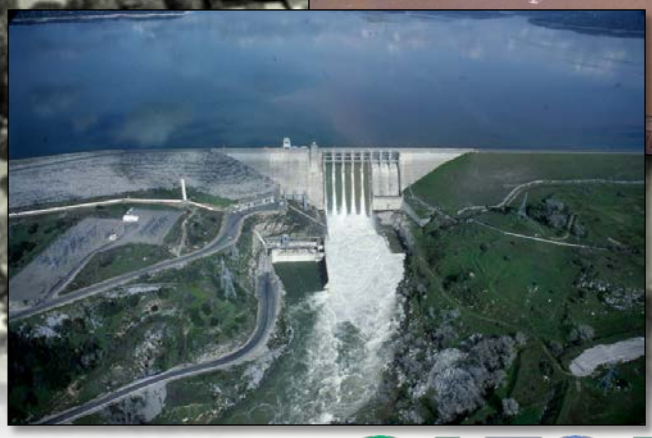
American River Watershed

Common Features
General Reevaluation Report



Attachment C
Geotechnical Report

December 2015

Sacramento Area Flood Control Agency

US Army Corps of Engineers ®
Sacramento District

Cover Photos courtesy of the Sacramento District:
Sacramento Weir during operation
Sacramento River facing south near the Pocket and Little Pocket neighborhoods
High flows on the American River at the Highway 160 overcrossing
Folsom Dam releasing high flows

AMERICAN RIVER, CALIFORNIA
COMMON FEATURES PROJECT
GENERAL REEVALUATION REPORT

Attachment C
Geotechnical Report

U.S. Army Corps of Engineers
Sacramento District

December 2015

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AMERICAN RIVER WATERSHED
COMMON FEATURES PROJECT

GENERAL REEVALUATION REPORT
ATTACHMENT C
GEOTECHNICAL REPORT

US Army Corps of Engineers
Sacramento District

PREPARED BY

GEOTECHNICAL ENGINEERING BRANCH

October 2013

TABLE OF CONTENTS

1.0 Introduction 1
2.0 Geology and Geomorphology 3
2.1 Geologic Setting 3
2.2 Geomorphology 3
2.3 Hydraulic Mining 4
3.0 Construction History 5
3.1 American River Levees 5
3.2 Sacramento River West Levee (South of American River) 6
3.3 Sacramento River West Levee (From NCC to American River) 7
3.4 Natomas Cross Canal South Levee 8
3.5 NEMDC, PGCC, Arcade Creek and Dry Creek Levees 8
4.0 Past Performance 10
5.0 Geotechnical Reach Description 12
6.0 Levee Failure Modes and Analyses Criteria 15
7.0 Typical Levee Improvement Measures 16
8.0 Cross-Section Selection 18
9.0 Hydraulic Loading Conditions 19
10.0 Seepage and Slope Stability Analyses 20
10.1 ARN Reach A – American River North – U9 LM 1.32 21
10.2 ARN Reach E – Arcade Creek North – U7 LM 0.90 21
10.3 ARS Reach B – American River South – U4 LM 3.90 22
10.4 ARS Reach F – Sacramento River East – U1 LM 5.92 23
10.5 NAT Reach D – NCC South – U1 LM 1.17 24
11.0 Erosion Assessment 25
12.0 Seismic Assessment 27
13.0 Vegetation Variance Request Supporting Analyses 27
14.0 Geotechnical Recommendations for Levee Improvement 28
15.0 Magpie Creek 30
16.0 Sacramento Weir and Bypass 30
17.0 Probabilistic Analyses 31
17.1 ARN Reach A – American River North – U9 LM 1.32 32
17.2 ARN Reach E – Arcade Creek North – U7 LM 0.90 33
17.3 ARS Reach B – American River South – U4 LM 3.90 34
17.4 ARS Reach F – Sacramento River East –U1 LM 5.92 36
17.5 NAT Reach D – NCC South –U1 LM 1.30 37
18.0 Material Requirements and Borrow Sites 38
19.0 Conclusions 38
20.0 References 40

LIST OF TABLES

Table 8-1: Index Point Locations 18
Table 9-1: Analyses Water Surface Elevations 19
Table 14-1: Sacramento River Reaches D through G Recommended Improvements 29
Table 14-2: East Side Tributaries Reaches C through F Proposed Cutoff Wall Extents 30

LIST OF FIGURES

Figure 1-1: Study Area Map of the American River Common Features Project..... 2
Figure 3-1: American River Typical Section 1940-1960 5
Figure 3-2: Dredge Neptune at RM 57.3 in 1942 6
Figure 3-3: Sacramento River Typical Levee Section, 1912-1915..... 7
Figure 3-4: Natomas Cross Canal Typical Levee Section, 1912-1914..... 8
Figure 3-5: NEMDC Typical Levee Section (East Bank), 1958 9
Figure 3-6: Robla Creek Typical Levee Section, 2001..... 9
Figure 4-1: 1986 Erosion Distress on the American River South Bank Near I-80..... 11
Figure 4-2: 1997 Flood Fighting on the Sacramento River in Natomas..... 11
Figure 10-1: ARN Reach A U9 LM 1.32 Without Project Analyses Results..... 21
Figure 10-2: ARN Reach D U7 LM 0.90 Without Project Analyses Results..... 22
Figure 10-3: ARN Reach D U7 LM 0.90 With Project Analyses Results..... 22
Figure 10-4: ARS Reach B U4 LM 3.90 Without Project Analyses Results 22
Figure 10-5: ARS Reach F U1 LM 5.92 Without Project Analyses Results..... 23
Figure 10-6: ARS Reach F U1 LM 5.92 With Project Analyses Results..... 23
Figure 10-7: NAT Reach D U1 LM 1.17 Without Project Analyses Results..... 24
Figure 11-1: Generalized, Composite Stratigraphic Section of the Lower American River..... 26
Figure 11-1: 3D Stratigraphic Model Section 11 Near RM 7.2..... 26
Figure 17-1: Combined Probability of Poor Performance for Without Project Conditions 32
Figure 17-2: Combined Probability of Poor Performance for With Project Conditions 33
Figure 17-3: Combined Probability of Poor Performance for Without Project Conditions 33
Figure 17-4: Combined Probability of Poor Performance for With Project Conditions 34
Figure 17-5: Combined Probability of Poor Performance for Without Project Conditions 35
Figure 17-6: Combined Probability of Poor Performance for With Project Conditions 35
Figure 17-7: Combined Probability of Poor Performance for Without Project Conditions 36
Figure 17-8: Combined Probability of Poor Performance for With Project Conditions 37
Figure 17-9: Combined Probability of Poor Performance for With Project Conditions 37

PLATES

Plate 1 – ARCF GRR Levee Mile and Stationing
Plate 2 – Analyses Section and Index Point Location Map
Plate 3 – Geotechnical Improvements Map
Plate 4 – Desktop Borrow Study High Confidence Locations Map
Plate 5 – Desktop Borrow Study Low Confidence Locations Map

ENCLOSURES

Enclosure 1 – Analyses Calculation Package
Enclosure 2 – Steady State Seepage and Landside Slope Stability Analyses Results
Enclosure 3 – Probabilistic Analyses and Levee Performance Curves

ABBREVIATIONS

ACN	Arcade Creek North
ACS	Arcade Creek South
ARCF	American River Common Features
ARFCD	American River Flood Control District
ARFCP	American River Flood Control Project
ARN	American River North Basin
ARS	American River South Basin
ASTM	American Society of Testing and Materials
ARWI	American River Watershed Investigation
BGS	Below Ground Surface
BTA	Blanket Theory Analysis
CB	Cement-Bentonite
CFS	Cubic Feet Per Second
CHP	California Highway Patrol
COS	City of Sacramento
CPT	Cone Penetrometer Test
CW	Cutoff Wall
CVFPB	Central Valley Flood Protection Board
CVFPP	Central Valley Flood Protection Plan
CY	Cubic Yard(s)
DBH	Diameter at Breast Height
DCN	Dry Creek North
DCS	Dry Creek South
DMM	Deep Mix Method
DSM	Deep Soil Mixing
DWR	Department of Water Resources
DWSC	Deep Water Ship Channel
EFA	Erosion Function Apparatus
EIP	Early Implementation Project
EM	Engineering Manual
ETL	Engineering Technical Letter
EVS	Environmental Visualization System
FEMA	Federal Emergency Management Agency
FOS	Factor(s) Of Safety
FOSM	First Order Second Moment
FT	Foot/Feet
FT/S	Feet Per Second
GER	Geotechnical Engineering Report
GIS	Geographical Information System
GMS	Groundwater Modeling Software
GRR	General Reevaluation Report
H:V	Horizontal To Vertical Ratio
HTRW	Hazardous, Toxic, and Radioactive Waste
HQUSACE	Headquarters U.S. Army Corps Of Engineers
IBC	International Building Code

IWM	In-Stream Woody Material
JET	Jet Erosion Test
K	Coefficient Of Permeability
K_H	Horizontal Hydraulic Conductivity Under Fully Saturated Conditions
K_H/K_V	Ratio Between The Vertical And Horizontal Conductivities; Anisotropic Ratio
K_V	Vertical Hydraulic Conductivity Under Fully Saturated Conditions
Ky	Yield Acceleration
LAR	Lower American River
LiDAR	Light Detection and Ranging
LM	Levee Mile
MA	Maintenance Area
MCDC	Magpie Creek Diversion Canal
MCY	Million Cubic Yards
MSWL	Mean Summer Water Level
MUSYM	Map Unit Symbol
Mw	Moment Magnitude
NAD83	North American Datum of 1983
NAFCI	Natomas Area Flood Control Improvement
NALP	North Area Levee Project
NAT	Natomas Basin
NAVD88	North American Vertical Datum of 1988
NCC	Natomas Cross Canal
NCEER	National Center for Earthquake Engineering Research
NCMWC	Natomas Central Mutual Water Company
NCSS	National Cooperative Soil Survey
NGA	Next Generation Attenuation
NGVD29	National Geodetic Vertical Datum of 1929
NEMDC	Natomas East Main Drainage Canal
NLD	National Levee Database
NLIP	Natomas Levee Improvement Project
NPACR	Natomas Post Authorization Change Report
NRCS	National Resources Conservation Service
NSF	National Science Foundation
NULE	Nonurban Levee Evaluations
OCR	Over-Consolidation Ratio
PACR	Post Authorization Change Report
PDT	Project Delivery Team
PED	Pre-Construction Engineering and Design
PGA	Peak Ground Acceleration
PGCC	Pleasant Grove Creek Canal
PGL	Policy Guidance Letter
Pr(f)	Probability of Failure
PSHA	Probabilistic Seismic Hazard Analysis
P1GDR	Phase 1 Geotechnical Data Report
P1GER	Phase 1 Geotechnical Engineering Report
QA	Quality Assurance

QC	Quality Control
RD	Reclamation District
RM	River Mile
SAFCA	Sacramento Area Flood Control Agency
SB	Soil-Bentonite
SCB	Soil-Cement-Bentonite
SGDR	Supplemental Geotechnical Data Report
SOP	Standard Operating Procedure
SPT	Standard Penetration Test
SRBPP	Sacramento River Bank Protection Project
SRFCP	Sacramento River Flood Control Project
SRN	Sacramento River North
SRS	Sacramento River South
SSURGO	Soil Survey Geographic Database
SUALRP	Sacramento Urban Area Levee Reconstruction Project
SWIF	System-Wide Improvement Framework Policy
TEC	Topographic Engineering Center
TM	Technical Memorandum
TRM	Technical Review Memorandum
ULE	Urban Levee Evaluations
USACE	U.S. Army Corps Of Engineers
USDA	United States Department of Agriculture
USGS	United States Geological Society
V:H	Vertical To Horizontal Ratio
$\overline{V}_{S30}$	Velocity Of The Upper 30 Meters
VVR	Vegetation Variance Request
WRDA	Water Resources Development Act
WSAFCA	West Sacramento Area Flood Control Agency
WSE	water surface elevation

1.0 INTRODUCTION

The following briefly outlines pertinent geotechnical information regarding a General Reevaluation Report (GRR) for the American River Common Features (ARCF) Project. This report presents the results of geotechnical analyses and feasibility level geotechnical design recommendations to address levee height, geometry, erosion, access, vegetation, seepage, and slope stability deficiencies within the ARCF GRR study area.

The project area includes portions of the Sacramento and American River Watersheds. The flood plain includes most of the developed portions of the City of Sacramento, the Natomas basin, and portions of Sacramento and Sutter Counties. The study area also includes other flood facilities, including the Fremont and Sacramento Weirs and Yolo Bypass. A Post Authorization Change Report (PACR) for the Natomas portion of the Common Features project and a Chief's Report for the Natomas Post Authorization Change Report (NPACR) were completed in December 2010. The remaining portion of the project, including potential Natomas Basin levee raises, is being addressed in this report.

The ARCF GRR study area, shown in Figure 1-1, has been divided into three basins; Natomas, American River North, and American River South, which were further subdivided into study reaches. This report covers the following areas:

- About 12 miles of the north and south banks of the American River
- About 33 miles of the east bank of the Sacramento River
- About 5 miles of the south bank of the Natomas Cross Canal (NCC)
- About 3 miles of the Pleasant Grove Creek Canal (PGCC)
- About 26 miles of the Natomas East Main Drainage Canal and tributaries (NEMDC)

The ARCF GRR study area has been divided into three basins; Natomas, American River North, and American River South, which were further subdivided into study reaches. For the purposes of the feasibility planning process, the three study area basins were further subdivided into reaches based on common properties (both technical and non technical), such as geographic and geomorphic features. The levees in the American River North Basin have been divided into nine planning reaches; ARN A, B, C, D, E, F, G, H, and I. The levees in the American River South Basin have been divided into seven planning reaches; ARS A, B, C, D, E, F, and G. The levees in the Natomas Basin have been divided into nine planning reaches; NAT A, B, C, D, E, F, G, H, and I.

The ARCF GRR is evaluating federal interest in alternatives to reduce flood risk in the study area. The ARCF GRR has identified several technical deficiencies associated with the flood risk management system protecting the study area. There are various alternatives under consideration to address these deficiencies and the geotechnical components of those alternatives are discussed and or evaluated in this report. The alternatives consist of a combination of structural measures to mitigate seepage, slope stability, erosion protection, and overtopping including the widening and construction of new levees on the Sacramento Bypass and Weir.

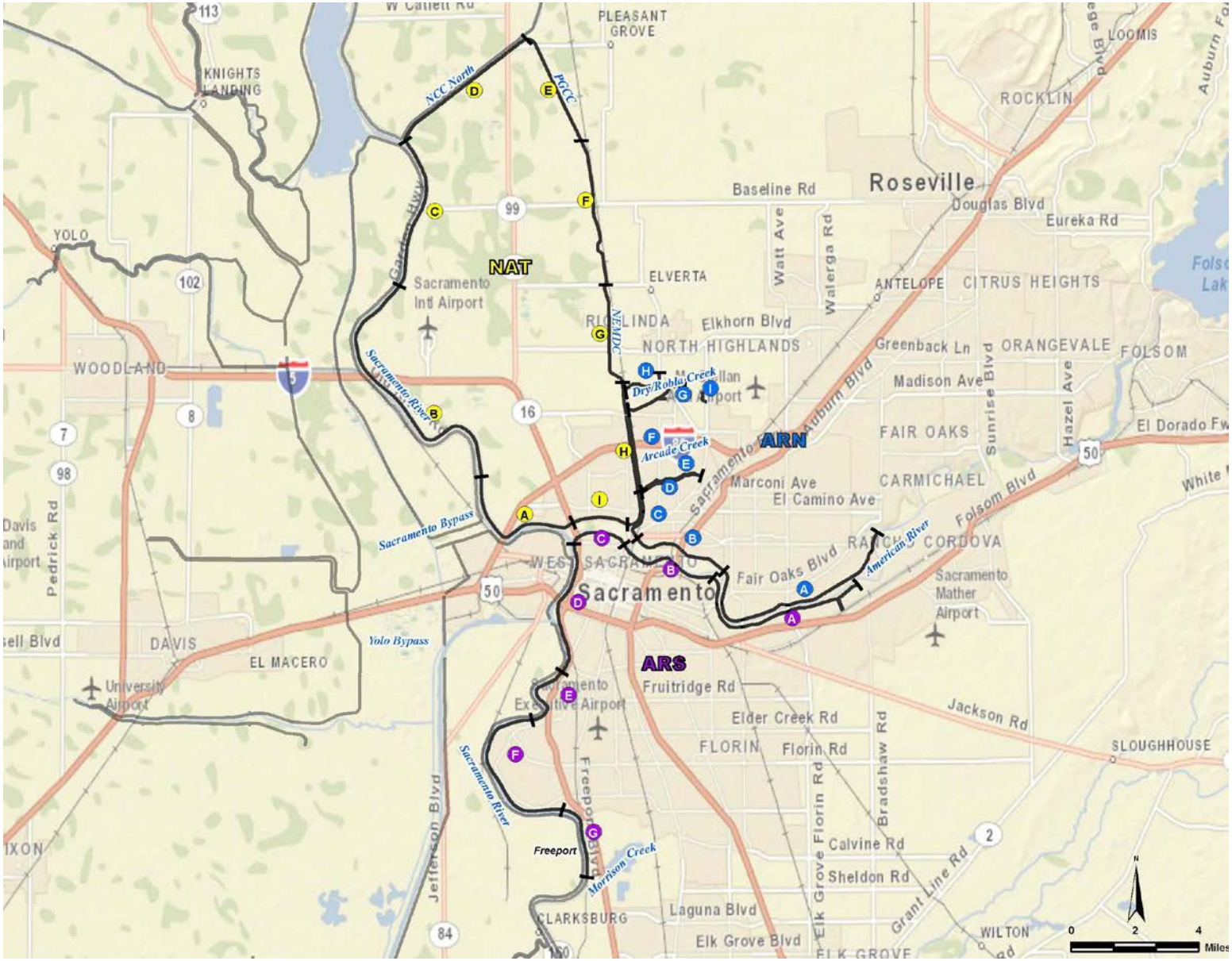

Figure 1-1: Study Area Map of the American River Common Features Project

2.0 GEOLOGY AND GEOMORPHOLOGY

2.1 GEOLOGIC SETTING

The ARCF GRR study area lies in the central portion of the Sacramento Valley which lies in the northern portion of the Great Valley Geomorphic Province of California. The Sacramento Valley lies between the northern Coast Ranges to the west and the northern Sierra Nevada to the east, and has been a depositional basin throughout most of the late Mesozoic and Cenozoic time. A large accumulation of sediments, estimated over two vertical miles in thickness in the Sacramento area, were deposited during cyclic transgressions and regressions of a shallow sea that once inundated the valley. This thick sequence of clastic sedimentary rock units was derived from adjoining easterly highlands erosion during the Late Jurassic period with interspersed Tertiary volcanics. They form bedrock units now buried in mid-basin valley areas. These bedrock units were covered by coalescing alluvial fans during Pliocene-Pleistocene periods by major ancestral west-flowing Sacramento Valley rivers (Feather, Yuba, Bear, and American). These rivers funneled large volumes of sediment into the Sacramento basin. Late Pleistocene and Holocene (Recent) alluvial deposits now cover low-lying areas. These deposits consist largely of reworked fan and stream materials deposited by meandering rivers prior to construction of existing flood control systems.

The Sacramento River is the main drainage feature of the region flowing generally southward from the Klamath Mountains to its discharge point into the Suisun Bay in the San Francisco Bay area. Located in central northern California, the Sacramento River is the largest river system and basin in the state. The 27,000 square mile Sacramento River Basin includes the eastern slopes of the Coast Ranges, Mount Shasta, and the western slopes of the southernmost region of the Cascades and the northern portion of the Sierra Nevada. The Sacramento River, stretching from the Oregon border to the Bay-Delta, carries 31% of the state’s total runoff water. Primary tributaries to the Sacramento River include the Pit, McCloud, Feather, and American Rivers. Within the Sacramento area, the Sacramento and American Rivers have been confined by man-made levees since the turn of the century. The confluence with the Sacramento River, only 20 feet above sea level, is subject to tidal fluctuation although more than 100 miles north of the Golden Gate and San Francisco Bay. Within the study area, these levees were generally constructed on Holocene age alluvial and fluvial sediments deposited by the current and historical Sacramento River and its tributaries. Pleistocene deposits underlie the Holocene deposits.

2.2 GEOMORPHOLOGY

Prior to the late Pleistocene (10,000 to 30,000 years ago), the Sacramento River Basin depositional environment was influenced by a lowered base level due to sea levels as low as 400 feet below present (Harden 1998). These lowered global sea levels would have had their greatest influence in present coastal areas such as the San Francisco Bay area, but based on interpretation of the depth to denser, coarser Pleistocene soils it is estimated that average river levels in this area could have been 50 to 60 feet below current levels. The rivers would have been characterized by high energy flow with greater downward erosion rather than deposition, and would have had greater capacity to carry and deposit sand and gravel deposits into the project

area. This older geomorphology is largely covered by the more recent (Holocene) sediments in the project area. The thick zone of materials deposited above the dense, older Pleistocene alluvial deposits are therefore less than 10,000 to 30,000 years old, which is reflected in these deposits consisting of very soft to firm clays and silts and abundant loose to medium dense sands.

The filling of the Sacramento Valley with sediments following the rise in sea level to the current level has significantly reduced the gradient of the rivers flowing down from the Sierra Nevada and Klamath Mountains (including the Sacramento and American Rivers). This gradient reduction has caused the energy of these rivers to transition from erosional to graded. Graded rivers are characterized by downward erosion that is less dominant and more directed toward side-to-side movements than down-cutting. The lateral energy of a graded river causes synchronous erosion and deposition in sweeping bands commonly referred to as meanders. The outside of the meander is a zone of erosion. Material removed by the river at this zone is then deposited downstream as point bars in zones of decreased velocity on the inside of the subsequent meanders. In this way, the river migrates laterally across the flood plain. Often this erosion is slowed where the river encounters more resistant materials in the flood plain. This allows the next closest upstream meander to catch up and gradually erode away the “neck” between the two meanders. Flooding often accelerates this process as the higher energy flows can more easily cut a new thalweg (base of the active channel). The result of the conjoining meanders is the straightening of the river across the opening of the neck and the creation of an abandoned bend in the river, commonly referred to as an oxbow lake.

2.3 HYDRAULIC MINING

Hydraulic mining activity in the Sierra Nevada during the mid- to late-1800s supplied a substantial amount of sediment to many river channels draining the Sierra Nevada, which resulted in aggradation of the channels and flooding due to decrease in channel cross section area. Gold dredging and mining operations have destroyed some fluvial deposits and surfaces, confounding the understanding of the long-term geomorphic history.

This phenomenon, coupled with a disastrous flood in 1862, prompted the channelization of the Sacramento and American Rivers and re-alignment of the American River to its present-day configuration, from the former confluence with the Sacramento River to about two miles upstream. It was hoped that these actions would provide flood control as well as stimulate the flushing of accumulated mining-derived sediment from the channel.

3.0 CONSTRUCTION HISTORY

A mix of Federal, State, and local agencies have been involved in flood control project construction and operation since levees were first constructed in California in the mid-1800's. Since the creation of the State Reclamation Board (now the Central Valley Flood Protection Board or CVFPB) in 1911 and the authorization of the Sacramento River Flood Control Project (SRFCP) in 1917, most levee improvements have been first Federally authorized by Congress, then subsequently authorized by the State Legislature.

The SRFCP was authorized by the Flood Control Act of 1917 (PL 64-367) as modified by the Acts of 1928, 1937, 1941 and 1950. Features of the SRFCP, in the study area, consisted of levees along the lower American River, NEMDC, Arcade and Dry (Linda) Creeks, PGCC, NCC, and Sacramento River improvements, including new and reconstructed levees. The American River Flood Control Project (ARFCP), authorized by the Flood Control Act of 1954 (PL 83-780), consisted of a levee along the north bank of the river, extending from the terminus of the SRFCP project levee near Cal Expo upstream about 8 miles to Carmichael Bluffs. The levee along the American River up to Mayhew Canal was enlarged in 1948. Bank protection was installed along the levee in 1951. The completed flood control system was documented in 1957 in a design memorandum, which included design water surface profiles. To this day, these are the profiles that govern the operation and maintenance requirements of the levee system.

3.1 AMERICAN RIVER LEVEES

The levees along the American River left bank were originally constructed in the late 1800s to early 1900s, likely using clamshell dredges with material sourced from the channel. The levees were then reconstructed on the left bank between 16th Street and Mayhew and on the north bank between NEMDC and Cal Expo with materials sourced from waterside borrow pits using scrapers, dozers, and compactors between 1947 and 1957. Waterside borrow material was used on the right bank of the American River from Carmichael Bluffs downstream to the upper end of the existing flood protection system near Cal Expo under the ARFCP in 1958. Figure 3-1 below represents a typical constructed levee section on the American River in the 1940’s through 1950’s.

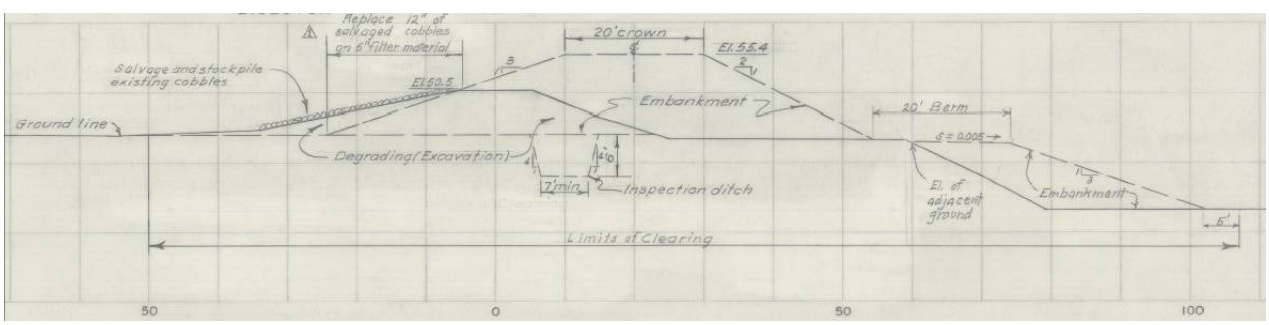

Figure 3-1: American River Typical Section 1940-1960

The ARCF Project was authorized by the WRDA 1996 and 1999 which included, seepage remediation and levee raising. Seepage remediation was completed by constructing a slurry cutoff wall to varying depths along the American River Right Bank Levee and Left Bank Levee

from the Mayhew Drain to the Sacramento River confluence. Due to restrictive site features, such as bridge and utility crossings, the cutoff wall was not constructed contiguously and gaps (windows) were left in the cutoff wall.

3.2 SACRAMENTO RIVER WEST LEVEE (SOUTH OF AMERICAN RIVER)

The levees along the Sacramento River south of the confluence with the American River were constructed by local interests using clamshell dredges excavating material from the Sacramento River in the early 1900's, Figure 3-2. This method of construction usually resulted in loose, sandy fill material that is deepest below the center of the levee. The current materials within the levee embankment are predominantly sands, silty sands, and cohesionless materials. A setback levee at the Edwards Break and riverbank protection was constructed in 1937 and in 1939 the Edwards Break levee slope had been rebuilt. In 1941 the levee was enlarged in the vicinity of Richfield Oil Co. Numerous riverbank and levee waterside slope protection were constructed along the Sacramento east bank levee. Shown below is the Dredge Neptune placing material at RM 57.3 in 1942 during the Sacramento Bank Protection Project.

Figure 3-2: Dredge Neptune at RM 57.3 in 1942

Under the SUALRP levee improvements were constructed along the Sacramento River between the NCC and Freeport. This included slurry cutoff walls constructed in the early 1990s varying in depth from 17 to 30 feet from the levee crest and were intended to address through-seepage. The American River Common Features, Pocket Geotechnical Project constructed a deep cutoff wall using deep soil mixing (DSM) in 2006 varying from 107 to 110 feet from the levee crest which is intended to address under-seepage. The Sacramento River East Bank Levee Under-Seepage Remediation Project, Pocket and Little Pocket Areas constructed a deep-mix method (DMM) cutoff wall in 2005 varying from 91 to 112 feet from the levee crest. This project also constructed an under-seepage cutoff wall using the DMM at the Sump 132 105 feet in depth.

3.3 SACRAMENTO RIVER WEST LEVEE (FROM NCC TO AMERICAN RIVER)

The levees protecting the Natomas Basin were constructed by a private mining and dredging company with the purpose of reclaiming and selling thousands of acres of farmland. The levees were constructed using large "clam shell" dredging machines. The work began in 1912 and was completed by the end of 1915. Based on typical construction schematics shown on basin-wide maps and historical literature, the levees along the Sacramento River were constructed in the following manner:

- A dragline was used to excavate a trench about 6 to 12 feet deep along the centerline of the levee alignment. The trench bottom width ranged from about 12 to 28 feet. The excavated material was deposited along both sides of the trench forming two small containment dikes.
- Hydraulic dredging operations placed material from the adjacent Sacramento River bottom into the excavation area between the dikes. This material consisted predominately of sands.
- The final levee configuration was achieved by covering the dredged sand with the adjacent dike materials. These materials consisted predominately of silt, clay, and fine sand, Figure 3-3.

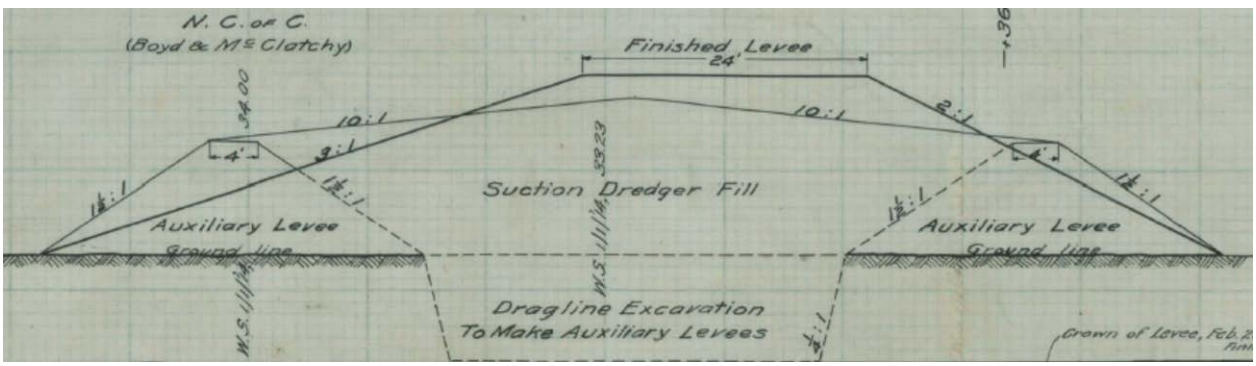

Figure 3-3: Sacramento River Typical Levee Section, 1912-1915

In 1991, between the Sacramento River and NCC confluence to Power Line Road, a drained stability berm was constructed to 10 feet in width extending to approximately half the levee height under the SUALRP. The berm was constructed over a drainage layer that extended as a chimney drain on the levee slope to prevent internal erosion due to seepage through the levee embankment. Filter fabric was placed between the drainage layer and the levee fill to preserve the functionality of the drainage layer. From Power Line Road to the confluence of the Sacramento and American rivers, an SCB cutoff wall was constructed to prevent through-seepage and internal erosion within the levee under SUALRP in 1994. The slurry wall was constructed to depths between 25 and 45 feet below the levee crest. The wall is considered to be hanging, as the tip is not "keyed in" to a lower impervious clay layer of the foundation.

3.4 NATOMAS CROSS CANAL SOUTH LEVEE

Construction on the south levee along the NCC began in 1909. The perimeter levees were constructed encompassing both RD 1000 and RD 1001 areas. In approximately 1912, clamshell dredgers were used to construct the drainage canal of what is now known as NCC between the two levee districts. Work was completed around 1914.

The NCC was excavated across an area that was not a preexisting drainage alignment. The clamshell dredges excavated the alignment of NCC by floating upon the excavated borrow channel located near the waterside levee toe. As the dredgers heaped spoils up from the channel, they were shaped into a levee configuration using small scrapers. The waterside slope was roughly at 3H:1V and the landside slope was about 2H:1V. The crest width was reported as 20 feet. A small core trench near the center of the embankment was also constructed, Figure 3-4.

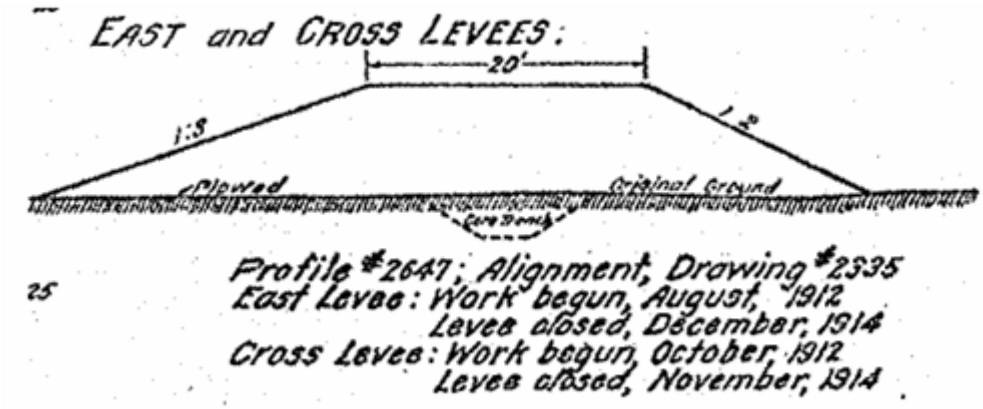

Figure 3-4: Natomas Cross Canal Typical Levee Section, 1912-1914

3.5 NEMDC, PGCC, ARCADE CREEK AND DRY CREEK LEVEES

The Natomas Company of California originally constructed the NEMDC and PGCC west levees from August 1912 to December 1914. A portion of the NEMDC levee was constructed using a clamshell dredge excavating from Steelhead Creek, but the majority of the NEMDC and PGCC west levees were constructed using horse-drawn excavators using material sourced from the channel.

From 1954 through 1958 the USACE completed construction and enlargement (widening and strengthening) portions of the NEMDC, PGCC, Arcade Creek, and Dry Creek levees. Portions of the NEMDC (east and west bank) and PGCC levees were enlarged to between 20 and 12 feet wide at the crest by placing additional material on the waterside levee slope. The NEMDC and PGCC levees were constructed with 3:1 waterside and 2:1 landside embankment slopes. The south bank levee of Arcade Creek was widened to have a 20-foot crest and the north bank levee was constructed (with a 20-foot levee crest). The south levee of Dry (Linda) Creek was constructed (with a 20-foot crest width). The Arcade and Cry Creek levees were constructed with 2:1 waterside and landside embankment slopes. The material was sourced from a waterside borrow trench that paralleled the levee alignment. Figure 3-5 shows a typical section from the 1958 enlargement of the NEMDC east levee.

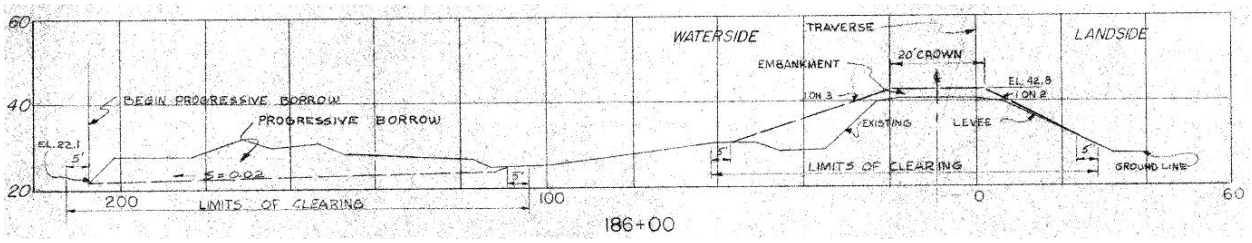

Figure 3-5: NEMDC Typical Levee Section (East Bank), 1958

SAFCA initiated construction of the North Area Local Project (NALP), in 1992 and completed work by 2001. Federal authorization occurred in 1993 under Section 9159 of the Defense Appropriation Act of 1993, as part Phase II of the Natomas Area Flood Control Improvement (NAFCI) Project of 1993, which was authorized by the SAFCA Board of Directors on April 28, 1996. The project consisted of levee embankment and floodwall improvements on the NEMDC east and west levee, Arcade Creek north and south levee, and construction of the Dry Creek north levee (see Figure 3-6).

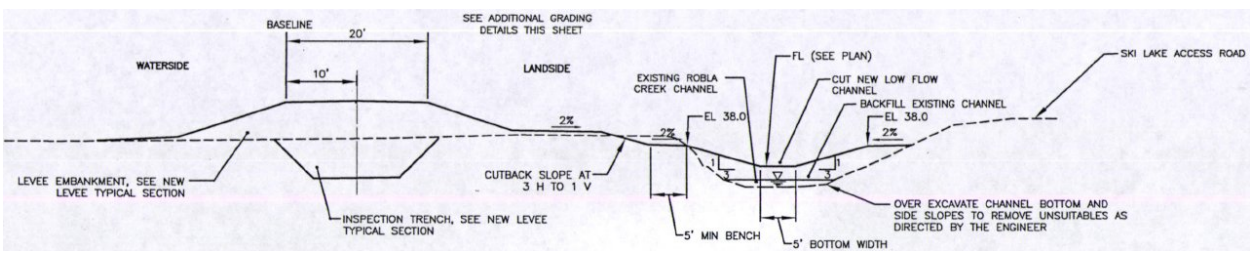

Figure 3-6: Robla Creek Typical Levee Section, 2001

4.0 PAST PERFORMANCE

The study area has experienced several large discharges in recorded history, the earliest was in 1850 when the City of Sacramento was founded and another, larger, flood occurred in January 1862, inundating and substantially damaging Sacramento. These flood events quickly spurred the construction of flood protection levees along many of the banks of the Sacramento River, as well as the cultural re-alignment of the American River in 1868. Additionally, a large flood in 1907 breeched the eastern Sacramento River levee near present day Derick Way (known as the "Edwards Break"), with subsequent flooding of reclamation districts on the eastern side of the river south to the Delta. Additional flood events occurred in 1907, the middle of the century in 1950 and 1955, and more recently in 1986 and 1997, despite the existence of the upstream Folsom Dam. At least eight large floods have occurred in the lower American and Sacramento River basins since Folsom Darn became operational, these occurred in 1955, 1963, 1964, 1969, 1970, 1980, 1982, and 1986. The early floods spurred construction of flood control levees along the lower American River near Sacramento, and the recent floods tested the performance and capacity of the modern levee system.

In February 1986 and January 1997, major storms in Northern California caused record flood flows on the Sacramento and American Rivers. Record high outflows from Folsom Dam and Reservoir, together with high flows in the Sacramento River, resulted in water levels rising above the design freeboard of levees protecting the Sacramento area. It is estimated that major sections of levees along the American and Sacramento rivers would likely have failed if the storms had lasted longer. These events caused undermining of the levee embankment and also washed away portions of the riverbank. Figure 4-1 below shows the erosion distress experienced on the American River as result of the 1986 event. Subsequently flood events in 1997, and late 2005 to early 2006 each caused minor surficial erosion along the American River.

Figure 4-1: 1986 Erosion Distress on the American River South Bank Near I-80

Flood events in 1986, 1997, and 2006 have also caused seepage at or near the landside levee toe as well as at distances of 2,500 to 4,000 feet landward. Seepage distress was experienced throughout the Sacramento River levee reaches. Further documentation including aerial photographs, and reports by landowners, detailed seepage boils as well as eroding and sloughing banks at locations of former channels and oxbows beginning in the late 1930's. Flood fighting (see Figure 4-2) has occurred throughout the Sacramento River reaches in both 1986 and 1997 as a response to seepage and stability concerns.

Figure 4-2: 1997 Flood Fighting on the Sacramento River in Natomas

5.0 GEOTECHNICAL REACH DESCRIPTION

American River North Basin

On the American River north bank (Reaches A and B), there is significant riparian habitat on a typically large waterside bench. In some areas, significant landside vegetation (mostly large trees) exists near the levee toe or on the levee slope. On the landside numerous encroachments include; fences at or near the landside levee toe, parking lots built, and residences. In Reach A the levee embankment is predominantly a silty sand to silt material constructed over a thick silt to silty sand blanket which is underlain by a poorly graded gravel aquifer. While in Reach B the levee embankment is predominantly a lean clay material constructed over a silt and lean clay blanket varying in thickness which is underlain by a silty sand and gravel aquifer. In both Reaches A and B a keyed in cutoff wall was constructed under WRDA 1996/1999 to mitigate underseepage.

On the East Side Tributaries (Reaches C through H), there is sparse vegetation on the levee slopes and adjacent to the embankment. On the landside of the NEMDC (Reaches C and F) levee embankment a railroad embankment is adjacent to the levee. Along approximately half of the Reach E alignment a concrete lined ditch is located at the landside levee toe which is approximately 5 to 10 feet deep. The NEMDC (Reaches C and F) levee embankment varies from clay sand and silt to lean clay and silt material. A lean clay blanket of variable thickness is underlain by a silty sand and poorly graded sand aquifer. On Arcade Creek (Reaches D and E), the levee embankment is predominantly clayey sand, lean clay, and silt constructed over a thin lean clay and silt blanket underlain by a silty sand to poorly graded sand aquifer. The Dry/Robla Creek (Reaches G and H) levee embankment is predominantly a clayey sand and silt constructed over a clayey sand, lean clay, and silt blanket of varying thickness. The blanket is underlain by a silty sand aquifer.

Reach I includes both leveed and non leveed portions of Magpie Creek and the Magpie Creek Diversion Canal (MCDC) between Rose Street, where the Magpie Diversion Canal flows into Robla Creek, to the west and McClellan Air Force Base to the east. The levees associated along Magpie Creek and the MCDC are composed of silty sand and is underlain by predominantly dense to very silty sand and stiff to hard sandy silt with a somewhat prevalent hardpan layer about 4 feet thick, 2 to 6 feet below grade.

American River South Basin

On the American River south bank (Reaches A, B and C), there is significant riparian habitat on a typically large waterside bench. In some areas, significant landside vegetation (mostly large trees) exists near the levee toe or on the levee slope. On the landside numerous encroachments include; fences at or near the landside levee toe, power poles, parking lots, and residences. The Reach A and B levee embankment is predominantly composed of silty sand and sandy silt while the Reach C levee is predominantly poorly graded sand. The levees are underlain by a thick silt to silty sand blanket which is underlain by a sand and gravel aquifer. In both Reaches A and B a

keyed in cutoff wall, and in Reach C a hanging cutoff wall, were constructed under WRDA 1996/1999 to mitigate underseepage.

On the Sacramento River, south of the American River confluence, (Reaches D through G), there is significant waterside and landside vegetation on both the slopes and at the toe of the levee. In all of the reaches, significant urban development has occurred up to the levee toe and/or the landside levee slope. Old Town Sacramento surrounds Reach D, Reaches E and F are residential areas of the Little Pocket and Pocket neighborhoods, and Reach G is the town of Freeport and an adjacent railroad alignment. On the landside numerous encroachments include; fences at or near the landside levee toe and across the levee crest, residences, commercial structures, stairways cut into the landside levee slope, and pools. The levee embankment is predominantly poorly graded sand and silty sand constructed over a lean clay and sandy silt blanket of varying thickness which is underlain by a poorly graded sand aquifer. A through-seepage cutoff wall was constructed which extends to a depth of approximately 18 to 40 feet in portions of Reach D and G and all of E through F. Sections of deep cutoff wall to approximately 110 feet were constructed in portions of Reaches E and F.

Natomas Basin

In the Natomas Basin, on the Sacramento River east bank (Reaches A, B, and C), the there is significant landside and waterside vegetation. On the waterside of the levee crest (levee slope and toe) there exists almost continuous residential structures and related features such as, driveways, out structures, and landscaping. On the landside numerous encroachments are mostly due to agricultural uses (ditches, utilities, and structures) in Reaches B and C and residential in Reach A. The levee embankment was constructed of hydraulically placed sandy core between clay trainer dikes. The trainer dikes were constructed of material obtained by excavating the natural impervious blanket. The levee was constructed over a lean clay and silt blanket underlain by a silty sand and poorly graded sand aquifer. In Reach A and portions of Reach B a shallow through seepage cutoff wall was constructed and in the rest of Reach B and C a landside stability berm. As part of the NPACR and adjacent levee is proposed for construction on the landside of the existing levee with either/or both a deep cutoff wall or landside seepage berm to mitigate levee underseepage.

On the Natomas Cross Canal south bank (Reach D), there is limited vegetation on both the landside and waterside of the levee, which was constructed on the canal bank. The levee embankment is predominantly a silt and clayey sand material constructed on a thin silt blanket which is underlain by poorly graded sand and silty sand aquifer. For a portion of the reach a landside stability berm was constructed to half the existing levee height. As part of the NPACR a cutoff wall is proposed for construction to mitigate levee underseepage.

On the PGCC and NEMDC west bank (Reaches E through H), there is vegetation on the waterside and landside of the levee. Encroachments are sparse for Reaches E through G (mostly agricultural uses) but in Reach H commercial development exists at the landside toe. The levee embankment is predominantly a clayey sand sandy lean clay constructed on a thin lean clay blanket which is underlain by silty sand to poorly graded sand aquifer. As part of the NPACR a

cutoff wall or landside seepage berm is proposed for construction to mitigate levee underseepage.

On the American River north bank (Reach I) there is significant vegetation on both the waterside and landside of the levee; predominantly comprised of trees. Encroachments include primarily commercial buildings near the landside levee toe, and parking lots adjacent to the levee embankment. The levee embankment is predominantly silty sand constructed on a sandy silt blanket which is underlain by silty sand and poorly graded sand aquifer. As part of the NPACR a cutoff wall is proposed for construction to mitigate levee underseepage.

6.0 LEVEE FAILURE MODES AND ANALYSES CRITERIA

For the purposes of problem identification and alternatives analysis, several different failure modes have been evaluated for the without project condition. The failure modes included seepage (under and through), slope stability, erosion, overtopping and seismic.

Steady state seepage analysis considered a maximum allowable vertical exit gradient at the toe of the levee to be less than 0.5 for the water at the design elevation and 0.80 for the water at the top of levee elevation. For landside seepage berms a maximum gradient of 0.8 is allowable at the berm toe. The minimum required factor of safety for the design water surface elevation for the landside steady state slope stability analysis was 1.40 and 1.20 for the top of levee water surface elevation.

The main purpose of seismic vulnerability analyses was to identify the potential seismic performance of a levee. Although seismic remediation generally will not be implemented based on these analysis results, a levee's seismic degradation potential should be considered during selection of a static remediation, or in developing an emergency action plan to be implemented following an earthquake. For the most critical category of levee (e.g., urban levees that are frequently hydraulically loaded) the following displacements are acceptable:

- Any deformation inducing crest displacement of 1 foot or less, unless larger lateral movements comprise the ability of foundation cut-offs or toe drains, etc. to provide for safe retention of high water.
- If more than 1 foot of seismic displacement is predicted, deformation is still acceptable if the levee continues to ensure water retention with 3 feet of freeboard for a 200-year flood event.
- If other safety criteria are met (e.g., cracking that can be repaired in a few days).

The typical USACE levee section, established by EM 1110-2-1913, is nationally considered to have a minimum 10-foot crest with 2:1 (horizontal: vertical) waterside and landside slopes. According to the Sacramento District 1969 "Design Manual for Levee Construction" levees should be constructed with 3:1 waterside and 2:1 landside slopes with either a 20 or 12-foot levee crest width for main stream or tributary levees respectively. The Sacramento District Geotechnical Engineering Branch, SOP-003 *Geotechnical Levee Practice*, suggests a 20-foot crest width with 3:1 waterside and landside slopes except existing levees with good past performance exists where existing 2:1 slopes are acceptable.

Vegetation, encroachment, and access policy includes EM 1110-2-1913, SOP 03, and ETL 1110-2-571 "Guidelines for Landscaping and Vegetation Management at Levees, Floodwalls, Embankments Dams, and Appurtenant Structures". The vegetation-free zone, as established by ETL 1110-2-571, is a three-dimensional corridor surrounding all levees, floodwalls, and critical appurtenant structures in a flood damage reduction system. The vegetation-free zone applies to all vegetation except grass. The minimum height of the corridor is 8 feet, measured vertically from any point on the ground. The minimum width of the corridor is the width of the flood-control structure (Levee toes or floodwall stem), plus 15 feet on each side, measured from the outer edge of the outermost critical structure.

7.0 TYPICAL LEVEE IMPROVEMENT MEASURES

Where levee height, geometry, erosion, access, vegetation, seepage, and slope stability deficiencies were identified (criteria not met) improvement measures consisting of cutoff walls, seepage berms, relief wells, stability berms, geotextile reinforcement, flattened embankment slopes, flood walls, retaining walls, sliver fills, and various other measures could be implemented.

Seepage cutoff walls are vertical walls of low hydraulic conductivity material constructed through the embankment and foundation to cut off potential through seepage and underseepage. In order to be effective for underseepage mitigation, cutoff walls usually tie into an impervious sublayer. The conventional method using a long stick and boom excavator has a maximum depth of 70 to 80 feet. Deeper cutoff walls, up to about 150 feet could be excavated using cable excavation method with crane rigs. Mix-in-place methods of cutoff wall construction include deep mixing method, jet grouting, and cutter soil mixing. Deep Mixing Method uses specialized construction equipment to mix the soil with bentonite and cement in situ and is capable of depths more than 100 feet. Pressure relief wells relieve excess pore pressures that can build up beneath a surficial blanket layer to reduce exit gradient. Relief wells collect seepage and bring it to the surface where it can be discharged freely on the ground surface or collected and drained away from the levee toe. Seepage berms are earth structures built at the landside toe that provide additional weight to prevent blanket layer heave, reduce exit gradients, and can allow safe exit of underseepage. The minimum seepage berm width is typically four times the levee height and the maximum width is generally 300 to 400 feet.

Slope flattening is a mechanical method to repair a slope that may not have stable slopes. Both the waterside and landside slopes can be graded using construction equipment. In most cases, this process requires the removal of all vegetation and encroachments from the levee slope being flattened. Slopes are typically flattened to 3H:1V to 5H:1V. Stability berms are constructed of a random fill material placed over blanket and chimney drainage features to capture seepage through the levee. A thin filter sand layer is placed between the drainage layer and the levee embankment and native soils. Drained stability berms have the benefit of also reducing susceptibility to through seepage. Geotextile is a type of synthetic material that is primarily used for soil reinforcement within an embankment. Geotextile is a woven pervious sheet of fabric constructed of synthetic plastic fibers. Geotextiles only provide reinforcement in tension, thus they are primarily buried within a soil at the tension surface to strengthen the soil.

Floodwalls are an efficient, space-conserving method for containing unusually high water surface elevations. They are primarily constructed from pre-fabricated materials, although they may be cast or constructed in place, and are constructed almost completely upright. Floodwalls are typically located along a levee hinge point to allow vehicular access along the crown. To address deficiencies found in the required levee freeboard various methods of raising the existing levee crown elevation could be implemented. A crown only levee raise assumes that the levee crown is currently wide enough to support the placement of additional embankment material while maintaining the minimum allowable crown width upon the completion of the raise. A full levee raise includes an embankment raise from the waterside crown hinge point upward at a

3H:1V slope, establishing a new crown width, and then down the landside at a new 3H:1V slope).

To protect against waterside erosion in areas where a waterside berm exists, a launchable rock trench may be constructed. This is accomplished by placing rip-rap a certain distance on the waterside slope and excavating a trench at the waterside toe, or where the waterside slope meets the berm. Rip-rap is then placed in the trench and then covered with random fill. As the waterside berm is erodes, it will eventually reach the launchable rock trench. At this point, the undermining action of the erosion event and soils surrounding the trench will allow for the rip-rap contained in the trench to “launch” into the void created adjacent to the trench. In areas that have no or minimal waterside berm, on bank rip-rap is placed on the waterside levee slope to protect against erosion. This entails filling the eroded portion of the bank and installing stone protection along the levee slope from the base of the erosion area to the top of the erosion area. Vegetation would be limited to grass. If there is a natural bank distinct from the levee that requires erosion protection, it would be treated with stone protection.

The purpose of the toe access easement is to allow for necessary maintenance, inspection, and floodfight access. For the ARCF project, the Project Delivery Team (PDT) has determined that a minimum toe access easement of 10 feet is required in association with other levee improvements. The actual toe access may vary depending on site specific constraints. Where vegetation management standards are not met, that levee section must be brought into compliance or a variance may be applied to a levee system or portion of that system to provide for the same levee functionality as intended in ETL 1110-2-571. In consideration for a vegetation variance request (VVR), the VVR will preserve, protect, and enhance the natural resources of the levee system or segment.

8.0 CROSS-SECTION SELECTION

Cross-sections for geotechnical analysis were selected to represent critical surface and subsurface conditions of each reach. The topography of each reach is inherently variable. The existence of access ramps on both landside and waterside of the levee, railroads running perpendicular and parallel to the levee, and/or pump stations or other structures built up adjacent to the levee section create difficulties to discern the typical versus critical cross-section. The sections were selected based on subsurface data, laboratory test results, geomorphology, surface conditions, field reconnaissance, historical performance, and levee geometry. The ground surface elevations used in the cross-sections were based on a LiDAR (light detection and ranging) survey completed in November 2008 for the DWR, ULE project. The natural soil layers were delineated based on boring logs and laboratory test results. Elevation references in this report are in feet and are based on the North American Vertical Datum of 1988 (NAVD88) unless otherwise noted. All horizontal references in this report are in feet and are based on the California State Plane, Zone II, North American Datum of 1983 (NAD83). Plate 1 shows the relationship between LM, RM, and stationing that were used to describe the location of the cross-sections. Table 8-1 and Plate 2 presents the cross-sections where geteochnical analyses were performed, and used in the economic analyses.

Table 8-1: Index Point Locations

Basin	Reach	Channel	Bank	Unit	Levee Mile
ARN	A	American River	North	9	1.32
ARN	E	Arcade Creek	North	7	0.90
ARS	B	American River	South	4	3.90
ARS	F	Sacramento River	East	1	5.92
NAT	D	NCC	South	2	1.17

9.0 HYDRAULIC LOADING CONDITIONS

Water surface profiles for the ARCF GRR study area were obtained from the Hydraulics and Hydrology Branch, Sacramento District. The profiles provide water surface elevations in NAVD 88 by river mile for various flood frequencies. Deterministic seepage and stability analyses were performed for various flood frequencies typically incorporating the 25yr, 50yr, 100yr, 200yr, 500yr, and top of levee. The probabilistic analyses were performed for a range of stages not correlated to flood frequency, but which represented stages from no head (landside toe of levee) to maximum head (top of levee).

During the preparation of this report, the hydraulic model was in the process being revised and updated. Due to the detailed review process required of the hydraulic model update, the decision was made to perform the deterministic analyses using draft hydraulic model water surface profiles for various flood frequencies. Water surface profiles for deterministic seepage and slope stability analyses for the Natomas Basin were based on the previous hydraulic model dated December 2010, for the American River North Basin (ARN) Reaches A and B and American River South Basin (ARS) Reaches A through G were based on a draft update dated July 2011, and for ARN Reaches C through H were based on a draft update dated March 2012. The various different models have a variability of 1 to 3 feet of stage for the same flood frequency.
Table 9-1 below summarizes the water surface elevations deterministically analyzed at each index point, by basin.

Table 9-1: Analyses Water Surface Elevations

Index Point	Event	Stage	Head
ARN Reach A U9 LM 1.32	Crest	52.95	9.69
	500yr	55.83	12.57
	200yr	51.1	7.84
	100yr	46.27	3.01
	50yr	46.16	2.9
	25yr	46.08	2.82
ARN Reach E U7 LM 0.90	Crest	43.94	12.25
	500yr	46.12	14.43
	200yr	41.34	9.65
	100yr	39.08	7.39
	50yr	37.68	5.99
	25yr	35.34	3.65
ARS Reach B U4 LM 3.90	Crest	48.83	16.03
	500yr	47.76	14.96
	200yr	41.31	8.51
	100yr	38.13	5.33
	50yr	37.73	4.93
	25yr	37.41	4.61

Index Point	Event	Stage	Head
ARS Reach F U1 LM 5.92	Crest	33.41	17.96
	500yr	33.33	17.88
	200yr	32.05	16.6
	100yr	30.33	14.88
	50yr	29.65	14.2
	25yr	29.03	13.58
NAT Reach D U4 LM 1.17	Crest	44.85	15.3
	500yr	45.16	N/A
	200yr	44.23	14.68
	100yr	42.84	13.29
	50yr	41.88	12.33
	25yr	41.11	11.56

10.0 SEEPAGE AND SLOPE STABILITY ANALYSES

Deterministic steady state seepage analysis was performed using the finite element program SEEP2D within GMS 6.5 (Groundwater Modeling System). Results from the seepage analysis were used to calculate average vertical exit gradients at the landside levee toe and/or at a more critical location near the levee toe if applicable, for example at the invert of the empty drainage ditch. The pore pressures and/or phreatic surfaces were exported to UTEXAS4.0 for use in slope stability analysis.

Boundary conditions along the waterside ground surface from the waterside model limits to the levee slope were assigned as fixed total head conditions corresponding to the analyzed water elevation. On the landside, exit face boundary conditions are applied from the landside crest hinge point to landside extents of the model. All other boundaries not explicitly assigned a condition are assumed by the program to be no flow which include both vertical faces of the model and the bottom nodes. The landside model extents were extended 2,000 feet from the levee centerline and for the waterside model extents to the channel centerline.

Embankment stability against shear failure was analyzed using the UTEXAS4.0 software package for steady state conditions. Analyses to find factors of safety against sliding were conducted using a floating grid automatic circular failure surface search routine to identify the critical failure surfaces with Spencer Procedure within the embankment and/or foundation. The Spencer Procedure satisfies both force and moment equilibrium for each slice. A minimum weight restriction was applied to the slices within the failure surface to eliminate surficial failure surfaces. Where tensile stresses exist on the failure surface, a water filled crack depth was introduced to eliminate the tensile stresses, but not compressive stresses.

Material properties including hydraulic conductivity for seepage analysis and drained (effective) shear strength and unit weight for slope stability analysis were developed based on a review of field and laboratory data that was then generalized into appropriate parameters by material type. The stratigraphy of the existing levee cross-section was divided into unique layers typically consisting of levee embankment fill, foundation or blanket layer, pervious aquifer layers separated by an aquitard, and a deeper fine grained layer. Analysis material parameters were assigned considering saturated conditions.

The results of the without project seepage and slope stability analyses indicate that the levees in ARN Reaches C through F and ARS Reaches D through G did not meet minimum criteria. The analyses showed that the levees did not meet criteria at varying flood frequencies typically between the 25 and 200 year events. In general, the analyses identified underseepage deficiencies and/or underseepage related slope stability deficiencies. Therefore, the with project analyses typically included deep cutoff walls which resulted in the with project levee analyses satisfying criteria.

10.1 ARN REACH A – AMERICAN RIVER NORTH – U9 LM 1.32

The without project conditions analyses includes the WRDA 1996/1999 cutoff wall and met criteria for both seepage gradients and slope stability factors of safety. As no seepage and stability deficiencies exist, no further improvements are recommended. Figure 10-1 displays steady state seepage and landside slope stability results for analyzed flood frequencies.

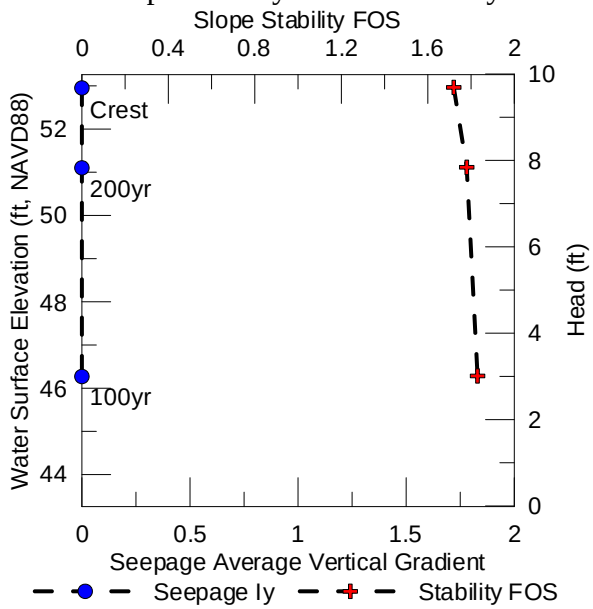

Figure 10-1: ARN Reach A U9 LM 1.32 Without Project Analyses Results

10.2 ARN REACH E – ARCADE CREEK NORTH – U7 LM 0.90

The without project conditions seepage analysis of the Arcade Creek north levee have shown the potential for seepage gradients to exceed criteria beginning at the 100 year flood frequency event due to a thin clay blanket underlain by poorly graded sand layer. Related to the underseepage deficiency, slope stability factors of safety do not meet criteria beginning at the 50 year flood frequency event. The 100 year flood frequency event corresponds to a water surface elevation of 39.08 feet and 7.39 feet of head and the 50 year flood frequency event corresponds to a water surface elevation of 37.68 feet and 5.99 feet of head. Additionally, an open drainage ditch to the landside levee toe from NEMDC to Norwood Avenue amplifies the slope stability deficiency. With project conditions analyses addressed the underseepage and slope stability deficiencies by incorporating a cutoff wall be keyed-in to a low permeability confining layer at elevation –6.0 feet. With the improvement measures described above seepage and stability analyses met criteria. Figure 10-2 displays the without project conditions analyses results and Figure 10-3 displays the with project analyses results for analyzed flood frequencies.

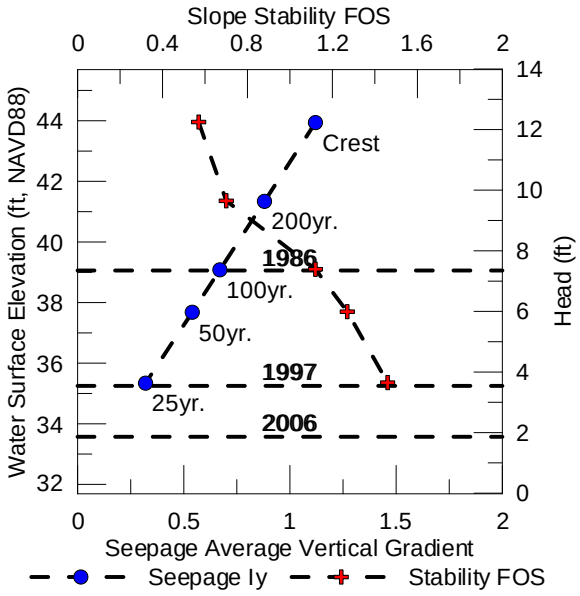

Figure 10-2: ARN Reach D U7 LM 0.90 Without Project Analyses Results

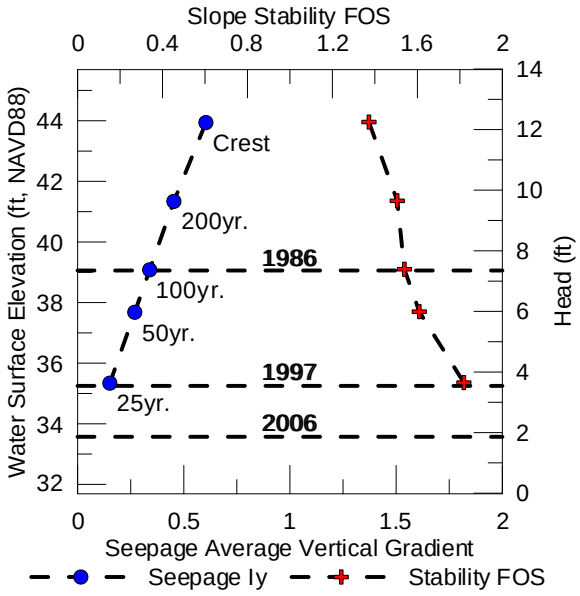

Figure 10-3: ARN Reach D U7 LM 0.90 With Project Analyses Results

10.3 ARS REACH B – AMERICAN RIVER SOUTH – U4 LM 3.90

The without project conditions analyses includes the WRDA 1996/1999 cutoff wall and met criteria for both seepage gradients and slope stability factors of safety. As no seepage and stability deficiencies exist, no further improvements are recommended. Figure 10-4 displays steady state seepage and landside slope stability results for analyzed flood frequencies.

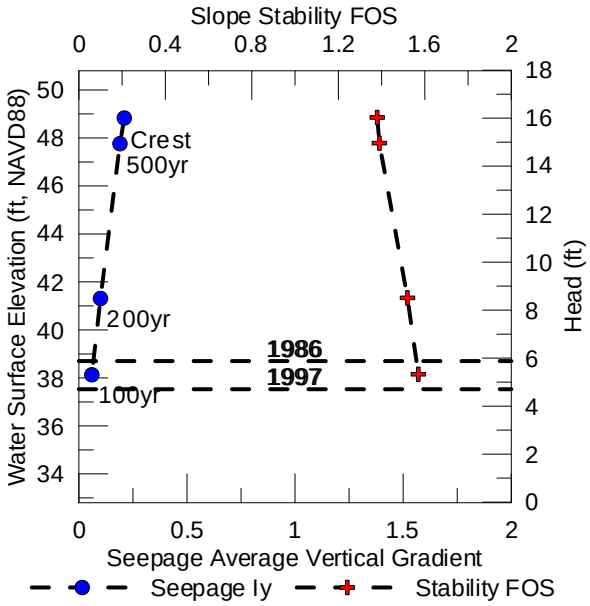

Figure 10-4: ARS Reach B U4 LM 3.90 Without Project Analyses Results

10.4 ARS REACH F – SACRAMENTO RIVER EAST – U1 LM 5.92

The without project conditions analysis on the Sacramento River, at this location, included a through seepage cutoff wall constructed by the SUALRP in the early 1990's. Slope stabilty analysis resulted in factors of safety below criteria beginning at the 25 year flood frequency event, which corresponded to a water surface elevation of 29.03 feet and 13.58 feet of head. Seepage analysis at the 25 year flood frequency event through crest water surface elevation indicated marginal underseepage gradients (0.4 to 0.5). A review of past performance indicated that seepage and boils were observed at numerous locations both before (1995) and after (1998) the construction of the through cutoff wall. Past flood event stages were compared to analyzed flood frequencies and the 1997 event (maximum recorded stage) was comparable to the 25 year flood frequency. The past performance is in agreement with the seepage and stability analyses results. With project conditions analyses addressed the underseepage deficiencies by incorporating a keyed-in cutoff wall to tip elevation -105.0 feet. Figure 10-5 displays the without project conditions analyses results and Figure 10-6 displays the with project analyses results for analyzed flood frequencies.

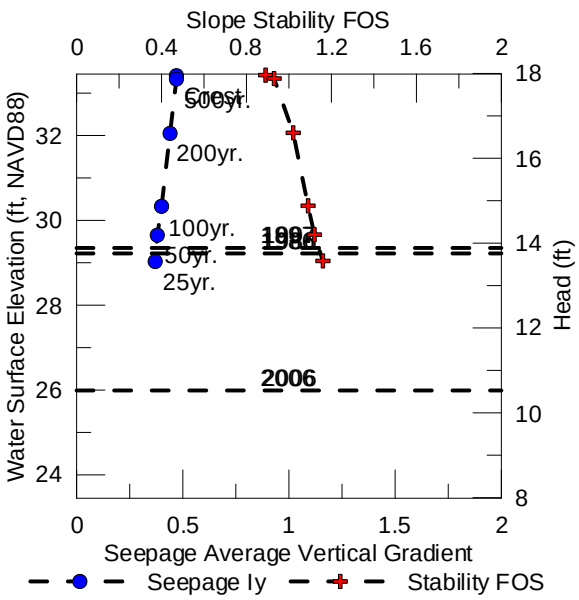

Figure 10-5: ARS Reach F U1 LM 5.92 Without Project Analyses Results

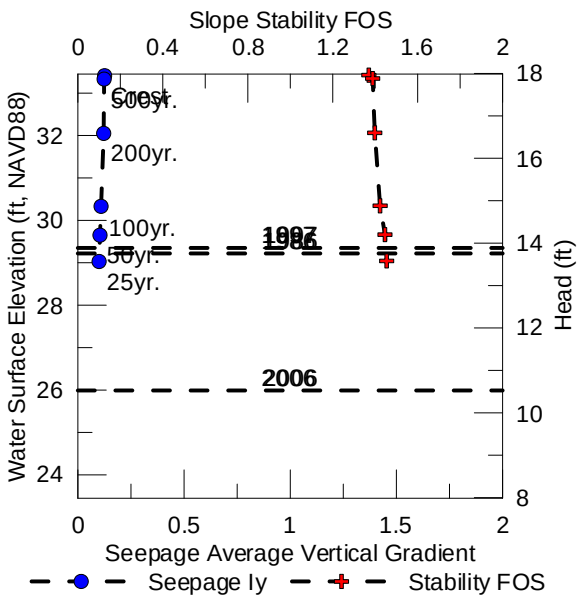

Figure 10-6: ARS Reach F U1 LM 5.92 With Project Analyses Results

10.5 NAT REACH D – NCC SOUTH – U1 LM 1.17

The without project conditions analyses includes the NPACR cutoff wall which satisfies criteria for both seepage gradients and slope stability factors of safety. The ARCF GRR included a levee raise, the NPACR analyses section met top of levee analyses criteria with the raise. Figure 10-7 displays steady state seepage and landside slope stability results for analyzed flood frequencies.

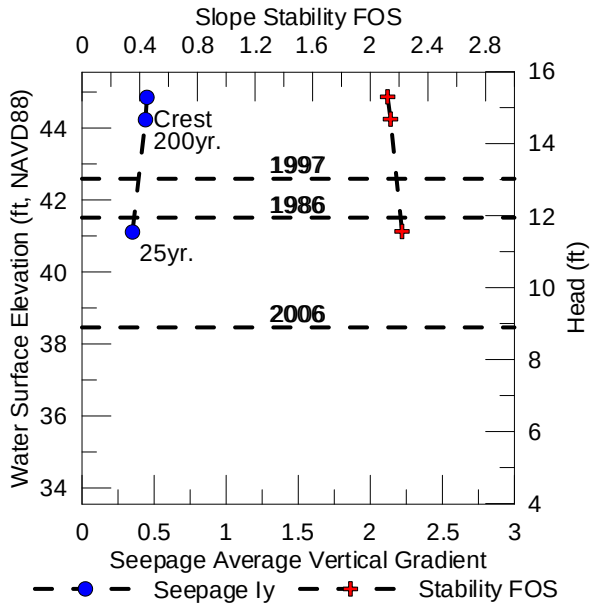

Figure 10-7: NAT Reach D U1 LM 1.17 Without Project Analyses Results

11.0 EROSION ASSESSMENT

The American River levees were originally intended to convey a release from Folsom Dam of 115,000 cfs. During several events since the construction of Folsom Dam, flows have exceeded design capacity and caused significant erosion distress. Additionally, the objective release from Folsom Dam is currently under review as part of the Folsom Dam Reoperations Study and the Joint Federal Project is currently constructing improvements to the dam for a release of 160,000 cfs.

Insufficient geotechnical data were available to adequately support existing and proposed channel stability analyses and potential design recommendations. Specifically the geotechnical and geologic study focused on characterization of soil properties through exploration and testing, geologic mapping, and 3-dimensional modeling of the subsurface stratigraphy. Additional geotechnical data was generated to characterize the material comprising the existing channel bed between the Right and Left bank levees of Lower American River (LAR) between River Mile (RM) 5.0 and 11.0. Specifically, the geotechnical study was directed to investigation the location and properties of a potentially erosionally resistant unit, better represent and organize the existing geotechnical data, and improve upon existing geologic mapping.

Subsurface exploration, soil borings and CPT, and subsequent laboratory testing were performed in support of the various tasks associated with studying erosion on the LAR. Relatively undisturbed samples were collected of the potentially erosionally resistant unit for erosion rate testing to be used in hydraulic modeling and analyses. Additional subsurface investigation consisted performing several geoelectrical surveys of the LAR channel and floodplain between RM 5.5 and RM 11.0 to characterize the extent and thickness of lithologic units that may have differing scour potential. The erosion resistance of the LAR was further assessed by performing Jet Erosion Tests (JET) and Erosion Function Apparatus (EFA) testing on undisturbed samples of cohesive materials located near the bed elevation of the LAR. The test results showed that the erodibility of each sample was related to the geologic unit and that most of the specimens within the Fair Oaks formation (below the erosionally resistant surface) could be categorized as Moderate Resistant to Very Resistant. Similarly, in general, the layer above erosionally resistant surface could be categorized as Very Erodible to Erodible.

Fugro Consultants performed the geologic portion of the erosion study, key findings from their report, *Lower American River Stratigraphic and Geomorphic Mapping Report* (2012), are reproduced below. Two levels of investigation were performed: (1) detailed mapping and analysis of the geologic deposits between the levees from RM 5.0 to 11.0, and (2) development of reconnaissance mapping along the channel corridor between RM 0.0 to 5.5 and RM 11.0 to 22.4. Detailed geologic mapping, as well as petrographic and pedogenic analyses, completed during this study demonstrated the presence of two potentially erosion-resistant units. These were: (1) a moderately cohesive silty and sandy interbed of relatively limited lateral and longitudinal extent within a thicker package of loose Holocene sediments (the “upper” unit); and (2) much thicker, more widespread relatively erosion-resistant deposits associated with the Pleistocene-aged Fair Oaks formation of Shlemon (1967) (the “lower unit”). Figure 11-1 presents a generalized stratigraphic section.

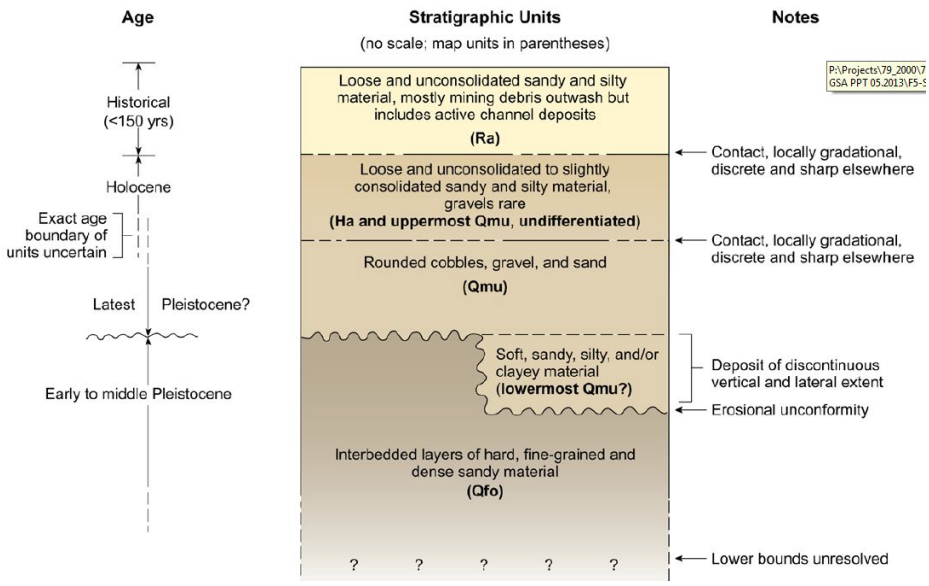

Figure 11-1: Generalized, Composite Stratigraphic Section of the Lower American River

A 3-dimensional (3D) stratigraphic model of the LAR study reach was developed by incorporating both existing and newly collected geotechnical and geologic data. The model described the stratigraphy and subsurface conditions of the study reach and help evaluate the stratigraphic susceptibility of this reach to erosion near the levee banks. Figure 11-2 presents a site specific representation of the generalized section presented in Figure 11-1.

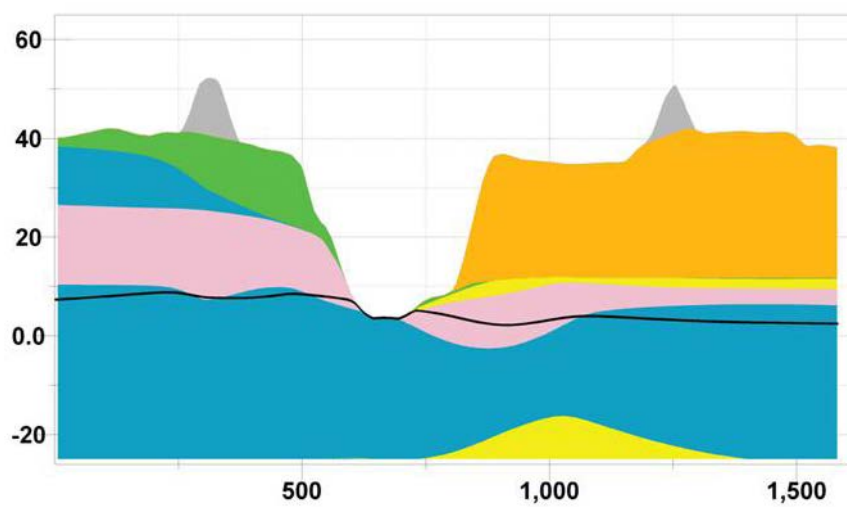

Figure 11-1: 3D Stratigraphic Model Section 11 Near RM 7.2

A review of the applied velocity and shear stresses at different simulated flows was performed on the left and right banks of the study area at several locations. Applied velocity exceeds permissible velocities for most soils by 50,000 cfs on the right bank and between 80,000 and 115,000 on the left bank. Therefore, it is reasonable to assume that, depending on flood event duration, channel and bank geometry, levee geometry, soil type, and vegetation cover, that erosion distress to the American River channel banks and levees has the potential to occur beginning at flows exceeding 30,000 cfs.

12.0 SEISMIC ASSESSMENT

To evaluate the potential to liquefaction resistance of soils, liquefaction triggering analysis was performed based on the procedure from the summary report of the 1996 NCEER and 1998 NCEER/NSF Workshops on Evaluation of Liquefaction Resistance of Soils, published as part of the Journal of Geotechnical and Geoenvironmental Engineer, dated October 2001 (Youd, Idriss, Andrus, & Arango, October 2001).

The result of the liquefaction triggering analysis and liquefaction-induced post-earthquake deformation based on limit equilibrium analysis indicates that liquefaction potential is highly likely at each critical location for all the reaches for Natomas Basin, Reach A of American River North Basin, and Reaches C to G of American River South Basin. Moreover, at these locations, the analysis indicates that the post-earthquake deformation as the result of liquefaction of the material beneath the embankment is a global or structural failure mode that is very likely to compromise the ability to provide flood protection at these critical locations.

13.0 VEGETATION VARIANCE REQUEST SUPPORTING ANALYSES

The majority of the Sacramento River levee within the study area, require seepage, slope stability, height, and erosion improvements in order to meet USACE criteria. Construction of the levee improvement measures will require complete vegetation removal on the levee from approximately 15 feet landward of the landside toe to approximately 1/3rd the height of the levee on the waterside slope. On the waterside, where construction does not remove vegetation, on the lower 1/3rd of the slope to 15 feet waterward of the waterside levee toe, the vegetation will be left in place and a Vegetation Variance Request (VVR) will be sought by the Sacramento District. To show that the safety, structural integrity, and functionality of the levee would be retained, an evaluation of underseepage and waterside embankment slope stability was completed given that a tree fell resulting in scouring of the root ball area.

The analyses section/index point at LM 5.92 was chosen for the VVR analyses because if was considered to be representative of the most critical channel and levee geometry and the without project analyses showed the section does not meet underseepage and slope stability criteria. The cross-section geometry of the index point incorporated tree fall and scour by using a maximum depth of scour for cottonwoods as approximately 11.0ft; the associated soil removed was projected at a 2:1 slope from the base of the scour toward both the landside, and waterside slopes. The base scour width was equal to the maximum potential diameter at breast height (dbh) of Cottonwoods (12.0ft) projected horizontally at a depth of 11.0ft below the existing ground profile. The results show that the tree fall and scour did not significantly affect levee performance and that the levee meets USACE seepage and slope stability criteria considering the seepage and stability improvement measures are in place (“with project” conditions). Therefore, it is a reasonable conclusion that with a VVR to allow vegetation to remain, the safety, structural integrity, and functionality of the Sacramento River levee would be retained.

14.0 GEOTECHNICAL RECOMMENDATIONS FOR LEVEE IMPROVEMENT

The levees protecting the ARCF GRR study area are susceptible to through seepage, underseepage, slope stability, and erosion. In some locations, on the levees along the American River and Natomas Basin, substantial projects have been authorized to address these deficiencies. However, seepage, slope stability, and/or erosion deficiencies still remain on portions of the Sacramento River, on the east bank of NEMDC, on both banks of Arcade Creek, and on both banks of the American River. To address seepage and seepage related slope stability deficiencies the predominant recommendation is cutoff walls. Due to several factors including constraints on expanding the levee footprint; seepage berms, relief, wells, and the vast majority of other seepage improvement measures were considered not feasible. Based on hydraulic modeling, some reaches may require raises to prevent overtopping at certain flood frequencies. Plate 3 shows the locations of those improvements.
On the American River erosion continues to be a potential failure mode that requires additional improvements to convey design flows. To accomplish this, two erosion protection measures have been proposed that could be implemented in combination along the levee alignment depending on factors such as, bank/bench geometry, existing habitat, and existing land use among other considerations. The two measures are a launchable rock trench and on bank rip-rap.

On the Sacramento River east levee (Reaches ARS D through G), the need for further seepage and slope stability improvements has been identified through geotechnical analyses. A combination of conventional open trench and Deep Soil Mixing (DSM) cutoff wall construction methods is anticipated. Levee raises are proposed in some segments of the Sacramento River levee which would be accomplished with a levee embankment raise and retaining wall at the landside levee toe or a flood wall constructed at the levee crest. The levee at Pioneer Reservoir was improved by the Sacramento District with relief wells and a landside seepage berm to meet criteria at the 100 year flood event. At this location, the seepage berm should be thickened to increase the level of protection (200 year flood event). To address a slope stability deficiency in Reach G, a full levee degrade and placement of geotextile within the reconstructed levee embankment is recommended. The Sacramento River levee requires erosion protection, which could be addressed with the measures presented for the American River. The extents of levee seepage and slope stability improvements for the Sacramento River are shown in Table 14-1.

Table 14-1: Sacramento River Reaches D through G Recommended Improvements

Reach	Beginning LM	Ending LM	Tip Elevation (ft)	Depth (ft)	Type	Description
D	0.00	0.18	NA	NA	NA	USACE 2000 CW
	0.18	1.25	NA	NA	NA	High Ground
	1.25	1.97	NA	NA	NA	Pioneer Reservoir
	1.97	3.2	-80	120	DSM	Hanging/Keyed In
	3.2	3.63	-45	80	Open Trench	Keyed In
	3.63	0.59	NA	NA	NA	High Ground
E	0.59	0.9	-95	135	DSM	Partial
	0.9	1.36	NA	NA	NA	SAFCA 2006 CW
	1.36	1.71	-75	115	DSM	Keyed In
	1.71	2.39	-65	105	DSM	Keyed In
E/F	2.39	3.39	-55	95	DSM	Partial
F	3.39	3.67	-75	115	DSM	Hanging
	3.67	3.99	NA	NA	NA	USACE 2006 CW
	3.99	4.57	-75	110	DSM	Keyed In
	4.57	5.01	-45	80	Open Trench	Keyed In
	5.01	6.03	-110	145	DSM	Partial
	6.03	6.11	NA	NA	NA	Sump 132 CW
	6.11	6.28	-85	120	DSM	Keyed In
	6.28	7.36	-65	100	DSM	Keyed In
F/G	7.36	8.32	-60	95	DSM	Hanging
G	8.32	10.64	NA	NA	NA	Geotextile

The NEMDC, Arcade Creek north, Dry Creek, and Robla Creek levees sections were improved in the 1990's to early 2000's by SAFCA and, although they did not include internal seepage improvements, the levees meet geotechnical analyses criteria for seepage and slope stability, except in limited segments. The exception being a portion of NEMDC from its confluence with the American River, both banks of Arcade Creek, and a section of NEMDC where the historic Magpie Creek intersects the levee foundation. To address underseepage and underseepage induced slope stability deficiencies the proposed improvement measure is a cutoff wall constructed with the conventional open trench method. The Arcade Creek south bank proposed cutoff wall is proposed in conjunction with a full levee height degrade and incorporation of geotextile placed within the reconstructed levee embankment. The Arcade Creek north bank a cutoff wall is proposed in conjunction with replacing the existing landside ditch with buried culverts from the confluence of NEMDC upstream to Rio Linda Blvd. Depths and locations of the proposed cutoff wall are shown in Table 14-2 below

Table 14-2: East Side Tributaries Reaches C through F Proposed Cutoff Wall Extents

Reach	Beginning		Ending		Tip Elevation (ft)	Depth (ft)
	Unit	LM	Unit	LM		
C	2	0.00	2	0.48	-45	80
D	1	0.00	1	2.08	-6	45
E	7	0.00	7	1.92	-6	45
F	2	2.01	2	3.24	-45	80

For the levees surrounding the Natomas Basin, the geotechnical recommendations for seepage and slope stability were addressed in the NPACR. The recommended alternative from that report included a combination of seepage berms and cutoff walls combined with either an adjacent levee or fix-in-place improvement to the existing levee. To address levee overtopping concerns, a floodwall at the waterside hinge point or a soil embankment raise is proposed where necessary.

15.0 MAGPIE CREEK

In the early 1990's, the Sacramento District and SAFCA began studying the Magpie Creek and MCDC flood control project after the realization that the system was overtopped during frequent events. In the late 1990's and early 2000's, both the Sacramento District and SAFCA developed varies improvement alternatives for the project. While the alternatives varied slightly, they included similar measures such as, levee raises (either embankment or floodwall), new levee construction, channel improvements (deepening or widening), and construction of detention basins. Levee improvements consisting of either levee embankment raises or flood wall raises were proposed for the left bank of Magpie Creek and the MCDC, while new levee construction was proposed for the right banks. Based on the available existing feasibility and design documents prepared in the 1990's and early 2000's by the Sacramento District and SAFCA, the levee, channel, and detention basin improvement measures appeared to be geotechnically adequate and require no further geotechnical analyses as part of the ARCF GRR.

16.0 SACRAMENTO WEIR AND BYPASS

The existing Sacramento Weir and Bypass, which allows high flows in the Sacramento River to be diverted into the Yolo Bypass, could be expanded to roughly twice their current width to accommodate increased bypass flows. The existing north levee of the Sacramento Bypass would be degraded and a new levee constructed approximately 1,500 feet in length to the north. The existing Sacramento Weir would be expanded to match the wider bypass.

The new north levee of the Sacramento Bypass would be constructed as per the standard levee section for new construction which includes; Type I Levee Fill, 3H:1V waterside and landside slopes, and a minimum crest width of 20 feet. As both the existing north and south levees have experienced underseepage and slope stability related distress, the new north levee would include a 300-foot wide drained landside seepage berm (5 feet thick at the landside levee toe tapering to 3 feet thick at the berm toe and constructed of random fill with a 1.5-foot thick drainage and filter layer at the base) with a system of relief wells located at least 15 feet landward of the berm toe and spaced at 200-foot intervals. A seepage cutoff wall with tip elevation of 5 feet (35 feet deep) should be constructed beneath the Sacramento Weir.

17.0 PROBABILISTIC ANALYSES

The First-Order-Second-Moment (FOSM) method, as recommended in ETL 1110-2-556, "Risk-Based Analysis in Geotechnical Engineering for Support of Planning Studies" dated 28 May 1999, was followed during the probabilistic evaluation of each index point. In this approach, the uncertainty in performance is taken to be a function of the uncertainty in model parameters. The standard deviations of a performance function were estimated based on the expected values (means) and the standard deviation of the random variable means. The performance functions considered were underseepage, through-seepage, and slope stability.

Potential sources of levee distress or failure considered in the analyses were underseepage through the levee foundation, through-seepage through the levee embankment, and instability of the landside levee slope under steady state conditions. The levees were evaluated against the above mentioned performance modes at five different water surface elevations (loading conditions), which included; levee crest, levee crest minus three feet, half levee height, toe plus three feet, and landside levee toe where the probability of failure was considered to be zero. Using this method of selecting loading conditions the curves should represent probability of poor performance at multiple flood frequencies.

The probability of poor performance was evaluated by assessing the foundation and embankment materials and assigning values for the probability moments of the random variables considered in the analyses. Random variables for underseepage were considered for the ratio of the horizontal permeability of the aquifer to the vertical permeability of the upper less permeable blanket, blanket thickness, and aquifer thickness. Random variables for through-seepage were considered for critical tractive stress, porosity, and intrinsic permeability of the levee embankment material. Random variables for slope stability were considered for effective friction angle, effective cohesion, and total unit weight of the levee embankment, and effective friction angle and cohesion of the foundation material.

A judgment based conditional probability function for each analyzed cross-section was based on existing conditions of the levee such as encroachments on the levee slopes, vegetation on the levee slopes and in the vicinity of the levee toes, existing cracks and holes due to animal burrows, erosion of the waterside levee slopes and riverbank, and considering the past history of sand boils or slope failures. Generally, past experience with poor performance at utility crossing and rodent activity indicates the risk of failure is somewhat significant in the analyzed areas.

The conditional probability of failure as a function of floodwater elevation has been developed by combining the probability of failure functions for all considered failure modes; underseepage, through-seepage, slope instability, and judgment.

The without project levee performance curves indicate that the levees in ARN Reaches C through F and ARS Reaches D through G would perform unsatisfactorily when minimally loaded. In general, the analyses identified underseepage deficiencies and/or underseepage related slope stability deficiencies. Therefore, the with project levee performance curves considered the proposed improvement measures for each failure mode, as necessary, which resulted in significant reduction in probabilities of poor performance.

17.1 ARN REACH A – AMERICAN RIVER NORTH – U9 LM 1.32

Borings chosen to be used in probabilistic analyses resulted in a mean blanket thickness value of 15.0 ft with a coefficient of variation of 96, and a mean aquifer thickness of 24.0 ft with a coefficient of variation of 42. The blanket was comprised of predominantly silty sands. The aquifer was made up of poorly graded sand to silty sand, and silty gravel.

The levee embankment contains an existing cutoff wall which mitigates underseepage, through seepage, and slope stability concerns. The without project judgment based probability portion of the curve was comprised mainly of erosion, and encroachments, accounting for 50.0% and 4.0% respectively at the crest. Past performance has indicated significant amounts of erosion of the riverbank, waterside levee slope and foundation. Overall judgment based contributions account for a Pr(f) of 55.3% of the without project combined curve at the levee crest. Figure 17-1 presents the without project conditions combined curve.

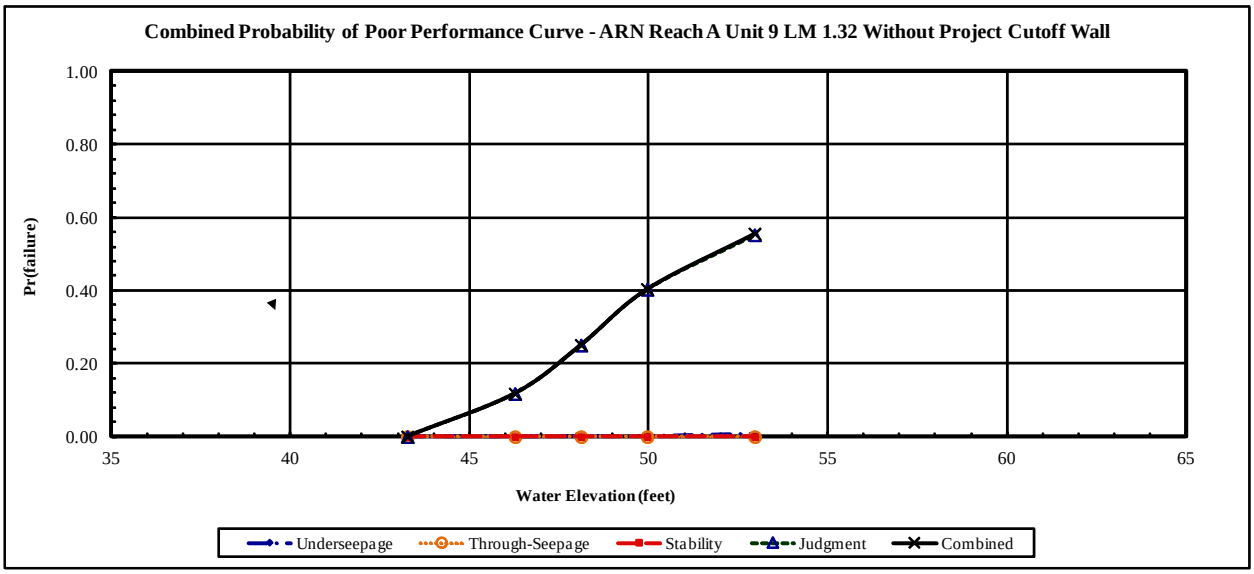

Figure 17-1: Combined Probability of Poor Performance for Without Project Conditions

The remaining probability of failure was primarily attributed to the judgment based failure modes, erosion, which is proposed to be mitigated through the placement riprap erosion protection. With project improvement measures reduce erosion to a Pr(f) of 5.0% at the levee crest. Figure 17-2 presents the with project conditions combined curve.

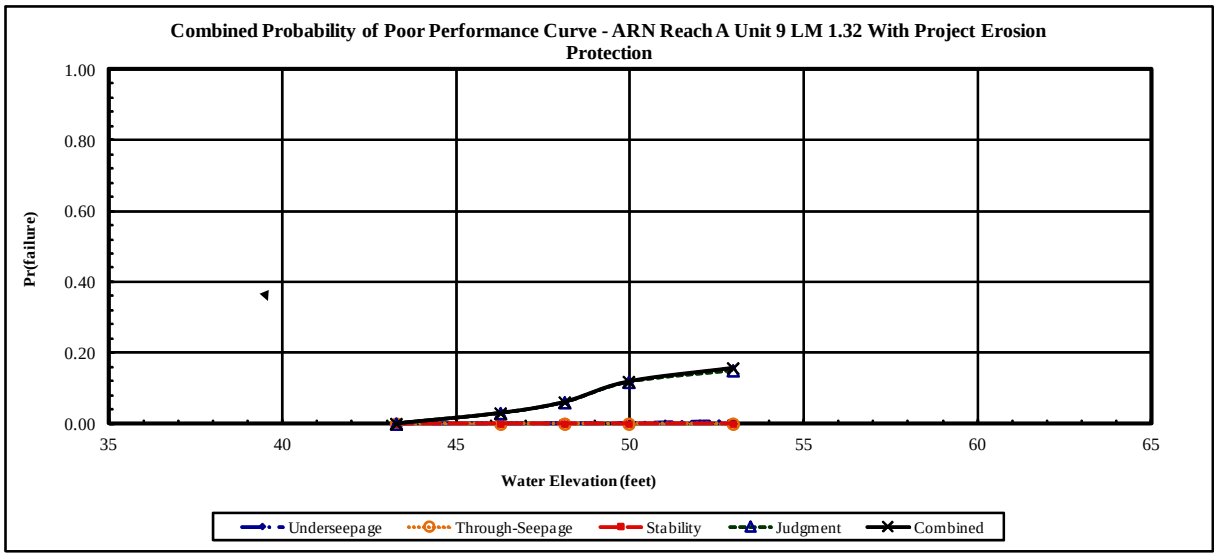

Figure 17-2: Combined Probability of Poor Performance for With Project Conditions

17.2 ARN REACH E – ARCADE CREEK NORTH – U7 LM 0.90

Borings chosen to be used in probabilistic analyses resulted in a mean blanket thickness value of 6.0 ft with a coefficient of variation of 50, and a mean aquifer thickness of 25.0 ft with a coefficient of variation of 36. The blanket was comprised of predominantly lean clay. The aquifer was made up of silty sands, poorly graded sands, and silts.

The without project underseepage analysis resulted in a Pr(f) of 72.4% at the levee crest and landside slope stability analysis resulted in a Pr(f) of 68.1% at the crest. The without project judgment based probability portion of the curve was comprised mainly of utilities and animal burrows both of which account for a Pr(f) of 6.0% at the crest. Overall judgment based contributions account for a Pr(f) of 17.7% of the without project combined curve at the levee crest. Figure 17-3 presents the without project conditions combined curve.

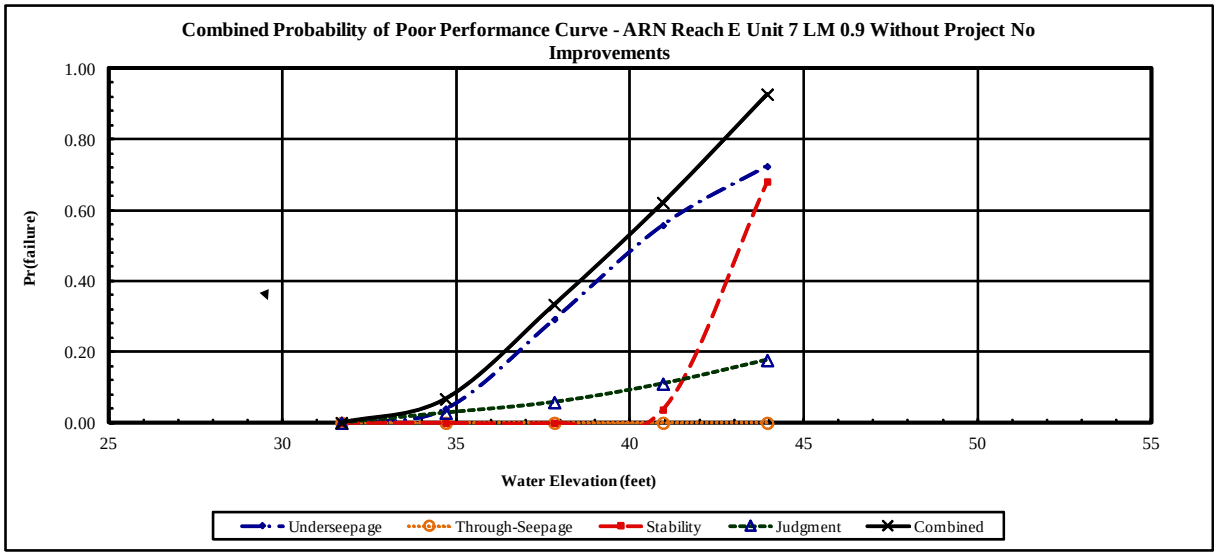

Figure 17-3: Combined Probability of Poor Performance for Without Project Conditions

With project conditions analyses were completed with the incorporation of an underseepage cutoff wall. This improvement mitigates underseepage and landside slope stability concerns. With project conditions did not provide a reduction to judgment based probabilities of failure. As such the Pr(f) for both utilities and animal burrows remained at 6.0% at the levee crest. Figure 17-4 presents the with project conditions combined curve.

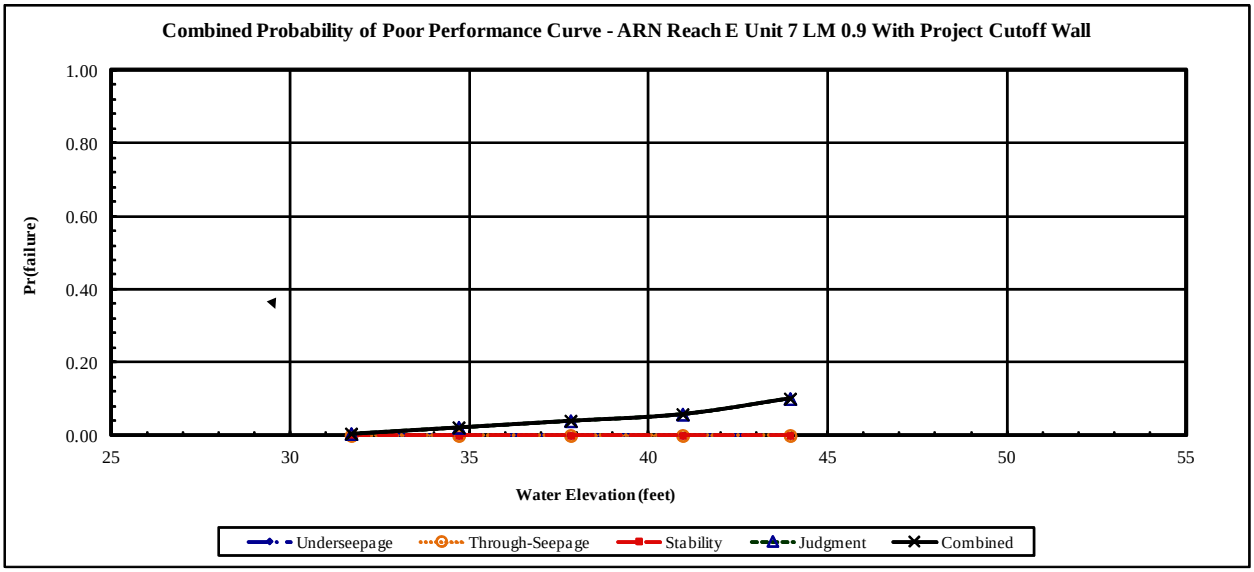

Figure 17-4: Combined Probability of Poor Performance for With Project Conditions

17.3 ARS REACH B – AMERICAN RIVER SOUTH – U4 LM 3.90

Borings chosen to be used in probabilistic analyses resulted in a mean blanket thickness value of 10.0 ft with a coefficient of variation of 30, and a mean aquifer thickness of 41.0 ft with a coefficient of variation of 24. The blanket was comprised of predominantly silts and lean clays. The aquifer was made up of silty sands and poorly graded sands.

The levee embankment contains an existing cutoff wall which mitigates both underseepage, through seepage, and slope stability concerns. The without project judgment based probability portion of the curve was comprised mainly of erosion, and encroachments, which accounted for 60.0% and 4.0% respectively at the crest. Past performance has indicated significant amounts of erosion of the riverbank, waterside levee slope and foundation. The combined without project levee performance curve resulted in a Pr(f) of 65.0% at the levee crest. Figure 17-5 presents the without project conditions combined curve.

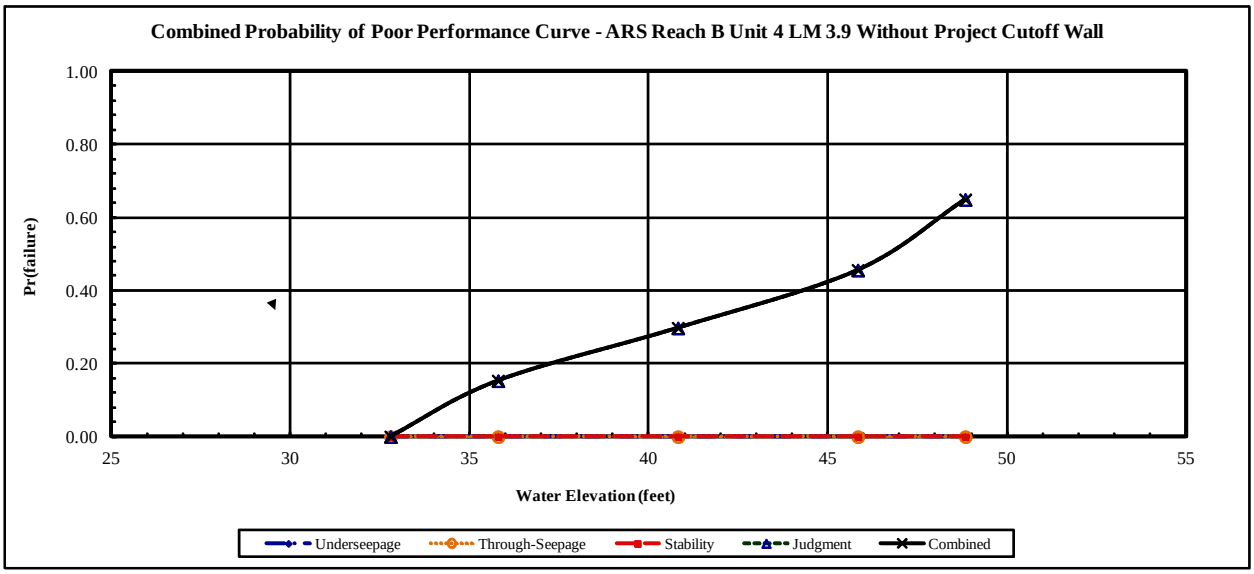

Figure 17-5: Combined Probability of Poor Performance for Without Project Conditions

The high probability of failure was primarily attributed to the erosion portion of the judgment based failure modes, which is proposed to be mitigated through the placement of riprap erosion protection. With project improvement measures reduce erosion to a Pr(f) of 5.0%. Figure 17-6 presents the with project conditions combined curve.

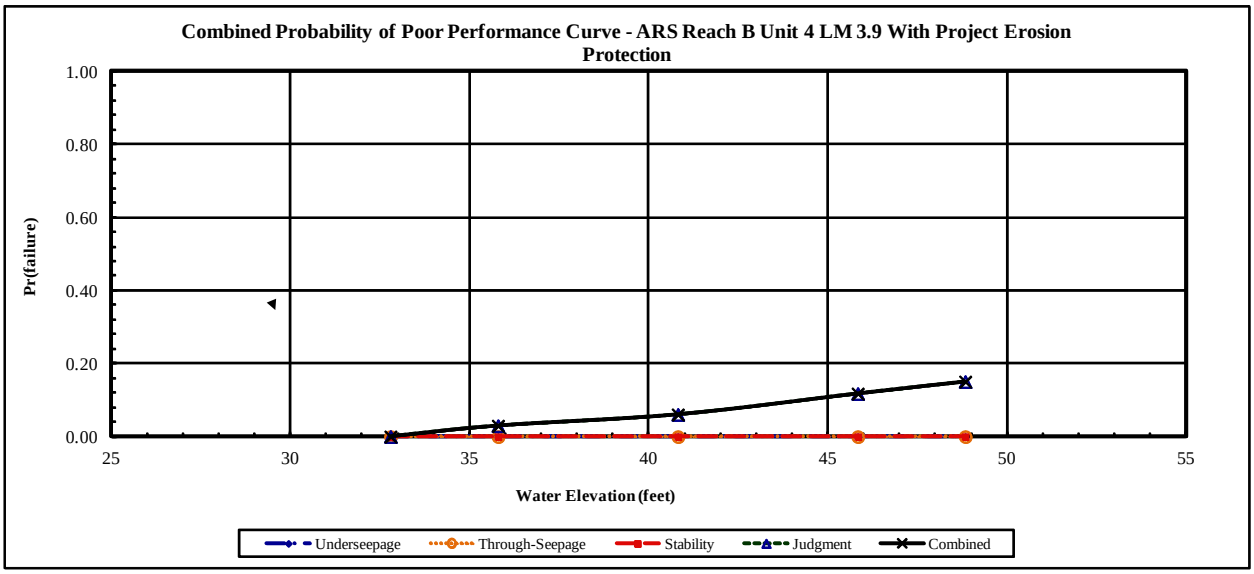

Figure 17-6: Combined Probability of Poor Performance for With Project Conditions

17.4 ARS REACH F – SACRAMENTO RIVER EAST –U1 LM 5.92

Borings chosen to be used in probabilistic analyses resulted in a mean blanket thickness value of 19.0 ft with a coefficient of variation of 47, and a mean aquifer thickness of 83.0 ft with a coefficient of variation of 19. The blanket was comprised of predominantly silts, and lean clays. The aquifer was made up of mainly silty sands, and poorly graded sands.

The without project underseepage analysis resulted in a Pr(f) of 25.8% at the levee crest and landside slope stability analysis resulted in a Pr(f) of 1.9% at the crest. The levee embankment contains an existing shallow cutoff wall which mitigates through seepage concerns. The without project judgment based probability portion of the curve was comprised mainly of erosion, and encroachments, which accounted for 16.0% and 6.0% respectively at the crest. Overall contributions account for a Pr(f) of 28.7% of the without project combined curve at the levee crest. Figure 17-7 presents the without project conditions combined curve.

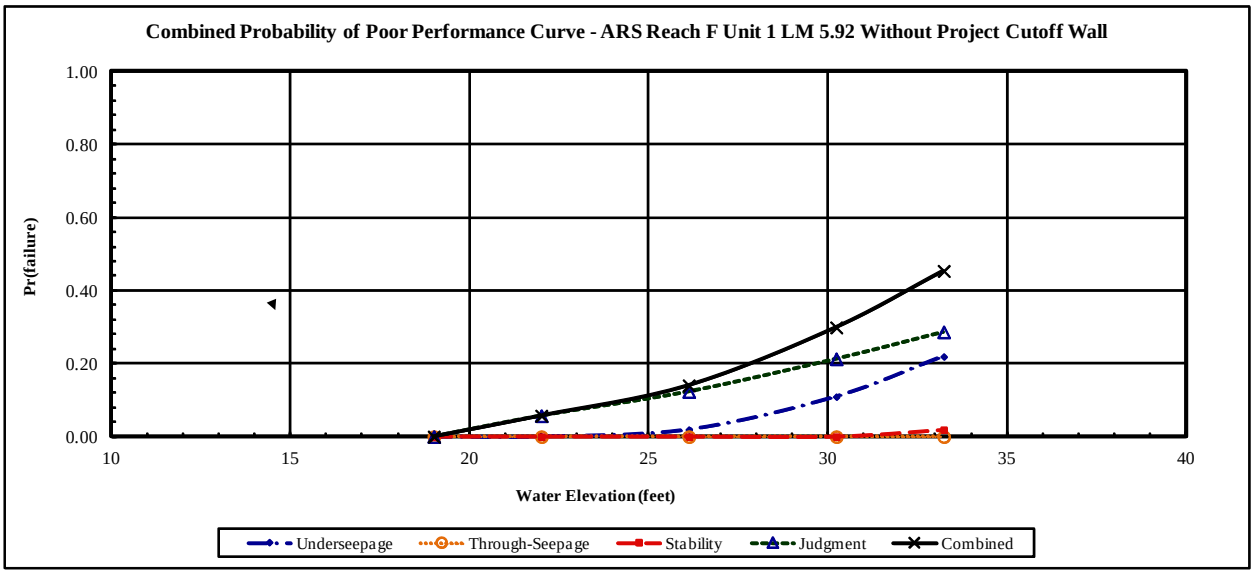

Figure 17-7: Combined Probability of Poor Performance for Without Project Conditions

With project conditions analyses were completed with the incorporation of an underseepage cutoff wall and waterside erosion protection. These improvements mitigated underseepage, landside slope stability, and erosion concerns. With project conditions analysis reduce erosion, encroachments, and utilities to a Pr(f) of 2.0%, 3.5%, and 1.0% as during construction, a portion of existing encroachments and utilities will be removed or relocated to allow for proper inspection and maintenance. Figure 17-8 presents the with project conditions combined curve.

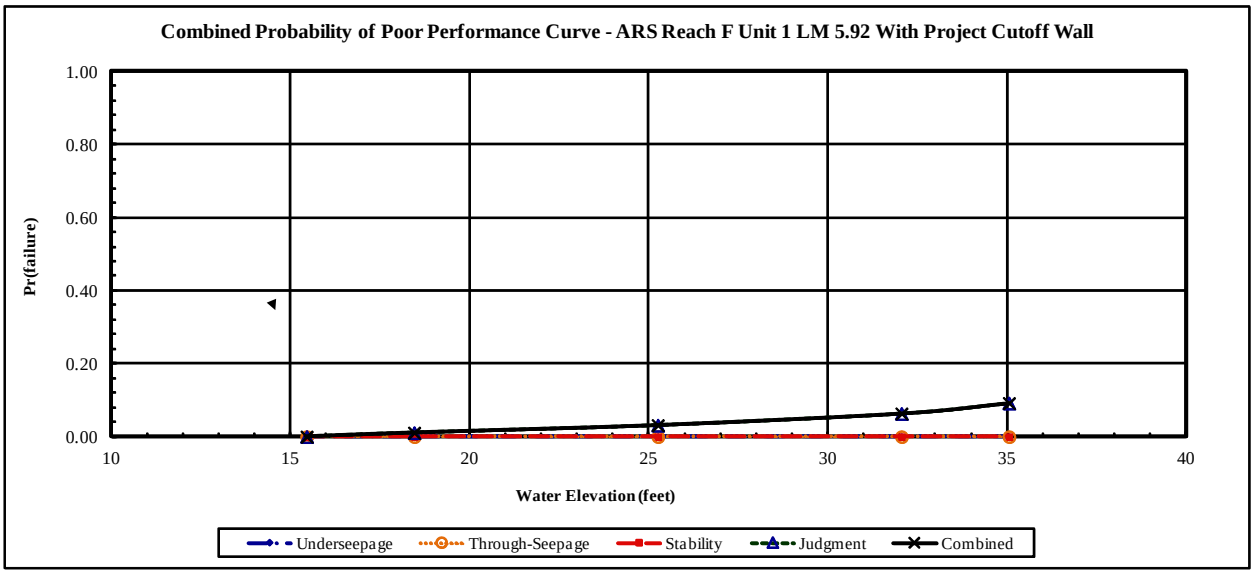

Figure 17-8: Combined Probability of Poor Performance for With Project Conditions

17.5 NAT REACH D – NCC SOUTH –U1 LM 1.30

The NPACR recommended a cutoff wall constructed through the existing levee section for Reach D of Natomas which mitigated underseepage and landside slope stability concerns. The change in Pr(f) for seepage was 4.2% from the design water surface elevation to the top of levee water surface elevation, given the inclusion of the cutoff wall. The judgment based probabilities also added a Pr(f) of 9.3%, comprised mainly of animal burrows and encroachments, which contributed a Pr(f) of 7.0% and 5.0% respectively. Figure 17-9 presents the with project levee performance curve from the NPACR which included a levee raise component. It is also the with project conditions levee performance curve for the ARCF GRR.

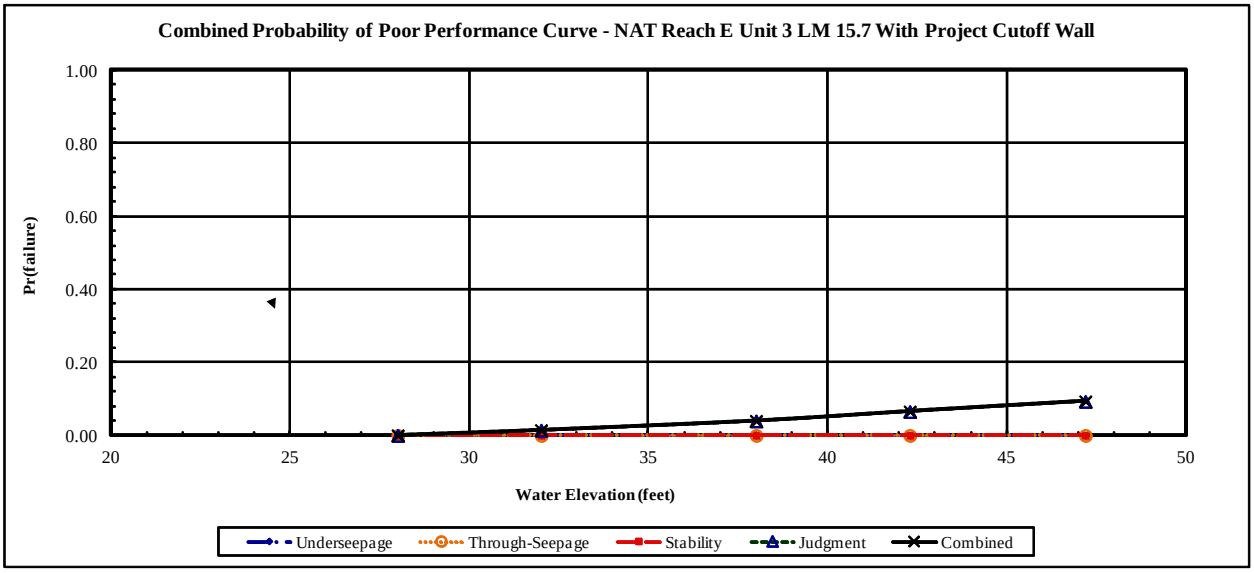

Figure 17-9: Combined Probability of Poor Performance for With Project Conditions

18.0 MATERIAL REQUIREMENTS AND BORROW SITES

It is anticipated that significant quantities of material will be required for construction of the proposed project. Several different improvement measures such as seepage berms, cutoff walls, embankment construction/reconstruction, and erosion protection are proposed. The SOP-03 established the requirements of engineered fill to be used for the construction of the levee embankments.

The material is expected to be sourced from several sites including; newly identified borrow sites within approximately 25 miles of the study area, existing borrow sites identified for the Natomas Basin by SAFCA, the DWSC dredge disposal area, the existing levees, and existing commercial sources. A desktop regional borrow study was performed to identify potential borrow sites, within 25 miles of the study area, where enough soil could be sourced to satisfy the project needs. Plates 4 and 5 show the high confidence and low confidence areas of potential borrow sites. Test pits and laboratory testing on materials collected from test pits were provided by SAFCA as part of the NLIP for borrow sites established for the Natomas Basin. Additionally, the Sacramento District has studied the DWSC spoil areas as a borrow source several time in the past, and a discussion of that borrow source is included below. Typically projects constructed by the Sacramento District utilize commercial borrow sites near the project area.

19.0 CONCLUSIONS

This report presented the results of geotechnical analyses and feasibility level geotechnical design recommendations associated with the various alternatives under consideration to address technical deficiencies in the flood risk management system protecting the study area. The alternatives consisted of a combination of structural measures to mitigate deficiencies with levee height, geometry, erosion, access, vegetation, seepage, and slope stability. They also included, the widening and construction of new levees on the Sacramento Bypass and Weir.

The results of the without project seepage and slope stability analyses indicated that the levees in ARN Reaches C through F and ARS Reaches D through G did not meet minimum criteria. The analyses showed that the levees did not meet criteria at varying flood frequencies typically between the 25 and 200 year events. The with project analyses typically included deep cutoff walls which resulted in the with project levee analyses satisfying criteria.

Two potentially erosion-resistant units were identified in the stratigraphy of the American River: (1) a moderately cohesive silty and sandy interbed of relatively limited lateral and longitudinal extent within a thicker package of loose Holocene sediments (the “upper” unit); and (2) much thicker, more widespread relatively erosion-resistant deposits associated with the Pleistocene-aged Fair Oaks formation (the “lower unit”). Erosion rate testing confirmed that erodibility was related to the geologic unit and that most of the specimens within the Fair Oaks formation could be categorized as Moderate Resistant to Very Resistant and similarly, the layers above erosionally resistant surface could be categorized as Very Erodible to Erodible.

The results of the liquefaction triggering analysis and liquefaction-induced post-earthquake deformation based on limit equilibrium analysis indicated that liquefaction potential is highly

likely at each critical location for all the reaches for Natomas Basin, Reach A of American River North Basin, and Reaches C to G of American River South Basin. Moreover, at these locations, the analysis indicates that the post-earthquake deformation as the result of liquefaction of the material beneath the embankment is a global or structural failure mode that is very likely to compromise the ability to provide flood protection at these critical locations.

Based on analyses at LM 5.92 that incorporated tree fall and scour it was shown that the tree fall and scour did not significantly affect levee performance and that the levee meets USACE seepage and slope stability criteria. Therefore, it was a reasonable conclusion that with a VVR to allow vegetation to remain, the safety, structural integrity, and functionality of the Sacramento River levee would be retained.

The without project levee performance curves indicate that the levees in ARN Reaches C through F and ARS Reaches D through G would perform unsatisfactorily when minimally loaded. In general, the analyses identified underseepage deficiencies and/or underseepage related slope stability deficiencies. Therefore, the with project levee performance curves typically included deep cutoff walls which resulted in significant reduction in probabilities of poor performance.

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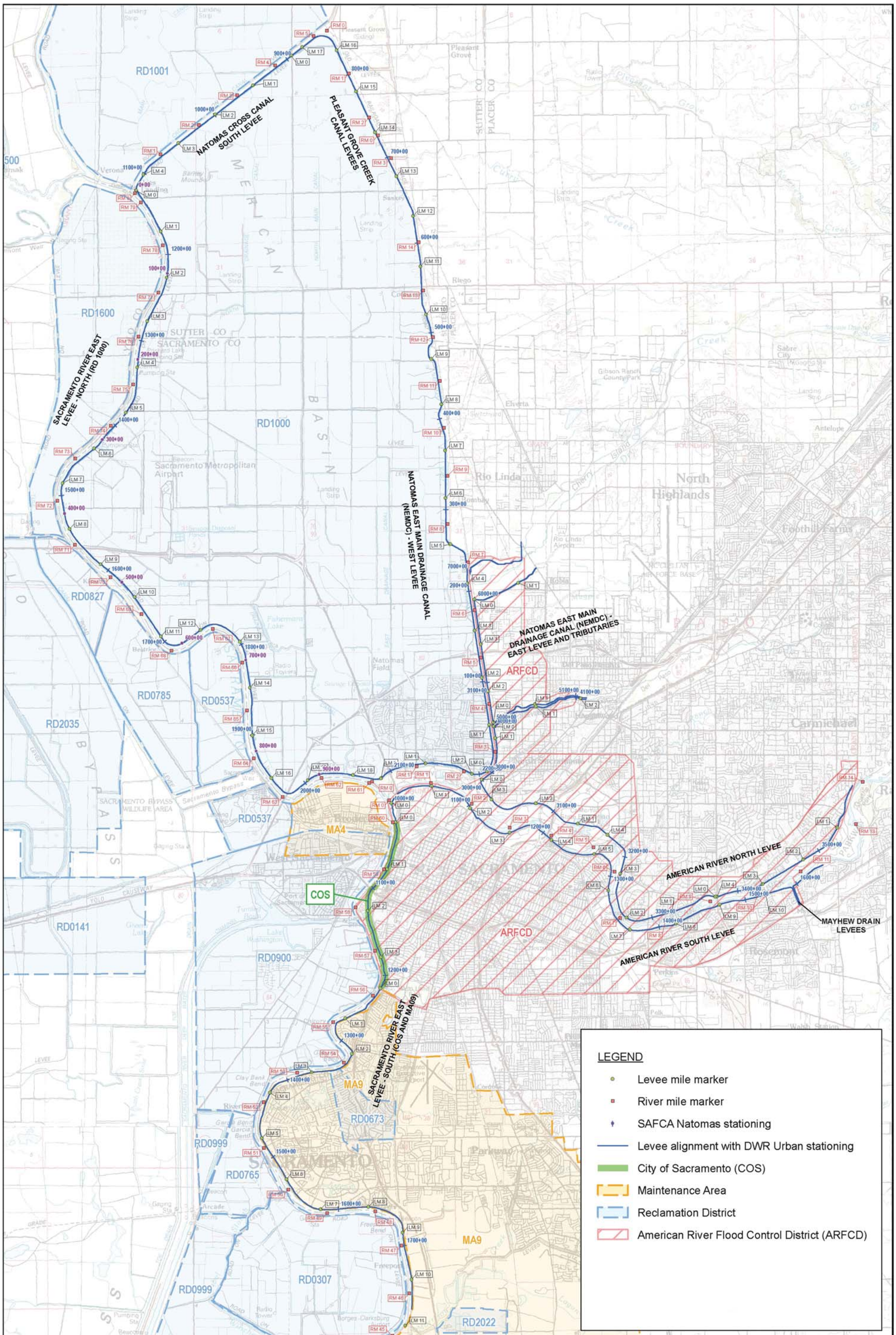

US Army Corps of Engineers
SACRAMENTO DISTRICT

PLATE 1 - ARCF GRR LEVEE MILE AND STATIONING MAP
ATTACHMENT C - GEOTECHNICAL REPORT

AMERICAN RIVER COMMON FEATURES
GENERAL REEVALUATION REPORT

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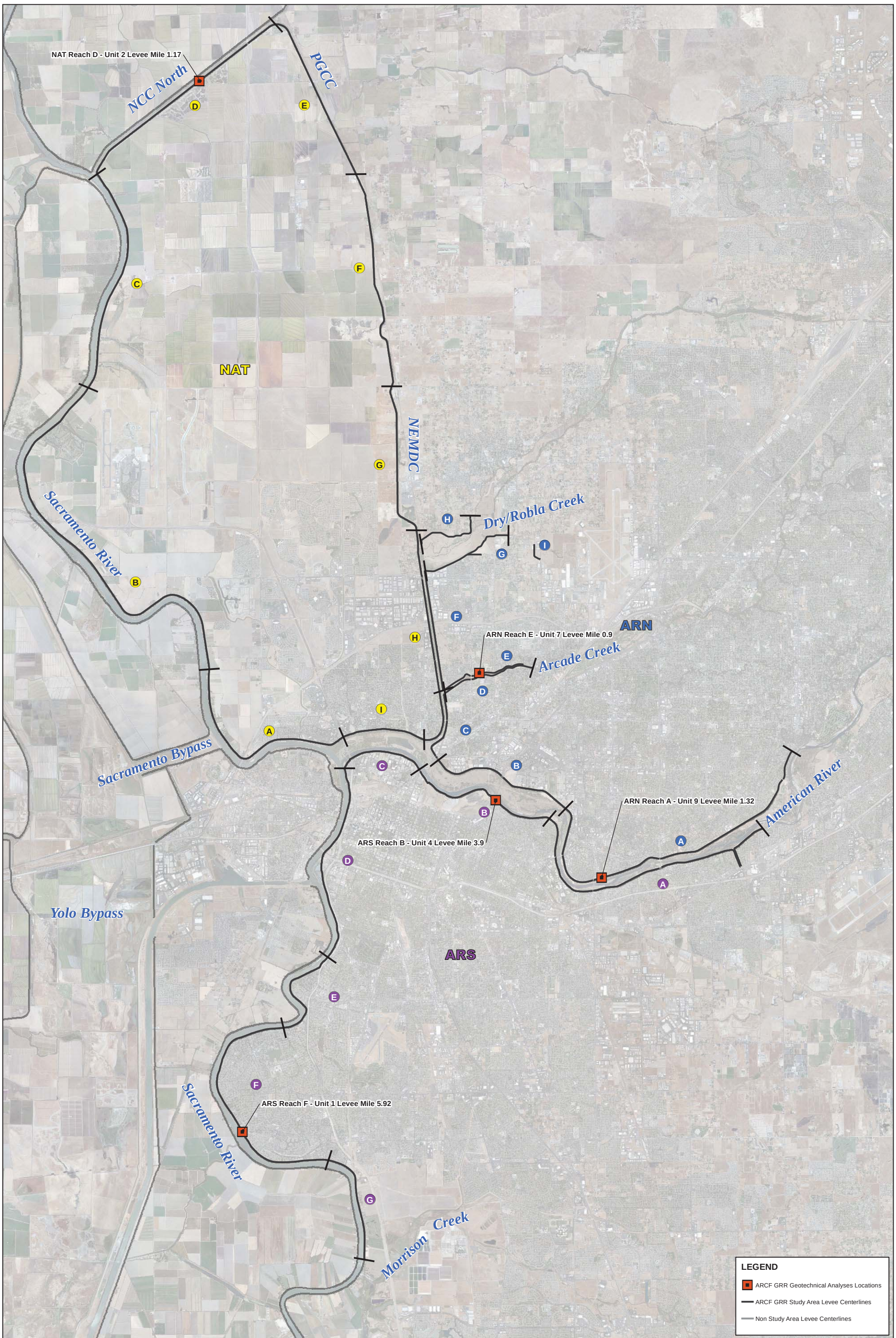

US Army Corps of Engineers
SACRAMENTO DISTRICT

PLATE 2 - ANALYSES SECTION AND INDEX POINT LOCATION MAP
ATTACHMENT C - GEOTECHNICAL REPORT

AMERICAN RIVER COMMON FEATURES
GENERAL REEVALUATION REPORT

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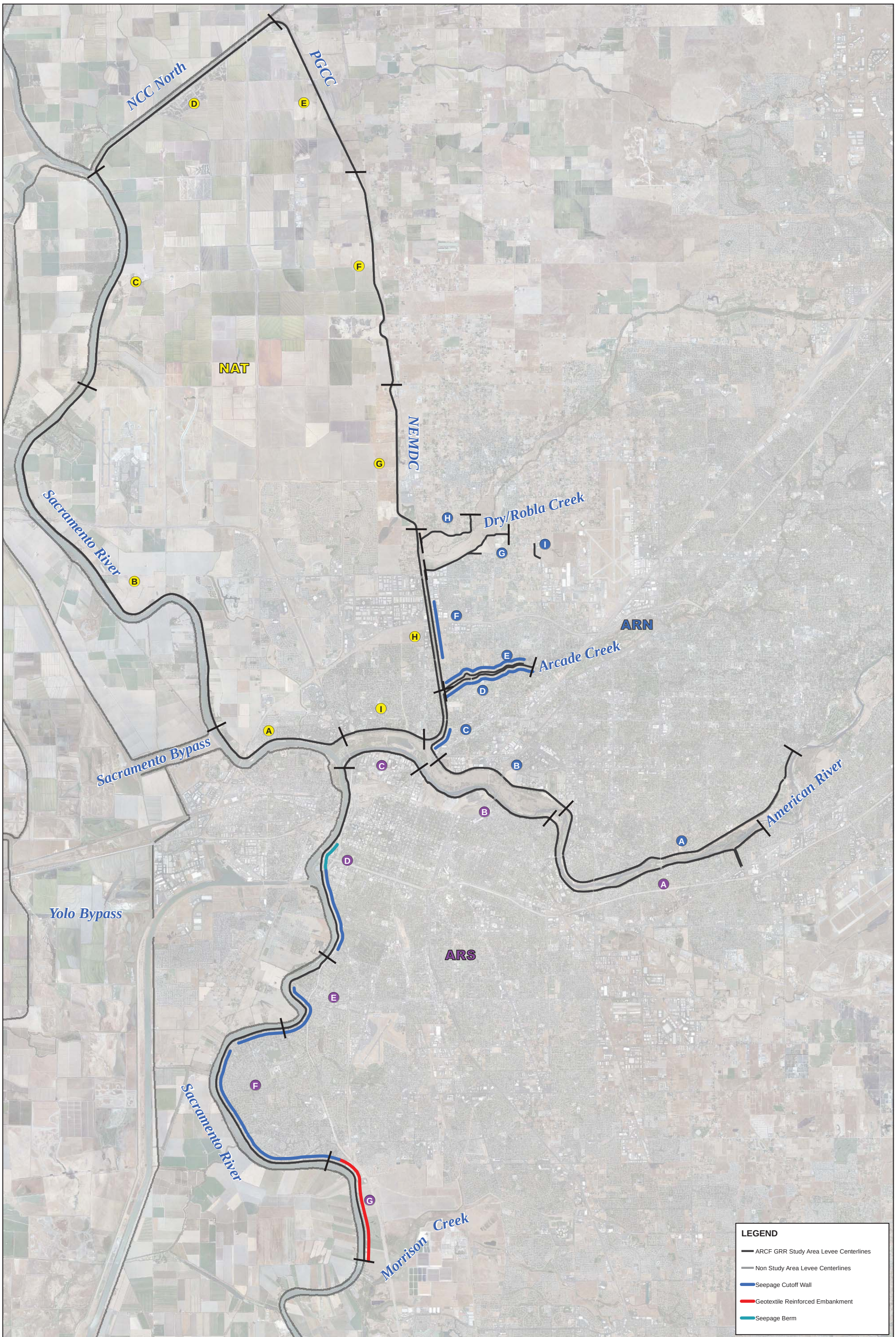

US Army Corps of Engineers
SACRAMENTO DISTRICT

PLATE 3 - GEOTECHNICAL IMPROVEMENTS MAP
ATTACHMENT C - GEOTECHNICAL REPORT

AMERICAN RIVER COMMON FEATURES
GENERAL REEVALUATION REPORT

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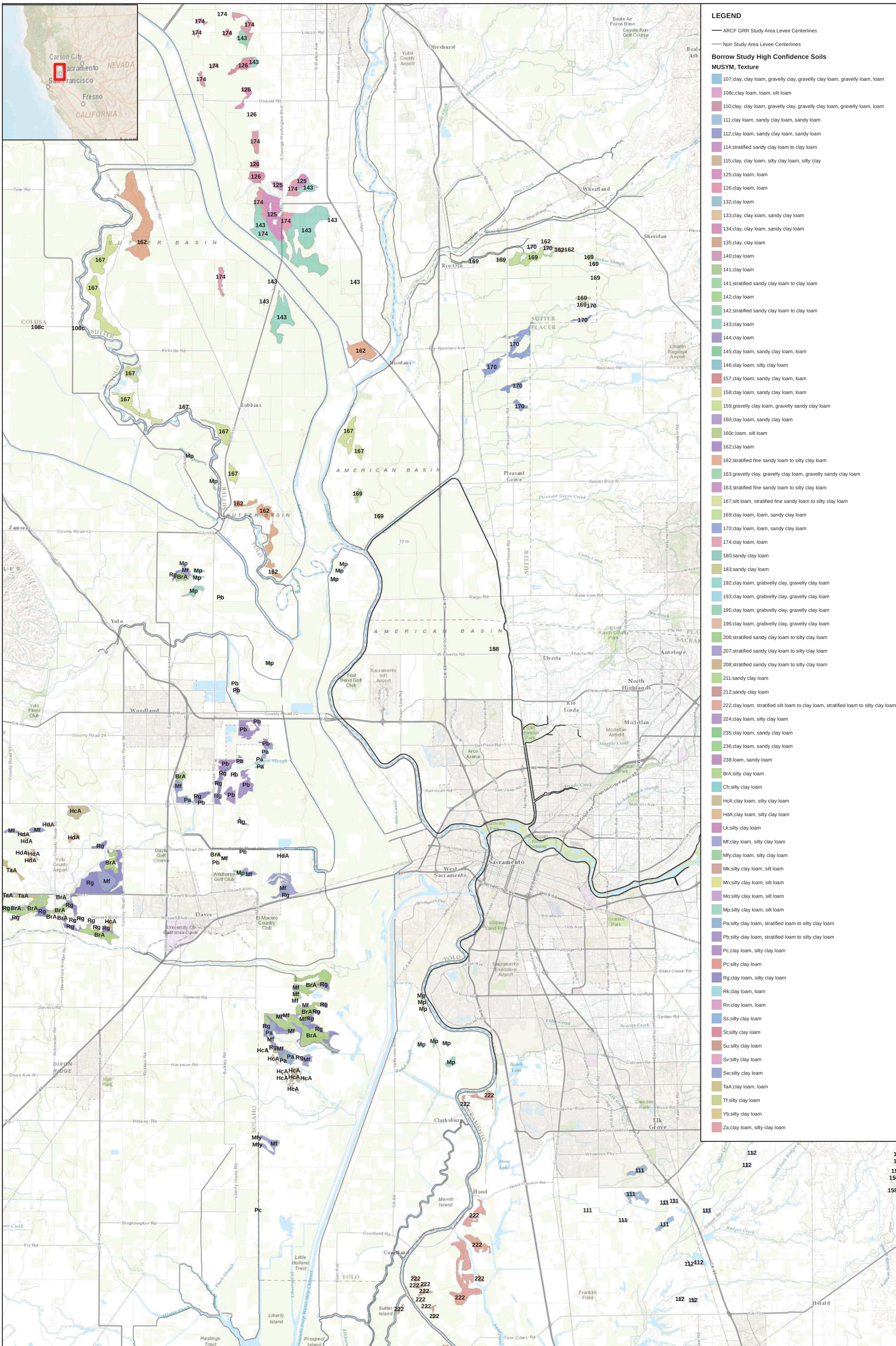

US Army Corps of Engineers
SACRAMENTO DISTRICT

PLATE 4 - DESKTOP BORROW STUDY HIGH CONFIDENCE LOCATION MAP
ATTACHMENT C - GEOTECHNICAL REPORT

AMERICAN RIVER COMMON FEATURES
GENERAL REEVALUATION REPORT

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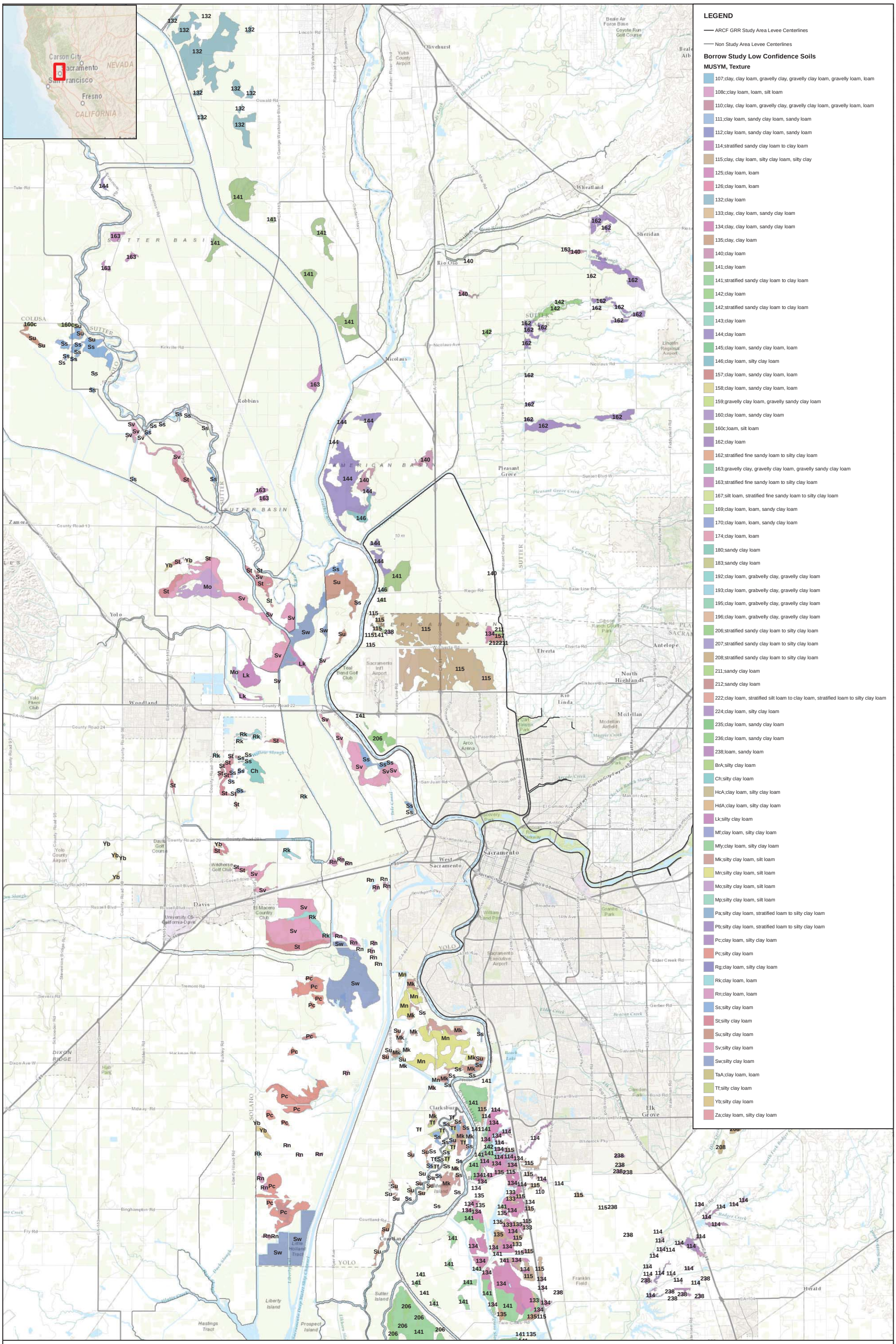

US Army Corps of Engineers
SACRAMENTO DISTRICT

PLATE 5 - DESKTOP BORROW STUDY LOW CONFIDENCE LOCATION MAP
ATTACHMENT C - GEOTECHNICAL REPORT

AMERICAN RIVER COMMON FEATURES
GENERAL REEVALUATION REPORT

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AMERICAN RIVER WATERSHED

COMMON FEATURES PROJECT

GENERAL REEVALUATION REPORT

ATTACHMENT C – GEOTECHNICAL REPORT

ENCLOSURE 1

ANALYSES CALCULATION PACKAGE

AMERICAN RIVER NORTH BASIN

ARN REACH A – AMERICAN RIVER NORTH – U9 LM 1.32

STRATIGRAPHY INPUT

BORING LOGS

LABORATORY TESTING

AMERICAN RIVER WATERSHED - COMMON FEATURES PROJECT
GENERAL REEVALUATION REPORT - GEOTECHNICAL ANALYSIS
AMERICAN RIVER NORTH RA U9 LM 1.32
Table F-2-1: Permeability and Strength Selection for Analysis

Boring Number	Top of Boring Elevation (ft, NAVD 88)	Layer ID	Soil Description	USCS Soil Classification	Depth to Top of Layer (ft)	Depth to Bottom of Layer (ft)	Elevation of Top of Layer (ft, NAVD 88)	Elevation of Bottom of Layer (ft, NAVD 88)	Layer Thickness (ft)	Average Depth to Groundwater During Drilling	Laboratory and Field Data										Comments
											Average % Fines	Average Field N (blows/ft)	Average N_{60} (blows/ft)[1]	Average Normalized Blow Count, $N_{1,60}$ (blows/ft)[2]	Torvane (tsf)	Pocket Penetrometer (tsf)	Average Unit Weight (pcf)	PI	LL	LI	
WNCBAR_003B, 2F-97-6, DH-7, DH-7A	53.01	1	Silty Sand (SM) with Silt (ML) Levee	SM	0.00	8.61	53.01	44.40	8.61		45	16	30								
		2	Silty Sand (SM) with Silty (ML)	ML	8.61	37.11	44.40	15.90	28.50		33	9	21								
		3	Poorly Graded Gravel (GP) with Lean Clay (CL)	GP	37.11	53.61	15.90	-0.60	16.50			76	89								
		4	Poorly Graded Sand with Silty Sand (SP-SM)	SP-SM	53.61	61.87	-0.60	-8.86	8.26		13	48	69								
		5	Lean Clay (CL) with Silt (ML)	CL	61.87	86.41	-8.86	-33.40	24.54			73	64								
		6	Impervious Clay Cap (CL)	CL																	
		7	Cutoff Wall	SB WALL														8	25	17.00	
					Total Depth (ft.)	**86.41**															

Layer ID	Recommended Hydraulic Conductivity					Strenth Coorelations								Strength from Lab Test Data						Recommended Strength Parameters			Comments
	Horizontal kh (kx) cm/sec	Anisotropy Ratio kh/kv	Vertical kv (ky) cm/sec	Horizontal kh (kx) ft/day	Vertical kv (ky) ft/day	Total Overburden Pressure at Mid Layer During Drilling (psf)	Effective Overburden Stress at Mid Layer During Drilling (psf)	OCR from N_{60}[3]	OCR from LI[3]	Su from N (psf)[4]	Su/σ'$_o$ from PI (psf)[4]	Calculated Maximum Past Pressure (psf)[5]	Drained Friction Angle[7]	OCR	σ'$_p$ (psf)	Su (psf)	Su/σ'$_o$	Φ'	C' (psf)	Φ'	C' (psf)	γ (pcf)	
1	5.00E-04	4.00	1.25E-04	1.418	0.354	0	-269													33	0	125	
2	2.00E-04	4.00	5.00E-05	0.567	0.142	0	-1426													33	0	125	
3	2.00E-01	4.00	5.00E-02	567.000	141.750	0	-2830													35	0	135	
4	1.00E-03	4.00	2.50E-04	2.835	0.709	0	-3603													33	0	125	
5	1.00E-05	4.00	2.50E-06	0.028	0.007	0	-4626	#VALUE!		9269		#NUM!								28	50	115	
6	1.00E-05	4.00	2.50E-06	0.028	0.007	0	0	#VALUE!	#VALUE!											28	50	115	
7	1.00E-06	4.00	2.50E-07	0.003	0.001															0	50	85	

2F-97-6

STA. 14+165

DEPTH		N	GR	SA	FI	LL	PI	MC	
EL. 15.48 m (50.80') - 0	SC	14	-	-	-	-	-	-	CLAYEY SAND, SC: Firm; moist; dark yellowish-brown; about 85% fine to medium sand; about 15% fines; no reaction with HCl; no odors present
(2.0') 0.61 m	SM	13	0	68	32	-	NP	-	SILTY SAND, SM: Firm; moist; dark yellowish-brown; fine to medium, mostly fine sand; nonplastic fines; no reaction with HCl; no odors present
(3.5') 1.07 m			-	-	-	-	-	-	
(4.0') 1.22 m									
		7	-	-	-	-	-	-	SILTY SAND, SM: Loose; moist; dark yellowish-brown; about 80% fine to medium sand; about 20% fines; no reaction with HCl; no odors present
(6.0') 1.83 m									
		29							SILTY SAND, SM: Very firm; moist; dusky yellowish-brown; about 75% fine to medium sand; about 25% fines; no reaction with HCl; no odors present; weak iron oxide staining
			-	-	-	-	-	-	
		19							At 2.6 m (8.5'), as above except firm
(10.3') 3.14 m	SC	22	-	-	-	-	-	-	CLAYEY SAND, SC: Loose; moist; dusky yellowish-brown; about 70% fine to medium sand; about 30% medium plasticity fines; no reaction with HCl; no odors present
(12.0') 3.66 m									
		10	-	-	-	-	-	-	SILTY SAND, SM: Loose; moist; dark yellowish-brown; about 80% fine to medium sand; about 20% fines; no reaction with HCl; no odors present
(14.0') 4.27 m									
		5	-	-	-	-	-	-	
(16.5') 5.03 m									
		5	0	59	41	-	NP	-	
(18.0') 5.49 m									
		8							SILTY SAND, SM: Loose; moist; moderate brown; fine to medium, mostly fine sand; nonplastic fines; no reaction with HCl; no odors present
			-	-	-	-	-	-	
		8							At 6.6 m (21.5'), as above except switched to mud rotary
(23.0') 7.01 m	SM	10							
			-	-	-	-	-	-	SILTY SAND, SM: Loose; moist; moderate brown; about 85% fine to medium sand; about 15% fines; no reaction with HCl; no odors present
		10							
(33.0') 10.06 m									

CONTINUED IN NEXT COLUMN

2F-97-6

CONTINUED FROM PREVIOUS COLUMN

DEPTH		N	GR	SA	FI	LL	PI	MC	
(33.0') 10.06 m	SP-SM	10							
			-	-	-	-	-	-	POORLY GRADED SAND WITH SILT, SP-SM: Loose; moist; moderate brown; fine to medium, mostly fine sand; nonplastic fines; no reaction with HCl; no odors present
(38.0') 11.58 m									
		10	0	90	10	-	NP	-	At 11.7 m (38.5'), as above except strong iron oxide staining
(39.5') 12.04 m									
			-	-	-	-	-	-	
(42.0') 12.80 m	GRAVEL AND COBBLES								At 12.8 m (42.0'), gravel and cobbles present; rough drilling; no recovery
			-	-	-	-	-	-	At 16.5 m (54.0'), no gravel and cobbles present; smoother drilling
(58.0') 17.68 m									LEAN CLAY WITH SAND, CL: Hard; moist; pale yellowish-brown; about 85% medium plasticity fines; about 15% fine sand; no reaction with HCl; no odors present
(58.2') 17.74 m	CL								
	SM	36	0	87	13	-	NP	-	
(59.5') 18.14 m									SILTY SAND, SM: Dense; moist; dark yellowish-brown; fine to medium, mostly fine, subangular to subrounded sand; nonplastic fines; no reaction with HCl; no odors present; strong iron oxide staining
			-	-	-	-	-	-	
(63.0') 19.20 m									
	CL	R							
			-	-	-	-	-	-	SANDY LEAN CLAY, CL: Hard; moist; pale yellowish-brown; about 65% medium plasticity fines; about 35% fine sand; no reaction with HCl; no odors present; hard but smooth drilling
(68.0') 20.73 m	SC								CLAYEY SAND, SC: Dense; dark yellowish-brown; about 60% fine to medium sand; about 40% medium plasticity fines; no reaction with HCl; no odors present
		38	-	-	-	-	-	-	
(69.5') 21.18 m									B.O.H.

GRAPHIC SCALE

SCALE 1 : 25 — 0, 0.5, 1, 1.5, 2, 2.5 METERS

NOTES:

1. THE LEGENDS AND NOTES FOR THE 2F-97-# EXPLORATIONS ARE SHOWN ON SHEET B-11.
2. ADDITIONAL LOGS OF EXPLORATIONS ARE SHOWN ON SHEET NOS. B-1 THROUGH B-12 AND B-14 THROUGH B-49.

US Army Corps of Engineers
Sacramento District

Symbol	Description	Date	Approved	Symbol	Description	Date	Approved

Designed by: R. IWASA
Dwn by: R. IWASA
Ckd by: SCANDRONE
Reviewed by: M. RAMSOTHAM
Submitted by: Chief, Design Section
Date: 8 FEB 1999
Rev. REV_#
Design file no: AMT – 4 – 783
SPEC. No: 98925
File name: AR-LOG1.DWG
Plot date: 8 FEB 1999
Plot scale: 1 : 1

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

AMERICAN RIVER
AMERICAN RIVER WATERSHED PROJECT
LOWER AMERICAN RIVER
RIGHT (NORTH) BANK LEVEE STRENGTHENING

CALIFORNIA

LOG OF EXPLORATION
2F-97-6

Sheet reference number:
B-13
SEQ. 24

Hole No. DH-7

DRILLING LOG

DIVISION	
INSTALLATION	
SHEET 1 OF 2 SHEETS	
1. PROJECT	American River FCD, Maint. Areas 10 & 11
2. LOCATION (Coordinates or Station)	American River, East Levee site #7
3. DRILLING AGENCY	P.C. Exploration
4. HOLE NO. (As shown on drawing title and file number)	DH-7
5. NAME OF DRILLER	Mike Moore
6. DIRECTION OF HOLE	☑ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN	NA
8. DEPTH DRILLED INTO ROCK	NA
9. TOTAL DEPTH OF HOLE	30.0
10. SIZE AND TYPE OF BIT	8 in" Hollow stem augers
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	
12. MANUFACTURER'S DESIGNATION OF DRILL	Mobile B-53
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN	DISTURBED 6 / UNDISTURBED Ø
14. TOTAL NUMBER CORE BOXES	NA
15. ~~ELEVATION~~ GROUND WATER	
16. DATE HOLE	STARTED 4-22-87 / COMPLETED 4-22-87
17. ELEVATION TOP OF HOLE	NA
18. TOTAL CORE RECOVERY FOR BORING	N.A. %
19. SIGNATURE OF INSPECTOR	Paul F. Schmidt (WA)

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% ~~CORE~~ RECOVERY e	~~BOX NO.~~ SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	10.0	ML	LEVEE 0.0-0.5 Gravel + dirt 0.5-11.2 SANDY SILT: Dk. yel brn (10YR 4/2), ~40-70% fines; non to slight plastic, quick dilatancy, no toughness; ~30-60% sand, very fine-grained, poorly graded, mica flakes; slight charcoal, organic lite; high permeabilities; firm to stiff; moist.			Sampling with a 2.0" (OD) split-spoon sampler, driven by a 140 lb. wire-line hammer, free-falling 30.0 in. per blow.
	2.0			4 / 5 / 10 — 0.8 / 1.5		1.5
				4 / 5 / 7 — 1.5 / 1.5		3.0 Drilling is easy
	4.0			4 / 5 / 6 — 1.5 / 1.5	B-1	4.5
	6.0			5 / 6 / 6 — 1.5 / 1.5		6.0
			7.8-9.2 gray silty sand medium dense	8 / 9 / 14 — 1.2 / 1.5	B-2	7.5
	8.0			7 / 8 / 8 — 1.3 / 1.5	B-3	9.0
	10.0		FOUNDATION 11.2-12.6 SAND: Salt & pepper; <5% fines; >95% fine-grained sand, mica and qtz; loose, dry.	5 / 7 / 7 — 1.5 / 1.5		10.5
		SP		4 / 2 / 3 — 1.4 / 1.5	B-4	12.0
	12.0	ML	12.6-30.0 SANDY SILT: as 0.5-11.2' No changes	3 / 3 / 3 — 1.5 / 1.5		13.5
	14.0			2 / 3 / 3 — 1.5 / 1.5	B-5	15.0
	16.0			2 / 3 / 3 — 1.5 / 1.5		16.5
	18.0			3 / 3 / 4 — 1.4 / 1.5		18.0
				3		19.5

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE.

PROJECT [illegible] | HOLE NO. DH-7

Hole No. DH-7

DRILLING LOG	DIVISION	INSTALLATION	SHEET 2 OF 2 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
	15. ELEVATION GROUND WATER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.	16. DATE HOLE — STARTED — COMPLETED
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING. %
9. TOTAL DEPTH OF HOLE	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	20.0	ML	12.6 - 30.0 SANDY SILT: (cont.)	3 1.5 / 5 1.5	B-5 (cont)	Drilling continues easy.
				3 / 2 1.2 / 3 1.5		21.0
	22.0					22.5
			22.8 - 23.5 more sandy lens	3 1.2 / 3 1.5 / 3		
	24.0		24.0 color getting reddish.	3 / 4 1.5 / 5 1.5		24.0
						25.5
	26.0			3 1.5 / 3 1.5 / 4	B-6	
						27.0
	28.0			4 1.5 / 4 1.5 / 4		
			28.0 - 30.0 slightly more sandy	5 1.5 / 5 1.5 / 4		28.5
	30.0		Bottom Hole 30.0'			30.0

Terminated boring at 30.0' (required depth) and back-filled hole with cuttings.

DATA ON THIS LOG ARE AN APPROXIMATION OF THE GEOLOGIC AND SUBSURFACE CONDITIONS BECAUSE THE INFORMATION WAS OBTAINED FROM INDIRECT, DISCONTINUOUS, AND POSSIBLY DISTURBED SAMPLING NECESSITATED BY USE OF SMALL-DIAMETER HOLES. ROTARY AND WASH BORING HOLES HAVE FURTHER COMPLICATIONS IN THIS REGARD BECAUSE OF THE NEED TO USE DRILLING FLUID AND/OR CASING IN ADVANCING HOLES.

THIS LOG INDICATES CONDITIONS IN THIS HOLE ONLY ON THE DATE INDICATED AND MAY NOT REPRESENT CONDITIONS AT OTHER LOCATIONS AND ON OTHER DATES. ANY WATER LEVELS SHOWN ARE SUBJECT TO VARIATION.

THIS HOLE WAS LOGGED IN SUCH A WAY AS TO PROVIDE DATA PRIMARILY FOR DESIGN PURPOSES AND NOT NECESSARILY FOR THE PURPOSES OF SPECIFIC CONTRACTORS.

THE STRATIFICATION LINES OR DEPTH INTERVALS REPRESENT THE APPROXIMATE BOUNDARIES BETWEEN MATERIAL TYPES, AND THE TRANSITIONS MAY BE GRADUAL.

SOIL CLASSIFICATIONS SHOWN ON LOGS ARE FIELD CLASSIFICATIONS BASED ON THE UNIFIED SOILS CLASSIFICATION SYSTEM

Hole No. DH-7A

DRILLING LOG	DIVISION	INSTALLATION	SHEET 1 OF 1 SHEETS

1. PROJECT: American River F.C.D., Maint. Area 10 & 11	10. SIZE AND TYPE OF BIT: 5.0" Hollow stem augers
2. LOCATION (Coordinates or Station): American River East levee, site #7 (toe)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL):
3. DRILLING AGENCY: E.C. Exploration	12. MANUFACTURER'S DESIGNATION OF DRILL: Mobile B-53
4. HOLE NO. (As shown on drawing title and file number): DH-7A	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 2; UNDISTURBED 0
5. NAME OF DRILLER: Mike Moore	14. TOTAL NUMBER CORE BOXES: NA
6. DIRECTION OF HOLE: ☒ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ~~ELEVATION~~ GROUND WATER:
7. THICKNESS OF OVERBURDEN: NA	16. DATE HOLE: STARTED 4-22-87; COMPLETED 4-22-87
8. DEPTH DRILLED INTO ROCK: NA	17. ELEVATION TOP OF HOLE: NA
9. TOTAL DEPTH OF HOLE: 20.0	18. TOTAL CORE RECOVERY FOR BORING: NA %
	19. SIGNATURE OF INSPECTOR: Paul F. Schmidt (WA)

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% ~~CORE~~ RECOVERY e	~~BOX OR~~ SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	0.0	ML	FOUNDATION 0.0 - 20.0 SANDY SILT: Dk yel brn (10YR 4/2) to mod brn (5YR 3/4), ~40-70% Fines, non to slight plastic, no toughness, ~30-60% sand, very fine- to fine-grained, poorly graded, mica flakes; high pervious ness; soft to firm; moist 2.0-2.4 sand lens, clean 3.2-3.5 sand lens 6.9-7.5 sandy lens 8.5-9.0' sand lens 10.5-11.1 sandy lens 12.0-12.3 sandy lens 17.0-17.3 sandy lens 18.5-20.0 more sandy Termination at 20.0	3 1 1 — 1.4/1.5 1 2 2 — 1.4/1.5 2 2 2 — 1.5/1.5 2 2 3 — 1.5/1.5 3 3 3 — 1.5/1.5 3 3 4 — 1.4/1.5 3 3 3 — 1.3/1.5 3 3 3 — 1.2/1.5 3 2 3 — 1.3/1.5 3 4 4 — 1.5/1.5 3 4 3 — 1.3/1.5 2 2 2 — 1.5/1.3	B-1 B-2	Sampling with a 2.0" (OD) split spoon sampler, driven by a 140 lb. wire-line hammer free-falling 30.0" per blow. Drilling is very easy Terminated boring at 20.0' (required depth) and backfilled hole with cuttings

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE.

PROJECT: [illegible] HOLE NO. DH-7A

DATE STARTED 5/22/08 **DATE COMPLETED** 5/22/08	**GROUND ELEVATION** 52.95 ft **ELEVATION DATUM** NAVD 88	**TOTAL DEPTH OF BORING** 75.0 ft
DRILLING CONTRACTOR Gregg Drilling & Testing, Inc.	**DRILLER'S NAME** E. Santellan **HELPER'S NAME** R. Ryon	**TOTAL DEPTH OF FILL** 9.8 ft
DRILLING METHOD 0 - 3 ft: HA, 3 - 10 ft: HSA, 10 - 75 ft: Rotary Wash	**DRILL RIG MAKE AND MODEL** MARL M-10 (Gregg Rig No. D-44)	**CONSULTANT COMPANY** GEI Consultants, Inc.
DRILL BIT SIZE AND TYPE (HOLE DIAMETER) 5-inch drag bit	**DRILLING ROD TYPE AND DIAMETER** 6" HSA, 94mm	**FIELD LOGGER** M. Horse
☒ **VERTICAL** ☐ **INCLINED**	**CASING TYPE, DIAMETER, INSTALLATION DEPTH** Surface, 6-in., 10 ft	**FIELD LOG REVIEWER** G. Bradner
SAMPLER TYPE(S) Bag, DCore(2.5"), PCore(2.5"), Shelby(2.37"), SPT(1.375")	**HAMMER TYPE, MAKE/MODEL, WEIGHT/DROP** Marl, automatic, 140 lbs / 30-inch drop	**HAMMER EFFICIENCY** 83%
BOREHOLE BACKFILL OR COMPLETION 5% bentonite grout	**GROUNDWATER READING: DURING DRILLING** N/A due to rotary wash drilling method	**AFTER DRILLING (DATE-TIME)**

Elevation, feet	Depth, feet	Material Graphics	CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in. [Blows per ft]	N_{60}(ASTM)	PP or TV, tsf	LABORATORY DATA: Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	Other Lab Tests	REMARKS
	0		Gravel Road Base.												
	1		[LEVEE FILL] LEAN CLAY with Sand (CL); yellowish brown (10YR 5/8); moist; 80% medium plasticity, medium dry strength, medium toughness fines; 20% fine sand; 0% gravel.		1										S01A_001_002B
	2				2										S02A_002_003B
50	3		[LEVEE FILL] SILT with Sand (ML); dark brown (10YR 3/3); moist; 85% low plasticity, medium dry strength, rapid dilatancy, low toughness fines; 15% fine sand; 0% gravel.												
	4				3	100									S03A_003_005T Pushed Shelby tube at 400 psi
	5														
	6		[LEVEE FILL] SANDY SILT (ML); medium dense; dark brown (10YR 3/3); moist; 52% medium dry strength, rapid dilatancy, low toughness fines; 48% fine sand; 0% gravel.		4	56	10 10 12 [22]	30	1.25P	16	NP	NP			S04A_005_007S
	7												52	HD	Box 1 Representative S05A_007_008P
45	8				5	100			1.5P						
FILL	9														
	10		[Approximate bottom of Levee Fill at 9.8'].												
	11		4-inch thick Silty Sand (SM) lense; 85% fine sand; 15% fines.		6	44	8 11 9 [20]	28	0.75P						S06B_010_012S S06A_011_012S
	12		SILTY SAND (SM); medium dense; very dark brown (10YR 2/2); wet; 58% fine sand; 42% no plasticity fines; 0% gravel; portion of fines are clay-sized.												S07A_012_013P
40	13				7	57									
	14														
	15														
	16				8	50	4 6 6 [12]	17					42	HD	S08A_015_017S
	17		As above except 70% sand; 30% fines; portion of fines are clay-sized.							20				SG	S09A_017_018P
35	18				9	86									
	19														
	20														

Draft 4 After Final Markups 11/5/2009

Borehole Location: North Bank Crest **County:** Sacramento
Coordinates: Northing: 1,967,149.09 **Easting:** 6,731,673.44
Latitude: 38.56228 **Longitude:** -121.40544
Levee Station or Milepost: 3306+35 **Levee Mile:** 1.31
Levee Segment
Survey Method: GIS/LiDAR **Coord. System:** CA State Plane Zone II
Channel / River Name / Feature: American River

LOG OF BORING
WCNBAR_003B
Sheet 1 of 4

Urban Levee Geotechnical Evaluations Program
Engineering Support Services

DWR LEVEE U/NU SOIL LOG REV1; AMERICAN RIVER LEVEE BORINGS 11-5-2009.GPJ; DWR WORKING LIBRARY 092009.GLB; 11/5/09

Elevation, feet	Depth, feet	Material Graphics	CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in. [Blows per ft]	N_{60}(ASTM)	PP or TV, tsf	LABORATORY DATA: Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	Other Lab Tests	REMARKS
	20		SILTY SAND (SM); as above.		10	50	5 6 6 [12]	17					30	HD	S10A_020_022S
	21														
	22		As above except increasing sand; decreasing fines.		11	36									S11_022_023P
30	23														
	24														
	25		SANDY SILT (ML); medium dense; very dark brown (10YR 2/2); moist; 57% low plasticity fines; 43% fine sand; 0% gravel.		12	50	4 5 8 [13]	18	0.5P				57	HD	S12A_025_027S
	26														
	27		As above except decreasing sand; increasing fines. SILTY SAND (SM); medium dense; very dark brown (10YR 2/2); moist; 60% fine sand; 40% low plasticity fines; 0% gravel.		13	50									S13C_027_027P S13B_027_028P S13A_028_029P
25	28														
	29														
	30		As above except 80% sand; 20% no plasticity fines.		14	39	7 8 9 [17]	24							S14A_030_032S
	31														
	32		11-inch Sandy Silt (ML) lense; 30% fine sand; 70% no plasticity fines.		15	60									S15B_032_033P S15A_033_034P
20	33		As above except dark yellowish brown (10YR 3/4); 70% sand; 30% fines; portion of fines are clay-sized.												
	34														
	35				16	44	7 7 8 [15]	21					30	HD	S16A_035_037S
	36														
	37		As above except 80% fine to medium sand; 20% fines.		17	95									S17A_037_037P
15	38														
	39														
	40		SILTY GRAVEL with Sand (GM); very dense; dark yellowish brown (10YR 3/6); moist; 50% fine to coarse, subrounded to rounded gravel, max. 1 in.; 35% fine to medium sand; 15% low plasticity fines.		18	39	23 23 20 [43]	59							S18A_040_042S 40' to 48': Rig chatter
	41														
	42		Gravel, max. 2.5 in.		19	0									No Recovery Gravels present in sampler
10	43														
	44														
	45														

Draft 4 After Final Markups 11/5/2009

Borehole Location: North Bank Crest **County:** Sacramento
Coordinates: Northing: 1,967,149.09 **Easting:** 6,731,673.44
Latitude: 38.56228 **Longitude:** -121.40544
Levee Station or Milepost: 3306+35 **Levee Mile:** 1.31
Levee Segment
Survey Method: GIS/LiDAR **Coord. System:** CA State Plane Zone II
Channel / River Name / Feature: American River

LOG OF BORING
WCNBAR_003B
Sheet 2 of 4

Urban Levee Geotechnical Evaluations Program
Engineering Support Services

DWR LEVEE U/NU SOIL LOG REV1; AMERICAN RIVER LEVEE BORINGS 11-5-2009.GPJ; DWR WORKING LIBRARY 092009.GLB; 11/5/09

Elevation, feet	Depth, feet	Material Graphics	CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in. [Blows per ft]	N_{60}(ASTM)	PP or TV, tsf	LABORATORY DATA: Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	Other Lab Tests	REMARKS
	45		Gravel; as above.		20	0									No Recovery Gravel fragments in mud cuttings
	46														
	47														S21A_051_051P
5	48		LEAN CLAY (CL); very stiff; olive brown (2.5Y 4/4); moist; 95% medium plasticity, medium toughness fines; 5% fine sand; 0% gravel.		21	19									
	49														
	50		6-inch thick gravel lense.		22	0	50/4"								No Recovery Driller notes gravel
	51								>3.0P						S22A_051_051P Driller notes rock in hole; pushing rock
	52		Gravel.												
0	53				22	16									Rig Chatter
	54														
	55		LEAN CLAY (CL); hard; yellowish brown (10YR 5/8); 90% low plasticity fines; 10% fine sand; 0% gravel; Iron oxide staining.		23	61	17 47 39 [86]	119	>4.5P						S23A_055_057S
	56														
	57		6-inch thick Silt (ML) lense; 10% fine sand; 90% low plasticity fines.												S24C_057_057P S24B_058_058P S24A_059_060P
-5	58		SILTY SAND (SM); dark yellowish brown (10YR 4/6); 60% fine to medium sand; 40% low plasticity fines; 0% gravel.		24	71									
	59		Poorly Graded SAND (SP); dark olive brown (2.5Y 3/3); moist; 95% fine to medium sand; 5% fines; 0% gravel.												
	60														S25B_060_061S S25A_061_062S
	61		1-foot thick Silty Sand (SM) lense; very dense; 60% fine to medium sand; 40% low plasticity fines.		25	50	21 29 31 [60]	83							
	62		Poorly Graded SAND (SP); dark olive brown (2.5Y 3/3); moist; 95% fine to medium sand; 5% low plasticity, slow dilatancy fines; 0% gravel.												Box 2 Representative S26A_062_062P
-10	63				26	43									
	64														
	65		8-inch thick Lean Clay (CL) lense; 5% fine sand; 95% medium plasticity fines.												S27B_065_067S S27A_065_067S
	66		SILT with Sand (ML); very dense; olive brown (2.5Y 4/4); moist; 85% low plasticity, slow dilatancy fines; 15% fine sand; 0% gravel.		27	50	13 19 21 [40]	55							
	67														S28B_067_067P S28A_070_070P
-15	68		LEAN CLAY (CL); hard; olive (5Y 5/4); moist; 95% medium toughness fines; 5% sand; 0% gravel.		28	100									
	69								>4.5P						
	70														

Draft 4 After Final Markups 11/5/2009

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WCNBAR_003B
Sheet 3 of 4

Urban Levee Geotechnical Evaluations Program
Engineering Support Services

DWR LEVEE U/NU SOIL LOG REV1; AMERICAN RIVER LEVEE BORINGS 11-5-2009.GPJ; DWR WORKING LIBRARY 092009.GLB; 11/5/09

Elevation, feet	Depth, feet	Material Graphics	CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in. [Blows per ft]	N_{60}(ASTM)	PP or TV, tsf	LABORATORY DATA: Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	Other Lab Tests	REMARKS
	70		LEAN CLAY (CL); as above except very stiff.		29	61	19 21 25 [46]	64	>3.3P	19	25	8			S29A_070_072P
	71														
	72		As above except dark yellowish brown (10YR 4/6); 10% fine sand; 90% fines.		30	26									S30A_072_072P
-20	73														
	74														
	75														
	76		Borehole terminated at 75 feet. Backfilled with 5% bentonite grout.												
	77														
-25	78														
	79														
	80														
	81														
	82														
-30	83														
	84														
	85														
	86														
	87														
-35	88														
	89														
	90														
	91														
	92														
-40	93														
	94														
	95														

Draft 4 After Final Markups 11/5/2009

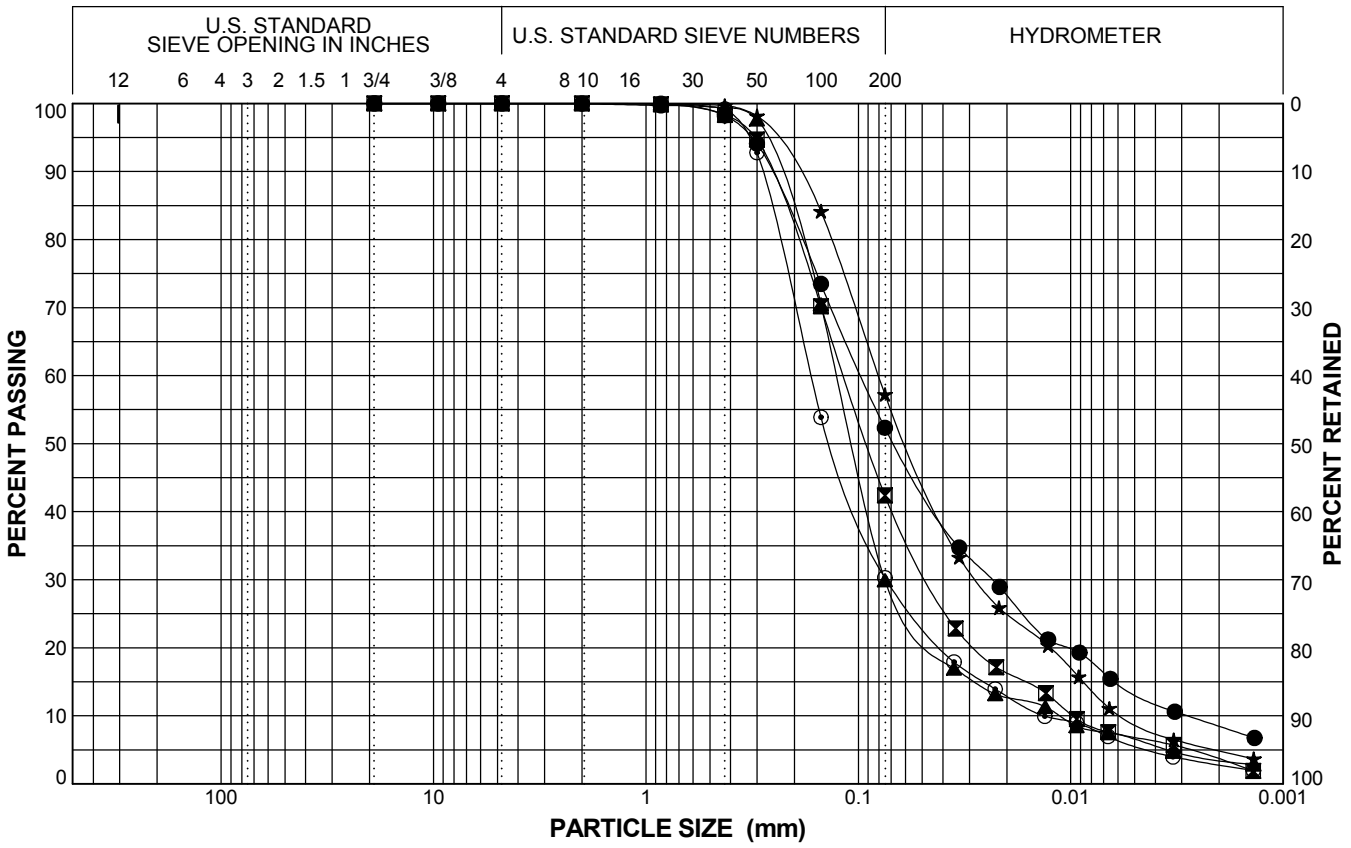
Borehole Location: North Bank Crest **County:** Sacramento
Coordinates: Northing: 1,967,149.09 **Easting:** 6,731,673.44
Latitude: 38.56228 **Longitude:** -121.40544
Levee Station or Milepost: 3306+35 **Levee Mile:** 1.31
Levee Segment
Survey Method: GIS/LiDAR **Coord. System:** CA State Plane Zone II
Channel / River Name / Feature: American River

LOG OF BORING
WCNBAR_003B
Sheet 4 of 4

Urban Levee Geotechnical Evaluations Program
Engineering Support Services

DWR LEVEE U/NU SOIL LOG REV1; AMERICAN RIVER LEVEE BORINGS 11-5-2009.GPJ; DWR WORKING LIBRARY 092009.GLB; 11/5/09

BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		coarse	fine	coarse	medium	fine	



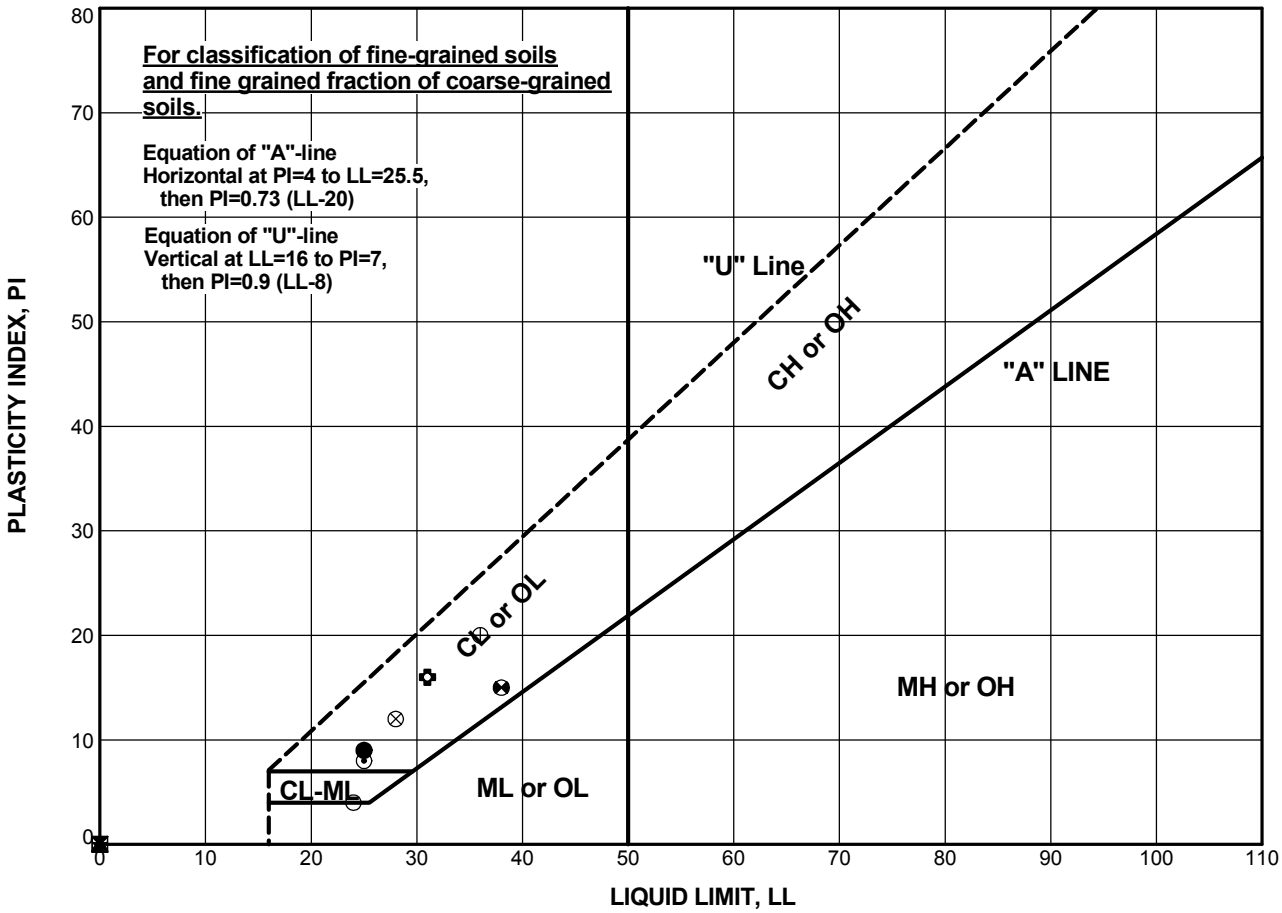
Boring Number	Sample Number	Depth (feet)	Symbol	%G	%S	%F	Classification
WCNBAR_003B	S05A_007_008P	7	●	0.0	47.7	52.3	SANDY SILT (ML)
WCNBAR_003B	S08A_015_017S	15	⊠	0.0	57.6	42.4	SILTY SAND (SM)
WCNBAR_003B	S10A_020_022S	20	▲	0.0	70.1	29.9	SILTY SAND (SM)
WCNBAR_003B	S12A_025_027S	25	★	0.0	42.8	57.2	SANDY SILT (ML)
WCNBAR_003B	S16A_035_037S	35	⊙	0.0	69.7	30.3	SILTY SAND (SM)

Urban Levee Geotechnical Evaluations Program
Engineering Support Services

American River

PARTICLE SIZE DISTRIBUTION CURVES

DWR LEVEE U/NU SIEVE CURVES #200 REV1; AMERICAN RIVER LEVEE BORINGS 11-5-2009.GPJ; DWR WORKING LIBRARY 092009.GLB; 2/3/10



Boring Number	Sample Number	Depth (feet)	Test Symbol	WC (%)	LL	PL	PI	Classification
WCNBAR_001B	S06A_015_017S	15	●	13.7	25	16	9	CLAYEY SAND (SC)
WCNBAR_002B	S04A_005_007S	5	⊠	17.5	NP	NP	NP	SANDY SILT (ML)
WCNBAR_002B	S08A_015_017S	15	▲		NP	NP	NP	SILTY SAND (SM)
WCNBAR_003B	S04A_005_007S	5	★	15.6	NP	NP	NP	SANDY SILT (ML)
WCNBAR_003B	S29A_070_072S	70	⊙	18.5	25	17	8	LEAN CLAY (CL)
WCNBAR_004B	S02A_002_003B	2	✿	15.9	31	15	16	LEAN CLAY (CL)
WCNBAR_004B	S08A_014_014P	13.5	○	17.6	24	20	4	SANDY SILTY CLAY (CL-ML)
WCNBAR_005B	S08A_010_012S	10	△	10.4	NP	NP	NP	SILTY SAND (SM)
WCNBAR_005B	S16A_036_036S	35	⊗	17.8	28	16	12	LEAN CLAY with Sand (CL)
WCNBAR_005B	S18A_041_042S	40	⊕	16.3	36	16	20	LEAN CLAY with Sand (CL)
WCNBAR_005B	S22A_050_052S	50	□	17.7	NP	NP	NP	SILTY SAND (SM)
WCSBAR_001B	S02A_002_003B	2	⊗	16.8	38	23	15	LEAN CLAY with Sand (CL)

Urban Levee Geotechnical Evaluations Program
Engineering Support Services

American River

PLASTICITY CHART

DWR LEVEE U/NU ATT. PLOT (U LINE) REV1; AMERICAN RIVER LEVEE BORINGS 11-3-2009.GPJ; DWR WORKING LIBRARY 092009.GLB; 11/3/09

ARN REACH E – ARCADE CREEK NORTH – U7 LM 0.90

STRATIGRAPHY INPUT

BORING LOGS

LABORATORY TESTING

AMERICAN RIVER WATERSHED - COMMON FEATURES PROJECT
GENERAL REEVALUATION REPORT - GEOTECHNICAL ANALYSIS
ARCADE CREEK NORTH RN U7 LM 0.90
Table F-2-5: Permeability and Strength Selection for Analysis

Boring Number	Top of Boring Elevation (ft, NAVD88)	Layer ID	Material Type	USCS Soil Classification	Depth to Top of Layer (ft)	Depth to Bottom of Layer (ft)	Elevation of Top of Layer (ft, NAVD 88)	Elevation of Bottom of Layer (ft, NAVD 88)	Layer Thickness (ft)	Average Depth to Groundwater During Drilling	Laboratory and Field Data						Recommended Hydraulic Conductivity					Recommended Strength Parameters		
											Average % Fines	Average Field N (blows/ft)	Average N_{60} (blows/ft)[1]	Average Normalized Blow Count, $N_{1,60}$ (blows/ft)[2]	PI	LL	Horizontal kh (kx) cm/sec	Anisotropy Ratio kh/kv	Vertical kv (ky) cm/sec	Horizontal kh (kx) ft/day	Vertical kv (ky) ft/day	Φ'	C' (psf)	γ (pcf)
WRARFC_003B	44.48	1	Sandy Lean Clay Levee	CL	0.00	12.79	44.48	31.69	12.79	12.89	61	10	9	16	14	27	1.00E-05	4.00	2.50E-06	0.028	0.007	24	50	115
		2	Sandy Lean Clay Blanket	CL	12.79	21.64	31.69	22.84	8.85		55	11	12	12	16 12	27 26	1.00E-05	1.00	1.00E-05	0.028	0.028	28	50	115
		3	Poorly Graded Sand	SP	21.64	40.14	22.84	4.34	18.50		12	35	51	38	19	47	5.00E-03	4.00	1.25E-03	14.175	3.544	35	0	130
		4	Silty Sand	SM	40.14	45.64	4.34	-1.16	5.50		22	82	121	82	7	33	1.00E-03	4.00	2.50E-04	2.835	0.709	33	0	125
		5	Sandy Silt	ML	45.64	55.64	-1.16	-11.16	10.00		94	50	74	48			2.00E-04	4.00	5.00E-05	0.567	0.142	30	0	120
		6	Silty Sand	SM	55.64	76.50	-11.16	-32.02	20.86		23	52	76	40	12 5 10 26	41 24 35 49	1.00E-03	4.00	2.50E-04	2.835	0.709	35	0	125
					Total Depth (ft.)	**76.50**																		

DATE STARTED **5/22/07**	DATE COMPLETED **5/23/07**	GROUND ELEVATION **44.48 ft**	ELEVATION BASIS **Survey crew**	TOTAL DEPTH OF BORING **76.5 ft**
DRILLING CONTRACTOR **Westex**		DRILLER'S NAME **K. Jensen**	HELPER'S NAME **T. Seaver/M. Daniels**	TOTAL DEPTH OF FILL **21.5 ft**
DRILLING METHOD **0 - 21.5 ft: Hollow-Stem Auger, 21.5 - 76.5 ft: Rotary Wash**		DRILL RIG MAKE AND MODEL **Mobile B61 HDX (Rig 103)**		CONSULTANT COMPANY **Geomatrix**
DRILL BIT SIZE AND TYPE (HOLE DIAMETER) **10" HSA, 4-3/8" Core Bit**		DRILLING ROD TYPE AND DIAMETER **NWJ 67 mm, HQ Core 94 mm**		FIELD LOGGER **A. Behan**
☒ VERTICAL ☐ INCLINED		CASING TYPE, DIAMETER, INSTALLATION DEPTH **10" HSA to 20'**		FIELD LOG REVIEWER **Y. Ma**
SAMPLER TYPE(S) **Mod Cal (2"), Punch Core (2.25"), Shelby (1.87"), SPT (1.4")**		HAMMER TYPE, MAKE/MODEL, WEIGHT/DROP **Mobile, self compensating auto, 140 lbs/30-inch drop**		HAMMER EFFICIENCY **77%**
BOREHOLE BACKFILL OR COMPLETION **See Termination Notes**		GROUNDWATER READING: DURING DRILLING **N/A due to rotary wash drilling method**	AFTER DRILLING (DATE-TIME)	

Elevation, feet	Depth, feet	Material Graphics	FIELD CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in.	Blows per Foot	N_{60}(ASTM)	PP or TV, tsf	LABORATORY DATA: Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	REMARKS
	0		SANDY LEAN CLAY (CL); dark yellowish brown (10YR 4/6) mottled with light brownish gray (10YR 6/2) and very dark grayish brown (10YR 3/2); dry; 61% low plasticity, high dry strength, no dilatancy, medium toughness fines; 39% fine to medium sand; trace coarse sand; (FILL).												
	1														
	2														
	3			▌	1	78	5 8 14	22			15				S01B_003_004M S01A_004_004M
	4														
40	5		Color changes to very dark brown (10YR 2/2) mottled with dark yellowish brown (10YR 4/6), fine sand, slow dilatancy fines at 4.5'.												
	6			▌	2	89	4 4 5	9			15	27	14		S02B_006_006M S02A_006_007M
	7														
	8		6" clayey sand lens at 8'.	╳	3	78	2 3 3	6	8						S03B_008_008S S03A_008_009S
	9														
35	10		Fine to medium sand; fines content varies throughout layer with zones of clayey sand interbedded throughout at 9.5'. 4" silty sand lens at 10.3'.	╳	4	89	1 1 2	3	4						S04A_010_012S
	11		1" silty sand lens at 10.9'. 1" silty sand lens at 11.2'.												
	12														
	13		3" silty sand lense at 12.8'.	╳	5	100	2 3 5	8	10						S05A_013_014S
	14														
30	15														
	16			▌	6	100					16	27	16	61	S06A_015_017T 300 psi
	17														
	18		Color changes to dark brown (10YR 3/3); moist at 17.3'. CLAYEY SAND (SC); dark yellowish brown (10YR 3/6); moist; 52% fine sand; 48% fines; (FILL).	╳	7	89	1 3 4	7	9		15	26	12	48	S07B_018_018S S07A_018_019S
	19		SANDY LEAN CLAY (CL); dark brown (10YR 3/3) mottled with dark yellowish brown (10YR 3/6); moist; 57% low plasticity, high dry strength, slow dilatancy, medium toughness fines; 43% sand; (FILL).												
25	20														

Draft 4 After Final Markups 5/21/2008

Borehole Location: Crest of the Levee
Coordinates: North 1,990,149.70 East 6,717,833.03
Levee Station or Milepost: STA: 5048+89 OFFSET: 2.4 Left
GPS: Latitude 38.62567 Longitude -121.45337
Channel / River Name / Feature: Arcade Creek
County: Sacramento

LOG OF BORING
WRARFC_003B

Engineering Support Services
Urban Levee Geotechnical Evaluations

Elevation, feet	Depth, feet	Material Graphics	FIELD CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in.	Blows per Foot	N_{60}(ASTM)	PP or TV, tsf	LABORATORY DATA: Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	REMARKS
	20														
	21		(BASE OF FILL).		8	78	5 7 8	15			22			57	S08B_021_021M S08A_021_022M
	22		SILTY SAND (SM); brown (7.5YR 4/4); dry; 80% fine sand; 20% fines; (NATIVE).												S09A_022_023P Switched to rotary wash at 21.5'
	23				9	21									
	24		Poorly Graded SAND (SP); medium dense; dark yellowish brown (10YR 4/4); wet; 95% fine to medium sand; 5% fines; no cementation.												
20	25														
	26				10	78	1 4 6	10	13					5	S10A_025_027S
	27														
	28				NR	0									
	29														
15	30														
	31		SANDY SILT (ML); olive brown (2.5Y 4/4); moist; 51% low dry strength, no to slow dilatancy, low toughness fines; 49% fine sand; few concretions.		11	56	6 21 38	59	76		28	47	19	51	S11B_030_031S S11A_031_031S
	32		Poorly Graded SAND with Silt (SP-SM); dense; olive brown (2.5Y 4/4); moist; 88% sand (mostly fine sand, little medium sand, few coarse sand); 12% fines; with few clayey interbeds; few fine gravel; micaceous.												
	33				NR	0									
	34														
10	35		Color changes to light brownish gray (2.5Y 6/2) at 35'.												
	36				12	39	7 13 17	30	39					12	S12A_035_037S
	37														
	38				13	2									
	39														
5	40		2" sandy silt lens at 39.8'.												
	41		SILTY SAND (SM); dense to very dense; olive brown (2.5Y 4/4); moist; 72% fine sand; 28% fines; mostly fine sand, little medium sand, few coarse sand; with few clayey interbeds; few fine gravel; micaceous.		14	33	3 17 22	39	50					28	S13A_040_040P S14A_040_041S
	42														DN: Thickening mud at 41.5' to get better recovery
	43		LEAN CLAY with Sand (CL); olive brown (2.5Y 4/4); moist; 80% medium plasticity, medium dry strength, slow dilatancy, medium toughness fines; 20% fine sand; with concretions.		15	67					31	33	7	88	S15A_043_044P
	44		SILT (ML); olive brown (2.5Y 4/4); moist; 88% low dry strength, rapid dilatancy, low toughness fines; 12% fine sand.												
0	45		SILTY SAND (SM); very dense; light yellowish brown												

Draft 4 After Final Markups 5/21/2008

Borehole Location: Crest of the Levee
Coordinates: North 1,990,149.70 East 6,717,833.03
Levee Station or Milepost: STA: 5048+89 OFFSET: 2.4 Left
GPS: Latitude 38.62567 Longitude -121.45337
Channel / River Name / Feature: Arcade Creek
County: Sacramento

LOG OF BORING
WRARFC_003B

Engineering Support Services
Urban Levee Geotechnical Evaluations

Elevation, feet	Depth, feet	Material Graphics	FIELD CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in.	Blows per Foot	N_{60}(ASTM)	PP or TV, tsf	LABORATORY DATA Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	REMARKS
	45		(2.5Y 6/3) to grayish brown (2.5Y 5/2); moist; 84% fine sand; 16% fines; weak cementation.		16	60	10 32 50/3"	82/ 9"						16	S16B_045_046S S16A_046_046S
	46		SILT (ML); very dense; olive brown (2.5Y 4/4); moist; 91% low plasticity, low dry strength, rapid dilatancy, low toughness fines; 9% sand.											91	S17A_047_048P
	47														
	48		SILT with Sand (ML); very dense; olive brown (2.5Y 4/4); moist; 73% no dry strength, rapid dilatancy, low toughness fines; 27% fine sand.		17	27									
	49														
-5	50				18	100	23 50/6"	50/ 6"			24	NP	NP	73	S18B_050_051S S18A_051_051S
	51		SILT (ML); very dense; olive brown (2.5Y 4/4); moist; 95% low dry strength, rapid dilatancy, low toughness fines; 5% sand.												
	52		SILTY SAND (SM); olive brown (2.5Y 4/4); moist; 60% fine sand; 40% fines.												S19B_052_053P
	53		SANDY SILT (ML); olive brown (2.5Y 4/4); moist; 60% low plasticity, low dry strength, rapid dilatancy, low toughness fines; 40% fine sand.		19	63									
	54		SILT (ML); very dense; olive brown (2.5Y 4/4); moist; 95% low plasticity, low dry strength, rapid dilatancy, low toughness fines; 5% sand; grades sandy with depth.												S19A_054_054P
-10	55				20	100	22 50/6"	50/ 6"							S20B_055_056S S20A_056_056S
	56		SILTY SAND (SM); very dense; olive brown (2.5Y 4/4); moist; 70% fine sand; 30% fines.												
	57														
	58				NR	0									DN: Thinks low recovery is due to material type and not to drilling fluid thickness
	59														
-15	60				21	75	35 50/6"	50/ 6"							S21A_060_061S
	61		Wet; fine to medium sand at 61'.												
	62														
	63				22	50									
	64		74% sand, 26% fines at 64'.											26	S22B_064_065P S22A_065_065P
-20	65		55% sand, 45% fines, strong cementation, with numerous fine to coarse sand-sized and fine gravel-sized concretions, with oxide staining at 65'.		23	58	22 50/6"	50/ 6"			27	41	12	45	S23A_065_066S
	66														
	67		SANDY SILTY CLAY (CL-ML); olive brown (2.5Y 4/4) mottled with dark yellowish brown (10YR 4/6); wet; 51% low to medium dry strength, slow to rapid dilatancy, low toughness fines; 49% fine sand; with oxide staining.								27	24	5	51	S24C_067_067P
	68		SILTY SAND (SM); olive brown (2.5Y 4/4); moist; 70% fine sand; 30% fines.		24	88									S24B_068_068P
	69		CLAYEY SAND (SC); olive brown (2.5Y 4/4) mottled with dark yellowish brown (10YR 4/6); wet; 85% fine sand; 15% fines; with oxide staining.								36	35	10	58	S24A_069_070P
-25	70		SANDY SILT (ML); very dense; olive brown (2.5Y 4/4);												

Draft 4 After Final Markups 5/21/2008

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Levee Station or Milepost: STA: 5048+89 OFFSET: 2.4 Left
GPS: Latitude 38.62567 Longitude -121.45337
Channel / River Name / Feature: Arcade Creek
County: Sacramento

LOG OF BORING
WRARFC_003B

Engineering Support Services
Urban Levee Geotechnical Evaluations

Elevation, feet	Depth, feet	Material Graphics	FIELD CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in.	Blows per Foot	N_{60}(ASTM)	PP or TV, tsf	LABORATORY DATA: Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	REMARKS
	70		moist; 58% low plasticity, low to medium dry strength, slow dilatancy, low toughness fines; 42% fine sand; with concretions; grades sandier with depth.		25	64	27 50/5"	50/ 5"							S25B_070_071S S25A_071_071S
	71		SILTY SAND (SM); very dense; olive brown (2.5Y 4/4); moist; 85% fine sand; 15% fines.												
	72														
	73				26	49									
	74		70% sand, 30% fines at 74'.											30	S26A_074_075P
-30	75		LEAN CLAY (CL); light olive brown (2.5Y 5/3); dry; 87% high to very high dry strength, no dilatancy, medium to high toughness fines; 13% fine sand; strong cementation.		27	56	5 26 30	56	72		26	49	26	87	S27A_075_076S
	76														
	77		Borehole terminated at 76.5 feet. Backfilled with 5% bentonite grout.												
	78														
	79														
-35	80														
	81														
	82														
	83														
	84														
-40	85														
	86														
	87														
	88														
	89														
-45	90														
	91														
	92														
	93														
	94														
-50	95														

Draft 4 After Final Markups 5/21/2008

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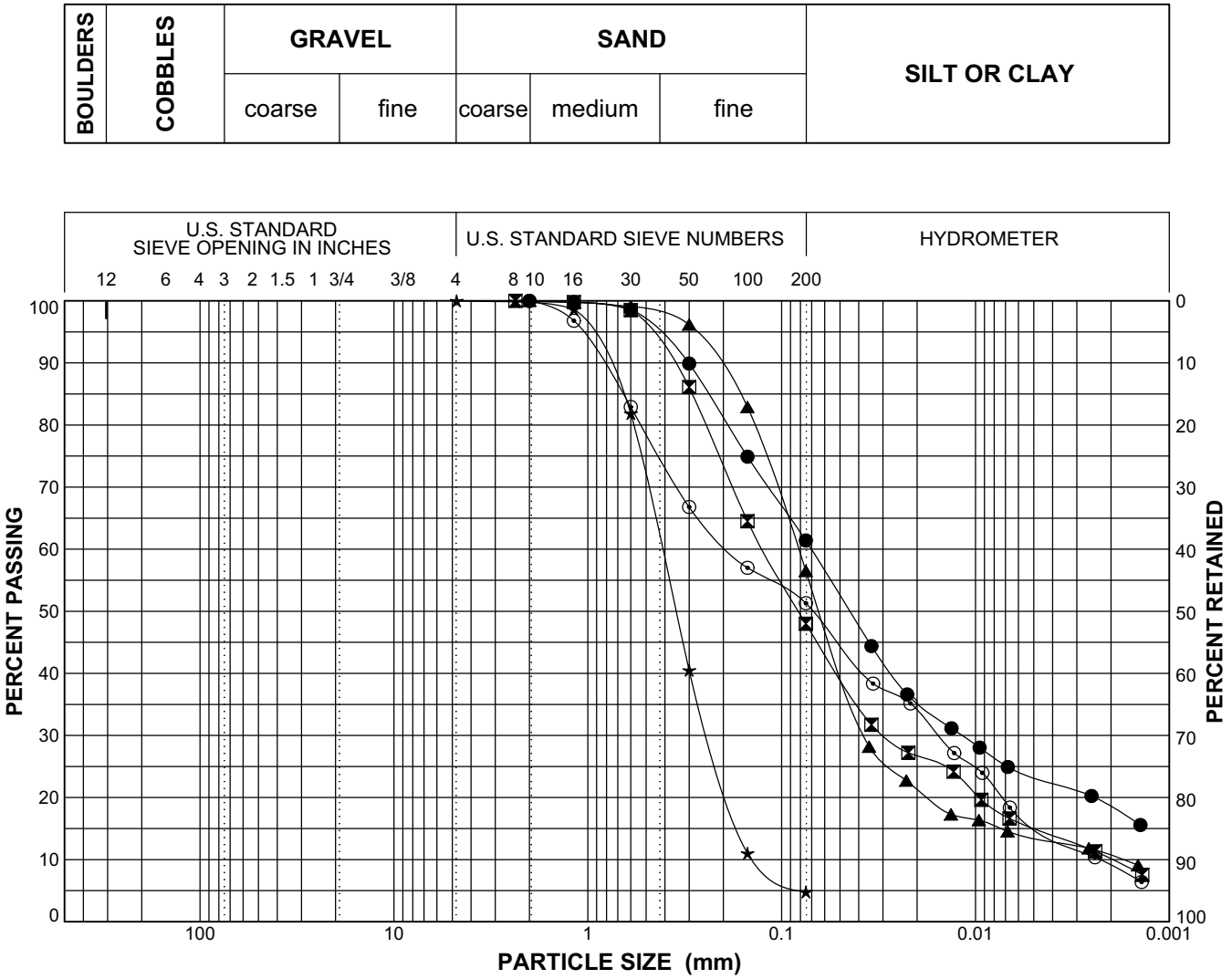
LOG OF BORING
WRARFC_003B

Engineering Support Services
Urban Levee Geotechnical Evaluations



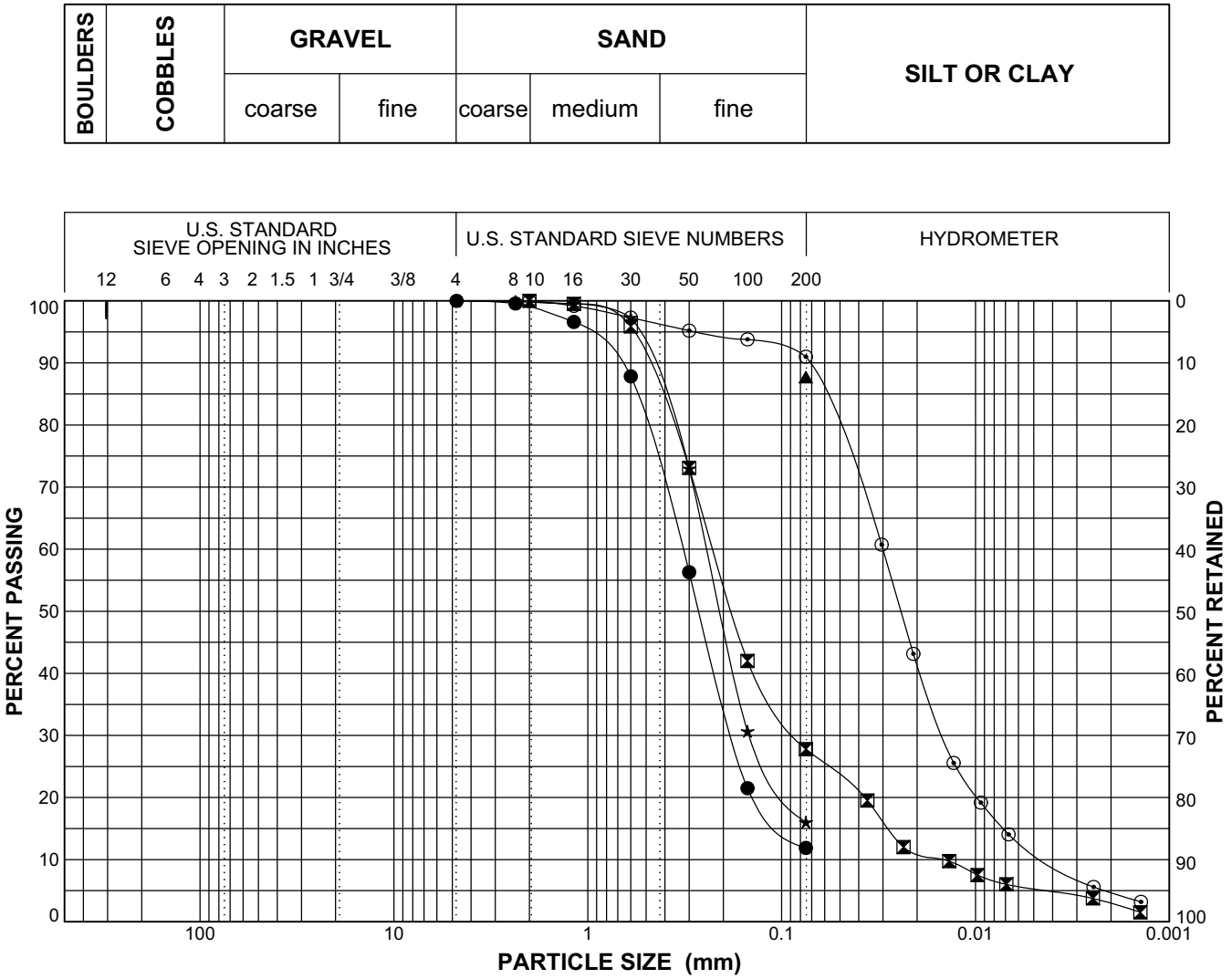
Boring Number	Sample Number	Depth (feet)	Symbol	%G	%S	%F	Classification
WRARFC_003B	6A	15	●	0	39	61	SANDY LEAN CLAY CL
WRARFC_003B	7A	17.8	⊠	0	52	48	CLAYEY SAND SC
WRARFC_003B	8A	21	▲	0	44	57	SANDY LEAN CLAY CL
WRARFC_003B	10A	25	★	0	95	5	Poorly Graded SAND SP
WRARFC_003B	11B	30	⊙	0	49	51	SANDY SILT ML

Engineering Support Services
Urban Levee Geotechnical Evaluations

Natomas East Main Drainage Canal

PARTICLE SIZE DISTRIBUTION CURVES

DWR SIEVE CURVES ALL EXPLORATIONS REV10.GPJ DWR TEST 81507.GDT 5/27/08



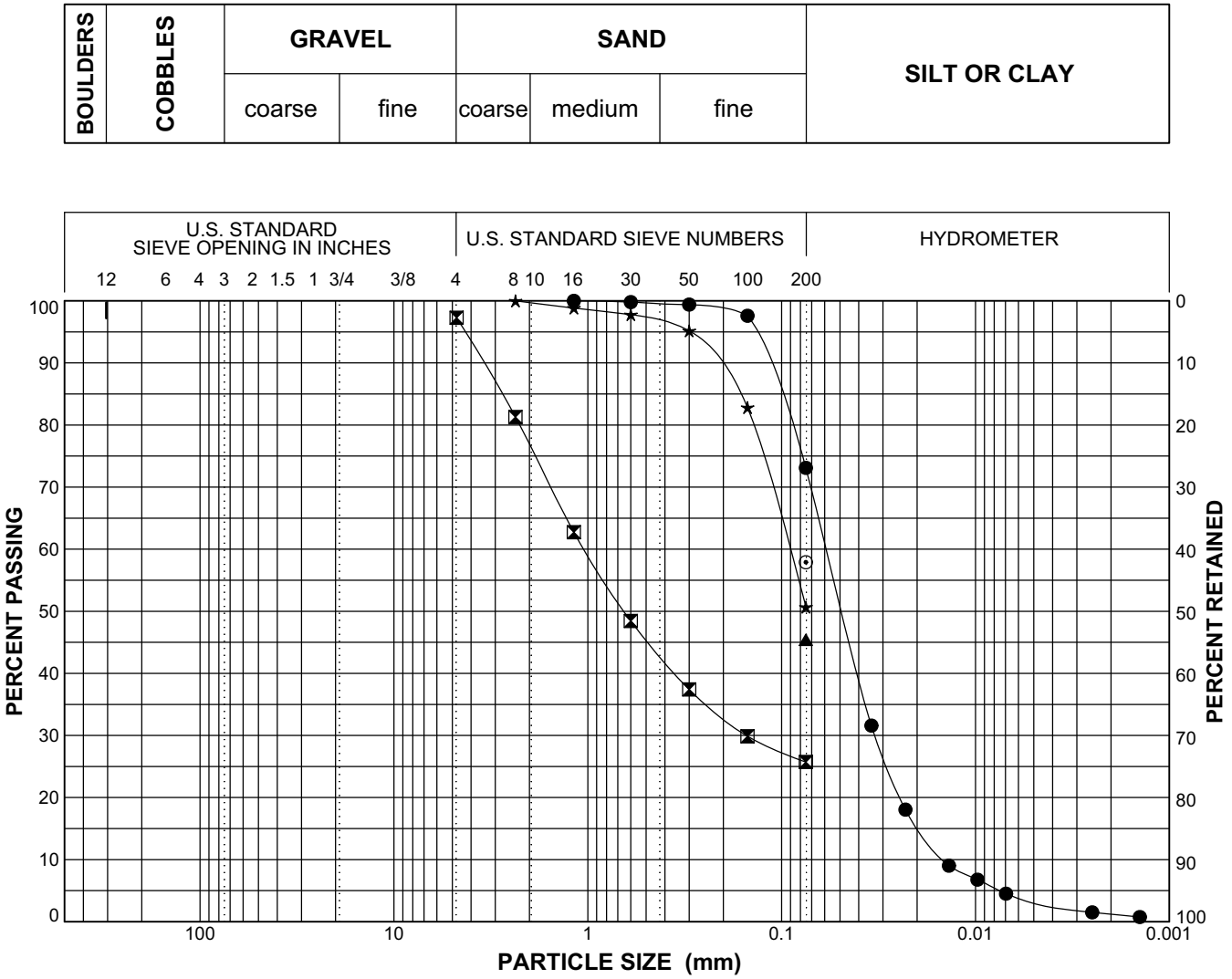
Boring Number	Sample Number	Depth (feet)	Symbol	%G	%S	%F	Classification
WRARFC_003B	12A	35	●	0	88	12	SILTY SAND SM
WRARFC_003B	14A	40	⊠	0	72	28	SILTY SAND SM
WRARFC_003B	15A	43	▲	0	0	88	SILT ML
WRARFC_003B	16B	45	★	0	84	16	SILTY SAND SM
WRARFC_003B	17A	46.5	⊙	0	9	91	SILT ML

Engineering Support Services
Urban Levee Geotechnical Evaluations

Natomas East Main Drainage Canal

PARTICLE SIZE DISTRIBUTION CURVES

DWR SIEVE CURVES ALL EXPLORATIONS REV10.GPJ DWR TEST 81507.GDT 5/27/08



Boring Number	Sample Number	Depth (feet)	Symbol	%G	%S	%F	Classification
WRARFC_003B	18B	50	●	0	27	73	SILT with Sand ML
WRARFC_003B	22A	64	⊠	0	72	26	SILTY SAND SM
WRARFC_003B	23A	65	▲	0	0	45	SILTY SAND SM
WRARFC_003B	24C	66.5	★	0	49	51	SANDY SILTY CLAY CL-ML
WRARFC_003B	24A	69	⊙	0	0	58	SANDY SILT ML

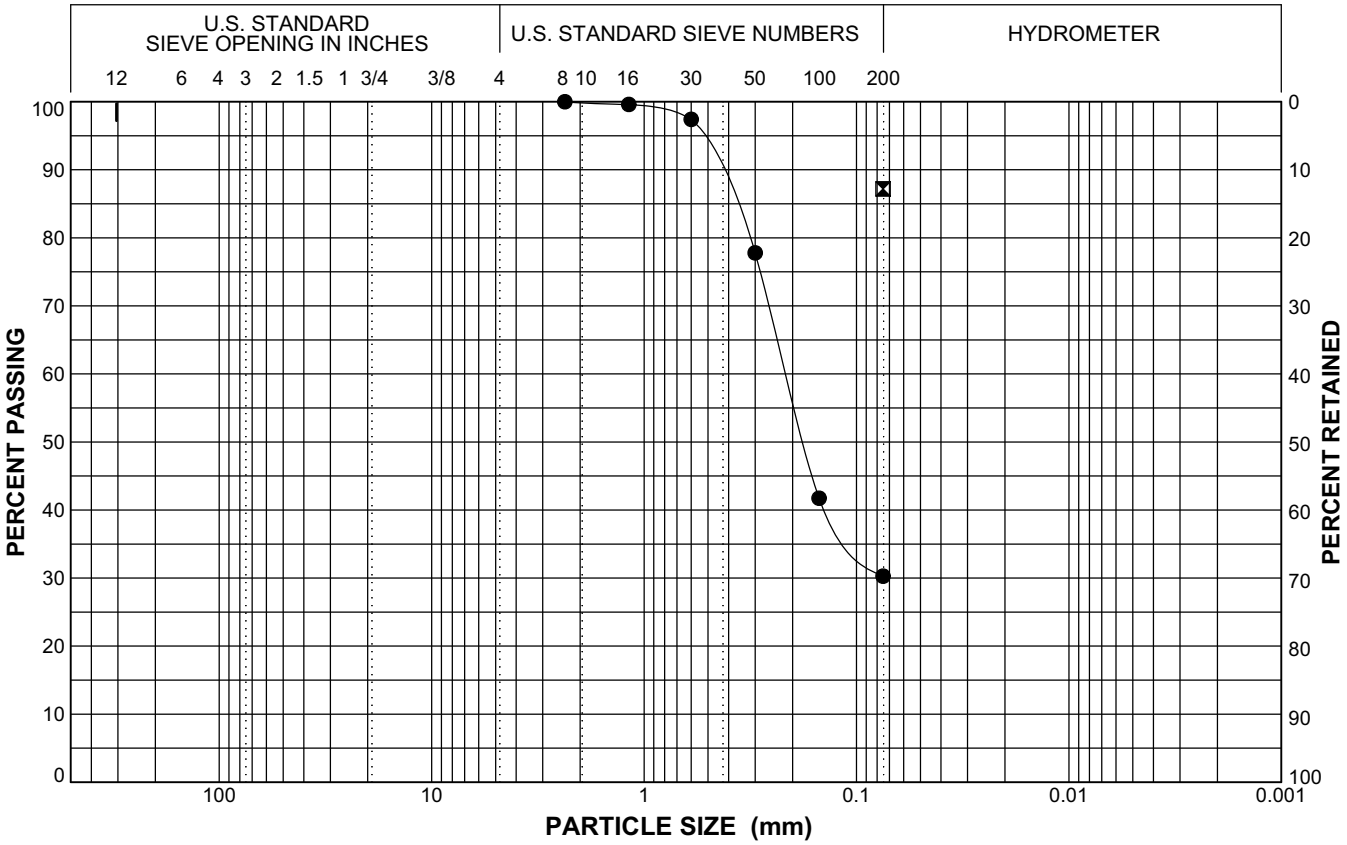
Engineering Support Services
Urban Levee Geotechnical Evaluations

Natomas East Main Drainage Canal

PARTICLE SIZE DISTRIBUTION CURVES

DWR SIEVE CURVES ALL EXPLORATIONS REV10.GPJ DWR TEST 81507.GDT 5/27/08

BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		coarse	fine	coarse	medium	fine	



Boring Number	Sample Number	Depth (feet)	Symbol	%G	%S	%F	Classification
WRARFC_003B	26A	74	●	0	70	30	SILTY SAND SM
WRARFC_003B	27A	75	⊠	0	0	87	LEAN CLAY CL

DWR SIEVE CURVES ALL EXPLORATIONS REV10.GPJ DWR TEST 81507.GDT 5/27/08

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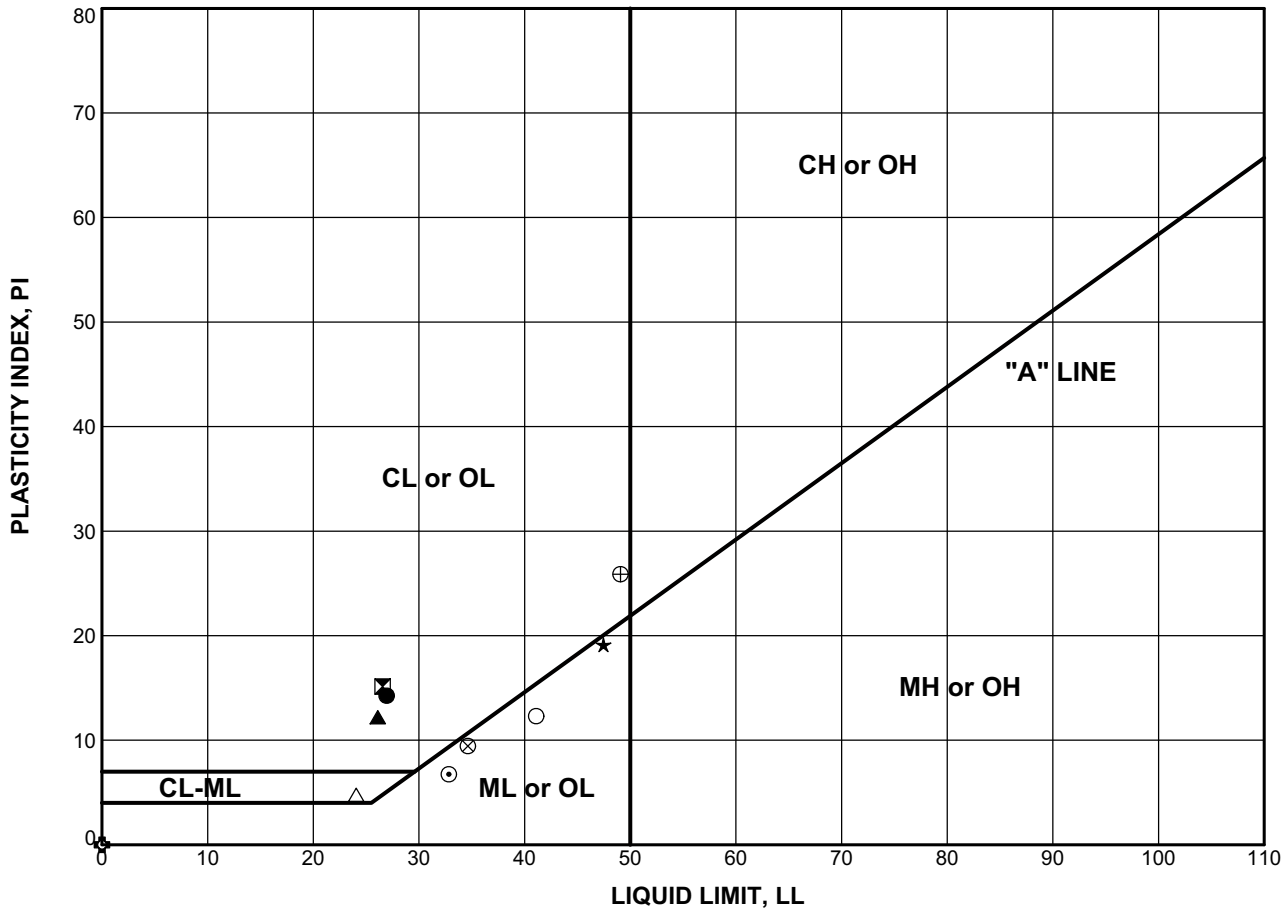
Natomas East Main Drainage Canal

PARTICLE SIZE DISTRIBUTION CURVES



Boring Number	Sample Number	Depth (feet)	Test Symbol	WC (%)	LL	PL	PI	Classification
WRARFC_003B	2A	6	●	14.8	27	13	14	SANDY LEAN CLAY CL
WRARFC_003B	6A	15	⧗	15.7	27	11	16	SANDY LEAN CLAY CL
WRARFC_003B	7A	17.8	▲	15.1	26	14	12	CLAYEY SAND SC
WRARFC_003B	11B	30	★	27.5	47	28	19	SANDY SILT ML
WRARFC_003B	15A	43	⊙	31.0	33	26	7	SILT ML
WRARFC_003B	18B	50	✿	24.4	NP	NP	NP	SILT with Sand ML
WRARFC_003B	23A	65	○	26.5	41	29	12	SILTY SAND SM
WRARFC_003B	24C	66.5	△	27.3	24	19	5	SANDY SILTY CLAY CL-ML
WRARFC_003B	24A	69	⊗	35.7	35	25	10	SANDY SILT ML
WRARFC_003B	27A	75	⊕	25.5	49	23	26	LEAN CLAY CL

DWR ATTERBERG PLOT ALL EXPLORATIONS REV10.GPJ DWR LEVEES 111507.GDT 5/27/08

Engineering Support Services
Urban Levee Geotechnical Evaluations

Natomas East Main Drainage Canal

PLASTICITY CHART

AMERICAN RIVER SOUTH BASIN

ARS REACH B – AMERICAN RIVER SOUTH – U4 LM 3.90

STRATIGRAPHY INPUT

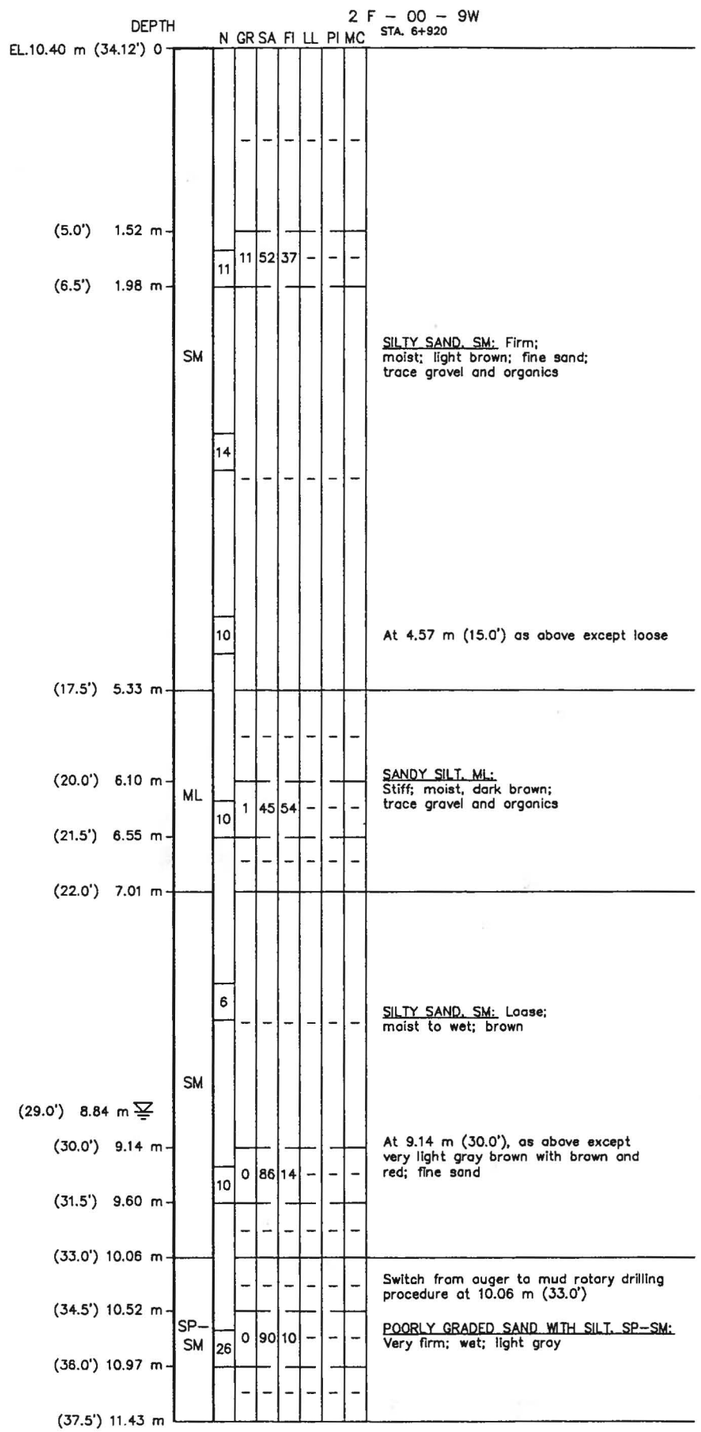
BORING LOGS

LABORATORY TESTING

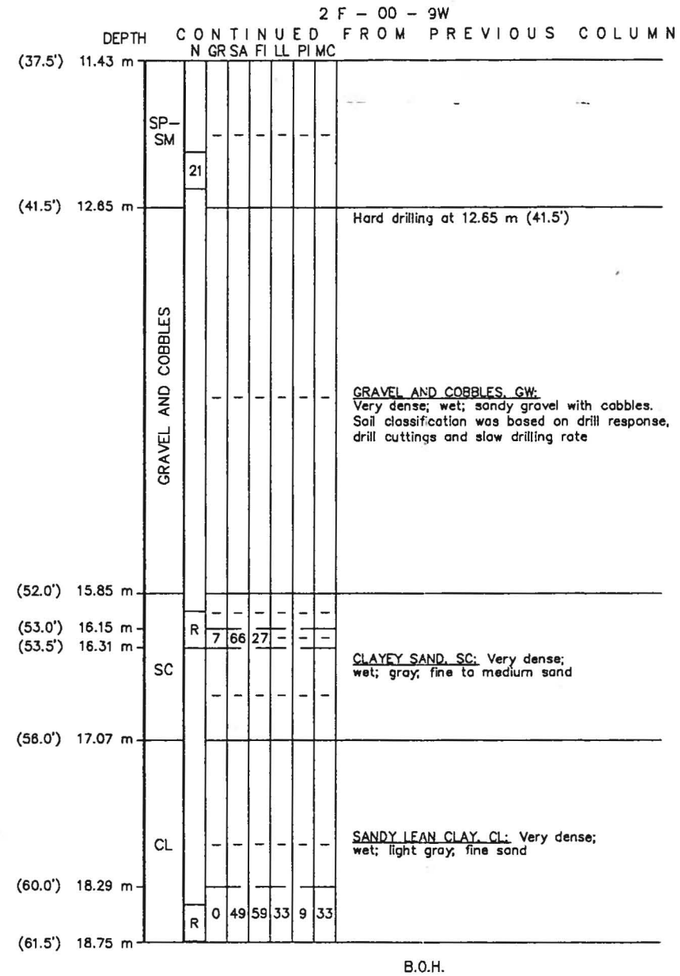
AMERICAN RIVER WATERSHED - COMMON FEATURES PROJECT
GENERAL REEVALUATION REPORT - GEOTECHNICAL ANALYSIS
AMERICAN RIVER SOUTH RB U4 LM 3.90
Table F-2-10: Permeability and Strength Selection for Analysis

Boring Number	Top of Boring Elevation (ft, NAVD 88)	Layer ID	Soil Description	USCS Soil Classification	Depth to Top of Layer (ft)	Depth to Bottom of Layer (ft)	Elevation of Top of Layer (ft, NAVD 88)	Elevation of Bottom of Layer (ft, NAVD 88)	Layer Thickness (ft)	Average Depth to Groundwater During Drilling	Laboratory and Field Data										Comments
											Average % Fines	Average Field N (blows/ft)	Average N_{60} (blows/ft)[1]	Average Normalized Blow Count, $N_{1,60}$ (blows/ft)[2]	Torvane (tsf)	Pocket Penetrometer (tsf)	Average Unit Weight (pcf)	PI	LL	LI	
2F-96-29, 2F-00-9W, 2F-00-114, WCSBAR_003B, 2F-99-17, 2F-97-23	49.70	1	Poorly Graded Sand to Silty Sand (SP-SM)	SP-SM	0.00	22.10	49.70	27.60	22.10	13.30	19	12									
		2	Levee Foundation Silt (ML)	ML	22.10	32.10	27.60	17.60	10.00		54	6									
		3	Poorly Graded Silty Sand (SP-SM) with Clay &	SP-SM	32.10	54.60	17.60	-4.90	22.50		10	13									
		4	Poorly Graded Gravel & Cobbles (GP)	GP	54.60	70.70	-4.90	-21.00	16.10		47	49									
		5	Silt and Clay (CL-ML)	ML	70.70	82.80	-21.00	-33.10	12.10		71	73									
		6	Cut-off Wall	SCB WALL																	
		7	Impervious Clay Cap	CL																	
					Total Depth (ft.)	**82.80**															

Layer ID	Recommended Hydraulic Conductivity					Strenth Coorelations								Strength from Lab Test Data						Recommended Strength Parameters			Comments
	Horizontal kh (kx) cm/sec	Anisotropy Ratio kh/kv	Vertical kv (ky) cm/sec	Horizontal kh (kx) ft/day	Vertical kv (ky) ft/day	Total Overburden Pressure at Mid Layer During Drilling (psf)	Effective Overburden Stress at Mid Layer During Drilling (psf)	OCR from N_{60}[3]	OCR from LI[3]	Su from N (psf)[4]	Su/σ'_o from PI (psf)[4]	Calculated Maximum Past Pressure (psf)[5]	Drained Friction Angle[7]	OCR	σ'_p (psf)	Su (psf)	Su/σ'_o	Φ'	C' (psf)	Φ'	C' (psf)	γ (pcf)	
1	1.00E-03	4.00	2.50E-04	2.835	0.709	0	0													33	0	125	
2	2.00E-04	4.00	5.00E-05	0.567	0.142	0	-861													30	0	120	
3	5.00E-03	4.00	1.25E-03	14.175	3.544	0	-1875													33	0	125	
4	1.20E-02	4.00	3.00E-03	34.020	8.505	0	-3079													35	0	135	
5	2.00E-04	4.00	5.00E-05	0.567	0.142	0	-3959													30	0	120	
6	1.00E-06	1.00	1.00E-06	0.003	0.003	0	0													0	50	85	
7	1.00E-05	1.00	1.00E-05	0.028	0.028	0	0	#VALUE!	#VALUE!											28	50	115	



CONTINUED IN NEXT COLUMN



NOTES:

1. SEE FIGURE B–1 FOR LEGEND AND NOTES.

GRAPHIC SCALE

SCALE 1 : 25 — 0, 0.5, 1, 1.5, 2, 2.5 METERS

AMERICAN RIVER WATERSHED PROJECT (COMMON FEATURES), CALIFORNIA LEFT (SOUTH) BANK LEVEE STRENGTHENING CONTRACT 2	DEPARTMENT OF THE ARMY CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA **URS Greiner Woodward Clyde** OAKLAND, CALIFORNIA	DEEP CUTOFF WALL FIELD INVESTIGATION **PIEZOMETER INSTALLATION PROGRAM** LOG OF EXPLORATION 2F–00–9W	FIGURE B–7

2F-00-114

STA. 6+500

Depth	Class	N	GR	SA	FI	LL	PI	MC	Description
EL. 14.0m (45.9') 0	MH	25	-	-	-	-	-	-	SANDY ELASTIC SILT, MH: Dense; moist; brown; about 60% low plasticity fines; about 40% fine sand; trace of organic matter; easy drilling
(3.0') 0.91m	SM	10	-	-	-	-	-	-	SILTY SAND, SM: Firm; moist; brown; about 70% fine to medium sand; about 30% low plasticity fines; trace of organic matter (roots); easy drilling
(6.0') 1.83m	SM	8	2	85	13	-	-	-	SILTY SAND, SM: Firm; dry; grayish-brown; fine to medium sand; low plasticity fines; trace of hard, coarse, subrounded, sand; easy drilling
(9.0') 2.74m	SM	8 / 13	-	-	-	-	-	-	SILTY SAND, SM: Firm; moist; brown; about 70% fine to medium sand; about 30% low plasticity fines; trace of organic matter; easy drilling
(15.0') 4.57m	SM	9	0	70	30	-	-	-	SILTY SAND, SM: Firm; moist; olive-gray; mostly fine sand; low plasticity fines; trace of organic matter; easy drilling
(18.0') 5.49m (water level 1:35pm 5/2/00)	SM	13	-	-	-	-	-	-	SILTY SAND, SM: Firm; moist; dark grayish-brown; about 70% fine sand; about 30% low plasticity fines; perched water; easy drilling
(19.2') 5.85m	SP-SM		-	-	-	-	-	-	POORLY GRADED SAND WITH SILT, SP-SM: Firm; moist; dark gray; about 90% fine to medium sand; about 10% low plasticity fines; easy drilling
(21.0') 6.40m	CL	7	-	-	-	-	-	-	LEAN CLAY WITH SAND, CL: Stiff; very moist to almost wet; very dark grayish-brown; about 85% medium plasticity fines; about 15% fine sand; trace of organic matter; easy drilling
(24.0') 7.32m	ML	10	0	47	53	-	-	11	SANDY SILT, ML: Firm; moist; very dark grayish-brown; low plasticity fines; fine sand; easy drilling
(27.0') 8.23m (water level 8:55am 5/2/00)	CL	11	-	-	-	-	-	-	LEAN CLAY WITH SAND, CL: Stiff; very moist to almost wet; olive-gray; about 75% medium plasticity fines; about 25% fine sand; perched water; easy drilling
(30.0') 9.14m	ML	8	0	39	61	-	NP	21	SANDY SILT, ML: Stiff; moist; black; non-plastic fines; fine sand; trace of organic matter; easy drilling. From 9.5m (31.3') to 9.6m (31.4'), contains sand lens
(33.0') 10.06m	SC	14	-	-	-	-	-	-	CLAYEY SAND, SC: Firm; moist; very dark gray; about 80% fine to medium sand; about 20% medium plasticity fines
(36.0') 10.97 m	SM	14 / 11	-	-	-	-	-	-	SILTY SAND, SM: Firm; very moist; very dark gray; about 80% fine sand; about 20% low plasticity fines
(39.0') 11.90m (water level 10:20am 7/21/00)	SM								At 11.9m (39.0'), as above except wet; flowing sands
(42.0') 12.80m									

(Continued in Next Column)

2F-00-114

(Continued from Previous Column)

Depth	Class	N	GR	SA	FI	LL	PI	MC	Description
(42.0') 12.80m	SP-SM	11	0	92	8	-	NP	-	POORLY GRADED SAND WITH SILT, SP-SM: Firm; wet; very dark gray; hard, fine to coarse, subrounded sand; nonplastic fines; flowing sands; switched to mud rotary
(44.0') 13.41m	SP	12	-	-	-	-	-	-	POORLY GRADED SAND, SP: Firm; wet; very dark gray; about 95% fine to medium sand; about 5% nonplastic fines
(47.0') 14.33m	SM	12	0	87	13	-	NP	-	SILTY SAND, SM: Firm; wet; very dark gray; fine to medium sand; nonplastic fines
(50.0') 15.2m	SP-SM	12	-	-	-	-	-	-	POORLY GRADED SAND WITH SILT, SP-SM: Firm; wet; very dark gray; about 90% fine to medium sand; 10% nonplastic fines
(53.0') 16.16m	SP-SM	55	16	77	7	-	NP	-	POORLY GRADED SAND WITH SILT AND GRAVEL SP-SM: Very dense; wet; dark gray; hard, fine to coarse, subrounded sand; hard, subrounded gravel maximum particle size >38mm (1-1/2"); nonplastic fines; very rough, hard and slow drilling; encountered cobbles
(56.0') 17.07m	GRAVEL & COBBLES								At 18.6m (61.0'), flowing sand with clear water. At 19.5m (64.0'), gravel and cobbles with abundant water. At 21.3m (70.0'), lost circulation, 5 batches of mud mixed and placed down hole. At 22.9m (75.0'), bringing up gravel and fine sand, abundant water; flowing sands. At 24.4m (80.0'), very fast, easy drilling through fine sand; abundant water and flowing sands
(83.0') 25.30m									

(Continued in Next Column)

2F-00-114

(Continued from Previous Column)

Depth	Class	N	GR	SA	FI	LL	PI	MC	Description
(83.0') 25.30m	GRAVEL & COBBLES								At 26.2m (86.0') bringing up clayey material; no appreciable amount of water; switched to CalMod sampler
(87.5') 26.67m	SM	73	6	52	42	-	NP	32	SILTY SAND, SM: Very dense; moist; dark grayish-brown; mostly fine sand; nonplastic fines; gravel maximum particle size 76mm (3")
(89.0') 27.13m	ML	74	1	36	63	-	NP	29	SANDY SILT, ML: Very dense; moist; dark grayish-brown; nonplastic fines; mostly fine sand; gravel maximum particle size 76mm (3")
(90.4') 27.55m									B.O.H.

STANDARD PENETROMETER DESCRIPTIVE DATA

COHESIONLESS		COHESIVE	
BLOWS*	RELATIVE DENSITY	BLOWS*	CONSISTENCY
0-4	VERY LOOSE	0-1	VERY SOFT
5-10	LOOSE	2-4	SOFT
11-20	FIRM	5-8	FIRM
21-30	VERY FIRM	9-15	STIFF
31-50	DENSE	16-30	VERY STIFF
51+	VERY DENSE	31+	HARD

*BLOWS PER 0.3 m OF PENETRATION OF A 51 mm O.D. AND 35 mm I.D. SAMPLER DRIVEN BY A 63.5 kg HAMMER, WITH A 0.76 m FREEFALL.

LEGEND:

N	NUMBER OF BLOWS WITH THE STANDARD PENETROMETER
GR	GRAVEL, PERCENT BY WEIGHT PASSING THE 76mm (3-INCH) SIEVE AND RETAINED ON THE NO. 4 SIEVE
SA	SAND, PERCENT BY WEIGHT PASSING THE NO. 4 SIEVE AND RETAINED ON THE NO. 200 SIEVE
FI	FINES, PERCENT BY WEIGHT PASSING THE NO. 200 SIEVE
LL	LIQUID LIMIT
PI	PLASTICITY INDEX (LIQUID LIMIT MINUS PLASTIC LIMIT)
MC	LABORATORY DETERMINED MOISTURE CONTENT IN PERCENT OF DRY WEIGHT
NP	NONPLASTIC
SM	COMBINED FIELD VISUAL IDENTIFICATION AND/OR LABORATORY CLASSIFICATION
B.O.H.	BOTTOM OF HOLE
R	REFUSAL WITH THE STANDARD PENETROMETER (SEE NOTE 10)
A	ATTEMPT WITH THE STANDARD PENETROMETER (SEE NOTE 11)
▽	WATER LEVEL
GRAVEL & COBBLES	COBBLES WITH MATRIX MATERIAL (GRAVEL, SAND AND FINES) MATRIX MATERIAL IS CLASSIFIED IN ACCORDANCE WITH ASTM STANDARDS

NOTES:

1. THIS DRAWING IS TO BE USED ONLY FOR APPROXIMATE DESCRIPTIONS OF SUBSURFACE CONDITIONS.
2. SOIL CLASSIFICATIONS AND DESCRIPTIONS ARE BASED ON FIELD LOG DESCRIPTIONS IN ACCORDANCE WITH ASTM D 2488 (DESCRIPTION AND IDENTIFICATION OF SOILS, VISUAL-MANUAL PROCEDURE) AND/OR LABORATORY TEST RESULTS IN ACCORDANCE WITH ASTM D 2487 (CLASSIFICATION OF SOILS FOR ENGINEERING PURPOSES).
3. ALL COLORS SHOWN ARE IN ACCORDANCE WITH THE MUNSELL SOIL COLOR CHART.
4. ALL SIEVE SIZES SHOWN ARE METRIC WITH U.S. STANDARD IN PARENTHESES.
5. BORING 2F-00-114 WAS DRILLED BETWEEN 2 MAY AND 21 JULY 2000 USING AN INGERSALL RAND A-400 DRILL RIG UTILIZING A 152mm (6") O.D. AND A 203mm (8") HOLLOW STEM FLIGHT AUGER.
6. WHERE COBBLES WERE ENCOUNTERED, LABORATORY GRADATION DATA REPRESENTS MATERIAL PASSING THE 76mm (3-INCH) SIEVE. PARTICLES LARGER THAN THE INSIDE DIAMETER OF SAMPLER WERE NOT RECOVERED. HENCE, ALL GRAVEL AND COBBLE LAYERS REFERENCED IN SOIL BORINGS CONTAINED LARGER PARTICLES OF GRAVEL AND COBBLES THAT ARE NOT REFLECTED IN THE LABORATORY GRADATION TEST RESULTS SHOWN IN THE SOIL BORING LOGS.
7. STANDARD PENETROMETER DATA WERE OBTAINED IN ACCORDANCE WITH ASTM D 1586 UTILIZING A 610mm LONG STANDARD 51mm O.D. BY 35mm I.D. SPLIT BARREL SAMPLER. THE SPLIT-SPOON PENETROMETER WAS DRIVEN USING AN AUTOMATIC-TRIP, 63.5 KG SAFETY HAMMER. ALL SPT "N" VALUES ARE "FIELD", I.E. UNCORRECTED FOR DEPTH.
8. GROUNDWATER WAS ENCOUNTERED AT THE TIME OF EXPLORATIONS; GROUNDWATER LEVELS CAN BE EXPECTED TO FLUCTUATE IN RESPONSE TO RAINFALL VARIATIONS, PARTICULARLY IN THE VICINITY OF SITE DRAINAGE FEATURES.
9. DEPENDING ON THE SOIL MOISTURE AT THE TIME OF CONSTRUCTION, THE SOIL ENCOUNTERED MAY BE UNSTABLE OR POTENTIALLY UNSTABLE. THE PROBABILITY OF UNSTABLE CONDITIONS IS HIGHEST WHEN THE SOIL MOISTURE IS GREATEST.
10. REFUSAL WITH THE STANDARD PENETROMETER IS DEFINED AS ONE OF THE FOLLOWING:
    A. 10 BLOWS FOR NO APPARENT ADVANCEMENT OF THE SAMPLER; OR
    B. 50 BLOWS FOR LESS THAN 152mm (6") ADVANCEMENT OF THE SAMPLER; OR
    C. 100 BLOWS FOR 152mm (6") TO 457mm (18") ADVANCEMENT OF THE SAMPLER.
11. ATTEMPT WITH THE STANDARD PENETROMETER IS DEFINED AS REFUSAL WITHIN THE FIRST 152mm (6") OF SEATING PENETRATION.
12. △ ADDITIONAL LOGS OF EXPLORATIONS ARE SHOWN ON SHEET NOS. B-4 THROUGH B-17 AND B-19 THROUGH B-21.

GRAPHIC SCALE

SCALE 1 : 25 — 0, 0.5, 1, 1.5, 2, 2.5 METERS

US Army Corps of Engineers
Sacramento District

Symbol	Description	Date	Approved
△	Updated title block information Modified note		

Designed by: J. SCIANDRONE | Dwn by: COE-SOIL | Ckd by: R. IWASA | Reviewed by: J. SCIANDRONE | Submitted by: /S/ KEN PATTERMANN ACTG. CHIEF, SOIL DES. SEC.

Date: | Design file no: 1-04-474 | SPEC. No: 1034 | File name: 1034B18.dwg | Plot date: 5 OCT 2001 | Plot scale: 1:1

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 'J' STREET
SACRAMENTO, CA 95814-2922

AMERICAN RIVER CALIFORNIA
AMERICAN RIVER WATERSHED PROJECT
JET GROUT SECTIONS
CONTRACT 1

LOG OF EXPLORATION
2F-00-114

Sheet reference number: B-18
SEQ. 24

Reference – Exploration Log File No.: 1-01-486 Soil Design Section Sheet No.: 18 OF 21 △

MASTER DESIGN FILE: 1034B18.DWG
PLOT DATE: 05-OCT-2001
PLOT TIME:

2F – 96 – 28

STA. 4+737

EL. 12.8 m (41.9')

Depth (m)	Elev. (m)	Symbol	N	GR	SA	FI	LL	PI	MC	Description
0	12.8	SP–SM	44	–	–	–	–	–	–	POORLY GRADED SAND WITH SILT, SP–SM: Dense; moist; brown; about 90% fine to coarse, angular to subrounded sand; about 10% low plasticity fines
0.61 (2.0')	12.19	SM	40	–	–	–	–	–	–	SILTY SAND, SM: Dense; moist; brown; about 85% fine to coarse, angular to subrounded sand; about 15% low plasticity fines
1.22 (4.0')	11.58	ML	21	–	–	–	–	–	–	SANDY SILT, ML: Very stiff; moist; brown; about 65% low plasticity fines; about 35% fine to medium sand
1.83 (6.0')	10.97	ML	14	–	–	–	–	–	–	SILT WITH SAND, ML: Stiff; moist; very dark gray; about 80% low plasticity fines; about 20% fine to medium sand
2.44 (8.0')	10.36	ML	13	–	–	–	–	–	–	SILT WITH SAND, ML: Stiff; moist; olive–brown; about 75% low plasticity fines; about 25% fine to medium sand
3.05 (10.0')	9.75	SM	22	–	–	–	–	–	–	SILTY SAND, SM: Very firm; moist; dark brown; about 75% fine to coarse, subangular to subrounded sand; about 25% nonplastic fines
4.11 (13.5')	8.69	SC	11	1	66	33	28	8	–	CLAYEY SAND, SC: Firm; moist; olive–brown; fine to coarse, mostly medium, subangular to subrounded sand; low plasticity fines; gravel maximum particle size 19 mm (3/4"); charcoal material present
4.57 (15.0')	8.23									
5.18 (17.0')	7.62	ML	10	–	–	–	–	–	–	SANDY SILT, ML: Stiff; moist; brown; about 55% low plasticity fines; about 45% fine to medium sand
6.25 (20.5')	6.55	ML	8	–	–	–	–	–	–	SANDY SILT, ML: Firm; moist; brown; about 60% low plasticity fines; about 40% fine to medium sand
7.32 (24.0')	5.48	ML	6	–	–	–	–	–	–	SILT, ML: Firm; moist; dark gray; about 90% low plasticity fines; about 10% fine sand
8.38 (27.5')	4.42	SM	8	–	–	–	–	–	–	SILTY SAND, SM: Loose; moist; very dark gray; about 60% fine sand; about 40% nonplastic fines
9.45 (31.0')	3.35	ML	10	–	–	–	–	–	–	SANDY SILT, ML: Stiff; moist; very dark gray; about 60% nonplastic fines; about 40% fine sand
10.52 (34.5')	2.28									

CONTINUED IN NEXT COLUMN

2F – 96 – 28

CONTINUED FROM PREVIOUS COLUMN

Depth (m)	Elev. (m)	Symbol	N	GR	SA	FI	LL	PI	MC	Description
10.52 (34.5')	2.28	SM	10	–	–	–	–	–	–	SILTY SAND, SM: Loose; moist; very dark gray; about 85% fine to medium sand; about 15% low plasticity fines
11.58 (38.0')	1.22	SM	14	–	–	–	–	–	–	SILTY SAND, SM: Firm; wet; very dark gray; about 85% fine to medium sand; about 15% low plasticity fine; organic material present
12.65 (41.5')	0.15	SM	9	1	82	17	–	NP	–	SILTY SAND, SM: Loose; wet; very dark gray; fine to medium sand; nonplastic fines; gravel maximum particle size 10 mm (3/8"); organic material present
13.11 (43.0')	0.69	SP–SM	8	–	–	–	–	–	–	POORLY GRADED SAND WITH SILT, SP–SM: Loose; wet; very dark gray; about 90% fine to coarse, subangular to subrounded sand; about 10% nonplastic fines; organic material present;
13.72 (45.0')	0.00	SP–SM	7	–	–	–	–	–	–	
15.24 (50.0')										B.O.H.

2F – 96 – 29

STA. 8+904

EL. 14.1 m (46.1')

Depth (m)	Elev. (m)	Symbol	N	GR	SA	FI	LL	PI	MC	Description
0	14.1	SM	59	–	–	–	–	–	–	SILTY SAND WITH GRAVEL, SM: Very dense; moist; yellowish–brown; about 60% fine to coarse, subangular to subrounded sand; about 25% subangular gravel maximum particle size 19 mm (3/4"); about 15% low plasticity fines; no reaction with HCl; easy drilling
0.61 (2.0')	13.49	SM	32	–	–	–	–	–	–	SILTY SAND, SM: Dense; moist; yellowish–brown; about 85% fine to medium sand; about 15% low plasticity to nonplastic fines; trace of gravel maximum particle size 13 mm (1/2"); trace of charcoal present; no reaction with HCl; no odor present; easy drilling
1.22 (4.0')	12.88	SM	13	–	–	–	–	–	–	SILTY SAND, SM: Firm; moist; yellowish–brown; about 85% fine to medium sand; about 15% nonplastic to low plasticity fines; no reaction with HCl; no odor present; easy drilling
1.83 (6.0')	12.27	SM	15	–	–	–	–	–	–	SILTY SAND, SM: Firm; moist; yellowish–brown; about 80% fine to medium sand; about 20% low plasticity fines; no reaction with HCl; no odor present; easy drilling
2.44 (8.0')	11.66	SP–SM	14	–	–	–	–	–	–	
3.05 (10.0')	11.05	SP–SM	9	2	92	6	–	NP	–	POORLY GRADED SAND WITH SILT, SP–SM: Firm to loose; moist; brown; fine to coarse, mostly medium sand; nonplastic fines; gravel maximum particle size 19 mm (3/4"); no reaction with HCl; easy drilling
3.51 (11.5')	10.59									
4.11 (13.5')	10.00	SM	9	–	–	–	–	–	–	SILTY SAND, SM: Loose; moist; grayish–brown; about 85% fine to medium sand; about 15% nonplastic fines; trace of subrounded gravel present; no reaction with HCl; no odor present; easy drilling
5.18 (17.0')	8.93	SP–SM	15	–	–	–	–	–	–	POORLY GRADED SAND WITH SILT, SP–SM: Firm; moist; very dark grayish–brown; about 90% fine to coarse, subangular to subrounded sand; about 10% nonplastic fines; no reaction with HCl; no odor present
6.40 (21.0')	7.70	MH	5	–	–	–	–	–	–	ELASTIC SILT, MH: Firm; moist; dark brown; about 90% low plasticity fines; about 10% fine sand; no reaction with HCl; weak iron oxide staining
7.32 (24.0')	6.78	ML	4	0	25	75	33	3	–	SILT WITH SAND, ML: Soft; wet; dark yellowish–brown; nonplastic fines; fine sand; no reaction with HCl
7.77 (25.5')	6.33	SP–SM	4	–	–	–	–	–	–	POORLY GRADED SAND WITH SILT, SP–SM: Very loose; wet; dark brown; about 90% fine sand; about 10% nonplastic fines; no reaction with HCl
8.38 (27.5')	5.72	MH		–	–	–	–	–	–	ELASTIC SILT, MH: Soft; wet; dark yellowish–brown; about 95% low plasticity fines; about 5% fine sand; no reaction with HCl
8.75 (28.7')	5.35									
9.45 (31.0')	4.65									

CONTINUED IN PREVIOUS COLUMN

2F – 96 – 29

CONTINUED FROM NEXT COLUMN

Depth (m)	Elev. (m)	Symbol	N	GR	SA	FI	LL	PI	MC	Description
9.45 (31.0')	4.65	SM	8	–	–	–	–	–	–	SILTY SAND, SM: Loose; moist; dark brown; about 85% fine sand; about 15% nonplastic fines; no reaction with HCl
9.75 (32.0')	4.35	SP–SM	11	–	–	–	–	–	–	POORLY GRADED SAND WITH SILT, SP–SM: Loose; moist; very dark grayish–brown; about 90% fine to medium sand; about 10% nonplastic fines; no reaction with HCl
10.52 (34.5')	3.58	SP–SM	11	–	–	–	–	–	–	POORLY GRADED SAND WITH SILT, SP–SM: Firm; moist; very dark grayish–brown; about 90% fine to medium sand; about 10% nonplastic fines; no reaction with HCl
11.58 (38.0')	2.52	CL	17	–	–	–	–	–	–	LEAN CLAY WITH SAND, CL: Very stiff; moist; very dark grayish–brown; about 80% medium plasticity fines; about 20% fine to medium sand; no reaction with HCl
12.65 (41.5')	1.45	SM	13	–	–	–	–	–	–	SILTY SAND, SM: Firm; wet; dark brown; about 80% fine to medium with trace of coarse sand; about 20% nonplastic fines; no reaction with HCl; weak iron oxide staining
13.26 (43.5')	0.84	SP–SM	25	0	93	7	–	NP	–	POORLY GRADED SAND WITH SILT, SP–SM: Very firm; wet; dark brown; fine to medium, mostly medium sand; nonplastic fines; no reaction with HCl At 13.56 m (44.5'), as above except very dark grayish–brown
13.72 (45.0')	0.68									
										B.O.H.

NOTES:

1. THE LEGENDS AND NOTES ARE SHOWN ON SHEET B–1.

GRAPHIC SCALE

SCALE 1 : 25 — 0, 0.5, 1, 1.5, 2, 2.5 METERS

REGISTERED PROFESSIONAL ENGINEER — SAID SALAH-MARS — No. C 050445 — Exp. 06/30/01 — CIVIL — STATE OF CALIFORNIA

US Army Corps of Engineers Sacramento District

Symbol	Description	Symbol	Date Approved	Description	Date Approved

Designed by: R. IWASA (USACE) | Date: 18 JAN. 2000 | Rev.
Dwn by: R. AGUIANO | Ckd by: LI. LUSCHER | Design file no: 1-04-477
Reviewed by: S. PUNYAMURTHULA | SPEC. No: 9824 | 1145
Submitted by: Chief, Civil Design Section A | File name: AB98R02.DWG | Plot date: 14 JAN 2000 | Plot scale: 1:1

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

URS Greiner Woodward Clyde
OAKLAND, CALIFORNIA

SAID SALAH-MARS

AMERICAN RIVER WATERSHED PROJECT
AMERICAN RIVER, CALIFORNIA
LEFT (SOUTH) BANK LEVEE STRENGTHENING
CONTRACT 2

CALIFORNIA

LOGS OF EXPLORATIONS
2F–96–28 & 2F–96–29

Sheet reference number:
B–6
SEQ. 61

DATE=10-26-99 08

2F-97-23

STA. 7+1 17

DEPTH		N	GR	SA	FI	LL	PI	MC	Description
EL. 14.2 m (46.5') 0	SM	21	–	–	–	–	–	–	SILTY SAND, SM: Very firm; moist; dark yellowish-brown; about 60% fine to medium sand; about 40% low plasticity fines
(3.0') 0.91 m	SM	10	–	–	–	–	–	–	SILTY SAND, SM: Loose; moist; dark yellowish-brown; about 80% fine to medium sand; about 20% low plasticity fines
	SM	5	–	–	–	–	–	–	At 1.7 m (5.5'), as above except lenses of POORLY GRADED SAND, SP and SILTY SAND, SM present
(7.0') 2.13 m	SP	7	–	–	–	–	–	–	POORLY GRADED SAND, SP: Loose; moist; brown; about 95% fine to coarse, subangular to subrounded sand; about 5% fines
	SP	6							
(11.0') 3.35 m	SP	5	0	98	2	–	NP	4	
(12.5') 3.81 m	SP	6	–	–	–	–	–	–	POORLY GRADED SAND, SP: Loose; moist; fine to medium, mostly medium with trace of coarse sand; nonplastic fines
(15.0') 4.57 m	SM	6	–	–	–	–	–	–	SILTY SAND, SM: Loose; moist; dark yellowish-brown; about 65% fine to medium sand; about 35% low plasticity fines
(18.0') 5.49 m	SM	TUBE #1	0	58	42	26	3	14	SILTY SAND, SM: Moist; brown; fine to medium, mostly fine sand; nonplastic to low plasticity fines; easy to push tube
(20.0') 6.10 m			–	–	–	–	–	–	
(21.5') 6.55 m	ML	5	–	–	–	–	–	–	SILT, ML: Firm; moist; dark brown; about 95% low plasticity fines; about 5% fine sand
	ML	7	–	–	–	–	–	–	
(28.5') 8.69 m	ML	6	–	–	–	–	–	–	SILT, ML: Firm; moist; brown; about 90% low plasticity fines; about 10% fine sand
(31.5') 9.60 m	CL	3	–	–	–	–	–	–	LEAN CLAY WITH SAND, CL: Soft; moist; dark brown; about 80% low to medium plasticity fines; about 20% fine sand; mud added to hole in anticipation of flowing sands
(35.0') 10.67 m	CL	8	–	–	–	–	–	–	SANDY LEAN CLAY, CL: Firm; moist; dark brown; about 70% low to medium plasticity fines; about 30% fine sand
(38.5') 11.73 m									

CONTINUED IN NEXT COLUMN

2F-97-23

CONTINUED FROM PREVIOUS COLUMN

		N	GR	SA	FI	LL	PI	MC	Description
(38.5') 11.73 m	SM	13	–	–	–	–	–	–	SILTY SAND, SM: Firm; moist; olive-brown; about 80% fine sand; about 20% low plasticity fines
▽(41.5') 12.65 m									
(43.0') 13.11 m	SP-SM	12	0	88	12	–	NP	27	POORLY GRADED SAND WITH SILT, SP-SM: Firm; wet; olive-brown; fine to medium sand; nonplastic fines; water elevation varies
(45.0') 13.72 m	SM	9	–	–	–	–	–	–	SILTY SAND, SM: Loose; wet; dark olive-brown; about 60% fine sand; about 40% low plasticity fines
(48.5') 14.78 m	SP-SM	16	0	88	12	–	NP	33	POORLY GRADED SAND WITH SILT, SP-SM: Firm; wet; very dark gray; fine to medium, mostly fine sand; nonplastic fines
(50.0') 15.24 m									
(51.5') 15.70 m	SM	12	–	–	–	–	–	–	SILTY SAND, SM: Firm; wet; very dark gray; about 85% fine to coarse, subangular to subrounded sand; about 15% low plasticity fines; traces of fine, subrounded gravel maximum particle size 13 mm (1/2")
									At 16.3 m (53.5'), as above except gravels present; rough drilling
(55.0') 16.76 m	GRAVEL AND COBBLES	64	84	12	4	–	NP	8	GRAVEL AND COBBLES with a matrix of POORLY GRADED GRAVEL, GP: Very dense; wet; very dark gray; fine to coarse, angular to subrounded gravel maximum particle size 51 mm (2"); fine to coarse, angular to subrounded sand; nonplastic fines; switched to 64 mm (2-1/2") I.D. sampler; rough drilling but good rate of advancement
(56.5') 17.22 m			–	–	–	–	–	–	
(60.0') 18.29 m	GRAVEL AND COBBLES	84*	–	–	–	–	–	–	GRAVEL AND COBBLES with a matrix of POORLY GRADED SAND, SP: Very dense; wet; very dark gray; about 95% fine to coarse, subangular to subrounded sand; about 5% fines; 64 mm (2-1/2") I.D. sampler; rough drilling
									At 19.5 m (64.0'), as above except smooth drilling
(65.0') 19.81 m	GRAVEL AND COBBLES	24	23	66	1	1	NP	20	
(66.5') 20.27 m			–	–	–	–	–	–	GRAVEL AND COBBLES with a matrix of POORLY GRADED SAND WITH SILT AND GRAVEL, SP-SM: Very firm; wet; olive; fine to coarse, mostly fine, angular to subrounded sand; fine, angular to subangular gravel maximum particle size 25 mm (1"); smooth drilling
(70.0') 21.34 m	ML	A	0	17	83	–	9	34	
(71.5') 21.79 m	ML		–	–	–	–	–	–	SILT WITH SAND, ML: Hard; moist; light olive-brown; low plasticity fines; fine to medium, mostly fine sand
(73.0') 22.25 m	ML								At 22.3 m (73.0'), attempted Shelby tube; rock in tube, no recovery
	ML		–	–	–	–	–	–	At 23.2 m (76.0'), smooth drilling
(78.5') 23.93 m	CL	45	–	–	–	–	–	–	SANDY LEAN CLAY, CL: Hard; moist; olive-brown; about 70% low to medium plasticity fines; about 30% fine to coarse, mostly fine to medium, subangular to subrounded sand
(80.0') 24.38 m									B.O.H.

NOTES:

1. THE LEGENDS AND NOTES ARE SHOWN ON SHEET B-1.

GRAPHIC SCALE

SCALE 1 : 25 — 0, 0.5, 1, 1.5, 2, 2.5 METERS

REGISTERED PROFESSIONAL ENGINEER — SAID SALAH-MARS — No. C 050445 — Exp. 06/30/01 — CIVIL — STATE OF CALIFORNIA

US Army Corps of Engineers
Sacramento District

Symbol	Description	Date	Approved	Symbol	Description	Date	Approved

Designed by: R. IWASA (USACE)
Dwn by: FIA/MI
Ckd by: LL LUSCHER
Revised by: S. FUNYAMURTHULA
Submitted by: Chief, Design Section A
Date: 19 JAN. 2000
Design file no: 1-04-477
SPEC. No: 1140
File name: ABSDRAZ.DWG
File date: 14 JAN. 2000
Plot scale: 1 : 1
Rev.

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

URS Greiner Woodward Clyde
OAKLAND, CALIFORNIA

SAID SALAH-MARS

CALIFORNIA
AMERICAN RIVER WATERSHED PROJECT
AMERICAN RIVER WATERSHED (COMMON FEATURES), CALIFORNIA
LEFT (SOUTH) BANK LEVEE STRENGTHENING
CONTRACT 2

LOG OF EXPLORATION
2F-97-23

Sheet reference number:
B-20
SEQ. 75

J:\CADSHARED\ARVRFINAL\CONTRACT2\AR820-02.DWG 14FULL-75SIP.scp

2F-99-17

STA. 6+899

DEPTH	N	GR	SA	FI	LL	PI	MC	Description
EL.14.0 m (45.9') 0								
	6							POORLY GRADED SAND WITH SILT, SP-SM: Loose; moist; light brown; fine to medium sand; trace coarse sand; nonplastic fines
(10.0') 3.05 m	6	1	93	6				At 3.05m (10'), as above but becomes wet
(11.5') 3.51 m								
	7							At 4.57m (15'), as above but becomes moist to wet, gray
(17.5') 5.33 m								
(20.0') 6.10 m	7	0	68	32				
(21.5') 6.55 m	7							SILTY SAND, SM: Loose; moist; brown; fine sand; nonplastic fines; trace mica
	11							At 9.14m (30'), as above but becomes firm and sandier (about 75%-80% fine sand, about 20%-25% silt)
(35.0') 10.67 m								

SP-SM

SM

CONTINUED IN NEXT COLUMN

2F-99-17

CONTINUED FROM PREVIOUS COLUMN

DEPTH	N	GR	SA	FI	LL	PI	MC	Description
(35.0') 10.67 m	9							At 10.67m (35'), as above but becomes loose and wet, 85% fine sand, 15% nonplastic fines
(37.5') 11.43 m								
	9							WELL GRADED SAND WITH SILT, SW-SM: Loose; wet; brown; fine to coarse sand; nonplastic fines; trace mica
(45.0') 13.72 m	10	0	90	10				At 13.72m (45'), as above but becomes dark gray
(46.5') 14.17 m								
(49.0') 14.94 m								
(50.0') 15.24 m	14	34	62	4				POORLY GRADED SAND WITH GRAVEL, SP: Firm; wet; dark gray; fine to coarse sand; fine gravel; nonplastic fines; trace mica
(51.5') 15.70 m								
(52.5') 16.00 m	40							POORLY GRADED GRAVEL AND COBBLES WITH SAND, GP: Dense; wet; gray-brown; about 70% fine gravel; about 30% fine to coarse sand; cobbles
								Between 16.46m (54') and 20.4m (67') several thin layers of fine sand
(70.0') 21.33 m								

SM

SW-SM

SW

GRAVEL AND COBBLES

CONTINUED IN NEXT COLUMN

2F-99-17

CONTINUED FROM PREVIOUS COLUMN

DEPTH	N	GR	SA	FI	LL	PI	MC	Description
(70.0') 21.33 m								
(71.5') 21.79 m								
(75.0') 22.86 m	72	0	15	85				SILT WITH SAND, ML: Hard; wet; greenish-brown; low plasticity fines; fine to coarse sand
(76.5') 23.32 m								
(77.5') 23.62 m								
	62							ELASTIC SILT, MH: Hard wet; greenish brown; medium plasticity fines; trace fine to medium sand
(81.5') 24.84 m								

GRAVEL AND COBBLES

ML

MH

B.O.H.

NOTES:

1. SAMPLERS USED TO RECOVER SOIL SAMPLES IN THE FIELD GENERALLY CONSISTED OF STANDARD PENETRATION AND MODIFIED CALIFORNIA TEST SAMPLERS RAGING FROM 35mm (1 3/8-INCH) TO 64 mm (2 1/2-INCH) INSIDE DIAMETER. THEREFORE, PARTICLES LARGER THAN THE INSIDE DIAMETER OF SAMPLER WERE NOT RECOVERED. HENCE, ALL GRAVEL AND COBBLE LAYERS REFERENCED IN SOIL BORINGS CONTAINED LARGER PARTICLES OF GRAVEL, COBBLES, AND OCCASIONAL BOULDERS THAT ARE NOT REFLECTED IN THE LABORATORY GRADATION TEST RESULTS SHOWN IN THE SOIL BORING LOGS.
2. THE LEGENDS AND NOTES ARE SHOWN ON SHEET B-1.
3. DRILLING METHOD DID NOT ALLOW OBSERVATION OF DEPTH TO GROUNDWATER TABLE.

REGISTERED PROFESSIONAL ENGINEER
SAID SALAH-MARS
No. C 050445
Exp. 06/30/01
CIVIL
STATE OF CALIFORNIA

GRAPHIC SCALE

SCALE 1 : 25 — 0, 0.5, 1, 1.5, 2, 2.5 METERS

US Army Corps of Engineers
Sacramento District

Symbol	Description	Date	Approved	Symbol	Description	Date	Approved

Designed by: S. PARYANARTHULA
Dwn by: M. IBRAHIM
Ckd by: L. LIEBSCHER
Reviewed by: S. PARYANARTHULA
Submitted by: Chief, Civil Design section A
Date: 18 JAN. 2000
Design file no: 1-04-477
SPEC. No: 1140
File name: AR99R02.DWG
Plot date: 14 JAN. 2000
Plot scale: 1 : 1
Rev.

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

URS Greiner Woodward Clyde
OAKLAND, CALIFORNIA

SAID SALAH-MARS

AMERICAN RIVER
AMERICAN RIVER WATERSHED PROJECT
(COMMON FEATURES), CALIFORNIA
LEFT (SOUTH) BANK LEVEE STRENGTHENING
CONTRACT 2

LOG OF EXPLORATION
2F-99-17

Sheet reference number:
B-39
SEQ. 94

C:\DGN\ARV\ARV\WWW\CONTRACT2\DGN\ARV99R02.DWG 1-FULL-7656P.dwg

DATE STARTED 6/3/08 **DATE COMPLETED** 6/3/08	**GROUND ELEVATION** 48.07 ft **ELEVATION DATUM** NAVD 88	**TOTAL DEPTH OF BORING** 70.0 ft
DRILLING CONTRACTOR Gregg Drilling & Testing, Inc.	**DRILLER'S NAME** E. Santellan **HELPER'S NAME** R. Ryon/M. Ageev	**TOTAL DEPTH OF FILL** 13.2 ft
DRILLING METHOD 0 - 3 ft: HA, 3 - 16.5 ft: HSA, 16.5 - 70 ft: Rotary Wash	**DRILL RIG MAKE AND MODEL** MARL M-10 (Gregg Rig No. D-44)	**CONSULTANT COMPANY** GEI Consultants, Inc.
DRILL BIT SIZE AND TYPE (HOLE DIAMETER) 5-inch drag bit; tricone drill through bit	**DRILLING ROD TYPE AND DIAMETER** 6" HSA, 94mm	**FIELD LOGGER** M. Horse
☒ **VERTICAL** ☐ **INCLINED**	**CASING TYPE, DIAMETER, INSTALLATION DEPTH** Surface, 6-in., 15 ft	**FIELD LOG REVIEWER** G. Bradner
SAMPLER TYPE(S) Bag, DCore(2.5"), MCal(2"), PCore(2.5"), SPT(1.375")	**HAMMER TYPE, MAKE/MODEL, WEIGHT/DROP** Marl, automatic, 140 lbs / 30-inch drop	**HAMMER EFFICIENCY** 83%
BOREHOLE BACKFILL OR COMPLETION 5% bentonite grout	**GROUNDWATER READING: DURING DRILLING** N/A due to rotary wash drilling method	**AFTER DRILLING (DATE-TIME)**

Elevation, feet	Depth, feet	Material Graphics	CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in. [Blows per ft]	N_{60}(ASTM)	PP or TV, tsf	LABORATORY DATA: Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	Other Lab Tests	REMARKS
	0		Gravel Road Base.												
	1		[LEVEE FILL] FAT CLAY (CH); very stiff; greenish black (5G 2.5/1); moist; 95% high plasticity, high dry strength, high toughness fines; 5% sand; 0% gravel.		1				3.0P						S01A_001_002B
	2				2										No Recovery; cobble removed
45	3		1-foot thick Fat Clay with Sand (CH) lense; 5% gravel, max. 1/2 in.; 10% fine to medium sand; 85% high plasticity fines.												S03B_003_004P S03A_004_005P
	4		[LEVEE FILL] SILTY CLAYEY SAND (SC-SM); dense; dark brown (7.5YR 3/4); moist; 75% fine to medium sand; 25% low plasticity fines; 0% gravel.		3	100									
	5				4	44	12 16 13 [29]	40					25	HD	S04A_005_007S
	6														
	7		[LEVEE FILL] Poorly Graded SAND with Silt (SP-SM); medium dense; olive brown (2.5Y 4/4); dry; 91% fine to medium sand; 9% fines; 0% gravel.		5	71				3			9		S05A_007_008P
40	8														
	9				6	0	9 9 10 [19]	26							No Recovery; soft material
	10		As above except moist.												S07A_011_011P Driller notes very soft material
	11														
	12				7	40									Driller notes very easy drilling
FILL .35	13		[Approximate bottom of Levee Fill 13.2'].												
	14														
	15		SANDY SILT (ML); loose; dark yellowish brown (10YR 3/6); moist; 50% fine sand; 50% low plasticity fines; 0% gravel.		8	50	3 3 4 [7]	10					50	HD	S08A_016_016S
	16														
	17				9	0									No Recovery Very soft material; easy drilling
30	18														
	19														
	20														

Draft 4 After Final Markups 11/5/2009

Borehole Location: South Bank Crest **County:** Sacramento
Coordinates: Northing: 1,976,188.21 **Easting:** 6,719,198.27
Latitude: 38.58732 **Longitude:** -121.44887
Levee Station or Milepost: 1200+59 **Levee Mile:** 3.79
Levee Segment
Survey Method: GIS/LiDAR **Coord. System:** CA State Plane Zone II
Channel / River Name / Feature: American River

LOG OF BORING
WCSBAR_003B
Sheet 1 of 4

Urban Levee Geotechnical Evaluations Program
Engineering Support Services

DWR LEVEE U/NU SOIL LOG REV1; AMERICAN RIVER LEVEE BORINGS 11-5-2009.GPJ; DWR WORKING LIBRARY 092009.GLB; 11/5/09

Elevation, feet	Depth, feet	Material Graphics	CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in. [Blows per ft]	N_{60}(ASTM)	PP or TV, tsf	LABORATORY DATA: Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	Other Lab Tests	REMARKS
	20		SANDY SILT (ML); as above except medium dense.		10	0	5 6 6 [12]	17							No Recovery Rock stuck in hole
	21														
	22		SANDY SILT (ML); medium dense; very dark brown (7.5YR 2.5/3); moist; 65% low plasticity fines; 35% fine to medium sand; 0% gravel.		11	0	7 8 11 [19]								No Recovery Sandy Silt observed in cuttings
25	23				12	0	5 4 7 [11]	15							No Recovery Driller notes rock still present in hole
	24														
	25		Poorly Graded SAND with Silt (SP-SM); medium dense; dark brown (7.5YR 3/4); moist; 91% fine to medium sand; 9% low plasticity fines; 0% gravel; predominantly fine sand.		13	100									S13A_025_025P
	26				14	100	7 10 10 [20]						9		2.25-inch cobble fragment on top of sample S14A_025_027M
	27				15	44	5 5 9 [14]	19		11				SG	S15A_027_028S
20	28														S16A_028_029P
	29				16	42									
	30		SILTY CLAYEY SAND (SC-SM); medium dense; dark brown (7.5YR 3/4); moist; 77% fine sand; 23% low plasticity fines; 0% gravel.		17	56	7 5 11 [16]	22					23	HD	S17A_030_032S
	31														
	32				18	50									S18A_032_033P
15	33														
	34														
	35		SILTY SAND (SM); dense; dark yellowish brown (10YR 3/6); moist; 80% fine to medium sand; 20% fines; 0% gravel.		19	56	9 12 13 [25]	35		12			20		S19A_035_037S
	36														
	37				20	79									Box 1 Representative S20A_038_038P
10	38														
	39														
	40		As above except medium dense.		21	61	9 11 11 [22]	30							S21A_040_042P
	41														
	42		As above except very dark greenish gray (5G 3/1).		22	45									S22A_042_043P
5	43														
	44														
	45														

Draft 4 After Final Markups 11/5/2009

Borehole Location: South Bank Crest **County:** Sacramento
Coordinates: Northing: 1,976,188.21 **Easting:** 6,719,198.27
Latitude: 38.58732 **Longitude:** -121.44887
Levee Station or Milepost: 1200+59 **Levee Mile:** 3.79
Levee Segment
Survey Method: GIS/LiDAR **Coord. System:** CA State Plane Zone II
Channel / River Name / Feature: American River

LOG OF BORING
WCSBAR_003B
Sheet 2 of 4

Urban Levee Geotechnical Evaluations Program
Engineering Support Services

Elevation, feet	Depth, feet	Material Graphics	CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in. [Blows per ft]	N_{60}(ASTM)	PP or TV, tsf	LABORATORY DATA: Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	Other Lab Tests	REMARKS
	45		SILTY SAND (SM); as above.												
	46				23	67	7 8 8 [16]	22							S23A_045_047S
	47														S24B_047_047P S24A_048_048P
0	48		Well-Graded GRAVEL (GW); dense; dark olive gray (5Y 3/2); moist; 85% fine to coarse, subrounded gravel, max. 2 1/4 in.; 10% fine to medium sand; 5% fines.		24	36									Driller notes change; rig chatter
	49														
	50		3-inch thick Poorly Graded Sand (SP) lense; 96% fine to medium sand; 4% fines.												
	51				25	50	10 11 13 [24]	33		20			4		S25B_050_051S S25A_051_052S
	52														No Recovery Rig chatter and shaking
-5	53				26	0									
	54														
	55		3-inch thick Poorly Graded Sand (SP) lense; 95% fine to medium sand; 5% fines. As above except very dense.												
	56				27	39	32 40 30 [70]	97							S27B_055_056S S27A_056_057S
	57														No Recovery Rig chatter; gravel and cobble fragments present in slough
-10	58				28	0									
	59														
	60		Well-Graded GRAVEL with Sand (GW); very dense; dark olive gray (5Y 3/2); moist; 70% fine to coarse, subrounded gravel; 25% fine to medium sand; 5% fines.		29	67	50/6"								S29A_060_061S
	61														No Recovery Rig chatter and shaking; driller notes gravels/cobbles
	62				30	0									
-15	63														Use tricone bit; rig chatter and shaking; driller notes cobbles
	64														
	65		Gravel and cobble fragments, max. 1 1/2 in., present in slough.		31	0	50/3"								No Recovery
	66														
	67														Driller notes gravels/cobbles
-20	68														
	69														
	70														

Draft 4 After Final Markups 11/5/2009

Borehole Location: South Bank Crest **County:** Sacramento
Coordinates: Northing: 1,976,188.21 **Easting:** 6,719,198.27
Latitude: 38.58732 **Longitude:** -121.44887
Levee Station or Milepost: 1200+59 **Levee Mile:** 3.79
Levee Segment
Survey Method: GIS/LiDAR **Coord. System:** CA State Plane Zone II
Channel / River Name / Feature: American River

LOG OF BORING
WCSBAR_003B
Sheet 3 of 4

Urban Levee Geotechnical Evaluations Program
Engineering Support Services

Elevation, feet	Depth, feet	Material Graphics	CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in. [Blows per ft]	N_{60}(ASTM)	PP or TV, tsf	LABORATORY DATA: Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	Other Lab Tests	REMARKS
	70														Refusal due to gravel/cobbles
	71		Borehole terminated at 70 feet. Backfilled with 5% bentonite grout.												
	72														
-25	73														
	74														
	75														
	76														
	77														
-30	78														
	79														
	80														
	81														
	82														
-35	83														
	84														
	85														
	86														
	87														
-40	88														
	89														
	90														
	91														
	92														
-45	93														
	94														
	95														

Draft 4 After Final Markups 11/5/2009

Borehole Location: South Bank Crest **County:** Sacramento
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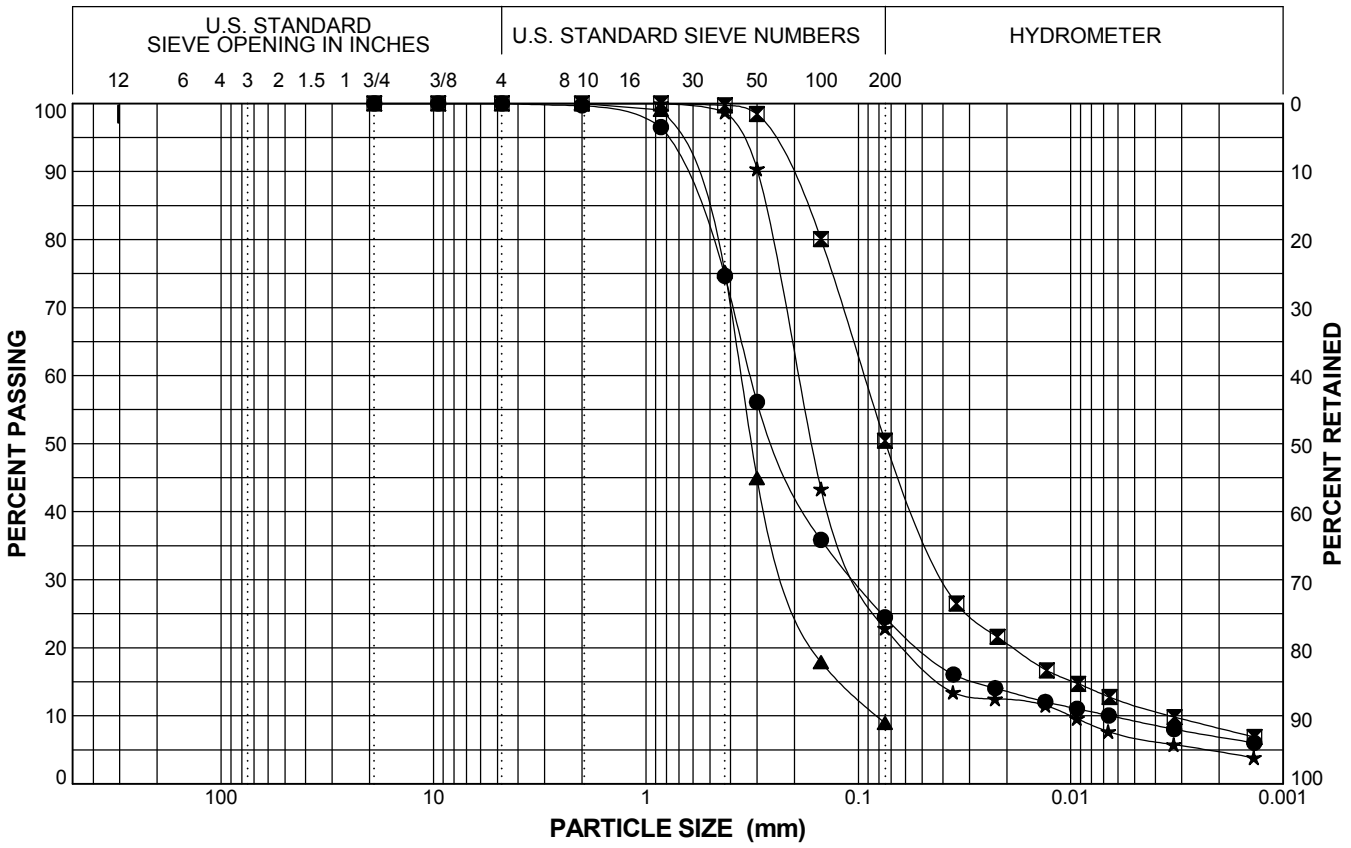
LOG OF BORING
WCSBAR_003B
Sheet 4 of 4

Urban Levee Geotechnical Evaluations Program
Engineering Support Services

DWR LEVEE U/NU SOIL LOG REV1; AMERICAN RIVER LEVEE BORINGS 11-5-2009.GPJ; DWR WORKING LIBRARY 092009.GLB; 11/5/09

BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		coarse	fine	coarse	medium	fine	



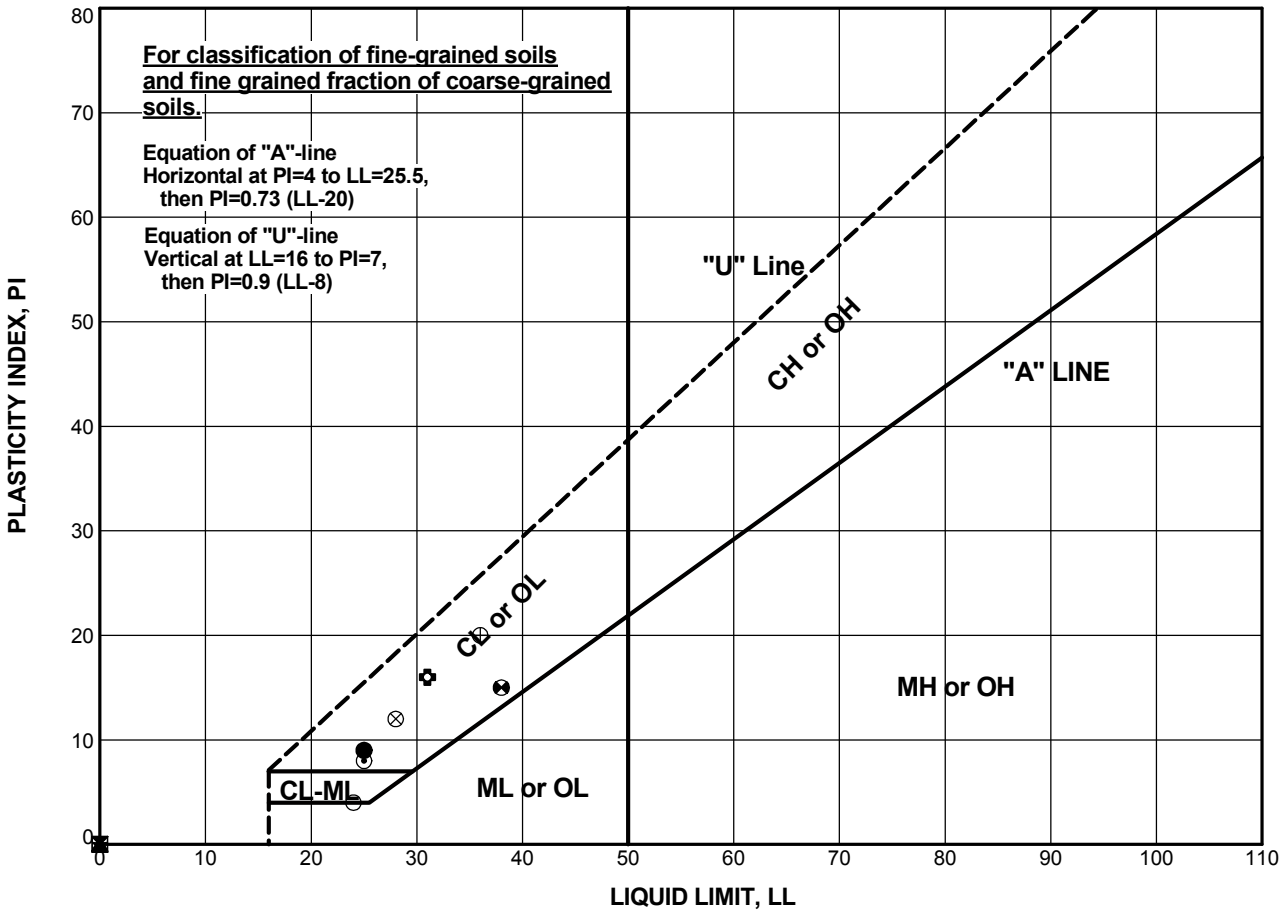
Boring Number	Sample Number	Depth (feet)	Symbol	%G	%S	%F	Classification
WCSBAR_003B	S04A_005_007S	5	●	0.0	75.5	24.5	SILTY CLAYEY SAND (SC-SM)
WCSBAR_003B	S08A_016_016S	15	⊠	0.0	49.6	50.4	SANDY SILT (ML)
WCSBAR_003B	S14A_025_027M	25	▲	0.0	91.0	9.0	Poorly Graded SAND with Silt (SP-SM)
WCSBAR_003B	S17A_030_032S	30	★	0.0	77.1	22.9	SILTY CLAYEY SAND (SC-SM)

Urban Levee Geotechnical Evaluations Program
Engineering Support Services

American River

PARTICLE SIZE DISTRIBUTION CURVES

DWR LEVEE U/NU SIEVE CURVES #200 REV1; AMERICAN RIVER LEVEE BORINGS 11-5-2009.GPJ; DWR WORKING LIBRARY 092009.GLB; 2/3/10



Boring Number	Sample Number	Depth (feet)	Test Symbol	WC (%)	LL	PL	PI	Classification
WCNBAR_001B	S06A_015_017S	15	●	13.7	25	16	9	CLAYEY SAND (SC)
WCNBAR_002B	S04A_005_007S	5	⊠	17.5	NP	NP	NP	SANDY SILT (ML)
WCNBAR_002B	S08A_015_017S	15	▲		NP	NP	NP	SILTY SAND (SM)
WCNBAR_003B	S04A_005_007S	5	★	15.6	NP	NP	NP	SANDY SILT (ML)
WCNBAR_003B	S29A_070_072S	70	⊙	18.5	25	17	8	LEAN CLAY (CL)
WCNBAR_004B	S02A_002_003B	2	✿	15.9	31	15	16	LEAN CLAY (CL)
WCNBAR_004B	S08A_014_014P	13.5	○	17.6	24	20	4	SANDY SILTY CLAY (CL-ML)
WCNBAR_005B	S08A_010_012S	10	△	10.4	NP	NP	NP	SILTY SAND (SM)
WCNBAR_005B	S16A_036_036S	35	⊗	17.8	28	16	12	LEAN CLAY with Sand (CL)
WCNBAR_005B	S18A_041_042S	40	⊕	16.3	36	16	20	LEAN CLAY with Sand (CL)
WCNBAR_005B	S22A_050_052S	50	□	17.7	NP	NP	NP	SILTY SAND (SM)
WCSBAR_001B	S02A_002_003B	2	⊗	16.8	38	23	15	LEAN CLAY with Sand (CL)

Urban Levee Geotechnical Evaluations Program
Engineering Support Services

American River

PLASTICITY CHART

DWR LEVEE U/NU ATT. PLOT (U LINE) REV1; AMERICAN RIVER LEVEE BORINGS 11-3-2009.GPJ; DWR WORKING LIBRARY 092009.GLB; 11/3/09

Vector Engineering Inc.

143E Spring Hill Drive, Grass Valley, CA 95945 (530) 272-2448

LABORATORY SERVICES

WATER CONTENT & MINUS # 200 % with GRAVEL

Client : GEI Consultants

Project No: 061724.0026

Lab Log: **2565**

Project Name: URS/DWR Urban Levee Program-American River TO-44 WO-26

Report Date: July 9, 2008

LSN	Sample ID	Soil Classification **	Water Content (%)	Percent Minus #200	Percent Sand	Percent Gravel
2565BC	WCSBAR_002B_50_S23A_050_052S	Brown Sand w/ Silt (SM)*	20.1	10.2	89.8	0.0
2565BE	WCSBAR_003B_7_S05A_007_008P	Brown Sand w/ Silt (SM)*	3.3	9.5	90.5	0.0
2565BJ	WCSBAR_003B_35_S19A_035_037S	Brown Sand w/ Silt (SM)*	12.3	19.9	80.1	0.0
2565BK	WCSBAR_003B_50_S25B_050_051S	Brown Sand w/ Silt (SM)*	20.2	4.0	96.0	0.0
2565BV	WCSBAR_005B_14_S07A_014_015P	Dark Brown Sandy Silt (ML)	22.9	50.6	49.4	0.0

Notes: ** Classifications are based on ASTM D-2487 when appropriate test results are available and per ASTM D-2488 when visual

These results apply only to the above listed samples. The data and information are proprietary and can not be released without authorization of Vector Engineering Inc. By accepting the data and results represented on this page, Client agrees to limit the liability of Vector Engineering, Inc. from Client and all other parties claims arising out of the use of this data to the cost for the respective test(s) represented here, and Client agrees to indemnify and hold harmless Vector from and against all liability in excess of the aforementioned limit.

Entered By: SK

Rev. By:

Lab Log: **2565**

ARS REACH F – SACRAMENTO RIVER EAST – U1 LM 5.92

STRATIGRAPHY INPUT

BORING LOGS

LABORATORY TESTING

AMERICAN RIVER WATERSHED - COMMON FEATURES PROJECT
GENERAL REEVALUATION REPORT - GEOTECHNICAL ANALYSIS
SACRAMENTO RIVER SOUTH RF2 U9 LM 5.92
Table F-2-14: Permeability and Strength Selection for Analysis

Boring Number	Top of Boring Elevation (ft, NAVD 88)	Layer ID	Soil Description	USCS Soil Classification	Depth to Top of Layer (ft)	Depth to Bottom of Layer (ft)	Elevation of Top of Layer (ft, NAVD 88)	Elevation of Bottom of Layer (ft, NAVD 88)	Layer Thickness (ft)	Average Depth to Groundwater During Drilling	Laboratory and Field Data										Comments
											Average % Fines	Average Field N (blows/ft)	Average N_{60} (blows/ft)[1]	Average Normalized Blow Count, $N_{1,60}$ (blows/ft)[2]	Torvane (tsf)	Pocket Penetrometer (tsf)	Average Unit Weight (pcf)	PI	LL	LI	
2F-05-G4-2, 2F-05-G4-2A	34.00	1	Silty Sand (SM) with Silty (ML) and Poorly Graded	SM	0.00	16.00	34.00	18.00	16.00			16	25								
		2	Silt Blanket (ML)	ML	16.00	21.50	18.00	12.50	5.50		57	6	7								
		3	Silty Sand (SM)	SM	14.49	28.69	12.50	4.80	7.70		44										
		4	Silt (ML) and Lean Clay (CL)	ML	21.50	40.00	4.80	-6.00	10.80		9	19	22								
		5	Silty Sand (SM), Poorly Graded Sand (SP)	SM	40.00	98.00	-6.00	-64.00	58.00		10	57	59								
		6	Poorly Graded Gravel (GP) Poorly Graded	GP	98.00	133.98	-64.00	-99.98	35.98		4	25									
		7	Lean Clay with Silt (CL w/ ML)	CL	133.98	143.00	-99.98	-109.00	9.02												
		8	Impervious Clay Cap (CL)	CL																	
		9	Cutoff Wall	SB WALL																	
					Total Depth (ft.)	**143.00**															

Layer ID	Recommended Hydraulic Conductivity					Strenth Coorelations								Strength from Lab Test Data						Recommended Strength Parameters			Comments
	Horizontal kh (kx) cm/sec	Anisotropy Ratio kh/kv	Vertical kv (ky) cm/sec	Horizontal kh (kx) ft/day	Vertical kv (ky) ft/day	Total Overburden Pressure at Mid Layer During Drilling (psf)	Effective Overburden Stress at Mid Layer During Drilling (psf)	OCR from N_{60}[3]	OCR from LI[3]	Su from N (psf)[4]	Su/σ'_o from PI (psf)[4]	Calculated Maximum Past Pressure (psf)[5]	Drained Friction Angle[7]	OCR	σ'_p (psf)	Su (psf)	Su/σ'_o	Φ'	C' (psf)	Φ'	C' (psf)	γ (pcf)	
1	1.00E-02	4.00	2.50E-03	28.350	7.088	0	-499													34	0	125	Sensitivity run w/ phi= 34. Matching URS Sac River P1GER. Original run at phi=
2	2.00E-04	4.00	5.00E-05	0.567	0.142	0	-1170													28	0	120	Sensitivity run w/ phi= 28. Matching URS Sac River P1GER. Original run at
3	5.00E-04	4.00	1.25E-04	1.418	0.354	0	-1144													30	0	125	
4	2.00E-04	4.00	5.00E-05	0.567	0.142	0	-1679													30	50	120	
5	5.00E-03	4.00	1.25E-03	14.175	3.544	0	-4306													30	0	125	
6	2.50E-02	10.00	2.50E-03	70.875	7.088	0	-7238													35	0	135	

4 | 3 | 2 | 1

2 F – 0 5 – G 4 – 2

N 38°29'08.2", W 121°32'55.7"

DEPTH — Levee Crown = 0

Columns: DEPTH | USCS | N | N_{60} | GR | SA | FI | LL | PI | MC | DESCRIPTION

Depth	USCS	Description
0 – 1.5'	GW-GC	AT SURFACE, AGGREGATE MATERIAL, 6" THICK; HOLE LOCATE NEAR LANDSIDE HINGE POINT. WELL GRADED GRAVEL WITH SILT AND SAND, GW-GC: FIRM; DRY; DARK GRAYISH-BROWN; 50% FINE, SUBANGULAR TO SUBROUNDED GRAVEL MAXIMUM PARTICLE SIZE 1/2"; 40% FINE SAND; 10% NONPLASTIC FINES; NO ODOR; NO REACTION WITH HCL; EASY DRILLING
1.5' – 6.0'	SM	SILTY SAND, SM: FIRM TO DENSE; DRY; DARK GRAYISH-BROWN; 80% FINE SAND; 20% NON-PLASTIC FINES; EASY DRILLING
6.0' – 9.0'	ML	SANDY SILT, ML: VERY STIFF; DRY; BROWN; 65% LOW PLASTICITY FINES; 35% FINE TO MEDIUM, SUBROUNDED SAND; NO ODOR; NO REACTION WITH HCL; EASY DRILLING; PP= 3.0 tsf
9.0' – 15.0'	SM	SILTY SAND, SM: FIRM; DRY; BROWN; 75% FINE SAND; 25% NONPLASTIC FINES; AT 9.0' TO 9.2' A LAYER OF CLAY PRESENT; NO ODOR; NO REACTION WITH HCL; EASY DRILLING. AT 12.0', AS ABOVE EXCEPT DENSE; STREAKS OF IRON OXIDE STAINING; TRACE OF CHARCOAL PRESENT
15.0' – 15.3'	ML	SILT WITH SAND, ML: HARD; DRY; BROWN; 85% LOW PLASTICITY FINES; 15% FINE SAND; NO ODOR; NO REACTION WITH HCL; ABUNDANT STREAKS OF IRON OXIDE STAINING; EASY DRILLING; PP=1.75 tsf
15.3' – 18.5'	SM	SILTY SAND, SM: DENSE TO FIRM; DRY; BROWN; 75% FINE SAND; 25% NONPLASTIC FINES; NO ODOR; NO REACTION WITH HCL; STREAKS OF IRON OXIDE STAINING; TRACE OF PYRITE PRESENT; EASY DRILLING
18.5' – 19.0'	CL	
19.0' – 19.7'	SM	SILTY SAND, SM: FIRM; DRY; VERY DARK OLIVE-GRAY; 55% FINE SAND; 45% NONPLASTIC FINES; NO ODOR; NO REACTION WITH HCL; EASY DRILLING
19.7' – 21.0'	CL	LEAN CLAY, CL: STIFF; MOIST; VERY DARK GREENISH-GRAY; MEDIUM PLASTICITY FINES; TRACE OF FINE SAND; NO ODOR; NO REACTION WITH HCL; EASY DRILLING; PP=3.25 tsf
21.0' – 30.2'	SM	SILTY SAND, SM: LOOSE; DRY; VERY DARK OLIVE-GRAY; 55% FINE SAND; 45% NONPLASTIC FINES; NO ODOR; NO REACTION WITH HCL; EASY DRILLING. LEAN CLAY, CL: FIRM; MOIST; VERY DARK GREENISH-GRAY; MEDIUM PLASTICITY FINES; TRACE OF FINE SAND; NO ODOR; NO REACTION WITH HCL; EASY DRILLING; PP=2.25 tsf. LEAN CLAY, CL: FIRM; MOIST; BROWN; MEDIUM PLASTICITY FINES; TRACE OF FINE SAND; NO ODOR; NO REACTION WITH HCL; ABUNDANT STREAKS OF IRON OXIDE STAINING; EASY DRILLING; PP=1.5 tsf. SILTY SAND, SM: LOOSE TO VERY LOOSE; MOIST; BROWN; NONPLASTIC FINES; TRACE OF FINE SAND; NO ODOR; NO REACTION WITH HCL; EASY DRILLING. AT 25.0', AS ABOVE EXCEPT WET; GROUND-WATER ENCOUNTERED. AT 29.0', AS ABOVE EXCEPT LOOSE
30.2' – 41.0'	ML	SANDY SILT, ML: FIRM TO SOFT; WET; BROWN; LOW PLASTICITY FINES; FINE SAND; NO ODOR; NO REACTION WITH HCL; ABUNDANT STREAKS OF IRON OXIDE STAINING. SANDY SILT, ML: SOFT TO FIRM; WET; VERY DARK GREENISH-GRAY; LOW PLASTICITY FINES; FINE SAND; NO ODOR; NO REACTION WITH HCL; EASY DRILLING; PP= 1.25 tsf. AT 33.0', AS ABOVE EXCEPT FIRM; STREAKS OF IRON OXIDE STAINING; PP=1.75 tsf. SANDY SILT, ML: SOFT TO FIRM; WET; VERY DARK GREENISH-GRAY; 65% NONPLASTIC FINES; 35% FINE SAND; NO ODOR; NO REACTION WITH HCL; ABUNDANT MICA PRESENT; EASY DRILLING; PP= 1.75 tsf. AT 37.0', PP=1.0 tsf. AT 39.0', PP=1.5 tsf
41.0' – 54.0'	SP-SM	POORLY GRADED SAND WITH SILT, SP-SM: FIRM TO LOOSE; WET; VERY DARK GREENISH-GRAY; FINE SAND; NONPLASTIC FINES; NO ODOR; NO REACTION WITH HCL; TRACE OF MICA PRESENT; EASY DRILLING. AT 45.0', AS ABOVE EXCEPT FIRM;

Sample data (in order of depth):

N	N_{60}	GR	SA	FI	LL	PI	MC
13	17	–	–	–	–	–	–
28	37	–	–	–	–	–	–
16	21	–	–	–	–	–	–
14	19	–	–	–	–	–	–
25	33	–	–	–	–	–	–
28	37	–	–	–	–	–	–
11	15	–	–	–	–	–	–
5	7	–	–	–	–	–	–
4	5	–	–	–	–	–	–
4	5	–	–	–	–	–	–
2	3	–	–	47	25	1	–
3	4	–	–	–	–	–	–
4	5	–	–	–	–	–	–
3	4	–	–	55	30	4	–
4	5	–	–	–	–	–	–
2	3	–	–	–	–	–	–
6	8	–	–	–	–	–	–
6	8	–	–	–	–	–	–
8	11	–	–	–	–	–	–
6	8	–	–	8	–	–	–
10	13	–	–	–	–	–	–
13	17	–	–	–	–	–	–
13	17	–	–	–	–	–	–

2 F – 0 5 – G 4 – 2

(CONTINUED FROM PREVIOUS COLUMN)

Depth	USCS	Description
54.0' – 69.0'	SM	SILTY SAND, SM: FIRM TO LOOSE; WET; VERY DARK GREENISH-GRAY; 75% FINE TO COARSE, SUBANGULAR TO SUBROUNDED SAND; 25% FINES; TRACE OF FINE GRAVEL MAXIMUM PARTICLE SIZE 3/16"; NO ODOR; NO REACTION WITH HCL; EASY DRILLING. SILTY SAND, SM: FIRM; WET; VERY DARK GREENISH-GRAY; 75% FINE TO MEDIUM, SUBROUNDED SAND; 25% NONPLASTIC FINES; NO ODOR; NO REACTION WITH HCL; EASY DRILLING. SILTY SAND, SM: FIRM; WET; VERY DARK GREENISH-GRAY; 75% FINE TO COARSE, SUBANGULAR TO SUBROUNDED SAND; 25% FINES; TRACE OF FINE GRAVEL MAXIMUM PARTICLE SIZE 3/16"; NO ODOR; NO REACTION WITH HCL; EASY DRILLING
69.0' – 72.0'	SP-SM	POORLY GRADED SAND WITH SILT, SP-SM: FIRM; WET; VERY DARK GREENISH-GRAY; 90% FINE TO MEDIUM, SUBANGULAR TO SUBROUNDED SAND; 10% NONPLASTIC FINES; NO REACTION WITH HCL; EASY DRILLING
72.0' – 81.0'	SM	SILTY SAND, SM: DENSE TO VERY FIRM; WET; VERY DARK GREENISH-GRAY; 75% FINE TO COARSE, SUBANGULAR TO SUBROUNDED SAND; 25% NON-PLASTIC FINES; TRACE OF FINE TO COARSE, SUBANGULAR TO SUBROUNDED GRAVEL MAXIMUM PARTICLE SIZE 7/8"; NO ODOR; NO REACTION WITH HCL; MODERATE DRILLING. AT 75.0', AS ABOVE EXCEPT TRACE OF FINE GRAVEL MAXIMUM PARTICLE SIZE 5/8". SILTY SAND, SM: DENSE; WET; VERY DARK GREENISH-GRAY; 75% FINE TO COARSE, SUBANGULAR TO SUBROUNDED SAND; 25% FINES; TRACE OF FINE GRAVEL MAXIMUM PARTICLE SIZE 1/2"; NO ODOR; NO REACTION WITH HCL; MODERATE DRILLING
81.0' – 99.0'	SP-SM	POORLY GRADED SAND WITH SILT, SP-SM: VERY DENSE TO DENSE; WET; VERY DARK GREENISH-GRAY; FINE TO COARSE, SUBANGULAR TO SUBROUNDED SAND; NONPLASTIC FINES; TRACE OF FINE, SUBANGULAR TO SUBROUNDED GRAVEL MAXIMUM PARTICLE SIZE 1/2"; NO ODOR; NO REACTION WITH HCL; MODERATE DRILLING. POORLY GRADED SAND WITH SILT AND GRAVEL, SP-SM: DENSE; WET; VERY DARK GREENISH-GRAY; FINE TO COARSE, SUBANGULAR TO SUBROUNDED SAND; NONPLASTIC FINES; FINE, SUBANGULAR TO SUBROUNDED GRAVEL MAXIMUM PARTICLE SIZE 3/4"; NO ODOR; NO REACTION WITH HCL; MODERATE DRILLING. POORLY GRADED SAND WITH SILT, SP-SM: VERY FIRM; WET; VERY DARK GREENISH-GRAY; 75% FINE TO COARSE, SUBANGULAR TO SUBROUNDED SAND; 25% NONPLASTIC FINES; TRACE OF FINE TO COARSE, SUBANGULAR TO SUBROUNDED GRAVEL MAXIMUM PARTICLE SIZE 3/4"; NO ODOR; NO REACTION WITH HCL; MODERATE DRILLING. POORLY GRADED SAND WITH SILT AND GRAVEL, SP-SM: VERY FIRM; WET; VERY DARK GREENISH-GRAY; FINE TO COARSE, SUBANGULAR TO SUBROUNDED SAND; NONPLASTIC FINES; FINE, SUBANGULAR TO SUBROUNDED GRAVEL MAXIMUM PARTICLE SIZE 7/8"; NO ODOR; NO REACTION WITH HCL; MODERATE DRILLING. POORLY GRADED SAND WITH SILT AND GRAVEL, SP-SM: VERY FIRM; WET; VERY DARK GREENISH-GRAY; FINE TO COARSE, SUBANGULAR TO SUBROUNDED SAND; FINE TO COARSE, SUBANGULAR TO SUBROUNDED GRAVEL MAXIMUM PARTICLE SIZE 1.0"; NONPLASTIC FINES; NO ODOR; NO REACTION WITH HCL; MODE- RATE DRILLING
99.0' – 99.8'	GM	SILTY GRAVEL WITH SAND, GM: FIRM; WET; VERY DARK GREENISH-GRAY; 50% FINE, SUBANGULAR TO SUBROUNDED GRAVEL MAXIMUM PARTICLE SIZE 3/4"; 35% FINE TO COARSE, SUBANGULAR TO SUBROUNDED SAND; 15% NONPLASTIC FINES; NO ODOR; NO REACTION WITH HCL; MODERATE DRILLING
99.8' – 102.0'	CL	LEAN CLAY WITH GRAVEL, CL: STIFF; WET; VERY DARK GREENISH-GRAY; 75% MEDIUM PLASTICITY FINES; 15% FINE, SUBANGULAR TO SUBROUNDED GRAVEL MAXIMUM PARTICLE SIZE 3/4"; 10% FINE TO COARSE, SUBANGULAR TO SUBROUNDED SAND; NO ODOR; NO REACTION WITH HCL; MODERATE DRILLING; PP=1.25 tsf

Sample data (in order of depth):

N	N_{60}	GR	SA	FI	LL	PI	MC
13	17	–	–	–	–	–	–
15	20	–	–	–	–	–	–
7	9	–	–	–	–	–	–
12	16	–	–	–	–	–	–
13	17	–	–	–	–	–	–
10	13	–	–	–	–	–	–
32	43	–	–	–	–	–	–
17	23	–	–	–	–	–	–
25	33	–	–	–	–	–	–
46	61	–	–	–	–	–	–
25	33	–	–	9	–	–	–
26	35	–	–	–	–	–	–
20	27	–	–	–	–	–	–
19	25	16	78	6	–	–	–
20	27	–	–	–	–	–	–
8	11	–	–	–	–	–	–

(CONTINUED IN NEXT COLUMN)

2 F – 0 5 – G 4 – 2

(CONTINUED FROM PREVIOUS COLUMN)

Depth	USCS	Description
102.0' – 108.0'	GM	SILTY GRAVEL WITH SAND, GM: DENSE TO VERY DENSE; WET; VERY DARK GREENISH-GRAY; 50% FINE, SUBANGULAR TO SUBROUNDED GRAVEL MAXIMUM PARTICLE SIZE 3/4"; 35% FINE TO COARSE, SUBANGULAR TO SUBROUNDED SAND; 15% NONPLASTIC FINES; NO ODOR; NO REACTION WITH HCL; HARD DRILLING. AT 105.0', AS ABOVE EXCEPT 50% FINE, SUBANGULAR TO SUBROUNDED GRAVEL MAXIMUM PARTICLE SIZE 1.0". AT 106.5', CONVERT TO CAL-MOD SAMPLER
108.0' – 117.0'	GW	WELL-GRADED GRAVEL WITH SAND, GW: VERY DENSE; WET; DARK GREENISH-GRAY; FINE TO COARSE, MOSTLY FINE, SUBANGULAR TO SUBROUNDED GRAVEL MAXIMUM PARTICLE SIZE 1-½"; FINE TO COARSE, SUBANGULAR TO SUBROUNDED SAND; NONPLASTIC FINES; NO ODOR; NO REACTION WITH HCL; HARD DRILLING; DRILLING MUD USED
117.0' – 117.4'	SM	SILTY SAND WITH GRAVEL, SM: VERY DENSE; WET; DARK GREENISH-GRAY; 60% FINE TO MEDIUM, SUBANGULAR TO SUBROUNDED SAND; 20% NON-PLASTIC FINES; 20% FINE TO COARSE, SUBANGULAR TO SUBROUNDED GRAVEL MAXIMUM PARTICLE SIZE 1-½"; NO ODOR; NO REACTION WITH HCL; HARD DRILLING. SILTY SAND, SM: VERY DENSE; WET; DARK GREENISH-GRAY; 80% FINE TO MEDIUM, SUBANGULAR TO SUBROUNDED SAND; 20% NON-PLASTIC FINES; NO ODOR; NO REACTION WITH HCL; HARD DRILLING
117.7' – 135.0'	GW	WELL-GRADED GRAVEL WITH SAND, GW: VERY DENSE; WET; DARK GREENISH-GRAY; 70% FINE, SUBANGULAR TO SUBROUNDED GRAVEL MAXIMUM PARTICLE SIZE 1-1/4"; 25% FINE TO COARSE, SUBANGULAR TO SUBROUNDED SAND; 5% NONPLASTIC FINES; NO ODOR; NO REACTION WITH HCL; HARD DRILLING. AT 120.0', AS ABOVE EXCEPT GRAVEL MAXIMUM PARTICLE SIZE 1-½". AT 123.0', AS ABOVE EXCEPT GRAVEL MAXIMUM PARTICLE SIZE 2.0". AT 132.0', AS ABOVE EXCEPT GRAVEL MAXIMUM PARTICLE SIZE 1-¼"; MODERATE DRILLING
135.0' – 141.0'	CL	LEAN CLAY WITH SAND, CL: HARD; MOIST; DARK GREENISH-GRAY; 85% MEDIUM PLASTICITY FINES; 15% FINE SAND; NO ODOR; STRONG REACTION TO HCL; STREAK OF CALCIUM CARBONATE STAINING; VERY HARD DRILLING;. PP=3.25 tsf. AT 138.0', AS ABOVE EXCEPT HARD DRILLING; PP=3.0 tsf
141.0' – 144.0'	ML	SILT WITH SAND, ML: HARD; MOIST; DARK GREENISH-GRAY; 75% LOW PLASTICITY FINES; 25% FINE SAND; NO ODOR; STRONG REACTION TO HCL; VERY HARD DRILLING; PP=2.75 tsf

B.O.H.

Sample data (in order of depth):

N	N_{60}	GR	SA	FI	LL	PI	MC
25	33	–	–	–	–	–	–
R*	R*	–	–	–	–	–	–
A*	A*	–	–	–	–	–	–
70*	93*	64	32	4	–	–	–
R*	R*	–	–	–	–	–	–
83*	R*	–	–	–	–	–	–
R*	R*	–	–	–	–	–	–
R*	R*	–	–	–	–	–	–
R*	R*	–	–	–	–	–	–
84*	R*	–	–	–	–	–	–
93*	R*	–	–	–	–	–	–
R*	R*	–	–	–	–	–	–
R*	R*	–	–	–	–	–	–
58*	77*	–	–	–	–	–	–

(CONTINUED IN NEXT COLUMN)

NOTES:

1. LEGEND AND NOTES ARE SHOWN ON SHEET B-1.
2. LOCATION OF EXPLORATIONS ARE SHOWN IN APPENDIX C.

GRAPHIC SCALE

VERTICAL SCALE 1 : 3 — 0, 3, 6, 9, 12 FEET

VERTICAL SCALE: 1" = 3'

US Army Corps of Engineers
Sacramento District

Symbol	Description	Date	Approved

Designed by: SCIANDRONE | Dwn by: PHAN | Spec No.: | Reviewed by: EDWARDS | Submitted by: /s/ Section Chief, Chief, Soil Design Sec. | Date: 24 Aug 2005 | Design file no: | Drawing Code: | File name: | Plot date: 1:1 | Dsg scale: AS_NOTED | Rev.

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 'J' STREET
SACRAMENTO, CA 95814-2922

SACRAMENTO RIVER — CALIFORNIA
AMERICAN RIVER WATERSHED PROJECT
(COMMON FEATURES), CALIFORNIA
POCKET AREA FEMA EVALUATION (LEFT BANK)
GEOTECHNICAL SITE 4
LOG OF EXPLORATIONS
G4 – 2

Sheet reference number:
B–24
24 of 50

MAY 2005

Mapping Unit (S/S) No.: MAPPING_UNIT_(S/S)_NO.

Soil Design Section Sheet No.: X of X

Reference – Exploration Log file no.: XXX-01-XXX

2F-05-G4-2A

N XX°XX'XX.X", WXXX°XX'XX.X", ±XX'

DEPTH		N	N_{60}	GR	SA	FI	LL	PI	MC	
Levee Toe = 0										
	ML	11	14	-	-	-	-	-	-	SILT WITH SAND, ML: STIFF TO FIRM; DRY; VERY DARK GRAYISH-BROWN; NONPLASTIC FINES; FINE SAND; TRACE OF SUBANGULAR TO ANGULAR GRAVEL MAXIMUM PARTICLE SIZE 1/2"; TRACE OF IRON OXIDE STAINING; ORGANIC MATERIAL (ROOTS) PRESENT
2.0'										
	ML	5	7	-	-	-	-	-	-	AT 2.0', AS ABOVE EXCEPT DARK YELLOWISH-BROWN
4.0'										AT 4.0', AS ABOVE EXCEPT MOIST
		4	5	-	-	83	33	10	-	
6.0'				-	-	-	-	-	-	
		2	3	-	-	-	-	-	-	
8.0'	SM									SILTY SAND, SM: VERY LOOSE; WET; DARK YELLOWISH-BROWN; FINE SAND; NONPLASTIC FINES
		3	4	-	-	40	23	0	-	
10.0'				-	-	-	-	-	-	
	ML/CL			-	-	-	-	-	-	CLAYEY SILT, ML/CL: FIRM; WET; DARK YELLOWISH-BROWN; NONPLASTIC TO LOW PLASTICITY FINES
11.0'	CL/ML	4	5	-	-	-	-	-	-	SILTY CLAY, CL/ML: FIRM; WET; VERY DARK GRAY; LOW PLASTICITY TO NONPLASTIC, MOSTLY LOW PLASTICITY FINES
12.0'										
		2	3	-	-	53	27	4	-	
14.0'	ML			-	-	-	-	-	-	SANDY SILT, ML: SOFT; WET; DARK YELLOWISH-BROWN; NONPLASTIC FINES; FINE SAND
		3	4	-	-	-	-	-	-	
16.0'										
		2	3	-	-	-	-	-	-	
18.0'	CL/ML									SILTY CLAY, CL/ML: SOFT TO FIRM; WET; VERY DARK GRAY; LOW PLASTICITY TO NONPLASTIC FINES
		4	5	-	-	-	-	-	-	
20.0'										
	ML	4	5	-	-	-	-	-	-	SILT, ML: FIRM; WET; VERY DARK GRAY; NONPLASTIC FINES
22.0'										
		4	5	-	-	-	-	-	-	
24.0'										CLAYEY SILT, ML/CL: FIRM TO SOFT; WET; VERY DARK GRAY; NONPLASTIC TO LOW PLASTICITY FINES
	ML/CL	3	4	-	-	-	-	-	-	
26.0'										AT 26.0', AS ABOVE EXCEPT STIFF
		8	11	-	-	-	-	-	-	
28.0'	ML			-	-	-	-	-	-	SILT, ML: STIFF; WET; VERY DARK GRAY; NONPLASTIC FINES
28.8'		10	13	-	-	-	-	-	-	POORLY GRADED SAND WITH SILT, SP-SM: FIRM; WET; VERY DARK GRAY; 90% FINE TO MEDIUM SAND; 10% NONPLASTIC FINES
30.0'										
		13	17	-	-	-	-	-	-	
32.0'										POORLY GRADED SAND WITH SILT, SP-SM: FIRM TO VERY FIRM; WET; VERY DARK GRAY; FINE TO MEDIUM SAND; NONPLASTIC FINES
		15	20	-	-	-	-	-	-	
34.0'										AT 34.0', AS ABOVE EXCEPT FINE SAND
	SP-SM	16	21	-	-	6	-	-	-	
36.0'				-	-	-	-	-	-	AT 36.0', AS ABOVE EXCEPT FINE TO MEDIUM SAND; TRACE OF SUBANGULAR TO SUBROUNDED GRAVEL MAXIMUM PARTICLE SIZE 1/4"
		17	23	-	-	-	-	-	-	
38.0'										
		21	28	-	-	-	-	-	-	
40.0'										AT 40.0', AS ABOVE EXCEPT NO GRAVEL
		18	24	-	-	-	-	-	-	
42.0'				-	-	-	-	-	-	AT 42.2', AS ABOVE EXCEPT VERY LOOSE
42.2'	CL	3	4	-	-	-	-	-	-	LEAN CLAY, CL: SOFT; WET; VERY DARK GRAY; LOW PLASTICITY FINES
44.0'	SM			-	-	-	-	-	-	SILTY SAND, SM: FIRM; WET; VERY DARK GRAY; 80% FINE TO MEDIUM SAND; 20% NONPLASTIC FINES
44.6'		15	20							
	ML			-	-	-	-	-	-	SILT, ML: VERY STIFF; WET; VERY DARK GRAY; NONPLASTIC FINES
47.0'										
	SM	36	48	-	-	-	-	-	-	SILTY SAND, SM: DENSE; WET; VERY DARK GRAY; 60% FINE TO MEDIUM SAND; 40% NONPLASTIC FINES
50.0'										

(CONTINUED IN NEXT COLUMN)

2F-05-G4-2A

(CONTINUED FROM PREVIOUS COLUMN)

DEPTH		N	N_{60}	GR	SA	FI	LL	PI	MC	
50.0'										
		13	17	-	-	-	-	-	-	
53.0'										SILTY SAND, SM: FIRM TO LOOSE; WET; VERY DARK GRAY; 85% FINE SAND; 15% NONPLASTIC FINES; MICA PRESENT
		10	13	-	-	-	-	-	-	
56.0'										AT 56.0', AS ABOVE EXCEPT TRACE OF SUBANGULAR TO SUBROUNDED GRAVEL MAXIMUM PARTICLE SIZE 1-½", MOSTLY SMALLER THAN 1/4"
		7	9	-	-	-	-	-	-	
59.0'										AT 59.0', AS ABOVE EXCEPT FIRM; NO GRAVEL
		9	12	-	-	-	-	-	-	
62.0'										AT 56.0', AS ABOVE EXCEPT TRACE OF SUBANGULAR TO SUBROUNDED GRAVEL MAXIMUM PARTICLE SIZE 1.0"
		12	16	-	-	-	-	-	-	
65.0'	SM									AT 65.0', AS ABOVE EXCEPT NO GRAVEL
		11	14	-	-	18	-	-	-	
68.0'										AT 68.0', AS ABOVE EXCEPT DENSE; 4% OF SUBANGULAR TO SUBROUNDED GRAVEL MAXIMUM PARTICLE SIZE 1-½", MOSTLY SMALLER THAN 1/4"
		27	36	-	-	-	-	-	-	
71.0'										AT 71.0', AS ABOVE EXCEPT VERY FIRM TO DENSE; GRAVEL MAXIMUM PARTICLE SIZE 3/4", MOSTLY SMALLER THAN 1/4"
		21	28	-	-	-	-	-	-	
74.0'				-	-	-	-	-	-	
75.1'		23	31	-	-	-	-	-	-	SILTY SAND WITH GRAVEL, SM: DENSE; WET; VERY DARK GRAY; 70% FINE TO COARSE SAND; 15% NONPLASTIC FINES; 15% SUBANGULAR TO SUBROUNDED GRAVEL MAXIMUM PARTICLE SIZE 1.0"; MICA PRESENT
77.0'										
78.2'		18	24	-	-	-	-	-	-	SILTY SAND, SM: VERY FIRM; WET; VERY DARK GRAY; 60% FINE TO MEDIUM SAND; 40% NONPLASTIC FINES; TRACE OF GRAVEL MAXIMUM PARTICLE SIZE 3/4", MOSTLY SMALLER THAN 1/4"
80.0'										
81.1'		22	29	-	-	-	-	-	-	SILTY SAND WITH GRAVEL, SM: VERY FIRM; WET; VERY DARK GRAY; 70% FINE TO COARSE SAND; 15% NONPLASTIC FINES; 15% SUBANGULAR TO SUBROUNDED GRAVEL MAXIMUM PARTICLE SIZE 1.0"; MICA PRESENT
83.0'										
83.4'	CL			-	-	-	-	-	-	SILTY SAND, SM: VERY FIRM; WET; VERY DARK GRAY; 60% FINE TO MEDIUM SAND; 40% NONPLASTIC FINES; TRACE OF GRAVEL MAXIMUM PARTICLE SIZE 3/4", MOSTLY SMALLER THAN 1/4"
84.0'		35	47	-	-	-	-	-	-	SILTY SAND WITH GRAVEL, SM: VERY FIRM; WET; VERY DARK GRAY; 70% FINE TO COARSE SAND; 15% NONPLASTIC FINES; 15% SUBANGULAR TO SUBROUNDED GRAVEL MAXIMUM PARTICLE SIZE 1.0"; MICA PRESENT
	GP-GC			-	-	-	-	-	-	
86.0'										SILTY SAND, SM: DENSE; WET; VERY DARK GRAY; 60% FINE TO MEDIUM SAND; 40% NONPLASTIC FINES; TRACE OF GRAVEL MAXIMUM PARTICLE SIZE 1/4"
	SM	53	71	-	-	-	-	-	-	
										LEAN CLAY, CL: HARD; WET; VERY DARK GREENISH-GRAY; LOW PLASTICITY TO NONPLASTIC; MOSTLY LOW PLASTICITY FINES
89.0'										POORLY GRADED GRAVEL WITH CLAY AND SAND, GP-GC: DENSE; WET; VERY DARK GREENISH-GRAY; 75% SUBANGULAR TO SUBROUNDED GRAVEL MAXIMUM PARTICLE SIZE 1-½"; 15% FINE TO COARSE SAND; 10% LOW PLASTICITY FINES
	GP-GM	50	67	-	-	-	-	-	-	
										SILTY SAND WITH GRAVEL, SM: VERY DENSE; WET; VERY DARK GRAY; 70% FINE TO COARSE SAND; 15% NONPLASTIC FINES; 15% SUBANGULAR TO SUBROUNDED GRAVEL MAXIMUM PARTICLE SIZE 1-½", MICA PRESENT
92.0'										
	GP-GC	67	89	-	-	-	-	-	-	POORLY GRADED GRAVEL WITH SILT AND SAND, GP-GM: VERY DENSE; WET; VERY DARK GREENISH-GRAY; 70% SUBANGULAR TO SUBROUNDED GRAVEL MAXIMUM PARTICLE SIZE 1-½"; 20% FINE TO COARSE SAND; 10% NONPLASTIC FINES
95.0'	GP-GM			-	-	-	-	-	-	
96.0'		A	A							POORLY GRADED GRAVEL WITH CLAY AND SAND, GP-GC: VERY DENSE; WET; VERY DARK GREENISH-GRAY; 65% SUBANGULAR TO SUBROUNDED GRAVEL MAXIMUM PARTICLE SIZE 1-½"; 25% FINE TO COARSE SAND; 10% LOW PLASTICITY FINES
										POORLY GRADED GRAVEL WITH SILT AND SAND, GP-GM: VERY DENSE; WET; VERY DARK GREENISH-GRAY; 70% SUBANGULAR TO SUBROUNDED GRAVEL MAXIMUM PARTICLE SIZE 1-½"; 20% FINE TO COARSE SAND; 10% NONPLASTIC FINES

B.O.H.

NOTES:

1. LEGEND AND NOTES ARE SHOWN ON SHEET B-1.
2. LOCATION OF EXPLORATIONS ARE SHOWN IN APPENDIX C.

VERTICAL SCALE: 1" = 3'

GRAPHIC SCALE

VERTICAL SCALE 1 : 3 — 0 3 6 9 12 FEET

US Army Corps of Engineers
Sacramento District

Symbol	Description	Date	Approved

Mapping Unit (S/S) No.: MAPPING_UNIT_(S/S)_NO.

Date: 24 Aug 2005 | Rev.
Design file no. | Spec. No.
Drawing Code:
File name:
Plot date: 1:1
Dwg scale: AS NOTED

Designed by: SCANDRONE
Dwn by: PHAN
Reviewed by: EDWARDS
Submitted by: JV Section Chief
Chief, Soil Design Sec.

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 J STREET
SACRAMENTO, CA 95814-2922

SACRAMENTO RIVER — CALIFORNIA
AMERICAN RIVER WATERSHED PROJECT
(COMMON FEATURES), CALIFORNIA
POCKET AREA FEMA EVALUATION (LEFT BANK)

GEOTECHNICAL SITE 4
LOG OF EXPLORATIONS
G4 - 2A

Sheet reference number:
B-25
25 of 2005

MAY 2005

Soil Design Section Sheet No.: X of X

Reference - Exploration Log file no.: XXX-01-XXX

SIERRA TESTING LABORATORIES, INC.
GEOTECHNICAL AND MATERIALS TESTING SERVICES

Table 1

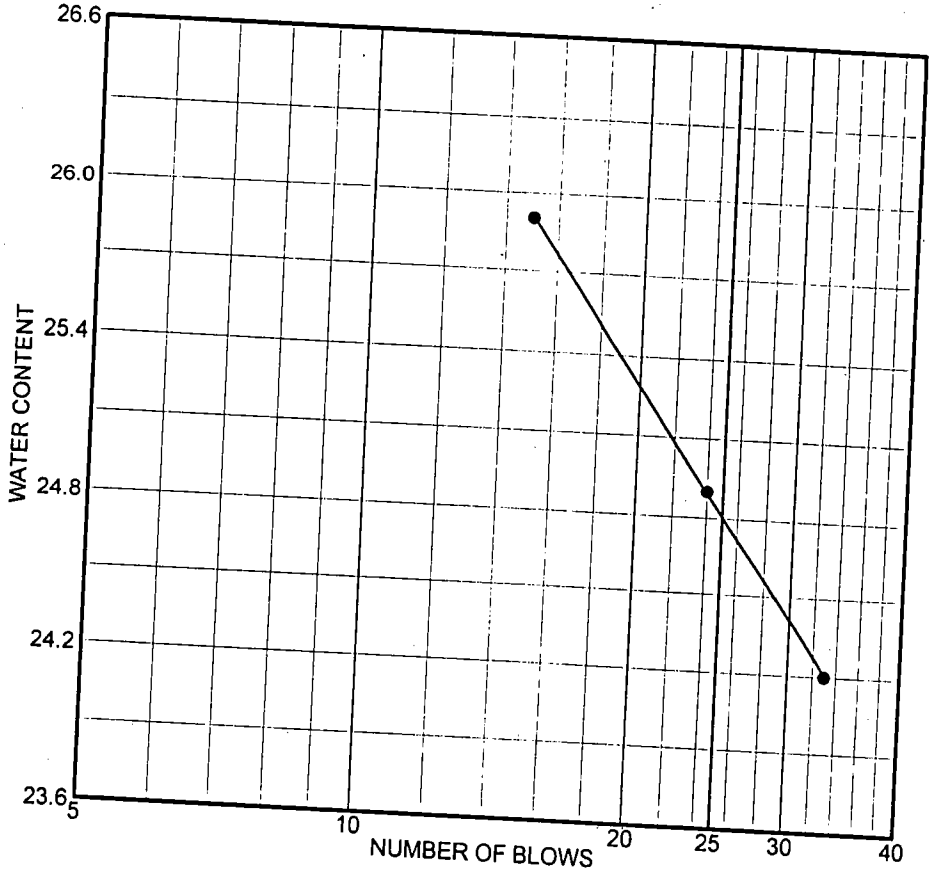
Percent Passing #200 (ASTM D1140)
Sacramento River FEMA –Geotech Sites
(Pocket Area)
STL Job #05-187

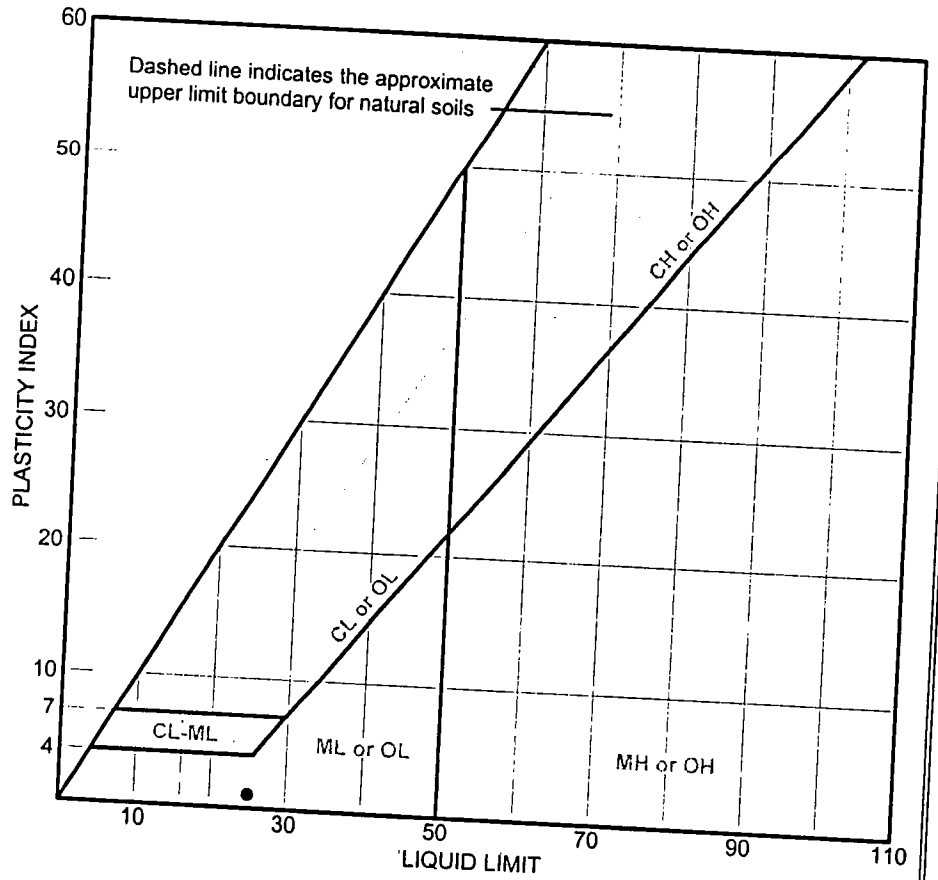
Sample Name	Percent Passing #200
2F-05-G4-2, FS11 25-26.5	47.3
2F-05-G4-2, FS14 31-32.5	55.1
2F-05-G4-2, FS20 43-44.5	7.9
2F-05-G4-2, FS34 84-85.5	8.7

Notes:

5040 Robert J. Mathews Parkway, El Dorado Hills, CA ph: 916-939-3460 fax: 916-939-3507

LIQUID AND PLASTIC LIMITS TEST REPORT





SOURCE	SAMPLE #	DEPTH/ELEV.	DATE SAMPLED	USCS	MATERIAL DESCRIPTION	NM %	LL	PI
2F-05-G4-2	FS11	25-26.5	4/20/05				25	1

Client U.S. Army Corps of Engineers

Project Sacramento River FEMA - Geotech Sites

(Pocket Area)

Project No. 05-187 | Figure

SIERRA TESTING LABS, INC.

LIQUID AND PLASTIC LIMIT TEST DATA

Client: U.S. Army Corps of Engineers
Project: Sacramento River FEMA - Geotech Sites
(Pocket Area)
W91238-05-P-0097
Project Number: 05-187

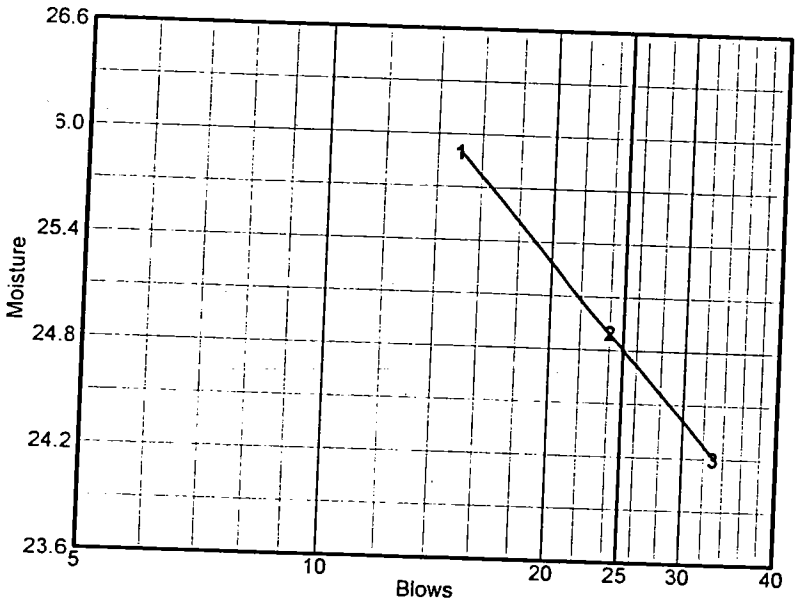
Sample Data

Source: 2F-05-G4-2
Sample No.: FS11
Elev. or Depth: 25-26.5
Location:
Description:
Date: 4/20/05
USCS Class.:
Testing Remarks:

Sample Length(in./cm.):
Natural Moisture:
AASHTO Class.:

Liquid Limit Data

Run No.	1	2	3	4	5	6
Wet+Tare	22.03	25.27	30.93			
Dry+Tare	17.80	20.53	25.18			
Tare	1.45	1.46	1.46			
# Blows	15	24	33			
Moisture	25.9	24.9	24.2			

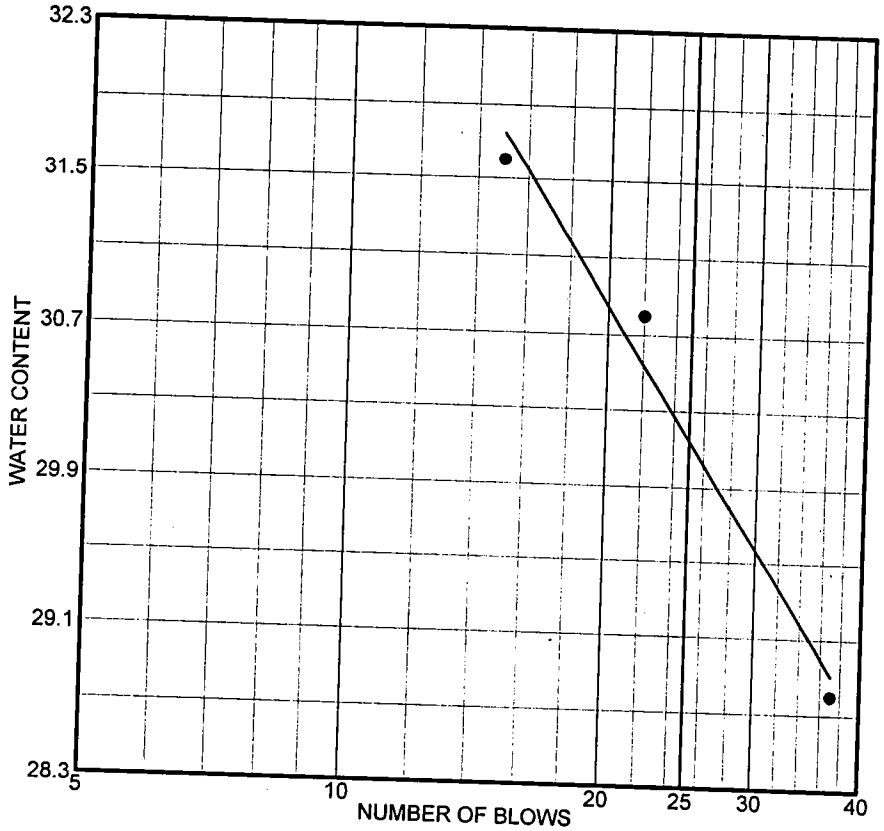


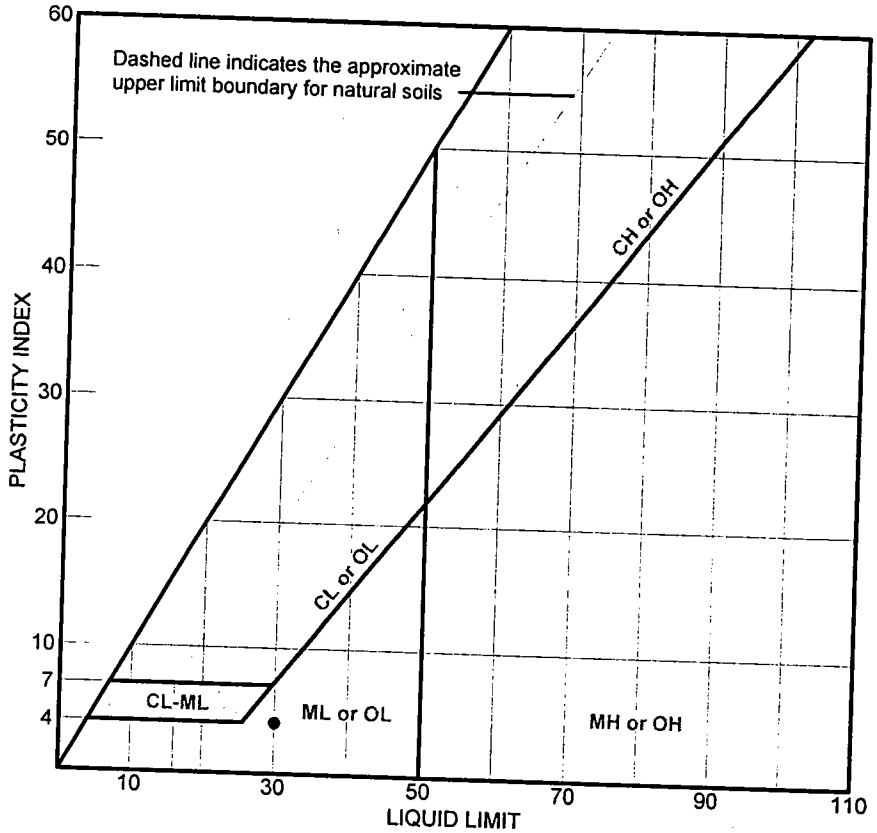
Liquid Limit= 25
Plastic Limit= 24
Plasticity Index= 1

Plastic Limit Data

Run No.	1	2	3	4	
Wet+Tare	4.05	4.95			
Dry+Tare	3.55	4.28			
Tare	1.45	1.46			
Moisture	23.8	23.8			

LIQUID AND PLASTIC LIMITS TEST REPORT





SOURCE	SAMPLE #	DEPTH/ELEV.	DATE SAMPLED	USCS	MATERIAL DESCRIPTION	NM %	LL	PI
2F-05-G4-2	FS14	31.0-32.5	4/20/05				30	4

Client U.S. Army Corps of Engineers

Project Sacramento River FEMA - Geotech Sites

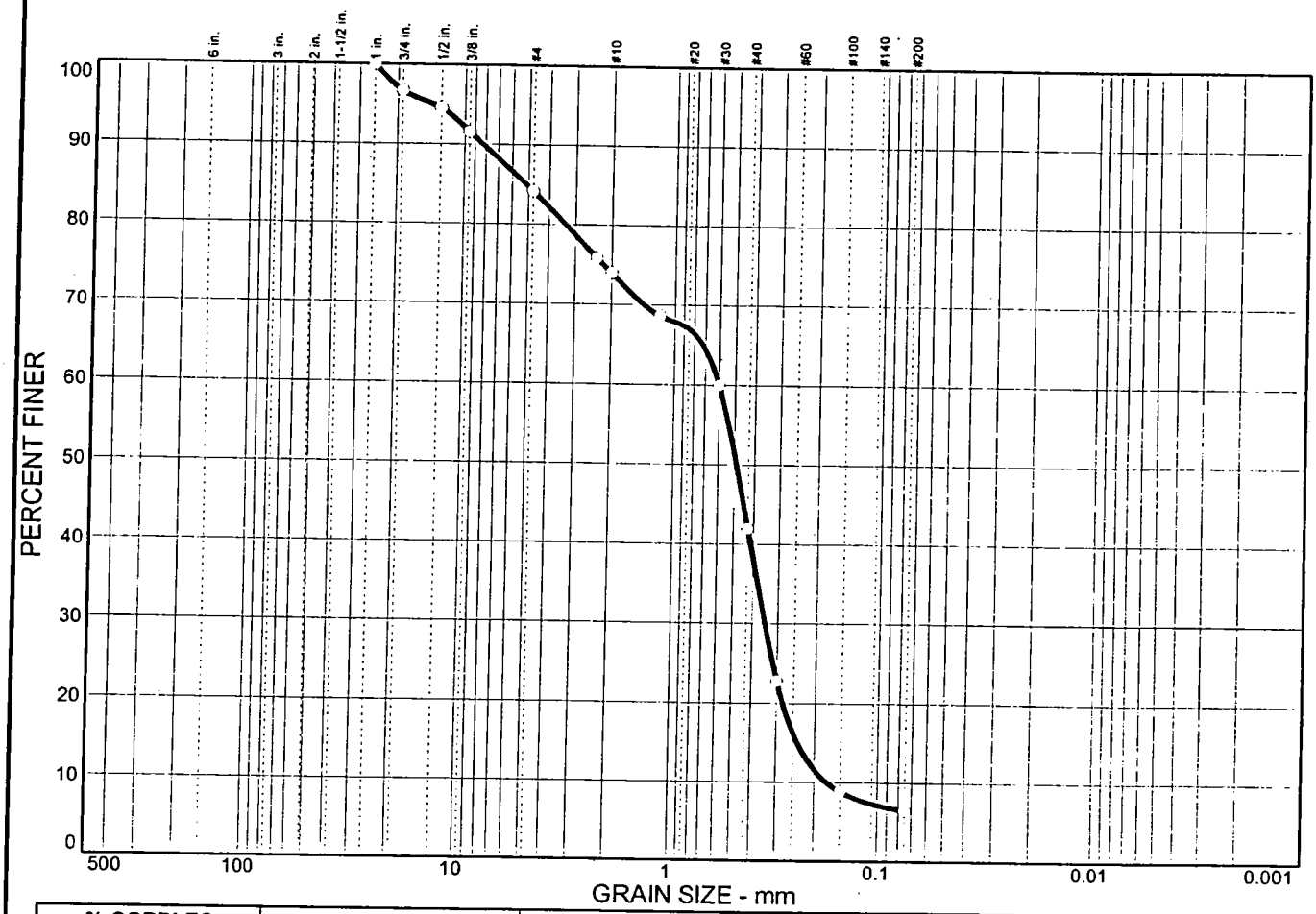
(Pocket Area)

Project No. 05-187 | Figure

SIERRA TESTING LABS, INC.

4.2

Particle Size Distribution Report



% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
0.0	15.8	77.7	6.5	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1 in.	100.0		
3/4 in.	96.7		
1/2 in.	94.6		
3/8 in.	91.6		
#4	84.2		
#8	75.9		
#10	74.0		
#16	68.6		
#30	60.0		
#40	42.0		
#50	22.8		
#100	8.9		
#200	6.5		

* (no specification provided)

Material Description

Atterberg Limits

PL= LL= PI=

Coefficients

D_{85}= 5.11 D_{60}= 0.600 D_{50}= 0.487
D_{30}= 0.346 D_{15}= 0.238 D_{10}= 0.174
C_u= 3.45 C_c= 1.15

Classification

USCS= AASHTO=

Remarks

Sample No.: FS37 **Source of Sample:** 2F-05-G4-2 **Date:** 4/20/05
Location: **Elev./Depth:** 93-94.5

SIERRA TESTING LABS, INC.

Client: U.S. Army Corps of Engineers
Project: Sacramento River FEMA - Geotech Sites (Pocket Area)
Project No: 05-187 **Figure**

GRAIN SIZE DISTRIBUTION TEST DATA

Client: U.S. Army Corps of Engineers
Project: Sacramento River FEMA - Geotech Sites
(Pocket Area)
W91238-05-P-0097
Project Number: 05-187

Sample Data

Source: 2F-05-G4-2
Sample No.: FS37
Elev. or Depth: 93-94.5
Location:
Description:
Date: 4/20/05
PL:
USCS Classification:
Testing Remarks:
Sample Length(in./cm.):
LL:
PI:
AASHTO Classification:

Mechanical Analysis Data

	Initial
Dry sample and tare=	317.80
Tare =	0.00
Dry sample weight =	317.80

Sieve tare method

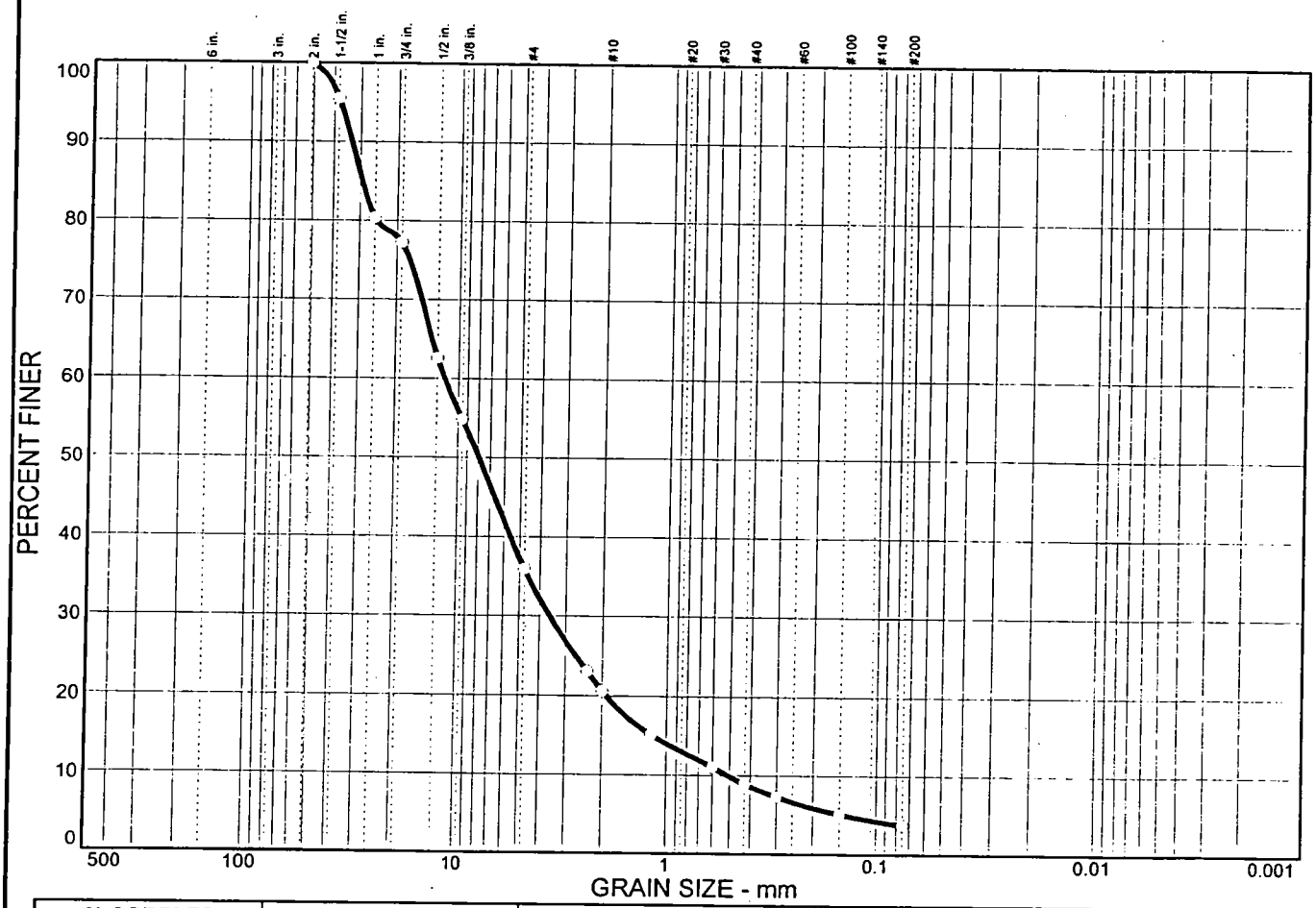
Sieve	Weight retained	Sieve tare	Percent finer
1 inch	0.00	0.00	100.0
3/4 inch	10.50	0.00	96.7
1/2 inch	6.80	0.00	94.6
3/8 inch	9.40	0.00	91.6
# 4	23.60	0.00	84.2
# 8	26.40	0.00	75.9
# 10	5.80	0.00	74.0
# 16	17.20	0.00	68.6
# 30	27.50	0.00	60.0
# 40	57.00	0.00	42.0
# 50	61.20	0.00	22.8
# 100	44.20	0.00	8.9
# 200	7.40	0.00	6.5

Fractional Components

Gravel/Sand based on #4
Sand/Fines based on #200
% COBBLES = % GRAVEL = 15.8 % SAND = 77.7
% FINES = 6.5

D_{85}= 5.11 D_{60}= 0.60 D_{50}= 0.49
D_{30}= 0.35 D_{15}= 0.24 D_{10}= 0.17
C_c= 1.1485 C_u= 3.4466

Particle Size Distribution Report



% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
0.0	64.0	32.3	3.7	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
2 in.	100.0		
1-1/2 in.	95.6		
1 in.	80.4		
3/4 in.	77.3		
1/2 in.	62.6		
3/8 in.	54.9		
#4	36.0		
#8	23.1		
#10	20.6		
#16	15.1		
#30	11.0		
#40	8.9		
#50	7.3		
#100	5.1		
#200	3.7		

* (no specification provided)

Material Description

Atterberg Limits

PL= LL= PI=

Coefficients

D_{85}= 29.3 D_{60}= 11.7 D_{50}= 7.90
D_{30}= 3.58 D_{15}= 1.16 D_{10}= 0.511
C_u= 22.89 C_c= 2.14

Classification

USCS= AASHTO=

Remarks

Sample No.: FS43 **Source of Sample:** 2F-05-G4-2 **Date:** 4/20/05
Location: **Elev./Depth:** 111-112.5

SIERRA TESTING LABS, INC.

Client: U.S. Army Corps of Engineers
Project: Sacramento River FEMA - Geotech Sites (Pocket Area)
Project No: 05-187 **Figure**

GRAIN SIZE DISTRIBUTION TEST DATA

Client: U.S. Army Corps of Engineers
Project: Sacramento River FEMA - Geotech Sites
(Pocket Area)
W91238-05-P-0097
Project Number: 05-187

Sample Data

Source: 2F-05-G4-2
Sample No.: FS43
Elev. or Depth: 111-112.5
Location:
Description:
Date: 4/20/05 **PL:**
USCS Classification:
Testing Remarks:

Sample Length(in./cm.):
LL: **PI:**
AASHTO Classification:

Mechanical Analysis Data

		Initial
Dry sample and tare	=	1919.80
Tare	=	0.00
Dry sample weight	=	1919.80

Sieve tare method

Sieve	Weight retained	Sieve tare	Percent finer
2 inch	0.00	0.00	100.0
1-1/2 inch	85.00	0.00	95.6
1 inch	290.50	0.00	80.4
3/4 inch	60.50	0.00	77.3
1/2 inch	281.60	0.00	62.6
3/8 inch	148.80	0.00	54.9
# 4	361.40	0.00	36.0
# 8	248.70	0.00	23.1
# 10	47.00	0.00	20.6
# 16	105.90	0.00	15.1
# 30	79.10	0.00	11.0
# 40	41.10	0.00	8.9
# 50	29.80	0.00	7.3
# 100	43.10	0.00	5.1
# 200	26.20	0.00	3.7

Fractional Components

Gravel/Sand based on #4
Sand/Fines based on #200
% COBBLES = % GRAVEL = 64.0 % SAND = 32.3
% FINES = 3.7

D_{85}= 29.29 D_{60}= 11.69 D_{50}= 7.90
D_{30}= 3.58 D_{15}= 1.16 D_{10}= 0.51
C_c= 2.1439 C_u= 22.892

SIERRA TESTING LABORATORIES, INC.
GEOTECHNICAL AND MATERIALS TESTING SERVICES

Table 1

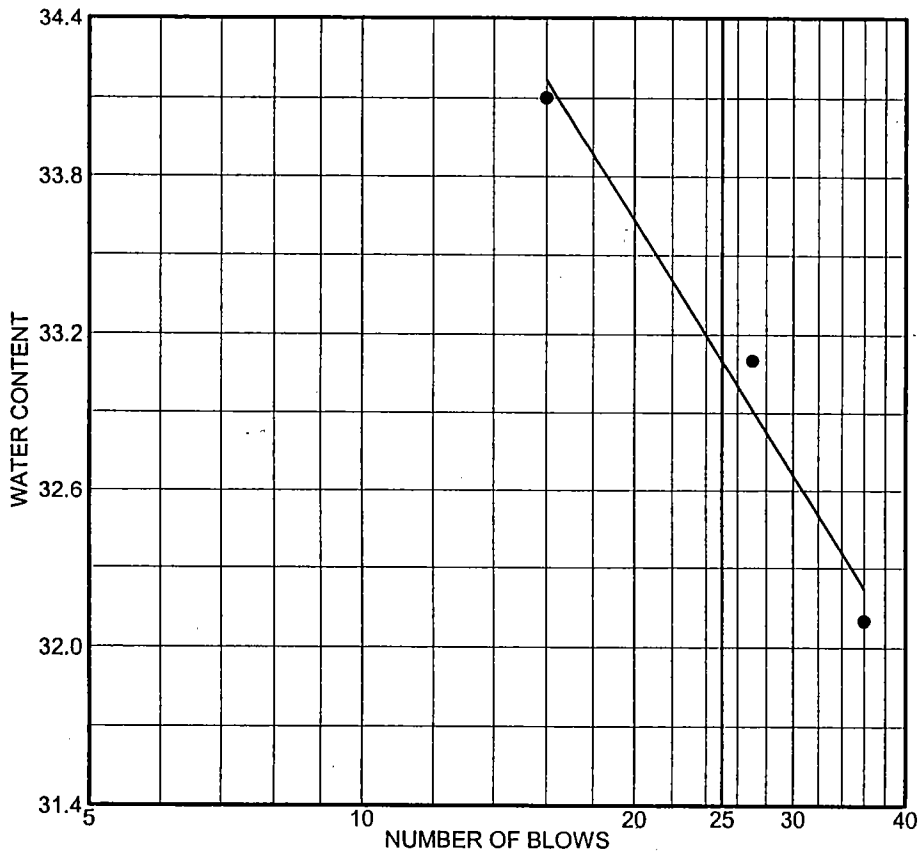
Percent Passing #200 (ASTM D1140)
Sacramento River FEMA-Geotech Sites
(Pocket Area)
STL Job #05-187

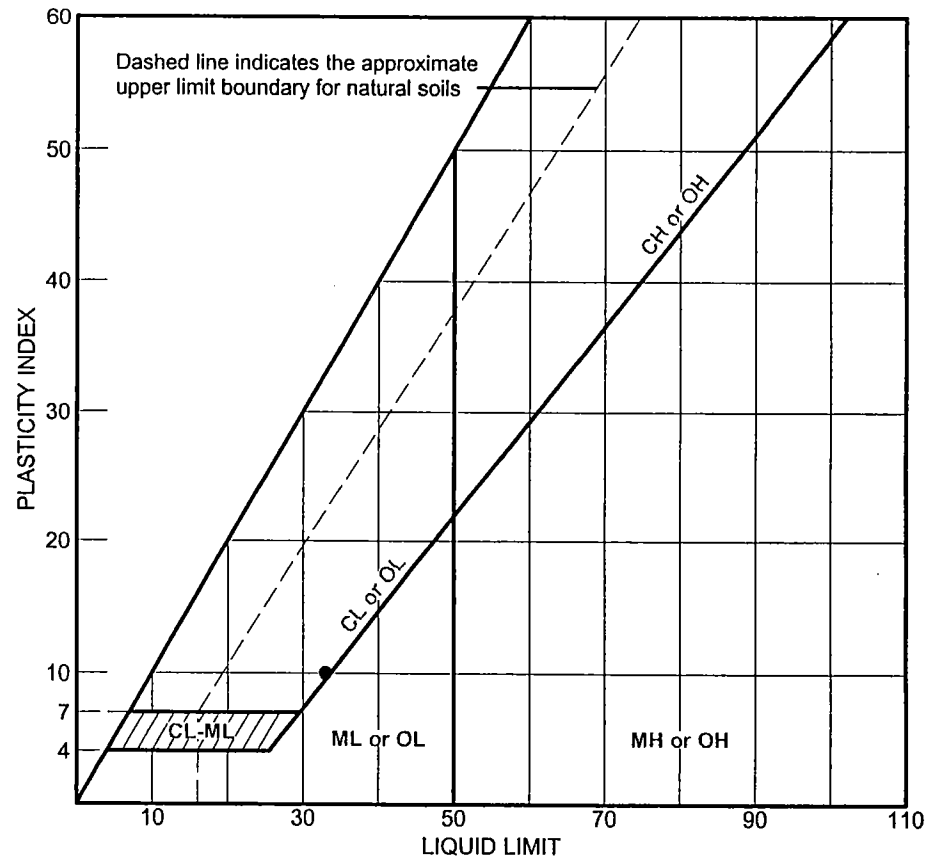
Sample Name	Percent Passing #200
2F-05-G4-2A, FS3 4.0'-5.5'	82.8
2F-05-G4-2A, FS5 8.0'-9.5'	40.4
2F-05-G4-2A, FS8 12.0'-13.5'	53.0
2F-05-G4-2A, FS20 34.0'-35.5'	5.8
2F-05-G4-2A, FS32 65.0'-66.5'	17.7

Notes:

5040 Robert J. Mathews Parkway, El Dorado Hills, CA ph: 916-939-3460 fax: 916-939-3507

LIQUID AND PLASTIC LIMITS TEST REPORT





	SOURCE	SAMPLE #	DEPTH/ELEV.	DATE SAMPLED	USCS	MATERIAL DESCRIPTION	NM %	LL	PI
●	2F-05-G4-2A	FS3	4.0-5.5	6/22/05				33	10

Client U.S. Army Corps of Engineers

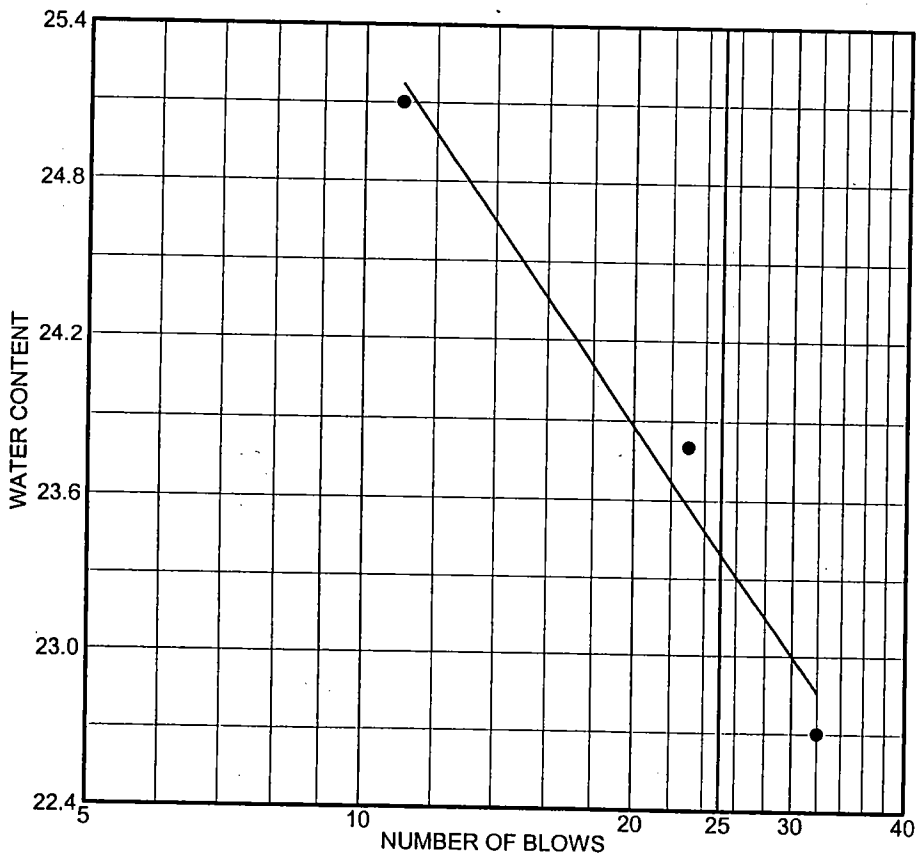
Project Sacramento River FEMA - Geotech Sites

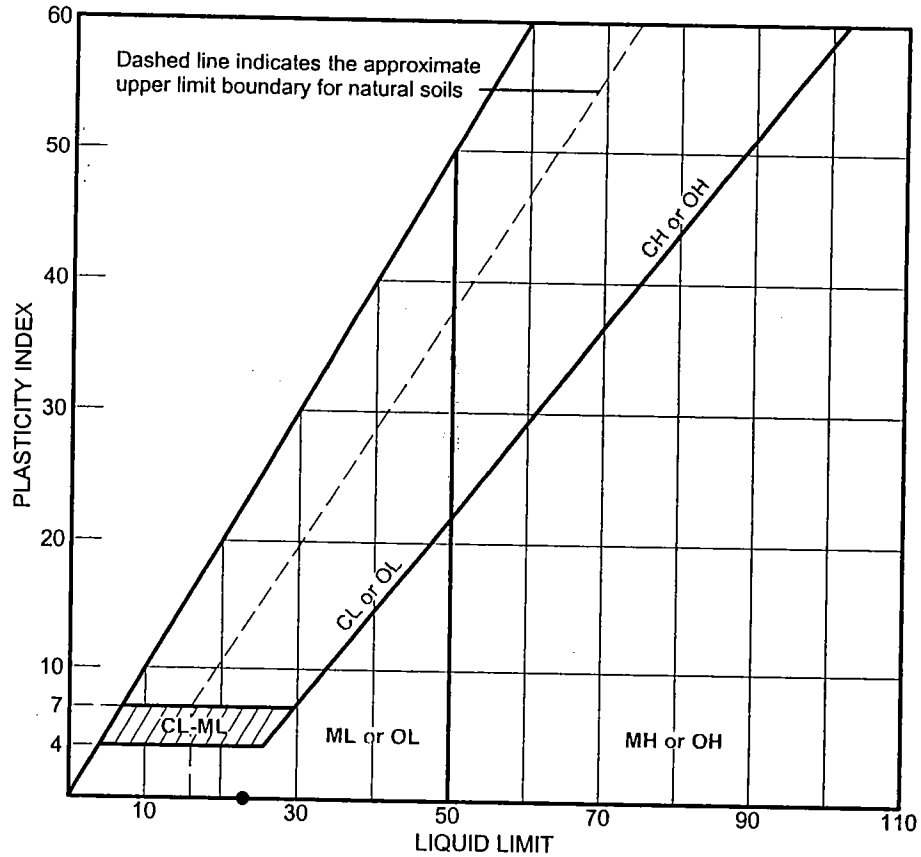
(Pocket Area)

Project No. 05-187 | Figure

SIERRA TESTING LABS, INC.

LIQUID AND PLASTIC LIMITS TEST REPORT





	SOURCE	SAMPLE #	DEPTH/ELEV.	DATE SAMPLED	USCS	MATERIAL DESCRIPTION	NM %	LL	PI
●	2F-05-G4-2A	FS5	8.0-9.5	6/22/05				23	0

Client U.S. Army Corps of Engineers

Project Sacramento River FEMA - Geotech Sites

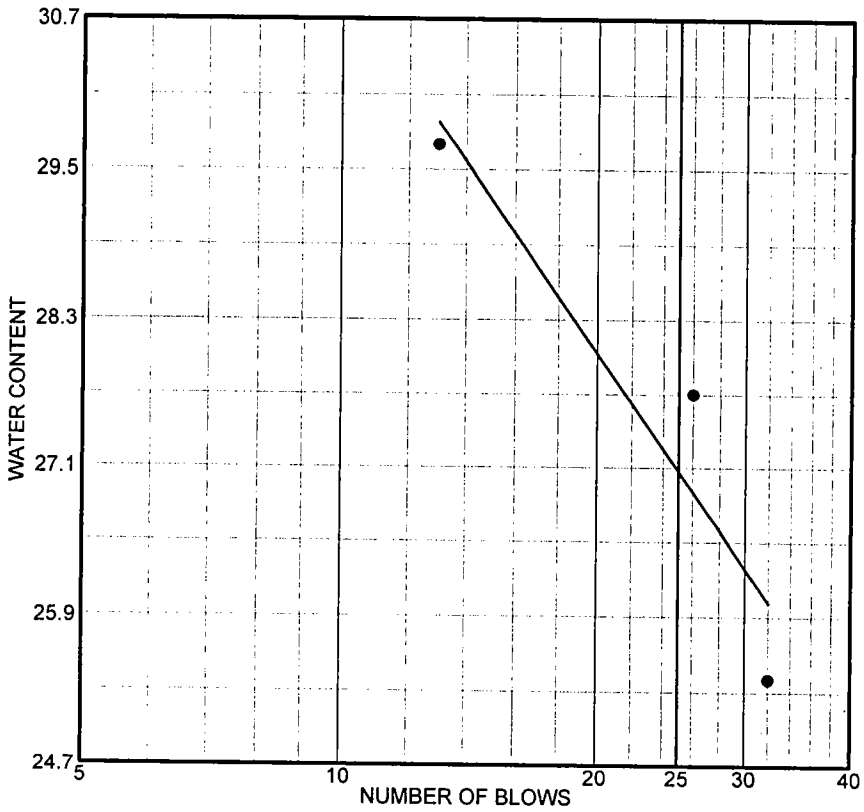
(Pocket Area)

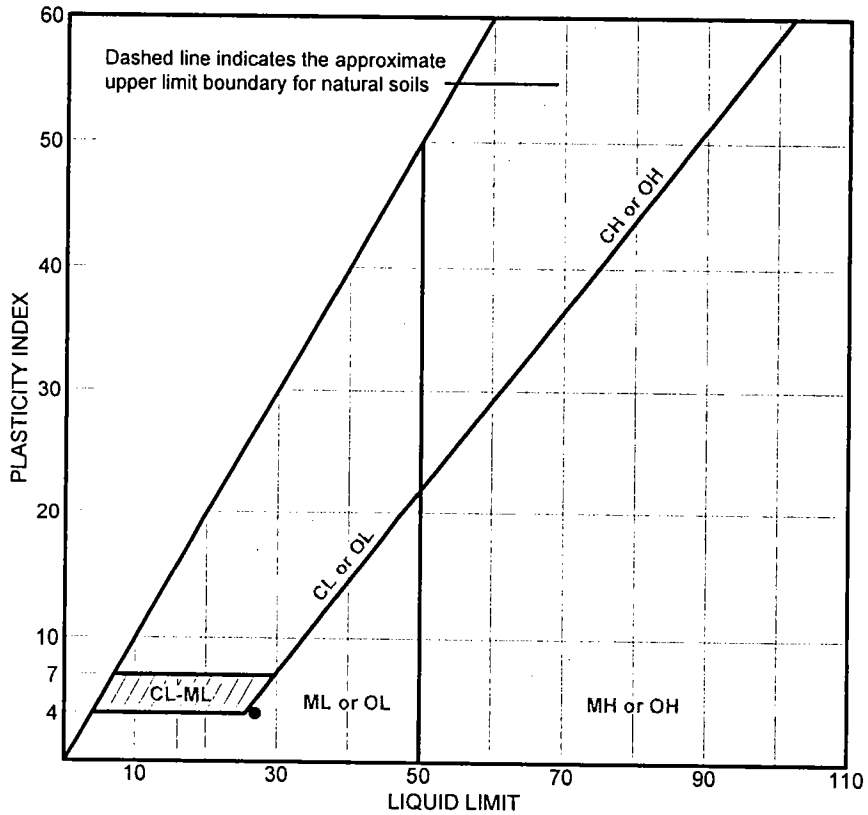
Project No. 05-187 Figure

SIERRA TESTING LABS, INC.

●

LIQUID AND PLASTIC LIMITS TEST REPORT





	SOURCE	SAMPLE #	DEPTH/ELEV.	DATE SAMPLED	USCS	MATERIAL DESCRIPTION	NM %	LL	PI
●	2F-05-G4-2A	FS8	12.0-13.5	6/22/05				27	4

Client U.S. Army Corps of Engineers

Project Sacramento River FEMA - Geotech Sites

(Pocket Area)

Project No. 05-187 Figure

SIERRA TESTING LABS, INC.

●

NATOMAS BASIN

NAT REACH D – NCC SOUTH – U1 LM 1.17

STRATIGRAPHY INPUT

BORING LOGS

LABORATORY TESTING

American River Common Features GRR
Natomas Cross Canal Sta. 956+00 LM 1.17
Table F-2-16: Permeability Selection for Seepage Analysis

Elevation of Levee Crest (NAVD 88)	Boring	Layer ID	USCS Soil Classification	Depth to Top of Layer (ft.)	Depth to Bottom of Layer (ft.)	Elevation of Top of Layer (NAVD 88)	Elevation of Bottom of Layer (NAVD 88)	Layer Thickness (ft.)	Laboratory and Field Data			Estimated Permeability for Seepage Analysis					Estimated Strength Parameters		
									% Fines (-Sieve 200) From Field Classification	PI	LL	Horizontal k_h (k_x) cm/sec	k_h/k_v	Vertical k_v (k_y) cm/sec	Horizontal k_h (k_x) ft/day	Vertical k_v (k_y) ft/day	Φ	C	γ
44.85	NCCB-6, NCCB-6-49	1	Clayey Sand (SC)	0	24.5	44.9	20.4	24.50	35			4.00E-05	4.00	1.00E-05	0.113	0.028	28	50	120
		2	Poorly Graded Sand w/ silt (SP-SM)	24.5	47	20.4	-2.2	22.50				1.00E-03	10.00	1.00E-04	2.835	0.284	33	0	130
		3	Poorly Graded Sand (SP)	47	81.5	-2.2	-36.7	34.50				5.00E-03	10.00	5.00E-04	14.175	1.418	34	0	135
		4	Sandy Fat Clay (CH)	81.5	86.2	-36.7	-41.4	4.70				1.00E-05	10.00	1.00E-06	0.028	0.003	30	50	110
		5	Clay Cap									1.00E-06	4.00	2.50E-07	0.00284	0.00071	28	50	115
		6	Cutoff Wall									1.00E-06	1.00	1.00E-06	0.00284	0.00284	0	50	85
				Total Depth (ft.)	**86.20**														

Landside Toe El **32.42** **(NAVD 88)**
Levee Height **12.4** **(ft.)**

Note:

NCC					NAVD 88			
		10-yr SAC	25-yr SAC	50-yr SAC	100-yr SAC	200-yr SHY	500-yr AMR	Top of Levee
Reach	River Sta	W.S. Elev	W.S. Elev	W.S. Elev	W.S. Elev	W.S. Elev	W.S. Elev	NLDB Left Bank
Main	**3.23**	**39.00**	**41.11**	**41.88**	**42.84**	**44.23**	**45.16**	**44.85**

Exit Gradient at Toe

Mitigation Height

500-yr +3 Levee Height	200-yr +3 Levee Height
48.16	**47.23**

Surface Conditions:	Levee crown, loose gravel	Date Completed:	6/26/2006
Groundwater:	Groundwater not measured.	Logged By:	Brian Honea
		Total Depth:	91-1/2 feet
Method:	Hollow Stem Auger/Mud Rotary	Boring Diameter:	8 inch/4 inch
Equipment:	CME 75 with 140lb. Automatic Hammer		

Approximate Elevation: 42.5 feet (NGVD29*)
Approximate Northing: 2048063.91 feet
Approximate Easting: 6675533.77 feet

Elevation (ft., msl)	Depth (feet)	Sample Type	Sample No.	Blows/6 inches	Pocket Penetrometer (tsf)	Dry Density (pcf)	Moisture Content (%)	Liquid Limit	Plasticity Index	Passing #4 Sieve (%)	Passing #200 Sieve (%)	Other Tests	Graphic Log	DESCRIPTION
														LOOSE GRAVEL (GM): (Levee Fill)
														Sandy SILT (ML): Gray brown, moist, firm (Levee Fill)
			1a	4										
			1b	5										
				6										
38	5													
			2a	2										
			2b	2										
				3										**Silty SAND** (SM): Gray, moist, fine sand, about 30% fines, about 30% fines (Levee Fill)
														Sandy FAT CLAY (CH): Gray brown, moist, firm, high plasticity, about 30% fine sand (Levee Fill)
			3a	3										
			3b	3										
				6										
33	10													
			4a	3										
			4b	5				51	29			Atterberg; see Plate B-2		
				6										
			5a	3										
			5b	4										
				6										
28	15													
			6a	2										
			6b	3										
				6										
			7a	2										
			7b	3										
				6										
23	20													
			8a	3										**Sandy FAT CLAY** (CH): Gray brown, moist, firm, high plasticity, about 30% fine sand
			8b	6										
				7										
			9a	3										
			9b	6										
				9										Some charcoal pieces
18	25													
			10a	4										
			10b	8										
				9										Dark gray to black
			11a	9										**Sandy SILT** (ML): Gray brown, moist, firm
			11b	10										
				14										

P-LOG_2006 BLOWS PER 6 INCHES 72834-DNCC06.GPJ 6/28/07

Drafted By: D. Ross
Date: 6/28/2007
Project No.: 72834/DNCC06
File Number: 72834-DNCC06

LOG OF BORING NCCB-6- 4

NATOMAS CROSS CANAL SOUTH LEVEE
REACHES 1 THROUGH 4
NATOMAS BASIN EVALUATION
SUTTER COUNTY, CALIFORNIA

PLATE
1 of 3
A-6

Elevation (ft., msl)	Depth (feet)	Sample Type	Sample No.	Blows/6 inches	Pocket Penetrometer (tsf)	Dry Density (pcf)	Moisture Content (%)	Liquid Limit	Plasticity Index	Passing #4 Sieve (%)	Passing #200 Sieve (%)	Other Tests	Graphic Log	DESCRIPTION
		FIELD				LABORATORY								
13	30			9										
			12a	14										
			12b	18							55			
				5										**Silty SAND** (SM): Olive brown, moist to wet, fine sand, about 25% fines
			13a	5										
			13b	7							25			
8	35			3										
			14a	7										
			14b	13										
				4										
			15a	5										
			15b	6							44			About 44% fines
3	40			4										**Sandy SILT** (ML): Olive brown, moist to wet, about 39% fine sand
			16a	6										
			16b	7							61			
				2										**Silty SAND** (SM): Gray brown, wet, fine sand, about 35% fines
			17a	5										
			17b	7										
-3	45			3										
			18a	9										
			18b	18							21			About 21% fines
				7										
			19a	13										About 44% fines
			19b	20							44			
-8	50			10										
			20a	15										
			20b	22										**SILT** (ML): Light gray with orange, moist, hard
				6										**Silty SAND** (SM): Gray brown, wet, fine sand, about 35% fines
			21a	11										
			21b	17										
-13	55			7										**Sandy SILT** (ML): Gray with orange, moist, very stiff, fine sand, about 16% fine sand
			22a	12										
			22b	21							84			
				9										
			23a	23										Decreasing sand
			23b	31							54			
														SILT (ML): Olive brown, moist, very hard
-18	60			11										
			24a	23										**Sandy SILT** (ML): Gray brown, moist to wet, very hard, about 47% fine to medium sand
			24b	26							53			
														SILT (ML): Gray with orange, moist, hard, about

P-LOG_2006 BLOWS PER 6 INCHES 72834-DNCC06.GPJ 6/28/07

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Date: 6/28/2007
Project No.: 72834/DNCC06
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LOG OF BORING NCCB-6- 4

NATOMAS CROSS CANAL SOUTH LEVEE
REACHES 1 THROUGH 4
NATOMAS BASIN EVALUATION
SUTTER COUNTY, CALIFORNIA

PLATE
2 of 3
A-6

Elevation (ft., msl)	Depth (feet)	Sample Type	Sample No.	Blows/6 inches	Pocket Penetrometer (tsf)	Dry Density (pcf)	Moisture Content (%)	Liquid Limit	Plasticity Index	Passing #4 Sieve (%)	Passing #200 Sieve (%)	Other Tests	Graphic Log	DESCRIPTION
														5% fine sand
-23	65			7										Firm
			25a	11										
			25b	18										
-28	70			13										Very hard
			26a	24										
			26b	32										
-33	75			8										Gray, about 20% fine sand
			27a	19										
			27b	25										**Silty SAND** (SM): Gray, moist to wet, fine to medium sand, about 25% fines
-38	80			6										
			28a	15										
			28b	21							27			About 27% fines
-43	85			10										**Sandy SILT** (ML): Dark gray, moist, very hard, about 30% fine sand
			29a	22										
			29b	31										Greenish gray
-48	90			14										**Silty SAND** (SM): Dark gray, wet, about 30% fines
			30a	23										
			30b	34							30			
														Boring completed at a depth of 91-1/2 feet below existing site grade.
-53	95													

FIELD | LABORATORY

P-LOG_2006 BLOWS PER 6 INCHES 72834-DNCC06.GPJ 6/28/07

Drafted By: D. Ross
Date: 6/28/2007
Project No.: 72834/DNCC06
File Number: 72834-DNCC06

LOG OF BORING NCCB-6- 4

NATOMAS CROSS CANAL SOUTH LEVEE
REACHES 1 THROUGH 4
NATOMAS BASIN EVALUATION
SUTTER COUNTY, CALIFORNIA

PLATE
3 of 3
A-6

Surface Conditions:	Levee toe, grassy	Date Completed:	7/5/2006
Groundwater:	Groundwater not measured.	Logged By:	C. Wilhite
		Total Depth:	66-1/2 feet
Method:	Mud Rotary	Boring Diameter:	4 inch
Equipment:	CME 750 with 140lb. Automatic Hammer		

Approximate Elevation: 21.5 feet (NGVD29*)
Approximate Northing: 2048016.25 feet
Approximate Easting: 6675610.83 feet

Elevation (ft., msl)	Depth (feet)	Sample Type	Sample No.	Blows/6 inches	Pocket Penetrometer (tsf)	Dry Density (pcf)	Moisture Content (%)	Liquid Limit	Plasticity Index	Passing #4 Sieve (%)	Passing #200 Sieve (%)	Other Tests	Graphic Log	DESCRIPTION
														LEAN CLAY (CL): Brown, dry, firm
			1a 1b	8 9 9										Moist
17	5		2a 2b	4 4 23	1.75									Olive brown
														Sandy SILT (ML): Brown, moist, firm, about 30% fine sand
			3a 3b	17 39 39	>4.5									**Clayey GRAVEL** (GC): Brown to red, moist, fine to coarse gravel, about 30% fines
														SILT (ML): Brown, moist, very hard
12	10		4a 4b	7 10 20										Firm, some red mottling
			5a 5b	7 13 20	>4.5									
7	15		6a 6b	9 15 15										**LEAN CLAY** (CL): Brownish gray, moist, firm
			7a 7b	6 7 8							39			**Silty SAND** (SM): Brown, moist, fine sand, about 39% fines
2	20		8a 8b	3 5 7										Olive brown
			9a 9b	3 5 6							39			
														Sandy SILT (ML): Brown, moist, firm, about 30% fine to medium sand
-4	25		10a 10b	3 6 10							32			**Silty SAND** (SM): Brown, moist, fine to medium sand, about 32% fines
			11a 11b	5 10 18							23			Medium sand, about 23% fines

P-LOG_2006 BLOWS PER 6 INCHES 72834-DNCC06.GPJ 6/28/07

Drafted By: D. Ross
Date: 6/28/2007
Project No.: 72834/DNCC06
File Number: 72834-DNCC06

LOG OF BORING NCCB-6- 5

NATOMAS CROSS CANAL SOUTH LEVEE
REACHES 1 THROUGH 4
NATOMAS BASIN EVALUATION
SUTTER COUNTY, CALIFORNIA

PLATE
1 of 3
A-7

Elevation (ft., msl)	Depth (feet)	Sample Type	Sample No.	Blows/6 inches	Pocket Penetrometer (tsf)	Dry Density (pcf)	Moisture Content (%)	Liquid Limit	Plasticity Index	Passing #4 Sieve (%)	Passing #200 Sieve (%)	Other Tests	Graphic Log	DESCRIPTION
-9	30			9										**Sandy SILT** (ML): Gray brown, moist, firm, about 30% fine sand
			12a	9										
			12b	11	3.25									
				9										**Silty SAND** (SM): Brown, moist, fine to medium sand, about 25% fines
			13a	17										
			13b	21							25			
-14	35			10										
			14a	11										**SILT With Sand** (ML): Gray brown, moist, firm, about 15% fine sand
			14b	10	1.75									
				11										**Silty SAND** (SM): Brown, moist, fine sand, about 20% fines
			15a	14										
			15b	17	4.0									**LEAN CLAY With Sand And Gravel** (CL): Brown, moist, firm, about 10% fine to coarse sand, about 5% fine gravel
-19	40			7										
			16a	23										**Poorly Graded SAND With Silt** (SP-SM): Brown, moist, about 10% fines
			16b	28							10			
				8										**LEAN CLAY** (CL): Brown, moist, hard
			17a	18										
			17b	17	3.25									
-24	45			7										Firm
			18a	14										
			18b	14	>4.5									
				17										**SILT With Sand** (ML): Olive brown, moist, very hard, about 10% fine sand
			19a	20										
			19b	28	>4.5									
-29	50			10										
			20a	12										
			20b	14										**LEAN CLAY** (CL): Olive brown, moist, firm, about 5% fine sand
				5										**SILT With Sand** (ML): Olive brown, moist, firm, about 10% fine sand
			21a	7										
			21b	11										
-34	55			3							63			**Sandy SILT** (ML): Olive gray, moist to wet, firm, about 37% fine sand
			22a	5										
			22b	7	.25									
				8										
			23a	10	3.25									
			23b	20										
-39	60			13										Very hard
			24a	18										
			24b	25	>4.5									

P-LOG_2006 BLOWS PER 6 INCHES 72834-DNCC06.GPJ 6/28/07

Drafted By: D. Ross
Date: 6/28/2007
Project No.: 72834/DNCC06
File Number: 72834-DNCC06

LOG OF BORING NCCB-6- 5

NATOMAS CROSS CANAL SOUTH LEVEE
REACHES 1 THROUGH 4
NATOMAS BASIN EVALUATION
SUTTER COUNTY, CALIFORNIA

PLATE
2 of 3
A-7

Elevation (ft., msl)	Depth (feet)	FIELD: Sample Type	FIELD: Sample No.	FIELD: Blows/6 inches	FIELD: Pocket Penetrometer (tsf)	LABORATORY: Dry Density (pcf)	LABORATORY: Moisture Content (%)	LABORATORY: Liquid Limit	LABORATORY: Plasticity Index	LABORATORY: Passing #4 Sieve (%)	LABORATORY: Passing #200 Sieve (%)	LABORATORY: Other Tests	Graphic Log	DESCRIPTION
														Silty SAND (SM): Brown, moist, fine sand, about 47% fines
-44	65			8										
			25a	12										
			25b	16							47			
														Boring completed at a depth of 66-1/2 feet below existing site grade.
-49	70													
-54	75													
-59	80													
-64	85													
-69	90													
-74	95													

P-LOG_2006 BLOWS PER 6 INCHES 72834-DNCC06.GPJ 6/28/07

Drafted By: D. Ross
Date: 6/28/2007
Project No.: 72834/DNCC06
File Number: 72834-DNCC06

LOG OF BORING NCCB-6- 5

NATOMAS CROSS CANAL SOUTH LEVEE
REACHES 1 THROUGH 4
NATOMAS BASIN EVALUATION
SUTTER COUNTY, CALIFORNIA

PLATE
3 of 3
A-7

BORING NO.	SAMPLE DEPTH (ft)	DRY UNIT WEIGHT (pcf)	MOISTURE CONTENT (% of dry weight)	PARTICLE SIZE SIEVE SIZE (percent passing)						ATTERBERG LIMITS		OTHER TESTS
				3"	3/4"	#4	#10	#40	#200	L.L.	P.I.	
CCB-6-1	8.5								41			
NCCB-6-1	16.0								41			
NCCB-6-1	18.5					100	100	99	57			Sieve; see Plate B-3
NCCB-6-1	21.0								34			
NCCB-6-1	23.5								19			
NCCB-6-1	25.5									31	10	Atterberg; see Plate B-2
NCCB-6-1	28.5								93			
NCCB-6-1	46.0								51			
NCCB-6-1	48.5								44			
NCCB-6-1	53.5								40			
NCCB-6-1	61.0								32			
NCCB-6-1	63.5								9			
NCCB-6-1	70.5					100	99	70	11			Sieve; see Plate B-3
NCCB-6-2	11.0								61			
NCCB-6-2	16.0								42			
NCCB-6-2	21.0								51			
NCCB-6-2	26.0									46	19	Atterberg; see Plate B-2
NCCB-6-2	46.0								16			
NCCB-6-2	51.0								11			
NCCB-6-2	53.5					100	100	65	14			Sieve; see Plate B-3
NCCB-6-2	81.0								10			
NCCB-6-3	6.0								49			
CCB-6-3	11.0									46	18	Atterberg; see Plate B-2
NCCB-6-3	16.0								81			
NCCB-6-3	18.5					100	100	99	20			Sieve; see Plate B-3
NCCB-6-3	23.5								59			
NCCB-6-3	36.0								54			
NCCB-6-3	38.5								54			
NCCB-6-3	43.5								48			
NCCB-6-4	11.0									51	29	Atterberg; see Plate B-2
NCCB-6-4	31.0								55			
NCCB-6-4	33.5								25			
NCCB-6-4	38.5								44			
NCCB-6-4	41.0								61			
NCCB-6-4	46.0								21			
NCCB-6-4	48.5								44			
NCCB-6-4	56.0								84			
NCCB-6-4	58.5								54			
NCCB-6-4	61.0								53			
NCCB-6-4	81.0								27			
NCCB-6-4	91.0								30			

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Drafted By: D. Ross
Date: 6/4/2008
Project No.: 72834/DNCC06
File Number: 72834-DNCC06

SUMMARY OF LABORATORY TESTS

NATOMAS CROSS CANAL SOUTH LEVEE
REACHES 1 THOUGH 4
NATOMAS BASIN EVALUATION
SUTTER COUNTY, CALIFORNIA

PLATE
1 of 5
B-1

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2834-DNCC06.GPJ 6/4/08
KA-LAB

BORING NO.	SAMPLE DEPTH (ft)	DRY UNIT WEIGHT (pcf)	MOISTURE CONTENT (% of dry weight)	PARTICLE SIZE SIEVE SIZE (percent passing)						ATTERBERG LIMITS		OTHER TESTS
				3"	3/4"	#4	#10	#40	#200	L.L.	P.I.	
CCB-6- 5	18.5								39			
NCCB-6- 5	23.0								39			
NCCB-6- 5	26.0								32			
NCCB-6- 5	28.5								23			
NCCB-6- 5	33.5								25			
NCCB-6- 5	41.0								10			
NCCB-6- 5	55.0								63			
NCCB-6- 5	66.0								47			
NCCB-6- 6	15.5								49			
NCCB-6- 6	28.5									61	38	Atterberg; see Plate B-2
NCCB-6- 6	43.5					100	100	49	9			Sieve; see Plate B-3
NCCB-6- 6	46.0								12			
NCCB-6- 6	53.5								60			
NCCB-6- 6	56.0								47			
NCCB-6- 6	61.0					100	100	90	16			Sieve; see Plate B-3
NCCB-6- 6	66.0					100	100	93	5			Sieve; see Plate B-3
NCCB-6- 6	86.0								58			
NCCB-6- 7	12.5									55	37	Atterberg; see Plate B-2
NCCB-6- 7	33.5								49			
NCCB-6- 7	36.0								34			
NCCB-6- 7	41.0								26			
NCCB-6- 7	55.5								90			
CCB-6- 8	31.0									53	37	Atterberg; see Plate B-2
NCCB-6- 8	58.5								41			
NCCB-6- 8	61.0								21			
NCCB-6- 8	81.0								61			
NCCB-6- 8	86.0								7			
NCCB-6- 8	91.0								7			
NCCB-6- 9	11.0								26			
NCCB-6- 9	16.0									54	34	Atterberg; see Plate B-2
NCCB-6- 9	31.0								65			
NCCB-6- 9	33.5								34			
NCCB-6- 9	36.0					100	99	31	6			Sieve; see Plate B-3
NCCB-6- 9	38.5								6			
NCCB-6- 9	41.0								21			
NCCB-6- 9	46.0								4			
NCCB-6-10	15.5								13			
NCCB-6-10	18.0								44			
NCCB-6-10	23.0								21			
NCCB-6-10	30.5								12			
NCCB-6-10	41.0								26			

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Drafted By: D. Ross
Date: 6/4/2008
Project No.: 72834/DNCC06
File Number: 72834-DNCC06

SUMMARY OF LABORATORY TESTS

NATOMAS CROSS CANAL SOUTH LEVEE
REACHES 1 THOUGH 4
NATOMAS BASIN EVALUATION
SUTTER COUNTY, CALIFORNIA

PLATE
2 of 5
B-1

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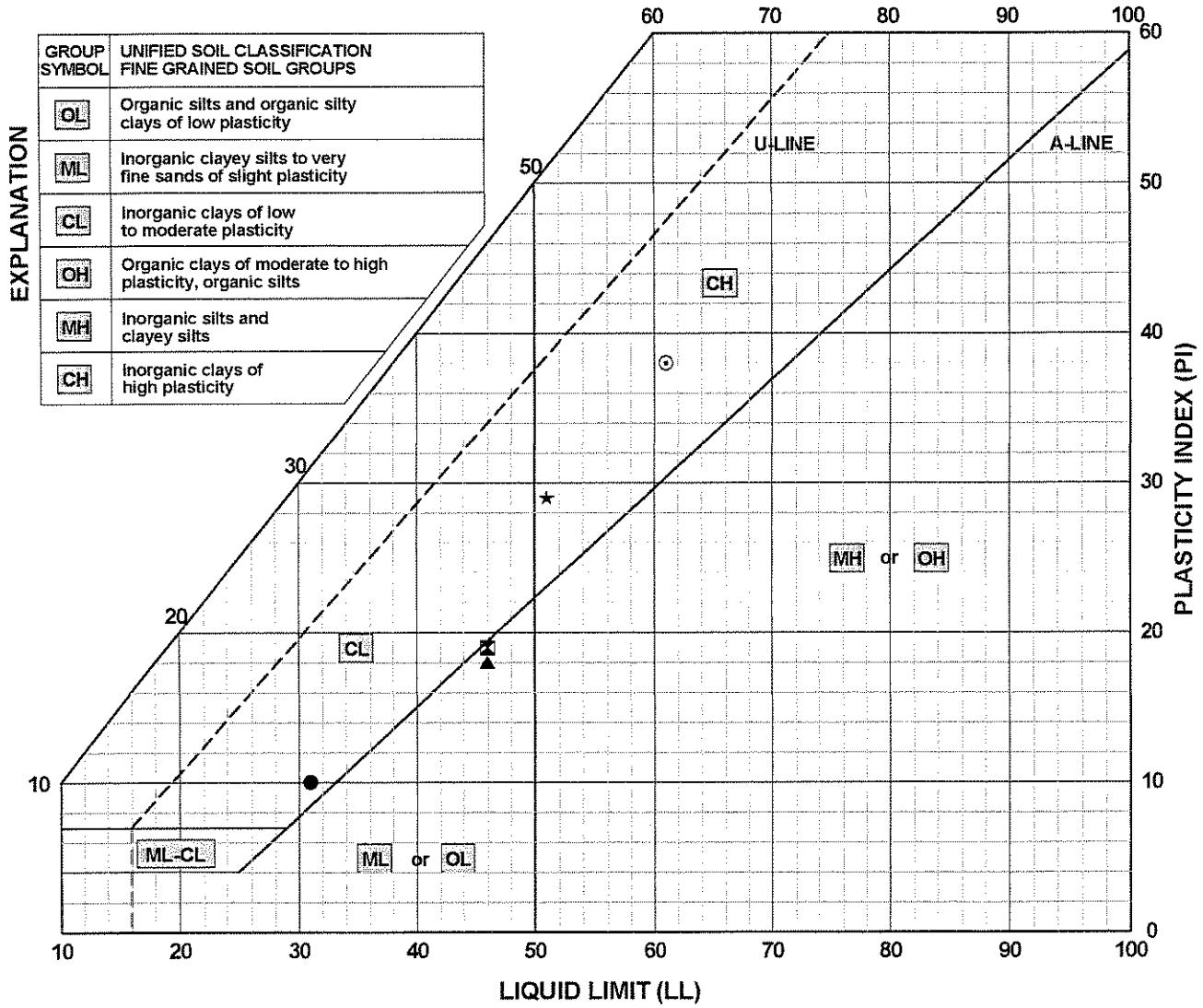

LEGEND:	SOURCE	DEPTH (ft)	LL	PL	PI	DESCRIPTION
●	NCCB-6-1	25.5	31	21	10	Lean CLAY (CL)
⊠	NCCB-6-2	26.0	46	27	19	Lean CLAY (CL)
▲	NCCB-6-3	11.0	46	28	18	Sandy CLAY (CL)
★	NCCB-6-4	11.0	51	22	29	Sandy Fat CLAY (CH)
⊙	NCCB-6-6	28.5	61	23	38	Fat CLAY (CH)

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Drafted By: D. Ross
Date: 6/4/2008
Project No.: 72834/DNCC06
File Number: 72834-DNCC06

PLASTICITY CHART

NATOMAS CROSS CANAL SOUTH LEVEE
REACHES 1 THOUGH 4
NATOMAS BASIN EVALUATION
SUTTER COUNTY, CALIFORNIA

PLATE
1 of 4
B-2

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KA_AT

AMERICAN RIVER WATERSHED

COMMON FEATURES PROJECT

GENERAL REEVALUATION REPORT

ATTACHMENT C – GEOTECHNICAL REPORT

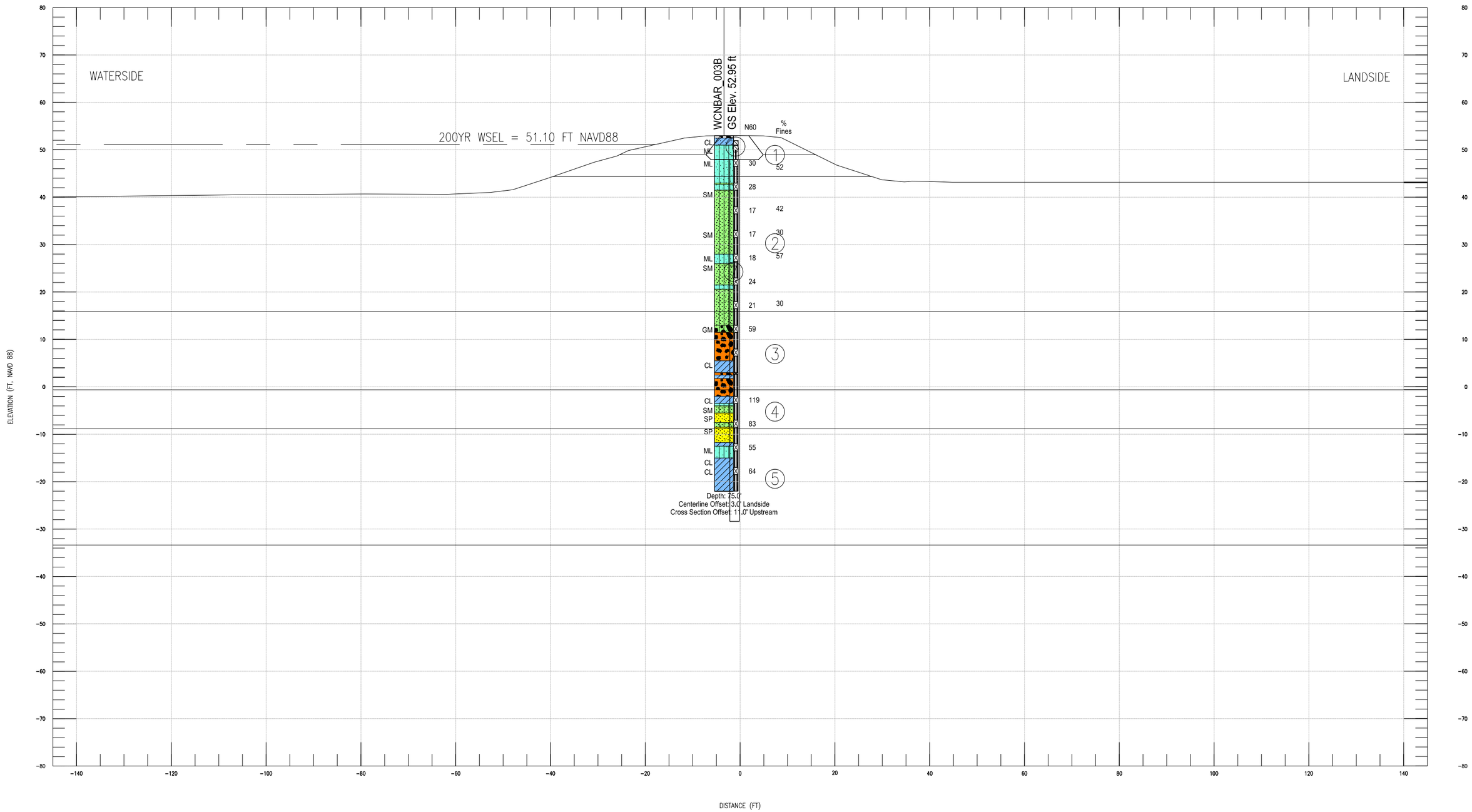
ENCLOSURE 2

STEADY STATE SEEPAGE AND LANDSIDE SLOPE STABILITY ANALYSES RESULTS

AMERICAN RIVER NORTH BASIN

ARN REACH A – AMERICAN RIVER NORTH – U9 LM 1.32

STEADY STATE SEEPAGE AND LANDSIDE SLOPE STABILITY ANALYSES RESULTS



Boring Number	Layer ID	USCS Soil Classification	Estimated Permeability for Seepage Analysis					Estimated Strength Parameters		
			Horizontal kh (kx) cm/sec	Anisotropy Ratio kh/kv	Vertical kv (ky) cm/sec	Horizontal kh (kx) ft/day	Vertical kv (ky) ft/day	Φ'	C' (psf)	γ (pcf)
WNCBAR_003B, 2F-97-6, DH-7, DH-7A	1	Silty Sand (SM) with Silt (ML) Levee Embankment	5.00E-04	4	1.25E-04	1.4175	0.3544	33	0	125
	2	Silty Sand (SM) with Silty (ML)	2.00E-04	4	5.00E-05	0.5670	0.1418	33	0	125
	3	Poorly Graded Gravel (GP) with Lean Clay (CL)	2.00E-01	4	5.00E-02	567.0000	141.7500	35	0	135
	4	Poorly Graded Sand with Silty Sand (SP-SM)	1.00E-03	4	2.50E-04	2.8350	0.7088	33	0	125
	5	Lean Clay (CL) with Silt (ML)	1.00E-05	4	2.50E-06	0.0284	0.0071	28	50	115
	6	Impervious Clay Cap (CL)	1.00E-05	4	2.50E-06	0.0284	0.0071	28	50	115
	7	Cutoff Wall	1.00E-06	4	2.50E-07	0.0028	0.0007	0	50	85

0 20' 40'
HORIZONTAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

0 20' 40'
VERTICAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

SACRAMENTO CALIFORNIA

AMERICAN RIVER WATERSHED - COMMON FEATURES
GENERAL REEVALUATION REPORT
GEOTECHNICAL ATTACHMENT
SECTION STRATIGRAPHY – 10 SCALE
ARN – REACH A – AMERICAN RIVER NORTH – U9 LM 1.32

DATE:	SCALE:	SHEET NO.
29-Jan-13	AS SHOWN	1

PLOT BY: I2EDGAJD - May 22, 2013 - 4:10:20pm
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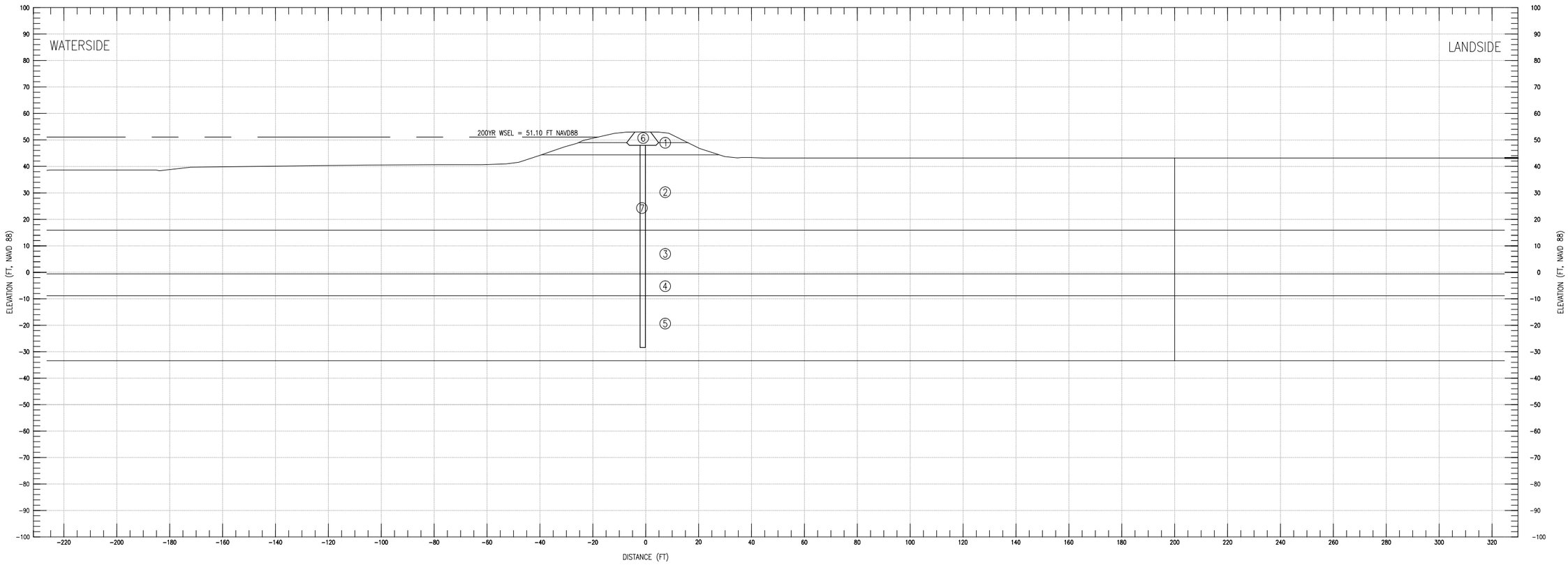

Boring Number	Layer ID	USCS Soil Classification	Estimated Permeability for Seepage Analysis					Estimated Strength Parameters		
			Horizontal kh (kx) cm/sec	Anisotropy Ratio kh/kv	Vertical kv (ky) cm/sec	Horizontal kh (kx) ft/day	Vertical kv (ky) ft/day	Φ'	C' (psf)	γ (pcf)
WNCBAR_003B, 2F-97-6, DH-7, DH-7A	1	Silty Sand (SM) with Silt (ML) Levee Embankment	5.00E-04	4	1.25E-04	1.4175	0.3544	33	0	125
	2	Silty Sand (SM) with Silty (ML)	2.00E-04	4	5.00E-05	0.5670	0.1418	33	0	125
	3	Poorly Graded Gravel (GP) with Lean Clay (CL)	2.00E-01	4	5.00E-02	567.0000	141.7500	35	0	135
	4	Poorly Graded Sand with Silty Sand (SP-SM)	1.00E-03	4	2.50E-04	2.8350	0.7088	33	0	125
	5	Lean Clay (CL) with Silt (ML)	1.00E-05	4	2.50E-06	0.0284	0.0071	28	50	115
	6	Impervious Clay Cap (CL)	1.00E-05	4	2.50E-06	0.0284	0.0071	28	50	115
	7	Cutoff Wall	1.00E-06	4	2.50E-07	0.0028	0.0007	0	50	85

0 20' 40'
HORIZONTAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

0 20' 40'
VERTICAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

DEPARTMENT OF THE ARMY
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SACRAMENTO CALIFORNIA

AMERICAN RIVER WATERSHED - COMMON FEATURES
GENERAL REEVALUATION REPORT
GEOTECHNICAL ATTACHMENT

SECTION STRATIGRAPHY – 20 SCALE

ARN – REACH A – AMERICAN RIVER NORTH – U9 LM 1.32

DATE:	SCALE:	SHEET NO.
29-Jan-13	AS SHOWN	2

PLOT BY: L2EDGAJD - May 22, 2013 - 4:10:25pm
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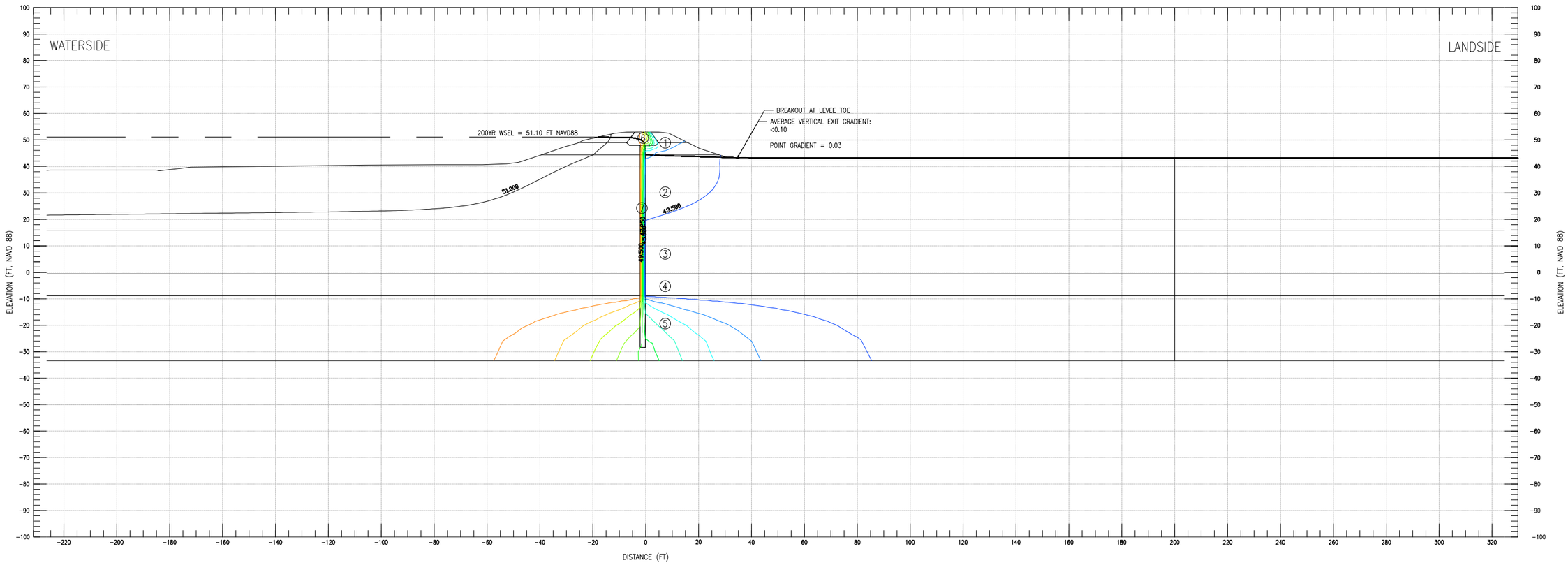

Boring Number	Layer ID	USCS Soil Classification	Estimated Permeability for Seepage Analysis					Estimated Strength Parameters		
			Horizontal kh (kx) cm/sec	Anisotropy Ratio kh/kv	Vertical kv (ky) cm/sec	Horizontal kh (kx) ft/day	Vertical kv (ky) ft/day	Φ'	C' (psf)	γ (pcf)
WNCBAR_003B, 2F-97-6, DH-7, DH-7A	1	Silty Sand (SM) with Silt (ML) Levee Embankment	5.00E-04	4	1.25E-04	1.4175	0.3544	33	0	125
	2	Silty Sand (SM) with Silty (ML)	2.00E-04	4	5.00E-05	0.5670	0.1418	33	0	125
	3	Poorly Graded Gravel (GP) with Lean Clay (CL)	2.00E-01	4	5.00E-02	567.0000	141.7500	35	0	135
	4	Poorly Graded Sand with Silty Sand (SP-SM)	1.00E-03	4	2.50E-04	2.8350	0.7088	33	0	125
	5	Lean Clay (CL) with Silt (ML)	1.00E-05	4	2.50E-06	0.0284	0.0071	28	50	115
	6	Impervious Clay Cap (CL)	1.00E-05	4	2.50E-06	0.0284	0.0071	28	50	115
	7	Cutoff Wall	1.00E-06	4	2.50E-07	0.0028	0.0007	0	50	85

0 20' 40'
HORIZONTAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

0 20' 40'
VERTICAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

DEPARTMENT OF THE ARMY
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SACRAMENTO, CALIFORNIA

SACRAMENTO CALIFORNIA

AMERICAN RIVER WATERSHED - COMMON FEATURES
GENERAL REEVALUATION REPORT
GEOTECHNICAL ATTACHMENT

200YR WSEL-HEAD CONTOURS-WITHOUT PROJECT
ARN – REACH A – AMERICAN RIVER NORTH – U9 LM 1.32

DATE:	SCALE:	SHEET NO.
29-Jan-13	AS SHOWN	3

PLOT BY: L2EDGAJD - May 22, 2013 - 4:10:30pm
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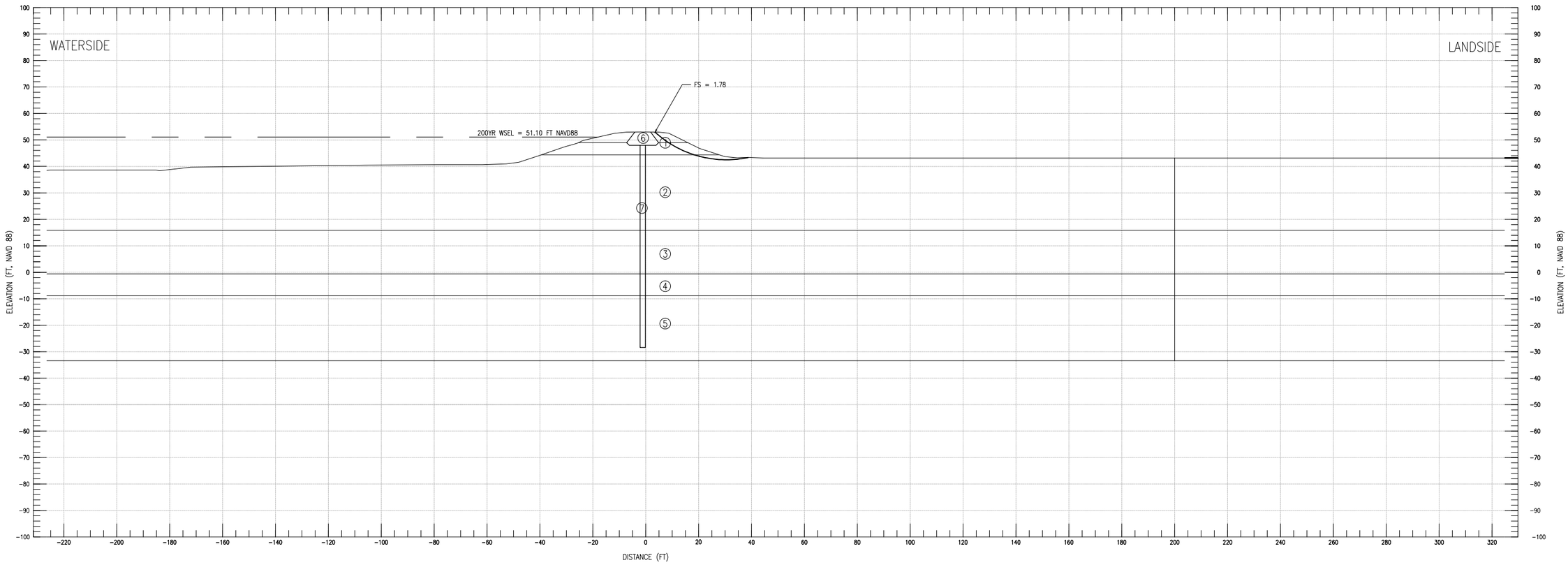

Boring Number	Layer ID	USCS Soil Classification	Estimated Permeability for Seepage Analysis					Estimated Strength Parameters		
			Horizontal kh (kx) cm/sec	Anisotropy Ratio kh/kv	Vertical kv (ky) cm/sec	Horizontal kh (kx) ft/day	Vertical kv (ky) ft/day	Φ'	C' (psf)	γ (pcf)
WNCBAR_003B, 2F-97-6, DH-7, DH-7A	1	Silty Sand (SM) with Silt (ML) Levee Embankment	5.00E-04	4	1.25E-04	1.4175	0.3544	33	0	125
	2	Silty Sand (SM) with Silty (ML)	2.00E-04	4	5.00E-05	0.5670	0.1418	33	0	125
	3	Poorly Graded Gravel (GP) with Lean Clay (CL)	2.00E-01	4	5.00E-02	567.0000	141.7500	35	0	135
	4	Poorly Graded Sand with Silty Sand (SP-SM)	1.00E-03	4	2.50E-04	2.8350	0.7088	33	0	125
	5	Lean Clay (CL) with Silt (ML)	1.00E-05	4	2.50E-06	0.0284	0.0071	28	50	115
	6	Impervious Clay Cap (CL)	1.00E-05	4	2.50E-06	0.0284	0.0071	28	50	115
	7	Cutoff Wall	1.00E-06	4	2.50E-07	0.0028	0.0007	0	50	85

0 20' 40'
HORIZONTAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

0 20' 40'
VERTICAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

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AMERICAN RIVER WATERSHED - COMMON FEATURES
GENERAL REEVALUATION REPORT
GEOTECHNICAL ATTACHMENT

200YR WSEL-CRITICAL SHEAR SURFACE-WITHOUT PROJECT
ARN – REACH A – AMERICAN RIVER NORTH – U9 LM 1.32

DATE:	SCALE:	SHEET NO.
29-Jan-13	AS SHOWN	4

PLOT BY: L2EDGAJD - May 22, 2013 - 4:10:36pm
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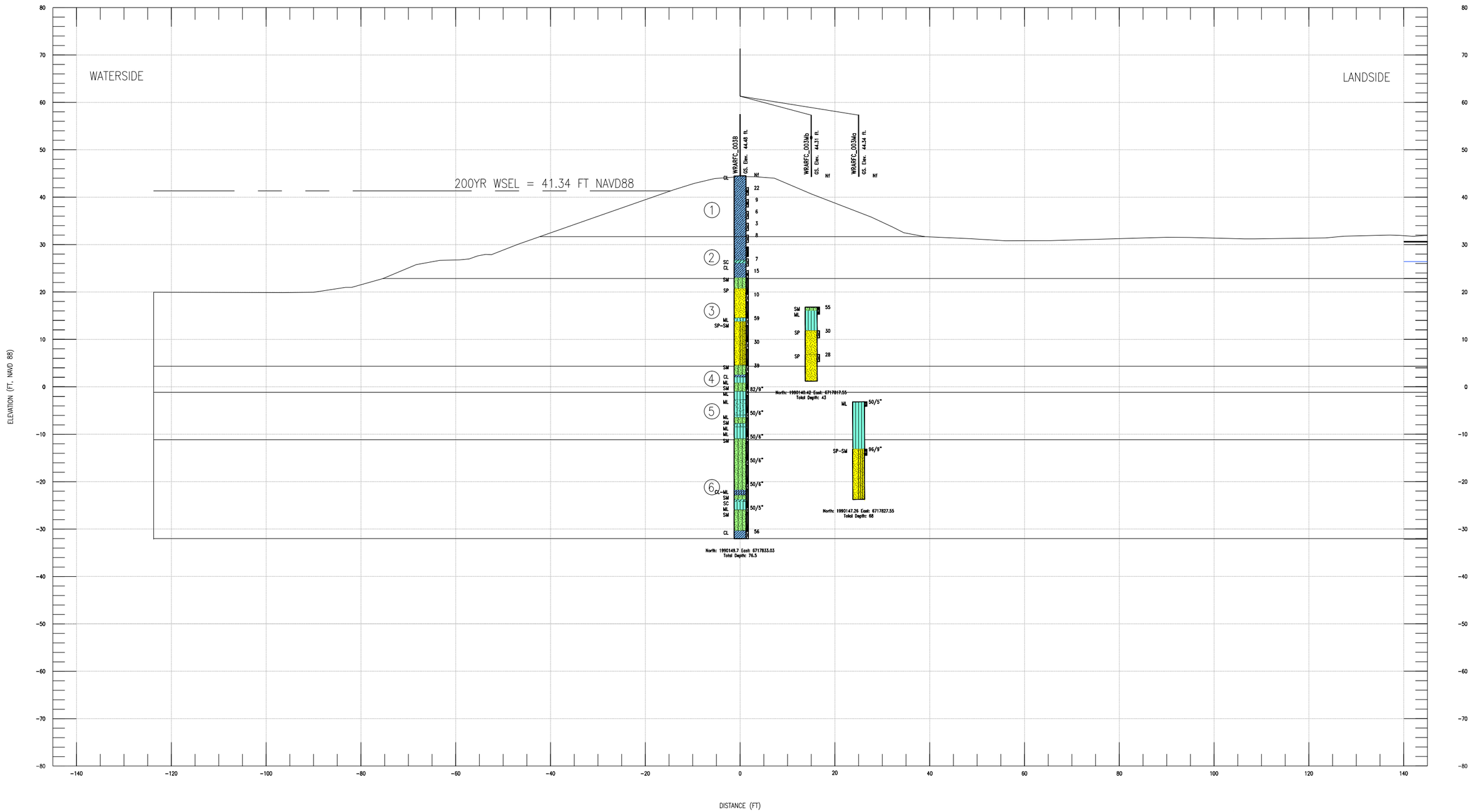
ARN REACH E – ARCADE CREEK NORTH – U7 LM 0.90

STEADY STATE SEEPAGE AND LANDSIDE SLOPE STABILITY ANALYSES RESULTS



Boring Number	Layer ID	Material Type	Estimated Permeability for Seepage Analysis					Estimated Strength Parameters		
			Horizontal kh (kx) cm/sec	Anisotropy Ratio kh/kv	Vertical kv (ky) cm/sec	Horizontal kh (kx) ft/day	Vertical kv (ky) ft/day	Φ'	C' (psf)	γ (pcf)
WRARFC_003B	1	Sandy Lean Clay Levee	1.00E-05	4	2.50E-06	0.028	0.007	24	50	115
	2	Sandy Lean Clay Blanket	1.00E-05	1	1.00E-05	0.028	0.028	28	50	115
	3	Poorly Graded Sand	5.00E-03	4	1.25E-03	14.175	3.544	35	0	130
	4	Silty Sand	1.00E-03	4	2.50E-04	2.835	0.709	33	0	125
	5	Sandy Silt	2.00E-04	4	5.00E-05	0.567	0.142	30	0	120
	6	Silty Sand	1.00E-03	4	2.50E-04	2.835	0.709	35	0	125

0 20' 40'
HORIZONTAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

0 20' 40'
VERTICAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
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SACRAMENTO, CALIFORNIA

SACRAMENTO CALIFORNIA

AMERICAN RIVER WATERSHED - COMMON FEATURES
GENERAL REEVALUATION REPORT
GEOTECHNICAL ATTACHMENT
SECTION STRATIGRAPHY – 10 SCALE
ARN – REACH E – ARCADE CREEK NORTH – U7 LM 0.90

DATE:	SCALE:	SHEET NO.
29-Jan-13	AS SHOWN	1

PLOT BY: L2EDGAJD - May 22, 2013 - 4:56:12pm
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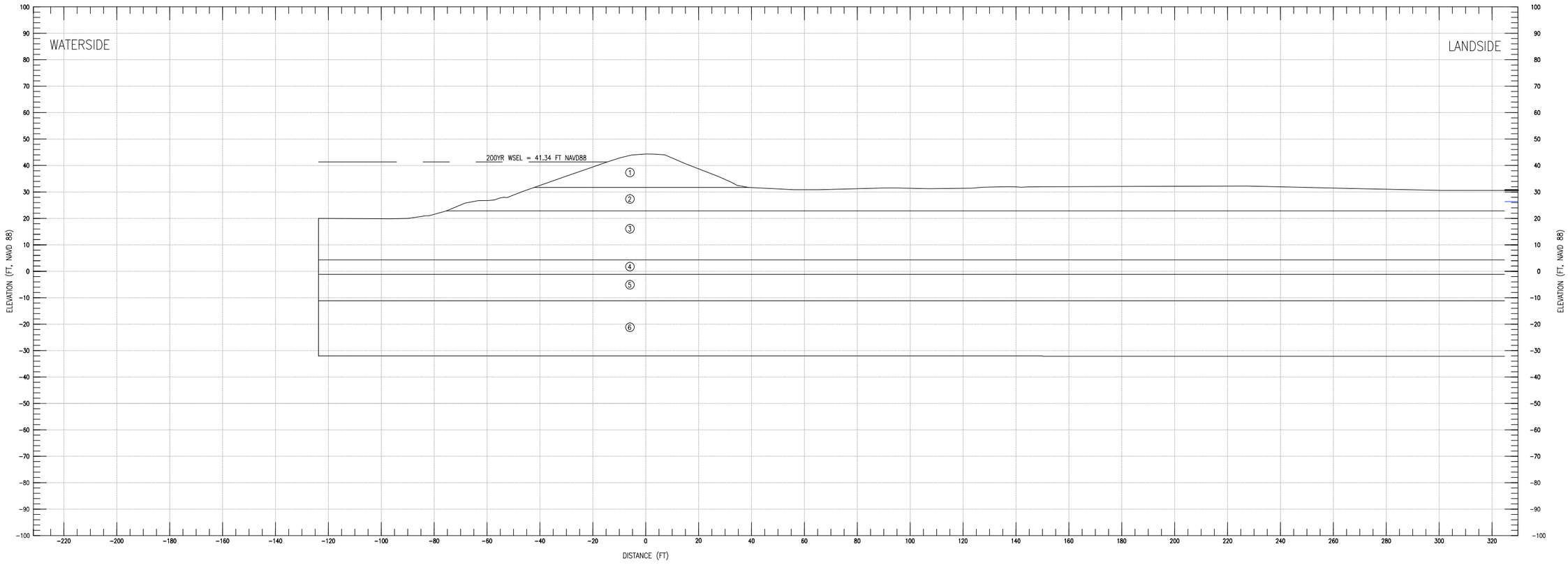

Boring Number	Layer ID	Material Type	Estimated Permeability for Seepage Analysis					Estimated Strength Parameters		
			Horizontal kh (kx) cm/sec	Anisotropy Ratio kh/kv	Vertical kv (ky) cm/sec	Horizontal kh (kx) ft/day	Vertical kv (ky) ft/day	Φ'	C' (psf)	γ (pcf)
WRARF C_003B	1	Sandy Lean Clay Levee	1.00E-05	4	2.50E-06	0.028	0.007	24	50	115
	2	Sandy Lean Clay Blanket	1.00E-05	1	1.00E-05	0.028	0.028	28	50	115
	3	Poorly Graded Sand	5.00E-03	4	1.25E-03	14.175	3.544	35	0	130
	4	Silty Sand	1.00E-03	4	2.50E-04	2.835	0.709	33	0	125
	5	Sandy Silt	2.00E-04	4	5.00E-05	0.567	0.142	30	0	120
	6	Silty Sand	1.00E-03	4	2.50E-04	2.835	0.709	35	0	125

0 20' 40'
HORIZONTAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

0 20' 40'
VERTICAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

SACRAMENTO CALIFORNIA

AMERICAN RIVER WATERSHED - COMMON FEATURES
GENERAL REEVALUATION REPORT
GEOTECHNICAL ATTACHMENT

SECTION STRATIGRAPHY – 20 SCALE
ARN – REACH E – ARCADE CREEK NORTH – U7 LM 0.90

DATE:	SCALE:	SHEET NO.
29-Jan-13	AS SHOWN	2

PLOT BY: I2EDGAJD - May 22, 2013 - 4:56:17pm
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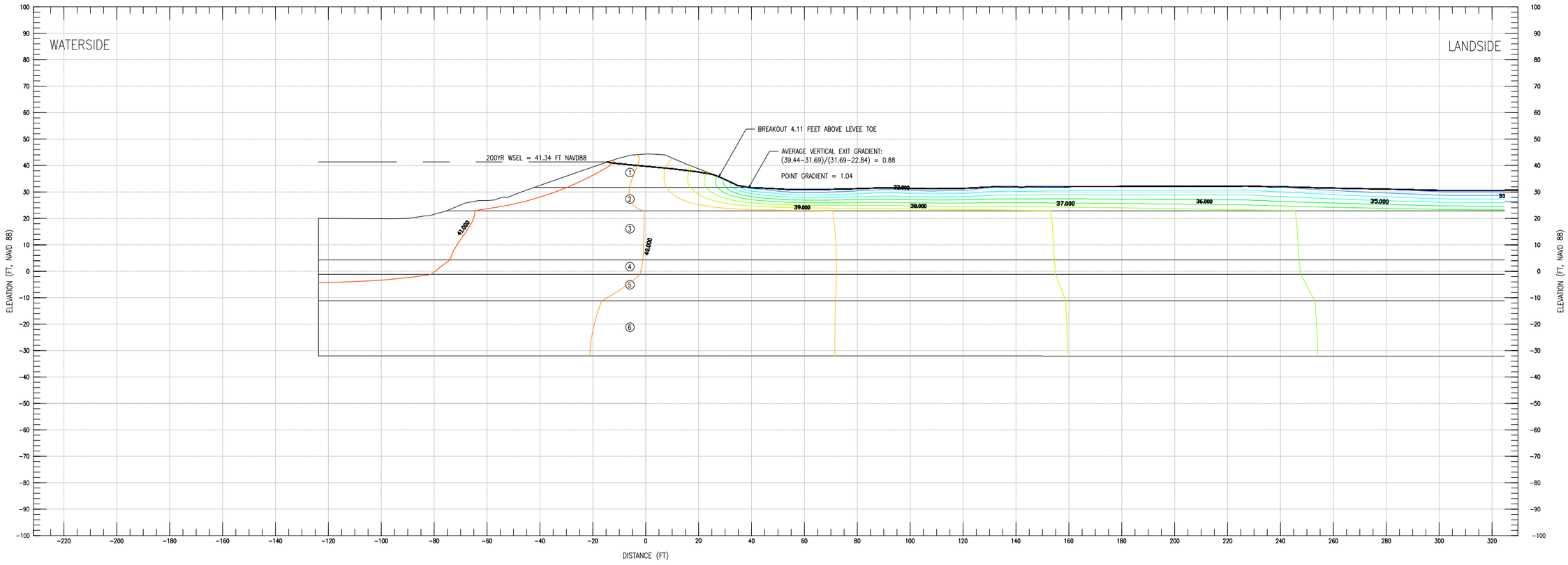

Boring Number	Layer ID	Material Type	Estimated Permeability for Seepage Analysis					Estimated Strength Parameters		
			Horizontal kh (kx) cm/sec	Anisotropy Ratio kh/kv	Vertical kv (ky) cm/sec	Horizontal kh (kx) ft/day	Vertical kv (ky) ft/day	Φ'	C' (psf)	γ (pcf)
WRARF C_003B	1	Sandy Lean Clay Levee	1.00E-05	4	2.50E-06	0.028	0.007	24	50	115
	2	Sandy Lean Clay Blanket	1.00E-05	1	1.00E-05	0.028	0.028	28	50	115
	3	Poorly Graded Sand	5.00E-03	4	1.25E-03	14.175	3.544	35	0	130
	4	Silty Sand	1.00E-03	4	2.50E-04	2.835	0.709	33	0	125
	5	Sandy Silt	2.00E-04	4	5.00E-05	0.567	0.142	30	0	120
	6	Silty Sand	1.00E-03	4	2.50E-04	2.835	0.709	35	0	125

0 20' 40'
HORIZONTAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

0 20' 40'
VERTICAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

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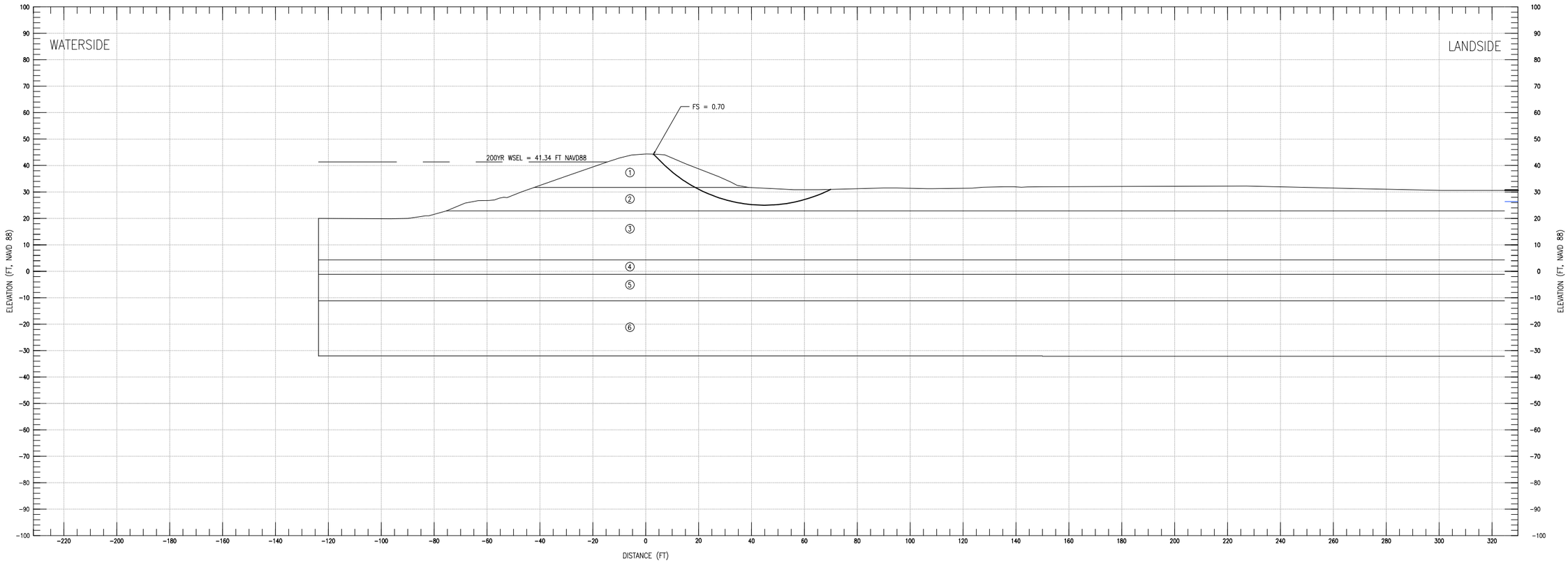
AMERICAN RIVER WATERSHED - COMMON FEATURES
GENERAL REEVALUATION REPORT
GEOTECHNICAL ATTACHMENT

200YR WSEL-HEAD CONTOURS-WITHOUT PROJECT
ARN – REACH E – ARCADE CREEK NORTH – U7 LM 0.90

DATE:	SCALE:	SHEET NO.
29-Jan-13	AS SHOWN	3

PLOT BY: I2EDGAJD - May 22, 2013 - 4:56:22pm
DRAWING: X:\SOIL\Scommon features gr\14 - cf gr\15 - submittals\arcf gr geotechnical report\arcf geotechnical appendix\gr appendix plates\REACH N UNIT 7 LM 0.90 - 200YR WSEL - HEAD CONTOURS.dwg



Boring Number	Layer ID	Material Type	Estimated Permeability for Seepage Analysis					Estimated Strength Parameters		
			Horizontal kh (kx) cm/sec	Anisotropy Ratio kh/kv	Vertical kv (ky) cm/sec	Horizontal kh (kx) ft/day	Vertical kv (ky) ft/day	Φ'	C' (psf)	γ (pcf)
WRARF C_003B	1	Sandy Lean Clay Levee	1.00E-05	4	2.50E-06	0.028	0.007	24	50	115
	2	Sandy Lean Clay Blanket	1.00E-05	1	1.00E-05	0.028	0.028	28	50	115
	3	Poorly Graded Sand	5.00E-03	4	1.25E-03	14.175	3.544	35	0	130
	4	Silty Sand	1.00E-03	4	2.50E-04	2.835	0.709	33	0	125
	5	Sandy Silt	2.00E-04	4	5.00E-05	0.567	0.142	30	0	120
	6	Silty Sand	1.00E-03	4	2.50E-04	2.835	0.709	35	0	125

0 20' 40'
HORIZONTAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

0 20' 40'
VERTICAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

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AMERICAN RIVER WATERSHED - COMMON FEATURES
GENERAL REEVALUATION REPORT
GEOTECHNICAL ATTACHMENT

200YR WSEL-CRITICAL SHEAR SURFACE-WITHOUT PROJECT
ARN – REACH E – ARCADE CREEK NORTH – U7 LM 0.90

DATE:	SCALE:	SHEET NO.
29-Jan-13	AS SHOWN	4

PLOT BY: LZEDGAJD - May 22, 2013 - 4:56:28pm
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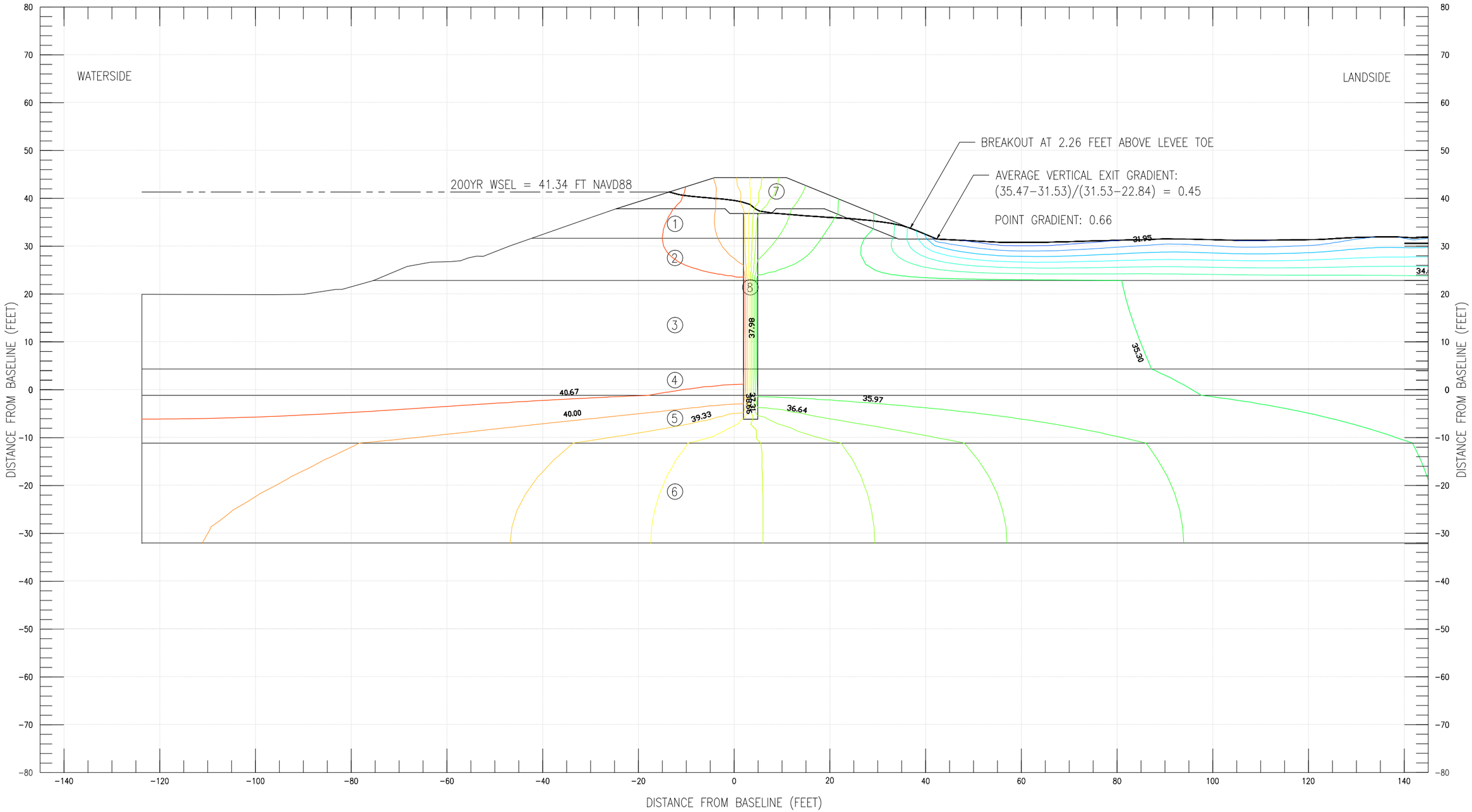

Boring Number	Layer ID	Material Type	Estimated Permeability for Seepage Analysis					Estimated Strength Parameters		
			Horizontal kh (kx) cm/sec	Anisotropy Ratio kh/kv	Vertical kv (ky) cm/sec	Horizontal kh (kx) ft/day	Vertical kv (ky) ft/day	Φ'	C' (psf)	γ (pcf)
WRARF C_003B	1	Sandy Lean Clay Levee	1.00E-05	4	2.50E-06	0.028	0.007	24	50	115
	2	Sandy Lean Clay Blanket	1.00E-05	1	1.00E-05	0.028	0.028	28	50	115
	3	Poorly Graded Sand	5.00E-03	4	1.25E-03	14.175	3.544	35	0	130
	4	Silty Sand	1.00E-03	4	2.50E-04	2.835	0.709	33	0	125
	5	Sandy Silt	2.00E-04	4	5.00E-05	0.567	0.142	30	0	120
	6	Silty Sand	1.00E-03	4	2.50E-04	2.835	0.709	35	0	125
	7	Engineered Fill (SC)	1.00E-05	1.00	1.00E-05	0.028	0.028	32	50	125
	8	Cutoff Wall	1.00E-05	1.00	1.00E-05	0.028	0.028	0	50	85

0 20' 40'
HORIZONTAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

0 20' 40'
VERTICAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

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AMERICAN RIVER WATERSHED - COMMON FEATURES
GENERAL REEVALUATION REPORT
GEOTECHNICAL ATTACHMENT

200YR WSEL-HEAD CONTOURS-WITH PROJECT
ARN – REACH E – ARCADE CREEK NORTH – U7 LM 0.90

DATE:	SCALE:	SHEET NO.
29-Jan-13	AS SHOWN	5

PLOT BY: L2EDGAJD - Feb 27, 2013 - 11:57:04am
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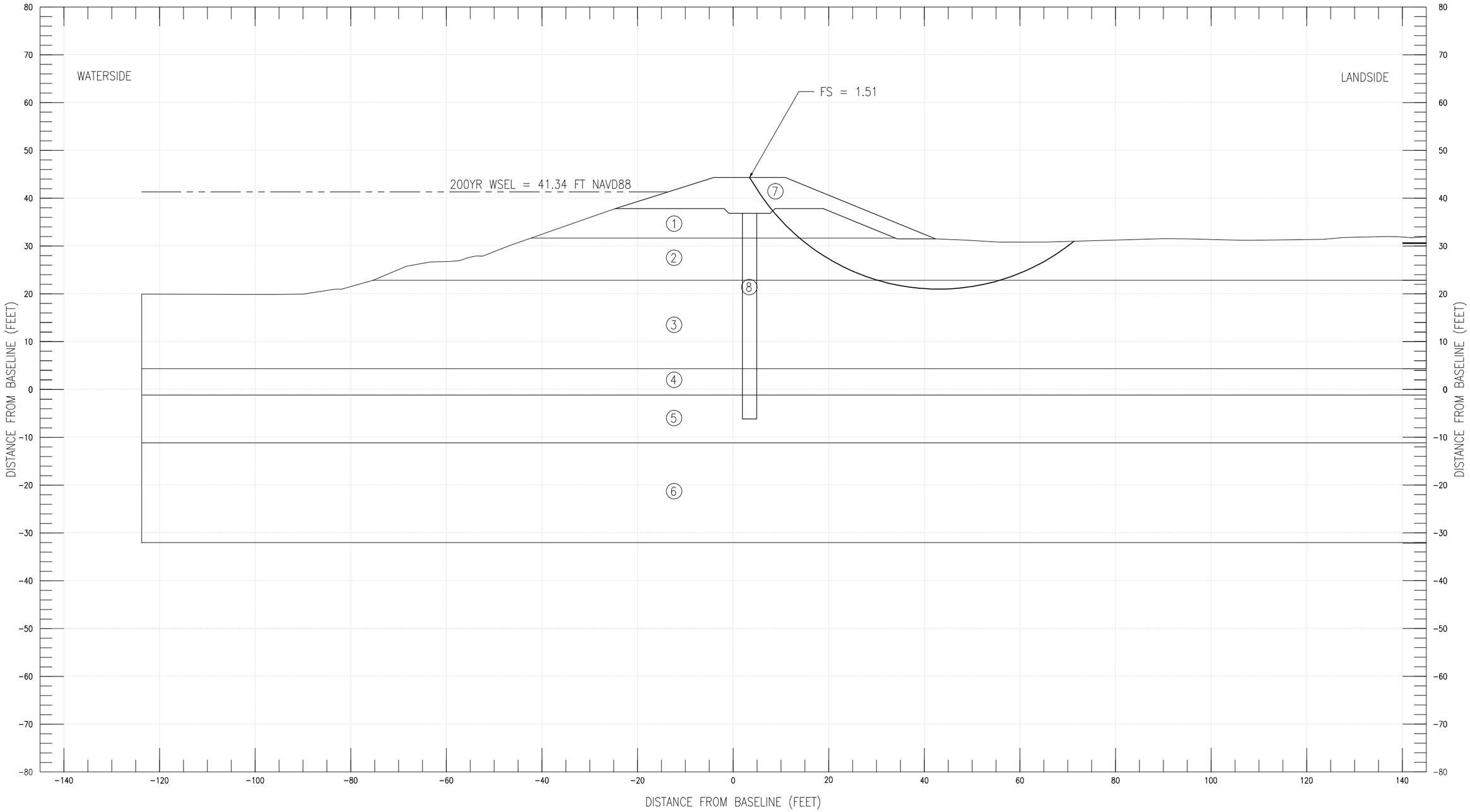

Boring Number	Layer ID	Material Type	Estimated Permeability for Seepage Analysis					Estimated Strength Parameters		
			Horizontal kh (kx) cm/sec	Anisotropy Ratio kh/kv	Vertical kv (ky) cm/sec	Horizontal kh (kx) ft/day	Vertical kv (ky) ft/day	Φ'	C' (psf)	γ (pcf)
WRARF C_003B	1	Sandy Lean Clay Levee	1.00E-05	4	2.50E-06	0.028	0.007	24	50	115
	2	Sandy Lean Clay Blanket	1.00E-05	1	1.00E-05	0.028	0.028	28	50	115
	3	Poorly Graded Sand	5.00E-03	4	1.25E-03	14.175	3.544	36	0	130
	4	Silty Sand	1.00E-03	4	2.50E-04	2.835	0.709	33	0	125
	5	Sandy Silt	2.00E-04	4	5.00E-05	0.567	0.142	30	0	120
	6	Silty Sand	1.00E-03	4	2.50E-04	2.835	0.709	35	0	125
	7	Engineered Fill (SC)	1.00E-05	1.00	1.00E-05	0.028	0.028	32	50	125
	8	Cutoff Wall	1.00E-05	1.00	1.00E-05	0.028	0.028	0	50	85

0 20' 40'
HORIZONTAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

0 20' 40'
VERTICAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

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AMERICAN RIVER WATERSHED - COMMON FEATURES
GENERAL REEVALUATION REPORT
GEOTECHNICAL ATTACHMENT

200YR WSEL-CRITICAL SHEAR SURFACE-WITH PROJECT
ARN – REACH E – ARCADE CREEK NORTH – U7 LM 0.90

DATE:	SCALE:	SHEET NO.
29-Jan-13	AS SHOWN	6

PLOT BY: I2EDGAJD - Feb 27, 2013 - 11:57:12am
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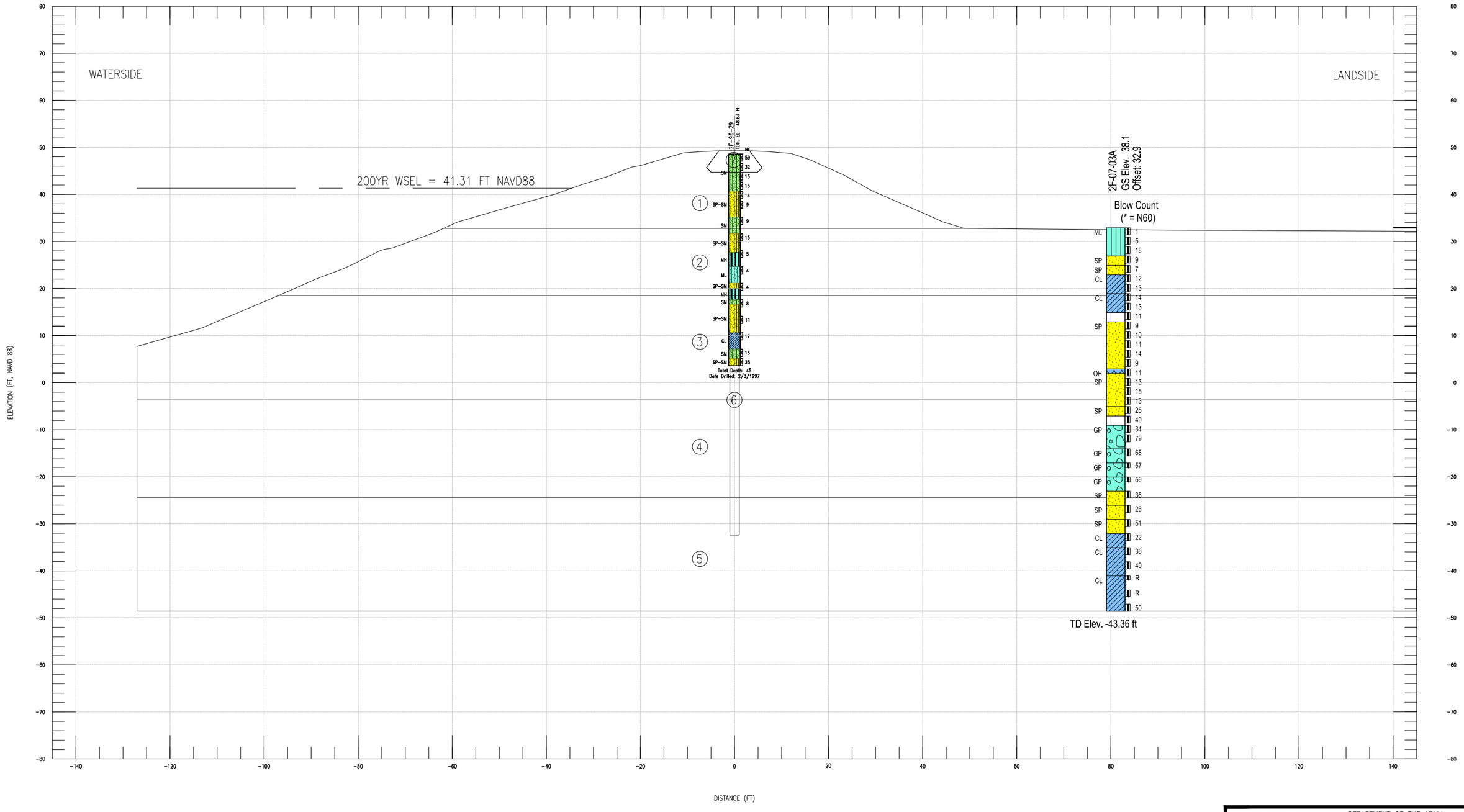
AMERICAN RIVER SOUTH BASIN

ARS REACH B – AMERICAN RIVER SOUTH – U4 LM 3.90

STEADY STATE SEEPAGE AND LANDSIDE SLOPE STABILITY ANALYSES RESULTS



Boring Number	Layer ID	USCS Soil Classification	Estimated Permeability for Seepage Analysis					Estimated Strength Parameters		
			Horizontal kh (kx) cm/sec	Anisotropy Ratio kh/kv	Vertical kv (ky) cm/sec	Horizontal kh (kx) ft/day	Vertical kv (ky) ft/day	Φ'	C' (psf)	γ (pcf)
2F-96-29,	1	Poorly Graded Sand to Silty Sand (SP-SM)	1.00E-03	4	2.50E-04	2.8350	0.7088	33	0	125
2F-00-9W,	2	Levee Foundation Silt (ML)	2.00E-04	4.0	5.00E-05	0.5670	0.1418	30	0	120
2F-00-114,	3	Poorly Graded Silty Sand (SP-SM) with Clay & Silt	5.00E-03	4	1.25E-03	14.1750	3.5438	33	0	125
WCSBAR_0	4	Poorly Graded Gravel & Cobbles (GP)	1.20E-02	4	3.00E-03	34.0200	8.5050	35	0	135
03B, 2F-99-	5	Silt and Clay (CL-ML)	2.00E-04	4	5.00E-05	0.5670	0.1418	30	0	120
17, 2F-97-	6	Cut-off Wall	1.00E-06	1	1.00E-06	0.0028	0.0028	0	50	85
23	7	Impervious Clay Cap	1.00E-05	1	1.00E-05	0.0284	0.0284	28	50	115

0 20' 40'
HORIZONTAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

0 20' 40'
VERTICAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

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AMERICAN RIVER WATERSHED - COMMON FEATURES
GENERAL REEVALUATION REPORT
GEOTECHNICAL ATTACHMENT
SECTION STRATIGRAPHY – 10 SCALE
ARS – REACH B – AMERICAN RIVER SOUTH – U4 LM 3.90

DATE:	SCALE:	SHEET NO.
29-Jan-13	AS SHOWN	1

PLOT BY: LZEDGAJD - May 23, 2013 - 9:42:06am
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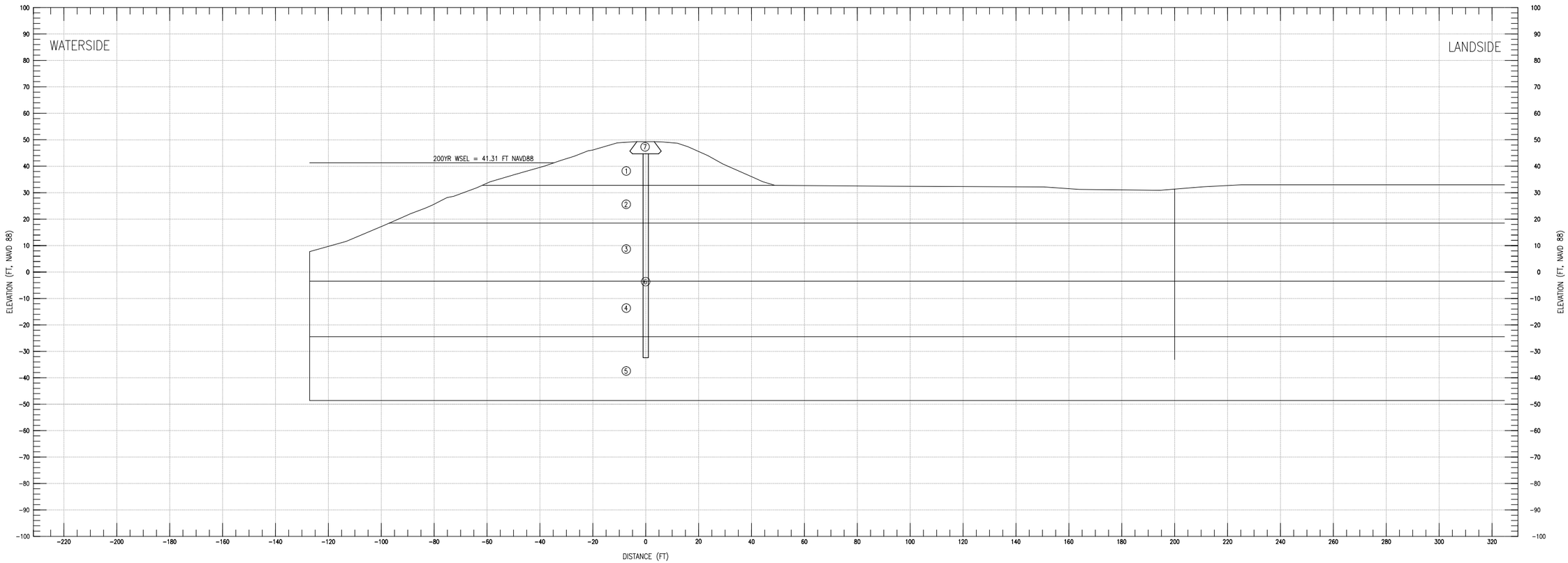

Boring Number	Layer ID	USCS Soil Classification	Estimated Permeability for Seepage Analysis					Estimated Strength Parameters		
			Horizontal kh (kx) cm/sec	Anisotropy Ratio kh/kv	Vertical kv (ky) cm/sec	Horizontal kh (kx) ft/day	Vertical kv (ky) ft/day	Φ'	C' (psf)	γ (pcf)
2F-96-29, 2F-00-9W, 2F-00-114, WCSBAR_0 03B, 2F-99-17, 2F-97-23	1	Poorly Graded Sand to Silty Sand (SP-SM)	1.00E-03	4	2.50E-04	2.8350	0.7088	33	0	125
	2	Levee Foundation Silt (ML)	2.00E-04	4.0	5.00E-05	0.5670	0.1418	30	0	120
	3	Poorly Graded Silty Sand (SP-SM) with Clay & Silt	5.00E-03	4	1.25E-03	14.1750	3.5438	33	0	125
	4	Poorly Graded Gravel & Cobbles (GP)	1.20E-02	4	3.00E-03	34.0200	8.5050	35	0	135
	5	Silt and Clay (CL-ML)	2.00E-04	4	5.00E-05	0.5670	0.1418	30	0	120
	6	Cut-off Wall	1.00E-06	1	1.00E-06	0.0028	0.0028	0	50	85
	7	Impervious Clay Cap	1.00E-05	1	1.00E-05	0.0284	0.0284	28	50	115

0 20' 40'
HORIZONTAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

0 20' 40'
VERTICAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

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AMERICAN RIVER WATERSHED - COMMON FEATURES
GENERAL REEVALUATION REPORT
GEOTECHNICAL ATTACHMENT
SECTION STRATIGRAPHY – 20 SCALE
ARS – REACH B – AMERICAN RIVER SOUTH – U4 LM 3.90

DATE:	SCALE:	SHEET NO.
29-Jan-13	AS SHOWN	2

PLOT BY: LZEDGAJD - May 23, 2013 - 9:42:13am
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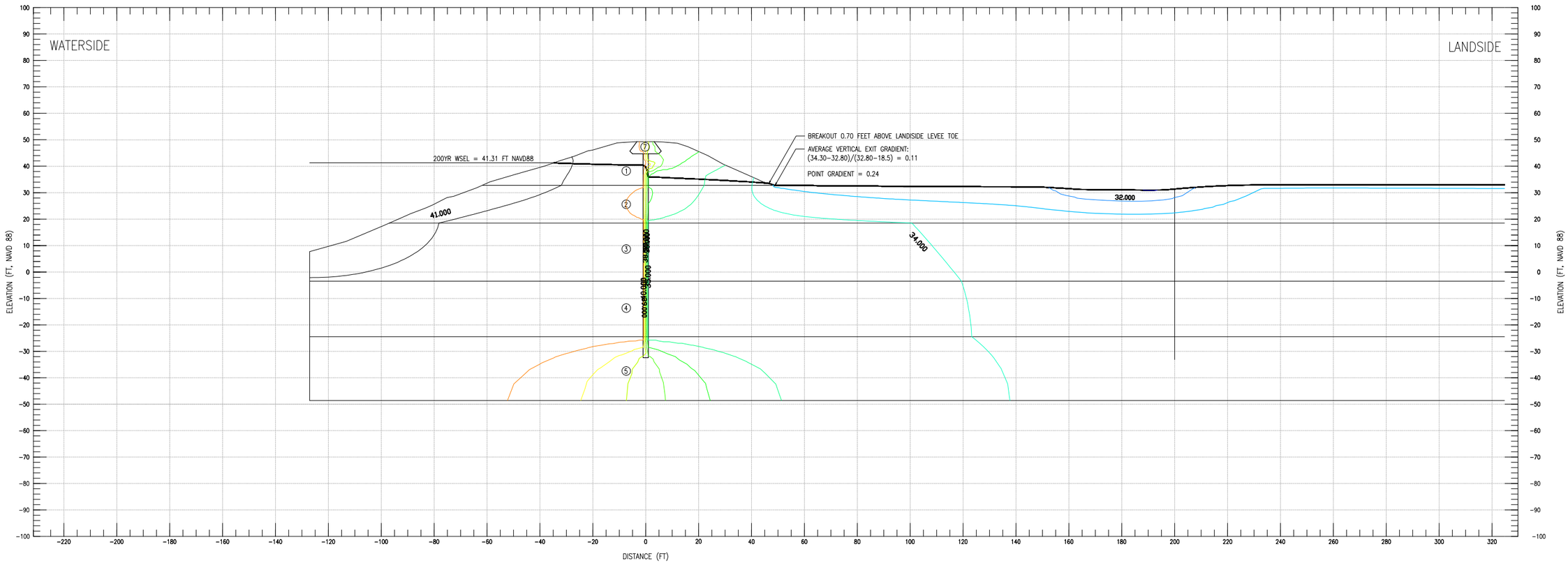

Boring Number	Layer ID	USCS Soil Classification	Estimated Permeability for Seepage Analysis					Estimated Strength Parameters		
			Horizontal kh (kx) cm/sec	Anisotropy Ratio kh/kv	Vertical kv (ky) cm/sec	Horizontal kh (kx) ft/day	Vertical kv (ky) ft/day	Φ'	C' (psf)	γ (pcf)
2F-96-29,	1	Poorly Graded Sand to Silty Sand (SP-SM)	1.00E-03	4	2.50E-04	2.8350	0.7088	33	0	125
2F-00-9W,	2	Levee Foundation Silt (ML)	2.00E-04	4.0	5.00E-05	0.5670	0.1418	30	0	120
2F-00-114,	3	Poorly Graded Silty Sand (SP-SM) with Clay & Silt	5.00E-03	4	1.25E-03	14.1750	3.5438	33	0	125
WCSBAR_0	4	Poorly Graded Gravel & Cobbles (GP)	1.20E-02	4	3.00E-03	34.0200	8.5050	35	0	135
03B, 2F-99-	5	Silt and Clay (CL-ML)	2.00E-04	4	5.00E-05	0.5670	0.1418	30	0	120
17, 2F-97-	6	Cut-off Wall	1.00E-06	1	1.00E-06	0.0028	0.0028	0	50	85
23	7	Impervious Clay Cap	1.00E-05	1	1.00E-05	0.0284	0.0284	28	50	115

0 20' 40'
HORIZONTAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

0 20' 40'
VERTICAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

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AMERICAN RIVER WATERSHED - COMMON FEATURES
GENERAL REEVALUATION REPORT
GEOTECHNICAL ATTACHMENT
200YR WSEL-HEAD CONTOURS-WITHOUT PROJECT
ARS - REACH B - AMERICAN RIVER SOUTH - U4 LM 3.90

DATE:	SCALE:	SHEET NO.
29-Jan-13	AS SHOWN	

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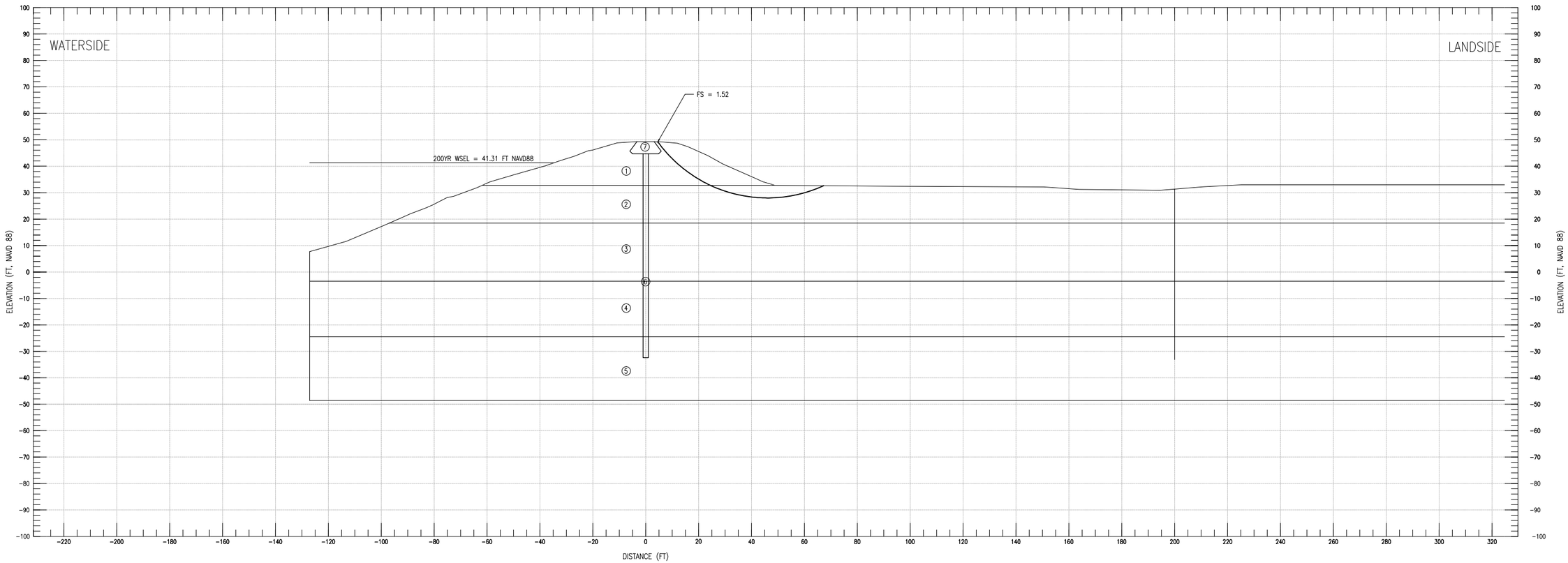

Boring Number	Layer ID	USCS Soil Classification	Estimated Permeability for Seepage Analysis					Estimated Strength Parameters		
			Horizontal kh (kx) cm/sec	Anisotropy Ratio kh/kv	Vertical kv (ky) cm/sec	Horizontal kh (kx) ft/day	Vertical kv (ky) ft/day	Φ'	C' (psf)	γ (pcf)
2F-96-29, 2F-00-9W, 2F-00-114, WCSBAR_0 03B, 2F-99-17, 2F-97-23	1	Poorly Graded Sand to Silty Sand (SP-SM)	1.00E-03	4	2.50E-04	2.8350	0.7088	33	0	125
	2	Levee Foundation Silt (ML)	2.00E-04	4.0	5.00E-05	0.5670	0.1418	30	0	120
	3	Poorly Graded Silty Sand (SP-SM) with Clay & Silt	5.00E-03	4	1.25E-03	14.1750	3.5438	33	0	125
	4	Poorly Graded Gravel & Cobbles (GP)	1.20E-02	4	3.00E-03	34.0200	8.5050	35	0	135
	5	Silt and Clay (CL-ML)	2.00E-04	4	5.00E-05	0.5670	0.1418	30	0	120
	6	Cut-off Wall	1.00E-06	1	1.00E-06	0.0028	0.0028	0	50	85
	7	Impervious Clay Cap	1.00E-05	1	1.00E-05	0.0284	0.0284	28	50	115

0 20' 40'
HORIZONTAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

0 20' 40'
VERTICAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

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AMERICAN RIVER WATERSHED - COMMON FEATURES
GENERAL REEVALUATION REPORT
GEOTECHNICAL ATTACHMENT
200YR WSEL-CRITICAL SHEAR SURFACE-WITHOUT PROJECT
ARS – REACH B – AMERICAN RIVER SOUTH – U4 LM 3.90

DATE:	SCALE:	SHEET NO.
29-Jan-13	AS SHOWN	4

PLOT BY: LZEDGAJD - May 23, 2013 - 5:12:21pm
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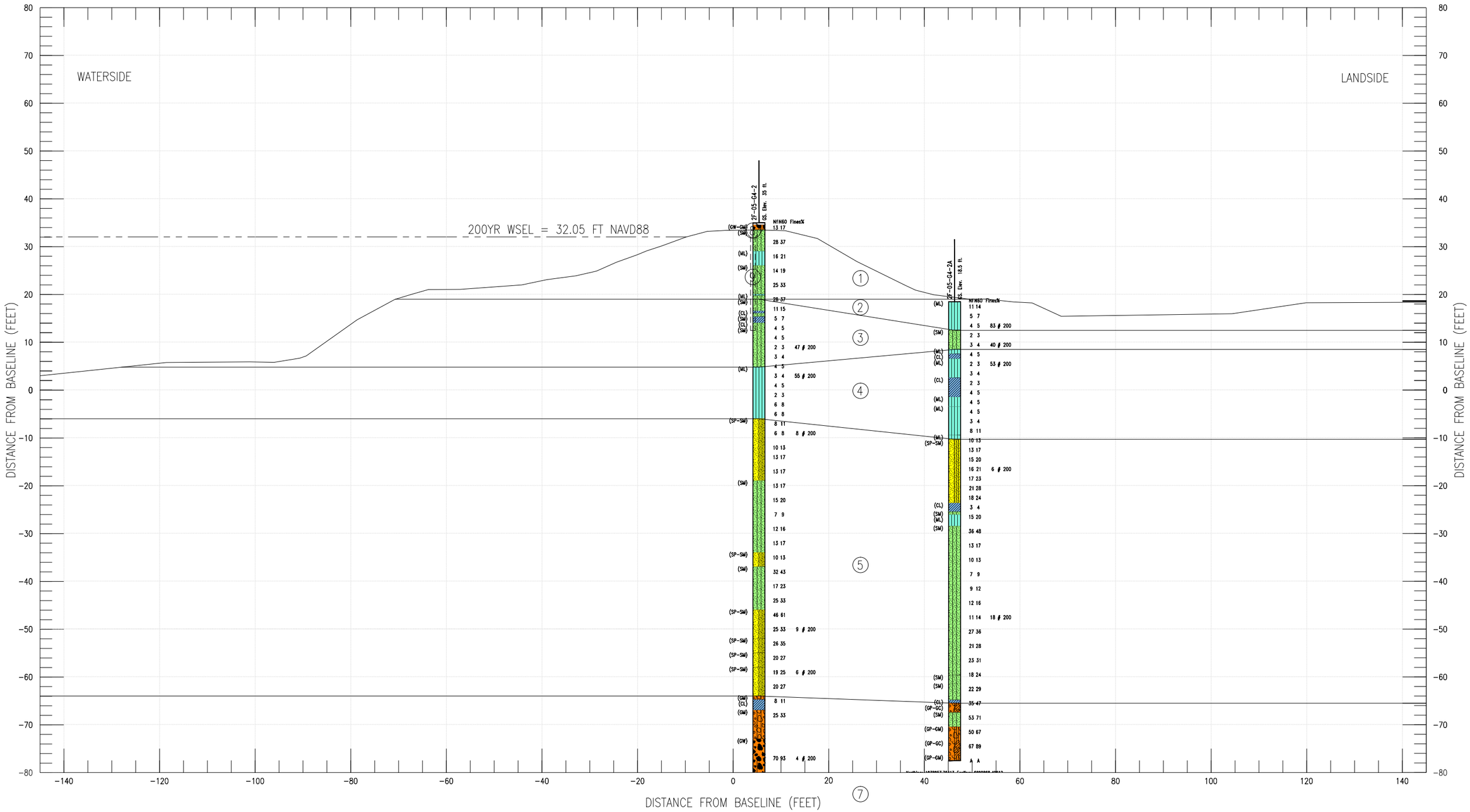
ARS REACH F – SACRAMENTO RIVER EAST – U1 LM 5.92

STEADY STATE SEEPAGE AND LANDSIDE SLOPE STABILITY ANALYSES RESULTS



Boring Number	Layer ID	USCS Soil Classification	Estimated Permeability for Seepage Analysis					Estimated Strength Parameters		
			Horizontal kh (kx) cm/sec	Anisotropy Ratio kh/kv	Vertical kv (ky) cm/sec	Horizontal kh (kx) ft/day	Vertical kv (ky) ft/day	Φ'	C' (psf)	γ (pcf)
2F-05-G4-2, 2F-05-G4-2A	1	Silty Sand (SM) with Silty (ML) and Poorly Graded Sand (SP) Levee Embankment	1.00E-02	4	2.50E-03	28.3500	7.0875	34	0	125
	2	Silt Blanket (ML)	2.00E-04	4	5.00E-05	0.5670	0.1418	28	0	120
	3	Silty Sand (SM)	5.00E-04	4	1.25E-04	1.4175	0.3544	30	0	125
	4	Silt (ML) and Lean Clay (CL)	2.00E-04	4	5.00E-05	0.5670	0.1418	30	50	120
	5	Silty Sand (SM), Poorly Graded Sand (SP)	5.00E-03	4	1.25E-03	14.1750	3.5438	30	0	125
	6	Poorly Graded Gravel (GP) Poorly Graded Sand (SP)	2.50E-02	10	2.50E-03	70.8750	7.0875	35	0	135
	7	Lean Clay with Silt (CL w/ ML)	1.00E-05	4	2.50E-06	0.0284	0.0071	28	50	115
	8	Impervious Clay Cap (CL)	1.00E-05	1	1.00E-05	0.0284	0.0284	28	50	115
	9	Cutoff Wall	1.00E-06	1	1.00E-06	0.0028	0.0028	0	50	85

0 20' 40'
HORIZONTAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

0 20' 40'
VERTICAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

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AMERICAN RIVER WATERSHED - COMMON FEATURES
GENERAL REEVALUATION REPORT
GEOTECHNICAL ENCLOSURE - F3

SECTION STRATIGRAPHY– 10 SCALE

ARS – REACH F – SACRAMENTO RIVER EAST – U1 LM 5.92

DATE:	SCALE:	SHEET NO.
29-Jan-13	AS SHOWN	1

PLOT BY: L2EDGJAD - May 23, 2013 - 5:41:29pm
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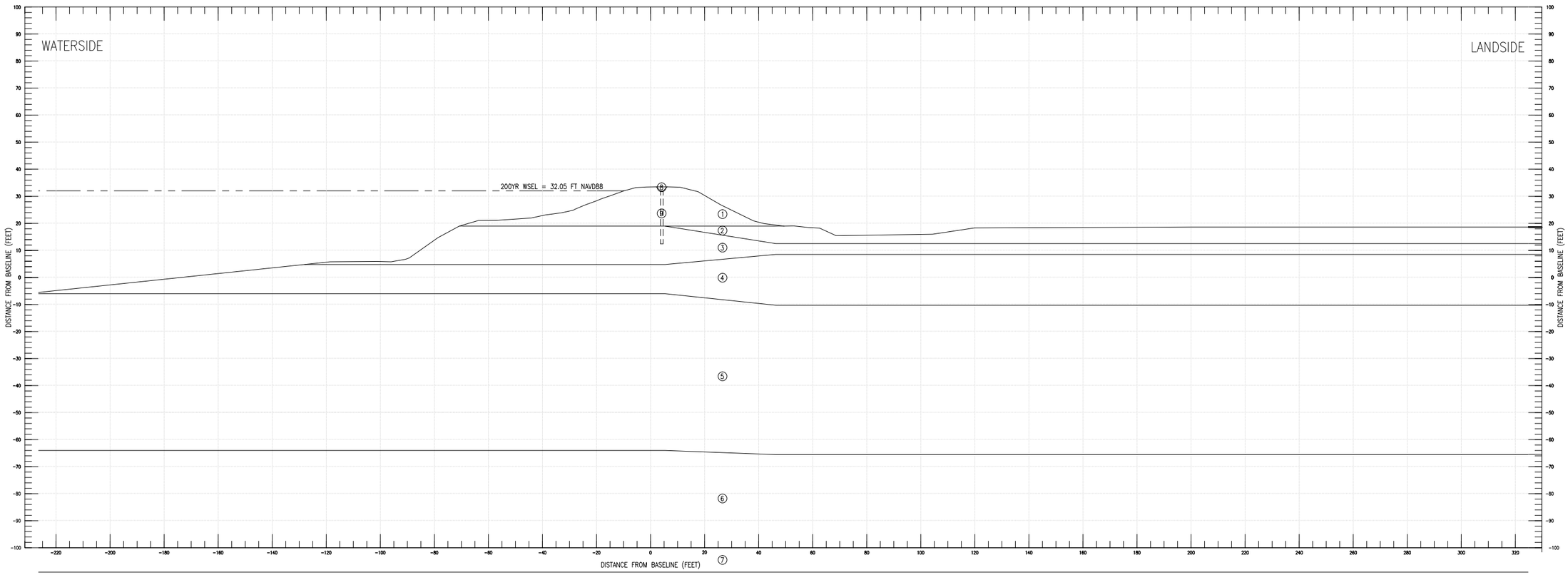

Boring Number	Layer ID	USCS Soil Classification	Estimated Permeability for Seepage Analysis					Estimated Strength Parameters		
			Horizontal kh (kx) cm/sec	Anisotropy Ratio kh/kv	Vertical kv (ky) cm/sec	Horizontal kh (kx) ft/day	Vertical kv (ky) ft/day	Φ'	C' (psf)	γ (pcf)
2F-05-G4-2, 2F-05-G4-2A	1	Silty Sand (SM) with Silty (ML) and Poorly Graded Sand (SP) Levee Embankment	1.00E-02	4	2.50E-03	28.3500	7.0875	34	0	125
	2	Silt Blanket (ML)	2.00E-04	4	5.00E-05	0.5670	0.1418	28	0	120
	3	Silty Sand (SM)	5.00E-04	4	1.25E-04	1.4175	0.3544	30	0	125
	4	Silt (ML) and Lean Clay (CL)	2.00E-04	4	5.00E-05	0.5670	0.1418	30	50	120
	5	Silty Sand (SM), Poorly Graded Sand (SP)	5.00E-03	4	1.25E-03	14.1750	3.5438	30	0	125
	6	Poorly Graded Gravel (GP) Poorly Graded Sand (SP)	2.50E-02	10	2.50E-03	70.8750	7.0875	35	0	135
	7	Lean Clay with Silt (CL w/ ML)	1.00E-05	4	2.50E-06	0.0284	0.0071	28	50	115
	8	Impervious Clay Cap (CL)	1.00E-05	1	1.00E-05	0.0284	0.0284	28	50	115
	9	Cutoff Wall	1.00E-06	1	1.00E-06	0.0028	0.0028	0	50	85

0 20' 40'
HORIZONTAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

0 20' 40'
VERTICAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

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AMERICAN RIVER WATERSHED - COMMON FEATURES
GENERAL REEVALUATION REPORT
GEOTECHNICAL ENCLOSURE - F3

SECTION STRATIGRAPHY– 20 SCALE

ARS – REACH F – SACRAMENTO RIVER EAST – U1 LM 5.92

DATE:	SCALE:	SHEET NO.
29-Jan-13	AS SHOWN	2

PLOT BY: L2EDGAJD - May 23, 2013 - 5:41:33pm
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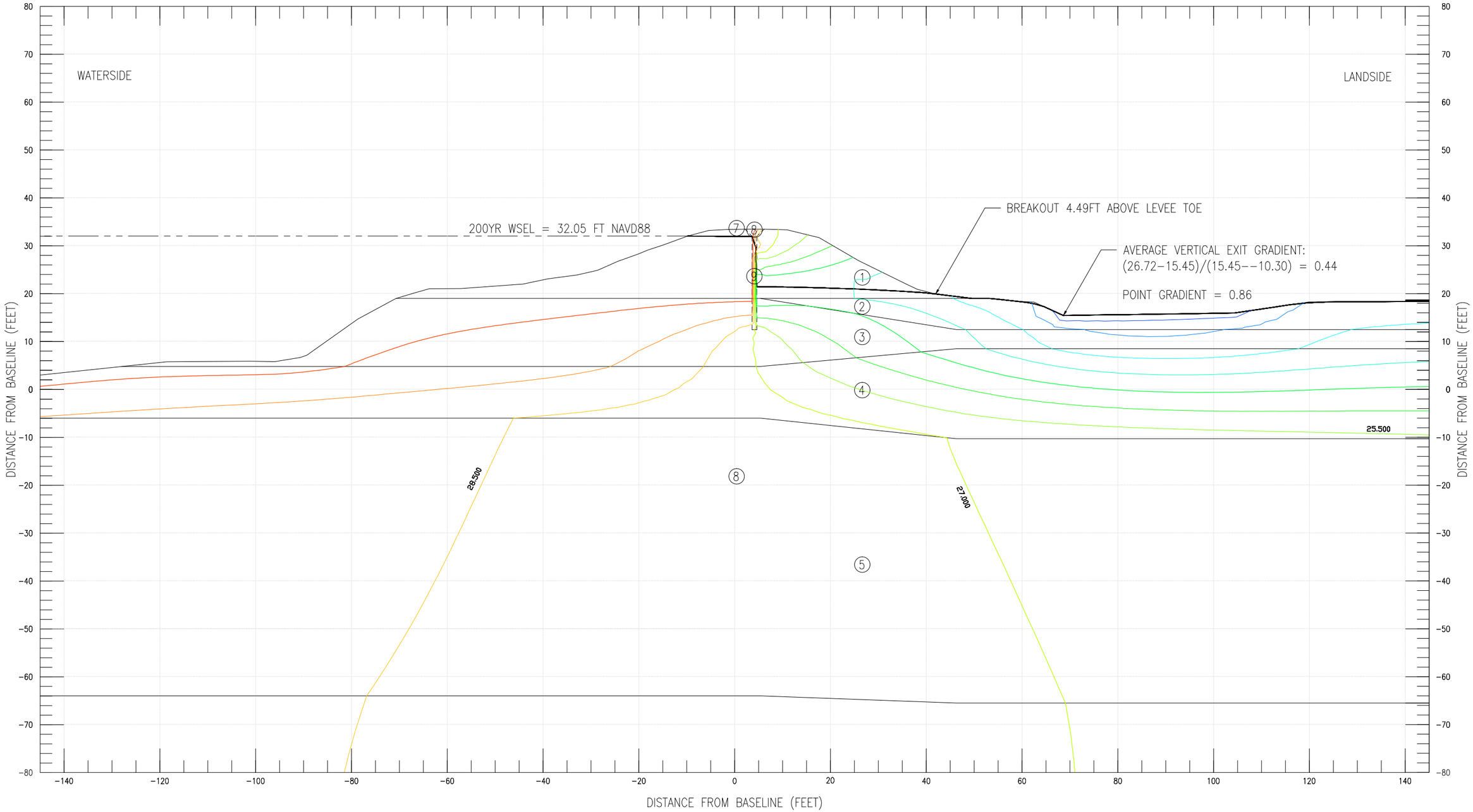

Boring Number	Layer ID	USCS Soil Classification	Estimated Permeability for Seepage Analysis					Estimated Strength Parameters		
			Horizontal kh (kx) cm/sec	Anisotropy Ratio kh/kv	Vertical kv (ky) cm/sec	Horizontal kh (kx) ft/day	Vertical kv (ky) ft/day	Φ'	C' (psf)	γ (pcf)
2F-05-G4-2, 2F-05-G4-2A	1	Silty Sand (SM) with Silty (ML) and Poorly Graded Sand (SP) Levee Embankment	1.00E-02	4	2.50E-03	28.3500	7.0875	34	0	125
	2	Silt Blanket (ML)	2.00E-04	4	5.00E-05	0.5670	0.1418	28	0	120
	3	Silty Sand (SM)	5.00E-04	4	1.25E-04	1.4175	0.3544	30	0	125
	4	Silt (ML) and Lean Clay (CL)	2.00E-04	4	5.00E-05	0.5670	0.1418	30	50	120
	5	Silty Sand (SM), Poorly Graded Sand (SP)	5.00E-03	4	1.25E-03	14.1750	3.5438	30	0	125
	6	Poorly Graded Gravel (GP) Poorly Graded Sand (SP)	2.50E-02	10	2.50E-03	70.8750	7.0875	35	0	135
	7	Lean Clay with Silt (CLw/ ML)	1.00E-05	4	2.50E-06	0.0284	0.0071	28	50	115
	8	Impervious Clay Cap (CL)	1.00E-05	1	1.00E-05	0.0284	0.0284	28	50	115
	9	Cutoff Wall	1.00E-06	1	1.00E-06	0.0028	0.0028	0	50	85

0 20' 40'
HORIZONTAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

0 20' 40'
VERTICAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

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GENERAL REEVALUATION REPORT
GEOTECHNICAL ENCLOSURE - F3

200YR WSEL-HEAD CONTOURS-WITHOUT PROJECT
ARS – REACH F – SACRAMENTO RIVER EAST – U1 LM 5.92

DATE:	SCALE:	SHEET NO.
29-Jan-13	AS SHOWN	3

PLOT BY: I:2EDGAJD - May 23, 2013 - 5:41:42pm
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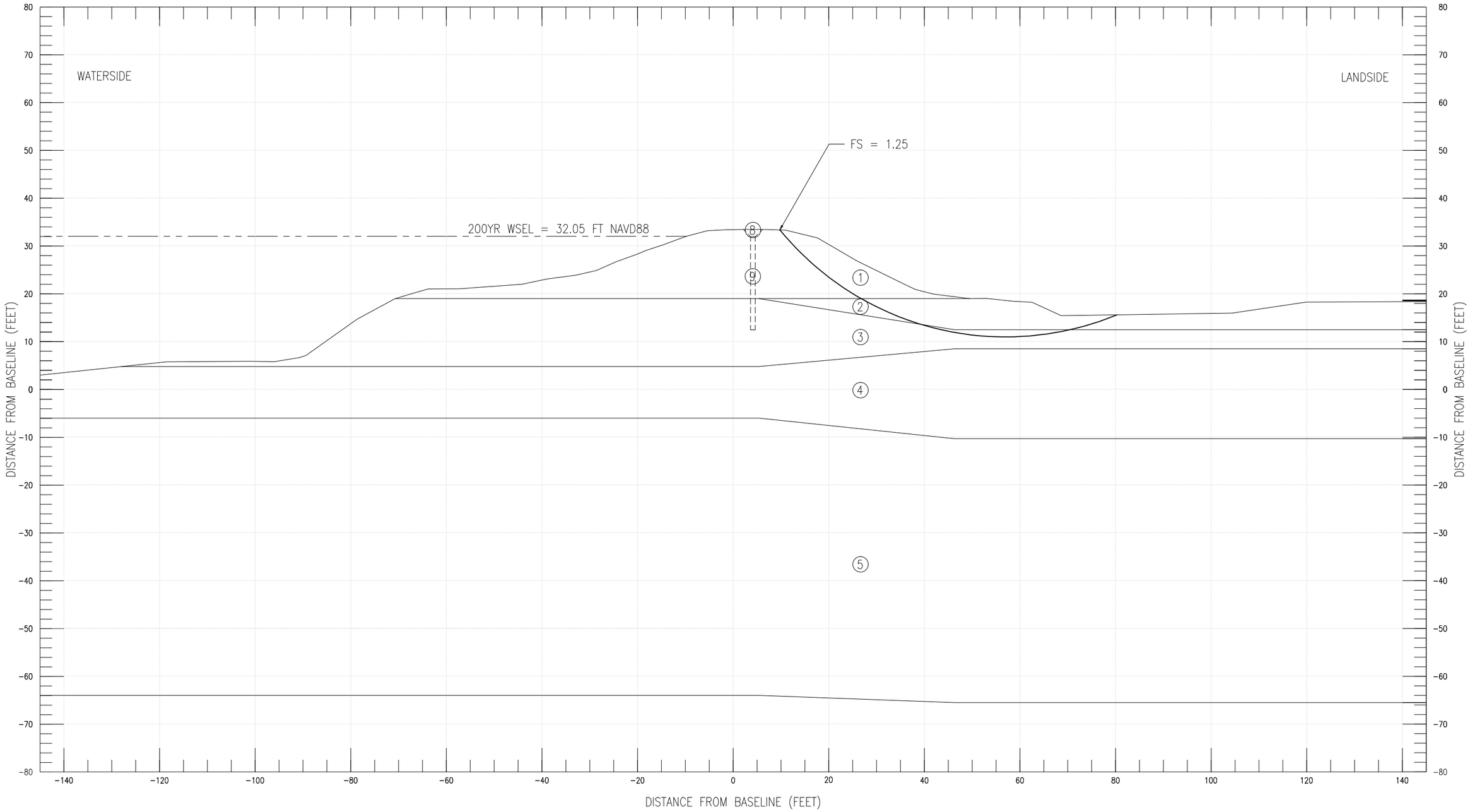

Boring Number	Layer ID	USCS Soil Classification	Estimated Permeability for Seepage Analysis					Estimated Strength Parameters		
			Horizontal kh (kx) cm/sec	Anisotropy Ratio kh/kv	Vertical kv (ky) cm/sec	Horizontal kh (kx) ft/day	Vertical kv (ky) ft/day	Φ'	C' (psf)	γ (pcf)
2F-05-G4-2, 2F-05-G4-2A	1	Silty Sand (SM) with Silty (ML) and Poorly Graded Sand (SP) Levee Embankment	1.00E-02	4	2.50E-03	28.3500	7.0875	34	0	125
	2	Silt Blanket (ML)	2.00E-04	4	5.00E-05	0.5670	0.1418	28	0	120
	3	Silty Sand (SM)	5.00E-04	4	1.25E-04	1.4175	0.3544	30	0	125
	4	Silt (ML) and Lean Clay (CL)	2.00E-04	4	5.00E-05	0.5670	0.1418	30	50	120
	5	Silty Sand (SM), Poorly Graded Sand (SP)	5.00E-03	4	1.25E-03	14.1750	3.5438	30	0	125
	6	Poorly Graded Gravel (GP) Poorly Graded Sand (SP)	2.50E-02	10	2.50E-03	70.8750	7.0875	35	0	135
	7	Lean Clay with Silt (CL w/ ML)	1.00E-05	4	2.50E-06	0.0284	0.0071	28	50	115
	8	Impervious Clay Cap (CL)	1.00E-05	1	1.00E-05	0.0284	0.0284	28	50	115
	9	Cutoff Wall	1.00E-06	1	1.00E-06	0.0028	0.0028	0	50	85

0 20' 40'
HORIZONTAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

0 20' 40'
VERTICAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

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AMERICAN RIVER WATERSHED - COMMON FEATURES
GENERAL REEVALUATION REPORT
GEOTECHNICAL ENCLOSURE - F3
200YR WSEL-CRITICAL SHEAR SURFACE-WITHOUT PROJECT
ARS – REACH F – SACRAMENTO RIVER EAST – U1 LM 5.92

DATE:	SCALE:	SHEET NO.
29-Jan-13	AS SHOWN	4

PLOT BY: LZEDGAJD - May 23, 2013 - 5:41:50pm
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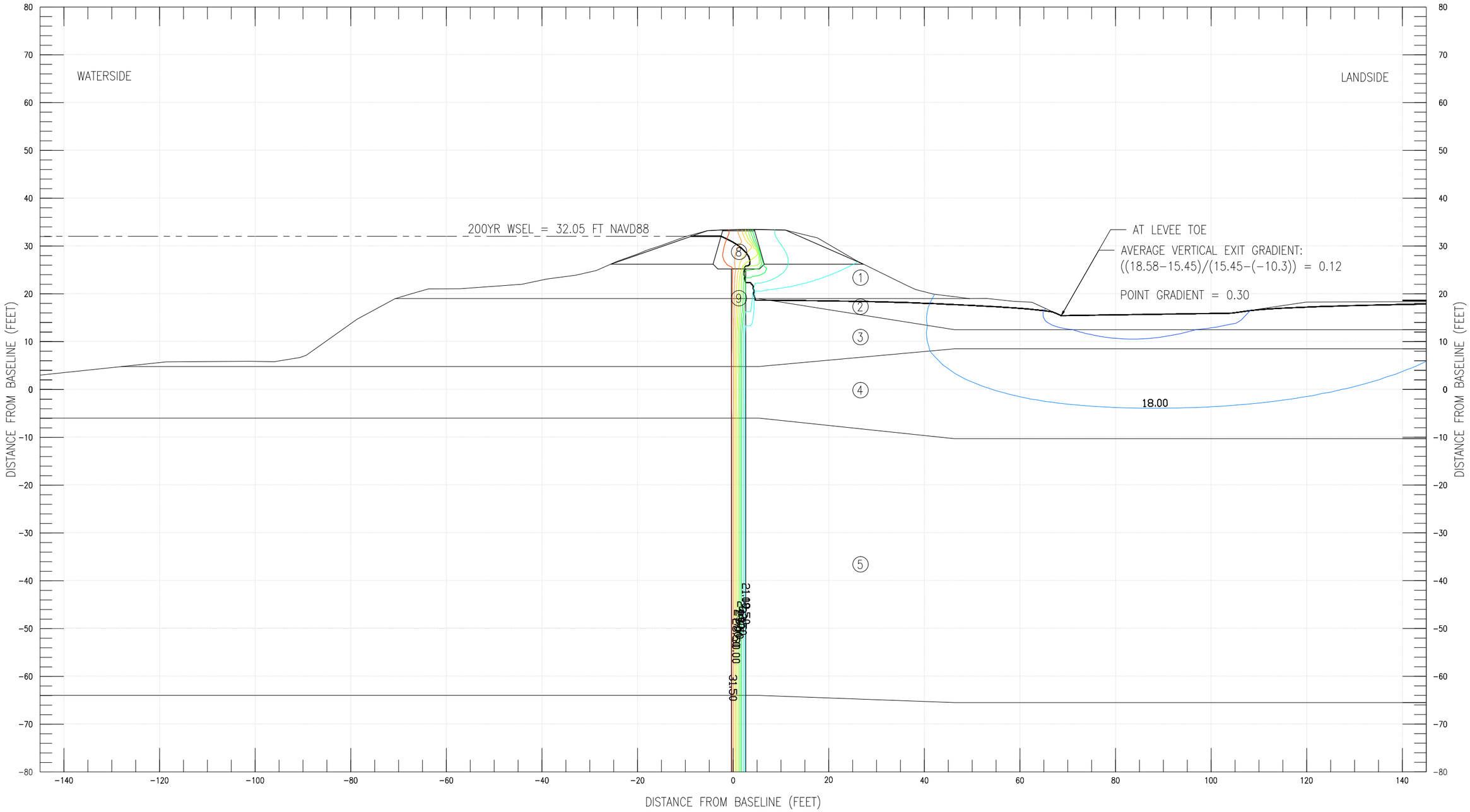

Boring Number	Layer ID	USCS Soil Classification	Estimated Permeability for Seepage Analysis					Estimated Strength Parameters		
			Horizontal kh (kx) cm/sec	Anisotropy Ratio kh/kv	Vertical kv (ky) cm/sec	Horizontal kh (kx) ft/day	Vertical kv (ky) ft/day	Φ'	C' (psf)	γ (pcf)
2F-05-G4-2, 2F-05-G4-2A	1	Silty Sand (SM) with Silty (ML) and Poorly Graded Sand (SP) Levee Embankment	1.00E-02	4	2.50E-03	28.3500	7.0875	34	0	125
	2	Silt Blanket (ML)	2.00E-04	4	5.00E-05	0.5670	0.1418	28	0	120
	3	Silty Sand (SM)	5.00E-04	4	1.25E-04	1.4175	0.3544	30	0	125
	4	Silt (ML) and Lean Clay (CL)	2.00E-04	4	5.00E-05	0.5670	0.1418	30	50	120
	5	Silty Sand (SM), Poorly Graded Sand (SP)	5.00E-03	4	1.25E-03	14.1750	3.5438	30	0	125
	6	Poorly Graded Gravel (GP) Poorly Graded Sand (SP)	2.50E-02	10	2.50E-03	70.8750	7.0875	35	0	135
	7	Lean Clay with Silt (CL w/ ML)	1.00E-05	4	2.50E-06	0.0284	0.0071	28	50	115
	8	Impervious Clay Cap (CL)	1.00E-05	1	1.00E-05	0.0284	0.0284	28	50	115
	9	Cutoff Wall	1.00E-06	1	1.00E-06	0.0028	0.0028	0	50	85

0 20' 40'
HORIZONTAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

0 20' 40'
VERTICAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

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AMERICAN RIVER WATERSHED - COMMON FEATURES
GENERAL REEVALUATION REPORT
GEOTECHNICAL ENCLOSURE - F3

200YR WSEL–HEAD CONTOURS– WITH PROJECT
ARS – REACH F – SACRAMENTO RIVER EAST – U1 LM 5.92

DATE:	SCALE:	SHEET NO.
29-Jan-13	AS SHOWN	5

PLOT BY: I2EDGAJD - May 23, 2013 - 5:41:59pm
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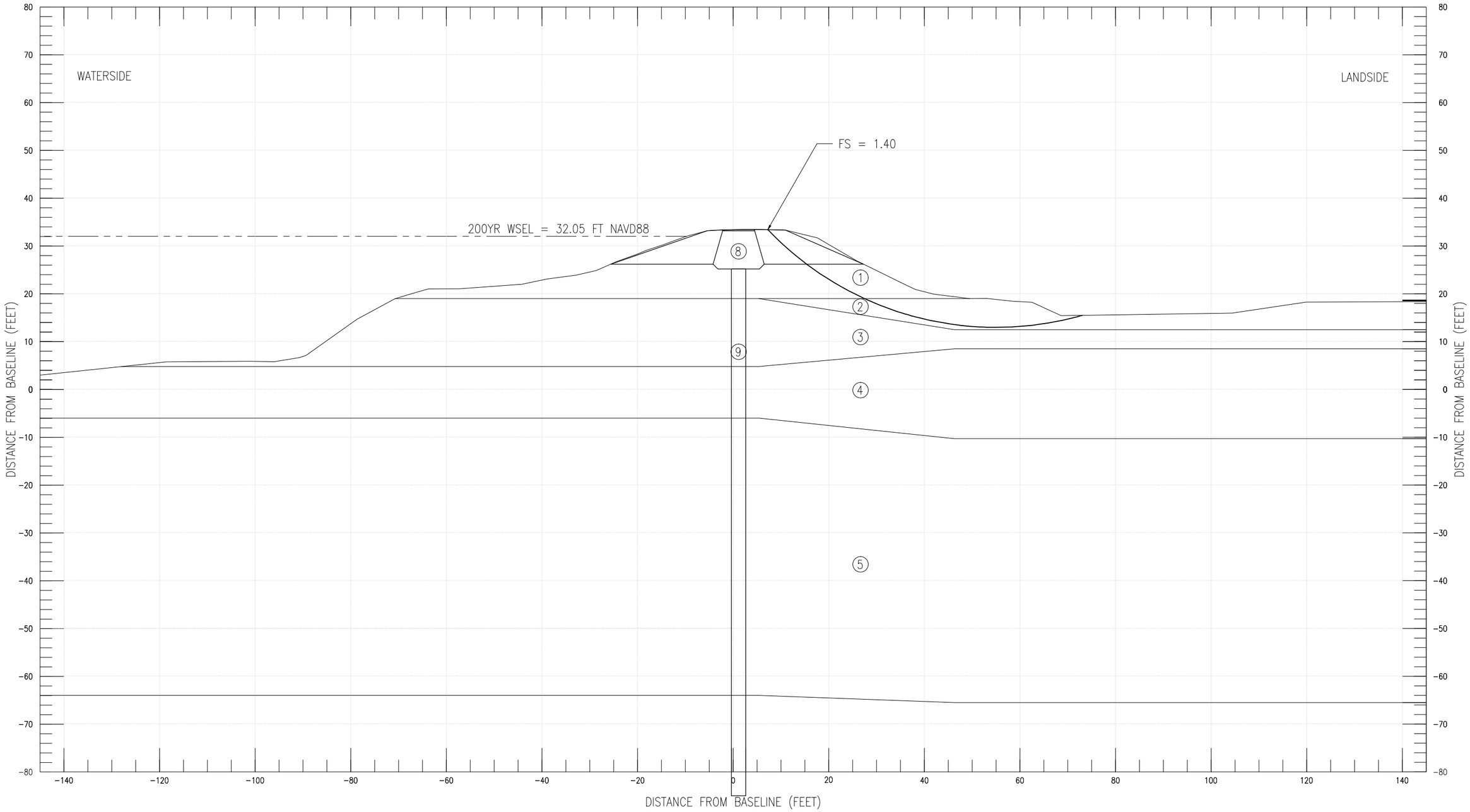

Boring Number	Layer ID	USCS Soil Classification	Estimated Permeability for Seepage Analysis					Estimated Strength Parameters		
			Horizontal kh (kx) cm/sec	Anisotropy Ratio kh/kv	Vertical kv (ky) cm/sec	Horizontal kh (kx) ft/day	Vertical kv (ky) ft/day	Φ'	C' (psf)	γ (pcf)
2F-05-G4-2, 2F-05-G4-2A	1	Silty Sand (SM) with Silty (ML) and Poorly Graded Sand (SP) Levee Embankment	1.00E-02	4	2.50E-03	28.3500	7.0875	34	0	125
	2	Silt Blanket (ML)	2.00E-04	4	5.00E-05	0.5670	0.1418	28	0	120
	3	Silty Sand (SM)	5.00E-04	4	1.25E-04	1.4175	0.3544	30	0	125
	4	Silt (ML) and Lean Clay (CL)	2.00E-04	4	5.00E-05	0.5670	0.1418	30	50	120
	5	Silty Sand (SM), Poorly Graded Sand (SP)	5.00E-03	4	1.25E-03	14.1750	3.5438	30	0	125
	6	Poorly Graded Gravel (GP) Poorly Graded Sand (SP)	2.50E-02	10	2.50E-03	70.8750	7.0875	35	0	135
	7	Lean Clay with Silt (CL w/ ML)	1.00E-05	4	2.50E-06	0.0284	0.0071	28	50	115
	8	Impervious Clay Cap (CL)	1.00E-05	1	1.00E-05	0.0284	0.0284	28	50	115
	9	Cutoff Wall	1.00E-06	1	1.00E-06	0.0028	0.0028	0	50	85

0 20' 40'
HORIZONTAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

0 20' 40'
VERTICAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

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AMERICAN RIVER WATERSHED - COMMON FEATURES
GENERAL REEVALUATION REPORT
GEOTECHNICAL ENCLOSURE - F3

200YR WSEL–CRITICAL SHEAR SURFACE– WITH PROJECT
ARS – REACH F – SACRAMENTO RIVER EAST – U1 LM 5.92

DATE:	SCALE:	SHEET NO.
29-Jan-13	AS SHOWN	6

PLOT BY: LZEDGAJD - May 23, 2013 - 5:42:08pm
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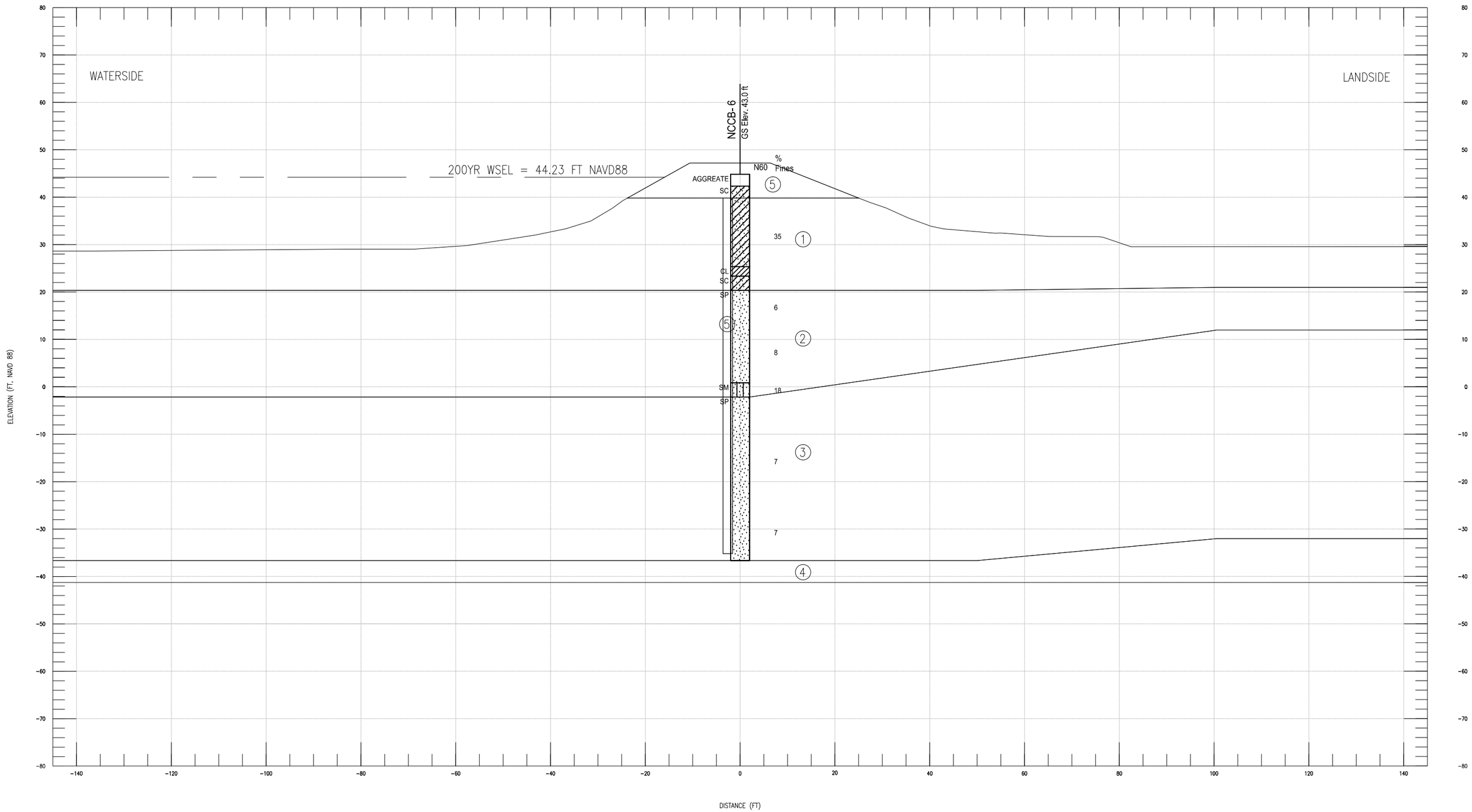
NATOMAS BASIN

NAT REACH D – NCC SOUTH – U1 LM 1.17

STEADY STATE SEEPAGE AND LANDSIDE SLOPE STABILITY ANALYSES RESULTS



Natomas Cross Canal Sta. 956+00 LM 1.17										
Boring	Layer ID	USCS Soil Classification	Estimated Permeability for Seepage Analysis					Estimated Strength Parameters		
			Horizontal k_h (k_x) cm/sec	k_h/k_v	Vertical k_v (k_y) cm/sec	Horizontal k_h (k_x) ft/day	Vertical k_v (k_y) ft/day	Φ	C	γ
NCCB-6, NCCB-6-49	1	Clayey Sand (SC)	4.0E-05	4	1.0E-05	0.113	0.028	28	50	120
	2	Poorly Graded Sand w/ silt (SP-SM)	1.0E-03	10	1.0E-04	2.835	0.284	33	0	130
	3	Poorly Graded Sand (SP)	5.0E-03	10	5.0E-04	14.175	1.418	34	0	135
	4	Sandy Fat Clay (CH)	1.0E-05	10	1.0E-06	0.028	0.003	30	50	110
	5	Clay Cap	1.0E-06	4	2.5E-07	0.0028	0.0007	28	50	115
	6	Cutoff Wall	1.0E-06	1	1.0E-06	0.0028	0.0028	0	50	85

0 20' 40'
HORIZONTAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

0 20' 40'
VERTICAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

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AMERICAN RIVER WATERSHED - COMMON FEATURES
GENERAL REEVALUATION REPORT
GEOTECHNICAL ATTACHMENT

NAT REACH D UNIT 1 LM 1.17–SECTION STRATIGRAPHY–10 SCALE
NATOMAS BASIN

DATE:	SCALE:	SHEET NO.
29-Jan-13	AS SHOWN	1

PLOT BY: L2EDGAJD - Jan 31, 2013 - 4:12:56pm
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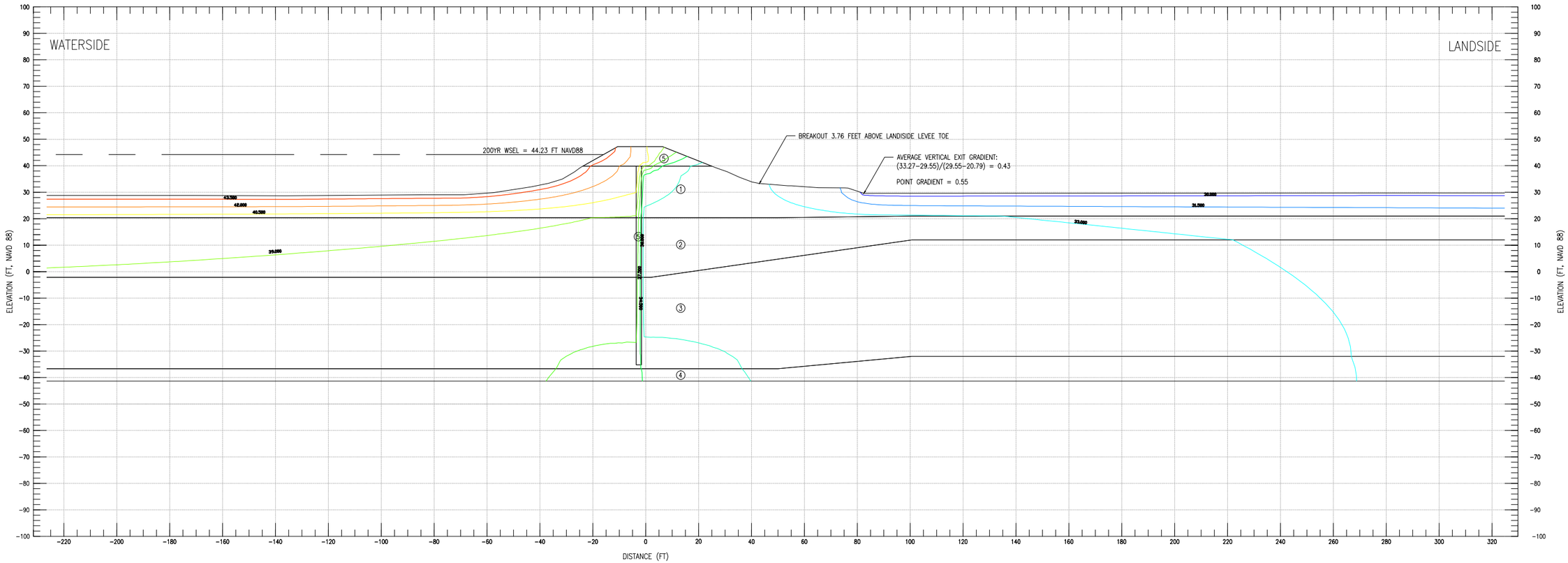

Natomas Cross Canal Sta. 956+00 LM 1.17										
Boring	Layer ID	USCS Soil Classification	Estimated Permeability for Seepage Analysis					Estimated Strength Parameters		
			Horizontal k_h (k_x) cm/sec	k_h/k_v	Vertical k_v (k_y) cm/sec	Horizontal k_h (k_x) ft/day	Vertical k_v (k_y) ft/day	Φ	C	γ
NCCB-6, NCCB-6-49	1	Clayey Sand (SC)	4.0E-05	4	1.0E-05	0.113	0.028	28	50	120
	2	Poorly Graded Sand w/ silt (SP-SM)	1.0E-03	10	1.0E-04	2.835	0.284	33	0	130
	3	Poorly Graded Sand (SP)	5.0E-03	10	5.0E-04	14.175	1.418	34	0	135
	4	Sandy Fat Clay (CH)	1.0E-05	10	1.0E-06	0.028	0.003	30	50	110
	5	Clay Cap	1.0E-06	4	2.5E-07	0.0028	0.0007	28	50	115
	6	Cutoff Wall	1.0E-06	1	1.0E-06	0.0028	0.0028	0	50	85

0 20' 40'
HORIZONTAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

0 20' 40'
VERTICAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

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AMERICAN RIVER WATERSHED - COMMON FEATURES
GENERAL REEVALUATION REPORT
GEOTECHNICAL ATTACHMENT

NAT REACH D UNIT 1 LM 1.17-200YR WSEL-HEAD CONTOURS
NATOMAS BASIN

DATE:	SCALE:	SHEET NO.
29-Jan-13	AS SHOWN	

PLOT BY: L2EDGAJD - Jan 31, 2013 - 4:13:00pm
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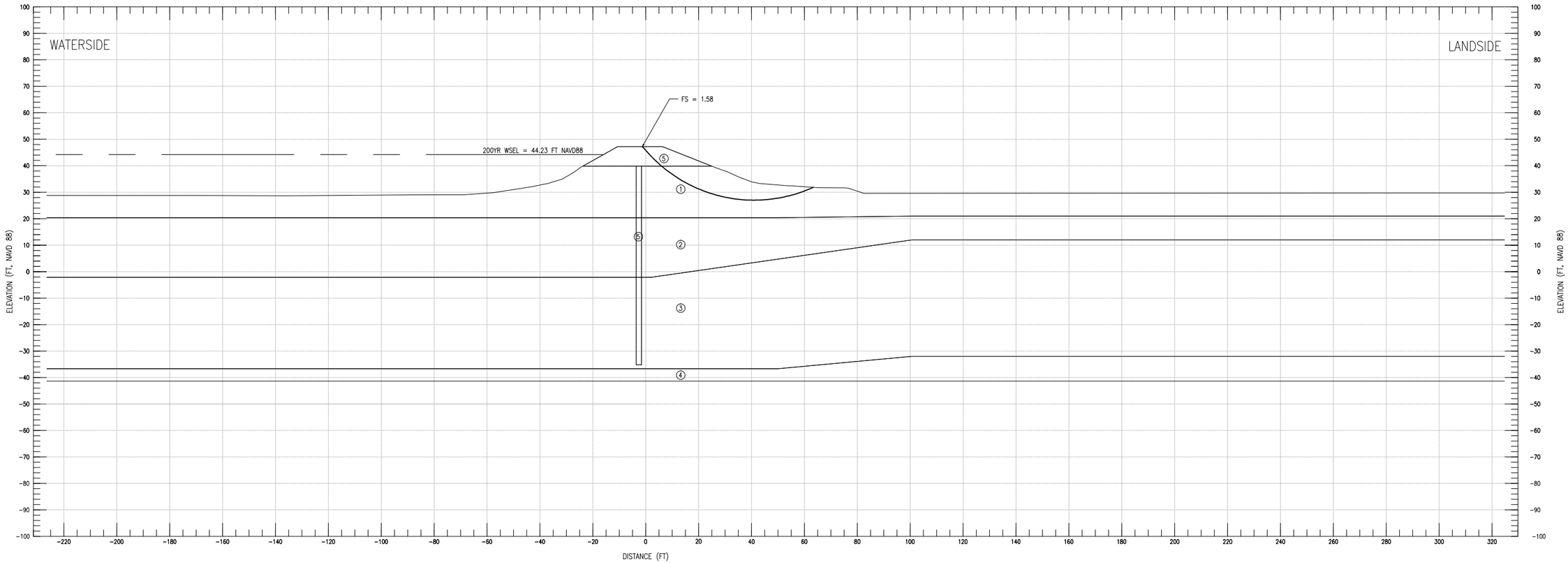

Natomas Cross Canal Sta. 956+00 LM 1.17										
Boring	Layer ID	USCS Soil Classification	Estimated Permeability for Seepage Analysis					Estimated Strength Parameters		
			Horizontal k_h (k_x) cm/sec	k_h/k_v	Vertical k_v (k_y) cm/sec	Horizontal k_h (k_x) ft/day	Vertical k_v (k_y) ft/day	Φ	C	γ
NCCB-6, NCCB-6-49	1	Clayey Sand (SC)	4.0E-05	4	1.0E-05	0.113	0.028	28	50	120
	2	Poorly Graded Sand w/ silt (SP-SM)	1.0E-03	10	1.0E-04	2.835	0.284	33	0	130
	3	Poorly Graded Sand (SP)	5.0E-03	10	5.0E-04	14.175	1.418	34	0	135
	4	Sandy Fat Clay (CH)	1.0E-05	10	1.0E-06	0.028	0.003	30	50	110
	5	Clay Cap	1.0E-06	4	2.5E-07	0.0028	0.0007	28	50	115
	6	Cutoff Wall	1.0E-06	1	1.0E-06	0.0028	0.0028	0	50	85

0 20' 40'
HORIZONTAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

0 20' 40'
VERTICAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

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AMERICAN RIVER WATERSHED - COMMON FEATURES
GENERAL REEVALUATION REPORT
GEOTECHNICAL ATTACHMENT
NAT REACH D UNIT 1 LM 1.17-200YR WSEL-CRITICAL SHEAR SURFACE
NATOMAS BASIN

DATE:	SCALE:	SHEET NO.
29-Jan-13	AS SHOWN	4

PLOT BY: L2EDGAJD - Jan 31, 2013 - 4:13:03pm
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AMERICAN RIVER WATERSHED

COMMON FEATURES PROJECT

GENERAL REEVALUATION REPORT

ATTACHMENT C – GEOTECHNICAL REPORT

ENCLOSURE 3

PROBABILISTIC ANALYSES AND LEVEE PERFORMANCE CURVES

Without Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Determination of Random Variables For Underseepage Reliability Analysis

Project: American River Common Features GRR
Channel: American River
Basin and Reach: ARN Reach A Unit 9

Levee Mile: 1.32
River Mile: 7.82
Analysis Case Without Project Cutoff Wall

Crest Elev.: 52.95
L/S Toe Elev.: 43.26
W/S Toe Elev.: 40.62

Analysis By: M. Kynett
Checked By: H. Mulder
Date: 4/29/2011

Boring #	Blanket Thickness Variable (z)					Aquifer Thickness Variable (d)					Hydraulic Conductivity Vairables (Kb and Kf)								
	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Blanket Material	Blanket Kb (ft/day)	Aquifer Material Material	Aquifer Material Kf (ft/day)	Kf/Kb	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation
WCNBAR_03B	20					15					SM	0.709	GM	34	48				
2F-97-06	22.7					30					SM	0.709	SP-SM/GM	24.8	35				
2F-99-08A	24					10					SM	0.709	SP-SM/GM	28	39				
2F-99-15A	6					39					SM	0.709	SP-SM/GM	30.92	44				
2F-02-17	10	15	8	96	53	24	24	10	214	42	SM	0.709	SP-SM/GM	27.33	39	41	4	456	10
2F-07-18A	10					26					SM	0.709	SP/GP	28.62	40				

Boring #	Blanket Material 1 (lowest permeability)			Blanket Material 2			Transformed Blanket Thickness (z)	Aquifer Material 1			Aquifer Material 2			Aquifer Material 3			Transformed Aquifer Horizontal Permeability (kf)
	Material Type	Thickness (z)	Permeability (Kb)	Material Type	Thickness (z)	Permeability (Kb)		Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	
WCNBAR_03B	SM	20	0.709				20	GM	15	34							34
2F-97-06	SM	22.7	0.709				22.7	SP-SM	13.8	14	GM	16.2	34				24.8
2F-99-08A	SM	24	0.709				24	SP-SM	3	14	GM	7	34				28
2F-99-15A	SM	6	0.709				6	SP-SM	6	14	GM	33	34				30.92
2F-02-17	SM	10	0.709				10	SP-SM	8	14	GM	16	34				27.33
2F-07-18A	SM	10	0.709				10	SP	7	14	GP	19	34				28.62

Without Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Underseepage Reliability Analysis With Blanket Theory Analysis

Project: American River Common Features GRR
Study Area: American River
River Section: ARN Reach A Unit 9

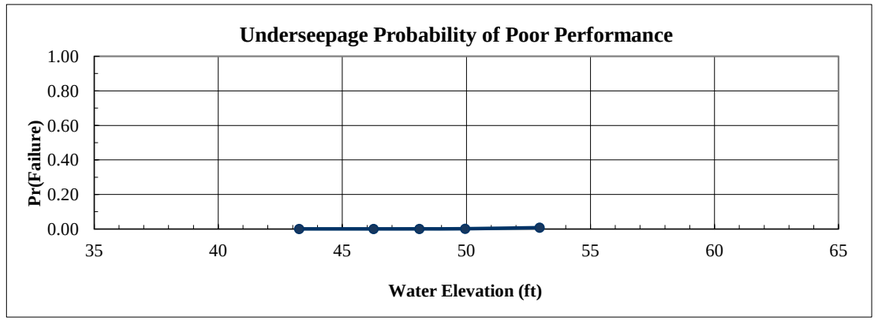
Levee Mile: 1.32
River Mile: 7.82
Analysis Case Without Project Cutoff Wall

Crest Elev.: 52.95
L/S Toe Elev.: 43.26
W/S Toe Elev.: 40.62

Analysis By: M. Kynett
Checked By: H. Mulder
Date: 4/29/2011

Random Variables			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Permaebility Ratio	41	4	10
Blanket Thickness (z)	15	8	53
Aquifer Thickness (d)	24	10	42

Blanket Theory Analysis Inputs					
Pr(f)=0	BTA Case No.	L1	L2	L3	γ Blanket
NO	7A	265	85	∞	112



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	43.26	0.0000
Toe+3ft	3.00	46.26	0.0000
Half Height	4.85	48.11	0.0002
Crest-3ft	6.69	49.95	0.0010
Crest	9.69	52.95	0.0076

Crest	Rh
Head = 9.69	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	41	15.00	24.00	118.43	121.49	0.0739	3.62	0.24		
2	45	15.00	24.00	123.38	127.28	0.0715	3.67	0.24	0.000000	0.00
3	37	15.00	24.00	113.10	115.41	0.0766	3.57	0.24		
4	41	23.00	24.00	141.81	150.44	0.0636	3.86	0.17	0.021025	98.94
5	41	7.00	24.00	82.71	82.99	0.0957	3.21	0.46		
6	41	15.00	34.00	137.38	144.60	0.0926	3.82	0.25	0.000225	1.06
7	41	15.00	14.00	92.18	92.79	0.0519	3.33	0.22		
								Total	0.021250	100.00

E[I] = 0.240000
Var[I]= 0.021250
σ[I]= 0.145774
V(I) = 0.607391

E[ln I] = -1.584129
σ [ln I] = 0.560379

Ic= 0.80
ln(I crit) = -0.223144

β =	-2.826888
F(z) =	0.992423
Pr(f) % =	0.757681

Crest-3ft	Rh
Head = 6.69	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	41	15.00	24.00	118.43	121.49	0.0739	2.50	0.17		
2	45	15.00	24.00	123.38	127.28	0.0715	2.54	0.17	0.000025	0.24
3	37	15.00	24.00	113.10	115.41	0.0766	2.46	0.16		
4	41	23.00	24.00	141.81	150.44	0.0636	2.67	0.12	0.010000	97.56
5	41	7.00	24.00	82.71	82.99	0.0957	2.21	0.32		
6	41	15.00	34.00	137.38	144.60	0.0926	2.64	0.18	0.000225	2.20
7	41	15.00	14.00	92.18	92.79	0.0519	2.30	0.15		
								Total	0.010250	100.00

E[I] = 0.170000
Var[I]= 0.010250
σ[I]= 0.101242
V(I) = 0.595543

E[ln I] = -1.923736
σ [ln I] = 0.550962

Ic= 0.80
ln(I crit) = -0.223144

β =	-3.491597
F(z) =	0.998988
Pr(f) % =	0.101233

Half Height	Rh
Head = 4.85	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	41	15.00	24.00	118.43	121.49	0.0739	1.81	0.12		
2	45	15.00	24.00	123.38	127.28	0.0715	1.84	0.12	0.000000	0.00
3	37	15.00	24.00	113.10	115.41	0.0766	1.78	0.12		
4	41	23.00	24.00	141.81	150.44	0.0636	1.93	0.08	0.005625	98.25
5	41	7.00	24.00	82.71	82.99	0.0957	1.60	0.23		
6	41	15.00	34.00	137.38	144.60	0.0926	1.91	0.13	0.000100	1.75
7	41	15.00	14.00	92.18	92.79	0.0519	1.67	0.11		
								Total	0.005725	100.00

E[I] = 0.120000
Var[I]= 0.005725
σ[I]= 0.075664
V(I) = 0.630531

E[ln I] = -2.287631
σ [ln I] = 0.578563

Ic= 0.80
ln(I crit) = -0.223144

β =	-3.953991
F(z) =	0.999820
Pr(f) % =	0.017965

Toe+3ft	Rh
Head = 3.00	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	41	15.00	24.00	118.43	121.49	0.0739	1.12	0.07		
2	45	15.00	24.00	123.38	127.28	0.0715	1.14	0.08	0.000025	1.20
3	37	15.00	24.00	113.10	115.41	0.0766	1.10	0.07		
4	41	23.00	24.00	141.81	150.44	0.0636	1.20	0.05	0.002025	97.59
5	41	7.00	24.00	82.71	82.99	0.0957	0.99	0.14		
6	41	15.00	34.00	137.38	144.60	0.0926	1.18	0.08	0.000025	1.20
7	41	15.00	14.00	92.18	92.79	0.0519	1.03	0.07		
								Total	0.002075	100.00

E[I] = 0.070000
Var[I]= 0.002075
σ[I]= 0.045552
V(I) = 0.650745

E[ln I] = -2.835809
σ [ln I] = 0.594220

Ic= 0.80
ln(I crit) = -0.223144

β =	-4.772323
F(z) =	0.999995
Pr(f) % =	0.000549

Without Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Through-Seepage Reliability Analysis With Khilar's Extended Model

Project: American River Common Features GRR
Study Area: American River
River Section: ARN Reach A Unit 9

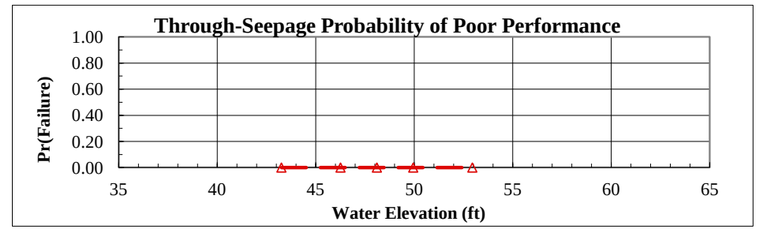
Levee Mile: 1.32
River Mile: 7.82
Analysis Case Without Project Cutoff Wall

Crest Elev.: 52.95
L/S Toe Elev.: 43.26
W/S Toe Elev.: 40.62

Analysis By: M. Kynett
Checked By: H. Mulder
Date: 4/29/2011

Random Variables - Silty Sand (SM) Levee			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Tractive Stress (Tc)	1	0.1	10.00
Initial Porosity (n)	0.5	0.05	10.00
Intrinsic Permeability (Ko)	1.00E-07	3.00E-08	30.00

Pr(f)=0
YES



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	43.26	0.0000
Toe+3ft	3.00	46.26	0.000000
Half Height	4.85	48.11	0.000000
Crest-3ft	6.69	49.95	0.000000
Crest	9.69	52.95	0.000000

Crest | **Head =** 9.69 | **Horizontal Gradient (Ix) =** 0.000

Run	Tractive Stress (Tc)	Initial Porosity (n)	Intrinsic Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	1.00	0.50	1.00E-07	0.81			
2	0.90	0.50	1.00E-07	0.73			
3	1.10	0.50	1.00E-07	0.89			
4	1.00	0.45	1.00E-07	0.76			
5	1.00	0.55	1.00E-07	0.85			
6	1.00	0.50	7.00E-08	0.96			
7	1.00	0.50	1.30E-07	0.71			

E[FS] =
Var[FS]=
σ[FS]=
V(FS) =
FS req'd = 1.00

E[ln FS] =
σ[ln FS]=
ln(FS req'd) = 0.000000

Total

β =
F(z) =
Pr(f) % = 0.000000

Crest-3ft | **Head =** 6.69 | **Horizontal Gradient (Ix) =** 0.000

Run	Tractive Stress (Tc)	Initial Porosity (n)	Intrinsic Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	1.00	0.50	1.00E-07	0.81			
2	0.90	0.50	1.00E-07	0.73			
3	1.10	0.50	1.00E-07	0.89			
4	1.00	0.45	1.00E-07	0.76			
5	1.00	0.55	1.00E-07	0.85			
6	1.00	0.50	7.00E-08	0.96			
7	1.00	0.50	1.30E-07	0.71			

E[FS] =
Var[FS]=
σ[FS]=
V(FS) =
FS req'd = 1.00

E[ln FS] =
σ[ln FS]=
ln(FS req'd) = 0.000000

Total

β =
F(z) =
Pr(f) % = 0.000000

Half Height | **Head =** 4.85 | **Horizontal Gradient (Ix) =** 0.000

Run	Tractive Stress (Tc)	Initial Porosity (n)	Intrinsic Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	1.00	0.50	1.00E-07	0.81			
2	0.90	0.50	1.00E-07	0.73			
3	1.10	0.50	1.00E-07	0.89			
4	1.00	0.45	1.00E-07	0.76			
5	1.00	0.55	1.00E-07	0.85			
6	1.00	0.50	7.00E-08	0.96			
7	1.00	0.50	1.30E-07	0.71			

E[FS] =
Var[FS]=
σ[FS]=
V(FS) =
FS req'd = 1.00

E[ln FS] =
σ[ln FS]=
ln(FS req'd) = 0.000000

Total

β =
F(z) =
Pr(f) % = 0.000000

Toe+3ft | **Head =** 3.00 | **Horizontal Gradient (Ix) =** 0.000

Run	Tractive Stress (Tc)	Initial Porosity (n)	Intrinsic Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	1.00	0.50	1.00E-07	0.81			
2	0.90	0.50	1.00E-07	0.73			
3	1.10	0.50	1.00E-07	0.89			
4	1.00	0.45	1.00E-07	0.76			
5	1.00	0.55	1.00E-07	0.85			
6	1.00	0.50	7.00E-08	0.96			
7	1.00	0.50	1.30E-07	0.71			

E[FS] =
Var[FS]=
σ[FS]=
V(FS) =
FS req'd = 1.00

E[ln FS] =
σ[ln FS]=
ln(FS req'd) = 0.000000

Total

β =
F(z) =
Pr(f) % = 0.000000

Without Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Landside Long-Term Stability Analysis With UTEXAS4

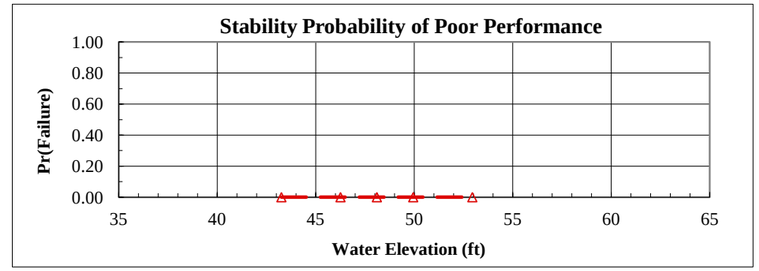
Project: American River Common Features GRR
Study Area: American River
River Section: ARN Reach A Unit 9

Levee Mile: 1.32
River Mile: 7.82
Analysis Case Without Project Cutoff Wall

Crest Elev.: 52.95
L/S Toe Elev.: 43.26
W/S Toe Elev.: 40.62

Analysis By: M. Kynett
Checked By: H. Mulder
Date: 4/29/2011

Random Variables			
Parameter	**Expected Value**	**Standard Deviation**	**Coefficient of Variation, %**
Levee Φ	33	4	13.00
Levee Cohesion	0	0	40.00
Levee γ	125	9	7.00
Foundation Φ	33	4	13.00
Foundation Cohesion	0	0	40.00



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	43.26	0.0000
Toe+3ft	3.00	46.26	0.000000
Half Height	4.85	48.11	0.000000
Crest-3ft	6.69	49.95	0.000000
Crest	9.69	52.95	0.000000

Crest	Head =	9.69	Pr(f)=0	YES

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	33	0	125	33	0	1.76		
2	29	0	125	33	0			
3	37	0	125	33	0			
4	33	0	125	33	0			
5	33	0	125	33	0			
6	33	0	116	33	0			
7	33	0	134	33	0			
8	33	0	125	29	0			
9	33	0	125	37	0			
10	33	0	125	33	0			
11	33	0	125	33	0			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

Crest-3ft	Head =	6.69	Pr(f)=0	YES

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	33	0	125	33	0	1.79		
2	29	0	125	33	0			
3	37	0	125	33	0			
4	33	0	125	33	0			
5	33	0	125	33	0			
6	33	0	116	33	0			
7	33	0	134	33	0			
8	33	0	125	29	0			
9	33	0	125	37	0			
10	33	0	125	33	0			
11	33	0	125	33	0			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

Half Height	Head =	4.85	Pr(f)=0	YES

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	33	0	125	33	0	1.80		
2	29	0	125	33	0			
3	37	0	125	33	0			
4	33	0	125	33	0			
5	33	0	125	33	0			
6	33	0	116	33	0			
7	33	0	134	33	0			
8	33	0	125	29	0			
9	33	0	125	37	0			
10	33	0	125	33	0			
11	33	0	125	33	0			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

Toe+3ft	Head =	3.00	Pr(f)=0	YES

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	33	0	125	33	0	1.81		
2	29	0	125	33	0			
3	37	0	125	33	0			
4	33	0	125	33	0			
5	33	0	125	33	0			
6	33	0	116	33	0			
7	33	0	134	33	0			
8	33	0	125	29	0			
9	33	0	125	37	0			
10	33	0	125	33	0			
11	33	0	125	33	0			

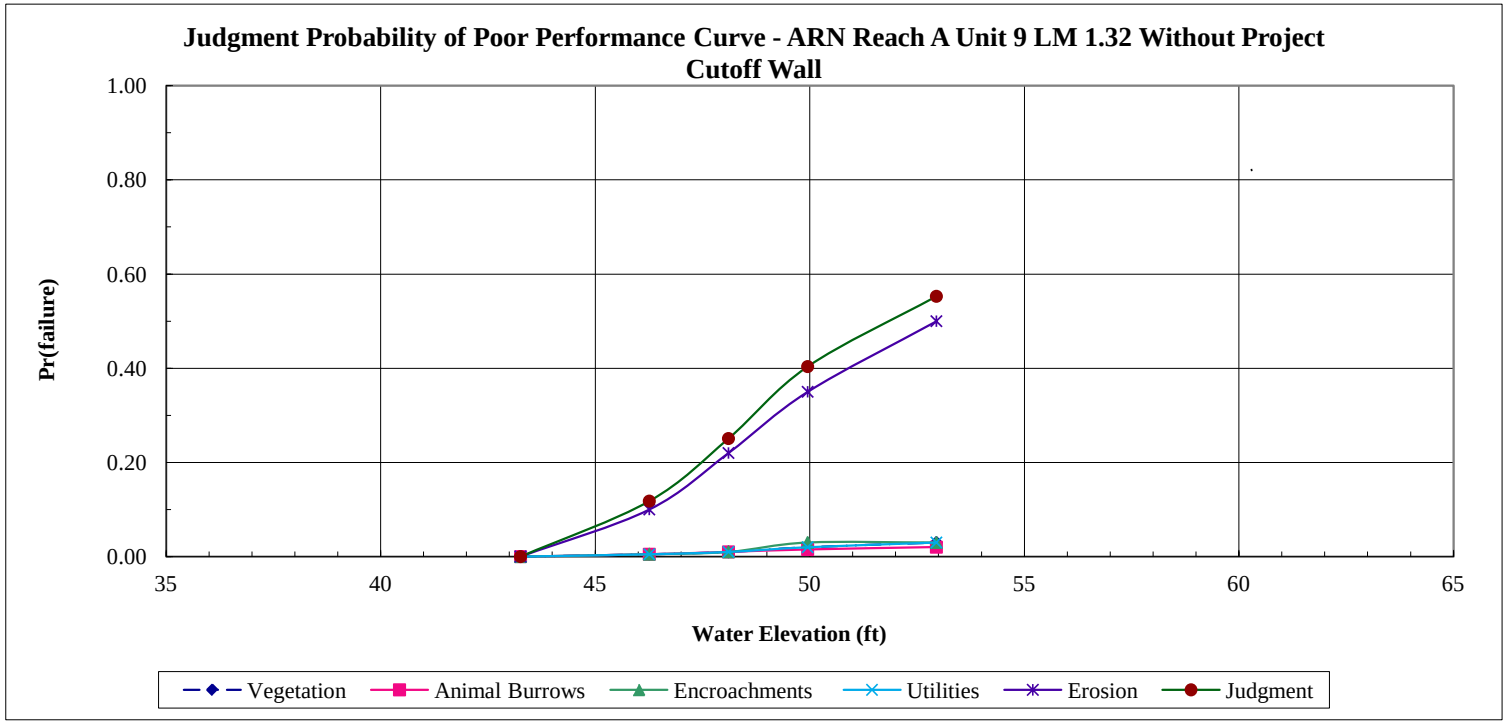
E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

Without Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Judgment Probability of Poor Performance Curve

Project:	American River Common Features GRR	**Levee Mile:**	1.32	**Crest Elev.:**	52.95	**Analysis By:**	M. Kynett
Study Area:	American River	**River Mile:**	7.82	**L/S Toe Elev.:**	43.26	**Checked By:**	H. Mulder
River Section:	ARN Reach A Unit 9	**Analysis Case:**	Without Project Cutoff Wall	**W/S Toe Elev.:**	40.62	**Date:**	4/29/2011

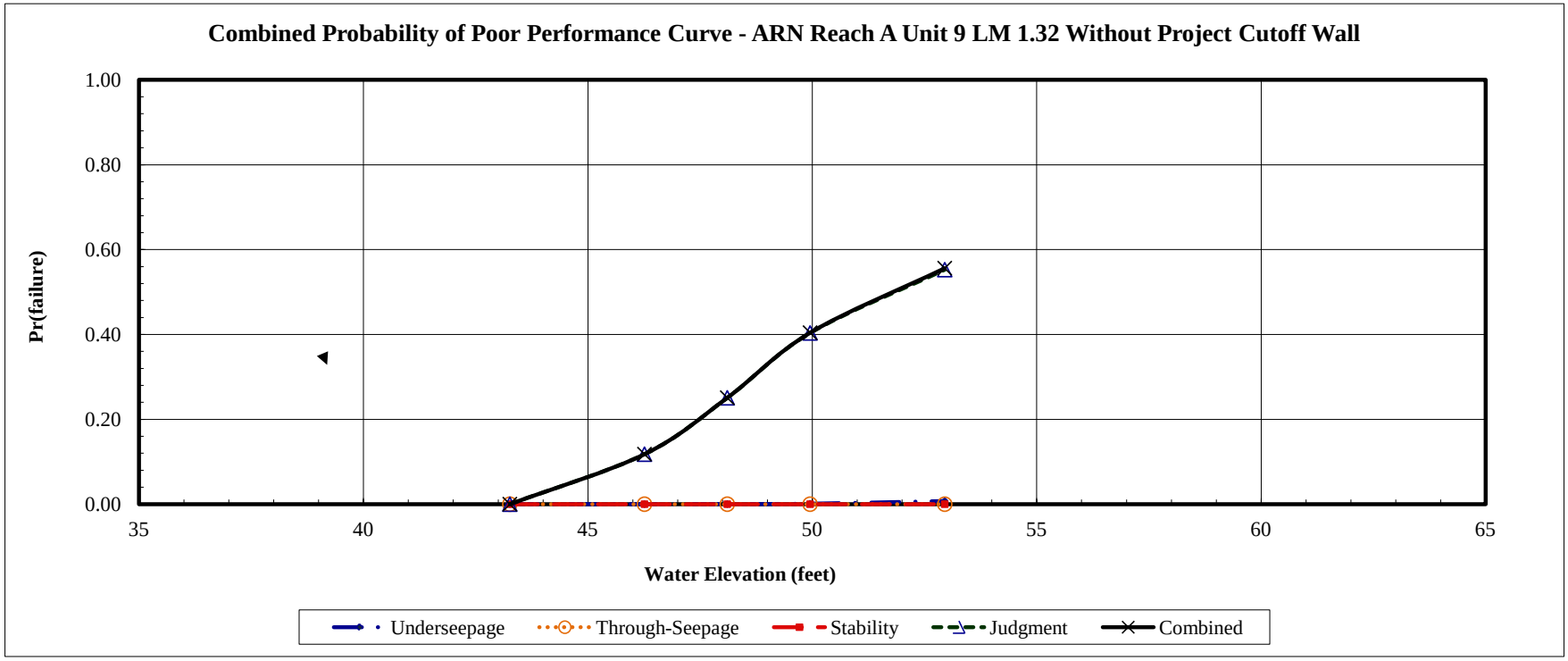
Water Surface Elevation	Vegetation		Animal Burrows		Encroachments		Utilities		Erosion		Judgment	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
43.26	0.00000	1.0000	0.00000	1.0000	0.00000	1.0000	0.00000	1.0000	0.00000	1.0000	0.0000	1.0000
46.26	0.00500	0.9950	0.00500	0.9950	0.00500	0.9950	0.00500	0.9950	0.10000	0.9000	0.1179	0.8821
48.11	0.01000	0.9900	0.01000	0.9900	0.01000	0.9900	0.01000	0.9900	0.22000	0.7800	0.2507	0.7493
49.95	0.02000	0.9800	0.01500	0.9850	0.03000	0.9700	0.02000	0.9800	0.35000	0.6500	0.4036	0.5964
52.95	0.03000	0.9700	0.02000	0.9800	0.03000	0.9700	0.03000	0.9700	0.50000	0.5000	0.5528	0.4472



Without Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

Project:	American River Common Features GRR	**Levee Mile:**	1.32	**Crest Elev.:**	52.95	**Analysis By:**	M. Kynett
Study Area:	American River	**River Mile:**	7.82	**L/S Toe Elev.:**	43.26	**Checked By:**	H. Mulder
River Section:	ARN Reach A Unit 9	**Analysis Case:**	Without Project Cutoff Wall	**W/S Toe Elev.:**	40.62	**Date:**	4/29/2011

Water Surface	Underseepage		Through-Seepage		Stability		Judgment		Combined	
Elevation	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
43.26	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
46.26	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.1179	0.8821	0.1179	0.8821
48.11	0.0002	0.9998	0.0000	1.0000	0.0000	1.0000	0.2507	0.7493	0.2509	0.7491
49.95	0.0010	0.9990	0.0000	1.0000	0.0000	1.0000	0.4036	0.5964	0.4042	0.5958
52.95	0.0076	0.9924	0.0000	1.0000	0.0000	1.0000	0.5528	0.4472	0.5562	0.4438



With Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Determination of Random Variables For Underseepage Reliability Analysis

Project: American River Common Features GRR
Channel: American River
Basin and Reach: ARN Reach A Unit 9

Levee Mile: 1.32
River Mile: 7.82
Analysis Case With Project Erosion Protection

Crest Elev.: 52.95
L/S Toe Elev.: 43.26
W/S Toe Elev.: 40.62

Analysis By: A. Deus
Checked By: H. Mulder
Date: 7/5/2012

Boring #	Blanket Thickness Variable (z)					Aquifer Thickness Variable (d)					Hydraulic Conductivity Vairables (Kb and Kf)								
	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Blanket Material	Blanket Kb (ft/day)	Aquifer Material Material	Aquifer Material Kf (ft/day)	Kf/Kb	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation
WCNBAR_03B	20					15					SM	0.709	GM	34	48				
2F-97-06	22.7					30					SM	0.709	SP-SM/GM	24.8	35				
2F-99-08A	24					10					SM	0.709	SP-SM/GM	28	39				
2F-99-15A	6					39					SM	0.709	SP-SM/GM	30.92	44				
2F-02-17	10	15	8	96	53	24	24	10	214	42	SM	0.709	SP-SM/GM	27.33	39	41	4	456	10
2F-07-18A	10					26					SM	0.709	SP/GP	28.62	40				

Boring #	Blanket Material 1 (lowest permeability)			Blanket Material 2			Transformed Blanket Thickness (z)	Aquifer Material 1			Aquifer Material 2			Aquifer Material 3			Transformed Aquifer Horizontal Permeability (kf)
	Material Type	Thickness (z)	Permeability (Kb)	Material Type	Thickness (z)	Permeability (Kb)		Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	
WCNBAR_03B	SM	20	0.709				20	GM	15	34							34
2F-97-06	SM	22.7	0.709				22.7	SP-SM	13.8	14	GM	16.2	34				24.8
2F-99-08A	SM	24	0.709				24	SP-SM	3	14	GM	7	34				28
2F-99-15A	SM	6	0.709				6	SP-SM	6	14	GM	33	34				30.92
2F-02-17	SM	10	0.709				10	SP-SM	8	14	GM	16	34				27.33
2F-07-18A	SM	10	0.709				10	SP	7	14	GP	19	34				28.62

With Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Underseepage Reliability Analysis With Blanket Theory Analysis

Project: American River Common Features GRR
Study Area: American River
River Section: ARN Reach A Unit 9

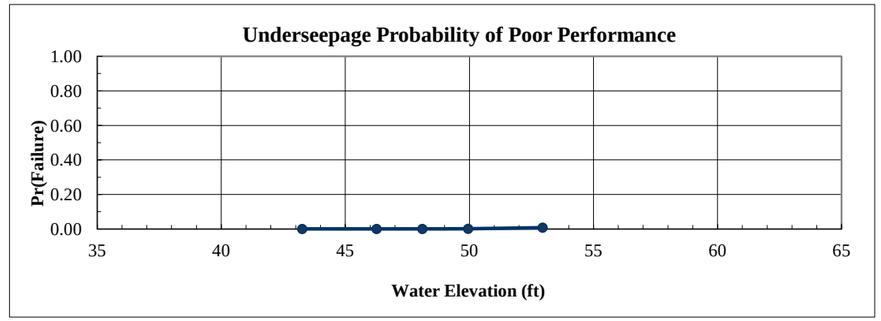
Levee Mile: 1.32
River Mile: 7.82
Analysis Case With Project Erosion Protection

Crest Elev.: 52.95
L/S Toe Elev.: 43.26
W/S Toe Elev.: 40.62

Analysis By: A. Deus
Checked By: H. Mulder
Date: 7/5/2012

Random Variables			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Permaebility Ratio	41	4	10
Blanket Thickness (z)	15	8	53
Aquifer Thickness (d)	24	10	42

Blanket Theory Analysis Inputs					
Pr(f)=0	BTA Case No.	L1	L2	L3	γ Blanket
NO	7A	265	85	∞	112



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	43.26	0.0000
Toe+3ft	3.00	46.26	0.0000
Half Height	4.85	48.11	0.0002
Crest-3ft	6.69	49.95	0.0010
Crest	9.69	52.95	0.0076

Crest	Rh
Head = 9.69	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	41	15.00	24.00	118.43	121.49	0.0739	3.62	0.24		
2	45	15.00	24.00	123.38	127.28	0.0715	3.67	0.24	0.000000	0.00
3	37	15.00	24.00	113.10	115.41	0.0766	3.57	0.24		
4	41	23.00	24.00	141.81	150.44	0.0636	3.86	0.17	0.021025	98.94
5	41	7.00	24.00	82.71	82.99	0.0957	3.21	0.46		
6	41	15.00	34.00	137.38	144.60	0.0926	3.82	0.25	0.000225	1.06
7	41	15.00	14.00	92.18	92.79	0.0519	3.33	0.22		
								Total	0.021250	100.00

E[I] = 0.240000
Var[I]= 0.021250
σ[I]= 0.145774
V(I) = 0.607391

E[ln I] = -1.584129
σ [ln I] = 0.560379

Ic= 0.80
ln(I crit) = -0.223144

β =	-2.826888
F(z) =	0.992423
Pr(f) % =	0.757681

Crest-3ft	Rh
Head = 6.69	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	41	15.00	24.00	118.43	121.49	0.0739	2.50	0.17		
2	45	15.00	24.00	123.38	127.28	0.0715	2.54	0.17	0.000025	0.24
3	37	15.00	24.00	113.10	115.41	0.0766	2.46	0.16		
4	41	23.00	24.00	141.81	150.44	0.0636	2.67	0.12	0.010000	97.56
5	41	7.00	24.00	82.71	82.99	0.0957	2.21	0.32		
6	41	15.00	34.00	137.38	144.60	0.0926	2.64	0.18	0.000225	2.20
7	41	15.00	14.00	92.18	92.79	0.0519	2.30	0.15		
								Total	0.010250	100.00

E[I] = 0.170000
Var[I]= 0.010250
σ[I]= 0.101242
V(I) = 0.595543

E[ln I] = -1.923736
σ [ln I] = 0.550962

Ic= 0.80
ln(I crit) = -0.223144

β =	-3.491597
F(z) =	0.998988
Pr(f) % =	0.101233

Half Height	Rh
Head = 4.85	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	41	15.00	24.00	118.43	121.49	0.0739	1.81	0.12		
2	45	15.00	24.00	123.38	127.28	0.0715	1.84	0.12	0.000000	0.00
3	37	15.00	24.00	113.10	115.41	0.0766	1.78	0.12		
4	41	23.00	24.00	141.81	150.44	0.0636	1.93	0.08	0.005625	98.25
5	41	7.00	24.00	82.71	82.99	0.0957	1.60	0.23		
6	41	15.00	34.00	137.38	144.60	0.0926	1.91	0.13	0.000100	1.75
7	41	15.00	14.00	92.18	92.79	0.0519	1.67	0.11		
								Total	0.005725	100.00

E[I] = 0.120000
Var[I]= 0.005725
σ[I]= 0.075664
V(I) = 0.630531

E[ln I] = -2.287631
σ [ln I] = 0.578563

Ic= 0.80
ln(I crit) = -0.223144

β =	-3.953991
F(z) =	0.999820
Pr(f) % =	0.017965

Toe+3ft	Rh
Head = 3.00	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	41	15.00	24.00	118.43	121.49	0.0739	1.12	0.07		
2	45	15.00	24.00	123.38	127.28	0.0715	1.14	0.08	0.000025	1.20
3	37	15.00	24.00	113.10	115.41	0.0766	1.10	0.07		
4	41	23.00	24.00	141.81	150.44	0.0636	1.20	0.05	0.002025	97.59
5	41	7.00	24.00	82.71	82.99	0.0957	0.99	0.14		
6	41	15.00	34.00	137.38	144.60	0.0926	1.18	0.08	0.000025	1.20
7	41	15.00	14.00	92.18	92.79	0.0519	1.03	0.07		
								Total	0.002075	100.00

E[I] = 0.070000
Var[I]= 0.002075
σ[I]= 0.045552
V(I) = 0.650745

E[ln I] = -2.835809
σ [ln I] = 0.594220

Ic= 0.80
ln(I crit) = -0.223144

β =	-4.772323
F(z) =	0.999995
Pr(f) % =	0.000549

With Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Through-Seepage Reliability Analysis With Khilar's Extended Model

Project: American River Common Features GRR
Study Area: American River
River Section: ARN Reach A Unit 9

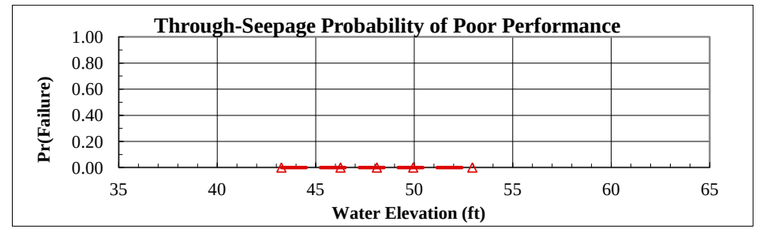
Levee Mile: 1.32
River Mile: 7.82
Analysis Case With Project Erosion Protection

Crest Elev.: 52.95
L/S Toe Elev.: 43.26
W/S Toe Elev.: 40.62

Analysis By: A. Deus
Checked By: H. Mulder
Date: 7/5/2012

Random Variables - Silty Sand (SM) Levee			
Parameter	**Expected Value**	**Standard Deviation**	**Coefficient of Variation, %**
Tractive Stress (Tc)	1	0.1	10.00
Initial Porosity (n)	0.5	0.05	10.00
Intrinsic Permeability (Ko)	1.00E-07	3.00E-08	30.00

Pr(f)=0
YES



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	43.26	0.0000
Toe+3ft	3.00	46.26	0.000000
Half Height	4.85	48.11	0.000000
Crest-3ft	6.69	49.95	0.000000
Crest	9.69	52.95	0.000000

Crest | **Head =** 9.69 | **Horizontal Gradient (Ix) =** 0.000

Run	Tractive Stress (Tc)	Initial Porosity (n)	Intrinsic Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	1.00	0.50	1.00E-07	0.81			
2	0.90	0.50	1.00E-07	0.73			
3	1.10	0.50	1.00E-07	0.89			
4	1.00	0.45	1.00E-07	0.76			
5	1.00	0.55	1.00E-07	0.85			
6	1.00	0.50	7.00E-08	0.96			
7	1.00	0.50	1.30E-07	0.71			

E[FS] =
Var[FS]=
σ[FS]=
V(FS) =
FS req'd = 1.00

E[ln FS] =
σ[ln FS]=
ln(FS req'd) = 0.000000

Total

β =
F(z) =
Pr(f) % = 0.000000

Crest-3ft | **Head =** 6.69 | **Horizontal Gradient (Ix) =** 0.000

Run	Tractive Stress (Tc)	Initial Porosity (n)	Intrinsic Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	1.00	0.50	1.00E-07	0.81			
2	0.90	0.50	1.00E-07	0.73			
3	1.10	0.50	1.00E-07	0.89			
4	1.00	0.45	1.00E-07	0.76			
5	1.00	0.55	1.00E-07	0.85			
6	1.00	0.50	7.00E-08	0.96			
7	1.00	0.50	1.30E-07	0.71			

E[FS] =
Var[FS]=
σ[FS]=
V(FS) =
FS req'd = 1.00

E[ln FS] =
σ[ln FS]=
ln(FS req'd) = 0.000000

Total

β =
F(z) =
Pr(f) % = 0.000000

Half Height | **Head =** 4.85 | **Horizontal Gradient (Ix) =** 0.000

Run	Tractive Stress (Tc)	Initial Porosity (n)	Intrinsic Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	1.00	0.50	1.00E-07	0.81			
2	0.90	0.50	1.00E-07	0.73			
3	1.10	0.50	1.00E-07	0.89			
4	1.00	0.45	1.00E-07	0.76			
5	1.00	0.55	1.00E-07	0.85			
6	1.00	0.50	7.00E-08	0.96			
7	1.00	0.50	1.30E-07	0.71			

E[FS] =
Var[FS]=
σ[FS]=
V(FS) =
FS req'd = 1.00

E[ln FS] =
σ[ln FS]=
ln(FS req'd) = 0.000000

Total

β =
F(z) =
Pr(f) % = 0.000000

Toe+3ft | **Head =** 3.00 | **Horizontal Gradient (Ix) =** 0.000

Run	Tractive Stress (Tc)	Initial Porosity (n)	Intrinsic Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	1.00	0.50	1.00E-07	0.81			
2	0.90	0.50	1.00E-07	0.73			
3	1.10	0.50	1.00E-07	0.89			
4	1.00	0.45	1.00E-07	0.76			
5	1.00	0.55	1.00E-07	0.85			
6	1.00	0.50	7.00E-08	0.96			
7	1.00	0.50	1.30E-07	0.71			

E[FS] =
Var[FS]=
σ[FS]=
V(FS) =
FS req'd = 1.00

E[ln FS] =
σ[ln FS]=
ln(FS req'd) = 0.000000

Total

β =
F(z) =
Pr(f) % = 0.000000

With Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Landside Long-Term Stability Analysis With UTEXAS4

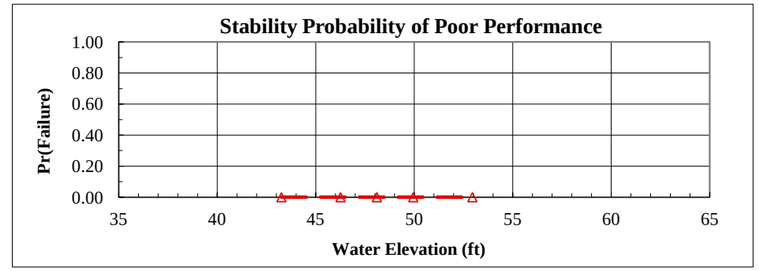
Project: American River Common Features GRR
Study Area: American River
River Section: ARN Reach A Unit 9

Levee Mile: 1.32
River Mile: 7.82
Analysis Case With Project Erosion Protection

Crest Elev.: 52.95
L/S Toe Elev.: 43.26
W/S Toe Elev.: 40.62

Analysis By: A. Deus
Checked By: H. Mulder
Date: 7/5/2012

Random Variables			
Parameter	**Expected Value**	**Standard Deviation**	**Coefficient of Variation, %**
Levee Φ	33	4	13.00
Levee Cohesion	0	0	40.00
Levee γ	125	9	7.00
Foundation Φ	33	4	13.00
Foundation Cohesion	0	0	40.00



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	43.26	0.0000
Toe+3ft	3.00	46.26	0.000000
Half Height	4.85	48.11	0.000000
Crest-3ft	6.69	49.95	0.000000
Crest	9.69	52.95	0.000000

Crest	Head =	9.69	Pr(f)=0	YES

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	33	0	125	33	0	1.76		
2	29	0	125	33	0			
3	37	0	125	33	0			
4	33	0	125	33	0			
5	33	0	125	33	0			
6	33	0	116	33	0			
7	33	0	134	33	0			
8	33	0	125	29	0			
9	33	0	125	37	0			
10	33	0	125	33	0			
11	33	0	125	33	0			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

Crest-3ft	Head =	6.69	Pr(f)=0	YES

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	33	0	125	33	0	1.79		
2	29	0	125	33	0			
3	37	0	125	33	0			
4	33	0	125	33	0			
5	33	0	125	33	0			
6	33	0	116	33	0			
7	33	0	134	33	0			
8	33	0	125	29	0			
9	33	0	125	37	0			
10	33	0	125	33	0			
11	33	0	125	33	0			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

Half Height	Head =	4.85	Pr(f)=0	YES

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	33	0	125	33	0	1.80		
2	29	0	125	33	0			
3	37	0	125	33	0			
4	33	0	125	33	0			
5	33	0	125	33	0			
6	33	0	116	33	0			
7	33	0	134	33	0			
8	33	0	125	29	0			
9	33	0	125	37	0			
10	33	0	125	33	0			
11	33	0	125	33	0			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

Toe+3ft	Head =	3.00	Pr(f)=0	YES

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	33	0	125	33	0	1.81		
2	29	0	125	33	0			
3	37	0	125	33	0			
4	33	0	125	33	0			
5	33	0	125	33	0			
6	33	0	116	33	0			
7	33	0	134	33	0			
8	33	0	125	29	0			
9	33	0	125	37	0			
10	33	0	125	33	0			
11	33	0	125	33	0			

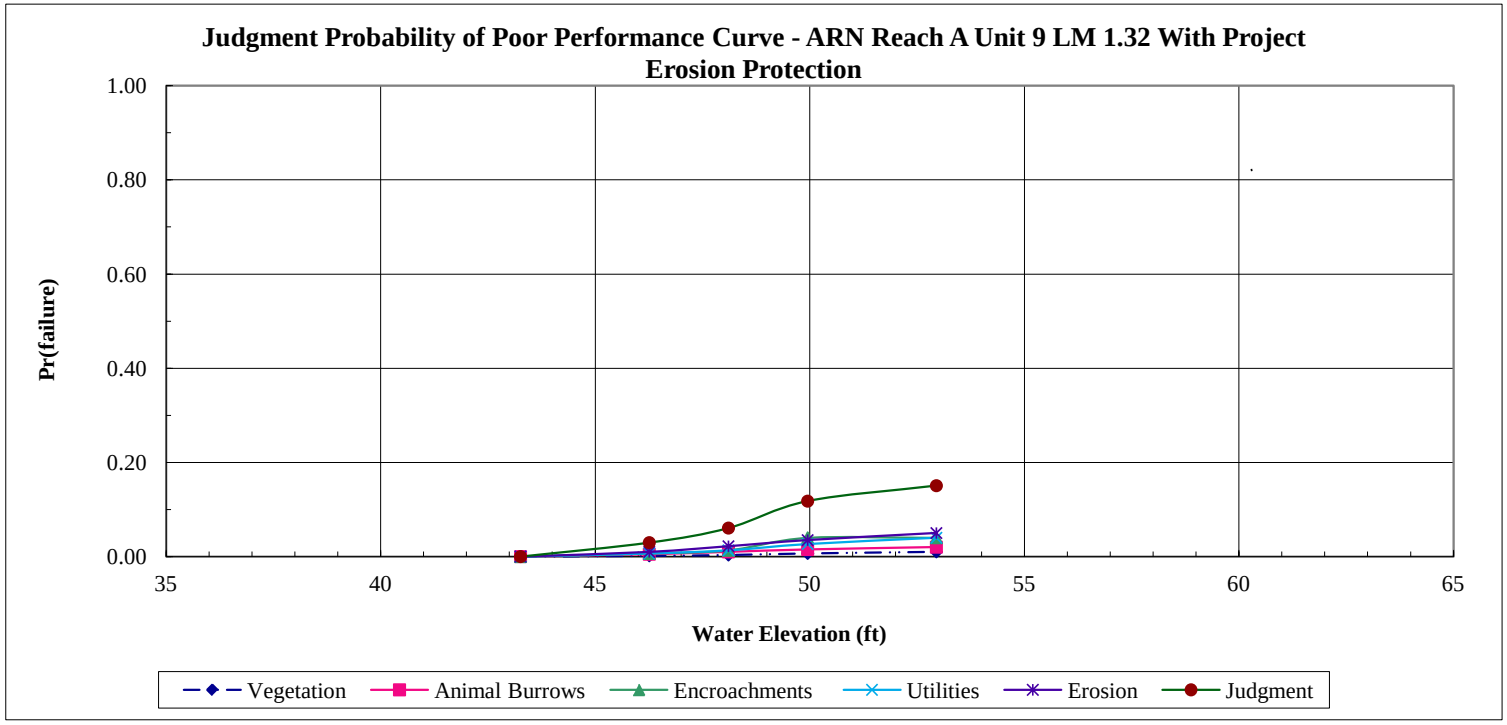
E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

With Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Judgment Probability of Poor Performance Curve

Project:	American River Common Features GRR	**Levee Mile:**	1.32	**Crest Elev.:**	52.95	**Analysis By:**	A. Deus
Study Area:	American River	**River Mile:**	7.82	**L/S Toe Elev.:**	43.26	**Checked By:**	H. Mulder
River Section:	ARN Reach A Unit 9	**Analysis Case:**	With Project Erosion Protect	**W/S Toe Elev.:**	40.62	**Date:**	7/5/2012

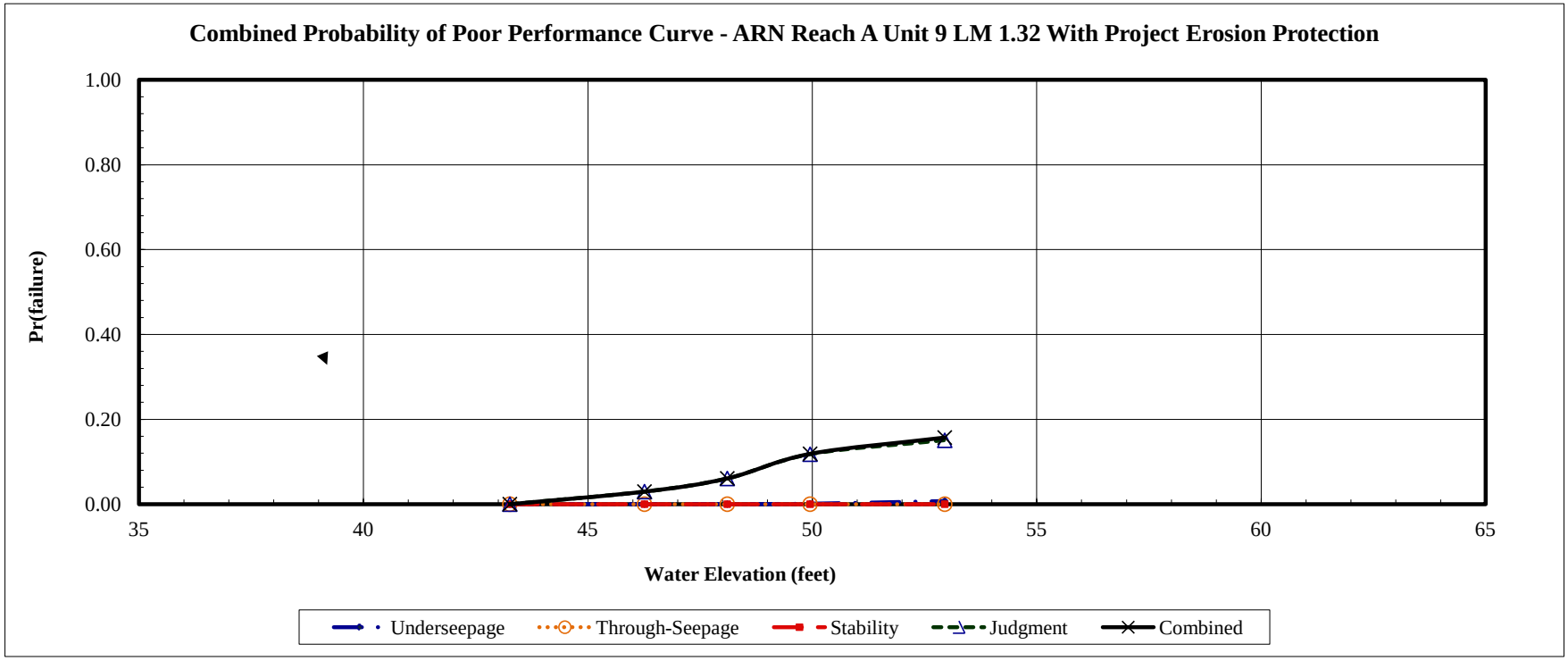
Water Surface Elevation	Vegetation		Animal Burrows		Encroachments		Utilities		Erosion		Judgment	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
43.26	0.00000	1.0000	0.00000	1.0000	0.00000	1.0000	0.00000	1.0000	0.00000	1.0000	0.0000	1.0000
46.26	0.00167	0.9983	0.00500	0.9950	0.00667	0.9933	0.00667	0.9933	0.01000	0.9900	0.0297	0.9703
48.11	0.00333	0.9967	0.01000	0.9900	0.01333	0.9867	0.01333	0.9867	0.02200	0.9780	0.0606	0.9394
49.95	0.00667	0.9933	0.01500	0.9850	0.04000	0.9600	0.02667	0.9733	0.03500	0.9650	0.1178	0.8822
52.95	0.01000	0.9900	0.02000	0.9800	0.04000	0.9600	0.04000	0.9600	0.05000	0.9500	0.1506	0.8494



With Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

Project:	American River Common Features GRR	**Levee Mile:**	1.32	**Crest Elev.:**	52.95	**Analysis By:**	A. Deus
Study Area:	American River	**River Mile:**	7.82	**L/S Toe Elev.:**	43.26	**Checked By:**	H. Mulder
River Section:	ARN Reach A Unit 9	**Analysis Case:**	With Project Erosion Protection	**W/S Toe Elev.:**	40.62	**Date:**	7/5/2012

Water Surface	Underseepage		Through-Seepage		Stability		Judgment		Combined	
Elevation	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
43.26	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
46.26	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0297	0.9703	0.0297	0.9703
48.11	0.0002	0.9998	0.0000	1.0000	0.0000	1.0000	0.0606	0.9394	0.0607	0.9393
49.95	0.0010	0.9990	0.0000	1.0000	0.0000	1.0000	0.1178	0.8822	0.1186	0.8814
52.95	0.0076	0.9924	0.0000	1.0000	0.0000	1.0000	0.1506	0.8494	0.1570	0.8430



Without Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Determination of Random Variables For Underseepage Reliability Analysis

Project: American River Common Features GRR
Channel: Arcade Creek North
Basin and Reach: ARN Reach E Unit 7

Levee Mile: 0.90
River Mile: 0.88
Analysis Case Without Project No Improvements

Crest Elev.: 43.94
L/S Toe Elev.: 31.69
W/S Toe Elev.: 26.77

Analysis By: M. Kynett
Checked By: H. Mulder
Date: 4/29/2011

Boring #	Blanket Thickness Variable (z)					Aquifer Thickness Variable (d)					Hydraulic Conductivity Vairables (Kb and Kf)								
	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Blanket Material	Blanket Kb (ft/day)	Aquifer Material Material	Aquifer Material Kf (ft/day)	Kf/Kb	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation
WRARFC_024S	5					27.5					CL	0.28	SM/ML	1.54	6				
WRARFC_003B	9					15.45					CL	0.028	SP	28	1000				
K94a_BA4	4					33.5					CL	0.28	ML/SM/SP	3.05	11				
		6	3	10	50		25	9	170	36						339	573	99649	98

Boring #	Blanket Material 1 (lowest permeability)			Blanket Material 2			Transformed Blanket Thickness (z)	Aquifer Material 1			Aquifer Material 2			Aquifer Material 3			Transformed Aquifer Horizontal Permeability (kf)
	Material Type	Thickness (z)	Permeability (Kb)	Material Type	Thickness (z)	Permeability (Kb)		Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	
WRARFC_024S	CL	5	0.28				5	SM	12	2.8	ML	15.5	0.57				1.54
WRARFC_003B	CL	9	0.028				9	SP	15.45	28							28
K94a_BA4	CL	4	0.28				4	ML	7.5	0.57	SM	25	2.8	SP	1	28	3.05

Without Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Underseepage Reliability Analysis With Blanket Theory Analysis

Project: American River Common Features GRR
Study Area: Arcade Creek North
River Section: ARN Reach E Unit 7

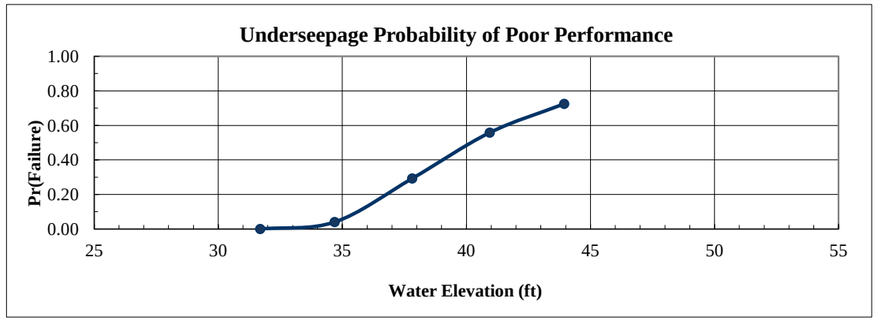
Levee Mile: 0.90
River Mile: 0.88
Analysis Case Without Project No Improvements

Crest Elev.: 43.94
L/S Toe Elev.: 31.69
W/S Toe Elev.: 26.77

Analysis By: M. Kynett
Checked By: H. Mulder
Date: 4/29/2011

Random Variables			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Permaebility Ratio	339	332	98
Blanket Thickness (z)	6	3	50
Aquifer Thickness (d)	25	9	36

Blanket Theory Analysis Inputs					
Pr(f)=0	BTA Case No.	L1	L2	L3	γ Blanket
NO	7A	10	100	∞	112



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	31.69	0.0000
Toe+3ft	3.00	34.69	0.0403
Half Height	6.13	37.82	0.2925
Crest-3ft	9.25	40.94	0.5580
Crest	12.25	43.94	0.7245

Crest	Rh
Head = 12.25	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	339	6.00	25.00	9.99	225.50	0.0745	8.23	1.37		
2	671	6.00	25.00	10.00	317.31	0.0585	9.10	1.52	0.280900	34.52
3	7	6.00	25.00	9.68	31.89	0.1766	2.76	0.46		
4	339	9.00	25.00	10.00	276.18	0.0647	8.76	0.97	0.525625	64.59
5	339	3.00	25.00	9.99	159.45	0.0928	7.25	2.42		
6	339	6.00	34.00	10.00	262.98	0.0912	8.64	1.44	0.007225	0.89
7	339	6.00	16.00	9.99	180.40	0.0551	7.61	1.27		
								Total	0.813750	100.00

E[I] = 1.370000
Var[I]= 0.813750
σ[I]= 0.902081
V(I) = 0.658453

E[ln I] = 0.134730
σ [ln I] = 0.600134

Ic= 0.80
ln(I crit) = -0.223144

β =	0.224500
F(z) =	0.275480
Pr(f) % =	72.452008

Crest-3ft	Rh
Head = 9.25	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	339	6.00	25.00	9.99	225.50	0.0745	6.22	1.04		
2	671	6.00	25.00	10.00	317.31	0.0585	6.87	1.15	0.160000	35.10
3	7	6.00	25.00	9.68	31.89	0.1766	2.08	0.35		
4	339	9.00	25.00	10.00	276.18	0.0647	6.62	0.74	0.291600	63.97
5	339	3.00	25.00	9.99	159.45	0.0928	5.47	1.82		
6	339	6.00	34.00	10.00	262.98	0.0912	6.52	1.09	0.004225	0.93
7	339	6.00	16.00	9.99	180.40	0.0551	5.75	0.96		
								Total	0.455825	100.00

E[I] = 1.040000
Var[I]= 0.455825
σ[I]= 0.675148
V(I) = 0.649181

E[ln I] = -0.136613
σ [ln I] = 0.593016

Ic= 0.80
ln(I crit) = -0.223144

β =	-0.230370
F(z) =	0.441994
Pr(f) % =	55.800618

Half Height	Rh
Head = 6.13	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	339	6.00	25.00	9.99	225.50	0.0745	4.12	0.69		
2	671	6.00	25.00	10.00	317.31	0.0585	4.55	0.76	0.070225	34.86
3	7	6.00	25.00	9.68	31.89	0.1766	1.38	0.23		
4	339	9.00	25.00	10.00	276.18	0.0647	4.38	0.49	0.129600	64.34
5	339	3.00	25.00	9.99	159.45	0.0928	3.62	1.21		
6	339	6.00	34.00	10.00	262.98	0.0912	4.32	0.72	0.001600	0.79
7	339	6.00	16.00	9.99	180.40	0.0551	3.81	0.64		
								Total	0.201425	100.00

E[I] = 0.690000
Var[I]= 0.201425
σ[I]= 0.448804
V(I) = 0.650441

E[ln I] = -0.547473
σ [ln I] = 0.593985

Ic= 0.80
ln(I crit) = -0.223144

β =	-0.921694
F(z) =	0.707475
Pr(f) % =	29.252520

Toe+3ft	Rh
Head = 3.00	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	339	6.00	25.00	9.99	225.50	0.0745	2.02	0.34		
2	671	6.00	25.00	10.00	317.31	0.0585	2.23	0.37	0.016900	35.26
3	7	6.00	25.00	9.68	31.89	0.1766	0.68	0.11		
4	339	9.00	25.00	10.00	276.18	0.0647	2.15	0.24	0.030625	63.90
5	339	3.00	25.00	9.99	159.45	0.0928	1.78	0.59		
6	339	6.00	34.00	10.00	262.98	0.0912	2.12	0.35	0.000400	0.83
7	339	6.00	16.00	9.99	180.40	0.0551	1.86	0.31		
								Total	0.047925	100.00

E[I] = 0.340000
Var[I]= 0.047925
σ[I]= 0.218918
V(I) = 0.643876

E[ln I] = -1.252225
σ [ln I] = 0.588923

Ic= 0.80
ln(I crit) = -0.223144

β =	-2.126297
F(z) =	0.959716
Pr(f) % =	4.028435

Without Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Through-Seepage Reliability Analysis With Khilar's Extended Model

Project: American River Common Features GRR
Study Area: Arcade Creek North
River Section: ARN Reach E Unit 7

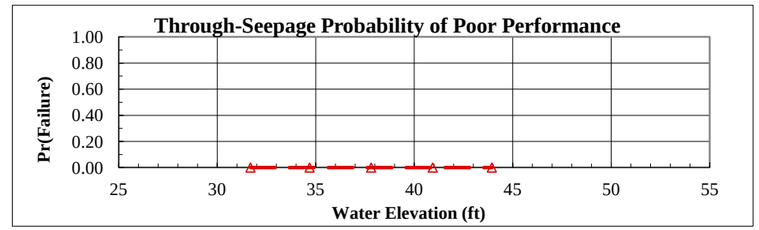
Levee Mile: 0.90
River Mile: 0.88
Analysis Case Without Project No Improvements

Crest Elev.: 43.94
L/S Toe Elev.: 31.69
W/S Toe Elev.: 26.77

Analysis By: M. Kynett
Checked By: H. Mulder
Date: 4/29/2011

Random Variables - Clay (CL) and Clayey Sand (SC) Levee			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Tractive Stress (Tc)	0.4	0.0	10.00
Initial Porosity (n)	0.7	0.07	10.00
Intrinsic Permeability (Ko)	1.00E-10	3.00E-11	30.00

Pr(f)=0
NO



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	31.69	0.0000
Toe+3ft	3.00	34.69	0.000000
Half Height	6.13	37.82	0.000000
Crest-3ft	9.25	40.94	0.000000
Crest	12.25	43.94	0.000000

Crest | **Head =** 12.25 | **Horizontal Gradient (Ix) =** 0.500

Run	Tractive Stress (Tc)	Initial Porosity (n)	Intrinsic Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	0.40	0.70	1.00E-10	12.07	24.13		
2	0.36	0.70	1.00E-10	10.86	21.72	5.824342	26.44
3	0.44	0.70	1.00E-10	13.27	26.55		
4	0.40	0.63	1.00E-10	11.45	22.90	1.459744	6.63
5	0.40	0.77	1.00E-10	12.66	25.31		
6	0.40	0.70	7.00E-11	14.42	28.85	14.740321	66.93
7	0.40	0.70	1.30E-10	10.58	21.17		

E[FS] = 24.133673 | E[ln FS] = 3.165050 | Total 22.024406 | 100.00
Var[FS]= 22.024406
σ[FS]= 4.693017 | σ[ln FS]= 0.192658
V(FS) = 0.194459
FS req'd = 1.00 | ln(FS req'd) = 0.000000

β =	16.428361
F(z) =	0.000000
Pr(f) % =	0.000000

Crest-3ft | **Head =** 9.25 | **Horizontal Gradient (Ix) =** 0.470

Run	Tractive Stress (Tc)	Initial Porosity (n)	Intrinsic Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	0.40	0.70	1.00E-10	12.07	25.67		
2	0.36	0.70	1.00E-10	10.86	23.11	6.591605	26.44
3	0.44	0.70	1.00E-10	13.27	28.24		
4	0.40	0.63	1.00E-10	11.45	24.36	1.652042	6.63
5	0.40	0.77	1.00E-10	12.66	26.93		
6	0.40	0.70	7.00E-11	14.42	30.69	16.682119	66.93
7	0.40	0.70	1.30E-10	10.58	22.52		

E[FS] = 25.674120 | E[ln FS] = 3.226925 | Total 24.925765 | 100.00
Var[FS]= 24.925765
σ[FS]= 4.992571 | σ[ln FS]= 0.192658
V(FS) = 0.194459
FS req'd = 1.00 | ln(FS req'd) = 0.000000

β =	16.749528
F(z) =	0.000000
Pr(f) % =	0.000000

Half Height | **Head =** 6.13 | **Horizontal Gradient (Ix) =** 0.400

Run	Tractive Stress (Tc)	Initial Porosity (n)	Intrinsic Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	0.40	0.70	1.00E-10	12.07	30.17		
2	0.36	0.70	1.00E-10	10.86	27.15	9.100534	26.44
3	0.44	0.70	1.00E-10	13.27	33.18		
4	0.40	0.63	1.00E-10	11.45	28.62	2.280850	6.63
5	0.40	0.77	1.00E-10	12.66	31.64		
6	0.40	0.70	7.00E-11	14.42	36.06	23.031751	66.93
7	0.40	0.70	1.30E-10	10.58	26.46		

E[FS] = 30.167091 | E[ln FS] = 3.388193 | Total 34.413135 | 100.00
Var[FS]= 34.413135
σ[FS]= 5.866271 | σ[ln FS]= 0.192658
V(FS) = 0.194459
FS req'd = 1.00 | ln(FS req'd) = 0.000000

β =	17.586599
F(z) =	0.000000
Pr(f) % =	0.000000

Toe+3ft | **Head =** 3.00 | **Horizontal Gradient (Ix) =** 0.230

Run	Tractive Stress (Tc)	Initial Porosity (n)	Intrinsic Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	0.40	0.70	1.00E-10	12.07	52.46		
2	0.36	0.70	1.00E-10	10.86	47.22	27.525245	26.44
3	0.44	0.70	1.00E-10	13.27	57.71		
4	0.40	0.63	1.00E-10	11.45	49.77	6.898601	6.63
5	0.40	0.77	1.00E-10	12.66	55.03		
6	0.40	0.70	7.00E-11	14.42	62.71	69.661250	66.93
7	0.40	0.70	1.30E-10	10.58	46.01		

E[FS] = 52.464507 | E[ln FS] = 3.941578 | Total 104.085096 | 100.00
Var[FS]= 104.085096
σ[FS]= 10.202210 | σ[ln FS]= 0.192658
V(FS) = 0.194459
FS req'd = 1.00 | ln(FS req'd) = 0.000000

β =	20.458975
F(z) =	0.000000
Pr(f) % =	0.000000

Without Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Landside Long-Term Stability Analysis With UTEXAS4

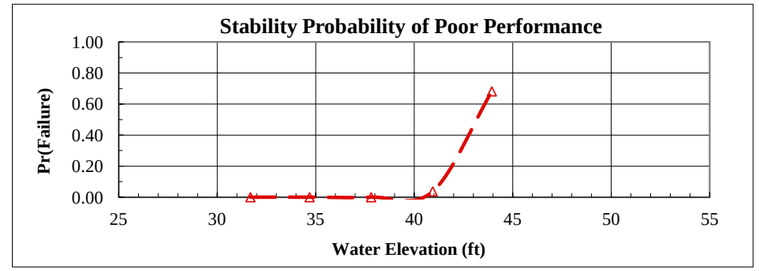
Project: American River Common Features GRR
Study Area: Arcade Creek North
River Section: ARN Reach E Unit 7

Levee Mile: 0.90
River Mile: 0.88
Analysis Case Without Project No Improvements

Crest Elev.: 43.94
L/S Toe Elev.: 31.69
W/S Toe Elev.: 26.77

Analysis By: M. Kynett
Checked By: H. Mulder
Date: 4/29/2011

Random Variables			
Parameter	**Expected Value**	**Standard Deviation**	**Coefficient of Variation, %**
Levee Φ	28	4	13.00
Levee Cohesion	50	20	40.00
Levee γ	115	8	7.00
Foundation Φ	28	4	13.00
Foundation Cohesion	50	20	40.00



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	31.69	0.0000
Toe+3ft	3.00	34.69	0.000000
Half Height	6.13	37.82	0.000000
Crest-3ft	9.25	40.94	0.037401
Crest	12.25	43.94	0.681442

Crest	Head =	12.25	Pr(f)=0	NO

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	28	50	115	28	50	0.92		
2	24	50	115	28	50	0.73	0.018225	37.73
3	32	50	115	28	50	1.00		
4	28	30	115	28	50	0.85	0.000025	0.05
5	28	70	115	28	50	0.86		
6	28	50	107	28	50	0.75	0.011025	22.83
7	28	50	123	28	50	0.96		
8	28	50	115	24	50	0.76	0.009025	18.69
9	28	50	115	32	50	0.95		
10	28	50	115	28	30	0.75	0.010000	20.70
11	28	50	115	28	70	0.95		

E[FS] = 0.920000 E[ln FS] = -0.111130 Total 0.048300 100.00
Var[FS]= 0.048300
σ[FS]= 0.219773 σ[ln FS]= 0.235577
V(FS) = 0.238883
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	-0.471735
F(z) =	0.681442
Pr(f) % =	68.144204

Crest-3ft	Head =	9.25	Pr(f)=0	NO

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	28	50	115	28	50	1.18		
2	24	50	115	28	50	1.08	0.005625	49.02
3	32	50	115	28	50	1.23		
4	28	30	115	28	50	1.12	0.002025	17.65
5	28	70	115	28	50	1.21		
6	28	50	107	28	50	1.12	0.000100	0.87
7	28	50	123	28	50	1.14		
8	28	50	115	24	50	1.11	0.002500	21.79
9	28	50	115	32	50	1.21		
10	28	50	115	28	30	1.15	0.001225	10.68
11	28	50	115	28	70	1.22		

E[FS] = 1.180000 E[ln FS] = 0.161411 Total 0.011475 100.00
Var[FS]= 0.011475
σ[FS]= 0.107121 σ[ln FS]= 0.090595
V(FS) = 0.090781
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	1.781680
F(z) =	0.037401
Pr(f) % =	3.740068

Half Height	Head =	6.13	Pr(f)=0	YES

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	28	50	115	28	50	1.40		
2	24	50	115	28	50			
3	32	50	115	28	50			
4	28	30	115	28	50			
5	28	70	115	28	50			
6	28	50	107	28	50			
7	28	50	123	28	50			
8	28	50	115	24	50			
9	28	50	115	32	50			
10	28	50	115	28	30			
11	28	50	115	28	70			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	
F(z) =	
Pr(f) % =	0.000000

Toe+3ft	Head =	3.00	Pr(f)=0	YES

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	28	50	115	28	50	1.52		
2	24	50	115	28	50			
3	32	50	115	28	50			
4	28	30	115	28	50			
5	28	70	115	28	50			
6	28	50	107	28	50			
7	28	50	123	28	50			
8	28	50	115	24	50			
9	28	50	115	32	50			
10	28	50	115	28	30			
11	28	50	115	28	70			

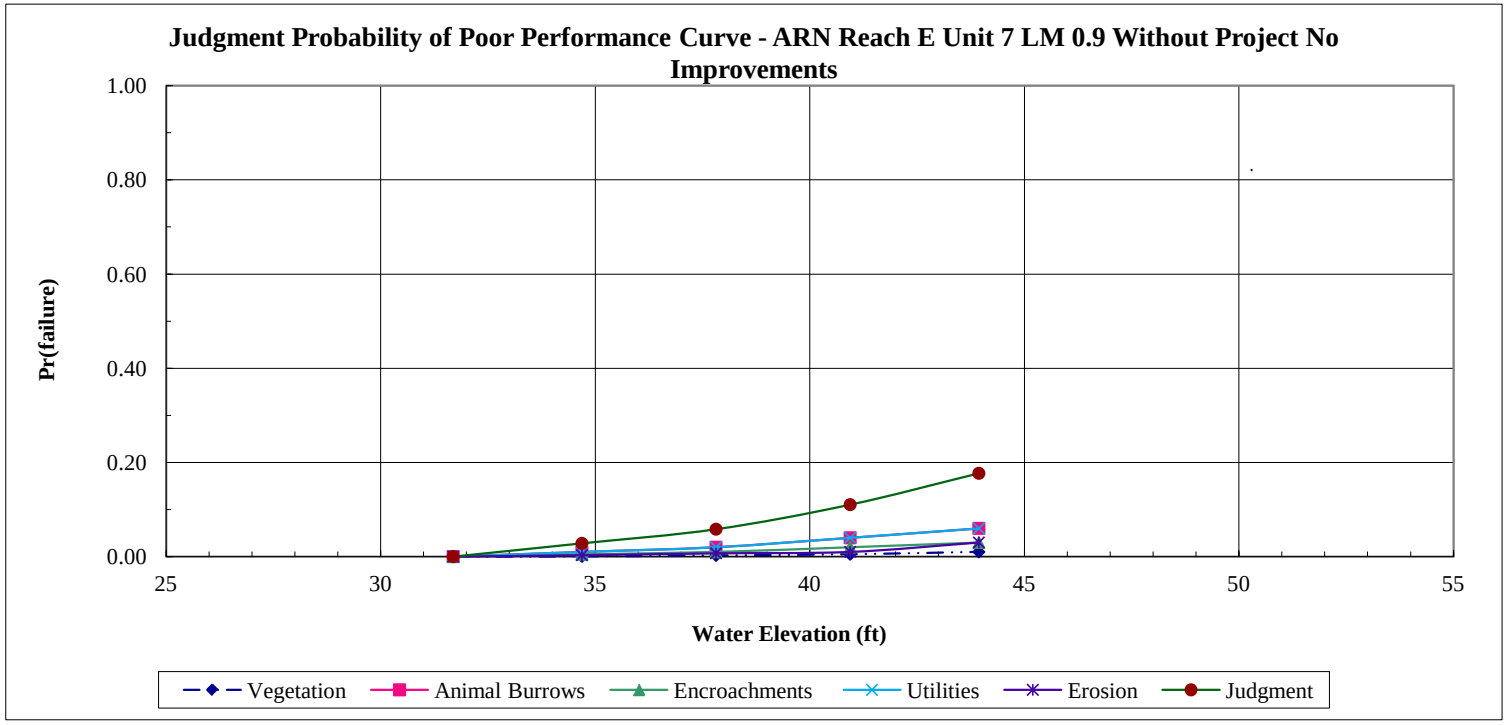
E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	
F(z) =	
Pr(f) % =	0.000000

Without Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Judgment Probability of Poor Performance Curve

Project:	American River Common Features GRR	**Levee Mile:**	0.90	**Crest Elev.:**	43.94	**Analysis By:**	M. Kynett
Study Area:	Arcade Creek North	**River Mile:**	0.88	**L/S Toe Elev.:**	31.69	**Checked By:**	H. Mulder
River Section:	ARN Reach E Unit 7	**Analysis Case:**	Without Project No Improver	**W/S Toe Elev.:**	26.77	**Date:**	4/29/2011

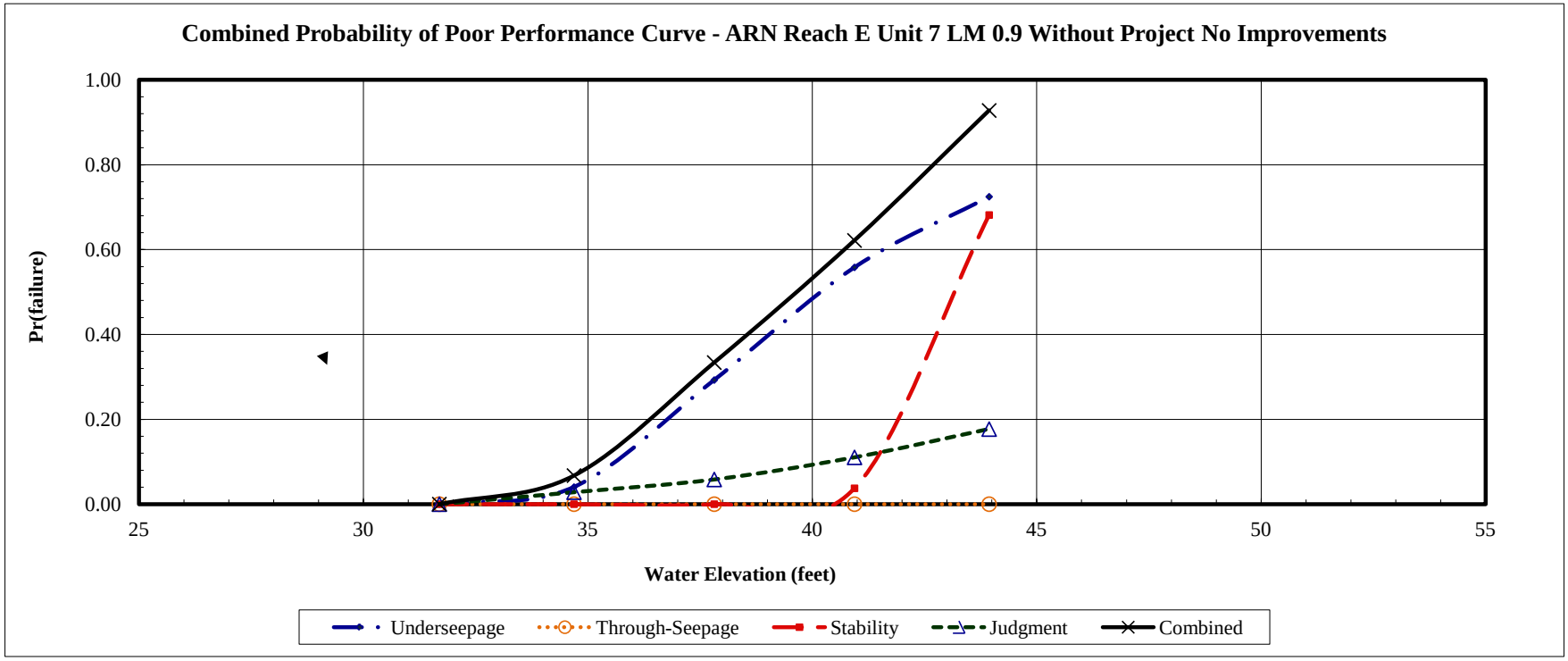
Water Surface Elevation	Vegetation		Animal Burrows		Encroachments		Utilities		Erosion		Judgment	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
31.69	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
34.69	0.0005	0.9995	0.0100	0.9900	0.0050	0.9950	0.0100	0.9900	0.0030	0.9970	0.0282	0.9718
37.82	0.0025	0.9975	0.0200	0.9800	0.0100	0.9900	0.0200	0.9800	0.0070	0.9930	0.0582	0.9418
40.94	0.0050	0.9950	0.0400	0.9600	0.0200	0.9800	0.0400	0.9600	0.0100	0.9900	0.1103	0.8897
43.94	0.0100	0.9900	0.0600	0.9400	0.0300	0.9700	0.0600	0.9400	0.0300	0.9700	0.1769	0.8231



Without Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

Project:	American River Common Features GRR	**Levee Mile:**	0.90	**Crest Elev.:**	43.94	**Analysis By:**	M. Kynett
Study Area:	Arcade Creek North	**River Mile:**	0.88	**L/S Toe Elev.:**	31.69	**Checked By:**	H. Mulder
River Section:	ARN Reach E Unit 7	**Analysis Case:**	Without Project No Improvements	**W/S Toe Elev.:**	26.77	**Date:**	4/29/2011

Water Surface	Underseepage		Through-Seepage		Stability		Judgment		Combined	
Elevation	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
31.69	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
34.69	0.0403	0.9597	0.0000	1.0000	0.0000	1.0000	0.0282	0.9718	0.0674	0.9326
37.82	0.2925	0.7075	0.0000	1.0000	0.0000	1.0000	0.0582	0.9418	0.3337	0.6663
40.94	0.5580	0.4420	0.0000	1.0000	0.0374	0.9626	0.1103	0.8897	0.6215	0.3785
43.94	0.7245	0.2755	0.0000	1.0000	0.6814	0.3186	0.1769	0.8231	0.9278	0.0722



With Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Determination of Random Variables For Underseepage Reliability Analysis

Project: American River Common Features GRR
Channel: Arcade Creek North
Basin and Reach: ARN Reach E Unit 7

Levee Mile: 0.90
River Mile: 0.88
Analysis Case With Project Cutoff Wall

Crest Elev.: 43.94
L/S Toe Elev.: 31.69
W/S Toe Elev.: 26.77

Analysis By: M. Kynett
Checked By: H. Mulder
Date: 4/29/2011

Boring #	Blanket Thickness Variable (z)					Aquifer Thickness Variable (d)					Hydraulic Conductivity Vairables (Kb and Kf)								
	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Blanket Material	Blanket Kb (ft/day)	Aquifer Material Material	Aquifer Material Kf (ft/day)	Kf/Kb	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation
WRARFC_024S	5					27.5					CL	0.28	SM/ML	1.54	6				
WRARFC_003B	9					15.45					CL	0.028	SP	28	1000				
K94a_BA4	4					33.5					CL	0.28	ML/SM/SP	3.05	11				
		6	3	10	50		25	9	170	36						339	573	99649	98

Boring #	Blanket Material 1 (lowest permeability)			Blanket Material 2			Transformed Blanket Thickness (z)	Aquifer Material 1			Aquifer Material 2			Aquifer Material 3			Transformed Aquifer Horizontal Permeability (kf)
	Material Type	Thickness (z)	Permeability (Kb)	Material Type	Thickness (z)	Permeability (Kb)		Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	
WRARFC_024S	CL	5	0.28				5	SM	12	2.8	ML	15.5	0.57				1.54
WRARFC_003B	CL	9	0.028				9	SP	15.45	28							28
K94a_BA4	CL	4	0.28				4	ML	7.5	0.57	SM	25	2.8	SP	1	28	3.05

With Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Underseepage Reliability Analysis With Blanket Theory Analysis

Project: American River Common Features GRR
Study Area: Arcade Creek North
River Section: ARN Reach E Unit 7

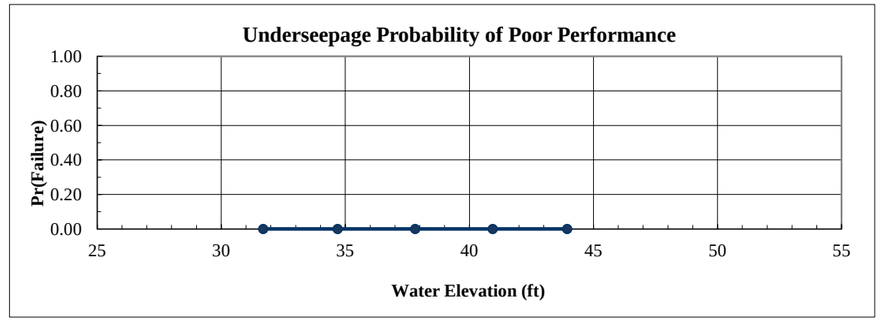
Levee Mile: 0.90
River Mile: 0.88
Analysis Case With Project Cutoff Wall

Crest Elev.: 43.94
L/S Toe Elev.: 31.69
W/S Toe Elev.: 26.77

Analysis By: M. Kynett
Checked By: H. Mulder
Date: 4/29/2011

Random Variables			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Permaebility Ratio	339	332	98
Blanket Thickness (z)	6	3	50
Aquifer Thickness (d)	25	9	36

Blanket Theory Analysis Inputs					
Pr(f)=0	BTA Case No.	L1	L2	L3	γ Blanket
YES	7A	10	100	∞	112



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	31.69	0.0000
Toe+3ft	3.00	34.69	0.0000
Half Height	6.13	37.82	0.0000
Crest-3ft	9.25	40.94	0.0000
Crest	12.25	43.94	0.0000

Crest	Rh
Head = 12.25	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	339	6.00	25.00	9.99	225.50	0.0745	8.23			
2	671	6.00	25.00	10.00	317.31	0.0585	9.10			
3	7	6.00	25.00	9.68	31.89	0.1766	2.76			
4	339	9.00	25.00	10.00	276.18	0.0647	8.76			
5	339	3.00	25.00	9.99	159.45	0.0928	7.25			
6	339	6.00	34.00	10.00	262.98	0.0912	8.64			
7	339	6.00	16.00	9.99	180.40	0.0551	7.61			
								Total		

E[I] =
Var[I]=
σ[I]=
V(I) =

E[ln I] =
σ [ln I] =

Ic= 0.80

ln(I crit) = -0.223144

β =
F(z) =
Pr(f) % = 0.000000

Crest-3ft	Rh
Head = 9.25	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	339	6.00	25.00	9.99	225.50	0.0745	6.22			
2	671	6.00	25.00	10.00	317.31	0.0585	6.87			
3	7	6.00	25.00	9.68	31.89	0.1766	2.08			
4	339	9.00	25.00	10.00	276.18	0.0647	6.62			
5	339	3.00	25.00	9.99	159.45	0.0928	5.47			
6	339	6.00	34.00	10.00	262.98	0.0912	6.52			
7	339	6.00	16.00	9.99	180.40	0.0551	5.75			
								Total		

E[I] =
Var[I]=
σ[I]=
V(I) =

E[ln I] =
σ [ln I] =

Ic= 0.80

ln(I crit) = -0.223144

β =
F(z) =
Pr(f) % = 0.000000

Half Height	Rh
Head = 6.13	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	339	6.00	25.00	9.99	225.50	0.0745	4.12			
2	671	6.00	25.00	10.00	317.31	0.0585	4.55			
3	7	6.00	25.00	9.68	31.89	0.1766	1.38			
4	339	9.00	25.00	10.00	276.18	0.0647	4.38			
5	339	3.00	25.00	9.99	159.45	0.0928	3.62			
6	339	6.00	34.00	10.00	262.98	0.0912	4.32			
7	339	6.00	16.00	9.99	180.40	0.0551	3.81			
								Total		

E[I] =
Var[I]=
σ[I]=
V(I) =

E[ln I] =
σ [ln I] =

Ic= 0.80

ln(I crit) = -0.223144

β =
F(z) =
Pr(f) % = 0.000000

Toe+3ft	Rh
Head = 3.00	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	339	6.00	25.00	9.99	225.50	0.0745	2.02			
2	671	6.00	25.00	10.00	317.31	0.0585	2.23			
3	7	6.00	25.00	9.68	31.89	0.1766	0.68			
4	339	9.00	25.00	10.00	276.18	0.0647	2.15			
5	339	3.00	25.00	9.99	159.45	0.0928	1.78			
6	339	6.00	34.00	10.00	262.98	0.0912	2.12			
7	339	6.00	16.00	9.99	180.40	0.0551	1.86			
								Total		

E[I] =
Var[I]=
σ[I]=
V(I) =

E[ln I] =
σ [ln I] =

Ic= 0.80

ln(I crit) = -0.223144

β =
F(z) =
Pr(f) % = 0.000000

With Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Through-Seepage Reliability Analysis With Khilar's Extended Model

Project: American River Common Features GRR
Study Area: Arcade Creek North
River Section: ARN Reach E Unit 7

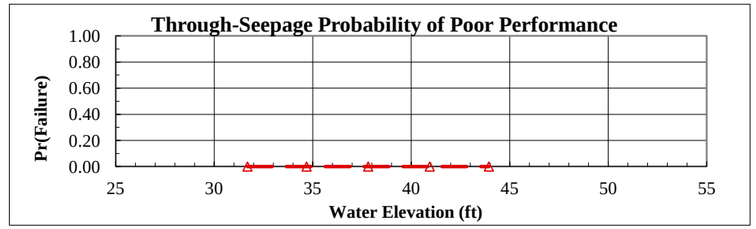
Levee Mile: 0.90
River Mile: 0.88
Analysis Case With Project Cutoff Wall

Crest Elev.: 43.94
L/S Toe Elev.: 31.69
W/S Toe Elev.: 26.77

Analysis By: M. Kynett
Checked By: H. Mulder
Date: 4/29/2011

Random Variables - Clay (CL) and Clayey Sand (SC) Levee			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Tractive Stress (Tc)	0.4	0.0	10.00
Initial Porosity (n)	0.7	0.07	10.00
Intrinsic Permeability (Ko)	1.00E-10	3.00E-11	30.00

Pr(f)=0
YES



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	31.69	0.0000
Toe+3ft	3.00	34.69	0.000000
Half Height	6.13	37.82	0.000000
Crest-3ft	9.25	40.94	0.000000
Crest	12.25	43.94	0.000000

Crest | **Head =** 12.25 | **Horizontal Gradient (Ix) =** 0.500

Run	Tractive Stress (Tc)	Initial Porosity (n)	Intrinsic Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	0.40	0.70	1.00E-10	12.07			
2	0.36	0.70	1.00E-10	10.86			
3	0.44	0.70	1.00E-10	13.27			
4	0.40	0.63	1.00E-10	11.45			
5	0.40	0.77	1.00E-10	12.66			
6	0.40	0.70	7.00E-11	14.42			
7	0.40	0.70	1.30E-10	10.58			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

Crest-3ft | **Head =** 9.25 | **Horizontal Gradient (Ix) =** 0.470

Run	Tractive Stress (Tc)	Initial Porosity (n)	Intrinsic Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	0.40	0.70	1.00E-10	12.07			
2	0.36	0.70	1.00E-10	10.86			
3	0.44	0.70	1.00E-10	13.27			
4	0.40	0.63	1.00E-10	11.45			
5	0.40	0.77	1.00E-10	12.66			
6	0.40	0.70	7.00E-11	14.42			
7	0.40	0.70	1.30E-10	10.58			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

Half Height | **Head =** 6.13 | **Horizontal Gradient (Ix) =** 0.400

Run	Tractive Stress (Tc)	Initial Porosity (n)	Intrinsic Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	0.40	0.70	1.00E-10	12.07			
2	0.36	0.70	1.00E-10	10.86			
3	0.44	0.70	1.00E-10	13.27			
4	0.40	0.63	1.00E-10	11.45			
5	0.40	0.77	1.00E-10	12.66			
6	0.40	0.70	7.00E-11	14.42			
7	0.40	0.70	1.30E-10	10.58			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

Toe+3ft | **Head =** 3.00 | **Horizontal Gradient (Ix) =** 0.230

Run	Tractive Stress (Tc)	Initial Porosity (n)	Intrinsic Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	0.40	0.70	1.00E-10	12.07			
2	0.36	0.70	1.00E-10	10.86			
3	0.44	0.70	1.00E-10	13.27			
4	0.40	0.63	1.00E-10	11.45			
5	0.40	0.77	1.00E-10	12.66			
6	0.40	0.70	7.00E-11	14.42			
7	0.40	0.70	1.30E-10	10.58			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

With Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Landside Long-Term Stability Analysis With UTEXAS4

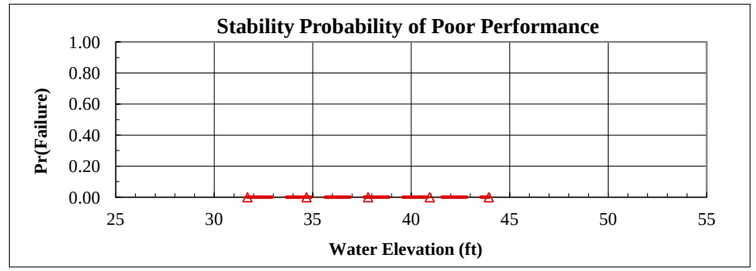
Project: American River Common Features GRR
Study Area: Arcade Creek North
River Section: ARN Reach E Unit 7

Levee Mile: 0.90
River Mile: 0.88
Analysis Case With Project Cutoff Wall

Crest Elev.: 43.94
L/S Toe Elev.: 31.69
W/S Toe Elev.: 26.77

Analysis By: M. Kynett
Checked By: H. Mulder
Date: 4/29/2011

Random Variables			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Levee Φ	24	3	13.00
Levee Cohesion	50	20	40.00
Levee γ	115	8	7.00
Foundation Φ	28	4	13.00
Foundation Cohesion	50	20	40.00



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	31.69	0.0000
Toe+3ft	3.00	34.69	0.000000
Half Height	6.13	37.82	0.000000
Crest-3ft	9.25	40.94	0.000000
Crest	12.25	43.94	0.000000

Crest	Head =	12.25	Pr(f)=0	YES

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	24	50	115	28	50	1.37		
2	21	50	115	28	50			
3	27	50	115	28	50			
4	24	30	115	28	50			
5	24	70	115	28	50			
6	24	50	107	28	50			
7	24	50	123	28	50			
8	24	50	115	24	50			
9	24	50	115	32	50			
10	24	50	115	28	30			
11	24	50	115	28	70			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	
F(z) =	
Pr(f) % =	0.000000

Crest-3ft	Head =	9.25	Pr(f)=0	YES

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	24	50	115	28	50	1.51		
2	21	50	115	28	50			
3	27	50	115	28	50			
4	24	30	115	28	50			
5	24	70	115	28	50			
6	24	50	107	28	50			
7	24	50	123	28	50			
8	24	50	115	24	50			
9	24	50	115	32	50			
10	24	50	115	28	30			
11	24	50	115	28	70			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	
F(z) =	
Pr(f) % =	0.000000

Half Height	Head =	6.13	Pr(f)=0	YES

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	24	50	115	28	50	1.54		
2	21	50	115	28	50			
3	27	50	115	28	50			
4	24	30	115	28	50			
5	24	70	115	28	50			
6	24	50	107	28	50			
7	24	50	123	28	50			
8	24	50	115	24	50			
9	24	50	115	32	50			
10	24	50	115	28	30			
11	24	50	115	28	70			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	
F(z) =	
Pr(f) % =	0.000000

Toe+3ft	Head =	3.00	Pr(f)=0	YES

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	24	50	115	28	50	1.61		
2	21	50	115	28	50			
3	27	50	115	28	50			
4	24	30	115	28	50			
5	24	70	115	28	50			
6	24	50	107	28	50			
7	24	50	123	28	50			
8	24	50	115	24	50			
9	24	50	115	32	50			
10	24	50	115	28	30			
11	24	50	115	28	70			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	
F(z) =	
Pr(f) % =	0.000000

With Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Judgment Probability of Poor Performance Curve

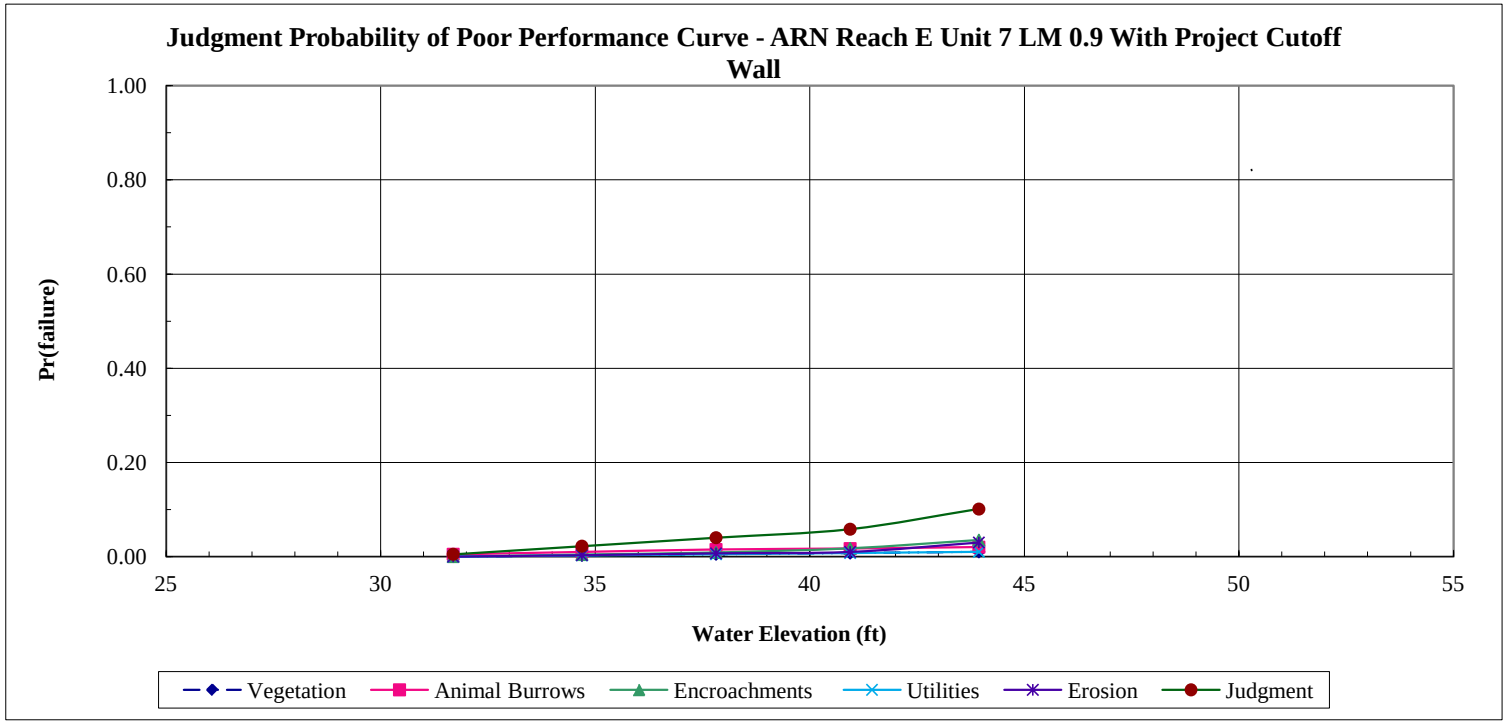
Project: American River Common Features GRR
Study Area: Arcade Creek North
River Section: ARN Reach E Unit 7

Levee Mile: 0.90
River Mile: 0.88
Analysis Case: With Project Cutoff Wall

Crest Elev.: 43.94
L/S Toe Elev.: 31.69
W/S Toe Elev.: 26.77

Analysis By: M. Kynett
Checked By: H. Mulder
Date: 4/29/2011

Water Surface Elevation	Vegetation		Animal Burrows		Encroachments		Utilities		Erosion		Judgment	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
31.69	0.0000	1.0000	0.0050	0.9950	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0050	0.9950
34.69	0.0025	0.9975	0.0100	0.9900	0.0044	0.9956	0.0025	0.9975	0.0030	0.9970	0.0222	0.9778
37.82	0.0050	0.9950	0.0150	0.9850	0.0088	0.9913	0.0050	0.9950	0.0070	0.9930	0.0401	0.9599
40.94	0.0075	0.9925	0.0170	0.9830	0.0175	0.9825	0.0075	0.9925	0.0100	0.9900	0.0581	0.9419
43.94	0.0100	0.9900	0.0200	0.9800	0.0350	0.9650	0.0100	0.9900	0.0300	0.9700	0.1009	0.8991



With Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

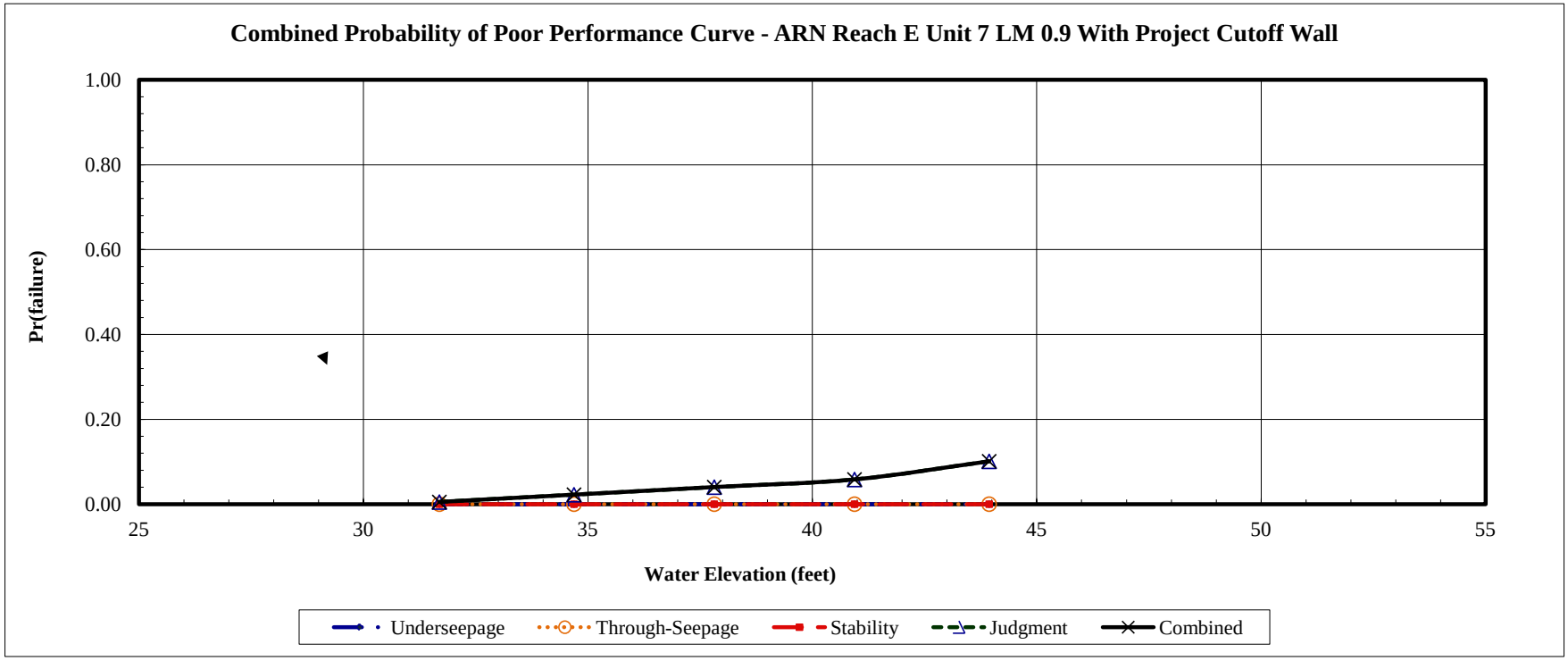
Project: American River Common Features GRR
Study Area: Arcade Creek North
River Section: ARN Reach E Unit 7

Levee Mile: 0.90
River Mile: 0.88
Analysis Case: With Project Cutoff Wall

Crest Elev.: 43.94
L/S Toe Elev.: 31.69
W/S Toe Elev.: 26.77

Analysis By: M. Kynett
Checked By: H. Mulder
Date: 4/29/2011

Water Surface	Underseepage		Through-Seepage		Stability		Judgment		Combined	
Elevation	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
31.69	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0050	0.9950	0.0050	0.9950
34.69	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0222	0.9778	0.0222	0.9778
37.82	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0401	0.9599	0.0401	0.9599
40.94	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0581	0.9419	0.0581	0.9419
43.94	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.1009	0.8991	0.1009	0.8991



Without Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Determination of Random Variables For Underseepage Reliability Analysis

Project: American River Common Features GRR
Channel: American River
Basin and Reach: ARS Reach B Unit 4

Levee Mile: 3.90
River Mile: 3.94
Analysis Case Without Project Cutoff Wall

Crest Elev.: 48.83
L/S Toe Elev.: 32.79
W/S Toe Elev.: 28.64

Analysis By: M. Kynett
Checked By: H. Mulder
Date: 4/29/2011

Boring #	Blanket Thickness Variable (z)					Aquifer Thickness Variable (d)					Hydraulic Conductivity Vairables (Kb and Kf)								
	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Blanket Material	Blanket Kb (ft/day)	Aquifer Material Material	Aquifer Material Kf (ft/day)	Kf/Kb	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation
WCSBAR-003B	9.5					45.5					ML	0.14	SM/SP-SM/GW	19.58	140				
2F-00-9W	7.96					30					ML/SM	0.14	SM/SP-SM/GW	16.89	121				
2F-97-23	9					31.2					CL/ML/SM	0.028	SM/SP-SM/GW	20.08	717				
2F-00-114	10.5					53					CL/SC/ML	0.035	SM/SP-SM/GW	20.84	595				
2F-99-17	20	12	4	44	33	34	40	9	427	23	SM	0.709	SW-SM/GW	25.18	36	661	1000	769160	98
2F-08-03	14.5					43					ML	0.14	SP/GP	23.77	170				
2F-07-03A	10.51					45					CL/ML	0.00709	SP/GP	20.22	2852				

Boring #	Blanket Material 1 (lowest permeability)			Blanket Material 2			Transformed Blanket Thickness (z)	Aquifer Material 1			Aquifer Material 2			Aquifer Material 3			Transformed Aquifer Horizontal Permeability (kf)
	Material Type	Thickness (z)	Permeability (Kb)	Material Type	Thickness (z)	Permeability (Kb)		Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	
WCSBAR-003B	ML	9.5	0.14				9.5	SM	17.5	2.8	SP-SM	5.5	14	GW	22.5	34	19.58
2F-00-9W	ML	4.5	0.14	SM	17.5	0.709	7.96	SM	11	2.8	SP-SM	8.5	14	GW	10.5	34	16.89
2F-97-23	CL	7	0.028	ML/SM	10	0.14	9	SM	9.85	2.8	SP-SM	6.35	14	GW	15	34	20.08
2F-00-114	CL/SC	9	0.035	ML	6	0.14	10.5	SM	10.5	2.8	SP-SM	18.5	14	GW	24	34	20.84
2F-99-17	SM	20	0.709				20	SW-SM	15	14	GW	19	34				25.18
2F-08-03	ML	14.5	0.14				14.5	SP	22	14	GP	21	34				23.77
2F-07-03A	CL	10	0.00709	ML	10	0.14	10.51	SP	31	14	GP	14	34				20.22

Without Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Underseepage Reliability Analysis With Blanket Theory Analysis

Project: American River Common Features GRR
Study Area: American River
River Section: ARS Reach B Unit 4

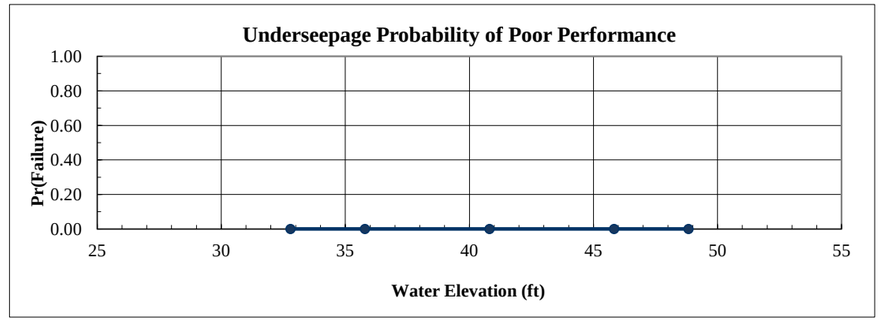
Levee Mile: 3.90
River Mile: 3.94
Analysis Case Without Project Cutoff Wall

Crest Elev.: 48.83
L/S Toe Elev.: 32.79
W/S Toe Elev.: 28.64

Analysis By: M. Kynett
Checked By: H. Mulder
Date: 4/29/2011

Random Variables			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Permaebility Ratio	661	648	98
Blanket Thickness (z)	12	4	33
Aquifer Thickness (d)	40	9	23

Blanket Theory Analysis Inputs					
Pr(f)=0	BTA Case No.	L1	L2	L3	γ Blanket
YES	7A	0	125	∞	112



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	32.79	0.0000
Toe+3ft	3.00	35.79	0.0000
Half Height	8.02	40.81	0.0000
Crest-3ft	13.04	45.83	0.0000
Crest	16.04	48.83	0.0000

Crest	Rh
Head = 16.04	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	661	12.00	40.00	0.00	563.28	0.0581	13.13			
2	1309	12.00	40.00	0.00	792.60	0.0436	13.85			
3	13	12.00	40.00	0.00	79.66	0.1954	6.24			
4	661	16.00	40.00	0.00	650.42	0.0516	13.45			
5	661	8.00	40.00	0.00	459.91	0.0684	12.61			
6	661	12.00	49.00	0.00	623.43	0.0655	13.36			
7	661	12.00	31.00	0.00	495.87	0.0499	12.81			
								Total		

E[I] =
Var[I]=
σ[I]=
V(I) =

E[ln I] =
σ [ln I] =

Ic= 0.80

ln(I crit) = -0.223144

β =
F(z) =
Pr(f) % = 0.000000

Crest-3ft	Rh
Head = 13.04	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	661	12.00	40.00	0.00	563.28	0.0581	10.67			
2	1309	12.00	40.00	0.00	792.60	0.0436	11.26			
3	13	12.00	40.00	0.00	79.66	0.1954	5.08			
4	661	16.00	40.00	0.00	650.42	0.0516	10.94			
5	661	8.00	40.00	0.00	459.91	0.0684	10.25			
6	661	12.00	49.00	0.00	623.43	0.0655	10.86			
7	661	12.00	31.00	0.00	495.87	0.0499	10.41			
								Total		

E[I] =
Var[I]=
σ[I]=
V(I) =

E[ln I] =
σ [ln I] =

Ic= 0.80

ln(I crit) = -0.223144

β =
F(z) =
Pr(f) % = 0.000000

Half Height	Rh
Head = 8.02	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	661	12.00	40.00	0.00	563.28	0.0581	6.56			
2	1309	12.00	40.00	0.00	792.60	0.0436	6.93			
3	13	12.00	40.00	0.00	79.66	0.1954	3.12			
4	661	16.00	40.00	0.00	650.42	0.0516	6.73			
5	661	8.00	40.00	0.00	459.91	0.0684	6.31			
6	661	12.00	49.00	0.00	623.43	0.0655	6.68			
7	661	12.00	31.00	0.00	495.87	0.0499	6.41			
								Total		

E[I] =
Var[I]=
σ[I]=
V(I) =

E[ln I] =
σ [ln I] =

Ic= 0.80

ln(I crit) = -0.223144

β =
F(z) =
Pr(f) % = 0.000000

Toe+3ft	Rh
Head = 3.00	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	661	12.00	40.00	0.00	563.28	0.0581	2.46			
2	1309	12.00	40.00	0.00	792.60	0.0436	2.59			
3	13	12.00	40.00	0.00	79.66	0.1954	1.17			
4	661	16.00	40.00	0.00	650.42	0.0516	2.52			
5	661	8.00	40.00	0.00	459.91	0.0684	2.36			
6	661	12.00	49.00	0.00	623.43	0.0655	2.50			
7	661	12.00	31.00	0.00	495.87	0.0499	2.40			
								Total		

E[I] =
Var[I]=
σ[I]=
V(I) =

E[ln I] =
σ [ln I] =

Ic= 0.80

ln(I crit) = -0.223144

β =
F(z) =
Pr(f) % = 0.000000

Without Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Through-Seepage Reliability Analysis With Khilar's Extended Model

Project: American River Common Features GRR
Study Area: American River
River Section: ARS Reach B Unit 4

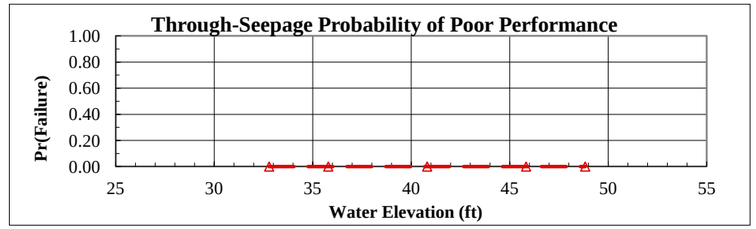
Levee Mile: 3.90
River Mile: 3.94
Analysis Case Without Project Cutoff Wall

Crest Elev.: 48.83
L/S Toe Elev.: 32.79
W/S Toe Elev.: 28.64

Analysis By: M. Kynett
Checked By: H. Mulder
Date: 4/29/2011

Random Variables - Silty Sand (SM) and Sand (SP) Levee			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Tractive Stress (Tc)	1.2	0.1	10.00
Initial Porosity (n)	0.25	0.03	10.00
Intrinsic Permeability (Ko)	1.50E-07	4.50E-08	30.00

Pr(f)=0
NO



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	32.79	0.0000
Toe+3ft	3.00	35.79	0.000000
Half Height	8.02	40.81	0.000000
Crest-3ft	13.04	45.83	0.000000
Crest	16.04	48.83	0.000000

Crest | **Head =** 16.04 | **Horizontal Gradient (Ix) =** 0.120

Run	Tractive Stress (Tc)	Initial Porosity (n)	Intrinsic Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	1.20	0.25	1.50E-07	0.56	4.65		
2	1.08	0.25	1.50E-07	0.50	4.19	0.216679	26.44
3	1.32	0.25	1.50E-07	0.61	5.12		
4	1.20	0.23	1.50E-07	0.53	4.42	0.054306	6.63
5	1.20	0.28	1.50E-07	0.59	4.88		
6	1.20	0.25	1.05E-07	0.67	5.56	0.548375	66.93
7	1.20	0.25	1.95E-07	0.49	4.08		

E[FS] = 4.654883 E[ln FS] = 1.519358 Total 0.819360 100.00
Var[FS]= 0.819360
σ[FS]= 0.905185 σ[ln FS]= 0.192658
V(FS) = 0.194459
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	7.886311
F(z) =	0.000000
Pr(f) % =	0.000000

Crest-3ft | **Head =** 13.04 | **Horizontal Gradient (Ix) =** 0.090

Run	Tractive Stress (Tc)	Initial Porosity (n)	Intrinsic Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	1.20	0.25	1.50E-07	0.56	6.21		
2	1.08	0.25	1.50E-07	0.50	5.59	0.385208	26.44
3	1.32	0.25	1.50E-07	0.61	6.83		
4	1.20	0.23	1.50E-07	0.53	5.89	0.096544	6.63
5	1.20	0.28	1.50E-07	0.59	6.51		
6	1.20	0.25	1.05E-07	0.67	7.42	0.974889	66.93
7	1.20	0.25	1.95E-07	0.49	5.44		

E[FS] = 6.206511 E[ln FS] = 1.807040 Total 1.456641 100.00
Var[FS]= 1.456641
σ[FS]= 1.206914 σ[ln FS]= 0.192658
V(FS) = 0.194459
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	9.379541
F(z) =	0.000000
Pr(f) % =	0.000000

Half Height | **Head =** 8.02 | **Horizontal Gradient (Ix) =** 0.040

Run	Tractive Stress (Tc)	Initial Porosity (n)	Intrinsic Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	1.20	0.25	1.50E-07	0.56	13.96		
2	1.08	0.25	1.50E-07	0.50	12.57	1.950114	26.44
3	1.32	0.25	1.50E-07	0.61	15.36		
4	1.20	0.23	1.50E-07	0.53	13.25	0.488754	6.63
5	1.20	0.28	1.50E-07	0.59	14.65		
6	1.20	0.25	1.05E-07	0.67	16.69	4.935375	66.93
7	1.20	0.25	1.95E-07	0.49	12.25		

E[FS] = 13.964650 E[ln FS] = 2.617971 Total 7.374243 100.00
Var[FS]= 7.374243
σ[FS]= 2.715556 σ[ln FS]= 0.192658
V(FS) = 0.194459
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	13.588718
F(z) =	0.000000
Pr(f) % =	0.000000

Toe+3ft | **Head =** 3.00 | **Horizontal Gradient (Ix) =** 0.010

Run	Tractive Stress (Tc)	Initial Porosity (n)	Intrinsic Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	1.20	0.25	1.50E-07	0.56	55.86		
2	1.08	0.25	1.50E-07	0.50	50.27	31.201831	26.44
3	1.32	0.25	1.50E-07	0.61	61.44		
4	1.20	0.23	1.50E-07	0.53	52.99	7.820057	6.63
5	1.20	0.28	1.50E-07	0.59	58.58		
6	1.20	0.25	1.05E-07	0.67	66.76	78.966003	66.93
7	1.20	0.25	1.95E-07	0.49	48.99		

E[FS] = 55.858599 E[ln FS] = 4.004265 Total 117.987891 100.00
Var[FS]= 117.987891
σ[FS]= 10.862223 σ[ln FS]= 0.192658
V(FS) = 0.194459
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	20.784354
F(z) =	0.000000
Pr(f) % =	0.000000

Without Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Landside Long-Term Stability Analysis With UTEXAS4

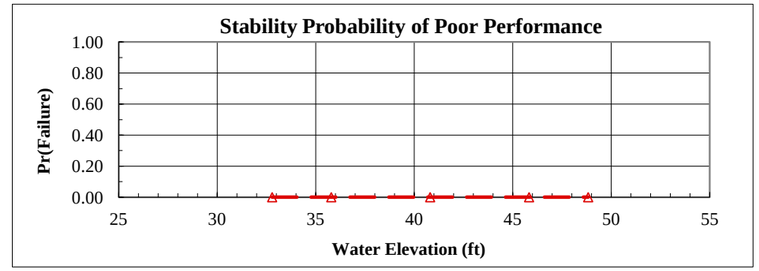
Project: American River Common Features GRR
Study Area: American River
River Section: ARS Reach B Unit 4

Levee Mile: 3.90
River Mile: 3.94
Analysis Case Without Project Cutoff Wall

Crest Elev.: 48.83
L/S Toe Elev.: 32.79
W/S Toe Elev.: 28.64

Analysis By: M. Kynett
Checked By: H. Mulder
Date: 4/29/2011

Random Variables			
Parameter	**Expected Value**	**Standard Deviation**	**Coefficient of Variation, %**
Levee Φ	33	4	13.00
Levee Cohesion	0	0	40.00
Levee γ	125	9	7.00
Foundation Φ	30	4	13.00
Foundation Cohesion	0	0	40.00



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	32.79	0.0000
Toe+3ft	3.00	35.79	0.000000
Half Height	8.02	40.81	0.000000
Crest-3ft	13.04	45.83	0.000000
Crest	16.04	48.83	0.000000

Crest	Head =	16.04	Pr(f)=0	YES

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	33	0	125	30	0	1.58		
2	29	0	125	30	0			
3	37	0	125	30	0			
4	33	0	125	30	0			
5	33	0	125	30	0			
6	33	0	116	30	0			
7	33	0	134	30	0			
8	33	0	125	26	0			
9	33	0	125	34	0			
10	33	0	125	30	0			
11	33	0	125	30	0			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	
F(z) =	
Pr(f) % =	0.000000

Crest-3ft	Head =	13.04	Pr(f)=0	YES

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	33	0	125	30	0	1.59		
2	29	0	125	30	0			
3	37	0	125	30	0			
4	33	0	125	30	0			
5	33	0	125	30	0			
6	33	0	116	30	0			
7	33	0	134	30	0			
8	33	0	125	26	0			
9	33	0	125	34	0			
10	33	0	125	30	0			
11	33	0	125	30	0			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	
F(z) =	
Pr(f) % =	0.000000

Half Height	Head =	8.02	Pr(f)=0	YES

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	33	0	125	30	0	1.61		
2	29	0	125	30	0			
3	37	0	125	30	0			
4	33	0	125	30	0			
5	33	0	125	30	0			
6	33	0	116	30	0			
7	33	0	134	30	0			
8	33	0	125	26	0			
9	33	0	125	34	0			
10	33	0	125	30	0			
11	33	0	125	30	0			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	
F(z) =	
Pr(f) % =	0.000000

Toe+3ft	Head =	3.00	Pr(f)=0	YES

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	33	0	125	30	0	1.67		
2	29	0	125	30	0			
3	37	0	125	30	0			
4	33	0	125	30	0			
5	33	0	125	30	0			
6	33	0	116	30	0			
7	33	0	134	30	0			
8	33	0	125	26	0			
9	33	0	125	34	0			
10	33	0	125	30	0			
11	33	0	125	30	0			

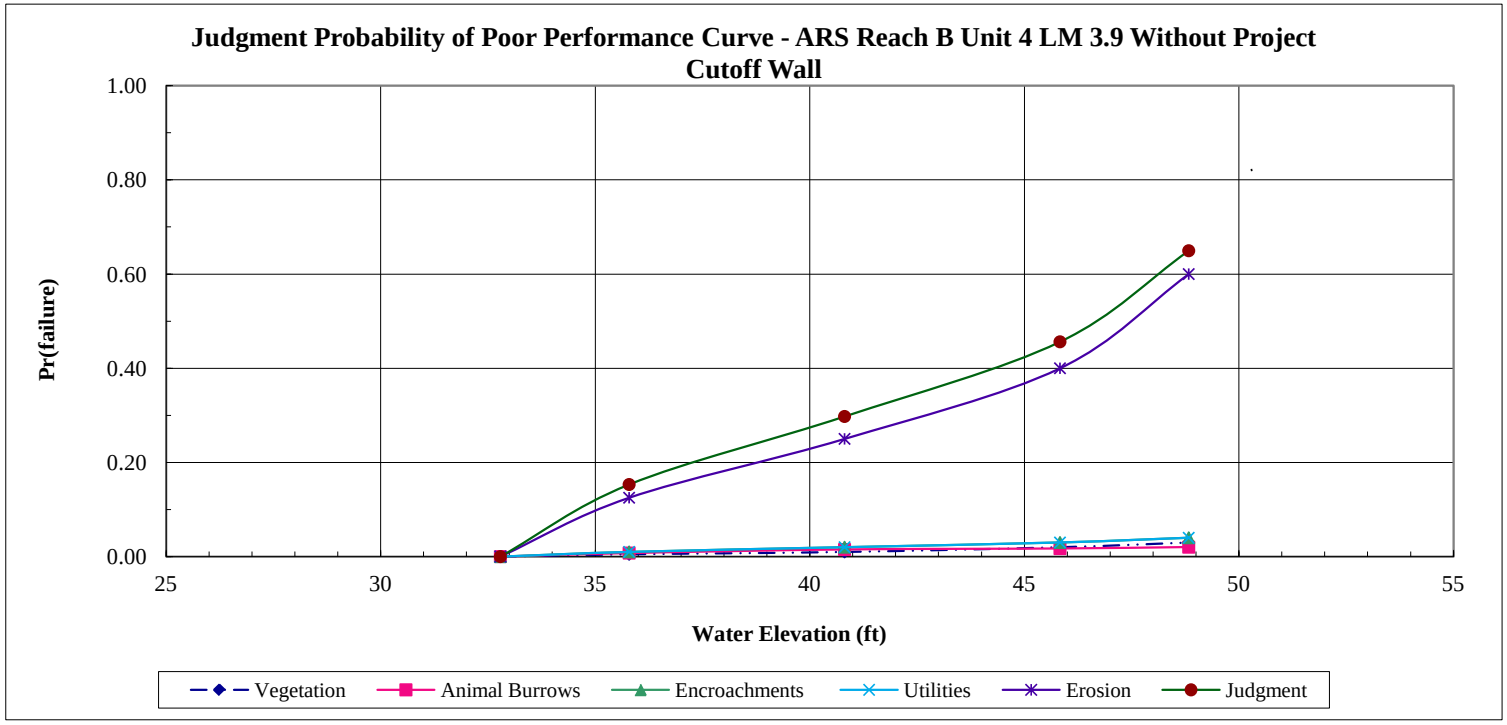
E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	
F(z) =	
Pr(f) % =	0.000000

Without Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Judgment Probability of Poor Performance Curve

Project:	American River Common Features GRR	**Levee Mile:**	3.90	**Crest Elev.:**	48.83	**Analysis By:**	M. Kynett
Study Area:	American River	**River Mile:**	3.94	**L/S Toe Elev.:**	32.79	**Checked By:**	H. Mulder
River Section:	ARS Reach B Unit 4	**Analysis Case:**	Without Project Cutoff Wall	**W/S Toe Elev.:**	28.64	**Date:**	4/29/2011

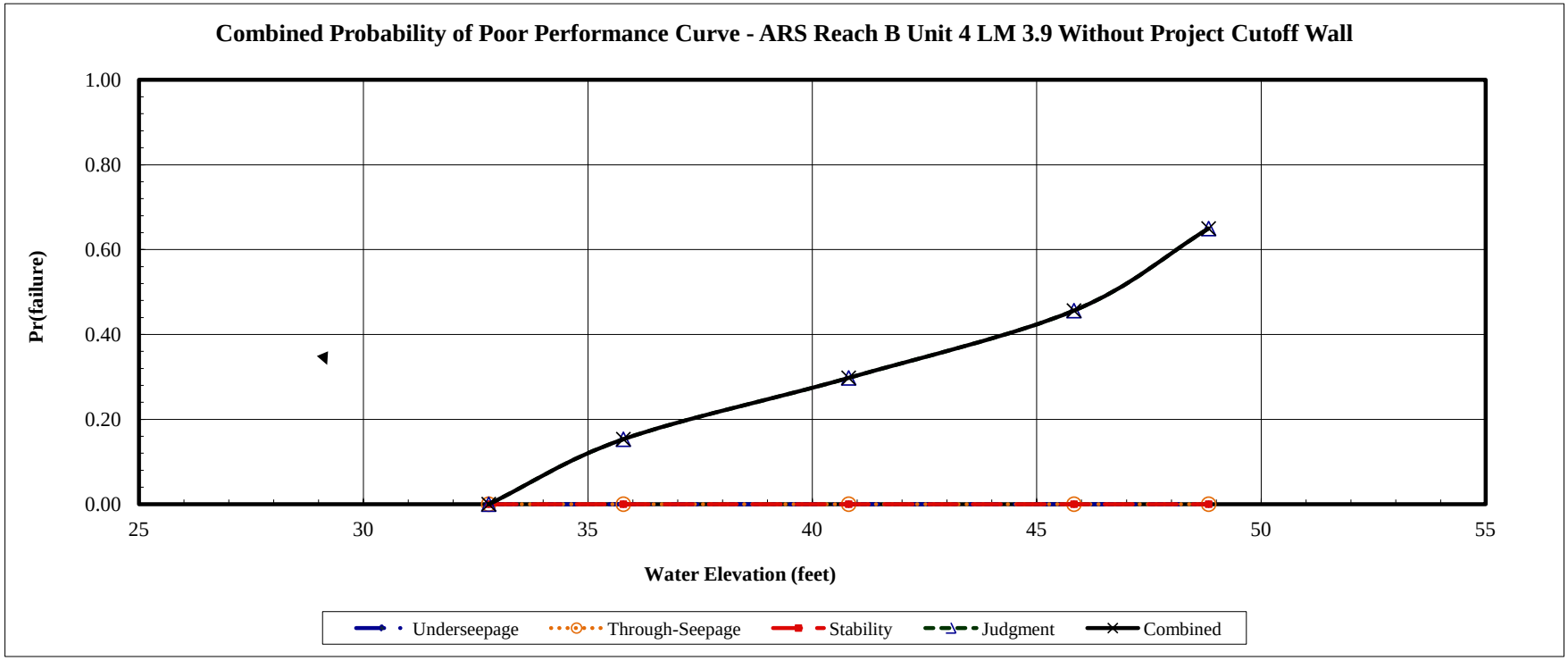
Water Surface Elevation	Vegetation		Animal Burrows		Encroachments		Utilities		Erosion		Judgment	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
32.79	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
35.79	0.0050	0.9950	0.0075	0.9925	0.0100	0.9900	0.0100	0.9900	0.1250	0.8750	0.1531	0.8469
40.81	0.0100	0.9900	0.0150	0.9850	0.0200	0.9800	0.0200	0.9800	0.2500	0.7500	0.2976	0.7024
45.83	0.0200	0.9800	0.0170	0.9830	0.0300	0.9700	0.0300	0.9700	0.4000	0.6000	0.4562	0.5438
48.83	0.0300	0.9700	0.0200	0.9800	0.0400	0.9600	0.0400	0.9600	0.6000	0.4000	0.6496	0.3504



Without Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

Project:	American River Common Features GRR	**Levee Mile:**	3.90	**Crest Elev.:**	48.83	**Analysis By:**	M. Kynett
Study Area:	American River	**River Mile:**	3.94	**L/S Toe Elev.:**	32.79	**Checked By:**	H. Mulder
River Section:	ARS Reach B Unit 4	**Analysis Case:**	Without Project Cutoff Wall	**W/S Toe Elev.:**	28.64	**Date:**	4/29/2011

Water Surface	Underseepage		Through-Seepage		Stability		Judgment		Combined	
Elevation	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
32.79	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
35.79	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.1531	0.8469	0.1531	0.8469
40.81	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.2976	0.7024	0.2976	0.7024
45.83	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.4562	0.5438	0.4562	0.5438
48.83	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.6496	0.3504	0.6496	0.3504



With Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Determination of Random Variables For Underseepage Reliability Analysis

Project: American River Common Features GRR
Channel: American River
Basin and Reach: ARS Reach B Unit 4

Levee Mile: 3.90
River Mile: 3.94
Analysis Case With Project Erosion Protection

Crest Elev.: 48.83
L/S Toe Elev.: 32.79
W/S Toe Elev.: 28.64

Analysis By: A. Deus
Checked By: H. Mulder
Date: 7/5/2012

Boring #	Blanket Thickness Variable (z)					Aquifer Thickness Variable (d)					Hydraulic Conductivity Vairables (Kb and Kf)								
	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Blanket Material	Blanket Kb (ft/day)	Aquifer Material Material	Aquifer Material Kf (ft/day)	Kf/Kb	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation
WCSBAR-003B	9.5					45.5					ML	0.14	SM/SP-SM/GW	19.58	140				
2F-00-9W	7.96					30					ML/SM	0.14	SM/SP-SM/GW	16.89	121				
2F-97-23	9					31.2					CL/ML/SM	0.028	SM/SP-SM/GW	20.08	717				
2F-00-114	10.5					53					CL/SC/ML	0.035	SM/SP-SM/GW	20.84	595				
2F-08-03	14.5	10	3	32	30	43	41	10	499	24	ML	0.14	SP/GP	23.77	170	349	285	69780	82

Boring #	Blanket Material 1 (lowest permeability)			Blanket Material 2			Transformed Blanket Thickness (z)	Aquifer Material 1			Aquifer Material 2			Aquifer Material 3			Transformed Aquifer Horizontal Permeability (kf)
	Material Type	Thickness (z)	Permeability (Kb)	Material Type	Thickness (z)	Permeability (Kb)		Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	
WCSBAR-003B	ML	9.5	0.14				9.5	SM	17.5	2.8	SP-SM	5.5	14	GW	22.5	34	19.58
2F-00-9W	ML	4.5	0.14	SM	17.5	0.709	7.96	SM	11	2.8	SP-SM	8.5	14	GW	10.5	34	16.89
2F-97-23	CL	7	0.028	ML/SM	10	0.14	9	SM	9.85	2.8	SP-SM	6.35	14	GW	15	34	20.08
2F-00-114	CL/SC	9	0.035	ML	6	0.14	10.5	SM	10.5	2.8	SP-SM	18.5	14	GW	24	34	20.84
2F-08-03	ML	14.5	0.14				14.5	SP	22	14	GP	21	34				23.77

With Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Underseepage Reliability Analysis With Blanket Theory Analysis

Project: American River Common Features GRR
Study Area: American River
River Section: ARS Reach B Unit 4

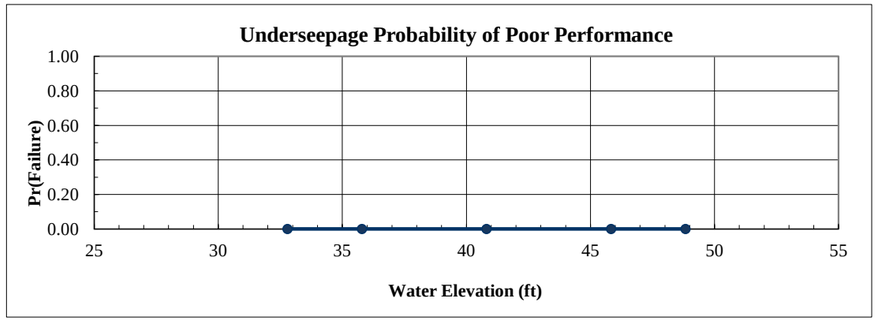
Levee Mile: 3.90
River Mile: 3.94
Analysis Case With Project Erosion Protection

Crest Elev.: 48.83
L/S Toe Elev.: 32.79
W/S Toe Elev.: 28.64

Analysis By: A. Deus
Checked By: H. Mulder
Date: 7/5/2012

Random Variables			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Permaebility Ratio	349	285	82
Blanket Thickness (z)	10	3	30
Aquifer Thickness (d)	41	10	24

Blanket Theory Analysis Inputs					
Pr(f)=0	BTA Case No.	L1	L2	L3	γ Blanket
YES	7A	0	125	∞	112



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	32.79	0.0000
Toe+3ft	3.00	35.79	0.0000
Half Height	8.02	40.81	0.0000
Crest-3ft	13.04	45.83	0.0000
Crest	16.04	48.83	0.0000

Crest	Rh
Head = 16.04	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	349	10.00	41.00	0.00	378.27	0.0815	12.06			
2	634	10.00	41.00	0.00	509.84	0.0646	12.88			
3	64	10.00	41.00	0.00	161.99	0.1429	9.05			
4	349	13.00	41.00	0.00	431.30	0.0737	12.44			
5	349	7.00	41.00	0.00	316.49	0.0929	11.50			
6	349	10.00	51.00	0.00	421.89	0.0933	12.37			
7	349	10.00	31.00	0.00	328.92	0.0683	11.62			
								Total		

E[I] =
Var[I]=
σ[I]=
V(I) =

E[ln I] =
σ [ln I] =

Ic= 0.80

ln(I crit) = -0.223144

β =
F(z) =
Pr(f) % = 0.000000

Crest-3ft	Rh
Head = 13.04	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	349	10.00	41.00	0.00	378.27	0.0815	9.80			
2	634	10.00	41.00	0.00	509.84	0.0646	10.47			
3	64	10.00	41.00	0.00	161.99	0.1429	7.36			
4	349	13.00	41.00	0.00	431.30	0.0737	10.11			
5	349	7.00	41.00	0.00	316.49	0.0929	9.35			
6	349	10.00	51.00	0.00	421.89	0.0933	10.06			
7	349	10.00	31.00	0.00	328.92	0.0683	9.45			
								Total		

E[I] =
Var[I]=
σ[I]=
V(I) =

E[ln I] =
σ [ln I] =

Ic= 0.80

ln(I crit) = -0.223144

β =
F(z) =
Pr(f) % = 0.000000

Half Height	Rh
Head = 8.02	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	349	10.00	41.00	0.00	378.27	0.0815	6.03			
2	634	10.00	41.00	0.00	509.84	0.0646	6.44			
3	64	10.00	41.00	0.00	161.99	0.1429	4.53			
4	349	13.00	41.00	0.00	431.30	0.0737	6.22			
5	349	7.00	41.00	0.00	316.49	0.0929	5.75			
6	349	10.00	51.00	0.00	421.89	0.0933	6.19			
7	349	10.00	31.00	0.00	328.92	0.0683	5.81			
								Total		

E[I] =
Var[I]=
σ[I]=
V(I) =

E[ln I] =
σ [ln I] =

Ic= 0.80

ln(I crit) = -0.223144

β =
F(z) =
Pr(f) % = 0.000000

Toe+3ft	Rh
Head = 3.00	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	349	10.00	41.00	0.00	378.27	0.0815	2.25			
2	634	10.00	41.00	0.00	509.84	0.0646	2.41			
3	64	10.00	41.00	0.00	161.99	0.1429	1.69			
4	349	13.00	41.00	0.00	431.30	0.0737	2.33			
5	349	7.00	41.00	0.00	316.49	0.0929	2.15			
6	349	10.00	51.00	0.00	421.89	0.0933	2.31			
7	349	10.00	31.00	0.00	328.92	0.0683	2.17			
								Total		

E[I] =
Var[I]=
σ[I]=
V(I) =

E[ln I] =
σ [ln I] =

Ic= 0.80

ln(I crit) = -0.223144

β =
F(z) =
Pr(f) % = 0.000000

With Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Through-Seepage Reliability Analysis With Khilar's Extended Model

Project: American River Common Features GRR
Study Area: American River
River Section: ARS Reach B Unit 4

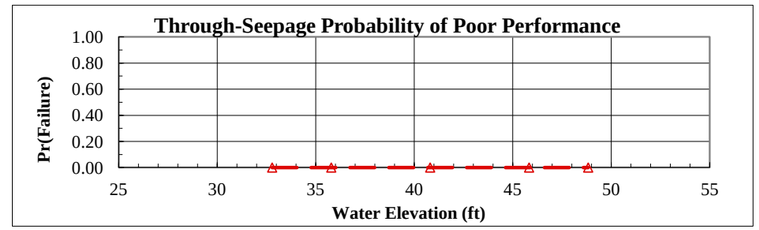
Levee Mile: 3.90
River Mile: 3.94
Analysis Case With Project Erosion Protection

Crest Elev.: 48.83
L/S Toe Elev.: 32.79
W/S Toe Elev.: 28.64

Analysis By: A. Deus
Checked By: H. Mulder
Date: 7/5/2012

Random Variables - Silty Sand (SM) and Sand (SP) Levee			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Tractive Stress (Tc)	1.2	0.1	10.00
Initial Porosity (n)	0.25	0.03	10.00
Intrinsic Permeability (Ko)	1.50E-07	4.50E-08	30.00

Pr(f)=0
NO



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	32.79	0.0000
Toe+3ft	3.00	35.79	0.000000
Half Height	8.02	40.81	0.000000
Crest-3ft	13.04	45.83	0.000000
Crest	16.04	48.83	0.000000

Crest	Head =	16.04	Horizontal Gradient (Ix) =	0.120

Run	Tractive Stress (Tc)	Initial Porosity (n)	Intrinsic Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	1.20	0.25	1.50E-07	0.56	4.65		
2	1.08	0.25	1.50E-07	0.50	4.19	0.216679	26.44
3	1.32	0.25	1.50E-07	0.61	5.12		
4	1.20	0.23	1.50E-07	0.53	4.42	0.054306	6.63
5	1.20	0.28	1.50E-07	0.59	4.88		
6	1.20	0.25	1.05E-07	0.67	5.56	0.548375	66.93
7	1.20	0.25	1.95E-07	0.49	4.08		

E[FS] =	4.654883	E[ln FS] =	1.519358	Total	0.819360	100.00
Var[FS]=	0.819360				
σ[FS]=	0.905185	σ[ln FS]=	0.192658	β =	7.886311
V(FS) =	0.194459			F(z) =	0.000000
FS req'd =	1.00	ln(FS req'd) =	0.000000	Pr(f) % =	0.000000

Crest-3ft	Head =	13.04	Horizontal Gradient (Ix) =	0.090

Run	Tractive Stress (Tc)	Initial Porosity (n)	Intrinsic Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	1.20	0.25	1.50E-07	0.56	6.21		
2	1.08	0.25	1.50E-07	0.50	5.59	0.385208	26.44
3	1.32	0.25	1.50E-07	0.61	6.83		
4	1.20	0.23	1.50E-07	0.53	5.89	0.096544	6.63
5	1.20	0.28	1.50E-07	0.59	6.51		
6	1.20	0.25	1.05E-07	0.67	7.42	0.974889	66.93
7	1.20	0.25	1.95E-07	0.49	5.44		

E[FS] =	6.206511	E[ln FS] =	1.807040	Total	1.456641	100.00
Var[FS]=	1.456641				
σ[FS]=	1.206914	σ[ln FS]=	0.192658	β =	9.379541
V(FS) =	0.194459			F(z) =	0.000000
FS req'd =	1.00	ln(FS req'd) =	0.000000	Pr(f) % =	0.000000

Half Height	Head =	8.02	Horizontal Gradient (Ix) =	0.040

Run	Tractive Stress (Tc)	Initial Porosity (n)	Intrinsic Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	1.20	0.25	1.50E-07	0.56	13.96		
2	1.08	0.25	1.50E-07	0.50	12.57	1.950114	26.44
3	1.32	0.25	1.50E-07	0.61	15.36		
4	1.20	0.23	1.50E-07	0.53	13.25	0.488754	6.63
5	1.20	0.28	1.50E-07	0.59	14.65		
6	1.20	0.25	1.05E-07	0.67	16.69	4.935375	66.93
7	1.20	0.25	1.95E-07	0.49	12.25		

E[FS] =	13.964650	E[ln FS] =	2.617971	Total	7.374243	100.00
Var[FS]=	7.374243				
σ[FS]=	2.715556	σ[ln FS]=	0.192658	β =	13.588718
V(FS) =	0.194459			F(z) =	0.000000
FS req'd =	1.00	ln(FS req'd) =	0.000000	Pr(f) % =	0.000000

Toe+3ft	Head =	3.00	Horizontal Gradient (Ix) =	0.010

Run	Tractive Stress (Tc)	Initial Porosity (n)	Intrinsic Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	1.20	0.25	1.50E-07	0.56	55.86		
2	1.08	0.25	1.50E-07	0.50	50.27	31.201831	26.44
3	1.32	0.25	1.50E-07	0.61	61.44		
4	1.20	0.23	1.50E-07	0.53	52.99	7.820057	6.63
5	1.20	0.28	1.50E-07	0.59	58.58		
6	1.20	0.25	1.05E-07	0.67	66.76	78.966003	66.93
7	1.20	0.25	1.95E-07	0.49	48.99		

E[FS] =	55.858599	E[ln FS] =	4.004265	Total	117.987891	100.00
Var[FS]=	117.987891				
σ[FS]=	10.862223	σ[ln FS]=	0.192658	β =	20.784354
V(FS) =	0.194459			F(z) =	0.000000
FS req'd =	1.00	ln(FS req'd) =	0.000000	Pr(f) % =	0.000000

With Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Landside Long-Term Stability Analysis With UTEXAS4

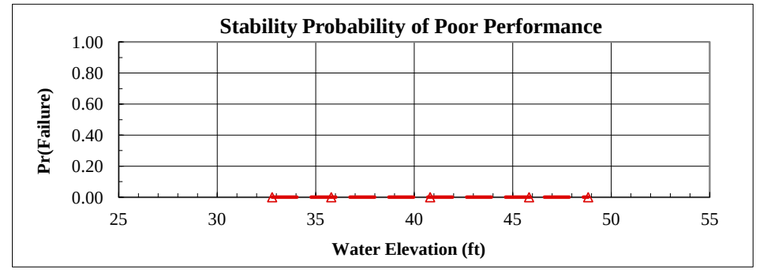
Project: American River Common Features GRR
Study Area: American River
River Section: ARS Reach B Unit 4

Levee Mile: 3.90
River Mile: 3.94
Analysis Case With Project Erosion Protection

Crest Elev.: 48.83
L/S Toe Elev.: 32.79
W/S Toe Elev.: 28.64

Analysis By: A. Deus
Checked By: H. Mulder
Date: 7/5/2012

Random Variables			
Parameter	**Expected Value**	**Standard Deviation**	**Coefficient of Variation, %**
Levee Φ	33	4	13.00
Levee Cohesion	0	0	40.00
Levee γ	125	9	7.00
Foundation Φ	30	4	13.00
Foundation Cohesion	0	0	40.00



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	32.79	0.0000
Toe+3ft	3.00	35.79	0.000000
Half Height	8.02	40.81	0.000000
Crest-3ft	13.04	45.83	0.000000
Crest	16.04	48.83	0.000000

Crest	Head =	16.04	Pr(f)=0	YES

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	33	0	125	30	0	1.58		
2	29	0	125	30	0			
3	37	0	125	30	0			
4	33	0	125	30	0			
5	33	0	125	30	0			
6	33	0	116	30	0			
7	33	0	134	30	0			
8	33	0	125	26	0			
9	33	0	125	34	0			
10	33	0	125	30	0			
11	33	0	125	30	0			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

Crest-3ft	Head =	13.04	Pr(f)=0	YES

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	33	0	125	30	0	1.59		
2	29	0	125	30	0			
3	37	0	125	30	0			
4	33	0	125	30	0			
5	33	0	125	30	0			
6	33	0	116	30	0			
7	33	0	134	30	0			
8	33	0	125	26	0			
9	33	0	125	34	0			
10	33	0	125	30	0			
11	33	0	125	30	0			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

Half Height	Head =	8.02	Pr(f)=0	YES

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	33	0	125	30	0	1.61		
2	29	0	125	30	0			
3	37	0	125	30	0			
4	33	0	125	30	0			
5	33	0	125	30	0			
6	33	0	116	30	0			
7	33	0	134	30	0			
8	33	0	125	26	0			
9	33	0	125	34	0			
10	33	0	125	30	0			
11	33	0	125	30	0			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

Toe+3ft	Head =	3.00	Pr(f)=0	YES

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	33	0	125	30	0	1.67		
2	29	0	125	30	0			
3	37	0	125	30	0			
4	33	0	125	30	0			
5	33	0	125	30	0			
6	33	0	116	30	0			
7	33	0	134	30	0			
8	33	0	125	26	0			
9	33	0	125	34	0			
10	33	0	125	30	0			
11	33	0	125	30	0			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

With Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Judgment Probability of Poor Performance Curve

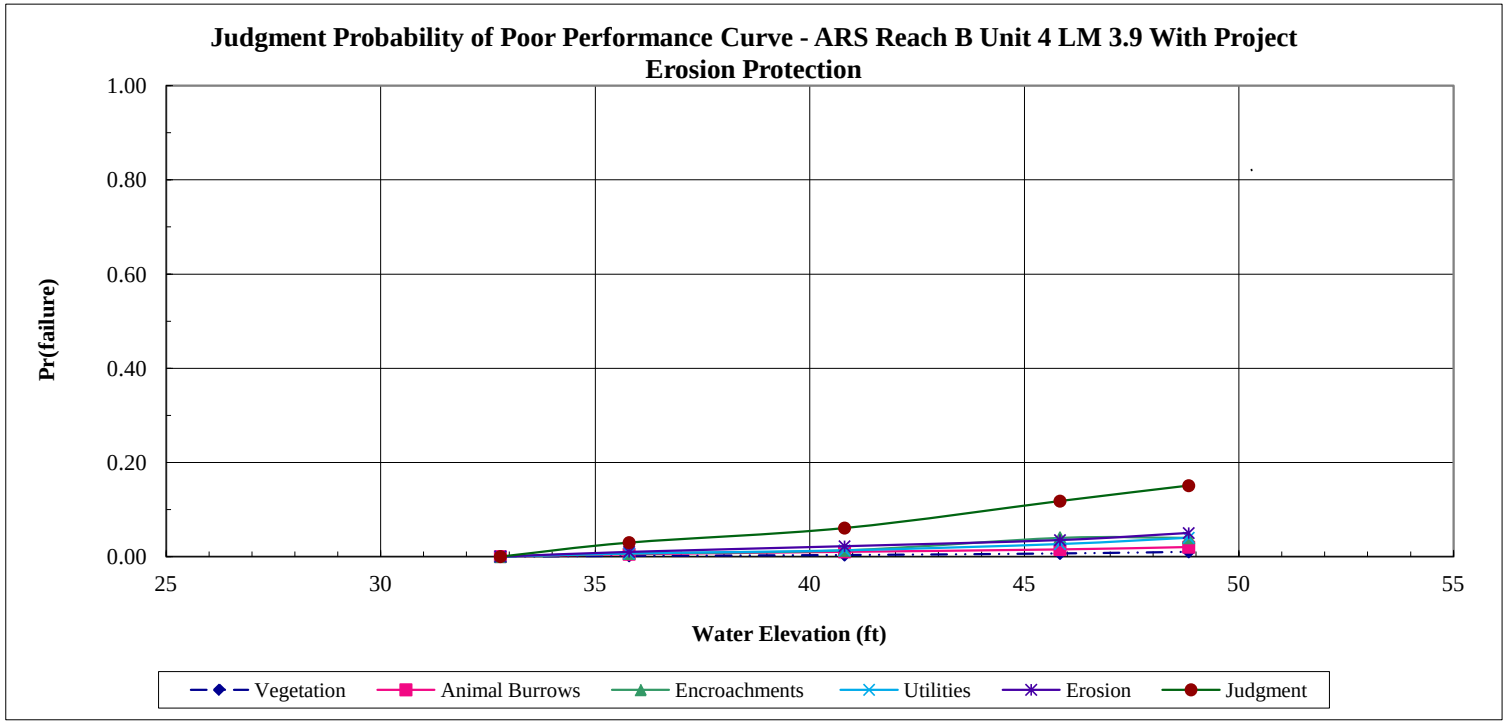
Project: American River Common Features GRR
Study Area: American River
River Section: ARS Reach B Unit 4

Levee Mile: 3.90
River Mile: 3.94
Analysis Case: With Project Erosion Protect

Crest Elev.: 48.83
L/S Toe Elev.: 32.79
W/S Toe Elev.: 28.64

Analysis By: A. Deus
Checked By: H. Mulder
Date: 7/5/2012

Water Surface Elevation	Vegetation		Animal Burrows		Encroachments		Utilities		Erosion		Judgment	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
32.79	0.00000	1.0000	0.00000	1.0000	0.00000	1.0000	0.00000	1.0000	0.00000	1.0000	0.0000	1.0000
35.79	0.00167	0.9983	0.00500	0.9950	0.00667	0.9933	0.00667	0.9933	0.01000	0.9900	0.0297	0.9703
40.81	0.00333	0.9967	0.01000	0.9900	0.01333	0.9867	0.01333	0.9867	0.02200	0.9780	0.0606	0.9394
45.83	0.00667	0.9933	0.01500	0.9850	0.04000	0.9600	0.02667	0.9733	0.03500	0.9650	0.1178	0.8822
48.83	0.01000	0.9900	0.02000	0.9800	0.04000	0.9600	0.04000	0.9600	0.05000	0.9500	0.1506	0.8494



With Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

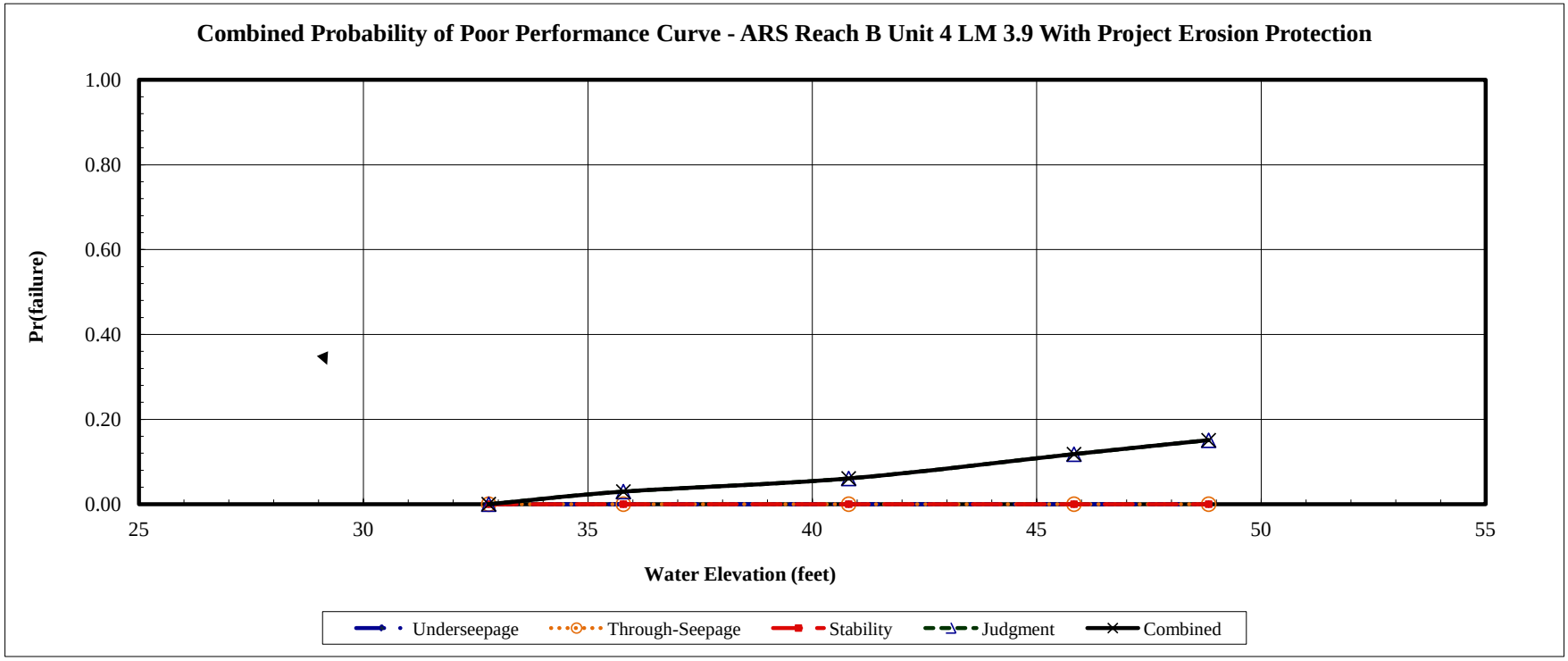
Project: American River Common Features GRR
Study Area: American River
River Section: ARS Reach B Unit 4

Levee Mile: 3.90
River Mile: 3.94
Analysis Case: With Project Erosion Protection

Crest Elev.: 48.83
L/S Toe Elev.: 32.79
W/S Toe Elev.: 28.64

Analysis By: A. Deus
Checked By: H. Mulder
Date: 7/5/2012

Water Surface	Underseepage		Through-Seepage		Stability		Judgment		Combined	
Elevation	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
32.79	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
35.79	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0297	0.9703	0.0297	0.9703
40.81	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0606	0.9394	0.0606	0.9394
45.83	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.1178	0.8822	0.1178	0.8822
48.83	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.1506	0.8494	0.1506	0.8494



Without Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Determination of Random Variables For Underseepage Reliability Analysis

Project: American River Common Features GRR
Channel: Sacramento River
Basin and Reach: ARS Reach F Unit 1

Levee Mile: 5.92
River Mile: 50.21
Analysis Case Without Project Cutoff Wall

Crest Elev.: 33.23
L/S Toe Elev.: 19.00
W/S Toe Elev.: 22.00

Analysis By: M. Kynett
Checked By: H. Mulder
Date: 4/29/2011

Boring #	Blanket Thickness Variable (z)					Aquifer Thickness Variable (d)					Hydraulic Conductivity Vairables (Kb and Kf)								
	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Blanket Material	Blanket Kb (ft/day)	Aquifer Material Material	Aquifer Material Kf (ft/day)	Kf/Kb	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation
2F-05-G4-1	32					57.4					ML	0.14	SP/ML	25.13	180				
2F-05-G4-1A	32					63.5					ML	0.14	L/SM/SP/GP-G	24.85	178				
2F-05-G4-2	13.11					94					ML/SM	0.14	SM/SP/GW	20.88	149				
2F-05-G4-2A	16					67.2					ML	0.14	SM/SP/GP-GM	12.47	89				
K-S-4	9.75	20	9	118	45	95.25	83	16	911	19	CL/ML/ML/SM	0.028	SP/GP	29.51	1054	289	361	124190	98
2F-05-G4-3	26					96.8					ML	0.14	SM/SP/GP	22.23	159				
2F-05-G4-3A	8.5					90					CL	0.028	SM/SP/GP-GM	20.99	750				
K-S-2	28					91					SM	0.709	SM/SP-SM/GP	15.12	21				
K-S-3	18.5					93.5					SM	0.709	SM/SP-SM/GM	13.54	19				

Boring #	Blanket Material 1 (lowest permeability)			Blanket Material 2			Transformed Blanket Thickness (z)	Aquifer Material 1			Aquifer Material 2			Aquifer Material 3			Transformed Aquifer Horizontal Permeability (kf)
	Material Type	Thickness (z)	Permeability (Kb)	Material Type	Thickness (z)	Permeability (Kb)		Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	
2F-05-G4-1	ML	32	0.14				32	SP	51.4	28	ML	6	0.57				25.13
2F-05-G4-1A	ML	32	0.14				32	ML/SM	9	2.8	SP	50	28	GP-GM	4.5	34	24.85
2F-05-G4-2	ML	10.8	0.14	SM	11.7	0.709	13.11	SM	33	2.8	SP	34	28	GW	27	34	20.88
2F-05-G4-2A	ML	16	0.14				16	SM	43.8	2.8	SP	13.4	28	GP-GM	10	34	12.47
K-S-4	CL/ML	6	0.028	ML/SM	18.75	0.14	9.75	SP	71.25	28	GP	24	34				29.51
2F-05-G4-3	ML	26	0.14				26	SM	33	2.8	SP	18.3	28	GP	45.5	34	22.23
2F-05-G4-3A	CL	8.5	0.028				8.5	SM	31	2.8	SP	34	28	GP-GM	25	34	20.99
K-S-2	SM	28	0.709				28	SM	15	2.8	SP-SM	62.5	14	GP	13.5	34	15.12
K-S-3	SM	18.5	0.709				18.5	SM	19	2.8	SP-SM	66	14	GM	8.5	34	13.54

Without Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Underseepage Reliability Analysis With Blanket Theory Analysis

Project: American River Common Features GRR
Study Area: Sacramento River
River Section: ARS Reach F Unit 1

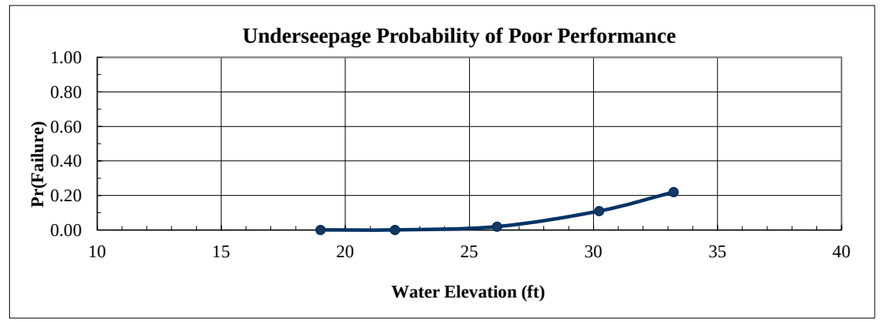
Levee Mile: 5.92
River Mile: 50.21
Analysis Case Without Project Cutoff Wall

Crest Elev.: 33.23
L/S Toe Elev.: 19.00
W/S Toe Elev.: 22.00

Analysis By: M. Kynett
Checked By: H. Mulder
Date: 4/29/2011

Random Variables			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Permaebility Ratio	289	283	98
Blanket Thickness (z)	20	9	45
Aquifer Thickness (d)	83	16	19

Blanket Theory Analysis Inputs					
Pr(f)=0	BTA Case No.	L1	L2	L3	γ Blanket
NO	7A	20	95	∞	112



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	19.00	0.0000
Toe+3ft	3.00	22.00	0.0001
Half Height	7.12	26.12	0.0193
Crest-3ft	11.23	30.23	0.1094
Crest	14.23	33.23	0.2194

Crest	Rh
Head = 14.23	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	289	20.00	83.00	19.99	692.63	0.1028	12.20	0.61		
2	572	20.00	83.00	20.00	974.62	0.0762	12.73	0.64	0.024025	19.48
3	6	20.00	83.00	19.73	97.95	0.3903	6.55	0.33		
4	289	29.00	83.00	20.00	834.04	0.0875	12.51	0.43	0.099225	80.44
5	289	11.00	83.00	19.99	513.67	0.1320	11.63	1.06		
6	289	20.00	99.00	20.00	756.45	0.1136	12.35	0.62	0.000100	0.08
7	289	20.00	67.00	19.99	622.30	0.0909	12.01	0.60		
								Total	0.123350	100.00

E[I] = 0.610000
Var[I]= 0.123350
σ[I]= 0.351212
V(I) = 0.575758

E[ln I] = -0.637448
σ [ln I] = 0.535074

Ic= 0.80
ln(I crit) = -0.223144

β = -1.191328
F(z) = 0.780622
Pr(f) % = 21.937828

Crest-3ft	Rh
Head = 11.23	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	289	20.00	83.00	19.99	692.63	0.1028	9.63	0.48		
2	572	20.00	83.00	20.00	974.62	0.0762	10.04	0.50	0.014400	19.32
3	6	20.00	83.00	19.73	97.95	0.3903	5.17	0.26		
4	289	29.00	83.00	20.00	834.04	0.0875	9.87	0.34	0.060025	80.54
5	289	11.00	83.00	19.99	513.67	0.1320	9.18	0.83		
6	289	20.00	99.00	20.00	756.45	0.1136	9.75	0.49	0.000100	0.13
7	289	20.00	67.00	19.99	622.30	0.0909	9.48	0.47		
								Total	0.074525	100.00

E[I] = 0.480000
Var[I]= 0.074525
σ[I]= 0.272993
V(I) = 0.568735

E[ln I] = -0.874094
σ [ln I] = 0.529385

Ic= 0.80
ln(I crit) = -0.223144

β = -1.651148
F(z) = 0.890583
Pr(f) % = 10.941717

Half Height	Rh
Head = 7.12	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	289	20.00	83.00	19.99	692.63	0.1028	6.10	0.31		
2	572	20.00	83.00	20.00	974.62	0.0762	6.36	0.32	0.006400	21.02
3	6	20.00	83.00	19.73	97.95	0.3903	3.28	0.16		
4	289	29.00	83.00	20.00	834.04	0.0875	6.25	0.22	0.024025	78.90
5	289	11.00	83.00	19.99	513.67	0.1320	5.81	0.53		
6	289	20.00	99.00	20.00	756.45	0.1136	6.18	0.31	0.000025	0.08
7	289	20.00	67.00	19.99	622.30	0.0909	6.01	0.30		
								Total	0.030450	100.00

E[I] = 0.310000
Var[I]= 0.030450
σ[I]= 0.174499
V(I) = 0.562901

E[ln I] = -1.308807
σ [ln I] = 0.524641

Ic= 0.80
ln(I crit) = -0.223144

β = -2.494672
F(z) = 0.980743
Pr(f) % = 1.925683

Toe+3ft	Rh
Head = 3.00	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	289	20.00	83.00	19.99	692.63	0.1028	2.57	0.13		
2	572	20.00	83.00	20.00	974.62	0.0762	2.68	0.13	0.000900	17.56
3	6	20.00	83.00	19.73	97.95	0.3903	1.38	0.07		
4	289	29.00	83.00	20.00	834.04	0.0875	2.64	0.09	0.004225	82.44
5	289	11.00	83.00	19.99	513.67	0.1320	2.45	0.22		
6	289	20.00	99.00	20.00	756.45	0.1136	2.60	0.13	0.000000	0.00
7	289	20.00	67.00	19.99	622.30	0.0909	2.53	0.13		
								Total	0.005125	100.00

E[I] = 0.130000
Var[I]= 0.005125
σ[I]= 0.071589
V(I) = 0.550685

E[ln I] = -2.172653
σ [ln I] = 0.514650

Ic= 0.80
ln(I crit) = -0.223144

β = -4.221614
F(z) = 0.999924
Pr(f) % = 0.007592

Without Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Through-Seepage Reliability Analysis With Khilar's Extended Model

Project: American River Common Features GRR
Study Area: Sacramento River
River Section: ARS Reach F Unit 1

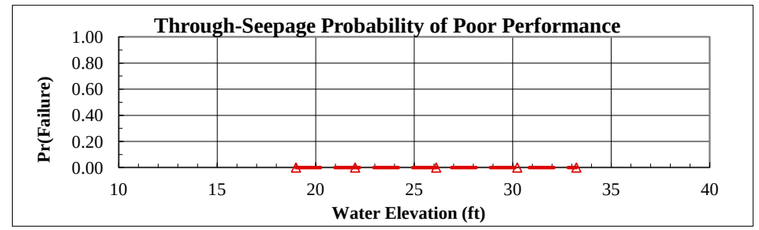
Levee Mile: 5.92
River Mile: 50.21
Analysis Case Without Project Cutoff Wall

Crest Elev.: 33.23
L/S Toe Elev.: 19.00
W/S Toe Elev.: 22.00

Analysis By: M. Kynett
Checked By: H. Mulder
Date: 4/29/2011

Random Variables - Silty Sand (SM) and Sand (SP) Levee			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Tractive Stress (Tc)	0.8	0.1	10.00
Initial Porosity (n)	0.35	0.04	10.00
Intrinsic Permeability (Ko)	5.00E-07	1.50E-07	30.00

Pr(f)=0
YES



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	19.00	0.0000
Toe+3ft	3.00	22.00	0.000000
Half Height	7.12	26.12	0.000000
Crest-3ft	11.23	30.23	0.000000
Crest	14.23	33.23	0.000000

Crest | **Head =** 14.23 | **Horizontal Gradient (Ix) =** 0.000

Run	Tractive Stress (Tc)	Initial Porosity (n)	Intrinsic Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	0.80	0.35	5.00E-07	0.24			
2	0.72	0.35	5.00E-07	0.22			
3	0.88	0.35	5.00E-07	0.27			
4	0.80	0.32	5.00E-07	0.23			
5	0.80	0.39	5.00E-07	0.25			
6	0.80	0.35	3.50E-07	0.29			
7	0.80	0.35	6.50E-07	0.21			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

Crest-3ft | **Head =** 11.23 | **Horizontal Gradient (Ix) =** 0.000

Run	Tractive Stress (Tc)	Initial Porosity (n)	Intrinsic Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	0.80	0.35	5.00E-07	0.24			
2	0.72	0.35	5.00E-07	0.22			
3	0.88	0.35	5.00E-07	0.27			
4	0.80	0.32	5.00E-07	0.23			
5	0.80	0.39	5.00E-07	0.25			
6	0.80	0.35	3.50E-07	0.29			
7	0.80	0.35	6.50E-07	0.21			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

Half Height | **Head =** 7.12 | **Horizontal Gradient (Ix) =** 0.000

Run	Tractive Stress (Tc)	Initial Porosity (n)	Intrinsic Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	0.80	0.35	5.00E-07	0.24			
2	0.72	0.35	5.00E-07	0.22			
3	0.88	0.35	5.00E-07	0.27			
4	0.80	0.32	5.00E-07	0.23			
5	0.80	0.39	5.00E-07	0.25			
6	0.80	0.35	3.50E-07	0.29			
7	0.80	0.35	6.50E-07	0.21			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

Toe+3ft | **Head =** 3.00 | **Horizontal Gradient (Ix) =** 0.000

Run	Tractive Stress (Tc)	Initial Porosity (n)	Intrinsic Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	0.80	0.35	5.00E-07	0.24			
2	0.72	0.35	5.00E-07	0.22			
3	0.88	0.35	5.00E-07	0.27			
4	0.80	0.32	5.00E-07	0.23			
5	0.80	0.39	5.00E-07	0.25			
6	0.80	0.35	3.50E-07	0.29			
7	0.80	0.35	6.50E-07	0.21			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

Without Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Landside Long-Term Stability Analysis With UTEXAS4

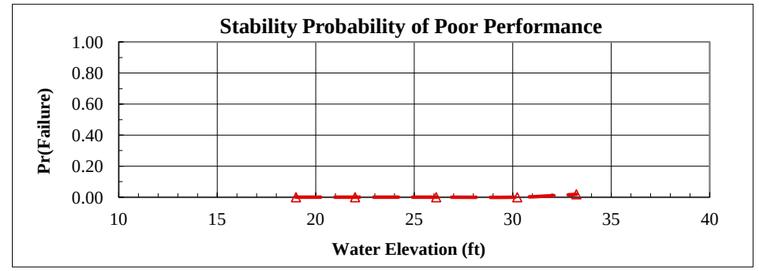
Project: American River Common Features GRR
Study Area: Sacramento River
River Section: ARS Reach F Unit 1

Levee Mile: 5.92
River Mile: 50.21
Analysis Case Without Project Cutoff Wall

Crest Elev.: 33.23
L/S Toe Elev.: 19.00
W/S Toe Elev.: 22.00

Analysis By: M. Kynett
Checked By: H. Mulder
Date: 4/29/2011

Random Variables			
Parameter	**Expected Value**	**Standard Deviation**	**Coefficient of Variation, %**
Levee Φ	33	4	13.00
Levee Cohesion	0	0	40.00
Levee γ	125	9	7.00
Foundation Φ	30	4	13.00
Foundation Cohesion	0	0	40.00



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	19.00	0.0000
Toe+3ft	3.00	22.00	0.000000
Half Height	7.12	26.12	0.000000
Crest-3ft	11.23	30.23	0.000000
Crest	14.23	33.23	0.019060

Crest	Head =	14.23	Pr(f)=0	NO

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	33	0	125	30	0	1.28		
2	29	0	125	30	0	1.21	0.010000	45.20
3	37	0	125	30	0	1.41		
4	33	0	125	30	0	1.28	0.000000	0.00
5	33	0	125	30	0	1.28		
6	33	0	116	30	0	1.33	0.000025	0.11
7	33	0	134	30	0	1.32		
8	33	0	125	26	0	1.21	0.012100	54.69
9	33	0	125	34	0	1.43		
10	33	0	125	30	0	1.28	0.000000	0.00
11	33	0	125	30	0	1.28		

E[FS] = 1.280000 E[ln FS] = 0.240153 Total 0.022125 100.00
Var[FS]= 0.022125
σ[FS]= 0.148745 σ[ln FS]= 0.115817
V(FS) = 0.116207
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	2.073551
F(z) =	0.019060
Pr(f) % =	1.906050

Crest-3ft	Head =	11.23	Pr(f)=0	YES

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	33	0	125	30	0	1.32		
2	29	0	125	30	0			
3	37	0	125	30	0			
4	33	0	125	30	0			
5	33	0	125	30	0			
6	33	0	116	30	0			
7	33	0	134	30	0			
8	33	0	125	26	0			
9	33	0	125	34	0			
10	33	0	125	30	0			
11	33	0	125	30	0			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	
F(z) =	
Pr(f) % =	0.000000

Half Height	Head =	7.12	Pr(f)=0	YES

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	33	0	125	30	0	1.40		
2	29	0	125	30	0			
3	37	0	125	30	0			
4	33	0	125	30	0			
5	33	0	125	30	0			
6	33	0	116	30	0			
7	33	0	134	30	0			
8	33	0	125	26	0			
9	33	0	125	34	0			
10	33	0	125	30	0			
11	33	0	125	30	0			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	
F(z) =	
Pr(f) % =	0.000000

Toe+3ft	Head =	3.00	Pr(f)=0	YES

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	33	0	125	30	0	1.46		
2	29	0	125	30	0			
3	37	0	125	30	0			
4	33	0	125	30	0			
5	33	0	125	30	0			
6	33	0	116	30	0			
7	33	0	134	30	0			
8	33	0	125	26	0			
9	33	0	125	34	0			
10	33	0	125	30	0			
11	33	0	125	30	0			

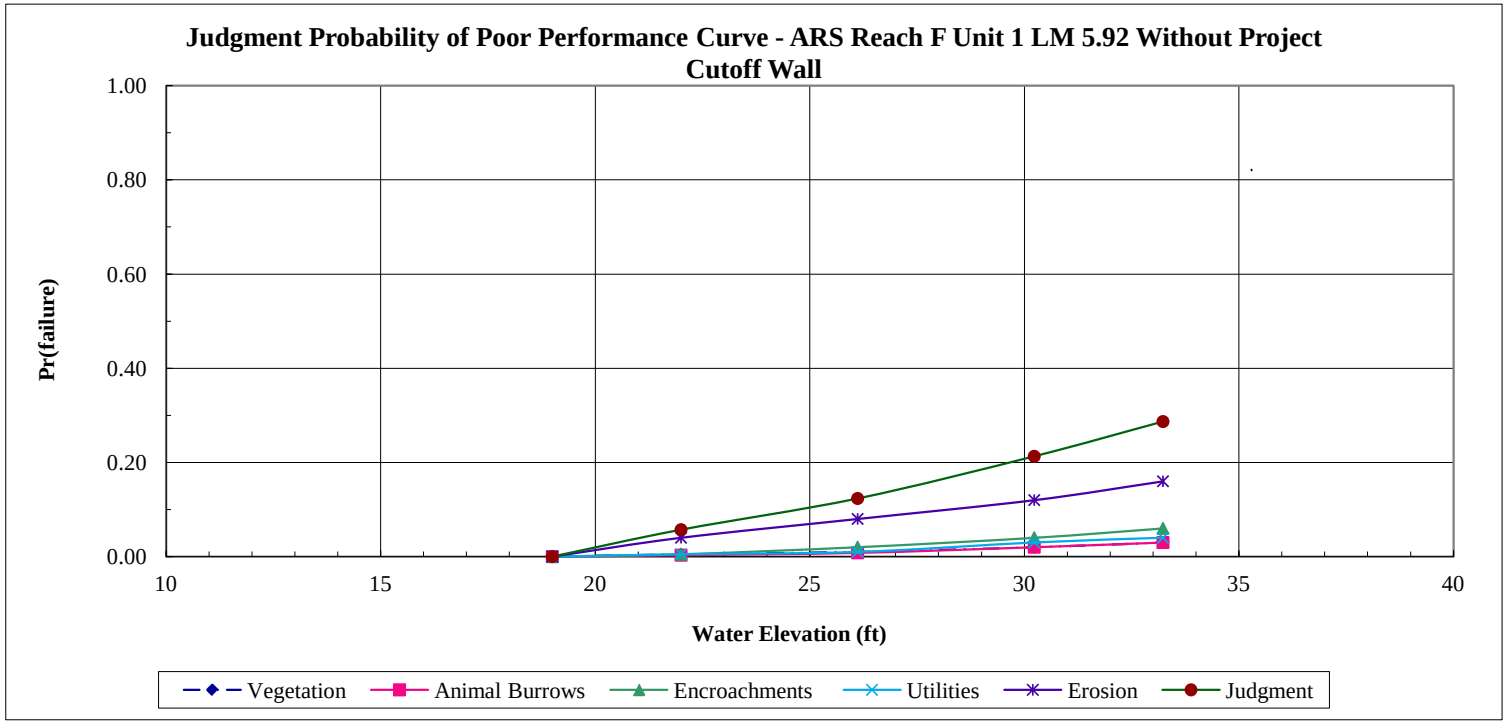
E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	
F(z) =	
Pr(f) % =	0.000000

Without Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Judgment Probability of Poor Performance Curve

Project:	American River Common Features GRR	**Levee Mile:**	5.92	**Crest Elev.:**	33.23	**Analysis By:**	M. Kynett
Study Area:	Sacramento River	**River Mile:**	50.21	**L/S Toe Elev.:**	19.00	**Checked By:**	H. Mulder
River Section:	ARS Reach F Unit 1	**Analysis Case:**	Without Project Cutoff Wall	**W/S Toe Elev.:**	22.00	**Date:**	4/29/2011

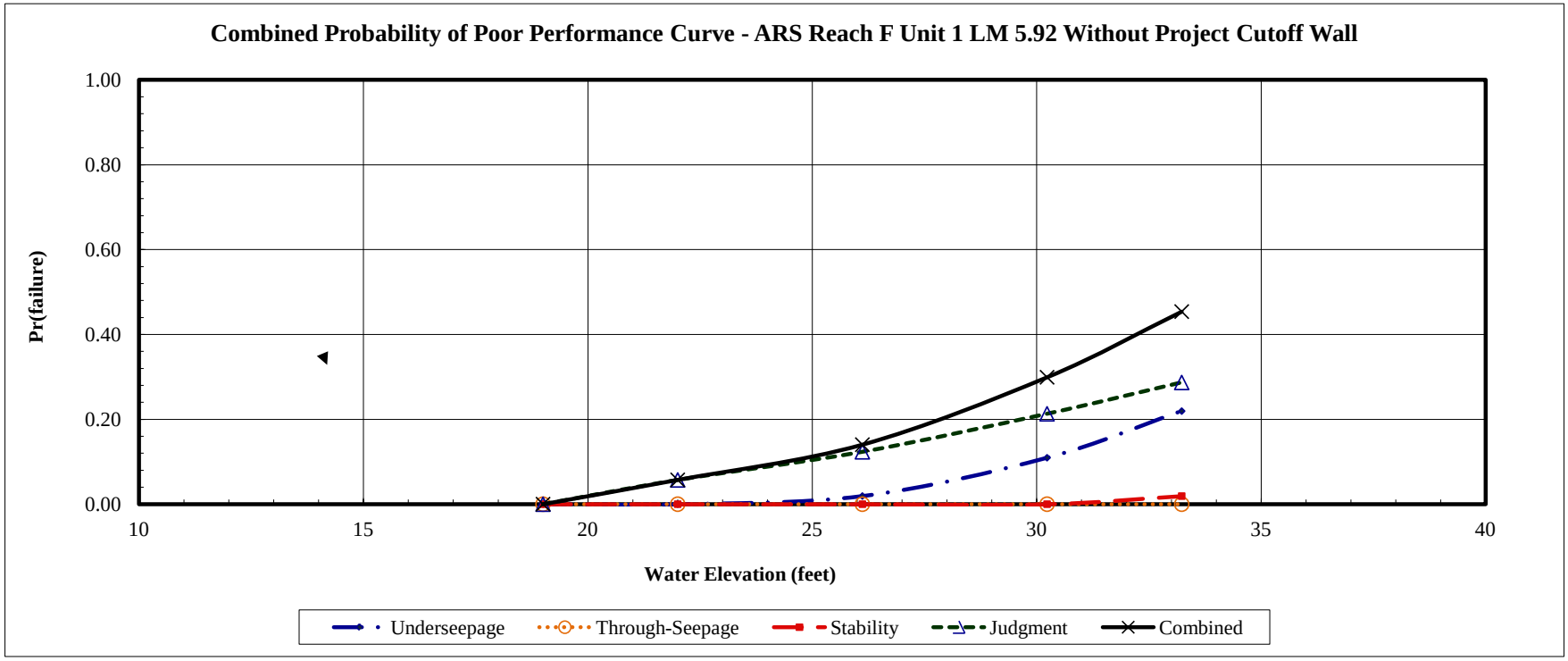
Water Surface Elevation	Vegetation		Animal Burrows		Encroachments		Utilities		Erosion		Judgment	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
19.00	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
22.00	0.0050	0.9950	0.0030	0.9970	0.0050	0.9950	0.0050	0.9950	0.0400	0.9600	0.0572	0.9428
26.12	0.0100	0.9900	0.0080	0.9920	0.0200	0.9800	0.0100	0.9900	0.0800	0.9200	0.1234	0.8766
30.23	0.0200	0.9800	0.0200	0.9800	0.0400	0.9600	0.0300	0.9700	0.1200	0.8800	0.2130	0.7870
33.23	0.0300	0.9700	0.0300	0.9700	0.0600	0.9400	0.0400	0.9600	0.1600	0.8400	0.2868	0.7132



Without Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

Project:	American River Common Features GRR	**Levee Mile:**	5.92	**Crest Elev.:**	33.23	**Analysis By:**	M. Kynett
Study Area:	Sacramento River	**River Mile:**	50.21	**L/S Toe Elev.:**	19.00	**Checked By:**	H. Mulder
River Section:	ARS Reach F Unit 1	**Analysis Case:**	Without Project Cutoff Wall	**W/S Toe Elev.:**	22.00	**Date:**	4/29/2011

Water Surface	Underseepage		Through-Seepage		Stability		Judgment		Combined	
Elevation	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
19.00	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
22.00	0.0001	0.9999	0.0000	1.0000	0.0000	1.0000	0.0572	0.9428	0.0572	0.9428
26.12	0.0193	0.9807	0.0000	1.0000	0.0000	1.0000	0.1234	0.8766	0.1403	0.8597
30.23	0.1094	0.8906	0.0000	1.0000	0.0000	1.0000	0.2130	0.7870	0.2991	0.7009
33.23	0.2194	0.7806	0.0000	1.0000	0.0191	0.9809	0.2868	0.7132	0.4539	0.5461



With Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Determination of Random Variables For Underseepage Reliability Analysis

Project: American River Common Features GRR
Channel: Sacramento River
Basin and Reach: ARS Reach F Unit 1

Levee Mile: 5.92
River Mile: 50.21
Analysis Case With Project Cutoff Wall

Crest Elev.: 35.05
L/S Toe Elev.: 15.45
W/S Toe Elev.: 21.05

Analysis By: A. Deus
Checked By: H. Mulder
Date: 6/28/2012

Boring #	Blanket Thickness Variable (z)					Aquifer Thickness Variable (d)					Hydraulic Conductivity Vairables (Kb and Kf)								
	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Blanket Material	Blanket Kb (ft/day)	Aquifer Material Material	Aquifer Material Kf (ft/day)	Kf/Kb	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation
2F-05-G4-1	32					57.4					ML	0.14	SP/ML	25.13	180				
2F-05-G4-1A	32					63.5					ML	0.14	L/SM/SP/GP-G	24.85	178				
2F-05-G4-2	13.11					94					ML/SM	0.14	SM/SP/GW	20.88	149				
2F-05-G4-2A	16					67.2					ML	0.14	SM/SP/GP-GM	12.47	89				
K-S-4	9.75	19	9	111	47	95.25	83	16	911	19	CL/ML/ML/SM	0.028	SP/GP	29.51	1054	359	393	150273	98
2F-05-G4-3	16					96.8					CL/ML	0.028	SM/SP/GP	22.23	794				
2F-05-G4-3A	8.5					90					CL	0.028	SM/SP/GP-GM	20.99	750				
K-S-2	28					91					SM	0.709	SM/SP-SM/GP	15.12	21				
K-S-3	18.5					93.5					SM	0.709	SM/SP-SM/GM	13.54	19				

Boring #	Blanket Material 1 (lowest permeability)			Blanket Material 2			Transformed Blanket Thickness (z)	Aquifer Material 1			Aquifer Material 2			Aquifer Material 3			Transformed Aquifer Horizontal Permeability (kf)
	Material Type	Thickness (z)	Permeability (Kb)	Material Type	Thickness (z)	Permeability (Kb)		Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	
2F-05-G4-1	ML	32	0.14				32	SP	51.4	28	ML	6	0.57				25.13
2F-05-G4-1A	ML	32	0.14				32	ML/SM	9	2.8	SP	50	28	GP-GM	4.5	34	24.85
2F-05-G4-2	ML	10.8	0.14	SM	11.7	0.709	13.11	SM	33	2.8	SP	34	28	GW	27	34	20.88
2F-05-G4-2A	ML	16	0.14				16	SM	43.8	2.8	SP	13.4	28	GP-GM	10	34	12.47
K-S-4	CL/ML	6	0.028	ML/SM	18.75	0.14	9.75	SP	71.25	28	GP	24	34				29.51
2F-05-G4-3	CL	10	0.028	ML	30	0.14	16	SM	33	2.8	SP	18.3	28	GP	45.5	34	22.23
2F-05-G4-3A	CL	8.5	0.028				8.5	SM	31	2.8	SP	34	28	GP-GM	25	34	20.99
K-S-2	SM	28	0.709				28	SM	15	2.8	SP-SM	62.5	14	GP	13.5	34	15.12
K-S-3	SM	18.5	0.709				18.5	SM	19	2.8	SP-SM	66	14	GM	8.5	34	13.54

With Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Underseepage Reliability Analysis With Blanket Theory Analysis

Project: American River Common Features GRR
Study Area: Sacramento River
River Section: ARS Reach F Unit 1

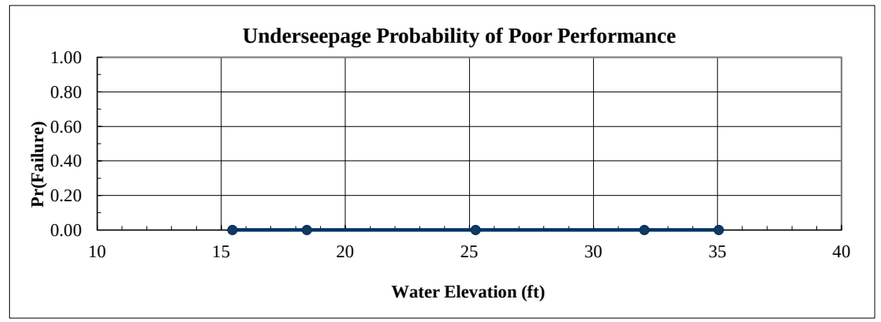
Levee Mile: 5.92
River Mile: 50.21
Analysis Case With Project Cutoff Wall

Crest Elev.: 35.05
L/S Toe Elev.: 15.45
W/S Toe Elev.: 21.05

Analysis By: A. Deus
Checked By: H. Mulder
Date: 6/28/2012

Random Variables			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Permaebility Ratio	359	352	98
Blanket Thickness (z)	19	9	47
Aquifer Thickness (d)	83	16	19

Blanket Theory Analysis Inputs					
Pr(f)=0	BTA Case No.	L1	L2	L3	γ Blanket
YES	7A	20	95	∞	112



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	15.45	0.0000
Toe+3ft	3.00	18.45	0.0000
Half Height	9.80	25.25	0.0000
Crest-3ft	16.60	32.05	0.0000
Crest	19.60	35.05	0.0000

Crest		Rh
Head =	19.60	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	359	19.00	83.00	20.00	752.42	0.0957	17.00			
2	711	19.00	83.00	20.00	1058.76	0.0707	17.68			
3	7	19.00	83.00	19.77	106.41	0.3753	9.43			
4	359	28.00	83.00	20.00	913.41	0.0807	17.41			
5	359	10.00	83.00	19.99	545.87	0.1256	16.19			
6	359	19.00	99.00	20.00	821.75	0.1057	17.19			
7	359	19.00	67.00	19.99	676.02	0.0847	16.75			
								Total		

E[I] =
Var[I]=
σ[I]=
V(I) =

E[ln I] =
σ [ln I] =

Ic=	0.80

ln(I crit) = -0.223144

β =	
F(z) =	
Pr(f) % =	0.000000

Crest-3ft		Rh
Head =	16.60	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	359	19.00	83.00	20.00	752.42	0.0957	14.40			
2	711	19.00	83.00	20.00	1058.76	0.0707	14.97			
3	7	19.00	83.00	19.77	106.41	0.3753	7.99			
4	359	28.00	83.00	20.00	913.41	0.0807	14.74			
5	359	10.00	83.00	19.99	545.87	0.1256	13.71			
6	359	19.00	99.00	20.00	821.75	0.1057	14.56			
7	359	19.00	67.00	19.99	676.02	0.0847	14.19			
								Total		

E[I] =
Var[I]=
σ[I]=
V(I) =

E[ln I] =
σ [ln I] =

Ic=	0.80

ln(I crit) = -0.223144

β =	
F(z) =	
Pr(f) % =	0.000000

Half Height		Rh
Head =	9.80	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	359	19.00	83.00	20.00	752.42	0.0957	8.50			
2	711	19.00	83.00	20.00	1058.76	0.0707	8.84			
3	7	19.00	83.00	19.77	106.41	0.3753	4.71			
4	359	28.00	83.00	20.00	913.41	0.0807	8.70			
5	359	10.00	83.00	19.99	545.87	0.1256	8.09			
6	359	19.00	99.00	20.00	821.75	0.1057	8.60			
7	359	19.00	67.00	19.99	676.02	0.0847	8.38			
								Total		

E[I] =
Var[I]=
σ[I]=
V(I) =

E[ln I] =
σ [ln I] =

Ic=	0.80

ln(I crit) = -0.223144

β =	
F(z) =	
Pr(f) % =	0.000000

Toe+3ft		Rh
Head =	3.00	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	359	19.00	83.00	20.00	752.42	0.0957	2.60			
2	711	19.00	83.00	20.00	1058.76	0.0707	2.71			
3	7	19.00	83.00	19.77	106.41	0.3753	1.44			
4	359	28.00	83.00	20.00	913.41	0.0807	2.66			
5	359	10.00	83.00	19.99	545.87	0.1256	2.48			
6	359	19.00	99.00	20.00	821.75	0.1057	2.63			
7	359	19.00	67.00	19.99	676.02	0.0847	2.56			
								Total		

E[I] =
Var[I]=
σ[I]=
V(I) =

E[ln I] =
σ [ln I] =

Ic=	0.80

ln(I crit) = -0.223144

β =	
F(z) =	
Pr(f) % =	0.000000

With Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Through-Seepage Reliability Analysis With Khilar's Extended Model

Project: American River Common Features GRR
Study Area: Sacramento River
River Section: ARS Reach F Unit 1

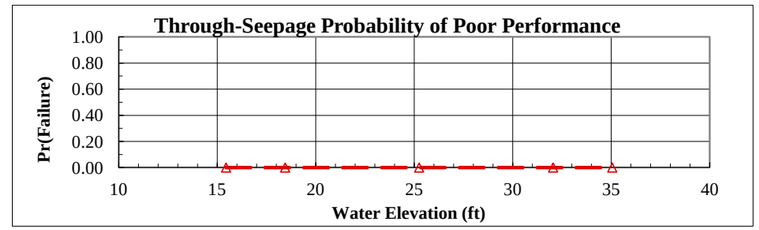
Levee Mile: 5.92
River Mile: 50.21
Analysis Case With Project Cutoff Wall

Crest Elev.: 35.05
L/S Toe Elev.: 15.45
W/S Toe Elev.: 21.05

Analysis By: A. Deus
Checked By: H. Mulder
Date: 6/28/2012

Random Variables - Silty Sand (SM) and Sand (SP) Levee			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Tractive Stress (Tc)	0.8	0.1	10.00
Initial Porosity (n)	0.35	0.04	10.00
Intrinsic Permeability (Ko)	5.00E-07	1.50E-07	30.00

Pr(f)=0
YES



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	15.45	0.0000
Toe+3ft	3.00	18.45	0.000000
Half Height	9.80	25.25	0.000000
Crest-3ft	16.60	32.05	0.000000
Crest	19.60	35.05	0.000000

Crest | **Head =** 19.60 | **Horizontal Gradient (Ix) =** 0.000

Run	Tractive Stress (Tc)	Initial Porosity (n)	Intrinsic Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	0.80	0.35	5.00E-07	0.24			
2	0.72	0.35	5.00E-07	0.22			
3	0.88	0.35	5.00E-07	0.27			
4	0.80	0.32	5.00E-07	0.23			
5	0.80	0.39	5.00E-07	0.25			
6	0.80	0.35	3.50E-07	0.29			
7	0.80	0.35	6.50E-07	0.21			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

Crest-3ft | **Head =** 16.60 | **Horizontal Gradient (Ix) =** 0.000

Run	Tractive Stress (Tc)	Initial Porosity (n)	Intrinsic Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	0.80	0.35	5.00E-07	0.24			
2	0.72	0.35	5.00E-07	0.22			
3	0.88	0.35	5.00E-07	0.27			
4	0.80	0.32	5.00E-07	0.23			
5	0.80	0.39	5.00E-07	0.25			
6	0.80	0.35	3.50E-07	0.29			
7	0.80	0.35	6.50E-07	0.21			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

Half Height | **Head =** 9.80 | **Horizontal Gradient (Ix) =** 0.000

Run	Tractive Stress (Tc)	Initial Porosity (n)	Intrinsic Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	0.80	0.35	5.00E-07	0.24			
2	0.72	0.35	5.00E-07	0.22			
3	0.88	0.35	5.00E-07	0.27			
4	0.80	0.32	5.00E-07	0.23			
5	0.80	0.39	5.00E-07	0.25			
6	0.80	0.35	3.50E-07	0.29			
7	0.80	0.35	6.50E-07	0.21			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

Toe+3ft | **Head =** 3.00 | **Horizontal Gradient (Ix) =** 0.000

Run	Tractive Stress (Tc)	Initial Porosity (n)	Intrinsic Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	0.80	0.35	5.00E-07	0.24			
2	0.72	0.35	5.00E-07	0.22			
3	0.88	0.35	5.00E-07	0.27			
4	0.80	0.32	5.00E-07	0.23			
5	0.80	0.39	5.00E-07	0.25			
6	0.80	0.35	3.50E-07	0.29			
7	0.80	0.35	6.50E-07	0.21			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

With Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Landside Long-Term Stability Analysis With UTEXAS4

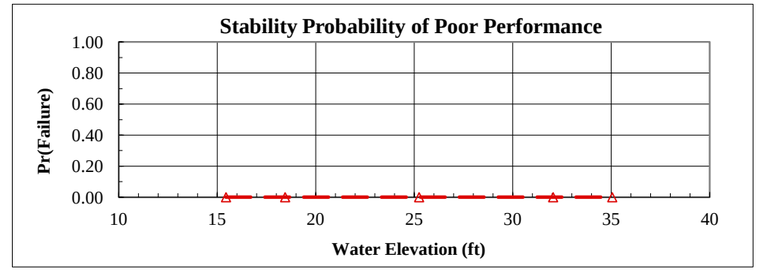
Project: American River Common Features GRR
Study Area: Sacramento River
River Section: ARS Reach F Unit 1

Levee Mile: 5.92
River Mile: 50.21
Analysis Case With Project Cutoff Wall

Crest Elev.: 35.05
L/S Toe Elev.: 15.45
W/S Toe Elev.: 21.05

Analysis By: A. Deus
Checked By: H. Mulder
Date: 6/28/2012

Random Variables			
Parameter	**Expected Value**	**Standard Deviation**	**Coefficient of Variation, %**
Levee Φ	34	4	13.00
Levee Cohesion	0	0	40.00
Levee γ	125	9	7.00
Foundation Φ	28	4	13.00
Foundation Cohesion	0	0	40.00



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	15.45	0.0000
Toe+3ft	3.00	18.45	0.000000
Half Height	9.80	25.25	0.000000
Crest-3ft	16.60	32.05	0.000000
Crest	19.60	35.05	0.000001

Crest	Head =	19.60	Pr(f)=0	NO

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	34	0	125	28	0	1.37		
2	30	0	125	28	0	1.28	0.005625	71.62
3	38	0	125	28	0	1.43		
4	34	0	125	28	0	1.37	0.000000	0.00
5	34	0	125	28	0	1.37		
6	34	0	116	28	0	1.39	0.000380	4.84
7	34	0	134	28	0	1.35		
8	34	0	125	24	0	1.43	0.001849	23.54
9	34	0	125	32	0	1.52		
10	34	0	125	28	0	1.37	0.000000	0.00
11	34	0	125	28	0	1.37		

E[FS] = 1.370000 E[ln FS] = 0.312723 Total 0.007854 100.00
Var[FS]= 0.007854
σ[FS]= 0.088624 σ[ln FS]= 0.064622
V(FS) = 0.064689
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	4.839286
F(z) =	0.000001
Pr(f) % =	0.000065

Crest-3ft	Head =	16.60	Pr(f)=0	YES

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	34	0	125	28	0			
2	30	0	125	28	0			
3	38	0	125	28	0			
4	34	0	125	28	0			
5	34	0	125	28	0			
6	34	0	116	28	0			
7	34	0	134	28	0			
8	34	0	125	24	0			
9	34	0	125	32	0			
10	34	0	125	28	0			
11	34	0	125	28	0			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	
F(z) =	
Pr(f) % =	0.000000

Half Height	Head =	9.80	Pr(f)=0	YES

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	34	0	125	28	0			
2	30	0	125	28	0			
3	38	0	125	28	0			
4	34	0	125	28	0			
5	34	0	125	28	0			
6	34	0	116	28	0			
7	34	0	134	28	0			
8	34	0	125	24	0			
9	34	0	125	32	0			
10	34	0	125	28	0			
11	34	0	125	28	0			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	
F(z) =	
Pr(f) % =	0.000000

Toe+3ft	Head =	3.00	Pr(f)=0	YES

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	34	0	125	28	0			
2	30	0	125	28	0			
3	38	0	125	28	0			
4	34	0	125	28	0			
5	34	0	125	28	0			
6	34	0	116	28	0			
7	34	0	134	28	0			
8	34	0	125	24	0			
9	34	0	125	32	0			
10	34	0	125	28	0			
11	34	0	125	28	0			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	
F(z) =	
Pr(f) % =	0.000000

With Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Judgment Probability of Poor Performance Curve

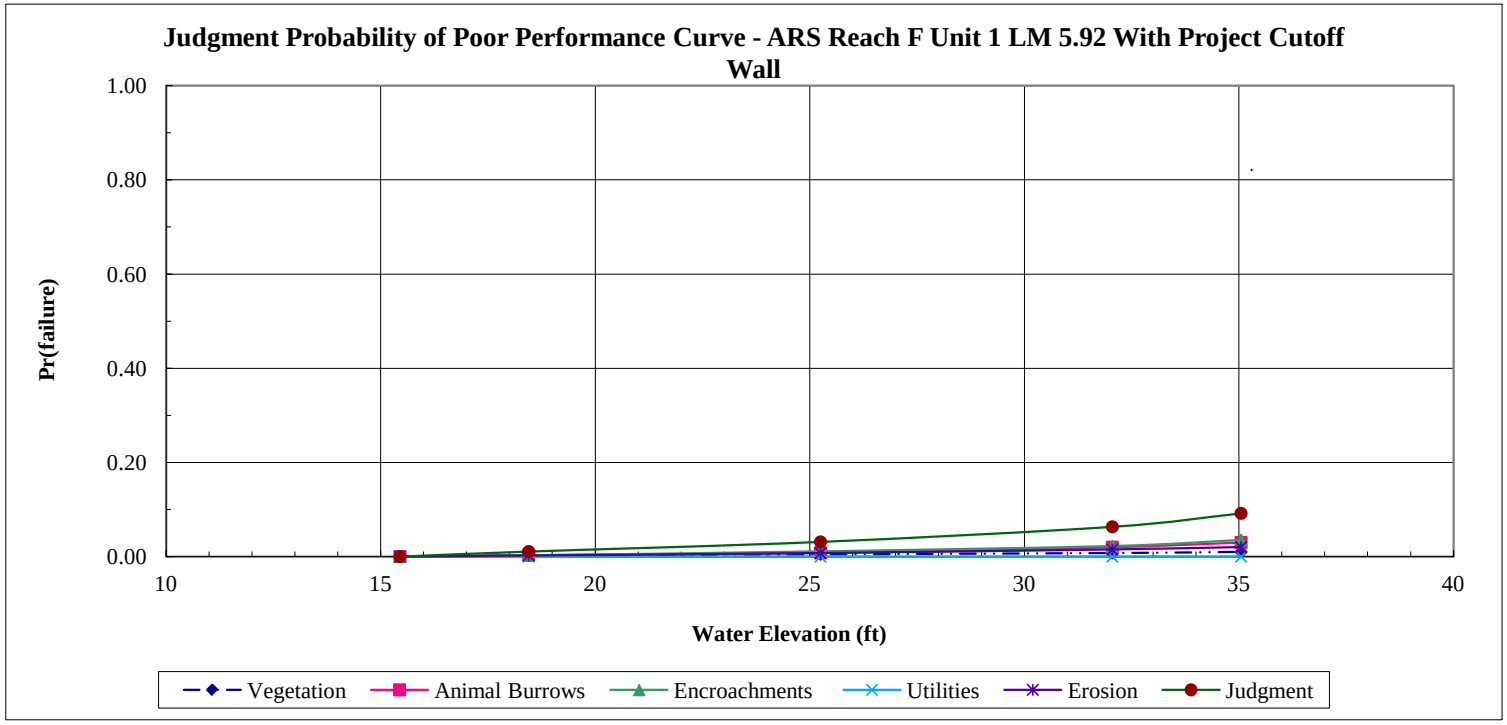
Project: American River Common Features GRR
Study Area: Sacramento River
River Section: ARS Reach F Unit 1

Levee Mile: 5.92
River Mile: 50.21
Analysis Case: With Project Cutoff Wall

Crest Elev.: 35.05
L/S Toe Elev.: 15.45
W/S Toe Elev.: 21.05

Analysis By: A. Deus
Checked By: H. Mulder
Date: 6/28/2012

Water Surface Elevation	Vegetation		Animal Burrows		Encroachments		Utilities		Erosion		Judgment	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
15.45	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
18.45	0.0025	0.9975	0.0030	0.9970	0.0028	0.9972	0.0000	1.0000	0.0025	0.9975	0.0107	0.9893
25.25	0.0050	0.9950	0.0080	0.9920	0.0112	0.9889	0.0000	1.0000	0.0075	0.9925	0.0313	0.9687
32.05	0.0075	0.9925	0.0200	0.9800	0.0223	0.9777	0.0000	1.0000	0.0150	0.9850	0.0633	0.9367
35.05	0.0100	0.9900	0.0300	0.9700	0.0350	0.9650	0.0000	1.0000	0.0200	0.9800	0.0918	0.9082



With Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

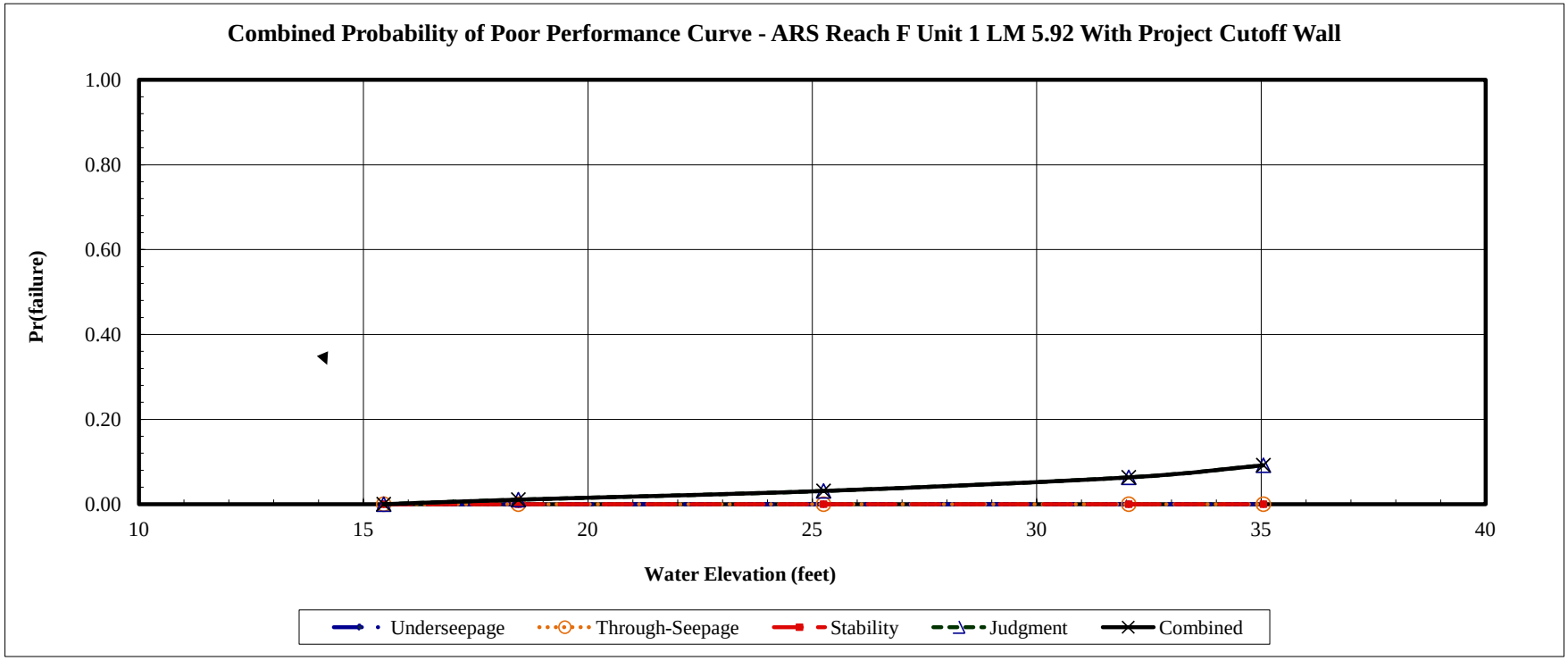
Project: American River Common Features GRR
Study Area: Sacramento River
River Section: ARS Reach F Unit 1

Levee Mile: 5.92
River Mile: 50.21
Analysis Case: With Project Cutoff Wall

Crest Elev.: 35.05
L/S Toe Elev.: 15.45
W/S Toe Elev.: 21.05

Analysis By: A. Deus
Checked By: H. Mulder
Date: 6/28/2012

Water Surface	Underseepage		Through-Seepage		Stability		Judgment		Combined	
Elevation	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
15.45	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
18.45	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0107	0.9893	0.0107	0.9893
25.25	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0313	0.9687	0.0313	0.9687
32.05	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0633	0.9367	0.0633	0.9367
35.05	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0918	0.9082	0.0918	0.9082

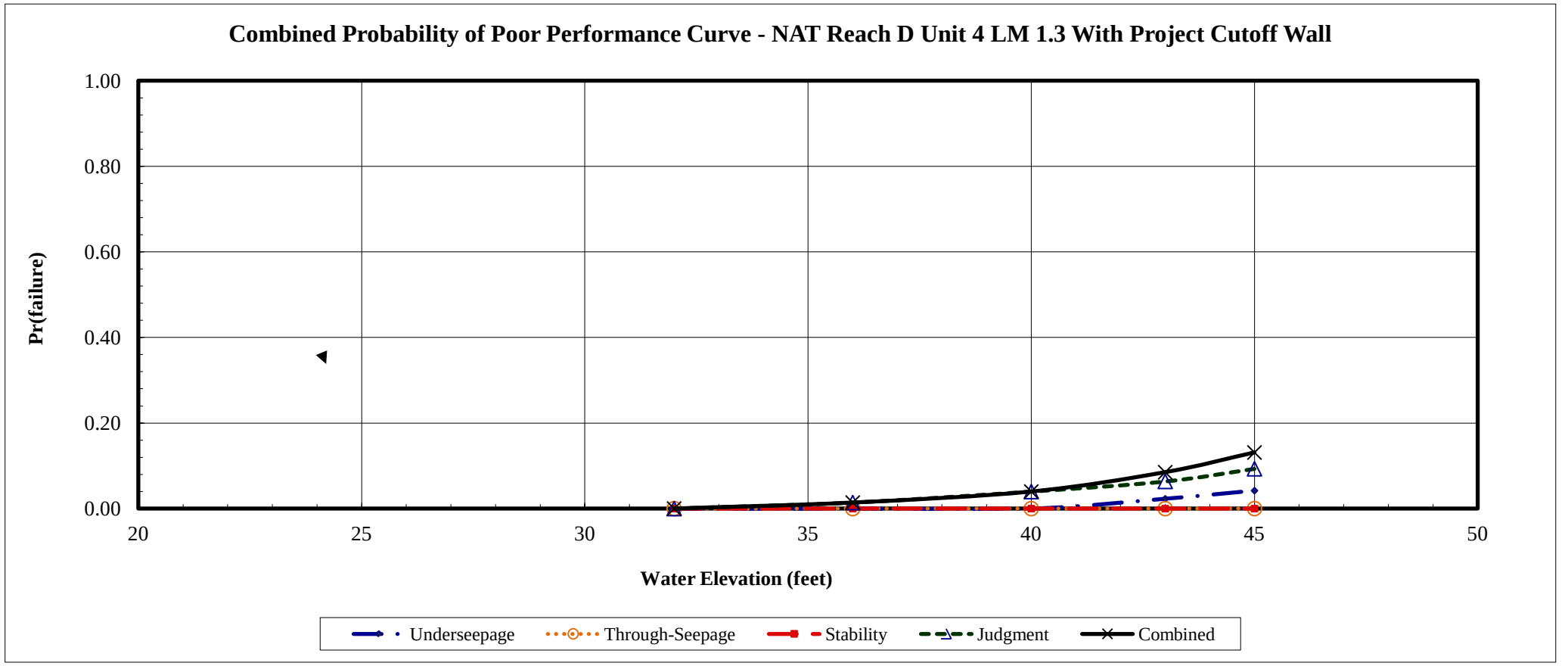


With Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

Project: American River Common Features GRR
Study Area: Sacramento River
River Section: NAT Reach D Unit 4

Levee Mile: 1.30
River Mile: 3.10
Analysis Case: With Project Cutoff Wall

Crest Elev.: 45.00
L/S Toe Elev.: 29.00
W/S Toe Elev.:

Analysis By: M. Perlea
Checked By: M. Kynett
Date:

Water Surface Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
32.00	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
36.00	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0140	0.9860	0.0140	0.9860
40.00	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0398	0.9602	0.0398	0.9602
43.00	0.0230	0.9770	0.0000	1.0000	0.0000	1.0000	0.0635	0.9365	0.0850	0.9150
45.00	0.0420	0.9580	0.0000	1.0000	0.0000	1.0000	0.0931	0.9069	0.1312	0.8688