# Certification Report for Camelback Ranch Levee South (ID#11)

## Camelback Road to 3600 feet south along the east bank of the Agua Fria River

## Maricopa County, Arizona

**Prepared for:**

Flood Control District of Maricopa County

2801 W. Durango Street
Phoenix, AZ 85009

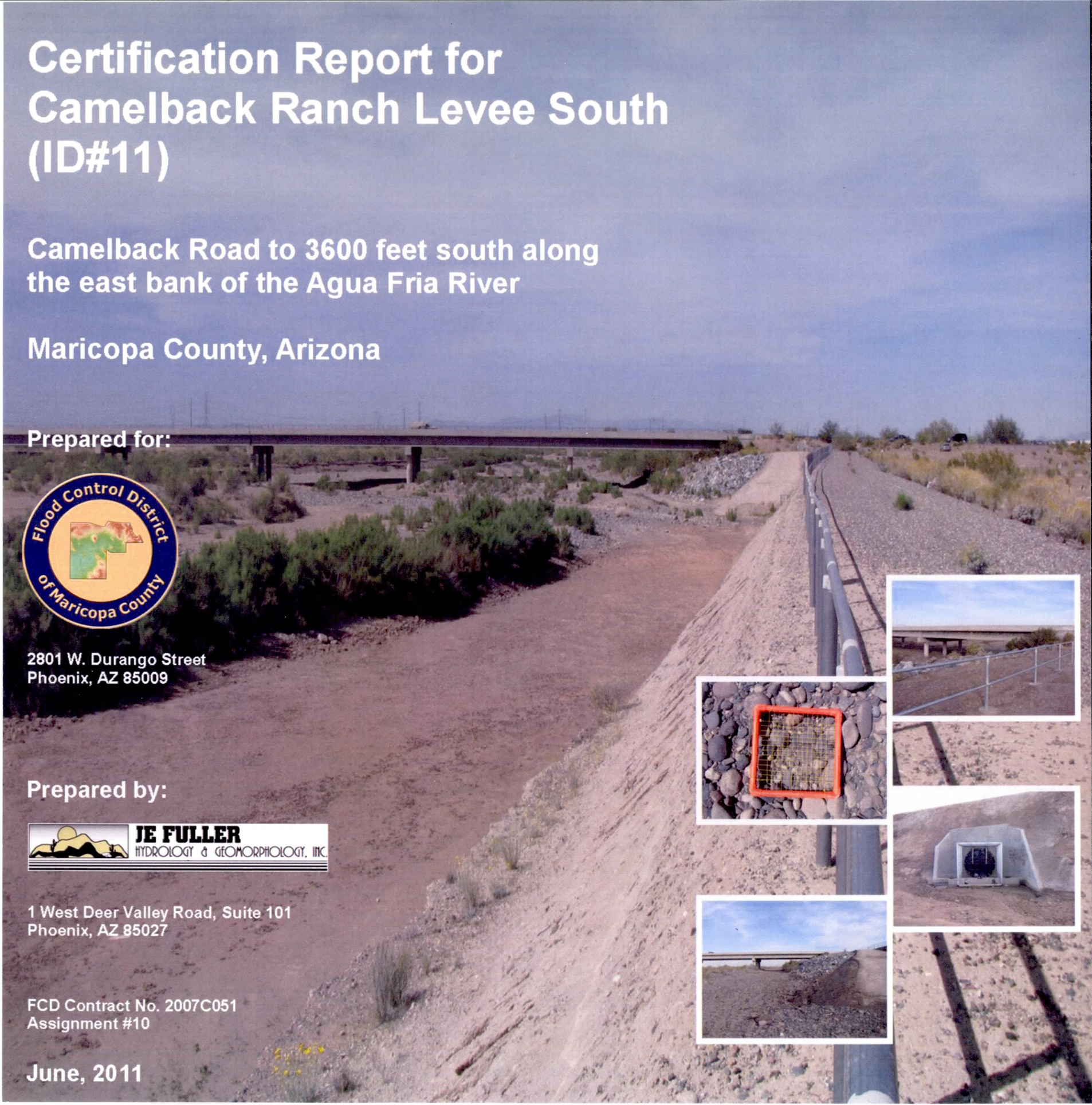
**Prepared by:**

JE FULLER
HYDROLOGY & GEOMORPHOLOGY, INC.

1 West Deer Valley Road, Suite 101
Phoenix, AZ 85027

FCD Contract No. 2007C051
Assignment #10

**June, 2011**



**U.S. Department of Homeland Security**
1111 Broadway, Suite 1200
Oakland, CA 94607-4052

FEMA

March 16, 2012

Frank Brown, P.E., CFM
Senior Civil Engineer
Flood Control District Maricopa County
2801 West Durango Street
Phoenix, Arizona 85009

RE: Floodplain Delineations in Support of Levee Certification Packages for Agua Fria River Levees with IDs #8, 11, 16 and 18

Dear Mr. Brown:

This letter is in reference to your submittal of a Technical Data Notebook prepared by Stanley Consultants, Inc. and WEST Consultants, Inc. to update the floodplain delineations along the Agua Fria River, generally from the Salt/Gila River to New River in August 2011. The study was submitted in support of the Provisionally Accredited Agua Fria River Levees (IDs 8, 11, 16 and 18) that were determined to meet the levee certification requirements outlined in the Code of Federal Regulation, Title 44, Section 65.10 (44 CFR 65.10).

We have completed our review and have approved the submitted data. The revised floodplain delineations for the Agua Fria River will be incorporated into a future Physical Map Revision (PMR) for Maricopa County.

If you have any questions regarding this matter, please contact me, either by telephone at (510) 627-7274, or by email at robert.bezek@fema.dhs.gov.

Sincerely,

Robert J. Bezek, CFM
Regional Engineer
Mitigation Division

cc: Brian Cosson, AZ DWR, NFIP State Coordinator
Scott Buchanan, Stanley Consultants, Inc.
Brian T. Wahlin, WEST Consultants, Inc.
Charlie McClendon, City Manager, City of Avondale
Sue McDermott, Floodplain Administrator, City of Avondale
Charles Andrews, Senior Project Manager, City of Avondale
David Cavazos, City Manager, City of Phoenix
Hasan Mushtaq, Floodplain Administrator, City of Phoenix

**U.S. Department of Homeland Security**
1111 Broadway, Suite 1200
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FEMA

November 23, 2011

Frank Brown, P.E., CFM
Senior Civil Engineer
Flood Control District Maricopa County
2801 West Durango Street
Phoenix, Arizona 85009

Dear Mr. Brown:

This correspondence is in reference to the June 23, 2011, and August 25, 2011, letters and data submissions to the U.S. Department of Homeland Security's Federal Emergency Management Agency (FEMA) regarding certification of the city of Avondale, the city of Phoenix, and Maricopa County portions of the Agua Fria River Levee System in order to meet the criteria of the Code of Federal Regulations, Title 44, Section 65.10 (44 CFR 65.10). The submitted data has been approved, and the levees are considered accredited. The pertinent information regarding the specific levees is listed below.

| | |
|---|---|
| **Identifier:** | Agua Fria Levee System (Levee ID Nos. 8, 11, 16, and 18) |
| **Flooding Source:** | Agua Fria River |
| **September 30, 2005 Effective FIRM panels affected:** | 04013C1620H, 04013C2080J, 04013C2085G & 04013C2090H |
| **December 3, 2010 Preliminary FIRM panels affected:** | 04013C1695L, 04013C2155L, 04013C2160L & 04013C2165L |

In support of the Agua Fria Levee System segment certifications the following information was submitted:

1. A report prepared by West Consultants, Inc., "Agua Fria River FEMA Levee Certification Package for Levee ID #8."
2. A report prepared by JE Fuller Hydrology & Geomorphology, Inc., "Certification Report for Camelback Ranch Levee South (ID #11) – Camelback Road to 3600 feet south along the east bank of the Agua Fria River – Maricopa County, Arizona."
3. A report prepared by West Consultants, Inc., "Agua Fria River FEMA Levee Certification Package for Levee ID #16."
4. A report prepared by West Consultants, Inc., "Agua Fria River FEMA Levee Certification Package for Levee ID #18."

The Technical Data Notebooks prepared by JE Fuller Hydrology & Geomorphology, Inc. and West Consultants, Inc., were reviewed to verify 44 CFR 65.10 compliance. The following is a summary of the review:

1. Freeboard: Analysis and Supporting Documentation was reviewed and found to be in compliance with 44 CFR 65.10(b)(1).
2. Closures: Analysis and Supporting Documentation was reviewed and found to be in compliance with 44 CFR 65.10(b)(2).
3. Embankment Protection: Analysis and Supporting Documentation was reviewed and found to be in compliance with 44 CFR 65.10(b)(3).
4. Embankment and Foundation Stability: Analysis and Supporting Documentation was reviewed and found to be in compliance with 44 CFR 65.10(b)(4).
5. Settlement: Analysis and Supporting Documentation was reviewed and found to be in compliance with 44 CFR 65.10(b)(5).
6. Maintenance Plans and Criteria: Supporting Documentation was reviewed and found to be in compliance with 44 CFR 65.10(d).

All of the above documentation and data, along with the previously submitted documentation, have been reviewed and based on receipt of this information the Agua Fria River Levee System (Levee ID Nos. 8, 11, 16 and 18) as shown on the attached Agua Fria River Levee System Map, meets the minimum certification criteria outlined in 44 CFR 65.10. Therefore, we plan to continue to accredit this levee system on the new Digital Flood Insurance Rate Map (FIRM) as providing protection from the 1-percent-annual-chance (base) flood. The area protected from the base flood by this levee will continue to be mapped as a shaded Zone X and a note will be placed in that area warning of the flood risk that still exists.

Please be advised that levee systems and the estimated level of protection provided by these systems can and do change with time. Future map updates may require the levee system to be certified again at the time of update. Also, design, construction, operation, and/or maintenance documents may be requested at any time. Deviations from the documentation and data submitted to FEMA could result in the levee system no longer being mapped as providing protection from the base flood on future FIRMs. If at any point additional information is provided to FEMA that shows the levee system no longer meets certification criteria as outlined in 44 CFR 65.10, we will contact the levee owner and community about the possibility of de-accrediting the levee system.

Even though we have mapped the referenced levees as providing protection from the 1-percent-annual-chance flood, it is important to note that levees are only designed to provide a specific level of protection. They can be overtopped or fail in larger flood events. Levee systems require regular maintenance and periodic upgrades to retain their level of protection. When levees do fail, they fail catastrophically, and damage may be more significant than if the levee was not there. Therefore, we encourage you to annually discuss the status and condition of your levees with your governing body. Additionally, it is highly recommended that you consider this risk in your local emergency management plans, including creating evacuation plans for this area.

Everyone should understand the risk to life and property that resides behind levees—risk that even the best flood-control system can not completely eliminate. For this reason, FEMA encourages people to understand their risk. The National Flood Insurance Program (NFIP) was created to reduce flood damages by identifying flood risks, encouraging sound community floodplain management practices, and

providing flood insurance to lessen the financial impact of flooding. Through the NFIP, property owners in participating communities are able to purchase flood insurance that will insure against flood losses. We hope that you will encourage property owners to purchase flood insurance.

If you have additional questions regarding this matter, please contact me, either by telephone at (510) 627-7274, or by email at robert.bezek@fema.dhs.gov.

Sincerely,

Robert J. Bezek, CFM
Regional Engineer
Mitigation Division

Enclosure:
Agua Fria River Levee System Map

Copies Furnished (w/out enclosures):
Brian Cosson, AZ DWR, NFIP Coordinator
Tony Freiman, AMEC Earth & Environmental, Inc.
Steve Nowaczyk, Ninyo and Moore
Jon T. Ahern, JE Fuller Hydrology & Geomorphology, Inc.
Scott Buchanan, Stanley Consultants, Inc.
Brian T. Wahlin, WEST Consultants, Inc.
Charlie McClendon, City Manager, City of Avondale
Sue McDermott, Floodplain Administrator, City of Avondale
David Cavazos, City Manager, City of Phoenix
Hasan Mushtaq, Floodplain Administrator, City of Phoenix

**Board of Directors**
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# Flood Control District
## of Maricopa County

www.fcd.maricopa.gov

2801 West Durango Street
Phoenix, Arizona 85009
Phone: 602-506-1501
Fax: 602-506-4601
TT: 602-505-5897

February 1, 2012

Charles Andrews, P.E.
Senior Project Manager, Engineering Department
City of Avondale
11465 W. Civic Center Dr., Ste. 120
Avondale, AZ 85323

**Subject: Floodplains for the Agua Fria River from the Salt / Gila River to New River**

Dear Mr. Andrews:

This letter is in response to a recent data request from an outside engineer, which the City will fulfill. In reviewing previous data that the District sent to the City, it appears some files were not sent to the City of Avondale. The District previously received a signed Public Records request for this data and some of the enclosed data should have been on that disk. For the City's convenience, the previous (January 11, 2012 and others) data is repeated here, so that the City has all applicable floodplain data on one disk. The City's GIS data request, fulfilled per the District's letter dated December 15, 2011, is not repeated on this disk.

As stated in the January 11 letter to you, this update to the lower 10 miles of the Agua Fria River floodplain and floodway presents new BFE's and ponded water surface elevations from the Salt / Gila River to New River, based on recent topographic mapping much newer than the current FCD95-05 study. About 6 miles of the 10 mile study reach were flown in January 2011.

Although the levees adjacent to this floodplain are now accredited by FEMA, which included a review of the HEC-RAS hydraulic model, this floodplain information is currently being reviewed by FEMA for any outstanding floodplain mapping issues. FEMA has not yet asked the District to provide a City of Avondale Community Acknowledgment Form. After FEMA's final approval, the District would like to borrow your copy of the TDN in order to finalize it.

It is important that the City of Avondale understand this floodplain information is pending FEMA review and could be revised by review comments. Everyone at the City of Avondale obtaining or using this data should be made aware of this fact and use appropriate caution. If you have questions concerning this information, please call me at 602-506-4617.

Sincerely,

Frank Brown

Frank Edward Brown, P.E., CFM , Senior Civil Engineer, Mitigation Planning & Technical Programs Branch, Floodplain Management and Services Division

C: Linda Mendenhall, FCDMC
Charlie McClendon, City Manager
Wayne Janis, Floodplain Administrator
Sue McDermott, City Engineer, City of Avondale

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December 22, 2011

Thomas W. Smith, P.E.
Engineering Technical Services Group
FEMA PTS Contractor
Michael Baker, Jr., Inc.
3601 Eisenhower Avenue
Alexandria, VA 22304

**Subject: Floodplains Review for Agua Fria River Levees, Data Request**

Dear Mr. Smith:

The Federal Emergency Management Agency, via Sarah Houghland, P.E., CFM, at BakerAECOM, has requested the digital floodplain information, recent aerial photographs and recent topographic mapping (contours and DTM) for the lower Agua Fria River. Enclosed is a DVD disk with the requested data in the appropriate format files. The District does not require a signed Public Records request for this data, because this data is in support of documents previously submitted to FEMA for levee accreditation. The data disk contains the data described in the attached File Inventory Report.

It is important to note that the topographic information has not been edge-matched for this project, therefore a map, from the interior Drainage Report (ID#8&16), listing the data sources for the contours is sent to assist you in loading/viewing the correct shape file, depending on which floodplain area you are reviewing.

If you have questions concerning this information, please call me at 602-506-4617.

Sincerely,

Frank Edward Brown

Frank Edward Brown, P.E., CFM
Senior Civil Engineer, Mitigation Planning & Technical Programs Branch,
Floodplain Management and Services Division

C: Bob Bezek, FEMA Region IX
Sarah Houghland, BakerAECOM

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August 25, 2011

Robert J. Bezek, CFM
Regional Engineer
U.S. Department of Homeland Security
Mitigation Division, FEMA Region IX
1111 Broadway, Suite 1200
Oakland, CA 94607-4052

**Subject: Floodplain Delineations in support of Levee Certification Packages for Agua Fria River Levees, PAL ID#8-11-16-18**

Dear Mr. Bezek:

This letter is in response to the Provisionally Accredited Levee (PAL) agreements which the District, the City of Avondale and the City of Phoenix entered into with the Federal Emergency Management Agency in June 2009 for the Agua Fria River Levees, generally between the New River and the Salt / Gila River. The Levee Certification Reports for each of PAL ID#8, ID#11, ID#16, and ID #18 were submitted in June 2011.

Provided in this submittal is an update to the Agua Fria River Floodplain work maps from the Salt / Gila River to New River. As discussed with you, the District directed Stanley Consultants to correct some graphic presentation items on the new work maps, and added the Zone AH delineations prepared by WEST Consultants for the interior drainage analysis. The work maps also depict the floodplain delineation adjacent to PAL ID#11 prepared by JE Fuller. On August 4 we met with the City of Avondale to coordinate some floodplain issues for proper depiction of certain areas on the work maps.

Submitted are 1 hard copy Agua Fria River Floodplain Re-Delineation Technical Data Notebook, 2 hard copy Interior Drainage Reports (one for each river side), work maps and annotated FIRM Panels. As stated in past conversations and stated in a one page TDN addendum, the HEC-RAS models are unchanged and are the same as the June 2011 submittal. The enclosed disks contain PDF format files of the submitted data along with the HEC-RAS models previously submitted.

Shipped are one box with the reports and disks and one tube with the floodplain / floodway work maps. Please replace the previously submitted information with this update information. A minor update is made to the levee certification reports to document the revised reference report dates.

FEMA now has all applicable information to begin review of the Agua Fria River levees. We ask that FEMA agree with the District that these Agua Fria River Levees are in full compliance with 44CFR §65.10 to provide protection from flooding during from the 1 percent annual chance flood, and request that all four of these levees be moved from Provisionally Accredited to Accredited status on the FIRM Panels.

If you have questions concerning this submittal, please call me at 602-506-4617.

Sincerely,

Frank Edward Brown

Frank Edward Brown, P.E., CFM
Senior Civil Engineer, Mitigation Planning & Technical Programs Branch,
Floodplain Management and Services Division

Cc: Sarah Houghland, Michael Baker Corporation (1 CD/DVD disk for each report, and 1 roll of floodplain work maps)
Brian Cosson, ADWR, NFIP Coordinator
Jon T. Ahern, JE Fuller Hydrology & Geomorphology, Inc.
Scott Buchanan, Stanley Consultants, Inc.
Brian T. Wahlin, WEST Consultants, Inc.
Charlie McClendon, City Manager, City of Avondale
Wayne Janis, Floodplain Administrator, City of Avondale
Sue McDermott, City Engineer, City of Avondale
Charles Andrews, Senior Project Manager, Engineering Dept., City of Avondale
David Cavazos, City Manager, City of Phoenix
Hasan Mushtaq, Floodplain Administrator, City of Phoenix

**Flood Control District**
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June 23, 2011

Ed Curtis, P.E., CFM
Senior Civil Engineer
Risk Analysis Branch, FEMA Region IX
U.S. Department of Homeland Security
1111 Broadway, Suite 1200
Oakland, CA 94607-4052

**Subject: Levee Certification Packages for Agua Fria River Levees, PAL ID#8-11-16-18**

Dear Mr. Curtis:

This letter is in response to the Provisionally Accredited Levee (PAL) agreements (attached) which Maricopa County, the City of Avondale and the City of Phoenix entered into with the Federal Emergency Management Agency in June 2009 for the Agua Fria River Levees, generally between the New River and the Salt / Gila River. The submittal package is separate Levee Certification Reports for each of PAL ID#8, ID#11, ID#16, and ID #18, dated June 2011.

In addition, we are providing an update to the Agua Fria River floodplain and floodway with new BFE's from the Salt / Gila River to New River, based on recent topographic mapping. The Agua Fria River Floodplain Re-Delineation Technical Data Notebook is being sent to you on disk (only), along with the HEC-RAS models. As recently agreed, Maricopa County will correct some graphic presentation items on the new work maps, add Zone AH delineations prepared by others for the new interior drainage analysis and submit a paper TDN with updated disks and updated work maps by July 18, 2011. The HEC-RAS models will be unchanged with this update.

You are receiving two boxes with the reports and disks and one tube with the floodplain / floodway work maps. As previously agreed, you are receiving the survey disks with sealed report scan without a paper copy of each survey report.

We ask that FEMA agree with Maricopa County that these Agua Fria River Levees are in full compliance with 44CFR §65.10 to provide protection from flooding during from the 1 percent annual chance flood, and request that all four of these levees be moved from Provisionally Accredited to Accredited status on the FIRM Panels.

If you have questions concerning this submittal, please call me at 602-506-4617.

Sincerely,

Frank Edward Brown

Frank Edward Brown, P.E., CFM
Senior Civil Engineer, Mitigation Planning & Technical Programs Branch,
Floodplain Management and Services Division

Cc: Sarah Houghland, Michael Baker Corporation (1 CD/DVD disk for each levee report, and 1 roll of floodplain work maps)
Brian Cosson, AZ DWR, NFIP Coordinator
Tony Freiman, AMEC Earth & Environmental, Inc.
Steve Nowaczyk, Ninyo and Moore
Jon T. Ahern, JE Fuller Hydrology & Geomorphology, Inc.
Scott Buchanan, Stanley Consultants, Inc.
Brian T. Wahlin, WEST Consultants, Inc.
Charlie McClendon, City Manager, City of Avondale
Wayne Janis, Floodplain Administrator, City of Avondale
David Cavazos, City Manager, City of Phoenix
Hasan Mushtaq, Floodplain Administrator, City of Phoenix

# Certification Report for Camelback Ranch Levee South (ID#11)

# Camelback Road to 3600 feet south along the east bank of the Agua Fria River

# Maricopa County, Arizona

**Prepared for:**

Flood Control District of Maricopa County

2801 W. Durango Street
Phoenix, AZ 85009

Registered Professional Engineer (Civil)
CERTIFICATE NO.
34141
JON T.
AHERN
Date Signed 6/22/2011
ARIZONA, U. S. A.
Expires 09/30/2011

**Prepared by:**

JE FULLER
HYDROLOGY & GEOMORPHOLOGY, INC.

1 West Deer Valley Road, Suite 101
Phoenix, AZ 85027

June 2011

This document, together with the concepts and designs presented herein, as an instrument of service, is intended only for the specific purpose and client for which it was prepared. Reuse of and improper reliance on this document without written authorization and adaptation by JE Fuller Hydrology & Geomorphology, Inc., shall be without liability to JE Fuller Hydrology & Geomorphology, Inc.

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## List of Acronyms

| | |
|---|---|
| 44CFR65.10 | Title 44 of the Code of Federal Regulations, Section 65.10, Mapping of Areas Protected by Levees |
| ADOT | Arizona Department of Transportation |
| cfs | cubic feet per second |
| DEM | digital elevation model |
| DFIRM | Digital Flood Insurance Rate Map |
| DTM | Digital Terrain Model |
| FEMA | Federal Emergency Management Agency |
| FCDMC | Flood Control District of Maricopa County |
| fps | feet per second |
| ft | feet |
| H&H | Hydrology and Hydraulics |
| H:V | Horizontal:Vertical |
| HEC-1 | U.S. Army Corps of Engineers hydrologic modeling program |
| HEC-2 | U.S. Army Corps of Engineers hydraulic modeling program |
| HEC-GeoRAS | An extension for support of HEC-RAS using ArcGIS |
| HEC-RAS | Hydrologic Engineering Centers River Analysis System (USACE, Hydraulic Model) |
| Hr | Hour |
| Hrs | Hours |
| in | Inches |
| mins | Minutes |
| NAD 83 | North American Datum of 1983 |
| NFIP | National Flood Insurance Program |
| NAVD88 | North American Vertical Datum of 1988 |
| NGVD 29 | National Geodetic Vertical Datum of 1929 |
| P.E. | Professional Engineer |
| PAL | Provisionally Accredited Levees |
| RGRCP | Rubber Gasket Reinforced Concrete Pipe |
| SPF | Standard Project Flood |
| USACE | U.S. Army Corps of Engineers |

# 1 Introduction

## 1.1 Project Objectives

This Levee Certification Report has been prepared to document Federal Emergency Management Agency (FEMA) accreditation requirements for the Levee Certification Report for the Camelback Ranch Levee South from Camelback Road to 3600 feet south along the Agua Fria River located in Maricopa County, AZ. The objectives of the Levee Certification Report are as follows:

1. Collect and review existing studies and design/construction documentation pertaining to the Camelback Ranch Levee South System (FEMA ID #11).

2. Document compliance with the requirements put forth in Title 44 Code of Federal Regulations Section 65.10 (44CFR65.10).

The Camelback Ranch Levee South System is currently shown on effective FEMA Federal Insurance Rate Map (FIRM) Panels 04013C1620F and 04013C2085E, reflecting the Camelback Ranch Levee South Project which was accepted by FEMA April 16, 1998 per LOMR Case Number 98-09-226P.

FEMA's LOMR acceptance letter and effective FIRM Panels (in a FIRMette format) are provided in **Appendix A**.

At the time of this report, FEMA has classified the Camelback Ranch Levee South System via a Provisionally Accredited Levee (PAL) letter based on the understanding that the Flood Control District of Maricopa County (FCDMC) will have the systems certified within a two-year time frame. The PAL agreement is scheduled to expire June 25, 2011. The assessment discussed in this report is intended to aid in the FEMA accreditation process.

## 1.2 Authority for the Study

Study team contact information is presented below:

**JE Fuller Hydrology & Geomorphology, Inc.**

Address: 1 W. Deer Valley Rd, Suite 101
Phoenix, Arizona 85027

Phone: (623) 889-01688

Project Managers: Jon Ahern, P.E., CFM

**Flood Control District of Maricopa County.**

Address: 2801 W. Durango Street
Phoenix, AZ 85009

Phone: (602) 506-1501

Project Manager: Frank E. Brown P.E. CFM.

## 1.3 Site Location and Description

The Camelback Ranch Levee South System is owned, maintained, and operated by FCDMC, and is located within a portion of Sections 24 of T02N, R01W, and Section 19 of T02N, R01E,of the Salt River Baseline and Meridian, within Maricopa County, Arizona (see **Figure 1-1**).

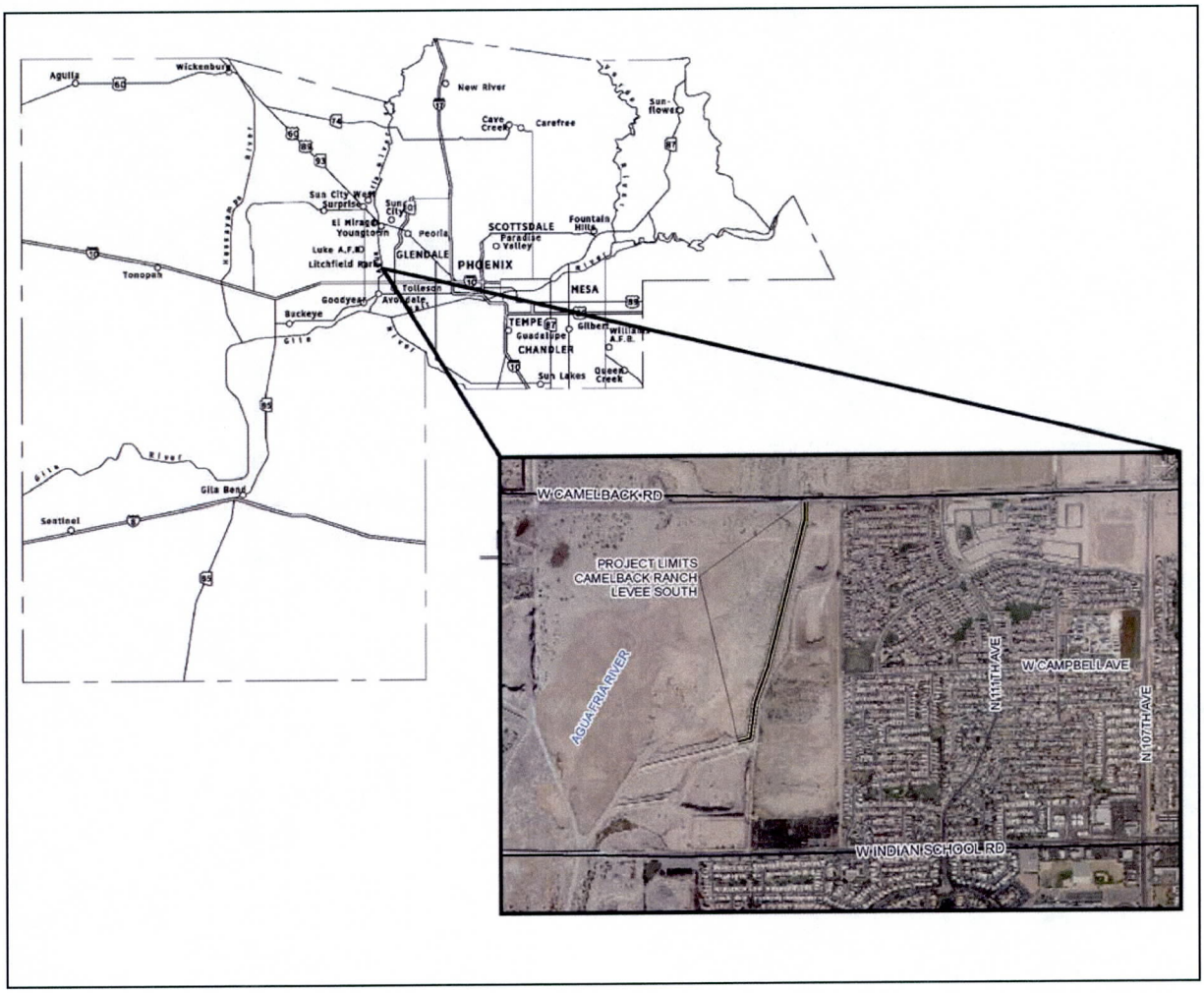


**Figure 1-1: Project Location**

## 1.4 General Discussion of the Levee System

The Camelback Ranch Levee South System was designed and constructed from 1997 to 1998. This flood control facility, located within an arid geographic region that experiences an annual average precipitation of less than 7.7 inches, was built to protect low lying developed areas from flows in the Agua Fria River near the confluence with the New River.

The Camelback Ranch Levee South System extends in a northerly direction from the terminus of an existing soil cement diversion structure to the downstream end of the east abutment of the Camelback Road Bridge over the Agua Fria River. Typical levee characteristics, based on as-built plans, are provided in **Table 1-1**. In addition, Camelback Ranch Levee South as-built drawings are provided in **Appendix E** with an electronic (pdf) copy in the data disk in Appendix **H**.

**Table 1-1: Typical Camelback Ranch Levee South System Characteristics**

| Levee Characteristic | Description |
|---|---|
| Cross-Section | Trapezoidal |
| Length | Approximately 3775 feet |
| Height | Approx. 10 to 20 feet |
| Levee Top Width | Approximately 16 feet (includes 9 foot soil cement top and a 7 foot aggregate base path) |
| Side Slope (landside) | 3H:1V |
| Side Slope (waterside) | 1H:1V to 1.8H:1V |
| Embankment Armoring | Soil Cement |

## 1.5 Report Format

As noted above, this report discusses the Camelback Ranch Levee South (ID#11) compliance with the requirements put forth in 44CFR65.10. This compliance is documented in the following sections:

Section 2: 44CFR65.10 Requirements

Section 3: FEMA MT-2 Forms

Section 4: Certification Statement

Section 5: Limitations

## 1.6 Documents Under Separate Cover

Geotechnical elements assessed for compliance with 44CFR65.10 are documented within the *Geotechnical Study for Federal Emergency Management Agency (FEMA) Partial Certification, Camelback Ranch Levee South, Maricopa County, March 2011.*

Operation and Maintenance Elements are documented in *FCDMC, Operations and Maintenance Division, Standard Operating Procedures (SOP's) Deficiency Levels, Maintenance Standards, and Standard Drawings, Revised 2005.*

*Floodplain Delineation Study for a portion of the Agua Fria River, Agua Fria River from 1800 feet upstream (north) of Camelback Road Bridge to 1700 feet upstream (north) of Indian School Road Bridge, June 2011.*

# 2 44CFR65.10 Requirements

## 2.1 Levee Overview

The Camelback Ranch Levee South is a soil cement levee constructed along the east bank of the Agua Fria River from Camelback Road to the south for a distance of approximately 3600 feet. The southern section ties into a soil cement transverse diversion structures upstream of Indian School Road. The levee soil cement is approximately 9 feet wide at the base with side slopes of 1.8:1 below the foundation line and 1:1 above the foundation line (see **Figure 2-1**). The existing riprap spur dike at the southeast abutment of Camelback Road Bridge was removed, and replaced as shown on the Record Drawings in **Appendix E**. In addition, a storm drain connection through the levee was added by the City of Phoenix in 2008 that included the addition of an access ramp to facilitate maintenance and inspections activities for the outlet headwall and flap gate.

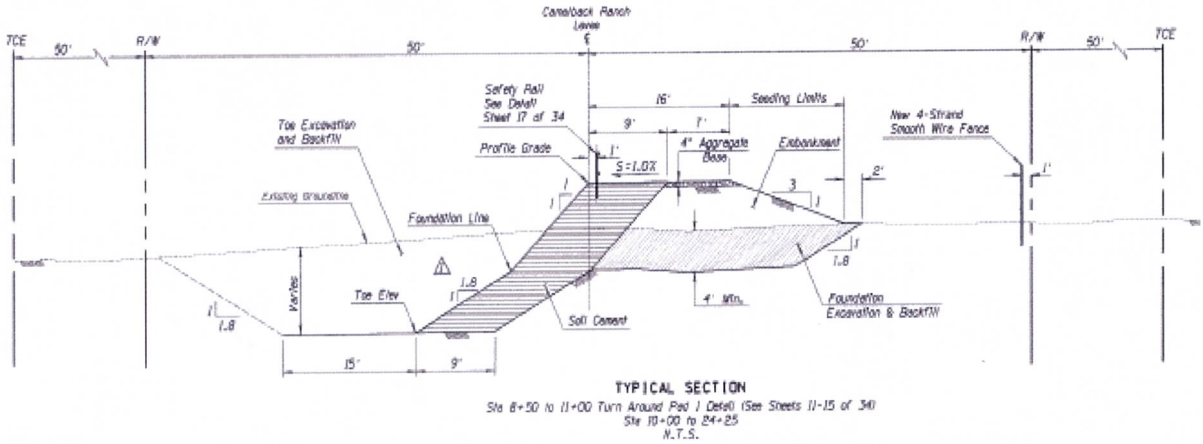


**Figure 2-1: Typical Levee Cross-section**

According to the *Final Interior Drainage Report, 1998* the general overview of the Camelback Ranch Levee project area is:

"During the 1980's development was accelerating in west Phoenix. Camelback Ranch was investigated and conceptually planned by several developers during the 1980's before the Willden-Red River Joint Venture filed an application with the City of Phoenix (COP) for Planned Community District (PCD) zoning in April 1988, case #108-88-4. See Figure 1 on page 2 for the boundaries of the Camelback Ranch property. This PCD application was approved by the Phoenix City Council, with stipulations, on November 1, 1988, with subsequent amendments. The PCD called for commercial and office uses at the northwest and southwest corners of Camelback Road and 101st Avenue, a major park on approximately 90 acres along the north edge of the property, and a variety of residential densities throughout the balance of the property. The City of Phoenix purchased the 90 acre park site along the north edge of the property. The plan also required that the developer to construct a levee along the north and west edges of the property to remove it from the floodplain. The basic design concept for the levee was approved by the Flood Control District of Maricopa County (FCDMC). Another key zoning stipulation was that construction on the project must begin within three (3) years of adoption of the PCD.

Due to the economic climate in the late 1980's and early 1990's, construction on the project including the levees, was never started. The original developer obtained several time extensions from the City of Phoenix. Ultimately, the property reverted to the lender and then to the Resolution Trust Corporation (RTC). During this time the FCDMC was under pressure to construct the levees or acquire flood control easements over the entire Camelback Ranch property plus a number of the existing homes east of 101st Avenue and north of Camelback Road which were now in the Standard Project Flood (SPF) zone. Due to the depressed real estate prices at the time, the FCDMC determined that it could purchase the entire Camelback Ranch property for about the same cost as the flood control easements. When the property was made available by the RTC the FCDMC purchased it. The levee on the north portion of Camelback Ranch, in the original PCD, required its construction across two areas of property not owned by the developer. One of these areas is owned by the City of Glendale who is not inclined to allow the levee to be constructed there and result in the development of additional residential uses in the flight path of the Glendale Municipal Airport. Therefore this portion of the levee was moved further south, to within the City of Phoenix's corporate boundary, when the FCDMC performed their alternative levee analysis. The FCDMC purchased the Camelback Ranch property in order to fulfill its obligation to provide flood protection to property that was brought under the SPF designation due to the increased flow in the New River resulting from the construction of the ACDC. Provision for this additional flood protection was a condition of the COE's approval of the ACDC."

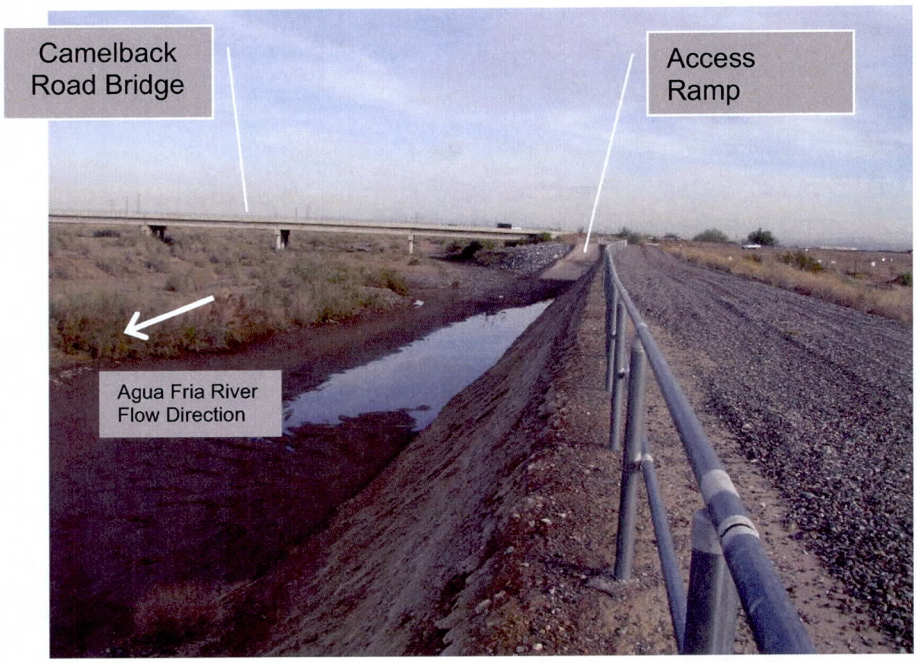


**Photo 2-1: Camelback Ranch Levee South looking North at Camelback Road Bridge**

## 2.2 Without Levee Evaluation

As part of the Federal Emergency Management Agency (FEMA) Procedure Memorandums 34 & 43 (PM 34/43), an analysis of embankments in Maricopa County, AZ that are potentially providing protection from the 1% annual chance flood has been conducted by HDR. In this analysis, HDR identified these embankments, determined their status as flood control structures, and delineated approximate floodplains, assuming a "without levee" scenario, downstream of and adjacent to the embankments where applicable.

A procedure memorandum along with the delineation figure is included in **Appendix A**

## 2.3 General

**Section 2.3, 2.4 and 2.5** contains excerpts in *"italics"* from 44CFR65.10. Below the excerpt, within each subsection, is a discussion on compliance of the Camelback Ranch Levee South System. Sections of code are reproduced in their entirety. Subsections that do not apply to this evaluation are so noted. In addition, **Table 2-1** lists 44CFR65.10 criteria cross referenced with the location of supporting documentation.

**Table 2-1: Levee Compliance Summary for 44CFR65.10**

| Criteria | Comment and Location of Supporting Documentation |
|---|---|
| **65.10.b Design Criteria** | |
| 65.10.b.1 Minimum freeboard<br>• 3' above BFE all along length<br>• Additional 1' within 100' of structures and at constrictions<br>• Additional 0.5' at the upstream end of levee (tie-in) | Discussed in **Section 2.4.1** |
| 65.10.b.2 All openings protected with closure devices | Discussed in **Section 2.4.2** |
| 65.10.b.3 Embankment erosion protection analysis | Discussed in **Section 2.4.3** |
| 65.10.b.4 Embankment and foundation stability analysis | Discussed in **Section 2.4.4** with detailed documentation presented in *Geotechnical Study for Federal Emergency Management Agency (FEMA) Partial Certification, Camelback Ranch Levee South, Maricopa County, March 2011* under separate cover |
| 65.10.b.5 Settlement analysis | Discussed in **Section 2.4.5** with detailed documentation presented in *Geotechnical Study for Federal Emergency Management Agency (FEMA) Partial Certification, Camelback Ranch Levee South, Maricopa County, March 2011* under separate cover |
| 65.10.b.6 Interior drainage analysis<br>• Identify Flooding Source<br>• Identify extents of flooding greater than 1 foot<br>• Analysis based on the joint probability of interior and exterior flooding | Discussed in **Section 2.4.6** |
| 65.10.b.7 Other design criteria may be required at FEMA's discretion | None Applicable |

**Table 2-1: Levee Compliance Summary for 44CFR65.10 (Continued)**

| Criteria | | Comment and Location of Supporting Documentation |
|---|---|---|
| **65.10.c Operation** | | |
| • Officially adopted manual<br>• Under jurisdiction of a recognized Agency | | Discussed in **Section 2.5.1**<br>• *FCDMC, Operations and Maintenance Division, Standard Operating Procedures (SOP's) Deficiency Levels, Maintenance Standards, and Standard Drawings, Revised 2005* (hereafter referred to as FCD O&M Manual) under separate cover<br>• Flood Control District of Maricopa County, Arizona<br>2801 W. Durango Street<br>Phoenix, AZ 85009 |
| 65.10.c.1 | Closure Devices | |
| 65.10.c.1.i | Documentation of flood warning system | Flood Emergency Operations and Assignment responsibilities are noted in SOP #18. |
| 65.10.c.1.ii | Formal plan of operation with specific assignments | FCD O&M Manual, SOP #14 |
| 65.10.c.1.iii | Provisions for periodic (annual or more often) operation (testing and training) | FCD O&M Manual, Standard Operating Procedure #9 (SOP #9) |
| 65.10.c.2 | Interior Drainage Systems | |
| 65.10.c.2.i | Documentation of interior drainage flood warning system with specific assignments | Flood Emergency Operations and Assignment responsibilities are noted in SOP #18. |
| 65.10.c.2.ii | Formal plan of operation for interior drainage | FCD O&M Manual, SOP #14 |
| 65.10.c.2.iii | Provisions for manual backup for activation of automatic systems | Not Applicable. No Automated Systems |
| 65.10.c.2.iv | Provisions for periodic (annual or more often) inspection and operation of mechanized systems (testing and training) | FCD O&M Manual, SOP #9 |
| 65.10.c.3 | Other operation plans may be required at FEMA's discretion | Not Applicable |

**Table 2-1: Levee Compliance Summary for 44CFR65.10 (Continued)**

| Criteria | Comment and Location of Supporting Documentation |
|---|---|
| **65.10.d Maintenance plan** | |
| • Officially adopted manual<br>• Under jurisdiction of a recognized Agency | Discussed in **Section 2.6.1**<br>FCD O&M Manual) under separate cover<br>• Flood Control District of Maricopa County, Arizona<br>2801 W. Durango Street<br>Phoenix, AZ 85009 |
| **65.10.e Certification** | |
| • Certification by a Registered Engineered | **Section 4** |
| • Certified As-built plans | Hard copy contained in **Appendix E** and electronic copy in pdf format on the data disk in **Appendix H**. |

## 2.4 Design Criteria

### 2.4.1 Freeboard

*"(1) Freeboard. (i) Riverine levees must provide a minimum freeboard of three feet above the water-surface level of the base flood. An additional one foot above the minimum is required within 100 feet in either side of structures (such as bridges) riverward of the levee or wherever the flow is constricted. An additional one-half foot above the minimum at the upstream end of the levee, tapering to not less than the minimum at the downstream end of the levee, is also required."*

#### 2.4.1.1 Camelback Ranch Levee South Freeboard

**Design Freeboard**

According to letter Report by Simons, Li and Associates, Inc. dated December 4, 1996 (SLA 96 Letter Report); the top of levee elevation has been set at 3-feet above the SPF (142,000 cfs) water surface elevation. See **Table 2-2** (Table 5 contained within the letter report).

**Table 2-2: Levee Design Elevations**

**TABLE 5**

**CAMELBACK RANCH LEVEE DESIGN**

**Phase 1**

**Recommended Design Elevations**

| Section Number | Channel Invert (Feet) | Rec. Toedown Elevation (Feet) | Water Surf. Elevation (Feet) | Rec. Top of Bank Elevation (Feet) | Bank Height (Feet) | Remarks |
|---|---|---|---|---|---|---|
| 13.0 | 1002.0 | 992.0 | 1016.6 | 1019.6 | 27.6 | Begin Phase 1 Levee (Mining section) |
| 14.0 | 1002.0 | 992.0 | 1017.4 | 1020.4 | 28.4 | Mining section |
| 15.0 | 1002.0 | 994.0 | 1017.9 | 1020.9 | 26.9 | Mining section |
| 16.0 | 1004.0 | 986.2 | 1019.1 | 1022.1 | 36.0 | Mining section |
| 17.0 | 1004.0 | 991.1 | 1020.4 | 1023.4 | 32.3 | Mining section |
| 18.0 | 1004.0 | 988.1 | 1021.6 | 1024.6 | 36.5 | |
| 18.5 | 1012.0 | 1000.6 | 1023.6 | 1026.6 | 26.1 | End Phase 1 Levee |

According to notes within the *Final Calculations, Camelback Ranch levee – South, Revised* February 24, 1997, Preliminary 30% Submittal Package included the following statement regarding the design top of Levee elevation:

"Top of levee elevation has been set at 3' above the SPF water surface elevation from the preliminary Hydraulic analysis. Elevation at north end set 4' above SPF at bridge opening. Elevation at south end was set to match existing top of transverse dike elevation and run level until 3" above SPF water surface elevation."

Within the original document "....level until 3" above.." more than likely refers to "feet"

and not "inches".

In Summary, the design discharge of 142,000 cfs (SPF) was used to determine the design levee freeboard as noted above. The effective FEMA discharge of 54,400 cfs, which reflects the reduced discharge from the New Waddell Dam, was used to map the revised floodplain limits displayed in the floodplain work maps in **Appendix B**.

## Effective FEMA Hydraulics for the Agua Fria River

According to documentation provided by FEMA for the LOMR Number 98-09-226P, Agua Fria River floodplain data accompanying the levee certification documentation included a hard copy of two HEC-2 models. Noted within the documentation, Exhibit 6 contains the Duplicate Effective HEC-2 Model input (aguafria.dat) and Exhibit 7 contains the Revised Hydraulic Model (cblp1.dat) input and output. Electronic versions of the HEC-2 models were collected from the FCDMC. A review of the cross section water surface elevations of both the hard copy and electronic model for the Revised Hydraulic Model compared favorably. See **Table 2-3** and the HEC-2 floodplain work maps in **Appendix B.**

**Table 2-3: Water Surface Elevation Comparison**

| (1)Levee Station (ft) | (2)Cross Section Station | (3)LOMR cblp1.dat (ft) | (4)FCDMC cblp1.dat (ft) | (5)FEMA Floodway Data Table 5 (ft) |
|---|---|---|---|---|
| 10+00 | 8.534 | 1014.38 | 1014.38 | 1014.4 |
| 16+12 | 8.646 | 1015.75 | 1015.75 | |
| 22+50 | 8.768 | 1017.22 | 1017.22 | 1017.2 |
| 28+43 | 8.875 | 1019.66 | 1019.66 | |
| 35+31 | 8.992 | 1021.66 | 1021.66 | 1021.7 |
| 41+41 | 9.098 | 1022.48 | 1022.48 | |
| 45+85 | 9.177 | 1023.06 | 1023.06 | 1023.1 |

Notes:
1. Levee stations approximated using data from As Built plans.
2. Cross section location from floodplain work maps in **Appendix A**.
3. Water surface elevations hard copy of cblp1.out in LOMR Report.
4. Water surface elevations electronic HEC-2 model output cblp1.out.
5. Water surface elevations Floodway Data Table 5 in LOMR in **Appendix A**.

The Revised Hydraulic Model (cblp1.dat) submitted as part of the LOMR is a truncated portion of the previous Effective FEMA Model. The Revised Hydraulic Model was truncated at HEC-2 model station 6.430 approximately 8000 feet downstream of Indian School Road Bridge. The starting water surface elevation of 989.0 ft was selected from the duplicate effective model.

Manning's n-values ranging from 0.035 to 0.040 within the study reach. Typical flow velocities were subcritical, ranging from 5.16 to 8.80 fps adjacent to the levee.

## Comparison of Design and Effective FEMA Water Surface Elevations

For preliminary freeboard assessment per 44 CFR 65.10 criteria, the top of levee elevations from the record drawings and HEC-2 model computed water surface elevation profile were plotted. This comparison is provided graphically in **Figure 2-2**.

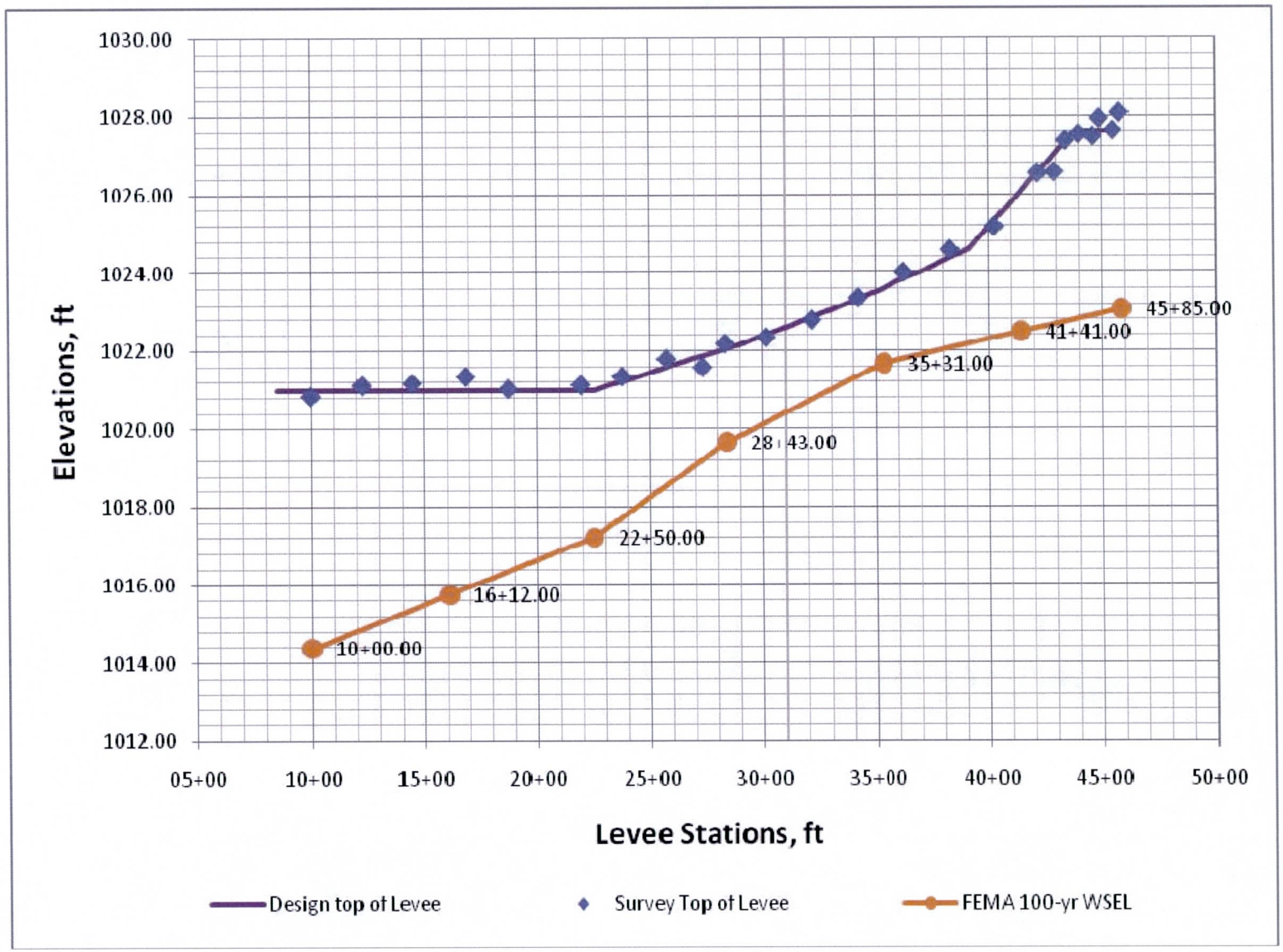


**Figure 2-2: Camelback Ranch Levee South As-Built and HEC-2 Profiles**

Even though the design document states that the levee freeboard was designed for the SPF plus three feet, a comparison of the design top of levee elevations and the effective FEMA water surface elevations show that the Camelback Ranch Levee South does not meet the required freeboard elevations between levee stations 25+70 to 40+20.

Results of this comparison indicate the levee does not meet the overall 3 feet of freeboard criteria, but does meet the 3.5 feet of freeboard required at the upstream levee limit. See **Table 2-4**.

**Table 2-4: Camelback Ranch Levee South Freeboard with Effective FEMA Model**

| (1)Levee Station | (2)Cross Section Station (HEC-2) | Peak Discharge (cfs) | (3)Water Surface Elevation (ft) | (4)Levee Elevation (ft) | Levee Freeboard (ft) | Meets 44CFR65.10 Minimum Criteria |
|---|---|---|---|---|---|---|
| 10+00 | 8.534 | 54,400 | 1014.38 | 1021 | 6.62 | Yes |
| 16+12 | 8.646 | 54,400 | 1015.75 | 1021 | 5.25 | Yes |
| 22+50 | 8.768 | 54,400 | 1017.22 | 1021 | 3.78 | Yes |
| 28+43 | 8.875 | 54,400 | 1019.66 | 1021.97 | 2.31 | No |
| 35+31 | 8.992 | 54,400 | 1021.66 | 1023.52 | 1.86 | No |
| 41+41 | 9.098 | 54,400 | 1022.48 | 1025.79 | 3.31 | Yes |
| 45+85 | 9.177 | 54,400 | 1023.06 | 1027.6 | 4.54 | Yes |

Note:
1. Levee stations from Camelback Ranch Levee Plans.
2. Cross sections per Effective FEMA HEC-2 model. Work maps in **Appendix A**.
3. 100-year water surface elevation from FEMA Effective Model (chlp1.out).
4. Levee elevations from Camelback Ranch Levee South Plans.

Based on these findings a Letter of Map Revision (LOMR) was prepared. The LOMR referenced in **Section 1.6** is submitted under separate cover. The HEC-RAS model included in **Appendix B** is consistent with the LOMR model except for the removal of the Floodway encroachments/plan and the addition of the 10-year flow added for use in the embankment scour evaluation discussed below and documented in **Appendix C**.

**Current Conditions Hydraulic Evaluation and LOMR**

A current conditions model was created using new topographic data (provided by FCDMC) and Geo-RAS/HEC-RAS. As noted previously, a LOMR is submitted concurrently with this levee assessment to revise the effective water surface elevations and document the available freeboard along the Camelback Ranch Levee South System.

Based upon the current conditions hydraulic evaluation and surveyed top of the levee, the available freeboard ranges from 6.2 feet to 10.9 feet. See **Table B-1** in **Appendix B** for freeboard determination at each HEC-RAS cross section along the levee.

### 2.4.1.2 Certification note for 44CFR65.10 (b)(1)

As shown in **Table B-1** in **Appendix B**, the Camelback Ranch Levee South between Stations 8+50 to 46+25, meet 44CFR65.10 (b)(1) freeboard requirements.

### 2.4.2 Closures

*"(2) Closures. All openings must be provided with closure devices that are structural parts of the system during operation and design according to sound engineering practice. "*

#### 2.4.2.1 Structures and Closures

**Bridge**

Camelback Road Bridge is upstream of the Camelback Ranch Levee South System. Both Camelback Road and Indian School Road Bridge are included in the current conditions HEC-RAS model.

**Closures**

Visual inspection of the culverts was conducted during site visits on December 11, 2009 (See **Appendix G** for additional site photographs and photograph location map). At that time the culvert flap gate appeared to be in operational condition. See Camelback Road Storm Drain plans, provided in **Appendix E**.

**Photo 3-1**: Looking at headwall with flap gate for storm drain outlet Levee Station ±42+85.

**Photo 3-2**: Looking at headwall with flap gate for storm drain outlet Levee Station ±42+85.

**Table 2-5: Levee Openings**

| Levee Station [ft] | HEC-RAS RM | Opening size | Structure type | Closure Type |
|---|---|---|---|---|
| 42+85 | 9.654 | 60 inch | RGRCP | Flap Gate |

**Figure 2-3: Levee Opening**

#### 2.4.2.2 Certification note for 44CFR65.10 (b)(2)

Based on visual observations the closure device at levee 42+85 along Camelback Ranch Levee South, meet the requirements of 44CFR65.10 (b)(2).

### 2.4.3 Embankment Protection for Levee

*"(3) Embankment protection. Engineering analyses must be submitted that demonstrate that no appreciable erosion of the levee embankment can be expected during the base flood, as a result of either currents or waves, and that anticipated erosion will not result in failure of the levee embankment or foundation directly or indirectly through reduction of the seepage path and subsequent instability. The factors to be addressed in such analyses include, but are not limited to: Expected flow velocities (especially in constricted areas); expected wind and wave action; ice loading; impact of debris; slope protection techniques; duration of flooding at various stages and velocities; embankment and foundation materials; levee alignment, bends, and transitions; and levee side slopes."*

#### 2.4.3.1 Existing Conditions Evaluation of the Embankment Protection

**Design Scour Computations used for Embankment Toe-Down.**

The toe-down elevations and top of levee elevations were documented in the SLA 1996 Letter Report. The report documented the calculations used to determine the total scour as the sum of four individual components: general scour, long term degradation, bedform scour and low-flow Incisement.

- **General scour** represents the general lowering of the channel bed during high flow events (SPF flows). General scour was calculated using guidance in the US Bureau of Reclamation report "Computing Degradation and Local Scour," 1984.
- **Bedform scour** describes the development of dunes and troughs along the channel bottom during high flow events; this form of scour is particularly prevalent in sand-bed watercourses. Bedform scour was calculated based upon the methodology presented in the Flood Control District of Maricopa County "Drainage Design Manual - Hydraulics". Variables for the calculations were derived from the project HEC-2 model. These variables included Froude number, channel velocity, and channel hydraulic depth. The generally low flow velocities and Froude numbers caused dune, rather than anti-dune, scour conditions to dominate through the project area. Bedform scour depths were generally less than one foot but as high as 2.5 feet at some cross sections.
- **Long-term scour** describes the gradual lowering of a watercourse through multiple events and longer periods of time. Long-term scour was determined using a stable channel slope methodology combined with a depth to armoring determination. Depth to armoring limited the long term scour to a maximum or 2.5 feet. These methods are also in "*Computing Degradation and Local Scour*", USBR.
- **Low-flow incisement** results from the persistence of low flows within the channel. Low flow incisement was estimate at 1.5 feet for areas where mining was **not** occurring and 0.0 ft where in-stream mining has occurred.

A safety factor was applied by increasing the calculated scour depth by an additional 30%.

**Current Conditions Scour Assessment for Embankment Toe-Down**

As discussed in **Section 2.4.1**, a HEC-RAS hydraulic model was prepared to assess the current hydraulic conditions within the Agua Fria River. The expected velocities adjacent to levees range from 2.3 fps to 11.6 fps.

During site visits conducted on December 11, 2009, the embankment protection appeared to be in satisfactory condition with minor general scouring visible along the toe of the levee embankment near levee station 42+00. (See **Photo 2-2**).

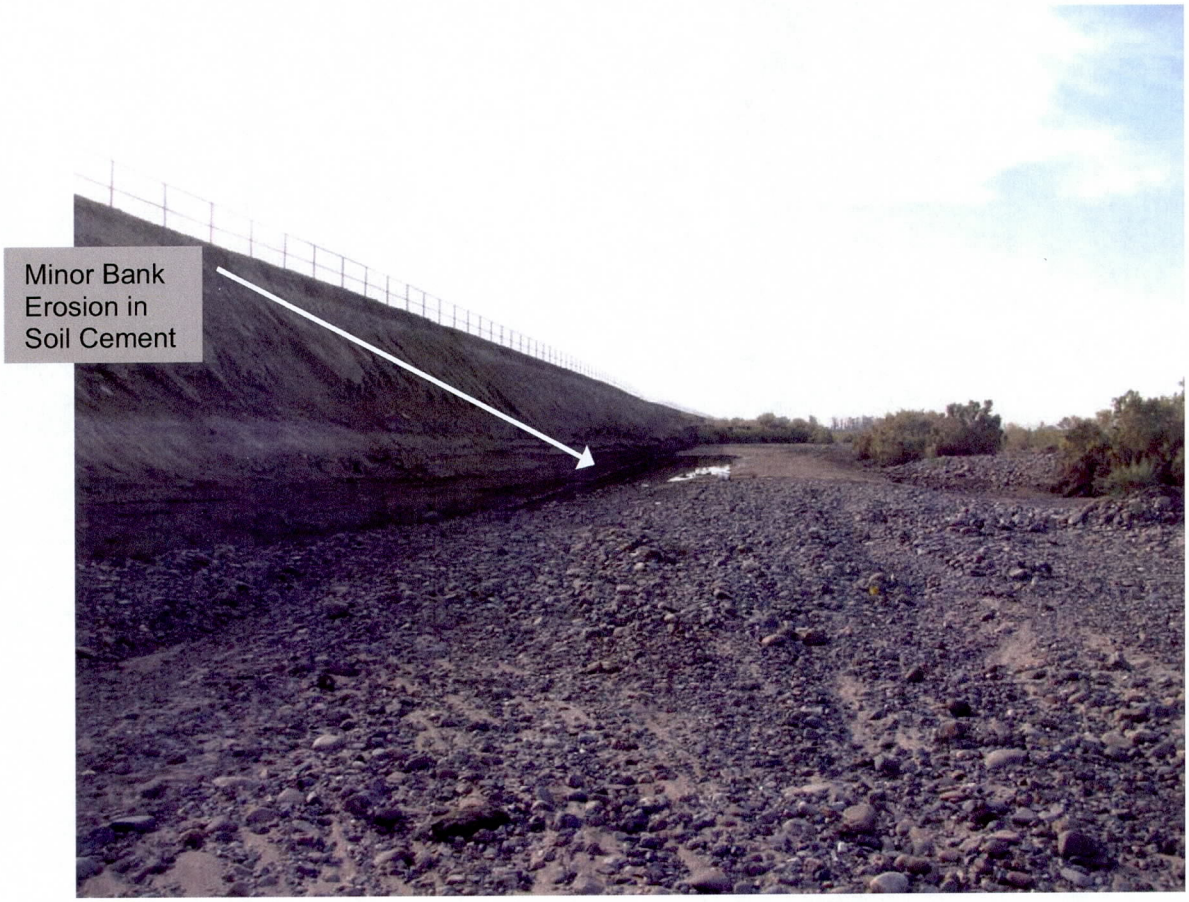


**Photo 2-2: Minor Soil Cement Bank Erosion, Approximate Levee Station 42+00.**

An evaluation was conducted as part of this assessment to evaluate the existing depth of the toe protection. A detailed evaluation using existing FCDMC methodology was conducted and is presented in **Appendix C**. The total scour potential is computed as the sum of six individual components: long term degradation, general scour, bend scour, bedform scour, local scour and low-flow incisement. Scour potential was evaluated along the entire length of the levee.

The results indicate that the computed toe-down elevations based on scour estimates are above the design toe elevations along the Camelback Ranch Levee South embankment from levee 10+00 to 42+80 (Interpolated between stations 42+43 and 43+53) with a minimum safety factor of 1.3.

However, at Levee Stations 44+81, the calculated scour elevation is below the design toe elevation by 0.7 ft with no applied safety factor. This segment of the levee is within an area where the soil cement is plated by salvaged riprap material from a spur dike removed during levee construction. In addition a thickened toe protection was included as part of the original design of Camelback Ranch Levee South. See **Figure 2-4** and **Photo 2-3**.

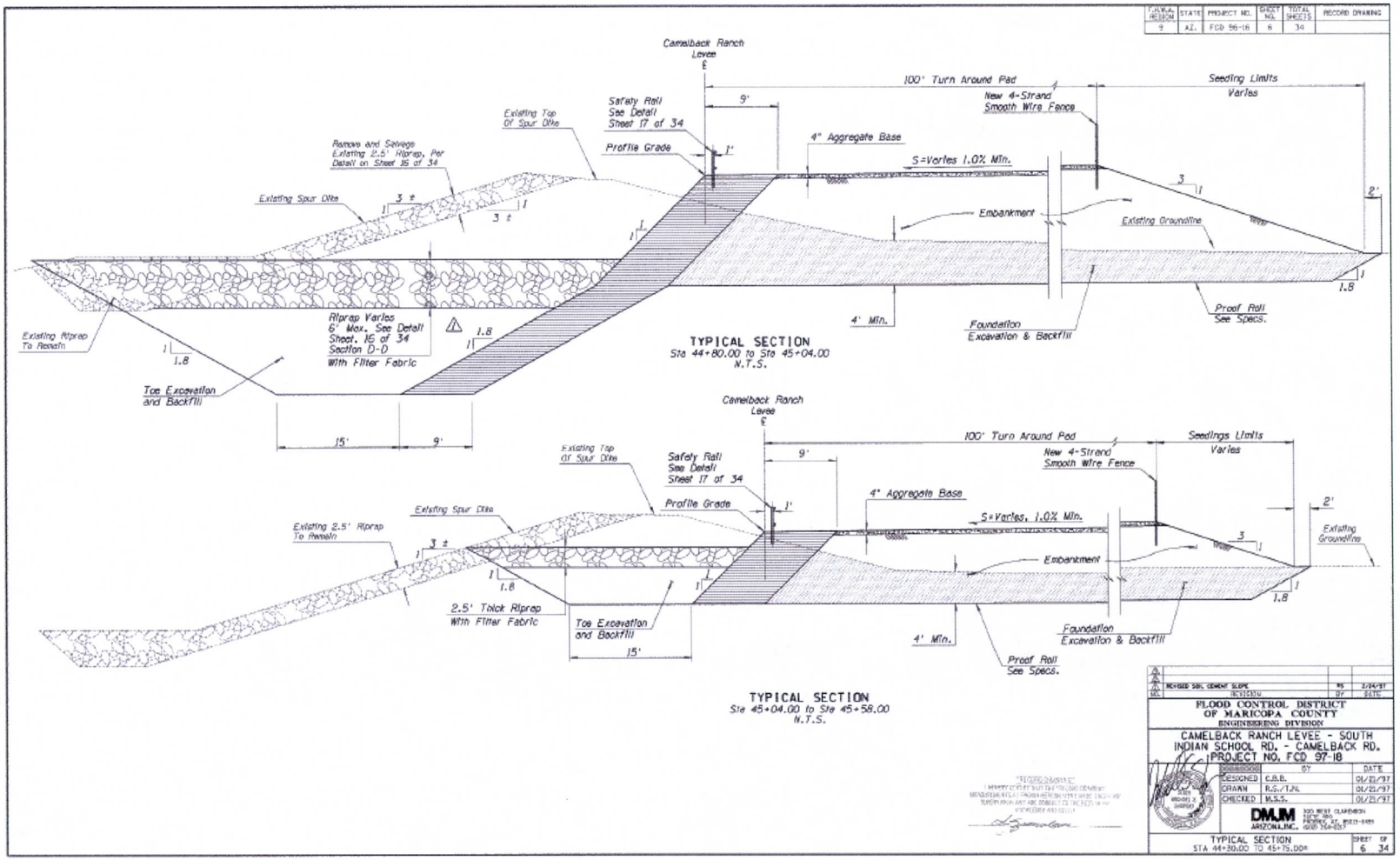


**Figure 2-4: Design Embankment Protection near End of Levee**

The riprap is part of the bridge protection that extends from the upstream guide bank through the bridge abutment continuing south to levee station 43+60. As designed, this additional riprap ($D_{50}$=16 in from Camelback Bridge Design Plans) material will provide enough volume of rock to mitigate the calculated deficit in toe protection depth from the soil cement embankment. In addition, riprap, placed on the 1H:1V slope of the soil cement embankment has sufficient volume to launch into a scour hole from levee station 45+04 (end of the levee toe) to levee station 43+35 (estimated in the field) See **Photo 2-3** below.

At levee station 43+53 the calculated scour is at the design toe elevation with no calculated safety factor. To mitigate, the FCDMC will maintain a minimum channel elevation invert elevation of 1008.0 ft. and initiate a Levee Toe Monitoring Plan that includes the segment from levee station 45+03 (end of levee toe) to 42+80 (end of levee maintenance ramp) where calculated safety factor is greater than 1.3. The Levee Toe Monitoring Plan will be included as part of the annual levee inspection with supplemental monitoring after flow events greater or equivalent to 5,000 cfs (approximately the 2-year event). At a future date, in lieu of the Levee Toe Monitoring Plan, FCDMC may consider the design and installation of additional levee toe protection to bring the levee up to a 1.3 safety factor.

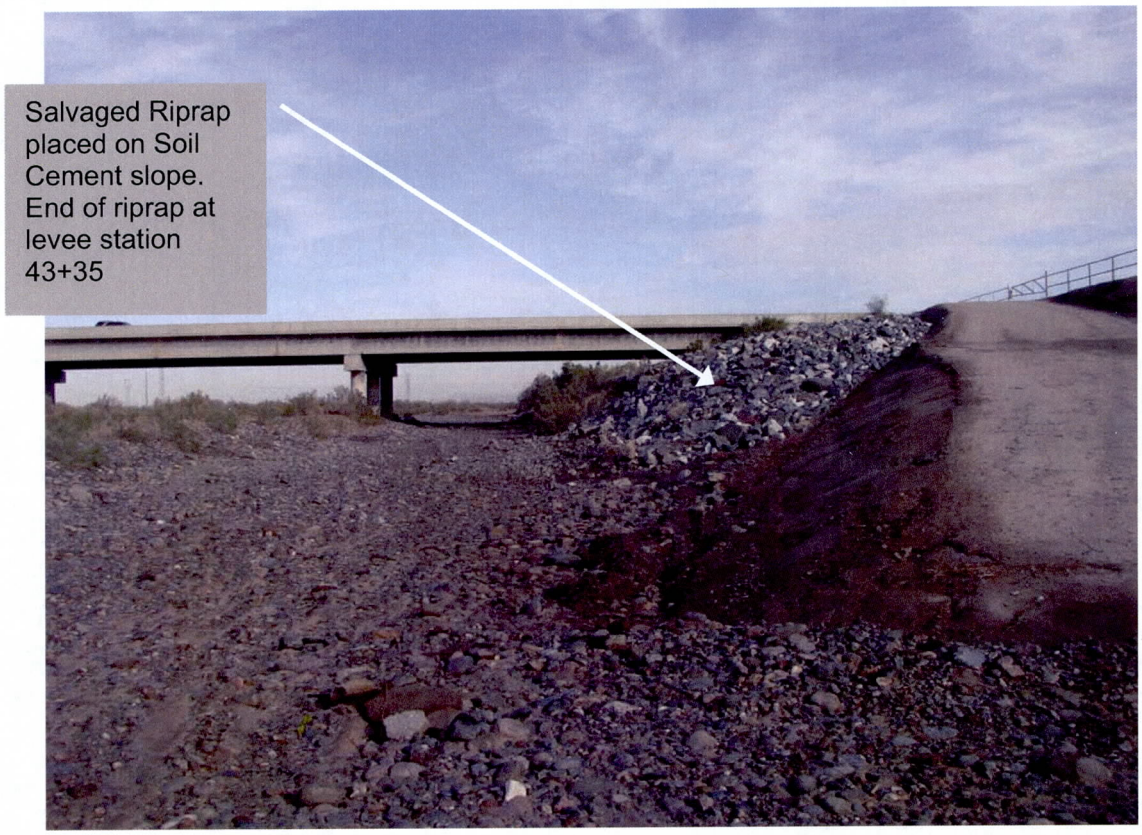


**Photo 2-3: Minor Soil Cement Bank Erosion, Approximate Levee Station 42+00.**

### 2.4.3.2 Certification note for 44CFR65.10 (b)(3)

Based on the calculations, initiation of a Levee Toe Monitoring Plan, and engineering judgment the embankment protection for the Camelback Ranch Levee South meets the 44CFR65.10 (b)(3) requirements.

### 2.4.4 Embankment and Foundation Stability

"*(4) Embankment and foundation stability. Engineering analyses that evaluate levee embankment stability must be submitted. The analyses provided shall evaluate expected seepage during loading conditions associated with the base flood and shall demonstrate that seepage into or through the levee foundation and embankment will not jeopardize embankment or foundation stability. An alternative analysis demonstrating that the levee is designed and constructed for stability against loading conditions for Case IV as defined in the U.S. Army Corps of Engineers (COE) manual, "Design and Construction of Levees" (EM 1110–2–1913, Chapter 6, Section II), may be used. The factors that shall be addressed in the analyses include: Depth of flooding, duration of flooding, embankment geometry and length of seepage path at critical locations, embankment and foundation materials, embankment compaction, penetrations, other design factors affecting seepage (such as drainage layers), and other design factors affecting embankment and foundation stability (such as berms).* "

#### 2.4.4.1 Certification note for 44CFR65.10 (b)(4)

Geotechnical analysis and review of design documentation, was conducted and documented by AMEC Earth & Environmental, Inc. (AMEC). Documentation is presented under separate cover (*Geotechnical Study for Federal Emergency Management Agency (FEMA) Partial Certification, Camelback Ranch Levee South, Maricopa County, March 2011.).*

### 2.4.5 Settlement

"*(5) Settlement. Engineering analyses must be submitted that assess the potential and magnitude of future losses of freeboard as a result of levee settlement and demonstrate that freeboard will be maintained within the minimum standards set forth in paragraph (b)(1) of this section. This analysis must address embankment loads, compressibility of embankment soils, compressibility of foundation soils, age of the levee system, and construction compaction methods. In addition, detailed settlement analysis using procedures such as those described in the COE manual, "Soil Mechanics Design— Settlement Analysis" (EM 1100–2–1904) must be submitted.* "

#### 2.4.5.1 Certification note for 44CFR65.10 (b)(5)

Geotechnical analysis and review of design documentation, was conducted and documented by AMEC Earth & Environmental, Inc. (AMEC). Documentation is presented under separate cover (*Geotechnical Study for Federal Emergency Management Agency (FEMA) Partial Certification, Camelback Ranch Levee South, Maricopa County, March 2011.).*

### 2.4.6 Interior Drainage

*"(6) Interior drainage. An analysis must be submitted that identifies the source(s) of such flooding, the extent of the flooded area, and, if the average depth is greater than one foot, the water-surface elevation(s) of the base flood. This analysis must be based on the joint probability of interior and exterior flooding and the capacity of facilities (such as drainage lines and pumps) for evacuating interior floodwaters."*

#### 2.4.6.1 Design Conditions for Interior Drainage

An evaluation was conducted for this levee certification effort to assess the interior drainage. The existing documentation and review of existing field conditions is detailed in **Appendix D**.

In general interior areas drain, via overland flow and small channels to the south. Several mining pits are located directly east of the levee. Minor ponding is expected within the mining pits due to rain falling directly on the pit area. No offsite flows contribute to the mining pits.

#### 2.4.6.2 Certification note for 44CFR65.10 (b)(6)

Interior drainage areas for the Camelback Ranch Levee South meet the requirements of 44CFR65.10 (b)(6).

## 2.5 Operation Plans and Criteria

"*(c) Operation plans and criteria. For a levee system to be recognized, the operational criteria must be as described below. All closure devices or mechanical systems for internal drainage, whether manual or automatic, must be operated in accordance with an officially adopted operation manual, a copy of which must be provided to FEMA by the operator when levee or drainage system recognition is being sought or when the manual for a previously recognized system is revised in any manner. All operations must be under the jurisdiction of a Federal or State agency, an agency created by Federal or State law, or an agency of a community participating in the NFIP.*

*(1) Closures. Operation plans for closures must include the following:*

*(i) Documentation of the flood warning system, under the jurisdiction of Federal, State, or community officials, that will be used to trigger emergency operation activities and demonstration that sufficient flood warning time exists for the completed operation of all closure structures, including necessary sealing, before floodwaters reach the base of the closure.*

*(ii) A formal plan of operation including specific actions and assignments of responsibility by individual name or title.*

*(iii) Provisions for periodic operation, at not less than one-year intervals, of the closure structure for testing and training purposes.*

*(2) Interior drainage systems. Interior drainage systems associated with levee systems usually include storage areas, gravity outlets, pumping stations, or a combination thereof. These drainage systems will be recognized by FEMA on NFIP maps for flood protection purposes only if the following minimum criteria are included in the operation plan:*

*(i) Documentation of the flood warning system, under the jurisdiction of Federal, State, or community officials, that will be used to trigger emergency operation activities and demonstration that sufficient flood warning time exists to permit activation of mechanized portions of the drainage system.*

*(ii) A formal plan of operation including specific actions and assignments of responsibility by individual name or title.*

*(iii) Provision for manual backup for the activation of automatic systems.*

*(iv) Provisions for periodic inspection of interior drainage systems and periodic operation of any mechanized portions for testing and training purposes. No more than one year shall elapse between either the inspections or the operations.*

*(3) Other operation plans and criteria. Other operating plans and criteria may be required by FEMA to ensure that adequate protection is provided in specific situations. In such cases, sound emergency management practice will be the standard upon which FEMA determinations will be based.*"

### 2.5.1 Levee System Operation Plan

**Operation Responsibility**

FCDMC operates and maintains County structures such as the Camelback Ranch Levee South under the *Standard Operating Procedures (SOP's), Deficiency Levels, Maintenance Standards, and Standard Drawings* (O&M Manual) under separate cover.

Within this document Flood Emergency Operations and Assignment responsibilities are noted in SOP #18.

**Closures Devices and Interior Drainage Plan**

Provisions for periodic operation of closure structures are noted in SOP #9.

## 2.6 Maintenance Plans and Criteria

*" (d) Maintenance plans and criteria. For levee systems to be recognized as providing protection from the base flood, the maintenance criteria must be as described herein. Levee systems must be maintained in accordance with an officially adopted maintenance plan, and a copy of this plan must be provided to FEMA by the owner of the levee system when recognition is being sought or when the plan for a previously recognized system is revised in any manner. All maintenance activities must be under the jurisdiction of a Federal or State agency, an agency created by Federal or State law, or an agency of a community participating in the NFIP that must assume ultimate responsibility for maintenance. This plan must document the formal procedure that ensures that the stability, height, and overall integrity of the levee and its associated structures and systems are maintained. At a minimum, maintenance plans shall specify the maintenance activities to be performed, the frequency of their performance, and the person by name or title responsible for their performance."*

### 2.6.1 Levee System Maintenance Plan

As noted above the FCDMC utilizes the O&M Manual for County structures. Under SOP #14, specific yearly inspection/maintenance intervals are outlined as well as a general list of priority maintenance items. Origination charts are included on pages 148 and 149.

Annual Inspection Reports for Camelback Ranch Levee South from 2001 to 2011 are included on the data disk in **Appendix H**.

Maintenance Inspection Reports for Camelback Ranch Levee South from 2001 to 2010 are included on the data disk in **Appendix H**. Inspections are combined with other structure inspections along the Agua Fria River. Camelback Ranch Levee South is in Reach 4 of the Agua Fria River.

## 2.7 Certification Requirements

*"(e) Certification requirements. Data submitted to support that a given levee system complies with the structural requirements set forth in paragraphs (b)(1) through (7) of this section must be certified by a registered professional engineer. Also, certified as-built plans of the levee must be submitted. Certifications are subject to the definition given at § 65.2 of this subchapter. In lieu of these structural requirements, a Federal agency with responsibility for levee design may certify that the levee has been adequately designed and constructed to provide protection against the base flood. "*

Certification Language is included in **Section 4** and the Record Drawings are included in **Appendix E** with a full electronic copy in pdf format included on the data disk in **Appendix H**.

# 3 FEMA Forms

Camelback Ranch Levee South, MT-2 Form 3, Pages 1 through 10

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

# RIVERINE STRUCTURES FORM

*O.M.B No. 1660-0016*
*Expires: 12/31/2010*

## PAPERWORK REDUCTION ACT

Public reporting burden for this form is estimated to average 7 hours per response. The burden estimate includes the time for reviewing instructions, searching existing data sources, gathering and maintaining the needed data, and completing, reviewing, and submitting the form. You are not required to respond to this collection of information unless a valid OMB control number appears in the upper right corner of this form. Send comments regarding the accuracy of the burden estimate and any suggestions for reducing this burden to: Information Collections Management, U.S. Department of Homeland Security, Federal Emergency Management Agency, 500 C Street, SW, Washington DC 20472, Paperwork Reduction Project (1660-0016). Submission of the form is required to obtain or retain benefits under the National Flood Insurance Program. **Please do not send your completed survey to the above address.**

Flooding Source: Agua Fria River
**Note:** Fill out one form for each flooding source studied

## A. GENERAL

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

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

Description Of Structure

1. **Name of Structure:** **Camelback Ranch Levee South**

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

Location of Structure: Maricopa County, Arizona

Downstream Limit/Cross Section: 1746 feet North of Indian School Road (Sta. 8+50)

Upstream Limit/Cross Section: East Abutment of Camelback Road Bridge (Sta. 45+58)

2. **Name of Structure:**

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

Location of Structure:

Downstream Limit/Cross Section:

Upstream Limit/Cross Section:

3. **Name of Structure:**

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

Location of Structure:

Downstream Limit/Cross Section:

Upstream Limit/Cross Section:

**NOTE: For more structures, attach additional pages as needed.**

## B. CHANNELIZATION

Flooding Source:

Name of Structure:

1. Accessory Structures

The channelization includes (check one):

- ☐ Levees [Attach Section E (Levee/Floodwall)]
- ☐ Superelevated sections
- ☐ Debris basin/detention basin [Attach Section D (Dam/Basin)]
- ☐ Other (Describe):
- ☐ Drop structures
- ☐ Transition in cross sectional geometry
- ☐ Energy dissipator

2. Drawing Checklist

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

3. Hydraulic Considerations

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

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

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

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

☐ Inlet to channel ☐ Outlet of channel ☐ At Drop Structures ☐ At Transitions
☐ Other locations (specify):

4. Sediment Transport Considerations

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

NOT APPLICABLE

## C. BRIDGE/CULVERT

Flooding Source:

Name of Structure:

1. This revision reflects (check one):

- ☐ Bridge/culvert not modeled in the FIS
- ☐ Modified bridge/culvert previously modeled in the FIS
- ☐ Revised analysis of bridge/culvert previously modeled in the FIS

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

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

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

4. Sediment Transport Considerations

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

NOT APPLICABLE

## D. DAM/BASIN

Flooding Source:

Name of Structure:

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

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

   Name of the agency or organization:

3. The Dam was permitted as (check one):

   a. ☐ Federal Dam ☐ State Dam

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

      Permit or ID number Permitting Agency or Organization

   b. ☐ Local Government Dam ☐ Private Dam

      Provided related drawings, specification and supporting design information.

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

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

   Was the dam/basin designed using critical duration storm?

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

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

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

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

6. Does the Base Flood Elevation behind the dam or downstream of the dam change?

   ☐ Yes ☐ No If Yes, complete the Riverine Hydrology & Hydraulics Form (Form 2) and complete the table below.

   Stillwater Elevation Behind the Dam

| FREQUENCY (% annual chance) | FIS | REVISED |
|---|---|---|
| 10-year (10%) | | |
| 50-year (2%) | | |
| 100-year (1%) | | |
| 500-year (0.2%) | | |
| Normal Pool Elevation | | |

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

NOT APPLICABLE

## E. LEVEE/FLOODWALL

1. System Elements

a. This Levee/Floodwall analysis is based on (check one):

- ☐ upgrading of an existing levee/floodwall system
- ☐ a newly constructed levee/floodwall system
- ☒ reanalysis of an existing levee/floodwall system

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

- ☒ earthen embankment, dike, berm, etc.
- ☐ structural floodwall
- ☐ Other (describe):

Upstream Levee Limit (Sta. 45+58)
Downstream Levee Limits (Sta. 8+50)
*(Construction beginning and end Stations)

c. Structural Type (check one):

- ☐ monolithic cast-in place reinforced concrete
- ☐ reinforced concrete masonry block
- ☐ sheet piling
- ☒ Other (describe): Earthen Embankment (Levee section is comprised of soil cement streamside facing over an earthen embankment).

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

☐ Yes ☒ No

If Yes, by which agency?

e. Attach certified drawings containing the following information (indicate drawing sheet numbers):
A portion of the As-Built drawings are included in **Appendix E** (8 ½ x 11) with electronic copy included on data disk in **Appendix H**. Profile plots do not include BFE.

1. Plan of the levee embankment and floodwall structures. — Sheet Numbers: Sheets 9 & 10
2. A profile of the levee/floodwall system showing the Base Flood Elevation (BFE), levee and/or wall crest and foundation, and closure locations for the total levee system. — Sheet Numbers: Sheets 9 &10
3. A profile of the BFE, closure opening outlet and inlet invert elevations, type and size of opening, and kind of closure. — Sheet Numbers: Sheets 59 & 60
   Camelback Road Storm Drain Project
   City of Phoenix
4. A layout detail for the embankment protection measures. — Sheet Numbers: Sheets 3 thru 6, Typical Sections
5. Location, layout, and size and shape of the levee embankment features, foundation treatment, floodwall structure, closure structures, and pump stations. — Sheet Numbers: Sheets 1 thru 34
   *As-Built Drawings do not include BFE Profile.

2. Freeboard

a. The minimum freeboard provided above the BFE is:

Riverine

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

Coastal

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

2. Freeboard (continued)

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

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

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

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

3. Closures

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

If opening exists, list all closures:

| Channel Station | Left or Right Bank | Opening Type | Highest Elevation for Opening Invert (NAVD 88) | Type of Closure Device |
|---|---|---|---|---|
| Levee Station 46+85 | Left | 60" RGRCP | Outlet Invert = 1006.02ft. | Flap Gate |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

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

Note: Geotechnical and geologic data

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

4. Embankment Protection

a. The maximum levee slope landside is: 3H:1V

b. The maximum levee slope floodside is: 1H:1V

c. The range of velocities along the levee during the base flood is: 2.3 ft/sec (min.) to 11.6 ft/sec (max.)

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

e. Riprap Design Parameters (check one): ☒ Velocity ☐ Tractive stress
Attach references
Soil Cement used to withstand velocities greater than 10 fps. See embankment scour assessment in Appendix C.

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

Hydraulic data from HEC-RAS model (AguaFriaRiver_CBRLS.prj). Electronic copy in **Appendix H**

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

4. Embankment Protection (continued)

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

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

Attach engineering analysis to support construction plans.

5. Embankment And Foundation Stability

a. Identify locations and describe the basis for selection of critical location for analysis: Sta: 33+72

| Milepost | Overall Height | Basis for Selection |
|---|---|---|
| Sta. 15+00 | 19 | Typical Section |
| Sta. 41+40 | 21 | Maximum Height |
| Sta. 42+00 | 15 | Typical Section |

*Please refer to Geotechnical Study for Federal Emergency Management Agency (FEMA) Partial Certification, Camelback Ranch Levee South, Maricopa County, Arizona, March 2011, for items in a. through h. below*

☒ Overall height: Sta. 41+40 ; height 21 ft.

☒ Limiting foundation soil strength:

| Description | Moist Unit Weight, (pcf) | Effective Friction Angle, Φ' ° | Effective Cohesion, c' psf | Saturated Hydraulic Conductivity, $K_{sat}$ cm/s |
|---|---|---|---|---|
| Embankment | 120 | 28.5 | 200 | $3 \times 10^{-4}$ |
| Soil cement | 115 | 20 | 3000 | $3 \times 10^{-6}$ |
| Foundation backfill | 110 | 33.5 | 200 | $3 \times 10^{-4}$ |
| Native soil | 120 | 30 | 200 | $3 \times 10^{-4}$ |

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

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

Circular slip circle, limit equilibrium analysis.

c. Summary of stability analysis results:

| Case | Loading Conditions | Critical Safety Factor | Criteria (Min.) |
|---|---|---|---|
| I | End of construction | Sta. 41+40, FOS = 2.67, riverside<br>Sta. 41+40, FOS = 4.33, landside | 1.3 |
| II | Sudden drawdown | Sta. 41+40, FOS = 1.14, riverside | 1.0 |
| III | Steady seepage at flood stage | Sta. 41+40, FOS = 3.76, landside | 1.4 |
| IV | Earthquake (Case I) | Sta. 41+40, FOS = 2.35, riverside<br>Sta. 41+40, FOS = 3.45, landside | 1.0 |

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

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

If Yes, describe methodology used: SEEP/W, a finite element analysis, was used to evaluate seepage under and through the levee.

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

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

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

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

Attach engineering analysis to support construction plans.

6. Floodwall And Foundation Stability

a. Describe analysis submittal based on Code (check one):

☐ UBC (1988) or ☐ Other (specify):

b. Stability analysis submitted provides for:

☐ Overturning ☐ Sliding If not, explain:

c. Loading included in the analyses were:

☐ Lateral earth @ $P_A$ = psf; $P_p$ = psf

☐ Surcharge-Slope @ , ☐ surface psf

☐ Wind @ $P_w$ = psf

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

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

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

d. Summary of Stability Analysis Results - Factors of Safety.

Itemize for each range in site layout dimension and loading condition limitation for each respective reach.

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

(Ref: FEMA 114 Sept 1986; USACE EM 1110-2-2502)

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

e. Foundation bearing strength for each soil type:

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

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

Attach engineering analysis to support construction plans.

NOT APPLICABLE

7. Settlement

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

b. The computed range of settlement is 0.6 inches.

c. Settlement of the levee crest is determined to be primarily from :

☐ Foundation consolidation
☒ Embankment compression
☐ Other (Describe):

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

Attach engineering analysis to support construction plans.

8. Interior Drainage

a. Specify size of each interior watershed:

Draining to pressure conduit: (Not applicable)
Draining to ponding area: (Not applicable)

b. Relationships Established

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

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

d. Specify the discharge capacity of the head pressure conduit: (Not applicable)

e. Which flooding conditions were analyzed?

| | | | |
|---|---|---|---|
| • Gravity flow (Interior Watershed) | ☒ Yes | ☐ No | (See interior drainage discussion in Appendix D) |
| • Common storm (River Watershed) | ☐ Yes | ☐ No | (Not applicable) |
| • Historical ponding probability | ☐ Yes | ☐ No | (Not applicable) |
| • Coastal wave overtopping | ☐ Yes | ☐ No | (Not applicable) |

If No for any of the above, attach explanation.

f. Interior drainage has been analyzed based on joint probability of interior and exterior flooding and the capacities of pumping and outlet facilities to provide the established level of flood protection. ☐ Yes ☐ No (Not applicable)

If No, attach explanation.

g. The rate of seepage through the levee system for the base flood is cfs (Seepage due to interior drainage was not analyzed)

h. The length of levee system used to drive this seepage rate in item g: ft. (Seepage due to interior drainage was not analyzed)

8. Interior Drainage (continued)

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

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

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

NOT APPLICABLE

Will the operation be automatic? ☐ Yes ☐ No

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

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

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

9. Other Design Criteria

a. The following items have been addressed as stated:

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

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

Not Applicable

Attach supporting documentation

c. If the levee/floodwall is new or enlarged, will the structure adversely impact flood levels and/or flow velocities floodside of the structure?
☐ Yes ☐ No Not Applicable

Attach supporting documentation

d. Sediment Transport Considerations:

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

See **Appendix C** for discussion on Channel/Embankment Scour

## E. LEVEE/FLOODWALL (CONTINUED)

10. Operational Plan And Criteria

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

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

c. Does the operation plan incorporate all the provisions for interior drainage as required in Paragraph 65.10(c)(2) of the NFIP regulations?
☒ Yes ☐ No

If the answer is No to any of the above, please attach supporting documentation.

11. Maintenance Plan

a. Are the planned/installed works in full compliance with Part 65.10 of the NFIP Regulations? ☒ Yes ☐ No
If No, please attach supporting documentation.

12. Operations and Maintenance Plan

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

See Operation and Maintenance Elements documented in *FCDMC, Operations and Maintenance Division, Standard Operating Procedures (SOP's) Deficiency Levels, Maintenance Standards, and Standard Drawings, Revised 2005* under separate Cover.

## F. SEDIMENT TRANSPORT

Flooding Source:

Name of Structure:

See **Appendix C** for discussion on Channel/Embankment Scour

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

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

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

Sediment transport rate (percent concentration by volume)

Method used to estimate sediment transport:

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

Method used to estimate scour and/or deposition:

Method used to revise hydraulic or hydrologic analysis (model) to account for sediment transport:
Please note that bulked flows are used to evaluate the performance of a structure during the base flood; however, FEMA does not map BFEs based on bulked flows.

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

# 4 Certification Statement

I, Jon Ahern, a registered Professional Civil Engineer in the State of Arizona (Certificate No. 34141), certify that based on my review of both the current on-site conditions of the Camelback Ranch Levee South System (ID#11), that this levee system does, as of the date of this certification, meet the minimum design criteria to provide protection from the base flood as set forth in the Code of Federal Regulations, 44CFR 65.10. The specific paragraphs of 44CFR65.10 that I certify are indicated directly below.

- (b)(1) Freeboard
- (b)(2) Closures
- (b)(3) Embankment protection related to adequate scour depth of levee toe down.
- (b)(6) Interior Drainage

No Other Design Criteria ((b) (7)) were identified for Certification.

Certification Statement for Embankment, Foundation Stability, and Settlement ((b)(3), (b)(4) and (b)(5)) are included in the Geotechnical analysis and review of design documentation, was conducted and documented AMEC Earth & Environmental, Inc. (AMEC). Documentation is presented under separate cover (*Geotechnical Study for Federal Emergency Management Agency (FEMA) Partial Certification, Camelback Ranch Levee South, Maricopa County, March 2011.).*

# 5 Limitations

According to FEMA and USACE documents, levee certification is a technical finding that, for the floodplain in question, there is a certainty that the levee system protecting the area will contain the base (1% annual exceedance) flood. The sole purpose of levee certification is to validate that areas protected from flooding by the levee in question may be shown on Flood Insurance Rate Maps (FIRMS) as protected from the 1% chance exceedance flood. Levee certification findings do not address, nor are the findings concerned, with public safety, performance of the levee system for floods other than the 1% event, or risk to floodplain residents from floods that will exceed system capacity. Recommendations contained in this report are based on our field observations, hydrologic/hydraulic assessments, and our present knowledge of the proposed construction.

We have prepared this report in substantial accordance with the generally accepted engineering practice as it exists in the site area at the time of our study. No warranty, either expressed or implied, is made.

Other standards or documents referenced in this report, or otherwise relied upon by the author of this report, are only mentioned in the given standard; they are not incorporated into this report body or "included by reference", as that latter term is used relative to contracts or other matters of law. This report may be used only by FCDMC for the purposes stated within a reasonable time from its issuance. The Camelback Ranch Levee South System Certification (**Section 4**) is valid within ten (10) years from the date of this report. It is recommended that the FCDMC re-evaluate the certification requirements of the Levee System following the 10-year date. Land or facility use, on and off-site conditions, regulations, or other factors may change over time, and additional work may be required with the passage of time.

# A. References

## A.1 References and Data Collection

## A.2 FEMA Documents

LOMR Acceptance Letter
Floodplain Work Maps
HDR "Without Levee" Assessment

# A.1 References and Data Collection

# 1. Data Collection and Reference Documents

## 1.1 Summary of Collected Data

Available Camelback Ranch Levee South data has been collected and assessed to determine its applicability for evaluation of compliance per 44 CFR 65.10 criteria. Discussion regarding collected documentation and data relevant to levee certification is provided below. In addition, a summary of relevant documents and data is listed in **Table 1-1**.

### 1.1.1 FEMA Data Request

A data request was submitted to the FEMA Library on 12/18/09. FEMA delivered, via ftp site, a compressed file containing several documents and FEMA forms associated with the FEMA approved LOMR request (Case Number 98-09-229P).

**98-09-226P (98-09-226P.pdf)**

This electronic file contains correspondence and support documentation for the LOMR 98-09-226P. The file contains the following items:

- LOMR Acceptance Letter (City of Phoenix)
- General project correspondence
- FEMA Internal review comment

**Technical Support Data Notebook (TSDN.pdf)**

This electronic file contains correspondence and support documentation for the CLOMR 98-09-226R (converted to LOMR 98-09-226P). The file contains the following items:

- General correspondence
- Exhibit A - USACE 404 Permit
- Exhibit B – Public Notice to of Study to Johnson-Stewart Materials, LLC
- Exhibit C – Bank Protection Agreement, Johnson-Stewart Materials, LLC
- FEMA MT-2 Form 1
- FCDMC O&M Procedures for Camelback Ranch Levee South
- Exhibit 2 – Affidavit of Publication
- Exhibit 3 – FEMA Form 2, Form 4, Form 5, Form 8
- Exhibit 4 – Flood Profiles
- Exhibit 5 – Annotated FIRM
- Exhibit 6 – HEC-2 model input file
- Exhibit 7 – HEC-2 model output file
- Exhibit 8 – Floodplain Work Maps

**Levee Backup (Levee Backup.pdf)**

This electronic file contains support documentation for the LOMR 98-09-226P. The file contains the following items:

- In-place density tests results
- Construction Special Provisions for Camelback Ranch Levee – South
- Simons, Li and Associates, Inc. – Letter report, Phase 1 Design Submittal
- Earthwork calculations
- 100% response to comments (FCDMC/DMJM)
- Calculations and Analysis, Geotechnical Investigation, Camelback Ranch Levee

- Final Calculations, Camelback Ranch Levee - South

**Interior Drainage Report (Interior Drainage Report.pdf)**

"Draft" Interior Drainage Report, Camelback Ranch Levee Design Project, April 1996 evaluating the interior drainage behind the Levee.

**Geotechnical Investigation Report (Geotechnical Investigation Report.pdf)**

Geotechnical Investigation Report, Camelback Ranch Levee, By ATL, Inc September 18, 1996.

**Miscellaneous**

- AutoCAD Files of Profiles 11P, 12P and 13P.
- CBR.zip file containing AutoCAD files of four floodplain work maps (zip file corrupt)

### 1.1.2 Other Data

Additional data collection efforts were conducted with a search of the FCDMC Library and City of Phoenix.

**Table 1-1: Summary List of Relevant Collected Data**

| Document Title | Prepared By | Date |
|---|---|---|
| FCDMC, Operations and Maintenance Division, Standard Operating Procedures (SOP's) Deficiency Levels, Maintenance Standards, and Standard Drawings. | FCDMC | Revised 2005 |
| Annual Inspection Report - Camelback Ranch Levee | FCDMC | March 4, 2009 |
| Flood Control District of Maricopa County, Maintenance Inspection Report, Camelback Ranch Levee | FCDMC | February 29, 2008 |
| Flood Control District of Maricopa County, Plans for the Construction of Camelback Ranch Levee - South (FCD 97-18) | FCDMC | February 5, 1997 |
| Final Interior Drainage Report, Camelback Ranch Levee Design Project, (FCD 95-15) | DMJM Arizona, Inc. | April 1, 1998 |
| Construction Special Provisions for Camelback Ranch Levee - South, Indian School Road to Camelback Road (FCD 97-18) | DMJM Arizona, Inc. | May 1, 1997 |
| Final Calculations, Camelback Ranch Levee South, Indian School Road to Camelback Road (FCD 95-15) | DMJM Arizona, Inc. | February 24, 1997 |
| Agua Fria River Floodplain Delineation Re-study, prepared for the Flood Control District of Maricopa County (FCD 95-05), Agua Fria River, Gila river to the New Waddell Dam | Coe & Van Loo Consultants, Inc. | September 24, 1997 |

## Table 1-1: Summary List of Relevant Collected Data (Continued)

| Document Title | Prepared By | Date |
|---|---|---|
| Camelback Ranch Levee - South Conditional Letter of Map Revision (CLOMR/LOMR Submittal, FCD A 400.916) | FCDMC | 1997 |
| Flood Control District of Maricopa County, Permit to use Flood Control District Right-of-way, | FCDMC | October 29, 2007 |
| Camelback Road, Agua Fria River to 99th Avenue, Project No. ST83110057, Storm Drain. Design Drawings | Tetra Tech, Inc | November 11, 2006 |
| Camelback Road, Agua Fria River to 99th Avenue, Project No. ST83110057, Storm Drain. Hydrologic and Hydraulic Design Report. | Tetra Tech, Inc | August 23, 2005 |

## 2. Reference Documents

## Camelback Ranch Levee South
## Data Collection Summary

**Abbreviation Descriptions-**
**ADEM** = Arizona Department of Emergency Management
**ADEQ** = Arizona Department of Environmental Quality
**ADOT** = Arizona Department of Transportation
**ADWR** = Arizona Department of Water Resources
**ARIA** = Arizona Regional Image Archive
**FEMA** = Federal Emergency Management Agency
**NRCS** = Natural Resource Conservation Service
**USGS** = United States Geological Survey
FCDMC = Flood Control District of Maricopa County

| Project | Document | DOCUMENT | | | | TRACKING | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Library No. | Reference No. | Title | Description | Author | Date | Source | Format | Date Collected | Collected By | File Name/Notes |
| AF11001 | A109.902 | System Analysis and Conceptual Design of Channelization in the Agua Fria River, Final Report Revised October 1983 | | Simons, Li and Assoc. for Flood Control District of Maricopa County-FCD | 1983 | | | | | Review. May need 2nd Priority |
| AF11002 | A109.903 | Hydraulic and Geomorphic Analysis of the Agua Fria River, Revised 1983 | AZ-MC-05 | Simons, Li and Assoc. for Flood Control District of Maricopa County-FCD | 1983 | | | | | Review. May need 2nd Priority |
| AF11003 | A109.912 | Agua Fria River Channelization, Thomas Road to Indian School Road, Maricopa County, Arizona, Report No. 2 - Final Report | LT83-3753 | Consulting Geotechnical Eng. | 1983 | | | | | Review. May need 2nd Priority |
| AF11004 | A109.914 | Geotechnical Engineering Investigation on Agua Fria River Channelization, Grade Control Structure at Indian School Road Bridge | 84-208 | Consulting Geotechnical Eng. for Simons, Li, and Assoc., Inc. | 1984 | | | | | Review. May need 2nd Priority |
| AF11005 | A109.939 | Final Sediment Transport Report, Draft (Agua Fria River) | PAZ-COE-03 RDN/R439 | Simons, Li and Assoc. Inc. for U. S. Corps of Engineers-COE | 1984 | | | | | Review. May need 2nd Priority |
| AF11006 | A109.602 | Standard Project Flood Analysis and Conceptual Design of Channelization in the Agua Fria River, Final Report, Revised May, 1984 | AZ-MC-05 (R347/RDF168/RDF170) | Simons, Li and Assoc. Inc. for Flood Control District of Maricopa County-FCD | 1984 | | | | | Review. May need 2nd Priority |
| AF11007 | A109.921 | Agua Fria River Improvement Project, Thomas Road North to Indian School Road, Geotechnical Investigation | 85-10 85-12 | Western Technologies Inc. for Flood Control District of Maricopa County-FCD | 1985 | | | | | Review. May need 2nd Priority |
| AF11008 | A109.917 | Agua Fria River Side Drainage Analysis | | Simons, Li and Assoc. | 1985 | | | | | Review. May need 2nd Priority |
| AF11009 | A109.301 | Agua Fria River Side Drainage Analysis : Section - I Buckeye Road to 1500 Feet' South of Interstate 10, Section - II Interstate 10 to McDowell Road and Thomas Road to Camelback Road | LAF 3.2 | Simons, Li and Assoc. for Flood Control District of Maricopa County-FCD | 1985 | | | | | Review. May need 1st Priority |
| AF11010 | A109.502 | Contract Documents and Special Provisions for Agua Fria River Improvements Phase I: Roosevelt Irrigation District Canal Reconstruction and Siphon, Phase II: Agua Fria River Channelization and Bank Protection (RID) | FCD 85-10 | Flood Control District of Maricopa County-FCD | 1985 | | | | | Review. May need 2nd Priority |
| AF11011 | A400.602S | Skunk Creek and the New and Agua Fria Rivers (Arizona Canal Diversion Channel to the Gila River) Design Memorandum No. 3, General Design Memorandum - Phase II, Project Design - Part 4, Final (ACDC) (Draft Report is Archived in Box 96-650/2, 98-124/1) | | U. S. Corps of Engineers-COE | 1986 | | | | | Review. May need 2nd Priority |
| AF11012 | A400.610S | Memo for the Record, Skunk Creek, New and Agua Fria Rivers, Phase II, General Design Memorandum, Depth of Toe Protection for Bank Stabilization and Levee Design | | U. S. Corps of Engineers-COE | 1986 | | | | | Review. May need 2nd Priority |

## Camelback Ranch Levee South
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| Project | Document | DOCUMENT | | | | TRACKING | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Library No. | Reference No. | Title | Description | Author | Date | Source | Format | Date Collected | Collected By | File Name/Notes |
| AF11013 | A037.015.002 | Flood Insurance Study, Town of Surprise Request for Letter of Map Revision, Agua Fria River Floodway Coyote Lakes a.k.a. Brookview Country Club (LOMR, FIS) | | Willdan Assoc. for Town of Surprise | 1987 | | | | | Review. May need 2nd Priority |
| AF11014 | A109.504 | Specifications for Agua Fria River Levees, Maricopa County, Arizona | DACW09-R-0010 | U. S. Corps of Engineers-COE | 1987 | | | | | Review. May need 2nd Priority |
| AF11015 | A400.604S | Skunk Creek and the New and Agua Fria Rivers (Arizona Canal Diversion Channel to the Gila River) Supplement to Design Memorandum No. 3, General Design Memorandum - Phase II, Project Design - Part 4, Final (ACDC) | | U. S. Corps of Engineers-COE | 1987 | | | | | Review. May need 2nd Priority |
| AF11016 | A888.701S | New Waddell Dam Study, Hydrology for Evaluation of Flood Reduction by New Waddell Dam, Agua Fria River below New Waddell Dam to the New River Confluence | | U. S. Corps of Engineers-COE | 1988 | | | | | Review. May need 2nd Priority |
| AF11017 | A400.920 | Geotechnical Investigation Report, Camelback Ranch Levee Design - Agua Fria River and New River, 113th Avenue and Camelback Road Maricopa County, Arizona | SHB Job No. E88-36 | Sergent, Hauskins and Beckwith Consult. Geotechnical Eng. | 1988 | | | | | Review. May need 2nd Priority |
| AF11018 | A400.603S | Skunk Creek and the New and Agua Fria Rivers (Arizona Canal Diversion Channel to the Gila River) Letter Report to Design Memorandum No. 3, General Design Memorandum - Phase II, Project Design - Part 4, Final (ACDC) | | U. S. Corps of Engineers-COE | 1989 | | | | | Review. May need 2nd Priority |
| AF11019 | A109.929 | Agua Fria River Cross Sections | | Jerry R. Jones and Assoc. | 1989 | | | | | Review. Probably Outdated 2nd Priority |
| AF11020 | A109.901 | Standard Project Flood, Agua Fria River Between the New River Confluence and the Gila River with New Waddell Dam in Place, Preliminary | | U. S. Corps of Engineers-COE | 1989 | | | | | Review. Probably Outdated 2nd Priority |
| AF11021 | A109.015.001 | Flood Insurance Study Agua Fria River, Maricopa County, Arizona (FIS) | FCD 87-2 | Jerry R. Jones and Assoc. for Flood Control District of Maricopa County-FCD | 1989 | | | | | Review. Probably Outdated 2nd Priority |
| AF11022 | A109.802S | Agua Fria River Exhibit 4 HEC II Computer Model, South Half, Preliminary | | Jerry R. Jones and Assoc. | 1989 | | | | | Review. Probably Outdated 2nd Priority |
| AF11023 | A109.803S | Agua Fria River Exhibit 4 HEC II Computer Model Floodway, Preliminary | | Jerry R. Jones and Assoc. | 1989 | | | | | Review. Probably Outdated 2nd Priority |
| AF11024 | A109.804 | Agua Fria River Exhibit 4 HEC I Computer Model Floodway, Preliminary | | Jerry R. Jones and Assoc. | 1989 | | | | | Review. Probably Outdated 2nd Priority |
| AF11025 | A109.920 | Agua Fria River, New River, and Skunk Creek Standard Project Flood Evaluation | Job 1090-04 CVL-4-1284-7- | Coe and Van Loo Consult. Eng. Inc. for Flood Control District of Maricopa County-FCD | 1990 | | | | | Review. Probably Outdated 2nd Priority |

## Camelback Ranch Levee South
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|---|---|---|---|---|---|---|---|---|---|---|
| Library No. | Reference No. | Title | Description | Author | Date | Source | Format | Date Collected | Collected By | File Name/Notes |
| AF11026 | 603.052S | Agua Fria River FIS Survey Notes | | Jerry R. Jones and Assoc., Inc. | 1990 | | | | | Review. Probably Outdated 2nd Priority |
| AF11027 | A109.947 | Agua Fria River Sediment Transport Study, Final Report | | Arizona State University-ASU, Dept. of Civil Engineering for Flood Control District of Maricopa County-FCD | 1992 | | | | | Review. May need 2nd Priority |
| AF11028 | A109.948 | Agua Fria River Sediment Transport Study, Appendices | | Arizona State University-ASU, Dept. of Civil Engineering for Flood Control District of Maricopa County-FCD | 1992 | | | | | Review. May need 2nd Priority |
| AF11029 | A109.910 | Economic Optimization of the Agua Fria River Levees | | Flood Control District of Maricopa County-FCD; Svechovsky, John | 1992 | | | | | Review. May need 2nd Priority |
| AF11030 | A109.932 | Development of Potential Mine Plans for the Barkley-Estes Property within the Agua Fria River between Indian School Road and Camelback Road, Summary Report | | Simons, Li and Assoc. Inc. for Flood Control District of Maricopa County-FCD | 1993 | | | | | Review. May need 2nd Priority |
| AF11031 | A109.605S | Camelback Road Channel - Litchfield Road to Agua Fria River, Concept Design Report (100-Year, 24-Hour and 5-Year, 24-Hour Interim) | | WLB Group for Maricopa County Dept. of Transportation-MCDOT | 1993 | | | | | Review. May need 2nd Priority |
| AF11032 | A109.951 | Agua Fria River Sediment Transport Study : Appendix J, HEC-6 Output Files | | Arizona State University-ASU, Dept. of Civil Engineering for Flood Control District of Maricopa County-FCD | 1994 | | | | | Review. May need 2nd Priority |
| AF11033 | A109.950 | Agua Fria River Sediment Transport Study : Appendix I, HEC-6 Input Files | | Arizona State University-ASU, Dept. of Civil Engineering for Flood Control District of Maricopa County-FCD | 1994 | | | | | Review. May need 2nd Priority |
| AF11034 | A109.949 | Agua Fria River Sediment Transport Study | | Arizona State University-ASU, Dept. of Civil Engineering for Flood Control District of | 1994 | | | | | Review. May need 2nd Priority |
| AF11035 | A109.935 | Agua Fria River Study, New Waddell Dam to Gila River Confluence, Arizona: Hydrologic Evaluation of Impacts of New Waddell Dam on Downstream Peak Discharges in the Agua Fria River | | U. S. Corps of Engineers-COE | 1995 | | | | | Review. May need 2nd Priority |
| AF11036 | A260.014.007S | Horizontal and Vertical Control Tabulation for the Agua Fria River Study Aerial Mapping Project, Maricopa County, Arizona, Vol. 4 of 4 | FCD 94-25 | Aerial Mapping Co. for Flood Control District of Maricopa County-FCD | 1995 | | | | | Review. May need 1st Priority |
| AF11037 | A260.014.004S | Agua Fria River Floodplain Delineation Re-Study, Between the Gila River Confluence and the New Waddell Dam, Technical Data Notebook, Vol. 1 of 4 (FDS, TDN) | FCD 95-05 | Coe and Van Loo Consult. Eng. Inc. for Flood Control District of Maricopa County-FCD | 1996 | | | | | Review. May need 1st Priority |

## Camelback Ranch Levee South
## Data Collection Summary

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| Project | Document | DOCUMENT | | | | TRACKING | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Library No. | Reference No. | Title | Description | Author | Date | Source | Format | Date Collected | Collected By | File Name/Notes |
| AF11038 | A260.014.005S | Agua Fria River Floodplain Delineation Re-Study, Between the Gila River Confluence and the New Waddell Dam, Hydraulic Analysis, Technical Data Notebook Section 4, Part 1 of 2, Vol. 2 of 4 (FDS, TDN) | FCD 95-05 | Coe and Van Loo Consult. Eng. Inc. for Flood Control District of Maricopa County-FCD | 1996 | | | | | Review. May need 1st Priority |
| AF11039 | A260.014.006S | Agua Fria River Floodplain Delineation Re-Study, Between the Gila River Confluence and the New Waddell Dam, Hydraulic Analysis, Technical Data Notebook Section 4, Part 2 of 2, Vol. 3 of 4 (FDS, TDN) | FCD 95-05 | Coe and Van Loo Consult. Eng. Inc. for Flood Control District of Maricopa County-FCD | 1996 | | | | | Review. May need 1st Priority |
| AF11040 | A109.909 | Bridge Scour Investigation and Design of Corrective Measures, Final Report, Structure Number 9145, Indian School Road Bridge over the Agua Fria River | Work Order No. 80407 | Michael Baker Jr., Inc. for Maricopa County Dept. of Transportation-MCDOT | 1997 | | | | | Review. May need 2nd Priority |
| AF11041 | A109.942 | Technical Data Notebook, Agua Fria River Reaches 1, 2, and 3, Levee Monitoring for Bank Stabilization, Assignment #2 (TDN) | FCD 98-20 | WLB Group for Flood Control District of Maricopa County-FCD | 1999 | | | | | Review. May need 1st Priority |
| AF11042 | A109.941 | Technical Data Notebook, Agua Fria River Reach 4, Levee Monitoring for Bank Stabilization, Assignment #1 (TDN) | FCD 98-20 | WLB Group for Flood Control District of Maricopa County-FCD | 1999 | | | | | Review. May need 1st Priority |
| AF11043 | 603.056S | Surveying for the Land Subsidence Evaluation of the Upper Agua Fria River Levees and for Levee Monitoring Camelback Ranch South Levee, Camelback Ranch North Levee, Glendale Airport Levee, New River Levees, and for Skunk Creek Levee | FCD 1999C067 | Premier Eng. Corp. for Flood Control District of Maricopa County-FCD | 2000 | FCDMC | Electronic File delivered on CD | 10/27/09 | Mark Mayer | 603_056SurveyingfortheLandSubsidenceEvaluationoftheUpperAguaFriaRiverLeveesandforLeveeMonitoringC.pdf |
| AF11044 | 603.055S | Surveying for the Land Subsidence Evaluation of the Agua Fria River, Assignment 1 | FCD 1999C067 | Premier Eng. Corp. for Flood Control District of Maricopa County-FCD | 2000 | | | | | Review. May need 1st Priority |
| AF11045 | A109.959 | Agua Fria River Conceptual Channelization Plan, Task Order No. 11 | FCD 2001C005 | JE Fuller Hydrology and Geomorphology, Inc. for Flood Control District of Maricopa County-FCD | 2002 | | | | | Have in-house. 2nd Priority |
| AF11046 | A260.901 | Modeling Sediment Transport in the Agua Fria River | FCD 1999C048, Assignment # 6 | WEST Consult., Inc. for Flood Control District of Maricopa County-FCD | 2002 | | | | | Review. May need 2nd Priority |
| AF11047 | FCDMC Flat Files | Agua Fria River Reach 1, 2, and 3 Levees Monitoring | FCD 93-20. Drawer 319 | None Given | | | | | | Review. May need 1st Priority |
| AF11048 | FCDMC Flat Files | Agua Fria River/Gila River to Pinnacle Peak Road FDS | Drawer 403 | Flood Control District of Maricopa County-FCD | 1975 | | | | | Review. May need 2nd Priority |
| AF11049 | FCDMC Flat Files | Agua Fria River, New River and Skunk Creek S. P. F. Delineation Maps | FCD 89-30. Drawer 303 | Coe & Van Loo | 1989 | | | | | Review. May need 1st Priority |

## Camelback Ranch Levee South
## Data Collection Summary

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**USGS** = United States Geological Survey
FCDMC = Flood Control District of Maricopa County

| Project | Document | DOCUMENT | | | | TRACKING | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Library No. | Reference No. | Title | Description | Author | Date | Source | Format | Date Collected | Collected By | File Name/Notes |
| AF11050 | FCDMC Flat Files | Agua Fria River FDS Restudy Between the Gila River Confluence and the New Waddell Dam | FCD 95-05. Drawer 303 | Coe & Van Loo | 1996 | | | | | Review. May need 1st Priority |
| AF11051 | FCDMC As-Built | Skunk Creek and New and Agua Fria Rivers | Drawer 216 | | | | | | | Review. May need 1st Priority |
| AF11052 | FCDMC As-Built | Agua Fria River Channel | 850439. Drawer 204 | | | | | | | Review. May need 2nd Priority |
| AF11053 | FCDMC As-Built | Agua Fria River Proposed Channelization (1984) | AZ-MC-05. Drawer 11 | | | | | | | Review. May need 2nd Priority |
| AF11054 | FCDMC As-Built | Agua Fria River Improvements Phase 1, 2 | FCD 85-10. Drawer 11 | | | | | | | Review. May need 1st Priority |
| AF11055 | | FCDMC, Operations and Maintenance Division, Standard Operating Procedures (SOP's) Deficiency Levels, Maintenance Standards, and Standard | Standard O&M Manual for the District. Scanned from hard copy | FCDMC | Revised 2005 | FCDMC | Hardcopy scanned to PDF | | Mark Mayer | FCDMC_SOPsDeficiencyLevelsMaintenanceStandardsandStandardDrawings.pdf |
| AF11056 | | Annual Inspection Report - Camelback Ranch Levee | Levee Inspection Report | FCDMC | 3/4/09 | FCDMC | Electronic File delivered via Email | 01/21/10 | Mark Mayer | 2009-Annual Inspection Camelback Ranch Levee.pdf |
| AF11057 | | Flood Control District of Maricopa County, Maintenance Inspection Report, Camelback Ranch Levee | Levee Inspection Report | FCDMC | 2/29/08 | FCDMC | Electronic File delivered via Email | 01/21/10 | Mark Mayer | Camelback Ranch Levee Maintenance Inspection 2008.pdf |
| AF11058 | | Flood Control District of Maricopa County, Plans for the Construction of Camelback Ranch Levee - South (FCD 97-18) | Record Drawings | FCDMC | 2/5/97 | FCDMC | Electronic File delivered via Email | 01/21/10 | Mark Mayer | Camelback Ranch Levee South.pdf |
| AF11059 | A400.307 | Final Interior Drainage Report, Camelback Ranch Levee Design Project, (FCD 95-15) | Interior Drainage Report | DMJM Arizona, Inc. | 4/1/98 | FCDMC | Electronic File delivered via ftp | 02/09/10 | Mark Mayer | A400_307Final_InteriorDrainageReport_CamelbackRanchLeveeDesignProject.pdf |
| AF11060 | A400.504 | Construction Special Provisions for Camelback Ranch Levee - South, Indian School Road to Camelback Road (FCD 97-18) | Construction Specifications | DMJM Arizona, Inc. | 5/1/97 | FCDMC | Electronic File delivered via ftp | 02/09/10 | Mark Mayer | A400_504Special Provisions.pdf |
| AF11061 | A400.803 | Final Calculations, Camelback Ranch Levee South, Indian School Road to Camelback Road (FCD 95-15) | Final Design Calculations | DMJM Arizona, Inc. | 2/24/97 | FCDMC | Electronic File delivered via ftp | 02/09/10 | Mark Mayer | A400_803Final Calculations.pdf |
| AF11062 | | Agua Fria River Floodplain Delineation Re-study, prepared for the Flood Control District of Maricopa County (FCD 95-05), Agua Fria River, Gila river to the New Waddell Dam | HEC-2 input and output files | Coe & Van Loo Consultants, Inc. | 9/24/97 | FCDMC | Electronic File delivered via ftp | 02/09/10 | Mark Mayer | AGUAFRIA.DAT, AGUAFRIA.OUT, AGUAFRIA.T95 |

## Camelback Ranch Levee South
## Data Collection Summary

**Abbreviation Descriptions-**
**ADEM** = Arizona Department of Emergency Management
**ADEQ** = Arizona Department of Environmental Quality
**ADOT** = Arizona Department of Transportation
**ADWR** = Arizona Department of Water Resources
**ARIA** = Arizona Regional Image Archive
**FEMA** = Federal Emergency Management Agency
**NRCS** = Natural Resource Conservation Service
**USGS** = United States Geological Survey
FCDMC = Flood Control District of Maricopa County

| Project | Document | DOCUMENT | | | | TRACKING | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Library No. | Reference No. | Title | Description | Author | Date | Source | Format | Date Collected | Collected By | File Name/Notes |
| AF11063 | A400.916 | Camelback Ranch Levee - South CLOMR/LOMR Submittal | TDN for CLOMR/LOMR with backup files | FCDMC | 1997 | FCDMC | Electronic File delivered via ftp | 02/22/10 | Mark Mayer | A400_916CamelbackRanchLevee_South_LetterofMapRevision_LOMR.pdf and backup HEC-2 and AutoCAD files |
| AF11064 | | Flood Control District of Maricopa County, Permit to use Flood Control District Right-of-way, | Permit to install storm drain through levee | FCDMC | 10/29/07 | FCDMC | Electronic File delivered via ftp | 04/20/10 | Mark Mayer | 2006P039.pdf |
| AF11065 | 98-09-226P | FEMA Data Request | Documents provided by FEMA in responce to a data Request | Various | 4/16/98 | FEMA | Electronic File delivered via ftp | 08/17/09 | Jon Ahern | Geotechnical Investigation Report.pdf<br>Interior Drainage Report.pdf<br>Levee Backup.pdf<br>TSDN.pdf<br>FEMAFORM.doc<br>CBR.ZIP<br>98-09-226P.pdf |

## A.2 FEMA Documents

# Federal Emergency Management Agency

Washington, D.C. 20472

FLOOD CONTROL DISTRICT
RECEIVED
APR 20 1998
REMARKS

CERTIFIED MAIL
RETURN RECEIPT REQUESTED

IN REPLY REFER TO:
Case No.: 98-09-226P

The Honorable Janice K. Brewer
Chairman, Maricopa County Board
of Supervisors
301 Jefferson Street
Phoenix, Arizona 85003

Community: Maricopa County, Arizona
Community No.: 040037
Panels Affected: 04013C1620 F and
04013C2085 E
Effective Date of This Revision: APR 16 1998

102-I-A-C

Dear Ms. Brewer:

This responds to a request that the Federal Emergency Management Agency (FEMA) revise the effective Flood Insurance Rate Map (FIRM) and Flood Insurance Study (FIS) report for Maricopa County, Arizona and Incorporated Areas (the effective FIRM and FIS report for your community), in accordance with Part 65 of the National Flood Insurance Program (NFIP) regulations. In a letter dated November 14, 1997, Mr. Hasan Mushtaq, P.E., Engineering Division, Flood Control District of Maricopa County, requested that FEMA revise the FIRM and FIS report to show the effects of construction of a levee along the left overbank (looking downstream) of the Agua Fria River from approximately 2,800 feet upstream of Indian School Road to just downstream of Camelback Road.

All data required to complete our review of this request were submitted with letters from Mr. Mushtaq.

We have completed our review of the submitted data and the flood data shown on the effective FIRM and FIS report. We have revised the FIRM and FIS report to modify the elevations, floodplain and floodway boundary delineations, and zone designations of the flood having a 1-percent chance of being equaled or exceeded in any given year (base flood) along the Agua Fria River from approximately 400 feet upstream of Indian School Road to approximately 400 feet upstream of Camelback Road. As a result of the modifications, the base flood elevations (BFEs) for the Agua Fria River increased; the width of the Special Flood Hazard Area (SFHA), the area that would be inundated by the base flood, decreased; and the width of the regulatory floodway increased. The increase in floodway width is contained within the constructed levee. The modifications are shown on the enclosed annotated copies of FIRM Panel(s) 04013C1620 F and 04013C2085 E, Profile Panel(s) 12P and 13P, and affected portions of the Floodway Data Table. This Letter of Map Revision (LOMR) hereby revises the above-referenced panel(s) of the effective FIRM dated September 4, 1991, and the affected portions of the FIS report dated September 30, 1995.

Because this revision request also affects the City of Phoenix, a separate LOMR for that community was issued on the same date as this LOMR.

The modifications are effective as of the date shown above. The map panel(s) as listed above and as modified by this letter will be used for all flood insurance policies and renewals issued for your community.

The following table is a partial listing of existing and modified BFEs:

| Location | Existing BFE (feet)* | Modified BFE (feet)* |
|---|---|---|
| Approximately 1,000 feet downstream of Camelback Road | 1,021 | 1,022 |

*Referenced to the National Geodetic Vertical Datum, rounded to the nearest whole foot

Public notification of the proposed modified BFEs will be given in the *Arizona Republic* on or about May 14 and May 21, 1998. A copy of this notification is enclosed. In addition, a notice of changes will be published in the *Federal Register*. Within 90 days of the second publication in the *Arizona Republic*, a citizen may request that FEMA reconsider the determination made by this LOMR. Any request for reconsideration must be based on scientific or technical data. All interested parties are on notice that, until the 90-day period elapses, the determination to modify the BFEs presented in this LOMR may itself be modified.

Because this LOMR will not be printed and distributed to primary users, such as local insurance agents and mortgage lenders, your community will serve as a repository for these new data. We encourage you to disseminate the information reflected by this LOMR throughout the community, so that interested persons, such as property owners, local insurance agents, and mortgage lenders, may benefit from the information. We also encourage you to prepare a related article for publication in your community's local newspaper. This article should describe the assistance that officials of your community will give to interested persons by providing these data and interpreting the NFIP maps.

We are processing a revised FIRM and FIS report for Maricopa County; therefore, we will not physically revise and republish the FIRM and FIS report for your community to incorporate the modifications made by this LOMR at this time. Preliminary copies of the FIRM and FIS report were submitted to your community for review on December 24, 1997. We will incorporate the modifications made by this LOMR into the FIRM and FIS report before they become effective.

The floodway is provided to your community as a tool to regulate floodplain development. Therefore, the floodway modifications described in this LOMR, while acceptable to FEMA, must also be acceptable to your community and adopted by appropriate community action, as specified in Paragraph 60.3(d) of the NFIP regulations.

This LOMR is based on minimum floodplain management criteria established under the NFIP. Your community is responsible for approving all floodplain development, and for ensuring all necessary permits required by Federal or State law have been received. State, county, and community officials, based on knowledge of local conditions and in the interest of safety, may set higher standards for construction in the SFHA. If the State, county, or community has adopted more restrictive or comprehensive floodplain management criteria, these criteria take precedence over the minimum NFIP criteria.

This determination has been made pursuant to Section 206 of the Flood Disaster Protection Act of 1973 (Public Law 93-234) and is in accordance with the National Flood Insurance Act of 1968, as amended (Title XIII of the Housing and Urban Development Act of 1968, Public Law 90-448), 42 U.S.C. 4001-4128, and 44 CFR Part 65. Pursuant to Section 1361 of the National Flood Insurance Act of 1968,

as amended, communities participating in the NFIP are required to adopt and enforce floodplain management regulations that meet or exceed minimum NFIP criteria. These criteria are the minimum and do not supersede any State or local requirements of a more stringent nature. This includes adoption of the effective FIRM to which the regulations apply and the modifications described in this LOMR. Our records show that your community has met this requirement.

A Consultation Coordination Officer (CCO) has been designated to assist your community. The CCO will be the primary liaison between your community and FEMA. For information regarding your CCO, please contact:

Ms. Dorothy M. Lacey
Director, Mitigation Division
Federal Emergency Management Agency, Region IX
The Presidio of San Francisco, Building 105
San Francisco, California 94129-1250
(415) 923-7177

If you have any questions regarding floodplain management regulations for your community or the NFIP in general, please contact the CCO for your community at the telephone number cited above. If you have any technical questions regarding this LOMR, please contact Mr. Mike Grimm of our staff in Washington, DC, either by telephone at (202) 646-2878 or by facsimile at (202) 646-4596.

Sincerely,

Matthew B. Miller

Matthew B. Miller, P.E., Chief
Hazards Study Branch
Mitigation Directorate

Enclosure(s)

cc: The Honorable Skip Rimsza
Mayor, City of Phoenix

Mr. Raymond U. Acuña, P.E.
Floodplain Manager
City of Phoenix Street
Transportation Department

Mr. Hasan Mushtaq, P.E.
Engineering Division
Flood Control District
of Maricopa County

CHANGES ARE MADE IN DETERMINATIONS OF BASE FLOOD ELEVATIONS FOR THE CITY OF PHOENIX AND THE UNINCORPORATED AREAS OF MARICOPA COUNTY, ARIZONA, UNDER THE NATIONAL FLOOD INSURANCE PROGRAM

On September 4, 1991, the Federal Emergency Management Agency identified Special Flood Hazard Areas (SFHAs) in the City of Phoenix and the unincorporated areas of Maricopa County, Arizona, through issuance of a Flood Insurance Rate Map (FIRM). The Mitigation Directorate has determined that modification of the elevations of the flood having a 1-percent chance of being equaled or exceeded in any given year (base flood) for certain locations in these communities is appropriate. The modified base flood elevations (BFEs) revise the FIRMs for the communities.

The changes are being made pursuant to Section 206 of the Flood Disaster Protection Act of 1973 (Public Law 93-234) and are in accordance with the National Flood Insurance Act of 1968, as amended (Title XIII of the Housing and Urban Development Act of 1968, Public Law 90-448), 42 U.S.C. 4001-4128, and 44 CFR Part 65.

A hydraulic analysis was performed to incorporate construction of a levee along the left overbank (looking downstream) of the Agua Fria River from approximately 2,800 feet upstream of Indian School Road to just downstream of Camelback Road and has resulted in a revised delineation of the regulatory floodway, a decrease in SFHA width, and increased BFEs for the Agua Fria River. The table below indicates existing and modified BFEs for selected locations along the affected lengths of the flooding source(s) cited above.

| Location | Existing BFE (feet)* | Modified BFE (feet)* |
|---|---|---|
| [1]Approximately 1,000 feet downstream of Camelback Road | 1,021 | 1,022 |

[1]Located within City of Phoenix and unincorporated areas of Maricopa County
*National Geodetic Vertical Datum, rounded to nearest whole foot

Under the above-mentioned Acts of 1968 and 1973, the Mitigation Directorate must develop criteria for floodplain management. To participate in the National Flood Insurance Program (NFIP), the community must use the modified BFEs to administer the floodplain management measures of the NFIP. These modified BFEs will also be used to calculate the appropriate flood insurance premium rates for new buildings and their contents and for the second layer of insurance on existing buildings and contents.

Upon the second publication of notice of these changes in this newspaper, any person has 90 days in which he or she can request, through the Chief Executive Officer of the community, that the Mitigation Directorate reconsider the determination. Any request for reconsideration must be based on knowledge of changed conditions or new scientific or technical data. All interested parties are on notice that until the 90-day period elapses, the Mitigation Directorate's determination to modify the BFEs may itself be changed.

Any person having knowledge or wishing to comment on these changes should immediately notify:

The Honorable Skip Rimsza
Mayor, City of Phoenix
200 West Washington Street, 11th Floor
Phoenix, Arizona 85003-1611

OR

The Honorable Janice K. Brewer
Chairman, Maricopa County Board
of Supervisors
301 Jefferson Street
Phoenix, Arizona 85003

NATIONAL FLOOD INSURANCE PROGRAM

# FIRM

## FLOOD INSURANCE RATE MAP

MARICOPA COUNTY, ARIZONA AND INCORPORATED AREAS

PANEL 1620 OF 4350

CONTAINS:

| COMMUNITY | NUMBER | PANEL | SUFFIX |
|---|---|---|---|
| GLENDALE, CITY OF | 040045 | 1620 | F |
| MARICOPA COUNTY, UNINCORPORATED AREAS | 040037 | 1620 | F |
| PEORIA, CITY OF | 040050 | 1620 | F |
| PHOENIX, CITY OF | 040051 | 1620 | F |

REVISED TO REFLECT LOMR DATED APR 16 1998

MAP NUMBER
04013C1620 F

MAP REVISED:
SEPTEMBER 4, 1991

Federal Emergency Management Agency

APPROXIMATE SCALE IN FEET
1000 0 1000

MAP LEGEND

Revised Floodway

Areas of 500-year flood; areas of 100-year flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 100-year flood.

MARICOPA COUNTY UNINCORPORATED AREAS 040037

CITY OF GLENDALE 040045

ZONE AE

BASELINE

AGUA FRIA RIVER

PROFILE BASE LINE

ZONE AE

CITY OF PHOENIX 040051

ZONE X

Levee

R 1 W
R 1 E

RM3123

11TH AVE

CAMPBELL AVE

REVISED AREA

JOINS PANEL 2085

THIS AREA WAS REVISED BY LOMR DATED AUGUST 5,1997

THIS AREA PROTECTED FROM THE ONE PERCENT ANNUAL CHANCE (100-YEAR) FLOOD BY LEVEE, DIKE OR OTHER STRUCTURES SUBJECT TO POSSIBLE FAILURE OR OVERTOPPING DURING LARGER FLOODS.

THIS AREA PROTECTED FROM THE ONE PERCENT ANNUAL CHANCE (100-YEAR) FLOOD BY LEVEE, DIKE OR OTHER STRUCTURES SUBJECT TO POSSIBLE FAILURE OR OVERTOPPING DURING LARGER FLOODS.

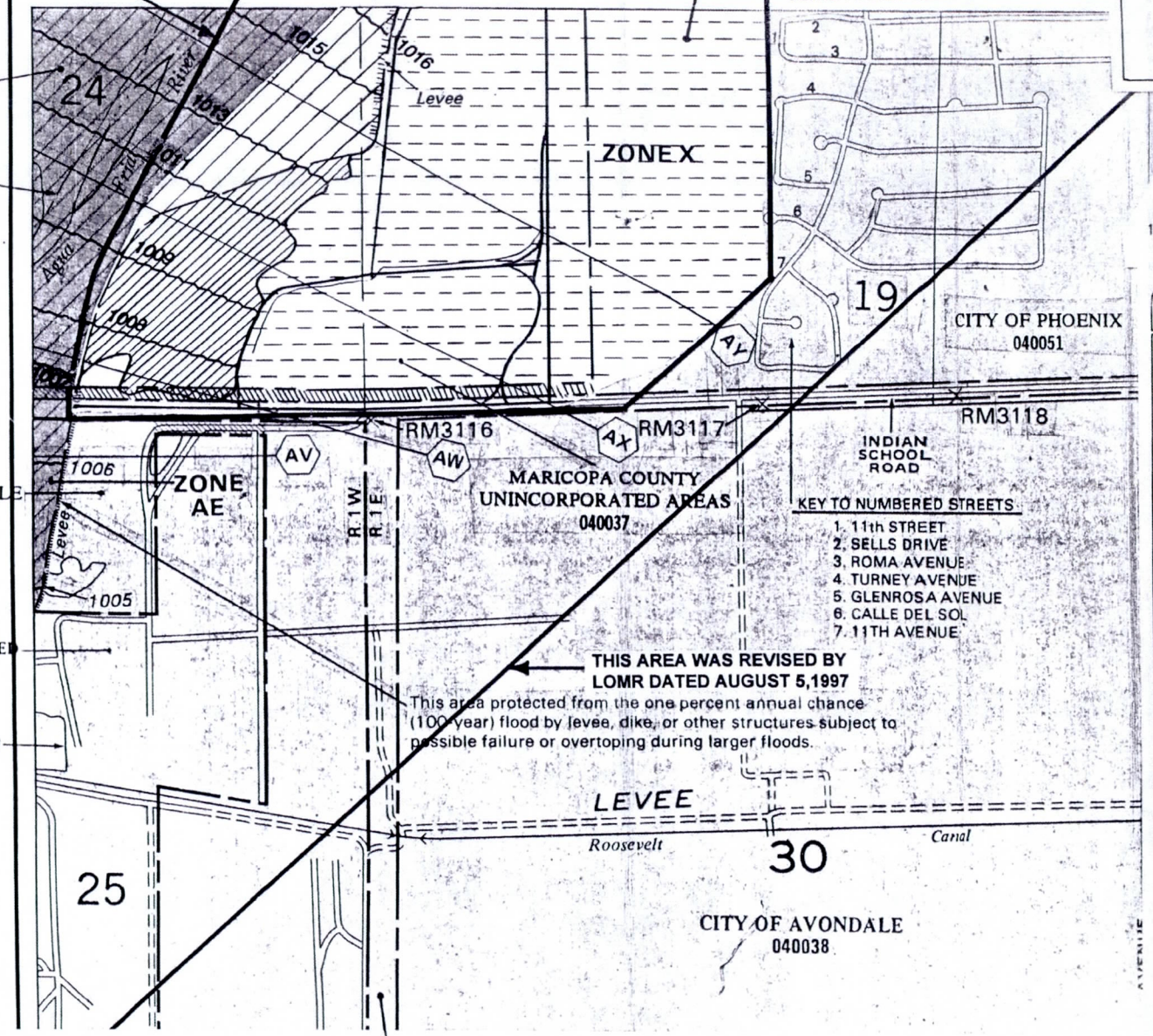
| REFERENCE MARK | ELEVATION (FT. NGVD) | DESCRIPTION OF LOCATION |
|---|---|---|
| RM401 | 1021.09 | Rim of handhole at centerline intersection of 99th Avenue and McDowell Road. |
| RM402 | 1025.39 | Rim of handhole at centerline intersection of 91st Avenue (Main Street) and McDowell Road. |
| RM403 | 1014.82 | Rim of handhole Street) and Van Bu |
| RM406 | 1008.13 | Rim of handhole Buren Street. |

REVISED AREA

ZONE AE

PROFILE BASE LINE

JOINS PANEL 1620




KEY TO NUMBERED STREETS

1. 11th STREET
2. SELLS DRIVE
3. ROMA AVENUE
4. TURNEY AVENUE
5. GLENROSA AVENUE
6. CALLE DEL SOL
7. 11TH AVENUE

MAP LEGEND

- Revised Floodway
- Revised 100-Year Floodplain
- Areas of 500-year flood; areas of 100-year flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 100-year flood.

N

APPROXIMATE SCALE IN FEET

1000 0 1000

NATIONAL FLOOD INSURANCE PROGRAM

# FIRM
## FLOOD INSURANCE RATE MAP

MARICOPA COUNTY, ARIZONA AND INCORPORATED AREAS

PANEL 2085 OF 4350

CONTAINS

| COMMUNITY | NUMBER | PANEL | SUFFIX |
|---|---|---|---|
| AVONDALE, CITY OF | 040038 | 2085 | E |
| MARICOPA COUNTY, UNINCORPORATED AREAS | 040037 | 2085 | E |
| PHOENIX, CITY OF | 040051 | 2085 | E |
| TOLLESON, CITY OF | 040055 | 2085 | E |

REVISED TO REFLECT LOMR DATED APR 16 1996

MAP NUMBER
04013C2085E

MAP REVISED:
SEPTEMBER 4, 1991

Federal Emergency Management Agency

| FLOODING SOURCE | | FLOODWAY | | | BASE FLOOD WATER-SURFACE ELEVATION | | | |
|---|---|---|---|---|---|---|---|---|
| CROSS SECTION | DISTANCE[1] | WIDTH (FEET) | SECTION AREA (SQUARE FEET) | MEAN VELOCITY (FEET PER SECOND) | REGULATORY | WITHOUT FLOODWAY | WITH FLOODWAY | INCREASE |
| | | | | | (FEET NGVD) | | | |
| Agua Fria River (Cont'd) | | | | | THESE DATA WERE REVISED BY LOMR DATED AUGUST 5,1997 | | | |
| AA | 4.760 | 1,107 | 8,872 | 5.9 | 967.6 | 967.6 | 967.6 | 0.0 |
| AB | 4.936 | 1,107 | 8,580 | 6.1 | 968.4 | 968.4 | 968.4 | 0.0 |
| AC | 5.031 | 1,115 | 6,687 | 7.8 | 968.7 | 968.7 | 968.7 | 0.0 |
| AD | 5.256 | 1,282 | 7,891 | 6.6 | 971.1 | 971.1 | 971.1 | 0.0 |
| AE | 5.385 | 1,389 | 5,712 | 9.1 | 972.5 | 972.5 | 972.5 | 0.0 |
| AF | 5.508 | 1,330 | 5,734 | 9.1 | 976.0 | 976.0 | 976.0 | 0.0 |
| AG | 5.567 | 1,387 | 7,518 | 7.2 | 977.5 | 977.5 | 977.5 | 0.0 |
| AH | 5.723 | 1,256 | 7,613 | 7.1 | 979.6 | 979.6 | 979.6 | 0.0 |
| AI | 5.887 | 1,127 | 7,882 | 6.9 | 981.6 | 981.6 | 981.6 | 0.0 |
| AJ | 5.997 | 1,119 | 8,113 | 6.7 | 982.4 | 982.4 | 982.4 | 0.0 |
| AK | 6.177 | 1,113 | 7,701 | 7.1 | 984.0 | 984.0 | 984.0 | 0.0 |
| AL | 6.349 | 1,112 | 7,853 | 6.9 | 985.4 | 985.4 | 985.4 | 0.0 |
| AM | 6.539 | 1,116 | 6,806 | 8.0 | 986.9 | 986.9 | 986.9 | 0.0 |
| AN | 6.718 | 1,067 | 6,188 | 8.8 | 989.0 | 989.0 | 989.0 | 0.0 |
| AO | 6.938 | 1,112 | 7,434 | 7.3 | 991.6 | 991.6 | 991.6 | 0.0 |
| AP | 7.093 | 1,106 | 7,359 | 7.4 | 993.7 | 993.7 | 993.7 | 0.0 |
| AQ | 7.290 | 1,115 | 7,493 | 7.3 | 997.6 | 997.6 | 997.6 | 0.0 |
| AR | 7.472 | 1,063 | 7,770 | 7.0 | 999.8 | 999.8 | 999.8 | 0.0 |
| AS | 7.66 | 1,002 | 7,106 | 7.7 | 1,001.7 | 1,001.7 | 1,001.7 | 0.0 |
| AT | 7.848 | 966 | 7,454 | 7.3 | 1,003.6 | 1,003.6 | 1,003.6 | 0.0 |
| AU | 8.04 | 1,032 | 8,204 | 6.6 | 1,004.7 | 1,004.7 | 1,004.7 | 0.0 |
| AV | 8.223 | 1,315 | 9,309 | 5.8 | 1,006.0 | 1,006.0 | 1,006.0 | 0.0 |
| AW | 8.365 | 1,501 | 8,089 | 6.7 | 1,007.4 | 1,007.4 | 1,007.4 | 0.0 |
| AX | 8.585 | 1,507 | 7,593 | 7.2 | 1,010.0 | 1,010.0 | 1,010.0 | 0.0 |
| AY | 8.794 | 2,452 | 9,655 | 5.6 | 1,014.4 | 1,014.4 | 1,014.5 | 0.1 |
| AZ | 9.027 | 2,040 | 7,829 | 6.9 | 1,017.2 | 1,017.2 | 1,017.5 | 0.3 |

[1]Miles above confluence with Gila River

REVISED DATA

TABLE 5

FEDERAL EMERGENCY MANAGEMENT AGENCY

MARICOPA COUNTY, AZ
AND INCORPORATED AREAS

FLOODWAY DATA

AGUA FRIA RIVER

REVISED TO REFLECT LOMR DATED APR 16 1998

| FLOODING SOURCE | | FLOODWAY | | | BASE FLOOD WATER-SURFACE ELEVATION | | | |
|---|---|---|---|---|---|---|---|---|
| CROSS SECTION | DISTANCE[1] | WIDTH (FEET) | SECTION AREA (SQUARE FEET) | MEAN VELOCITY (FEET PER SECOND) | REGULATORY | WITHOUT FLOODWAY | WITH FLOODWAY | INCREASE |
| | | | | | (FEET NGVD) | | | |
| Agua Fria River (Cont'd) | | | | | REVISED DATA | | | |
| BA | 9.252 | 1,738 | 10,150 | 5.4 | 1,021.7 | 1,021.7 | 1,021.7 | 0.0 |
| BB | 9.437 | 1,694 | 10,162 | 5.4 | 1,023.1 | 1,023.1 | 1,023.1 | 0.0 |
| BC | 9.6 | 1,852 | 9,435 | 5.8 | 1,024.4 | 1,024.4 | 1,024.5 | 0.1 |
| BD | 9.776 | 1,660 | 8,492 | 6.4 | 1,026.3 | 1,026.3 | 1,026.4 | 0.1 |
| BE | 9.953 | 1,510 | 7,156 | 7.6 | 1,028.7 | 1,028.7 | 1,028.7 | 0.0 |
| BF | 10.142 | 1,396 | 5,798 | 5.2 | 1,030.4 | 1,030.4 | 1,031.0 | 0.6 |
| BG | 10.327 | 1,231 | 5,360 | 5.6 | 1,032.8 | 1,032.8 | 1,033.2 | 0.4 |
| BH | 10.521 | 740 | 3,639 | 8.2 | 1,034.5 | 1,034.5 | 1,034.8 | 0.3 |
| BI | 10.699 | 749 | 4,886 | 6.1 | 1,038.5 | 1,038.5 | 1,039.1 | 0.6 |
| BJ | 10.889 | 985 | 6,513 | 4.6 | 1,040.5 | 1,040.5 | 1,041.1 | 0.6 |
| BK | 11.103 | 730 | 4,884 | 6.1 | 1,043.2 | 1,043.2 | 1,043.4 | 0.2 |
| BL | 11.481 | 812 | 5,451 | 5.5 | 1,046.8 | 1,046.8 | 1,047.0 | 0.2 |
| BM | 11.581 | 620 | 2,998 | 10.0 | 1,048.3 | 1,048.3 | 1,048.3 | 0.0 |
| BN | 11.823 | 892 | 5,128 | 6.7 | 1,054.4 | 1,054.4 | 1,054.4 | 0.0 |
| BO | 12.016 | 1,738 | 6,858 | 5.0 | 1,058.5 | 1,058.5 | 1,058.9 | 0.4 |
| BP | 12.164 | 2,408 | 6,640 | 5.2 | 1,061.1 | 1,061.1 | 1,061.4 | 0.3 |
| BQ | 12.307 | 2,709 | 17,026 | 2.0 | 1,064.0 | 1,064.0 | 1,064.5 | 0.5 |
| BR | 12.513 | 2,786 | 21,039 | 1.6 | 1,065.2 | 1,065.2 | 1,066.0 | 0.8 |
| BS | 12.73 | 2,300 | 11,248 | 3.1 | 1,065.8 | 1,065.8 | 1,066.7 | 0.9 |
| BT | 12.896 | 938 | 6,621 | 5.2 | 1,066.3 | 1,066.3 | 1,067.0 | 0.7 |
| BU | 13.082 | 703 | 4,849 | 7.1 | 1,067.6 | 1,067.6 | 1,068.2 | 0.6 |
| BV | 13.273 | 441 | 3,297 | 10.5 | 1,070.4 | 1,070.4 | 1,070.5 | 0.1 |
| BW | 13.465 | 551 | 5,555 | 6.2 | 1,073.6 | 1,073.6 | 1,073.7 | 0.1 |
| BX | 13.716 | 1,385 | 8,159 | 4.2 | 1,075.5 | 1,075.5 | 1,075.6 | 0.1 |
| BY | 13.929 | 1,334 | 5,387 | 6.4 | 1,079.2 | 1,079.2 | 1,079.4 | 0.2 |
| BZ | 14.123 | 1,040 | 5,776 | 6.0 | 1,082.2 | 1,082.2 | 1,082.5 | 0.3 |

THESE DATA WERE REVISED BY LOMR DATED AUGUST 5,1997

[1]Miles above confluence with Gila River

TABLE 5

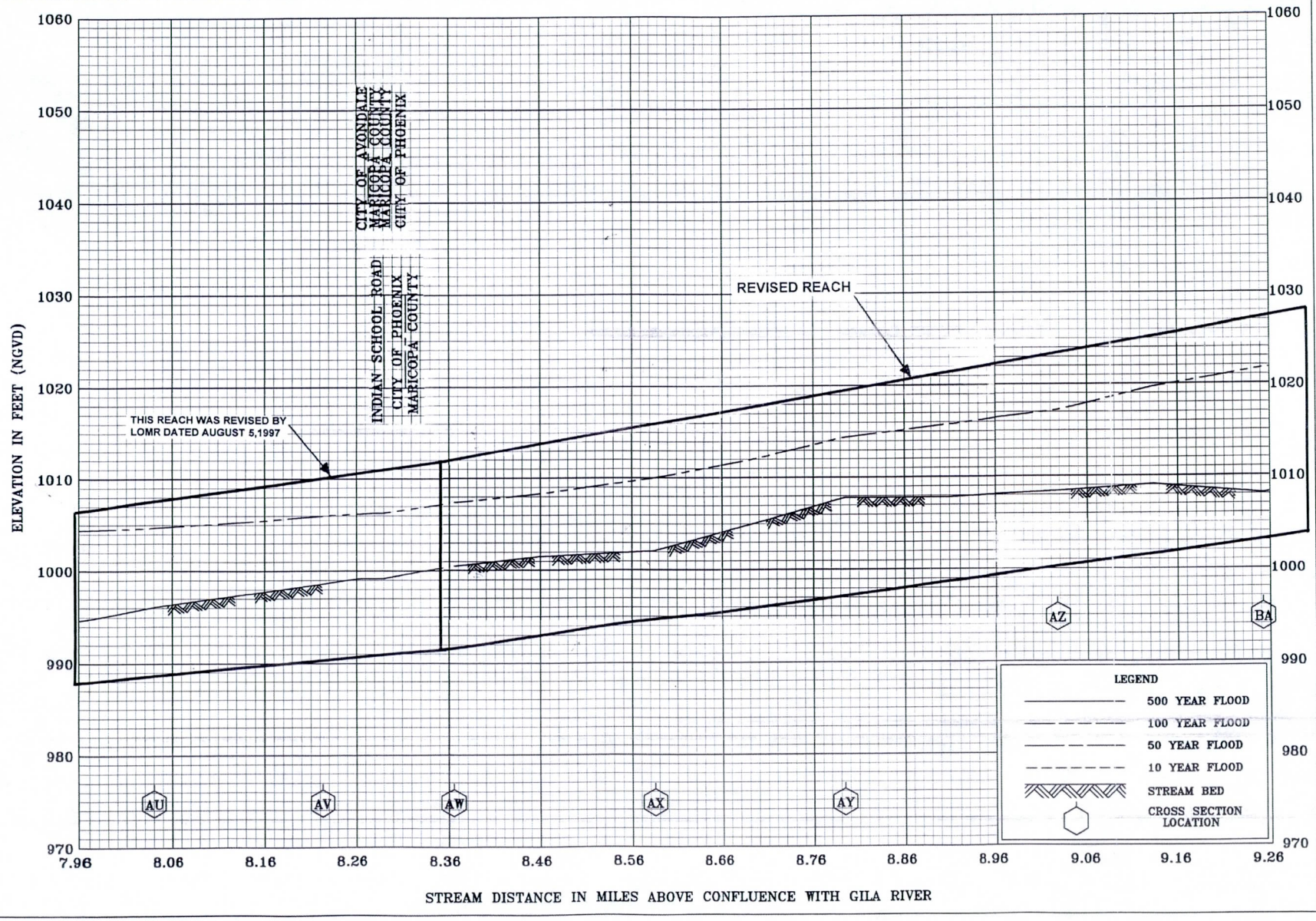
FEDERAL EMERGENCY MANAGEMENT AGENCY

MARICOPA COUNTY, AZ
AND INCORPORATED AREAS

FLOODWAY DATA

AGUA FRIA RIVER

REVISED TO REFLECT LOMR DATED APR 16 1998




REVISED TO REFLECT LOMR DATED APR 16 1998

FLOOD PROFILES

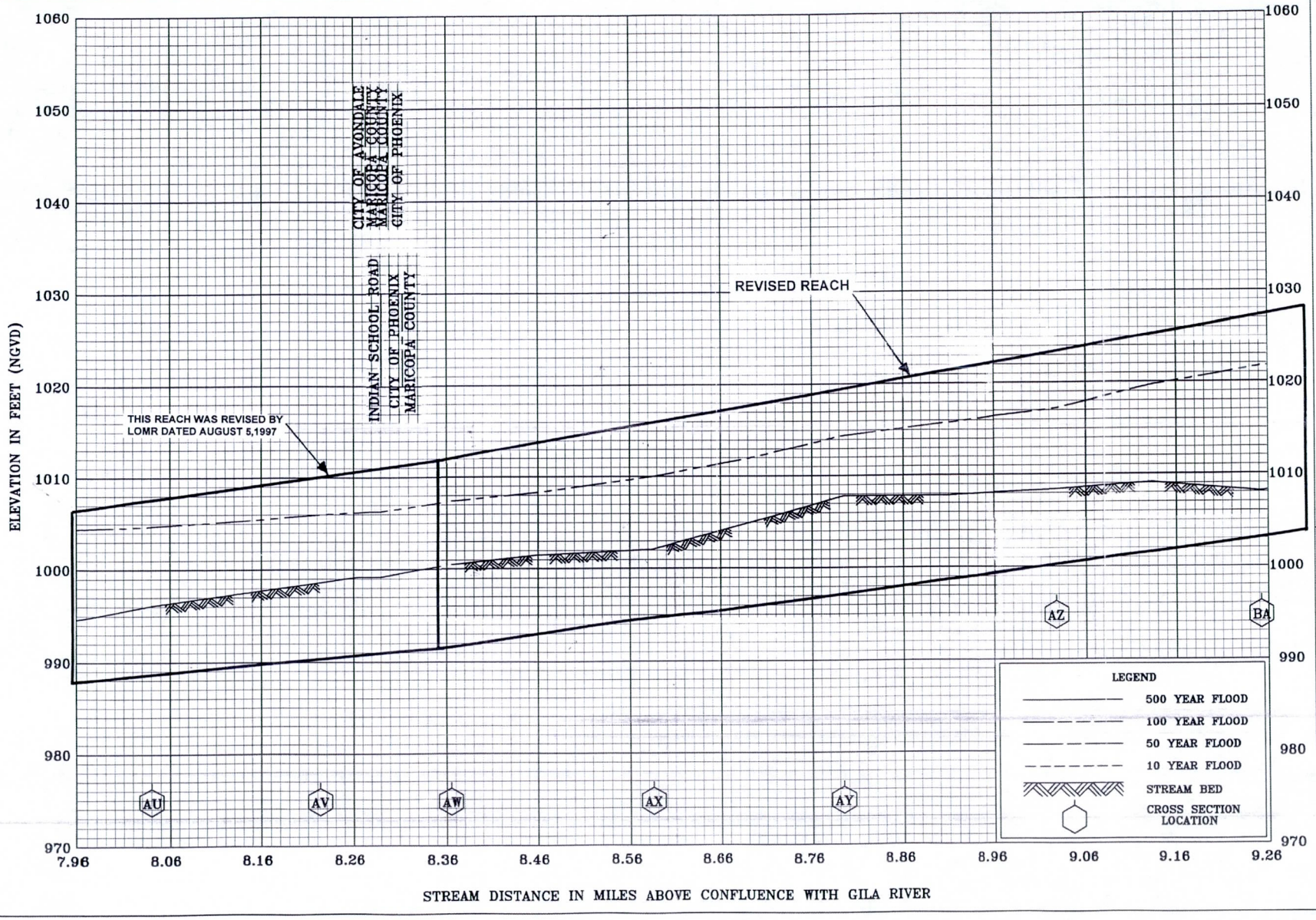
AGUA FRIA RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

MARICOPA COUNTY, AZ

AND INCORPORATED AREAS

12P




FLOOD PROFILES

AGUA FRIA RIVER

REVISED TO REFLECT LOMR DATED APR 16 1998

FEDERAL EMERGENCY MANAGEMENT AGENCY

MARICOPA COUNTY, AZ

AND INCORPORATED AREAS

12P

# FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

AGUA FRIA RIVER
FLOODPLAIN DELINEATION RE-STUDY

F. C. D. CONTRACT NO. 95-5

## LEGEND

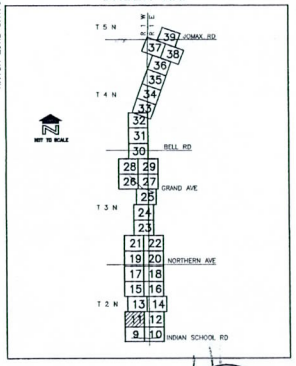
| | |
|---|---|
| 100-YR FLOODPLAIN BOUNDARY | |
| FLOODWAY BOUNDARY | |
| HYDRAULIC BASE LINE | |
| CROSS SECTION | 25.382 FP=100 Yr WSE FW=Floodway WSE |
| ELEVATION REFERENCE MARK | ERM3 X |
| BASE FLOOD ELEVATIONS | 1221 |
| ZONE DESIGNATIONS | ZONE AE |
| CITY LIMITS | |

## ELEVATION REFERENCE MARKS

NOTE: ALL ELEVATIONS ARE BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929 TO OBTAIN NAVD 88 ELEVATIONS, ADD 2.061 FEET

| I. D. NUMBER | ELEVATION (FT) | DESCRIPTION/LOCATION |
|---|---|---|
| ERM 13 | 1025.38 | See sheet 9 |
| ERM 17 | 1026.36 | Brass cap in hand hole at the intersection of 19th Ave. and Camelback Rd. |

## INDEX MAP




SCALE: 1" = 200'
CONTOUR INTERVAL = 2 FEET

CVL CONSULTANTS, INC.

| | BY | DATE |
|---|---|---|
| DESIGN | DB | 9/96 |
| DESIGN CHK. | JM | 9/96 |
| PLANS | PE/KR | 9/96 |
| PLANS CHK. | JM | 9/96 |

SUBMITTED BY: Jack K. Moody, P. E. DATE 9/96.

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

RECOMMENDED BY: DATE
APPROVED BY: DATE
CHIEF ENGINEER AND GENERAL MANAGER

SHEET 11 OF 45

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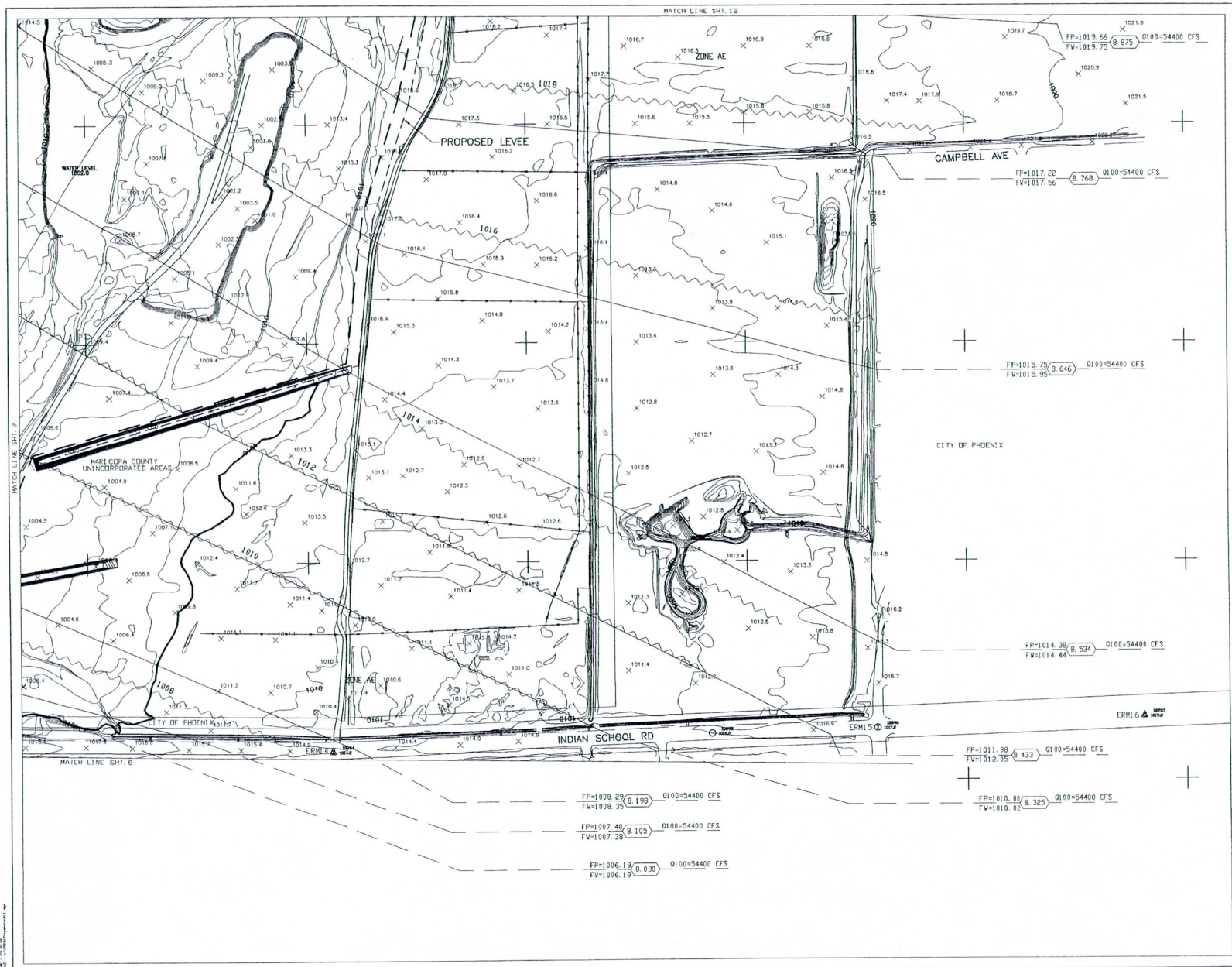



# FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

AGUA FRIA RIVER
FLOODPLAIN DELINEATION RE-STUDY

F. C. D. CONTRACT NO. 95-5

## LEGEND

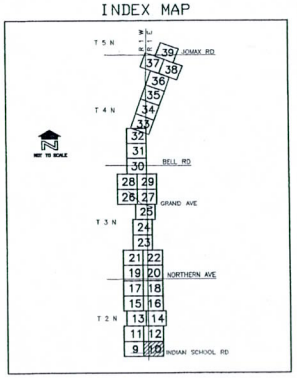
| | |
|---|---|
| 100-YR FLOODPLAIN BOUNDARY | |
| FLOODWAY BOUNDARY | |
| HYDRAULIC BASE LINE | |
| CROSS SECTION | (25.382) FP=100 Yr WSE / FW=Floodway WSE |
| ELEVATION REFERENCE MARK | ERM3 X |
| BASE FLOOD ELEVATIONS | 1221 |
| ZONE DESIGNATIONS | ZONE AE |
| CITY LIMITS | |

## ELEVATION REFERENCE MARKS

NOTE: ALL ELEVATIONS ARE BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929
TO OBTAIN NAVD 88 ELEVATIONS, ADD 2.061 FEET

| I.D. NUMBER | ELEVATION (FT) | DESCRIPTION/LOCATION |
|---|---|---|
| ERM 14 | 1014.11 | Brass Cap at the intersection of 115th Ave. and Indian School Rd. |
| ERM 15 | 1017.26 | Brass Cap in bond hole at the intersection of 111th Ave. and Indian School Rd. |
| ERM 18 | 1019.18 | Cotton picker spindle at the centerline of Indian School Rd. in line to the south with East wall of Salt River Project substation. |

## INDEX MAP




200 0' 200 400
SCALE: 1" = 200'
CONTOUR INTERVAL = 2 FEET

COE & VAN LOO CONSULTANTS, INC.

| | BY | DATE |
|---|---|---|
| DESIGN | DB | 9/96 |
| DESIGN CHK. | JM | 9/96 |
| PLANS | PE/KR | 9/96 |
| PLANS CHK. | JM | 9/96 |

SUBMITTED BY: Jack K. Moody, P.E. DATED 9/96

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

RECOMMENDED BY: DATE
APPROVED BY: DATE
CHIEF ENGINEER AND GENERAL MANAGER

SHEET 10 OF 45

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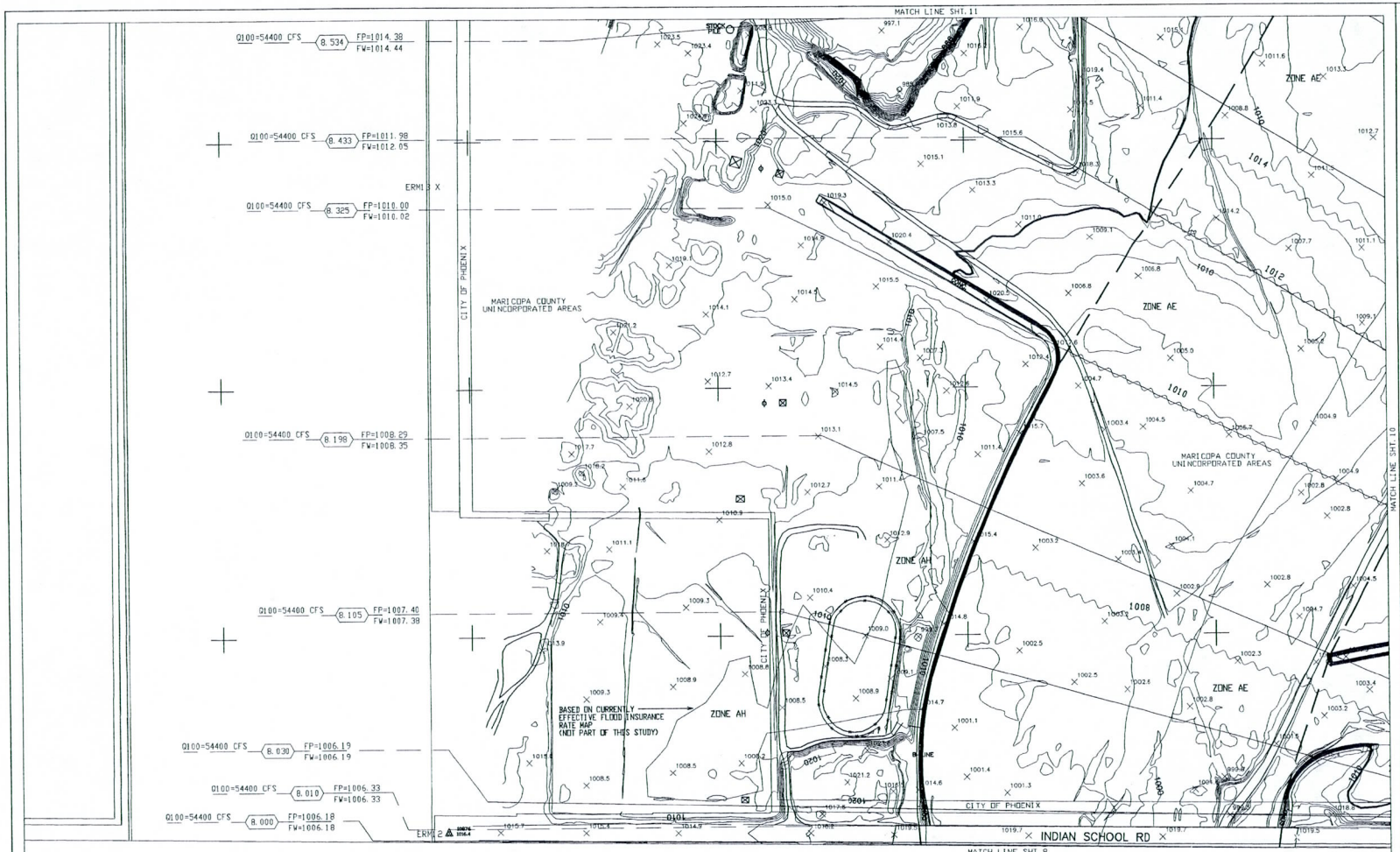


# FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

AGUA FRIA RIVER
FLOODPLAIN DELINEATION RE-STUDY

F. C. D. CONTRACT NO. 95-5

## LEGEND

| | |
|---|---|
| 100-YR FLOODPLAIN BOUNDARY | |
| FLOODWAY BOUNDARY | |
| HYDRAULIC BASE LINE | |
| CROSS SECTION | (25.382) FP=100 Yr WSE FW=Floodway WSE |
| ELEVATION REFERENCE MARK | ERM3 X |
| BASE FLOOD ELEVATIONS | 1221 |
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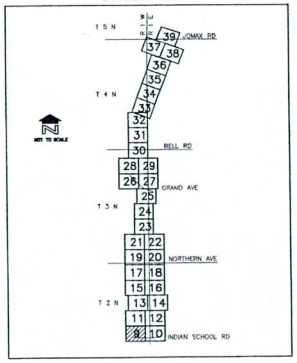
| CITY LIMITS | |

## ELEVATION REFERENCE MARKS

NOTE: ALL ELEVATIONS ARE BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929
TO OBTAIN NAVD 88 ELEVATIONS, ADD 2.061 FEET

| I.D. NUMBER | ELEVATION (FT) | DESCRIPTION/LOCATION |
|---|---|---|
| ERM 12 | 1018.04 (1016.3 per 1987 survey) | Brass Cap in hand hole at the intersection of Indian School and El Mirage Rd. |
| ERM 13 | 1025.38 | Brass Cap in hand hole at the Centerline of El Mirage Rd. and projection of Campbell Ave. |

## INDEX MAP




200 0' 200 400
SCALE: 1" = 200'
CONTOUR INTERVAL = 2 FEET

CVL CDE & VAN LOO CONSULTANTS, INC.

| | BY | DATE |
|---|---|---|
| DESIGN | DB | 9/96 |
| DESIGN CHK. | JM | 9/96 |
| PLANS | PE/KR | 9/96 |
| PLANS CHK. | JM | 9/96 |

SUBMITTED BY: Jack K. Moody, P.E. DATED 9/96

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

RECOMMENDED BY: DATE
APPROVED BY: DATE
CHIEF ENGINEER AND GENERAL MANAGER

SHEET 9 OF 45

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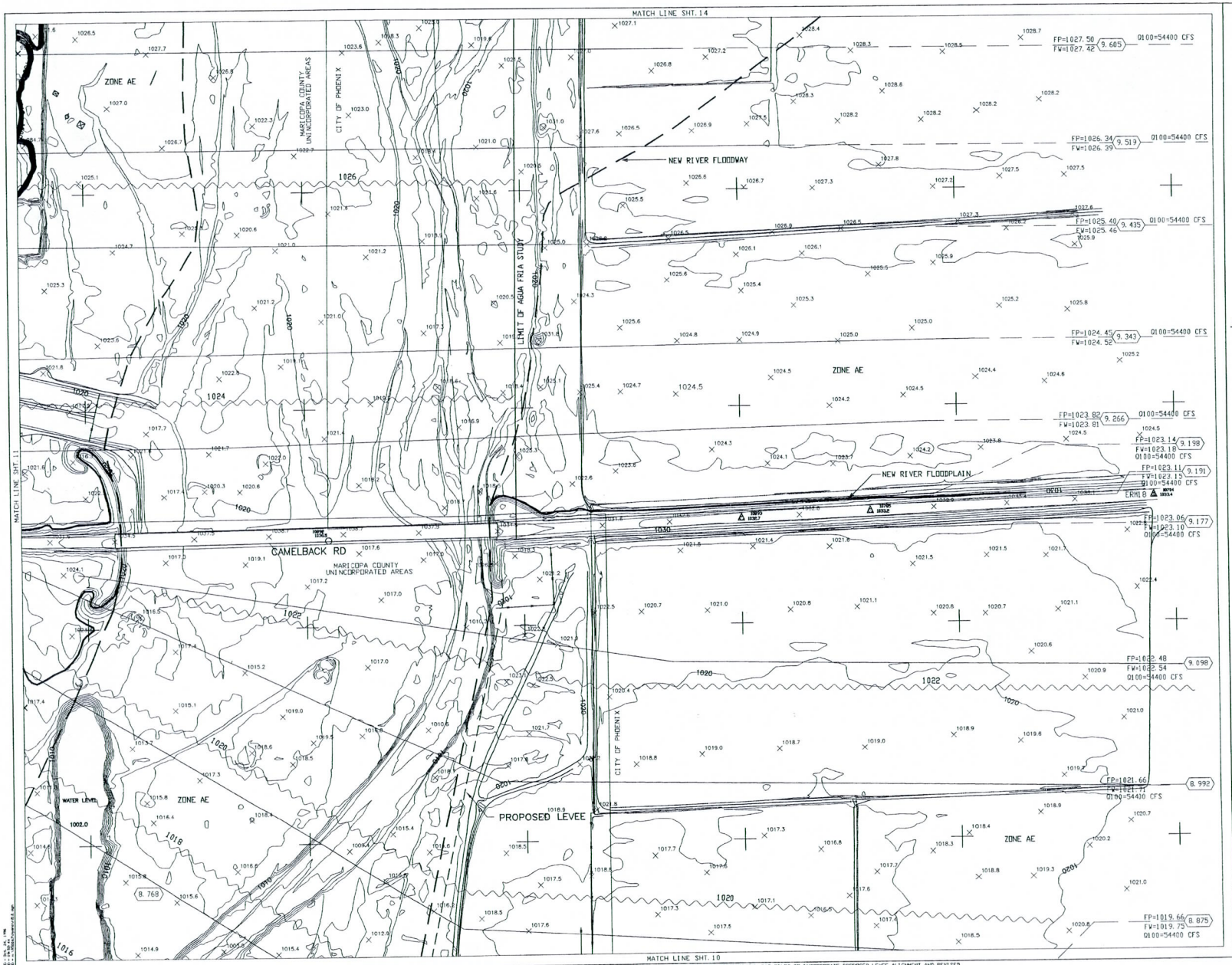


# FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

AGUA FRIA RIVER
FLOODPLAIN DELINEATION RE-STUDY

F. C. D. CONTRACT NO. 95-5

## LEGEND

| | |
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## ELEVATION REFERENCE MARKS

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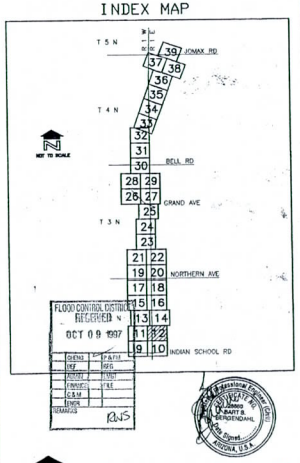
TO OBTAIN NAVD 88 ELEVATIONS, ADD 2.061 FEET

| I.D. NUMBER | ELEVATION (FT) | DESCRIPTION/LOCATION |
|---|---|---|
| ERM 15 | 1017.26 | See sheet 10 |
| ERM 18 | 1033.41 | Cotton picker spindle at the centerline of Camelback at approximately 109th Ave. |

## INDEX MAP




200 0' 200 400
SCALE: 1' = 200'
CONTOUR INTERVAL = 2 FEET

CVL CDE & VAN LOO CONSULTANTS, INC.

| | BY | DATE |
|---|---|---|
| DESIGN | DD | 9/96 |
| DESIGN CHK. | JM | 9/96 |
| PLANS | PE/KR | 9/96 |
| PLANS CHK. | JM | 9/96 |

SUBMITTED BY: Jack K. Moody, P.E. DATED 9/96

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

RECOMMENDED BY: DATE
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CHIEF ENGINEER AND GENERAL MANAGER

SHEET 12 OF 45

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HDR

# SUMMARY OF PM 34/43 WORK MAPS AND EMBANKMENT INVENTORY FOR MARICOPA COUNTY, AZ

## Maricopa County PM 34/43 November 21, 2008

Prepared by: HDR Engineering Inc.

As part of the Federal Emergency Management Agency (FEMA) Procedure Memorandums 34 & 43 (PM 34/43), an analysis of embankments in Maricopa County, AZ that are potentially providing protection from the 1% annual chance flood has been conducted by HDR. In this analysis, HDR identified these embankments, determined their status as flood control structures, and delineated approximate floodplains downstream of the embankments where applicable. The draft work maps and preliminary embankment inventory have been provided in this package for your review. Please feel free to mark up the draft work maps and provide any comments to HDR within 30 days (December 22, 2008). If you have any questions please contact Renato Espinoza Torres, EIT at (916) 817-4929 or Omar Sencion, EIT (916) 817-4992.

## Source of Data

- Shapefiles used to create the work maps were provided to HDR by the Flood Control District of Maricopa County (FCDMC) on March 31, 2008. These shapefiles include:
  - Currently effective information as shown on the Flood Insurance Rate Maps (FIRMs) for Maricopa County, AZ.
  - Special Flood Hazard Area (SFHA), Letter of Map Revision (LOMR), and Best Available Data (BAD) information, which contain data not shown in the effective FIRMs for Maricopa County.
  - Topographic data and elevation contours based on the North American Vertical Datum of 1988 (NAVD 88).
- Shapefiles were provided by the City of Scottsdale to aid in determining the locations, limits, and floodplain delineations for potentially failed embankments.
- A Letter of Map Change (LOMC) Revision Tracking Information spreadsheet was provided by the FCDMC. The spreadsheet contained a list of LOMRs and BAD Letters approved by FEMA to be included in the next edition of FIRMs.

- Information regarding a number of specific embankments was obtained by HDR from various communities via telephone and email.

- Conversion factors to convert from the National Geodetic Vertical Datum of 1929 (NGVD 29) to NAVD 88 were obtained for various locations within Maricopa County. An average conversion factor for the City of Scottsdale was provided by the City of Scottsdale. Conversion factors for other locations were calculated by HDR using Corpscon6 software and other methods. All conversion factors rounded to +2 ft.

## Assumptions

- GIS data contained in the effective FIRM shapefiles provided by the FCDMC was current, except where the LOMC Revision Tracking Information spreadsheet provided by the FCDMC indicated otherwise.

- Data provided via telephone or by email by communities regarding specific embankments was accurate and current.

- A conversion factor of +2 ft was used where converting NGVD 29 elevations to NAVD 88 elevations. The topographic data provided by the FCDMC had elevations listed in NAVD 88 while base flood elevations (BFE) were listed in NGVD 29. **A conversion factor of +2 ft must be added to all BFEs shown on the work maps.**

## Methodology

- Approximate floodplain delineation methods listed below were employed on the work maps enclosed:
    - Projecting BFEs to landward side of levees.
    - Extending floodplains down a grade based on topographic information.
    - Connecting upstream and downstream floodplains.
    - Delineating downstream floodplains based on other studies in the area.

- Work maps depicting floodplain delineations under failed conditions are not to scale.

- Floodplains under failed conditions were delineated for Category 2 embankments (Levees that meet the 44 CFR Section 65.10 criteria but need time to submit necessary documentation by signing a PAL Agreement). The work maps associated with these

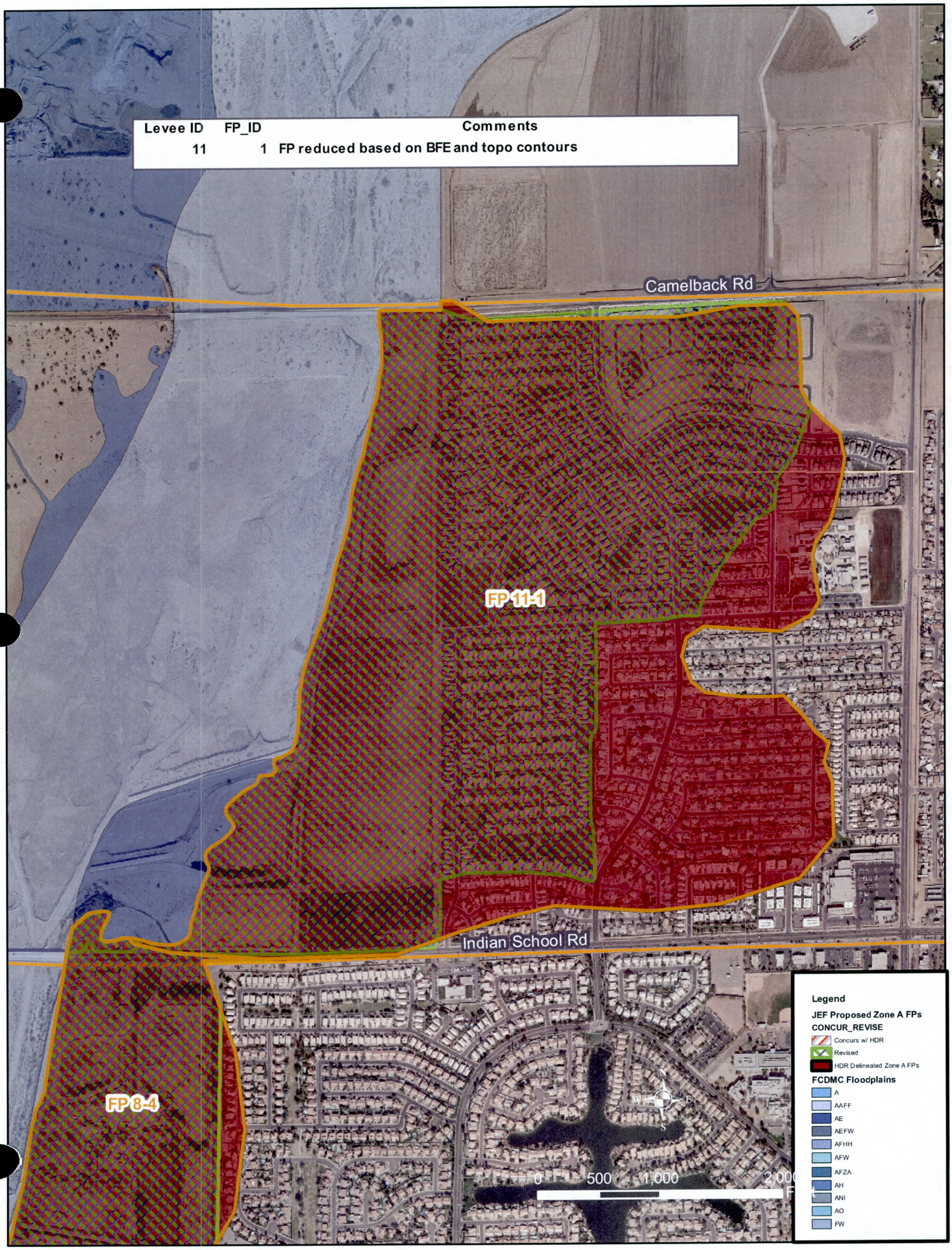
embankments show Zone A designations downstream of the failed structures. If PAL Agreement is signed and appropriate levee certification procedure is followed these areas **will not** be designated Zone A, they will be designated shaded Zone X.

- No floodplains under failed conditions were delineated for Category 1 embankments (Levees that meet the 44 CFR Section 65.10 criteria and have necessary documentation). Certification documents submitted to FEMA by the parties responsible for these embankments will be verified. The levee embankment will be accredited on the DFIRM if all certification documents meet 44 CFR Section 65.10 requirements.

- Delineations for embankments listed under ID numbers 51, 59, 66, 67a, 67b, and 68 were provided to HDR by the City of Scottsdale.

- Information regarding any specific embankment received by HDR from community floodplain managers was considered in delineations of associated floodplains.

| Levee ID | FP_ID | Comments |
|---|---|---|
| 11 | 1 | FP reduced based on BFE and topo contours |



# B. Hydraulic Evaluation for Levee Freeboard Determination

# Appendix B

## Camelback Ranch Levee South
## Maricopa County, Arizona

## Hydraulic Evaluation for Levee Freeboard Determination

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1.2 HEC-RAS Model Development ..... 1
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1.2.2 Boundary Conditions ..... 1
1.2.3 Flow Regime ..... 1
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1.3 Freeboard Evaluation ..... 2
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Figure E-3: HEC-RAS Work map ..... Appendix B.4

## List of Appendices:

B.1 Roughness Coefficient Estimation
B.2 Cross Section Plots
B.3 HEC-RAS Summary Tables
B.4 Figures

# 1. HEC-RAS Modeling

## 1.1 Method Description

A HEC-RAS model was developed for hydraulic analysis (*AguaFriaRiver_CBRLS_Eval.prj*) of the Agua Fria River from Camelback Road to 3500 feet south. The analysis was completed using the U.S. Army Corps of Engineers HEC-RAS River Analysis System, Version 4.1.0 (January 2010). The subcritical steady-state flow regime option was selected. A hydraulic profile was computed for the 10- and 100-year peak discharge and the results were used in the freeboard and the embankment scour evaluation documented in **Appendix C**.

## 1.2 HEC-RAS Model Development

The Agua Fria River was modeled using the steady-flow routine in HEC-RAS. For the purpose of this evaluation, only an existing condition HEC-RAS model was created. To aid in HEC-RAS modeling, ArcView procedures, tools and utilities were used to process topographic data and incorporated into the HEC-RAS model.

Additional discussion pertaining to HEC-RAS model development is provided below and in *Floodplain Delineation Study for a portion of the Agua Fria River, Agua Fria River from 1800 feet upstream (north) of Camelback Road Bridge to 1700 feet upstream (north) of Indian School Road Bridge, June 2011*, (Agua Fria LOMR) under separate cover. In addition, HEC-RAS existing condition work map from the Agua Fria LOMR are shown in **Figure E-3** provided in **Appendix B.4**.

### 1.2.1 Steady Flow Data

The 100-year discharge of 54,400 cfs was applied based on the values used in the existing FIS HEC-2 model. The 10-year discharge was estimated at 19,040 cfs using a ratio of 0.35 to 100-year event. The value of 0.35 for the ratio was obtained from the guidelines presented in the FCDMC Hydrology Manual for computing the 10-year discharge using the 100-year discharge. It may be noted that the 1996 SLA report incorporated a 10-year discharge value of 23,000 cfs in their calculations. However, the source for the value of 23,000 cfs could not be confirmed. Therefore, it was deemed appropriate to use the FCDMC guidelines to determine the value of the 10-year discharge.

### 1.2.2 Boundary Conditions

The HEC-RAS downstream boundary condition for the 100-year discharge was provided in *Agua Fria River Floodplain Re-delineation, Salt/Gila River to New River, LOMR*, by Stanley Consultants, Inc. June 2011 (concurrently submitted for review) for the segment of the Agua Fria River located immediately downstream of the Camelback Ranch Levee South study reach. The water surface elevation of 1012.88 (NAVD88) was applied at cross-section 8.850 using the "Known WS" option. For the 10-year event the normal depth option was used. The channel slope in the vicinity of the cross section was estimated to be 0.0006 ft/ft.

### 1.2.3 Flow Regime

A subcritical flow regime was used for HEC-RAS modeling per FEMA Standards.

### 1.2.4 Development of the Hydraulic Modeling Parameters

HEC-RAS modeling parameters were developed and incorporated into the current conditions model. The following elements were developed:

**Stream Centerline**

The stream centerline was provided by FCDMC and no modifications were made.

**Cross-Section Cut Lines**

Based on the Existing HEC-2 cross section locations with supplemental cross sections added between each HEC-2 cross section location below Camelback Road Bridge.

**Bank Stations**

Bank stations are located at the hinge point along the top of the soil cement bank protection and at locations along the western pit limits to adequately model the ineffective areas.

**Flow Path Centerlines**

Flow path centerlines are used to identify the hydraulic flow path in the left overbank, main channel, and right overbank by identifying the center-of-mass of flow. Downstream reach lengths are calculated for each cut line based on the distance between cut lines along the flow path centerlines.

**Cross-Sectional Roughness Coefficients**

Roughness coefficients represent the resistance to flow in channels and overbank areas. HEC-RAS accounts for this roughness by use of the Manning's "n" value. The "n" value is determined from the values of the factors that affect the roughness, such as vegetation type and density, bed material and channel irregularities.

Manning's "n" value categories used in the current conditions model are consistent with the existing HEC-2 model although the existing limits were adjusted due to the changes in geometry since the HEC-2 model was created.

**Ineffective flow areas**

Ineffective flow areas were added for the dry-side of the Camelback Levee, Ineffective areas were used to represent ponded conditions with the sand and gravel mining pits. Ineffective areas were also used on the eastern end of the cross-sections located between river-stations 9.059 and 9.225. This was implemented to represent a low-conveyance zone due to sharp turn of the levee alignment.

Additional discussion of the Agua Fria River Hydraulic model is included in *Floodplain Delineation for a Portion of the Agua Fria River*, JE Fuller Hydrology/Geomorphology, Inc. June 2011 under separate cover.

## 1.3 Freeboard Evaluation

The water surface profile from the HEC-RAS model was compared to the top-of-levee profiles from the HEC-RAS model. The evaluation model, representing the current hydraulic conditions, was used as the primary base flood elevation source. The minimum freeboard provided is 6.0 feet.

In addition to the summary table below, Standard Table 1 results are located in **Appendix B.3**. The HEC-RAS output report is included on the data disk in **Appendix H**. HEC-RAS cross-sections plots are provided in **Appendix B.2**.

**Table B-1: Freeboard Results for Agua River**

| (1)Levee Station | (1)HEC-RAS Cross Section | 100-year Water Surface Elevation (ft) | (2)Top of Levee (ft) | Available Freeboard (ft) | Required Freeboard (ft) | Is the available freeboard adequate? |
|---|---|---|---|---|---|---|
| 44+81 | 9.686 | 1023.07 | 1029.27 | 6.2 | 3.5 | Yes |
| 43+53 | 9.663 | 1022.73 | 1028.77 | 6.04 | 3 | Yes |
| 42+43 | 9.643 | 1022.1 | 1028.37 | 6.27 | 3 | Yes |
| 41+39 | 9.624 | 1021 | 1027.50 | 6.5 | 3 | Yes |
| 40+16 | 9.602 | 1020.01 | 1026.92 | 6.91 | 3 | Yes |
| 38+35 | 9.569 | 1017.83 | 1026.27 | 8.44 | 3 | Yes |
| 37+02 | 9.546 | 1014.64 | 1025.53 | 10.89 | 3 | Yes |
| 35+38 | 9.518 | 1014.21 | 1024.55 | 10.34 | 3 | Yes |
| 33+59 | 9.487 | 1014.14 | 1024.71 | 10.57 | 3 | Yes |
| 32+39 | 9.467 | 1014.08 | 1024.24 | 10.16 | 3 | Yes |
| 31+04 | 9.445 | 1014 | 1023.71 | 9.71 | 3 | Yes |
| 29+69 | 9.422 | 1013.94 | 1023.49 | 9.55 | 3 | Yes |
| 28+49 | 9.4 | 1013.9 | 1023.29 | 9.39 | 3 | Yes |
| 27+40 | 9.379 | 1013.86 | 1023.28 | 9.42 | 3 | Yes |
| 25+95 | 9.353 | 1013.8 | 1022.94 | 9.14 | 3 | Yes |
| 24+33 | 9.324 | 1013.73 | 1022.28 | 8.55 | 3 | Yes |
| 22+51 | 9.292 | 1013.65 | 1022.27 | 8.62 | 3 | Yes |
| 21+19 | 9.267 | 1013.6 | 1022.31 | 8.71 | 3 | Yes |
| 18+97 | 9.225 | 1013.55 | 1022.38 | 8.83 | 3 | Yes |
| 17+05 | 9.193 | 1013.52 | 1022.21 | 8.69 | 3 | Yes |
| 16+12 | 9.172 | 1013.51 | 1022.28 | 8.77 | 3 | Yes |
| 14+24 | 9.131 | 1013.48 | 1022.64 | 9.16 | 3 | Yes |
| 13+03 | 9.109 | 1013.46 | 1022.42 | 8.96 | 3 | Yes |
| 11+27 | 9.082 | 1013.44 | 1022.23 | 8.79 | 3 | Yes |
| 09+82 | 9.059 | 1013.42 | 1022.37 | 8.95 | 4 | Yes |

Note: 1. Levee Stations and HEC-RAS cross sections were derived using HEC-RAS cross section line crossing Levee Alignment Stationing.
2. Levee elevation from HEC-RAS model.
All elevations NAVD 1988.

## 1.4 Summary

The results for the HEC-RAS model were utilized to evaluate the Camelback Ranch Levee South freeboard and for the embankment scour evaluation documented in **Appendix C**. The results indicate that Camelback Ranch Levee South has adequate freeboard.

# B Hydraulic Evaluation for Levee Freeboard Determination

## B.1 Roughness Coefficient Estimation

Main Channel Only

## B.2 Cross Section Plots

Agua Fria River HEC-RAS cross sections 9.059 to 9.686
(Only cross sections adjacent to Camelback Ranch Levee South were plotted)

## B.3 HEC-RAS Summary Tables

Standard Table 1 for 10-year
Standard Table 1 for 100-year

**HEC-RAS Report (AguaFriaRiver_CBRLS_Eval.prj) on data disk in **Appendix H**

## B.4 Figure

**Figure E-3: Floodplain Work map (Sheets 1 and 2)**
***Floodplain* work map from *Floodplain Delineation Study for a portion of the Agua Fria River, Agua Fria River from 1800 feet upstream (north) of Camelback Road Bridge to 1700 feet upstream (north) of Indian School Road Bridge, June 2011* under separate cover.

## B.1 Roughness Coefficient Estimation

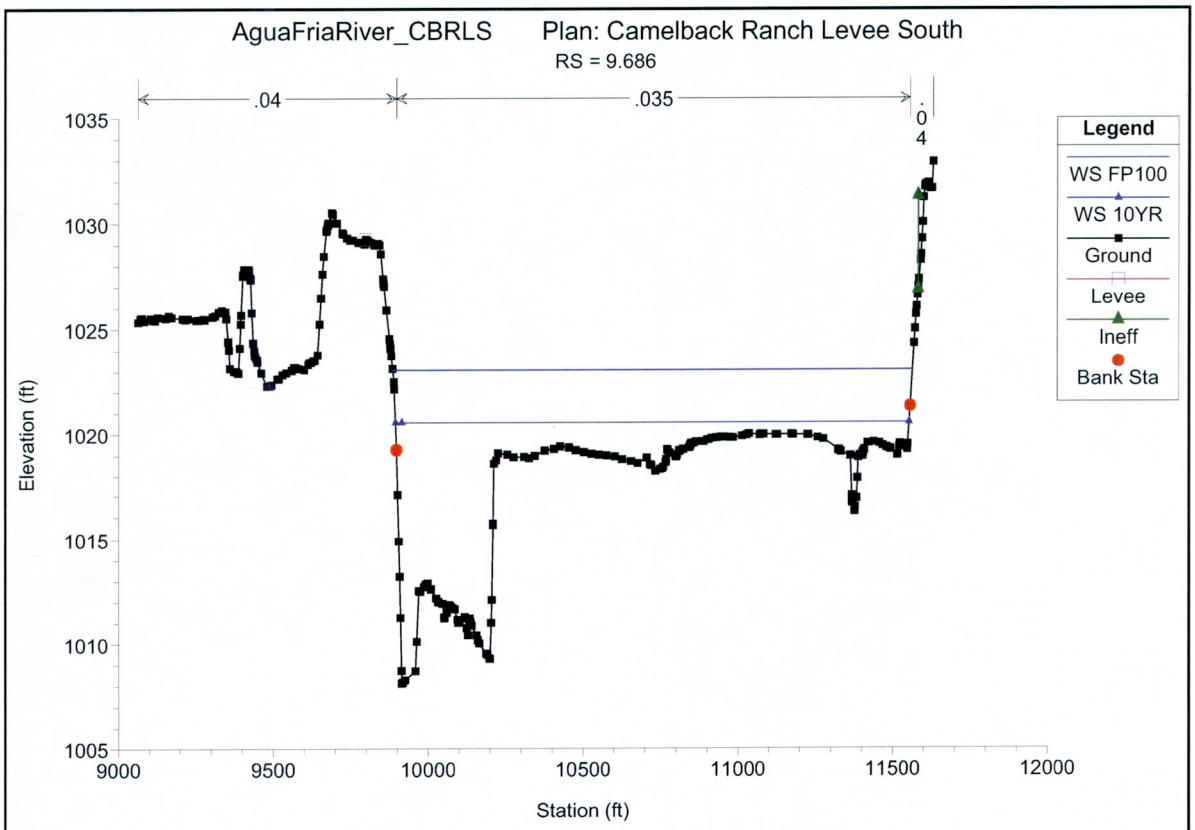
**Project:** **Camelback Ranch Levee South**
**Stream:** **Agua Fria River**
**Location:** **Maricopa County, Arizona**

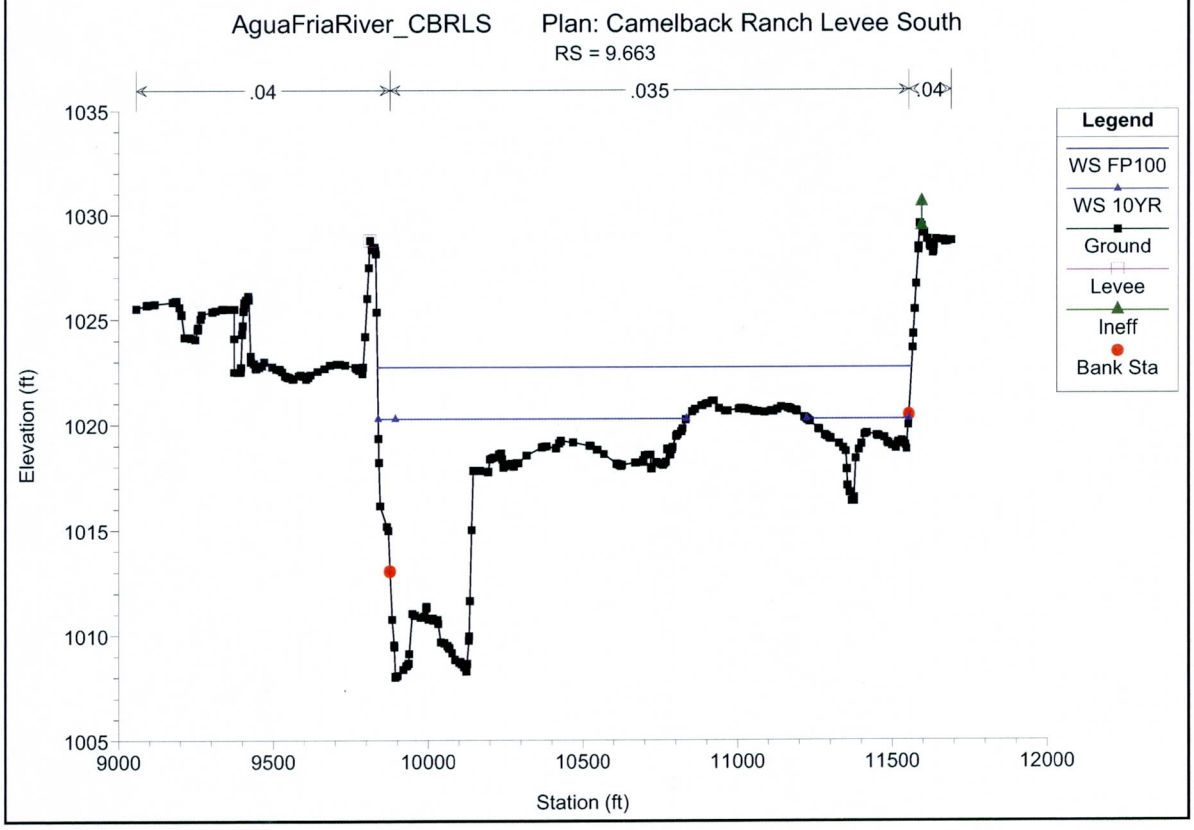
Photo B1 : Typical photo of Agua Fria River Main Channel

| Channel Conditions | | Manning's n Adjustment | | n Value |
|---|---|---|---|---|
| Channel Material | Concrete | $n_b$ | 0.012-0.018 | |
| | Firm Soil | | 0.025-0.032 | |
| | Coarse Sand | | 0.026-0.035 | |
| | Gravel | | 0.028-0.035 | 0.03 |
| | Cobble | | 0.030-0.050 | |
| | Boulder | | 0.040-0.070 | |
| Degree of Irregularity | Smooth | $n_1$ | 0.000 | |
| | Minor | | 0.001-0.005 | |
| | Moderate | | 0.006-0.010 | |
| | Severe | | 0.011-0.020 | |
| Effects of Obstruction | Negligible | $n_2$ | 0.000-0.004 | 0.002 |
| | Minor | | 0.005-0.015 | |
| | Appreciable | | 0.020-0.030 | |
| | Severe | | 0.040-0.060 | |
| Vegetation | Small | $n_3$ | 0.002-0.010 | 0.003 |
| | Medium | | 0.010-0.025 | |
| | Large | | 0.025-0.050 | |
| | Very Large | | 0.050-0.100 | |
| Variations in Channel Cross Section | Gradual | $n_4$ | 0.000 | |
| | Occ. Alt. | | 0.001-0.005 | |
| | Frequently Alt. | | 0.010-0.015 | |
| Intermediate Sum | | | | 0.035 |
| Degree of Meandering | Minor | m | 1 | 1 |
| | Appreciable | | 1.15 | |
| | Severe | | 1.3 | |
| $n=(n_b+n_1+n_2+n_3+n_4)m$ | | | | **0.035** |

Main Channel

## B.2 Cross Section Plots


AguaFriaRiver_CBRLS
Plan: Camelback Ranch Levee South
RS = 9.686
.04
.035
.04
Legend
WS FP100
WS 10YR
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
1035
1030
1025
1020
1015
1010
1005
9000
9500
10000
10500
11000
11500
12000
Station (ft)


AguaFriaRiver_CBRLS
Plan: Camelback Ranch Levee South
RS = 9.663
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.035
.04
Legend
WS FP100
WS 10YR
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
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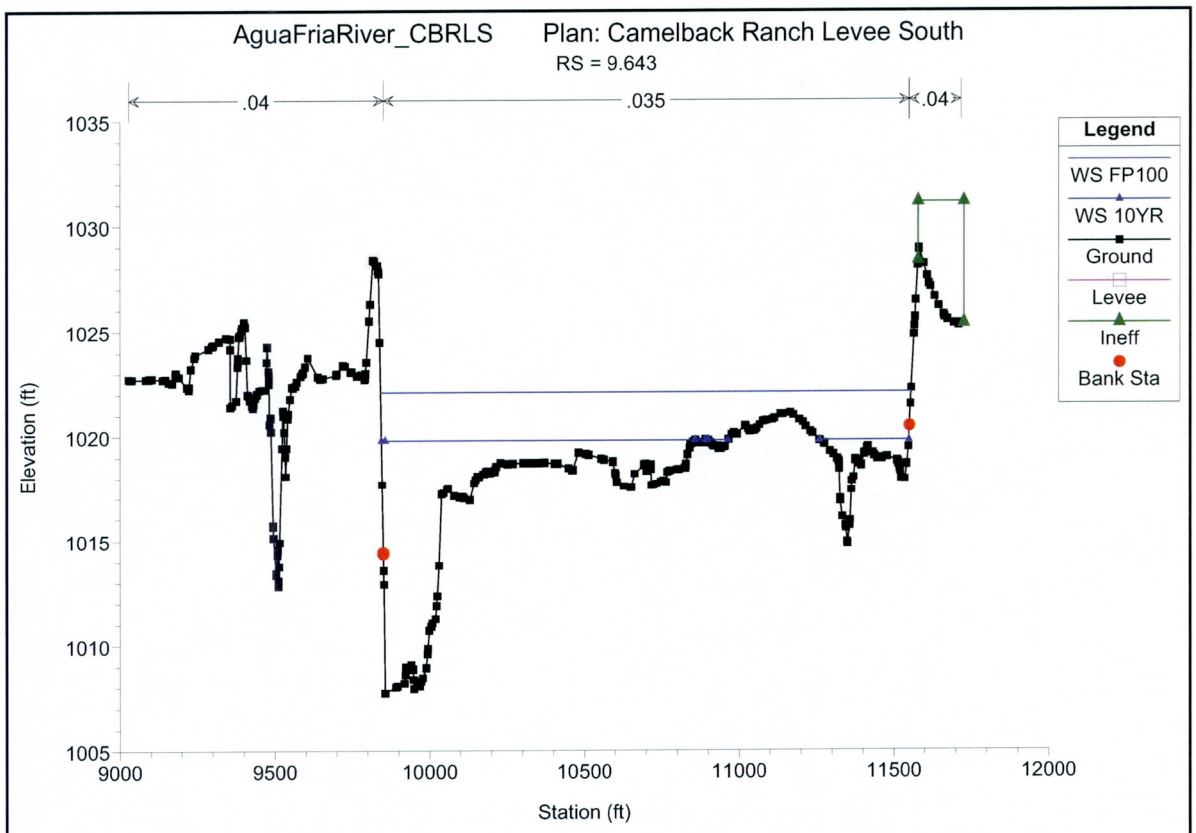
1025
1020
1015
1010
1005
9000
9500
10000
10500
11000
11500
12000
Station (ft)


AguaFriaRiver_CBRLS
Plan: Camelback Ranch Levee South
RS = 9.643
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.04
Legend
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WS 10YR
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
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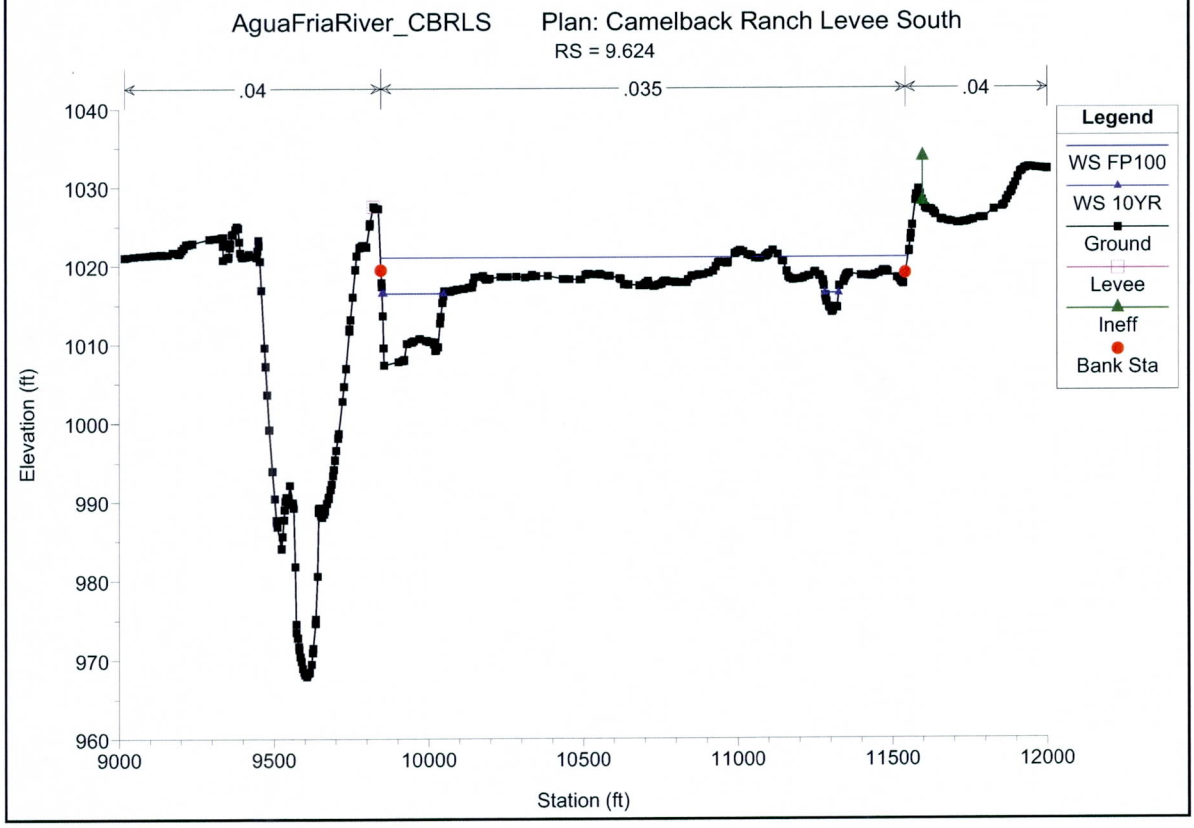
1030
1025
1020
1015
1010
1005
9000
9500
10000
10500
11000
11500
12000
Station (ft)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Legend
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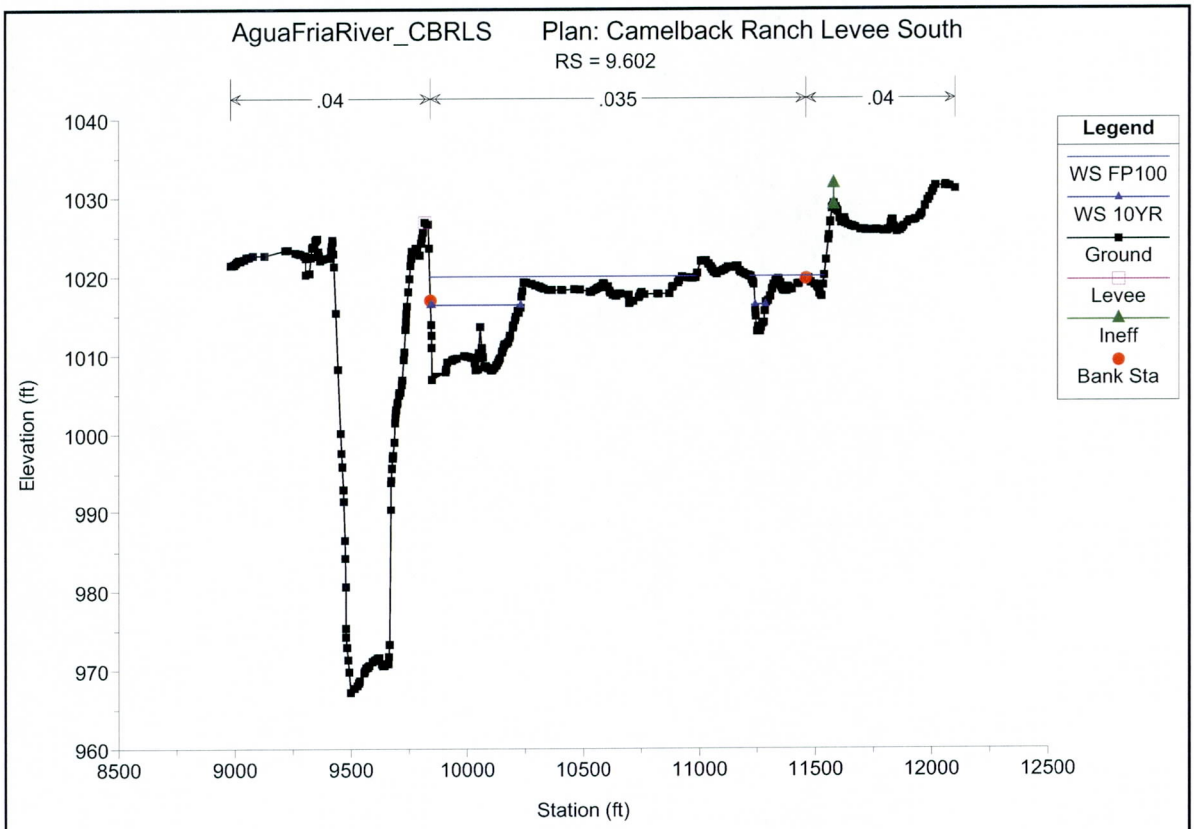
WS 10YR
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
1040
1030
1020
1010
1000
990
980
970
960
9000
9500
10000
10500
11000
11500
12000
Station (ft)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WS 10YR
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)
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960
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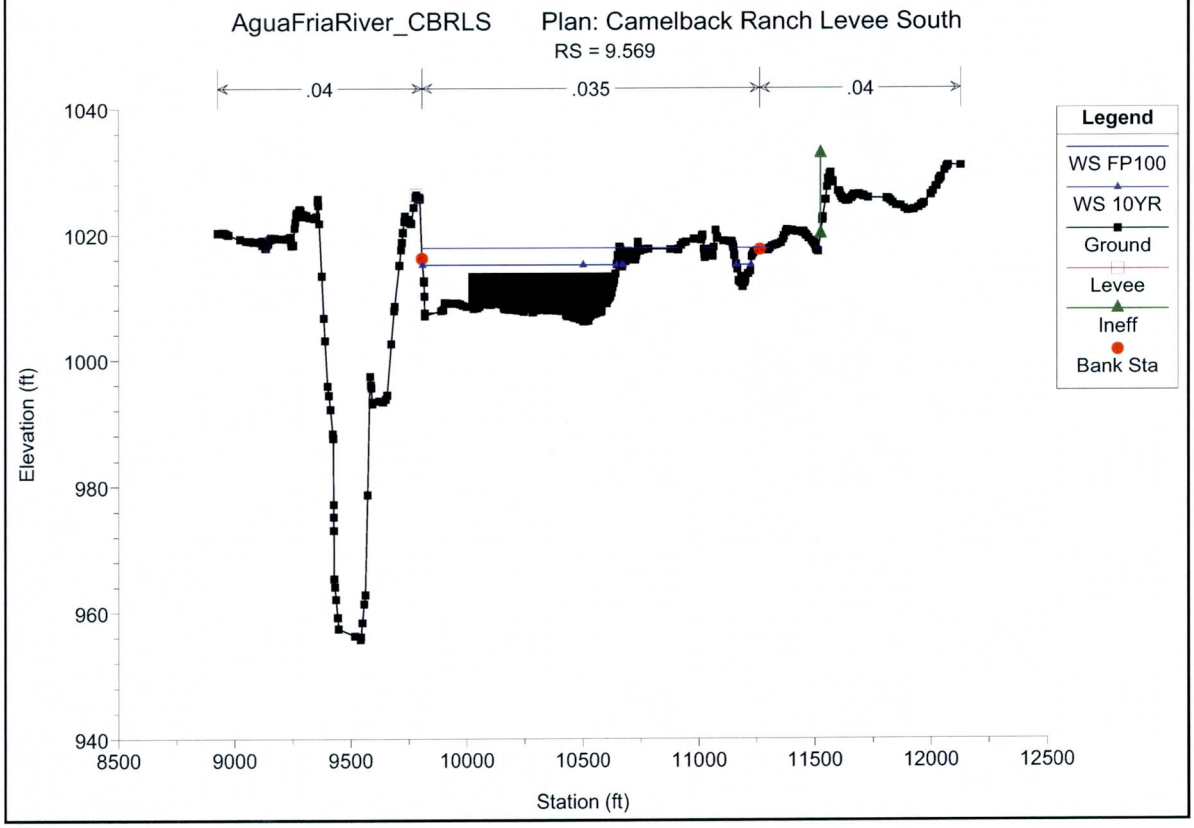
12000
12500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WS 10YR
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)
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960
940
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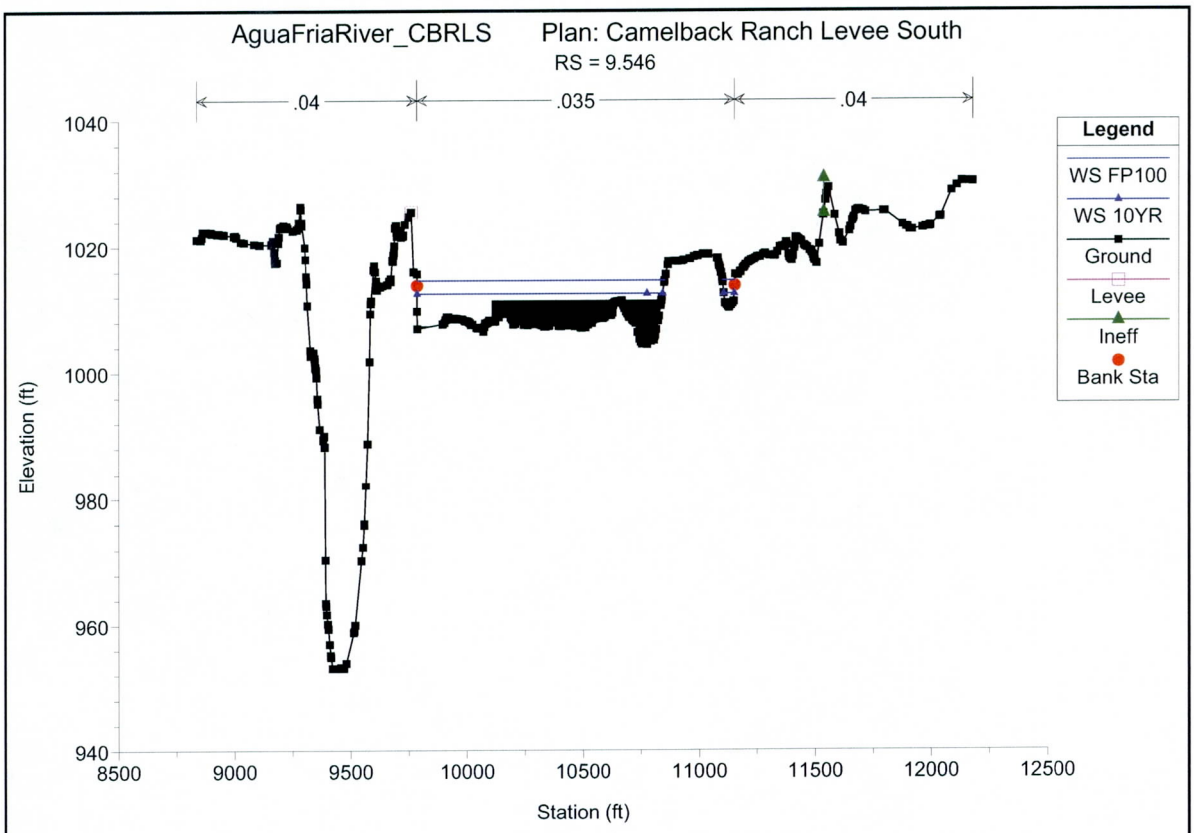
9000
9500
10000
10500
11000
11500
12000
12500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Legend
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Ground
Levee
Ineff
Bank Sta
Elevation (ft)
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9000
9500
10000
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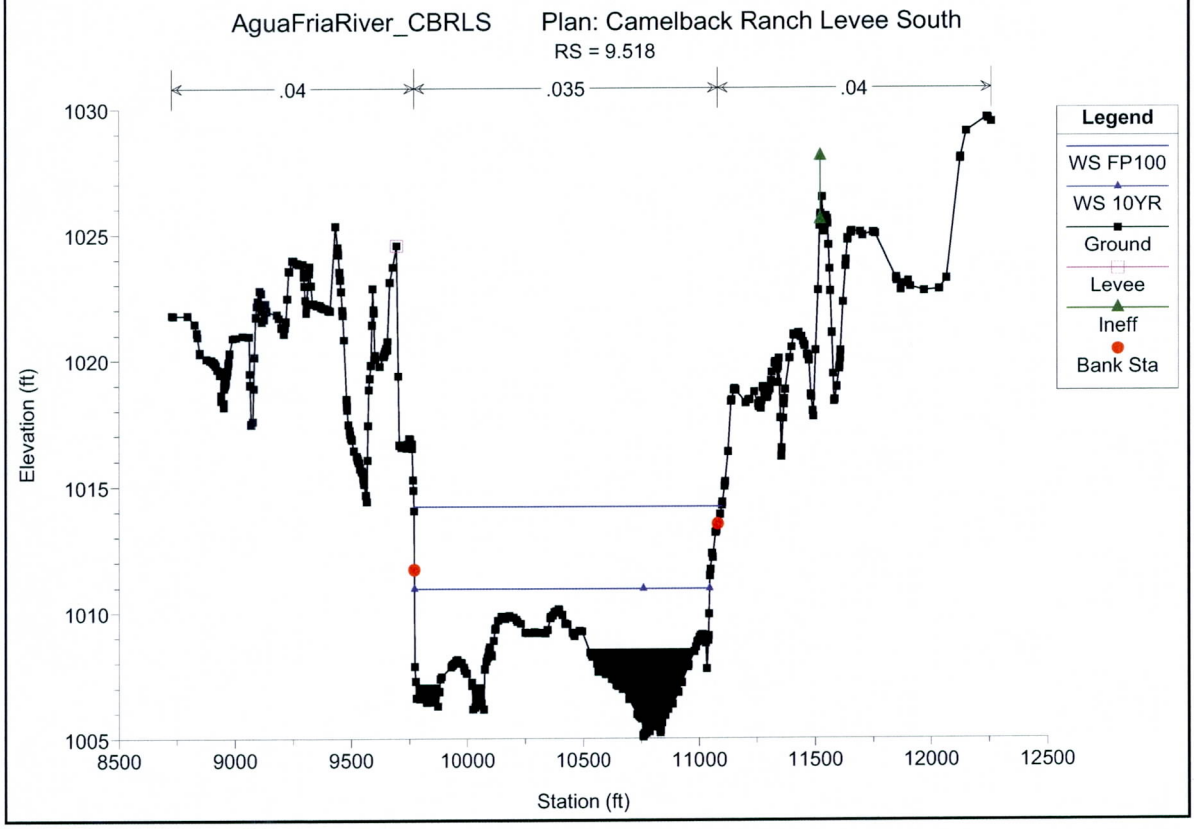
11500
12000
12500
Station (ft)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Legend
WS FP100
WS 10YR
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
1030
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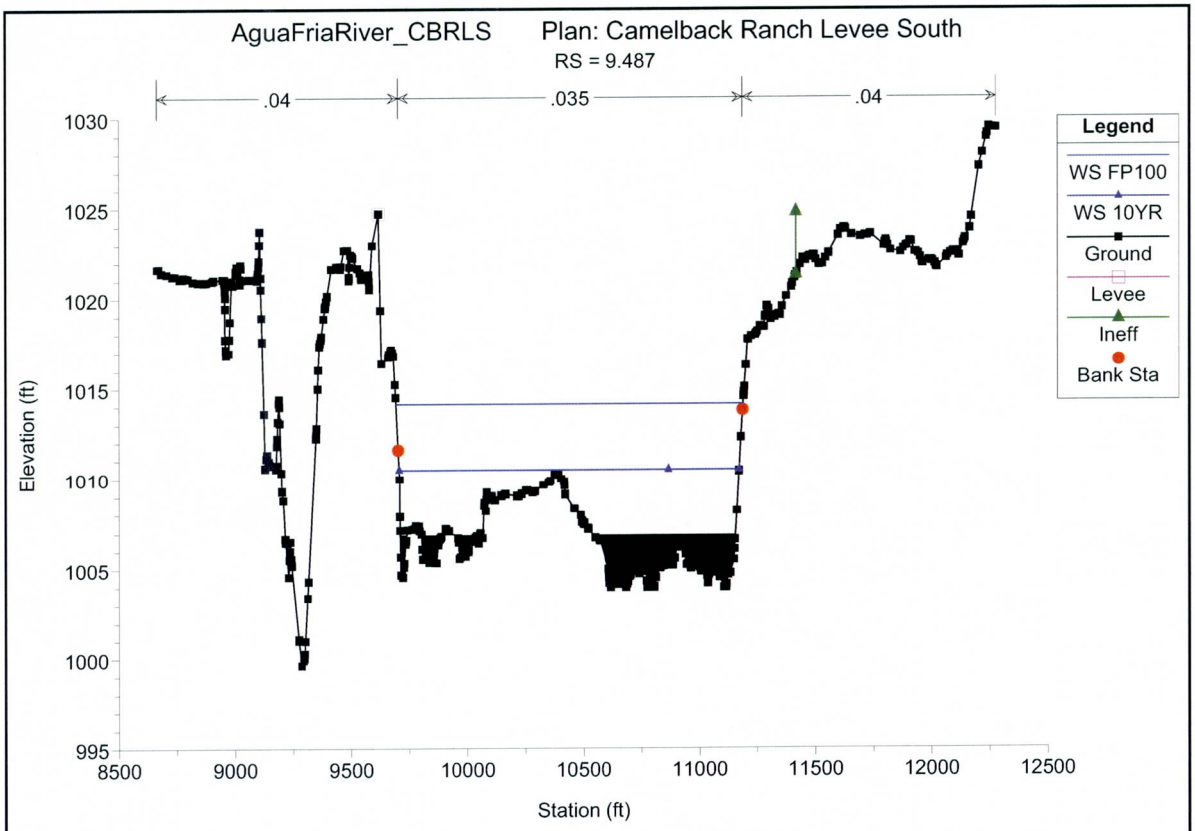
1010
1005
8500
9000
9500
10000
10500
11000
11500
12000
12500
Station (ft)


AguaFriaRiver_CBRLS
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Legend
WS FP100
WS 10YR
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)
1030
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995
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10000
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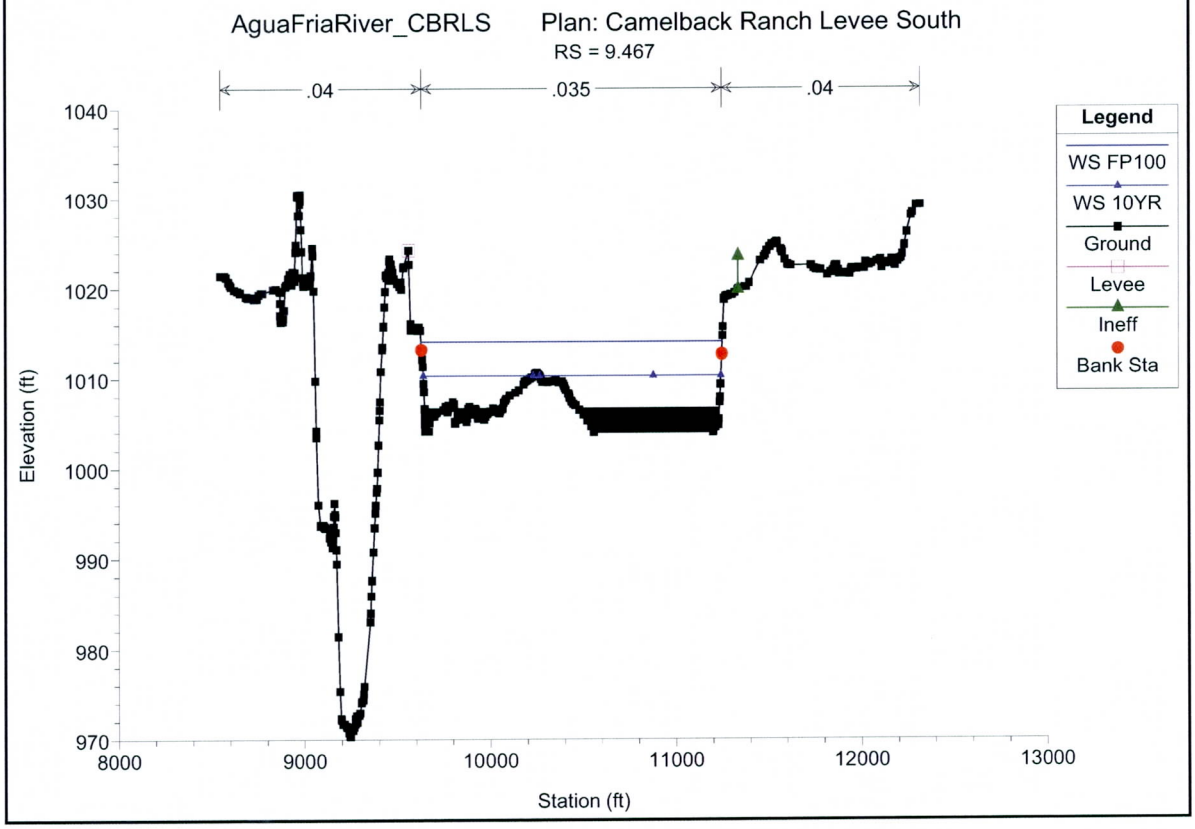
12500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Legend
WS FP100
WS 10YR
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)
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970
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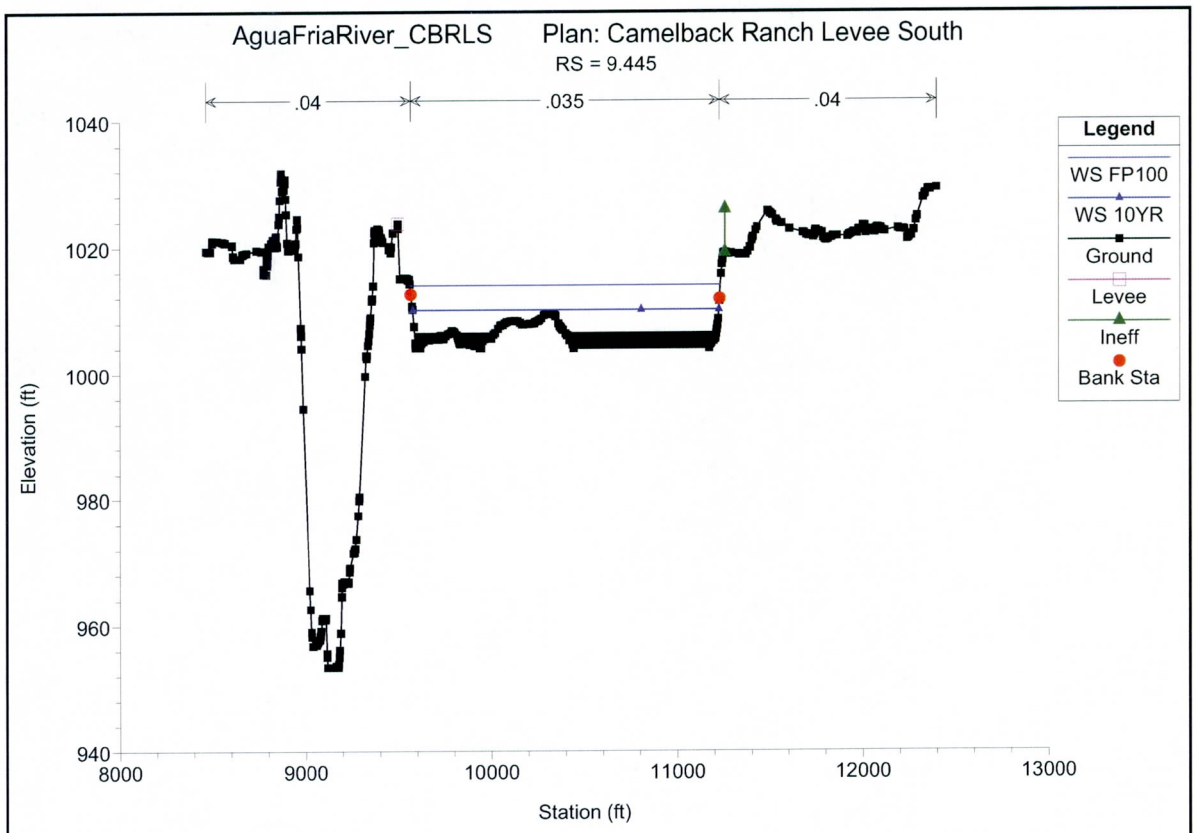
12000
13000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Legend
WS FP100
WS 10YR
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
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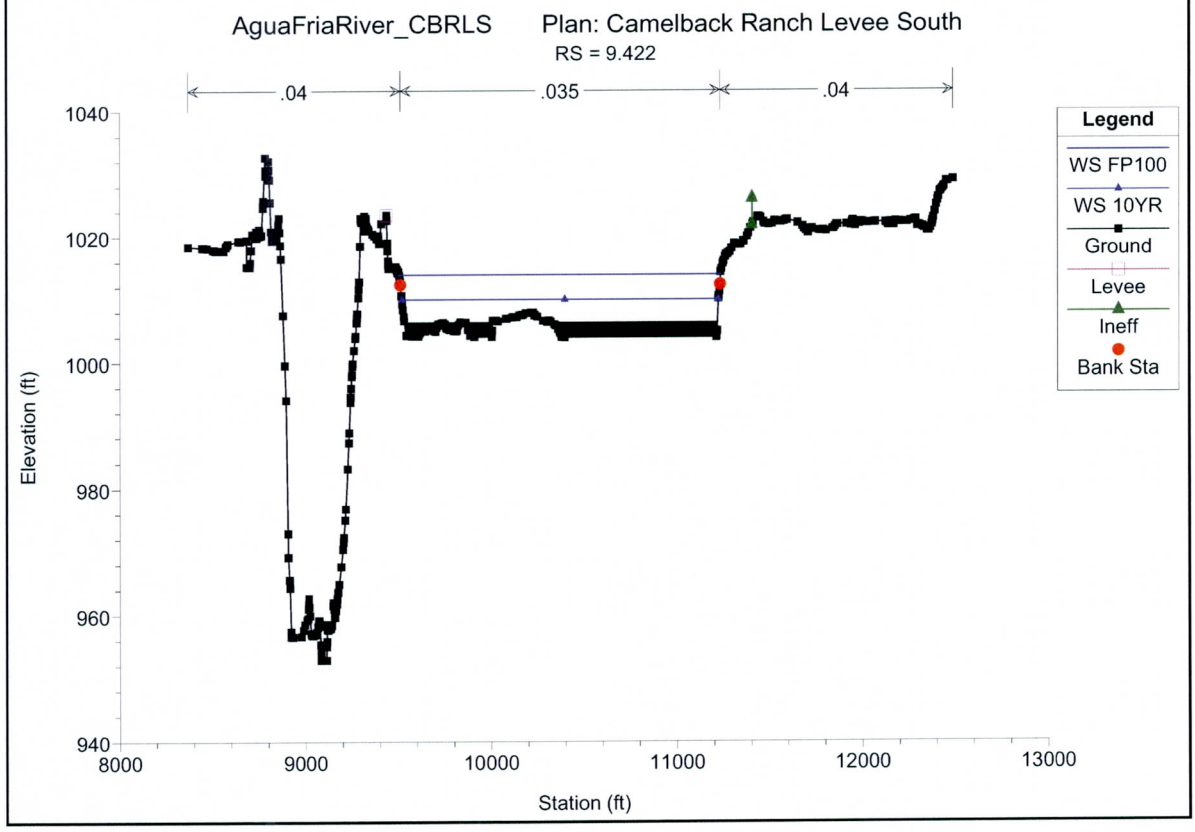
960
940
8000
9000
10000
11000
12000
13000
Station (ft)


AguaFriaRiver_CBRLS
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.035
.04
Legend
WS FP100
WS 10YR
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
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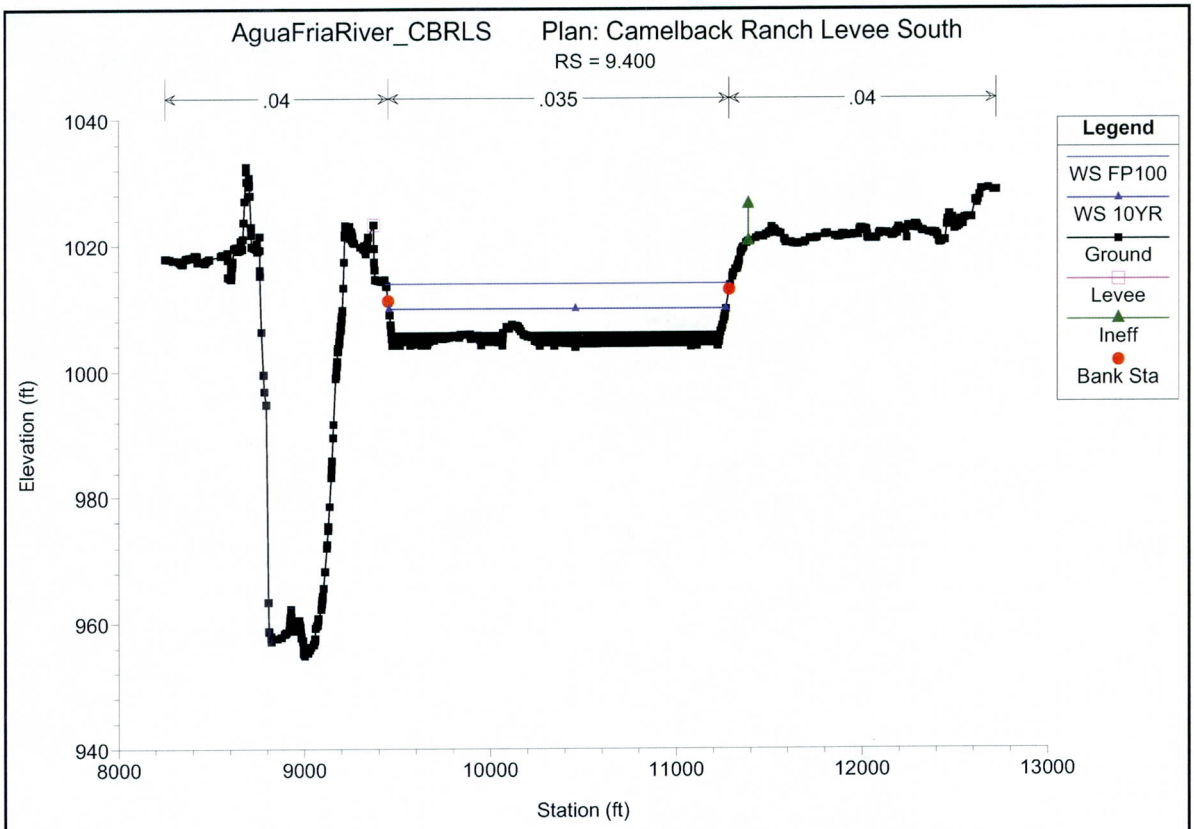
1000
980
960
940
8000
9000
10000
11000
12000
13000
Station (ft)


AguaFriaRiver_CBRLS
Plan: Camelback Ranch Levee South
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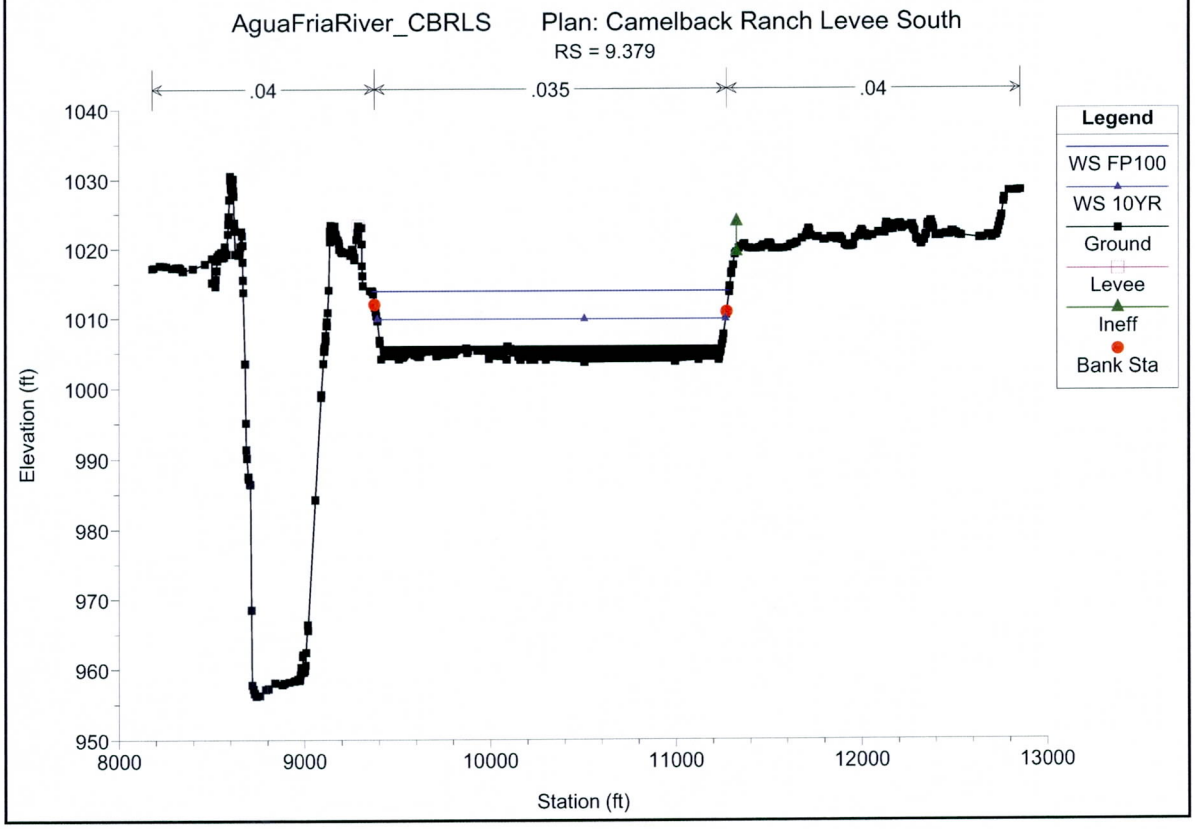
.04
.035
.04
Legend
WS FP100
WS 10YR
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
1040
1020
1000
980
960
940
8000
9000
10000
11000
12000
13000
Station (ft)


AguaFriaRiver_CBRLS
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Legend
WS FP100
WS 10YR
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
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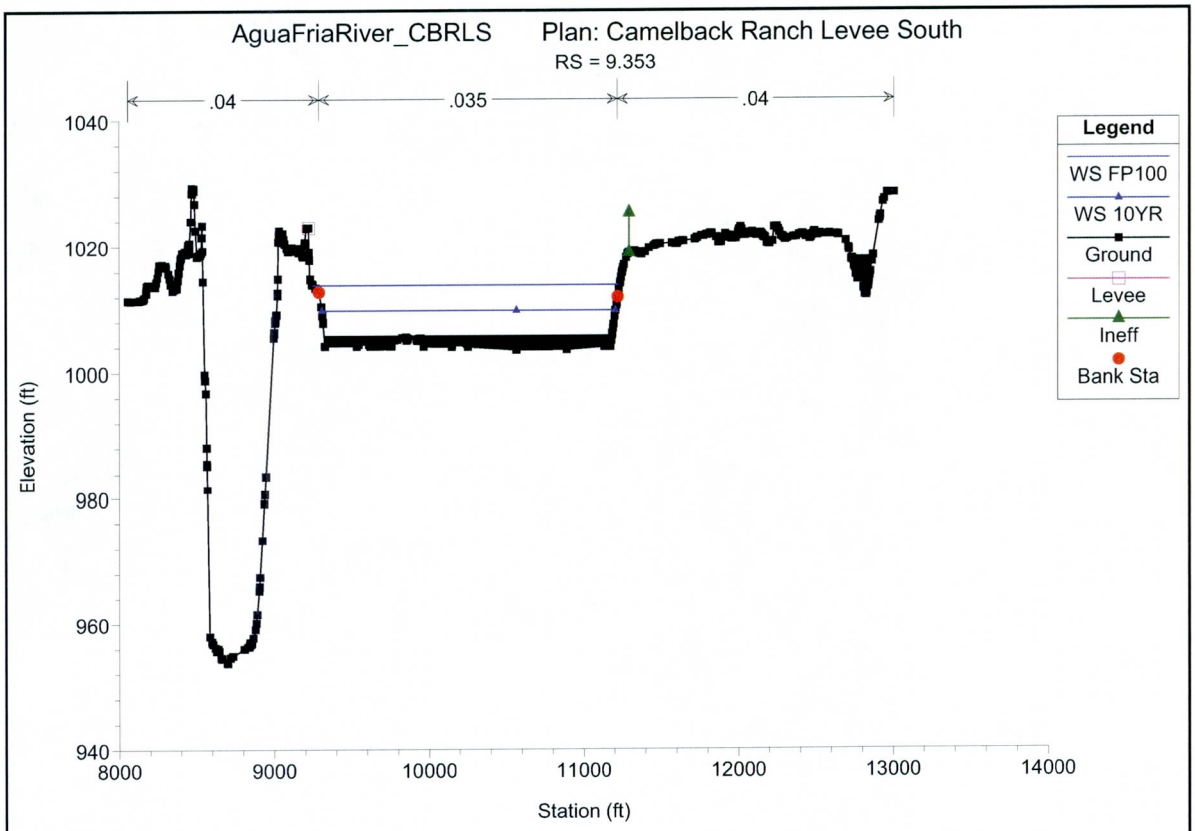
1010
1000
990
980
970
960
950
8000
9000
10000
11000
12000
13000
Station (ft)


AguaFriaRiver_CBRLS
Plan: Camelback Ranch Levee South
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.035
.04
Legend
WS FP100
WS 10YR
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
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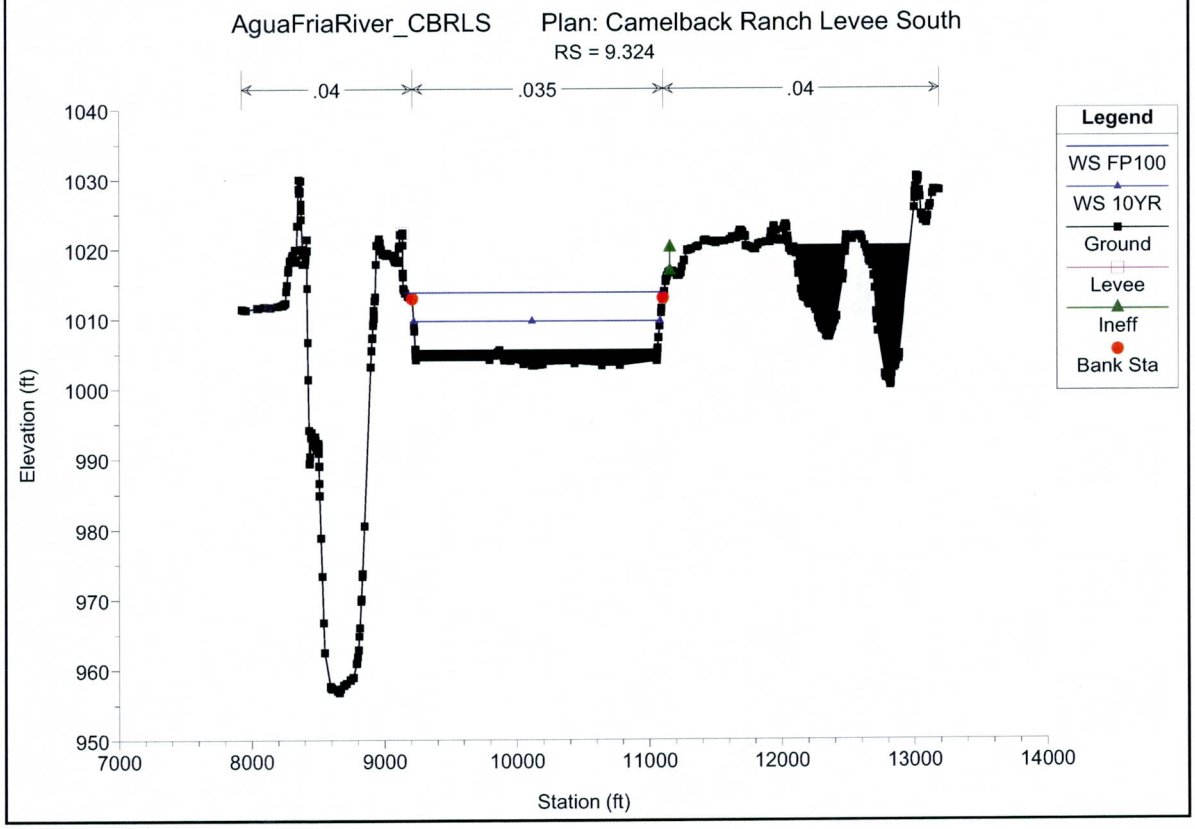
1000
980
960
940
8000
9000
10000
11000
12000
13000
14000
Station (ft)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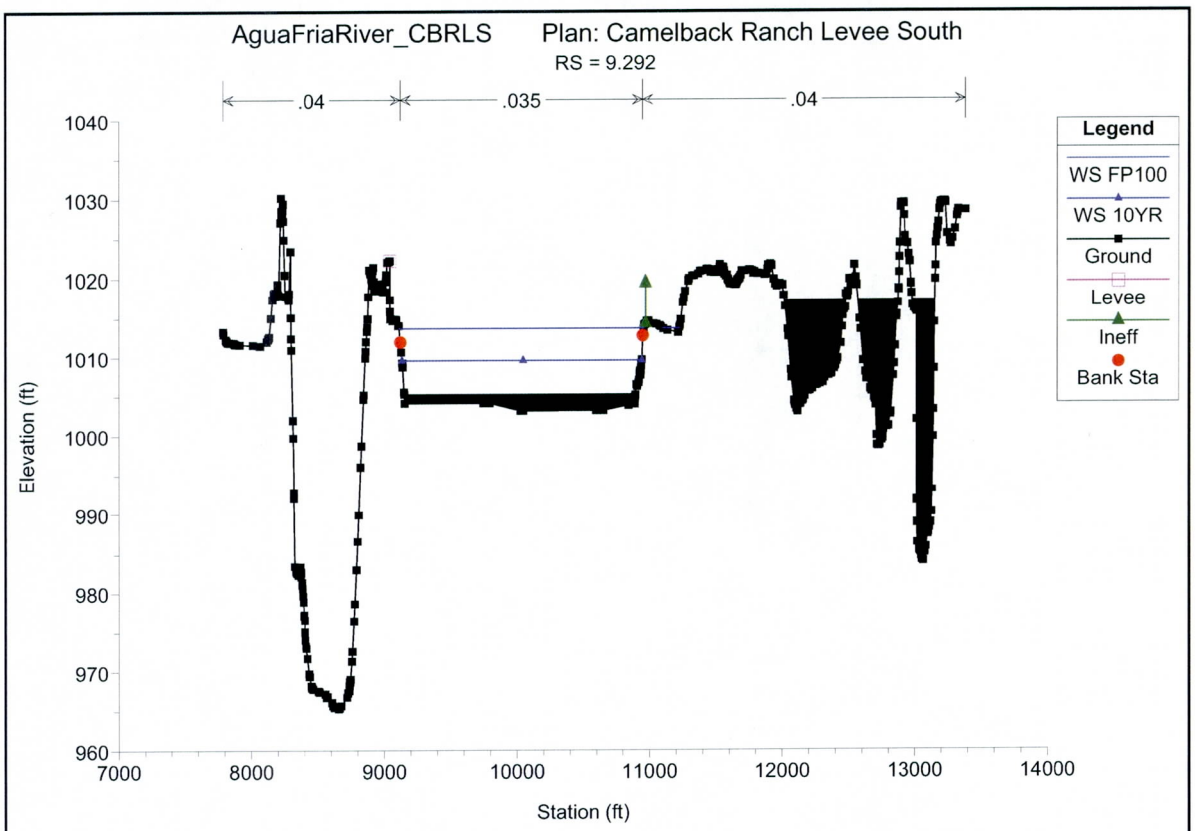
Legend
WS FP100
WS 10YR
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
1040
1030
1020
1010
1000
990
980
970
960
950
7000
8000
9000
10000
11000
12000
13000
14000
Station (ft)


AguaFriaRiver_CBRLS
Plan: Camelback Ranch Levee South
RS = 9.292
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.035
.04
Legend
WS FP100
WS 10YR
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)
1040
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1020
1010
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990
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970
960
7000
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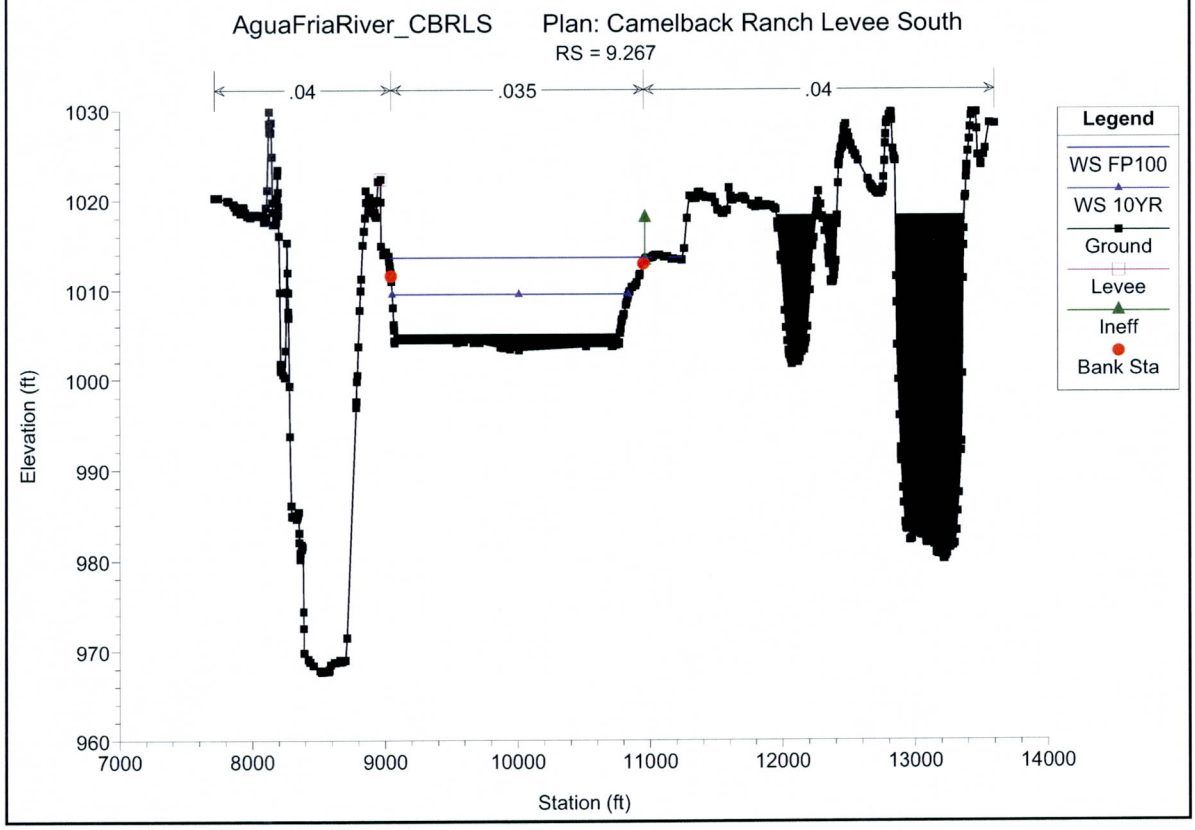
14000


AguaFriaRiver_CBRLS
Plan: Camelback Ranch Levee South
RS = 9.267
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Legend
WS FP100
WS 10YR
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)
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1000
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980
970
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7000
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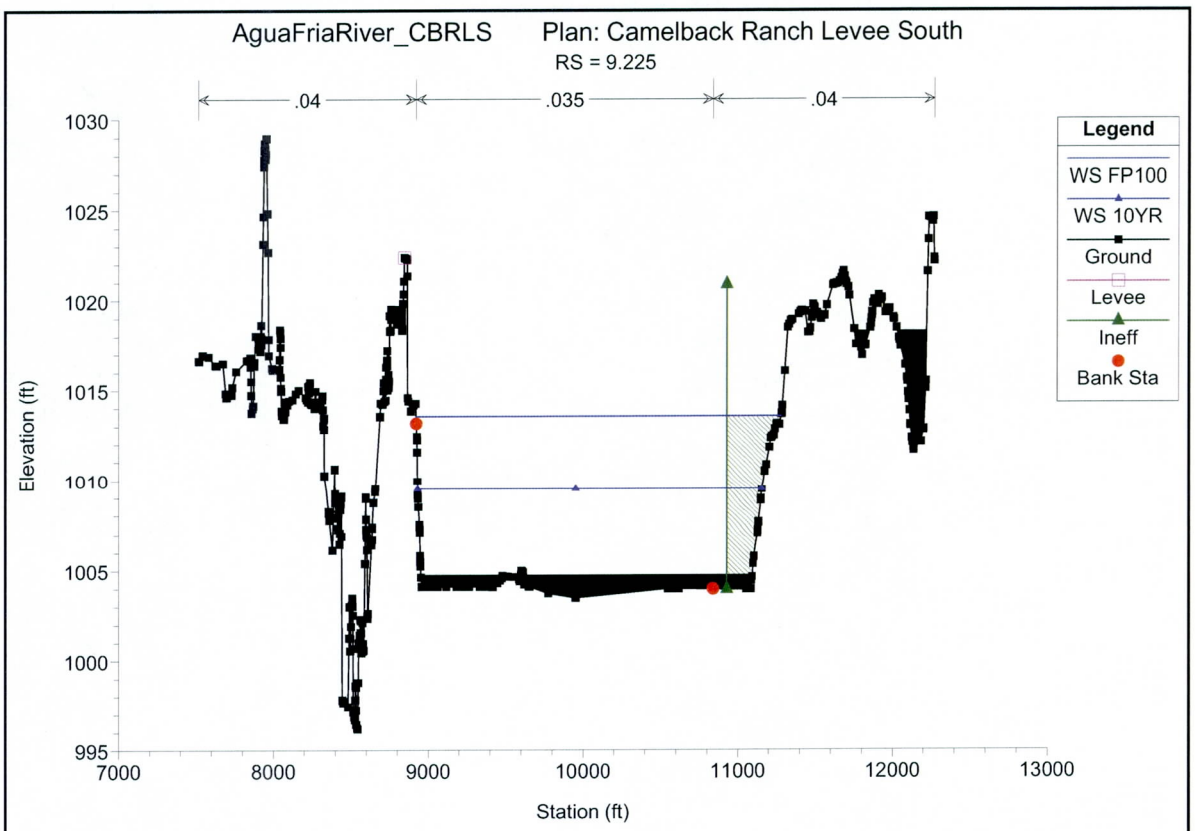
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Plan: Camelback Ranch Levee South
RS = 9.225
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Legend
WS FP100
WS 10YR
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)
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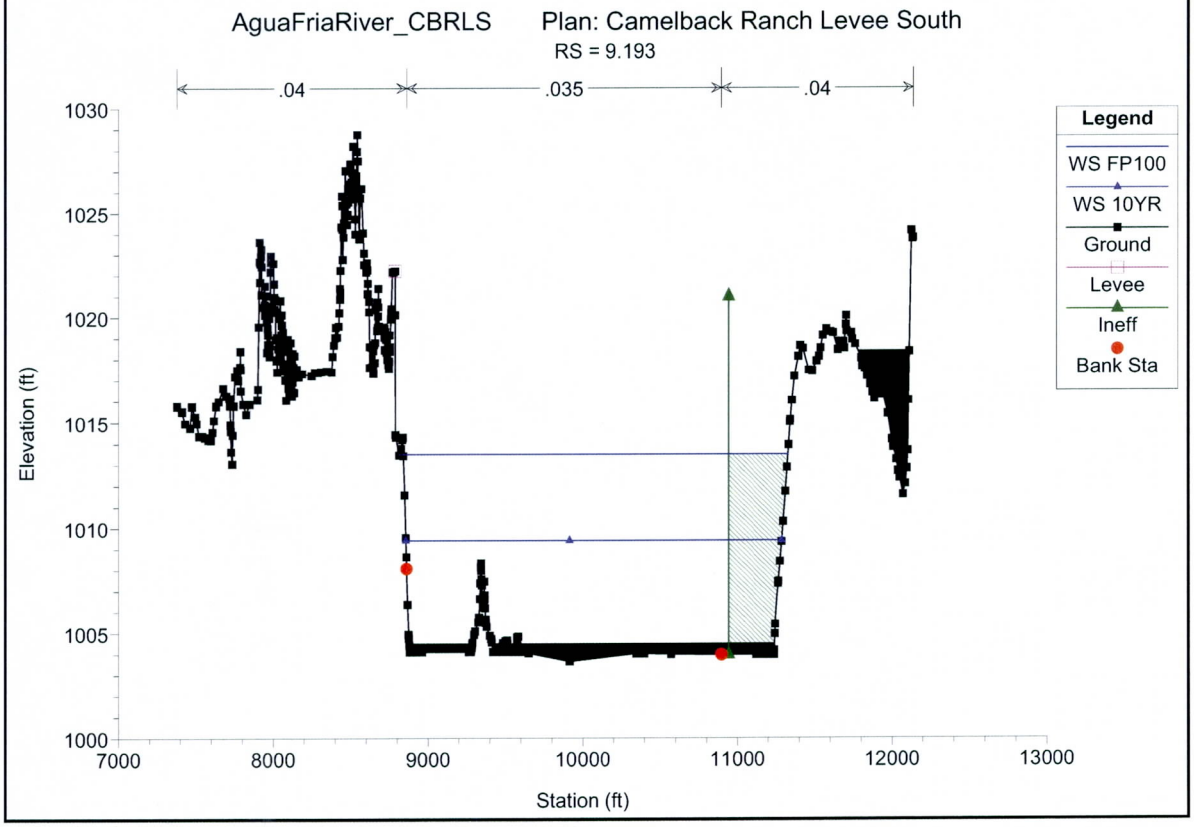
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Legend
WS FP100
WS 10YR
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
Station (ft)
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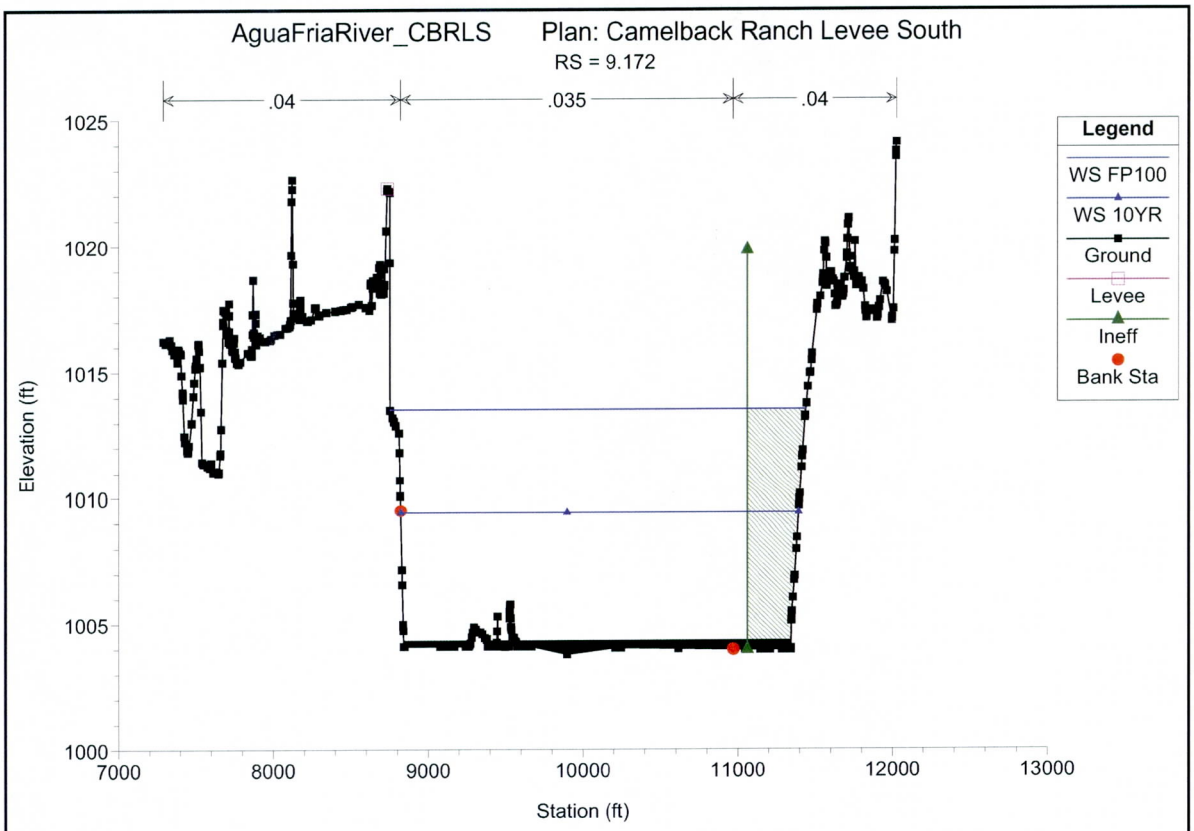
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Legend
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WS 10YR
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
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1005
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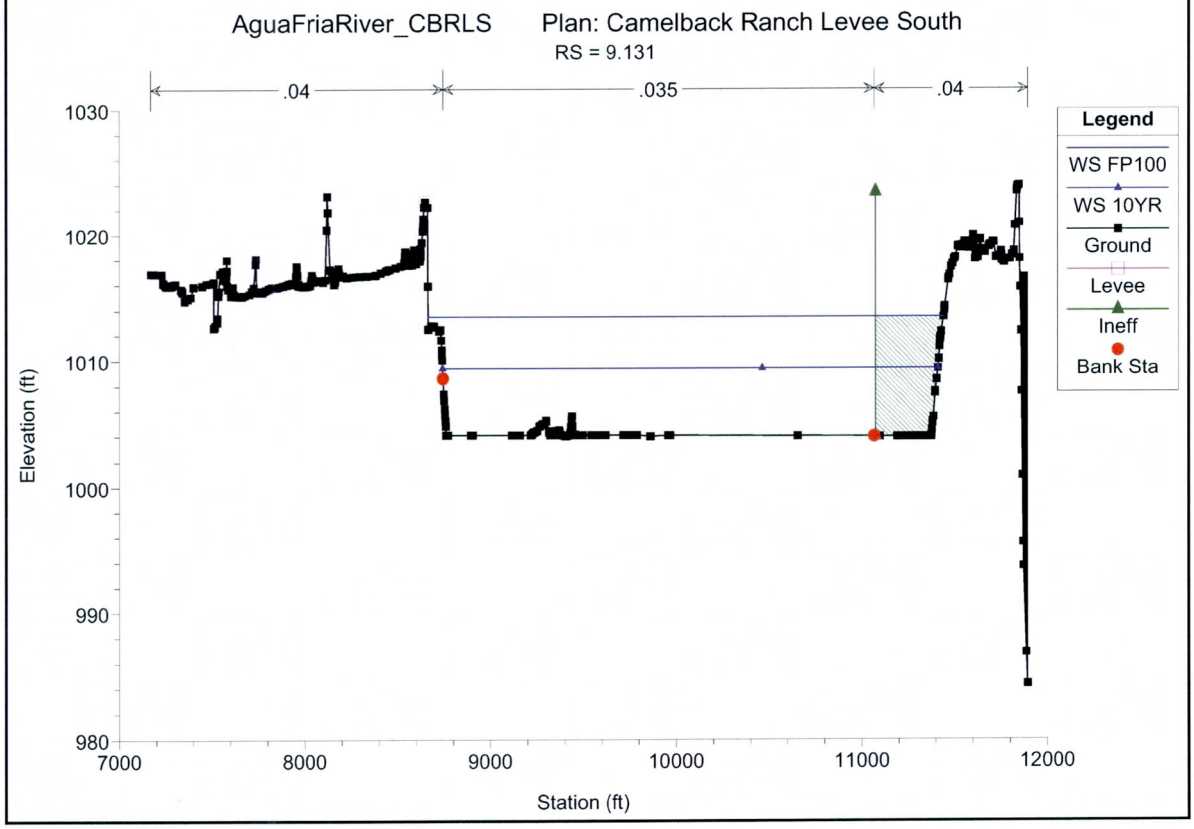
7000
8000
9000
10000
11000
12000
13000
Station (ft)


AguaFriaRiver_CBRLS
Plan: Camelback Ranch Levee South
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.035
.04
Legend
WS FP100
WS 10YR
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
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1020
1010
1000
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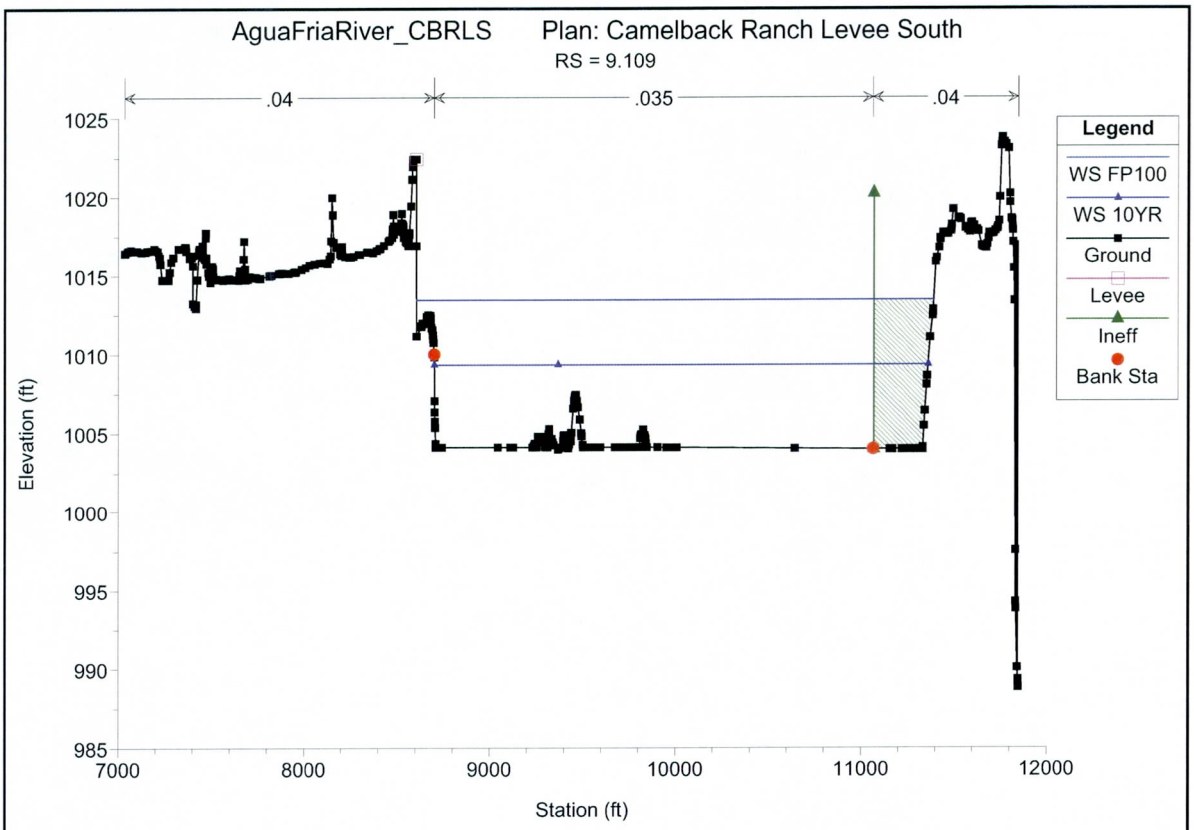
980
7000
8000
9000
10000
11000
12000
Station (ft)


AguaFriaRiver_CBRLS
Plan: Camelback Ranch Levee South
RS = 9.109
.04
.035
.04
Legend
WS FP100
WS 10YR
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
1025
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1005
1000
995
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985
7000
8000
9000
10000
11000
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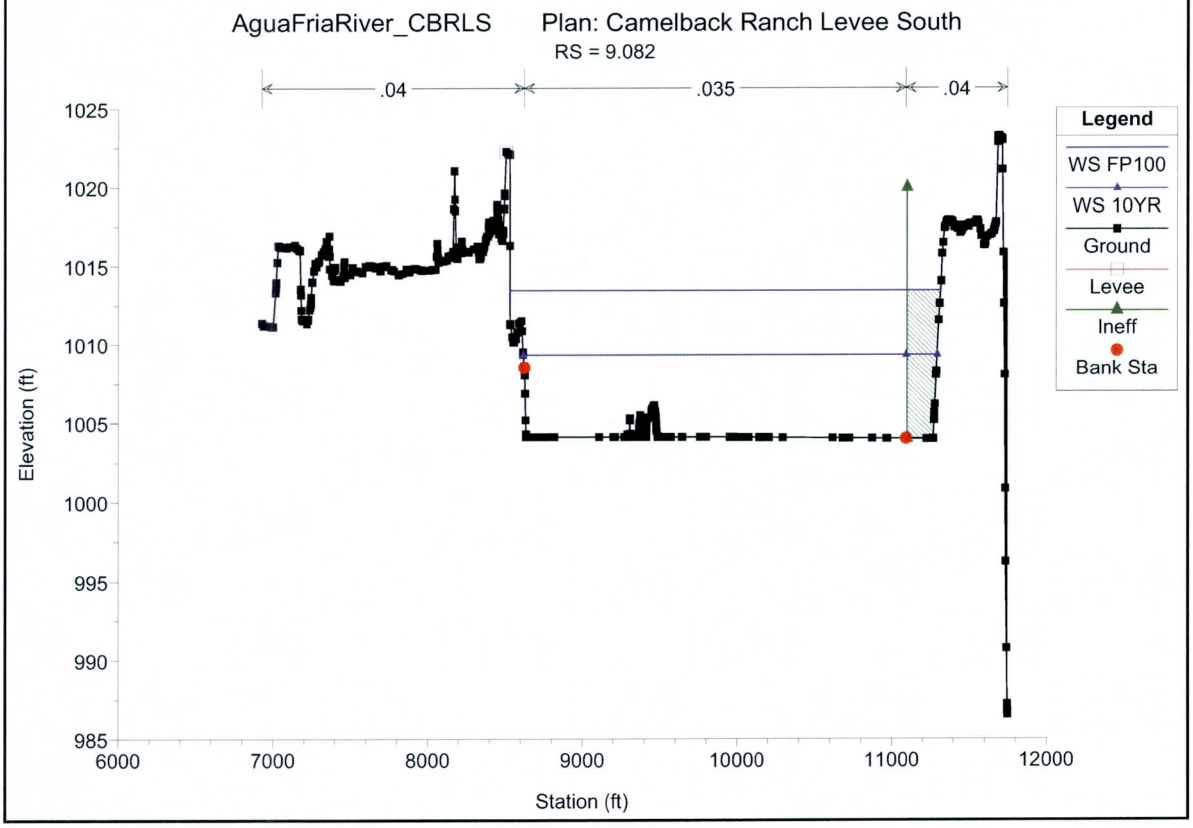
Station (ft)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Plan: Camelback Ranch Levee South
RS = 9.082
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.035
.04
Legend
WS FP100
WS 10YR
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
1025
1020
1015
1010
1005
1000
995
990
985
6000
7000
8000
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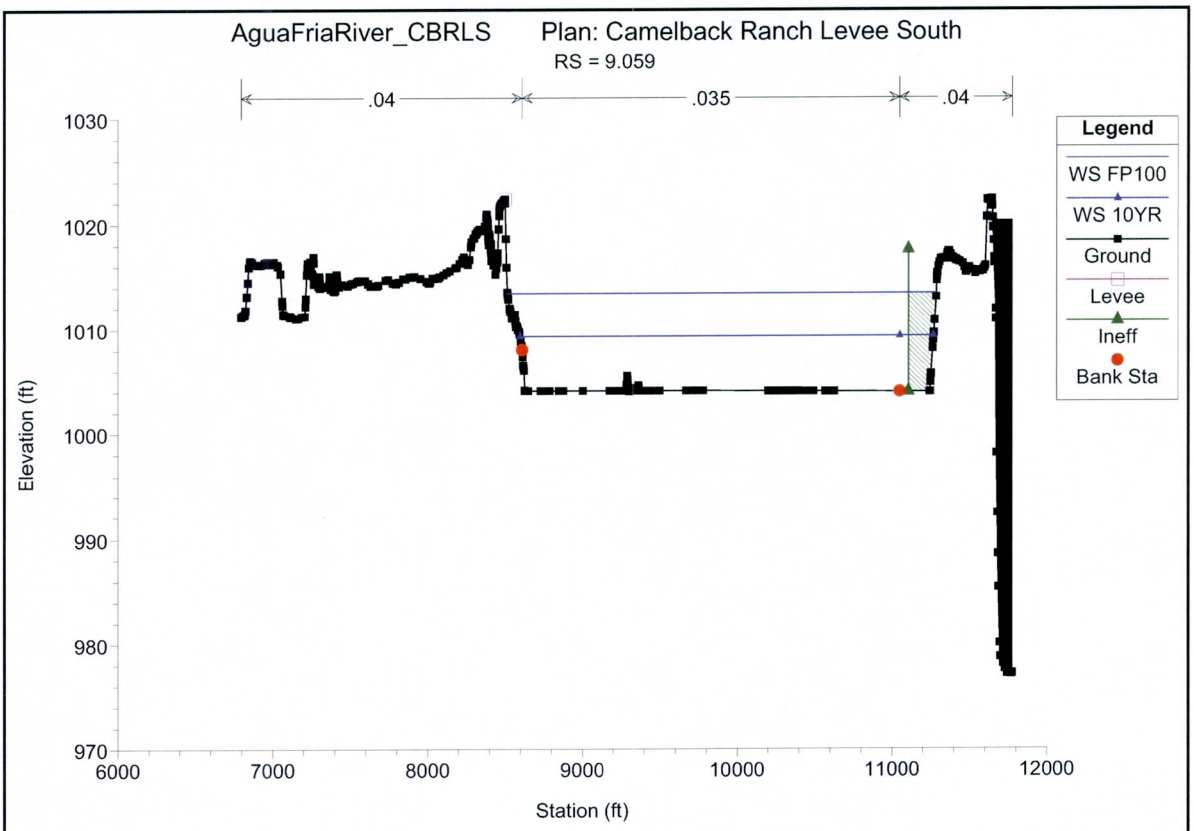
10000
11000
12000
Station (ft)


AguaFriaRiver_CBRLS
Plan: Camelback Ranch Levee South
RS = 9.059
.04
.035
.04
Legend
WS FP100
WS 10YR
Ground
Levee
Ineff
Bank Sta
Elevation (ft)
1030
1020
1010
1000
990
980
970
6000
7000
8000
9000
10000
11000
12000
Station (ft)

## B.3 HEC-RAS Summary Tables

# Standard Table 1 - 10-Year

HEC-RAS Plan: LeveeCert River: Agua Fria Reach: Reach Profile: 10YR

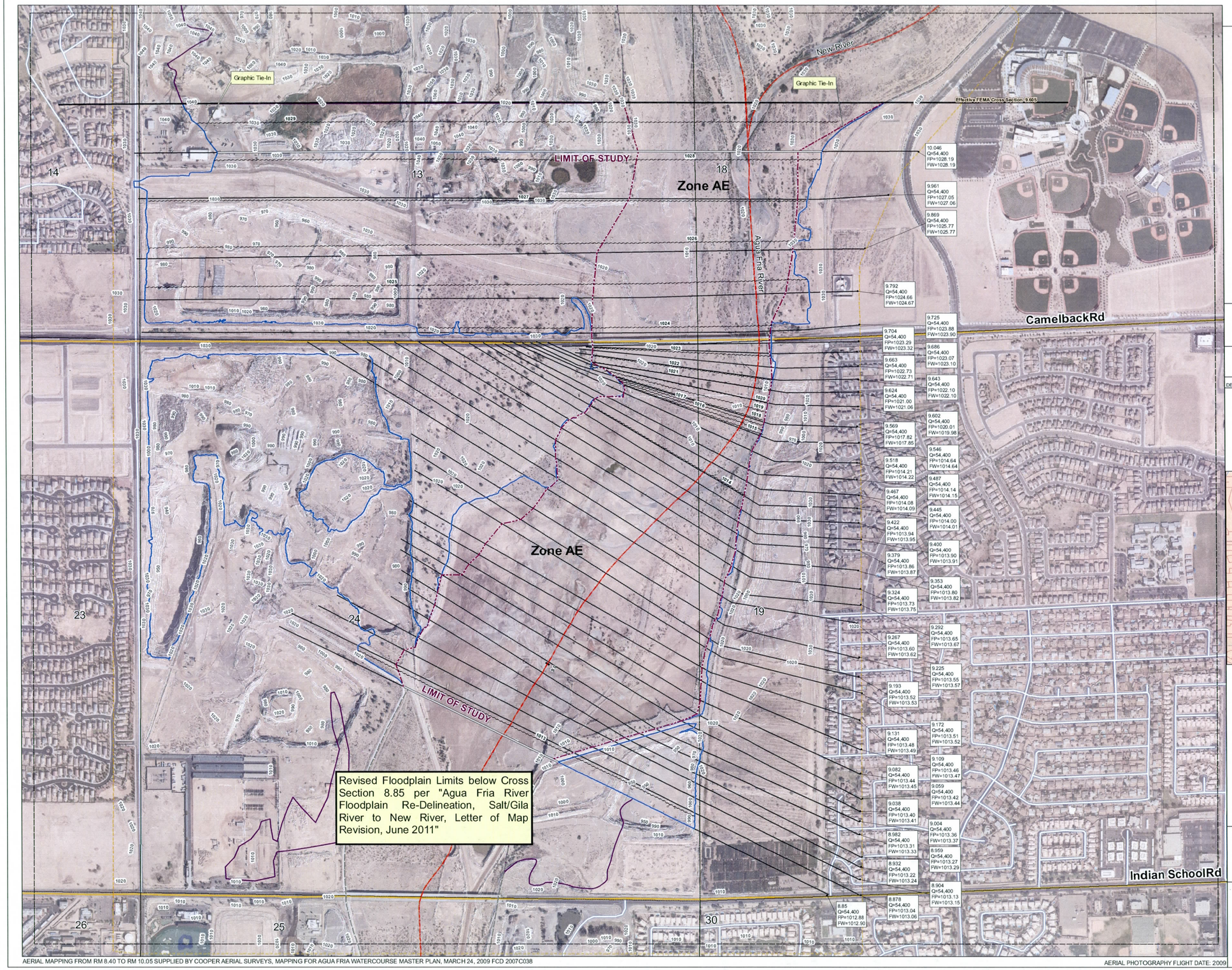
| Reach | River Sta | Profile | Q Total | Min Ch El | W.S. Elev | Crit W.S. | E.G. Elev | E.G. Slope | Vel Chnl | Flow Area | Top Width | Froude # Chl |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (cfs) | (ft) | (ft) | (ft) | (ft) | (ft/ft) | (ft/s) | (sq ft) | (ft) | |
| Reach | 10.046 | 10YR | 19040.00 | 1016.43 | 1025.66 | 1024.24 | 1026.00 | 0.003022 | 4.66 | 4086.92 | 3342.00 | 0.49 |
| Reach | 9.961 | 10YR | 19040.00 | 1014.64 | 1024.53 | 1022.29 | 1024.81 | 0.002311 | 4.22 | 4513.38 | 3279.50 | 0.43 |
| Reach | 9.869 | 10YR | 19040.00 | 1013.18 | 1022.53 | 1021.52 | 1023.18 | 0.005013 | 6.46 | 2947.36 | 4020.23 | 0.64 |
| Reach | 9.792 | 10YR | 19040.00 | 1011.61 | 1021.61 | 1018.67 | 1021.94 | 0.001765 | 4.65 | 4092.38 | 3321.66 | 0.40 |
| Reach | 9.725 | 10YR | 19040.00 | 1009.19 | 1021.08 | 1016.83 | 1021.34 | 0.001513 | 4.11 | 4636.53 | 2720.52 | 0.36 |
| Reach | 9.71 | | Bridge | | | | | | | | | |
| Reach | 9.704 | 10YR | 19040.00 | 1008.21 | 1020.78 | 1016.49 | 1021.04 | 0.002265 | 4.05 | 4712.21 | 1661.30 | 0.42 |
| Reach | 9.686 | 10YR | 19040.00 | 1008.12 | 1020.55 | 1015.91 | 1020.82 | 0.002394 | 4.11 | 4635.41 | 1660.14 | 0.43 |
| Reach | 9.663 | 10YR | 19040.00 | 1008.00 | 1020.28 | 1015.25 | 1020.55 | 0.001949 | 4.21 | 4518.97 | 1326.11 | 0.40 |
| Reach | 9.643 | 10YR | 19040.00 | 1007.74 | 1019.78 | 1016.36 | 1020.23 | 0.004729 | 5.40 | 3527.99 | 1394.49 | 0.60 |
| Reach | 9.624 | 10YR | 19040.00 | 1007.39 | 1016.44 | 1016.44 | 1019.31 | 0.010331 | 13.59 | 1400.90 | 243.80 | 1.00 |
| Reach | 9.602 | 10YR | 19040.00 | 1007.83 | 1016.41 | 1014.07 | 1017.24 | 0.002800 | 7.30 | 2608.83 | 436.38 | 0.53 |
| Reach | 9.569 | 10YR | 19040.00 | 1007.57 | 1015.11 | 1015.11 | 1016.30 | 0.013441 | 8.75 | 2175.57 | 907.90 | 1.00 |
| Reach | 9.546 | 10YR | 19040.00 | 1007.38 | 1012.50 | 1012.50 | 1013.54 | 0.013901 | 8.19 | 2324.77 | 1102.66 | 0.99 |
| Reach | 9.518 | 10YR | 19040.00 | 1007.15 | 1010.96 | 1010.50 | 1011.58 | 0.007049 | 6.32 | 3012.23 | 1272.75 | 0.72 |
| Reach | 9.487 | 10YR | 19040.00 | 1006.90 | 1010.50 | 1009.23 | 1010.82 | 0.002748 | 4.51 | 4226.23 | 1464.79 | 0.47 |
| Reach | 9.467 | 10YR | 19040.00 | 1006.73 | 1010.29 | 1008.72 | 1010.54 | 0.002031 | 4.00 | 4755.54 | 1568.88 | 0.41 |
| Reach | 9.445 | 10YR | 19040.00 | 1006.55 | 1010.11 | 1008.47 | 1010.32 | 0.001591 | 3.65 | 5218.06 | 1648.07 | 0.36 |
| Reach | 9.422 | 10YR | 19040.00 | 1006.37 | 1009.99 | 1008.09 | 1010.15 | 0.001096 | 3.22 | 5916.46 | 1705.47 | 0.30 |
| Reach | 9.400 | 10YR | 19040.00 | 1006.19 | 1009.90 | 1007.76 | 1010.03 | 0.000827 | 2.89 | 6597.22 | 1813.76 | 0.27 |
| Reach | 9.379 | 10YR | 19040.00 | 1006.02 | 1009.83 | 1007.51 | 1009.95 | 0.000682 | 2.69 | 7086.32 | 1877.16 | 0.24 |
| Reach | 9.353 | 10YR | 19040.00 | 1005.81 | 1009.75 | 1007.29 | 1009.85 | 0.000596 | 2.57 | 7412.38 | 1898.46 | 0.23 |
| Reach | 9.324 | 10YR | 19040.00 | 1005.57 | 1009.67 | 1007.07 | 1009.77 | 0.000546 | 2.52 | 7549.04 | 1859.83 | 0.22 |
| Reach | 9.292 | 10YR | 19040.00 | 1005.31 | 1009.58 | 1006.85 | 1009.68 | 0.000515 | 2.51 | 7596.27 | 1809.23 | 0.22 |
| Reach | 9.267 | 10YR | 19040.00 | 1005.11 | 1009.51 | 1006.68 | 1009.61 | 0.000490 | 2.48 | 7664.58 | 1783.96 | 0.21 |
| Reach | 9.225 | 10YR | 19040.00 | 1004.76 | 1009.45 | 1006.19 | 1009.52 | 0.000302 | 2.06 | 9306.44 | 2226.95 | 0.17 |
| Reach | 9.193 | 10YR | 19040.00 | 1004.50 | 1009.41 | 1005.93 | 1009.47 | 0.000246 | 1.90 | 10047.63 | 2431.45 | 0.15 |
| Reach | 9.172 | 10YR | 19040.00 | 1004.33 | 1009.40 | 1005.68 | 1009.44 | 0.000187 | 1.70 | 11233.34 | 2570.90 | 0.13 |
| Reach | 9.131 | 10YR | 19040.00 | 1004.00 | 1009.36 | 1005.37 | 1009.40 | 0.000147 | 1.56 | 12242.69 | 2671.43 | 0.12 |
| Reach | 9.109 | 10YR | 19040.00 | 1003.97 | 1009.35 | 1005.39 | 1009.39 | 0.000150 | 1.55 | 12260.38 | 2660.07 | 0.12 |
| Reach | 9.082 | 10YR | 19040.00 | 1004.03 | 1009.33 | 1005.34 | 1009.36 | 0.000136 | 1.48 | 12857.62 | 2676.77 | 0.11 |
| Reach | 9.059 | 10YR | 19040.00 | 1004.00 | 1009.31 | 1005.30 | 1009.35 | 0.000132 | 1.47 | 13037.93 | 2672.62 | 0.11 |
| Reach | 9.038 | 10YR | 19040.00 | 1003.97 | 1009.30 | 1005.31 | 1009.33 | 0.000140 | 1.51 | 12665.77 | 2463.88 | 0.12 |
| Reach | 9.004 | 10YR | 19040.00 | 1003.97 | 1009.26 | 1005.38 | 1009.30 | 0.000165 | 1.63 | 11809.84 | 2395.43 | 0.13 |
| Reach | 8.982 | 10YR | 19040.00 | 1003.97 | 1009.23 | 1005.45 | 1009.28 | 0.000195 | 1.76 | 10913.50 | 2238.62 | 0.14 |
| Reach | 8.959 | 10YR | 19040.00 | 1003.97 | 1009.20 | 1005.49 | 1009.26 | 0.000220 | 1.86 | 10348.04 | 2126.81 | 0.15 |
| Reach | 8.932 | 10YR | 19040.00 | 1003.95 | 1009.17 | 1005.52 | 1009.22 | 0.000243 | 1.95 | 9914.13 | 2052.73 | 0.15 |
| Reach | 8.904 | 10YR | 19040.00 | 1003.93 | 1009.10 | 1005.67 | 1009.18 | 0.000348 | 2.34 | 8532.05 | 1971.53 | 0.18 |
| Reach | 8.878 | 10YR | 19040.00 | 1003.91 | 1009.02 | 1005.77 | 1009.12 | 0.000443 | 2.60 | 7614.12 | 1845.59 | 0.21 |
| Reach | 8.850 | 10YR | 19040.00 | 1003.94 | 1008.91 | 1005.96 | 1009.04 | 0.000601 | 2.96 | 6623.82 | 1533.98 | 0.24 |

# Standard Table 1 - 100-Year

HEC-RAS Plan: LeveeCert River: Agua Fria Reach: Reach Profile: FP100

| Reach | River Sta | Profile | Q Total | Min Ch El | W.S. Elev | Crit W.S. | E.G. Elev | E.G. Slope | Vel Chnl | Flow Area | Top Width | Froude # Chl |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | (cfs) | (ft) | (ft) | (ft) | (ft) | (ft/ft) | (ft/s) | (sq ft) | (ft) | |
| Reach | 10.046 | FP100 | 54400.00 | 1016.43 | 1028.19 | 1026.38 | 1028.94 | 0.002947 | 6.94 | 7847.98 | 4517.20 | 0.53 |
| Reach | 9.961 | FP100 | 54400.00 | 1014.64 | 1027.05 | 1024.98 | 1027.70 | 0.002499 | 6.46 | 8425.94 | 5214.58 | 0.49 |
| Reach | 9.869 | FP100 | 54400.00 | 1013.18 | 1025.77 | 1024.12 | 1026.40 | 0.002880 | 6.38 | 8615.02 | 5935.00 | 0.52 |
| Reach | 9.792 | FP100 | 54400.00 | 1011.61 | 1024.66 | 1022.05 | 1025.26 | 0.002608 | 6.21 | 8784.70 | 6062.22 | 0.50 |
| Reach | 9.725 | FP100 | 54400.00 | 1009.19 | 1023.88 | 1021.50 | 1024.43 | 0.002059 | 5.94 | 9161.39 | 5302.00 | 0.45 |
| Reach | 9.71 | | Bridge | | | | | | | | | |
| Reach | 9.704 | FP100 | 54400.00 | 1008.21 | 1023.29 | 1021.17 | 1023.87 | 0.002240 | 6.13 | 8919.58 | 1686.95 | 0.47 |
| Reach | 9.686 | FP100 | 54400.00 | 1008.12 | 1023.07 | 1020.96 | 1023.66 | 0.002302 | 6.17 | 8830.52 | 1679.88 | 0.47 |
| Reach | 9.663 | FP100 | 54400.00 | 1008.00 | 1022.73 | 1020.86 | 1023.36 | 0.002669 | 6.35 | 8567.93 | 1727.52 | 0.50 |
| Reach | 9.643 | FP100 | 54400.00 | 1007.74 | 1022.10 | 1020.95 | 1022.97 | 0.004542 | 7.49 | 7272.44 | 1714.41 | 0.64 |
| Reach | 9.624 | FP100 | 54400.00 | 1007.39 | 1021.00 | 1020.55 | 1022.32 | 0.008185 | 9.23 | 5903.46 | 1584.68 | 0.84 |
| Reach | 9.602 | FP100 | 54400.00 | 1007.83 | 1020.01 | 1019.43 | 1021.39 | 0.007620 | 9.46 | 5809.75 | 1471.36 | 0.82 |
| Reach | 9.569 | FP100 | 54400.00 | 1007.57 | 1017.83 | 1017.83 | 1019.76 | 0.011479 | 11.16 | 4888.25 | 1313.15 | 1.00 |
| Reach | 9.546 | FP100 | 54400.00 | 1007.38 | 1014.64 | 1014.64 | 1016.72 | 0.011150 | 11.59 | 4696.03 | 1121.44 | 1.00 |
| Reach | 9.518 | FP100 | 54400.00 | 1007.15 | 1014.21 | 1012.45 | 1015.09 | 0.003263 | 7.55 | 7213.23 | 1326.87 | 0.57 |
| Reach | 9.487 | FP100 | 54400.00 | 1006.90 | 1014.14 | 1011.11 | 1014.64 | 0.001483 | 5.67 | 9607.22 | 1495.00 | 0.39 |
| Reach | 9.467 | FP100 | 54400.00 | 1006.73 | 1014.08 | 1010.63 | 1014.47 | 0.001108 | 5.02 | 10849.48 | 1623.54 | 0.34 |
| Reach | 9.445 | FP100 | 54400.00 | 1006.55 | 1014.00 | 1010.18 | 1014.33 | 0.000902 | 4.67 | 11663.77 | 1672.43 | 0.31 |
| Reach | 9.422 | FP100 | 54400.00 | 1006.37 | 1013.94 | 1009.68 | 1014.22 | 0.000712 | 4.28 | 12700.88 | 1731.27 | 0.28 |
| Reach | 9.400 | FP100 | 54400.00 | 1006.19 | 1013.90 | 1009.30 | 1014.13 | 0.000572 | 3.91 | 13918.53 | 1856.05 | 0.25 |
| Reach | 9.379 | FP100 | 54400.00 | 1006.02 | 1013.86 | 1009.01 | 1014.07 | 0.000495 | 3.70 | 14729.68 | 1922.55 | 0.23 |
| Reach | 9.353 | FP100 | 54400.00 | 1005.81 | 1013.80 | 1008.78 | 1014.00 | 0.000455 | 3.58 | 15212.56 | 1979.91 | 0.23 |
| Reach | 9.324 | FP100 | 54400.00 | 1005.57 | 1013.73 | 1008.59 | 1013.93 | 0.000444 | 3.58 | 15213.72 | 1955.41 | 0.22 |
| Reach | 9.292 | FP100 | 54400.00 | 1005.31 | 1013.65 | 1008.41 | 1013.86 | 0.000440 | 3.62 | 15031.01 | 1968.48 | 0.22 |
| Reach | 9.267 | FP100 | 54400.00 | 1005.11 | 1013.60 | 1008.26 | 1013.80 | 0.000439 | 3.56 | 15297.17 | 2078.35 | 0.22 |
| Reach | 9.225 | FP100 | 54400.00 | 1004.76 | 1013.55 | 1007.62 | 1013.70 | 0.000302 | 3.12 | 17512.19 | 2361.60 | 0.19 |
| Reach | 9.193 | FP100 | 54400.00 | 1004.50 | 1013.52 | 1007.35 | 1013.65 | 0.000258 | 2.93 | 18648.25 | 2491.18 | 0.17 |
| Reach | 9.172 | FP100 | 54400.00 | 1004.33 | 1013.51 | 1007.01 | 1013.62 | 0.000208 | 2.67 | 20490.61 | 2686.81 | 0.16 |
| Reach | 9.131 | FP100 | 54400.00 | 1004.00 | 1013.48 | 1006.67 | 1013.57 | 0.000175 | 2.49 | 21916.49 | 2780.10 | 0.14 |
| Reach | 9.109 | FP100 | 54400.00 | 1003.97 | 1013.46 | 1006.69 | 1013.55 | 0.000174 | 2.47 | 22132.58 | 2786.01 | 0.14 |
| Reach | 9.082 | FP100 | 54400.00 | 1004.03 | 1013.44 | 1006.60 | 1013.52 | 0.000157 | 2.35 | 23287.07 | 2785.09 | 0.14 |
| Reach | 9.059 | FP100 | 54400.00 | 1004.00 | 1013.42 | 1006.54 | 1013.51 | 0.000154 | 2.33 | 23528.09 | 2770.57 | 0.13 |
| Reach | 9.038 | FP100 | 54400.00 | 1003.97 | 1013.40 | 1006.58 | 1013.49 | 0.000162 | 2.39 | 22967.03 | 2580.84 | 0.14 |
| Reach | 9.004 | FP100 | 54400.00 | 1003.97 | 1013.36 | 1006.71 | 1013.45 | 0.000186 | 2.55 | 21667.88 | 2419.41 | 0.15 |
| Reach | 8.982 | FP100 | 54400.00 | 1003.97 | 1013.31 | 1006.85 | 1013.43 | 0.000219 | 2.75 | 20106.99 | 2270.63 | 0.16 |
| Reach | 8.959 | FP100 | 54400.00 | 1003.97 | 1013.27 | 1006.94 | 1013.40 | 0.000245 | 2.90 | 19032.17 | 2144.51 | 0.17 |
| Reach | 8.932 | FP100 | 54400.00 | 1003.95 | 1013.22 | 1007.01 | 1013.36 | 0.000269 | 3.02 | 18283.47 | 2071.29 | 0.18 |
| Reach | 8.904 | FP100 | 54400.00 | 1003.93 | 1013.13 | 1007.42 | 1013.31 | 0.000362 | 3.50 | 16448.33 | 2252.20 | 0.20 |
| Reach | 8.878 | FP100 | 54400.00 | 1003.91 | 1013.04 | 1007.58 | 1013.26 | 0.000438 | 3.84 | 15036.03 | 2263.09 | 0.23 |
| Reach | 8.850 | FP100 | 54400.00 | 1003.94 | 1012.88 | 1007.92 | 1013.17 | 0.000604 | 4.42 | 12797.10 | 1561.72 | 0.26 |

## B.4 Figure




AERIAL MAPPING FROM RM 8.40 TO RM 10.05 SUPPLIED BY COOPER AERIAL SURVEYS, MAPPING FOR AGUA FRIA WATERCOURSE MASTER PLAN, MARCH 24, 2009 FCD 2007C038

AERIAL PHOTOGRAPHY FLIGHT DATE: 2009

## LEGEND

- 100-YR FLOODPLAIN BOUNDARY
- 100-YR FLOODWAY
- 500-YR FLOODPLAIN
- EFFECTIVE 100-YR FLOODPLAIN BOUNDARY
- EFFECTIVE 100-YR FLOODWAY BOUNDARY
- BASE FLOOD ELEATION — 1020
- HYDRAULIC BASE LINE WITH RIVER MILE — 9.0
- SECTION BOUNDARY
- CROSS SECTION — 9.602 Q = 54,400 FP = 1019.98 FW = 1020.01
- ZONE DESIGNATION — ZONE AE
- CORPORATE LIMITS — CORPORATE LIMITS
- ELEVATION REFERENCE MARK
- TOPOGRAPHIC BOUNDARY

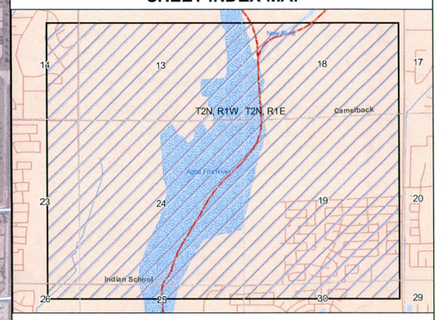
## NOTES

1. THE PORTIONS OF AGUA FRIA RIVER BEING STUDIED ARE LOCATED WITHIN SECTIONS 13 AND 24 OF TOWNSHIP 0201, RANGE 0104 AS WELL AS SECTIONS 18 AND 19 OF TOWNSHIP 0201, RANGE 0102 OF THE SALT RIVER BASELINE AND MERIDIAN.
2. HORIZONTAL PROJECTION IS ARIZONA STATE PLANE, CENTRAL ZONE, NORTH AMERICAN DATUM OF 1983.
3. ALL ELEVATIONS ARE BASED ON NORTH AMERICAN VERTICAL DATUM OF 1988.

## ELEVATION REFERENCE MARKS

| STATION DESIGNATION | NAD 83 EASTING (FEET) | NAD 83 NORTHING (FEET) | NAVD 88 ELEVATION (FEET) | DESCRIPTION |
|---|---|---|---|---|

## SHEET INDEX MAP




# FLOODPLAIN DELINEATION STUDY FOR A PORTION OF AGUA FRIA RIVER

## FLOODPLAIN WORK MAP

## MARICOPA COUNTY, ARIZONA

## JUNE, 2011

JE FULLER HYDROLOGY & GEOMORPHOLOGY, INC

Flood Control District of Maricopa County

400 200 0 400 800
Feet

CONTOUR INTERVAL = 2 FEET

FIGURE E-3

# C. Scour Evaluation for Embankment Toe Down

# Appendix C

## Camelback Ranch Levee South
## Maricopa County, Arizona

## Scour Evaluation for Embankment Toe Down

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C.2 HEC-RAS Summary Table
C.3 Scour Calculations
C.4 Figures

# 1. Design Toe-down Recommendations

## 1.1 Design Scour Computations used for Embankment Toe-Down.

The toe-down elevations and top of levee elevations were documented in the letter report by Simons, Li and Associates, Inc. dated December 4, 1996 (SLA 96 Letter Report). The SLA 96 Letter Report documented the calculations used to determine the total scour as the sum of four individual components: long term degradation, general scour, bedform scour and low-flow Incisement.

**Long-term scour**

Long-term scour was determined using a stable channel slope methodology combined with a depth to armoring determination. Depth to armoring limited the long term scour to a maximum of 2.5 feet.

**General scour**

SLA 96 Letter Report mentions a sediment transport model named QUASED in the scour table title and has 0 general scour for a portion of the cross-section and approx. 2-3 ft for others. The letter report did not mention of how the general scour was determined.

**Bedform scour**

Bedform scour was calculated based upon the methodology presented in the Flood Control District of Maricopa County "Drainage Design Manual - Hydraulics". Variables for the calculations were derived from the project HEC-2 model. These variables included Froude number, channel velocity, and channel hydraulic depth. The generally low flow velocities and Froude numbers caused dune, rather than anti-dune, scour conditions to dominate through the project area. Bedform scour depths were generally less than one foot but as high as 2.5 feet at some cross sections.

**Low-flow incisement**

Low flow incisement was estimate at 1.5 feet for areas where mining was **not** occurring and 0.0 ft where in stream mining was occurring.

A safety factor was applied by increasing the calculated scour depth by an additional 30%.

**Table C-1** below lists the calculated scour depths developed from the methodology discussed above, for cross sections along the levee for the 10-year/SPF flooding events. Additional data is included in SLA 1996 Letter Report in **Appendix C.1.** See **Table C-1** below (Table 5 contained within the letter report).

## Table C-1: Recommended Levee Design Elevations

**TABLE 5**

**CAMELBACK RANCH LEVEE DESIGN**

**Phase 1**

**Recommended Design Elevations**

| Section Number | Channel Invert (Feet) | Rec. Toedown Elevation (Feet) | Water Surf. Elevation (Feet) | Rec. Top of Bank Elevation (Feet) | Bank Height (Feet) | Remarks |
|---|---|---|---|---|---|---|
| 13.0 | 1002.0 | 992.0 | 1016.6 | 1019.6 | 27.6 | Begin Phase 1 Levee (Mining section) |
| 14.0 | 1002.0 | 992.0 | 1017.4 | 1020.4 | 28.4 | Mining section |
| 15.0 | 1002.0 | 994.0 | 1017.9 | 1020.9 | 26.9 | Mining section |
| 16.0 | 1004.0 | 986.2 | 1019.1 | 1022.1 | 36.0 | Mining section |
| 17.0 | 1004.0 | 991.1 | 1020.4 | 1023.4 | 32.3 | Mining section |
| 18.0 | 1004.0 | 988.1 | 1021.6 | 1024.6 | 36.5 | |
| 18.5 | 1012.0 | 1000.6 | 1023.6 | 1026.6 | 26.1 | End Phase 1 Levee |

Note: Elevations reported in NGVD 1929.

# 2. Current Conditions Topography and Hydraulics

## 2.1 Topographic Changes

Topographic data was obtained from FCDMC for the Agua Fria Mapping, FCD 07-38 (Agua Fria 2009). Mapping limits extend from downstream of Indian School Road to upstream past the project limits. Additional survey data was also obtained at FIS cross-sections to supplement the mapping obtained from FCDMC. The topographic mapping from the FCDMC was obtained when a portion of the sand and gravel mining pits contained water. The FCDMC mapping captured the surface water elevation instead of the actual pit bottom. The supplemental survey data was based on actual pit bottom rather than a ponded water surface elevation. This supplemental survey information was used to provide depth of the pit bottom and minimum channel elevation (Applied Invert in **Table C-2**) for the scour calculations.

## 2.2 Hydraulic Modeling

A new steady-state HEC-RAS model was developed, as described in **Appendix B,** based on the recent Agua Fria 2009 Mapping.

# 3. Current Conditions Scour Assessment

## 3.1 Total Scour Equation

The scour computations used to evaluate the adequacy of the levee toe-down are presented in this section. The total scour is computed as the sum of four individual components: long term degradation, general scour, bedform scour and low-flow Incisement. The scour was evaluated along the entire length of the levee to reflect changes in the recent channel bed conditions due to the expansions of the in-stream gravel mining operation adjacent to Camelback Ranch Levee South. The changes in the in-stream mining limits were outlined from aerial and topographic information dated 1995 (Agua Fria Mapping FCD 94-25) and 2009 (Agua Fria Mapping FCD 07-38). See **Figure C-2** in **Appendix C.4**.

The scour analysis for the Camelback Ranch Levee South is estimated using procedures outlined in the Arizona Department of Water Resources Engineering Analysis of Fluvial Systems (ADWR, 1985; hereafter, "the ADWR Manual"), USBR report on "Computing Degradation and Local Scour" by Pemberton and Lara (1984) and Maricopa County Flood Control District, Draft River Mechanics Manual for DDMSW, 2009. The total scour equation (ADWR Manual) is:

$$Z_t = SF\ (Z_{deg} + Z_{gs} + \tfrac{1}{2} Z_a + Z_{ls} + Z_{bs} + Z_{lft})$$

where:

$Z_t$ = Design scour depth, (ft)
SF = Safety factor (1.0 – 1.5)
$Z_{deg}$= Long-term degradation, (ft)
$Z_{gs}$ = General scour depth, (ft)
$Z_a$ = Anti-dune trough depth, (ft)
$Z_{ls}$ = Local scour depth, (ft)
$Z_{bs}$ = Bend scour depth, (ft)
$Z_{lft}$ = Low-flow thalweg depth, (ft)

The total scour depth is applied downwards starting from the channel thalweg elevation taken from the cross-sectional geometry.

## 3.2 Scour Components

### 3.2.1 Long-Term Channel Degradation

Long-term scour describes the gradual lowering of a watercourse through multiple events and longer periods of time. Long-term scour was determined using a stable channel slope methodology combined with a depth to armoring determination. Depth to armoring limited the long term scour to a maximum of 2.5 feet. In addition to the stable channel slope method, impacts due to headcut development from the in-stream mining pit were also considered.

The long-term scour component is determined based on the potential lowering of the channel bed within the project reach in the long-term. There can be a variety of causes leading to the wide scale lowering of the channel. Any significant disruption in sediment continuity could result in bed changes over the long-term.

The presence of a soil cement grade control structure 150 ft south (downstream) of Indian School Road provides a control point for applying long-term scour based on stable channel slope methodology. This grade control protects against long-term lowering of the bed

elevations at the location of the grade control. The locations upstream of the grade control could be subject to long-term lowering with the constraint that bed elevations at the grade control are fixed by the grade control elevation.

Another factor influencing the long-term degradation adjacent to the levees is the presence of in-stream sand and gravel mining pit (See **Figure C-2** in **Appendix C.4**.). This mining pit also contributes to the long-term degradation in terms of a headcut and tailcut which are, respectively, formed at the upstream and downstream boundaries of the pit. In general, in-stream mining undermines the stability of the channel. However, the impacts from the in-stream mining to neighboring structures are usually minimized due to prescribed setbacks of mining activities from the adjacent structures by FCDMC.

The mining pit within the study reach is located adjacent to most of the levee in the main channel flow direction. The upstream end of the pit is located approximately 500 ft downstream of the Camelback Road Bridge. In the channel cross-section, the pit is centrally located. As a result, the overall long-term lowering of the channel due to change in channel slope could impact the channel bed adjacent to the pit which includes locations adjacent to the levee.

Another phenomenon influencing the long-term channel bed variations is armoring. The channel bed within the study reach consists of sediment ranging from fine sand to large cobbles. The overall channel bed conditions indicate a presence of armored layer consisting of gravels and cobbles. This is an indication that the presence of limited sediment supply to the study reach and a low tendency towards channel aggradation

The procedures adopted for determining the long term potential for channel degradation are discussed below.

#### 3.2.1.1 Equilibrium Slope

Equilibrium slope[1] is defined as the slope which causes the channel's sediment transport capacity to equal the incoming sediment supply (ADWR, 1985). If the existing slope is too steep, channel velocities will be high and net degradation will occur. If the existing slope is too flat, channel velocities will be low and net aggradation will occur. The equilibrium slope is the slope that the undisturbed, natural channel will tend towards over the long term.

Equilibrium slope computations are performed to determine the long-term stable slope. The equilibrium slope can be viewed as the slope that the channel would tend to move towards in the long-term. Grade control located near Indian School Road (**Figure C-1**) provides a hardpoint and is used as the downstream starting point in determining stable channel bed elevations based upon an equilibrium slope. Aggradation is anticipated in places where the pit/channel bottom is lower than the stable slope channel elevation and degradation can be expected to occur elsewhere. This criterion is used to determine the extent of long-term scour that could result from the overall lowering of the channel bed caused by the tendency of the river to shift towards an equilibrium slope.

[1] Equilibrium slope is also referred to as stable slope or limiting slope.

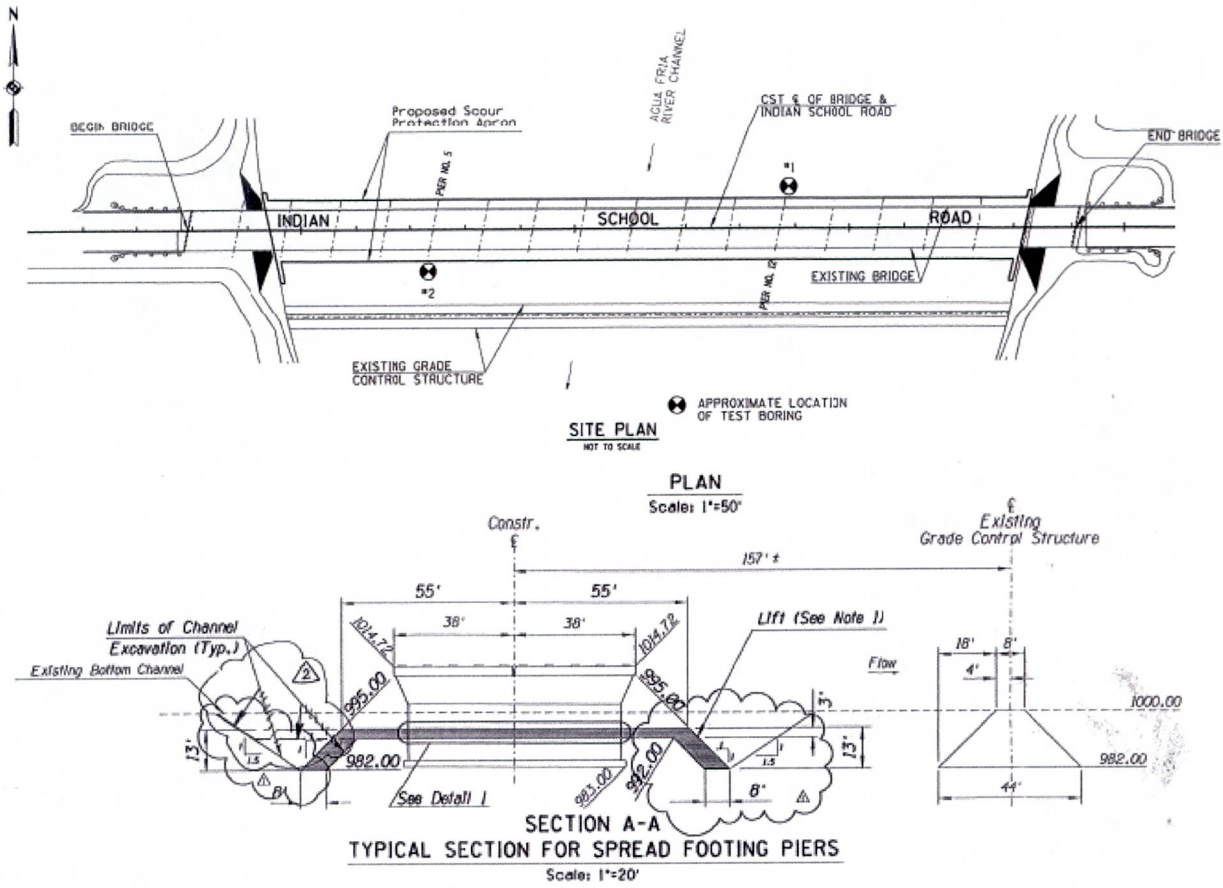



**Figure C-1: Grade Control Structure below Indian School Road**

## Methodology

Most equilibrium slope equations are based on the mean annual flood, the "channel-forming," or "bankfull" discharge. On many perennial alluvial streams, particularly in humid climates, the mean annual flood and the channel-forming and bankfull discharges are nearly equivalent. However, on ephemeral streams where flow events are rare, the channel-forming discharge is often difficult to determine. It is assumed that the 10-year event better approximates bankfull conditions in the study reach.

The 10-year hydraulic results from the HEC-RAS model have been used in the application of equilibrium slope equations for the study area

Guidelines provided in BUREC's (Pemberton and Lara, 1984) manual for computing scour and channel degradation downstream of dams or other structures that interrupt the natural sediment supply to the downstream channel has been used in the estimation of the equilibrium slope. Specifically, the following equations are used:

- Schoklitsch Equation
- Meyer-Peter Muller Equation
- Shield's Diagram Method

These three equations are zero bed sediment discharge (clear water) equations, and represent minimum slopes that would occur if sediment supply were disrupted. Clear water conditions can be expected to occur in the study reach due to the presence of an in-stream mining pit.

**Schoklitsch Equation**

The Schoklitsch (Shulits, 1935) equation is based on the concept of zero bedload transport.

$$S_L = K_s (D W_{bf}/Q)^{3/4}$$

Where $S_L$ = Stable slope (ft/ft)
$K_s$ = 0.00174
$W_{bf}$ = Bankfull width (ft)
D = Mean bed sediment diameter (mm)
Q = Dominant discharge (cfs)

**Meyer-Peter, Muller Equation**

The Meyer-Peter, Muller (1948) equation is based on the incipient motion theory, or the point of initiation of sediment transport, for zero sediment inflow.

$$S_L = K_{mpm} (Q/Q_{bf}) (n_s/D_{90}^{1/6})^{3/2} D / d$$

Where $S_L$ = Stable slope (ft/ft)
$K_{mpm}$ = 0.19
$Q/Q_{bf}$ = Ratio of total flow to flow over the channel
$Q_{bf}$ = Dominant discharge (cfs)
$n_s$ = Manning's n for the stream bed
$D_{90}$ = Bed sediment diameter for which 90 percent is smaller (mm)
D = Mean sediment diameter (mm)
d = Channel depth (ft)

**Shields Diagram Method**

The Shields diagram (1936) for determining the boundary condition for no sediment transport can be used to define an equation for stable slope.

$$R_* = U_* D / \upsilon$$
$$U_* = (S_L R g)^{1/2}$$
$$T_* = \tau_c / ((\gamma_s - \gamma_w) D )$$

Where $S_L$ = Stable slope (ft/ft)
$R_*$ = Boundary Reynold's number
$U_*$ = Shear velocity = $(S_L R g)^{\wedge 0.5}$
D = Mean sediment diameter (mm)
$\upsilon$ = Kinematic viscosity of water ($ft^2$/sec)
R = Hydraulic radius for wide channels (ft)

$g$ = Gravitational constant = 32.2 ft/sec$^2$
$T_*$ = Dimensionless shear stress
$\tau_c$ = Critical shear stress (lb/ft$^2$)
$\gamma_s, \gamma_w$ = Specific weight of sediment (lb/ft$^3$) and water (lb/ft$^3$)

The average slope calculated using all three methods was used to determine the channel equilibrium slope. See **Table C-7**.

### 3.2.1.2 Headcut Computations

Headcut calculations for the sand and gravel mining pit are used to investigate the lowering of the bed elevations due to the headcut caused by the presence of the pit. The pit is located within the channel cross-section while the main focus of this evaluation is the long-term scour adjacent to the levee. To adequately address these scenarios, five potential headcut alignments have been identified using engineering judgment (See **Figure C-3** in **Appendix C.4**.). These alignments depict the potential paths the headcut formation can take over the long-term. The headcut computations are performed to provide bed elevations at the headcut along the alignments. Tailcut is not considered in this study as the downstream end of the pit is located downstream of the end of the levee. Hence, tailcut from the mining pit is not expected to have any impact to the levee toe-down. Three methods were evaluated.

**ADOT Procedure**

Simons, Li and Associates (**Reference 9**) investigated the effects of in-stream mining on channel stability and presented a procedure to compute the headcut and tailcut resulting from a pit with a simplified rectangular geometry. The Engineering Division of FCDMC (2007) has developed a computer software tool incorporating this methodology. This tool was used to investigate the potential impacts of headcut on the levee. The results of the computations include the profile of headcut which are presented in the **Appendix C.3**. The computations were repeated for the five potential headcut paths. The results indicate that the maximum total impact distance is less than 233 ft. The levee is located at least 800 ft from the pit boundary while the results using the ADOT procedure computes a maximum headcut distance of 233 ft. In other words, these results indicate that there will be no significant impact to Camelback Ranch Levee South due to the headcut. See **Tables C-11**, **C-12**, **C-13**, **C-14** and **C-15**.

**Simplified Headcut Methods**

In addition to the ADOT Methodology, two simplified methods were used to compute the headcut profile. These two methods are summarized as follows:

- The max scour depth is one half of the pit depth at the brink point. The length is = (PitDepth)/(2 x RiverSlope). This method is based on Williams et al. (2002).
- The max scour depth is one half of the pit depth at the brink point. The length is = (PitDepth/2) x 100. This method is based on Boyle Engineering (1980) and USACE (1987).

These two methods are anticipated to be conservative in nature. The results are presented in **Tables C-9** and **C-10** in **Appendix C.3**. The results computed using the two procedures indicate that the existing channel thalweg elevations are **lower** than the computed headcut elevations. In other words, the results do not show a long-tem impact to the levee due to headcut.

### 3.2.1.3 Armoring Potential Evaluation

The armoring potential is investigated to determine whether any of the degradation including headcut can be limited by channel bed armoring. The applicability of the armoring potential is applied to locations outside the mining pit boundary. As mentioned earlier, five headcut alignments have been identified (See **Figure C-2**). The development of the headcut could potentially be restricted by armoring of the channel bed. Armoring computations are used to estimate the armoring depth which is, in turn, used to estimate the channel elevation limited by armoring.

When the channel sediment transport capacity exceeds the upstream sediment supply, the balance of the sediment load may be eroded from the channel bed, causing the channel to degrade. As the fine sediments can be transported at more frequent, lower discharges and velocities than coarse sediments, which may require large floods to be moved, fine sediment tends to be preferentially removed from the channel bed. Selective removal of fine sediments causes the channel bed material to become progressively coarser over time, as long as the upstream sediment supply is limited. If this process continues over a long period, it ultimately creates a surficial layer of coarse channel sediments, called an armor layer, that the stream is incapable of transporting (Yang, 1996).

The U.S. Bureau of Reclamation (USBR) recommends the following methodologies for estimating the minimum sediment size and depth of scour required to form an armor layer for a given flow rate as found in Pemberton and Lara (**Reference 5**):

- Meyer-Peter, Muller Bedload Transport Function
- Competent Bottom Velocity
- Shields Diagram
- Yang Incipient Motion

Each of these methodologies was applied to Agua Fria River within the study reach.

**<u>Meyer-Peter, Muller Bedload Transport Function</u>**

The Meyer-Peter, Muller (**Reference 6**) bedload sediment transport function for the beginning of transport of individual grain sizes can be used to estimate the non-transportable sediment size.

$$D_c = d\ S\ /\ (K_{mpm}\ (n/D_{90}^{(1/6)})^{3/2})$$

Where:

$D_c$ = Non-transportable sediment diameter (mm)
d = Average flow depth (ft)
S = Energy slope (ft/ft)
$K_{mpm}$ = 0.19
n = Manning's n for the stream bed
$D_{90}$ = Particle size for which 90% of the bed material is finer (mm)

**<u>Competent Bottom Velocity</u>**

This methodology is based on the work of Mavis and Lushey (1948), who developed an equation for the beginning of sediment movement on a stream bed.

$$D_c = 1.88\ V_m^2$$

Where:

$D_c$ = Armor size (mm)
$V_m$ = Average channel velocity (ft/s)

**Shields Diagram**

The Shields (**Reference 6**) diagram is a standard method used to define the initiation of motion for various channel bed sediment sizes. The method uses an iterative process to compute dimensionless shear stress (T*) and the armor diagram from the Shields diagram.

$$T_* = \tau_c / ((\gamma_s - \gamma_w)\ D_c)$$

Where:

$T_*$ = Dimensionless shear stress
$D_c$ = Armor size (mm)
$\tau_c$ = Critical shear stress (lb/ft$^2$)
$\gamma_s$ = Specific weight of water = 62.4 lb/ft$^3$
$\gamma_w$ = Specific weight of sediment = 165 lb/ft$^3$

Note that for gravel sediment sizes and turbulence levels typical in natural streams:

$T_*$ = 0.05 for sediment sizes greater than 1 mm and Boundary Reynold's Number ($R_*$) > 500

**Yang Incipient Motion**

Yang (1973) developed a relationship between dimensionless critical velocity ($V_{cr}$/w, where w = fall velocity, ft/s) and shear velocity Reynold's number R* at incipient motion. Under natural stream conditions for sediment sizes greater than 2 mm, Yang's equation can be written as follows:

$$D_c = 0.00659\ V_{cr}^2 \qquad \text{(For D > 2 mm)}$$

Where:

$D_c$ = Armor size (ft)
$V_{cr}$ = Critical average velocity at incipient motion (ft/s)

**Depth to Armor Equation**

Once the size of material ($D_c$) that will form an armor layer is estimated from one or more of the equations listed above, the depth of scour required to form a stable armor layer can be estimated from the sediment distribution of the channel bed material. The equation for the depth to armor is the following:

$$Y_d = y_a\ (1/\Delta p - 1)$$

Where:

$Y_d$ = Depth from original streambed to the bottom of the armor layer (ft)
$y_a$ = Thickness of the armor layer (ft)

$\Delta p$ = Decimal percentage of the bed material larger than the armor size

**Armoring Results**

The armoring calculations were performed using the 10-year discharge as representative of the dominant discharge. The computations incorporate the HEC-RAS hydraulic results at cross-sections intersecting the levee. The average critical diameter computed for the cross-sections upstream of pit where the channel thalweg is above the equilibrium slope, is approximately 32 mm. General channel conditions immediately downstream of Camelback Road can be seen in **Photo C-1, C-2 and C-3** below. This value is consistent with the value of 36 mm used in SLA 1996 Letter Report. Based on the similarity in the computed values, the armoring depth of 2.5 ft computed in the SLA report has been adopted to evaluate armoring potential within the study reach.

### 3.2.1.4 Long-term Results

The equilibrium slope computations were performed to determine the potential overall lowering of the channel going upstream from the grade control structure located 150 feet downstream of Indian School Road. The presence of the large in-stream mining pit with pit depths lower than the stable slope elevations indicated that the long-term potential for deposition within the pit. This resulted in computation of no long-term scour for levee stations 9+82 to 29+69 (HEC-RAS cross sections 8.534 to 8.897 respectively). The headcut computations using three procedures indicated no additional long-term impact to the levees due to the presence of the headcut. The armoring computations with the HEC-RAS Evaluation model results indicated similar armoring sediment size of 36 mm as computed in the SLA 1996 Letter Report. This permitted the use of armoring depth of 2.5 ft as computed in the SLA 1996 Letter Report. A combination of armoring and stable slope methods were applied between levee stations 31+04 to 44+81 (HEC-RAS cross sections 8.92 to 9.161 respectively) to include the overall lowering of the channel towards stable slope with armoring limiting the degradation. The results indicated a long-term of 0 to 2.5 ft along the levee between station 31+04 and 44+81 (HEC-RAS cross sections 8.92 to 9.161 respectively). Long-term scour results are summarized in **Table C-2** and in **Appendix C.3**.

**Photo C-1:** Looking downstream along low flow channel near Levee Station ±42+00.

**Photo C-2:** Looking upstream along low flow channel near Levee Station ±42+00.

**Photo C-3:** Channel bed material in low flow channel near Levee Station ±42+00.

### 3.2.2 General Scour

General scour, $Z_{gs}$, is the component of scour that represents the mobile portion of the bed-material of the channel bottom during a specified flow event. General scour was computed using the Lacey method as described in the US Bureau of Reclamation's "Computing Degradation and Local Scour" (Pemberton and Lara, 1984, **Reference 5**). The Lacey equation is well suited to channels in which live-bed scour occurs. It is anticipated that the Lacey equation provides a realistic value and is appropriate for the conditions encountered in the Agua Fria River.

Lacey's equation for general scour is applicable to natural streams where the sediment is not captured upstream. It is given by

$$Z_{gs} = Z\,(0.47\,[Q/f]^{1/3})$$

where

$Z_{gs}$ = general scour depth (ft);
$Q$ = design discharge (cfs);
$f$ = Lacey's silt factor = $1.76(D_m)^{1/2}$
$D_m$ = mean grain size which is taken as $D_{50}$, (mm);
$D_{50}$ = defined as the diameter where 50% is finer by weight, (mm);
$Z$ = multiplying factor (0.25 for straight reach, 0.5 for moderate bend, 0.75 for severe bend, 1.0 for right angle bends, 1.25 for a vertical rock bank or wall).

For the 100-year event, the general scour component was calculated to be 3.1 ft for the length of the levee where the existing channel is above the equilibrium slope. General Scour is applied to the total scour depth from the upstream limits of the levee (HEC-RAS cross section 9.686) to where the main channel enters the deeper portion of the mining pit (after HEC-RAS cross section 9.379). For areas within the mining pit, where aggradation is expected, the general scour component was set to 0.0 ft.

### 3.2.3 Bend Scour

Bend scour, $Z_{bs}$, occurs on the outside of bends in a stream channel. The general scour component described above using the Lacey Equation incorporates the bend scour. Agua Fria

River flood flows are expected to be parallel to the levee alignment, thus a general scour component was not computed for bend scour.

### 3.2.4 Bedform Scour

Bedform scour describes the development of dunes and troughs along the channel bottom during high flow events; this form of scour is particularly prevalent in sand-bed watercourses. Bedform scour was calculated based upon the methodology presented in the Flood Control District of Maricopa County "Drainage Design Manual - Hydraulics". Variables for the calculations were derived from the project HEC-RAS model. These variables included Froude number, channel velocity, and channel hydraulic depth.

The dune height for lower regime flow where Froude numbers are less than 0.7 is given by (Gyr and Hoyer, 2006, Zanke, 1976) as

$$0.15 < d_h/y_h < 0.3$$

where $d_h$ is the dune height and $y_h$ is the hydraulic radius.

Since a range is given for dune height in above equation, the ratio $d_h/y_h$ is assumed to be 0.2 due presence of larger size sediment present in the study reach.

Anti-dune trough depth, $Z_a$, is the component of scour caused by movement of dune shaped bed forms along the bottom of the channel. The anti-dune trough depth was estimated using the following equation:

$$Z_a = 0.0273\ V^2_m$$

where:

$V_m$ = Average velocity of flow at design discharge (ft/sec)

The anti-dune trough depth is limited to a maximum of ½ the flow depth (since $Z_a$ cannot be greater than flow depth, ADWR Manual p. 24).

The results indicate that the bedform scour is generally less than one foot. The calculations indicate formation of anti-dune at the upstream end of the levee with bedform scour of up to 2 feet. Similar to General Scour, Bedform Scour is applied to the total scour depth from the upstream limits of the levee (HEC-RAS cross section 9.686) to where the main channel enters the deeper portion of the mining pit (after HEC-RAS cross section 9.379). See **Table C-6**.

### 3.2.5 Low-flow/Thalweg Scour

Low-flow thalweg scour, $Z_{lft}$, occurs if a small channel forms to convey minor flows within the main channel of a stream. The low-flow thalweg component of scour is not considered for a natural channel, since the natural channel minimum elevation already reflects the elevation of the thalweg. Therefore, for this reach of the Agua Fria River, the low-flow thalweg scour component is set as zero.

### 3.2.6 Local Scour

Local scour, $Z_{ls}$, occurs where there is an abrupt change in the direction of flow caused by obstructions such as bridge piers, abutments, or other structures such as grade control

structures. The Camelback Road Bridge is the only structure other than the levee in the vicinity of the levee. Since the Camelback Road Bridge is located outside the upstream end of the levee, there is no local scour impact to the levee. Scour impacts at Camelback Road Bridge are not considered as part of this study.

### 3.2.7 Applied Invert

The applied invert varied along the channel reach for the levee. The applied invert for the levee was taken from the minimum channel elevation within 1500 feet of the levee embankment protection. **Table C-2** provides the station/elevation of the levee embankment along with the station/elevation for the minimum channel elevation (Applied Invert) for each of the HEC-RAS model cross section within the levee limits.

### 3.2.8 Factor of Safety

The ADWR Manual states that the safety factor generally varies between 1.0 and 1.5, but should be selected based on risk, consequence of failure, incremental construction cost, and regulatory factors. For the purpose of this toe-down evaluation, a resultant safety factor was determine by comparing the calculated scour elevation to the design toe of soil cement from the Record Drawing for *Camelback Ranch Levee South (FCD 97-18), DMJM, 1989* for the levees.

or

$$\text{Calculated Safety Factor} = \frac{\text{Applied Invert} - \text{Design Toe of Soil Cement}}{\text{Total Scour Depth}}$$

## Table C-2: Applied Invert

| (1)Levee Station | (1)HEC-RAS Cross Section | Toe of Embankment | | (2)Applied Invert Elevation within 1000 ft of Embankment | | (3)Source for Applied Invert |
|---|---|---|---|---|---|---|
| | | Station (ft) | Elevation (ft) | Station (ft) | Elevation (ft) | |
| 44+81 | 9.686 | 9914.87 | 1008.12 | 9914.87 | 1008.1 | HEC-RAS |
| 43+53 | 9.663 | 9894.25 | 1008.0 | 9894.25 | 1008.0 | HEC-RAS |
| 42+43 | 9.643 | 9856.19 | 1007.74 | 9856.19 | 1007.7 | HEC-RAS |
| 41+39 | 9.624 | 9856.94 | 1007.39 | 9860 | 1004.7 | Survey |
| 40+16 | 9.602 | 9847.83 | 1007.8 | 9847.83 | 1007.0 | HEC-RAS |
| 38+35 | 9.569 | 9818.37 | 1007.6 | 9818.37 | 1007.0 | HEC-RAS |
| 37+02 | 9.546 | 9785.45 | 1007.4 | 10071.17 | 1006.5 | HEC-RAS |
| 35+38 | 9.518 | 9779.55 | 1007.2 | 10025.71 | 1006.2 | HEC-RAS |
| 33+59 | 9.487 | 9630.08 | 1016.42 | NA | 1005.4 | Interpolated |
| 32+39 | 9.467 | 9571.36 | 1015.36 | NA | 1004.6 | Interpolated |
| 31+04 | 9.445 | 9507.34 | 1015.03 | NA | 1003.6 | Interpolated |
| 29+69 | 9.422 | 9447.36 | 1014.95 | NA | 1002.7 | Interpolated |
| 28+49 | 9.4 | 9380.43 | 1014.54 | 10400 | 1001.8 | Survey |
| 27+40 | 9.379 | 9314.63 | 1014.66 | NA | 1000.5 | Interpolated |
| 25+95 | 9.353 | 9234.65 | 1014.72 | NA | 998.7 | Interpolated |
| 24+33 | 9.324 | 9143.48 | 1014.39 | NA | 996.7 | Interpolated |
| 22+51 | 9.292 | 9045.88 | 1014.93 | 10465 | 994.5 | Survey |
| 21+19 | 9.267 | 8970.40 | 1014.93 | NA | 994.7 | Interpolated |
| 18+97 | 9.225 | 8865.70 | 1014.57 | NA | 995.2 | Interpolated |
| 17+05 | 9.193 | 8789.04 | 1014.43 | NA | 995.7 | Interpolated |
| 16+12 | 9.172 | 8754.07 | 1013.51 | 10120 | 995.9 | Survey |
| 14+24 | 9.131 | 8662.99 | 1012.46 | NA | 995.8 | Interpolated |
| 13+03 | 9.109 | 8605.81 | 1011.18 | NA | 995.7 | Interpolated |
| 11+27 | 9.082 | 8533.06 | 1011.32 | NA | 995.6 | Interpolated |
| 09+82 | 9.059 | 8544.87 | 1011.09 | 9944 | 995.6 | Survey |

Note:
1. Levee Stations and HEC-RAS cross sections were derived using HEC-RAS cross section line crossing Levee Alignment Stationing.
2. Applied invert from HEC-RAS model or survey point at equivalent station.
3. HEC-RAS minimum channel invert, Field Survey point in the vicinity of the cross section line or interpolated elevations from bounding survey points.

All elevations NAVD 1988.

# 4. Results

The scour calculations for each of the scour components were performed using the procedures discussed in **Section 3**. The hydraulic parameters were obtained from the 10- and 100-year HEC-RAS hydraulic modeling results. The details of the computations and results are presented in **Appendix B. Table C-3** lists the summary of calculated scour depths estimated using the methodology presented in this evaluation.

**Table C-3: Embankment Toe-down Adequacy**

| (1)Levee Station | (1)HEC-RAS Cross Section | Total Scour Depth (ft) | (2)Applied Invert (ft) | Calculated Scour Elevation (ft) | (3)Design Toe of Soil Cement (ft) | (4)Calculated Safety Factor | (5)Adequate Toe-down? |
|---|---|---|---|---|---|---|---|
| 44+81 | 9.686 | 6.1 | 1008.1 | 1002.0 | 1002.7 | 0.9 | See Further Discussion in **Section 2.4.3** |
| 43+53 | 9.663 | 6.1 | 1008.0 | 1001.9 | 1001.9 | 1.0 | |
| 42+43 | 9.643 | 5.4 | 1007.7 | 1000.7 | 999.0 | 1.6 | Yes |
| 41+39 | 9.624 | 3.1 | 1004.7 | 1000.7 | 996.2 | 2.8 | Yes |
| 40+16 | 9.602 | 6.4 | 1007.8 | 999.8 | 992.9 | 2.4 | Yes |
| 38+35 | 9.569 | 7.0 | 1007.6 | 998.8 | 990.3 | 2.6 | Yes |
| 37+02 | 9.546 | 7.2 | 1007.4 | 999.0 | 990.4 | 2.6 | Yes |
| 35+38 | 9.518 | 5.4 | 1007.2 | 1000.6 | 990.6 | 3.3 | Yes |
| 33+59 | 9.487 | 4.4 | 1005.4 | 999.7 | 990.3 | 3.4 | Yes |
| 32+39 | 9.467 | 3.1 | 1004.6 | 1000.6 | 989.8 | 4.8 | Yes |
| 31+04 | 9.445 | 3.1 | 1003.6 | 999.6 | 989.2 | 4.7 | Yes |
| 29+69 | 9.422 | 3.1 | 1002.7 | 998.7 | 988.7 | 4.6 | Yes |
| 28+49 | 9.4 | 3.1 | 1001.8 | 997.9 | 988.5 | 4.3 | Yes |
| 27+40 | 9.379 | 3.1 | 1000.5 | 996.5 | 989.5 | 3.6 | Yes |
| 25+95 | 9.353 | 0.0 | 998.7 | 998.7 | 990.9 | NA | Yes |
| 24+33 | 9.324 | 0.0 | 996.7 | 996.7 | 992.4 | NA | Yes |
| 22+51 | 9.292 | 0.0 | 994.5 | 994.5 | 994.1 | NA | Yes |
| 21+19 | 9.267 | 0.0 | 994.7 | 994.7 | 994.1 | NA | Yes |
| 18+97 | 9.225 | 0.0 | 995.2 | 995.2 | 994.1 | NA | Yes |
| 17+05 | 9.193 | 0.0 | 995.7 | 995.7 | 994.1 | NA | Yes |
| 16+12 | 9.172 | 0.0 | 995.9 | 995.9 | 994.1 | NA | Yes |
| 14+24 | 9.131 | 0.0 | 995.8 | 995.8 | 994.1 | NA | Yes |
| 13+03 | 9.109 | 0.0 | 995.7 | 995.7 | 994.1 | NA | Yes |
| 11+27 | 9.082 | 0.0 | 995.6 | 995.6 | 994.1 | NA | Yes |
| 09+82 | 9.059 | 0.0 | 995.6 | 995.6 | 994.1 | NA | Yes |

Note:
1. Levee Stations and HEC-RAS cross sections were derived using HEC-RAS cross section line crossing Levee Alignment Stationing.
2. Applied invert from HEC-RAS model. See Section 3.2.7
3. Levee elevations from *Camelback Ranch Levee – South, Indian School Rd. – Camelback Rd., FCD 97-12, January 1997.*
4. NA. Total Scour = 0 for gravel mining area. Levee toe elevation lower than Applied Invert at each cross section in this area.
5. See Additional discussions for levee stations 42+43 to 45+04.

All elevations NAVD 1929.

# 5. References

1) ADWR, 1985. Design Manual for Engineering Analysis of Fluvial Systems. Prepared by Simons Li Associates.

2) ADWR, 1996, Watercourse System Sediment Balance. State Standard Attachment SSA 5-96.

3) FCDMC (2007), Pit Scour 1.0.2, Sand/Gravel Mining Pit Headcut/Tailcut Profile

4) Calculation Tool (Pit Scour 1.0.2), User's Manual.

5) Pemberton, E.L., and Lara, J.M., 1984, Computing Degradation and Local Scour, Technical Guideline for Bureau of Reclamation. Denver, Colorado. January.

6) Shields, A., 1936, Anwendung der Aenlichkeitsmechanik und der Turbulenzforschung anf die Geshciebebewegung, Mitteil, PVWES, Berlin, No. 26.

7) Meyer-Peter, E., and Muller, R., 1948, Formulas for Bed-Load Transport, International Association for Hydraulic Structures, Second Meeting, Stockholm.

8) Meyer-Peter, E., and Muller, R., 1948, Formulas for Bed-Load Transport, International Association for Hydraulic Structures, Second Meeting, Stockholm.

9) Simons, Li and Associates, "Effects of In-Stream Mining on Channel Stability," FHWA Report Number: FHWA-AZ89-250, Arizona Department of Transportation (ADOT), June 1989 (3 Volumes).

10) Williams, D. T., H. H. Hu, B. J. Doeing, and C. Phillips (2002). Headcut Analysis Due to Overbank Sand and Gravel Mining, Association of State Floodplain Managers, Annual Conference, Phoenix, Arizona

11) Boyle Engineering Corporation (1980). Central Arizona Water Control Study: Sand and Gravel Mining Guidelines. Report prepared for the U.S. Army Corps of Engineers, Los Angeles District, July 1980.

12) USACE (1987). Sand and Gravel Mining Guidelines: Skunk Creek, New, and Agua Fria

13) Mavis, F. T., and L. M. Laushey (1948), "A Reappraisal of the Beginning of Bed-Movement-Competent Velocity," International Association of Hydraulic Research, Second Meeting, Stockholm.

14) Yang, C. T., (1973), "Incipient Motion and Sediment Transport," Journal of Hydraulic Division, ASCE, vol. 99, No. HY10, Proceeding Paper 10067.

# C Hydraulic Data for Levee Freeboard Evaluation

## C.1 SLA 96 Letter Report

## C.2 HEC-RAS Summary Table

See **Appendix B.3** for Standard Table 1, 10-Year Flows and Standard Table 1, 100-Year Flows

**HEC-RAS Report (AguaFriaRiver_CBRLS_Eval.pdf) on data disk in **Appendix H**

## C.3 Scour Calculations

Table C-4: Scour Calculations Summary
Table C-5: General Scour Calculations using Lacey Equation
Table C-6: Bedform Scour
Table C-7: Equilibrium Slope Differences
Table C-8: Armoring
Table C-9: Headcut Method #1
Table C-10: Headcut Method #2
Table C-11: ADOT Method Headcut Profile #1
Table C-12: ADOT Method Headcut Profile #2
Table C-13: ADOT Method Headcut Profile #3
Table C-14: ADOT Method Headcut Profile #4
Table C-15: ADOT Method Headcut Profile #5

## C.4 Figures

Figure C-2: Approximate Mining Pit Limits
Figure C-3: Head Cut Profile Locations

## C.1 SLA 96 Letter Report

sla Simons, Li & Associates, Inc.
Water Resources & Civil Engineering Consultants

December 4, 1996

Michael Shapiro, P.E.
Project Manager
Daniel, Mann, Johnson & Mendenhall
300 West Clarendon Avenue - Suite #400
Phoenix, AZ 85013

**RE: CAMELBACK RANCH LEVEE DESIGN, PHASE 1 DESIGN SUBMITTAL**

Dear Michael:

Enclosed for the above submittal to the Flood Control District of Maricopa County is the following support information for the top-of-bank and toe-down elevations recommended by Simons, Li & Associates, Inc.:

- Table 1 - Sediment transport and scour analysis for existing conditions
- Table 2 - Sediment transport and scour analysis for proposed conditions
- Table 3 - Sediment transport and scour analysis for proposed conditions with mining
- Table 4 - Comparison of HEC-2 and QUASED water-surface elevations
- Table 5 - Recommended design elevations
- Table 6 - Calculated average equilibrium slope and armoring sediment size
- Table 7 - Cross-section stations
- Figure 1 - Cross-section locations
- Example hand calculations for long-term scour, bed-form scour, and factor of safety
- Disk (3.5") containing eight (8) HEC-2 input and output files, and six (6) QUASED output files.

The Standard Project Flood (SPF) of 142,000 cfs was used to determine all levee design elevations and scour components, except for long-term scour. The 10-year discharge of 23,000 cfs was used to estimate long-term scour.

4600 South Mill Avenue, Suite 200 • Tempe, AZ 85282 • Phone: (602) 491-1393 • Fax: (602) 491-1396
*An Equal Opportunity Employer*

This information is being provided with the understanding that it will be modified, as necessary, during the Phase 2 design analysis. If you have any questions or need additional information, please do not hesitate to call me.

Sincerely,

SIMONS, LI & ASSOCIATES, INC.

Bart S. Bergendahl, P.E.
Project Manager

Registered Professional Engineer (Civil)
CERTIFICATE NO.
23660
BART S.
BERGENDAHL
Date Signed 12-4-96
ARIZONA, U.S.A.

Enclosures

BSB/DLR/ad

[PAZ-DMJM-11]
rwpdos6:let001

TABLE 7 - Cross-section stations

| Cross-Section No. | Section No. |
|---|---|
| 13 | 10+10 |
| 14 | 16+50 |
| 15 | 22+60 |
| 16 | 28+80 |
| 17 | 34+50 |
| 18 | 39+25 |
| 18.5 | 43+90 |

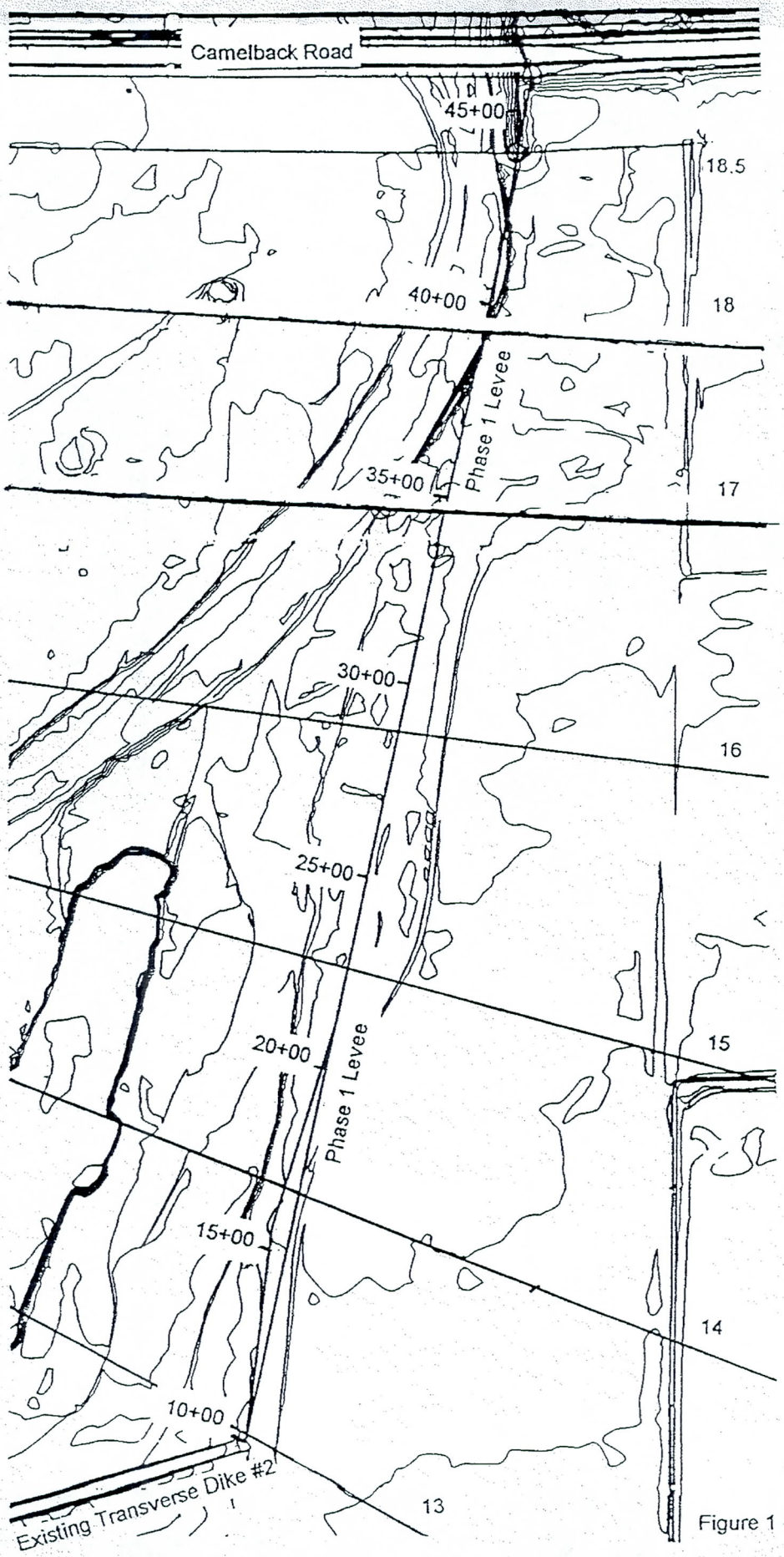



Figure 1 - Cross-section locations

## TABLE 1

## CAMELBACK RANCH LEVEE DESIGN

### Sediment Transport and Scour Analysis

### Existing Conditions (QUASED)

| Section Number | Distance upstream from g.c.s (Feet) | Channel Invert (Feet) | Computed W.S. Elevation (Feet) | Maximum Depth (Feet) | Channel Velocity (Feet/sec.) | Energy Slope ( Ft/Ft) | General Scour (Feet) | LONG-TERM | | Low Flow Scour (Feet) | BEDFORM SCOUR | | Factor of Safety (30%) (Feet) | Total calc. toe down (Feet) | Total calc. toe down elev. (Feet) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Stable Slope (Feet) | Armoring (Feet) | | Dune (Feet) | Antidune (Feet) | | | |
| | | | [1] | [1] | [1] | [1] | | [2] | [2] | | | | | | |
| 13.00 | 2959 | 1002.0 | 1016.54 | 14.54 | 7.04 | 0.00135 | 0.00 | 0.88 | 2.50 | 1.5 | 0.83 | 0.67 | 0.51 | 3.72 | 998.28 |
| 14.00 | 3468 | 1002.0 | 1017.26 | 15.26 | 6.63 | 0.00112 | 0.00 | 0.68 | 2.50 | 1.5 | 0.88 | 0.59 | 0.47 | 3.54 | 998.46 |
| 15.00 | 3959 | 1002.0 | 1017.90 | 15.90 | 6.99 | 0.00180 | 0.00 | 0.50 | 2.50 | 1.5 | 0.93 | 0.66 | 0.43 | 3.35 | 998.65 |
| 16.00 | 4463 | 1004.0 | 1018.88 | 14.88 | 8.07 | 0.00295 | 2.20 | 2.30 | 2.50 | 1.5 | 0.86 | 0.88 | 1.61 | 8.50 | 995.50 |
| 17.00 | 5013 | 1004.0 | 1020.29 | 16.29 | 9.26 | 0.00255 | 3.00 | 2.10 | 2.50 | 1.5 | 0.96 | 1.16 | 1.88 | 9.63 | 994.37 |
| 18.00 | 5444 | 1004.0 | 1021.54 | 17.54 | 6.15 | 0.00128 | 1.60 | 1.93 | 2.50 | 1.5 | 1.05 | 0.51 | 1.37 | 7.45 | 996.55 |
| 18.50 | 5914 | 1012.0 | 1022.60 | 10.60 | 13.99 | 0.00661 | 2.50 | 9.75 | 2.50 | 1.5 | 0.57 | 2.64 | 2.29 | 11.43 | 1000.57 |

[1] SPF Hydraulics
[2] 10-year Hydraulics

## TABLE 2

## CAMELBACK RANCH LEVEE DESIGN

### Sediment Transport and Scour Analysis

### Proposed Conditions w/o Mining (QUASED)

| Section Number | Distance upstream from g.c.s (Feet) | Channel Invert (Feet) | Computed W.S. Elevation (Feet) | Maximum Depth (Feet) | Channel Velocity (Feet/sec.) | Energy Slope ( Ft/Ft) | General Scour (Feet) | LONG-TERM | | Low Flow Scour (Feet) | BEDFORM SCOUR | | Factor of Safety (30%) (Feet) | Total calc. toe down (Feet) | Total calc. toe down elev. (Feet) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Stable Slope (Feet) | Armoring (Feet) | | Dune (Feet) | Antidune (Feet) | | | |
| | | | [1] | [1] | [1] | [1] | | [2] | [2] | | | | | | |
| 13.00 | 2959 | 1002.0 | 1016.64 | 14.64 | 6.93 | 0.00132 | 0.00 | 0.88 | 2.50 | 1.5 | 0.84 | 0.65 | 0.51 | 3.73 | 998.27 |
| 14.00 | 3468 | 1002.0 | 1017.42 | 15.42 | 4.10 | 0.00114 | 0.00 | 0.68 | 2.50 | 1.5 | 0.89 | 0.23 | 0.47 | 3.55 | 998.45 |
| 15.00 | 3959 | 1002.0 | 1017.34 | 15.34 | 7.39 | 0.00161 | 0.00 | 0.50 | 2.50 | 1.5 | 0.89 | 0.74 | 0.42 | 3.30 | 998.70 |
| 16.00 | 4463 | 1004.0 | 1019.06 | 15.06 | 8.33 | 0.00302 | 2.10 | 2.30 | 2.50 | 1.5 | 0.87 | 0.94 | 1.60 | 8.44 | 995.56 |
| 17.00 | 5013 | 1004.0 | 1020.38 | 16.38 | 9.02 | 0.00235 | 2.50 | 2.10 | 2.50 | 1.5 | 0.96 | 1.10 | 1.71 | 8.90 | 995.10 |
| 18.00 | 5444 | 1004.0 | 1021.56 | 17.56 | 6.23 | 0.00147 | 0.00 | 1.93 | 2.50 | 1.5 | 1.05 | 0.52 | 0.89 | 5.37 | 998.63 |
| 18.50 | 5914 | 1012.0 | 1023.58 | 11.58 | 11.99 | 0.00636 | 2.00 | 9.75 | 2.50 | 1.5 | 0.63 | 1.94 | 1.93 | 9.87 | 1002.13 |

[1] SPF Hydraulics
[2] 10-year Hydraulics

## TABLE 3

## CAMELBACK RANCH LEVEE DESIGN

### Sediment Transport and Scour Analysis

### Proposed Conditions With Mining (QUASED)

| Section Number | Distance upstream from g.c.s (Feet) | Mining Invert (Feet) | Computed W.S. Elevation (Feet) | Maximum Depth (Feet) | Channel Velocity (Feet/sec.) | Energy Slope ( Ft/Ft) | General Scour (Feet) | LONG-TERM | | Low Flow Scour (Feet) | BEDFORM SCOUR | | Factor of Safety (30%) (Feet) | Total calc. toe down (Feet) | Total calc. toe down elev. (Feet) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Stable Slope (Feet) | Armoring (Feet) | | Dune (Feet) | Antidune (Feet) | | | |
| | | | [1] | [1] | [1] | [1] | | [2] | [2] | | | | | | |
| 13.00 | 2959 | 992.0 | 1016.62 | 24.62 | 4.04 | 0.00022 | 0.00 | 0.00 | 0.00 | 0.0 | 0.00 | 0.00 | 0.00 | 0.00 | 992.00 |
| 14.00 | 3468 | 992.0 | 1016.72 | 24.72 | 4.37 | 0.00029 | 0.00 | 0.00 | 0.00 | 0.0 | 0.00 | 0.00 | 0.00 | 0.00 | 992.00 |
| 15.00 | 3959 | 994.0 | 1016.83 | 22.83 | 4.72 | 0.00032 | 0.00 | 0.00 | 0.00 | 0.0 | 0.00 | 0.00 | 0.00 | 0.00 | 994.00 |
| 16.00 | 4463 | 996.0 | 1016.66 | 20.66 | 8.33 | 0.00211 | 3.80 | 0.00 | 2.50 | 0.0 | 1.27 | 0.94 | 2.27 | 9.85 | 986.15 |
| 17.00 | 5013 | 1000.0 | 1017.71 | 17.71 | 7.26 | 0.00094 | 3.30 | 0.00 | 2.50 | 0.0 | 1.06 | 0.71 | 2.06 | 8.91 | 991.09 |
| 18.00 | 5444 | 1004.0 | 1019.01 | 15.01 | 11.60 | 0.00816 | 7.30 | 1.93 | 2.50 | 1.5 | 0.87 | 1.82 | 3.31 | 15.86 | 988.14 |
| 18.50 | 5914 | 1012.0 | 1022.66 | 10.66 | 13.85 | 0.00639 | 0.00 | 9.75 | 2.50 | 1.5 | 0.57 | 2.59 | 1.53 | 8.12 | 1003.88 |

1] SPF Hydraulics
2] 10-year Hydraulics

## TABLE 4

## CAMELBACK RANCH LEVEE DESIGN

## COMPARISON OF HEC-2 AND QUASED WATER-SURFACE ELEVATIONS

| | EXISTING | | PROPOSED W/O MINING | | PROPOSED WITH MINING | |
|---|---|---|---|---|---|---|
| | QUASED | HEC-2 | QUASED | HEC-2 | QUASED | HEC-2 |
| Section Number | Computed W.S. Elevation (Feet) | Computed W.S. Elevation (Feet) | Computed W.S. Elevation (Feet) | Computed W.S. Elevation (Feet) | Computed W.S. Elevation (Feet) | Computed W.S. Elevation (Feet) |
| 13.00 | 1015.96 | 1016.54 | 1015.97 | 1016.64 | 1015.52 | 1016.62 |
| 14.00 | 1016.68 | 1017.26 | 1016.70 | 1017.42 | 1015.77 | 1016.72 |
| 15.00 | 1017.31 | 1017.90 | 1017.23 | 1017.34 | 1015.99 | 1016.83 |
| 16.00 | 1018.32 | 1018.88 | 1018.07 | 1019.06 | 1016.21 | 1016.66 |
| 17.00 | 1019.43 | 1020.29 | 1019.26 | 1020.38 | 1016.84 | 1017.71 |
| 18.00 | 1020.68 | 1021.54 | 1020.47 | 1021.56 | 1017.77 | 1019.01 |
| 18.50 | 1021.20 | 1022.60 | 1021.33 | 1023.58 | 1023.64 | 1022.66 |

## TABLE 5

## CAMELBACK RANCH LEVEE DESIGN

### Phase 1

### Recommended Design Elevations

| Section Number | Channel Invert (Feet) | Rec. Toedown Elevation (Feet) | Water Surf. Elevation (Feet) | Rec. Top of Bank Elevation (Feet) | Bank Height (Feet) | Remarks |
|---|---|---|---|---|---|---|
| 13.0 | 1002.0 | 992.0 | 1016.6 | 1019.6 | 27.6 | Begin Phase 1 Levee (Mining section) |
| 14.0 | 1002.0 | 992.0 | 1017.4 | 1020.4 | 28.4 | Mining section |
| 15.0 | 1002.0 | 994.0 | 1017.9 | 1020.9 | 26.9 | Mining section |
| 16.0 | 1004.0 | 986.2 | 1019.1 | 1022.1 | 36.0 | Mining section |
| 17.0 | 1004.0 | 991.1 | 1020.4 | 1023.4 | 32.3 | Mining section |
| 18.0 | 1004.0 | 988.1 | 1021.6 | 1024.6 | 36.5 | |
| 18.5 | 1012.0 | 1000.6 | 1023.6 | 1026.6 | 26.1 | End Phase 1 Levee |

11/23/96

# TABLE 6

## Average Equilibrium and Armorizing Sediment Size

| | | | | 10-YR HYDRAULICS | | | | ARMORING SIZE | | | | | | | | EQUILIBRIUM SLOPE | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Section Number | Manning's n | D50 (mm.) | D90 (mm.) | Hydraulic Depth (Feet) | Channel Velocity (Feet/sec.) | Energy Slope ( Ft/Ft) | Top Width (Feet) | | Meyer-Peter Muller Dc (mm) | Competent Bottom Dc (mm) | Shields Diagram Dc (Feet) | (mm) | Yang Incip. motion Dc (Feet) | (mm) | | Schoklitsch Method | Meyer-Peter Muler | Shield's Diagram |
| 1.00 | 0.025 | 3.00 | 35.00 | 4.44 | 5.21 | 0.001054 | 994.4 | | 15.18 | 51.03 | 0.05 | 15.77 | 0.18 | 54.52 | | 0.00038 | 0.00021 | 0.00020 |
| 2.00 | 0.025 | 3.00 | 35.00 | 3.79 | 6.00 | 0.001725 | 1011.4 | | 21.21 | 67.68 | 0.07 | 20.19 | 0.24 | 72.31 | | 0.00038 | 0.00024 | 0.00026 |
| 3.00 | 0.025 | 3.00 | 35.00 | 3.01 | 6.92 | 0.003124 | 1102.5 | | 30.51 | 90.03 | 0.10 | 29.04 | 0.32 | 96.19 | | 0.00041 | 0.00031 | 0.00032 |
| 4.00 | 0.025 | 3.00 | 35.00 | 3.32 | 5.36 | 0.001642 | 1291.5 | | 17.69 | 54.01 | 0.06 | 17.42 | 0.19 | 57.71 | | 0.00046 | 0.00028 | 0.00028 |
| 5.00 | 0.025 | 3.00 | 35.00 | 4.22 | 3.98 | 0.000659 | 1369.2 | | 9.02 | 29.78 | 0.03 | 9.91 | 0.10 | 31.82 | | 0.00048 | 0.00022 | 0.00020 |
| 6.00 | 0.022 | 3.00 | 35.00 | 3.50 | 4.77 | 0.000860 | 1378.8 | | 11.83 | 42.78 | 0.03 | 10.52 | 0.15 | 45.70 | | 0.00048 | 0.00022 | 0.00024 |
| 7.00 | 0.025 | 3.00 | 35.00 | 3.13 | 5.20 | 0.001176 | 1410.6 | | 11.94 | 50.84 | 0.04 | 12.63 | 0.18 | 54.31 | | 0.00049 | 0.00030 | 0.00028 |
| 8.00 | 0.025 | 3.00 | 35.00 | 3.57 | 4.52 | 0.001060 | 1424.1 | | 12.28 | 38.41 | 0.04 | 12.99 | 0.13 | 41.04 | | 0.00049 | 0.00026 | 0.00024 |
| 9.00 | 0.025 | 3.00 | 35.00 | 3.34 | 4.55 | 0.001176 | 1511.9 | | 12.74 | 38.92 | 0.04 | 13.48 | 0.14 | 41.58 | | 0.00051 | 0.00028 | 0.00026 |
| 10.00 | 0.025 | 3.00 | 35.00 | 2.87 | 5.35 | 0.001986 | 1498.1 | | 18.49 | 53.81 | 0.06 | 18.21 | 0.19 | 57.49 | | 0.00051 | 0.00032 | 0.00033 |
| 11.00 | 0.028 | 3.00 | 35.00 | 2.68 | 5.32 | 0.002704 | 1611.5 | | 19.84 | 53.21 | 0.07 | 22.38 | 0.19 | 58.85 | | 0.00054 | 0.00041 | 0.00036 |
| 12.00 | 0.028 | 3.00 | 35.00 | 2.06 | 6.26 | 0.005315 | 1782.0 | | 29.97 | 73.67 | 0.11 | 33.82 | 0.26 | 78.71 | | 0.00058 | 0.00053 | 0.00047 |
| 13.00 | 0.028 | 3.00 | 35.00 | 3.11 | 4.00 | 0.001253 | 1849.8 | | 10.67 | 30.08 | 0.04 | 13.13 | 0.11 | 32.14 | | 0.00060 | 0.00035 | 0.00029 |
| 14.00 | 0.028 | 3.00 | 35.00 | 4.01 | 3.51 | 0.000689 | 1633.6 | | 7.56 | 23.16 | 0.03 | 9.85 | 0.08 | 24.75 | | 0.00055 | 0.00027 | 0.00021 |
| 15.00 | 0.028 | 3.00 | 35.00 | 4.17 | 3.98 | 0.000840 | 1385.7 | | 9.59 | 29.78 | 0.04 | 12.02 | 0.10 | 31.82 | | 0.00048 | 0.00026 | 0.00021 |
| 16.00 | 0.028 | 3.00 | 35.00 | 2.48 | 7.55 | 0.006040 | 1226.0 | | 41.00 | 107.16 | 0.15 | 46.27 | 0.38 | 114.50 | | 0.00044 | 0.00044 | 0.00039 |
| 17.00 | 0.028 | 3.00 | 35.00 | 4.45 | 6.28 | 0.001916 | 823.1 | | 23.34 | 74.14 | 0.09 | 28.33 | 0.26 | 79.22 | | 0.00033 | 0.00025 | 0.00022 |
| 18.00 | 0.028 | 3.00 | 35.00 | 1.87 | 8.17 | 0.010335 | 1508.2 | | 52.90 | 125.49 | 0.20 | 59.69 | 0.44 | 134.07 | | 0.00051 | 0.00059 | 0.00052 |
| 18.50 | 0.028 | 3.00 | 35.00 | 3.02 | 4.46 | 0.001617 | 1713.0 | | 13.37 | 37.23 | 0.05 | 15.88 | 0.13 | 39.78 | | 0.00057 | 0.00036 | 0.00031 |
| 19.00 | 0.022 | 3.00 | 35.00 | 2.97 | 4.64 | 0.001116 | 1667.6 | | 13.03 | 40.48 | 0.04 | 11.37 | 0.14 | 43.25 | | 0.00055 | 0.00026 | 0.00029 |
| 20.00 | 0.022 | 3.00 | 35.00 | 3.08 | 4.47 | 0.000985 | 1665.6 | | 11.92 | 37.56 | 0.03 | 10.61 | 0.13 | 40.13 | | 0.00055 | 0.00025 | 0.00028 |
| 20.50 | 0.022 | 3.00 | 35.00 | 3.33 | 4.14 | 0.001225 | 1667.0 | | 16.03 | 32.22 | 0.05 | 14.00 | 0.11 | 34.43 | | 0.00055 | 0.00023 | 0.00026 |
| 21.00 | 0.028 | 3.00 | 35.00 | 3.14 | 4.38 | 0.001479 | 1671.5 | | 12.71 | 36.07 | 0.05 | 15.65 | 0.13 | 38.53 | | 0.00056 | 0.00035 | 0.00028 |
| 22.00 | 0.028 | 3.00 | 35.00 | 2.87 | 4.19 | 0.001533 | 1964.7 | | 12.04 | 33.01 | 0.05 | 15.10 | 0.12 | 35.26 | | 0.00063 | 0.00038 | 0.00030 |
| 23.00 | 0.028 | 3.00 | 35.00 | 2.61 | 5.53 | 0.003028 | 1592.7 | | 21.63 | 57.49 | 0.08 | 24.82 | 0.20 | 61.43 | | 0.00054 | 0.00042 | 0.00037 |
| 24.00 | 0.028 | 3.00 | 35.00 | 3.20 | 3.35 | 0.000846 | 2142.9 | | 7.41 | 21.10 | 0.03 | 9.84 | 0.07 | 22.54 | | 0.00067 | 0.00034 | 0.00026 |
| | 0.028 | 3.00 | 35.00 | 2.86 | 3.70 | 0.001198 | 2170.9 | | 9.38 | 25.74 | 0.04 | 11.76 | 0.09 | 27.50 | | 0.00068 | 0.00038 | 0.00031 |
| 26.00 | 0.028 | 3.00 | 35.00 | 3.53 | 3.19 | 0.000679 | 2043.0 | | 6.56 | 19.13 | 0.03 | 8.88 | 0.07 | 20.44 | | 0.00065 | 0.00031 | 0.00023 |
| 27.00 | 0.030 | 3.00 | 35.00 | 2.17 | 8.36 | 0.010162 | 1268.1 | | 54.42 | 131.39 | 0.22 | 68.11 | 0.46 | 140.38 | | 0.00045 | 0.00056 | 0.00045 |
| 28.00 | 0.030 | 3.00 | 35.00 | 3.37 | 4.84 | 0.001741 | 1472.6 | | 14.48 | 40.48 | 0.06 | 18.75 | 0.14 | 43.25 | | 0.00050 | 0.00036 | 0.00028 |
| 29.00 | 0.035 | 3.00 | 35.00 | 2.14 | 8.38 | 0.008198 | 7240.1 | | 34.36 | 132.02 | 0.18 | 54.19 | 0.46 | 141.05 | | 0.00263 | 0.00072 | 0.00045 |
| 30.00 | 0.035 | 3.00 | 35.00 | 2.08 | 6.40 | 0.001918 | 7267.3 | | 7.81 | 77.00 | 0.04 | 13.69 | 0.27 | 82.27 | | 0.00264 | 0.00074 | 0.00042 |
| 31.00 | 0.035 | 3.00 | 35.00 | 2.32 | 5.21 | 0.002327 | 7122.2 | | 10.57 | 51.03 | 0.06 | 17.25 | 0.18 | 54.52 | | 0.00260 | 0.00066 | 0.00040 |
| 32.00 | 0.035 | 3.00 | 35.00 | 1.69 | 4.97 | 0.002795 | 7032.9 | | 9.25 | 46.44 | 0.05 | 15.92 | 0.16 | 49.62 | | 0.00258 | 0.00091 | 0.00053 |
| 33.00 | 0.035 | 3.00 | 35.00 | 1.78 | 4.32 | 0.001896 | 7165.2 | | 8.61 | 35.09 | 0.04 | 11.58 | 0.12 | 37.49 | | 0.00261 | 0.00086 | 0.00049 |
| 34.00 | 0.035 | 3.00 | 35.00 | 1.75 | 5.34 | 0.001470 | 6935.9 | | 5.04 | 28.00 | 0.03 | 9.35 | 0.10 | 30.08 | | 0.00255 | 0.00088 | 0.00047 |
| 35.00 | 0.035 | 3.00 | 35.00 | 2.27 | 4.49 | 0.001975 | 7656.3 | | 8.78 | 37.90 | 0.05 | 15.39 | 0.13 | 40.49 | | 0.00275 | 0.00068 | 0.00038 |
| 36.00 | 0.035 | 3.00 | 35.00 | 2.71 | 5.91 | 0.002163 | 7442.6 | | 11.48 | 65.66 | 0.06 | 18.73 | 0.23 | 70.16 | | 0.00269 | 0.00057 | 0.00035 |
| 37.00 | 0.035 | 3.00 | 35.00 | 3.16 | 7.05 | 0.005409 | 7825.3 | | 33.48 | 93.44 | 0.17 | 52.79 | 0.33 | 99.83 | | 0.00263 | 0.00049 | 0.00031 |
| 38.00 | 0.035 | 3.00 | 35.00 | 3.53 | 5.85 | 0.003210 | 8189.3 | | 22.19 | 64.34 | 0.11 | 35.00 | 0.23 | 68.74 | | 0.00273 | 0.00043 | 0.00027 |
| 39.00 | 0.035 | 3.00 | 35.00 | 4.13 | 3.88 | 0.004061 | 8678.0 | | 32.85 | 28.30 | 0.17 | 51.80 | 0.10 | 30.24 | | 0.00285 | 0.00037 | 0.00023 |
| 40.00 | 0.035 | 3.00 | 35.00 | 4.11 | 2.93 | 0.002670 | 8557.9 | | 21.49 | 16.14 | 0.11 | 33.89 | 0.06 | 17.24 | | 0.00282 | 0.00037 | 0.00024 |
| | | | | | | | | AF aver. | 18.29 | 51.53 | 0.07 | 20.28 | 0.18 | 55.05 | | 0.00052 | 0.00033 | 0.00030 |

AF Average Size (mm) 36.29

Percent Coarser 0.09

AF Average Slope 0.00038

HYDRAULICS @ (13)

Source : Computing Degradation and Local Scour
USBR, 1984

A) ARMORING (Based on 10-yr hydraulics, $Q_{10}$, dominant discharge)

1) Meyer-Peter, Muller

$$D_c = \frac{d\,S}{K\left(\frac{n_s}{D_{90}^{1/6}}\right)^{3/2}}$$

where

$D_c$ : Individual particle size (mm.)

K : 0.19 inch-lb units

d : Mean water depth at dominant discharge (ft.)

S : Slope of energy gradient (ft/ft.)

$n_s$ : Manning's n for bed of stream

$D_{90}$ : Particle size in mm. at which 90% of bed material by weight is finer.

$$D_c = \frac{(3.11)\ (0.001253)}{0.19 \left( \frac{0.028}{35^{1/6}} \right)^{3/2}} = 10.67 \text{ mm.}$$

2) Competent Bottom Velocity

$$D_c = 1.88\ V_m^2$$

where

$V_m$ : mean channel velocity (ft/sec.)

$D_c$ : armor size (mm.)

$$D_c = 1.88\ (4.0)^2 = 30.08 \text{ mm.}$$

3) Shield's Diagram

$$R_* = \frac{V_* D_{50}}{\nu}$$

$V_*$ = shear velocity (ft/sec.)
$= \sqrt{SRg}$

$D_{50}$ = particle size (ft.)

$\nu$ = kinematic viscosity ($ft^2$/sec.)

$$V_* = \sqrt{0.001253 * 3.11 * 32.2} = 0.354 \text{ ft/sec.}$$

$$R_* = \frac{0.354 * (3/1000/0.305)}{1*10^{-5}} = 348 < 500$$

$$\therefore \quad D_c = \frac{\gamma_w \; d \; S}{(\gamma_s - \gamma_w)\, 0.059}$$

$$D_c = \frac{62.4 * 3.11 * 0.001253}{(165 - 62.4)\, 0.059} = 0.04 \text{ ft.} \equiv 12.19 \text{ mm}$$

4) Yang's Incipient Motion

$$D_c = 0.00659 \, (V_{cr})^2$$

$$D_c = 0.00659 \, (4.0)^2$$

$$= 0.105 \text{ ft} \equiv 32.14 \text{ mm.}$$

B) STABLE SLOPE (Based on 10-yr hydraulics)

1) Schoklitsch Method

$$S_L = K \left( \frac{D_{50}\ B}{Q} \right)^{3/4}$$

where B: channel width (ft.)

Q: dominant discharge ($ft^3$/sec.)

K: 0.00174 in-lb units

$D_{50}$: in mm.

$$S_L = 0.00174 \left( \frac{3\ (1849.8)}{23{,}000} \right)^{3/4} = 0.00060$$

2) Meyer-Peter Muller Method

$$S_L = \frac{K \left( \frac{Q}{Q_B} \right) \left( \frac{n_s}{D_{90}^{1/6}} \right)^{3/2} D_{50}}{d}$$

where K = 0.19 in-lb units

$\frac{Q}{Q_B}$ = Ratio of total flow to channel flow

$D_{50}$ & $D_{90}$: in mm.

$$S_L = \frac{0.19\ (1) \left( \frac{0.028}{35^{1/6}} \right)^{3/2} (3)}{(3.11)} = 0.00035$$

3) Shield's Diagram Method

As computed on page 3, $R_* = 332 < 500$

$\therefore \quad T_* = 0.052$

$$S_L = \frac{0.052\ (\gamma_s - \gamma_w)\ D_{50}}{\gamma_w\ d}$$

$$= \frac{0.052\ (165 - 62.4)\ (3/1000/0.305)}{(62.4)\ (3.11)} = 0.0003$$

LONG TERM SCOUR

ARMORING Source : USBR, 1984

$$y_d = y_a \left( \frac{1}{\Delta p} - 1 \right)$$

where

$y_a$ : thickness of armoring layer (ft.) $(2\ D_c)$

$y_d$ : depth to armor (ft.)

$\Delta p$ : decimal percentage of original bed material larger than the armor size, $D_c$

$D_c$ = 36.29 mm (Average of the 4 methods)

$\Delta p$ = 9%

$$y_d = 2\left(\frac{36.29}{304.8}\right)\left(\frac{1}{0.09} - 1\right) = 2.41 \text{ ft} \approx 2.5 \text{ ft.}$$

## Equilibrium Slope

Use G.C.S. constructed 150 ft. downstream of the Indian School Road Bridge as the pivot point

G.C.S. Elevation = 1000 ft.

Distance of x-section 13 from GCS = 2959 ft.

Equilibrium Slope = 0.00038 (Average of the 3 methods)

Stable Invert = 1000 + 0.00038(2959) = 1001.12 ft.

$y_d$ = 1002 − 1001.12 = 0.88 ft.

## BED-FORM SCOUR (SPF HYDRAULICS)

### Antidune Scour

$$\Delta z_{as} = \frac{1}{2} h_a = 0.0135 V^2$$

$$= 0.0135 (7.04)^2 = 0.67 \text{ ft.}$$

### Dune Scour

$$\Delta z_{ds} = \frac{1}{2} (0.0655 d^{1.209})$$

$$= \frac{1}{2} (0.0655 (14.54)^{1.209})$$

$$= 0.83 \text{ ft.}$$

FACTOR OF SAFETY

$$F.S. = 0.3 * \left[ \text{General} + \underbrace{\text{Min (Stable, Armoring)}^{*}}_{\text{Long-Term}} + \underbrace{\text{Max (Dune, Antidune)}}_{\text{Bed form}} \right]$$

$$= 0.3 * ( 0 + 0.88 + 0.83 )$$

$$= 0.51'$$

* For the proposed conditions with mining at sections 16 and 17; Max (Stable, Armoring) is used.

## C.2 HEC-RAS Summary Table

See **Appendix B.3** for Standard Table 1, 10-Year Flows and Standard Table 1, 100-Year Flows

## C.3 Scour Calculations

**Project:** Camelback Ranch Levee South
**Location:** Maricopa County, Arizona

**Table C-4: Scour Calculations Summary**

Calc'd by: HR
Date: 6/12/2011

Checked: JTA
Date: 6/12/2011

| (1)Levee Station | (1)HEC-RAS Cross Section | (2)Long Term Scour | (3)General Scour | (4)Bedform Scour | (5)Low Flow Incisement | Total Scour Depth | (6)Applied Invert | Calculated Scour Elevation | Design Toe of Soil Cement | (7)Safety Factor | Adequate Toe-down? |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | (ft) | (ft) | (ft) | (ft) | (ft) | (ft) | (ft) | (ft) | | |
| 44+81 | 9.686 | 2.5 | 3.07 | 0.53 | 0.0 | 6.1 | 1008.1 | 1002.0 | 1002.7 | 0.9 | See Section 2.4.3 |
| 43+53 | 9.663 | 2.5 | 3.07 | 0.50 | 0.0 | 6.1 | 1008.0 | 1001.9 | 1001.9 | 1.0 | |
| 42+43 | 9.643 | 1.9 | 3.07 | 0.42 | 0.0 | 5.4 | 1007.7 | 1000.7 | 999.0 | 1.6 | Yes |
| 41+39 | 9.624 | 0.0 | 3.07 | 1.15 | 0.0 | 4.2 | 1004.7 | 999.2 | 996.2 | 2.0 | Yes |
| 40+16 | 9.602 | 1.9 | 3.07 | 1.21 | 0.0 | 6.2 | 1007.0 | 998.9 | 992.9 | 2.3 | Yes |
| 38+35 | 9.569 | 2.0 | 3.07 | 1.68 | 0.0 | 6.8 | 1007.0 | 998.2 | 990.3 | 2.5 | Yes |
| 37+02 | 9.546 | 1.6 | 3.07 | 1.81 | 0.0 | 6.5 | 1006.5 | 998.1 | 990.4 | 2.5 | Yes |
| 35+38 | 9.518 | 1.4 | 3.07 | 0.54 | 0.0 | 5.0 | 1006.2 | 999.6 | 990.6 | 3.1 | Yes |
| 33+59 | 9.487 | 0.7 | 3.07 | 0.64 | 0.0 | 4.4 | 1005.4 | 999.7 | 990.3 | 3.4 | Yes |
| 32+39 | 9.467 | 0.0 | 3.07 | 0.67 | 0.0 | 3.7 | 1004.6 | 999.7 | 989.8 | 4.0 | Yes |
| 31+04 | 9.445 | 0.0 | 3.07 | 0.70 | 0.0 | 3.8 | 1003.6 | 998.7 | 989.2 | 3.8 | Yes |
| 29+69 | 9.422 | 0.0 | 3.07 | 0.73 | 0.0 | 3.8 | 1002.7 | 997.7 | 988.7 | 3.7 | Yes |
| 28+49 | 9.4 | 0.0 | 3.07 | 0.75 | 0.0 | 3.8 | 1001.8 | 996.9 | 988.5 | 3.5 | Yes |
| 27+40 | 9.379 | 0.0 | 3.07 | 0.77 | 0.0 | 3.8 | 1000.5 | 995.5 | 989.5 | 2.9 | Yes |
| 25+95 | 9.353 | 0.0 | 0.00 | 0.00 | 0.0 | 0.0 | 998.7 | 998.7 | 990.9 | NA | Yes |
| 24+33 | 9.324 | 0.0 | 0.00 | 0.00 | 0.0 | 0.0 | 996.7 | 996.7 | 992.4 | NA | Yes |
| 22+51 | 9.292 | 0.0 | 0.00 | 0.00 | 0.0 | 0.0 | 994.5 | 994.5 | 994.1 | NA | Yes |
| 21+19 | 9.267 | 0.0 | 0.00 | 0.00 | 0.0 | 0.0 | 994.7 | 994.7 | 994.1 | NA | Yes |
| 18+97 | 9.225 | 0.0 | 0.00 | 0.00 | 0.0 | 0.0 | 995.2 | 995.2 | 994.1 | NA | Yes |
| 17+05 | 9.193 | 0.0 | 0.00 | 0.00 | 0.0 | 0.0 | 995.7 | 995.7 | 994.1 | NA | Yes |
| 16+12 | 9.172 | 0.0 | 0.00 | 0.00 | 0.0 | 0.0 | 995.9 | 995.9 | 994.1 | NA | Yes |
| 14+24 | 9.131 | 0.0 | 0.00 | 0.00 | 0.0 | 0.0 | 995.8 | 995.8 | 994.1 | NA | Yes |
| 13+03 | 9.109 | 0.0 | 0.00 | 0.00 | 0.0 | 0.0 | 995.7 | 995.7 | 994.1 | NA | Yes |
| 11+27 | 9.082 | 0.0 | 0.00 | 0.00 | 0.0 | 0.0 | 995.6 | 995.6 | 994.1 | NA | Yes |
| 09+82 | 9.059 | 0.0 | 0.00 | 0.00 | 0.0 | 0.0 | 995.6 | 995.6 | 994.1 | NA | Yes |

Notes:
(1) - Levee Stations and HEC-RAS cross sections were derived using HEC-RAS cross section line crossing Levee Alignment Stationing.
(2) - Long Term Scour from Equilibrium slope in SLA Dec. 4 1996 Letter Report. Long Term scour applies only to cross sections where minimum channel invert above the equilibrium Slope
(3) - General Scour applied to cross sections upstream of low flow channel enters the mining pit, Live bed conditions assumed - Lacey Equation applied for general scour (USBR, "Computing Degradation and Local Scour", 1984)
(4) - Bedform scour calculated per Flood Control District of Maricopa County Method (FCDMC, "Hydraulics Design Manual").
(5)- Low flow Incisement set to 0.
(6) - Applied invert from HEC-RAS model except cross sections with supplemental field survey points.
(7) - NA for cross sections with 0.0 ft of calculated scour
All Elevations in NAVD 1988

**Project:** Camelback Ranch Levee South
**Location:** Maricopa County, Arizona

**Table C-5: General Scour Calculations using Lacey Equation**

Calc'd by: HR Date: 5/9/2011 Checked: JTA Date: 6/12/2011

| (1)Levee Station | (1)HEC-2 Cross Section | (2)Q cfs | (3)D50 mm | Z Factor | General Scour Depth (ft) | Comments |
|---|---|---|---|---|---|---|
| 44+81 | 9.686 | 54400 | 3.000 | 0.25 | 3.07 | |
| 43+53 | 9.663 | 54400 | 3.000 | 0.25 | 3.07 | |
| 42+43 | 9.643 | 54400 | 3.000 | 0.25 | 3.07 | |
| 41+39 | 9.624 | 54400 | 3.000 | 0.25 | 3.07 | |
| 40+16 | 9.602 | 54400 | 3.000 | 0.25 | 3.07 | |
| 38+35 | 9.569 | 54400 | 3.000 | 0.25 | 3.07 | |
| 37+02 | 9.546 | 54400 | 3.000 | 0.25 | 3.07 | |
| 35+38 | 9.518 | 54400 | 3.000 | 0.25 | 3.07 | |
| 33+59 | 9.487 | 54400 | 3.000 | 0.25 | 3.07 | |
| 32+39 | 9.467 | 54400 | 3.000 | 0.25 | 3.07 | |
| 31+04 | 9.445 | 54400 | 3.000 | 0.25 | 3.07 | |
| 29+69 | 9.422 | 54400 | 3.000 | 0.25 | 3.07 | |
| 28+49 | 9.4 | 54400 | 3.000 | 0.25 | 3.07 | |
| 27+40 | 9.379 | 54400 | 3.000 | 0.25 | 3.07 | |
| 25+95 | 9.353 | 54400 | 3.000 | 0.25 | 3.07 | |
| 24+33 | 9.324 | 54400 | 3.000 | 0.25 | 3.07 | |
| 22+51 | 9.292 | 54400 | 3.000 | 0.25 | 3.07 | |
| 21+19 | 9.267 | 54400 | 3.000 | 0.25 | 3.07 | |
| 18+97 | 9.225 | 54400 | 3.000 | 0.25 | 3.07 | |
| 17+05 | 9.193 | 54400 | 3.000 | 0.25 | 3.07 | |
| 16+12 | 9.172 | 54400 | 3.000 | 0.25 | 3.07 | |
| 14+24 | 9.131 | 54400 | 3.000 | 0.25 | 3.07 | |
| 13+03 | 9.109 | 54400 | 3.000 | 0.25 | 3.07 | |
| 11+27 | 9.082 | 54400 | 3.000 | 0.25 | 3.07 | |
| 09+82 | 9.059 | 54400 | 3.000 | 0.25 | 3.07 | |

Notes:
(1) - Levee Stations and HEC-2 cross sections were derived using HEC-2 cross section line crossing Levee Alignment Stationing.
(2) - Q100 per FCDMC Hydrology Manual
(3) - D50 from SLA Dec. 4, 1996 Letter Report

**Project:** **Camelback Ranch Levee South**
**Location:** **Maricopa County, Arizona**

**Table C-6: Bedform Scour**

Calc'd by: HR Date: 5/9/2011 Checked: JTA Date: 6/12/2011

| Levee Station | HEC-RAS Cross Section | Hydraulic Depth (ft) | Froude No. | Channel Velocity ft/s | Controlling: | Dune Height (ft) | Anti-Dune Height (ft) | Scour Component (ft) | Notes |
|---|---|---|---|---|---|---|---|---|---|
| 44+81 | 9.686 | 5.26 | 0.47 | 6.17 | Dune | 1.05 | 1.03 | 0.53 | |
| 43+53 | 9.663 | 4.96 | 0.50 | 6.35 | Dune | 0.99 | 1.09 | 0.50 | |
| 42+43 | 9.643 | 4.24 | 0.64 | 7.49 | Dune | 0.85 | 1.51 | 0.42 | |
| 41+39 | 9.624 | 3.73 | 0.84 | 9.23 | Anti-Dune | 0.75 | 2.30 | 1.15 | |
| 40+16 | 9.602 | 3.95 | 0.82 | 9.46 | Anti-Dune | 0.79 | 2.42 | 1.21 | |
| 38+35 | 9.569 | 3.72 | 1.00 | 11.16 | Anti-Dune | 0.74 | 3.36 | 1.68 | |
| 37+02 | 9.546 | 4.19 | 1.00 | 11.59 | Anti-Dune | 0.84 | 3.63 | 1.81 | |
| 35+38 | 9.518 | 5.44 | 0.57 | 7.55 | Dune | 1.09 | 1.54 | 0.54 | |
| 33+59 | 9.487 | 6.43 | 0.39 | 5.67 | Dune | 1.29 | 0.87 | 0.64 | |
| 32+39 | 9.467 | 6.68 | 0.34 | 5.02 | Dune | 1.34 | 0.68 | 0.67 | |
| 31+04 | 9.445 | 6.97 | 0.31 | 4.67 | Dune | 1.39 | 0.59 | 0.70 | |
| 29+69 | 9.422 | 7.34 | 0.28 | 4.28 | Dune | 1.47 | 0.49 | 0.73 | |
| 28+49 | 9.4 | 7.5 | 0.25 | 3.91 | Dune | 1.50 | 0.41 | 0.75 | |
| 27+40 | 9.379 | 7.66 | 0.23 | 3.7 | Dune | 1.53 | 0.37 | 0.77 | |
| 25+95 | 9.353 | 7.68 | 0.23 | 3.58 | Dune | 1.54 | 0.35 | 0.77 | |
| 24+33 | 9.324 | 7.78 | 0.22 | 3.58 | Dune | 1.56 | 0.35 | 0.78 | |
| 22+51 | 9.292 | 8.14 | 0.22 | 3.62 | Dune | 1.63 | 0.35 | 0.81 | |
| 21+19 | 9.267 | 7.92 | 0.22 | 3.56 | Dune | 1.58 | 0.34 | 0.79 | |
| 18+97 | 9.225 | 8.72 | 0.19 | 3.12 | Dune | 1.74 | 0.26 | 0.87 | |
| 17+05 | 9.193 | 8.85 | 0.17 | 2.93 | Dune | 1.77 | 0.23 | 0.89 | |
| 16+12 | 9.172 | 8.88 | 0.16 | 2.67 | Dune | 1.78 | 0.19 | 0.89 | |
| 14+24 | 9.131 | 9.09 | 0.14 | 2.49 | Dune | 1.82 | 0.17 | 0.91 | |
| 13+03 | 9.109 | 8.99 | 0.14 | 2.47 | Dune | 1.80 | 0.16 | 0.90 | |
| 11+27 | 9.082 | 9.07 | 0.14 | 2.35 | Dune | 1.81 | 0.15 | 0.91 | |
| 09+82 | 9.059 | 9.09 | 0.13 | 2.33 | Dune | 1.82 | 0.15 | 0.91 | |

Note:
From Equations 10.13 and 10.14 in Draft Flood Control District of Maricopa County Drainage Design Manual Hydraulics
- Yh is channel hydraulic depth from the cblp1_a.dat HEC-2 model.

**Project: Camelback Ranch Levee South**
**Location: Maricopa County, Arizona**

**Table C-7: Equilibrium Slope Difference**

Calc'd by: HR Date: 5/9/2011 Checked: JTA Date: 6/12/2011

| Levee Station | (1)HEC-RAS Cross Section | Minimum Channel Invert | Cumulative Distance from GCS | Average Equilibrium Slope | Elevation from Equilibrium slope | Depth below Equilibrium Slope |
|---|---|---|---|---|---|---|
| | | (ft) | (ft) | ft/ft | (ft) | (ft) |
| 44+81 | 9.686 | 1008.12 | 8902.08 | 0.0006 | 1005.34 | 2.8 |
| 43+53 | 9.663 | 1008.00 | 8780.64 | 0.0006 | 1005.27 | 2.7 |
| 42+43 | 9.643 | 1007.06 | 8675.04 | 0.0006 | 1005.21 | 1.9 |
| 41+39 | 9.624 | 1004.67 | 8574.72 | 0.0006 | 1005.14 | 0.0 |
| 40+16 | 9.602 | 1007.20 | 8458.56 | 0.0006 | 1005.08 | 2.1 |
| 38+35 | 9.569 | 1007.22 | 8284.32 | 0.0006 | 1004.97 | 2.2 |
| 37+02 | 9.546 | 1007.23 | 8162.88 | 0.0006 | 1004.90 | 2.3 |
| 35+38 | 9.518 | 1006.66 | 8015.04 | 0.0006 | 1004.81 | 1.8 |
| 33+59 | 9.487 | 1005.39 | 7851.36 | 0.0006 | 1004.71 | 0.7 |
| 32+39 | 9.467 | 1004.55 | 7745.76 | 0.0006 | 1004.65 | 0.0 |
| 31+04 | 9.445 | 1003.60 | 7629.60 | 0.0006 | 1004.58 | 0.0 |
| 29+69 | 9.422 | 1002.64 | 7508.16 | 0.0006 | 1004.50 | 0.0 |
| 28+49 | 9.4 | 1001.80 | 7392.00 | 0.0006 | 1004.44 | 0.0 |
| 27+40 | 9.379 | 1000.46 | 7281.12 | 0.0006 | 1004.37 | 0.0 |
| 25+95 | 9.353 | 998.68 | 7143.84 | 0.0006 | 1004.29 | 0.0 |
| 24+33 | 9.324 | 996.69 | 6990.72 | 0.0006 | 1004.19 | 0.0 |
| 22+51 | 9.292 | 994.46 | 6821.76 | 0.0006 | 1004.09 | 0.0 |
| 21+19 | 9.267 | 994.75 | 6689.76 | 0.0006 | 1004.01 | 0.0 |
| 18+97 | 9.225 | 995.24 | 6468.00 | 0.0006 | 1003.88 | 0.0 |
| 17+05 | 9.193 | 995.66 | 6299.04 | 0.0006 | 1003.78 | 0.0 |
| 16+12 | 9.172 | 995.86 | 6188.16 | 0.0006 | 1003.71 | 0.0 |
| 14+24 | 9.131 | 995.77 | 5971.68 | 0.0006 | 1003.58 | 0.0 |
| 13+03 | 9.109 | 995.71 | 5855.52 | 0.0006 | 1003.51 | 0.0 |
| 11+27 | 9.082 | 995.63 | 5712.96 | 0.0006 | 1003.43 | 0.0 |
| 09+82 | 9.059 | 995.56 | 5591.52 | 0.0006 | 1003.35 | 0.0 |
| | GCS | 1000.00 | 0.00 | | 1000.00 | |

GCS - Grade Control Structure

**Project:** **Camelback Ranch Levee South**
**Location:** **Maricopa County, Arizona**

**Table C-8: Armoring**

Calc'd by: HR Checked: JTA
Date: 5/9/2011 Date: 6/12/2011

| Levee Station | HEC-RAS Cross Section | MPM Bedload Transport | Competant Bottom Velocity | Yang incipient motion | Shield Diagram | Average |
|---|---|---|---|---|---|---|
| | | Dc (mm) | Dc (mm) | Dc (mm) | Dc (mm) | Dc (mm) |
| 44+81 | 9.686 | 15 | 32 | 34 | 23 | 26 |
| 43+53 | 9.663 | 15 | 33 | 36 | 22 | 27 |
| 42+43 | 9.643 | 27 | 55 | 59 | 40 | 45 |
| 41+39 | 9.624 | 136 | 347 | 371 | 199 | 263 |
| 40+16 | 9.602 | 38 | 100 | 107 | 56 | 75 |
| 38+35 | 9.569 | 74 | 144 | 154 | 108 | 120 |
| 37+02 | 9.546 | 67 | 126 | 135 | 98 | 107 |
| 35+38 | 9.518 | 38 | 75 | 80 | 56 | 62 |
| 33+59 | 9.487 | 18 | 38 | 41 | 27 | 31 |
| 32+39 | 9.467 | 14 | 30 | 32 | 21 | 24 |
| 31+04 | 9.445 | 12 | 25 | 27 | 17 | 20 |
| 29+69 | 9.422 | 9 | 19 | 21 | 13 | 15 |
| 28+49 | 9.4 | 7 | 16 | 17 | 10 | 12 |
| 27+40 | 9.379 | 6 | 14 | 15 | 9 | 11 |
| 25+95 | 9.353 | 5 | 12 | 13 | 8 | 10 |
| 24+33 | 9.324 | 5 | 12 | 13 | 7 | 9 |
| 22+51 | 9.292 | 5 | 12 | 13 | 7 | 9 |
| 21+19 | 9.267 | 5 | 12 | 12 | 7 | 9 |
| 18+97 | 9.225 | 3 | 8 | 9 | 5 | 6 |
| 17+05 | 9.193 | 3 | 7 | 7 | 4 | 5 |
| 16+12 | 9.172 | 2 | 5 | 6 | 3 | 4 |
| 14+24 | 9.131 | 2 | 5 | 5 | 3 | 3 |
| 13+03 | 9.109 | 2 | 5 | 5 | 3 | 3 |
| 11+27 | 9.082 | 2 | 4 | 4 | 2 | 3 |
| 09+82 | 9.059 | 2 | 4 | 4 | 2 | 3 |

Notes:
Methodology from US Bureau of Reclamation, "Computing Degradation and Local Scour", 1984

**Project:** Camelback Ranch Levee South
**Location:** Maricopa County, Arizona

**Table C-9: Headcut Method #1**

Calc'd by: HR
Date: 5/9/2011

Checked: JTA
Date: 6/12/2011

| | Profile #1 | Profile #2 | Profile #3 | Profile #4 | Profile #5 |
|---|---|---|---|---|---|
| Pit Bottom (ft) | 1004 | 1001.71 | 1002.58 | 1003.91 | 998.61 |
| Pit Top (ft) | 1018 | 1019 | 1010 | 1009 | 1003.67 |
| Headcut Elevation at Pit (ft) | 1011 | 1010.36 | 1006.29 | 1006.46 | 1001.14 |
| Headcut Pit Depth (ft) | 14 | 17.29 | 7.42 | 5.09 | 5.06 |

| | | Profile #1 | | Profile #2 | | Profile #3 | | Profile #4 | | Profile #5 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1)Levee Station | (1)HEC-RAS Cross Section | Distance from Pit | Headcut Elevation | Distance from Pit | Headcut Elevation | Distance from Pit | Headcut Elevation | Distance from Pit | Headcut Elevation | Distance from Pit | Headcut Elevation | Minimum Headcut Elevation | Design Toe-Down Elevation | Headcut Scour Depth |
| | | (ft) | (ft) | (ft) | (ft) | (ft) | (ft) | (ft) | (ft) | (ft) | (ft) | (ft) | (ft) | (ft) |
| 44+81 | 9.686 | 1679 | 1027.79 | 1866 | 1029.02 | 1638 | 1022.67 | 1652 | 1022.98 | 2390 | 1025.04 | 1022.67 | 1009.09 | 0 |
| 43+53 | 9.663 | 1546 | 1026.46 | 1740 | 1027.76 | 1513 | 1021.42 | 1527 | 1021.73 | 2264 | 1023.78 | 1021.42 | 1008.61 | 0 |
| 42+43 | 9.643 | 1237 | 1023.37 | 1595 | 1026.31 | 1403 | 1020.32 | 1412 | 1020.58 | 2153 | 1022.67 | 1020.32 | 1007.06 | 0 |
| 41+39 | 9.624 | 940 | 1020.40 | 1417 | 1024.53 | 1295 | 1019.24 | 1293 | 1019.39 | 2048 | 1021.62 | 1019.24 | 1004.67 | 0 |
| 40+16 | 9.602 | 731 | 1018.31 | 1227 | 1022.63 | 1163 | 1017.92 | 1166 | 1018.12 | 1924 | 1020.38 | 1017.92 | 1007.20 | 0 |
| 38+35 | 9.569 | 539 | 1016.39 | 988 | 1020.24 | 978 | 1016.07 | 973 | 1016.19 | 1743 | 1018.57 | 1016.07 | 1007.22 | 0 |
| 37+02 | 9.546 | 424 | 1015.24 | 845 | 1018.81 | 848 | 1014.77 | 825 | 1014.71 | 1613 | 1017.27 | 1014.71 | 1007.23 | 0 |
| 35+38 | 9.518 | 311 | 1014.11 | 696 | 1017.32 | 689 | 1013.18 | 661 | 1013.07 | 1454 | 1015.68 | 1013.07 | 1006.66 | 0 |
| 33+59 | 9.487 | 159 | 1012.59 | 523 | 1015.59 | 514 | 1011.43 | 488 | 1011.34 | 1285 | 1013.99 | 1011.34 | 1005.39 | 0 |
| 32+39 | 9.467 | 59 | 1011.59 | 412 | 1014.48 | 401 | 1010.30 | 381 | 1010.27 | 1173 | 1012.87 | 1010.27 | 1004.55 | 0 |
| 31+04 | 9.445 | 0 | | 294 | 1013.30 | 278 | 1009.07 | 259 | 1009.05 | 1041 | 1011.55 | 1009.05 | 1003.60 | 0 |
| 29+69 | 9.422 | 0 | | 164 | 1012.00 | 142 | 1007.71 | 135 | 1007.81 | 904 | 1010.18 | 1007.71 | 1002.64 | 0 |
| 28+49 | 9.4 | 0 | | 8 | 1010.44 | 3 | 1006.32 | 2 | 1006.48 | 766 | 1008.80 | 1006.32 | 1001.80 | 0 |
| 27+40 | 9.379 | 0 | | 0 | | 0 | | 0 | | 640 | 1007.54 | 1007.54 | 1000.46 | 0 |
| 25+95 | 9.353 | 0 | | 0 | | 0 | | 0 | | 451 | 1005.65 | 1005.65 | 998.68 | 0 |
| 24+33 | 9.324 | 0 | | 0 | | 0 | | 0 | | 234 | 1003.48 | 1003.48 | 996.69 | 0 |
| 22+51 | 9.292 | 0 | | 0 | | 0 | | 0 | | **0** | **1001.14** | | 994.46 | |
| 21+19 | 9.267 | 0 | | 0 | | 0 | | 0 | | 0 | | | 994.75 | |
| 18+97 | 9.225 | 0 | | 0 | | 0 | | 0 | | 0 | | | 995.24 | |
| 17+05 | 9.193 | 0 | | 0 | | 0 | | 0 | | 0 | | | 995.66 | |
| 16+12 | 9.172 | 0 | | 0 | | 0 | | 0 | | 0 | | | 995.86 | |
| 14+24 | 9.131 | 0 | | 0 | | 0 | | 0 | | 0 | | | 995.77 | |
| 13+03 | 9.109 | 0 | | 0 | | 0 | | 0 | | 0 | | | 995.71 | |
| 11+27 | 9.082 | 0 | | 0 | | 0 | | 0 | | 0 | | | 995.63 | |
| 09+82 | 9.059 | 0 | | 0 | | 0 | | 0 | | 0 | | | 995.56 | |

**Project:** Camelback Ranch Levee South
**Location:** Maricopa County, Arizona

**Table C-10: Headcut Method #2**

Calc'd by: HR
Date: 5/9/2011

Checked: JTA
Date: 6/12/2011

| | Profile #1 | Profile #2 | Profile #3 | Profile #4 | Profile #5 |
|---|---|---|---|---|---|
| Pit Bottom (ft) | 1004 | 1001.71 | 1002.58 | 1003.91 | 998.61 |
| Pit Top (ft) | 1018 | 1019 | 1010 | 1009 | 1007.6 |
| Headcut Elevation at Pit (ft) | 1011 | 1010.36 | 1006.29 | 1006.46 | 1003.11 |
| Headcut Pit Depth (ft) | 14 | 17.29 | 7.42 | 5.09 | 8.99 |
| Channel Slope 0.0024 | | | | | |

| | | Profile #1 | | Profile #2 | | Profile #3 | | Profile #4 | | Profile #5 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1)Levee Station | (1)HEC-RAS Cross Section | Distance from Pit | Headcut Elevation | Distance from Pit | Headcut Elevation | Distance from Pit | Headcut Elevation | Distance from Pit | Headcut Elevation | Distance from Pit | Headcut Elevation | Minimum Headcut Elevation | Design Toe-Down Elevation | Headcut Scour Depth |
| | | (ft) | (ft) | (ft) | (ft) | (ft) | (ft) | | | | | | | |
| 44+81 | 9.686 | 1679 | 1015.03 | 1866 | 1015.48 | 1638 | 1014.93 | 1652 | 1014.96 | 2390 | 1016.74 | 1014.93 | 1009.09 | 0 |
| 43+53 | 9.663 | 1546 | 1014.71 | 1740 | 1015.18 | 1513 | 1014.63 | 1527 | 1014.66 | 2264 | 1016.43 | 1014.63 | 1008.61 | 0 |
| 42+43 | 9.643 | 1237 | 1013.97 | 1595 | 1014.83 | 1403 | 1014.37 | 1412 | 1014.39 | 2153 | 1016.17 | 1013.97 | 1007.06 | 0 |
| 41+39 | 9.624 | 940 | 1013.26 | 1417 | 1014.40 | 1295 | 1014.11 | 1293 | 1014.10 | 2048 | 1015.92 | 1013.26 | 1004.67 | 0 |
| 40+16 | 9.602 | 731 | 1012.75 | 1227 | 1013.94 | 1163 | 1013.79 | 1166 | 1013.80 | 1924 | 1015.62 | 1012.75 | 1007.20 | 0 |
| 38+35 | 9.569 | 539 | 1012.29 | 988 | 1013.37 | 978 | 1013.35 | 973 | 1013.34 | 1743 | 1015.18 | 1012.29 | 1007.22 | 0 |
| 37+02 | 9.546 | 424 | 1012.02 | 845 | 1013.03 | 848 | 1013.04 | 825 | 1012.98 | 1613 | 1014.87 | 1012.02 | 1007.23 | 0 |
| 35+38 | 9.518 | 311 | 1011.75 | 696 | 1012.67 | 689 | 1012.65 | 661 | 1012.59 | 1454 | 1014.49 | 1011.75 | 1006.66 | 0 |
| 33+59 | 9.487 | 159 | 1011.38 | 523 | 1012.26 | 514 | 1012.23 | 488 | 1012.17 | 1285 | 1014.08 | 1011.38 | 1005.39 | 0 |
| 32+39 | 9.467 | 59 | 1011.14 | 412 | 1011.99 | 401 | 1011.96 | 381 | 1011.91 | 1173 | 1013.82 | 1011.14 | 1004.55 | 0 |
| 31+04 | 9.445 | 0 | | 294 | 1011.71 | 278 | 1011.67 | 259 | 1011.62 | 1041 | 1013.50 | 1011.62 | 1003.60 | 0 |
| 29+69 | 9.422 | 0 | | 164 | 1011.39 | 142 | 1011.34 | 135 | 1011.32 | 904 | 1013.17 | 1011.32 | 1002.64 | 0 |
| 28+49 | 9.4 | 0 | | 8 | 1011.02 | 3 | 1011.01 | 2 | 1011.00 | 766 | 1012.84 | 1011.00 | 1001.80 | 0 |
| 27+40 | 9.379 | 0 | | 0 | | 0 | | 0 | | 640 | 1012.54 | 1012.54 | 1000.46 | 0 |
| 25+95 | 9.353 | 0 | | 0 | | 0 | | 0 | | 451 | 1012.08 | 1012.08 | 998.68 | 0 |
| 24+33 | 9.324 | 0 | | 0 | | 0 | | 0 | | 234 | 1011.56 | 1011.56 | 996.69 | 0 |
| 22+51 | 9.292 | 0 | | 0 | | 0 | | 0 | | **0** | **1003.11** | | 994.46 | |
| 21+19 | 9.267 | 0 | | 0 | | 0 | | 0 | | 0 | | | 994.75 | |
| 18+97 | 9.225 | 0 | | 0 | | 0 | | 0 | | 0 | | | 995.24 | |
| 17+05 | 9.193 | 0 | | 0 | | 0 | | 0 | | 0 | | | 995.66 | |
| 16+12 | 9.172 | 0 | | 0 | | 0 | | 0 | | 0 | | | 995.86 | |
| 14+24 | 9.131 | 0 | | 0 | | 0 | | 0 | | 0 | | | 995.77 | |
| 13+03 | 9.109 | 0 | | 0 | | 0 | | 0 | | 0 | | | 995.71 | |
| 11+27 | 9.082 | 0 | | 0 | | 0 | | 0 | | 0 | | | 995.63 | |
| 09+82 | 9.059 | 0 | | 0 | | 0 | | 0 | | 0 | | | 995.56 | |

**Project:** Camelback Ranch Levee South
**Location:** Maricopa County, Arizona

**Table D-11: ADOT Method Headcut Profile #1**

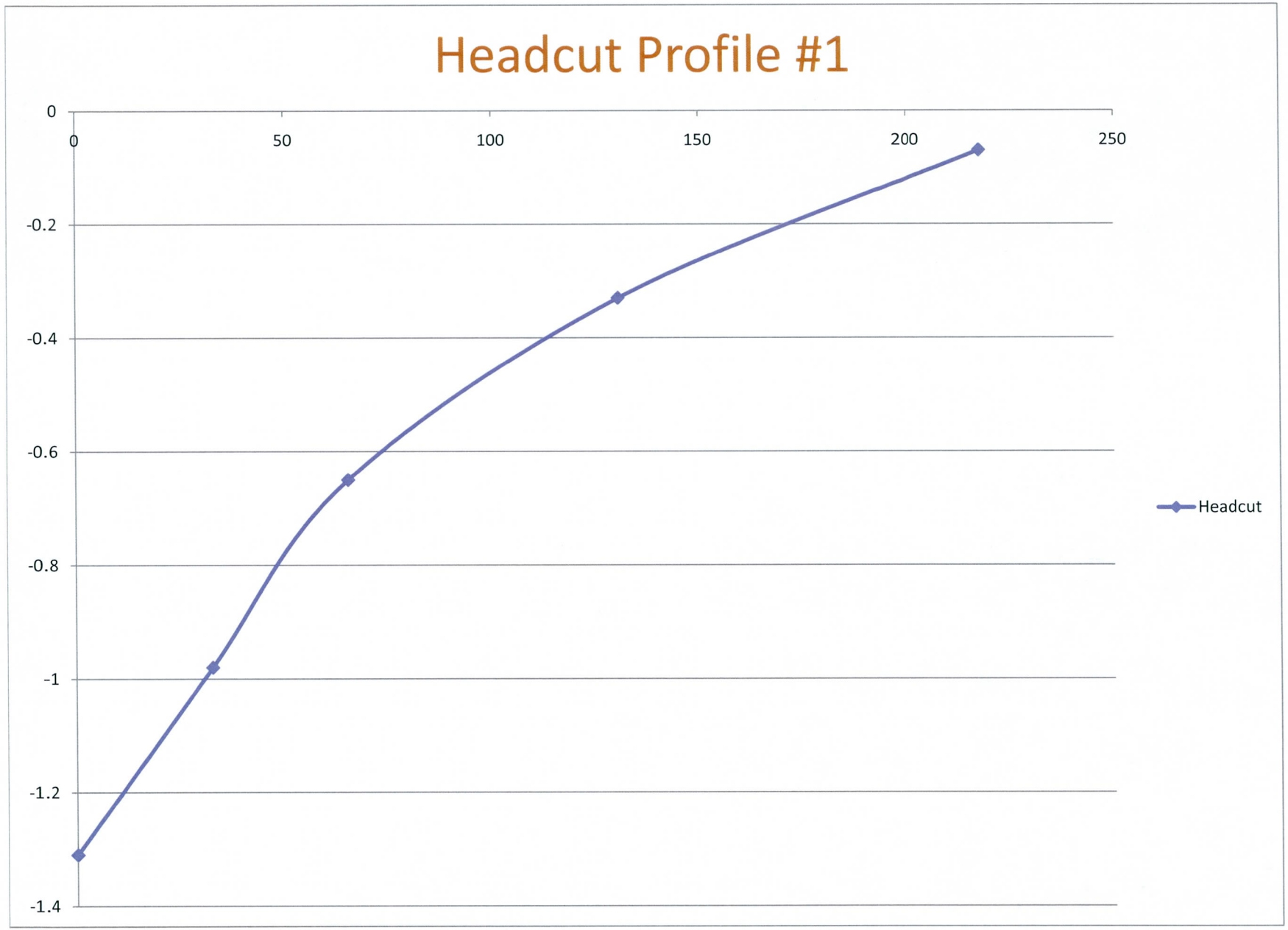
Calc'd by: HR Date: 5/9/2011 Checked: JTA Date: 5/9/2011

## Gravel Bed Headcut Profiles

| Pit Information Summary | |
|---|---|
| **Hydrograph File** | hydrograph.txt |
| **Time Unit** | Hour |
| **Alluvial Material** | Gravel Bed |
| **Pit Length** | 3,500.00 (ft) |
| **Pit Width** | 1,600.00 (ft) |
| **Pit Depth** | 14.00 (ft) |
| **Effective Pit Depth** | 14.00 (ft) |
| **GroundWater Depth** | 0.00 (ft) |
| **DrownoutWater Depth** | 0.00 (ft) |
| **Pit Volume** | 78,400,000.00 (cubic ft) |
| **Pitside Slope** | 0 |
| **Channel Slope** | 0.005 |
| **Fill Time** | 6.21 (hr) |

| Dimensionless Scour Profile | |
|---|---|
| *Ys/Ysbrink* | *Ls/Ls5* |
| 0.05 | 1.00 |
| 0.25 | 0.60 |
| 0.50 | 0.30 |
| 0.75 | 0.15 |
| 1.00 | 0.00 |

| Headcut Profile | |
|---|---|
| *Ys (ft)* | *Ls (ft)* |
| 0.07 | 217.68 |
| 0.33 | 130.61 |
| 0.65 | 65.30 |
| 0.98 | 32.65 |
| 1.31 | 0.00 |


Headcut Profile #1
0
-0.2
-0.4
-0.6
-0.8
-1
-1.2
-1.4
0
50
100
150
200
250
Headcut

**Project:** Camelback Ranch Levee South
**Location:** Maricopa County, Arizona

**Table D-12: ADOT Method Headcut Profile #2**

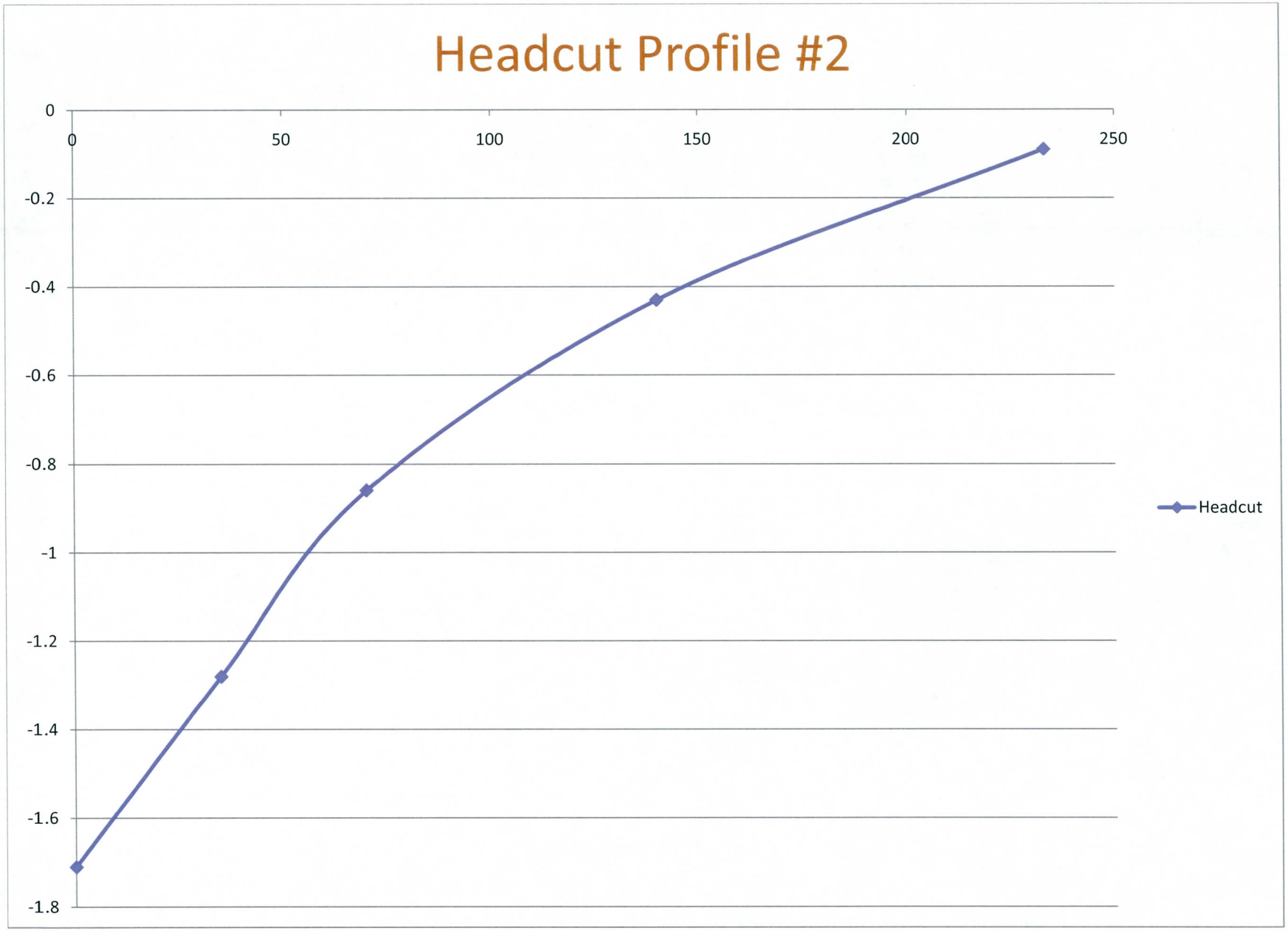
Calc'd by: HR Date: 5/9/2011
Checked: JTA Date: 5/9/2011

## Gravel Bed Headcut Profiles

| Pit Information Summary | |
|---|---|
| Hydrograph File | hydrograph.txt |
| Time Unit | Hour |
| Alluvial Material | Gravel Bed |
| Pit Length | 3,500.00 (ft) |
| Pit Width | 1,600.00 (ft) |
| Pit Depth | 17.29 (ft) |
| Effective Pit Depth | 17.29 (ft) |
| GroundWater Depth | 0.00 (ft) |
| DrownoutWater Depth | 0.00 (ft) |
| Pit Volume | 96,824,000.00 (cubic ft) |
| Pitside Slope | 0 |
| Channel Slope | 0.005 |
| Fill Time | 6.63 (hr) |

| Dimensionless Scour Profile | |
|---|---|
| *Ys/Ysbrink* | *Ls/Ls5* |
| 0.05 | 1.00 |
| 0.25 | 0.60 |
| 0.50 | 0.30 |
| 0.75 | 0.15 |
| 1.00 | 0.00 |

| Headcut Profile | |
|---|---|
| *Ys (ft)* | *Ls (ft)* |
| 0.09 | 233.26 |
| 0.43 | 139.96 |
| 0.86 | 69.98 |
| 1.28 | 34.99 |
| 1.71 | 0.00 |


Headcut Profile #2
0
-0.2
-0.4
-0.6
-0.8
-1
-1.2
-1.4
-1.6
-1.8
0
50
100
150
200
250
Headcut

**Project:** Camelback Ranch Levee South
**Location:** Maricopa County, Arizona

**Table D-13: ADOT Method Headcut Profile #3**

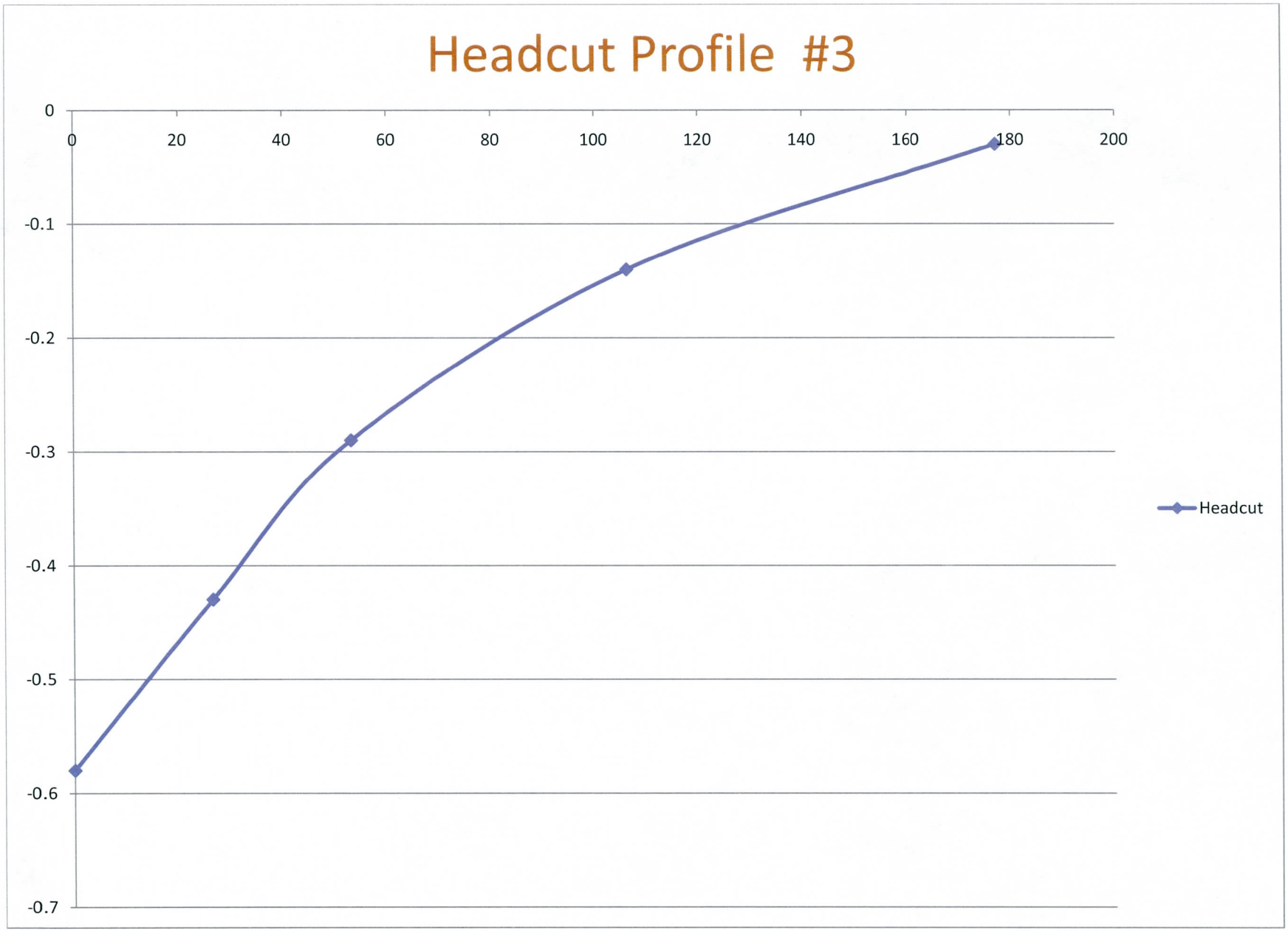
Calc'd by: HR Date: 5/9/2011
Checked: JTA Date: 5/9/2011

## Gravel Bed Headcut Profiles

| Pit Information Summary | |
|---|---|
| **Hydrograph File** | hydrograph.txt |
| **Time Unit** | Hour |
| **Alluvial Material** | Gravel Bed |
| **Pit Length** | 3,500.00 (ft) |
| **Pit Width** | 1,600.00 (ft) |
| **Pit Depth** | 7.40 (ft) |
| **Effective Pit Depth** | 7.40 (ft) |
| **GroundWater Depth** | 0.00 (ft) |
| **DrownoutWater Depth** | 0.00 (ft) |
| **Pit Volume** | 41,440,000.00 (cubic ft) |
| **Pitside Slope** | 0 |
| **Channel Slope** | 0.005 |
| **Fill Time** | 5.06 (hr) |

| Dimensionless Scour Profile | |
|---|---|
| *Ys/Ysbrink* | *Ls/Ls5* |
| 0.05 | 1.00 |
| 0.25 | 0.60 |
| 0.50 | 0.30 |
| 0.75 | 0.15 |
| 1.00 | 0.00 |

| Headcut Profile | |
|---|---|
| *Ys (ft)* | *Ls (ft)* |
| 0.03 | 177.12 |
| 0.14 | 106.27 |
| 0.29 | 53.14 |
| 0.43 | 26.57 |
| 0.58 | 0.00 |


Headcut Profile #3
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
0
20
40
60
80
100
120
140
160
180
200
Headcut

**Project:** Camelback Ranch Levee South
**Location:** Maricopa County, Arizona

**Table D-14: ADOT Method Headcut Profile #4**

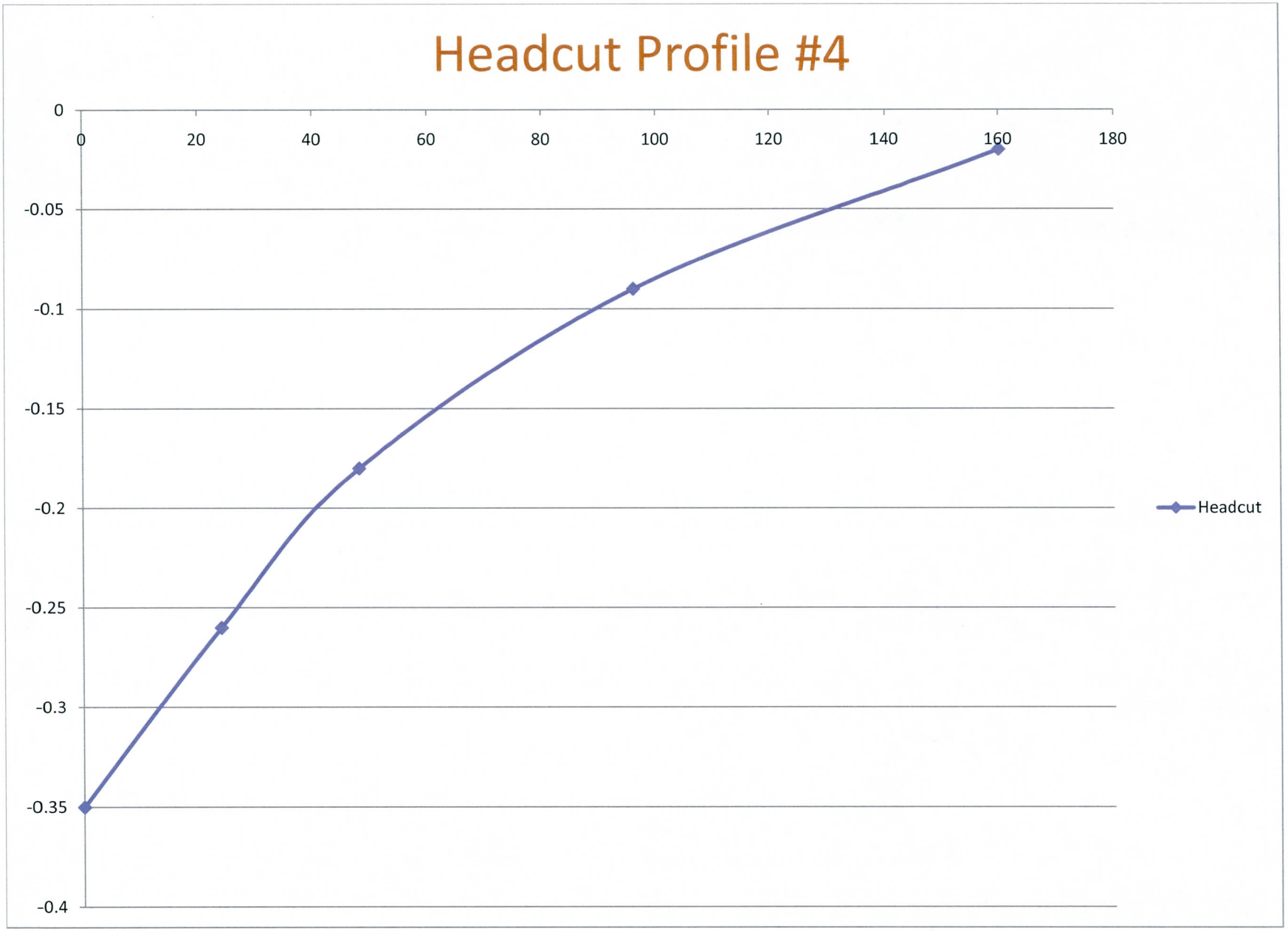
Calc'd by: HR Date: 5/9/2011
Checked: JTA Date: 5/9/2011

## Gravel Bed Headcut Profiles

| Pit Information Summary | |
|---|---|
| Hydrograph File | hydrograph.txt |
| Time Unit | Hour |
| Alluvial Material | Gravel Bed |
| Pit Length | 3,500.00 (ft) |
| Pit Width | 1,600.00 (ft) |
| Pit Depth | 5.00 (ft) |
| Effective Pit Depth | 5.00 (ft) |
| GroundWater Depth | 0.00 (ft) |
| DrownoutWater Depth | 0.00 (ft) |
| Pit Volume | 28,000,000.00 (cubic ft) |
| Pitside Slope | 0 |
| Channel Slope | 0.005 |
| Fill Time | 4.42 (hr) |

| Dimensionless Scour Profile | |
|---|---|
| *Ys/Ysbrink* | *Ls/Ls5* |
| 0.05 | 1.00 |
| 0.25 | 0.60 |
| 0.50 | 0.30 |
| 0.75 | 0.15 |
| 1.00 | 0.00 |

| Headcut Profile | |
|---|---|
| *Ys (ft)* | *Ls (ft)* |
| 0.02 | 160.13 |
| 0.09 | 96.08 |
| 0.18 | 48.04 |
| 0.26 | 24.02 |
| 0.35 | 0.00 |


Headcut Profile #4
0
-0.05
-0.1
-0.15
-0.2
-0.25
-0.3
-0.35
-0.4
0
20
40
60
80
100
120
140
160
180
Headcut

**Project:** Camelback Ranch Levee South
**Location:** Maricopa County, Arizona

**Table D-15: ADOT Method Headcut Profile #5**

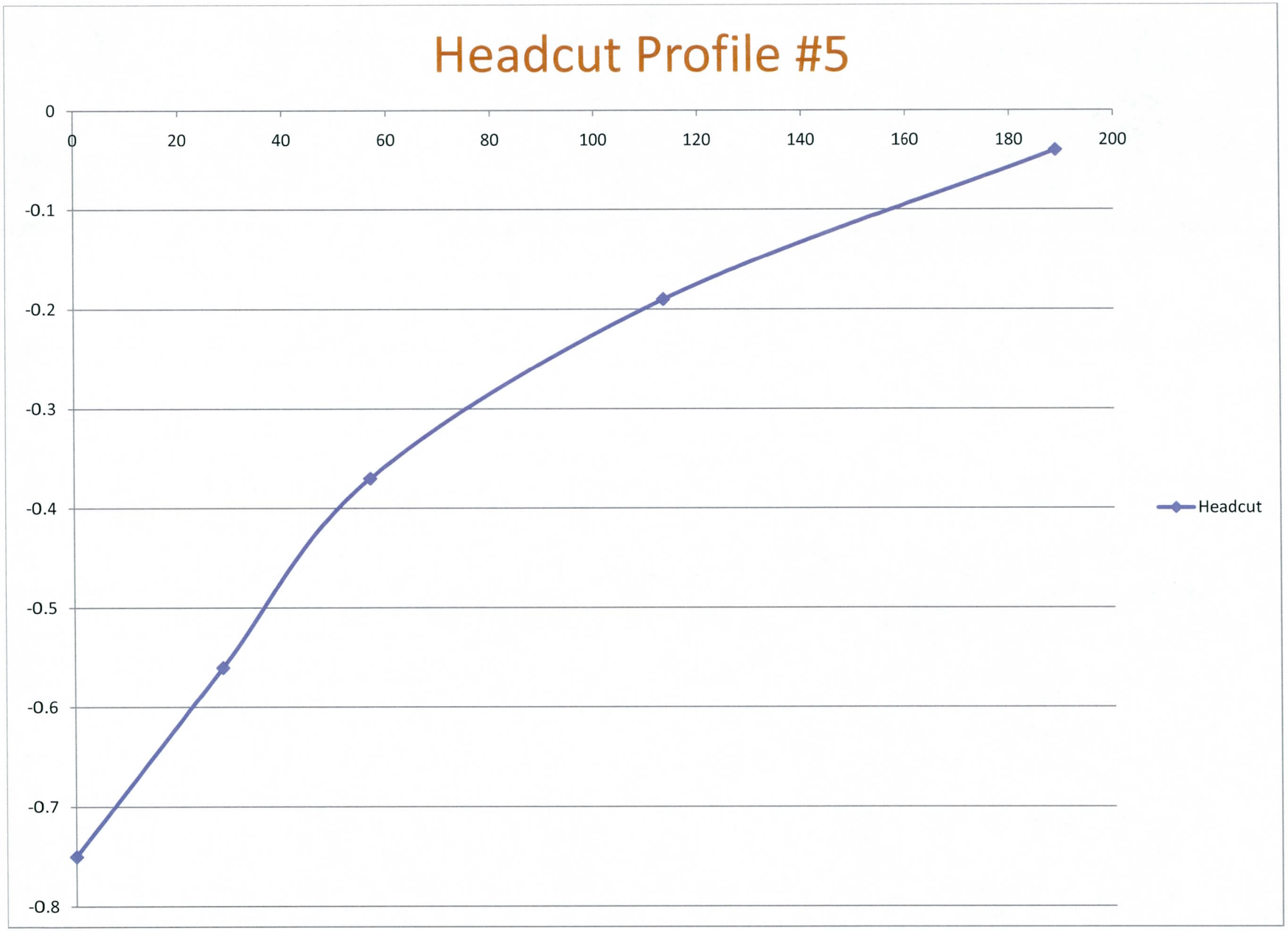
Calc'd by: HR Date: 5/9/2011
Checked: JTA Date: 5/9/2011

## Gravel Bed Headcut Profiles

| Pit Information Summary | |
|---|---|
| Hydrograph File | hydrograph.txt |
| Time Unit | Hour |
| Alluvial Material | Gravel Bed |
| Pit Length | 3,500.00 (ft) |
| Pit Width | 1,600.00 (ft) |
| Pit Depth | 9.00 (ft) |
| Effective Pit Depth | 9.00 (ft) |
| GroundWater Depth | 0.00 (ft) |
| DrownoutWater Depth | 0.00 (ft) |
| Pit Volume | 50,400,000.00 (cubic ft) |
| Pitside Slope | 0 |
| Channel Slope | 0.005 |
| Fill Time | 5.41 (hr) |

| Dimensionless Scour Profile | |
|---|---|
| *Ys/Ysbrink* | *Ls/Ls5* |
| 0.05 | 1.00 |
| 0.25 | 0.60 |
| 0.50 | 0.30 |
| 0.75 | 0.15 |
| 1.00 | 0.00 |

| Headcut Profile | |
|---|---|
| *Ys (ft)* | *Ls (ft)* |
| 0.04 | 189.00 |
| 0.19 | 113.40 |
| 0.37 | 56.70 |
| 0.56 | 28.35 |
| 0.75 | 0.00 |


Headcut Profile #5
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
0
20
40
60
80
100
120
140
160
180
200
Headcut

## C.4 Figures

JE FULLER
HYDROLOGY & GEOMORPHOLOGY, INC.

0 100 200 400 600 800 Feet

N

# FIGURE C-2: APPROXIMATE GRAVEL MINING LIMITS

CREATED BY: HR
DATE: 5/30/2011

CHECKED BY: JTA
DATE: 6/10/2011

Flood Control District of Maricopa County

**CAMELBACK RANCH LEVEE SOUTH - ASSIGNMENT #10 - FCD2007C051**

JE FULLER HYDROLOGY & GEOMORPHOLOGY, INC.

0 100 200 Feet

N

# FIGURE C-3: HEADCUT PROFILE LOCATIONS

CREATED BY: HR
DATE: 5/30/2011

CHECKED BY: JTA
DATE: 6/10/2011

Flood Control District of Maricopa County

**CAMELBACK RANCH LEVEE SOUTH - ASSIGNMENT #10 - FCD2007C051**

# D. Interior Drainage

# Appendix D

## Levee Certification Report
## Camelback Ranch Levee South
## Maricopa County, Arizona

## Interior Drainage

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D.2 Portions of *Camelback Road Drainage Report*

# 1. Interior Drainage

## 1.1 Overview

This appendix discusses the interior drainage and summarizes the drainage structures within the project.

## 1.2 Final Interior Drainage Report, Camelback Ranch Levee Design Project (April 1998)

Interior drainage methods and assumptions were documented in "*Final Interior Drainage Report, Camelback Ranch Levee Design Project", April 1998* (CBR Interior Drainage Report). The document includes the analysis of Camelback Ranch Levee North (North of Camelback Road) and Camelback Ranch Levee South (South of Camelback Road). This assessment pertains to Camelback Ranch Levee South interior drainage only.

The interior drainage area for the Camelback Ranch Levee South includes the contributing areas and peak runoff flows identified as DA3 and DA4. The areas associated with these basins are included in **Table D-1**.

**Table D-1: Camelback Ranch Levee South Interior Drainage Sub Basin Summary**

| SOUTH AREA | | | |
|---|---|---|---|
| SUBBASIN | AREA (ac.) | Q peak (cfs) EXISTING | Q peak (cfs) FUTURE |
| DA3 | 236.67 | 131 | N/A |
| DA4 | 38.91 | 14 | N/A |
| TOTAL PEAK FLOW (cfs) = | | 145 | 158 |

According to the CBR Interior Drainage Report, the total on-site drainage area for the Camelback Ranch Levee South Property is 275.6 acres. The southern area's on-site drainage sub basins (referred to as sub basin area DA3 and DA4) are bounded by Camelback Road to the north, Campbell Avenue to the south, 107th Avenue to the east and the levee alignment to the west. These two sub basins drain to the south. The two subbasins in the south area, DA3 and DA4, have a 100-yr, 6-hr existing-condition peak runoff of 131 cfs and 14 cfs respectively. These two subbasins will continue to drain to the south per existing conditions. Based on normal depth calculations, the depth of flow behind the levee will not exceed 0.39 feet in the south area. Therefore, the impoundment criteria set by the committee on "A Levee Policy for the National Flood Insurance Program" will be met i.e. interior flood depths less than 1 ft are acceptable per 44 CFR 65.10(b)(6). Portions of CBR Interior Drainage Report are included in **Appendix D.1** with the full report included on data disk in **Appendix H**.

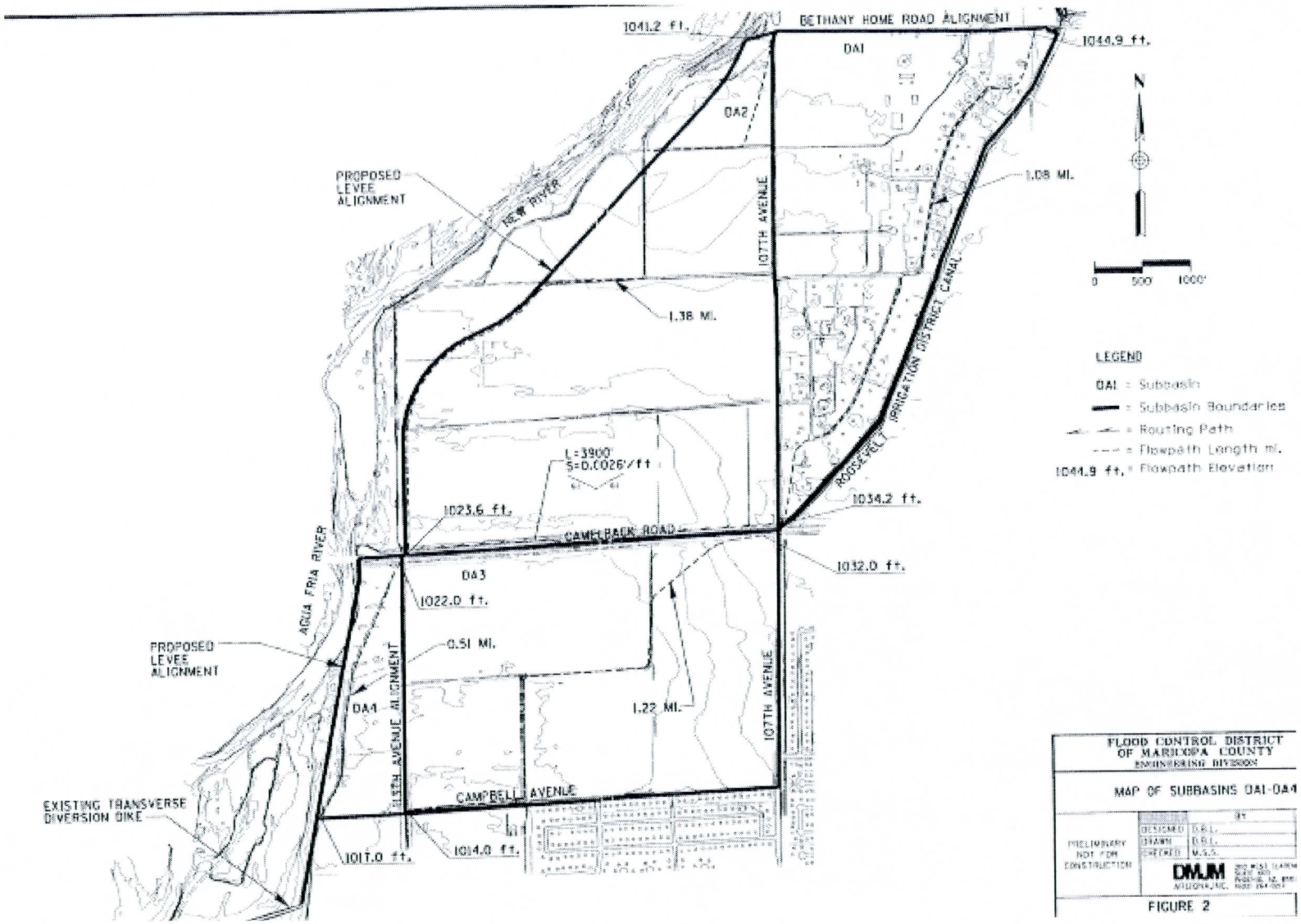


**Figure D-1: Camelback Ranch Levee South Interior Drainage Sub Basin Map**

The joint probability of interior and river side flow peaks were not analyzed because the interior drainage areas will be drained through property to the south and discharge into the Agua Fria River behind the existing Transverse Diversion Dike north of Indian School Road. The southern limits of the interior drainage analysis terminate at the Campbell Avenue alignment, 1000 feet upslope of the southern terminus of the levee. A review of the FCD 1994 and 2009 topography shows a general southern flow direction (see **Figure D-2**) and should not be considered as contributing to the interior drainage for the Camelback Ranch Levee South.

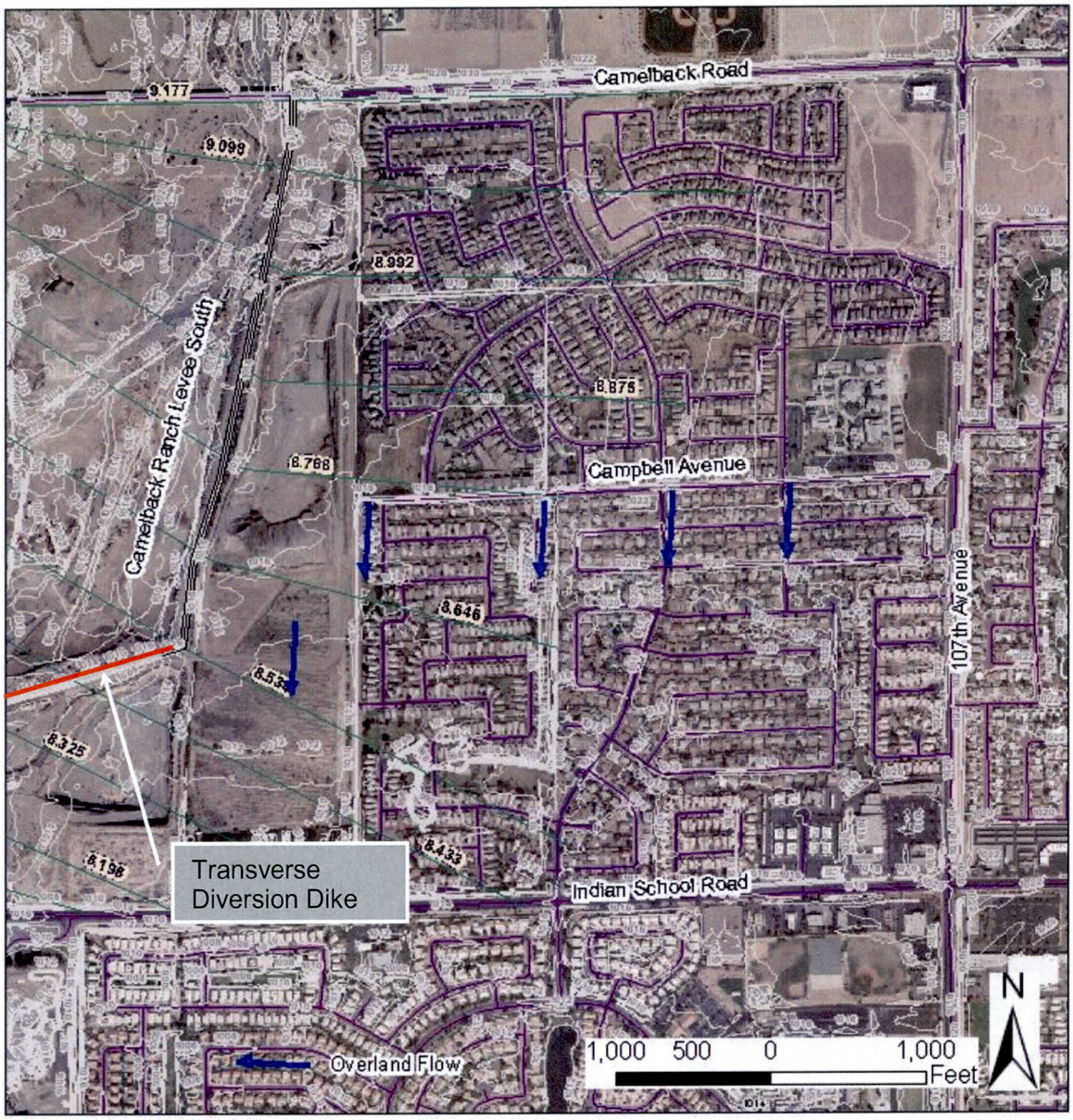


**Figure D-2: Drainage Area South of Campbell Avenue**

## 1.3 Camelback Road Storm Drain Design, City of Phoenix (August 2005)

The Camelback Road Storm Drain project included the design of a parallel storm drain pipe within Camelback Road between 99th Avenue and the Agua Fria River. The existing 54-inch RCP storm drain pipe conveyed offsite and onsite flows north and east of the intersection of Camelback Road and 107th Avenue. The existing 54-inch storm drain conveyed flows to the Roosevelt Irrigation District (RID) Canal. With the combination of the existing 54-inch storm drain system and the new 60-inch storm drain system, the outlet at RID was eliminated.

The Camelback Road Storm Drain system conveys existing storm drain flows plus the street drainage within the southern half of Camelback Road, between 99th Avenue and 107th avenue, to the new outfall along the Agua Fria River at approximate levee station 42+85. As noted in **Section 2** a flap gate is installed in the headwall at the storm drain outlet into the Agua Fria River. The storm drain system was analyzed and designed for the 2-year storm event.

**Table D-2** includes storm drain manhole and catch basin information from the Camelback Road Storm Drain project to an elevation where the storm drain inverts are above the projected 100-year water surface elevation from the Agua Fria River.

Note that the projected 100-year water surface elevation is more than 4.5 feet below the rim/inlet elevation for all structures on the new and existing storm drain.

**Table D-2: Camelback Road Storm Drain Structure Elevations**

| (1)Location | Storm Drain Station (ft) | (2)100-Year Floodplain Elevation (ft) | Rim/Inlet Elevation (ft) | Rim/inlet Elevation Above Floodplain (ft) | Lowest Invert (ft) | Notes |
|---|---|---|---|---|---|---|
| Outlet | 6+25 | 1022.1 | NA | NA | 1008.01 | 60-inch RCP |
| SDMH#32 | 6+77 | 1022.1 | 1027.04 | 4.7 | 1008.05 | 60-inch RCP |
| SDMH#31 | 9+73 | 1022.1 | 1031.29 | 9.0 | 1008.61 | 60-inch RCP |
| SDMH#30 | 14+00 | 1022.1 | 1031.47 | 9.1 | 1011.84 | 60-inch RCP |
| SDMH#29 | 19+00 | 1022.1 | 1031.88 | 9.5 | 1012.34 | 60-inch RCP |
| SDMH#28 | 25+00 | 1022.1 | 1032.57 | 10.2 | 1013.04 | 60-inch RCP |
| SDMH#27 | 31+00 | 1022.1 | 1033.09 | 10.8 | 1013.73 | 60-inch RCP |
| SDMH#26 | 37+00 | 1022.1 | 1032.73 | 10.4 | 1014.43 | 60-inch RCP |
| SDMH#25 | 43+00 | 1022.1 | 1033.2 | 10.9 | 1015.13 | 60-inch RCP |
| SDMH#24 | 47+00 | 1022.1 | 1033.99 | 11.7 | 1015.77 | 60-inch RCP |
| CB#16 | 47+41 | 1022.1 | 1033.58 | 11.2 | 1028.88 | 18-inch RCP |
| SDMH#23 | 49+57 | 1022.1 | 1034.5 | 12.2 | 1016.00 | Camelback and 107th Avenue |
| SDMH#22 | 52+35 | 1022.1 | 1035.1 | 12.8 | 1018.02 | 24-inch RCP |
| CB#15 | 52+35 | 1022.1 | 1034.12 | 11.8 | 1031.12 | 18-inch RCP |
| SDMH#21 | 55+50 | 1022.1 | 1035.91 | 13.6 | 1018.75 | 24-inch RCP |
| CB#14 | 55+50 | 1022.1 | 1036.36 | 14.0 | 1032.16 | 18-inch RCP |
| SDMH#20 | 57+49 | 1022.1 | 1036.18 | 13.8 | 1019.24 | 24-inch RCP |
| SDMH#19 | 60+25 | 1022.1 | 1036.49 | 14.2 | 1019.90 | 24-inch RCP |
| CB#13 | 60+25 | 1022.1 | 1035.91 | 13.6 | 1028.71 | 18-inch RCP |
| SDMH#18 | 61+00 | 1022.1 | 1036.45 | 14.1 | 1020.16 | 24-inch RCP |
| SDMH#17 | 62+25 | 1022.1 | 1036.56 | 14.2 | 1020.51 | 24-inch RCP |
| CB#12 | 62+25 | 1022.1 | 1036.18 | 13.8 | 1029.95 | 18-inch RCP |
| SDMH#16 | 64+25 | 1022.1 | 1036.85 | 14.5 | 1021.01 | 24-inch RCP |
| SDMH#15 | 67+50 | 1022.1 | 1036.74 | 14.4 | 1021.76 | 24-inch RCP |
| CB#11 | 67+50 | 1022.1 | 1036.26 | 13.9 | 1030.16 | 18-inch RCP |
| SDMH#14 | 70+74 | 1022.1 | 1035.8 | 13.5 | 1022.51 | 24-inch RCP |
| CB#10 | 70+74 | 1022.1 | 1036.48 | 14.1 | 1029.49 | 18-inch RCP |
| SDMH#13 | 74+04 | 1022.1 | 1036.58 | 14.2 | 1023.27 | 24-inch RCP |
| CB#9 | 74+04 | 1022.1 | 1035.48 | 13.1 | 1029.98 | 18-inch RCP |
| SDMH#13 | 49+97 | 1022.1 | 1034.8 | 12.5 | 1020.12 | Tie into Existing 54-inch Storm Drain |
| SDMH#35 | 49+97 | 1022.1 | 1035.2 | 12.9 | 1027.88 | 54-inch RCP |

Note:
1. Storm Drain Stations from Camelback Road Storm Drain Plans.
2. 100-year water surface elevation interpolated from elevations between cross sections 9.643 and 9.662.
3. Lowest invert elevation refers to lowest pipe invert into/out of structure.
4. Rim elevations for mainline laterals north and south along 107th street are all well above the projected 100-year water surface elevation. See Design plans in **Appendix B**. Plan sheets showing rim elevation are located on CD.

*All elevations are NAVD88

Based on the discussion above, drainage areas identified in the *Camelback Road Drainage Report* are not co-mingled with interior drainage areas identified in *Final Interior Drainage Report* for Camelback Ranch Levee thus will not be considered as interior drainage for the Camelback Ranch Levee South.

# D. Data for Interior Drainage

## D.1 Portions of Final Interior Drainage Report, Camelback Ranch Levee

## D.2 Portions of *Camelback Road Drainage Report*

# D.1 Portions of Final Interior Drainage Report, Camelback Ranch Levee

# "FINAL" INTERIOR DRAINAGE REPORT

# CAMELBACK RANCH LEVEE DESIGN PROJECT

## CONTRACT NO. FCD 95-15

Property of
Flood Control District of MC Library
Please Return to
2801 W. Durango
Phoenix, AZ 85009

**Prepared For:**

**FLOOD CONTROL DISTRICT OF MARICOPA COUNTY**

**2801 WEST DURANGO**

**PHOENIX, ARIZONA 85009**

**Prepared By:**

**DMJM ARIZONA, INC.**

**300 WEST CLARENDON AVENUE, SUITE 400**

**PHOENIX, ARIZONA**

**DMJM PROJECT No. 6526.01**

REGISTERED PROFESSIONAL ENGINEER (CIVIL)
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21029
MICHAEL S.
SHAPIRO
Date Signed 4/1/98
ARIZONA, U.S.A.

**APRIL 1998**

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## III. INTRODUCTION

DMJM has been engaged by the Flood Control District of Maricopa County, (Contract No. FCD 95-15) to design soil cement levee improvements for the following locations:

- East bank of Agua Fria River, from the transverse diversion spur dike north of Indian School Road to the Agua Fria-New River Junction.
- East bank of New River, from the Agua Fria-New River Junction to the Bethany Home Road alignment.

The proposed improvements are shown on Figure 1 on page 2 and are located in Township 2 North, Range 1 East, in Sections 18 and 19 of the Salt River Gila Base and Meridian, Maricopa County, Arizona.

The goals and objectives for the Camelback Ranch Levee Design project is to produce plans, specification and estimate for the construction of a new soil cement levee, in two construction phases, to prepare the necessary documentation for obtaining a Conditional Letter of Map Revision (CLOMR) from the Federal Emergency Management Agency (FEMA) and to meet the conditions agreed to with the U.S. Army Corps of Engineers (COE) for the construction of the Arizona Canal Diversion Channel (ACDC).

The South Phase consists of a soil cement levee that runs along the east bank of the Agua Fria River connecting from the southeast spur dike at the Camelback Road bridge to the existing transverse diversion dike, north of Indian School Road.

Replace with Figure 1

The North Phase consists of a soil cement levee from the embankment of Camelback Road, north, along the west property line of Camelback Ranch, along the east side of the Agua Fria River to the existing soil cement levee embankment along the Bethany Home Road alignment, along the east side of the New River. The levee runs along the east bank of Agua Fria River to the New River junction where it turns to the northeast and runs along the east bank of New River. The North Phase is scheduled to begin construction after the South Phase is completed. See Figure 1 on page 2 for the proposed levee alignment.

## A. PURPOSE OF REPORT

The purpose of this report is to evaluate and document the existing on-site drainage conditions for the Camelback Ranch Levee Design project and make recommendations for incorporating drainage improvements into the design. In addition this report will be incorporated into the CLOMR to remove the flood plain delineation from the subject property.

## B. BACKGROUND AND OVERVIEW

During the 1980's development was accelerating in west Phoenix. Camelback Ranch was investigated and conceptually planned by several developers during the 1980's before the Willden-Red River Joint Venture filed an application with the City of Phoenix (COP) for Planned Community District (PCD) zoning in April 1988, case #108-88-4. See Figure 1 on page 2 for the boundaries of the Camelback Ranch property. This PCD application was approved by the Phoenix City Council, with stipulations, on November 1, 1988, with subsequent amendments.

The PCD called for commercial and office uses at the northwest and southwest corners of Camelback Road and 107th Avenue, a major park on approximately 90 acres along the north edge of the property, and a variety of residential densities throughout the balance of the property. The City of Phoenix purchased the 90 acre

park site along the north edge of the property. The plan also required that the developer to construct a levee along the north and west edges of the property to remove it from the floodplain. The basic design concept for the levee was approved by the Flood Control District of Maricopa County (FCDMC). Another key zoning stipulation was that construction on the project must begin within three (3) years of adoption of the PCD. Due to the economic climate in the late 1980's and early 1990's, construction on the project including the levees, was never started. The original developer obtained several time extensions from the City of Phoenix. Ultimately, the property reverted to the lender and then to the Resolution Trust Corporation (RTC). During this time the FCDMC was under pressure to construct the levees or acquire flood control easements over the entire Camelback Ranch property plus a number of the existing homes east of 107th Avenue and north of Camelback Road which were now in the Standard Project Flood (SPF) zone. Due to the depressed real estate prices at the time, the FCDMC determined that it could purchase the entire Camelback Ranch property for about the same cost as the flood control easements. When the property was made available by the RTC the FCDMC purchased it. The levee on the north portion of Camelback Ranch, in the original PCD, required its construction across two areas of property not owned by the developer. One of these areas is owned by the City of Glendale who is not inclined to allow the levee to be constructed there and result in the development of additional residential uses in the flight path of the Glendale Municipal Airport. Therefore this portion of the levee was moved further south, to within the City of Phoenix's corporate boundary, when the FCDMC performed their alternative levee analysis. The FCDMC purchased the Camelback Ranch property in order to fulfill its obligation to provide flood protection to property that was brought under the SPF designation due to the increased flow in the New River resulting from the construction of the ACDC. Provision for this additional flood protection was a condition of the COE's approval of the ACDC.

FCDMC's goals for Camelback Ranch are:

- Sell all available land after the levees are designed and constructed.

- Sell this available land at the highest price based on a land use plan and zoning approved by the City of Phoenix.
- Sell this available land in the shortest time possible consistent with receiving the best reasonable price.
- Construct the South Phase (south of Camelback Road), sell that portion of the property and use the proceeds of the sale to construct the levee for the North Phase (north of Camelback Road).

The width of the Agua Fria River within the project limits ranges from approximately 1,400-feet where it is channelized, south of Indian School Road to approximately 2,700-feet between Indian School Road and Camelback Road. The FEMA 100-year flood boundary for the Agua Fria River, shows a flood boundary that ranges from approximately 1,400-feet in the channelized portion, south of Indian School Road, to approximately 11,000-feet in width south of the confluence of the Agua Fria and New Rivers. Along the east side of the 100-year flood boundary approximately 457-acres of the 584 -acre Camelback Ranch property is within the 100-year flood boundary. In addition, approximately 15-acres of partially developed residential land, lying east of 107th Avenue between Camelback Road and the Bethany Home Road alignment are within the 100-year flood boundary.
There is a sand and gravel mining operation owned by Johnson-Stewart Materials L.L.C. within the project limits. For the south parcel of the Camelback Ranch Property an agreement between Johnson-Stewart and the FCD has been made for a right-of-way easement for the proposed levee. The easement is 100 feet wide and it extends from the northern most transverse diversion dike north of Indian School Road to the southeast spur dike at Camelback Road bridge.

## C. INTERIOR DRAINAGE

The total on-site drainage area for the Camelback Ranch Property is 517.12 acres and it is bound by the Bethany Home Road alignment to the north, Campbell

Avenue to the south, 107th Avenue to the east and the proposed levee along the Agua Fria River-New River to the west. Refer to Figure 2, Subbasin Map, on page 7.

Camelback Road is elevated above the adjacent properties, and therefore divides the watershed into two areas. The north area on-site drainage subbasin (referred to as subbasin area DA2) is bound by the Bethany Home Road alignment to the north, Camelback Road to the south, 107th Avenue to the east and the proposed soil cement levee to the west.

The south area on-site drainage subbasin (referred to as subbasin area DA3) is bound by Camelback Road to the north, Campbell Avenue to the south, 107th Avenue to the east and the 113th Avenue alignment to the west.

Replace with Figure 2

There are two off-site drainage areas that impact the on-site areas and are located adjacent to both the north and south areas. The off-site area contributing to the north area (subbasin area DA1) is located east of the Camelback Ranch Property and is bound by the Bethany Home Alignment to the north, Camelback Road to the south, 107th Avenue to the west and the Roosevelt Irrigation District (RID) Canal to the east. The off-site drainage area in the south area (subbasin area DA4) is located west of the Camelback Ranch Property and is bound by Camelback Road to the north, Campbell Avenue to the south, 113th Avenue alignment to the east and the proposed levee along the Agua Fria River on the west. See Figure 2 on the previous page for the drainage areas and subbasin boundaries.

Both drainage areas drain towards the southwest with the slope for the north area being 0.273 percent and the south area 0.316 percent. The vegetative cover for the developed subbasin DA1 is five percent for the land use type Light Density Residential (L.D.R.) and 15.0 percent for Very Light Density Residential (V.L.D.R.). The remaining existing land use is agricultural with a vegetative cover of 50.0 percent.

Runoff from the north area will concentrate along the north embankment of the Camelback Road and the proposed levee. Since the proposed levee could prevent the north area from draining into the Agua Fria River, a detention basin with a levee penetration pipe is proposed to be constructed at the southwest corner of the north area. The detention basin will allow for the metered release of storm water once the flows in the Agua Fria River has subsided. The south area will continue to drain as per existing conditions.

## IV. OBJECTIVES

The objectives of the Interior Drainage Report are as follows:

- Determine the peak runoff flows from the 100-yr, 6-hr event for both the north and south area for existing conditions.
- Determine the existing condition peak runoff volume from the 100-yr, 6-hr storm for sizing a detention basin in the north area.
- Determine the peak runoff volume from the 100-yr, 2-hr (City of Phoenix requirement) event for the north area future conditions to size a levee penetration pipe to drain the detention basin within 36 hours after the flows have subsided in the Agua Fria River.
- To ensure that back water from penetrations through the levee will not impact interior drainage behind the levee.
- To meet FEMA requirements of section 65.10 and therefore not impound more than one foot of stormwater behind the levee.

## V. CONCLUSIONS

For the north area, the 100-yr, 6-hr existing condition peak runoff from subbasin area (referred as DA) DA1 is 199 cubic feet per second (cfs) and DA2 is 192 cfs. These two subbasins combine and therefore, the 100-yr, 6-hr existing peak runoff is 366 cfs and require 54 acre feet (ac-ft) of detention storage. For the 100-yr, 2-hr future conditions (PCD), the north area will generate a peak runoff flow of 507 cfs and require 67 ac-ft of detention storage. A 36-inch concrete penetration pipe with a drop inlet structure will be required to drain the detention basin. Results from the HEC-1 models show that the 54 ac-ft detention basin for existing conditions, with the 36-inch concrete pipe will drain the basin in 22 hours, once the flows in the Agua Fria River has subsided. It also shows that the detention basin can be increased in storage to 67 ac-ft for future PCD conditions and the same 36-inch concrete pipe will drain within 27 hours, once the flows in the Agua Fria River has subsided. It is recommended that the right-of-way for the 54 ac-ft basin be reserved so that the basin can be maintained by the FCDMC until the basin is expanded for its post development configuration. The expansion of the detention basin from 54 ac-ft to 67 ac-ft can be easily accomplished by widening the basin to the north and east. At the time the basin is expanded an agreement can be made between the FCDMC and the new owner to take over the maintenance of the basin. A flapgate will be required on the outlet of the penetration pipe that will drain the detention basin into the Agua Fria River. The flapgate will prevent backwater from flows in the river from impacting interior drainage behind the levee.

The two subbasins in the south area, DA3 and DA4, have a 100-yr, 6-hr existing condition peak runoff of 131 cfs and 14 cfs respectively. These two subbasins will continue to drain to the south as per existing conditions. Table 1, on page 11, summarizes the subbasin areas and peak runoff flows.

Based on normal depth calculations, the depth of flow behind the levee will not exceed 0.37 feet in the north area and 0.39 feet in the south area. Therefore, the

impoundment criteria set by the committee on "A Levee Policy For The National Flood Insurance Program" will be met.

**SUBBASIN AREAS, PEAK RUNOFF FLOWS AND VOLUMES FOR THE 100-YR, 6-HR STORM EVENT EXISTING CONDITION AND 100-YR, 2-HR STORM EVENT FUTURE CONDITION**

NORTH AREA

| SUBBASIN | AREA (ac.) | Q peak (cfs) EXISTING | Q peak (cfs) FUTURE |
|---|---|---|---|
| DA1 | 193.47 | 199 | *N/A |
| DA2 | 280.45 | 192 | N/A |
| TOTAL PEAK FLOW (cfs) = | | 366 | 663 |
| TOTAL STORAGE VOLUME (ac-ft) = | | 54 | 67 |

SOUTH AREA

| SUBBASIN | AREA (ac.) | Q peak (cfs) EXISTING | Q peak (cfs) FUTURE |
|---|---|---|---|
| DA3 | 236.67 | 131 | N/A |
| DA4 | 38.91 | 14 | N/A |
| TOTAL PEAK FLOW (cfs) = | | 145 | 158 |

TABLE 1

*N/A – not applicable sub basins were sub divided for future developed conditions.

# VI. PROCEDURES AND METHODOLOGIES

This section documents the procedures and methodologies used for hydrology, detention basin sizing and hydraulics within this report.

The FCD controls the Camelback Ranch property. The City of Phoenix (COP) through its drainage policies, ordinances, and retention basin requirements for proposed developments will require that the proposed development retain the 100-yr, 2-hr event for proposed conditions. Therefore, the interior drainage system behind the proposed levees were designed and analyzed using existing conditions.

The only exception to the above was for the design of the outlet penetration pipe through the soil cement levee in the north area. Both the existing and proposed PCD hydrologic conditions were evaluated to size the outlet pipe. The existing conditions hydrology was used to develop a runoff hydrograph of the north area so that a detention basin can be designed to retain the 100-yr, 6-hr runoff. When the area is developed, the detention storage requirements will increase, subsequently, the outlet pipe will have to be increased to drain the detention basin within 36 hours. To avoid reconstructing the pipe, which would require removal of a portion of the levee, when the area is developed, the future condition hydrology was developed to compute a runoff hydrograph for the north area so that a penetration pipe can be sized to drain the future detention basin within 36 hours.

## A. HYDROLOGY

The following lists the procedures, methodologies and standards that were used to develop the hydrologic model (HEC-1) for the interior drainage on the Camelback Ranch Levee Design project.

### 1. Standards Used

- Drainage Design Manual for Maricopa County, Arizona - Volume 1, Hydrology was used to develop the hydrological parameters.
- HEC-1 was used for the hydrological computations.
- Drainage Design Menu System (DDMS) version 1.1 was used to develop the HEC-1 model.
- Rainfall loss parameters were calculated using the Green and Ampt infiltration equation. Loss parameters were obtained from the Soil Conservation Service's soil survey of Maricopa County Central Part II supplied by the FCD's ,Geographic Information Systems (GIS) group in digital format.
- Land use types were derived based on present usage for the existing conditions model.
- Land use types for the future development conditions model were derived from the existing PCD.
- The Clark Unit Hydrograph method was used to calculate the peak runoff flows.

### 2. HEC-1 Parameters

a. Watershed Delineation

The overall watershed was delineated using topographic mapping provided by the FCD GIS group, for Maryvale Area Drainage Master Study (ADMS), reviews of previous reports including the Coe and Van Loo Engineering Inc. Camelback Ranch Floodplain and Interior Drainage Report and field reconnaissance to verify their overall delineation.

The watershed was divided into two areas, called the north and south area, at Camelback Road because it's raised high enough in elevation that it prevents the storm water runoff from crossing the roadway. The north and south areas were divided into two subbasins, DA1 and DA2 for the north area, DA3 and DA4 for the south area. Subbasin DA2 and DA3 are the Camelback Ranch Property owned by the FCD and DA1 and DA4 are owned by private parties. Once the areas were subdivided Microstation was used to determine the areas of each subbasin.

b. Time of Concentration

The flow paths for obtaining the time of concentrations were determined by: 1) taking into account variables such as, the longest flow paths and the flow paths that appear to carry the majority of the runoff flows; 2) making field visits to approximate actual flow paths adjacent to and through the Camelback Ranch property and 3) using topographic mapping. Using the these three components subbasin concentration points were determined to be at the lowest elevation where the flow path outlets the subbasin. Flow path, elevation, length and slope were estimated from the topographic mapping.

c. Routing

The Muskingum-Cunge routing was used in the north area for routing runoff from subbasin DA1 through DA2. The routing flow path was modeled as a V-ditch with 6:1 side slopes. It traverses along the north embankment of Camelback Road from the concentration point of subbasin DA1 (107$^{th}$ Avenue and Camelback Road) to where the proposed levee ties into the north embankment at Camelback Road. Other parameters used for Muskingum-Cunge routing are shown in Figure 2 on page 7 and in the HEC-1 model.

d. Rainfall

The precipitation depths were estimated using the NOAA ATLAS II isopluvial maps. The PREFRE program provided with DDMS was used to calculate the return year rainfall depths. The 100 year 6-hour rainfall depth was determined by using the storm distribution pattern number 1.4 with an aerial reduction factor of .987. The rainfall depth for the 100-yr, 6-hr storm is 2.96 inches. The 100-yr, 2-hr precipitation depth is 2.64 inches.

e. Soils Type

The soil types found in the four subbasins are shown in Figure 3 on page 16. Soil types were identified by merging of the Soil Conservation Service's soil survey of Maricopa County Central Part II with the topographic mapping digital files. The soil type areas were calculated by using area measurement in Microstation. The soils types and the corresponding loss rate parameters were identified within the DDMS software and determined from default lookup tables included within the software. A breakdown of the soils types per subbasin and the Green Ampt Loss rates associated with the soils type are listed in Table 2 on page 17.

f. Land Use

The land use for the subbasins were determined by their present use for the existing condition model. For subbasins DA2, DA3 and DA4 the land use is agricultural even though it is zoned for residential. Subbasin DA1 is partially developed and classified as Very Light Density Residential (V.L.D.R., zoned as RE-43) and Light Density Residential (L.D.R., zoned RE-35). Figure 4 on page 18 shows the land usage per subbasin for existing conditions and Table 2 on page 17 shows the associated Green Ampt loss rates. Land use used for the future conditions model is described in subsection C.1., Outlet Design.

Reserved for figure 3

Replace with table 2

Replace with figure 4

### 3. HEC-1 Data Input

The HEC-1 data input was created by DDMS and the default lookup tables. Table 2 on page 17 lists the area weighted loss rates associated with the soil types and land usage calculated by the DDMS program that was input into HEC-1 model. Located in the appendix are printouts of the HEC-1 data input and output. Printout CBRANCH.OUT reflects the existing conditions. Printout CBR-PCDA.OUT is the HEC-1 model used to determine the future detention volume requirements of the north area PCD so that the penetration pipe could be sized.

## B. DETENTION BASIN SIZING

The detention basin located in the north area is sized based on combining subbasins DA1 and DA2 and calculating the area under the hydrograph from the HEC-1 existing condition model. The existing condition outflow volume for the 100-yr, 6-hr storm event was used to size the detention basin. The detention basin was sized to retain the full amount of storm water runoff volume in the event that the Agua Fria River is flowing and there may be a time delay before the river subsides and the outlet can begin to discharge. The detention basin does not include freeboard due to the desire to maximize the amount of land to be developed. Figure 5 on page 20 shows the predeveloped detention basin size and location. Detention was also determined for the post developed (100-yr, 2-hr storm) conditions. The ultimate developer can add the additional storage to the basin by widening it when development occurs.

Replace with Figure 5

## C. HYDRAULICS

### 1. Outlet Design

The outlet (i.e. penetration pipe) was designed to drain the future developed PCD conditions. As previously discussed, when the area is developed, the detention storage requirements will increase. This in turn will increase the penetration pipe diameter to increase the discharge rate required to drain the detention basin within the 36 hour time requirement. To avoid reconstructing the pipe and levee once the north area is developed, the future condition hydrology was used, from the Master Drainage Report For Camelback Ranch Planned Community District Amendment Case No. 108-B-88-05 prepared by DMJM, to develop a runoff hydrograph for the north area so that the penetration pipe could be sized to drain the detention basin within 36 hours.

The detention basin will be expanded to detain the full 100-year, 2-hour runoff volume of 67 ac-ft for the north area. The size of the detention basin will be approximately 18 acres. The basin will have approximate dimensions of 770 feet (east-west) by 985 feet (north-south), with an average depth of 4.25 feet. The depth of the basin is controlled by the outlet elevation at the southwest corner of the basin and may not exceed 4.5 feet. The detention basin will be graded to drain to the outlet at the southwest corner of the basin. The depth varies from 4.0 feet at northwest, northeast, and southeast corners of the basin to 4.5 feet deep at the outlet at the southwest corner of the basin. The basin will have side slopes of 4:1. There will be no freeboard incorporated into the design of the detention basin to allow for maximum land available for development.

A culvert analysis using FHWA's computer program HY8, for a concrete pipe, was performed and a stage versus discharge curve was plotted. From the curve, a stage versus discharge table was computed using increments of 0.50 feet of depth. A corresponding stage versus storage volume table was tabulated so that the values could be entered into the Modified Puls routing in the HEC-1 model. The detention basin being analyzed, by using Modified Puls routing in the HEC-1 model, ensures that the detention basin will drain within the 36 hour requirement, after the flows in the Agua Fria River have subsided.

Due to the flat conditions and the need to minimize the detention basin size and penetration pipe size, a modified drop inlet structure was analyzed to increase the discharge capacity. The modified drop inlet structure allows for a greater head above the pipe, in relation to the water surface depth in the detention basin, so that the pipe can operate in a more efficient manner. To ensure that the modified inlet will allow enough flow into the pipe a weir flow analysis ($Q = CLH^{3/2}$) was performed on the inlet structure to determine if more flow can enter the inlet than the pipe can discharge. A weir coefficient of 3.0 was used and the length on the inlet opening of 7.75 ft. for the weir length (L).

The pipe was analyzed for two conditions. The first condition assumes minimal flow in the Agua Fria River (flow below flapgate at the penetration pipe outlet) while the penetration pipe discharges as the detention basin begins to fill. The second condition assumes that the Agua Fria River is flowing full, the flapgate is closed, the detention basin fills up completely before the river subsides and then the detention basin begins to drain. The detention basin was sized for the worse case scenario where the basin fills (due to the river flowing full) and then drains.

## 2. Impoundment Behind the Levee

Normal depth calculations were performed at two locations behind the levee using the modified Manning's equation to verify the depth of flow.

The modified Manning's equation is:

$$Q = 0.56/n \; S_x^{1.67} \; S^{0.5} \; T^{2.67}$$

where $n$ = Manning's coefficient

$S_x$ = the cross slope

$S$ = the longitudinal slope

$T$ = the width of flow

See Figure 5 on page 19 for the cross section locations. One calculation was performed for the north area and one for the south area. To be conservative, the total 100-yr, 6-hr peak runoff flow was used to calculate the depth of flow behind the levee. The modified Manning's equation was used due to the shallow depth of flow and the wide width of flow. A Manning roughness coefficient "n" value of 0.040 was used to simulate post grading condition behind the levee with minimal vegetative growth.

# VII. DESIGN RECOMMENDATIONS

## A. NORTH AREA

### 1. Detention Basin

The detention basin will be designed to detain the full 100-yr, 6-hr runoff volume of 54 ac-ft in the event the Agua Fria River is flowing full. The detention basin was assumed to be square, 770 feet wide by 770 feet long, with an average depth of 4.25 feet. The detention basin will be graded at a slope of 0.0007 '/ft so that it can drain to the outlet. The depth varies from four feet at the upstream end to 4.5 feet deep at the downstream (outlet) end with side slopes of 4:1. There will be no freeboard incorporated into the design of the detention basin so that there will be maximum land available for development. Erosion protection for the inlet to the detention basin will be incorporated into the final design.

The post developed detention basin will need to be 780 feet by 985 feet (assumed square), it will have 4:1 side slopes and have an average depth of 4.25 feet.

### 2. Outlet to the Agua Fria River

A 36-inch concrete pipe will be used to drain the detention basin for the existing and future conditions within the 36-hr requirement. A headwall and flap gate will be designed at the 36-inch outlet to the Agua Fria River to prevent backwater into the interior drainage system. A modified drop inlet structure [modified Maricopa Association of Governments (M.A.G.) Standard Detail No. 501-5] will be required at the entrance to the pipe. The modified drop inlet structure will add an additional one half foot of head at the pipe entrance to optimize the pipe performance. It will also have an access barrier for safety. Since the detention basin will store more than three feet of water, safety fencing will be placed around the entire detention basin.

In addition, a 15 foot wide maintenance road, with ramps down to the floor of the basin, will be included.

## B. SOUTH AREA

The south area will be drained through the Johnson-Stewart property and discharge into the Agua Fria River behind the north Indian School Road transverse spur dike by means of a swale.

# VIII. HYDROLOGIC AND HYDRAULIC CALCULATIONS

## A. INTERIOR DRAINAGE CALCULATIONS

The interior drainage calculations are shown in Appendix A and in the HEC-1 computer output hardcopies.

The following lists the HEC-1 models included in Appendix A:

| | |
|---|---|
| CBRANCH.DAT | Models the existing 100-yr, 6-hr conditions. |
| CBRANCH2.DAT | Analyzes detention basin for existing 100-yr, 6-hr conditions where the basin drains as the basin fills. |
| CBR-EXTB.DAT | Analyzes detention basin for existing 100-yr, 6-hr conditions where the basin drains after the basin reaches the maximum storage capacity. |
| CBR-PCDA.DAT | Analyzes detention basin for PCD 100-yr, 2-hr conditions where the basin drains as the basin fills. |
| CBR-PCDB.DAT | Analyzes detention basin for PCD 100-yr, 2-hr conditions where the basin drains after the basin reaches the maximum storage capacity. |

## B. HYDRAULIC CALCULATIONS

The hydraulic calculations are included in Appendix B. The following lists the calculations performed and the methods used.

| | |
|---|---|
| Culvert Analysis | FHWA's HY8 see file: 1-36. |
| Detention Basin Sizing | Excel spreadsheet. file:DET-SZ.XLS. |
| Stage Volume Calculations Existing Conditions | Existing Conditions Excel spreadsheet. file: STG-VOL1.XLS. |
| Stage Volume Calculations PCD Conditions | Excel spreadsheet. file: STG-VOL2.XLS. |
| Stage/Storage/Discharge Existing Conditions | Analyzes 36" concrete pipe for stage vs. discharge curve for existing conditions file: 1-36EXT.XLS. |
| Stage/Storage/Discharge PCD Conditions | Analyzes 36-inch concrete pipe for stage versus discharge and defines curve for PCD conditions file: 1-36PCD.XLS. |
| Modified Inlet Analysis | Analyzes modified inlet capacity using the weir flow equation File: WEIR.XLS. |
| Depth of Impoundment Behind Levee | Calculates the depth of flow behind levee utilizing modified Manning equation file: LEVEEEQ.XLS. |

## IX. REFERENCES


1. Aerial Mapping Company Inc. Aerial Mapping of Agua Fria River and Camelback Ranch Property. March 21, 1996
2. Coe & Van Loo Engineering Inc. ADDENDUM TO: CAMELBACK RANCH FLOODPLAIN STUDY AND CONDITIONAL LOMR REQUEST. May, 1988.
3. Coe & Van Loo Engineering Inc. CAMELBACK RANCH FLOODPLAIN AND INTERIOR DRAINAGE REPORT. June, 1988.
4. Coe & Van Loo Engineering Inc. CAMELBACK RANCH FLOODPLAIN AND INTERIOR DRAINAGE REPORT. November, 1988.
5. Coe & Van Loo Engineering Inc. CAMELBACK RANCH FLOODPLAIN STUDY AND CONDITIONAL LOMR REQUEST. January, 1988.
6. Coe & Van Loo Engineering Inc. CAMELBACK RANCH LEVEE AND INTERIOR DRAINAGE SYSTEM PHASING PLAN. April 6, 1990.
7. Coe & Van Loo Engineering Inc. MASTER DRAINAGE REPORT CAMELBACK RANCH. January 14, 1986.
8. Dooley - Jones & Associates. DRAINAGE STUDY AND CONCEPTUAL DESIGN. August 14, 1985.
9. Flood Control District of Maricopa County White Tanks ADMS Mapping in digital format.
10. Flood Control District of Maricopa County. Maryvale ADMS Mapping in digital format.
11. Flood Control District of Maricopa County. Drainage Design Manual for Maricopa County Volume I Hydrology. January 1, 1995.
12. Flood Control District of Maricopa County. Drainage Design Manual for Maricopa County Volume II Hydraulics. September 1, 1992.
13. Flood Control District of Maricopa County. Master Drainage Report for Camelback Ranch Planned Community District Amendment Case No. 108-B-88-05. August 1996.
14. Flood Control District of Maricopa County. SOIL SURVEY OF MARICOPA COUNTY ARIZONA. in digital format. March 1996.

14. Flood Control District of Maricopa County. SOIL SURVEY OF MARICOPA COUNTY ARIZONA. in digital format. March 1996.

15. Flood Insurance Rate Map Panel No. 1615 of 4350 No. 04013C1615G. December 3 1993.

16. Flood Insurance Rate Map Panel No. 1620 of 4350 No. 04013C1620F. September 4, 1991.

17. Flood Insurance Rate Map Panel No. 2080 of 4350 No. 04013C2080F. September 4, 1991.

18. Flood Insurance Rate Map Panel No. 2085 of 4350 No. 04013C2085E. September 4, 1991.

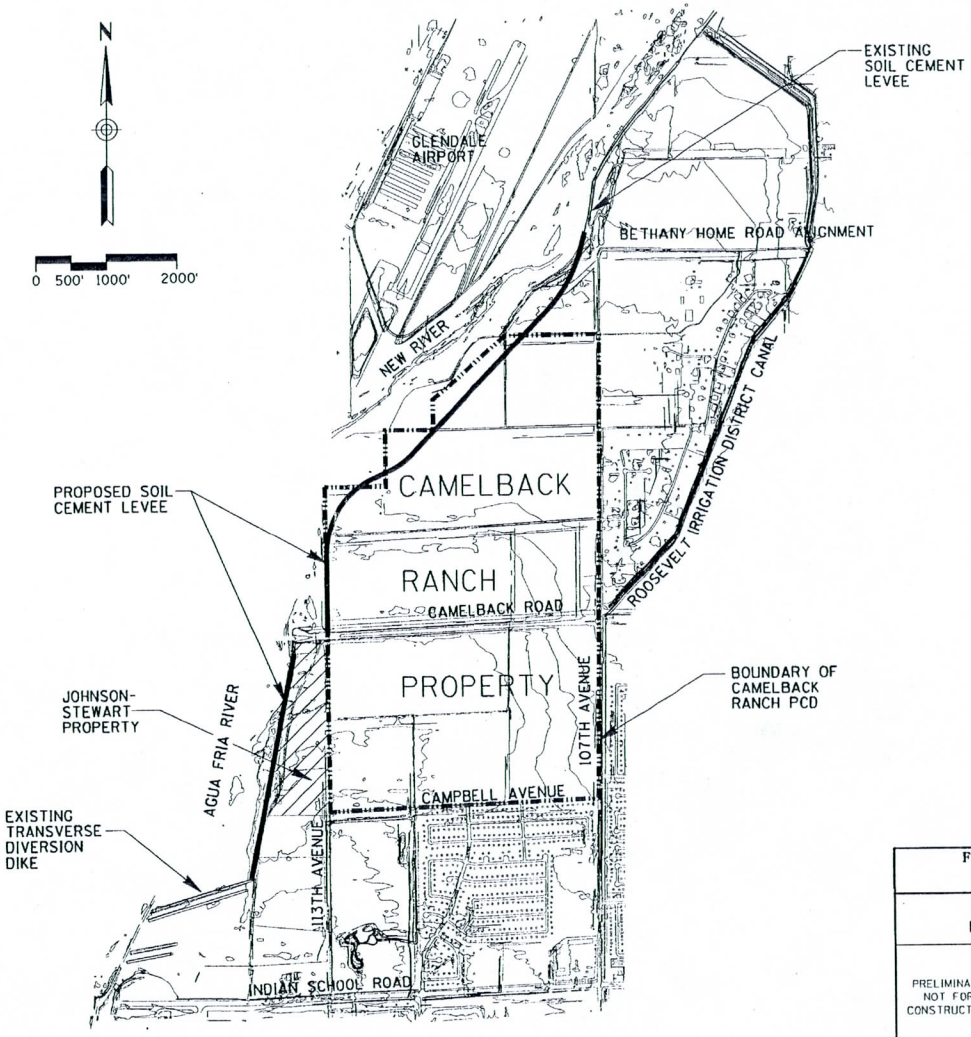
19. Haestad Methods QUICK HEC-12. January 1988.

20. National Research Council. A LEVEE POLICY FOR THE NATIONAL FLOOD INSURANCE PROGRAM. National Academy Press, 1982 National Research Council.

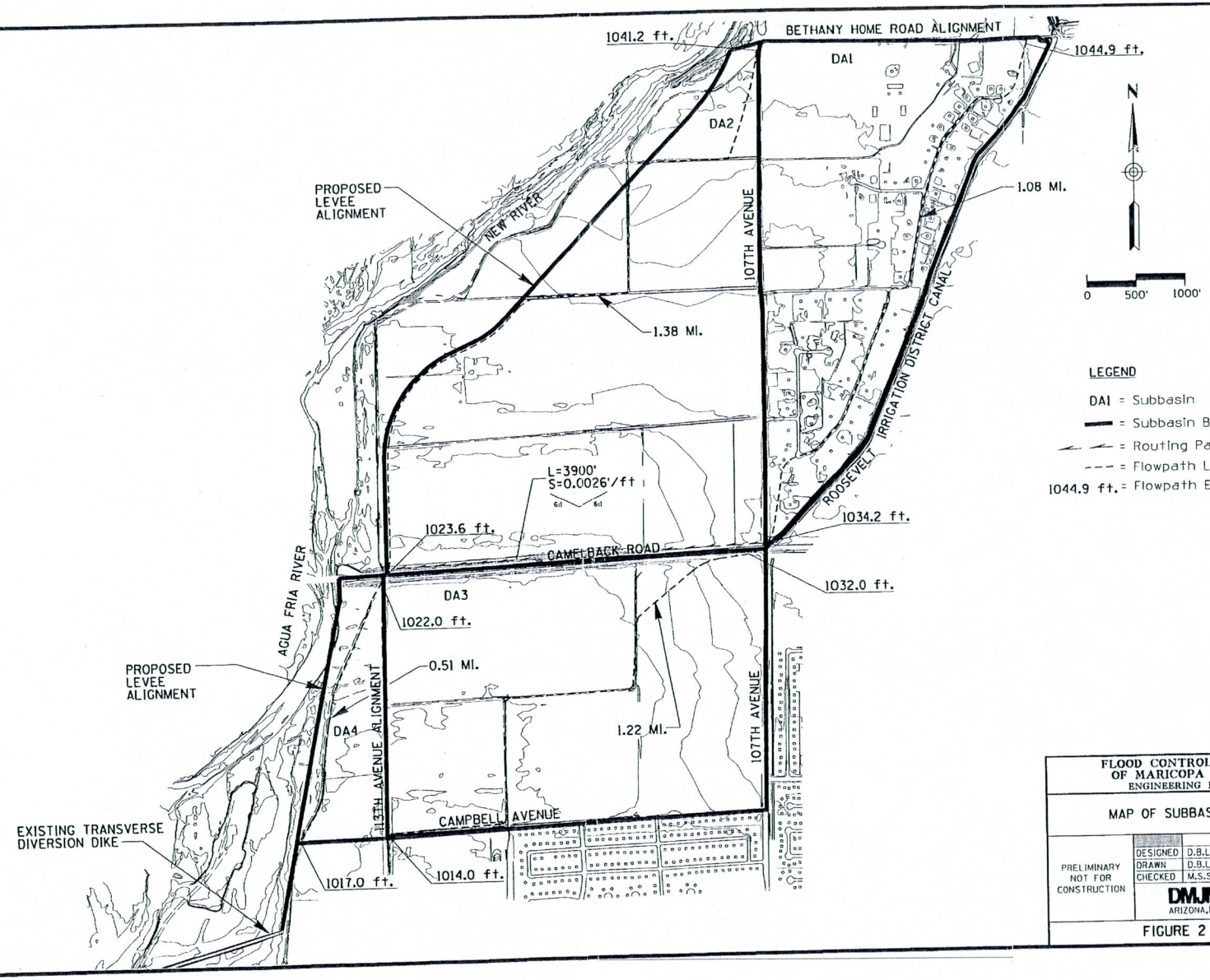
# X. APPENDIX

## A. INTERIOR DRAINAGE CALCULATIONS

## B. HYDRAULIC CALCULATIONS




| FLOOD CONTROL DISTRICT OF MARICOPA COUNTY ENGINEERING DIVISION | | | |
|---|---|---|---|
| CAMELBACK RANCH PCD AND PROPOSED LEVEE ALIGNMENT | | | |
| PRELIMINARY NOT FOR CONSTRUCTION | | BY | DATE |
| | DESIGNED | D.B.L. | 4/10/98 |
| | DRAWN | D.B.L. | 4/10/98 |
| | CHECKED | M.S.S. | 4/10/98 |
| | DMJM ARIZONA, INC. 300 WEST CLARENDON SUITE 400 PHOENIX, AZ. 85013-3499 (602) 264-0217 | | |
| FIGURE 1 | | | PAGE 2 |




FLOOD CONTROL DISTRICT OF MARICOPA COUNTY
ENGINEERING DIVISION

MAP OF SUBBASINS DA1-DA4

| | | BY | DATE |
|---|---|---|---|
| PRELIMINARY NOT FOR CONSTRUCTION | DESIGNED | D.B.L. | 4/10/98 |
| | DRAWN | D.B.L. | 4/10/98 |
| | CHECKED | M.S.S. | 4/10/98 |

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300 WEST CLARENDON
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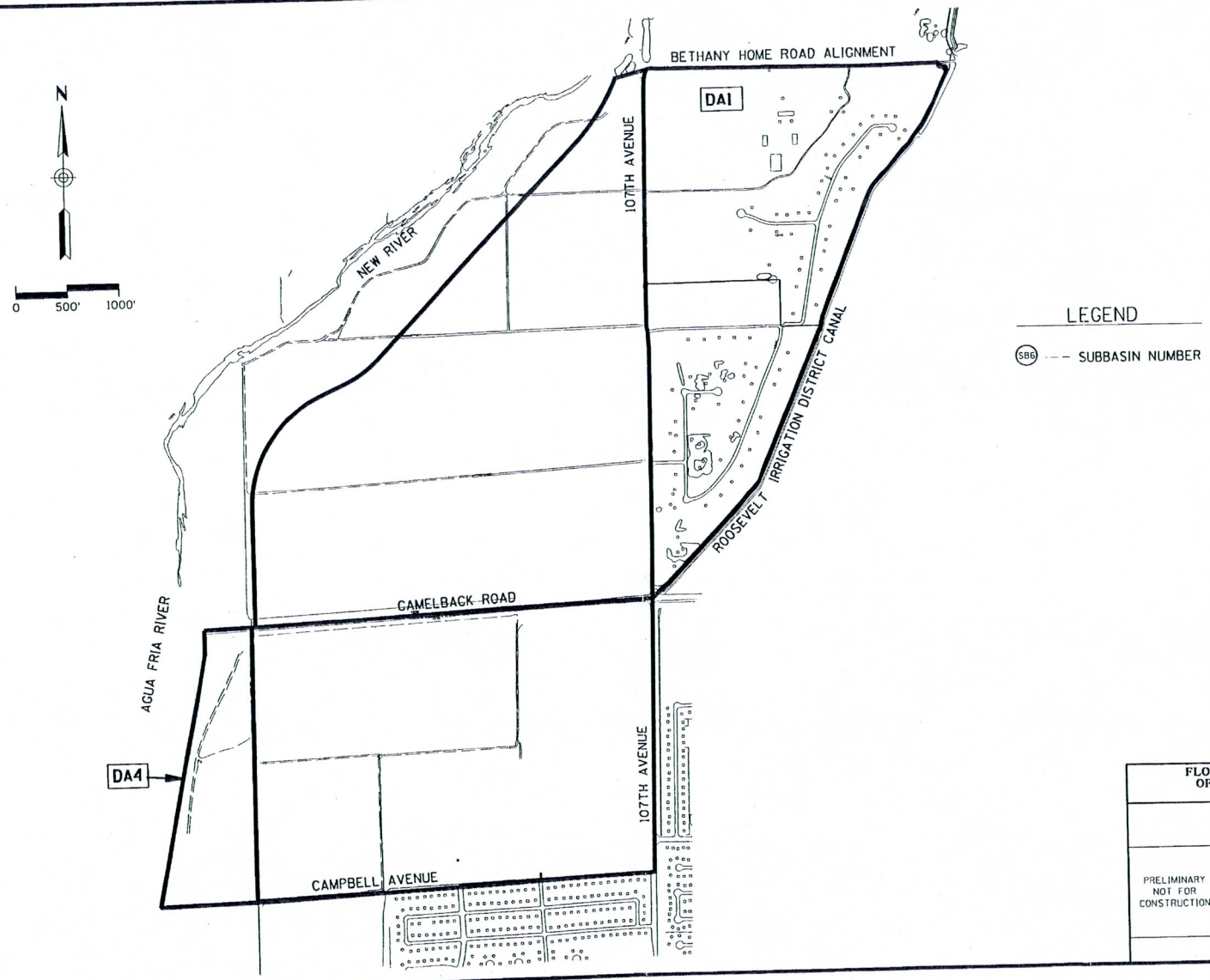
PHOENIX, AZ. 85013-3499
(602) 264-0217

FIGURE 2

PAGE 7




LEGEND

(SB6) --- SUBBASIN NUMBER

FLOOD CONTROL DISTRICT
OF MARICOPA COUNTY
ENGINEERING DIVISION

MAP OF SUBBASINS

| | | BY | DATE |
|---|---|---|---|
| PRELIMINARY NOT FOR CONSTRUCTION | DESIGNED | D.B.L. | 4/10/98 |
| | DRAWN | D.B.L. | 4/10/98 |
| | CHECKED | M.S.S. | 4/10/98 |

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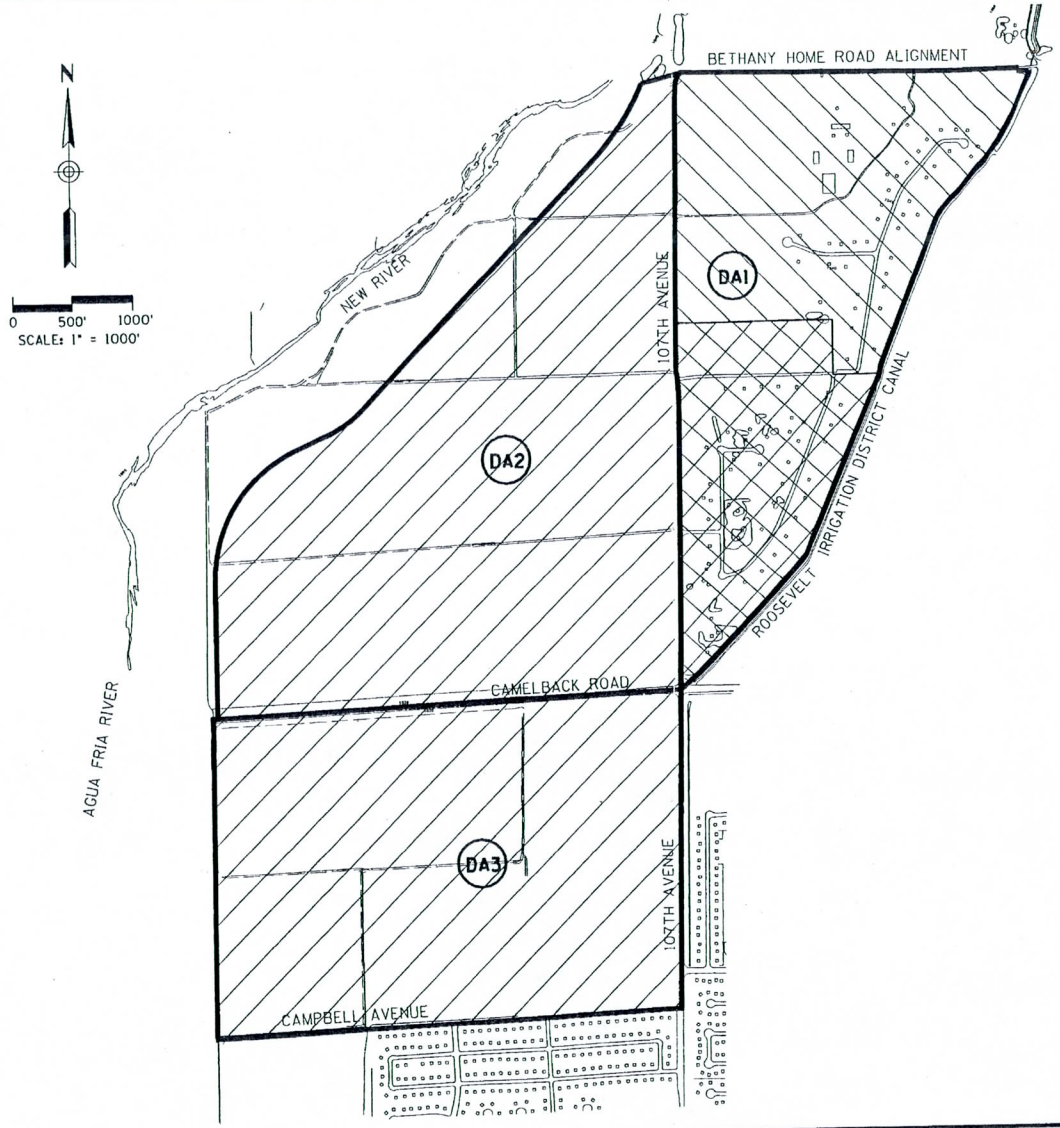
SUITE 400
PHOENIX, AZ. 85013-3499
(602) 264-0217

FIGURE 3




## LEGEND

- = SUBBASIN BOUNDARY
- = LANDUSE BOUNDARY
- = LIGHT DENSITY RESIDENTIAL (L.D.R.)
- = Agricultural
- = VERY LIGHT DENSITY RESIDENTIAL (V.L.D.R.)

**FLOOD CONTROL DISTRICT OF MARICOPA COUNTY**
ENGINEERING DIVISION

EXISTING CONDITIONS
LAND USE MAP

| | | BY | DATE |
|---|---|---|---|
| PRELIMINARY NOT FOR CONSTRUCTION | DESIGNED | D.B.L. | 4/98 |
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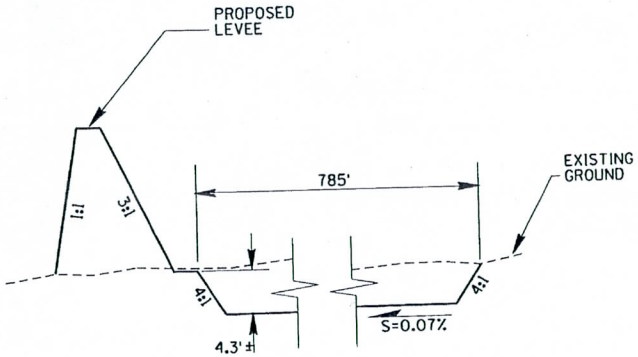
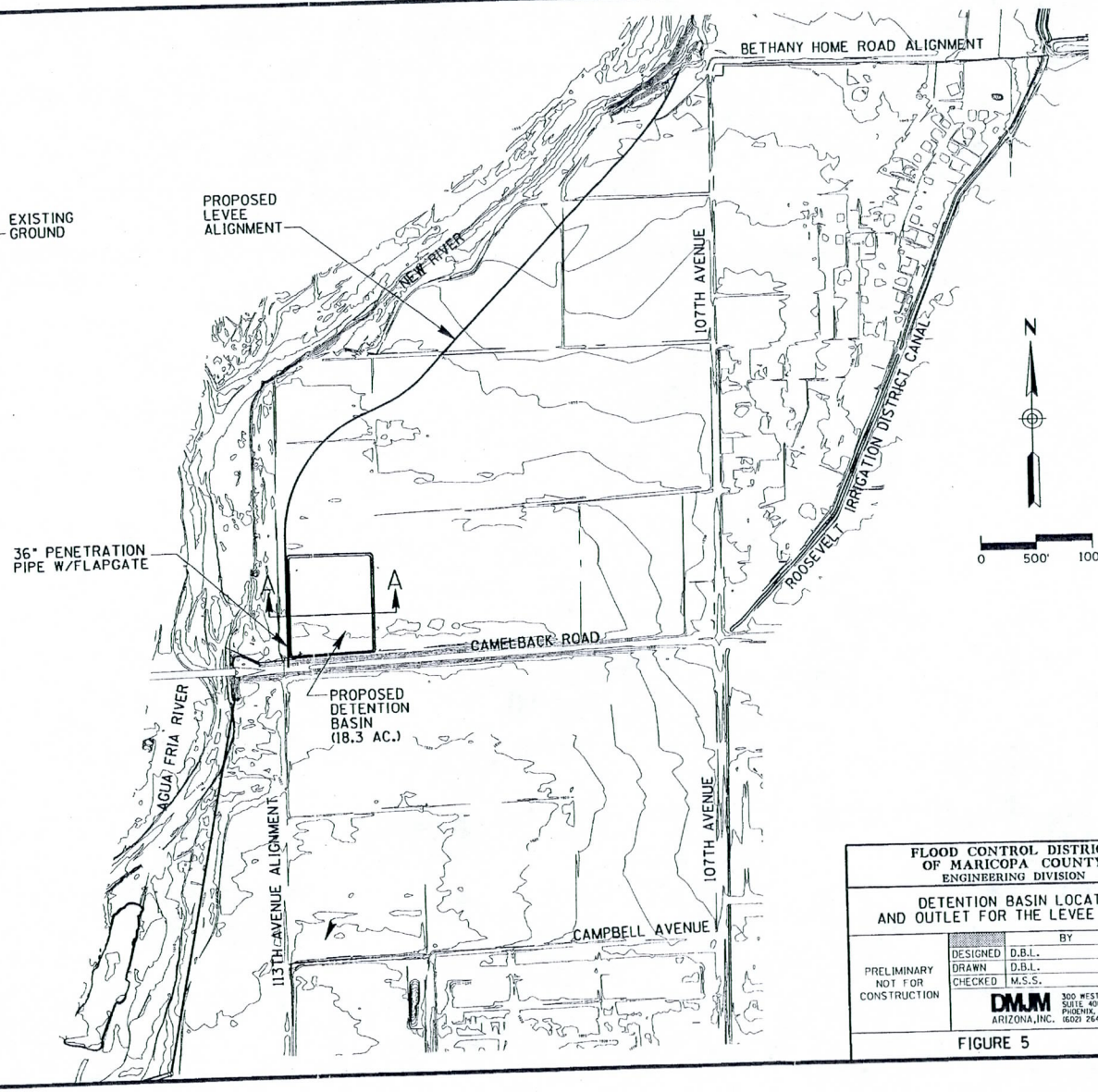
FIGURE 4




SECTION A-A
NTS




FLOOD CONTROL DISTRICT
OF MARICOPA COUNTY
ENGINEERING DIVISION

DETENTION BASIN LOCATION
AND OUTLET FOR THE LEVEE PROJECT

| | | BY | DATE |
|---|---|---|---|
| PRELIMINARY NOT FOR CONSTRUCTION | DESIGNED | D.B.L. | 4/98 |
| | DRAWN | D.B.L. | 4/98 |
| | CHECKED | M.S.S. | 4/98 |

DMJM ARIZONA, INC.
300 WEST CLARENDON
SUITE 400
PHOENIX, AZ. 85013-3499
(602) 264-0217

FIGURE 5

## D.2 Portions of *Camelback Road Drainage Report*

CITY OF PHOENIX
STREET TRANSPORTATION DEPARTMENT

# CAMELBACK ROAD STORM DRAIN DESIGN
(99TH AVENUE TO AGUA FRIA RIVER)
PROJECT NO. ST8311057

# HYDROLOGIC AND HYDRAULIC DESIGN REPORT


City of Phoenix
STREET TRANSPORTATION DEPARTMENT
DESIGN AND CONSTRUCTION MANAGEMENT DIVISION

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Tetra Tech, Inc.

CITY OF PHOENIX
STREET TRANSPORTATION DEPARTMENT

# CAMELBACK ROAD STORM DRAIN DESIGN
(99TH AVENUE TO AGUA FRIA RIVER)
PROJECT NO. ST8311057

# HYDROLOGIC AND HYDRAULIC DESIGN REPORT

Prepared for:

City of Phoenix
Street Transportation Department
Phoenix City Hall
200 West Washington, 5th Floor
Phoenix, AZ 85033
520-629-8266

By:

Tetra Tech, Inc.
4801 E. Washington, Suite 260
Phoenix, Arizona 85034-2004
602-682-3300

Registered Professional Engineer (Civil)
CERTIFICATE NO. 24026
ROBERT L. SHAND
Date Signed 8-23-05
ARIZONA U.S.A.

August 23, 2005

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# I. STORM DRAIN CHECKLIST

| NO. | | STATUS | ITEM |
|---|---|---|---|
| 1. | | _____ | A complete drainage report, sealed by a Civil Engineer licensed to practice in Arizona containing the following: |
| | a. | _____ | A drainage area map at an appropriate scale. |
| | b. | _____ | Each sub-basin area delineated in different colors and labeled with an alpha-numeric character on the Drainage Area Map. |
| | c. | _____ | Directional drainage arrows on all streets, parking lots, paved areas, and vacant land. |
| | d. | _____ | Zoning shown on each parcel. |
| | e. | _____ | Catch basins shown (existing catch basins shown with dashed lines). |
| | f. | _____ | Each catch basin number corresponding to the number of the sub-basin area which contributes to it. |
| | g. | _____ | Catch basins numbered, beginning with number 1 as the first catch basin contributing to the storm drain at the upstream end. The next catch basin contributing shall be number 2, etc. |
| | h. | _____ | The same catch basin number is used throughout the project – on the drainage area map, in the design report, on the Storm Drain Design Summary Sheet, and on the plans |
| | i. | _____ | Minimum catch basin freeboard provided per "Minimum Hydraulic Design Standards" table in Section 6.4 of the Manual. |
| | j. | _____ | Completed Storm Drain Design Summary sheet is included in Drainage Report. |
| 2. | | _____ | Conformance with previous drainage studies checked and differences discussed. |
| 3. | | _____ | Storm Drain Quantity Summary sheet is included in plans. |
| 4. | | _____ | Storm Drain Design Summary sheet is included in plans. |
| 5. | | _____ | Hydraulic & Energy Grade Line Profile sheet included in Drainage Report and in plans. |
| | a. | _____ | Maximum design HGL meets requirements specified in "Minimum Hydraulic Design Standards" table in Section 6.4 of the Manual. |
| 6. | | _____ | Design complies with pipe flow velocity standards shown in "Minimum Hydraulic Design Standards" table in Section 6.4 of the Manual. |
| 7. | | _____ | Dry lane requirements are met. |

| NO. | STATUS | ITEM |
|---|---|---|
| 8. | _____ | Appropriate drainage runoff was assumed: |
| a. | _____ | No contributing runoff was assumed for properties with existing 100-year on-site retention, or properties with plans for 100-year on-site retention which have been reviewed and approved by the City. |
| b. | _____ | Existing condition land-use runoff coefficients were used where contributory land is vacant or developed prior to storm water storage requirements. |
| 9. | _____ | All underground utilities identified in plan & profile. |
| 10. | _____ | Utility potholes requested (as needed) for capital improvement projects. |
| 11. | _____ | Water, sewer, and natural gas service taps shown in plan & profile. |
| 12. | _____ | All sanitary sewer manhole rim and invert elevations shown on plans. |
| 13. | _____ | Existing top of water valve nut elevations noted on storm drain plans. |
| 14. | _____ | Storm drain and catch basin connector pipe conflicts with other utilities identified. |
| 15. | _____ | SRP, RID, and private irrigation facilities checked for conflicts. |
| 16. | _____ | Waterline thrust block conflicts shown. |
| 17. | _____ | Pipe supports for sanitary sewer lines above main storm drain per MAG Detail 403, are called out. |
| 18. | _____ | Any existing Portland Cement concrete pavement underlay shown. |
| 19. | _____ | Existing topography and buildings shown at least 30 feet beyond street R.O.W. |
| 20. | _____ | Intersecting side street elevations at least 100 feet beyond curb returns noted on plans. |
| 21. | _____ | Potential ponding behind sidewalks checked and resolved. |
| 22. | _____ | Driveway/catch basin conflicts checked and resolved. |
| 23. | _____ | Finish floor elevations checked relative to 100-Year water surface elevations (6 inches), top of curb elevations (14 inches low curb, 6 inches high curb), street crown elevations (6 inches), and sump outfall elevations (6 inches) as appropriate. |
| 24. | _____ | One typical full-street cross-section with storm drain and all other underground utilities drawn at 1" = 10' H & V scale on each storm drain profile sheet. The section should be taken at a specific station location on that sheet, and that station location shall be noted on the cross-section. |
| 25. | _____ | Main line storm drain plans shall be 1 inch = 20 feet horizontal and 1 inch=2 feet vertical (unless otherwise approved). |

| NO. | STATUS | ITEM |
|---|---|---|
| 26. | _____ | Scales for connector pipe/catch basin profiles shall be 1 inch = 5 feet horizontal and 1 inch=5 feet vertical (unless otherwise approved). |
| 27. | _____ | Mainline storm drain has minimum 5-foot cover (unless otherwise approved). |
| 28. | _____ | Maximum distance that surface drainage is carried in a collector/arterial is 660 feet before reaching a catch basin |
| 29. | _____ | Maximum manhole spacing meets requirements specified in "Minimum Hydraulic Design Standards" table in Section 6.4 of the Manual. |
| 30. | _____ | At mainline storm drain pipe size changes, inside top of pipe (crown) elevations are matched, unless otherwise approved. |
| 31. | _____ | Soil boring(s) extending at least 2 feet below proposed storm drain have been taken and shown on the plans. |
| 32. | _____ | Soil boring logs and information including pH & resistivity shown on plans. Alternate pipe materials selected are appropriate for soil conditions. |
| 33. | _____ | Existing and proposed ground elevation shown for all mainline and connector pipe profiles. |
| 34. | _____ | Storm Drain Key Map is included. |
| 35. | _____ | Completed Alternate Pipe Material sheet is included. |
| a. | _____ | D-loads for RGRCP calculated and shown. |
| b. | _____ | Existing soil conditions suitable for CIPP or concrete-lined CSP alternate mainline pipe materials. |
| c. | _____ | For CIPP and CSP mainline storm drain pipe, Alternate Pipe Chart shows required oversized pipe diameter (over precast concrete pipe size). |
| d. | _____ | Alternate Pipe Chart shows CIPP no smaller than 30 inches in diameter. |
| e. | _____ | The calculated pipe wall thickness for CIPP is based on the required oversized pipe diameter. |
| f. | _____ | Maximum allowable pipe size for HDPE pipe is 48-inches in diameter. |
| 36. | _____ | Checked and specified Ductile Iron Pipe replacements for all existing ACP waterline crossings above new storm drain mainline pipe per COP Supplement to MAG, Section 601.2.10. |

_____

# II. INTRODUCTION

## 2.1 Location

The project site is located within the incorporated boundary of the City of Phoenix, Arizona. The site occupies portions of Section 17 through 20 of Township 2 North, Range 1 East, Gila and Salt River Meridian, Maricopa County, Arizona (see Figure 1).

## 2.2 Site and Project Description

The project area includes the Camelback Road right-of-way from the 99th Avenue intersection to just west of the 107th Avenue intersection and a 20-foot drainage easement from Camelback Road to the Agua Fria River. The Camelback Road street section between 99th Street and 107th Street consists of two travel lanes in each direction. Curb and gutter exists along the majority of the north side of the roadway and along the south side between 99th Street and 103rd Avenue. Between 107th Avenue and the Agua Fria River Bridge, the street section consists of two travel lanes with shoulders but no curbs.

Within the northern half of the right-of-way, there is an existing storm drain located beneath the sidewalk and landscaped area. This storm drain extends between 101st Avenue and the Roosevelt Irrigation District (RID) canal, which is located just east of the 107th Avenue intersection. The existing storm drain was constructed primarily to intercept a portion of the runoff from the three subdivisions to the north (Larrisa, Camelback Greens and Palisades Park) before it entered the Camelback Road street section. However, it also intercepts a portion of the runoff conveyed in the eastbound (north) lane of Camelback Road.

Stormwater conveyed in the existing storm drain will be augmented by constructing a new parallel storm drain with laterals beneath the eastbound (south) lane. The new storm drain will be used primarily to intercept and convey runoff generated within the southern half of the Camelback Road right-of-way between 99th Avenue and 107th Avenue. However, it will also intercept and convey runoff generated within a portion of the northern half of the right-of-way between 99th Avenue and 101st Avenue. Although the existing storm drain currently outfalls to the RID, this outfall will be eliminated. The downstream portion of the existing storm drain will be realigned to provide a connection to the new storm drain. The new junction structure will be located beneath the intersection of 107th Avenue, and it will include a stub-out to the north to accommodate a future storm drain for 107th Avenue. The combined flows from the existing storm drain, the new Camelback Road storm drain, and the future 107th Avenue storm drain will be convey to the Agua Fria River in a new outfall pipe.

In addition to the existing storm drain, the project area is crisscrossed by several large Salt River Project (SRP) conduits. The location of these conduits will affect both the location and the profile of the new storm drain.

A 10-inch sanitary sewer located beneath the westbound lanes extends from just east of 101st Avenue to 105th Avenue. However, this sanitary sewer does not have a significant impact on the design of the new storm drain.

## III. OFF-SITE DRAINAGE

### 3.1 Background

The project area receives a small amount of runoff from the three subdivisions to the north via 101st Avenue, 103rd Avenue, and 105th Avenue (see Figure 2 and 3). As previously noted, these subdivisions are Larrisa, which is situated between the RID and 103rd Avenue, Camelback Greens, which is situated between 103rd Avenue and 101st Avenue, and Palisades Park, which is located to the north of the Camelback Greens subdivision. The majority of the runoff from these subdivisions is intercepted by the existing storm drain. The approximate quantity of runoff from each subdivision was determined by an independent hydrologic analysis, since the drainage reports for the subdivisions were not available for review. Instead, the paving and grading plans were used to define the drainage areas, and the peak discharges were defined using the rational method as outlined in References 1 and 2. The corresponding hydrologic data sheets are provided in Appendix A.

The Palisades Park subdivision contributes most of the runoff conveyed in 101st Avenue. Only a very small portion of the Camelback Greens subdivision contributes to 101st Avenue. There was a storm drain constructed in 101st Avenue in conjunction with the development of the Camelback Greens subdivision; however, only two catch basins and one culvert-type inlet were provided. The two curb-opening catch basins are located along the northbound and southbound curbs just upstream of Camelback Road. The culvert-type inlet is located at the northeast corner of Camelback Road and 101st Avenue. It collects surface runoff from a drainage ditch that parallels the east side of 101st Avenue.

The majority of the Camelback Greens subdivision drains to a neighborhood detention basin that outlets into the existing storm drain. However, the timing of the two peak discharges (i.e., surface runoff intercepted by the catch basins versus attenuated outflows from the detention basin) is such that neither contributes to the peak discharge of the other. Consequently, the two drainage areas can utilize the same storm drain. The design capacity of the existing storm drain is a function of the surface hydrology as opposed to the peak outflow from either the Camelback Greens detention basin or the Larrisa detention basin, which also outflows to the existing storm drain. This conclusion was reached after examining the size of the detention basin outflow pipes. Both detention basins have relatively small outflow pipes (10 to 12 inches in diameter), and the inlets are covered with debris grates that further limit their discharge capacity. Therefore, it was reasonable to assume that the peak outflows from the detention basins would lag the composite peak discharge from the catch basins.

The majority of the drainage area contributing to 103rd Avenue is the street section itself. However, the adjacent right-of-way, and the first tier of homes that flank the street were also

included in the contributing drainage area. The majority of runoff conveyed in 103rd Avenue is intercepted by two curb-opening catch basins that are located along the northbound and southbound curbs just upstream of Camelback Road.

The drainage area contributing to 105th Avenue is limited to a portion of the Larrisa subdivision. Runoff conveyed along 105th Avenue concentrates at two curb-opening catch basins located approximately 300 feet north of Camelback Road. One basin is located in a sump along the northbound curb and one is located in a sump along the southbound curb.

Under existing conditions, the drainage area contributing to 107th Avenue, between Camelback Road and Bethany Home Road, does not concentrate flows at the Camelback Road intersection. Currently, Colter Avenue is the most prominent low point in the existing roadway profile. However, a secondary concentration point exists at Missouri Avenue. The total drainage area associated with both concentration points is approximately 197 acres. If the total area is subdivided relative to the two concentration points, approximately 112 acres contributes to the Missouri Avenue concentration point and approximately 85 acres contributes to the Colter Avenue concentration point. Since the Missouri Avenue concentration point closer to the New River tributary than it is to the Camelback Road intersection, it would probably be more cost effective to provide an outfall storm drain to the New River tributary than it would be to provide an outfall to the proposed Camelback Road storm drain. Therefore, it was assumed that the future contribution from 107th Avenue would be limited to the sub-basin runoff concentrating at the Colter Avenue.

Table 3.1 summarizes the hydrology for each individual offsite drainage area. The composite hydrology, which provides discharges that can be applied to each segment of the existing storm drain, was determined using the procedure outlined in Reference 3. Table 3.2 summarizes the results of the composite analysis. A schematic of the existing storm is shown on Figure 2. It should be noted that the sub-areas associated with Basin A (i.e., Camelback Road between 99th and 107th), as identified in Table 3.2, includes the entire width of the Camelback Road right-of-way (i.e., 110 feet). An analysis of the existing storm drain was initially conducted to determine if it had the capacity to accommodate all of Camelback Road and thus eliminate the need for a separate parallel drain. However, design constraints related to the existing utilities and irrigation conduits prevented use of the existing storm drain. Consequently, portions of Camelback Road are accounted for twice in the final composite analysis, which includes both the existing and the new storm drains. The results of the final composite analysis are discussed in Section IV.

**Table 3.1 Summary of Offsite Hydrology Concentrating at Camelback Road**

| Offsite Drainage Concentration Point (north side of Camelback Road) | Basin ID | Subbasin Runoff Parameters | | | | $Q_{sub}$ (cfs) |
|---|---|---|---|---|---|---|
| | | C | $T_c$ (min) | I (in/hr) | A (acres) | |
| 101st | D | 0.66 | 34 | 1.40 | 13.4 | 12.4 |
| 103rd | C | 0.67 | 39 | 1.27 | 10.8 | 9.2 |
| 105th | B | 0.60 | 26 | 1.70 | 24.0 | 24.4 |
| 107th | E | 0.45 | 42 | 1.03 | 85.0 | 46.2 |

**Table 3.2 Summary of Offsite and Onsite Hydrology for the Existing Storm Drain**

| Onsite Drainage Concentration Point (along Camelback Road) | Basin ID | Composite Offsite and Onsite Runoff Parameters | | | | | $Q_{composite}$ (cfs) |
|---|---|---|---|---|---|---|---|
| | | $C_w$ | SD(1) Tt (min) | Total $T_c$ (min) | I (in/hr) | A (acres) | |
| at ~100th alignment | A1 | 0.67 | -- | 13.3 | 2.51 | 1.65 | 2.8 |
| east of 101st | $A1_D$ | 0.67 | 1.0 | 14.3 | 2.49 | 3.30 | 5.5 |
| west of 101st | $D_{combined}$ | 0.66 | -- | 33.7 | 1.40 | 16.70 | 15.4 |
| east of 103rd | $A2_C$ | 0.66 | 13.0 | 46.7 | 1.17 | 20.03 | 15.5 |
| west of 103rd | $C_{combined}$ | 0.66 | -- | 46.7 | 1.27 | 30.83 | 26.0 |
| east of 105th | $A2_B$ | 0.67 | 9.0 | 55.7 | 1.01 | 34.16 | 22.9 |
| west of 105th | $B_{combined}$ | 0.64 | -- | 55.7 | 1.01 | 58.16 | 37.5 |
| east of 107th | $A2_A$ | 0.64 | 6.0 | 61.7 | 0.93 | 61.49 | 36.6 |

Notes: (1) estimated travel time in existing storm drain.

### 3.2 Proposed Offsite Flow Management

Offsite flows will be allowed to enter the project area in a manner that is consistent with existing conditions. The existing storm drain will be used to convey both offsite and onsite flows. As previously noted, the existing storm drain outfall at the RID will be eliminated. The existing 54-inch RCP will be extended over the RID to a new manhole/junction structure to be located beneath the intersection of Camelback Road and 107th Avenue. The new Camelback Road storm drain, new intersection laterals, and the future 107th storm-drain stub-out will also be connected to this new manhole/junction structure. Offsite and onsite flows will exit this structure to the west in a new storm drain that will extend along Camelback Road for approximately 4,000 feet before it is redirected to the southwest – exiting the Camelback Road right-of-way in a 20-foot drainage easement. Approximately 330 feet south of the east abutment to the Camelback Road bridge at the Agua Fria River, the new storm drain will outfall into the river. A flap gate will be provided at the outlet to prevent floodwaters in the Agua Fria River from entering the storm drain.

## IV. ON-SITE DRAINAGE

As previous noted, runoff generated within the northern half of the Camelback Road right-of-way, between 99th Avenue and the approximate alignment of 100th Avenue, and the southern half of the right-of-way, between 99th Avenue and 107th Avenue, will be captured by a series of new catch basins and conveyed to the 107th Avenue junction structure in a new storm drain. The hydrologic analysis of the roadway and the hydraulic design analysis of the storm drain network were conducted using the standards and criteria outlined in References 1 through 3. The street drainage design equations and the storm drain design equations and procedures provided in Reference 3 are consistent with the equations and procedures outlined in Reference

4. An Excel spreadsheet that automates the procedures from these references was used in the design analysis of the individual catch basins and the main line of the new storm drain.

Street drainage improvements for this project will include a total of 19 catch basins – ten (10) Type M basins with 3-foot wings, three (3) Type M basins with 6-foot wings, four (4) Type N basins with a single grate, and two (2) Type N basins with double grates. Grates were primarily used when the area behind the curb was limited due to existing utilities or other conflicts. The allowable spread used in the design of each catch basin was 17 feet. All catch basins, except those in sumps, were designed to allow some carry-over to the next downstream basin. Typically, 80 percent interception is the most cost-effective interception ratio or percentage. Although 80 percent was the initial target value, actual interception efficiencies range from 45% to 100%. The final interception ratio was based on engineering judgment that considered the type of basin used, its location, and its design flow rate. At sumps in the roadway profile, each catch basin was designed to intercept 100 percent of the flow; however, if the design depth exceeded the downstream high point, the break-over potential was factored into the design of the next downstream basin.

The 2-year peak discharge computation sheets used in the design of each catch basin are provided in Appendix A. Tables 4.1 and 4.2 summarize the design data for each catch basin. The individual design data sheets are provided in Appendix B.

The new storm drain network, excluding laterals and stub outs, will consist of 29 standard manholes, one (1) manhole/junction structure, one (1) box/junction structure, approximately 4450 linear feet of 60-inch reinforced concrete pipe (RCP), approximately 200 linear feet of 54-inch RCP, approximately 4450 linear feet of 24-inch RCP, and approximately 850 linear feet of 18-inch RCP. A manhole summary table with associated catch basins is provided as Table 4.3. The hydraulic analysis of the proposed network begins at the Agua Fria River. The peak discharge associated with each segment of the storm drain (i.e., the segments located between each contributing catch basin) was determined using the procedure outlined in Reference 3. The hydrologic routing data and peak discharges applied to the individual segments of the storm drain, which served as the basis for determination of the hydraulic-grade line (HGL), are summarized in Table 4.4. The starting hydraulic-grade-line (HGL) elevation at the outlet corresponds to the crown of the proposed outlet pipe, since the hydraulics of the storm drain will not be controlled by flows conveyed in the Agua Fria River.

Three hydraulic-grade line/energy-grade line (HGL/EGL) summary tables were prepared for the new storm drain network. These tables are provided in Appendix B. The first sheet summarizes the hydraulic properties of the 60-inch storm drain between the Agua Fria River and manhole number 23 (MH 23), which is the manhole/junction structure at the intersection of Camelback Road and 107th Avenue, and approximately 50 feet of the 54-inch storm drain between MH 23 and MH 32. The second sheet summarizes the hydraulic properties of the 24-inch/18-inch Camelback Road storm drain from 107th Avenue to 99th Avenue (MH 23 to MH 1). The third sheet summarizes the hydraulic properties of the 54-inch connection to the existing storm drain (MH 32 to the new box/junction structure). Along the majority of the study reach, the HGL is below the crown or top of the main line of the storm drain network. Under no circumstances does the HGL extend more than one foot above the crown or top of the main line.

**Table 4.1 Catch Basin Design Data - 107th Avenue to 99th Avenue**

| South (eastbound) Lane | Connecting Manhole No. | 60% Plans Roadway | | | Drainage Area (ac) | | 2-year Discharge (cfs) | Roadway Grade | Catch Basin Type | Discharge Intercepted (cfs) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Station | Distance | Length | pavement | sidewalk | | | | |
| HP | -- | 5061.57 | 177.93 | | | | | HP | | |
| CB 15 | 22 | 5239.50 | 310.50 | 488.43 | 0.36 | 0.26 | 1.29 | sump | M w/ 3' wing | 1.29 |
| CB 14 | 21 | 5550.00 | 199.65 | 199.65 | 0.15 | 0.11 | 0.54 | continuous | M w/ 3' wing | 0.54 |
| HP | 20 | 5749.65 | 275.35 | | | | | HP | | |
| CB 13 | 19 | 6025.00 | 200.00 | 475.35 | 0.35 | 0.25 | 1.12 | sump | N w/ single | 1.28 |
| | 18 | 6100.00 | -- | | | | | | | |
| CB 12 | 17 | 6225.00 | 214.05 | 214.05 | 0.16 | 0.11 | 0.57 | continuous | N w/ double | 0.57 |
| | 16 | 6425.00 | -- | | | | | | | |
| HP | -- | 6439.05 | 310.95 | | | | | HP | | |
| CB 11 | 15 | 6750.00 | 324.64 | 310.95 | 0.23 | 0.16 | 0.73 | continuous | N w/ single | 0.54 |
| CB 10 | 14 | 7074.64 | 330.01 | 654.65 | 0.48 | 0.35 | 1.73 | sump (match ext) | N w/ single | 2.19 |
| CB 9 | 13 | 7404.65 | 307.35 | 307.35 | 0.23 | 0.16 | 0.73 | continuous | N w/ double | 0.89 |
| | 12 | 7725.00 | -- | | | | | | | |
| HP (ext) | -- | 7712 | -- | | | | | HP (ext) | | |
| CB 8 | 11 | 7775.00 | 570.00 | 633.00 | 0.47 | 0.33 | 1.33 | sump (ext) | N w/ single | 1.33 |
| | 10 | 8100.00 | -- | | | | | | | |
| HP (ext) | -- | 8345 | -- | | | | | HP (ext) | | |
| CB 7 | 9 | 8425.00 | 285.50 | 365.50 | 0.27 | 0.19 | 0.86 | sump (ext) | M w/ 3' wing | 1.06 |
| HP (ext) | -- | 8650 | -- | | | | | HP (ext) | | |
| CB 6 | 8 | 8710.50 | 443.50 | 504.00 | 0.37 | 0.27 | 1.14 | sump (ext) | M w/ 3' wing | 1.26 |
| | 7 | 8909.30 | -- | | | | | | | |
| CB 5 | 6 | 9154.00 | 546.00 | 546.00 | 0.40 | 0.29 | 1.14 | continuous | M w/ 6' wing | 1.23 |
| | 5 | 9375.00 | -- | | | | | | | |
| CB 3 | 4 | 9700.00 | 505.38 | 505.38 | 0.37 | 0.27 | 1.51 | continuous | M w/ 6' wing | 1.39 |
| | 3 | 10000.00 | -- | | | | | | | |
| | 2 | 10050.00 | -- | | | | | | | |
| CB 1 | 1 | 10205.38 | -- | 120 | 0.15 | 0.05 | 0.51 | continuous | M w/ 3' wing | 0.42 |
| HP (ext) | -- | 10334.01 | -- | | | | | HP (ext) | | |

| North (westbound) Lane | Connecting Manhole No. | 60% Plans Roadway | | | Drainage Area (ac) | | 2-year Discharge (cfs) | Roadway Grade | Catch Basin Type | Discharge Intercepted (cfs) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Station | Distance | Length | pavement | sidewalk | | | | |
| CB 16 | -- | 4748 | 252 | 252 | 0.21 | 0.10 | | continuous | M w/ 3' wing | 0.69 |
| HP | -- | 5000 | -- | | | | | | | |
| CB ext | -- | 9043 | 111.00 | 332.00 | 0.24 | 0.18 | 0.78 | continuous | M w/ 3' wing | 0.94 |
| | 6 | 9154.00 | 76.00 | | | | | | | |
| HP (ext) | -- | 9230 | 145.00 | | | | | HP (ext) | | |
| CB 4 | 5 | 9375.00 | 837.77 | 982.77 | 0.90 | 0.34 | 2.32 | sump (ext) | M w/ 3' wing | 2.52 |
| | 4 | 9700.00 | -- | | | | | | | |
| | 3 | 10000.00 | -- | | | | | | | |
| | 2 | 10050.00 | -- | | | | | | | |
| CB 2 | 1 | 10212.77 | -- | 220 | 0.24 | 0.08 | 0.81 | continuous | M w/ 6' wing | 0.61 |

**Table 4.2 Catch Basin Design Data - 107th Avenue at Cameback Road**

| East (northbound) Lane | Connecting Manhole No. | 60% Plans Roadway | | | Drainage Area (ac) | | 2-year Discharge (cfs) | Roadway Grade | Catch Basin Type | Discharge Intercepted (cfs) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Station | | Distance | pavement | sidewalk | | | | |
| CB 18 | 33 | 1250.00 | | | | | | CB at HP | M w/ 3' wing | 0.53 |
| LP | -- | 1071.60 | 178.40 | 250.00 | 0.15 | 0.10 | 0.53 | sump (proposed) | | |
| | 32 | 1047.48 | | | | | | | | |
| HP | -- | 1000 | 71.60 | | | | | | | |
| CB 17 | 31 | 750 | 250 | 250.00 | 0.15 | 0.07 | 0.49 | continuous | M w/ 3' wing | 0.49 |

| West (southbound) Lane | Connecting Manhole No. | 60% Plans Roadway | | | Drainage Area (ac) | | 2-year Discharge (cfs) | Roadway Grade | Catch Basin Type | Discharge Intercepted (cfs) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Station | | Distance | pavement | sidewalk | | | | |
| HP | -- | 1000 | 68.45 | | | | | | | |
| | 32 | 1047.48 | | | | | | | | |
| LP | -- | 1068.45 | 181.55 | 250.00 | 0.21 | 0.10 | 0.69 | sump (proposed) | | |
| CB 19 | 33 | 1250.00 | | | | | | CB at HP | M w/ 3' wing | 0.69 |

**Table 4.3 Manhole Summary - Agua Fria River to 99th Ave.**

| Manhole No. | 60% Plans Roadway | | Connecting Catch Basin/Bend No./Location | Roadway Grade |
|---|---|---|---|---|
| | Station | Distance | | |
| outlet | 625 | 0 | none | n/a |
| 30 | 1000 | 375 | B7 | n/a |
| 29 | 1400 | 400 | none | n/a |
| 28 | 2000 | 600 | none | n/a |
| 27 | 2600 | 600 | none | n/a |
| 26 | 3200 | 600 | none | n/a |
| 25 | 3800 | 600 | none | n/a |
| 24 | 4400 | 600 | none | n/a |
| -- | 4748 | 348 | CB 16N | continuous |
| 23 | 4957.92 | 209.92 | JT1 | -- |
| 22 | 5239.5 | 281.58 | CB 15S | sump |
| 21 | 5550 | 310.5 | CB 14S | continuous |
| 20 | 5749.65 | 199.65 | none | -- |
| 19 | 6025 | 275.35 | CB 13S, B6 | sump |
| 18 | 6100 | 75 | B5 | -- |
| 17 | 6225 | 125 | CB 12S | continuous |
| 16 | 6425 | 200 | none | -- |
| 15 | 6750 | 325 | CB11S | continuous |
| 14 | 7074.64 | 324.64 | CB 10S | sump (ext) |
| 13 | 7404.65 | 330.01 | CB 9S | continuous |
| 12 | 7725 | 320.35 | B4 | -- |
| 11 | 7775 | 50 | CB 8S B3 | sump |
| 10 | 8100 | 325 | none | -- |
| 9 | 8425 | 325 | CB 7S | sump (ext) |
| 8 | 8710.5 | 285.5 | CB 6S | sump (ext) |
| 7 | 8909.3 | 198.8 | none | -- |
| 6 | 9154 | 244.7 | CB 5S | continuous |
| 5 | 9375 | 221 | CB 4N | sump (ext) |
| 4 | 9700 | 325 | CB 3S | continuous |
| 3 | 10000 | 300 | B2 | -- |
| 2 | 10050 | 50 | B1 | -- |
| 1 | 10200 | 150 | CB 1S, CB 2N | continuous |

Table 4.4 Composite Hydrology for the Proposed Storm Drain

| Pipe Diameter | MH No. | Length (ft) | Basin No. | Length (ft) | Subbasin Runoff Parameters C | Subbasin Runoff Parameters $i_1$ (in/hr) | Subbasin Runoff Parameters A (acres) | Pipe Flow. Prop. Y/D | Pipe Flow. Prop. V (fps) | Flow Time Street (min) | Flow Time Pipe (min) | Accumulated $T_c$ (min) | Composite Runoff Parameters $C_w$ | Composite Runoff Parameters $i_p$ (in/hr) | Composite Runoff Parameters A (acres) | $Q_{pipe}$ (cfs) | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | | 1, 2 | | 0.90 | 2.82 | 0.52 | | | | | 10.00 | 0.90 | | 0.52 | 1.32 | Composite for CB #1 and CB #2 |
| 18-inch | | 150 | | | | | | | | | | | | | | | |
| | 2 | | | | | | | | | | | | | | | | |
| 18-inch | | 50 | | | | | | | | | | | | | | | |
| | 3 | | | | | | | 0.34 | 2.49 | | 3.35 | 13.35 | | | | | |
| 18-inch | | 300 | | | | | | | | | | | 0.88 | 2.60 | 1.16 | 2.56 | Discharge exiting Manhole |
| | 4 | | 3 | 505.38 | 0.87 | 2.72 | 0.64 | | | | | | | | | | |
| 18-inch | | 325 | | | | | | 0.49 | 2.97 | | 1.82 | 15.17 | | | | | |
| | 5 | | 4 | 838.00 | 0.81 | 2.30 | 1.24 | | | | | | 0.85 | 2.38 | 2.40 | 4.67 | Discharge exiting Manhole |
| 24-inch | | 221 | | | | | | 0.45 | 3.41 | | 1.08 | 16.25 | | | | | |
| | 6 | | 5 | 546.00 | 0.74 | 2.24 | 0.69 | | | | | | 0.82 | 2.31 | 3.09 | 5.68 | Discharge exiting Manhole |
| 24-inch | | 245 | | | | | | | | | | | | | | | |
| | 7 | | | | | | | 0.50 | 3.62 | | 2.04 | 18.29 | | | | | |
| 24-inch | | 199 | | | | | | | | | | | 0.81 | 2.18 | 3.73 | 6.35 | Discharge exiting Manhole |
| | 8 | | 6 | 443.50 | 0.74 | 2.40 | 0.64 | | | | | | | | | | |
| 24-inch | | 286 | | | | | | 0.53 | 3.76 | | 1.27 | 19.56 | | | | | |
| | 9 | | 7 | 285.50 | 0.74 | 2.51 | 0.46 | | | | | | 0.80 | 2.05 | 4.19 | 6.65 | Discharge exiting Manhole |
| 24-inch | | 325 | | | | | | | | | | | | | | | |
| | 10 | | | | | | | 0.59 | 3.45 | | 3.14 | 22.70 | | | | | |
| 24-inch | | 325 | | | | | | | | | | | 0.79 | 1.90 | 4.99 | 7.25 | Discharge exiting Manhole |
| | 11 | | 8 | 570.00 | 0.74 | 2.24 | 0.80 | | | | | | | | | | |
| 24-inch | | 50 | | | | | | | | | | | | | | | |
| | 12 | | | | | | | 0.63 | 3.48 | | 1.77 | 24.47 | | | | | |
| 24-inch | | 320 | | | | | | | | | | | 0.79 | 1.85 | 5.38 | 7.58 | Discharge exiting Manhole |
| | 13 | | 9 | 307.35 | 0.74 | 2.51 | 0.39 | | | | | | | | | | |
| 24-inch | | 330 | | | | | | 0.65 | 3.51 | | 1.57 | 26.04 | | | | | |
| | 14 | | 10 | 330.00 | 0.74 | 2.82 | 0.83 | | | | | | 0.78 | 1.76 | 6.21 | 8.24 | Discharge exiting Manhole |
| 24-inch | | 325 | | | | | | 0.68 | 3.62 | | 1.50 | 27.54 | | | | | |
| | 15 | | 11 | 310.95 | 0.74 | 2.51 | 0.39 | | | | | | 0.78 | 1.67 | 6.60 | 8.29 | Discharge exiting Manhole |
| 24-inch | | 325 | | | | | | | | | | | | | | | |
| | 16 | | | | | | | 0.69 | 3.59 | | 2.44 | 29.98 | | | | | |
| 24-inch | | 200 | | | | | | | | | | | 0.78 | 1.58 | 6.87 | 8.16 | Discharge exiting Manhole |
| | 17 | | 12 | 214.05 | 0.75 | 2.82 | 0.27 | | | | | | | | | | |
| 24-inch | | 125 | | | | | | | | | | | | | | | |
| | 18 | | | | | | | 0.69 | 3.59 | | 0.93 | 30.90 | | | | | |
| 24-inch | | 75 | | | | | | | | | | | 0.78 | 1.55 | 7.47 | 8.66 | Discharge exiting Manhole |
| | 19 | | 13 | 275.35 | 0.74 | 2.51 | 0.60 | | | | | | | | | | |
| 24-inch | | 275 | | | | | | | | | | | | | | | |
| | 20 | | | | | | | 0.71 | 3.63 | | 2.18 | 33.08 | | | | | |
| 24-inch | | 200 | | | | | | | | | | | 0.77 | 1.48 | 7.73 | 8.58 | Discharge exiting Manhole |
| | 21 | | 14 | 199.65 | 0.74 | 2.82 | 0.28 | | | | | | | | | | |
| 24-inch | | 311 | | | | | | 0.71 | 3.63 | | 1.43 | 34.51 | | | | | |
| | 22 | | 15 | 310.50 | 0.74 | 2.82 | 0.62 | | | | | | 0.77 | 1.42 | 8.35 | 8.84 | Discharge exiting Manhole |
| 24-inch | | 282 | | | | | | 0.72 | 3.65 | | 1.29 | 35.80 | | | | | |
| 24inch | 23 | | 17, 18, 19 | n/a | 0.78 | 2.82 | 0.78 | | | | | | 0.77 | 1.39 | 9.13 | 9.49 | 107th intersection, north/south laterals |
| 54-inch | 23 | | existing | | | | | | | | | 61.70 | 0.64 | 0.93 | 61.49 | 35.35 | 54-inch Main at MH #23 |
| | 23 | | | | | | | | | | | | 0.66 | 0.93 | 70.62 | 41.68 | Composite for new 24-inch and existing 54-inch Mains |
| 107th | 23 | | | | | | | | | | | | 0.45 | 1.25 | 85.00 | 46.20 | Future contribution from 48-inch stub-out Main |
| 60-inch | 23 | | | | | | | | | | | | 0.54 | 0.93 | 155.62 | 76.05 | |
| 60-inch | | 210 | | | | | | 1.00 | 2.12 | | 1.65 | 63.35 | | | | | |
| | pipe junction | | 16 | 252.00 | 0.79 | 2.82 | 0.31 | | | | | | 0.54 | 0.93 | 155.93 | 76.27 | Composite in 60-inch Main downstream of CB #16 |

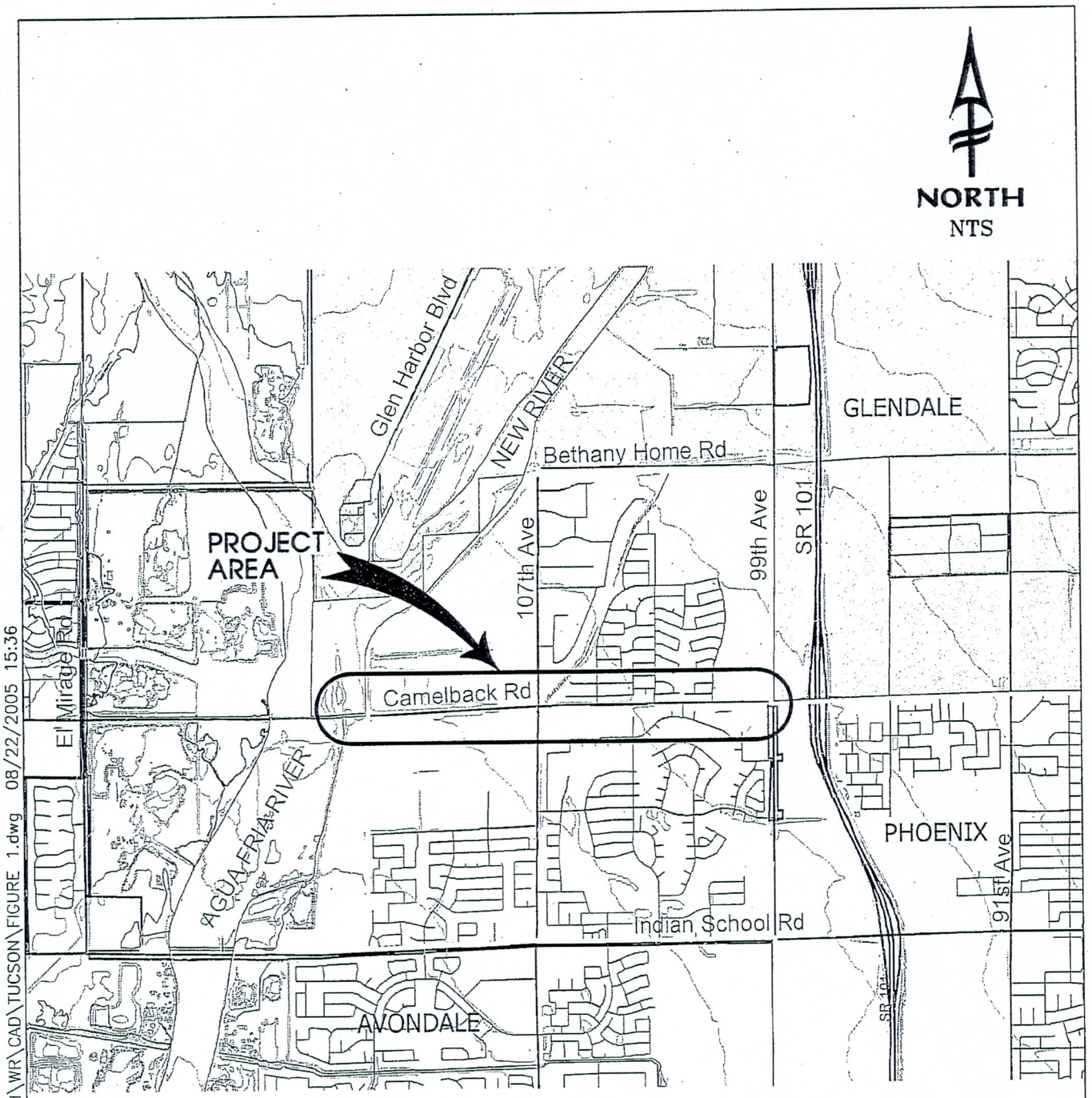
## IV. REFERENCES

1. City of Phoenix, Arizona, *Storm Water Policies and Standards*, March 2004.

2. Maricopa County Flood Control District, *Drainage Design Manual for Maricopa County, Arizona, Volume I, Hydrology*, 1991 with updates.

3. Maricopa County Flood Control District, *Drainage Design Manual for Maricopa County, Arizona, Volume II, Hydraulics*, 1991 with updates.

4. U.S. Department of Transportation, Federal Highway Administration, *Urban Drainage Design Manual, Hydraulic Engineering Circular No. 22, Second Edition*, August 2001.




# FIGURE 1:
# LOCATION MAP

TETRA TECH, INC.

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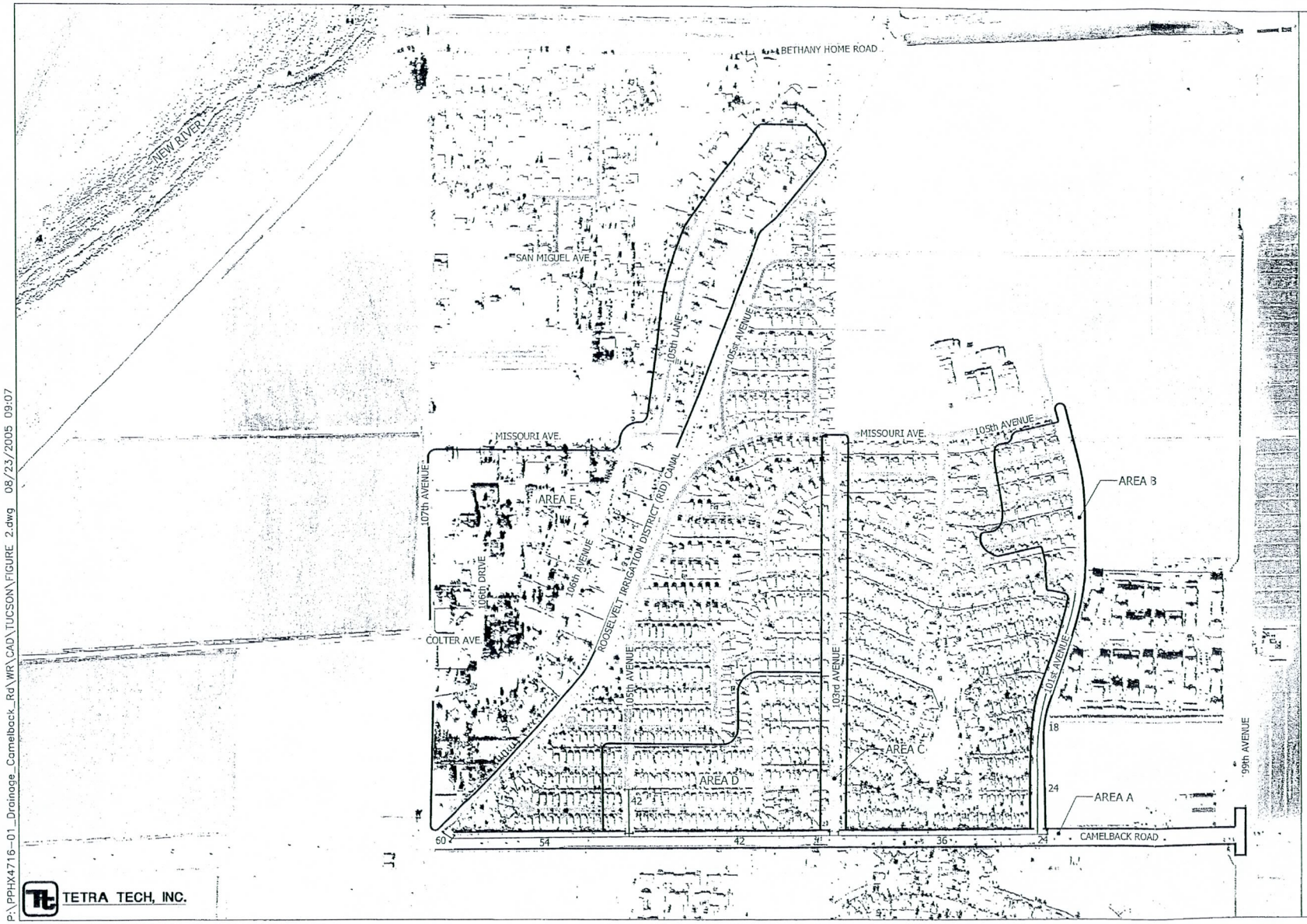


NORTH

FEET

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FIGURE 2

TETRA TECH, INC.

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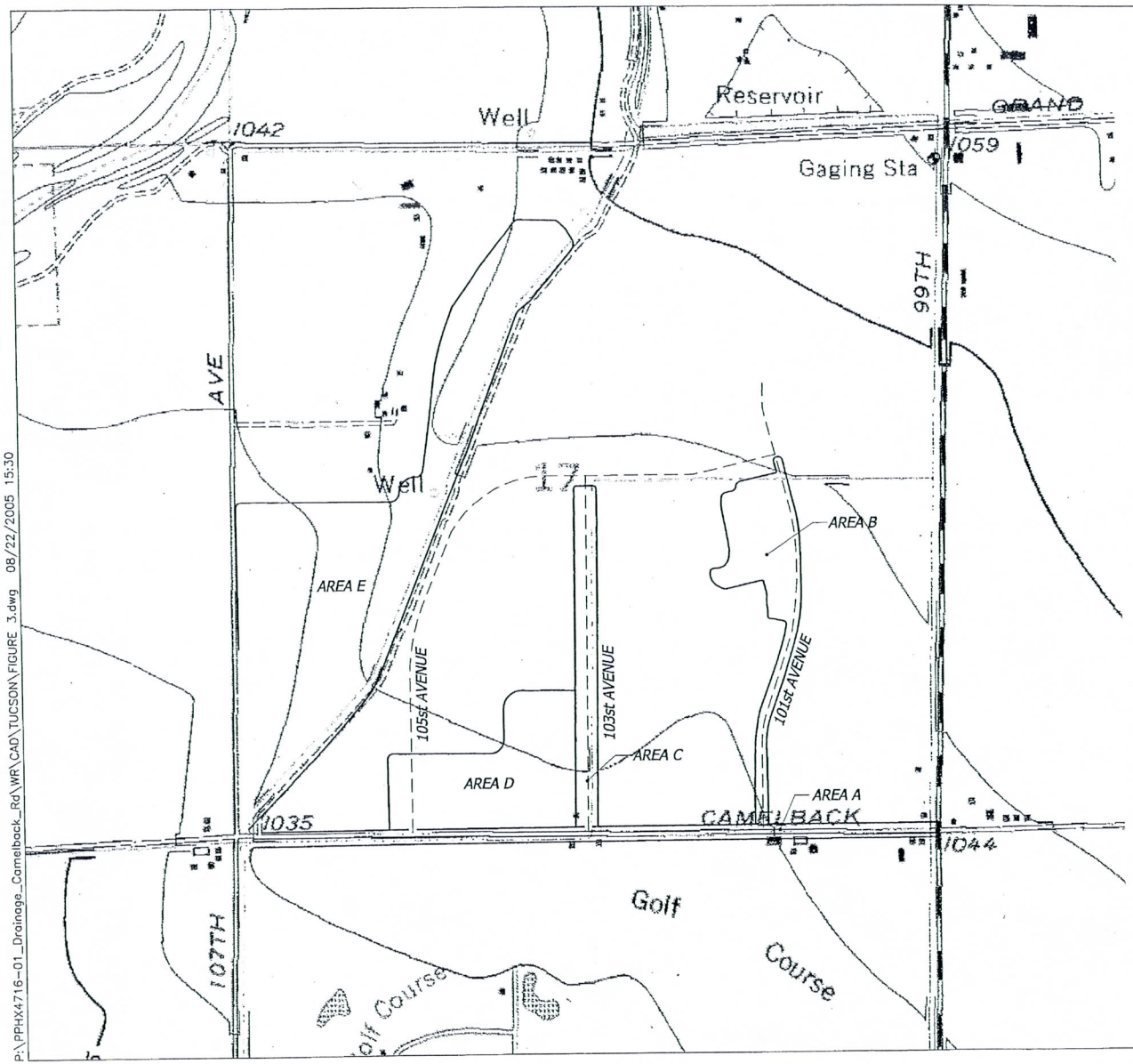


NORTH

FEET

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FIGURE 3

TETRA TECH, INC.

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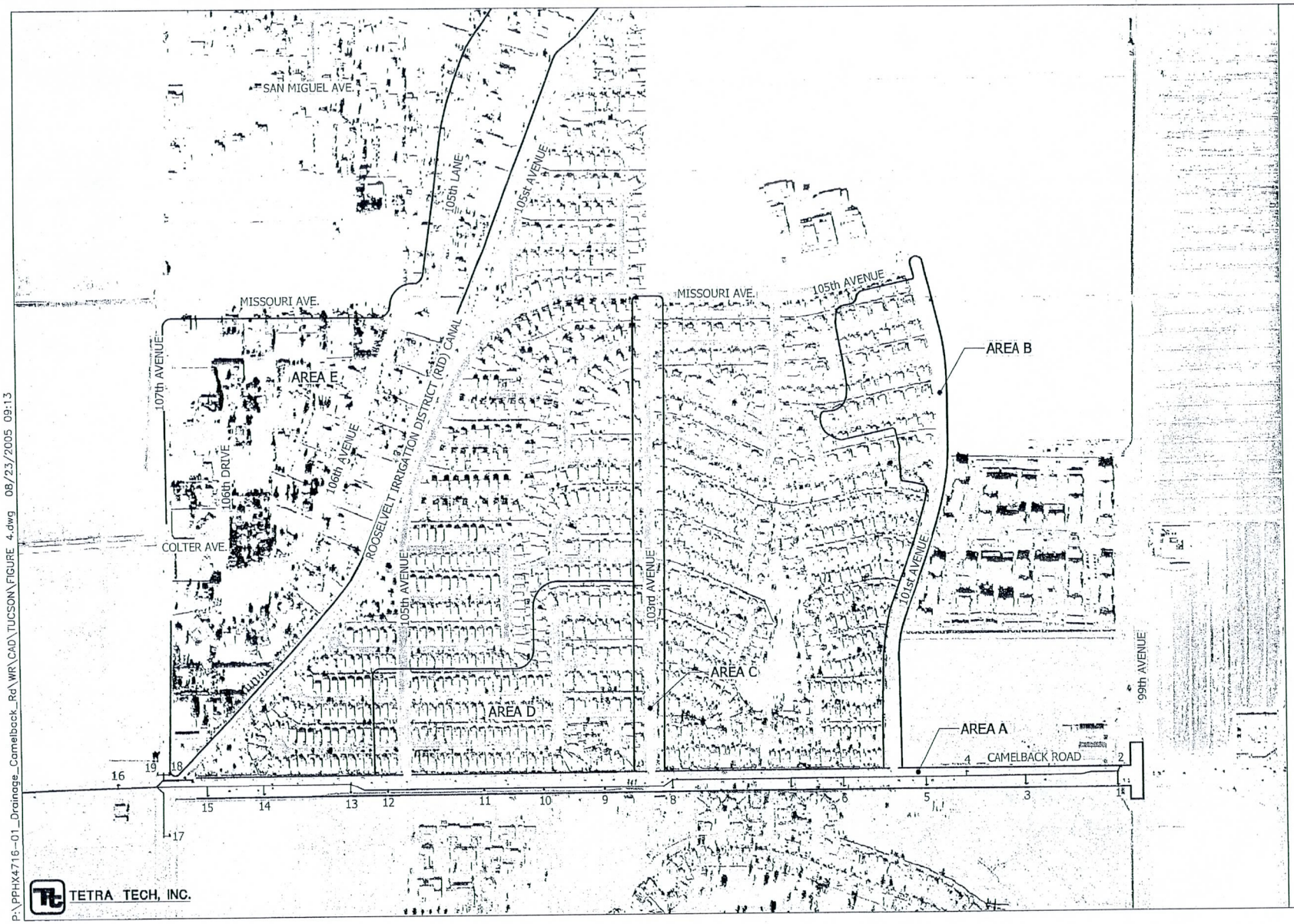


NORTH

FEET

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FIGURE 4

P:\PPHX4716-01_Drainage_Camelback_Rd\WR\CAD\TUCSON\FIGURE 4.dwg 08/23/2005 09:13

## New 60-Inch Storm Drain from the Agua Fria River to 107th Ave. -- Hydraulic/Energy Grade-Line Calculation Summary Sheet

Camelback Road Storm Drain Design (99th Ave. to Agua Fria River), City of Phoenix Project No. ST8311057

| Roadway Station / Pipe Length | Cumulative Length (ft) | Invert Elevation | Section Height (H) (ft) | Section Description w/ slope (%) | Allowable HGL Elev. | Computed HGL Elev. EGL-$h_v$ | HGL Depth (ft) | Basic Flow Parameters: Area (A) (sq. ft.) | Discharge (Q) (cfs) | Y/D | Velocity (V) (ft/ft) | Manning's n-value | Hydraulic Radius (ft) | Velocity Head (ft) | Friction Slope (Sf) (ft/ft) | Average Sf (ft/ft) | Length L (ft) | head loss (h): friction (f) (ft) | bend (b) (ft) | junction (j) (ft) | transition (t) (ft) | man-hole (mh) (ft) | access-hole inlet/outlet (ft) | EGL Elevation |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6+25 | 625.00 | 1010.87 | 5.0 | 1 - 60" RCP | 1027.00 | 1015.87 | 5.00 | 19.63 | 80 | 1 | 4.07 | 0.013 | 1.25 | 0.26 | 0.0009 | | | | | | | | | 1016.13 |
| 469 | *reach* | | | 0.10% | | | | | | | | | | | | 0.0009 | 469.00 | 0.43 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| 10+00 | 1094.00 | 1011.34 | 5.0 | 1 - 60" RCP | 1031.14 | 1016.30 | 4.96 | 19.60 | 80 | 0.99 | 4.08 | 0.013 | 1.33 | 0.26 | 0.0009 | | | | | | | | | 1016.55 |
| 0 | *MH #30* | | | 0.00% | | | | | | | | | | | | 0.0009 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.10 | 0.00 | |
| 10+00 | 1094.00 | 1011.44 | 5.0 | 1 - 60" RCP | 1031.14 | 1016.40 | 4.96 | 19.60 | 80 | 0.99 | 4.08 | 0.013 | 1.33 | 0.26 | 0.0009 | | | | | | | | | 1016.66 |
| 404 | *reach* | | | 0.10% | | | | | | | | | | | | 0.0009 | 404.00 | 0.35 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| 14+00 | 1498.00 | 1011.84 | 5.0 | 1 - 60" RCP | 1031.47 | 1016.74 | 4.90 | 19.54 | 80 | 0.98 | 4.09 | 0.013 | 1.37 | 0.26 | 0.0008 | | | | | | | | | 1017.00 |
| 0 | *MH #29* | | | 0.00% | | | | | | | | | | | | 0.0008 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | |
| 14+00 | 1498.00 | 1011.94 | 5.0 | 1 - 60" RCP | 1031.47 | 1016.75 | 4.81 | 19.37 | 80 | 0.96 | 4.13 | 0.013 | 1.41 | 0.26 | 0.0008 | | | | | | | | | 1017.02 |
| 600 | *reach* | | | 0.10% | | | | | | | | | | | | 0.0008 | 600.00 | 0.49 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| 20+00 | 2098.00 | 1012.54 | 5.0 | 1 - 60" RCP | 1032.05 | 1017.24 | 4.70 | 19.15 | 80 | 0.94 | 4.18 | 0.013 | 1.45 | 0.27 | 0.0008 | | | | | | | | | 1017.51 |
| 0. | *MH #28* | | | 0.00% | | | | | | | | | | | | 0.0008 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | |
| 20+00 | 2098.00 | 1012.64 | 5.0 | 1 - 60" RCP | 1032.05 | 1017.24 | 4.60 | 18.90 | 80 | 0.92 | 4.23 | 0.013 | 1.47 | 0.28 | 0.0008 | | | | | | | | | 1017.52 |
| 600 | *reach* | | | 0.10% | | | | | | | | | | | | 0.0008 | 600.00 | 0.50 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| 26+00 | 2698.00 | 1013.24 | 5.0 | 1 - 60" RCP | 1032.54 | 1017.73 | 4.49 | 18.61 | 80 | 0.9 | 4.30 | 0.013 | 1.49 | 0.29 | 0.0008 | | | | | | | | | 1018.02 |
| 0 | *MH #27* | | | 0.00% | | | | | | | | | | | | 0.0008 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | |
| 26+00 | 2698.00 | 1013.34 | 5.0 | 1 - 60" RCP | 1032.54 | 1017.74 | 4.40 | 18.30 | 80 | 0.88 | 4.37 | 0.013 | 1.50 | 0.30 | 0.0009 | | | | | | | | | 1018.03 |
| 600 | *reach* | | | 0.10% | | | | | | | | | | | | 0.0009 | 600.00 | 0.52 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| 32+00 | 3298.00 | 1013.94 | 5.0 | 1 - 60" RCP | 1033.12 | 1018.24 | 4.30 | 17.96 | 80 | 0.86 | 4.45 | 0.013 | 1.51 | 0.31 | 0.0009 | | | | | | | | | 1018.55 |
| 0 | *MH #26* | | | 0.00% | | | | | | | | | | | | 0.0009 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 | 0.00 | |
| 32+00 | 3298.01 | 1014.04 | 5.0 | 1 - 60" RCP | 1033.12 | 1018.25 | 4.21 | 17.61 | 80 | 0.84 | 4.54 | 0.013 | 1.52 | 0.32 | 0.0009 | | | | | | | | | 1018.57 |
| 600 | *reach* | | | 0.10% | | | | | | | | | | | | 0.0009 | 600.00 | 0.55 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| 38+00 | 3898.01 | 1014.64 | 5.0 | 1 - 60" RCP | 1032.79 | 1018.79 | 4.15 | 17.42 | 80 | 0.83 | 4.59 | 0.013 | 1.52 | 0.33 | 0.0009 | | | | | | | | | 1019.12 |
| 0 | *MH #25* | | | 0.00% | | | | | | | | | | | | 0.0009 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 | 0.00 | |
| 38+00 | 3898.01 | 1014.74 | 5.0 | 1 - 60" RCP | 1032.79 | 1018.79 | 4.05 | 17.04 | 80 | 0.81 | 4.70 | 0.013 | 1.52 | 0.34 | 0.0010 | | | | | | | | | 1019.13 |
| 600 | *reach* | | | 0.10% | | | | | | | | | | | | 0.0010 | 600.00 | 0.58 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| 44+00 | 4498.01 | 1015.34 | 5.0 | 1 - 60" RCP | 1033.20 | 1019.37 | 4.03 | 17.04 | 80 | 0.81 | 4.70 | 0.013 | 1.52 | 0.34 | 0.0010 | | | | | | | | | 1019.71 |
| 0 | *MH #24* | | | 0.00% | | | | | | | | | | | | 0.0010 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 | 0.00 | |
| 44+00 | 4498.01 | 1015.44 | 5.0 | 1 - 60" RCP | 1033.20 | 1019.37 | 3.93 | 16.64 | 80 | 0.79 | 4.81 | 0.013 | 1.52 | 0.36 | 0.0010 | | | | | | | | | 1019.73 |
| 558 | *reach* | | | 0.10% | | | | | | | | | | | | 0.0010 | 558.00 | 0.57 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| 49+57.92 | 5056.01 | 1016.00 | 5.0 | 1 - 60" RCP | 1034.37 | 1019.94 | 3.94 | 16.64 | 80 | 0.79 | 4.81 | 0.013 | 1.52 | 0.36 | 0.0010 | | | | | | | | | 1020.30 |
| 0 | *MH#23 (JS)* | | | 0.00% | | | | | | | | | | | | 0.0013 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 | 0.00 | |
| 49+57.92 | 5056.01 | 1017.46 | 2.0 | 1 - 24" RCP | 1034.37 | 1020.19 | 2.73 | 3.14 | 9 | 1 | 2.86 | 0.013 | 0.50 | 0.13 | 0.0016 | | | | | | | | | 1020.32 |
| | *MH#23 (JS)* | | | | | | | | | | | | | | | | | | | | | | | |
| 49+57.92 | 5056.01 | 1023.17 | 4.5 | 1 - 54" RCP | 1034.37 | 1027.67 | 4.50 | 15.90 | 75 | 1 | 4.72 | 0.013 | 1.13 | 0.35 | 0.0015 | | | | | | | | | 1028.02 |
| 52 | *reach (d/s MH#32)* | | | 4.52% | | | | | | | | | | | | 0.0030 | 52.00 | 0.16 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| 49+95 (48' LT) | 5108.01 | 1025.52 | 4.5 | 1 - 54" RCP | 1034.73 | 1027.95 | 2.43 | 8.76 | 75 | 0.54 | 8.56 | 0.013 | 1.18 | 1.14 | 0.0045 | | | | | | | | | 1029.09 |

Tetra Tech, Inc.

## New Storm Drain from 107th Ave. to 99th Ave. -- Hydraulic/Energy Grade-Line Calculation Summary Sheet

Camelback Road Storm Drain Design (99th Ave. to Agua Fria River), City of Phoenix Project No. ST8311057

| Roadway Station | Cumulative Station | Invert Elevation | Section Height (H) | Section Description | Allowable HGL Elev. | Computed HGL Elev. | HGL Depth | Basic Flow Parameters: Area (A) | Discharge (Q) | Y/D | Velocity (V) | Manning's n-value | Hydraulic Radius | Velocity Head | Friction Slope (Sf) | Average Sf | Length L | head loss (h): friction (f) | bend (b) | junction (j) | transition (t) | man-hole (mh) | access-hole inlet/outlet | EGL Elevation |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pipe Length | (ft) | | (ft) | w/ slope (%) | | EGL-$h_v$ | (ft) | (sq. ft.) | (cfs) | | (ft/ft) | | (ft) | (ft) | (ft/ft) | (ft/ft) | (ft) | (ft) | (ft) | (ft) | (ft) | (ft) | (ft) | |
| 49+57.92 | 4957.92 | 1017.46 | 2.0 | 1 - 24" RCP | 1034.37 | 1020.19 | 2.73 | 3.14 | 9 | 1 | 2.86 | 0.013 | 0.50 | 0.13 | 0.0016 | | | | | | | | | 1020.32 |
| 282 | reach | | | 0.20% | | | | | | | | | | | | 0.0016 | 282.00 | 0.45 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| 52+39.50 | 5239.92 | 1018.02 | 2.0 | 1 - 24" RCP | 1034.94 | 1020.64 | 2.61 | 3.14 | 9 | 1 | 2.86 | 0.013 | 0.50 | 0.13 | 0.0016 | | | | | | | | | 1020.76 |
| 0 | MH #22 | | | 0.00% | | | | | | | | | | | | 0.0016 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | |
| 52+39.50 | 5239.92 | 1018.12 | 2.0 | 1 - 24" RCP | 1034.94 | 1020.64 | 2.52 | 3.14 | 9 | 1 | 2.86 | 0.013 | 0.50 | 0.13 | 0.0016 | | | | | | | | | 1020.77 |
| 310 | reach | | | 0.20% | | | | | | | | | | | | 0.0016 | 310.00 | 0.49 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| 55+50 | 5549.92 | 1018.74 | 2.0 | 1 - 24" RCP | 1035.86 | 1021.13 | 2.39 | 3.14 | 9 | 1 | 2.86 | 0.013 | 0.50 | 0.13 | 0.0016 | | | | | | | | | 1021.26 |
| 0 | MH #21 | | | 0.00% | | | | | | | | | | | | 0.0016 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | |
| 55+50 | 5549.920 | 1018.84 | 2.0 | 1 - 24" RCP | 1035.86 | 1021.14 | 2.30 | 3.14 | 9 | 1 | 2.86 | 0.013 | 0.50 | 0.13 | 0.0016 | | | | | | | | | 1021.27 |
| 200 | reach | | | 0.20% | | | | | | | | | | | | 0.0016 | 200.00 | 0.32 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| 57+49.65 | 5749.92 | 1019.24 | 2.0 | 1 - 24" RCP | 1036.18 | 1021.45 | 2.21 | 3.14 | 9 | 1 | 2.86 | 0.013 | 0.50 | 0.13 | 0.0016 | | | | | | | | | 1021.58 |
| 0 | MH #20 | | | 0.00% | | | | | | | | | | | | 0.0016 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | |
| 57+49.65 | 5749.92 | 1019.34 | 2.0 | 1 - 24" RCP | 1036.18 | 1021.46 | 2.12 | 3.14 | 9 | 1 | 2.86 | 0.013 | 0.50 | 0.13 | 0.0016 | | | | | | | | | 1021.59 |
| 275 | reach | | | 0.20% | | | | | | | | | | | | 0.0016 | 275.00 | 0.43 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| 60+25 | 6024.92 | 1019.89 | 2.0 | 1 - 24" RCP | 1036.49 | 1021.90 | 2.01 | 3.14 | 9 | 1 | 2.86 | 0.013 | 0.50 | 0.13 | 0.0016 | | | | | | | | | 1022.02 |
| 0 | MH #19 | | | 0.00% | | | | | | | | | | | | 0.0014 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.05 | 0.00 | |
| 60+25 | 6024.92 | 1020.00 | 2.0 | 1 - 24" RCP | 1036.49 | 1021.97 | 1.97 | 3.14 | 8 | 0.99 | 2.55 | 0.013 | 0.53 | 0.10 | 0.0012 | | | | | | | | | 1022.07 |
| 82 | reach | | | 0.20% | | | | | | | | | | | | 0.0011 | 82.00 | 0.09 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| 61+00 | 6106.92 | 1020.16 | 2.0 | 1 - 24" RCP | 1036.45 | 1022.06 | 1.90 | 3.08 | 8 | 0.95 | 2.59 | 0.013 | 0.57 | 0.10 | 0.0011 | | | | | | | | | 1022.17 |
| 0 | MH #18 | | | 0.00% | | | | | | | | | | | | 0.0011 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.04 | 0.00 | |
| 61+00 | 6106.92 | 1020.26 | 2.0 | 1 - 24" RCP | 1036.45 | 1022.10 | 1.84 | 3.02 | 8 | 0.92 | 2.65 | 0.013 | 0.59 | 0.11 | 0.0011 | | | | | | | | | 1022.21 |
| 125 | reach | | | 0.20% | | | | | | | | | | | | 0.0011 | 125.00 | 0.14 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| 62+25 | 6231.92 | 1020.51 | 2.0 | 1 - 24" RCP | 1036.55 | 1022.23 | 1.72 | 2.87 | 8 | 0.86 | 2.78 | 0.013 | 0.61 | 0.12 | 0.0012 | | | | | | | | | 1022.35 |
| 0 | MH #17 | | | 0.00% | | | | | | | | | | | | 0.0012 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | |
| 62+25 | 6231.92 | 1020.61 | 2.0 | 1 - 24" RCP | 1036.55 | 1022.22 | 1.61 | 2.69 | 8 | 0.8 | 2.97 | 0.013 | 0.61 | 0.14 | 0.0013 | | | | | | | | | 1022.35 |
| 200 | reach | | | 0.20% | | | | | | | | | | | | 0.0014 | 200.00 | 0.29 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| 64+25 | 6431.92 | 1021.01 | 2.0 | 1 - 24" RCP | 1036.85 | 1022.48 | 1.47 | 2.49 | 8 | 0.74 | 3.21 | 0.013 | 0.60 | 0.16 | 0.0016 | | | | | | | | | 1022.64 |
| 0 | MH #16 | | | 0.00% | | | | | | | | | | | | 0.0018 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | |
| 64+25 | 6431.92 | 1021.11 | 2.0 | 1 - 24" RCP | 1036.85 | 1022.45 | 1.34 | 2.24 | 8 | 0.67 | 3.58 | 0.013 | 0.58 | 0.20 | 0.0020 | | | | | | | | | 1022.65 |
| 325 | reach | | | 0.20% | | | | | | | | | | | | 0.0020 | 325.00 | 0.65 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| 67+50 | 6756.92 | 1021.78 | 2.0 | 1 - 24" RCP | 1036.74 | 1023.10 | 1.34 | 2.24 | 8 | 0.67 | 3.58 | 0.013 | 0.58 | 0.20 | 0.0020 | | | | | | | | | 1023.30 |
| 0 | MH #15 | | | 0.00% | | | | | | | | | | | | 0.0020 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | |
| 67+50 | 6756.92 | 1021.86 | 2.0 | 1 - 24" RCP | 1036.74 | 1023.18 | 1.32 | 2.20 | 8 | 0.66 | 3.64 | 0.013 | 0.58 | 0.21 | 0.0021 | | | | | | | | | 1023.39 |
| 325 | reach | | | 0.20% | | | | | | | | | | | | 0.0020 | 325.00 | 0.67 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| 70+74.64 | 7081.92 | 1022.51 | 2.0 | 1 - 24" RCP | 1036.06 | 1023.85 | 1.34 | 2.24 | 8 | 0.67 | 3.58 | 0.013 | 0.58 | 0.20 | 0.0020 | | | | | | | | | 1024.05 |
| 0 | MH #14 | | | 0.00% | | | | | | | | | | | | 0.0020 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | |
| 70+74.64 | 7081.92 | 1022.61 | 2.0 | 1 - 24" RCP | 1036.06 | 1023.93 | 1.32 | 2.20 | 8 | 0.66 | 3.64 | 0.013 | 0.58 | 0.21 | 0.0021 | | | | | | | | | 1024.14 |
| 330 | reach | | | 0.20% | | | | | | | | | | | | 0.0020 | 330.00 | 0.68 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| 74+04.65 | 7411.92 | 1023.27 | 2.0 | 1 - 24" RCP | 1036.58 | 1024.61 | 1.34 | 2.24 | 8 | 0.67 | 3.58 | 0.013 | 0.58 | 0.20 | 0.0020 | | | | | | | | | 1024.81 |
| 0 | MH #13 | | | 0.00% | | | | | | | | | | | | 0.0019 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | |
| 74+04.65 | 7411.92 | 1023.37 | 2.0 | 1 - 24" RCP | 1036.58 | 1024.65 | 1.28 | 2.12 | 7 | 0.64 | 3.30 | 0.013 | 0.57 | 0.17 | 0.0017 | | | | | | | | | 1024.82 |
| 320 | reach | | | 0.20% | | | | | | | | | | | | 0.0019 | 320.00 | 0.60 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| 77+25 | 7731.92 | 1024.01 | 2.0 | 1 - 24" RCP | 1036.87 | 1025.23 | 1.22 | 2.01 | 7 | 0.61 | 3.49 | 0.013 | 0.56 | 0.19 | 0.0020 | | | | | | | | | 1025.42 |
| 0 | MH #12 | | | 0.00% | | | | | | | | | | | | 0.0020 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.08 | 0.00 | |
| 77+25 | 7731.92 | 1024.11 | 2.0 | 1 - 24" RCP | 1036.87 | 1025.33 | 1.22 | 2.01 | 7 | 0.61 | 3.49 | 0.013 | 0.56 | 0.19 | 0.0020 | | | | | | | | | 1025.52 |
| 60 | reach | | | 0.20% | | | | | | | | | | | | 0.0020 | 60.00 | 0.12 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| 77+75 | 7791.92 | 1024.23 | 2.0 | 1 - 24" RCP | 1037.28 | 1025.45 | 1.22 | 2.01 | 7 | 0.61 | 3.49 | 0.013 | 0.56 | 0.19 | 0.0020 | | | | | | | | | 1025.64 |
| 0 | MH #11 | | | 0.00% | | | | | | | | | | | | 0.0020 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.08 | 0.00 | |
| 77+75 | 7791.92 | 1024.33 | 2.0 | 1 - 24" RCP | 1037.28 | 1025.55 | 1.22 | 2.01 | 7 | 0.61 | 3.49 | 0.013 | 0.56 | 0.19 | 0.0020 | | | | | | | | | 1025.74 |
| 325 | reach | | | 0.20% | | | | | | | | | | | | 0.0020 | 325.00 | 0.66 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| 81+00 | 8116.92 | 1024.98 | 2.0 | 1 - 24" RCP | 1037.82 | 1026.21 | 1.23 | 2.01 | 7 | 0.61 | 3.49 | 0.013 | 0.56 | 0.19 | 0.0020 | | | | | | | | | 1026.39 |
| 0 | MH #10 | | | 0.00% | | | | | | | | | | | | 0.0020 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | |
| 81+00 | 8116.92 | 1025.08 | 2.0 | 1 - 24" RCP | 1037.82 | 1026.30 | 1.22 | 2.01 | 7 | 0.61 | 3.49 | 0.013 | 0.56 | 0.19 | 0.0020 | | | | | | | | | 1026.49 |
| 325 | reach | | | 0.20% | | | | | | | | | | | | 0.0020 | 325.00 | 0.66 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| 84+25 | 8441.92 | 1025.73 | 2.0 | 1 - 24" RCP | 1038.02 | 1026.95 | 1.23 | 2.01 | 7 | 0.61 | 3.49 | 0.013 | 0.56 | 0.19 | 0.0020 | | | | | | | | | 1027.14 |
| 0 | MH #9 | | | 0.00% | | | | | | | | | | | | 0.0022 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | |
| 84+25 | 8441.92 | 1027.23 | 2.0 | 1 - 24" RCP | 1038.02 | 1028.27 | 1.04 | 1.65 | 6 | 0.52 | 3.63 | 0.013 | 0.51 | 0.21 | 0.0025 | | | | | | | | | 1028.48 |
| 286 | reach | | | 0.25% | | | | | | | | | | | | 0.0025 | 286.00 | 0.70 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| 87+10.50 | 8727.92 | 1027.95 | 2.0 | 1 - 24" RCP | 1038.09 | 1028.99 | 1.04 | 1.65 | 6 | 0.52 | 3.63 | 0.013 | 0.51 | 0.21 | 0.0025 | | | | | | | | | 1029.19 |
| 0 | MH #8 | | | 0.00% | | | | | | | | | | | | 0.0025 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | |
| 87+10.50 | 8727.92 | 1028.04 | 2.0 | 1 - 24" RCP | 1038.09 | 1029.08 | 1.04 | 1.65 | 6 | 0.52 | 3.63 | 0.013 | 0.51 | 0.21 | 0.0025 | | | | | | | | | 1029.29 |
| 199 | reach | | | 0.25% | | | | | | | | | | | | 0.0025 | 199.00 | 0.49 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| 89+09.30 | 8926.92 | 1028.54 | 2.0 | 1 - 24" RCP | 1038.23 | 1029.58 | 1.04 | 1.65 | 6 | 0.52 | 3.63 | 0.013 | 0.51 | 0.21 | 0.0025 | | | | | | | | | 1029.78 |
| 0 | MH #7 | | | 0.00% | | | | | | | | | | | | 0.0025 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | |
| 89+09.30 | 8926.92 | 1028.64 | 2.0 | 1 - 24" RCP | 1038.23 | 1029.68 | 1.04 | 1.65 | 6 | 0.52 | 3.63 | 0.013 | 0.51 | 0.21 | 0.0025 | | | | | | | | | 1029.89 |
| 245 | reach | | | 0.25% | | | | | | | | | | | | 0.0025 | 245.00 | 0.60 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| 91+54 | 9171.92 | 1029.25 | 2.0 | 1 - 24" RCP | 1038.72 | 1030.29 | 1.04 | 1.65 | 6 | 0.52 | 3.63 | 0.013 | 0.51 | 0.21 | 0.0025 | | | | | | | | | 1030.50 |
| 0 | MH #6 | | | 0.00% | | | | | | | | | | | | 0.0025 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | |
| 91+54 | 9171.92 | 1031.01 | 2.0 | 1 - 24" RCP | 1038.72 | 1031.94 | 0.93 | 1.43 | 5 | 0.465 | 3.49 | 0.013 | 0.48 | 0.19 | 0.0025 | | | | | | | | | 1032.13 |
| 221 | reach | | | 0.25% | | | | | | | | | | | | 0.0025 | 221.00 | 0.55 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| 93+75 | 9392.92 | 1031.58 | 2.0 | 1 - 24" RCP | 1038.92 | 1032.46 | 0.93 | 1.43 | 5 | 0.465 | 3.49 | 0.013 | 0.48 | 0.19 | 0.0025 | | | | | | | | | 1032.65 |
| 0 | MH #5 | | | 0.00% | | | | | | | | | | | | 0.0025 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | |
| 93+75 | 9392.92 | 1031.68 | 1.5 | 1 - 18" RCP | 1038.92 | 1032.47 | 0.81 | 0.97 | 3 | 0.54 | 3.08 | 0.013 | 0.39 | 0.15 | 0.0025 | | | | | | | | | 1032.62 |
| 325 | reach | | | 0.25% | | | | | | | | | | | | 0.0025 | 325.00 | 0.82 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| 97+00 | 9717.92 | 1032.47 | 1.5 | 1 - 18" RCP | 1039.44 | 1033.29 | 0.82 | 0.97 | 3 | 0.54 | 3.08 | 0.013 | 0.39 | 0.15 | 0.0025 | | | | | | | | | 1033.44 |
| 0 | MH #4 | | | 0.00% | | | | | | | | | | | | 0.0020 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | |
| 97+00 | 9717.92 | 1032.58 | 1.5 | 1 - 18" RCP | 1039.44 | 1033.22 | 0.64 | 0.72 | 2 | 0.425 | 2.10 | 0.013 | 0.34 | 0.07 | 0.0014 | | | | | | | | | 1033.29 |
| 300 | reach | | | 0.25% | | | | | | | | | | | | 0.0014 | 300.00 | 0.43 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| 100+00 | 10017.92 | 1033.33 | 1.5 | 1 - 18" RCP | 1040.73 | 1033.97 | 0.64 | 0.72 | 2 | 0.425 | 2.10 | 0.013 | 0.34 | 0.07 | 0.0014 | | | | | | | | | 1034.04 |
| 0 | MH #3 | | | 0.00% | | | | | | | | | | | | 0.0014 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 | 0.00 | |
| 100+00 | 10017.92 | 1033.43 | 1.5 | 1 - 18" RCP | 1040.73 | 1034.07 | 0.64 | 0.72 | 2 | 0.425 | 2.10 | 0.013 | 0.34 | 0.07 | 0.0014 | | | | | | | | | 1034.14 |
| 51 | reach | | | 0.25% | | | | | | | | | | | | 0.0014 | 51.00 | 0.07 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| 100+50 | 10068.92 | 1033.55 | 1.5 | 1 - 18" RCP | 1040.84 | 1034.20 | 0.64 | 0.72 | 2 | 0.425 | 2.10 | 0.013 | 0.34 | 0.07 | 0.0014 | | | | | | | | | 1034.27 |
| 0 | MH #2 | | | 0.00% | | | | | | | | | | | | 0.0014 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 | 0.00 | |
| 100+50 | 10068.92 | 1033.65 | 1.5 | 1 - 18" RCP | 1040.84 | 1034.29 | 0.64 | 0.72 | 2 | 0.425 | 2.10 | 0.013 | 0.34 | 0.07 | 0.0014 | | | | | | | | | 1034.36 |
| 150 | reach | | | 0.25% | | | | | | | | | | | | 0.0014 | 150.00 | 0.22 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| 102+00 | 10218.92 | 1034.03 | 1.5 | 1 - 18" RCP | 1041.51 | 1034.67 | 0.64 | 0.72 | 2 | 0.425 | 2.10 | 0.013 | 0.34 | 0.07 | 0.0014 | | | | | | | | | 1034.73 |
| 0 | MH #1 | | | 0.00% | | | | | | | | | | | | 0.0014 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| 102+00 | 10218.92 | 1034.13 | 1.5 | 1 - 18" RCP | 1041.51 | 1034.77 | 0.64 | 0.72 | 2 | 0.425 | 2.10 | 0.013 | 0.34 | 0.07 | 0.0014 | | | | | | | | | 1034.84 |

Tetra Tech, Inc.

## New 54-inch crossing of RID connecting to existing 54-Inch -- Hydraulic/Energy Grade-Line Calculation Summary Sheet

Camelback Road Storm Drain Design (99th Ave. to Agua Fria River), City of Phoenix Project No. ST8311057

| New Roadway Station | Manhole | Applied Station (ft) | Invert Elevation | Section Height (H) (ft) | Section Description w/ slope (%) | Allowable HGL Elev. | Computed HGL Elev. EGL-$h_v$ | HGL Depth (ft) | Basic Flow Parameters: Area (A) (sq. ft.) | Discharge (Q) (cfs) | Y/D | Velocity (V) (ft/ft) | Manning's n-value | Hydraulic Radius (ft) | Velocity Head (ft) | Friction Slope (Sf) (ft/ft) | Average Sf (ft/ft) | Length L (ft) | head loss (h): friction (f) (ft) | bend (b) (ft) | junction (j) (ft) | transition (t) (ft) | man-hole (mh) (ft) | access-hole inlet/outlet (ft) | EGL Elevation |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 49+95 (48' LT) | MH # 32 | 4998 | 25.62 | 4.5 | 1 - 54" RCP | 34.73 | 30.12 | 4.50 | 15.90 | 38 | 1 | 2.39 | 0.013 | 1.13 | 0.09 | 0.0004 | | | | | | | | | 30.21 |
| As-Built Station | Incremental Distance | reach 5155 | 25.88 | 4.5 | 0.15% 1 - 54" RCP | 35.26 | 30.17 | 4.31 | 15.69 | 38 | 0.96 | 2.42 | 0.013 | 1.27 | 0.09 | 0.0003 | 0.0003 | 159.00 | 0.06 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 30.26 |
| 148.98 | (ft) | MH #1 w/ CB # 0.5 | | | 0.00% | | | | | | | | | | | | 0.0003 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| | | 5155.00 | 25.86 | 4.5 | 1 - 54" RCP | 35.26 | 30.36 | 4.50 | 15.90 | 37 | 1 | 2.33 | 0.013 | 1.13 | 0.08 | 0.0004 | | | | | | | | | 30.44 |
| | | reach 5719 | 26.46 | 4.5 | 0.11% 1 - 54" RCP | 35.37 | 30.54 | 4.08 | 15.20 | 37 | 0.91 | 2.43 | 0.013 | 1.33 | 0.09 | 0.0003 | 0.0003 | 564.00 | 0.19 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 30.63 |
| 713.04 | 564.06 | MH #2 | | | 0.00% | | | | | | | | | | | | 0.0003 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| | | 5719.00 | 26.48 | 4.5 | 1 - 54" RCP | 35.37 | 30.54 | 4.09 | 15.20 | 37 | 0.91 | 2.43 | 0.013 | 1.33 | 0.09 | 0.0003 | | | | | | | | | 30.63 |
| | | reach 6264 | 27.06 | 4.5 | 0.11% 1 - 54" RCP | 35.30 | 30.71 | 3.65 | 13.80 | 37 | 0.81 | 2.68 | 0.013 | 1.37 | 0.11 | 0.0004 | 0.0003 | 545.00 | 0.18 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 30.82 |
| 1257.67 | 544.63 | CB #1 | | | 0.00% | | | | | | | | | | | | 0.0004 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| | | 6264.00 | 27.06 | 4.5 | 1 - 54" RCP | 35.30 | 30.71 | 3.65 | 13.80 | 37 | 0.81 | 2.68 | 0.013 | 1.37 | 0.11 | 0.0004 | | | | | | | | | 30.82 |
| | | reach 6330 | 27.13 | 4.5 | 0.11% 1 - 54" RCP | 35.65 | 30.73 | 3.60 | 13.64 | 37 | 0.8 | 2.71 | 0.013 | 1.37 | 0.11 | 0.0004 | 0.0004 | 66.00 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 30.84 |
| 1323.29 | 65.62 | MH #3 (105th) | | | 0.00% | | | | | | | | | | | | 0.0005 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | |
| | | 6330.00 | 30.35 | 3.5 | 1 - 42" RCP | 35.65 | 33.85 | 3.50 | 9.62 | 26 | 1 | 2.70 | 0.013 | 0.88 | 0.11 | 0.0007 | | | | | | | | | 33.96 |
| | | reach 6761 | 30.47 | 3.5 | 0.03% 1 - 42" RCP | 36.55 | 34.14 | 3.67 | 9.62 | 26 | 1 | 2.70 | 0.013 | 0.88 | 0.11 | 0.0007 | 0.0007 | 431.00 | 0.29 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 34.25 |
| 1754.29 | 431 | MH #4 | | | 0.00% | | | | | | | | | | | | 0.0007 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | |
| | | 6761.00 | 30.47 | 3.5 | 1 - 42" RCP | 36.55 | 34.14 | 3.67 | 9.62 | 26 | 1 | 2.70 | 0.013 | 0.88 | 0.11 | 0.0007 | | | | | | | | | 34.26 |
| | | reach 7119 | 30.98 | 3.5 | 0.14% 1 - 42" RCP | 36.18 | 34.37 | 3.39 | 9.54 | 26 | 0.97 | 2.73 | 0.013 | 0.98 | 0.12 | 0.0006 | 0.0006 | 358.00 | 0.23 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 34.48 |
| 2111.82 | 357.53 | CB #2 | | | 0.00% | | | | | | | | | | | | 0.0006 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| | | 7119.00 | 30.98 | 3.5 | 1 - 42" RCP | 36.18 | 34.37 | 3.39 | 9.54 | 26 | 0.97 | 2.73 | 0.013 | 0.98 | 0.12 | 0.0006 | | | | | | | | | 34.48 |
| | | reach 7162 | 31.04 | 3.5 | 0.14% 1 - 42" RCP | 36.57 | 34.39 | 3.35 | 9.49 | 26 | 0.96 | 2.74 | 0.013 | 0.99 | 0.12 | 0.0006 | 0.0006 | 43.00 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 34.51 |
| 2154.57 | 42.75 | MH #5 | | | 0.00% | | | | | | | | | | | | 0.0006 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | |
| | | 7162.00 | 31.04 | 3.5 | 1 - 42" RCP | 36.57 | 34.40 | 3.36 | 9.49 | 26 | 0.96 | 2.74 | 0.013 | 0.99 | 0.12 | 0.0006 | | | | | | | | | 34.51 |
| | | reach 7593 | 31.08 | 3.5 | 0.01% 1 - 42" RCP | 36.63 | 34.67 | 3.58 | 9.62 | 26 | 1 | 2.70 | 0.013 | 0.88 | 0.11 | 0.0007 | 0.0006 | 431.00 | 0.27 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 34.78 |
| 2585.54 | 430.97 | CB #3 | | | 0.00% | | | | | | | | | | | | 0.0007 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| | | 7593.00 | 31.08 | 3.5 | 1 - 42" RCP | 36.63 | 34.67 | 3.58 | 9.62 | 26 | 1 | 2.70 | 0.013 | 0.88 | 0.11 | 0.0007 | | | | | | | | | 34.78 |
| | | reach 7658 | 31.09 | 3.5 | 0.01% 1 - 42" RCP | 36.96 | 34.71 | 3.62 | 9.62 | 26 | 1 | 2.70 | 0.013 | 0.88 | 0.11 | 0.0007 | 0.0007 | 65.00 | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 34.83 |
| 2650.57 | 65.03 | MH #6 (103rd) | | | 0.00% | | | | | | | | | | | | 0.0006 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | |
| no a/b noted @6 | | 7658.00 | 31.59 | 3.0 | 1 - 36" RCP | 36.96 | 34.75 | 3.16 | 7.07 | 16 | 1 | 2.26 | 0.013 | 0.75 | 0.08 | 0.0006 | | | | | | | | | 34.83 |
| | | reach 8102 | 31.89 | 3.0 | 0.07% 1 - 36" RCP | 38.03 | 35.01 | 3.12 | 7.07 | 16 | 1 | 2.26 | 0.013 | 0.75 | 0.08 | 0.0006 | 0.0006 | 444.00 | 0.26 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 35.09 |
| 3094.57 | 444 | MH #7 | | | 0.00% | | | | | | | | | | | | 0.0006 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| | | 8102.00 | 31.89 | 3.0 | 1 - 36" RCP | 38.03 | 35.01 | 3.12 | 7.07 | 16 | 1 | 2.26 | 0.013 | 0.75 | 0.08 | 0.0006 | | | | | | | | | 35.09 |
| | | reach 8298 | 31.74 | 3.0 | -0.08% 1 - 36" RCP | 38.07 | 35.12 | 3.38 | 7.07 | 16 | 1 | 2.26 | 0.013 | 0.75 | 0.08 | 0.0006 | 0.0006 | 198.00 | 0.11 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 35.20 |
| 3290.48 | 195.91 | MH #7A w/ CB # 4 | | | 0.00% | | | | | | | | | | | | 0.0006 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| | | 8298.00 | 31.74 | 3.0 | 1 - 36" RCP | 38.07 | 35.13 | 3.39 | 7.07 | 16 | 1 | 2.26 | 0.013 | 0.75 | 0.08 | 0.0006 | | | | | | | | | 35.21 |
| | | reach 8546 | 31.87 | 3.0 | 0.05% 1 - 36" RCP | 38.17 | 35.27 | 3.40 | 7.07 | 16 | 1 | 2.26 | 0.013 | 0.75 | 0.08 | 0.0006 | 0.0006 | 248.00 | 0.14 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 35.35 |
| 3538.57 | 248.09 | MH #8 | | | 0.00% | | | | | | | | | | | | 0.0006 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| | | 8546.00 | 31.87 | 3.0 | 1 - 36" RCP | 38.17 | 35.28 | 3.41 | 7.07 | 16 | 1 | 2.26 | 0.013 | 0.75 | 0.08 | 0.0006 | | | | | | | | | 35.35 |
| | | reach 8918 | 32.30 | 3.0 | 0.12% 1 - 36" RCP | 37.95 | 35.49 | 3.19 | 7.07 | 16 | 1 | 2.26 | 0.013 | 0.75 | 0.08 | 0.0006 | 0.0006 | 372.00 | 0.21 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 35.57 |
| 3910.1 | 371.53 | CB #5 | | | 0.00% | | | | | | | | | | | | 0.0006 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| | | 8918.00 | 32.30 | 3.0 | 1 - 36" RCP | 37.95 | 35.49 | 3.19 | 7.07 | 16 | 1 | 2.26 | 0.013 | 0.75 | 0.08 | 0.0006 | | | | | | | | | 35.57 |
| | | reach 8993 | 32.39 | 3.0 | 0.12% 1 - 36" RCP | 38.45 | 35.53 | 3.14 | 7.07 | 16 | 1 | 2.26 | 0.013 | 0.75 | 0.08 | 0.0006 | 0.0006 | 75.00 | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 35.61 |
| 3984.8 | 74.7 | MH #9 (101st) | | | 0.00% | | | | | | | | | | | | 0.0006 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| no a/b noted @6 | | 8993.00 | 32.89 | 2.0 | 1 - 24" RCP | 38.45 | 35.56 | 2.67 | 3.14 | 6 | 1 | 1.91 | 0.013 | 0.50 | 0.06 | 0.0007 | | | | | | | | | 35.62 |
| | | reach 9051 | 32.98 | 2.0 | 0.15% 1 - 24" RCP | 38.09 | 35.60 | 2.62 | 3.14 | 6 | 1 | 1.91 | 0.013 | 0.50 | 0.06 | 0.0007 | 0.0007 | 58.00 | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 35.66 |
| 4042.8 | 58 | CB #6 | | | 0.15% | | | | | | | | | | | | 0.0007 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| | | 9051.00 | 32.98 | 2.0 | 1 - 24" RCP | 38.09 | 35.60 | 2.62 | 3.14 | 6 | 1 | 1.91 | 0.013 | 0.50 | 0.06 | 0.0007 | | | | | | | | | 35.66 |

Tetra Tech, Inc.

# E. Record Drawings

## E.1 Portion of Camelback Ranch Levee South Record Drawings

## E.2 Portion of Camelback Road Storm Drain Record Drawings

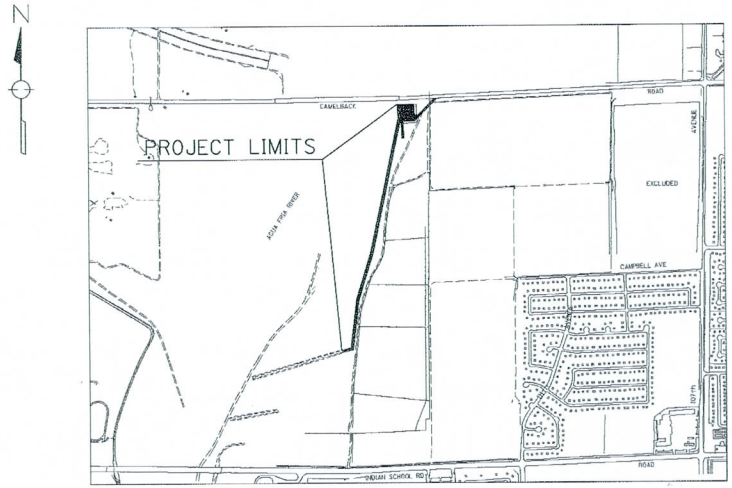
## E.1 Portion of Camelback Ranch Levee South Record Drawings

# FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

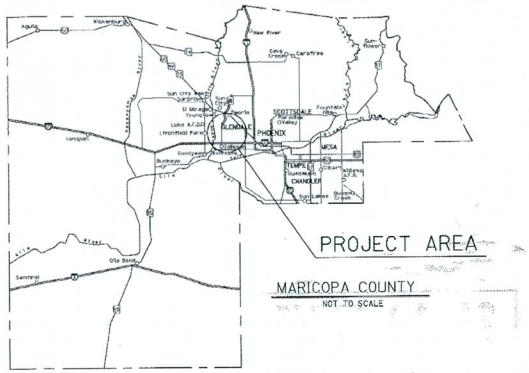
PLANS FOR THE CONSTRUCTION OF

## CAMELBACK RANCH LEVEE - SOUTH

## FCD 97-18




PROJECT SITE
NOT TO SCALE




MARICOPA COUNTY
NOT TO SCALE

Two working days before you dig
CALL FOR THE BLUE STAKES
263-1100
Blue Stake Center
CALL COLLECT

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

ISSUED FOR PUBLIC BIDDING BY:

CHIEF ENGINEER AND GENERAL MANAGER — DATE 2-5-97

BOARD OF DIRECTORS OF THE FLOOD CONTROL DISTRICT

TOM RAWLES - CHAIRMAN

| | |
|---|---|
| DISTRICT 1 | TOM RAWLES |
| DISTRICT 2 | DON STAPLEY |
| DISTRICT 3 | BETSEY BAYLESS |
| DISTRICT 4 | EDWARD KING |
| DISTRICT 5 | MARY ROSE WILCOX |

CAMELBACK RANCH LEVEE-SOUTH
RECORD DRAWINGS
FCD 97-18

400

42

| F.H.W.A. REGION | STATE | PROJECT NO. | SHEET NO. | TOTAL SHEETS | RECORD DRAWING |
|---|---|---|---|---|---|
| 9 | AZ. | FCD 96-16 | 2 | 34 | |

## GENERAL NOTES

All construction shall be completed in accordance with the Maricopa Association of Governments (MAG) "Uniform Standard Specifications for Public Works Construction", 1992 Edition inclusive of the latest revisions and amendments, these Design Plans, and the Special Provisions.

The Maricopa Association of Governments "Uniform Standard Details for Public Works Construction", with the latest revisions and amendments are the Standard Drawings for this project, are an integral part of the Contract, and these Design Plans.

Where noted, references shall also be made to the "Arizona Department of Transportation Standard Specifications for Road and Bridge Construction", 1990 Edition inclusive of the latest revisions.

A Geotechnical Report has been prepared by ATL, Inc. Copies of this report can be reviewed at the Flood Control District of Maricopa County.

The Contractor will be responsible for ensuring that all necessary permits have been obtained prior to construction. Dust shall be controlled in accordance with Federal, State, and local laws, ordinances and regulations. The Contractor shall obtain a permit from the Maricopa County Air Pollution Officer prior to start of construction.

All construction signing, barricading and traffic delineation shall conform to the MAG Standard Specifications and to the "Manual of Uniform Traffic Control Devices - 1984" and any of their latest revisions.

Clearing and Grubbing shall include the removal of all trash and debris within project work area. The removal of trees will not be measured or paid for separately, but considered as part of the clearing and grubbing work.

The Contractor shall take all precautionary measures necessary to protect existing improvements from damage; and all such improvements or structures damaged by the Contractor's operations shall be repaired or reconstructed satisfactory to the Engineer at the expense of the Contractor.

The construction plans are based on topo survey and cross-sections taken on approximately 100 feet increments 100 feet each side of the construction control lines show on the plans. Background mapping was taken from three sources- 1) Aerial Mapping Inc. mapping of the Agua Fria and New Rivers for the redelineation of the Agua Fria River. 2)The west side of the Agua Fria River was provided from the White Tanks ADMS mapping. 3)The upper end of the New River and areas along 107th Ave. was provided from the Maryvale ADMS mapping.

In the event that a discrepancy is encountered on these plans or within the Special Provisions, the Contractor shall notify the Engineer immediately for advisement and prior to any construction activity.

All quantities shown hereon and in the Bid Schedule are estimates and are included for comparison of bids only. The Contractor shall satisfy himself as to the accuracy and completeness of all quantities.

Stations shown on the profile are along the construction control line. Earthwork cross-sections are stationed along the construction control line and are drawn perpendicular or radial to the construction control line. Cross-sections are provided as an aid in evaluating earthwork quantities only and should not be used for staking centerline control or grades.

Utility locations shown hereon are approximate only. It shall be the Contractor's responsibility to determine the exact vertical and horizontal location of all existing underground utilities prior to commencing construction. No representation is made that all existing utilities are shown heron. The Engineer assumes no responsibility for utilities not shown or utilities not shown in their proper location. The Contractor shall notify Blue Stake and all utility companies at least 48 hours prior to commencing construction.

All Coordinates are ground coordinates based upon the State Plane Coordinate System, 1927.
Vertical control is based on NGVD 1929 datum = Corp of Engineers Datum.

## BASIS OF DESIGN

$Q_{DESIGN}$ = SPF = 142,000 cfs
DESIGN FREEBOARD = 3 FEET
$Q_{100}$ = 54,400 cfs

## ESTIMATED EARTHWORK

| | | | |
|---|---|---|---|
| 1 | Soil Cement (Above Existing Grade) | 7,000 | C.Y. |
| 1 | Soil Cement (Below Existing Grade) | 31,800 | C.Y. |
| | Foundation Excavation/Backfill | 17,000 | C.Y. |
| 1 | Toe Excavation/Backfill | 200,100 | C.Y. |
| | Embankment | 17,400 | C.Y. |

## LEGEND

- Soil Cement (In Sections)
- Aggregate Base
- Existing Rock Riprap
- Rock Riprap
- Foundation Excavation (In Sections)
- 27 Test Pit & Number (Text Location Varies)
- 2 Soil Boring Location & Number (Text Location Varies)
- --x---x-- Existing Fence
- —x—x— New Fence
- —C— Cut Line
- —F— Fill Line (Toe of Slope)
- —··· New Right of Way (R/W)
- — — New Temporary Construction Easement (TCE)
- ═IR═ Existing Irrigation Ditch
- —G— Existing Gas Line
- ℄ Section Line
- ℄ Control Line
- N.T.S. Not To Scale
- F.L. Flow Line
- SPF Standard Project Flood
- 21 Horizontal Control Point
- Top of Levee (In Detail)
- Pt. Point
- C.Y. Cubic Yard

## SHEET INDEX


| | |
|---|---|
| 1 | Cover Sheet |
| 2 | General Notes & Sheet Index & Legend |
| 3-6 | Typical Sections |
| 7 | Geometric Control |
| 8 | Vertical Control |
| 9-10 | Plan & Profile |
| 11-15 | Turn Around Pad 1 Details |
| 16 | Turn Around Pad 2 Detail |
| 17 | Safety Rail & Gate Details |
| 18-32 | Cross-Sections |
| 33-34 | Soil Borings Logs |


"RECORD DRAWING"
I HEREBY CERTIFY THAT THE "RECORD DRAWING" REPRESENTS AS BUILT DRAWINGS WHICH WERE MADE UNDER MY SUPERVISION AND ARE CORRECT TO THE BEST OF MY KNOWLEDGE AND BELIEF.

| NO. | REVISION | BY | DATE |
|---|---|---|---|
| 1 | REVISED QUANTITY | RS | 2/24/97 |

**FLOOD CONTROL DISTRICT OF MARICOPA COUNTY**
ENGINEERING DIVISION

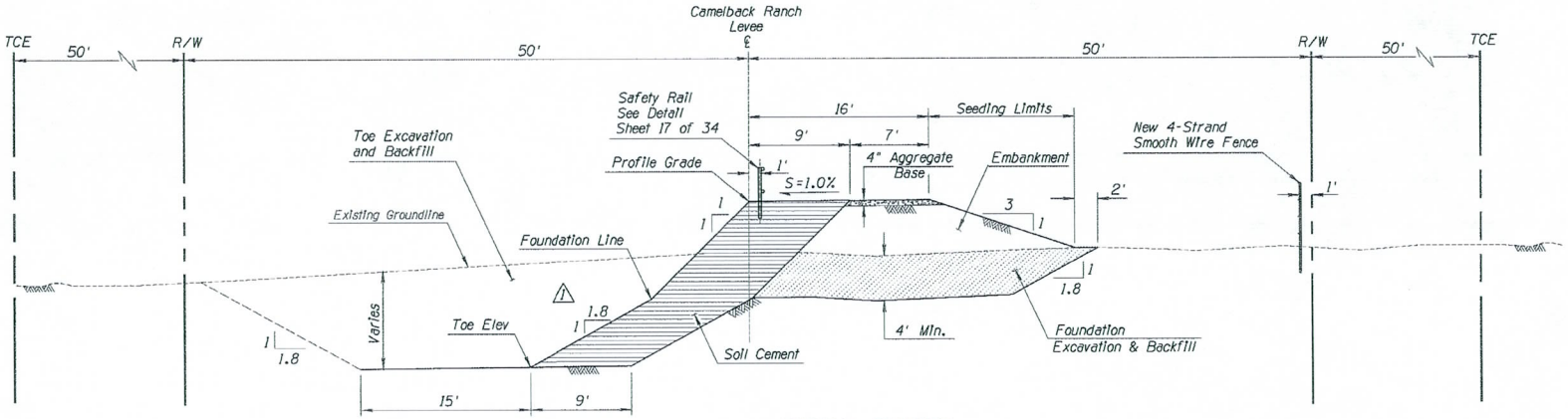
CAMELBACK RANCH LEVEE - SOUTH
INDIAN SCHOOL RD. - CAMELBACK RD.
PROJECT NO. FCD 97-18

| | BY | DATE |
|---|---|---|
| DESIGNED | C.B.B. | 01/21/97 |
| DRAWN | R.S. | 01/21/97 |
| CHECKED | M.S.S. | 01/21/97 |

DMJM ARIZONA, INC.
300 WEST CLARENDON SUITE 400 PHOENIX, AZ. 85013-3499 (602) 264-0217

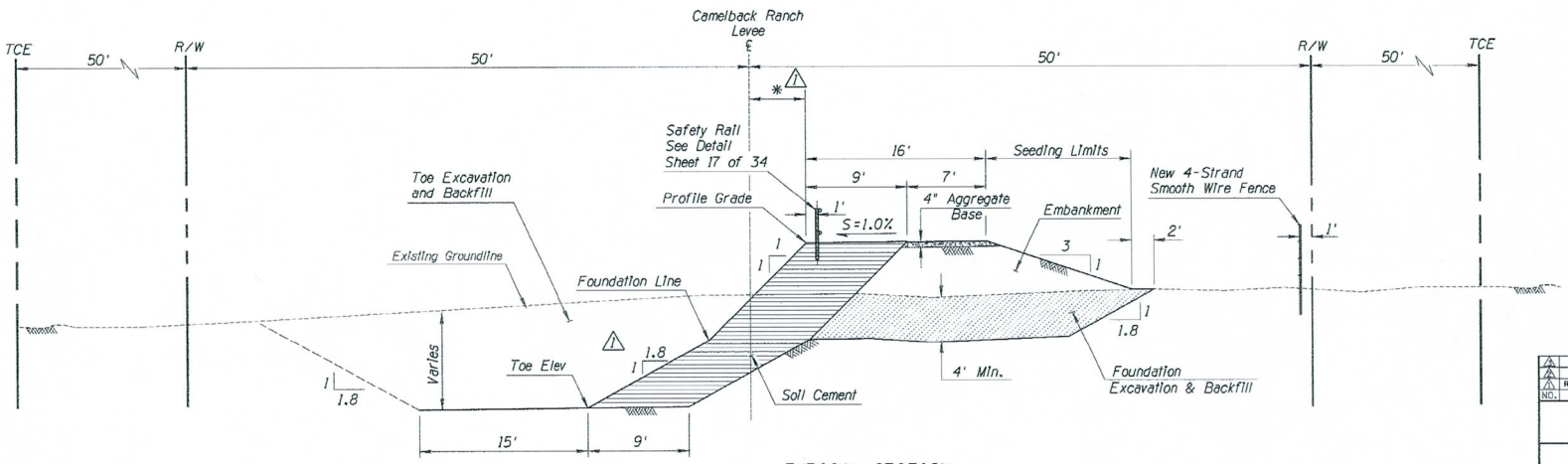
GENERAL NOTES, SHEET INDEX, & LEGEND — SHEET 2 OF 34

| F.H.W.A. REGION | STATE | PROJECT NO. | SHEET NO. | TOTAL SHEETS | RECORD DRAWING |
|---|---|---|---|---|---|
| 9 | AZ. | FCD 96-16 | 3 | 34 | |




**TYPICAL SECTION**

Sta 8+50 to 11+00 Turn Around Pad 1 Detail (See Sheets 11-15 of 34)
Sta 10+00 to 24+25
N.T.S.




**TYPICAL SECTION**

* Sta 24+25 to 28+75, Offset Varies 0' to 9' Rt
Sta 28+75 to 37+00, Offset = 9' Rt
Sta 37+00 to 38+50, Offset Varies 9' Rt to 4.5'

"RECORDED DRAWINGS"
I HEREBY CERTIFY THAT THE "RECORD DRAWINGS" MEASUREMENTS AS SHOWN HEREON ARE MADE UNDER MY SUPERVISION AND ARE CORRECT TO THE BEST OF MY KNOWLEDGE AND BELIEF.

| NO. | REVISION | BY | DATE |
|---|---|---|---|
| 3 | | | |
| 2 | | | |
| 1 | REVISED SOIL CEMENT SLOPE & OFFSETS | RS | 2/24/97 |

**FLOOD CONTROL DISTRICT OF MARICOPA COUNTY**
ENGINEERING DIVISION

CAMELBACK RANCH LEVEE - SOUTH
INDIAN SCHOOL RD. - CAMELBACK RD.
PROJECT NO. FCD 97-18

| | BY | DATE |
|---|---|---|
| DESIGNED | C.B.B. | 01/21/97 |
| DRAWN | R.S./T.N. | 01/21/97 |
| CHECKED | M.S.S. | 01/21/97 |

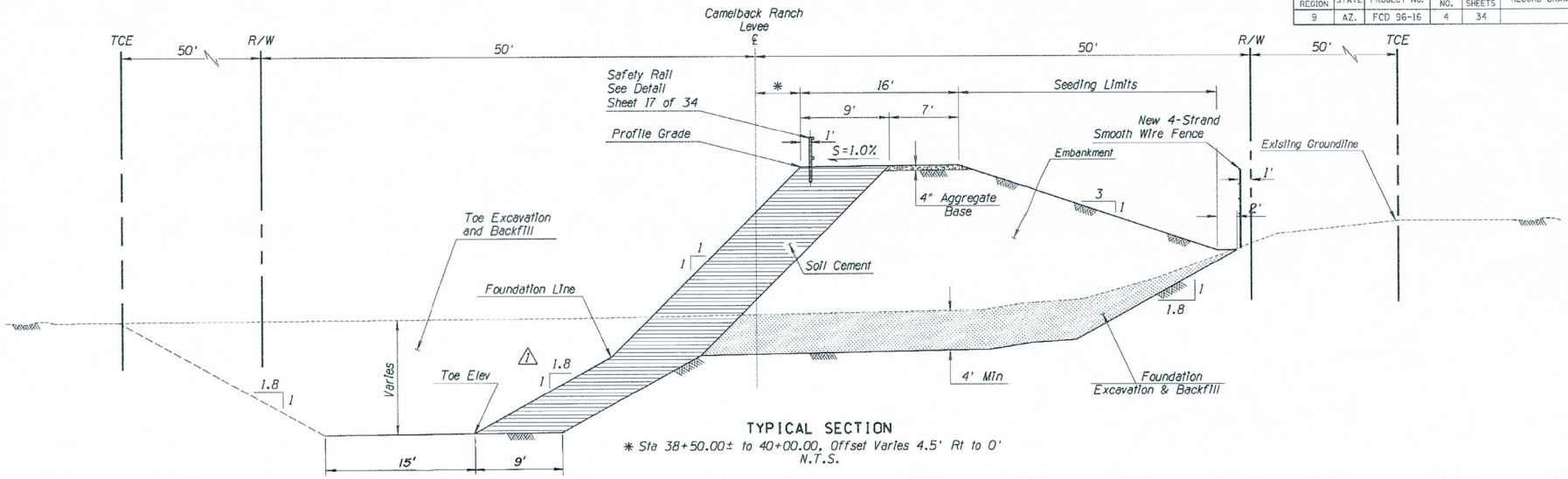
21009 MICHAEL S. SHARROD 1/29/97 REGISTERED PROFESSIONAL ENGINEER ARIZONA, U.S.A.

DMJM ARIZONA, INC.
300 WEST CLARENDON SUITE 400 PHOENIX, AZ. 85013-3499 (602) 264-0217

TYPICAL SECTION
STA 9+00.00 TO 38+50.00

SHEET 3 OF 34

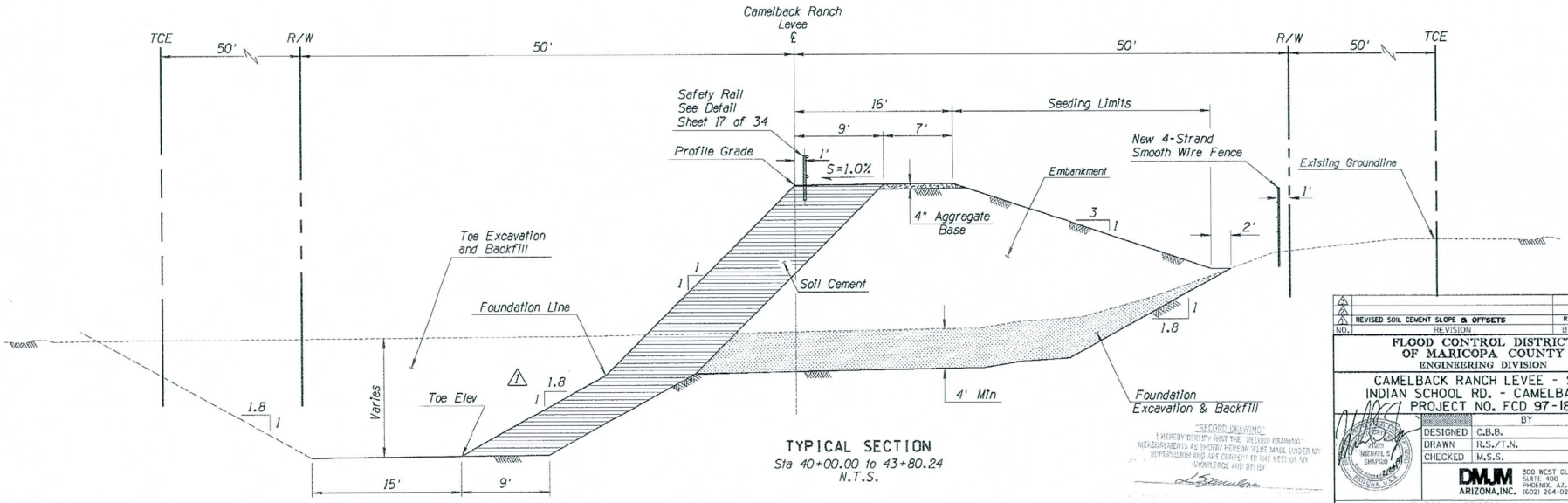
| F.H.W.A. REGION | STATE | PROJECT NO. | SHEET NO. | TOTAL SHEETS | RECORD DRAWING |
|---|---|---|---|---|---|
| 9 | AZ. | FCD 96-16 | 4 | 34 | |




**TYPICAL SECTION**

* Sta 38+50.00± to 40+00.00, Offset Varies 4.5' Rt to 0'

N.T.S.




**TYPICAL SECTION**

Sta 40+00.00 to 43+80.24

N.T.S.

"RECORD DRAWING"
I HEREBY CERTIFY THAT THE "RECORD DRAWING" MEASUREMENTS AS SHOWN HEREON WERE MADE UNDER MY SUPERVISION AND ARE CORRECT TO THE BEST OF MY KNOWLEDGE AND BELIEF

| NO. | REVISION | BY | DATE |
|---|---|---|---|
| 3 | | | |
| 2 | | | |
| 1 | REVISED SOIL CEMENT SLOPE & OFFSETS | RS | 2/24/97 |

**FLOOD CONTROL DISTRICT OF MARICOPA COUNTY**
ENGINEERING DIVISION

CAMELBACK RANCH LEVEE - SOUTH
INDIAN SCHOOL RD. - CAMELBACK RD.
PROJECT NO. FCD 97-18

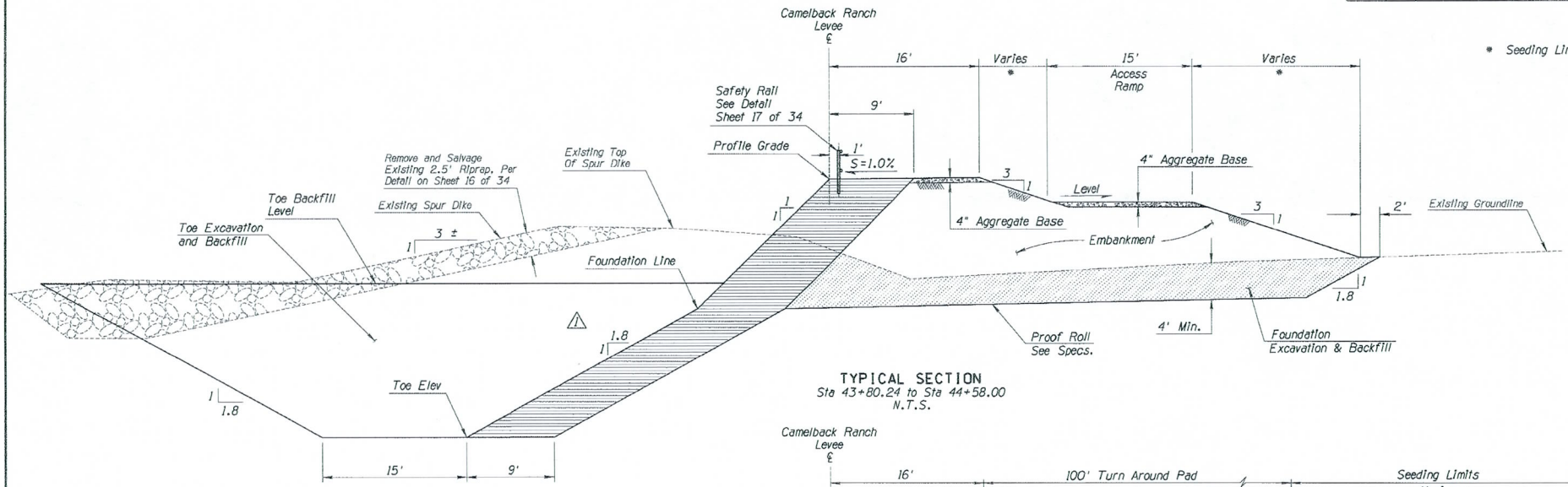
| | BY | DATE |
|---|---|---|
| DESIGNED | C.B.B. | 01/21/97 |
| DRAWN | R.S./T.N. | 01/21/97 |
| CHECKED | M.S.S. | 01/21/97 |

DMJM ARIZONA, INC.
300 WEST CLARENDON
SUITE 400
PHOENIX, AZ. 85013-3499
(602) 264-0217

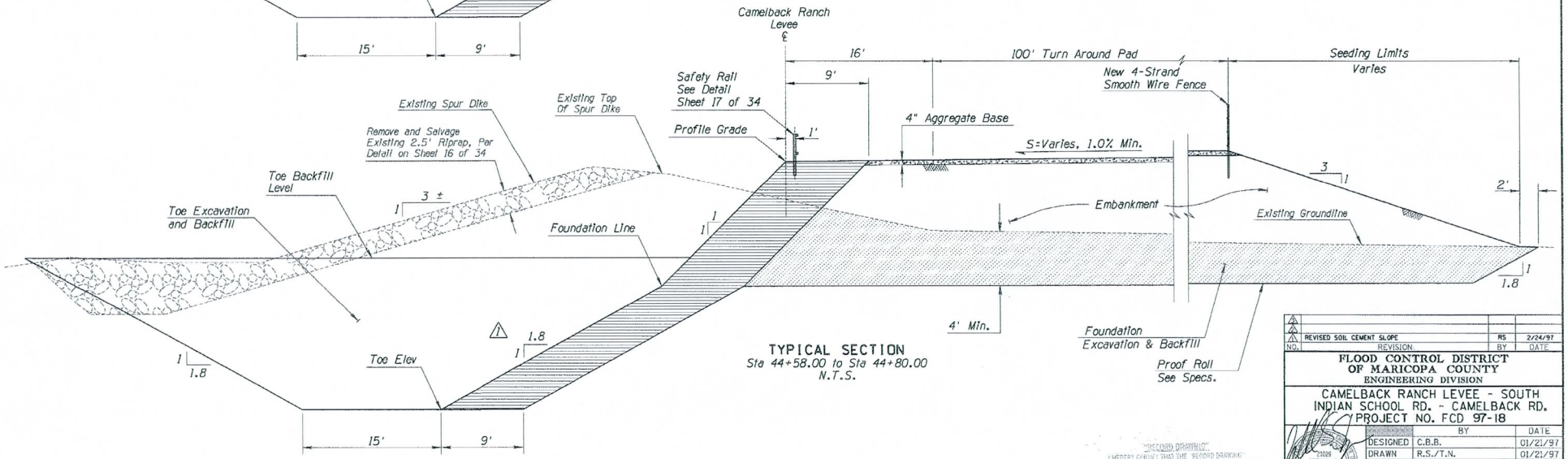
TYPICAL SECTION
STA 38+50.00 TO 43+80.24

SHEET 4 OF 34

| F.H.W.A. REGION | STATE | PROJECT NO. | SHEET NO. | TOTAL SHEETS | RECORD DRAWING |
|---|---|---|---|---|---|
| 9 | AZ. | FCD 96-16 | 5 | 34 | |




TYPICAL SECTION
Sta 43+80.24 to Sta 44+58.00
N.T.S.




TYPICAL SECTION
Sta 44+58.00 to Sta 44+80.00
N.T.S.

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I HEREBY CERTIFY THAT THE "RECORD DRAWING" MEASUREMENTS AS SHOWN HEREON WERE MADE UNDER MY SUPERVISION AND ARE CORRECT TO THE BEST OF MY KNOWLEDGE AND BELIEF.

| NO. | REVISION | BY | DATE |
|---|---|---|---|
| 1 | | | |
| 2 | | | |
| 3 | REVISED SOIL CEMENT SLOPE | RS | 2/24/97 |

**FLOOD CONTROL DISTRICT OF MARICOPA COUNTY**
ENGINEERING DIVISION

CAMELBACK RANCH LEVEE - SOUTH
INDIAN SCHOOL RD. - CAMELBACK RD.
PROJECT NO. FCD 97-18

| | BY | DATE |
|---|---|---|
| DESIGNED | C.B.B. | 01/21/97 |
| DRAWN | R.S./T.N. | 01/21/97 |
| CHECKED | M.S.S. | 01/21/97 |

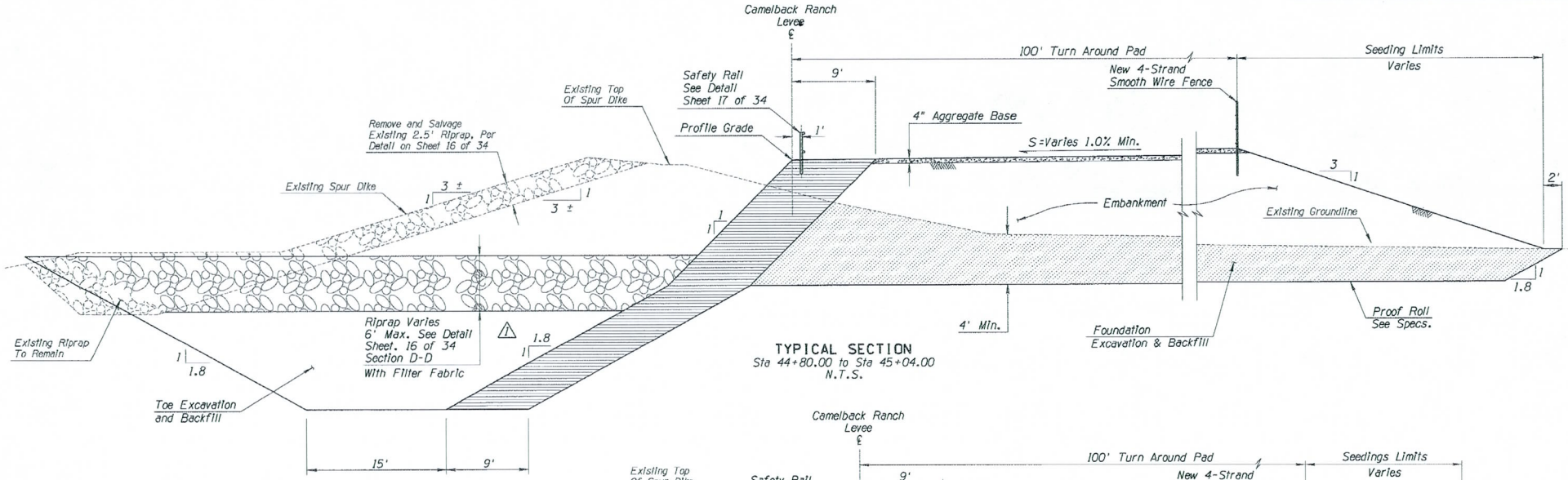
21029 MICHAEL S. SHAPIRO 2/24/97 ARIZONA, U.S.A.

DMJM ARIZONA, INC. 300 WEST CLARENDON SUITE 400 PHOENIX, AZ. 85013-3499 (602) 264-0217

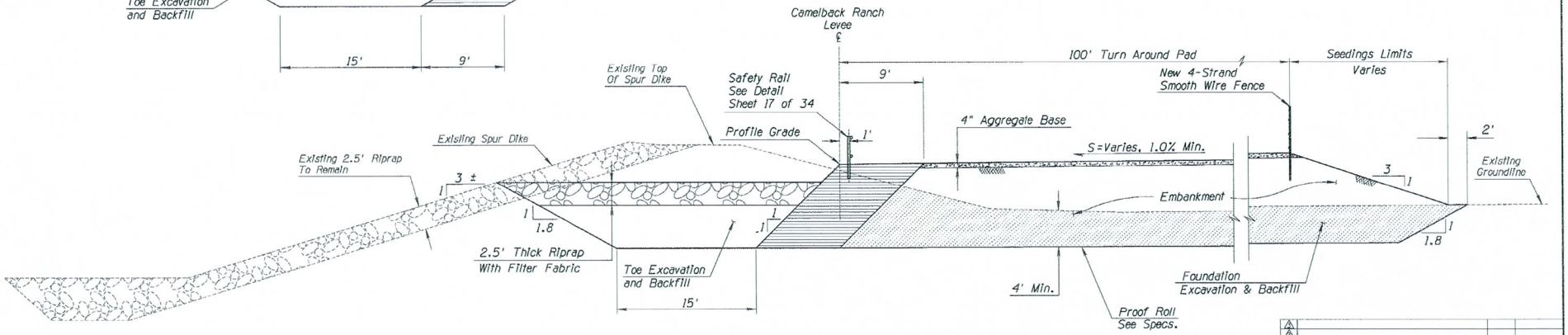
TYPICAL SECTION
STA 44+30.00 TO 45+75.00±

SHEET 5 OF 34

| F.H.W.A. REGION | STATE | PROJECT NO. | SHEET NO. | TOTAL SHEETS | RECORD DRAWING |
|---|---|---|---|---|---|
| 9 | AZ. | FCD 96-16 | 6 | 34 | |




TYPICAL SECTION
Sta 44+80.00 to Sta 45+04.00
N.T.S.




TYPICAL SECTION
Sta 45+04.00 to Sta 45+58.00
N.T.S.

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| NO. | REVISION | BY | DATE |
|---|---|---|---|
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | REVISED SOIL CEMENT SLOPE | RS | 2/24/97 |

FLOOD CONTROL DISTRICT
OF MARICOPA COUNTY
ENGINEERING DIVISION

CAMELBACK RANCH LEVEE - SOUTH
INDIAN SCHOOL RD. - CAMELBACK RD.
PROJECT NO. FCD 97-18

| | BY | DATE |
|---|---|---|
| DESIGNED | C.B.B. | 01/21/97 |
| DRAWN | R.S./T.N. | 01/21/97 |
| CHECKED | M.S.S. | 01/21/97 |

MICHAEL S. SHAPIRO
Registered Professional Engineer
ARIZONA, U.S.A.

DMJM ARIZONA, INC.
300 WEST CLARENDON
SUITE 400
PHOENIX, AZ. 85013-3499
(602) 264-0217

TYPICAL SECTION
STA 44+30.00 TO 45+75.00±

SHEET 6 OF 34

| F.H.W.A. REGION | STATE | PROJECT NO. | SHEET NO. | TOTAL SHEETS | RECORD DRAWING |
|---|---|---|---|---|---|
| 9 | AZ. | FCD 96-16 | 7 | 34 | |

## ☐ LIST OF COORDINATES

| PT NO. | DESCRIPTION | NORTHING | EASTING | REMARKS |
|---|---|---|---|---|
| 3 | NE COR. | 912718.771 | 386478.978 | FND BC IN HH |
| 4 | E ¼ COR. | 910072.452 | 386437.398 | FND BC FLUSH |
| 5 | SE COR. | 907425.778 | 386395.827 | FND BC IN HH |
| 6 | S ¼ COR. | 907324.246 | 383858.840 | FND BC FLUSH |
| 7 | SW COR. | 907224.943 | 381374.552 | FND BC IN HH |
| 8 | CEN. OF SEC. | 909961.133 | 383864.100 | FND BC IN HH |
| 9 | N ¼ COR. | 912596.235 | 383868.434 | FND BC FLUSH |
| 10 | NW COR. | 912482.385 | 381374.744 | FND BC FLUSH |
| 15 | W ¼ COR. | 909853.663 | 381374.648 | CALCULATED |
| 20 | PT ON EXISTING LEVEE | 908556.331 | 380063.541 | NOT FOUND OR SET |
| 21 | BEGIN LEVEE STA 8+50 | 908928.180 | 381313.840 | |
| 22 | PI STA 10+00.00 | 908970.940 | 381457.616 | |
| 23 | PI STA 15+52.27 | 909519.323 | 381523.005 | |
| 24 | PI STA 21+04.54 | 910046.925 | 381686.211 | |
| 25 | PI STA 43+80.24 | 912272.941 | 382159.132 | |
| 26 | END LEVEE STA 46+25.44 | 912518.142 | 382157.948 | |

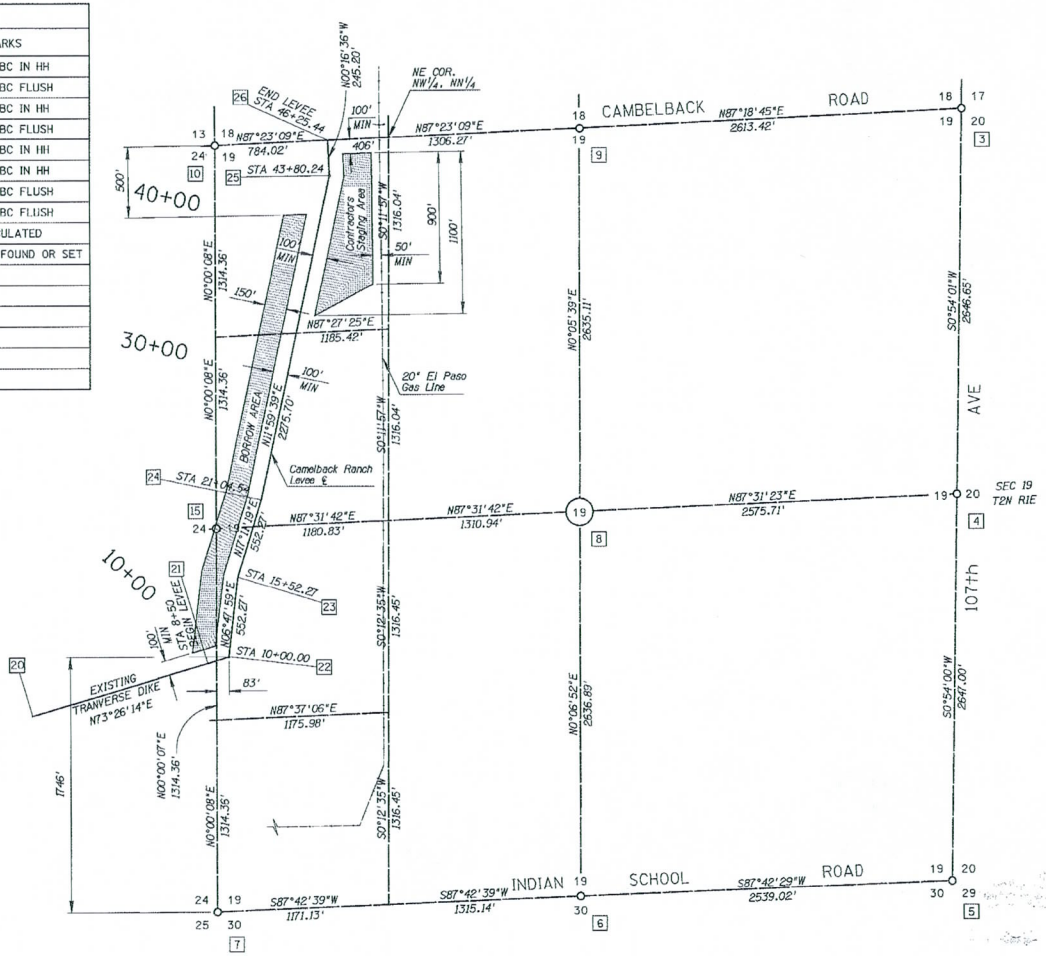
**BENCH MARKS:**

SW CORNER SEC 19
BC IN HH ELEV= 1014.17

S¼ CORNER SEC 19
BC FLUSH ELEV= 1016.88

NE CORNER SEC 19
BC IN HH ELEV= 1034.55

N¼ CORNER SEC 19
BC FLUSH ELEV= 1033.04




NOTE: CONTRACTOR STAGING AREA SHALL NOT DISTURB THE EXISTING IRRIGATION DITCHES, EL PASO GAS LINE EASEMENT, WELL SITE AND STORAGE TANK.

| NO. | REVISION | BY | DATE |
|---|---|---|---|
| 1 | | | |
| 2 | | | |
| 3 | | | |

**FLOOD CONTROL DISTRICT OF MARICOPA COUNTY**
ENGINEERING DIVISION

CAMELBACK RANCH LEVEE - SOUTH
INDIAN SCHOOL RD. - CAMELBACK RD.
PROJECT NO. FCD 97-18

| | BY | DATE |
|---|---|---|
| DESIGNED | C.B.B. | 01/21/97 |
| DRAWN | R.S./J.C. | 01/21/97 |
| CHECKED | M.S.S. | 01/21/97 |

DMJM ARIZONA, INC.
300 WEST CLARENDON
SUITE 400
PHOENIX, AZ. 85013-3499
(602) 264-0217

GEOMETRIC CONTROL

SHEET 7 OF 34

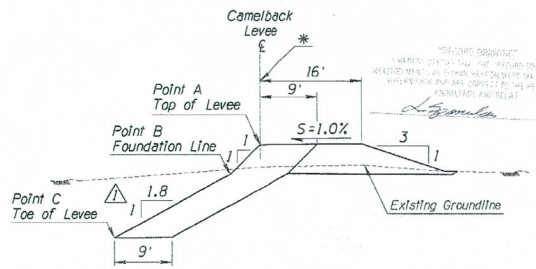
5526cbr2.dgn 5/14/96

| F.H.W.A. REGION | STATE | PROJECT NO. | SHEET NO. | TOTAL SHEETS | RECORD DRAWING |
|---|---|---|---|---|---|
| 9 | AZ. | FCD 96-16 | 8 | 34 | |

| STATION | DESCRIPTION | POINT 'A' | | POINT 'B' | | POINT 'C' | |
|---|---|---|---|---|---|---|---|
| | | OFFSET FEET | ELEV | OFFSET FEET | ELEV | OFFSET FEET | ELEV |
| 8+50.00 | MATCH EXISTING | -10.00 | 1,021.00 | -11.00 | 1,020.00 | -11.00 | 1,020.00 |
| 8+72.00 | Begin Foundation | -10.00 | 1,021.00 | -22.00 | 1,009.00 | -22.00 | 1,009.00 |
| 9+00.00 | EXISTING TOE | -10.00 | 1,021.00 | -21.58 | 1,009.42 | -47.53 | 995.00 |
| 9+06.00 | BEGIN TOE | -10.00 | 1,021.00 | -21.50 | 1,009.50 | -53.00 | 992.00 |
| 9+20.00 | | -10.00 | 1,021.00 | -21.29 | 1,009.71 | -53.17 | 992.00 |
| 9+40.00 | | -10.00 | 1,021.00 | -20.99 | 1,010.01 | -53.41 | 992.00 |
| 9+60.00 | | -10.00 | 1,021.00 | -20.69 | 1,010.31 | -53.65 | 992.00 |
| 9+80.00 | | -10.00 | 1,021.00 | -20.40 | 1,010.60 | -53.88 | 992.00 |
| 10+00.00 | END SOIL CEMENT BACK | -10.00 | 1,021.00 | -20.10 | 1,010.90 | -54.12 | 992.00 |
| 10+00.00 | PI #22 GB FOUNDATION | -5.00 | 1,021.00 | -15.10 | 1,010.90 | -49.12 | 992.00 |
| 10+60.00 | END TURNAROUND | -5.00 | 1,021.00 | -15.34 | 1,010.66 | -48.93 | 992.00 |
| 11+00.00 | END TRANSITION | 0.00 | 1,021.00 | -10.50 | 1,010.50 | -43.80 | 992.00 |
| 12+00.00 | | 0.00 | 1,021.00 | -10.90 | 1,010.10 | -43.48 | 992.00 |
| 13+00.00 | GB FOUNDATION | 0.00 | 1,021.00 | -11.30 | 1,009.70 | -43.16 | 992.00 |
| 14+00.00 | | 0.00 | 1,021.00 | -10.40 | 1,010.60 | -43.88 | 992.00 |
| 15+00.00 | | 0.00 | 1,021.00 | -9.50 | 1,011.50 | -44.60 | 992.00 |
| 15+52.27 | PI #23 | 0.00 | 1,021.00 | -9.03 | 1,011.97 | -44.98 | 992.00 |
| 16+00.00 | GB FOUNDATION | 0.00 | 1,021.00 | -8.60 | 1,012.40 | -45.32 | 992.00 |
| 17+00.00 | | 0.00 | 1,021.00 | -8.51 | 1,012.49 | -45.39 | 992.00 |
| 18+00.00 | | 0.00 | 1,021.00 | -8.42 | 1,012.58 | -45.46 | 992.00 |
| 19+00.00 | | 0.00 | 1,021.00 | -8.33 | 1,012.67 | -45.54 | 992.00 |
| 20+00.00 | | 0.00 | 1,021.00 | -8.24 | 1,012.76 | -45.61 | 992.00 |
| 21+00.00 | | 0.00 | 1,021.00 | -8.15 | 1,012.85 | -45.68 | 992.00 |
| 21+04.54 | PI #24 | 0.00 | 1,021.00 | -8.15 | 1,012.85 | -45.68 | 992.00 |
| 22+00.00 | | 0.00 | 1,021.00 | -8.06 | 1,012.94 | -45.75 | 992.00 |
| 22+50.00 | GB TOP/TOE | 0.00 | 1,021.00 | -8.01 | 1,012.99 | -45.79 | 992.00 |
| 23+00.00 | | 0.00 | 1,021.09 | -8.06 | 1,013.03 | -46.75 | 991.54 |
| 24+00.00 | | 0.00 | 1,021.26 | -8.14 | 1,013.12 | -48.67 | 990.61 |
| 24+25.00 | PI TOP | 0.00 | 1,021.31 | -8.17 | 1,013.14 | -49.15 | 990.38 |
| 25+00.00 | | 1.50 | 1,021.44 | -6.73 | 1,013.21 | -49.08 | 989.68 |
| 26+00.00 | GB FOUNDATION | 3.50 | 1,021.62 | -4.82 | 1,013.30 | -49.00 | 988.75 |
| 27+00.00 | GB FOUNDATION | 5.50 | 1,021.79 | -1.59 | 1,014.70 | -49.97 | 987.82 |
| 28+00.00 | GB FOUNDATION | 7.50 | 1,021.97 | -1.57 | 1,012.90 | -48.38 | 986.90 |
| 28+75.00 | GB TOP/TOE PI TOP | 9.00 | 1,022.10 | 0.02 | 1,013.13 | -48.44 | 986.20 |
| 29+00.00 | | 9.00 | 1,022.16 | 0.04 | 1,013.20 | -48.37 | 986.30 |

| STATION | DESCRIPTION | POINT 'A' | | POINT 'B' | | POINT 'C' | |
|---|---|---|---|---|---|---|---|
| | | OFFSET FEET | ELEV | OFFSET FEET | ELEV | OFFSET FEET | ELEV |
| 30+00.00 | | 9.00 | 1,022.38 | 0.12 | 1,013.50 | -48.09 | 986.72 |
| 31+00.00 | | 9.00 | 1,022.60 | 0.20 | 1,013.80 | -47.81 | 987.13 |
| 32+00.00 | GB FOUNDATION | 9.00 | 1,022.83 | 0.27 | 1,014.10 | -47.53 | 987.54 |
| 33+00.00 | GB FOUNDATION | 9.00 | 1,023.05 | -0.65 | 1,013.40 | -46.45 | 987.96 |
| 34+00.00 | GB FOUNDATION | 9.00 | 1,023.28 | 0.12 | 1,014.40 | -46.73 | 988.37 |
| 34+55.00 | GB TOP/TOE | 9.00 | 1,023.40 | 0.08 | 1,014.48 | -46.51 | 988.60 |
| 35+00.00 | | 9.00 | 1,023.52 | 0.03 | 1,014.55 | -46.77 | 988.55 |
| 36+00.00 | GB FOUNDATION | 9.00 | 1,023.78 | -0.08 | 1,014.70 | -47.34 | 988.44 |
| 37+00.00 | PI TOP | 9.00 | 1,024.04 | 1.76 | 1,016.80 | -49.48 | 988.33 |
| 38+00.00 | | 6.00 | 1,024.30 | -6.25 | 1,012.05 | -49.13 | 988.23 |
| 39+00.00 | | 3.00 | 1,024.56 | -14.26 | 1,007.30 | -48.79 | 988.12 |
| 39+15.00 | GB TOP/TOE | 2.55 | 1,024.60 | -14.75 | 1,007.30 | -49.31 | 988.10 |
| 40+00.00 | PI TOP | 0.00 | 1,025.15 | -17.85 | 1,007.30 | -48.30 | 990.38 |
| 41+00.00 | | 0.00 | 1,025.79 | -18.49 | 1,007.30 | -44.11 | 993.07 |
| 42+00.00 | | 0.00 | 1,026.44 | -19.14 | 1,007.30 | -39.91 | 995.76 |
| 43+00.00 | | 0.00 | 1,027.08 | -13.08 | 1,014.00 | -41.08 | 998.44 |
| 43+80.24 | PI #25 GB TOP/TOE | 0.00 | 1,027.60 | -13.60 | 1,014.00 | -37.72 | 1,000.60 |
| 44+00.00 | | 0.00 | 1,027.60 | -13.60 | 1,014.00 | -37.72 | 1,000.60 |
| 45+00.00 | | 0.00 | 1,027.60 | -13.60 | 1,014.00 | -37.72 | 1,000.60 |
| 45+04.00 | END TOE | 0.00 | 1,027.60 | -13.60 | 1,014.00 | -37.72 | 1,000.60 |
| 45+30.80 | END FOUNDATION | 0.00 | 1,027.60 | -13.60 | 1,014.00 | -13.60 | 1,014.00 |
| 45+58.00 | MATCH EXISTING | 0.00 | 1,027.60 | 0.00 | 1,027.60 | 0.00 | 1,027.60 |

NOTE: Positive Offset Right
Negative Offset Left




N.T.S.

*Offset From ℄ to Point 'A' Varies From Sta 8+50 to Sta 11+00 and Sta 24+25 to Sta 40+00

"RECORD DRAWING"
I HEREBY CERTIFY THAT THE INFORMATION PRESENTED HEREON REPRESENTS THE CONDITIONS EXISTING AT THE DATE SHOWN AND WHERE EXISTING PLANS ARE CORRECT TO THE BEST OF MY KNOWLEDGE AND BELIEF.

| NO. | REVISION | BY | DATE |
|---|---|---|---|
| 3 | | | |
| 2 | | | |
| 1 | REVISED SOIL CEMENT SLOPE & OFFSETS | RS | 2/24/97 |

FLOOD CONTROL DISTRICT
OF MARICOPA COUNTY
ENGINEERING DIVISION

CAMELBACK RANCH LEVEE - SOUTH
INDIAN SCHOOL RD. - CAMELBACK RD.
PROJECT NO. FCD 97-18

| | BY | DATE |
|---|---|---|
| DESIGNED | C.B.B. | 01/21/97 |
| DRAWN | R.S. | 01/21/97 |
| CHECKED | M.S.S. | 01/21/97 |

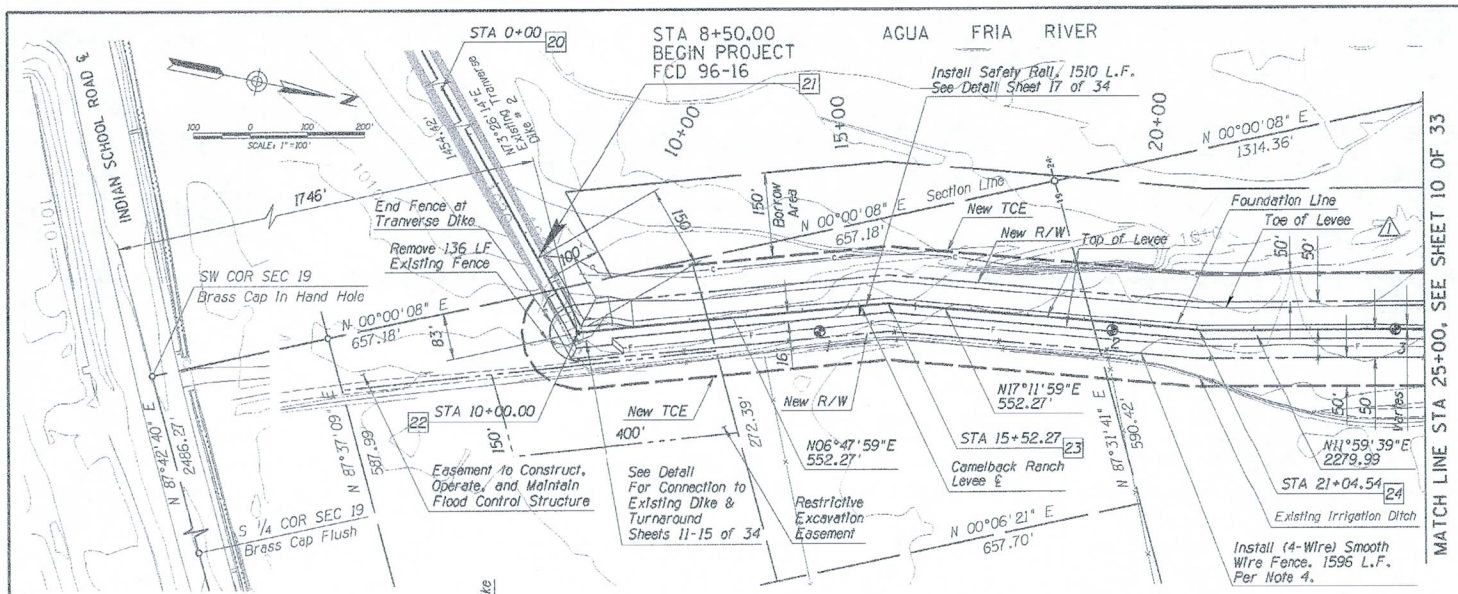
MICHAEL S. SHAPIRO 16811 REGISTERED PROFESSIONAL ENGINEER ARIZONA, U.S.A.

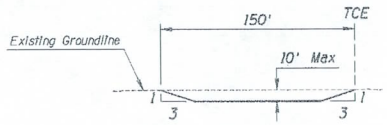
DMJM ARIZONA, INC.
3001 WEST CLARENDON
SUITE 400
PHOENIX, AZ. 85013-3499
(602) 264-0217

VERTICAL CONTROL

SHEET 8 OF 34

| F.H.W.A. REGION | STATE | PROJECT NO. | SHEET NO. | TOTAL SHEETS | RECORD DRAWING |
|---|---|---|---|---|---|
| 9 | AZ. | FCD 96-16 | 9 | 34 | |

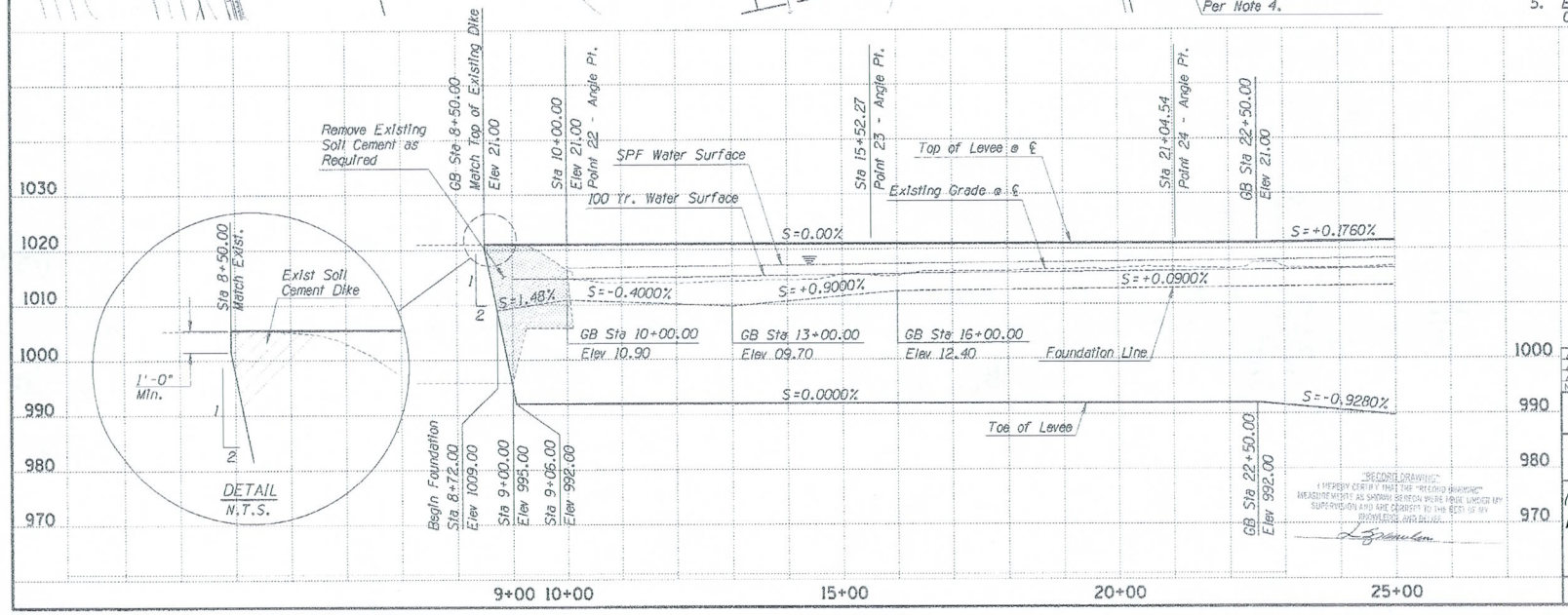



BORROW AREA
TYPICAL SECTION

NOTES:

1. For Geometric Control See Sheet 7 of 34.
2. For Vertical Control See Sheet 8 of 34.
3. For Typical Section See Sheet 3 of 34.
4. Smooth Wire Fence Installed per ADOT Std. C-12.10, Type 1 Barbed Wire (BW) (4-Wire).
5. Existing Irrigation Ditch to Remain. Contractor to Protect During Construction.




"RECORD DRAWING"
I HEREBY CERTIFY THAT THE "RECORD DRAWINGS" MEASUREMENTS AS SHOWN BEREON WERE MADE UNDER MY SUPERVISION AND ARE CORRECT TO THE BEST OF MY KNOWLEDGE AND BELIEF.

| NO. | REVISION | BY | DATE |
|---|---|---|---|
| 1 | | | |
| 2 | | | |
| 3 | REVISED SOIL CEMENT SLOPE @ OFFSETS | RS | 2/24/97 |

FLOOD CONTROL DISTRICT
OF MARICOPA COUNTY
ENGINEERING DIVISION

CAMELBACK RANCH LEVEE - SOUTH
INDIAN SCHOOL RD. - CAMELBACK RD.
PROJECT NO. FCD 97-18

| | BY | DATE |
|---|---|---|
| DESIGNED | C.B.B. | 01/21/97 |
| DRAWN | R.S. | 01/21/97 |
| CHECKED | M.S.S. | 01/21/97 |

MICHAEL S. SHAPIRO 21029 ARIZONA, U.S.A.

DMM ARIZONA, INC.
300 WEST CLARENDON
SUITE 400
PHOENIX, AZ. 85013-3499
(602) 264-0217

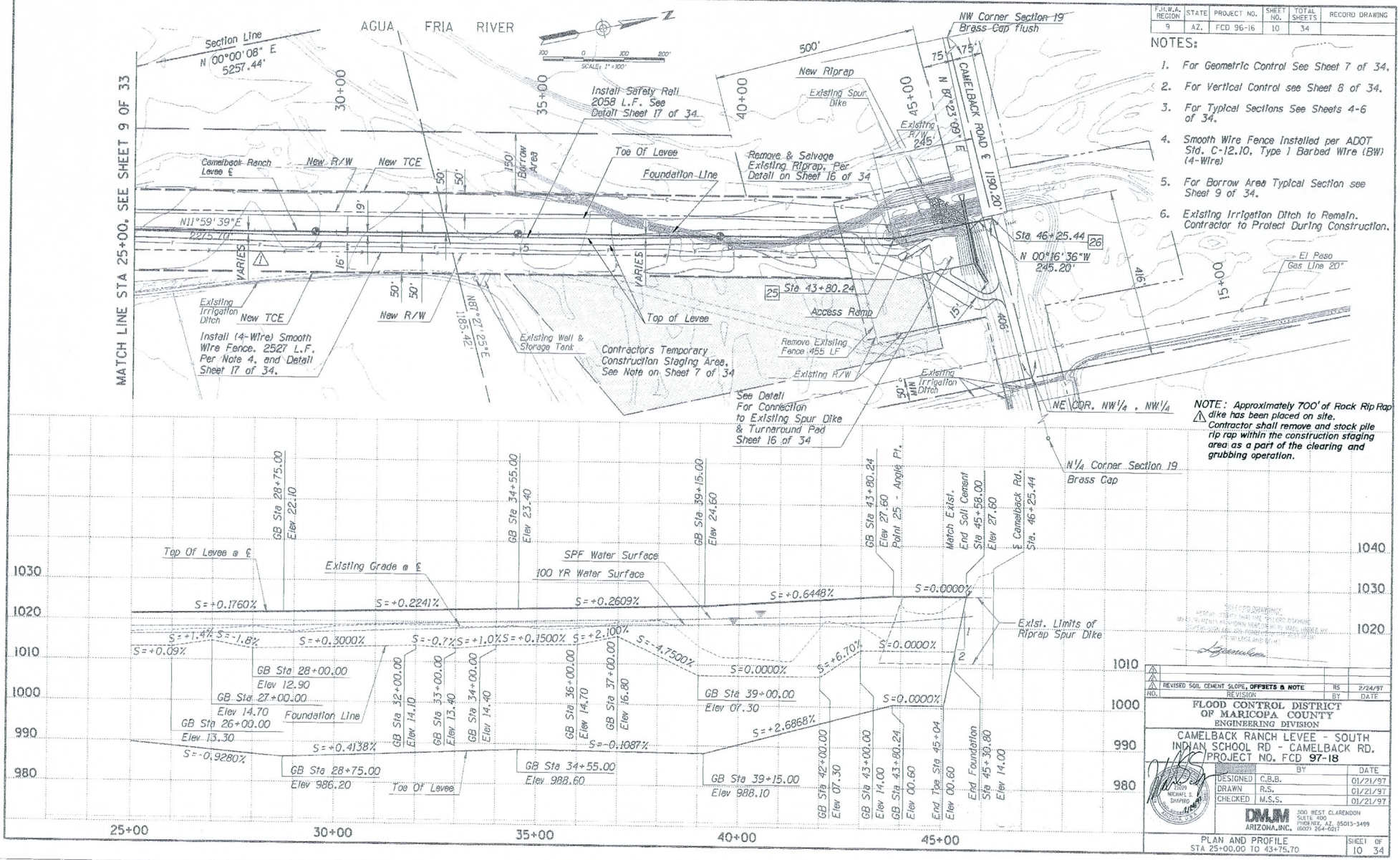
PLAN AND PROFILE
STA 9+00.00 TO 25+00.00

SHEET 9 OF 34

| F.H.W.A. REGION | STATE | PROJECT NO. | SHEET NO. | TOTAL SHEETS | RECORD DRAWING |
|---|---|---|---|---|---|
| 9 | AZ. | FCD 96-16 | 10 | 34 | |

NOTES:

1. For Geometric Control See Sheet 7 of 34.
2. For Vertical Control see Sheet 8 of 34.
3. For Typical Sections See Sheets 4-6 of 34.
4. Smooth Wire Fence Installed per ADOT Std. C-12.10, Type 1 Barbed Wire (BW) (4-Wire)
5. For Borrow Area Typical Section see Sheet 9 of 34.
6. Existing Irrigation Ditch to Remain. Contractor to Protect During Construction.




NOTE: Approximately 700' of Rock Rip Rap dike has been placed on site. Contractor shall remove and stock pile rip rap within the construction staging area as a part of the clearing and grubbing operation.

| NO. | REVISION | BY | DATE |
|---|---|---|---|
| 1 | | | |
| 2 | | | |
| 3 | REVISED SOIL CEMENT SLOPE, OFFSETS & NOTE | RS | 2/24/97 |

FLOOD CONTROL DISTRICT
OF MARICOPA COUNTY
ENGINEERING DIVISION

CAMELBACK RANCH LEVEE - SOUTH
INDIAN SCHOOL RD - CAMELBACK RD.
PROJECT NO. FCD 97-18

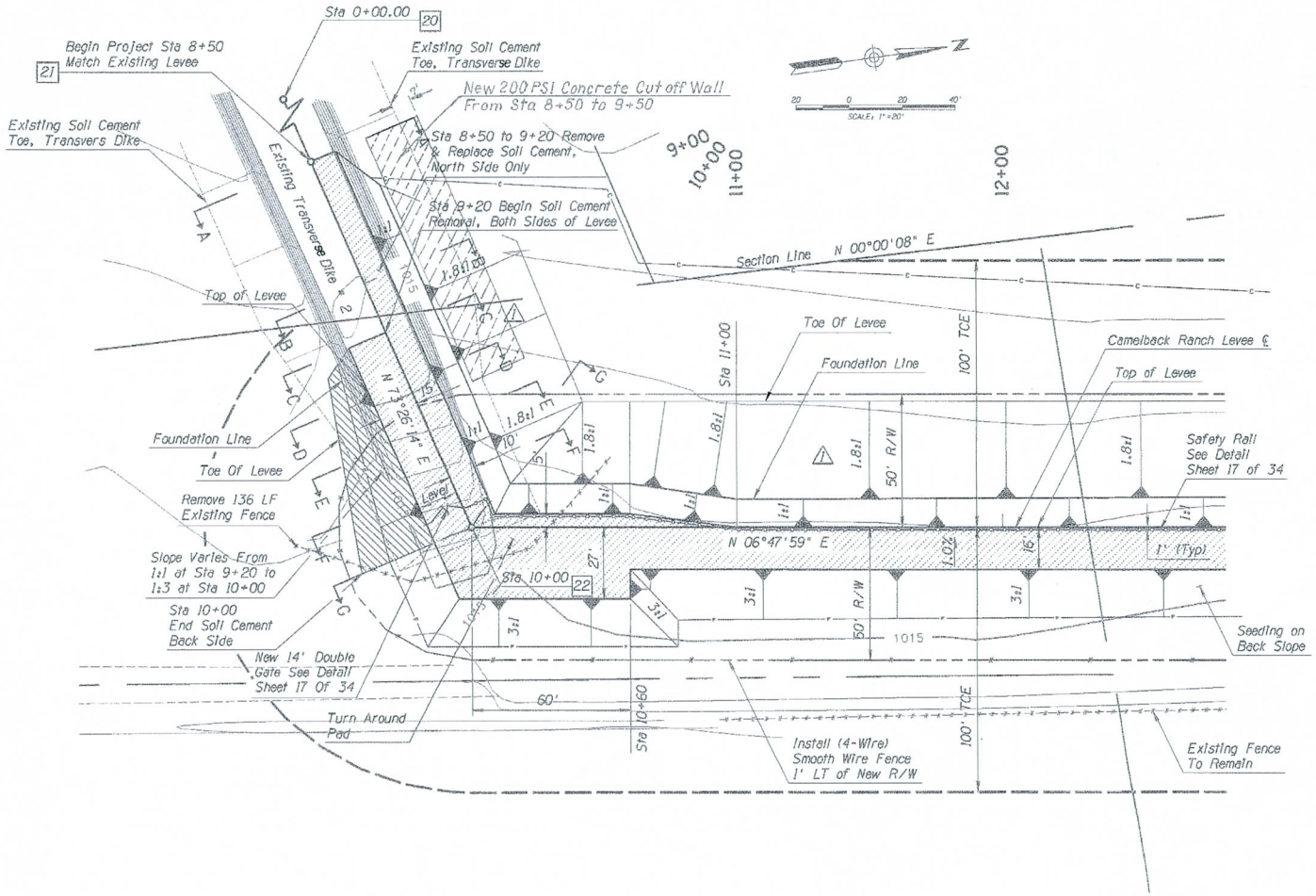
| | BY | DATE |
|---|---|---|
| DESIGNED | C.B.B. | 01/21/97 |
| DRAWN | R.S. | 01/21/97 |
| CHECKED | M.S.S. | 01/21/97 |

DMJM
300 WEST CLARENDON
SUITE 400
PHOENIX, AZ. 85013-3499
(602) 264-0217

PLAN AND PROFILE
STA 25+00.00 TO 43+75.70

SHEET 10 OF 34

| F.H.W.A. REGION | STATE | PROJECT NO. | SHEET NO. | TOTAL SHEETS | RECORD DRAWING |
|---|---|---|---|---|---|
| 9 | AZ. | FCD 96-16 | 11 | 34 | |




NOTE:

For Sections A-A Thru G-G See Sheet 12-15 of 34. Match Point Between New and Existing Soil Cement Shall Be Clean and Free of Loose Material to the Satisfaction of the FDC Inspector.

"RECORD DRAWING"
I HEREBY CERTIFY THAT THE "RECORD DRAWINGS" MEASUREMENTS AS SHOWN HEREON WERE MADE UNDER MY SUPERVISION AND ARE CORRECT TO THE BEST OF MY KNOWLEDGE AND BELIEF.

| NO. | REVISION | BY | DATE |
|---|---|---|---|
| 3 | | | |
| 2 | | | |
| 1 | REVISED SOIL CEMENT SLOPE & OFFSETS | RS | 2/24/97 |

FLOOD CONTROL DISTRICT
OF MARICOPA COUNTY
ENGINEERING DIVISION

CAMELBACK RANCH LEVEE - SOUTH
INDIAN SCHOOL RD - CAMELBACK RD.
PROJECT NO. FCD 97-18

| | BY | DATE |
|---|---|---|
| DESIGNED | C.B.B. | 01/21/97 |
| DRAWN | R.S./T.N. | 01/21/97 |
| CHECKED | M.S.S. | 01/21/97 |

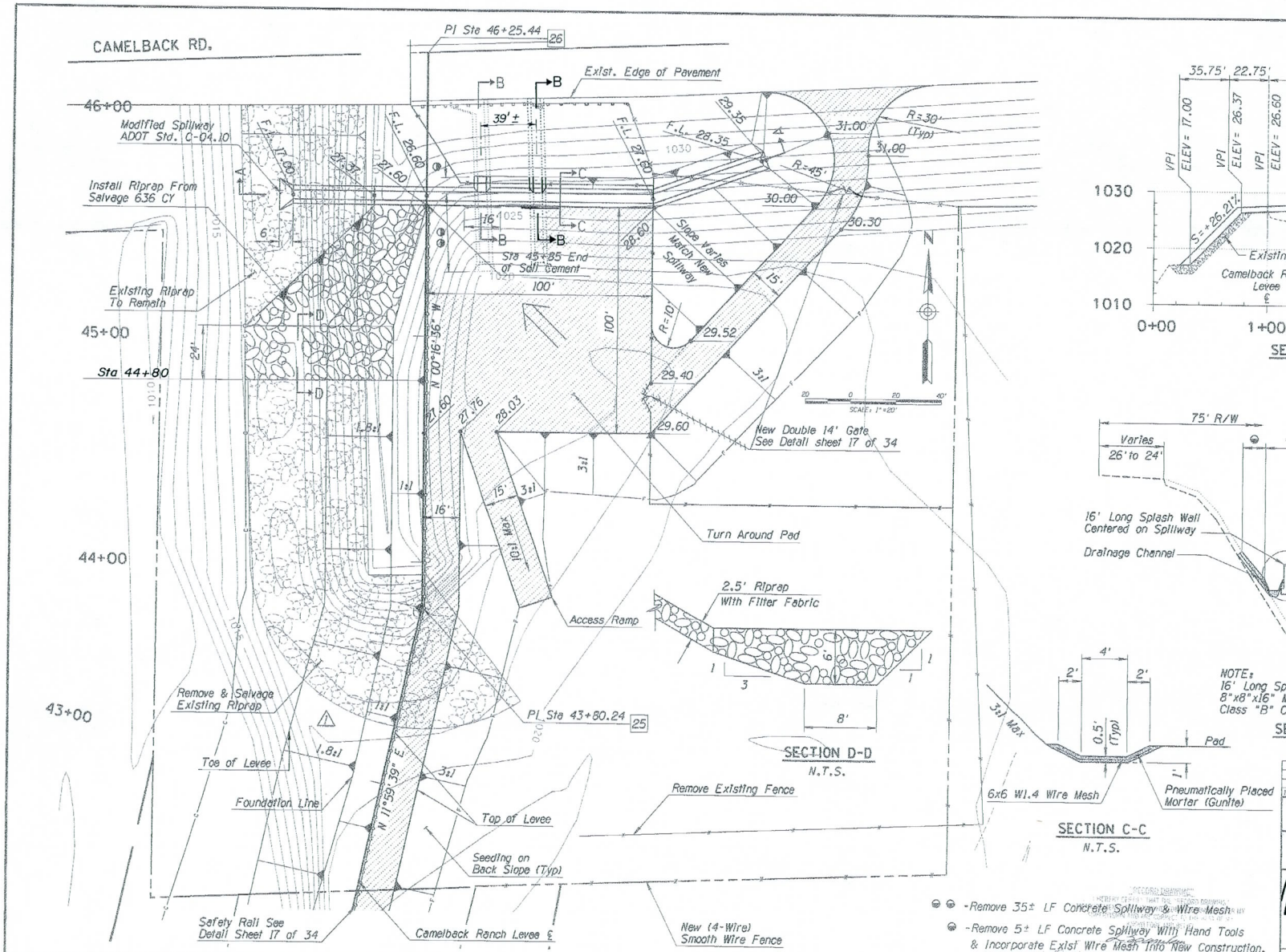
MICHAEL S. SNAPIRO
ARIZONA, U.S.A.

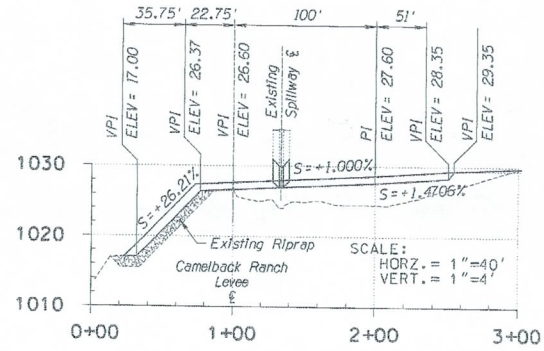
DMJM ARIZONA, INC.
300 WEST CLARENDON
SUITE 400
PHOENIX, AZ. 85013-3499
(602) 264-0217

TURN AROUND PAD 1 DETAIL

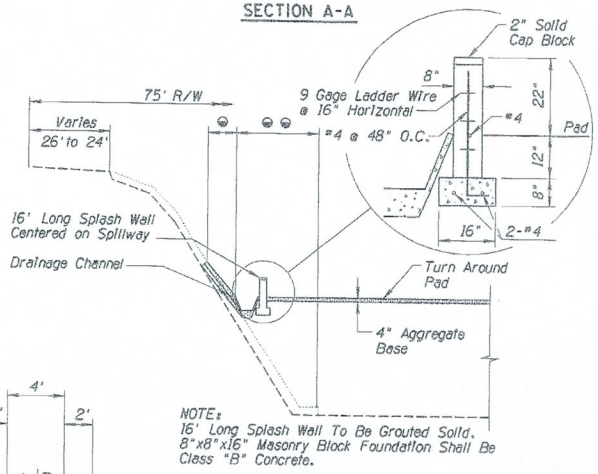
SHEET 11 OF 34

| F.H.W.A. REGION | STATE | PROJECT NO. | SHEET NO. | TOTAL SHEETS | RECORD DRAWING |
|---|---|---|---|---|---|
| 9 | AZ. | FCD 96-16 | 16 | 34 | |




SECTION A-A




NOTE:
16' Long Splash Wall To Be Grouted Solid. 8"x8"x16" Masonry Block Foundation Shall Be Class "B" Concrete.

SECTION B-B
N.T.S.




SECTION C-C
N.T.S.

-Remove 35± LF Concrete Spillway & Wire Mesh

-Remove 5± LF Concrete Spillway With Hand Tools & Incorporate Exist Wire Mesh Into New Construction.

| NO. | REVISION | BY | DATE |
|---|---|---|---|
| 3 | | | |
| 2 | | | |
| 1 | REVISED SOIL CEMENT SLOPE | RS | 2/24/97 |

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY
ENGINEERING DIVISION

CAMELBACK RANCH LEVEE - SOUTH
INDIAN SCHOOL RD - CAMELBACK RD.
PROJECT NO. FCD 97-18

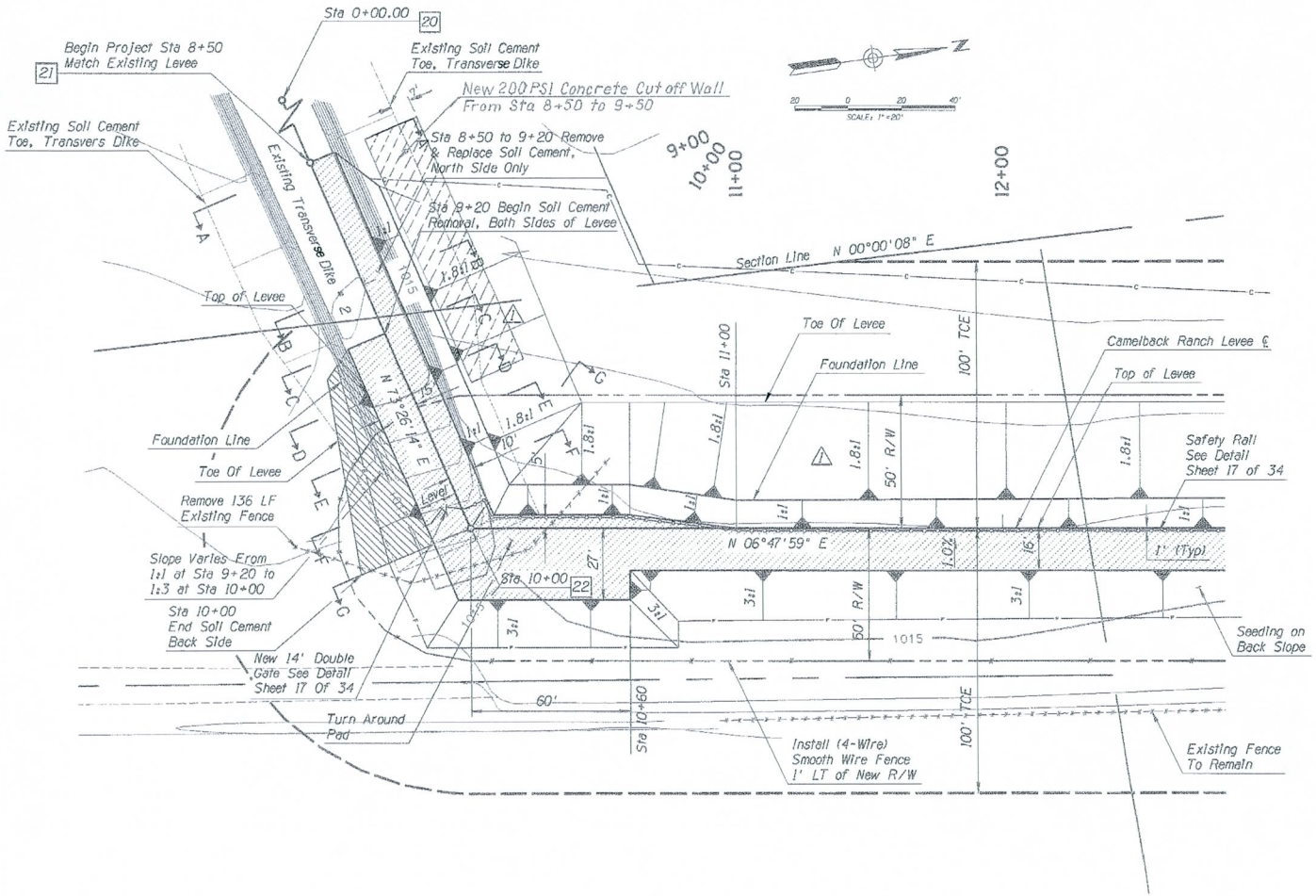
| | BY | DATE |
|---|---|---|
| DESIGNED | C.B.B. | 01/21/97 |
| DRAWN | R.S./T.N. | 01/21/97 |
| CHECKED | M.S.S. | 01/21/97 |

DMJM ARIZONA, INC. 300 WEST CLARENDON SUITE 400 PHOENIX, AZ. 85013-3499 (602) 264-0217

TURN AROUND PAD 2 DETAIL

SHEET 16 OF 34

| F.H.W.A. REGION | STATE | PROJECT NO. | SHEET NO. | TOTAL SHEETS | RECORD DRAWING |
|---|---|---|---|---|---|
| 9 | AZ. | FCD 96-16 | 11 | 34 | |




NOTE:

For Sections A-A Thru G-G See Sheet 12-15 of 34. Match Point Between New and Existing Soil Cement Shall Be Clean and Free of Loose Material to the Satisfaction of the FDC Inspector.

"RECORD DRAWING"
I HEREBY CERTIFY THAT THE "RECORD DRAWING" MEASUREMENTS AS SHOWN HEREON WERE MADE UNDER MY SUPERVISION AND ARE CORRECT TO THE BEST OF MY KNOWLEDGE AND BELIEF.

| NO. | REVISION | BY | DATE |
|---|---|---|---|
| 3 | | | |
| 2 | | | |
| 1 | REVISED SOIL CEMENT SLOPE & OFFSETS | RS | 2/24/97 |

FLOOD CONTROL DISTRICT
OF MARICOPA COUNTY
ENGINEERING DIVISION

CAMELBACK RANCH LEVEE - SOUTH
INDIAN SCHOOL RD - CAMELBACK RD.
PROJECT NO. FCD 97-18

| | BY | DATE |
|---|---|---|
| DESIGNED | C.B.B. | 01/21/97 |
| DRAWN | R.S./T.N. | 01/21/97 |
| CHECKED | M.S.S. | 01/21/97 |

REGISTERED MICHAEL S. SNAPP ARIZONA U.S.A.

DMJM ARIZONA, INC.
300 WEST CLARENDON
SUITE 400
PHOENIX, AZ. 85013-3499
(602) 264-0217

TURN AROUND PAD I DETAIL

SHEET 11 OF 34

## E.2 Portion of Camelback Road Storm Drain Record Drawings

PHOENIX STREETS–MARICOPA CO.

| F.H.W.A. REGION | STATE | PROJ. NO. | NO. | TOTAL | AS BUILT |
|---|---|---|---|---|---|
| 9 | ARIZ | ST85100046<br>ST85100057 | 1 | 68 | |

TETRA TECH, INC.
CONSULTING ENGINEER

DES: CFL | DR: SRK | CK: JBL | DATE: 11/01/06

# CITY OF PHOENIX
# STREET TRANSPORTATION DEPARTMENT
# DESIGN AND CONSTRUCTION MANAGEMENT DIVISION

MAYOR
PHIL GORDON

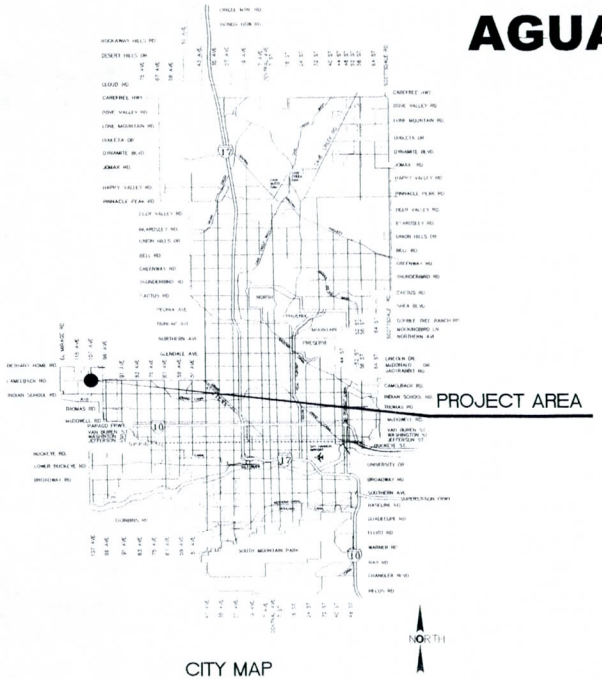
CITY MANAGER
FRANK FAIRBANKS

CITY COUNCIL

| | |
|---|---|
| DISTRICT NO. 1 | DAVE SIEBERT |
| DISTRICT NO. 2 | PEGGY NEELY |
| DISTRICT NO. 3 | PEGGY BILSTEN |
| DISTRICT NO. 4 | TOM SIMPLOT |
| DISTRICT NO. 5 | CLAUDE MATTOX |
| DISTRICT NO. 6 | GREG STANTON |
| DISTRICT NO. 7 | DOUG LINGNER |
| DISTRICT NO. 8 | MICHAEL JOHNSON |

CITY ENGINEER
WYLIE BEARUP, PE

# CAMELBACK ROAD
# AGUA FRIA RIVER TO 99TH AVENUE




CITY MAP
N.T.S.

2006

## PROJECT NO. ST85100046
## PAVING

**PT00140162 - WESTBOUND CAMELBACK ROAD WEST OF 107TH AVENUE**
**PT00140161 - EASTBOUND CAMELBACK ROAD EAST OF 107TH AVENUE**
**PT00140157 - EASTBOUND CAMELBACK ROAD EAST OF 99TH AVENUE**
**PT00140156 - SOUTHBOUND 99TH AVENUE SOUTH OF CAMELBACK ROAD**

## BUS BAYS
## AND
## PROJECT NO. ST83110057
## STORM DRAIN

INDEX OF SHEETS


| SHEET NO. | DESCRIPTION |
|---|---|
| 1 | PROJECT COVER SHEET |
| 2 | KEY MAP |
| 3 | LEGEND AND NOTES |
| 4 | PAVING COVER SHEET |
| 5 | TYPICAL SECTIONS |
| 6 | PAVING AND TRANSIT SUMMARY SHEET |
| 7-25 | PAVING SHEETS |
| 26 | BUS BAY AND SIDEWALK GEOMETRY |
| 27 | BUS PAD AND SIDEWALK GEOMETRY |
| 28 | IRRIGATION DETAIL SHEET |
| 29 | STORM DRAIN COVER SHEET |
| 30 | STORM DRAIN SUMMARY SHEET |
| 31-54 | STORM DRAIN SHEETS |
| 55-58 | CONNECTOR PIPE PROFILES |
| 59 | STORM DRAIN DETAIL SHEET |
| 60 | STORM DRAIN RAMP DETAIL |
| 61 | RIPRAP AND GATE DETAIL SHEET |
| 62 | ALTERNATE PIPE CHART |
| 63 | SOIL BORING LOGS |
| 64-68 | SUE EXHIBIT SHEETS |
| | LANDSCAPE AND IRRIGATION SHEETS |
| | STREET LIGHT SHEETS |
| | SIGNAL AND STRIPING SHEETS |


APPROVALS

STREET TRANSPORTATION ACTING DEPUTY DIRECTOR — DATE 11-3-06

STREET TRANSPORTATION ACTING ASSISTANT DIRECTOR — DATE 11/3/06

EXPIRES: 3/31/2011

I HEREBY CERTIFY THAT THESE ARE OFFICIAL RECORD DRAWINGS
2/6/09
Drawn By:
Inspector: KYLE VANCE
Party Chief: FRANK WOLF
Contractor: ACTION CONTRACTOR

PROJECT LENGTH:

PAVING = 5,950 LF
1.13 MI
STORM DRAIN = 9,700 LF
1.84 MI

BASIS OF VERTICAL CONTROL

▲ COP BENCH MARK:
M.C.E.D. BRASS CAP IN HANDHOLE @ WEST EDGE OF 99TH AVENUE AND CAMELBACK ROAD, SE CORNER OF SEC 17, T2N, R1E
STATION 103+02.11, ELEVATION=1041.70
COP DATUM NGVD 1929
(ELEVATION=1043.63 NAVD 1988)

BASIS OF HORIZONTAL CONTROL

CAMELBACK ROAD: BCHH AT 111TH AVENUE, BCHH AT 107TH AVENUE, BC 103RD AVENUE, AND BCHH 99TH AVENUE. ARIZONA COORDINATE SYSTEM, CENTRAL ZONE, HORIZONTAL DATUM OF 1983.

Two working days before you dig, CALL FOR THE BLUE STAKES 263-1100 Blue Stake Center

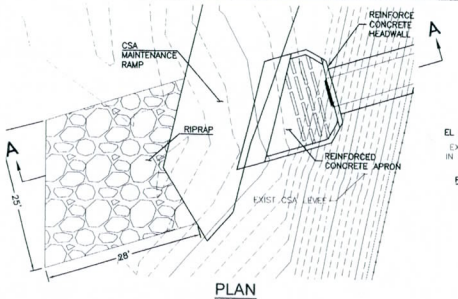
PER CITY OF PHOENIX ORDINANCE G-4396, THESE PLANS ARE FOR OFFICIAL USE ONLY AND MAY NOT BE SHARED WITH OTHERS EXCEPT AS REQUIRED TO FULFILL THE OBLIGATIONS OF YOUR CONTRACT WITH THE CITY OF PHOENIX.



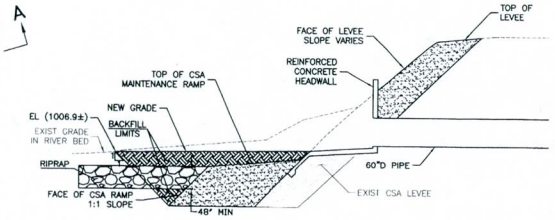
CAMELBACK RD PAVING + STORM DRAIN AGUA FRIA RIVER TO 99TH AVE

ST85100046 + ST83110057

P:\4716 Camelback Phase II\Transportation\DWG\4716-P01 CVR.dwg 11/02/2006 15:18




PLAN
N.T.S.

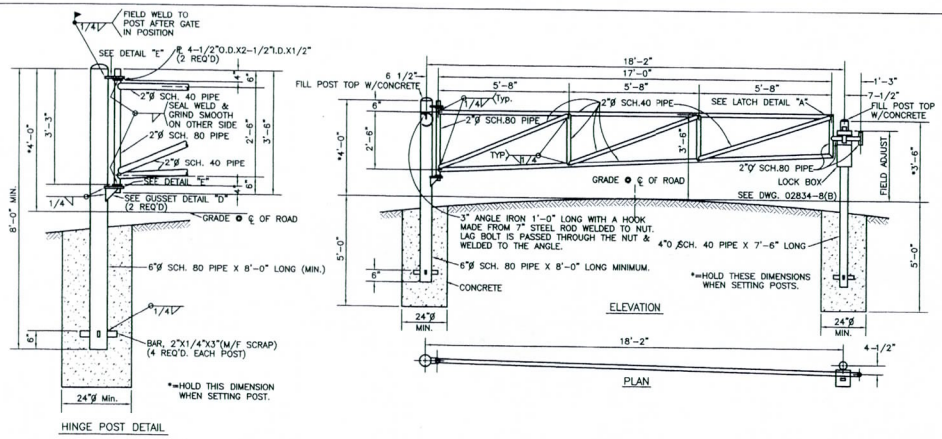



SECTION A-A
N.T.S.

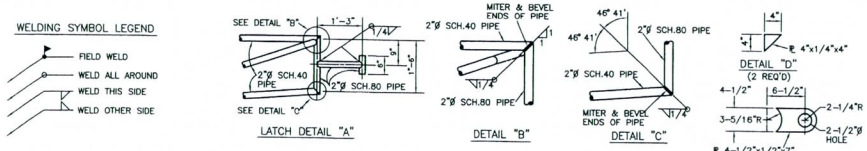
RIPRAP NOTES:
1. RIPRAP SHALL BE SALVAGED FROM THAT REMOVED TO ACCOMMODATE CONSTRUCTION OF THE CSA MAINTENANCE RAMP. THE RIPRAP WHEN PLACED SHALL BE REASONABLY WELL GRADED FROM LARGEST TO SMALLEST DIAMETERS.

MCFCD GENERAL NOTES:
1. ALL CONSTRUCTION WITHIN FLOOD CONTROL DISTRICT (DISTRICT) RIGHTS-OF-WAY JURISDICTION SHALL CONFORM TO THE LATEST MARICOPA ASSOCIATION OF GOVERNMENTS' (MAG) SPECIFICATIONS.
2. CONTRACTOR MUST OBTAIN NECESSARY DISTRICT PERMIT PRIOR TO COMMENCEMENT OF CONSTRUCTION WITHIN DISTRICT RIGHT-OF-WAY AND MAINTAIN A COPY OF THE PERMIT ON THE PROJECT SITE AT ALL TIMES.
3. NOTIFY THE DISTRICT'S PERMITS INSPECTOR AT 602-506-4727 OR 602-506-4723 AT LEAST 48 HRS PRIOR TO ANY WORK BEING PERFORMED IN THE DISTRICT'S RIGHTS-OF-WAY.
4. CONTRACTOR PERFORMING EXCAVATION OPERATIONS IS RESPONSIBLE FOR LOCATING AND PROTECTING ALL UNDERGROUND UTILITIES.
5. ALL COMPACTION AND BACKFILL WITHIN DISTRICT'S RIGHT-OF-WAY SHALL CONFORM TO THE LATEST MAG SPECIFICATIONS UNLESS STIPULATED OTHERWISE IN THE DISTRICT'S PERMIT.
6. ANY DAMAGE TO DISTRICT'S STRUCTURES, EQUIPMENT, MATERIALS, VEGETATION, AND/OR PROPERTY SHALL BE REPLACED AND/OR REPAIRED IN-KIND TO THE SATISFACTION OF THE DISTRICT.

1 RIPRAP DETAIL
N.T.S.




WELDING SYMBOL LEGEND




NOTE:
1. THE EXPOSED SURFACE OF THE CONCRETE SHALL BE CROWNED TO SHED WATER.

2 STEEL PIPE GATE
N.T.S.

| F.H.W.A. REGION | STATE | PROJ. NO. |
|---|---|---|
| 9 | ARIZ | ST83110057 |

TEC 4801 East Washington, Suite 260 Phoenix, AZ 85034 TEL:(602)682-3300 FAX:(602)244-11

DES: CFL | DR: SRK | CK:

MCDOT GENERAL NOTES
1. ALL CONSTRUCTION SHALL CONFORM TO THE LATEST MARICOPA COUNTY DEPARTMENT OF TRANSPORTATION (MCDOT) ROADWAY MANUAL AND M.A.G. SPECIFICATIONS AND MARICOPA COUNTY SPECIAL PROVISIONS FOR CONSTRUCTION OF STREET IMPROVEME
2. CONTRACTOR TO OBTAIN NECESSARY MCDOT PERMITS PRIOR TO CONSTRUCTION WITHIN COUNTY RIGHT-OF-WAY.
3. THE ENGINEERING DESIGNS ON THESE PLANS ARE ONLY APPROVED BY MARICOPA COUNTY DEPARTMENT OF TRANSPORTATION AND NOT IN DETAIL. CONSTRUCTION QUANTITIES ON THESE PLANS ARE NOT VERIFIED BY MARICOPA COUNTY DEPARTMENT OF TRANSPORTATION. APPROVAL OF THESE PLANS ARE FOR PERMIT PURPOSES ONLY AND SHALL NOT PREVENT MARICOPA COUNT DEPARTMENT OF TRANSPORTATION FROM REQUIRING CORRECTION OF ERRORS IN THE PLANS WHERE SUCH ERRORS ARE SUBS FOUND TO BE IN VIOLATION OF ANY LAW, ORDINANCE, HEALTH, SAFETY, OR OTHER DESIGN ISSUES.
4. CONTRACTOR SHALL NOTIFY THE MCDOT INSPECTION DEPARTMENT AT LEAST 24 HOURS IN ADVANCE OF ANY CONSTRUCTION A (602) 506-8606.
5. AN APPROVED SET OF PLANS SHALL BE ON THE SITE DURING CONSTRUCTION AND INSPECTIONS.
6. CONTRACTOR PERFORMING CONSTRUCTION OR EXCAVATING OPERATIONS IS RESPONSIBLE FOR LOCATING, RELOCATING AND/OR ALL UTILITIES IN CONFLICT OR WITHIN THE CLEAR ZONE, AT NO EXPENSE TO MARICOPA COUNTY.
7. ALL COMPACTION AND BACKFILL WITHIN COUNTY RIGHT-OF-WAY SHALL CONFORM TO THE MCDOT SUPPLEMENT TO M.A.G. SPE BACKFILL UNDER ANY EXISTING OR PROPOSED PAVEMENT, CURB AND GUTTER OR WITHIN TWO FEET (2') OR LESS FROM THE PAVEMENT SHALL CONSIST OF ONE-HALF (1/2) SACK CLSM.
8. ALL STRUCTURES, SUCH AS MANHOLES, VALVE BOX & COVERS, AND MONITORING WELLS MUST BE MARKED WITH AT LEAST TW REFLECTIVE YELLOW FLEX POST WHEN STRUCTURES ARE LOCATED OUTSIDE THE TRAVELED WAY AND WITHIN THE RIGHT-OF-WA ("APPLIES ONLY WHEN THERE IS NO CURB.")
9. ALL EXISTING PAVEMENT MARKING, TRAFFIC SIGNS AND SIGNAL EQUIPMENT THAT NEEDS TO BE REMOVED, REPLACED, RELOCAT REPAIRED BECAUSE OF CONTRACTOR'S WORK WILL BE DONE BY THE CONTRACTOR AT HIS EXPENSE. ALL TRAFFIC SIGNS THAT REMOVED SHALL BE STOCKPILED ON THE PROJECT SITE AND THE CONTRACTOR IS TO NOTIFY THE INSPECTOR WHEN ALL SIGN BEEN REMOVED. ALL NEW STREET NAME SIGNS SHALL BE PROVIDED AND INSTALLED BY PERMITTEE AT NO EXPENSE TO MARIC
10. PAVEMENT MARKING, SIGNING AND SIGNAL WORK WILL BE INSPECTED AND WILL HAVE TO MEET COUNTY STANDARDS BEFORE R OF BOND.
11. ASPHALT MIX DESIGN SHALL BE SUBMITTED TO MCDOT A MINIMUM OF 48 HOURS PRIOR TO PLACING ANY ASPHALT COURSES. (TRENCH WORK EXCLUDED.)
12. PRIOR TO CONDUCTING EXCAVATION OPERATIONS, THE CONTRACTOR SHALL OBTAIN FROM THE ARIZONA STATE HISTORICAL PRES OFFICER (SHPO) (602) 542-4009, RECOMMENDATIONS REGARDING THE NEED FOR CULTURAL RESOURCES (ARCHAEOLOGICAL) ALL DISCOVERIES OF HUMAN REMAINS, CULTURAL ARTIFACTS, OR PALEONTOLOGICAL REMAINS SHALL BE REPORTED TO THE AR MUSEUM AND MCDOT. UPON DISCOVERY, CONTRACTOR SHALL CEASE OPERATIONS IN THE VICINITY OF THE FIND AND PROTECT DISCOVERY AREA FROM FURTHER DISTURBANCE UNTIL THE FIND CAN BE PROFESSIONALLY INVESTIGATED BY THE ARIZONA STAT AND MCDOT.
13. PRIOR TO MOVING OR DESTROYING PROTECTED NATIVE PLANT SPECIES, THE CONTRACTOR SHALL FILE A FORMAL NOTICE OF IN THE ARIZONA DEPARTMENT OF AGRICULTURE NATIVE PLANTS (602) 542-6408.
14. EXCEPT UNDER EMERGENCY CONDITIONS, ROADS SHALL NOT BE CLOSED FOR CONSTRUCTION ACTIVITY UNLESS PRIOR APPROV OBTAINED FROM THE TRANSPORTATION DIRECTOR OR HIS REPRESENTATIVE.
15. ALL BOX CULVERTS CONSTRUCTED IN THE PUBLIC RIGHT-OF-WAY SHALL COMPLY WITH ARIZONA DEPARTMENT OF TRANSPORT (ADOT) LATEST DESIGN SPECIFICATIONS AND STANDARDS. MINIMUM CLEAR HEIGHT OF BOX CULVERT SHALL BE 4 FEET.
16. PRIOR TO INSTALLATION OF THE BASE COURSE AND WEARING SURFACE, SUBMIT SOIL TEST(S) OF SUB-GRADE AND REVISED F DESIGN/CALCULATIONS TO THE MARICOPA COUNTY DEPARTMENT OF TRANSPORTATION FOR REVIEW AND APPROVAL.

DISTRICT GENERAL NOTES:
1. THE TERM DISTRICT AS USED IN THESE PLANS SHALL REFER TO THE ROOSEVELT IRRIGATION DISTRICT (RID).
2. THE DISTRICT OBSERVER MUST APPROVE THE SCHEDULING OF ALL CONSTRUCTION ACTIVITIES WITHIN THE DISTRICT RIGHT-OF- DISTRICT MAY REQUIRE THAT SOME OR ALL OF THE CONSTRUCTION FOR THE PROJECT BE COMPLETED ONLY DURING A SCHEE UP OF THE MAIN CANAL.
3. ALL CONSTRUCTION PLANS AFFECTING DISTRICT FACILITIES MUST BE REVIEWED AND APPROVED BY THE IRRIGATION DISTRICT.
4. THE CONTRACTOR SHALL CONTACT THE DISTRICT CONSTRUCTION OBSERVER AT (602) 421-9864, A MINIMUM OF 15 CALENDAR PRIOR TO COMMENCEMENT OF CONSTRUCTION.
5. THE CONTRACTOR IS RESPONSIBLE FOR OBTAINING AN RID RIGHT-OF-WAY CROSSING PERMIT(S) BEFORE ANY WORK CAN COM WITHIN DISTRICT RIGHT-OF-WAY.
6. THE CONTRACTOR SHALL PROVIDE SHOP DRAWINGS FOR REVIEW BY THE DISTRICT'S ENGINEER AS MAY BE NECESSARY FOR TH OF THE WORK AND AS REQUIRED BY THE DRAWINGS AND SPECIFICATIONS.
7. STATIONS SHOWN ARE APPROXIMATE AND MAY BE VARIED AS DIRECTED BY THE DEVELOPER'S ENGINEER.
8. ALL EXISTING IRRIGATION FACILITIES DISTURBED BY NEW CONSTRUCTION SHALL BE RECONSTRUCTED TO CURRENT RID STANDAR
9. ALL CONSTRUCTION INCLUDING, BUT NOT LIMITED TO: EQUIPMENT, FENCING, SPOILS, ETC. MUST REMAIN OUTSIDE OF DISTRIC WAY UNLESS OTHERWISE APPROVED BY THE DISTRICT CONSTRUCTION OBSERVER.
10. EXISTING RID FACILITIES MUST REMAIN OPERATIONAL, AND SHALL NOT BE DISTURBED OR RENDERED INACCESSIBLE TO RID OPE AND MAINTENANCE STAFF.

DISTRICT GRADING NOTES:
1. THE CONTRACTOR SHALL PROVIDE SMOOTHLY AND EVENLY GRADED FINISHED GROUND SURFACES ABOUT ALL DISTRICT FACILITIE THE PROJECT AREA.
2. THE CONTRACTOR SHALL IMPORT ADDITIONAL FILL MATERIAL OR EXPORT EXCESS CUT MATERIAL AS REQUIRED TO PROVIDE SAT FINISHED GRADING ABOUT DISTRICT FACILITIES AS INDICATED ON THE APPROVED PLANS OR AS DIRECTED BY THE DISTRICT CO OBSERVER.
3. FINISHED GRADING SHALL BLEND SMOOTHLY INTO EXISTING GRADES.
4. FINISHED SURFACES SHALL BE GRADED TO DIRECT DRAINAGE AWAY FROM DISTRICT FACILITIES.
5. O&M ROADS SHALL BE CONSTRUCTED WITH A MINIMUM ELEVATION 6" ABOVE ADJACENT FIELDS AND A 2% CROSS SLOPE UNL OTHERWISE NOTED.
6. O&M ROADS ADJACENT TO CANAL PRISM SHALL BE CONSTRUCTED WITH A MINIMUM ELEVATION 6" ABOVE ADJACENT FIELDS AN SLOPE AWAY FROM CANAL PRISM AREA UNLESS OTHEWISE NOTED.

PER CITY OF PHOENIX ORDINANCE ARE FOR OFFICIAL USE ONLY AND OTHERS EXCEPT AS REQUIRED TO OF YOUR CONTRACT WITH TH

RECORD DRAWING CERTIFICATION

I HEREBY CERTIFIED THAT THIS "RECORD DRAWING" WAS MADE UNDER MY SUPERVISION OR AS NOTED AND IS CORRECT TO THE BEST OF MY KNOWLEDGE AND BELIEF

REGISTERED PROFESSIONAL ENGINEER (CIVIL) DATE

RIPRAP & GATE D
CITY OF PHOENI
STREET TRANSPORTATIO
CAMELBACK RD S
AGUA FRIA RVR T
ST83110

| DR:SRK | DES:CFL | CK:JBL |
|---|---|---|
| DATE:11/06 | DATE:11/06 | DATE:11/06 |

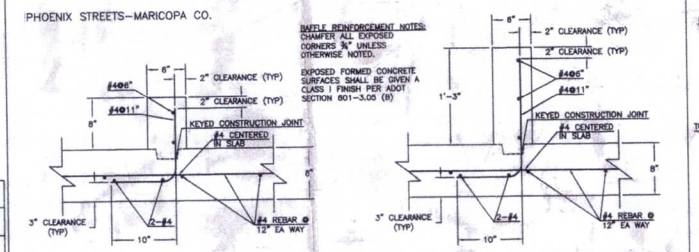
SCALE: HORIZONTAL VERTICAL

| F.H.W.A. REGION | STATE | PROJ. NO. | NO. | TOTAL | AS BUILT |
|---|---|---|---|---|---|
| 9 | ARIZ | ST83110057 | 59 | 68 | |

TETRA TECH, INC.
4801 East Washington, Suite 280
Phoenix, AZ 85034
TEL(602)267-1300 FAX(602)244-1164
CONSULTING ENGINEER

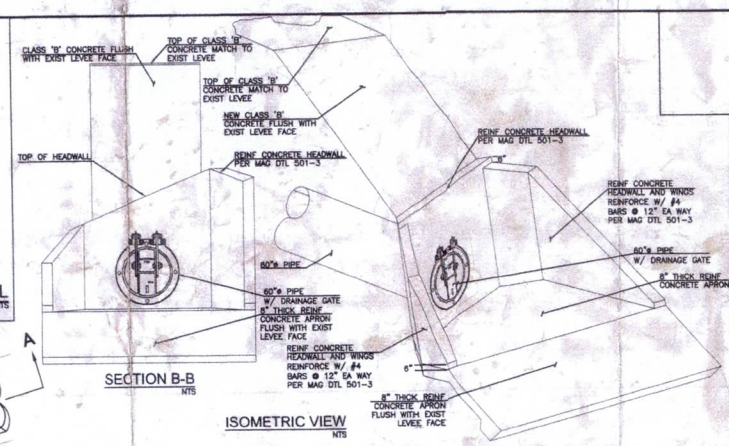
DES: CFL DR: SRK CK: JBL DATE: 07/26/07

PHOENIX STREETS–MARICOPA CO.



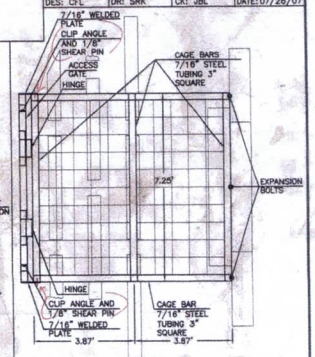

8" BAFFLE REINFORCEMENT DETAIL NTS

1'-3" BAFFLE REINFORCEMENT DETAIL NTS

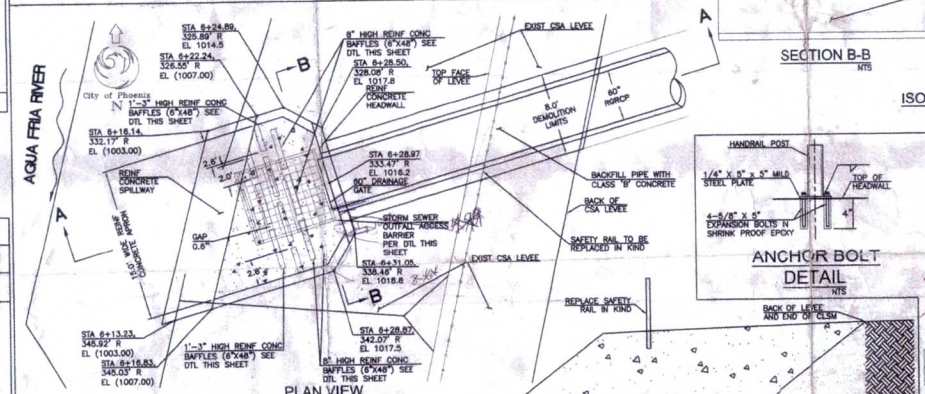



SECTION B-B NTS

ISOMETRIC VIEW NTS



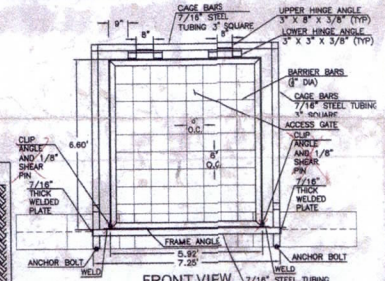

PLAN VIEW NTS



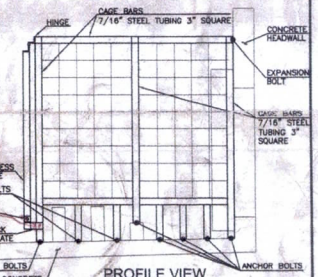

PLAN VIEW NTS




ANCHOR BOLT DETAIL NTS

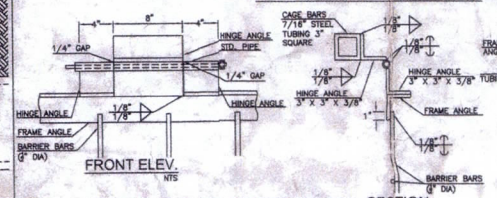



FRONT VIEW NTS




PROFILE VIEW NTS

ACCESS BARRIER DETAIL




FRONT ELEV. NTS

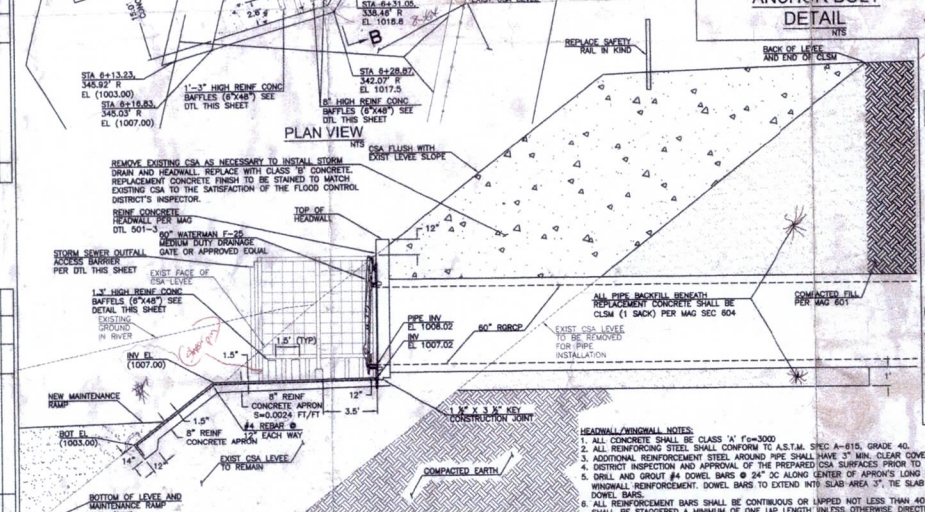
SECTION NTS

FRONT ELEV. NTS

SIDE ELEV. NTS

WELDED PLATE DETAIL

HINGE INSTALLATION DETAIL




NOTE:
LEVEE SURFACE MUST BE PREPPED BEFORE APPLICATION OF CSA. CLEAN AND REMOVE ALL LOOSE MATERIAL FROM SURFACE TO THE SATISFACTORY OF THE MCFCD INSPECTOR.

SECTION A-A NTS

OUTFALL HEADWALL DETAIL

HEADWALL/WINGWALL NOTES:
1. ALL CONCRETE SHALL BE CLASS 'A' f'c=3000
2. ALL REINFORCING STEEL SHALL CONFORM TO A.S.T.M. SPEC A-615, GRADE 40.
3. ADDITIONAL REINFORCEMENT STEEL AROUND PIPE SHALL HAVE 3" MIN. CLEAR COVER.
4. DISTRICT INSPECTION AND APPROVAL OF THE PREPARED CSA SURFACES PRIOR TO POURING THE CONCRETE.
5. DRILL AND GROUT #4 DOWEL BARS @ 24" 'C' ALONG CENTER OF APRON'S LONG AXIS AND FOR VERTICAL WINGWALL REINFORCEMENT. DOWEL BARS TO EXTEND INTO SLAB AREA 3", TIE SLAB REINFORCEMENT TO DOWEL BARS.
6. ALL REINFORCEMENT BARS SHALL BE CONTINUOUS OR LAPPED NOT LESS THAN 40 BAR DIAMETERS. LAPS SHALL BE STAGGERED A MINIMUM OF ONE LAP LENGTH UNLESS OTHERWISE DIRECTED BY THE ENGINEER.
7. PROVIDE 2"X2" KEY WAY IN APRON SLAB FOR WINGWALL CONSTRUCTION.
8. MINIMUM COVER OVER REINFORCING BARS SHALL BE 2 INCHES.

MCFCD GENERAL NOTES:
1. ALL CONSTRUCTION WITHIN FLOOD CONTROL DISTRICT (DISTRICT) RIGHTS-OF-WAY JURISDICTION SHALL CONFORM TO THE LATEST MARICOPA ASSOCIATION OF GOVERNMENTS' (MAG) SPECIFICATIONS.
2. CONTRACTOR MUST OBTAIN NECESSARY DISTRICT PERMIT PRIOR TO COMMENCEMENT OF CONSTRUCTION WITHIN DISTRICT RIGHT-OF-WAY AND MAINTAIN A COPY OF THE PERMIT ON THE PROJECT SITE AT ALL TIMES.
3. NOTIFY THE DISTRICT'S PERMITS INSPECTOR AT 602-506-4727 OR 602-506-4723 AT LEAST 48 HRS PRIOR TO ANY WORK BEING PERFORMED IN THE DISTRICT'S RIGHTS-OF-WAY.
4. CONTRACTOR PERFORMING EXCAVATION OPERATIONS IS RESPONSIBLE FOR LOCATING AND PROTECTING ALL UNDERGROUND UTILITIES.
5. ALL COMPACTION AND BACKFILL WITHIN DISTRICT'S RIGHTS-OF-WAY SHALL CONFORM TO THE LATEST MAG SPECIFICATIONS UNLESS STIPULATED OTHERWISE IN THE DISTRICT'S PERMIT.
6. ANY DAMAGE TO DISTRICT'S STRUCTURES, EQUIPMENT, MATERIALS, VEGETATION AND/OR PROPERTY SHALL BE REPLACED AND/OR REPAIRED IN-KIND TO THE SATISFACTION OF THE DISTRICT.

ACCESS BARRIER NOTES:
1. ALL SHEAR PIN ANGLES SHALL FIT SNUGLY AND TRULY FACE TO FACE, COVER WITH WATERPROOF GREASE PRIOR TO INSTALLATION OF PIN.
2. GALVANIZE ALL FERROUS PARTS AFTER FABRICATION.
3. THE SHEAR PIN HOLES IN THE ANGLES SHALL BE DRILLED FOR A TIGHT FIT OF THE SHEAR PINS.
4. FRAME AND HINGE ANGLES SHALL HAVE THE OUTSTANDING LEGS OUT FOR THE OUTLET.
5. ALL ANCHOR BOLTS SHALL BE 5/8"ø ANCHOR BOLTS EMBEDDED 4"(MIN.) INTO EPOXY GROUT.
6. ALL SHEAR PINS ARE TO BE PEENED BOTH ENDS AFTER INSTALLATION.
7. SHEAR PIN MATERIAL SHALL BE COMMERCIALLY PURE ALUMINUM WIRE, ALLOY 1100, TEMPER O, FEDERAL SPEC. QQ-A-411.
8. SEE BARRIER SCHEDULE FOR ADDITIONAL INFORMATION.
9. COVER ALL MOVABLE CONTACT SURFACE WITH A COAT OF WATERPROOF GREASE PRIOR TO INSTALLATION.

Call 48 hours before you dig.
CALL FOR THE BLUE STAKES
263-1100
Blue Stake Center

PER CITY OF PHOENIX ORDINANCE G-4398, THESE PLANS ARE FOR OFFICIAL USE ONLY AND MAY NOT BE SHARED WITH OTHERS EXCEPT AS REQUIRED TO FULFILL THE OBLIGATIONS OF YOUR CONTRACT WITH THE CITY OF PHOENIX.

STORM DRAIN DETAIL SHEET
CITY OF PHOENIX, ARIZONA
STREET TRANSPORTATION DEPARTMENT

CAMELBACK RD STORM DRAIN
AGUA FRIA RVR TO 99TH AVE

ST83110057

| DESIGN | DESIGN | DRAWN | SHEET NO. | TOTAL SHEETS | AS BUILT |
|---|---|---|---|---|---|
| DATE 07/07 | DATE 07/23 | DATE 11/08 | 59 | 68 | |

SCALE: NTS HORIZONTAL VERTICAL

| NO. | DESCRIPTION | REV BY | DWG BY | DATE |
|---|---|---|---|---|
| | | | | |

| NO. | DESCRIPTION | REV BY | DWG BY | DATE |
|---|---|---|---|---|
| | | | | |

| NO. | DESCRIPTION | REV BY | DWG BY | DATE |
|---|---|---|---|---|
| | | | | |

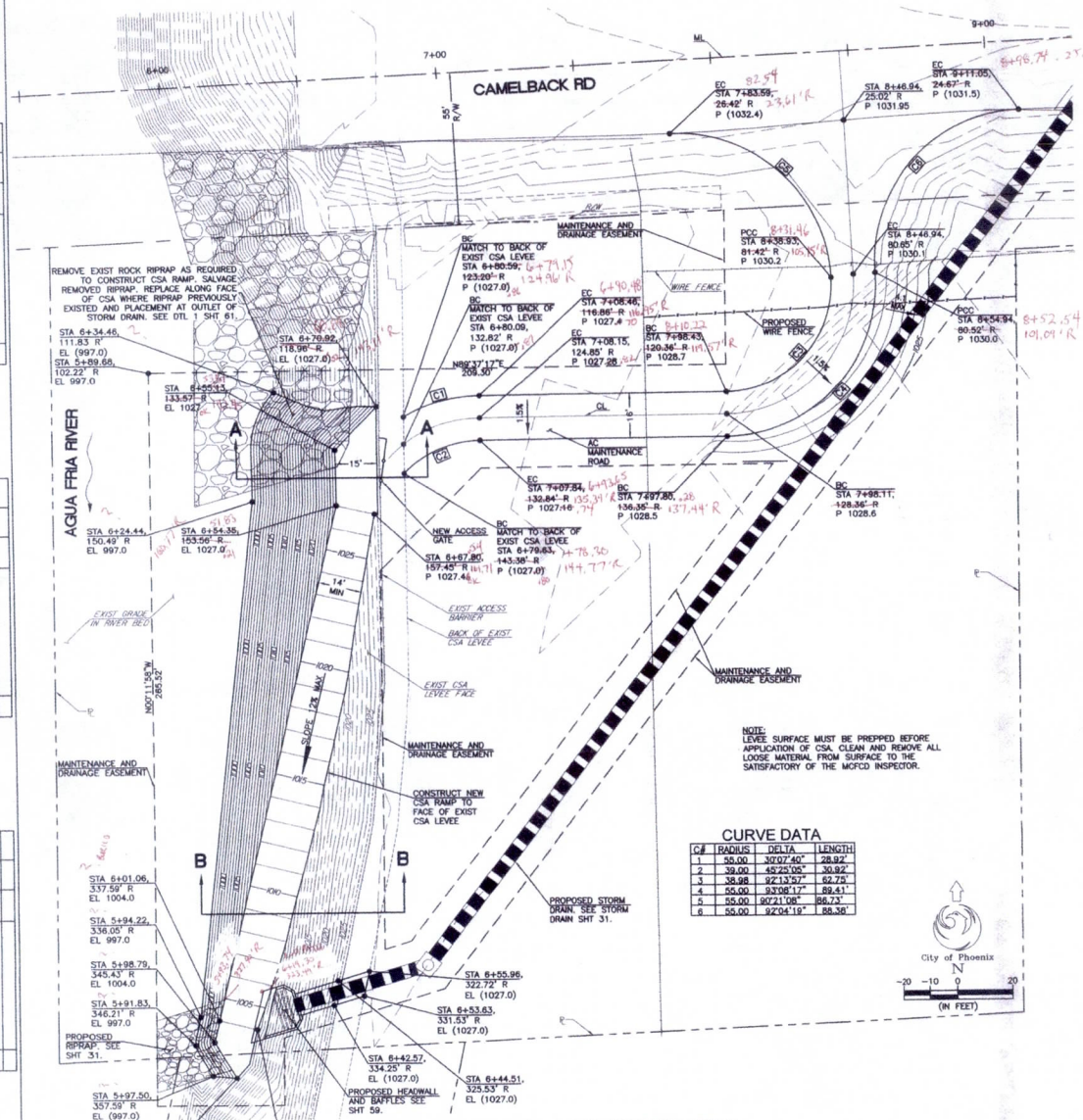
REVISION BY CITY OF PHOENIX

P:\4716 Camelback Phase II Storm Drain.dwg,4716-PSB SD details.dwg 07/26/2007 09:00

PHOENIX STREETS–MARICOPA CO.

| F.H.W.A. REGION | STATE | PROJ. NO. | NO. | TOTAL | AS BUILT |
|---|---|---|---|---|---|
| 9 | ARIZ | ST83110057 | 60 | 68 | |

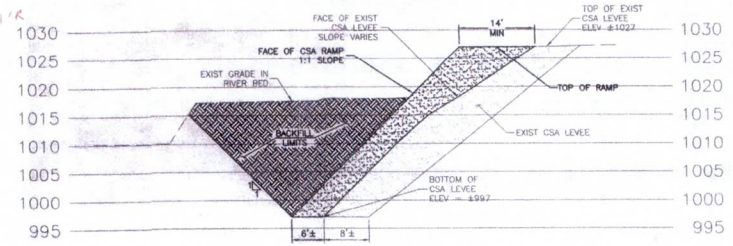
TETRA TECH, INC. CONSULTING ENGINEER
4801 East Washington, Suite 260 Phoenix, AZ 85034 TEL:(602)682-3300 FAX:(602)244-1184
DES: CFL DR: SRK CK: JBL DATE: 11/10/08



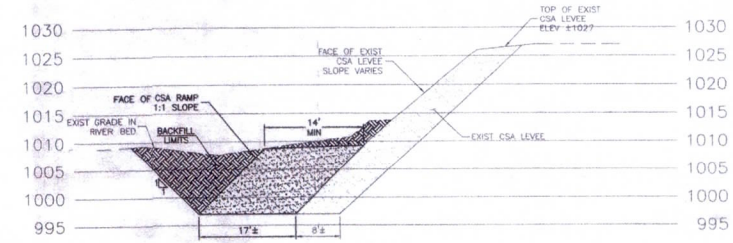

MAINTENANCE ACCESS RAMP AND ROAD DETAIL
SCALE 1"=20'

## CURVE DATA

| C# | RADIUS | DELTA | LENGTH |
|---|---|---|---|
| 1 | 55.00 | 30°07'40" | 28.92' |
| 2 | 39.00 | 45°25'05" | 30.92' |
| 3 | 38.98 | 92°13'57" | 62.75' |
| 4 | 55.00 | 93°08'17" | 89.41' |
| 5 | 55.00 | 90°21'08" | 86.73' |
| 6 | 55.00 | 92°04'19" | 88.38' |




SECTION A-A
SCALE 1"=10'




SECTION B-B
SCALE 1"=10'

MCFCD GENERAL NOTES:

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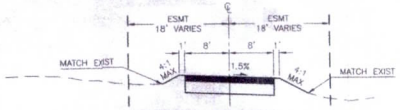
6. ANY DAMAGE TO DISTRICT'S STRUCTURES, EQUIPMENT, MATERIALS, VEGETATION, AND/OR PROPERTY SHALL BE REPLACED AND/OR REPAIRED IN-KIND TO THE SATISFACTION OF THE DISTRICT.




TYPICAL SECTION
MAINTENANCE ROAD NTS

MAINTENANCE ROAD
PAVEMENT
STRUCTURAL SECTION

Two working days before you dig, CALL FOR THE BLUE STAKES 263-1100 Blue Stake Center

PER CITY OF PHOENIX ORDINANCE G-4396, THESE PLANS ARE FOR OFFICIAL USE ONLY AND MAY NOT BE SHARED WITH OTHERS EXCEPT AS REQUIRED TO FULFILL THE OBLIGATIONS OF YOUR CONTRACT WITH THE CITY OF PHOENIX.

STORM DRAIN RAMP DETAIL
CITY OF PHOENIX, ARIZONA
STREET TRANSPORTATION DEPARTMENT
CAMELBACK RD STORM DRAIN
AGUA FRIA RVR TO 99TH AVE
ST83110057

| DR: SRK | DES: CFL | CK: JBL | SHEET NO. | TOTAL SHEETS | AS BUILT |
|---|---|---|---|---|---|
| DATE: 11/08 | DATE: 11/08 | DATE: 11/08 | 60 | 68 | |

SCALE: NTS HORIZONTAL VERTICAL

CAMELBACK RD STORM DRAIN AGUA FRIA RIVER TO 99TH AVE

ST83110057

REVISION BY CITY OF PHOENIX

| NO. | DESCRIPTION | REV BY | CKD BY | DATE |
|---|---|---|---|---|
| | | | | |

P:\4716 Camelbac... Drain\dwg\4716-P60 SD details.dwg 11/10/2006 13:28

# F. Field Survey Data

## F.1 Project Survey and Topographic Data

## F.2 Field Survey Report

Select Pages from Survey Report, Camelback Ranch Levee South, Premier Engineering Inc.

Full Survey Report and electronic files included on data disk in **Appendix H**

# F.1 Project Survey and Topographic Data

# 1. Project Survey and Topographic Data

Two sources of topographic information were used for the evaluation of the Camelback Ranch Levee South and the Agua Fria River.

1. Field survey data points (March 2010) were collected at 200 foot intervals along the Agua Fria River starting at the Camelback Road Bridge ending approximately 1350 feet north of Indian School Road. Field survey data was collected at natural ground elevation in the left overbank near existing Flood Control District of Maricopa County (FCDMC) right-of-way, top and toe of levee elevations. Field survey points (June 2010) were also collected along HEC-2 cross sections alignments for 8.325, 8.534, 8.646, 8.768, 8.875, 8.992, 9.098 and 9.177. Natural ground points and grade breaks were collected within the Agua Fria River Main Channel.

   - Horizontal Control: North American Datum 1983 (NAD 83)
   - Vertical Control: National Geodetic Vertical Datum 1929 (NGVD 29).

2. FCDMC-provided 2-foot contour data (March 2009) within the Agua Fria River 2- foot contour data (March 1994) for the overall project limits within Agua Fria River and in the overbank areas. Digital data included an ESRI shape file containing contours based on the following control:

   **March 2009**
   - Horizontal Control: North American Datum 1983 (NAD 83)
   - Vertical Control: National Geodetic Vertical Datum 1988 (NAVD 88).

   **March 1994**
   - Horizontal Control: North American Datum 1927 (NAD 27)
   - Vertical Control: National Geodetic Vertical Datum 1929 (NGVD 29).

The HEC-2 models (Effective FEMA and Project Design models), discussed in **Section 2** were based on the NGVD 29. A conversion in needed to compare the NAVD 88 FCD topo with the NGVD 29 model and survey data. The conversion factor was determined by comparing local benchmarks, survey control within the project area and the datum shift using the American Vertical Datum Conversion Utility software. The final data shift was determined to be equivalent to be consistent with the original CVL 1995 Study.

NGVD 29 = NAVD 88 – 2.06 feet.

This conversion is consistent with the Levee Certification and Floodplain Delineation Study for Lower Agua Fria River conducted concurrently on Levee ID's 8, 16 and 18.

Additional survey electronic data is included on data disk in the **Appendix H.**

# F.2 Field Survey Report

PREMIER
ENGINEERING CORPORATION

# AGUA FRIA LEVEE #11 COORDINATE AND ELEVATION POINT LIST

## HORIZONTAL DATUM:

ARIZONA STATE PLANE COORDINATE SYSTEM, NAD '83 SCALED BY A COMBINED SCALE FACTOR OF 1.00013 ABOUT THE CARTESIAN ORIGIN (NORTHING 0, EASTING 0).

## VERTICAL DATUM:

NORTH AMERICAN VERTICAL DATUM 1988 (NAVD '88).

REGISTERED LAND SURVEYOR
CERTIFICATE NO.
39783
MARK A.
LUOND
Date Signed 03/10/11
ARIZONA, U.S.A.
Expires 09/30/12

Project No. 2010003

6437 W. Chandler Blvd., Suite 1 • Chandler, AZ 85226 • (480) 829-6000 • Fax (480) 829-6016

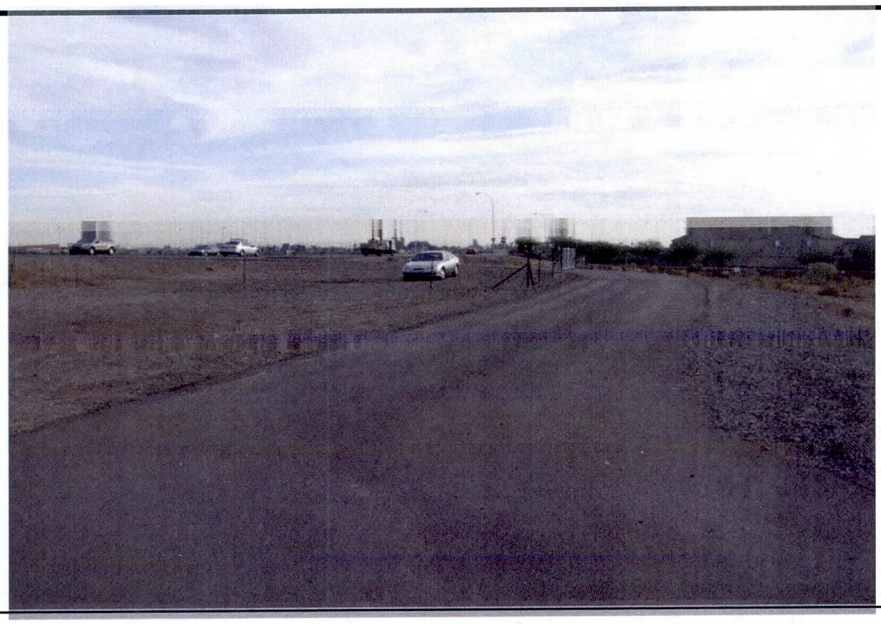
# G. Camelback Ranch Levee South Photos

## G.1 Field Photos

## G.2 Field Photo Locations

Figure G-1: Field Photo Locations

# G.1 Field Photos

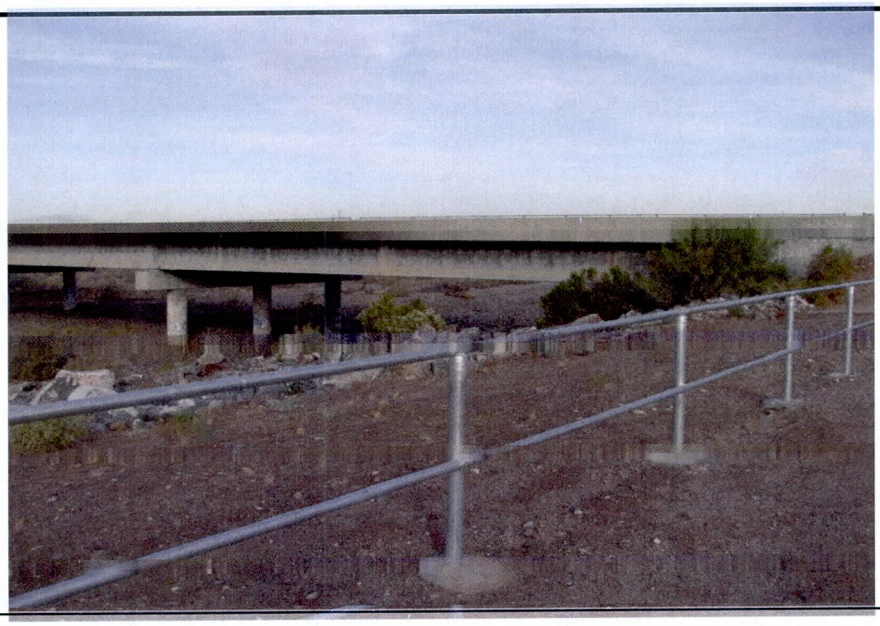


**Photograph #1** **December 11, 2009**

Looking east at levee access road off of Camelback Road.

**Photograph #2** **December 11, 2009**

Looking North at Camelback Road approach to bridge over the Agua Fria River

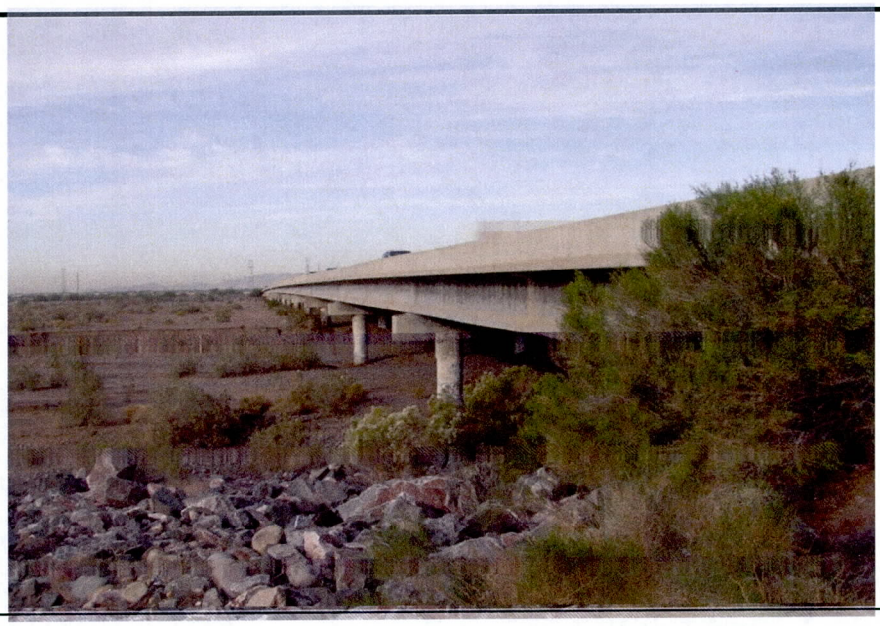


**Photograph #3** **December 11, 2009**

Looking north at the east abutment for the Camelback Road Bridge

**Photograph #4** **December 11, 2009**

Looking east at local drainage swale along Camelback Road

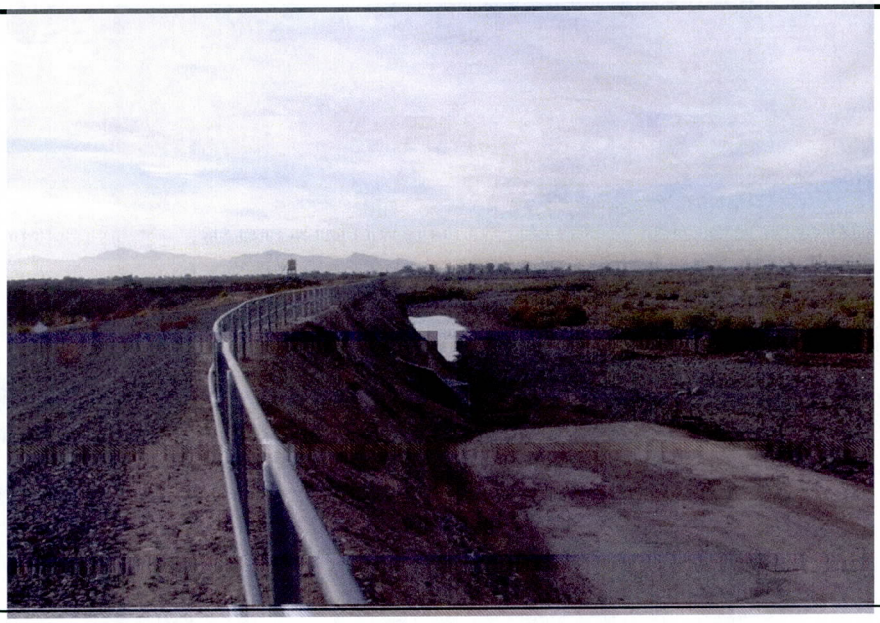


**Photograph #5** **December 11, 2009**

Looking west along the downstream face of the Camelback Road Bridge over the Agua Fria River

**Photograph #6** **December 11, 2009**

Looking south along the levee



**Photograph #7** **December 11, 2009**

Looking south along the levee

**Photograph #8** **December 11, 2009**

Looking south at Camelback Road Storm Drain manhole SDMH#32

**Photograph #9** **December 11, 2009**

Looking north along the levee

**Photograph #10** **December 11, 2009**

Looking southeast behind levee

**Photograph #11** **December 11, 2009**

Looking north along the levee

**Photograph #12** **December 11, 2009**

Looking south along the levee

**Photograph #13** **December 11, 2009**

Looking north along the levee

**Photograph #14** **December 11, 2009**

Looking north along the levee

**Photograph #15** **December 11, 2009**

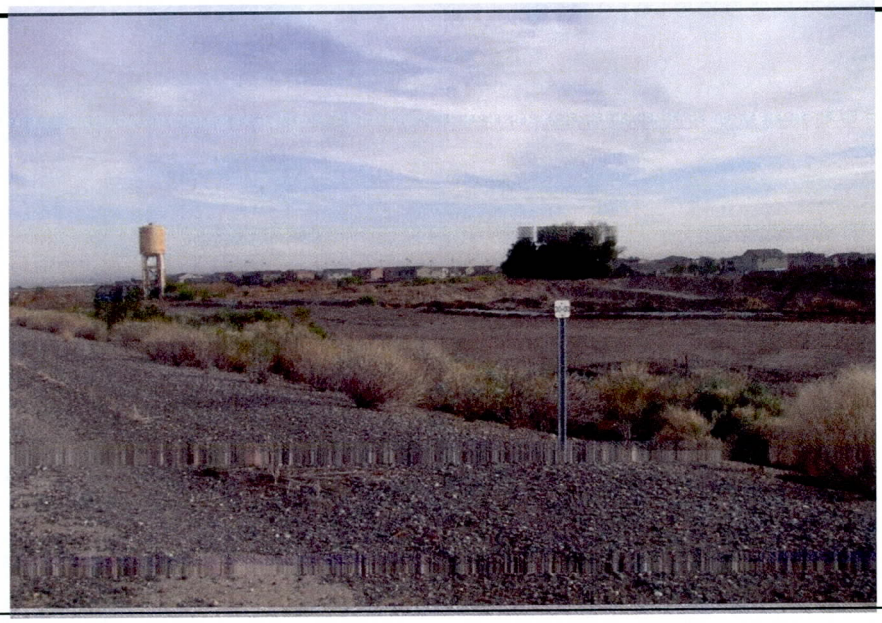
Looking south along the levee

**Photograph #16** **December 11, 2009**

Looking at Camelback Ranch Levee South survey station marker along the top of levee

**Photograph #17** **December 11, 2009**

Looking north along the levee



**Photograph #18** **December 11, 2009**

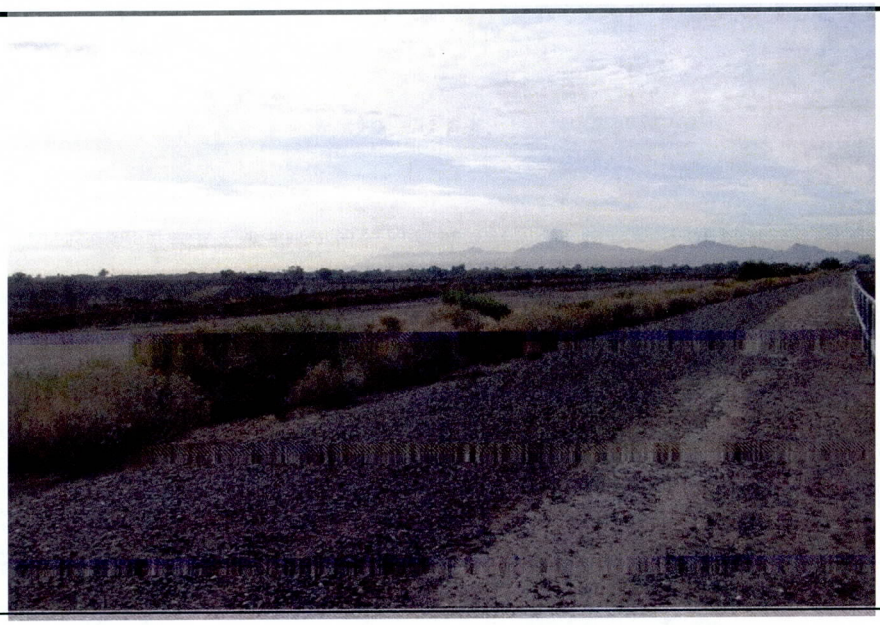
Looking northeast behind the levee

**Photograph #19** **December 11, 2009**

Looking east behind the levee

**Photograph #20** **December 11, 2009**

Looking east behind the levee



**Photograph #21** **December 11, 2009**

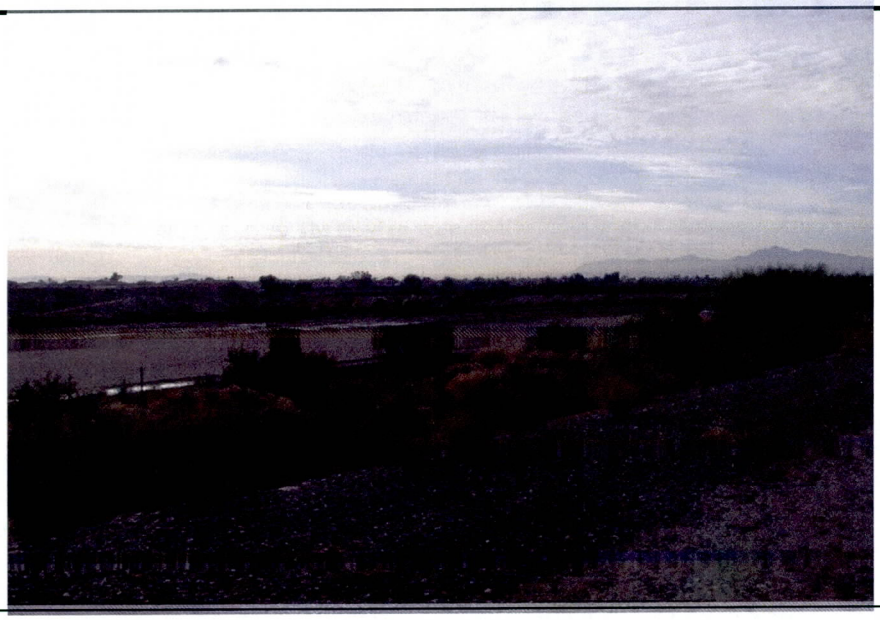
Looking southeast behind levee

**Photograph #22** **December 11, 2009**

Looking south along the levee

**Photograph #23** **December 11, 2009**

Looking south along the levee



**Photograph #24** **December 11, 2009**

Looking southeast behind levee

**Photograph #25** **December 11, 2009**

Looking northeast behind levee

**Photograph #26** **December 11, 2009**

Looking north along the levee

**Photograph #27** **December 11, 2009**

Looking at Camelback Ranch Levee South station marker along the east side of the maintenance road

**Photograph #28** **December 11, 2009**

Looking north along the levee

**Photograph #29** **December 11, 2009**

Looking south along the levee

**Photograph #30** **December 11, 2009**

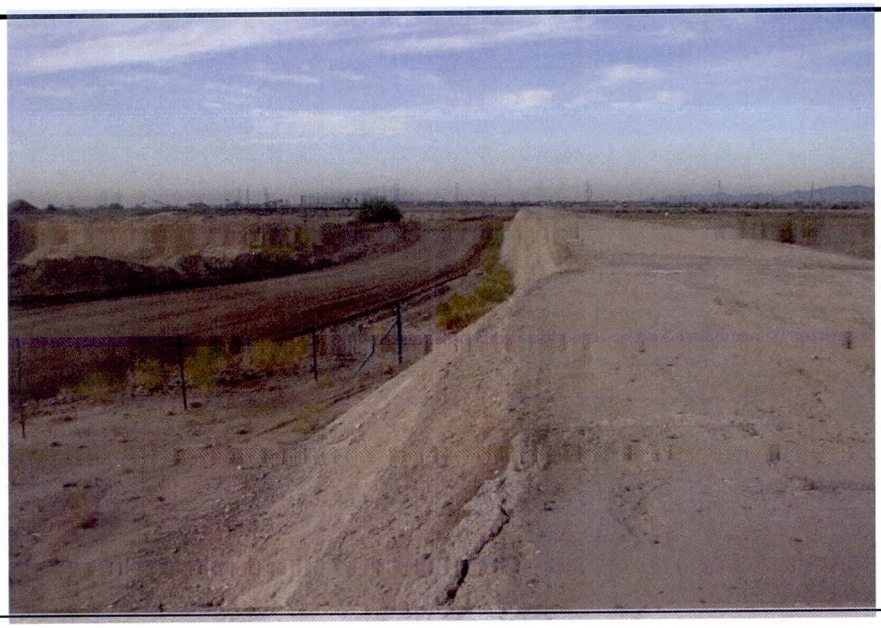
Looking south along the levee

**Photograph #31** **December 11, 2009**

Looking north along the levee

**Photograph #32** **December 11, 2009**

Looking south along the levee

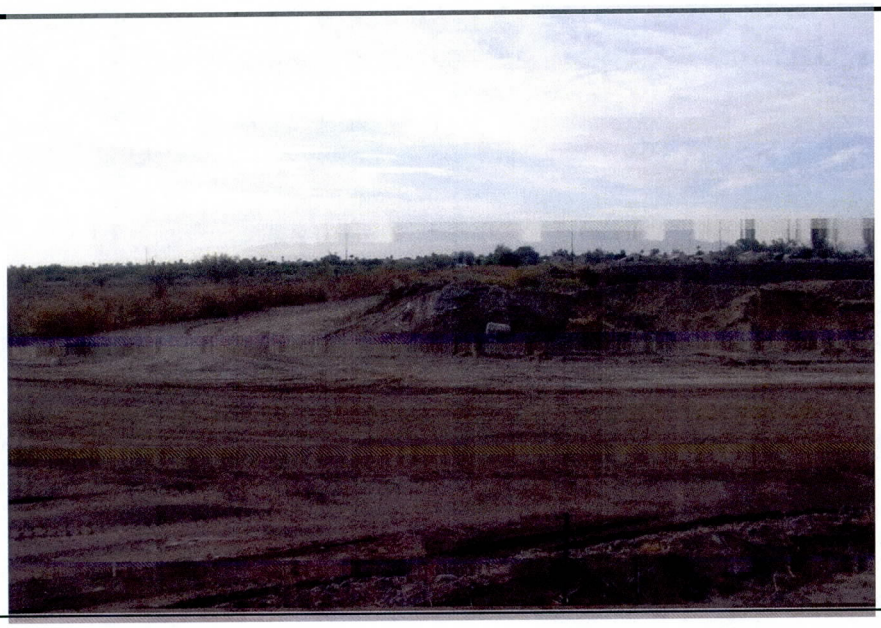


**Photograph #33** **December 11, 2009**

Looking southeast behind levee

**Photograph #34** **December 11, 2009**

Looking southeast behind levee



**Photograph #35** **December 11, 2009**

Looking east behind levee

**Photograph #36** **December 11, 2009**

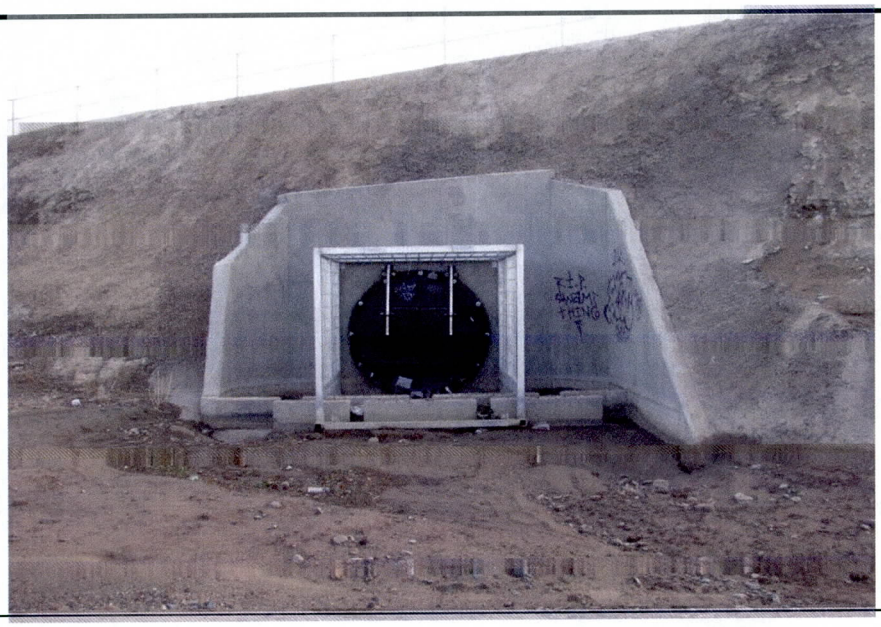
Looking north along the levee

**Photograph #37** **December 11, 2009**

Looking west along the river side of the transverse diversion structures at the southern limits of the levee

**Photograph #38** **December 11, 2009**

Looking at the headwall and outlet structure at the newly constructed Camelback Road Storm Drain



**Photograph #39** **December 11, 2009**

Looking at the headwall and outlet structure at the newly constructed Camelback Road Storm Drain

**Photograph #40** **December 11, 2009**

Looking north at the levee access ramp and east abutment of the Camelback Road Bridge over the Agua Fria River

**Photograph #41** **December 11, 2009**

Looking south along the water side of the levee embankment south of the access ramp

## G.2 Field Photo Locations

JE FULLER HYDROLOGY & GEOMORPHOLOGY, INC.

0 150 300 600 Feet

N

**FIGURE G-1: FIELD PHOTO LOCATIONS**

CREATED BY: SRW
DATE: 5-10-2010

CHECKED BY: JTA
DATE: 5-11-2010

Flood Control District of Maricopa County

**CAMELBACK RANCH LEVEE SOUTH - FCD2007C051**

# H. Data Disk

## Field Photos

## General Support Documents

A400_307Final_InteriorDrainageReport_CamelbackRanchLeveeDesignProject.pdf
A400_803Final Calculations.pdf
A400_916CamelbackRanchLevee_South_LetterofMapRevision_LOMR.pdf
CamelbackRoadStormDrain_H&H.pdf
98-09-226P.pdf
FEMAFORM.doc
Interior Drainage Report.pdf
Levee Backup.pdf
TSDN.pdf

## Hydraulic Models

AGUAFRIA.DAT
AGUAFRIA.OUT
cblp1.dat
cblp1.out
AguaFriaRiver_CBRLS_Eval.prj
AguaFriaRiver_CBRLS_Eval.rep

## Inspection Reports (FCDMC)

## Record Drawings and Design Plans

Camelback Road Storm Drain Design Plans (folder)
Camelback Ranch Levee South.pdf
Camelback Road Storm Drain Right-of-Way Permit (2006P039.pdf)
Camelback Road Bridge Plans
Indian School Road Grade Control

## Survey Report

Field survey report