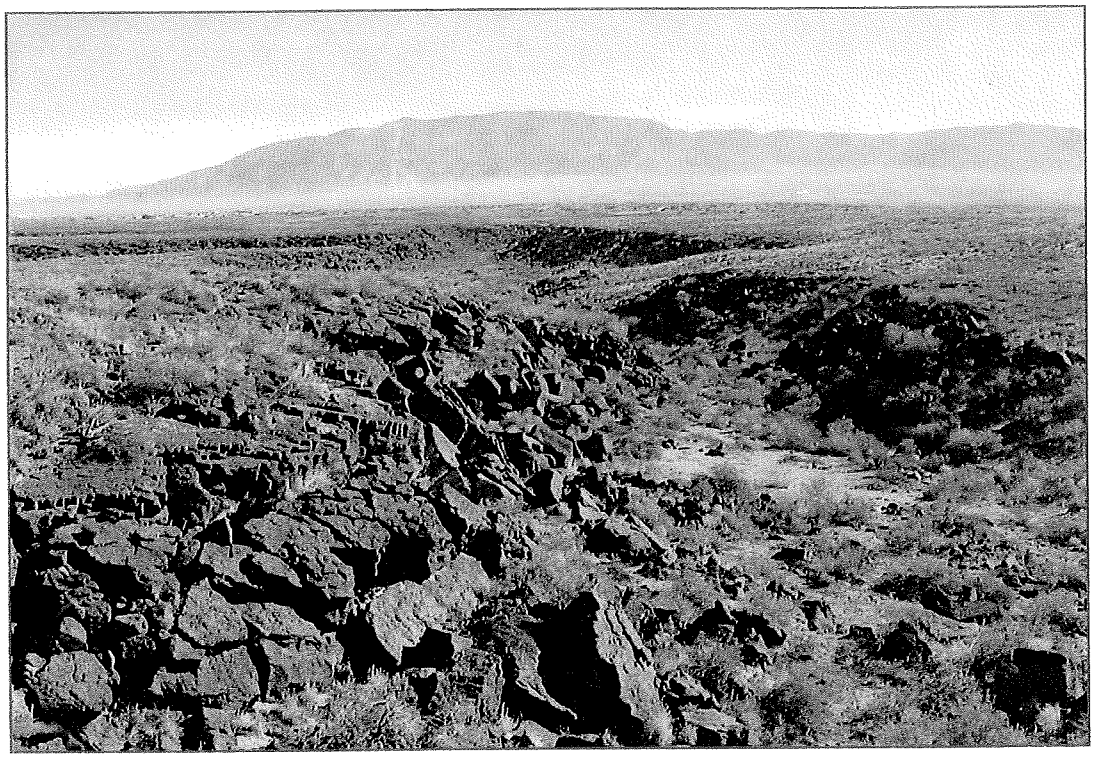
BOCA NEGRA – MARIPOSA ARROYO DRAINAGE MANAGEMENT PLAN

Prepared For:

ALBUQUERQUE
METROPOLITAN ARROYO
FLOOD CONTROL AUTHORITY



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April 2005

RESOLUTION 2005-7

FURTHER MODIFICATIONS OF THE DRAINAGE MANAGEMENT PLAN WESTERN ALBUQUERQUE METORPOLITAN AREA AS IT PERTAINS TO THE BOCA NEGRA AND MARIPOSA ARROYO WATERSHEDS

WHEREAS, the Drainage Management Plan Western Albuquerque Metropolitan Area Resolution 1975-8 adopted by AMAFCA, July 24, 1975, called for the construction of the Boca Negra Arroyo and Mariposa Arroyo Channels.

WHEREAS, Resolution 1980-15 revised AMAFCA's Drainage Policy and provided additional criteria for development in the Albuquerque area watersheds.

WHEREAS, in 1983, AMAFCA completed design and construction of the Mariposa Detention Basin and upstream channels on the Boca Negra and Mariposa Arroys below the volcanic escarpment;

WHEREAS, the CITY participated in the planning, design and funding for construction on the Mariposa Detention Basin and upstream channels on the Boca Negra and Mariposa Arroyos flood control facilities; and

WHEREAS, in 1983, the CITY assumed ownership and maintenance of the Mariposa Detention Basin and the upstream channels pursuant to the Deed Agreement between the CITY as grantee and AMAFCA as grantor for the Mariposa Detention Basin System within Taylor Ranch, dated August 1, 1983, and recorded as document number 8355861. The CITY has since completed construction of multi-use park facilities within Mariposa Detention Dam; and

WHEREAS, in 1991, the CITY and AMAFCA shared in the cost of improvements to the Boca Negra Arroyo between San Ildefonso Drive and Tesuque Street, which is now the upper limit of channel improvements on the Boca Negra Arroyo; and

WHEREAS, in 2001, recognizing that the Boca Negra - Mariposa watershed had not been restudied since the construction of the Mariposa Detention Dam and upstream channels, AMAFCA contracted for a hydrology and hydraulic study of the Boca Negra and Mariposa Watershed; and

WHEREAS, the results of the study indicate that existing conditions 100-year storm flows are contained within the Mariposa Detention Dam and upstream channels, but that future developed 100-year storm flows would exceed the capacity of the Mariposa Detention Dam and certain reaches of the upstream channels; and

WHEREAS, AMAFCA and the CITY recognize the impending development in the area and the potentially limited downstream storm water capacity, and recognized the need for preparation of a Drainage Management Plan for the Boca Negra and Mariposa Watersheds.

WHEREAS, in August 2003, the Board approved an engineering service contract with Resource Technology Inc. to prepare the Boca Negra - Mariposa Arroyos Drainage Management Plan.

NOW THEREFORE, BE IT RESOLVED BY THE BOARD OF DIRECTORS OF THE ALBUQUERQUE METROPOLITAN ARROYO FLOOD CONTROR AUTHORITY:

1. The improvements recommended by the Boca Negra - Mariposa Arroyo Drainage Management Plan, prepared by Resource Technology, dated April 2005, are hereby adopted, subject to the following.

    a. Modifications to the adopted plan may be as circumstances dictate, but shall be approved by the AMAFCA Board of Directors.

    b. Final decisions regarding arroyo treatments shall be made in accordance with existing and future planning documents, including but not limited to the Rio

Bravo Sector Plan, the Facility Plan for Arroyos, the Bikeways Master Plan, and the Trails Facility Plan.

c. The Drainage Management Plan utilizes various criteria to establish general project priorities from a technical perspective, these do not necessarily reflect the priorities to be used by the Board of Directors for funding and construction. Specific projects, if any, will be funded and scheduled by AMAFCA Board action based on evaluation of public safety needs, cost sharing benefits, orderly development of flood control infrastructure, overall community needs and regional planning requirements.

d. The Drainage Management Plan identifies drainage and flood control infrastructure necessary to provide protection to the community from storm water runoff, the adoption of this plan does not imply a commitment on the part of AMAFCA Board of Directors to build any or all of said facilities. Financing and scheduling of improvements are subject to the availability of the public funds and to initiatives by the private sector.

2. The adoption of this Resolution modifies the Western Albuquerque Metropolitan Area Drainage Management Plan, and any other previous Resolutions or actions by the AMAFCA Board of Directors regarding Boca Negra and Mariposa Arroyos.

PASSED, ADOPTED AND SIGNED THIS 26th **DAY OF** May **, 2005**

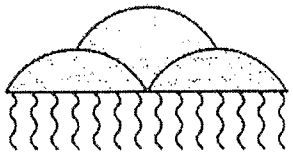
Ronald D. Brown, Chairman

ATTEST:

Tim Eichenberg, Secretary/Treasurer

BOCA NEGRA – MARIPOSA ARROYO
DRAINAGE MANAGEMENT PLAN

Prepared For:



ALBUQUERQUE
METROPOLITAN ARROYO
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April 2005

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EXECUTIVE SUMMARY

The twenty-one square mile Boca Negra watershed extends east from the rim of the Rio Puerco Valley to the Mariposa Basin at Taylor Ranch Drive near Montaño Road. It crosses the West Mesa escarpment at the Petroglyph National Monument. The lava flows of the Albuquerque Volcanoes are a major feature of the land surface above the escarpment, and they control the natural drainage channels and slopes. These rock formations also give the area its archeological issues / parks /problems /sensitivity. Development is progressing into the area at a rapid pace, with three Special Assessment Districts (SAD Nos. 227, 228, and 230), and several subdivisions and roadways under construction.

During the preparation of the Drainage Management Plan (DMP), RTI held several meetings with property owners in the watershed, including the National Park Service, State Historic Preservation Office, City of Albuquerque including Open Space, Drainage Design, Aviation, and Planning Divisions, City of Rio Rancho, Bernalillo County Public Works, and members of the development community. One meeting was held in the field at the North Geologic Window, which is a site of particular concern for the National Park Service.

This Drainage Management Plan contains substantial information on the characteristics of the watershed, identifies past drainage studies that have been performed, and describes recommended drainage improvements necessary to provide master drainage facilities above the escarpment, which will also prevent flooding of existing drainage facilities below the escarpment.

Two key assumptions in this plan are that the Double Eagle II Airport pond will control 100-year developed condition outflows to 45 cfs, and that Quail Ranch Subdivision will limit 100-year developed condition outflows into Boca Negra Arroyo to 325 cfs at its' eastern boundary.

Some of the major drainage improvements included in the plan are as follows:

- A major detention pond (storage volume of 173 acre-feet) on the main Boca Negra Arroyo in City of Albuquerque Open Space west of the North Geologic Window with a 36-inch diameter outfall storm drain pipe to reduce downstream flows and minimize developed condition drainage and erosion impacts to the Geologic Window.

- Boca Negra Dam (storage volume of 200 acre-feet) near the intersection of Universe Blvd. and Unser Blvd., with a major storm drain outfall pipe in existing Atrisco Road, down the escarpment, and discharging into the existing Boca Negra Arroyo near Petroglyph Park. The Boca Negra Dam will be the initial and primary drainage collection and control facility above the escarpment on Boca Negra Arroyo, and will control drainage from the Universe Blvd. storm drain, Unser Blvd. storm drain, and private and Open Space lands to the west of Unser Blvd.

- Boca Negra Arroyo channel improvements between the NM State Land Office property (just downstream from the North Geologic Window) and Boca Negra Dam to provide developed condition drainage conveyance, erosion control, and floodplain containment.

The proposed watershed drainage management plan will sufficiently reduce downstream flows to allow existing improvements below the escarpment to remain as currently constructed; the recommended projects will significantly reduce the frequency and volume of runoff reaching Mariposa Basin. The proposed improvements will reduce 100-year developed condition inflows into the basin from 6470 cfs without the improvements to 1580 cfs, thus reducing the magnitude and frequency of flooding in the park section of Mariposa Basin.

Also, the existing Boca Negra Arroyo channel downstream from the escarpment has the capacity to convey this reduced flow rate without any changes to the channel or crossing structures. Without the proposed improvements, this reach of the arroyo has inadequate freeboard (additional channel depth to control waves, flow disturbance, debris, minor sedimentation, etc.) for existing condition 100-year flows (approximately 2000 cfs) and is totally inadequate for developed condition 100-year flows (>6000 cfs). The reduced downstream flows also eliminate potential capacity problems at the San Ildefonso St. bridge which is presently at full capacity (2000 cfs).

1.0 INTRODUCTION

1.1 Purpose and Scope

The Albuquerque Metropolitan Arroyo Flood Control Authority (AMAFCA) commissioned the development of a drainage management plan for Boca Negra Arroyo and it's tributary, Mariposa Arroyo; both arroyos flow into the Mariposa Detention Basin. Peak discharges and volumes for the 10% (10-year) and 1% (100-year) flood for current existing and future developed conditions are included in this analysis. Resource Technology, Inc. used the hydrologic and hydraulic analyses discussed in this report to investigate future drainage improvements to be considered for this watershed.

The purpose of the Boca Negra-Mariposa Arroyo Drainage Management Plan is to prepare a coherent framework that will serve as the basis for ongoing and future land development through appropriate storm drainage improvements within the watershed. Utilizing existing studies where possible, supplemented with additional hydrologic and hydraulic analyses when required, and coordinating with the activities of other governmental agencies and private parties, the goal of the project is to provide a conceptual framework for future storm water management activities. Furthermore, proposed solutions are integrated with existing facilities to the greatest extent possible, and make maximum utilization of existing right-of-way and drainage easements. Where additional right-of-way or drainage easements are required, these are identified.

This Drainage Management Plan builds upon the Boca Negra-Mariposa Arroyos, Hydrologic and Hydraulic Analysis (H & H Study) conducted by Resource Technology, Inc. in 2002. Issues identified in that report were updated and form the basis for the analyses and recommendations in this plan.

Resource Technology, Inc. also hosted three meetings and two field visits with the National Park Service, Bernalillo County, the City of Albuquerque, the City of Rio Rancho, AMAFCA and other government agencies to obtain input on concerns regarding proposed development within the study area. Discussions with the attendees determined that future developed conditions need to be assessed and modeled for proposed scenarios as described in this report.

1.2 Study Objectives

The following is a general outline of the scope of the study and how each item was addressed:

1. Review of previous studies and reports for the study area.
   Seventeen previous studies of the area were reviewed and summarized. These summary descriptions chronicle the history of drainage facility development in the watershed and provide a background for this report.

2. Summary and comparison of all pertinent information.
   Hydrologic data differences among the various studies are compared and evaluated as described in Section 4 of this report.

3. Aerial photography and mapping.
   The 1999 orthophotography and LIDAR mapping available from Bernalillo County was used as base mapping.

4. Field surveying to identify and measure physical constraints.
   The downstream improved channels were surveyed for the H & H Study, and up-dates for planned improvements around the Tesuque and Mojave street crossings, were added.

5. Hydrologic analysis of total watershed area.
   Based on the H & H Study, sub-basin mapping and modeling were up-dated for current road construction and current development plans.

6. Hydraulic analysis of major arroyos.
   The flow capacity of pressure flow in pipes or structures was determined with the Darcy-Weisbach Equation and the FlowMaster program; and HEC-RAS v.3.11 was used for the improved Boca Negra and Mariposa Channels below the escarpment, and a proposed new channel downstream from the North Geologic Window.

7. Coordination with other public works agencies.
Three meetings with city, state and interested agencies were held at the Resource Technology, Inc., office in Albuquerque; and two meetings were held on-site in the Boca Negra Arroyo, at the North Geologic Window.

8. Coordination with planning agencies.
Resource Technology, Inc. has met with or interviewed agencies, landowners, and consultants involved in the development of Double Eagle II Airport, Quail Ranch, SAD 227 and 228, The Trails Subdivision, La Cuentista Subdivision, the crossing structures at Tesuque and Mojave Streets, and Unser Boulevard realignment.

9. Development of drainage management options.
Future conditions were modeled for options regarding diversions, detention facilities and flow routing.

10. Project coordination
Progress, evaluation and coordination meetings, and periodic meetings were conducted with other governmental agencies, consultants involved in projects within the study area, landowners and developers, citizen advisory groups, and elected officials.

1.3 Existing Ownership, Land Use and Platting

The lands within the Boca Negra watershed are owned, controlled or managed by a wide variety of individuals, organizations and government agencies (see Figures 1.A and 1.B). Of the government agencies, the City of Albuquerque is the largest landowner, with the State of New Mexico and the United States owning or controlling other large tracts. City of Albuquerque Open Space Division controls the shooting range area at the west end of the watershed and the Soil Amendment Facility and adjacent lands northwest of the Double Eagle II Airport. City of Albuquerque Open Space areas around the volcanoes, the North and South Geologic Windows and Petroglyph Park at the escarpment are managed by the National Park Service.

1.3.1 Atrisco Boulevard/Drive

Atrisco Drive was the name of the service road following the high pressure natural gas line that crosses the escarpment a short distance south of Boca Negra Canyon. The name Atrisco Drive or Boulevard was also applied to the road going up Boca Negra Canyon.

1.3.2 Unser Boulevard

Unser Boulevard has been designated as a limited access principal arterial on the Long Range Major Street Master Plan for the Albuquerque Urban Area. The proposed plan is to construct a north-south divided, limited access principal arterial up Albuquerque's and Rio Rancho's west side. In the study area, the former Atrisco Drive below the escarpment is now Unser Boulevard.

Drainage improvements associated with Unser Boulevard are major features in all drainage plans for Boca Negra Arroyo. The present Unser is also known as Atrisco Drive going through Boca Negra Canyon. This is also the only route that the National Park Service has agreed to be used to convey Boca Negra Arroyo flows down the escarpment. This road right-of-way has a variable width but is adequate for the proposed conduit for the expected design flows.

A new alignment for Unser Boulevard to ascend the escarpment from Montaño Road has been designed concurrent with SAD 227 and is currently under construction. This route follows a long established natural gas pipeline right-of-way that generally follows what has previously been known as Atrisco Drive. As part of the SAD 227 improvements, the new Unser Boulevard will include a storm drain pipe system that will divert developed condition flows out of the Boca Negra watershed and discharge to the San Antonio Arroyo channel. The developed SAD 227 area between Boca Negra Arroyo channel and the South Branch of Boca Negra Arroyo channel will drain to the SAD 227 storm drain in Unser Boulevard.

North of Boca Negra Canyon, Unser Boulevard will be realigned from its earlier platting and follow a higher path slightly to the west. The new alignment will connect Unser Boulevard with Lyon Boulevard in Paradise Hills. Lyon will also be renamed as Unser Boulevard. The earlier eastern alignment of Unser Boulevard northeast of the head of Boca Negra Canyon is now called Kimmick Drive. Another planned storm drain pipe system in Unser Boulevard will collect runoff from the areas extending to Paseo Del Norte. This storm drain will discharge to a proposed detention pond at the top of Boca Negra Canyon, the Boca Negra Pond.

1.3.3 Universe Boulevard

The former Compass Drive was renamed as Universe Boulevard and follows a rocky natural divide south from the east side of Ventana Ranch Subdivision to the top of Boca Negra Canyon. A storm drain pipe system along Universe Boulevard will convey runoff from the Trails Subdivision and the proposed APS High School to the detention pond at the top end of Boca Negra Canyon.

1.3.4 Paseo del Norte

Paseo del Norte (PdN) has been designated as a limited access east-west principal arterial on the Long Range Major Street Master Plan for the Albuquerque Urban Area. Paseo Del Norte will ultimately be extended from the escarpment in the Piedras Marcadas watershed west to the future Paseo del Volcan alignment in Quail Ranch and to the Northwest Loop Road in the Rio Puerco Valley. A 2-lane roadway was built from the existing Paseo del Volcan intersection to borrow pots inside the Quail Ranch east boundary in April of 2004.

To date, Paseo del Norte has been constructed from the existing Paseo del Volcan to Universe. The Universe to Golf Course Road segment of PdN is currently under design with some of the eastern portions already constructed. The design of the remainder of the project (from Universe to Golf Course Road) is sponsored by the City of Albuquerque. 3000 feet west of the existing Paseo Del Volcan, a future extension of Paseo del Norte will re-enter the Boca Negra watershed where the drainage area is within Quail Ranch and the City of Rio Rancho.

Paseo del Norte west of Universe is the divide between the Boca Negra and Piedras Marcadas watersheds from Kimmick Drive on the east to west of the Trails Subdivision at the steel water reservoir. This divide may be extended further west along Paseo del Norte. The natural watershed divide is located up to 1000 feet south of Paseo del Norte from west of the reservoir to the Quail Ranch east boundary. This area between Paseo del Norte and the natural watershed divide is an area of potential diversion to the Boca Negra Arroyo.

Within Quail Ranch to the proposed Paseo del Volcan three contributing sub-basins are located on the north side of the road.

1.3.5 Paseo del Volcan

Paseo del Volcan is the existing access road to the Double Eagle II Airport (DE II) from Interstate 40. The Storm Drainage Master Plan for Double Eagle II recommends installation of storm drain pipes connecting the proposed detention pond system along Paseo del Volcan. The existing Paseo del Volcan is now the eastern border for airport development. The road extending north from the hangars at DE II has also been called Paradise Boulevard but will be referred to as the existing Paseo del Volcan in this report.

A new Paseo del Volcan alignment has been proposed along the west side of the airport lands and extends through Quail Ranch and beyond. The proposed western re-alignment will affect drainage paths in the Boca Negra watershed at the north end of the Shooting Range and in Quail Ranch. The future Paseo del Volcan will be the cut-off point for diverting runoff from the Boca Negra drainage area on the west side of Quail Ranch to the Calabacillas Arroyo.

1.3.6 Other Roadways and Routes

The proposed Scenic Drive runs straight west 1.5 miles along a quarter section line from the top of Boca Negra Canyon to Boulevard de La Oest at the Open Space boundary. The drainage areas in this part of the watershed were modeled as discharging to the Boca Negra Pond, as proposed by the engineering consultants for SAD 227.

The proposed Molten Rock Road 1000 feet south of Scenic Drive was modeled as discharging into the SAD 227 storm drain to the San Antonio system.

Rainbow Boulevard begins at Universe Boulevard and follows the natural gas transmission line along the former Atrisco Road alignment to The Trails Subdivision where it turns due north to connect with the central Ventana Ranch collector street. This road alignment has favorable grades to conduct flows to the Boca Negra Pond.

Faciel Road along the south boundary of the North Geologic Window is the shortest route to the Boca Negra Arroyo for the discharge pipe from the North Geologic Window Pond proposed in this plan.

The Double Eagle II Airport trail and utility (water and sanitary sewer) route alignment within the City of Albuquerque Open Space requires the sanitary sewer pipe to be a force main. However, some segments of the alignment have favorable grades for gravity drainage in storm drains, and were considered as potential alignments for proposed storm drains.

The Double Eagle II Airport area is predominantly owned by the City of Albuquerque, although it also contains state and private land. Molzen-Corbin and Associates has recently written a drainage management plan for the Double Eagle II Airport and the results of that study have been included in hydrologic modeling for this study. The outlet hydrograph from the system of airport ponds was input to the hydrologic models for this study.

Black Ranch, with the Quail Ranch development, is the largest privately owned land tract in the watershed. Several units of Volcano Cliffs were platted approximately 40 years ago with owners and heirs holding single and multiple lots of varying sizes. This diverse ownership pattern with minimal attention to drainage needs, has resulted in a very difficult situation, such that land development is not easy to accomplish.

Areas below the escarpment are developed primarily with single-family residences at densities averaging approximately five dwellings per acre. Figure 1.C identifies street names in the study area below the escarpment.

Land use above the escarpment is dominated by recreational use of desert habitat, some cattle grazing on Quail Ranch and the Double Eagle II Airport facilities. These land uses are affected by an extensive lava field as shown on Figure 1.D. The city Shooting Range, a sewage sludge disposal area and a rock quarry are other current uses. Quail Ranch is the only subdivision proposed in the western half of the watershed. On the eastern half, above the escarpment, earthmoving and rock blasting have recently begun on the SAD 227 Project. Other subdivisions in various stages of development, as shown on Figure 1.B, are La Cuentista, The Trails, Vista Vieja and a Albuquerque Public Schools high school site south of The Trails.

Below the escarpment most of the watershed is already developed. The only remaining area is Volcano Cliffs Unit 3 subdivision and a Post Office site on the west side of Tesuque Drive.

1.4 Transportation Corridors

Road names in the study area have changed over the time period of the several studies. With reference to Figures 1.A and 1.B, which locate the various features listed in the following discussion, the evolution of street names is as follows.

1.5 Other Agency Involvement

The Drainage Management Plan and the transportation design effort both involve multiple agency jurisdictions. These include AMAFCA, Bernalillo County, the City of Albuquerque, the State of New Mexico, the City of Rio Rancho and the National Park Service. City of Albuquerque departments have interests in the Boca Negra watershed that range from total preservation of historic conditions to development of an aerospace technical park. The landowners in the watershed have a similar range of interests. Therefore, coordination of effort among all these agencies was essential in the drainage plan development.

1.6 Concerns of Interested Agencies

Issues of concern to the attendees of the agency meetings were dominated by the National Park Service. They have requested that all runoff from developed lands be eliminated from Boca Negra Arroyo in the North Geologic Window. Other runoff from developed areas crossing the Petroglyph Park escarpment land will also be restricted. Historic flows through park lands that are usually allowed to follow existing drainage paths have not been modeled to the satisfaction of the National Park Service because they have not funded their own hydrologic studies for comparison. Until the National Park Service determines an acceptable historic flow rate, their preferred flow rate is assumed to be zero.

Also, the National Park Service states 23 tribes have interests in the North Geologic Window, but the identity of this group's members and its contacts are confidential to National Park Service personnel. All communication with these tribes concerning issues of adjacent land developments will be through the National Park Service. Visual effects of nearby improvements are also a concern to the National Park Service.

The municipality of Rio Rancho has recently annexed the Quail Ranch property and land to the east of Quail Ranch into its city limits. The annexation area extends east to approximately 600 feet west of the existing Paseo del Volcan and south to approximately 600 feet north of Paseo del Norte (See Figure 1.A). Rio Rancho has historically required developers to control runoff at undeveloped condition rates; however, to reduce downstream impacts, stricter controls will be required in the Boca Negra watershed.

According to the West Side Strategic Plan, adopted by the City of Albuquerque in 1997, Bernalillo County has considered Quail Ranch to be a high priority for expansion of services. Also, since it was annexed by Rio Rancho, Quail Ranch continues to be a high priority. However the North Mesa area east of Quail Ranch was assigned a low priority. The only area not inside the cities of Albuquerque or Rio Rancho municipal limits are parts of the North Geologic Window and the North Mesa (of the Westside Strategic Plan). This area is bound by the Alameda Grant South Boundary on the south, The Trails Subdivision on the east and the Rio Rancho City Limits on the north side of Paseo del Norte and west side of the existing Paseo del Volcan.

The State Historic Preservation Officer and interested archeologists with the University of New Mexico have attended meetings and one site visit and discussed locations of historic sites along Boca Negra Arroyo below the North Geologic Window and at the Ladera Playa 2 southwest of Bond Volcano. The sites that will be developed should be excavated and recorded by archeologists before earthwork is begun.

The City of Albuquerque Public Works Department is concerned with keeping upstream developed conditions compatible with the capacities of existing downstream facilities. Special Assessment Districts (SADs) are being used to create a coherent pattern of development for expansion of services by the City of Albuquerque. City of Albuquerque Open Space prefers no improvements on lands they manage. They will accept improvements that have minimal visual or environmental impacts that provide enhancements and protection of park features. However, they have areas of aesthetic interest around the North Geologic Window that should be protected. Because AMAFCA is concerned with the maintenance of proposed ponds and channels, a few large ponds which would require less maintenance than many small ponds, were selected for this plan.

1.7 Related Master Drainage Plans – Comparison With Previous Studies

The hydrologic data in previous reports are presented on Table 1 for runoff volume and watershed area. Comparing the 2001 Condition study to the Mariposa Basin Regional Athletic Complex study by Easterling and Associates, Inc., June 1991, a slight difference in rainfall input, 2.65 inches versus 2.66 inches, applied over the area of 21.22 square miles accounts for one third of the increase in volume from 396 acre feet in the former model to 433 acre feet in the current model. A decrease in peak flow from 3042 cfs in the former model to 2022 cfs in the current model and an increase in time to peak from 2.07 to 2.45 hours in the current model cannot be fully explained without a more detailed analysis of the former model. It appears that in the former model land treatments in the upper area of the basin produce less runoff and downstream areas produce more runoff.

The following studies were reviewed and individual study summaries are included in Appendix A:

1. Drainage Management Plan, Western Albuquerque Metropolitan Area, Matotan and Associates, 1974 and August 1975
2. Hydrologic Report-San Antonio, Mariposa, and Boca Negra Arroyos, Part1, Fred Denney and Associates, Inc., October, 1980
3. Design Report Mariposa Diversion, Boca Negra Improvements & Detention Basin, Denny-Gross & Associates, 1982
4. Far Northwest Drainage Management Plan, Bohannon-Huston, Inc., March 1986
5. Unser Boulevard, Dellyne to Paradise, Drainage Report, Leedshill-Herkenhoff, 1990
6. Mariposa Basin Regional Athletic complex Study, Phase I, Easterling & Associates, Inc., June 1991
7. Black Ranch Drainage Management Plan, Easterling & Associates, Inc., September 1993 Update
8. Mariposa Basin Athletic Regional Athletic Complex, Phase II, Resource Technology, Inc, 1994
9. Flood Insurance Study, FEMA, 1983, rev. 1996
10. Westside Strategic Plan, COA Planning Department, rev. 2000
11. Boca Negra-Mariposa Arroyos, Hydrologic & Hydraulic Analysis, Resource Technology, Inc., December, 2002
12. SAD 227, Unser Boulevard Middle Section Drainage Report, Wilson and Company, June 2003
13. SAD 228, Wilson and Company, Inc., July 2003
14. Double Eagle II Municipal Airport, Storm Drainage Master Plan, Molzen-Corbin and Associates, December 2003
15. La Cuentista Subdivision Drainage Report, Wilson & Company, Inc., 2003
16. The Trails Subdivision, Master Drainage Study, Wilson & Company, Inc., 2004
17. Vista Vieja Drainage Report, Wilson & Company, Inc., 2004

2.0 GENERAL INFORMATION

2.1 Site Location and Description

The Boca Negra-Mariposa Arroyo Drainage Management Plan project area is located in the northwest quadrant of Albuquerque. The watershed of the Boca Negra-Mariposa Arroyos. Within the watershed boundary of the existing condition totals 21.8 square miles (Figure 1.A). The watershed is bounded on the northwest by the Calabacillas Arroyo basin and on the northeast by the Piedras Marcardas Arroyo basin approximately along the Paseo del Norte corridor. It is bounded on the south by the San Antonio Arroyo basin approximately on a line projected west from Montaño Road. The area is located mostly on the surface of the eastward sloping west mesa of Albuquerque, with a small area below the escarpment.

The north western portion of the Boca Negra watershed (Quail Ranch) was recently annexed by the City of Rio Rancho and is the subject of a private development plan. The annexation action along with other watershed development activity in recent years has led to renewed interest in solving drainage problems in this area.
The area mapped as North Mesa, in the West Side Strategic Plan, between Quail Ranch and Ventana Ranch, north of the Alameda Grant south boundary is the only part of the Boca Negra watershed located in Bernalillo County and not within any city limits.

2.2 Basin Characteristics

Elevations in the lower watershed range from approximately 5108 ft. near Mariposa Detention Dam to 5180 ft. at the base of the west mesa escarpment. Above the escarpment, elevations range from 5315 ft. at the head of the Boca Negra Canyon to 6156 ft. at the sand dunes on the west edge of the mesa, approximately 10 miles to the west.

The main Boca Negra Arroyo extends from the east edge of the Rio Puerco Valley on the west side of the watershed, across the mesa to the escarpment at the Petroglyph Park. The arroyo originates on privately owned land of the Black Ranch. Near midway across the mesa, the main channel enters City of Albuquerque Open Space lands and National Park administered land known as the North Geologic Window. From that location to the east edge of the mesa, the drainage area consists of privately owned platted lots within several units of Volcano Cliffs Subdivision. Discontinuous right of way and easements exist along some of the drainage channels.

The drainage area dividing line between the main arroyo and South Branch of Boca Negra Arroyo extends from the north side of the Soil Amendment Facility (SAF) to Butte Volcano. The South Branch originates west of Butte and Bond Volcanoes located on the east side of the City of Albuquerque Aviation lands. This arroyo drains east to join the main arroyo just below the escarpment, on the east side of existing Unser Boulevard, formerly Atrisco Drive. All runoff in the South Branch west of 81st Street drains from Open Space or National Park Service Lands.
The Soil Amendment Facility/County Jail (SAF) has a berm and ponding area capable of containing the on-site one hundred year runoff; and, therefore, this area was considered as non-contributing for this study.

There are two large natural playas in the southwest part of the study area. The area north of the City of Albuquerque Shooting Park and west of the SAF to the western edge of the mesa drains to a playa that can contain more than the one hundred year runoff. Consequently, this drainage area into the playa was considered non-contributing.

At the Double Eagle II Airport, the northeast half of the runways and taxiways, the aircraft parking areas and the hangars at the north end currently drain to a second playa on the west side of the volcanoes (SBP-3 of the DE II Storm Drainage Master Plan, Molzen-Corbin, 2003). Under existing conditions, this playa spills to the South Branch of Boca Negra Arroyo during storm events greater than the 100-year runoff. Generally, the southern half of the existing runways and taxiways drain south to the Mirehaven Arroyo watershed and were not investigated in this study.

The Storm Drainage Master Plan for Double Eagle II Airport proposes to construct additional detention (initially retention) ponds on the airport property. These new ponds will intercept much of the existing drainage contributing area to the second playa. Controlled releases from these new ponds will be diverted north with an outfall into the main Boca Negra Arroyo at a maximum rate of 43 cfs. Therefore, the remaining area contributing runoff to this second playa was also considered non-contributing. The South Branch of the Boca Negra Arroyo descends the escarpment slightly south of the City of Albuquerque (COA) Petroglyph Park Headquarters. The main arroyo descends the escarpment just north of the COA Petroglyph Park Headquarters. These two branches join below a narrowing of the embayment eroded into the face of the escarpment and downstream from two RCP culverts crossing Unser Boulevard.

With reference to Figure 2, 2001 Conditions Sub-basins and Analysis Points, four tributaries join Boca Negra Arroyo at the Boca Negra Canyon. The tributary draining sub-basins 46, 47 and 48 of the Existing Condition Model originates in The Trails Subdivision near Paseo del Norte and joins the Boca Negra as it falls over the escarpment. Another tributary draining the west side of the SAD 228 area (Volcano Cliffs Unit 18 and parts of others; Sub-basin 88 of the Existing Condition Model) falls over the escarpment north of the City of Albuquerque Petroglyph Park Headquarters and joins the Boca Negra Arroyo at the Tesuque Drive Crossing. The drainage from Sub-basin 51 falls over the escarpment west of the upper end of the road through the canyon. The Sub-basin 83 tributary originates at Butte Volcano on Open Space land and crosses the south side of Volcano Cliffs before joining the South Branch of the Boca Negra as it goes over the escarpment.

Downstream from the escarpment both the main arroyo and the South Branch are confined to deeply entrenched channels for a short distance, where active head-cutting is still occurring. However, within 300 feet of the arroyo confluence from Unser Boulevard east to Tesuque Drive, the arroyo drains in a broad natural channel across City Open Space/National Park Service lands. East of Tesuque Drive to the Mariposa Detention Basin, the arroyo channel has been improved and the grade stabilized with gabion and concrete drop structures.

The improved channel of Boca Negra Arroyo extends east from Tesuque Drive for one mile to the Mariposa Detention Basin and Dam, as shown on Figure 2. The adjacent roads are paved to City of Albuquerque standards with storm sewers discharging to the channel at road crossings.

The Mariposa Arroyo watershed is located in the northeast part of the study area. The watershed originates at Paseo del Norte and Universe Boulevard, drains southeast across the escarpment and combines with the Boca Negra Arroyo approximately 1000 feet west of the Mariposa Detention Basin.

2.3 Soils and Vegetation

From the escarpment to Double Eagle II Airport, basaltic lava flow rock is at or near the ground surface. This is the fundamental characteristic of the area. Development of these lands is difficult where utilities must be buried. The primary soil types, by USDA Texture Classification, are loams and clay loams. The major soil series is windblown sand and lightly cemented and calcified sand.

Soils within the study area between the escarpment and the west edge of the mesa are largely wind blown sand within the AmB (Alameda); BKD and BCC (Bluepoint); WAB and MWA (Madurez-Wink); LtB (Latene); and PAC (Pajarito) complexes, (Soil Conservation Service, 1977). Rock and shallow rock areas shown on the SCS map are AkC (Akela); KR (Kokan); RBE (Rock Outcrop) complexes. The soils are moderately permeable, well drained and subject to erosion. Vegetation generally covers about 15 percent of the surface area. Vegetation density increases near and in arroyos due to the concentration of runoff.

The soils in the lower area east of the escarpment are generally deep (from 4 to 10 feet in depth) and are classified into two soil series: Madurez-Wink and Bluepoint sandy loams (Soil Conservation Service, 1977). Runoff is rapid and the soils are subject to moderate erosion. The lower slopes have moderate vegetation density.

The surface soils west of the volcanoes are derived from sediments of the Santa Fe Group geologic formation and consist of Latene and Madurez-Wink Associations. The Santa Fe Group deposits have filled the deeply subsided Rio Grande Rift with sand, silt, clay and gravel in a shallow lake environment. These materials are unconsolidated to lightly cemented and have variable permeability depending on the degree of "caliche" development at shallow depths.

The northern two of Albuquerque's four major west side volcanoes are located approximately in the middle of the watershed as shown on Figure 2. East of the volcanoes the study area is underlain at a shallow depth by basaltic lava flows. The depth to rock is typically not more than ten feet. The buried lava flow surface is generally more hummocky near the volcanoes and is smoother near the edge of the mesa. Approximately five percent of the area east of the volcanoes has rock at the surface or less than one foot below the surface. The thickness of the lava flows varies from less than ten feet at the escarpment to more than one hundred feet near the volcanoes. These lava flows overlie Santa Fe Group sandy sediments.

Soils covering the lava flows are wind blown deposits of fine sand, and stream-transported sand and gravel derived from Santa Fe Group materials to the west. The geologic structure of the mesa is evident as north-south trending faults that step down to the east.

Soils of the west mesa above the escarpment are less susceptible to moisture related swell and collapse as are common on Albuquerque's East Mesa. Runoff infiltration features were discussed in the Black Ranch Drainage Report though any specific site should have a subsurface investigation. Shallow rock will limit water infiltration in the area from the escarpment to the existing Paseo del Volcan. West of the existing Paseo del Volcan, well developed caliche near the ground surface will also limit infiltration in some locations.

2.4 Existing Drainage Infrastructure

The City of Albuquerque has three significant existing flood control structures in the watershed:
The Mariposa Detention Basin Dam and Reservoir/Park
The Boca Negra Arroyo channel
The Mariposa Arroyo channel

The following two flood control structures are planned in the watershed and are assumed to be existing developments for this study, as shown on Figure 3:

- The Double Eagle II Airport Pond System
- The Quail Ranch Western Area Diversion to the Calabacillas Arroyo

Three structures in the construction or design stage or under construction that are modeled in the Future Condition are:

- SAD 227 Storm Drain to San Antonio Arroyo
- Tesuque and Mojave Drive Crossings

2.4.1 The Mariposa Detention Dam and Basin/Park

Mariposa Dam is located along the Boca Negra drainage path from the mesa to the Rio Grande on the west side of Taylor Ranch Road and north of Montaño Road (Analysis Point AP 93.81, see Figure 2). AMAFCA built this structure in a natural depression in the 1980's. This AMAFCA facility became a City of Albuquerque Park in the early 1990's. This was made possible with the construction of an internal berm from material excavated from within the basin. The partitioning allowed low flows to pass directly to the Mariposa Diversion Channel and the San Antonio Arroyo system without flooding the entire reservoir area. The larger section is now a park with grass athletic fields, a paved parking lot and two sumps that collect runoff from this section. An emergency spillway, 300 feet wide, is constructed from soil-cement and asphalt paved to serve as the access road into the park.

During high runoff, flow spills over the internal berm and into a sump within the detention basin. In higher than 100-year existing condition flow situations, the park area would fill and the water surface would rise to a spillway discharging to Taylor Ranch Drive. The existing sump pond within the reservoir is emptied with electric pumps discharging to the low flow channel. The second sump pond in the parking lot has a controlled outlet to a storm drain at Taylor Ranch Road.

Elevations used in this study are NAVD1988. Elevations within the basin were determined from 1999 contour mapping obtained from Bernalillo County. The bottom of the low flow channel at the northwest (inflow) end is 5110 feet, and 5107 feet at the south (outflow) end. The sump in the park section of the basin has a bottom elevation at 5095 feet. The playing fields are at 5105 feet to 5109 feet and the parking lot is from 5105 to 5110 feet. The berm separating the two sections of the basin has an uneven top elevation of approximately 5115.5 feet and the emergency spillway is at 5119 feet. The perimeter embankment surrounding the entire basin is at 5121 feet.

For flows over approximately 560 cfs, the low flow channel fills and water spills over the internal berm into the park section of the basin. The low flow storage volume of 8 acre feet is less than the 2-year runoff volume, as determined in previous studies. The Boca Negra Arroyo enters the Mariposa Basin in the low flow partition of the basin.

For flowrates less than 560 cfs, runoff passes through the 8 feet by 6 feet box culvert under the embankment and Kachina Street to the Mariposa Diversion Channel.

For flows greater than 560 cfs, the excess water backs-up in the low flow channel until 8 acre feet has accumulated. At that point, the internal berm is overtopped and water spills over to a sump in the park area.

2.4.2 The Boca Negra Arroyo Channel

The Boca Negra Arroyo channel flows east from the confluence of the main arroyo and South Branch of Boca Negra Arroyo below the escarpment and east of Unser (Atrisco) Boulevard. Upstream from the Tesuque Drive crossing, the channel is less defined and unimproved. Downstream from this crossing the channel has been constructed with raised banks and a uniform slope with both cast in-place concrete and gabion drop structures. Riprap protection has been installed on several bank sections and at grade control drops in the channel.

The channel has an unlined bottom and a light to heavy growth of grass and brush. This channel receives flow from drop inlets near the two existing road crossings, a dip section at Tesuque (currently being replaced by culverts), and a bridge at San Ildefonso Drive. Storm drain outlets are also located at Mojave Street and Baer Place. Surface rundowns convey water from Goldrush Drive, Chuckwagon Trail, and Homestead Circle west of LBJ Middle School. A storm drain system from LBJ Middle School discharges to the channel northwest of the Mariposa Detention Basin.

2.4.3 The Mariposa Arroyo Channel

This channel is unimproved and not well defined north of Tesuque Drive, although the path down the escarpment is well incised. Above the escarpment there is a small natural playa. An existing drainage easement is shown through the Petroglyph Park on drawings in the Matotan (1975) Report. However, the Plat of Volcano Cliffs does not show easements or R.O.W. across the escarpment.

A drop structure and roadway bridge crosses the channel at Tesuque Drive. A storm drain pipe that enters the channel below Tesuque Drive collects water from an area as far away as Stag Horn Drive. In addition, there are drop inlets located in Mojave Street discharging to the channel. Street flow also passes through a surface rundown from the intersection of Painted Pony Trail and Brahma Drive.

Below Tesuque Drive, the channel is improved with raised banks and riprap bank protection. At San Ildefonso Drive crossing, the channel is concrete lined for a length of 300 feet. This channel combines with the Boca Negra Channel 1000 feet west of the Mariposa Detention Basin.

2.5 Assumed Existing Improvements

2.5.1 Double Eagle II Airport Pond System

The Double Eagle II Airport Pond System Ultimate Conditions will collect runoff that has historically flowed across National Park Service and City of Albuquerque Open Space Lands. The areas surrounding the terminal building and the hangars are within the South Branch of Boca Negra Arroyo watershed. The runoff from this area will be collected in ponds connecting to a pond at the northeast corner of the airport property through a deep storm drain pipe in existing Paseo del Volcan (also referred to as Paradise Boulevard). These ponds will be built as retention ponds until the downstream system is improved. For the Existing Condition model, the final pond will have a maximum controlled release rate of 43 cfs to Boca Negra Arroyo.

2.5.2 Quail Ranch Western Area Diversion

Quail Ranch is a single owner property with a masterplan for land use and infrastructure. The area was annexed into the City of Rio Rancho at the end of 2003 and the Paseo del Norte paving was extended to the east boundary of Quail Ranch in April of 2004. The planners of Quail Ranch have acknowledged the limitation of the downstream capacity and the National Park Service concerns for the Boca Negra Arroyo. To avoid these issues the plans for Quail Ranch include a diversion to the Calabacillas Arroyo from the Boca Negra watershed west of the proposed western alignment of the new Paseo del Volcan. This planned diversion parallels existing contours to a point slightly north of the proposed Paseo del Norte and Paseo del Volcan intersection. This diversion includes 2.9 square miles of the 5.5 square mile drainage area of Quail Ranch within the Boca Negra Watershed.

2.5.3 Quail Ranch East Side Detention Pond

According to the Black Ranch Drainage Management Plan, 1993 Update, the 2.6 sq. mi. drainage area of Quail Ranch remaining in the Boca Negra Watershed is a mix of commercial, residential, recreational and industrial uses. This report included discussion of reduced runoff discharge to the Boca Negra Arroyo. The assumed dam location below the confluence of the Boca Negra Arroyo and the tributary from open space and the airport is at the point where the Boca Negra leaves Quail Ranch. A maximum discharge of 325 cfs. (approximately half the 2001 Condition watershed runoff rate) from this Quail Ranch Pond was modeled as the Existing Condition. Improvements within Quail Ranch and open space may be used to achieve this controlled release.

2.5.4 SAD 227 Storm Drain

SAD 227 is under construction south of the Boca Negra Canyon within the Unser Boulevard crossing of the escarpment. This storm drain system will discharge to the San Antonio Arroyo. All developed Boca Negra watershed areas within SAD 227 (Sub-basin 227in Figure 4) will be collected in a pipe system and carried south in the Unser Storm Drain. Part of the north fork of the South Branch of Boca Negra Arroyo that drains both Open Space and private lands (Sub-basins 83B and 83C) will also be drained by the Unser Storm Drain; however, flows exceeding 229 cfs will go to the Boca Negra Pond.. The south fork of the South Branch of Boca Negra Arroyo (Sub-basins 80, 81, and 82) drains Open Space lands and will be passed across SAD 227 in a 72-inch pipe that outfalls at the top of the escarpment in the historic flow path. The corresponding sub-basins are shown on Figure 4.

2.5.5 Tesuque and Mojave Drive Crossings

The Tesuque and Mojave Drive crossings will be improved with box culverts. The Tesuque Drive crossing, a roadway dip section, is currently being replaced by culverts; and Mojave dead ends on both sides of the arroyo channel. The proposed box culverts are designed with capacities of 1900 cfs which is approximately the capacity at the San Ildefonso bridge and the existing channel near the bridge.

2.6 Existing Problem Areas

2.6.1 Specific Issues

The following issues were identified during the development of this plan: The developer and engineering consultant for Quail Ranch have not made any recent submittal concerning drainage plans for the development. Therefore the status of drainage plan development for this subdivision is unknown. This study assumes that internal drainage will be designed by the developer, but that both the diversion to Calabacillas Arroyo and the proposed Quail Ranch detention pond will be part of these plans. Quail Ranch includes sub-basins 12 through 23 on Figure 4.

Open Space areas at the north end of the Shooting Range Park that drain across the airport have not been included in the Double Eagle II Airport detention pond plan. These will have to be added and that plan will have to be modified accordingly. These sub-basins include the areas of sub-basins 25 and 30 of the future conditions, see Figure 4.

Double Eagle II Airport has not yet constructed the pond system that is assumed to be the accepted method of drainage management. Future condition modeling for the Boca Negra Drainage Management Plan assumed the system was in place and a constant outflow of 43 cfs from the terminal pond (Analysis Point 36.5 in Figure 4) was assumed.

Drainage easements and/or right-of-way have not been granted for most of the arroyos above the escarpment. FEMA has mapped the existing arroyo as Zone A. Also, the Double Eagle II Airport Pond outlet does not have an easement to Boca Negra Arroyo. An alternative outlet route would be along the water and utility line through Open Space to the pond above the North Geologic Window. Volcano Cliffs Units 6, 8, 9, 10, 11, 12, 13, and 14 (see Figure1.B) are large tracts with multiple owners. The continuity of road and drainage easements or right-of-way on these tracts have not been verified.

Shallow rock across the east half of the mesa requires adding fill to building sites. This may improve some drainage conditions but does constrain all options. This issue will have to be addressed by individual developments as they occur.

The National Park Service prefers natural drainage across the North Geologic Window, which will require detention ponding and a by-pass conveyance around that location. Also, the State Historic Preservation Officer has not signed off on development in the area; this clearance will be required and may affect some development plans.

Head-cutting is occurring at the base of Boca Negra Canyon, at the main arroyo and South Branch confluence. The proposed improvements will have to address this issue.

The San Ildefonso bridge can pass the existing condition 100-year runoff, but not the developed condition uncontrolled 100-year runoff. Freeboard is less than three feet along much of the Boca Negra Channel and is zero or less at more than three locations during the 2001 Condition 100-year runoff event. Therefore reduction of design flow rates to less than existing conditions is very desirable.

Sedimentation in culverts and bridges is a common problem at the existing road crossings. The Paseo del Volcan bridge on Boca Negra Arroyo has a twenty feet by five feet cross section and is at maximum capacity with the 100-year existing condition. As development increases and runoff rates increase, this channel reach may require improvements to prevent overtopping and flooding.

2.6.2 Flood Plains

Zone A flood plains are mapped by Federal Emergency Management Agency along branches of Boca Negra Arroyo from Mariposa Detention Basin to Quail Ranch and the North Shooting Range State Park. Other Zone A flood plains are mapped in the playa areas that are non-contributing to the Boca Negra near Bond Volcano and the Central Shooting Range State Park. Copies of the FEMA maps are included as Appendix B to this report.

Although FEMA's detailed study limits extended to just above the escarpment, Zone A mapping (without Base Flood Elevations) extends to the upstream limits of the watershed and includes the playa areas.

In developed areas below the escarpment, the floodplains are confined to the improved channels. Above the escarpment, the floodplains are based on existing unimproved channels. Where these floodplains are wide, future development may have to improve the channel to limit the floodplain width. However, in the National Park Service and Open Space lands, no changes will be necessary.

3.0 HYDROLOGIC ANALYSIS

3.1 Hydrologic Criteria

The computer program AHYMO-97 (Arid Land Hydrologic Modeling, 1997) as adopted by the Albuquerque Metropolitan Arroyo Flood Control Authority (AMAFCA) was used to determine peak flows and volumes for all sub-basins in the watershed. The precipitation depths, areas, land treatments, slope lengths and centroid geometry for each sub-basin are the data input into AHYMO-97.

The City of Albuquerque Development Process Manual (DPM) (1997) specifies three different equations to determine time of runoff concentration (T_c) based on flow lengths up to 4,000 feet, 4,000 to 12,000 ft., and in excess of 12,000 ft. A subroutine in AHYMO computes the time of concentration for each flow length using the appropriate equation, as described in the DPM.

AHYMO uses land treatment conditions to facilitate accounting of rainfall infiltration and other losses. The land treatment percentages for each sub-basin were estimated using the most current orthophotos, taken in 1999, which were made available by the Bernalillo County Information Technologies GIS Web Section. These orthophotos were plotted to a scale of 1 inch = 500 feet. Most watersheds contain a mix of land treatments; to determine proportional treatments, respective sub-basin areas in each treatment can be measured. However, for this study, the proportional area in each sub-basin was visually estimated with guidance from the DPM, Section 22. Areas with surface outcrops of basalt lava flow or shallow depth to rock were assigned to Treatment Type C. The percentage of the total sub-basin area in each type of land treatment was input to AHYMO.

The resulting computer model of the watershed was used to determine the then existing (2001) watershed conditions 100-year (1%-chance) peak discharges and volumes. As previously mentioned, the 2001 Condition sub-basin map is presented as Figure 2. All flood control features existing in 2001 were included in the model. The AHYMO input data (sub-basin area, land treatments, length, slope, and time of concentration (Tc) are provided on Table 2.A.

3.2 Existing and Future Condition Sub-basins

The hydrologic models developed by Resource Technology, Inc. for the 2002 H & H Study were revised for existing (2003) conditions and for proposed future scenarios. These results are presented as the Existing and Future Conditions data in this report.

The existing (2003) Boca Negra watershed was divided into 55 sub-basins ranging in size from approximately 38 acres to 635 acres, as shown on Figure 3. Basin and sub-basin boundaries were drawn along appropriate ridges and high ground including natural features, roads, berms, and other raised structures. All of the sub-basins contribute to the three primary flow paths that drain into Boca Negra Arroyo. Site visits, in conjunction with topography and orthophotography from Bernalillo County, were used to identify these flow paths. These sub-basins were identified on the 1999 digital mapping at a scale of 1 inch = 500 feet and a 2-foot contour interval. The area of each sub-basin was determined digitally using AutoCAD by constructing a polyline around the sub-basin boundary. Channel lengths were similarly measured, and the slopes were determined from the detailed mapping. These inputs and resulting values for time of concentration are given in Table 2.B. Hydrologic analysis points, at locations where peak discharges and total hydrographs were computed, are also shown on Figure 3.

The Future Conditions (FC) model was developed to evaluate the downstream impacts of anticipated watershed development and drainage detention at the Double Eagle II Airport, at Quail Ranch Subdivision, above the North Geologic Window, and SAD 228 (Boca Negra Arroyo at Unser Blvd) plus three small detention ponds (La Cuentista Subdivision) on Mariposa Arroyo. Sub-basin characteristics for the Future Conditions analysis are presented on Table 2.C. Hydrologic analysis points, at locations where peak discharges and total hydrographs were computed, are shown on Figure 4.

Future (developed) Conditions modeling for the watershed is based on the best information available from local government planning departments, private and public land owners, and publicly available development studies. Three meetings and two site visits were held to discuss potential future development of the area with interested parties. The major outcome was that Future Condition flows across Petroglyph Park lands must be limited to Existing Condition rates, or all off-site runoff must be excluded from Park lands.

No development affecting surface runoff is planned within the Petroglyph National Park or the City of Albuquerque Open Space lands. A detention pond and outfall pipe upstream of the North Geologic Window is proposed to prevent runoff (from developed property) from entering the North Geologic Window. However, habitat enhancement projects may affect flow rates on Open Space lands.

As previously described, according to a 1993 Drainage Management Plan submitted to the City of Albuquerque by Easterling & Associates, the western half of the Quail (Black) Ranch development in the Boca Negra watershed will be diverted to the north along the proposed Paseo del Volcan to the Calabacillas Arroyo watershed. The 100-yr. Future Condition runoff from the diverted part of the development is estimated to total 317 acre-feet. The diverted area is 2.9 square miles of the 5.5 square miles of Quail Ranch within the Boca Negra watershed.

The Black Ranch Drainage Management Plan includes a detailed community development plan with residential, recreational and industrial areas. Land treatments and runoffs were tabulated for areas less than one block in size. For this study, RTI has delineated sub-basins and routed the runoff to an outfall location at the southeast side of Quail Ranch, where a proposed detention basin will control flow released from the property to a maximum rate of 325 cfs.

For this study, RTI used land treatments presented in the 1993 Update Drainage Management Plan for Black (Quail) Ranch. A value of 6 du/ac would correspond to the average percentage for Land Treatment D as described in the COA-DPM, Chapter 22, Table A-5 out of that report. The other proposed residential areas in the watershed, including Volcano Cliffs Subdivisions, have also been assigned a development density of six dwelling units per acre.

Maximum 100-year Future Condition discharges from the Double Eagle II Airport ponding system will be the planned 43 cfs which will allow emptying the ponds in 96 hours, as required by the New Mexico State Engineer Office.

The Future Conditions model assumes that Volcano Cliffs Units 17 and 18 immediately above the Petroglyph Park and east of the new Unser Boulevard alignment will be drained to the outlet pipe for the Boca Negra Dam (SAD 228, Wilson and Company, Inc., July 2003); this pipe will be located in the existing right-of-way down the escarpment along the existing Atrisco Blvd. alignment.

The La Cuentista Subdivision (Volcano Cliffs Unit 22) will drain to three proposed La Cuentista Ponds and then to the Mariposa Arroyo through an existing easement through the Petroglyph Park above the Mariposa Channel. In Sub-basin 90-D (Figure 4) a 50-acre part of the east side of La Cuentista Subdivision from the Piedras Marcadas watershed will drain to this pond system. A small part of La Cuentista will drain to local detention ponds and then to a storm drain pipe to the Piedras Marcadas in Calle Norteña, with a 15 cfs maximum outflow rate.

Another Future Condition adjustment to the Boca Negra watershed boundary is the 150-acre addition (Sub-basin 49, Figure 4) of the area south of Paseo del Norte between Universe and Unser. The northeast corner of The Trails Subdivision at Universe and Paseo del Norte adds another 90 acres to the Boca Negra watershed, and the northwest corner adds 160 acres. A 60-acre area was added to the northeast corner of Quail Ranch in Future Condition Sub-basin 19 (Figure 4). The 250-acre area south of Paseo del Norte between the North Geologic Window and Quail Ranch is a potential diversion to the watershed, however this area was not included in the Future Condition model.

3.3 Rainfall Data

This study investigates the impacts of the 10-year and 100-year frequency rainfall. The methods and procedures described in the City of Albuquerque Design Process Manual (DPM), 1997, were used to determine the rainfall distributions, land treatment values, time to peak, and other unit hydrograph parameters for each sub-basin. The design rainfalls in the DPM are based on the NOAA Atlas 2, Precipitation-Frequency Atlas of the Western United States, Vol. IV - New Mexico; and, in addition, they assume an Antecedent Moisture Condition (AMC) II for a normally dry watershed.

A depth-area reduction in rainfall was considered for this study. Upon inspection, and application of the NOAA Atlas 2 guidelines, the reduction was determined to be 12 percent for the one-hour, 5 percent for the 6-hour and 3 percent for the 24-hour storm in all sub-basins.

The following table lists the areally reduced rainfall depths for the 10-year and 100-year storms.

Duration (min)	10-year Depth (in)	100-year Depth (in)
60	0.95	1.64
360	1.34	2.11
1440	1.73	2.66

3.4 Routing

The Muskingum-Cunge Method of routing a hydrograph through a channel reach was used in the current model. Slopes, lengths and typical channel cross section profiles were determined from the 1999 digital mapping. Cross section locations were selected on orthophoto contour maps to represent average channel shapes through each routing segment. A Manning's n value of 0.035 was selected for the sparsely vegetated sandy soil channels. Flood plain slopes were assumed to be the same as channel slopes.

3.5 Sediment Yield and Flow Bulking

All Existing Condition flows in undeveloped areas were bulked by five percent above the escarpment, and nine percent below the escarpment, to account for sediment transport in the flow. Two percent bulking was applied to flows from developed areas. The five percent value has been used for other studies on the west mesa, eg. The Southwest Mesa watersheds. The nine percent value was used in studies of San Antonio Arroyo.

Annual sediment yield using the Flaxman Method was determined to be 0.132 ac-ft. /sq.mi. /yr. for the Boca Negra Arroyo and 0.171 ac-ft. /sq.mi. /yr. for the Mariposa in the Matotan Study.

According to the Design Analysis Report for the Mariposa Detention Basin Regional complex, by Easterling and Associates, June 1991, the Mariposa Basin/Dam "has received only approximately 1.1 acre feet of sediment since its construction in 1983 (0.011 acre-feet/square mile/year)."

During the present study, sediment sampling and equilibrium slope analysis was performed on the arroyo channel from the North Geologic Window to Boca Negra Pond. This is discussed in Section 6.5.

3.6 Watershed Conditions Used in Modeling

3.6.1 2001 Conditions – as used in the 2002 H & H Analysis Report by RTI

No improvements above the escarpment were modeled and land treatments reflected natural vegetation with no roads as prior to 20th Century development. The Double Eagle II Airport sub-basins were modeled as in the 1999 orthophotography from Bernalillo County, with no detention ponding being considered.

3.6.2 Existing (2003) Development Conditions

The Existing Conditions model was revised from the 2001 Conditions model to include recent modifications to several drainage systems in the study area. The construction of Universe Boulevard from the east side of Ventana Ranch to the head of Boca Negra Canyon has divided some existing sub-basins and redirected flows to the south. SAD 227 diversions to San Antonio Arroyo and the Quail Ranch Pond were not included in the Existing Conditions model (but are included in the Future Conditions model).

3.6.3 Interim Condition Model (2005 Condition)

After the construction of Boca Negra Dam in conjunction with The Trails and Vista Vieja Subdivisions an interim condition will be a combination of developed and existing condition flows. This model assumes full development below the North Geologic Window (NGW) and no improvements or developed land treatment above the NGW. The Trails, Vista Vieja, the APS high school, and all Volcano Cliffs Units are modeled with developed land treatments and drainage improvements. The Double Eagle II, NGW Pond, Quail Ranch Pond and the diversion to Callabacillas Arroyo are not included.

3.6.4 Future (Developed) Conditions with No Improvements

All contributing privately owned areas are modeled as fully developed. This model only considered land use changes and did not include already planned improvements such as the Double Eagle II Airport Ponds, the Quail Ranch Diversion to Calabacillas Arroyo, ponding in Quail Ranch, The Trails and La Cuentista Subdivisions, and proposed ponds at the North Geologic Window and upper Boca Negra Canyon.

3.6.5 Future (Developed) Conditions with Improvements - 200 AF Boca Negra Pond Only

Future development conditions included the Double Eagle II Airport Ponds, the Quail Ranch Diversion to Calabacillas Arroyo and Universe Boulevard features as well as the addition of Unser Boulevard and its associated storm drain (SAD 227 improvements). Also, controlled releases from The Trails Subdivision, as provided by the design engineers, (with uncontrolled runoff from an APS High School site also contributing) are routed in a storm drain in Universe Boulevard. Vista Vieja and La Cuentista Subdivision are modeled according to the current conceptual drainage plan. SAD 227 is modeled according to the plan submitted to the City of Albuquerque.

3.6.6 Future (Developed) Condition With Improvements - 100 AF Boca Negra Pond

To evaluate the effects of storage changes in Boca Negra Pond on downstream facilities, a smaller pond volume with a larger out flow was also modeled.

3.6.7 Future (Developed) Condition with All Improvements

In addition to the Future (Developed) Conditions with a 200 acre-foot Boca Negra Pond, a pond above the North Geologic Window (NGW) with an outlet pipe by-passing the sensitive areas within the NGW was modeled. All of these proposed improvements are shown on Figure 5.

3.7 Proposed Detention Ponds

3.7.1 Quail Ranch Detention Pond

According to the Black Ranch Drainage Management Plan, (Easterling & Associates, Inc., September, 1993 Update), the area of Quail Ranch remaining in the Boca Negra Watershed is a mix of commercial, residential, recreational and industrial uses. The 1993 plan also proposes that the discharge from Quail Ranch to the Boca Negra should be severely limited. The assumed dam location below the confluence of the Boca Negra Arroyo and the northern tributary from the airport and Open Space (Sub-basins 25 and 30, Figure 4) is at the point where Boca Negra Arroyo leaves Quail Ranch. A water treatment facility, a sports complex and open space are also shown on the plan in this area. The pond created by an earthen embankment with a soil cement spillway and an ungated pipe outlet would have a depth of fifteen feet. A maximum outflow discharge of 325 cfs (less than half the 2001 Condition rate of 712 cfs. and approximately the same as for the undeveloped conditions with the diversion to the Calabacillas Arroyo) from this Quail Ranch Pond would require a storage volume of 155 acre-feet. A conceptual embankment layout is presented in Figure 6.

3.7.2 Airport Detention Pond

As proposed in the Double Eagle II Drainage Master Plan (Molzen-Corbin & Associates, December, 2003) the Double Eagle II Airport Pond at the northeast corner of the airport property would have a storage depth of 8 feet (bottom elevation 5718 ft.) and a soil cement paved spillway (elevation 5726 ft.) Excavation would start at an elevation of 5753 ft. The structure would have no outlet in the interim condition until downstream improvements are built. The design outlet would be two 18-inch pipes with a maximum release of 43 cfs. The 100-year storage would be 61 acre-feet and the spillway elevation capacity would be 86 acre-feet. A general layout for this structure, as proposed by Molzen-Corbin and Associates, is presented in Figure 7.

3.7.3 North Geologic Window Pond

The location of this pond was suggested by City of Albuquerque Open Space with the concurrence of interested archeologists. Low flow runoff from undeveloped open space can continue to pass through the North Geological Window. The pond area would require approximately 20 acres. This pond would control runoff from the area below Quail Ranch and above the North Geologic Window. The 36-inch diameter outlet pipe would discharge to an improved Boca Negra Arroyo channel downstream from and near the southeast corner of the North Geologic Window.

The proposed pond would have a storage capacity of 173 acre-feet. A 36-inch diameter outlet pipe could convey developed condition flows in Boca Negra Arroyo around the south side of the North Geologic Window (NGW). A pipe alignment around the northside of the Geologic Window would require more rock excavation and traverse higher elevations; therefore, a southerly route was selected. At peak storage the 36-inch diameter pressure pipe outlet will discharge 116 cfs.

The proposed outlet pipe will have a minimal slope in a southerly direction along the existing DEII utility and trail alignment, and turning east at Faciel Road. The pipe will have a 3% average slope in an easterly direction to its outfall to Boca Negra Arroyo downstream from the North Geologic Window. The emergency spillway will discharge to the southwest side of the North Geologic Window where a minor tributary (Sub-basin 42) also drains from the Open Space area around Butte Volcano.

Another tributary with undeveloped condition runoff (Sub-basin 38) draining from the northwest part of the Open Space (north of Butte Volcano) could continue flowing into the North Geologic Window through a culvert under the diversion channel to the pond and by-pass the pond inlet channel. The dam and outlet pipe location are shown on the options map, Figure 5. A conceptual plan layout of the embankment is included as Figure 8.

3.7.4 La Cuentista Ponds

The La Cuentista Ponds were modeled as a single pond with a capacity of 16 acre-feet and a total depth of five feet. The ponds as shown on the recent drainage report are located on the south center of the subdivision on three sides of an existing playa. The outlet would be a non-gated pipe to an easement through the escarpment and then into the Mariposa Arroyo. A maximum discharge of 270 cfs has been agreed to by the National Park Service, as indicated in a letter of agreement included in the La Cuentista Drainage Report (Wilson & Company, Inc., 2003). A conceptual pond layout is presented in Figure 9.

3.7.5 Boca Negra Pond

Two optional storage volumes were modeled for the proposed Boca Negra Pond to be located west of Unser Boulevard at the head of Boca Negra Canyon. A 200 acre-foot volume with a controlled release of 665 cfs with additional ponding at Quail Ranch, Double Eagle II and The Trails is approximately as Wilson and Company has proposed (SAD 228, July, 2003). With the addition of the NGW Pond, the required storage volume would be 160 acre-feet and the controlled release would be 571 cfs.. A 100 acre-foot pond volume with a controlled release of 1340 cfs was also modeled to evaluate the effect on downstream crossings and capacity of the Boca Negra channel banks. A general conceptual layout of the 200 acre-foot pond is presented on Figure 10.

3.7.6 Dam Storage-Elevation-Outflow Data

These data for all of the existing and proposed dams were developed using the 1999 mapping and are listed in Table 3.

3.8 Existing Mariposa Detention Basin

The proposed detention ponds will protect the existing downstream improvements below the escarpment. The frequency and volume of runoff spilling into the park section of the Mariposa Basin will be reduced significantly.

3.9 Hydrologic Results

Tables 4.A, 4.B and 4.C list the peak flows and volumes generated from each sub-basin for each watershed development condition. Table 5 lists flow rates at selected analysis points for each of the 2001 and Existing Development conditions, and with four future detention pond alternatives, including the no-pond alternative for Future Development Conditions. An Interim Development Condition (with the Boca Negra Pond and surrounding land developed, but no development west of the North Geologic Window) was also modeled. The AHYMO output results summaries are listed in Appendix C and the corresponding electronic files are located on the CD in the back pocket. The detention pond alternatives are discussed in Section 6 of this report.

Representative hydrographs for 10-year and 100-year Existing and Future Conditions at the North Geologic Window Dam, the Boca Negra Dam and the Mariposa Detention Dam are presented on Figures 11.A through 11.F. AHYMO modeling of the 2001 Conditions 100-year storm routed through the Mariposa Detention Basin shows a maximum storage volume of 203 acre-feet. This would fill the park section of the basin to an elevation of 5115.4 feet. Maximum storage volumes and elevations in Mariposa Basin for each of the watershed development conditions and detention pond alternatives are listed in Table 6. The park area of the basin has a capacity of 238 acre-feet to the top of the interior berm elevation of 5115.5 ft. The total basin has a capacity of 390 acre-feet to the emergency spillway elevation of 5119 ft.

4.0 HYDRAULIC ANALYSIS

4.1 Existing (2003) Conditions

Hydraulic modeling of Boca Negra channel below the escarpment was started as part of the 2002 H & H study by RTI. This effort included research and acquisition of as-built and construction details of all hydraulic features of both Boca Negra Arroyo and Mariposa Arroyo. Sources of information included AMAFCA, City of Albuquerque Maps and Records, and Bernalillo County Hydrology Department. Site visits allowed visual confirmation of existing structures, and confirmation that plan data matched existing structures.

For this drainage management plan, the HEC-RAS model was modified to include planned improvements (under design) for crossings at Tesuque and Mojave Drives. The hydraulic model of the Boca Negra Arroyo begins at the culverts at Atrisco Blvd (Station 9076), and ends at the Mariposa Detention Basin. Figure 12 shows the extent of the hydraulic study reaches for Boca Negra Arroyo and for Mariposa Arroyo. Input data and summary results from the hydraulic analyses are included in Appendix D.

The computed water surface and energy grade profiles for Existing Conditions, Future Conditions with no improvements, and Future Conditions with all proposed improvements are presented on Figures 13.A, 13.B and 13.C for the reach below the escarpment. Similar analyses for the reach upstream from Boca Negra Pond are discussed in the following section of this report.

The existing improved Boca Negra Channel east of Tesuque Drive adequately contains the 2001 Conditions and Existing Conditions peak flows, but does not provide the freeboard recommended by the City of Albuquerque for major channels. It has been noted that the previously modeled 100-year event (2001 Conditions) peak flow passes underneath the San Ildefonso Bridge with only 0.5 ft (6 in) of clearance below the bridge deck. This was recognized as a limiting factor to Future Conditions (developed) flows in the arroyo.

Available freeboard along the study reach below the escarpment is compared in Appendix E for the various development and detention ponding alternatives. These graphs depict all locations along the channel where the freeboard is deficient, and to what extent. Negative freeboard on these graphs indicates overflow locations.

As shown in Figure 12, the only bank overflows occur at the unimproved channel west of Tesuque Drive in the Petroglyph Park area and in the Mariposa Detention Basin where bank overflows go into the park section.

Mariposa Arroyo contains the 100-year Existing (2003) Condition flows because these have been reduced from the earlier 2001 Condition rate with the Double Eagle II Pond and the Quail Ranch Diversion to Calabacillas Arroyo.

4.2 Future Conditions

The Boca Negra channel below Atrisco Boulevard is inadequate to convey the developed condition flow rates without upstream detention pond improvements on Boca Negra Arroyo. Without improvements, the peak flow would more than triple over Existing Condition flows, as shown on Table 4.

With a combination of the Boca Negra Pond, the North Geologic Window Pond, the Double Eagle II Airport Ponds, the Quail Ranch Pond and controlled releases from the proposed subdivisions, the peak flow in Boca Negra channel below the escarpment will be less than 1,100 cfs, at Tesuque Drive which is less than the Existing Condition 100-year peak flow of 1,840 cfs.

4.3 Outstanding Issues

The following issues had to be addressed in this Drainage Management Plan in order to assure comprehensive solutions to drainage problems in the watershed.

- By-passing the North Geologic Window with all developed condition flows will require a ponding area and a route for the outfall pipe.

- Drainage easements or right-of-way along the majority of the Boca Negra Arroyo alignment have not been dedicated.

- Release rates for the Quail Ranch, North Geologic Window, and Boca Negra Ponds will have to conform to this Drainage Management Plan rates.

- In order to verify flow capacity plus freeboard at critical overbank locations for future-developed conditions, further field investigation of overbank areas along the Boca Negra Arroyo should be performed.

- Both the minimal freeboard at the San Ildefonso Bridge in the 100-year 2001 Conditions model, and the predicted overtopping with any significant development without improvements during a 100-year event, indicate the necessity for upstream controlled releases.

- As development occurs upstream of Boca Negra Dam, the hydrologic impact to the dam and reservoir (as discussed in Section 3) will have to be re-evaluated.

5.0 DRAINAGE MANAGEMENT SYSTEM

5.1 Drainage Management Options

As discussed previously, a goal of this Drainage Management Plan was to integrate the drainage solutions for Boca Negra Arroyo, South Branch of Boca Negra Arroyo, and Mariposa Arroyo. The San Antonio and Piedras Marcadas systems adjacent to the eastern Boca Negra Basin to the south and north are considered to be at their maximum capacity, and further diversions to these systems are not possible.

More than 200 acres of the Piedras Marcadas Watershed has been added to the Boca Negra system along Paseo del Norte from Calle Norteña to Rainbow Road. Another 200 acres was added along Paseo del Norte from Rainbow Boulevard to the steel water reservoir. A 50-acre area was added to the northeast corner of Quail Ranch from the Calabacillas Arroyo watershed. A potential 200-acre diversion to the Boca Negra is feasible for the area south of Paseo del Norte, from the steel water reservoir to the east boundary of Quail Ranch.

The Calabacillas Arroyo on the northwest has a larger drainage area and longer time to peak compared to the Boca Negra; and therefore, is a potential receiving water for any feasible diversions.

The Mariposa Detention Basin has limited capacity and cannot accept all of the developed condition uncontrolled flows from the Boca Negra and Mariposa arroyos. An additional outlet pipe option from Mariposa Detention Basin to the Rio Grande along La Orilla Road was investigated, but determined to be not feasible because the capacity of the Boca Negra Arroyo channel below the escarpment and upstream from Mariposa Detention Basin is the limiting factor on the downstream drainage system.

The Double Eagle II Airport Pond System, the Quail Ranch Pond and diversion to Calabacillas Arroyo, as well as Boca Negra Pond are currently proposed in other drainage plans. These improvements are described in Section 2 of this report.

In addition, because the Open Space and National Park Service properties are major features of this study area, archeological and habitat preservation features are incorporated into the models and options. Therefore, all drainage options consider the corresponding drainage effects on the Boca Negra Arroyo channel and the Petroglyph National Park crossings.

With the existing drainage improvements and commitment for other improvements which are already planned, as previously described, the options considered in this study were:

A. Limit all developed condition flows to existing or undeveloped flow rates as a minimum. Collect and convey all flows approaching the Boca Negra Canyon to the existing Unser Boulevard (Atrisco Drive) right-of-way using either storm drains or channels.

B. Collect all future developed condition flows approaching Boca Negra Canyon and convey them to a 200 acre-foot capacity Boca Negra Dam with controlled releases into a pipe through the Boca Negra Canyon and outfalling to the Boca Negra channel below the escarpment.

C. Use several local detention ponds in Volcano Cliffs Units 8, 9, 10, 11, 12, 13, and 15, in addition to the Double Eagle II Airport Ponds, and additional local ponds in The Trails, La Cuentista, and Quail Ranch subdivisions. Collect all future developed condition flows and controlled releases approaching Boca Negra Canyon and convey them to a 100 acre-foot capacity Boca Negra Dam.

D. Construct a second major storm water detention facility on Boca Negra Arroyo between the Double Eagle II Airport and the North Geologic Window. This pond would detain all Boca Negra Arroyo flows above the North Geologic Window. The pond would drain through a pipe going south to the southwest corner of the North Geologic Window, through the Open Space (formerly called Bond Ranches) lands; and then east along Faciel Road to a new drainage easement for the Boca

Negra Arroyo at the southeast corner of the North Geologic Window. An alternative route would go from Faciel Road along Agave Street to Squaw Road (or Scenic Road) and into Boca Negra Arroyo. Scenic Road is a major east-west route aligned with the Boca Negra Pond and could be a storm drain alignment to serve Volcano Cliffs Units 8, 9, 10, 11, 12, 13, and 15.

E. Divert Boca Negra Arroyo flows from above the Alameda Grant South Boundary line to a smaller pond and then to a bigger storm drain in Faciel Road south of the North Geologic Window. The remainder of Boca Negra Arroyo flows, from Open Space lands only, would continue through the North Geologic Window to maintain geomorphology, vegetation, habitat, and other natural processes. This option may be considered during more detailed analyses but was not modeled for this study.

F. Intercept a major portion of the upper Boca Negra Arroyo flows and transfer them with storm water diversion projects to a lined channel along Paseo del Norte, and Universe Boulevard to the Boca Negra Pond. These major diversions from the Boca Negra system would require a perched channel or pipe running parallel to Paseo del Norte, or significant rock excavation for a below grade channel or pipe.

G. Collect drainage from the westside of La Cuentista, Unit 26 of Volcano Cliffs and some of the Lands of Bedrock, LLC, south of Paseo del Norte in a storm drain pipe to Kimmick Drive. Near the drainage easement to Mariposa Arroyo at Kimmick Drive a natural depression would be modified to form La Cuentista Pond, which would contain up to 16 acre-feet of stormwater and release it at a maximum rate of 250 cfs.

H. No improvements. For comparison purposes only, all drainage improvements were excluded in the initial Future Conditions model.

Each of these eight approaches were examined and developed into three detention dam options; the results of that modeling are listed in Table 7, which also includes the name of the AHYMO file used to model that option. These options are described as follows:

Option I

- the west half of Quail Ranch is diverted to Calabacillas Arroyo and 325 cfs. maximum discharge out of the east half of Quail Ranch.

- the Double Eagle II pond system will limit maximum 100-year outflow to 43 cfs. into Boca Negra Arroyo

- controlled runoff from local detention ponds in the Trails Subdivision will drain through a storm drain system to the Boca Negra Pond

- a 60-inch diameter orifice plate would control outflows from Boca Negra Pond so that the maximum storage volume would not exceed 200 ac.-ft.

- the La Cuentista Ponds will discharge to Mariposa Arroyo a total of 255 cfs. (maximum outflow of 270 cfs.)

Option II

- same as Option I but the Boca Negra Pond outlet would have a 96-inch diameter orifice plate (instead of the 60-inch orifice) so that the maximum storage volume would not exceed 100 ac.-ft.

Option III

- same as Option I but adding in the North Geologic Window Pond with a maximum storage capacity of 200 ac.-ft. Both Options I and II did not include this pond

5.2 Drainage Features Common to all Drainage Options

The common feature of all options is to delay or intercept enough flow from the Boca Negra system to take care of the restrictions for the use of existing flow paths though National Park Service lands, and limited downstream channel and storage capacity. The South Branch of Boca Negra Arroyo watershed consists of mostly Open Space and National Park Service land. No improvements to storm drainage management in the Open Space part of the South Branch are recommended. The adopted plan, according to SAD 227 development plans, is for the South Branch to outfall through a pipe from the west side of SAD 227 to the edge of the escarpment, discharging to the historic drainage path, and dropping down the escarpment to the confluence with Boca Negra Arroyo. Minor ponding will occur at the inlet to the pipe.

Within the Open Space area, potential brush and boulder detention structures on the South Branch of Boca Negra Arroyo were modeled for erosion control, runoff management, and habitat enhancement but were found to have no effect on peak flow on the Boca Negra Arroyo channel downstream. Therefore, these features will not affect downstream peak flows, but would improve local conditions within the Open Space area.

The North Fork of the South Branch will drain to Boca Negra Pond up to a flow of 229 cfs. Flows in excess of 229 cfs. will go to the Unser Storm Drain to San Antonio Arroyo, which is a SAD 227 project. SAD 227 is currently under construction. Consequently, no part of the South Branch of Boca Negra Arroyo watershed located within the SAD 227 area will drain to Boca Negra Arroyo.

The north half of the SAD 227 area, which lies within the Boca Negra Arroyo watershed, will also be drained by the SAD 227 Unser Boulevard storm drain to the San Antonio Arroyo, and will not contribute to Boca Negra Arroyo flows, as shown on Figure 5.

A major tributary area above Boca Negra Canyon between the main arroyo and South Branch of Boca Negra Arroyo (sometimes called the Middle Branch) will drain to Boca Negra Pond. This Middle Branch originates in Open Space and is almost totally included in Sub-basin 44. The area is privately owned and will drain to Boca Negra Pond through storm drains in Scenic Drive and Squaw Road, as shown on Figure 5. The Squaw Road storm drain will discharge to Boca Negra Arroyo in Sub-basin 48. The Scenic Drive storm drain will go directly into Boca Negra Pond.

North of Boca Negra Canyon, the La Cuentista Subdivision will be divided into two separate flow paths; the drainage area west of Cerro Azul Place will drain to Mariposa Arroyo, and a storm drain pipe in Calle Norteña will drain the area east of Cerro Azul Place.

For all options Quail Ranch drainage areas west of Paseo del Volcan are assumed to be diverted to Calabacillas Arroyo. Also, the Double Eagle II Airport ponds would be constructed as temporary retention ponds and later would have controlled outflows to Boca Negra Arroyo. Peak flows on Boca Negra Arroyo from Quail Ranch east of Paseo del Volcan will be reduced to 325 cfs at the eastern boundary of Quail Ranch. This can be achieved either by multiple small ponds or a large detention pond, as determined by the developer. The latter approach was used in the development of this plan.

The Trails Subdivision at Paseo del Norte and Universe, will control on-site flow releases using local detention ponds with outlets into a storm drain along Universe. The proposed APS high school south of The Trails, will add to the flows in this storm drain discharge to the Boca Negra Pond. Drainage at a peak rate of 512 cfs from the west side of La Cuentista will be detained in La Cuentista Pond and released at a maximum rate of 270 cfs to the Mariposa Arroyo.

5.3 Discussion of Optional Improvement Plans

Options I, II and III, as described above, include various combinations of ponds and their storage volumes. These options were evaluated based on the following factors: drainage to each site, principal and emergency spillway, embankment, other infrastructure and right-of-way acquisition. Figures 6 through 10 show the general dam and reservoir layout, and flow diversions for each of the options.

5.3.1 Quail Ranch Pond

The pond location at the southeast side of Quail Ranch is the confluence of two flowpaths from sub-basins in Quail Ranch and Open Space lands on the south side of the South Alameda Grant Line. Subsurface rock is not mapped at this location on the V. C. Kelly and A. M. Kudo Geologic Map, 1978 (Figure 1.D). Dam construction could be a conventional compacted earth embankment with a hardened soil cement spillway and a non-gated principal outlet pipe to Boca Negra Arroyo; or several on-site local ponds could be constructed to achieve the same controlled release to Boca Negra Arroyo.

5.3.2 Double Eagle II Ponds

The proposed Double Eagle II Airport Ponds, for control of runoff from the Boca Negra watershed, will be located on the east side of the airport property. The current plan is to build these as retention ponds, and convert them to detention ponds when downstream outfall locations and capacity can be provided. Dam construction will require mostly excavation with some above grade compacted earth embankment construction. A potential problem may be rock excavation at each of the ponds and the pipes connecting them.

Another possibility was a combined Double Eagle II Airport and Quail Ranch pond, which would require an upstream diversion from Double Eagle II to match the higher elevation of the Quail Ranch Pond. The Albuquerque Volcanoes Geologic Map shows the limit of the lava flow at the center of the Double Eagle II Airport (NBP1) Pond.

5.3.3 North Geologic Window Pond

The North Geologic Window Pond, upstream from the national park land and south of the Alameda Grant South Boundary line, would detain all flows in Boca Negra Arroyo. This area is the triangle formed by the Open Space property lines and the Double Eagle II Airport trail and utility (waterline and sanitary sewer) route. Subsurface rock is visible and mapped at this location on the V. C. Kelly and A. M. Kudo Geologic Map, 1978 (Figure 1-D). Dam construction would be a conventional compacted earth embankment with a hardened soil cement emergency spillway and a non-gated principal outlet to a pipe going south and east through Volcano Cliffs Units 10, 11, and 12.

Visible features of the structure would need to reflect the natural landscape, preserve archeological and habitat features and not impose on views of the horizon from the North Geologic Window. If only runoff from the area north of the Alameda Grant South Boundary line (the only developable area) is to be retained, a by-pass structure for the Open Space runoff would be needed. The emergency spillway would discharge to a flowpath that enters the North Geologic Window along its southwest boundary. This emergency overflow path, for storms greater than 100-year, would be maintained as existing. The City of Albuquerque Open Space also wishes to preserve the Boca Negra Arroyo channel along the Alameda Grant South Boundary approaching the North Geologic Window. Therefore, the pond was located away from the channel, as shown on Figure 8.

The recently constructed trail and airport utility route are a constraint on the location of the North Geologic Window Pond. An alternative to this location would be on the west side of the Double Eagle II Airport utility lines and trail; this would reduce visual impacts from the North Geologic Window. An open channel or pipe along the Double Eagle II Airport utility line and trail with a smaller pond was also an option, but was found to be economically impractical and was not modeled in this study.

5.3.4 Boca Negra Pond

The Boca Negra Dam on the west side of Unser Boulevard at the top of Boca Negra Canyon would detain all drainage from Boca Negra Arroyo. Subsurface rock is visible and mapped at this location on the V. C. Kelly and A. M. Kudo Geologic Map, 1978 (Figure 1-D). According to rock core drilling completed for the Environmental Impact Statement for Unser Boulevard in 1992, the thickness of rock in the three holes in the area of the dam were 14.5, 20 and 35.5 ft.

Dam construction would be a conventional compacted earth embankment with a hardened soil cement emergency spillway and a non-gated principal outlet to a pipe going to the Boca Negra Canyon. If voids or fissures are found in the rock in the base of the pond a suitable membrane liner should be considered.

The storage volume of the pond is related to the release rate of the principal outlet. A maximum release rate similar to Existing Condition flow would require a storage capacity of 100 acre-feet. With the North Geologic window Pond included and a storage capacity of 200 acre-feet, the maximum out-flow rate can be reduced to 570 cfs, and a maximum storage volume of 158 acre-feet. The latter option was selected for this Drainage Management Plan.

The reservoir will be similar to the Mariposa Basin Park with playing fields at an intermediate level in the pond and a deeper section of the pond that would receive more frequent lower volume events.

5.3.5 La Cuentista Ponds

At La Cuentista Subdivision the outfall to the Mariposa Channel through the Petroglyph Park has been limited to 270 cfs by agreement with City of Albuquerque Open Space and approval of the National Park Service. To satisfy this requirement three small ponds (La Cuentista Ponds) have been proposed to detain a total of approximately 32 acre-feet. The outfall area of the three ponds is a natural playa with rock outcropping. The non-gated principal outlet pipes to Mariposa Arroyo would be designed to peak at 255 cfs. from all three outlets.

5.4 Channel Improvement Alternatives

5.4.1 Natural Channel with Prudent Line

Existing natural channel boundaries are wide and poorly defined in the reach above Boca Negra Canyon and above the North Geologic Window to Paseo del Volcan; also, soil cover over the lava flows along this reach is thin. Mariposa Arroyo above the escarpment is similarly not well defined. The western part of Volcano Cliffs bounded by Boulevard de la Oest, Gila Road, Albericoque Place, and Faciel Road is currently platted with large multi-acre tracts. Soil depths here are deeper and arroyo banks are susceptible to erosion.

A Prudent Line may be defined as a line along a watercourse beyond which development would not be prudent because of flood and erosion hazards. A naturalized channel with Prudent Line setback easements may be appropriate for Boca Negra Arroyo from the eastern boundary of the North Geologic Window to State Land property line in sub-basin 46A; and from below the Quail Ranch east boundary to the Open Space Boundary west of the North Geologic Window.

Bernalillo County Ordinance Number 90-6 defines the Prudent Line as follows:

"Prudent line" also referred to as "Erosion Limit Line" means that line which will not be disturbed by erosion, scour, or meandering of a natural (unlined) arroyo, channel or watercourse over a period of thirty (30) years and which will not be disturbed by a 100-year storm occurring at any time during the 30-year period. The Prudent Line shall be so located as to include all freeboard required to contain any wave action from 100-year flows.

The Prudent Line is particularly applicable in sparse development areas such as most areas within Units 6, 8, 9, 10, 11, 12, 13, and 15 of Volcano Cliffs where low density development is proposed. This is because individual lot owners typically could not fund major drainage improvements such as storm sewers, channels, etc. Figure 14 illustrates that the Prudent Line is always greater than the 100-yr. flood plain.

The Prudent Line is an interim measure that will most likely require revision due to changing watershed conditions (upstream sediment supply and developed condition discharge rates) and due to the difficulty in predicting future geomorphic changes. Furthermore, the Prudent Line may be reduced or eliminated if drainage structures such as lined channels or partially lined channels are constructed.

5.4.2 Partial Lining with Grade Control

Boca Negra Arroyo from the east boundary of Quail Ranch to the escarpment will require open channel treatment to manage developed condition flows. Shallow rock over this area east of Paseo del Volcan to the escarpment is the dominant limiting factor on natural arroyo bed erosion and grade control. Channel construction will be easiest using a perched channel design. Bank protection would be soil cement or riprap. This type of channel treatment could be useful in locations where the bank must be stabilized or controlled due to proposed development and right-of-way constraints, or where the Prudent Line is so wide as to be impractical.

Where soils are deeper, grade control structures will be required downstream from bridges and other locations to reduce the damage associated with "head cutting". Also, bank protection may be required in select locations along the unimproved channel. Figure 15 illustrates a typical bank protection assuming the use of soil cement. The bottom width of a channel with partial (banks only) lining will generally be much wider than a fully lined channel. Also, local scour in a partially lined channel section can become a maintenance problem. Therefore, a partially lined channel should only be selected after careful consideration.

5.4.3 Soil Cement or Concrete Channel Lining

Either soil cement or concrete may be viable channel treatments for high density development areas where a Prudent Line or partial lining with grade control is not acceptable or where these treatments are losing their effectiveness. Figure 15 illustrates a typical soil cement or concrete channel section.

5.5 Channelization from Northern Geologic Window to Boca Negra Pond

The Boca Negra Arroyo from the North Geologic Window to Boca Negra Pond will require improvements. Naturalistic channelization similar to Boca Negra Arroyo below the escarpment in the area of Tesuque Drive may be appropriate for this reach.

Channel Slope

Stream channels naturally progress to a condition where the sediment transport capacity in a given reach is in balance with the reach supplying it, at which time no further degradation or aggradation occurs. This state of equilibrium can be achieved through changes in channel slope. Ultimately natural channels will achieve what is called the equilibrium slope. To reduce erosion or deposition in the proposed earthen channel, the channel is designed with a proposed equilibrium slope.

The Alternative Method for Approximating the Equilibrium Slope, as presented in AMAFCA's Sediment and Erosion Design Guide (1994) in Section 4.2.3.3.2, was used in determining the equilibrium slope (Ss) for the proposed channel from Northern Geologic Window (NGW) to Boca Negra Pond. See Tables 8.1 through 8.5 for a brief description of method used, a summary of data input, and equilibrium slope results.

For this analysis, the dominant discharge was set to be equal to the 10-year Future Condition storm peak flow, 195 cfs. Using the method described briefly in Table 8.1, the equilibrium slope is 0.8%, with a channel bottom width (W) of 41 feet. A trapezoidal channel, with a 41-foot bottom width, 8H:1V side slopes, and a channel slope of 0.8% was chosen. 195 cfs through the proposed section results in subcritical flow, a top width of 57 feet, a flow depth of 1.0 foot, and a velocity of 4 ft/s. Flowmaster output is included in Table 8.2

Channel Hydraulics – 100-Year Future Condition Storm

Future Condition hydraulics for the proposed channel for the100-year peak flow was determined using the Flowmaster program. A 588 cfs, 100-year this flow rate in a trapezoidal channel 41 feet wide at the bottom, with 8H:1V sides and a channel slope of 0.8% results in subcritical flow, a top width of 70.6 feet, a flow depth of 1.85 feet, and a velocity of 5.7 ft/s. (Table 8.3).

Proposed Typical Section

A trapezoidal channel with a 41 foot bottom width, 8H:1V side slopes, a depth of 3.85 feet, and a channel slope of 0.8% was analyzed for the proposed channelization. This will provide 2 feet of freeboard during the 100-year Future Condition storm. This section could be modified in the future for recreational trails and other considerations.

Channel Alignment

The proposed channel alignment was chosen to fit most conveniently with parcel boundaries and existing flood plain mapping, keeping in mind road alignments, the North Geologic Window Pond outfall pipe at the start of channelization, the Boca Negra Pond at the end of channelization, and the existing channel alignment. See Figures 16.A through 16.C for horizontal and vertical alignments of the proposed channel. Channelization will begin at the NGW pipe outlet, Station 25+50 approximately, and end at the Boca Negra Pond inlet, Station 76+00 approximately.

Grade Control Structures

A 0.8% channel slope along the proposed alignment will result in an elevation difference of 38.85 feet along the proposed channel length. This can be achieved using several drop structures, equal to a total height of 22.25 feet. Drop structure locations, as shown on the plan and profile in Figures 16.A through 16.C, coincide with street crossings to provide erosion/deposition protection as well.

A 10% channel slope with rip-rap lining occurring just upstream of Squaw Road, will provide erosion protection from Station 46+49 to Station 48+15. This provides 16.6 feet of elevation difference, and reduces the number of drop structures required to attain the 0.8% equilibrium slope. Natural rock outcrops occur in the channel bottom in this reach. Tables 8.4 and 8.5 show the hydraulic computations for the 10-year and 100-year flows, respectively.

Channel Excavation Limits

The channel excavation limits shown on Figures 16.A through 16.C were determined using a minimum of 3H:1V slopes on grading outside the proposed channel.

5.6 Right-of-Way and Easements

Additional right-of-way or drainage easements are required on the Boca Negra Arroyo and Mariposa Arroyo. Below the escarpment, Boca Negra Arroyo, from the culverts under Atrisco Boulevard to Mariposa Basin, is in a 150-foot wide Drainage Utility Easement. From Boca Negra Pond through SAD 230 to the State Land west of the proposed APS High School, 2000 feet of 100-foot wide right-of-way (R.O.W.) is shown on the most recent City of Albuquerque Zone Atlas Map. This R.O.W. extends from the west side of the gas line route in Atrisco Drive through Squaw Road and along the east side of the eight lots on Faciel Road north of Squaw Road.

An additional 900 feet of 100-foot wide R.O.W. as shown on Fig ??? along the front lot lines of properties on the east side of Atrisco (future Rainbow Boulevard) is needed to extend the channel to Boca Negra Pond, if the channel follows its current path and the flood plain mapping. Within the State Land there is no easement or R.O.W. for the Boca Negra Arroyo. Multiple use concepts have been discussed for new channels that include open space with trails. An open space connection from the recreational area of Boca Negra Pond to the State Land or the North Geologic Window may be desired by the City of Albuquerque.

Mariposa Arroyo, from the Petroglyph National Monument boundary below the escarpment to the confluence with the Boca Negra Arroyo, is in the Mariposa Arroyo Drainage Right-of-Way. Above and across the escarpment, it appears that no drainage easements are provided. In the 1975 study by Matotan (1975) on sheets 104 and 105 of 121 a 50-foot wide drainage easement is shown from Urraca Street crossing Kimmick Drive to the north end of the Mariposa Arroyo Drainage ROW within the Petroglyph National Monument; however, current plats do not show this easement.

The area shown as North Mesa in the West Side Strategic Plan, between Quail Ranch and the North Geologic Window, is platted with 5-acre tracts. These properties have multiple owners and no easements or right-of-way are shown along Boca Negra Arroyo according to the COA Zone Atlas and the Bernalillo County GIS Parcels Database. FEMA flood plain is mapped along the arroyo. Also, an easement may be needed for the Double Eagle II Airport Pond outflow channel to Boca Negra Arroyo, although a route along the existing Paseo del Volcan right-a-way appears feasible. A FEMA mapped flood plain extends from the north east corner of the Double Eagle II Pond to Boca Negra Arroyo.

6.0 CONCLUSIONS

6.1 Recommended Facilities

Land owners and interested parties have already initiated and guided the development of a workable plan for the management of drainage above and across the escarpment. Because land development above the escarpment is proceeding at a very rapid pace, some of the improvements evaluated and proposed in this plan are already being designed. Boca Negra Dam is one of these features. The subdivisions proposed around this pond, especially SAD 227, are already in progress and this outfall for developed condition flows will be needed very soon. The alignments for the various storm drains and channels into the pond are yet to be finalized. Consequently, Boca Negra Dam is already the key feature of the recommended plan.

The pond sizing and outlet works are still being investigated – the interim conditions analysis, described in Section 6, is a result of this occurrence. The recommended facilities in this report will provide a comprehensive, watershed-wide context for the improvements already being designed. Also, Boca Negra Dam, at the top of Boca Negra Canyon, is necessary to control flows to the existing channel, bridges, and Mariposa Basin below the escarpment and to satisfy the National Park Service requirements for excluding developed condition flows through the Petroglyph National Park.

The North Geologic Window Pond is also necessary to meet National Park Service requirements. The outlet pipe along Faciel Road, from the North Geologic Window Pond to Boca Negra Arroyo below the North Geologic Window, is the shortest route for the outflow from this dam. A naturalistic channel below the North Geologic Window to Boca Negra Pond with appropriate drop structures will also provide for future recreational trails, as described in Section 7.3 of this report.

Above and below the North Geologic Window, mapped FEMA floodplains have already identified the lands and alignments necessary for flow paths or channels. Before any drainage easements or right-of-way can be dedicated, however, FEMA's CLOMR or LOMR process will have to be implemented to establish flow widths and alignments for developed conditions.

The two other ponds, at Double Eagle II Airport and Quail Ranch, are in the 100-acre-foot size range as opposed to the 20-acre-foot size being built in the northeast section of the watershed. The Double Eagle II Pond is part of the approved drainage master plan for the airport and will be constructed as planned. However, the Quail Ranch Pond is a master plan concept and the only requirement, for purposes of this Boca Negra Watershed Drainage Management Plan, is that the outflow rate from Quail Ranch does not exceed 325 cfs. after development.

6.2 Other Recommended Improvements

Many private and public improvements have been planned and some approved for the eastern part of the mesa within the Boca Negra watershed. Multiple small ponds in residential areas of The Trails and La Cuentista are appropriate for managing drainage from these areas and will also provide open space benefits. Storm drain systems in the Volcano Cliffs Units west of Universe Boulevard should be planned such that Scenic Road and Squaw Road will drain into Boca Negra Pond. Earlier disposal of flows from areas nearer to Boca Negra Pond would slightly reduce the peak storage and outflow from the pond.

The recently constructed utility lines and trail to Double Eagle II Airport should allow drainage from Open Space areas to flow to the main arroyo channel on the west side of the North Geologic Window. In designing the North Geologic Window Pond, Open Space runoff should be bypassed to enter the North Geologic Window and maintain some natural condition flows. An energy dissipater just below the confluence of the main and south branches of Boca Negra Arroyo should be constructed for the pipe outlet in the lower Boca Negra Canyon. This structure should be designed to complement escarpment views and minimally disrupt the local environment.

Naturalistic channel construction with rip rap protected drop structures is an option for the Boca Negra channel from the Quail Ranch east boundary to the North Geologic Window Pond. This can be initiated when land development in this area is imminent.

Brush and boulder structures being considered on the South Branch of Boca Negra Arroyo in the Open Space areas will improve habitat and reduce natural erosion. These improvements should be encouraged and facilitated to the maximum extent possible.

6.3 City Trails Plan

Trails for pedestrians, bicycles and horses have been conceptually planned within the Boca Negra watershed. The Northwest Mesa Escarpment Plan by the City of Albuquerque, 1987, Map 11, Conceptual Trail and Facility Locations, shows routes for equestrians and pedestrians along the escarpment and along Boca Negra Arroyo from Mariposa Basin to the North Geologic Window. This map is included in this report as Figure 17. Bikeways follow Unser Boulevard, Paseo del Norte and Paseo del Volcan as well as Boca Negra Arroyo. Other pedestrian and equestrian trails extend from the North and South Geologic Windows to the volcanoes.

TABLES

TABLE 1
COMPARISON OF EXISTING AND FUTURE CONDITION FLOW RATES AT SELECT LOCATIONS FROM PREVIOUS DRAINAGE STUDIES

Location and Analysis Point*	Development Condition	RTI Flow Rates	RTI Runoff Volume	Far NW DMP BHI, 1986		West Albuquerque Metropolitan Area DMP Matotan 1975		Fred Denney 1980		Unser Middle Corridor Study Unser-Dellyne to Paradise 1992		Mariposa Basin Regional Atheletic Park Easterling, 1991	
		(cfs)	(ac-ft)	(cfs)	(ac-ft)	(cfs)	(ac-ft)	(cfs)	(ac-ft)	(cfs)	(ac-ft)	(cfs)	(ac-ft)
Black Ranch Well AP17.8	Ex	385	55.11										
	FC												
Grassland Reserve AP25.75	Ex	275	27.49										
	FC												
North Aviation AP30.9	Ex	275	34.84										
	FC												
North Boca Negra AP32.9	Ex	711	135.14										
	FC												
Northeast Aviation AP36.5	Ex	596	39.15										
	FC			5180									
Quarry AP40.9	Ex	1064	205.46										
	FC												
North Geologic Window AP42.7	Ex	1092	230.28										
	FC												
Gas Pipeline AP44.8	Ex	1104	254.48										
	FC												
Volcano Cliffs AP47.8	Ex	331	19.26										
	FC												
Unser & Atrisco AP48.8	Ex	1244	280.33			639				2500			
	FC			1210						6600			
East Double Eagle Aviation AP74.7	Ex	465	58.94										
	FC												
Volcano Playa AP79.8	Ex	0	0.00										
	FC												
South Geologic Window AP81.8	Ex	384	30.66										
	FC												
Pumping Station AP83.7	Ex	576	60.06			588	62			1800			
	FC			1960		1272	143			2600			
Below Atrisco Culvert AP85.9	Ex	1829	346.24										
	FC												
Tesuque AP86.9	Ex	1836	356.55			1653	207	2425					
	FC												
Mariposa North Channel AP91.8	Ex	532	51.42			564	51	381		600			
	FC	320	36.30							830			
Mariposa Dam Inflow AP92.7	Ex	2093	430.59					2720				3042	395.7
	FC	5022		8790									
Mariposa Dam Outflow AP93.83	Ex	567	433.66					740					
	FC			850									

*Analysis Points are shown on Figures 3 (Existing Conditions) and 4 (Future Conditions)

TABLE 2.A
2001 CONDITIONS
BOCA NEGRA SUB-BASIN CHARACTERISTICS

Sub-Basin ID	Hydrologic Condition	Sub-Basin Area	Land Treatment				L_{basin}	L_{CA}	slope	T_P
			A	B	C	D				
#		(mi^2)					(ft)	(ft)	(ft/ft)	(hrs)
10	Existing	0.472	100%	0%	0%	0%	9650	5790	0.025	0.4055
11	Existing	0.389	100%	0%	0%	0%	9450	7088	0.023	0.4315
12	Existing	0.304	99%	1%	0%	0%	7890	3945	0.011	0.4128
14	Existing	0.513	99%	1%	0%	0%	10650	5325	0.023	0.4257
15	Existing	0.304	99%	1%	0%	0%	4900	2695	0.008	0.416
16	Existing	0.533	99%	1%	0%	0%	10200	5100	0.022	0.4141
17	Existing	0.265	99%	1%	0%	0%	6600	3300	0.007	0.4499
20	Existing	0.717	95%	5%	0%	0%	9000	7650	0.018	0.4516
21	Existing	0.239	99%	1%	0%	0%	6000	3000	0.022	0.2878
22	Existing	1.043	99%	1%	0%	0%	19000	9500	0.009	0.747
24	Existing	0.361	100%	0%	0%	0%	6000	3000	0.001	0.9901
25	Existing	0.296	100%	0%	0%	0%	10700	5350	0.026	0.4175
26	Existing	0.323	100%	0%	0%	0%	7687	4997	0.022	0.353
27	Existing	0.396	100%	0%	0%	0%	9723	4862	0.018	0.4157
30	Existing	0.379	95%	5%	0%	0%	10950	7118	0.01	0.5522
32	Existing	0.257	100%	0%	0%	0%	4900	2940	0.02	0.2796
33	Existing	0.770	100%	0%	0%	0%	6280	3140	0.016	0.2537
35	Existing	0.592	100%	0%	0%	0%	6260	3756	0.008	0.4337
36	Existing	0.548	98%	0%	0%	2%	8800	7920	0.015	0.4693
37	Existing	0.687	100%	0%	0%	0%	14880	7440	0.008	0.6482
38	Existing	0.292	96%	4%	0%	0%	6500	4225	0.015	0.3565
40	Existing	0.534	88%	2%	10%	0%	5880	2940	0.015	0.3288
41A	Existing	0.264	70%	0%	30%	0%	3100	1860	0.031	0.1828
41B	Existing	0.200	70%	0%	30%	0%	4222	2533	0.031	0.2179
42	Existing	0.575	90%	0%	10%	0%	10581	5291	0.035	0.3908
43	Existing	0.439	80%	10%	10%	0%	12440	6220	0.015	0.5192
44	Existing	0.674	90%	0%	10%	0%	10730	5365	0.029	0.4101
45	Existing	0.128	90%	0%	10%	0%	4300	2150	0.015	0.3085
46	Existing	0.407	90%	0%	10%	0%	7935	4364	0.026	0.3336

TABLE 2.A (cont'd)
2001 CONDITIONS
BOCA NEGRA SUB-BASIN CHARACTERISTICS

Sub-Basin ID	Hydrologic Condition	Sub-Basin Area	Land Treatment				L_{basin}	L_{CA}	slope	T_P
			A	B	C	D				
#		(mi^2)					(ft)	(ft)	(ft/ft)	(hrs)
47	Existing	0.473	90%	0%	10%	0%	7900	4345	0.025	0.3359
48	Existing	0.182	90%	0%	10%	0%	5900	2950	0.013	0.3476
51	Existing	0.072	85%	0%	15%	0%	3428	1371	0.019	0.2482
60	Existing	0.354	100%	0%	0%	0%	7302	4381	0.023	0.3304
62	Existing	0.2	100%	0%	0%	0%	5327	2664	0.017	3030
63	Existing	0.973	100%	0%	0%	0%	5849	3509	0.029	0.2643
64	Existing	0.305	98%	0%	0%	2%	1040	525	0.025	0.105
65	Existing	0.338	100%	0%	0%	0%	2000	1000	0.023	0.1675
66	Existing	2.449	98%	0%	0%	2%	27869	16721	0.012	0.9742
67	Existing	0.109	85%	0%	15%	0%	6000	3000	0.012	0.2924
68	Existing	0.467	99%	0%	0%	1%	7041	3521	0.012	0.3816
69	Existing	0.615	95%	0%	0%	5%	6600	3960	0.006	0.4877
73	Existing	0.723	97%	0%	1%	2%	8840	4420	0.007	0.4923
74	Existing	0.647	91%	0%	2%	7%	7500	3750	0.008	0.4451
75	Existing	0.865	91%	0%	2%	7%	11800	4720	0.008	0.5176
79	Existing	0.411	84%	1%	15%	0%	3300	1980	0.006	0.4315
80	Existing	0.871	80%	0%	20%	0%	12369	7241	0.029	0.4927
81	Existing	0.447	90%	0%	10%	0%	9239	6005	0.023	0.4065
82	Existing	0.304	90%	0%	10%	0%	6557	3606	0.026	0.2905
83	Existing	0.990	89%	0%	10%	1%	15574	7787	0.036	0.5212
84	Existing	0.112	90%	0%	10%	0%	4800	2400	0.02	0.2747
85	Existing	0.073	80%	0%	20%	0%	1300	650	0.006	0.2442
86	Existing	0.132	80%	0%	20%	0%	2110	1055	0.006	0.3366
88	Existing	0.314	90%	0%	10%	0%	6280	3140	0.012	0.3653
89	Existing	0.209	10%	20%	30%	40%	4500	2250	0.006	0.4761
90	Existing	0.993	80%	0%	20%	0%	9740	4870	0.006	0.5328
91	Existing	0.337	10%	20%	20%	50%	4445	2223	0.006	0.477
92	Existing	0.097	0%	30%	30%	40%	2700	1350	0.006	0.3837
93	Existing	0.064	0%	65%	20%	15%	1700	850	0.006	0.292

TABLE 2.B
EXISTING (2003) CONDITIONS
BOCA NEGRA SUB-BASIN CHARACTERISTICS

Sub-Basin ID	Hydrologic Condition	Sub-Basin Area	Land Treatment				L_{basin}	L_{CA}	Slope	T_P
			A	B	C	D				
#		(mi^2)					(ft)	(ft)		(hrs)
10	Existing	0.472	99%	0%	1%	0%	9650	5790	0.025	0.4055
11	Existing	0.389	99%	0%	1%	0%	9450	7088	0.023	0.4315
12A	Existing	0.140	99%	1%	0%	0%	7890	3945	0.011	0.4128
12B	Existing	0.164	99%	0%	1%	0%	5000	2500	0.011	0.3598
14A	Existing	0.140	99%	1%	0%	0%	10650	5325	0.023	0.4257
14B	Existing	0.373	99%	0%	1%	0%	7700	3850	0.023	0.3301
15	Existing	0.304	99%	1%	0%	0%	4900	2695	0.008	0.416
16A	Existing	0.060	99%	1%	0%	0%	10200	5100	0.022	0.4141
16B	Existing	0.473	99%	0%	1%	0%	8340	4170	0.022	0.3537
17	Existing	0.265	99%	1%	0%	0%	6600	3300	0.007	0.4499
20	Existing	0.940	95%	5%	0%	0%	9000	7650	0.018	0.4516
21A	Existing	0.072	99%	1%	0%	0%	6000	3000	0.022	0.2878
21B	Existing	0.167	99%	0%	1%	0%	10700	5350	0.026	0.4175
22A	Existing	0.500	99%	1%	0%	0%	19000	9500	0.009	0.747
22B	Existing	0.543	99%	0%	1%	0%	19000	9500	0.009	0.747
24	Existing	0.361	100%	0%	0%	0%	6000	3000	0.001	0.9901
25	Existing	0.296	100%	0%	0%	0%	10700	5350	0.026	0.4175
26	Existing	0.323	100%	0%	0%	0%	7687	3843.5	0.022	0.353
27	Existing	0.396	100%	0%	0%	0%	9723	4861.5	0.018	0.4157
30	Existing	0.379	95%	5%	0%	0%	10950	7118	0.01	0.5522
32	Existing	0.257	100%	0%	0%	0%	4900	2940	0.02	0.2796
33	Existing	0.770	100%	0%	0%	0%	6280	3140	0.016	0.2537
35	Existing	0.592	100%	0%	0%	0%	6260	3750	0.008	0.4337
36	Existing	0.548	98%	0%	0%	2%	8800	7920	0.015	0.4693
37	Existing	0.687	100%	0%	0%	0%	14880	7440	0.008	0.6482
38	Existing	0.292	96%	4%	0%	0%	6500	4225	0.015	0.3565

TABLE 2.B (cont'd)
EXISTING (2003) CONDITIONS
BOCA NEGRA SUB-BASIN CHARACTERISTICS

Sub-Basin ID	Hydrologic Condition	Sub-Basin Area	Land Treatment				L_{basin}	L_{CA}	Slope	T_P
			A	B	C	D				
40	Existing	0.534	88%	2%	10%	0%	5880	2940	0.015	0.3288
41	Existing	0.464	70%	0%	30%	0%	6222	3733	0.031	0.2684
42	Existing	0.575	90%	0%	10%	0%	10581	5290.5	0.035	0.3908
43	Existing	0.485	80%	10%	10%	0%	12440	6220	0.015	0.5192
44	Existing	0.674	90%	0%	10%	0%	10730	5365	0.029	0.4101
45	Existing	0.128	90%	0%	10%	0%	4300	2150	0.015	0.3085
46	Existing	0.407	90%	0%	10%	0%	7935	4364	0.026	0.3336
47	Existing	0.526	90%	0%	10%	0%	7900	4345	0.025	0.3359
48	Existing	0.147	90%	0%	10%	0%	5900	2950	0.013	0.3476
51	Existing	0.072	85%	0%	15%	0%	3428	1371	0.019	0.2482
74	Existing	0.647	91%	0%	2%	7%	750	3750	0.008	0.4451
75	Existing	0.865	91%	0%	2%	7%	11800	4720	0.008	0.5176
79	Existing	0.411	84%	1%	15%	0%	3300	1980	0.006	0.4315
80	Existing	0.871	80%	0%	20%	0%	12369	7421	0.029	0.4927
81	Existing	0.447	90%	0%	10%	0%	9239	6005	0.023	0.4065
82	Existing	0.304	90%	0%	10%	0%	6557	3606	0.026	0.2905
83	Existing	0.990	89%	0%	10%	1%	15574	7787	0.036	0.5212
84	Existing	0.112	90%	0%	10%	0%	4800	2400	0.02	0.2747
85	Existing	0.073	80%	0%	20%	0%	1300	650	0.006	0.2442
86	Existing	0.132	80%	0%	20%	0%	2110	1055	0.006	0.3366
88	Existing	0.314	90%	0%	10%	0%	6280	3140	0.012	0.3653
89	Existing	0.209	10%	20%	30%	40%	4500	2250	0.006	0.4761
90	Existing	0.993	80%	0%	20%	0%	9740	4870	0.006	0.5328
91	Existing	0.337	10%	20%	20%	50%	4445	2222.5	0.006	0.477
92	Existing	0.097	0%	30%	30%	40%	2700	1350	0.006	0.3837
93	Existing	0.064	0%	65%	20%	15%	1700	850	0.006	0.292

TABLE 2.C
FUTURE CONDITIONS
BOCA NEGRA SUB-BASIN CHARACTERISTICS

Sub-Basin ID	Hydrologic Condition	Sub-Basin Area (Mi^2)	Land Treatment				L_{basin} (ft)	L_{CA} (ft)	Slope	T_P (hrs)
			A	B	C	D				
10	Future	0.472	6%	19%	19%	57%	9650	5790	0.025	0.4055
11	Future	0.389	6%	19%	19%	57%	9450	7088	0.023	0.4315
12A	Future	0.227	7%	20%	20%	53%	5155	2578	0.011	0.3762
12B	Future	0.164	6%	19%	19%	57%	5000	2500	0.011	0.3598
13	Future	0.180	0%	25%	25%	50%	3530	1942	0.016	0.2574
14A	Future	0.264	0%	22%	23%	55%	3530	1765	0.023	0.3895
14B	Future	0.373	6%	19%	19%	57%	7700	3850	0.023	0.3301
15	Future	0.130	0%	25%	25%	50%	3623	1993	0.016	0.28
16A	Future	0.270	0%	15%	15%	70%	5432	2716	0.007	0.4395
16B	Future	0.473	6%	19%	19%	57%	8340	4170	0.022	0.3537
17	Future	0.280	0%	15%	15%	70%	4466	2456	0.012	0.3444
18	Future	0.280	0%	15%	15%	70%	4675	2571	0.007	0.4425
19	Future	0.140	0%	25%	25%	50%	3114	1713	0.006	0.4166
20	Future	0.160	8%	25%	28%	40%	3335	1834	0.021	0.2321
21A	Future	0.157	99%	1%	0%	0%	5800	2900	0.027	0.2624
21B	Future	0.096	99%	1%	0%	0%	2010	1005	0.005	0.36
22A	Future	0.220	0%	15%	15%	70%	3335	1834	0.021	0.2321
22B	Future	0.543	6%	19%	19%	57%	19000	9500	0.009	0.747
23	Future	0.210	0%	15%	15%	70%	3725	2049	0.013	0.3161
24	Future	0.361	6%	19%	19%	57%	6000	3000	0.001	0.9901
25	Future	0.856	99%	0%	1%	0%	9300	4650	0.0234	0.3787
30	Future	0.495	95%	5%	0%	0%	7700	5005	0.0156	0.3895
32	Future	0.307	6%	19%	19%	57%	3200	1920	0.0153	0.2652
38	Future	0.478	96%	4%	0%	0%	9000	5850	0.0267	0.3842
40	Future	0.348	6%	19%	19%	57%	4700	2350	0.013	0.3319
41	Future	0.175	6%	19%	19%	57%	2500	1500	0.024	0.1839
42	Future	0.499	70%	0%	30%	0%	7000	4200	0.0286	0.3003
43	Future	0.420	80%	10%	10%	0%	4000	2000	0.0225	0.2516

TABLE 2.C (cont'd)
FUTURE CONDITIONS
BOCA NEGRA SUB-BASIN CHARACTERISTICS

Sub-Basin ID	Hydrologic Condition	Sub-Basin Area (Mi^2)	Land Treatment				L_{basin} (ft)	L_{CA} (ft)	Slope	T_P (hrs)
			A	B	C	D				
44	Future	0.685	6%	19%	19%	57%	6500	3250	0.017	0.3277
45	Future	0.149	6%	19%	19%	57%	5200	2600	0.017	0.3009
46A	Future	0.267	6%	19%	19%	57%	2600	1300	0.0115	0.2714
46B	Future	0.099	6%	19%	19%	57%	3600	1980	0.036	0.1859
47	Future	0.904	6%	19%	19%	57%	4500	2250	0.024	0.2489
48	Future	0.256	6%	19%	19%	57%	3500	1750	0.031	0.1968
49	Future	0.146	6%	19%	19%	57%	3000	1500	0.0133	0.2763
50	Future	0.339	6%	19%	19%	57%	3200	1280	0.019	0.238
51	Future	0.050	6%	19%	19%	57%	400	160	0.019	0.0768
79	Future	0.411	84%	1%	15%	0%	3300	1980	0.006	0.4315
80	Future	0.873	80%	0%	20%	0%	9000	5400	0.029	0.369
81	Future	0.447	90%	0%	10%	0%	8500	5525	0.023	0.3788
82	Future	0.253	90%	0%	10%	0%	5500	3025	0.02	0.2899
83A	Future	0.410	89%	0%	10%	1%	6000	3000	0.036	0.2417
83B	Future	0.236	6%	19%	19%	57%	9000	4500	0.036	0.3345
83C	Future	0.098	6%	19%	19%	57%	2500	1250	0.02	0.2014
84	Future	0.256	6%	19%	19%	57%	7637	3819	0.02	0.3414
85	Future	0.257	80%	0%	20%	0%	1500	750	0.006	0.2681
88	Future	0.069	6%	19%	19%	57%	4000	2000	0.012	0.3445
86	Future	0.150	6%	19%	19%	57%	2000	1000	0.012	0.2318
89	Future	0.209	10%	20%	30%	40%	4500	2250	0.006	0.4761
90A	Future	0.246	6%	19%	19%	57%	3200	1000	0.023	0.2163
90C	Future	0.090	80%	0%	20%	0%	2000	1000	0.006	0.3279
91A	Future	0.257	10%	20%	20%	50%	4000	2000	0.006	0.4873
91B	Future	0.096	80%	0%	20%	0%	400	200	0.02	0.0748
92	Future	0.097	0%	30%	30%	40%	2700	1350	0.006	0.3837
93	Future	0.064	0%	65%	20%	15%	1700	850	0.006	0.292

TABLE 3
DAM STORAGE - ELEVATION - OUTFLOW DATA

BOCA NEGRA POND			
Outflow (cfs)	Storage (ac-ft)	Elev (ft)	Depth (ft)
0	0.01	5300	0
157	3	5301	1
273	29	5303	3
417	80	5307	7
498	118	5310	10
546	143	5312	12
589	169	5314	14
610	182	5315	15
630	195	5316	16
668	207	5318	18
2000	210	5319	19
5000	340	5320	20
9000	357	5321	21

QUAIL RANCH POND			
Outflow (cfs)	Storage (ac-ft)	Elev (ft)	Depth (ft)
0	0.01	5100	0
5	5	5101	1
30	30	5102	2
70	60	5103	3
100	80	5104	4
150	120	5106	6
350	160	5108	8
450	200	5110	10
550	240	5112	12
650	280	5114	14
750	320	5116	16
850	360	5118	18
2550	400	5120	20

NORTH GEOLOGIC WINDOW POND			
Outflow (cfs)	Storage (ac-ft)	Elev (ft)	Depth (ft)
0	0.01	5600	0
5	5	5601	1
30	30	5602	2
70	60	5603	3
100	80	5604	4
110	120	5606	6
115	160	5608	8
120	200	5610	10
550	240	5612	12
650	280	5614	14
750	320	5616	16
850	360	5618	18
2550	400	5620	20

LA CUENTISTAS PONDS			
Outflow (cfs)	Storage (ac-ft)	Elev (ft)	Depth (ft)
0	0.01	5100	0
166	0.4	5101	1
186	1	5102	2
204	1.8	5103	3
235	2.6	5104	4
264	4.2	5106	6
270	6	5108	8
270	8	5110	10
270	10.2	5112	12
270	12.6	5114	14
270	16	5116	16
850	19	5118	18
2550	20	5120	20

MARIPOSA DETENTION BASIN			
Outflow (cfs)	Storage (ac-ft)	Elev (ft)	Depth (ft)
0	0	5106	0
65	0.03	5108	2
180	3.2	5110	4
350	6.68	5112	6
490	8.17	5114	8
543	8.85	5115	9
571	238.22	5115.5	9.5
595	272.67	5116	10
690	349.82	5118	12
714	370	5118.5	12.5
1398	410	5119.5	13.5
2740	450	5120.5	14.5
4430	485	5121.5	15.5
5100	490	5121.6	15.6

DOUBLE EAGLE II POND			
Outflow (cfs)	Storage (ac-ft)	Elev (ft)	Depth (ft)
0	0	5718	0
17.99	10.03	5719	1
25.01	20.26	5720	2
30.63	30.68	5721	3
35.37	41.29	5722	4
39.55	52.09	5723	5
43.32	63.09	5724	6
46.79	74.29	5725	7
50.02	85.69	5726	8

TABLE 4.A
2001 CONDITIONS
SUB-BASIN RUNOFF

Sub-Basin ID	Hydrologic Condition	Sub-Basin Area	Flow Rate	Runoff Volume
		(mi^2)	(cfs	(ac-ft)
10	Existing	0.472	132	9
11	Existing	0.389	103	8
12	Existing	0.304	84	6
14	Existing	0.513	138	10
15	Existing	0.304	83	6
16	Existing	0.533	147	11
17	Existing	0.265	65	5
20	Existing	0.717	185	15
21	Existing	0.239	90	5
22	Existing	1.043	161	21
24	Existing	0.361	42	7
25	Existing	0.296	80	6
26	Existing	0.323	103	6
27	Existing	0.396	108	8
30	Existing	0.379	80	8
32	Existing	0.257	100	5
33	Existing	0.770	339	15
35	Existing	0.592	156	12
36	Existing	0.548	144	12
37	Existing	0.687	121	14
38	Existing	0.292	93	6
40	Existing	0.534	207	12
41A	Existing	0.264	207	7
41B	Existing	0.200	132	5
42	Existing	0.575	186	13
43	Existing	0.439	113	10
44	Existing	0.674	208	15
45	Existing	0.128	47	3
46	Existing	0.407	154	9

TABLE 4.A (cont'd)
2001 CONDITIONS
SUB-BASIN RUNOFF

Sub-Basin ID	Hydrologic Condition	Sub-Basin Area	Flow Rate	Runoff Volume
47	Existing	0.473	177	10
48	Existing	0.182	62	4
51	Existing	0.072	34	2
60	Existing	0.354	121	7
62	Existing	0.2	70	4
63	Existing	0.973	415	19
64	Existing	0.305	252	7
65	Existing	0.338	221	7
66	Existing	2.449	319	55
67	Existing	0.109	60	4
68	Existing	0.467	144	10
69	Existing	0.615	174	16
73	Existing	0.723	183	16
74	Existing	0.647	215	18
75	Existing	0.865	252	25
79	Existing	0.411	128	9
80	Existing	0.871	250	21
81	Existing	0.447	139	10
82	Existing	0.304	130	7
83	Existing	0.990	251	23
84	Existing	0.112	46	3
85	Existing	0.073	38	2
86	Existing	0.132	53	3
88	Existing	0.314	108	7
89	Existing	0.209	161	15
90	Existing	0.993	264	24
91	Existing	0.337	275	28
92	Existing	0.097	91	7
93	Existing	0.064	52	3

TABLE 4.B
EXISTING (2003) CONDITIONS
SUB-BASIN RUNOFF

Sub-Basin ID	Hydrologic Condition	Sub-Basin Area	Flow Rate	Runoff Volume
		(mi^2)	(cfs)	(ac-ft)
10	Existing	0.472	133	10
11	Existing	0.389	104	8
12A	Existing	0.140	48	3
12B	Existing	0.164	35	3
14A	Existing	0.140	129	8
14B	Existing	0.373	34	3
15	Existing	0.304	83	12
16A	Existing	0.060	153	10
16B	Existing	0.473	14	1
17	Existing	0.265	65	5
20	Existing	0.940	243	19
21A	Existing	0.072	25	1
21B	Existing	0.167	42	3
22A	Existing	0.500	77	10
22B	Existing	0.543	84	11
24	Existing	0.361	42	7
25	Existing	0.296	80	6
26	Existing	0.323	103	6
27	Existing	0.396	108	8
30	Existing	0.379	80	8
32	Existing	0.257	100	5
33	Existing	0.770	339	15
35	Existing	0.592	156	12
36	Existing	0.548	144	12
37	Existing	0.687	121	14
38	Existing	0.292	93	6

TABLE 4.B (cont'd)
EXISTING (2003) CONDITIONS
SUB-BASIN RUNOFF

Sub-Basin ID	Hydrologic Condition	Sub-Basin Area	Flow Rate	Runoff Volume
40	Existing	0.534	207	12
41	Existing	0.464	264	12
42	Existing	0.575	186	13
43	Existing	0.485	125	11
44	Existing	0.674	208	15
45	Existing	0.128	47	3
46	Existing	0.407	154	9
47	Existing	0.526	197	12
48	Existing	0.147	49	3
51	Existing	0.072	34	2
74	Existing	0.647	215	18
75	Existing	0.865	252	25
79	Existing	0.411	128	9
80	Existing	0.871	250	21
81	Existing	0.447	139	10
82	Existing	0.304	130	7
83	Existing	0.990	251	23
84	Existing	0.112	46	2
85	Existing	0.073	38	2
86	Existing	0.132	53	3
88	Existing	0.314	108	7
89	Existing	0.209	161	15
90	Existing	0.993	264	24
91	Existing	0.337	275	28
92	Existing	0.097	91	7
93	Existing	0.064	52	3

TABLE 4.C
FUTURE CONDITIONS
SUB-BASIN RUNOFF

Sub-Basin ID	Hydrologic Condition	Sub-Basin Area	Flow Rate	Runoff Volume
		(mi^2)	(cfs)	(ac-ft)
10	Future	0.472	465	42
11	Future	0.389	367	35
12A	Future	0.140	229	19
12B	Future	0.164	178	15
13	Future	0.180	220	15
14A	Future	0.260	270	24
14B	Future	0.373	422	33
15	Future	0.130	163	11
16A	Future	0.270	284	28
16B	Future	0.473	510	42
17	Future	0.280	235	19
18	Future	0.280	293	29
19	Future	0.140	167	15
20	Future	0.160	344	20
21A	Future	0.157	62	3
21B	Future	0.096	26	2
22A	Future	0.220	346	22
22B	Future	0.543	347	49
23	Future	0.210	280	22
24	Future	0.361	186	32
25	Future	0.856	260	17
30	Future	0.495	148	10
32	Future	0.307	399	27
38	Future	0.478	144	10
40	Future	0.348	392	31
41	Future	0.175	287	16
42	Future	0.499	254	13
43	Future	0.420	216	10

TABLE 4.C (cont'd)
FUTURE CONDITIONS
SUB-BASIN RUNOFF

Sub-Basin ID	Hydrologic Condition	Sub-Basin Area	Flow Rate	Runoff Volume
44	Future	0.780	830	65
45	Future	0.149	226	13
46A	Future	0.208	345	24
46B	Future	0.160	163	9
47	Future	0.904	1219	81
48	Future	0.256	400	23
49	Future	0.313	398	28
50	Future	0.352	492	32
51	Future	0.050	125	6
79	Future	0.411	128	9
80	Future	0.873	332	21
81	Future	0.447	149	10
82	Future	0.253	106	6
83A	Future	0.410	292	16
83B	Future	0.580	57	4
83C	Future	0.098	157	9
84	Future	0.256	368	23
85	Future	0.257	141	7
86	Future	0.150	216	13
88	Future	0.056	63	5
89	Future	0.209	161	15
90A	Future	0.246	367	22
90C	Future	0.090	28	2
91A	Future	0.257	208	21
91B	Future	0.096	84	2
92	Future	0.097	91	7
93	Future	0.064	52	3

TABLE 5
FLOW RATES AT SELECT ANALYSIS POINTS

Location and Analysis Point *	Hydrologic Condition	Flow Rates (cfs)	Runoff Volume (ac-ft)
Main Boca Negra Quail Ranch AP 23.10 (Ex 20.8)	2001 Condition	627	95.3
	Interim (2005) Condition	736	107.4
	Existing (2003) with Diversion to Calabacillas	366	48.5
	Future Conditions-No Improvements	4164	474.0
	Future Conditions with Improvements	1783	225.3
Shooting Range AP 25.90 (Ex 25.75)	2001 Condition	275	27.5
	Interim (2005) Condition	275	27.5
	Existing (2003) with Diversion to Calabacillas	275	27.5
	Future Conditions-No Improvements	291	20.4
	Future Conditions with Improvements	291	20.4
Northwest Corner Double Eagle II Airport AP30.9	2001 Condition	275	34.8
	Interim (2005) Condition	275	34.8
	Existing (2003) with DEII Ponds & Diversion to Calabacillas	275	34.8
	Future Conditions-No Improvements	287	30.0
	Future Conditions with Improvements	287	30.0
Quail Ranch Confluence AP 23.75 (Ex 20.75)	2001 Condition	712	130.1
	Interim (2005) Condition	792	142.2
	Existing (2003) with DEII Ponds & Diversion to Calabacillas	443	83.3
	Future Conditions-No Improvements	4260	503.9
	Future Conditions with Improvements	1915	255.3
Double Eagle Aviation AP36.5	2001 Condition	498	39.2
	Interim (2005) Condition	498	39.2
	Existing (2003) with DEII Ponds & Diversion to Calabacillas	43	65.0
	Future Conditions-No Improvements **	498	39.2
	Future Conditions with Improvements	43	65.0
Paseo del Volcan AP 32.90 (Ex 36.70)	2001 Condition	999	174.1
	Interim (2005) Condition	986	186.4
	Existing (2003) with DEII Ponds & Diversion to Calabacillas	499	153.6
	Future Conditions-No Improvements	4650	571.2
	Future Conditions with Improvements	439	321.9
Upstream North Geologic Window AP 41.87	2001 Condition	1066	212.4
	Interim (2005) Condition	1080	224.7
	Existing (2003) with DEII Ponds & Diversion to Calabacillas	534	178.0
	Future Conditions-No Improvements **	4940	639.8
	Future Conditions with Improvements	780	376.8

TABLE 5 (cont'd)
FLOW RATES AT SELECT ANALYSIS POINTS

Location and Analysis Point *	Hydrologic Condition	Flow Rates (cfs)	Runoff Volume (ac-ft)
North Geologic Window East Side AP 43.90	2001 Condition	1090	240.4
	Interim (2005) Condition	1085	247.2
	Existing (2003) with DEII Ponds & Diversion to Calabacillas	695	206.4
	Future Conditions-No Improvements **	5068	661.8
	Future Conditions with Improvements	1032	398.7
	Future Conditions with Improvements & NGW Pond ***	399	278.7
State Land South Boundary AP 46.70	2001 Condition	NA	NA
	Interim (2005) Condition	1092	271.1
	Existing (2003) with DEII Ponds & Diversion to Calabacillas	NA	NA
	Future Conditions-No Improvements **	5115	685.7
	Future Conditions with Improvements	1201	422.0
	Future Conditions with Improvements & NGW Pond ***	545	300.3
Unser-Universe Storm Drain AP 50.71	2001 Condition	N/A	N/A
	Interim (2005) Condition	1247	152.3
	Existing (2003) with DEII Ponds & Diversion to Calabacillas	N/A	N/A
	Future Conditions-No Improvements **	1211	81.9
	Future Conditions with Improvements	1247	152.3
Boca Negra Above Unser Boulevard AP 52.19 (85.95) Boca Negra Pond	2001 Condition	1328	282.4
	Interim (2005) Condition	3069	565.3
	Existing (2003) with DEII Ponds & Diversion to Calabacillas	1050	248.9
	Future Conditions-No Improvements **	5496	871.8
	Future Conditions with Improvements	3059	715.4
	Future Conditions with Improvements & NGW Pond ***	2983	591.7
South Geologic Window Petroglyph Monument AP 81.8	2001 Condition	384	30.7
	Interim (2005) Condition	481	30.7
	Existing (2003) with DEII Ponds & Diversion to Calabacillas	384	30.7
	Future Conditions-No Improvements **	481	30.7
	Future Conditions with Improvements	481	30.7
	Future Conditions with Improvements & NGW Pond ***	481	30.7
South Boca Negra Outfall to Canyon SAD 227 AP 85.12 (85.80)	2001 Condition	589	62.5
	Interim (2005) Condition	492	36.1
	Existing (2003) with DEII Ponds & Diversion to Calabacillas	589	62.5
	Future Conditions-No Improvements **	492	36.1
	Future Conditions with Improvements	492	36.1

TABLE 5 (cont'd)
FLOW RATES AT SELECT ANALYSIS POINTS

Location and Analysis Point *	Hydrologic Condition	Flow Rates (cfs)	Runoff Volume (ac-ft)
Tesuque Crossing AP 85.17 (EX 86.9)	2001 Condition	1838	357.2
	Interim (2005) Condition	1374	621.9
	Existing (2003) with DEII Ponds & Diversion to Calabacillas	1622	323.2
	Future Conditions-No Improvements **	6257	990.4
	Future Conditions with Improvements 200AF Boca Negra Pond	1089	645.9
	Future Conditions with Improvements 100AF Boca Negra Pond	1945	771.6
	Future Conditions with Improvements & NGW Pond ***	1089	645.9
Mariposa Arroyo at Mojave St AP 91.80	2001 Condition	532	51.4
	Interim (2005) Condition	469	73.7
	Existing (2003) with DEII Ponds & Diversion to Calabacillas	532	51.4
	Future Conditions-No Improvements **	743	60.9
	Future Conditions with Improvements	469	73.7
	Future Conditions with Improvements & NGW Pond ***	469	73.7
Boca Negra Confluence with Mariposa AP 91.90	2001 Condition	2236	424.0
	Interim (2005) Condition	1873	390.0
	Existing (2003) with DEII Ponds & Diversion to Calabacillas	1573	711.0
	Future Conditions-No Improvements **	6477	1066.2
	Future Conditions with Improvements 200AF Boca Negra Pond	1571	859.5
	Future Conditions with Improvements 100AF Boca Negra Pond	2397	860.1
	Future Conditions with Improvements & NGW Pond ***	1546	732.3
Inflow Mariposa Basin Park AP 93.81	2001 Condition	2249	431.2
	Interim (2005) Condition	1885	397.0
	Existing (2003) with DEII Ponds & Diversion to Calabacillas	1603	718.2
	Future Conditions-No Improvements **	6473	1073.4
	Future Conditions with Improvements 200AF Boca Negra Pond	1600	866.5
	Future Conditions with Improvements 100AF Boca Negra Pond	2426	867.2
	Future Conditions with Improvements & NGW Pond ***	1576	738.8
( ) 2001 Condition Analysis Point Number			
* Analysis points are shown on Figure 3 (Existing Conditions) and 4 (Future Conditions)			
** Future Conditions-No Improvements uses Double Eagle II Airport Undeveloped Cond. Land Treatments			
*** Future Conditions with Improvements & NGW Pond includes 200AF Boca Negra Pond			

* Analysis points are shown on Figure 3 (Existing Conditions) and 4 (Future Conditions)

TABLE 6
MARIPOSA DETENTION BASIN STORAGE ROUTING RESULTS

Emergency Spillway	=	5119 ft.	Storage = 390 ac.ft.
Top of Dam	=	5121 ft.	Storage = 468 ac.ft
Top of Dividing Berm	=	5115.5 ft.	

Condition	Maximum Storage Volume (ac./ft)	Maximum Elevation (feet)
1. 2001 Conditions (No improvements or development above escarpment)	203.4	5115.4
2. Interim Condition - with 200 ac.ft. Boca Negra Pond only and development east of Volacano Open Space	210.2	5115.4
3. Existing Conditions (with DE II Ponds, Calabacillas Diversion and Universe Blvd.)	133.2	5115.3
4. Future Conditions with No Ponds or Diversions (Developed Land Treatment, No Improvements)	457.1	5120.7
5. Future Conditions with all Improvements by others and 200 ac./ft Boca Negra Pond without North Geologic Window Pond	155.3	5115.3
6. Future Conditions with all Improvements by Others and 100 ac./ft. Boca Negra Pond without North Geologic Window Pond	307.2	5116.5
7. Future Conditions with all Improvements by Others and 200 ac./ft. Boca Negra Pond with North Geologic Window Pond	117.0*	5115.2

* Upstream storage attenuates hydrograph so that most inflow does not spill into park sections.

TABLE 7.A
IMPROVEMENTS INCLUDED WITH EACH MODEL RUN

IMPROVEMENTS	2001 CONDITIONS	EXISITING CONDITIONS	FUTURE CONDITIONS	OPTION I	OPTION II	OPTION III	INTERIM
	BNEX100	BN EX REV	FC- NO DAMS	FC200AF	FC100AF	NGW-PND	
1. Diversion to Calabacillas Arroyo	No	Yes	No	Yes	Yes	Yes	No
2. 43 cfs Controlled Release from Double Eagle II Airport	No	Yes	No	Yes	Yes	Yes	No
3. Quail Ranch Detention Basin	No	No	Yes	Yes	Yes	Yes	No
4. Boca Negra Detention Basin - 200 ac.ft. storage	No	No	No	Yes	No	Yes	Yes
5. Boca Negra Detention Basin - 100 ac,ft, storage	No	No	No	No	Yes	No	No
6. 60-in. dia. Outlet in Boca Negra Dam	No	No	No	Yes	No	Yes	Yes
7. 96-in. dia. Outlet in Boca Negra Dam	No	No	No	No	Yes	No	No
8. Controlled releases from The Trails Subdivision to Boca Negra Basin	No	No	Yes	Yes	Yes	Yes	Yes
9. North Geologic Window Pond	No	No	No	No	No	Yes	No
10. La Cuentista Ponds with 227 cfs. Controlled release	No	No	No	Yes	Yes	Yes	Yes

TABLE 7.B
COMPARISON OF FLOWS FOR EXISITING AND FUTURE CONDITIONS WITH NEW DAM OPTIONS

IMPROVEMENTS	CONDITION MODEL FILE NAME	2001 BNEX100	EXISTING CONDTIONS BN EX REV	FUTURE CONDITIONS FC-NO DAMS	OPTION I BN POND FC200AF	OPTION II BN POND FC100AF	OPTION III BN POND + NGW PND	BN POND INTERIM
POND AT QUAIL	PEAK IN	712	443	4260	1915	1915	1915	792
RANCH	PEAK OUT	712	443	4260	325	325	325	792
AP 23.99 (20.75)	HYD VOLUME	130	83	504	255	255	255	142
	POND STORAGE	0	0	0	155	155	155	0
ENTRANCE TO NGW	PEAK IN	1066	534	4940	780	780	780	1080
AP 41.87	PEAK OUT	1066	534	4940	780	780	117	1080
	HYD VOLUME	212	178	640	377	377	377	225
	POND STORAGE	0	0	0	173	173	172	0
POND AT BOCA NEGRA	PEAK IN	1328	1050	5496	3059	3059	2983	3069
AP 52.19 (85.95)	PEAK OUT	1328	1050	5496	665	1467	571	1336
	HYD VOLUME	282	249	872	715	715	590	565
	POND STORAGE	0	0	0	206	118	160	223
TESUQUE	PEAK IN	1840	1967	6493	1069	1844	1089	1394
CROSSING	HYD VOLUME	357	323	1048	744	722	597	
AP 85.70 (86.90)								
MARIPOSA AT	PEAK IN	532	532	743	469	469	510	469
SAN ILDEFONSO	HYD VOLUME	51.4	51.4	61	74	74	74	74
AP 91.8								
CONFLUENCE OF BOCA NEGRA	PEAK IN	2236	1873	6477	1571	2397	1546	1573
AND MARIPOSA CHANNELS	HYD VOLUME	424	390	1066	860	860	723	711
AP 91.80								
MARIPOSA	PEAK IN	2249	1885	6473	1600	2426	1576	1603
BASIN	PEAK OUT	567	558	3170	560	637	556	
AP 93.81	HYD VOLUME	431	397	1073	866	867	738	
	POND STORAGE	203	133	459	155	307	117	

TABLE 8.A

ALTERNATIVE EQUILIBRIUM SLOPE ANALYSIS CHANNELIZATION FROM NGW TO BN DMP POND ANALYSIS POINT 46.7

This method is based on the argument that average Froude (Fr) numbers in stable sand-bed streams range from 0.7 to 1.0. The equation for maximum equilibrium slope (Ss, ft/ft), derived from Manning's formula (assuming a wide rectangular channel), is shown below:

$S_s = C \cdot Q_d^{-0.133}$ in ft/ft

$W = 0.5F^{0.6}Fr^{-.4}Q^{0.4}$, in ft.

where:

$C = 18.28\ n^2 \cdot F^{0.133} \cdot Fr^{2.133}$

n = Manning's Roughness coefficient

F = top width/depth

Fr = Froude Number

Q_d = 10-year peak flow = dominant discharge, in cfs

1. Find S_s and W:

Q_d	195	cfs
n	0.03	
F	40	
Fr	0.8	
C	0.01669	
Ss	0.00828	ft/ft
W	41	ft

2. Verify S_s: Trapezoidal Section with 41' Wide Bottom and 8H:1V Side Slopes, 0.8% Slope

Q_d	195	cfs
n	0.03	
TW	56.95	ft
D	1	ft
Fr	0.76	
C	0.01568	
Ss	0.008	ft/ft

TABLE 8.B
10-YR EARTHEN TRAPEZOIDAL CHANNEL

Project Description	
Project File	c:\docume~1\susanl~1\desktop\oldcom~1\c\projec~1\03-160~1\seqbnd~1.fm2
Worksheet	Proposed Channel
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.030	
Channel Slope	0.8000	%
Left Side Slope	8.000000	H : V
Right Side Slope	8.000000	H : V
Bottom Width	41.00	ft
Discharge	195.00	cfs

Results		
Depth	1.00	ft
Flow Area	48.84	ft²
Wetted Perimeter	57.08	ft
Top Width	56.95	ft
Critical Depth	0.84	ft
Critical Slope	0.014562	ft/ft
Velocity	3.99	ft/s
Velocity Head	0.25	ft
Specific Energy	1.24	ft
Froude Number	0.76	
Flow is subcritical.		

TABLE 8.C
100-YR EARTHEN TRAPEZOIDAL CHANNEL

Project Description	
Project File	c:\docume~1\susanl~1\desktop\oldcom~1\c\projec~1\03-160~1\seqbnd~1.fm2
Worksheet	Proposed Channel
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.030	
Channel Slope	0.8000	%
Left Side Slope	8.000000	H : V
Right Side Slope	8.000000	H : V
Bottom Width	41.00	ft
Discharge	588.00	cfs

Results		
Depth	1.85	ft
Flow Area	103.25	ft²
Wetted Perimeter	70.83	ft
Top Width	70.60	ft
Critical Depth	1.66	ft
Critical Slope	0.011971	ft/ft
Velocity	5.70	ft/s
Velocity Head	0.50	ft
Specific Energy	2.35	ft
Froude Number	0.83	
Flow is subcritical.		

TABLE 8.D
10-YR RIP RAP REACH TRAPEZOIDAL CHANNEL

Project Description	
Project File	c:\docume~1\susanl~1\desktop\oldcom~1\c\projec~1\03-160~1\seqbnd~1.fm2
Worksheet	rip rap
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.035	
Channel Slope	10.00	H : V
Left Side Slope	8.000000	H : V
Right Side Slope	8.000000	H : V
Bottom Width	41.00	ft
Discharge	195.00	cfs

Results		
Depth	0.52	ft
Flow Area	23.71	ft²
Wetted Perimeter	49.46	ft
Top Width	49.39	ft
Critical Depth	0.84	ft
Critical Slope	0.019821	ft/ft
Velocity	8.22	ft/s
Velocity Head	1.05	ft
Specific Energy	1.58	ft
Froude Number	2.09	
Flow is supercritical.		

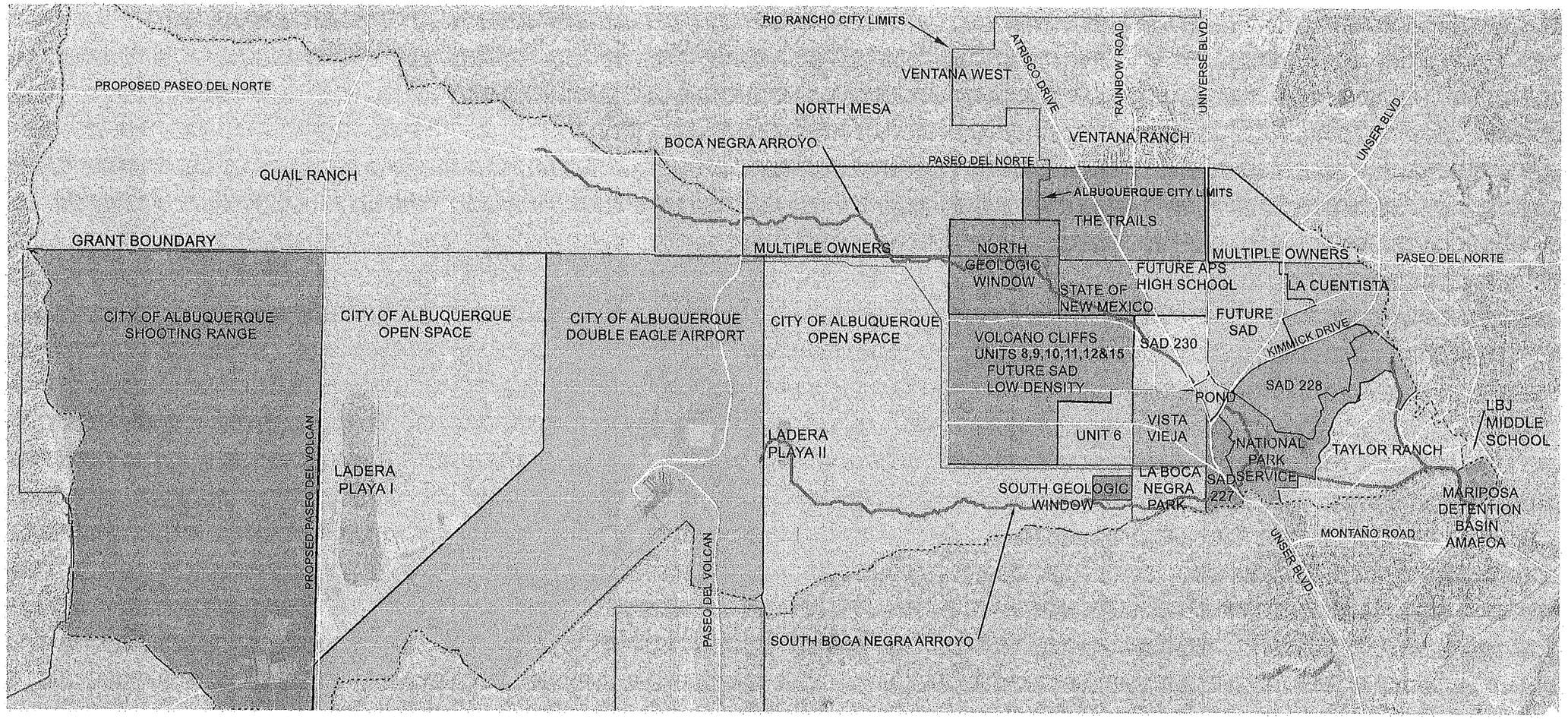
TABLE 8.E
100-YR RIP RAP REACH TRAPEZOIDAL CHANNEL

Project Description	
Project File	c:\docume~1\susanl~1\desktop\oldcom~1\c\projec~1\03-160~1\seqbnd~1.fm2
Worksheet	rip rap
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.035	
Channel Slope	10.00	H : V
Left Side Slope	8.000000	H : V
Right Side Slope	8.000000	H : V
Bottom Width	41.00	ft
Discharge	588.00	cfs

Results		
Depth	0.99	ft
Flow Area	48.68	ft^2
Wetted Perimeter	57.03	ft
Top Width	56.91	ft
Critical Depth	1.66	ft
Critical Slope	0.016294	ft/ft
Velocity	12.08	ft/s
Velocity Head	2.27	ft
Specific Energy	3.26	ft
Froude Number	2.30	
Flow is supercritical.		

FIGURES



N
W E
S

0 1,000 2,000 4,000 6,000 8,000 Feet

LAND OWNERSHIP/ LAND USE

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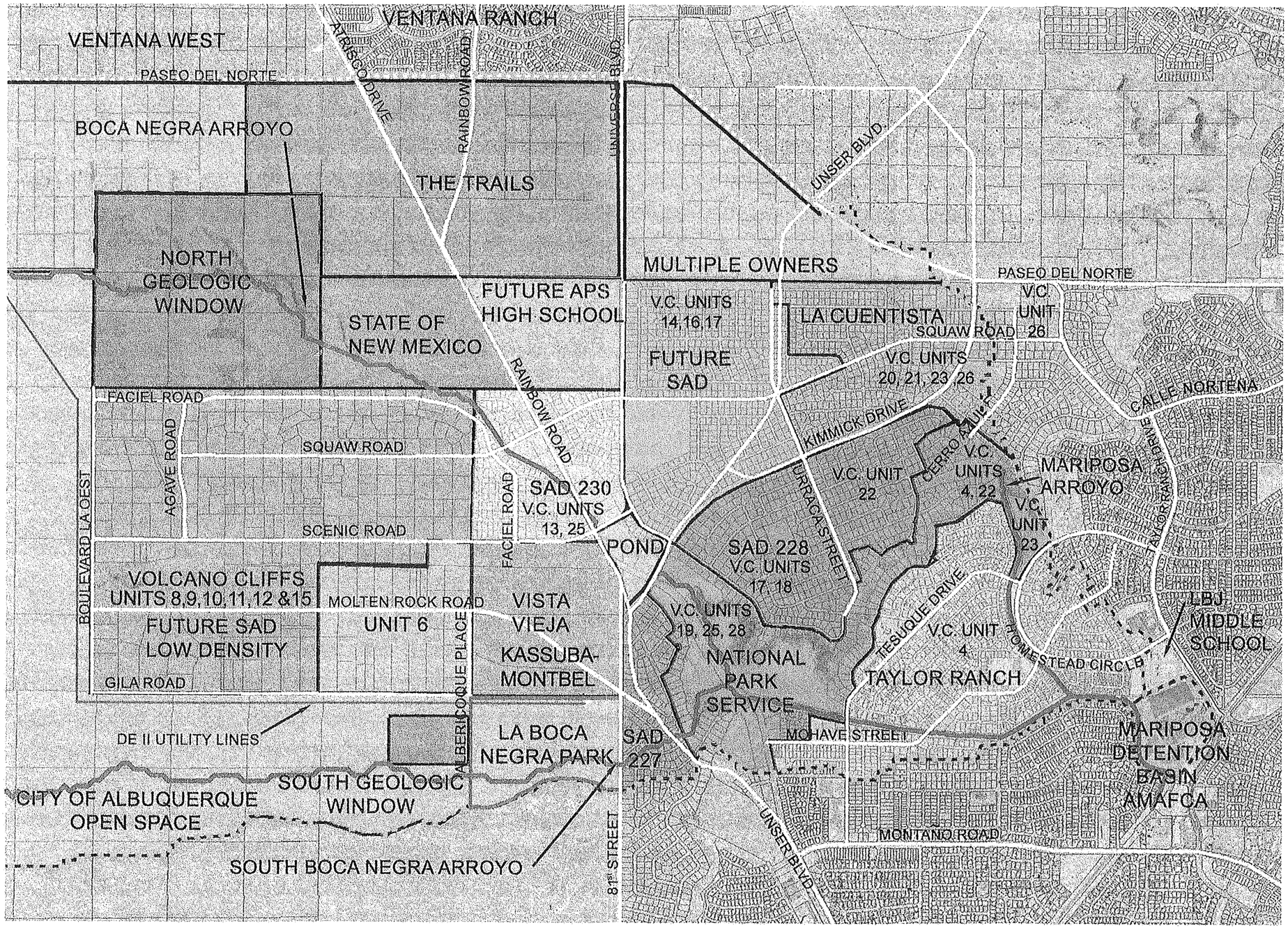
Civil Engineering - Environmental Sciences - Water Resources
Landscape Architecture - Planning

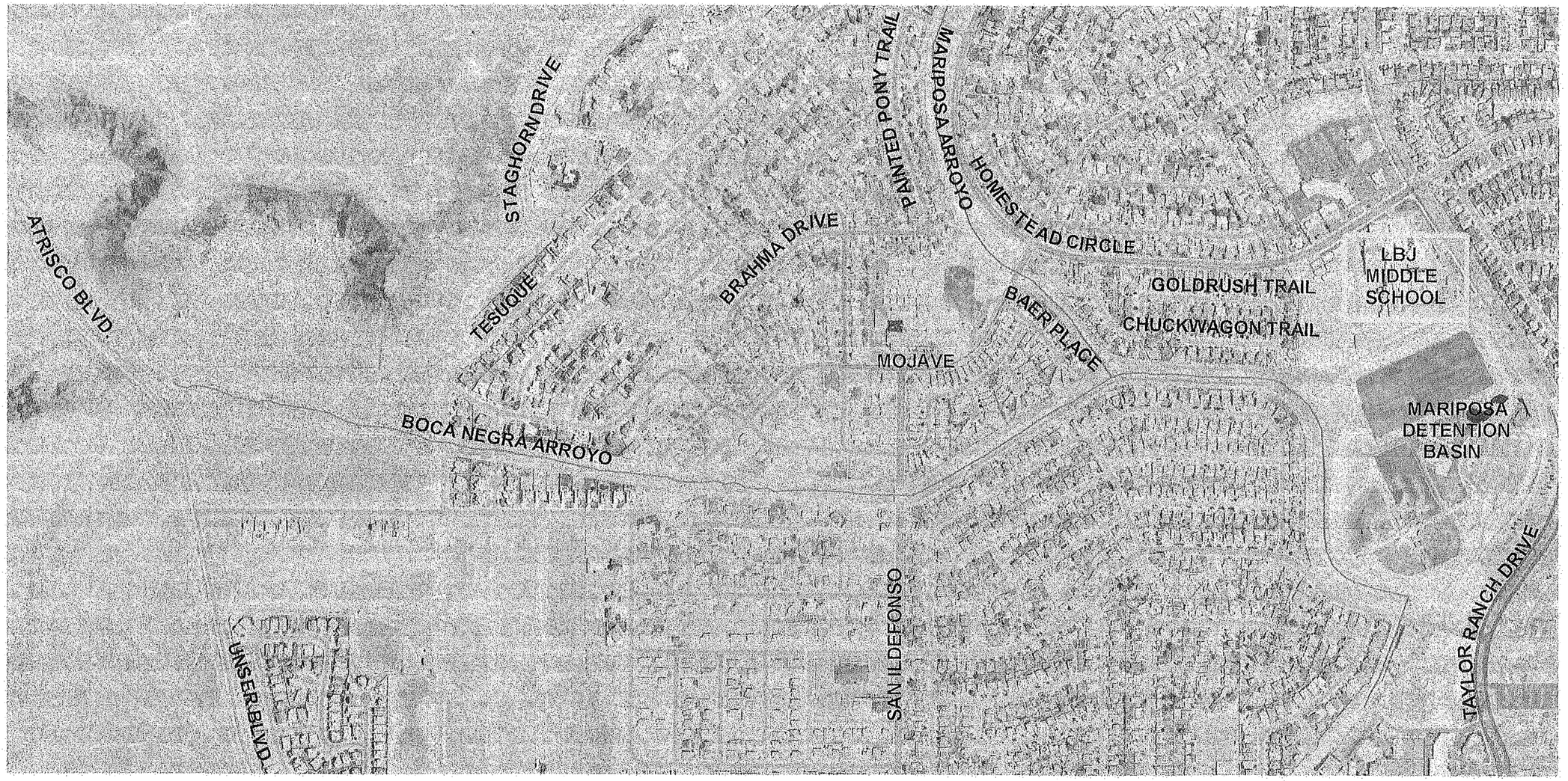
FIGURE 1.A



LAND OWNERSHIP/ LAND USE DETAIL

Resource Technology, Inc.

FIGURE 1.B



STREET IDENTIFICATION DETAIL

Resource Technology, Inc.
Civil Engineering • Environmental Sciences • Water Resources
Landscape Architecture • Planning

FIGURE 1.C

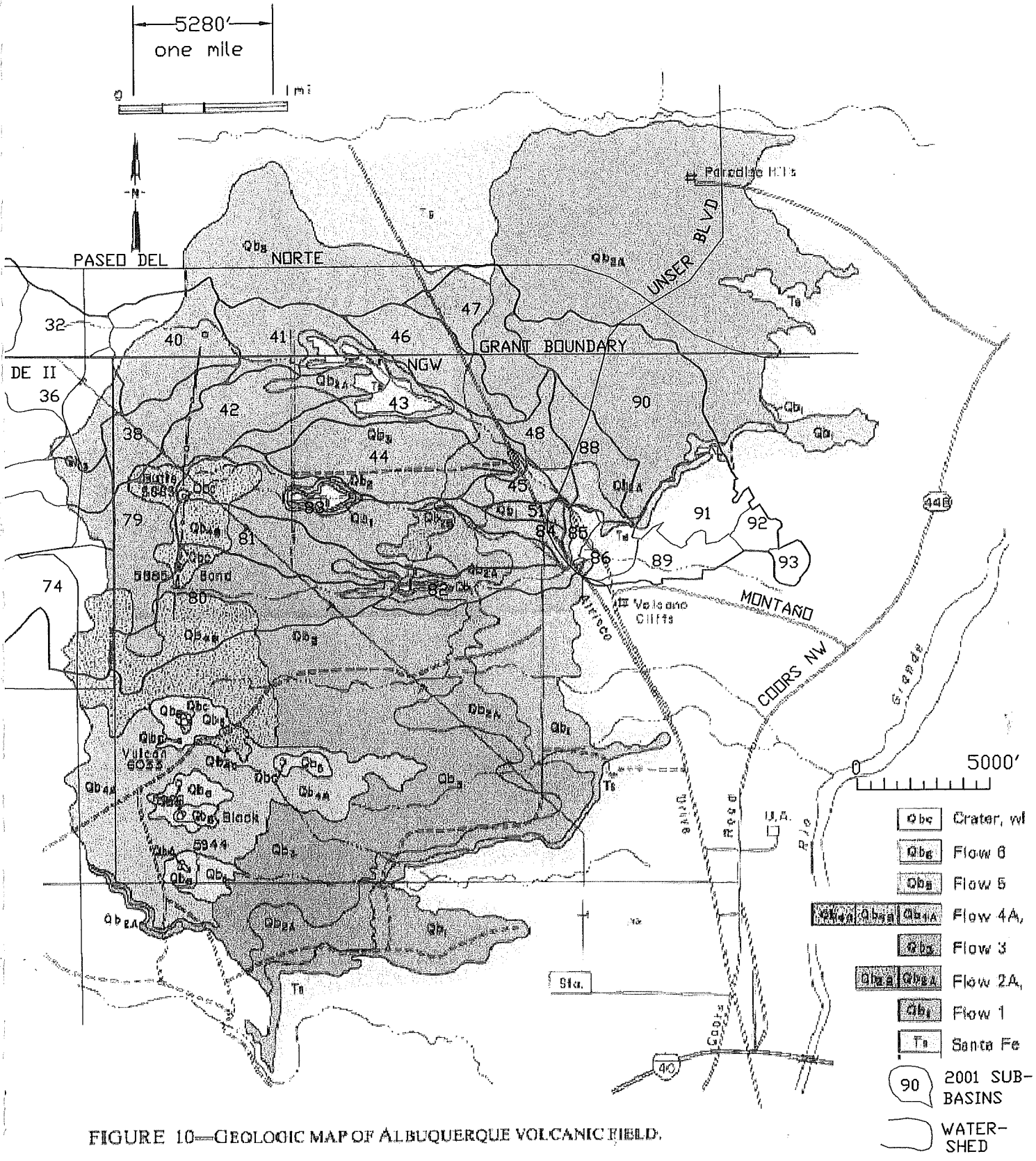
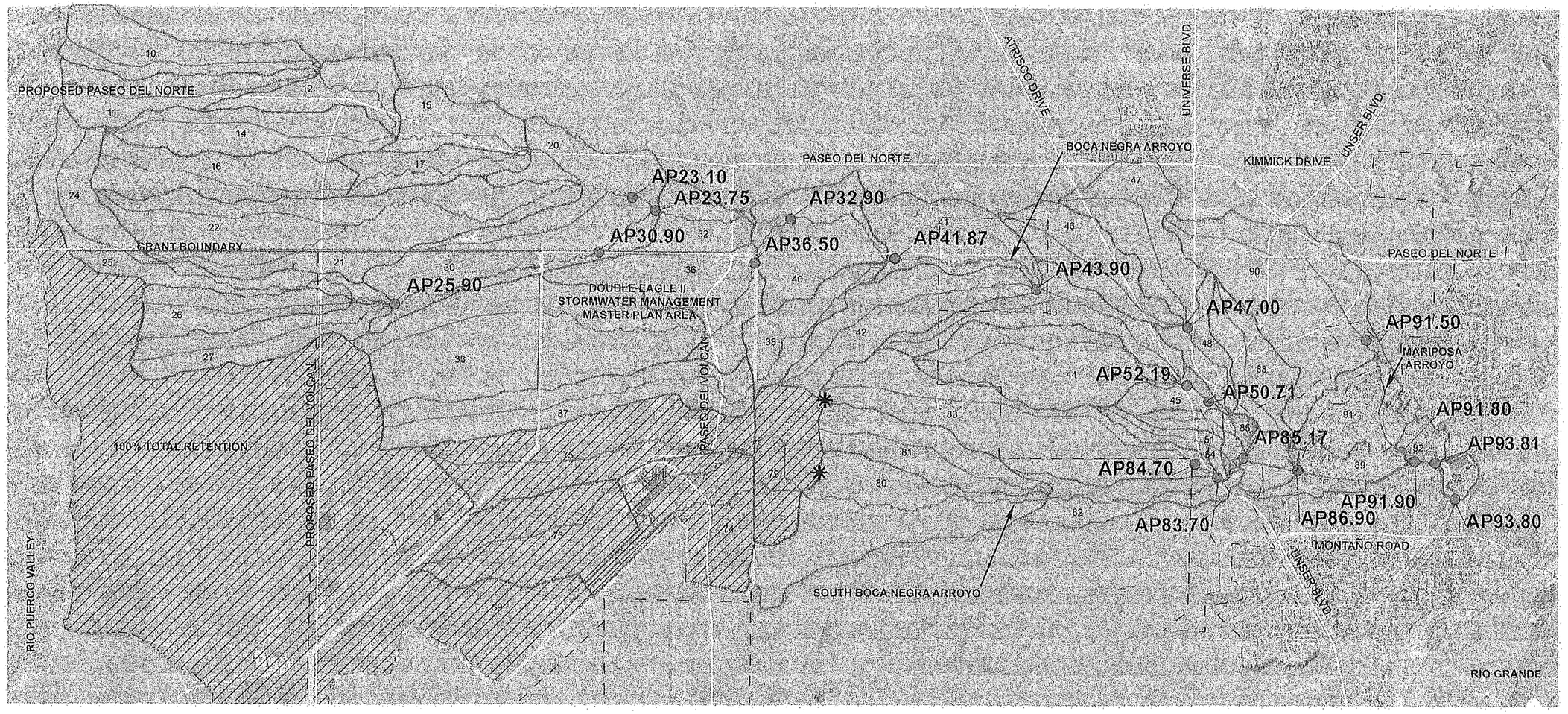


FIGURE 10—GEOLOGIC MAP OF ALBUQUERQUE VOLCANIC FIELD.

CIRCULAR 156 1978 V.C. KELLY and A.M. KUDO

FIGURE 1.D

GTM



Feet
0 1,000 2,000 4,000 6,000 8,000

LEGEND

- ANALYSIS POINTS
- ARROYOS
- GRANT BOUNDARY LINE
- NON-CONTRIBUTING
- PROPERTY LINES
- 81 SUB-BASINS
- SUB-BASIN BOUNDARY
- VOLCANOS
- WATERSHED BOUNDARY

2001 CONDITIONS
SUB-BASINS AND ANALYSIS POINTS

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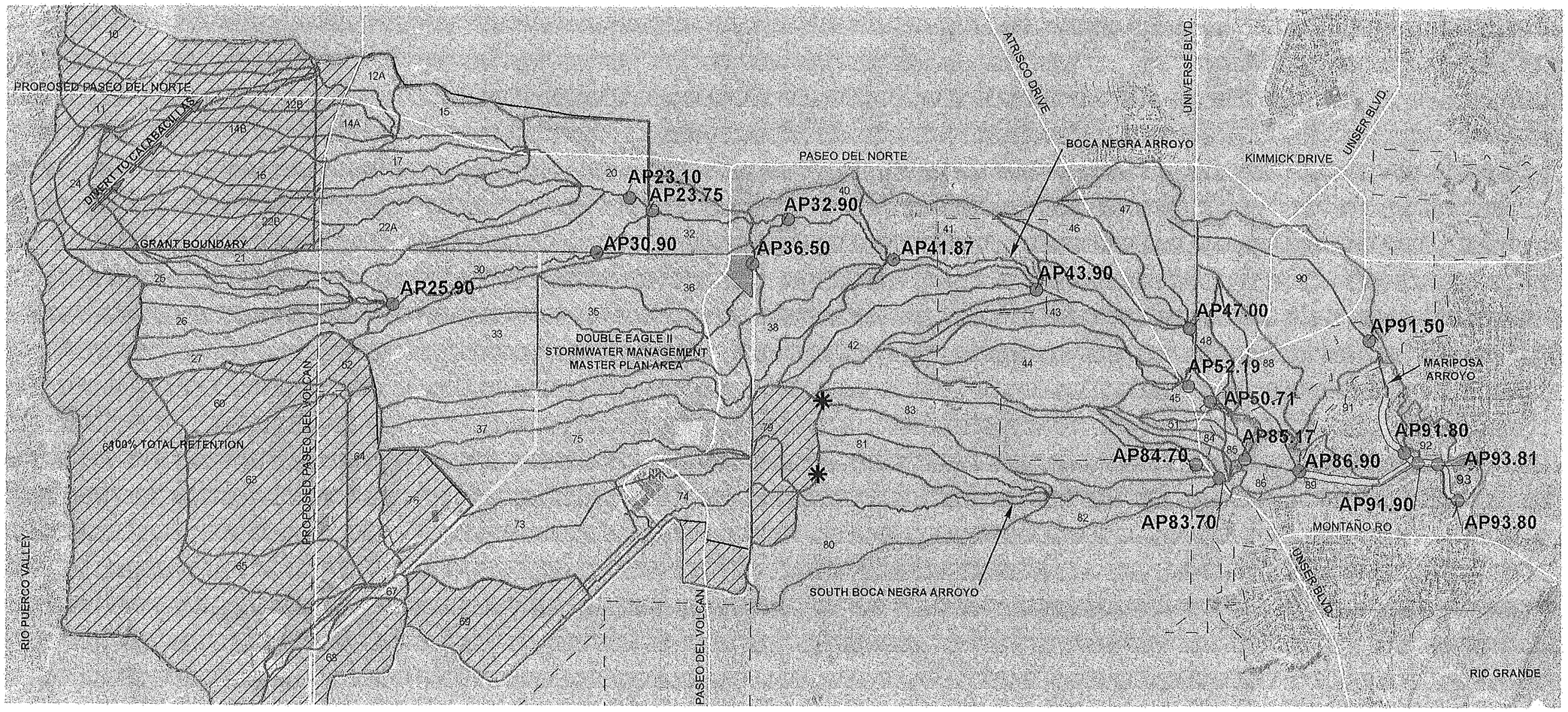
Landscape Architecture - Planning

FIGURE 2



LEGEND

- ANALYSIS POINTS
- ARROYOS
- CONTROLLED RUNOFF AREA
- EXISTING IMPROVED CHANNELS
- EXISTING PONDS
- GRANT BOUNDARY LINE
- NON-CONTRIBUTING
- PROPERTY LINES
- 81 SUB-BASINS
- SUB-BASIN BOUNDARY
- VOLCANOS
- WATERSHED BOUNDARY

EXISTING CONDITIONS
SUB-BASINS AND ANALYSIS POINTS

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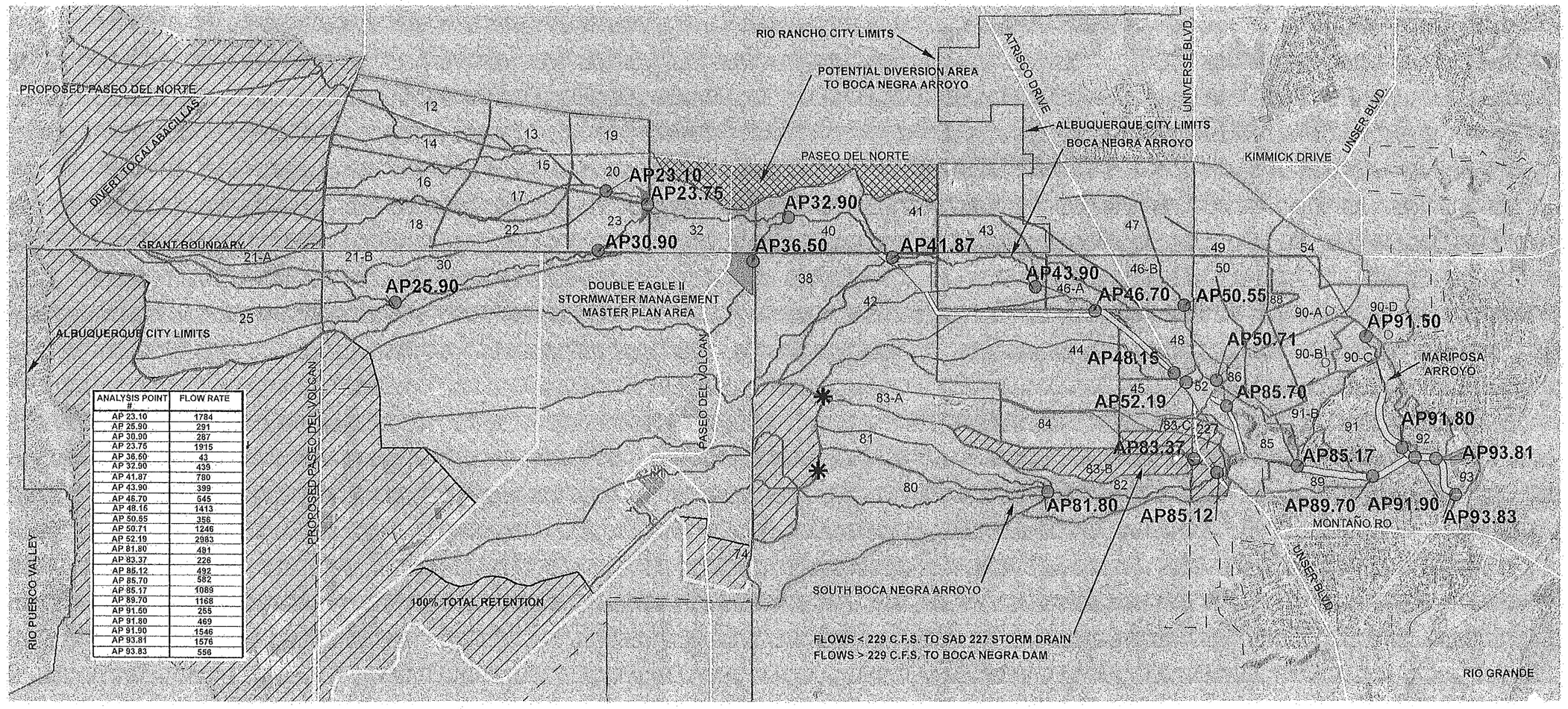
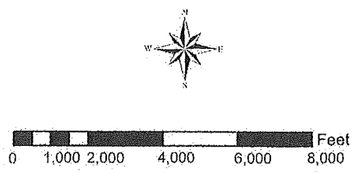
FIGURE 3



ANALYSIS POINT #	FLOW RATE
AP 23.10	1784
AP 25.90	291
AP 30.90	287
AP 23.75	1915
AP 36.50	43
AP 32.90	439
AP 41.87	780
AP 43.90	399
AP 46.70	545
AP 48.16	1413
AP 50.55	356
AP 50.71	1246
AP 52.19	2983
AP 81.80	491
AP 83.37	226
AP 85.12	492
AP 85.70	582
AP 85.17	1089
AP 89.70	1168
AP 91.50	255
AP 91.80	469
AP 91.90	1546
AP 93.81	1576
AP 93.83	556



LEGEND

- ANALYSIS POINTS
- ARROYOS
- CONTROLLED RUNOFF AREA
- EXISTING CHANNELS
- EXISTING PONDS
- GRANT BOUNDARY LINE
- NON-CONTRIBUTING
- PROPERTY LINES
- PROPOSED CHANNELS
- PROPOSED OUTLET PIPE
- PROPOSED PONDS
- 81 SUB-BASINS
- SUB-BASIN BOUNDARY
- VOLCANOS
- WATERSHED BOUNDARY

FUTURE CONDITIONS SUB-BASINS AND ANALYSIS POINTS

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FIGURE 4

QUAIL RANCH

POTENTIAL ADDITIONAL WATERSHED AREA

PASEO DEL NORTE

ATRISCO

VENTANA RANCH

UNIVERSE

THE TRAILS

BOCA NEGRA ARROYO

PROPOSED UNSER

ALAMEDA GRANT BOUNDARY LINE

NORTH GEOLOGIC WINDOW

DOUBLE EAGLE II AIRPORT LANDS

OPEN SPACE

STATE

APS HIGH SCHOOL

FUTURE SAD

LA CUENTISTA

PASEO DEL VOLCAN

VOLCANO CLIFFS

SAD 228

PNM

MARIPOSA CHANNEL

SAD 230

SAD 228

VISTA VIEJA

PNM

PNM

MARIPOSA DETENTION BASIN

BOCA NEGRA CHANNEL

OPEN SPACE

DE-II WATER & SEWER LINES

POWER LINES

SOUTH GEOLOGIC WINDOW

OPEN SPACE

TESUQUE CROSSING

MOJAVE CROSSING

SAD 227

STATE LAND

PETROGLYPH NATL. MON.

NOTES:

1. PROPOSED QUAIL RANCH DAM (155 AF)
2. DOUBLE EAGLE II INTERIM DETENTION POND (61 AF)
3. NORTH GEOLOGIC WINDOW POND AND SOIL CEMENT INLET CHANNEL (173 AF)
4. SAD 228 POND (200 AF)
5. THREE LA CUENTISTA PONDS (16 AF)
6. 36" PIPE IN FACIEL RD
7. NATURALIZED CHANNEL (1400 CFS/600 CFS WITH NGW DAM)
8. UNSER STORM DRAIN
9. UNIVERSE STORM DRAIN (72") FROM THE TRAILS PONDS
10. 60" PIPE ACROSS SAD 227 FOR SOUTH BRANCH OF BOCA NEGRA ARROYO
11. ENERGY DISIPATOR
12. 72" OUTLET PIPE IN ATRISCO R.O.W.
13. 60" PIPE IN UNSER BLVD FOR SAD 227 FLOWS– TO SAN ANTONIO ARROYO
14. REALIGNED BOCA NEGRA ARROYO
15. SQUAW RD STORM DRAIN
16. SCENIC RD STORM DRAIN

LEGEND

- LAND PARCEL BOUNDARY
- WATERSHED BOUNDARY
- PROPOSED STORM DRAINS
- PROPOSED CHANNELS
- FUTURE COND. SUB–BASINS
- EXISTING CHANNELS
- PROPOSED ROAD ALIGNMENT
- ARROYO CHANNEL
- UTILITY LINES
- PONDS PROPOSED IN DMP
- PONDS PROPOSED BY OTHERS
- NON–CONTRIBUTING AREAS
- CONTROLLED RUNOFF AREA

N

0 2000

1000

SCALE: 1"= 2000'

DRAINAGE MANAGEMENT OPTIONS, DAMS, STORM DRAINS, AND CHANNELS

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Water Resources
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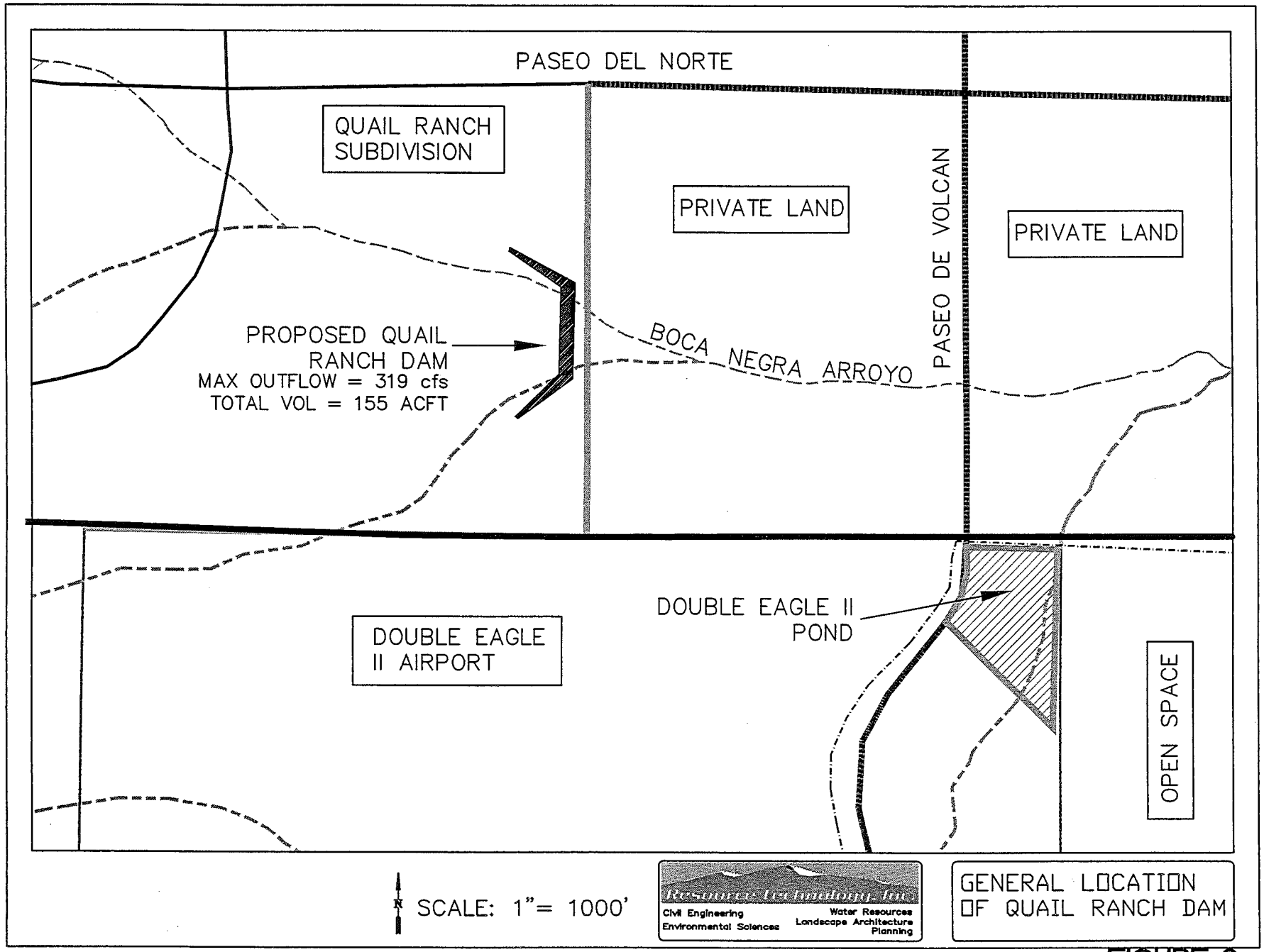
FIGURE 5


PASEO DEL NORTE
QUAIL RANCH SUBDIVISION
PRIVATE LAND
PRIVATE LAND
PASEO DE VOLCAN
PROPOSED QUAIL RANCH DAM
MAX OUTFLOW = 319 cfs
TOTAL VOL = 155 ACFT
BOCA NEGRA ARROYO
DOUBLE EAGLE II AIRPORT
DOUBLE EAGLE II POND
OPEN SPACE
N
SCALE: 1"= 1000'
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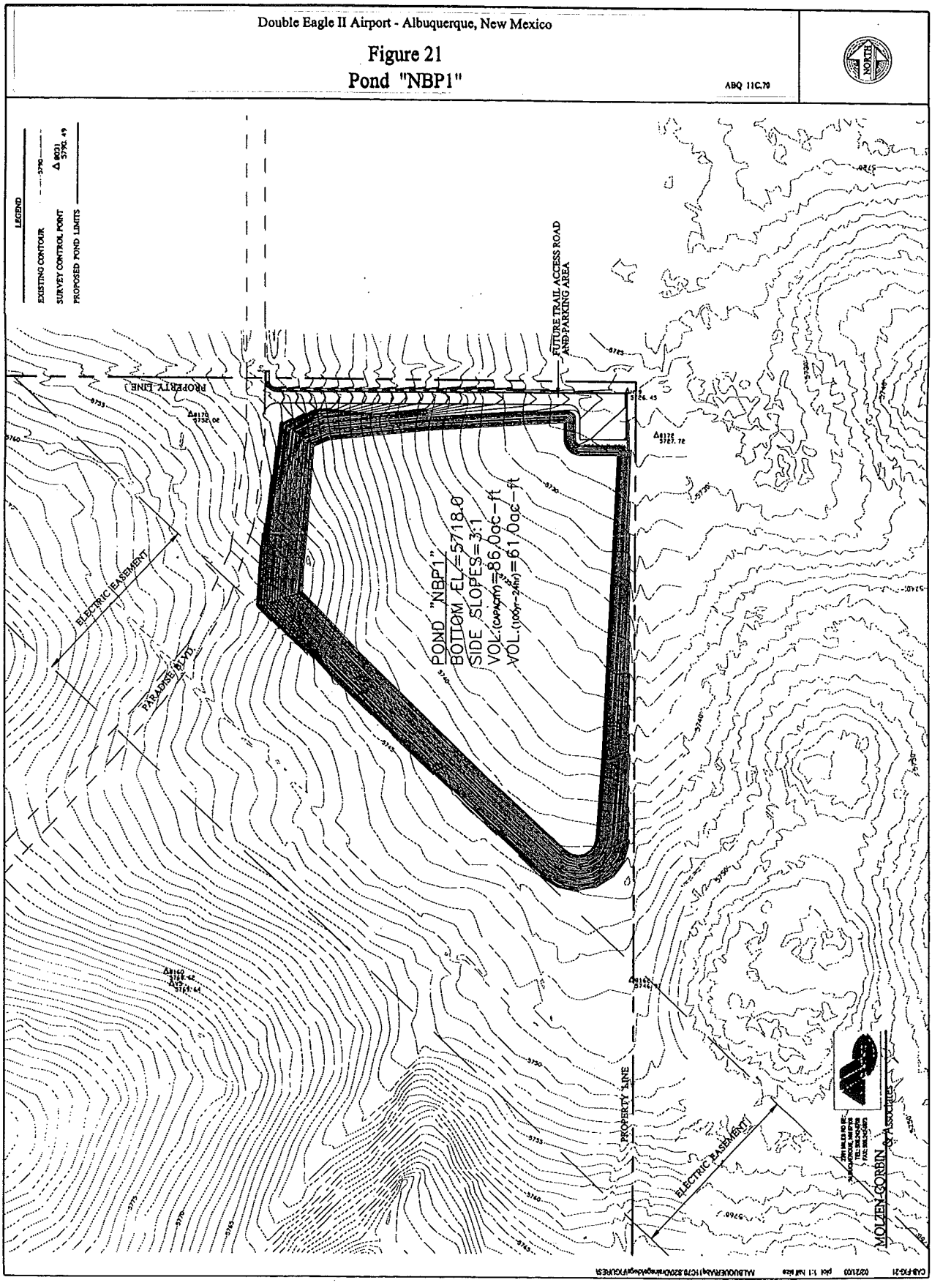
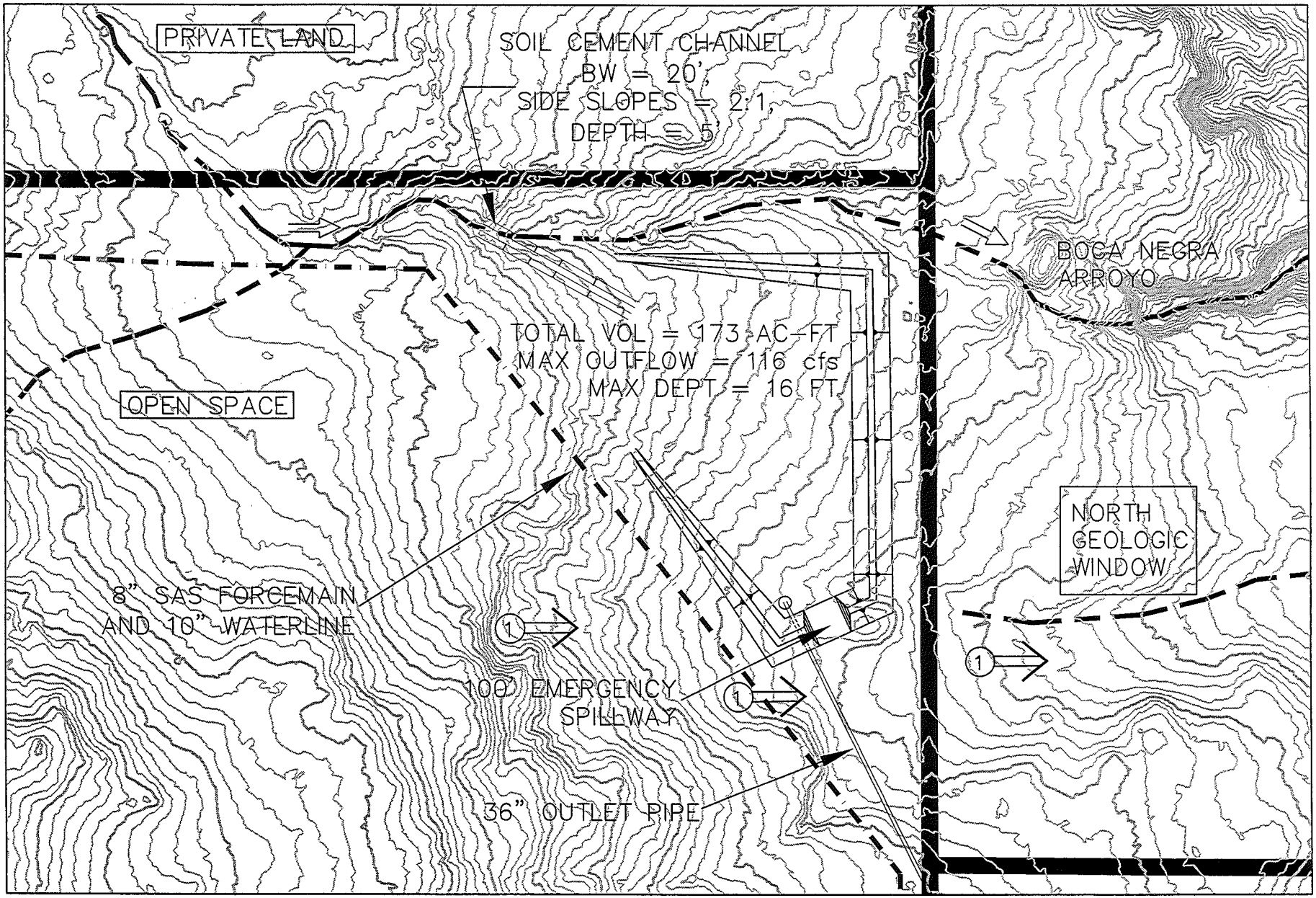
GENERAL LOCATION OF QUAIL RANCH DAM

FIGURE 6



GENERAL LAYOUT OF
DOUBLE EAGLE II AIRPORT (NBP1) POND

FIGURE 7



(1) Natural Drainage from Open Space Areas will continue to drain through the North Geologic Window.

N

SCALE: 1"= 400'

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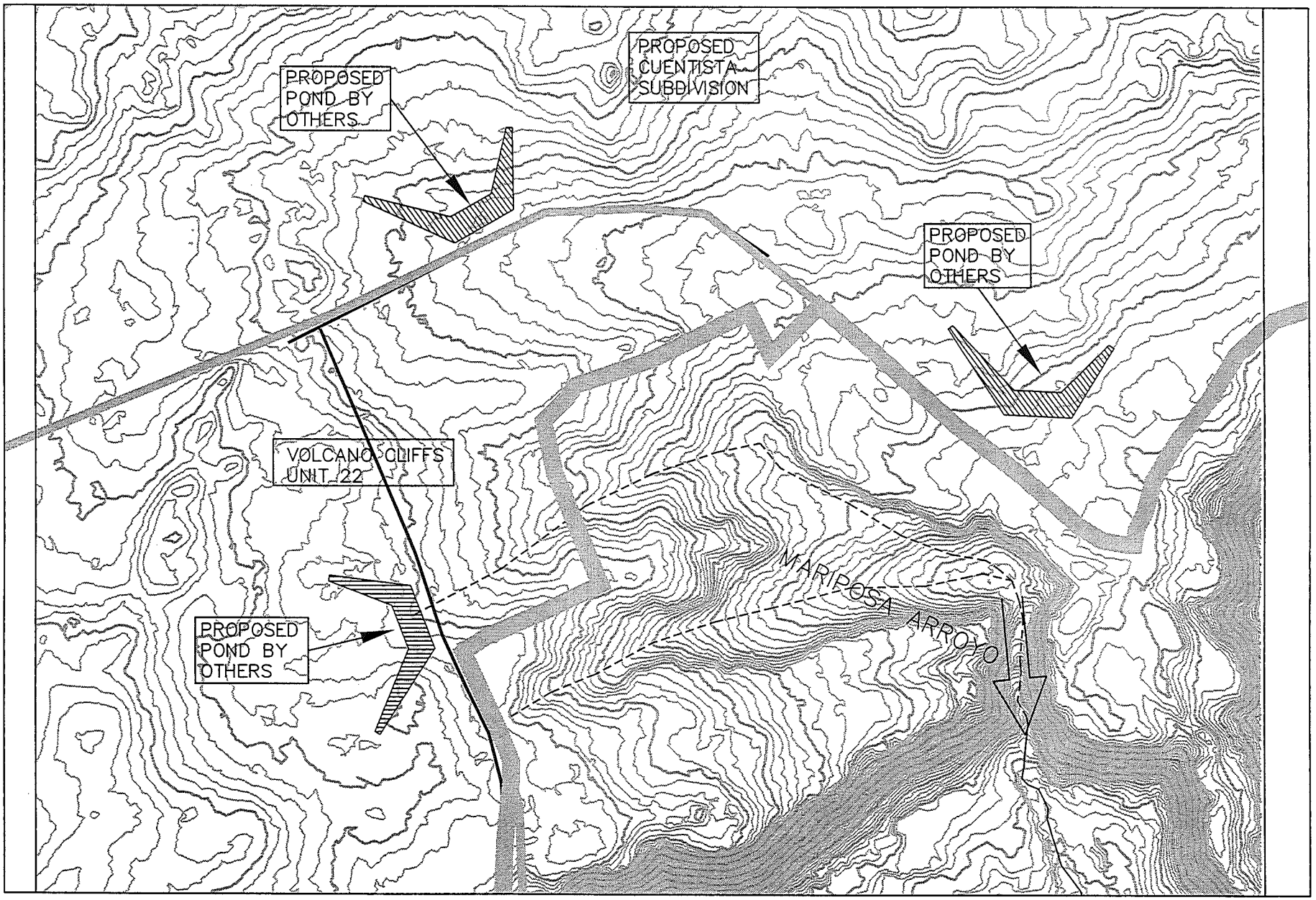
GENERAL LAYOUT OF NORTH GEOLOGIC WINDOW DAM

FIGURE 8



N

SCALE: 1"= 400'

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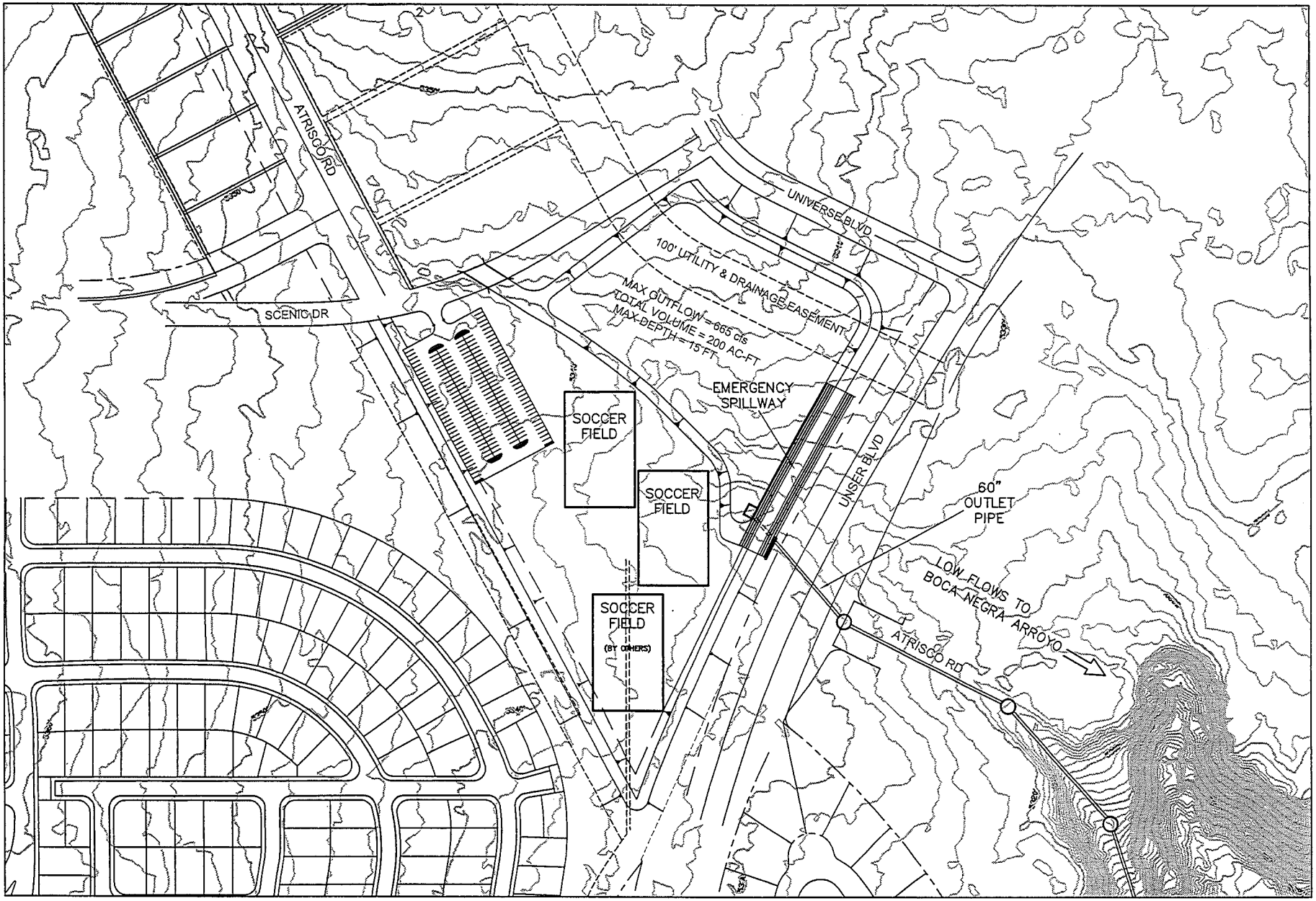
GENERAL LAYOUT OF
LA CUENTISTA PONDS

FIGURE 9



BASE MAP PROVIDED BY
WILSON AND COMPANY

N

SCALE: 1"= 300'

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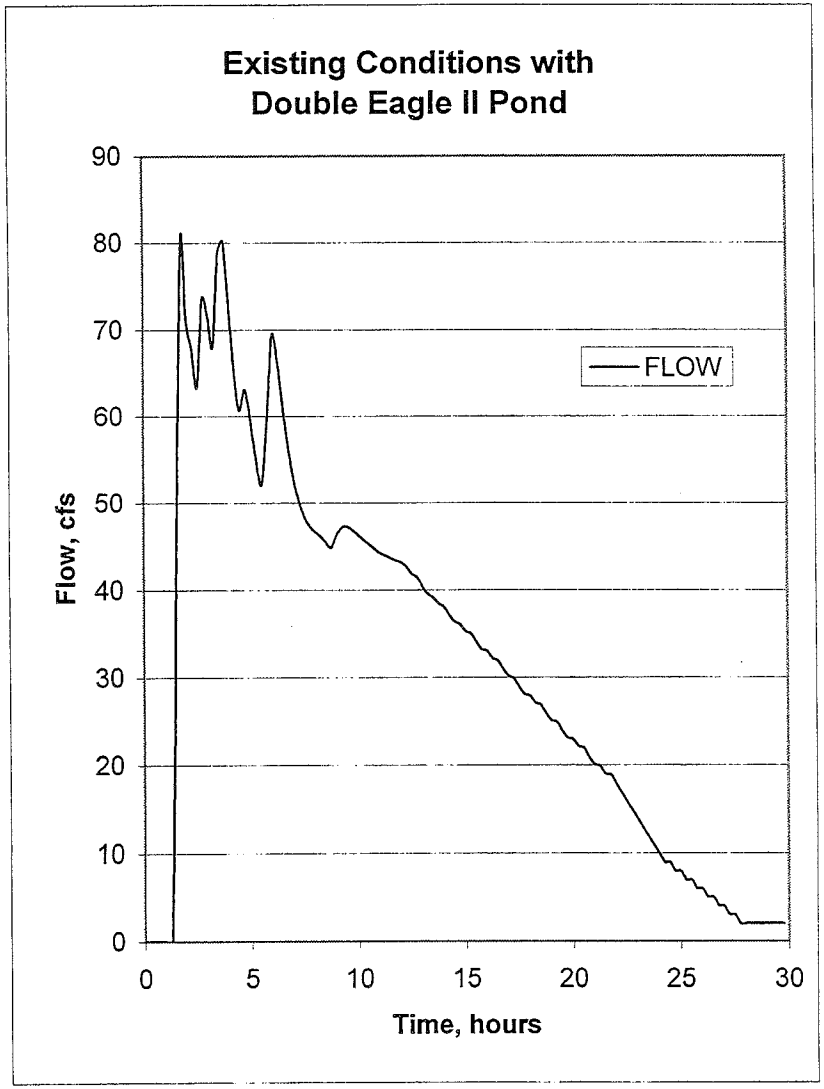
GENERAL LAYOUT OF
BOCA NEGRA DAM

FIGURE 10

10-YEAR INFLOW AND OUTFLOW HYDROGRAPHS
NORTH GEOLOGIC WINDOW



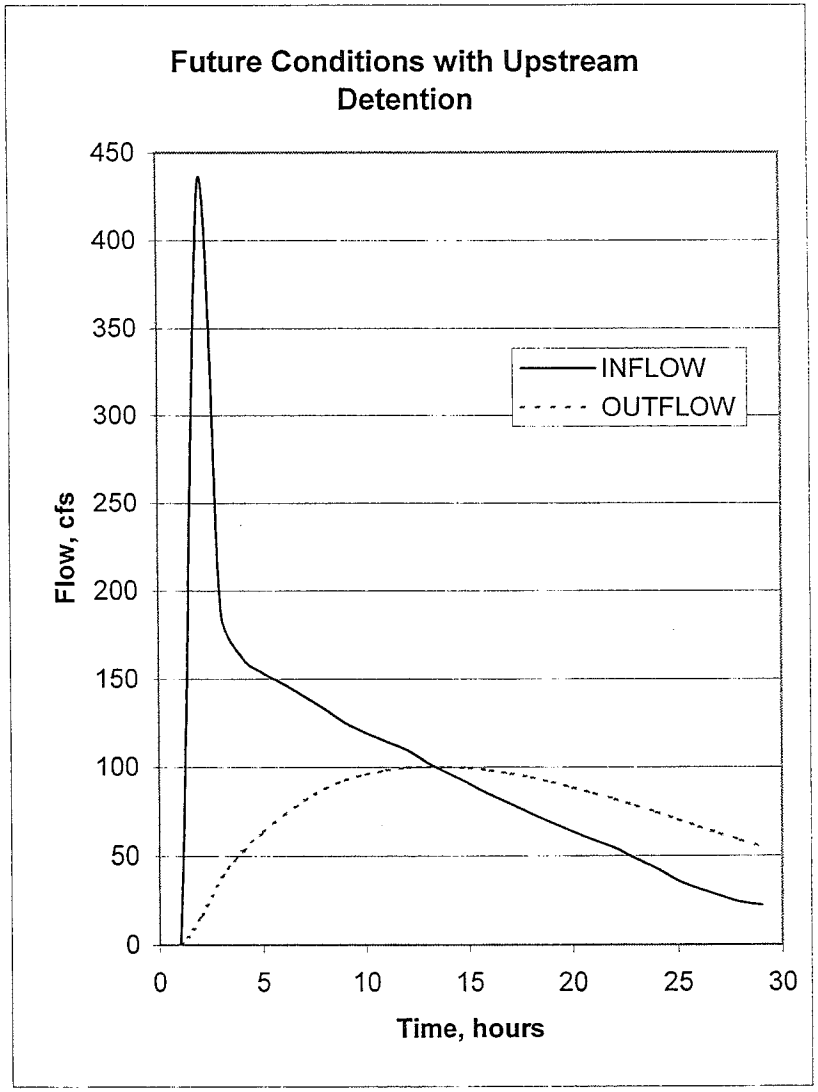
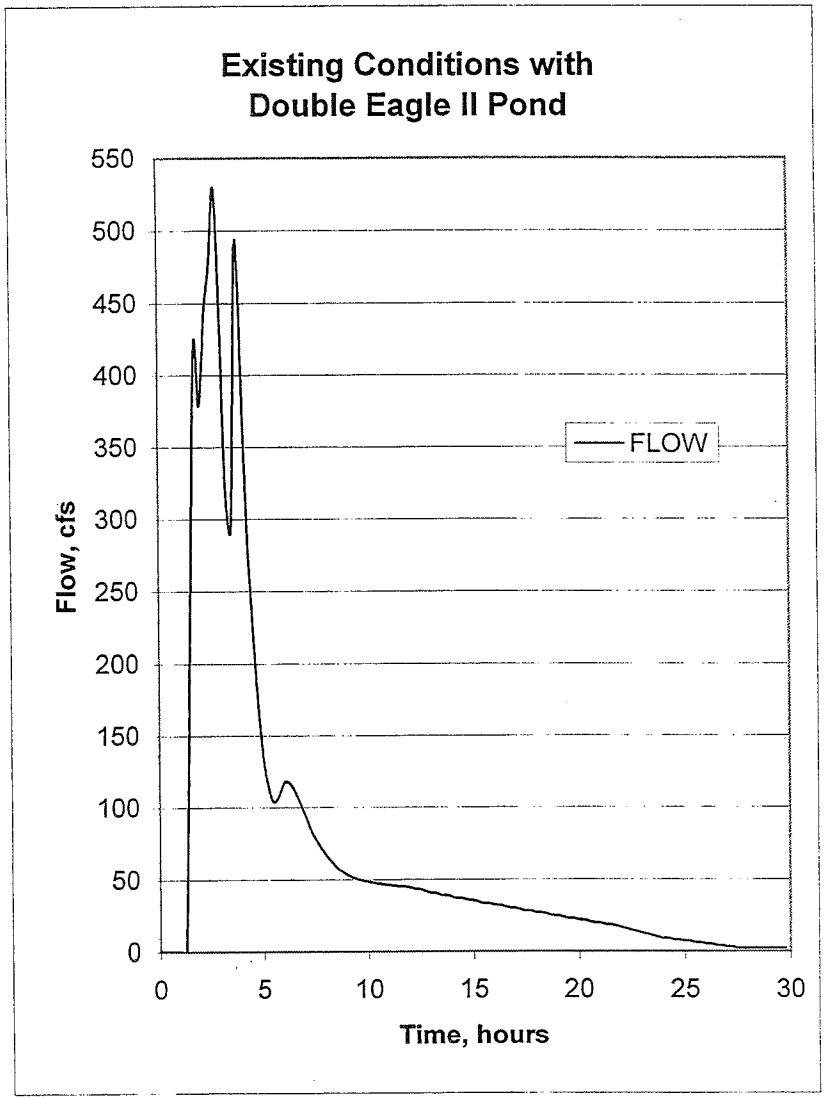


Figure 11.A

100-YEAR
NORTH GEOLOGIC WINDOW DAM



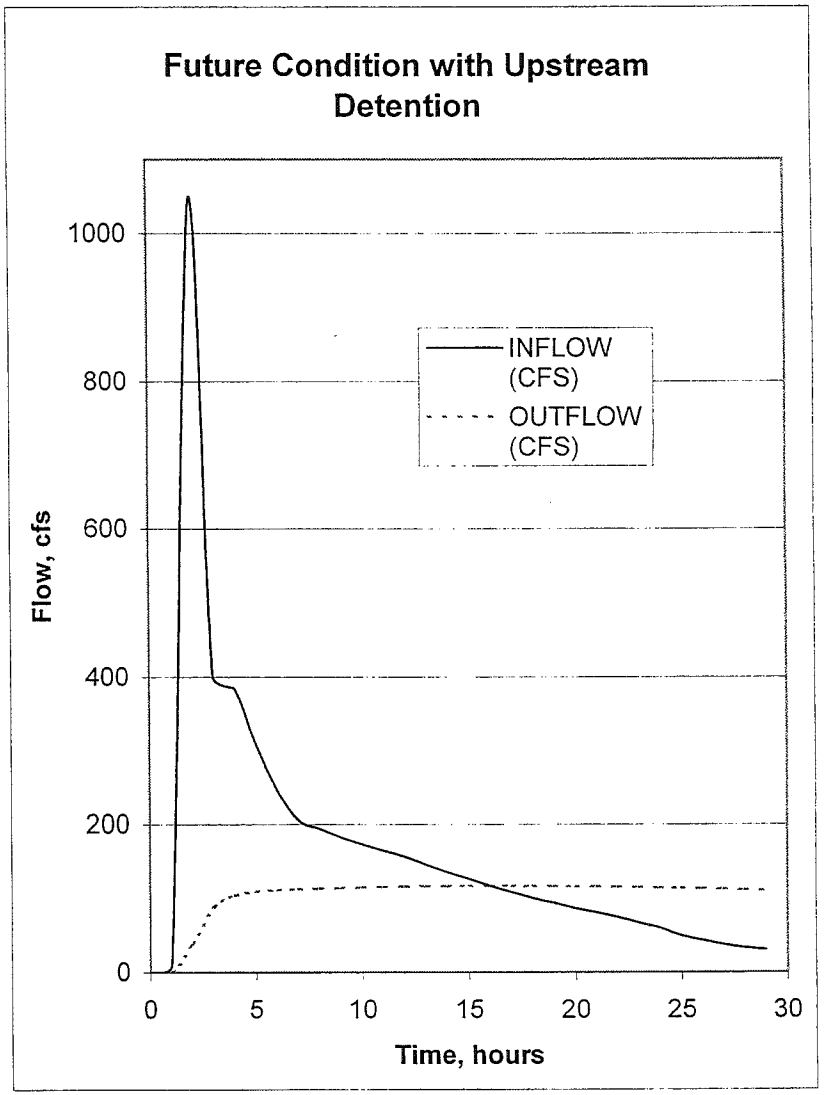
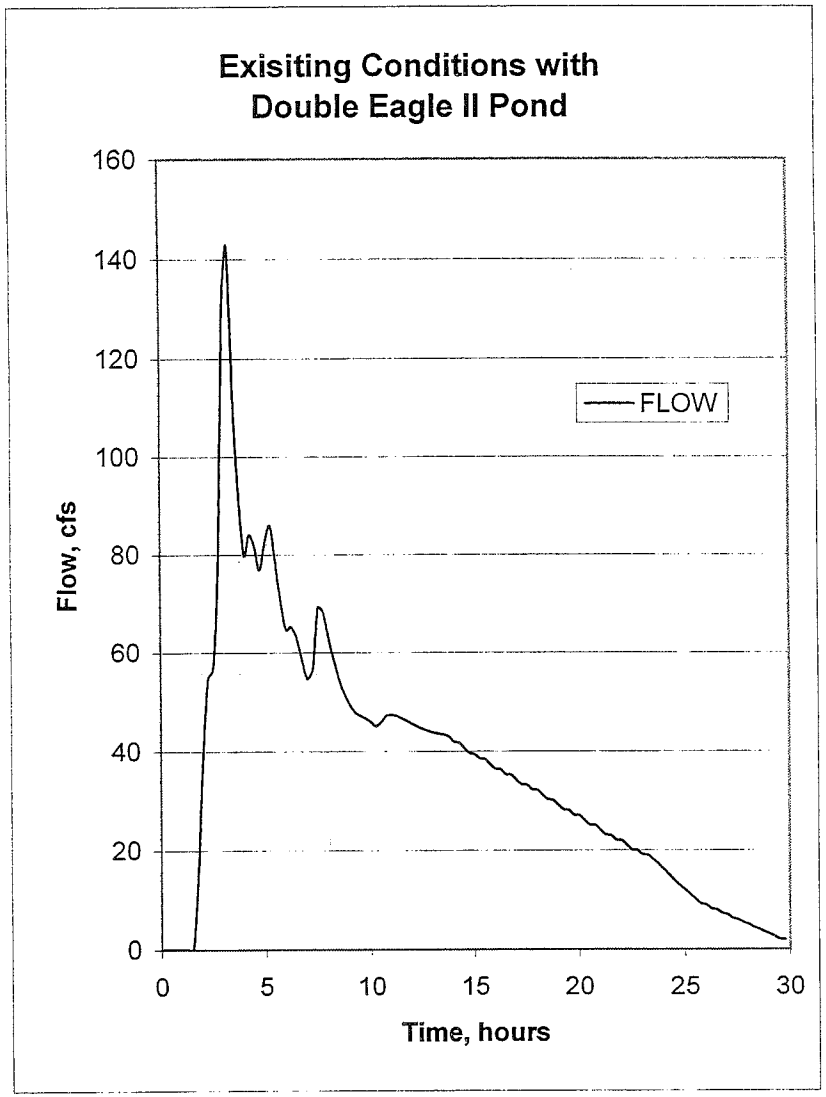


Figure 11.B

10-YEAR
SAD 228 POND



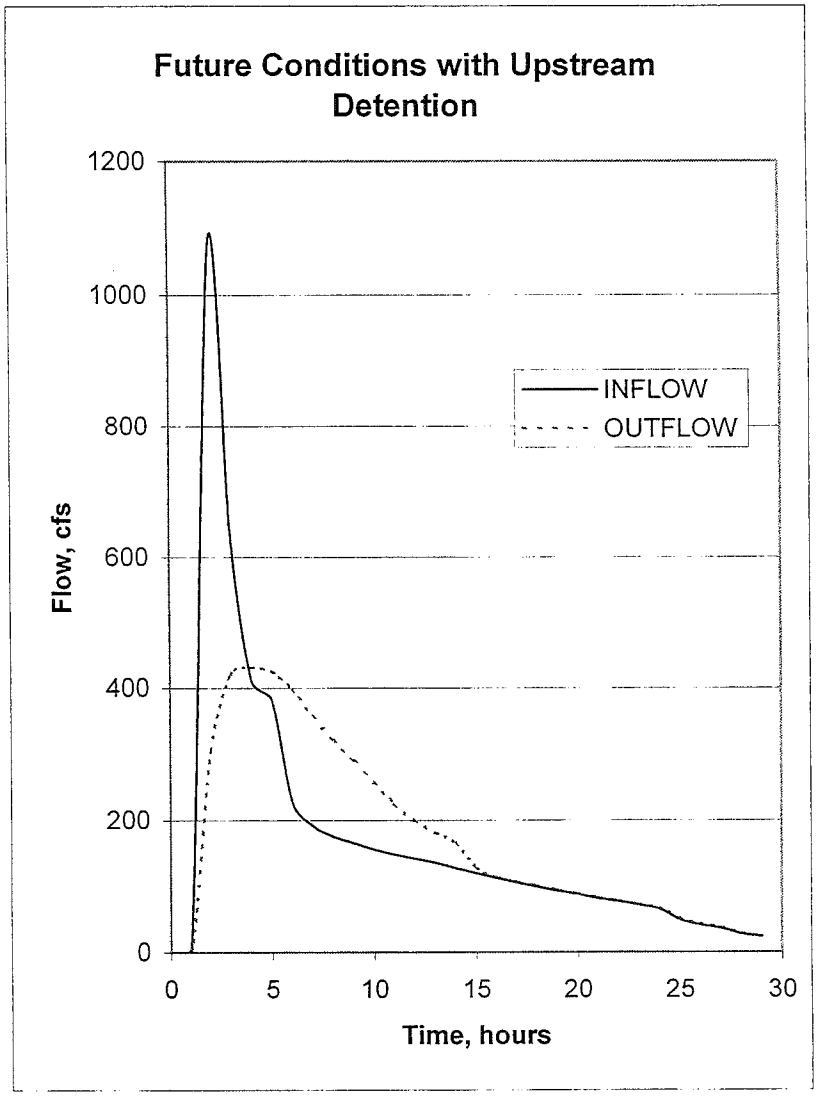
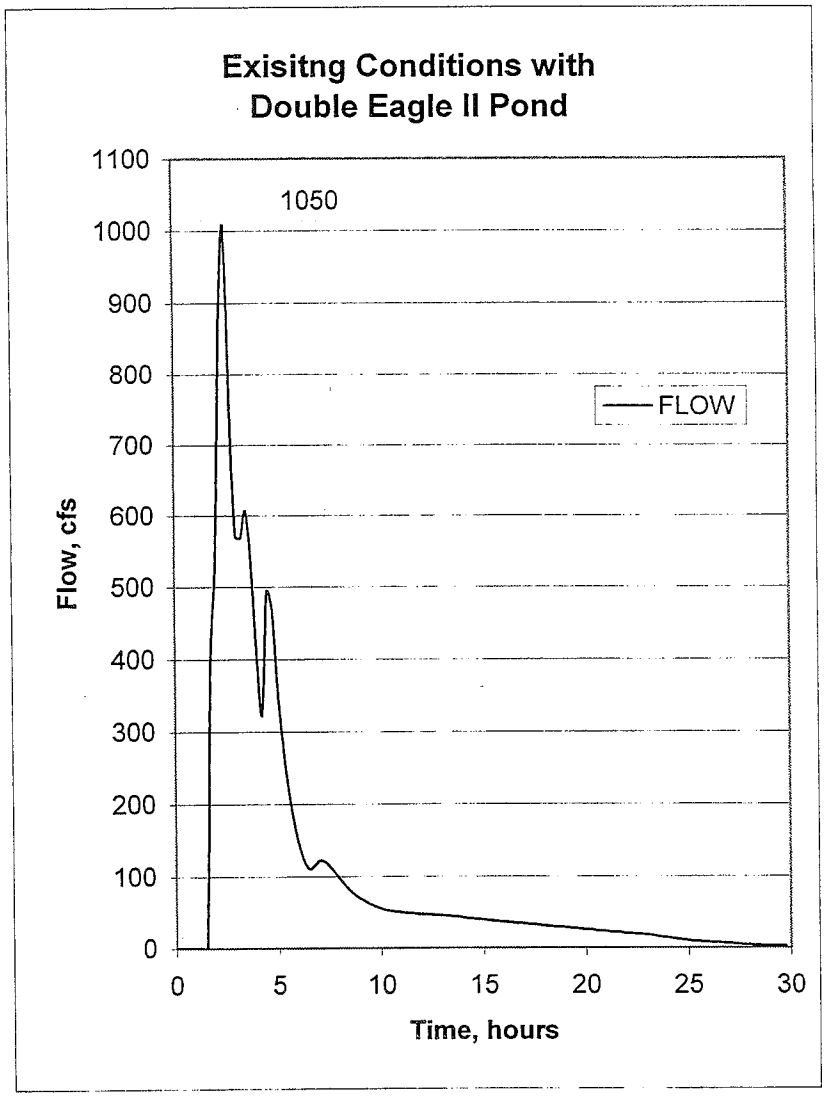


Figure 11.C

100-YEAR
SAD 228 POND



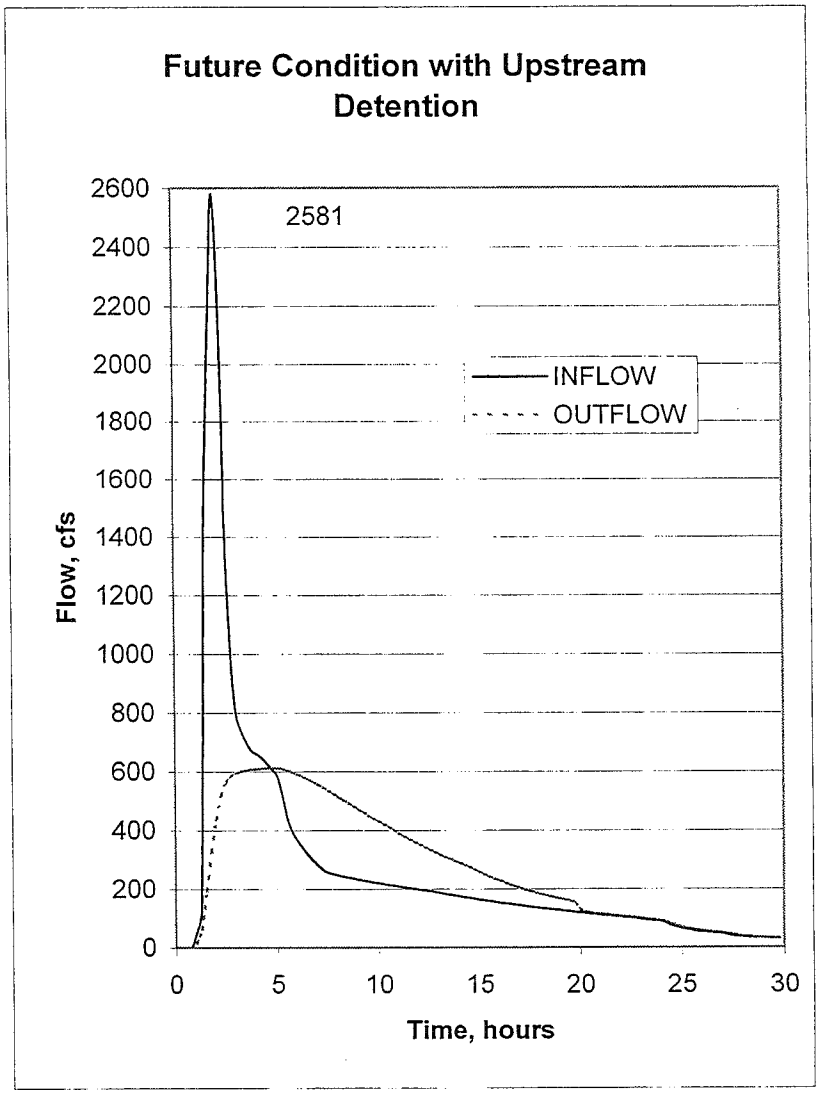
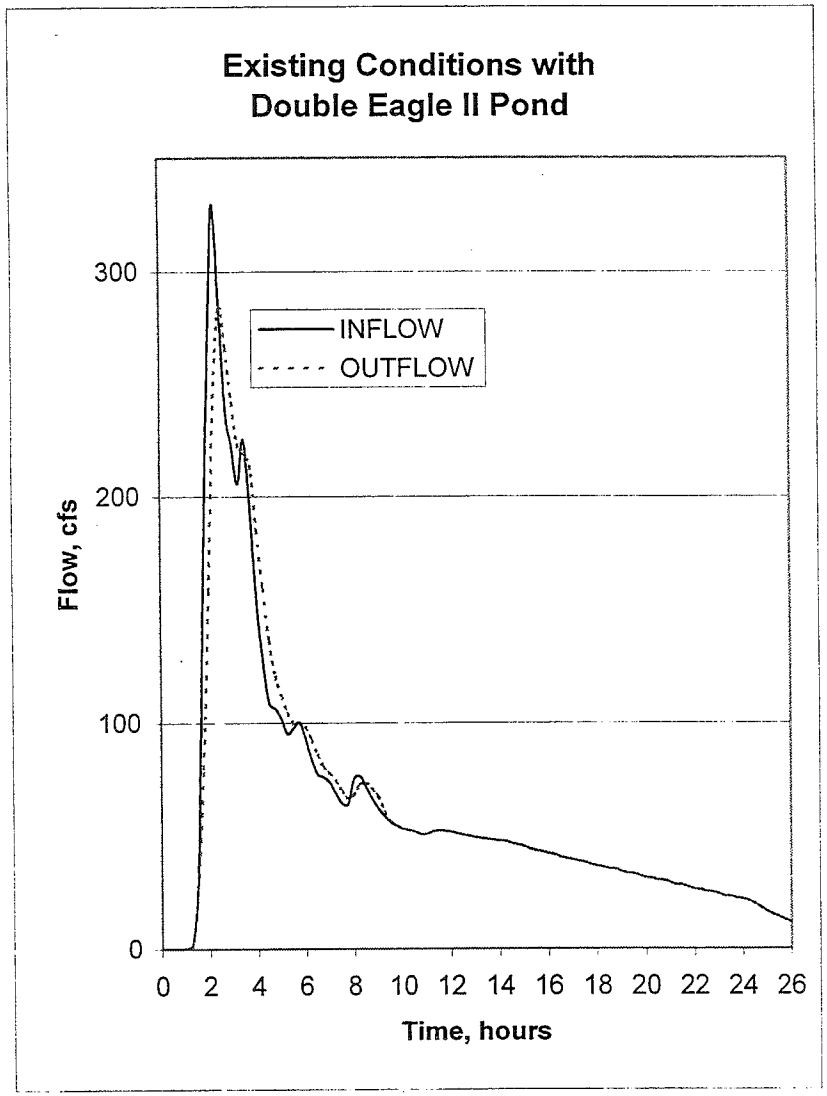


Figure 11.D

10-YEAR
MARIPOSA DETENTION BASIN



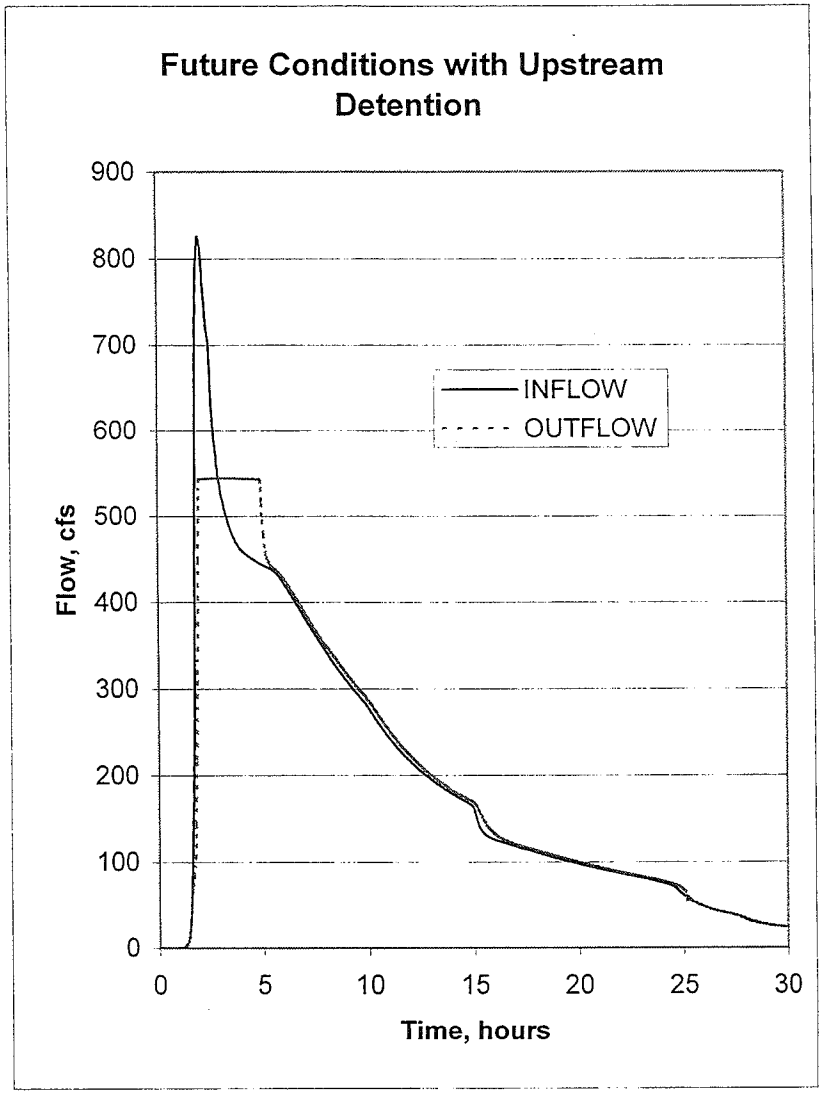
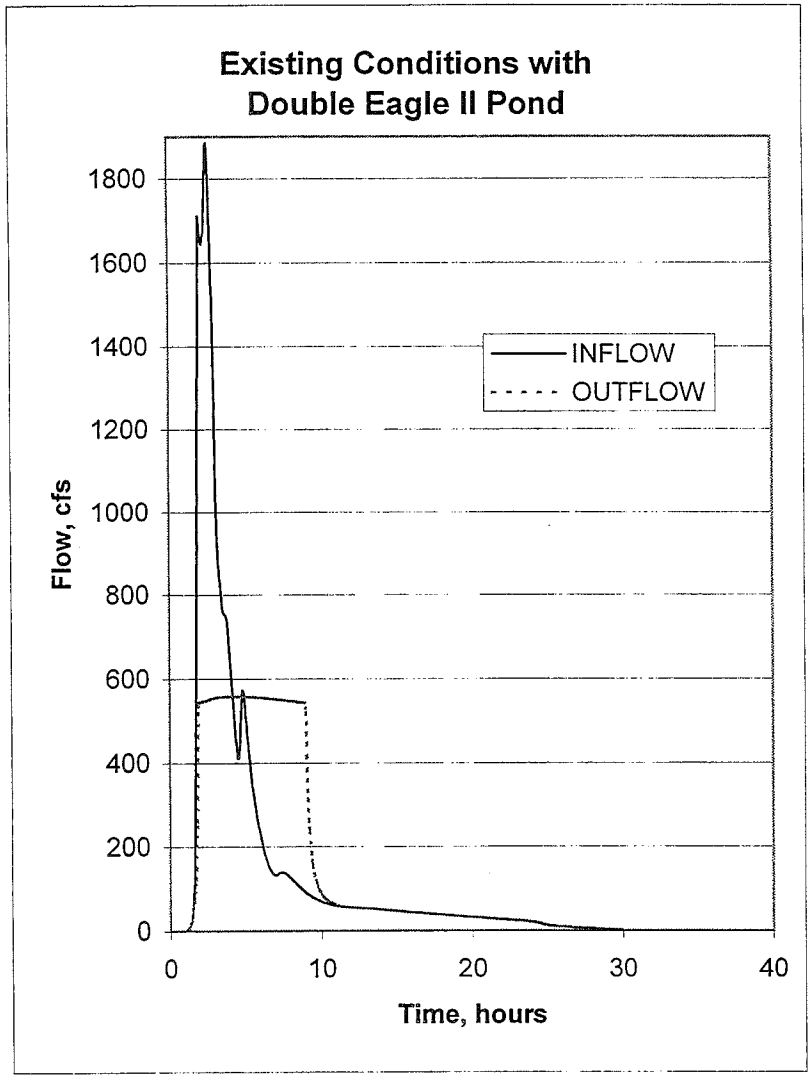


Figure 11.E

100-YEAR INFLOW AND OUTFLOW HYDROGRAPHS
MARIPOSA DETENTION BASIN



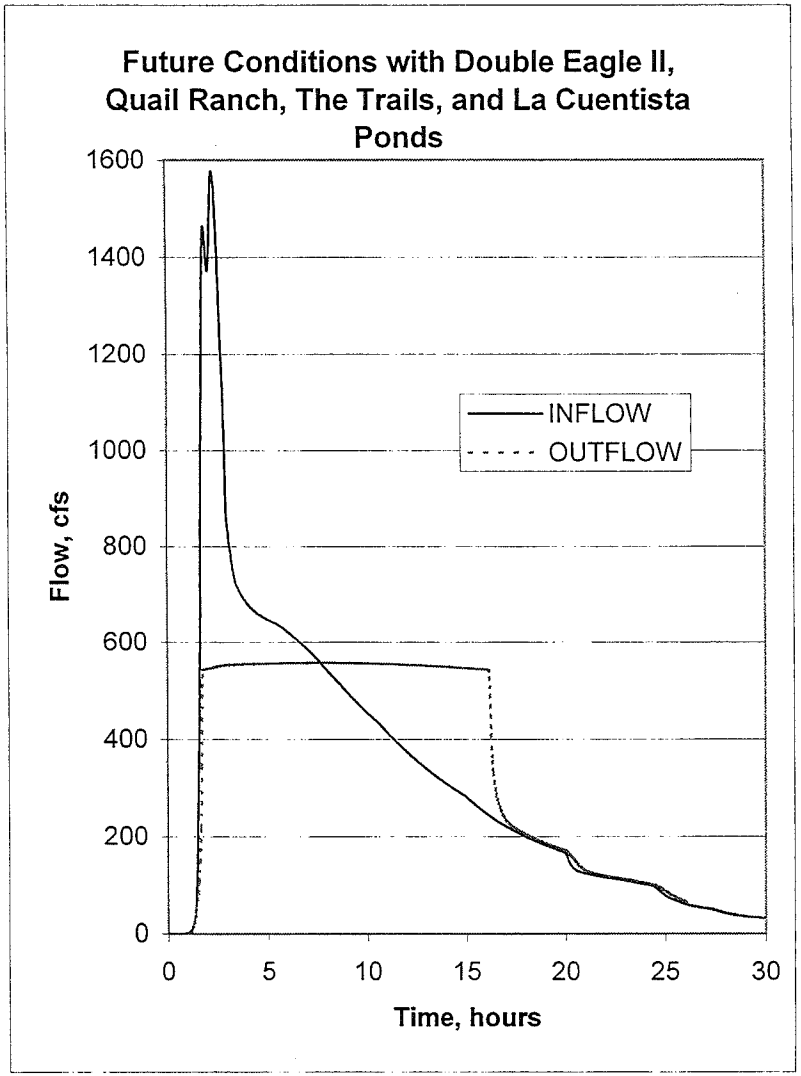
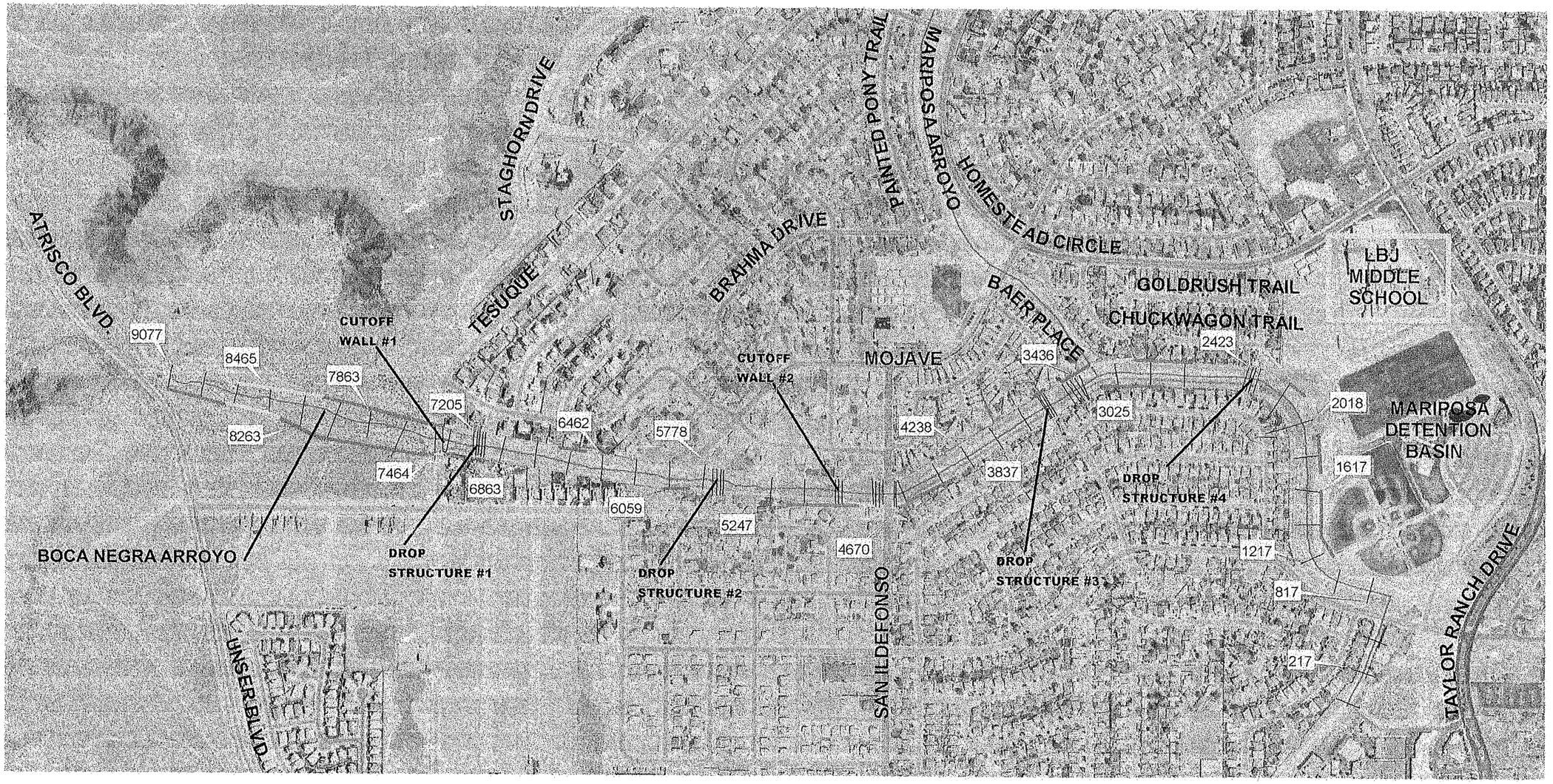


Figure 11.F



N
W E
S

0 250 500 1,000 1,500 2,000 Feet

LEGEND

- LESS THAN 1' FREEBOARD
- 1'-2' FREEBOARD
- 2'-3' FREEBOARD
- HEC RAS CROSS SECTIONS

HYDRAULIC MODELING REACHES AND FREEBOARD DEFICIENCY LOCATIONS

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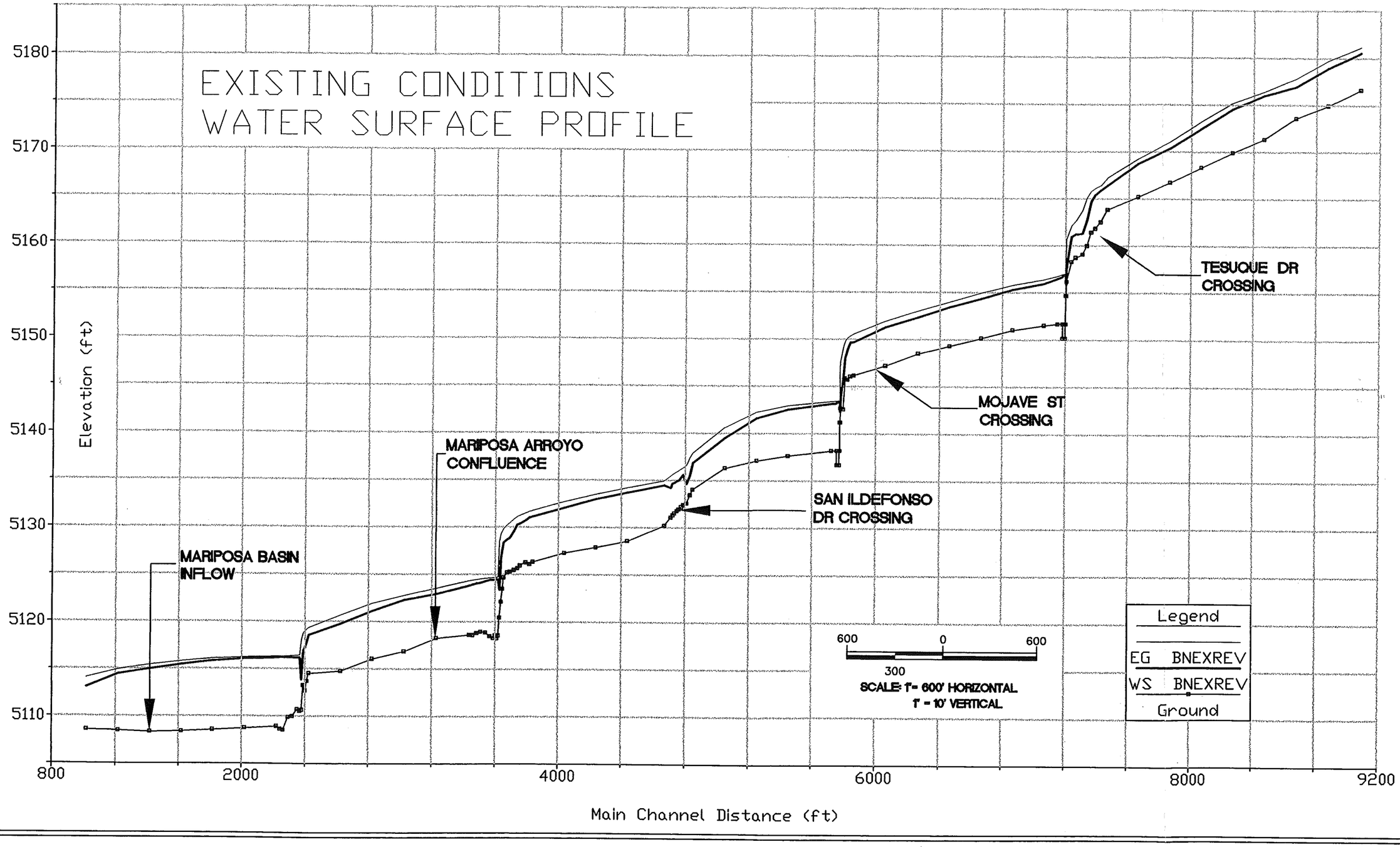
FIGURE 12

EXISTING CONDITIONS
WATER SURFACE PROFILE



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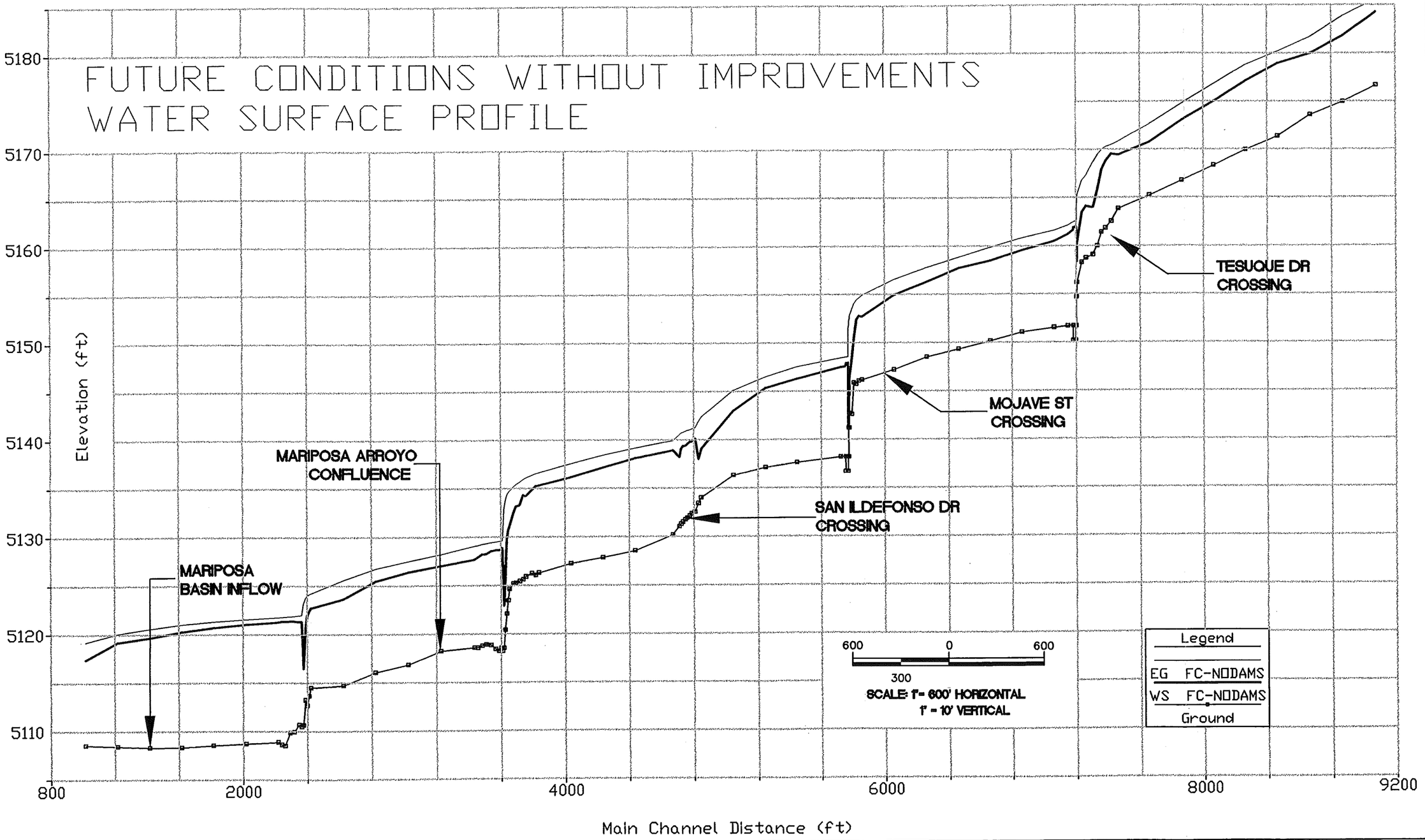
EXISTING CONDITIONS
WATER SURFACE PROFILE

FIGURE 13.A

FUTURE CONDITIONS WITHOUT IMPROVEMENTS
WATER SURFACE PROFILE



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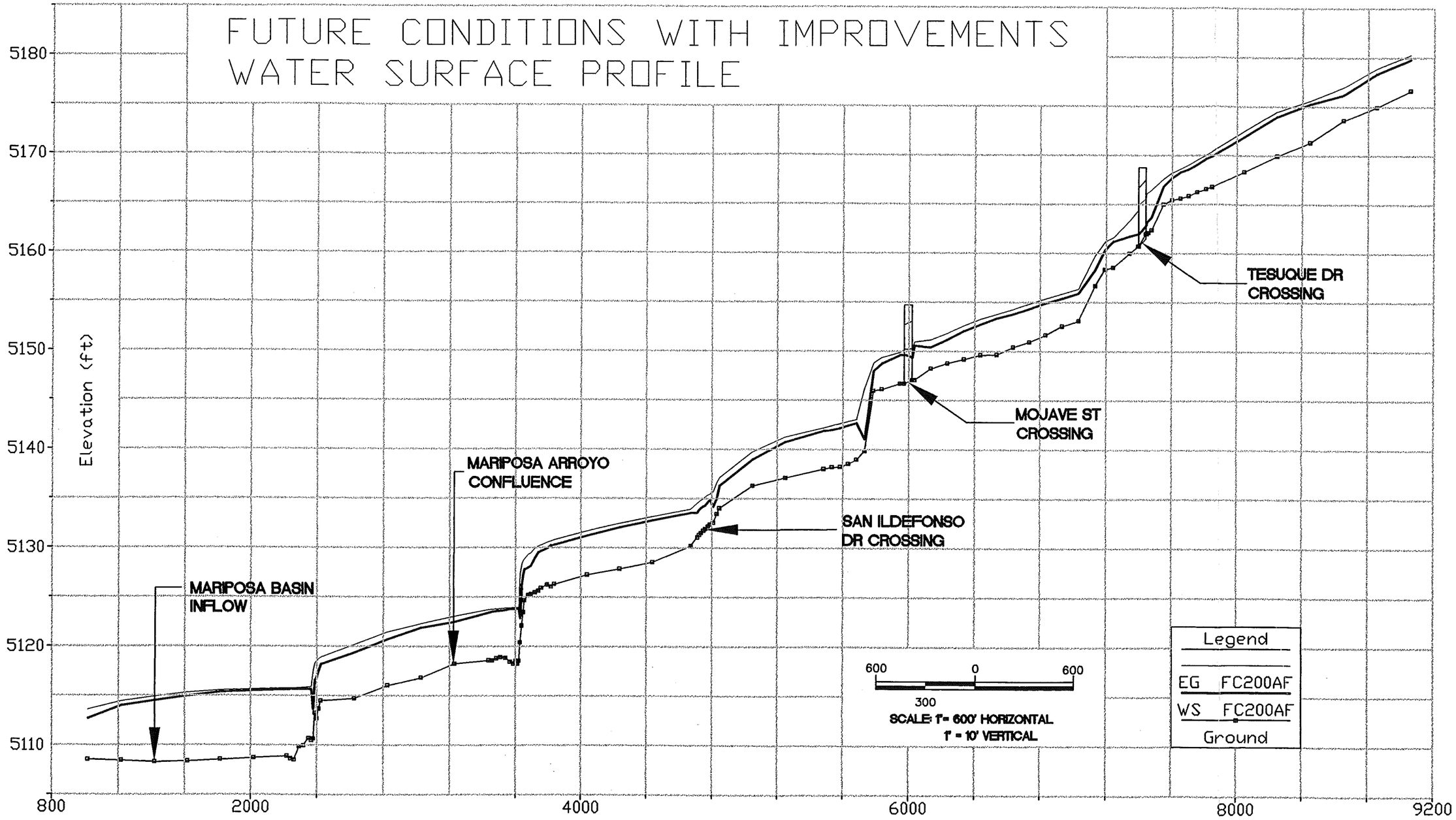
FUTURE CONDITIONS WITHOUT IMPROVEMENTS WATER SURFACE PROFILE

FIGURE 13.B

FUTURE CONDITIONS WITH IMPROVEMENTS WATER SURFACE PROFILE



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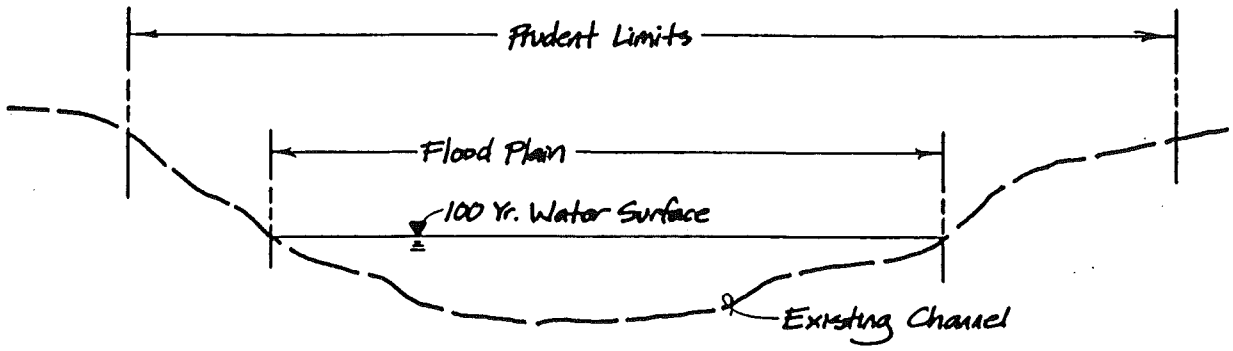
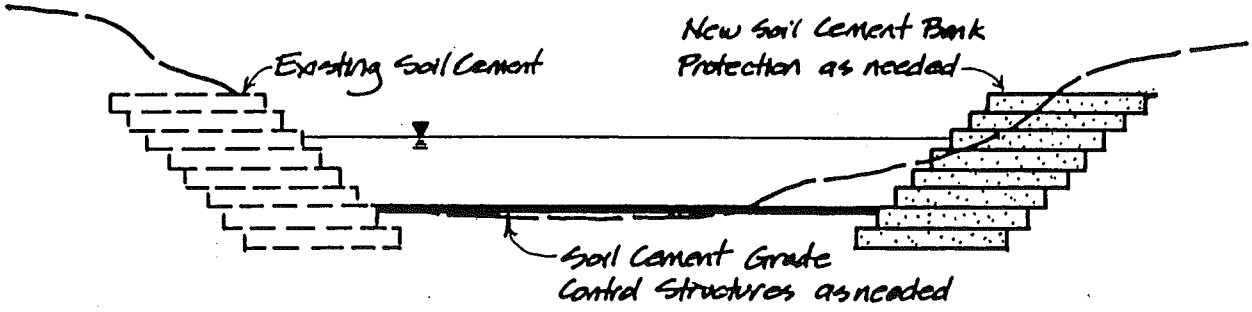
FUTURE CONDITIONS WITH IMPROVEMENTS WATER SURFACE PROFILE

FIGURE 13.C

PRUDENT LINES



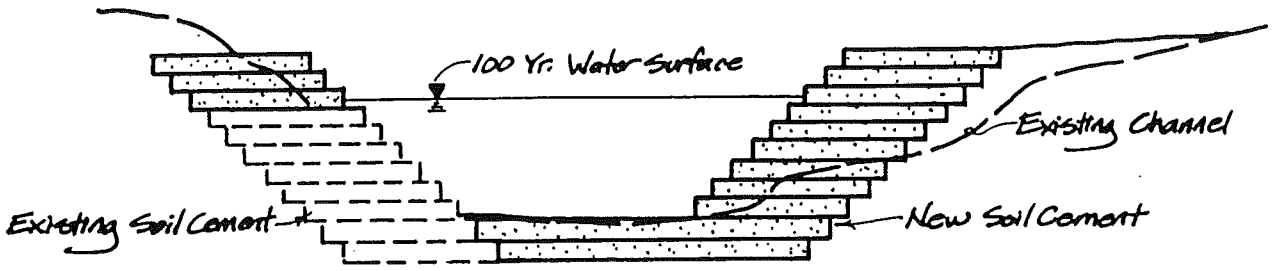
BANK PROTECTION
with Drop Structures



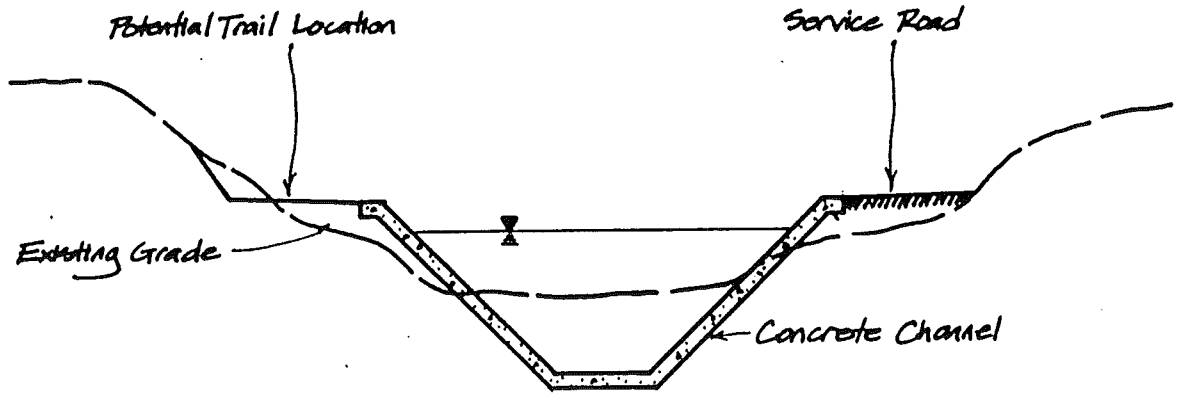
TYPICAL PRUDENT LINE AND
BANK PROTECTION CHANNEL SECTIONS

FIGURE 14

SOIL CEMENT CHANNEL

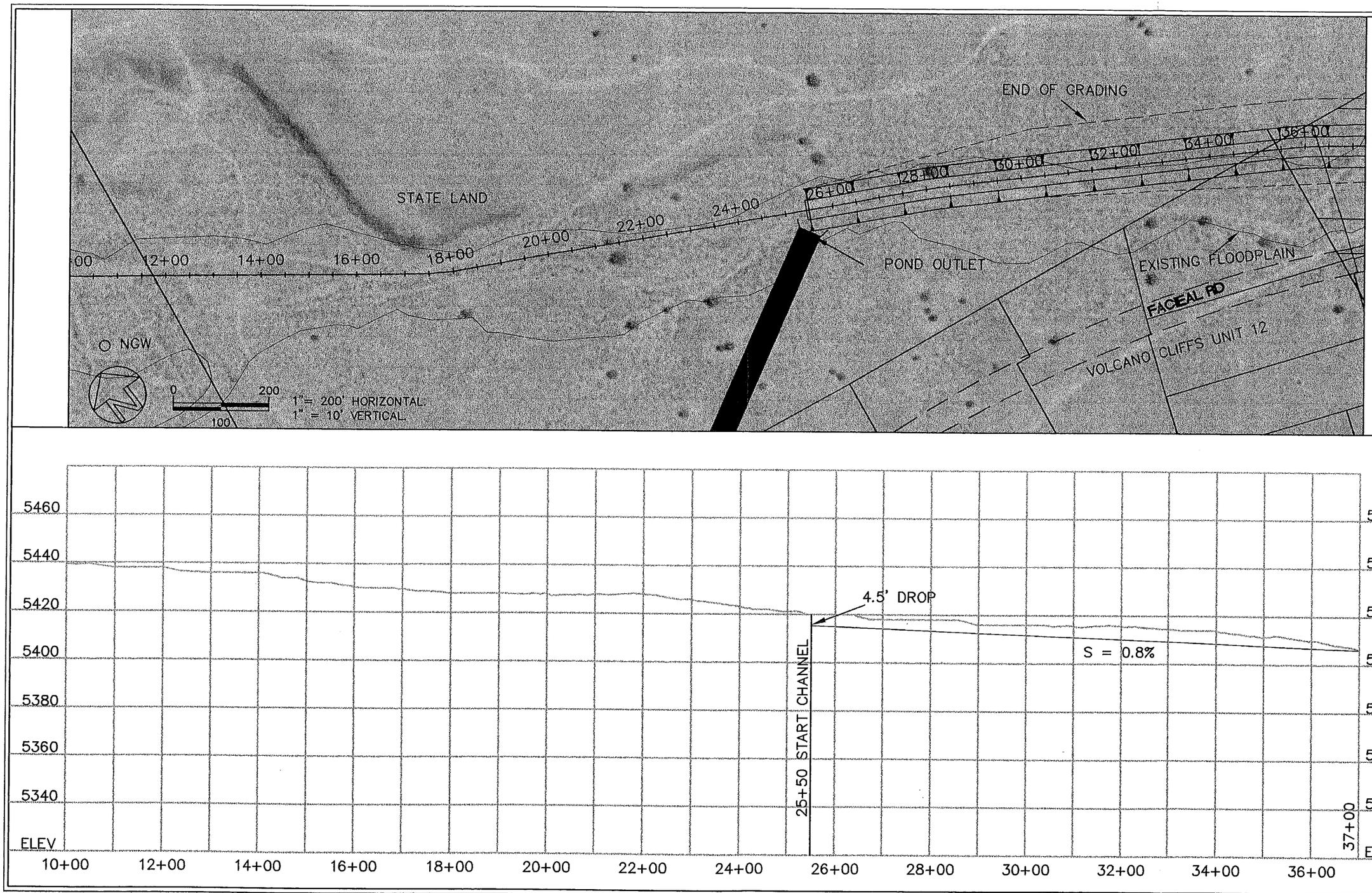


CONCRETE CHANNEL



TYPICAL SOIL CEMENT AND CONCRETE CHANNEL SECTIONS

FIGURE 15



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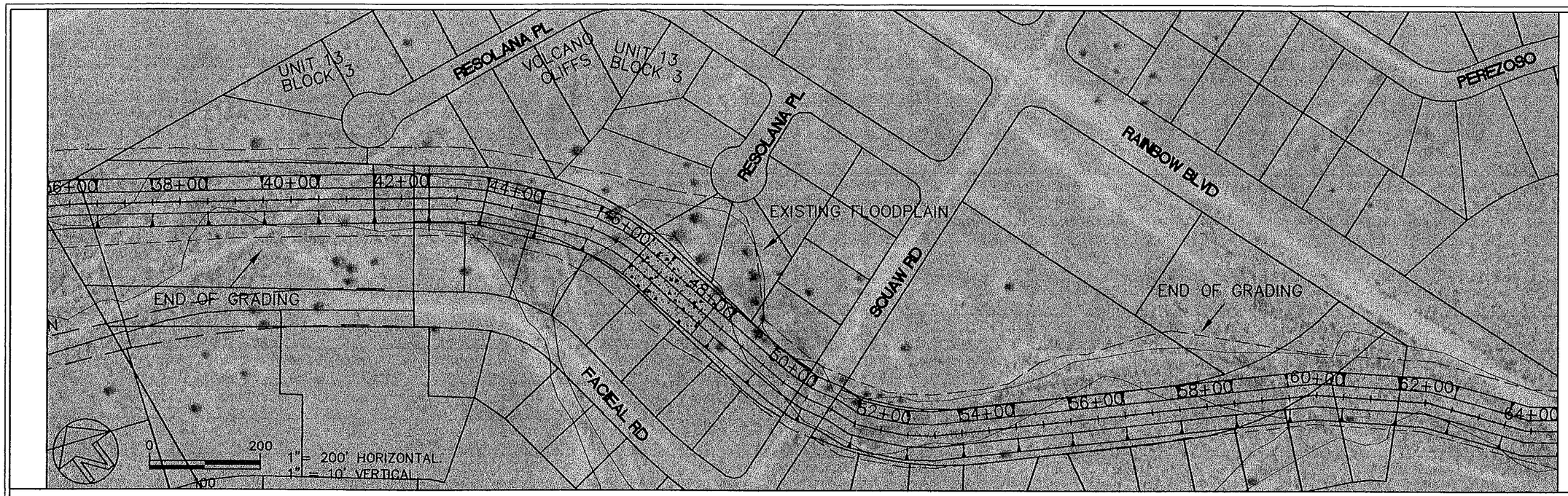
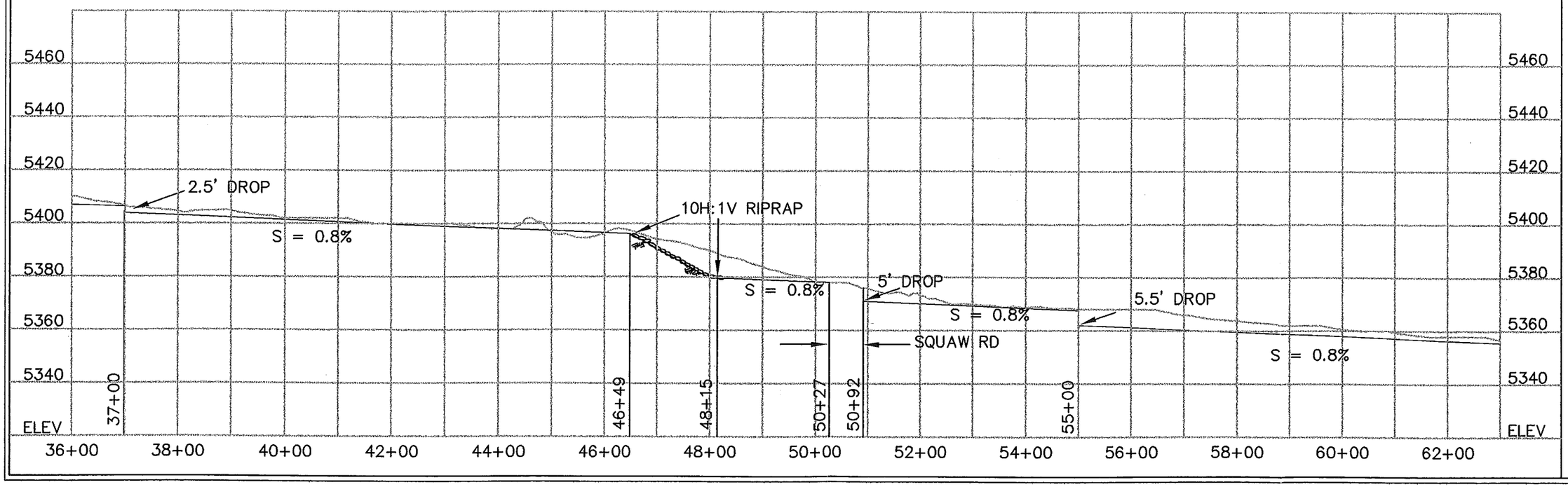
BOCA NEGRA DMP
PROPOSED CHANNEL IMPROVEMENTS

FIGURE
16.A





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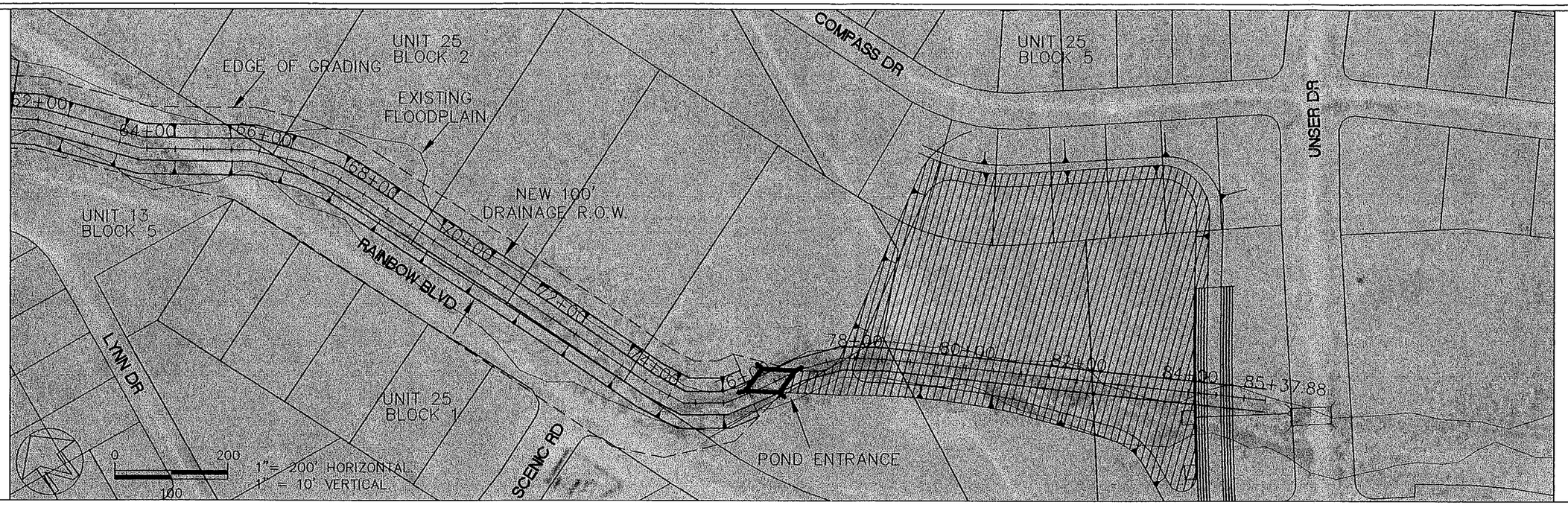
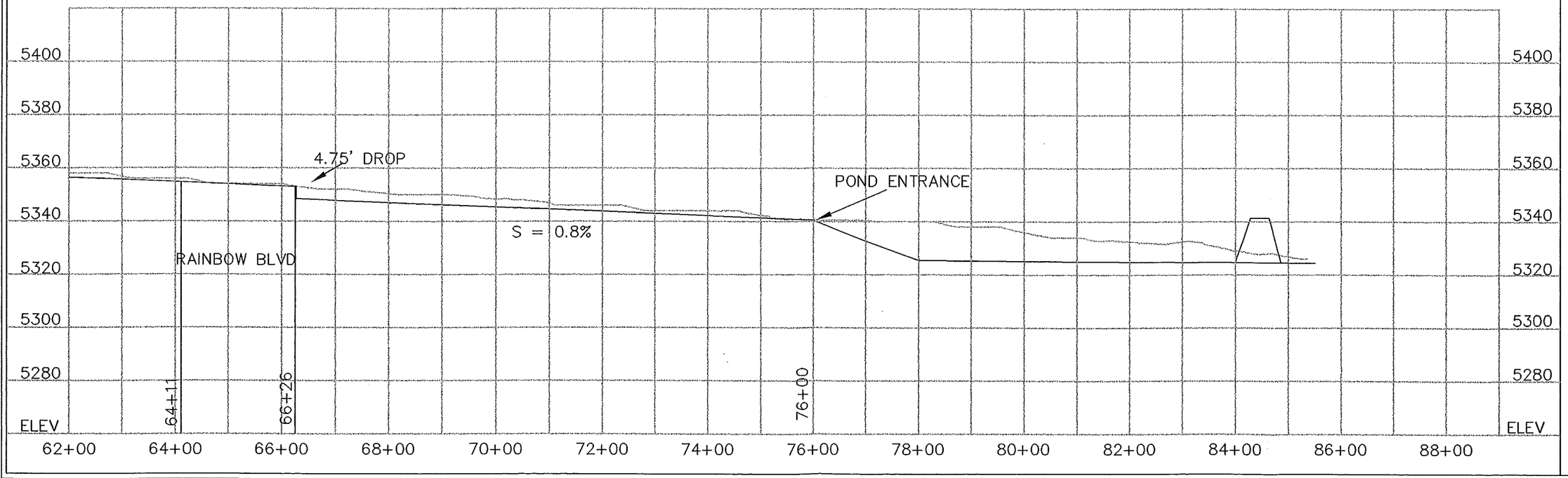
BOCA NEGRA DMP
PROPOSED CHANNEL IMPROVEMENTS

FIGURE
16.B





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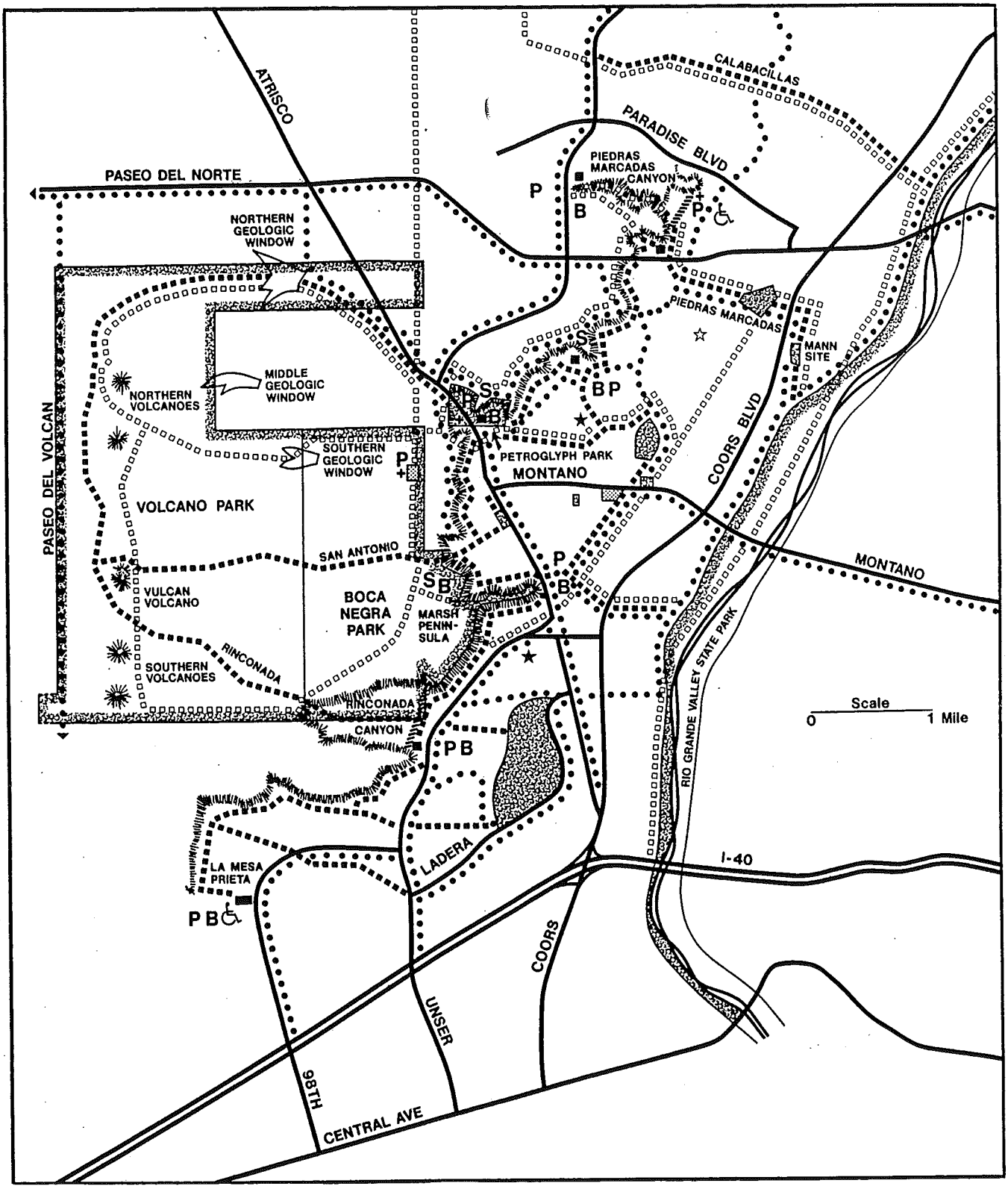
BOCA NEGRA DMP

PROPOSED CHANNEL IMPROVEMENTS

FIGURE
16.C



CONCEPTUAL TRAIL AND FACILITY LOCATIONS* ~~MAP 11~~

- Pedestrian Trails
- Bikeways
- Equestrian Trails
- Equestrian Center
- Equestrian Staging Area
- Escarpment
- Major Roads
- Restricted Access
- Park
- Proposed Park
- Handicapped Access
- School
- Visitor Center (Staffed)
- Interpretive Exhibit (Unstaffed)
- P Parking
- B Bicycle Rack
- S Scenic Overlook

*Trails shown are conceptual--based on existing City plans--and subject to change. Designation of a Petroglyph National Monument would result in comprehensive facility planning for the area, including inter-agency coordination and extensive public input.

FIGURE 17