\$3,310,000
West I-40 Diversion From Unser Blvd Pond to (and including) 98th Street Pond	IV	By 2005	\$2,560,000	\$2,560,000
West I-40 Diversion From 98th Street Pond to Atrisco Terrace	V	By 2005	\$2,450,000	\$2,450,000
West I-40 Diversion From Atrisco Terrace to (and including) East Amole Dam	VI	2005 – 2010	\$5,390,000	\$3,200,000
West I-40 Diversion From East Amole Dam to (and including) West Amole Dam	VII	2005 - 2010	\$6,210,000	\$5,610,000
Dam 5 Arroyo	VIII	After 2010	\$3,710,000	\$2,440,000
Arroyo Stabilization in Atrisco Terrace and Upsizing Dams 1 and 3 of Ladera System	IX	After 2010	\$3,330,000	\$760,000
West Mesa Diversion Channel Including West Mesa Pond	CITY	By 2003	\$3,410,000	\$3,410,000



C. PREFERRED OPTIONS

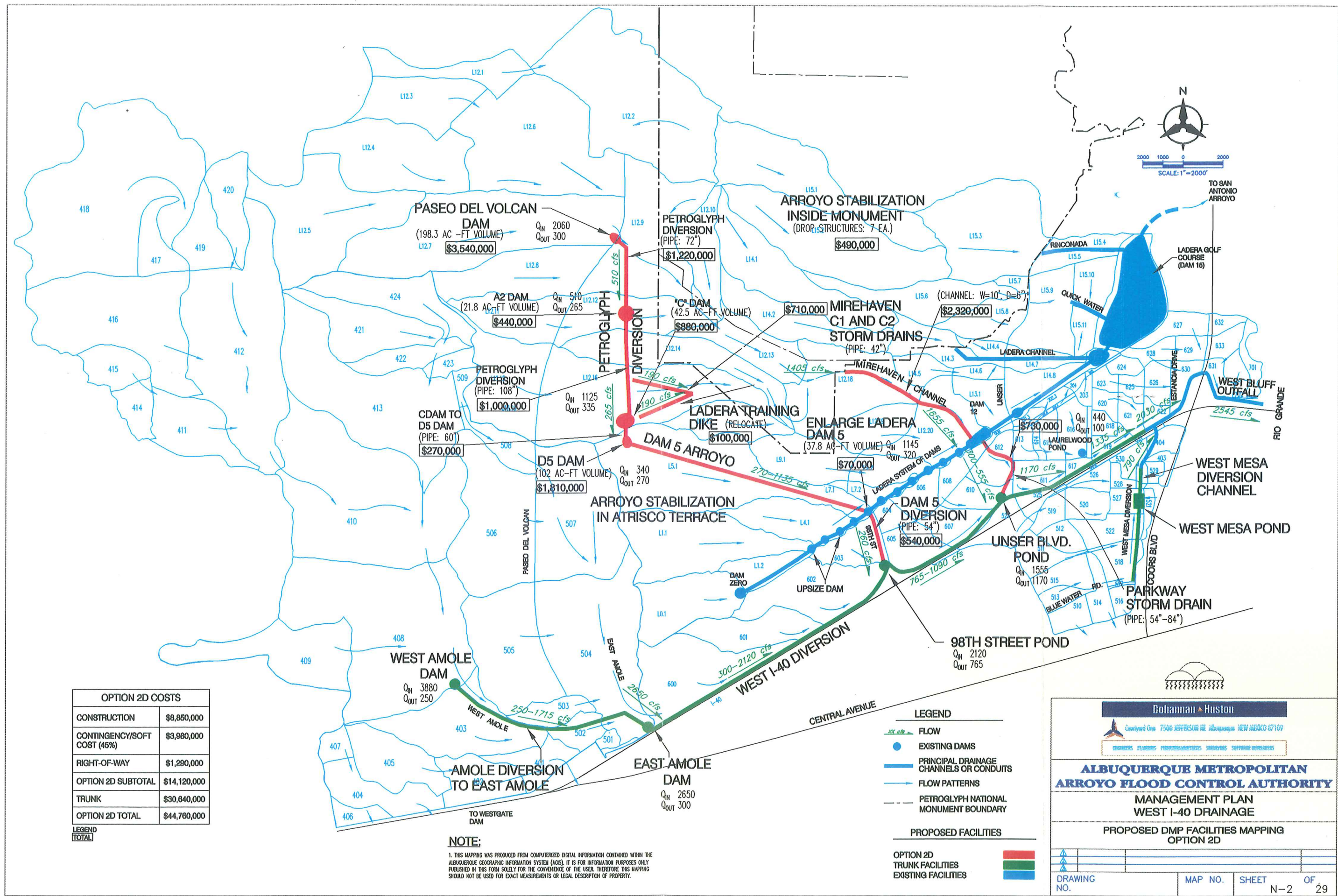
As noted previously, based on extensive review of the options, the Tech Team reduced the fifteen options to two preferred options, Options 2D and 3C.1. However, agreement on one option and hence, a decision on how the Monument is treated was not reached. Consequently, a third preferred option that allows more time to determine a drainage management plan for the upper watershed and the Monument is included and is the recommended option of this DMP. This option, referred to as Option 6A, along with Options 2D and 3c.1 is described more fully in the following sections.

1. Option 2D

The National Park Service, one of the major landowners in the area, prefers Option 2 in general and Option 2D in particular (see Figure 8). The key elements of this option, not including the trunk facilities, can be seen in the table below.

TABLE 13
Option 2D Key Elements

DESCRIPTION	Pipe			Channel			Dam		100yr Storage Volume (ac-ft)	Total Cost
	Dia.	Length (ft)	Flow (cfs)	Depth (ft)	Length (ft)	Flow (cfs)	Flow in (cfs)	Flow Out (cfs)		
Petroglyph National Monument Arroyo Stabilization (Drop Structures)	-	-	-	-	-	-	-	-	-	\$490,000
Paseo del Volcan Dam	-	-	-	-	-	-	2060	300	198	\$3,540,000
Petroglyph Diversion – Paseo del Volcan to A2 Dam	72"	4000	510	-	-	-	-	-	-	\$1,220,000
Mirehaven A2 Dam	-	-	-	-	-	-	510	265	22	\$440,000
Petroglyph Diversion – A2 Dam to C Dam	72"	3250	265	-	-	-	-	-	-	\$1,000,000
C Dam	-	-	-	-	-	-	925	335	42.5	\$880,000
Petroglyph Diversion C Dam to D5 Dam	60"	1000	335	-	-	-	-	-	-	\$270,000
D5 Dam	-	-	-	-	-	-	340	270	102	\$1,810,000
C1 and C2 Storm Drains	42"	4800	380	-	-	-	-	-	-	\$710,000
Enlarge Ladera Dam 5	-	-	-	-	-	-	-	-	37.8 (was 31.5)	\$70,000
Dam 5 Diversion from Ladera Dam 5 to I-40 Diversion	54"	2200	255	-	-	-	-	-	-	\$540,000
Mirehaven Channel – Petroglyph National Monument to Ladera Dam 12	-	-	-	6	6500	1655	-	-	-	\$2,310,000
Parkway Storm Drain (Dam 12 Diversion); Dam 12 to I-40 Diversion	54" – 84"	2250	300-555	-	-	-	-	-	-	\$730,000
Relocate Ladera Training Dike	-	-	-	-	-	635	-	-	-	\$100,000



Option 2D is one of the preferred options because it diverts flows around the Monument, thus protecting the Monument. It accomplishes this diversion with a series of buried storm drain rather than open channels, reducing the potential future constraints on development while also creating several opportunities for neighborhood parks and multi use facilities. Flow from the proposed Paseo Del Volcan Dam will be conveyed in a pipe through two Dams, the A2 Dam and the C Dam, to the D5 Dam. From this point, flow will be conveyed to Ladera Dam 5 via the Dam 5 Arroyo. These dams present opportunities to create ball fields and parks. Flows that enter the Petroglyph National Monument will be maintained at historic levels and follow their natural paths along Mirehaven A, B, and C Arroyos, in existing drainage easements, until the south east boundary of the Monument where an improved channel will convey the flow to Dam 12 of the Ladera system (see Figure 8).

a) Option 2D – Divert Mirehaven Arroyos In Pipe to New D5 Dam and Build Dam 5 Diversion (Figure 8)

The key elements for this option are:

- Option 2D is essentially the same as Option 2B except the Petroglyph Diversion is an entirely underground facility. This is accomplished the inclusion of two additional detention dams.
- At Mirehaven A2 Arroyo a 22 ac-ft detention dam, known as the A2 dam, will be constructed at the top of the escarpment.
- A 43 ac-ft dam referred to as the C Dam will be constructed along the Mirehaven C2 Arroyo at the top of the escarpment.
- Storm drains will convey runoff below the Petroglyph Diversion and the C Dam to the Monument at historic levels where they will discharge across the Monument in the existing Mirehaven C Arroyo.
- A diversion from Ladera Dam 12 to the I-40 Diversion is not required.

Option 2D Cost Summary:

Total Construction Cost:	\$ 8,850,000
Contingency/Soft Cost:	\$ 3,980,000
Construction Subtotal:	\$ 12,830,000
Total Right-of-Way Cost:	\$ 1,290,000
Option 2D Subtotal:	\$ 14,120,000
Trunk:	\$ 30,640,000
Total:	\$ 44,760,000

2. Option 3C.1

Westland Development Corporation, the second major landowner in the area, prefers Option 3 in general, and Option 3C.1 specifically (see Figure 9). The key elements of this option, not including trunk facilities, can be seen in the table below.

TABLE 14
Option 3C.1 Key Elements

DESCRIPTION	Pipe			Channel			Dam		100yr Storage Volume (ac-ft)	Total Cost
	Dia.	Length (ft)	Flow (cfs)	Depth (ft)	Length (ft)	Flow (cfs)	Flow in (cfs)	Flow Out (cfs)		
Paseo del Volcan Dam							2060	300	198	\$3,540,000
Paseo del Volcan Dam Outfall – PDV Dam to A2 Dam	72"	4000	510	-	-	-	-	-	-	\$1,220,000
Mirehaven A2 Dam	-	-	-	-	-	-	510	265	21.8	\$440,000
A2 Dam Outfall – A2 Dam to Training Dike	60"	8000	450	-	-	-	-	-	-	\$1,910,000
Mirehaven C1 and C2 Storm Drain	72"	5200	645	-	-	-	-	-	-	\$1,540,000
Mirehaven C Dam	-	-	-	-	-	-	1290	260	54	\$1,030,000
Mirehaven Pipe from C Dam to Confluence	48"	3600	260	-	-	-	-	-	-	\$590,000
Mirehaven Pipe from Confluence to National Monument Boundary	84"	4500	1325	-	-	-	-	-	-	\$1,810,000
Mirehaven Channel – Petroglyph National Monument to 98 th Street	-	-	-	6	3250	1495	-	-	-	\$1,190,000
Mirehaven Channel – 98 th Street to Dam 12	-	-	-	6	3250	1650	-	-	-	\$1,130,000
Parkway Storm Drain (Dam 12 Diversion); Dam 12 to I-40 Diversion	54" – 84"	2250	300- 615	-	-	-	-	-	-	\$710,000
Enlarge Ladera Dam 5	-	-	-	-	-	-	-	-	35.8 (was 31.5)	\$60,000
Enlarge Ladera Dam 11	-	-	-	-	-	-	-	-	45.5 (was 29)	\$210,000

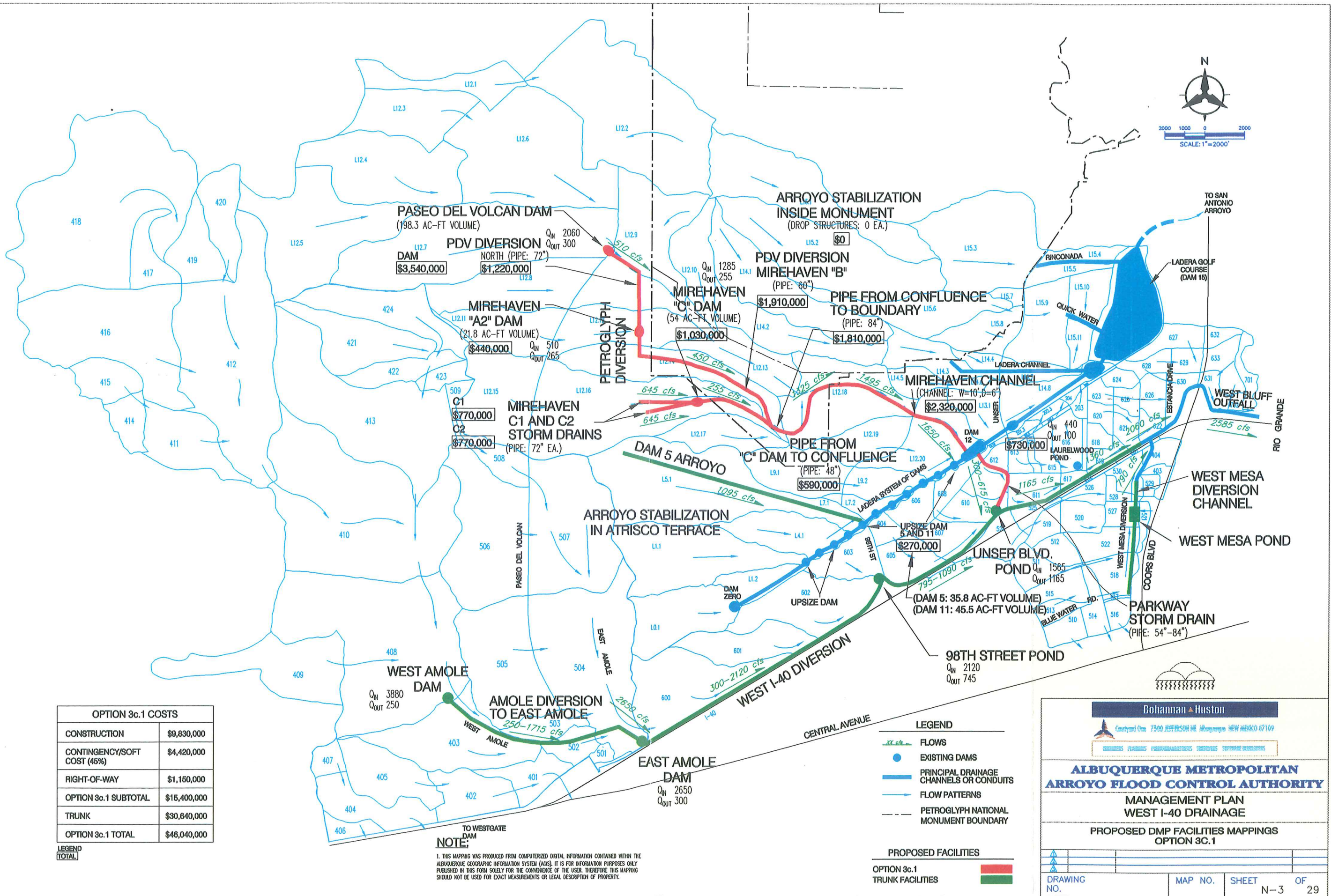


FIGURE 9

Bohannon & Huston
Consulting Engineers, Inc.
7500 JEFFERSON AVE. ALBUQUERQUE, NEW MEXICO 87116

**ALBUQUERQUE METROPOLITAN
ARROYO FLOOD CONTROL AUTHORITY**

**MANAGEMENT PLAN
WEST I-40 DRAINAGE**

**PROPOSED DMP FACILITIES MAPPINGS
OPTION 3C.1**

DRAWING NO.	MAP NO.	SHEET	OF
		N-3	29

Option 3C.1 is one of the preferred options because it has less of a negative impact on the Monument compared to Option 1 but also places fewer constraints on Westland's property upstream of the Monument. Option 3C.1 proposes to convey flows through the Monument using a series of buried storm drain that follow the natural path of the existing arroyos. Flow from the proposed Paseo del Volcan Dam is diverted to Mirehaven A2 Dam in a pipe and then diverted to Mirehaven Arroyo B. Mirehaven C flows are regulated by Mirehaven C Dam before entering the Monument. Flows are conveyed through the Monument along both Mirehaven B and Mirehaven C Arroyos in buried storm drains in existing drainage easements. These Mirehaven flows exit the Petroglyph Monument Boundary at the southeast boundary and are then conveyed in an improved channel to Ladera Dam 12.


a) Option 3C.1– Divert Mirehaven Arroyos “A” to “B” with Detention at “C” and Through Monument (Figure 9)

- Flows are diverted from Mirehaven A to B upstream of the Monument.
- Runoff is conveyed through the Monument along both the Mirehaven B and C Arroyo alignments via storm drains.
- The need to relocate the Ladera Training Dike is eliminated since the flow is conveyed in a storm drain rather than in the existing, unlined arroyos.
- Developed flows cross the Monument in a pipe rather than the existing, unlined arroyo. Consequently, only minimal arroyo stabilization within the Monument is anticipated with this option.

Option 3C.1 Cost Summary:

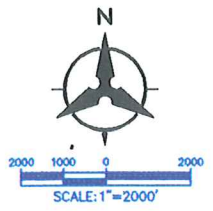
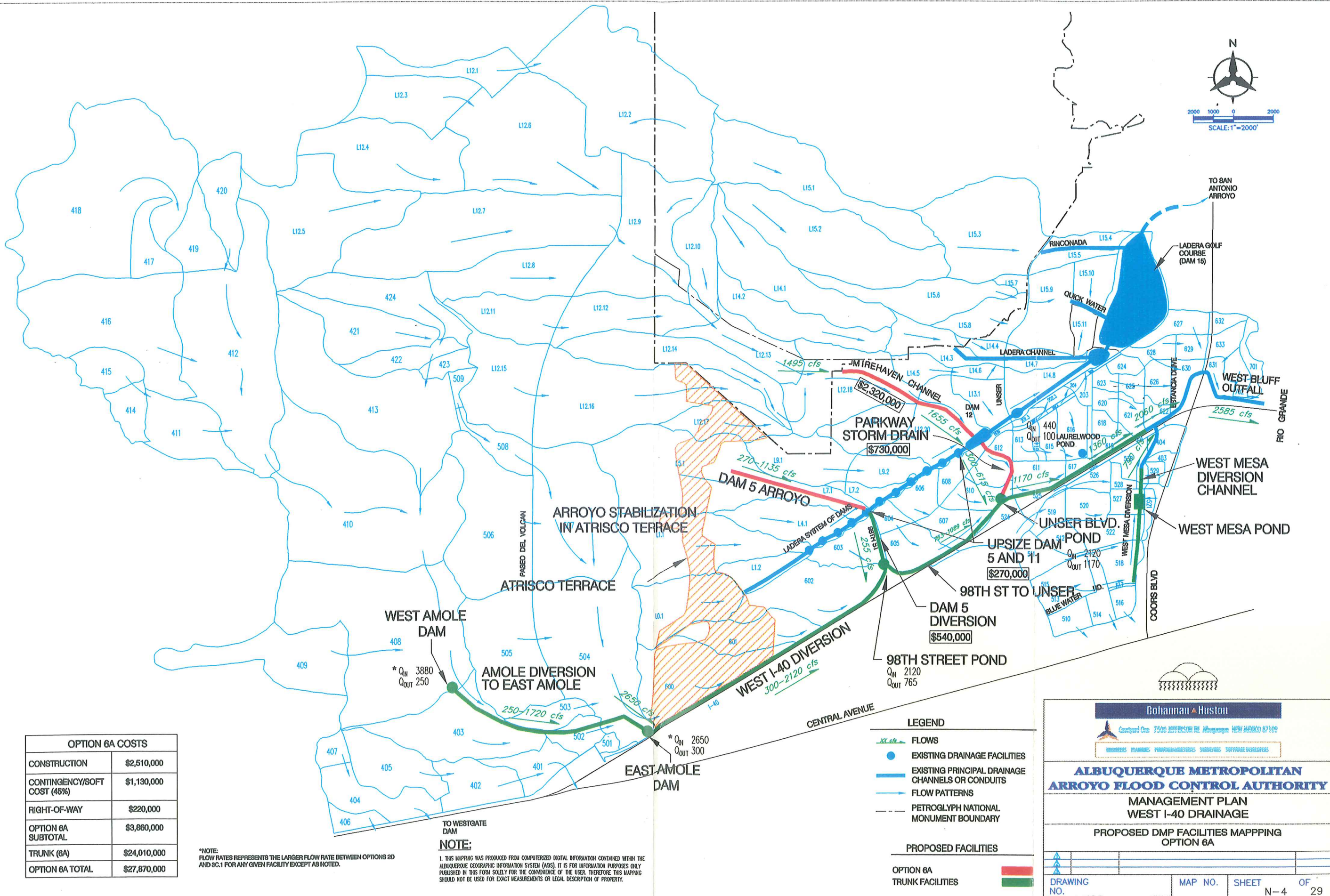
Total Construction Cost:	\$ 9,830,000
Contingency/Soft Cost:	\$ 4,420,000
Construction Subtotal:	\$ 14,250,000
Total Right-of-Way Cost:	\$ 1,150,000
Option 3C.1 Subtotal:	\$ 15,400,000
Trunk:	\$ 30,640,000
Total:	\$ 46,040,000

3. Option 6A



Option 6A (see Figure 10) is the recommended option for a number of reasons. Under this option, the immediate needs in the lower watershed and the requirements of the adopted Amole Westgate and Amole Hubbell DMP's are met. Option 6A also establishes sizes for drainage facilities in the lower portion of the watershed (below the Atrisco Terrace and along the Amole Watershed at I-40) without precluding future selection on either option 2D or 3C.1. This is accomplished by sizing the drainage facilities for the worst case (highest) flow rate and volume from either option 2D or 3C.1 with the exception of the two Amole Dams which are sized for existing conditions.

Under option 6A, the Amole dams will be designed to allow expansion of the dams pools to accommodate developed conditions runoff and volumes, should development occur on the top of the escarpment. The costs included in Option 6A size the dam pools for existing conditions. The dams principal spillway will be the same for both existing and developed conditions, while the dam should be designed with provisions to expand the dam's emergency spillway to handle the Probable Maximum Flood (PMF) under fully developed conditions. It should be noted that, with the multiple detention facilities in the upper portion of the watershed in both option 2D and 3C.1 that the developed flow rates for each option in the lower portion of the watershed are nearly identical. Further, due to upstream detention proposed with both Options 2D and 3C.1, the flow rates to size conveyances for arroyos, such as the Mirehaven, between the Monument/Atrisco Terrace, and the Ladera Dams are only slightly larger than existing conditions flow rates, plus sediment. This increase is due to the increase in runoff from development of the area between the Monument/Atrisco Terrace and the Ladera Dams. Finally, Option 6A allows more time for the two major landowners, Westland Development and the National Park Service, to reach an agreement concerning drainage and the Monument.



OPTION 6A COSTS	
CONSTRUCTION	\$2,510,000
CONTINGENCY/SOFT COST (46%)	\$1,130,000
RIGHT-OF-WAY	\$220,000
OPTION 6A SUBTOTAL	\$3,860,000
TRUNK (6A)	\$24,010,000
OPTION 6A TOTAL	\$27,870,000

*NOTE:
FLOW RATES REPRESENTS THE LARGER FLOW RATE BETWEEN OPTIONS 2D
AND 3C.1 FOR ANY GIVEN FACILITY EXCEPT AS NOTED.

NOTE:
1. THIS MAP WAS PRODUCED FROM COMPUTERIZED DIGITAL INFORMATION CONTAINED WITHIN THE
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LEGEND

xx cfs FLOWS
● EXISTING DRAINAGE FACILITIES
— EXISTING PRINCIPAL DRAINAGE CHANNELS OR CONDUITS
— FLOW PATTERNS
--- PETROGLYPH NATIONAL MONUMENT BOUNDARY

PROPOSED FACILITIES

OPTION 6A TRUNK FACILITIES

Bohannon & Huston
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ENGINEERS PLANNERS PROGRAM MANAGERS DESIGNERS SOFTWARE DEVELOPERS

**ALBUQUERQUE METROPOLITAN
ARROYO FLOOD CONTROL AUTHORITY**

**MANAGEMENT PLAN
WEST I-40 DRAINAGE**

**PROPOSED DMP FACILITIES MAPPPING
OPTION 6A**

DRAWING NO.	MAP NO.	SHEET N-4	OF 29
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The key elements of Option 6A, not including trunk facilities) are as shown in the table below:

TABLE 15
Option 6A Key Elements

DESCRIPTION	Pipe			Channel			Dam		100yr Storage Volume (ac-ft)	Total Cost
	Dia.	Length (ft)	Flow (cfs)	Depth (ft)	Length (ft)	Flow (cfs)	Flow in (cfs)	Flow Out (cfs)		
Dam 5 Diversion from Ladera Dam 5 to I-40 Diversion	54"	2200	260	-	-	-	-	-	-	\$540,000
Mirehaven Channel - Petroglyph National Monument to Ladera Dam 12	-	-	-	6	6500	1655	-	-	-	\$2,320,000
Parkway Storm Drain	54"- 84"	2600	300- 615	-	-	-	-	-	-	\$730,000

a) Option 6A—Growth to the Atrisco Terrace with Consideration of Full Watershed Development (Figure10)

- Drainage facilities, including Trunk Facilities but not the two Amole Dams, are sized for the highest flow rate from either option 2D or 3C.1.
- The West and East Amole dam flood pools are sized for existing conditions flow rates and volumes.
- The length of the Dam 5 and Dam 1 conveyances are substantially reduced and extend only to the base of the Atrisco Terrace and the Dam 0 Arroyo improvements are not required.
- The Dam 5 Diversion is included so as to not preclude the future selection of Option 2D.
- Enlarge Ladera Dams 5 and 11.

Option 6A Cost Summary:

Total Construction Cost:	\$ 2,510,000
Contingency/Soft Cost:	\$ 1,130,000
Construction Subtotal:	\$ 3,640,000
Total Right-of-Way Cost:	\$ 220,000
Option 6A Subtotal	\$ 3,860,000
Trunk	\$ 24,010,000
Total: (w/trunk) \$	27,870,000

IV. CONCLUSION

The three preferred options represent the best options for drainage management within the West I-40 study area. These options are the result of years of analysis and refinement based on input from both the AMAFCA Board and the Tech Team.

Based on the inability of the two major landowners to reach an agreement concerning either Option 2D or 3C.1, Option 6A is the recommended option. This option addresses immediate and short-term drainage needs in the study area, while allowing the two majority landowners more time to reach an agreement with regard to management of drainage relating to the Monument.

APPENDIX A

COST ESTIMATES

ALL OPTIONS: TRUNK FACILITIES

DAM 0 ARROYO: Pipe		CONSTRUCTION COST:	\$650,000
		RIGHT-OF-WAY COST:	\$20,000
Pipe Diameter =		54 in	
Slope =		0.055	
Length =		3800 ft	
Flow =		460 cfs	
Total Right-of-Way Acquisition =		4.36 ac	
DAM 1 ARROYO: Pipe and Channel (Options 2D and 3C.1)		CONSTRUCTION COST:	\$1,550,000
		RIGHT-OF-WAY COST:	\$110,000
Pipe:		48 in	
Slope =		0.054	
Length =		9300 ft	
Flow =		300 cfs	
Channel:		10 ft	
Bottom Width =		0.036	
Slope =		4 ft	
Depth =		2:1	
Side Slope =		2900 ft	
Length =		745 cfs	
Flow =		3.99 ac	
Total Right-of-Way Acquisition =			
DAM 1 ARROYO: Channel (Option 6A)		CONSTRUCTION COST:	\$500,000
		RIGHT-OF-WAY COST:	\$40,000
Channel:		10 ft	
Bottom Width =		0.036	
Slope =		4 ft	
Depth =		2:1	
Side Slope =		2900 ft	
Length =		745 cfs	
Flow =		3.99 ac	
Total Right-of-Way Acquisition =			

DAM 5 ARROYO: Pipe and Channel (Options 2D and 3C.1)

Pipe:	Pipe Diameter = 48 in	CONSTRUCTION COST: \$2,450,000
	Slope = 0.045	RIGHT-OF-WAY COST: \$160,000
	Length = 7400 ft	
	Flow = 270 cfs	
Channel:	Bottom Width = 10 ft	
	Slope = 0.035	
	Depth = 5 ft	
	Side Slope = 2:1 (H:V)	
	Length = 6900 ft	
	Flow = 1135 cfs	
	Total Right-of-Way Acquisition = 11.09 ac	

DAM 5 ARROYO: Channel (Option 6A)

Channel:	Bottom Width = 10 ft	CONSTRUCTION COST: \$1,600,000
	Slope = 0.035	RIGHT-OF-WAY COST: \$110,000
	Depth = 5 ft	
	Side Slope = 2:1 (H:V)	
	Length = 6900 ft	
	Flow = 1135 cfs	
	Total Right-of-Way Acquisition = 11.09 ac	

ENLARGE LADERA DAMS 1 AND 3:

		CONSTRUCTION COST: \$150,000
		RIGHT-OF-WAY COST: \$50,000
	Dam 1 100 yr. volume =	41 ac-ft (was 30)
	Dam 3 100 yr. volume =	45.4 ac-ft (was 29.7)
	Total Right-of-Way Acquisition =	5.2 ac

WEST AMOLE DAM: (Options 2D and 3C.1)		CONSTRUCTION COST:	\$1,920,000
		RIGHT-OF-WAY COST:	\$680,000

Pond Invert =	5752 ft
Qin =	3880 cfs
Qout =	250 cfs
Principal Spillway =	48" pipe
Emergency Spillway elevation/100 yr. Water Depth =	5769 ft
100 yr. volume =	600 ac-ft
Total Right-of-Way Acquisition =	135 ac

WEST AMOLE DAM: (Option 6A)		CONSTRUCTION COST:	\$1,510,000
		RIGHT-OF-WAY COST:	\$680,000

Pond Invert =	5752 ft
Qin =	3880 cfs
Qout =	250 cfs
Principal Spillway =	48" pipe
Emergency Spillway elevation/100 yr. Water Depth =	5769 ft
100 yr. volume =	136 ac-ft
Total Right-of-Way Acquisition =	135 ac

AMOLE DIVERSION CHANNEL: West Amole Dam to Paseo Del Volcan		CONSTRUCTION COST:	\$1,430,000
		RIGHT-OF-WAY COST:	\$80,000

Pipe:	Pipe Diameter =	66 in
	Slope =	0.006
	Length =	3000 ft
	Flow =	250 cfs
Total Right-of-Way Acquisition =		3.44 ac
Channel:	Bottom Width =	10 ft
	Slope =	0.006
	Depth =	5 ft
	Side Slope =	2:1 (H:V)
	Total Length =	3900 ft
	Flow =	665 cfs
Total Right-of-Way Acquisition =		6.27 ac

AMOLE DIVERSION CHANNEL: Paseo Del Volcan to East Amole Dam

CONSTRUCTION COST:	\$380,000
RIGHT-OF-WAY COST:	\$40,000
Bottom Width =	10 ft
Slope =	0.006
Depth =	7 ft
Side Slope =	2:1 (H:V)
Length =	1500 ft
Flow =	1715 cfs
Total Right-of-Way Acquisition =	2.41 ac

EAST AMOLE DAM: (Options 2D and 3C.1)

CONSTRUCTION COST:	\$2,240,000
RIGHT-OF-WAY COST:	\$270,000
Pond Invert =	5672 ft
Qin =	2650 cfs
Qout =	300 cfs
Principal Spillway =	48 pipe
Emergency Spillway elevation/100 yr. Water Depth =	5695 ft
100 yr. volume =	270 ac-ft
Total Right-of-Way Acquisition =	27 ac

EAST AMOLE DAM: (Option 6A)

CONSTRUCTION COST:	\$730,000
RIGHT-OF-WAY COST:	\$270,000
Pond Invert =	5672 ft
Qin =	2650 cfs
Qout =	300 cfs
Principal Spillway =	48 pipe
Emergency Spillway elevation/100 yr. Water Depth =	5695 ft
100 yr. volume =	60 ac-ft
Total Right-of-Way Acquisition =	27 ac

I-40 DIVERSION: East Amole to 98th Street

Pipe:	Pipe Diameter = 54 to 90 in	CONSTRUCTION COST: \$2,750,000
	Slope = 0.0150 to 0.0444	RIGHT-OF-WAY COST: \$330,000
	Length = 8500 ft	
	Flow = 300 to 805 cfs	
Total Right-of-Way Acquisition =	19.51 ac	
Channel:	Bottom Width = 10 ft	
	Slope = .0129 to .0277	
	Depth = 5 to 7 ft	
	Side Slope = 2:1 (H:V)	
	Length = 3800 ft	
	Flow = 805 to 1805 cfs	
Total Right-of-Way Acquisition =	8.72 ac	

I-40 POND @ 98TH STREET:

Pond Invert = 5260 cfs	CONSTRUCTION COST: \$590,000
Qin = 2120 cfs	RIGHT-OF-WAY COST: \$0
Qout = 765 cfs	
Principal Spillway = 4 - 4' x 5' CBC's	
Emergency Spillway elevation/100 yr. Water Depth = 5267.2 ft	
100 yr. volume = 49 ac-ft	
100 yr. Water Surface Area = 8 ac	
Total Right-of-Way Acquisition (Already Owned) = 12 ac	

I-40 DIVERSION CHANNEL: 98th Street to Unser Blvd.

Bottom Width = 10 ft	CONSTRUCTION COST: \$1,090,000
Slope = 0.018	RIGHT-OF-WAY COST: \$130,000
Depth = 5 ft	
Side Slope = 2:1 (H:V)	
Length = 5500 ft	
Flow = 1090 cfs	
Total Right-of-Way Acquisition = 12.16 ac	
Already owned Right-of-Way = 7.76	

I-40 POND @ UNSER: CONSTRUCTION COST: \$560,000
RIGHT-OF-WAY COST: \$0

Pond Invert = 5165 ft
 Qin = 1565 cfs
 Qout = 1170 cfs
 Principal Spillway = 4 - 4' x 6' CBC's (existing)
 Emergency Spillway elevation/100 yr. Water Depth = 5171.8 ft
 100 yr. volume = 44.4 ac-ft
 100 yr. Water Surface Area = 6 ac
 Total Right-of-Way Acquisition = 9 ac

I-40 DIVERSION CHANNEL: Unser Blvd. to West Mesa Diversion CONSTRUCTION COST: \$1,550,000
RIGHT-OF-WAY COST: \$250,000

Bottom Width = 10 ft
 Slope = 0.0105
 Depth = 6 ft
 Side Slope = 2:1
 Length = 6850 ft
 Flow = 1360 cfs
 Total Right-of-Way Acquisition = 15.73 ac

WEST MESA DIVERSION POND: Modified for 790 cfs West Mesa Diversion CONSTRUCTION COST: \$90,000
RIGHT-OF-WAY COST: \$80,000

Pond Invert = 5085 ft
 Qin = 530 cfs
 Qout = 420 cfs
 Principal Spillway = 2-66" pipe
 Emergency Spillway elevation/100 yr. Water Depth = 5095 ft
 100 yr. volume = 6.5 ac-ft
 100 yr. Water Surface Area = 1 ac
 Total Right-of-Way Acquisition = 1.5 ac

WEST MESA DIVERSION CHANNEL:

CONSTRUCTION COST: \$2,210,000
RIGHT-OF-WAY COST: \$0

Pipe:

Pipe Diameter = 90 in
 Slope = 0.0014
 Length = 2000 ft
 Flow = 255 cfs
 Box Dimensions = 10 x 10 ft
 Slope = 0.0015
 Side Slope = 2:1 (H:V)
 Length = 5800 ft
 Flow = 790 cfs
 Total Right-of-Way (Already owned) = 7.99 ac

CBC:

OPTIONS 2D AND 3C.1	
TOTAL CONSTRUCTION COST:	\$19,610,000
CONTINGENCY/SOFT COST (45%):	\$8,830,000
CONSTRUCTION SUBTOTAL:	\$28,440,000
TOTAL RIGHT-OF-WAY COST:	\$2,200,000
TOTAL:	\$30,640,000
(Trunk Facilities)	

OPTION 6A	
TOTAL CONSTRUCTION COST:	\$15,150,000
CONTINGENCY/SOFT COST (45%):	\$6,810,000
CONSTRUCTION SUBTOTAL:	\$21,960,000
TOTAL RIGHT-OF-WAY COST:	\$2,050,000
TOTAL:	\$24,010,000
(Trunk Facilities)	

**DAM 0 ARROYO PIPE
--TRUNK FACILITIES--**

Item No.	Spec. No.	Short Description	Unit	Quantity	Unit Price Lining/ Pipe	Unit Price Exca- vation	Total Unit Price	Amount	Slope	Area	WP	Velocity (fps)	Max Flow (cfs)
		54" RCP, IV	54	LF	3800	\$123.20	\$47.52	\$170.72	\$648,736.00	0.0550	15.5	32.09	497.43
		ROW		AC	4.36			\$5,000.00	\$21,809.00				

**DAM 1 ARROYO (OPTIONS 2D and 3C.1)
--TRUNK FACILITIES--**

Item No.	Spec. No.	Short Description	Unit	Quantity	Unit Price Lining/Pipe	Unit Price Exca- vation	Total Unit Price	Amount	Slope	Area	WP	Velocity (fps)	Max Flow (cfs)
		48" RCP, IV	48 LF	9300	\$71.50	\$42.24	\$113.74	\$1,057,782.00	0.0540	12.2	10.56	29.40	360.03
		ROW	AC	6.66			\$5,000.00	\$33,287.42					
		ROW	AC	4.02			\$10,000.00	\$40,174.47					

Channel - Dam 1 Arroyo

CHANNELS(Excavation and Lining)					n = 0.013
Thickness =	7 inches				
Earthwork=	\$2.50	CY	=		
Concrete Lining =	\$254.50	CY	=	\$5.50	SF
BOTTOM					
WIDTH(ft)	DEPTH(ft)				
10	1	LF	\$90.57	\$1.11	
10	2	LF	\$115.16	\$2.59	
10	3	LF	\$139.75	\$4.44	
10	4	LF	\$164.34	\$6.67	
10	5	LF	\$188.93	\$9.26	
10	6	LF	\$213.52	\$12.22	
10	7	LF	\$238.11	\$15.56	
10	8	LF	\$262.70	\$19.26	
10	9	LF	\$287.29	\$23.33	
10	10	LF	\$311.88	\$27.78	

CHANNEL SUBTOTAL

\$495,922

ROW AC 3.99

\$10,000.00 \$39,944.90

INPUT:
Desired Flow = 745 CFS
Slope = 0.036

Flow Depth (ft)	Velocity (fps)	Required Freeboard (ft)	Required Channel Depth (ft)
1.94	27.73	2.00	3.94

Known
34.25801
Variable
34.258

TOTAL CONSTRUCTION COST \$1,553,704
TOTAL ROW COST \$113,407

**DAM 1 ARROYO (OPTION 6A)
--TRUNK FACILITIES--**

Item No.	Spec. No.	Short Description	Unit	Quantity	Unit Price Lining/ Pipe	Unit Price Excava- tion	Total Unit Price	Amount	Slope	Area	WP	Velocity (fps)	Max Flow (cfs)
Channel - Dam 1 Arroyo													
CHANNELS(Excavation and Lining)													
Thickness = 7 inches n = 0.013													
Earthwork= \$2.50 CY													
Concrete Lining = \$254.50 CY = \$5.50 SF													
BOTTOM													
		WIDTH(ft)	DEPTH(ft)										
		10	1	LF	\$90.57	\$1.11	\$91.68	\$0	0.0360	12.0	14.47	19.19	230.33
		10	2	LF	\$115.16	\$2.59	\$117.75	\$0	0.0360	28.0	18.94	28.22	790.08
		10	3	LF	\$139.75	\$4.44	\$144.20	\$0	0.0360	48.0	23.42	35.09	1684.42
		10	4	LF	\$164.34	\$6.67	\$171.01	\$495,922	0.0360	72.0	27.89	40.93	2946.67
		10	5	LF	\$188.93	\$9.26	\$198.19	\$0	0.0360	100.0	32.36	46.14	4613.70
		10	6	LF	\$213.52	\$12.22	\$225.74	\$0	0.0360	132.0	36.83	50.93	6722.45
		10	7	LF	\$238.11	\$15.56	\$253.67	\$0	0.0360	168.0	41.30	55.41	9309.11
		10	8	LF	\$262.70	\$19.26	\$281.96	\$0	0.0360	208.0	45.78	59.66	12408.93
		10	9	LF	\$287.29	\$23.33	\$310.62	\$0	0.0360	252.0	50.25	63.71	16056.18
		10	10	LF	\$311.88	\$27.78	\$339.66	\$0	0.0360	300.0	54.72	67.61	20284.22
CHANNEL SUBTOTAL								\$495,922					
ROW								\$10,000.00					
								\$39,944.90					

INPUT: Desired Flow = 745 CFS
Slope = 0.036

Flow Depth (ft)	Velocity (fps)	Required Freeboard (ft)	Required Channel Depth (ft)
1.94	27.73	2.00	3.94

Known
34.25801
Variable
34.258

TOTAL CONSTRUCTION COST \$495,922
TOTAL ROW COST \$39,945

DAM 5 ARROYO OPTIONS 2D and 3C.1
--TRUNK FACILITIES--

Item No.	Spec. No.	Short Description	Unit	Quantity	Unit Price Lining/ Pipe	Unit Price Exca- vation	Total Unit Price	Amount	Slope	Area	WP	Velocity (fps)	Max Flow (cfs)
Pipe - Dam 5 Arroyo													
		48" RCP, IV	48	LF	7400	\$71.50	\$42.24	\$113.74	\$841,676.00	0.0450	12.2	26.84	328.66
		ROW		AC	7.12		\$5,000.00	\$35,583.10					
		ROW		AC	1.38		\$10,000.00	\$13,774.10					

Dam 5 Arroyo Channel OPTION 2D and 3C.1

CHANNELS(Excavation and Lining)

Thickness = 8 inches

Earthwork= \$2.50 CY

Concrete Lining = \$263.25 CY = \$6.50 SF

n = 0.013

BOTTOM	WIDTH(ft)	DEPTH(ft)	LF	\$107.07	\$1.11	\$108.18	\$0	0.0350	12.0	14.47	18.93	227.10
10	10	1	LF	\$136.14	\$2.59	\$138.73	\$0	0.0350	28.0	18.94	27.82	779.03
10	10	2	LF	\$165.21	\$4.44	\$169.65	\$0	0.0350	48.0	23.42	34.60	1660.86
10	10	3	LF	\$194.28	\$6.67	\$200.94	\$0	0.0350	72.0	27.89	40.35	2905.45
10	10	4	LF	\$223.34	\$9.26	\$232.60	\$1,604,965	0.0350	100.0	32.36	45.49	4549.17
10	10	5	LF	\$252.41	\$12.22	\$264.64	\$0	0.0350	132.0	36.83	50.22	6628.42
10	10	6	LF	\$281.48	\$15.56	\$297.04	\$0	0.0350	168.0	41.30	54.64	9178.91
10	10	7	LF	\$310.55	\$19.26	\$329.81	\$0	0.0350	208.0	45.78	58.82	12235.37
10	10	8	LF	\$339.62	\$23.33	\$362.95	\$0	0.0350	252.0	50.25	62.82	15831.60
10	10	9	LF	\$368.69	\$27.78	\$396.47	\$0	0.0350	300.0	54.72	66.67	20000.51

CHANNEL SUBTOTAL

\$1,604,965

ROW

AC

11.09

\$10,000.00

\$110,881.54

INPUT:

Desired Flow = 1135 CFS

Slope = 0.035

Flow Depth (ft)	Velocity (fps)	Required Freeboard (ft)	Required Channel Depth (ft)
2.45	31.06	2.13	4.58

Known

52.93208

Variable

52.932

TOTAL CONSTRUCTION COST \$2,446,641

TOTAL ROW COST \$160,239

Dam 5 Arroyo Channel OPTION 6A

CHANNELS(Excavation and Lining)

Thickness = 8 inches

Earthwork= 2.5 CY

Concrete Lining = \$263.25 CY = 6.5 SF

n = 0.013

DEPTH(ft)	1	2	3	4	5	6	7	8	9	10
WIDTH(ft)	10	10	10	10	10	10	10	10	10	10
BOTTOM	LF	LF	LF	LF	LF	LF	LF	LF	LF	LF
107.07	136.14	165.21	194.28	223.34	252.41	281.48	310.55	339.62	368.69	
1.11	2.59	4.44	6.67	9.26	12.22	15.56	19.26	23.33	27.78	
108.18	138.73	169.65	200.94	232.60	264.64	297.04	329.81	362.95	396.47	
0	\$0	\$0	\$0	\$1,604,965	\$0	\$0	\$0	\$0	\$0	
0.0350	0.0350	0.0350	0.0350	0.0350	0.0350	0.0350	0.0350	0.0350	0.0350	
12.0	28.0	48.0	72.0	100.0	132.0	168.0	208.0	252.0	300.0	
14.47	18.94	23.42	27.89	32.36	36.83	41.30	45.78	50.25	54.72	
18.93	27.82	34.60	40.35	45.49	50.22	54.64	58.82	62.82	66.67	
227.10	779.03	1660.86	2905.45	4549.17	6628.42	9178.91	12235.37	15831.60	20000.51	

CHANNEL SUBTOTAL

\$1,604,965

ROW

AC

11.09

\$10,000.00

\$110,881.54

INPUT:

Desired Flow 1135 CFS

Slope = 0.035

Flow Depth (ft)	Velocity (fps)	Required Freeboard (ft)	Required Channel Depth (ft)
2.45	31.05	2.13	4.58

Known Variable

52.88544 52.885455

TOTAL CONSTRUCTION COST \$1,604,965

TOTAL ROW COST \$110,882

ENLARGE DAMS 1 & 3 --TRUNK FACILITIES--

Item No.	Spec. No.	Short Description	Unit	Quantity	Unit Price Lining/ Pipe	Unit Price Exca- vation	Total Unit Price	Amount	Slope	Area	WP	Velocity (fps)	Max Flow (cfs)
		ENLARGE DAM 1 BY 1.35 (100-yr vol: from 30 to 41.0 ac-ft)	CY	17746.66667		\$3.50	\$3.50	\$62,113.33					
		ENLARGE DAM 3 BY 1.6X (100-yr vol: from 29.7 to 45.4 ac-ft)	CY	25329.33333		\$3.50	\$3.50	\$88,652.67					
		ROW	AC	5.2			\$10,000.00	\$52,000.00					
TOTAL CONSTRUCTION COST (Based on Excavation)								\$150,766					
TOTAL ROW COST								\$52,000					

**WEST AMOLE DAM OPTIONS 2D and 3C.1
--TRUNK FACILITIES--**

Item No.	Spec. No.	Short Description	Unit	Quantity	Unit Price Lining/ Pipe	Unit Price Exca- vation	Total Unit Price	Amount	Slope	Area	WP	Velocity (fps)	Max Flow (cfs)
		NEW DAM (From Dam Storage vs. Cost per ac-ft curve)	AC-FT	600			\$3,200.00	\$1,920,000.00					
		ROW	AC	135			\$5,000.00	\$675,000.00					
TOTAL CONSTRUCTION COST								\$1,920,000					
TOTAL ROW COST								\$675,000					

**WEST AMOLE DAM OPTION 6A
--TRUNK FACILITIES--**

Item No.	Spec. No.	Short Description	Unit	Quantity	Unit Price Lining/ Pipe	Unit Price Exca- vation	Total Unit Price	Amount	Slope	Area	WP	Velocity (fps)	Max Flow (cfs)
		NEW DAM (From Dam Storage vs. Cost per ac-ft curve)	AC-FT	136			\$11,100.00	\$1,509,600.00					
		ROW	AC	135			\$5,000.00	\$675,000.00					
TOTAL CONSTRUCTION COST								\$1,509,600					
TOTAL ROW COST								\$675,000					

AMOLE DIVERSION CHANNEL - WEST AMOLE DAM TO PDV
--TRUNK FACILITIES--

Item No.	Spec. No.	Short Description	Unit	Quantity	Unit Price Lining/ Pipe	Unit Price Exca- vation	Total Unit Price	Amount	Slope	Area	WP	Velocity (fps)	Max Flow (cfs)
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Pipe - From West Amole Dam L=3000'

66" RCP, IV	66	LF	3000		\$123.20	\$58.08	\$181.28	\$543,840.00	0.0060	23.2	14.52	12.12	280.56
ROW		AC	3.44				\$5,000.00	\$17,217.63					

Channel - From end of Pipe to Paseo del Volcan

CHANNELS(Excavation and Lining)

Thickness = 7 inches n = 0.013

Earthwork= \$2.50 CY

Concrete Lining = \$254.50 CY = \$5.50 SF

BOTTOM

WIDTH(ft)	DEPTH(ft)	LF	\$90.57	\$1.11	\$91.68	\$0	12.0	14.47	7.84	94.03
10	1	LF	\$115.16	\$2.59	\$117.75	\$0	28.0	18.94	11.52	322.55
10	2	LF	\$139.75	\$4.44	\$144.20	\$0	48.0	23.42	14.33	687.66
10	3	LF	\$164.34	\$6.67	\$171.01	\$0	72.0	27.89	16.71	1202.97
10	4	LF	\$188.93	\$9.26	\$198.19	\$772,941	100.0	32.36	18.84	1883.53
10	5	LF	\$213.52	\$12.22	\$225.74	\$0	132.0	36.83	20.79	2744.43
10	6	LF	\$238.11	\$15.56	\$253.67	\$0	168.0	41.30	22.62	3800.43
10	7	LF	\$262.70	\$19.26	\$281.96	\$0	208.0	45.78	24.36	5065.92
10	8	LF	\$287.29	\$23.33	\$310.62	\$0	252.0	50.25	26.01	6554.91
10	9	LF	\$311.88	\$27.78	\$339.66	\$0	300.0	54.72	27.60	8281.00
10	10	LF								

CHANNEL SUBTOTAL

ROW	AC	6.27	\$10,000.00	\$772,941
ROW	AC	0.00	\$25,000.00	\$62,672
				\$0

INPUT:

Desired Flow = 665 CFS
Slope = 0.006

Flow Depth (ft)	Velocity (fps)	Required Freeboard (ft)	Required Channel Depth (ft)
2.95	14.19	1.76	4.70

Known Variable
74.90367 74.904

CBC's Under Paseo del Volcan

Concrete	CY	250	\$300.00	\$23.98	\$323.98	\$80,995
Reinforcing Steel	LB	35488	\$0.65	\$0.00	\$0.65	\$23,067
Saw, Remove & Replace Pavement	SY	330	\$33.00	\$0.00	\$33.00	\$10,890

CBC Subtotal

\$114,952

TOTAL CONSTRUCTION COST \$1,431,733

TOTAL ROW COST \$79,890

**AMOLE DIVERSION CHANNEL - PDV TO EAST AMOLE DAM
--TRUNK FACILITIES--**

Item No.	Spec. No.	Short Description	Unit	Quantity	Unit Price Lining/ Pipe	Unit Price Exca- vation	Total Unit Price	Amount	Slope	Area	WP	Velocity (fps)	Max Flow (cfs)
CHANNELS(Excavation and Lining)													
		Thickness =	7 inches			n =	0.013						
		Earthwork=	\$2.50 CY										
		Concrete Lining =	\$254.50 CY	=	\$5.50 SF								
BOTTOM													
		WIDTH(ft)	DEPTH(ft)										
		10	1	LF	\$90.57	\$1.11	\$91.68	\$0	0.0060	12.0	14.47	7.84	94.03
		10	2	LF	\$115.16	\$2.59	\$117.75	\$0	0.0060	28.0	18.94	11.52	322.55
		10	3	LF	\$139.75	\$4.44	\$144.20	\$0	0.0060	48.0	23.42	14.33	687.66
		10	4	LF	\$164.34	\$6.67	\$171.01	\$0	0.0060	72.0	27.89	16.71	1202.97
		10	5	LF	\$188.93	\$9.26	\$198.19	\$0	0.0060	100.0	32.36	18.84	1883.53
		10	6	LF	\$213.52	\$12.22	\$225.74	\$0	0.0060	132.0	36.83	20.79	2744.43
		10	7	LF	\$238.11	\$15.56	\$253.67	\$380,499	0.0060	168.0	41.30	22.62	3800.43
		10	8	LF	\$262.70	\$19.26	\$281.96	\$0	0.0060	208.0	45.78	24.36	5065.92
		10	9	LF	\$287.29	\$23.33	\$310.62	\$0	0.0060	252.0	50.25	26.01	6554.91
		10	10	LF	\$311.88	\$27.78	\$339.66	\$0	0.0060	300.0	54.72	27.60	8281.00

CHANNEL SUBTOTAL

ROW	AC	1.12
ROW	AC	1.29

\$380,499

\$25,000.00
\$10,000.00

INPUT:
Desired Flow = 1715 CFS
Slope = 0.006

Flow Depth (ft)	Velocity (fps)	Required Freeboard (ft)	Required Channel Depth (ft)
4.77	18.37	1.94	6.72

Known
193.1726
Variable
193.17

TOTAL CONSTRUCTION COST \$380,499
TOTAL ROW COST \$40,978

EAST AMOLE DAM OPTIONS 2D and 3C.1 **--TRUNK FACILITIES--**

Item No.	Spec. No.	Short Description	Unit	Quantity	Unit Price Lining/ Pipe	Unit Price Exca- vation	Total Unit Price	Amount	Slope	Area	WP	Velocity (fps)	Max Flow (cfs)
		NEW DAM (From Dam Storage vs. Cost per ac-ft curve)	AC-FT	270			\$8,300.00	\$2,241,000.00					
		ROW	AC	27	\$10,000.00		\$10,000.00	\$270,000.00					
TOTAL CONSTRUCTION COST								\$2,241,000					
TOTAL ROW COST								\$270,000					

EAST AMOLE DAM OPTION 6A **--TRUNK FACILITIES--**

Item No.	Spec. No.	Short Description	Unit	Quantity	Unit Price Lining/ Pipe	Unit Price Exca- vation	Total Unit Price	Amount	Slope	Area	WP	Velocity (fps)	Max Flow (cfs)
		NEW DAM (From Dam Storage vs. Cost per ac-ft curve)	AC-FT	60			\$12,200.00	\$732,000.00					
		ROW	AC	27	\$10,000.00		\$10,000.00	\$270,000.00					
TOTAL CONSTRUCTION COST								\$732,000					
TOTAL ROW COST								\$270,000					

**I-40 DIVERSION FROM EAST AMOLE DAM TO 98TH STREET
--TRUNK FACILITIES--**

Item No.	Spec. No.	Short Description	Unit	Quantity	Unit Price Lining/ Pipe	Unit Price Exca- vation	Total Unit Price	Amount	Slope	Area	WP	Velocity (fps)	Max Flow (cfs)
I-40 Amole to 98th Reach 1 & 2													
		54" RCP, IV	LF	3550	\$123.20	\$47.52	\$170.72	\$606,056.00	4.00%	15.5	11.88	27.37	424.21
		ROW	AC	8.15			\$5,000.00	\$40,748.39					
TOTAL CONSTRUCTION COST								\$606,056					
TOTAL ROW COST								\$40,748					
I-40 Amole to 98th Reach 3, 4, & 5													
		90" RCP, IV	LF	4950	\$165.00	\$79.20	\$244.20	\$1,208,790.00	1.30%	43.1	19.80	21.93	944.32
		ROW	AC	11.36			\$10,000.00	\$113,636.36					
TOTAL CONSTRUCTION COST								\$1,208,790					
TOTAL ROW COST								\$113,636					
I-40 Amole to 98th Reach 6													
CHANNELS(Excavation and Lining)													
Thickness = 8 inches n = 0.013													
Earthwork= \$2.50 CY													
Concrete Lining = \$263.45 CY = \$6.50 SF													
BOTTOM													
		WIDTH(ft)	DEPTH(ft)										
		10	1	LF	\$107.15	\$1.11	\$108.26	\$0	0.0277	12.0	14.47	16.84	202.04
		10	2	LF	\$136.24	\$2.59	\$138.83	\$0	0.0277	28.0	18.94	24.75	693.04
		10	3	LF	\$165.33	\$4.44	\$169.78	\$0	0.0277	48.0	23.42	30.78	1477.54
		10	4	LF	\$194.42	\$6.67	\$201.09	\$0	0.0277	72.0	27.89	35.90	2584.76
		10	5	LF	\$223.51	\$9.26	\$232.77	\$302,605	0.0277	100.0	32.36	40.47	4047.04
		10	6	LF	\$252.61	\$12.22	\$264.83	\$0	0.0277	132.0	36.83	44.67	5896.80
		10	7	LF	\$281.70	\$15.56	\$297.25	\$0	0.0277	168.0	41.30	48.61	8165.76
		10	8	LF	\$310.79	\$19.26	\$330.05	\$0	0.0277	208.0	45.78	52.33	10884.86
		10	9	LF	\$339.88	\$23.33	\$363.21	\$0	0.0277	252.0	50.25	55.89	14084.16
		10	10	LF	\$368.97	\$27.78	\$396.75	\$0	0.0277	300.0	54.72	59.31	17792.91
CHANNEL SUBTOTAL								\$302,605					
ROW								\$29,844					
								\$10,000.00					

Flow Depth (ft)	Velocity (fps)	Required Freeboard (ft)	Required Channel Depth (ft)
2.63	28.71	2.09	4.73

INPUT:
Desired Flow = 1155 CFS
Slope = 0.0277

TOTAL CONSTRUCTION COST \$302,605
TOTAL ROW COST \$29,844

Known Variable
60.54791 60.548001

I-40 DIVERSION FROM EAST AMOLE DAM TO 98TH STREET (cont'd)
 --TRUNK FACILITIES--

Item No.	Spec. No.	Short Description	Unit	Quantity	Unit Price Lining/ Pipe	Unit Price Exca- vation	Total Unit Price	Amount	Slope	Area	WP	Velocity (fps)	Max Flow (cfs)
I-40 Amole to 98th Reach 7													
CHANNELS(Excavation and Lining)													
Thickness = 7 inches n = 0.013													
Earthwork= \$2.50 CY													
Concrete Lining = \$254.50 CY = \$5.50 SF													
BOTTOM													
		WIDTH(ft)	DEPTH(ft)										
		10	1	LF	\$90.57	\$1.11	\$91.68	\$0	0.0129	12.0	14.47	11.49	137.87
		10	2	LF	\$115.16	\$2.59	\$117.75	\$0	0.0129	28.0	18.94	16.89	472.95
		10	3	LF	\$139.75	\$4.44	\$144.20	\$0	0.0129	48.0	23.42	21.01	1008.31
		10	4	LF	\$164.34	\$6.67	\$171.01	\$0	0.0129	72.0	27.89	24.50	1763.90
		10	5	LF	\$188.93	\$9.26	\$198.19	\$0	0.0129	100.0	32.36	27.62	2761.80
		10	6	LF	\$213.52	\$12.22	\$225.74	\$0	0.0129	132.0	36.83	30.49	4024.12
		10	7	LF	\$238.11	\$15.56	\$253.67	\$608,798	0.0129	168.0	41.30	33.17	5572.52
		10	8	LF	\$262.70	\$19.26	\$281.96	\$0	0.0129	208.0	45.78	35.71	7428.10
		10	9	LF	\$287.29	\$23.33	\$310.62	\$0	0.0129	252.0	50.25	38.14	9611.38
		10	10	LF	\$311.88	\$27.78	\$339.66	\$0	0.0129	300.0	54.72	40.47	12142.33
CHANNEL SUBTOTAL								\$608,798					
ROW								\$10,000.00					
ROW								\$35,000.00					

Flow Depth (ft)	Velocity (fps)	Required Freeboard (ft)	Required Channel Depth (ft)
4.05	24.65	2.09	6.13

INPUT:
 Desired Flow = 1805 CFS
 Slope = 0.0129

TOTAL CONSTRUCTION COST \$608,798
 TOTAL ROW COST \$135,445

Known Variable
 138.6562 138.66

I-40 DIVERSION FROM EAST AMOLE DAM TO 98TH STREET (cont'd)
 --TRUNK FACILITIES--

Item No.	Spec. No.	Short Description	Unit	Quantity	Unit Price Lining/ Pipe	Unit Price Exca- vation	Total Unit Price	Amount	Slope	Area	WP	Velocity (fps)	Max Flow (cfs)
I-40 Amole to 98th Reach 8													
CHANNELS(Excavation and Lining)													
Thickness = 7 inches n = 0.013													
Earthwork= \$2.50 CY													
Concrete Lining = \$254.50 CY = \$5.50 SF													
BOTTOM													
		WIDTH(ft)	DEPTH(ft)										
		10	1	LF	\$90.57	\$1.11	\$91.68	\$0	0.0129	12.0	14.47	11.49	137.87
		10	2	LF	\$115.16	\$2.59	\$117.75	\$0	0.0129	28.0	18.94	16.89	472.95
		10	3	LF	\$139.75	\$4.44	\$144.20	\$0	0.0129	48.0	23.42	21.01	1008.31
		10	4	LF	\$164.34	\$6.67	\$171.01	\$0	0.0129	72.0	27.89	24.50	1763.90
		10	5	LF	\$188.93	\$9.26	\$198.19	\$0	0.0129	100.0	32.36	27.62	2761.80
		10	6	LF	\$213.52	\$12.22	\$225.74	\$0	0.0129	132.0	36.83	30.49	4024.12
		10	7	LF	\$238.11	\$15.56	\$253.67	\$25,367	0.0129	168.0	41.30	33.17	5572.52
		10	8	LF	\$262.70	\$19.26	\$281.96	\$0	0.0129	208.0	45.78	35.71	7428.10
		10	9	LF	\$287.29	\$23.33	\$310.62	\$0	0.0129	252.0	50.25	38.14	9611.38
		10	10	LF	\$311.88	\$27.78	\$339.66	\$0	0.0129	300.0	54.72	40.47	12'42.33

CHANNEL SUBTOTAL

\$25,367

ROW

AC

0.23

\$35,000.00

\$8,035

INPUT:
 Desired Flow = 2120 CFS
 Slope = 0.0129

Flow Depth (ft)	Velocity (fps)	Required Freeboard (ft)	Required Channel Depth (ft)
4.39	25.74	2.14	6.52

Known
162.8539

Variable
162.85

TOTAL CONSTRUCTION COST

\$25,367

TOTAL ROW COST

\$8,035

**I-40 POND AT 98TH STREET
--TRUNK FACILITIES--**

Item No.	Spec. No.	Short Description	Unit	Quantity	Unit Price Lining/ Pipe	Unit Price Exca- vation	Total Unit Price	Amount	Slope	Area	WP	Velocity (fps)	Max Flow (cfs)
		NEW DAM (From Dam Storage vs. Cost per ac-ft curve)	AC-FT	49			\$12,000.00	\$588,000.00					
		ROW	AC	12	\$0.00		\$0.00	\$0.00					
TOTAL CONSTRUCTION COST								\$588,000					
TOTAL ROW COST								\$0					

I-40 DIVERSION CHANNEL 98TH STREET POND TO UNSER BLVD
--TRUNK FACILITIES--

Item No.	Spec. No.	Short Description	Unit	Quantity	Unit Price Lining/ Pipe	Unit Price Exca- vation	Total Unit Price	Amount	Slope	Area	WP	Velocity (fps)	Max Flow (cfs)								
CHANNELS(Excavation and Lining)																					
		Thickness =	7 inches	n = 0.013																	
		Earthwork=	\$2.50 CY																		
		Concrete Lining =	\$254.50 CY	=	\$5.50 SF																
BOTTOM																					
		WIDTH(ft)	DEPTH(ft)																		
		10	1	LF	\$90.57	\$1.11	\$91.68	\$0	0.0180	12.0	14.47	13.57	162.86								
		10	2	LF	\$115.16	\$2.59	\$117.75	\$0	0.0180	28.0	18.94	19.95	558.67								
		10	3	LF	\$139.75	\$4.44	\$144.20	\$0	0.0180	48.0	23.42	24.81	1191.06								
		10	4	LF	\$164.34	\$6.67	\$171.01	\$0	0.0180	72.0	27.89	28.94	2083.61								
		10	5	LF	\$188.93	\$9.26	\$198.19	\$1,090.045	0.0180	100.0	32.36	32.62	3262.38								
		10	6	LF	\$213.52	\$12.22	\$225.74	\$0	0.0180	132.0	36.83	36.01	4753.49								
		10	7	LF	\$238.11	\$15.56	\$253.67	\$0	0.0180	168.0	41.30	39.18	6582.54								
		10	8	LF	\$262.70	\$19.26	\$281.96	\$0	0.0180	208.0	45.78	42.18	8774.44								
		10	9	LF	\$287.29	\$23.33	\$310.62	\$0	0.0180	252.0	50.25	45.05	11353.43								
		10	10	LF	\$311.88	\$27.78	\$339.66	\$0	0.0180	300.0	54.72	47.81	14343.11								

CHANNEL SUBTOTAL

\$1,090,045

ROW AC 7.76
ROW TO BE PURCHASED AC 4.40

\$30,000.00

\$132,000

INPUT:

Desired Flow = 1090 CFS
Slope = 0.018

Flow Depth (ft)	Velocity (fps)	Required Freeboard (ft)	Required Channel Depth (ft)
2.86	24.20	2.00	4.87

Known Variable
70.88386 70.884001

TOTAL CONSTRUCTION COST \$1,090,045
TOTAL ROW COST \$132,000

I-40 POND AT UNSER BLVD
--TRUNK FACILITIES--

Item No.	Spec. No.	Short Description	Unit	Quantity	Unit Price Lining/ Pipe	Unit Price Exca- vation	Total Unit Price	Amount	Slope	Area	WP	Velocity (fps)	Max Flow (cfs)
		NEW DAM (From Dam Storage vx. Cost per ac-ft curve)	AC-FT	44.4			\$12,690.00	\$563,436.00					
		ROW	AC	9	\$35,000.00		\$35,000.00	\$0.00					
TOTAL CONSTRUCTION COST								\$563,436					
TOTAL ROW COST								\$0					

I-40 DIVERSION CHANNEL UNSER BLVD TO ESTANCIA
--TRUNK FACILITIES--

Item No.	Spec. No.	Short Description	Unit	Quantity	Unit Price Lining/ Pipe	Unit Price Exca- vation	Total Unit Price	Amount	Slope	Area	WP	Velocity (fps)	Max Flow (cfs)
CHANNELS(Excavation and Lining)													
		Thickness =	7 inches	n = 0.013									
		Earthwork=	\$2.50 CY										
		Concrete Lining =	\$254.50 CY	=	\$5.50 SF								
BOTTOM													
		WIDTH(ft)	DEPTH(ft)										
		10	1	LF	\$90.57	\$1.11	\$91.68	\$0	0.0105	12.0	14.47	10.37	124.39
		10	2	LF	\$115.16	\$2.59	\$117.75	\$0	0.0105	28.0	18.94	15.24	426.69
		10	3	LF	\$139.75	\$4.44	\$144.20	\$0	0.0105	48.0	23.42	18.95	909.69
		10	4	LF	\$164.34	\$6.67	\$171.01	\$0	0.0105	72.0	27.89	22.10	1591.38
		10	5	LF	\$188.93	\$9.26	\$198.19	\$0	0.0105	100.0	32.36	24.92	2491.68
		10	6	LF	\$213.52	\$12.22	\$225.74	\$1,546,338	0.0105	132.0	36.83	27.50	3630.54
		10	7	LF	\$238.11	\$15.56	\$253.67	\$0	0.0105	168.0	41.30	29.93	5027.49
		10	8	LF	\$262.70	\$19.26	\$281.96	\$0	0.0105	208.0	45.78	32.22	6701.59
		10	9	LF	\$287.29	\$23.33	\$310.62	\$0	0.0105	252.0	50.25	34.41	8671.33
		10	10	LF	\$311.88	\$27.78	\$339.66	\$0	0.0105	300.0	54.72	36.52	10954.73

CHANNEL SUBTOTAL

\$1,546,338

TOT ROW AC 15.73
ROW TO BE PURCHASED AC 4.97

\$50,000.00

\$248,500

INPUT:

Desired Flow = 1360 CFS
Slope = 0.0105

Flow Depth (ft)	Velocity (fps)	Required Freeboard (ft)	Required Channel Depth (ft)
3.69	21.18	1.97	5.67

Known Variable
115.7981 115.8

TOTAL CONSTRUCTION COST \$1,546,338

TOTAL ROW COST \$248,500

**WEST MESA DIVERSION POND
--TRUNK FACILITIES--**

Item No.	Spec. No.	Short Description	Unit	Quantity	Unit Price Lining/ Pipe	Unit Price Exca- vation	Total Unit Price	Amount	Slope	Area	WP	Velocity (fps)	Max Flow (cfs)
		NEW DAM (From Dam Storage vx. Cost per ac-ft curve)	AC-FT	6.5			\$14,000.00	\$91,000.00					
		ROW	AC	1.5	\$50,000.00		\$50,000.00	\$75,000.00					
TOTAL CONSTRUCTION COST								\$91,000					
TOTAL ROW COST								\$75,000					

**WEST MESA DIVERSION
--TRUNK FACILITIES--**

Item No.	Spec. No.	Short Description	Unit	Quantity	Unit Price Lining/ Pipe	Unit Price Exca- vation	Total Unit Price	Amount	Slope	Area	WP	Velocity (fps)	Max Flow (cfs)
Pipe - West Mesa Diversion to Inflow from 521													
		90" RCP, IV	90	LF	2000	\$165.00	\$79.20	\$244.20	\$488,400.00	0.0014	43.1	19.80	309.89
		ROW		AC	2.75		\$0.00	\$0.00					
Box Culvert - West Mesa Diversion Inflow 521 to I-40													
		10' CBC	10	LF	5800	\$310.00	\$115.00	\$425.00	\$2,465,000.00	0.0015	100.0	30.00	990.55
		ROW		AC	7.99		\$0.00	\$0.00					
								TOTAL CONSTRUCTION COST		\$2,953,400			
								TOTAL ROW COST		\$0			

OPTION 2D:

PETROGLYPH NATIONAL MONUMENT ARROYO STABILIZATION:		CONSTRUCTION COST:	\$340,000
		RIGHT-OF-WAY COST:	\$0

Total Arroyo Length = 6500 ft
 4 ft. Gabion Drop Structures = 7 ea
 Total Right-of-Way Acquisition = 3.0 ac

PASEO DEL VOLCAN DAM:		CONSTRUCTION COST:	\$1,920,000
		RIGHT-OF-WAY COST:	\$750,000

Pond Invert = 5780 ft
 Qin = 2060 cfs
 Qout = 300 cfs
 Principal Spillway = 1-60" pipe
 Emergency Spillway elevation/100 yr. Water Depth = 5789 ft
 100 yr. volume = 198.3 ac-ft
 100 yr. Water Surface Area = 30 ac
 Total Right-of-Way Acquisition = 75 ac

PETROGLYPH DIVERSION: PASEO DEL VOLCAN TO A2 DAM		CONSTRUCTION COST:	\$790,000
		RIGHT-OF-WAY COST:	\$60,000

Pipe Dia = 72 in
 Slope = 0.02
 Length = 4000 ft
 Flow = 510 cfs
 Total Right-of-Way Acquisition = 4.5 ac

MIREHAVEN A2 DAM:		CONSTRUCTION COST:	\$280,000
		RIGHT-OF-WAY COST:	\$40,000

Qin = 510 cfs
 Qout = 265 cfs
 Principal Spillway = 36" pipes
 Pond Invert = 5625 ft
 Emergency Spillway elevation/100 yr. Water Depth = 5637 ft
 100 yr. volume = 21.8 ac-ft
 Total Area = 8 ac
 Total Right-of-Way Acquisition = 10 ac

PETROGLYPH DIVERSION: A2 DAM TO C DAM
 CONSTRUCTION COST: \$650,000
 RIGHT-OF-WAY COST: \$60,000

Pipe Dia = 72 in
 Slope = 0.006
 Length = 3250 ft
 Flow = 265 cfs
 Total Right-of-Way Acquisition = 4.5 ac

C DAM:
 CONSTRUCTION COST: \$540,000
 RIGHT-OF-WAY COST: \$100,000

Qin = 925 cfs
 Qout = 335 cfs
 Principal Spillway = 60" pipes
 Pond Invert = 5730 ft
 Emergency Spillway elevation/100 yr. Water Depth = 5752 ft
 100 yr. volume = 42.5 ac-ft
 Total Area = 5.6 ac
 Total Right-of-Way Acquisition = 10 ac

C DAM TO D5 DAM:
 CONSTRUCTION COST: \$170,000
 RIGHT-OF-WAY COST: \$30,000

Pipe Dia = 60 in
 Slope = 0.02
 Length = 1000 ft
 Flow = 335 cfs
 Total Right-of-Way Acquisition = 1.5 ac

c1 and c2 STORM DRAINS:
 CONSTRUCTION COST: \$470,000
 RIGHT-OF-WAY COST: \$30,000

Pipe Dia = 42 in
 Slope = 0.036
 Length = 4800 ft
 Flow = 380 / 2 cfs
 Total Right-of-Way Acquisition = 5.5 ac

D5 DAM:		CONSTRUCTION COST:	\$1,190,000
		RIGHT-OF-WAY COST:	\$80,000

Qin = 340 cfs
 Qout = 270 cfs
 Principal Spillway = 1-60" pipes
 Pond Invert = 5740 ft
 Emergency Spillway elevation/100 yr. Water Depth = 5753 ft
 100 yr. volume = 102 ac-ft
 Total Area = 14 ac
 Total Right-of-Way Acquisition = 16 ac

ENLARGE LADERA DAM 5:		CONSTRUCTION COST:	\$40,000
		RIGHT-OF-WAY COST:	\$10,000

Dam 5, 100 yr. volume = 37.8 ac-ft (was 31.5)
 Total Right-of-Way Acquisition (Already Owned) = 1.4 ac

DAM 5 DIVERSION FROM LADERA DAM 5 TO I-40 DIVERSION:		CONSTRUCTION COST:	\$380,000
		RIGHT-OF-WAY COST:	\$0

Pipe Diameter = 54 in
 Slope = 0.0195
 Length = 2200 ft
 Flow = 260 cfs
 Total Right-of-Way Acquisition = 2.5 ac

MIREHAVEN CHANNEL: Petroglyph National Monument to Ladera Dam 12		CONSTRUCTION COST:	\$1,520,000
		RIGHT-OF-WAY COST:	\$120,000

Bottom Width = 10 ft
 Slope = 0.022
 Depth = 6 ft
 Side Slope = 2:1
 Length = 6500 ft
 Flow = 1655 cfs
 Total Right-of-Way Acquisition = 8.06 ac

DAM 12 DIVERSION:	CONSTRUCTION COST:	\$500,000
	RIGHT-OF-WAY COST:	\$0

Pipe Diameter = 54 to 84 in
 Slope = 1 to 3%
 Length = 2250 ft
 Flow = 300 to 555 cfs
 Total Right-of-Way (Already owned) = 3.6 ac

MOVE TRAINING DIKE:	CONSTRUCTION COST:	\$70,000
	RIGHT-OF-WAY COST:	\$0

Qin = 635 cfs
 Total Right-of-Way Acquisition = 1.0 ac

TOTAL CONSTRUCTION COST:	\$8,850,000
CONTINGENCY/SOFT COST (45%):	\$3,980,000
CONSTRUCTION SUBTOTAL:	\$12,830,000
TOTAL RIGHT-OF-WAY COST:	\$1,290,000
OPTION 2D SUBTOTAL:	\$14,120,000
TRUNK:	\$30,640,000
TOTAL:	\$44,760,000

PETROGLYPH NATIONAL MONUMENT ARROYO STABILIZATION WORKSHEET 2d

ID	ARROYO	Qd	Depth	Width d	Ratio	Mannings	Fr	C	Ss	Existing Slope	Length	Required Drop	Gabion Drop	# Required	ROW (acres)	Cost/acre	ROW Cost
L12.13_1	Mirehaven A	203	0.6	66	110.00	0.03	0.7	0.014365	0.007086	0.019	5000	59.57	4	14.9	4.35	\$10,000	\$43,538
L12.14E	Mirehaven B	73	0.4	31	77.50	0.03	0.7	0.013712	0.007749	0.03	8000	178.00	4	44.5	7.32	\$10,000	\$73,202
L12.16E	Mirehaven C	167	0.5	65	130.00	0.03	0.7	0.014688	0.007436	0.035	4000	110.26	4	27.6	5.60	\$10,000	\$56,016
DIKE	Mirehaven BC	294	0.5	125	250.00	0.03	0.7	0.015023	0.007524	0.03	3000	67.43	4	16.9	5.31	\$10,000	\$53,053
L12.18_2	Mirehaven ABC	468	0.7	127	181.43	0.03	0.7	0.015354	0.006778	0.019	1300	15.89	4	4.0	1.54	\$15,000	\$23,028
L12.9E	Mirehaven A1	140	0.7	44	62.86	0.03	0.7	0.013335	0.006911	0.018	2800	31.05	4	7.8	2.08	\$5,000	\$10,419
L12.12E	Mirehaven A2	88	0.5	40	80.00	0.03	0.7	0.013770	0.007591	0.025	1600	27.85	4	7.0	1.41	\$5,000	\$7,030
(L12.16E)/2	Mirehaven C1	84	0.5	37	74.00	0.03	0.7	0.013628	0.007559	0.032	2200	53.77	4	0.0	0.00	\$5,000	\$0
(L12.16E)/2	Mirehaven C2	84	0.5	37	74.00	0.03	0.7	0.013628	0.007559	0.031	2600	60.95	4	0.0	0.00	\$5,000	\$0
													TOTAL	122.5	27.6		\$266,287

Q FROM 100-YR ROW

HYD NO	ARROYO	Q100	Width100	Length	GabTotLength	ROW
L12.13_1	Mirehaven A	534	73	5000	1087	10.7
L12.14E	Mirehaven B	196	45	3500	2003	5.2
L12.16E	Mirehaven C	382	68	4000	1874	8.1
DIKE	Mirehaven BC	726	128	3000	2158	10.2
L12.18_2	Mirehaven ABC	1404	134	1300	532	4.6
L12.9E	Mirehaven A1	390	55	2800	427	4.8
L12.12E	Mirehaven A2	226	47	1600	327	2.5
(L12.16E)/2	Mirehaven C1	191	45	2200	0	3.3
(L12.16E)/2	Mirehaven C2	191	45	2600	0	3.9
TotArroyoLength						53.2
GabAvgWid						TotROW

PETROGLYPH NATIONAL MONUMENT ARROYO STABILIZATION:
CONSTRUCTION COST:
RIGHT-OF-WAY COST:

\$5,970,000
\$800,000

\$5,973,561
\$798,175

Total Arroyo Length = 26000 ft
4 ft Gabion Drop Structures = 122.5
Total Right-of-Way Acquisition = 53.2 ac
Total Right-of-Way Acquisition = 798174.9 ac

**PASEO DEL VOLCAN DAM
--COMMON TO OPTION 2--**

Item No.	Spec. No.	Short Description	Unit	Quantity	Unit Price Lining/ Pipe	Unit Price Exca- vation	Total Unit Price	Amount	Slope	Area	WP	Velocity (fps)	Max Flow (cfs)
		NEW DAM	AC-FT	198.3			\$9,700.00	\$1,923,510.00					
		(From Dam Storage vx. Cost per ac-ft curve)											
		ROW	AC	75	\$10,000.00		\$10,000.00	\$750,000.00					
		TOTAL CONSTRUCTION COST						\$1,923,510					
		TOTAL ROW COST						\$750,000					

PASEO DEL VOLCAN DAM OUTFALL TO A2 dam

Item No.	Spec. No.	Short Description	Unit	Quantity	Unit Price Lining/ Pipe	Unit Price Exca- vation	Total Unit Price	Amount	Slope	Area	WP	Velocity (fps)	Max Flow (cfs)
72" rcp	72		LF	4000	\$135.30	\$63.36	\$198.66	\$794,640.00	0.0200	27.6	15.84	23.44	646.01
66" rcp	66		LF	0	\$123.20	\$58.08	\$181.28	\$0.00	0.0220	23.2	14.52	23.20	537.24
struct conc.			cy	0	\$412.50	\$2.50	\$415.00	\$0.00					
ROW			AC	0.34			\$10,000.00	\$3,400.00					
ROW			AC	1.95			\$25,000.00	\$48,750.00					
ROW			AC	2.20			\$5,000.00	\$11,000.00					
TOTAL CONSTRUCTION COST								\$794,640					
TOTAL ROW COST								\$63,150					

MIREHAVEN A2 DAM

Item No.	Spec. No.	Short Description	Unit	Quantity	Unit Price Lining/ Pipe	Unit Price Exca- vation	Total Unit Price	Amount	Slope	Area	WP	Velocity (fps)	Max Flow (cfs)
		NEW DAM	AC-FT	21.8			\$12,800.00	\$279,040.00					
		(From Dam Storage vx. Cost per ac-ft curve)											
		ROW	AC	8	\$5,000.00		\$5,000.00	\$40,000.00					
		TOTAL CONSTRUCTION COST						\$279,040					
		TOTAL ROW COST						\$40,000					

PASEO DEL VOLCAN DIVERSION FROM A2 DAM TO CDAM

Item No.	Spec. No.	Short Description	Unit	Quantity	Unit Price Lining/ Pipe	Unit Price Exca- vation	Total Unit Price	Amount	Slope	Area	WP	Velocity (fps)	Max Flow (cfs)
72" rcp		72	LF	3250	\$135.30	\$63.36	\$198.66	\$645,645.00	0.0060	27.6	15.84	12.84	353.83
66" rcp		66	LF	0	\$123.20	\$58.08	\$181.28	\$0.00	0.0220	23.2	14.52	23.20	537.24
struct conc.			cy	0	\$412.50	\$2.50	\$415.00	\$0.00					
ROW			AC	0.34			\$10,000.00	\$3,400.00					
ROW			AC	1.95			\$25,000.00	\$48,750.00					
ROW			AC	2.20			\$5,000.00	\$11,000.00					
				4.49									
TOTAL CONSTRUCTION COST								\$645,645					
TOTAL ROW COST								\$63,150					

C DAM

Item No.	Spec. No.	Short Description	Unit	Quantity	Unit Price Lining/ Pipe	Unit Price Exca- vation	Total Unit Price	Amount	Slope	Area	WP	Velocity (fps)	Max Flow (cfs)
		CDAM (From Dam Storage vx. Cost per ac-ft curve)	AC-FT	43			\$12,700.00	\$539,750.00					
		ROW	AC	10	\$10,000.00		\$10,000.00	\$100,000.00					

C DAM TO D5 DAM

Item No.	Spec. No.	Short Description	Unit	Quantity	Unit Price Lining/ Pipe	Unit Price Exca- vation	Total Unit Price	Amount	Slope	Area	WP	Velocity (fps)	Max Flow (cfs)
		60" RCP,	LF	1000	\$114.40	\$52.80	\$167.20	\$167,200.00	0.0200	19.1	13.20	20.76	397.27
		ROW	AC	1.50			\$20,000.00	\$30,000.00					

MIREHAVEN C1 AND C2 PIPE

Item No.	Spec. No.	Short Description	Unit	Quantity	Unit Price Lining/ Pipe	Unit Price Exca- vation	Total Unit Price	Amount	Slope	Area	WP	Velocity (fps)	Max Flow (cfs)
		42" RCP,	42	LF	4800	\$60.50	\$36.96	\$97.46	\$467,808.00	0.0360	9.4	21.96	205.90
		ROW		AC	5.50		\$5,000.00	\$27,500.00					

D5 DAM

Item No.	Spec. No.	Short Description	Unit	Quantity	Unit Price Lining/ Pipe	Unit Price Exca- vation	Total Unit Price	Amount	Slope	Area	WP	Velocity (fps)	Max Flow (cfs)
		NEW DAM (From Dam Storage vs. Cost per ac-ft curve)	AC-FT	102.1			\$11,700.00	\$1,194,570.00					
		ROW	AC	16	\$5,000.00		\$5,000.00	\$80,000.00					
		ROW	AC	1.4	\$10,000.00		\$10,000.00	\$14,000.00					

ENLARGE DAM 5

Item No.	Spec. No.	Short Description	Unit	Quantity	Unit Price Lining/ Pipe	Unit Price Exca- vation	Total Unit Price	Amount	Slope	Area	WP	Velocity (fps)	Max Flow (cfs)
		ENLARGE DAM 5 1.2X (100-yr vol: from 31.5 to 37.8 ac-ft)	CY	10164		\$3.50	\$3.50	\$35,574.00					
		ROW	AC	1.4	\$10,000.00		\$10,000.00	\$14,000.00					

DAM 5 DIVERSION PIPE FROM DAM 5 TO I-40 DIVERSION

Item No.	Spec. No.	Short Description	Unit	Quantity	Unit Price Lining/ Pipe	Unit Price Exca- vation	Total Unit Price	Amount	Slope	Area	WP	Velocity (fps)	Max Flow (cfs)
		54" RCP,	54	2200	\$123.20	\$47.52	\$170.72	\$375,584.00	0.0195	15.5	11.88	19.11	296.19
		ROW	AC	2.53			\$50,000.00	\$0.00					

MIREHAVEN CHANNEL - PETROGLYPH NATIONAL MONUMENT TO DAM 12
 --COMMON TO OPTION 2--

Item No.	Spec. No.	Short Description	Unit	Quantity	Unit Price Lining/ Pipe	Unit Price Exca- vation	Total Unit Price	Amount	Slope	Area	WP	Velocity (fps)	Max Flow (cfs)
CHANNELS(Excavation and Lining)													
Thickness = 7 inches				n = 0.013									
Earthwork= \$2.50 CY													
Concrete Lining = \$263.25 CY =				\$5.69 SF									
BOTTOM WIDTH DEPTH(ft)													
		10	1	LF	\$93.69	\$1.11	\$94.80	\$0	0.0220	12.0	14.47	15.00	180.05
		10	2	LF	\$119.12	\$2.59	\$121.71	\$0	0.0220	28.0	18.94	22.06	617.64
		10	3	LF	\$144.56	\$4.44	\$149.00	\$0	0.0220	48.0	23.42	27.43	1316.77
		10	4	LF	\$169.99	\$6.67	\$176.66	\$0	0.0220	72.0	27.89	31.99	2303.52
		10	5	LF	\$195.43	\$9.26	\$204.69	\$0	0.0220	100.0	32.36	36.07	3606.69
		10	6	LF	\$220.86	\$12.22	\$233.08	\$1,515.034	0.0220	132.0	36.83	39.81	5255.18
		10	7	LF	\$246.30	\$15.56	\$261.85	\$0	0.0220	168.0	41.30	43.32	7277.27
		10	8	LF	\$271.73	\$19.26	\$290.99	\$0	0.0220	208.0	45.78	46.64	9700.51
		10	9	LF	\$297.17	\$23.33	\$320.50	\$0	0.0220	252.0	50.25	49.81	12551.69
		10	10	LF	\$322.60	\$27.78	\$350.38	\$0	0.0220	300.0	54.72	52.86	15856.91
CHANNEL SUBTOTAL				AC	8.06		\$15,000.00	\$1,515.034					
ROW								\$120,900.00					

Flow Depth (ft)	Velocity (fps)	Required Freeboard (ft)	Required Channel Depth (ft)
3.38	29.23	2.17	5.55

Known Variable
 97.3517452 97.35170015

INPUT:
 Desired Flow = 1655 CFS
 Slope = 0.022

TOTAL CONSTRUCTION COST \$1,515.034
 TOTAL ROW COST \$120,900

**DAM 12 DIVERSION PIPE FROM DAM 12 TO I-40 DIVERSION
--COMMON TO OPTION 2--**

Item No.	Spec. No.	Short Description	Unit	Quantity	Unit Price Lining/ Pipe	Unit Price Exca- vation	Total Unit Price	Amount	Slope	Area	WP	Velocity (fps)	Max Flow (cfs)	
		54" RCP,	54	LF	350	\$126.50	\$47.52	\$174.02	\$60,907.00	0.0320	15.5	11.88	24.48	379.43
		ROW	AC	0.48			\$0.00	\$0.00						
		72" RCP,	72	LF	1250	\$136.40	\$63.36	\$199.76	\$249,700.00	0.0147	27.6	15.84	20.10	553.84
		ROW	AC	1.72			\$0.00	\$0.00						
		84" RCP,	84	LF	650	\$144.00	\$73.92	\$217.92	\$141,648.00	0.0106	37.5	18.48	18.92	709.42
		ROW	AC	0.90			\$30,000.00	\$0.00						
Install 66" pipe in Dam 12														
		Excavation and installation						\$50,000						
		TOTAL CONSTRUCTION COST						\$502,255						
		TOTAL ROW COST						\$0						

REMOVE & RELOCATE TRAINING DIKE

Item No.	Spec. No.	Short Description	Unit	Quantity	Unit Price Lining/Pipe	Unit Price xcavation	Total Unit Price	Amount
		SITE CLEAR & GRUB	AC	2			\$650.00	\$1,300
		FOUNDATION PREP	SY	4500	\$2.75		\$2.75	\$12,375
		EXCAV OLD DIKE; BF & COMP NEW DIKE	CY	5100	\$5.17		\$5.17	\$26,367
		ADDITIONAL FILL FOR LONGER DIKE	CY	250	\$6.60		\$6.60	\$1,650
		EXCAV OLD ROCK; PLACE AT NEW DIKE	CY	700	\$30.00		\$30.00	\$21,000
		ADDIT'NL ROCK FILL FOR LONGER DIKE	CY	50	\$70.00		\$70.00	\$3,500
TOTAL CONSTRUCTION COST								\$66,192
TOTAL ROW COST								\$0

OPTION 3c1: DIVERT MIRHAVEN "A", "B", "C" ARROYOS THROUGH MONUMENT

PASEO DEL VOLCAN DAM:		CONSTRUCTION COST:	\$1,920,000
		RIGHT-OF-WAY COST:	\$750,000

Qin = 2060 cfs
 Qout = 300 cfs
 Principal Spillway = 1-60" pipes
 Pond Invert = 5780 ft
 Emergency Spillway elevation/100 yr. Water Depth = 5789 ft
 100 yr. volume = 198.3 ac-ft
 Total Area = 30 ac
 Total Right-of-Way Acquisition = 75 ac

PASEO DEL VOLCAN DAM OUTFALL --PDV Dam to A2 DAM:		CONSTRUCTION COST:	\$790,000
		RIGHT-OF-WAY COST:	\$60,000

Pipe Diameter = 72 in
 Slope = .007 to .022
 Length = 4000 ft
 Flow = 510 cfs
 Total Right-of-Way Acquisition = 4.5 ac

MIREHAVEN A2 DAM		CONSTRUCTION COST:	\$280,000
		RIGHT-OF-WAY COST:	\$40,000

Qin = 510 cfs
 Qout = 265 cfs
 Principal Spillway = 36" pipes
 Pond Invert = 5625 ft
 Emergency Spillway elevation/100 yr. Water Depth = 5637 ft
 100 yr. volume = 21.8 ac-ft
 Total Area = 8 ac
 Total Right-of-Way Acquisition = 10 ac

A2 DAM OUTFALL --A2 DAM TO DIKE:		CONSTRUCTION COST:	\$1,320,000
		RIGHT-OF-WAY COST:	\$0

Pipe Diameter = 60 in
 Slope = 0.034
 Length = 8000 ft
 Flow = 450 cfs
 Total Right-of-Way Acquisition = - ac

MIREHAVEN C1 PIPE:	CONSTRUCTION COST:		\$520,000
	RIGHT-OF-WAY COST:		\$20,000

Pipe Diameter = 72 in
 Slope = 0.036
 Length = 2600 ft
 Flow = 645 cfs
 Total Right-of-Way Acquisition = 3.6 ac

MIREHAVEN C2 PIPE:	CONSTRUCTION COST:		\$520,000
	RIGHT-OF-WAY COST:		\$20,000

Pipe Diameter = 72 in
 Slope = 0.036
 Length = 2600 ft
 Flow = 645 cfs
 Total Right-of-Way Acquisition = 3.58 ac

MIREHAVEN C DAM:	CONSTRUCTION COST:		\$680,000
	RIGHT-OF-WAY COST:		\$50,000

Qin = 1285 cfs
 Qout = 255 cfs
 Principal Spillway = 54" pipes
 Pond Invert = 5625 ft
 Emergency Spillway elevation/100 yr. Water Depth = 5637 ft
 100 yr. volume = 54 ac-ft
 Total Area = 7 ac
 Total Right-of-Way Acquisition = 9 ac

MIREHAVEN PIPE FROM C DAM TO CONFLUENCE:	CONSTRUCTION COST:		\$410,000
	RIGHT-OF-WAY COST:		\$0

Pipe Diameter = 48 in
 Slope = 0.027
 Length = 3600 ft
 Flow = 260 cfs
 Total Right-of-Way Acquisition = - ac

MIREHAVEN PIPE FROM CONFLUENCE TO BOUNDARY:

CONSTRUCTION COST: \$1,250,000
RIGHT-OF-WAY COST: \$0

Pipe Diameter = 84 in
Slope = 0.032
Length = 4500 ft
Flow = 1325 cfs
Total Right-of-Way Acquisition = - ac

MOVE TRAINING DIKE:

CONSTRUCTION COST: \$0
RIGHT-OF-WAY COST: \$0

Qin = 460 cfs
Total Right-of-Way Acquisition = 1 ac

MIREHAVEN CHANNEL -- From Petroglyph National Monument to 98th St:

CONSTRUCTION COST: \$760,000
RIGHT-OF-WAY COST: \$90,000

Bottom Width = 10 ft
Slope = 0.017
Depth = 6 ft
Side Slope = 2:1 (H:V)
Length = 3250 ft
Flow = 1495 cfs
Total Right-of-Way Acquisition = 6.0 ac

MIREHAVEN CHANNEL -- From 98th St to Dam 12:

CONSTRUCTION COST: \$760,000
RIGHT-OF-WAY COST: \$30,000

Bottom Width = 10 ft
Slope = 0.016
Depth = 6 ft
Side Slope = 2:1 (H:V)
Length = 3250 ft
Flow = 1650 cfs
Total Right-of-Way Acquisition = 2.1 ac

DAM 12 DIVERSION -- From Dam 12 to I-40 Diversion (same as option 2 diversion):

CONSTRUCTION COST:	\$500,000
RIGHT-OF-WAY COST:	\$0

Pipe Diameter = 54 to 84 in
 Slope = 1 to 3%
 Length = 2250 ft
 Flow = 300 to 615 cfs
 Total Right-of-Way Acquisition = 3.6 ac

PETROGLYPH NATIONAL MONUMENT ARROYO STABILIZATION:

CONSTRUCTION COST:	\$0
RIGHT-OF-WAY COST:	\$0

Total Arroyo Length = 24700 ft
 4 ft. Gabion Drop Structures Required = 0 ea
 Total Right-of-Way Acquisition = 0.0 ac

ENLARGE LADERA DAM 5 & 11:

CONSTRUCTION COST:	\$120,000
RIGHT-OF-WAY COST:	\$100,000

Dam 5, 100 yr. volume = 35.8 ac-ft (was 31.5)
 Dam 11, 100 yr. volume = 45.5 ac-ft (was 29)
 Total Right-of-Way Acquisition (Already Owned) = 4.5 ac

CONSTRUCTION COST:	\$9,830,000
CONTINGENCY/SOFT COST (45%):	\$4,420,000
CONSTRUCTION SUBTOTAL:	\$14,250,000
TOTAL RIGHT-OF-WAY COST:	\$1,150,000
OPTION 3c1 SUBTOTAL:	\$15,400,000
TRUNK:	\$30,640,000
TOTAL:	\$46,040,000

**PASEO DEL VOLCAN DAM
--COMMON TO OPTION 2--**

Item No.	Spec. No.	Short Description	Unit	Quantity	Unit Price Lining/ Pipe	Unit Price Exca- vation	Total Unit Price	Amount	Slope	Area	WP	Velocity (fps)	Max Flow (cfs)
		NEW DAM (From Dam Storage vx. Cost per ac-ft curve)	AC-FT	198.3			\$9,700.00	\$1,923,510.00					
		ROW	AC	75	\$10,000.00		\$10,000.00	\$750,000.00					
TOTAL CONSTRUCTION COST								\$1,923,510					
TOTAL ROW COST								\$750,000					

**North Portion Petroglyph Diversion - Paseo del Volcan Dam to Mirehaven C Arroyo
PASEO DEL VOLCAN DAM OUTFALL TO A2 dam**

Item No.	Spec. No.	Short Description	Unit	Quantity	Unit Price Lining/ Pipe	Unit Price Exca- vation	Total Unit Price	Amount	Slope	Area	WP	Velocity (fps)	Max Flow (cfs)
		72" rcp	72	LF	4000	\$135.30	\$533.20	\$533.20					
		66" rcp	66	LF	0	\$123.20	\$0.00	\$0.00					
		struct conc.		cy	0	\$412.50	\$0.00	\$0.00					
		ROW		AC	0.34		\$10,000.00	\$3,400.00					
		ROW		AC	1.95		\$25,000.00	\$48,750.00					
		ROW		AC	2.20		\$5,000.00	\$11,000.00					
TOTAL CONSTRUCTION COST								\$794,640					
TOTAL ROW COST								\$63,150					

MIREHAVEN A2 DAM

Item No.	Spec. No.	Short Description	Unit	Quantity	Unit Price Lining/ Pipe	Unit Price Exca- vation	Total Unit Price	Amount	Slope	Area	WP	Velocity (fps)	Max Flow (cfs)
		NEW DAM (From Dam Storage vs. Cost per ac-ft curve)	AC-FT	21.8			\$12,800.00	\$279,040.00					
		ROW	AC	8	\$5,000.00		\$5,000.00	\$40,000.00					
TOTAL CONSTRUCTION COST								\$279,040					
TOTAL ROW COST								\$40,000					

A2 DAM TO TRAINING DIKE

Item No.	Spec. No.	Short Description	Unit	Quantity	Unit Price Lining/ Pipe	Unit Price Exca- vation	Total Unit Price	Amount	Slope	Area	WP	Velocity (fps)	Max Flow (cfs)
		60" Top	LF	8000	\$112.20	\$52.80	\$165.00	\$1,320,000.00	0.0344	19.1	13.20	27.23	521.02
		ROW	AC	0.34			\$0.00	\$0.00					
		ROW	AC	1.95			\$0.00	\$0.00					
		ROW	AC	2.20			\$0.00	\$0.00					
TOTAL CONSTRUCTION COST								\$1,320,000					
TOTAL ROW COST								\$0					

MIREHAVEN C1 PIPE

Item No.	Spec. No.	Short Description	Unit	Quantity	Unit Price Lining/ Pipe	Unit Price Exca- vation	Total Unit Price	Amount	Slope	Area	WP	Velocity (fps)	Max Flow (cfs)
		72" RCP, IV	72	2600	\$135.30	\$63.36	\$198.66	\$516,516.00	0.0360	27.6	15.84	31.45	866.71
		ROW	AC	3.58			\$5,000.00	\$17,900.00					

MIREHAVEN C2 PIPE

Item No.	Spec. No.	Short Description	Unit	Quantity	Unit Price Lining/ Pipe	Unit Price Exca- vation	Total Unit Price	Amount	Slope	Area	WP	Velocity (fps)	Max Flow (cfs)
		72" RCP, IV	72	LF	2600	\$135.30	\$63.36	\$198.66	\$516,516.00	0.0360	27.6	31.45	866.71
		ROW	AC	3.58			\$5,000.00	\$17,900.00					

MIREHAVEN C DAM

Item No.	Spec. No.	Short Description	Unit	Quantity	Unit Price Lining/ Pipe	Unit Price Exca- vation	Total Unit Price	Amount	Slope	Area	WP	Velocity (fps)	Max Flow (cfs)
		NEW DAM (From Dam Storage vx. Cost per ac-ft curve)	AC-FT	54			\$12,600.00	\$680,400.00					
		ROW	AC	9	\$5,000.00		\$5,000.00	\$45,000.00					
							TOTAL CONSTRUCTION COST	\$880,400					
							TOTAL ROW COST	\$45,000					

MIREHAVEN PIPE FROM C DAM THROUGH MONUMENT

Item No.	Spec. No.	Short Description	Unit	Quantity	Unit Price Lining/ Pipe	Unit Price Exca- vation	Total Unit Price	Amount	Slope	Area	WP	Velocity (fps)	Max Flow (cfs)
Pipe - Dam 1 Arroyo													
		48" RCP, IV	48	3600	\$71.50	\$42.24	\$113.74	\$409,464.00	0.0320	12.2	10.56	22.63	277.15
		96" RCP, IV	96	4500	\$193.38	\$84.48	\$277.86	\$1,250,370.00	0.0270	49.0	21.12	33.00	1616.50
		ROW	AC	-			\$0.00	\$0.00					
		ROW	AC	-			\$0.00	\$0.00					
TOT=								\$1,659,834.00					

REMOVE & RELOCATE TRAINING DIKE

Item No.	Spec. No.	Short Description	Unit	Quantity	Unit Price Lining/ Pipe	Unit Price Exca- vation	Total Unit Price	Amount
		SITE CLEAR & GRUB	AC	1			\$650.00	\$650
		FOUNDATION PREP	SY	3791		\$2.75	\$2.75	\$10,425
		EXCAV OLD DIKE; BF & COMP	CY	5045		\$5.17	\$5.17	\$26,083
		ADDITIONAL FILL FOR LONGER	CY	238		\$6.60	\$6.60	\$1,571
		EXCAV OLD ROCK; PLACE AT	CY	675		\$30.00	\$30.00	\$20,250
		ADDITNL ROCK FILL FOR LON	CY	32		\$70.00	\$70.00	\$2,240
		TOTAL CONSTRUCTION COST						\$61,219
		TOTAL ROW COST						\$10,000

MIREHAVEN CHANNEL --From Pet. National Monument to 98th st

CHANNELS(Excavation and Lining)									
Thickness =	7 inches	n = 0.013							
Earthwork=	\$2.50 CY								
Concrete Lining =	\$263.25 CY =	\$5.69 SF							
BOTTOM WIDTH(DEPTH(ft)								
10	1	LF	\$93.69	\$1.11	\$94.80	\$0	0.0170	12.0	14.47
10	2	LF	\$119.12	\$2.59	\$121.71	\$0	0.0170	28.0	18.94
10	3	LF	\$144.56	\$4.44	\$149.00	\$0	0.0170	48.0	23.42
10	4	LF	\$169.99	\$6.67	\$176.66	\$0	0.0170	72.0	27.89
10	5	LF	\$195.43	\$9.26	\$204.69	\$0	0.0170	100.0	32.36
10	6	LF	\$220.86	\$12.22	\$233.08	\$757,523	0.0170	132.0	36.83
10	7	LF	\$246.30	\$15.56	\$261.85	\$0	0.0170	168.0	41.30
10	8	LF	\$271.73	\$19.26	\$290.99	\$0	0.0170	208.0	45.78
10	9	LF	\$297.17	\$23.33	\$320.50	\$0	0.0170	252.0	50.25
10	10	LF	\$322.60	\$27.78	\$350.38	\$0	0.0170	300.0	54.72

CHANNEL SUBTOTAL	AC	5.97							
ROW			\$15,000.00			\$757,523			
						\$89,550.00			

INPUT: Desired Flow = 1495 CFS
Slope = 0.017

Flow Depth (ft)	Velocity (fps)	Required Freeboard (ft)	Required Channel Depth (ft)
3.43	25.89	2.08	5.51

Known Variable
100.0400306 100.0400006

TOTAL CONSTRUCTION COST \$757,523
TOTAL ROW COST \$89,550

MIREHAVEN CHANNEL-- FROM 98TH TO DAM 12

CHANNELS (Excavation and Lining)

Thickness = 7 inches n = 0.013

Earthwork= \$2.50 CY

Concrete Lining = \$263.25 CY = \$5.69 SF

BOTTOM WIDTH(DEPTH(ft)

10	1	LF	\$93.69	\$1.11	\$94.80	\$0	0.0170	12.0	14.47	13.19	158.28
10	2	LF	\$119.12	\$2.59	\$121.71	\$0	0.0170	28.0	18.94	19.39	542.93
10	3	LF	\$144.56	\$4.44	\$149.00	\$0	0.0170	48.0	23.42	24.11	1157.50
10	4	LF	\$169.99	\$6.67	\$176.66	\$0	0.0170	72.0	27.89	28.12	2024.90
10	5	LF	\$195.43	\$9.26	\$204.69	\$0	0.0170	100.0	32.36	31.70	3170.46
10	6	LF	\$220.86	\$12.22	\$233.08	\$757,523	0.0170	132.0	36.83	35.00	4619.56
10	7	LF	\$246.30	\$15.56	\$261.85	\$0	0.0170	168.0	41.30	38.08	6397.07
10	8	LF	\$271.73	\$19.26	\$290.99	\$0	0.0170	208.0	45.78	41.00	8527.22
10	9	LF	\$297.17	\$23.33	\$320.50	\$0	0.0170	252.0	50.25	43.78	11033.55
10	10	LF	\$322.60	\$27.78	\$350.38	\$0	0.0170	300.0	54.72	46.46	13939.00

CHANNEL SUBTOTAL

\$757,523

ROW	AC	2.09
ROW	AC	3.88

\$15,000.00
\$30,000.00

\$31,350.00

\$0.00

INPUT:

Desired Flow = 1650 CFS
Slope = 0.016

Flow Depth (ft)	Velocity (fps)	Required Freeboard (ft)	Required Channel Depth (ft)
3.66	26.02	2.10	5.76

Known Variable
113.8101608 113.8099993

TOTAL CONSTRUCTION COST \$757,523
TOTAL ROW COST \$31,350

DAM 12 DIVERSION PIPE FROM DAM 12 TO I-40 DIVERSION

Item No.	Spec. No.	Short Description	Unit	Quantity	Unit Price Lining/ Pipe	Unit Price Exca- vation	Total Unit Price	Amount	Slope	Area	WP	Velocity (fps)	Max Flow (cfs)
		54" RCP, IV	54	LF	350	\$126.50	\$47.52	\$174.02	\$60,907.00	0.0320	15.5	24.48	379.43
		ROW		AC	0.48		\$0.00	\$0.00					
		72" RCP, IV	72	LF	1250	\$136.40	\$63.36	\$199.76	\$249,700.00	0.0147	27.6	20.10	553.84
		ROW		AC	1.72		\$0.00	\$0.00					
		84" RCP, IV	84	LF	650	\$144.00	\$73.92	\$217.92	\$141,648.00	0.0106	37.5	18.92	709.42
		ROW		AC	0.90		\$30,000.00	\$0.00					

Install 66' Pipe in Dam 12

Excavation and installation

\$50,000

TOTAL CONSTRUCTION COST \$502,255
TOTAL ROW COST \$0

ARROYO STABILIZATION WORKSHEET

OPTION 3c

ARROYO	Q10	Depth10	Width10	Ratio	Mannings	Fr	C	Ss	Existing Slope	Length	Required Drop	Gabion Drop	# Required	ROW (acres)	Cost/ acre	ROW Cost
Mirehavan A	111	0.9	69	76.67	0.03	0.7	0.013692	0.007319	0.0179	5000	52.91	4	13.2	10.8	\$10,000	\$108,000
Mirehavan B	30	0.4	63.7	159.25	0.03	0.7	0.015090	0.009599	0.03125	8000	173.21	4	43.3	8.0	\$10,000	\$80,000
Mirehavan C	0.0015	0.6	63.5	105.83	0.03	0.7	0.014292	0.03937	0.0357	3600	6.35	4	1.6	7.4	\$10,000	\$74,000
Mirehavan BC	192	0.4	124	310.00	0.03	0.7	0.016488	0.008194	0.0327	2600	63.72	4	15.9	8.7	\$10,000	\$87,000
Mirehavan ABC	279	0.8	128	160.00	0.03	0.7	0.015099	0.007140	0.0192	1300	15.68	4	3.9	4.5	\$15,000	\$67,500
Mirehavan A1	72	0.8	50	62.50	0.03	0.7	0.013325	0.007545	0.021	4800	64.59	4	16.1	8.0	\$5,000	\$40,000
Mirehavan A2	71	0.7	44	62.86	0.03	0.7	0.013335	0.007564	0.029	3400	72.88	4	18.2	5.5	\$5,000	\$27,500
												TOTAL	112.3	52.9		\$484,000

[illegible]

ENLARGE DAM 5

Item No.	Spec. No.	Short Description	Unit	Quantity	Unit Price Lining/ Pipe	Unit Price Exca- vation	Total Unit Price	Amount	Slope	Area	WP	Velocity (fps)	Max Flow (cfs)
		ENLARGE DAM 5 1.14X (100-yr vol: from 31.5 to 35.8 ac-ft)	CY	6837		\$3.50	\$3.50	\$24,279.50					
		ROW	AC	2			\$10,000.00	\$20,000.00					

ENLARGE DAM 11

Item No.	Spec. No.	Short Description	Unit	Quantity	Unit Price Lining/ Pipe	Unit Price Exca- vation	Total Unit Price	Amount	Slope	Area	WP	Velocity (fps)	Max Flow (cfs)
		ENLARGE DAM 11 (100-yr vol: from 29 to 45.5 ac-ft)	CY	26620		\$3.50	\$3.50	\$93,170.00					
		ROW	AC	2.5			\$30,000.00	\$75,000.00					

OPTION 6A: PHASED GROWTH

MIREHAVEN CHANNEL: Monument Boundary to Dam 12

CONSTRUCTION COST: \$1,520,000
RIGHT-OF-WAY COST: \$120,000

Bottom Width = 10 ft
Slope = 0.0226
Depth = 6 ft
Side Slope = 2:1
Length = 6500 ft
Flow = 1655 cfs
Right-of-Way Acquisition = 8.06 ac
Already Owned ROW (Blanket Easement) = 5.88 ac
Total Right-of Way = 13.94 ac

DAM 12 DIVERSION:

CONSTRUCTION COST: \$500,000
RIGHT-OF-WAY COST: \$0

Pipe Diameter = 54 to 84 in
Slope = 1 to 3%
Length = 2250 ft
Flow = 300 to 615 cfs
Total Right-of-Way (Already owned) = 3.6 ac

DAM 5 DIVERSION FROM LADERA DAM 5 TO I-40 DIVERSION:

CONSTRUCTION COST: \$380,000
RIGHT-OF-WAY COST: \$0

Pipe Diameter = 54 in
Slope = 0.0195
Length = 2200 ft
Flow = 255 cfs
Total Right-of-Way Acquisition = 2.5 ac

ENLARGE LADERA DAMS 5 AND 11:

CONSTRUCTION COST: \$120,000
RIGHT-OF-WAY COST: \$100,000

Dam 5 100 yr. volume = 35.8 ac-ft (was 31.5)
Dam 11 100 yr. volume = 45.5 ac-ft (was 29)
Total Right-of Way Acquisition = 0.0 ac

TOTAL CONSTRUCTION COST:	\$2,510,000
CONTINGENCY/SOFT COST (45%):	\$1,130,000
CONSTRUCTION SUBTOTAL:	\$3,640,000
TOTAL RIGHT-OF-WAY COST:	\$220,000
OPTION 6A SUBTOTAL:	\$3,860,000
TOTAL: (Option 6 w/Trunk)	\$27,870,000

**MIREHAVEN CHANNEL --
monument boundary to dam 12**

Item No.	Spec. No.	Short Description	Unit	Quantity	Unit Price Lining/Pipe	Unit Price Excavation	Total Unit Price	Amount	Slope	Area	WP	Velocity (fps)	Max Flow (cfs)
CHANNELS(Excavation and Lining)													
			7 inches	n =									
			Thickness =										
			Earthwork=										
			Concrete Lining =										
			\$2.50 CY										
			\$253.25 CY =										
			DEPTH(ft)										
			BOTTOM WIDTH(ft)										
			10										
			1	LF	\$93.69	\$1.11	\$94.80	\$0	0.0226	12.0	14.47	15.21	182.49
			2	LF	\$119.12	\$2.59	\$121.71	\$0	0.0226	28.0	18.94	22.36	626.00
			3	LF	\$144.56	\$4.44	\$149.00	\$0	0.0226	48.0	23.42	27.80	1334.60
			4	LF	\$169.99	\$6.67	\$176.66	\$0	0.0226	72.0	27.89	32.43	2334.72
			5	LF	\$195.43	\$9.26	\$204.69	\$0	0.0226	100.0	32.36	36.56	3655.54
			6	LF	\$220.86	\$12.22	\$233.08	\$1,515.034	0.0226	132.0	36.83	40.35	5326.36
			7	LF	\$246.30	\$15.56	\$261.85	\$0	0.0226	168.0	41.30	43.90	7375.84
			8	LF	\$271.73	\$19.26	\$290.99	\$0	0.0226	208.0	45.78	47.27	9831.90
			9	LF	\$297.17	\$23.33	\$320.50	\$0	0.0226	252.0	50.25	50.48	12721.70
			10	LF	\$322.60	\$27.78	\$350.38	\$0	0.0226	300.0	54.72	53.57	16071.68

ENLARGE DAMS 5 & 11 --COMMON TO OPTION 1--

Item No.	Spec. No.	Short Description	Unit	Quantity	Unit Price Lining/Pipe	Unit Price Excavation	Total Unit Price	Amount	Slope	Area	WP	Velocity (fps)	Max Flow (cfs)
		ENLARGE DAM 5 1.14X (100-yr vol: from 31.5 to 35.8 ac-ft)	CY	6937		\$3.50	\$3.50	\$24,279.50					
		ROW	AC	2	\$10,000.00			\$20,000					
		ENLARGE DAM 11 1.6X (100-yr vol: from 29 to 45.5 ac-ft)	CY	26620		\$3.50	\$3.50	\$93,170.00					
		ROW	AC	2.5	\$30,000.00			\$75,000					
		TOTAL CONSTRUCTION COST (Based on Excavation)						\$117,449.50					
		TOTAL ROW COST		4.5				\$95,000.00					

**DAM 12 DIVERSION PIPE FROM DAM 12 TO I-40 DIVERSION
--COMMON TO OPTION 2--**

Item No.	Spec. No.	Short Description	Unit	Quantity	Unit Price Lining/Pipe	Unit Price Exca- vation	Total Unit Price	Amount	Slope	Area	WP	Velocity (fps)	Max Flow (cfs)
		54" RCP, IV	LF	350	\$126.50	\$47.52	\$174.02	\$60,907.00	0.0320	15.5	11.88	24.48	379.43
		ROW	AC	0.48			\$0.00	\$0.00					
		72" RCP, IV	LF	1250	\$136.40	\$63.36	\$199.76	\$249,700.00	0.0147	27.6	15.84	20.10	553.84
		ROW	AC	1.72			\$0.00	\$0.00					
		84" RCP, IV	LF	650	\$144.00	\$73.92	\$217.92	\$141,648.00	0.0106	37.5	18.48	18.92	709.42
		ROW	AC	0.90			\$30,000.00	\$0.00					
		Install 66" pipe in Dam 12											
		Excavation and installation											
		TOTAL CONSTRUCTION COST											
		TOTAL ROW COST											
		\$0											

Install 66" pipe in Dam 12

Excavation and installation

TOTAL CONSTRUCTION COST

TOTAL ROW COST

\$0

DAM 5 DIVERSION PIPE FROM DAM 5 TO I-40 DIVERSION

Item No.	pec.	NoShort	Description	Unit	Quantity	Unit Price	Unit Price	Total Unit	Amount	Slope	Area	WP	Velocity (fps)	Max Flow
54			54" RCP, IV	LF	2200	\$123.20	\$47.52	\$170.72	\$375,584.00	0.0195	15.5	11.88	19.11	296.19
			ROW	AC	2.53			\$50,000.00	\$0.00					

**DAM 12 DIVERSION PIPE FROM DAM 12 TO I-40 DIVERSION
--COMMON TO OPTION 2--**

Item No.	Spec. No.	Short Description	Unit	Quantity	Unit Price Lining/Pipe	Unit Price Exca- vation	Total Unit Price	Amount	Slope	Area	WP	Velocity (fps)	Max Flow (cfs)
		54" RCP, IV	54	LF	350	\$126.50	\$47.52	\$174.02	\$60,907.00	0.0320	15.5	11.88	379.43
		ROW		AC	0.48		\$0.00	\$0.00					
		72" RCP, IV	72	LF	1250	\$136.40	\$63.36	\$199.76	\$249,700.00	0.0147	27.6	15.84	553.84
		ROW		AC	1.72		\$0.00	\$0.00					
		84" RCP, IV	84	LF	650	\$144.00	\$73.92	\$217.92	\$141,648.00	0.0106	37.5	18.48	709.42
		ROW		AC	0.90		\$30,000.00	\$0.00					
		Install 66" pipe in Dam 12											
		Excavation and installation						\$50,000					
		TOTAL CONSTRUCTION COST						\$502,255					
		TOTAL ROW COST						\$0					

DAM 5 DIVERSION PIPE FROM DAM 5 TO I-40 DIVERSION

Item No.	pec.	NoShort	Description	Unit	Quantity	Unit Price	Unit Price	Total Unit	Amount	Slope	Area	WP	Velocity (fps)	Max Flow
54"	RCP, IV			LF	2200	\$123.20	\$47.52	\$170.72	\$375,584.00	0.0195	15.5	11.88	19.11	296.19
	ROW			AC	2.53			\$50,000.00	\$0.00					

