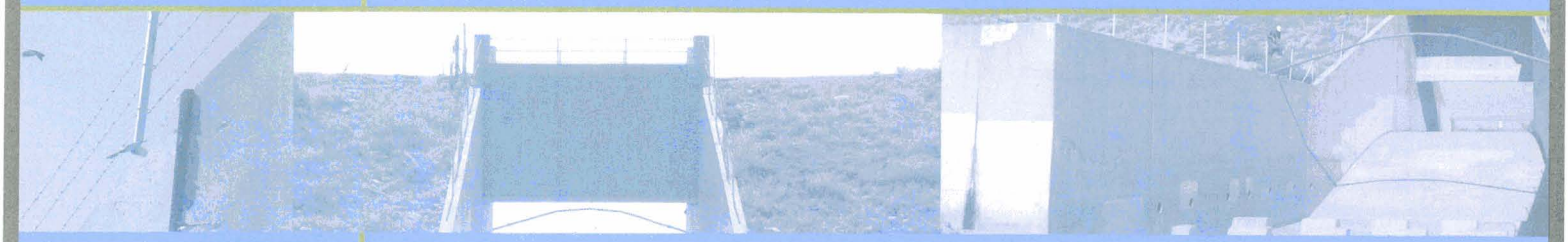

McMicken Dam Principal Spillway

Data Summary Report

For:
The Flood Control District
of Maricopa County

Prepared by:

Ninyo & Moore

May 27, 2005

FCD2004C029
PCN 202.01.26

Ninyo & Moore

Geotechnical and Environmental Sciences Consultants

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DATA SUMMARY REPORT
MCMICKEN DAM PRINCIPAL SPILLWAY
MARICOPA COUNTY, ARIZONA
CONTRACT FCD 2004C029
WORK ASSIGNMENT NO. 1

PREPARED FOR:
Flood Control District of Maricopa County
2801 West Durango Street
Phoenix, Arizona 85009-6399

PREPARED BY:
Ninyo & Moore
Geotechnical and Environmental Sciences Consultants
3001 South 35th Street, Suite 6
Phoenix, Arizona 85034

May 27, 2005
Project No. 600996001

Ninyo & Moore
Geotechnical and Environmental Sciences Consultants

May 27, 2005
Project No. 600996001

Mr. Michael Greenslade, P.E.
Flood Control District of Maricopa County
2801 West Durango Street
Phoenix, Arizona 85009-6399

Subject: Data Summary Report
McMicken Dam Principal Spillway
Maricopa County, Arizona
Contract FCD 2004C029
Work Assignment No. 1

Dear Mr. Greenslade:

In accordance with your authorization dated February 9, 2005, Ninyo & Moore has performed a review of data pertaining to the McMicken Dam Principal Spillway. Transmitted herewith is our Data Summary Report, which represents the deliverable for sub-task no. 1 on Work Assignment No. 1 (PCN 202.01.26). Included are a description of our methodologies and summaries of pertinent information.

We appreciate the opportunity to be of service to you on this project. If you have any questions or comments regarding this report, please contact us at your convenience.

Sincerely,
NINYO & MOORE

A. Tom MacDougall
Project Engineer

Registered Professional Engineer (Civil)
CERTIFICATE NO. 31423
ROBERT W. McMICHAEL
Date Signed 5/26/05
ARIZONA, U.S.A.

Robert W. McMichael, P.E.
Principal Engineer

ATM/RM/avv

Distribution: (5) Addressee

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Appendices

Appendix A – Summary of Previously Prepared Documents

1. INTRODUCTION

In accordance with the notice to proceed dated February 9, 2005, Ninyo & Moore collected and reviewed data relating to the principal spillway (PS) at McMicken Dam located near the City of Surprise, in Maricopa County, Arizona. This report presents a compilation and summary of salient information.

1.1. Methodology and Documents Summarized

Ninyo & Moore conducted a search for available documents and information related to the PS. The majority of the information was obtained from three sources at the Flood Control District of Maricopa County (the District): Mr. Michael Greenslade (the District's project manager), the General Library, and the Structures Management Library. Some information was obtained from the Arizona Department of Water Resources (ADWR) file on McMicken Dam. Further, we examined reference lists provided in existing reports to find additional documents to include in our review. From these efforts, we developed a bibliography of documents related to McMicken Dam.

Using the bibliography compiled, a cursory review of each document was performed to evaluate its relevance to the PS. A document was considered relevant if it contained information about one of the following:

- Regional geology, geologic hazards, or hydrology;
- Geotechnical data within approximately 500 feet of the PS; or
- Structural information for the PS.

Next, the pertinent documents were carefully reviewed and summarized. The documents used to develop this report are listed in Table 1. Appendix A contains the summaries and selected excerpts from reviewed reports.

Table 1 – Documents Summarized

Title	Prepared By	Date	Appendix
Hydrology and Hydraulic Design for the Trilby Wash Detention Basin and Outlet Channel	USACE[1]	11/1953	A1
Design Analysis for Trilby Wash Detention Basin and Outlet Channel	USACE[1]	03/1954	A2
Trilby Wash Detention Basin Dam and Appurtenances (Original as-builts)	USACE[1]	7/26/1956	A3
Trilby Wash Detention Basin - "Embankment Cracking Report"	USACE[1]	01/1973	A4
Trilby Wash Detention Basin (Memo regarding plan to breach dam to prevent failure)	USACE[1]	5/11/1977	N/A
Geotechnical Investigation Report - McMicken Dam Restoration Study	SH&B[2]	7/27/1982	A5
Design Report - McMicken Dam Restoration Study	SH&B[2]	1/27/1983	A6
Surface Water Hydrology Report - McMicken Dam Restoration Study	SH&B[2]	1983	A1
McMicken Dam Restoration (Restoration as-builts)	SH&B[2]	12/21/1984	A7
A Hydrologic Analysis of the McMicken Dam Watershed	FCDMC[5]	03/1987	A1
Seismic Exposure Evaluation	AMEC	5/2/2002	A8
Preliminary Failures Modes Identification Report	URS	5/16/2002	A9
Geotechnical Investigation	AMEC	1/8/2003	A10
McMicken Dam Design Review	AMEC	2/24/2003	A11
Earth Fissure Investigation	AMEC	4/11/2003	A12
Geological Input to Structures Assessment Reports (Revision 3)	GCI[3]	6/4/2003	A13
McMicken Dam Individual Structure Assessment	URS	06/2003	A14
Final Report of Alternative Analysis	AMEC	10/1/2003	A15
Principal Spillway at McMicken Dam Geotechnical Investigation(Supplement)	RAM[4]	1/5/2004	A16
Land Subsidence and Earth Fissure Investigation	GCI[3].	1/30/2004	A17
Principal Spillway at McMicken Dam Geotechnical Investigation	RAM[4]	4/1/2004	A18
Wittman ADMSU	Entellus	2003	A1
Wittman ADMSU - Hydrology	Entellus	07/2004	A1
Crest Elevation Survey Data	FCDMC[5]	3/14/2005	A19

1. U.S. Army Corps of Engineers
2. Sergent, Hauskins & Beckwith
3. Geological Consultants Inc.
4. Ricker, Atkinson, & McBee
5. Flood Control District of Maricopa County

2. MCMICKEN DAM PRINCIPAL SPILLWAY FACT SUMMARY

This section contains an overview summary of important information related to the PS. The general dam information is summarized in Table 2.

Table 2 – General Dam Information

Embankment	
Type	Homogeneous Earth with Center Filter Drain[1]
Length (feet)	50,100
Average Height (feet)	20.5
Crest Elevation (feet)	1,361.0
Crest Width (feet)	12
Upstream Slope	2.5:1 (H:V)
Downstream Slope	2:1 (H:V)
Height at Principal Spillway (feet)	26.7
Principal Spillway	
Type	Ungated reinforced concrete box culvert
Location	Station 476+80
Height of orifice (feet)	11
Width (feet)	20
Length including stilling basin (feet)	188.33
Invert elevation at intake	1,333.6[1]
Capacity (cfs)	4,450
Outlet Channel	
Type	Lined for the initial 300 feet, then Unlined Trapezoidal
Length (feet)	30,000
Depth (feet)	11 to 15
Maximum Discharge (cfs)	4,450
Constructed by	U.S. Army Corps of Engineers
Construction date	1956
ADWR Size Classification	Intermediate
ADWR Hazard Potential Classification	High

1. Center filter drain does not tie into the principal spillway - it extends to within approximately 28 feet from the south side and to within 23 feet of the north side.
2. Also reported as 1333.5 in the same report.

Hydrologic information is summarized in Table 3:

Table 3 – Hydrologic Information

100-year 24-hour Rainfall Depth (inches)	4.6
Design Storm	Standard Project Flood
1987 Revised SPF Rainfall Depth (inches)	8.6
1987 Revised SPF Peak Inflow (cfs)	42,000
Emergency Spillway Design Crest Elevation (ft)	1354.0
Reservoir Storage Capacity (acre-feet)	19,300
Primary Outlet Design Capacity (cfs)	4,450
ADWR IDF	PMF
PMP Depth (inches)	15.7
PMF Peak Inflow (cfs)	114,850

Other relevant information includes:

- An original dam across Trilby Wash was constructed by Maricopa County Municipal Water Conservation District No. 1 in 1952. The structure extended between approximately Stations 357+00 and 480+00. It had a maximum height of 20 feet, and was approximately 21,000 feet long. It had a crest elevation of approximately 1,352.5 feet.

- McMicken Dam was designed to incorporate the embankment of the original dam across Trilby Wash.

- The embankment soils (structural fill) generally consist of sandy clay, sandy silt, silty sand, or clayey sand with trace to some amounts of gravel.

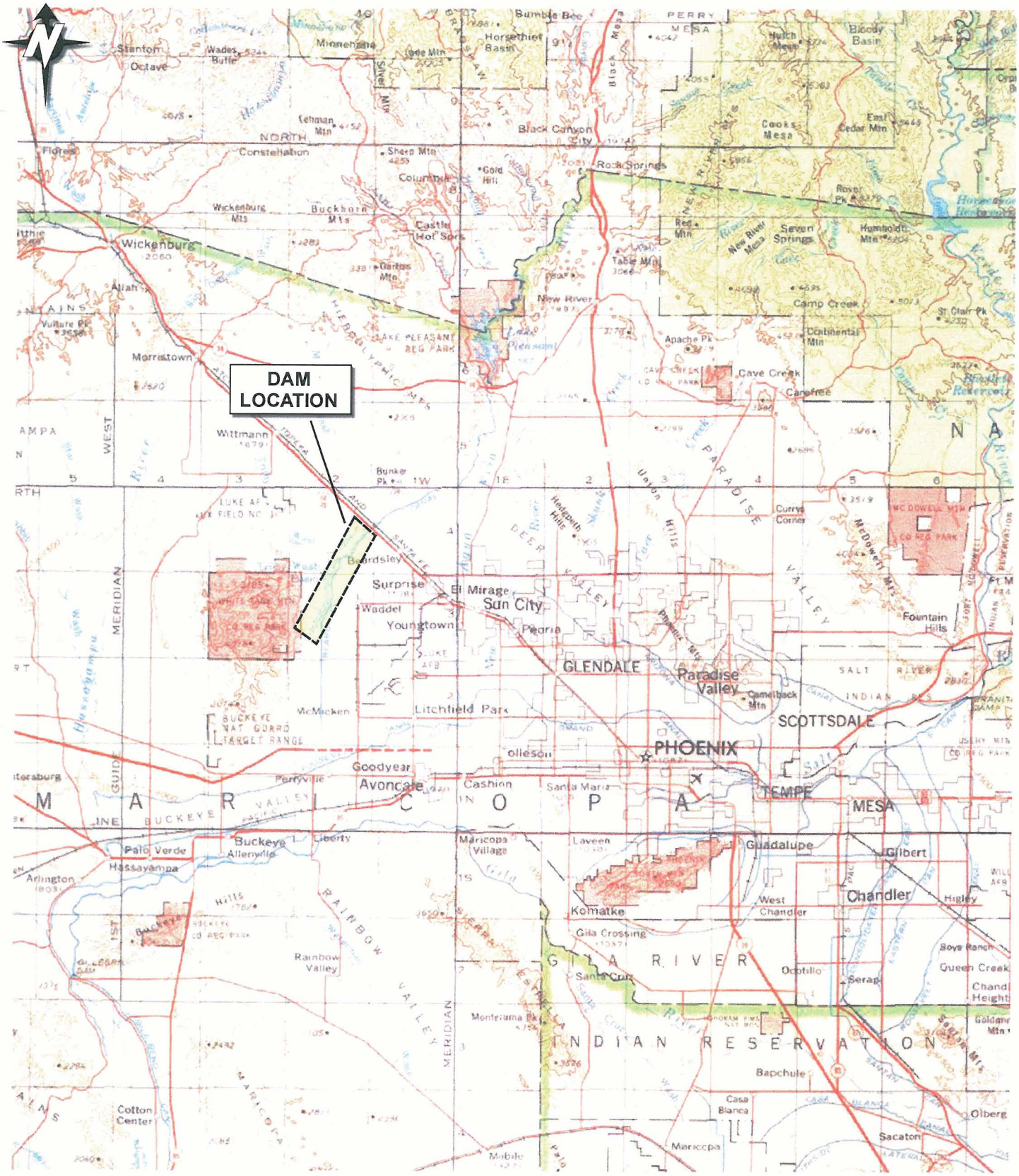
- The embankment is underlain by a shallow, weakly cemented, relatively loose stratum of Holocene alluvium soil overlying moderately cemented, middle to late Pleistocene soils. At some locations, coarser sand and gravel deposits extend from near ground surface to 10 or more feet below the natural ground surface elevation.

- The surface geology of the dam area is dominated by three alluvial fan units that range in age from Holocene to middle to late Pleistocene. The three alluvial units, as described by Field and Pearthree, are: Middle Pleistocene Alluvium (M1), Middle or late Pleistocene Alluvium (M12), or Late to early Holocene Alluvium (Y)

- Foundation soils in the vicinity of the PS are considered collapsible, with some tests showing as much as 10 percent collapse.

- Cracking of the embankment has been reported along the entire length of the dam, with extensive cracking reported near the PS.
- Due to the presence of observed cracking, McMicken Dam was intentionally breached in 1977 at two locations: from Station 316+50 to 325+50 and Station 480+25 to 482+25.
- Restoration of McMicken Dam began in 1983 and was completed in 1984. Restoration of the dam included the construction of a centerline filter/drain system, raising the embankment, and repairing the breaches.
- The centerline filter system does not tie into the PS. It extends to within about 28 feet south of the PS and 23 feet north of the PS.
- The PS is comprised of different sections. Generally, the sections consist of an entrance channel, a bridge/wier section, a chute section, and a stilling basin section. The PS discharges into an engineered outlet channel.
- The stilling basin section, canal siphon and outlet channel were designed so that minor flows would fill the stilling basin area to a depth of five feet before flows discharge through outlet channel.
- The design of the stilling basin includes two independent drainage systems. One system extends below the floor of the stilling basin and is apparently intended to relieve uplift pressures. The other system extends laterally behind the stilling basin walls to relieve hydrostatic pressures that could develop against those walls.
- Both systems are comprised of a combination of perforated and non-perforated 8-inch diameter vitrified clay pipes placed in pervious backfill. Structural backfill was placed against the PS walls in the entrance, bridge/wier, and chute sections.
- High water marks on the walls of the stilling basin indicate that the drains from the two systems have periodically been submerged.
- Video inspection of the drain pipes showed the pipes to be clogged, displaced and, in some cases installed with perforations down (as-builts show perforations were designed to be up).
- McMicken Dam runs parallel to the Beardsley Canal. The canal is siphoned under the PS.
- Cracks have been reported in the right training wall of the principal outlet at the location of Beardsley Canal siphon. The siphon reportedly has leaked at one of the crack locations.
- Regional land subsidence is well documented in the vicinity of McMicken Dam.
- The invert elevation at the entrance of the PS was designed at 1,335 feet but is currently 1,333.6 feet.

- The greatest historical subsidence in Arizona is documented in the Sun City West area along the McMicken Dam-Beardsley Canal corridor between Fenne knoll and US 60 (south of the spillway approximately 7.5 miles).
- Possible earth fissures have been documented within approximately 1,000 feet of the PS. Land Subsidence and earth fissuring in the vicinity of the dam is considered to be ongoing.
- The closest fault is the Horseshoe fault located approximately 71 kilometers from the dam. The largest earthquake reported on this fault had a magnitude of 7.0.
- An MCI fiber optic line crosses over the top of the PS.



0 50,000

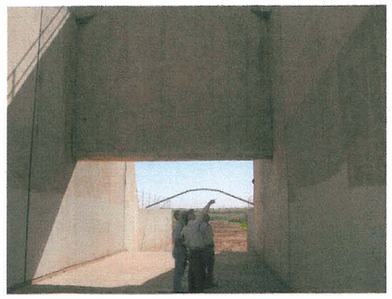
Approximate Scale:
1 inch = 50,000 feet

SOURCE: US Geological Survey 500K topographic map, Phoenix, Arizona, rev. 1981.

Ninyo & Moore	DAM LOCATION MAP	
McMICKEN DAM PRINCIPAL SPILLWAY DATA REPORT FLOOD CONTROL DISTRICT OF MARICOPA COUNTY		FIGURE 1
PROJECT No: 600996001	FILE No: 996vmap0405	DATE: 05/05

AREA OF SUBSIDENCE AND EARTH FISSURES

PRINCIPAL SPILLWAY



BEARDSLEY CANAL

EMERGENCY SPILLWAY

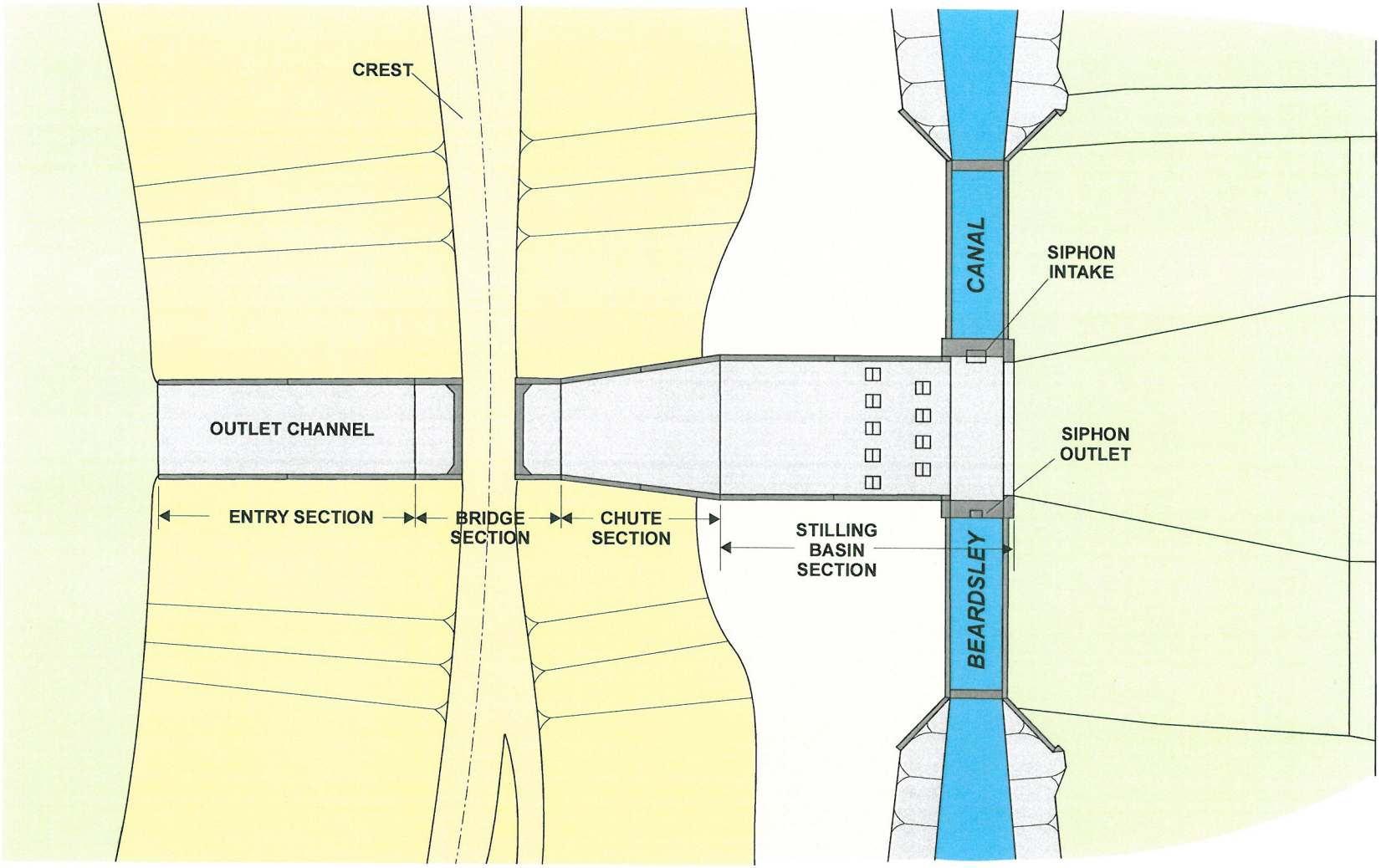
0 1600 3200

Approximate Scale:
1 inch = 3200 feet

SOURCE: Maricopa County Floor Control District GIS Dept, 2005.

Ninyo & Moore	McMICKEN DAM FEATURES AND SPILLWAY LOCATION MAP		
McMICKEN DAM PRINCIPAL SPILLWAY DATA REPORT FLOOD CONTROL DISTRICT OF MARICOPA COUNTY			FIGURE
PROJECT No: 600996001	FILE No: 996arl0405b	DATE: 05/05	2

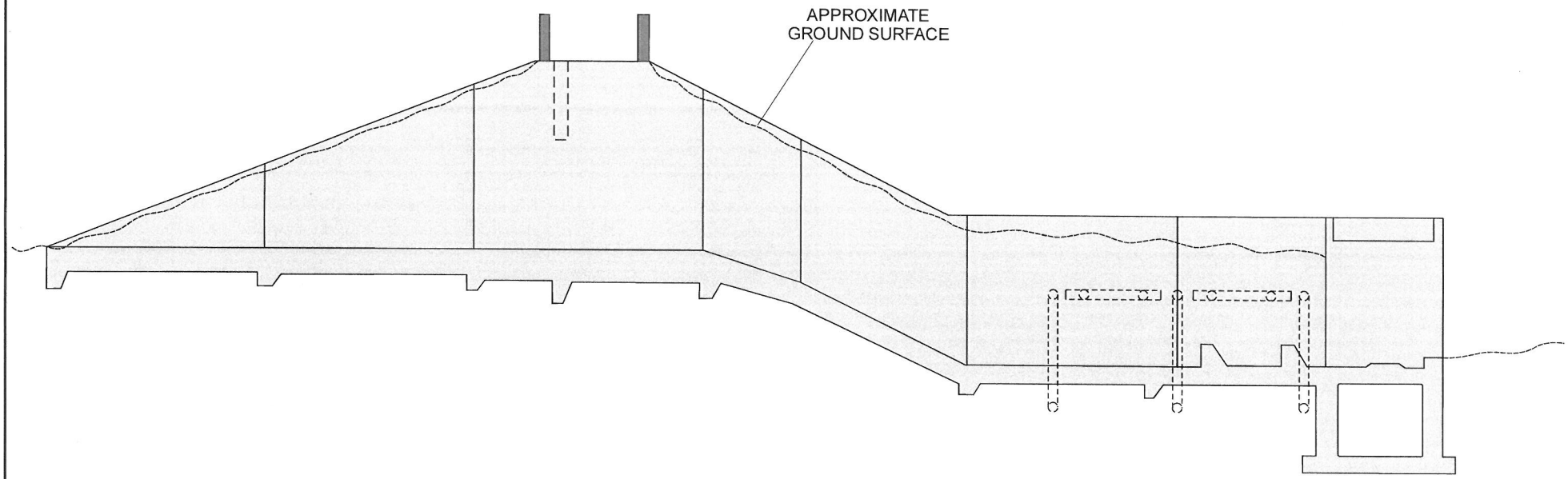
PRINCIPAL SPILLWAY SCHEMATIC
PLAN VIEW



Note: Modified after U.S. Army Corps of Engineers, 1954.

Ninyo & Moore	PRINCIPAL SPILLWAY SCHEMATIC PLAN VIEW		
McMICKEN DAM PRINCIPAL SPILLWAY DATA REPORT FLOOD CONTROL DISTRICT OF MARICOPA COUNTY			FIGURE
PROJECT No: 600996001	FILE No: 996dtl0405a	DATE: 05/05	3A

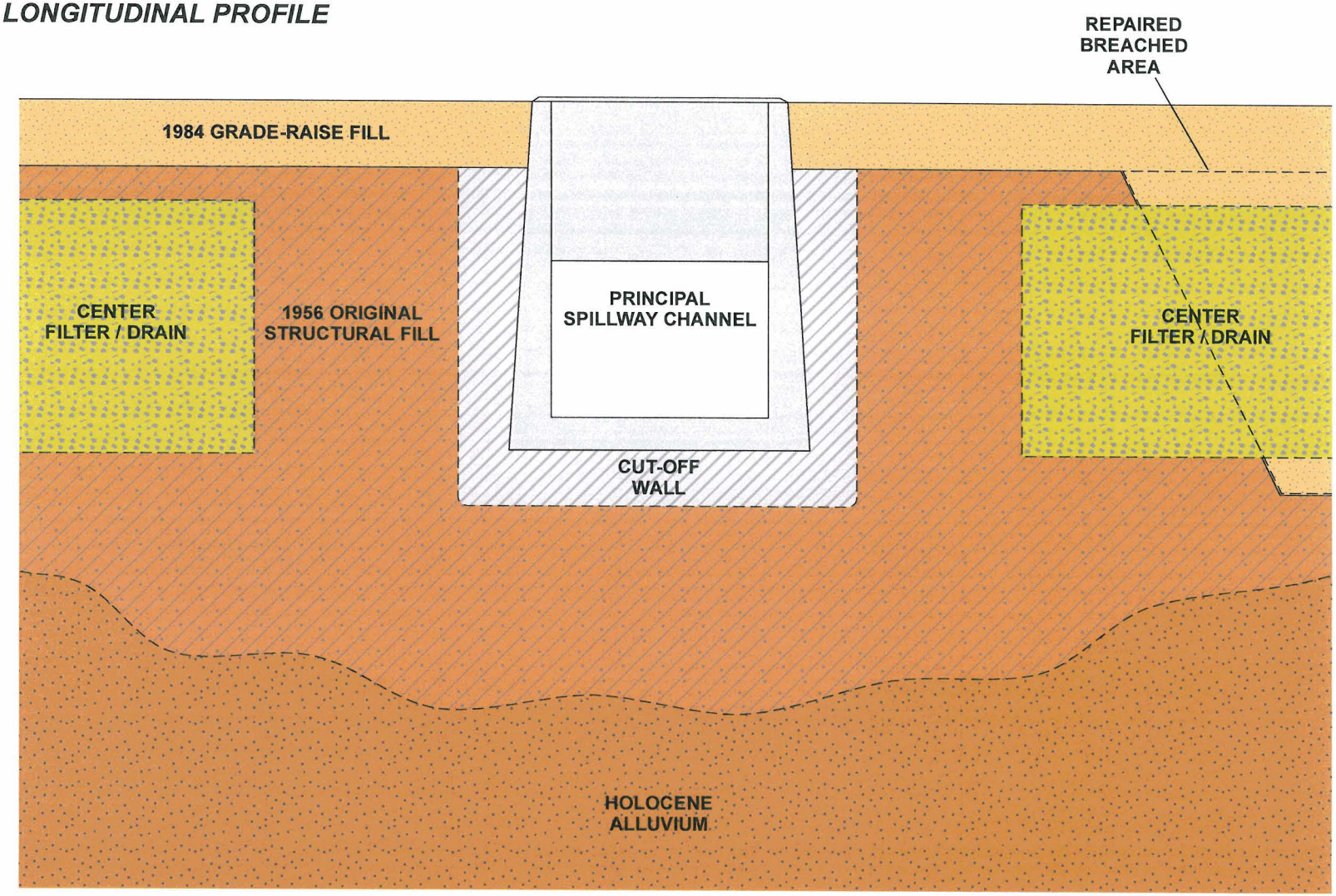
PRINCIPAL SPILLWAY SCHEMATIC TRANSVERSE PROFILE



Note: Modified after U.S. Army Corps of Engineers, 1954.

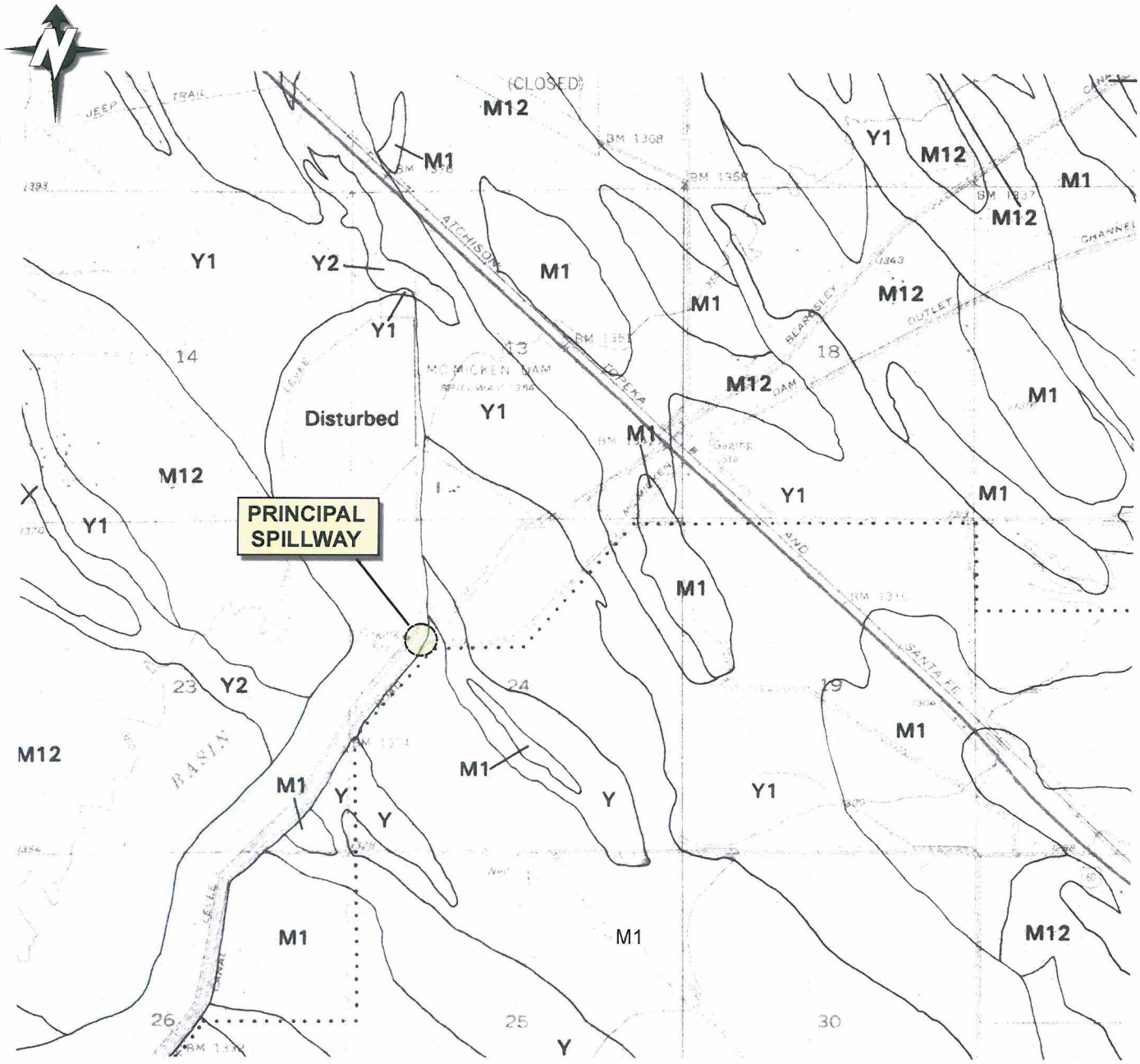
Ninyo & Moore	PRINCIPAL SPILLWAY SCHEMATIC TRANSVERSE PROFILE		
McMICKEN DAM PRINCIPAL SPILLWAY DATA REPORT FLOOD CONTROL DISTRICT OF MARICOPA COUNTY			FIGURE 3B
PROJECT No: 600996001	FILE No: 996dtl0405b	DATE: 05/05	

PRINCIPAL SPILLWAY SCHEMATIC LONGITUDINAL PROFILE



Note: Modified after U.S. Army Corps of Engineers, 1954.

Ninyo & Moore	PRINCIPAL SPILLWAY SCHEMATIC LONGITUDINAL PROFILE		
McMICKEN DAM PRINCIPAL SPILLWAY DATA REPORT FLOOD CONTROL DISTRICT OF MARICOPA COUNTY			FIGURE 3C
PROJECT No: 600996001	FILE No: 996dtl0405c	DATE: 05/05	



LEGEND

Y	Undifferentiated Holocene (o to 10ka) Alluvium Surfaces
Y1	Late to Early Holocene (1 to 10ka) Alluvial Fans and Terraces
Y2	Late Holocene (<3ka) Alluvial Fans, Low Terraces, and Active Stream Channels
M1	Middle Pleistocene (150 to 1,000ka) Alluvial Fans
M2	Middle or Late Pleistocene (10 to 300ka) Alluvial Fans

0 2,500

Approximate Scale:
1 inch = 2,500 feet

SOURCE: Arizona Geological Survey, McMicken Dam Quadrangle, 1991.

Ninyo & Moore

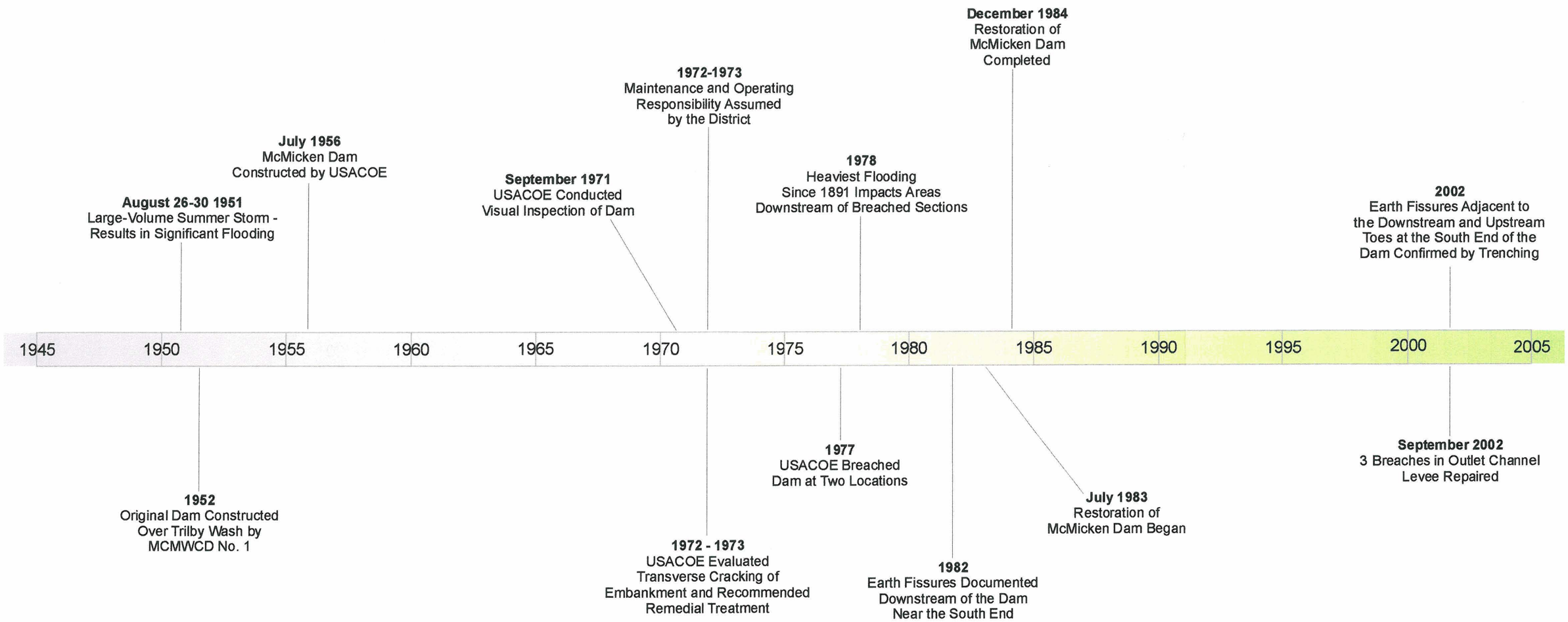
GEOLOGIC MAP

McMICKEN DAM PRINCIPAL SPILLWAY DATA REPORT
FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

FIGURE 4

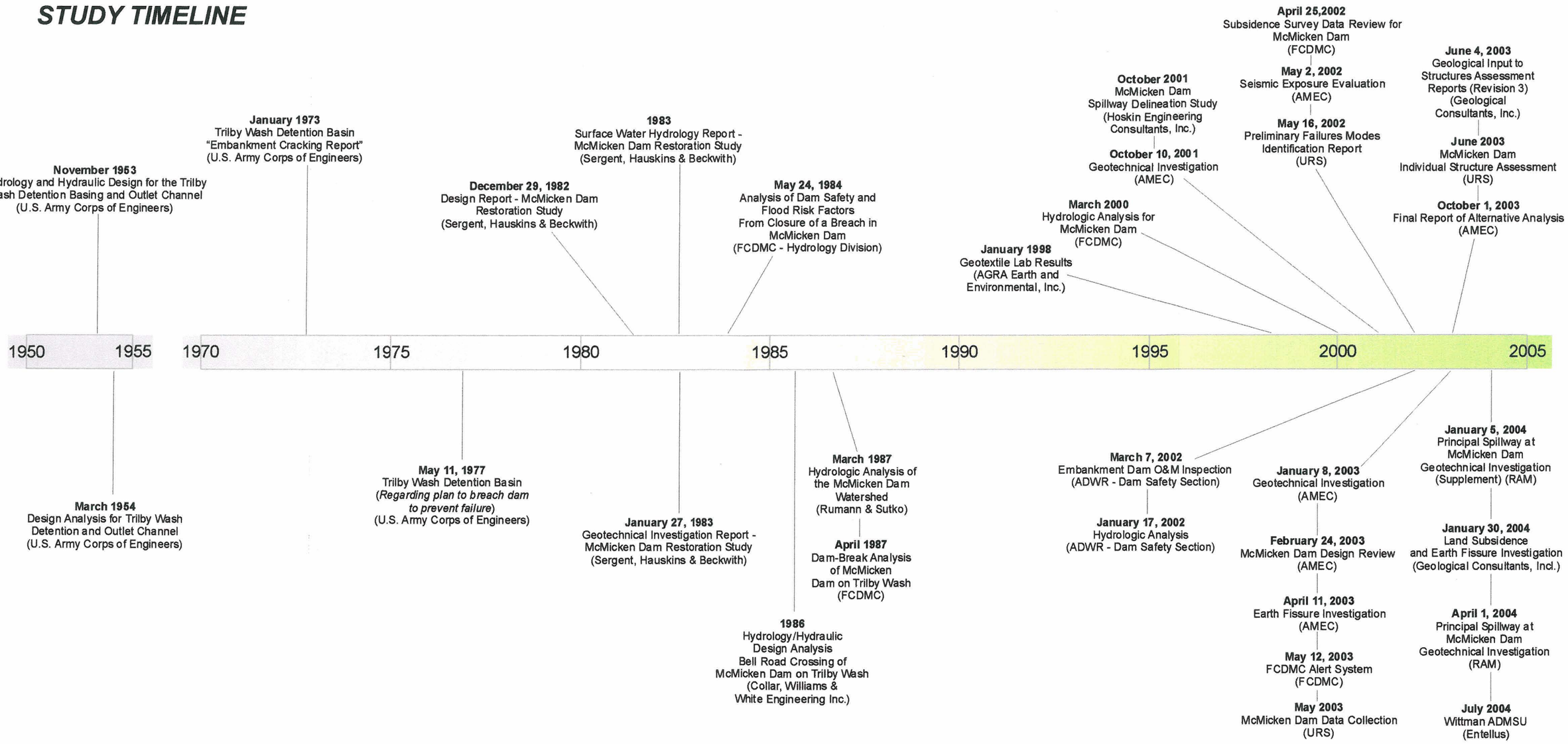
PROJECT No:	FILE No:	DATE:
600996001	996geo0405	05/05

McMICKEN DAM EVENT TIMELINE



Ninyo & Moore	McMICKEN DAM EVENT TIMELINE		
McMICKEN DAM PRINCIPAL SPILLWAY DATA REPORT FLOOD CONTROL DISTRICT OF MARICOPA COUNTY			FIGURE 5A
PROJECT No: 600996001	FILE No: 996tml0405a	DATE: 05/05	

McMICKEN DAM STUDY TIMELINE



Ninyo & Moore	McMICKEN DAM STUDY TIMELINE	
McMICKEN DAM PRINCIPAL SPILLWAY DATA REPORT FLOOD CONTROL DISTRICT OF MARICOPA COUNTY		FIGURE
PROJECT No: 600996001	FILE No: 996tml0405b	DATE: 05/05	5B

Ninyo & Moore

APPENDIX A

SUMMARY OF PREVIOUSLY PREPARED DOCUMENTS

APPENDIX A1 – SUMMARY OF INFORMATION RELEVANT TO SITE HYDROLOGY

DOCUMENTS SUMMARIZED:

- Hydrology and Hydraulic Design for the Trilby Wash Detention Basin and Outlet Channel, *USACE*, November 1953.
- Design Analysis for Trilby Wash Detention Basin and Outlet Channel, *USACE,* March, 1954
- Surface Water Hydrology Report - McMicken Dam Restoration Study, *SH&B*, 1983
- A Hydrologic Analysis of the McMicken Dam Watershed, FCD / *Rumann & Sutko*, March, 1987
- McMicken Dam Individual Structure Assessment, *URS*, June, 2003
- Wittman ADMSU, *Entellus,* 2003
- Wittman ADMSU - Hydrology, *Entellus,* July 2003

SUMMARIZED BY: Kimley-Horn and Associates, Inc.

SUMMARY:

The original hydrologic and hydraulic design for McMicken Dam was completed by the US Army Corps of Engineers (USACE) in 1953 and 1954 (USACE, 1953, 1954). Seargent, Hauskins, and Beckwith completed surface water hydrology update for the McMicken Dam watershed in 1983 (SHB, 1983). The District (Rumman & Sutko) completed a hydrologic analysis of the McMicken Dam Watershed in 1987 (FCD, 1987). URS completed a review of these previous analyses as part of the Individual Structures Assessment for McMicken Dam in 2003 (URS, 2003). In 2003 and 2004, Entellus completed a hydrologic analysis for the McMicken Dam Hydrology and for the entire Wittman area, respectively, in the Wittman Area Drainage Master Study Update-McMicken Dam Hydrology Report (Entellus, 2003) and the Wittman Area Drainage Master Study Update-Hydrology (Entellus, 2004). A two-dimensional hydraulic model of the

reservoir, emergency spillway, and primary outlet is being completed by Stantec for the District (Stantec, 2005). All of these studies, with the exception of the Stantec study, were reviewed and summarized for this report.

The principal spillway for the McMicken Dam is an ungated, reinforced concrete box channel/culvert that has a span of 20 feet and a rise of 11 feet. The centerline of the outlet is at Station 476+80 of the dam. The outlet extends from the upstream toe of the dam to the downstream toe. The principal spillway discharges into a concrete transition chute and energy dissipation basin with baffle blocks. The energy dissipating basin is 30 feet wide and 65 feet long. There are two rows of baffle blocks that are three feet wide, three feet tall, and spaced six feet on center. The end sill on the stilling basin is 1.5 feet tall. The total length of the primary outlet, transition chute and basin is 188.33 feet.

The design invert elevation of the principal spillway is at 1335.0 and has a slope of 0.0136 ft/ft. The region has experienced subsidence in the past and the primary spillway invert elevation has subsided to elevation 1333.6. The design capacity of the primary outlet is 4,450 cfs when the reservoir WSEL is 1354.0, which is the design emergency spillway crest elevation. (USACE, 1953). The emergency spillway elevation has also been subject to subsidence and is at elevation 1353.0. It does not appear that subsidence has adversely impacted the hydraulic capacity of the principal or emergency spillway.

The principal spillway rating curve developed by the USACE was based upon a physical hydraulic model completed during the design of the structure. Part of the reservoir, the outlet works, stilling basin, and 300 feet of the return channel were modeled physically (USACE 1954). It does not appear the rating curve for the principal spillway has been altered by any subsequent studies of McMicken Dam or watershed.

The downstream return or outlet channel is a trapezoidal channel with varying side slopes that has a bottom width of 60 feet that ultimately transitions to 100 feet and is nearly six miles long. The outlet channel discharges into the McMicken Dam Outfall Channel, which is a tributary to the Agua Fria River. The capacity of the outlet channel varies from 4,450 cfs at the primary outlet to 14,000 at the outlet to the Outfall Channel.

The reservoir has an original design capacity of 19,300 acre-feet at the emergency spillway crest elevation, and was designed to detain the Standard Project Flood (SPF). Drawdown time was estimated to be between 3 to 4.5 days. The emergency spillway is 2,000 feet wide and has a design capacity of 95,000 cfs, but has since been estimated at 120,000 cfs. Studies completed by the District in 1987 revised many of the original hydrologic design parameters. Table 3 (in the report) shows the hydrologic and hydraulic parameters that were used in the Individual Structures Assessment Report (URS, 2003).

Table 7

Summary of pertinent data, Trilby Wash detention basin, Arizona

Item	Unit	Quantity
Drainage area	Square miles	247
Dam (earth-, sand-, and gravel-fill):		
Crest elevation	Feet, m.s.l.	1,361.0
Height above streambed	Feet	31.5
Average height	do	20.5
Length at crest	do	49,500
Freeboard	do	5.0
Spillway, on left abutment (broad crest - grouted stone):		
Crest length	do	2,000
Crest elevation	Feet, m.s.l.	1,354.0
Outlets:		
Flood control (ungated):		
10'x10' double box	Number	1
Invert elevation at intake	Feet, m.s.l.	1,335.0
Conduit length	Feet	110
Drainage (gated):		
24" diameter pipes	Number	6
Standard project flood (design flood):		
Peak inflow	C.f.s	35,000
Peak outflow	do	4,450
Volume (3.5 days)	Acre-feet	32,800
Spillway design flood:		
Peak inflow	C.f.s	52,000
Peak outflow	do	22,000
Volume (3.5 days)	Acre-feet	44,000
Storage allocation:		
Flood control	Acre-feet	16,800
Sediment	do	2,500
Total	do	19,300
Spillway:		
Crest elevation	Feet, m.s.l.	1,354.0
Area	Acres	2,230
Maximum water surface:		
Elevation	Feet, m.s.l.	1,356.0
Area	Acres	2,520
Capacity (Gross)	Acre-feet	23,800

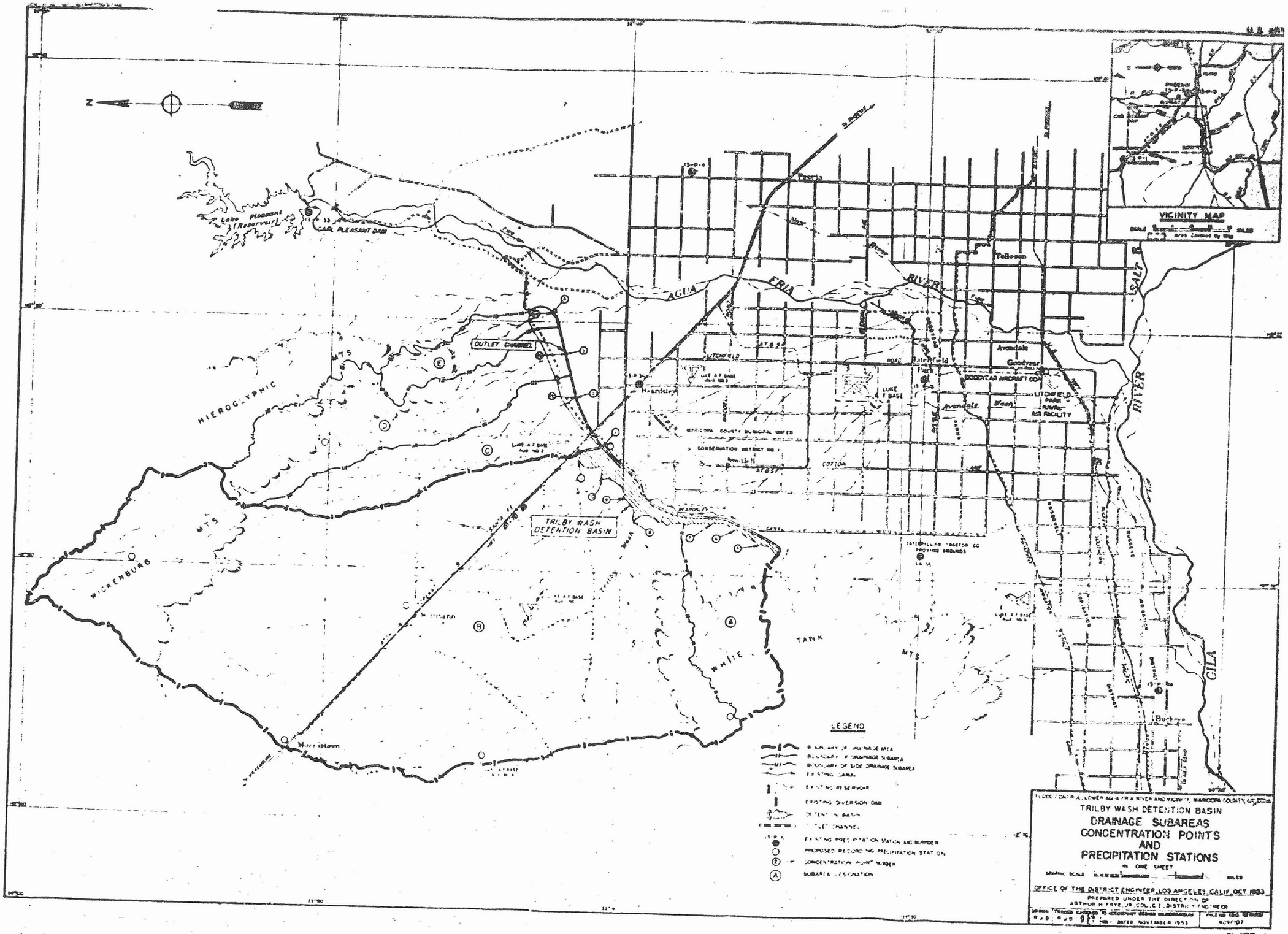
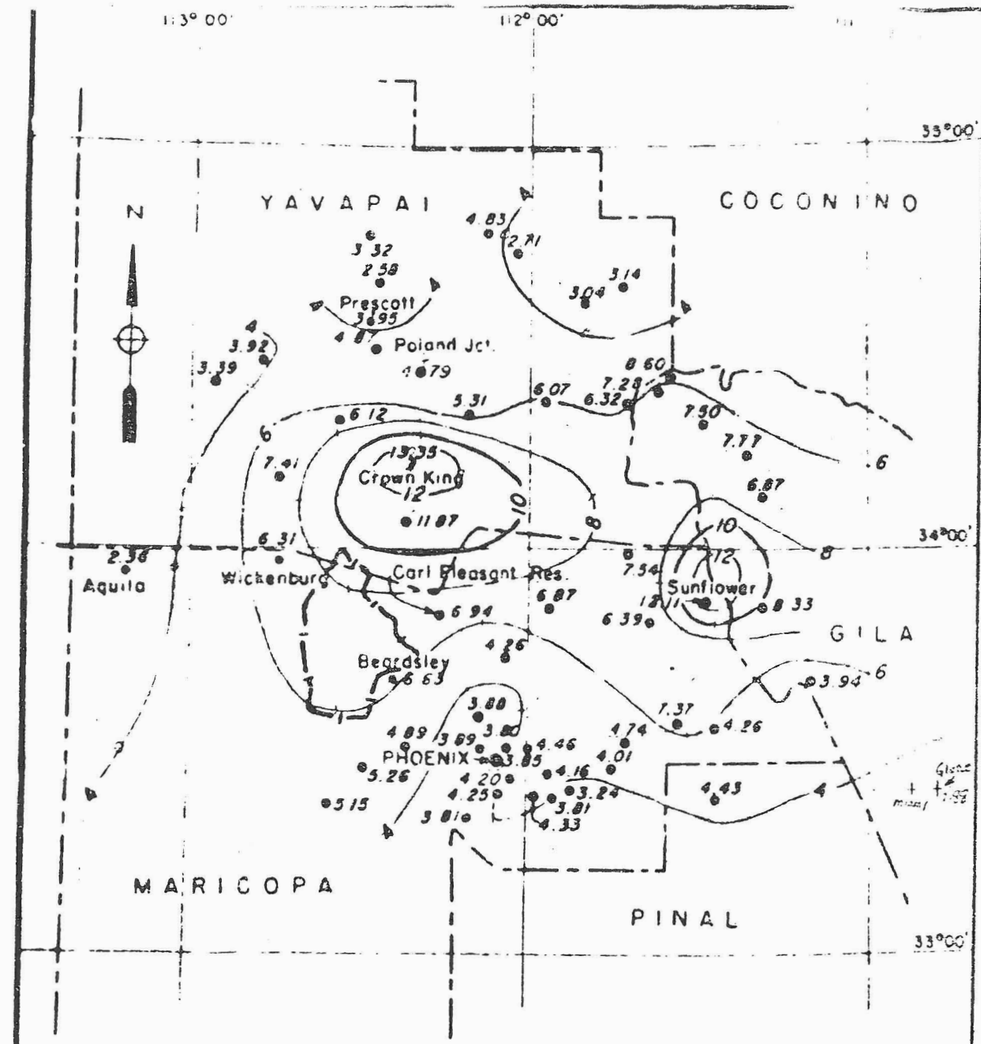

VICINITY MAP
TRILBY WASH DETENTION BASIN
DRAINAGE SUBAREAS
CONCENTRATION POINTS
AND
PRECIPITATION STATIONS
IN ONE SHEET
OFFICE OF THE DISTRICT ENGINEER, LOS ANGELES, CALIF. OCT 1953
PREPARED UNDER THE DIRECTION OF
ARTHUR H. FRYE JR. COL., C.E. DISTRICT ENGINEER
LEGEND
EXISTING RESERVOIR
EXISTING DIVERSION DAM
DETENTION BASIN
EXISTING PRECIPITATION STATION AND NUMBER
PROPOSED RECORDING PRECIPITATION STATION
CONCENTRATION POINT NUMBER
SUBAREA DESIGNATION
OUTLET CHANNEL
TRILBY WASH DETENTION BASIN
HIEROGLYPHIC MTS
WICKENBURG MTS
WHITE TANK MTS
GILA RIVER
SALT RIVER
Tolleson
Avondale
Goodyear
Buckeye
Morristown
Wickenburg
Lake Pleasant (Reservoir)
CARL PLEASANT DAM
LITCHFIELD PARK NAVAL AIR FACILITY
GOODYEAR AIRCRAFT CO.
CATERPILLAR TRACTOR CO PROVING GROUNDS
MARICOPA COUNTY MUNICIPAL WATER CONSERVATION DISTRICT NO. 1

PLATE 1

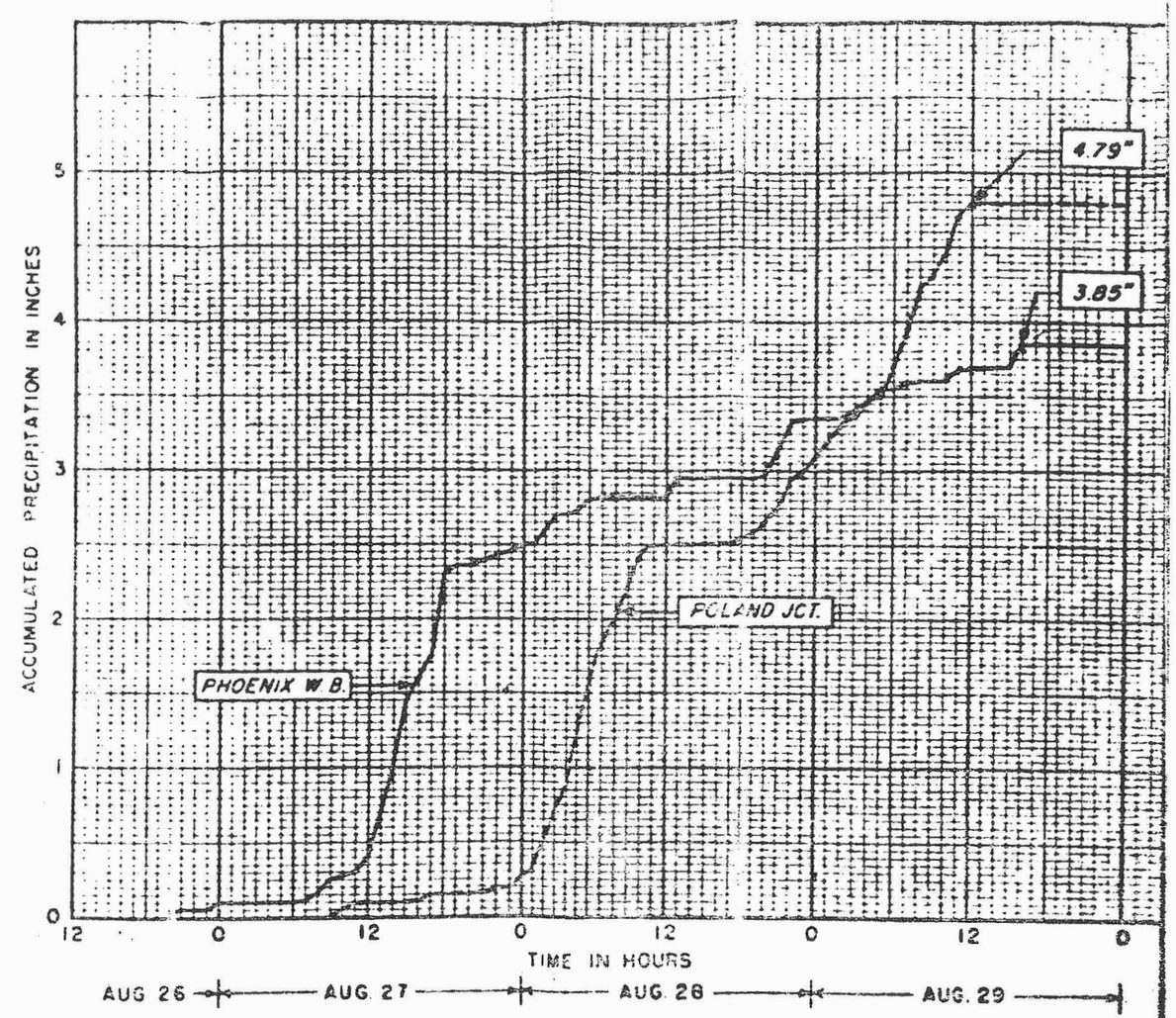


ISOHYETS
TOTAL STORM PRECIPITATION

SCALE 10 0 10 20 30 40 MILES

LEGEND

- BOUNDARY OF DRAINAGE AREA.
- LINE OF EQUAL PRECIPITATION IN INCHES.
- 6.31 RECORDED PRECIPITATION DEPTH IN INCHES.



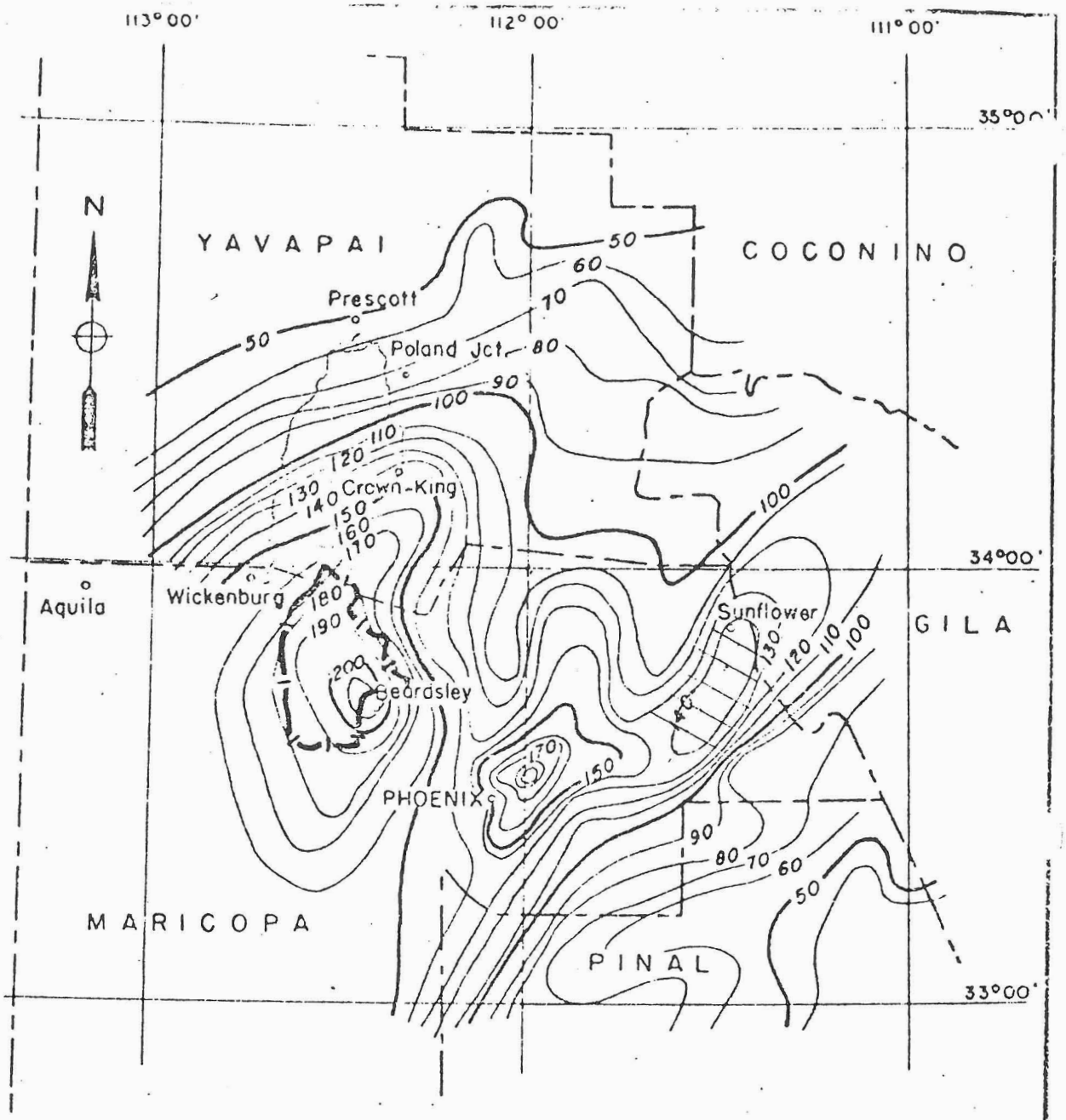
MASS CURVES OF PRECIPITATION

FLOOD CONTROL, LOWER AGUA FRIA RIVER AND VICINITY, MARICOPA COUNTY, ARIZONA

TRILBY WASH DETENTION BASIN
HYDROLOGIC DATA
STORM OF AUG. 28-29, 1951

OFFICE OF THE DISTRICT ENGINEER
LOS ANGELES, CALIFORNIA
TO ACCOMPANY DESIGN MEMO NO. 1 DATED: NOV. 1954

FILE NO. 409/108 PLATE 2



SCALE 10 0 10 20 30 40 MILES

LEGEND

BOUNDARY OF DRAINAGE AREA.

140 LINE OF EQUAL PERCENTAGE.

FLOOD CONTROL, LOWER AGUA FRIA RIVER AND VICINITY, MARICOPA COUNTY, ARIZONA

TRILBY WASH DETENTION BASIN

ISOPERCENTUAL LINES

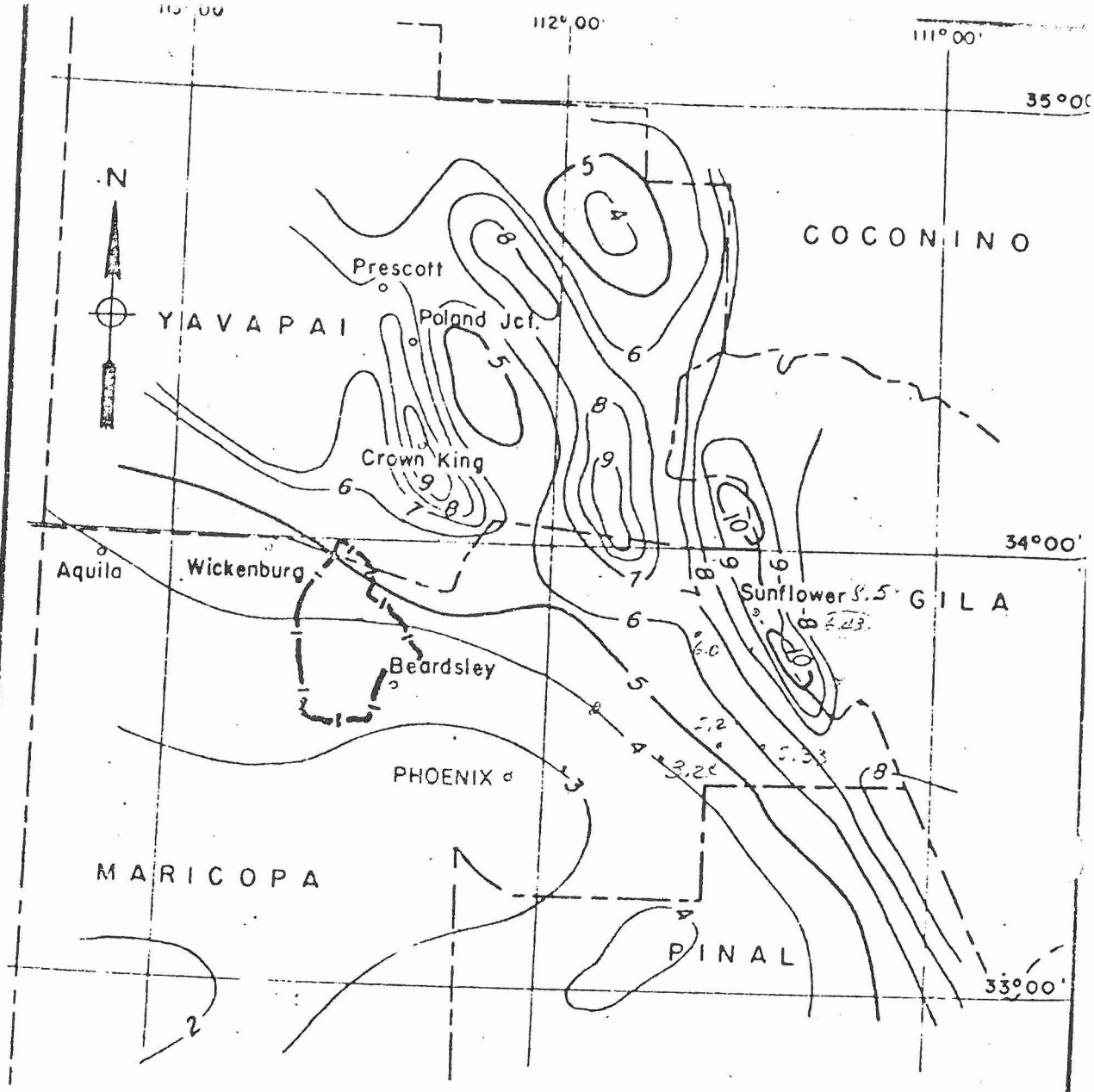
TOTAL STORM PRECIPITATION IN PERCENT OF MEAN SUMMER SEASONAL PRECIPITATION

STORM OF AUG. 26-29, 1951

OFFICE OF THE DISTRICT ENGINEER
LOS ANGELES, CALIFORNIA

TO ACCOMPANY DESIGN MEMO NO 1 DATED: NOV. 1953

FILE NO. 409/109 PLATE 3



SCALE 10 0 10 20 30 40 MILES

LEGEND

—I— BOUNDARY OF DRAINAGE AREA.

—8— LINE OF EQUAL PRECIPITATION IN INCHES.

FLOOD CONTROL, LOWER AGUA FRIA RIVER AND VICINITY, MARICOPA COUNTY, ARIZONA

TRILBY WASH DETENTION BASIN

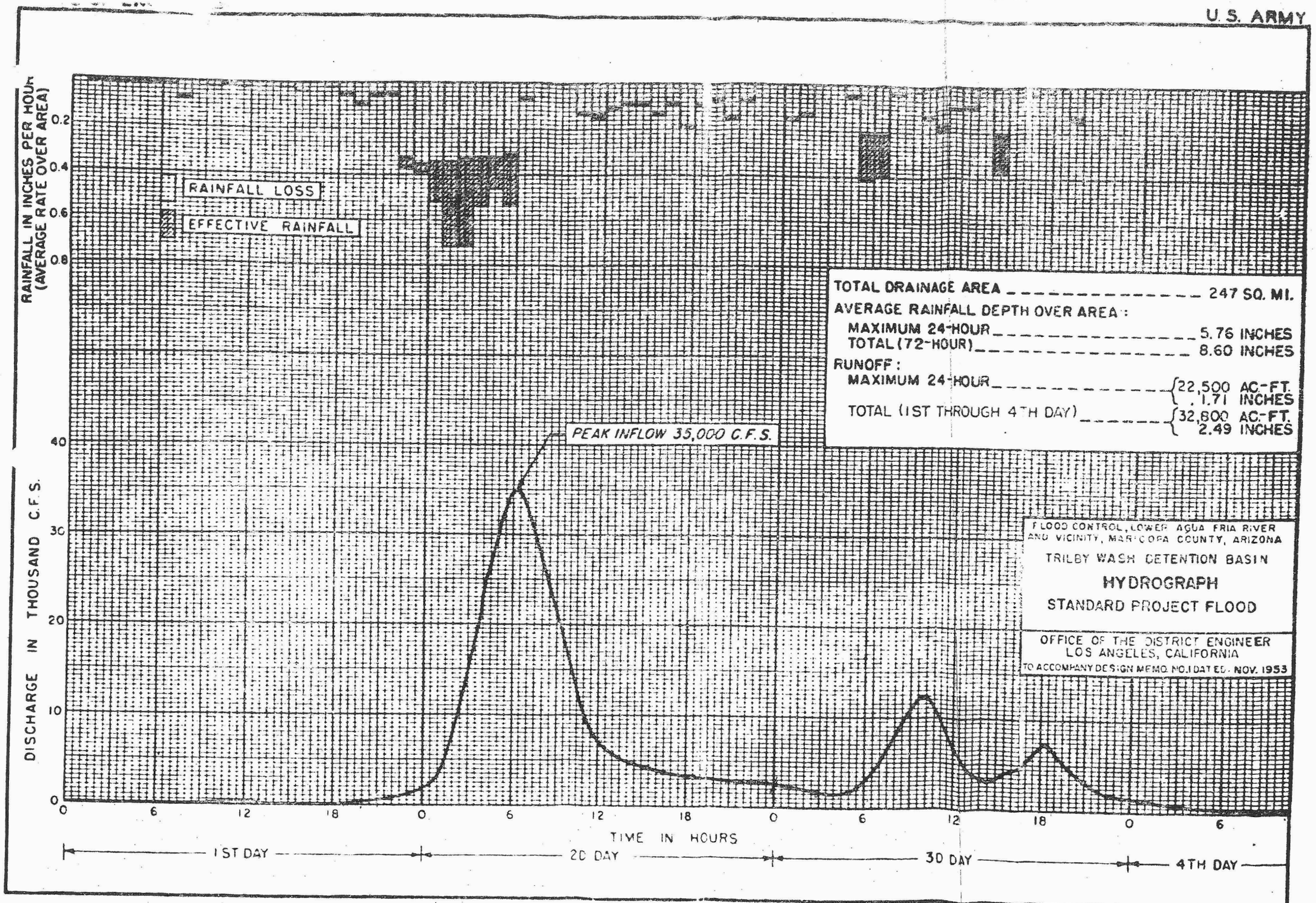
ISOHYETS

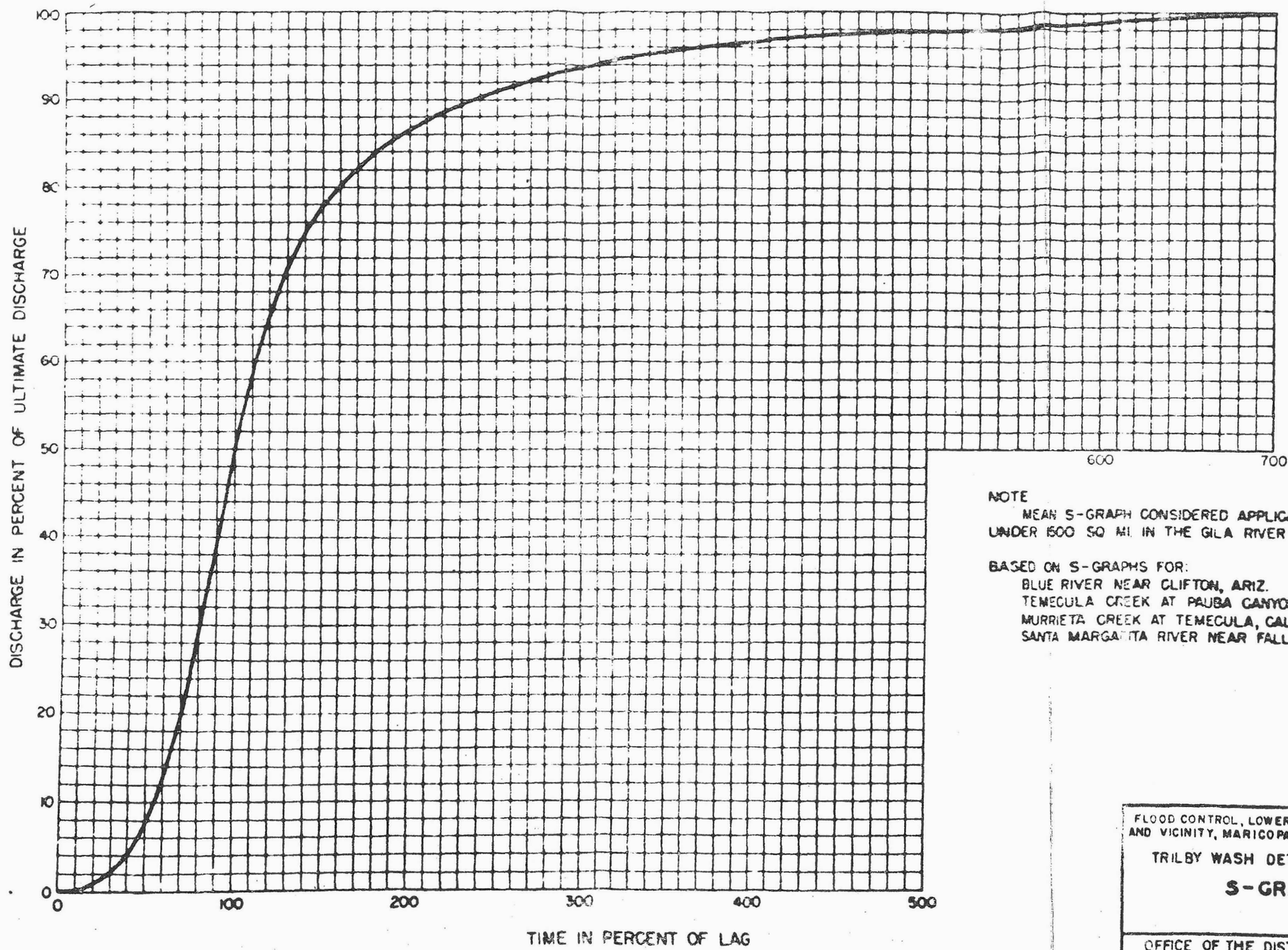
MEAN SUMMER ~~SEASONAL~~ PRECIPITATION

OFFICE OF THE DISTRICT ENGINEER
LOS ANGELES, CALIFORNIA
TO ACCOMPANY DESIGN MEMO. NO. 1 DATED NOV. 1953

FILE NO. 409/110

PLATE 4


RAINFALL IN INCHES PER HOUR (AVERAGE RATE OVER AREA)
0.2
0.4
0.6
0.8
RAINFALL LOSS
EFFECTIVE RAINFALL
PEAK INFLOW 35,000 C.F.S.
DISCHARGE IN THOUSAND C.F.S.
40
30
20
10
0
0
6
12
18
0
6
12
18
0
6
12
18
0
6
TIME IN HOURS
1ST DAY
2D DAY
3D DAY
4TH DAY
TOTAL DRAINAGE AREA 247 SQ. MI.
AVERAGE RAINFALL DEPTH OVER AREA:
MAXIMUM 24-HOUR 5.76 INCHES
TOTAL (72-HOUR) 8.60 INCHES
RUNOFF:
MAXIMUM 24-HOUR 22,500 AC.-FT. 1.71 INCHES
TOTAL (1ST THROUGH 4TH DAY) 32,800 AC.-FT. 2.49 INCHES
FLOOD CONTROL, LOWER AGUA FRIA RIVER AND VICINITY, MARICOPA COUNTY, ARIZONA
TRILBY WASH DETENTION BASIN
HYDROGRAPH
STANDARD PROJECT FLOOD
OFFICE OF THE DISTRICT ENGINEER
LOS ANGELES, CALIFORNIA
TO ACCOMPANY DESIGN MEMO. NO. 1 DATED NOV. 1953



NOTE
MEAN S-GRAPH CONSIDERED APPLICABLE FOR AREAS UNDER 1500 SQ MI. IN THE GILA RIVER BASIN.

BASED ON S-GRAPHS FOR:
BLUE RIVER NEAR CLIFTON, ARIZ.
TEMECULA CREEK AT PAUBA CANYON, CALIF.
MURRIETA CREEK AT TEMECULA, CALIF.
SANTA MARGARITA RIVER NEAR FALLBROOK, CALIF.

FLOOD CONTROL, LOWER AGUA FRIA RIVER AND VICINITY, MARICOPA COUNTY, ARIZONA

TRILBY WASH DETENTION BASIN

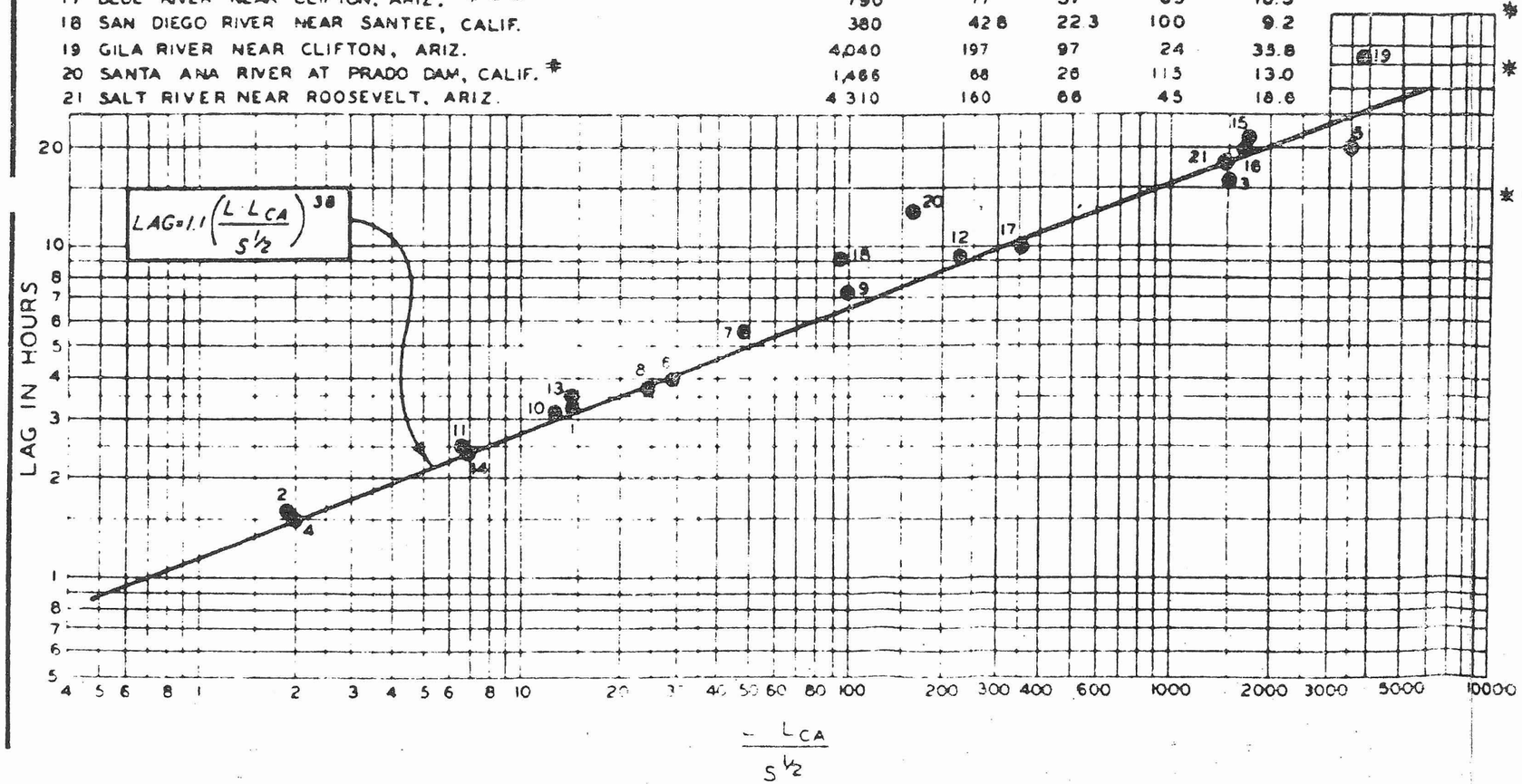
S-GRAPH

OFFICE OF THE DISTRICT ENGINEER
LOS ANGELES, CALIFORNIA
TO ACCOMPANY DESIGN MEMO. NO. 1 DATED NOV. 1953

FILE NO. 409/112

PLATE 6

		DRAINAGE AREA SQ. MI.	L MILES	L_{CA} MILES	S FT./MI.	LAG HOURS
1	SAN GABRIEL RIVER AT SAN GABRIEL DAM NO. 1, CALIF. *	162	23.2	11.6	350	3.3
2	WEST FORK SAN GABRIEL RIVER AT SAN GABRIEL DAM NO. 2, CALIF.	40.4	9.3	4.2	450	1.8
3	SANTA ANITA CREEK AT SANTA ANITA DAM, CALIF.	10.8	5.8	2.5	690	1.1
4	SAN DIMAS CREEK AT SAN DIMAS DAM, CALIF.	16.2	3.8	4.8	440	1.5
5	EATON WASH AT EATON WASH DAM, CALIF.	9.5	7.3	4.4	600	1.3
6.	MURRIETA CREEK AT TEMECULA, CALIF.	220	27.2	10.3	95	4.0
7	SANTA CLARA RIVER NEAR SAUGUS, CALIF.	355	38.0	15.8	140	5.6
8	TEMECULA CREEK AT PAUBA CANYON, CALIF. **	168	26.0	11.3	150	3.7
9	SANTA MARGARITA RIVER NEAR FALLBROOK, CALIF.	645	46.0	22.0	105	7.3
10	SAN VICENTE CREEK AT FOSTER, CALIF.	75	18.2	7.4	111	3.2
11	TUJUNGA CREEK AT BIG TUJUNGA DAM NO. 1, CALIF.	81.4	15.1	7.3	290	2.5
12	SANTA MARGARITA RIVER AT YSIDORA, CALIF.	740	61.2	34.3	85	9.5
13	LOS ANGELES RIVER AT SEPULVEDA DAM, CALIF.	152	19.0	9.0	145	3.5
14	PACOIMA WASH AT PACOIMA DAM, CALIF.	27.8	15.0	8.0	315	2.4
15	GILA RIVER AT CONNER NO 4 DAM SITE, ARIZ.	2,840	131	71	29	21.5
16.	SAN FRANCISCO RIVER AT JUNCTION WITH BLUE RIVER, ARIZ. ***	2,000	130	74	32	20.8
17	BLUE RIVER NEAR CLIFTON, ARIZ. ***	790	77	37	65	10.3
18	SAN DIEGO RIVER NEAR SANTEE, CALIF.	380	42.8	22.3	100	9.2
19	GILA RIVER NEAR CLIFTON, ARIZ.	4,040	197	97	24	35.8
20	SANTA ANA RIVER AT PRADO DAM, CALIF. #	1,466	68	28	113	13.0
21	SALT RIVER NEAR ROOSEVELT, ARIZ.	4,310	160	66	45	18.6



TERMINOLOGY

L = LENGTH OF LONGEST WATERCOURSE.

L_{CA} = LENGTH OF LONGEST WATERCOURSE, MEASURED UPSTREAM, TO POINT OPPOSITE CENTER OF AREA.

S = OVER-ALL SLOPE OF DRAINAGE AREA BETWEEN HEADWATERS AND COLLECTION POINT.

LAG = ELAPSED TIME FROM BEGINNING OF UNIT RAINFALL TO INSTANT THAT SUMMATION HYDROGRAPH REACHES 50% OF ULTIMATE DISCHARGE.

* EXCLUDES AREA ABOVE SAN GABRIEL DAM NO. 2.

** PALOMAR MOUNTAIN PORTION. ENTIRE AREA IS 319 SQUARE MILES, OF WHICH 151 SQUARE MILES DID NOT CONTRIBUTE APPRECIABLE FLOOD FLOWS DURING THE FLOODS ANALYZED.

*** UNIT-GRAPH STUDY BASED ON RUN-OFF RECORDS FOR SAN FRANCISCO RIVER AT CLIFTON (DRAINAGE AREA = 2790 SQ. MI.)

\# EXCLUDES 25 SQUARE MILES TRIBUTARY TO BALDWIN LAKE AND 767 SQUARE MILES TRIBUTARY TO LAKE ELSINORE.

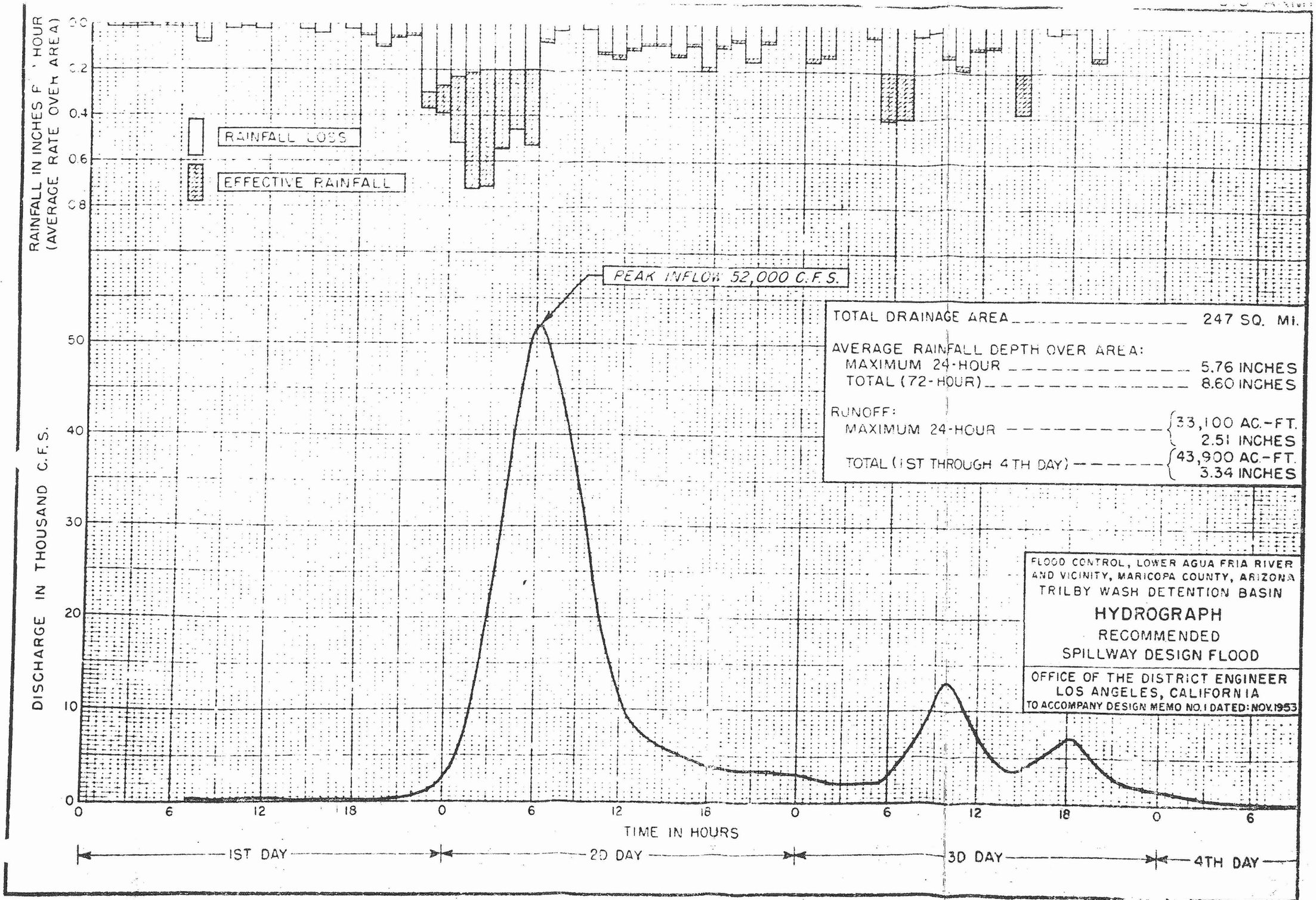
FLOOD CONTROL, LOWER AGUA FRIA RIVER AND VICINITY, MARICOPA COUNTY, ARIZONA

TRILBY WASH DETENTION BASIN

LAG RELATIONSHIPS

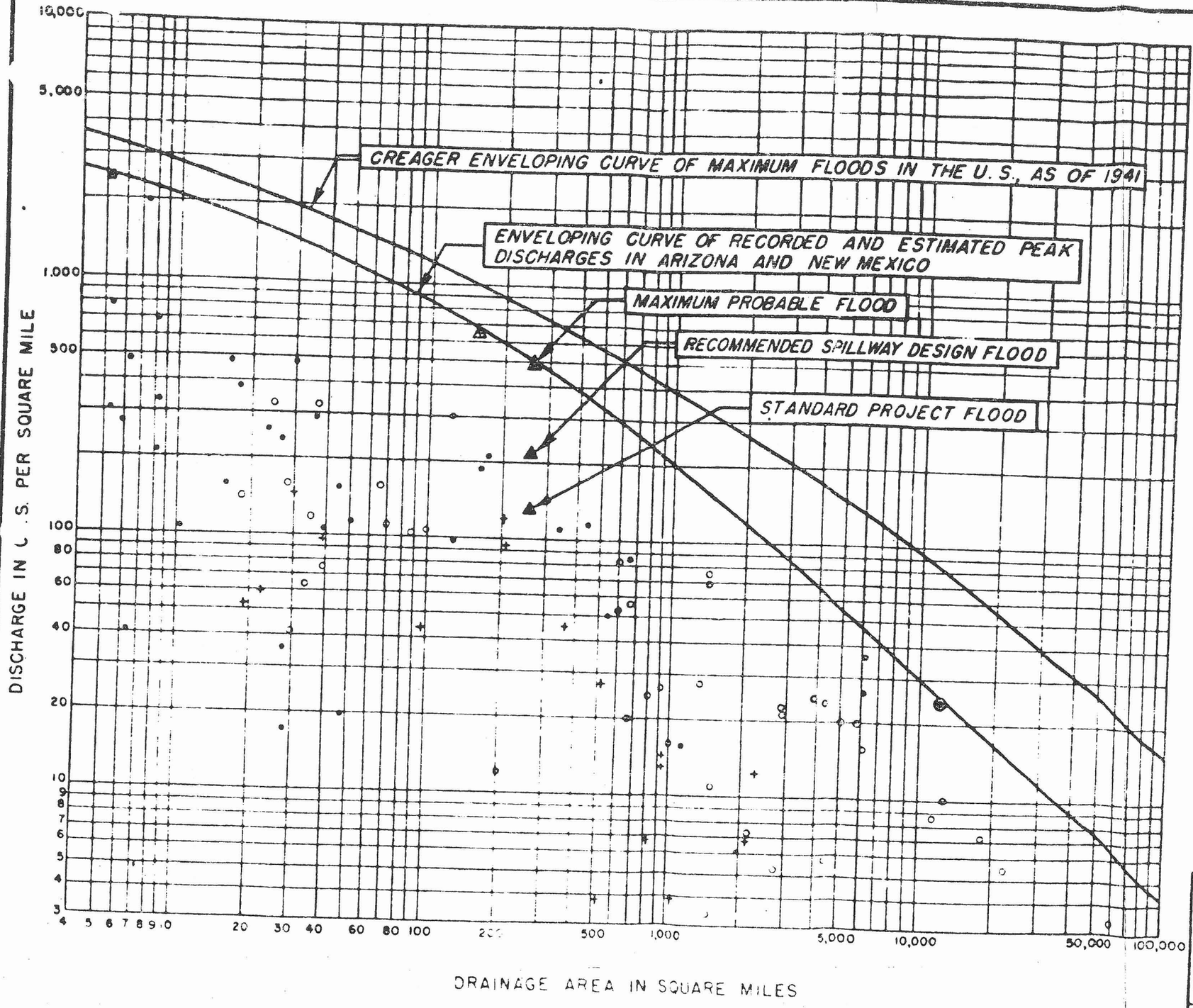
OFFICE OF THE DISTRICT ENGINEER
LOS ANGELES, CALIFORNIA
TO ACCOMPANY DETION MEMO NO. LA-LO NOV 1953

FILE NO. 409/113 PLATE 7



FILE NO. 409/114

PLATE 8



LEGEND

- ○ FLOODS FROM GENERAL RAIN OR SNOW MELT RUNOFF
- + FLOODS FROM LOCAL SUMMER STORMS.
- • FLOOD TYPE UNDETERMINED.
- ■ ALDER CREEK AT MOUTH-LOCAL STORM.
- △ BEAR CREEK AT MOUTH-LOCAL STORM.
- ● SALT RIVER AT GRANITE REEF DAM-GENERAL STORM.

FLOOD CONTROL, LOWER AGUA FRIA RIVER AND VICINITY, MARICOPA COUNTY, ARIZONA

TRILBY WASH DETENTION BASIN

PEAK DISCHARGES

STREAMS IN ARIZONA AND NEW MEXICO

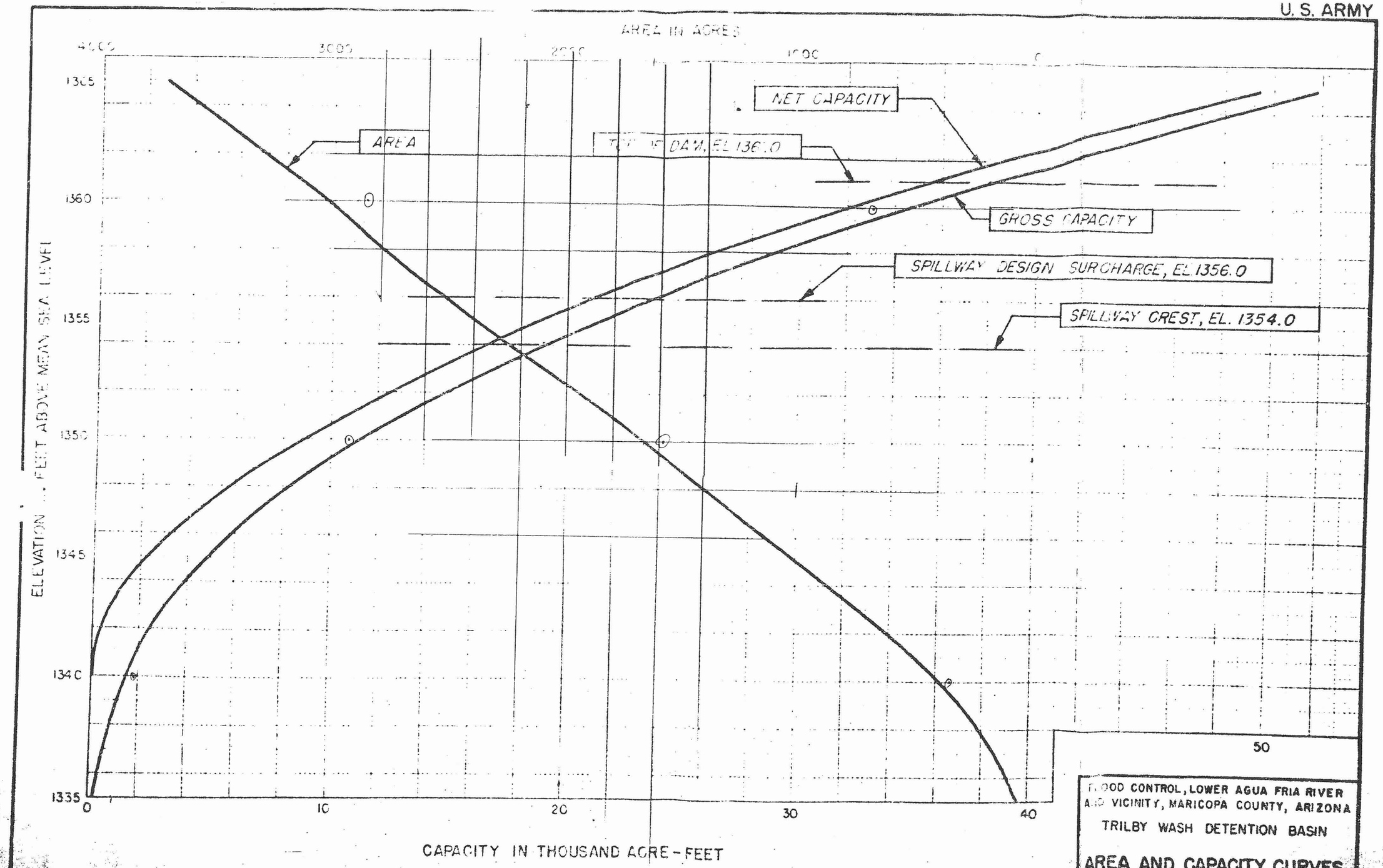
OFFICE OF THE DISTRICT ENGINEER
LOS ANGELES, CALIFORNIA

TO ACCOMPANY DESIGN MEMO. NO. 1 DATED. NOV. 1953

FILE NO. 409/115

PLATE 9

U. S. ARMY



FLOOD CONTROL, LOWER AGUA FRIA RIVER AND VICINITY, MARICOPA COUNTY, ARIZONA

TRILBY WASH DETENTION BASIN

AREA AND CAPACITY CURVES

OFFICE OF THE DISTRICT ENGINEER
LOS ANGELES, CALIFORNIA
TO ACCOMPANY DESIGN MEMO NO. 1 DATED NOV. 1953

FILE NO. 409/116 PLATE 10

DOCUMENT TITLE: Design Memorandum No. 2, Design Analysis for Trilby Wash Detention Basin and Outlet Channel

DATE: March 1, 1954

PREPARED BY: USACE Sacramento District, (CESPK)

PURPOSE:

Present design analysis for dam, outlet works, and outlet channel.

SUMMARY:

- Memo documents revisions to original hydraulic design memo (No. 1)
- Changes from original design include:
  - Stilling basin and Beardsley Channel Siphon geometry design changes
  - Embankment design length increased by ~700 feet at right abutment
  - Outlet channel widened from 20 to 30 feet
  - All 48-inch and four 24-inch drain pipes eliminated
  - Foundation inspection trench eliminated
  - Sand and gravel blanket on upstream face eliminated
  - Spillway approach channel lowered by two feet
- New dam to be incorporated into old dam (1952)
- New outlet works will provide uncontrolled releases up to 4,450 second-feet
- An open channel design of the Beardsley Channel
- Outlet works design incorporated saturated soil condition at concrete outlet structure
- Case loading for various outlet works structures discussed
- Emergency Spillway designed to be:

- 2,000 feet long located at north end of dam
- Grouted rock broad-crested weir with grouted rock abutments
- Left and right abutments to be protected by one foot thick grouted rock paving on six inch sand/gravel filter
- Emergency spillway training dike slopes designed with 2.5:1 channel side and 2:1 landward side
- Several loading conditions analyzed

- Drainage pipe design discussed
- Bridge design discussed
- Hydraulic design of structures discussed
- Borrow site for embankment fill is from the proposed "minor flood channel," located on the upstream face/reservoir side of dam.
- Generally, the borrow soils are fine-grained including: sandy clay, sandy silt, and clayey and silty sand
- Numerous small washes cross the axis of the dam, and are filled with sand and gravelly soils
- June & July 1952, 34 borings were advanced,16- to 24-inch diameter and 4 to 35 feet deep
- October 1953, twenty-four 30-inch diameter borings drilled at various locations along the proposed embankment alignment, outlet works, and canal siphon from 10 to 40 feet deep
- Six test pits were excavated along dam axis, from 5 to 10 feet deep
- Laboratory analysis included: density, compaction, direct shear (remolded borrow, compacted to 95% std AASHTO), triaxial shear (on foundation sample, and one existing embankment sample), permeability (remolded borrow, compacted to 95% of standard AASHTO), consolidation (one foundation, and one existing embankment)

FINDINGS/RESULTS:

- Stability analysis conditions:
  - Embankment will never see full saturation as design time for full storage is only five days

- Drawdown conditions exist while reservoir empties at rate of 4 ft/day
- Seismic forces not considered
- FS = 1.25 for gravity forces only
- FS = 1.25 for water at el. 1354
- FS = 1.00 for sudden drawdown from el. 1354
- Infinite arc and circular arc failure surfaces analyzed

- Settlement analysis revealed that consolidation will occur mostly during construction
- Relatively low permeability of embankment soils results in only partial saturation of embankment; saturation line would extend only 1/2 of base width of embankment (4ft/day permeability)
- Sand and gravel filter will be placed beneath riprap at outlet works and spillway; to be borrowed from Agua Fria riverbed near Luke Air Force Base

CONCLUSIONS AND RECOMMENDATIONS:

- Generally, neither conclusions nor recommendations were provided. One exception is a statement that the principal spillway will be "very satisfactory" as designed

07-21

FLOOD CONTROL

LOWER AGUA FRIA RIVER AND VICINITY

MARICOPA COUNTY, ARIZ.

DESIGN MEMORANDUM NO. 2

DESIGN ANALYSIS

FOR 07-21

TRILBY WASH DETENTION BASIN

AND

OUTLET CHANNEL

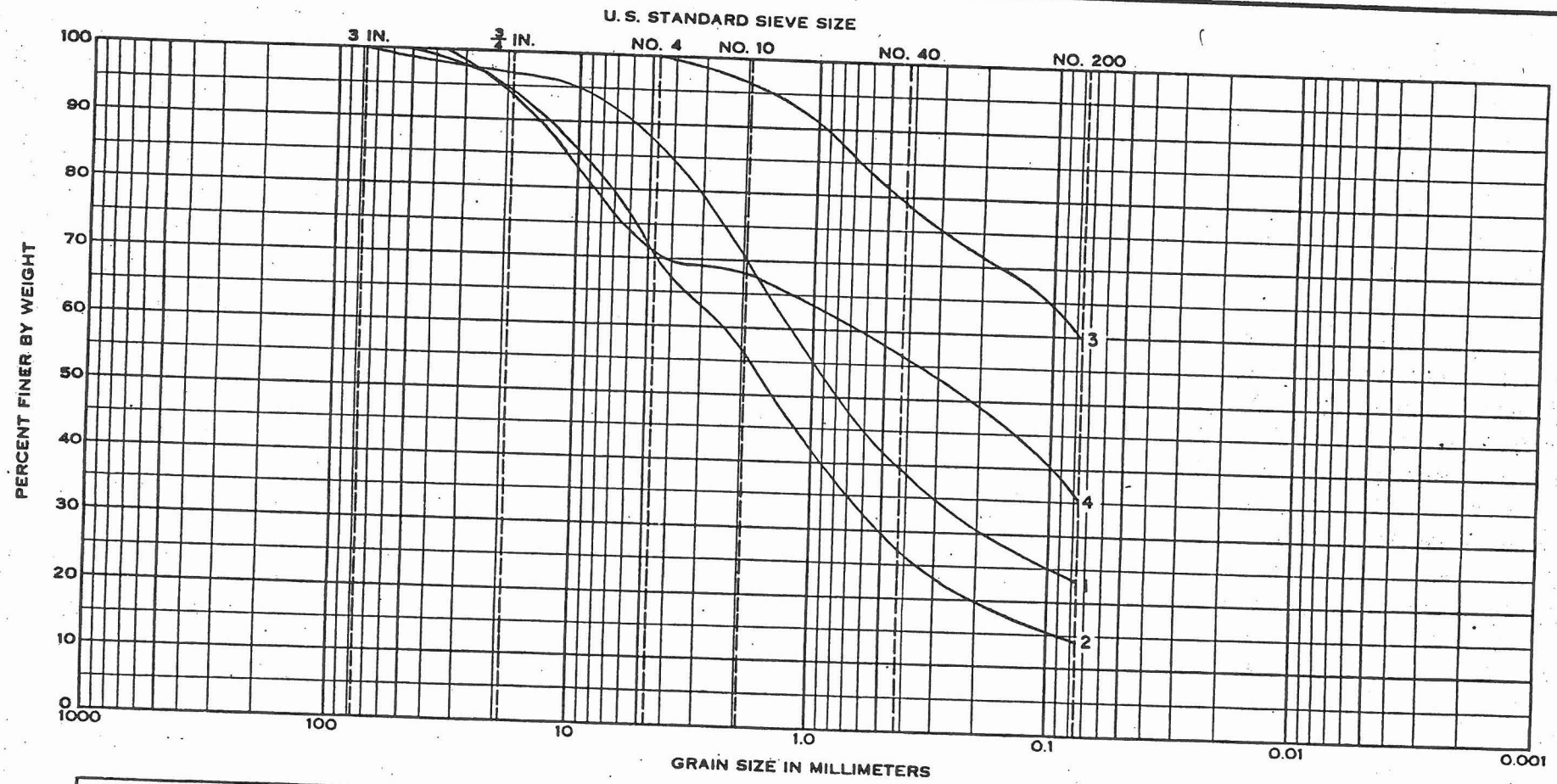
MARCH 1954

SACRAMENTO DISTRICT

CORPS OF ENGINEERS

U. S. ARMY

SACRAMENTO, CALIFORNIA



COBBLES	GRAVEL		SAND			SILT OR CLAY
	Coarse	Fine	Coarse	Medium	Fine	

Hole No.	Elev or Depth	Classification	Nat WC	LL	PL	PI	Curve No.
4F-2	8.0-10.0	SILTY SAND (SM)	2.9%			NP	1
52-6	9.0-12.0	SILTY GRAVELLY SAND (SM)	–			NP	2
2F-4 & 4F-6	1.5-2.5	SANDY CLAY (CL)	6.6%	39	18	21	3
2F-12	0.0-3.5	GRAVELLY SILTY SAND (SM)	4.1%			NP	4

GRADATION CURVES

AGUA FRIA PROJECT
DAM AND APPURTENANCES

TYPICAL GRADATION CURVES

OFFICE OF THE DISTRICT ENGINEER
SACRAMENTO, CALIFORNIA

Soils Section December 1953

ENG FORM 1 DEC 51 2087

GPO 53-72489

Sheet 1 Inclosure 4

SOUTH PACIFIC DIVISION LABORATORY
CORPS OF ENGINEERS- U.S. ARMY
SAUSALITO, CALIFORNIA

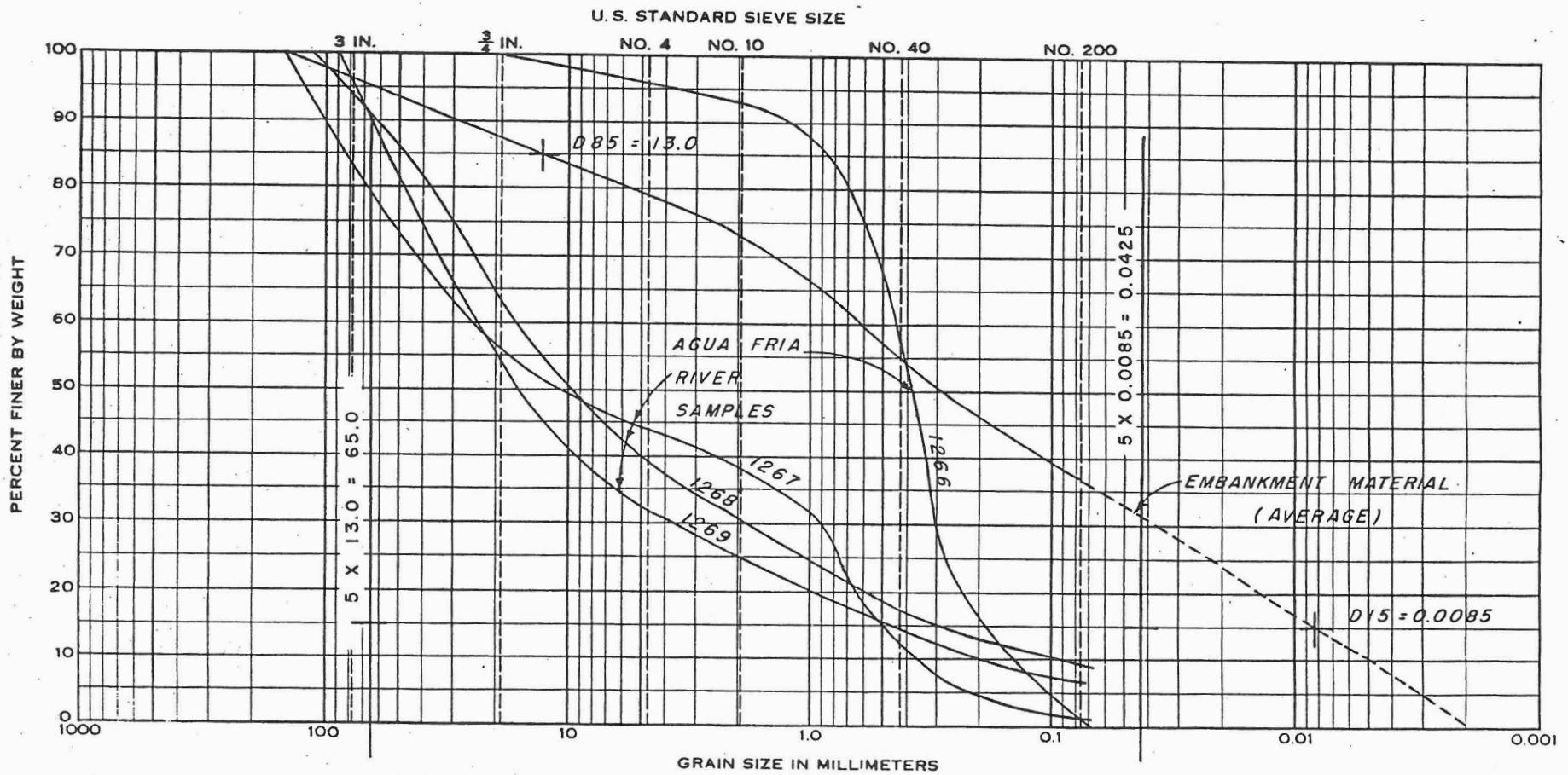
AGUA FRIA PROJECT

SUMMARY OF PERMEABILITY TESTS

DIVISION NO.	HOLE NO.	F.S. NO.	DEPTH, (FT.)	DENSITY lbs/cu.ft.	PERMEABILITY "K" Ft/Day	HYDRAULIC GRADIENT i
3755-LA	4F-1	1-UD	2.5-3.5	125 *	28.0 **	.20
3756-LA	4F-1	2-UD	5.0-6.0	105	1.2	.35
3757-LA	4F-2	1-UD	2.3-3.3	82	4.0	.29
3758-LA	4F-2	2-UD	4.0-5.0	100	1.6	.37
3759-LA	4F-3	1-UD	3.0-4.0	100	0.1	.39
3760-LA	4F-3	2-UD	8.0-9.0	101 *	1.9	.27
3761-LA	4F-4	1-UD	3.2-4.2	108	1.0	.29
3762-LA	4F-4	2-UD	9.0-10.0	99	0.5	.42
3764-LA	4F-5	2-UD	8.5-9.5	106	1.1	.46
3765-LA	4F-6	1-UD	1.5-2.5	102	1.0	.51
3766-LA	4F-6	2-UD	3.5-4.5	99	3.0	.33

* Density obtained after permeability.

** Permeability performed on entire sample.



COBBLES	GRAVEL		SAND			SILT OR CLAY
	Coarse	Fine	Coarse	Medium	Fine	

Sample No.	Elev or Depth	Classification	NatWC	LL	PL	PI
1266	RIVER BED	SAND (SP)				
1267	RIVER BED	SANDY GRAVEL (GW) W/COBBLES				
1268	WEST BANK	SANDY GRAVEL (GW)				
1269	WEST BANK	SANDY GRAVEL (GW)				

GRADATION CURVES

AGUA FRIA PROJECT
DAM AND APPURTENANCES
GRADATION AND LIMITS FOR FILTER MATERIALS

OFFICE OF THE DISTRICT ENGINEER
SACRAMENTO, CALIFORNIA

Soils Section December 1953

Sheet 1 Inclosure 5

ENG FORM 1 DEC 51 2067

DOCUMENT TITLE: Trilby Wash Detention Basin Dam and Appurtenances (As Constructed)

DATE: July 26, 1956

PREPARED BY: USACE (Los Angeles District)

PURPOSE:

Present construction plan and record of actual construction.

SUMMARY:

- Principal Spillway is an ungated, reinforced concrete box and U-channel with an entry section, a bridge/wier section, a chute section and a stilling basing section
- Principal Spillway has a 4-foot cut-off wall outside the channel at the weir location
- "Outlet works" are at dam Station 476+80.02
- Soil types reported on the boring logs for boreholes advanced near the Principal Spillway are generally clayey or silty sands with some cementation noted
- Smallest opening in Spillway is 20 feet by 11 feet
- The length from the west end to the east end is 188.33 feet.
- Steel reinforcement in channel walls is 12 inches on center and ranges from #5 bars to #11 bars
- Beardsley Canal is siphoned under east end of stilling basin through a box culvert

GILA RIVER AND TRIBUTARIES, ARIZONA

AGUA FRIA PROJECT

LOWER AGUA FRIA RIVER

TRILBY WASH DETENTION BASIN DAM AND APPURTENANCES

U.S. ARMY ENGINEER DISTRICT, LOS ANGELES
CORPS OF ENGINEERS

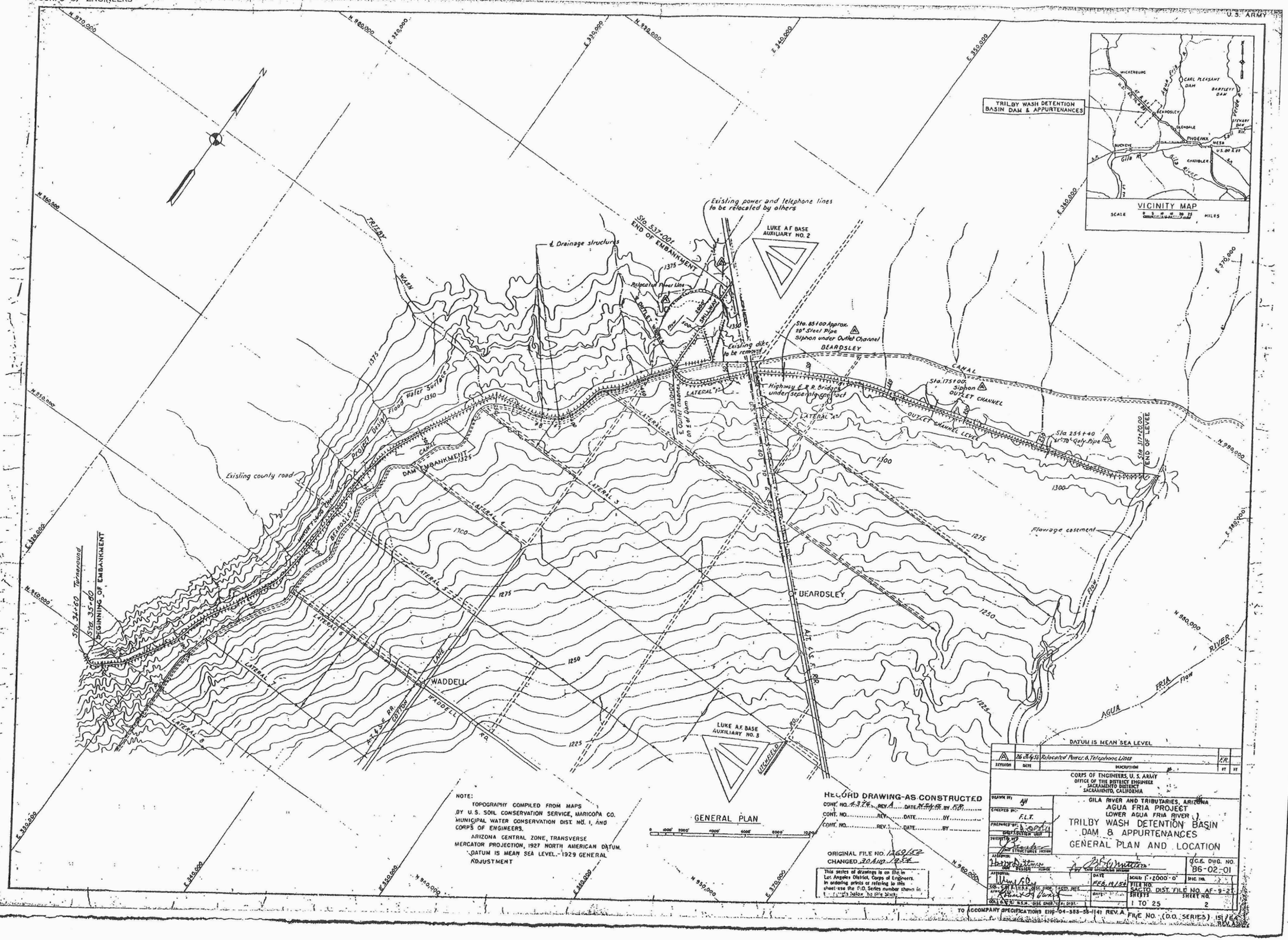
AS CONSTRUCTED

TO ACCOMPANY SPECIFICATIONS
ENG 04-353-55-141
DATED:

DRAWINGS IN THIS FOLIO HAVE BEEN REDUCED TO ONE HALF THE ORIGINAL SCALE

CORPS OF ENGINEERS

U.S. ARMY



NOTE:

TOPOGRAPHY COMPILED FROM MAPS BY U.S. SOIL CONSERVATION SERVICE, MARICOPA CO. MUNICIPAL WATER CONSERVATION DIST. NO. 1, AND CORPS OF ENGINEERS.

ARIZONA CENTRAL ZONE, TRANSVERSE MERCATOR PROJECTION, 1927 NORTH AMERICAN DATUM. DATUM IS MEAN SEA LEVEL.-1929 GENERAL ADJUSTMENT

GENERAL PLAN

0 1000' 2000' 4000' 6000' 8000' 10000'

RECORD DRAWING-AS CONSTRUCTED

CONT. NO. 4376 REV. A DATE 4-24-58 BY F.R.

CONT. NO. ..... REV. ..... DATE ..... BY .....

CONT. NO. ..... REV. ..... DATE ..... BY .....

ORIGINAL FILE NO. 1269/152

CHANGED 20 Aug 1954

This series of drawings is on file in Los Angeles District, Corps of Engineers. In ordering prints or referring to this sheet use the D.O. Series number shown in parentheses below the title block.

DATUM IS MEAN SEA LEVEL

REVISION	DATE	DESCRIPTION		
A	26 Apr 58	Relocated Power & Telephone Lines	F.R.	

CORPS OF ENGINEERS, U. S. ARMY
OFFICE OF THE DISTRICT ENGINEER
SACRAMENTO DISTRICT
SACRAMENTO, CALIFORNIA

DRAWN BY: AH
CHECKED BY: F.L.T.
PREPARED BY: [illegible]
DESCRIPTION UNIT
SUBMITTED BY: [illegible]
STRUCTURES DIVISION
APPROVED: [illegible]
CHIEF DESIGN BRANCH
APPROVED: [illegible]
CHIEF DESIGN DIVISION
APPROVED: [illegible]
COL., CORPS OF ENGINEERS, DIST. ENGR., SACTO. DIST.
APPROVED: [illegible]
COL., C.E., U.S.A., DIST. ENGR., L.A. DIST.

GILA RIVER AND TRIBUTARIES, ARIZONA
AGUA FRIA PROJECT
LOWER AGUA FRIA RIVER
TRILBY WASH DETENTION BASIN
DAM & APPURTENANCES
GENERAL PLAN AND LOCATION

C.E. DWG. NO. 86-02-01

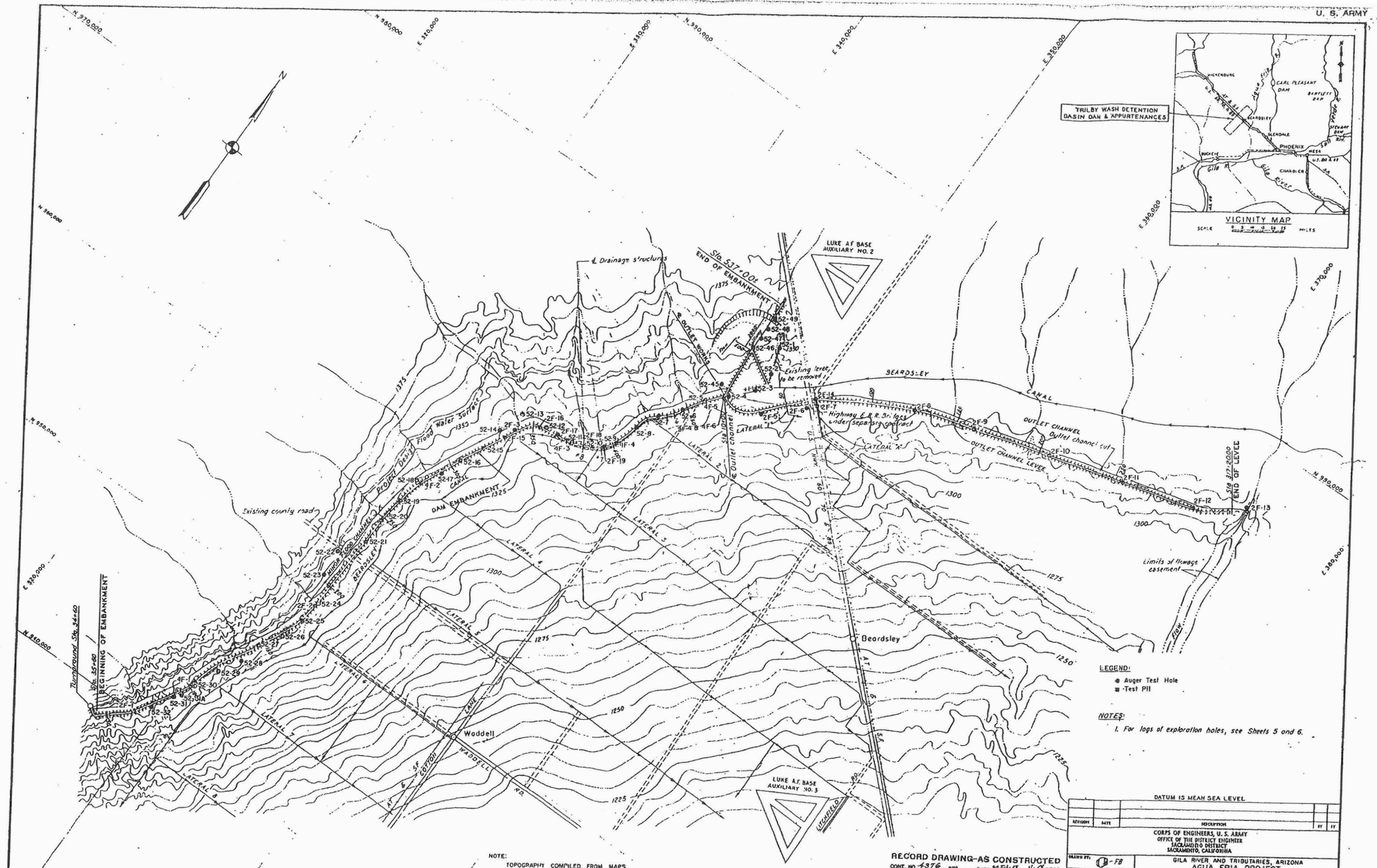
DATE FEB. 19, 1954
SCALE 1" = 2000'-0"
SHC. NO.
FILE NO. SACTO. DIST. FILE NO. AF-9-27
SHEETS 1 TO 25
SHEET NO. 2

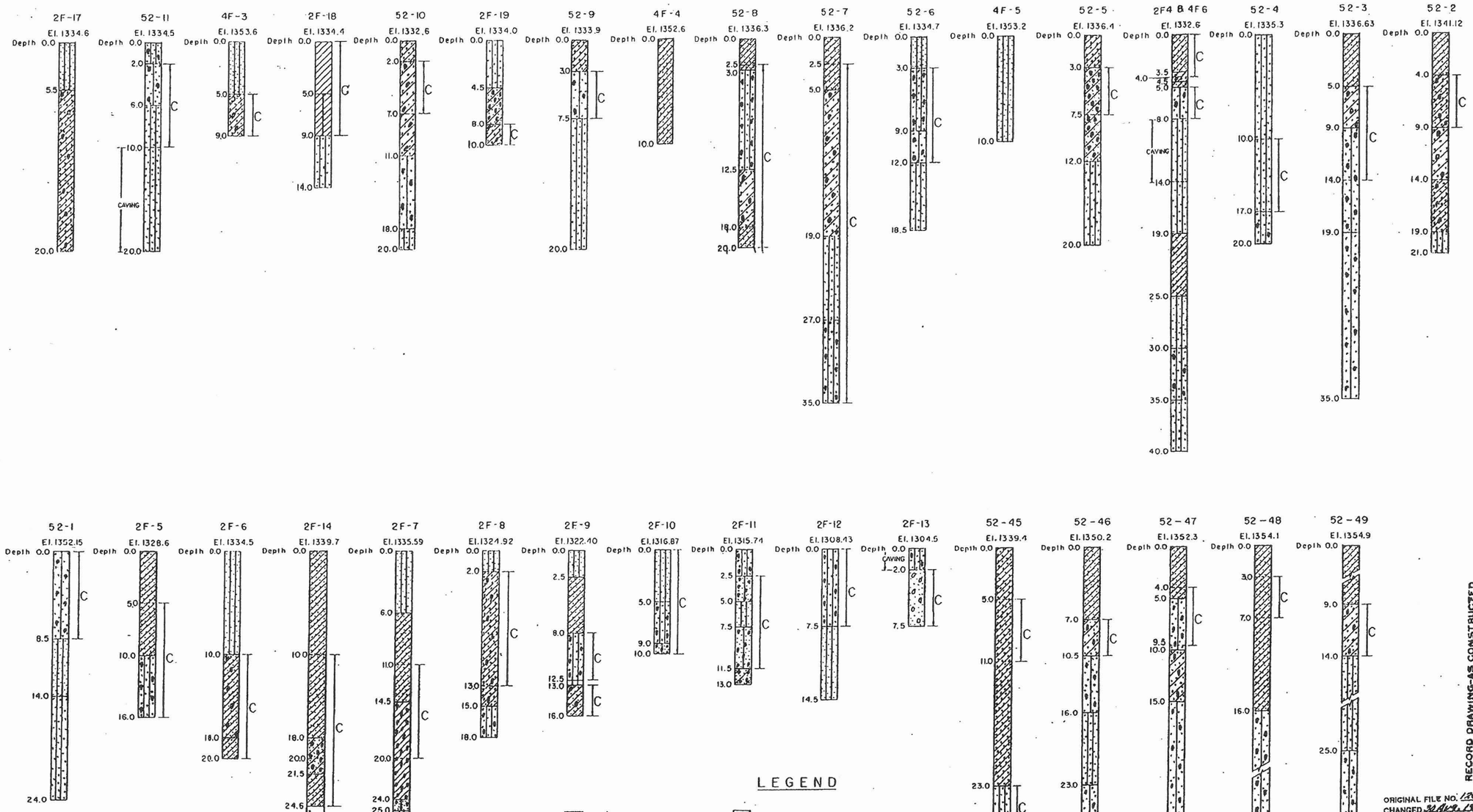
TO ACCOMPANY SPECIFICATIONS ENG-04-383-55-141 REV. A

FILE NO. (D.O. SERIES) 1517

CORPS OF ENGINEERS

U. S. ARMY





NOTES:

1. All Classifications are in accordance with the Corps of Engineers "Unified Soil Classification System" dated March 1953.
2. All logs with the prefix "4F" are test pits; all others are power auger holes.
3. For location of exploration holes, see Sheet 4.

LEGEND

- Sandy Gravel (GW)
- Silty Sandy Gravel (GM)
- Clayey Sandy Gravel (GC)
- Clayey Gravel (GC)
- Silty Gravelly Sand (SM)
- Gravelly Silty Sand (SM)
- Gravelly Sand (SP)
- Silty Sand (SM)
- Clayey Gravelly Sand (SC)
- Gravelly Clayey Sand (SC)
- Clayey Sand (SC)
- Sandy Silt (ML)
- Silt (ML)
- Gravelly Sandy Clay (CL)
- Sandy Clay (CL)
- Silty Clay (CL)
- Lean Clay (CL)

VERTICAL SCALE
4 0 4 8 12 FEET

"C" indicates the presence of caliche which is found in varying amounts and degrees of cementation.

RECORD DRAWING-AS CONSTRUCTED
CONT. NO. AF-9-16 REV. DATE 8/10/65 Rev. No. Change
CONT. NO. ..... REV. ..... DATE ..... BY .....
CONT. NO. ..... REV. ..... DATE ..... BY .....

ORIGINAL FILE NO. 1269-X
CHANGED 22 Aug. 1974

This series of drawings is on file in Los Angeles District, Corps of Engineers. In ordering prints or referring to this sheet use the D.O. Series number shown in the margin below the title block.

DATUM IS MEAN SEA LEVEL

REVISION	DATE	DESCRIPTION	BY	BY

CORPS OF ENGINEERS, U. S. ARMY
OFFICE OF THE DISTRICT ENGINEER
SACRAMENTO DISTRICT
SACRAMENTO, CALIFORNIA

PREPARED BY: FEB
DRAWN BY: M.A.
CHECKED BY: RCR
SUBMITTED BY: SOILS SECTION
APPROVED: CHIEF SOILS BRANCH
APPROVED: CHIEF ENGINEERING DIVISION

GILA RIVER AND TRIBUTARIES, ARIZONA
AGUA FRIA PROJECT
LOWER AGUA FRIA RIVER

TRILBY WASH DETENTION BASIN
DAMS AND APPURTENANCES
LOGS OF EXPLORATION HOLES

O.C.E. DWG. NO. 86-02-01
SPEC. NO.
DATE: FEB. 19, 1969
SCALE: 1" = 4' Vert.
TITLE NO. SACTO. DIST.: FILE NO. AF-9-27
SHEETS 1 to 25
SHEET NO. 6

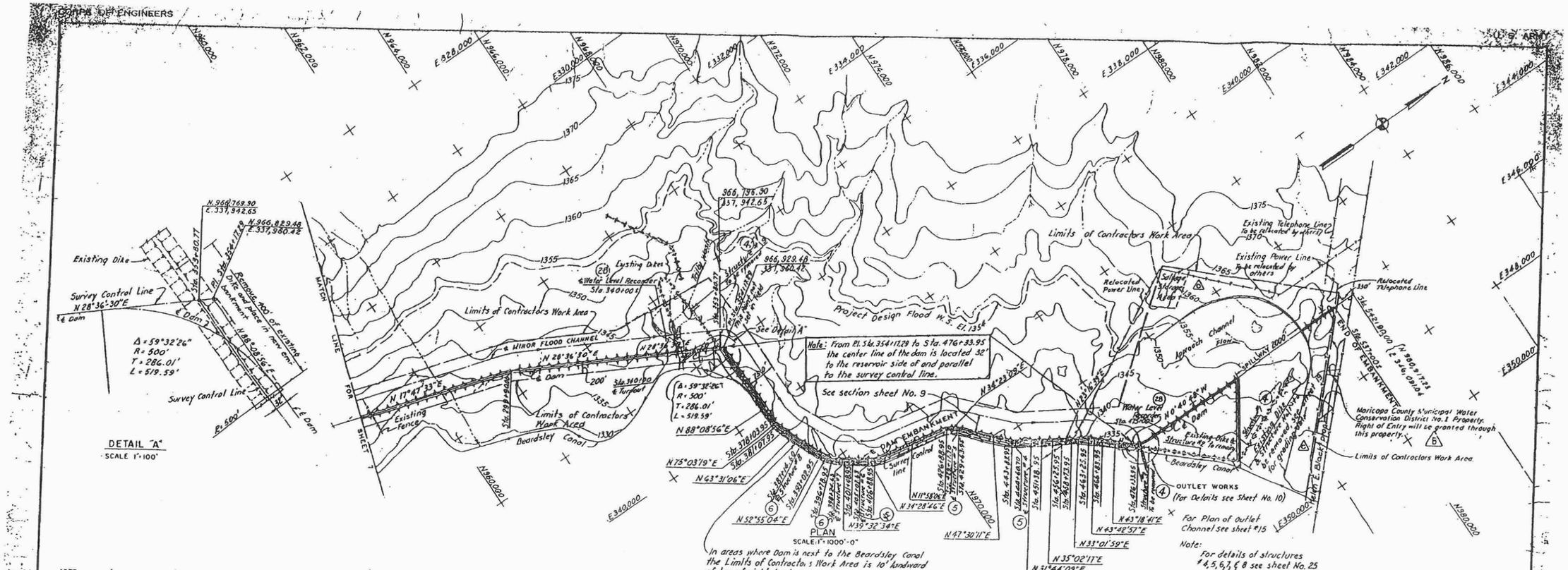
COL. CHIEF R. E. BR. DIST. ENGR. SACTO. DIST.
COL. CHIEF E. C. BR. DIST. ENGR. L.A. DIST.

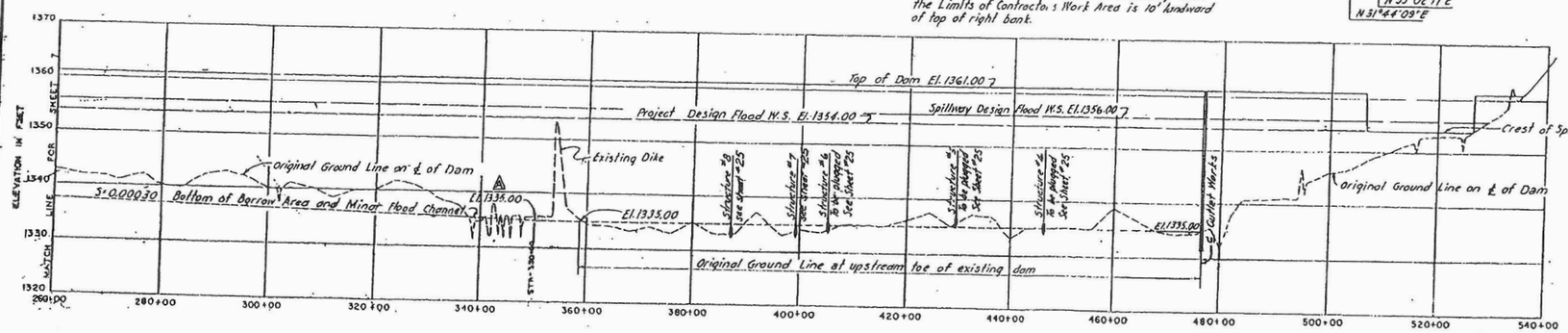
TO ACCOMPANY SPECIFICATIONS ENG-04-953-95-141

FILE NO. (D.O. SERIES) 151/66

CORPS OF ENGINEERS

U.S. ARMY





PROFILE OF DAM

SCALE: 1" = 10'-0" VERT. 1" = 1000'-0" HORIZ.

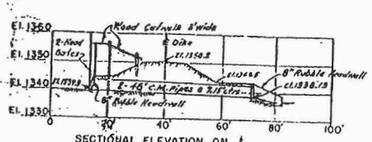
REFERENCE DRAWINGS

1. For general plan, see sheet 2
2. For plan of outlet channel, see sheet 15
3. For details of spillway, see sheet 19, 20
4. For details of outlet structure, see sh. 10
5. For details of lateral "A", see sh. 17.
6. For details of lateral 1, see sh 18
7. For details of minor flood channel, see sh. 9.
8. For work to be done on structures 4, 5, 6, 7 & 8 See sheet #25

GRAPHIC SCALES

1" = 10'-0" 0 5' 10' 20' 30' 40' 50' 60'

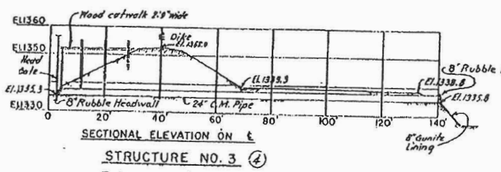
1" = 1000'-0" 0 500' 1000' 2000' 3000' 4000' 5000' 6000'



SECTIONAL ELEVATION ON ℄

STRUCTURE NO. 1 (A)

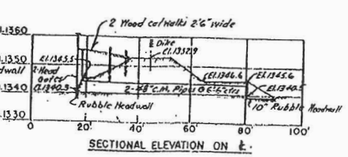
To be removed, see note



SECTIONAL ELEVATION ON ℄

STRUCTURE NO. 3 (4)

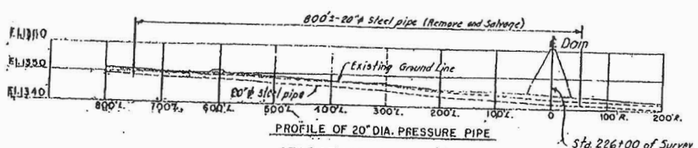
To be removed, see note



SECTIONAL ELEVATION ON ℄

STRUCTURE NO. 9 (4)

To be removed, see note



PROFILE OF 20" DIA. PRESSURE PIPE

STRUCTURE NO. 10 (7)

Note: Remove and Salvage Headgates, Corrugated Metal Pipe and Cutwalks from Structures No. 1, 3 and 9. Rubble headwalls and Gunite lining to be removed and wasted as designated by the Contracting Officer. Remove and salvage 800'±/- feet of 20"ϕ steel pressure pipe from structure No. 10. For location see sheet 7

GENERAL NOTES

1. Topography compiled from maps by U.S. Soils Conservation Service, and Corps of Engineers.
2. Datum is Mean Sea Level, 1929 General Adjustment.
3. Contour interval 5 feet.
4. Arizona Central Zone, Transverse Mercator Projection, 1927 North American Datum.
5. U.S.C.E. Bench Marks, 1½" Brass Capped Pipe, intermittently available, approximately 200' landward of survey control line.
6. Figures in circles indicate items under which payment will be made.

RECORD DRAWING AS CONSTRUCTED

CONT. NO. 43-76 REV. G DATE 30 July 56 BY F.R.

CONT. NO. ..... REV. ..... DATE ..... BY .....

CONT. NO. ..... REV. ..... DATE ..... BY .....

ORIGINAL FILE NO. 1269/93

CHANGED 20 Aug. 1956

This series of drawings is [illegible] Los Angeles District, Corps of Engineers. In ordering prints or referring to this sheet, use the O.D.-Series number shown in the matrix below the title block.

REVISION	DATE	DESCRIPTION	BY	BY
C	30 July 56	Relocated Telephone & Power Lines "As Constructed"		F.R.
B	7-13-55	Revised Limits of Contractors Work Area	"	
A	5-20-55	Added El. 1355.00 (Addendum 2, dated 16 May 1955)		

CORPS OF ENGINEERS, U. S. ARMY
OFFICE OF THE DISTRICT ENGINEER
SACRAMENTO DISTRICT
SACRAMENTO, CALIFORNIA

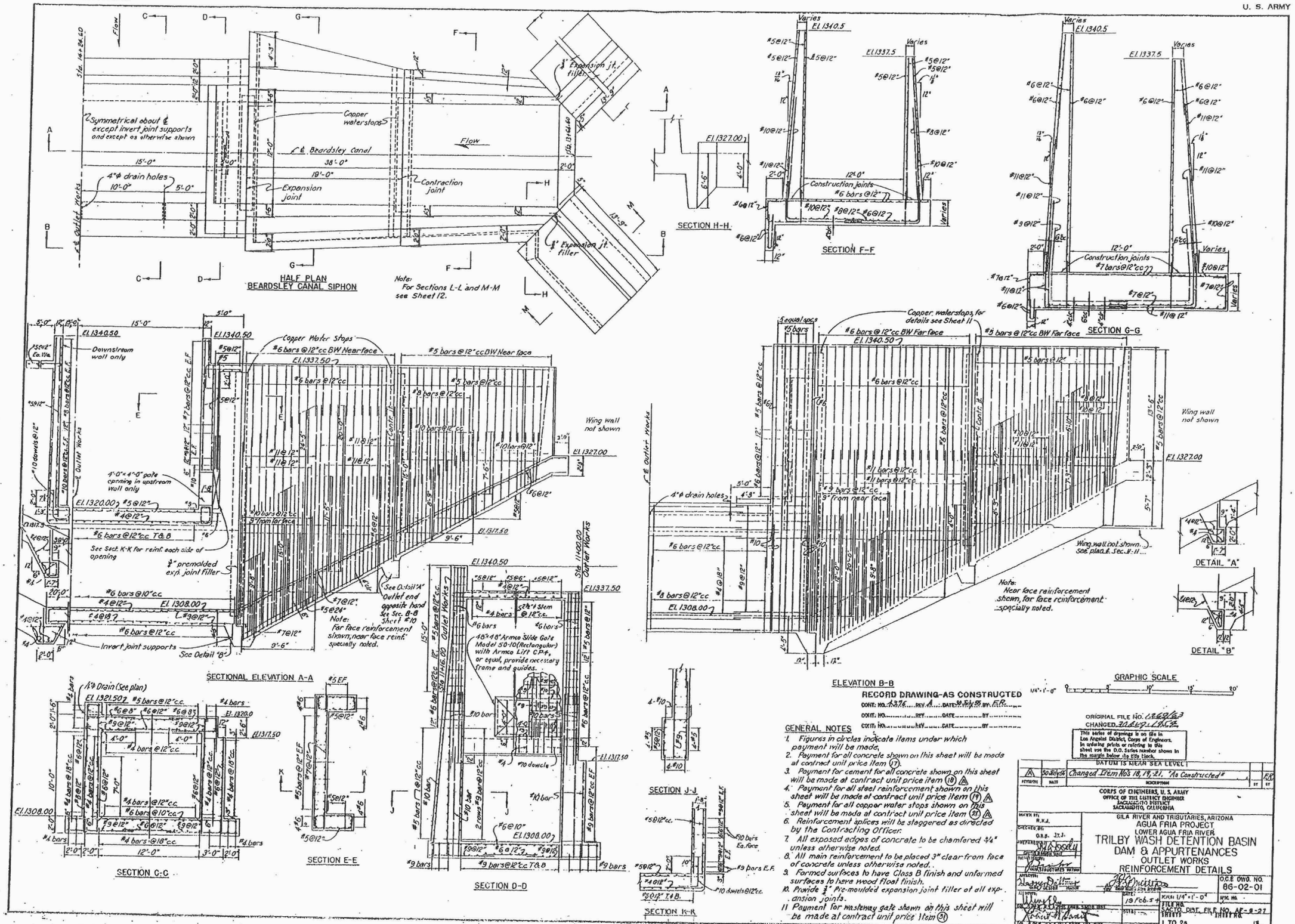
DRAWN BY: R.K.J. & K.E.M.
CHECKED BY: F.L.T.
FIELD PARTY: [illegible]
SUBMITTED BY: [illegible] CHIEF, STRUCTURES SECTION
APPROVED: [illegible] CHIEF, DESIGN BRANCH
APPROVED: [illegible] CHIEF, ENGINEERING DIVISION
APPROVED: [illegible] CHIEF, ENGINEERING DIVISION
DATE: 19 Feb 1956
SCALE: AS SHOWN
PLOTTED: SACTO. DIST. FILE NO. AF 4-27
SHEET NO. 1 TO - 25

GILA RIVER AND TRIBUTARIES, ARIZONA
AGUA FRIA PROJECT
LOWER AGUA FRIA RIVER
TRILBY WASH DETENTION BASIN
DAM & APPURTENANCES
DAM
PLAN AND PROFILE

O.C.E. DWG. NO. 86-102-104

W.R.C. NO.

TO ACCOMPANY SPECIFICATIONS ENG-04-983-56-141 FILE NO. (D.O. SERIES) 931/70



RECORD DRAWING-AS CONSTRUCTED

CONT. NO. 13.76 REV. A DATE 30 July 86 BY F.R.

CONT. NO. REV. DATE BY

CONT. NO. REV. DATE BY

GENERAL NOTES

1. Figures in circles indicate items under which payment will be made.
2. Payment for all concrete shown on this sheet will be made at contract unit price item (17).
3. Payment for cement for all concrete shown on this sheet will be made at contract unit price item (18)
4. Payment for all steel reinforcement shown on this sheet will be made at contract unit price item (19)
5. Payment for all copper water stops shown on this sheet will be made at contract unit price item (21)
6. Reinforcement splices will be staggered as directed by the Contracting Officer.
7. All exposed edges of concrete to be chamfered ¾" unless otherwise noted.
8. All main reinforcement to be placed 3" clear from face of concrete unless otherwise noted.
9. Formed surfaces to have Class B finish and unformed surfaces to have wood float finish.
10. Provide ½" Pre-moulded expansion joint filler at all expansion joints.
11. Payment for waterway gate shown on this sheet will be made at contract unit price item (31)

ORIGINAL FILE No. 12269a3

CHANGED 20 July 1972

This series of drawings is on file in Los Angeles District, Corps of Engineers. In ordering prints or referring to this sheet use the D.O. Series number shown in the margin below the title block.

DATUM IS MEAN SEA LEVEL

REVISION	DATE	DESCRIPTION	BY	BY
A	30 July 86	Changed Item Nos 18, 19, 21. "As Constructed"		F.R.

CORPS OF ENGINEERS, U. S. ARMY
OFFICE OF THE DISTRICT ENGINEER
SACRAMENTO DISTRICT
SACRAMENTO, CALIFORNIA

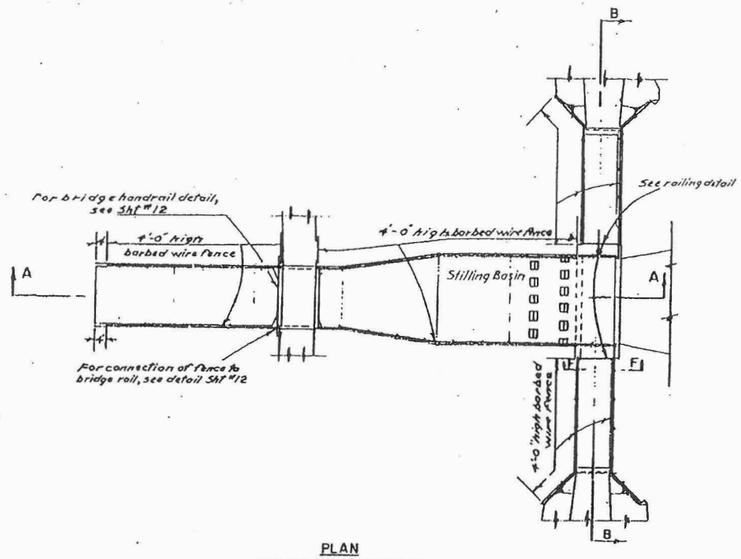
GILA RIVER AND TRIBUTARIES, ARIZONA
AGUA FRIA PROJECT
LOWER AGUA FRIA RIVER

TRILBY WASH DETENTION BASIN
DAM & APPURTENANCES
OUTLET WORKS
REINFORCEMENT DETAILS

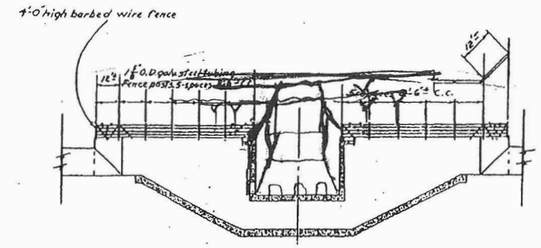
DRAWN BY: R.K.J.
CHECKED BY: O.R.B. J.T.J.
PREPARED BY: [signature]
CHIEF, DESIGN BRANCH: [signature]
CHIEF, STRUCTURES SECTION: [signature]
APPROVED: [signature] CHIEF, DESIGN BRANCH; [signature] CHIEF, ENGINEERING DIVISION
DATE: 19 Feb. 84
SCALE: AS NOTED 1/4"=1'-0"
O.C.E. DWG. NO. 86-02-01
NOC NO.
FILE NO. SACTO DIST. FILE NO. AE-8-27
SHEET 1 TO 25
SHEET NO. 13

TO ACCOMPANY SPECIFICATIONS ENG-04-393-85-141

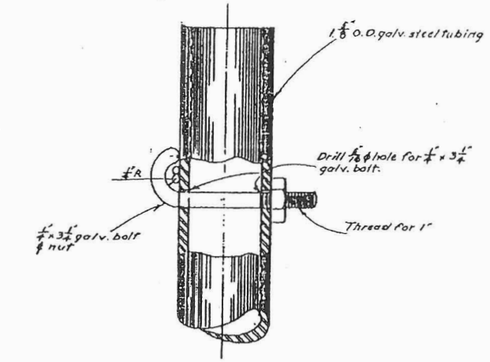
FILE NO. (D.O. SERIES) 161/78 REV A



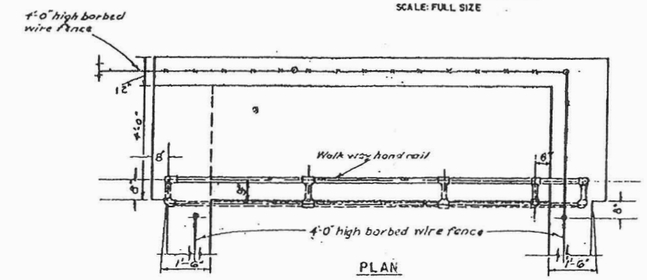
PLAN
OUTLET WORKS FENCING
& HAND RAIL
SCALE: 1" = 20'-0"



SECTION B - B
OPPOSITE SIDE SIMILAR
SCALE: 1" = 20'-0"

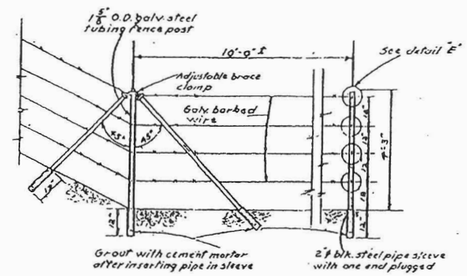


DETAIL 'E'
BARBED WIRE POST HOOK
SCALE: FULL SIZE

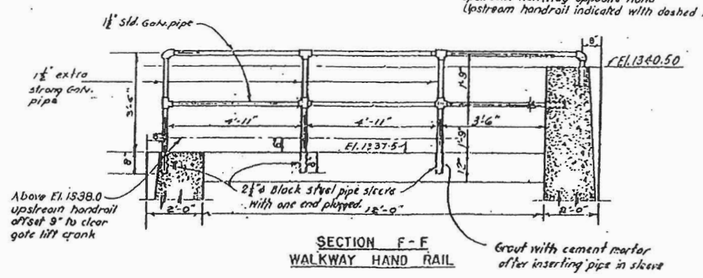


PLAN

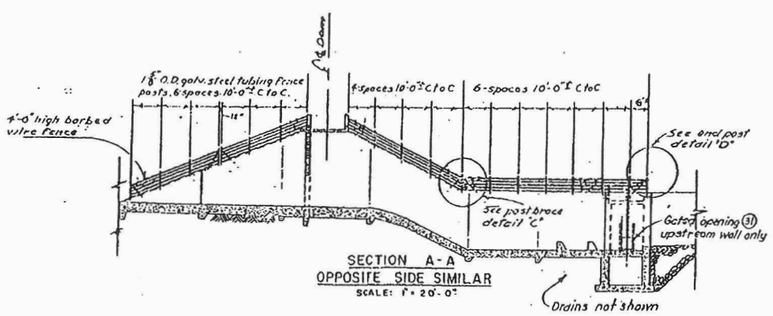
Note:
Downstream walkway and handrail shown, upstream walkway opposite hand (upstream handrail indicated with dashed lines.



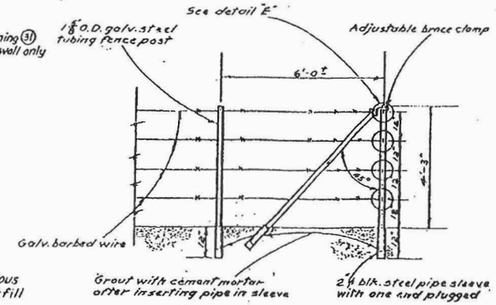
DETAIL 'C'
CENTER POST BRACE
SCALE: 1/2" = 1'-0"



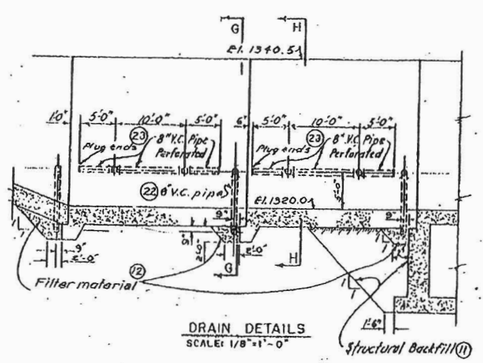
SECTION F - F
WALKWAY HAND RAIL
SCALE: 1/2" = 1'-0"



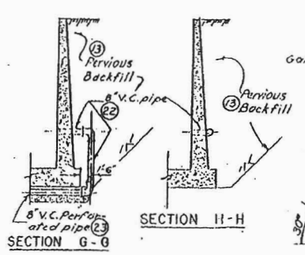
SECTION A - A
OPPOSITE SIDE SIMILAR
SCALE: 1" = 20'-0"



DETAIL 'D'
END POST BRACE
SCALE: 1/2" = 1'-0"



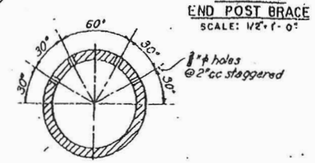
DRAIN DETAILS
SCALE: 1/8" = 1'-0"



SECTION G - G

SECTION H - H

Note:
Symmetrical about ℄ Outlet Structure (drains continuous under invert slab-wall to wall).



DETAIL OF PERFORATED PIPE
NOT TO SCALE

REFERENCE DRAWINGS:
1. For General Plan see sheet No.2.

RECORD DRAWING-AS CONSTRUCTED
CONT. NO. 43.76 REV. A DATE 30 July 86 BY No Change
CONT. NO. ..... REV. ..... DATE ..... BY .....
CONT. NO. ..... REV. ..... DATE ..... BY .....

GENERAL NOTES
1. Figures in circles indicate item under which payment will be made
2. Payment for all barbed wire fence shown on this sheet will be made at contract unit price item (20)
3. Payment for all pipe handrail shown on this sheet will be made at contract unit price item (25)
4. Payment for all 8" vitrified clay pipe shown on this sheet will be made at contract unit price item (23).
5. Payment for all 8" perforated vitrified clay pipe shown on this sheet will be made at contract unit price item (24).
6. Payment for all filter material shown on this sheet will be made at contract unit price item (12).
7. Payment for all pervious backfill shown on this sheet will be made at contract unit price item (13).
8. Payment for all Structural Backfill shown on this sheet will be made at contract unit price item (11).

GRAPHIC SCALES
1/8" = 1'-0"
1/2" = 1'-0"
1" = 20'-0"

ORIGINAL FILE NO. 86-02-01
CHANGED 30 July 86

This series of drawings is on file in Los Angeles District, Corps of Engineers. In ordering prints or referring to this sheet use the O.D. Series number shown in the margin below the title block.

DATUM IS MEAN SEA LEVEL

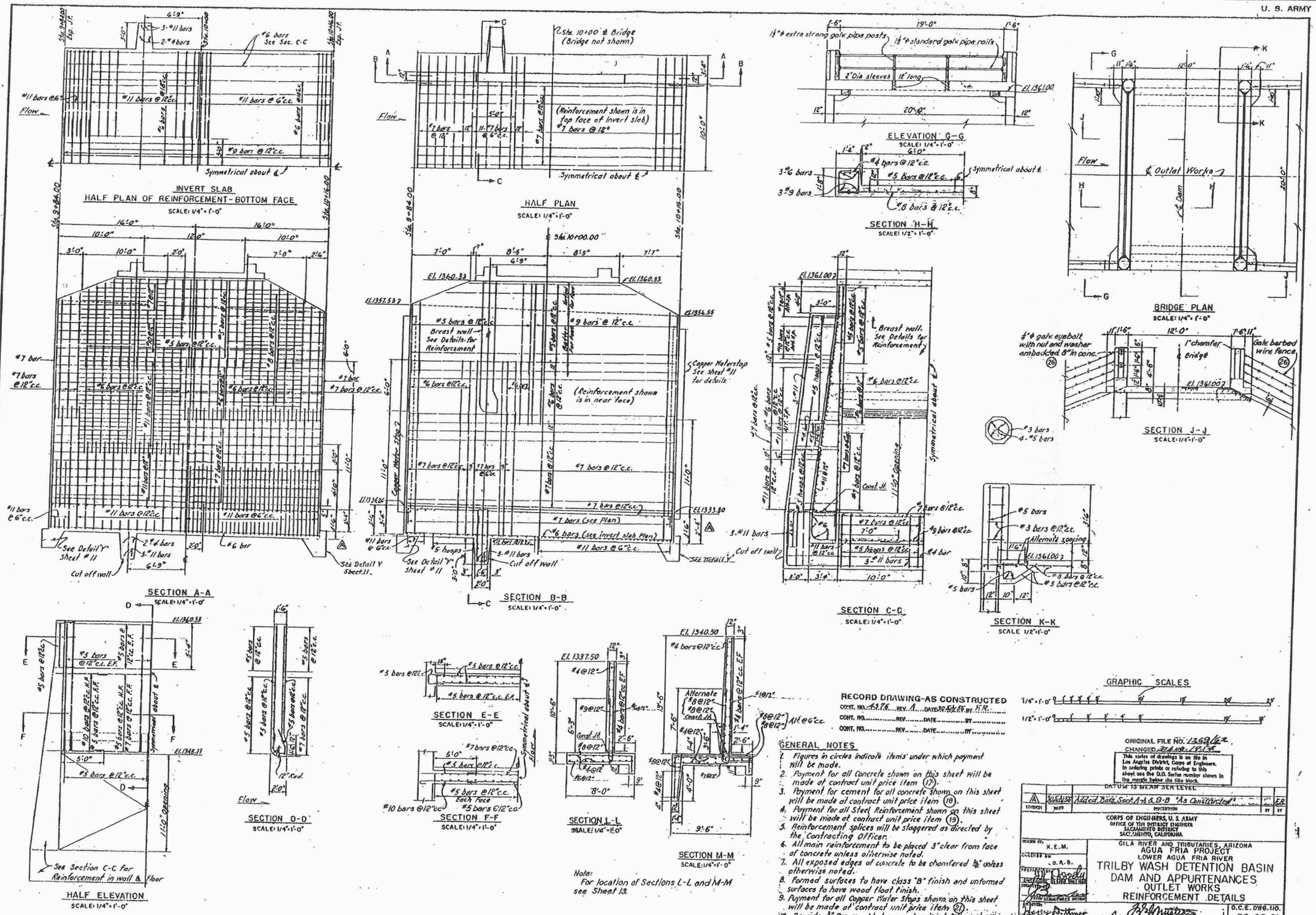
REVISION	DATE	DESCRIPTION	BY	BY
A	21 May 85	Changed Item Nos. in General Notes 2 & 3 (Add on June 9, 11 May 85)		

CORPS OF ENGINEERS, U. S. ARMY
OFFICE OF THE DISTRICT ENGINEER
SACRAMENTO DISTRICT
SACRAMENTO, CALIFORNIA

DRAWN BY: G. H. G.
CHECKED BY: F.L.T.
FOR CHIEF, DESIGN BRANCH
CHIEF, DESIGN BRANCH
CHIEF, STRUCTURES SECTION
APPROVED: Gary Dettinger, CHIEF, DESIGN BRANCH
APPROVED: CHIEF, ENGINEERING DIVISION
APPROVED: CHIEF, ENGINEERING DIVISION
DATE: 13 Feb 54
SHEET: 1 TO 25

GILA RIVER AND TRIBUTARIES, ARIZONA
AGUA FRIA PROJECT
LOWER AGUA FRIA RIVER
TRILBY WASH DETENTION BASIN
DAM AND APPURTENANCES
OUTLET WORKS
MISCELLANEOUS DETAILS

O.C.E. DWG. NO. 86-02-01
SCALE: AS SHOWN
SPEC. NO.
FILE NO. SACTO DIST. FILE NO. AF-9-27
SHEET NO. 14



RECORD DRAWING-AS CONSTRUCTED

CONT. NO. 63.76 REV. A DATE 30 Jan 86 BY F.R.

CONT. NO. ..... REV. ..... DATE ..... BY .....

CONT. NO. ..... REV. ..... DATE ..... BY .....

GENERAL NOTES

1. Figures in circles indicate items under which payment will be made.
2. Payment for all concrete shown on this sheet will be made at contract unit price item (17).
3. Payment for cement for all concrete shown on this sheet will be made at contract unit price item (18).
4. Payment for all Steel Reinforcement shown on this sheet will be made at contract unit price item (19).
5. Reinforcement splices will be staggered as directed by the Contracting Officer.
6. All main reinforcement to be placed 3" clear from face of concrete unless otherwise noted.
7. All exposed edges of concrete to be chamfered ¾" unless otherwise noted.
8. Formed surfaces to have class "B" finish and unformed surfaces to have wood float finish.
9. Payment for all Copper Water Stops shown on this sheet will be made at contract unit price item (21).
10. Provide ½" Pre-moulded expansion joint filler at all expansion joints.
11. Payment for all handrails will be made at contract unit price item (25)

GRAPHIC SCALES

1/4" = 1'-0" 0 5' 10' 15' 20' 25'

1/2" = 1'-0" 0 5' 10'

ORIGINAL FILE NO. 1369/62

CHANGED 24 Mar 1978

This series of drawings is on file in Los Angeles District, Corps of Engineers. In ordering prints or referring to this sheet use the D.O. Series number shown in the margin below the title block.

DATUM IS MEAN SEA LEVEL

REVISION	DATE	DESCRIPTION	BY	BY
A	30 Jan 86	Added Bars Sect A-A & B-B "As Constructed"		F.R.

CORPS OF ENGINEERS, U. S. ARMY
OFFICE OF THE DISTRICT ENGINEER
SACRAMENTO DISTRICT
SACRAMENTO, CALIFORNIA

DESIGN BY K.E.M.
CHECKED BY O.R.B.
PREPARED BY
SUBMITTED BY
REVIEWED BY
ATTEST

GILA RIVER AND TRIBUTARIES, ARIZONA
AGUA FRIA PROJECT
LOWER AGUA FRIA RIVER

TRILBY WASH DETENTION BASIN
DAM AND APPURTENANCES
OUTLET WORKS
REINFORCEMENT DETAILS

O.C.E. DWG. NO. 86-02-01

19 Feb 58

SCALE: AS SHOWN

REC. NO.

TITLE NO.

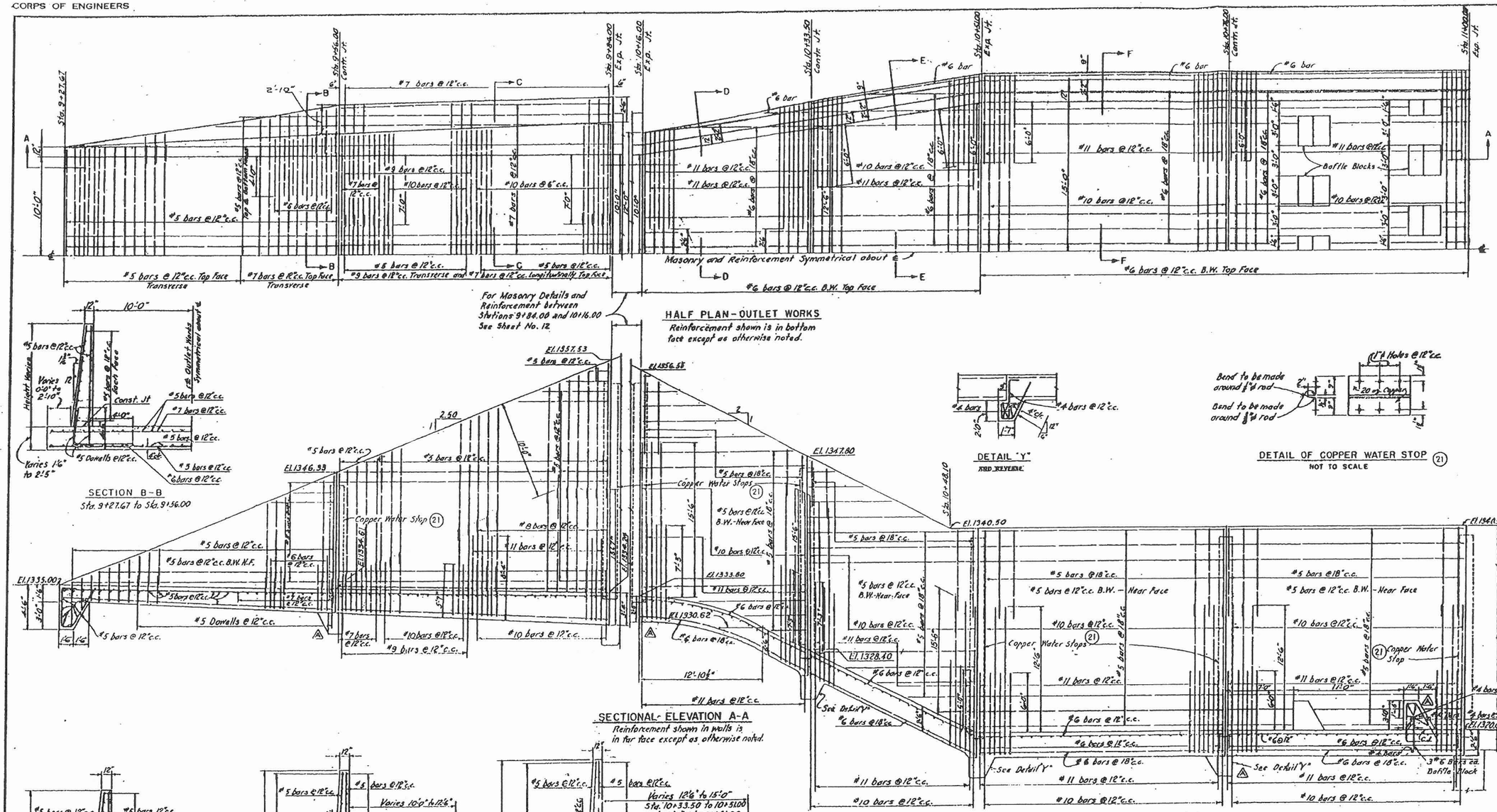
SACTO. DIST. FILE NO. 2-F-8-27

SHEETS 1 TO 28

SHEET NO. 12

TO ACCOMPANY SPECIFICATIONS ENG-04-1059-Chg1

FILE NO. (D.O. SERIES) 1519/74 REV. A



HALF PLAN-OUTLET WORKS

Reinforcement shown is in bottom face except as otherwise noted.

SECTION B-B

Sta. 9+27.67 to Sta. 9+56.00

SECTIONAL-ELEVATION A-A

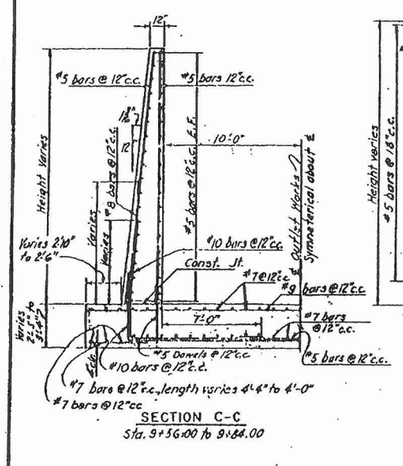
Reinforcement shown in walls is in far face except as otherwise noted.

DETAIL "Y"

AND REVERSE

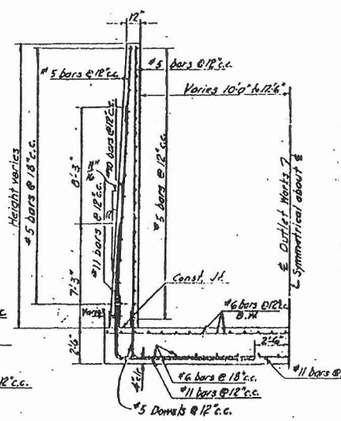
DETAIL OF COPPER WATER STOP (21)

NOT TO SCALE



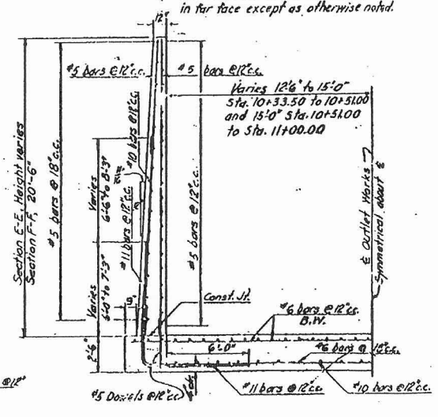
SECTION C-C

Sta. 9+56.00 to 9+84.00



SECTION D-D

Sta. 10+16.00 to Sta. 10+33.50



SECTIONS E-E AND F-F

Sta. 10+33.50 to Sta. 11+00.00

RECORD DRAWING-AS CONSTRUCTED

CONT. NO. 4376 REV. A DATE 30 July 68 BY F.R.

CONT. NO. ..... REV. ..... DATE ..... BY .....

CONT. NO. ..... REV. ..... DATE ..... BY .....

GRAPHIC SCALE

1/4"=1'-0" 0 5' 10' 15' 20' 25'

GENERAL NOTES

1. Figures in circles indicate items under which payment will be made.
2. Payment for all Concrete shown on this sheet will be made at contract unit price item (17)
3. Payment for all Cement for all concrete shown on this sheet will be made at contract unit price item (18)
4. Payment for all Reinforcement bars shown on this sheet will be made at contract unit price item (19)
5. Payment for all Copper Water Stops shown on this sheet will be made at contract unit price item (21)
6. Reinforcement splices will be staggered as directed by the Contracting Officer.
7. All exposed edges of concrete to be chamfered 3/4" unless otherwise noted.
8. All main reinforcement to be placed 3" clear from face of concrete unless otherwise noted.
9. Formed surfaces to have Class "B" finish and unformed surfaces to have wood float finish.
10. Provide 1/2" Pre-moulded expansion joint filler at all expansion joints.

DATUM IS MEAN SEA LEVEL

REVISION	DATE	DESCRIPTION		
A	30 July 68	General Revisions. "As Constructed"	F.R.	

CORPS OF ENGINEERS, U. S. ARMY
OFFICE OF THE DISTRICT ENGINEER
SACRAMENTO DISTRICT
SACRAMENTO, CALIFORNIA

DRAWN BY: K.E.M.
CHECKED BY: J.T.J.
SUBMITTED BY: Chief, Design Branch
APPROVED BY: Chief, Structures Section

GILA RIVER AND TRIBUTARIES, ARIZONA
AGUA FRIA PROJECT
LOWER AGUA FRIA RIVER
TRILBY WASH DETENTION BASIN
DAM & APPURTENANCES
OUTLET WORKS
REINFORCEMENT DETAILS

O.C.E. DWG. NO. 86-02-01

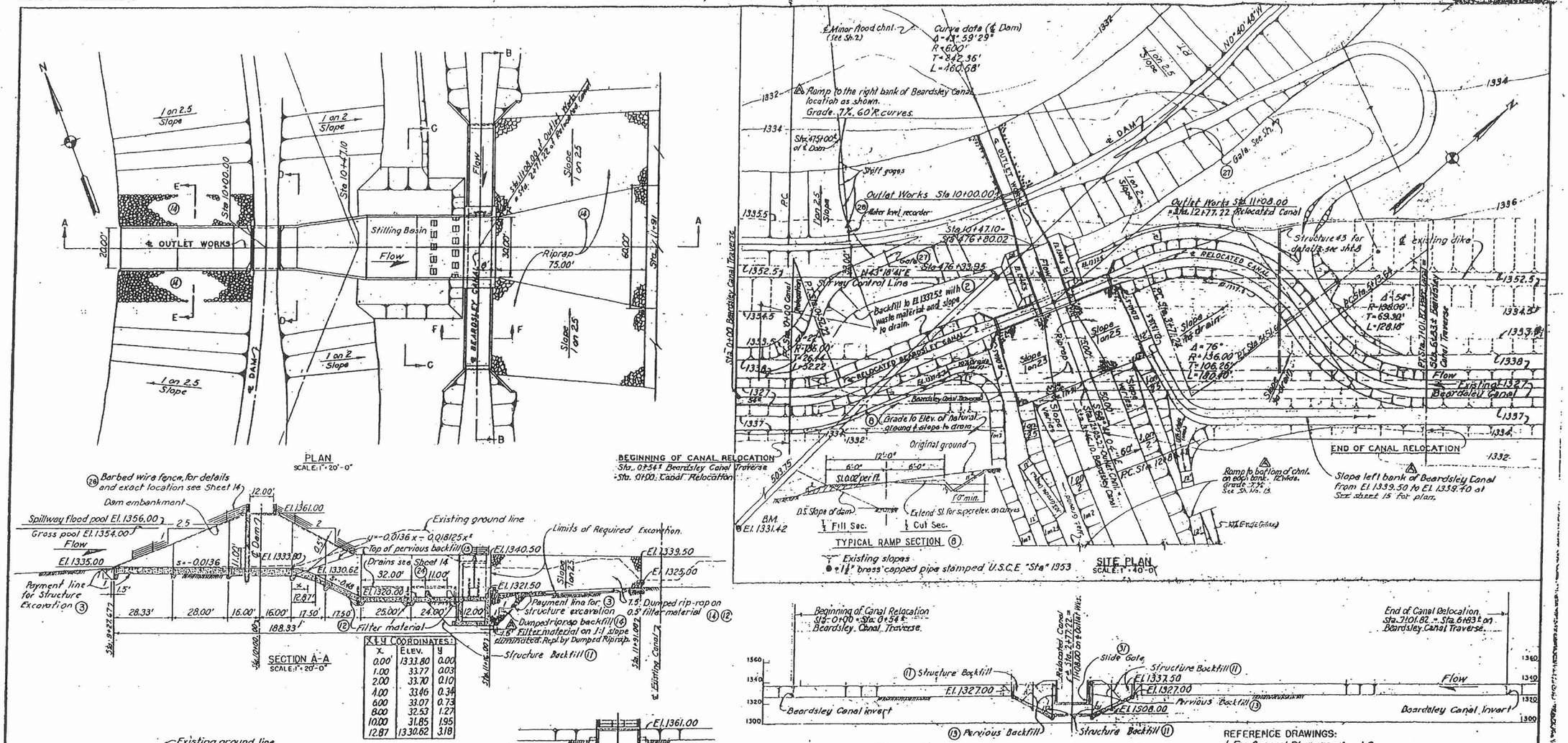
SCALE: 1/4" = 1'-0"
DATE: 19 Feb. 1954
FILE NO. SAC. DIST. FILE NO. NL-9-27
SHEET 1 TO 25

ORIGINAL FILE NO. 1269/61
CHANGED 30 Aug. 1973

This series of drawings is on file in Los Angeles District, Corps of Engineers. In ordering prints or referring to this sheet use the D.O. Series number shown in the margin below the title block.

TO ACCOMPANY SPECIFICATIONS NO. 04-883-68-141

FILE NO. (D.O. SERIES) 151/73 REV. A



X	Elev.	Y
0.00'	1333.80	0.00
1.00	33.77	0.03
2.00	33.70	0.10
4.00	33.46	0.34
6.00	33.07	0.73
8.00	32.53	1.27
10.00	31.85	1.95
12.87	1330.62	3.18

REFERENCE DRAWINGS:
1. For General Plan see sheet 2.
2. For Plan of Outlet Channel see sheet 15.
3. For Structural Details of Outlet Works see sheets 11 & 12
4. For Structural Details of Beardsley Canal Siphon see sheet 13.

GRAPHIC SCALES

GENERAL NOTES
1. Datum is mean sea level, 1929 General Adjustment
2. Figures in circles indicate item under which payment will be made.

DATUM IS MEAN SEA LEVEL

REVISION	DATE	DESCRIPTION	BY	CK
A	30 July 56	Changed Notes "As Constructed"		F.R.

CORPS OF ENGINEERS, U. S. ARMY
OFFICE OF THE DISTRICT ENGINEER
SACRAMENTO DISTRICT
SACRAMENTO, CALIFORNIA

GILA RIVER AND TRIBUTARIES, ARIZONA
AGUA FRIA PROJECT
LOWER AGUA FRIA RIVER
TRILBY WASH DETENTION BASIN
DAM & APPURTENANCES
OUTLET WORKS
PLAN, PROFILES AND SECTIONS

DRAWN BY: R.H.J.
DESIGNED BY: J.T.J. ORB.
DATE: 13 Feb. 54
SCALE: AS SHOWN
O.C.E. DWG. NO. 86-02-01
SPEC. NO.
FILE NO.
SOCTO DIST. FILE NO. AF-9-27
SHEETS 1 TO 25
SHEET NO. 10.

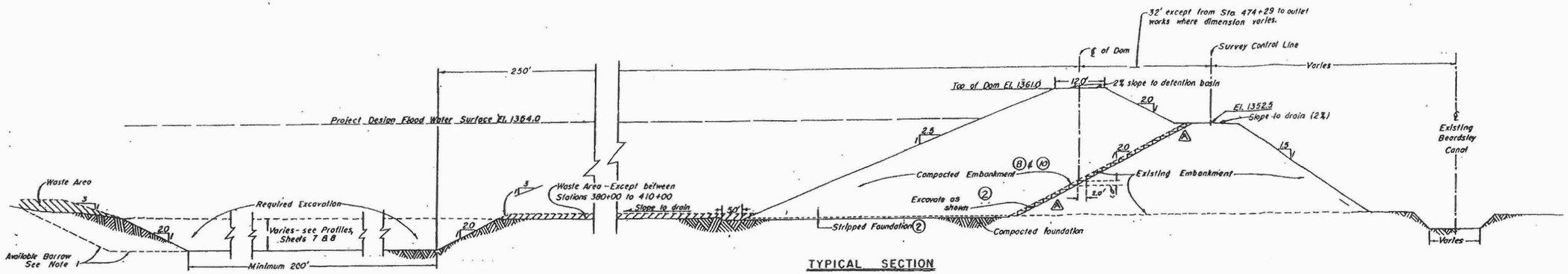
RECORD DRAWING-AS CONSTRUCTED
CONT. NO. 13.76 REV. A DATE 30 July 56 BY F.R.
CONT. NO. ..... REV. ..... DATE ..... BY .....
CONT. NO. ..... REV. ..... DATE ..... BY .....

ORIGINAL FILE NO. 12-29-60
CHANGED 30 July 1956

This series of drawings is on file in Los Angeles District, Corps of Engineers. In ordering prints or referring to this sheet use the D.O. Series number shown in the margin below the title block.

TO ACCOMPANY SPECIFICATIONS SRG-04-358-55-141

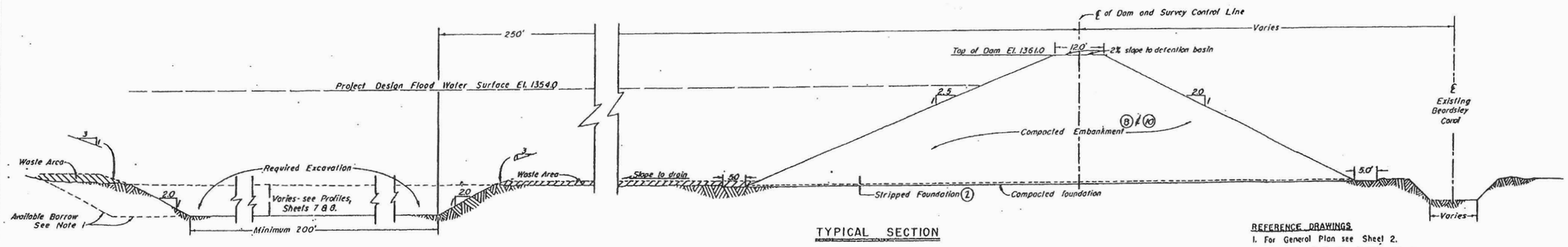
FILE NO. (D.O. SERIES) 151/72 REV. A



MINOR FLOOD CHANNEL

TYPICAL SECTION

STA. 357+00 TO OUTLET WORKS



MINOR FLOOD CHANNEL

TYPICAL SECTION

STA. 42+00 TO STA. 357+00; OUTLET WORKS TO STA. 505+70, & STA. 527+18 TO STA. 537+00

REFERENCE DRAWINGS

1. For General Plan see Sheet 2.
2. For Plan and Profile of Minor Flood Channel, see Sheets 7 and 8.

NOTES:

1. Embankment material is to be obtained from the excavation for the Minor Flood Channel which is to be increased in width as is necessary to provide sufficient material for the embankment. Additional material may be obtained by degrading of existing levees opposite Sta. 343 to Sta. 355
2. Stations shown hereon designating the limits of the sections are approximate. The exact stations are to be determined in the field.
3. Figures in circles indicate item under which payment will be made.

SCALE IN FEET

DATUM IS MEAN SEA LEVEL

REVISION	DATE	DESCRIPTION	BY	BY
A	30 July 68	Added Excavation as shown. "As Constructed"		F.R.

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SACRAMENTO, CALIFORNIA

GILA RIVER AND TRIBUTARIES, ARIZONA
AGUA FRIA PROJECT
LOWER AGUA FRIA RIVER
TRILBY WASH DETENTION BASIN
DAM AND APPURTENANCES
DAM
EMBANKMENT SECTIONS

PREPARED: R.B.
DRAWN BY: R.B.
CHECKED BY: R.C.R.
SCALE: 1" = 10.0'
DATE: 19 Feb 68
C.E.C.E. DWG. NO. 86-02-01
TILTHA
SACTO. DIST. FILE NO. AF-9-27
SHEETS 1 to 25
SHEET NO. 9.

RECORD DRAWING-AS CONSTRUCTED
CONT. NO. 4376 REV. A DATE 30 July 68 BY F.R.
CONT. NO. REV. DATE BY
CONT. NO. REV. DATE BY

ORIGINAL FILE NO. 1269/69
CHANGED 30 Aug 1968

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TO ACCOMPANY SPECIFICATIONS ENG-04-385-68-141

FILE NO. (DO. SERIES) 151/7 REV. A

DOCUMENT TITLE: Trilby Wash Detention Basin, Lower Aqua Fria River, Maricopa County, AZ

DATE: January, 1973

PREPARED BY: USACE, Los Angeles District (CESPL)

PURPOSE:

Presents information pertinent to the embankment cracking and to recommend remedial treatments. Report incorporates existing and new field and lab data.

SUMMARY:

- Reviewed the existing data from previous field explorations along embankment alignment which includes: 38 borings in 1952; 24 borings in 1953; 10 in-situ densities; test pits; test excavations.
- Additional exploration for this report included:
  - September 1971: detailed survey of all surface erosion, holes and cracks (USACE).
  - March 1972: five test excavations from Station 283+28 to 467+60 at locations where holes were observed during 1971 survey. Significant cracks were found in all but one excavation. Excavations extended up to 14.5 feet deep. Disturbed samples taken for laboratory analyses.
  - June 1972: 40 shallow backhoe test trenches excavated to determine if cracking in embankment was ubiquitous. Trenches were on the order of 2 feet wide by 20 feet long by 3 feet deep.
  - July 1972: 12 bucket auger test holes drilled between Station 435+00 and 460+00 (TH-1 through -12). Four lines of three holes were drilled to determine soil profile at area of most intense cracking. All samples were obtained by SPT. Holes drilled up to 75 feet deep. Disturbed samples taken for moisture content, dry density, Atterberg Limits, and gradation.
  - August 1972: Five 'undisturbed' samples taken adjacent to TH-5, TH-7, TH-10, and TH-12. Laboratory analyses on undisturbed samples included shrinkage limit and consolidation (collapse).

FINDINGS/RESULTS:

- Explorations revealed considerable variability in foundation materials and lack of continuity of soil strata.
- Larger degree of cementation (caliche) found in sandy soils.
- Numerous small washes crossed embankment with sandy and gravelly soils. These zones were designated for removal during initial construction.
- Generally, fine-grained soils comprised upper portion of foundation from approximately 2.5 to 16.5 feet thick. Coarser grained materials underlie the fine-grained units.
- Moisture content of foundation soils found under embankment was 2% lower than those outside of embankment.
- Average dry density of foundation soils was 89.6 pounds per square foot; average compaction was 73%.
- 1953 tests indicated potential for collapse during inundation of foundation and embankment soils. Old data showed 25 to 30 percent reduction in void ratio when loaded under saturation (foundation and embankment). New data showed similar results with 12 to 34 percent reduction in void ratio of downstream samples. The two upstream samples showed no potential for collapse.
- Upstream materials have experienced saturation and collapse, downstream materials have not. Degree of saturation of material beneath embankment assumed minimal.
- No QA/QC testing performed on foundation during construction.
- Predominance of transverse cracking found at Station 445+00 to 475+00 and Station 265+00 to 295+00. Cracking found in other areas but not to the same degree.
- During construction of embankment, 55 percent of compaction tests on embankment material found moisture content to be below optimum. Eighteen percent of tests were found to have been compacted to less than 93 percent of max value. Estimated that 18 percent of embankment materials placed at densities or moisture content low enough to cause collapse.
- Cracking due to shrinkage was found to be improbable.
- Upper 15 feet of embankment had blow counts of 27 to 60+ with lower embankment materials between 12 to 35 blow-per foot.

- Effective vertical stresses estimated to have increased approximately six tons per square foot at a depth of 500 feet due to decline of groundwater (apparently at south end of alignment). Cannot explain why subsidence at north end is significantly less.

- It appears that the embankment cracking could be attributed to regional subsidence.

CONCLUSIONS AND RECOMMENDATIONS:

- Results indicate high frequency of transverse cracking between Station 445+00 to 445+00 and Station 265+00 to 295+00.

- Continuing groundwater decline and resulting subsidence has and will continue to affect embankment.

- Embankment materials are brittle and highly susceptible to cracking.

- Foundation and embankment materials have not yet been saturated.

- Some foundation materials will collapse when saturated; up to one foot at locations.

- Collapse of foundation cannot be economically prevented.

- Treatment to increase embankment integrity at areas of cracking (Station 445+00 to 475+00 and Station 265+00 to 295+00) is required. Recommendations include:

    - Remove and replace outer six feet of upstream slope material.

    - Overlay with six feet of compacted fill.

    - Install buried membrane.

    - Pave with AC.

    - Raise crest to elevation 1361 feet MSL to re-establish design freeboard.

    - Establish settlement monuments at 500-foot intervals along crest, 1,000-foot at toes, and monitor yearly.

- Treatment to increase embankment integrity outside areas of cracking may be required in future.

- Monitor embankment and foundation.

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TRILBY WASH DETENTION BASIN

LOWER AGUA FRIA RIVER

MARICOPA COUNTY, ARIZONA

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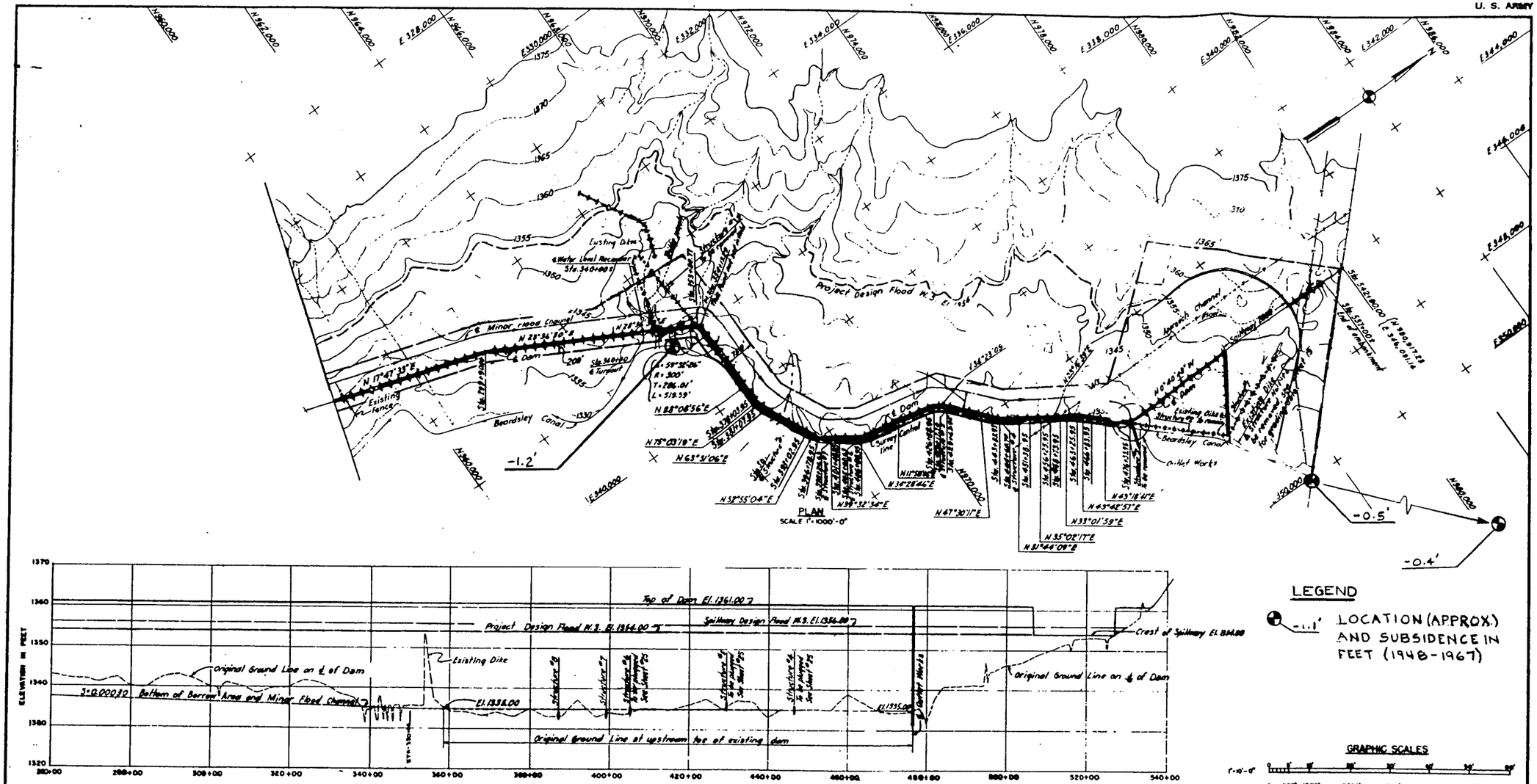


LEGEND

-1.1' LOCATION (APPROX.) AND SUBSIDENCE IN FEET (1948-1967)

GRAPHIC SCALES

1"=10'-0"

1"=1000'-0"

GENERAL NOTES

1. Topography compiled from maps by U.S. Soils Conservation Service, and Corps of Engineers.
2. Datum is Mean Sea Level, 1929 General Adjustment
3. Contour interval 5 feet.
4. Arizona Central Zone, Transverse Mercator Projection, 1927 North American Datum.
5. U.S.C.E. Bench Marks, 1½" Brass Capped Pipe, intermittently available, approximately 200' lrndhward of survey control line

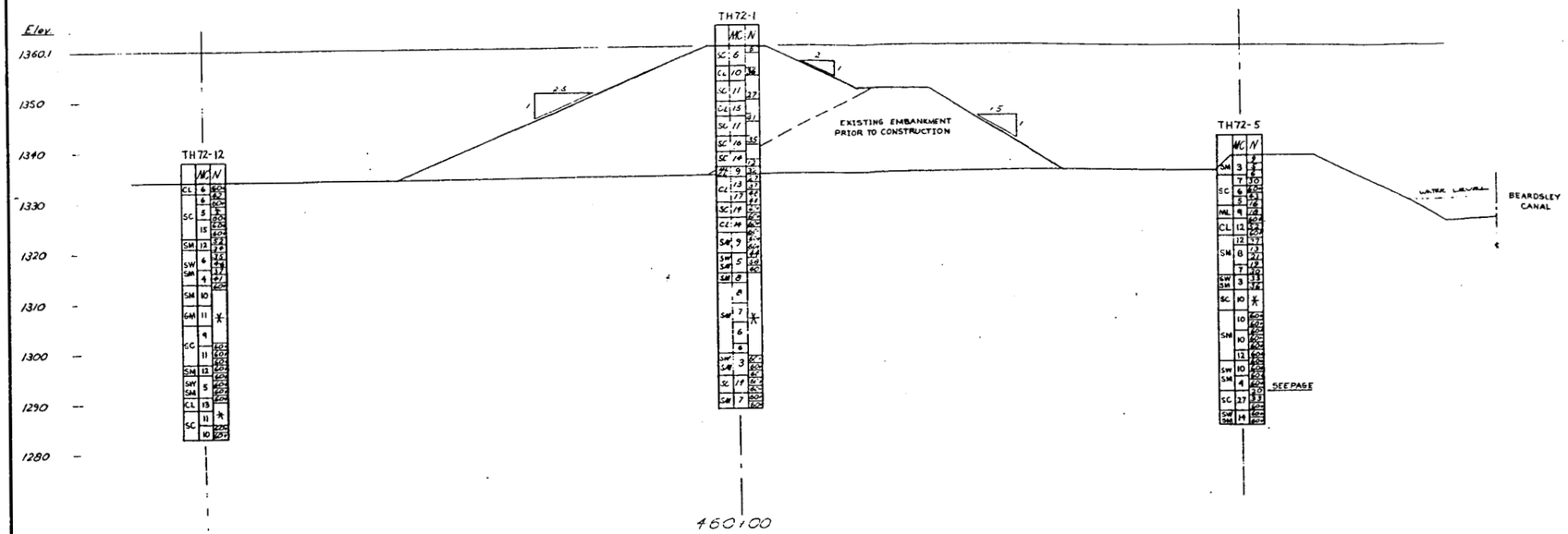
DESIGNED	DATE	DESCRIPTION	BY	CK

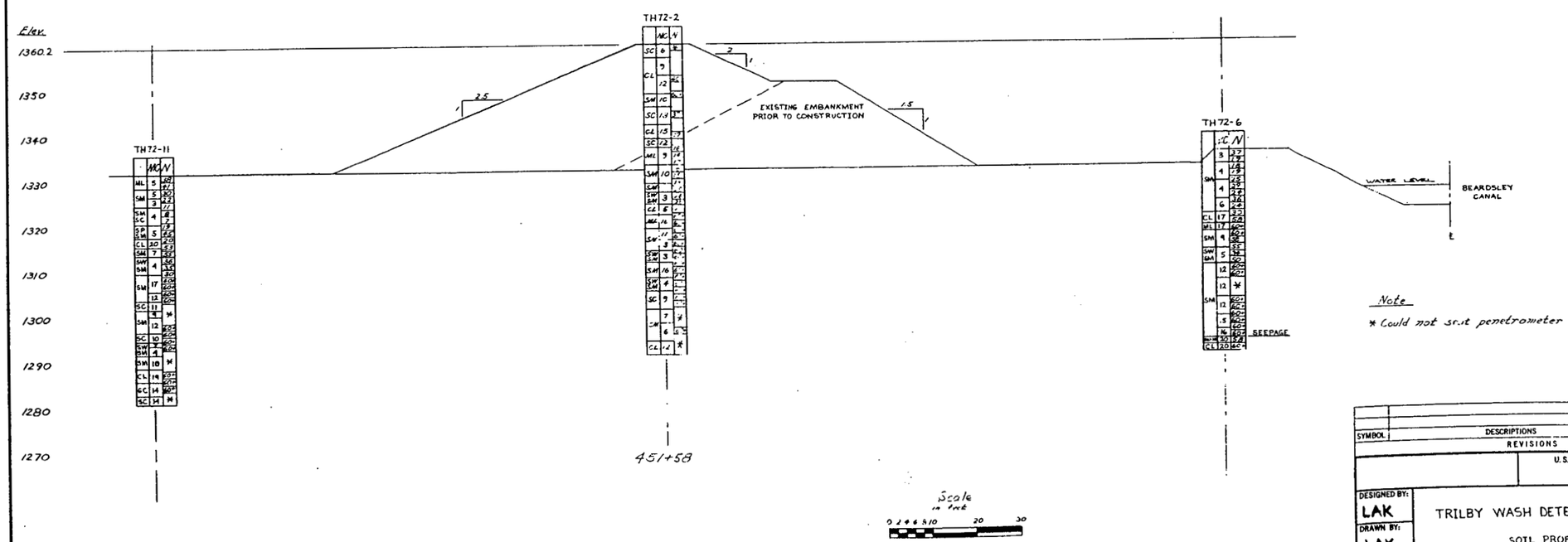
CORPS OF ENGINEERS, U. S. ARMY
OFFICE OF THE DISTRICT ENGINEER
SACRAMENTO DISTRICT
SACRAMENTO, CALIFORNIA

GILA RIVER AND TRIBUTARIES, ARIZONA
AGUA FRIA PROJECT
LOWER AGUA FRIA RIVER
TRILBY WASH DETENTION BASIN
DAM & APPURTENANCES
SUBSIDENCE MEASUREMENTS

DRAWN BY: R.A.J. & K.E.M.
TRACED BY: F.L.T.
DATE: 19 Feb '54
SCALE: AS SHOWN
FILE NO.
O.C.E. DWG. NO. ~~BC-00-01~~
SPEC. NO. 1850
~~1DCA-150~~

PLATE 14





Note

* Could not sr.it penetrometer

SYMBOL	DESCRIPTIONS	DATE	APPROVAL
	REVISIONS		

U.S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY: LAK
DRAWN BY: LAK
CHECKED BY: MPC

TRILBY WASH DETENTION BASIN

SOIL PROFILES

SUBMITTED BY:

DATE:

SPEC. NO.

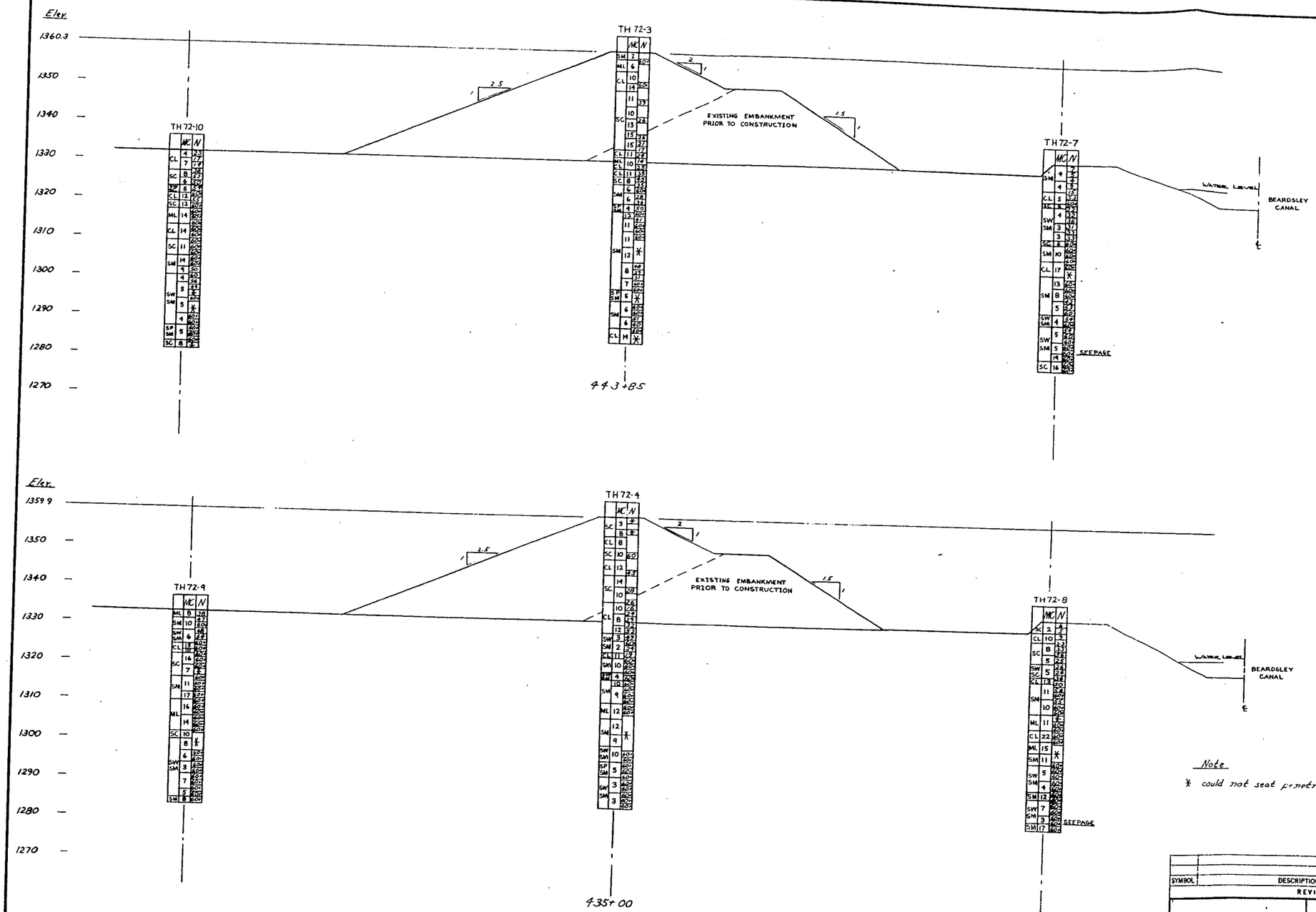
DRAWING NUMBER

DISTRICT FILE NO.

SHEET

U.S. ARMY ENGINEER DISTRICT

CORPS OF ENGINEERS



Note

* could not seat penetrometer

Scale in Feet

0 2 4 6 8 10 20 30

SYMBOL	DESCRIPTIONS	DATE	APPROVAL
	REVISIONS		

U.S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY: LAK

DRAWN BY: LAK

CHECKED BY: MPC

TRILBY WASH DETENTION BASIN

SOIL PROFILES

SUBMITTED BY:

DATE

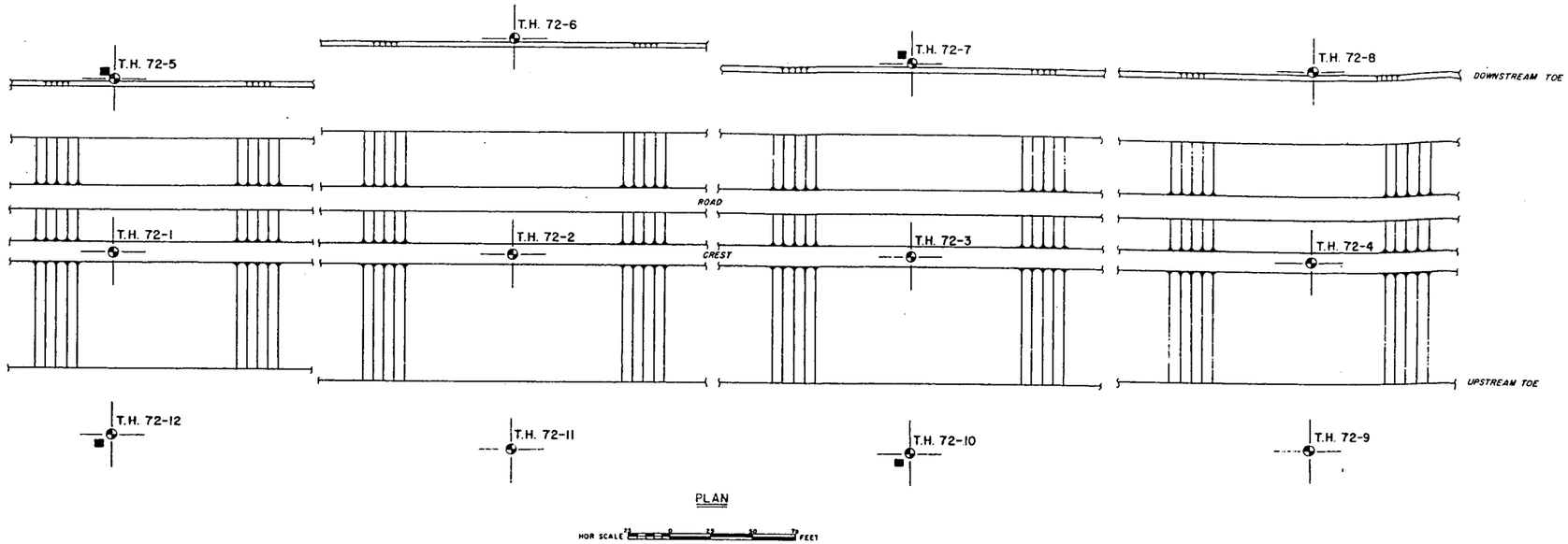
SPEC. NO.

DRAWING NUMBER

DISTRICT FILE NO.

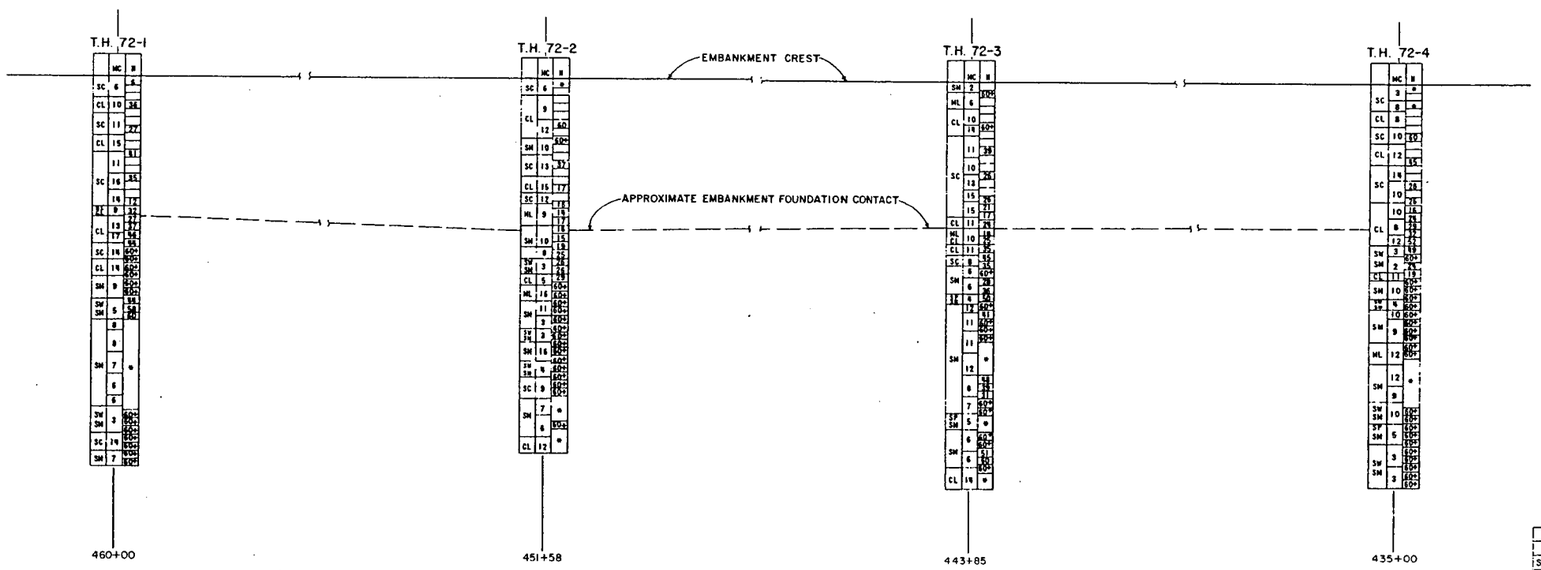
SHEET

PLATE 11



PLAN

HOR SCALE 20 0 10 20 30 FEET



PROFILE

VERT SCALE 10 0 10 20 30 FEET

LEGEND

- LOCATION AND NUMBER OF TEST HOLES
- UNDISTURBED SAMPLES

SYMBOL	DESCRIPTIONS	DATE	APPROVAL
	REVISIONS		

U.S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY: LAK
DRAWN BY: L.L.W.
CHECKED BY: MPC

TRILBY WASH DETENTION BASIN

SOIL PROFILES

SUBMITTED BY:
DATE:

SPEC. NO.
DRAWING NUMBER
DISTRICT FILE NO.
SHEET

T.H. 72-5

		MC	LL	PI	-#4	-#200	#	
4.0'	SM	3		NP	90	27	3	SILTY SAND, tan, loose, gravel to 3" max.
							5	
6.0'		7	35	12	88	46	6	CLAYEY SAND, tan, loose to medium dense, gravel to 1/2" max.
8.0'	SC	6	34	13	86	42	50	GRAVELLY CLAYEY SAND, tan, caliche cemented, gravel to 3" max.
10.0'		5	35	13	88	29	60+	CLAYEY SAND, tan, dense to medium dense, gravel to 2" max., 1-5" cobble.
12.5'	ML	9		NP	95	52	18	SANDY SILT, tan, medium dense.
16.0'	CL	12	32	10	100	62	60+	SANDY CLAY, tan, caliche cemented.
							52	
		12			100	48	60+	SILTY SAND, brown, dense to medium dense.
							37	
	SM	6			100	27	33	
							31	
24.0'		7			98	18	18	
27.0'	SW SM	3			87	9	33	SAND-SILTY SAND, brown & gray, dense, gravel & cobbles to 4" max., caving.
							36	
31.0'	SC	10	39	17	100	46	1	CLAYEY SAND, tan w/black streaks, very hard drilling.
							1	
							1	
		10		NP	100	35	60+	SILTY SAND, tan to brown, highly cemented, a few gravels to 2" max.
							60+	
	SM						60+	
		10		NP	100	36	60+	
							60+	
41.0'		12		NP	100	40	60+	
	SW SM	10			99	19	60+	GRAVELLY SAND-SILTY GRAVELLY SAND, brown, very dense, gravel to 3" max.
							60+	
		6			79	9	60+	
47.0'							60+	
							20	
51.0'	SC	27	38	18	95	39	33	CLAYEY SAND, brown, stiff to very hard, gravel to 1 1/2" max., very wet at 47 feet.
							60+	
54.0'	SW SM	16			91	12	60+	SAND-SILTY SAND, brown, very dense, wet, gravel to 2" max.
							60+	

T.H. 72-6

		MC	LL	PI	-#4	-#200	#	
		3		NP	94	42	37	GRAVELLY SILTY SAND, tan, dense to medium dense, gravel & cobbles to 4" max.
	SM						19	
		9		NP	79	22	18	
7.0'							18	
							25	
		9		NP	72	20	28	SILTY GRAVELLY SAND, tan, medium dense, gravel to 3" max.
11.0'	SM						24	
		6		NP	88	39	34	SILTY SAND, light brown, dense to medium dense, gravel to 2" max.
14.0'							24	
16.5'	CL	17	33	13	100	71	30	SANDY CLAY, tan w/white caliche streaks, gravel to 2" max.
							58	
18.0'	ML	17		NP	100	62	60+	SANDY SILT, light brown, cemented.
22.0'	SM	9		NP	100	27	60+	SILTY SAND, light brown, very dense & cemented.
							58	
							55	
25.5'	SW SM	5		NP	82	9	34	GRAVELLY SAND-SILTY GRAVELLY SAND, brown, dense, gravel to 3" max.
							50	
29.0'		12		NP	84	38	60+	GRAVELLY SILTY SAND, light brown, cemented, gravel to 1" max.
							60+	
							1	
		12	43	16	100	67	1	SILTY SAND, tan, highly cemented, very hard
							1	
	SM						60+	
		12	36	9	100	95	60+	
							60+	
							60+	
40.0'		15		NP	95	31	60+	gravel to 2" max.
							60+	
42.0'		16		NP	85	19	60+	SILTY GRAVELLY SAND, light brown, very dense, gravel to 3" max.
							60	
43.5'	SM	20		NP	88	9	58	SAND-SILTY SAND, brown, very dense, very wet.
45.0'	CL	20	36	16	100	55	60+	SANDY CLAY, tan w/white, very hard.
							60+	

T.H. 72-7

		MC	LL	PI	-#4	-#200	#	
		9		NP	90	17	7	SILTY SAND, tan, loose, gravel & cobbles to 5" max.
	SM						5	
		9		NP	90	10	9	
7.0'							15	
10.0'	CL	5	35	12	88	51	53	SANDY CLAY, tan, cemented, gravel to 1 1/2" max.
11.0'	SC	6	36	15	80	30	60+	CLAYEY GRAVELLY SAND, tan, dense, gravel & cobbles to 6" max.
		9		NP	76	12	32	GRAVELLY SAND-SILTY GRAVELLY SAND, light brown, dense, gravel & cobbles to 5" max., caving.
	SW SM						34	
		3		NP	65	11	31	
							33	
19.5'		3		NP	76	11	33	
21.0'	SC	6	28	8	89	35	60+	CLAYEY SAND, brown, hard, gravel to 1" max.
25.0'	SM	10		NP	100	35	60+	SILTY SAND, brown, cemented.
							60+	
29.0'	CL	17	44	18	87	55	60+	SANDY CLAY, tan w/white streaks, cemented.
							1	
							1	
		13		NP	91	36	60+	SILTY SAND, tan to brown, cemented, gravel to 2" max.
							60+	
	SM	8		NP	90	24	60+	
							60+	
		5			82	16	47	
39.0'							53	
							60	GRAVELLY SAND-SILTY GRAVELLY SAND, brown, very dense, gravel to 2 1/2" max.
42.0'	SW SM	9			76	7	56	
							60+	
	SW SM	5			82	8	58	SAND-SILTY SAND, brown, very dense, gravel & cobbles to 5" max.
46.0'							60+	
	SW SM	5			83	10	60+	GRAVELLY SAND-SILTY GRAVELLY SAND, brown, very dense, gravel & cobbles to 5" max.
49.0'							60+	
51.0'	SW SM	19			86	12	60+	SAND-SILTY SAND, brown, very dense, wet, gravel & cobbles to 5" max.
							60+	
54.0'	SC	16	35	15	96	46	60+	CLAYEY SAND, brown, cemented, moist.
							60+	

T.H. 72-8

		MC	LL	PI	-#4	-#200	#	
3.0'	SC	2	34	12	85	33	4	CLAYEY SAND, tan, loose, gravel to 1 1/2" max.
							5	
5.5'	CL	10	33	11	96	65	3	SANDY CLAY, brown, stiff.
							33	
8.5'	SC	8	36	16	88	48	33	CLAYEY SAND, tan, dense, gravel to 1 1/2" max.
							54	
11.0'		5	39	20	68	15	25	CLAYEY GRAVELLY SAND, brown, dense to medium dense, gravel to 2 1/2" max.
							25	
14.5'	SW SC	5	42	24	82	12	28	GRAVELLY SAND-CLAYEY GRAVELLY SAND, red-brown, medium dense, gravel to 1 1/2" max.
							28	
16.0'	CL	13	29	11	88	54	50	SANDY CLAY, brown, hard, gravel to 2" max.
	SM	11		NP	93	38	56	SILTY SAND, brown to light brown, very dense, gravel to 2" max.
							60+	
							55	
		10		NP	92	38	60+	
24.0'							60+	
	NL	11		NP	84	56	1	SANDY SILT, light brown, cemented, gravel to 1 1/2" max.
28.0'							60+	
							60+	
31.0'	CL	22	39	14	100	68	60+	SANDY CLAY, light brown, cemented.
							60+	
34.0'	ML	15	47	16	100	52	1	SANDY SILT, tan, highly cemented.
							1	
37.0'	SM	11		NP	86	24	1	SILTY SAND, light brown, very hard, gravel & cobbles to 5" max.
							60+	
	SW SM	5		NP	84	11	60+	SAND-SILTY SAND, brown, very dense, gravel & cobbles to 6" max., caving.
							60+	
44.0'		6			86	9	60+	
							60+	
46.0'	SM	12		NP	82	29	60+	SILTY SAND, brown, cemented, gravel to 2" max.
							60+	
	SW SM	7			77	11	60+	GRAVELLY SAND-SILTY GRAVELLY SAND, brown, very dense, gravel to 3" max.
							60+	
52.0'		3			84	8	60+	
							60+	
54.0'	SM	17		NP	100	27	60+	SILTY SAND, brown, cemented lenses.
							60+	

T.H. 72-9

		MC	LL	PI	-#4	-#200	#	
2.0'	ML	6	37	11	93	53	34	SANDY SILT, red-brown, dense, gravel & cobbles to 4" max.
							47	
5.0'	SM	10	41	15	92	48	60+	SILTY SAND, tan w/white cementation, gravel to 1/2" max.
							48	
8.5'	SW SM	6		NP	84	10	54	GRAVELLY SAND-SILTY GRAVELLY SAND, red-brown, dense, gravel to 3" max.
							60+	
11.0'	CL	15	33	13	97	52	60+	SANDY CLAY, brown, very hard, gravel & cobbles to 5" max.
		10	35	15	90	53	60+	
14.0'	SC	16	35	15	88	30	60+	CLAYEY SAND, light brown, very dense & cemented, gravel to 1/2" max.
							60+	
17.0'		7	37	16	89	16	1	CLAYEY GRAVELLY SAND, brown, very dense & cemented, gravel & cobbles to 4" max.
							60+	
	SM	11		NP	100	36	60+	SILTY SAND, tan, very dense & cemented.
							60+	
23.0'		17		NP	100	62	60+	
							60+	
		16	48	16	100	53	60+	SANDY SILT, tan w/brown cementation, hard to drill.
							60+	
	ML						60+	
		14	45	14	100	53	60+	
							60+	
31.0'							60+	
33.0'	SC	10	46	26	91	29	1	CLAYEY SAND, tan, highly cemented, gravel to 1" max.
							1	
36.0'	SW SM	8			71	11	1	GRAVELLY SAND-SILTY GRAVELLY SAND, brown, very dense, gravel & cobbles to 5" max., caving.
							1	
		6			97	6	60+	SAND-SILTY SAND, very dense, gravel & cobbles to 8" max., caving.
	SW SM						60+	
42.0'		3			99	8	60+	
							60+	
		7			89	10	60+	GRAVELLY SAND-SILTY GRAVELLY SAND, brown, very dense, gravel to 3" max.
							60+	
48.0'	SW SM	5			80	12	60+	
							60+	
50.0'		9		NP	96	37	60+	SILTY SAND, brown, cemented.
							60+	

T.H. 72-10

		MC	LL	PI	-#4	-#200	#	
		4	26	8	94	52	25	SANDY CLAY, tan, caliche cementation, gravel to 1 1/2" max.
	CL						17	
5.0'		7	30	14	96	58	18	
							18	
		8	41	18	79	26	36	CLAYEY GRAVELLY SAND, tan, medium to very dense, gravel & cobbles to 6" max.
	SC						52	
9.0'		6	38	15	61	17	50	
	SW SC	5	38	18	73	12	34	GRAVELLY SAND-CLAYEY GRAVELLY SAND, brown, very dense, gravel to 3" max.
11.0'							60+	
13.0'	CL	12	34	16	97	52	60+	SANDY CLAY, tan, caliche cemented.
							55	
15.0'	SC	12	30	11	93	33	60+	CLAYEY SAND, brown, very dense.
							60+	
	ML	14		NP	96	58	60+	SANDY SILT, light brown, highly cemented & hard to drill
19.0'							60+	
							60+	
							60+	SANDY CLAY, light brown, highly cemented, hard to drill.
	CL	14	42	22	100	55	60+	
23.0'							60+	
27.0'	SC	11	42	17	95	45	60+	CLAYEY SAND, tan, highly cemented, hard drilling.
							60+	
	SM	14		NP	100	48	60+	SILTY SAND, light brown, highly cemented, gravel to 1" max.
32.0'		9		NP	95	16	60+	
							60+	
		9			79	6	60	GRAVELLY SAND-SILTY GRAVELLY SAND, brown to light brown, very dense, gravel to 3" max.
							54	
	SW SM	5			67	8	59	
							1	
							60+	
		5			74	7	60+	
							1	
42.0'							1	
45.0'	SW SM	9			86	9	60+	SAND-SILTY SAND, brown, very dense, gravel to 2" max.
							60+	
	SP SM	5			86	6	60+	
							60+	
49.0'							60+	
51.0'	SC	9	31	11	94	32	60+	SILTY SAND, brown, very dense, hard to drill.
							1	

T.H. 72-11

		MC	LL	PI	-#4	-#200	#	
3.0'	ML	5		NP	96	67	38	SANDY SILT, tan, dense, gravel to 1 1/2" max.
							61	
5.0'		5		NP	96	61	30	SILTY SAND, tan, dense, 1-4" cobble.
7.0'	SM	3		NP	78	17	22	SILTY GRAVELLY SAND, brown, medium dense, gravel to 3" max.
							11	
11.0'	SW SC	4	21	5	77	13	8	SILTY GRAVELLY SAND-CLAYEY GRAVELLY SAND, brown, loose, gravel to 2" max.
							7	
14.0'	SP SM	5	20	2	77	12	19	GRAVELLY SAND-SILTY GRAVELLY SAND, brown, medium to dense, gravel to 3" max.
							45	
16.0'	CL	20	30	9	100	60	20	SANDY CLAY, brown, dense.
18.0'	SM	7			95	16	53	SILTY SAND, brown, dense, gravel to 1" max.
							55	
22.0'	SW SM	4			95	10	36	SAND-SILTY SAND, light brown, gravel to 2" max.
							35	
							20	
		17	37	12	95	92	60+	SILTY SAND, light brown, very dense, gravel to 2" max.
	SM						60+	
		12		NP	88	35	60+	
							60+	
28.0'	SC	11	38	14	80	19	1	CLAYEY GRAVELLY SAND, tan, caliche cemented, gravel to 2 1/2" max.
30.0'		9		NP	76	16	1	SILTY GRAVELLY SAND, light brown, dense, gravel & cobbles to 5" max.
31.5'	SM						1	
		12		NP	90	27	1	SILTY SAND, light brown, highly cemented.
35.0'							60+	
	SC	10	27	9	88	25	60+	CLAYEY SAND, light brown, cemented, gravel to 2 1/2" max.
37.0'	SM	7			94	8	60+	SAND-SILTY SAND, light brown, dense.
38.0'	SM	6			70	7	60+	GRAVELLY SAND-SILTY GRAVELLY SAND, light brown, very dense, gravel to 3" max.
40.0'							1	
	SM	10		NP	100	36	1	SILTY SAND, brown, highly cemented, hard drilling.
43.0'							1	
							60+	
46.0'	CL	19	36	14	100	68	60+	SANDY CLAY, brown, very hard drilling.
							60+	
49.0'	SC	14	31	12	55	29	60+	CLAYEY SANDY GRAVEL, brown, very hard, gravels are caliche clods.
							1	
51.0'	SC	14	26	7	62	19	1	CLAYEY GRAVELLY SAND, brown, cemented, gravels are caliche clods.
							1	

T.H. 72-12

		MC	LL	PI	-#4	-#200	#	
2.0'	CL	6	33	13	95	51	60+	SANDY CLAY, brown, cemented, gravel to 1 1/2" max.
							60+	
4.0'		6	39	12	91	62	42	CLAYEY SAND, tan, caliche cemented, gravel to 1" max.
							60+	
7.0'	SC	5	36	15	69	20	1	CLAYEY GRAVELLY SAND, tan, highly cemented, gravel to 3" max.
							60+	
11.0'		15	43	18	85	44	60+	CLAYEY SAND, tan, highly cemented, gravel to 2" max.
							60+	
13.0'	SM	12		NP	100	46	52	SILTY SAND, light brown, dense.
							35	
	SW SM	6		NP	83	12	35	GRAVELLY SAND-SILTY GRAVELLY SAND, light brown, dense, gravel to 2 1/2" max., 2-5" cobbles.
17.0'							46	
20.0'	SW SM	6		NP	95	7	37	SAND-SILTY SAND, light brown, dense, gravel & cobbles to 5" max.
							41	
24.0'	SM	10	39	13	90	44	60+	SILTY SAND, tan, very hard drilling, cemented.
							1	
							1	
	GM	11	42	14	50	20	1	SILTY SANDY GRAVEL, light brown, highly cemented, +40 material is cemented particles.
28.0'							1	
							1	CLAYEY SAND, tan, highly cemented.
							1	
32.0'	SC	11	33	10	75	33	60+	GRAVELLY CLAYEY SAND, brown, highly cemented, +40 material is cemented particles.
							60+	
36.0'	SM	12			97	22	60+	SILTY SAND, brown, very dense gravel to 2" max.
							60+	
38.0'	SW SM	5			90	10	60+	SAND-SILTY SAND, light brown, very dense, gravel & cobbles to 4" max.
							60+	
42.5'							60+	
	CL	19	54	15	100	52	60+	SANDY CLAY, tan w/white caliche streaks.
45.0'							1	
		11	30	10	68	29	1	CLAYEY GRAVELLY SAND, brown w/black streaks, highly cemented, +40 is cemented particles.
	SC						60+	
51.0'		10	33	11	100	49	60+	CLAYEY SAND, brown w/black streaks, highly cemented.
							60+	

NOTES:

1. See Sheet 8 for Locations of Test Holes.
2. See Sheet 8 for General Notes, Legend and Basis For Classification.

VERT SCALE 5 0 5 10 15 FEET

SYMBOL	DESCRIPTIONS	DATE	APPROVAL
	REVISIONS		

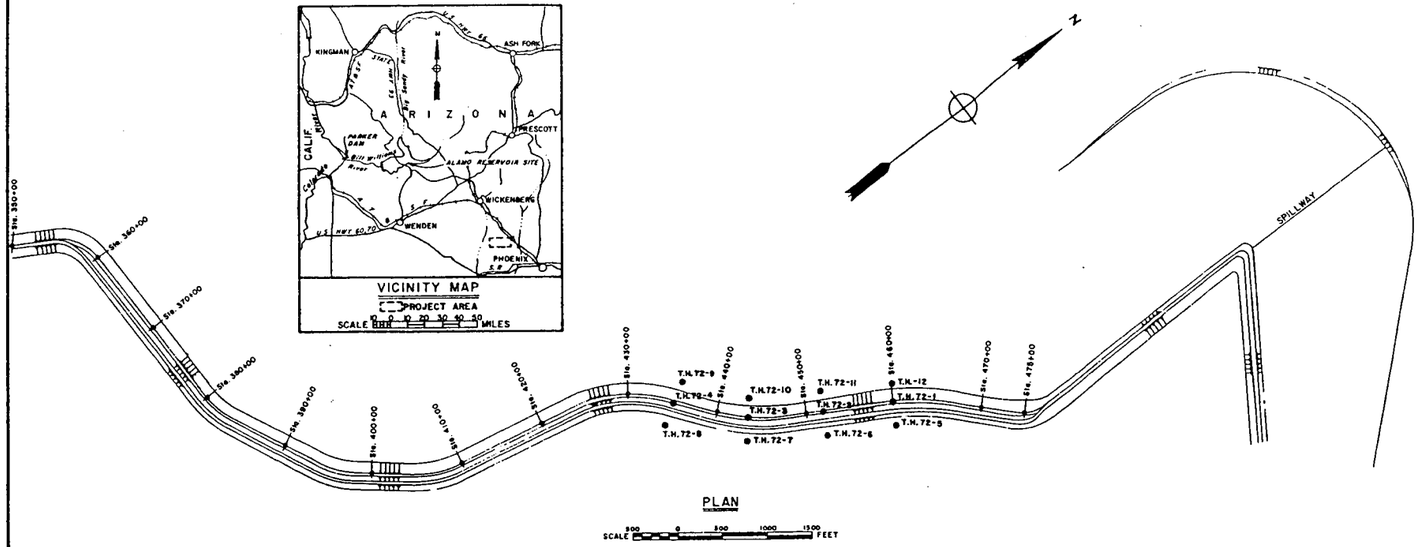
U.S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY: LAK
DRAWN BY: L.L.W.
CHECKED BY: MPC

TRILBY WASH DETENTION BASIN

LOGS OF TEST HOLES

SUBMITTED BY:
DATE:
SPEC. NO.
DRAWING NUMBER
DISTRICT FILE NO.
SHEET



UNIFIED SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			GROUP SYMBOLS	TYPICAL NAMES
COARSE GRAINED SOILS More than half of material is larger than no. 200 sieve size.	GRAVELS More than half of coarse fraction is larger than no. 4 sieve size.	Clean gravels	GW	Well-graded gravels, gravel-sand mixtures, little or no fines.
			GP	Poorly-graded gravels, gravel-sand mixtures, little or no fines.
		Gravels with fines	GM	Silty gravels, gravel-sand-silt mixtures.
			GC	Clayey gravels, gravel-sand-clay mixtures.
	SANDS More than half of coarse fraction is smaller than no. 4 sieve size.	Clean sands	SW	Well-graded sands, gravelly sands, little or no fines.
			SP	Poorly-graded sands, gravelly sands, little or no fines.
		Sands with fines	SM	Silty sands, sand-silt mixtures.
			SC	Clayey sands, sand-clay mixtures.
FINE GRAINED SOILS More than half of material is smaller than no. 200 sieve size.	SILTS AND CLAYS	Low liquid limit.	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands, or clayey silts, with slight plasticity.
			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.
			OL	Organic silts and organic silty clays of low plasticity.
		High liquid limit.	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
			CH	Inorganic clays of high plasticity, fat clays.
			OH	Organic clays of medium to high plasticity, organic silts.
Highly organic soils			Pt	Peat and other highly organic soils.

NOTES:

1. Boundary Classification: Soils possessing characteristics of two groups are designated by combinations of group symbols. For example, GW-GC, well-graded gravel-sand mixture with clay binder.
2. All sieve sizes on this chart are U. S. Standard.
3. The terms "silt" and "clay" are used respectively to distinguish materials exhibiting lower plasticity from those with higher plasticity. The minus no. 200 sieve material is silt if the liquid limit and plasticity index plot below the "A" line on the plasticity chart (Table VI, Military Standard 619A), and is clay if the liquid limit and plasticity index plot above the "A" line on the chart.
4. For a complete description of the Unified Soil Classification System, see "Military Standard 619A" dated 20 March 1962

LEGEND

T. H.	
⊕	LOCATION AND NUMBER OF TEST HOLE (SEE PLATE 10).
M C	FIELD MOISTURE CONTENT IN PERCENT OF DRY WEIGHT.
L L	LIQUID LIMIT.
P I	PLASTICITY INDEX (LIQUID LIMIT MINUS PLASTIC LIMIT).
N P	NONPLASTIC
-4	PERCENT OF MATERIAL BY WEIGHT PASSING NO. 4 SIEVE.
-200	PERCENT OF MATERIAL BY WEIGHT PASSING NO. 200 SIEVE.
N	NUMBER OF BLOWS OF A 140-POUND DROPHAMMER FALLING 30 INCHES REQUIRED TO DRIVE A SAMPLING SPOON 6IN. FOOT. OUTSIDE DIAMETER OF SPOON IS 2 INCHES; INSIDE DIAMETER IS 1-3/8 INCHES. PROCEDURE IS CALLED STANDARD PENETRATION TEST.
W	DEPTH TO WATER

T.H. 72-1

Elev.	MC	LL	PI	-4	-200	N	Description
EMBANKMENT							
4.0'	SC	6	38	17	89	40	CLAYEY SAND, light brown, medium dense, gravel & cobbles to 5" max.
7.0'	CL	10	36	16	90	51	SANDY CLAY, brown w/white caliche streaks, hard, gravel to 1" max.
	SC	11	35	16	89	50	CLAYEY SAND, light brown, caliche streaks, gravel to 2" max.
11.0'	CL	15	29	11	97	66	SANDY CLAY, brown, caliche streaks, very stiff.
14.0'	SC	11	38	16	79	29	GRAVELLY CLAYEY SAND, light brown, dense, gravel to 2" max.
18.0'		16	44	23	86	44	CLAYEY SAND, brown, dense, gravel to 2" max.
21.0'		16	37	17	83	40	GRAVELLY CLAYEY SAND, brown, medium dense, gravel to 2" max.
24.0'	ML CL	9	29	6	95	52	SANDY SILT-SANDY CLAY, brown, dense, gravel to 1" max.
26.0'	CL	13	36	18	92	64	SANDY CLAY, light brown to tan, some caliche, gravel to 2" max.
31.0'		17	46	20	93	70	
34.0'	SC	14	38	19	96	48	CLAYEY SAND, brown with tan caliche, gravel to 2" max.
37.0'	CL	16	38	16	96	59	SANDY CLAY, light brown w/dark brown lenses, gravel to 1" max.
41.0'	SM	9		NP	100	28	SILTY SAND, light brown, cemented, 2-4" cobbles.
45.0'	SW SM	5		NP	65	6	GRAVELLY SAND-SILTY GRAVELLY SAND, light brown, dense, gravel to 2" max.
47.0'		8		NP	78	22	GRAVELLY SILTY SAND, tan, cemented with caliche, gravel & cobbles to 4" max.
		8		NP	100	63	SILTY SAND, light brown w/brown & black streaks, very hard, gravel to 2 1/2" max.
	SM	7		NP	99	40	
		6		NP	98	67	
61.0'		6		NP	91	30	
65.5'	SW SM	3			93	12	SAND-SILTY SAND, tan, gravel & cobbles to 4" max., caving.
69.0'	SC	19	34	15	100	50	CLAYEY SAND, light brown, very hard.
72.0'	SM	7		NP	100	40	SILTY SAND, light brown, cemented, very dense.

T.H. 72-2

Elev.	MC	LL	PI	-4	-200	N	Description
EMBANKMENT							
3.0'	SC	6	35	14	91	45	CLAYEY SAND, light brown, caliche cemented, gravel to 1 1/2" max.
	CL	9	35	16	94	56	SANDY CLAY, light brown to brown w/gray streaks, very hard, gravel to 1 1/2" max.
11.0'		12	26	7	98	64	
14.0'	SM	10		NP	94	47	SILTY SAND, brown, very dense, gravel to 1" max.
	SC	13	41	20	83	34	GRAVELLY CLAYEY SAND, brown w/white streaks, dense, gravel to 1" max.
18.0'	CL	15	33	16	98	59	SANDY CLAY, brown, very stiff.
21.0'	SC	12	33	16	92	47	CLAYEY SAND, tan & light brown, medium dense, gravel to 2" max.
23.0'	ML	9		NP	95	59	SANDY SILT, brown, medium dense, gravel to 1 1/2" max.
27.0'							
31.0'	SM	10		NP	91	41	SILTY SAND, brown, medium dense, gravel to 1 1/2" max.
33.0'		8		NP	78	28	GRAVELLY SILTY SAND, brown, medium dense, gravel to 2" max.
35.5'	SW SM	3		NP	65	10	GRAVELLY SAND-SILTY GRAVELLY SAND, brown, medium dense, gravel & cobbles to 4" max.
38.0'	CL	5	35	15	95	56	SANDY CLAY, light brown, very stiff, gravel to 1 1/2" max.
41.0'	ML	16		NP	100	65	SANDY SILT, tan, very dense, cemented.
	SM	11		NP	90	47	SILTY SAND, tan to brown, very dense, gravel to 2" max.
46.0'		2			92	13	
48.5'	SW SM	3			93	7	SAND-SILTY SAND, light brown, very dense, gravel to 2" max.
52.0'	SM	16		NP	94	47	SILTY SAND, tan, cemented, hard to drill, gravel to 3" max.
55.0'	SW SM	4		NP	68	8	GRAVELLY SAND-SILTY GRAVELLY SAND, light brown, dense, gravel to 3" max., caving.
59.0'	SC	9	39	18	92	38	CLAYEY SAND, tan w/white and black streaks, very hard, gravel to 2" max.
		7		NP	95	26	SILTY SAND, light brown, cemented, very dense, gravel & cobbles to 6" max.
66.0'	SM	6		NP	89	13	
69.0'	CL	12	36	18	96	54	SANDY CLAY, light tan w/brown & white streaks, very hard drilling.

T.H. 72-3

Elev.	MC	LL	PI	-4	-200	N	Description
EMBANKMENT							
2.0'	SM	2		NP	93	41	SILTY SAND, tan, dense, gravel to 1/2" max., 1-5" cobble.
5.0'	ML	6		NP	97	55	SANDY SILT, brown, dense and cemented, gravel to 2" max.
10.0'	CL	10	38	17	85	56	SANDY CLAY, brown, very dense & cemented, gravel to 3" max.
		18	35	17	94	57	
14.0'	SC	11	40	20	89	38	CLAYEY SAND, brown, dense, gravel to 2" max.
17.0'		10	44	21	73	35	GRAVELLY CLAYEY SAND, tan, medium dense, gravel to 2" max.
		13	39	19	89	47	CLAYEY SAND, tan, medium dense, gravel to 1" max., several cobbles to 6" max.
		15	43	23	89	45	
25.0'		15	40	18	88	48	
27.0'	CL	11	32	12	97	67	SANDY CLAY, light brown, very stiff.
30.0'	ML CL	10	29	5	94	53	SANDY SILT-SANDY CLAY, brown, stiff to very stiff.
32.0'	CL	11	35	15	91	51	SANDY CLAY, tan w/white caliche streaks, gravel to 2" max.
34.0'	SC	8	39	16	65	27	CLAYEY GRAVELLY SAND, tan, dense, gravel to 2" max.
36.0'	SM	6		NP	83	13	SILTY GRAVELLY SAND, tan, dense, gravel & cobbles to 4" max.
39.0'		6		NP	89	16	SILTY SAND, light brown, medium to dense, gravel to 1" max.
41.0'	SP SM	6		NP	68	8	GRAVELLY SAND-SILTY GRAVELLY SAND, brown, dense, gravel to 2" max.
	SM	12		NP	98	48	SILTY SAND, tan to light brown, dense to very dense & highly cemented, gravel to 2" max.,
		11		NP	97	38	
		11		NP	96	49	
		12	34	5	94	36	
58.0'		8		NP	89	20	dense, gravel to 1 1/2" max.
61.0'		7		NP	78	16	SILTY GRAVELLY SAND, light brown & gray, very dense, gravel to 3" max.
64.0'	SP SM	5		NP	62	9	GRAVELLY SAND-SILTY GRAVELLY SAND, brown, very dense, gravel & cobbles to 5" max.
71.0'	SM	6		NP	90	14	SILTY SAND, brown, very dense, gravel to 3" max.
		6		NP	92	13	
75.0'	CL	19	36	14	96	53	SANDY CLAY, tan, very hard, slow drilling.

T.H. 72-4

Elev.	MC	LL	PI	-4	-200	N	Description
EMBANKMENT							
3.0'	SC	3	35	16	87	36	GRAVELLY CLAYEY SAND, tan, caliche cemented, gravel to 2" max.
5.0'		8	38	20	89	41	CLAYEY SAND, brown, slight cementation, gravel to 1" max.
8.0'	CL	8	33	14	92	51	SANDY CLAY, tan w/white cementation, gravel to 2" max.
11.0'	SC	10	41	19	85	40	CLAYEY SAND, tan w/white cementation, gravel to 2" max.
	CL	12	43	23	91	58	SANDY CLAY, brown, hard, gravel to 2" max.
15.0'		18	39	18	85	57	CLAYEY SAND, dark brown, slightly cemented, gravel to 3" max.
22.0'	SC	10	37	17	89	48	
25.0'		10	38	16	91	58	SANDY CLAY, brown to tan, cemented zones, gravel to 2" max.
	CL	8	40	17	92	56	
30.0'		12	44	18	96	51	
32.0'	SW SM	3		NP	69	11	GRAVELLY SAND-SILTY GRAVELLY SAND, brown, dense, gravel to 2" max.
35.0'	SW SM	2		NP	80	11	SAND-SILTY SAND, brown, dense to medium dense, gravel to 2" max., caving.
36.5'	CL	11	31	12	96	53	SANDY CLAY, brown, very stiff.
	SM	10		NP	96	48	SILTY SAND, brown, cemented, gravel to 1/2" max.
40.0'	SW SM	4		NP	76	12	GRAVELLY SAND-SILTY GRAVELLY SAND, brown, very dense, gravel to 1 1/2" max.
42.0'		10		NP	100	43	SILTY SAND, tan w/white caliche cementation, gravel to 1" max.
	SM	9		NP	100	46	
48.0'	ML	12		NP	100	51	SANDY SILT, tan, cemented, gravel to 1" max.
52.0'		12		NP	100	46	SILTY SAND, light brown, highly cemented, gravel to 2" max.
	SM	9		NP	94	22	
59.0'		14			86	11	SAND-SILTY SAND, brown & gray, very dense, gravel to 2" max.
63.0'	SP SM	5			87	8	
67.0'	SW SM	3			75	6	GRAVELLY SAND-SILTY GRAVELLY SAND, brown, very dense, gravel to 3" max.
		3			82	9	
75.0'							

LOGS

VERT SCALE 0 5 10 15 FEET

SYMBOL	DESCRIPTIONS	DATE	APPROVAL
	REVISIONS		

U.S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY: LAK
DRAWN BY: L.L.V.
CHECKED BY: MPC
SUBMITTED BY:
DATE:

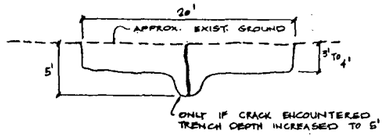
TRILBY WASH DETENTION BASIN

LOCATIONS AND LOGS OF TEST HOLES

SPEC. NO.
DRAWING NUMBER
DISTRICT FILE NO.
SHEET

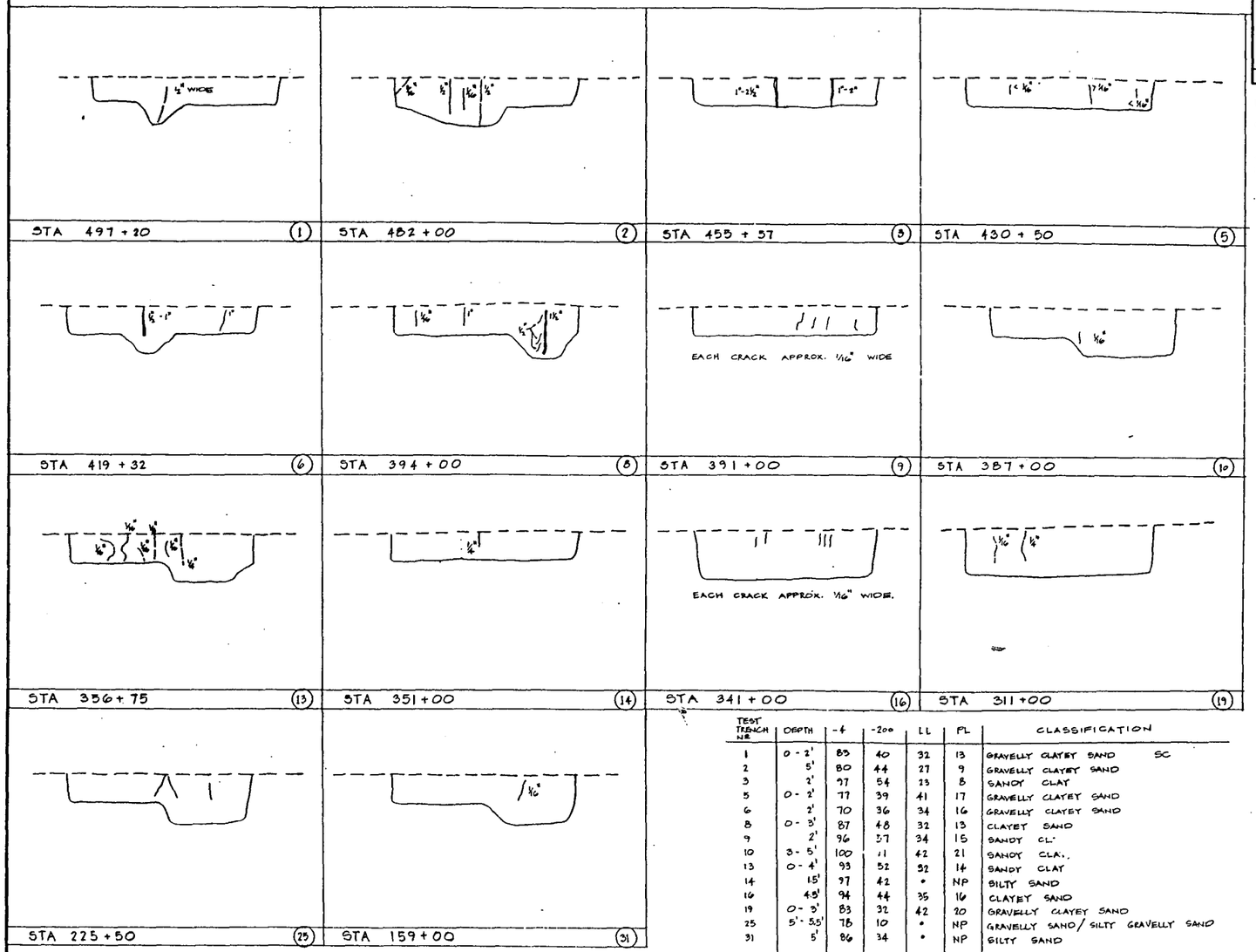
D. O. SERIES

PLATE 8



TYPICAL TRENCH

(3) NUMBER OF TEST TRENCH



TEST TRENCH NO.	DEPTH	-4	-200	LL	PL	CLASSIFICATION
1	0 - 2'	83	40	32	13	GRAVELLY CLAYEY SAND SC
2	5'	80	44	27	9	GRAVELLY CLAYEY SAND
3	2'	97	54	23	8	SANDY CLAY
5	0 - 2'	77	39	41	17	GRAVELLY CLAYEY SAND
6	2'	70	36	34	16	GRAVELLY CLAYEY SAND
8	0 - 3'	87	48	32	13	CLAYEY SAND
9	2'	96	57	34	15	SANDY CL
10	3 - 5'	100	61	42	21	SANDY CLAY
13	0 - 4'	93	52	32	14	SANDY CLAY
14	1.5'	97	42	*	NP	SILTY SAND
16	4.5'	94	44	35	16	CLAYEY SAND
19	0 - 3'	83	32	42	20	GRAVELLY CLAYEY SAND
25	5' - 5.5'	78	10	*	NP	GRAVELLY SAND / SILTY GRAVELLY SAND
31	5'	86	34	*	NP	SILTY SAND

* TESTED

NP NON PLASTIC

TABULATION of SOIL SAMPLE TESTS

UNIFIED SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			GROUP SYMBOLS	TYPICAL NAMES
COARSE GRAINED SOILS More than half of material is larger than no. 200 sieve size.	GRAVELS More than half of coarse fraction is larger than no. 4 sieve size.	Clean gravels	GW	Well-graded gravels, gravel-sand mixtures, little or no fines.
			GP	Poorly-graded gravels, gravel-sand mixtures, little or no fines.
		Gravels with fines	GM	Silty gravels, gravel-sand-silt mixtures.
			GC	Clayey gravels, gravel-sand-clay mixtures.
	SANDS More than half of coarse fraction is smaller than no. 4 sieve size.	Clean sands	SW	Well-graded sands, gravelly sands, little or no fines.
			SP	Poorly-graded sands, gravelly sands, little or no fines.
		Sands with fines	SM	Silty sands, sand-silt mixtures.
			SC	Clayey sands, sand-clay mixtures.
FINE GRAINED SOILS More than half of material is smaller than no. 200 sieve size.	SILTS AND CLAYS	Low liquid limit	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands, or clayey silts, with slight plasticity.
			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.
			OL	Organic silts and organic silty clays of low plasticity.
		High liquid limit	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
			CH	Inorganic clays of high plasticity, fat clays.
			OH	Organic clays of medium to high plasticity, organic silts.
Highly organic soils			Pt	Peat and other highly organic soils.

NOTES:

1. Boundary Classification: Soils possessing characteristics of two groups are designated by combinations of group symbols. For example, GW-GC, well-graded gravel-sand mixture with clay binder.
2. All sieve sizes on this chart are U. S. Standard.
3. The terms "silt" and "clay" are used respectively to distinguish materials exhibiting lower plasticity from those with higher plasticity. The minus no. 200 sieve material is silt if the liquid limit and plasticity index plot below the "A" line on the plasticity chart (Table VI, Military Standard 619A), and is clay if the liquid limit and plasticity index plot above the "A" line on the chart.
4. For a complete description of the Unified Soil Classification System, see "Military Standard 619A" dated 20 March 1962

LEGEND

T.H.	
⊕	LOCATION AND NUMBER OF TEST HOLE.
M C	FIELD MOISTURE CONTENT IN PERCENT OF DRY WEIGHT.
L L	LIQUID LIMIT.
P I	PLASTICITY INDEX (LIQUID LIMIT MINUS PLASTIC LIMIT).
N P	NONPLASTIC
-4	PERCENT OF MATERIAL BY WEIGHT PASSING NO. 4 SIEVE.
-200	PERCENT OF MATERIAL BY WEIGHT PASSING NO. 200 SIEVE.
N	NUMBER OF BLOWS OF A 140-POUND DROP-HAMMER FALLING 30 INCHES REQUIRED TO DRIVE A SAMPLING SPOON ONE FOOT. OUTSIDE DIAMETER OF SPOON IS 2 INCHES; INSIDE DIAMETER IS 1-3/8 INCHES. PROCEDURE IS CALLED STANDARD PENETRATION TEST.
W	DEPTH TO WATER

NOTE:

1. TRENCHES NOT SHOWN DIDN'T ENCOUNTER ANY CRACKS.

SYMBOL	DESCRIPTIONS	DATE	APPROVAL
	REVISIONS		

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY: LSH
DRAWN BY: LSH
CHECKED BY: MPC

TRILBY WASH DETENTION BASIN

TEST TRENCH PROFILES

SUBMITTED BY:

DATE:

SPEC. NO.

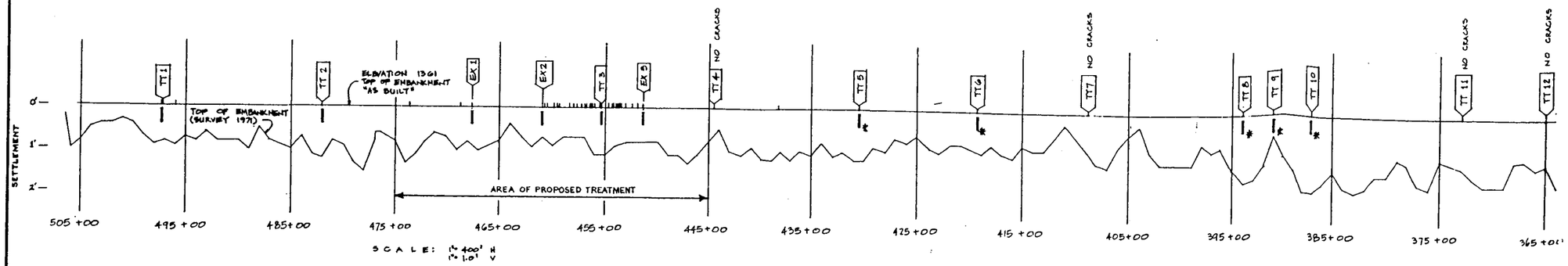
DRAWING NUMBER

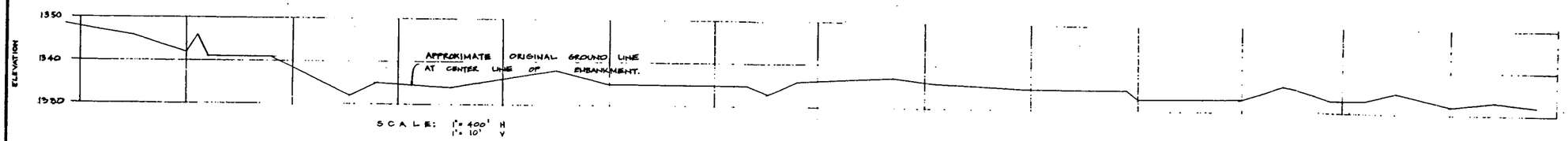
DISTRICT FILE NO.

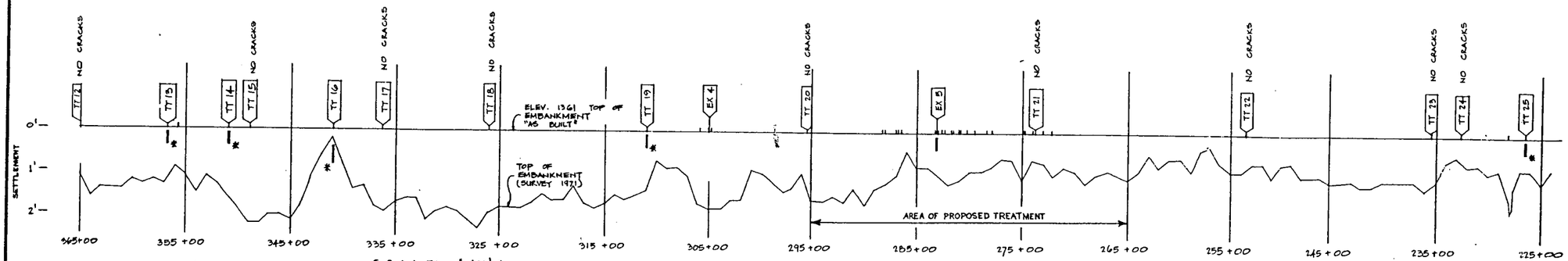
SHEET

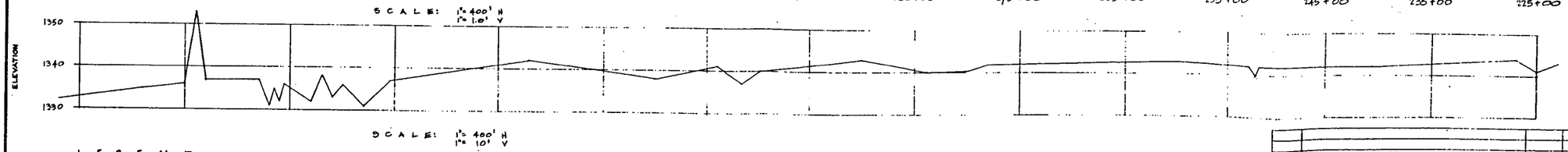
PLATE 7

D. O. SERIES









LEGEND

- TT 1 — APPROXIMATE LOCATION AND NUMBER OF TEST TRENCHES (JUNE 1972)
- EX 1 — APPROXIMATE LOCATION AND NUMBER OF EXCAVATIONS (MARCH 1972)
- CRACK ENCOUNTERED IN TEST TRENCH OR EXCAVATION. * INDICATES INSIGNIFICANT CRACKS
- SURFACE IRREGULARITIES "HOLES" (SEPT 1971)

GENERAL NOTES:

1. SEE PLATE 7 FOR PROFILES OF TEST TRENCHES (JUNE 1972).
2. SEE APPENDIX A FOR A DESCRIPTION OF EXCAVATIONS (MARCH 1972).

SYMBOL	DESCRIPTIONS	DATE	APPROVAL
	REVISIONS		

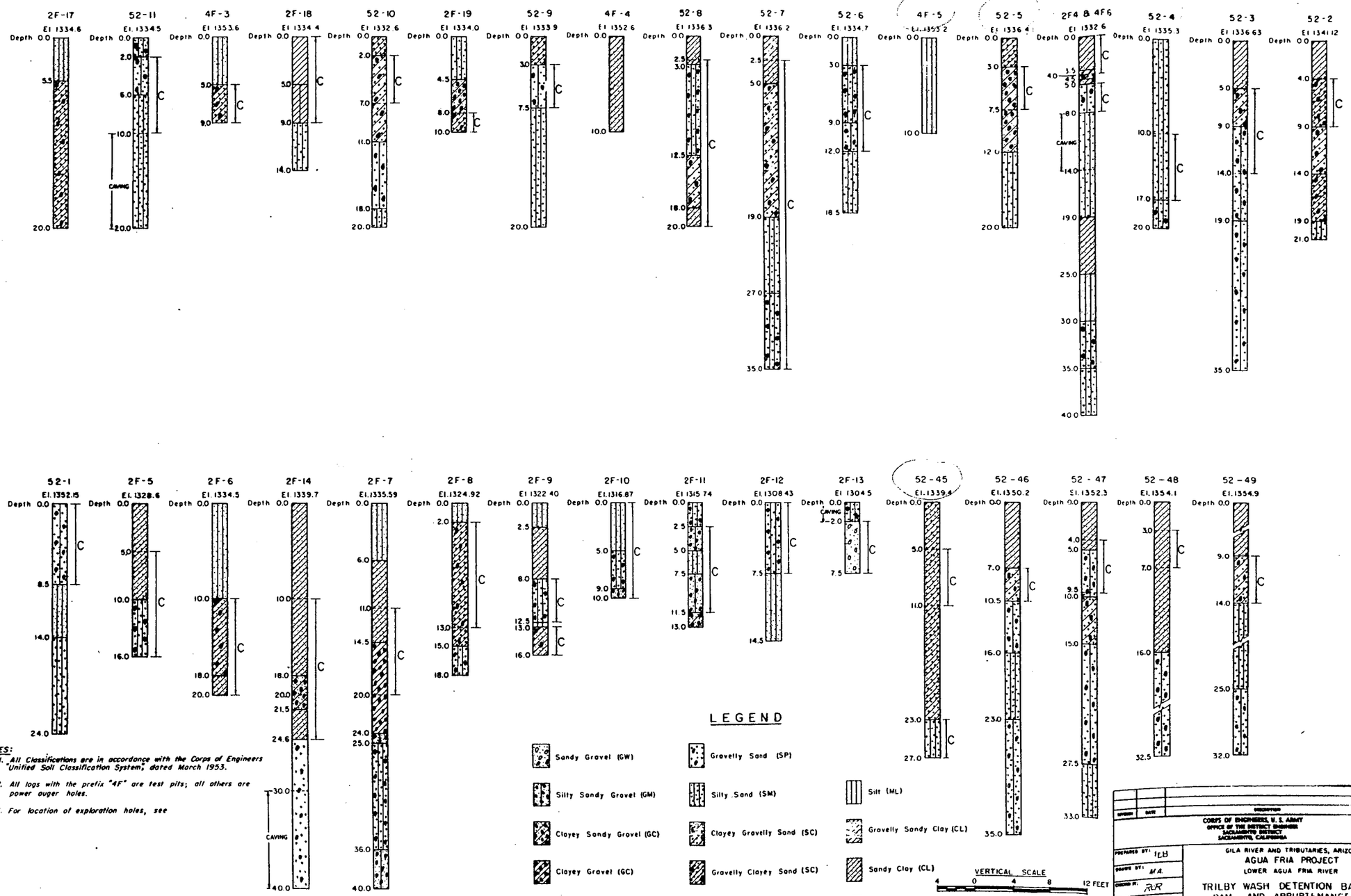
U.S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:
DRAWN BY: LSH
CHECKED BY: MPC
SUBMITTED BY:
DATE:

TRILBY WASH DETENTION BASIN

LOCATION OF TEST TRENCHES, EXCAVATIONS AND SURFACE IRREGULARITIES

SPEC. NO.
DRAWING NUMBER
DISTRICT FILE NO
SHEET



NOTES:

1. All Classifications are in accordance with the Corps of Engineers "Unified Soil Classification System", dated March 1953.
2. All logs with the prefix "4F" are test pits; all others are power auger holes.
3. For location of exploration holes, see

CORPS OF ENGINEERS, U. S. ARMY
OFFICE OF THE DISTRICT ENGINEER
SACRAMENTO DISTRICT
SACRAMENTO, CALIFORNIA

GILA RIVER AND TRIBUTARIES, ARIZONA
AGUA FRIA PROJECT
LOWER AGUA FRIA RIVER

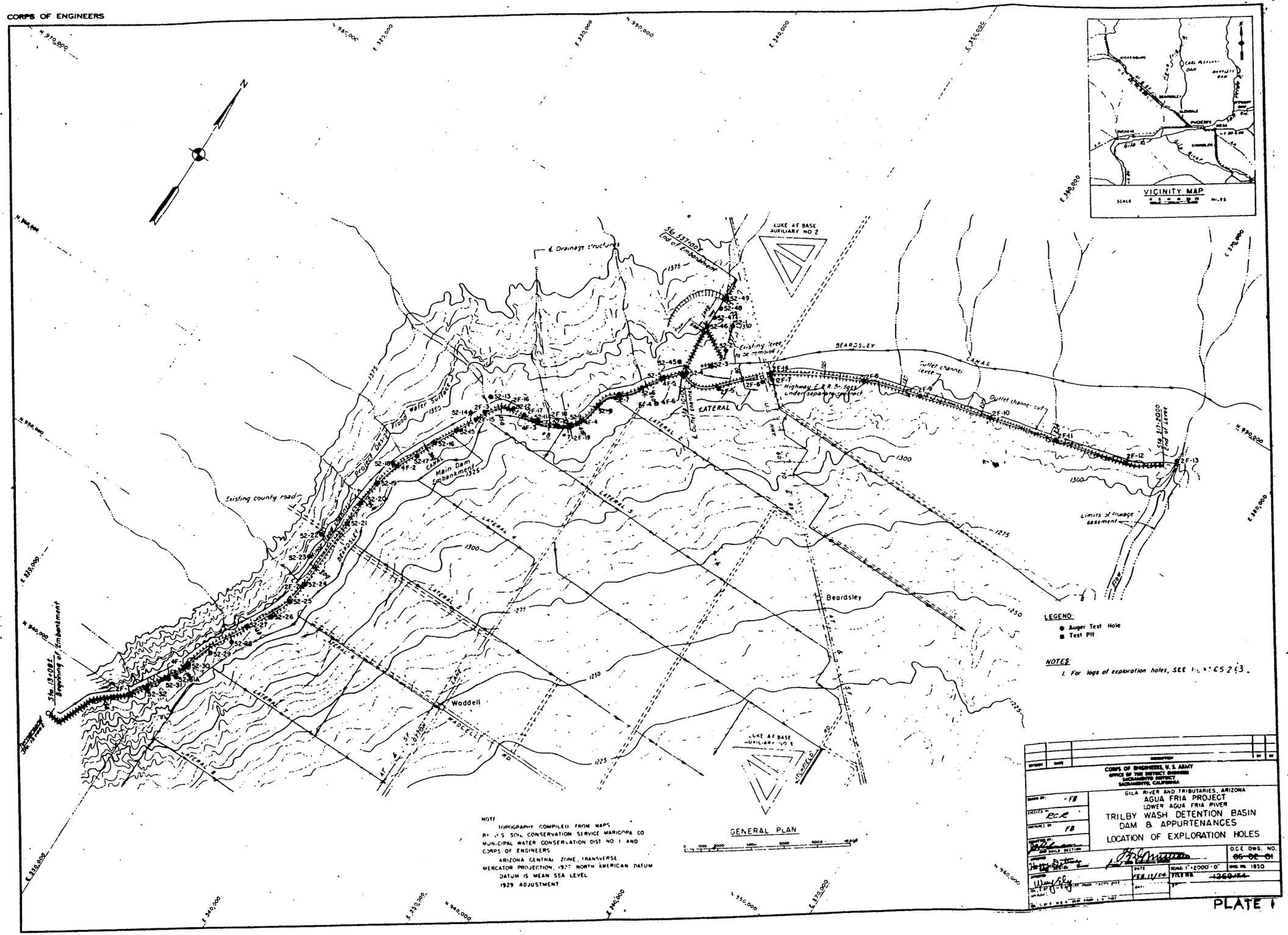
TRILBY WASH DETENTION BASIN
DAM AND APPURTENANCES
LOGS OF EXPLORATION HOLES

PREPARED BY: F.E.B.
DRAWN BY: M.A.
CHECKED BY: R.R.R.
DATE: Feb. 17, 1959
SCALE: 1" = 4' Vert.
O.C.E. DWG. NO. 56-03-01
SPEC. NO. 1550
FILE NO.

PLATE 3

CORPS OF ENGINEERS

U. S. ARMY



DOCUMENT TITLE: Geotechnical Investigation Report, McMicken Dam Restoration Study

DATE: July 27, 1982

PREPARED BY: Sergent, Hauskins & Beckwith (SHB)

PURPOSE:

- Investigate the cause(s) of cracking of the dam and evaluate the possible effects that subsidence and earth fissuring may have on the dam.
- Identify regional fissuring network, subsurface conditions in and below dam, and the extent of cracking in the embankment.
- Evaluate the changes in embankment geometry which have occurred since construction.
- Develop alternatives for repair to the dam and channel embankments and recommend approach.
- Provide cost estimates for repair alternatives
- Prepare schedule of maintenance and inspections.

SUMMARY:

- Documents reviewed for this report include:
  - USACE, 1973
  - The District, 1977
  - Reports of embankment cracking of other dams
  - Geologic literature on subsidence, fissuring, etc.
  - Available aerial photography
- Low sun angle photography analyses were performed
- Trenching of possible fissure locations
- Subsurface exploration program included hollow-stem auger borings, test pits, shallow trenching, and flooding of crest

- Lab analyses of samples
- Engineering analyses to evaluate cause(s) of cracks
- Review/analysis of original soils investigation and report (1955)
- Older embankment across Trilby Wash constructed in 1953
- Dam was used as impoundment from 1958 to early 1970s by blocking off outlet works with wood poles. Water levels reached five to six feet above flow line.
- Dam breached in July, 1977 to prevent flooding Sun City and Luke Air Force Base
- Eight trenches were excavated to 12 feet (or refusal) at suspected earth fissure sites, two trenches revealed fissures, three trenches extended to 21 feet.
- In January 1982, detailed reconnaissance of dam performed.
- Advanced 75 hollow-stem auger borings from 355+00 to 475+00 (1000 feet centers along crest, downstream, and upstream toes) from 8 to 60 feet deep.
- In February 1982, 21 shallow trenches were excavated along the crest to expose cracks. Trenches were 8-inches wide, 18-inches deep, and 50 to 100 feet long. Water was pumped into the trench until full or until obvious that cracks would preclude filling.
- Also, 36 backhoe test pits were excavated and ranged from 4 to 21 feet deep; 14 in suspected earth fissure locations; 22 in areas of suspected collapsing soils.
- The laboratory analyses included: gradation, Atterberg limits, in-situ moisture content, direct shear, consolidation, permeability, UU triaxial shear, specific gravity, pinhole dispersion, compaction.
- Earth fissures detected by low sun angle photography were focused near Luke Air Force Base No. 3, western edge of Luke Air Force Base, and several miles east of the base.
- Five trenches were excavated near the Fenne Knoll fissure area. Fissures up to four inches wide were found in trenches.
- Collapse potential was up to 0% in embankment soils.
- Collapse potential was up to 14% in foundation soils.
- Many large cracks were found north of Station 425+00.

- The outlet channel was found to have erosional features. Minor cracking found in the downstream channel dike.
- The mechanism and cause of groundwater table elevation being lowered, the resulting subsidence, and fissures were discussed.
- Finite element model of cracking was used to evaluate the mechanism of the cracks. Linear plastic model was used.
- Slope stability analysis (SSTAB1) performed on four design repair alternatives, lowest FS = 1.60.
- Seepage analysis was performed on embankment; parallel-plate flow and pipe-flow models used.

CONCLUSIONS AND RECOMMENDATIONS:

- Primary cause of cracking is due to collapse or settlement of embankment and foundation soils.
- The dam has experienced some compressive and tensile horizontal strains due to subsidence. However, this will not cause cracks without first causing fissures.
- Desiccation may be minor contributing factor in cracking but alone cannot cause cracks.
- Settlement and/or shrinkage within embankment may have contributed to cracking.
- Moisture sensitive foundation soils and cracking intensity is greater at Trilby Wash (north); predominantly in silty and clayey sands.
- Probability of future cracking due to collapsing soils is low.
- No evidence that earth fissures (from subsidence) contributed to cracking.
- Earth fissures (at south end of dam) will probably form and produce nearly vertical cracks from 1/2- to 3/4-inches wide through dam and foundation soils. Fissure will probably lead to rapid failure of dam (when filled).
- Recommended repair includes installation of a central vertical drain system tied into a toe drain, grouting existing cracks, and re-grading crest back to as-built height.
- Re-grade outlet channel.
- The design alternatives developed to repair embankment include and are ranked:

- Preferred: center drain to finger drain to downstream toe drain system.
- #2: downstream slope rockfill berm with downstream toe cutoff to caliche foundation layer.
- #3: upstream impermeable AC berm with toe cutoff to caliche foundation layer.
- #4: upstream gabion-mastic liner with toe cutoff to caliche foundation layer.

- An inspection and maintenance schedule was drafted and included:
  - Annual survey of crest elevations and NGS monuments.
  - Quarterly visual inspections of upstream, crest and downstream faces.
  - Continuous monitoring and inspection anytime water is impounded.
  - Crest should be finished and graded to drain and restricted from vehicle travel.
  - Alert the District to any retention behind dam.
  - Test geotextiles every five years for deterioration.
  - Perform reconnaissance of Fenne Knoll fissures every six months
  - Monitor possible earth fissures within 1,000 feet of dam using low sun angle photography every three years.
  - Perform detailed investigation and documentation of any new fissures discovered within 200 feet of dam. Repair (grout) if within 50 feet of downstream toe of the dam.

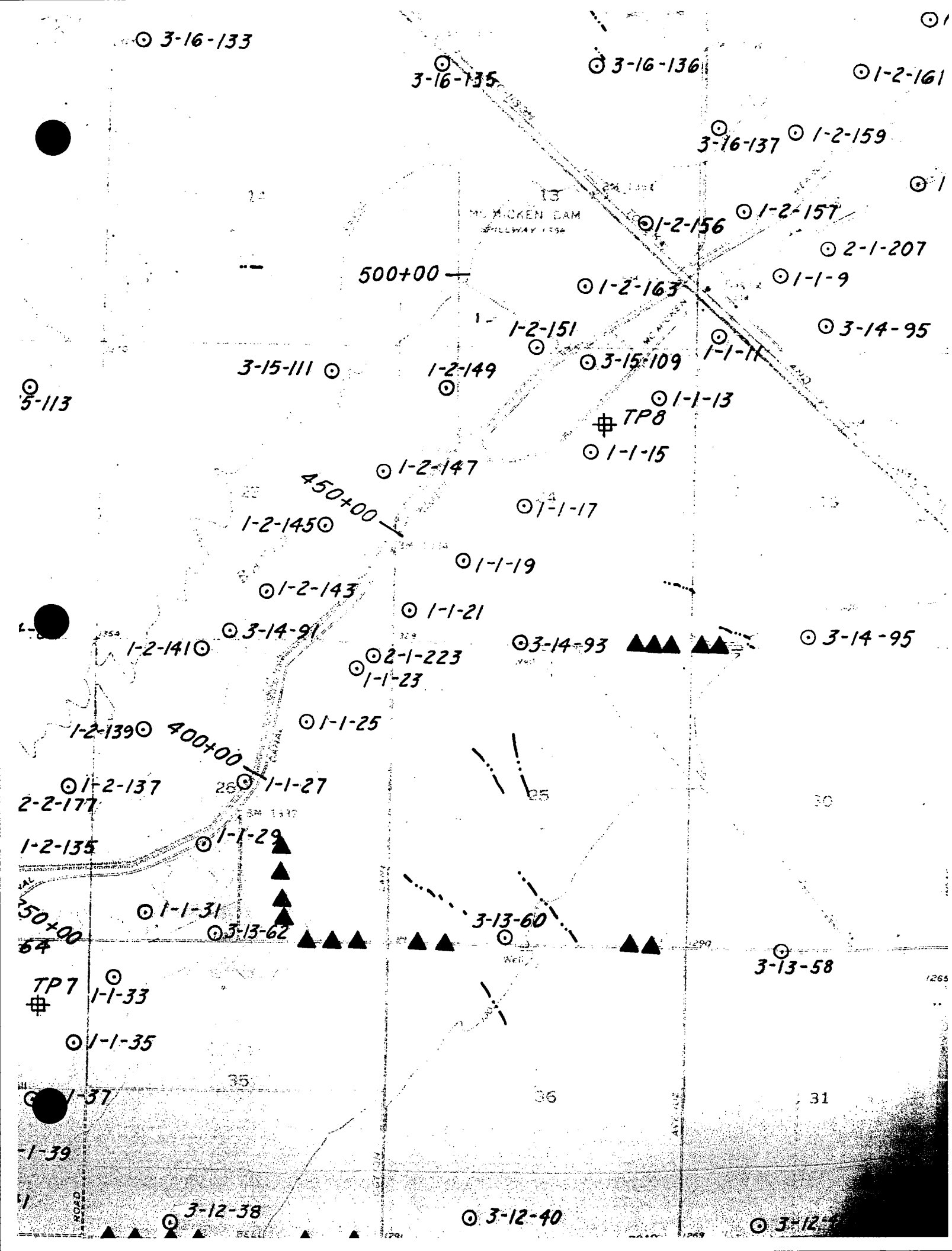
SERGENT, HAUSKINS & BECKWITH

GEOTECHNICAL INVESTIGATION REPORT
McMicken Dam Restoration Study
Maricopa County, Arizona

SHB Job No. E81-138
Phase II

Consulting Geotechnical Engineers
PHOENIX • ALBUQUERQUE

SR-20 Duplicate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3-12-40

GENERALIZED SUMMARY SHEET : RESULTS OF FIELD INVESTIGATION AND LABORATORY TESTING

EMBANKMENT STATIONING	60+00	20+00	475+00	450+00	400+00	350+00	300+00	250+00	200+00	150+00	100+00	50+00
HEIGHT OF DAM (FEET)	–		12	25	26	23	19	18	18	17	16	11
EMBANKMENT SOIL (UNIFIED CLASSIFICATION)	–		SC-CL	ML-CL, SC	CL, SC-CL	CL, SC-CL, CL	CL, CL, SP	CL, ML	CL, CL, ML-SM	SC-CL, SC, ML-CL	ML-CL, SM, ML	SC, SM
DEPTH TO SPT BLOWCOUNTS > 50/FT. U.S.				10 4	10	35+	35 30	30 12	35+ 10		10 4	
DEPTH TO SPT BLOWCOUNTS > 50/FT. D.S.	20 15 15			8 17	4	4	8 12	25 3	17 4		8 10	
DEPTH TO SPT BLOWCOUNTS > 100/FT. U.S.				20 25	–	35+	35 30	30 +	35+ 10		10 3	
DEPTH TO SPT BLOWCOUNTS > 100/FT. D.S.		25		10 20	75	5	10 30	40 5	20 10		8 4	
COLLAPSING SOIL VISUAL = O TEST = ●			●●●●●		O	O O O ●		●●●	O●●	O	O	
SOIL MOISTURE > 9%			△	△	△	△△ △△△△△△△△	△△△△△△△	△	△	△	△△	
EMBANKMENT CRACKS FOUND IN THIS INVESTIGATION												

NOTE: U.S. = UPSTREAM
D.S. = DOWNSTREAM

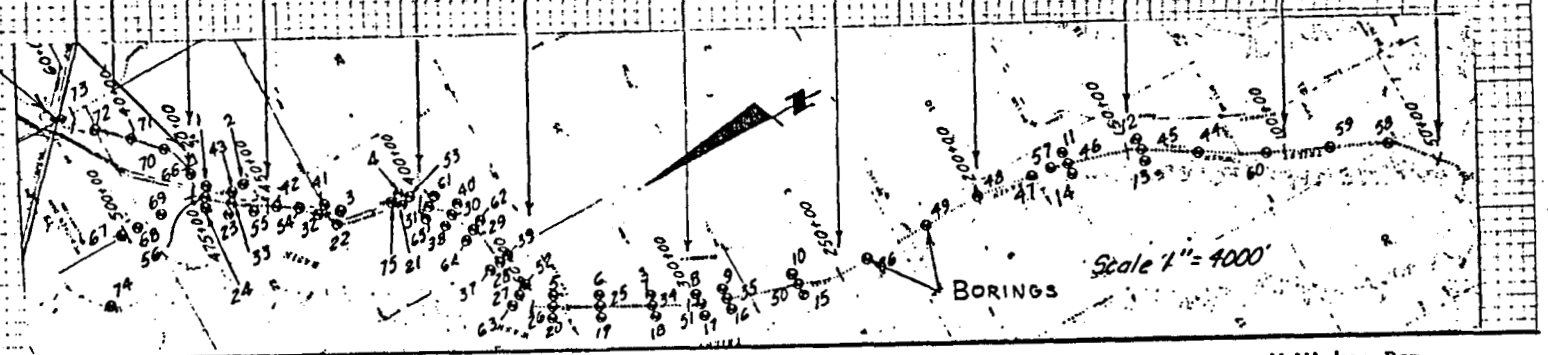

FIGURE 16

SERGENT, HAUSKINS & BECKWITH
CONSULTING CHEMICAL ENGINEERS
PHOENIX • ALBUQUERQUE • SANTA FE

Project McMicken Dam
Job No: E81-138
Computed by: JDD Ckd. by: JDD
Date 7/82 Page ___ of ___

PROJECT McMicken Dam Restoration Study

JOB NO. E81-138 DATE 12-14-81

LOG OF TEST BORING NO. 1

location Station 472+00, 18' E of toe

RIG TYPE CME-55

BORING TYPE 6½" Hollow Stem Auger

SURFACE ELEV. 1336.0'

DATUM 1982 A.H.A. Survey

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0			X	S	26				slightly moist to dry	SANDY CLAY, considerable silt, some gravel, predominantly well graded, subangular, weakly to moderately cemented, medium plasticity, brown to light brown
			X	S	38				firm to hard	
5			X	S	25			CL		
10			X	S	50/4"				slightly moist very firm	CLAYEY SAND, considerable silt, some fine, subangular gravel, predominantly fine to medium, weakly cemented, medium to low plasticity, brown
15			X	S	46			SC	slightly moist hard	CLAYEY SILT, considerable fine sand, weakly to moderately cemented, low to medium plasticity, tan to light brown
20			X	S	50/2"			ML	slightly moist hard	SANDY, SILTY CLAY, some fine, subangular to subrounded gravel in lenses, moderately cemented, medium plasticity, brown to light brown
25			X	S	50/3"					
30			X	S	50/3"			CL	slightly moist very dense	SAND, considerable silt, predominantly fine to medium, nonplastic, brown
35			X	S	56			SP	slightly moist dense	SILTY SAND, predominantly fine to medium, nonplastic to low plasticity, brown
40			X	S	85				slightly moist hard	SANDY, SILTY CLAY, small amount of fine, subangular gravel, weakly to moderately cemented, medium plasticity, brown
45			X	S	40			SM		
50			X	S	50/5"			CL		Stopped auger at 49'6" Sampler refused at 49'11"

GROUND WATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.
T – 3" O.D. thin-walled Shelby tube.

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CONSULTING GEOTECHNICAL ENGINEERS
PHOENIX • ALBUQUERQUE • SANTA FE

PROJECT McMicken Dam Restoration Study

JOB NO. E81-138 DATE 1-4-82

LOG OF TEST BORING NO. 24

location Station ≈472+00, 5' W of toe

RIG TYPE CME-55

BORING TYPE 6½" Hollow Stem Auger

SURFACE ELEV. 1336.3'

DATUM 1982 A.H.A. Survey

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0			X	U	13	108	11	CL	very moist moderately firm	CLAY, considerable silt & fine to medium sand, low to medium plasticity, brown
			X	S	10					
5			X	S	18		13	CL	moist firm to hard	SILTY CLAY, considerable fine sand in lenses, occasionally weakly cemented, medium plasticity, brown
10			X	S	51					
15			X	S	148		14		slightly moist to moist hard	CLAYEY SILT, some fine to medium sand & gravel in lenses, weakly cemented, low plasticity, light brown to brown note: trace of gravel below 18'
20			X	S	50/2"		18	ML		
25			X	S	50/3½"		13			
30			X	S	56		8	SM	moist hard	SILTY SAND, small amount of clay & fine gravel, predominantly fine to medium, non-plastic to low plasticity, brown
35			X	S	67		5			
40										Stopped auger at 34'6" Stopped sampler at 36'

GROUND WATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE

A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.
T – 3" O.D. thin-walled Shelby tube.

SERGENT, HAUSKINS & BECKWITH

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PROJECT McMicken Dam Restoration Study
JOB NO. E81-138 DATE 1-20-82

LOG OF TEST BORING NO. 56

location Station 472+00, ¢ of old dike
RIG TYPE CME-55
BORING TYPE 6½" Hollow Stem Auger
SURFACE ELEV. 1351.5'
DATUM 1982 A.H.A. Survey

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0			X	S	16				slightly moist firm	SANDY SILT, considerable clay, predominantly fine, low plasticity, brown
								ML		
5			X	S	24					
10			X	S	9				slightly moist moderately firm to very firm	SILTY CLAY, some to considerable sand, predominantly fine, low to medium plasticity, light brown
15			X	U	13	100	8			
								CL		
20			X	S	21					
25			X	S	46					note: considerable gravel, occasionally weakly cemented below 24'
30			X	S	16			SC	slightly moist to moist firm	CLAYEY SAND, predominantly well graded, some weak cementation, medium plasticity, light brown
35			X	S	50/5"				slightly moist hard	SILT, some sand & clay, low plasticity, light brown
40			X	S	50/2"			ML		
45			X	S	50/5"					
								SP		
50										

GROUND WATER

DEPTH	HOUR	DATE
	none	

SAMPLE TYPE
A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.
T – 3" O.D. thin-walled Shelby tube.

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PHOENIX • ALBUQUERQUE • SANTA FE

PROJECT McMicken Dam Restoration Study

JOB NO. E81-138 DATE 1-20-82

LOG OF TEST BORING NO. 56

location Station 472+00, ℄ of old dike

RIG TYPE CME-55

BORING TYPE 6½" Hollow Stem Auger

SURFACE ELEV. 1351.5'

DATUM 1982 A.H.A. Survey

Depth Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows per foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cu. ft.	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
50		• • •	X	S	84			SP	slightly moist very dense	SAND, predominantly fine, nonplastic, light brown to tan
55										Stopped auger at 49'6" Stopped sampler at 51'

GROUND WATER

DEPTH	HOUR	DATE

SAMPLE TYPE

A – Auger cuttings. B – Block sample
S – 2" O.D. 1.38" I.D. tube sample.
U – 3" O.D. 2.42" I.D. tube sample.
T – 3" O.D. thin-walled Shelby tube.

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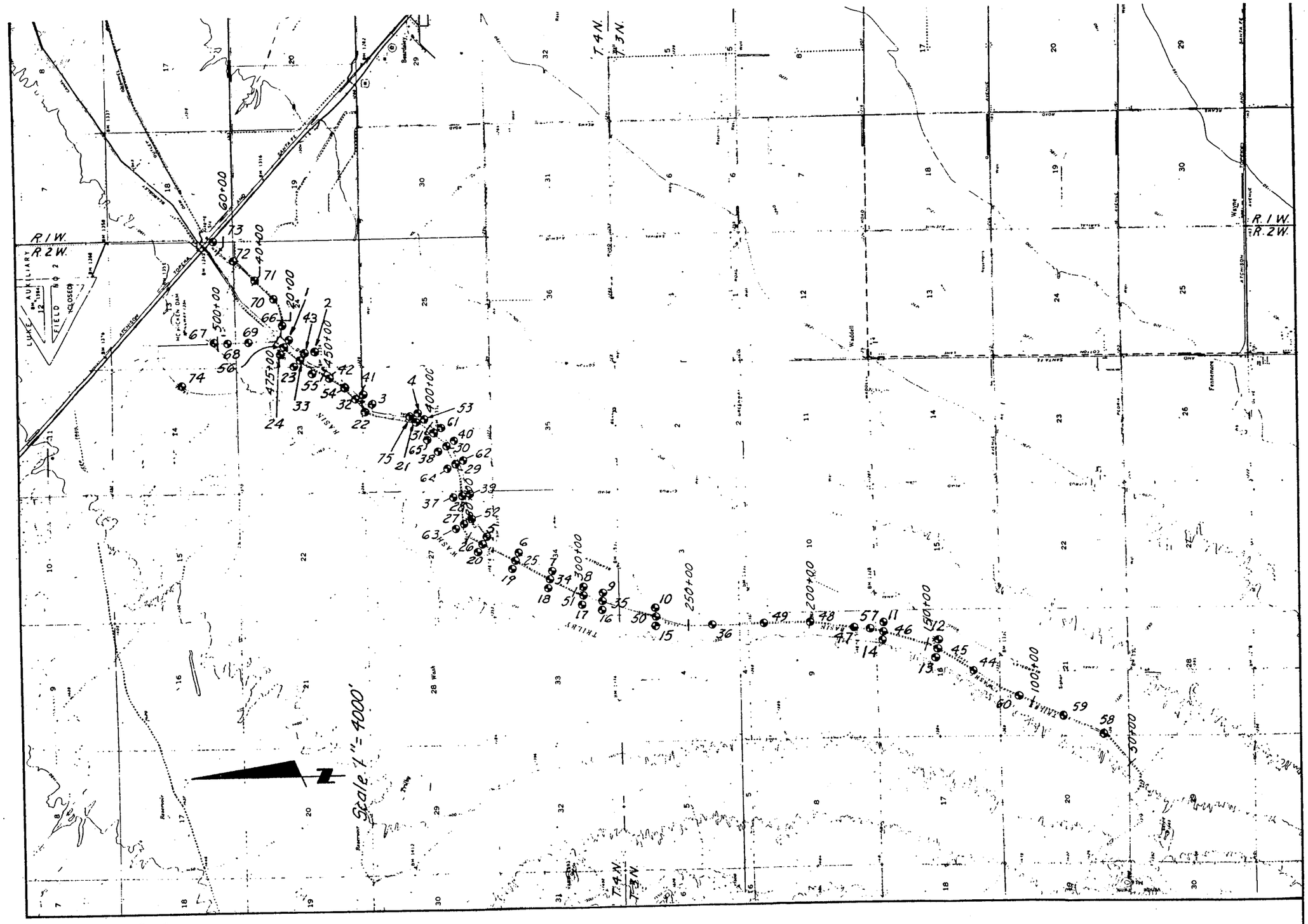

FIGURE B-2

SITE PLAN
Showing Test Boring Locations

McMicken Dam Restoration Study
Maricopa County, Arizona
SHB Job No. E81-138

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CONSULTING SOIL AND FOUNDATION ENGINEERS
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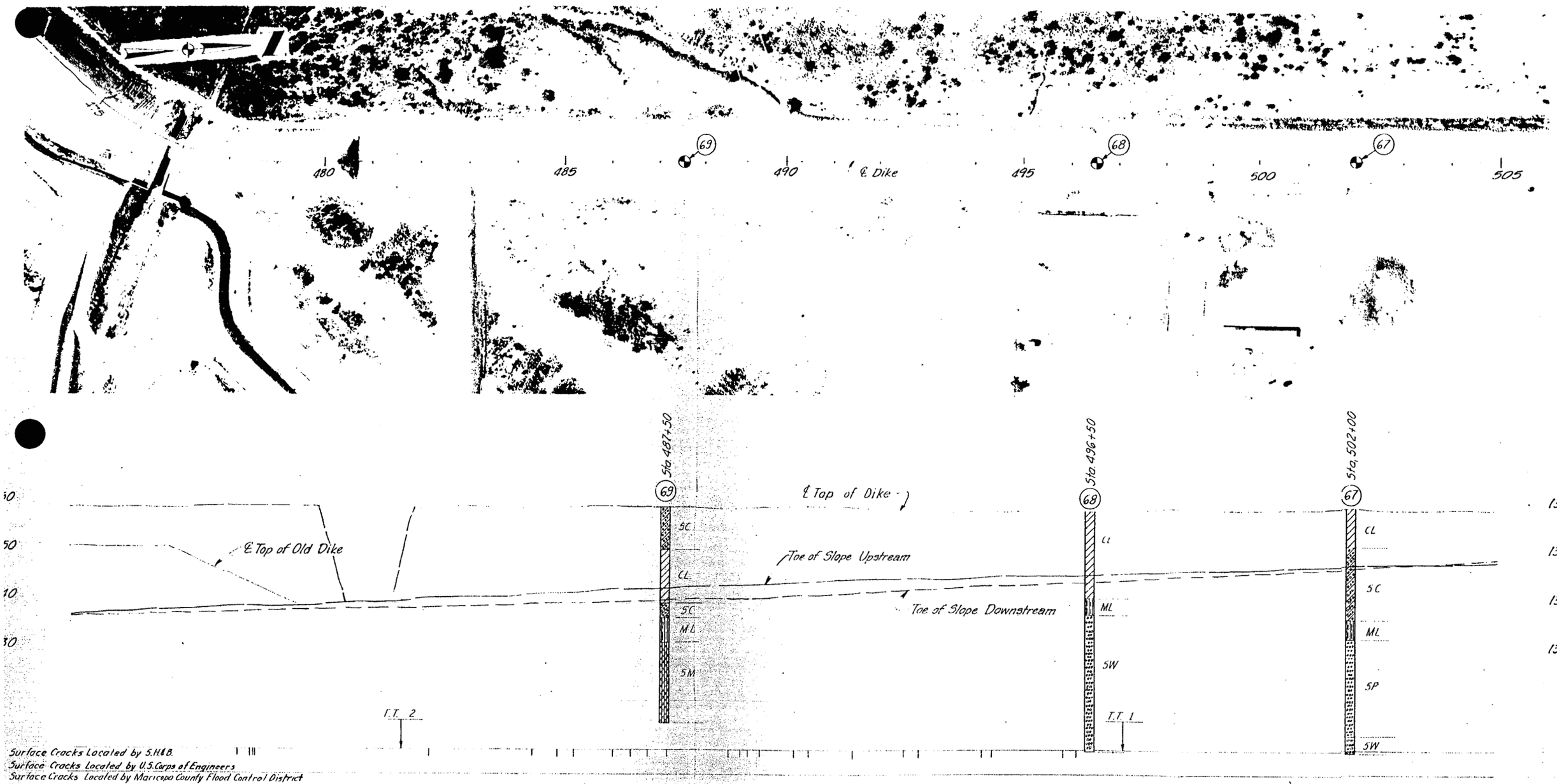


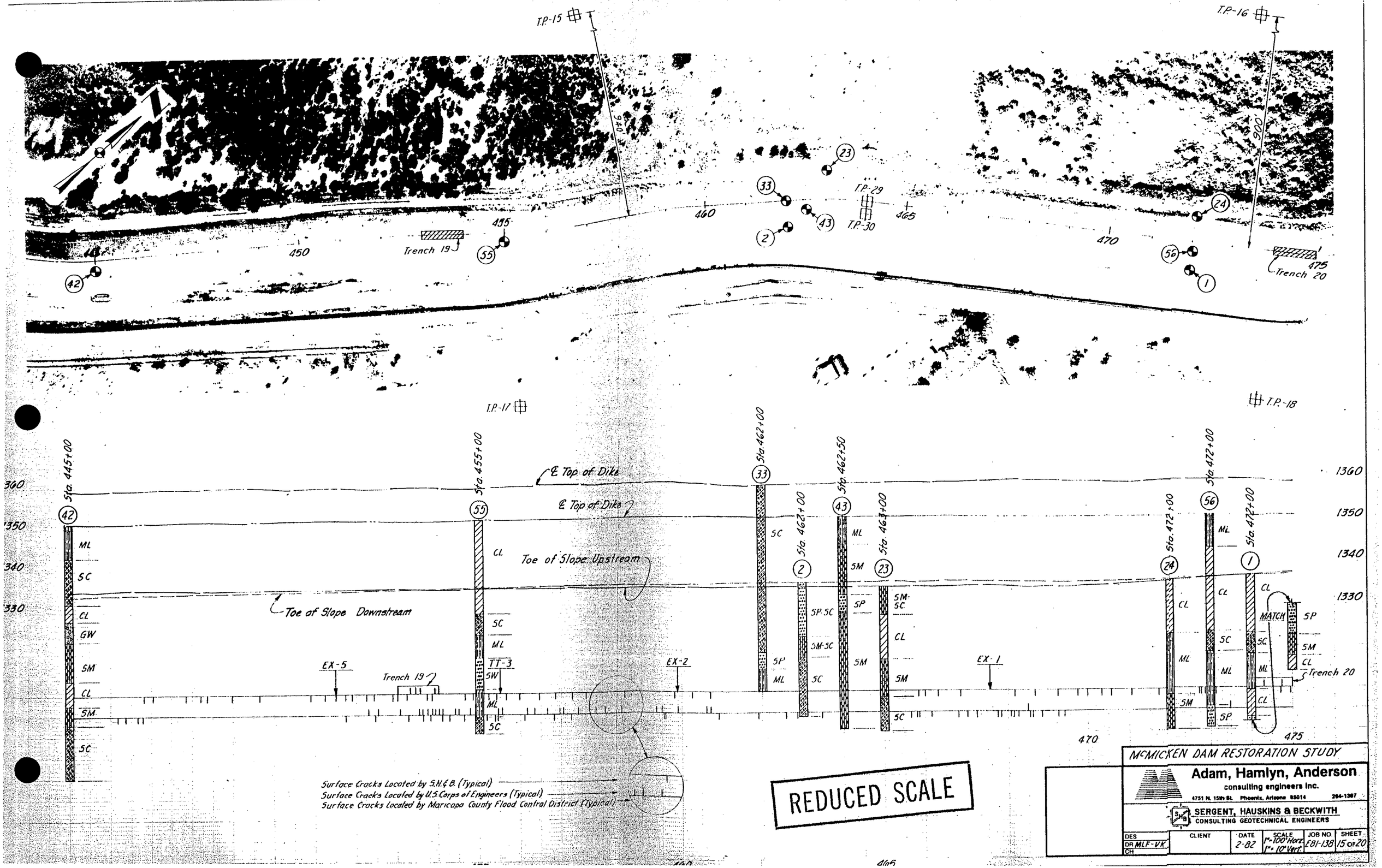
REDUCED SCALE

McMICKEN DAM RESTORATION STUDY

Adam, Hamlyn, Anderson
consulting engineers inc.
4751 N. 15th St. Phoenix, Arizona 85014 264-1397

SERGENT, HAUSKINS & BECKWITH
CONSULTING GEOTECHNICAL ENGINEERS

DES	CLIENT	DATE	SCALE	JOB NO	SHEET
DR MLF-VK		2-82	1"=100' Horz. 1"=10' Vert.	E81-138	16 OF 20
CH					


T.P.-15
T.P.-16
T.P.-29
T.P.-30
T.P.-17
T.P.-18
940
900
450
460
465
470
475
Trench 19
Trench 20
42
55
33
43
2
23
24
56
1
Sta. 445+00
Sta. 455+00
Sta. 462+00
Sta. 462+50
Sta. 463+00
Sta. 472+00
1360
1350
1340
1330
℄ Top of Dike
Toe of Slope Upstream
Toe of Slope Downstream
ML
SC
CL
GW
SM
SW
SP
SP-SC
SM-SC
TT-3
EX-5
EX-2
EX-1
MATCH
Surface Cracks Located by S.H.&B. (Typical)
Surface Cracks Located by U.S. Corps of Engineers (Typical)
Surface Cracks Located by Maricopa County Flood Control District (Typical)
REDUCED SCALE
McMICKEN DAM RESTORATION STUDY
Adam, Hamlyn, Anderson
consulting engineers inc.
4751 N. 15th St. Phoenix, Arizona 85014 264-1387
SERGENT, HAUSKINS & BECKWITH
CONSULTING GEOTECHNICAL ENGINEERS
DES
DR MLF-VK
CH
CLIENT
DATE 2-82
SCALE 1"=100' Horz. 1"=10' Vert.
JOB NO. E81-138
SHEET 15 OF 20

DOCUMENT TITLE: Design Report - McMicken Dam Restoration Study

DATE OF REPORT: January 27, 1983

PREPARED BY: Sergent, Hauskins & Beckwith (SHB)

PURPOSE:

To delineate potential borrow source for raising the crest elevation, perform a subsurface investigation of the embankment, perform an investigation of the toe drain depth, and analyze the design concept. The study also included inspection and sampling of drain rock sources, test grouting program, laboratory testing of filter fabric, laboratory analysis of construction materials, and surveying and compiling of dam cross sections.

SUMMARY:

- 39 backhoe test pits were excavated upstream of McMicken Dam to evaluate the borrow source. Of the 39 test pits, two (TP-2 and TP-4) were performed within about 1,000 feet of the principal spillway and extended to depths of 7.5 and 9 feet, respectively.
- 19 backhoe test pits were excavated along the downstream toe of the embankment to observe the caliche development and cementation properties of the shallow alluvial soils. Of the 19 test pits, one (TT-1) was excavated within about 800 feet of the principal spillway and extended to a depth of 10.5 feet.
- Four areas were selected to test the effectiveness of sealing embankment cracks using non-pressurized grout. One of the test locations (ET-4) was approximately 2,000 feet from the principal spillway.
- Seven trenches were excavated parallel to and along the embankment crest. Test trench ET-4 was excavated to evaluate future center trench stability, observe grout penetration (from the above-mentioned test program), and characterize embankment cracks.
- Laboratory testing included sieves, Atterbergs, proctors, direct shears, pinhole tests, permeability tests, and corrosivity tests.
- A new laboratory test was devised to analyze a geotextile's ability to strain across a crack in the dam.

FINDINGS/RESULTS:

- Based on laboratory test results and visual observations of the 39 tests pits (excavated to evaluate borrow sources), soil within the general vicinity of the test pits was deemed suitable for use as embankment fill. There was a noted risk of inundation which would restrict access and cause overwetting of the borrow material.

- Two other borrow sources were identified: the embankment material removed from the dam breach between Stations 316+00 and 326+00 and a section of the downstream portion of the old embankment between Stations 360+00 and 480+00.

- Test pits performed along the dam toe indicated that the degree of induration of the shallow soils in the dam foundation appears to be mostly dependent on soil particle-size distribution. Erratic soil caliche development was observed from about 1-1/2 to 11 feet.

- The optimum grout mix for sealing embankment cracks was found to be a soil/water composition with approximately 1.5 percent by weight of pozzalan cement. The penetration of grout laterally was not accomplished in several cases.

- Majority of the cracks observed were not detectable below a depth of five feet. Two longitudinal cracks with no surface expression were found near the principal spillway, at ET-4. These cracks ranged in depth from 3.5 to 8 feet.

- The walls of the seven trenches excavated in the dam crest were stable. No sloughing or failure of compacted dam fill was experienced. The trenches were left open for periods of 6 to 9.5 days. Some caving was experienced in silty sand and gravel during excavation of test pits near the downstream toe.

- Outlets from the center drain were spaced between 200 feet apart to 1,000 feet apart (depending on the outlet capacity that was deemed needed for a section.

CONCLUSIONS AND RECOMMENDATIONS:

- The depth of the toe intercept should be a minimum of 9 feet and a maximum of 10 feet, except in strongly cemented soils where there should be, "three-foot continuous penetration of strongly cemented soils below a depth of 4 feet." Also, the trenching operation should be constantly monitored with the rate of penetration recorded and used to establish trench depth.

- A design engineer should decide which embankment cracks need grouting based on a comprehensive review of the cracking survey (yet to be completed). The selected cracks should be grouted on the upstream side of the center drain after completion of the drain system. The grout mix should be a soil/water product with a small percentage of cement as discussed in the findings (noted above).

- Trench stability during construction of the center drain does not appear to be a major concern. No shoring should be required to install the filter fabric or drain aggregate. Caving may cause some difficulty in the excavation of the toe intercept. Water may be introduced to increase stability.

- Construction sequencing recommendations were provided. Example drawings of the repair concepts were provided. The repair recommendations included raising the embankment to elevation 1361 and widening the crest to 12-feet.

- Construction methods should include proper foundation preparation and benching into the existing embankment.

SERGENT, HAUSKINS & BECKWITH

[illegible]

[illegible]

[illegible]

SHB Job No. [illegible]

Consulting Geotechnical Engineers

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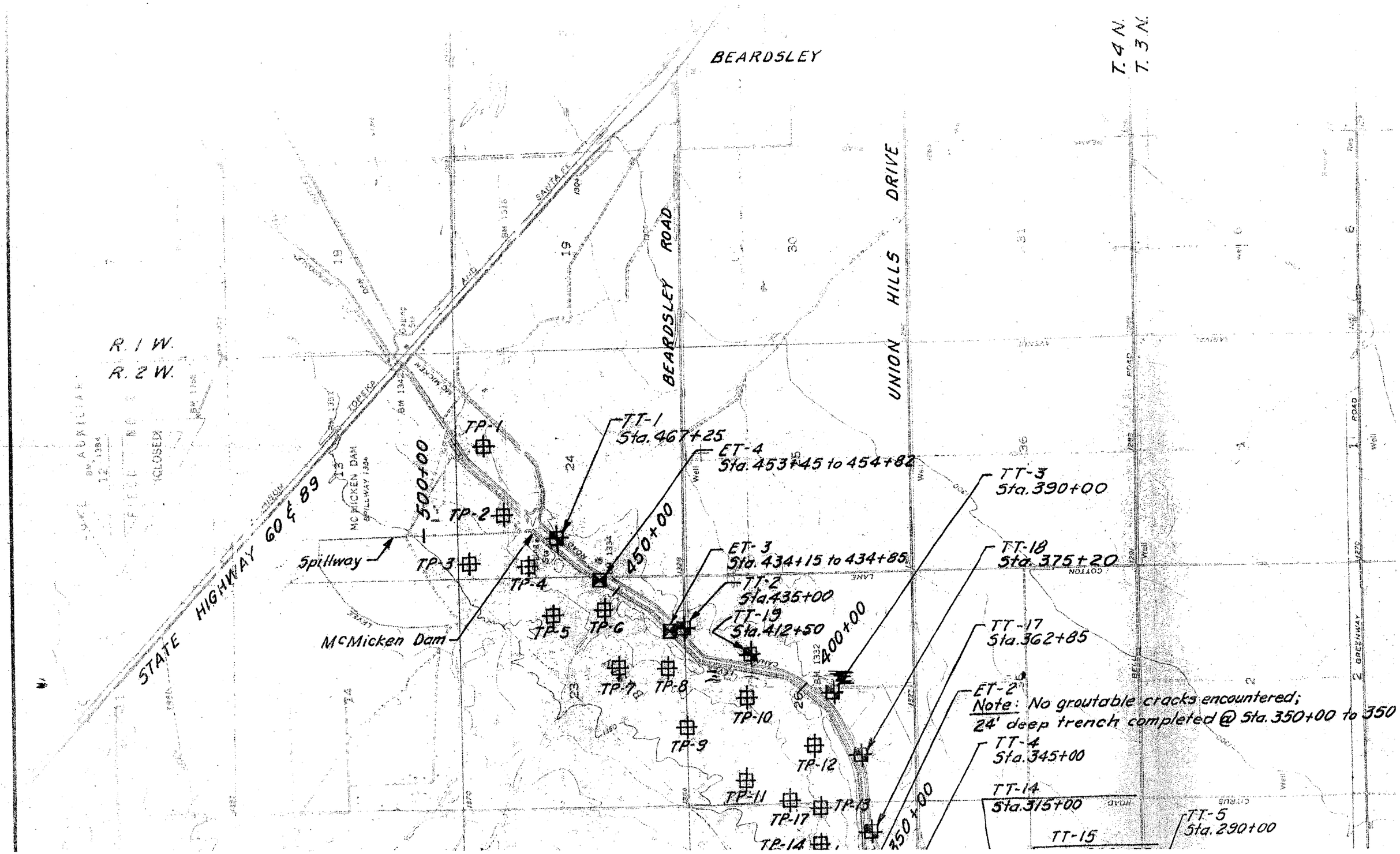
SHB


BEARDSLEY
T. 4 N.
T. 3 N.
R. 1 W.
R. 2 W.
BEARDSLEY ROAD
UNION HILLS DRIVE
STATE HIGHWAY 60 & 89
SANTA FE
TOPEKA
McMICKEN DAM SPILLWAY
Spillway
McMicken Dam
500+00
450+00
400+00
350+00
TP-1
TP-2
TP-3
TP-4
TP-5
TP-6
TP-7
TP-8
TP-9
TP-10
TP-11
TP-12
TP-13
TP-14
TP-17
TT-1
Sta. 467+25
ET-4
Sta. 453+45 to 454+82
ET-3
Sta. 434+15 to 434+85
TT-2
Sta. 435+00
TT-19
Sta. 412+50
TT-3
Sta. 390+00
TT-18
Sta. 375+20
TT-17
Sta. 362+85
ET-2
Note: No groutable cracks encountered;
24' deep trench completed @ Sta. 350+00 to 350
TT-4
Sta. 345+00
TT-14
Sta. 315+00
TT-15
TT-5
Sta. 290+00

PROJECT McMicken Dam Restoration Study

JOB NO. E82-111 DATE 10-8-82

LOG OF TEST PIT NO. TP-1

Backhoe Type Case 580C

Location

Elevation

Datum

GROUND WATER

DEPTH	HOUR	DATE
	none	

Depth in Feet	Graphical Log	Sample	Sample Type	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0		X	D		CL	slightly moist	SILTY CLAY, some fine sand, medium plasticity, brown
		X	D		CL	very slightly moist	SILTY CLAY, some sand & fine gravel, weakly to moderately lime cemented, medium plasticity, brown
5		X				very slightly moist	SILTY SAND, considerable clay in lenses, some gravel, predominantly fine to medium grained, cemented, very low plasticity, brown
		X	D		SM-SC	slightly moist	SAND, occasional lens of gravel, fine grained, cemented, nonplastic, brown
		X			SP		Stopped backhoe at 10'
10							

DATE 10-8-82

LOG OF TEST PIT NO. TP-2

Backhoe Type Case 580C

Location

Elevation

Datum

GROUND WATER

DEPTH	HOUR	DATE
	none	

Depth in Feet	Graphical Log	Sample	Sample Type	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0		X	D		CL	slightly moist	SILTY CLAY, some sand, low to medium plasticity, brown
		X	D		CL	very slightly moist	SILTY CLAY, some sand, trace of gravel, weakly lime cemented, low to medium plasticity, brown
5		X	D		SP-SM	very slightly moist	SAND & SILTY SAND, some gravel, poorly graded, predominantly fine to medium grained, predominantly angular, nonplastic to low plasticity, brown
					CL	very slightly moist	SILTY CLAY, small amount of sand, weakly to moderately lime cemented, medium to low plasticity, brown
10							Stopped backhoe at 7'6"

SAMPLE TYPE
B — Undisturbed Block Sample
D — Disturbed Bulk Sample

SERGENT, HAUSKINS & BECKWITH

CONSULTING SOIL AND FOUNDATION ENGINEERS
PHOENIX • ALBUQUERQUE • SANTA FE

PROJECT McMicken Dam Restoration Study

JOB NO. E82-111 DATE 10-8-82

LOG OF TEST PIT NO. TP-3

Backhoe Type Case 580C

Location

Elevation

Datum

GROUND WATER

DEPTH	HOUR	DATE
	none	

Depth	Graphical Log	Sample	Sample Type	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0			D		CL	slightly moist	SILTY CLAY, trace of sand & gravel, weakly lime cemented, medium plasticity, light brown
			D		CL	slightly moist	SILTY CLAY, considerable sand, small amount of gravel, medium plasticity, brown
5					CL	very slightly moist	SILTY CLAY, small amount of sand & gravel, weakly to moderately lime cemented, medium plasticity, light brown
							Stopped backhoe at 6'6"
10							

DATE 10-8-82

LOG OF TEST PIT NO. TP-4

Backhoe Type Case 580C

Location

Elevation

Datum

GROUND WATER

DEPTH	HOUR	DATE
	none	

Depth in Feet	Graphical Log	Sample	Sample Type	Moisture Content Per Cent of Dry Wt.	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0			D		CL	slightly moist	SILTY CLAY, some sand & fine, angular to subangular gravel, medium plasticity, brown note: very weakly cemented lens from 3' to 4'
5			D		SC	moist to slightly moist	CLAYEY SAND, some fine, angular to subangular gravel, well graded, weakly lime cemented in stringers, medium to high plasticity, dark brown
					CL	slightly moist	SILTY CLAY, some sand & fine gravel, weakly to moderately lime cemented, medium plasticity, light brown
10							Stopped backhoe at 9'

SAMPLE TYPE
B — Undisturbed Block Sample
D — Disturbed Bulk Sample

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McMicken Dam Restoration Study
Maricopa County, Arizona
SHB Job No. E82-111

Log of Test Trench ET-4 December 7, 1982

Two sections excavated; Centerline Stations 453+25 to 453+95 and 454+55 to 454+90

Located parallel to centerline along dam crest

Equipment Type: American 35A Backhoe with 26-inch bucket

Trench Length: 70 feet and 35 feet

Trench Depth: 19 to 23 feet

Condition of Excavation

Trench stability excellent; no sloughing of trench walls; top 1 foot loose due to previous trenching; trenches left open for nine days with no drastic change in conditions; some minor cracking and drying of trench walls noted; trenches shored for personnel safety, not required to hold excavations open.

Embankment Soil Description

Silty to sandy clay; considerable fine, angular gravel; occasional pockets of clayey sand with gravel; weakly to moderately cemented; medium plasticity clays; very firm and moist; light reddish-brown.

McMicken Dam Restoration Study
Maricopa County, Arizona
SHB Job No. E82-111

Log of Test Trench TT-1 October 19, 1982

Station 467+25
Downstream Toe

Equipment Type: Case 580C Backhoe

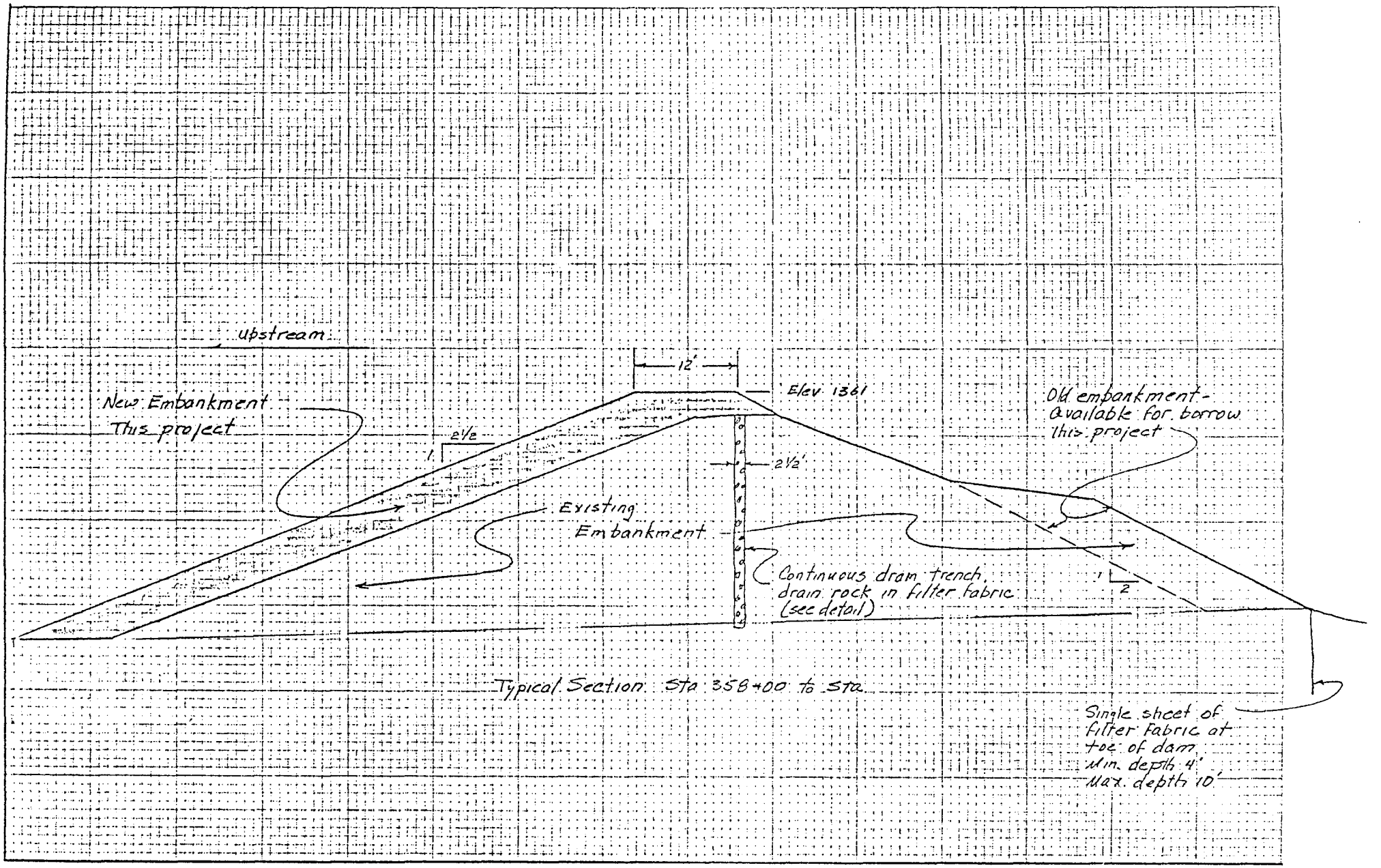
Total Depth of Trench: 10.5 feet

Depth	Description
0 - 3.0 feet	Silty, sandy clay, firm, very moist, trace of fine, subangular to angular gravel, medium to low plasticity, brown Cementation Properties Very weakly lime cemented
3 - 4.5 feet	Clayey sand, hard, slightly moist, considerable silt & gravel, well graded, angular to subangular, weakly stratified, low to medium plasticity, gray Cementation Properties Moderately to strongly lime cemented, all space between grains has been filled with cement
4.5 - 10.5 feet	Silty sand, firm, slightly moist, some clayey sand in thin lenses, some clean sand in thin lenses, considerable angular to subangular gravel in lenses, well graded, stratified, nonplastic to medium plasticity, light brown to tan Cementation Properties Weakly clay cemented throughout, some extension of lime cemented unit above into this unit

TABULATION OF TEST RESULTS

Job No. E82-111
W/O 1

HOLE NO	DEPTH	UNIFIED CLASS	L.L.	P.I.	#200	#100	#40	#16	#10	#4	.25"	.375"	.75"	1"	1.5"	2"	LAB NO
					SIEVE ANALYSIS-ACCUM % PASSING												
TP-3	1.5′-5′	CL	32	16	66	72	82	92	95	97	98	98	100				2-111-9
TP-4	6′-7.5′	SC	59	40	43	46	54	67	74	87	91	96	99	99	100		2-111-11
TP-5	1.5′-5′	SC	51	25	31	34	39	45	50	66	74	84	95	97	99	100	2-111-13
TP-8	2.5′-5.5′	GC	53	31	30	32	38	45	50	57	60	64	73	76	80	83	2-111-21
TP-11	2.5′-5.5′	SP-SC	31	11	11	13	19	29	39	61	68	76	90	94	100		2-111-29+30
TP-12	0.0′-3′	SC	42	22	44	46	56	71	78	88	90	93	97	98	100		2-111-31
TP-14	0.0′-4.5′	SC	29	9	34	40	56	75	82	91	93	96	99	100			2-111-34
TP-15	4′-8′	SC	26	10	19	22	30	47	55	67	73	79	89	92	96	97	2-111-37
TP-19	2.5′-7.5′	SW-SM	-	NP	11	13	28	60	72	84	87	91	96	97	100		2-111-43
TP-21	3.5′-5.5′	SC	43	22	47	51	61	80	88	94	96	97	100				2-111-47
TP-25	0.0′-7′	CL	37	17	68	73	82	94	97	100							2-111-55
TP-27	0.0′-8′	ML	21	2	54	62	75	84	89	95	97	99	100				2-111-60
TP-28	0.0′-5′	CL	48	26	62	66	75	88	93	97	98	98	100				2-111-61
TP-30	0.0′-4.5′	CL	31	12	54	60	68	79	85	95	97	98	100				2-111-65
TP-32	0.0′-2.5′	CL-ML	26	7	63	70	76	82	87	96	98	99	100				2-111-69
TP-33	1.5′-7.5′	CL	28	8	53	59	70	80	84	91	92	93	95	96	98	100	2-111-73
TP-35	0.0′-6.5′	SW-SM	-	NP	11	13	24	44	57	76	82	88	95	96	98	98	2-111-77
TP-36	1.5′-7′	GM-GC	27	7	14	17	23	30	34	40	42	45	51	54	58	63	2-111-80
TP-38	1′-7.5′	GP-GM	-	NP	9	12	21	36	44	54	57	60	67	71	73	79	2-111-83
TP-39	0.0′-3.5′	CL	30	10	58	63	71	82	87	92	93	95	97	99	100		2-111-84



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CONSULTING GEOTECHNICAL ENGINEERS
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Project McAllicken Dam
Job No: E82-111
Computed by: RRV Ckd. by:
Date 12/22/82 Page ___ of

D-1

DETAIL OF TYPICAL OUTLET DRAIN

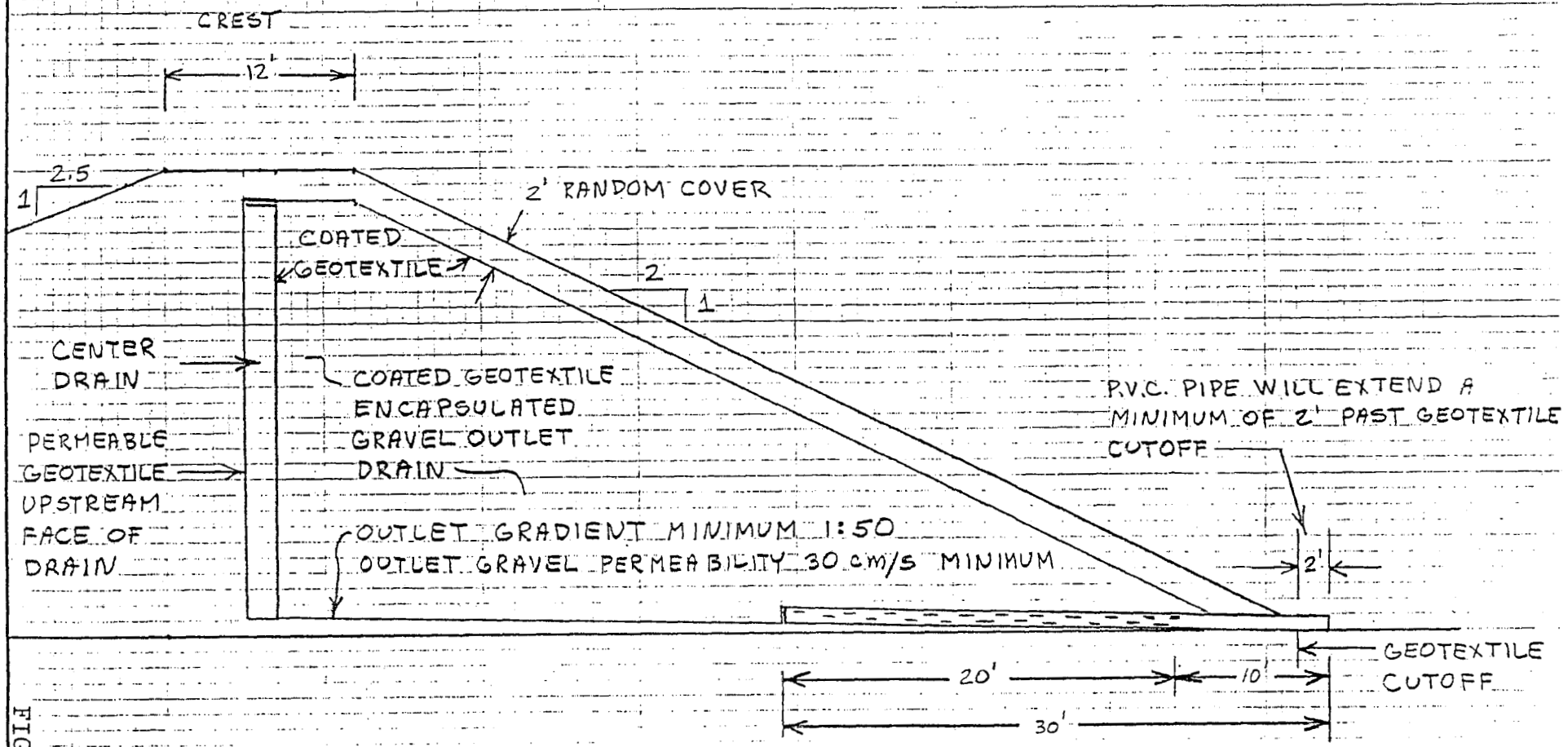

FIGURE E-1

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CONSULTING GEOTECHNICAL ENGINEERS
PHOENIX • ALBUQUERQUE • SANTA FE • SALT LAKE CITY

Project: [illegible]
Job No: [illegible]
Computed by: [illegible] Ckd. by: _____
Date [illegible]

DOCUMENT TITLE: McMicken Dam Restoration (As-Builts)

DATE OF REPORT: December 21, 1984

PREPARED BY: Sergent, Hauskins, & Beckwith

PURPOSE:

Present construction plan and record of actual construction to restore McMicken Dam to an active flood control structure.

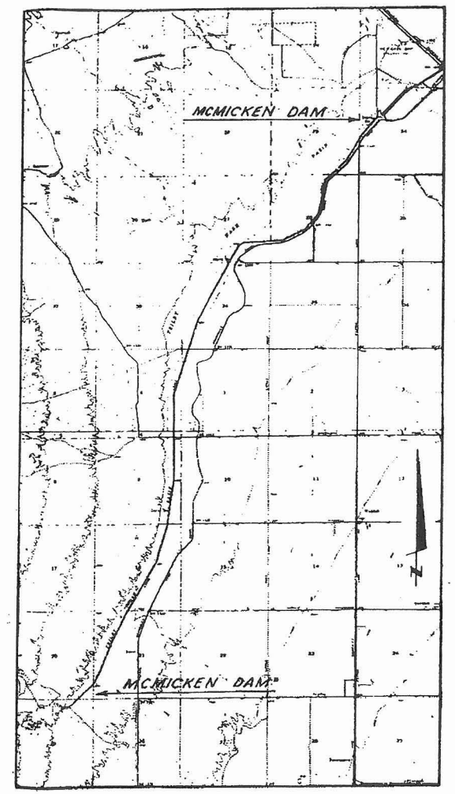
SUMMARY:

The plans show the as-constructed details about modifications to McMicken Dam. Some include:

- Restore dam crest elevation to 1361.0 feet in areas where settlement/subsidence has occurred
- Center filter drain and outlets were constructed into the dam embankment
- Filter consists of drain rock wrapped in a geotextile fabric - the upstream portion was non-coated and permeable, and the downstream portion is coated and non-permeable
- Two breached sections (316+50 to 325+50 and 480+25 to 482+25) were repaired
- Approximately two vertical feet of new material was placed on the upstream side of the embankment
- A key trench used to place new fill

MCMICKEN DAM RESTORATION

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

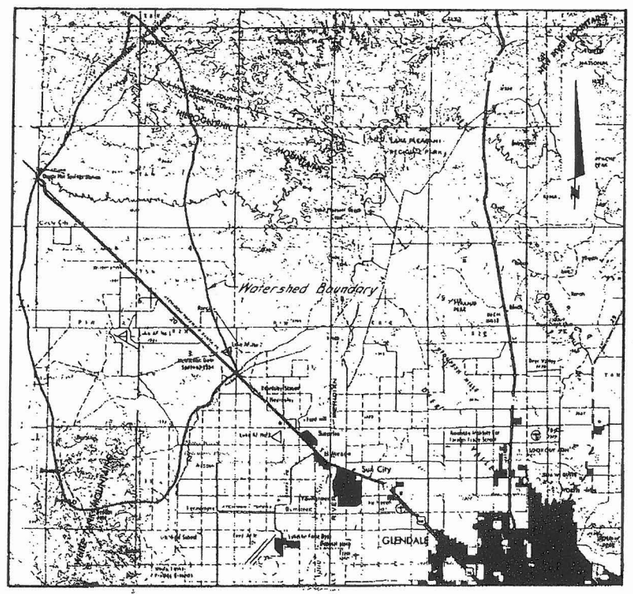


VICINITY MAP

Base Map Reference: U.S.G.S. 7.5 Minute Quadrangle Maps, McMicken Dam (1957) and Waddell (1977)

LIST OF SHEETS

Sheet No.	Description
1	Title Sheet, Vicinity Map, Location & Watershed Map
2	Outlet Details
3	Cross Sections
4	Cross Sections
5	Gated Outlet Details
6	Gated Outlet Details
7-24	Plan & Profile
△ 25	Principal Spillway Outlet Channel Dike
26	Work Area Limits



LOCATION MAP & WATERSHED MAP

Base Map Reference: U.S.G.S. 1:250,000 Scale Map, Phoenix, 1954-69

APPROVED BY: Stanley L. Smith Deputy 7-19-83
CHIEF ENGINEER & GENERAL MANAGER
FLOOD CONTROL DISTRICT OF Maricopa County

RECOMMENDED BY: [illegible] 7-19-83
CHIEF, ENGINEERING DIVISION
FLOOD CONTROL DISTRICT OF Maricopa County

FLOOD CONTROL DISTRICT of MARICOPA CO.
3335 West Durango Street - Phoenix Arizona 85009 - Tel. 602-262-1501

NO.	DESCRIPTION	DATE
2	RECORD DRAWINGS	12/21/84
△	REVISED 7-19-83 E.R.	

REVISIONS

SERGENT, HAUSKINS & BECKWITH
CONSULTING GEOTECHNICAL ENGINEERS

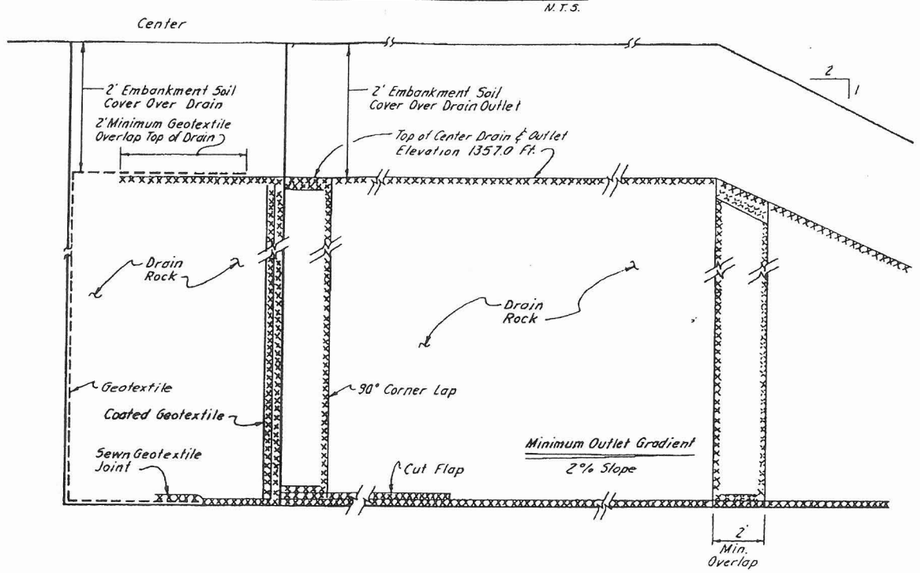
TITLE SHEET
McMicken Dam Restoration

JOB NO.	DATE	DESIGNED BY	DRAWN BY	CHECKED BY	SHEET NO
E82-111	1-83	J.D.D.	V.K.	G.H.B.	1 of 26

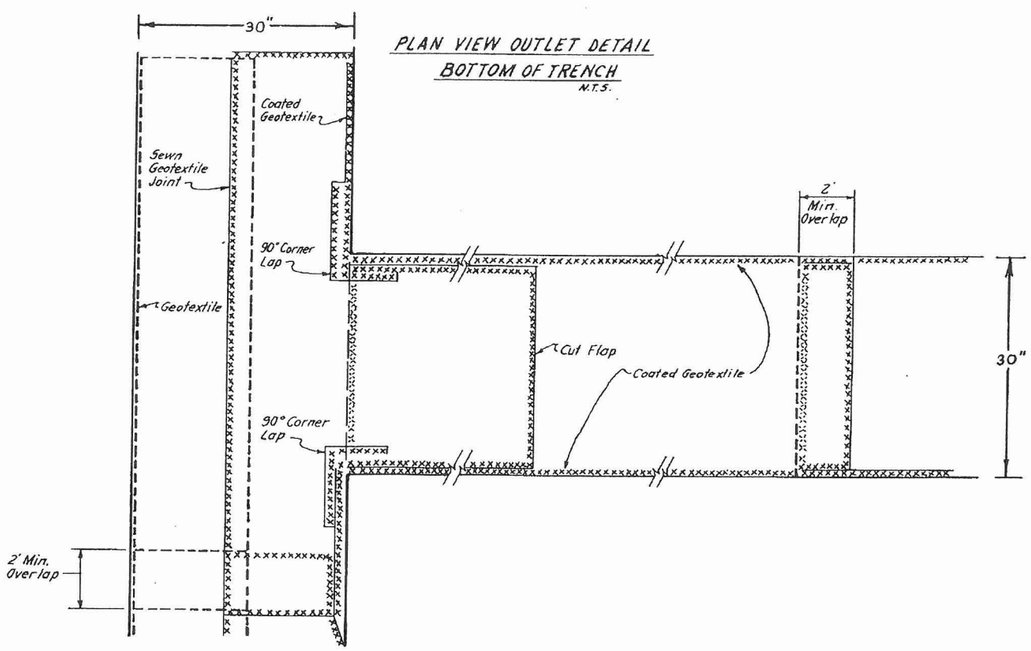
MCMICKEN DAM RESTORATION
AS BUILT
E82-111 202

34

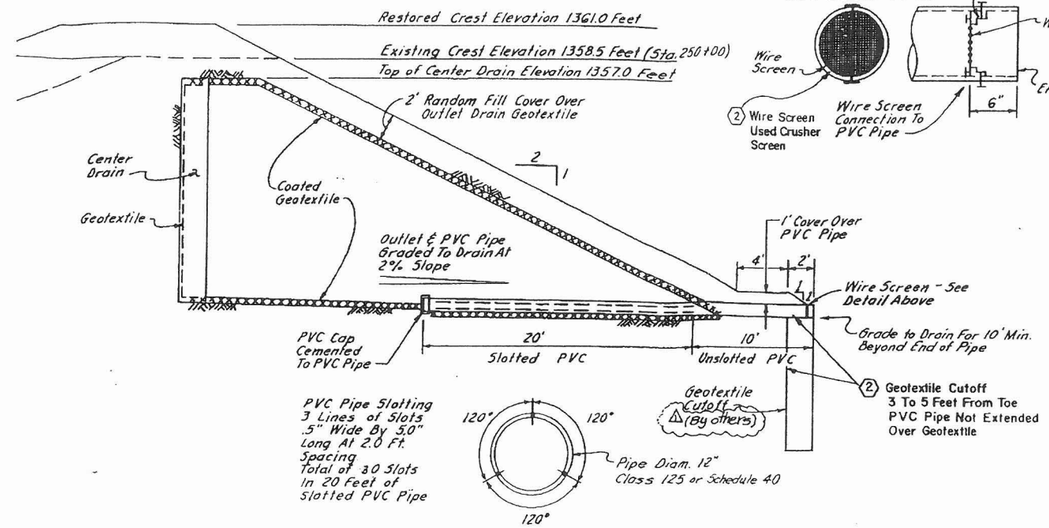
SIDE VIEW OUTLET DETAIL
N.T.S.



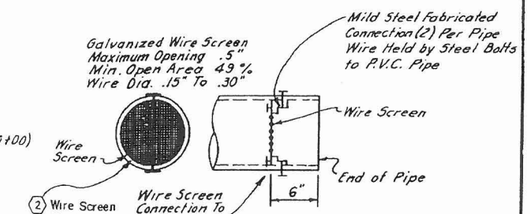
PLAN VIEW OUTLET DETAIL
BOTTOM OF TRENCH
N.T.S.



OUTLET DETAIL STA. 250+00 (TYPICAL)
Scale: 1" = 5'



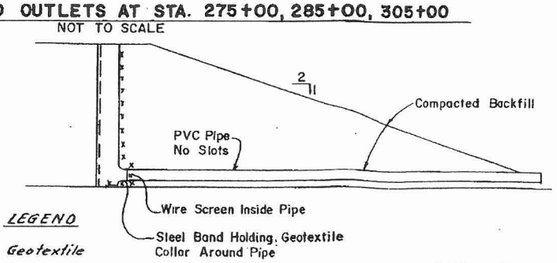
WIRE SCREEN DETAIL
N.T.S.



NOTE:
Outlets will be installed as located by the Engineer in the field. Outlet spacing will vary but will not exceed 1,000 feet. Estimated number of outlets required is 67, however, the actual number may be greater than or less than the estimated number.

2 Actual Number Of Installed Outlets 66

2 MODIFIED OUTLETS AT STA. 275+00, 285+00, 305+00
NOT TO SCALE



LEGEND

Geotextile

Coated Geotextile

NO.	DESCRIPTION	DATE
2	RECORD DRAWINGS	12-21-84
1	REVISED 7-19-83 E.R.	

REVISIONS

FLOOD CONTROL DISTRICT of MARICOPA CO.
3335 West Durango Street – Phoenix, Arizona 85009 – Tel. 602-262-1501

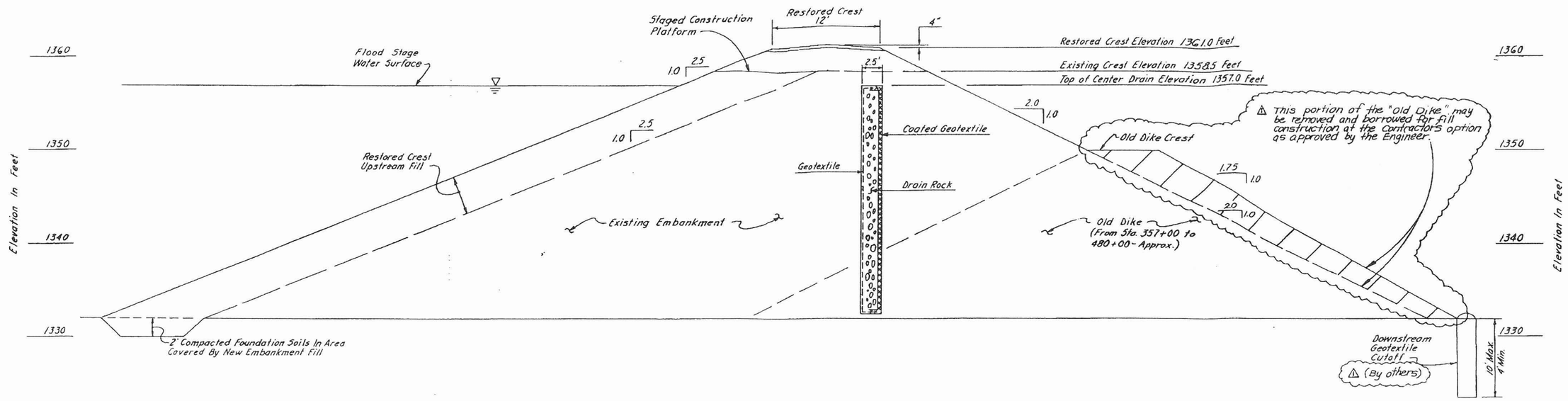
SERGENT, HAUSKINS & BECKWITH
CONSULTING GEOTECHNICAL ENGINEERS

OUTLET DETAILS
McMicken Dam Restoration

JOB NO.	DATE	DESIGNED BY	DRAWN BY	CHECKED BY	SHEET NO
E82-111	1-83	J.D.D.	V.K.	G.H.B.	2 of 26

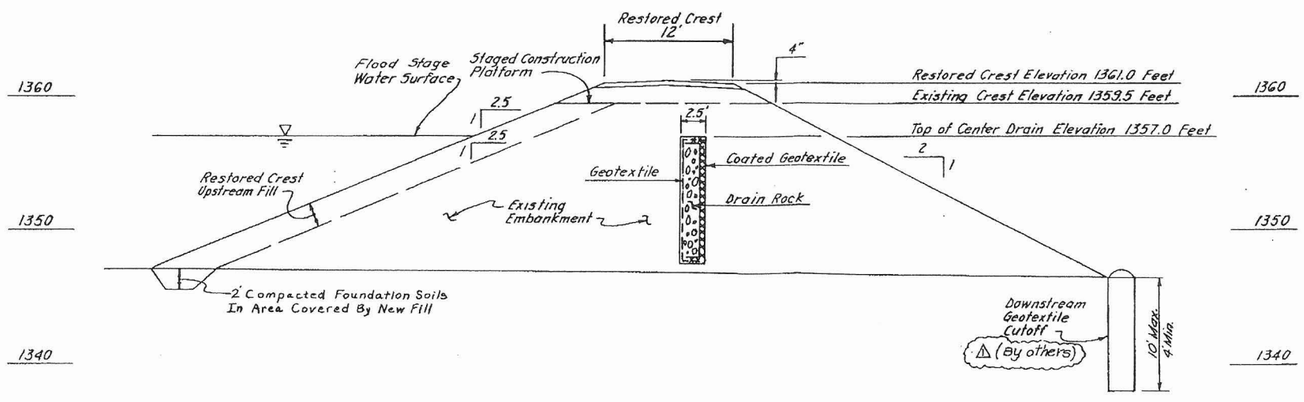
MAXIMUM CROSS SECTION STA. 400+00

Scale: 1" = 5'



EMBANKMENT CROSS SECTION STA. 500+00

Scale: 1" = 5'



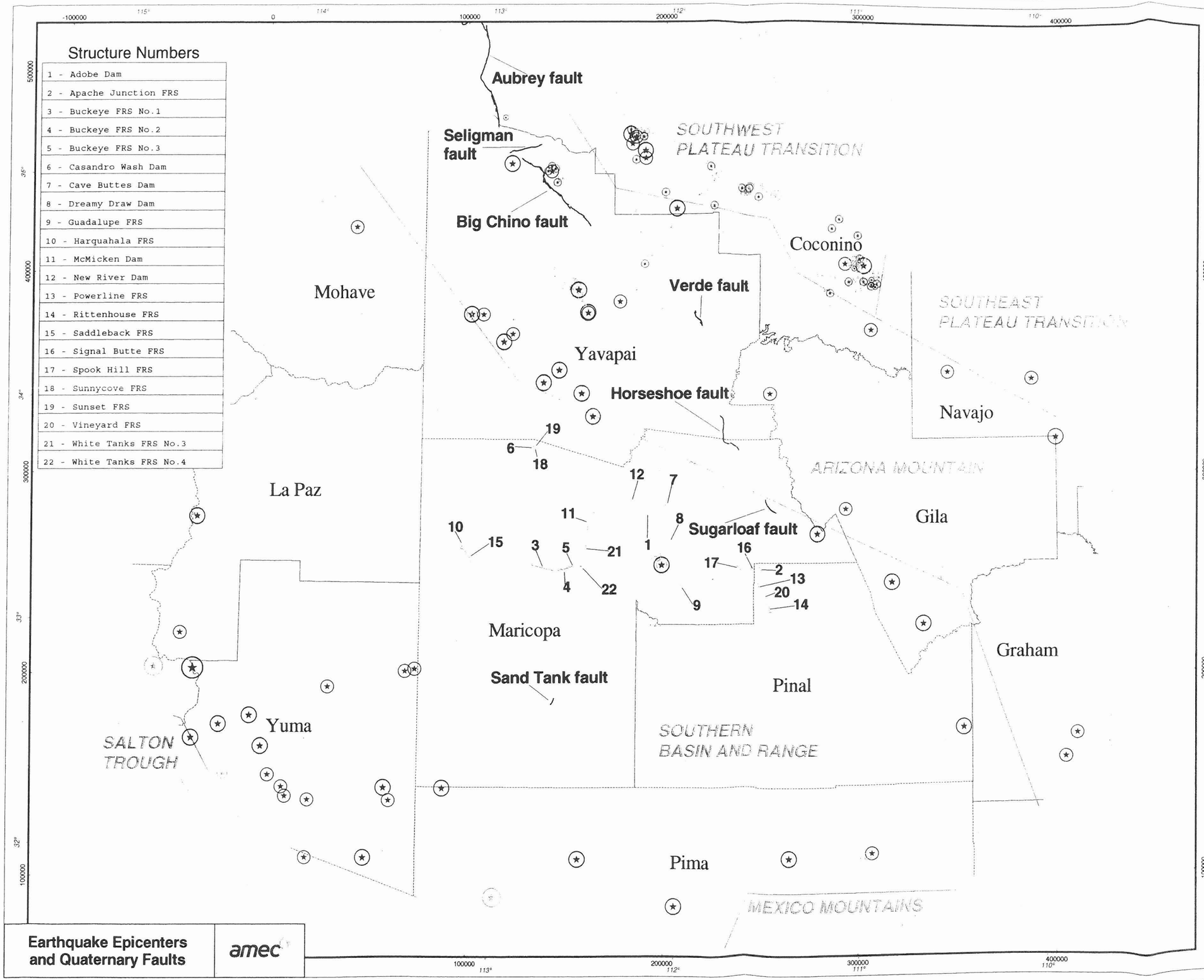
FLOOD CONTROL DISTRICT of MARICOPA CO.		
3335 West Durango Street — Phoenix, Arizona 85009 — Tel. 602-262-1501		
2	RECORD DRAWINGS	12/21/84
1	REVISED 7-19-83 B.R.	
NO.	DESCRIPTION	DATE
REVISIONS		

SERGENT, HAUSKINS & BECKWITH
CONSULTING GEOTECHNICAL ENGINEERS

CROSS SECTIONS

McMicken Dam Restoration

JOB NO.	DATE	DESIGNED BY	DRAWN BY	CHECKED BY	SHEET NO
E 82-111	1-83	J.D.D.	V.K.	G.H.B.	4 of 26



Structure Numbers

1	Adobe Dam
2	Apache Junction FRS
3	Buckeye FRS No.1
4	Buckeye FRS No.2
5	Buckeye FRS No.3
6	Casandro Wash Dam
7	Cave Buttes Dam
8	Dreamy Draw Dam
9	Guadalupe FRS
10	Harquahala FRS
11	McMicken Dam
12	New River Dam
13	Powerline FRS
14	Rittenhouse FRS
15	Saddleback FRS
16	Signal Butte FRS
17	Spook Hill FRS
18	Sunnycove FRS
19	Sunset FRS
20	Vineyard FRS
21	White Tanks FRS No.3
22	White Tanks FRS No.4

Earthquake Epicenters and Quaternary Faults

amec

Seismic Exposure Evaluation
Structures Assessment Phase II
FCD Contract No. 2000C006
AMEC Job No. 0-117-001122
May, 2002

LEGEND

Earthquake Epicenters (magnitude)
- 0
- 0 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 5
- 5 - 6
- 6 - 7

Quaternary Faults
- Active
- Inactive

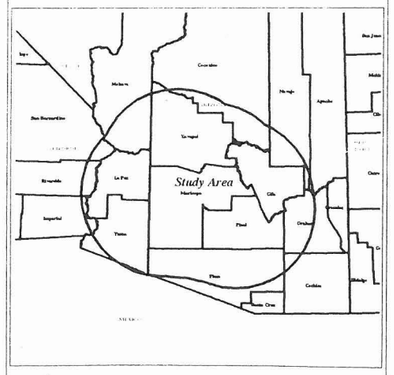
County Lines
Flood Control District Structures
Seismic Source Zone Boundaries

NOTES

The study area encompasses 100 miles around the 22 district flood control structures.

Data Sources:
Earthquake epicenters - combined USGS/NOAA/AEIC data
Source zones - after Euge & others (1992)

Projection: Transverse Mercator
Coordinate System: State Plane Arizona Central (feet)
Datum: North America 1983



N

10 0 10 20 30 Miles

20 0 20 40 Kilometers

AMEC Job No. 0-117-001122

	By	Date	
DESIGN	EMP	May 2002	FLOOD CONTROL DISTRICT OF MARICOPA COUNTY
DESIGN CHK			RECOMMENDED BY: Date:
PLANS			APPROVED BY: Date:
PLANS CHK			CHIEF ENGINEER AND GENERAL MANAGER
SUBMITTED BY: Date:			FIGURE 3

amec

TABLE 2

Active Fault Characteristics & Maximum Magnitude
Seismic Exposure Evaluation
Dam Safety Program

Fault No.[1]	Fault Name[2]	Source Zone	County	Sense of Movement[3]	Dip/ Strike[3]	Length[3] (km)	Slip Rate[3] (mm/yr)	Recurrence Interval[3] (yrs)	Maximum Magnitude (Reported)	Maximum Magnitude (Calculated)[4]	Remarks
943	Sand Tank	Southern B&R	Maricopa	Normal/down to west	45-90° NW/ N27°E	3.5[5]	<0.02	100 k	6.2 – 6.6[5]	5.7	Holocene and latest Pleistocene deposits not faulted. Scarp morphology suggests latest Pleistocene age of youngest movement (ca 10-20 ka)[3].
995	Aubrey	Arizona Mountain	Coconino	Normal/down to west	Steep/N18°W	53	<0.2	100 k	7.25[6]	7.1	Only southern segment with latest Pleistocene movement; Contiguous with Toroweap fault to the north
951	Big Chino	Arizona Mountain	Yavapai	Normal/right lateral[6]	60°-70° SW/N44°W	46	0.05 - 0.12	25 - 50 k 20 - 30 k[6]	7.0 – 7.25[6]	7.0	Holocene and post-glacial (<15 ka) displacement on segments of the fault. Upper Pleistocene terrace deposits displaced 7 to 8 m.
952	Seligman	Arizona Mountain	Yavapai	Normal/down to north	To north/N78°E	16	<0.2	(not reported)	---	6.5	20 m of Quaternary displacement; last movement less than 15 k years ago.
948	Verde	Arizona Mountain	Yavapai	Normal/down to northeast	62-85°NE/N26°W	8-30	<0.02	(not reported)	7.25 [6]	7.2	Late Quaternary movement restricted to short segment; Investigators do not agree on age of last rupture; Pearthree assigns latest Pleistocene.
946	Horseshoe	Arizona Mountain	Yavapai/ Maricopa	Normal/down to north and east[7]	To east/ N8°W[7] 70-75° N/N54°W	22[8]	<0.2[7] <0.02	100 k[7] 85 - 140 k	7.0[9]	6.6	Two segments; one with late Quaternary (<130 ka) displacement, one with Holocene/post-glacial activity.
945	Sugarloaf	Arizona Mountain	Maricopa	Normal/down to north	70-80° E/N40°W	20[10]	<0.02	100 k	6.75[9]	6.6	Latest Pleistocene age of last displacement interpreted by Pearthree (1998).

NOTES:

(1) Number designation in Pearthree (1998).
(2) See Figure 3.
(3) From Pearthree (1998), unless otherwise noted.
(4) Calculated using fault length/magnitude relationship presented in Wells and Coppersmith (1994) for normal displacement.
(5) Dempsey and Pearthree (1990).
(6) Euge and others (1992).
(7) First data for Hell Canyon section; data that follows for Horseshoe Reservoir section.
(8) Combined length of two fault segments.
(9) From Piety and Anderson (1990).
(10) From Pearthree and others (1995).

DOCUMENT TITLE: Seismic Exposure Evaluation Dam Safety Program, FCDMC.

DATE: May 2, 2002

PREPARED BY: AMEC

PURPOSE:

Establish seismic design parameters including peak horizontal ground accelerations for all 22 flood control dams operated by the District.

SUMMARY:

- Based on Krinitzsky's recommendation, both deterministic and probabilistic analyses were used to develop the peak ground accelerations (PGA).
- Because the District dams are founded on stiff soil or rock, the PGAs developed are for stiff soil or rock conditions
- Maximum Credible Earthquake criterion used because District dams are High Hazard
- All faults within 100-mile radius of any dam structure considered in probabilistic analysis.
- Background earthquake of Mw=6.5 deemed approximated
- Most 'active' faults for this study are located within the Arizona Mountain source zone (Aubrey, Seligman, Big Chino, Verde, Horseshoe faults); Sugarloaf and Sand Tank faults in Southern Basin & Range source zone.
- Attenuation relationships used in deterministic analysis included: Spudich, et al (1999), Abrahamson & Silva (1997), & Campbell (2000).
- Probabilistic peak ground accelerations were derived from NEHRP maps for 10%, 5%, &2% in 50 years

FINDINGS/RESULTS:

- Maximum PGA calculated for the District Structures is 0.15 g (Sugarloaf fault on Apache Junction FRS).
- The PGA recommended for McMicken dam is 0.10g. See attached tables for full results.

amec

Seismic Exposure Evaluation
Dam Safety Program
Flood Control District of Maricopa County

Submitted to:

Flood Control District of Maricopa County
Phoenix, Arizona

REGISTERED GEOLOGIST
CERTIFICATE NO.
12999
RALPH E.
WEEKS
Date Signed 5/2/02
ARIZONA U.S.A.

Submitted by:

AMEC Earth & Environmental, Inc.
Phoenix, Arizona

May 2, 2002

AMEC Job No. 0-117-001122, Task 2

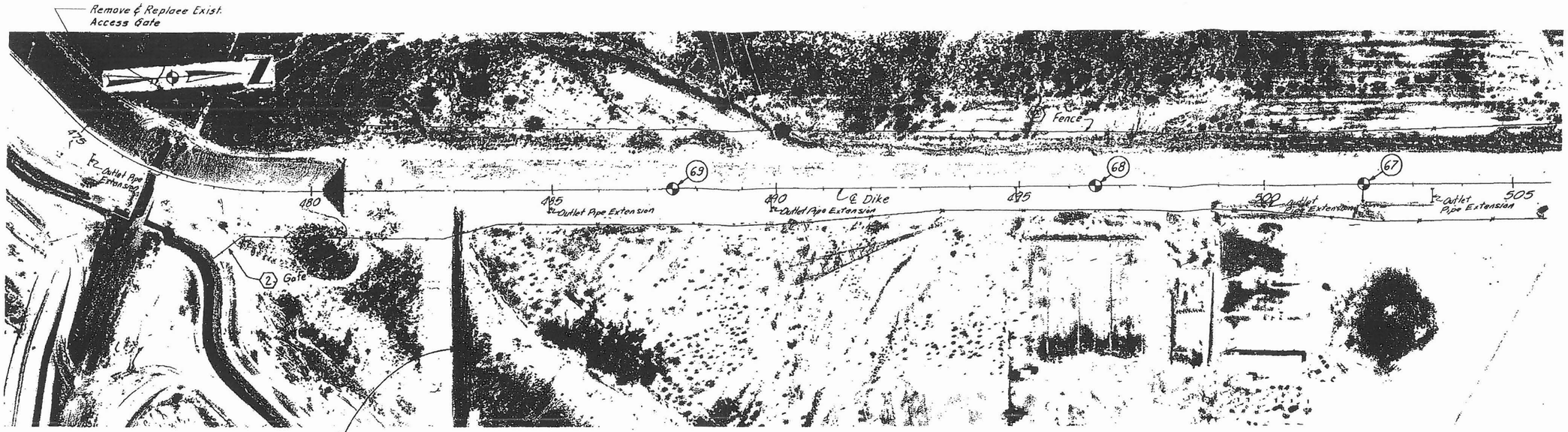
TABLE 4

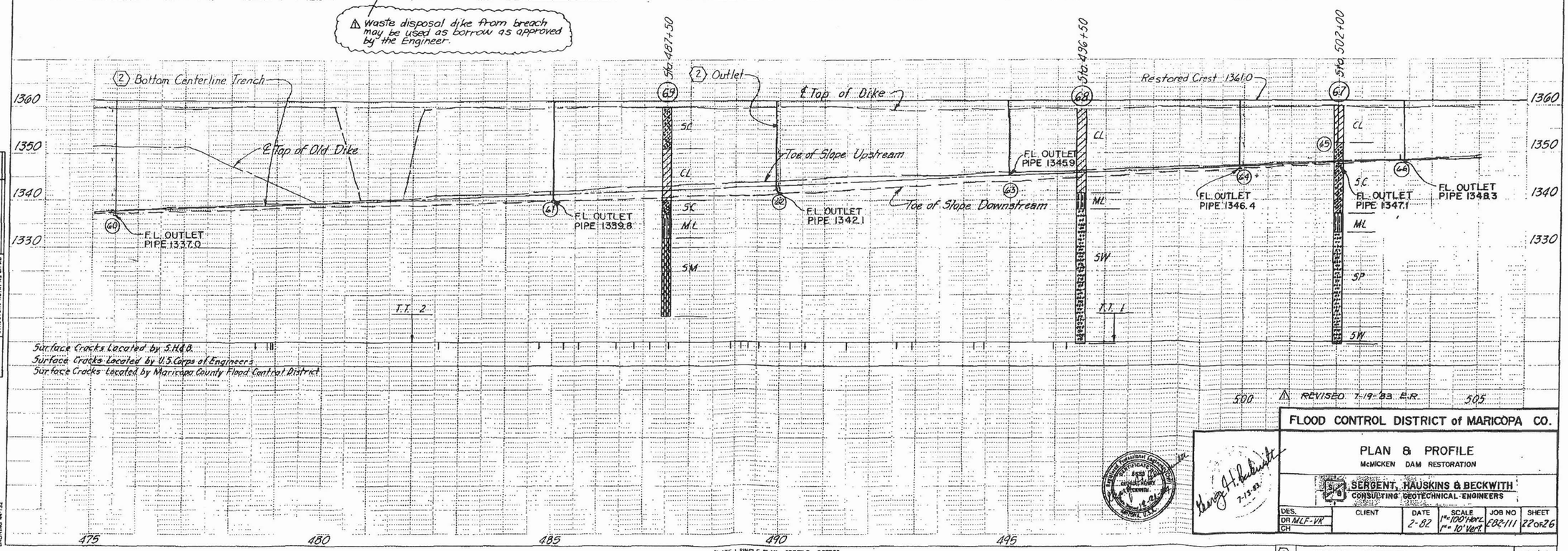
Recommended Peak Horizontal Acceleration
Seismic Exposure Evaluation
Dam Safety Program

Map ID	Facility Name	Source	Recommended PGA (%g)
1	Adobe Dam	Background	10
2	Apache Junction FRS	Sugarloaf Fault	**15**
3	Buckeye FRS No. 1	Background	10
4	Buckeye FRS No. 2	Background	10
5	Buckeye FRS No. 3	Background	10
6	Casandro Wash Dam	Background	10
7	Cave Buttes Dam	Horseshoe Fault	**10**
8	Dreamy Draw Dam	Background	10
9	Guadalupe FRS	Background	10
10	Harquahala FRS	Background	10
11	McMicken Dam	Background	10
12	New River Dam	Background	10
13	Powerline FRS	Sugarloaf Fault	**11**
14	Rittenhouse FRS	Background	10
15	Saddleback FRS	Background	10
16	Signal Butte FRS	Sugarloaf Fault	**14**
17	Spook Hill FRS	Sugarloaf Fault	**13**
18	Sunnycove FRS	Background	10
19	Sunset FRS	Background	10
20	Vineyard FRS	Sugarloaf Fault	**10**
21	White Tanks FRS No. 3	Background	10
22	White Tanks FRS No. 4	Background	10

Note:

Deterministically-derived values presented in red.





PLAN — SURVEYED; PLOTTED; ALIGNMENT CHECKED; RT. OF WAY CHECKED; NOTE BOOK; NO. — BY — DATE

PROFILE — SURVEYED; PLOTTED; GRADES CHECKED; BY; STRUCTURE NOTATNS CH'KD; NOTE BOOK; NO. — BY — DATE

FLOOD CONTROL DISTRICT of MARICOPA CO.

PLAN & PROFILE

McMICKEN DAM RESTORATION

SERGENT, HAUSKINS & BECKWITH
CONSULTING GEOTECHNICAL ENGINEERS

DES.	CLIENT	DATE	SCALE	JOB NO	SHEET
DR MLF-VK		2-82	1"=100' Horz. 1"=10' Vert.	E82-111	22 OF 26
CH					

(2) RECORD DRAWINGS 12/21/84

BRUNING 44-132

PLATE 1 SINGLE PLAN - PROFILE - DOTTED
CHARLES BRUNING COMPANY
MADE IN U.S.A.

DOCUMENT TITLE: Preliminary Failure Modes Identification Report

DATE OF REPORT: May 16, 2002

PREPARED BY: URS Corporation

PURPOSE:

To document discussions related to the Preliminary Failure Modes Identification workshop for McMicken Dam conducted on April 29, 2002. The objective of the workshop was to identify potential failure modes for the dam and its appurtenant facilities.

SUMMARY:

- The workshop includes representatives of the Flood Control District of Maricopa County, ADWR, Geological Consultants Inc, and URS Corporation.
- The principal outlet is an ungated, reinforced concrete box culvert about 20 feet wide and 11 feet high. It is located at Station 476+80.
- The outlet extends a total length of 188.33 feet from the upstream toe of the dam to the downstream toe. The length includes the entrance channel, a transition section, and a 30-foot wide stilling basin.
- The invert elevation at the entrance of the outlet is 1335.0 feet and slopes down to 1333.8 feet at the entrance of the transition section.
- URS reviewed 15 inspection reports dated from June 1988 to March 2002. Key findings included:
    - Reported erosion rills along the entire embankment and particularly large erosion gullies in need of repair at Station 488+00.
    - Cracks were reported in the right training wall of the principal outlet at the location of the Beardsley Canal siphon. The siphon was reportedly leaking through gate into the spillway.
    - During March 2001, the wing walls of the stilling basin appeared to be offset by approximately 1 inch from the sidewalls of the principal spillway. During the March 2002 inspection, the offset appeared to have increased by 0.25 inches.

- Preliminary failure modes identified include the failure of the Principal Outlet. The following items require review:
  - Review available information to assess the structural adequacy of the principal outlet.
  - Assess the potential for piping around the principal outlet
  - Inspect the wing walls of the principal outlet to assess and document if the walls have deflected due to lateral pressures.
  - Evaluate the structural capacity of the bridge spanning the principal outlet.
  - Review available geotechnical information to assess if the principal outlet is underlain by collapsible soils.
  - Visually inspect and document the crack in the right training wall at the location of the Beardsley Canal siphon.
  - Visually inspect the wing walls of the stilling basin for the offset from the sidewalls of the principal outlet.

DOCUMENT TITLE: Geotechnical Investigation Report

DATE OF REPORT: January 8, 2003

PREPARED BY: AMEC Earth & Environmental, Inc.

PURPOSE:

To determine the source, extent and implication of the cracking and depressions located along the dam.

SUMMARY:

- Construction of McMicken Dam incorporated parts of an existing dam on Trilby Wash located between Station 357+00 and the outlet works at about Station 474+50.
- Older embankment soils predominantly consist of sandy clay, with silty and clayey sand and gravel of low to medium plasticity. In-place dry densities along these sections vary from 92 to 124 pcf.
- Newer embankment soils between Stations 250+00 and 500+00 are predominantly sandy clay, sandy silt and clayey sand of low to medium plasticity. In-place dry density along this section ranged from 97 to 128 pcf.
- Moisture contents of near surface embankment soils ranged from 1 to 11 percent based on laboratory testing, and from 3 to 11 percent based on in-place nuclear density testing.
- The embankment is typically underlain by shallow weakly cemented, less dense surface layer of Holocene soils overlying denser, moderately cemented mid to late Pleistocene soils. At some locations coarser sand and gravel deposits extend from the surface to more than 10 feet.
- The shallow surface soils are predominantly fine-grained, consisting of sandy silt and clay, and silty and clayey sand with varying contents of gravel. The underlying soils are comprised of sand and clayey sand.
- Surface soils are moderate to firm and have plasticity indices ranging from 2 to 20, and occasionally as high as 30. The moisture content varies from 2 to 7 percent. The underlying soils are very firm to hard, with medium plasticity and moisture contents ranging from 5 to 10 percent.

- Native soils along the downstream alignment of the dam have low to moderate collapse potential upon wetting. Values ranged from 0 to 6 percent for samples with dry densities of 89 to 112 pcf and in-situ moisture contents of 5 to 26 percent. Summarized in Table 7.

- The principal outlet includes a 20-foot wide outlet channel, a transition section, and a 30-foot wide stilling basin located at Station 474+50. The structure is 11 feet high and is spanned by a reinforced concrete bridge.

- The USACE prepared a detailed study of cracking at McMicken Dam in 1973. Forty backhoe test pits were excavated along the embankment crest in June 1972. Transverse cracks greater than 1/8-inch wide were encountered at six locations between Stations 356+75 and 497+20.

- 19 possible cracks were noted between Stations 445+00 and 475+00 during a visual survey conducted by the District in 1977. This area was further explored by the District.

- McMicken Dam was breached at two locations. One of the breaches (110 feet wide at the base) was located near the outlet works at Station 479+39.

- Thirty test pits and 19 borings were excavated. An additional 34 test pits were excavated to sample and characterize the embankment soils. Of these excavations, one test pit (TP-S5) and one boring (B-16) were located within 800 feet of the principal outlet.

- Test pit TP-S5 and boring B-16 extended to depths of two feet and 15.5 feet, respectively.

- Thirteen locations along the downstream slope where transverse cracking and surficial disturbance had been identified were investigated by trenching or hand digging. A crack near the crest of the dam on the upstream face was observed at Station 474+21, adjacent to the principal outlet.

- Features at Stations 449+27 and 493+18 were further explored with test pits.

- The most extensive cracking was reported at Station 474+21. The crack was probed to a depth of about four feet and extended about 19 feet down the face of the dam. This feature is about 19 feet from the south wall of the outlet works.

- The inward deflection of the wall was measured to evaluate if the cracking could be related to the deflection of the retaining walls forming the outlet works. These retaining walls include a central section which is 32 feet long and is supported laterally by a bridge.

- The deflections of the retaining walls were measured at the upstream and downstream sides of the expansion joint between the two wall sections.

- The design of the stilling basin includes two independent drainage systems intended to relieve uplift pressures which could develop beneath the invert slab of the basin, and relieve hydrostatic pressures that could develop against the walls of the basin.

- Both drainage systems are comprised of a combination of perforated and non-perforated 8-inch diameter vitrified clay pipe placed in pervious backfill. It is noted that structural backfill and not pervious backfill was placed against the walls located upstream of the stilling basin.

- The high water marks on the walls of the stilling basin reveal that the drains from both systems have periodically been below water surface. During a February 2002 inspection by ADWR and the District, one of the drain pipes was observed to be broken, exposing backfill soils.

- Embankment sampling and testing was performed at eight locations along the length of the dam. Samples were collected at two feet and in-place density and moisture content was determined.

- SHB performed collapse tests on 13 native foundation soil samples collected from both upstream and downstream locations, and beneath the dam between Station 260 and 474. Collapse potential ranged from 0 to 14 percent for samples having dry densities of 89 to 112 pcf, and in-situ moisture contents of 5 to 26 percent. Summarized in Table 8.

- Laboratory testing included sieve analysis, moisture content, hydrometer tests, pinhole tests, hydraulic conductivity tests, proctors, and consolidation tests.

FINDINGS/RESULTS:

- Embankment soils have undergone continuous drying since their placement.

- Plasticity index values varied in comparison to those obtained in other studies:

  - AMEC: 1 to 16

  - COE (1973): 14 to 23

  - The District (1977): 6 to 19

  - SHB (1982): 3 to 29

- Embankment soils are generally not dispersive but have erosive characteristics. The soils were also found to be resistant to piping.

- Transverse cracks identified at Station 471+21 seem to be related to animal and/or rodent origin and have become more developed with erosion.

- Only surface cracking related to desiccation was noted at Stations 449+27 and 493+18 where existing features were explored with test pits. Roots about 1/2 inches in diameter were found at a depth of 2.8 feet at Station 493+18 indicating softer soil conditions or deeper desiccation cracking.

- Surficial voids/cracks observed at Station 474+21 did not appear to be of recent animal origin. Test pits and probing revealed cracks up to 19 feet long.

- On the downstream side of the dam, deflections of the laterally unsupported outlet works wall were 2-3/4 and 2-1/2 inches compared to 1 and 1-1/8 inches for the supported section. On the upstream side, deflections of the laterally unsupported wall were 1-5/8 and 7/8 inches compared to one inch for the supported section.

CONCLUSIONS AND RECOMMENDATIONS:

- The District concluded that the cracking was not entirely caused by regional subsidence.

- SHB restoration study concluded that the dam is underlain by collapsing soils from about Stations 250 to 500.

- Transverse cracking at Station 474+21 may be related to the deflection of the retaining walls at outlet works. It is likely that the deflection of the supported section occurred when the embankment sections adjacent to the walls were constructed.

- Recommend monitoring future deflection of the walls.

- The broken clay pipe may be indicative of more extensive damage to the independent invert slab and wall drainage systems designed to protect the structure. Further investigation of the two drainage systems is recommended.

- A detailed investigation plan including exposing all or part of the independent drainage systems should be undertaken if damage to several pipe sections is indicated.

- Longitudinal and transverse cracks neither pose an immediate dam safety concern nor impact stability.

Geotechnical Investigation Report
McMicken Dam
Work Assignment No. 1
Contract FCD 2000C006
Maricopa County, Arizona

Submitted to:

Flood Control District of Maricopa County
Maricopa County, Arizona

Submitted by:

AMEC Earth & Environmental, Inc.
Phoenix, Arizona

8 January, 2003

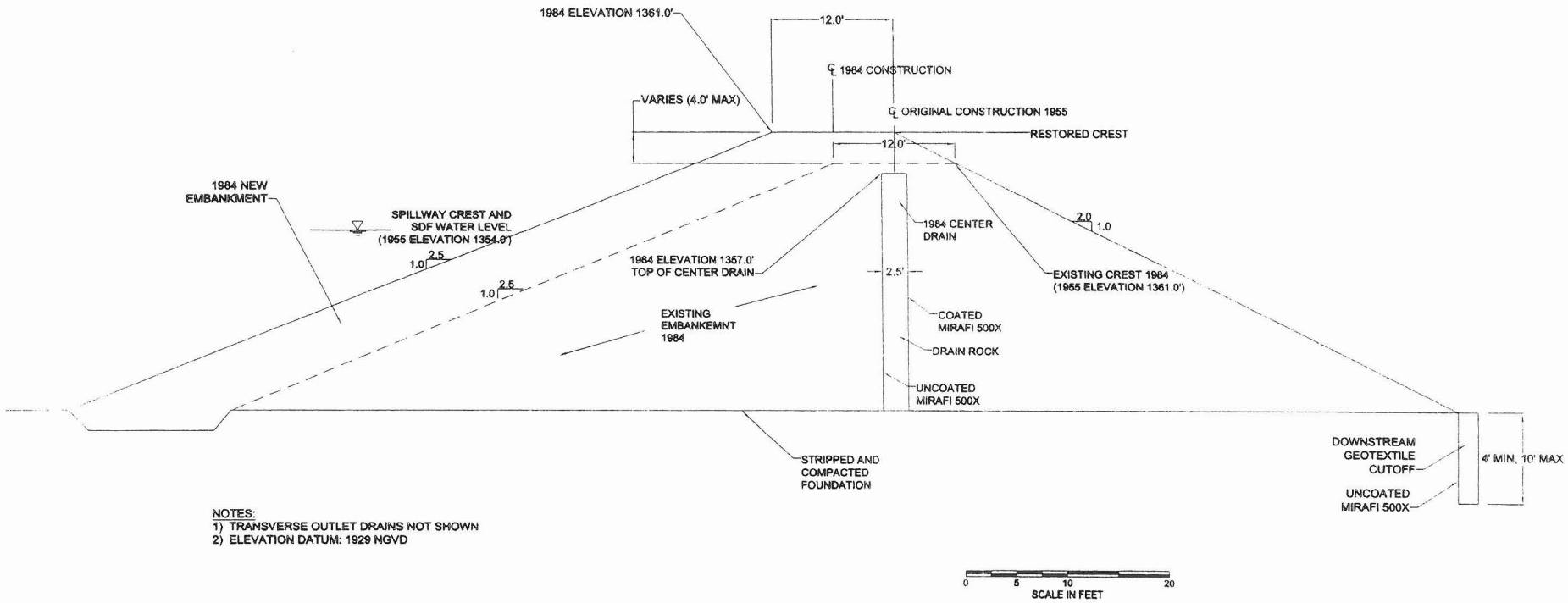
AMEC Job No. 0-117-001122, Task 1

TABLE 2
SUMMARY OF TRANSVERSE CRACK INVESTIGATION

Station	Test Pit No.	Crack Identified	Notes	Backfill Method
208+11	-	ADH	No crack identified in apparent animal dug hole (ADH). Spoil pile adjacent to downstream portion of hole.	-
436+63	-	ADH	No crack identified in apparent animal dug hole. Spoil pile adjacent to downstream portion of hole.	-
441+40	-	ADH	Indication of small voids at surface. Area was dug out with shovel and hammer. No evident cracking below grade. Small voids may be due to surficial desiccation and/or erosion.	-
445+20	-	ADH	Appears to be animal dug hole. Area was excavated with shovel and hammer. No evident cracking beyond surface. Wasp nest found in hole.	-
447+06	TP-S1	ADH	Appears to be animal dug hole. Spoil pile downhill of hole. Excavated with backhoe. No cracks found below grade.	C
449+27	TP-S2	No	Area excavated with backhoe. No cracking found in soil with exception of surface soils where most desiccation has occurred. Excavation did uncover some small roots up to 1/8" in diameter.	C
452+62	-	ADH	No crack identified in apparent animal dug hole. Spoil pile adjacent to downstream portion of hole.	-
453+60	-	ADH	No crack identified in apparent animal dug hole. Spoil pile adjacent to downstream portion of hole.	-
454+88	TP-S3	Yes	Two backhoe test pits excavated. Significant crack excavated. Portion of crack probed to depth of 4.2'. Surficial evidence of crack indicated limits to be on extent of 2.5' by 1.3'. Excavation of area indicated crack to be at least 8' in length. Probing horizontally indicated an additional 30" of extent beyond initial 6 feet excavated.	D
455+28	TP-S4	Yes	Two backhoe test pits excavated. Significant crack identified. Cracking was observed to be a minimum of 14' in length with additional 3.3 feet of crack probed outside excavation limits. Maximum depth of probing vertically was 4.5 feet.	D
471+21	-	ADH	Appears to be animal dug hole. Area was excavated with shovel and hammer. No evident cracking beyond surface.	-

TABLE 2 (Cont.)
SUMMARY OF TRANSVERSE CRACK INVESTIGATION

Station	Test Pit No.	Crack Identified	Notes	Backfill Method
474+21	TP-S5	Yes	Two backhoe test pits excavated. Crack evident after some excavation. Excavation uncovered crack with minimum length of 19 feet. Maximum depth of probing vertically was 4.0 feet. Voids in immediate area were examined. No additional cracks were identified.	D
493+18	TP-S6	No	Two backhoe test pits excavated. No cracking was observed beyond surface. Some surficial desiccation cracks were apparent in upper portion of excavation. Roots up to ½" were found at depth of 2.8 feet.	C



NOTES:
1) TRANSVERSE OUTLET DRAINS NOT SHOWN
2) ELEVATION DATUM: 1929 NGVD

JOB NO. 0-117-001122 Task 1	TYPICAL EMBANKMENT CROSS SECTION STATION 42+00 TO STATION 357+00 OUTLET WORKS TO STATION 504+00±	
DESIGN: LAH		
DRAWN: KAS		
DATE: 10/2002	MCMICKEN DAM GEOTECHNICAL INVESTIGATION WORK ASSIGNMENT No. 1- CONTRACT FCD 2000C006 MARICOPA COUNTY, ARIZONA	FIGURE 1
SCALE: 1" = 10'		

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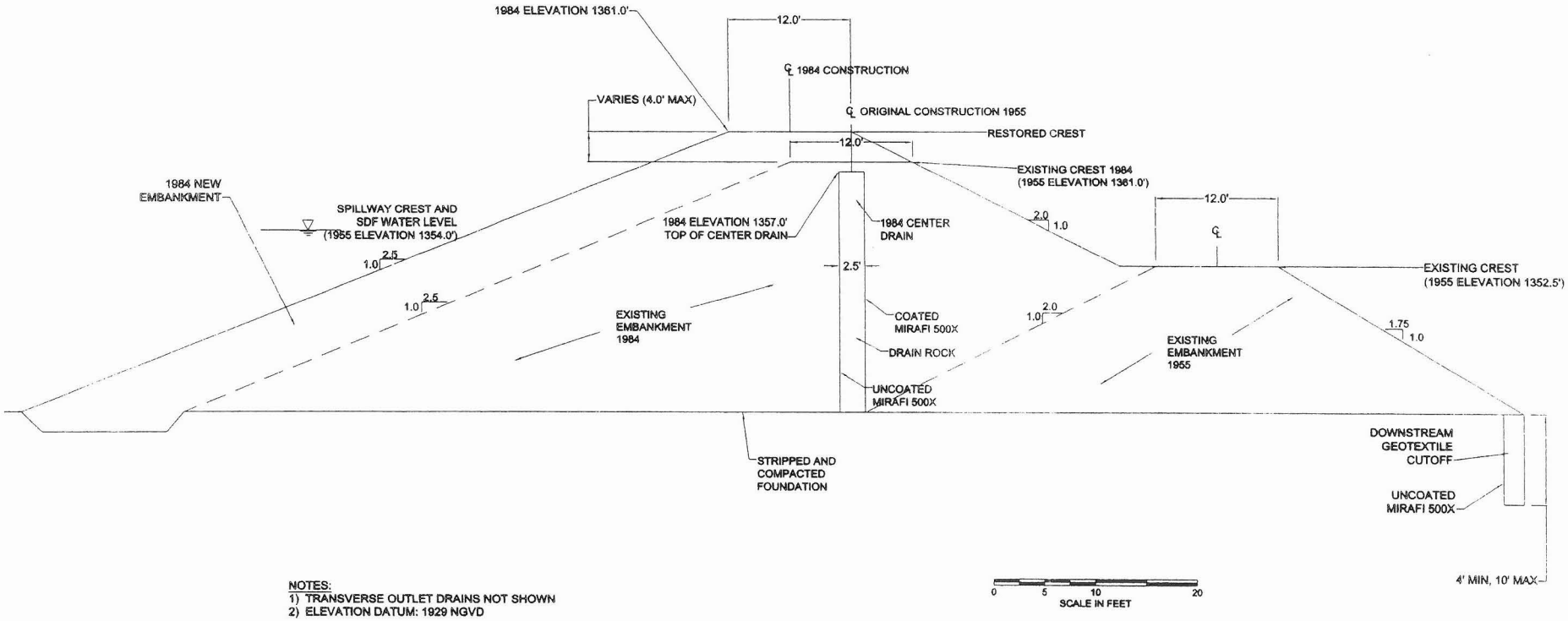
G:\Engineering Development\2000 Projects\0-117-001122 Bureau Area Assessment - Ph III\Task 1 - McMicken Dam\CAD\Initial Embankment cross section Fig 1.dwg



NOTES:
1) TRANSVERSE OUTLET DRAINS NOT SHOWN
2) ELEVATION DATUM: 1929 NGVD

JOB NO.	0-117-001122 Task 1
DESIGN:	LAH
DRAWN:	KAS
DATE:	10/2002
SCALE:	1" = 10'

TYPICAL EMBANKMENT CROSS SECTION
STATION 357+00 TO OUTLET WORKS (STATION 474+00±)

MCMICKEN DAM GEOTECHNICAL INVESTIGATION
WORK ASSIGNMENT No. 1- CONTRACT FCD 2000C006
MARICOPA COUNTY, ARIZONA

FIGURE
2

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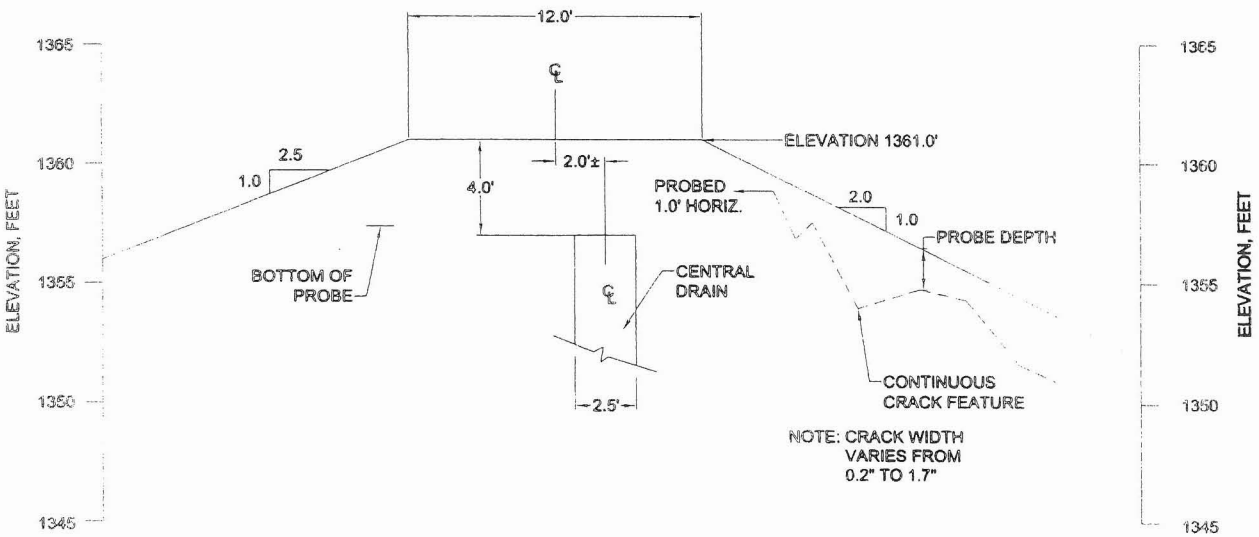
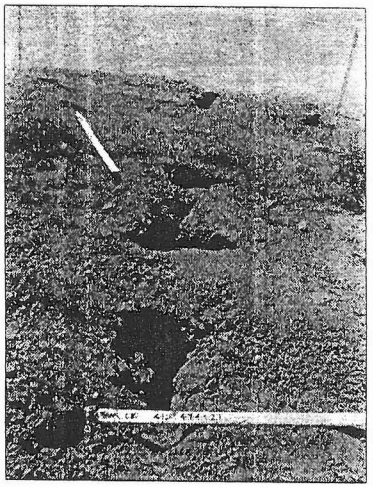


NOTE: SEE SHEET 4 FOR OTHER PHOTOGRAPHS

CRACK FEATURE ON UPSTREAM SLOPE NEAR CREST. LATH IS EXTENDED ABOUT 3 FEET INTO THE FEATURE.



LINEAR SEQUENCE OF HOLES AND CRACK FEATURES EXTENDING FROM NEAR THE CREST DOWWNSLOPE

JOB NO.	0-117-001122 Task 1
DESIGN:	LAH
DRAWN:	KAJ
DATE:	07/2002
SCALE:	1" = 5'

LOCATION OF CRACKING AT STATION 474+21
RELATIVE TO CENTRAL DRAIN

McMICKEN DAM GEOTECHNICAL INVESTIGATION
WORK ASSIGNMENT No. 1- CONTRACT FCD 2000C006
MARICOPA COUNTY, ARIZONA

FIGURE 5

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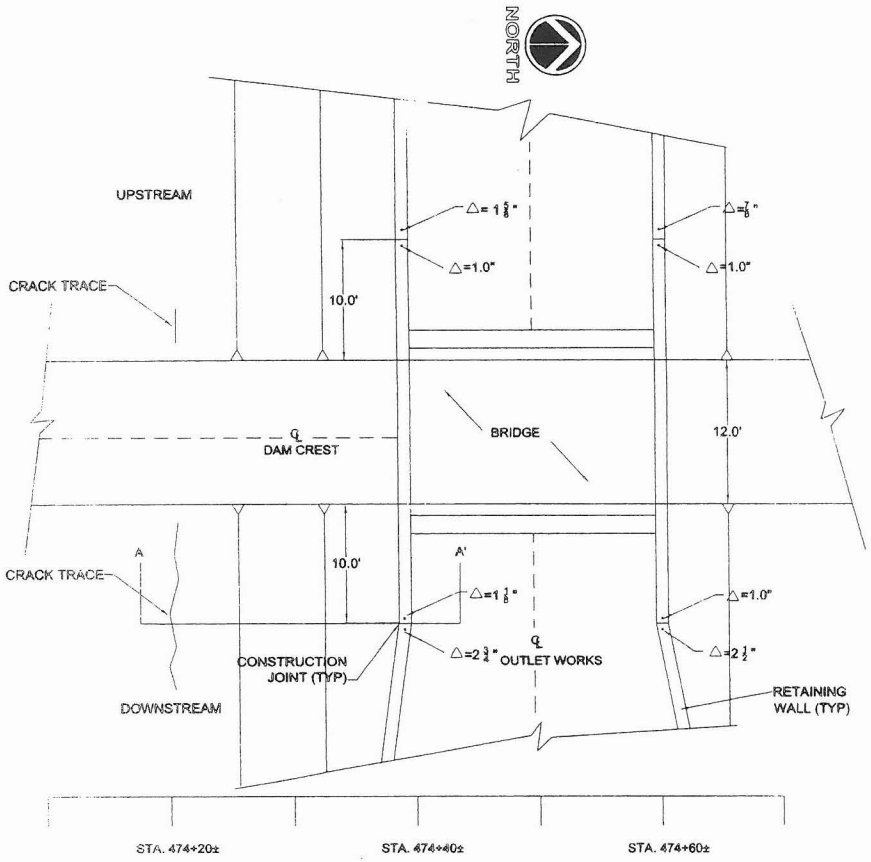
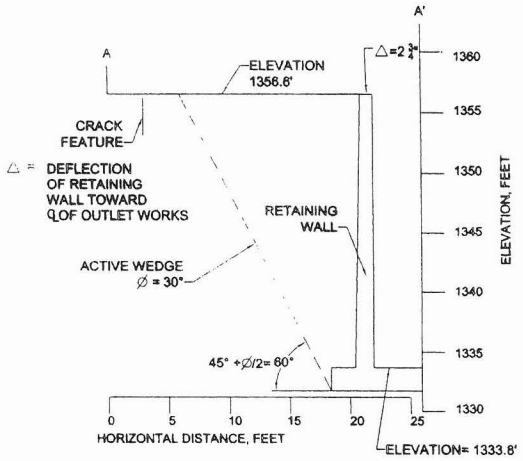


a) PLAN VIEW

0 5 10 20
SCALE IN FEET



b) ELEVATION VIEW (SECTION A-A')

0 5 10 20
SCALE IN FEET

JOB NO.	0-117-001122 Task 1
DESIGN:	LAH
DRAWN:	KAJ
DATE:	07/2002
SCALE:	1" = 10'

LOCATION OF CRACKING AT STATION 474+21
RELATIVE TO OUTLET WORKS

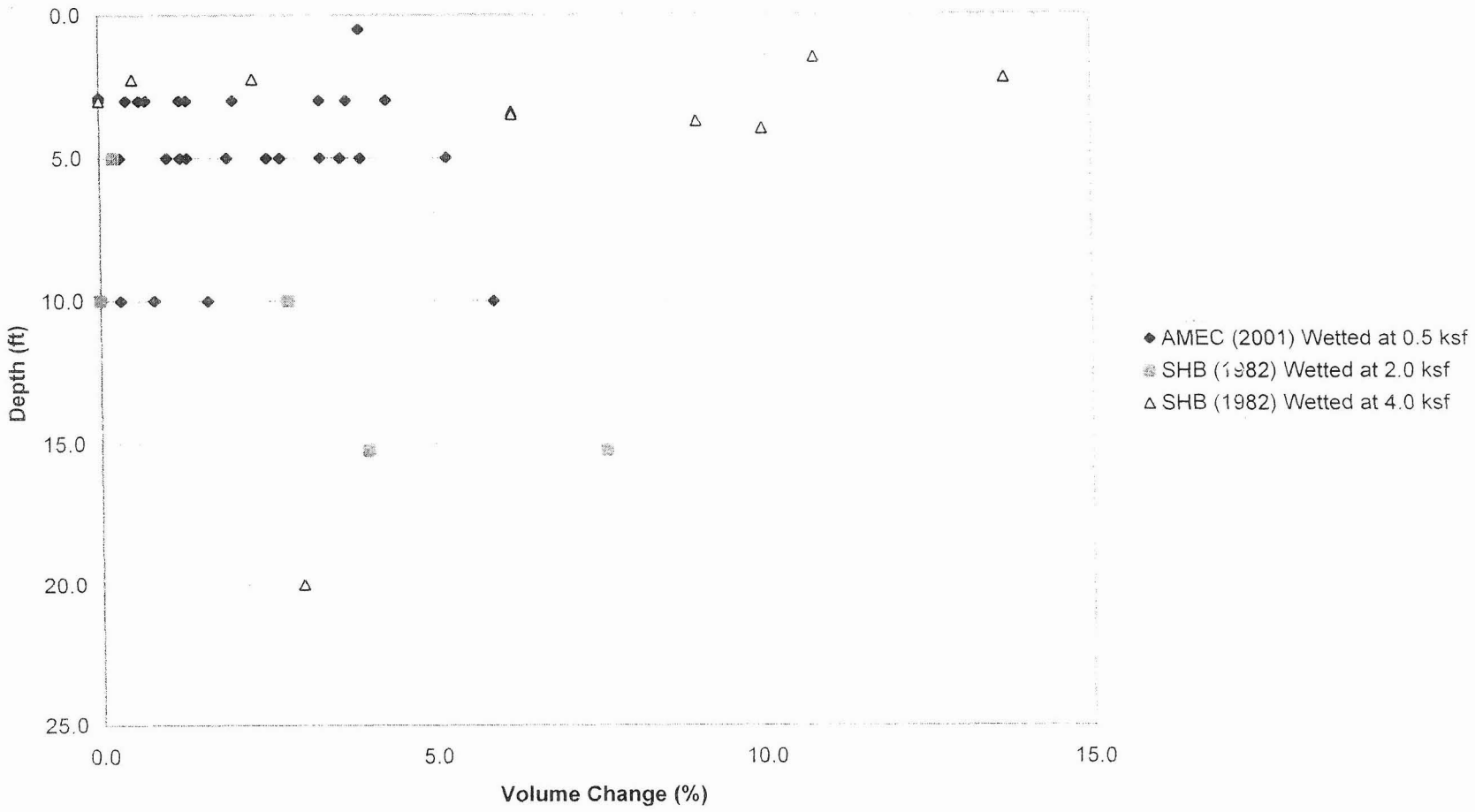
MCMICKEN DAM GEOTECHNICAL INVESTIGATION
WORK ASSIGNMENT No. 1- CONTRACT FCD 2000C006
MARICOPA COUNTY, ARIZONA

FIGURE
6

amec

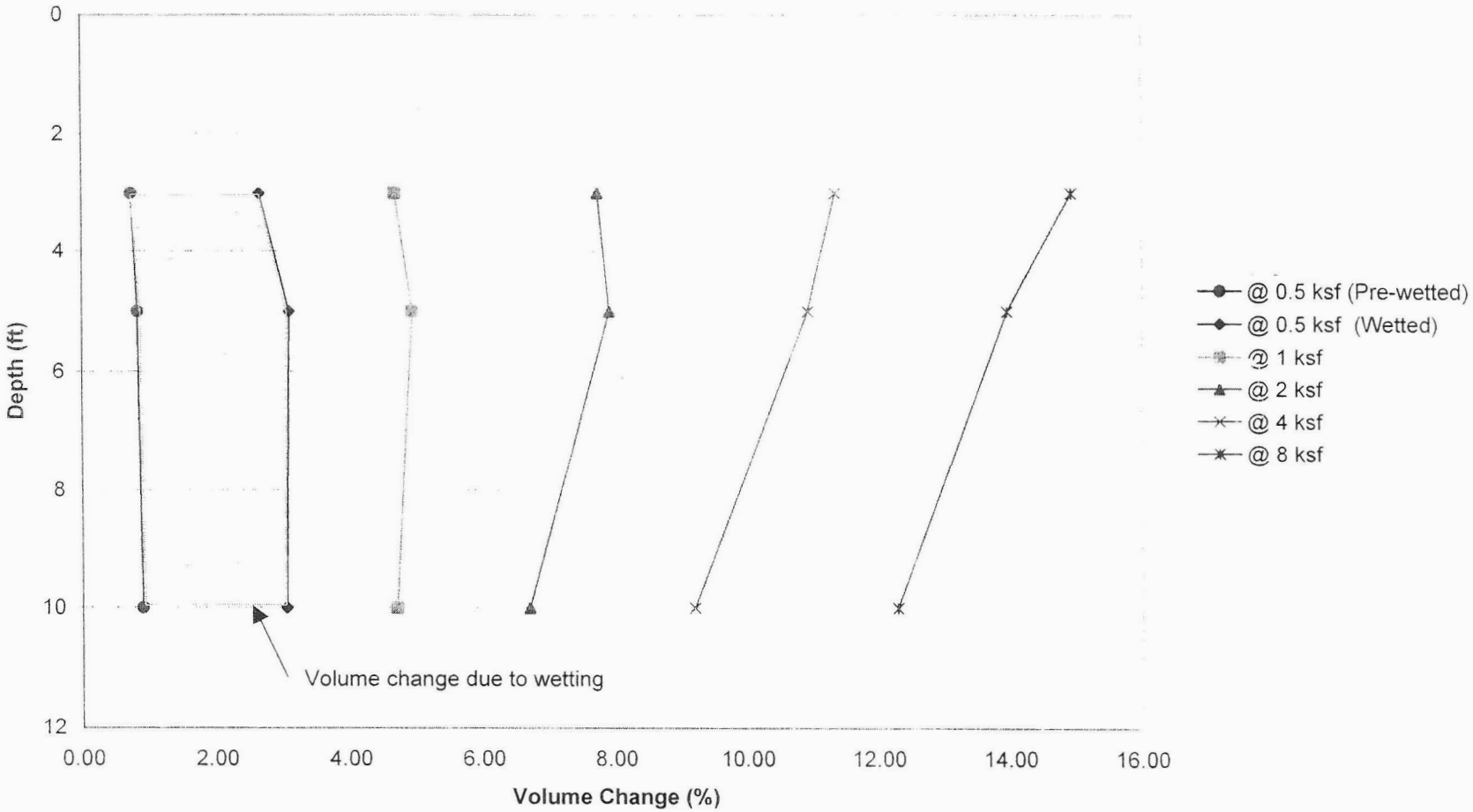
Flood Control District of Maricopa County
McMicken Dam Geotechnical Investigation
Work Assignment No. 1
Contract FCD 2000C006
Maricopa County, Arizona
June, 2002

FIGURE 7
Change in Volume on Wetting
Native Foundation Soils



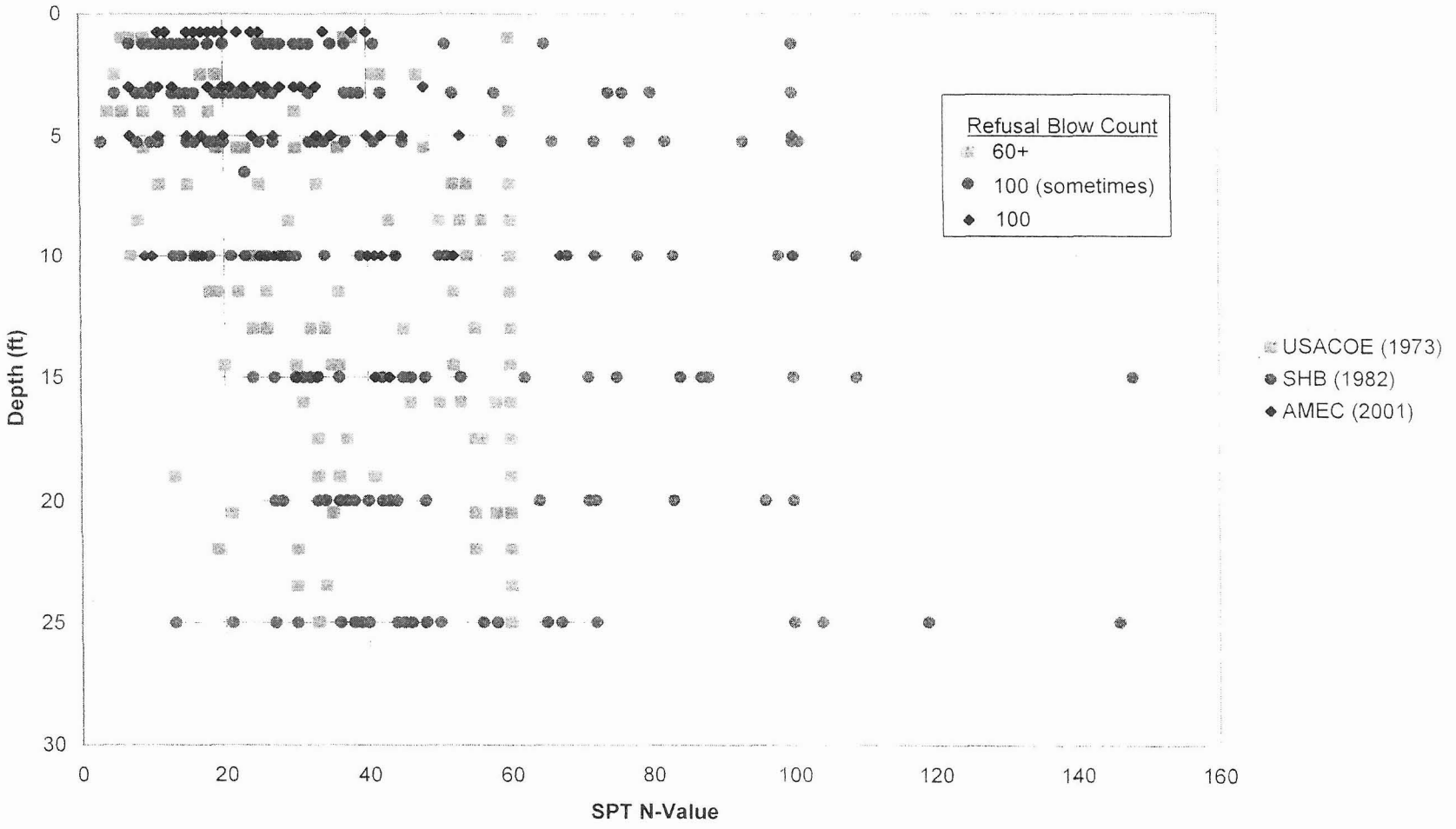
Flood Control District of Maricopa County
McMicken Dam Geotechnical Investigation
Work Assignment No. 1
Contract FCD 2000C006
Maricopa County, Arizona
June, 2002

FIGURE 8
Mean Volume Change vs Sample Depth for Various Pressures
AMEC (2001) Consolidation tests



Flood Control District of Maricopa County
McMicken Dam Geotechnical Investigation
Work Assignment No. 1
Contract FCD 2000C006
Maricopa County, Arizona
June, 2002

FIGURE 9
Blowcount Profile



Blow Counts.xls

Flood Control District of Maricopa County
Structures Assessment Phase II
Investigation of Cracking
AMEC Job No. 0-117-001122
FCD Contract No. 2000C006
Assignment 1, McMicken Dam

FIGURE 10
Summary of Moisture Content Data

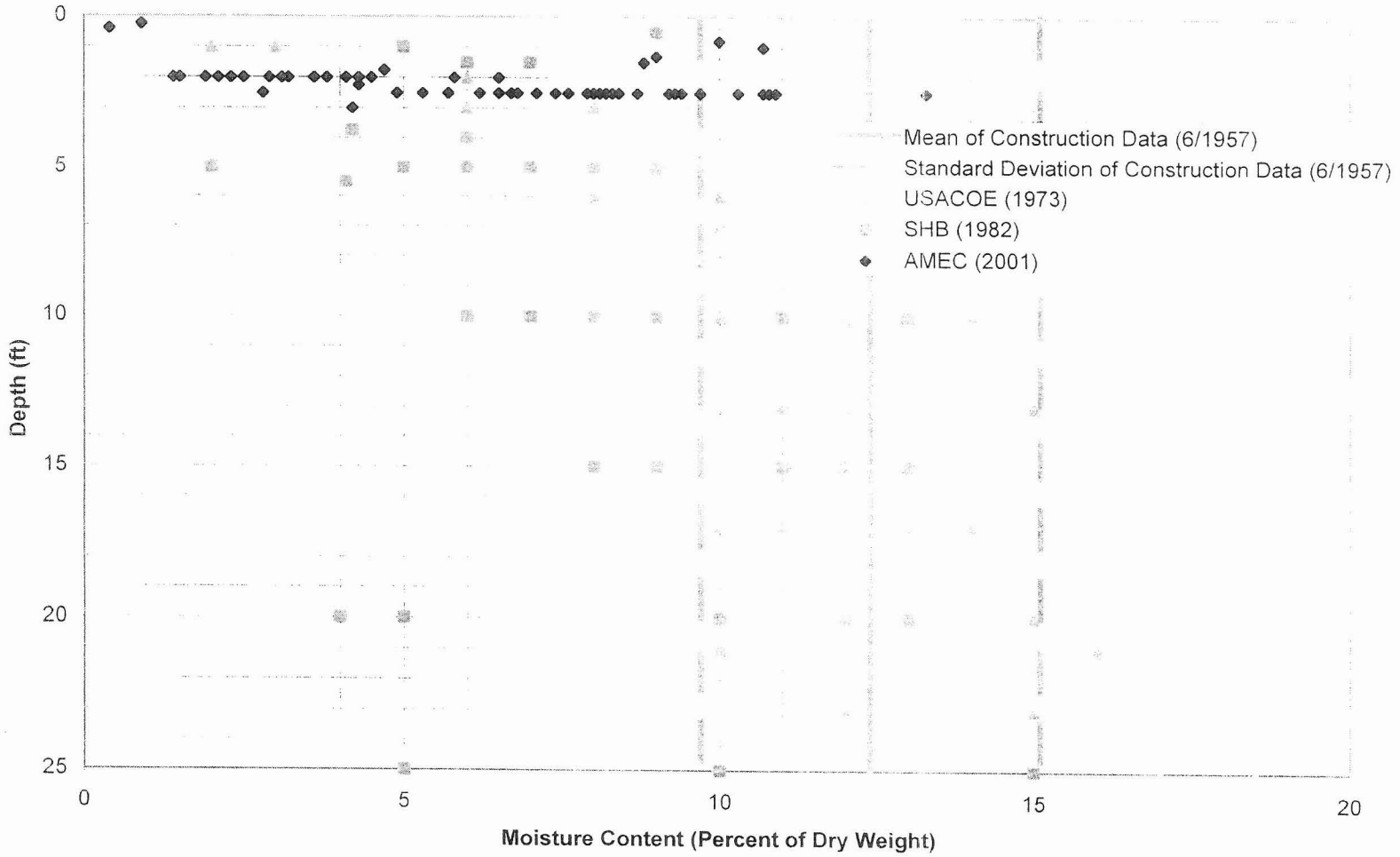
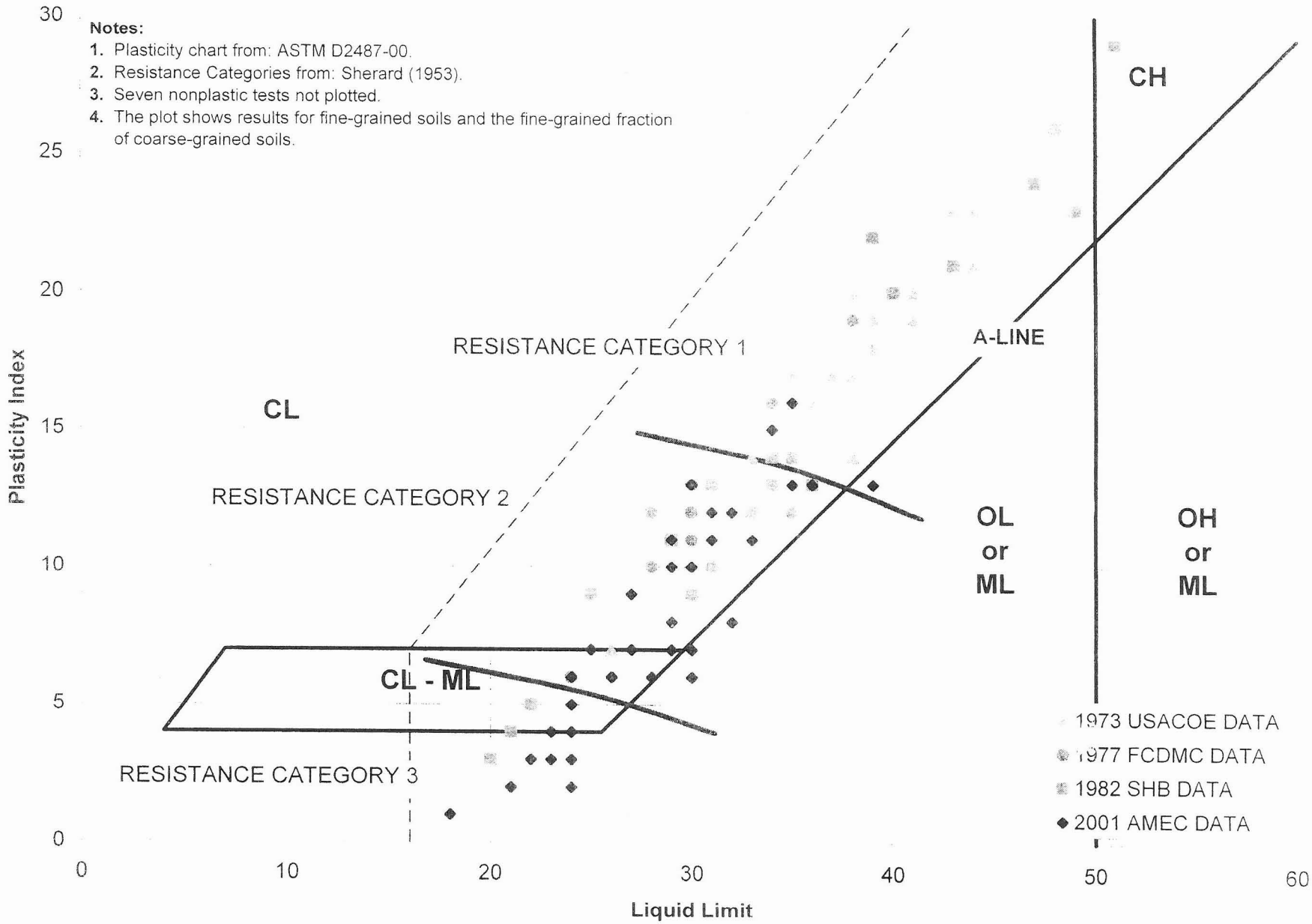


FIGURE 15
McMicken Dam Embankment Material Properties



PROJECT Structures Assessment: McMicken Dam

JOB NO. 0-117-001122 Task 1 DATE 5/2/01

LOCATION Sta. 473+30, East of Maintenance Road

RIG TYPE CME-75

BORING TYPE 6 5/8" Hollow Stem Auger

SURFACE ELEV.

DATUM

Depth in Feet	Blows Per Foot	Graphical Log	Sample	Sample Type	Blow Count / % Recovery	Dry Density lbs per Cubic ft	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0				S	9-15-23			SM	slightly moist	**SILTY SAND**, predominantly medium to fine grained, low plasticity, light brown
								CL	moderately firm	note: small diameter roots
								SC-SM	slightly moist	**SANDY CLAY**, predominantly fine grained sand, weakly lime cemented, low to medium plasticity, brown to reddish brown
				U	45				moderately firm to firm	
5				U	30	100	5		slightly moist	**SILTY TO CLAYEY SAND**, predominantly fine grained, weakly lime cemented, low to medium plasticity, reddish brown
									firm	
								SM	slightly moist	**SILTY SAND**, trace of fine grained, subangular to subrounded gravel, well graded sand, weakly lime cemented, low plasticity, light brown
10				U	15	103	10		moderately firm	
								SP	slightly moist	**SAND**, trace of silt, predominantly medium to coarse grained, subangular to subrounded, nonplastic, brown
15				U	50				medium dense	
								SC	slightly moist	**CLAYEY SAND**, predominantly medium to fine grained, weakly lime cemented, low to medium plasticity, brown to reddish brown
									very firm	
20										Stopped Auger at 14'6" Stopped Sampler at 15'6"
25										

GROUNDWATER

DEPTH(ft)	HOUR	DATE
	none	

SAMPLE TYPE

A - Drill cuttings; NR - No Recovery
S - 2" O.D. 1.38" I.D. tube sample
U - 3" O.D. 2.42" I.D. tube sample
T - 1" O.D. thin-walled tube sample
D - 2.5" O.D. 1.9" I.D. tube sample
C - 2.5" O.D. 2.0" I.D. tube sample

LOG OF TEST BORING NO. B-16

BORING LOG 0117122.GPJ AGRA_PHX.GDT 8/30/01

PROJECT Structures Assessment: McMicken Dam

JOB NO. 0-117-001122 Task 1 DATE 5/2/01

BACKHOE TYPE CASE 580L, Extendahoe

LOCATION Sta. 474+21, downstream slope

SURFACE ELEV.

DATUM

GROUNDWATER

	DEPTH	HOUR	DATE
▽		none	
▼			

Depth in Feet	Graphical Log	Sample	Sample Type	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	SOIL DESCRIPTION
0					SM	slightly moist	Surficial Evidence: Series of small holes in linear fashion, deepest probe to 3'
			D			soft to moderately firm	**SILTY SAND**, trace of clay, fine to medium grained sand, weakly cemented, low plasticity, brown
1							note: zones of clayey material, weakly cemented, trace of small diameter roots to 2'
							note: significant crack observed up to 19' in length, probed to 4' deep, maximum width 0.3'
2							Stopped Backhoe at 2'
3							
4							
5							
6							
7							
8							
9							
10							

GEOTECH_TP 0117122.GPJ AGRA_PHX.GDT 7/25/02

SAMPLE TYPE

B - Undisturbed Block Sample
D - Disturbed Bulk Sample
U - 3" O.D. 2.42" I.D. tube sample
A - Drill Cuttings
G - Grab sample

LOG OF TEST PIT NO. TP-S5

Flood Control District of Maricopa County
McMicken Dam Geotechnical Investigation
Work Assignment No. 1
Contract FCD 2000C006
Maricopa County, Arizona
June, 2002

TABLE 7
SUMMARY OF AMEC (2001) CONSOLIDATION TESTS

Station	Boring No.	Sample Depth (ft)	Intermediate Depth (ft)	Overburden Pressure (σ_v) (ksf)	Water Content (w) (%)	Initial Dry Density (γ_d) (pcf)	Total Volumetric Change (ΔV) @ 0.5 ksf: Pre-Wetting (%)	Post-Wetting (%)	Collapse (%)	@ 1 ksf (%)	@ 2 ksf (%)	@ 4 ksf (%)	@ 8 ksf (%)	Unified Soil Classification Symbol	Blow Count (Ring Sampler)
200+00	B-1	2.5-3.5	3.0	0.345	4.7	102.2	0.8	1.4	0.6	2.6	4.6	7.2	9.9	SC-SM	15
		4.5-5.5	5.0	0.575	2.8	93.7	0.9	6.1	5.2	9.0	12.5	16.0	18.8	SC-SM	30
		9.5-10.5	10.0	1.15	3.6	98.2	1.3	7.2	5.9	10.2	12.3	15.3	18.3	SC	37
210+00	B-2	2.5-3.5	3.0	0.345	7.5	94.6	0.5	0.5	0.0	1.1	2.3	5.2	9.5	CL	42
220+00	B-3	2.5-3.3	2.9	0.3335	5.3	94.9	0.5	0.5	0.0	1.3	3.0	5.8	8.9	CL	35
230+00	B-4	2.5-3.5	3.0	0.345	5.2	96.8	1.0	3.0	2.0	5.0	8.2	11.4	14.8	SC	11
240+00	B-5	4.5-5.5	5.0	0.575	7.2	89.1	1.0	2.0	1.0	3.7	6.7	10.4	14.3	CL	36
250+00	B-6	2.5-3.5	3.0	0.345	4.8	87.0	0.7	1.1	0.4	2.0	3.9	6.3	10.3	SM	32
		4.5-5.5	5.0	0.575	6.3	93.0	0.8	2.0	1.2	3.0	5.0	7.8	11.1	ML	40
		9.5-10.5	10.0	1.15	5.6	91.1	0.7	1.5	0.8	2.7	5.2	8.0	12.0	CH	42
260+00	B-7	4.5-5.5	5.0	0.575	4.5	105.0	0.7	4.0	3.3	6.3	9.3	12.0	14.5	SC	17
292+00	B-8	2.5-3.5	3.0	0.345	6.0	95.2	0.9	1.3	0.4	2.9	5.2	8.5	12.4	CL	72
302+00	B-9	2.5-3.5	3.0	0.345	5.9	95.8	0.8	1.5	0.7	2.8	5.1	8.7	12.2	CL	47
312+00	B-10	4.5-5.5	5.0	0.575	4.3	103.8	0.7	1.0	0.3	2.1	3.9	6.3	8.9	SC	Refusal
420+05	B-11	2.5-3.5	3.0	0.345	6.3	97.8	1.1	4.8	3.7	7.7	11.5	15.1	16.5	SC	20
		4.5-5.5	5.0	0.575	7.0	94.2	0.7	1.0	0.3	2.0	3.9	6.4	9.6	CL	17
430+10	B-12	2.5-3.5	3.0	0.345	2.9	100.0	0.7	5.0	4.3	7.2	10.3	13.2	16.3	SC-SM	16
		4.5-5.5	5.0	0.575	6.4	90.5	0.9	4.5	3.6	7.1	10.7	14.8	18.6	CL	17
440+05	B-13	4.5-5.5	5.0	0.575	6.2	95.1	0.7	3.2	2.5	5.4	9.0	12.3	15.8	SC	60
450+00	B-14	4.5-5.5	5.0	0.575	4.1	107.8	1.4	3.3	1.9	4.7	6.5	8.5	10.7	SM	25
		9.5-10.5	10.0	1.15	7.1	105.9	0.8	2.4	1.6	4.3	6.7	9.2	11.8	SC	24
460+15	B-15	2.5-3.5	3.0	0.345	4.5	103.5	0.6	1.9	1.3	3.1	5.1	7.5	10.1	SC-SM	30
		4.5-5.5	5.0	0.575	3.3	107.3	0.6	3.3	2.7	4.9	6.8	8.9	10.9	SM	11
473+30	B-16	4.5-5.5	5.0	0.575	6.3	102.8	0.8	4.7	3.9	6.9	12.9	15.9	18.3	SC-SM	30
		9.5-10.5	10.0	1.15	10.3	103.0	0.8	1.1	0.3	1.6	2.6	4.3	7.1	SM	15
484+00	B-17	2.5-3.5	3.0	0.345	4.9	99.6	0.6	1.8	1.2	4.1	7.8	11.8	15.3	SC-SM	17
494+00	B-18	2.5-3.5	3.0	0.345	9.8	94.7	0.6	1.0	0.4	2.8	5.8	9.5	13.7	SC	27
503+14	B-19	0.0-1.0	0.5	0.0575	2.7	97.6	0.9	4.8	3.9	6.4	8.9	11.7	14.1	SC	17
		2.5-3.5	3.0	0.345	5.4	89.8	0.6	3.9	3.3	6.9	11.1	16.5	21.0	CL	35
		4.5-5.5	5.0	0.575	6.0	95.4	0.8	2.1	1.3	4.2	7.8	11.9	16.0	CL	22

Flood Control District of Maricopa County
McMicken Dam Geotechnical Investigation
Work Assignment No. 1
Contract FCD 2000C006
Maricopa County, Arizona
June, 2002

TABLE 8
SUMMARY OF SHB (1982) CONSOLIDATION TESTS

Station	Boring/ Test Pit No.	Location*	Sample Depth (ft)	Intermediate Depth (ft)	Overburden Pressure (σ_v) (ksf)	Pressure when Wetted (ksf)	Water Content (w) (%)	Initial Dry Density (γ_d) (pcf)	Total Volumetric Change (ΔV) Pre-Wetting (%)	Post-Wetting (%)	Collapse (%)	@ 1 ksf (%)	@ 2 ksf (%)	@ 4 ksf (%)	@ 8 ksf (%)	Unified Soil Classification Symbol	Blow Count (Ring Sampler)
260+50	15	10' US of Toe	9.5-10.5	10.0	1.15	2.0	8.7	90.8	1.9	4.7	2.8	---	4.7	7.5	10.6	ML	Refusal
280+00	16	10' US of Toe	4.5-5.5	5.0	0.58	2.0	7.9	111.7	2.0	2.2	0.2	---	2.2	3.4	5.2	CL	48
282+05	TP26	120' DS of Toe	2.0-2.5	2.3	0.26	4.0	6.0	111.4	1.2	3.5	2.3	---	---	3.5	7.0	SC	N/A
284+00	TP24	600' US of CL	2.5-3.5	3.0	0.35	4.0	5.9	93.4	1.6	15.3	13.7	---	---	15.3	19.0	CL	N/A
292+25	TP25	145' DS of CL	3.0-3.75	3.4	0.39	4.0	6.6	97.0	2.0	2.5	0.5	---	---	2.5	4.5	CH	N/A
425+00	22	8' US of Toe	19.5-20.5	20.0	2.30	4.0	25.7	92.7	2.9	2.9	0.0	---	---	2.9	4.1	CH	60
455+00	55	CL of Old Dike	14.5-16.0	15.3	1.75	2.0	11.0	93.8	1.7	5.7	4.0	---	5.7	9.7	14.0	CL	12
457+70	TP15	940' US of CL	3.0-4.0	3.5	0.40	4.0	6.6	88.7	1.8	8.0	6.2	---	---	8.0	13.0	CL	N/A
462+00	2	3' DS of Toe	9.5-10.5	10.0	1.15	2.0	15.4	103.5	1.6	1.6	0.0	---	1.6	1.9	2.6	SP-SC	34
472+00	24	5' US of Toe	1.0-2.0	1.5	0.17	4.0	10.8	107.6	2.5	5.5	3.0	---	---	5.5	8.6	CL	13
472+00	56	CL of Old Dike	14.5-16.0	15.3	1.75	2.0	8.3	100.1	1.9	9.5	7.6	---	9.5	12.6	16.0	CL	13
473+00	TP16	900' US of CL	3.25-4.25	3.8	0.43	4.0	4.7	103.6	1.8	8.0	6.2	---	---	8.0	11.1	CL	N/A
474+00	TP18	360' DS of CL	3.5-4.5	4.0	0.46	4.0	5.7	88.6	1.2	12.0	10.8	---	---	10.8	16.0	CL	N/A
Old Dike Soils																	
260+00	TP32	CL of Old Dike	3.5-4.5	4.0	0.46	4.0	6.0	100.8	2.5	12.5	10.0	---	---	12.5	15.5	SM-SC	N/A
464+00	TP30	CL of Old Dike	3.5-4.0	3.8	0.43	4.0	6.0	115.8	2.0	3.3	1.3	---	---	3.3	5.2	CL	N/A
Embankment																	
355+00	27	CL of Dam	24.5-25.5	25.0	2.88	4.0	4.6	100.6	6.8	8.9	2.1	---	---	8.9	11.6	ML	13
464+00	TP29	CL of Dam	3.5-4.0	3.8	0.43	2.0	4.2	105.1	1.5	9.0	7.5	---	9.0	12.0	15.0	SM	N/A

*Note: US = Upstream
DS = Downstream
CL = Centerline

amec

PROJECT: STRUCTURES ASSESSMENT PHASE II
LOCATION: McMICKEN DAM
SAMPLE SOURCE: SEE BELOW

JOB NO: 0-117-001122
WORK ORDER NO: 3
DATE SAMPLED:

MECHANICAL SIEVE ANALYSIS
GROUP SYMBOL, USCS (ASTM D-2487)

SIEVE SIZES

				Silt or Clay	SAND							GRAVEL								COBBLES		
					Fine			Medium			Coarse		Fine			Coarse						
Location & Depth	USCS	LL	PI	#200	#100	#50	#40	#30	#16	#10	#8	#4	1/4"	3/8"	1/2"	3/4"	1"	1 1/4"	1 1/2"	2"	3"	6"	Lab #

PERCENT PASSING BY WEIGHT

B-15 @ 2.5-3.5'	SC-SM	29	7	32	40	49	54	60	69	76	79	87	90	95	95	100	100	100	100	100	100	100	80
B-15 @ 4.5-5.5'	SM	19	2	34	46	58	63	67	73	77	79	85	88	93	98	100	100	100	100	100	100	100	81
B-16 @ 4.5-5.5'	SC-SM	25	7	46	63	83	87	91	95	97	98	99	100	100	100	100	100	100	100	100	100	100	84
B-16 @ 9.5-10.5	SM	39	11	20	25	34	39	44	54	66	71	85	89	94	94	100	100	100	100	100	100	100	85
B-17 @ 2.5-3.5'	SC-SM	23	6	46	62	79	84	87	92	95	96	98	99	99	100	100	100	100	100	100	100	100	88
B-18 @ 2.5-3.5'	SC	49	23	42	47	53	56	60	67	75	78	87	89	94	98	100	100	100	100	100	100	100	92
B-19 @ 4.5-5.5'	CL	27	8	69	82	91	93	95	97	98	99	99	100	100	100	100	100	100	100	100	100	100	97

amec

PROJECT:	STRUCTURES ASSESSMENT PHASE II	JOB NO:	0-117-001122
LOCATION:	McMICKEN DAM	WORK ORDER NO:	3
MATERIAL:		LAB NO:	SEE BELOW
SAMPLE SOURCE:	SEE BELOW	DATE SAMPLED:	

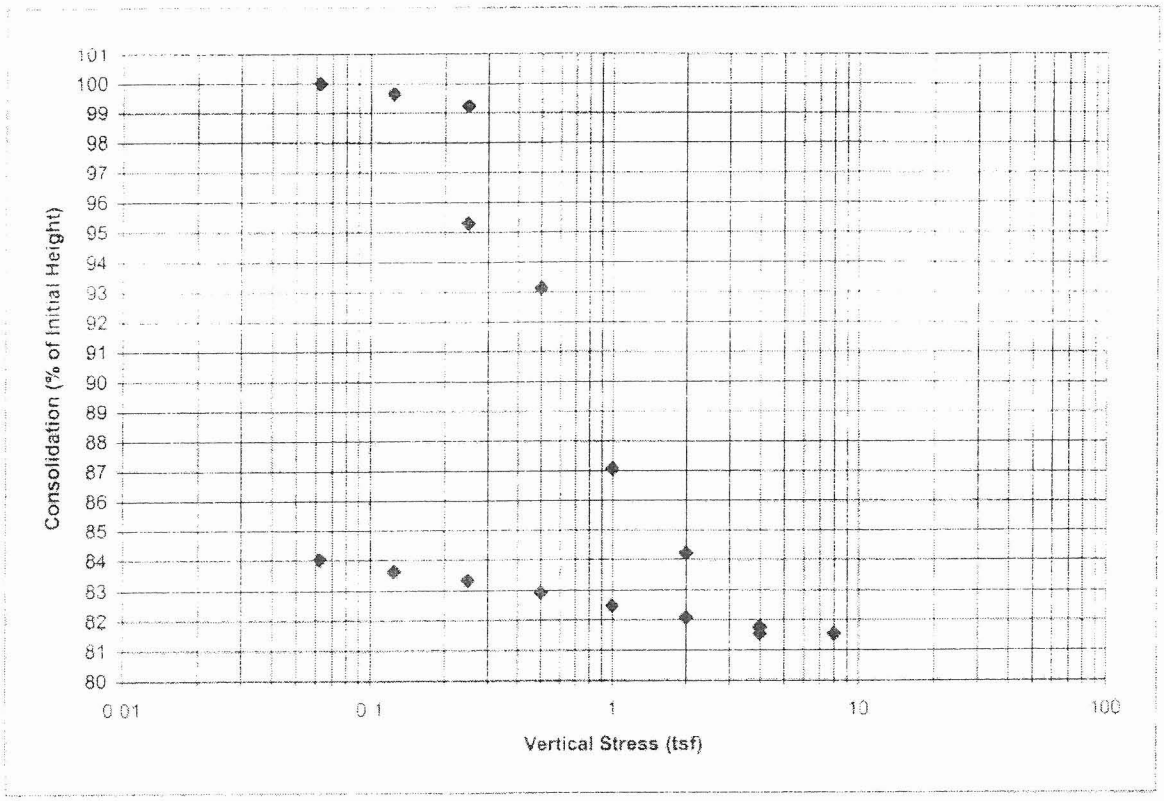
MOISTURE CONTENT OF SOIL (ASTM D2216)

LAB #	BORING	DEPTH RANGE	WET WT. (gram)	DRY WT. (gram)	MOISTURE CONTENT
27	B-1	2.5-3.5'	342.8	335.3	2.2%
31	B-2	2.5-3.5'	269.5	254.4	5.9%
35	B-3	2.5-3.5'	274.9	261.3	5.2%
39	B-4	2.5-3.5'	292.7	281.9	3.8%
42	B-5	4.5-5.5'	241.4	227.0	6.3%
45	B-6	4.5-5.5'	279.3	263.8	5.9%
48	B-7	4.5-5.5'	258.7	241.5	7.1%
51	B-8	2.5-3.5'	297.9	282.7	5.4%
54	B-9	2.5-3.5'	280.1	266.2	5.2%
59	B-10	4.5-5.5'	339.3	326.9	3.8%
62	B-11	2.5-3.5'	274.6	259.2	5.9%
63	B-11	4.5-5.5'	283.6	269.0	5.4%
67	B-12	4.5-5.5'	273.1	260.2	5.0%
71	B-13	4.5-5.5'	270.2	257.2	5.0%
76	B-14	4.5-5.5'	340.4	331.1	2.8%
77	B-14	9.5-10.5'	299.5	279.0	7.3%
80	B-15	2.5-3.5'	305.2	293.7	3.9%
81	B-15	4.5-5.5'	309.6	301.0	2.8%
84	B-16	4.5-5.5'	271.8	258.2	5.3%
85	B-16	9.5-10.5'	322.8	294.7	9.5%
88	B-17	2.5-3.5'	334.3	322.6	3.6%
92	B-18	2.5-3.5'	278.9	259.9	7.3%
97	B-19	4.5-5.5'	297.1	283.2	4.9%

PROJECT:	STRUCTURES ASSESSMENT	JOB NO:	0-117-CC1122
LOCATION:	McMICKEN DAM	WORK ORDER NO:	3
MATERIAL:	SC-SM	LAB NO:	84
SAMPLE SOURCE:	B-16 @ 4.5-5.5'	DATE SAMPLED:	

ONE-DIMENSIONAL CONSOLIDATION PROPERTIES OF SOILS (ASTM D2435)

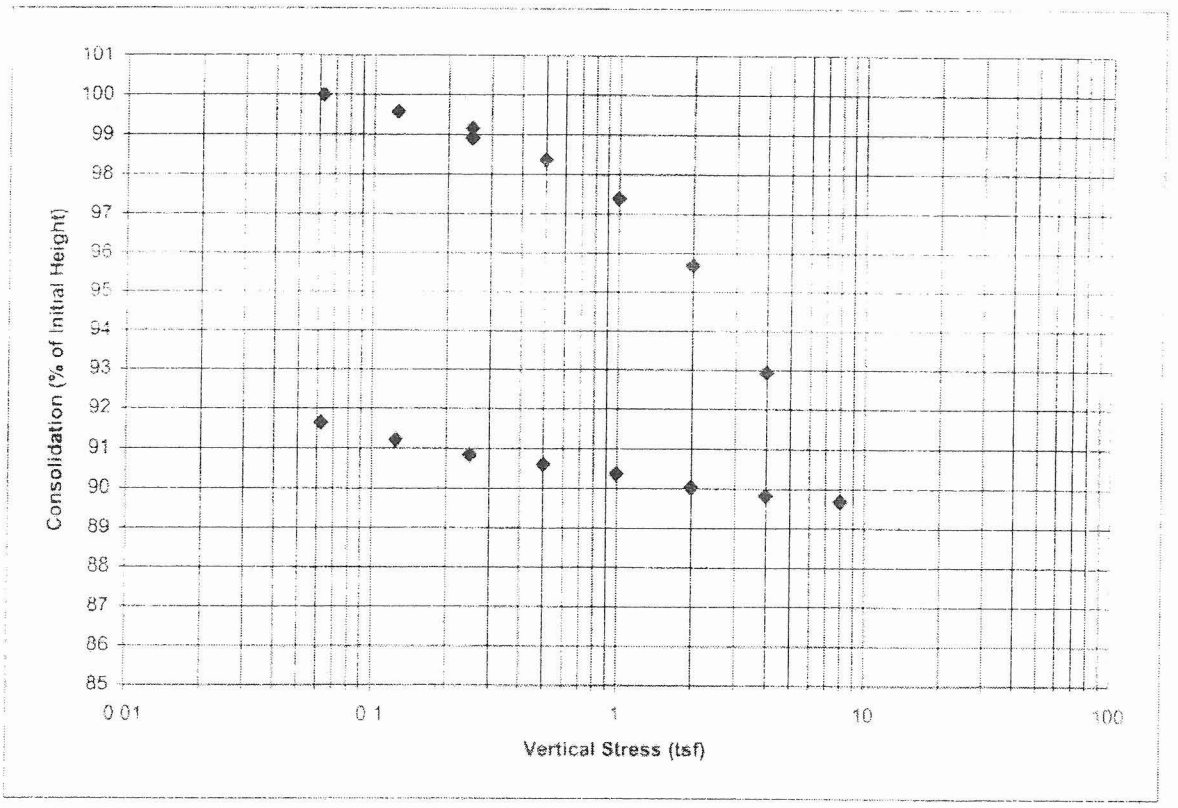
INITIAL VOLUME (cu.in)	4.60	FINAL VOLUME (cu.in)	3.75
INITIAL MOISTURE CONTENT	6.3%	FINAL MOISTURE CONTENT	14.6%
INITIAL DRY DENSITY(pcf)	102.8	FINAL DRY DENSITY(pcf)	125.5
INITIAL VOID RATIO	0.6	FINAL VOID RATIO	0.3
ESTIMATED SPECIFIC GRAVITY	2.651	SATURATED AT	0.25tsf

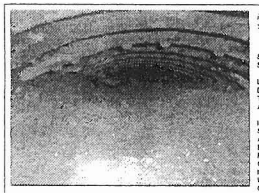


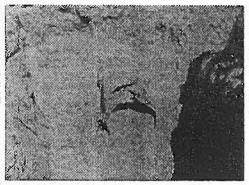
PROJECT:	STRUCTURES ASSESSMENT	JOB NO:	0-117-001122
LOCATION:	McMICKEN DAM	WORK ORDER NO:	3
MATERIAL:	SM	LAB NO:	85
SAMPLE SOURCE:	B-16 @ 9.5-10.5'	DATE :	
SAMPLE PREP:	INSITU		

ONE-DIMENSIONAL CONSOLIDATION PROPERTIES OF SOILS (ASTM D2435)

INITIAL VOLUME (cu.in)	4.60	FINAL VOLUME (cu.in)	4.13
INITIAL MOISTURE CONTENT	10.3%	FINAL MOISTURE CONTENT	18.6%
INITIAL DRY DENSITY(pcf)	103.0	FINAL DRY DENSITY(pcf)	114.4
INITIAL VOID RATIO	0.6	FINAL VOID RATIO	0.4
ESTIMATED SPECIFIC GRAVITY	2.651	SATURATED AT	0.25tsf







ABANDONED STRUCTURE

STRUCTURE NO. 5
STATION 402+66

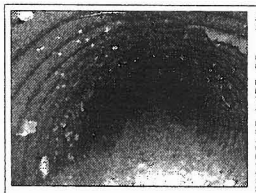
LOCATION OF STRUCTURE DETERMINED THROUGH TRENCHING AND HISTORIC AERIAL PHOTOGRAPHS.

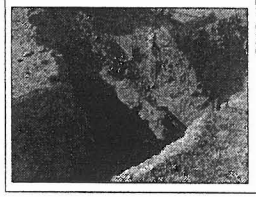
INVERT OF ABANDONED STRUCTURE FOUND APPROXIMATELY 5 FEET BELOW GRADE. END OF PIPE IS COINCIDENT WITH GEOTEXTILE FABRIC INSTALLED DURING 1983. UPPER 6" OF 24" Ø PIPE OPEN.

LIVE SNAKES FOUND AT ABOUT 8 FT. BEYOND OPENING DURING EXCAVATION.

VIDEO INSPECTION DID NOT INDICATE SIGNIFICANT DEGRADATION OF PIPE.

DAMAGE NEAR OPENING OF PIPE LIKELY FROM TIME OF FILTER FABRIC INSTALLATION.





ABANDONED STRUCTURE

STRUCTURE NO. 5
STATION 427+17

LOCATION OF STRUCTURE DETERMINED THROUGH TRENCHING AND HISTORIC AERIAL PHOTOGRAPHS.

INVERT OF ABANDONED STRUCTURE FOUND APPROXIMATELY 5 FEET BELOW GRADE. END OF PIPE IS COINCIDENT WITH GEOTEXTILE FABRIC INSTALLED DURING 1983. PIPE OPEN TO FULL LENGTH, APPROXIMATELY 12'

DAMAGE NEAR OPENING OF PIPE LIKELY FROM TIME OF FILTER FABRIC INSTALLATION.

ABANDONED STRUCTURE

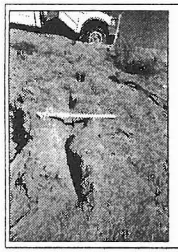
STRUCTURE NO. 4
STATION 440+80

LOCATION OF STRUCTURE DETERMINED THROUGH USE OF GROUND PENETRATION RADAR (GPR) AND HISTORIC AERIAL PHOTOGRAPHS.

INVERT OF ABANDONED STRUCTURE FOUND APPROXIMATELY 4.5 FEET BELOW GRADE. END OF PIPE IS COINCIDENT WITH GEOTEXTILE FABRIC INSTALLED DURING 1983. UPPER 6" OF 24" Ø PIPE OPEN. EVIDENCE OF WATER TRAVEL ON SOIL SURFACE WITHIN PIPE

PIPE APPEARS TO BE IN GOOD CONDITION.

DAMAGE NEAR OPENING OF PIPE LIKELY FROM TIME OF FILTER FABRIC INSTALLATION.



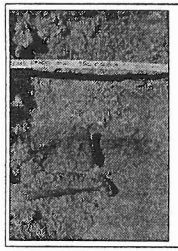
TRANSVERSE CRACK TP-S5

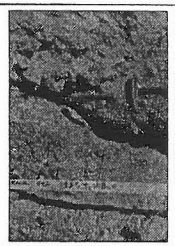
STATION 474+21

SURFICIAL EVIDENCE OF CRACK APPARENT WITH ELONGATED CRACK AND SMALL HOLES UP TO 7" IN DIAMETER. PRIOR TO TRENCHING SOME HOLES COULD BE PROBED UP TO 3.5'.

EXTENT OF CRACK FOUND TO BE APPROXIMATELY 19 FEET IN LENGTH WITH PORTIONS OF THE CRACK ABLE TO BE PROBED TO A DEPTH OF 4.0 FEET. EVIDENCE OF CRACK POSSIBLY CONTINUING THROUGH DAM TO UPSTREAM FACE, IDENTIFIED BY LINEAR SERIES OF HOLES.

BACKFILLING OPERATIONS INCLUDED APPROXIMATELY 25 CU. YD. OF SAND BEING WATER INJECTED UNTIL FILLED.



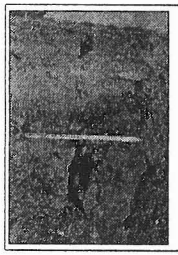


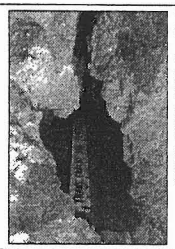
TRANSVERSE CRACK TP-S4

STATION 456+25

SURFICIAL EVIDENCE OF CRACK APPARENT WITH ELONGATED CRACK UP TO 4" WIDE. EXCAVATION UNCOVERED CRACK TO BE A MINIMUM OF 14' IN LENGTH. PRACK PROBED UP TO 4.8'.

EVIDENCE THAT CRACK WAS EXTENSIVE FOUND DURING BACKFILLING OPERATIONS. APPROXIMATELY ½ TO 1 YD OF SAND WAS WATER INJECTED INTO HOLE UNTIL FILLED DURING BACKFILLING OPERATIONS.





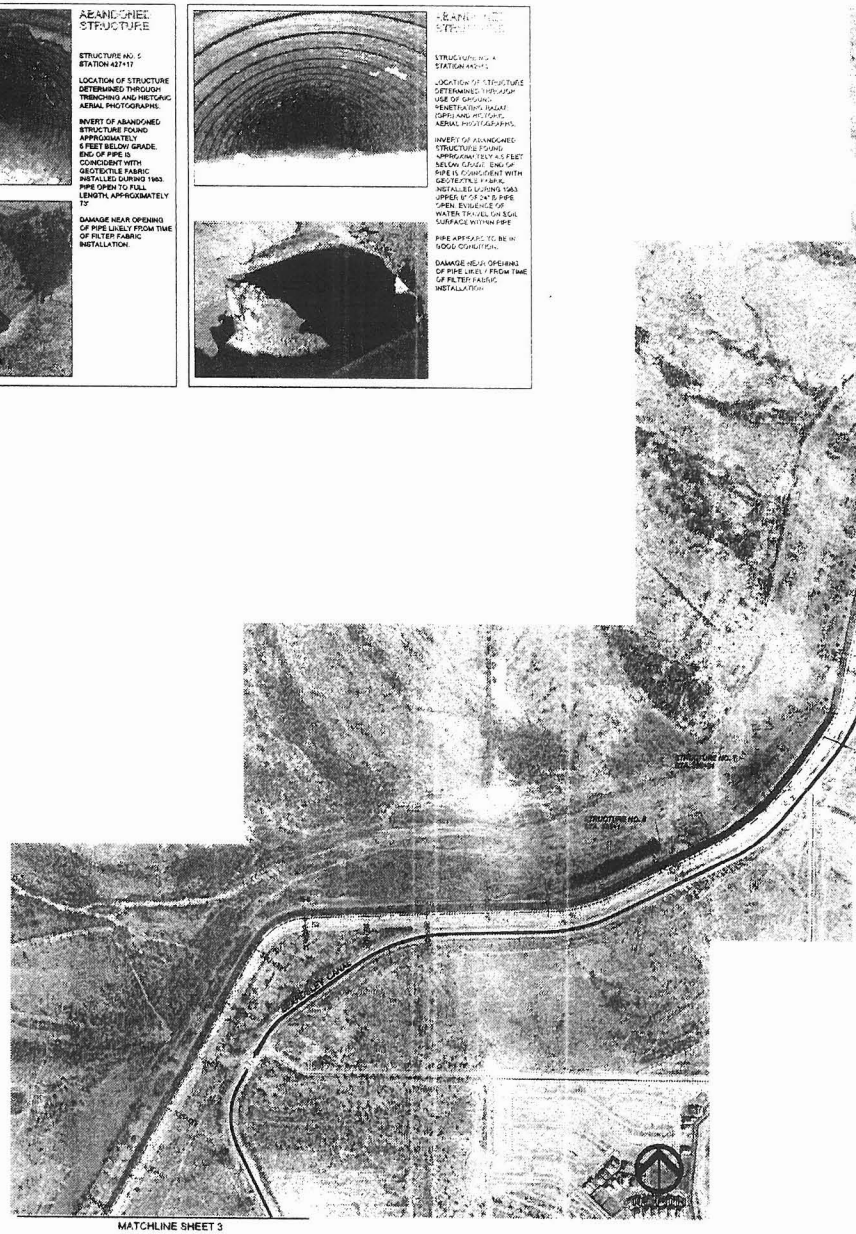
TRANSVERSE CRACK TP-S3

STATION 454+68

SURFICIAL EVIDENCE OF CRACK APPARENT FROM 2.2' BY 1.2' VOID AT SURFACE.

EXCAVATION OF AREA INDICATED A MINIMUM LATERAL EXTENT OF 6'. MAXIMUM DEPTH PROBED WAS 4.2'.

BACKFILLING OPERATIONS INCLUDED WATER INJECTING APPROXIMATELY ½ TO 1 CU. YARD OF SAND.



PLAN VIEW WITH SAMPLING LOCATIONS

SCALE: 1" = 400'

B-2 BORING LOCATION (2001)
BORING LOCATION (1981)
TP-37 TEST PIT (2001)
TEST PIT (1981)
TP-01 - CREST
TP-09 - E. OF MAINT. RD
TP-11 - TOE DRAIN
TP-41 - EMBANKMENT
E-1 EMBANKMENT SAMPLING LOCATIONS (2001)
GPR SURVEY LINE

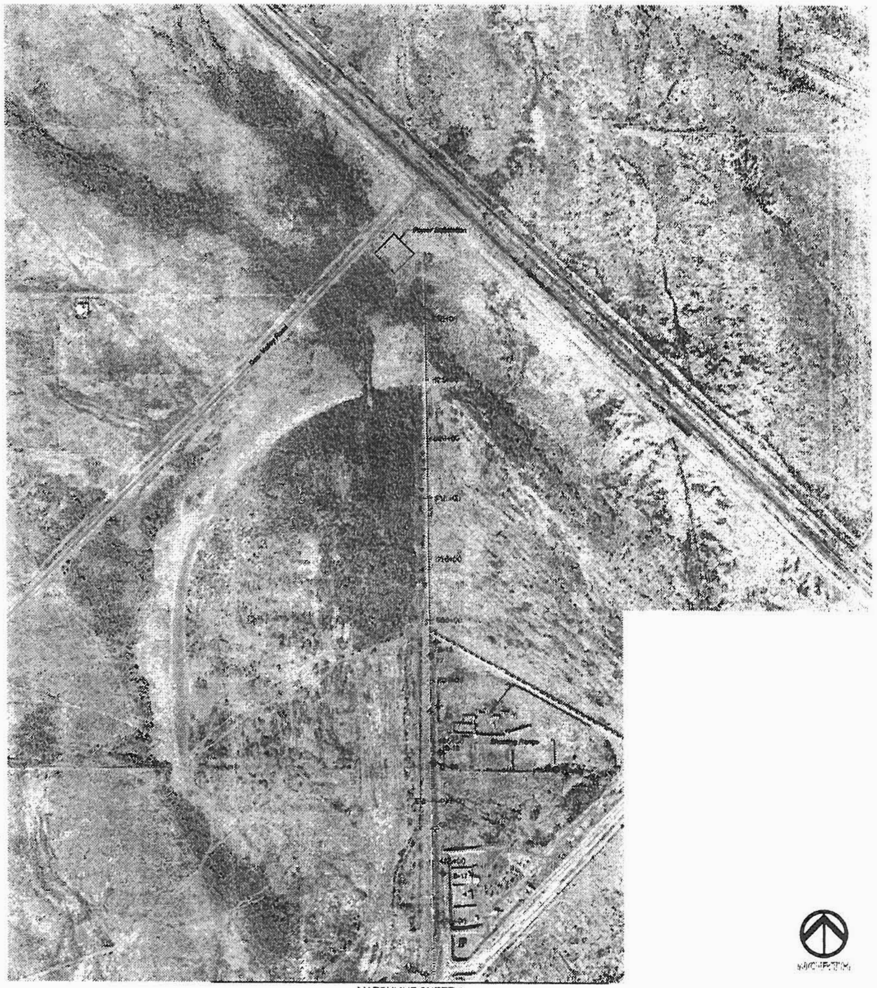
NO.	MADE	CKD.	DATE	NO.	REVISION	MADE	CKD.	DATE	NO.	REVISION	MADE	CKD.	DATE

SCALE	AS SHOWN	JOB NO.	9-117-001122 TASK 1
DESIGNED	LAM	DATE	OCT. 2001
DRAWN	EHS	DATE	
CHECKED	LAM	DATE	
APPROVED		SIGNED	

MCMICKEN DAM GEOTECHNICAL INVESTIGATION
WORK ASSIGNMENT NO. 1
CONTRACT PLD 200000
MARICOPA COUNTY, ARIZONA

SHEET

amec



MATCHLINE SHEET 4

PLAN VIEW WITH SAMPLING LOCATIONS

SCALE: 1" = 400'

BORING LOCATION (2001)

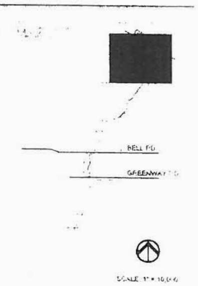
TEST PIT (2001)

TP-C1 - CREST
TP-D1 - E. OF MAINT. RD.
TP-T1 - TOE DRAIN
TP-E1 - EMBANKMENT

EMBANKMENT SAMPLING LOCATIONS (2001)

BORING LOCATION (1981)

TEST PIT (1981)



SCALE: 1" = 10,000'

SCALE	AS SHOWN	JOB NO.	0-117-001122 Task 1
DESIGNED	LAH	DATE	OCT. 2001
DRAWN	EHS/GWH	DATE	
CHECKED	LAH	DATE	
APPROVED		SIGNED	

McMICKEN DAM GEOTECHNICAL INVESTIGATION
WORK ASSIGNMENT NO. 1
CONTRACT FCD 2000C006
MARICOPA COUNTY, ARIZONA

SHEET

amec

DOCUMENT TITLE: McMicken Dam Design Review, Dam Fissure Zone Remediation Project Report (AMEC): dated April, 2003. (CD containing GIS data was included with report)

DATE: February 24, 2003

PREPARED BY: AMEC

PURPOSE:

Review the safety deficiencies previously identified for McMicken Dam. Review of existing data and identified other safety deficiencies that may be present. Develop and present GIS data for the Dam.

SUMMARY:

- The documents reviewed included:
  - URS, 2002, Draft Structures Assessment Report
  - The District, 1999, Draft McMicken Dam Data Book
  - 2002, Topographic Mapping of McMicken Dam and a Portion of the Watershed, 2-foot contour intervals
  - AMEC, 2002a, 2003a,
  - Dames & Moore, 1998, Draft Design Issues Report for White Tanks FRS No. 3
  - URS, 2001a, Design Issues/Basin Alternatives Report for White Tanks FRS No. 3
  - URS, 2001b, 2001c, General Environmental Report and Cultural Resources Inventory for White Tanks FRS No. 3
  - 2002, Structural Survey Data for McMicken Dam
  - USACE, 1954, Hydrology Analysis for McMicken Dam
  - Rumann & Sutko, 1987a, Cruff, 2000, Hydrologic Analyses of McMicken Dam by The District
  - Rumann & Sutko, 1987b, Dam Break Analysis of McMicken Dam by The District
  - Archived Files Maintained by The District

- Two other reports by AMEC were not provided: Soil Erosivity and Development of Procedures for Dam Breach Analysis.

FINDINGS/RESULTS:

- The dam safety deficiencies identified include:
  - Embankment overtopping during Probable Maximum Flow (PMF): Analyses by ADWR indicate that under 'current' conditions, the PMF would result in 0.43 feet of overtopping. Overtopping would result in failure of dam.
  - Earth Fissure Zone at Southern End of Dam (discussed in AMEC 2002a report)
  - North Dike Breaches: dikes north of emergency spillway were identified as unreliable, subsequently repaired.
  - Transverse Cracking of the Embankment as discussed in AMEC 2003a & 2003b
  - The presence of the central filter/drain may mitigate effects of cracking
  - Principal Spillway channel walls have rotated inward by 1.5 inches; may be sufficient to result in formation of transverse cracks adjacent to outlet works.
  - Clay pipes in drain system are broken and collapsed, which could result in higher hydrostatic pressures.
  - CMP Outlets were not constructed with sand diaphragms and some are dysfunctional
  - Video revealed structural damage in two CMPs which may present seepage path through embankment.
  - The Outlet channel at principal outlet may not have adequate capacity which could lead to overtopping of channel
  - South end of the Emergency Spillway Foundation is placed on fill soils that may be more susceptible to erosion than native soils leading to loss of bearing capacity.

CONCLUSIONS AND RECOMMENDATIONS:

- Based on the failure modes and effects analysis (FMEA), the following conclusions and recommendations were offered:

- Seepage and erosion along earth fissures is highest likelihood of occurrence. However, associated failure risk of dam is considered low because discharge resulting from breach was considered low.
- Overtopping of outlet channel high likelihood of occurrence but low consequence.
- Failures due to emergency spillway discharge during large events have moderate likelihood and high consequence.
- Failure modes associated with CMPs and internal erosion along non-fissure related cracks has moderate likelihood and moderate consequence.
- Data does not indicate a fissure zone in North Study Area so low risk of failure along fissures in this area.

- High hazard zone is near 56+00 and 75+00, also extends upstream of dam to north and west.
- Clear vegetation at emergency spillway inlet, and extend the length of spillway from 2000 feet to 5000 feet.
- Establish a monitoring program for channel wall rotations.

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McMicken Dam Design Review
McMicken Dam Fissure Risk Zone
Remediation Project
Contract FCD 2002C011
Work Assignment No. 1

Submitted to:

Flood Control District of Maricopa County
Phoenix, Arizona

Registered Professional Engineer (Civil)
CERTIFICATE NO.
22884
CHARLES V.
GOPPERTON
Date Signed 2/24/03
ARIZONA, U.S.A.

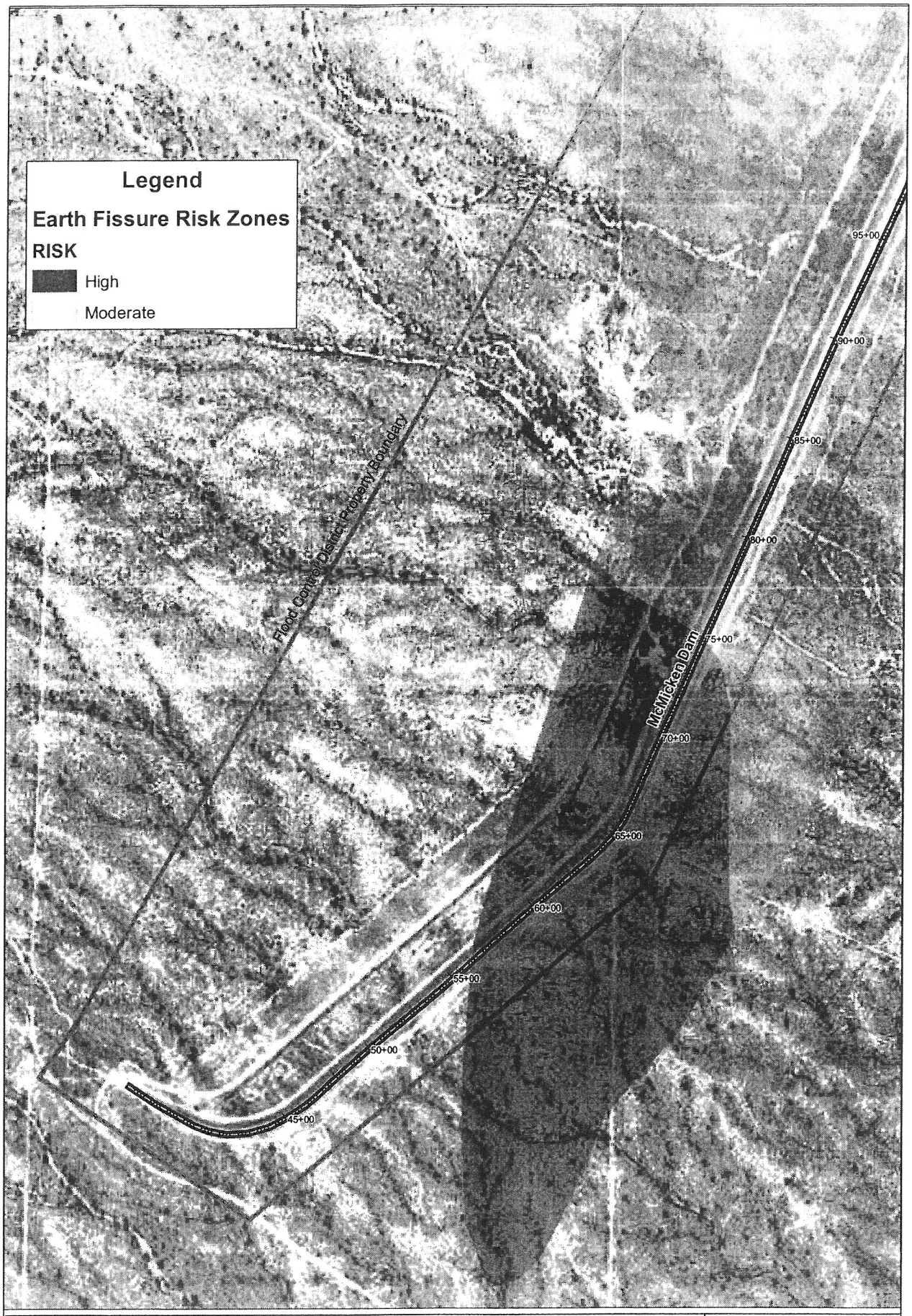
Registered Professional Engineer (Civil)
CERTIFICATE NO.
19872
LAWRENCE A.
HANSEN
Date Signed 2/24/03
ARIZONA, U.S.A.

Submitted by:

AMEC Earth & Environmental, Inc.
Phoenix, Arizona

24 February 2003

AMEC Job No. 2-117-001066



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DESIGN:	LAH
DRAWN:	EMP
DATE:	1/27/03
SCALE:	1"=400'

McMicken Dam Design Review
Work Assignment No. 1 Contract FCD 2002C011
Maricopa County, Arizona

South Study Area
Earth Fissure Risk Zones

FIGURE
1

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JOB NO.:	2-117-001066
DESIGN:	REW
DRAWN:	EMP
DATE:	1/21/03
SCALE:	1" = 500'

McMicken Dam Design Review
Work Assignment No. 1 Contract FCD 2002C011
Maricopa County, Arizona

NORTH STUDY AREA
PHOTOGEOLOGIC INTERPRETATION

FIGURE
2

amec

DOCUMENT TITLE: Earth Fissure Investigation report

DATE: April 11, 2003

PREPARED BY: AMEC

PURPOSE:

Report presents findings of investigation which detected and characterized distribution and nature of fissures in the southern-most six mile of McMicken Dam.

SUMMARY:

- Earlier studies (SHB, 1982) detected fissures approximately 600 feet east of 63+50. Fissures are a result of horizontal strains in alluvial basin sediments induced by large-scale ground subsidence. Subsidence results from lowering of the static groundwater table.
- Main fissures are located at Fenne Knoll.
- Fissures are associated with nearby protrusions of competent bedrock extending through thin mantle of unconsolidated sediments.
- Study of remote sensing indicated that subsidence leading to risk of fissures exists near 290+00 (North Study Area).
- Report focused on three study areas: Regional (entire alignment of dam), South Study Area (southern terminus to 120+00), and North Study Area (270+00 to 310+00) with most of the investigative tasks being performed in the South Study Zone
- Surface in Southern Study Zone contains multiple ephemeral arroyos draining to southeast at 65-90 feet/mile
- Investigative approach utilized the following techniques:
    - Review of existing data
    - Aerial Photo Review
    - Low-Sun-Angle Photography
    - Synthetic-Aperture Radar Interferometry (InSAR)
    - Ground Reconnaissance

- Ten test pits excavated on downstream side of dam near 54+00 to 63+00 up to nine feet deep and up to 76 feet long to investigate fissures.
- 93 seismic refraction surveys completed from 49+00 t 115+00.
- Seven test trenches located in the detention basin excavated 90 to 220 feet long and up to 10 feet deep, used to investigate the anomalies revealed during seismic lines and In-SAR.
- Relative gravity surveys were performed to support subsurface geometry characterization. Performed in North (64) and South (217) Study Areas.
- Deep resistivity soundings performed, four in South, two in North Study Areas.
- Nine Refraction Micro-Tremor (ReMi) Shear Wave Seismic Surveys performed in North (2) and South (7) Study Areas.

- Geological setting
  - 15 mi^3 salt body beneath Luke AFB extending from 5500 feet to 9000 feet bgs.
  - Gravity data suggests buried bedrock shelf beneath alluvial fan directly east of WTMs. Result is a rapid deepening of basin fill thickness northward and up-station along alignment. Relatively shallow bedrock beneath alluvial fan and upstream of southern one-third of dam also indicated by presence of inselbergs (Fenne Knoll) protruding through alluvial cover.

- Geohydrological characteristics
  - Over 350 wells present in study area
  - Average rate of decline of static groundwater table is 4.5 ft/year occurring mostly before mid-60s
  - Subsidence due to dewatering controlled by particle-size distribution of sediments. Fine-grained sediments in basin 1.5 miles east of southern dam to a depth of 600 feet bgs, area is offset by one mile east of measured subsidence.

FINDINGS/RESULTS:

- Ground subsidence due to groundwater withdrawal

- Subsidence at Luke AFB has been measured up to 15 feet or more. Up to seven feet in Paradise Valley with fissure.
- National Geodetic Survey elevation data taken along Beardsley Canal collected in 1947-48, 1967, and 1981. McMicken dam surveyed in 1955, 1981, 1985, 1998, and 2001. InSAR study shows relative elevation changes of study area from 12/96 to 12/99.
- National Geodetic Survey monuments along Beardsley Canal (one-mile intervals) indicate two to three feet total subsidence from 1947 to 1981 from Camelback Road to Olive Avenue; and three to four feet from Peoria Avenue to Bell Road.
- McMicken Dam crest settled 2.5 to 4 feet from 1955 to 1982 from Cactus Road to Bell Road, typically 3 to 3.5 feet.
- Three National Geodetic Survey monuments resurveyed in 2002 showed less than one foot settlement from 1981 to 2002.
- Subsidence rates from 1947 to 1967 up to 3 cm/yr. Decreased to approx 1.3 cm/yr from 1967 to 1981. Decreased to less than one cm/yr after 1981, in some locations, subsidence ceased.
- Subsidence data only presented at stationing up to 240+00.
- Correlation between falling ground water levels and subsidence highlighted. Greatest subsidence between 1940 & 1982 correlated to greatest pumping rates.
- Larger subsidence in areas near Glendale Avenue & Peoria Avenue does not appear to be related to pumping wells.
- SHB, 1982 report summarizes methods employed to search for fissures.
- 20-foot vertical discontinuities found in Fenne Knoll fissures (20 foot deep by 1/4- to 1/2-inch wide fissures).
- Discordant drainages (to alluvial pattern) may indicate prehistoric fissure patterns.
- Vegetation lineaments appear to be related to configuration of subsidence and resulting fissures. Fissures enhance root penetration providing favorable sites for vegetation.
- Correlated with test pits, seismic refraction study was able to locate lateral discontinuities (fissures) with reasonable accuracy.
- Fissures are more well defined in soils with higher degree of cementation (and finer grained) and less defined in uncemented sand and gravel.

- Gravity surveys indicate a sharp drop off of the bedrock depth (to over 1,000 feet bgs) at approximately 2,000 feet east of southern extent of dam
- ReMi (shear wave profiling) data characterizes soil profile.
- Resistivity soundings indicated presence of clayey soils well above GWT and depths to bedrock.
- North study area bedrock is well over 1000 feet bgs and gently slopes. No definitive support for development of conceptual geologic subsidence model for this area.
- The approximate limits of the earth fissuring hazard and risk zones are:
    - 40+00 to 56+00: low hazard
    - 56+00 to 75+00: high hazard
    - 75+00 to 105+00: moderate hazard
    - 105+00 to 125+00 low hazard
- Due to limited nature of investigation in North Study Area, it is recommended that area between 275+00 and 285+00 receive special consideration during future surveillance, monitoring, and characterization program.
- Lack of shallow, variable depth to bedrock zones and distinct linear contrasts in the rate of subsidence indicates that this area (North Study Area) is not comparable to moderate hazard zone at 75+00 and 105+00.

CONCLUSIONS AND RECOMMENDATIONS:

- It is unlikely that earth fissures detected upstream of embankment currently pose a risk of piping failure of the embankment during periods of floodwater detention. If further horizontal strains experienced, fissures will likely widen and create future hazard to safe operation of dam. Additional strains at 56+00 to 105+00 will cause new fissures to develop.
- Several alternatives of monitoring methods/programs are recommended.
- Further investigation of Northern Study Area is recommended.
- Shallow, relatively high permeability foundation soils should be investigated prior to designing modifications to prevent piping (due to fissures).

- Recommended to establish zone of no further development for region within 1,500 to 2,000 feet of dam south of 115+00.

- Subsidence radiates out from high capacity pumps for distance of 3/4- to one-mile. It is recommended to limit future citing of large-capacity wells within earth fissure risk zone.

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Earth Fissure Investigation Report
McMicken Dam
Work Assignment Nos. 4 & 5
Contract FCD 2000C006
Maricopa County, Arizona

Submitted to:

Flood Control District of Maricopa County
Maricopa County, Arizona

REGISTERED GEOLOGIST
CERTIFICATE NO.
16939
RALPH S.
WEEKS
Date Signed 7/11/03
ARIZONA U.S.A.

Submitted by:

AMEC Earth & Environmental, Inc.
Phoenix, Arizona

11 April, 2003

AMEC Job No. 0-117-001122

Figure 8 - Subsidence Data for 1947 to 2002

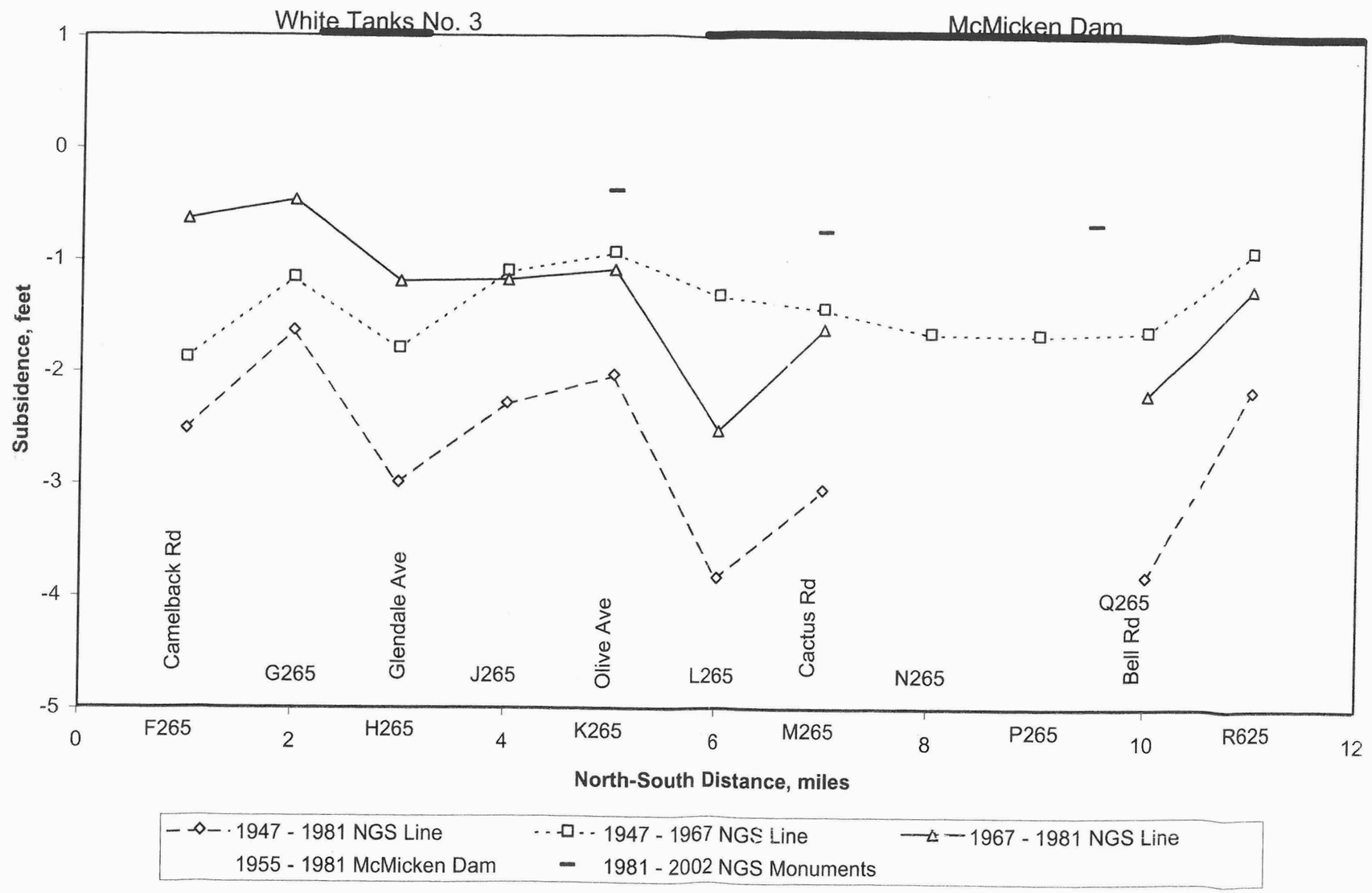
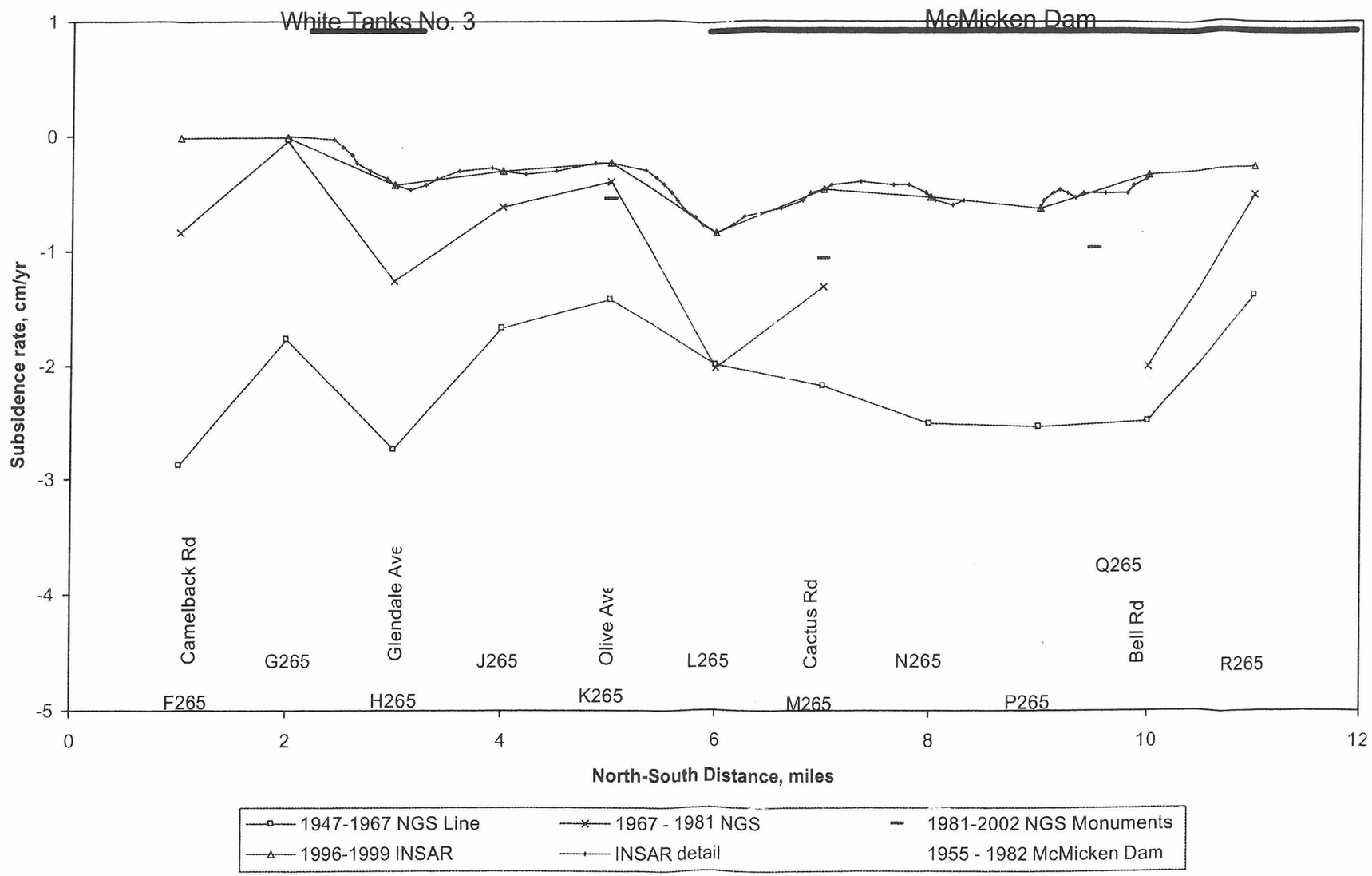
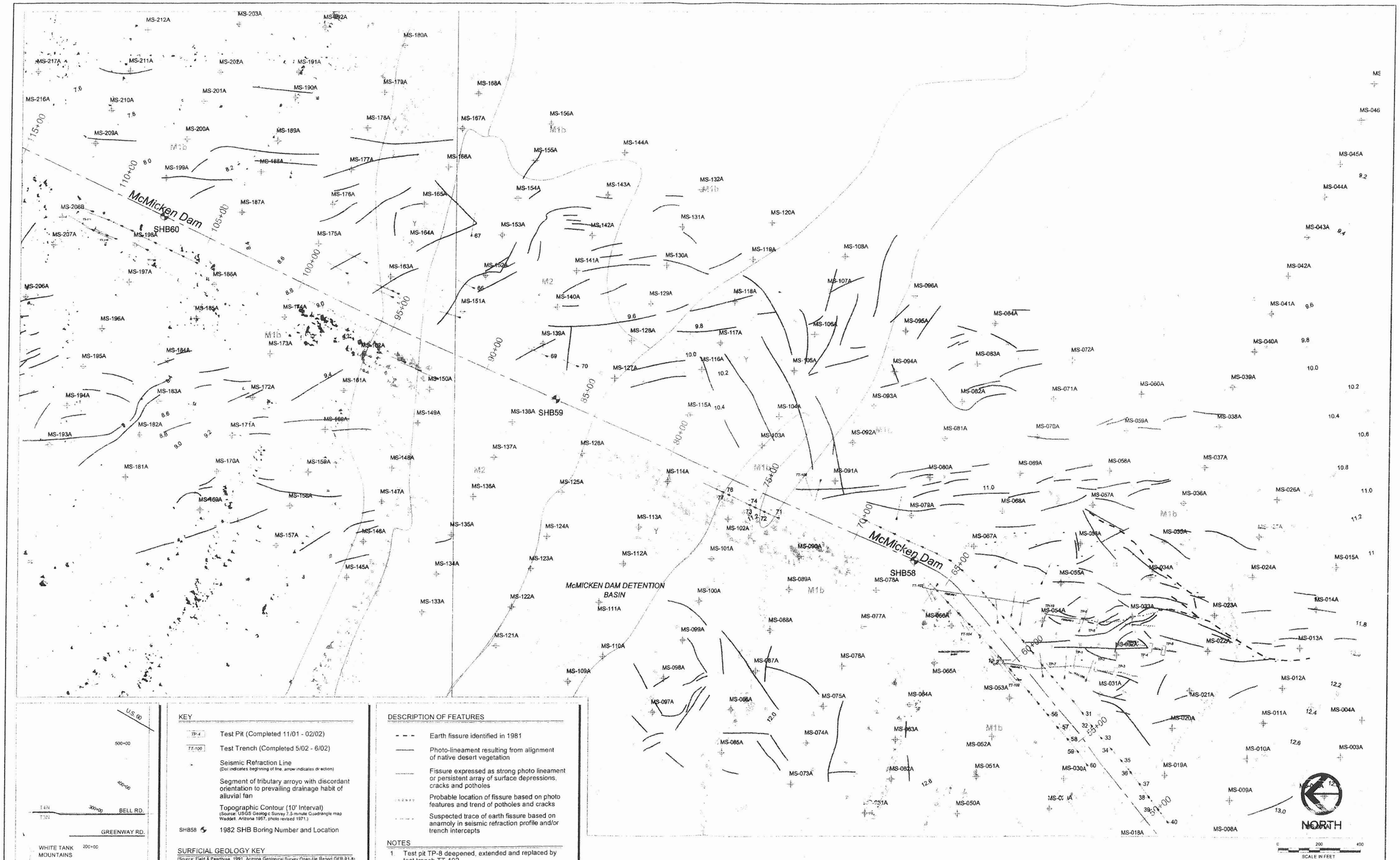
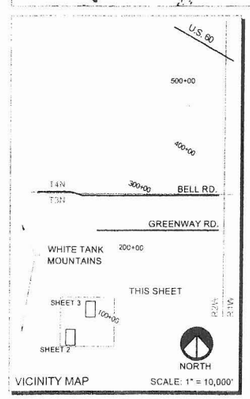


Figure 9 - Annual Subsidence Rates







KEY

- TP-4 — Test Pit (Completed 11/01 - 02/02)
- TT-100 — Test Trench (Completed 5/02 - 6/02)
- Seismic Refraction Line (Dot indicates beginning of line, arrow indicates direction)
- Segment of tributary arroyo with discordant orientation to prevailing drainage habit of alluvial fan
- Topographic Contour (10' Interval) (Source: USGS Geologic Survey 7.5-minute Quadrangle map Waddell, Arizona 1957, photo revised 1971.)
- SHB58 — 1982 SHB Boring Number and Location

SURFICIAL GEOLOGY KEY
(Source: Field & Pearthree, 1991, Arizona Geological Survey Open-file Report OFR 91-8)

- Undifferentiated Holocene Alluvial Deposits
- Latest to Late Pleistocene Alluvial Deposits
- Middle to Late Pleistocene Alluvial Deposits

Aerial photography performed by Landata Airborne Systems December 16, 17, 2000.

DESCRIPTION OF FEATURES

- Earth fissure identified in 1981
- Photo-lineament resulting from alignment of native desert vegetation
- Fissure expressed as strong photo lineament or persistent array of surface depressions, cracks and potholes
- Probable location of fissure based on photo features and trend of potholes and cracks
- Suspected trace of earth fissure based on anamoly in seismic refraction profile and/or trench intercepts

NOTES

1. Test pit TP-8 deepened, extended and replaced by test trench TT-102
2. Test trench designations TT-101, TT-105, TT-106 & TT-107 not used. (Total of seven test trenches and nine test pits completed)

SCALE:	1" = 200'	JOB NO.:	0-117-001122
DESIGNED:	R. WEEKS	DATE:	SEPT 2002
DRAWN:	E. SKULSTAD	DATE:	SEPT 2002
CHECKED:	R. WEEKS	DATE:	SEPT 2002
APPROVED:	L. HANSEN	SIGNED:	SEPT 2002

EARTH FISSURE INVESTIGATION
McMICKEN DAM
STRUCTURES ASSESSMENT/PHASE II
FLOOD CONTROL DISTRICT OF MARICOPA COUNTY
FCD CONTRACT NO. 2000C006

SITE PLAN SHOWING LINEAMENTS, FISSURES, SEISMIC REFRACTION SURVEYS, TEST PITS & TEST TRENCHES (STA. 49+00 TO 115+00)

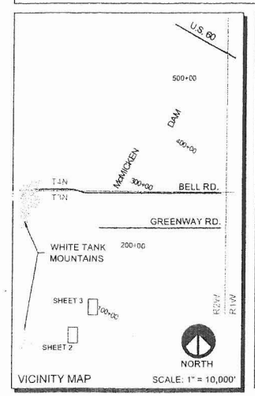
SHEET 1

amec

MS-091A
MS-080A
MS-069A
MS-058A
TT-108
11.0
MS-057A
MS-068A
MS-079A
MS-067A
MS-056A
MS-035A
MS-090A
MS-034A
SHB58
MS-055A
MS-089A
MS-078A
TT-103
FISSURE 4
TP-10
MS-054A
TP-9
MS-033A
MS-077A
MS-066A
FISSURE 3
TT-104
FISSURE 2
MS-032A
TP-5
McMICKEN DAM DETENTION BASIN
MS-076A
TP-1
TP-2
TP-4
12.2
FISSURE 1
TP-7
TP-3
NULL LINE
MS-031A
MS-053A
TT-102
L-1

70+00
65+00
60+00

SCALE IN FEET: 0 60 120



VICINITY MAP SCALE: 1" = 10,000'

KEY

- TP-4 — Test Pit (Completed 11/01 - 02/02)
- TT-100 — Test Trench (Completed 5/02 - 6/02)
- Seismic Refraction Line (Dot indicates beginning of line, arrow indicates direction)
- Segment of tributary arroyo with discordant orientation to prevailing drainage habit of alluvial fan
- Location of Seismic Refraction Anamoly
- Significant Ground Surface Depression

NOTES

1. Test pit TP-8 deepened, extended and replaced by test trench TT-102
2. See Sheet 3 for locations of test trenches TT-109, TT-110 & TT-111
3. Test trench designations TT-101, TT-105, TT-106 & TT-107 not used.
   (Total of seven test trenches and nine test pits completed)

Aerial photography performed by Landata Airborne Systems December 16 17 2000.

DESCRIPTION OF FEATURES

- Earth fissure Identified in 1981
- Photo-lineament resulting from alignment of native desert vegetation
- Fissure expressed as strong photo lineament or persistent array of surface depressions, cracks and potholes
- Probable location of fissure based on photo features and trend of potholes and cracks
- Suspected trace of earth fissure based on anamoly in seismic refraction profile and/or trench intercepts
- Discontinuity in cemented desert soils found in test trench
- Earth fissure found in test trench or pit

SCALE:	1" = 60'	JOB NO.:	0-117-001122
DESIGNED:	R. WEEKS	DATE:	SEPT 2002
DRAWN:	E. SKULSTAD	DATE:	SEPT 2002
CHECKED:	R. WEEKS	DATE:	SEPT 2002
APPROVED:	L. HANSEN	SIGNED:	SEPT 2002

EARTH FISSURE INVESTIGATION
McMICKEN DAM
STRUCTURES ASSESSMENT/PHASE II
FLOOD CONTROL DISTRICT OF MARICOPA COUNTY
FCD CONTRACT NO. 2000C006

SITE PLAN SHOWING LINEAMENTS, FISSURES, SEISMIC REFRACTION SURVEYS, TEST PITS & TEST TRENCHES (STA. 57+00 TO 74+00)

SHEET 2

amec

MS-199A

8.2

MS-187A

MS-176A

MS-165A

MS-208B

TT-111

SHB60

MS-198A

-207A

TT-110

MS-175A

MS-164A

8.4

8.6

TT-109

MS-163A

MS-197A

MS-186A

8.8

MS-185A

L-2

MS-174A

9.0

MS-196A

9.2

MS-173A

MS-168A

MS-184A

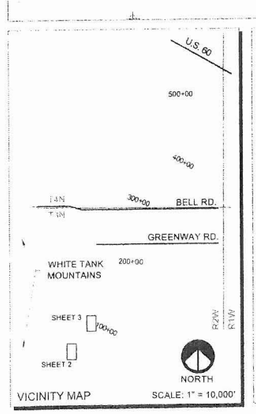
MS-195A

9.4

MS-161A

MS-150A

MS-172A



VICINITY MAP SCALE: 1" = 10,000'

KEY

- TP-4 — Test Pit (Completed 11/01 - 02/02)
- TT-100 — Test Trench (Completed 5/02 - 6/02)
- Seismic Refraction Line (Dot indicates beginning of line, arrow indicates direction)
- Segment of tributary arroyo with discordant orientation to prevailing drainage habit of alluvial fan
- Location of Seismic Refraction Anamoly
- Significant Ground Surface Depression

NOTES

1. Test pit TP-8 deepened, extended and replaced by test trench TT-102
2. See Sheet 3 for locations of test trenches TT-109, TT-110 & TT-111
3. Test trench designations TT-101, TT-105, TT-106 & TT-107 not used. (Total of seven test trenches and nine test pits completed)

Aerial photography performed by Landata Airborne Systems December 16 17, 2000.

DESCRIPTION OF FEATURES

- Earth fissure Identified in 1981
- Photo-lineament resulting from alignment of native desert vegetation
- Fissure expressed as strong photo lineament or persistent array of surface depressions, cracks and potholes
- Probable location of fissure based on photo features and trend of potholes and cracks
- Suspected trace of earth fissure based on anamoly in seismic refraction profile and/or trench intercepts
- Discontinuity in cemented desert soils found in test trench
- Earth fissure found in test trench or pit

0 60 120
SCALE IN FEET

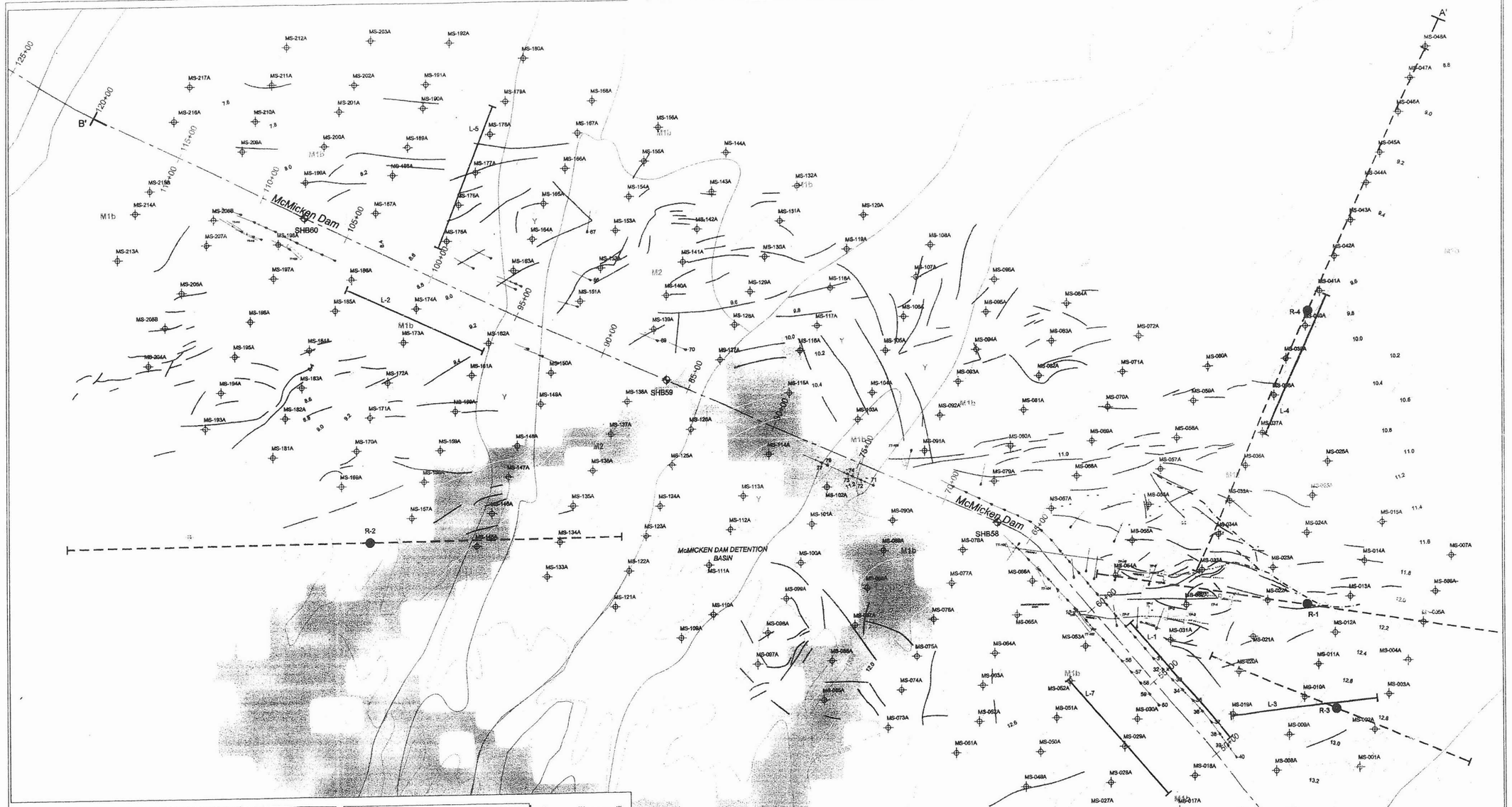
SCALE:	1" = 60'	JOB NO.	0-117-001122
DESIGNED:	R. WEEKS	DATE:	SEPT 2002
DRAWN:	E. SKULSTAD	DATE:	SEPT 2002
CHECKED:	R. WEEKS	DATE:	SEPT 2002
APPROVED:	L. HANSEN	SIGNED:	SEPT 2002

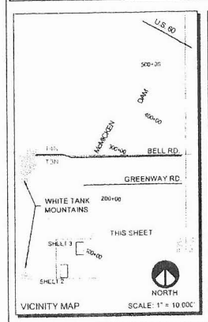
EARTH FISSURE INVESTIGATION
McMICKEN DAM
STRUCTURES ASSESSMENT/PHASE II
FLOOD CONTROL DISTRICT OF MARICOPA COUNTY
FCD CONTRACT NO. 2000C006

SITE PLAN SHOWING LINEAMENTS, FISSURES, SEISMIC REFRACTION SURVEYS, TEST PITS & TEST TRENCHES (STA. 91+00 TO 113+00)

SHEET 3

amec





VICINITY MAP

SCALE 1" = 10.00'

KEY

- TP-4 Test Pit (Completed 11/01 - 02/02)
- TT-102 Test Trench (Completed 5/02 - 6/02)
- Seismic Refraction Line (Dot indicates Beginning of Line. Arrow indicates Direction)
- Segment of tributary arroyo with discordant orientation to prevailing drainage habit of alluvial fan
- Topographic Contour (10' Interval) (Source: USGS Geologic Survey 7.5 minute Quadrangle map Wickiup, Arizona 1957 photo revised 1971)
- Seismic Remi Profile
- Resistivity Profile
- A — A' Geologic Profile End Points

SURFICIAL GEOLOGY KEY

(Source: Field & Pearlstine 1991, Arizona Geological Survey open file report OF-91-8)

- Undifferentiated Holocene Alluvial Deposits
- Latest to Late Pleistocene Alluvial Deposits
- Middle to Late Pleistocene Alluvial Deposits

Aerial photography performed by Landata Arizona Systems December 16, 17, 2000.

DESCRIPTION OF FEATURES

- Earth fissure Identified in 1981
- Photo-lineament resulting from alignment of native desert vegetation
- Fissure expressed as strong photo lineament or persistent array of surface depressions, cracks and potholes
- Probable location of fissure based on photo features and trend of potholes and cracks
- Suspected trace of earth fissure based on anamoly in seismic refraction profile and/or trench intercepts
- Gravity Station Number and Location
- Residual Gravity Anamoly Contour (milligal)

NOTES

1. Test pit TP-8 deepened, extended and replaced by test trench TT-102.
2. Test trench designations TT-101, TT-105, TT-106 & TT-107 not used.

(Total of seven test trenches and one test pit completed)

0 200 400
SCALE IN FEET

INTERFEROGRAM
FILE: 20100 166/001 .Y
FOR DATE INTERFEROGRAM 01/08/96 - 5/18/02

INTERFEROGRAMS PRODUCED BY
DR. SEAN EUCKELY
CENTER FOR SPACE RESEARCH
UNIVERSITY OF TEXAS, AUSTIN
FOR THE ARIZONA DEPARTMENT OF WATER RESOURCES

NO.	REVISION	MADE	CKD.	DATE	NO.	REVISION	MADE	CKD.	DATE	NO.	REVISION	MADE	CKD.	DATE	DWG. NO.	REFERENCES

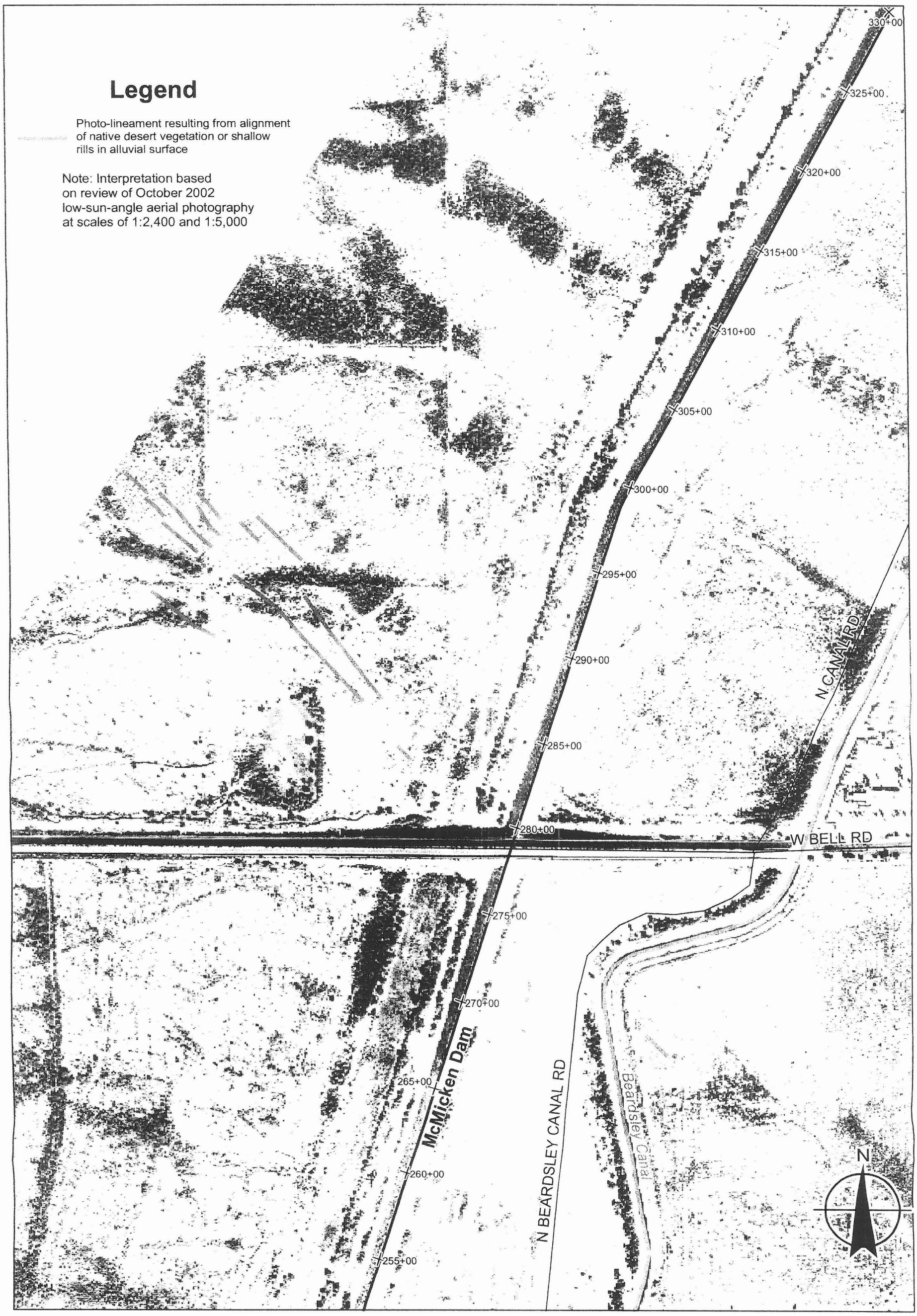
SCALE	1" = 200	JOB NO.	0 117 00122
DESIGNED	R. WEEKS	DATE	SEPT 2002
DRAWN	G. HUNTER	DATE	SEPT 2002
CHECKED	R. WEEKS	DATE	SEPT 2002
APPROVED	L. HANSEN	SIGNED	SEPT 2002

EARTH FISSURE INVESTIGATION
McMICKEN DAM
STRUCTURES ASSESSMENT/PHASE II
FLOOD CONTROL DISTRICT OF MARICOPA COUNTY
FCD CONTRACT NO. 2000C006

SITE PLAN SHOWING LINEAMENTS, FISSURES, INVESTIGATIVE LOCATIONS & INTERFEROMETRIC COVERAGE WITH RESIDUAL GRAVITY CONTOUR (STA. 41+50 TO 115+50)

SHEET 4

amec



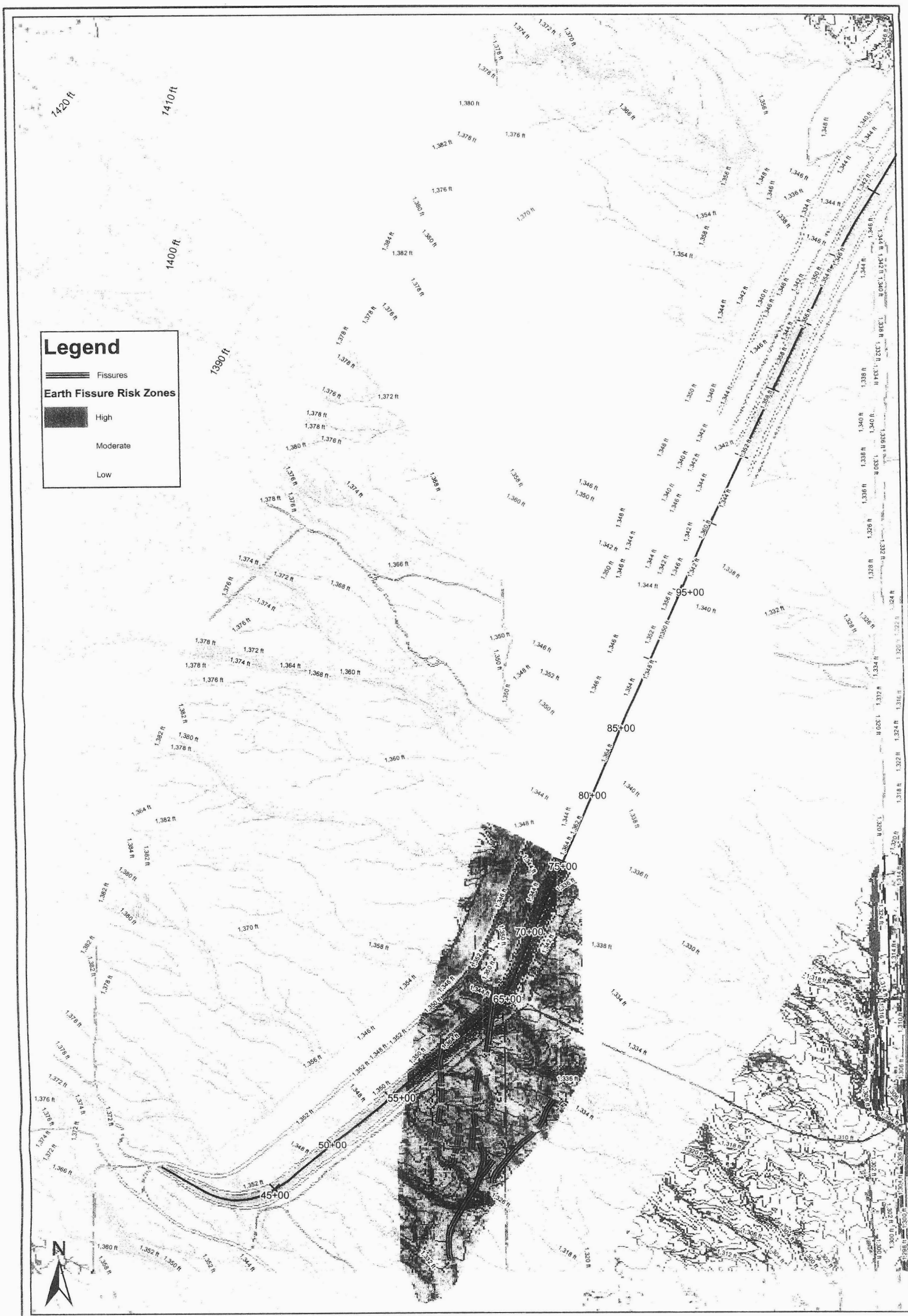
JOB NO.:	2-117-001066
DESIGN:	REW
DRAWN:	EMP
DATE:	1/21/03
SCALE:	1" = 500'

Supplemental Earth Fissure Investigation
Work Assignment No. 5 Contract FCD 2000C006
Maricopa County, Arizona

PHOTOGEOLOGIC INTERPRETATION OF NORTH STUDY AREA

FIGURE **26**

amec



JOB NO.:	0-117-001122
DESIGN:	REW
DRAWN:	EMP
DATE:	12/19/02
SCALE:	1 " = 600 '

Supplemental Earth Fissure Investigation - McMicken Dam
Work Assignment Nos. 4 & 5 Contract FCD 2000C006
Maricopa County, Arizona

Earth Fissure Risk Zones

FIGURE **29**

amec

DOCUMENT TITLE: Geological Input to Structures Assessment Reports (Revision 3)

DATE OF REPORT: June 4, 2003

PREPARED BY: Geological Consultants, Inc.

PURPOSE:

To provide geological input to URS for the McMicken Dam structures assessment report.

SUMMARY:

- McMicken Dam is located within the Sonoran Desert section of the Basin and Range Physiographic Province.
- GCI described the Basin and Range Province to be characterized by northwest, north, and northeast trending mountains, which rise abruptly to form broad, elongated, deep, sediment-filled valleys produced by block faulting and folding.
- The dam is located approximately three miles east of the northern White Tank Mountains. These mountains are composed of old, Pre-Cambrian age metamorphic and granitic crystalline bedrock, intruded by younger dikes. The bedrock is reported to be locally overlain by Tertiary volcanic rock and Quaternary alluvium.
- The McMicken Dam study area is situated at the western margin of a broad alluvium-filled valley known as the West Salt River Valley Basin.
- The alluvial deposits range in depth from a few feet near the mountains to more than 1,200 feet in the majority of the basin. The estimated thickness of the deposits at the dam ranges from 400 feet to over 1,600 feet thick. Alluvial thickness increase to the north along the dam.
- The basin fill within the valley commonly makes up the principal groundwater aquifer of the region.
- The surface geology of the dam area is dominated by three alluvial fan units that range in age from Holocene to middle to late Pleistocene. The three alluvial units, as described by Field and Pearthree, are:
    - Older Middle Alluvium: These are composed of poorly sorted, angular to subangular silt, sand and gravel. The surfaces are moderately dissected. A well developed cobble to pebble desert pavement is generally found over the surface. The underlying soils are

characterized by moderate to very strongly developed clay horizons overlying a well developed (Stage IV) caliche horizon.

- Younger Middle Alluvium: These are the late Pleistocene deposits which are also poorly sorted, angular to subangular admixtures of silt, sand, and gravel. The surfaces are moderately dissected. A poorly to moderately developed cobble to granule desert pavement is found over at least half or more of the surfaces. Underlying soils are typically poorly sorted, indurated clayey silty sand on top of a poorly to moderately developed (Stage I & II) caliche horizon.

- Young Alluvium: These deposits are composed of loose, poorly sorted admixtures of silt, sand, and gravel. The fragments are coarse-grained and angular to subangular except on the lower piedmont where the deposits are typically fine sand and silt. The soil on the surfaces are poorly developed because they are commonly confined to arroyos and drainage ways. These deposits are also subject to occasional and frequent flooding.

- The basin stratigraphy of the area is comprised of three distinct alluvial units. These three alluvial units that underlie the study area are:

  - Upper Alluvial Unit: This unit is composed of gravel and sand with lesser amounts of silt and clay. The deposits are mostly unconsolidated with locally strong cementation near the mountain fronts and stream courses (SGC, 2000).

  - Middle Alluvial Unit: This unit is composed of silt, and clay with thin interbeds of silty sand and gravel. The deposits are mostly weakly consolidated, but moderately to well-cemented. Grades to fine-grained mudstone and evaporite deposits in the center of the basin (Schumann, 1995).

  - Lower Alluvial Unit: This unit is composed of silt, gravel and conglomerate. The lower part of this unit is moderately to well-cemented. The sediment grades to fine-grained sand, silt and clay with intercalated massive evaporite deposits near the center of the basin, east of the study area. This layer is underlain by bedrock.

- The middle alluvial unit may not underlie the study area due to the proximity of the dam to the White Tank Mountains.

- The groundwater levels in the McMicken Dam area have reportedly dropped from 100 feet to 300 feet (Schumann, 1986). Groundwater levels may have stabilized or increased in the last 20 years; however, water levels have not recovered to pre-pumping levels within the basin.

- The level of groundwater has stabilized likely in response to flood recharge, increased use of Central Arizona Project (CAP) water rather than groundwater, and possibly changes of land use from agricultural to urban.

- Land subsidence has been well documented within the vicinity of McMicken Dam. A maximum subsidence of 0.9 feet was measured at Station 110+00. A recent study seems to suggest that subsidence in the area is ongoing.

- A regional and a site specific gravity survey were performed in the vicinity of the study area by Oppenheimer and AMEC, respectively. Earth fissures are documented at the south end of McMicken Dam.

Memorandum

June 4, 2003

To: Mr. Ravi Murthy, P.E.
Mr. Charles Masala

From: Ken Euge, R.G.
Principal Geologist

REGISTERED GEOLOGIST CERTIFICATE NO. 10338 KENNETH M. EUGE Date Signed 06/04/03 ARIZONA, U.S.A.

Subject: Geological Input to Structures Assessment Reports (Revision 3)
McMicken Dam
Maricopa County, Arizona.
FCDMC Contract No. FCD 2001C012
Geological Consultants Project No. 2001-125

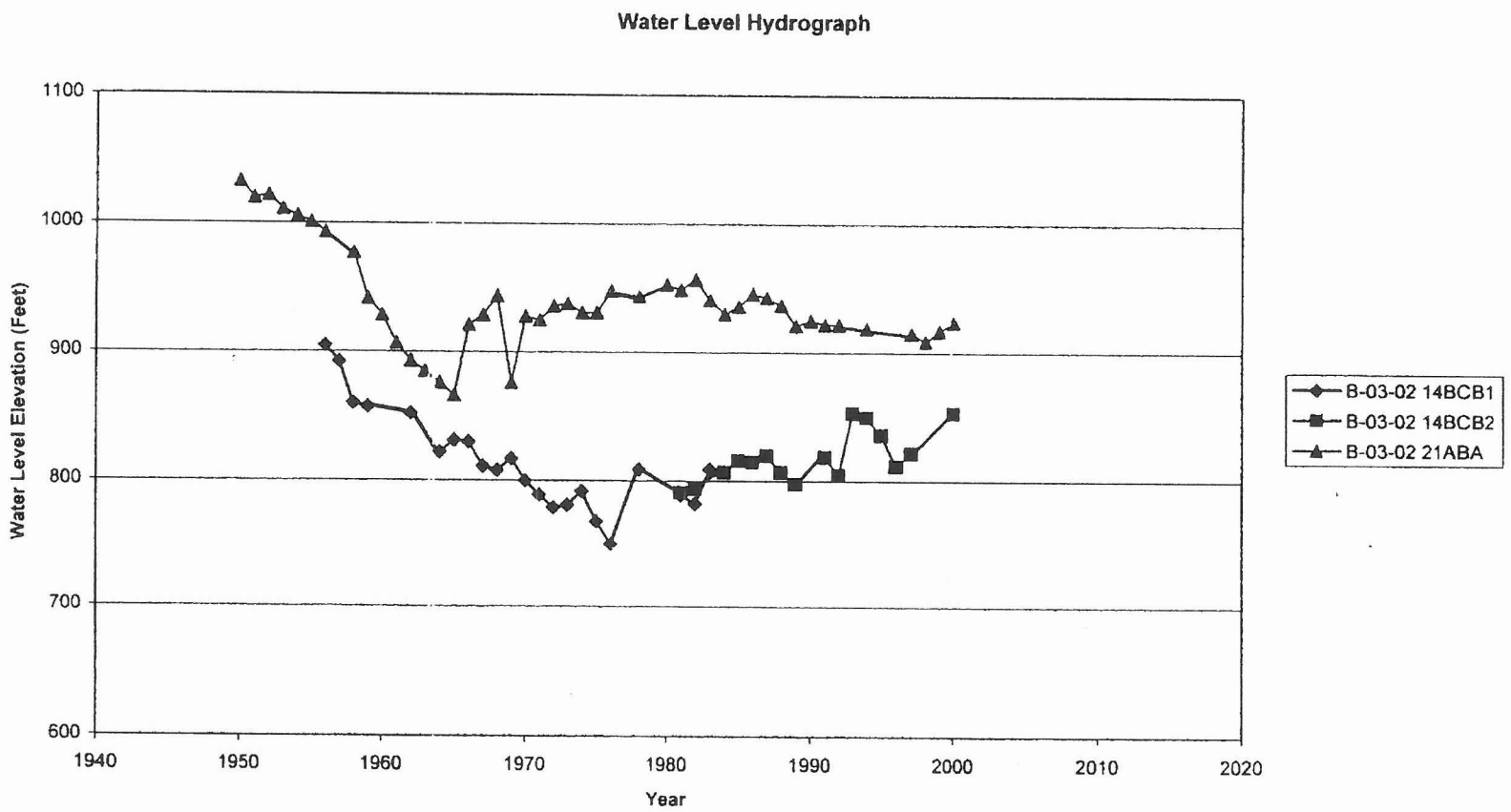
In response to your request, submitted herewith are the revised input sections, including geology and ground subsidence, for the McMicken Dam structures assessment report. As requested by FCDMC, the previously submitted seismicity section as been deleted. We have included the numbering of the report section based on previous Structures Assessment Report submittal. However, please edit as appropriate to conform to your report format.

McMicken Dam

3.5.1 Geologic Setting

The McMicken Dam is located within the Sonoran Desert section of the Basin and Range Physiographic Province. The latitude and longitude of the center part of the structure is approximately 033° 37' 52.94" N and 112° 27' 46.24"W based on NAD 83 datum. This portion of the Basin and Range is Characterized by northwest, north, and northeast trending mountains that rise abruptly to form broad, elongated, deep, sediment-filled valleys produced by block faulting and folding (Geological Consultants Inc., 1999) during past episodes of mountain/basin bounding fault movements (Cooley, 1977). McMicken Dam is located approximately 3-miles east of the northern White Tank Mountains.

The White Tank Mountains are composed predominately of old, Pre-Cambrian age (570 million years ago (mya)) metamorphic and granitic crystalline bedrock, intruded by younger dikes. The bedrock is locally overlain by Tertiary age (66 mya to 1.6 mya) volcanic rock and Quaternary are (younger than 1.6 mya) alluvium. The basin fill within the valley commonly makes up the principle groundwater aquifer of the region.



Note: Data from ADWR (2002) Groundwater Site Inventory (GWSI) Water Level Report.

Structures Assessment Report
McMicken Dam

Figure MD-2
Water Level Hydrograph

Geological Consultants

2333 West Northern Ave. Ste 1A
Phoenix, Arizona 85021

DOCUMENT TITLE: Individual Phase I Assessment Report

DATE OF REPORT: June 4, 2003

PREPARED BY: URS Corporation

PURPOSE:

The assessment included a review of available hydrologic, hydraulic, geotechnical, and construction information for the dam and appurtenant facilities, field inspection of the facility, and a Failure Modes and Effects Analysis (FMEA).

SUMMARY:

- McMicken Dam is situated on a broad, southeastward-dipping alluvial plain dissected by several stream or drainage channels.
- The following three alluvial units underlie the McMicken Dam study area:
  - Upper Alluvial Unit: Gravel and sand with lesser amounts of silt and clay. Mostly unconsolidated with locally strong cementation.
  - Middle Alluvial Unit: Silt and clay with thin interbeds of silty sand and gravel. Mostly weakly consolidated, but moderately to well cemented. Grades to fine-grained mudstone and evaporite deposits in the central part of the basin.
  - Lower Alluvial Unit: Silt, gravel and conglomerate. The lower part of this unit is moderately to well consolidated. Grades to a fine-grained sand, silt and clay with intercalated massive evaporite deposits toward the center of the basin. This unit is underlain by bedrock.
- The embankment is underlain by Holocene deposits consisting of weakly cemented sandy silts and clays with lesser amounts of clayey and silty sands. These deposits are moisture-sensitive and could be collapsible upon inundation. These soils are underlain by moderately cemented, granular Pleistocene deposits.
- SHB and USACE generally described the embankment soils as silty and clayey sands, and sandy clays of low to moderate plasticity. The angle of internal friction of these soils ranged from 29 degrees (USACE) to 30 degrees (SHB). The results of the unconsolidated-undrained tests on these soils were reported to be inconclusive (SHB). A cohesion of at least 2,000 psf was indicated.

- The embankment soils from Station 250+00 to 500+00 exhibited moisture contents ranging from 6 to 12 percent. N-values were typically in excess of 50 blows for 12 inches. Laboratory testing by SHB indicated that these soils exhibit two to seven percent collapse upon inundation.

- Land subsidence, which is a result of excessive withdrawal of groundwater, is well documented in the vicinity of McMicken Dam. No attempt was made to estimate and incorporate future subsidence in the design to restore the dam.

- Previous investigations conducted by AMEC identified earth fissures upstream and downstream of the southern segment of the dam.

- A recent study by AMEC indicates that the largest earthquake near the dam occurred at the Horseshoe fault located approximately 71 kilometers from the dam. The earthquake had a magnitude of 7.0 and resulted in a peak horizontal acceleration of 0.05 g.

- The principal outlet is an ungated, reinforced concrete box culvert located at Station 476+80. The culvert is 20 feet wide and 11 feet high with vertical walls.

- The outlet extends from the upstream toe of the dam to the downstream toe with a total length of approximately 188.33 feet. This length includes the entrance channel, a transition section, and a 30-foot wide stilling basin.

- The invert elevation at the entrance of the principal outlet was designed at elevation 1,335 feet and slopes down to 1,333.8 feet at the entrance of the transition section. The invert has been lowered to 1,333.6 feet probably due to subsidence.

- An FMEA was completed. Two of the seven identified dam safety deficiencies are related to the principal outlet: the wing walls at the principal outlet have rotated slightly inwards and that the outlet channel may be undersized for the maximum capacity of the principal outlet.

- The principal outlet has a capacity of 4,450 cfs at a pool elevation of 1,354 feet.

- The dam was designed to provide a freeboard of five feet above the emergency spillway. The freeboard available during the PMF was established to be approximately one foot.

FINDINGS/RESULTS:

- Large erosion gullies in need of repair were reported at Station 488+00.

- The highest intensity of transverse cracking was noted between Stations 445+00 and 475+00. The cracks were up to 0.75 inches wide and up to 14.5 feet deep.

- Cracks were noted in the right training wall of the principal outlet at the location of the Beardsley Canal siphon. The siphon was reportedly leaking through this crack.

- During an inspection conducted in March 2001, the wing wall of the stilling basin appeared to be offset by about 1 inch from the sidewalls of the spillway. This offset appeared to have increased by 0.25 inches during the March 2002 inspection.

- A relatively large rodent hole or pipe was observed on the downstream face near the principal outlet, at Station 468+85. The hole was probed a depth of nearly 12 feet.

- Three of the weep or drain holes in the south retaining walls of the principal outlet have collapsed. The remainder appeared to be in relatively good condition.

- The principal outlet appeared to be in relatively good conditions. The exposed concrete elements showed few signs of deterioration.

CONCLUSIONS AND RECOMMENDATIONS:

- The rotation of the wing walls at the principal spillway may be due to lateral earth pressures. It is recommended that the walls be monitored periodically for movement.

- It is likely that the lowered invert elevation of the principal outlet has had a significant impact on its capacity.

- None of the failure modes identified for the dam were judged to have a combination of both high likelihood of occurrence and high consequence (high risk).

- The USACE opined that the transverse cracking was caused by regional subsidence while SHB suggests that the cracking was probably due to collapsible foundation soils.

- It is recommended that preliminary assessment of earth fissures be conducted along the entire embankment.

- A further study of the mechanics and effects of seepage along a transverse crack through the embankment is recommended.

- The hydraulics of water conveyance from the southern segments of the dam to the principal outlet and emergency spillway should be evaluated in detail.

- The following evaluations/investigations were recommended by ADWR:

    - Investigation of the principal outlet wing walls and drains.

- Investigation of the mechanics and effects of seepage along fissure cracks in the Holocene and Pleistocene deposits.
- Investigation of the mechanics and effects of longitudinal cracks in the embankment and Holocene foundation soils.
- Evaluation of the outlet channel immediately downstream of the principal outlet to determine if the capacity is adequate for the various pool levels including the PMF.

URS

McMICKEN DAM
INDIVIDUAL STRUCTURE
ASSESSMENT REPORT

Prepared for
FLOOD CONTROL DISTRICT OF
MARICOPA COUNTY

URS Job No. 23442027
June 2003

Registered Professional Engineer (Civil)
Certificate No.
30016
RAVI
MURTHY
Date Signed 6/9/03
ARIZONA, U.S.A.

deposits. Survey data developed by the District at Station 110+00 on the dam suggests the following rates of subsidence:

Period	Subsidence Rate (feet per year)
1985 to 1991	.090
1991 to 1998	.026
1998 to 2001	.055

These data suggest that subsidence is ongoing at the dam location.

Uneven or non-uniform consolidation of the alluvium due to subsidence can result in the development of earth fissures within the subsurface. Earth fissures were first documented downstream of the dam near the south end of the embankment in the early 1980s. At that time, the closest distance between the fissure trace and the downstream toe of the embankment was approximately 600 feet. Recent studies by AMEC (2002) indicate that a possible fissure trace extends under the embankment. Based on this study (AMEC 2002), AMEC zoned the southern segment of the dam on a qualitative hazard risk level as follows:

Station	Qualitative Hazard Fissure Risk Level
50+00 to 56+00	Low
56+00 to 66+00	High
66+00 to 75+00	Moderate
75+00 to 89+00	Low
89+00 to 111+00	Moderate

It should be noted that the District is continuing to investigate the subsidence and fissure risk at the south end of McMicken Dam. Therefore, the qualitative risk level summarized above may change. However, the data presented above are consistent with the findings of the District's investigation results as of February 2003.

1.2.3 Foundation Soils

The near-surface soils underlying the embankment typically are sandy silts and clays with lesser amounts of clayey and silty sands. The clayey soils are generally of low to medium plasticity. These soils may be weakly cemented and are considered to be Holocene in geologic age. The near-surface soils are moisture-sensitive and could exhibit collapse-type settlement upon inundation. The underlying soils are somewhat granular and moderately cemented. These soils are considered to be Pleistocene in geologic age, and are expected to be relatively incompressible

measured subsidence along Perryville Road between 1957 and 1991. Continued releveling along the crest of McMicken Dam recovered relatively significant changes in elevation along the crest of the dam between 1985 and 2001. A maximum subsidence of 0.9 foot was measured during this time period at Station 110+00. At least 0.6 foot of subsidence has occurred between Stations 85+00 and 220+00 from 1985 to 2001 (District 2002). Interpretation of interferogram data indicated that changes in elevations occurred between 1996 and 2000 for portions of dam south of Bell Road.

Along Perryville Road, the calculated subsidence rate was 0.071 foot per year (ft/yr) at Olive Avenue and 0.182 ft/yr at Peoria Avenue (between 1957 and 1991). Along the Beardsley Canal, the subsidence rate was 0.077 ft/yr at Olive Avenue and 0.179 ft/yr at Peoria Avenue (between 1967 and 1981). Settlement/subsidence monitoring has been conducted by the District (2002) using survey data obtained in 1991, 1998, and 2001 at McMicken Dam. Crest monuments between Stations 40+00 and 500+00 have been surveyed. The data indicate that ground subsidence is ongoing in the McMicken Dam area. The subsidence calculated from the survey data recorded where the greatest elevation change has occurred at McMicken Dam (Station 110+00) is summarized below:

Record Period	Years of Record	Subsidence (ft)	Subsidence Rate (ft/yr)
1985-1991	6	0.540	0.090
1991-1998	7	0.186	0.026
1998-2001	3	0.166	0.055

3.3.4 Earth Fissures

Fissures occur in unconsolidated sediments, typically near the margins of alluvial valleys or near the bedrock pediment edge where land water levels have dropped from approximately 200 feet to 500 feet below land surface (Schumann and Genauldi 1986). Fissures are initiated deep underground when tensile stresses exceed the strength of the soils. Tensile stresses induced by the subsidence continue to increase until the ground breaks to form earth fissures. The fissures then propagate upwards to intersect the ground surface. Early signs of earth fissuring are small "en echelon" hairline cracks and irregularly spaced depressions at the surface. As fissures develop, the cracks grow in length to create fissures from 1 foot to more than 10 feet deep when subject to erosion caused by surface runoff. The fissures often have vegetation growing in them because the ground is commonly more moist along the earth fissure. Other physical features associated with fissures are slump-related escarpments from 1 inch to a few inches in height, as well as a drainage pattern associated with the fissure that does not conform to the area's local

of 29.5 degrees and a cohesion of 290 psf. A series of unconsolidated-undrained tests on relatively undisturbed samples from the embankment indicated a cohesion of at least 2,000 psf (SHB 1982a) when tested at in-situ moisture content.

- The following table summarizes the shear strength parameters used in stability analysis by COE and SHB:

Material	COE (1954b)		SHB (1982a)	
	Phi (degrees)	C (psf)	Phi (degrees)	C (psf)
Embankment	29	0	30	0
Upper Foundation	29	0	30	0
Lower Foundation	29	0	40	2000
Granular Drain	33	0	N/A	N/A

As can be seen in the above summary, the shear strength parameters selected by COE and SHB are in close agreement with each other with the exception of the soils of the lower foundation. Considering the increased cementation of the lower foundation soils, the shear strength parameters recommended by SHB seem appropriate. Overall, the shear strength parameters as described above seem acceptable for embankment stability assessment.

3.3.7 Embankment Cracking

In the early 1970s, the COE Los Angeles District initiated an investigative program at McMicken Dam. The purpose of the study was to present information pertinent to cracking of the embankment and to recommend remedial treatment. The results of the program were presented in a report prepared by COE (1973). As part of this investigative program, COE conducted a detailed, visual inspection of the embankment in September 1971. In March 1972, COE excavated five test pits along the crest in areas of cracking noted during the September 1971 inspection. An additional 40 backhoe test pits were excavated in June 1972. The following month, 12 bucket-auger holes were drilled between Stations 435+00 and 460+00. The principal findings of the investigation are summarized as follows:

- Transverse cracks up to 0.75-inch wide and with a maximum depth of 14.5 feet were identified in several of the test pits. The highest intensity of cracking was noted between Stations 445+00 and 475+00, and from Station 265+00 to 295+00.
- The embankment soils had a shrinkage limit of 16 percent. The COE (1973) report also includes a summary of compaction (moisture content and relative density) data from construction records. According to these data, 90 percent of the soils were compacted

Table 1. Hydrologic Calculations used for McMicken FMEA

Flood	Study	Peak in flow(cfs)	Peak out flow(cfs)	Reservoir Level (ft.)
Standard Project Flood (SPF)	Corps (1953)(design)	35,000	4,450 (storage = 33,000 A-ft	<1354[1]
Spillway Design Flood (1.5 SPF)	Corps (1953)(design)	52,000	22,000	1356
100-yr	CWW (1986)	56,200	7480[1]	1354.44
	FCD	72,000	-	-
Probable Maximum Flood	Corps (1953)(design)	120,000	95,000	1360.0
	SHB (1983)	155,800	123,800	1360.8
	CWW (1986)	163,267	166,790	<1361.5>
	FCD (1987)	114,850	90,105	1360.43
	FCD (2000) - spillway vegetation	>115,000	109,095 (total dischg. capacity @ el. 1361 = 61,360 cfs)	<1361.43>
	FCD (2000) - no spillway vegetation	>115,000	94,900	1360.77

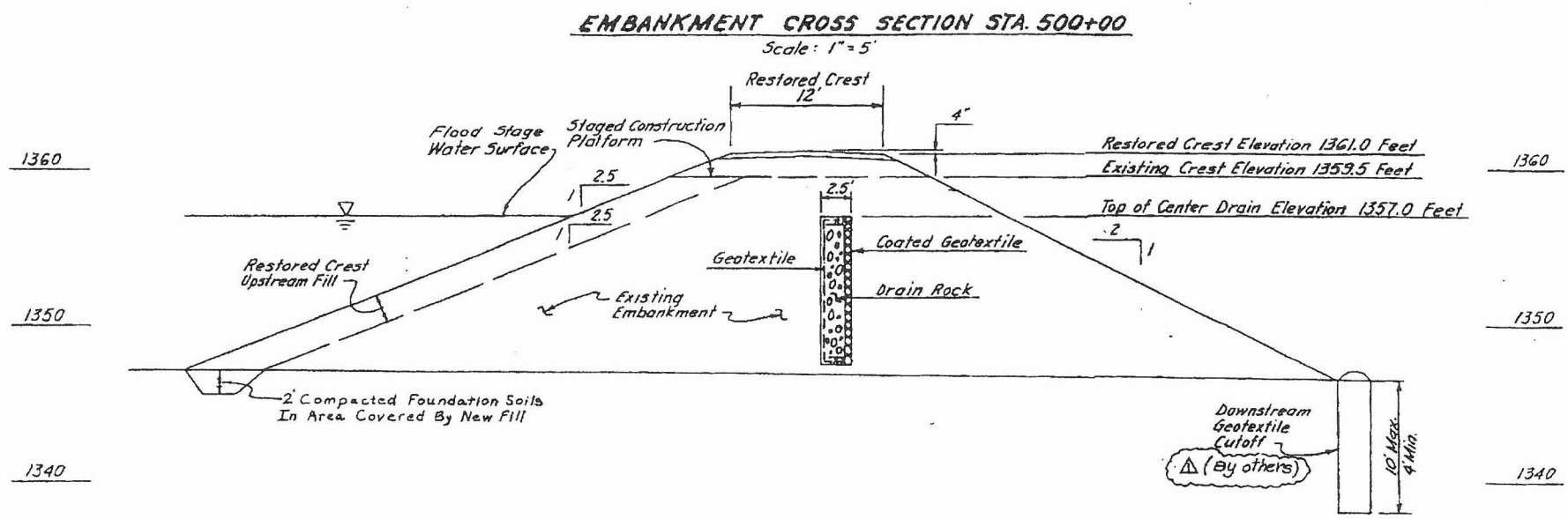
Note 1: The value was read from the spillway rating curve

Table 2. Chronology of Significant Events for McMicken Dam

Year	Feature
1955 - 56	Construction of original dam completed by Corps of Engineers
1956	Construction of raised dam completed by COE to crest el. 1361; 2 CMP outlets extended through new upstream fill and 3 abandoned in-place
1977	Dam removed from service and breached at two locations due to dam safety deficiencies identified by COE, including embankment cracking and loss of crest elevation due to regional ground subsidence
1982	Earth fissures lineations identified downstream from the south end of the dam
1983	Central drain and outlets and downstream cutoff installed; crest re-leveled to el. 1361; and dam returned to service
2002	Earth fissures adjacent to the downstream and upstream toes at the south end of the dam confirmed by trenching

Table 8. Highest Priority Failure Modes from McMicken FMEA

Criterion	Failure mode	Major reasons
Highest risk	3.0 - spillway discharge	large flows and inundated areas
	8.0 - spillway erosion	large flows and inundated areas
	7.0 - internal erosion at dam/foundation interface	continuous transverse cracking would provide continuous seepage and particle transport pathway
	11.0 – structural integrity operational CMPs	age, condition, subsidence settlement, possible joint separation
	12.0 - internal erosion along CMPs	embankment cracking, single seepage collar
Lowest confidence	4.0 - internal erosion due to earth fissures	dam breach characteristics highly specific to individual fissure locations and effects
	5.0 - internal erosion from geotextile defects	little construction information; uncertain influence of embankment cracking



P:\FCDMC\E1-2025 On-Call Phase 1\McMicken Dam\CADD\A15551.dwg 9-26-02

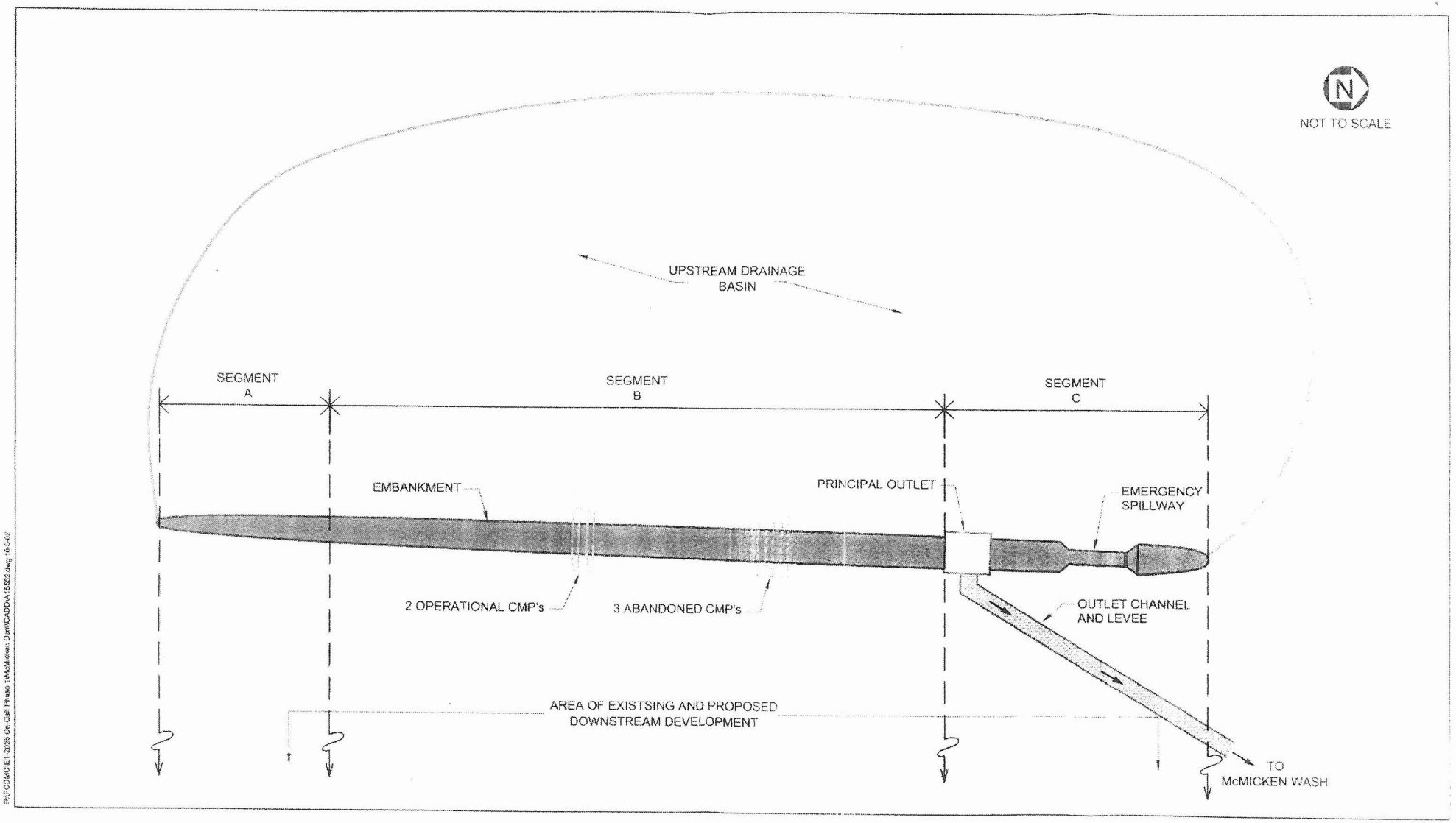
Source: Design Report McMicken Dam Restoration Study
Maricopa County, Arizona, SHB Consulting Geotechnical Engineers.

Typical Section of Embankment and Center Drain
FCDMC - McMicken Dam

Prepared By URS for Steven G. Vick, P.E.

Figure 1

23442027.00000



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Schematic Presentation of the McMicken Dam System

FCDMC - McMicken Dam

Prepared By URS for Steven G. Vick, P.E.

23442027.00000

Figure 2

DOCUMENT TITLE: Final Report of Alternatives Analysis, McMicken Dam Fissure Risk Zone Remediation Project

DATE: October 1, 2003

PREPARED BY: AMEC

PURPOSE:

Presents summary of alternatives analysis used to select preferred alternative for rehabilitation of south end of McMicken Dam (fissure risk zone).

- Approach:
  - Develop list of alternatives and list of criteria for evaluation.
  - Develop conceptual plans for listed alternatives, complete preliminary cost estimates, and perform preliminary failure modes and consequence analysis.
  - Initial screening of alternatives to reduce alternatives to approximately 8.
  - Intermediate screening to reduce alternatives approximately 3.
  - Complete a quantitative, structured risk analysis of remaining alternatives.
  - Complete structured value engineering analysis of remaining alternatives.
  - Additional studies which can be related to the possible presence of earth fissures, and analyses of the impact of breaching the existing Dam at locations south of 107+00.
  - Select an alternative.

SUMMARY:

- Screening of alternatives was performed in meetings attended by The District, AMEC, Stantec Consulting, Inc., and ADWR.
- Draft evaluation criterion included: function, performance, risk, cost, environmental considerations, land use, aesthetics, capability of being incorporated into future plans, and regulatory requirements.
- System alternatives and system component alternatives considered.

- Five general system alternative categories:
  - No action
  - Monitor only
  - Rehabilitation of existing structure :
    - Construction of new earthen embankment, roller compacted concrete, or soil cement embankment upstream or downstream of existing structure.
    - Widening existing structure to fulfill criteria of protection against shrinkage/settlement cracking and earth fissures.
    - Construction of upstream blanket, hydraulic barrier, and crack filling (grouting).
  - Abandonment of existing structure (sections) and:
    - Construction of an upstream dam and spur dike outside of the moderate and high hazard fissure zones.
    - Construction of same systems within the moderate and high hazard fissure zones.
    - Construction of an upstream diversion and spur dike outside of the moderate and high hazard fissure zones.
  - Segmenting existing structure alternative includes construction of a spur dike (or dam extension) only to segment that part of the dam within the moderate and high hazard fissure zones.
- Only rehab, abandonment, and segmentation alternatives were considered in high hazard zone.
- Any systems requiring new structures or dam extensions within moderate hazard zones were to include system components to protect against piping resulting from cracking or earth fissuring; including:
  - Removal of Holocene soils
  - Construction of upstream and downstream barriers extending into Pleistocene soils
  - Construction of a hydraulic barrier on the upstream face of the dam

- Preliminary design barriers include cutoffs (at toes) extending into Pleistocene soils using flowable backfill and geomembrane/geotextile barriers on upstream faces of new structures and cut-offs.

FINDINGS/RESULTS:

- Initial screening resulted in selection of 10 alternatives (rank).
    - Abandonment Alt. 4B (1): diversion structure located upstream of the existing dam, with further analyses to consider 500-year and PMF.
    - Isolation Alt. 5C (2): dam extension and segmentation with modification of existing dam and possible basin containment with further analyses to consider 500-year and PMF.
    - Rehabilitation Alt. 3B & 3A (3 & 4): new embankment dam located either upstream or downstream of the existing dam with further analyses to consider either the upstream or the downstream location but not both.
    - Rehabilitation Alt. 3E & 3D (6 & 8): RCC structure located either upstream or downstream of the existing dam with further analyses to consider either the upstream or the downstream location but not both.
    - Isolation Alt. 5B (10): dam extension and segmentation with limited rehabilitation of the existing dam, with further analyses to consider both the 500-year and PMF events, and the option of basin containment and downstream channels.
    - Abandonment Alt. 4A (11): dam extension or new dam located upstream of existing dam.
    - Note: the 5th ranked alternative was not considered, since it is a minor variation of alts 5B & 5C.

- More detailed plans and cost estimates were developed for selected alternatives for next screening.
- Secondary screening resulted in selection of 10 alternatives: 4B2, 5C1, 5C2, 4B1, 4A2, 3A, 3B, 5B, 4A1 & 5A. with 3A, 4A2, 5B, & 5C1 most likely to be selected.
- Risk assessment compared each alternative to a do nothing condition in the high hazard zone. Detailed cost estimates of failure were not computed; rather 4 (A, B, C, & D) levels of consequences were used.

- With regard to risk analysis, it was determined that the preferred alternative should be selected on the comparative design and construction costs.

- With respect to value engineering/preferred alternative analysis, alternative 5C-E/3A was selected.

- Computer simulations were used to further define hazard zones. Five profiles were selected and inputted to SEEP/W and SIGMA/W to perform subsidence and deformation analyses.

- Simulations confirmed high hazard zone boundaries at southern end of dam. Analysis of moderate hazard zone showed strains not exceeding threshold, and evaluation of northern (>317+00) section showed that strains could exceed thresholds.

- Upon request of the District, a dam breach analysis was performed introducing both opportunities and constraints; alternatives 6A through 6C; apparently none of these alternatives were feasible.

CONCLUSIONS AND RECOMMENDATIONS:

- Decided that only the high hazard zone would be mitigated, with extensive monitoring in moderate hazard zone.

- Alternative 5C was chosen with soil cement embankment structure.

DOCUMENT TITLE: Geotechnical Supplemental Report: Dam Repair, Sta. 478 to 480

DATE: January 5, 2004

PREPARED BY: R.A.M (Project # G08912)

PURPOSE:

To investigate a void (and subsequently discovered cracks and voids) located on the downstream toe near Station 478+18.

SUMMARY:

Field exploration activities included:

- Preparing a temporary repair plan for backfilling the exploration pits excavated in the toe of the dam
- Evaluating the void/flow channel by excavating south along the downstream toe of the dam
- Mapping horizontal and vertical cracks in the test trench, measuring the width and depth of the cracks, and evaluating their relationship with the breached section
- Evaluating the conditions and possible interaction of the void area and breached area
- Excavating, logging, and sampling five test trenches
- Drilling, logging, and sampling 13 test borings
- Performing laboratory tests including sieve analyses, Atterberg limits, standard proctors, and consolidation tests
- Evaluating and analyzing the data collected to determine possible causes of the void and cracks

FINDINGS/RESULTS:

- In Test Trench P1, a sandy clay or silty sand with trace amounts of gravel was observed. Cracking and a flow channel (seepage pipe) was noted.
- Test trench P2 was excavated in the breached area near the downstream toe of the dam at about Station 478+68 and extended horizontally about 18 feet west into the dam from the

toe. The excavation encountered a very dense clayey sand embankment fill. A horizontal 0.2 to 0.6-foot-thick layer of gravelly sand with some clay was encountered in the fill near the bottom of the test trench (at about elevation 1338.2 feet).

- Test trench P3 (breach area) was excavated downstream toe of the dam at about Station 479+ 47 and extended horizontally about 14 feet west into the dam from the toe. However, a horizontal, 0.3 to 0.7 foot thick gravelly sand with some clay layer was encountered in the fill near the test trench bottom at about elevation of 1338.5 feet.

- Test Trench P4 was excavated in the down stream toe of the dam at about Station 480+00 and extended horizontally about 12 feet west into the dam from the toe. The excavation encountered a dense clayey sand embankment fill which extended down below the toe of the embankment approximately 1.5 feet. The fill was underlain by silty to clayey sand with some gravel. These Holocene alluvial soils were medium dense and contained low plasticity fines.

- Test trench P5 was excavated in the downstream toe of the dam at about Station 480+50 and extended horizontally about 13 feet west from the toe. The excavation encountered a dense clayey sand embankment fill which extended down below the toe about two feet. The fill was underlain by silty to clayey sand with some gravel. These Holocene alluvial soils were medium dense and contained low plasticity fines.

- Generally, the 13 borings encountered fills consisting of silty or clayey sands, trace gravels, or sandy clays. Soil moisture contents were generally described as nearly dry to damp.

- Laboratory test results of the samples indicated that the soils were generally sandy clays or clayey sands, had a low to medium collapse potential, were low to medium plasticity, and had maximum densities of about 122 pounds per cubic foot.

- Field work in the void area discovered a network of voids/flows channels and associated block cracks in a sandy clay zone which is part of embankment fill.

CONCLUSIONS:

- Surface water enters a crack/void network from the original void in the ditch at the dam face/access road interface and from the vertical cracks that daylight in the disturbed surface material on the dam face.

- The water/moisture is probably dissipated by the underlying silty sand layer and probably percolates into the foundation materials.

- The crack network is located south of the surveyed area, likely just south of the eroded breached area.

- During construction of the access road, this area was kept covered, which retarded desiccation of the clay deposit containing the voids and cracks.
- During the breach this network may have undergone additional drying from the north side.
- The network of voids/flow channels and associated block cracking, if connected to the center filter drain, could act as a discharge for the center filter drain.
- No relationship has been identified between the breach area and the void area.

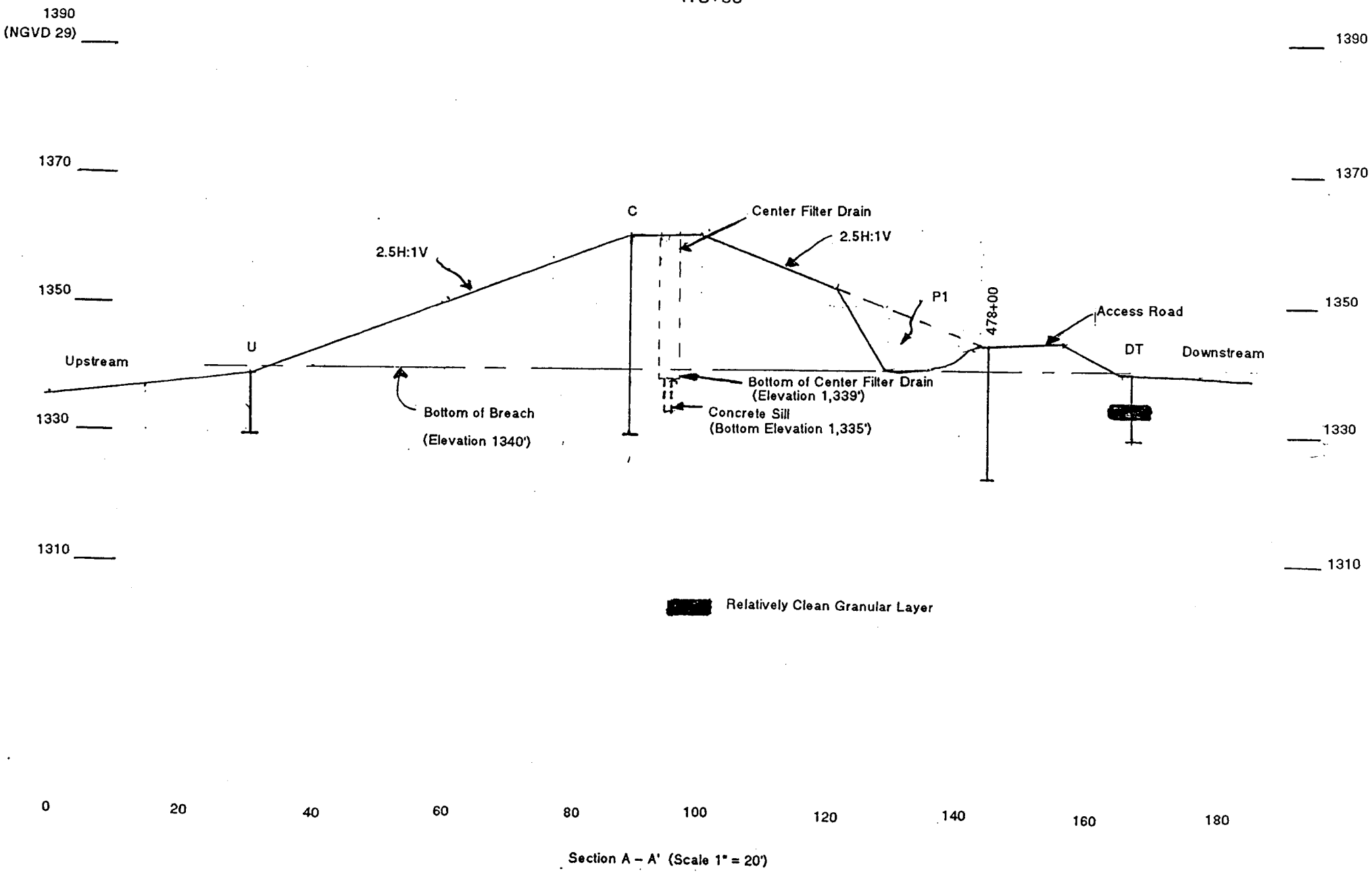
Findings and conclusions related to the breach of the dam include:

- COE designed and constructed two breaches of McMicken Dam.
- During the exploration for the breach area, two test trenches P2 and P3 were excavated in the downstream face of the dam at the toe. These test trenches did not encounter the same material as the test trench P1 in the void area.
- The breach contained a concrete sill which extended five feet below the breach.
- The center filter drain bottom was at an elevation below the bottom of the breach. Thus, the relatively clean granular layer encountered in test trenches P2 and P3 cannot exist any further west than the sill or the sill backfill or the center filter drain depending on whether or not the sill was removed.

RECOMMENDATIONS:

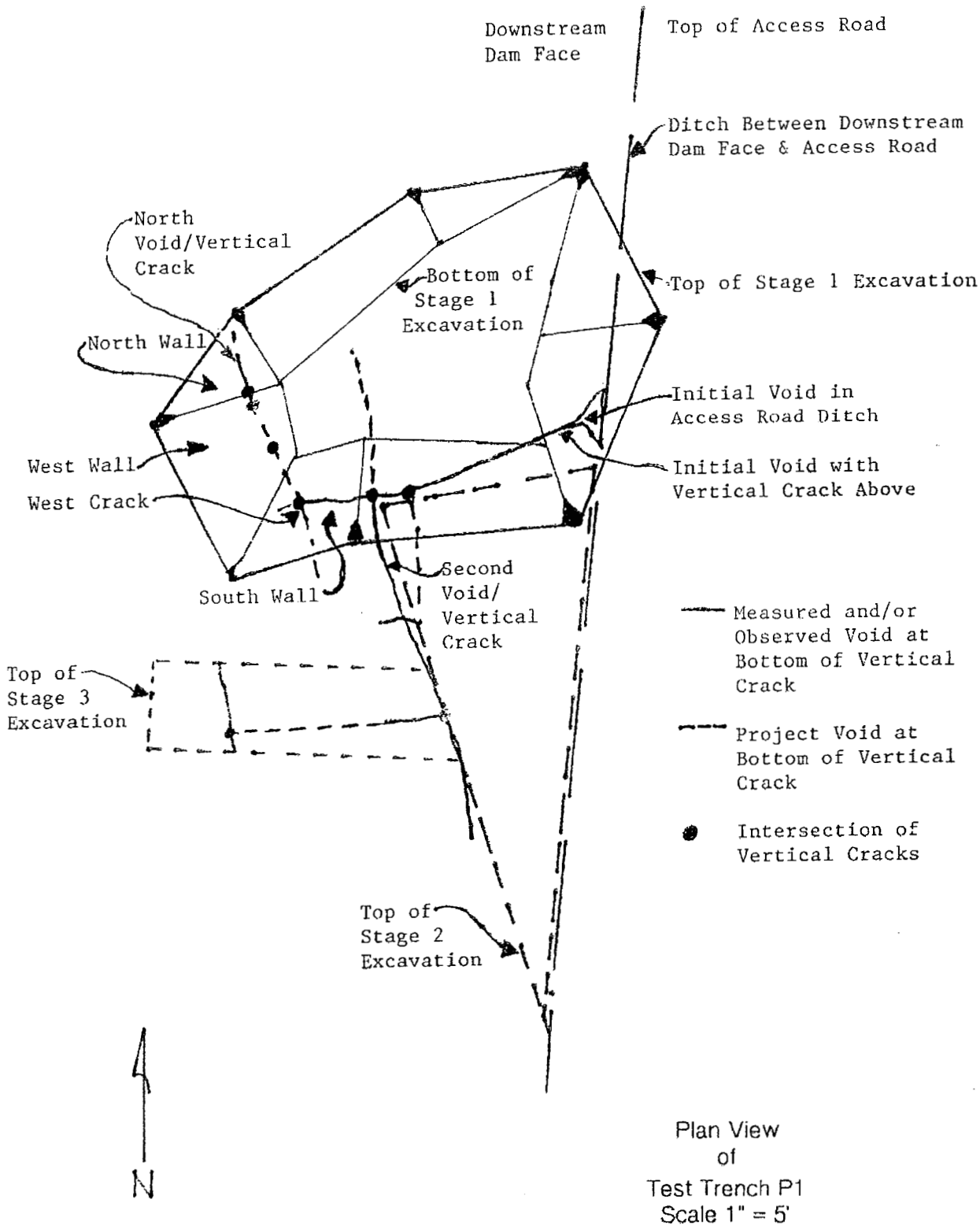
- Water entering the void network with sufficient head could result in piping of the dam material downstream of the center filter drain. Therefore the void should be treated in the same manner and priority as the other cracks encountered.
- The void area should be visually inspected on a daily basis by the District when impoundment levels are higher that elevation of 1,340 feet.
- Line the main source of water using gunite, asphaltic concrete, or cast-in-place concrete so as to limit concentrated surface flows in the downstream face above the access road from entering and potentially enlarging the void network.
- Regarding the breached area, no additional work in this area is needed since the soil type encountered here is considered to have low seepage potential.

Section A – A'
478+00

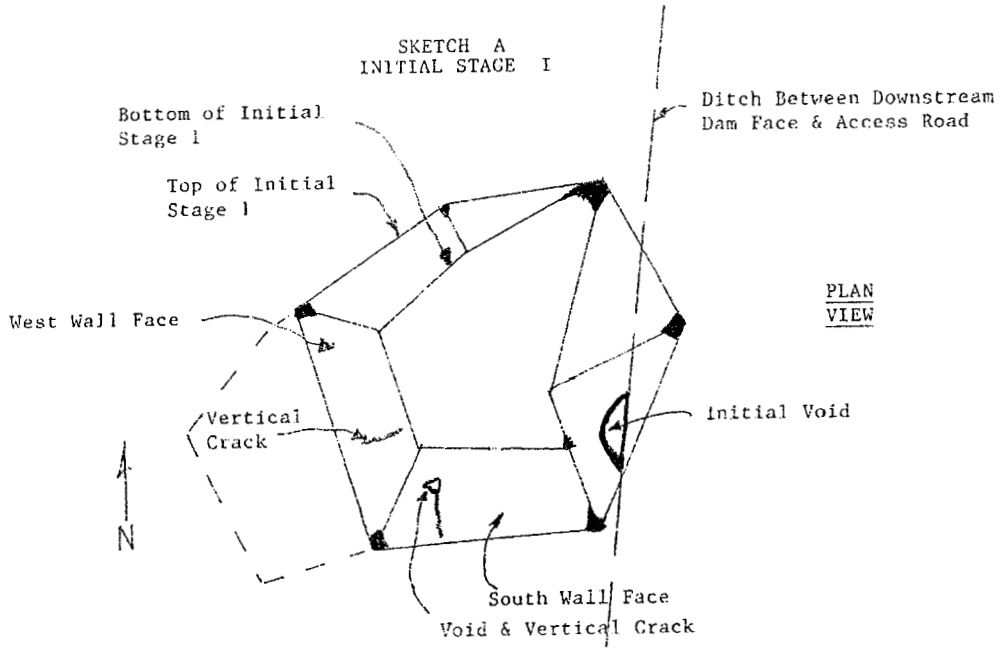


Section A – A' (Scale 1" = 20')

7-17/03
G08912 (Supplement)



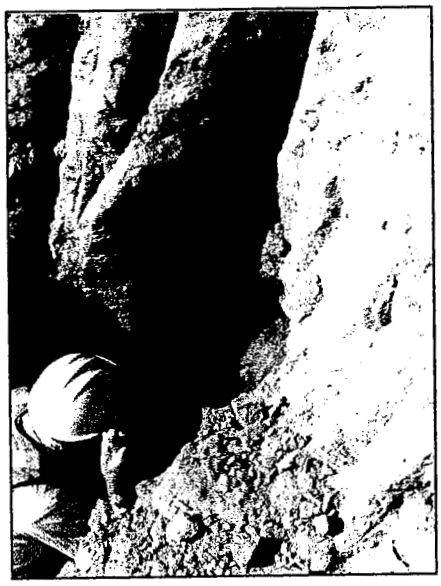
Plan View
of
Test Trench P1
Scale 1" = 5'



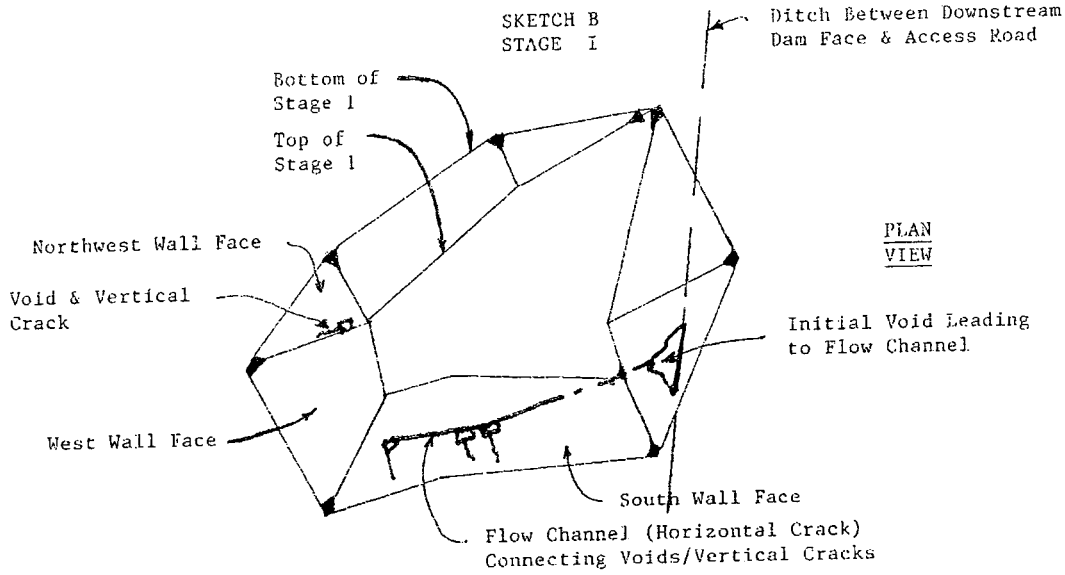
West Side

South Side

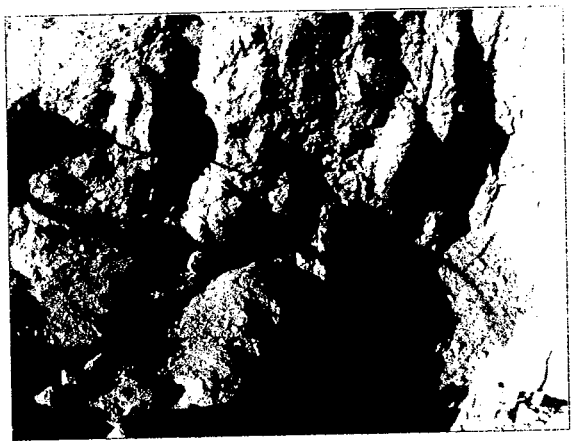
South Side



West Side

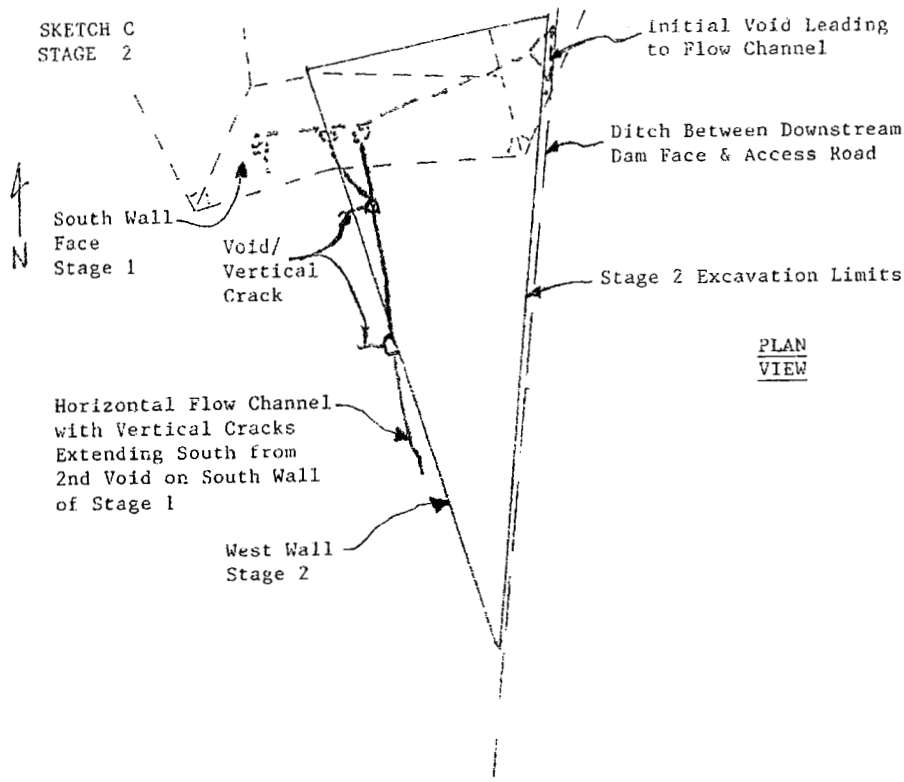


South Side

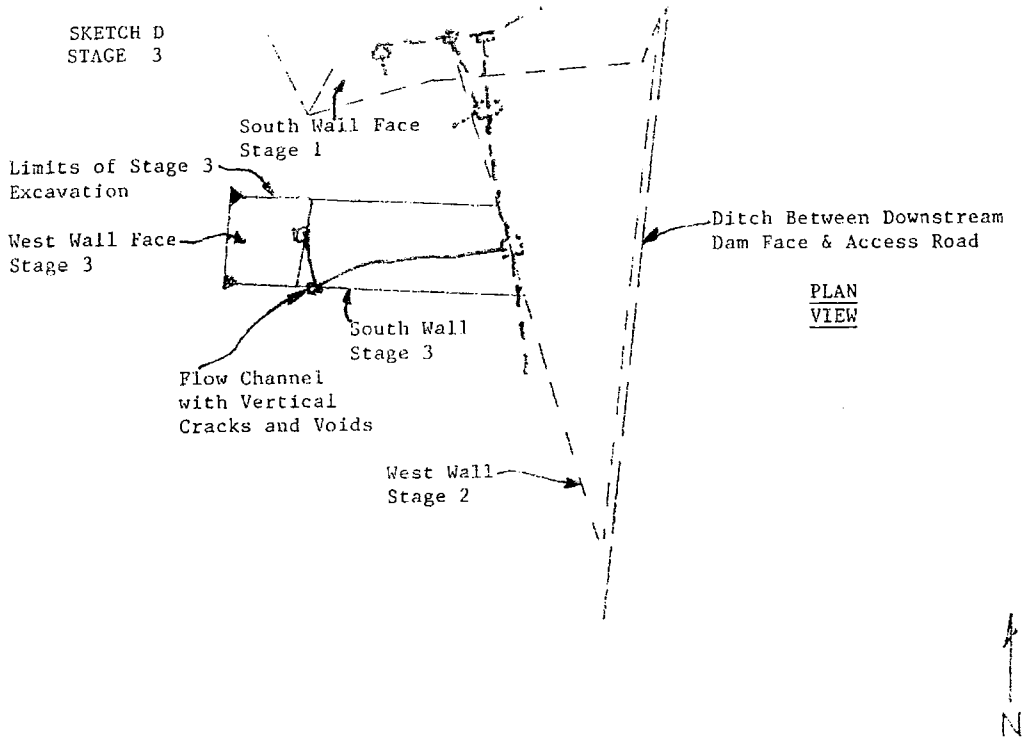


West Side

Northwest Side



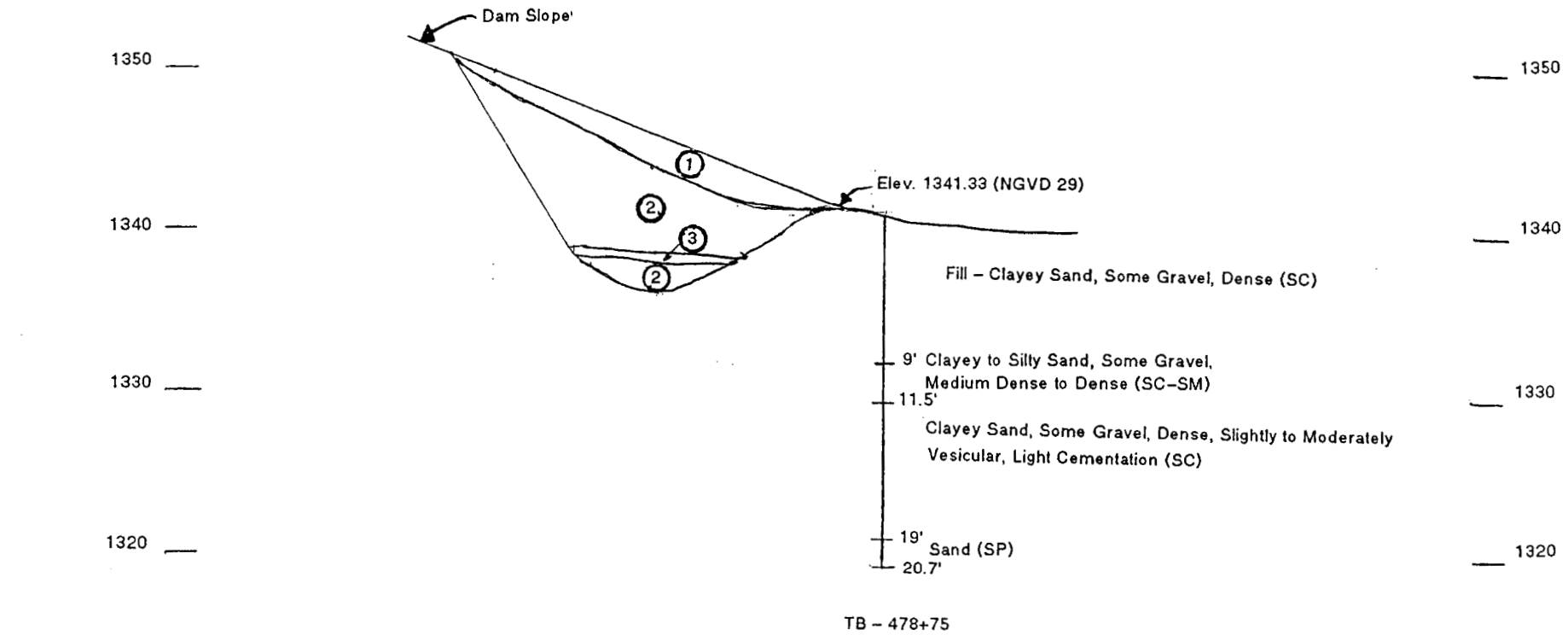
West Wall Stage 2



West Wall Stage 3

South Wall Stage 3

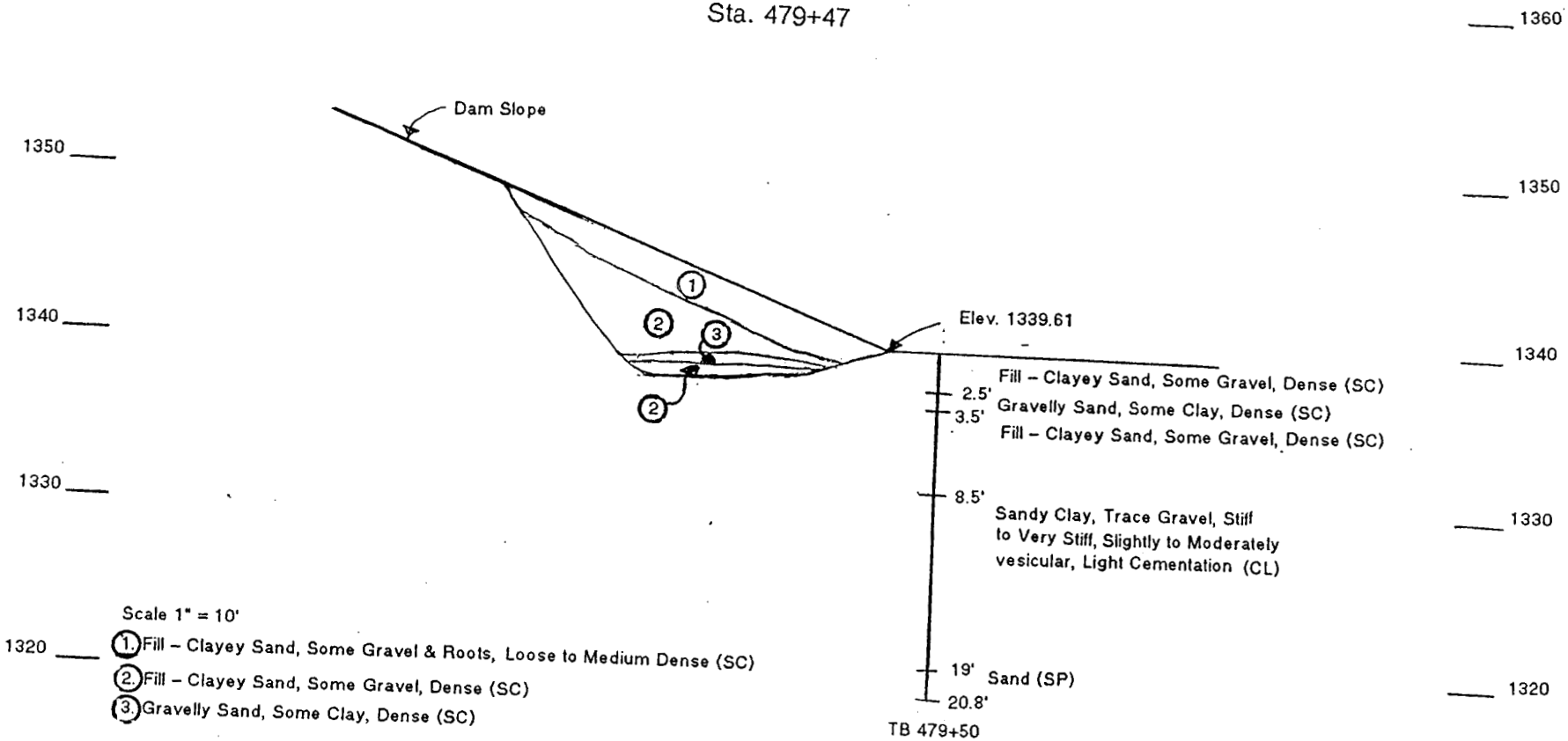
Test Trench P2
(Looking North)
Sta. 478+68



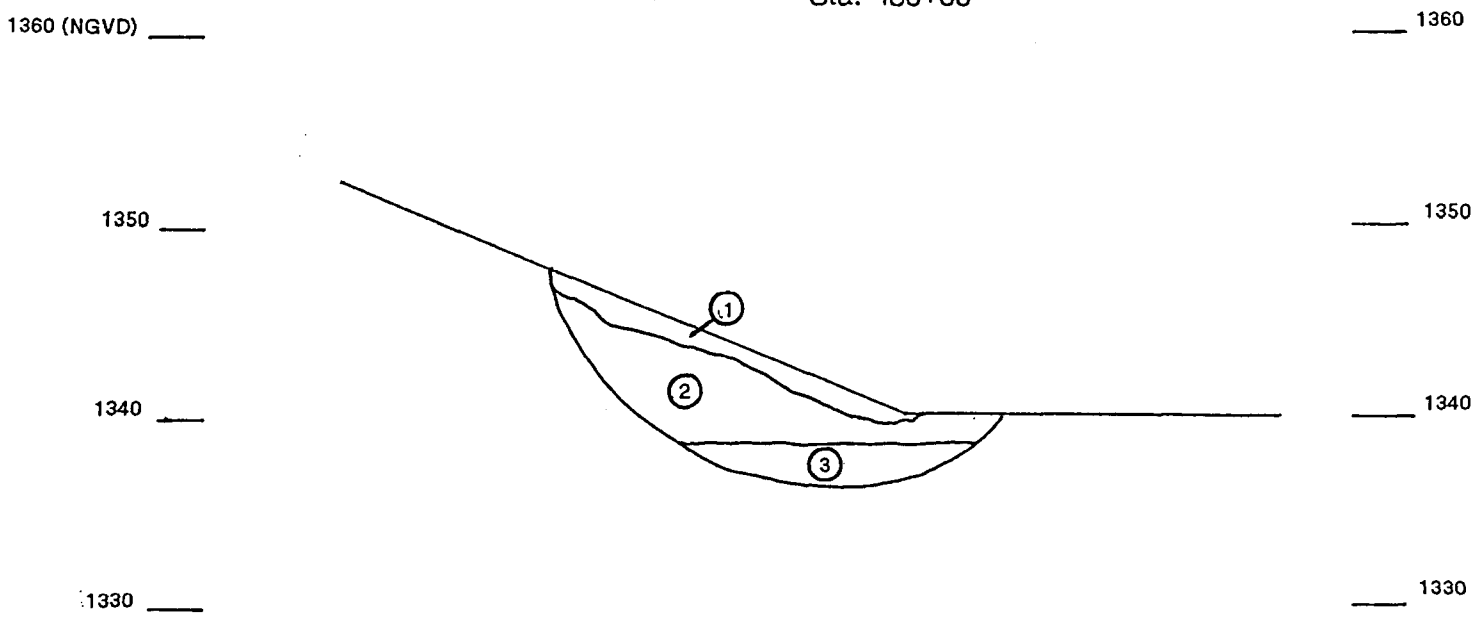
Scale 1" = 10'

1. Fill – Clayey Sand, Some Gravel & Roots, Loose to Medium Dense (SC)
2. Fill – Clayey Sand, Some Gravl, Dense (SC)
3. Gravelly Sand, Some Clay, Dense (SC)

Test Trench P3
(Looking North)
Sta. 479+47



Test Trench P4
(Looking North)
Sta. 480+00

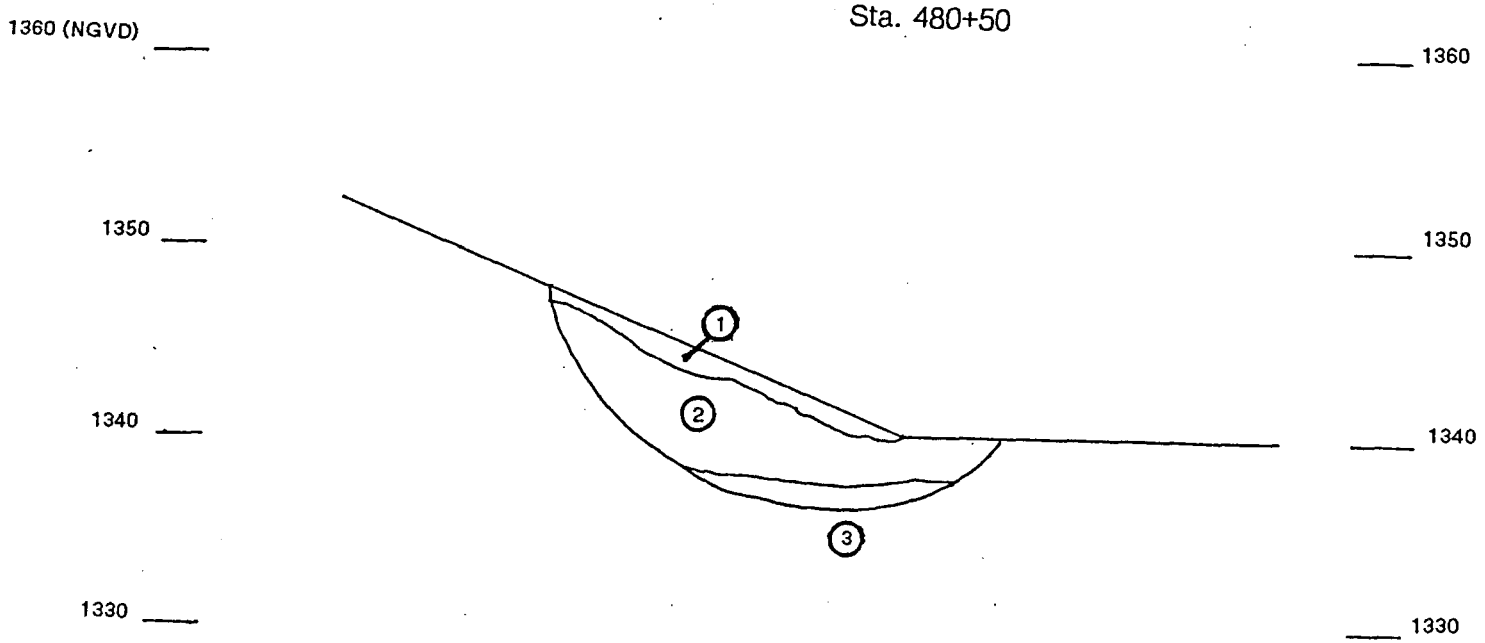


Scale 1" = 10'

1. Fill – Clayey Sand, Some Gravel & Roots, Loose to Medium Dense (SC)
2. Fill – Clayey Sand, Some Gravel, Dense (SC)
3. Silty to Clayey Sand, Some Gravel, Medium Dense (SM–SC)

G08912
(Supplement)

Test Trench P5
(Looking North)
Sta. 480+50

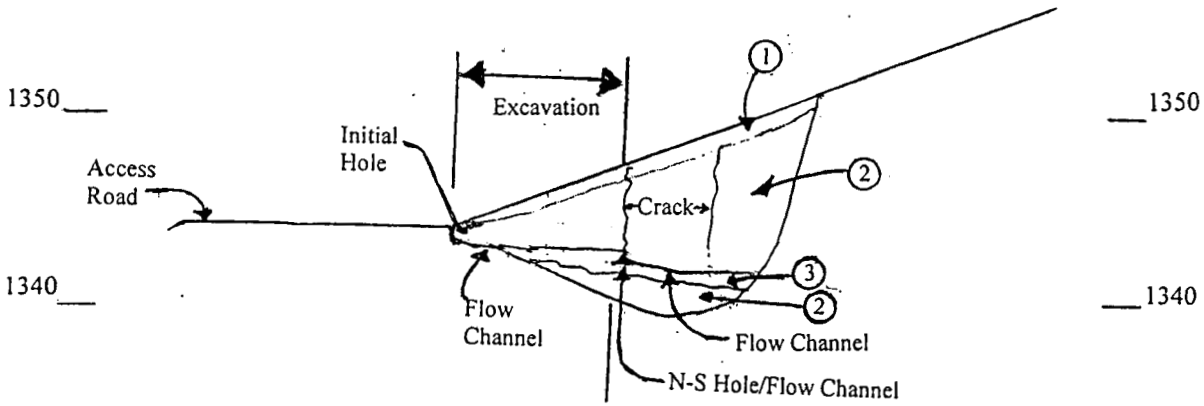


Scale 1" = 10'

1. Fill – Clayey Sand, Some Gravel & Roots, Loose to Medium Dense (SC)
2. Fill – Clayey Sand, Some Gravel, Dense (SC)
3. Silty to Clayey Sand, Some Gravel, Medium Dense (SM–SC)

G08912
(Supplement)

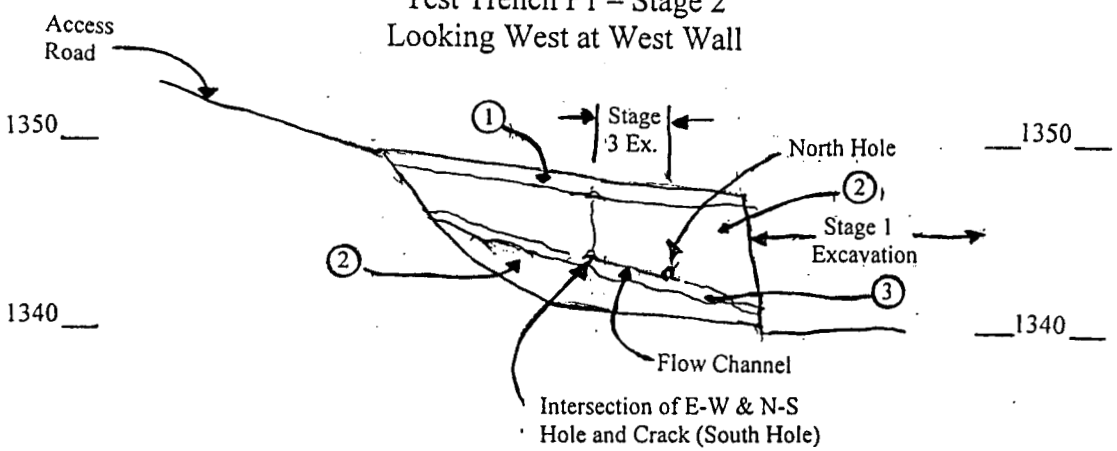
Test Trench P1 – Stage 1
Looking South at South Wall



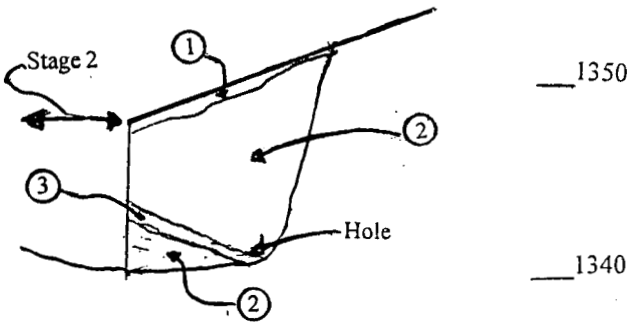
1" = 1'

1. Fill – Sandy Clay, Trace Gravel & Some Roots, Soft to Stiff (CL)
2. Fill – Sandy Clay, Trace Gravel, Very Stiff to Hard (CL)
3. Fill – Silty Sand, Trace Gravel, Dense, Low Plasticity Fines

Test Trench P1 – Stage 2
Looking West at West Wall

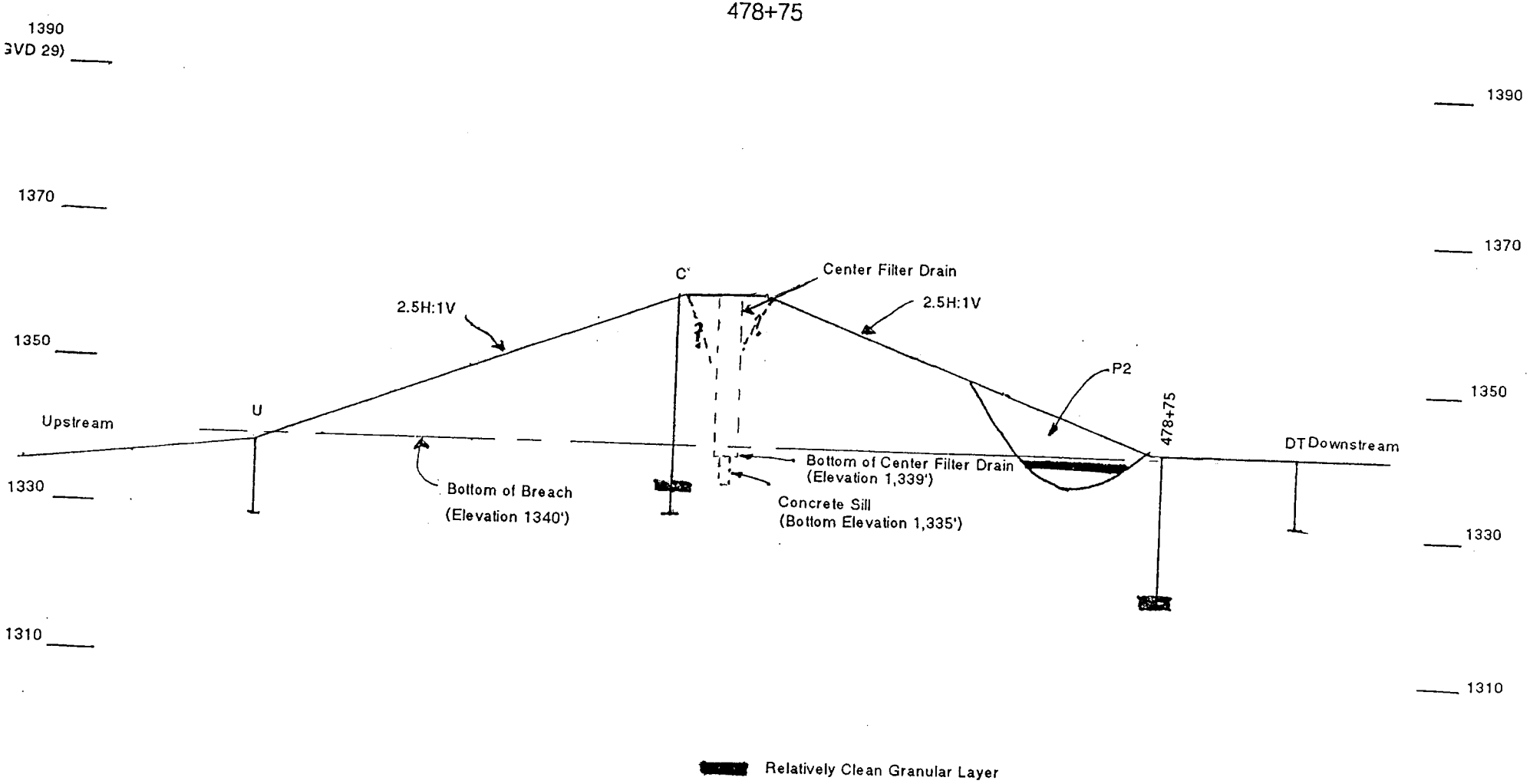


Test Trench P1 – Stage 3
Looking South at South Wall



G08912

Section B – B'
478+75

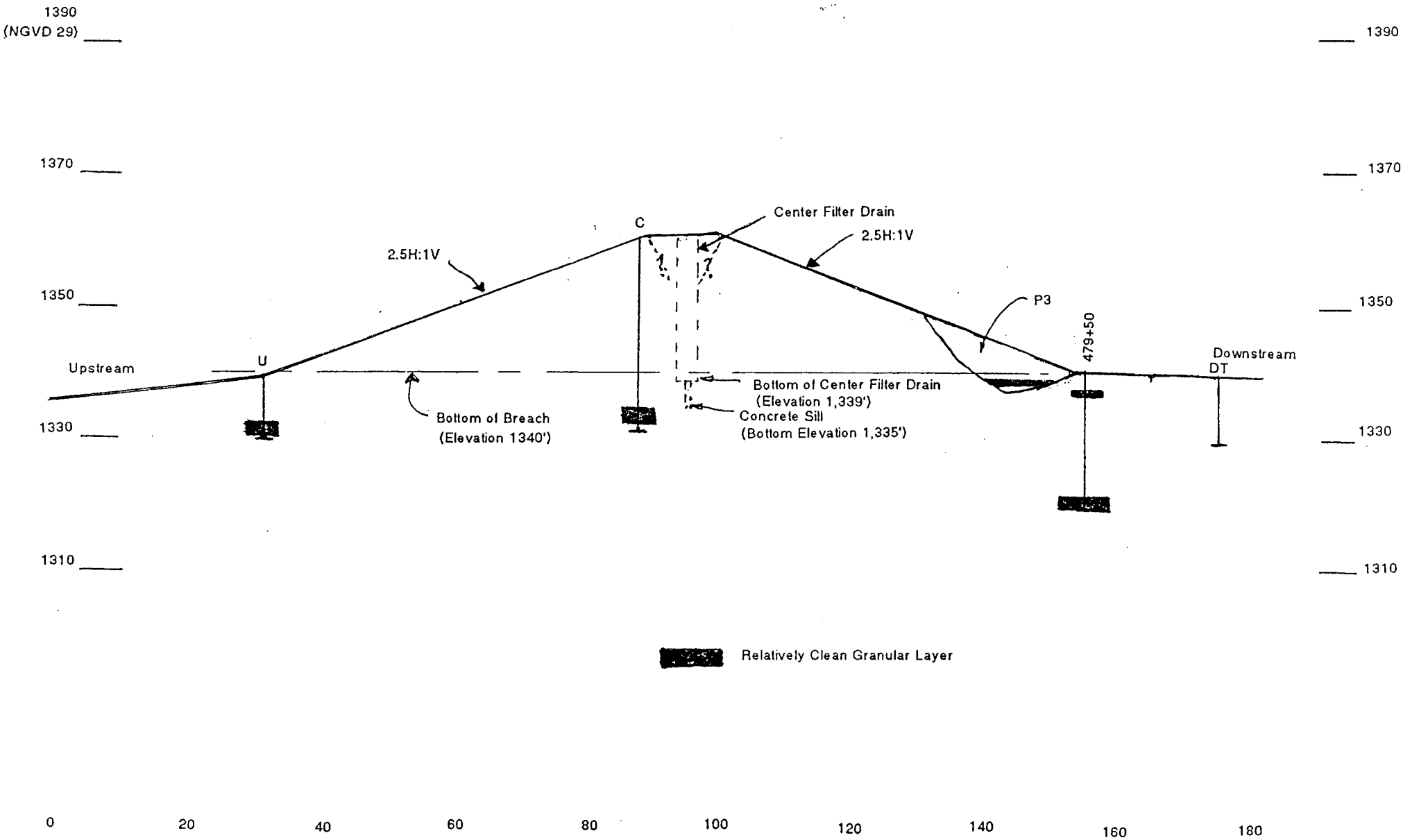


0 20 40 60 80 100 120 140 160 180

Section B – B' (Scale 1" = 20')

7-17/00

Section C – C'
479+50



Section C – C' (Scale 1" = 20')

7–17/03

TEST BORING LOG

BORING NO. 478+00 U
PROJECT NAME: Dam Repair
Principal Spillway at McMicken Dam
LOCATION: Sta. 478+08; Upstream Toe
DRILL EQUIPMENT: CME 55

DATE: 8-20-03 **BY:** DM
SHEET NO. 1 **OF** 1
GROUND ELEV. 1339.25' (NGVD 29)
W.T. ELEV. None Encountered
DRILLER: D & S Drilling

Depth, feet	Blows/Foot C	Blows/Foot N/R	Sample Type	Dry Density, pcf	Water Content, %	Unified Classification	Description
		12	R	98	7	CL	Fill: Sandy Clay, Trace Gravel; brown, nearly dry, very stiff, medium plasticity.
		27	R	105	5		
		43	R	100	5		
		39	R	105	5		
5		50/9"	R	117	4		5
		50/7"	R	116	3	SC-SM	Clayey Silty Sand, Trace to Some Gravel; brown, nearly dry, very dense, light cementation.
		50/11"	R	109	4		
		33	R	102	5	SC	Clayey Sand, Trace to Some Gravel; brown, nearly dry, dense to very dense, light cementation.
		50/5"	R	109	12		
		50/8"	R	111	8		
10							Stopped at 9.7 feet. 10
							No groundwater observed.
15							15
20							20
25							25

This boring log represents the conditions encountered on the date of drilling at this particular location. No other warranty is expressed or implied to the actual conditions which may exist within the vicinity of this boring location.

TEST BORING LOG

BORING NO. 478+00 C
PROJECT NAME: Dam Repair
Principal Spillway at McMicken Dam
LOCATION: Sta. 478+08; 6' L
DRILL EQUIPMENT: CME 55

DATE: 8-19-03 **BY:** DM
SHEET NO. 1 **OF** 2
GROUND ELEV. 1360.67' (NGVD 29)
W.T. ELEV. None Encountered
DRILLER: D & S Drilling

Depth, feet	Blows/Foot C	Blows/Foot N/R	Sample Type	Dry Density, pcf	Water Content, %	Unified Classification	Description
						SC	Fill: Clayey Sand, Trace to Some Gravel; brown, nearly dry, dense, well compacted, medium plasticity fines.
5							
10							
15							
20							
25		50/6"	R	117	6		
							- continued -

This boring log represents the conditions encountered on the date of drilling at this particular location. No other warranty is expressed or implied to the actual conditions which may exist within the vicinity of this boring location.

TEST BORING LOG

BORING NO. 478+00 C
PROJECT NAME: Dam Repair
Principal Spillway at McMicken Dam
LOCATION: Sta. 478+08; 6' L
DRILL EQUIPMENT: CME 55

DATE: 8-19-03 **BY:** DM
SHEET NO. 2 **OF** 2
GROUND ELEV. 1360.67' (NGVD 29)
W.T. ELEV. None Encountered
DRILLER: D & S Drilling

Depth, feet	Blows/Foot C	Blows/Foot N/R	Sample Type	Dry Density, pcf	Water Content, %	Unified Classification	Description
		50/4"	R	NR		SC	Fill: Clayey Sand, Trace to Some Gravel - continued
		50/8"	R	110	6		
		50/9"	R	119	4	CL/SC	Sandy Clay/Clayey Sand, Trace Gravel; brown, nearly dry, brown, nearly dry, very stiff, very dense, moderate cementation.
		50/5"	R	113	3		
		50/10"	R	115	4		
30		50/10"	R	105	9	SC-SM	Clayey Silty Sand, Trace to Some Gravel; brown, nearly dry, very dense, light cementation.
		50/11"	R	100	6		
						CL	Sandy Clay, Trace of Gravel; brown, slightly damp, very stiff, moderate cementation.
						SC	Clayey Sand, Trace to Some Gravel; brown, nearly dry, very dense, light cementation.
35							Stopped at 31 feet. No groundwater observed. NR = No Recovery
40							Note: Second attempt was drilled at Sta. 478+11, 6' R, Elev. 1360.72 on downstream crest to check for filter cloth and gravel. Found nothing to 10'.
45							
50							

This boring log represents the conditions encountered on the date of drilling at this particular location. No other warranty is expressed or implied to the actual conditions which may exist within the vicinity of this boring location.

TEST BORING LOG

BORING NO. 478+00
PROJECT NAME: Dam Repair
Principal Spillway at McMicken Dam
LOCATION: Sta. 478+18; R55' (ML)
DRILL EQUIPMENT: CME 55

DATE: 6-18-03 **BY:** DM
SHEET NO. 1 **OF** 1
GROUND ELEV. 1344.00' (NGVD 29)
W.T. ELEV. None Encountered
DRILLER: D & S Drilling

Depth, feet	Blows/Foot C	Blows/Foot N/R	Sample Type	Dry Density, pcf	Water Content, %	Unified Classification	Description
		50/6"	R	111	5	SC	Fill: Clayey Sand, Some Gravel; brown, nearly dry, dense, medium plasticity fines.
		50/7"	R	108	6		
5		50/6"	R	110	6		
		50/2"	R	NR			
10		50/10"	R	108	4	SC/SM	Clayey to Silty Sand, Some Gravel; brown, nearly dry, dense to medium dense, low plasticity fines.
		39	R	109	3		
15		50/7"	R	104	11	SC	Clayey Sand, Some Gravel; brown, slightly damp, very dense, light cementation, medium plasticity fines, slightly to moderately vesicular.
20		50/10"	R	95	7		
							Stopped drilling at 20.8 feet. No groundwater observed. NR = No Recovery
25							

This boring log represents the conditions encountered on the date of drilling at this particular location. No other warranty is expressed or implied to the actual conditions which may exist within the vicinity of this boring location.

TEST BORING LOG

BORING NO. 478+00 DT
PROJECT NAME: Dam Repair
Principal Spillway at McMicken Dam
LOCATION: Sta. 478+08; 14' L of Offset Fence Post
DRILL EQUIPMENT: CME 55

DATE: 8-20-03 **BY:** DM
SHEET NO. 1 **OF** 1
GROUND ELEV. 1339.53' (NGVD 29)
W.T. ELEV. None Encountered
DRILLER: D & S Drilling

Depth, feet	Blows/Foot C	Blows/Foot N/R	Sample Type	Dry Density, pcf	Water Content, %	Unified Classification	Description
		15	R	111	4	SC	Fill: Clayey Sand, Trace to Some Gravel; brown, nearly dry, medium dense, well compacted, medium plasticity fines.
		18	R	113	7		
		36	R	109	5	CL	Sandy Clay, Trace of Gravel; brown, slightly damp, stiff to very stiff, moderate cementation.
		43	R	115	5		
5		50/9"	R	112	5		
		37	R	114	4		
		31	R	113	1	SP-SM	Gravelly Sand, Some Silt; brown, nearly dry, medium dense, non-plastic fines.
		21	R	89	4		
		29	R	103	7	ML	Sandy Silt, Trace Gravel; brown, nearly dry, stiff, low plasticity, lightly cemented.
		44	R	117	6	SC	Clayey Sand, Trace to Some Gravel; brown, nearly dry, dense, light cementation.
10							
							Stopped at 10 feet. No groundwater observed.
15							
20							
25							

This boring log represents the conditions encountered on the date of drilling at this particular location. No other warranty is expressed or implied to the actual conditions which may exist within the vicinity of this boring location.

TEST BORING LOG

BORING NO. 478+75 U
PROJECT NAME: Dam Repair
Principal Spillway at McMicken Dam
LOCATION: Sta. 478+68; Upstream Toe
DRILL EQUIPMENT: CME 55

DATE: 8-20-03 **BY:** DM
SHEET NO. 1 **OF** 1
GROUND ELEV. 1340.00' (NGVD 29)
W.T. ELEV. None Encountered
DRILLER: D & S Drilling

Depth, feet	Blows/Foot C	Blows/Foot N/R	Sample Type	Dry Density, pcf	Water Content, %	Unified Classification	Description
		19	R	108	2	SC	Fill: Clayey Sand, Trace to Some Gravel; brown, nearly dry, dense, well compacted, medium plasticity fines.
		50/11"	R	108	4		
		50	R	117	4		
		50/8"	R	113	4	SC	Clayey Sand, Trace to Some Gravel; brown, nearly dry, medium dense to dense, light cementation.
5		38	R	109	4		
		27	R	101	4		
		30	R	111	2		
		29	R	96	4		
		25	R	107	4	ML	Sandy Silt, Trace Gravel; brown, nearly dry, stiff, low plasticity, lightly cemented.
		34	R	105	4	SC	Clayey Sand, Trace to Some Gravel; brown, nearly dry, dense, light cementation.
10							
							Stopped at 10 feet. No groundwater observed.
15							
20							
25							

This boring log represents the conditions encountered on the date of drilling at this particular location. No other warranty is expressed or implied to the actual conditions which may exist within the vicinity of this boring location.

TEST BORING LOG

BORING NO. 478+75 C
PROJECT NAME: Dam Repair
Principal Spillway at McMicken Dam
LOCATION: Sta. 478+68; 8' 6" L
DRILL EQUIPMENT: CME 55

DATE: 8-19-03 **BY:** DM
SHEET NO. 1 **OF** 2
GROUND ELEV. 1360.80' (NGVD 29)
W.T. ELEV. None Encountered
DRILLER: D & S Drilling

Depth, feet	Blows/Foot C	Blows/Foot N/R	Sample Type	Dry Density, pcf	Water Content, %	Unified Classification	Description
						SC	Fill: Clayey Sand, Trace to Some Gravel; brown, nearly dry, dense, well compacted, medium plasticity fines.
5							
10							
15							
20							
25		50/6"	R	118	4		
							- continued -

This boring log represents the conditions encountered on the date of drilling at this particular location. No other warranty is expressed or implied to the actual conditions which may exist within the vicinity of this boring location.

TEST BORING LOG

BORING NO. 478+75 C
PROJECT NAME: Dam Repair
Principal Spillway at McMicken Dam
LOCATION: Sta. 478+68; 8' 6" L
DRILL EQUIPMENT: CME 55

DATE: 8-19-03 **BY:** DM
SHEET NO. 2 **OF** 2
GROUND ELEV. 1360.80' (NGVD 29)
W.T. ELEV. None Encountered
DRILLER: D & S Drilling

Depth, feet	Blows/Foot C	Blows/Foot N/R	Sample Type	Dry Density, pcf	Water Content, %	Unified Classification	Description
		50/6"	R	101	4	SC	Fill: Clayey Sand, Trace to Some Gravel; - continued
		50/8"	R	118	4		
		38	R	118	2	SP-SM	Gravelly Sand, Some Silt; brown, nearly dry, very dense, non-plastic fines.
		50	R	116	3		
		45	R	94	4	SM	Silty Sand, Some Gravel; brown, nearly dry, dense, non-plastic to low plasticity fines.
30		50	R	103	5		
						CL	Sandy Clay, Trace of Gravel; brown, slightly damp, very stiff, moderate cementation.
							Stopped at 30 feet.
							No groundwater observed.
35							Note: First attempt was drilled at Sta. 478+65, 9' R, Elev. 1360.56. Hit filter cloth and washed gravel 7'. Moved to upstream crest.
40							
45							
50							

This boring log represents the conditions encountered on the date of drilling at this particular location. No other warranty is expressed or implied to the actual conditions which may exist within the vicinity of this boring location.

TEST BORING LOG

BORING NO. 478+75
PROJECT NAME: Dam Repair
Principal Spillway at McMicken Dam
LOCATION: Sta. 478+67.9; R56' (ML)
DRILL EQUIPMENT: CME 55

DATE: 6-18-03 **BY:** DM
SHEET NO. 1 **OF** 1
GROUND ELEV. 1341.33' (NGVD 29)
W.T. ELEV. None Encountered
DRILLER: D & S Drilling

Depth, feet	Blows/Foot C	Blows/Foot N/R	Sample Type	Dry Density, pcf	Water Content, %	Unified Classification	Description
		18	R	106	5	SC	Fill: Clayey Sand, Some Gravel; brown, nearly dry, dense to very dense, medium plasticity fines.
		50/4"	R	105	5		
5		50/7"	R	106	5		
		50/6"	R	NR			
10		35	R	118	3	SC/SM	Clayey to Silty Sand, Some Gravel; brown, nearly dry, medium dense to dense, low plasticity fines.
		50/9"	R	100	10	SC	Clayey Sand, Some Gravel; brown, slightly damp, very dense, light cementation, medium plasticity fines, slightly to moderately vesicular.
15		50/9"	R	96	6		
20		50/8"	R	106	4	SP	Sand, Trace Gravel and Silt; brown, nearly dry, very dense, non-plastic.
							Stopped drilling at 20.7 feet. No groundwater observed. NR = No Recovery
25							

This boring log represents the conditions encountered on the date of drilling at this particular location. No other warranty is expressed or implied to the actual conditions which may exist within the vicinity of this boring location.

TEST BORING LOG

BORING NO. 478+75 DT **DATE:** 8-20-03 **BY:** DM
PROJECT NAME: Dam Repair **SHEET NO.** 1 **OF** 1
Principal Spillway at McMicken Dam **GROUND ELEV.** 1340.00' (NGVD 29)
LOCATION: Sta. 478+68; 14' L of Offset Fence Post Align. **W.T. ELEV.** None Encountered
DRILL EQUIPMENT: CME 55 **DRILLER:** D & S Drilling

Depth, feet	Blows/Foot C	Blows/Foot N/R	Sample Type	Dry Density, pcf	Water Content, %	Unified Classification	Description
		50	R	119	3	SC	Fill: Clayey Sand, Trace to Some Gravel; brown, nearly dry, medium dense to dense, well compacted, medium plasticity fines.
		39	R	118	6		
		28	R	110	6		
		26	R	114	6		
5		26	R	105	6	SC-SM	Clayey Silty Sand, Trace to Some Gravel; brown, nearly dry, medium dense to very dense, light cementation.
		50/9"	R	113	6		
		50/9"	R	110	5		
		21	R	119	5		
		22	R	118	4		
		14	R	94	3		
10							Stopped at 10 feet. No groundwater observed.
15							
20							
25							

This boring log represents the conditions encountered on the date of drilling at this particular location. No other warranty is expressed or implied to the actual conditions which may exist within the vicinity of this boring location.

TEST BORING LOG

BORING NO. 479+50 U
PROJECT NAME: Dam Repair
Principal Spillway at McMicken Dam
LOCATION: Sta. 479+38; Upstream Toe
DRILL EQUIPMENT: CME 55

DATE: 8-20-03 **BY:** DM
SHEET NO. 1 **OF** 1
GROUND ELEV. 1341.12' (NGVD 29)
W.T. ELEV. None Encountered
DRILLER: D & S Drilling

Depth, feet	Blows/Foot C	Blows/Foot N/R	Sample Type	Dry Density, pcf	Water Content, %	Unified Classification	Description
		34	R	112	3	CL	Fill: Sandy Clay, Trace Gravel; brown, nearly dry, very stiff, medium plasticity.
		50/10"	R	120	4		
		50/7"	R	109	6		
		38	R	113	4		
5		33	R	111	4	CL	Sandy Clay, Trace of Gravel; brown, slightly damp, stiff, moderate cementation.
		26	R	108	4		
		46	R	107	4		
		18	R	112	2	SP-SM	Gravelly Sand, Some Silt; brown, nearly dry, medium dense, non-plastic fines.
		27	R	108	2		
		50/3"	R	*	9		
10						SC	Clayey Sand, Trace to Some Gravel; brown, nearly dry, very dense, light cementation.
							Stopped at 9.3 feet. No groundwater observed.
15							* Sample too disturbed to determine density.
20							
25							

This boring log represents the conditions encountered on the date of drilling at this particular location. No other warranty is expressed or implied to the actual conditions which may exist within the vicinity of this boring location.

TEST BORING LOG

BORING NO. 479+50 C
PROJECT NAME: Dam Repair
Principal Spillway at McMicken Dam
LOCATION: Sta. 479+38; 8' 6" L
DRILL EQUIPMENT: CME 55

DATE: 8-19-03 **BY:** DM
SHEET NO. 1 **OF** 2
GROUND ELEV. 1362.80' (NGVD 29)
W.T. ELEV. None Encountered
DRILLER: D & S Drilling

Depth, feet	Blows/Foot C	Blows/Foot N/R	Sample Type	Dry Density, pcf	Water Content, %	Unified Classification	Description
		22	R	120	2	SC	Fill: Clayey Sand, Trace to Some Gravel; brown, nearly dry, medium dense to very dense, well compacted, medium plasticity fines.
5		36	R	116	4		
10		50/8"	R	113	6		
15		50/5"	R	112	5		
20		50/6"	R	123	6		
		50/5"	N		9		
		70/6"	N		5		
		50/4"	N		5		
		50/4"	N		4		
		50	N		4		
25		45	R	110	10	SM	Silty Sand, Some Gravel; brown, nearly dry, dense, non-plastic to low plasticity fines.

- continued -

This boring log represents the conditions encountered on the date of drilling at this particular location. No other warranty is expressed or implied to the actual conditions which may exist within the vicinity of this boring location.

TEST BORING LOG

BORING NO. 479+50 C
PROJECT NAME: Dam Repair
Principal Spillway at McMicken Dam
LOCATION: Sta. 479+38; 8' 6" L
DRILL EQUIPMENT: CME 55

DATE: 8-19-03 **BY:** DM
SHEET NO. 2 **OF** 2
GROUND ELEV. 1362.80' (NGVD 29)
W.T. ELEV. None Encountered
DRILLER: D & S Drilling

Depth, feet	Blows/Foot C	Blows/Foot N/R	Sample Type	Dry Density, pcf	Water Content, %	Unified Classification	Description
		44	R	107	3	SM	Silty Sand, Some Gravel; - continued
		50/6"	R	97	4	SP	Sand, Some Silt and Gravel; brown, nearly dry, dense, non-plastic fines.
		40	R	113	1		
		50	R	107	10	SC	Clayey Sand, Trace to Some Gravel; brown, nearly dry, very dense, light cementation.
		50/4"	R	NR			
30							30
							Stopped at 29.3 feet.
							No groundwater observed.
							NR = No Recovery
							Note: First attemp to drill at Sta. 479+38, 9' R, Elev. 1360.69. Hit filter cloth and washed gravel 6'. Second attempt to drill at Sta. 479+43, 4' R, Elev. 1360.69. Hit filter cloth and washed gravel 7' and third attempt to drill at Sta. 479+44, 4' L, Elev. 1362.00. Hit cloth and washed gravel 7'.
35							35
40							40
45							45
50							50

This boring log represents the conditions encountered on the date of drilling at this particular location. No other warranty is expressed or implied to the actual conditions which may exist within the vicinity of this boring location.

TEST BORING LOG

BORING NO. 479+50
PROJECT NAME: Dam Repair
Principal Spillway at McMicken Dam
LOCATION: Sta. 479+47.3; R58' (ML)
DRILL EQUIPMENT: CME 55

DATE: 6-16-03 **BY:** DM
SHEET NO. 1 **OF** 1
GROUND ELEV. 1339.60' (NGVD 29)
W.T. ELEV. None Encountered
DRILLER: D & S Drilling

Depth, feet	Blows/Foot C	Blows/Foot N/R	Sample Type	Dry Density, pcf	Water Content, %	Unified Classification	Description
		26	R	114	3	SC	Fill: Clayey Sand, Some Gravel; brown, nearly dry, medium dense, medium plasticity fines.
		37	R	112	5	SC	Gravelly Sand, Some Clay; brown, nearly dry, medium dense, medium plasticity fines.
5		50/8"	R	107	4	SC	Fill: Clayey Sand, Some Gravel; brown, nearly dry, very dense, medium plasticity fines. (old fill ?)
		50/8"	R	114	4		
10		43	R	111	3	CL	Sandy Clay, Trace Gravel; brown, slightly damp, stiff to very stiff, light cementation, medium plasticity, slightly to moderately vesicular.
		35	R	*	7		
15		47	R	97	6		
20		50/10"	R	113	2	SP	Sand, Trace Gravel and Silt; brown, nearly dry, very dense, non-plastic.
							Stopped drilling at 20.8 feet. No groundwater observed.
25							* Sample to disturbed to determine density.

This boring log represents the conditions encountered on the date of drilling at this particular location. No other warranty is expressed or implied to the actual conditions which may exist within the vicinity of this boring location.

TEST BORING LOG

BORING NO. 479+50 DT
PROJECT NAME: Dam Repair
Principal Spillway at McMicken Dam
LOCATION: Sta. 479+38; 14' L of Offset Fence Post Align.
DRILL EQUIPMENT: CME 55

DATE: 8-20-03 **BY:** DM
SHEET NO. 1 **OF** 1
GROUND ELEV. 1340.00' (NGVD 29)
W.T. ELEV. None Encountered
DRILLER: D & S Drilling

Depth, feet	Blows/Foot C	Blows/Foot N/R	Sample Type	Dry Density, pcf	Water Content, %	Unified Classification	Description
		27	R	112	4	SC	Fill: Clayey Sand, Trace to Some Gravel; brown, nearly dry, medum dense to dense, well compacted, medium plasticity fines.
		35	R	112	6		
		28	R	112	5		
		9	R	102	7	SC	Clayey Sand, Trace to Some Gravel; brown, nearly dry, loose, light cementation.
5		5	R	99	7		
		5	R	97	7		
		4	R	93	5		
		4	R	94	6		
		9	R	91	10		
		5	R	95	7		
10							
							Stopped at 10 feet. No groundwater observed.
15							
20							
25							

This boring log represents the conditions encountered on the date of drilling at this particular location. No other warranty is expressed or implied to the actual conditions which may exist within the vicinity of this boring location.

LABORATORY TEST RESULTS

Date: 4-Jan-04

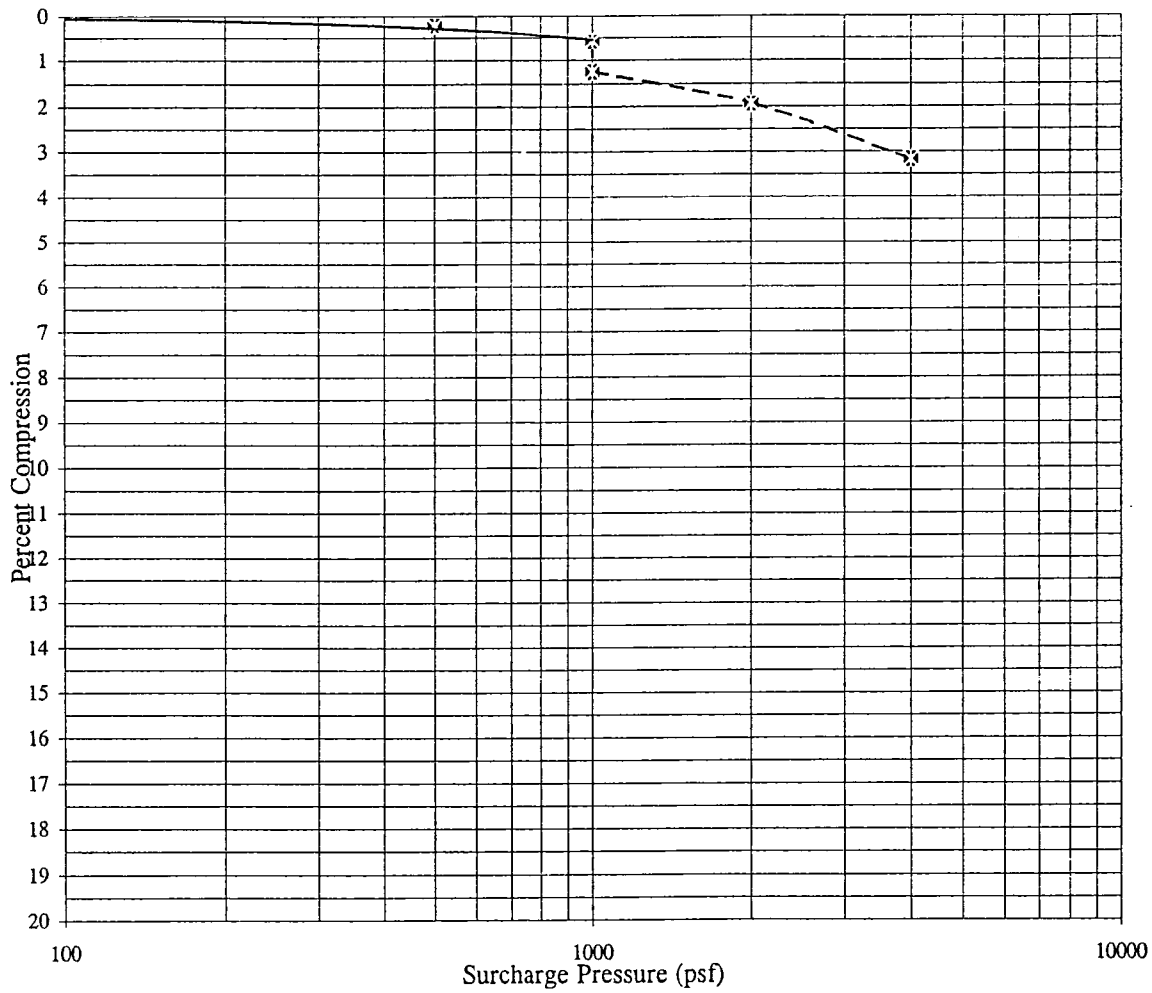
SAMPLE SOURCE: Sta. 478+00 @ 12.5'-13.5'

TESTING PERFORMED: Compression (ASTM D2434) - Driven Ring Sample

SAMPLED BY: RAM/Miller

RESULTS:

Dry Density (pcf): 109 Moisture Content (%): 3



REMARKS: Sample submerged at 1000 psf.

LABORATORY TEST RESULTS

Date: 4-Jan-04

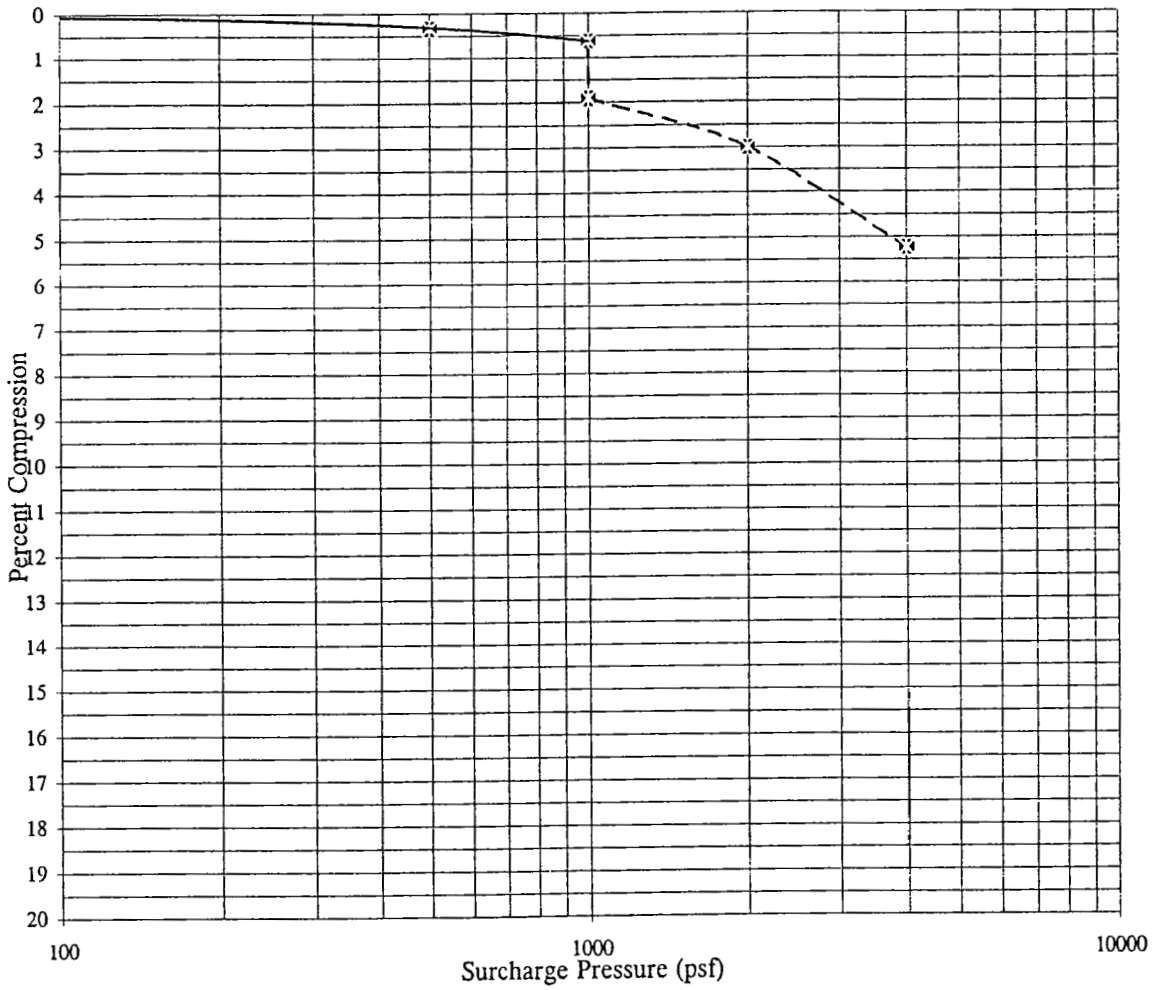
SAMPLE SOURCE: Sta. 478+75 @ 12.5'-13.5'

TESTING PERFORMED: Compression (ASTM D2434) - Driven Ring Sample

SAMPLED BY: RAM/Miller

RESULTS:

Dry Density (pcf): 100 Moisture Content (%): 10



REMARKS: Sample submerged at 1000 psf.

LABORATORY TEST RESULTS

Date: 4-Jan-04

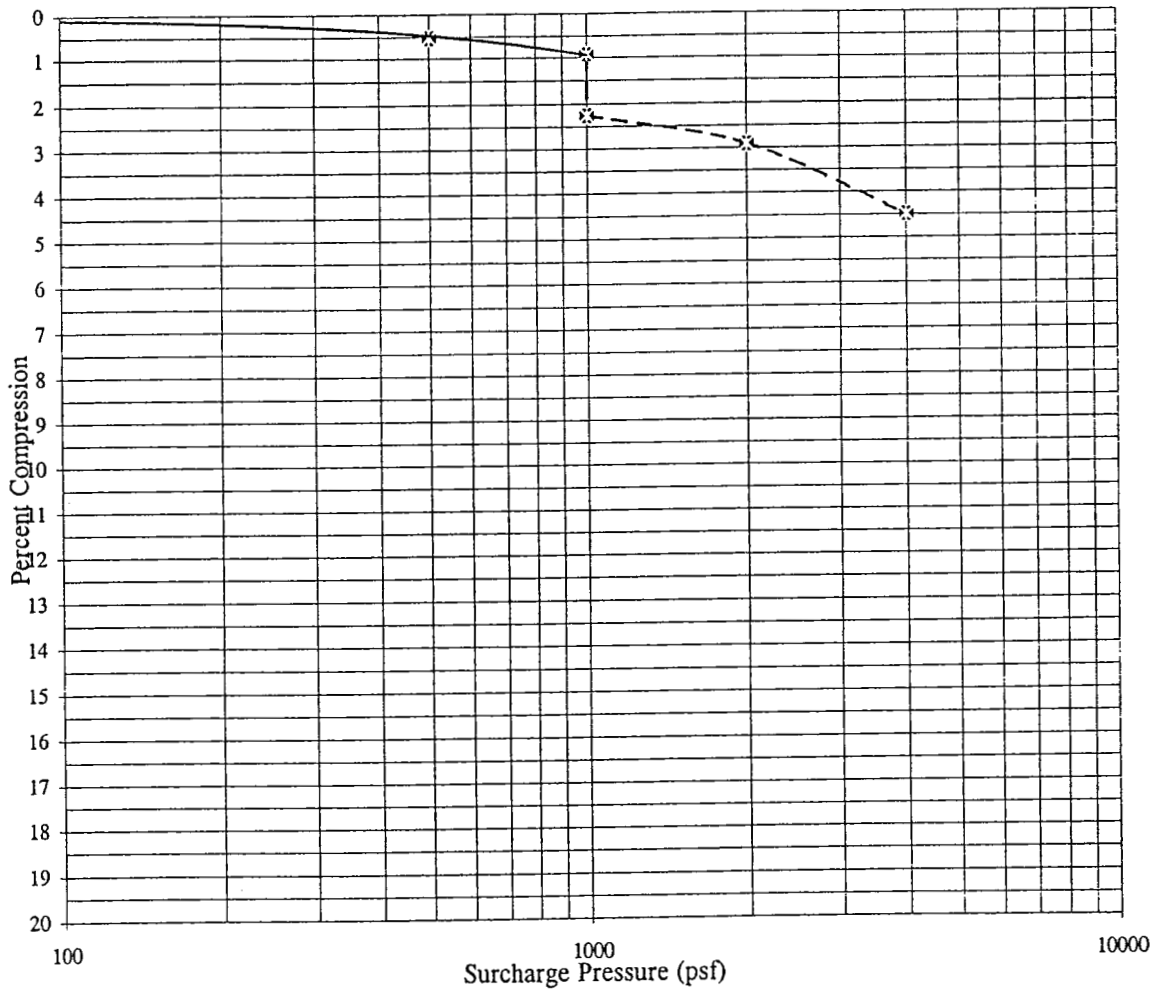
SAMPLE SOURCE: Sta. 479+50 @ 10'-11'

TESTING PERFORMED: Compression (ASTM D2434) - Driven Ring Sample

SAMPLED BY: RAM/Miller

RESULTS:

Dry Density (pcf): 111 Moisture Content (%): 3



REMARKS: Sample submerged at 1000 psf.

LABORATORY TEST RESULTS

Date: 4-Jan-04

SAMPLE SOURCE: As noted below

TESTING PERFORMED: Sieve Analysis, Percent Passing No. 200 Sieve, Atterberg Limits (ASTM C136, D1140, D4318)

SAMPLED BY: RAM/Miller

RESULTS:

Sample	Atterberg Limits		Sieve Size - Accumulative Percent Passing											Soil
Source	LL	PI	200	100	50	30	16	8	4	3/4"	1"	2"	3"	Class.*
P1 - Below														
Sand Zone	31	16	59	75	88	95	98	99	99	100				CL
P1 - West Wall														
above Hole	32	17	62	78	89	95	98	99	100					CL
P1 - West Wall														
below North Hole	21	2	35	51	68	78	86	93	98	100				SM
P1 - Cut above														
Crack	31	16	63	80	90	96	99	100						CL
P1 - South	28	12	55	70	82	88	91	93	95	100				CL
P1 - Below Crack	31	16	57	73	86	93	96	98	99	100				CL
P2 - Gravel	28	9	19	26	35	47	57	67	77	94	94	100		SC
P2	31	14	53	68	80	87	91	94	96	100				CL
P3	25	9	44	56	68	77	84	90	94	100				SC
P3 - Gravel	29	10	20	26	34	42	51	60	70	93	100			SC
C-33 Sand			1.4	3	14	39	66	89	100					SP

NP = Non-Plastic

* Unified Soil Classification System

LABORATORY TEST RESULTS

Date: 4-Jan-0

SAMPLE SOURCE: As noted below

TESTING PERFORMED: Sieve Analysis, Percent Passing No. 200 Sieve, Atterberg Limits (ASTM C136, D1140, D4318)

SAMPLED BY: RAM/Miller, Holck

RESULTS:

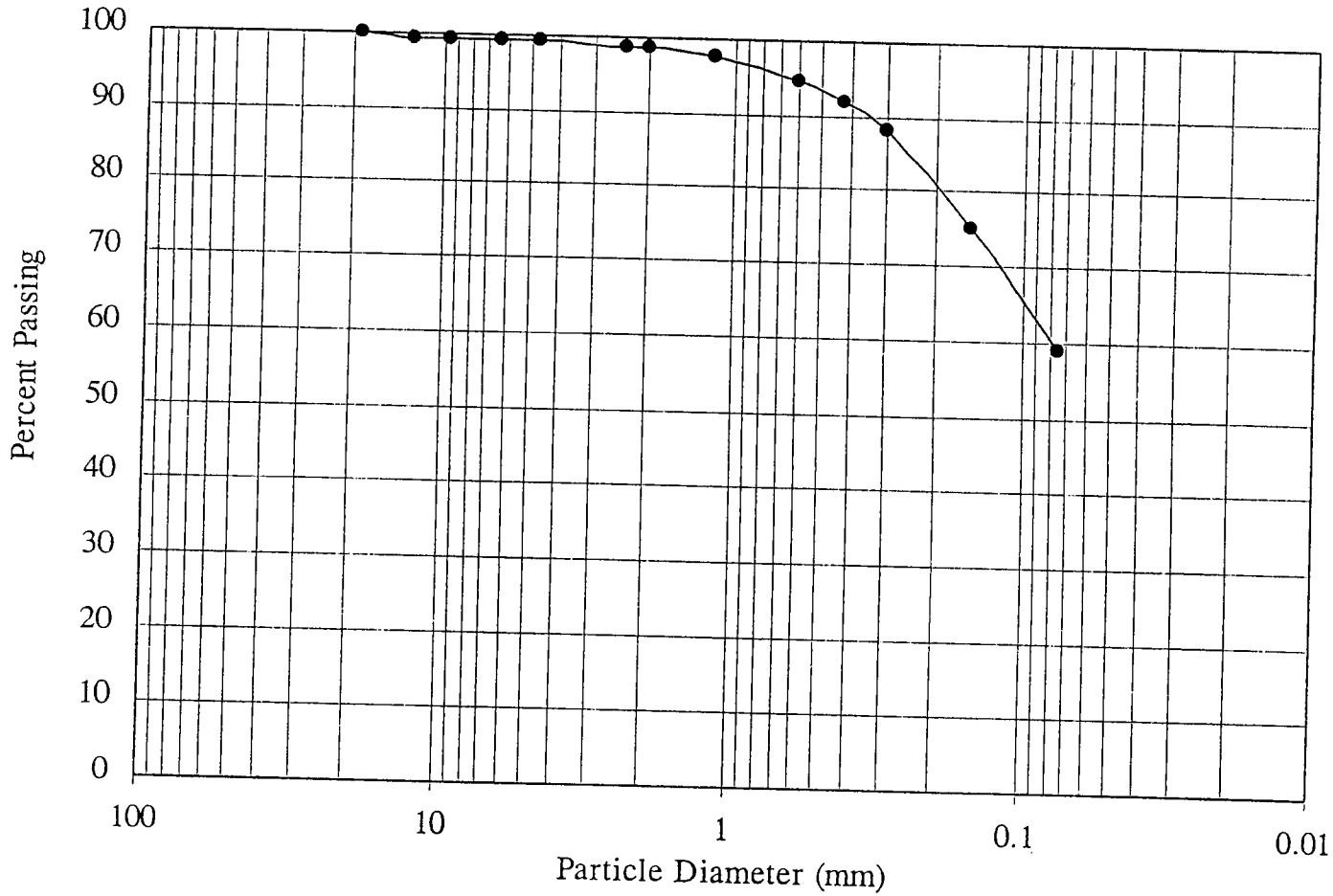
Sample	Atterberg Limits		Sieve Size - Accumulative Percent Passing											Soi
Source	LL	PI	200	100	50	30	16	8	4	3/4"	1"	2"	3"	Class
Borrow Area	21	6	47	63	77	85	91	95	97	100				SC-S
Sta. 478+00														
Stockpile	22	5	47	64	77	85	90	93	96	100				SC-S
Sta. 478+00 @ 0'-5'	29	13	43	54	64	71	77	83	89	94	94	100		SC
Sta. 478+00 @ 10'-15'	24	6	40	55	70	77	82	87	92	100				SC-S
Sta. 478+00 @ 15'-20'	29	12	37	47	58	67	75	83	90	100				SC
Sta. 478+75 @ 0'-5'	26	10	44	56	68	75	81	86	91	100				SC
Sta. 478+75 @ 5'-10'	26	10	37	49	62	70	76	81	86	100				SC
Sta. 478+75 @ 10'-15'	25	7	24	32	41	48	55	63	73	92	100			SC-S
Sta. 478+75 @ 15'-20'	28	10	47	57	67	76	82	87	93	100				SC
Sta. 479+50 @ 0'-5'	27	11	42	55	66	75	81	88	93	100				SC
Sta. 479+50 @ 5'-10'	25	8	38	51	66	75	81	87	92	100				SC
Sta. 479+50 @ 10'-15'	31	12	62	71	81	88	93	96	98	100				CL
Sta. 479+50 @ 15'-20'	34	16	62	70	78	85	90	94	97	100				CL

NP = Non-Plastic

* Unified Soil Classification System

McMicken Dam Embankment Repairs

P1 - Below Sand Zone



Liquid Limit: 31

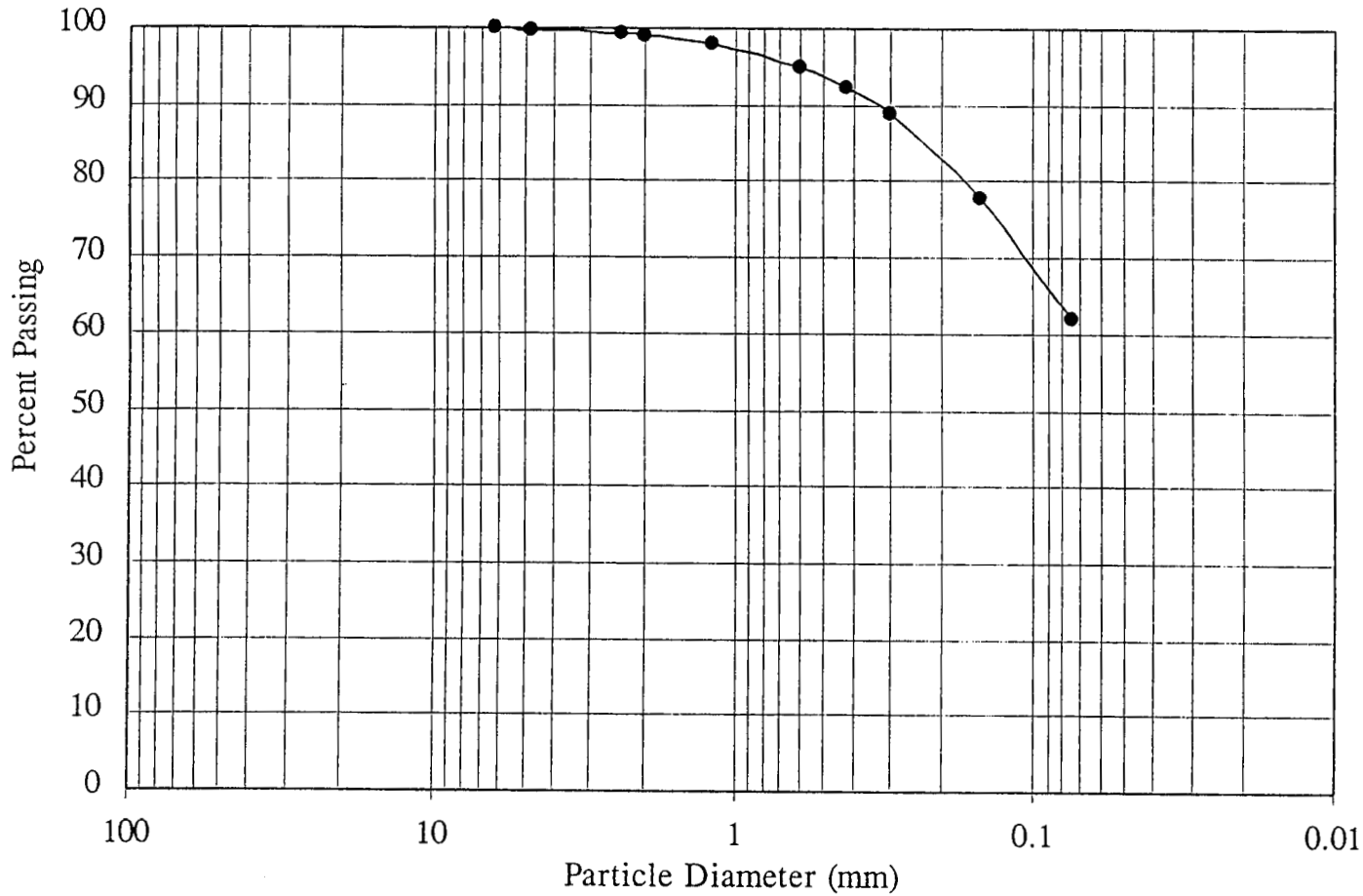
Plastic Limit: 15

Plasticity Index: 16

R.A.M. Project No. G08912

McMicken Dam Embankment Repairs

P1 - West Wall above Hole



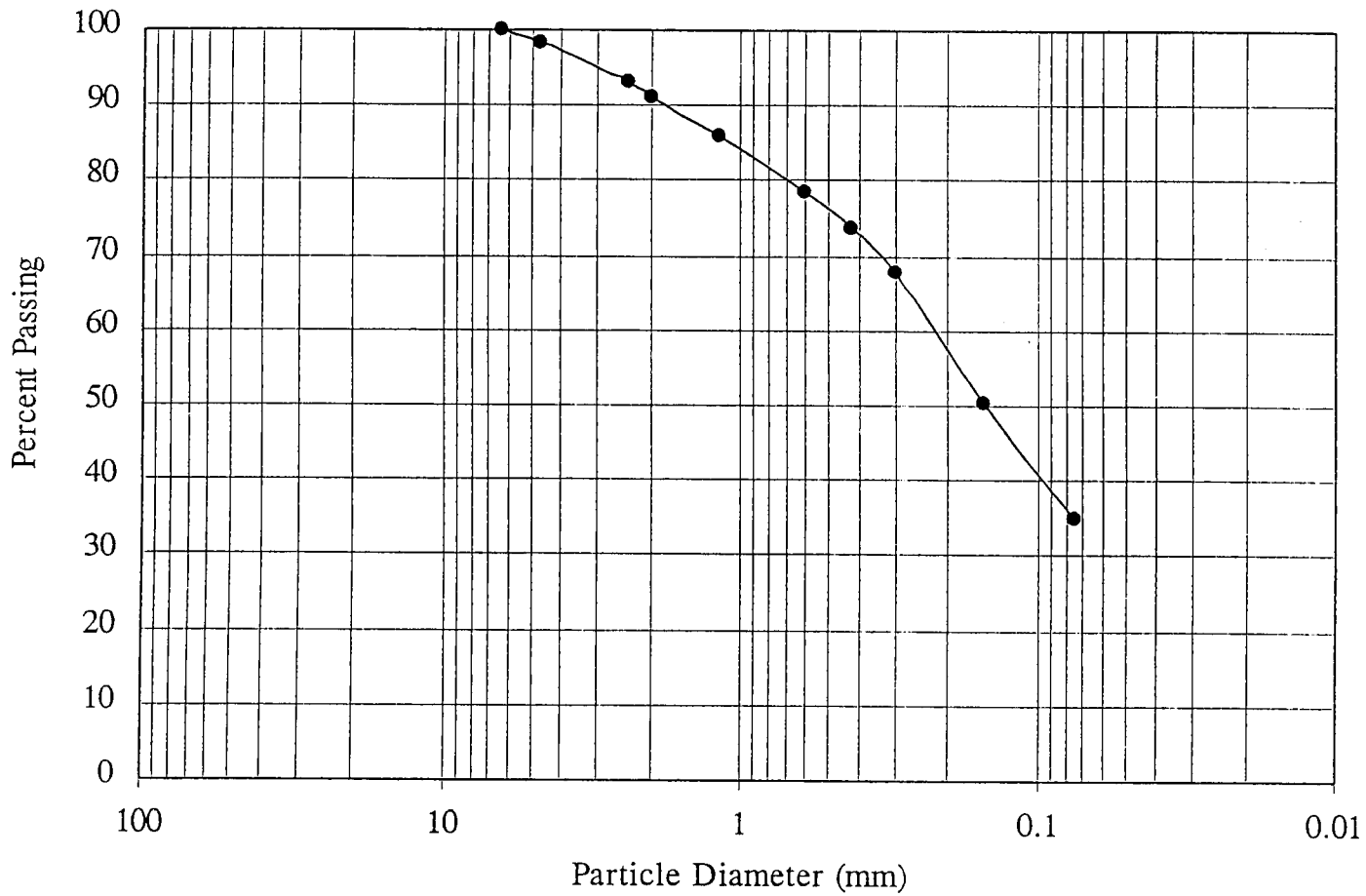
Liquid Limit: 32

Plastic Limit: 15

Plasticity Index: 17

McMicken Dam Embankment Repairs

P1 - West Wall below North Hole



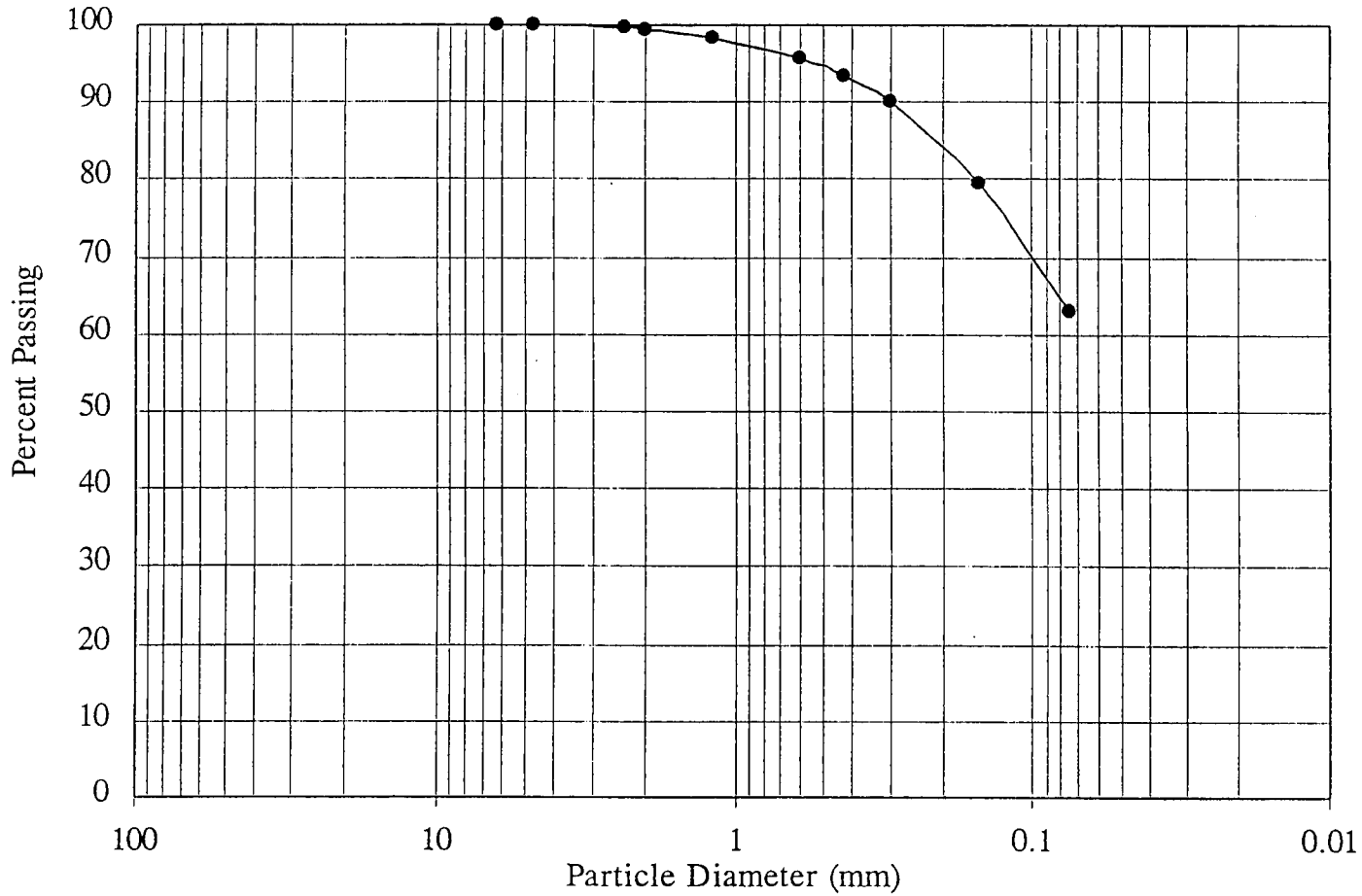
Liquid Limit: 21

Plastic Limit: 19

Plasticity Index: 2

McMicken Dam Embankment Repairs

P1 - Cut above Crack



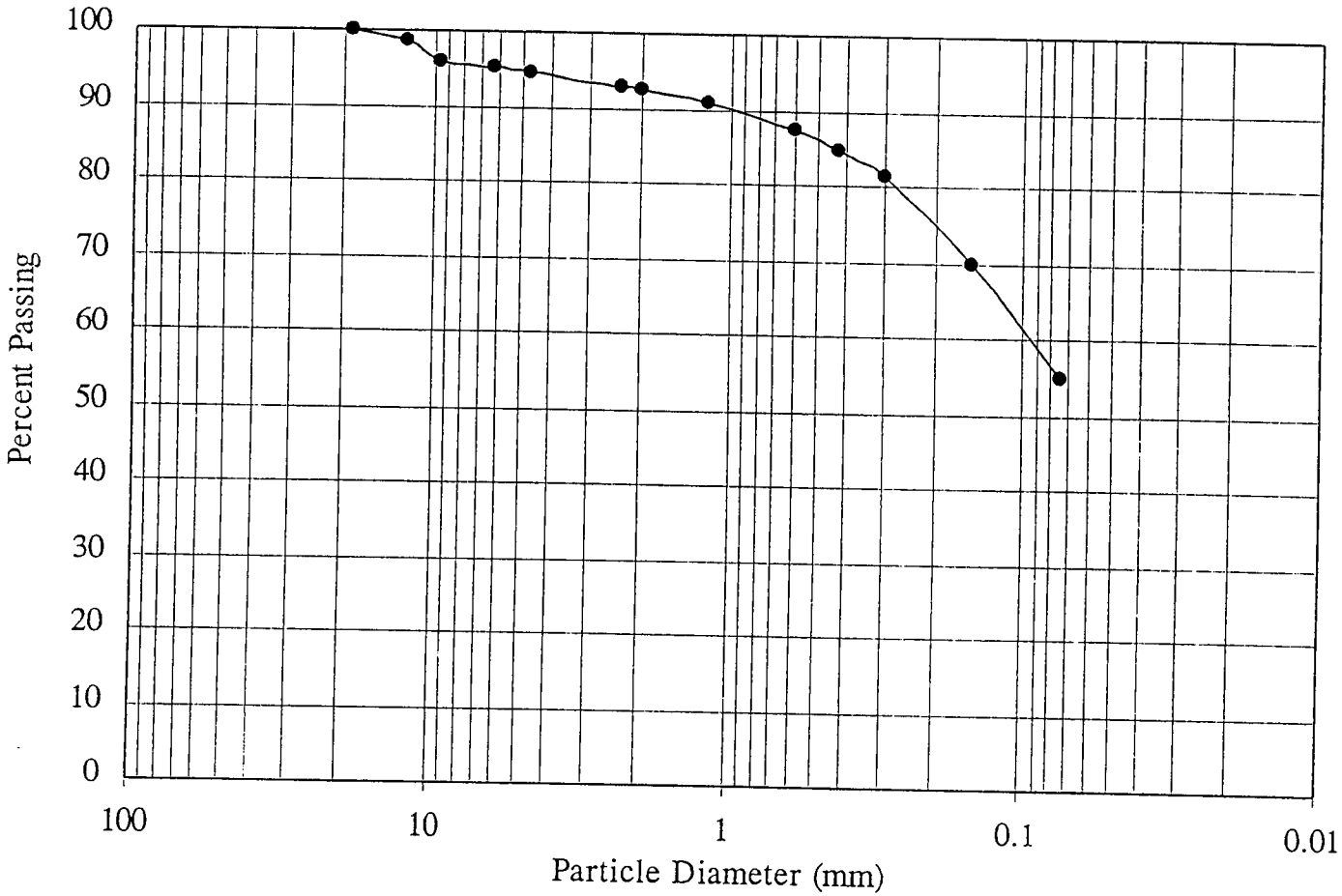
Liquid Limit: 31

Plastic Limit: 15

Plasticity Index: 16

McMicken Dam Embankment Repairs

P1 - South



Liquid Limit: 28

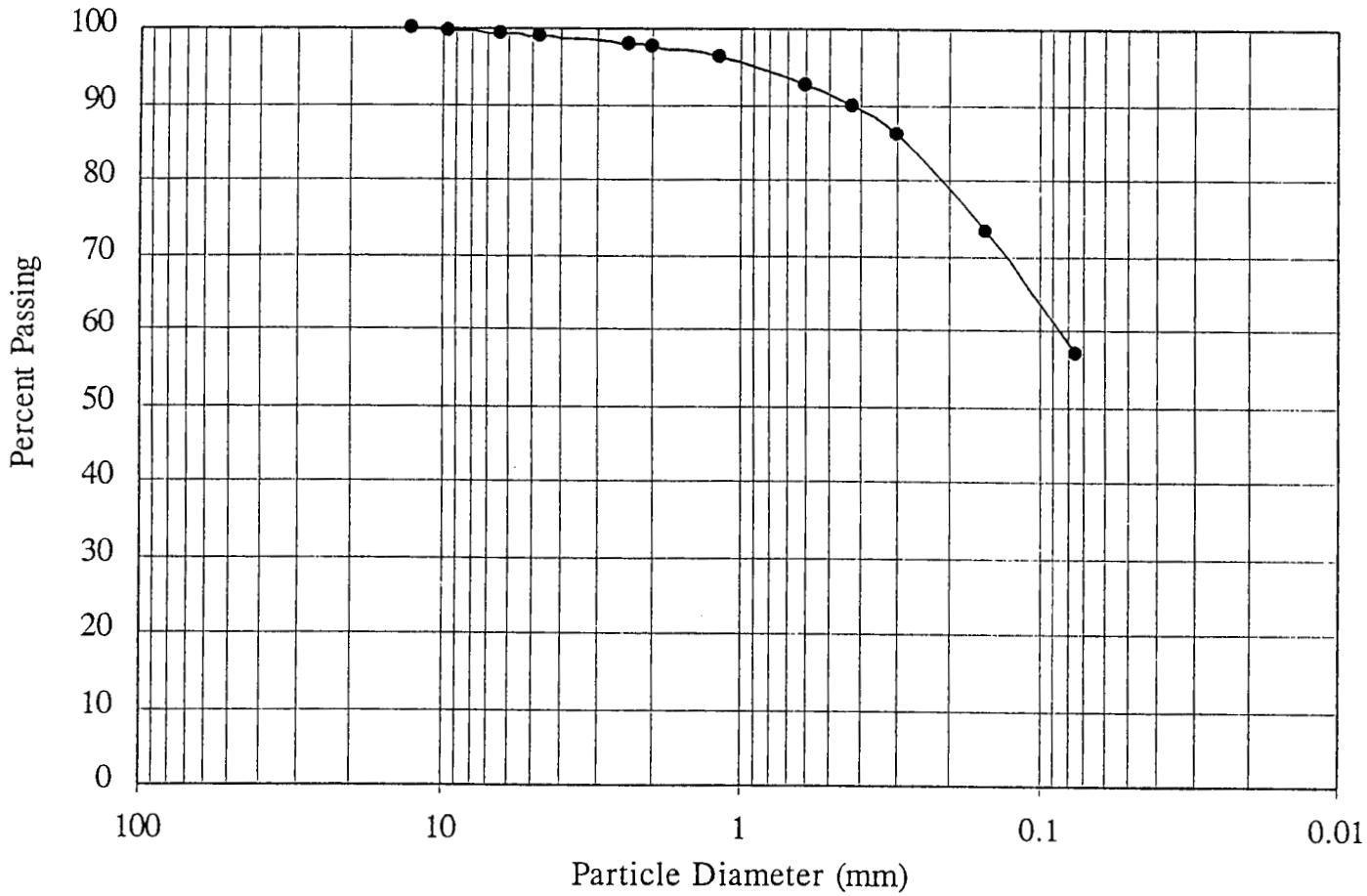
Plastic Limit: 16

Plasticity Index: 12

R.A.M. Project No. G08912

McMicken Dam Embankment Repairs

P1 - Below Crack



Liquid Limit: 31

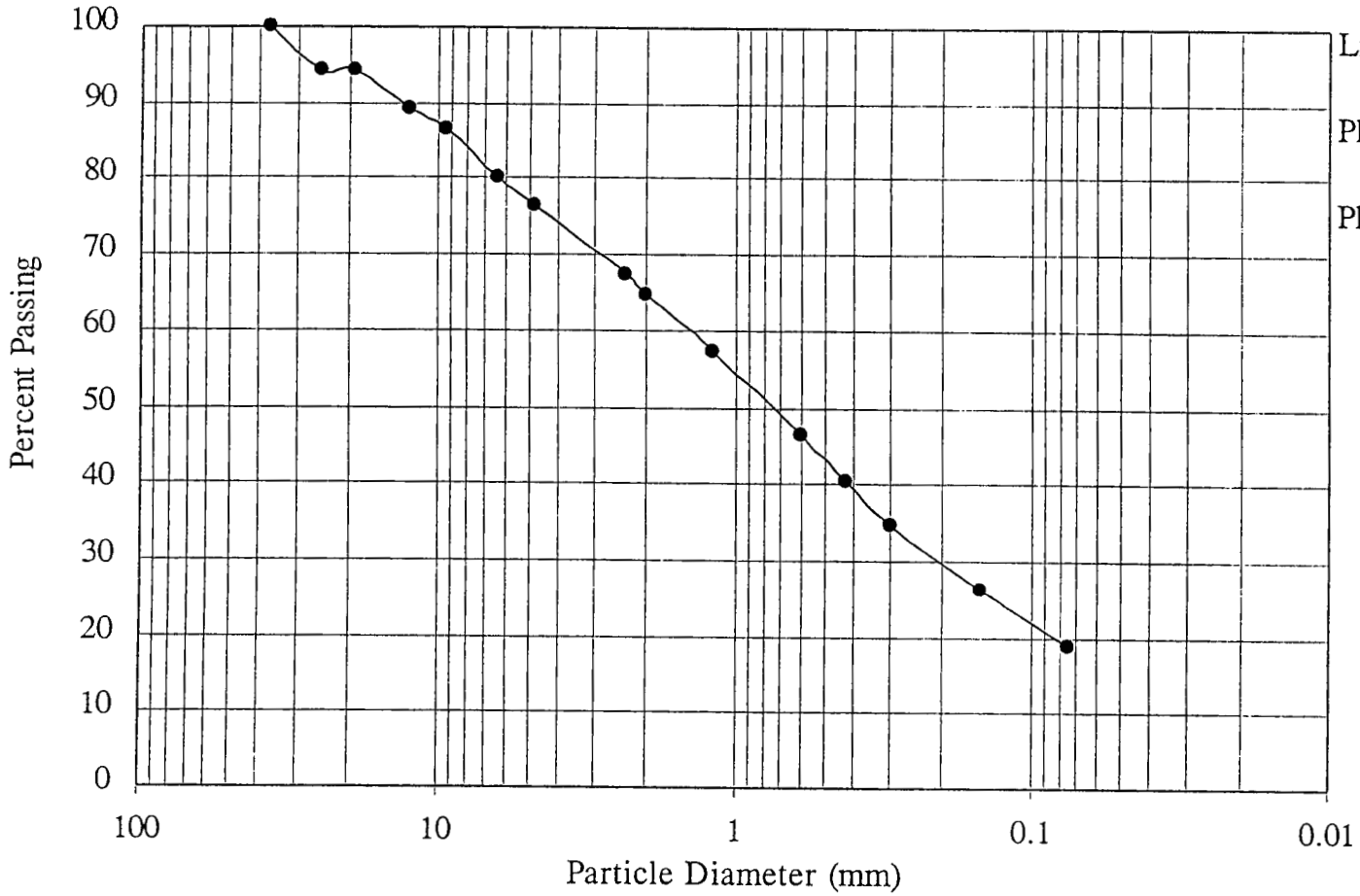
Plastic Limit: 15

Plasticity Index: 16

R.A.M. Project No. G08912

McMicken Dam Embankment Repairs

P2 - Gravel



Liquid Limit: 28

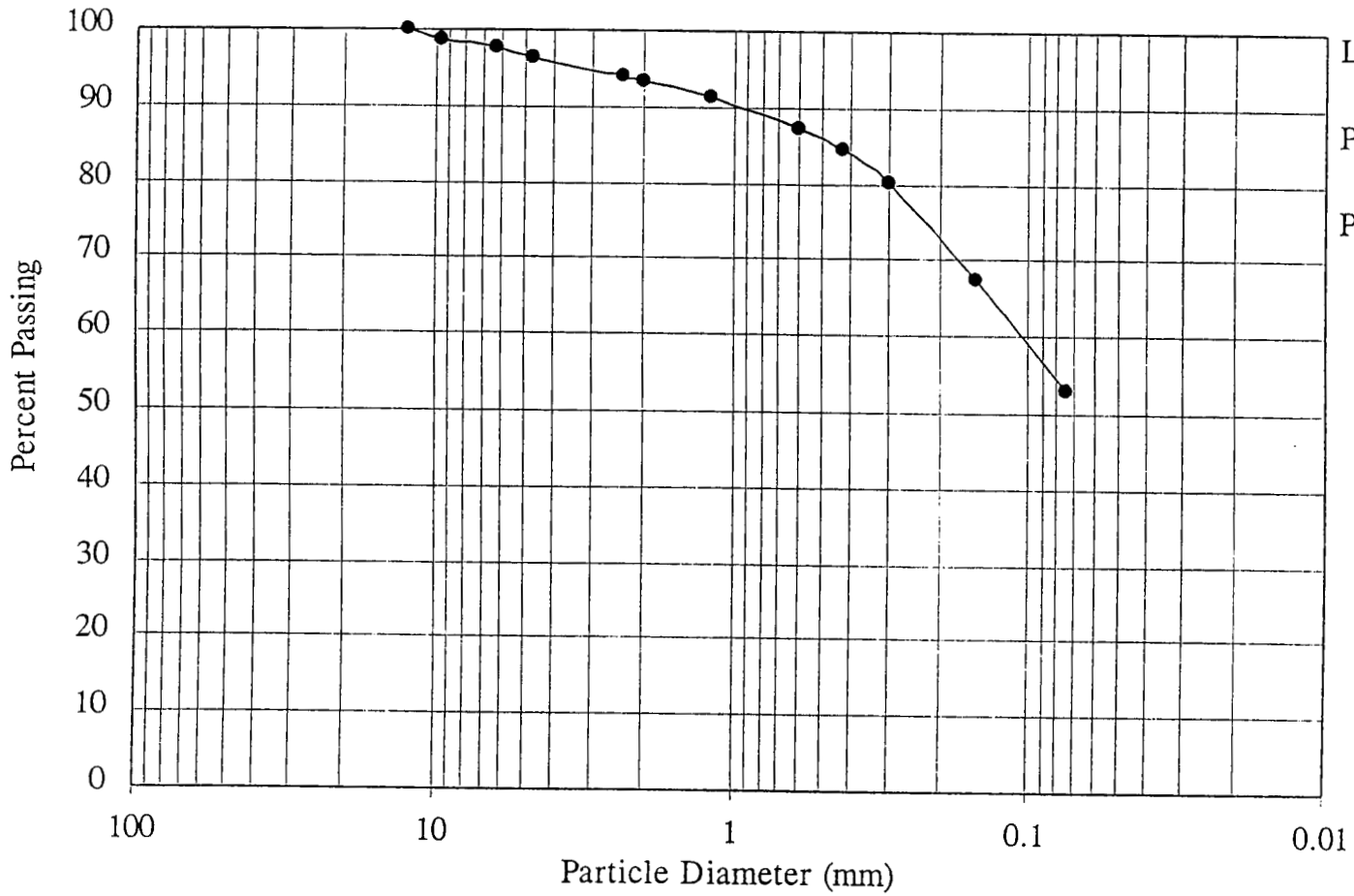
Plastic Limit: 19

Plasticity Index: 9

R.A.M. Project No. G08912

McMicken Dam Embankment Repairs

P2



Liquid Limit: 31

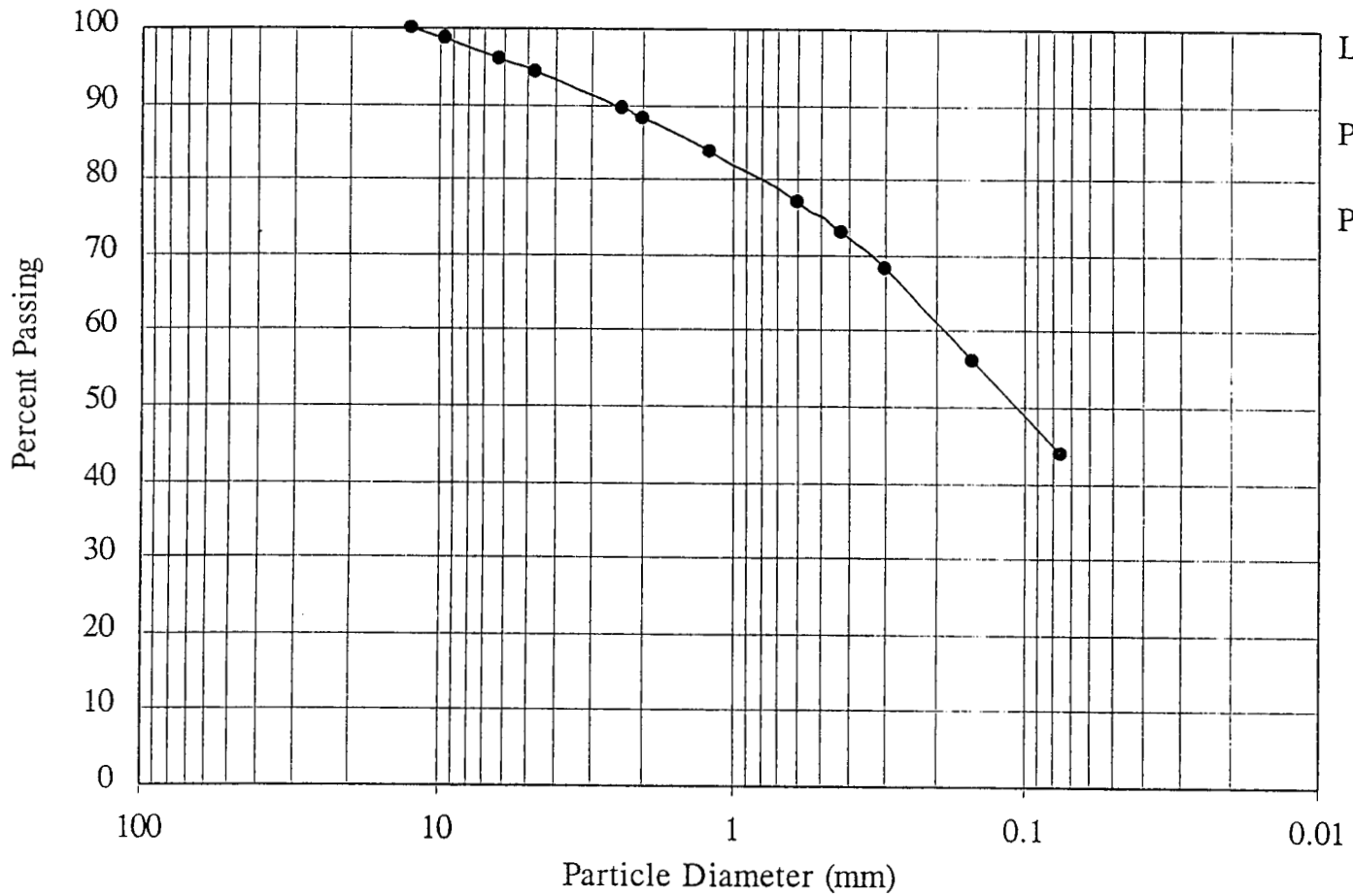
Plastic Limit: 17

Plasticity Index: 14

R.A.M. Project No. G08912

McMicken Dam Embankment Repairs

P3



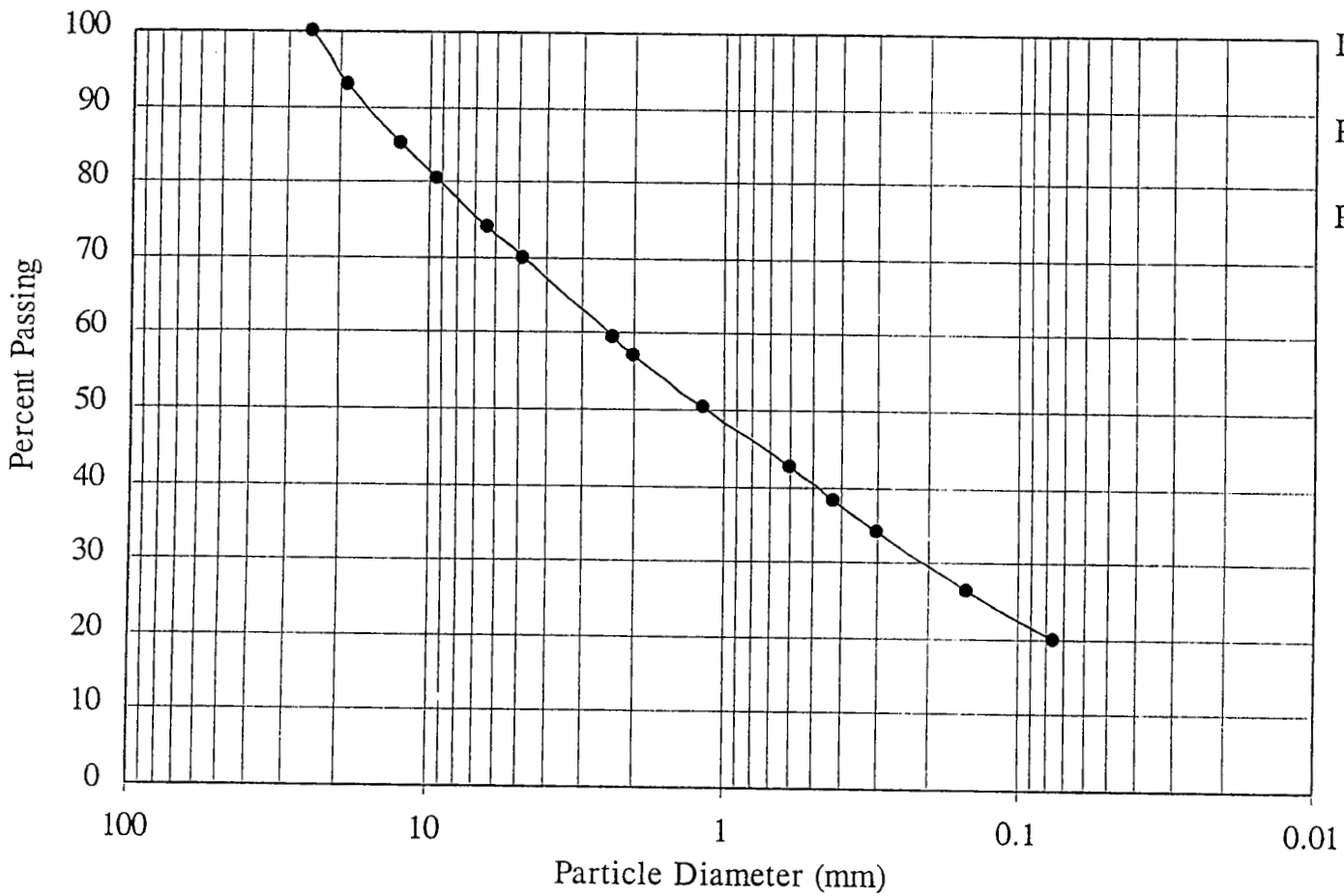
Liquid Limit: 25

Plastic Limit: 16

Plasticity Index: 9

McMicken Dam Embankment Repairs

P3 - Gravel



Liquid Limit: 29

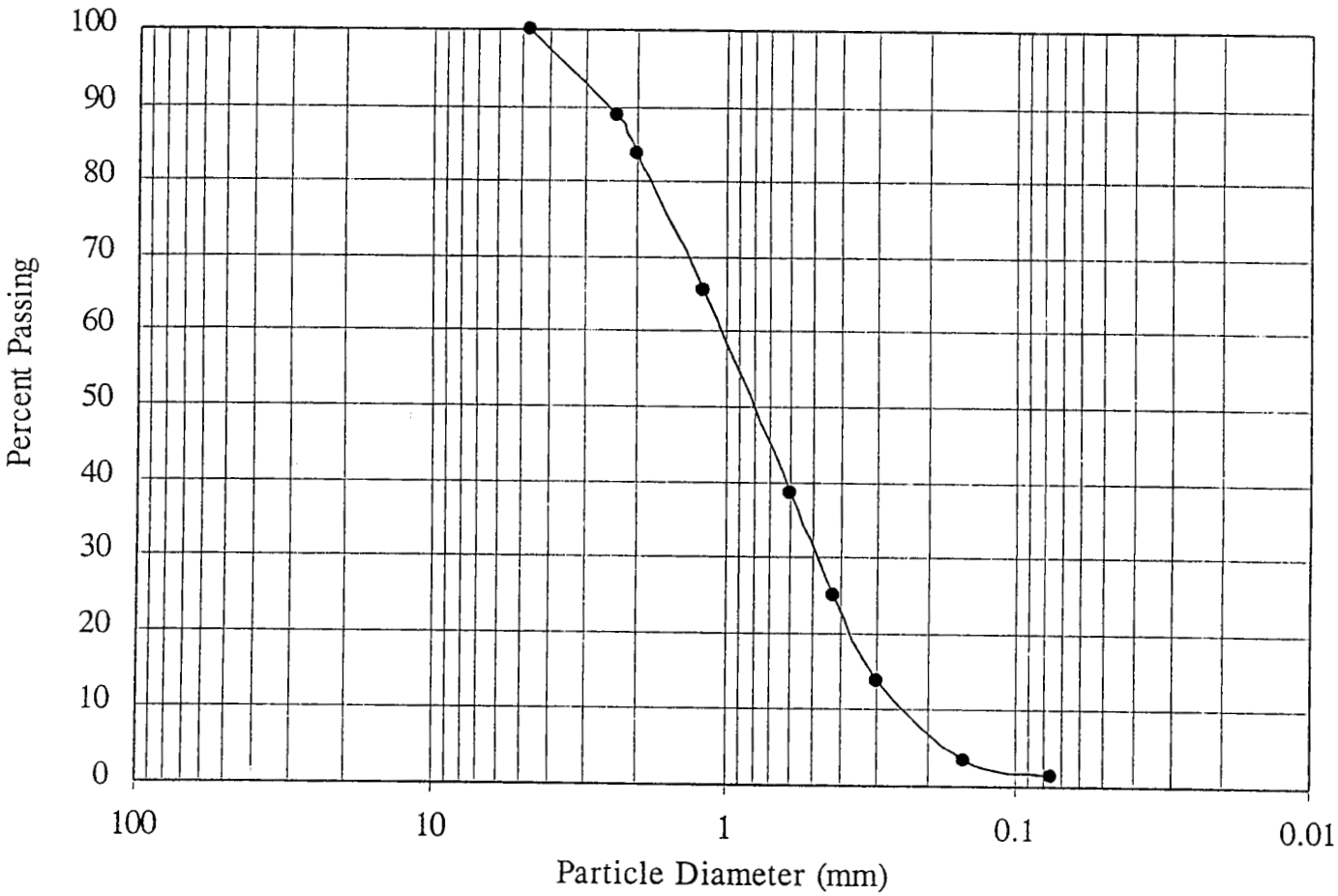
Plastic Limit: 19

Plasticity Index: 10

R.A.M. Project No. G08912

McMicken Dam Embankment Repairs

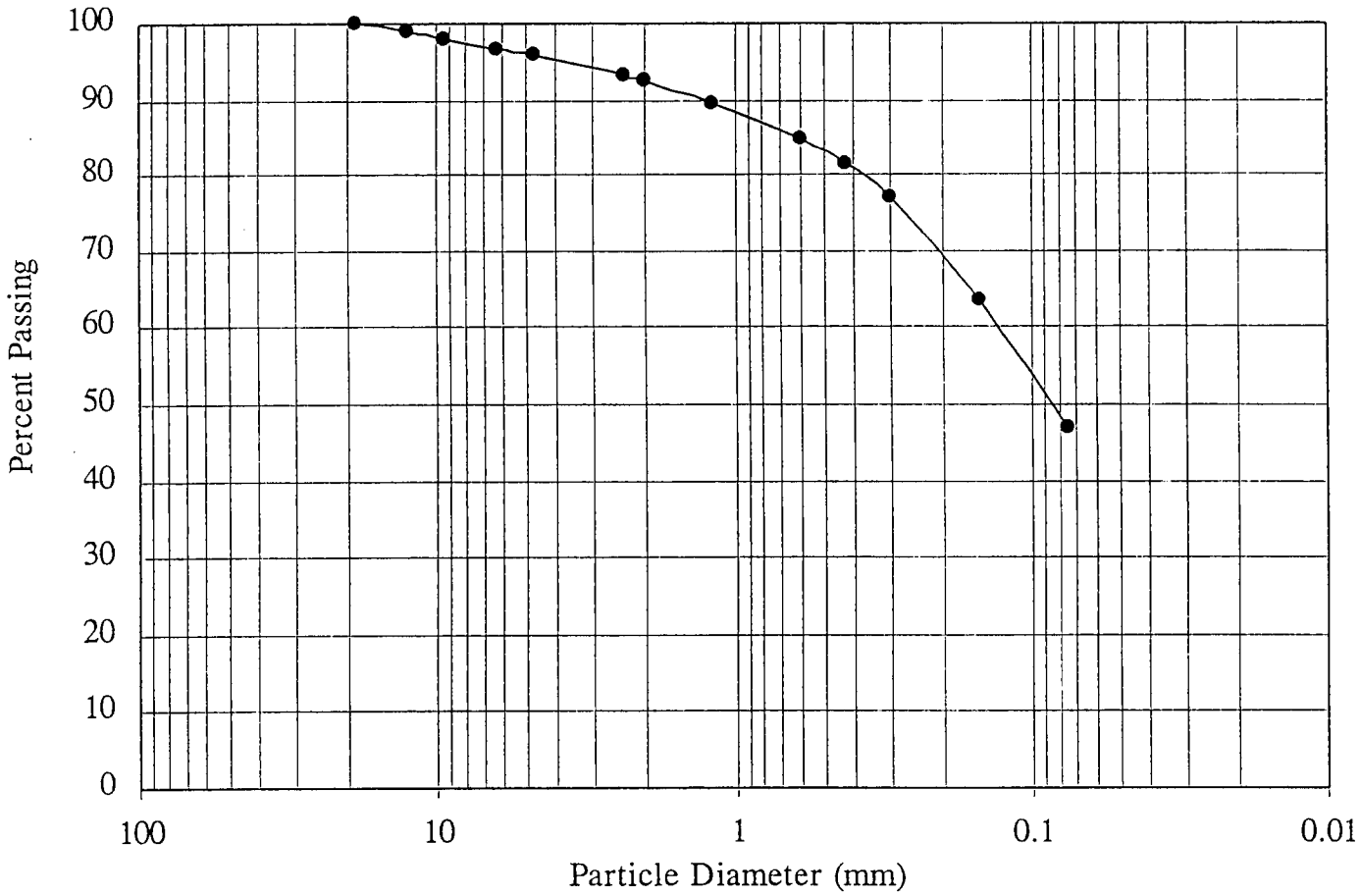
C-33 Sand



R.A.M. Project No. G08912

McMicken Dam Embankment Repairs

Sta. 478-00 Stockpile



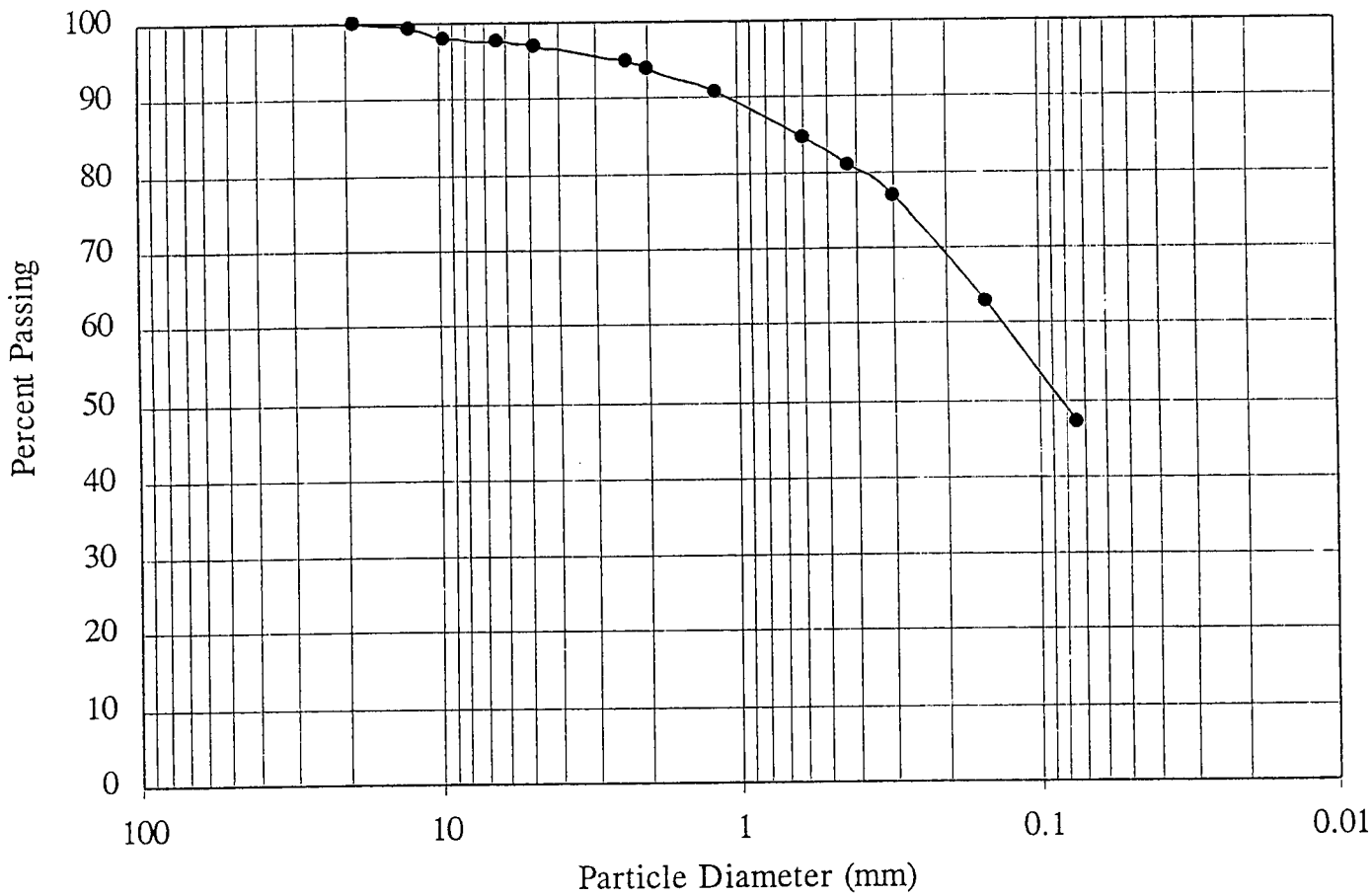
Liquid Limit: 22

Plastic Limit: 17

Plasticity Index: 5

McMicken Dam Embankment Repairs

Borrow Area



Liquid Limit: 21

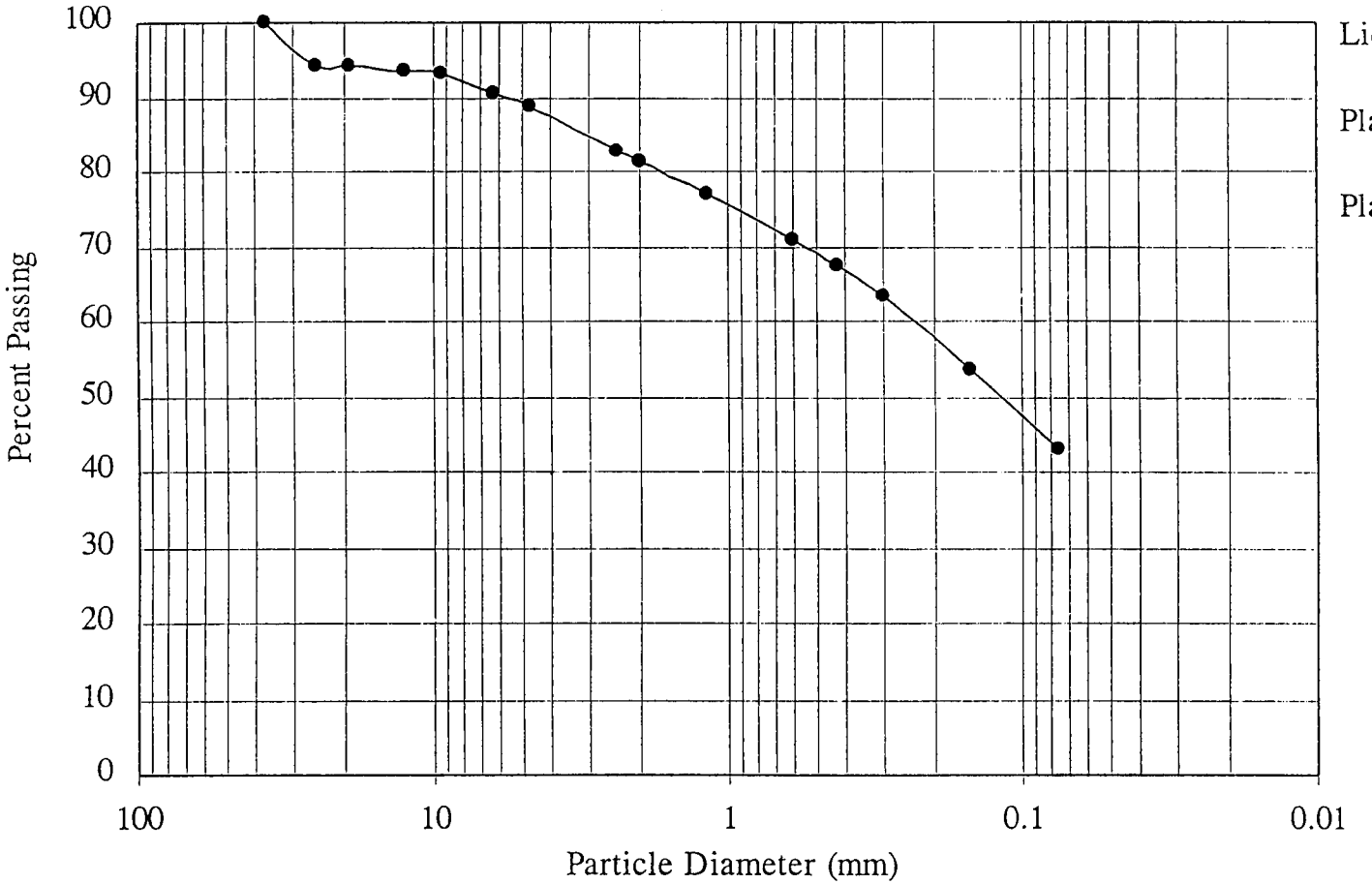
Plastic Limit: 15

Plasticity Index: 6

R.A.M. Project No. G08912

McMicken Dam Embankment Repairs

Sta. 478+00 @ 0'-5'



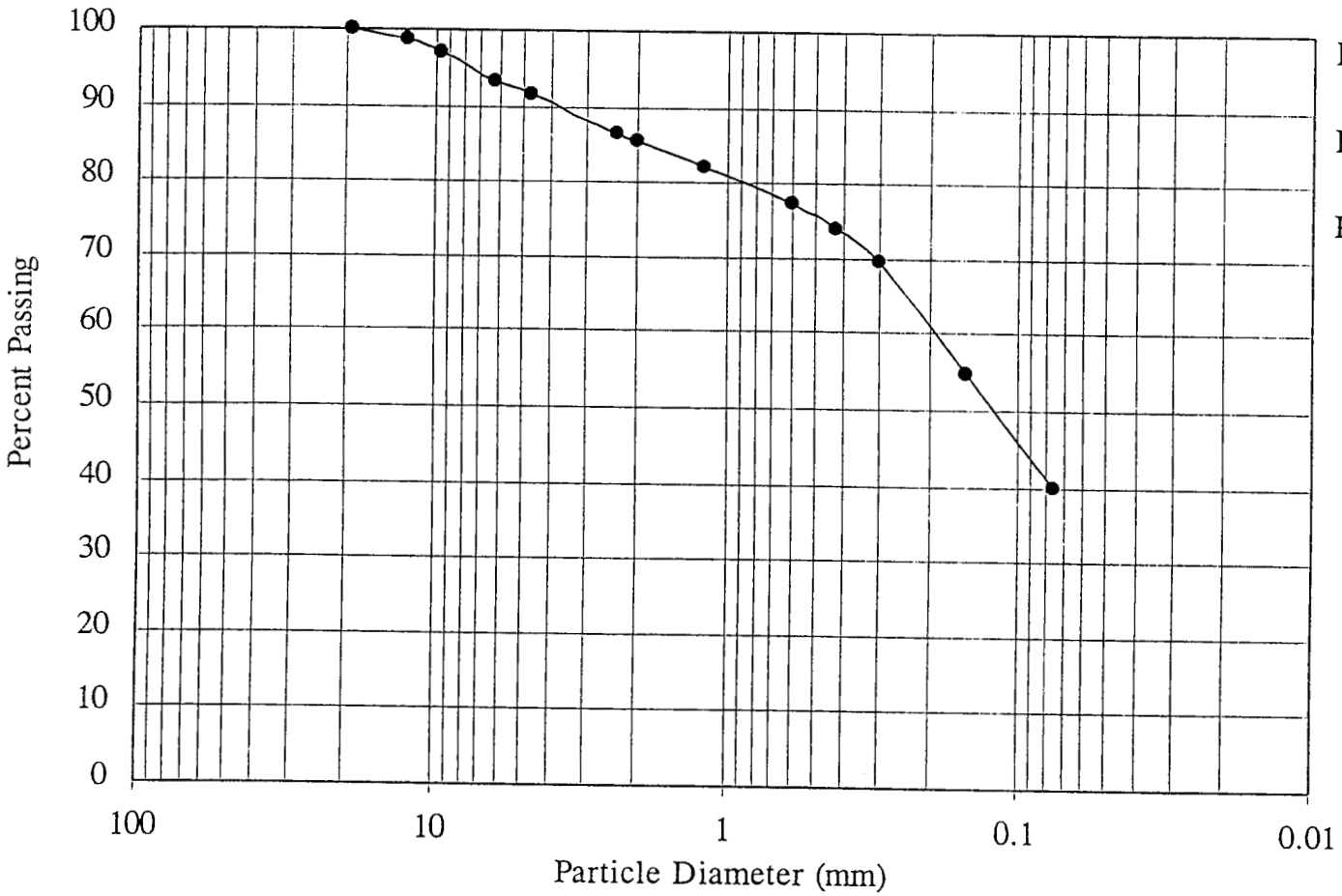
Liquid Limit: 29

Plastic Limit: 16

Plasticity Index: 13

McMicken Dam Embankment Repairs

Sta. 478+00 @ 10'-15'



Liquid Limit: 24

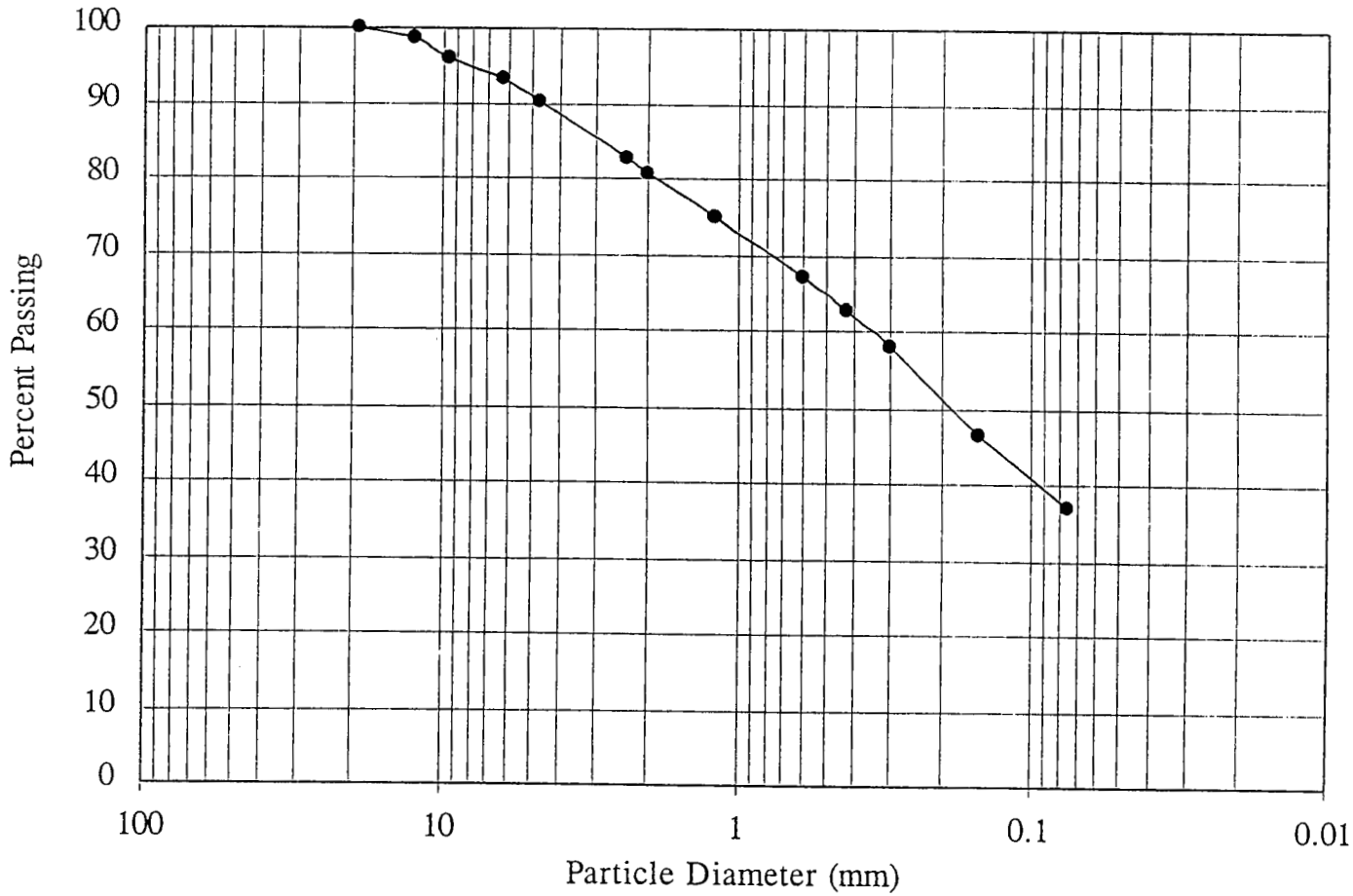
Plastic Limit: 18

Plasticity Index: 6

R.A.M. Project No. G08912

McMicken Dam Embankment Repairs

Sta. 478+00 @ 15'-20'



Liquid Limit: 29

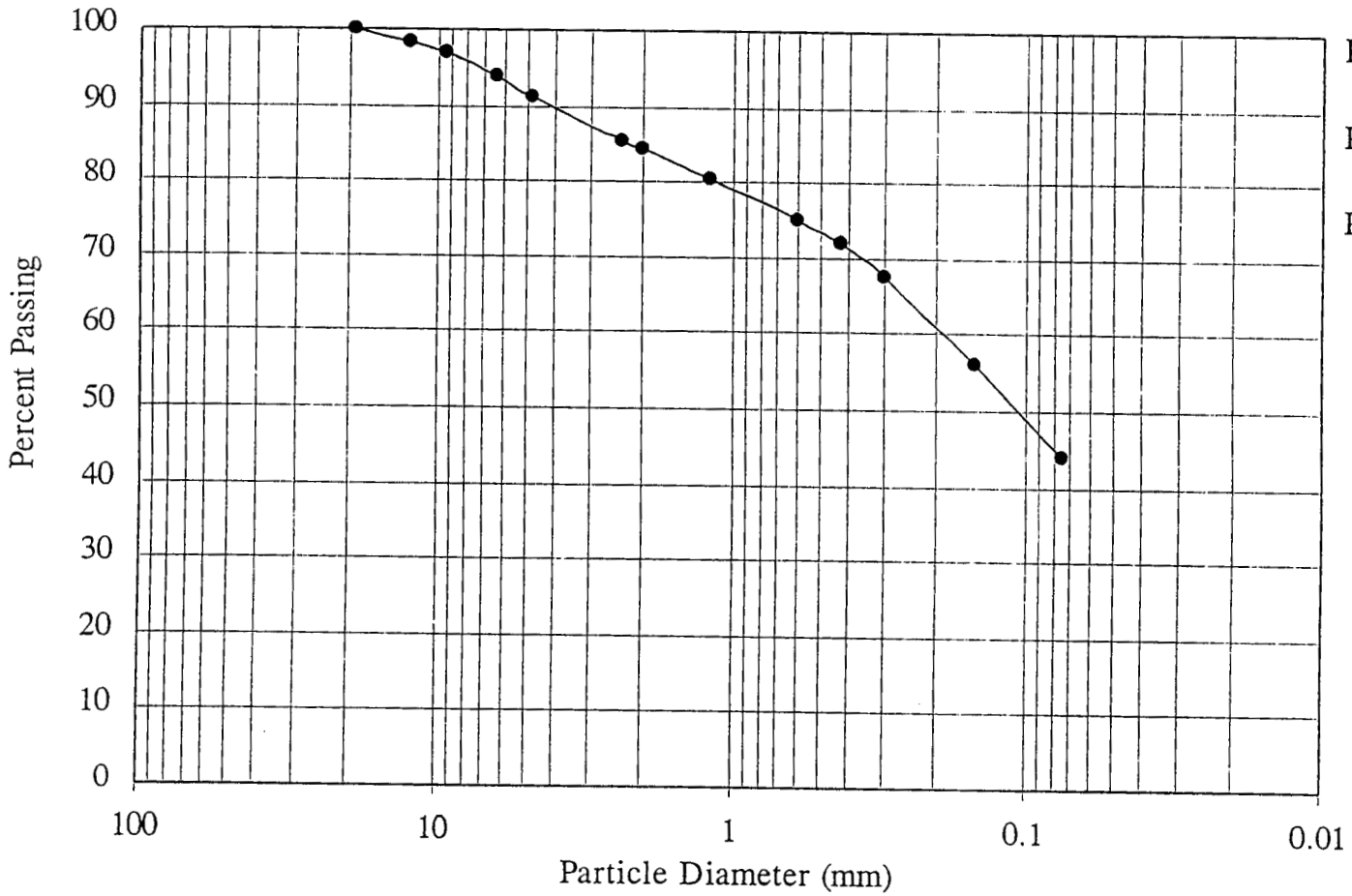
Plastic Limit: 17

Plasticity Index: 12

R.A.M. Project No. G08912

McMicken Dam Embankment Repairs

Sta. 478+75 @ 0'-5'



Liquid Limit: 26

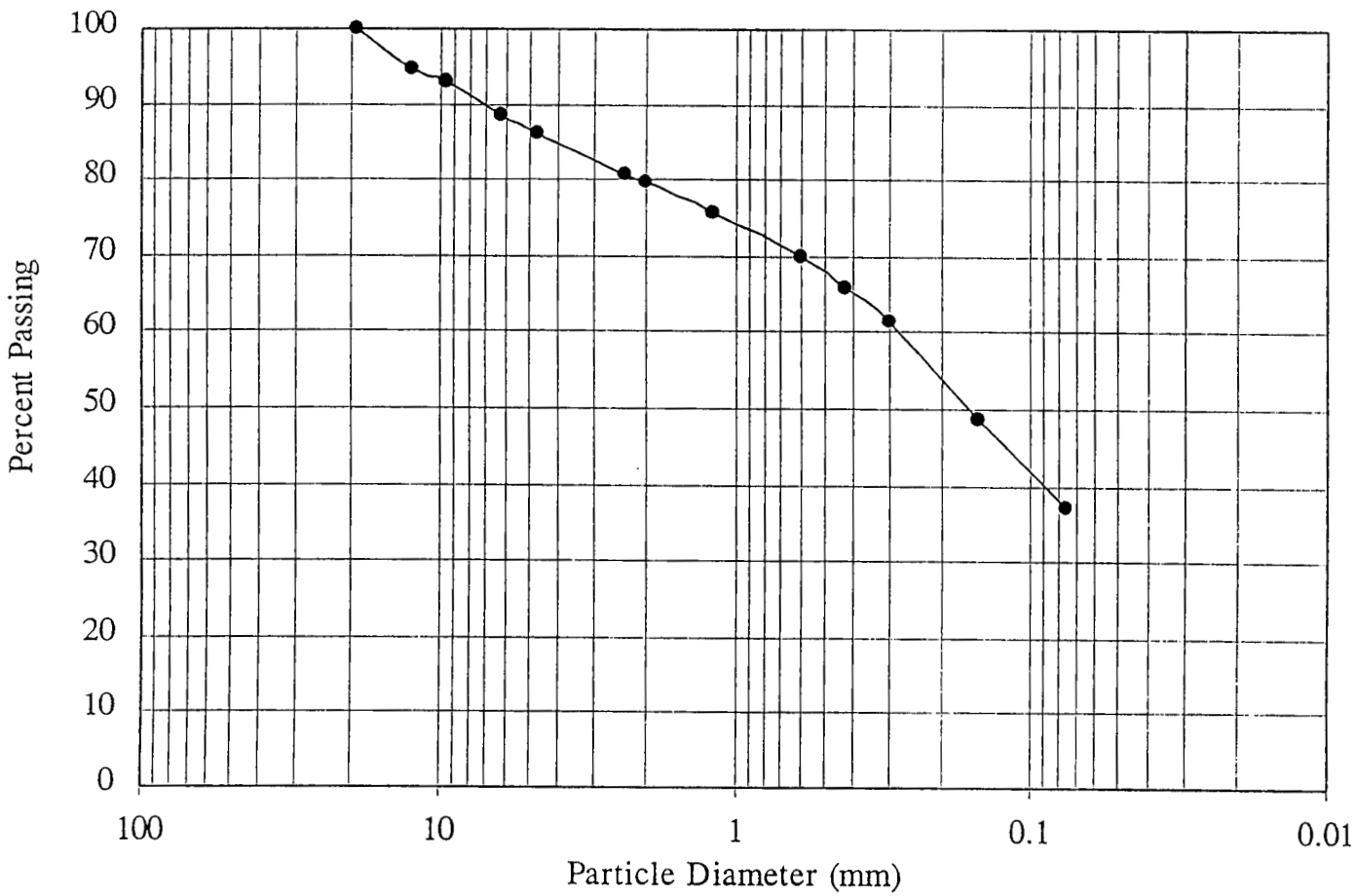
Plastic Limit: 16

Plasticity Index: 10

R.A.M. Project No. G08912

McMicken Dam Embankment Repairs

Sta. 478+75 @ 5'-10'



Liquid Limit: 26

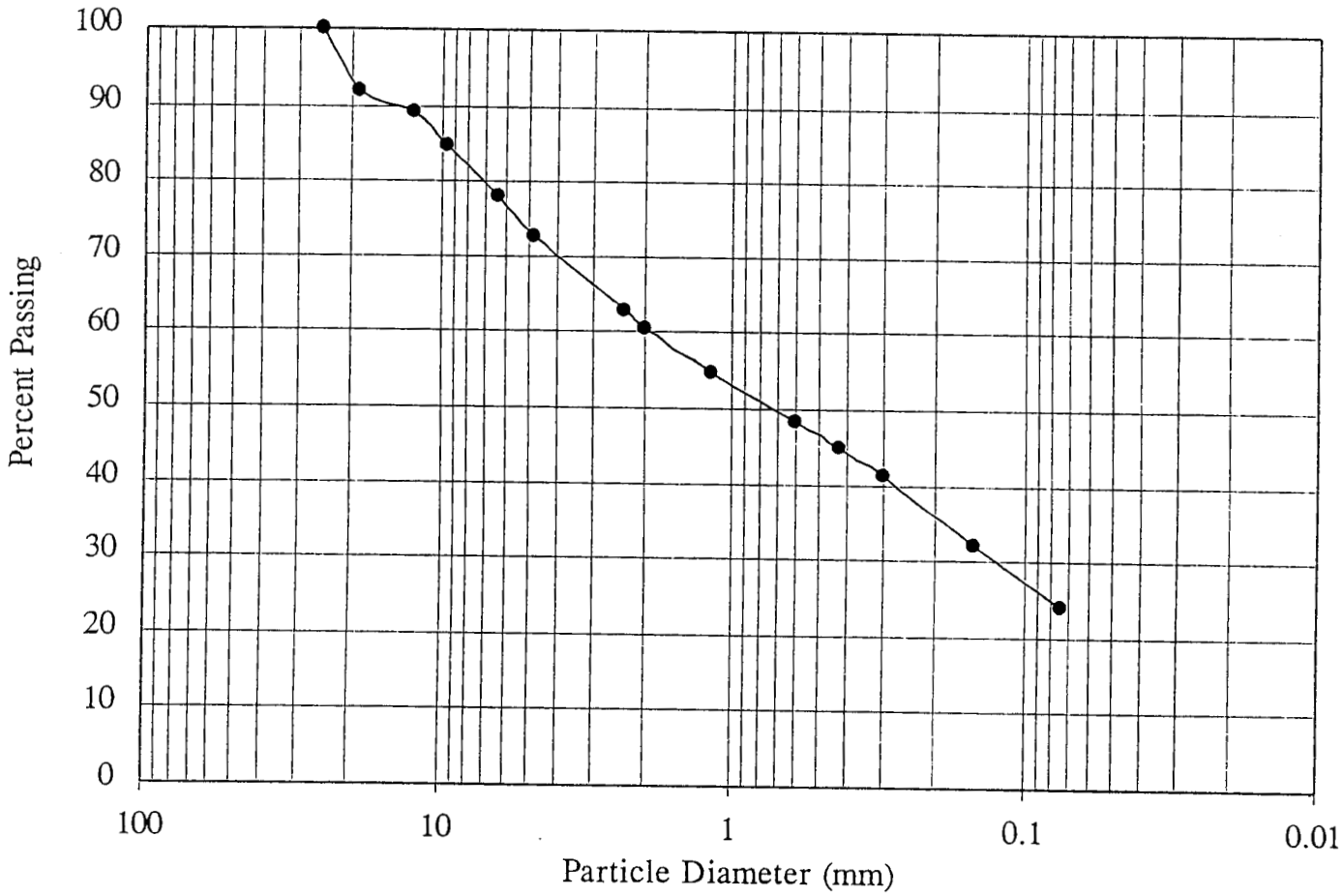
Plastic Limit: 16

Plasticity Index: 10

R.A.M. Project No. G08912

McMicken Dam Embankment Repairs

Sta. 478+75 @ 10'-15'



Liquid Limit: 25

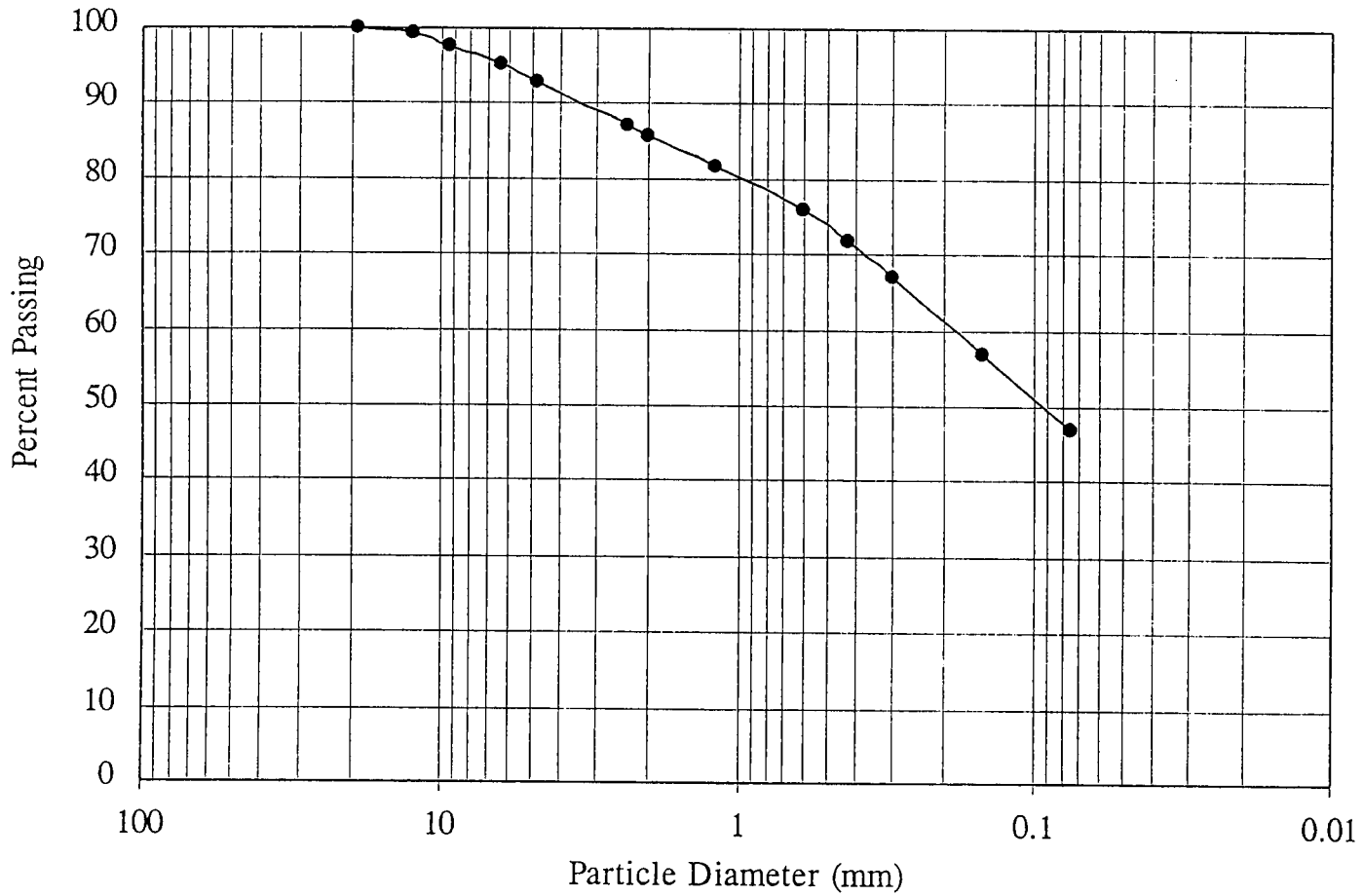
Plastic Limit: 18

Plasticity Index: 7

R.A.M. Project No. G08912

McMicken Dam Embankment Repairs

Sta. 478+75 @ 15'-20'



Liquid Limit: 28

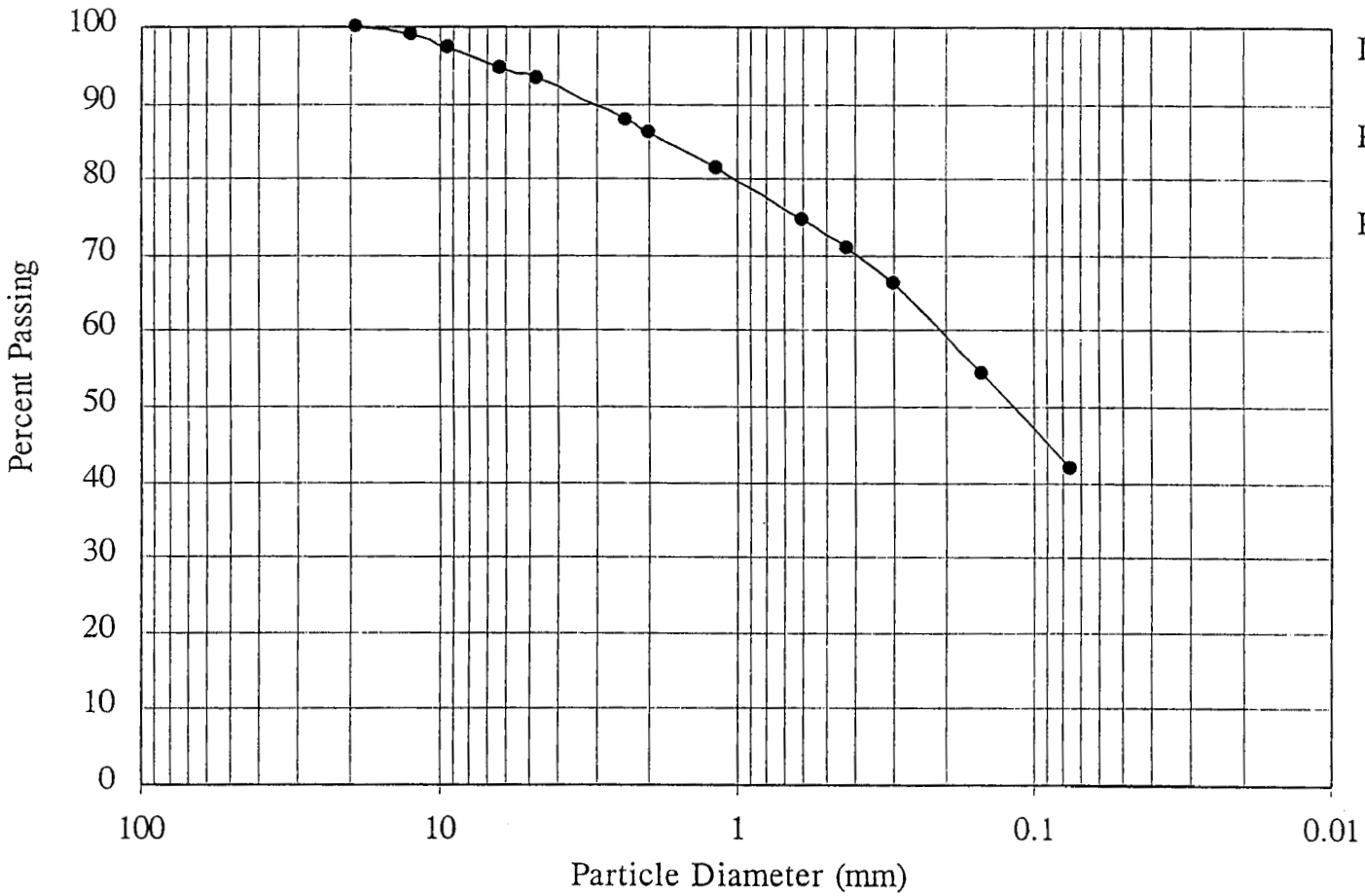
Plastic Limit: 18

Plasticity Index: 10

R.A.M. Project No. G08912

McMicken Dam Embankment Repairs

Sta. 479+50 @ 0'-5'



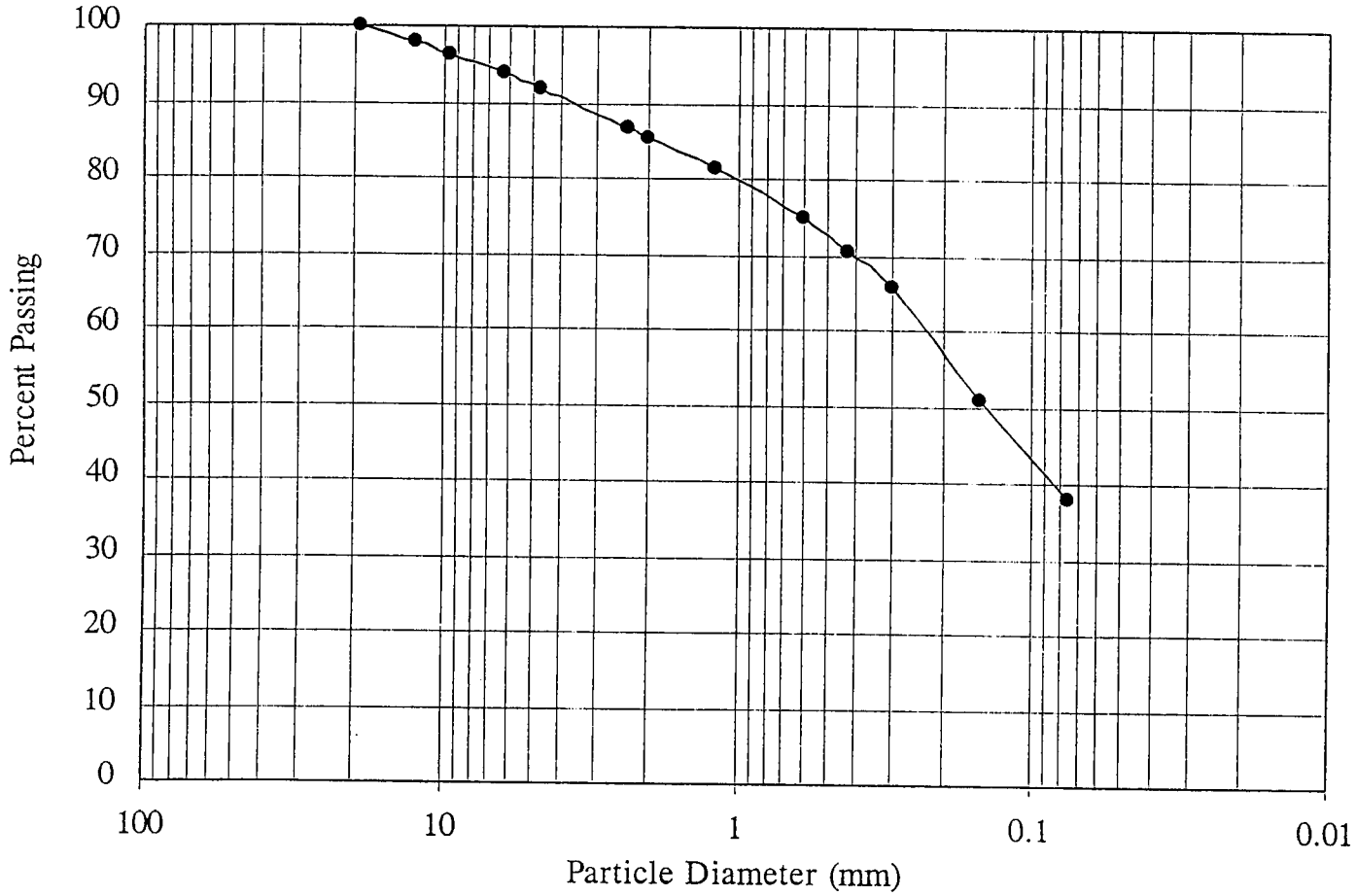
Liquid Limit: 27

Plastic Limit: 16

Plasticity Index: 11

McMicken Dam Embankment Repairs

Sta. 479+50 @ 5'-10'



Liquid Limit: 25

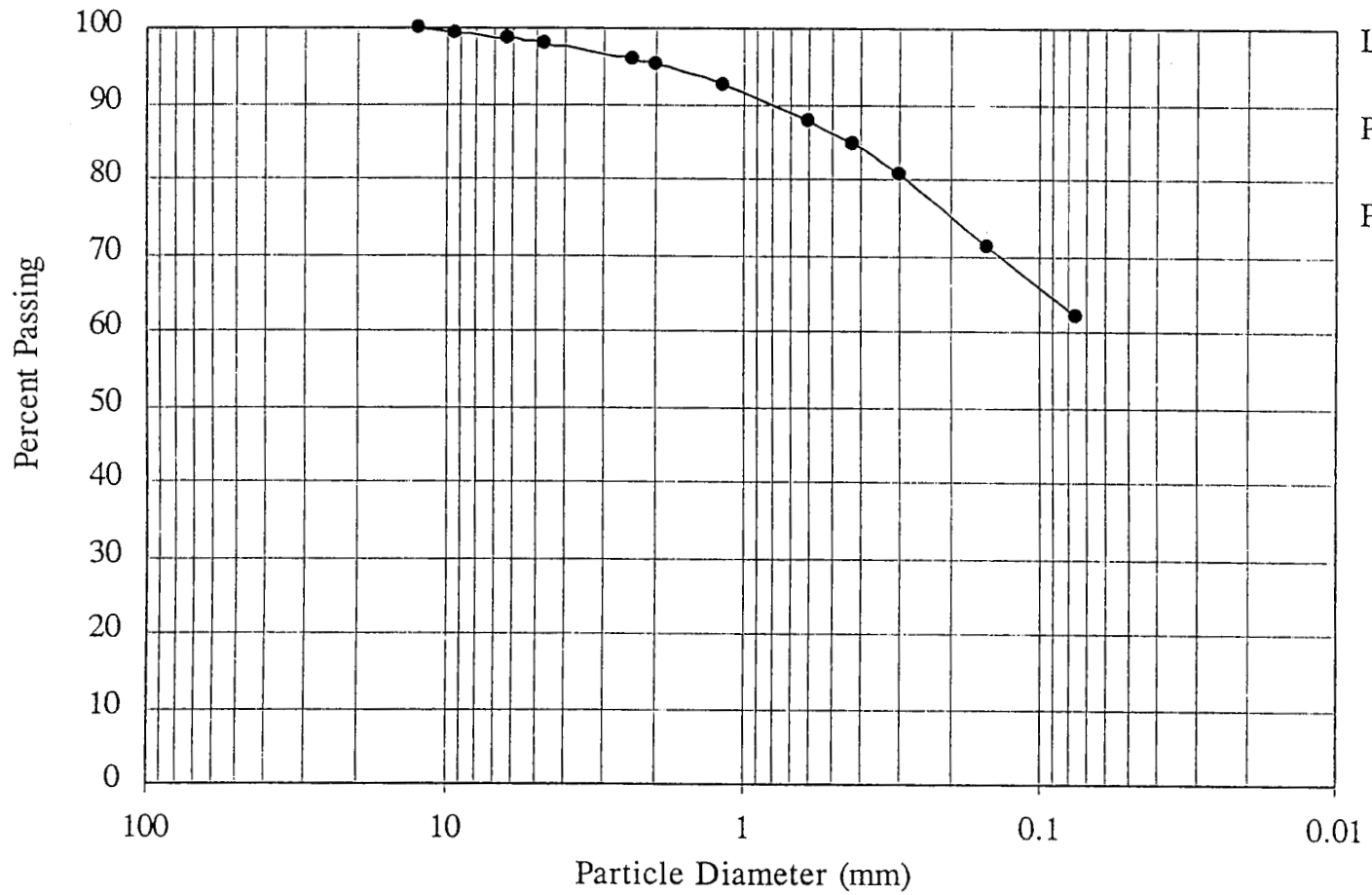
Plastic Limit: 17

Plasticity Index: 8

R.A.M. Project No. G08912

McMicken Dam Embankment Repairs

Sta. 479+50 @ 10'-15'



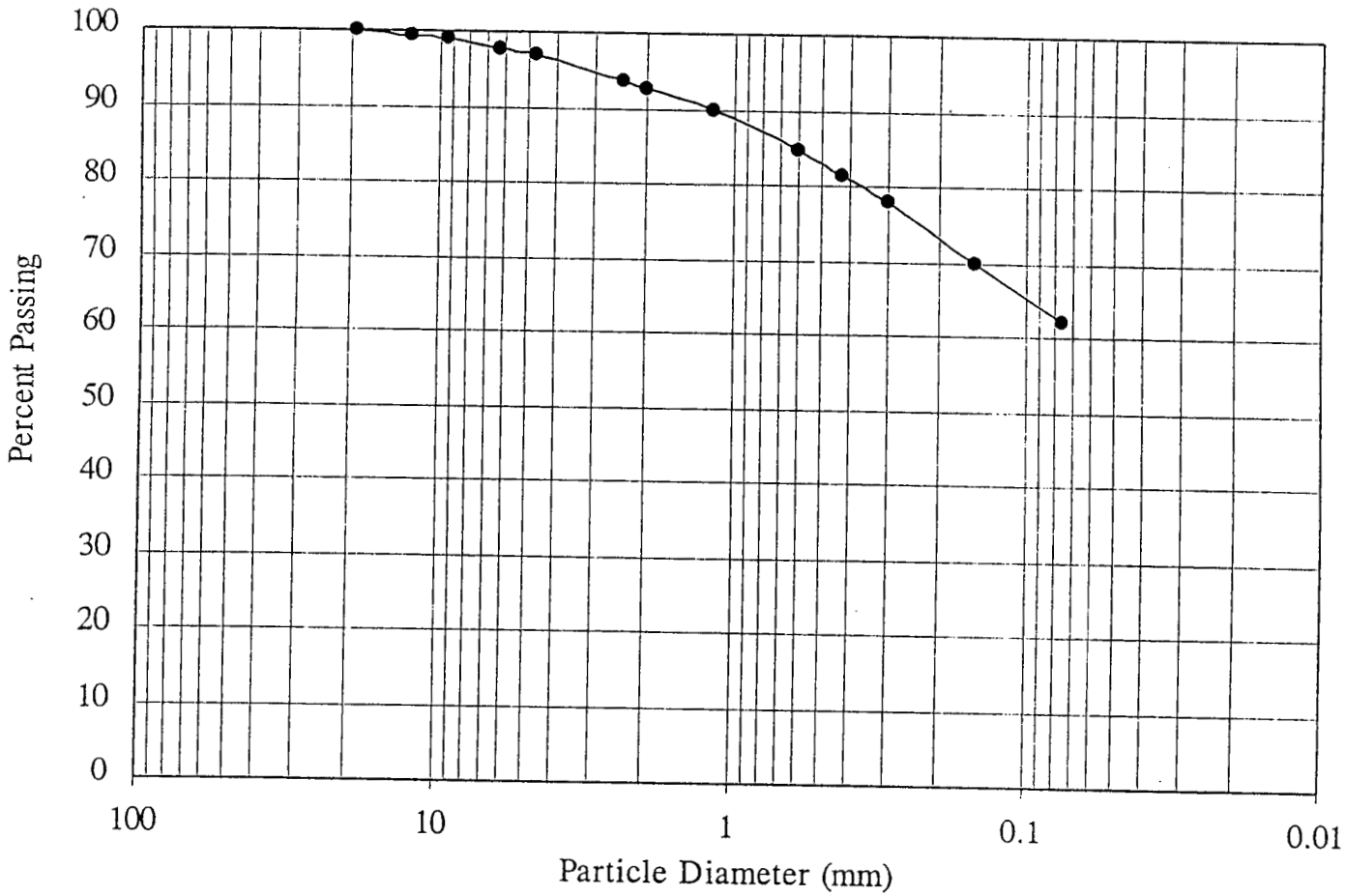
Liquid Limit: 31

Plastic Limit: 19

Plasticity Index: 12

McMicken Dam Embankment Repairs

Sta. 479+50 @ 15'-20'



Liquid Limit: 34

Plastic Limit: 18

Plasticity Index: 16

R.A.M. Project No. G08912

LABORATORY TEST RESULTS

Date: 4-Jan-04

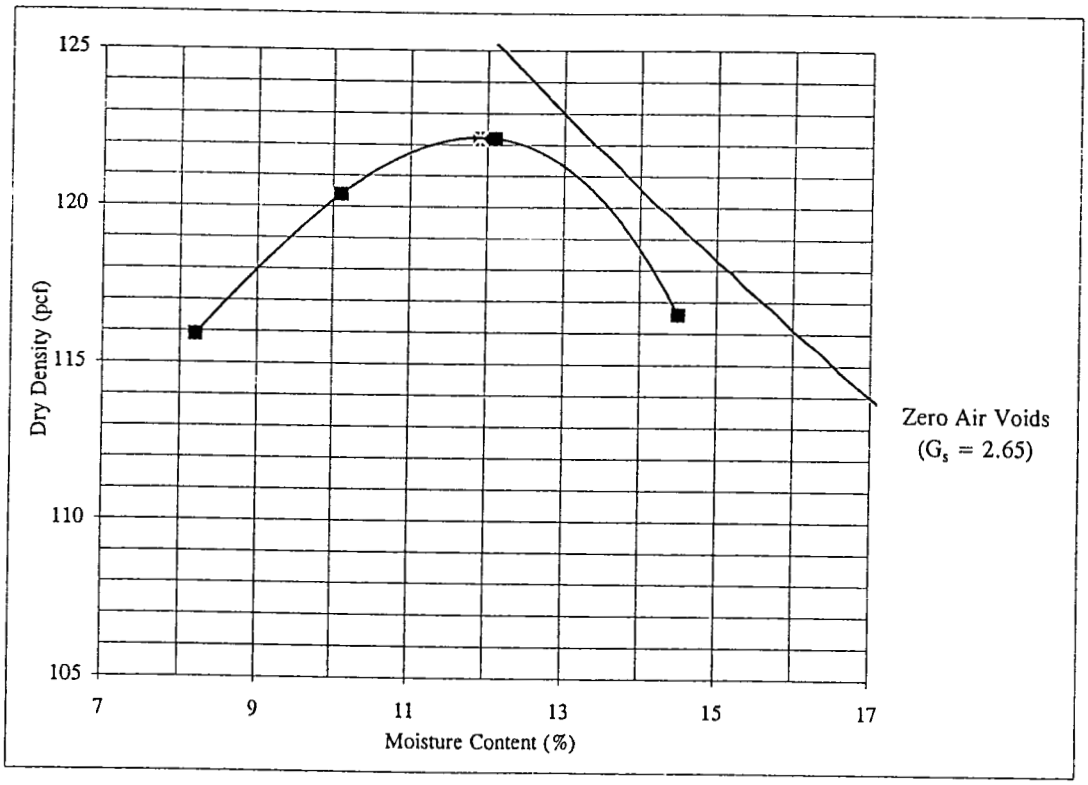
SAMPLE SOURCE: P1 - South

TESTING PERFORMED Maximum Density-Optimum Moisture Determination (ASTM D698 Method A)

SAMPLED BY: RAM/Miller

RESULTS:

Maximum Density (pcf) = 122.2 Optimum Moisture (%) = 11.9



LABORATORY TEST RESULTS

Date: 4-Jan-04

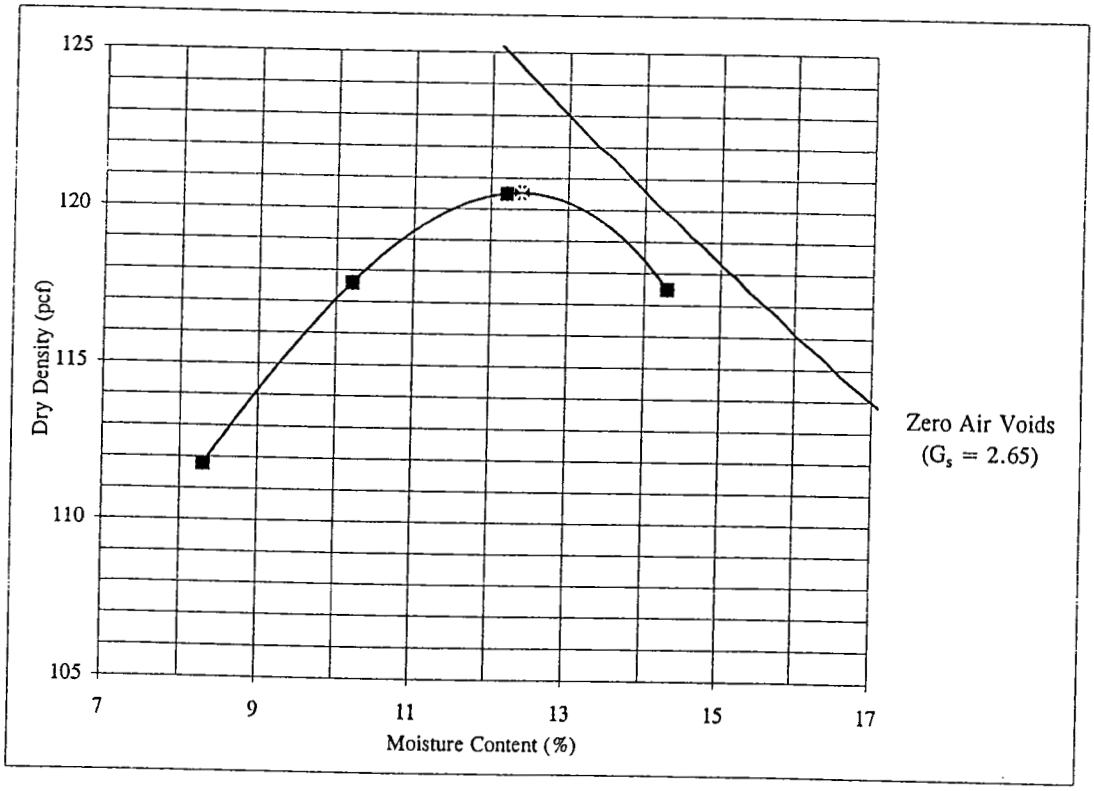
SAMPLE SOURCE: P2

TESTING PERFORMED Maximum Density-Optimum Moisture Determination (ASTM D698 Method A)

SAMPLED BY: RAM/Miller

RESULTS:

Maximum Density (pcf) = 120.5 Optimum Moisture (%) = 12.4



LABORATORY TEST RESULTS

Date: 4-Jan-04

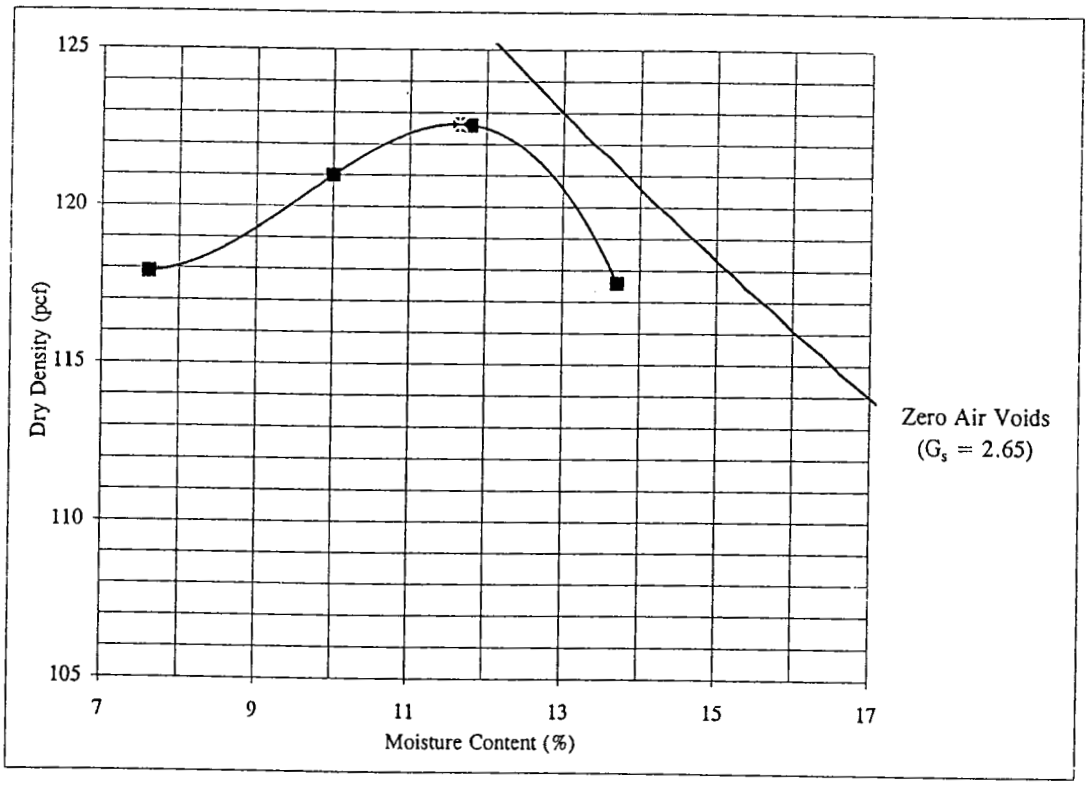
SAMPLE SOURCE: P3

TESTING PERFORMED Maximum Density-Optimum Moisture Determination (ASTM D698 Method A)

SAMPLED BY: RAM/Miller

RESULTS:

Maximum Density (pcf) = 122.6 Optimum Moisture (%) = 11.7



LABORATORY TEST RESULTS

Date: 4-Jan-04

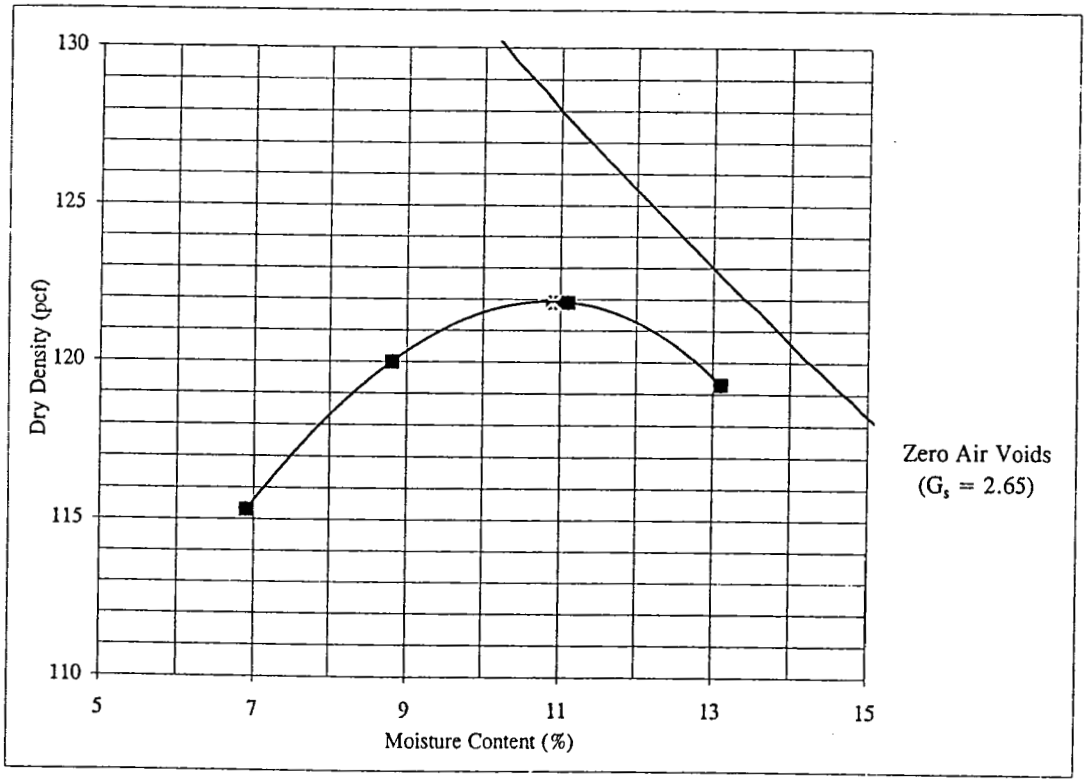
SAMPLE SOURCE: McMicken Dam Embankment Repairs: Borrow Area

TESTING PERFORMED Maximum Density-Optimum Moisture Determination (ASTM D698 Method A)

SAMPLED BY: RAM/Holck

RESULTS:

Maximum Density (pcf) = 121.9 Optimum Moisture (%) = 10.9



LABORATORY TEST RESULTS

Date: 4-Jan-04

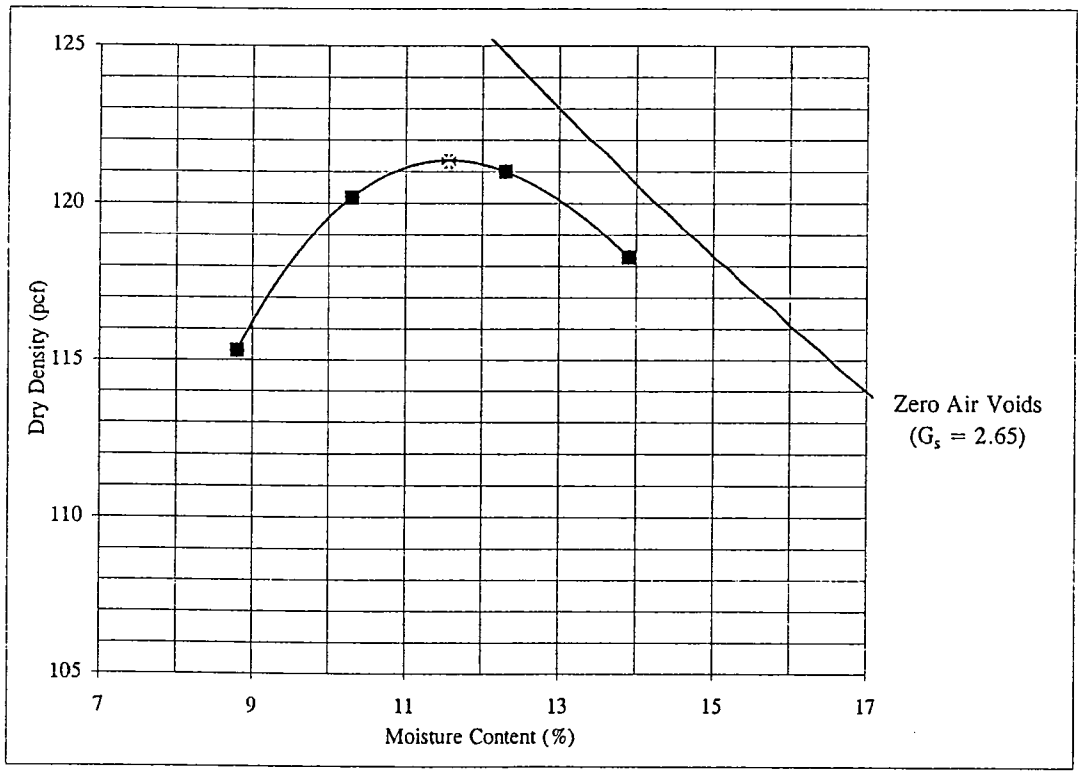
SAMPLE SOURCE: McMicken Dam Embankment Repairs: Stockpile, Sta. 478+00

TESTING PERFORMED Maximum Density-Optimum Moisture Determination (ASTM D698 Method A)

SAMPLED BY: RAM/Holck

RESULTS:

Maximum Density (pcf) = 121.3 Optimum Moisture (%) = 11.6



LABORATORY TEST RESULTS

Date: 4-Jan-

SAMPLE SOURCE: As noted below

TESTING PERFORMED: Sieve Analysis, Percent Passing No. 200 Sieve, Atterberg Limits (ASTM C136, D1140, D4318)

SAMPLED BY: RAM/Miller, Holck

RESULTS:

Sample	Atterberg Limits		Sieve Size - Accumulative Percent Passing											Soi
Source	LL	PI	200	100	50	30	16	8	4	3/4"	1"	2"	3"	Clas:
Sta. 478+00C @ 25'-26'	30	12	51	66	80	89	94	97	99	100				CL
Sta. 478+00C @ 28'-29'	22	4	31	43	60	72	79	85	91	100				SC-S
Sta. 478+00C @ 29'-30'	31	14	60	68	79	85	89	93	96	100				CL
Sta. 478+00C @ 30'-31'	32	13	40	51	63	77	85	91	96	100				SC
Sta. 478+75C @ 24'-25'		7*	50	68	83	90	93	96	98	100				CL-M
Sta. 478+75C @ 26'-27'	N/A	NP	10	19	35	49	57	68	76	93	100			SP-S
Sta. 478+75C @ 27'-28'	N/A	NP	20	30	47	60	70	79	90	100				SM
Sta. 478+75C @ 28'-29'	34	13	58	70	81	89	94	96	100					CL
Sta. 479+50C @ 0'-10'	29	10	39	52	63	72	79	86	91	100				SC
Sta. 479+50C @ 10'-20'	29	11	46	59	72	79	84	89	93	100				SC
Sta. 479+50C @ 25'-26'	22	1	40	54	65	75	82	89	94	100				SM
Sta. 479+50C @ 27'-28'	N/A	NP	6.7	13	31	58	71	82	90	99	100			SP-SI
Sta. 479+50C @ 28'-29'	54	32	44	52	65	81	92	96	98	100				SC
Sta. 478+00U @ 3'-4'	28	10	52	67	78	86	92	97	99	100				CL
Sta. 478+00U @ 5'-6'		5*	36	49	63	72	78	85	92	100				SC-SI
Sta. 478+00U @ 7'-8'	30	10	42	55	69	81	88	93	95	100				SC
Sta. 478+00U @ 8'-9'		10*	47	61	78	91	97	98	99	100				SC
Sta. 478+75U @ 2'-3'	30	11	49	63	75	83	89	93	96	100				SC
Sta. 478+75U @ 4'-5'	34	16	48	65	81	89	95	99	100					SC
Sta. 478+75U @ 5'-6'	33	11	43	57	74	83	89	94	97	100				SC
Sta. 478+75U @ 7'-8'	27	1	63	78	88	94	97	98	99	100				ML
Sta. 479+50U @ 3'-4'	31	12	56	70	84	90	94	97	99	100				CL
Sta. 479+50U @ 5'-6'	26	11	53	66	78	86	91	95	98	100				CL
Sta. 479+50U @ 7'-8'		4*	14	23	41	60	75	86	94	100				SC-SM
Sta. 479+50U @ 8'-9'	N/A	NP	4.7	9	26	45	55	63	74	89	89	100		SP
Sta. 478+00DT @ 1'-2'	29	8	41	53	63	70	75	81	87	100				SC
Sta. 478+00DT @ 3'-4'	29	8	52	70	84	91	95	98	99	100				CL
Sta. 478+00DT @ 6'-7'	N/A	NP	8.4	17	37	52	62	72	82	94	94	100		SP-SM

NP = Non-Plastic

* Unified Soil Classification System

* Plasticity Index estimated due to lack of sufficient material to perform test.

LABORATORY TEST RESULTS

Date: 4-Jar

SAMPLE SOURCE: As noted below

TESTING PERFORMED: Sieve Analysis, Percent Passing No. 200 Sieve, Atterberg Limits (ASTM C136, D1140, D4318)

SAMPLED BY: RAM/Miller, Holck

RESULTS:

Sample	Atterberg Limits		Sieve Size - Accumulative Percent Passing											S
Source	LL	PI	200	100	50	30	16	8	4	3/4"	1"	2"	3"	Cla
Sta. 478+00DT @ 7'-8'	N/A	NP	59	86	94	97	98	99	100					M
Sta. 478+75DT @ 2'-3'	29	12	45	59	71	80	85	90	94	100				S
Sta. 478+75DT @ 5'-6'	27	6	49	68	85	91	95	97	98	100				SC-
Sta. 478+75DT @ 7'-8'	26	5	37	53	71	79	83	86	90	98	100			SC-
Sta. 478+75DT @ 9'-10'	28	4	37	61	90	97	99	100						SC-
Sta. 479+50DT @ 2'-3'	38	17	39	48	57	67	75	84	91	100				S
Sta. 479+50DT @ 4'-5'	36	15	42	53	63	72	79	86	91	100				S
Sta. 479+50DT @ 6'-7'	36	17	36	44	53	64	71	80	86	92	92	100		S
Sta. 479+50DT @ 8'-9'	35	16	34	45	58	72	82	90	93	100				S

NP = Non-Plastic

* Unified Soil Classification System

* Plasticity Index estimated due to lack of sufficient material to perform test.

LABORATORY TEST RESULTS

Date: 4-Jan-04

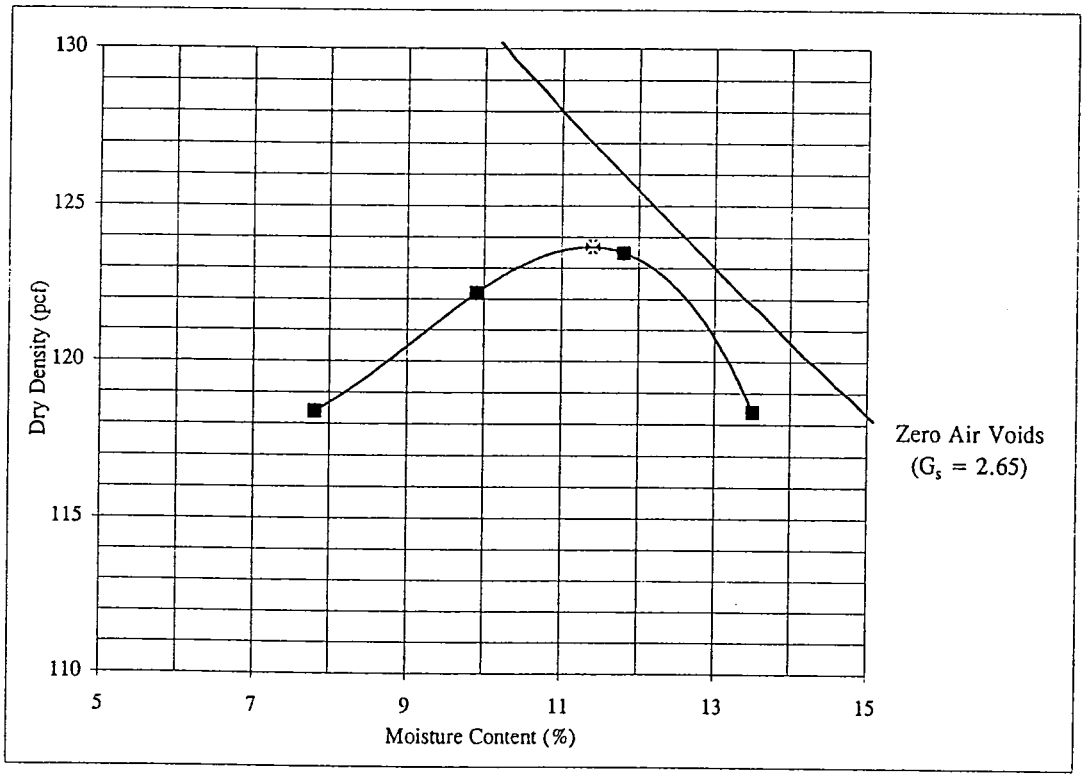
SAMPLE SOURCE: Sta. 479+50C @ 0-10' (Composite of 0-5' and 5'-10')

TESTING PERFORMED Maximum Density-Optimum Moisture Determination (ASTM D698 Method A)

SAMPLED BY: RAM/Miller

RESULTS:

Maximum Density (pcf) = 123.7 Optimum Moisture (%) = 11.4



LABORATORY TEST RESULTS

Date: 4-Jan-04

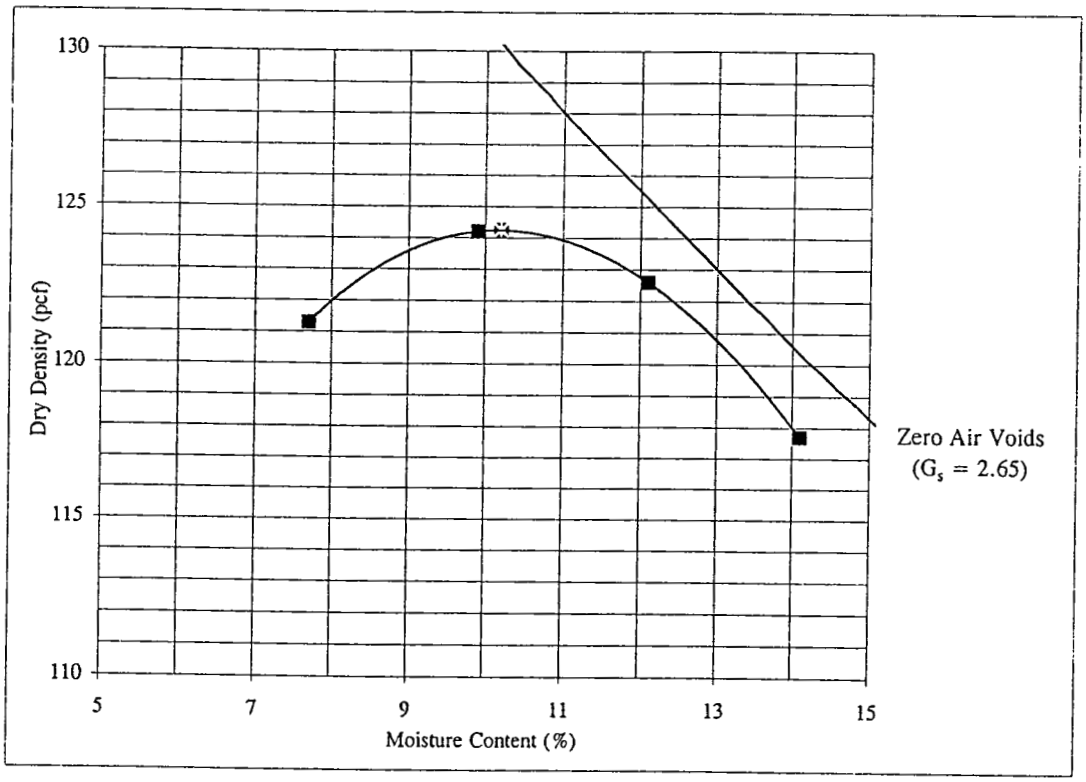
SAMPLE SOURCE: Sta. 479+50C @ 10-20' (Composite of 10-15' and 15'-20')

TESTING PERFORMED Maximum Density-Optimum Moisture Determination (ASTM D698 Method A)

SAMPLED BY: RAM/Miller

RESULTS:

Maximum Density (pcf) = 124.3 Optimum Moisture (%) = 10.2



DOCUMENT TITLE: Wittmann Area Drainage Master Study Update (ADMSU); Land Subsidence and Earth Fissure Investigation Report.

DATE: January 30, 2004

PREPARED BY: Geotechnical Consultants, Inc.

PURPOSE:

Report presents evaluation of land subsidence and earth fissures within Wittmann ADMSU. Determines whether there is an ongoing process land subsidence and earth fissuring or there is no credible evidence of the potential for land subsidence and earth fissuring.

OBJECTIVES:

- Assess historic and current land subsidence within and adjacent to the study area.
- Identify suspect and known earth fissures within and adjacent to the study area.
- Make appropriate recommendations in regards to the subsidence and earth fissure phenomena that could potentially impact future development within the Wittmann ADMSU.

SUMMARY:

- Subsidence rates approximated as 1/100- to 1/2-foot per 10-foot of groundwater elevation drop.
- Three categories of subsidence: active, residual, and total subsidence. Active is induced by groundwater over-pumping. Residual subsidence continues after groundwater levels stabilize. Cumulative subsidence (total) is measured after residual subsidence is zero.
- Level Line Data: NGS data dates back to 1905 (Appendix SU-6)
- Level Lines L21029 & L2455/2 follow Beardsley Canal & McMicken Dam alignment.
- USBR Level Line Data tie into bedrock benchmarks. Measures 0.35 feet of subsidence near McMicken primary outlet (1971 to 1986).
- The District data (2001) shows 0.9 ft of subsidence for Dam Crest from 1985 to 2001.
- The District annually performs crest surveys of McMicken Dam

- Gravity surveys reveal buried bedrock highs and bedrock drop-offs
- Earth fissures have only been documented at southern end of dam, near Fenne Knoll.

CONCLUSIONS AND RECOMMENDATIONS:

- There is an ongoing process of land subsidence occurring within portions of the Wittmann ADMSU study area. Earth fissuring appears to be ongoing in the vicinity of McMicken Dam. Fissuring could extend into other areas as the subsidence process continues to respond to groundwater mining.
- Due to anticipated urban growth, there is credible evidence to suggest the potential for future land subsidence and earth fissuring.
- Mountains and shallow bedrock areas within Wittmann ADMSU will not be affected by subsidence and earth fissuring.
- The greatest historical subsidence is documented in the Sun City West area along the McMicken Dam-Beardsley Canal corridor between Fenne knoll and US 60.
- InSAR imagery between 1996 and 2000 confirms that subsidence is ongoing within study area.
- The only documented earth fissure is located at south end of McMicken Dam, north of Fenne Knoll.
- Between 1900 and 1998 the groundwater elevation has declined 75 to 100 feet. Between Circle City & Hassayampa River the groundwater elevation increased 25 feet over same period. Southeast of Beardsley Canal, the groundwater elevation has declined 125 to 275 feet. A groundwater gradient exists between Wittmann sub-basin and West Salt River Valley sub-basin. Anticipated urban development will increase the rate at which the groundwater elevation is dropping.
- Additional recommended studies
    - Determine if future land subsidence and earth fissuring could develop in response to large GWT withdrawals.
    - Evaluate potential effects/impacts of future subsidence and earth fissuring.
    - Estimate rate and magnitude of potential subsidence and location of potential earth fissure risk zones.
    - Evaluate potential effects on surface water hydrology and engineered drainage systems.

Report Prepared for:

Entellus
2255 N. 44th Street, Suite 125
Phoenix, AZ 85008

Report Prepared by:

Geological Consultants Inc.
2333 West Northern Avenue, Suite 1A
Phoenix, Arizona 85021
Geological Consultants Inc. Project No. 2002-185

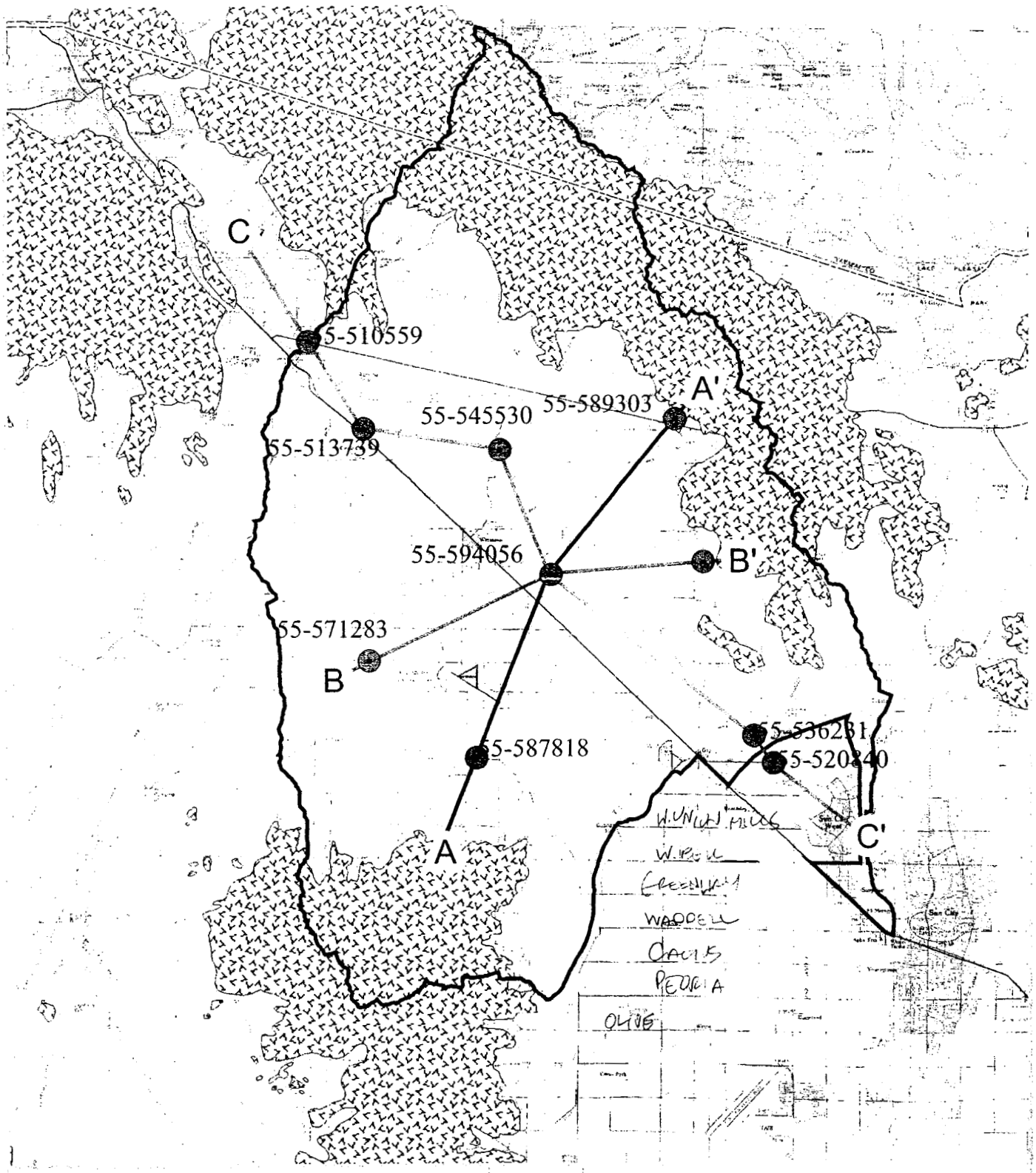
January 30, 2004

Contract FCD 2002C029

WITTMANN AREA DRAINAGE
MASTER STUDY UPDATE (ADMSU)

LAND SUBSIDENCE AND EARTH FISSURE
INVESTIGATION REPORT

VOLUME SU



Legend

- Wittmann ADMSU Boundary
- Bedrock
- Maricopa County Line
- Well location/ADWR Registration No.
- Cross Section Location - Refer to Figure 4

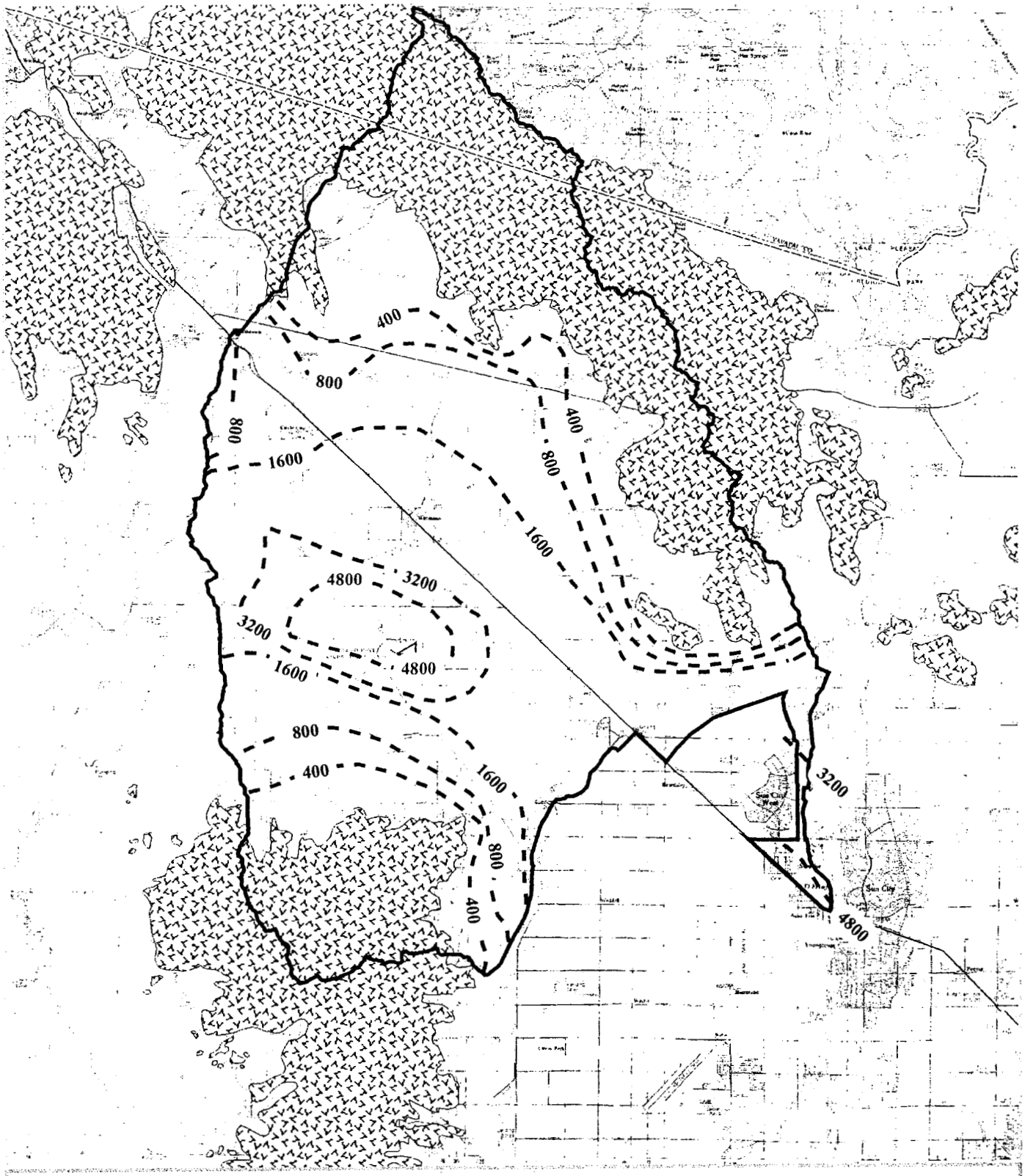
N

1:250,000

Land Subsidence and Earth Fissure Investigation
Wittmann ADMSU
Figure SU-2
Cross-Section Location Map

GEOLOGICAL CONSULTANTS INC.

Flood Control District of Maricopa County



Legend

- Maricopa County Line
- Bedrock
- Wittmann ADMSU Boundary
- Depth to Bedrock Contour (Feet)

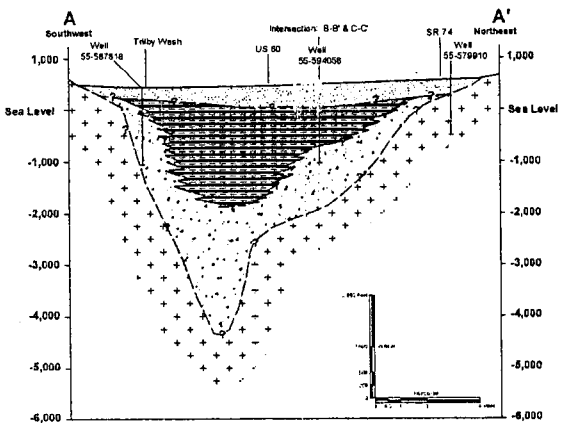
N

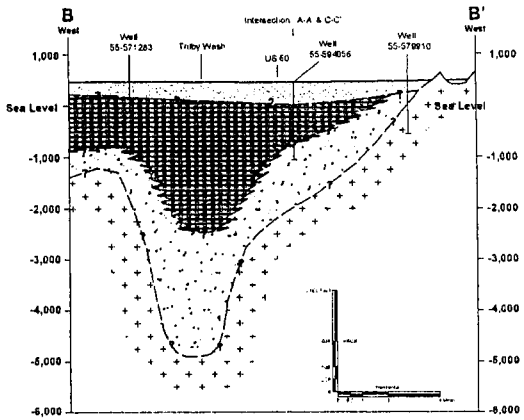
1:250,000

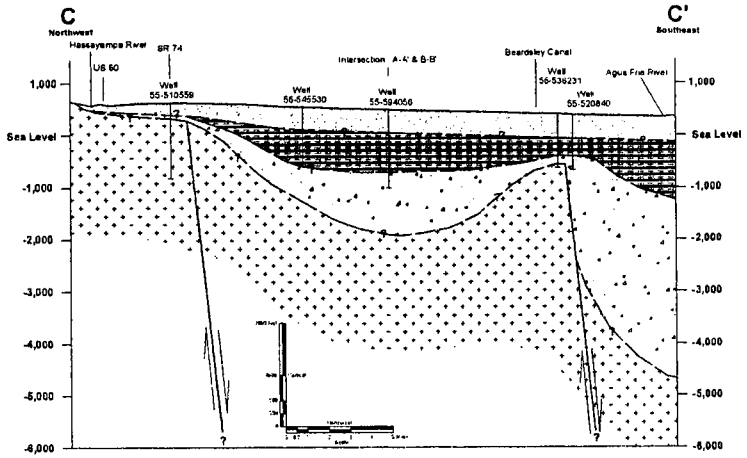
Land Subsidence and Earth Fissure Investigation
Wittmann ADMSU
Figure SU-3
Depth to Bedrock Map

GEOLOGICAL CONSULTANTS INC.

Flood Control District of Maricopa County







Explanation:

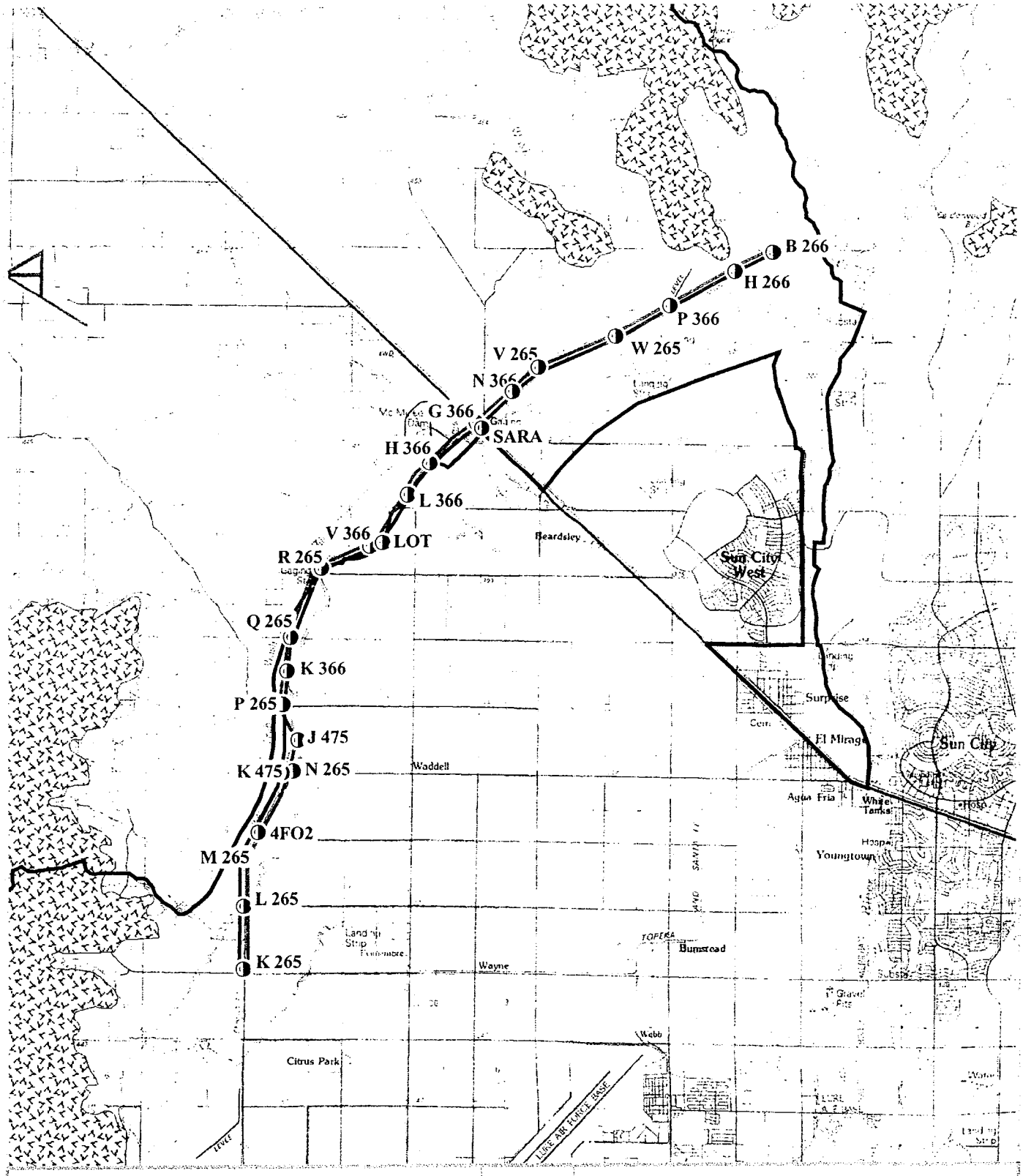
- Upper Coarse-Grained Unit
- Middle Fine-Grained Unit
- Lower Coarse-Grained Unit
- Bedrock

Data Sources: ADWR (2003 Groundwater Site Inventory (GWSI) well drillers logs and Oppenheimer & Sumner (1980) Depth to Bedrock map, Maricopa County, Arizona

Note: Refer to Figure SU-2 for Cross-Section Locations.

Land Subsidence and Earth Fissure Investigation
Wittmann ADMSU
Figure SU-4
Geologic Cross-Sections

GEOLOGICAL CONSULTANTS INC.



Legend

- Bedrock
- Wittmann ADMSU Boundary
- NGS Benchmark Location and Designation
- Level Line L21029
- Level Line L2455/2

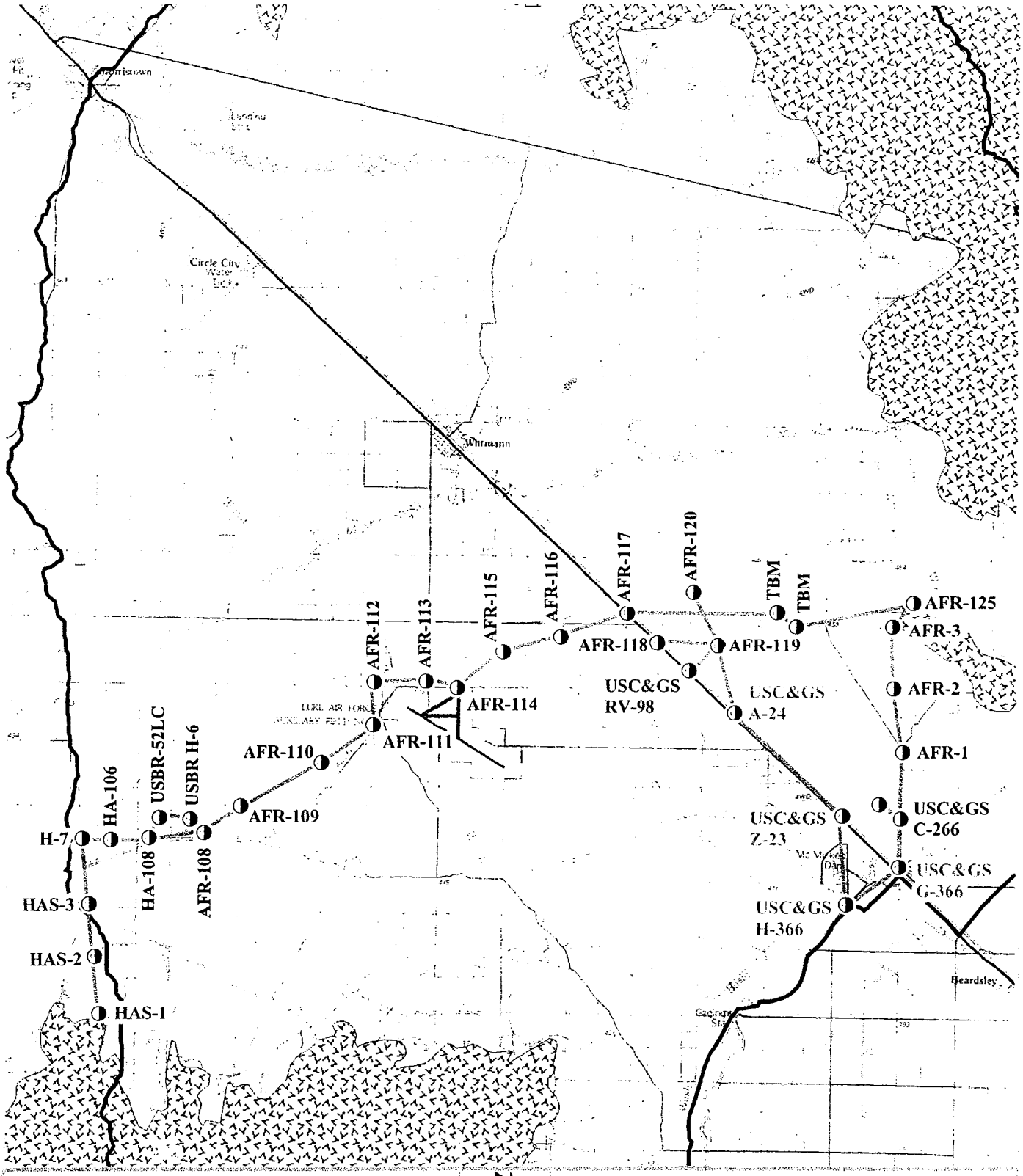
N

1:125,000

Land Subsidence and Earth Fissure Investigation
Wittmann ADMSU
Figure SU-6b
NGS Level Lines L21029 & L2455/2

GEOLOGICAL CONSULTANTS INC.

Flood Control District of Maricopa County



Legend

- Bedrock
- WittmannBdy
- USBR Benchmark Location and Designation
- Level Line Location

N

1:125,000

Land Subsidence and Earth Fissure Investigation
Wittmann ADMSU
Figure SU-6c
USBR Reach 8 Level Line

GEOLOGICAL CONSULTANTS INC.

Flood Control District of Maricopa County

DOCUMENT TITLE: McMicken Dam: Geotechnical Investigation of Principal Spillway

DATE OF REPORT: April 1, 2004

PREPARED BY: R.A.M (Project # G08912)

PURPOSE:

To evaluate, investigate, analyze, and review the following conditions that have been noted at McMicken Dam's Principal Spillway. These conditions include:

- A transverse crack on the dam crest at Station 474+20 (up and down stream slopes),
- Differential movements noted at wall joints along different sections of the principal spillway channel,
- Displacement and crushing of drainage pipes that are to relieve uplift and hydrostatic pressures on the bottom and sides (respectively) of the stilling basin, and
- A discrepancy between the as-built plans and some observations regarding the extent of the center filter drain near the principal spillway.

SUMMARY:

Field exploration activities included:

- A video inspection of the stilling basin drainage system.
- Fourteen vacuum truck excavations were advanced to delineate the extents of the center filter drain in the vicinity of the principal spillway. One vacuum boring was advanced to observe two holes noted in the dam crest (Approx Sta. 474+16.5). One vacuum boring was advanced to define the geometry and location of the south vertical cut-off wall (boring H1). Another vacuum boring was advanced to observe the backfill behind the channel walls. Thirteen vacuum borings were advanced north and south of the stilling basin section, "in order to define material types and lateral/vertical extent of pervious backfill zone against the stilling basin and canal channel walls."
- Seven test pits were excavated to observe items around the spillway. Five of the trenches excavated were to evaluate the backfill soils behind the stilling basin and canal/siphon walls. Two test pits were made in the outlet channel, downstream of the Principal Spillway, presumably to observe the soil conditions.
- Five test borings were advanced for this study. One boring (TD1) was drilled on the crest of the dam near the centerline to evaluate the "condition and type of structural backfill used."

Four borings were advanced adjacent to the stilling basin and canal/siphon sections of the spillway to observe the backfill soils, "determine the presence of or lack of water adjacent to the walls, and to install standpipe type piezometer for use in long term monitoring of the water in the backfill."

- The lateral movements in the spillway channel walls were measured by stretching a tape across the top of the channel and measuring the distance across the principal spillway at each wall joint. Measurements were made at the top of the walls, from inside face to inside face, and on either side of each wall joint.

- An MCI fiber optic line crosses over the top of the principal spillway and a Broadwing Communications fiber optic line crosses the riprap lined outlet channel approximately 30 feet east of the east end of the stilling basin section.

- Three outlets from the center filter are located near the principal spillway at Stations 470+00, 475+60, and 485+00.

Laboratory tests were performed on selected soils samples obtained during the field exploration program. Laboratory analyses included: consolidation potential (R.A.M. calls them compression tests), grain-size distribution, Atterberg limits, standard proctors, dry densities/moisture contents.

FINDINGS/RESULTS:

- Sub-floor drain pipes designated as 1N, 2N, 4N, 4S, &7N are clogged by soils and weeds at approximately the stilling basin floor elevation. Drain pipe 7S is choked with soil and broken about three feet from the wall face (therefore video inspection was blocked). Some of the piping that makes up the wall back-drains was laid with perforations downward rather than upward as shown on the as-built plans. Sediment build up in the pipes indicates that little to no seepage has flowed from the backfill to the stilling basin, but rather that water flows into the backfill from the stilling basin. Displacement is apparent at many of the pipe joints throughout the drainage system (R.A.M. suggests that the displacements are likely due to settlement of the surrounding structural backfill).

- No perched water or groundwater was found during any phase of field exploration.

- Density tests performed on backfill materials indicated relative compaction values of 81 to 94 percent (using ASTM D698-00 - see page 16 of the report for specific results). Soils observed in boring TD1 were classified as clayey sand with some gravel (from 0 to 25 feet below ground surface [bgs]) and silty sand with some gravel from 25 to 30 feet bgs. These soils were evaluated to be structural backfill and corresponded to the as-built plans. The structural backfill was generally dense at the surface and medium dense to loose as depth in-

creased. Native clayey soils were observed to underlie the structural backfill and some light to moderate cementation was noted.

- In four test borings advanced adjacent to the stilling basing channel walls, silty or clayey sand with gravel was encountered and was deemed to be pervious backfill material. Pervious backfill material extended to depths ranging from 22 feet bgs to 34 feet bgs. In each boring, except test boring 2, native clayey sand with some cementation was generally observed below the structural backfill. In test boring 2, a low strength concrete was encountered from 30 to 32 feet bgs, which in turn, was underlain by native clayey sand.

- Channel widths were compared to the designed widths to estimate wall movements. Top of wall movements ranged from 0.25 inches to 4 inches in an inward direction. Refer to page 19 and 20 of the report for specific results.

- Based on a review of the data, it appears that the stilling basin section, canal siphon and outlet channel were all designed so that all minor flows would fill the stilling basin area to a depth of five feet before flows discharge through outlet channel.

- Any flows in excess of this volume will also discharge water into the drainage system below the floor and behind the stilling basin walls.

- The dam center filter drain does not extend to the principal spillway. It is 23.5 feet north of the northern edge of the principal spillway and 28.1 feet south of the south edge of the principal spillway.

- Some variations were apparent between the as-built plans and construction specifications, and field observations. These included: (1) The pervious backfill zone behind the cantilever walls in the stilling basin section and the east part of the chute section does not exist as shown on the plans; (2) The structural backfill zone in the embankment part of the principal spillway was not compacted to the intent of he specifications; (3) the drainage systems behind and parallel to the walls were placed with the perforations down instead of up and the pipe extended further behind the wall than specified in as-builts; (4) The center filter drain does not intersect the principal spillway; and (5) the center filter drain outlet pipes locations in the field are 475+60 for outlet #60 and 482+72 for outlet #61.

CONCLUSIONS / RECOMMENDATIONS:

The conclusions and recommendations related to the under/back drainage system include:

- Limit further impairment and backfill movements by backfilling the open part of the system with sand.

- After sand has been placed, open ends of the pipe in the stilling basin walls should be equipped with PVC, brass or stainless steel screens or with a filter fabric to limit contami-

nating of sand with sediment and to prevent material from being removed through the open pipes

The conclusions and recommendations related to transverse cracking include:

- Grout the structural backfill zone on the north and south side of the principal spillway channel (extending 4 feet out normal to the channel wall). The grouted section should be about 24.5 feet wide (in a transverse direction) extending form the west boundary of the bridge/weir section to the east face of the bridge; and extend from the bottom of the structural backfill zone to the top of the center filter drain. The grout should be a urethane type grout to reduce weight and permeability.

- The area behind the stilling basin walls from the toe of the dam to the canal channel walls of the canal siphon/stilling basin section and from the stilling basin walls for a horizontal distance of 60' from the face of the bridge should be lowered uniformly to an elevation of 1,337 feet.

- A surface filter blanket should be installed in the downstream face of the dam on either side of the principal spillway.

The conclusions and recommendations related to the wall movements include:

- Wall movements are probably related to original design.

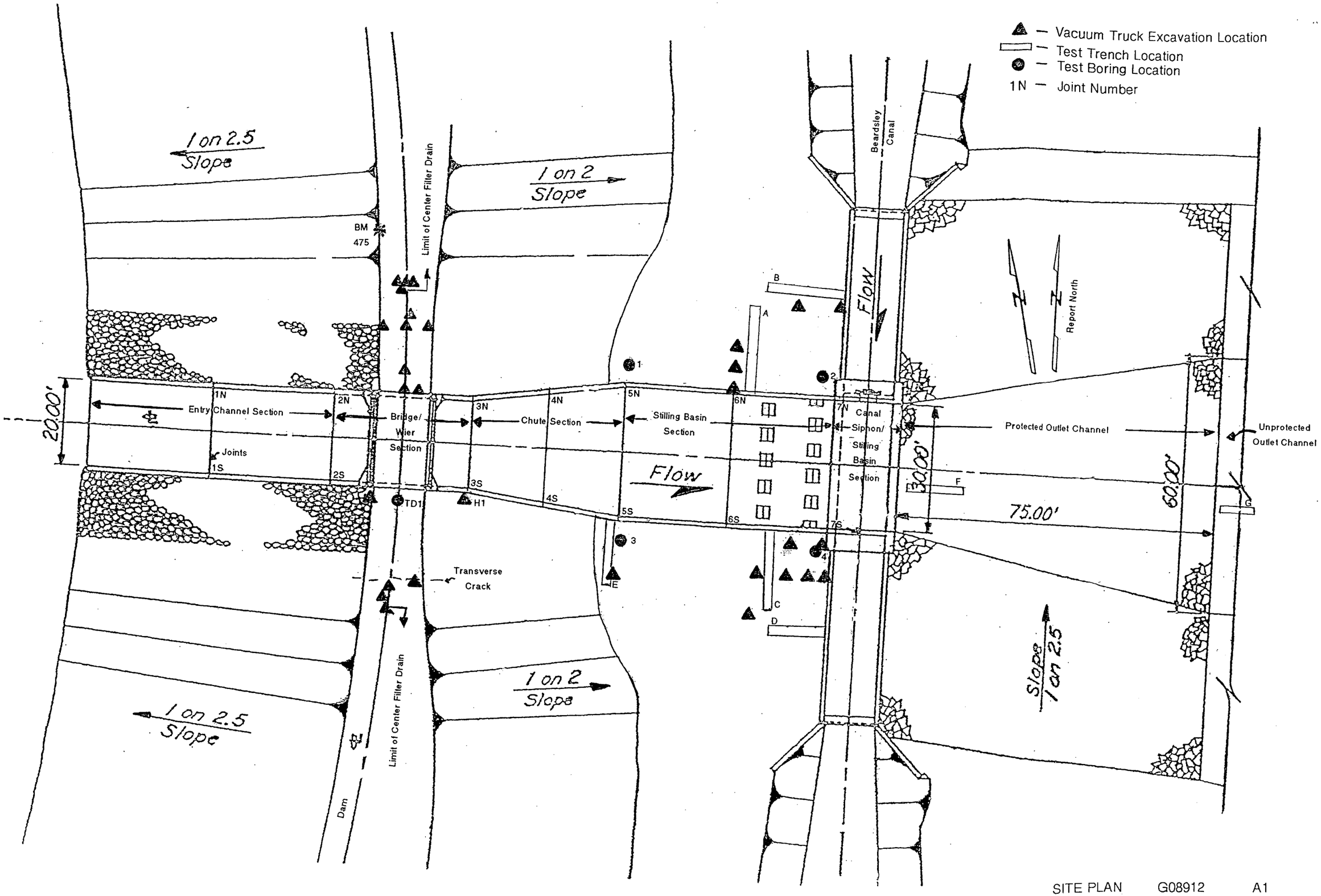
- Wall movements probably occurred during construction.

- Some additional movements may have occurred when flows of sufficient volume occurred in the principal spillway that caused water to enter the drainage system behind the walls and under the floor.

- Rainfall might have wetted the structural backfill and other backfill zones around the structure causing movements.

- A three-part monitoring system should be established to evaluate wall movements. One part utilizes piezometers, one part involving periodic cross-channel measurements at various joints along the tops of walls, and the third part taking periodic measurements of the relative offsets at adjacent joints. Measurements should be taken after storm events.

- District should review all readings to determine if wall movements are occurring and what the magnitude of the movements are and what action should be taken if any.



SITE PLAN G08912 A1

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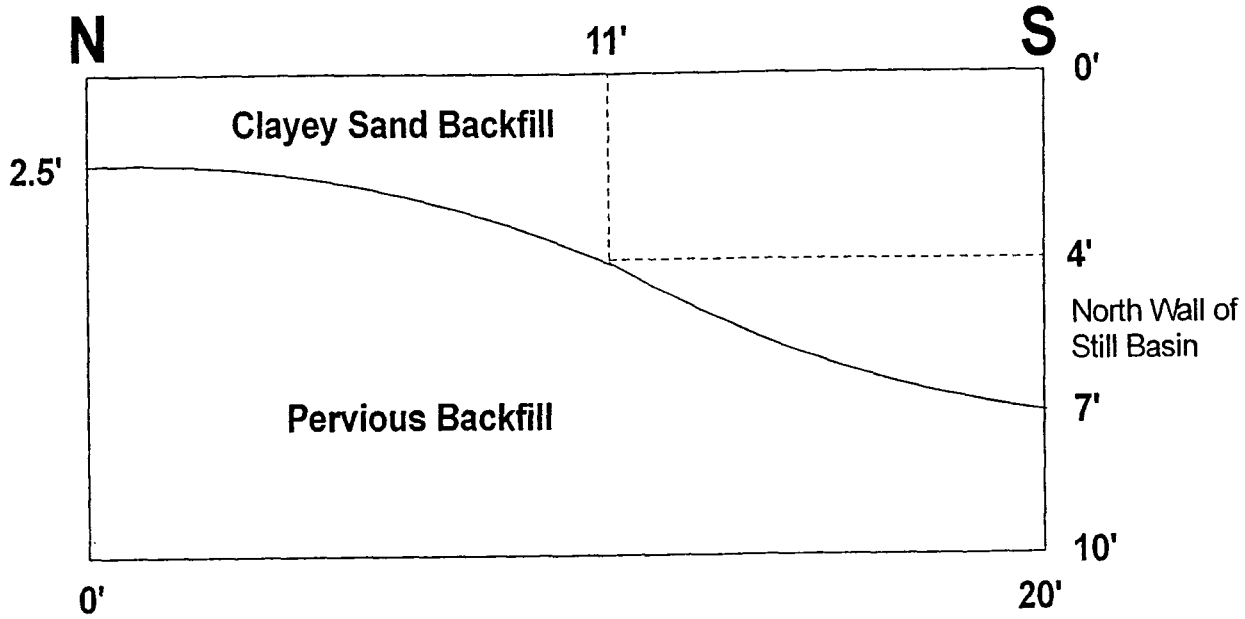

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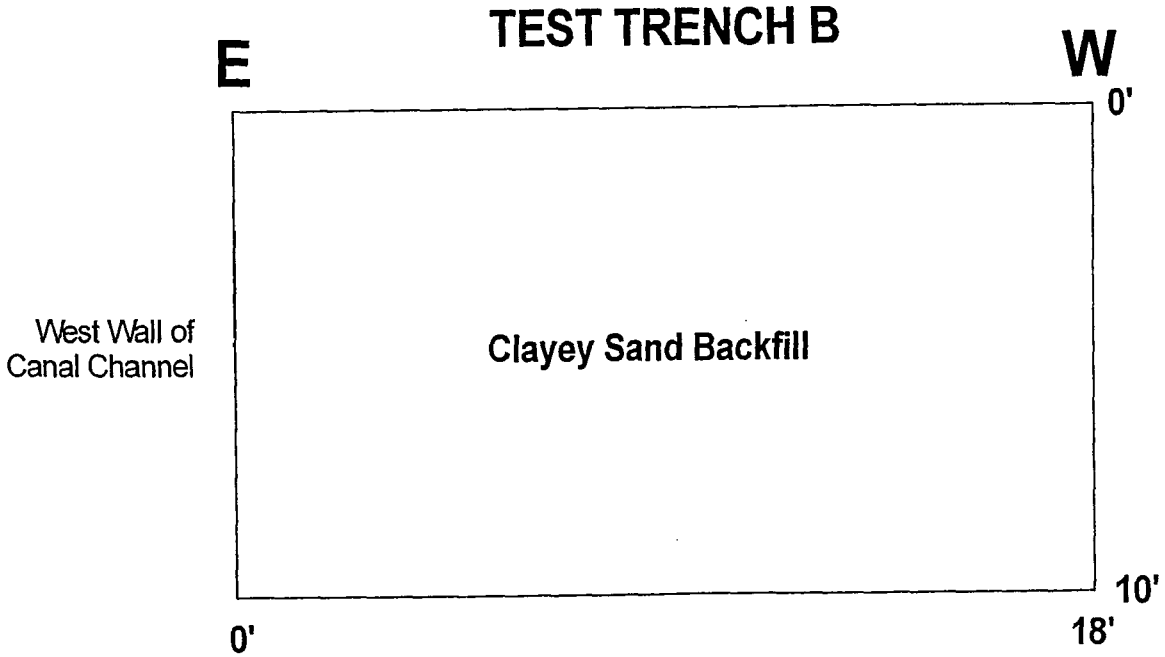

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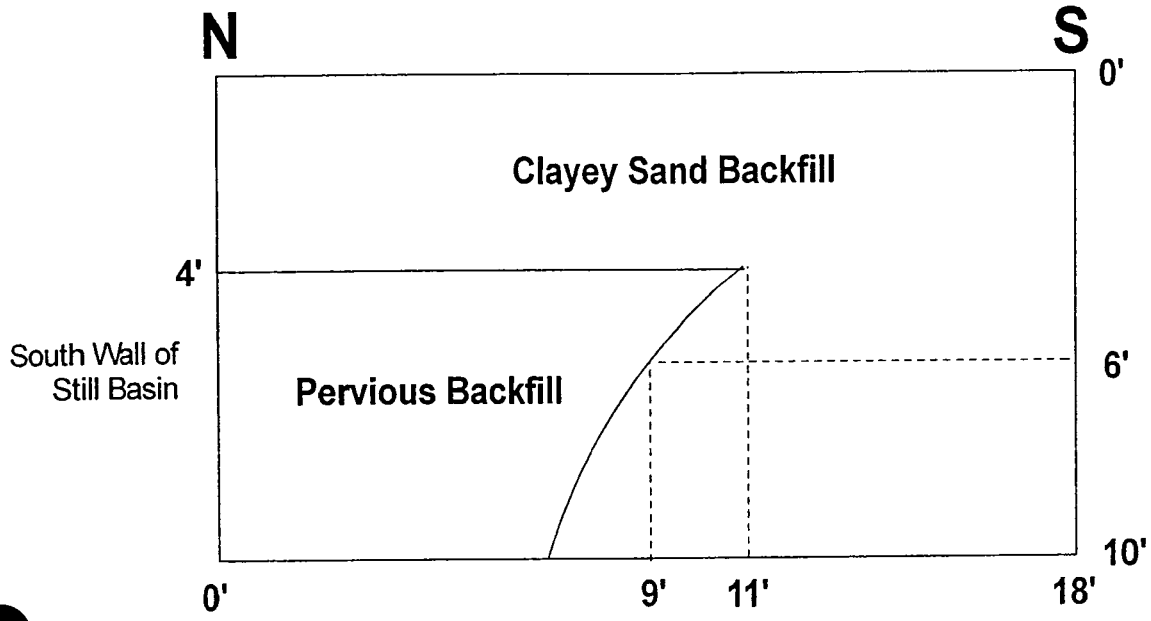
TEST TRENCH CROSS-SECTIONS

TEST TRENCH C



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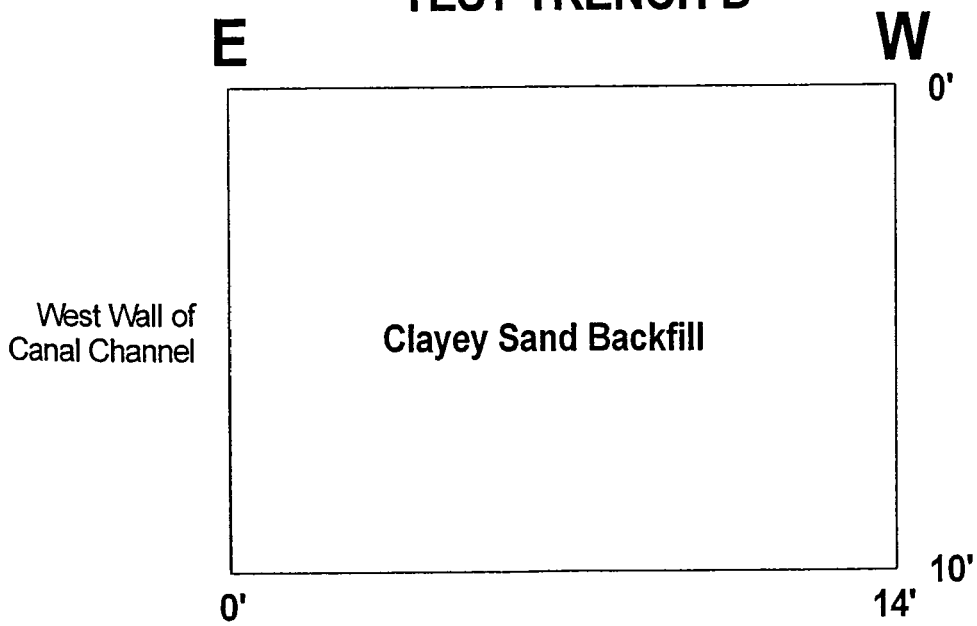

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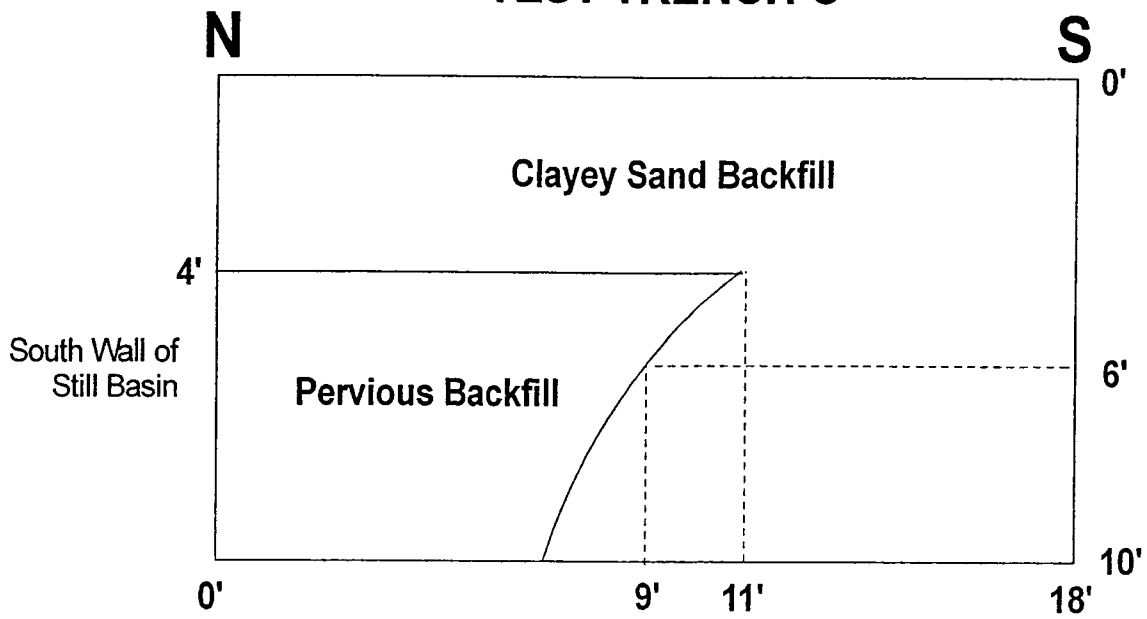

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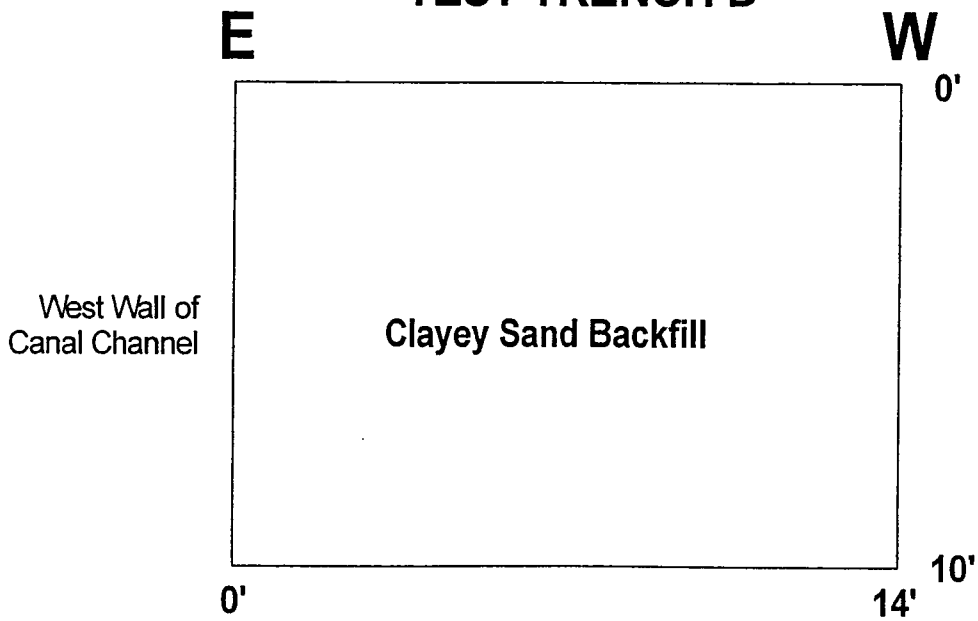

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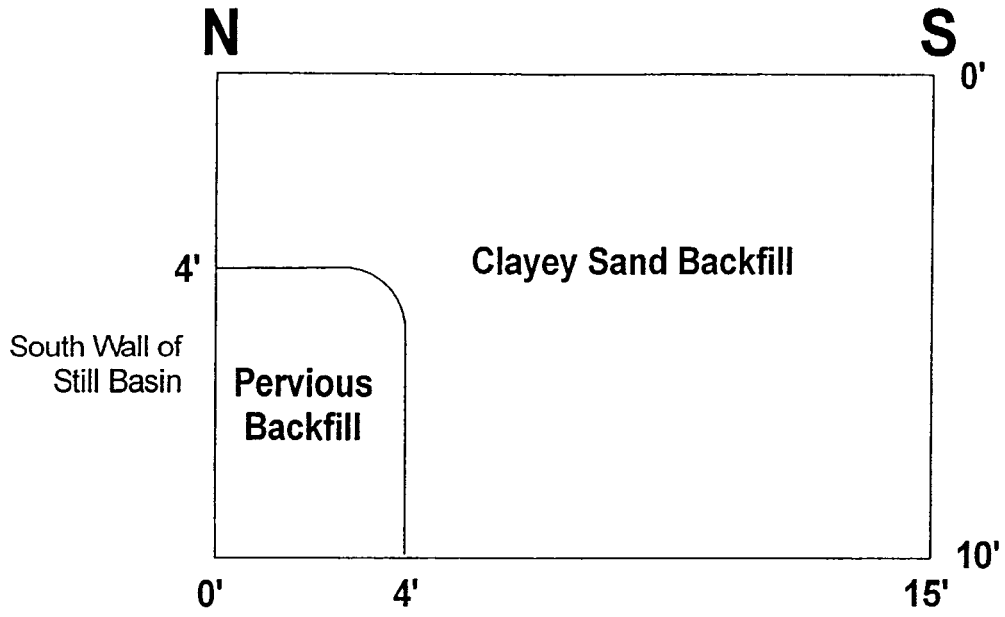
TEST TRENCH E



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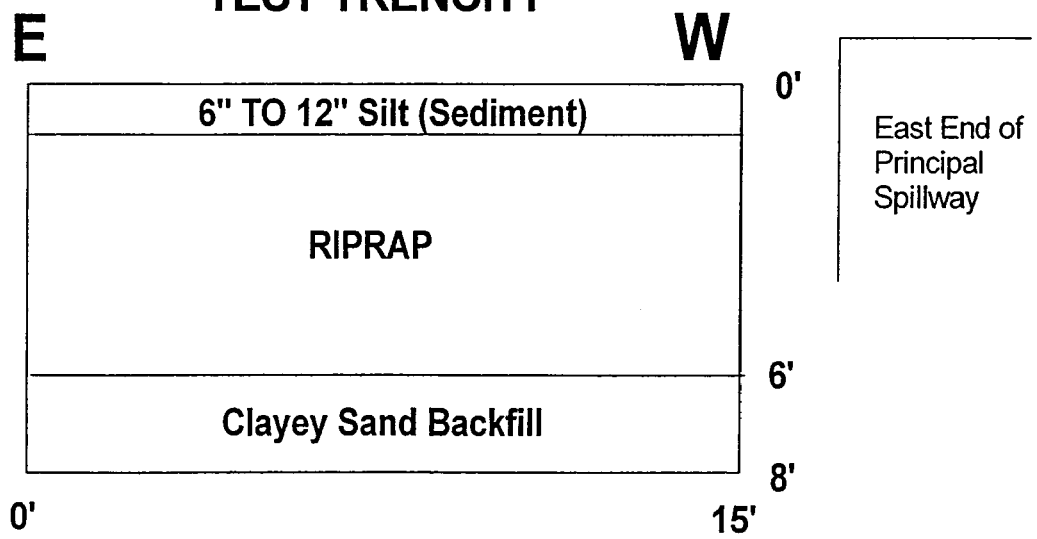

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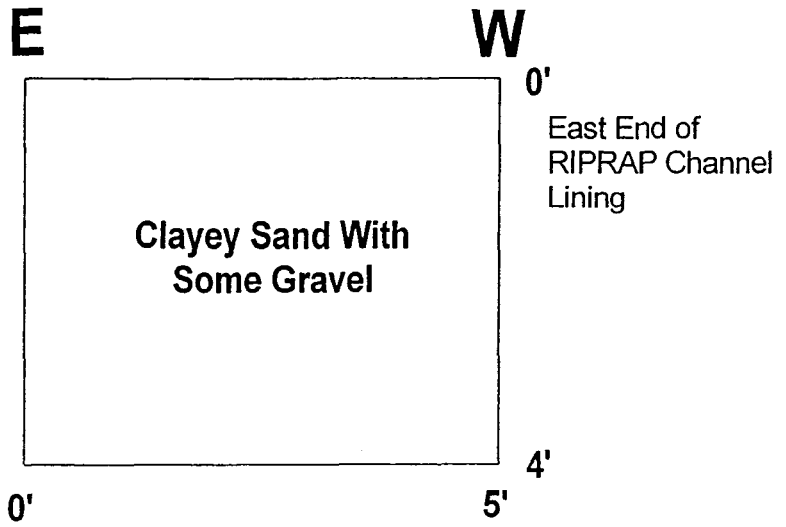
TEST TRENCH CROSS-SECTIONS

TEST TRENCH G



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TEST BORING LOG

BORING NO. H1
PROJECT NAME: Principal Spillway at McMicken Dam
LOCATION: Joint S3
DRILL EQUIPMENT: Vacuum Truck Excavation

DATE: 6-19-03 **BY:** DM
SHEET NO. 1 **OF** 1
GROUND ELEV. 1,355.5'
W.T. ELEV. None Encountered
DRILLER: AZTEC

Depth, feet	*Blows/Foot C	*Blows/Foot N/R	Sample Type	Dry Density, pcf	Water Content, %	Unified Classification	Description
						SM-SC	Structural Backfill - Silty to Clayey Sand, Trace Gravel; brown, nearly dry, loose, low plasticity fines.
5							5
		21	R	97	3		
		40	R	103	4		
		61	R	99	3		
							Stopped at 7.5 feet. Backfill too loose and dry to retain in sampler.
10							No groundwater observed. 10
							* Sampler driven with 40 pound hand operated slide hammer.
							Vacuum truck used 0 to 4.5 feet continuous drive sampling below.
15							15
20							20
25							25

This boring log represents the conditions encountered on the date of drilling at this particular location. No other warranty is expressed or implied to the actual conditions which may exist within the vicinity of this boring location.

TEST BORING LOG

BORING NO. TD1
PROJECT NAME: Principal Spillway at McMicken Dam
LOCATION: Dam Crest South of Bridge
DRILL EQUIPMENT: CME 75

DATE: 6-19-03 **BY:** DM
SHEET NO. 1 **OF** 3
GROUND ELEV. 1,360.2'
W.T. ELEV. None Encountered
DRILLER: D & S Drilling

Depth, feet	Blows/Foot C	Blows/Foot N/R	Sample Type	Dry Density, pcf	Water Content, %	Unified Classification	Description
		46	R	114	4	SC	Structural Backfill - Clayey Sand, Some Gravel; brown, nearly dry to slightly damp, dense at the surface, medium dense to loose below, medium plasticity fines.
5		14	R	114	7		
10		15	R	99	6		
15		9	R	101	11		
20		12	R	107	10		
						SM	Structural Backfill - Silty Sand, Some Gravel; brown, nearly dry to slightly damp, medium dense to loose, low plasticity fines.
25							

- continued -

This boring log represents the conditions encountered on the date of drilling at this particular location. No other warranty is expressed or implied to the actual conditions which may exist within the vicinity of this boring location.

TEST BORING LOG

BORING NO. TD1 **DATE:** 6-19-03 **BY:** DM
PROJECT NAME: Principal Spillway at McMicken Dam **SHEET NO.** 2 **OF** 3
GROUND ELEV. 1,360.2'
LOCATION: Dam Crest South of Bridge **W.T. ELEV.** None Encountered
DRILL EQUIPMENT: CME 75 **DRILLER:** D & S Drilling

Depth, feet	Blows/Foot C	Blows/Foot N/R	Sample Type	Dry Density, pcf	Water Content, %	Unified Classification	Description
		11	R	111	9	SM	Structural Backfill - Silty Sand, Some Gravel; - cont.
30		21	R	111	7	SC	Clayey Sand, Some Gravel; brown, slightly damp to nearly dry, medium dense to dense, intermittent light to moderate cementation 30 to 45 feet, moderate to heavy cementation below 45 feet.
35		33	R	115	4		
40		26	R	*	2		
45		50/7"	R	112	3		
50							

- continued -

This boring log represents the conditions encountered on the date of drilling at this particular location. No other warranty is expressed or implied to the actual conditions which may exist within the vicinity of this boring location.

TEST BORING LOG

BORING NO. TD1
PROJECT NAME: Principal Spillway at McMicken Dam
LOCATION: Dam Crest South of Bridge
DRILL EQUIPMENT: CME 75

DATE: 6-19-03 **BY:** DM
SHEET NO. 3 **OF** 3
GROUND ELEV. 1,360.2'
W.T. ELEV. None Encountered
DRILLER: D & S Drilling

Depth, feet	Blows/Foot C	Blows/Foot N/R	Sample Type	Dry Density, pcf	Water Content, %	Unified Classification	Description
		50/9"	R	104	7	SC	Clayey Sand, Some Gravel; - cont.
							Stopped at 50.8 feet. No groundwater observed.
55							* Ring sample too disturbed to determine density
60							
65							
70							
75							

This boring log represents the conditions encountered on the date of drilling at this particular location. No other warranty is expressed or implied to the actual conditions which may exist within the vicinity of this boring location.

TEST BORING LOG

BORING NO. 1
PROJECT NAME: Principal Spillway at McMicken Dam
LOCATION: Northwest Corner of Stilling Basin
DRILL EQUIPMENT: CME 75

DATE: 6-17-03 **BY:** DM
SHEET NO. 1 **OF** 2
GROUND ELEV. 1,338.6'
W.T. ELEV. None Encountered
DRILLER: D & S Drilling

Depth, feet	Blows/Foot C	Blows/Foot N/R	Sample Type	Dry Density, pcf	Water Content, %	Unified Classification	Description
		10	R	106	4	SM-SC	Backfill - Silty to Clayey Gravelly Sand; brown, nearly dry, medium dense to loose, low to medium plasticity fines.
5		7	R	112	3		
10							
		21	R	115	4	SM	Pervious Backfill - Gravelly Silty Sand; brown, nearly dry, medium dense to loose, low plasticity fines.
15		9	R	112	4		
20		6	R	110	9		
						SC	Clayey sand, Some Gravel; brown, slightly damp to nearly dry, medium dense to dense, intermittent moderate to heavy cementation.
25							

- continued -

This boring log represents the conditions encountered on the date of drilling at this particular location. No other warranty is expressed or implied to the actual conditions which may exist within the vicinity of this boring location.

TEST BORING LOG

BORING NO. 1 **DATE:** 6-17-03 **BY:** DM
PROJECT NAME: Principal Spillway at McMicken Dam **SHEET NO.** 2 **OF** 2
GROUND ELEV. 1,338.6'
LOCATION: Northwest Corner of Stilling Basin **W.T. ELEV.** None Encountered
DRILL EQUIPMENT: CME 75 **DRILLER:** D & S Drilling

Depth, feet	Blows/Foot C	Blows/Foot N/R	Sample Type	Dry Density, pcf	Water Content, %	Unified Classification	Description
		50/9"	R	108	14	SC	Clayey Sand, Some Gravel; - cont.
30		33	R	109	9		
35		41	R	111	10		
40		50/3"	R	NR			
							Stopped at 40.3 feet. No groundwater observed. NR = No Recovery Note: Set slotted pipe tip at 39.3 feet and completed piezometer.
45							
50							

This boring log represents the conditions encountered on the date of drilling at this particular location. No other warranty is expressed or implied to the actual conditions which may exist within the vicinity of this boring location.

TEST BORING LOG

BORING NO. 2 **DATE:** 6-17-03 **BY:** DM
PROJECT NAME: Principal Spillway at McMicken Dam **SHEET NO.** 1 **OF** 3
GROUND ELEV. 1,337.0'
LOCATION: Northeast Corner of Stilling Basin **W.T. ELEV.** None Encountered
DRILL EQUIPMENT: CME 75 **DRILLER:** D & S Drilling

Depth, feet	Blows/Foot C	Blows/Foot N/R	Sample Type	Dry Density, pcf	Water Content, %	Unified Classification	Description
		8	R	112	4	SM	Pervious Backfill - Gravelly Silty Sand; brown, nearly dry, medium dense to loose, low plasticity fines.
5		5	R	108	5		
10		10	R	118	5		
15		9	R	113	8		
20		6	R	NR		SM-SC	Backfill - Silty to Clayey Gravelly Sand; brown, nearly dry, medium dense to loose, low to medium plasticity fines.
25							

- continued -

This boring log represents the conditions encountered on the date of drilling at this particular location. No other warranty is expressed or implied to the actual conditions which may exist within the vicinity of this boring location.

TEST BORING LOG

BORING NO. 2
PROJECT NAME: Principal Spillway at McMicken Dam
LOCATION: Northeast Corner of Stilling Basin
DRILL EQUIPMENT: CME 75

DATE: 6-17-03 **BY:** DM
SHEET NO. 2 **OF** 3
GROUND ELEV. 1,337.0'
W.T. ELEV. None Encountered
DRILLER: D & S Drilling

Depth, feet	Blows/Foot C	Blows/Foot N/R	Sample Type	Dry Density, pcf	Water Content, %	Unified Classification	Description
		7	R	112	13	SM-SC	Backfill - Silty to Clayey Gravelly Sand; - cont.
30		42	R	104	6		Concrete Wash/Spoil/Spillage; gray, very hard to soft, low strength.
						SC	Clayey Sand, Some Gravel; brown, slightly damp to nearly dry, medium dense to dense, moderate cementation.
35		39	R	106	9	SP	Sand, Trace to Some Gravel, Trace Silt; brown, slightly damp to nearly dry, medium dense to dense, no to low plasticity fines.
40		36	R	110	3		
45		50/8"	R	111	9	SC	Clayey Sand, Some Gravel; brown, slightly damp to nearly dry, medium dense to dense, moderate cementation.
50							- continued -

This boring log represents the conditions encountered on the date of drilling at this particular location. No other warranty is expressed or implied to the actual conditions which may exist within the vicinity of this boring location.

TEST BORING LOG

BORING NO. 2
PROJECT NAME: Principal Spillway at McMicken Dam
LOCATION: Northeast Corner of Stilling Basin
DRILL EQUIPMENT: CME 75

DATE: 6-17-03 **BY:** DM
SHEET NO. 3 **OF** 3
GROUND ELEV. 1,337.0'
W.T. ELEV. None Encountered
DRILLER: D & S Drilling

Depth, feet	Blows/Foot C	Blows/Foot N/R	Sample Type	Dry Density, pcf	Water Content, %	Unified Classification	Description
		50	R	103	8	SC	Clayey Sand, Some Gravel; - cont.
							Stopped at 51 feet.
							No groundwater observed.
							NR = No Recovery
55							Note: Set porous stone/pipe tip at 49.8 feet, then completed piezometer.
60							
65							
70							
75							

This boring log represents the conditions encountered on the date of drilling at this particular location. No other warranty is expressed or implied to the actual conditions which may exist within the vicinity of this boring location.

TEST BORING LOG

BORING NO. 3
PROJECT NAME: Principal Spillway at McMicken Dam
LOCATION: Southwest Corner of Stilling Basin
DRILL EQUIPMENT: CME 75

DATE: 6-18-03 **BY:** DM
SHEET NO. 1 **OF** 2
GROUND ELEV. 1,339.6'
W.T. ELEV. None Encountered
DRILLER: D & S Drilling

Depth, feet	Blows/Foot C	Blows/Foot N/R	Sample Type	Dry Density, pcf	Water Content, %	Unified Classification	Description
		5	R	111	12	SC	Backfill - Clayey Sand, Some Gravel; brown, slightly damp to nearly dry, loose to medium dense, medium plasticity fines.
5		12	R	123	10		
10		7	R	NR		SM-SC	Backfill - Silty to Clayey Gravelly Sand; brown, nearly dry, medium dense to loose, low to medium plasticity fines.
15		10	R	116	5		
20		38	R	113	4		
25						SC	Clayey Sand, Some Gravel; brown, slightly damp to nearly dry, medium dense to dense, moderate cementation.

- continued -

This boring log represents the conditions encountered on the date of drilling at this particular location. No other warranty is expressed or implied to the actual conditions which may exist within the vicinity of this boring location.

TEST BORING LOG

BORING NO. 3
PROJECT NAME: Principal Spillway at McMicken Dam
LOCATION: Southwest Corner of Stilling Basin
DRILL EQUIPMENT: CME 75

DATE: 6-18-03 **BY:** DM
SHEET NO. 2 **OF** 2
GROUND ELEV. 1,339.6'
W.T. ELEV. None Encountered
DRILLER: D & S Drilling

Depth, feet	Blows/Foot C	Blows/Foot N/R	Sample Type	Dry Density, pcf	Water Content, %	Unified Classification	Description
		44	R	104	13	SC	Clayey Sand, Some Gravel; - cont.
30		36	R	115	11		
35		50/7"	R	113	11		
40		45	R	117	3		
							Stopped at 41 feet. No groundwater observed. NR = No Recovery
45							Note: Set porous stone/pipe tip at 40.5 feet, then completed piezometer.
50							

This boring log represents the conditions encountered on the date of drilling at this particular location. No other warranty is expressed or implied to the actual conditions which may exist within the vicinity of this boring location.

TEST BORING LOG

BORING NO. 4
PROJECT NAME: Principal Spillway at McMicken Dam
LOCATION: Southeast Corner of Stilling Basin
DRILL EQUIPMENT: CME 75

DATE: 6-18-03 **BY:** DM
SHEET NO. 1 **OF** 3
GROUND ELEV. 1,338.0'
W.T. ELEV. None Encountered
DRILLER: D & S Drilling

Depth, feet	Blows/Foot C	Blows/Foot N/R	Sample Type	Dry Density, pcf	Water Content, %	Unified Classification	Description
		8	R	102	3	SM-SC	Backfill - Silty to Clayey Gravelly Sand; brown, nearly dry, medium dense to loose, low to medium plasticity fines.
5		6	R	97	5		
10							
		12	R	119	3	SM	Pervious Backfill - Gravelly Silty Sand; brown, nearly dry, medium dense to loose, low plasticity fines.
15		11	R	109	4		
20							
		6	R	NR		SM-SC	Backfill - Silty to Clayey Gravelly Sand; brown, nearly dry, medium dense to loose, low to medium plasticity fines.
25							

- continued -

This boring log represents the conditions encountered on the date of drilling at this particular location. No other warranty is expressed or implied to the actual conditions which may exist within the vicinity of this boring location.

TEST BORING LOG

BORING NO. 4
PROJECT NAME: Principal Spillway at McMicken Dam
LOCATION: Southeast Corner of Stilling Basin
DRILL EQUIPMENT: CME 75

DATE: 6-18-03 **BY:** DM
SHEET NO. 2 **OF** 3
GROUND ELEV. 1,338.0'
W.T. ELEV. None Encountered
DRILLER: D & S Drilling

Depth, feet	Blows/Foot C	Blows/Foot N/R	Sample Type	Dry Density, pcf	Water Content, %	Unified Classification	Description
		7	R	117	12	SM-SC	Backfill - Silty to Clayey Gravelly Sand; - cont.
30		7	R	107	13		
35		19	R	107	16	SM	Silty Sand, Some Gravel; brown, slightly damp to nearly dry, medium dense, low plasticity fines.
40		50/9"	R	116	5	SC	Clayey Sand, Some Gravel; brown, slightly damp to nearly dry, medium dense to dense, moderate cementation.
45		50/8"	R	113	6		
50							

- continued -

This boring log represents the conditions encountered on the date of drilling at this particular location. No other warranty is expressed or implied to the actual conditions which may exist within the vicinity of this boring location.

TEST BORING LOG

BORING NO. 4
PROJECT NAME: Principal Spillway at McMicken Dam
LOCATION: Southeast Corner of Stilling Basin
DRILL EQUIPMENT: CME 75

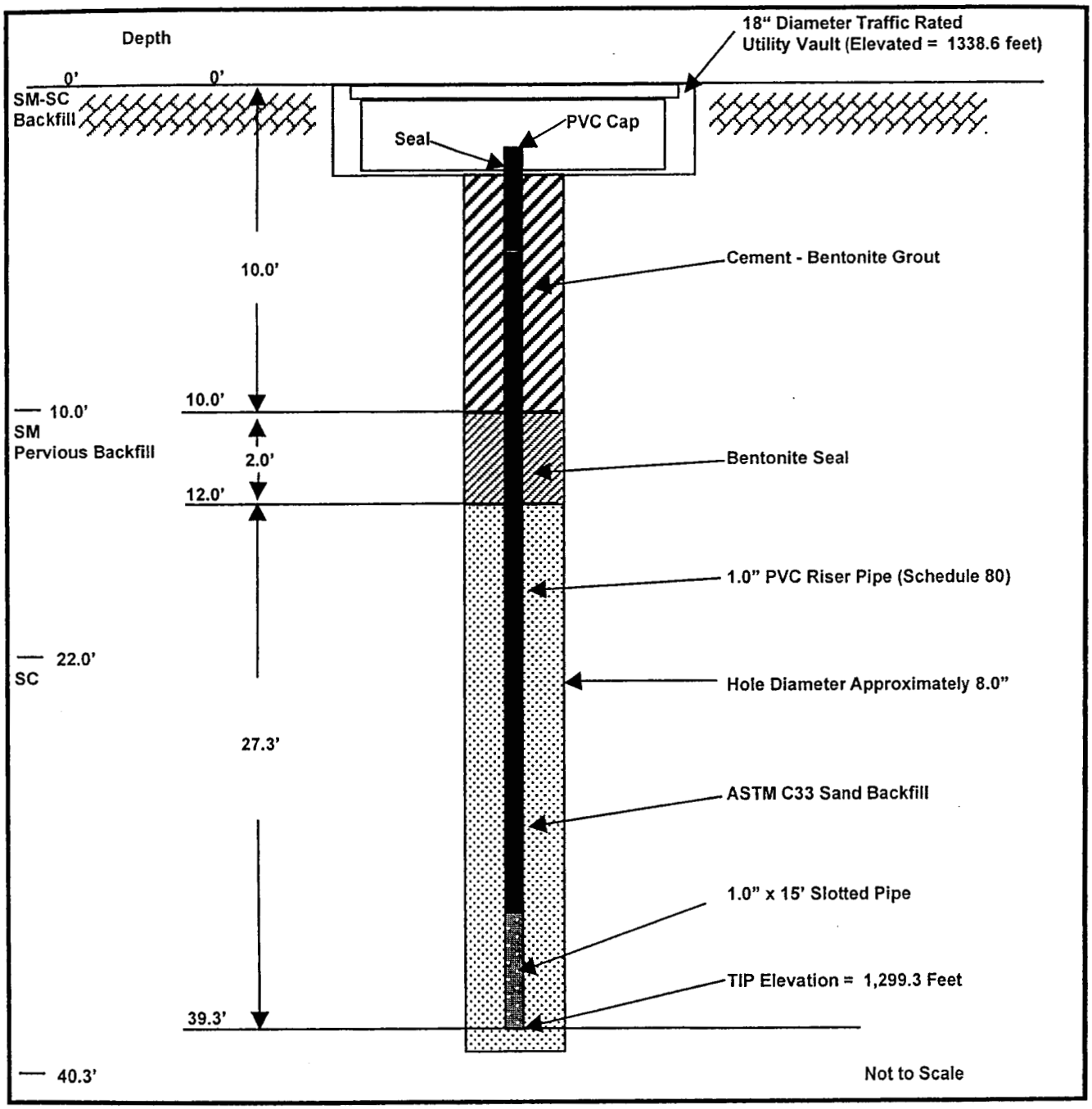
DATE: 6-18-03 **BY:** DM
SHEET NO. 3 **OF** 3
GROUND ELEV. 1,338.0'
W.T. ELEV. None Encountered
DRILLER: D & S Drilling

Depth, feet	Blows/Foot C	Blows/Foot N/R	Sample Type	Dry Density, pcf	Water Content, %	Unified Classification	Description
		50/7"	R	113	7	SC	Clayey Sand, Some Gravel; - cont.
							Stopped at 50.6 feet.
							No groundwater observed.
							NR = No Recovery
55							Note: Set porous stone/pipe tip at 50.0 feet, then completed piezometer.
60							
65							
70							
75							

This boring log represents the conditions encountered on the date of drilling at this particular location. No other warranty is expressed or implied to the actual conditions which may exist within the vicinity of this boring location.

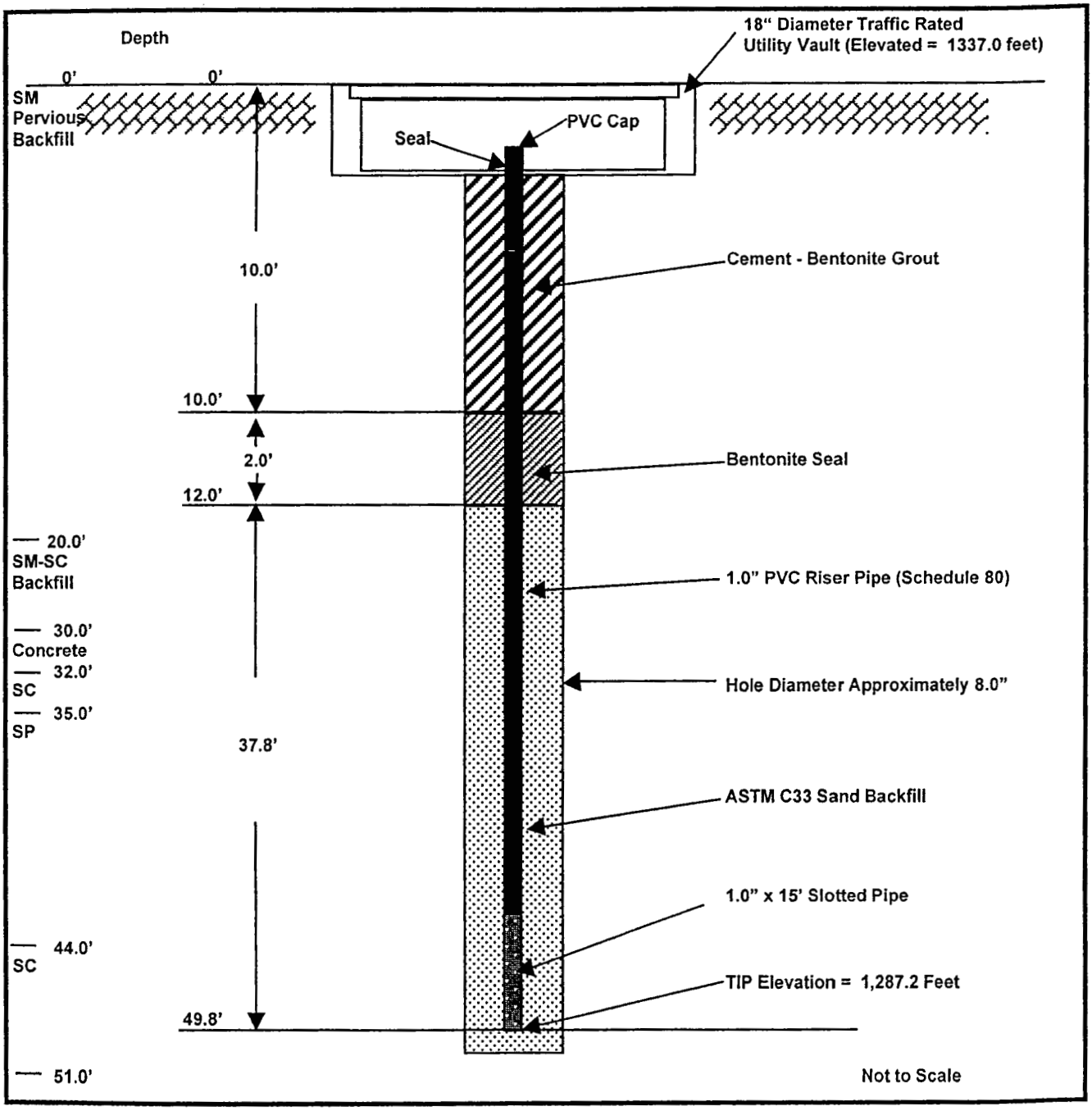
RICKER, ATKINSON, MCBEE & ASSOCIATES, INC.
GEOTECHNICAL SERVICES
PIEZOMETER LOG

PIEZOMETER NO. 1 **DATE:** 6-17-03 **BY:** DM
PROJECT NO. G08912 **GROUND ELEV.** 1,338.6'
PROJECT NAME: Principal Spillway McMicken Dam **W.T. DEPTH** None Encountered
DRILLER: D & S Drilling
LOCATION: --- **ADWR REGISTRATION NO.:** 55-598515
DRILL EQUIPMENT: CME 75 Using 8"-Dia HSA **FILE NO.** B (4-2) 24 BCA



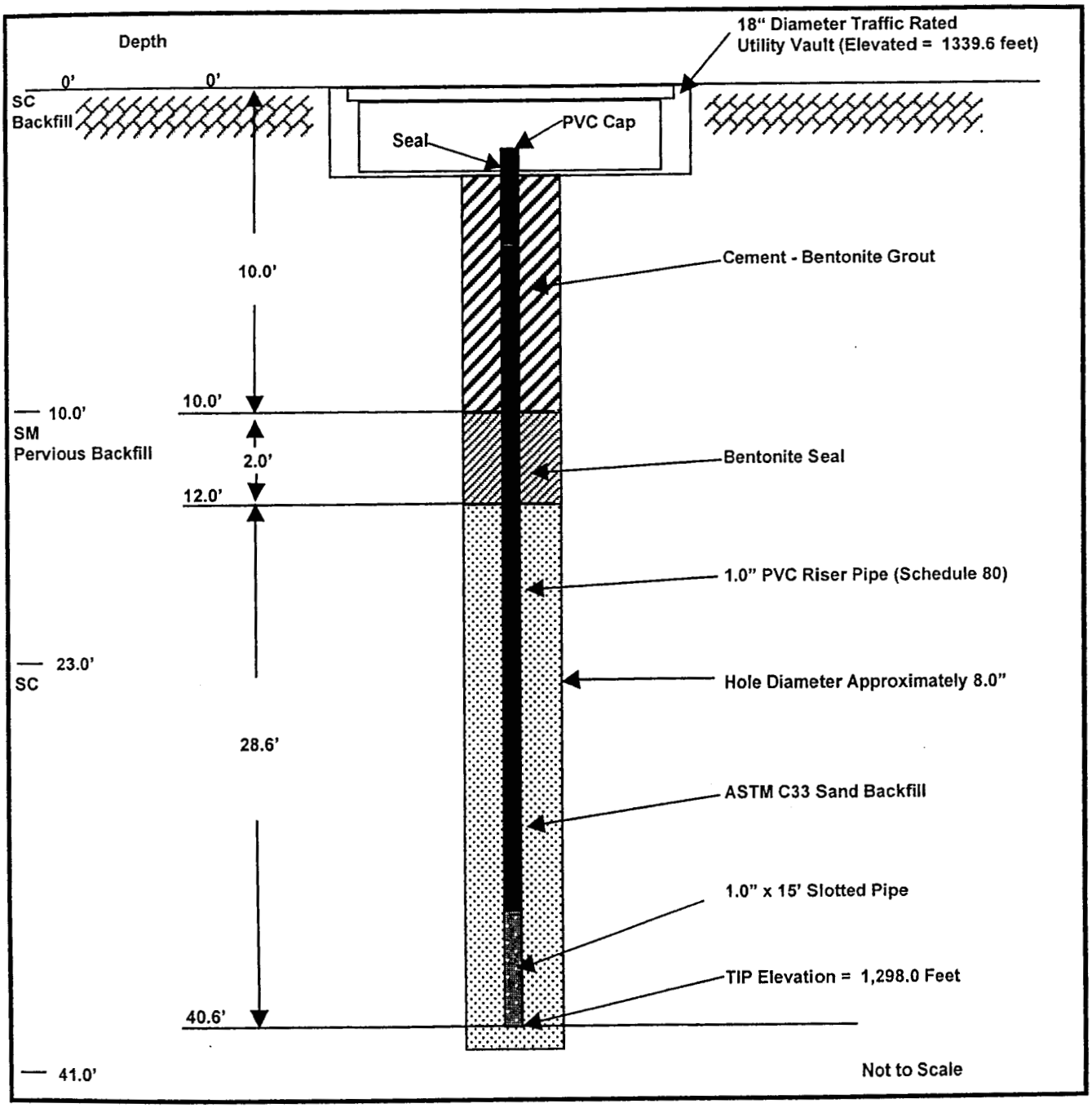
RICKER, ATKINSON, MCBEE & ASSOCIATES, INC.
GEOTECHNICAL SERVICES
PIEZOMETER LOG

PIEZOMETER NO. 2 **DATE:** 6-17-03 **BY:** DM
PROJECT NO. G08912 **GROUND ELEV.** 1,337.0'
PROJECT NAME: Principal Spillway McMicken Dam **W.T. DEPTH** None Encountered
DRILLER: D & S Drilling
LOCATION: --- **ADWR REGISTRATION NO.:** 55-598516
DRILL EQUIPMENT: CME 75 Using 8"-Dia HSA **FILE NO.** B (4-2) 24 BCA



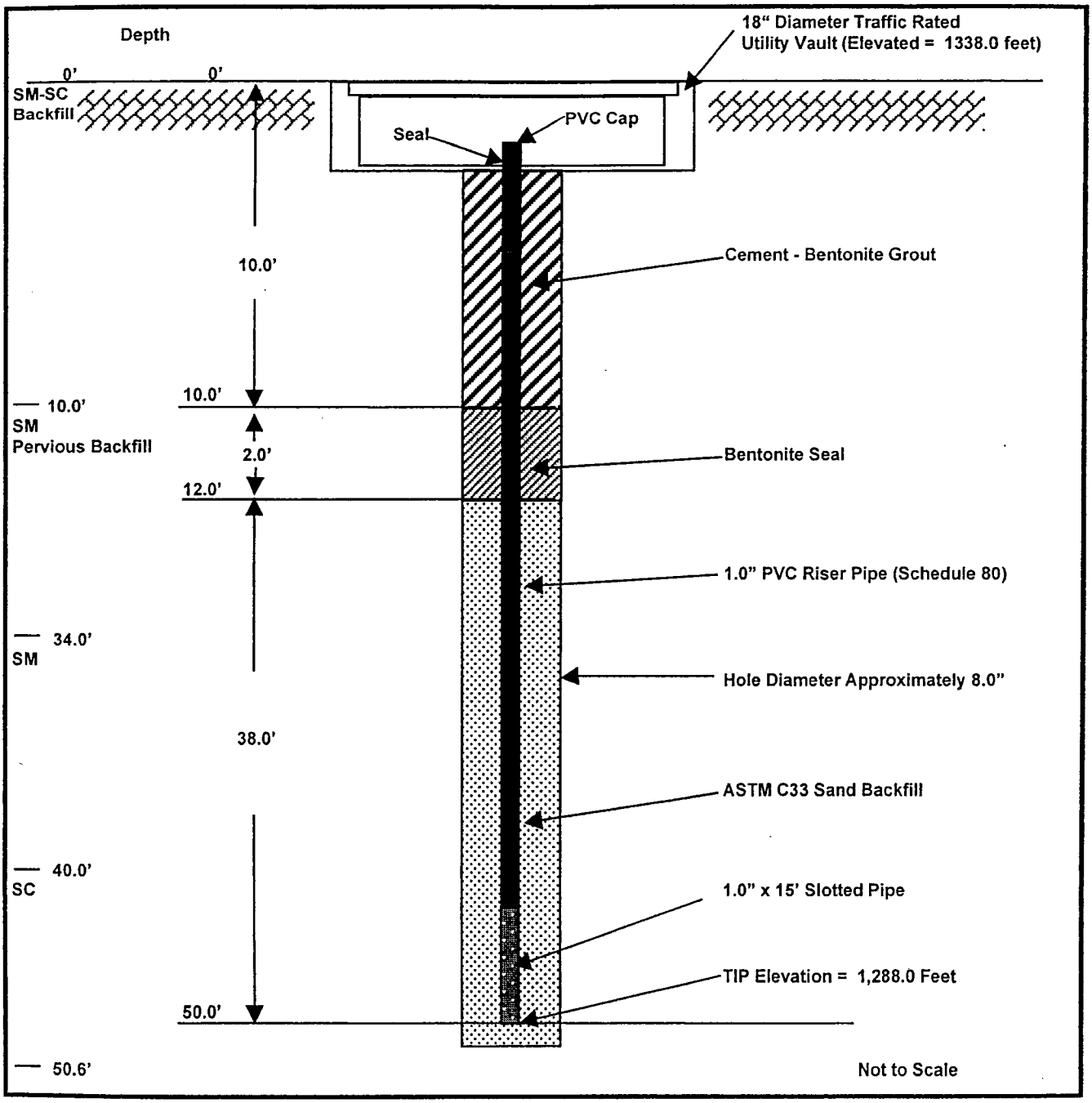
RICKER, ATKINSON, MCBEE & ASSOCIATES, INC.
GEOTECHNICAL SERVICES
PIEZOMETER LOG

PIEZOMETER NO. 3 **DATE:** 6-18-03 **BY:** DM
PROJECT NO. G08912 **GROUND ELEV.** 1,339.6'
PROJECT NAME: Principal Spillway McMicken Dam **W.T. DEPTH** None Encountered
DRILLER: D & S Drilling
LOCATION: --- **ADWR REGISTRATION NO.:** 55-598517
DRILL EQUIPMENT: CME 75 Using 8"-Dia HSA **FILE NO.** B (4-2) 24 BCA



RICKER, ATKINSON, MCBEE & ASSOCIATES, INC.
GEOTECHNICAL SERVICES
PIEZOMETER LOG

PIEZOMETER NO. 4 **DATE:** 6-18-03 **BY:** DM
PROJECT NO. G08912 **GROUND ELEV.** 1,338.0'
PROJECT NAME: Principal Spillway McMicken Dam **W.T. DEPTH** None Encountered
DRILLER: D & S Drilling
LOCATION: --- **ADWR REGISTRATION NO.:** 55-598518
DRILL EQUIPMENT: CME 75 Using 8"-Dia HSA **FILE NO.** B (4-2) 24 BCA



Piezometers 1 to 4 have been read at the following times and no perched water was observed or measured; 6-18-03, 8-20-03, 10-20-03 and 12-20-03.

Principal Spillway Wall Movements:

The top of the north and south walls along the principal spillway have undergone various movements. The magnitude of the movements was determined by measuring the distance across the principal spillway at the top of the walls inside face on either side of each wall joint with a tape and by measuring the difference across a joint on the inside face. The joint numbers are shown on the Site Plan (page A1 in Appendix A). The joint numbers are based on N is north wall, S is south wall, 1 is the first wall joint starting in the middle of the entry channel section and increasing to the east. The following tables present the results of these measurements:

			Distance Between North and South Walls				
				Measured Width		Difference**	
Joint to Joint	Location	Design Height	Design Width	West Side*	East Side*	West Side*	East Side*
1N-1S	Middle of entry channel	11.92'	20'-0"	19'-11 ¾"	19'-11 ½"	¼"	½"
2N-2S	Entry channel to bridge/wier	22.91'	20'-0"	19'-10"	19'-11 ½"	2"	½"
3N-3S	Bridge/wier to chute	22.75'	20'-0"	19'-10 ¾"	19'-8 ¼"	1 ¼"	3 ¾"
4N-4S	Middle of chute	19.4'	25'-0"	24'- 8 ½"	24'-9"	3 ½"	3"
5N-5S	Chute to stilling basin	20.5'	30'-0"	29'-8 ½"	29'-8"	3 ½"	4"
6N-6S	Middle of stilling basin	20.5'	30'-0"	29'-8 ½"	29'-8 ¾"	3 ½"	3 ¼"
7N-7S	Stilling basin to canal siphon/stilling basin	20.5'	30'-0"	29'-10"	29'-11 ¼"	2"	¾"

* Side of joint.
** Between design and measured.

Joint	Measured Difference Across Joint	Side That Moved In
1N	1/16"	East
1S	1/4"	East
2N	3/4"	West
2S	1"	West
3N	1 3/8"	East
3S	1 3/8"	East
4N	1/8"	West
4S	0	--
5N	0	--
5S	1/4"	East
6N	1/4"	West
6S	1/8"	West
7N	5/8"	West
7S	7/16"	West

All of the walls are cantilevered except for:

1. The east side of Joints 2N and 2S and the west side of Joints 3N and 3S which are bridge/wier sections. In this section the bridge and the wier beam restrain the top of the wall from moving.

2. The east side of Joints 7N and 7S which is the canal siphon/stilling basin section. Both ends of the upper stilling basin part of the section are restrained by the west and east Beardsley Canal channel walls which are structurally tied to and are perpendicular to the stilling basin walls. In addition, a 5-foot wide (horizontal) sidewalk spans between the channel walls and is structurally tied to the stilling basin wall.

Other Site Conditions:

The following site conditions were also observed:

1. An MCI fiber optic line crosses over the top of the principal spillway in a 4 ½-inch diameter steel pipe 14'-4" east of Joint 5N and 15'-2" east of Joint 5S. The line is buried from the

LABORATORY TEST RESULTS

Date: 31-Mar-04

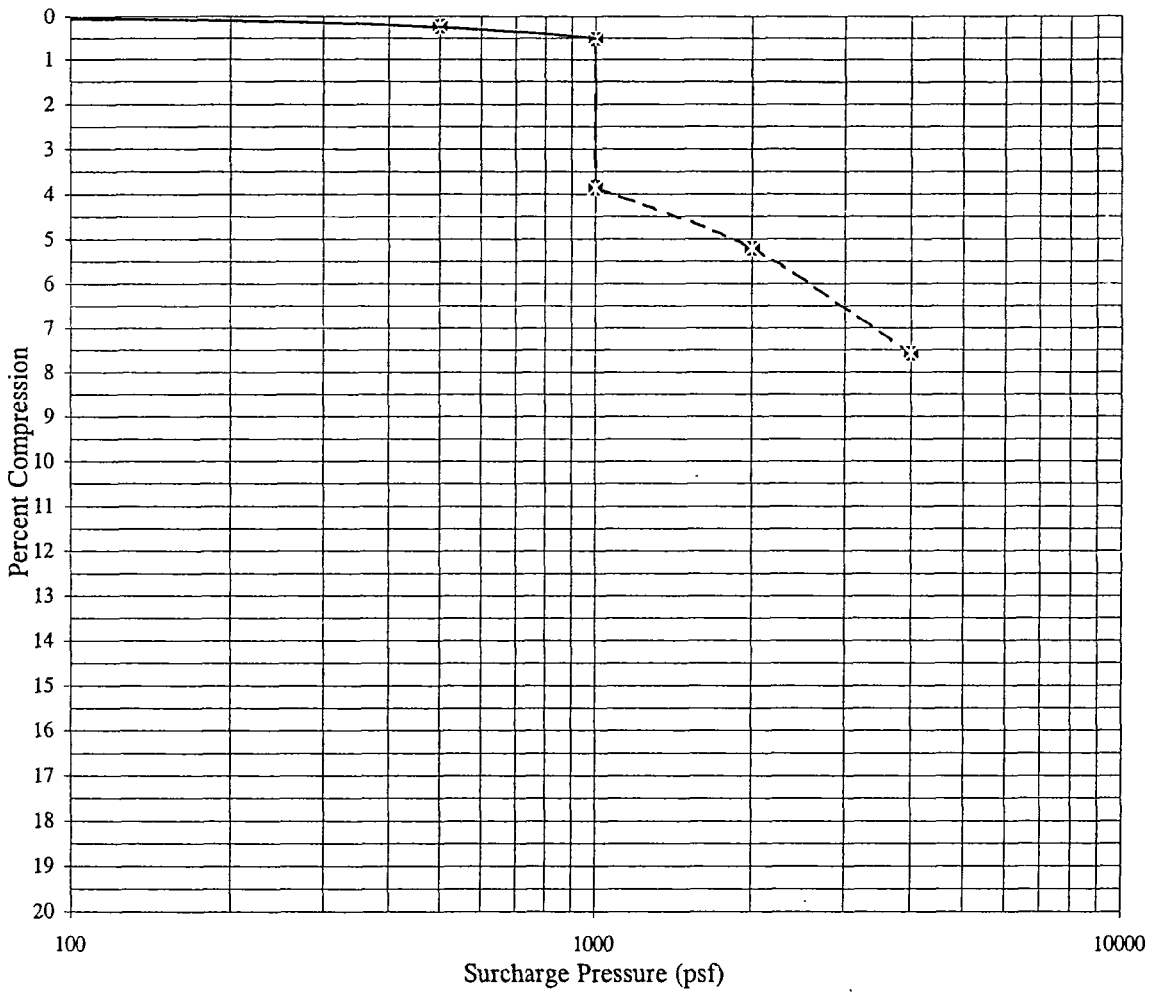
SAMPLE SOURCE: H1 @ 5.5'-6.5'

TESTING PERFORMED: Compression (ASTM D2434) - Driven Ring Sample

SAMPLED BY: RAM/Miller

RESULTS:

Dry Density (pcf): 103 Moisture Content (%): 4



REMARKS: Sample submerged at 1000 psf.

LABORATORY TEST RESULTS

Date: 31-Mar-04

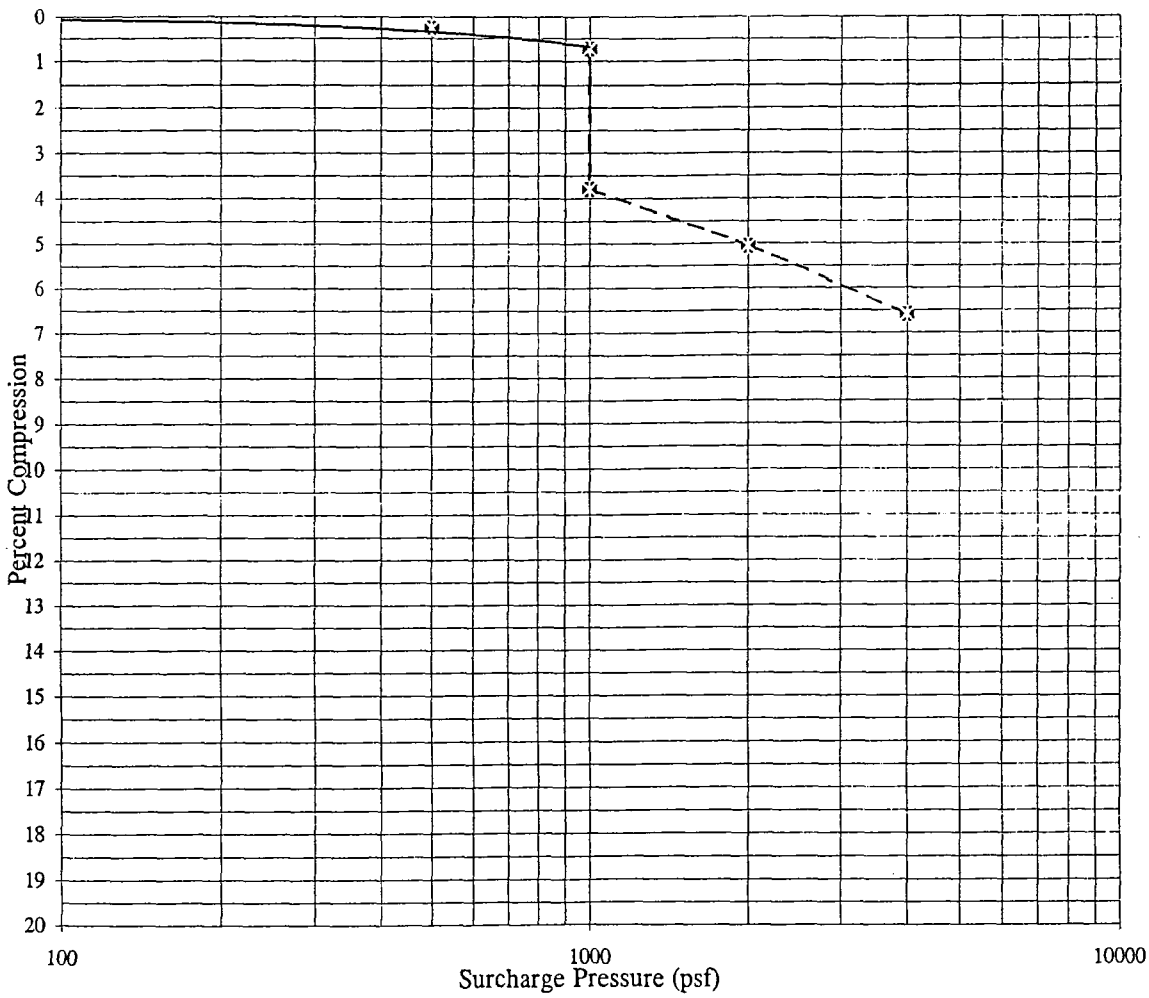
SAMPLE SOURCE: TD1 @ 25'-26'

TESTING PERFORMED: Compression (ASTM D2434) - Driven Ring Sample

SAMPLED BY: RAM/Miller

RESULTS:

Dry Density (pcf): 111 Moisture Content (%): 9



REMARKS: Sample submerged at 1000 psf.

LABORATORY TEST RESULTS

Date: 31-Mar-04

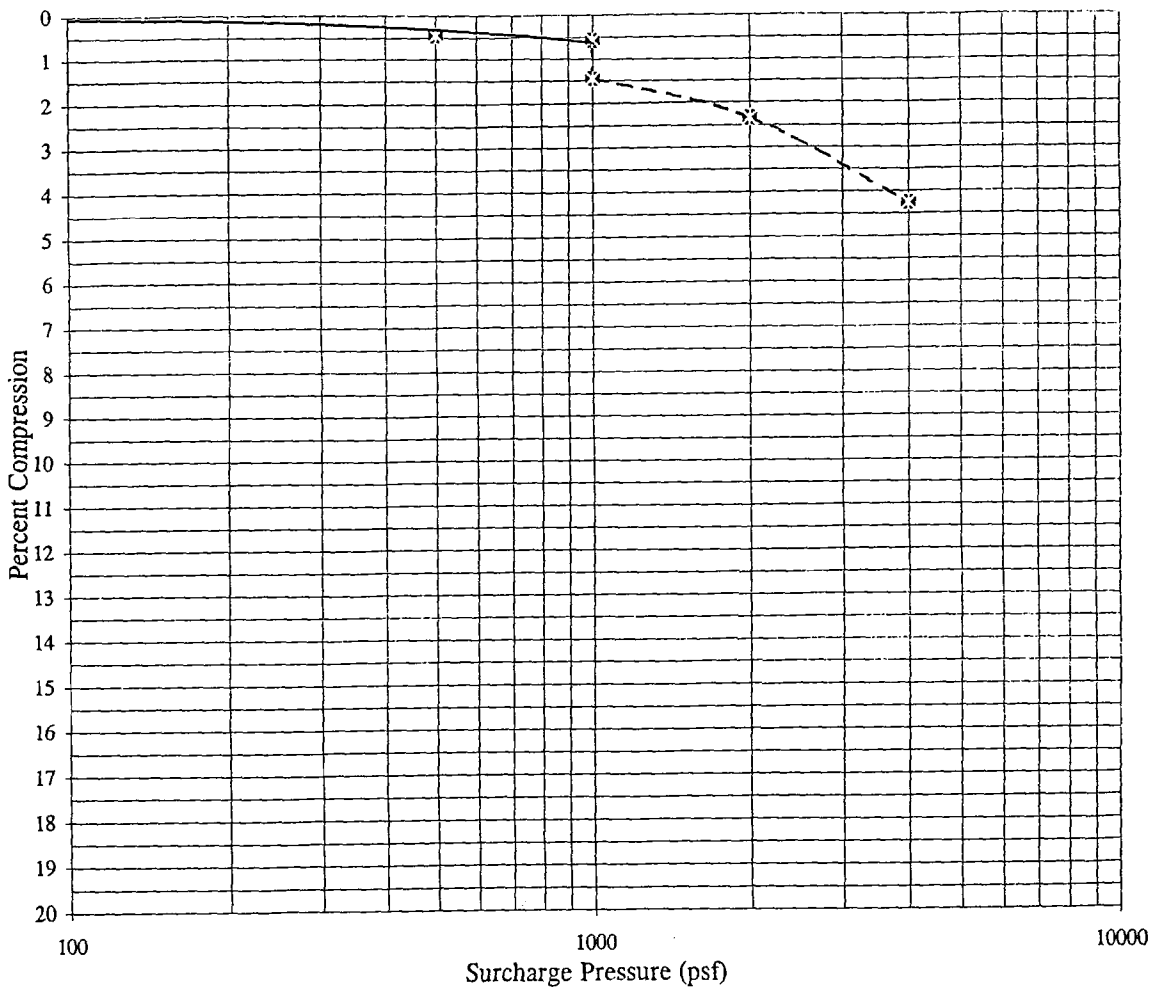
SAMPLE SOURCE: TD1 @ 30'-31'

TESTING PERFORMED: Compression (ASTM D2434) - Driven Ring Sample

SAMPLED BY: RAM/Miller

RESULTS:

Dry Density (pcf): 111 Moisture Content (%): 7



REMARKS: Sample submerged at 1000 psf.

LABORATORY TEST RESULTS

Date: 31-Mar-04

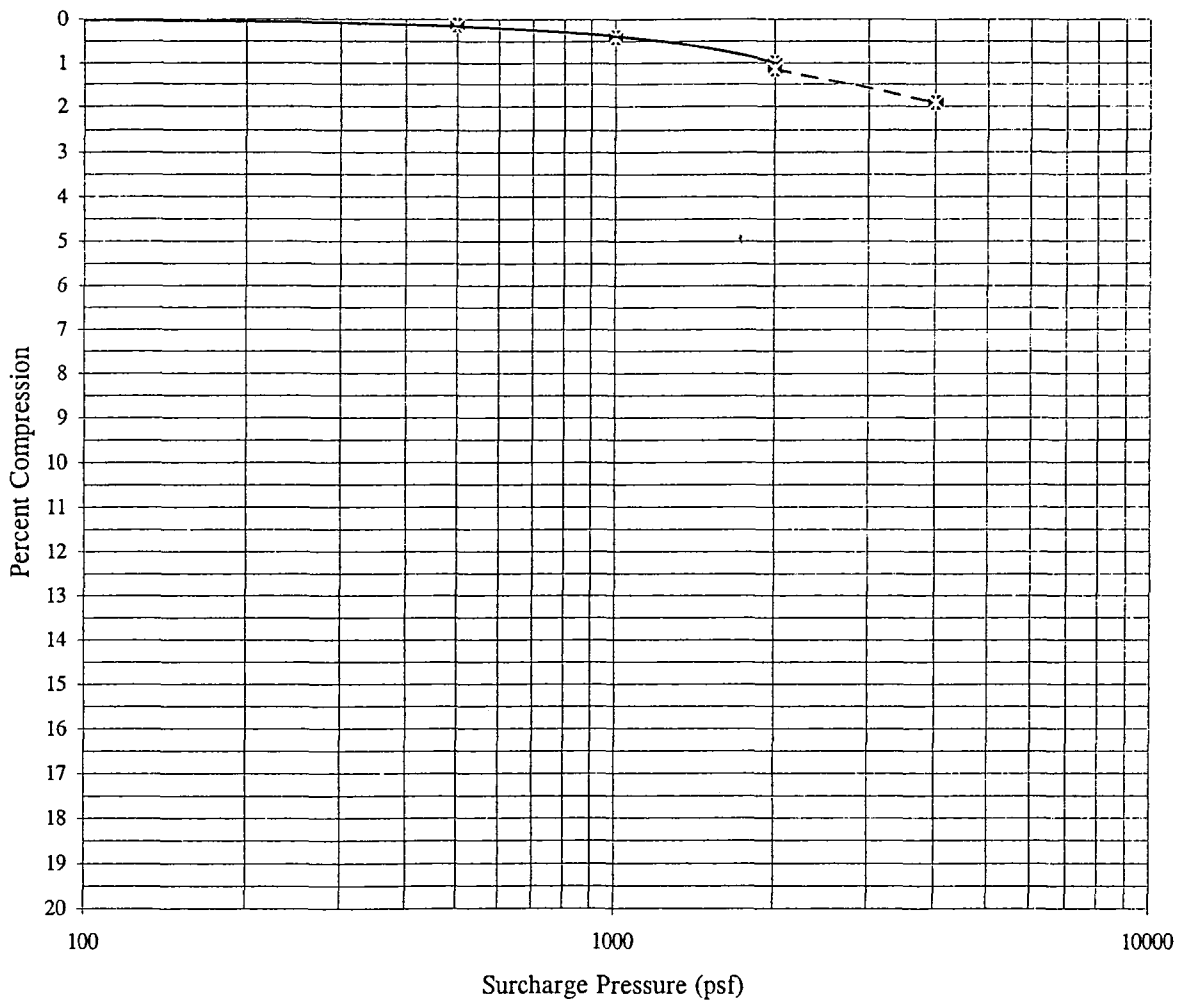
SAMPLE SOURCE: 1 @ 25'-26'

TESTING PERFORMED: Compression (ASTM D2434) - Driven Ring Sample

SAMPLED BY: RAM/Miller

RESULTS:

Dry Density (pcf): 108 Moisture Content (%): 14



REMARKS: Sample submerged at 2000 psf.

LABORATORY TEST RESULTS

Date: 31-Mar-04

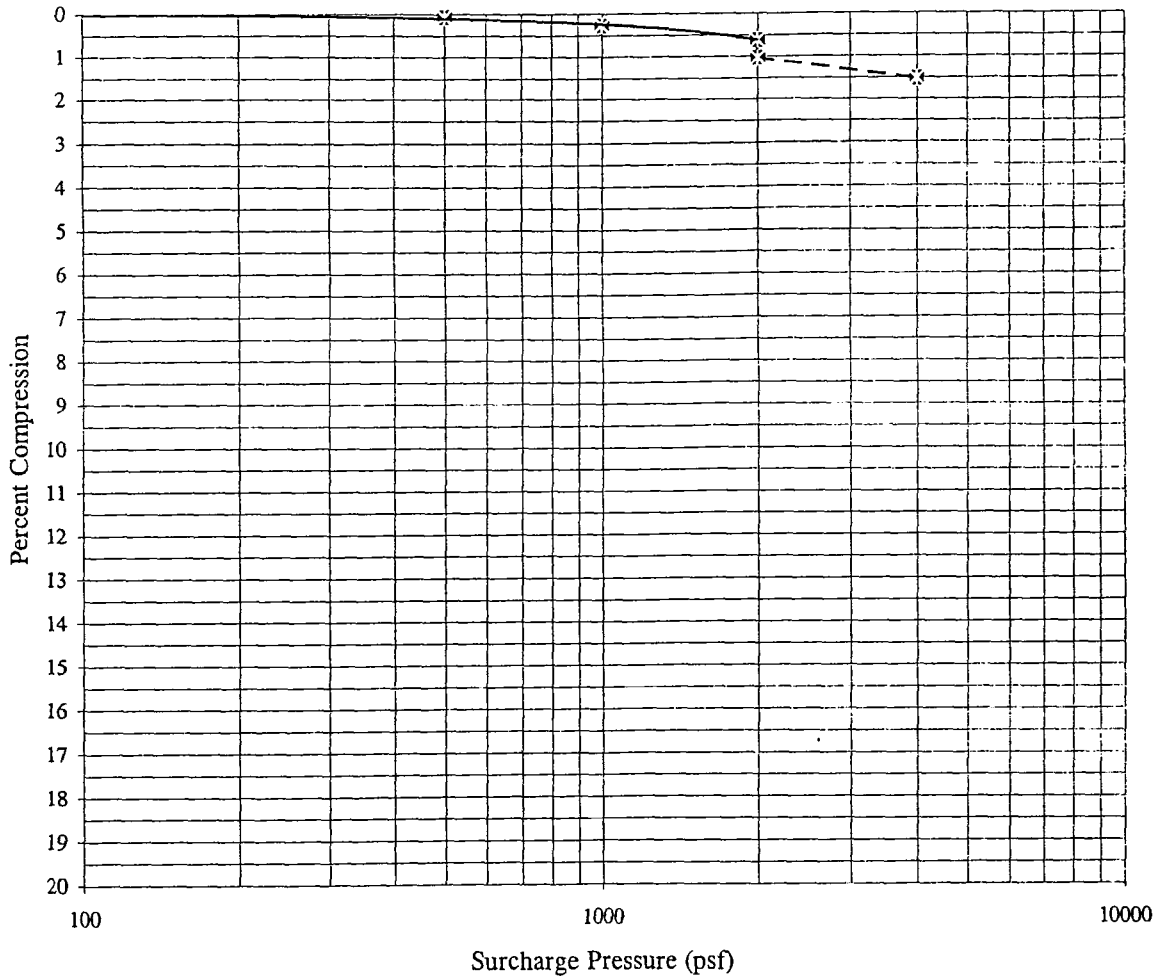
SAMPLE SOURCE: 2 @ 40'-41'

TESTING PERFORMED: Compression (ASTM D2434) - Driven Ring Sample

SAMPLED BY: RAM/Miller

RESULTS:

Dry Density (pcf): 110 Moisture Content (%): 3



REMARKS: Sample submerged at 2000 psf.

LABORATORY TEST RESULTS

Date: 31-Mar-04

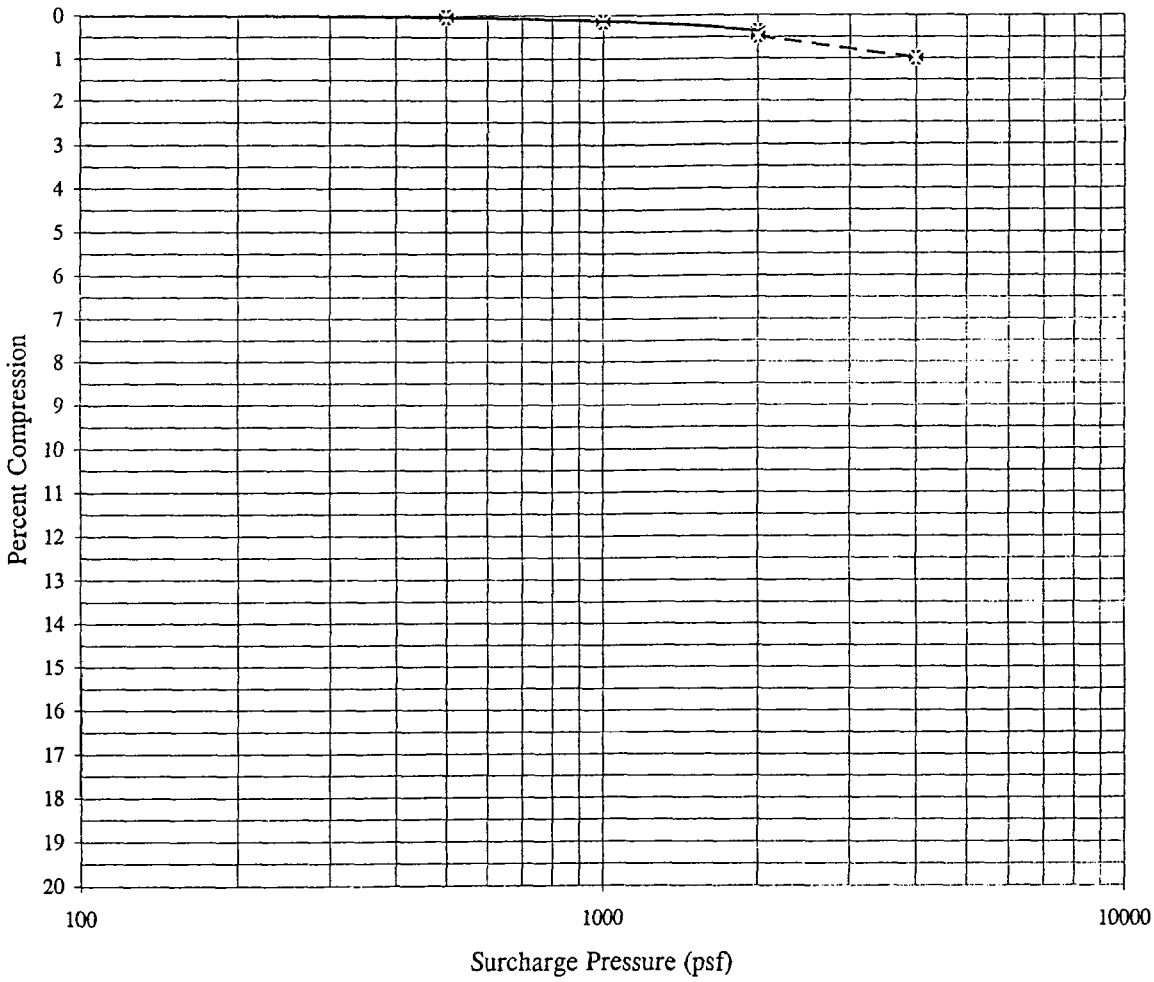
SAMPLE SOURCE: 3 @ 25'-26'

TESTING PERFORMED: Compression (ASTM D2434) - Driven Ring Sample

SAMPLED BY: RAM/Miller

RESULTS:

Dry Density (pcf): 104 Moisture Content (%): 13



REMARKS: Sample submerged at 2000 psf.

LABORATORY TEST RESULTS

Date: 31-Mar-04

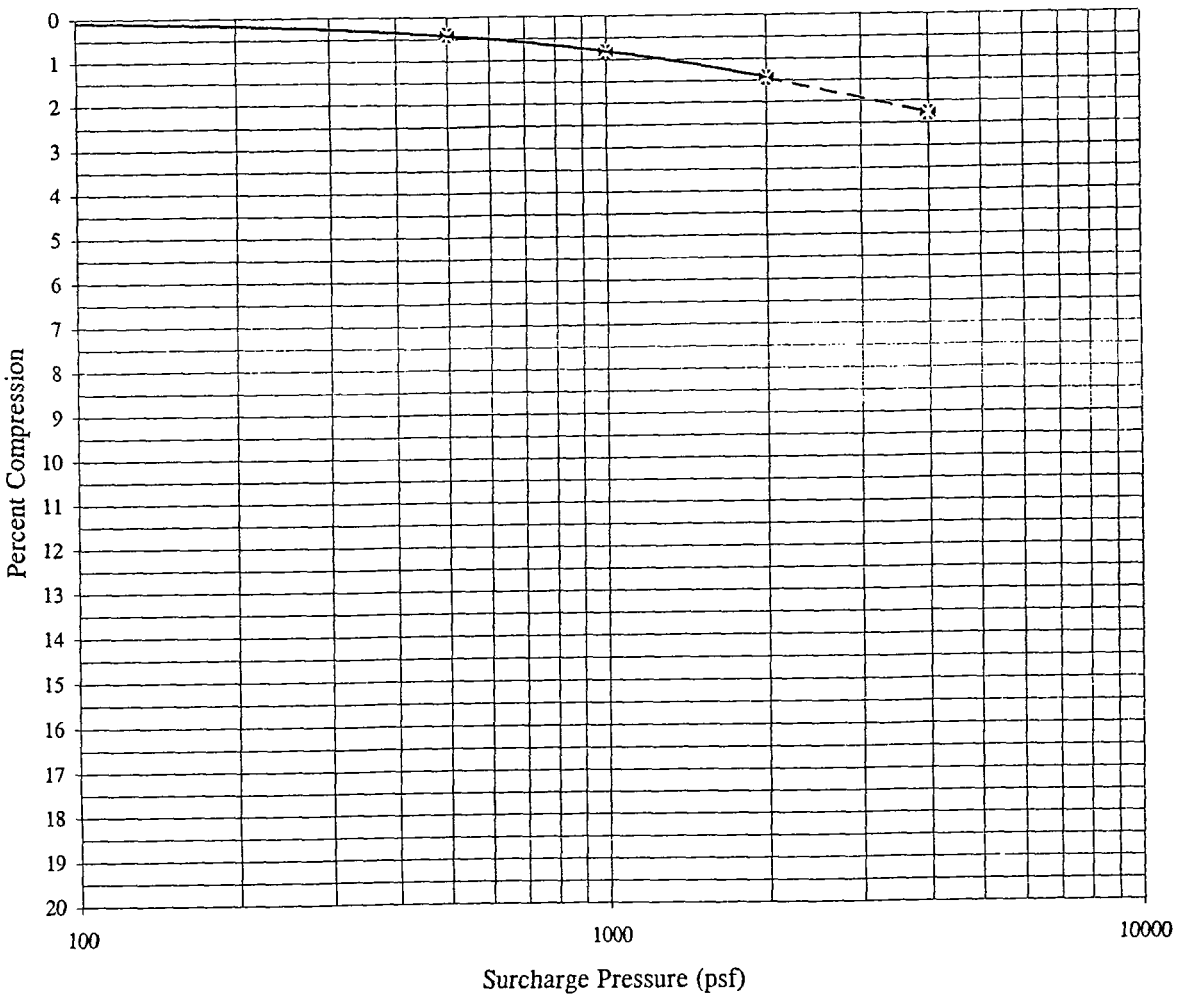
SAMPLE SOURCE: 4 @ 25'-26'

TESTING PERFORMED: Compression (ASTM D2434) - Driven Ring Sample

SAMPLED BY: RAM/Miller

RESULTS:

Dry Density (pcf): 117 Moisture Content (%): 12



REMARKS: Sample submerged at 2000 psf.

LABORATORY TEST RESULTS

Date: 31-Mar-04

SAMPLE SOURCE: As noted below

TESTING PERFORMED: Sieve Analysis, Percent Passing No. 200 Sieve, Atterberg Limits (ASTM C136, D1140, D4318)

SAMPLED BY: RAM/Miller

RESULTS:

Sample Source	Atterberg Limits		Sieve Size - Accumulative Percent Passing											Soil Class.*
	LL	PI	200	100	50	30	16	8	4	3/4"	1"	2"	3"	
H1 Ring Samples	22	5	43	60	74	84	89	94	97	100				SC-SM
TD1 @ 0'-5', 5'-10'	25	8	46	55	65	72	78	83	88	98	100			SC
TD1 @ 10'-15', 15'-20'	28	12	46	59	69	76	81	85	89	98	100			SC
TD1 @ 25'-30'	23	3	27	35	45	53	62	73	87	100				SM
TD1 @ 30'-35'	30	12	39	49	59	69	78	86	91	100				SC
TD1 @ 45'-50'	40	22	18	24	37	57	71	82	90	95	100			SC
1 @ 0'-5', 5'-10'	25	7	23	30	38	48	58	69	80	100				SC-SM
1 @ 10'-15', 15'-20'	19	2	16	24	33	42	51	63	77	91	94	100		SM
1 @ 25'-30'	36	19	33	44	55	69	82	90	95	100				SC
2 @ 0'-5', 5'-10'	19	1	15	21	30	41	52	62	74	98	100			SM
2 @ 10'-15', 15'-20'	19	1	15	20	27	34	43	60	83	100				SM
2 @ 20'-25', 25'-30'	22	5	29	39	50	58	66	76	90	100				SC-SM
2 @ 40'-45'	28	12	22	27	33	43	60	78	89	100				SC
3 @ 0'-5', 5'-10'	31	15	41	50	60	68	75	83	91	100				SC
3 @ 10'-15', 15'-20'	24	7	12	16	20	26	33	44	59	94	97	100		SC-SM
3 @ 25'-30'	34	15	40	46	54	64	75	83	90	100				SC
4 @ 0'-5', 5'-10'	24	6	32	43	54	65	73	81	88	100				SC-SM
4 @ 10'-15', 15'-20'	20	3	12	17	23	31	39	50	64	98	100			SM
4 @ 20'-25', 25'-30'	23	6	25	33	42	51	59	69	80	99	100			SC-SM
4 @ 35'-40'	20	2	34	42	53	65	78	87	92	100				SM

NP = Non-Plastic

* Unified Soil Classification System

LABORATORY TEST RESULTS

Date: 31-Mar-04

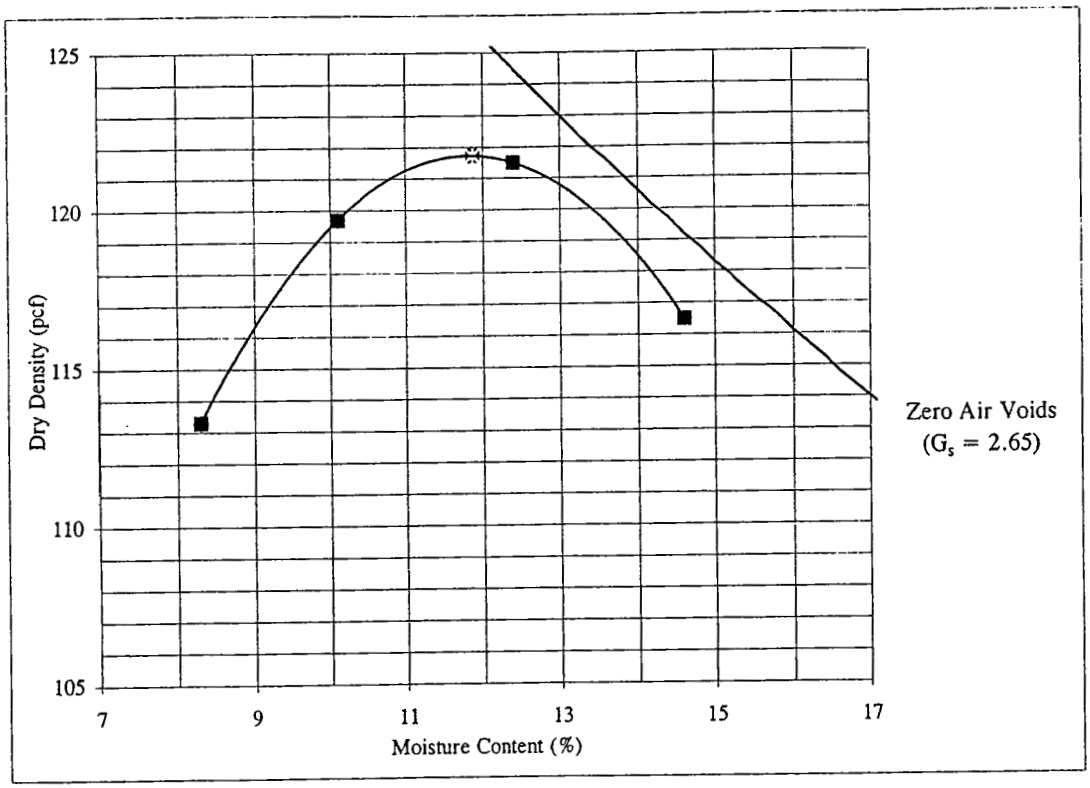
SAMPLE SOURCE: Composite: TD1 @ 0'-5' & TD1 @ 5'-10'

TESTING PERFORMED Maximum Density-Optimum Moisture Determination (ASTM D698 Method A)

SAMPLED BY: RAM/Miller

RESULTS:

Maximum Density (pcf) = 121.7 Optimum Moisture (%) = 11.9



LABORATORY TEST RESULTS

Date: 31-Mar-04

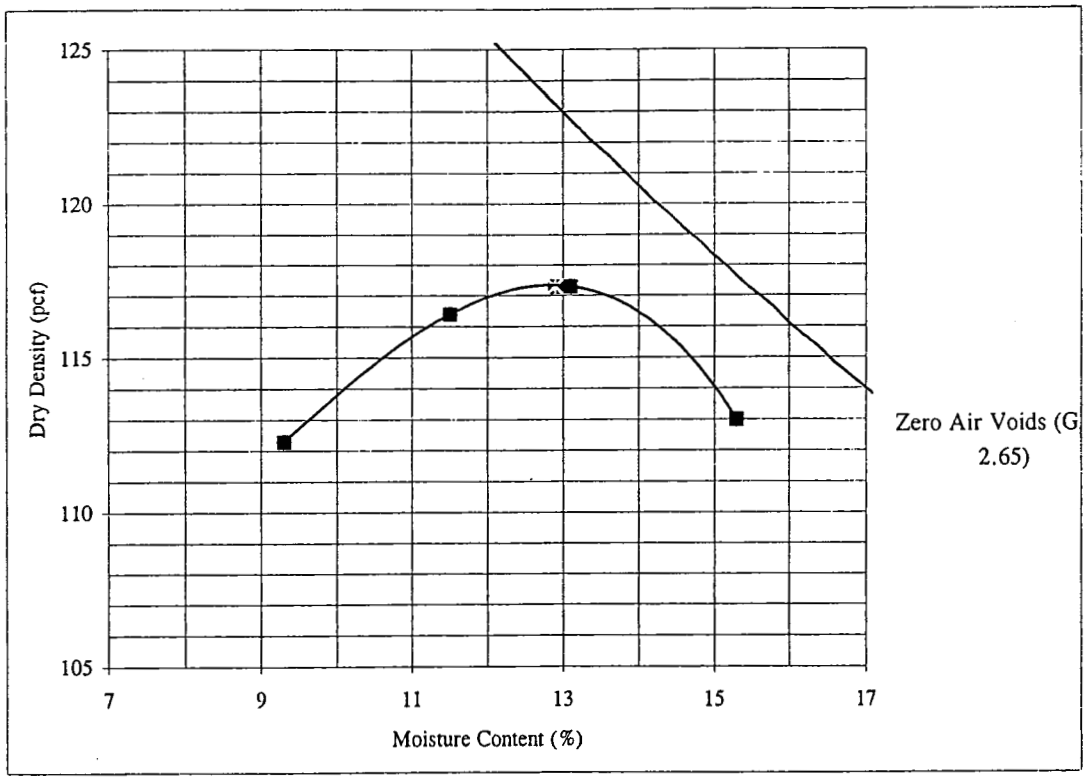
SAMPLE SOURCE: Composite: TD1 @ 10'-15' & TD1 @ 15'-20'

TESTING PERFORMED Maximum Density-Optimum Moisture Determination (ASTM D698 Method A)

SAMPLED BY: RAM/Miller

RESULTS:

Maximum Density (pcf) = 117.3 Optimum Moisture (%) = 12.9



LABORATORY TEST RESULTS

Date: 31-Mar-04

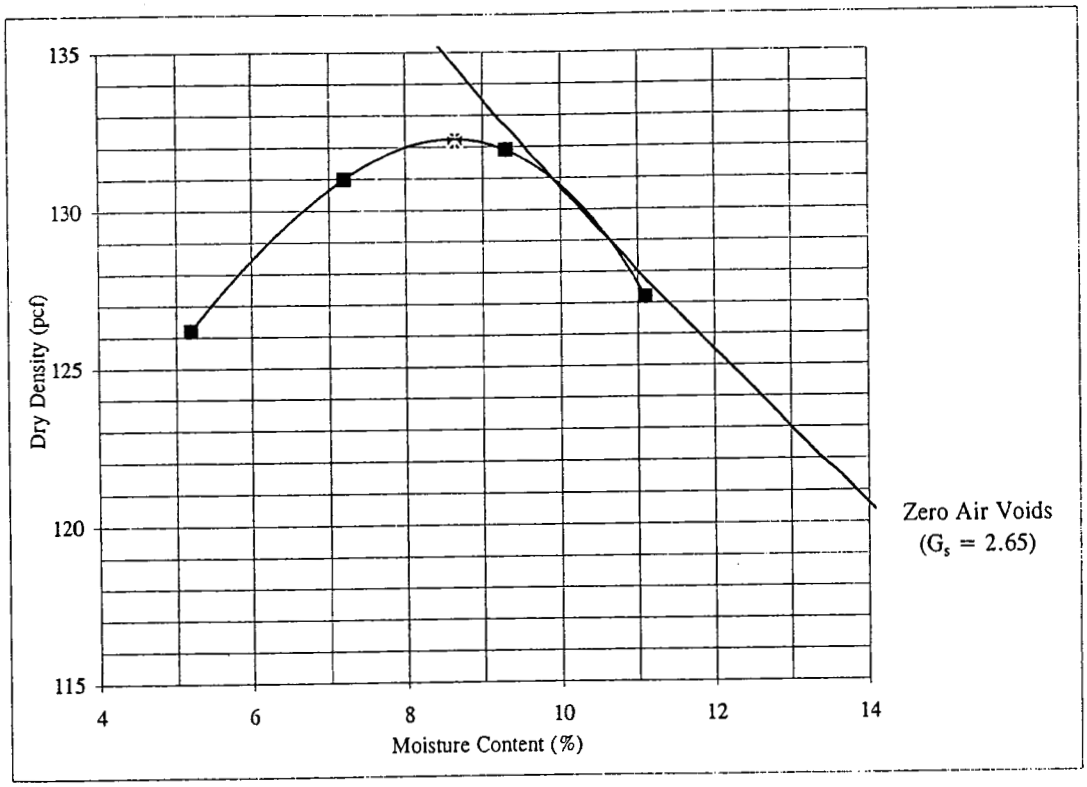
SAMPLE SOURCE: Composite: 1 @ 10'-15' & 1 @ 15'-20'

TESTING PERFORMED Maximum Density-Optimum Moisture Determination (ASTM D698 Method A)

SAMPLED BY: RAM/Miller

RESULTS:

Maximum Density (pcf) = 132.2 Optimum Moisture (%) = 8.6



LABORATORY TEST RESULTS

Date: 31-Mar-04

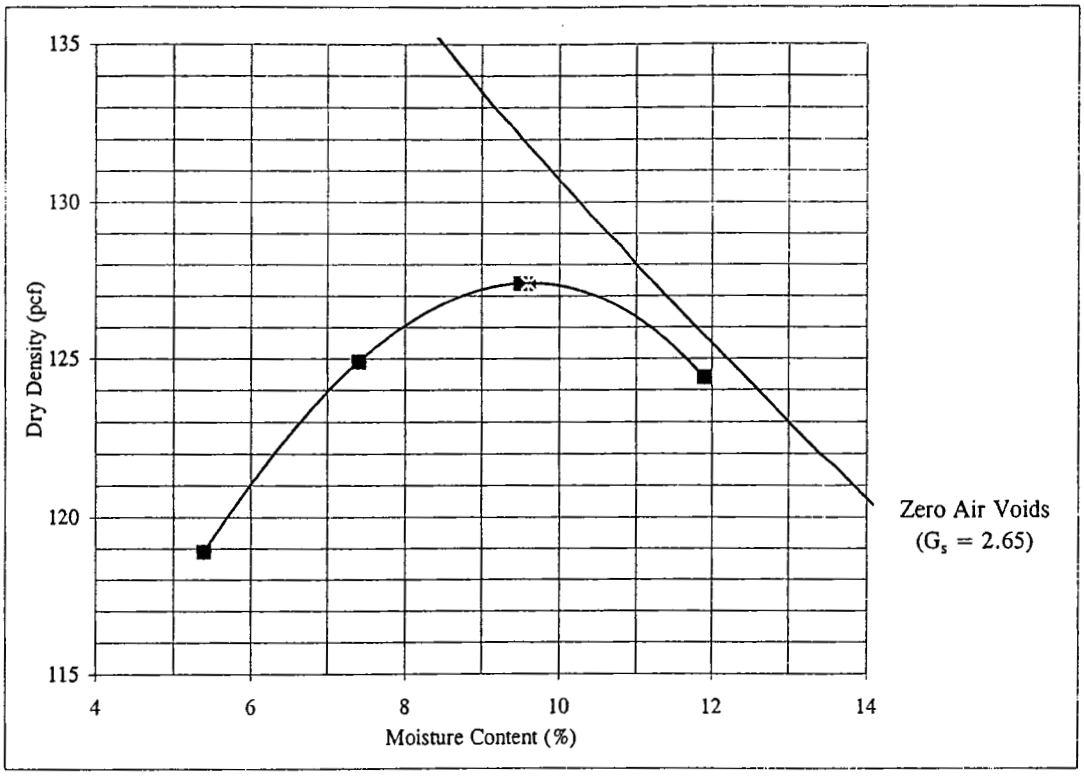
SAMPLE SOURCE: Composite: 2 @ 20'-25' & 2 @ 25'-30'

TESTING PERFORMED Maximum Density-Optimum Moisture Determination (ASTM D698 Method A)

SAMPLED BY: RAM/Miller

RESULTS:

Maximum Density (pcf) = 127.4 Optimum Moisture (%) = 9.6



LABORATORY TEST RESULTS

Date: 31-Mar-04

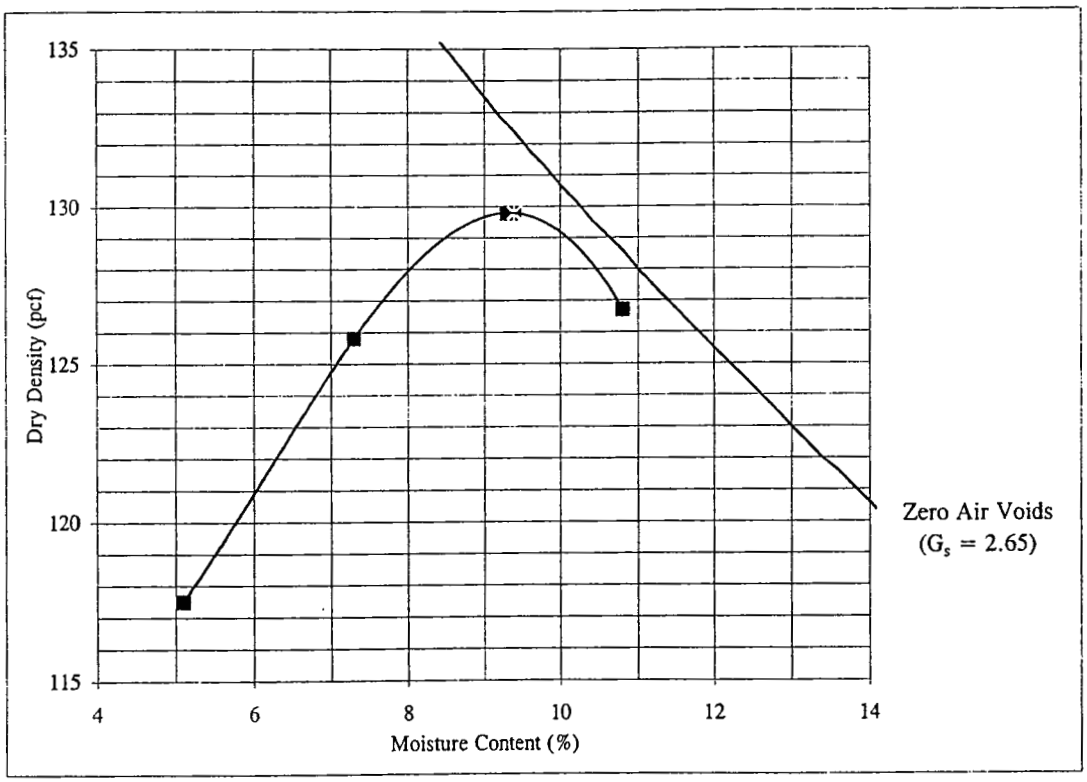
SAMPLE SOURCE: Composite: 3 @ 10'-15' & 3 @ 15'-20'

TESTING PERFORMED Maximum Density-Optimum Moisture Determination (ASTM D698 Method A)

SAMPLED BY: RAM/Miller

RESULTS:

Maximum Density (pcf) = 129.8 Optimum Moisture (%) = 9.4



LABORATORY TEST RESULTS

Date: 31-Mar-04

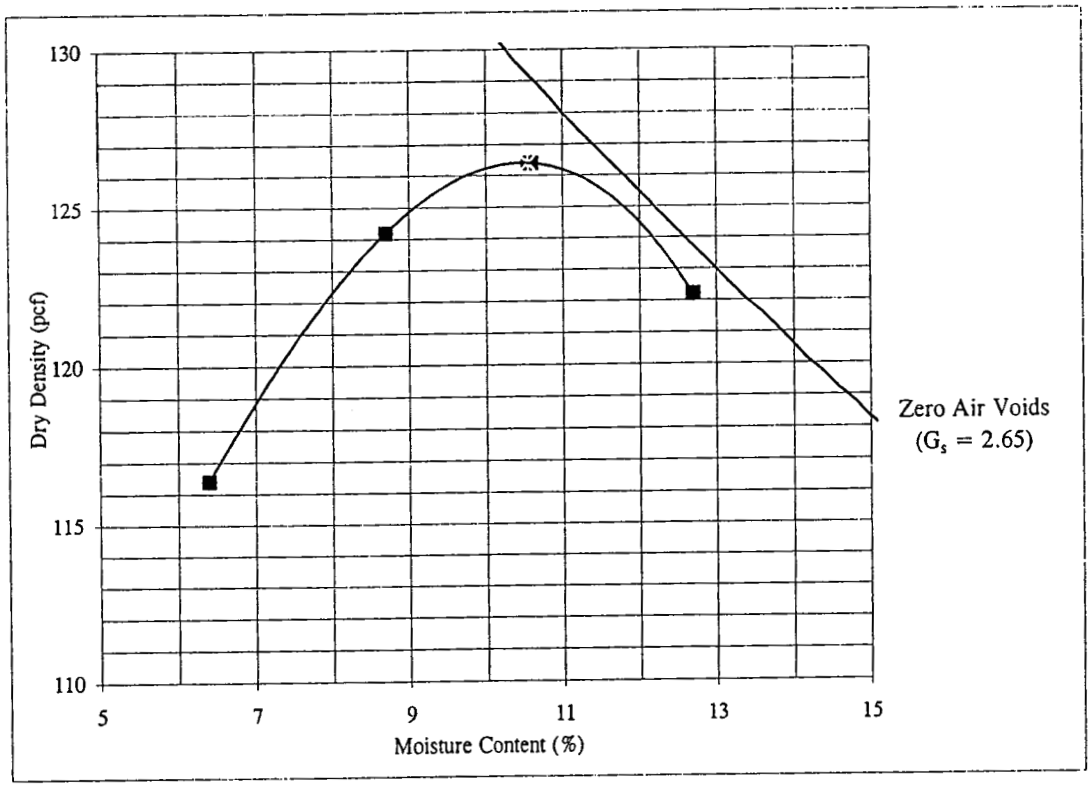
SAMPLE SOURCE: Composite: 4 @ 20'-25' & 4 @ 25'-30'

TESTING PERFORMED Maximum Density-Optimum Moisture Determination (ASTM D698 Method A)

SAMPLED BY: RAM/Miller

RESULTS:

Maximum Density (pcf) = 126.4 Optimum Moisture (%) = 10.6



LABORATORY TEST RESULTS

Date: 31-Mar-04

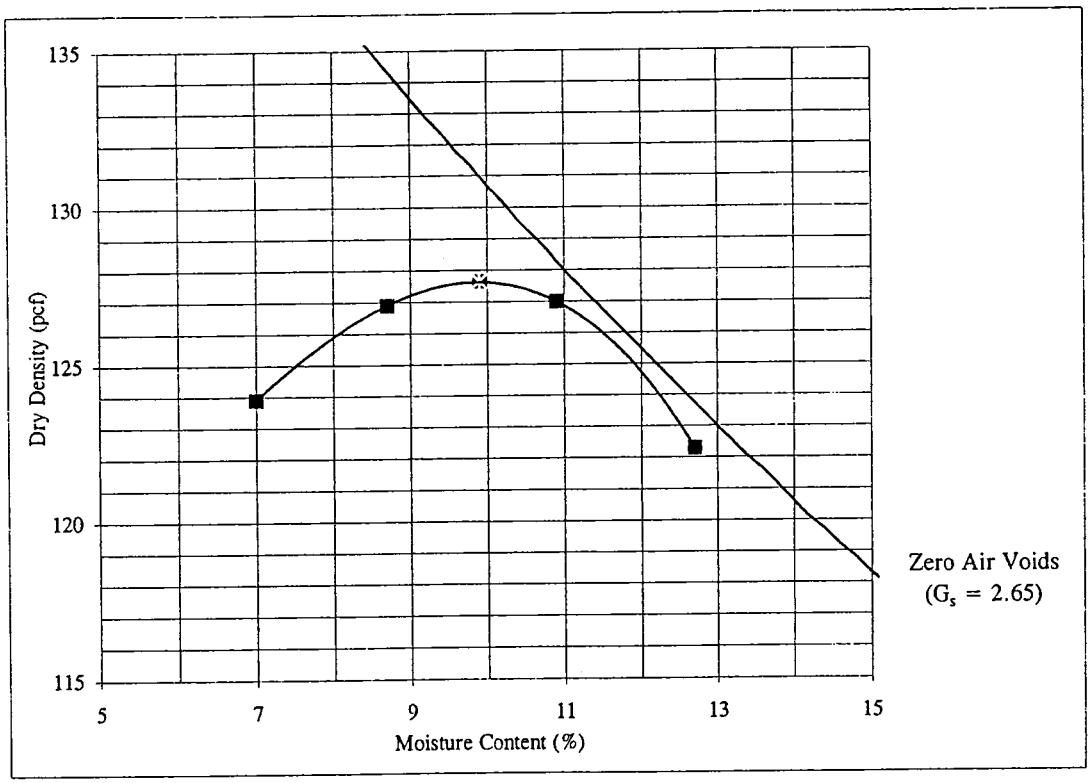
SAMPLE SOURCE: Trench A @ 4'-7'

TESTING PERFORMED Maximum Density-Optimum Moisture Determination (ASTM D698 Method A)

SAMPLED BY: RAM/Taylor

RESULTS:

Maximum Density (pcf) = 127.7 Optimum Moisture (%) = 9.9



LABORATORY TEST RESULTS

Date: 31-Mar-04

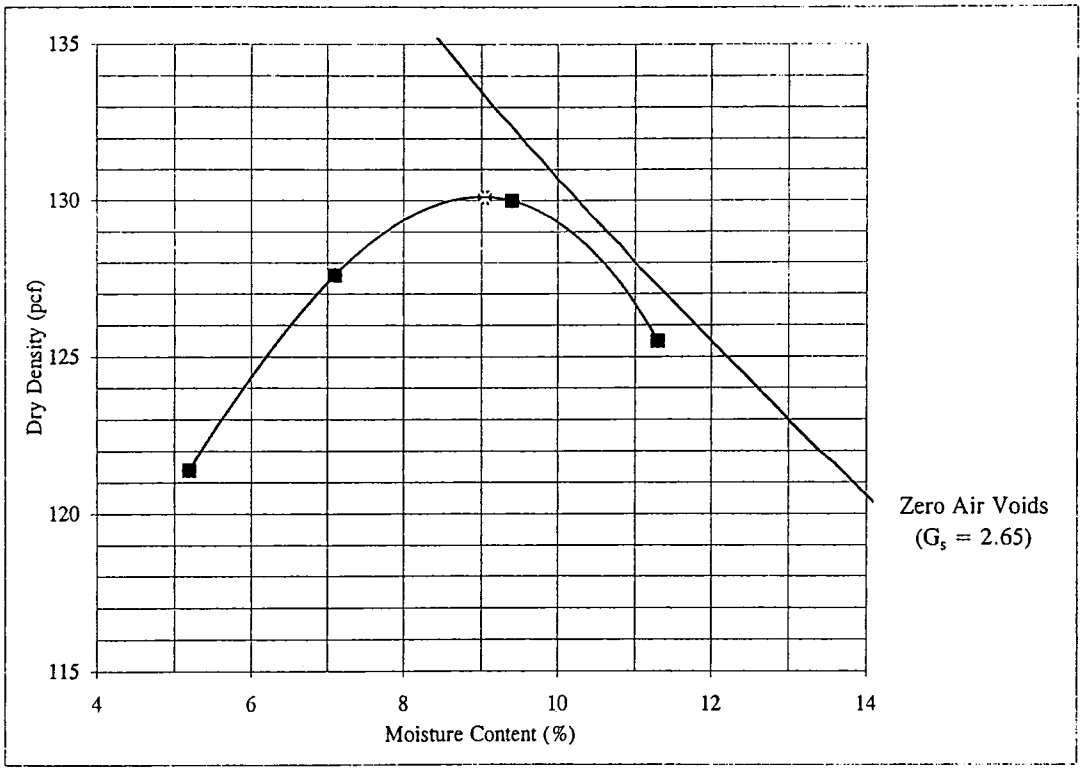
SAMPLE SOURCE: Trench D @ 3'-8'

TESTING PERFORMED Maximum Density-Optimum Moisture Determination (ASTM D698 Method A)

SAMPLED BY: RAM/Taylor

RESULTS:

Maximum Density (pcf) = 130.1 Optimum Moisture (%) = 9.1



LABORATORY TEST RESULTS

Date: 31-Mar-04

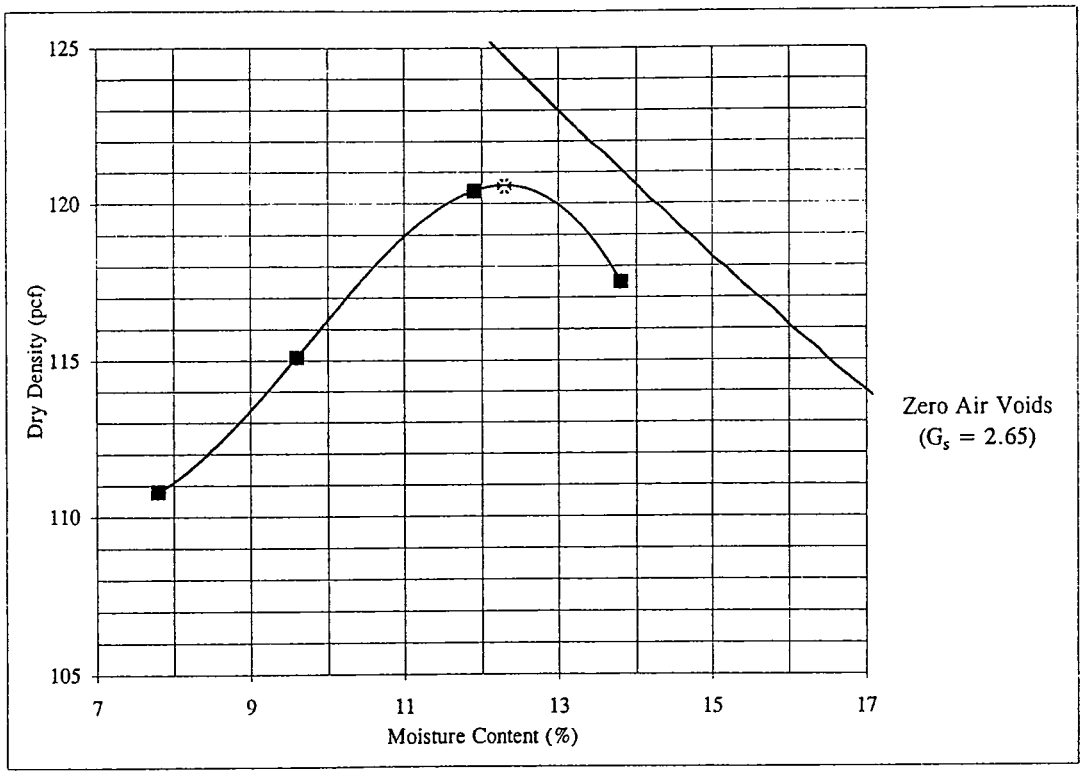
SAMPLE SOURCE: Trench G @ 0"-12"

TESTING PERFORMED Maximum Density-Optimum Moisture Determination (ASTM D698 Method A)

SAMPLED BY: RAM/Taylor

RESULTS:

Maximum Density (pcf) = 120.6 Optimum Moisture (%) = 12.3



DOCUMENT TITLE: McMicken Dam: Subsidence Survey Data Review

DATE OF REPORT: March 14, 2005

PREPARED BY: The District

PURPOSE:

Monitor Elevations at specific locations near/on the principal spillway.

SUMMARY:

Fourteen locations have been surveyed and compared to the elevations reported in the as-builts.

FINDINGS:

Settlement is ongoing in the vicinity of the principal spillway. Maximum settlement is approximately 0.83 feet at the southwest corner of the spillway bridge.

RECOMMENDATIONS:

N/A

Miscellaneous Elevations

Marker	Station	Northing	Easting	As-Built	Adj As-Built	2001	2001- Adj As-Built	2002	2002- Adj As-Built	2005	2005- Adj As-Built	Description
10002	398+24	967947.913	541821.301	unavailable[1]	-	1335.819	-	1335.771	-	1335.698	-	CHISELED "X" ON IRRIG. INLET STRUCTURE
10003	387+14	967376.792	540935.033	unavailable[1]	-	1335.459	-	1335.402	-	1335.362	-	CHISELED "X" ON IRRIG. INLET STRUCTURE
10004	398+35	967821.599	541967.453	unavailable[1]	-	1332.764	-	1332.717	-	1332.654	-	CHISELED "X" ON IRRIG. OUTLET INVERT
10005	387+50	967194.554	541020.636	unavailable[1]	-	1332.341	-	1332.280	-	1332.219	-	CHISELED "X" ON IRRIG. OUTLET INVERT
10101	474+50	974390.445	545839.327	1335.000	1336.870	~~1335.779~~	~~-1.091~~	1336.116	-0.754	1336.137	-0.733	SCRIBE "X" ON SPILLWAY (Upper Apron, LT)
10102	474+50	974408.460	545846.494	1335.000	1336.870	~~1335.777~~	~~-1.093~~	1336.116	-0.754	1336.133	-0.737	SCRIBE "X" ON SPILLWAY (Upper Apron, RT)
10103	474+50	974376.552	545928.266	1333.800	1335.670	~~1334.636~~	~~-1.034~~	1334.962	-0.708	1334.977	-0.693	SCRIBE "X" ON SPILLWAY (Drop Structure Top of Slope,RT)
10104	474+50	974358.664	545921.143	1333.800	1335.670	~~1334.575~~	~~-1.095~~	1334.909	-0.761	1334.920	-0.750	SCRIBE "X" ON SPILLWAY (Drop Structure Top of Slope,LT)
10105	474+50	974365.444	545900.894	1361.000	1362.870	~~1361.699~~	~~-1.171~~	1362.026	-0.844	1362.041	-0.829	SCRIBE "X" ON SPILLWAY (Roadway Overpass, Top Corners)
10106	474+50	974385.392	545908.644	1361.000	1362.870	~~1361.737~~	~~-1.133~~	1362.066	-0.804	1362.070	-0.800	SCRIBE "X" ON SPILLWAY (Roadway Overpass, Top Corners)
10107	474+50	974361.379	545911.682	1361.000	1362.870	~~1361.672~~	~~-1.198~~	1362.116	-0.754	1362.132	-0.738	SCRIBE "X" ON SPILLWAY (Roadway Overpass, Top Corners)
10108	474+50	974381.037	545919.264	1361.000	1362.870	~~1361.736~~	~~-1.134~~	1362.174	-0.696	1362.163	-0.707	SCRIBE "X" ON SPILLWAY (Roadway Overpass, Top Corners)
10109	474+50	974341.108	545952.353	1320.000	1321.870	~~1320.689~~	~~-1.181~~	1321.154	-0.716	1321.154	-0.716	SCRIBE "X" ON SPILLWAY (Drop Structure Toe of Slope, LT)
10110	474+50	974368.374	545963.055	1320.000	1321.870	~~1320.708~~	~~-1.162~~	1321.169	-0.701	1321.175	-0.695	SCRIBE "X" ON SPILLWAY (Drop Structure Toe of Slope, RT)
10111	474+50	974345.613	546021.218	1320.000	1321.870	~~1320.707~~	~~-1.163~~	1321.175	-0.695	1321.167	-0.703	SCRIBE "X" ON SPILLWAY (Stilling Basin Threshold Bottom,RT)
10112	474+50	974345.402	546021.909	1321.500	1323.370	~~1322.470~~	~~-1.200~~	1322.638	-0.732	1322.634	-0.736	SCRIBE "X" ON SPILLWAY (Stilling Basin Threshold Top, RT)
10113	474+50	974318.354	546010.581	1320.000	1321.870	~~1320.751~~	~~-1.119~~	1321.220	-0.650	1321.203	-0.667	SCRIBE "X" ON SPILLWAY (Stilling Basin Threshold Bottom,LT)
10114	474+50	974318.078	546011.195	1321.500	1323.370	~~1322.212~~	~~-1.158~~	1322.681	-0.689	1322.672	-0.698	SCRIBE "X" ON SPILLWAY (Stilling Basin Threshold Top, LT)
10234	474+50	974426.685	545771.225	-	-					1335.783	-	NLRT Nail Right (Old MCDOT Control Nail)
10235	474+50	974322.923	546045.439	-	-					1325.205	-	CIR * SET 1/2 RB (Control Iron Rod)

Marker	Station	Northing	Easting	As-Built	Adj As-Built	2003	2003- Adj As-Built	2004	2004- Adj As-Built	Description
10002	398+24	967947.913	541821.301	unavailable[1]	-	-	-	1335.710	-	CHISELED "X" ON IRRIG. INLET STRUCTURE
10003	387+14	967376.792	540935.033	unavailable[1]	-	-	-	1335.392	-	CHISELED "X" ON IRRIG. INLET STRUCTURE
10004	398+35	967821.599	541967.453	unavailable[1]	-	-	-	1332.691	-	CHISELED "X" ON IRRIG. OUTLET INVERT
10005	387+50	967194.554	541020.636	unavailable[1]	-	-	-	1332.299	-	CHISELED "X" ON IRRIG. OUTLET INVERT
10101	474+50	974390.445	545839.327	1335.000	1336.870	-	-	1336.117	-0.753	SCRIBE "X" ON SPILLWAY (Upper Apron, LT)
10102	474+50	974408.460	545846.494	1335.000	1336.870	-	-	1336.121	-0.749	SCRIBE "X" ON SPILLWAY (Upper Apron, RT)
10105	474+50	974365.444	545900.894	1361.000	1362.870	1361.882	-0.988	1362.049	-0.821	SCRIBE "X" ON SPILLWAY (Roadway Overpass, Top Corners)
10106	474+50	974385.392	545908.644	1361.000	1362.870	1361.926	-0.944	1362.064	-0.806	SCRIBE "X" ON SPILLWAY (Roadway Overpass, Top Corners)
10107	474+50	974361.379	545911.682	1361.000	1362.870	1361.988	-0.882	1362.115	-0.755	SCRIBE "X" ON SPILLWAY (Roadway Overpass, Top Corners)
10108	474+50	974381.037	545919.264	1361.000	1362.870	1362.047	-0.823	1362.198	-0.672	SCRIBE "X" ON SPILLWAY (Roadway Overpass, Top Corners)
10234	474+50	974426.685	545771.225	-	-	-	-	1335.757	-	NLRT Nail Right (Old MCDOT Control Nail)
10235	474+50	974322.923	546045.439	-	-	-	-	1325.192	-	CIR * SET 1/2 RB (Control Iron Rod)

Notes:
1. Irrigation pipes modified from construction plan details, elevation data for comparison with subsequent survey data unavailable.
2. Based on a review of the 2002 survey data, MCDOT informed the District that all 2001 positional information for points 10101 to 10114 were incorrect and should be deleted.

Table 5-B
Miscellaneous Structure Point Elevations

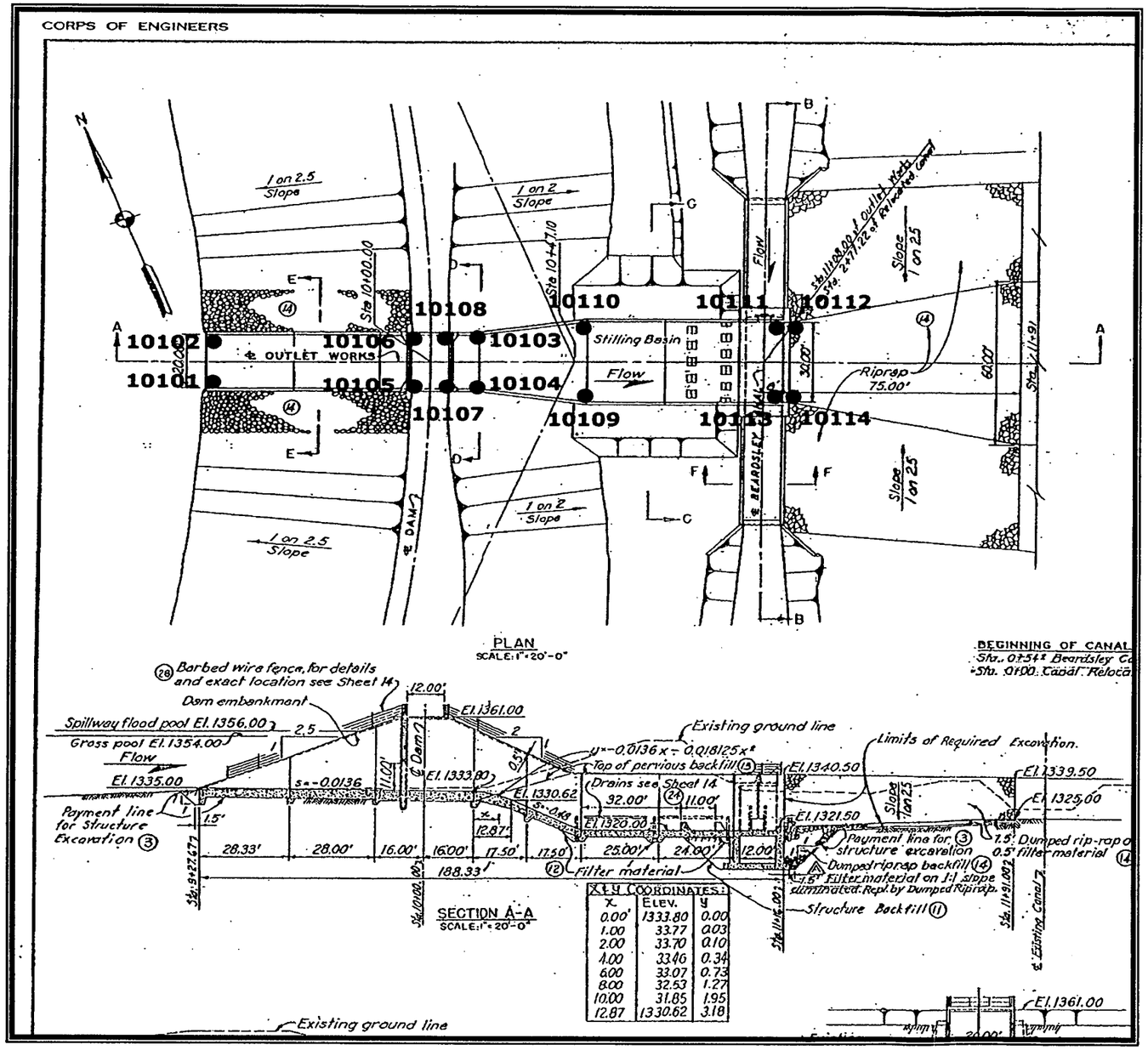


Figure 5-1
2002 - 2005 Survey Point Locations,
McMicken Dam Principal Outlet Structure

Spillway & Misc. Elevations

Marker	2001 - Adj As-Built	2002 - Adj As-Built	2005 - Adj As-Built	Description
10101	~~-1.001~~	-0.754	-0.733	TOE OF SLOPE
10102	~~-1.003~~	-0.708	-0.737	AVERAGE GROUND
10105	~~-1.171~~	-0.844	-0.829	(Overpass, Top Corners)
10106	~~-1.183~~	-0.804	-0.800	(Overpass, Top Corners)
10107	~~-1.188~~	-0.754	-0.738	(Overpass, Top Corners)
10108	~~-1.184~~	-0.696	-0.707	(Overpass, Top Corners)
10109	~~-1.161~~	-0.716	-0.716	(Drop Str. Toe Slope, LT)
10110	~~-1.162~~	-0.701	-0.695	(Drop Str. Toe Slope, RT)
10111	~~-1.163~~	-0.695	-0.703	(Stil. Bas.Thrsh. Bot., RT)
10112	~~-1.200~~	-0.732	-0.736	(Stil. Bas.Thrsh. Top, RT)
10113	~~-1.149~~	-0.650	-0.667	(Stil. Bas. Thrsh. Bot., LT)
10114	~~-1.158~~	-0.689	-0.698	(Stil. Bas. Thrsh. Top, LT)

Marker	2003 - Adj As-Built	2004 - Adj As-Built	Description
10102	-	-0.749	AVERAGE GROUND
10105	-0.988	-0.821	(Overpass, Top Corners)
10106	-0.944	-0.806	(Overpass, Top Corners)
10107	-0.882	-0.755	(Overpass, Top Corners)
10108	-0.823	-0.672	(Overpass, Top Corners)

Reference Marks

The McMicken Dam Subsidence Surveys, from 1985 through 2005, referenced several different vertical benchmarks. A Datum Shift must be applied to adjust measurements referenced in NGVD 1929 datum to an equivalent elevation in NAVD 1988 datum. Benchmarks BED1 and N475 are used to calculate the difference in NGS published elevations from NAVD 1988 to NGVD 1929 in order to determine this Datum Shift. A vertical datum transformation study on McMicken FRS was performed in August 2004 to investigate historic benchmarks of record, assess benchmark stability, and determine the permanent standard benchmark shift for this structure.

Based on the McMicken Vertical Transformation Report, the Datum Shift to NAVD 1988 Elevation equals NGVD 1929 Elevation plus **1.870 ft.** The highlighted 1985-1998 elevation values in the **"Adjusted"** Column for all preceding tables reflect this calculation. For additional information on the Datum Shift, please refer to the McMicken Vertical Transformation Report located in the Dam Safety file cabinet, in the McMicken FRS survey folder.

Historic Bench Mark	Description	Historic Benchmark Survey Records										McMicken Datum Shift
		1985 (NGVD29)	1991 (NGVD29)	1998 (NGVD29)	2001 (NAVD88)	2002 (NAVD88)	2003 (NAVD88)	2004 (NAVD88)	2005 (NAVD88)	NGS 29 (published)	NAVD 88 (published)	
BED1	Brass Cap PID DV1277	-	1515.115		1516.980	1516.942	1516.942	1516.952	1516.952	1515.115	1516.988	1.870
N475	Brass Cap		1474.354	1474.154	1476.185	1476.168	1476.179	1476.189	1476.189	1474.354	1476.224	1.870
Q475	BC. El. 2001 WT3 Survey	-	1434.646	-	1436.744	1436.661	-	-		1434.849	1436.716	1.867

Table 6-1
Reference Marks

Note: 1) The leveling and GPS surveying conducted in 2004 and 2005 utilized different vertical control for each method. A vertical discrepancy between the two control points, BED1 and FRIA-RM4, of -0.039 has been observed by the surveyors at Entranco. In order to put the GPS and leveled values on the same basis of elevations, a shift must be applied to the year 2004 and 2005 values. GPS values are shifted to agree with the leveled elevation basis due to the much higher accuracy of the leveled elevations. Therefore, **0.039 ft** must be *subtracted* from all GPS derived crest settlement monument elevations. The "Adjusted" 2004 and 2005 Crest Settlement Monument columns of the preceding tables reflect this shift. Crest Settlement Monument elevations between Stations 45+00 and 110+00 were derived through leveling and do not require a shift. For more details, please see the 2005 McMicken FRS Survey Report by Entranco, located in the Dam Safety Library.

Reference Marks

Table 6-2 below summarizes reference monuments previously surveyed that continue to be monitored for continuity and checks. Each set of monuments are separated by initial survey year to allow for a basis of elevation comparison, each having a different reference elevation year.

Bench Mark	Description	2001 (NAVD88)	2002 (NAVD88)	2003 (NAVD88)	2004 (NAVD88)	2005 (NAVD88)	2002 - 2001	2004 - 2001	2005 - 2001
FRI4	Brass Cap PID DV1860	1594.750	1594.750	-	1594.747	1594.747	0.000	-0.003	-0.003
H366	Brass Cap PID DV0094	1341.758	1341.702	-	1341.709	1341.694	-0.056	-0.049	-0.064
M265	Brass Cap	1327.582	1327.584	-	-	1327.539	0.002	-	-0.043
COT	Brass Cap PID DV1860	1361.774	1361.708	-	1361.650	1361.690	-0.066	-0.124	-0.084

2001 = Reference Elevation

Bench Mark	Description	2001 (NAVD88)	2002 (NAVD88)	2003 (NAVD88)	2004 (NAVD88)	2005 (NAVD88)	2004 - 2002	2005 - 2002
FRIA-RM3	CCF * 3.5"AL ADOT P&M CAP STAMPED "FRIA RM3 1947 1986"	-	1591.970	-	1591.988	1591.988	0.018	0.018
4FD2	NGS 3D MON (9/16" STAINLESS ROD DRIVEN TO UNK)	-	1327.758	-	-	1327.686	-	-0.072
4GC1	NGS 3D MON (9/16" STAINLESS ROD DRIVEN TO 48.5')	-	1252.615	-	-	1252.571	-	-0.044
4HD1	NGS 3D MON (9/16" STAINLESS ROD DRIVEN TO 14.4')	-	1393.293	-	-	1393.269	-	-0.024

2002 = Reference Elevation

Bench Mark	Description	2001 (NAVD88)	2002 (NAVD88)	2003 (NAVD88)	2004 (NAVD88)	2005 (NAVD88)	2005 - 2004
MCMC1	MCDOT Geodetic Ctrl Cap	-	-	-	1420.619	1420.619	0.000
MCMC2	MCDOT Geodetic Ctrl Cap	-	-	-	1419.529	1419.558	0.029
MCMC3	MCDOT Geodetic Ctrl Cap	-	-	-	1425.089	1425.118	0.029

2004 = Reference Elevation

Bench Mark	Description	2001 (NAVD88)	2002 (NAVD88)	2003 (NAVD88)	2004 (NAVD88)	2005 (NAVD88)
D266	CCF * 3.5"BRASS USC&GS CAP STAMPED "D266 1948"	-	-	-	-	1368.978
K366	CCF * 3.5"BRASS USC&GS CAP IN CASING STAMPED "K366 1967"	-	-	-	-	1328.723
N366	CCF * 3.5"BRASS USCGS CAP STAMPED "N366 1967"	-	-	-	-	1339.660
V265	CCF * 3.5"BRASS USCGS CAP STAMPED "V265 1948"	-	-	-	-	1338.371

2005 = Reference Elevation

Table 6-2
Reference Marks

Note: 1.) In 2004, three new control monuments were set in bedrock: MCMICKEN 1 (MCMC1), MCMICKEN 2 (MCMC2), and MCMICKEN 3 (MCMC3). MCMC1 was surveyed to NGS 'A' station precision and is used at the benchmark for the optical leveling portion of the 2005 survey. See **Figures 6-1** through **6-4**, on page 20.

2.) In 2005, thirteen never before surveyed NGS benchmarks were searched for, but only four were found and surveyed: D266, K366, N366, and V265. See **Figures 6-5** through **6-8**, on page 21.