

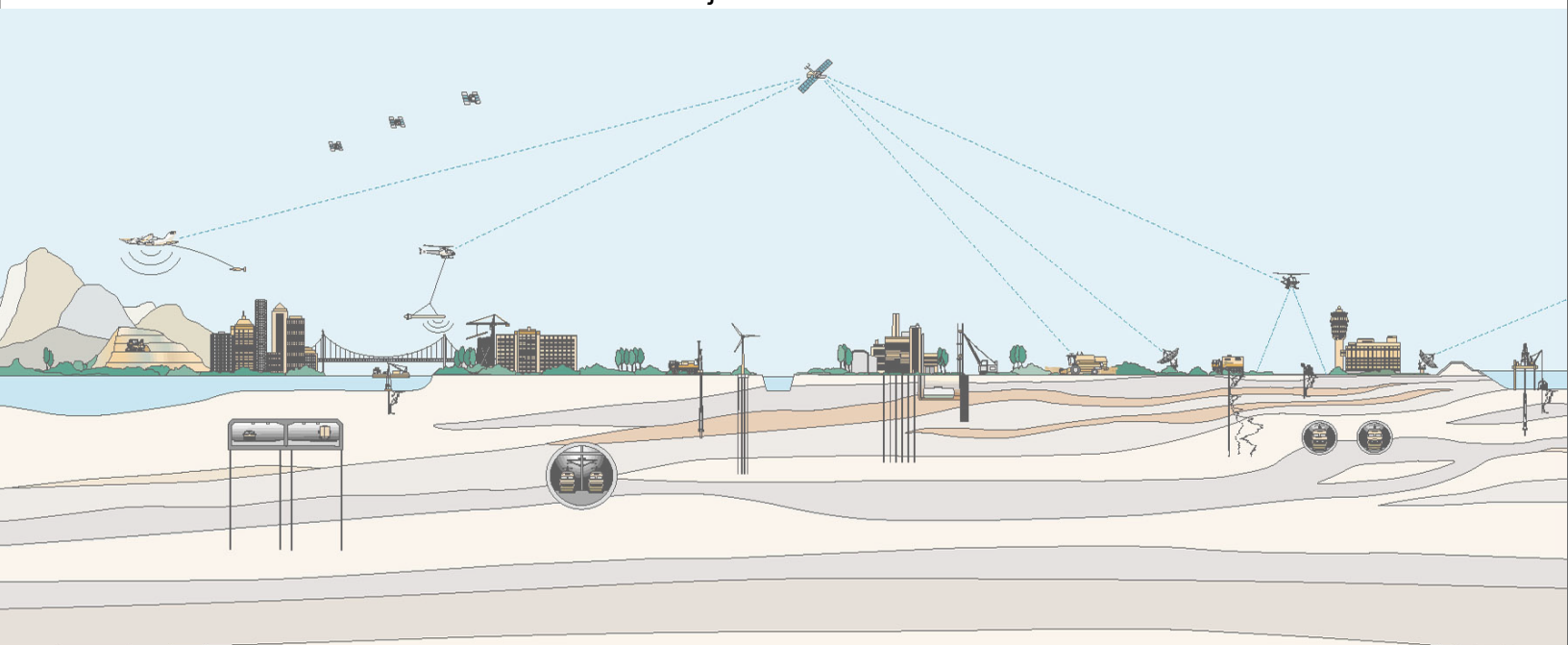
BLUE LAKE LEVEE GEOTECHNICAL EVALUATION PROJECT CITY OF BLUE LAKE & HUMBOLDT COUNTY, CALIFORNIA

Prepared for:
HUMBOLDT COUNTY,
PUBLIC WORKS DEPARTMENT
&
CITY OF BLUE LAKE

Prepared by:
Fugro Consultants, Inc.
660 Clarion Court, Suite A
San Luis Obispo, CA 93401
&
CGI Technical Services, Inc.
1612 Wedding Way
Redding, CA 96003

February 2015

Fugro Project No. 04.62140035
CGI Project No. 14-1949.02



February 9, 2015

Fugro Project No. 04.62140035
CGI Project No. 14-1949.02

Humboldt County Public Works Department
1106 Second Street
Eureka, California 95501

Attention: Mr. Hank Seemann, Environmental Services Manager

Subject: Geotechnical Report, Blue Lake Levee Geotechnical Evaluation Project, City of
Blue Lake and Humboldt County, California

Dear Mr. Seemann:

CGI Technical Services, Inc., in conjunction with Fugro Consultants, Inc., is pleased to present this Geotechnical Report for the Blue Lake Levee Geotechnical Evaluation Project located in the City of Blue Lake and unincorporated Humboldt County, California. This report is being submitted in accordance with the Agreement for Professional Services established between CGI and the County under County Project No. 251058.

This report summarizes the geotechnical engineering analyses performed to evaluate the levees for their ability to function in accordance with current United States Army Corps of Engineers performance guidelines and presents remedial-concept recommendations, where appropriate. In addition, this report also discusses field explorations performed, laboratory testing results, and general subsurface conditions encountered at the site during this study.

Please call if further information is required or if we can answer any questions.

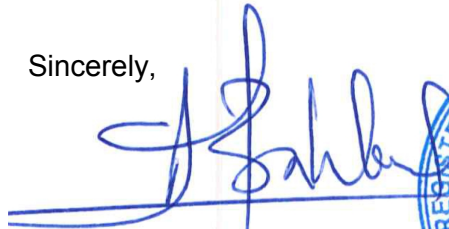
CGI TECHNICAL CONSULTANTS, INC.

James A. Bianchin, P.E., C.E.G.
Principal Engineering Geologist

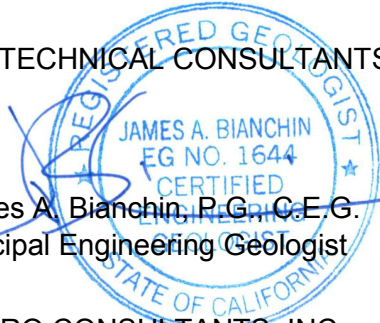
FUGRO CONSULTANTS, INC

Gresham D. Eckrich, P.E., C.E.G.
Senior Project Engineer/Geologist

Sincerely,



Azeddine Bahloul, P.E., G.E.
Principal Geotechnical Engineer



Copies Submitted: (3) Addressee and a digital file in PDF format

LIST OF ACRONYMS AND ABBREVIATIONS

ASTM	ASTM International
bgs	Below Ground Surface
cfs	Cubic feet per second
CGS	California Geologic Survey
CPT	Cone Penetration Test
CRR	Cyclic Resistance Ratio
CSR	Cyclic Stress Ratio
EI.	Elevation
FS	Factor of Safety
GIS	Geographic Information System
h:v	Horizontal:Vertical
NAVD88	North American Vertical Datum of 1988
NCEER	National Center for Earthquake Engineering Research
PHGA	Peak Horizontal Ground Acceleration
Station	Survey Station
SPT	Standard Penetration Test
USA	Underground Service Alert
USACE	United States Army Corps of Engineers
USGS	United States Geological Survey

CONTENTS

	Page
EXECUTIVE SUMMARY	ES-1
Summary of Findings and Recommendations	ES-2
Opinion Regarding Geotechnical Aspects of Levee Certification	ES-3
1.0 INTRODUCTION.....	1-1
1.1 Project Description.....	1-1
1.2 Purpose and Scope of Services.....	1-2
1.2.1 Data Review, Site Reconnaissance, and Access Coordination	1-3
1.2.2 Field Exploration	1-3
1.2.3 Laboratory Testing	1-4
1.2.4 Geotechnical Analyses and Evaluation	1-4
1.3 Authorization.....	1-4
1.4 Limitations	1-4
2.0 SITE DESCRIPTION.....	2-1
2.1 Station Nos. 0+00 (Downstream Terminus) to 24+50	2-1
2.2 Station Nos. 24+50 to 63+00	2-1
2.3 Station Nos. 63+00 to 77+00	2-3
3.0 FIELD EXPLORATION.....	3-1
3.1 Field Exploration Planning	3-1
3.1.1 Review of Previous Reports.....	3-1
3.1.2 Exploration Plan.....	3-2
3.1.3 Site Access & Permitting.....	3-3
3.1.4 Site Visit and Utility Clearance	3-3
3.2 Exploration Program	3-3
3.2.1 Subsurface Exploration	3-3
3.3 Reference Datum.....	3-4
3.4 Investigation Derived Cuttings Disposal.....	3-7
4.0 LABORATORY TESTING PROGRAM	4-1
5.0 GEOLOGIC AND SUBSURFACE CONDITIONS	5-1
5.1 Regional Setting	5-1
5.2 Local Geologic Setting.....	5-1
5.3 Geomorphology & Channel Degradation	5-2
5.4 Subsurface Conditions.....	5-3
5.4.1 Earth Materials.....	5-3
5.4.2 Groundwater	5-5
6.0 SEISMIC DESIGN CRITERIA	6-1
6.1 Strong Ground Motion	6-1
6.2 Surface Fault Rupture.....	6-1

7.0	CROSS SECTIONS FOR ANALYSES	7-1
8.0	GEOTECHNICAL ANALYSES	8-1
8.1	Liquefaction	8-1
8.1.1	Liquefaction Triggering Analyses per NCEER (1998).....	8-1
8.1.2	Seismic Settlement per Ishihara and Yoshimine (1992)	8-1
8.1.3	Seismically Induced Dry Settlement per Pradel (1998).....	8-2
8.1.4	Results.....	8-2
8.2	Permeability and Seepage.....	8-2
8.2.1	Through-Seepage Analyses.....	8-3
8.2.2	Underseepage Analyses	8-4
8.3	Slope Stability.....	8-5
8.3.1	USACE Acceptable Slope Stability Criteria	8-6
8.3.2	Methodology	8-7
8.4	Seismic Deformation.....	8-8
8.5	Settlement	8-9
9.0	CONCLUSIONS AND RECOMMENDATIONS.....	9-1
9.1	Vegetation And Erosion	9-1
9.2	Liquefaction And Seismically Induced Settlement.....	9-2
9.3	Permeability And Seepage	9-2
9.3.1	Underseepage	9-2
9.3.2	Through-Seepage.....	9-4
9.3.3	Design Considerations.....	9-5
9.4	Slope Stability.....	9-5
9.4.1	Existing	9-5
9.4.2	Pseudo-Static	9-5
9.4.3	Full Flood Event.....	9-6
9.4.4	Rapid Drawdown.....	9-6
9.5	Seismic Deformation.....	9-7
9.6	Seepage Mitigation Concepts.....	9-7
9.7	Static Settlement	9-9
10.0	REFERENCES.....	10-1

TABLES

	Page
Table 1-1. Explorations Performed for Study.....	1-3
Table 3-1. USACE Pre-Levee Construction Explorations	3-2
Table 3-2. Subsurface Exploration Summary	3-4
Table 3-3. CPT Nonperformance	3-6
Table 4-1. Summary of Laboratory Tests Performed on Selected Samples	4-1
Table 5-1. Groundwater Level Observations in Study Explorations	5-5
Table 5-2. Groundwater Data Reported by Others	5-6
Table 6-1. Fault Activity Ratings.....	6-1
Table 7-1. Cross Section Station Numbers	7-1
Table 8-1. Seismically Induced Settlement Analyses Results.....	8-2
Table 8-2. Summary of Results for Through-Seepage Analyses	8-4
Table 8-3. Summary of Results for Underseepage Analyses	8-5
Table 8-4. Minimum Acceptable Factor of Safety Values	8-7
Table 8-5. Summary of Slope Stability Analyses Results	8-8
Table 9-1. Time Stages of Transient Analyses at Station 34+00	9-4
Table C-1. Summary of Fugro Laboratory Testing Program	C-1
Table C-2. Summary of CGI Laboratory Testing Program	C-1

PLATES

	Plate
Vicinity Map	1-1
Exploration Location Plan	2-1
Geologic Map.....	5-1
Regional Faults	5-2
Cross Sections.....	5-3
Levee Profile	5-4
Landside Profile	5-5
Key to Cross Sections and Profiles	5-6
Groundwater Elevations.....	5-7

APPENDICES

APPENDIX A	HISTORICAL BORING LOGS, LABORATORY DATA, AND PLANS	
	Sheet No. 1: Plan of Improvement	A-1
	Sheet 1: Plan and Details (As Constructed)	A-2
	Sheets 7: Typical Levee Sections (As Constructed).....	A-3
	Plate B-1: Locations of Explorations and Typical Sections	A-4
	Plate B-2: Logs of Exploration Holes	A-5
	Table B-1: Summary of Soil Tests, Borrow Materials	A-6
	Table B-2: Summary of Soil Tests, Foundation Materials	A-7
	Historical 1962 Design Values.....	A-8
	Plate A-3: Hydrologic Data, Standard Project Flood.....	A-9
APPENDIX B	FIELD EXPLORATION	
	Key to Terms & Symbols Used on Logs	B-1
	Logs of Drill Holes	B-2
	Key to CPT Logs	B-4
	Logs of CPTs.....	B-4 through B-11
APPENDIX C	LABORATORY TEST RESULTS	
	Summary of Laboratory Test Results	C-1a through C-1c
	Grain Size Curves	C-2a through C-2f
	Plasticity Chart	C-3a through C-3b
	Hydraulic Conductivity	C-4a through C-4f
	Direct Shear Test Results.....	C-5a through C-5n
	Isotropically Consolidated, Undrained Triaxial Test Results.....	C-6a and C-6b
	Consolidation Test Results.....	C-7
	Compaction Test Results	C-8
APPENDIX D	GEOTECHNICAL ANALYSES	
	Soil Parameter Synthesis	D-1 through D-16
	Liquefaction Analysis Results.....	D-17 through D-24
APPENDIX E	SLIDE OUTPUT	

EXECUTIVE SUMMARY

The purpose of our investigation was to explore subsurface conditions at the project site to aid the County and City in evaluating the ability of the Blue Lake Levee system to function in accordance with current FEMA/USACE performance criteria. To achieve this objective, CGI/Fugro performed a subsurface exploration, laboratory testing, and engineering analyses in accordance with the standards of FEMA (2008), and USACE (2013, 2010a, 2008, 2005, 2003, and 2000a).

The following paragraphs summarize the analyses that were performed to assess the geotechnical aspects of the levee system and include brief summaries of our findings. It should be noted that our analyses addressed the geotechnical aspects of flood control protection for the 100-year recurrence interval (or 1% annual chance exceedance) flood event for the Blue Lake Levee system. Our evaluation did not address the hydrologic, hydraulic, or any other aspects of flood protection for the levee system.

Liquefaction and Seismic Settlement Potential. Based on our analysis, there is a potential for liquefaction and seismically induced dry settlement of the pervious foundation material during the design seismic event. The maximum estimated liquefaction and seismically induced dry settlements are approximately 7½ inches and 1 inch, respectively. For pseudo-static slope stability analyses, undrained residual strength parameters were estimated for potentially liquefiable strata.

Underseepage. For our seepage evaluation, the potential for underseepage was evaluated for steady-state flood stage conditions. Based on the results of our seepage analyses, the section at Station 71+00 does not meet performance criteria defined by USACE (2005). The estimated levee landside toe vertical exit gradient at Station 71+00 is about 0.8, which exceeds the USACE minimum allowable exit gradient of 0.5. That vertical exit gradient was estimated using generalized permeability parameters because site-specific permeability test samples were not available at Station 71+00. Furthermore, an impermeable bedrock boundary condition was modeled at that section due to the close proximity of bedrock towards the north and that boundary condition likely imposes greater seepage forces than actually exist. To refine site-specific permeability data at Station 71+00 and to better evaluate the potential for underseepage, we recommend that an additional drill hole be advanced to obtain samples for further permeability testing. It should be noted, as discussed below, that steady state analyses may represent improbable, excessively conservative geotechnical conditions for the Blue Lake Levee system.

Through-Seepage. The potential for through-seepage was evaluated for steady-state flood stage conditions. Based on the results of our analyses, through-seepage potential likely exists at Stations 22+00, 34+00 and 71+00. At Station 22+00, the phreatic surface was estimated to daylight on the landside slope about 2 feet above the landside toe. However, the phreatic surface daylights within an interior drainage ditch, and it is our opinion through-seepage is unlikely to destabilize the levee if the interior drainage ditch is filled with water when the phreatic surface emerges at that elevation. At Stations 34+00 and 71+00, the phreatic surface

was estimated to daylight on the landside slope about 1½ feet and 1 foot above the landside toe, respectively, assuming steady state conditions develop during the design 100-year event. As discussed below, steady state analyses may represent improbable, excessively conservative geotechnical conditions for the Blue Lake Levee system.

Slope Stability. Our slope stability analyses indicated that the slopes evaluated are generally stable for each of the conditions discussed in Section 8.3.1, with the exception of two slopes: the estimated FS for the Station 22+00 landside slope during full flood conditions is less than 1.4, and the estimated FS for the Station 34+00 waterside slope during sudden drawdown conditions is less than 1.0. However, slope stability analyses for these conditions assumed phreatic surfaces based on the results of steady state seepage evaluations. As noted below, phreatic surfaces corresponding to steady state conditions are not anticipated to develop during the design flood event.

Seismic Deformation. Based on the results of pseudo-static slope stability analyses, minimal or negligible seismic displacements are anticipated for the design seismic event.

SUMMARY OF FINDINGS AND RECOMMENDATIONS

On the basis of field observations, subsurface exploration, laboratory testing and engineering analyses performed for this investigation, the Blue Lake Levee system is generally capable of providing flood control protection to adjacent improvements. Based on our evaluation, three sections of the levee may be susceptible to seepage-related failure or instability if steady state seepage phreatic surfaces develop during the design storm event. However, it is our opinion that steady state conditions are generally not representative of anticipated base flood conditions for the Blue Lake Levee system, and that transient analyses will more accurately model the development of phreatic surfaces and pore pressures during a full flood event.

Although USACE guidance documents do not explicitly specify that seepage evaluations shall be performed considering only steady state conditions, USACE (2000a) specifies that slope stability analyses for steady seepage from full flood stage conditions (Case III) assume the water remains at or near full flood stage long enough so that the embankment becomes fully saturated. DWR (2010) states that a phreatic surface lower than the steady state phreatic surface may be justified for slope stability analysis depending on the duration of the design hydrograph, the composition and dimension and the levee's performance history. In addition, DWR (2012) notes that deviations from use of a steady-state phreatic surface for levees subjected to river stage loading for short durations must be substantiated through appropriate presentation of information such as hydraulic data, field piezometric data, and engineering evaluations.

The standard project flood hydrograph presented in USACE (1962) shows a flood duration of approximately 4 days, with peak discharges generally occurring over an approximately 36-hour period. Relative to levee performance history, the County of Humboldt (2014) notes the levee was damaged but did not fail during a major flood event in December 1964 between about Station Nos. 15+00 and 24+00. The estimated flow for the 1964 event was

up to approximately 81,000 cfs near Arcata; although this flow estimate was recorded downstream of Blue Lake, it should be noted this estimate exceeds the estimated flow for the 100-year flood event at Blue Lake (NHE, 2014).

Additionally, DWR (2010) notes that the lowest phreatic that could normally be justified for a homogeneous levee would be along a straight line extending from the landside levee toe to where the design water surface intersects the levee slope. Based on our subsurface exploration and review of as-constructed plans (1956, 1962), the levee system is composed of impervious and pervious fill and therefore would not be considered homogeneous.

OPINION REGARDING GEOTECHNICAL ASPECTS OF LEVEE CERTIFICATION

Based on the results of our study, the levee system's ability to provide flood protection is likely sufficient considering nearly all conditions evaluated at the eight cross section locations. Potential deficiencies identified by our analyses are estimated outcomes if steady state flood conditions develop during the 100-year flood event at 3 of the evaluated locations. Measures to mitigate the development of potentially adverse steady seepage conditions are discussed in Section 9.7 of this report.

This study provided baseline information regarding the composition and performance of the Blue Lake levee system relative to quantitative USACE performance criteria. As detailed in the report, localized levee sections do not meet the USACE performance criteria for underseepage, through-seepage, and slope stability. Use of the USACE criteria is not required for certification of a levee for compliance with the FEMA standards defined at 44 CFR 65.10, but use of these criteria is commonly used for levee certification. The USACE criteria are based on the assumption of steady-state conditions, which for some rivers like the Mad River may be considered conservative. Further analyses using the assumption of transient conditions could be performed to obtain a more representative scenario of flood conditions. However, USACE has not formally defined performance criteria for transient analyses, and thus the results of transient analyses may not be sufficient for achieving certification to the FEMA standards. Further evaluation, beyond the scope of this technical study, would be needed to determine whether a qualified engineer could use the results of transient analyses to certify compliance with the FEMA standards. Additional technical analyses, additional site characterization, and/or implementation of mitigation measures may be needed before a qualified engineer would certify the levee.

1.0 INTRODUCTION

1.1 PROJECT DESCRIPTION

CGI Technical Services, Inc. (CGI), has been authorized by Humboldt County Department of Public Works (County) to perform a geotechnical investigation of the Blue Lake Levee system on the Mad River and North Fork of the Mad River. This geotechnical evaluation has been performed in conjunction with Fugro Consultants, Inc. (Fugro), and our team is henceforth referred to as CGI/Fugro throughout this report. Funding for this study was provided by the California Department of Water Resources Local Levee Assistance Program (LLAP), Humboldt County, and the City of Blue Lake.

The purpose of the project was to collect and analyze selected geotechnical information in order to estimate the stability of the levee foundation and embankment, and to evaluate the potential for settlement, through-seepage, underseepage, or erosion to cause instability. Available information prior to this study was not sufficient to assess these risks for the Blue Lake Levee. The results of the project will assist Humboldt County and City of Blue Lake (City) in assessing the public safety risks associated with the levee system and in determining whether the levee meets the embankment and foundation stability criteria of FEMA's National Flood Insurance Program standards at 44 CFR 65.10.

The Mad River is about 113 miles long and drains a watershed encompassing about 497 square miles. It is composed of three watershed areas (Upper, Middle, and Lower) and is partially regulated at Mathews Dam, which impounds Ruth Lake and is located in the Upper watershed area. The Mad River is composed of 13 sub-basins, one of which consists of the North Fork of the Mad River (North Fork), which confluences with the Mad River along the Blue Lake Levee. The North Fork sub-basin area encompasses about 48.8 square miles (Stillwater Sciences, 2010). The project site vicinity is shown on Plate 1-1.

The Blue Lake Levee system extends along the right river bank from about 2,500 feet west to 5,100 feet east of Hatchery Road. The segment located west of Hatchery Road is located within the City of Blue Lake and the remainder is in unincorporated Humboldt County. The western approximately 3,500 lineal feet of the levee fronts the Mad River, and the remainder fronts the North Fork. In total, the levee crosses nine separate parcels that include industrial, commercial, and agricultural grounds. For the Mad River, the estimated flow for the 100-year flood event is 67,600 cfs above the North Fork Mad River, and 74,700 cfs below North Fork Mad River (NHE, 2014).

Prior to the current levee construction, significant floods impacted the Blue Lake area in 1861, 1878, 1879, 1881, 1884, 1890, 1903, 1906, 1907, 1915, 1927, 1932, 1937, 1953, and 1955 (Tolhurst, 1995, Stillwater Sciences, 2010). The 1955 flood event had a peak flow of 77,800 cubic feet per second (cfs). The highest recorded flows on the Mad River, which were recorded at the Arcata Gaging Station, occurred during floods in 1964 (after construction of the levee) with estimated flows up to 81,000 cfs (Stillwater Sciences, 2010).

The Blue Lake Levee system is maintained and operated jointly by Humboldt County and the City. We understand that following construction of the levees, degradation of the Mad River channel bottom has occurred. A cross section performed at about the Hatchery Road Bridge between 1982 and 1991 indicated that up to about 9 feet of degradation has occurred within the channel at that location (Lehre et al., 1993).

Three pipeline penetrations are present within the levee: 1) a 36-inch corrugated metal pipe (CMP) located at the western end of the levee; 2) a 24-inch CMP at the northwestern terminus of the levee (shown on *Plan of Improvement, Plan-Profile & Sections* sheet within USACE, 1962); and 3) an 18-inch CMP located about 1,400 feet upstream of Hatchery Road Bridge. A stop-log structure associated with the former Arcata and Mad River Railroad penetrates the levee near its upstream terminus. That structure consists of concrete abutments, slab, and sill with wooden stoplogs constructed to reduce the flow of water through the structure.

We understand that vegetation growth along the waterside flanks of the levee system is regulated by environmental laws and regulation, and permitting issues have constrained, to some extent, the County's and City's ability to maintain the levee system in strict accordance with the Operations and Maintenance Manual prepared for the levee system (USACE, 1964). The levee system is considered a federal flood control project and the USACE performs annual inspections to determine the levee system's continued status in the federal Rehabilitation and Inspection Program. The levee system was rated "minimally acceptable" based on the USACE's 2012 routine inspection (USACE, 2013).

For the last 15 years, FEMA has been updating Flood Insurance Rate Maps and Flood Insurance Studies across the country. In order to be accredited on the FEMA Flood Insurance Rate Map, levee owners are required to provide information certified by a qualified engineer substantiating that the levee meets criteria set forth by the Code of Federal Regulations, Title 44, Section 65.10 and standards developed by FEMA and USACE. This study is intended to assist the County in obtaining accreditation or identifying needs for the levee system to obtain accreditation.

1.2 PURPOSE AND SCOPE OF SERVICES

The purpose of our investigation was to explore subsurface conditions at the project site to aid the County and City in evaluating the ability of the Blue Lake Levee system to function in accordance with current USACE performance criteria. To achieve this objective, CGI/Fugro performed subsurface exploration, laboratory testing, and engineering analyses.

Levee stability evaluations utilize standards established by the USACE's National Flood Risk Management Program through various policy letters, engineering circulars, and engineering manuals (USACE, 2010a). The primary USACE standards utilized during this study consist of the following:

- Engineering Circular 1110-2-6067, Certification of Levee Systems for the NFIP (2010a)

- REF10L0 Rev 2, Geotechnical Levee Practice (2008)
- ETL 1110-2-569, Design Guidance for Levee Underseepage (2005)
- EM 1110-2-1902, Slope Stability (2003)
- EM 1110-2-1913, Design and Construction of Levees (2000a)
- EM 1110-2-301, Guidelines for Landscape Planting and Vegetation Management at Floodwalls, Levees, and Embankment Dams (2000b)
- EM 1110-2-1914, Design, Construction, and Maintenance of Relief Wells (1992)
- EM 1110-2-1901, Determination of Permeability of Soil (1986)

References for those standards are included in Section 10.0 of this report. The scope of work for this study included the following:

1.2.1 Data Review, Site Reconnaissance, and Access Coordination

In preparation for the field exploration program, CGI/Fugro performed a site reconnaissance and reviewed historic data, aerial photographs, and other documents, maps, and existing geologic and geotechnical literature relevant to the site. In addition, we met with City and County representatives at the site to discuss exploration and cross section locations in the field.

Relevant geotechnical data from previous reports prepared by the USACE and local consultants, including site and subsurface descriptions, groundwater data, laboratory test results, drill hole logs, and as-built plans, were reviewed during the study. Further details regarding previous reports are presented in Section 3.0 and in Appendix A.

Prior to performing drill holes and cone penetrometer test (CPT) soundings, CGI obtained drilling permits from the County and contacted Underground Service Alert (USA) to help identify potential buried utility conflicts at the proposed exploration locations, as required by California law. In addition, we marked all exploration locations and worked with the County to coordinate access onto private properties.

1.2.2 Field Exploration

Field exploration consisted of advancing a total of 37 subsurface explorations at selected locations along the levee alignment. In total, we performed the following explorations for this study:

Table 1-1. Explorations Performed for Study

Exploration Type	Total Advanced
Cone Penetrometer Soundings	10
Hollowstem-Auger Drilling	27

The field exploration program was performed in April 2014. Locations of explorations are presented on Plate 2-1 and additional information regarding the field exploration program are presented in Section 3.0 and Appendix B.

1.2.3 Laboratory Testing

Laboratory testing was performed on selected soil samples obtained during the field exploration program. The types and numbers of tests were chosen to help classify and characterize selected subsurface soil characteristics and engineering properties. Further details regarding the laboratory testing program are presented in Section 4.0 and in Appendix C.

1.2.4 Geotechnical Analyses and Evaluation

Using data obtained from the data review, field exploration, and laboratory testing programs, CGI/Fugro performed geotechnical analyses, as specified in the scope of work, at eight cross sections established along the length of the Blue Lake Levee system. The analyses were consistent with geotechnical criteria specified by the USACE in EM 1110-2-1913 (USACE, 2000a), REFP10L0 (USACE, 2008) and EM 1110-2-569 (USACE, 2005). This report summarizes the geotechnical analyses and presents recommendations for remedial action where applicable. The following analyses were performed:

- Seismic Design Criteria (Section 6.0)
- Liquefaction Potential (Section 8.1)
- Permeability and Seepage (Section 8.2)
- Slope Stability (Section 8.3)
- Seismic Deformation (Section 8.4)
- Settlement (Section 8.5)

1.3 AUTHORIZATION

This study was authorized by the County in the Agreement for Professional Services under County Project No. 251058.

1.4 LIMITATIONS

The factual findings for this investigation, described herein, are applicable for the project description as contained in Section 1.1. The factual information presented in this report was documented by CGI/Fugro solely for the County for use in evaluating the ability of the existing Blue Lake Levee system within the project extent to function in accordance with current USACE performance criteria. Although information contained in this report may be of some use for other purposes, it may not contain sufficient information for other parties or other uses.

The scope of services did not include any environmental assessments for the presence or absence of hazardous/toxic materials in surface water, groundwater, or atmosphere. Any statements, or absence of statements, in this report or data presented herein regarding odors,

unusual or suspicious items, or conditions observed are strictly for descriptive purposes and are not intended to convey engineering judgment regarding potential hazardous/toxic assessment.

In performing our professional services, we have used generally accepted geologic and geotechnical engineering principles and have applied that degree of care and skill ordinarily exercised under similar circumstances, by reputable geotechnical engineers and engineering geologists currently practicing in this or similar localities. No other warranty, either express or implied, is made.

2.0 SITE DESCRIPTION

The Blue Lake Levee system extends from about 2,500 feet west of Hatchery Road to about 5,100 feet east of that road. This approximately 1.5-mile alignment of earthen embankment levee extends through relatively flat terrain within the Mad River Valley, as shown on Plate 2-1. The following sections describe the site conditions along segments of the levee system.

2.1 STATION NOS. 0+00 (DOWNSTREAM TERMINUS) TO 24+50

This lower reach of the levee system runs adjacent to Blue Lake Power, vacant City property, and industrial property operated by Calgon Carbon Corporation. The entire landside margin of this section is bounded by a drainage ditch, which flows west through the westerly penetration of the levee located at about Station No. 1+00. A chain-link fence and eucalyptus trees separate the drainage ditch from the industrial development and lands to the north. One access ramp extends north from the levee at approximately Station No. 15+00 and a corrugated metal pipeline allows drainage to flow westerly beneath the ramp.

The levee crown along this segment ranges in width from about 16 to 20 feet. It is unpaved from about Station Nos. 0+00 to 10+50 and paved with asphaltic concrete between about Station Nos. 10+50 and 24+50 where it intersects the Hatchery Road bridge. A locked gate keeping motorized vehicles off the crown is located at about Station 23+85 and the levee is used as a walking trail.

The waterside portion of this levee section is bounded by active and high-flow channels of the main stem of the Mad River. The active channel extends from about Station No. 17+00 to 24+50, and the high-flow channel of the river is located downstream of Station No. 17+00. Various trees in varying densities bound the river margin along the toe of the levee. One access ramp is located on the waterside section at about Station No. 12+30.

The landside banks along this segment of the levee system are covered with seasonal grasses and locally with brambles and shrubs. Waterside banks are covered with seasonal vegetation, local brambles, poison oak, and local shrubs. Trees and other larger vegetation are locally present along the waterside toe of the levee system. The landside levee embankments are generally inclined at about 2h:1v with some slight local variances in the slope inclinations. The waterside levee embankment is inclined at 2.5h:1v to 3h:1v and is generally lined with rip-rap.

2.2 STATION NOS. 24+50 TO 63+00

This section of the levee system extends east from Hatchery Road bridge. The landside portion of the levee crosses relatively flat agricultural lands used for grass and hay production and cattle grazing. One access ramp is located along the landside portion of the levee within this segment at about Station No. 49+50. A barbed-wire fence extends along the toe of the levee for its entire length along this segment. Brambles and shrubs are locally located at the toe of the landside slope. Seasonal grasses are located on the agricultural lands north of the

levee. A power pole servicing a possibly abandoned water well is located at about Station 38+50.

The waterside toe of the levee is bounded by the main Mad River channel and the North Fork of the Mad River. The confluence of those two drainages was located at about Station No. 28+00 at the time this study was performed. The channel for the Mad River and North Fork are located immediately at the toe of the levee from about Station Nos. 24+50 to 46+00. From Station Nos. 46+00 to 60+00, a point-bar is present along the levee toe creating a terrace ranging in width up to about 380 feet between the active channel and levee. The channel of the North Fork is immediately adjacent to the waterside levee toe between about Station Nos. 60+00 to 63+00. Various trees in varying densities bound the river margin along the toe of the levee. One access ramp is located on the waterside section at about Station No. 49+00.

The levee crown along this segment ranges in width from about 14 to 25 feet. The crown is unpaved along this segment. A locked gate keeping motorized vehicles off the crown is located at about Station No. 25+00 and the levee is used as a walking trail.

At one levee segment, between about Stations 32+00 and 35+00, we observed the waterside levee slope to be oversteepened and armored with relatively large riprap. The slope in this segment was inclined at about 1.5h:1v and extended directly into the river with no bench or apparent toe above the river margin. The crown in this segment was also wider by six to eight feet than the levee crown along the remainder of this portion of the levee. The oversteepening of this section of the levee could be due to one or both of the following reasons:

1. This segment is located near the confluence of the main stem and North Fork of the river, which might generate the greatest amount of scour and turbulent flow, thus resulting in erosion of the levee toe at this site. This condition might have been exacerbated by the degradation, or lowering, of the river thalweg, which has been documented as occurring historically in this stretch of the river. Repair of that erosion might have resulted in placement of the oversized riprap.
2. This segment of the levee is wider than the remaining segments of the river and may have been widened at some point without moving the toe of the waterside levee slope. That would result in a steepening of the waterside slope. If the levee crown is adjusted to 17 feet wide and the levee toe is located as observed during this study, then the waterside levee slope would be inclined at about 2h:1v.

Thus, it is unclear whether the oversteepening of the waterside slope between about Station Nos. 32+00 and 35+00 is due to erosion, widening of the levee crown, or both.

One penetration is present along this section at about Station No. 39+50. At this location, an 18-inch diameter corrugated metal pipe extends through the levee and has a flap-gate affixed to its discharge end at the waterside toe of the levee. A three-inch diameter aluminum irrigation pipeline was observed to have been pushed through the penetration and

extended though the flap-gate, wedging the flap-gate in an open position as long as that pipeline is present.

The landside banks along this segment of the levee system are covered with seasonal grasses and locally with brambles and shrubs. Waterside banks are covered with seasonal vegetation, local brambles, poison oak, and local shrubs. Trees and other larger vegetation are locally present along the waterside toe of the levee system. The landside levee embankments are generally inclined at about 1.8h:1v to 2h:1v with some slight local variances in the slope inclinations. The waterside levee embankment is inclined at 1.6h:1v to 3h:1v with the steepest waterside levee face section extending between about Station Nos. 30+00 to 40+00. The waterside levee face is generally lined with rip-rap.

2.3 STATION NOS. 63+00 TO 77+00

This easterly segment of the levee system extends along the North Fork of the Mad River. The landside portion of the levee crosses relatively flat agricultural lands used for grass and hay production and cattle grazing. No access ramps are located along the landside portion of the levee within this segment. A barbed-wire fence extends along the toe of the levee along the westerly portion of its length within this segment. Brambles and shrubs are locally located at the toe of the landside slope. Seasonal grasses are located on the agricultural lands located north of the levee.

The channel for the North Fork diverges south of the waterside toe along this segment and has a point-bar ranging in width up to about 680 feet from the active channel to the levee. Various trees in varying densities bound the river margin along the toe of the levee. At the eastern end of this segment, between about Station Nos. 74+00 and 76+50, various structures, trailers, and debris are present at the waterside levee toe and south of the toe. No access ramps are located on the waterside section of this segment.

The levee crown along this segment is about 15 feet and is unpaved. A locked gate keeping motorized vehicles and people off the crown is located at about Station No. 63+00. At the eastern terminus of the levee, at about Station No. 76+00, a concrete log-stop structure is present. This structure was a penetration for the Arcata and Mad River Railroad alignment that allowed the former railroad to extend past Blue Lake to Korbel.

The landside banks along this segment of the levee system are covered with seasonal grasses and locally with brambles, shrubs, and poison oak. Waterside banks are covered with seasonal vegetation, local brambles, poison oak, and local shrubs. Trees and other larger vegetation are locally present along the waterside toe of the levee system. The landside levee embankments are generally inclined at about 2h:1v with some slight local variances in the slope inclinations. The waterside levee embankment is inclined at about 2.5h:1v. The waterside levee face is generally not lined with rip-rap; however, rip-rap is located on what appeared to be former levee faces located south of the existing levee.

3.0 FIELD EXPLORATION

3.1 FIELD EXPLORATION PLANNING

3.1.1 Review of Previous Reports

The County provided us with the following documents for use in the geotechnical investigation (Humboldt County, 2014):

- Project report on Mad River at Blue Lake Levee project (USACE, 1953)
- Project report for Blue Lake Local Flood Protection Project (USACE, 1962)
- Mad River at Blue Lake Flood Control Project Operations and Maintenance Manual (USACE, 1956)
- Mad River at Blue Lake Flood Control Project Operations and Maintenance Manual (USACE, 1964)
- Annual USACE inspection reports for the levee system between 2012 and 2009
- Hydrologic analysis of the Mad River near Blue Lake (Northern Hydrology & Engineering, 2013)

These documents and additional reports are referenced in Section 10.0 of this report.

Relevant geotechnical information from the reports listed above was reviewed during the investigation, including site and subsurface descriptions, historical groundwater data, laboratory testing results, drill hole logs, and as-built plans. Data from previous reports reviewed for the Blue Lake Levee study are presented in Appendix A of this report.

According to the USACE (1953 and 1962), field exploration programs were conducted during the following periods:

- May 1953
- July 1954
- November 1961
- March 1962

In total, those exploration programs advanced 22 explorations to depths ranging from 1.5 to 25 feet. The explorations included hand-auger and auger drill holes. Table 3-1 presents information regarding explorations performed by the USACE (1966) prior to construction of the levee system. It should be noted that explorations were only reported within USACE (1953) and USCAE (1962), so delineating explorations that reportedly occurred in 1954 and 1961 could not be made.

Table 3-1. USACE Pre-Levee Construction Explorations

Exploration Period	Exploration No.	Type of Exploration	Depth Range (ft)
May 1953	1-a through 1-c, 2 through 11	Hand-augers and power augers	2.5' – 12'
March 1962	2F-1 through 2F-9	Hand-augers and power augers	1.5' – 25'

In all of the explorations reported by USACE, artificial fill and/or alluvium was encountered. Artificial fill consisted of levee embankment materials that predated the current levee configuration. The alluvium was not fully penetrated by any of their explorations. Alluvial soils range from clay to sandy gravel, with interbedded sandy clay, silt, clayey sand, fine silty sand, coarse silty sand, gravelly sand, and clayey gravel. Layers of decayed organic matter were reported in some drill holes within the upper approximately 10 feet of the ground surface.

Depths to groundwater within the exploration programs advanced by USACE ranged from about 3.5 to 15 feet below the existing ground surface at the time of exploration (USACE 1953; USACE, 1962).

3.1.2 Exploration Plan

CGI/Fugro prepared an exploration plan for performing and executing the subsurface exploration for this study. The plan was described, in general, in our proposal to provide geotechnical services for this study, and in greater detail in a spreadsheet and maps forwarded to the County on March 11, 2014. The work plan, spreadsheet, and maps detailed the following:

- Exploration numbers, locations, and methods, including:
 - CPT locations
 - Hollow-stem auger locations
- Station number for each exploration
- Relative locations on the levee, levee toe, or offsets for each exploration
- Target depths of each exploration
- The Assessor's Parcel Number (APN) and landowner name for proposed exploration locations
- Dates or date ranges that each exploration were to be performed
- Anticipated permits required for the explorations
- Methods of destruction of each exploration following completion

This information was used for landowner notification by the County and also for permitting, as discussed in Section 3.1.3. In addition, a health and safety work plan was prepared for field personnel during exploration.

3.1.3 Site Access & Permitting

Exploration for this project was performed on private and public properties. Public properties included lands or easements controlled by the County and City. Private lands owned by three individuals or entities were located in areas of our exploration along proposed cross section lines. Per our contractual relationship, the County secured permission to access and explore private properties at selected locations along the levee system. Permission to access one private property was initially restricted due to landowner concerns. That access restriction excluded the use of CPT soundings due to scheduling constraints. Permission from that landowner was finally obtained and that property was explored using drill holes.

Environmental permits were required to perform exploration on public and private properties for this study. Environmental permits for all exploration locations for this project were obtained by CGI/Fugro from Humboldt County Department of Environmental Health. Prior to our field exploration program, the well permits were issued and documented in the project file.

3.1.4 Site Visit and Utility Clearance

Prior to performing drill holes and CPTs, each exploration location was visually inspected for the presence of overhead and underground utilities, and then marked with white paint and wood lathes, as required by Underground Service Alert (USA). Following the marking of the exploration locations, USA was contacted a minimum of 48 hours prior to subsurface investigation of the site. A total of eight USA ticket numbers, as well as clearance dates, expiration dates, and call-back-to-extend dates, were obtained for the project and documented in the project file.

No utility conflicts were identified at any of CGI/Fugro's exploration locations and no manmade subsurface obstructions were encountered during our field exploration program. However, it should be noted that other buried utilities and structures not located by USA or observed by CGI/Fugro may be present along the project extent.

3.2 EXPLORATION PROGRAM

The field exploration program completed by CGI/Fugro for the Blue Lake Levee Geotechnical Evaluation project consisted of advancing subsurface explorations using hollow-stem auger drill holes and CPTs. The following sections discuss those exploration services.

3.2.1 Subsurface Exploration

The locations of drill holes and CPTs performed for this investigation are shown on Plate 2-1. Information for each exploration including latitude and longitude, ground surface elevations, and total exploration depth are tabulated in Table 3-2.

3.3 REFERENCE DATUM

The following reference datums were used for this project:

Horizontal Datum. The horizontal datum reference for this project is State Plane, Zone 1, North American Datum 83 (NAD83, feet).

Vertical Datum. The vertical datum reference for this project is the North American Vertical Datum of 1988 (NAVD88, feet).

Coordinates and elevations for the exploration locations were estimated by CGI/Fugro during exploration performed in April 2014, using a Garmin *etrex* hand-held global positioning system receiver. Lidar data were provided by Humboldt County for CGI/Fugro's use in engineering analyses.

Table 3-2. Subsurface Exploration Summary

Hollowstem Boring or CPT No.	Estimated Ground Surface Elevation (feet, NAVD88)	Exploration Depth (feet)	Start Date	Completion Date	Coordinates	
					Latitude (degrees)	Longitude (degrees)
Cone Penetrometer Test Soundings						
C1RO	81	11	4/7/14	4/7/14	40.87915	-123.9992
C20RC	93	5.5	4/7/14	4/7/14	40.87663	-123.9933
C39RC	100	23	4/7/14	4/7/14	40.87308	-123.9879
C49RW	95.5	6.5	4/8/14	4/8/14	40.87208	-123.9857
C59RC	101.5	17	4/8/14	4/8/14	40.87248	-123.9818
C59RW	97	14	4/8/14	4/8/14	40.87237	-123.9818
C70RL	96	21	4/8/14	4/8/14	40.87253	-123.9783
C70RO	95	26	4/8/14	4/8/14	40.87280	-123.9781
Hollow-Stem Auger Drill Holes						
D1RW	82	26.5	4/16/14	4/16/14	40.87840	-123.9996
D1RC	87	51	4/10/14	4/10/14	40.87853	-123.9995
D1RL	73	16	4/10/14	4/10/14	40.87865	-123.9994
D10RW	82	26.5	4/16/14	4/16/14	40.87720	-123.9970
D10RC	91.5	50.9	4/11/14	4/11/14	40.87735	-123.9969
D10RL	76	26	4/10/14	4/10/14	40.87747	-123.9968
D10RO	87.5	25	4/9/14	4/9/14	40.87767	-123.9966
D20RC	93	51	4/14/14	4/14/14	40.87655	-123.9933
D20RL	82.5	26	4/14/14	4/14/14	40.87667	-123.9933
D20RO	84	26	4/9/14	4/9/14	40.87702	-123.9933
D30RC	98.5	51	4/15/14	4/15/14	40.87493	-123.9897

Hollowstem Boring or CPT No.	Estimated Ground Surface Elevation (feet, NAVD88)	Exploration Depth (feet)	Start Date	Completion Date	Coordinates	
					Latitude (degrees)	Longitude (degrees)
D30RL	86	25.5	4/17/14	4/17/14	40.87505	-123.9896
D30RO	86	25.5	4/17/14	4/17/14	40.87528	-123.9894
D39RW	86.5	25	4/16/14	4/16/14	40.87297	-123.9881
D39RC	100	51.5	4/24/14	4/24/14	40.87307	-123.9879
D39RL	88	26.5	4/17/14	4/17/14	40.87310	-123.9877
D39RO	88	25.5	4/17/14	4/17/14	40.87528	-123.9894
D49RW	95.5	26	4/14/14	4/14/14	40.87207	-123.9857
D49RC	99.5	41.5	4/24/14	4/24/14	40.87217	-123.9857
D49RL	94	25.5	4/16/14	4/16/14	40.87223	-123.9857
D49RO	94	26.5	4/16/14	4/16/14	40.87252	-123.9857
D59RW	97	26	4/15/14	4/15/14	40.87237	-123.9817
D59RC	101.5	51.5	4/25/14	4/25/14	40.87245	-123.9818
D59RL	95	26.5	4/17/14	4/17/14	40.87255	-123.9818
D59RO	94	26.5	4/17/14	4/17/14	40.87282	-123.9820
D70RW	98	26.5	4/15/14	4/15/14	40.87237	-123.9784
D70RC	103	41.5	4/25/14	4/25/14	40.87245	-123.9783

The hollow-stem auger drill holes were advanced through the levee crest at about where each cross section crosses the levee system. Crown drill hole depths of 50 feet were generally obtained during this study; however, two drill holes within the crown experienced practical refusal at depths of about 41.5 feet.

Twenty-three CPT soundings were planned for this study, of which only eight were able to be performed (some were not performed due to restricted access to private properties – see Section 3.1.3) and penetrated deeper than about five feet. CPTs were targeted to depths of 25 and 50 feet. Only one CPT sounding, C70RO, was able to reach the targeted depth. Table 3-3 presents CPTs that were not performed or that encountered practical refusal at depths of less than five feet.

Table 3-3. CPT Nonperformance

CPT Sounding	Reason for Nonperformance
C1RL	Refusal
C1RC	Refusal
C10RW	Refusal
C10RC	Refusal
C20RL	Refusal
C20RO	Refusal
C30RC	Refusal
C30RL	Access Restriction
C30RO	Access Restriction
C39RL	Access Restriction
C49RC	Refusal
C49RL	Access Restriction
C59RL	Access Restriction
C59RO	Access Restriction
C70RC	Refusal

Initially, 15 drill holes were planned for this study but due to the access restriction and penetration refusal rates for the CPT soundings, 27 drill holes were actually advanced for this study. The drill holes were advanced using a track-mounted hollow-stem auger drill rig. The drill holes were advanced in the following locations:

- At all accessible waterside toe locations at the cross section sites
- At all crown locations at the cross section sites
- At selected landside toe and offset locations downstream

The target depth of the drill holes was 50 feet at all crown locations and 25 feet all remaining locations. All the crown drill holes but two were advanced to the targeted depths. Drill holes D49RC and D70RC achieved practical refusal at depths of 41.5 feet. All non-crown drill holes achieved a depth of at least 25 feet.

Soil samples were obtained at selected depth intervals within the drill holes using California modified split-spoon, and Standard Penetration Test (SPT) samplers. A CGI engineering geologist logged the drill holes as they were advanced. Most California Modified split-spoon samples were delivered to Fugro's Ventura or Oakland laboratories for testing. All SPT samples were transmitted to CGI's Redding laboratory for testing.

All explorations were destroyed using cement grout in accordance with Humboldt County Department of Environmental Health (HCDEH) permit conditions. The grout was placed

through the hollow-stem auger or CPT rods, which were extracted as the grout was being placed to reduce the potential for bridging or collapse of the holes prior to grout placement.

3.4 INVESTIGATION DERIVED CUTTINGS DISPOSAL

CPT soundings did not generate cuttings that required disposal during the course of this study. The CPT soundings displace underlying sediments and, therefore, do not generate cuttings that require disposal.

Hollow-stem auger drill holes did generate cuttings during the exploration process. Because those holes were backfilled using cement grout, the cuttings required disposal. The cuttings were dispersed adjacent to the drill hole locations, as discussed in our exploration plan and as reviewed and approved of by HCDEH during permit application.

4.0 LABORATORY TESTING PROGRAM

The purpose of the laboratory testing program was to supplement field classification of soils and provide relevant physical indices and engineering properties of the subsurface materials. The primary objectives of the program were to:

- Classify and characterize sampled subsurface materials
- Evaluate the existing in situ conditions
- Develop relevant consolidation, strength, and permeability estimates of selected subsurface materials

To meet these objectives, various tests were performed on selected samples. Test types are generally grouped into the following categories: classification/index tests, moisture content/density evaluations, consolidation tests, permeability tests, relevant strength tests, and subgrade characterization tests. Classification/index and subgrade characterization tests were performed on both disturbed and relatively undisturbed samples, including 2.4-inch diameter drive (i.e., ring) samples, Standard Penetration Test (SPT) samples, and bulk samples. Density evaluations, consolidation tests, permeability tests and strength tests were typically performed only on relatively undisturbed ring samples.

The numbers of the various tests conducted for the Blue Lake Levee Evaluation are listed in Table 4-1.

Table 4-1. Summary of Laboratory Tests Performed on Selected Samples

Laboratory Testing	Number of Tests	ASTM Test Designation ¹
Moisture Content	61	ASTM D2216
Density	48	ASTM D2937
Sieve Analysis with #200 Wash	62	ASTM D422
Sieve and Hydrometer	4	ASTM D422
Atterberg Limits	16	ASTM D4318
Modified Proctor	1	ASTM D1557
Consolidation (Incremental Load Control)	1	ASTM D2435
Flexible Membrane Permeability	6	ASTM D5084
Direct Shear	5	ASTM D3080
Consolidated Undrained (CU) Triaxial Compression Test with R-Pore Pressure Measurement	2	ASTM D4767

1) ASTM International (2005)

Laboratory test results are tabulated or presented graphically in Appendix C. A tabular summary of laboratory test results for the Blue Lake Levee Evaluation is presented on Plates C-1a through C-1c. Various laboratory test results are also tabulated versus depth on the

individual drill hole logs (Plates B-1 and B-2.1 through B-2.27). Test results that cannot be conveniently tabulated or plotted versus depth on logs are also provided in Appendix C. Test results in this category include: grain-size curves, plasticity charts, direct shear test results, triaxial test results, and compaction test results.

5.0 GEOLOGIC AND SUBSURFACE CONDITIONS

5.1 REGIONAL SETTING

The project site is located in the Coast Ranges Geologic/Geomorphic Province of Northern California. The Coast Ranges province consists of an approximately 50-mile wide range of mountains extending from Santa Barbara County approximately 400 miles northward into Shasta and Humboldt Counties (Hinds, 1952). It is bounded to the north and east by the Klamath Mountains province, to the south by the Transverse Ranges province, to the southeast by the Great Valley province, and to the west by the Pacific Ocean.

The project region occupies a complex geologic environment characterized by high rates of active tectonic deformation and seismicity. The area lies immediately north of the Mendocino Triple Junction, which is the location of intersection of three crustal plates (i.e., the North American, Pacific, and Gorda plates). North of Cape Mendocino, the Gorda plate is being actively subducted beneath North America, forming what is commonly referred to as the Cascadia subduction zone, which is located west and offshore of the study area. In Humboldt County, stresses from the offshore subduction zone are manifested on-land as a series of northwest-trending, southeast-vergent thrust faults, and intervening folds (i.e., “fold and thrust belt”). The geomorphic landscape of the project region is largely a manifestation of the active tectonic processes and the setting in this dynamic coastal environment.

Basement rock within the Blue Lake region consists of the Cretaceous-Jurassic Franciscan Formation (McLaughlin et al., 2000). The Franciscan Formation is a sequence of metasedimentary, metavolcanic, metamorphic, and ultramafic rocks that have been and are continuing to be accreted to the North American plate during subduction of the Pacific plate. As a consequence, the Franciscan Formation has been mapped as three broad belts (Eastern, Central, and Coastal belts) that become younger from east to west (McLaughlin et al., 2000). The Blue Lake basin is situated on the Eastern Belt and is juxtaposed to the relatively older Klamath Mountains province to the northeast (Hardin et al., 1982). In the project region, it is composed of northwest-trending units of schist, sandstone, and mudstone, each separated by faults (Cashman et al., 1995).

5.2 LOCAL GEOLOGIC SETTING

Coastal valleys, such as the Mad River Valley, represent sediment-filled basins that reflect the late Quaternary history of sea level changes and tectonic deformation. During most of the late Quaternary, sea level was lower than its present position, resulting in a shoreline located farther to the west, and a lower fluvial base level to which all coastal streams would be graded. During these low sea levels, streams within the coastal valleys around Humboldt County would be incised. Subsequent sea level fluctuations would result in cycles of filling and incision in these coastal valleys, depending on the relative base level (i.e., the ocean shoreline). It is thought that sea level reached its current high level in the mid-Holocene, about 6,000 years ago. As such, most of the sediment filling the Mad River Valley would be anticipated to be mid-Holocene in age, or younger. A geologic map of the project area and a regional fault map are shown on Plates 5-1 and 5-2, respectively.

5.3 GEOMORPHOLOGY & CHANNEL DEGRADATION

The Mad River varies from a single-thread channel downstream from Hatchery Road Bridge to a braided channel upstream from that bridge. The North Fork is predominantly a single-thread channel. In the project region, the Mad River flows within a channel that is locally, artificially constrained. Those constraints include the Blue Lake Levee, riprap placed along the main channel upstream of the Hatchery Road Bridge, and impingements associated with that bridge.

The river branches are characterized by large meander belts that have fluctuated across the active channel over time. That meandering has occurred across the valley and is responsible for the original oxbow lakes for which Blue Lake was named (Bertolini and Collins, 2014), which reportedly were formed by the floods of 1861 (Tolhurst, 1995). Aside from minor channel relocations, significant changes within the river channels due to meander cut offs and channel captures have occurred historically. For instance, a meander cut-off occurred just below the hatchery during the 1889-90 floods, wiping 3 ranches out of existence within a 24-hour period (Tolhurst, 1995). In addition, the 1964 flood resulted in relocation of the confluence between the Mad River and the North Fork about 3,000 feet east of its former location.

Active channel area and sinuosity, two indicators of gradient changes and fluctuations of bedload, have changed over time. The active Mad River channel area increased by about 16 acres per year between 1948 and 1966, then decreased in area by 10 acres per year from 1966 through 1992 (Tolhurst, 1995). Between 1900 and 1948, sinuosity within the channel decreased from about 1.8 to 0.9 (sinuous length divided by straight line length; Tolhurst, 1995). Thus, the river changed from a meandering drainage to a straight-line water course within the project area during this time period. From 1949 through 1992, the sinuosity increased to 1.2, thus approaching the boundary between a braided and meandering stream.

The changes of the channel area and sinuosity imply that from 1900 to 1948 increased bedload recruitment resulted in the widening of the river channel and the relative straightening of the river. This bedload recruitment and aggradation of the river channel in the project area might have been associated with increased sediment yield within the watershed due to logging and other historical land activities that were initiated in the late 1800s but were intensified between 1880 and 1920 (Tolhurst, 1995). Flooding and mechanical manipulations of the channel also likely contributed to these conditions.

Starting in 1962 gravel extraction began within the river channel in the project area. Annual extraction volumes averaged about 425,000 cubic yards within the river channel resulting in a mean deficit recruitment rate within the channel (Tolhurst, 1995). The result of that deficit was the degradation of the river channel and the lowering of the active channel area. Estimates of the lower rates vary from 0.12 feet per year (feet/year) to 0.18 feet/year, with an average of 0.15 feet/year (Lehre et al., 1993). Cross sections measured at the Hatchery Road bridge in 1982 and 1991 found that the channel in this area had lowered up to 4.5 feet with a mean bed lowering of 1.6 feet across the measured channel. Thus, using the degradation rates estimated by Lehre et al. (1993), the river channel may have experienced a maximum lowering of about 7.5 feet in the project area since the levee was constructed.

Since 1996, extracted volumes of sand and gravel have been below calculated replenishment volumes (Klein, 2014). This implies that the river bed should be at a stable elevation and should not be appreciably aggrading or degrading. Obviously, gravel extraction is not the only factor that dictates river channel elevations; however, according to Lehre (1993) and Tolhurst (1995), it appears to be the most significant contributor to the channel elevation. Minor fluctuations should be expected annually and locally within the river channel within the project area.

The sediment filling Mad River Valley is alluvium derived from the Mad River, North Fork of the Mad River, Palmer Creek, and other upstream sources, and it is relatively unconsolidated and locally contains high concentrations of organics and woody debris. Associated with the alluvium are colluvial soils along the margins of the valley and concentrations of artificial fill materials, such as the levee system and approach ramps for the Hatchery Road crossing the Mad River.

5.4 SUBSURFACE CONDITIONS

As previously noted, the project field exploration program included CPT soundings and hollow-stem auger drill holes along the crest of the levee, at the landside and waterside toes, and at landside levee offset locations within the project extent. Subsurface conditions were explored to a depth of up to approximately 51.5 feet below ground surface (see Section 3.0 for details of the field exploration program). Subsurface conditions are described and illustrated in the drill hole and CPT logs (see Appendix B). The logs have also been projected onto cross sections to depict subsurface conditions across and along the levee system. See Plate 2-1 for a map showing the location of the cross-sections and Plate 5-3 for the cross-sections. Eight transverse cross sections (Station Nos. 2+00, 11+00, 22+00, 34+00, 42+00, 50+00, 61+00, and 71+00) were created by projecting exploration logs onto regional topographic and Lidar data provided by the County. Additionally, profiles along the levee crown and landside of the levee are shown on Plates 5-4 and 5-5, with a key to the profiles included as Plate 5-6.

5.4.1 Earth Materials

Subsurface conditions are generally similar throughout the project site, although some variability is seen along the levee system. In general, the embankment materials within the levee were relatively similar along the length of the levee system, whereas foundation soils are relatively variable. Earth materials encountered within the levee embankment and in the foundation soils are discussed in the following sections. Logs of the explorations for this study are presented in Appendix B. Laboratory data for earth materials are presented in Appendix C, and a summary of our data synthesis for geotechnical analyses is provided in Appendix D.

Levee Embankment Materials. Levee embankment thicknesses appear to range from about 6 feet to 14½ feet, as estimated from cross sections presented on Plate 5-3 and based on a review of USACE (1962). A total of 11 explorations, consisting of hollow-stem auger drill holes and CPT soundings, were advanced through the levee embankment materials to sample and characterize selected geotechnical conditions within the embankments.

Subsurface conditions within levee embankment materials were observed to be generally consistent throughout the levee system. The explorations encountered about 1½ to 6 feet of granular soils below the crown of the levee. Those granular soils consist of sand, sand with gravel, gravel with sand, gravel with silt, and gravel, some of which appears to be aggregate base materials. The granular soils were generally dry to moist, loose to dense, with fine to coarse grained sand, fine to coarse gravel, and fine to medium cobbles ranging from subrounded to subangular. Locally, the upper few inches of the granular soils were loose.

Clay, silty clay, silty clay with gravel, sandy clay, sandy clay with gravel and clayey silt were encountered beneath the surficial granular soils within the levee at all sections except Station No. 2+00. Those materials generally constitute the "Impervious Fill" noted on the USACE plans (1962) and extend to the bottom of the levee embankment soils. Occasionally, thin granular interbeds are present within the impervious fill. The impervious fill materials were generally moist and soft to stiff.

Foundation Soils. The USACE (1962) notes that, in general, impervious blanket materials and pervious foundation soils are present beneath the levee embankment. The following sections discuss foundation soils encountered during this study relative to generalized soil descriptions presented by USACE (1962). A summary of additional earth material properties is provided in Appendix D.

Impervious Foundation Materials. The USACE (1962) reports the presence of fine-grained materials consisting of silty sand, sandy silt, clayey sand, sandy clay, clay and silty clay varying in thickness from 2 to 17 feet in thickness. The USACE (1962) notes that the thickness of the impervious blanket materials generally increases upstream of Hatchery Road Bridge.

CGI/Fugro encountered materials during this study similar to those described by the USACE (1962) as "overburden materials." Those generally impervious materials predominantly consisted of sandy silt, clayey silt, silty clay, silty clay with gravel, sandy clay, and sandy clay with gravel. Impervious materials were encountered below levee fill material in crown explorations at all sections except Station No. 11+00. The maximum and minimum thickness of those materials below the levee was estimated to be about 17 feet and 2½ feet, respectively.

As shown on Plates 5-3 and 5-5, impervious materials were encountered on the landside of the levee at Station Nos. 34+00, 61+00, and 71+00, and on the waterside of the levee at Station Nos. 61+00 and 71+00. The maximum and minimum thicknesses of those materials on the landside of the levee were estimated to be about 14 feet and 1½ feet, respectively. The maximum and minimum thickness of impervious materials on the waterside of the levee were estimated to be about 13½ feet and 6 feet, respectively.

Pervious Foundation Materials. The USACE (1962) reports subsurface exploration indicated pervious foundation soils consisting of sand and gravel were encountered below overburden materials. The USACE explorations did not fully penetrate the thickness of the pervious foundation materials to depths of 25 feet.

CGI/Fugro encountered pervious foundation materials similar to those reported by the USACE (1962). In general, the pervious foundation materials encountered during our study consisted of loose to very dense, moist to wet, poorly- to well-graded sand, silty sand, sand with silt, sand with silt and gravel, sand with gravel, gravel with silt and sand, gravel with clay and sand, and gravel with sand. The pervious foundation soils were not fully penetrated by explorations performed for this study.

5.4.2 Groundwater

Depths to groundwater were measured in hollow-stem auger drill holes advanced during this study. Depths to groundwater cannot be measured directly using CPT soundings and dissipation tests were not performed because those soundings were generally placed proximal to the drill holes.

The observed groundwater levels varied from about 8 to 24.5 feet below ground surface, with elevations ranging from about 61 to 86 feet MSL (NAVD88). Table 5-1 summarizes the groundwater levels observed in the field.

Table 5-1. Groundwater Level Observations in Study Explorations

Station & Measurement Date	Groundwater Elevations (feet above NAVD88)			
	Right Levee			
	Offset	Landside Toe	Crest	Waterside Toe
Station 1+00	-	61	62.4	64
Date	NA	4/10/14	4/10/14	4/16/14
Station 10+00	75.5	68	67	67
Date	4/9/14	4/10/14	4/11/14	4/16/14
Station 20+00	70	72.5	69	
Date	4/9/14	4/14/14	4/14/14	NA
Station 30+00	73	72	74.3	
Date	4/17/14	4/17/14	4/15/14	NA
Station 39+00	76.5	75	78.5	78.5
Date	4/17/14	4/17/14	4/24/14	4/16/14
Station 49+00	78.5	79	78	78.5
Date	4/16/14	4/16/14	4/24/14	4/14/14
Station 59+00	80	81	82.5	81.5
Date	4/17/14	4/17/14	4/25/14	4/15/14
Station 70+00	-	-	80	86
Date	NA	NA	4/25/14	4/15/14

In addition, groundwater levels in the project area were researched through the California Department of Water Resources (2014) and through the California State Water Resources Control Board Geotracker database (2014). Based on information obtained from these sources and from data provided by the County at the start of this project, we have compiled historical groundwater levels in the project area. Those data are presented in Table 5-2.

Table 5-2. Groundwater Data Reported by Others

Source	General Location			Groundwater Elevation Range (datum unknown)	Monitoring Period Range
	Site	Longitude	Latitude		
Winzler & Kelly (2009)	630 Railroad Avenue	40° 52' 47"	123° 59' 17"	9.5' to 10.5'	10/9-12/2009
LACO (2008)	410 Railroad Avenue	40° 52' 51"	123° 59' 23"	8.0' to 14.0'	1994 - 2008
Moore & Taber (1983)	Hatchery Road Bridge	40° 52' 34"	123° 59' 33"	21.9' to 22.5'	10/26-27/1982

Groundwater depths and subsurface information was requested from SHN Consulting Engineers & Geologists, Inc., on a number of occasions for the City of Blue Lake Public Works Corporate Yard, located at 199 Taylor Way, in the City of Blue Lake, in which they have performed studies. The City of Blue Lake requested that we contact SHN directly to obtain that information. Despite numerous attempts to obtain those data, they have not been provided to CGI/Fugro at the time this report was prepared.

In general, groundwater levels were measured to be at relatively consistent depths beneath the ground surface along the levee system. Some variations in depths to water were observed; however, in a depositional environment that has the potential to have significant changes in soil types over relatively short distances, variations in groundwater depths should be anticipated. None of the variations measured during this study imply the presence of a significant aquitard or aquiclude impeding horizontal groundwater flow through sediments in the vicinity of the levee system. Variations in groundwater levels and soil moisture conditions can occur as a result of rainfall, runoff, and other factors. Therefore, groundwater conditions should be assumed to fluctuate.

6.0 SEISMIC DESIGN CRITERIA

6.1 STRONG GROUND MOTION

As part of our geotechnical analyses, a probabilistic seismic hazard evaluation was conducted with the aid of the United States Geological Survey (USGS) 2008 Interactive Deaggregation (beta) website. The USGS website provides probabilistic estimates of seismic hazards using three-dimensional earthquake sources. In accordance with ETL 1110-2-580 (USACE, 2013), we utilized the website to determine the peak ground acceleration estimated to have approximately 1-percent annual chance of exceedance (Statistical Return Period \approx 100 years).

Based on correlations developed by Sykora (1987), Mayne (2007), Dickenson (1994) and Mayne and Rix (1995), shear wave velocity data were estimated for the subsurface conditions encountered at the site. The average shear wave velocity for the upper 100 feet was estimated to be approximately 250 meters per second (m/s), based on data collected from explorations D1RC, D20RC, D30RC, D39RO, D49RL, D59RC, D70RC and D70RW.

The peak ground acceleration was calculated by the USGS website using equally-weighted averages of three (3) attenuation relationships: Boore and Atkinson (2008), Campbell and Bozorgnia (2008), and Chiou and Youngs (2008). For the purposes of our evaluation, the site coordinates (latitude and longitude) for the Blue Lake Levee project site were estimated to be 40.876 degrees north latitude and 123.992 degrees west longitude.

According to the USGS website, the peak horizontal ground acceleration (PHGA) for the project site is estimated to be approximately 0.23g, corresponding to deaggregated modal and mean magnitudes of 6.96 and 6.85, respectively. Based on the deaggregation graph generated by the USGS website, a magnitude 9.0 event also contributed a relatively large percentage to the estimated seismic hazard. Therefore, we considered a magnitude 9.0 earthquake with a PHGA of 0.23g as the design seismic event for our evaluation of the levee system.

6.2 SURFACE FAULT RUPTURE

The State of California designates faults as active, potentially active, and inactive depending on the recency of surface fault rupture that can be substantiated for a fault. Table 6-1 presents the current California fault activity ratings.

Table 6-1. Fault Activity Ratings

Fault Activity Rating	Geologic Period of Last Rupture	Time Interval (Years)
Active	Holocene	Within last 11,000 Years
Potentially Active	Quaternary	>11,000 to 1.6 Million Years
Inactive	Pre-Quaternary	Greater than 1.6 Million Years

The California Geologic Survey (CGS) evaluates the activity rating of a fault in fault evaluation reports (FER). FERs compile available geologic and seismologic data, and evaluate if a fault should be zoned as active, potentially active, or inactive. If a FER evaluates a fault as active, then it is typically incorporated into a Special Studies Zone in accordance with the Alquist-Priolo Earthquake Hazards Act (AP). AP Special Studies Zones require site-specific evaluation of a fault location and require a structure setback if the fault is found traversing a project site.

The site is not located within an Alquist-Priolo Earthquake Fault Zone and no active faults are known to pass through the project site (Smith, 1982; McLaughlin et al., 2000; Jennings, 1994; Hart & Bryant, 1997; Jennings & Bryant, 2010). However, a number of regional and local faults traverse the project region. The closest of these faults is an unnamed potentially active thrust fault located about 4,500 feet northwest of the levee system, as shown on Plate 5-1. In the project area, that fault separates Quaternary terrace deposits and Plio-Pleistocene-age Freshwater Formation from Jurassic-age Franciscan melange. That fault is a north-west trending, northeast-dipping thrust or reverse fault (Smith, 1982).

The closest zoned active fault is the McKinleyville fault, located about 6,000 feet southwest of where the levee intersects Hatchery Road, as shown on Plate 5-1. The McKinleyville fault is part of the larger Mad River fault zone, which includes the Trinidad, McKinleyville, Mad River, Fickle Hill, and related faults (Smith, 1982), which extends from south of Arcata to west and offshore of Trinidad. The fault is northwest-trending, east-dipping, and offsets a number of marine terraces along the coastal zone (Carver, 1982, Smith 1982).

In addition to the continental faulting noted above, the project area rests above the Cascadia subduction zone. West of the site, off the coast of California, the oceanic crust of the Gorda plate is being subducted beneath the continental crust of the Pacific Plate, in an area known as the Gorda Escarpment. The descending ramp caused by that subduction, called the Cascadia Subduction zone, extends beneath the project area at a depth of about 9 to 12 miles (McLaughlin et al., 2000). That ramp is capable of storing elastic stress that periodically causes earthquakes that could affect the project area.

7.0 CROSS SECTIONS FOR ANALYSES

Eight cross sections were selected for seepage and stability analysis. Cross section locations are shown on Plate 2-1. Selected cross sections are located about 800 and 1,200 feet apart, with an average spacing of about 1,130 feet. Five sections are located upstream and three sections are located downstream of the Hatchery Road Bridge crossing Mad River.

Selected cross sections have generalized station number names to indicate the approximate locations of the cross section. Table 7-1 presents cross section station numbers and the corresponding stations along the Blue Lake Levee crown.

Table 7-1. Cross Section Station Numbers

Cross Section Station Number	Exact Station Number
2+00	2+29
11+00	10+82
22+00	21+56
34+00	33+65
42+00	42+41
50+00	50+16
61+00	61+07
71+00	71+25

CGI/Fugro approximated cross section topography on the basis of Lidar data provided by Humboldt County. However, at each section, Lidar-based elevations were compared to field measurements by the field engineering geologist to reduce the potential impact that vegetation may have had on Lidar-based elevations.

Subsurface conditions were modeled as levee fill overlying fine- and coarse-grained alluvial deposits, which were designated as impervious and pervious foundation materials, respectively. The following paragraphs describe levee subsurface conditions modeled in seepage and slope stability analyses. Beneath the levee, alluvium was modeled as pervious material or as impervious material (blanket) overlying a pervious substratum.

Station Nos. 2+00 to 24+50. For sections evaluated between about Station Nos. 2+00 and 24+50, an impervious fill is present on the landside of existing antecedent levees, based on a review of the USACE Operation and Maintenance Manuals (1956, 1962). Based on our review of historical information, we understand the levee was damaged during a major flood event in December 1964 between about Station Nos. 15+00 and 24+00. However, as built drawings for the levee embankment repair have not been located (County of Humboldt, 2014).

Station Nos. 24+50 to 71+00. Based on our review of the USACE Operation and Maintenance Manuals (1956, 1962) and field exploration logs, we modeled the levee as a rectangular core of impervious fill material covered by a shell of pervious fill material between about Stations 34+00 and 71+00. For sections evaluated at Stations 34+00, 61+00, and 71+00, the core was modeled on the landside of antecedent levees, which were constructed as part of the 1956 project.

Estimated model dimensions were based on our review of USACE (1956, 1962) and field exploration logs. In general, the landside and waterside slope inclinations of our models were estimated to be about 2h:1v and 3h:1v, respectively, with the exception of Station No. 34+00, which is defined by a landside slope inclined at about 1.5h:1v. The dimensions of the impervious levee fill were based on our review of USACE as-constructed plans (1956, 1962).

Riprap. It should be noted the 12- to 27-inch thick layer of riprap slope protection placed on the waterside slope along sections of the existing levee was not included in our stability models. Based on our experience, including the riprap slope protection in our models would likely result in a relatively small increase in estimated factors of safety for surficial stability.

Design Water Surfaces. For existing conditions, river water surfaces were modeled to generally correspond with groundwater measurements collected during our field exploration program and field observations. Groundwater elevations were estimated based on data collected during our field exploration efforts, between April 10 and 25, 2014; groundwater data are presented in Table 5-1 and on Plate 5-7.

For flood-stage conditions, river water surfaces were modeled to represent 100-year water surface elevations as defined by Northern Hydrology & Engineering (NHE, 2014).

8.0 GEOTECHNICAL ANALYSES

8.1 LIQUEFACTION

Liquefaction triggering analyses were performed for drill holes advanced through the levee crest. The computer program LiqIT (Geologismiki, 2006) was used to: 1) perform the liquefaction triggering analyses according to the 1998 National Center for Earthquake Engineering Research (NCEER) guidelines (NCEER, 1998), and 2) to estimate seismic settlement using Ishihara and Yoshimine (1992). The results of the analyses are presented on individual drill hole plots in Appendix D as Plates D-17 through D-24.

Liquefaction analyses were performed as follows:

1. In accordance with ETL 1110-2-580 (USACE, 2013), groundwater depths corresponding to the median annual water surface elevation were assumed to approximate existing phreatic conditions.
2. Liquefaction triggering was evaluated for a PHGA of 0.23g and a moment magnitude of 9.0, corresponding to a statistical return period of 108 years. As noted in Section 6.1, a magnitude 9.0 event is not estimated to be the modal or mean event for the deaggregated seismic hazard. However, a magnitude 9.0 event contributed a relatively large percentage to the estimated seismic hazard. It should be noted that the minimum magnitude scaling factor defined by NCEER (1998) was applied in our analyses because values are not defined for magnitudes greater than 8.5.
3. Liquefaction analyses are based on estimates of two values: the cyclic stress ratio (CSR), which characterizes the seismic demand on the soil, and the cyclic resistance ratio (CRR), which characterizes the soil's capacity to resist liquefaction. CSR and CRR versus depth were calculated using 1998 NCEER guidelines (NCEER, 1998).
4. Seismic settlement resulting from potential liquefaction was estimated for each drill hole advanced through the levee crest using procedures presented in Ishihara and Yoshimine (1992).

8.1.1 Liquefaction Triggering Analyses per NCEER (1998)

NCEER (1998) guidelines (Youd and Idriss, 2001) present deterministic liquefaction triggering procedures based on SPT data. The factor of safety (FS) against liquefaction is computed as the ratio of CRR to CSR. The results of the analyses are presented on the liquefaction plots (Plates D-17 through D-24).

8.1.2 Seismic Settlement per Ishihara and Yoshimine (1992)

Seismic settlement resulting from liquefaction was estimated using procedures presented in Ishihara and Yoshimine (1992). The procedure relates volumetric strain to the FS against liquefaction and normalized N values. Estimated volumetric strains are multiplied by layer thickness to obtain incremental settlement in each liquefiable layer. The increments are

summed from the bottom of the exploration to the ground surface. Cumulative seismic settlement versus depth estimates are presented on Plates D-17 through D-24.

8.1.3 Seismically Induced Dry Settlement per Pradel (1998)

Seismically induced dry settlement can occur in association with liquefaction, or in soils not prone to liquefaction (above the water table) that are loose to medium dense. Seismically induced dry settlement differs from settlement resulting from liquefaction of saturated granular materials, discussed above.

We estimated the potential for seismically induced dry settlement to occur at the site using procedures presented in Pradel (1998). In general, the granular materials encountered in our field explorations ranged from loose to very dense sandy silt, silty sand, sand, sand with gravel, gravelly sand, gravel with sand, sandy gravel, and gravel. The loose to medium dense granular materials may be susceptible to dry seismic settlement. On the basis of our analysis, we estimate the potential magnitude of seismically induced dry settlement to be up to about one inch.

8.1.4 Results

The results of our seismically induced settlement analyses for the eight cross sections are summarized in Table 8-1 below, and presented graphically in Appendix D as Plates D-17 through D-24.

Table 8-1. Seismically Induced Settlement Analyses Results

Section Station Number	Liquefaction-Induced Settlement (inches)	Seismically-Induced Dry Settlement (inches)
2+00	1.6	≤1
11+00	1.7	≤1
22+00	0.8	≤1
34+00	0.0	≤1
42+00	3.0	≤1
50+00	5.6	≤1
61+00	7.7	≤1
71+00	3.3	≤1

8.2 PERMEABILITY AND SEEPAGE

The potential for seepage to influence the stability of a levee is dependent upon a number of factors that include:

1. The geometry of the levee.
2. The composition and engineering properties of the levee and foundation soils.

3. The elevation of the water being retained by the levee.

The geometry and composition of the levee evaluated during this study are discussed in Sections 5.0 and 7.0 of this report. The water surface elevations of the 100-year flood event are discussed below. Estimated water surface elevations along the Blue Lake Levee correspond to freeboards ranging from about 5 to 11 feet. Freeboards of those magnitudes will generally have a positive influence relative to stability associated with seepage forces. If those freeboard values were smaller, seepage forces could have a relatively greater detrimental influence on levee stability.

Seepage analyses were performed for eight cross sections along the Blue Lake Levee system. Analyses were performed using the finite element modeling program SLIDE (Rocscience, 2014).

A discussion of the data synthesis performed to develop soil parameters for seepage analyses is provided in Appendix D. As noted in Appendix D, our approach to seepage analyses assumed generalized parameters that could be applied to all of the sections evaluated. However, for sections with estimated factors of safety (FS) less than the criteria established by the USACE (2005, 2000a), we further refined parameters, where possible, to be more site-specific and better correspond with data collected at those sections. The generalized parameters selected for initial analyses are generally more conservative than the site-specific parameters selected for subsequent analyses of some sections. Discussion of sections where site-specific parameters were applied in lieu of generalized parameters is provided in Section 9.3.

In accordance with EM 1110-2-1913 (USACE, 2000a), seepage analyses were performed for steady-state seepage during a full flood event. As noted above, water surfaces for flood-stage conditions were modeled to represent the 100-year water surface elevations, as defined by Northern Hydrology & Engineering (NHE, 2014). Groundwater elevations for existing conditions were estimated on the basis of data collected during our field exploration, which are presented in Table 5-1 and on Plate 5-7.

Seepage analyses evaluate two conditions for levees:

- Through-seepage, where seepage daylights on the landside face of the levee
- Underseepage, where seepage flows beneath the levee and daylights at the landside ground surface

These analyses are discussed in greater detail below.

8.2.1 Through-Seepage Analyses

The potential for through-seepage was estimated at each section by review of seepage analyses output to determine if the estimated phreatic surface emerges on the landside slope during the design flood event. As noted in USACE (2000a), seepage exiting on the landside

slope could potentially decrease the stability of the slope as a result of sloughing or internal erosion of the slope. An example of output illustrating through-seepage is presented below.

The results of our seepage analyses for the eight cross sections are summarized below, and presented graphically in Appendix E.

Table 8-2. Summary of Results for Through-Seepage Analyses

Section	Potential for Through-Seepage Estimated	Approximate Height of Daylight Point above Landside Toe (ft)
2+00	No	--
11+00	No	--
22+00	Yes*	1.8
34+00	Yes	1.4
42+00	No	--
50+00	No	--
61+00	No	--
71+00	Yes	1.0

* Phreatic surface daylights on landside surface and intersects interior drainage ditch.

8.2.2 Underseepage Analyses

Acceptance criteria have been established by the USACE to reduce the potential impacts of levee underseepage (USACE, 2005). Those criteria specify that underseepage beneath an existing levee is acceptable if the exit gradient is 0.5 or less, which would provide a factor of safety against seepage-related failures of at least about 1.6 (USACE, 2005).

For cross sections modeled with landside impervious foundation (i.e., blanket) material, average exit gradients were estimated by dividing the difference in total head across the thickness of the blanket material by the thickness of the stratum. As noted above, impervious materials were encountered on the landside of the levee at Station Nos. 34+00, 61+00, and 71+00. For cross sections modeled without landside blanket material, localized vertical exit gradients were estimated by our analyses. Factors of safety for underseepage estimated below are based on an assumed critical gradient value of approximately 0.8 for impervious and pervious foundation materials.

For steady-state seepage analyses, the landside extent of the seepage models was defined by the lesser of the perpendicular horizontal distance to the valley basin limits (bedrock slope) and a distance of 2,000 feet from the levee centerline.

To simulate the general hydrogeologic conditions we anticipate during a flood event, a no-flow condition was assigned as the landside boundary condition if the landside model extent

was defined by the valley basin limits (i.e., relatively impermeable bedrock). Alternatively, estimated groundwater elevations were applied as boundary conditions at the landside boundary if the landside model extent was defined by a distance of 2,000 feet from the levee centerline.

The results of our seepage analyses for the eight cross sections are summarized below, and presented graphically in Appendix E.

Table 8-3. Summary of Results for Underseepage Analyses

Section	Exit Gradient at Landside Toe	Factor of Safety
Maximum Threshold per USACE (2005)	0.5	1.6
2+00	0.4	2.0
11+00	0.4	2.0
22+00	0.4	2.0
34+00	0.4**	2.0
42+00	<0.1	>8.0
50+00	<0.1	>8.0
61+00	<0.1	>8.0
71+00	0.8	1.0

**Site-specific parameters applied to seepage analysis. All other analyses performed using generalized parameters.

As noted in the table above, site-specific permeability parameters were applied to the seepage analysis at Station 34+00. It should be noted the seepage analysis performed with generalized permeability parameters estimated a vertical exit gradient of about 0.8, corresponding to a factor of safety of about 1.0 relative to underseepage.

8.3 SLOPE STABILITY

Slope stability analyses were performed for the eight cross sections along the Blue Lake Levee. The analyses were performed using the limit equilibrium program SLIDE (Rocscience, 2014). A discussion of the data synthesis performed to develop soil parameters for slope stability analyses is provided in Appendix D. Our approach to slope stability analyses assumed generalized parameters for all of the sections evaluated. In addition, slope stability analyses focused on failure surfaces that intersected the levee crest. Shallow failure surfaces typically cut only a small portion of the levee slope and typically do not pose substantial threat to the integrity and safety of the levees (DWR, 2013).

Geotechnical design values for impervious and pervious (sand and gravel) materials were also included in the *Detailed Project Report* (USACE, 1962). Listed values include dry unit weights, moist weights, saturated weights, buoyed weights, and shear strength parameters. These values are presented in Appendix A.

8.3.1 USACE Acceptable Slope Stability Criteria

The USACE has established minimum factor of safety (FS) thresholds for levee slope stability conditions (USACE, 2000a). The FS against slope failure is estimated by calculating the forces resisting slope failure divided by the forces causing slope failure. Thus, a FS of greater than one implies a stable slope, a FS less than one implies a failing slope, and a FS equal to one implies that a slope is on the verge of failure.

The conditions for analysis specified by the USACE consist of four slope stability cases:

- Case I – End of Construction
- Case II – Sudden Drawdown
- Case III – Steady Seepage from Full Flood Stage
- Case IV – Earthquake

Case I represents approximate as-constructed embankment conditions that would be present at the time when levee construction is just completed. Under this scenario, fine-grained soils (impervious embankment and foundation soils) are modeled using undrained (more likely unsaturated) shear strength parameters, whereas granular soils (pervious soils) are modeled using drained shear strength parameters. Slope stability analyses for this case are performed for both the landside and waterside slopes. Case I is typically not performed for existing levees.

Case II represents the scenario when a prolonged flood stage saturates the levee embankment and then recedes faster than the soil can drain (rapid drawdown). Slope stability analyses for this case are performed on the waterside slopes.

Conditions for **Case III** occur when a prolonged flood stage allows steady state seepage flow to occur through the levee. Under this scenario, the landside slope stability is evaluated.

Case IV represents the effects of earthquake forces on the levee stability.

The USACE (2000a, 2013) has established minimum FS values for each levee slope stability case evaluated. Those allowable minimum FS values, presented in Table 8-4 below, were referenced in our interpretation of slope stability analyses discussed herein.

Table 8-4. Minimum Acceptable Factor of Safety Values

Case	Minimum Factor of Safety
Case I – End of Construction	1.30
Case II – Rapid Drawdown	1.00 to 1.20*
Case III – Steady State Seepage	1.40
Case IV – Earthquake (pseudo-static)	1.00

*FS of 1.0 applies to pool levels prior to drawdown for conditions where these water levels are unlikely to persist for long periods preceding drawdown. FS of 1.2 applies to pool levels likely to persist prior to drawdown.

8.3.2 Methodology

A discussion of the data synthesis performed to develop soil parameters for stability analyses is provided in Appendix D. As noted in Appendix D, our approach to stability analyses assumed generalized parameters that could be applied to all of the sections evaluated. However, for sections with estimated factors of safety (FS) less than the performance criteria established by the USACE (2000a, 2003), we further refined parameters, where possible, to be more site-specific and better correspond with data collected at those sections. The generalized parameters selected for initial analyses were generally more conservative than the site-specific parameters selected for subsequent analyses. Discussion of sections where site-specific parameters were applied in lieu of generalized parameters is provided in Sections 9.3 and 9.4.

For our stability analyses of existing conditions and landside slope conditions during a full flood event, drained shear strength parameters were assigned to the subsurface materials. Phreatic surfaces and pore pressures used for slope stability analyses of full flood and rapid drawdown conditions were based on steady-state seepage results.

Rapid drawdown slope stability evaluations used the three-stage method, as described in Appendix G of EM 1110-2-1902 (USACE, 2003), and programmed into SLIDE. The three-stage method uses both drained and consolidated-undrained shear strength parameters, estimated as described in Appendix G of EM 1110-2-1902 (USACE, 2003).

For pseudo-static stability analyses of slopes with soils considered to be potentially liquefiable during the design seismic event, undrained residual strength parameters were estimated for potentially liquefiable strata according to the empirical correlation proposed by Seed and Harder (1990). Potential liquefaction is discussed in Section 8.1 and estimated undrained residual strength values for potentially liquefiable strata are presented in Appendix E.

We performed screening-level pseudo-static slope stability analyses by applying a horizontal seismic coefficient equal to approximately half of the estimated PGHA [i.e., $0.5 \times 0.23g = 0.115g$ (rounded up to $0.12g$)]. If the estimated FS for the initial pseudo-static slope stability analyses was less than 1.0, we performed a seismic deformation analysis to estimate the levee's performance during the design seismic event. If the FS was estimated to be equal to or greater than 1.0, minimal or negligible seismic displacements are anticipated for the design

seismic event and post-earthquake slope stability analyses were not performed, as recommended by DWR (2013).

The results of our slope stability analyses for the eight cross sections evaluated are summarized below, and presented graphically in Appendix E.

Table 8-5. Summary of Slope Stability Analyses Results

Section	Levee Slope	Factor of Safety For Each Case Evaluated			
		Existing Conditions	Seepage During a Full Flood Event	Rapid Drawdown	Pseudo-static
Minimum Thresholds per USACE (2000a, 2013)		1.3	1.4	1.0	1.0
2+00	Landside	1.4	1.4	--	1.1
	Waterside	1.3	-----	1.5	1.2
11+00	Landside	1.6	1.4	--	1.5
	Waterside	2.1	-----	1.7	1.5
22+00	Landside	1.6	1.3	--	1.2
	Waterside	2.1	-----	1.4	1.4
34+00	Landside	1.7	1.6	--	1.3
	Waterside	1.6	-----	0.9	1.3
42+00	Landside	1.6	1.5	--	1.2
	Waterside	2.4	-----	1.5	1.1
50+00	Landside	1.9	1.9	--	1.5
	Waterside	2.3	-----	2.3	1.0
61+00	Landside	2.4	2.4	--	1.3
	Waterside	2.8	-----	1.8	1.0
71+00	Landside	2.8	1.9	--	3.5
	Waterside	3.3	-----	2.0	2.4

8.4 SEISMIC DEFORMATION

As shown in Table 8-4, the estimated factors of safety for the screening-level pseudo-static slope stability analyses were equal to or greater than 1.0 for all of the sections evaluated. Therefore, minimal or negligible seismic displacements are anticipated for the design seismic event and post-earthquake slope stability analyses were not performed to estimate seismic deformation.

8.5 SETTLEMENT

In addition to liquefaction-induced settlement analyses, as discussed above, a qualitative evaluation of static settlement was also performed. The potential for static settlement can arise through several cases, including consolidation of underlying soils due to fill or structural loads at the ground surface; subsidence due to removal of groundwater or other subsurface fluids, such as petroleum; and hydroconsolidation due to saturation of collapsible soils.

Due to the age of the levee (on the order of 52 years or more for most of the project site), it is very likely that all of the consolidation of underlying soils has already taken place in response to the weight of the levee fill material. Additional settlements are possible if fill or structural loads are placed on or in close proximity to the levees.

The project site is not in an area where the withdrawal of groundwater or other subsurface fluids is known to have caused subsidence. There is a potential for settlement to occur under the levees if sufficient lowering of the groundwater table were to occur in close proximity to the project site. Two scenarios that could induce such settlement are construction dewatering and large-scale pumping of groundwater for industrial, agricultural, or municipal purposes.

Hydroconsolidation, or hydrocollapse, is a phenomenon associated with soils that are prone to relatively rapid settling when subjected to wetting or saturation. Near-surface deposits of dry, porous soils where the particles are cemented with soluble salts are particularly vulnerable to hydrocollapse. The results of our subsurface exploration and laboratory testing did not indicate the presence of such soils within or below the levees.

9.0 CONCLUSIONS AND RECOMMENDATIONS

9.1 VEGETATION AND EROSION

According to USACE (2000b), landscapes within 15 feet of the levee should be free of vegetation. Based on our observations, there is generally dense vegetation on segments of the levee slopes and within 15 feet of both the landside and waterside levee toes along the levee system extent. We noted erosion of waterside access ramps in the vicinity of Station Nos. 2+00 and 12+00. Additionally, we noted erosion along the active channel banks and generally below the waterside toe of the levee. The erosion we noted does not appear to cut into the levee prism, although the waterside slope is obscured by large trees and dense vegetation along most of the levee extent, including between about Station Nos. 31+00 and 33+00, where the waterside slope appears to be oversteepened. As noted by AMEC (2011), the erosion generally appears to be due to high water flow events.

Vegetation on the waterside slopes of the levee generally consists of seasonal grasses, berry vines, and other low shrubs. Trees were not observed on the waterside levee slope faces. Trees and dense vegetation were observed within 15 feet of the waterside toe of the levee along most of the levee extent. Additionally, relatively dense vegetation and isolated trees are also present within 15 feet of the landside levee toe along sections of the levee extent.

According to the USACE, vegetation in these areas has the potential to compromise the functionality of the levee and limit access for operations and maintenance (USACE, 2000a and 2000b). In our opinion, based on observations at the site, the waterside vegetation, while not desirable according to the USACE, might not be an adverse condition to the stability of the levee system. The vegetation could induce more turbulent water and cause some mounding effect during high flows; however, it also appears to have helped anchor foundation soils along the waterside levee toes and likely helps stabilize channel banks, thus reducing erosion within these areas.

While the vegetation treatments should attempt to address recommendations presented in the most recent inspection reports (USACE, 2013 and AMEC, 2011), it is a much more complex issue that we understand is currently under consideration and development at the national and state level. Until updated guidelines are developed, we recommend that the County continue efforts to reduce vegetation along the waterside and landside levee faces and toes.

At one levee segment, between about Stations 32+00 and 35+00, we observed the waterside levee slope to be oversteepened and armored with relatively large riprap. The slope in this segment was inclined at about 1.5h:1v and extended directly into the river with no bench or apparent toe above the river margin. The crown in this segment was also wider by six to eight feet than the levee crown along the remainder of this portion of the levee. The oversteepening of this section of the levee could be due to one or both of the following reasons:

1. This segment is located near the confluence of the main stem and North Fork of the river, which might generate the greatest amount of scour and turbulent flow,

thus resulting in erosion of the levee to at this site. This condition might have been exacerbated by the degradation, or lowering, of the river thalweg, which has been documented as occurring historically in this stretch of the river. Repair of that erosion might have resulted in placement of the oversize riprap.

2. This segment of the levee is wider than the remaining segments of the river and may have been widened at some point without moving the toe of the waterside levee slope. That would result in a steepening of the waterside slope. If the levee crown is adjusted to 17 feet wide and the levee toe is located as observed during this study, then the waterside levee slope would be inclined at about 2h:1v.

Thus, it is unclear whether the oversteepening of the waterside slope between about Station Nos. 32+00 and 35+00 is due to erosion, widening of the levee crown, or both.

9.2 LIQUEFACTION AND SEISMICALLY INDUCED SETTLEMENT

There is a likely potential for liquefaction and seismically induced dry settlement of the pervious foundation material at the project site during the design seismic event, as described in Section 8.1 of this report. The maximum estimated liquefaction and seismically induced dry settlements are approximately 7½ inches and 1 inch, respectively.

In our opinion, the need for remedial action should be based on an assessment of risk posed to adjacent improvements. The estimated levee settlement due to liquefaction and seismically induced dry settlement is not anticipated to result in freeboards less than three feet at any cross section evaluated. In addition, most liquefaction will occur in relatively deeper foundation soils underlying the levee.

It should be noted that the probability of a high-water flood event and design seismic event occurring simultaneously is considered to be relatively low. If levee slopes settle during or after the design seismic event, water levels in the river will likely be lower than the adjacent land, and the consequences of settlement may be relatively minimal.

Based on these conclusions, it is our opinion that mitigation measures for liquefaction are not necessary for the Blue Lake Levee system. However, we recommend that the levees be inspected for signs of settlement, cracking, or failure as soon as possible following an earthquake and repaired as soon as conditions will allow.

9.3 PERMEABILITY AND SEEPAGE

9.3.1 Underseepage

The steady state seepage analyses resulted in estimated vertical exit gradients ranging from about 0.1 to 0.8 at the levee landside toe, for the conditions analyzed at each of the 8 cross section locations (Table 8-3). According to USACE (2005), the allowable FS for underseepage corresponds to a maximum exit gradient of 0.5. Our initial steady state seepage

analyses indicated that vertical exit gradients at Station Nos. 34+00 and 71+00 will exceed 0.5 at the levee landside toe.

To further refine our analysis at Station 34+00, we modeled the pervious foundation and impervious foundation units with permeability estimates based on laboratory data from samples collected near Station 34+00 in lieu of the generalized permeability estimates applied to the seepage models at other locations. Our seepage analysis at Station 34+00 with site-specific permeability estimates resulted in an estimated vertical exit gradient of about 0.4, which is below the maximum allowable value defined by USACE (2005).

Site-specific permeability data were not available to refine our seepage analysis at Station 71+00. The permeability values applied to analyses at this cross section were based on generalized engineering data estimated for all cross sections, and not on site-specific permeability testing of soil samples collected within the vicinity of Station 71+00. Samples were unavailable at Station 71+00 for permeability testing due to disturbance during the sampling process. Sample disturbance was caused by an abundance of coarse gravel and cobbles in the soils encountered, which made obtaining intact samples of those soils difficult using methods within our exploration plan. To improve seepage analyses at Station 71+00 and better estimate the potential for exit gradients to exceed USACE performance criteria during steady state conditions, additional samples should be obtained to estimate site-specific permeability parameters. If intact samples cannot be obtained, grain size testing could be performed on disturbed samples to estimate the permeability of soils based on grain size data correlations.

It should be noted that the estimated exit gradient of 0.8 is also likely attributable to the proximity of the relatively impermeable bedrock that defines the valley limits at a distance of approximately 300 feet from the levee centerline. For our steady state seepage evaluations, we modeled the relatively impermeable bedrock as a no-flow condition to simulate the general hydrogeologic conditions we anticipate during a flood event. Thus, the dissipation of seepage forces in a two-dimensional analysis is relatively limited in the horizontal direction, which results in relatively high exit gradients at the landside toe.

It should be noted that steady state seepage evaluations assume that base flood elevations are maintained for a sufficient time to allow steady state seepage flow conditions to develop through and beneath the levee system. However, it is our opinion that steady state conditions are generally not representative of anticipated base flood conditions for the Blue Lake Levee system. Based on a review of the standard project flood hydrograph presented in USACE (1962), it is our understanding that water elevations within the Mad River and North Fork of the Mad River rise and fall relatively rapidly during and following storm events. With responsive drainages such as the Mad River, water elevations may not be elevated for durations sufficient to establish steady state seepage flow through the embankment and foundation materials. Thus, steady state evaluations of through-seepage flow paths and exit gradients may represent improbable, conservative geotechnical conditions.

In an effort to model the development of phreatic surfaces and pore pressures during a full flood event, we conducted a preliminary transient seepage analysis at Station 34+00, based on the standard project flood hydrograph presented in USACE (1962) as a basis for the

waterside boundary condition. The transient seepage analysis was conducted with the following time stages:

Table 9-1. Time Stages of Transient Analyses at Station 34+00

Transient Analysis Stage (days)	Mad River Water Surface Elevation (ft)
0	72.8
1	92.5
2	92.5
3	92.5
4	92.5
5	92.5

The maximum water surface elevation shown in the table above corresponds to the 100-year water surface elevation at Station 34+00 defined by NHE (2014). Based on this rudimentary transient analysis, steady state conditions did not develop after applying the water surface elevation corresponding to peak discharge for about five days. For comparison, the standard project flood hydrograph presented in USACE (1962) shows a flood duration of approximately 4 days, with peak discharges generally occurring over an approximately 36-hour period. Based on the results of our rudimentary transient analysis, it is our opinion that conditions evaluated in our steady state seepage analyses are unlikely to develop during the estimated duration of a 100-year flood event. However, if subsequent transient analyses are to be performed, then time-stages will need to be developed by the project hydrologist and those stages should be applied to evaluations at each cross section to estimate the effect of transient water levels on levee stability.

9.3.2 Through-Seepage

The steady state seepage analyses indicated through-seepage could develop at three of the eight sections evaluated, which are identified in Table 8-2 of this report. Excessive seepage forces acting on the landward slope could potentially decrease the stability of the slope as a result of sloughing or internal erosion of the slope. However, as noted above, it is our opinion that steady state phreatic surfaces are unlikely to develop during the projected duration of a 100-year flood event.

It should be noted that the levee section at Station Nos. 22+00, where our seepage analyses indicated the potential for through-seepage, was modeled with an interior drainage ditch to be consistent with our field observations and design drawings (USACE, 1965). Initially, we modeled the levee section with no water in the ditch, and the results of our analyses indicated the potential for through-seepage. Based on a review of DWR (2013), we performed additional analyses at these sections assuming the ditch would be filled with water during the design storm event. The results of our analyses for the water-filled ditch condition indicate that

the phreatic surface would intersect the ditch water surface. Thus, it is our opinion that sloughing or internal erosion of the slope would likely not occur if the interior drainage ditch is filled with water during the design storm event.

9.3.3 Design Considerations

Design concepts to mitigate the potential for seepage-related failure and instability are discussed in Section 9.7. Design plans provided in USACE (1962) indicate that construction of a toe trench was planned between about Stations 39+50 and 47+50, where the overburden material was estimated to be less than 5 feet in thickness. However, the toe trench is not shown on as-constructed plans (USACE, 1964), and evidence of a toe trench was not observed by CGI/Fugro during the field exploration program.

Prior to developing any remedial actions to address underseepage and through-seepage at the potentially deficient locations identified by this study, we recommend additional engineering analyses to better evaluate the anticipated hydrologic conditions and refine the seepage model. This could also include field exploration to verify whether the toe drain noted on the USACE drawings was ever constructed.

9.4 SLOPE STABILITY

As discussed in Section 8.3 of this report, slope stability analyses were performed at each cross section for various conditions. The results are discussed relative to each condition below.

9.4.1 Existing

Our slope stability analyses of existing levee conditions estimated factors of safety ranging from approximately 1.4 to 2.8 and 1.3 to 2.8 for the landside and waterside slopes, respectively. Based on our review of historical information and observations during the field exploration program, we understand the levee slopes have not experienced past instability, which is consistent with our estimated factors of safety.

Although a minimum FS is not defined for existing levees in USACE (2000a), our estimated factors of safety for existing levee conditions meet or exceed the minimum end-of-construction FS for a new levee, defined as 1.3 (USACE, 2000a).

9.4.2 Pseudo-Static

Our slope stability analyses of existing levee conditions subjected to pseudo-static (i.e., earthquake) loading estimated factors of safety ranging from approximately 1.1 to 3.2 and 1.0 to 2.4 for the landside and waterside slopes, respectively. A minimum FS is not defined for pseudo-static loading conditions in USACE (2000a). As discussed above, if the FS was estimated to be equal to or greater than 1.0, minimal or negligible seismic displacements are anticipated for the design seismic event and post-earthquake slope stability analyses were not performed, as recommended by DWR (2013).

Based on our review of historical information, we understand the levee slopes have not experienced instability during a seismic event. At a minimum, it is recommended that the levees be inspected for signs of instability or slope failure as soon as possible following an earthquake and, if necessary, repaired as soon as conditions will allow.

9.4.3 Full Flood Event

Our slope stability analyses of existing landside levee slopes, based on steady-state full flood conditions, estimated factors of safety ranging from approximately 1.3 to 2.4. Station No. 22+00 was the only section evaluated with an estimated factor of safety below the minimum FS of 1.4 defined for long-term (steady-state seepage) flood conditions in USACE (2000a).

Based on our review of historical information, we understand the levee was damaged during a major flood event in December 1964 between about Station Nos. 15+00 and 24+00 (USACE, 1965). However, we are unaware of documents describing the damage and as built drawings for the repair have not been located (County of Humboldt, 2014). We understand the estimated flow for the 1964 event was approximately 81,000 cfs, which exceeds the estimated flow for the 100-year flood event (NHE, 2014).

As noted above, phreatic surfaces and pore pressures modeled in slope stability analyses of full flood conditions were based on the results of our steady-state seepage analyses. It is our opinion that steady state phreatic surfaces are unlikely to develop during the projected duration of a 100-year flood event. Furthermore, slope stability analyses of sections with phreatic surfaces more likely to develop during the design flood event are anticipated to result in higher estimated factors of safety than the FS values shown in Section 8.3, including Station No. 22+00, considering full flood conditions.

Therefore, the potential for landside slope failures during the 100-year flood event is considered to be low. Design concepts to mitigate the potential for seepage-related failure and instability are discussed in Section 9.6. At a minimum, it is recommended that the levees be inspected for signs of instability or slope failure during a flood event and, if necessary, repaired as soon as conditions will allow.

9.4.4 Rapid Drawdown

Our slope stability analyses of existing waterside levee slopes following a rapid drawdown of full flood water levels estimated factors of safety ranging from approximately 0.9 to 2.3. Station No. 34+00 was the only section evaluated with an estimated factor of safety below the minimum FS of 1.0 defined by USACE (2000a) for rapid drawdown conditions where water levels are unlikely to persist for long periods preceding drawdown.

As noted above, phreatic surfaces and pore pressures modeled in slope stability analyses of rapid drawdown conditions were based on the results of our steady-state seepage analyses. It is our opinion that steady state phreatic surfaces are unlikely to develop during the projected duration of a 100-year flood event. Furthermore, slope stability analyses with phreatic surfaces likely to develop during the design flood event are anticipated to result in higher

estimated factors of safety than the FS values shown in Section 8.3, including Station No. 34+00, following rapid drawdown.

Therefore, the potential for waterside slope failures due to rapid drawdown during the 100-year flood event is considered to be low. Design concepts to mitigate the potential for seepage-related failure and instability are discussed in Section 9.7. Following flood events, we recommend that the levees be inspected for signs of instability or slope failure and, if necessary, repaired as soon as conditions will allow.

9.5 SEISMIC DEFORMATION

As noted in Section 8.4, the estimated factors of safety for the screening-level pseudo-static slope stability analyses were equal to or greater than 1.0 for all of the sections evaluated. Therefore, minimal or negligible seismic displacements are anticipated for the design seismic event and post-earthquake slope stability analyses were not performed to estimate seismic deformation. Therefore, no remedial actions are considered necessary at this time.

9.6 SEEPAGE MITIGATION CONCEPTS

Based on our steady state seepage evaluation of eight cross sections spaced along the length of the levee system, levee segments in the vicinity of Stations 22+00, 34+00 and 71+00 are potentially susceptible to seepage-related failure or instability relative to USACE performance criteria. Therefore, seepage mitigation measures at these locations may be necessary to achieve FEMA certification for the levee. However, based on a preliminary transient seepage analysis at Station 34+00, it is our opinion that steady state seepage conditions are unlikely to develop and the existing Blue Lake Levee system may not be susceptible to seepage-related failure or instability during the 100-year flood event considering transient conditions. Thus, a detailed evaluation of mitigation concepts, including estimated implementation costs, is not included in this report. Nevertheless, if the County prefers to further reduce the potential for steady state seepage-related failure or instability of the existing levee, a discussion of potential mitigation concepts is provided below. General considerations for each concept relative to construction and land use are included.

Typical mitigation measures to control foundation underseepage below the levee include cutoff trenches or sheet pile cutoff walls, landside seepage berms, pervious toe trenches, and pressure relief wells. Typical mitigation measures to control seepage through the levee embankment include cutoff trenches or sheet pile cutoff walls, landside seepage berms, and toe drains.

The concepts presented are not intended to be all-inclusive; it may be that a combination, modification or alternative concept is more appropriate for design, based on additional considerations and input from the design team. Generalized illustrations and further discussion of the mitigation alternatives discussed herein are presented in USACE (2000a).

Cutoffs. Cutoffs reduce the potential for underseepage failure by blocking seepage paths through the pervious foundation material. Cutoffs may consist of excavated trenches,

backfilled with low-permeability soil or slurry, located within the levee footprint or along the levee toe. Alternatively, a steel sheet pile cutoff wall may be driven through the pervious foundation. Although sheet piling is not entirely watertight, it will likely reduce the possibility of piping of sand strata in the foundation. Cutoff walls located within the levee footprint may also serve as mitigation for through-seepage, as potential through-seepage paths could be blocked by the cutoff.

To maximize effectiveness, cutoffs are typically designed to penetrate approximately 95-percent or more of the thickness of the pervious foundation material. Based on our review of boring logs for this investigation and historical subsurface data, the thickness of the pervious foundation unit may be greater than 40 feet thick in some sections of the levee alignment. As a result, cutoff trench excavations for low-permeability earth backfill would likely extend below the water table and require a dewatering system. However, slurry cutoff trenches and sheet pile cutoff walls could be constructed without dewatering.

Landside Seepage Berms. Landside berms are constructed on the landward side of embankments to reduce the potential for underseepage failure by lengthening seepage paths to reduce hydraulic head, and providing additional weight to counteract upward seepage forces. Berms may also mitigate through-seepage by lengthening seepage paths and providing protection against sloughing of the levee landside slope. In addition, berms may serve as a source of borrow material for emergency repairs to the levee.

Berms may be composed of impervious or semi-pervious material, sand, or free-draining gravel. However, the configuration (thickness and width) of berms should be designed for site-specific conditions, and may require an impractical amount of space.

Pervious Toe Trenches. Pervious toe trenches are constructed along the levee landside toe to improve seepage conditions by allowing controlled drainage of excess seepage forces at the levee toe. Trenches are typically excavated with dimensions suited to site-specific seepage conditions and space limitations. Excavations extending below the water table may require a dewatering system. Trench backfill should consist of graded-granular material that will help to retain foundation material where the seepage exits. Trenches are typically provided with a perforated pipe to collect and convey seepage to a suitable collection point.

It should be noted that the effectiveness of a pervious toe trench may be limited by the thickness of pervious foundation material, as seepage paths may bypass the trench and generate excess seepage forces beyond the limits of the trench. Therefore, the primary purpose of a pervious toe trench would be to control shallow underseepage and protect the area in the vicinity of the levee toe.

As noted above, design plans provided in USACE (1962) indicate that construction of a toe trench was planned between about Stations 39+50 and 47+50, where the overburden material was estimated to be less than 5 feet in thickness. However, the toe trench is not shown on as-constructed plans (USACE, 1964), and evidence of a toe trench was not observed by CGI/Fugro during the field exploration program.

Pressure Relief Wells. Pressure relief wells are installed along the landside toe of levees to reduce uplift pressure by intercepting and providing controlled outlets for seepage. Well systems are usually effective where pervious foundation material is too thick to be penetrated by cutoffs or toe drains, or where space for landside berms is limited. Wells must offer little resistance to the discharge of water and prevent the loss of any soil, although the discharge capacity of wells can be temporarily increased by pumping if necessary.

Well spacing, size, and penetration depth should be evaluated relative to site-specific conditions; individual wells should be designed by an experienced professional and suited to subsurface materials encountered at the site. Pressure relief wells require periodic maintenance, and frequently lose efficiency with time due to clogging of well screens, bacteria growth, or carbonate incrustation.

Pervious Toe Drain. Pervious drainage material placed along the landside levee toe would provide a controlled exit for seepage passing through the embankment and lower the phreatic surface to reduce the potential for seepage to emerge on the landside levee slope. Drainage material should consist of graded-granular material that will help to retain levee fill material where the seepage exits. A pervious toe drain could likely be combined with the pervious toe trench discussed above.

9.7 STATIC SETTLEMENT

As discussed in Section 8.5, the potential for static settlement to impact the levees is considered to be minimal under the present conditions. Therefore, no remedial actions are considered necessary at this time.

10.0 REFERENCES

- AMEC Geomatrix, Inc. (2011), Periodic Inspection Report No. 1, Mad River, Blue Lake, Humboldt County, California, dated June.
- ASTM (2005), Volume 4.08 Soil and Rock D420 to D5876.
- Bertolini, J.C., and Collins, R. (2014), Where's the Lake?, Stories of Blue Lake and the Mad River Valley, Blue Lake Museum Society, March, 214 p.
- Bing Yen & Associates (2000), Earthquake Faults.
- Boore, D.M., and Atkinson, G.M. (2008), Ground-motion prediction equations for the average horizontal component of PGA, PGV, and 5%-damped PSA at spectral periods between 0.01 s and 10.0 s: Earthquake Spectra, v. 24, no. 1.
- California Department of Water Resources (2014), Water Data Library, access on line at: <http://www.water.ca.gov/waterdatalibrary>.
- California Geological Survey (CGS) (2002), California Geomorphic Provinces, CGS Note 36, 4 p.
- California State Water Resources Control Board (2014), Geotracker database, accessed online at: <http://geotracker.swrcb.ca.gov/>.
- Campbell, K.W., and Bozorgnia, Y. (2008), Ground motion model for the geometric mean horizontal component of PGA, PGV, PGD and 5% damped linear elastic response spectra for periods ranging from 0.01 to 10.0 s: Earthquake Spectra, v.24, no. 1.
- Carver, G.A., Stephens, T.A., Young, J.C., Quaternary Reverse and Thrust Faults, Mad River Fault Zone, in Harden, D.R., Marron, D.C., and MacDonald, A., Late Cenozoic History and Forest Geomorphology, Humboldt County, California: Friends of the Pleistocene, Pacific Cell Field Trip, 1982, p. 93-98.
- Cashman, S.M., Kelsey, H.M., and Harden, D.R., 1995, Geology of the Redwood Creek Basin, Humboldt County, California, in Geomorphic Processes and Aquatic Habitat in the Redwood Creek Basin, Northwestern California: US Geological Survey Professional Paper 1454-B, p.B1-B13.
- Chapuis, R.P (2004), Predicting the Saturated Hydraulic Conductivity of Sand and Gravel using Effective Diameter and Void Ratio, Canadian Geotechnical Journal, 41(t5), pp 787-795.
- Chiou, B., and Youngs, R. (2008), A NGA model for the average horizontal component of peak ground motion and response spectra: Earthquake Spectra, v. 24, no. 1.
- County of Humboldt (2014), Memorandum: Summary of Available Technical Information for the Blue Lake Levee, dated January 3.

Department of Water Resources [DWR] (2013), Guidance Document for Geotechnical Analyses, Urban Levee Evaluations Project, Contracts 4600007418 and 4600008101, Version 13, Draft 1, prepared by URS in association with GEI Consultants and Fugro Consultants, dated July.

_____ (2012), Urban Levee Design Criteria, Flood Safe California, dated May.

_____ (2010), Interim Levee Design Criteria for Urban and Urbanizing Areas in the Sacramento-San Joaquin Valley, Version 4, Central Valley Flood Management Planning Program, State of California, The Natural Resources Agency, dated December 15.

Dickenson, S.E. (1994), Dynamic Response of Soft and Deep Cohesive Soils During the Loma Prieta Earthquake of October 17, 1989; Dissertation for Doctor of Philosophy in Civil Engineering at the University of California at Berkeley, pp. 104-112.

Federal Emergency Management Agency [FEMA] (2008), Requirements for Mapping Levees, Complying with Section 65.10 of the NFIP Regulations, dated November.

Geologismiki (2006), LiqIT 4.7 (Version 4.7.6.2), Soil Liquefaction Assessment Software.

Hardin, D.R., Kelsey, H.M., Morrison, S.D., and Stephens, T.A., 1982, Geologic map of the Redwood Creek drainage basin, Humboldt County, California, U.S. Geological Survey Water Resources Investigations Open-file Report 81-496, scale 1:62,500.

Hart, E.W. and Bryant, W.A. (1997), Fault-Rupture Zones in California, Alquist-Priolo Earthquake Fault Zoning Act with Index to earthquake Fault Zone Maps, California Division of Mines and Geology Special Publication 42, with supplements 1 and 2 added in 1999, 38 p.

Hinds, N.E. (1952), Evolution of the California Landscape, California Division of Mines and Geology Bulletin 158, pp 145-152.

Ishihara, K. and Yoshimine, M. (1992). "Evaluation of Settlements in Sand Deposits Following Earthquakes," Soils and Foundations, Vol. 32, No. 1, 173-188.

Jennings C.W. and Bryant, W.A. (2010), 2010 Fault Activity Map of California, California Geological Survey, Geologic Data Map No. 6, accessed on line at: <http://www.quake.ca.gov/gmaps/FAM/faultactivitymap.html>.

Jennings, C.W. (1994), Fault Activity Map of California and Adjacent Areas: California Dept. of Conservation, Division of Mines and Geology, Geologic Data Map No. 6, Scale 1:750,000 (CD-ROM).

LACO Associates (2008), Groundwater Monitoring Report – Second and Third Quarter 2008, Blue Lake Market, 410 Railroad Avenue, Blue Lake, California, LOP No. 12229; CRWQCB Case No. 1THU229; USTCF Claim No. 11658, unpublished consultant's report prepared for County of Humboldt Department of Health and Human Services, dated October 13, 12 p. with figures and appendices.

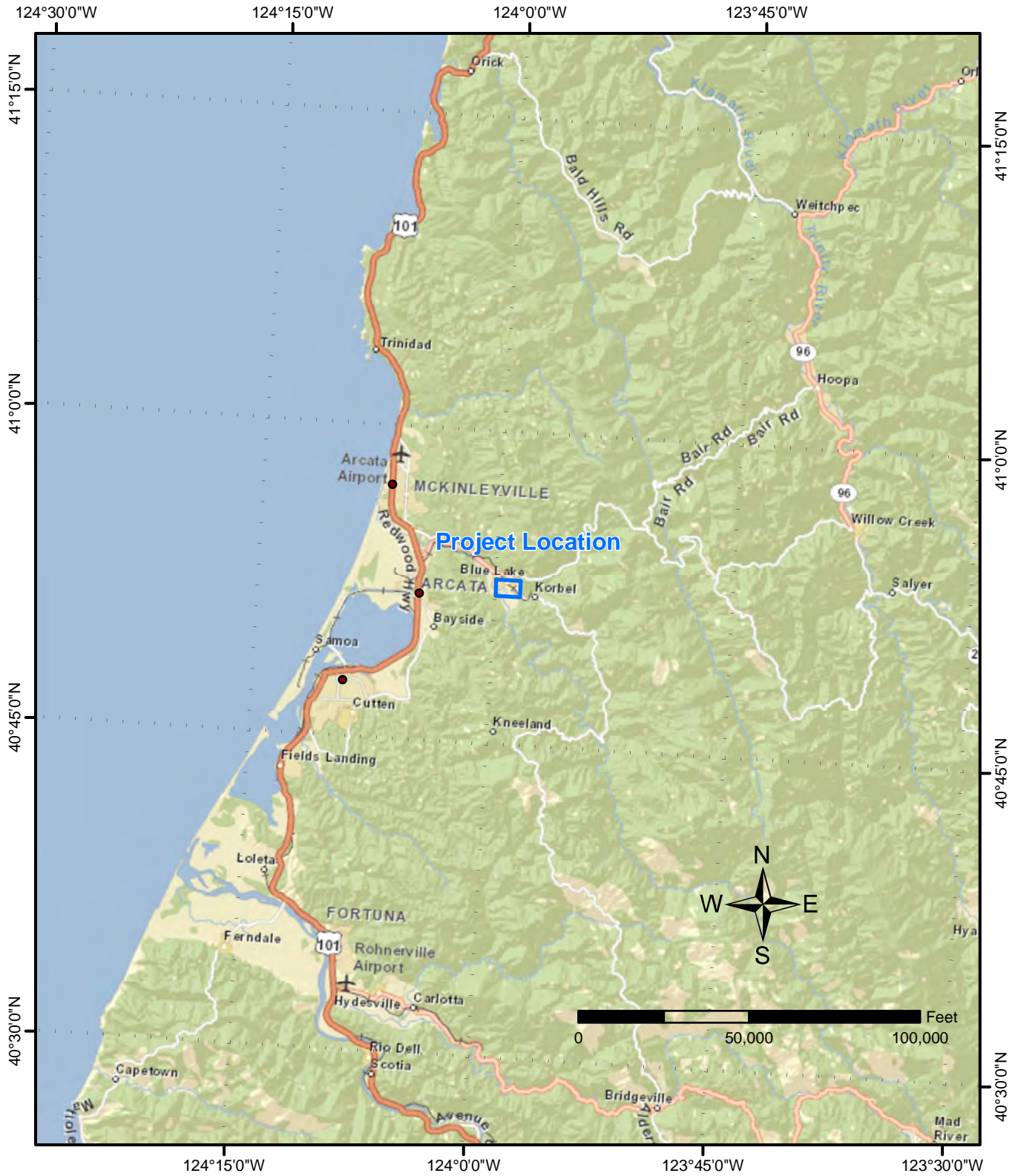
- Lehre, A. (1993), Estimation of Mad River Gravel Recruitment and Analysis of Channel Degradation, Mad River EIR Technical Supplement. Department of Geology and Institute for River Ecosystems, Humboldt State University, Arcata, California, dated April 5.
- Lehre, A., Klein, R., and Jager, D. (2009), County of Humboldt Extraction Review Team (CHERT), Historical Analyses of the Mad River: 2004 – 2007 Update, prepared for Humboldt County Board of Supervisors, February 18, 16 p. with attachments.
- Klein, R., Jaber, D., Lehre, A., and Trush, B. (2014), County of Humboldt Extraction Review Team (CHERT), 2013 Post-Extraction Report, Discussion Draft, prepared for Humboldt County Board of Supervisors, February, 14 p.
- Manhard Consulting & Northern Hydrology and Engineering (2013), Hydrologic Analysis for Mad River near the City of Blue Lake, Humboldt County, California, unpublished consultant's report prepared for Humboldt County Department of Public Works, June 3, 18 p. with appendices.
- Marcuson, W.F. et al. (1983), 'Seismic Design, Analysis and Remedial Measures to Improve the Stability of Existing Earth Dams - Corps of Engineers Approach', In 'Seismic Design and Embankments and Caverns' (ed: Howard, T.R.) ASCE, New York.
- Mayne, P.W., and Rix, G.J. (1995), 'Correlations between Shear Wave Velocity and Cone Tip Resistance in Natural Clays.' Soils and Foundations, 35 (2), pp. 107-110.
- Mayne, P.W. (2007), Cone Penetration Testing State-of-Practice. NCHRP Project 20-05 Topic 37 - pp. 14.
- McLaughlin, R.J., Ellen, S.D., Blake, M.C., Jr., Jayko, A.S., Irwin, W.P., Aalto, K.R., Carver, G.A., and Clarke, S.H., Jr. (2000), Geology of the Cape Mendocino, Eureka, Garberville, and Southwest part of the Hayfork 30 x 60 Minute Quadrangles and Adjacent Offshore Area, Northern California, U.S. Geological Miscellaneous Field Studies MF-2336, Version 1.0, 27 p. with Maps.
- Moore & Taber (1983), Foundation Investigation (Phase I), Hatchery Road Bridge across Mad River, unpublished consultant's report prepared for Humboldt County, January, 11 p. with drawings.
- NCEER (1997), "Proceedings of the NCEER Workshop on Evaluation of Liquefaction Resistance of Soils." Edited by Youd, T.L., Idriss, I.M., Technical Report No. NCEER-97-0022, December 31, 1997.
- Northern Hydrology & Engineering (2014), Blue Lake Levee Evaluation – Water Surface Elevation Estimates for Mad River 100-Yr Flood Flow near the City of Blue Lake, Humboldt County, California, unpublished consultant's report prepared for Humboldt County Public Works Department, dated June 26, 4 p.

- Northern Hydrology and Engineering & Manhard Consulting (2013), Hydrologic Analysis for Mad River near the City of Blue Lake, Humboldt County, California, unpublished consultant's report prepared for Humboldt County Department of Public Works, February 8, 17 p. with appendices.
- Pradel, D. (1998), "Procedure to evaluate earthquake-induced settlements in dry sandy soils," ASCE Journal of Geotechnical and Geoenvironmental Engineering, 124 (4), pp. 364 - 368.
- Rocscience Inc. (2014), "SLIDE (Version 6.029, Build Date: Apr 25 2014)" Toronto, Ontario, Canada.
- Seed, R.B et al. (2003). "Recent Advances in Soil Liquefaction Engineering: A Unified and Consistent Framework," Keynote Address, Proceedings, 26th Annual Geotechnical Spring Seminar, Los Angeles Section of the Geoinstitute, American Society of Civil Engineers.
- Seed, R.B. and Harder, L.F. (1990). "SPT-Based Analysis of Cyclic Pore Pressure Generation and Undrained Residual Strength," H.B. Seed Memorial Symposium, Berkeley, California, BiTech Publishing, Ltd., v. 2, pp. 351-376.
- Smith, T.R. (1982), Fault Evaluation Report FER-138, Mad River fault zone (Trinidad, McKinleyville, Mad River, Fickle Hill, and related faults), California Division of Mines and Geology, October 19, 31 p. with figures
- Stillwater Sciences (2010), Mad River Watershed Assessment, Final Report, dated June, 169 p.
- Strand, R.G. (1962), Geologic Map of California, Redding Sheet: California Division of Mines and Geology, Scale 1:250,000.
- Sykora, D.W. (1987), 'Examination of Existing Shear Wave Velocity and Shear Modulus Correlations in Soils.' Department of the Army, Waterways Experiment Station, Corps of Engineers, Miscellaneous Paper GL-87-22.
- Tolhurst, J.W. (1995), Historical Analysis of Geomorphic Channel Changes, Lower Mad River, Humboldt County, California, Masters of Science Thesis, Department of Geology, Humboldt State University, August, 267 p.
- U.S. Army Corps of Engineers [USACE] (2013), Engineering Technical Letter 1110-2-580, Engineering and Design, Guidelines for Seismic Evaluation of Levee, 1 December.
- _____ (2010a), Engineering Circular 1110-2-6067, Engineering and Design, Certification of Levee Systems for the National Flood Insurance Program (NFIP), 31 August.
- _____ (2008), Geotechnical Levee Practice, REFP10L0 Rev. 2, Sacramento District, April 11.

- _____ (2005) "Design Guidance for Levee Underseepage," ETL 1110-2-569, May 1.
- _____ (2003), Engineering Manual 1110-2-1902, Engineering and Design, Slope Stability, 31 October.
- _____ (2000a), Engineering Manual 1110-2-1913, Engineering and Design, Design and Construction of Levees, 30 April.
- _____ (2000b), Engineering Manual 1110-2-301, Engineering and Design, Guidelines for Landscape Planting and Vegetation Management at Floodwalls, Levees, and Embankment Dams, 1 January.
- _____ (1992), Engineering Manual 1110-2-1914, Design, Construction, and Maintenance of Relief Wells, 29 May.
- _____ (1986), Engineering Manual 1110-2-1901, Chapter 2, Determination of Permeability of Soil and Chemical Composition of Water, 30 September.
- US Army Corps of Engineers, San Francisco District [USACE] (1953), Project Report on Mad River at Blue Lake, California for Flood Control, November 4, 49 p.
- _____ (1956), Operation and Maintenance Manual for Flood Control Project, Mad River at Blue Lake, Humboldt County, June, 42 p.
- _____ (1962), Detailed Project Report, Local Flood Protection Project on North Fork, Mad River, near Blue Lake, Humboldt County, California, May, 96 p.
- _____ (1964), Mad River at Blue Lake Local Flood Protection Project, Operation and Maintenance Manual, July, 41 p.
- _____ (1965), North Fork Mad River at Blue Lake Levee Restoration, June, 9 sheets.
- _____ (2013), Routine Inspection Report, Mad River at Blue Lake, Federal Flood Control Project, approved April 5.
- United States Geological Survey, Earthquake Hazards Program, ShakeMap, accessed December 2010:
<http://earthquake.usgs.gov/earthquakes/shakemap/nc/shake/71338066/>
- Waananen, A.O., Harris, D.D., and Williams, R.C. (1971), Floods of December and January 1965 in the Far Western United States, Part 1 – Description, U.S. Geological Survey Water-Supply Paper 1866-A, 258 p.
- Winzler & Kelly (2009), Report of Subsurface Investigation Activities, Jackson's Garage, 630 Railroad Avenue, Blue Lake, California, LOP #12014, unpublished consultant's report prepared for County of Humboldt Department of Health and Human Services, dated December 3, 5 p. with figures and appendices.

Youd, T. L. and Idriss, I.M. (2001), "Liquefaction Resistance of Soils: Summary Report from the 1996 NCEER and 1998 NCEER/NSF Workshops on Evaluation of Liquefaction Resistance of Soils, Co-chairs Youd, T.L. and Idriss, I.M., Journal of Geotechnical and Geoenvironmental Engineering, Vol. 127, No. 10, pp. 817-833.

PLATES

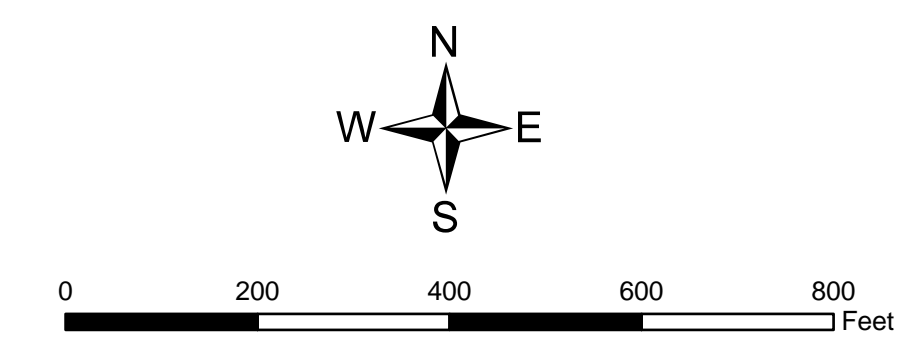


N:\Projects\04_2014\04_6214_0035_BlueLake\Outputs\2014_10_9_Edits_for_Gresh\MXD\Plate_X-X_Vicinity_Map.mxd, 10/10/2014, wcupples

VICINITY MAP
Blue Lake Levee Evaluation
Humboldt County, California



- Legend**
- Cross Section Line
 - RC — RC' Approximate Levee Centerline with Stations
 - RL — RL' Landside Profile Line
- Explorations**
- CGI/Fugro Hollow Stem Auger
 - ▼ CGI/Fugro CPTs



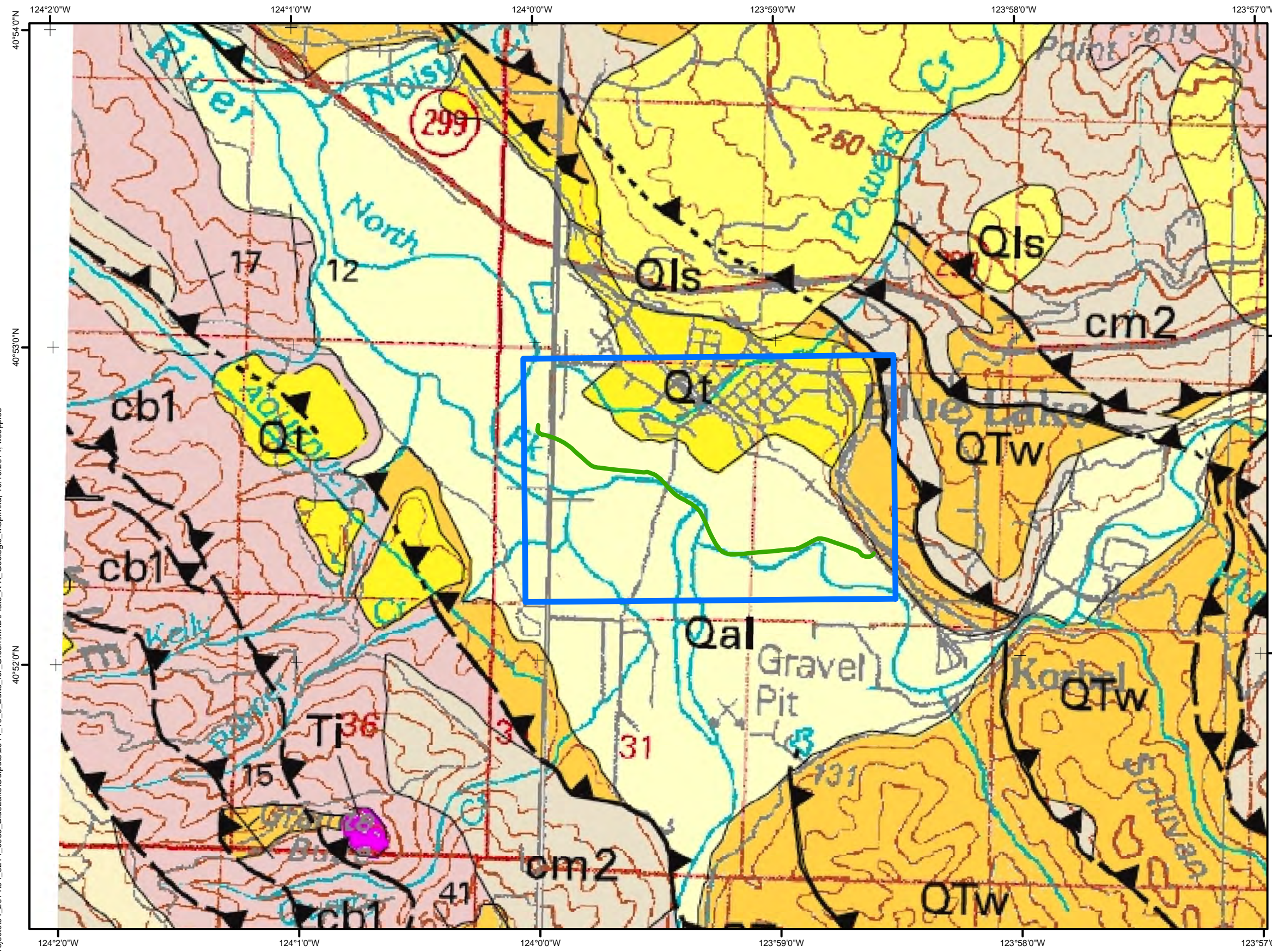
Humboldt County Public Works Department
 Fugro Project No. 04-021-00035
 CGI Project No. 10-1949-02

CGI TECHNICAL SERVICES INC.

EXPLORATION LOCATION PLAN
 Blue Lake Levee Evaluation
 Humboldt County, California

NO.	DATE	DESCRIPTION	DRAWN	CHKD	APPR
1	Oct. 2014	Exploration Plan			

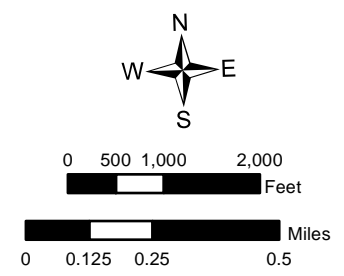
PLATE 2-1



- Legend**
- Project Location
 - Levee Crown
 - River
 - Thrust Fault - dashed where approximately located

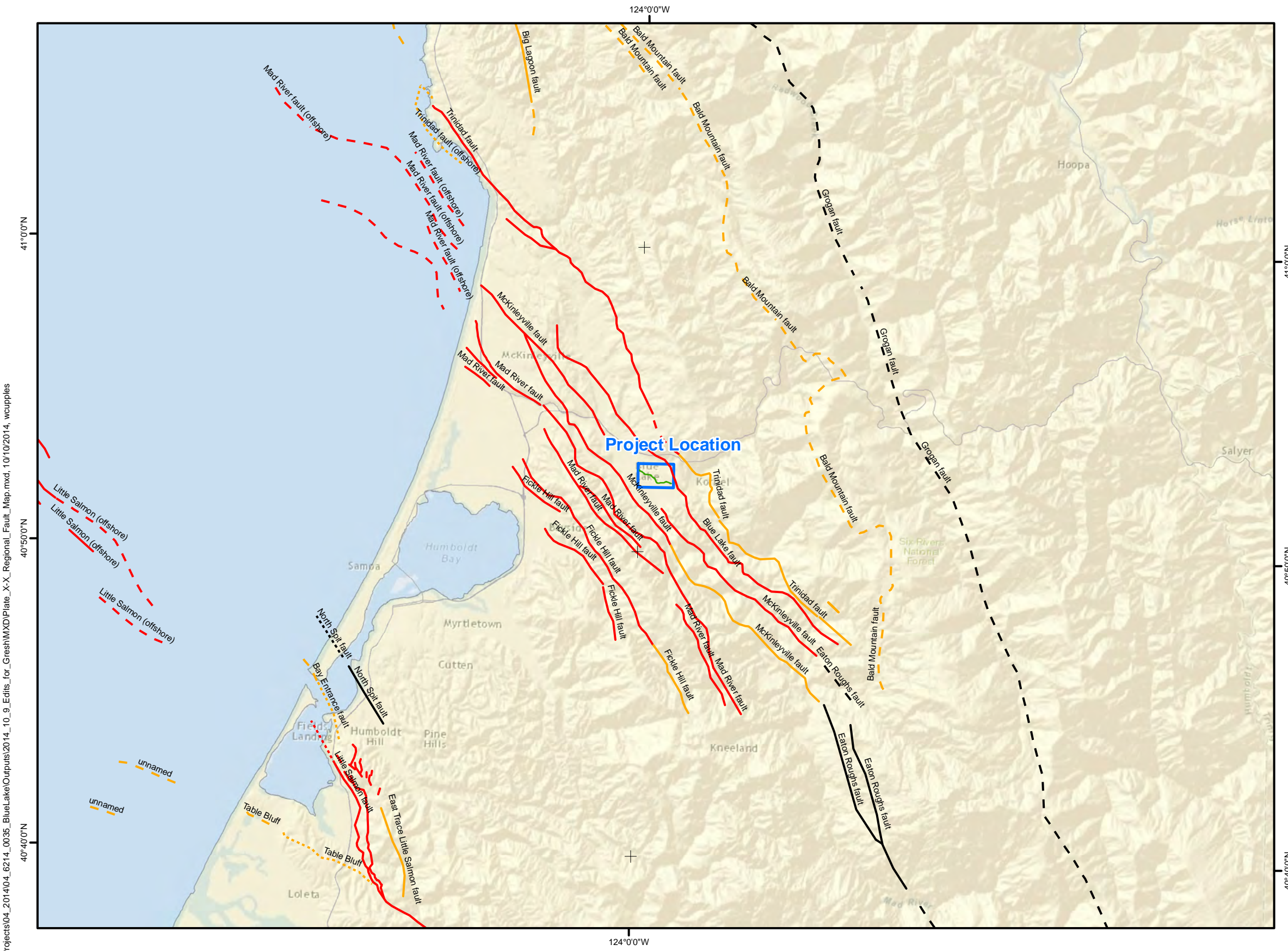
- Geologic Units**
- Qal - Alluvial deposits
 - Qt - Undifferentiated nonmarine terrace deposits
 - Qls - Landslide deposits
 - QTW - Marine and nonmarine overlap deposits
 - Ti - Volcanic rocks of Fickle Hill
 - cm2 - Melange
 - cb1 - Broken formation

SOURCE: Geology of the Cape Mendocino, Eureka, Garberville, and southwestern part of the Hayfork 30 x 60 Quadrangles and Adjacent Offshore Area, Northern California (2000)



GEOLOGIC MAP
 Blue Lake Levee Evaluation
 Humboldt County, California

N:\Projects\04_2014\04_6214_0035_BlueLake\Outputs\2014_10_9_Edits_for_GreshmXD\Plate_X-X_Geologic_Map.mxd, 10/10/2014, wcupples



Legend

- Site
- Highways

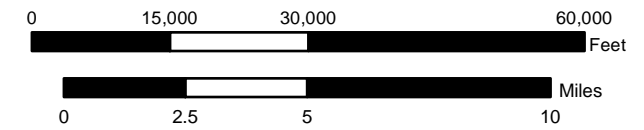
Faults

- Active Fault
- - - Potentially Active Fault
- Inactive Fault

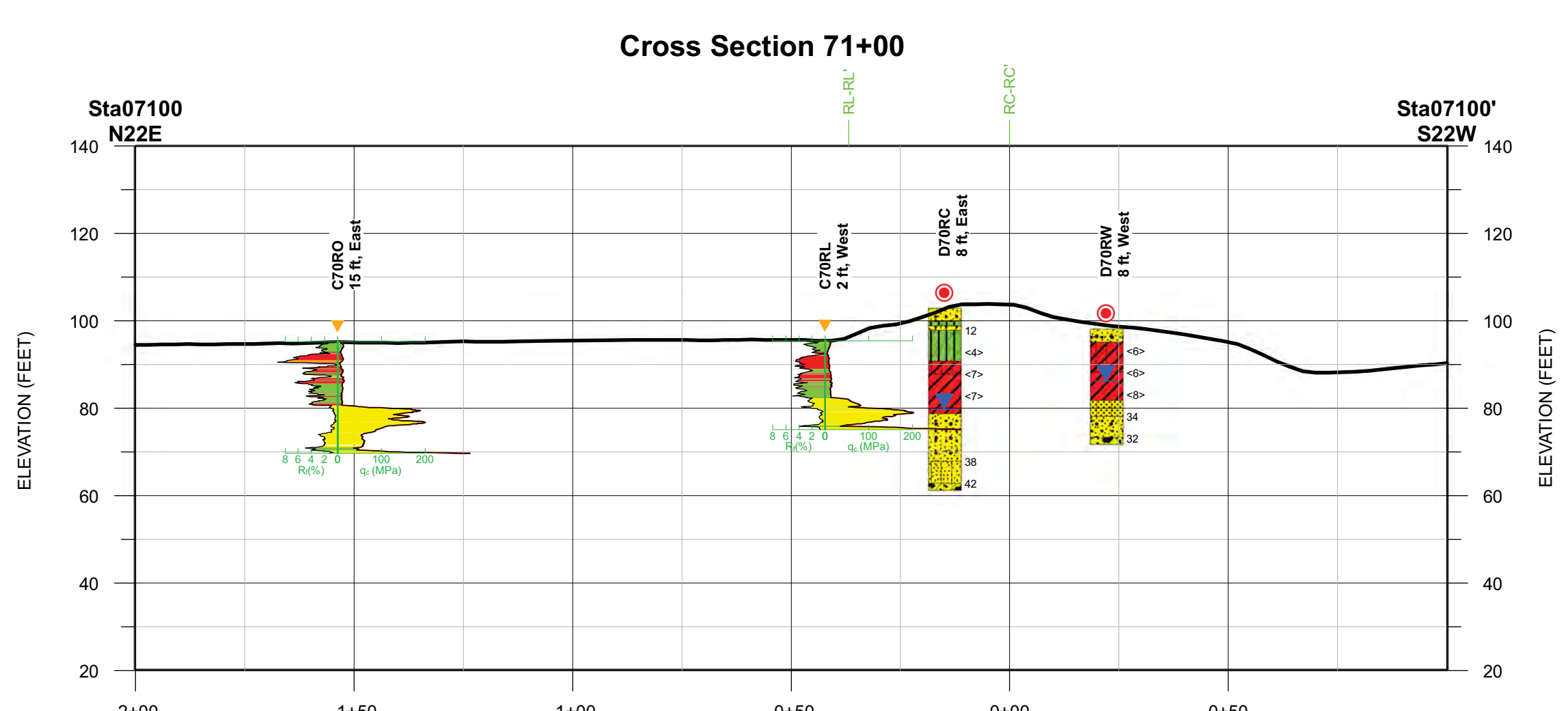
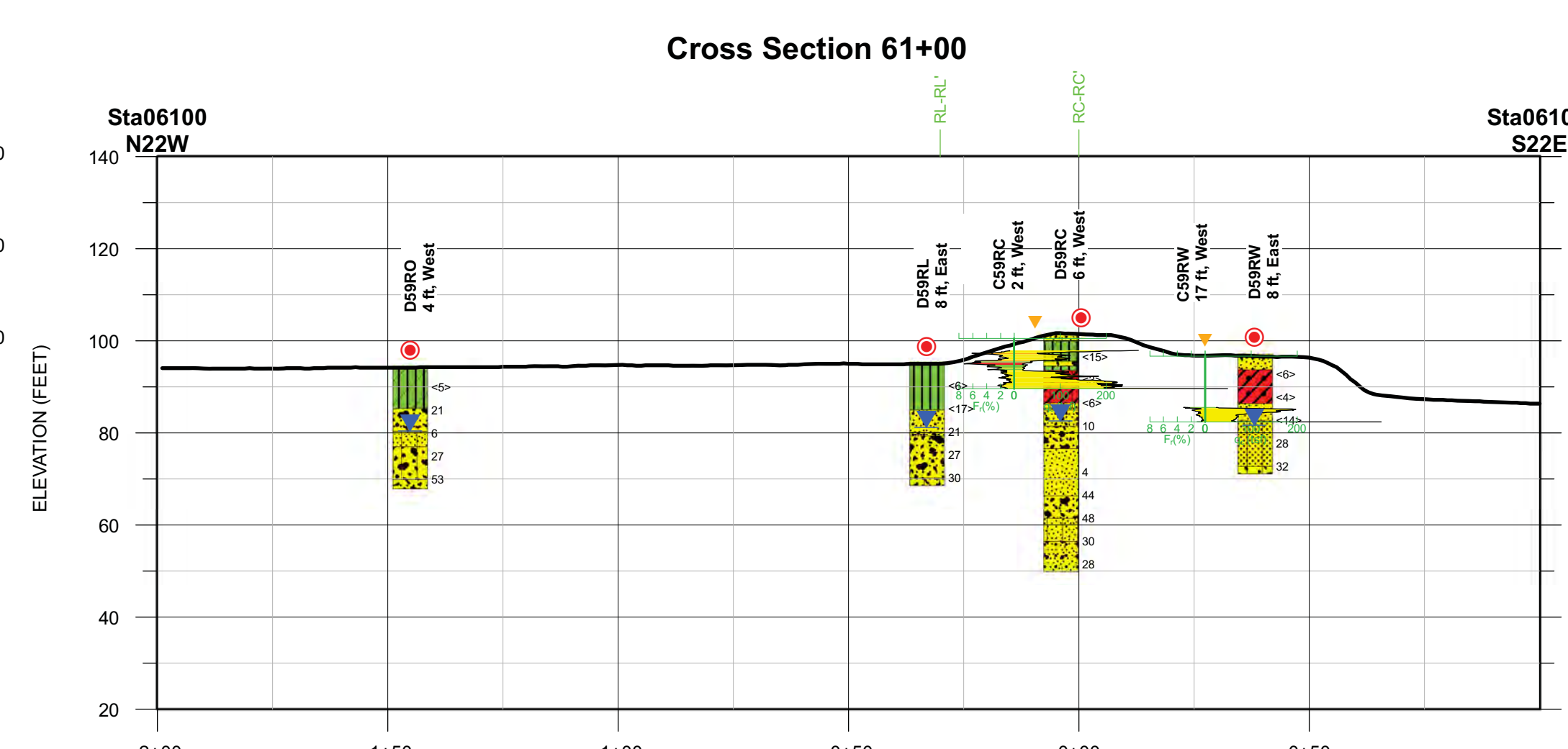
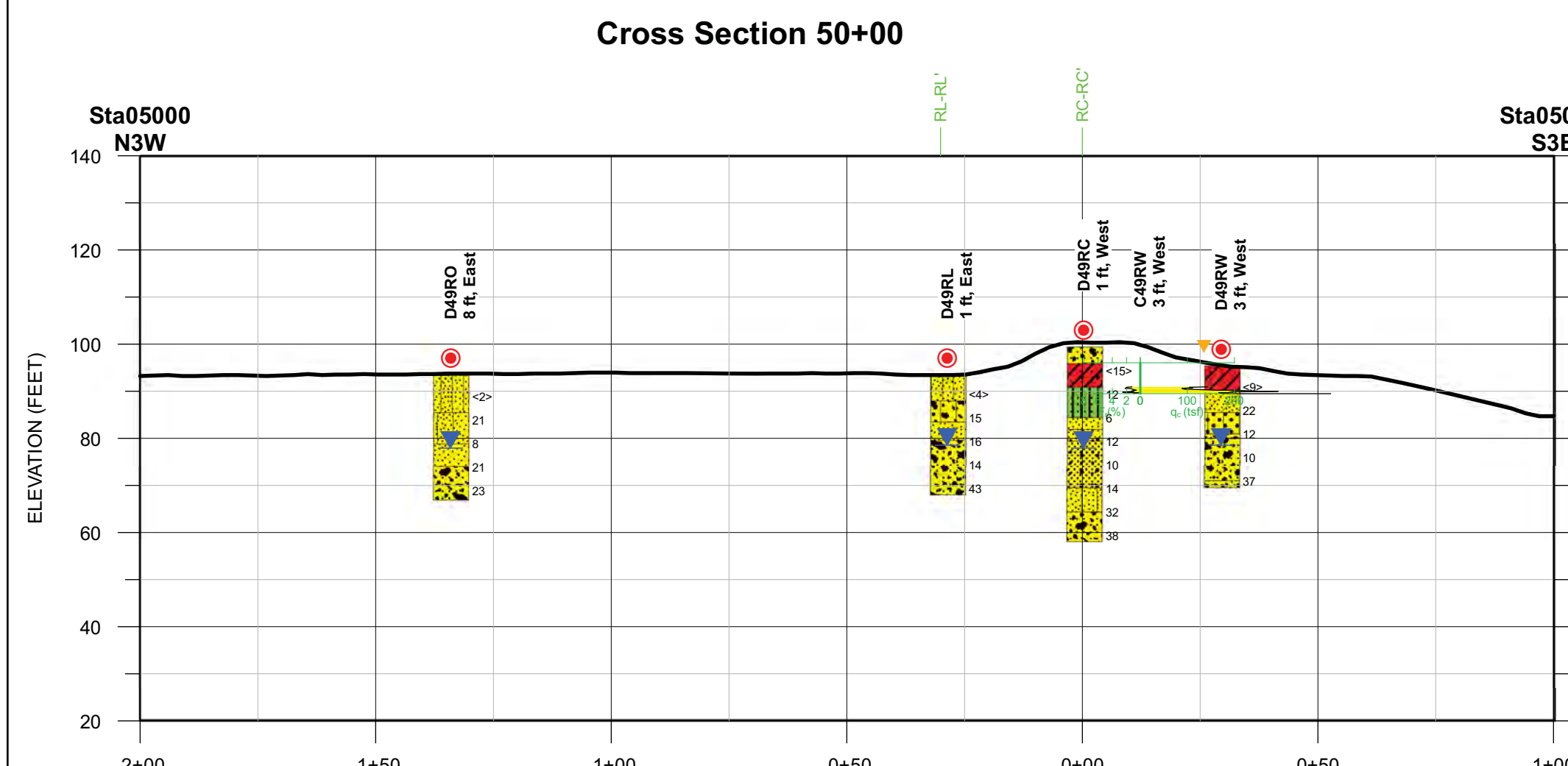
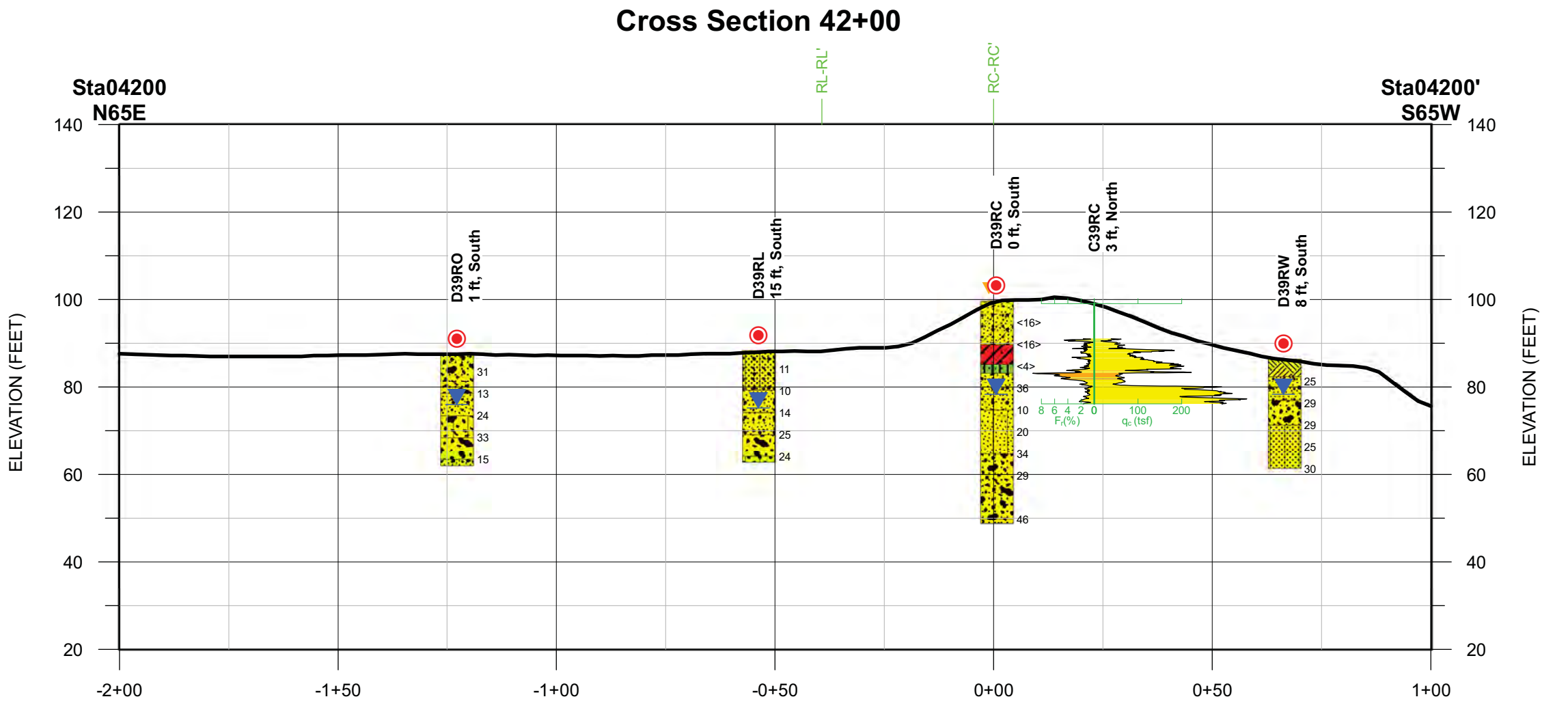
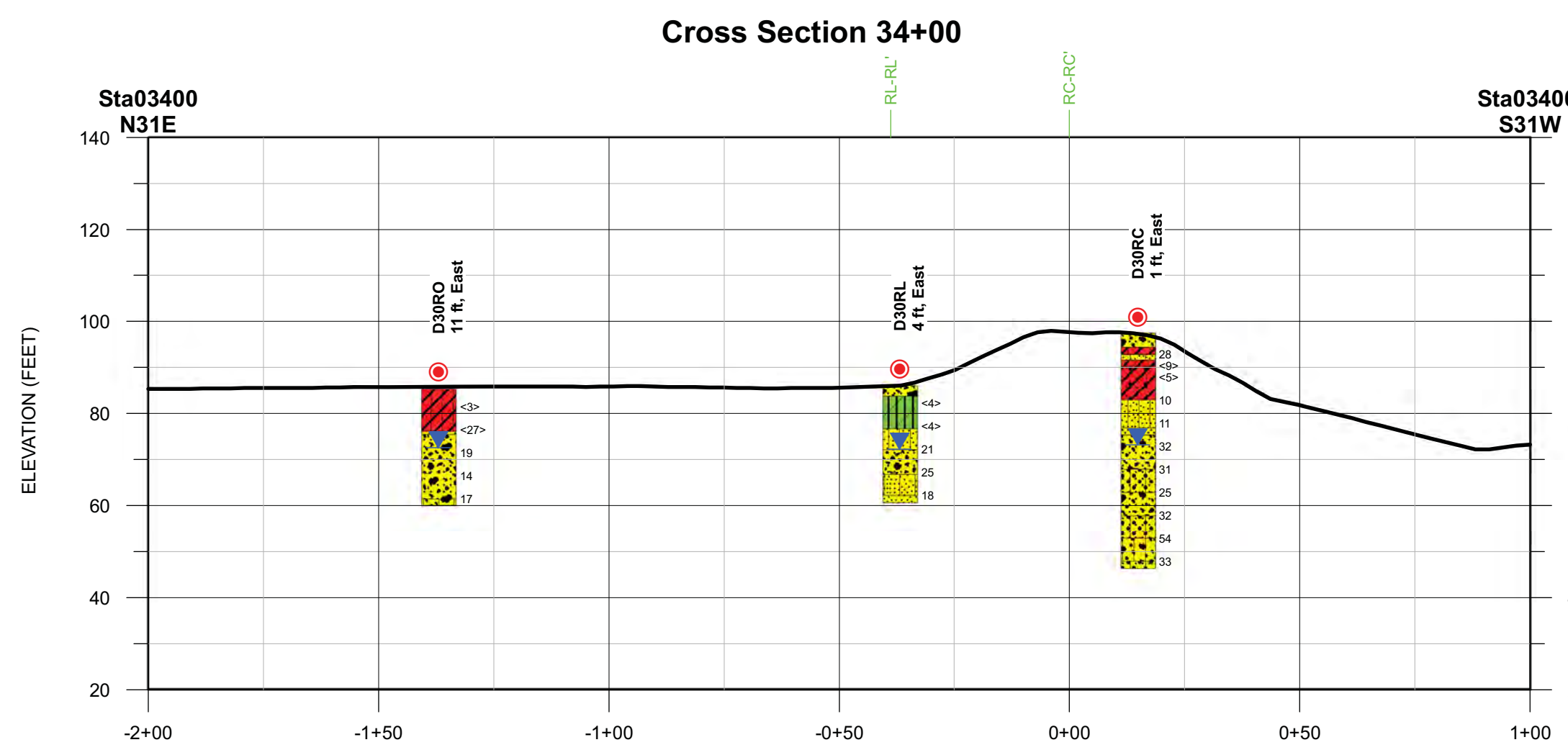
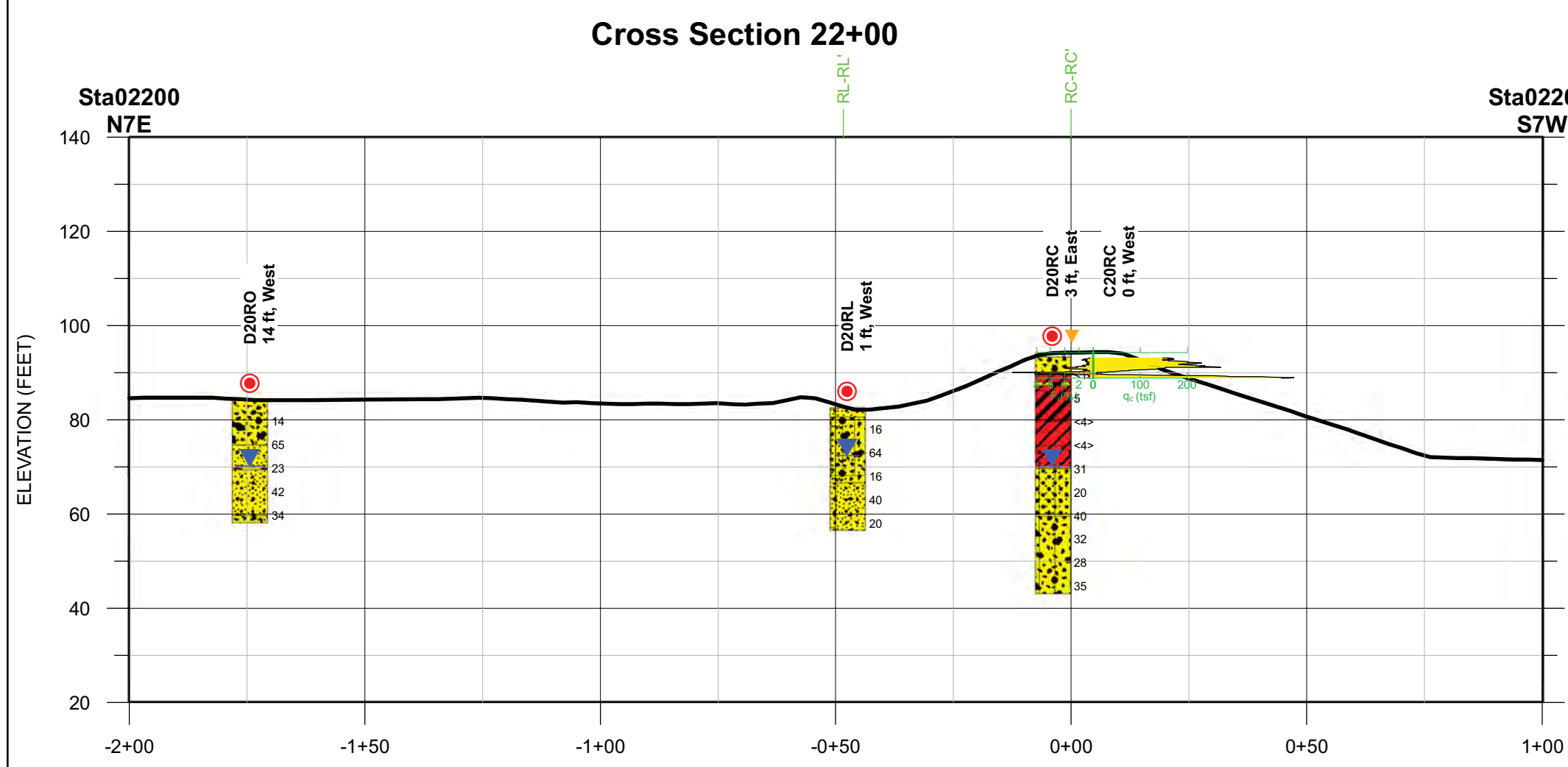
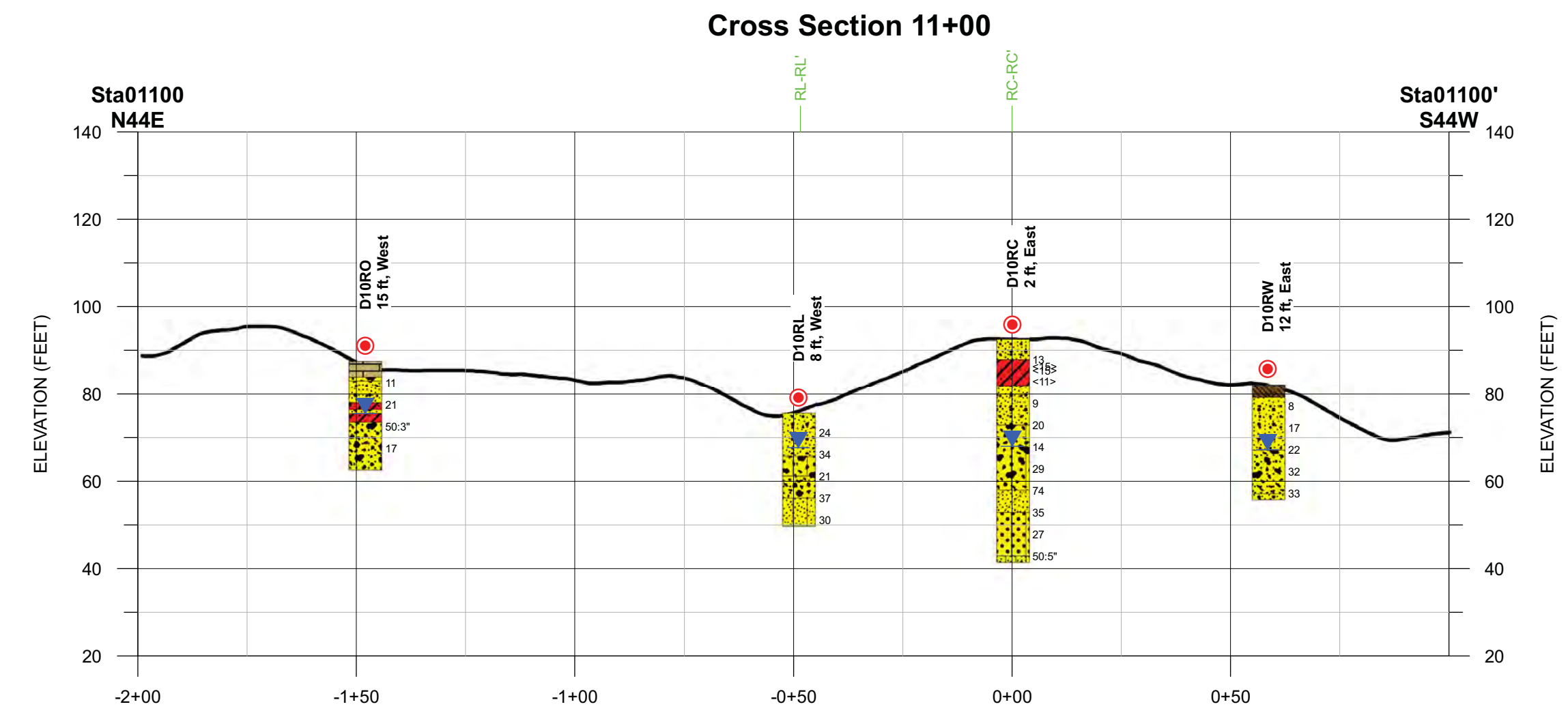
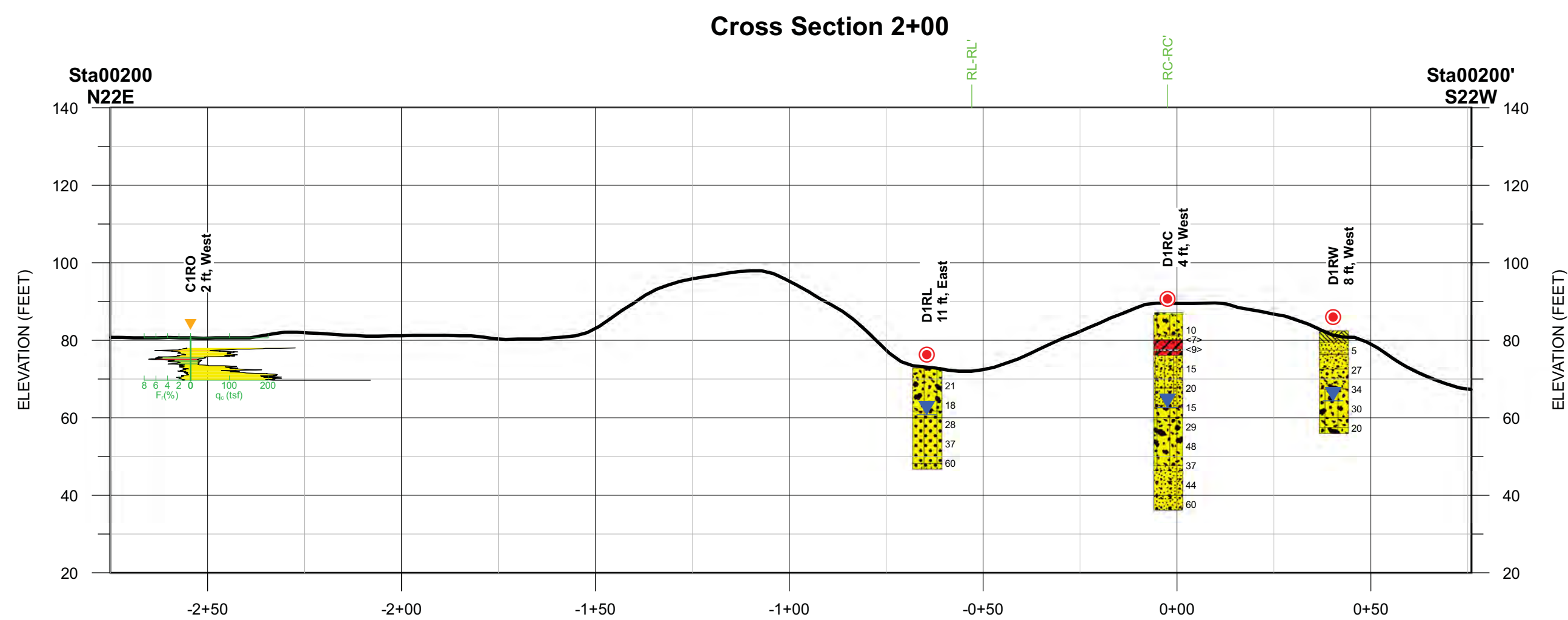
Dashed where approximate,
 dotted where concealed

SOURCES:

- Faults:
- 1) Bryant, W.A. (compiler), 2005, Digital Database of Quaternary and Younger Faults from the Fault Activity Map of California, version 2.0: California Geological Survey Web Page, http://www.consrv.ca.gov/CGS/information/publications/QuaternaryFaults_ver2.htm; (2005).
 - 2) Jennings, C.W., 1994, Fault Activity Map of California and Adjacent Areas: California Dept. of Conservation, Division of Mines and Geology, Geologic Data Map No. 6, Scale 1:750,000 (CD-ROM)
 - 3) Bing Yen & Associates, Inc., Earthquake Faults, (2000).



REGIONAL FAULT MAP
 Blue Lake Levee Evaluation
 Humboldt County, California

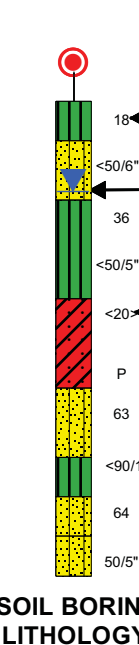
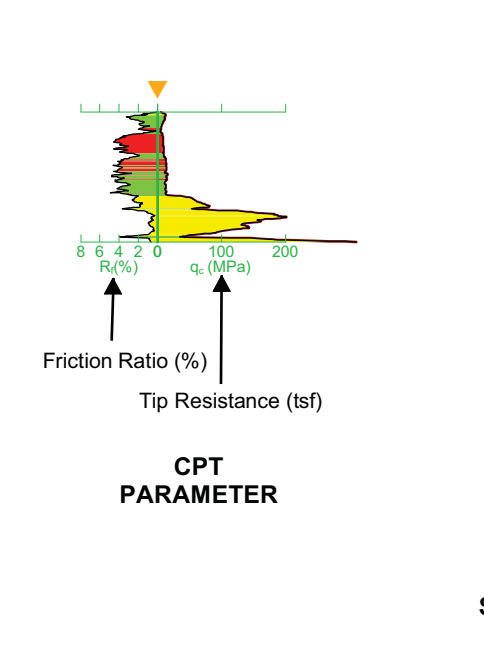


W:\Projects\10-10-14\10-10-14_015_Levee\Drawings\Cross Sections\AS010101.dwg
 10/10/2014 10:00 AM

Zone	Soil Behavior Type
1	Sensitive Fine-grained
2	Peats
3	Silty Clay to Clay
4	Clayey Silt to Silty Clay
5	Silty Sand to Sandy Silt
6	Clean Sand to Silty Sand
7	Gravelly Sand to Dense Sand
8	Very Stiff Sand to Clayey Sand*
9	Very Stiff Fine-Grained*

*heavily overconsolidated or cemented

Fr Friction Ratio (%)
 Ts Tip Resistance (tsf)



<ul style="list-style-type: none"> Lean CLAY (CL) Silty CLAY (CL-ML) Sandy Lean Clay (CL) Sandy, Gravelly Lean CLAY (CL) Gravelly Lean CLAY (CL) Silt (ML) Sandy, Gravelly SILT (ML) Sandy SILT (ML) Gravelly SILT (ML) Poorly-Graded SAND (SP) 	<ul style="list-style-type: none"> Poorly-Graded SAND with Silt (SP-SM) Gravelly Poorly-Graded SAND with Silt (SP-SM) Gravelly Poorly-Graded SAND (SP) Well-Graded SAND (SW) Well-Graded SAND with Clay (SW) Well-Graded SAND with Silt (SW-SM) Gravelly Well-Graded SAND (SW) Clayey SAND (SC) Gravelly, Clayey SAND (SC) Silty SAND (SM) 	<ul style="list-style-type: none"> Gravelly Silty SAND (SM) Poorly-Graded GRAVEL (GP) Poorly-Graded GRAVEL with Clay (GP-GC) Poorly-Graded GRAVEL with Silt (GP-GM) Sandy GRAVEL with Silt (GP-GM) Sandy GRAVEL (GP) Well-Graded GRAVEL with Clay (GW-GC) Well-Graded GRAVEL with Silt (GW-GM) Sandy Well-Graded GRAVEL (GW) Sandy, Clayey GRAVEL (GC) 	<ul style="list-style-type: none"> Silty Gravel (GM) Sandy, Silty GRAVEL (GM) Fill Fill (Wood) Asphaltic Concrete
---	--	--	--

Humboldt County Public Works Department
 Fugro Project No. 04.62140035
 CGI Project No. 10-1949.02

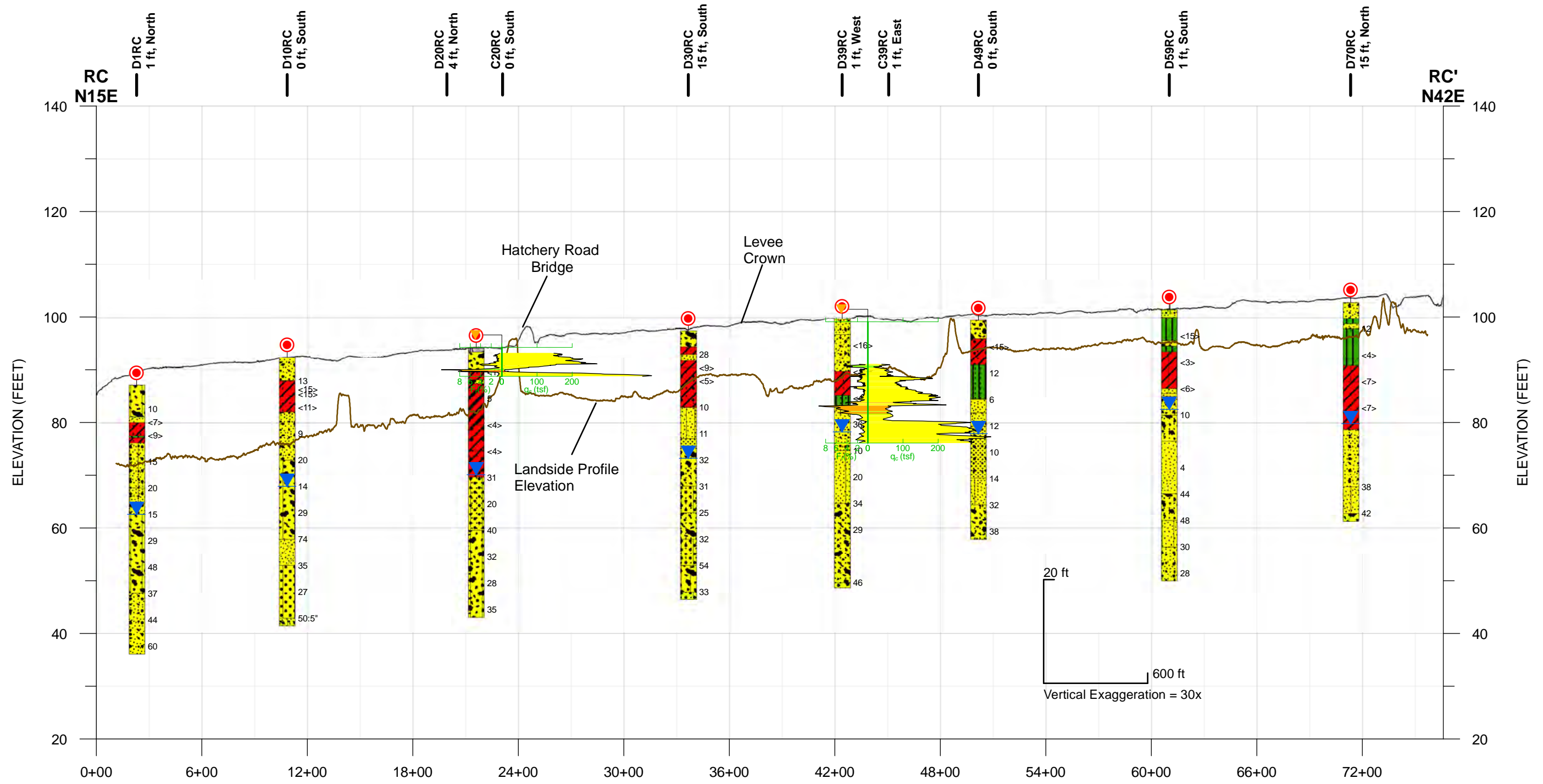
CGI TECHNICAL SERVICES INC.

FUGRO

CROSS SECTIONS Blue Lake Levee Evaluation Humboldt County, California

NO:	DATE:	DESCRIPTION:	DRAWN:	CHKD:	APPR:
1	Oct. 2014	Levee Cross Sections			

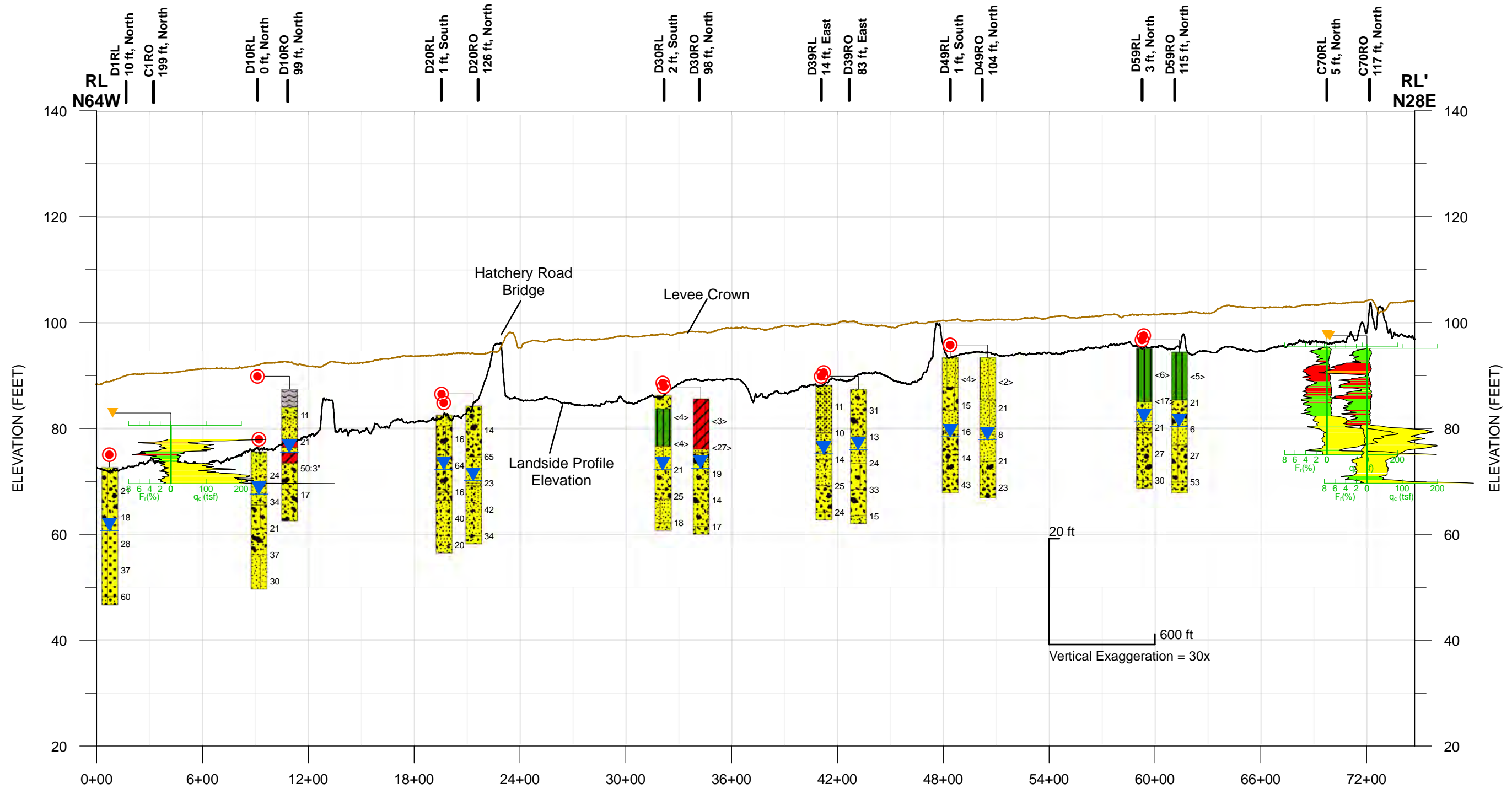
PLATE 5-3



Notes: 1. Key to Profiles shown on Plate 5-6
 2. Landside profile elevation surface defined by interior drainage ditch downstream of Hatchery Road Bridge

LEVEE PROFILE
 Blue Lake Levee Evaluation
 Humboldt County, California

N:\Projects\04_2014\04_6214_0035_BlueLake\Outputs\Working\mxd\11x17_Long_Levee_Profile.mxd, 8/28/2014, wcupples



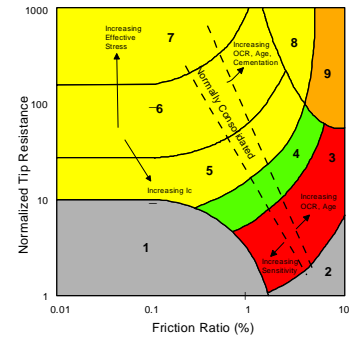
Notes: 1. Key to Profiles shown on Plate 5-6
 2. Landside profile elevation surface defined by interior drainage ditch downstream of Hatchery Road Bridge

LANDSIDE PROFILE
 Blue Lake Levee Evaluation
 Humboldt County, California

N:\Projects\04_2014\04_6214_0035_BlueLake\Outputs\Working\mxd\11x17_Long_Toe_of_Levee_Profile.mxd, 10/15/2014, wcupples

SOIL TYPES

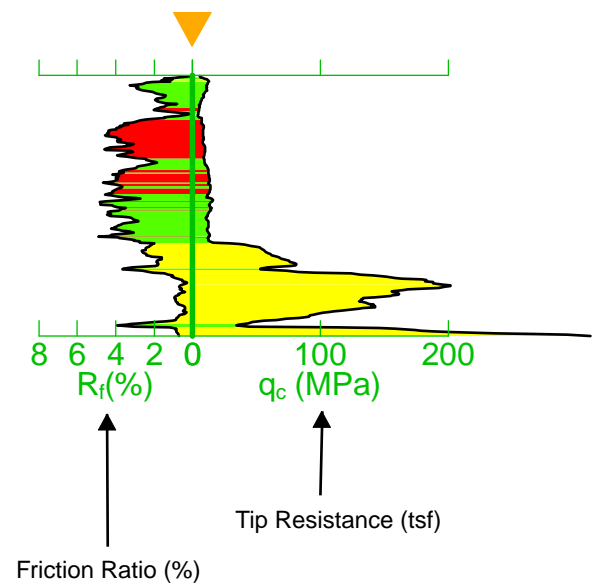
- Lean CLAY (CL)
- Silty CLAY (CL-ML)
- Lean CLAY with Sand (CL)
- Sandy Lean Clay (CL)
- Sandy, Gravelly Lean CLAY (CL)
- Fat CLAY (CH)
- Silt (ML)
- Clayey SILT (ML)
- Sandy SILT (ML)
- Poorly-Graded SAND (SP)
- Poorly-Graded SAND with Silt (SP-SM)
- Gravelly Poorly-Graded SAND with Silt (SP-SM)
- Gravelly Poorly-Graded SAND (SP)
- Well-Graded SAND (SW)
- Well-Graded SAND with Clay (SW)
- Well-Graded SAND with Silt (SW-SM)
- Gravelly Well-Graded SAND (SW)
- Clayey SAND (SC)
- Gravelly, Clayey SAND (SC)
- Silty SAND (SM)
- Gravelly Silty SAND (SM)
- Poorly-Graded GRAVEL with Silt (GP-GM)
- Sandy GRAVEL with Silt (GP-GM)
- Well-Graded GRAVEL (GW)
- Well-Graded GRAVEL with Silt (GW-GM)
- Sandy Well-Graded GRAVEL (GW)
- Clayey GRAVEL (GC)
- Silty Gravel (GM)
- Sandy, Silty GRAVEL (GM)
- PEAT
- Fill
- Fill (Wood)
- Asphaltic Concrete



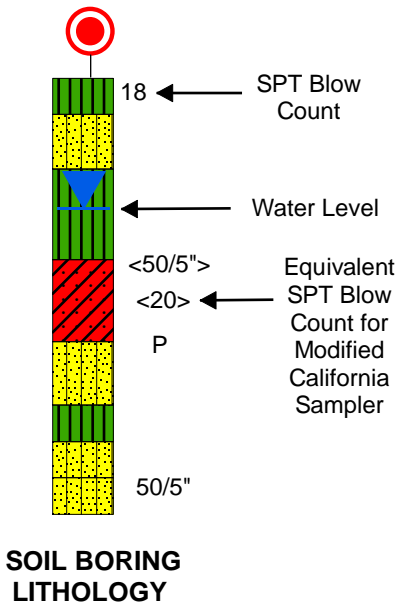
Zone	Soil Behavior Type
1	Sensitive Fine-grained
2	Peats
3	Silty Clay to Clay
4	Clayey Silt to Silty Clay
5	Silty Sand to Sandy Silt
6	Clean Sand to Silty Sand
7	Gravelly Sand to Dense Sand
8	Very Stiff Sand to Clayey Sand*
9	Very Stiff Fine-Grained*

*heavily overconsolidated or cemented

Friction Ratio (%)
 Tip Resistance (tsf)

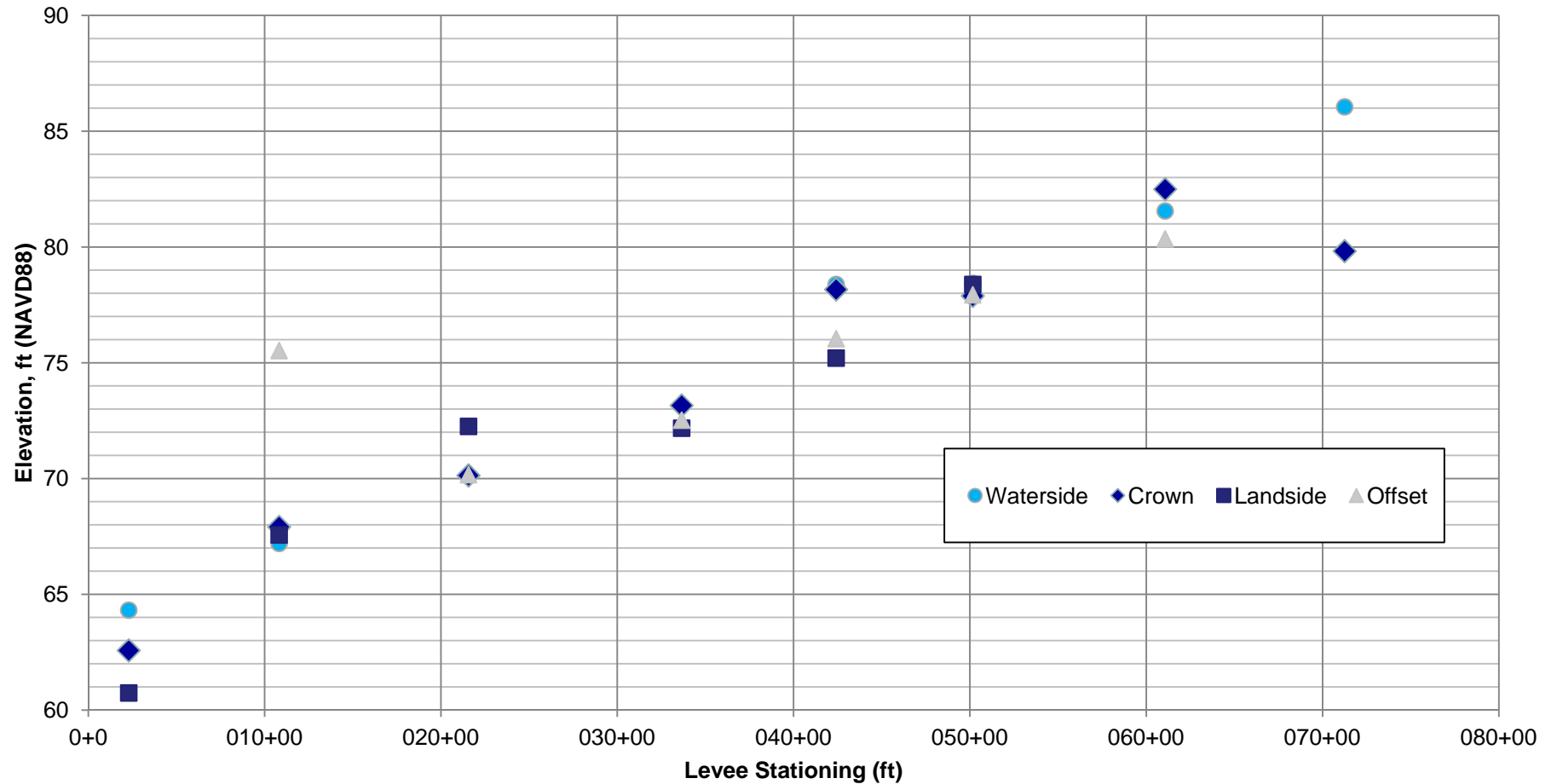


CPT SOUNDING WITH INTERPRETED LITHOLOGY



KEY TO PROFILES
 Blue Lake Levee Evaluation
 Humboldt County, California

(Measured in Drill Holes between April 10 and 25, 2014)



Groundwater Elevations

APPENDIX A
HISTORICAL BORING LOGS, LABORATORY DATA, AND PLANS

APPENDIX A - HISTORICAL BORING LOGS, LABORATORY DATA, AND PLANS

As part of our investigation, we reviewed the following documents for geotechnical data or qualitative information relevant to our evaluation, including site and subsurface descriptions, groundwater data, laboratory testing results, boring logs, and as-built plans.

HUMBOLDT COUNTY

Northern Hydrology & Engineering and Manhard Consulting

- Northern Hydrology and Engineering & Manhard Consulting (2013), Hydrologic Analysis for Mad River near the City of Blue Lake, Humboldt County, California, unpublished consultant's report prepared for Humboldt County Department of Public Works, February 8, 17 p. with appendices.
- Manhard Consulting & Northern Hydrology and Engineering (2013), Hydrologic Analysis for Mad River near the City of Blue Lake, Humboldt County, California, unpublished consultant's report prepared for Humboldt County Department of Public Works, June 3, 18 p. with appendices.
- Northern Hydrology & Engineering (2014), Blue Lake Levee Evaluation – Water Surface Elevation Estimates for Mad River 100-Yr Flood Flow near the City of Blue Lake, Humboldt County, California, unpublished consultant's report prepared for Humboldt County Public Works Department, dated June 26, 4 p.

U. S. Army Corps of Engineers, San Francisco District (USACE)

- USACE (1953), Project Report on Mad River at Blue Lake, California for Flood Control, November 4, 49 p.
- USACE (1956), Operation and Maintenance Manual for Flood Control Project, Mad River at Blue Lake, Humboldt County, June, 42 p.
- USACE (1962), Detailed Project Report, Local Flood Protection Project on North Fork, Mad River, near Blue Lake, Humboldt County, California, May, 96 p.
- USACE (1964), Mad River at Blue Lake Local Flood Protection Project, Operation and Maintenance Manual, July, 41 p.

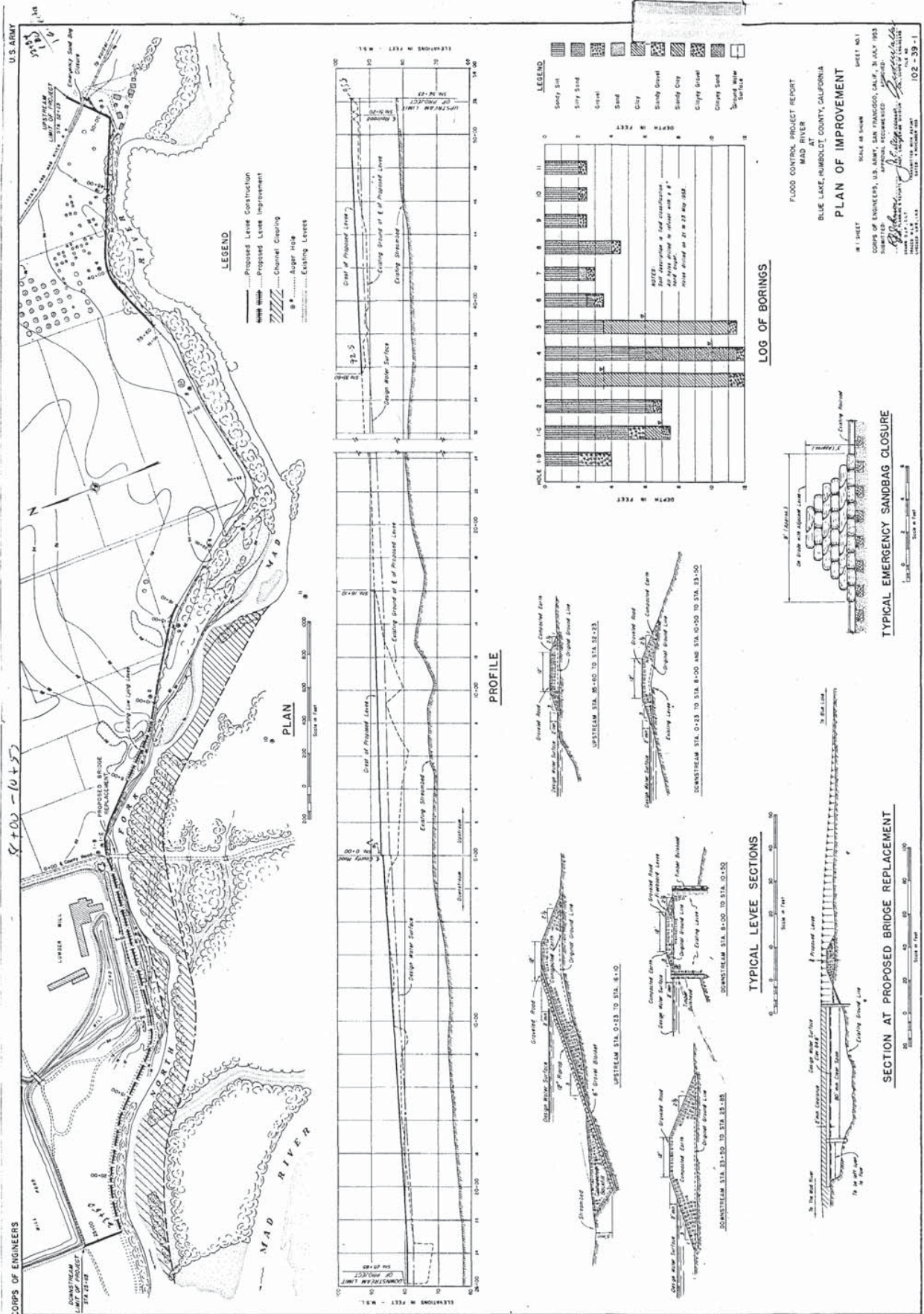
The *Project Report* (USACE, 1953) includes design plans, included herein as Plate A-1, showing typical sections for the original proposed levee and logs of 12 borings drilled along the proposed levee alignment. Plate A-2 shows as-constructed plans and typical levee sections from the *Operation and Maintenance Manual for Flood Control Project* (USACE, 1956).

The *Operation and Maintenance Manual* (USACE, 1964) included as-constructed typical levee sections following the improvement and expansion of the levee system, which are shown on Plate A-3.

The *Detailed Project Report* (USACE, 1962) notes that approximately 22 borings were drilled along the banks and proposed channel alignment of Blue Lake Levee between May 1952 and March 1962. The locations and logs of these explorations were presented in the *Detailed Project Report* (USACE, 1962), and are presented in this appendix as Plates A-4 and A-5, respectively.

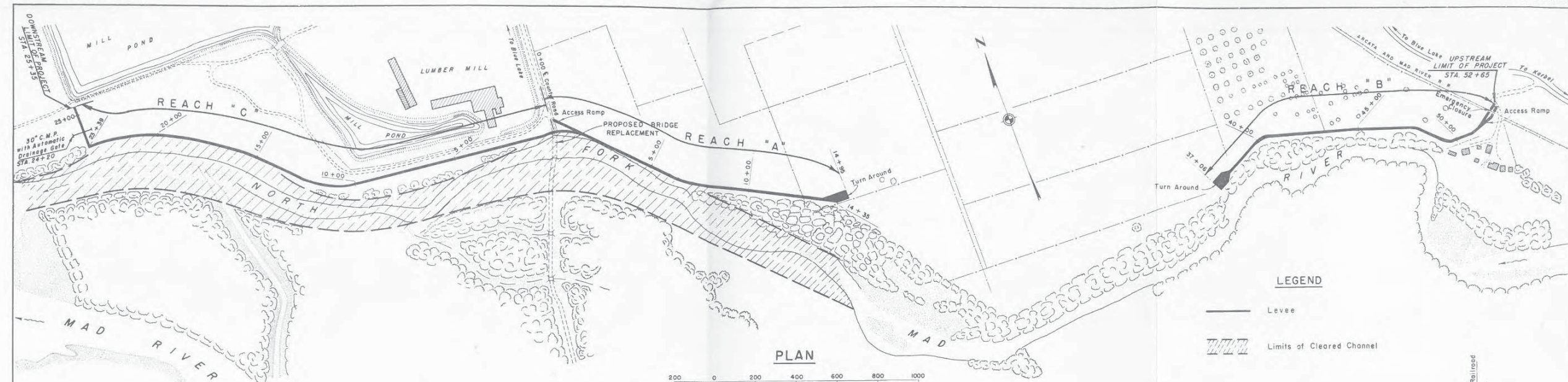
Laboratory data for borrow area samples and foundation material samples were included in the *Detailed Project Report* (USACE, 1962). These are presented as Plates A-6 and A-7, respectively. In addition, geotechnical design values for impervious and pervious (sand and gravel) materials were also included in the *Detailed Project Report* (USACE, 1962). Listed values, which are presented on Plate A-8, include dry unit weights, moist weights, saturated weights, buoyed weights, and shear strength parameters.

A standard project flood hydrograph based on the December 1955 flood event was included in the *Detailed Project Report* (USACE, 1962), and is included herein as Plate A-9

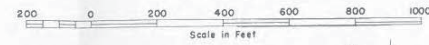


CORPS OF ENGINEERS

U. S. ARMY

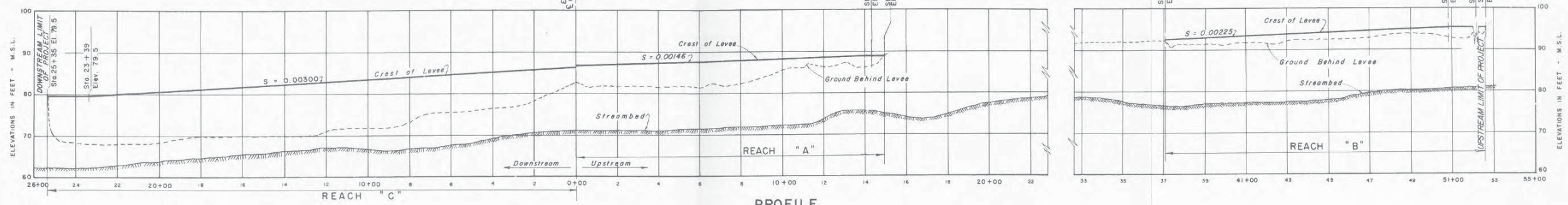


PLAN

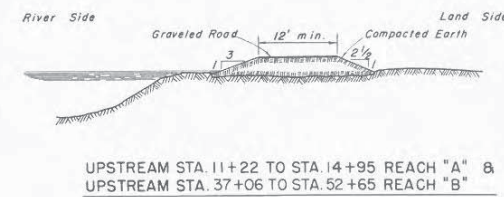
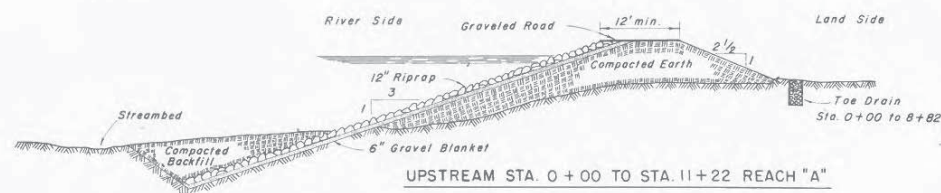


LEGEND

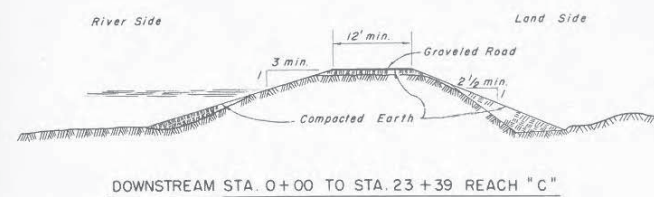
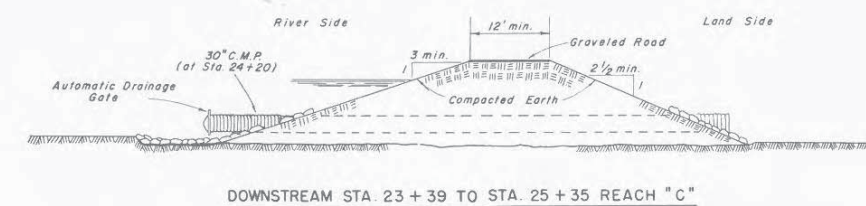
- Levee
- ▨ Limits of Cleared Channel



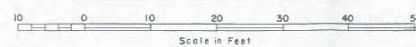
PROFILE



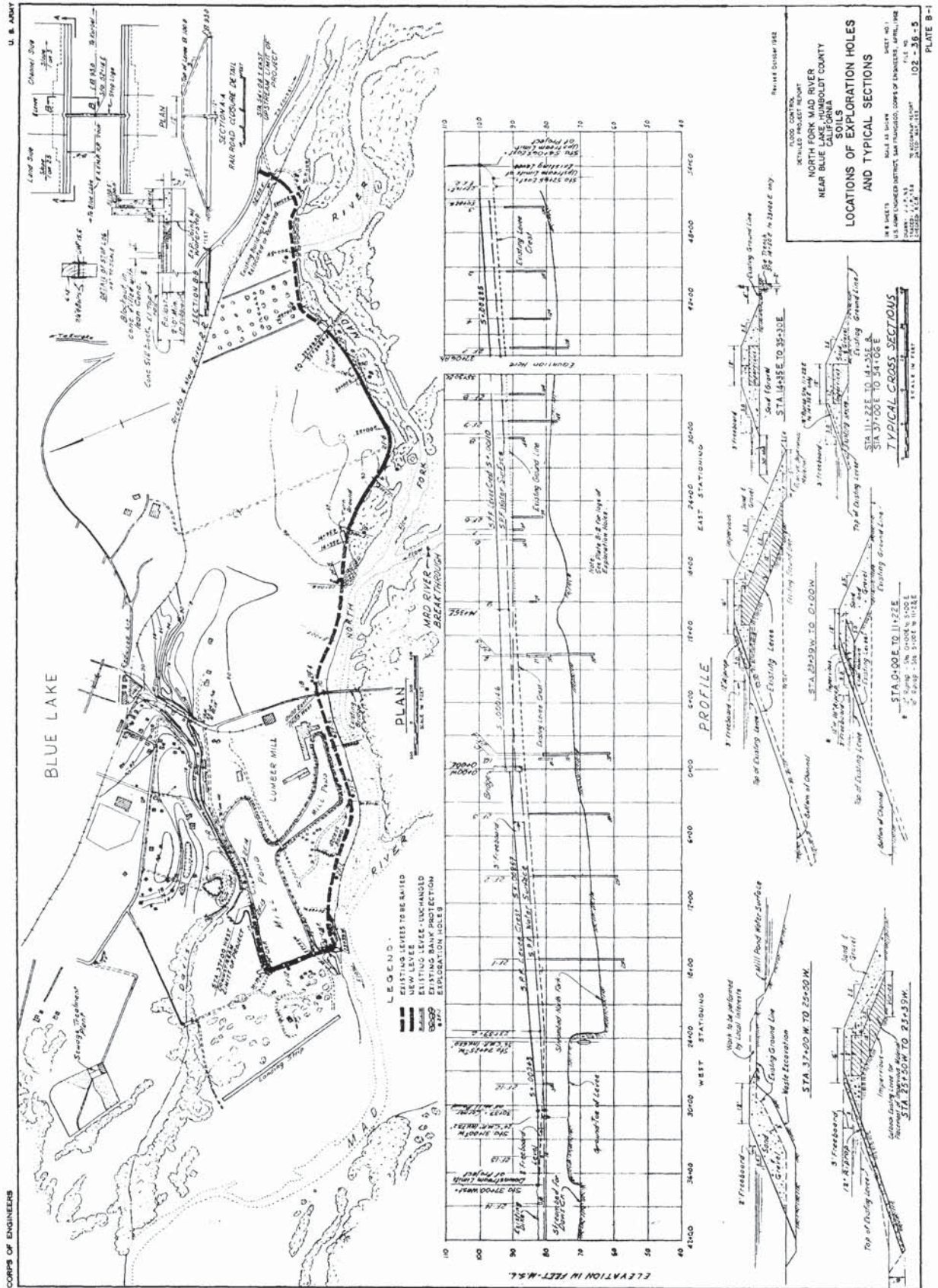
Note: Data on this sheet show the conditions existing at the time of completion of the project in November, 1955.



TYPICAL LEVEE SECTIONS



AS CONSTRUCTED			
SYMBOL	DESCRIPTION	DATE	APPROVAL
REVISIONS			
CORPS OF ENGINEERS U. S. ARMY OFFICE OF THE DISTRICT ENGINEER, SAN FRANCISCO DISTRICT SAN FRANCISCO, CALIFORNIA			
DRAWN BY D. P. W. L. W.	MAD RIVER AT BLUE LAKE, CALIFORNIA		
TRACED BY G. K. T.	FLOOD CONTROL PROJECT		
CHECKED BY V. W. C.	PLAN AND DETAILS		
DESIGNED BY I. H. S.	APPROVAL RECOMMENDED DATE: JUNE 1956		
SUBMITTED BY A. C. Long	SCALE: AS SHOWN SPEC. NO.		
APPROVED BY J. J. ...	DRAWING NUMBER: SHEET 1 OF 102 39 4		





00000 R0000

TABLE B-1
 SUMMARY OF SOIL TESTS
 BORROW MATERIALS
 MAD RIVER AT BLUE LAKE

Hole No.	Depth (Ft.)		CLASSIFICATION	Mechanical Analysis			Atterberg Limits		Specific Gravity	Standard Comp.		Direct Shear Remolded				
	From	To		Gravel %	Sand %	Fines %	LL	PI		Dry Den. #/CF	MC %	Dry Den. #/CF	MC %	ϕ	C T/SF	
2B-1	0	0.0	Fine Sand *													
2B-2	1.5	6.0	Clayey Sand (SC)	4	48	48	29	11	2.71	112	17.0	107	17.2	29	.04	
2B-3	0	7.0	Clayey Sand (SC)	4	52	48	27	9								
2B-5	0	14.0	Sandy Clay (CL)	6	41	53	26	8		114	15.7	109	15.5	23	.15	
			*Visual Classification													



RECORD
 00000

c. Stations 0+00 To 54+06E

Between Stations 0+00 and 23+00E, the thickness of the fine-grained overburden materials varies from 3 to 5 feet in depth and from 9 to 17 feet upstream of Station 23+00E. The overburden materials consist of sandy silt, silty sand, clayey sand, clay and silty clay. Sand and gravel were encountered below the fine-grained materials.

B-10. GROUND WATER

During foundation exploration in May 1953, July 1954, and November 1961, ground water was encountered in 19 exploration holes. In 5 of the exploration holes, located between Stations 23+39W and 30+00E, the ground water level was 2 to 4 feet higher than the existing bottom of the channel. In 4 of the exploration holes drilled along the alignment of the set-back levees, between Stations 30+00E and 54+06E, ground water was encountered 3.5 to 10 feet below the existing ground line. On Plate B-2, the ground water readings made during exploration are indicated on the logs of exploration holes.

B-11. DESIGN VALUES

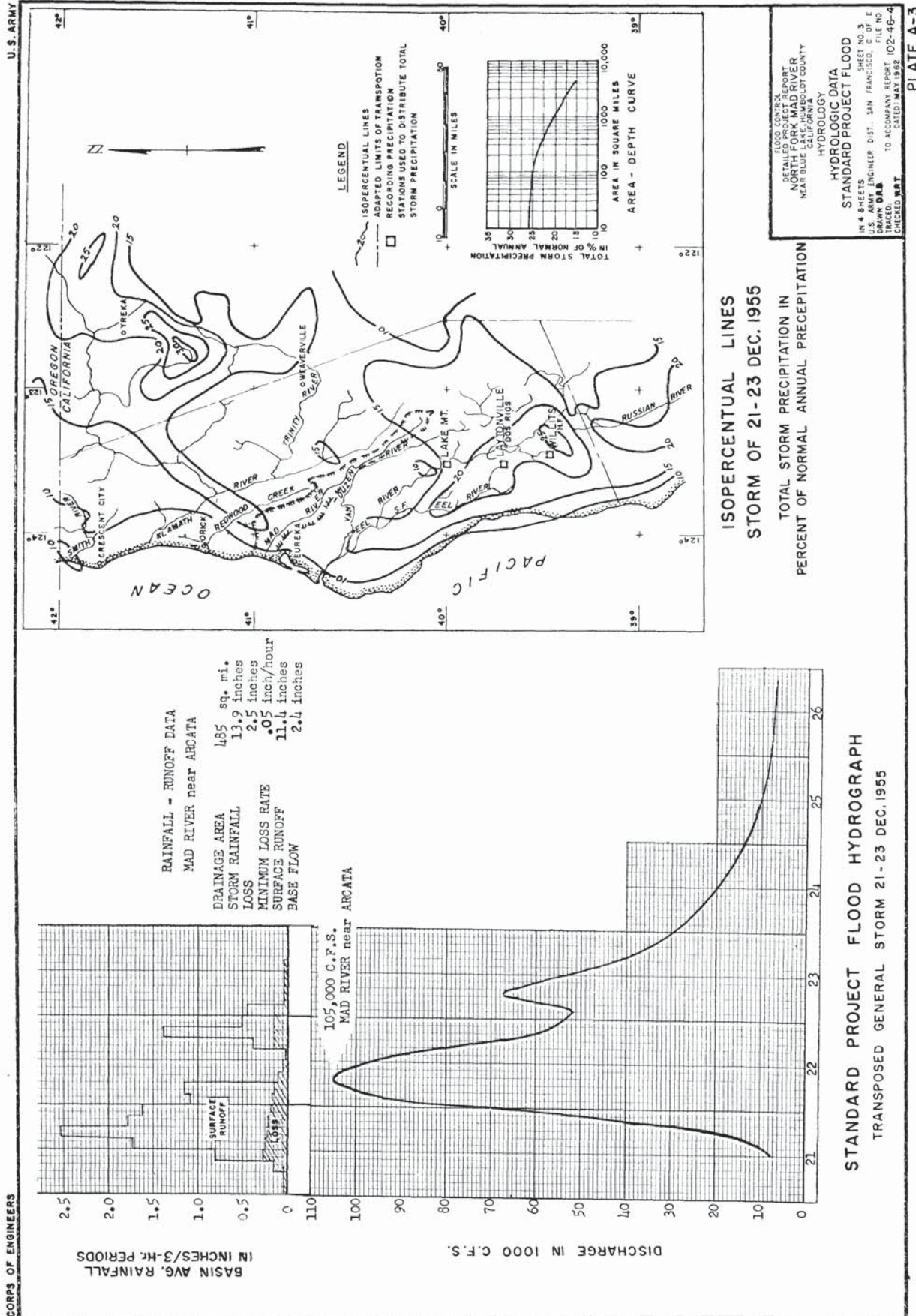
Results of all secondary laboratory tests are summarized on Tables B-1 and B-2. The foundations and the levee section were divided into zones according to their soil characteristics. Based on a study of the laboratory tests results, the following design values for the foundation and the embankment materials were adopted:

a. Impervious, Silty Sand, Sandy Silt, Silty Clay:

Dry weight - - - - -	107 lbs./cu. ft.
Moist weight - - - - -	123 lbs./cu. ft.
Saturated weight - - - - -	130 lbs./cu. ft.
Buoyed weight - - - - -	68 lbs./cu. ft.
Angle of internal friction - - - -	28 degrees
Cohesion - - - - -	0

b. Sand and Gravel, (Assumed)

Dry weight - - - - -	110 lbs./cu. ft.
Moist weight - - - - -	115 lbs./cu. ft.
Saturated weight - - - - -	130 lbs./cu. ft.
Buoyed weight - - - - -	68 lbs./cu. ft.
Angle of internal friction - - - -	33 degrees
Cohesion - - - - -	0



CORPS OF ENGINEERS

BASIN AVG. RAINFALL
 IN INCHES/3-HR PERIODS

DISCHARGE IN 1000 C.F.S.

RAINFALL - RUNOFF DATA
 MAD RIVER near ARCATA

DRAINAGE AREA	485 sq. mi.
STORM RAINFALL	13.9 inches
LOSS	2.5 inches
MINIMUM LOSS RATE	0.05 inch/hour
SURFACE RUNOFF	11.4 inches
BASE FLOW	2.4 inches

105,000 C.F.S.
 MAD RIVER near ARCATA

STANDARD PROJECT FLOOD HYDROGRAPH
 TRANSPPOSED GENERAL STORM 21-23 DEC. 1955

ISOPERCENTUAL LINES
 STORM OF 21-23 DEC. 1955
 TOTAL STORM PRECIPITATION IN
 PERCENT OF NORMAL ANNUAL PRECIPITATION

U.S. ARMY
 FLOOD CONTROL DISTRICT
 NORTH FORK MAD RIVER
 NEAR BLUE LAKE, HUMBOLDT COUNTY
 CALIFORNIA

HYDROLOGIC DATA
 STANDARD PROJECT FLOOD

IN 4 SHEETS SHEET NO. 3
 U.S. ARMY ENGINEER DIST. SAN FRANCISCO, CALIF. FILE NO. 102-46-4
 DRAWN BY: [Name] TO ACCOMPANY REPORT 102-46-4
 CHECKED BY: [Name] DATED: MAY 1952

PLATE A-3

APPENDIX B
FIELD EXPLORATION

APPENDIX B - FIELD EXPLORATION

The field exploration program for the Blue Lake Geotechnical Levee Evaluation Program consisted of explorations advanced using cone penetration test (CPT) soundings and hollow-stem auger drill holes. CPT services were provided by California Push Technologies, Inc., of Menlo Park, California using a Geoprobe Model 6625CPT track-mounted CPT rig. A CME-75 track-mounted drill rig was provided by Britton Exploration of Los Gatos, California, for hollow-stem auger drill holes. In addition, Fisch Environmental of Eureka, California provided hollow-stem auger drilling services using a Geoprobe Model 6625 track mounted rig.

CONE PENETRATION TESTS

CPTs were located at roughly 1,000-foot intervals along the levee crests and at various landside toe and offset locations, as shown on Plate 2-1. Seventeen CPT soundings were attempted between April 7 and 8, 2014, nine of which experienced refusal on gravel and eight of which were able to achieve moderate to full penetration. Depths of those CPT soundings ranged from 5.5 to 25 feet below the existing ground surface. Six CPT soundings along the levee crest (C1RL, C1RC, C10RW, C10RC, C20RL, C20RO, C30RC, C30RL, C30RO, C39RL, C49RC, C49RL, C59RL, C59RO, and C70RC) met almost immediate refusal on gravels and cobbles.

The CPTs were performed using an electric cone penetrometer with a diameter of approximately 15 square centimeters. The instrumented cone is hydraulically pushed into the ground at a rate of about 2 centimeters per second (cm/s). Cone penetration resistance (q_c), and sleeve resistance (f_s) were monitored continuously during penetration and recorded. The friction ratio (FR) was computed for each value of q_c and f_s recorded. CPT data and soil classifications were used in conjunction with drill hole and core hole information to estimate soil boundaries encountered at the site. A key to the CPT logs is provided on Plate B-3. Logs of the CPT profiles are shown on Plates B-4 through B-11.

Each CPT hole was backfilled with cement-bentonite grout pumped through open-ended CPT casing from the surface to the bottom of the hole and filled upward. When grout returned to the surface, the grout hose was removed, CPT casing pulled, and the holes were topped off with additional grout as needed.

HOLLOW-STEM AUGER DRILL HOLES

Drill holes were advanced along the levee crown, and at selected locations along the waterside toes, landside toes, and offset locations along the levee system. Approximate drill hole locations are shown on Plate 2-1. Drill holes were advanced between April 10 and 25, 2014.

To advance the drill holes, hollow-stem flight augers were used for the entire depth of each drill hole. The hollow-stem augers have an outside diameter of 8.25-inches and have a center tube that is 4.25 inches in diameter. During drilling, a plug is inserted at the cutting shoe of the auger to keep the interior tube open. During drilling, cuttings are mobilized upwards by

the flights along the outside of the auger. To sample, the interior plug was removed and the selected sampler extended down to the hole bottom using drilling rods. The samplers for this project were driven using a 140-pound CME automatic-trip hammer having a vertical throw of 30 inches, in conformance with standard test method ASTM D1586-99.

Twenty-seven drill holes were advanced to depths ranging from 25 to 51.5 feet bgs. Soil samples were obtained from the drill holes at selected depths using a driven 2-3/8 inch-inside-diameter (ID) modified California sampler and a 1-3/8-inch ID Standard Penetration Test (SPT) sampler. Samples were obtained at roughly 5-foot depth intervals, although the interval was frequently adjusted to sample critical layers encountered in the CPT soundings. The samplers were driven using the automatic-trip hammer discussed above. The number of blows needed to drive the sampler the last 12 inches into the soils was recorded, and is shown on the drill hole logs. Recovered samples were placed in containers and transported to the laboratory for further classification and testing.

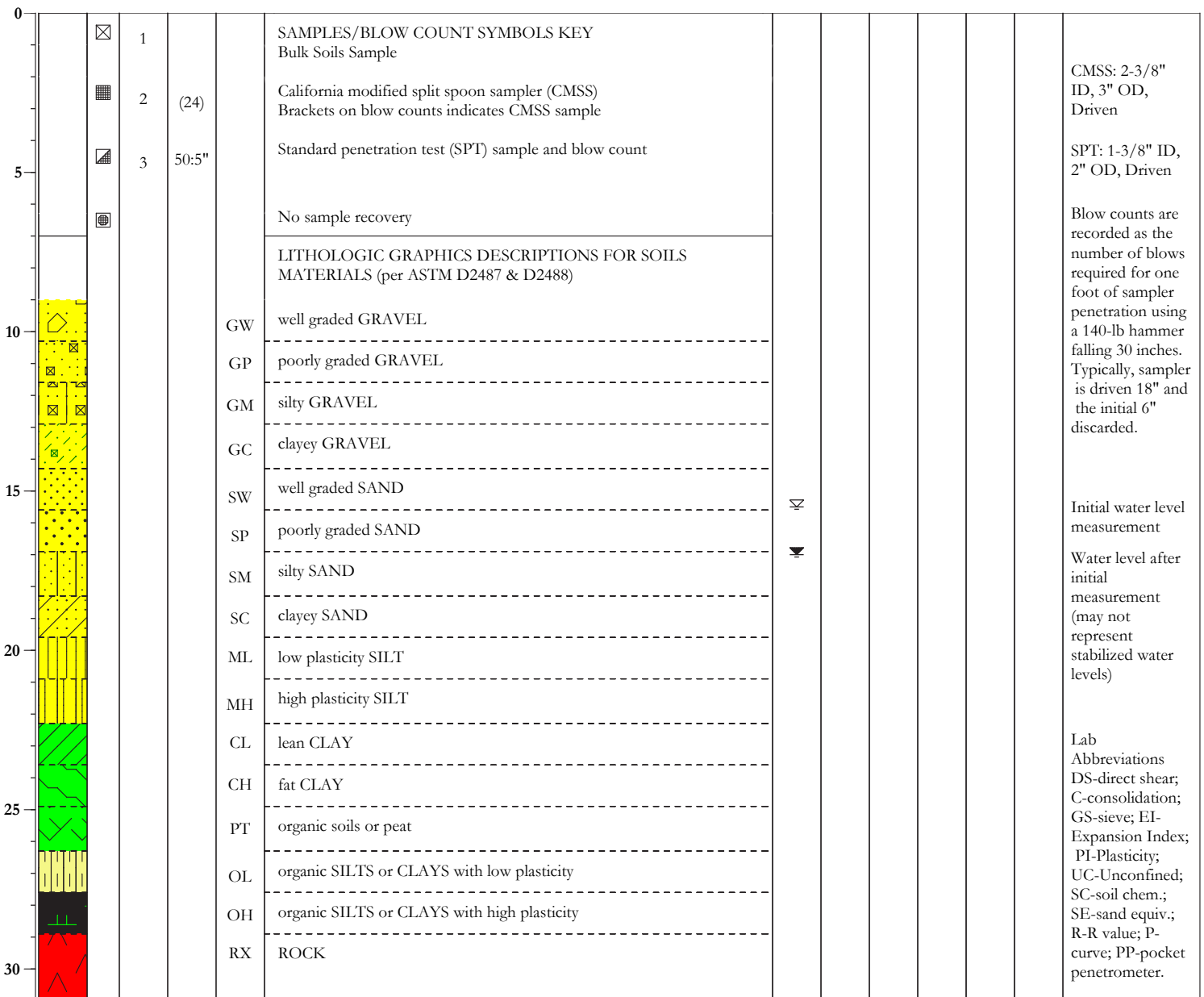
The drill hole logs present descriptions of the earth materials encountered, sampling method used, and field and laboratory tests performed. The logs also show the location, drill hole number, date of start and completion, and the name of the logger and drilling subcontractor. A field engineering geologist logged the drill holes in general accordance with ASTM D2488 for visual soil classification. The boundaries between soil types shown on the logs are approximate and the transition between different soil layers may be gradual. The logs of the drill holes are presented as Plates B-2.1 through B-2.27 - Logs of Explorations. A legend to the logs is presented on Plate B-1.

Each drill hole was backfilled with cement-bentonite grout pumped from the surface to the bottom of the hole and filled upward. When grout returned to the surface, the grout hose was removed and the holes were topped off with additional grout as needed.

LOG OF EXPLORATION: Expl. No.

PROJECT: CGI's Project Name	EXPL. VENDOR: Expl. Subcontractor	SURFACE ELEVATION: Expl. Elevation
PROJECT NO.: CGI's Project No.	EXPL. METHOD: Method of Expl.	TOTAL DEPTH OF HOLE: Total Depth of Expl.
LOCATION: General Location	LOGGED BY: CGI's Logger	DEPTH TO WATER: Depth to Water
START DATE: Date Started	CHECKED BY: CGI's Reviewer	BACKFILLED WITH: Backfill Materials
END DATE: Date Finished	HAMMER TYPE: Type of Sample Hammer	

Depth (ft)	Material Symbol	Sample	Sample No.	Blow Count (blows/ft)	USCS Symbol	Material Description	Water Table	Unit Dry Weight, pcf	Water Content, %	% Passing No. 200	Liquid Limit	Plasticity Index	Notes & Assigned Laboratory
------------	-----------------	--------	------------	-----------------------	-------------	----------------------	-------------	----------------------	------------------	-------------------	--------------	------------------	-----------------------------



LOG OF EXPLORATION: D1RC

PROJECT: Blue Lake Levee	EXPL. VENDOR: Britton Exploration	SURFACE ELEVATION: 87 feet
PROJECT NO.: 14-1949.02	EXPL. METHOD: 8.25" HSA	DEPTH OF HOLE: 51.0
LOCATION: Humboldt Co., CA	LOGGED BY: J.Bianchin	DEPTH TO WATER: 24.5 feet
START DATE: April 10, 2014	CHECKED BY: J.Bianchin	BACKFILLED WITH: Cement grout
END DATE: April 10, 2014	HAMMER TYPE: 140-Lb	

Depth (ft)	Material Symbol	Sample	Sample No.	Blow Count (blows/ft)	USCS Symbol	Material Description	Water Table	Unit Dry Weight, pcf	Water Content, %	% Passing No. 200	Liquid Limit	Plasticity Index	Notes & Assigned Laboratory
------------	-----------------	--------	------------	-----------------------	-------------	----------------------	-------------	----------------------	------------------	-------------------	--------------	------------------	-----------------------------

0					GW/ SW	ARTIFICIAL FILL (af) Sandy GRAVEL to Gravelly SAND, moderate brown, dry to moist, fine to coarse grained with subrounded to rounded fine to coarse gravel.							
5			1	10		At 5 feet: loose to medium dense.			2.7		6		GS
					SW	ALLUVIUM (Qal) SAND, moderate brown to grey, moist, loose to medium dense, fine to coarse grained with trace subrounded fine gravel.							
			2	(11)	CL	Sandy to Silty CLAY, moderate yellowish brown, moist, firm, slightly plastic, with fine to medium sand, trace coarse sand, and trace fine subrounded gravel.							
10			3a	(15)					111		33	9	PI
			3b							17	28	11	PI
					SM/ SW	Silty SAND with Gravel, greyish brown to grey, moist, fine to medium grained with trace coarse grains, moderate to abundant subrounded fine to medium gravel, and trace to moderate wood fragments and organic debris.							
15			4	15		At 15 feet: medium dense.			16.2		13		GS

LOG OF EXPLORATION: D1RC

PROJECT: Blue Lake Levee	EXPL. VENDOR: Britton Exploration	SURFACE ELEVATION: 87 feet
PROJECT NO.: 14-1949.02	EXPL. METHOD: 8.25" HSA	DEPTH OF HOLE: 51.0
LOCATION: Humboldt Co., CA	LOGGED BY: J.Bianchin	DEPTH TO WATER: 24.5 feet
START DATE: April 10, 2014	CHECKED BY: J.Bianchin	BACKFILLED WITH: Cement grout
END DATE: April 10, 2014	HAMMER TYPE: 140-Lb	

Depth (ft)	Material Symbol	Sample	Sample No.	Blow Count (blows/ft)	USCS Symbol	Material Description	Water Table	Unit Dry Weight, pcf	Water Content, %	% Passing No. 200	Liquid Limit	Plasticity Index	Notes & Assigned Laboratory
------------	-----------------	--------	------------	-----------------------	-------------	----------------------	-------------	----------------------	------------------	-------------------	--------------	------------------	-----------------------------

20			5	20	SW	Gravelly SAND, medium grey, moist, medium dense, fine to coarse grained with subrounded fine to coarse gravel.							
25			6	15	GW	Sandy GRAVEL, medium grey, wet, medium dense, with fine to coarse sand and subrounded fine to medium gravel and trace coarse gravel. Between 27 and 29 feet: decrease in gravels.	▼		17.7	9			GS
30			7	29		Between 32 and 33.5 feet: Increased gravels with possible cobbles and boulders.							
35			8	48		At 34.5 feet: dense to very dense. Between 36 and 37 feet: decrease in gravels.			17.3	9			GS



The log and data presented are a simplification of actual conditions encountered at the given location and time of exploration. Subsurface conditions may differ at other locations and with the passage of time.

PLATE NO.: B-2.1

LOG OF EXPLORATION: D1RC

PROJECT: Blue Lake Levee	EXPL. VENDOR: Britton Exploration	SURFACE ELEVATION: 87 feet
PROJECT NO.: 14-1949.02	EXPL. METHOD: 8.25" HSA	DEPTH OF HOLE: 51.0
LOCATION: Humboldt Co., CA	LOGGED BY: J.Bianchin	DEPTH TO WATER: 24.5 feet
START DATE: April 10, 2014	CHECKED BY: J.Bianchin	BACKFILLED WITH: Cement grout
END DATE: April 10, 2014	HAMMER TYPE: 140-Lb	

Depth (ft)	Material Symbol	Sample	Sample No.	Blow Count (blows/ft)	USCS Symbol	Material Description	Water Table	Unit Dry Weight, pcf	Water Content, %	% Passing No. 200	Liquid Limit	Plasticity Index	Notes & Assigned Laboratory
40			9	37	SW	Gravelly SAND, moderate grey, wet, dense, fine to coarse grained with trace to moderate subangular to subrounded fine to medium gravel.							
45			10	44		At 44.5 feet: with trace subrounded coarse gravel.							
50			11	60		At 49.5 feet: with abundant coarse gravel and possible cobbles.							
						Bottom of Drill Hole at a Depth of 51 feet.							



The log and data presented are a simplification of actual conditions encountered at the given location and time of exploration. Subsurface conditions may differ at other locations and with the passage of time.

PLATE NO.: B-2.1

LOG OF EXPLORATION: D10RC

PROJECT: Blue Lake Levee	EXPL. VENDOR: Britton Exploration	SURFACE ELEVATION: 91.5 feet
PROJECT NO.: 14-1949.02	EXPL. METHOD: 8.25" HSA	DEPTH OF HOLE: 50.9 Feet
LOCATION: Humboldt Co., CA	LOGGED BY: J.Bianchin	DEPTH TO WATER: 24.5 feet
START DATE: April 11, 2014	CHECKED BY: J.Bianchin	BACKFILLED WITH: Cement Grout
END DATE: April 11, 2014	HAMMER TYPE: 140-Lb	

Depth (ft)	Material Symbol	Sample	Sample No.	Blow Count (blows/ft)	USCS Symbol	Material Description	Water Table	Unit Dry Weight, pcf	Water Content, %	% Passing No. 200	Liquid Limit	Plasticity Index	Notes & Assigned Laboratory
------------	-----------------	--------	------------	-----------------------	-------------	----------------------	-------------	----------------------	------------------	-------------------	--------------	------------------	-----------------------------

0					SW	ARTIFICIAL FILL (af) Gravelly SAND, light brown to medium grey, dry to moist, fine to coarse grained with subrounded to rounded fine to medium gravel and trace coarse gravel.							
5			1	13	CL	Silty to Sandy CLAY, moderate yellowish brown, moist, soft, slightly plastic, with trace to few fine sand and trace subrounded fine gravel.			14				
			B1	(24)									Sampled with sand catcher, no return
				(24)									Sampled with sand catcher, no return
10			2a	(17)									PI; Sampled with sand catcher
			2b		SW	ALLUVIUM (Qal) Gravelly SAND to SAND, moderate grey, moist, loose to medium dense, fine to coarse grained with trace to few subrounded fine gravel.	109	16	29	8			
15			3	9		At 14.5 feet: loose with trace to moderate amounts of woody debris.							



The log and data presented are a simplification of actual conditions encountered at the given location and time of exploration. Subsurface conditions may differ at other locations and with the passage of time.

PLATE NO.: B-2.2

LOG OF EXPLORATION: D10RC

PROJECT: Blue Lake Levee	EXPL. VENDOR: Britton Exploration	SURFACE ELEVATION: 91.5 feet
PROJECT NO.: 14-1949.02	EXPL. METHOD: 8.25" HSA	DEPTH OF HOLE: 50.9 Feet
LOCATION: Humboldt Co., CA	LOGGED BY: J.Bianchin	DEPTH TO WATER: 24.5 feet
START DATE: April 11, 2014	CHECKED BY: J.Bianchin	BACKFILLED WITH: Cement Grout
END DATE: April 11, 2014	HAMMER TYPE: 140-Lb	

Depth (ft)	Material Symbol	Sample	Sample No.	Blow Count (blows/ft)	USCS Symbol	Material Description	Water Table	Unit Dry Weight, pcf	Water Content, %	% Passing No. 200	Liquid Limit	Plasticity Index	Notes & Assigned Laboratory
20			4	20	GW/GM	Gravelly SAND to Sandy GRAVEL, moderate grey, moist, medium dense, fine to coarse grained with subangular to subrounded fine to coarse gravel and trace silt.			5.5	6			GS
25			5	14		At 23 feet: abundant gravel with possible cobbles and boulders.	▼						
30			6	29					7.2	9			GS
35			7	74	SW/SC	SAND with Gravel, moderate grey, wet, very dense, fine to coarse grained with subrounded fine to coarse gravel.		131	8	7			GS



The log and data presented are a simplification of actual conditions encountered at the given location and time of exploration. Subsurface conditions may differ at other locations and with the passage of time.

PLATE NO.: B-2.2

LOG OF EXPLORATION: D10RC

PROJECT: Blue Lake Levee	EXPL. VENDOR: Britton Exploration	SURFACE ELEVATION: 91.5 feet
PROJECT NO.: 14-1949.02	EXPL. METHOD: 8.25" HSA	DEPTH OF HOLE: 50.9 Feet
LOCATION: Humboldt Co., CA	LOGGED BY: J.Bianchin	DEPTH TO WATER: 24.5 feet
START DATE: April 11, 2014	CHECKED BY: J.Bianchin	BACKFILLED WITH: Cement Grout
END DATE: April 11, 2014	HAMMER TYPE: 140-Lb	

Depth (ft)	Material Symbol	Sample	Sample No.	Blow Count (blows/ft)	USCS Symbol	Material Description	Water Table	Unit Dry Weight, pcf	Water Content, %	% Passing No. 200	Liquid Limit	Plasticity Index	Notes & Assigned Laboratory
------------	-----------------	--------	------------	-----------------------	-------------	----------------------	-------------	----------------------	------------------	-------------------	--------------	------------------	-----------------------------

40	8	35	GW/GM	GRAVEL with Sand, moderate grey, wet, dense, with fine to coarse sand and subangular to subrounded fine to coarse gravel.	6.6	9	GS
45	9	27		Between 46 and 49.5 feet: abundant gravel, cobbles, and boulders.			
50	10	50:5"	SM	Silty SAND with Gravel, moderate yellowish brown mottled doark brown, moist, very dense, fine to medium grained with trace coarse sand, sunangular to subrounded fine to coarse gravel, and trace to few clay.	9.0	17	GS
				Bottom of Drill Hole at a Depth of 50.9 Feet.			






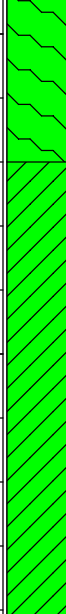
The log and data presented are a simplification of actual conditions encountered at the given location and time of exploration. Subsurface conditions may differ at other locations and with the passage of time.

PLATE NO.: B-2.2

LOG OF EXPLORATION: D20RC

PROJECT: Blue Lake Levee	EXPL. VENDOR: Britton Exploration	SURFACE ELEVATION: 93 feet
PROJECT NO.: 14-1949.02	EXPL. METHOD: 8.25" HSA	DEPTH OF HOLE: 51.0 Feet
LOCATION: Humboldt Co., CA	LOGGED BY: J.Bianchin	DEPTH TO WATER: 24.0 feet
START DATE: April 14, 2014	CHECKED BY: J.Bianchin	BACKFILLED WITH: Cement Grout
END DATE: April 14, 2014	HAMMER TYPE: 140-Lb	

Depth (ft)	Material Symbol	Sample	Sample No.	Blow Count (blows/ft)	USCS Symbol	Material Description	Water Table	Unit Dry Weight, pcf	Water Content, %	% Passing No. 200	Liquid Limit	Plasticity Index	Notes & Assigned Laboratory
------------	-----------------	--------	------------	-----------------------	-------------	----------------------	-------------	----------------------	------------------	-------------------	--------------	------------------	-----------------------------

0					af	ARTIFICIAL FILL (af) Asphaltic Concrete (2 inches); Aggregate Base (6 inches)							
5			1	(17)	GW CL	GRAVEL to Sandy GRAVEL, moderate brown to moderate grey, dry, fine to coarse grained with subrounded fine to coarse gravel and few subrounded cobbles up to at least 6 inches in diameter. Silty CLAY, moderate yellowish brown, moist, soft, slightly plastic, with trace fine sand.	107	17	40	20	PI, DS		
10			2	5	GW/SW CL CL/CH	Sandy GRAVEL to Gravelly SAND, moderate grey, moist, fine to coarse grained with subrounded fine to medium gravel. Silty CLAY, moderate yellowish brown, moist, soft, slightly plastic, with trace fine sand. Silty CLAY to CLAY, moderate brown, moist, soft, plastic.			20.4				Sampled with sand catcher, no return Sampled with sand catcher, no return
15			3	(7)	CL	ALLUVIUM (Qal) CLAY with Sand, greenish grey, moist, soft, plastic, with trace to moderate fine sand and trace subrounded fine to medium gravel.							Sampled with sand catcher

LOG OF EXPLORATION: D20RC

PROJECT: Blue Lake Levee	EXPL. VENDOR: Britton Exploration	SURFACE ELEVATION: 93 feet
PROJECT NO.: 14-1949.02	EXPL. METHOD: 8.25" HSA	DEPTH OF HOLE: 51.0 Feet
LOCATION: Humboldt Co., CA	LOGGED BY: J.Bianchin	DEPTH TO WATER: 24.0 feet
START DATE: April 14, 2014	CHECKED BY: J.Bianchin	BACKFILLED WITH: Cement Grout
END DATE: April 14, 2014	HAMMER TYPE: 140-Lb	

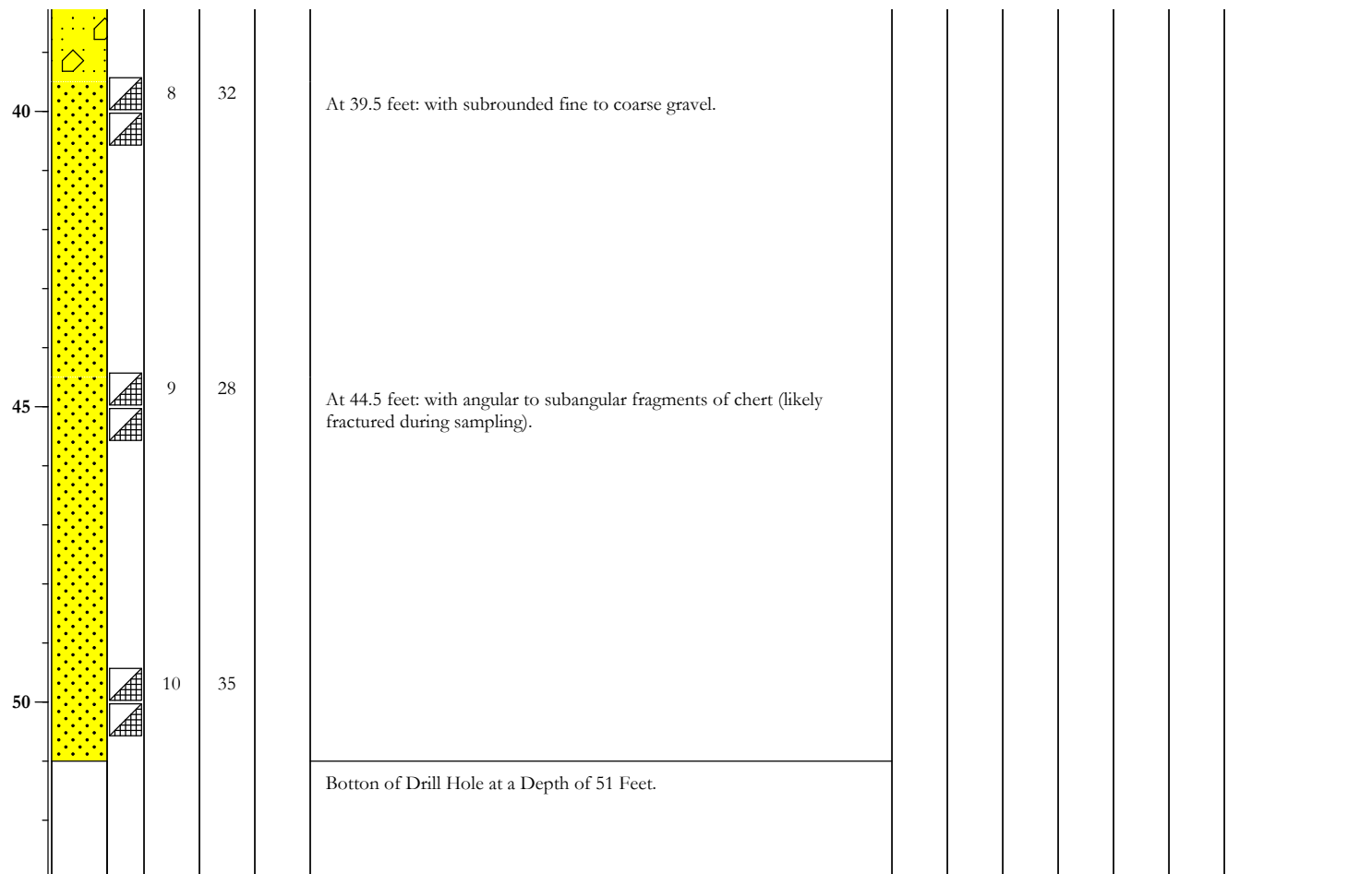
Depth (ft)	Material Symbol	Sample	Sample No.	Blow Count (blows/ft)	USCS Symbol	Material Description	Water Table	Unit Dry Weight, pcf	Water Content, %	% Passing No. 200	Liquid Limit	Plasticity Index	Notes & Assigned Laboratory
------------	-----------------	--------	------------	-----------------------	-------------	----------------------	-------------	----------------------	------------------	-------------------	--------------	------------------	-----------------------------



LOG OF EXPLORATION: D20RC

PROJECT: Blue Lake Levee	EXPL. VENDOR: Britton Exploration	SURFACE ELEVATION: 93 feet
PROJECT NO.: 14-1949.02	EXPL. METHOD: 8.25" HSA	DEPTH OF HOLE: 51.0 Feet
LOCATION: Humboldt Co., CA	LOGGED BY: J.Bianchin	DEPTH TO WATER: 24.0 feet
START DATE: April 14, 2014	CHECKED BY: J.Bianchin	BACKFILLED WITH: Cement Grout
END DATE: April 14, 2014	HAMMER TYPE: 140-Lb	

Depth (ft)	Material Symbol	Sample	Sample No.	Blow Count (blows/ft)	USCS Symbol	Material Description	Water Table	Unit Dry Weight, pcf	Water Content, %	% Passing No. 200	Liquid Limit	Plasticity Index	Notes & Assigned Laboratory
------------	-----------------	--------	------------	-----------------------	-------------	----------------------	-------------	----------------------	------------------	-------------------	--------------	------------------	-----------------------------



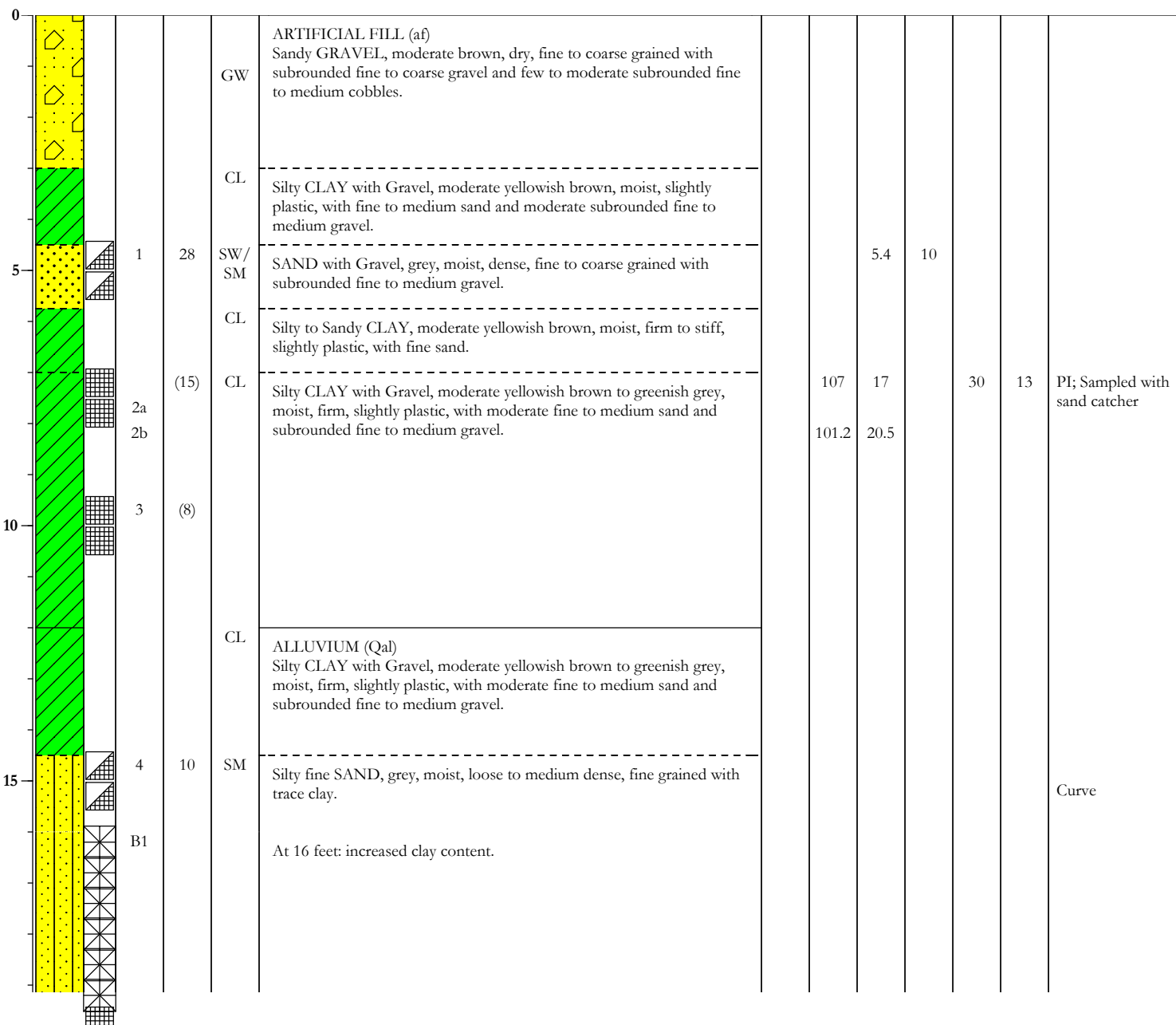
The log and data presented are a simplification of actual conditions encountered at the given location and time of exploration. Subsurface conditions may differ at other locations and with the passage of time.

PLATE NO.: B-2.3

LOG OF EXPLORATION: D30RC

PROJECT: Blue Lake Levee	EXPL. VENDOR: Britton Exploration	SURFACE ELEVATION: 98.5 feet
PROJECT NO.: 14-1949.02	EXPL. METHOD: 8.25" HSA	DEPTH OF HOLE: 51.0 Feet
LOCATION: Humboldt Co., CA	LOGGED BY: J.Bianchin	DEPTH TO WATER: 24.2 feet
START DATE: April 15, 2014	CHECKED BY: J.Bianchin	BACKFILLED WITH: Cement Grout
END DATE: April 15, 2014	HAMMER TYPE: 140-Lb	

Depth (ft)	Material Symbol	Sample	Sample No.	Blow Count (blows/ft)	USCS Symbol	Material Description	Water Table	Unit Dry Weight, pcf	Water Content, %	% Passing No. 200	Liquid Limit	Plasticity Index	Notes & Assigned Laboratory
------------	-----------------	--------	------------	-----------------------	-------------	----------------------	-------------	----------------------	------------------	-------------------	--------------	------------------	-----------------------------



The log and data presented are a simplification of actual conditions encountered at the given location and time of exploration. Subsurface conditions may differ at other locations and with the passage of time.

PLATE NO.: B-2.4

LOG OF EXPLORATION: D30RC

PROJECT: Blue Lake Levee	EXPL. VENDOR: Britton Exploration	SURFACE ELEVATION: 98.5 feet
PROJECT NO.: 14-1949.02	EXPL. METHOD: 8.25" HSA	DEPTH OF HOLE: 51.0 Feet
LOCATION: Humboldt Co., CA	LOGGED BY: J.Bianchin	DEPTH TO WATER: 24.2 feet
START DATE: April 15, 2014	CHECKED BY: J.Bianchin	BACKFILLED WITH: Cement Grout
END DATE: April 15, 2014	HAMMER TYPE: 140-Lb	

Depth (ft)	Material Symbol	Sample	Sample No.	Blow Count (blows/ft)	USCS Symbol	Material Description	Water Table	Unit Dry Weight, pcf	Water Content, %	% Passing No. 200	Liquid Limit	Plasticity Index	Notes & Assigned Laboratory
20			5	11		At 19.5 feet: slightly plastic with organics and woody debris.		99.5	28.6	74			GS
					SP	SAND, dark brown, moist, loose, medium grained.		100	20	46			GS, DS
					SW/ GW	Gravelly SAND to Sandy GRAVEL, grey, wet, dense, fine to coarse grained, with subangular to subrounded fine to coarse gravel.	▼						
25			6	32									
					GP/ GM	Sandy to Silty GRAVEL, grey, wet, medium dense, fine to coarse grained, with subangular to subrounded fine to coarse gravel.			7.7	8			GS
30			7	31									
					GW	Sandy GRAVEL, moderate brown, wet, medium dense, fine to coarse grained with fine to medium subangular to subrounded gravel.							
35			8	25		Between 36 and 38 feet: abundant gravel and cobbles.							



The log and data presented are a simplification of actual conditions encountered at the given location and time of exploration. Subsurface conditions may differ at other locations and with the passage of time.

PLATE NO.: B-2.4

LOG OF EXPLORATION: D30RC

PROJECT: Blue Lake Levee	EXPL. VENDOR: Britton Exploration	SURFACE ELEVATION: 98.5 feet
PROJECT NO.: 14-1949.02	EXPL. METHOD: 8.25" HSA	DEPTH OF HOLE: 51.0 Feet
LOCATION: Humboldt Co., CA	LOGGED BY: J.Bianchin	DEPTH TO WATER: 24.2 feet
START DATE: April 15, 2014	CHECKED BY: J.Bianchin	BACKFILLED WITH: Cement Grout
END DATE: April 15, 2014	HAMMER TYPE: 140-Lb	

Depth (ft)	Material Symbol	Sample	Sample No.	Blow Count (blows/ft)	USCS Symbol	Material Description	Water Table	Unit Dry Weight, pcf	Water Content, %	% Passing No. 200	Liquid Limit	Plasticity Index	Notes & Assigned Laboratory
------------	-----------------	--------	------------	-----------------------	-------------	----------------------	-------------	----------------------	------------------	-------------------	--------------	------------------	-----------------------------

40	GP/GM	9	32	GP/GM	GRAVEL with Sand, grey, wet, dense, fine to coarse grained, with subangular to subrounded fine to coarse gravel.			11.6		9			GS
45	GM/GW	10	54	GM/GW	Silty GRAVEL with Sand, moderate brown to grey, wet, very dense, fine to coarse grained with subangular to subrounded fine to coarse gravel.								
50	GP/GM	11	33	GP/GM	Sandy GRAVEL, moderate grey, wet, dense, fine to coarse grained with subangular to subrounded fine to coarse gravel.			8.8		8			GS
					Bottom of Drill Hole at a Depth of 51 Feet.								



The log and data presented are a simplification of actual conditions encountered at the given location and time of exploration. Subsurface conditions may differ at other locations and with the passage of time.

PLATE NO.: B-2.4

LOG OF EXPLORATION: D39RC

PROJECT: Blue Lake Levee	EXPL. VENDOR: Fisch Drilling	SURFACE ELEVATION: 100 feet
PROJECT NO.: 14-1949.02	EXPL. METHOD: 8.25" HSA	DEPTH OF HOLE: 51.0 Feet
LOCATION: Humboldt Co., CA	LOGGED BY: J.Bianchin	DEPTH TO WATER: 21.5 feet
START DATE: April 24, 2014	CHECKED BY: J.Bianchin	BACKFILLED WITH: Cement grout
END DATE: April 24, 2014	HAMMER TYPE: 140-Lb	

Depth (ft)	Material Symbol	Sample	Sample No.	Blow Count (blows/ft)	USCS Symbol	Material Description	Water Table	Unit Dry Weight, pcf	Water Content, %	% Passing No. 200	Liquid Limit	Plasticity Index	Notes & Assigned Laboratory
------------	-----------------	--------	------------	-----------------------	-------------	----------------------	-------------	----------------------	------------------	-------------------	--------------	------------------	-----------------------------

0					SW	ARTIFICIAL FILL (af) Gravelly SAND, moderate grey, moist, fine to coarse grained with subrounded fine to coarse gravel and trace subrounded fine to medium cobbles.							
5			1	(26)	SC	Clayey SAND, moderate yellowish brown to moderate brown, dry to moist, slightly plastic, fine grained. At 5 feet: medium dense, fine to coarse grained with trace to moderate subrounded fine to moderate gravel. At 7 feet: increased gravel.				38			GS
10			2a 2b	(26)	CL	Sandy CLAY with Gravel, moderate brown, moist, stiff, fine to coarse grained with subrounded fine to medium gravel.	104	17	32	10	PI		
15			3	(7)	ML	Fine Sandy SILT, grey, moist, loose.							
					SW	Gravelly SAND, grey, wet, fine to coarse grained with subrounded fine to medium gravel.							



The log and data presented are a simplification of actual conditions encountered at the given location and time of exploration. Subsurface conditions may differ at other locations and with the passage of time.

PLATE NO.: B-2.5

LOG OF EXPLORATION: D39RC

PROJECT: Blue Lake Levee	EXPL. VENDOR: Fisch Drilling	SURFACE ELEVATION: 100 feet
PROJECT NO.: 14-1949.02	EXPL. METHOD: 8.25" HSA	DEPTH OF HOLE: 51.0 Feet
LOCATION: Humboldt Co., CA	LOGGED BY: J.Bianchin	DEPTH TO WATER: 21.5 feet
START DATE: April 24, 2014	CHECKED BY: J.Bianchin	BACKFILLED WITH: Cement grout
END DATE: April 24, 2014	HAMMER TYPE: 140-Lb	

Depth (ft)	Material Symbol	Sample	Sample No.	Blow Count (blows/ft)	USCS Symbol	Material Description	Water Table	Unit Dry Weight, pcf	Water Content, %	% Passing No. 200	Liquid Limit	Plasticity Index	Notes & Assigned Laboratory
------------	-----------------	--------	------------	-----------------------	-------------	----------------------	-------------	----------------------	------------------	-------------------	--------------	------------------	-----------------------------

20	●●●●	▲	4	36		At 20 feet: dense.	▼						
						At 23 feet: increased gravel.							Woody debris in cuttings
25	●●●●	▲	5	10		SAND with Gravel, grey, wet, fine to coarse grained with subrounded fine to medium gravel.			6.3	5			GS
						Between 32 and 34 feet: fewer gravels.							
30	●●●●	▲	6	20									
35	●●●●	▲	7	34	GW	Sandy GRAVEL, grey, wet, dense, fine to coarse grained, with subrounded fine to medium gravel.			6.3				



The log and data presented are a simplification of actual conditions encountered at the given location and time of exploration. Subsurface conditions may differ at other locations and with the passage of time.

PLATE NO.: B-2.5

LOG OF EXPLORATION: D39RC

PROJECT: Blue Lake Levee	EXPL. VENDOR: Fisch Drilling	SURFACE ELEVATION: 100 feet
PROJECT NO.: 14-1949.02	EXPL. METHOD: 8.25" HSA	DEPTH OF HOLE: 51.0 Feet
LOCATION: Humboldt Co., CA	LOGGED BY: J.Bianchin	DEPTH TO WATER: 21.5 feet
START DATE: April 24, 2014	CHECKED BY: J.Bianchin	BACKFILLED WITH: Cement grout
END DATE: April 24, 2014	HAMMER TYPE: 140-Lb	

Depth (ft)	Material Symbol	Sample	Sample No.	Blow Count (blows/ft)	USCS Symbol	Material Description	Water Table	Unit Dry Weight, pcf	Water Content, %	% Passing No. 200	Liquid Limit	Plasticity Index	Notes & Assigned Laboratory
------------	-----------------	--------	------------	-----------------------	-------------	----------------------	-------------	----------------------	------------------	-------------------	--------------	------------------	-----------------------------

40			8	29		<p>At 40 feet: medium dense with trace to few clay.</p> <p>Between 44 and 50 feet: abundant gravel, cobbles, and/or boulders.</p>							
50			9	46	GW	<p>Sandy GRAVEL with Clay, moderate brown, wet, dense, slightly plastic, fine to coarse grained, with subangular to subrounded fine to medium gravel and trace to moderate clay.</p> <p>Bottom of Drill Hole at a Depth of 51 Feet.</p>							

LOG OF EXPLORATION: D49RC

PROJECT: Blue Lake Levee	EXPL. VENDOR: Fisch Drilling	SURFACE ELEVATION: 99.5 feet
PROJECT NO.: 14-1949.02	EXPL. METHOD: 8.25" HSA	DEPTH OF HOLE: 41.5 Feet
LOCATION: Humboldt Co., CA	LOGGED BY: J.Bianchin	DEPTH TO WATER: 21.5 feet
START DATE: April 24, 2014	CHECKED BY: J.Bianchin	BACKFILLED WITH: Cement grout
END DATE: April 24, 2014	HAMMER TYPE: 140-Lb	

Depth (ft)	Material Symbol	Sample	Sample No.	Blow Count (blows/ft)	USCS Symbol	Material Description	Water Table	Unit Dry Weight, pcf	Water Content, %	% Passing No. 200	Liquid Limit	Plasticity Index	Notes & Assigned Laboratory
------------	-----------------	--------	------------	-----------------------	-------------	----------------------	-------------	----------------------	------------------	-------------------	--------------	------------------	-----------------------------

0					GW/ SW	ARTIFICIAL FILL (af) Sandy GRAVEL to Gravelly SAND, grey, moist, fine to coarse grained with subrounded fine to coarse gravel and trace subrounded fine to medium cobbles.							
5			1	(24)	CL	Sandy CLAY with Gravel, moderate yellowish brown, moist, slightly plastic, with fine to medium sand and trace subrounded fine to medium gravel. At 5 feet: very stiff.	107	17		31	8	PI	
10			2	12	ML	Fine Sandy SILT, grey, moist. At 10 feet: loose to medium dense.		22.5		51			GS
15			3	6	SW	SAND, dark grey, moist, loose, fine to medium grained with interbeds of fine sand.							
					SW	Gravelly SAND, moderate grey, moist, fine to coarse grained, with moderate subrounded fine to coarse gravel.							



The log and data presented are a simplification of actual conditions encountered at the given location and time of exploration. Subsurface conditions may differ at other locations and with the passage of time.

PLATE NO.: B-2.6

LOG OF EXPLORATION: D49RC

PROJECT: Blue Lake Levee	EXPL. VENDOR: Fisch Drilling	SURFACE ELEVATION: 99.5 feet
PROJECT NO.: 14-1949.02	EXPL. METHOD: 8.25" HSA	DEPTH OF HOLE: 41.5 Feet
LOCATION: Humboldt Co., CA	LOGGED BY: J.Bianchin	DEPTH TO WATER: 21.5 feet
START DATE: April 24, 2014	CHECKED BY: J.Bianchin	BACKFILLED WITH: Cement grout
END DATE: April 24, 2014	HAMMER TYPE: 140-Lb	

Depth (ft)	Material Symbol	Sample	Sample No.	Blow Count (blows/ft)	USCS Symbol	Material Description	Water Table	Unit Dry Weight, pcf	Water Content, %	% Passing No. 200	Liquid Limit	Plasticity Index	Notes & Assigned Laboratory
------------	-----------------	--------	------------	-----------------------	-------------	----------------------	-------------	----------------------	------------------	-------------------	--------------	------------------	-----------------------------

20	●●●●●●	▲▲▲▲	4	12	SP	<p>SAND with Gravel, moderate grey, moist, medium dense, fine to coarse grained with moderate subrounded fine to coarse gravel.</p>	▼		2.6	3			GS
25	●●●●●●	●●●●		10									
30	●●●●●●	▲▲▲▲	5	14	SW/SM	<p>SAND, moderate grey, wet, medium dense, fine to medium grained with trace coarse grains.</p> <p>Between 32 and 35 feet: with interbeds of gravel and/or cobbles.</p>			9.8	11			GS
35	●●●●●●	▲▲▲▲	6	32	GW	<p>Sandy GRAVEL, moderate brown, wet, dense, fine to coarse grained with subrounded fine to coarse gravel and trace to moderate clay.</p>							



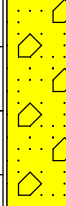
The log and data presented are a simplification of actual conditions encountered at the given location and time of exploration. Subsurface conditions may differ at other locations and with the passage of time.

PLATE NO.: B-2.6

LOG OF EXPLORATION: D49RC

PROJECT: Blue Lake Levee	EXPL. VENDOR: Fisch Drilling	SURFACE ELEVATION: 99.5 feet
PROJECT NO.: 14-1949.02	EXPL. METHOD: 8.25" HSA	DEPTH OF HOLE: 41.5 Feet
LOCATION: Humboldt Co., CA	LOGGED BY: J.Bianchin	DEPTH TO WATER: 21.5 feet
START DATE: April 24, 2014	CHECKED BY: J.Bianchin	BACKFILLED WITH: Cement grout
END DATE: April 24, 2014	HAMMER TYPE: 140-Lb	

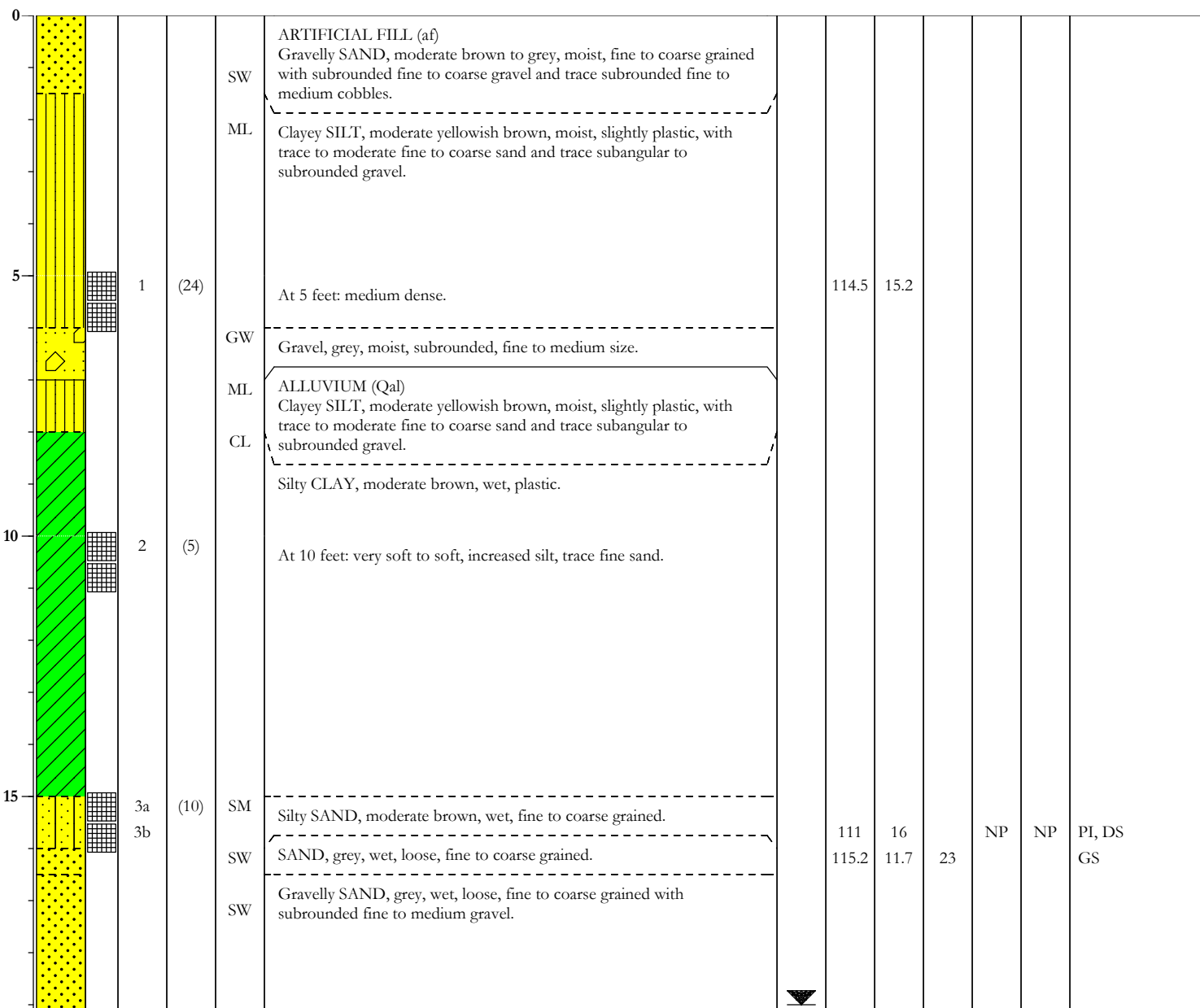
Depth (ft)	Material Symbol	Sample	Sample No.	Blow Count (blows/ft)	USCS Symbol	Material Description	Water Table	Unit Dry Weight, pcf	Water Content, %	% Passing No. 200	Liquid Limit	Plasticity Index	Notes & Assigned Laboratory
------------	-----------------	--------	------------	-----------------------	-------------	----------------------	-------------	----------------------	------------------	-------------------	--------------	------------------	-----------------------------

40			7	38									
Bottom of Drill Hole at a Depth of 41.5 Feet.													

LOG OF EXPLORATION: D59RC

PROJECT: Blue Lake Levee	EXPL. VENDOR: Fisch Drilling	SURFACE ELEVATION: 101.5 feet
PROJECT NO.: 14-1949.02	EXPL. METHOD: 8.25" HSA	DEPTH OF HOLE: 51.0 Feet
LOCATION: Humboldt Co., CA	LOGGED BY: J.Bianchin	DEPTH TO WATER: 19.0 feet
START DATE: April 25, 2014	CHECKED BY: J.Bianchin	BACKFILLED WITH: Cement grout
END DATE: April 25, 2014	HAMMER TYPE: 140-Lb	

Depth (ft)	Material Symbol	Sample	Sample No.	Blow Count (blows/ft)	USCS Symbol	Material Description	Water Table	Unit Dry Weight, pcf	Water Content, %	% Passing No. 200	Liquid Limit	Plasticity Index	Notes & Assigned Laboratory
------------	-----------------	--------	------------	-----------------------	-------------	----------------------	-------------	----------------------	------------------	-------------------	--------------	------------------	-----------------------------



The log and data presented are a simplification of actual conditions encountered at the given location and time of exploration. Subsurface conditions may differ at other locations and with the passage of time.

PLATE NO.: B-2.7

LOG OF EXPLORATION: D59RC

PROJECT: Blue Lake Levee	EXPL. VENDOR: Fisch Drilling	SURFACE ELEVATION: 101.5 feet
PROJECT NO.: 14-1949.02	EXPL. METHOD: 8.25" HSA	DEPTH OF HOLE: 51.0 Feet
LOCATION: Humboldt Co., CA	LOGGED BY: J.Bianchin	DEPTH TO WATER: 19.0 feet
START DATE: April 25, 2014	CHECKED BY: J.Bianchin	BACKFILLED WITH: Cement grout
END DATE: April 25, 2014	HAMMER TYPE: 140-Lb	

Depth (ft)	Material Symbol	Sample	Sample No.	Blow Count (blows/ft)	USCS Symbol	Material Description	Water Table	Unit Dry Weight, pcf	Water Content, %	% Passing No. 200	Liquid Limit	Plasticity Index	Notes & Assigned Laboratory
------------	-----------------	--------	------------	-----------------------	-------------	----------------------	-------------	----------------------	------------------	-------------------	--------------	------------------	-----------------------------

20	◆	◆	4	10	GW	GRAVEL with Sand, dark grey, wet, loose to medium dense, fine to coarse grained with subrounded fine to medium gravel.	▼		7.2	1			GS
25	●	●			SW/SM	SAND with few gravels.							
30	●	●		4									
35	◆	◆	5	44	GW	Sandy GRAVEL with Clay, moderate brown, wet, medium dense to dense, fine to coarse grained with subangular to subrounded fine to medium gravel and trace to moderate clay.							



The log and data presented are a simplification of actual conditions encountered at the given location and time of exploration. Subsurface conditions may differ at other locations and with the passage of time.

PLATE NO.: B-2.7

LOG OF EXPLORATION: D59RC

PROJECT: Blue Lake Levee	EXPL. VENDOR: Fisch Drilling	SURFACE ELEVATION: 101.5 feet
PROJECT NO.: 14-1949.02	EXPL. METHOD: 8.25" HSA	DEPTH OF HOLE: 51.0 Feet
LOCATION: Humboldt Co., CA	LOGGED BY: J.Bianchin	DEPTH TO WATER: 19.0 feet
START DATE: April 25, 2014	CHECKED BY: J.Bianchin	BACKFILLED WITH: Cement grout
END DATE: April 25, 2014	HAMMER TYPE: 140-Lb	

Depth (ft)	Material Symbol	Sample	Sample No.	Blow Count (blows/ft)	USCS Symbol	Material Description	Water Table	Unit Dry Weight, pcf	Water Content, %	% Passing No. 200	Liquid Limit	Plasticity Index	Notes & Assigned Laboratory
------------	-----------------	--------	------------	-----------------------	-------------	----------------------	-------------	----------------------	------------------	-------------------	--------------	------------------	-----------------------------

40			6	48		<p>SAND with Gravel, grey, wet, loose, fine to coarse grained with subrounded fine to medium gravel.</p> <p>Between 42 and 43.5 feet: increased gravel and/or cobbles.</p>			3.5	12			GS
45				30	SW	<p>Gravelly SAND with Clay, moderate brown, wet, medium dense, fine to coarse grained with trace to moderate subrounded fine to medium gravel and trace to moderate clay.</p>							
50				28		<p>Bottom of Drill Hole at a Depth of 51.5 feet.</p>							



The log and data presented are a simplification of actual conditions encountered at the given location and time of exploration. Subsurface conditions may differ at other locations and with the passage of time.

PLATE NO.: B-2.7

LOG OF EXPLORATION: D70RC

PROJECT: Blue Lake Levee	EXPL. VENDOR: Fisch Drilling	SURFACE ELEVATION: 103 feet
PROJECT NO.: 14-1949.02	EXPL. METHOD: 8.25" HSA	DEPTH OF HOLE: 41.5 Feet
LOCATION: Humboldt Co., CA	LOGGED BY: J.Bianchin	DEPTH TO WATER: 23.0 feet
START DATE: April 25, 2014	CHECKED BY: J.Bianchin	BACKFILLED WITH: Cement grout
END DATE: April 25, 2014	HAMMER TYPE: 140-Lb	

Depth (ft)	Material Symbol	Sample	Sample No.	Blow Count (blows/ft)	USCS Symbol	Material Description	Water Table	Unit Dry Weight, pcf	Water Content, %	% Passing No. 200	Liquid Limit	Plasticity Index	Notes & Assigned Laboratory
------------	-----------------	--------	------------	-----------------------	-------------	----------------------	-------------	----------------------	------------------	-------------------	--------------	------------------	-----------------------------

0					GW/ SW	ARTIFICIAL FILL (af) Sandy GRAVEL to Gravelly SAND, moderate brown to grey, moist, fine to coarse grained with subrounded fine to coarse gravel and trace subrounded fine to medium cobbles.							
5			1	12	ML	Clayey SILT, moderate yellowish brown, moist, slightly plastic, with fine sand.							
5					SW	Sandy GRAVEL to Gravelly SAND, moderate brown to grey, moist, fine to coarse grained with subrounded fine to coarse gravel.							
5					ML	Clayey SILT, moderate yellowish brown, moist, medium dense, slightly plastic, with fine sand and trace subrounded fine gravel.							
5					ML	ALLUVIUM (Qal) Clayey SILT, moderate yellowish brown, moist, medium dense, slightly plastic, with fine sand and trace subrounded fine gravel.							
10			2	(6)		At 10 feet: grey, very loose to loose, plastic, with charcoal, woody debris, and interspersed organics.	94.7	29.5					
10					CL	Silty CLAY, grey, wet, plastic, with trace fine sand.							
15			3	(11)	CL	CLAY, moderate brown, mottled moderate yellowish brown, moist, soft to firm, plastic.	99	26	36	20	PI		



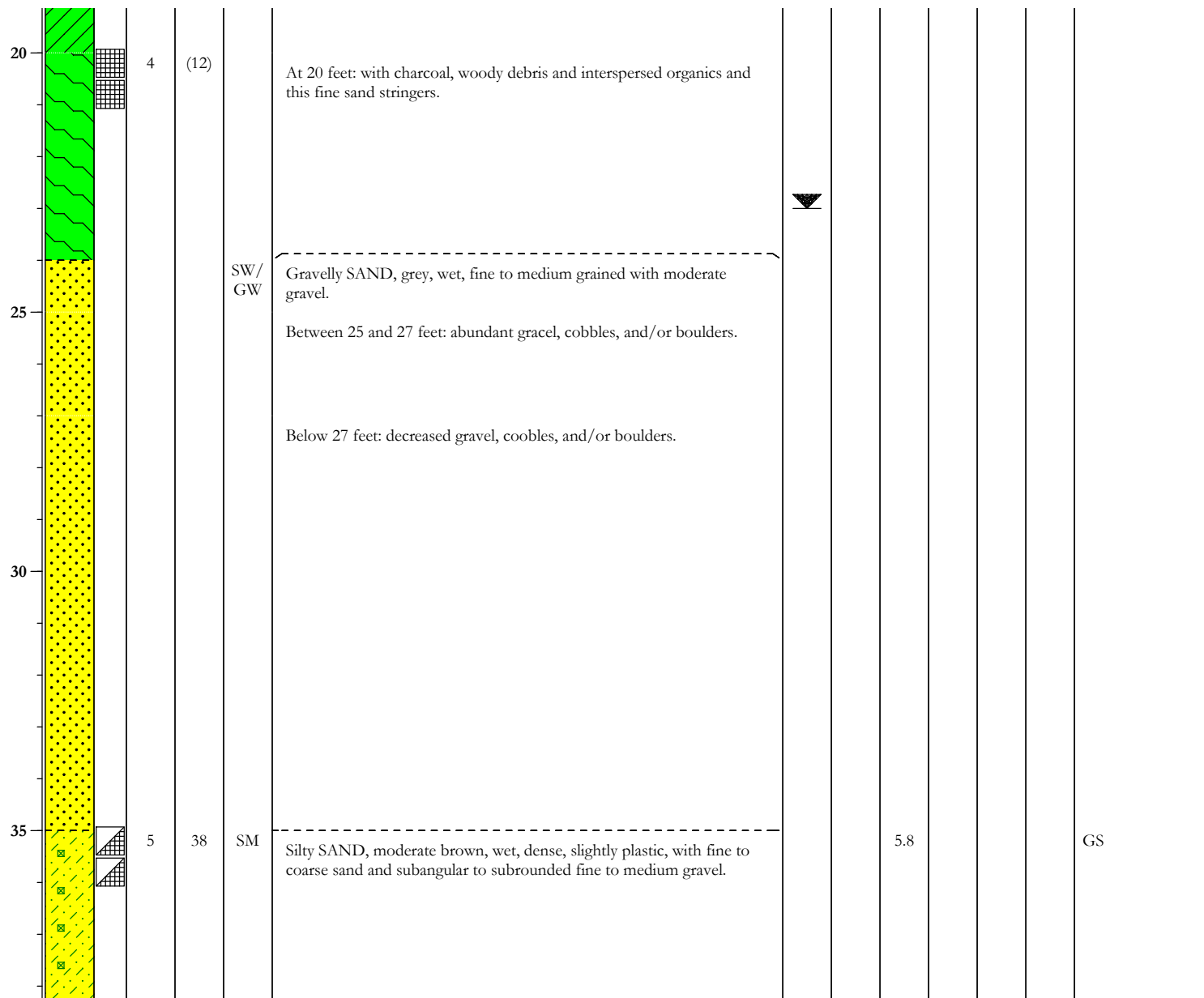
The log and data presented are a simplification of actual conditions encountered at the given location and time of exploration. Subsurface conditions may differ at other locations and with the passage of time.

PLATE NO.: B-2.8

LOG OF EXPLORATION: D70RC

PROJECT: Blue Lake Levee	EXPL. VENDOR: Fisch Drilling	SURFACE ELEVATION: 103 feet
PROJECT NO.: 14-1949.02	EXPL. METHOD: 8.25" HSA	DEPTH OF HOLE: 41.5 Feet
LOCATION: Humboldt Co., CA	LOGGED BY: J.Bianchin	DEPTH TO WATER: 23.0 feet
START DATE: April 25, 2014	CHECKED BY: J.Bianchin	BACKFILLED WITH: Cement grout
END DATE: April 25, 2014	HAMMER TYPE: 140-Lb	

Depth (ft)	Material Symbol	Sample	Sample No.	Blow Count (blows/ft)	USCS Symbol	Material Description	Water Table	Unit Dry Weight, pcf	Water Content, %	% Passing No. 200	Liquid Limit	Plasticity Index	Notes & Assigned Laboratory
------------	-----------------	--------	------------	-----------------------	-------------	----------------------	-------------	----------------------	------------------	-------------------	--------------	------------------	-----------------------------



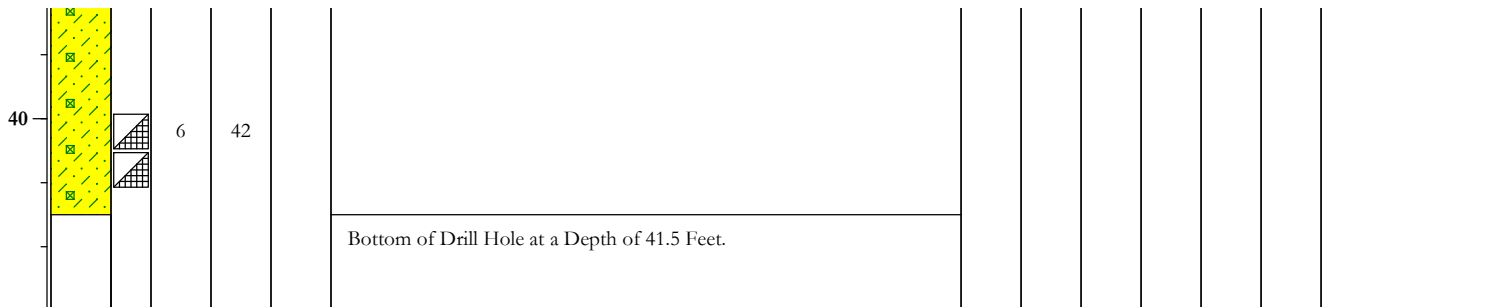
The log and data presented are a simplification of actual conditions encountered at the given location and time of exploration. Subsurface conditions may differ at other locations and with the passage of time.

PLATE NO.: B-2.8

LOG OF EXPLORATION: D70RC

PROJECT: Blue Lake Levee	EXPL. VENDOR: Fisch Drilling	SURFACE ELEVATION: 103 feet
PROJECT NO.: 14-1949.02	EXPL. METHOD: 8.25" HSA	DEPTH OF HOLE: 41.5 Feet
LOCATION: Humboldt Co., CA	LOGGED BY: J.Bianchin	DEPTH TO WATER: 23.0 feet
START DATE: April 25, 2014	CHECKED BY: J.Bianchin	BACKFILLED WITH: Cement grout
END DATE: April 25, 2014	HAMMER TYPE: 140-Lb	

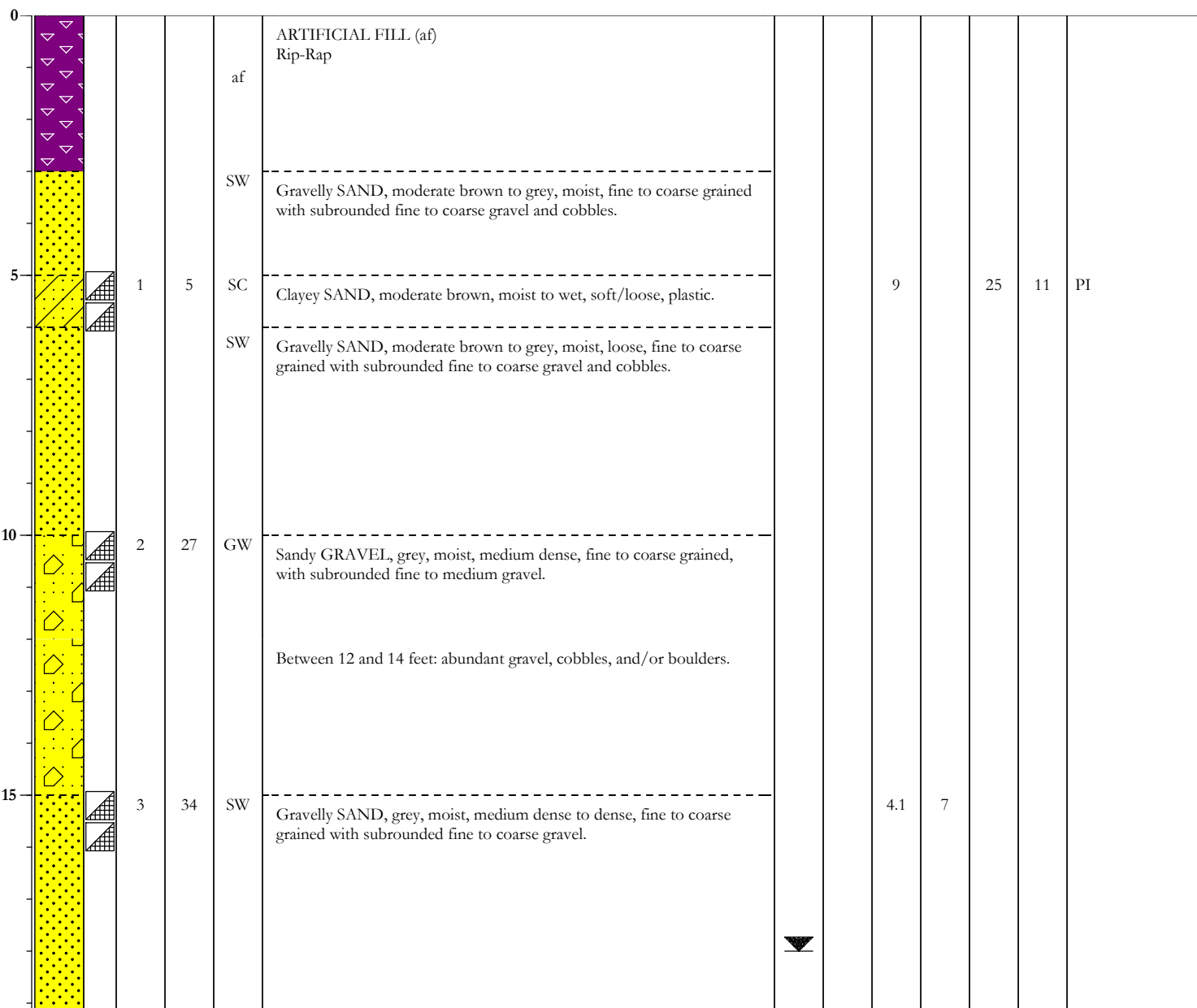
Depth (ft)	Material Symbol	Sample	Sample No.	Blow Count (blows/ft)	USCS Symbol	Material Description	Water Table	Unit Dry Weight, pcf	Water Content, %	% Passing No. 200	Liquid Limit	Plasticity Index	Notes & Assigned Laboratory
------------	-----------------	--------	------------	-----------------------	-------------	----------------------	-------------	----------------------	------------------	-------------------	--------------	------------------	-----------------------------



LOG OF EXPLORATION: D1RW

PROJECT: Blue Lake Levee	EXPL. VENDOR: Britton Exploration	SURFACE ELEVATION: 82 feet
PROJECT NO.: 14-1949.02	EXPL. METHOD: 8.25" HSA	DEPTH OF HOLE: 26.5 Feet
LOCATION: Humboldt Co., CA	LOGGED BY: J.Bianchin	DEPTH TO WATER: 18.0 feet
START DATE: April 16, 2014	CHECKED BY: J.Bianchin	BACKFILLED WITH: Cement grout
END DATE: April 16, 2014	HAMMER TYPE: 140-Lb	

Depth (ft)	Material Symbol	Sample	Sample No.	Blow Count (blows/ft)	USCS Symbol	Material Description	Water Table	Unit Dry Weight, pcf	Water Content, %	% Passing No. 200	Liquid Limit	Plasticity Index	Notes & Assigned Laboratory
------------	-----------------	--------	------------	-----------------------	-------------	----------------------	-------------	----------------------	------------------	-------------------	--------------	------------------	-----------------------------



LOG OF EXPLORATION: D1RW

PROJECT: Blue Lake Levee	EXPL. VENDOR: Britton Exploration	SURFACE ELEVATION: 82 feet
PROJECT NO.: 14-1949.02	EXPL. METHOD: 8.25" HSA	DEPTH OF HOLE: 26.5 Feet
LOCATION: Humboldt Co., CA	LOGGED BY: J.Bianchin	DEPTH TO WATER: 18.0 feet
START DATE: April 16, 2014	CHECKED BY: J.Bianchin	BACKFILLED WITH: Cement grout
END DATE: April 16, 2014	HAMMER TYPE: 140-Lb	

Depth (ft)	Material Symbol	Sample	Sample No.	Blow Count (blows/ft)	USCS Symbol	Material Description	Water Table	Unit Dry Weight, pcf	Water Content, %	% Passing No. 200	Liquid Limit	Plasticity Index	Notes & Assigned Laboratory
------------	-----------------	--------	------------	-----------------------	-------------	----------------------	-------------	----------------------	------------------	-------------------	--------------	------------------	-----------------------------

20			4	30									
						Between 22 and 24.5 feet: abundant gravels, cobbles, and/or boulders.							
25			5	20	GW	Sandy GRAVEL, greyish brown, wet, medium dense, fine to coarse grained with subangular fine gravel and trace subrounded medium gravel.		9.5	5				
						Bottom of Drill Hole at a Depth of 26.5 Feet.							



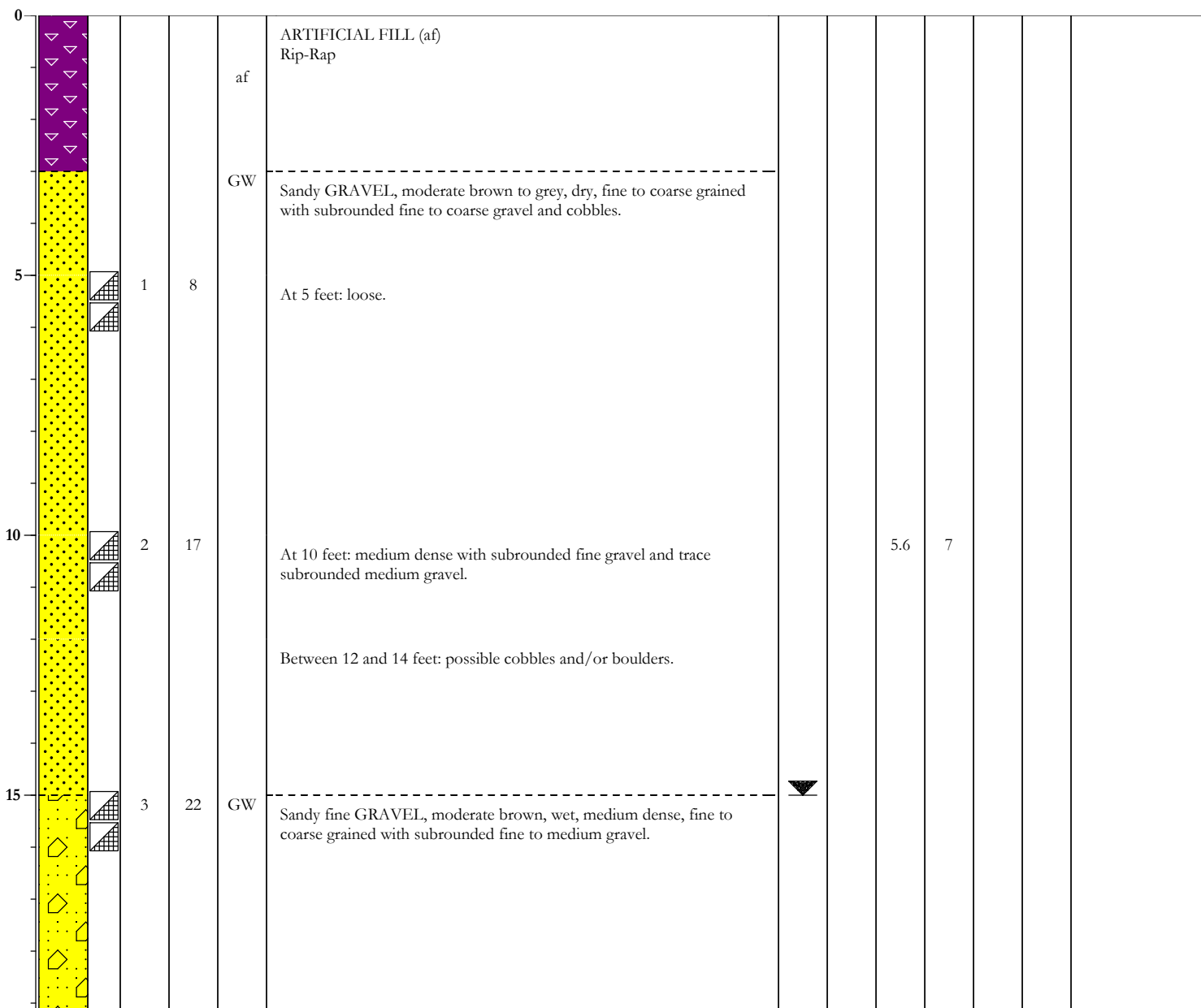
The log and data presented are a simplification of actual conditions encountered at the given location and time of exploration. Subsurface conditions may differ at other locations and with the passage of time.

PLATE NO.: B-2.9

LOG OF EXPLORATION: D10RW

PROJECT: Blue Lake Levee	EXPL. VENDOR: Britton Exploration	SURFACE ELEVATION: 82 feet
PROJECT NO.: 14-1949.02	EXPL. METHOD: 8.25" HSA	DEPTH OF HOLE: 26.5 Feet
LOCATION: Humboldt Co., CA	LOGGED BY: J.Bianchin	DEPTH TO WATER: 15.0 feet
START DATE: April 11, 2014	CHECKED BY: J.Bianchin	BACKFILLED WITH: Cement grout
END DATE: April 16, 2014	HAMMER TYPE: 140-Lb	

Depth (ft)	Material Symbol	Sample	Sample No.	Blow Count (blows/ft)	USCS Symbol	Material Description	Water Table	Unit Dry Weight, pcf	Water Content, %	% Passing No. 200	Liquid Limit	Plasticity Index	Notes & Assigned Laboratory
------------	-----------------	--------	------------	-----------------------	-------------	----------------------	-------------	----------------------	------------------	-------------------	--------------	------------------	-----------------------------




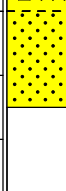
The log and data presented are a simplification of actual conditions encountered at the given location and time of exploration. Subsurface conditions may differ at other locations and with the passage of time.

PLATE NO.: B-2.10

LOG OF EXPLORATION: D10RW

PROJECT: Blue Lake Levee	EXPL. VENDOR: Britton Exploration	SURFACE ELEVATION: 82 feet
PROJECT NO.: 14-1949.02	EXPL. METHOD: 8.25" HSA	DEPTH OF HOLE: 26.5 Feet
LOCATION: Humboldt Co., CA	LOGGED BY: J.Bianchin	DEPTH TO WATER: 15.0 feet
START DATE: April 11, 2014	CHECKED BY: J.Bianchin	BACKFILLED WITH: Cement grout
END DATE: April 16, 2014	HAMMER TYPE: 140-Lb	

Depth (ft)	Material Symbol	Sample	Sample No.	Blow Count (blows/ft)	USCS Symbol	Material Description	Water Table	Unit Dry Weight, pcf	Water Content, %	% Passing No. 200	Liquid Limit	Plasticity Index	Notes & Assigned Laboratory
------------	-----------------	--------	------------	-----------------------	-------------	----------------------	-------------	----------------------	------------------	-------------------	--------------	------------------	-----------------------------

20			4	32					7.2	9			
25			5	33	SW	<p>Gravelly SAND, moderate brown to grey, wet, dense, fine grained with trace to moderate subangular to subrounded fine to medium gravel and trace clay.</p> <p>Bottom of Drill Hole at a Depth of 26.5 Feet.</p>							



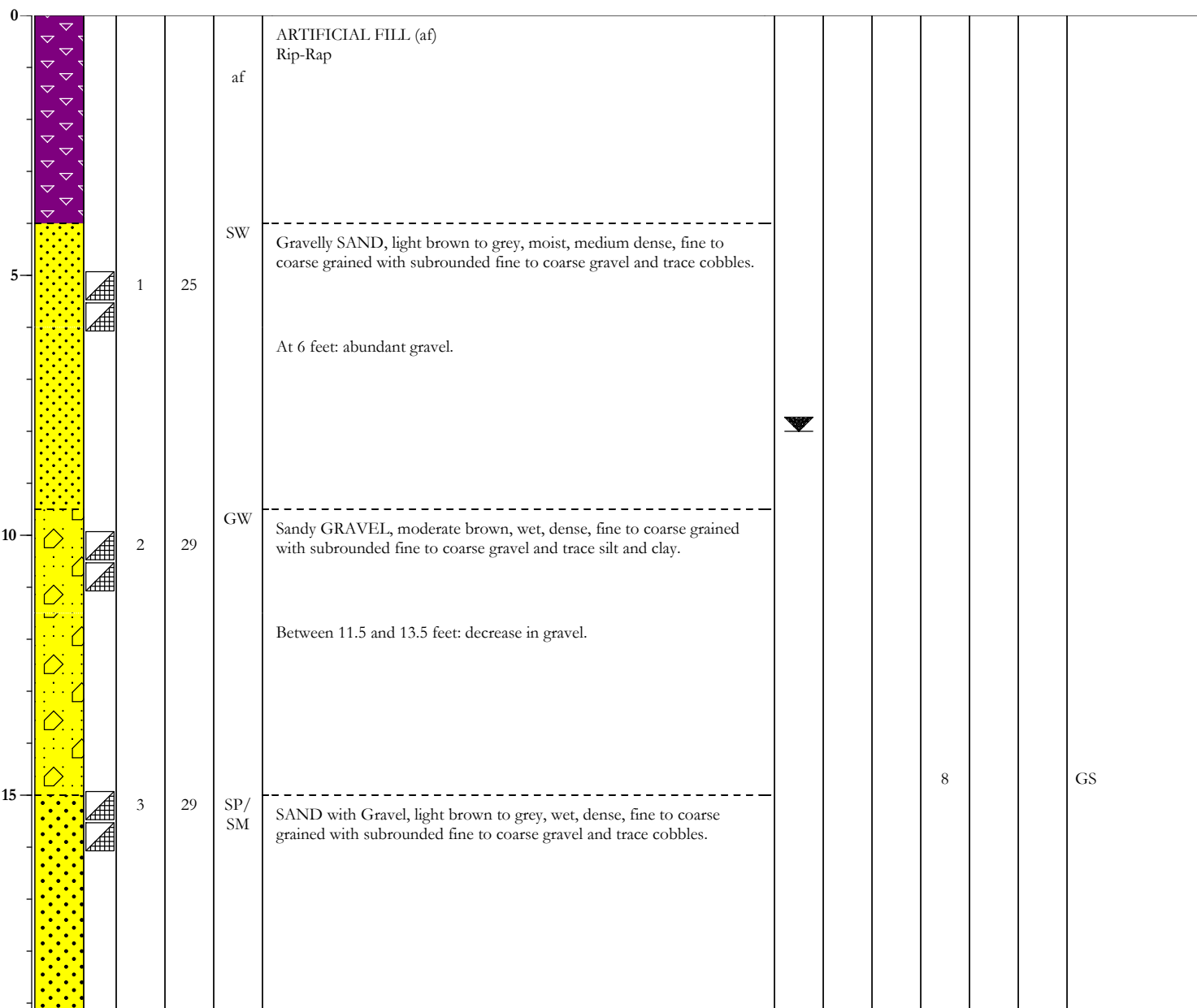
The log and data presented are a simplification of actual conditions encountered at the given location and time of exploration. Subsurface conditions may differ at other locations and with the passage of time.

PLATE NO.: B-2.10

LOG OF EXPLORATION: D39RW

PROJECT: Blue Lake Levee	EXPL. VENDOR: Britton Exploration	SURFACE ELEVATION: 86.5 feet
PROJECT NO.: 14-1949.02	EXPL. METHOD: 8.25" HSA	DEPTH OF HOLE: 25.0 Feet
LOCATION: Humboldt Co., CA	LOGGED BY: J.Bianchin	DEPTH TO WATER: 8.0 feet
START DATE: April 16, 2014	CHECKED BY: J.Bianchin	BACKFILLED WITH: Cement grout
END DATE: April 16, 2014	HAMMER TYPE: 140-Lb	

Depth (ft)	Material Symbol	Sample	Sample No.	Blow Count (blows/ft)	USCS Symbol	Material Description	Water Table	Unit Dry Weight, pcf	Water Content, %	% Passing No. 200	Liquid Limit	Plasticity Index	Notes & Assigned Laboratory
------------	-----------------	--------	------------	-----------------------	-------------	----------------------	-------------	----------------------	------------------	-------------------	--------------	------------------	-----------------------------



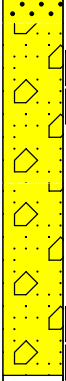
The log and data presented are a simplification of actual conditions encountered at the given location and time of exploration. Subsurface conditions may differ at other locations and with the passage of time.

PLATE NO.: B-2.11

LOG OF EXPLORATION: D39RW

PROJECT: Blue Lake Levee	EXPL. VENDOR: Britton Exploration	SURFACE ELEVATION: 86.5 feet
PROJECT NO.: 14-1949.02	EXPL. METHOD: 8.25" HSA	DEPTH OF HOLE: 25.0 Feet
LOCATION: Humboldt Co., CA	LOGGED BY: J.Bianchin	DEPTH TO WATER: 8.0 feet
START DATE: April 16, 2014	CHECKED BY: J.Bianchin	BACKFILLED WITH: Cement grout
END DATE: April 16, 2014	HAMMER TYPE: 140-Lb	

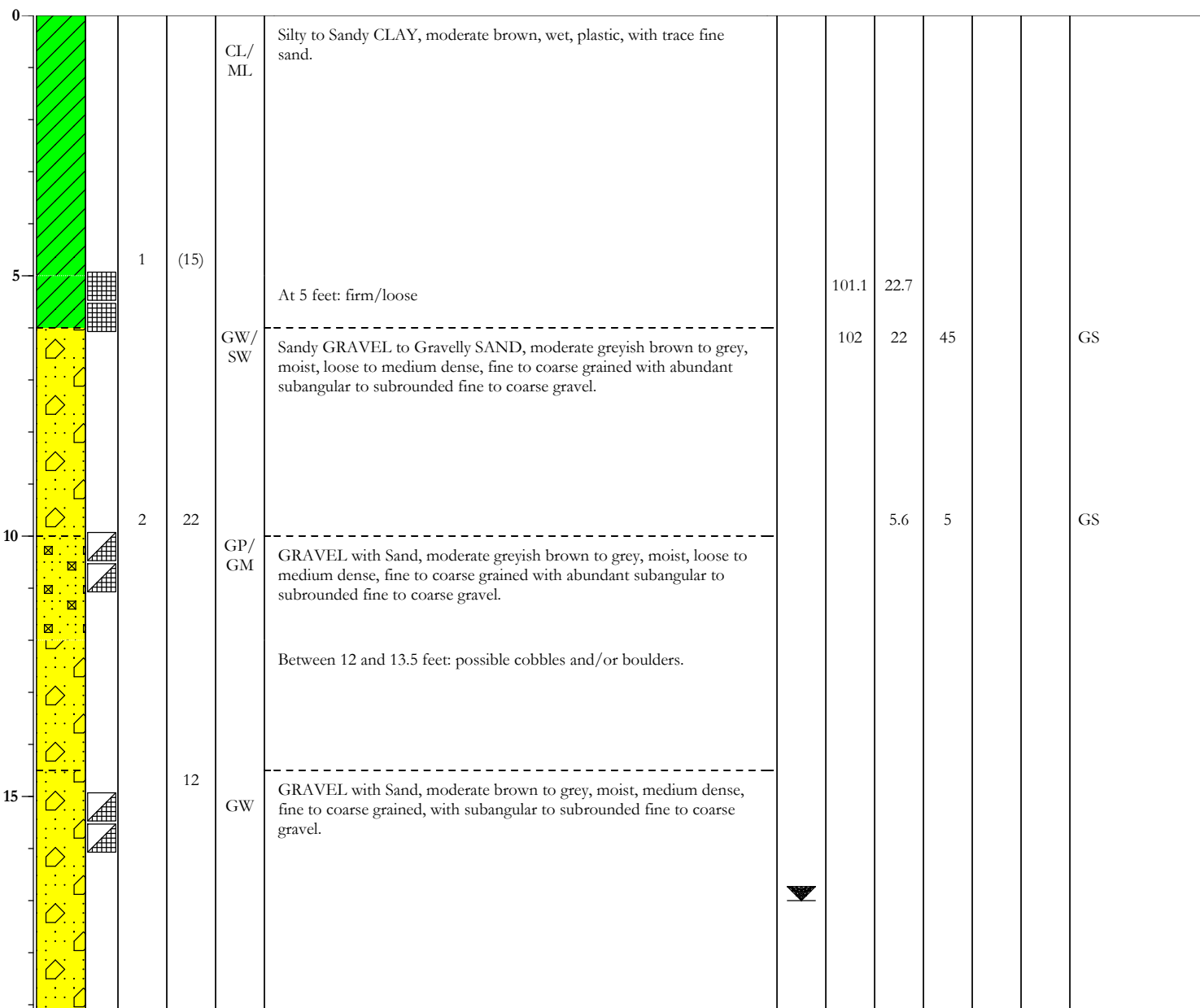
Depth (ft)	Material Symbol	Sample	Sample No.	Blow Count (blows/ft)	USCS Symbol	Material Description	Water Table	Unit Dry Weight, pcf	Water Content, %	% Passing No. 200	Liquid Limit	Plasticity Index	Notes & Assigned Laboratory
------------	-----------------	--------	------------	-----------------------	-------------	----------------------	-------------	----------------------	------------------	-------------------	--------------	------------------	-----------------------------

20			4	25		At 19.5 feet: with subangular to subrounded fine to coarse gravel.							
						Between 22 and 23 feet: decrease in volume or size of gravel.			8.1				
25			5	30		Bottom of Drill Hole at a Depth of 25 Feet.							

LOG OF EXPLORATION: D49RW

PROJECT: Blue Lake Levee	EXPL. VENDOR: Britton Exploration	SURFACE ELEVATION: 95.5 feet
PROJECT NO.: 14-1949.02	EXPL. METHOD: 8.25" HSA	DEPTH OF HOLE: 26.0 Feet
LOCATION: Humboldt Co., CA	LOGGED BY: J.Bianchin	DEPTH TO WATER: 17.0 feet
START DATE: April 14, 2014	CHECKED BY: J.Bianchin	BACKFILLED WITH: Cement grout
END DATE: April 14, 2014	HAMMER TYPE: 140-Lb	

Depth (ft)	Material Symbol	Sample	Sample No.	Blow Count (blows/ft)	USCS Symbol	Material Description	Water Table	Unit Dry Weight, pcf	Water Content, %	% Passing No. 200	Liquid Limit	Plasticity Index	Notes & Assigned Laboratory
------------	-----------------	--------	------------	-----------------------	-------------	----------------------	-------------	----------------------	------------------	-------------------	--------------	------------------	-----------------------------



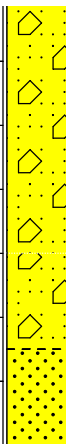

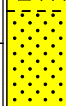

The log and data presented are a simplification of actual conditions encountered at the given location and time of exploration. Subsurface conditions may differ at other locations and with the passage of time.

PLATE NO.: B-2.12

LOG OF EXPLORATION: D49RW

PROJECT: Blue Lake Levee	EXPL. VENDOR: Britton Exploration	SURFACE ELEVATION: 95.5 feet
PROJECT NO.: 14-1949.02	EXPL. METHOD: 8.25" HSA	DEPTH OF HOLE: 26.0 Feet
LOCATION: Humboldt Co., CA	LOGGED BY: J.Bianchin	DEPTH TO WATER: 17.0 feet
START DATE: April 14, 2014	CHECKED BY: J.Bianchin	BACKFILLED WITH: Cement grout
END DATE: April 14, 2014	HAMMER TYPE: 140-Lb	

Depth (ft)	Material Symbol	Sample	Sample No.	Blow Count (blows/ft)	USCS Symbol	Material Description	Water Table	Unit Dry Weight, pcf	Water Content, %	% Passing No. 200	Liqud Limit	Plasticity Index	Notes & Assigned Laboratory
------------	-----------------	--------	------------	-----------------------	-------------	----------------------	-------------	----------------------	------------------	-------------------	-------------	------------------	-----------------------------

20			3	10					9.5	1			GS
25			4	37	SW/ GW	<p>Between 23 and 24 feet: increased gravel and/or cobbles.</p> <hr style="border-top: 1px dashed black;"/> <p>Gravelly SAND to Sandy GRAVEL, moderate grey, wet, dense, fine to coarse grained, with subangular to subrounded fine to coarse gravel.</p> <hr/> <p>Bottom of Drill Hole at a Depth of 26 Feet.</p>							



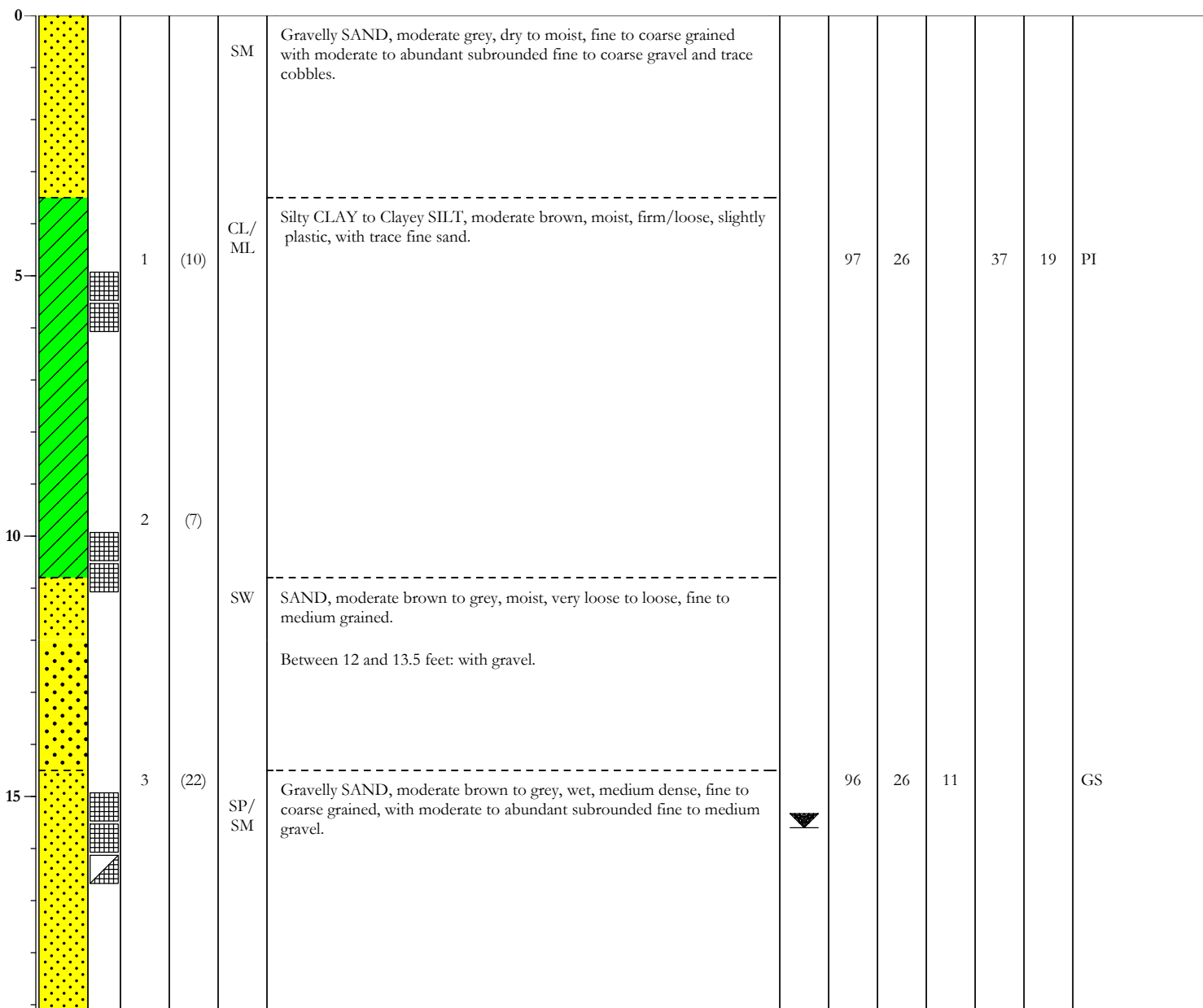
The log and data presented are a simplification of actual conditions encountered at the given location and time of exploration. Subsurface conditions may differ at other locations and with the passage of time.

PLATE NO.: B-2.12

LOG OF EXPLORATION: D59RW

PROJECT: Blue Lake Levee	EXPL. VENDOR: Britton Exploration	SURFACE ELEVATION: 97 feet
PROJECT NO.: 14-1949.02	EXPL. METHOD: 8.25" HSA	DEPTH OF HOLE: 26.0 Feet
LOCATION: Humboldt Co., CA	LOGGED BY: J.Bianchin	DEPTH TO WATER: 15.6 feet
START DATE: April 15, 2014	CHECKED BY: J.Bianchin	BACKFILLED WITH: Cement grout
END DATE: April 15, 2014	HAMMER TYPE: 140-Lb	

Depth (ft)	Material Symbol	Sample	Sample No.	Blow Count (blows/ft)	USCS Symbol	Material Description	Water Table	Unit Dry Weight, pcf	Water Content, %	% Passing No. 200	Liquid Limit	Plasticity Index	Notes & Assigned Laboratory
------------	-----------------	--------	------------	-----------------------	-------------	----------------------	-------------	----------------------	------------------	-------------------	--------------	------------------	-----------------------------



The log and data presented are a simplification of actual conditions encountered at the given location and time of exploration. Subsurface conditions may differ at other locations and with the passage of time.

PLATE NO.: B-2.13

LOG OF EXPLORATION: D59RW

PROJECT: Blue Lake Levee	EXPL. VENDOR: Britton Exploration	SURFACE ELEVATION: 97 feet
PROJECT NO.: 14-1949.02	EXPL. METHOD: 8.25" HSA	DEPTH OF HOLE: 26.0 Feet
LOCATION: Humboldt Co., CA	LOGGED BY: J.Bianchin	DEPTH TO WATER: 15.6 feet
START DATE: April 15, 2014	CHECKED BY: J.Bianchin	BACKFILLED WITH: Cement grout
END DATE: April 15, 2014	HAMMER TYPE: 140-Lb	

Depth (ft)	Material Symbol	Sample	Sample No.	Blow Count (blows/ft)	USCS Symbol	Material Description	Water Table	Unit Dry Weight, pcf	Water Content, %	% Passing No. 200	Liquid Limit	Plasticity Index	Notes & Assigned Laboratory
------------	-----------------	--------	------------	-----------------------	-------------	----------------------	-------------	----------------------	------------------	-------------------	--------------	------------------	-----------------------------

20			4	28		<p>At 19.5 feet: medium dense to dense.</p> <p>Between 21 and 23 feet: increase in gravel, cobbles, and/or boulders.</p>							
25			5	32	GW/ GM	<p>GRAVEL with Sand, moderate brown, wet, dense, fine to coarse grained with subangular to subrounded fine to coarse gravel and trace clay.</p> <p>Bottom of Drill Hole at a Depth of 26 Feet.</p>		5.3	9				GS



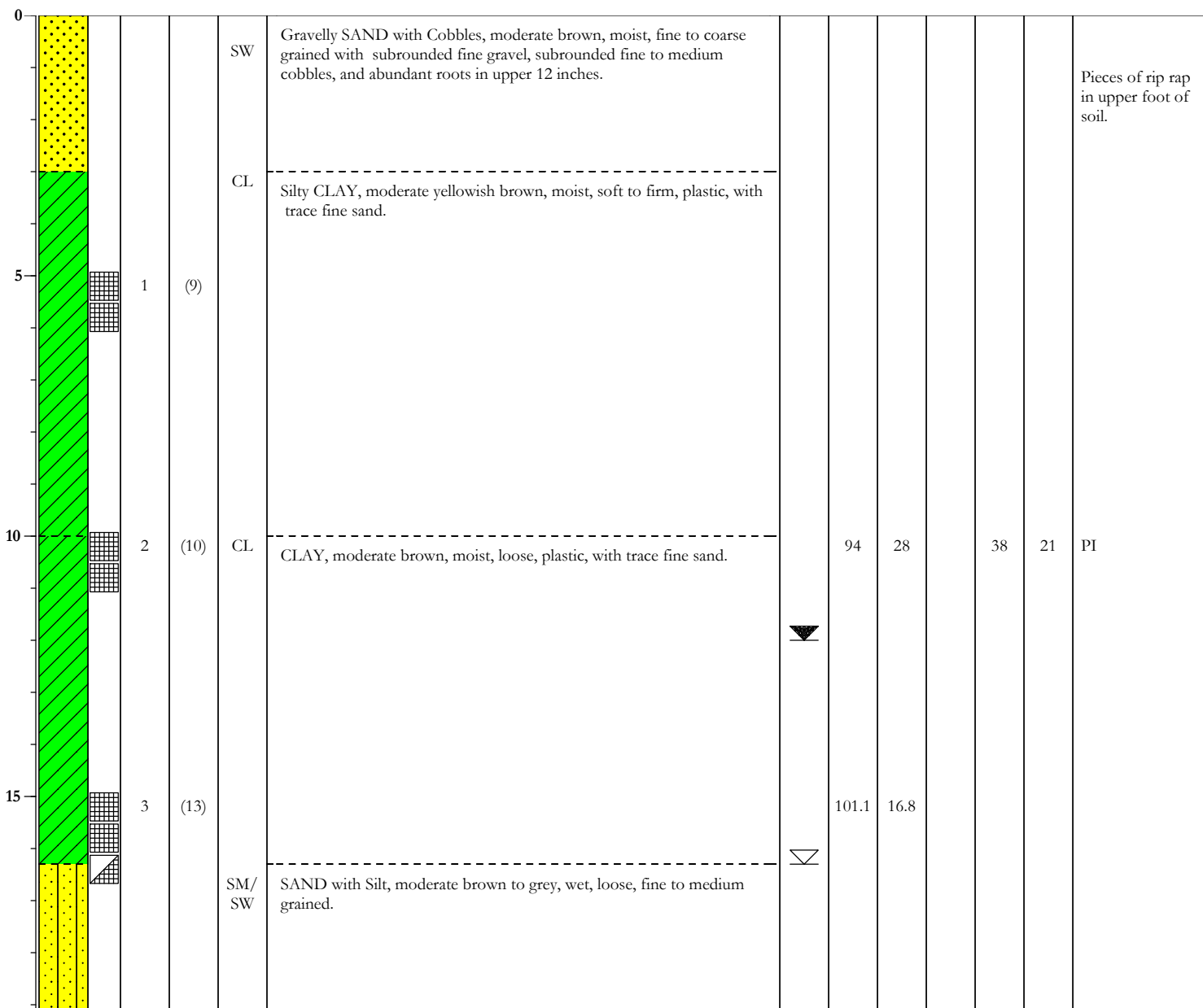
The log and data presented are a simplification of actual conditions encountered at the given location and time of exploration. Subsurface conditions may differ at other locations and with the passage of time.

PLATE NO.: B-2.13

LOG OF EXPLORATION: D70RW

PROJECT: Blue Lake Levee	EXPL. VENDOR: Britton Exploration	SURFACE ELEVATION: 98 feet
PROJECT NO.: 14-1949.02	EXPL. METHOD: 8.25" HSA	DEPTH OF HOLE: 26.5 Feet
LOCATION: Humboldt Co., CA	LOGGED BY: J.Bianchin	DEPTH TO WATER: 12.0 feet
START DATE: April 15, 2014	CHECKED BY: J.Bianchin	BACKFILLED WITH: Cement grout
END DATE: April 15, 2014	HAMMER TYPE: 140-Lb	

Depth (ft)	Material Symbol	Sample	Sample No.	Blow Count (blows/ft)	USCS Symbol	Material Description	Water Table	Unit Dry Weight, pcf	Water Content, %	% Passing No. 200	Liquid Limit	Plasticity Index	Notes & Assigned Laboratory
------------	-----------------	--------	------------	-----------------------	-------------	----------------------	-------------	----------------------	------------------	-------------------	--------------	------------------	-----------------------------



The log and data presented are a simplification of actual conditions encountered at the given location and time of exploration. Subsurface conditions may differ at other locations and with the passage of time.

PLATE NO.: B-2.14

LOG OF EXPLORATION: D70RW

PROJECT: Blue Lake Levee	EXPL. VENDOR: Britton Exploration	SURFACE ELEVATION: 98 feet
PROJECT NO.: 14-1949.02	EXPL. METHOD: 8.25" HSA	DEPTH OF HOLE: 26.5 Feet
LOCATION: Humboldt Co., CA	LOGGED BY: J.Bianchin	DEPTH TO WATER: 12.0 feet
START DATE: April 15, 2014	CHECKED BY: J.Bianchin	BACKFILLED WITH: Cement grout
END DATE: April 15, 2014	HAMMER TYPE: 140-Lb	

Depth (ft)	Material Symbol	Sample	Sample No.	Blow Count (blows/ft)	USCS Symbol	Material Description	Water Table	Unit Dry Weight, pcf	Water Content, %	% Passing No. 200	Liquid Limit	Plasticity Index	Notes & Assigned Laboratory
------------	-----------------	--------	------------	-----------------------	-------------	----------------------	-------------	----------------------	------------------	-------------------	--------------	------------------	-----------------------------

20	[Symbol]		4	34	SW	Gravelly SAND with Clay, moderate brown, wet, dense, fine to coarse grained with trace to moderate subrounded fine to medium gravel.							
25	[Symbol]		5	32	GW/ SW	Sandy GRAVEL to Gravelly SAND, moderate brown, wet, dense, fine to coarse grained with subangular to subrounded fine to medium gravel and trace silt and clay.							
						Bottom of Drill Hole at a Depth of 26.5 Feet.							



The log and data presented are a simplification of actual conditions encountered at the given location and time of exploration. Subsurface conditions may differ at other locations and with the passage of time.

PLATE NO.: B-2.14

LOG OF EXPLORATION: D1RL

PROJECT: Blue Lake Levee	EXPL. VENDOR: Britton Exploration	SURFACE ELEVATION: 73 feet
PROJECT NO.: 14-1949.02	EXPL. METHOD: 8.25" HSA	DEPTH OF HOLE: 26.0 Feet
LOCATION: Humboldt Co., CA	LOGGED BY: J.Bianchin	DEPTH TO WATER: 12.0 feet
START DATE: April 10, 2014	CHECKED BY: J.Bianchin	BACKFILLED WITH: Cement grout
END DATE: April 10, 2014	HAMMER TYPE: 140-Lb	

Depth (ft)	Material Symbol	Sample	Sample No.	Blow Count (blows/ft)	USCS Symbol	Material Description	Water Table	Unit Dry Weight, pcf	Water Content, %	% Passing No. 200	Liquid Limit	Plasticity Index	Notes & Assigned Laboratory
------------	-----------------	--------	------------	-----------------------	-------------	----------------------	-------------	----------------------	------------------	-------------------	--------------	------------------	-----------------------------

0	●●●●●				SW	Gravelly SAND, moderate grey, moist, fine to coarse grained with subrounded fine to coarse gravel.							
5	●●●●●	1	21			At 4.5 feet: wet, medium dense.			1.7	6			GS
	●●●●●					Between 6 and 7.5 feet: abundant gravel, cobbles, and/or boulders.							
	●●●●●					Between 7.5 and 9.5 feet: few gravels.							
10	●●●●●	2	18		GW	Sandy GRAVEL, moderate grey, wet, fine to coarse grained with abundant subangular to subrounded fine to coarse gravel and fine cobbles.	▼						
15	●●●●●	3	28			At 15 feet: dense.			6.7	6			GS





The log and data presented are a simplification of actual conditions encountered at the given location and time of exploration. Subsurface conditions may differ at other locations and with the passage of time.

PLATE NO.: B-2.15

LOG OF EXPLORATION: D1RL

PROJECT: Blue Lake Levee	EXPL. VENDOR: Britton Exploration	SURFACE ELEVATION: 73 feet
PROJECT NO.: 14-1949.02	EXPL. METHOD: 8.25" HSA	DEPTH OF HOLE: 26.0 Feet
LOCATION: Humboldt Co., CA	LOGGED BY: J.Bianchin	DEPTH TO WATER: 12.0 feet
START DATE: April 10, 2014	CHECKED BY: J.Bianchin	BACKFILLED WITH: Cement grout
END DATE: April 10, 2014	HAMMER TYPE: 140-Lb	

Depth (ft)	Material Symbol	Sample	Sample No.	Blow Count (blows/ft)	USCS Symbol	Material Description	Water Table	Unit Dry Weight, pcf	Water Content, %	% Passing No. 200	Liquid Limit	Plasticity Index	Notes & Assigned Laboratory
------------	-----------------	--------	------------	-----------------------	-------------	----------------------	-------------	----------------------	------------------	-------------------	--------------	------------------	-----------------------------

20			4	37									
25			5	60		<p>At 24.5 feet: very dense.</p> <hr/> <p>Bottom of Drill Hole at a Depth of 26 feet.</p>			8.5	9			GS



The log and data presented are a simplification of actual conditions encountered at the given location and time of exploration. Subsurface conditions may differ at other locations and with the passage of time.

LOG OF EXPLORATION: D10RL

PROJECT: Blue Lake Levee	EXPL. VENDOR: Britton Exploration	SURFACE ELEVATION: 76 feet
PROJECT NO.: 14-1949.02	EXPL. METHOD: 8.25" HSA	DEPTH OF HOLE: 26.0 Feet
LOCATION: Humboldt Co., CA	LOGGED BY: J.Bianchin	DEPTH TO WATER: 8.0 feet
START DATE: April 10, 2014	CHECKED BY: J.Bianchin	BACKFILLED WITH: Cement grout
END DATE: April 10, 2014	HAMMER TYPE: 140-Lb	

Depth (ft)	Material Symbol	Sample	Sample No.	Blow Count (blows/ft)	USCS Symbol	Material Description	Water Table	Unit Dry Weight, pcf	Water Content, %	% Passing No. 200	Liquid Limit	Plasticity Index	Notes & Assigned Laboratory
------------	-----------------	--------	------------	-----------------------	-------------	----------------------	-------------	----------------------	------------------	-------------------	--------------	------------------	-----------------------------

0	●●●●●				SW	Gravelly SAND, moderate brown, moist, fine to coarse grained with moderate to abundant subrounded fine to coarse gravel.							
5	●●●●●	1	24			At 4.5 feet: medium dense with trace to moderate subrounded fine to medium gravel. Between 6.5 to 8 feet: abundant gravel, cobbles, and/or boulders. Between 8 and 9.5 feet: interbedded gravelly sand and gravel.	▼						
10	□□□□□	2	34		GW/ GM	Sandy GRAVEL, moderate grey, wet, medium dense, fine to coarse grained, with subangular to subrounded medium to coarse gravel. Between 11.5 and 13.5 feet: abundant gravel, cobbles, and/or boulders.			7.0	7			GS
15	□□□□□	3	21		GW	Sandy GRAVEL, moderate grey, wet, medium dense, fine to coarse grained, with subangular to subrounded medium to coarse gravel.							



The log and data presented are a simplification of actual conditions encountered at the given location and time of exploration. Subsurface conditions may differ at other locations and with the passage of time.

PLATE NO.: B-2.16

LOG OF EXPLORATION: D10RL

PROJECT: Blue Lake Levee	EXPL. VENDOR: Britton Exploration	SURFACE ELEVATION: 76 feet
PROJECT NO.: 14-1949.02	EXPL. METHOD: 8.25" HSA	DEPTH OF HOLE: 26.0 Feet
LOCATION: Humboldt Co., CA	LOGGED BY: J.Bianchin	DEPTH TO WATER: 8.0 feet
START DATE: April 10, 2014	CHECKED BY: J.Bianchin	BACKFILLED WITH: Cement grout
END DATE: April 10, 2014	HAMMER TYPE: 140-Lb	

Depth (ft)	Material Symbol	Sample	Sample No.	Blow Count (blows/ft)	USCS Symbol	Material Description	Water Table	Unit Dry Weight, pcf	Water Content, %	% Passing No. 200	Liquid Limit	Plasticity Index	Notes & Assigned Laboratory
------------	-----------------	--------	------------	-----------------------	-------------	----------------------	-------------	----------------------	------------------	-------------------	--------------	------------------	-----------------------------

20	[Symbol: Yellow dotted pattern]		4	37	SW/SM	Gravelly SAND, moderate grey, wet, medium dense to dense, fine to coarse grained, with abundant subangular to subrounded fine to coarse gravel.			9.8	7			GS
25	[Symbol: Yellow dotted pattern]		5	30		Bottom of Drill Hole at a Depth of 26 Feet.							



The log and data presented are a simplification of actual conditions encountered at the given location and time of exploration. Subsurface conditions may differ at other locations and with the passage of time.

LOG OF EXPLORATION: D20RL

PROJECT: Blue Lake Levee	EXPL. VENDOR: Britton Exploration	SURFACE ELEVATION: 82.5 feet
PROJECT NO.: 14-1949.02	EXPL. METHOD: 8.25" HSA	DEPTH OF HOLE: 26.0 Feet
LOCATION: Humboldt Co., CA	LOGGED BY: J.Bianchin	DEPTH TO WATER: 10.2 feet
START DATE: April 14, 2014	CHECKED BY: J.Bianchin	BACKFILLED WITH: Cement grout
END DATE: April 14, 2014	HAMMER TYPE: 140-Lb	

Depth (ft)	Material Symbol	Sample	Sample No.	Blow Count (blows/ft)	USCS Symbol	Material Description	Water Table	Unit Dry Weight, pcf	Water Content, %	% Passing No. 200	Liquid Limit	Plasticity Index	Notes & Assigned Laboratory
------------	-----------------	--------	------------	-----------------------	-------------	----------------------	-------------	----------------------	------------------	-------------------	--------------	------------------	-----------------------------

0	SW				SW	Gravelly SAND, moderate brown to greyish brown, dry, fine to coarse grained with moderate subrounded to rounded fine to coarse gravel.							
5	GW		1	16	GW	GRAVEL with Sand, moderate grey, moist, fine to coarse grained with abundant subrounded fine to medium gravel and few subrounded coarse gravel. At 4.5 feet: medium dense.		7.4	14			GS	
10	GW		2	64	GW	At 9.5 feet: very dense with possible cobbles. Between 12 and 14 feet: abundant gravel, cobbles, and/or boulders.	▼						
15	GW		3	16	GW	At 14.5 feet: medium dense. GRAVEL with Sand, moderate brown to moderate grey, wet, fine to coarse grained with moderate to abundant subangular to subrounded fine to coarse gravel.	▽	4.0	1			GS	



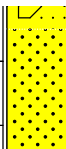

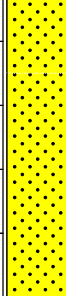

The log and data presented are a simplification of actual conditions encountered at the given location and time of exploration. Subsurface conditions may differ at other locations and with the passage of time.

PLATE NO.: B-2.17

LOG OF EXPLORATION: D20RL

PROJECT: Blue Lake Levee	EXPL. VENDOR: Britton Exploration	SURFACE ELEVATION: 82.5 feet
PROJECT NO.: 14-1949.02	EXPL. METHOD: 8.25" HSA	DEPTH OF HOLE: 26.0 Feet
LOCATION: Humboldt Co., CA	LOGGED BY: J.Bianchin	DEPTH TO WATER: 10.2 feet
START DATE: April 14, 2014	CHECKED BY: J.Bianchin	BACKFILLED WITH: Cement grout
END DATE: April 14, 2014	HAMMER TYPE: 140-Lb	

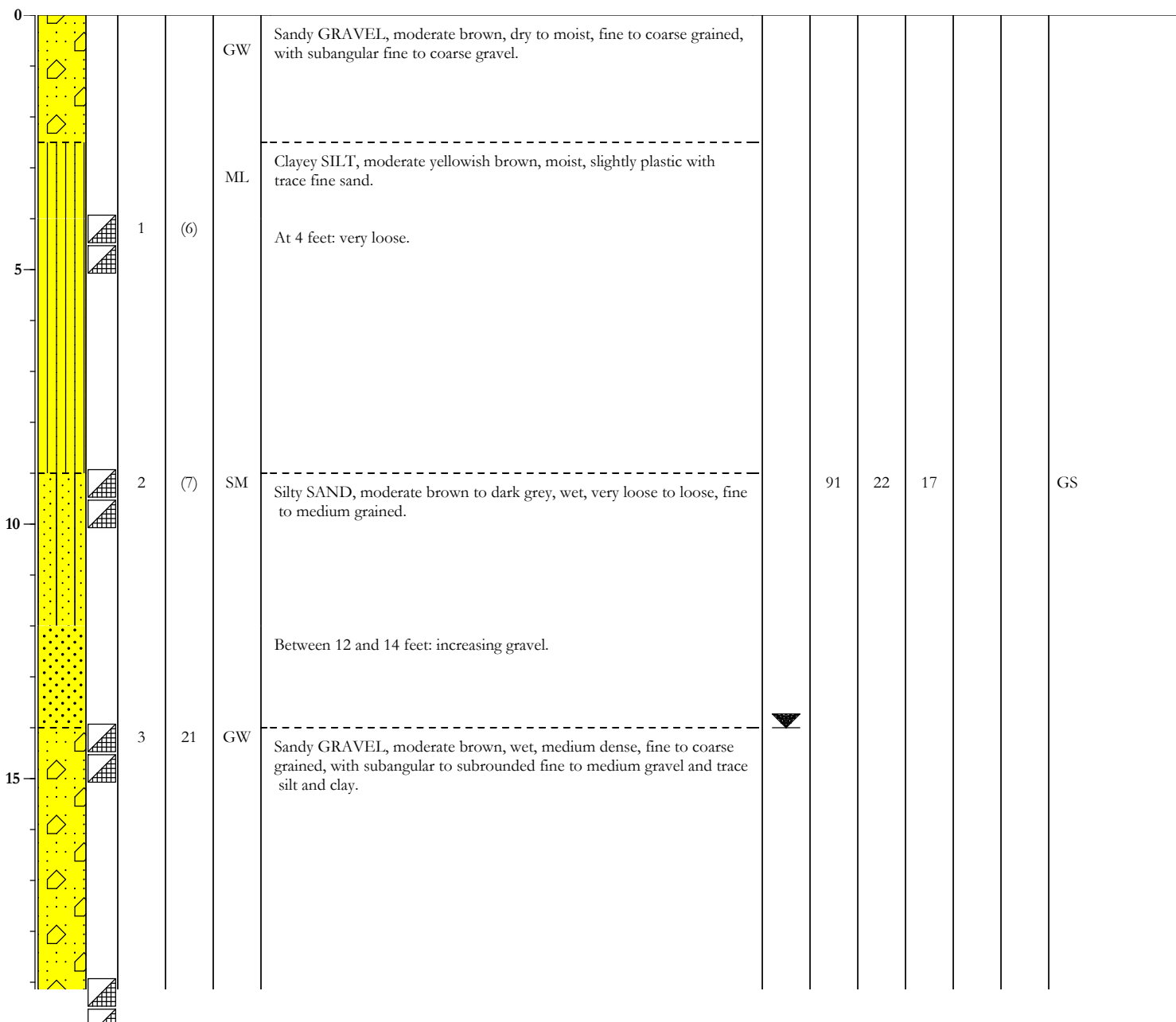
Depth (ft)	Material Symbol	Sample	Sample No.	Blow Count (blows/ft)	USCS Symbol	Material Description	Water Table	Unit Dry Weight, pcf	Water Content, %	% Passing No. 200	Liquid Limit	Plasticity Index	Notes & Assigned Laboratory
------------	-----------------	--------	------------	-----------------------	-------------	----------------------	-------------	----------------------	------------------	-------------------	--------------	------------------	-----------------------------

20			4	40	SW	At 19.5 feet: dense.							
25			5	20		Between 22.5 and 23.5 feet: abundant gravel.		7.8					
						Bottom of Drill Hole at a Depth of 26 Feet.							

LOG OF EXPLORATION: D30RL

PROJECT: Blue Lake Levee	EXPL. VENDOR: Britton Exploration	SURFACE ELEVATION: 86 feet
PROJECT NO.: 14-1949.02	EXPL. METHOD: 8.25" HSA	DEPTH OF HOLE: 25.5 Feet
LOCATION: Humboldt Co., CA	LOGGED BY: J.Bianchin	DEPTH TO WATER: 14.0 feet
START DATE: April 17, 2014	CHECKED BY: J.Bianchin	BACKFILLED WITH: Cement grout
END DATE: April 17, 2014	HAMMER TYPE: 140-Lb	

Depth (ft)	Material Symbol	Sample	Sample No.	Blow Count (blows/ft)	USCS Symbol	Material Description	Water Table	Unit Dry Weight, pcf	Water Content, %	% Passing No. 200	Liquid Limit	Plasticity Index	Notes & Assigned Laboratory
------------	-----------------	--------	------------	-----------------------	-------------	----------------------	-------------	----------------------	------------------	-------------------	--------------	------------------	-----------------------------



The log and data presented are a simplification of actual conditions encountered at the given location and time of exploration. Subsurface conditions may differ at other locations and with the passage of time.

PLATE NO.: B-2.18

LOG OF EXPLORATION: D30RL

PROJECT: Blue Lake Levee	EXPL. VENDOR: Britton Exploration	SURFACE ELEVATION: 86 feet
PROJECT NO.: 14-1949.02	EXPL. METHOD: 8.25" HSA	DEPTH OF HOLE: 25.5 Feet
LOCATION: Humboldt Co., CA	LOGGED BY: J.Bianchin	DEPTH TO WATER: 14.0 feet
START DATE: April 17, 2014	CHECKED BY: J.Bianchin	BACKFILLED WITH: Cement grout
END DATE: April 17, 2014	HAMMER TYPE: 140-Lb	

Depth (ft)	Material Symbol	Sample	Sample No.	Blow Count (blows/ft)	USCS Symbol	Material Description	Water Table	Unit Dry Weight, pcf	Water Content, %	% Passing No. 200	Liquid Limit	Plasticity Index	Notes & Assigned Laboratory
------------	-----------------	--------	------------	-----------------------	-------------	----------------------	-------------	----------------------	------------------	-------------------	--------------	------------------	-----------------------------

20	[Symbol: Yellow with black dots]		4	25	SW/SM	Gravelly SAND, greyish brown, wet, medium dense, fine to coarse grained, with subangular to subrounded fine gravel and trace subangular to subrounded medium gravel.			9.7	8			GS
25	[Symbol: Yellow with black dots]		5	18	SW	Gravelly SAND to Sandy GRAVEL, greyish brown, wet, medium dense, fine to coarse grained, with subangular to subrounded fine gravel and trace subangular to subrounded medium gravel.							
						Bottom of Drill Hole at a Depth of 25.5 Feet.							



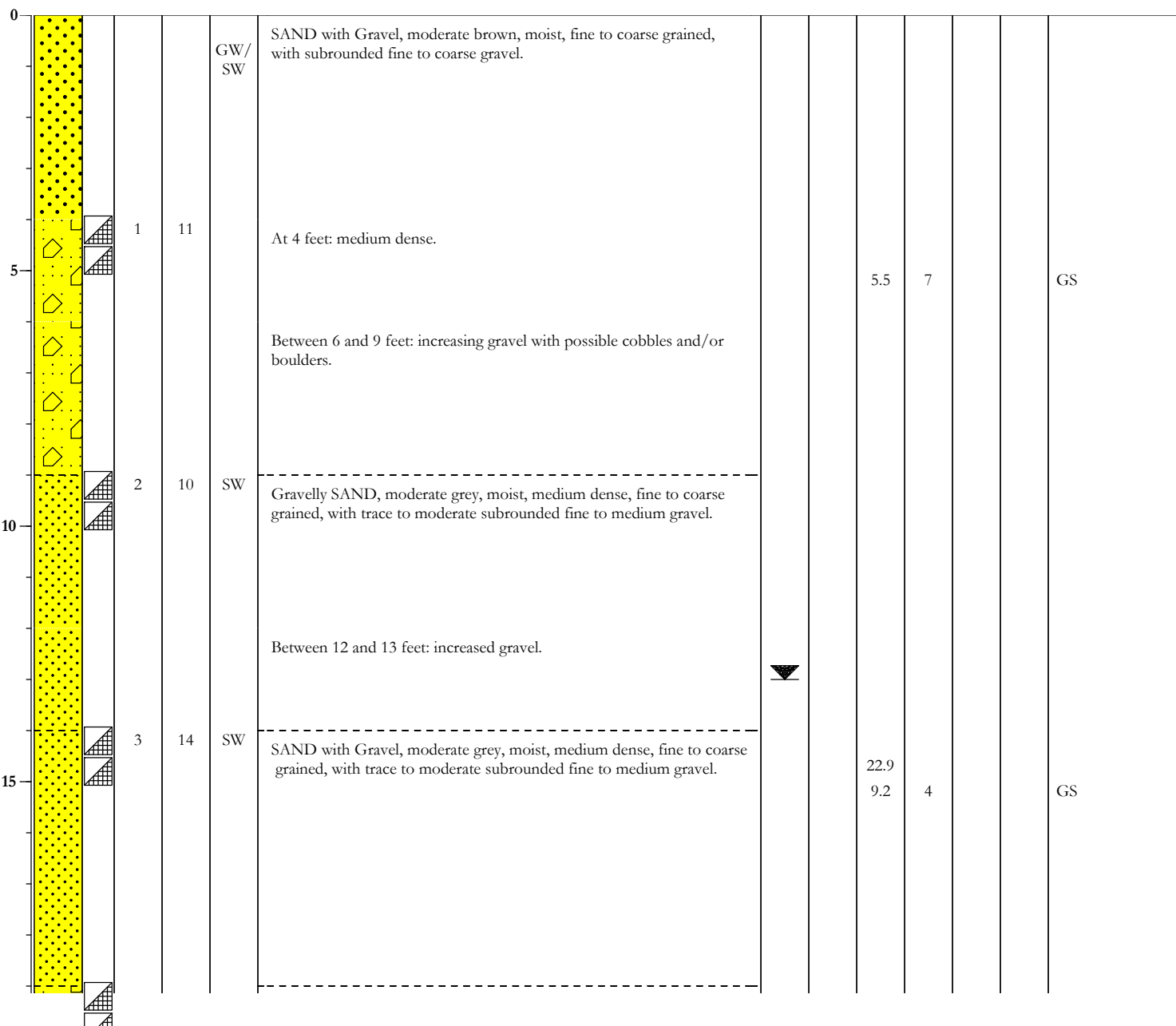
The log and data presented are a simplification of actual conditions encountered at the given location and time of exploration. Subsurface conditions may differ at other locations and with the passage of time.

PLATE NO.: B-2.18

LOG OF EXPLORATION: D39RL

PROJECT: Blue Lake Levee	EXPL. VENDOR: Britton Exploration	SURFACE ELEVATION: 88 feet
PROJECT NO.: 14-1949.02	EXPL. METHOD: 8.25" HSA	DEPTH OF HOLE: 25.5 Feet
LOCATION: Humboldt Co., CA	LOGGED BY: J.Bianchin	DEPTH TO WATER: 13.0 feet
START DATE: April 17, 2014	CHECKED BY: J.Bianchin	BACKFILLED WITH: Cement grout
END DATE: April 17, 2014	HAMMER TYPE: 140-Lb	

Depth (ft)	Material Symbol	Sample	Sample No.	Blow Count (blows/ft)	USCS Symbol	Material Description	Water Table	Unit Dry Weight, pcf	Water Content, %	% Passing No. 200	Liquid Limit	Plasticity Index	Notes & Assigned Laboratory
------------	-----------------	--------	------------	-----------------------	-------------	----------------------	-------------	----------------------	------------------	-------------------	--------------	------------------	-----------------------------



LOG OF EXPLORATION: D39RL

PROJECT: Blue Lake Levee	EXPL. VENDOR: Britton Exploration	SURFACE ELEVATION: 88 feet
PROJECT NO.: 14-1949.02	EXPL. METHOD: 8.25" HSA	DEPTH OF HOLE: 25.5 Feet
LOCATION: Humboldt Co., CA	LOGGED BY: J.Bianchin	DEPTH TO WATER: 13.0 feet
START DATE: April 17, 2014	CHECKED BY: J.Bianchin	BACKFILLED WITH: Cement grout
END DATE: April 17, 2014	HAMMER TYPE: 140-Lb	

Depth (ft)	Material Symbol	Sample	Sample No.	Blow Count (blows/ft)	USCS Symbol	Material Description	Water Table	Unit Dry Weight, pcf	Water Content, %	% Passing No. 200	Liquid Limit	Plasticity Index	Notes & Assigned Laboratory
------------	-----------------	--------	------------	-----------------------	-------------	----------------------	-------------	----------------------	------------------	-------------------	--------------	------------------	-----------------------------

20			4	25	GW	GRAVEL, moderate brown, wet, medium dense, coarse. Below 22 feet: decreasing gravel increasing sand							
25			5	24	SW	GRAVEL with Sand, moderate brown, moist, medium dense, fine to coarse grained, with trace to moderate subrounded fine to medium gravel. Bottom of Drill Hole at a Depth of 25.5 Feet		4.7	8			GS	



The log and data presented are a simplification of actual conditions encountered at the given location and time of exploration. Subsurface conditions may differ at other locations and with the passage of time.

PLATE NO.: B-2.19

LOG OF EXPLORATION: D49RL

PROJECT: Blue Lake Levee	EXPL. VENDOR: Britton Exploration	SURFACE ELEVATION: 94 feet
PROJECT NO.: 14-1949.02	EXPL. METHOD: 8.25" HSA	DEPTH OF HOLE: 25.5 Feet
LOCATION: Humboldt Co., CA	LOGGED BY: J.Bianchin	DEPTH TO WATER: 15.0 feet
START DATE: April 16, 2014	CHECKED BY: J.Bianchin	BACKFILLED WITH: Cement grout
END DATE: April 16, 2014	HAMMER TYPE: 140-Lb	

Depth (ft)	Material Symbol	Sample	Sample No.	Blow Count (blows/ft)	USCS Symbol	Material Description	Water Table	Unit Dry Weight, pcf	Water Content, %	% Passing No. 200	Liquid Limit	Plasticity Index	Notes & Assigned Laboratory
------------	-----------------	--------	------------	-----------------------	-------------	----------------------	-------------	----------------------	------------------	-------------------	--------------	------------------	-----------------------------

0	SM				SM	Silty SAND, moderate brown, moist, fine grained with trace clay.							
5	GW/GP		1	(7)		At 4 feet: very loose to loose.	93.0	23.0	46				GS
10	SW		2	15		SAND, moderate grey, moist, medium dense, fine to coarse grained.		3.5	5				GS
15	GW/SW		3	16		Sandy GRAVEL to Gravelly SAND, moderate brown, wet, medium dense, fine to coarse grained with subrounded fine to coarse gravel.	▼						

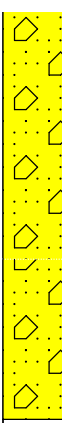



The log and data presented are a simplification of actual conditions encountered at the given location and time of exploration. Subsurface conditions may differ at other locations and with the passage of time.

LOG OF EXPLORATION: D49RL

PROJECT: Blue Lake Levee	EXPL. VENDOR: Britton Exploration	SURFACE ELEVATION: 94 feet
PROJECT NO.: 14-1949.02	EXPL. METHOD: 8.25" HSA	DEPTH OF HOLE: 25.5 Feet
LOCATION: Humboldt Co., CA	LOGGED BY: J.Bianchin	DEPTH TO WATER: 15.0 feet
START DATE: April 16, 2014	CHECKED BY: J.Bianchin	BACKFILLED WITH: Cement grout
END DATE: April 16, 2014	HAMMER TYPE: 140-Lb	

Depth (ft)	Material Symbol	Sample	Sample No.	Blow Count (blows/ft)	USCS Symbol	Material Description	Water Table	Unit Dry Weight, pcf	Water Content, %	% Passing No. 200	Liquid Limit	Plasticity Index	Notes & Assigned Laboratory
------------	-----------------	--------	------------	-----------------------	-------------	----------------------	-------------	----------------------	------------------	-------------------	--------------	------------------	-----------------------------

20			4	14					16.6	5			GS
25				43		<p style="margin: 0;">Below 23 feet: decreasing gravel.</p> <hr style="border: 0.5px solid black;"/> <p style="margin: 0;">Bottom of Drill Hole at a Depth of 25.5 Feet.</p>							



The log and data presented are a simplification of actual conditions encountered at the given location and time of exploration. Subsurface conditions may differ at other locations and with the passage of time.

LOG OF EXPLORATION: D59RL

PROJECT: Blue Lake Levee	EXPL. VENDOR: Britton Exploration	SURFACE ELEVATION: 59 feet
PROJECT NO.: 14-1949.02	EXPL. METHOD: 8.25" HSA	DEPTH OF HOLE: 26.5 Feet
LOCATION: Humboldt Co., CA	LOGGED BY: J.Bianchin	DEPTH TO WATER: 14.0 feet
START DATE: April 17, 2014	CHECKED BY: J.Bianchin	BACKFILLED WITH: Cement grout
END DATE: April 17, 2014	HAMMER TYPE: 140-Lb	

Depth (ft)	Material Symbol	Sample	Sample No.	Blow Count (blows/ft)	USCS Symbol	Material Description	Water Table	Unit Dry Weight, pcf	Water Content, %	% Passing No. 200	Liquid Limit	Plasticity Index	Notes & Assigned Laboratory
------------	-----------------	--------	------------	-----------------------	-------------	----------------------	-------------	----------------------	------------------	-------------------	--------------	------------------	-----------------------------

0					ML	SILT, moderate brown, moist, plastic with trace fine sand.							
5		1	(10)			At 5 feet: firm/loose.		103	23		36	11	PI
10		2	(27)		GW/ SW	Sandy GRAVEL to Gravelly SAND, moderate grey, moist to wet, medium dense, fine to coarse grained, with subrounded fine to medium gravel. Between 12 and 13.5 feet: increased gravel, cobbles, and/or boulders.	▼						
15		3	21		SP	SAND with Gravel, moderate brown, wet, medium dense, fine to coarse grained, with subrounded fine to medium gravel and trace clay. Below 18.5 feet: increasing gravel.			10.7	7			GS



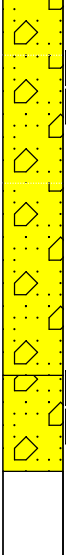
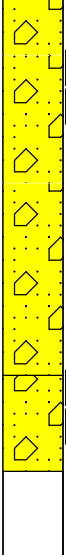
The log and data presented are a simplification of actual conditions encountered at the given location and time of exploration. Subsurface conditions may differ at other locations and with the passage of time.

PLATE NO.: B-2.21

LOG OF EXPLORATION: D59RL

PROJECT: Blue Lake Levee	EXPL. VENDOR: Britton Exploration	SURFACE ELEVATION: 59 feet
PROJECT NO.: 14-1949.02	EXPL. METHOD: 8.25" HSA	DEPTH OF HOLE: 26.5 Feet
LOCATION: Humboldt Co., CA	LOGGED BY: J.Bianchin	DEPTH TO WATER: 14.0 feet
START DATE: April 17, 2014	CHECKED BY: J.Bianchin	BACKFILLED WITH: Cement grout
END DATE: April 17, 2014	HAMMER TYPE: 140-Lb	

Depth (ft)	Material Symbol	Sample	Sample No.	Blow Count (blows/ft)	USCS Symbol	Material Description	Water Table	Unit Dry Weight, pcf	Water Content, %	% Passing No. 200	Liquid Limit	Plasticity Index	Notes & Assigned Laboratory
------------	-----------------	--------	------------	-----------------------	-------------	----------------------	-------------	----------------------	------------------	-------------------	--------------	------------------	-----------------------------

20			4	27		<p>At 20 feet: increased clay, with subangular to subrounded fine to coarse gravel.</p> <p>Below 22 feet: decreasing gravel.</p>							
25				30	GW/ GM	<p>GRAVEL with Sand, moderate grey, wet, medium dense, fine to coarse grained, with subrounded fine to medium gravel.</p> <p>Bottom of Drill Hole at a Depth of 26.5 Feet.</p>		8.5	11			GS	



The log and data presented are a simplification of actual conditions encountered at the given location and time of exploration. Subsurface conditions may differ at other locations and with the passage of time.

PLATE NO.: B-2.21

LOG OF EXPLORATION: D10RO

PROJECT: Blue Lake Levee	EXPL. VENDOR: Britton Exploration	SURFACE ELEVATION: 87.5 feet
PROJECT NO.: 14-1949.02	EXPL. METHOD: 8.25" HSA	DEPTH OF HOLE: 25.0 Feet
LOCATION: Humboldt Co., CA	LOGGED BY: J.Bianchin	DEPTH TO WATER: 12.0 feet
START DATE: April 9, 2014	CHECKED BY: J.Bianchin	BACKFILLED WITH: Cement grout
END DATE: April 9, 2014	HAMMER TYPE: 140-Lb	

Depth (ft)	Material Symbol	Sample	Sample No.	Blow Count (blows/ft)	USCS Symbol	Material Description	Water Table	Unit Dry Weight, pcf	Water Content, %	% Passing No. 200	Liquid Limit	Plasticity Index	Notes & Assigned Laboratory
------------	-----------------	--------	------------	-----------------------	-------------	----------------------	-------------	----------------------	------------------	-------------------	--------------	------------------	-----------------------------



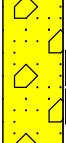
The log and data presented are a simplification of actual conditions encountered at the given location and time of exploration. Subsurface conditions may differ at other locations and with the passage of time.

PLATE NO.: B-2.22

LOG OF EXPLORATION: D10RO

PROJECT: Blue Lake Levee	EXPL. VENDOR: Britton Exploration	SURFACE ELEVATION: 87.5 feet
PROJECT NO.: 14-1949.02	EXPL. METHOD: 8.25" HSA	DEPTH OF HOLE: 25.0 Feet
LOCATION: Humboldt Co., CA	LOGGED BY: J.Bianchin	DEPTH TO WATER: 12.0 feet
START DATE: April 9, 2014	CHECKED BY: J.Bianchin	BACKFILLED WITH: Cement grout
END DATE: April 9, 2014	HAMMER TYPE: 140-Lb	

Depth (ft)	Material Symbol	Sample	Sample No.	Blow Count (blows/ft)	USCS Symbol	Material Description	Water Table	Unit Dry Weight, pcf	Water Content, %	% Passing No. 200	Liquid Limit	Plasticity Index	Notes & Assigned Laboratory
------------	-----------------	--------	------------	-----------------------	-------------	----------------------	-------------	----------------------	------------------	-------------------	--------------	------------------	-----------------------------

20			4	17					8.2				
25						Bottom of Drill Hole at a Depth of 25 feet.							

LOG OF EXPLORATION: D20RO

PROJECT: Blue Lake Levee	EXPL. VENDOR: Britton Exploration	SURFACE ELEVATION: 84 feet
PROJECT NO.: 14-1949.02	EXPL. METHOD: 8.25" HSA	DEPTH OF HOLE: 26.0 Feet
LOCATION: Humboldt Co., CA	LOGGED BY: J.Bianchin	DEPTH TO WATER: 14.0 feet
START DATE: April 9, 2014	CHECKED BY: J.Bianchin	BACKFILLED WITH: Cement grout
END DATE: April 9, 2014	HAMMER TYPE: 140-Lb	

Depth (ft)	Material Symbol	Sample	Sample No.	Blow Count (blows/ft)	USCS Symbol	Material Description	Water Table	Unit Dry Weight, pcf	Water Content, %	% Passing No. 200	Liquid Limit	Plasticity Index	Notes & Assigned Laboratory
------------	-----------------	--------	------------	-----------------------	-------------	----------------------	-------------	----------------------	------------------	-------------------	--------------	------------------	-----------------------------

0	GW/SW				GW/SW	<p>Sandy GRAVEL to Gravelly SAND, moderate brown, dry, fine to coarse grained, with subrounded fine to coarse gravel and trace fine cobbles.</p> <p>At 2 feet: moderate grey.</p> <p>At 4.5 feet: medium dense.</p>							
5	SW			14									
10	SW		1	65	SW	<p>Gravelly SAND, moderate brown to light grey, moist, very dense, fine to coarse grained, with subrounded fine to coarse gravel and possibly cobbles.</p> <p>Below 12 feet: increasing gravel, cobbles, and/or boulders.</p>	▼						
15	SW/SM		2	23	SW/SM	<p>Gravelly SAND to SAND, moderate brown, wet, medium dense, fine to coarse grained with trace to moderate subrounded fine to medium gravel.</p>		7.1	4			GS	



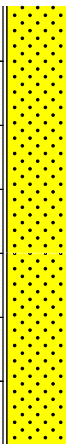
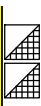
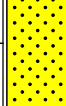

The log and data presented are a simplification of actual conditions encountered at the given location and time of exploration. Subsurface conditions may differ at other locations and with the passage of time.

PLATE NO.: B-2.23

LOG OF EXPLORATION: D20RO

PROJECT: Blue Lake Levee	EXPL. VENDOR: Britton Exploration	SURFACE ELEVATION: 84 feet
PROJECT NO.: 14-1949.02	EXPL. METHOD: 8.25" HSA	DEPTH OF HOLE: 26.0 Feet
LOCATION: Humboldt Co., CA	LOGGED BY: J.Bianchin	DEPTH TO WATER: 14.0 feet
START DATE: April 9, 2014	CHECKED BY: J.Bianchin	BACKFILLED WITH: Cement grout
END DATE: April 9, 2014	HAMMER TYPE: 140-Lb	

Depth (ft)	Material Symbol	Sample	Sample No.	Blow Count (blows/ft)	USCS Symbol	Material Description	Water Table	Unit Dry Weight, pcf	Water Content, %	% Passing No. 200	Liquid Limit	Plasticity Index	Notes & Assigned Laboratory
------------	-----------------	--------	------------	-----------------------	-------------	----------------------	-------------	----------------------	------------------	-------------------	--------------	------------------	-----------------------------

20			3	42									
25			4	34		<p>Between 23 and 24.5 feet: increased gravels, cobbles, and/or boulders</p>							
						Bottom of Drill Hole at a Depth of 26 Feet.							



The log and data presented are a simplification of actual conditions encountered at the given location and time of exploration. Subsurface conditions may differ at other locations and with the passage of time.

PLATE NO.: B-2.23

LOG OF EXPLORATION: D30RO

PROJECT: Blue Lake Levee	EXPL. VENDOR: Britton Exploration	SURFACE ELEVATION: 86 feet
PROJECT NO.: 14-1949.02	EXPL. METHOD: 8.25" HSA	DEPTH OF HOLE: 25.50 Feet
LOCATION: Humboldt Co., CA	LOGGED BY: J.Bianchin	DEPTH TO WATER: 13.0 feet
START DATE: April 17, 2014	CHECKED BY: J.Bianchin	BACKFILLED WITH: Cement grout
END DATE: April 17, 2014	HAMMER TYPE: 140-Lb	

Depth (ft)	Material Symbol	Sample	Sample No.	Blow Count (blows/ft)	USCS Symbol	Material Description	Water Table	Unit Dry Weight, pcf	Water Content, %	% Passing No. 200	Liquid Limit	Plasticity Index	Notes & Assigned Laboratory
------------	-----------------	--------	------------	-----------------------	-------------	----------------------	-------------	----------------------	------------------	-------------------	--------------	------------------	-----------------------------

0					CL	Silty CLAY, moderate yellowish brown to moderate brown, moist, plastic with trace fine sand.							
5			1	(5)		At 4 feet: very soft to soft.		94.8	27.9				
10			2	(44)	SW	SAND, dark grey, wet, dense, fine grained.							
					GW	Sandy GRAVEL, moderate brown to grey, wet, dense, fine to coarse grained with subrounded fine to medium gravel.							
15			3	19		At 9 feet: medium dense with subangular to subrounded fine to medium gravel.	▼			5		GS	
						Between 16 and 19 feet: decrease in gravel.							



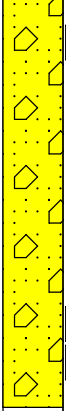
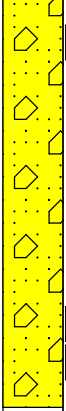
The log and data presented are a simplification of actual conditions encountered at the given location and time of exploration. Subsurface conditions may differ at other locations and with the passage of time.

PLATE NO.: B-2.24

LOG OF EXPLORATION: D30RO

PROJECT: Blue Lake Levee	EXPL. VENDOR: Britton Exploration	SURFACE ELEVATION: 86 feet
PROJECT NO.: 14-1949.02	EXPL. METHOD: 8.25" HSA	DEPTH OF HOLE: 25.50 Feet
LOCATION: Humboldt Co., CA	LOGGED BY: J.Bianchin	DEPTH TO WATER: 13.0 feet
START DATE: April 17, 2014	CHECKED BY: J.Bianchin	BACKFILLED WITH: Cement grout
END DATE: April 17, 2014	HAMMER TYPE: 140-Lb	

Depth (ft)	Material Symbol	Sample	Sample No.	Blow Count (blows/ft)	USCS Symbol	Material Description	Water Table	Unit Dry Weight, pcf	Water Content, %	% Passing No. 200	Liquid Limit	Plasticity Index	Notes & Assigned Laboratory
------------	-----------------	--------	------------	-----------------------	-------------	----------------------	-------------	----------------------	------------------	-------------------	--------------	------------------	-----------------------------

20			4	14									
25			5	17				6.7					



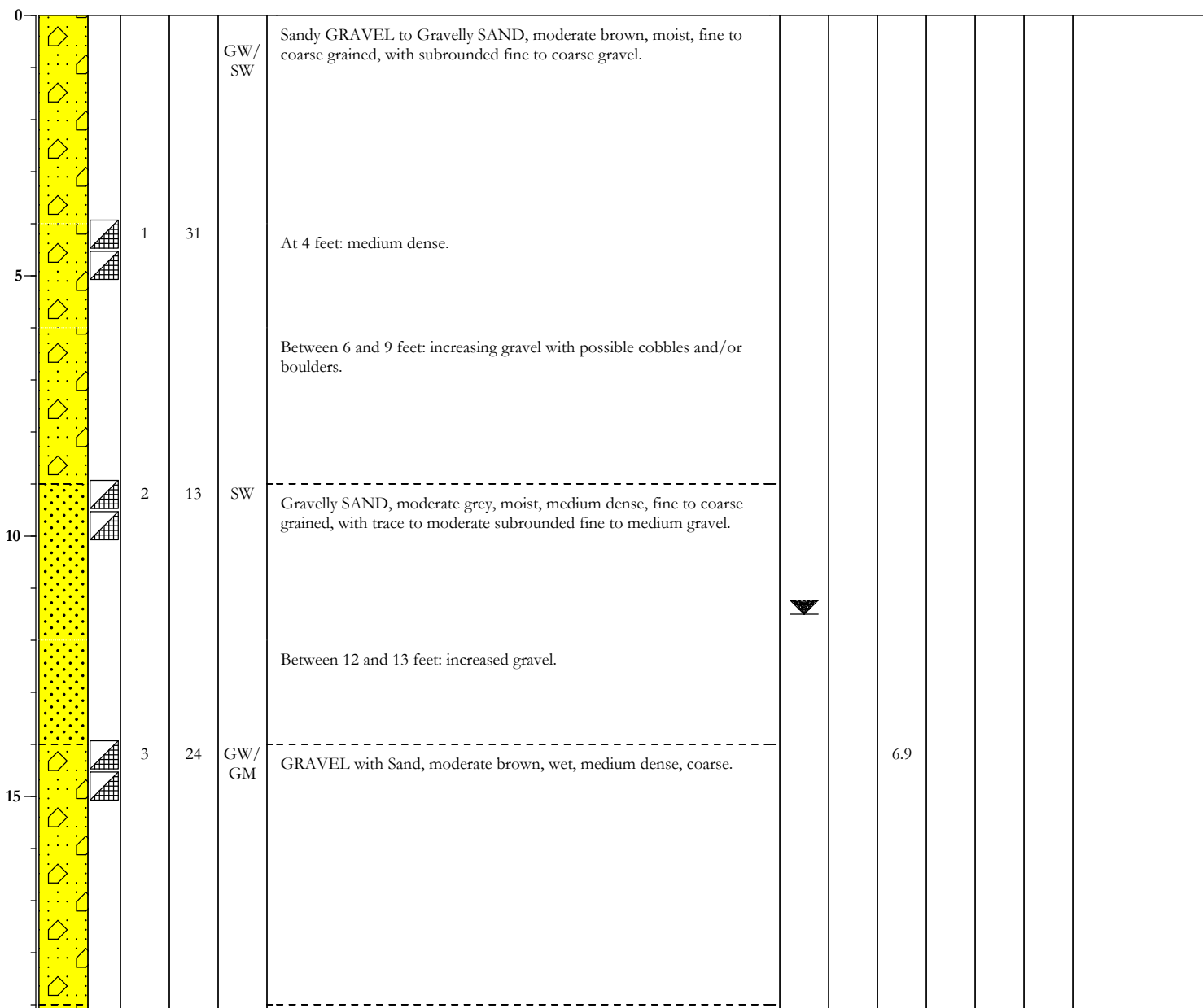
The log and data presented are a simplification of actual conditions encountered at the given location and time of exploration. Subsurface conditions may differ at other locations and with the passage of time.

PLATE NO.: B-2.24

LOG OF EXPLORATION: D39RO

PROJECT: Blue Lake Levee	EXPL. VENDOR: Britton Exploration	SURFACE ELEVATION: 88 feet
PROJECT NO.: 14-1949.02	EXPL. METHOD: 8.25" HSA	DEPTH OF HOLE: 25.5 Feet
LOCATION: Humboldt Co., CA	LOGGED BY: J.Bianchin	DEPTH TO WATER: 11.5 feet
START DATE: April 17, 2014	CHECKED BY: J.Bianchin	BACKFILLED WITH: Cement grout
END DATE: April 17, 2014	HAMMER TYPE: 140-Lb	

Depth (ft)	Material Symbol	Sample	Sample No.	Blow Count (blows/ft)	USCS Symbol	Material Description	Water Table	Unit Dry Weight, pcf	Water Content, %	% Passing No. 200	Liquid Limit	Plasticity Index	Notes & Assigned Laboratory
------------	-----------------	--------	------------	-----------------------	-------------	----------------------	-------------	----------------------	------------------	-------------------	--------------	------------------	-----------------------------



The log and data presented are a simplification of actual conditions encountered at the given location and time of exploration. Subsurface conditions may differ at other locations and with the passage of time.

PLATE NO.: B-2.25

LOG OF EXPLORATION: D39RO

PROJECT: Blue Lake Levee	EXPL. VENDOR: Britton Exploration	SURFACE ELEVATION: 88 feet
PROJECT NO.: 14-1949.02	EXPL. METHOD: 8.25" HSA	DEPTH OF HOLE: 25.5 Feet
LOCATION: Humboldt Co., CA	LOGGED BY: J.Bianchin	DEPTH TO WATER: 11.5 feet
START DATE: April 17, 2014	CHECKED BY: J.Bianchin	BACKFILLED WITH: Cement grout
END DATE: April 17, 2014	HAMMER TYPE: 140-Lb	

Depth (ft)	Material Symbol	Sample	Sample No.	Blow Count (blows/ft)	USCS Symbol	Material Description	Water Table	Unit Dry Weight, pcf	Water Content, %	% Passing No. 200	Liquid Limit	Plasticity Index	Notes & Assigned Laboratory
------------	-----------------	--------	------------	-----------------------	-------------	----------------------	-------------	----------------------	------------------	-------------------	--------------	------------------	-----------------------------

20	4	33	GW	GRAVEL, moderate brown, wet, medium dense, coarse.									
				5	15	SW	Below 22 feet: decreasing gravel increasing sand			5		GS	
25							Gravelly SAND to Sandy GRAVEL, moderate brown, moist, medium dense, fine to coarse grained, with trace to moderate subrounded fine to medium gravel.						
							Bottom of Drill Hole at a Depth of 25.5 Feet						



The log and data presented are a simplification of actual conditions encountered at the given location and time of exploration. Subsurface conditions may differ at other locations and with the passage of time.

PLATE NO.: B-2.25

LOG OF EXPLORATION: D49RO

PROJECT: Blue Lake Levee	EXPL. VENDOR: Britton Exploration	SURFACE ELEVATION: 94 feet
PROJECT NO.: 14-1949.02	EXPL. METHOD: 8.25" HSA	DEPTH OF HOLE: 26.5 Feet
LOCATION: Humboldt Co., CA	LOGGED BY: J.Bianchin	DEPTH TO WATER: 15.5 feet
START DATE: April 16, 2014	CHECKED BY: J.Bianchin	BACKFILLED WITH: Cement grout
END DATE: April 16, 2014	HAMMER TYPE: 140-Lb	

Depth (ft)	Material Symbol	Sample	Sample No.	Blow Count (blows/ft)	USCS Symbol	Material Description	Water Table	Unit Dry Weight, pcf	Water Content, %	% Passing No. 200	Liquid Limit	Plasticity Index	Notes & Assigned Laboratory
------------	-----------------	--------	------------	-----------------------	-------------	----------------------	-------------	----------------------	------------------	-------------------	--------------	------------------	-----------------------------

0	SM				SM	Silty SAND, moderate brown, moist, slightly plastic, fine grained, with trace clay.							
5	SM	1	(4)			At 4.5 feet: very loose.	98	18	49				GS, DS
10	SW/SM				SW/SM	Gravelly SAND, brownish grey, moist, fine to coarse grained, with subrounded fine to medium gravel.							
15	SW/GW	2		21		At 9.5 feet: medium dense.		5.5	5				GS
15	SW/GW	3		8	SW/GW	SAND, moderate grey, wet, loose, fine to coarse grained interbedded with Sandy GRAVEL, moderate grey, wet, loose, fine to coarse grained with subrounded fine gravel.	▼						
	SW/GW					Between 16.5 and 19 feet: few gravels.							




The log and data presented are a simplification of actual conditions encountered at the given location and time of exploration. Subsurface conditions may differ at other locations and with the passage of time.

PLATE NO.: B-2.26

LOG OF EXPLORATION: D49RO

PROJECT: Blue Lake Levee	EXPL. VENDOR: Britton Exploration	SURFACE ELEVATION: 94 feet
PROJECT NO.: 14-1949.02	EXPL. METHOD: 8.25" HSA	DEPTH OF HOLE: 26.5 Feet
LOCATION: Humboldt Co., CA	LOGGED BY: J.Bianchin	DEPTH TO WATER: 15.5 feet
START DATE: April 16, 2014	CHECKED BY: J.Bianchin	BACKFILLED WITH: Cement grout
END DATE: April 16, 2014	HAMMER TYPE: 140-Lb	

Depth (ft)	Material Symbol	Sample	Sample No.	Blow Count (blows/ft)	USCS Symbol	Material Description	Water Table	Unit Dry Weight, pcf	Water Content, %	% Passing No. 200	Liquid Limit	Plasticity Index	Notes & Assigned Laboratory
------------	-----------------	--------	------------	-----------------------	-------------	----------------------	-------------	----------------------	------------------	-------------------	--------------	------------------	-----------------------------

20			4	21	GW	GRAVEL with Sand, moderate brown, wet, medium dense, fine to coarse grained with subangular to subrounded fine to medium gravel and trace silt and clay.							
25			5	23				9.3	5			GS	
Bottom of Drill Hole at a DEpth of 26.5 Feet.													



The log and data presented are a simplification of actual conditions encountered at the given location and time of exploration. Subsurface conditions may differ at other locations and with the passage of time.

PLATE NO.: B-2.26

LOG OF EXPLORATION: D59RO

PROJECT: Blue Lake Levee	EXPL. VENDOR: Britton Exploration	SURFACE ELEVATION: 94 feet
PROJECT NO.: 14-1949.02	EXPL. METHOD: 8.25" HSA	DEPTH OF HOLE: 26.5 Feet
LOCATION: Humboldt Co., CA	LOGGED BY: J.Bianchin	DEPTH TO WATER: 14.0 feet
START DATE: April 17, 2014	CHECKED BY: J.Bianchin	BACKFILLED WITH: Cement grout
END DATE: April 17, 2014	HAMMER TYPE: 140-Lb	

Depth (ft)	Material Symbol	Sample	Sample No.	Blow Count (blows/ft)	USCS Symbol	Material Description	Water Table	Unit Dry Weight, pcf	Water Content, %	% Passing No. 200	Liquid Limit	Plasticity Index	Notes & Assigned Laboratory
------------	-----------------	--------	------------	-----------------------	-------------	----------------------	-------------	----------------------	------------------	-------------------	--------------	------------------	-----------------------------

0					ML	Clayey SILT, moderate brown, moist, slightly plastic.							
5		1	1	(8)		At 4.5 feet: loose.		96.3	28				
10		2	2	21	GW	Sandy GRAVEL, moderate grey, moist, medium dense, fine to coarse grained, with subangular to subrounded fine to medium gravel.							
15		3	3	6	SW	SAND with Silt, moderate grey, wet, loose, fine to coarse grained.	▼		17.5	8			GS
					GW/ SW	GRAVEL with Sand, moderate brown, wet, fine to coarse grained with abundant subangular to subrounded fine to medium gravel and trace silt and clay.							

LOG OF EXPLORATION: D59RO

PROJECT: Blue Lake Levee	EXPL. VENDOR: Britton Exploration	SURFACE ELEVATION: 94 feet
PROJECT NO.: 14-1949.02	EXPL. METHOD: 8.25" HSA	DEPTH OF HOLE: 26.5 Feet
LOCATION: Humboldt Co., CA	LOGGED BY: J.Bianchin	DEPTH TO WATER: 14.0 feet
START DATE: April 17, 2014	CHECKED BY: J.Bianchin	BACKFILLED WITH: Cement grout
END DATE: April 17, 2014	HAMMER TYPE: 140-Lb	

Depth (ft)	Material Symbol	Sample	Sample No.	Blow Count (blows/ft)	USCS Symbol	Material Description	Water Table	Unit Dry Weight, pcf	Water Content, %	% Passing No. 200	Liquid Limit	Plasticity Index	Notes & Assigned Laboratory
------------	-----------------	--------	------------	-----------------------	-------------	----------------------	-------------	----------------------	------------------	-------------------	--------------	------------------	-----------------------------

20			4	27		<p>At 19.5 feet: medium dense.</p> <p>Below 22.5 feet: increased gravel, cobbles, and/or boulders.</p>			7	9			GS
25			5	53	GW	<p>Sandy GRAVEL, moderate brown, wet, very dense, fine to coarse grained with subangular to subrounded fine to medium gravel and trace to moderate clay.</p> <p>Bottom of Drill Hole at a Depth of 26.5 Feet.</p>							



The log and data presented are a simplification of actual conditions encountered at the given location and time of exploration. Subsurface conditions may differ at other locations and with the passage of time.

PLATE NO.: B-2.27



Cone penetration testing and soil sampling methods description.

Rig Description

Our services are based on the state-of-the-art, Geoprobe Model 6625CPT rig, a limited-access, self-anchoring, 20-ton push capacity, track-mounted push platform for dedicated Geotechnical CPT applications with the unique and valuable added ability to quickly perform intermittent or continuous soil sampling.

Weight = ~ 9,500 pounds

Surface load = ~ 4.5 psi

Push capacity = ~ 20 tons; self-anchoring achieved using 10- or 15-inch diameter helical soil anchors driven 4- to 10-feet into the soil

Sampling hammer percussion rate = 32 Hz & 20,000 lbs force/blow

Length = ~ 12 feet; Width = ~ 7 feet

Height (folded) = 7 feet; Height (unfolded) = 14 feet

CPT Description

Our Geoprobe 6625CPT incorporates the Swedish-made Geotech AB Cone Penetration Testing tools which meet the ASTM D-5778 Standard Test Method for Performing Electronic Friction Cone and Piezocone Penetration Testing of Soils. Cones have 10 cm² tips and 150 cm² friction sleeves, and include a porous filter and pressure sensor located in the u₂ position directly behind the cone. The cone and porous filter are saturated under vacuum with glycerin to promote rapid equilibration with in-situ pore pressures. Cones are advanced at the ASTM standard rate of 2 cm/second. Baseline readings are performed both before and after each push to check for load cell drift. The cone measures bearing (max load = 100 MPa ~ 1044 TSF), friction sleeve (max load = 1.0 MPa ~ 10.4 TSF), and dynamic pore pressure (max load = 2.5 MPa ~ 363 psi) at 2 cm or 4 cm intervals (client's choice) and this data is plotted in real-time and recorded on a laptop computer adjacent to the push platform. Holes are grouted upon completion of each push, or at the end of each day, as site conditions and regulations warrant.

The basic equation to determine the depth to the free water surface from the pore pressure dissipation test is;

Depth to phreatic surface = [Dissipation depth] – [equilibrium pore pressure / unit weight of H₂O x unit conversion factor]

...where;

- 1) Surface elevation is always assumed to be 0 feet
- 2) Dissipation depth = the depth (feet) below surface elevation where the cone advancement was paused while waiting for equilibrium pore pressure to be achieved
- 3) Equilibrium pore pressure = the pore pressure after an elapsed time where no increase or decrease in pore pressure is occurring, in pounds per square inch (psi)
- 4) Unit weight of water = 62.3 pounds per cubic foot (lb/ft³)
- 5) Unit conversion factor (for dimensional analysis): 1 psi = 144 lb/ft³

From the dissipation plots, simply read the dissipation depth and dissipated pressure for the values to plug into the equation above. On the plots, pore pressure (psi) is on the abscissa and log time (seconds) is on the ordinate.

Sampling Description

Geoprobe® brand Dual Tube Sampling Systems are efficient methods of collecting continuous soil cores with the added benefit of a cased hole. Dual tube sampling uses two sets of probe rods to collect continuous soil cores. One set of rods is driven into the ground as an outer casing (2.2 or 3.25 inches in diameter). These rods receive the driving force from the hammer and provide a sealed hole from which soil samples may be recovered without the threat of cross contamination. The second, smaller set of rods are placed inside the outer casing. The smaller rods hold a sample liner in place as the outer casing is driven one sampling interval. The small rods are then retracted to retrieve the filled liner. Soil samples are collected in 1.85-inch diameter or 1.125-inch diameter clear PVC sample sheaths.

Interpretations

Soil behavior type (SBT), SPT N60 energy ratio, undrained shear strength, OCR, and unit weights are calculated and/or are interpretations generated by the CPT-Pro software based on empirical relationships derived in the following references;

P.K. Robertson, R.G. Campanella, D. Gillespie, and J. Greig, 1986, Use of Piezometer Cone Data, Proceedings of the ASCE Specialty Conference In Situ '86: Use of In Situ Tests in Geotechnical Engineering; pp. 1263-1280.

P.K. Roberston, 1990, Soil Classification Using the Cone Penetration Test, Canadian Geotechnical Journal, 27(1), pp. 151-158.

T. Lunne, P.K. Robertson, and J.J.M. Powell, 1997, Cone Penetration in Geotechnical Practice, Taylor and Francis Publishing.

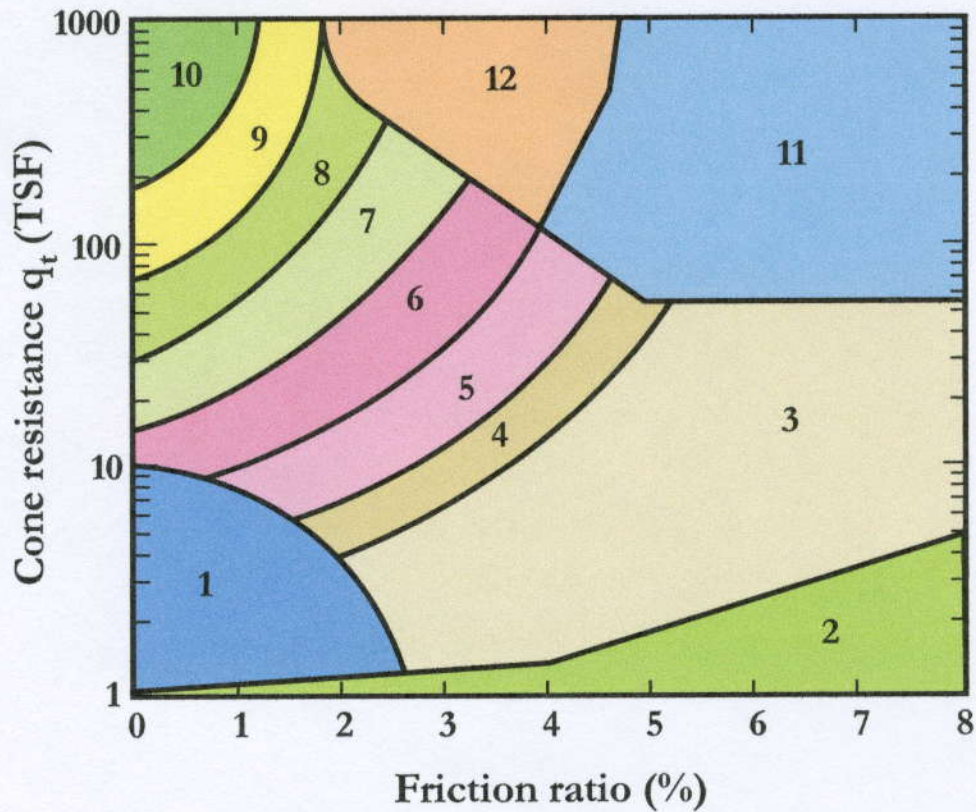
CPT Inc. makes no recommendation on which soil behavior type analysis is “most-correct”. The engineer should be aware of the limitations of using CPT data to derive soil behavior type and other engineering parameters and is encouraged to review the above references to better understand the applicability and limitations of CPT data. It is sometimes not possible to determine soil type based solely on tip resistance, sleeve friction, and dynamic pore pressure response, and confirmatory samples may be required.

Please do not hesitate to contact CPT Inc. if you have questions.

Sincerely,
John Rogie



President
California Push Technologies, Inc.



Zone	Soil Behavior Type
1	sensitive fine grained
2	organic material
3	clay
4	silty clay to clay
5	clayey silt to silty clay
6	sandy silt to clayey silt
7	silty sand to sandy silt
8	sand to silty sand
9	sand
10	gravelly sand to sand
11	very stiff fine grained (overconsolidated or cemented)
12	sand to clayey sand (overconsolidated or cemented)

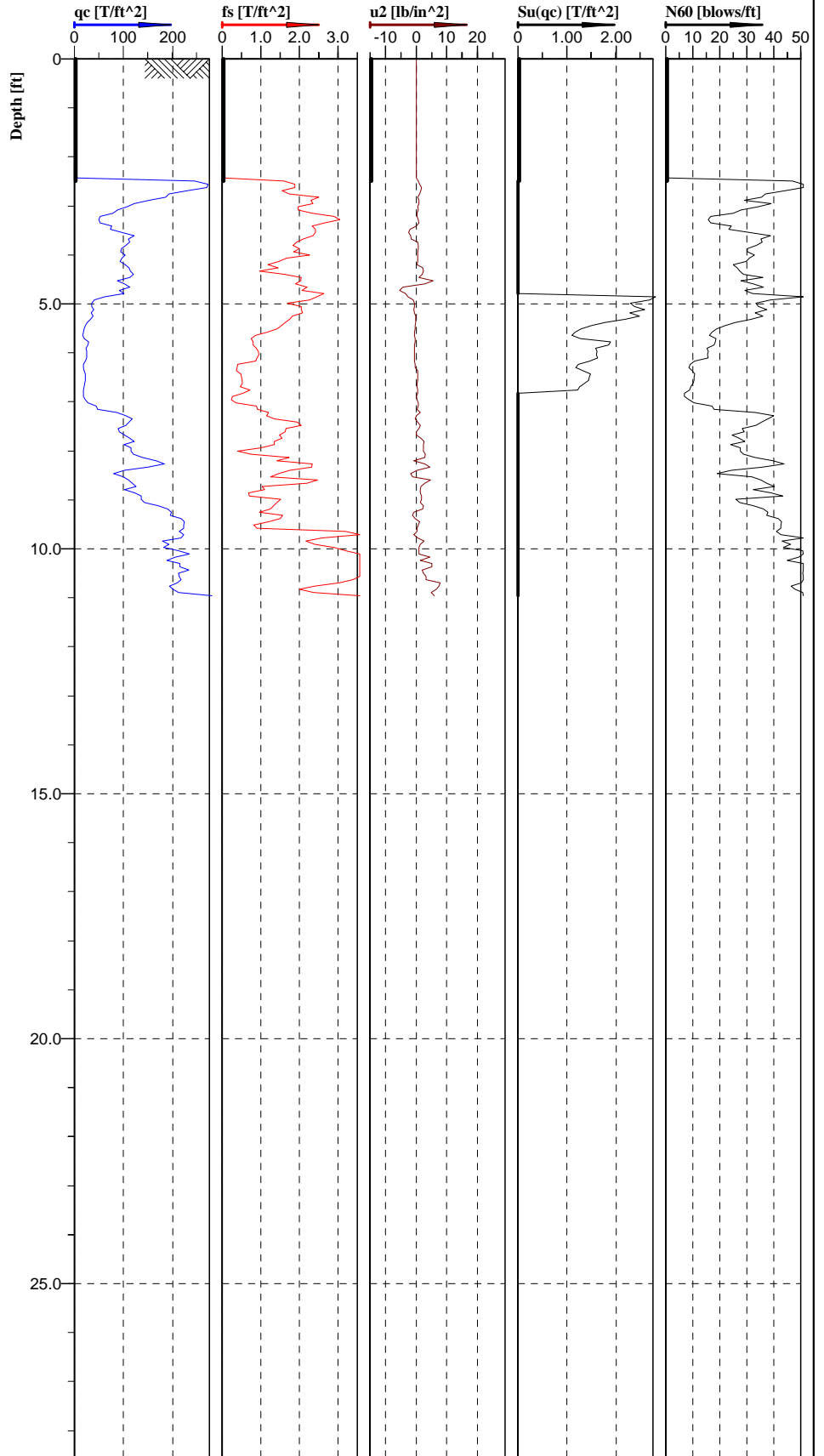
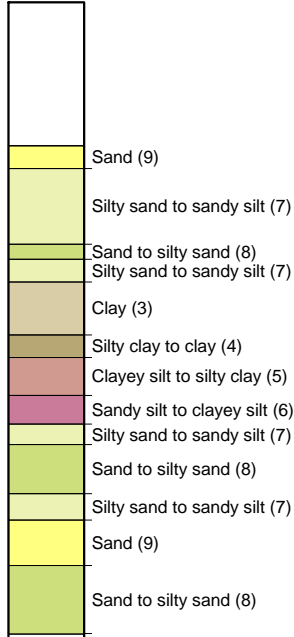
Source: Robertson, P.K., Campanella, R.G., Gillespie, D., and Greig, J., 1986, Use of Piezometer Cone Data. Proceedings of the ASCE Specialty Conference In Situ 86: Use of In Situ Tests in Geotechnical Engineering.



CALIFORNIA PUSH
TECHNOLOGIES
INCORPORATED

Soil Behavior Type (SBT) Model

Classification by
Robertson 1986

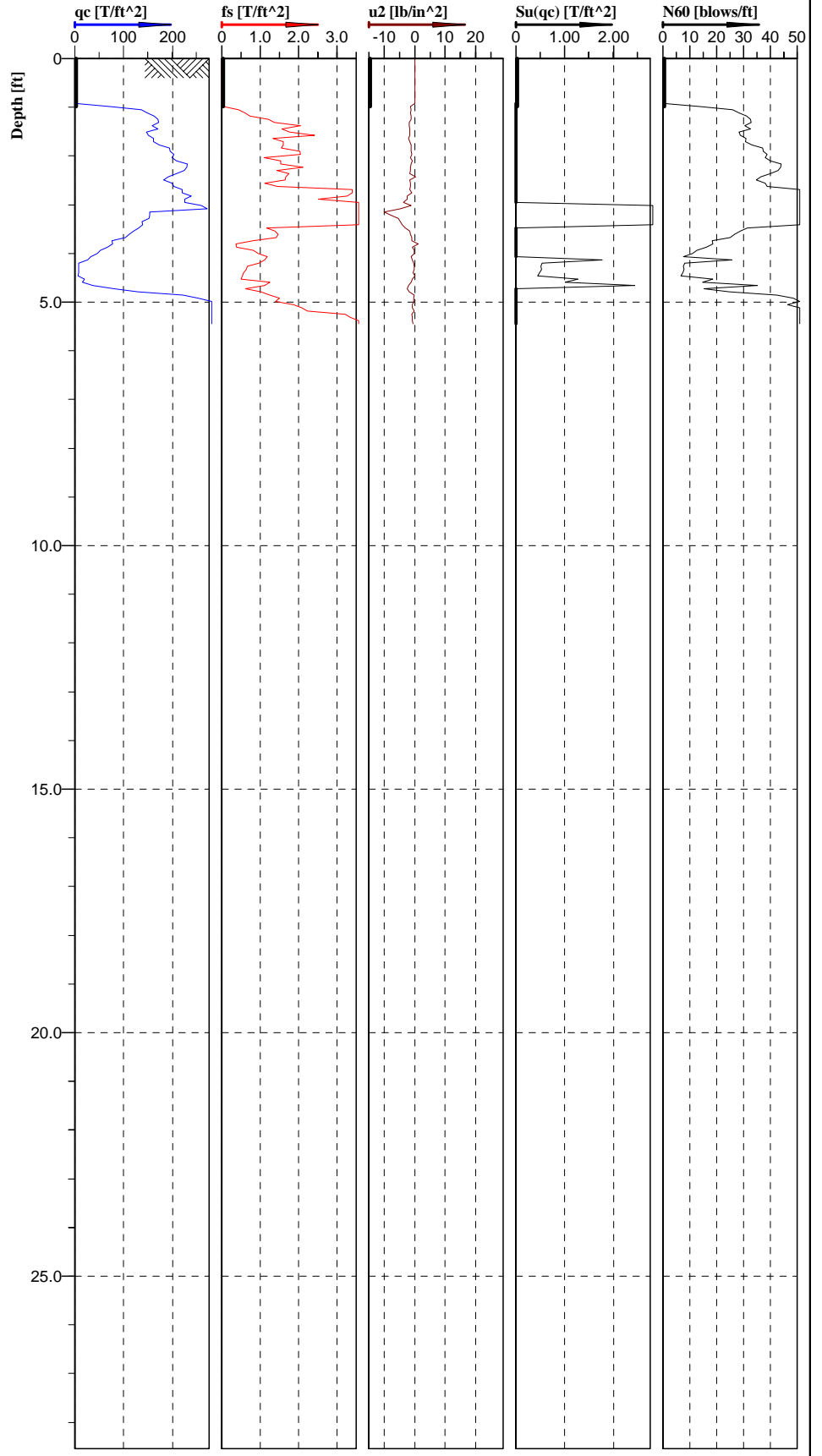


Cone No: 4141
Tip area [cm2]: 10
Sleeve area [cm2]: 150

Location: Blue Lake, California	Position:	Ground level:	Test no: C1RO
Project ID: 14-1149.02	Client: CGI Technical Services	Date: 4/7/2014	Scale: 1 : 40
Project: Blue Lake Levee		Page: 1/1	Fig:
		File: C1RO.cpd	

Classification by
Robertson 1986

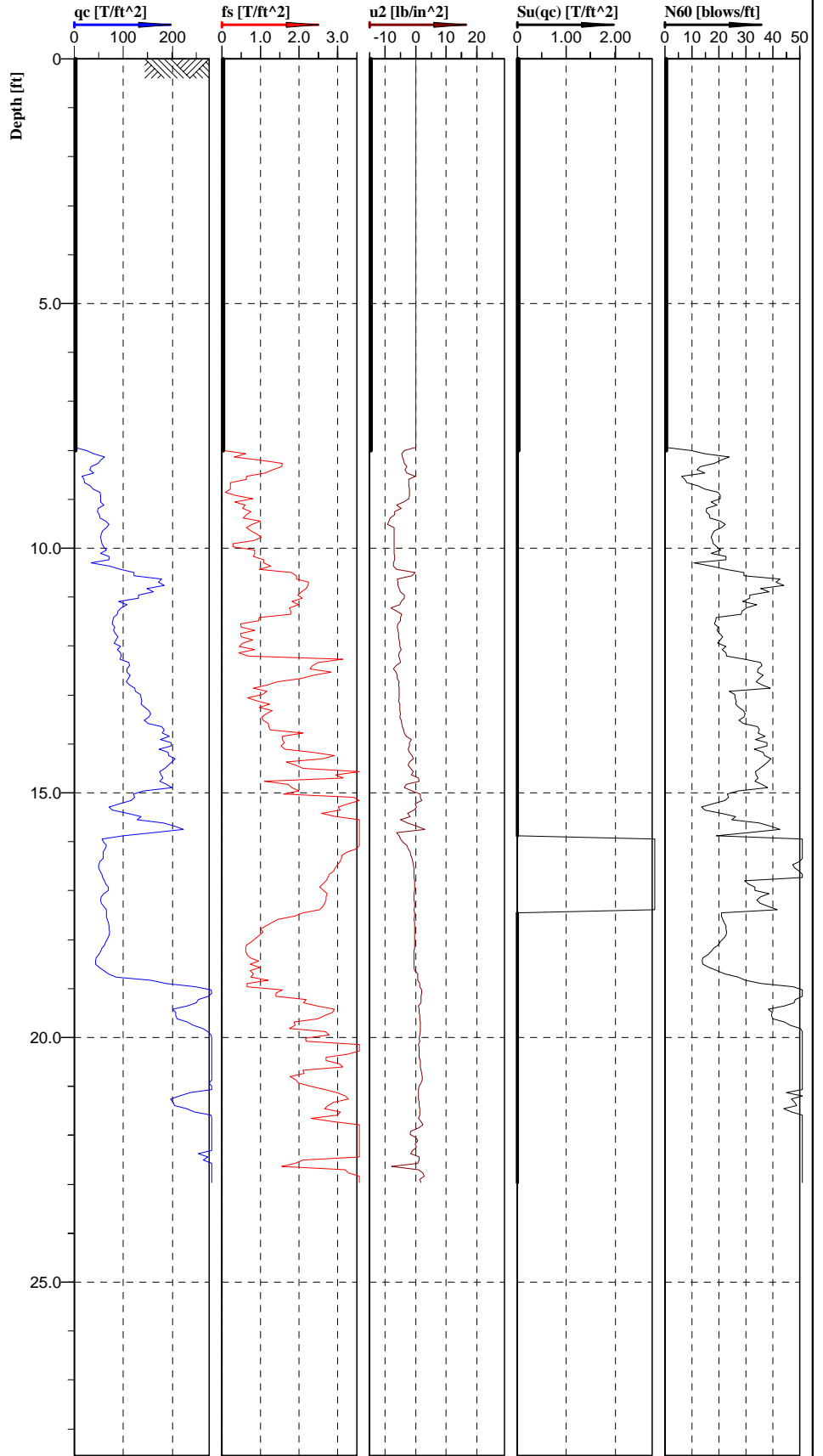
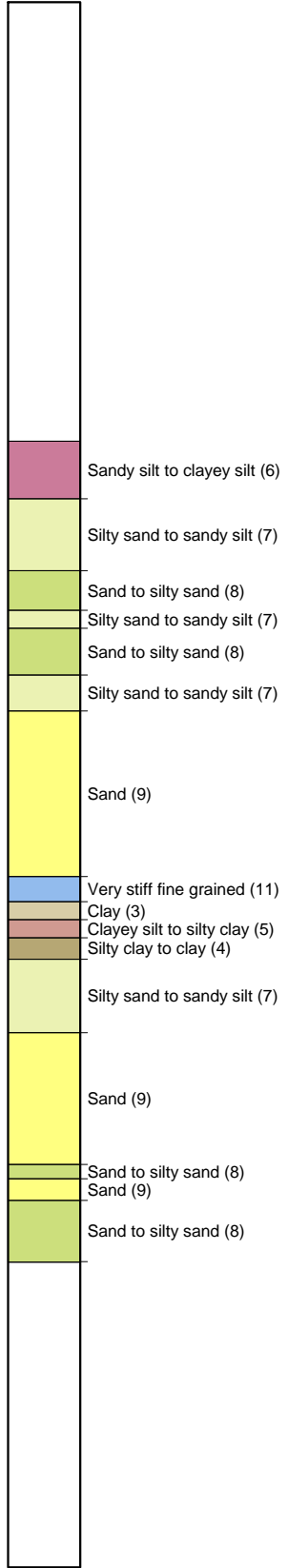
- Sand (9)
- Sand to silty sand (8)
- Very stiff fine grained (11)
- Sand to silty sand (8)
- Clay (3)
- Sand (9)
- Gravelly sand to sand (10)



Cone No: 4141
Tip area [cm2]: 10
Sleeve area [cm2]: 150

Location: Blue Lake, California	Position:	Ground level:	Test no: C20RC
Project ID: 14-1149.02	Client: CGI Technical Services	Date: 4/7/2014	Scale: 1 : 40
Project: Blue Lake Levee		Page: 1/1	Fig:
File: C20RC.cpd			

Classification by
Robertson 1986



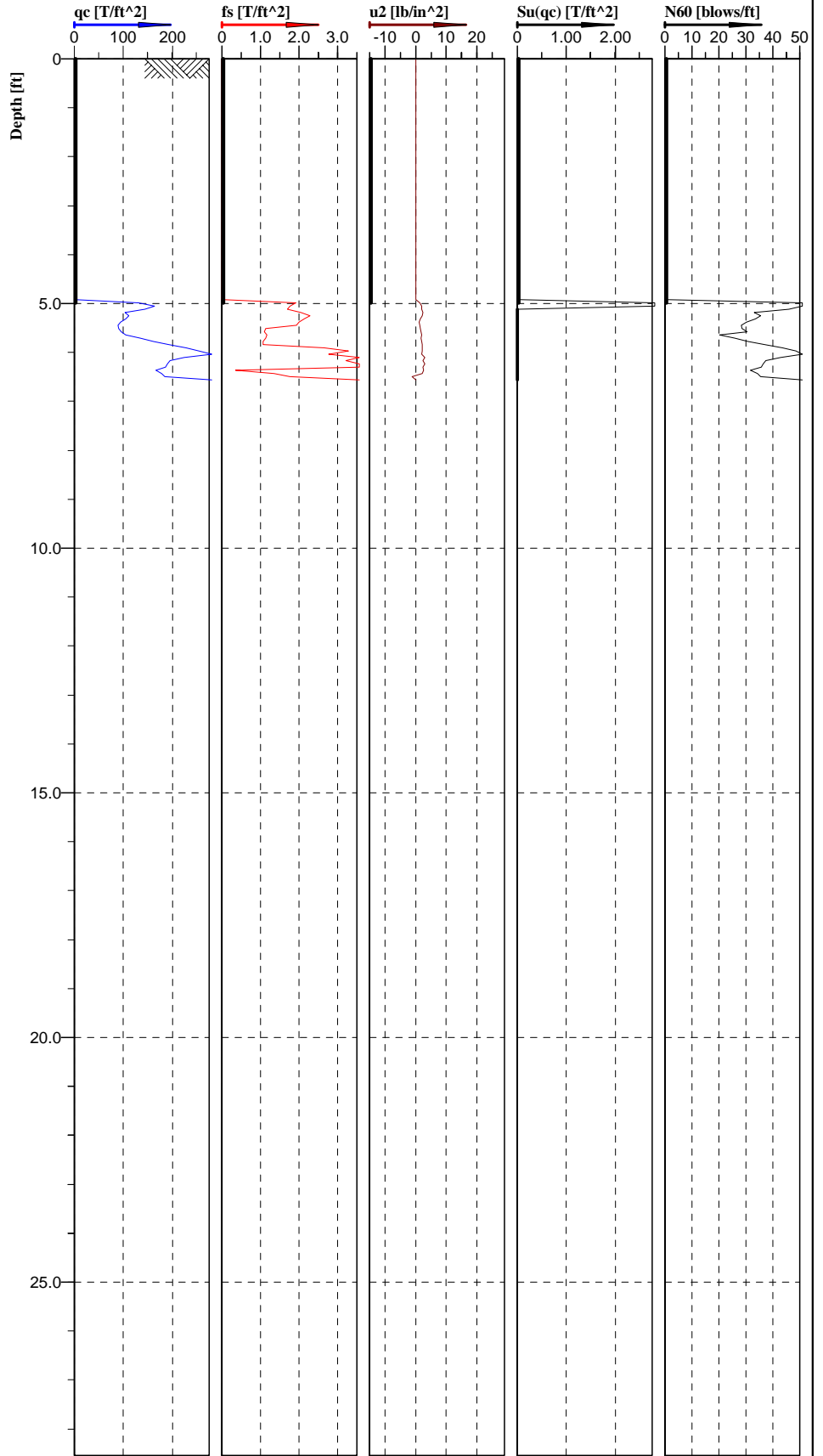
Cone No: 4141
Tip area [cm2]: 10
Sleeve area [cm2]: 150

Location: Blue Lake, California	Position:	Ground level:	Test no: C39RC
Project ID: 14-1149.02	Client: CGI Technical Services	Date: 4/7/2014	Scale: 1 : 40
Project: Blue Lake Levee		Page: 1/1	Fig:
		File: C39RC.cpd	

Classification by
Robertson 1986



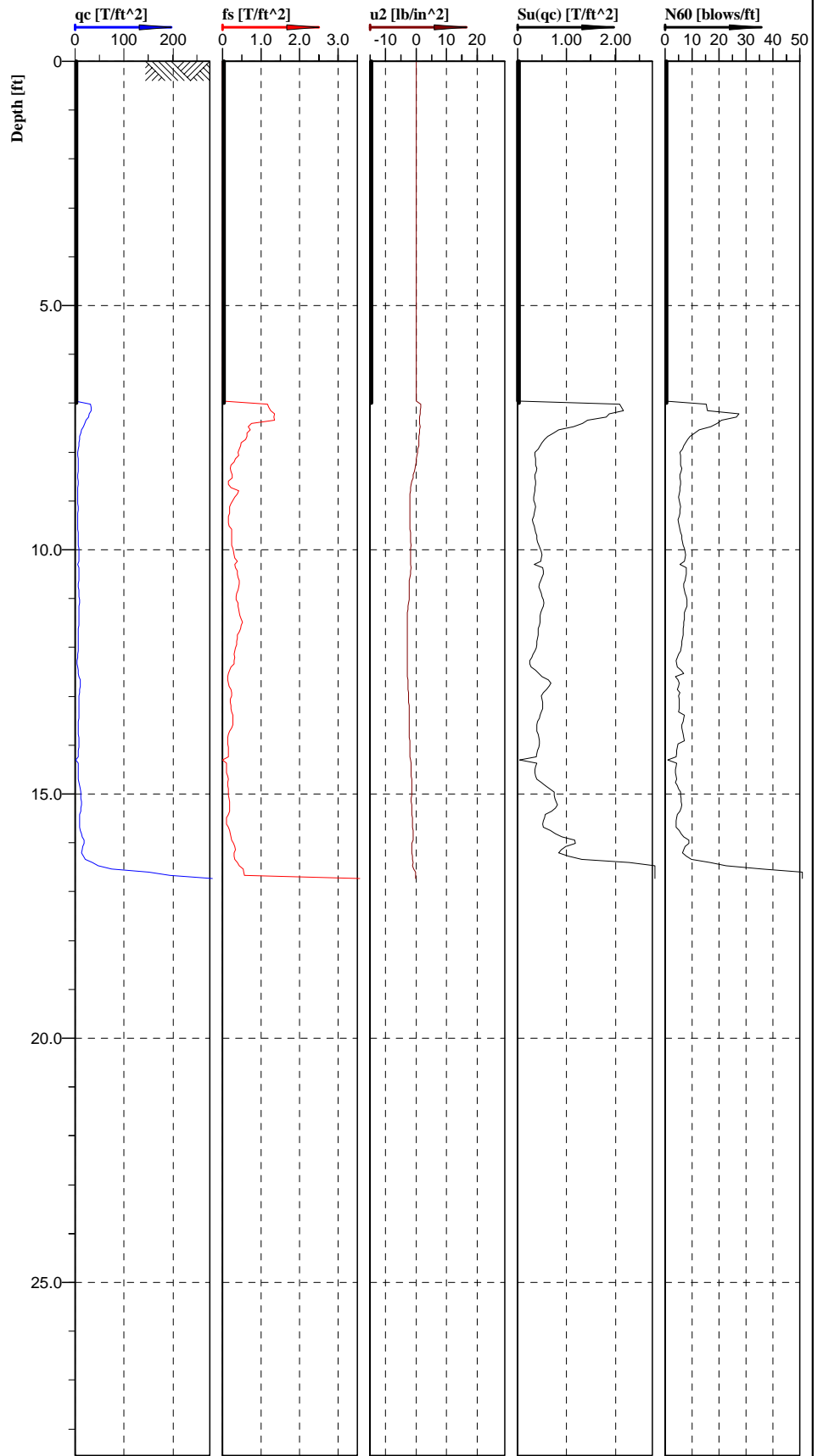
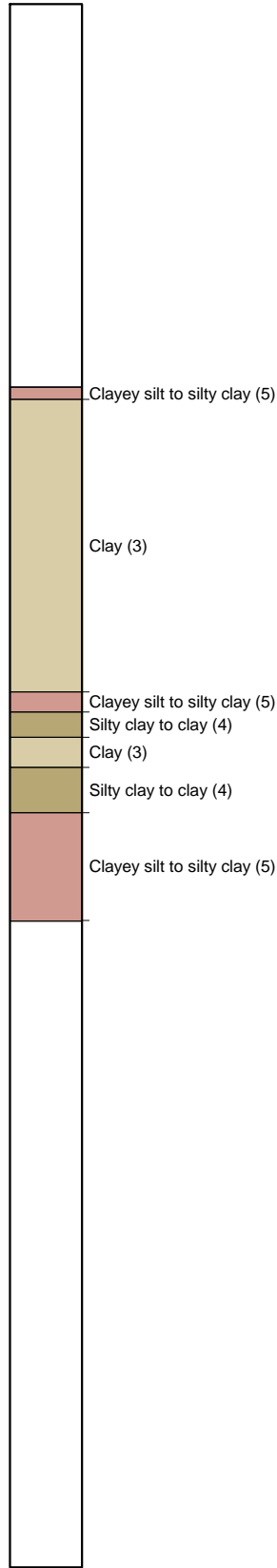
Silty sand to sandy silt (7)
Sand (9)



Cone No: 4141
Tip area [cm²]: 10
Sleeve area [cm²]: 150

Location: Blue Lake, California	Position:	Ground level:	Test no: C49RW
Project ID: 14-1149.02	Client: CGI Technical Services	Date: 4/8/2014	Scale: 1 : 40
Project: Blue Lake Levee		Page: 1/1	Fig:
		File: C49RW.cpd	

Classification by
Robertson 1986



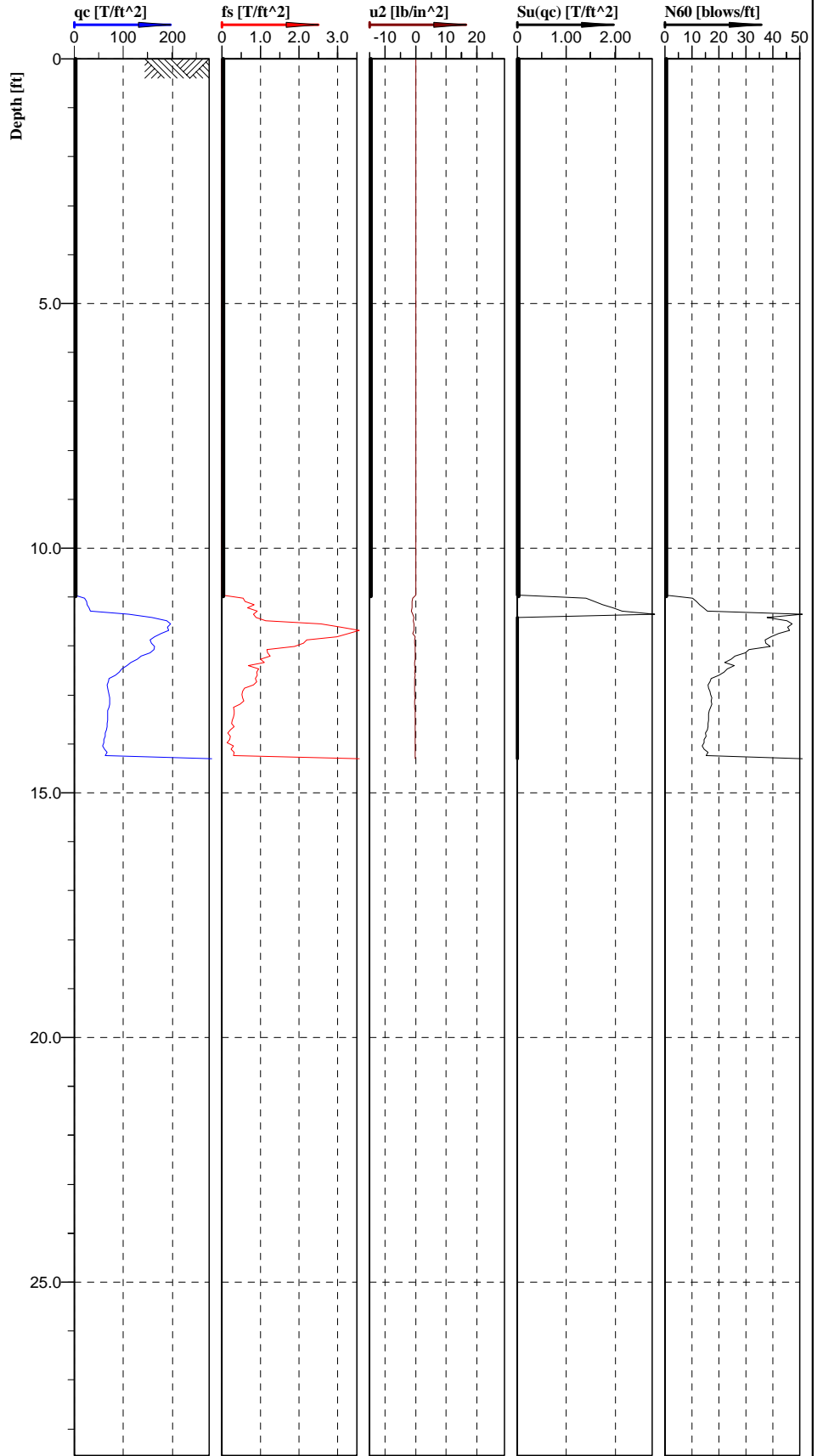
Cone No: 4141
Tip area [cm²]: 10
Sleeve area [cm²]: 150

Location: Blue Lake, California	Position:	Ground level:	Test no: C59RC
Project ID: 14-1149.02	Client: CGI Technical Services	Date: 4/8/2014	Scale: 1 : 40
Project: Blue Lake Levee		Page: 1/1	Fig:
		File: C59RC.cpd	

Classification by
Robertson 1986



Clayey silt to silty clay (5)
Sand to silty sand (8)
Sand (9)
Sand to silty sand (8)

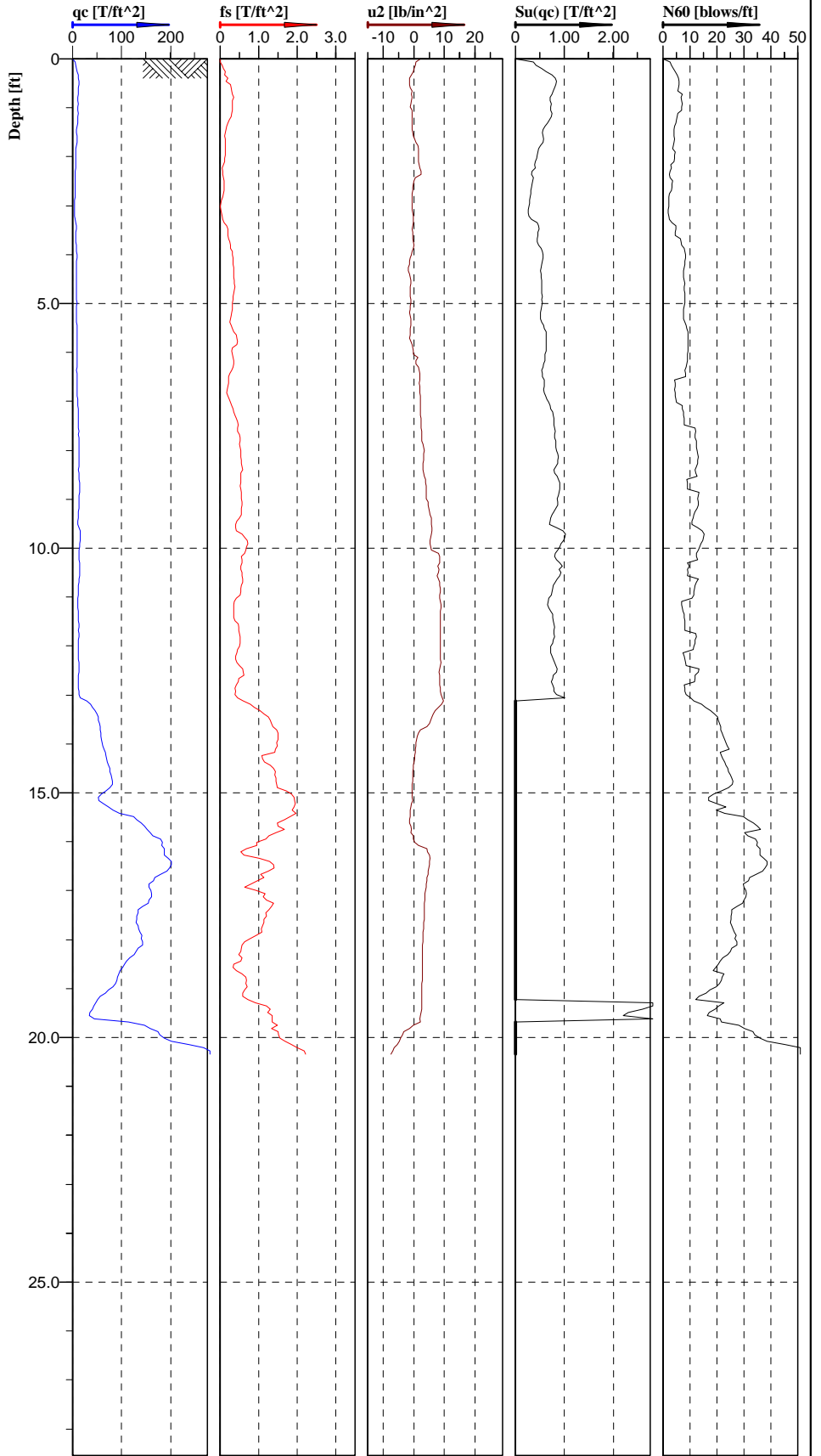


Cone No: 4141
Tip area [cm²]: 10
Sleeve area [cm²]: 150

Location: Blue Lake, California	Position:	Ground level:	Test no: C59RW
Project ID: 14-1149.02	Client: CGI Technical Services	Date: 4/8/2014	Scale: 1 : 40
Project: Blue Lake Levee		Page: 1/1	Fig:
		File: C59RW.cpd	

**Classification by
Robertson 1986**

- Sensitive fine grained (1)
- Clayey silt to silty clay (5)
- Silty clay to clay (4)
- Clayey silt to silty clay (5)
- Silty clay to clay (4)
- Sensitive fine grained (1)
- Silty clay to clay (4)
- Sensitive fine grained (1)
- Silty clay to clay (4)
- Clay (3)
- Clayey silt to silty clay (5)
- Silty clay to clay (4)
- Clay (3)
- Silty clay to clay (4)
- Clay (3)
- Silty clay to clay (4)
- Clay (3)
- Silty clay to clay (4)
- Silty clay to clay (4)
- Sandy silt to clayey silt (6)
- Silty sand to sandy silt (7)
- Sand to silty sand (8)
- Sand (9)
- Sand to silty sand (8)
- Clayey silt to silty clay (5)
- Sand (9)

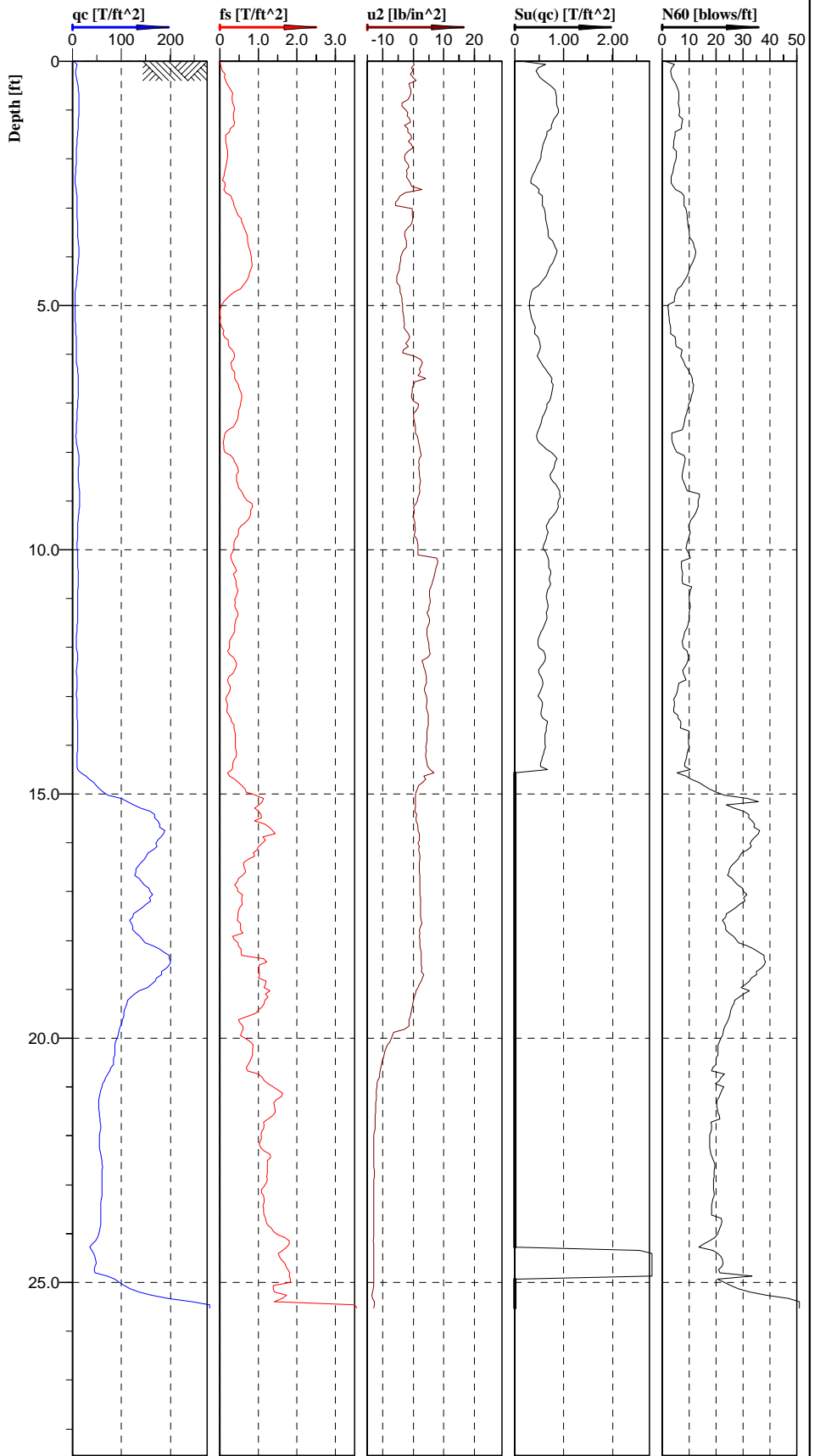


Cone No: 4141
Tip area [cm2]: 10
Sleeve area [cm2]: 150

Location: Blue Lake, California	Position:	Ground level:	Test no: C70RL
Project ID: 14-1149.02	Client: CGI Technical Services	Date: 4/8/2014	Scale: 1 : 40
Project: Blue Lake Levee		Page: 1/1	Fig:
		File: C70RL.cpd	

**Classification by
Robertson 1986**

- Sensitive fine grained (1)
- Clayey silt to silty clay (5)
- Silty clay to clay (4)
- Clayey silt to silty clay (5)
- Silty clay to clay (4)
- Clay (3)
- Sensitive fine grained (1)
- Silty clay to clay (4)
- Clay (3)
- Clayey silt to silty clay (5)
- Silty clay to clay (4)
- Clay (3)
- Silty clay to clay (4)
- Clay (3)
- Silty clay to clay (4)
- Clayey silt to silty clay (5)
- Silty clay to clay (4)
- Clay (3)
- Silty sand to sandy silt (7)
- Sand (9)
- Sand to silty sand (8)
- Silty sand to sandy silt (7)
- Sandy silt to clayey silt (6)
- Silty sand to sandy silt (7)
- Sandy silt to clayey silt (6)
- Clayey silt to silty clay (5)
- Sand to silty sand (8)



Cone No: 4141
Tip area [cm2]: 10
Sleeve area [cm2]: 150

Location: Blue Lake, California	Position:	Ground level:	Test no: C70RO
Project ID: 14-1149.02	Client: CGI Technical Services	Date: 4/8/2014	Scale: 1 : 40
Project: Blue Lake Levee		Page: 1/1	Fig:
File: C70RO.cpd			

APPENDIX C
LABORATORY TESTING

APPENDIX C LABORATORY TESTING

This appendix discusses the results of the laboratory testing program performed for this geotechnical investigation. Laboratory soil testing was performed subsequent to the field exploration program at Fugro's laboratories in Ventura and Oakland, California, and CGI's laboratory in Redding, California. Laboratory tests were performed on selected samples to help classify the soils encountered and to estimate some of their engineering properties.

Driven-ring and bulk samples tested in the laboratory testing program were obtained from various locations during the course of the field exploration, as discussed in Appendix B. Each sample is identified by sample number and depth. The various laboratory tests performed are described below. A summary of the laboratory tests performed on selected samples is presented on Plates C-1a to C-1c - Summary of Laboratory Test Results.

The testing programs performed at Fugro's and CGI's laboratories are listed in Tables C-1 and C-2, respectively, and described below. Results of gradation, hydraulic conductivity, shear strength, triaxial, consolidation, and compaction testing are included in this appendix.

Table C-1. Summary of Fugro Laboratory Testing Program

Laboratory Test	Quantity	Testing Standard
Density (in situ)	14	ASTM D2937
Grain Size Distribution	6	ASTM D422
Consolidation	1	ASTM D2435
Atterberg Limits	14	ASTM D4318
Hydraulic Conductivity	6	ASTM 5084
Direct Shear	4	ASTM D3080
CU (R) Triaxial	2	ASTM D4767

Table C-2. Summary of CGI Laboratory Testing Program

Laboratory Test	Quantity	Testing Standard
Grain Size Distribution	60	ASTM D422
Compaction (maximum density/optimum moisture content)	1	ASTM D1557

- **Laboratory Moisture Content and Density.** Water content and unit weight tests were performed on selected driven samples obtained during the field exploration to evaluate the natural moisture content and dry unit weight of the various materials encountered. The results are presented on Plates C-1a to C-1c and the drill hole logs.
- **Sieve Analyses.** Sieve analyses were performed to determine the gradation of soil grains. Selected samples were tested in accordance with ASTM D422. The results of the sieve analyses are presented on Plates C-2a to C-2f - Grain Size Curves.
- **Atterberg Limit Tests.** Tests for liquid limit, plastic limit, and plasticity index were conducted on selected samples in general accordance with ASTM D4318. The Atterberg limit test results are presented on Plates C-1a to C-1c, Plates C-3a and C-3b - Plasticity Chart, and the drill hole logs.
- **Hydraulic Conductivity.** Flexible Wall and constant head hydraulic conductivity tests were performed in accordance with ASTM D5084 and ASTM D2434, respectively, to evaluate saturated permeability of selected samples. The results of the permeability tests are presented on Plates C-4a to C-4f - Hydraulic Conductivity Test Results.
- **Direct Shear Tests.** Direct shear tests were performed on selected driven ring samples in general accordance with ASTM D3080. The results of the direct shear tests are presented on Plates C-5a to C-5d - Direct Shear Test Results.
- **Isotropically Consolidated, Undrained Triaxial Test with Pore Water Pressure Measurements.** Two triaxial compression tests with R-pore pressure measurement were performed on relatively undisturbed samples in general accordance with ASTM D4767. Results of the individual triaxial tests are presented on Plates C-6a and Plate C-6b.
- **Consolidation Tests.** A one-dimensional consolidation tests were performed on selected driven-ring samples in accordance with ASTM D2435. The sample was incrementally loaded to up to 32 kips per square foot (ksf), with water introduced at a of load of 1 ksf. The samples were allowed to consolidate under each load increment. Rebound was measured by unloading the sample. Results of the consolidation tests are presented as Plates C-7 - Consolidation Test Results.
- **Modified Proctor Test.** A Modified Proctor compaction test was performed on a bulk sample to assess compaction characteristics. Bulk samples of surficial material were obtained from locations adjacent to selected drill holes. The test was performed in general accordance with ASTM D1557. A compaction curves is presented on Plate C-8 - Compaction Test Results.



DRILL HOLE	DEPTH, ft	SAMPLE NUMBER	MATERIAL DESCRIPTION	U _{WW} pcf	U _{MC} pcf	MC %	FINES %	ATTERBERG LIMITS		COMPACTION TEST			DIRECT SHEAR		COMPRESSIVE STRENGTH TESTS		CORROSIIVITY TESTS				R-VALUE	EXPANSION INDEX	SAND EQUIVALENT (SE)	SPECIFIC GRAVITY
								LL	PI	MAX DD pcf	OPT DD %	MC %	C ksf	PHI deg	Q _u ksf	S _h (Cell Pres.) ksf	R	pH	Cl	So _r (%)				
D1RC	5.0		Well-graded GRAVEL with silt and sand (GW-GM)				6																	
D1RC	9.5	3a	Sandy SILT (ML)					33	9															
D1RC	10.0	3b	Sandy Lean CLAY with gravel (CL)	130	111	17		28	11															
D1RC	14.5		Silty SAND with gravel (SM)				13																	
D1RC	24.5		Well-graded GRAVEL with silt and sand (GW-GM)				9																	
D1RC	34.5		Well-graded GRAVEL with silt and sand (GW-GM)				9																	
D1RL	4.5		Well-graded GRAVEL with silt and sand (GW-GM)				6																	
D1RL	14.5		Poorly-graded GRAVEL with silt and sand (GP-GM)				6																	
D1RL	24.5		Well-graded SAND with silt and gravel (SW-SM)				9																	
D1RW	5.0	1	Clayey SAND (SC)				9	25	11															
D1RW	15.0		Well-graded GRAVEL with silt and sand (GW-GM)				7																	
D1RW	25.0		Well-graded GRAVEL with silt and sand (GW-GM)				5																	
D10RC	10.0	2a	Sandy Lean CLAY (CL)	127	109	16		29	8															
D10RC	19.5		Well-graded GRAVEL with silt and sand (GW-GM)				6																	
D10RC	29.5		Well-graded GRAVEL with silt and sand (GW-GM)				9																	
D10RC	34.5	7a	Well-graded SAND with clay and gravel (SW-SC)	142	131	8	7																	
D10RC	39.5		Well-graded GRAVEL with silt and sand (GW-GM)				9																	
D10RC	49.5		Silty SAND with gravel (SM)				17																	
D10RL	9.5		Well-graded GRAVEL with silt and sand (GW-GM)				7																	
D10RL	19.5		Well-graded SAND with silt and gravel (SW-SM)				7																	
D10RO	4.5		Silty SAND with gravel (SM)				23																	
D10RO	9.5		Silty SAND with gravel (SM)				26																	
D10RW	10.0		Well-graded GRAVEL with silt and sand (GW-GM)				7																	
D10RW	20.0		Well-graded GRAVEL with silt and sand (GW-GM)				9																	
D20RC	4.5	1	Sandy CLAY (CL)	125	107	17		40	20					0.4	32									
D20RC	20.0	4	Sandy Lean CLAY with gravel (CL)					33	20															
D20RC	24.5		Poorly-graded GRAVEL with silt and sand (GP-GM)				9																	
D20RC	34.5		Well-graded GRAVEL with silt and sand (GW-GM)				7																	
D20RL	4.5		Silty GRAVEL with sand (GM)				14																	
D20RL	14.5		Well-graded GRAVEL with sand (GW)				1																	

SUMMARY OF LABORATORY TEST RESULTS
 Blue Lake Levee Evaluation
 Humboldt County, California



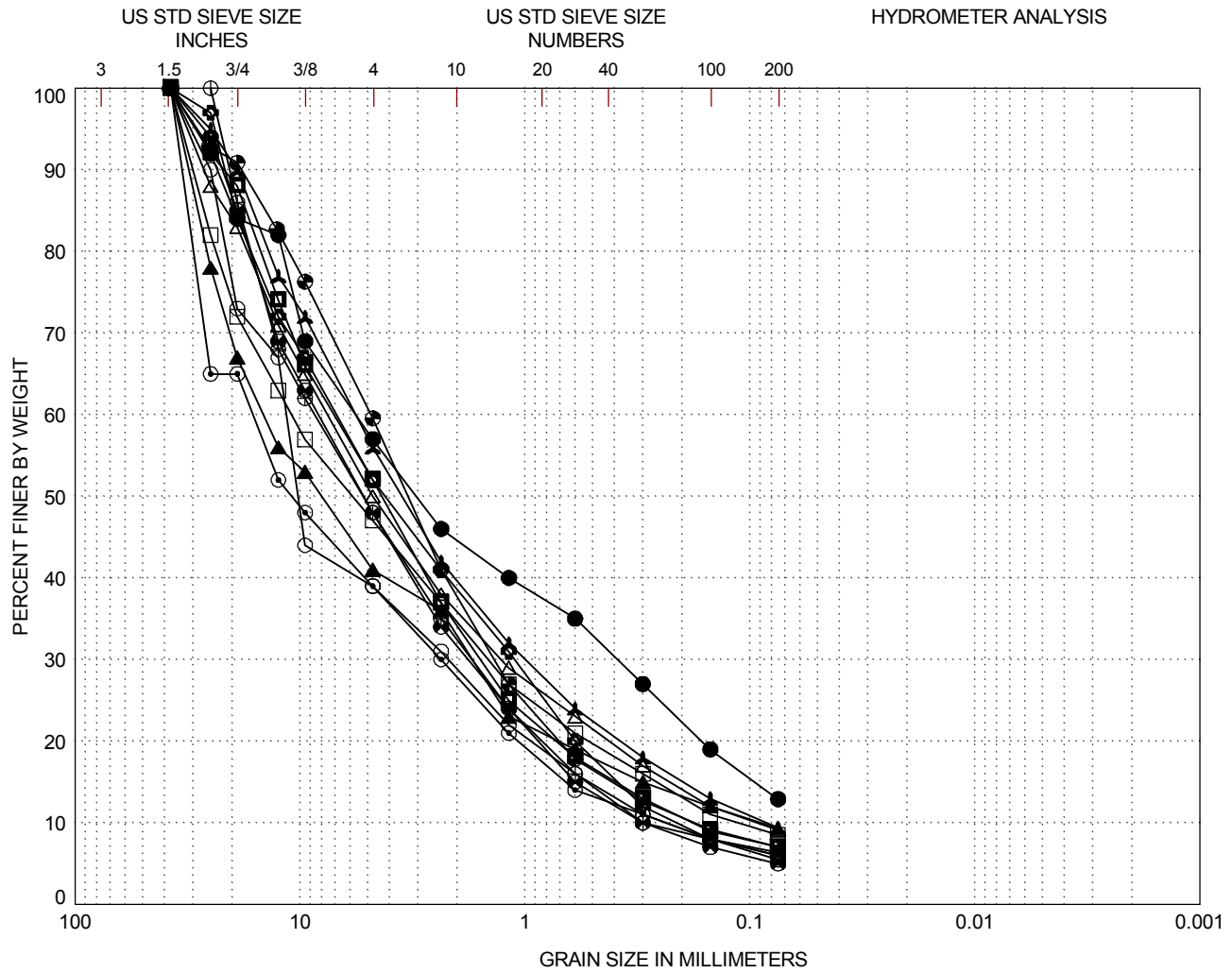
DRILL HOLE	DEPTH, ft	SAMPLE NUMBER	MATERIAL DESCRIPTION	U _{WW} pcf	U _{MC} %	FINES %	ATTERBERG LIMITS		COMPACTION TEST		DIRECT SHEAR		COMPRESSIVE STRENGTH TESTS		CORROSIIVITY TESTS				R-VALUE	EXPANSION INDEX	SAND EQUIVALENT (SE)	SPECIFIC GRAVITY		
							LL	PI	MAX DD pcf	OPT MC %	C ksf	PHI deg	Q _u ksf	S _h (Cell Pres.) ksf	R	pH	Cl	S _o (%)						
D20RO	14.5		Well-graded SAND with silt and gravel (SW-SM)			4																		
D30RC	4.5		Well-graded SAND with silt and gravel (SW-SM)			10																		
D30RC	7.0	2a	Sandy Lean CLAY with gravel (CL)	125	107	17	30	13																
D30RC	20.0		SILT (ML)			74																		
D30RC	20.5	5b	Silty SAND (SM)	121	100	20	46				0.3	33												
D30RC	29.5		Poorly-graded GRAVEL with silt and sand (GP-GM)			8																		
D30RC	39.5		Poorly-graded GRAVEL with silt and sand (GP-GM)			9																		
D30RC	49.5		Poorly-graded GRAVEL with silt and sand (GP-GM)			8																		
D30RL	9.0	2	Silty SAND (SM)	111	91	22	17																	
D30RL	19.0		Well-graded SAND with clay (SW-SC)			8																		
D30RO	24.0		Well-graded GRAVEL with silt and sand (GW-GM)			6																		
D39RC	5.0	1	Clayey SAND with gravel (SC)			17	38																	
D39RC	11.0	2b	Sandy Lean CLAY (CL)	121	104	17	32	10																
D39RC	25.0		Well-graded SAND with silt and gravel (SW-SM)			5																		
D39RL	5.0		Poorly-graded SAND with silt and gravel (SP-SM)			7																		
D39RL	15.0		Well-graded SAND gravel (SW)			4																		
D39RL	25.0		Poorly-graded GRAVEL with silt and sand (GP-GM)			8																		
D39RO	14.0		Well-graded GRAVEL with silt and sand (GW-GM)			5																		
D39RW	14.5		Poorly-graded SAND with silt and gravel (SP-SM)			8																		
D49RC	5.0	1	Sandy Lean CLAY with gravel (CL)	125	107	17	31	8																
D49RC	10.0		Sandy SILT (ML)			51																		
D49RC	20.0		Poorly-graded SAND with gravel (SF)			3																		
D49RC	30.0		Well-graded SAND with silt and gravel (SW-SM)			11																		
D49RL	4.0		Silty SAND (SM)			46																		
D49RL	9.0		Well-graded GRAVEL with silt and sand (GW-GM)			5																		
D49RL	19.0		Well-graded GRAVEL with sand (GW)			5																		
D49RO	4.5	1	Silty SAND (SM)	116	98	18	49				0.5	31												
D49RO	9.5		Well-graded SAND with silt and gravel (SW-SM)			5																		
D49RO	24.5		Well-graded GRAVEL with sand (GW)			5																		
D49RW	6.0	1b	Clayey SAND (SC)	124	102	22	45																	

SUMMARY OF LABORATORY TEST RESULTS
 Blue Lake Levee Evaluation
 Humboldt County, California



DRILL HOLE	DEPTH, ft	SAMPLE NUMBER	MATERIAL DESCRIPTION	U _{WW} pcf	U _{MC} %	FINES %	ATTERBERG LIMITS		COMPACTION TEST			DIRECT SHEAR		COMPRESSIVE STRENGTH TESTS		CORROSIIVITY TESTS				R-VALUE	EXPANSION INDEX	SAND EQUIVALENT (SE)	SPECIFIC GRAVITY	
							LL	PI	MAX DD pcf	OPT MC %	C ksf	PHI deg	Q _u ksf	S _h (Cell Pres.) ksf	R	pH	Cl	S _o (%)						
D49RW	9.5		Poorly-graded GRAVEL with silt and sand (GP-GM)			5																		
D49RW	19.5		Well-graded GRAVEL with sand (GW)			1																		
D59RC	15.5	3a	Silty SAND (SM)	129	111	16	NP	NP																
D59RC	16.0		Silty SAND (SM)			23																		
D59RC	20.0		Well-graded GRAVEL with sand (GW)			1																		
D59RC	40.0		Well-graded SAND with silt and gravel (SW-SM)			12																		
D59RL	5.0	1	Sandy SILT (ML)	127	103	23	36	11																
D59RL	15.0		Poorly-graded SAND with silt and gravel (SP-SM)			7																		
D59RL	25.0		Well-graded GRAVEL with silt and sand (GW-GM)			11																		
D59RO	14.5		Well-graded SAND with silt (SW-SM)			8																		
D59RW	19.5		Well-graded GRAVEL with silt and sand (GW-GM)			9																		
D59RW	4.5	1	Lean CLAY with sand (CL)	122	97	26	37	19																
D59RW	14.5	3a	Poorly-graded SAND with SILT (SP-SM)	121	96	26	11																	
D59RW	24.5		Well-graded GRAVEL with silt and sand (GW-GM)			9																		
D70RC	15.0	3	Lean CLAY (CL)	125	99	26	36	20																
D70RC	35.0		Silty SAND (SM)			14																		
D70RW	10.0	2	Lean CLAY (CL)	121	94	28	38	21																

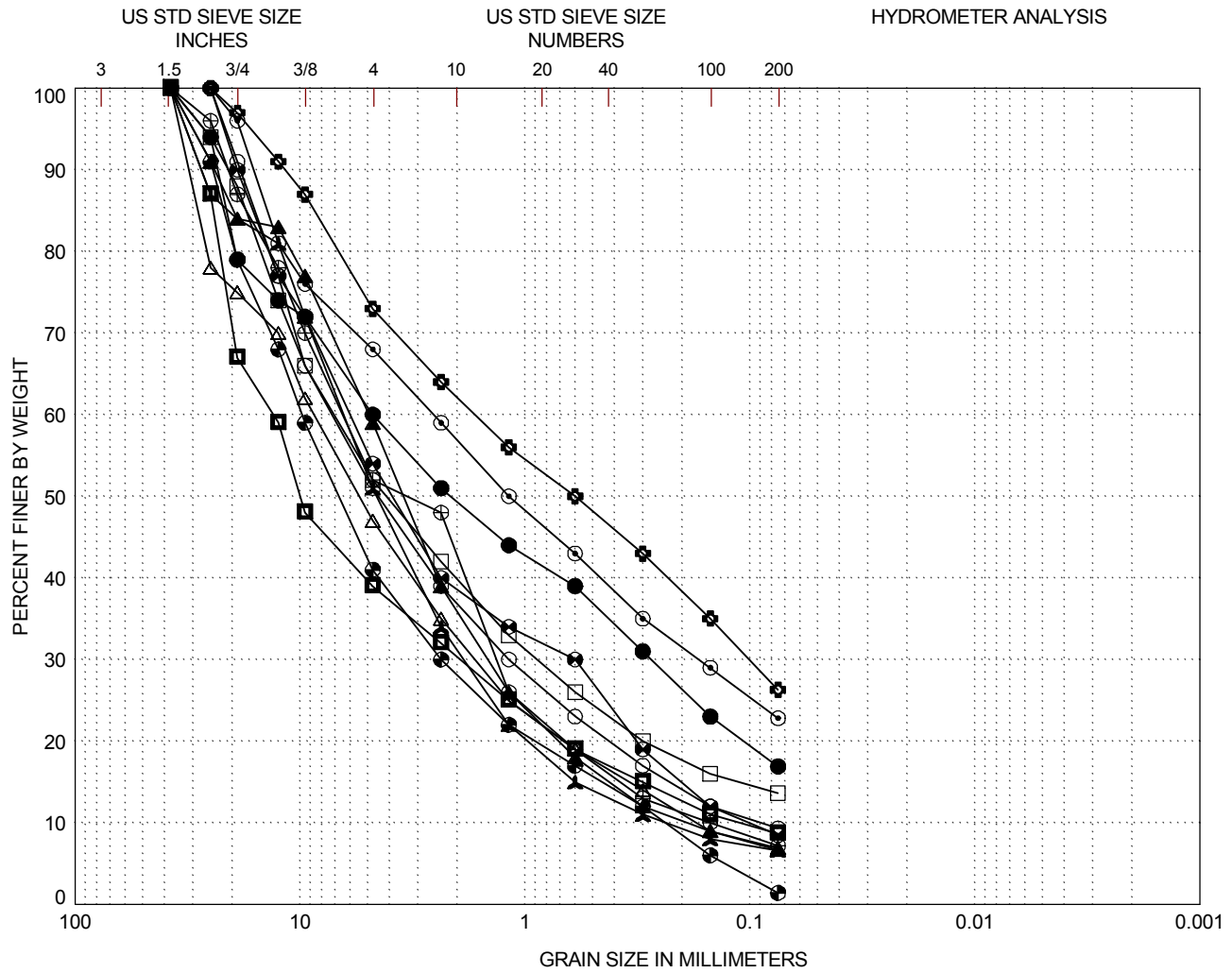
SUMMARY OF LABORATORY TEST RESULTS
 Blue Lake Levee Evaluation
 Humboldt County, California



GRAVEL		SAND			SILT or CLAY
Coarse	Fine	Coarse	Medium	Fine	

LEGEND			CLASSIFICATION	Cc	Cu
(location)	(depth,ft)				
○	D1RC	5.0	Well-graded GRAVEL with silt and sand (GW-GM)	1.7	48.3
●	D1RC	14.5	Silty SAND with gravel (SM)		
△	D1RC	24.5	Well-graded GRAVEL with silt and sand (GW-GM)	2.3	81.1
▲	D1RC	34.5	Well-graded GRAVEL with silt and sand (GW-GM)	2.2	162.2
⊙	D1RL	4.5	Well-graded GRAVEL with silt and sand (GW-GM)	1.4	67.9
⊕	D1RL	14.5	Poorly-graded GRAVEL with silt and sand (GP-GM)	0.8	32.4
▲	D1RL	24.5	Well-graded SAND with silt and gravel (SW-SM)	2.1	67.1
⊕	D1RW	15.0	Well-graded GRAVEL with silt and sand (GW-GM)	2.0	39.6
⊕	D1RW	25.0	Well-graded GRAVEL with silt and sand (GW-GM)	1.3	27.6
⊕	D1RC	19.5	Well-graded GRAVEL with silt and sand (GW-GM)	1.1	28.7
□	D10RC	29.5	Well-graded GRAVEL with silt and sand (GW-GM)	1.7	95.9
⊕	D10RC	34.5	Well-graded SAND with clay and gravel (SW-SC)	2.2	27.5

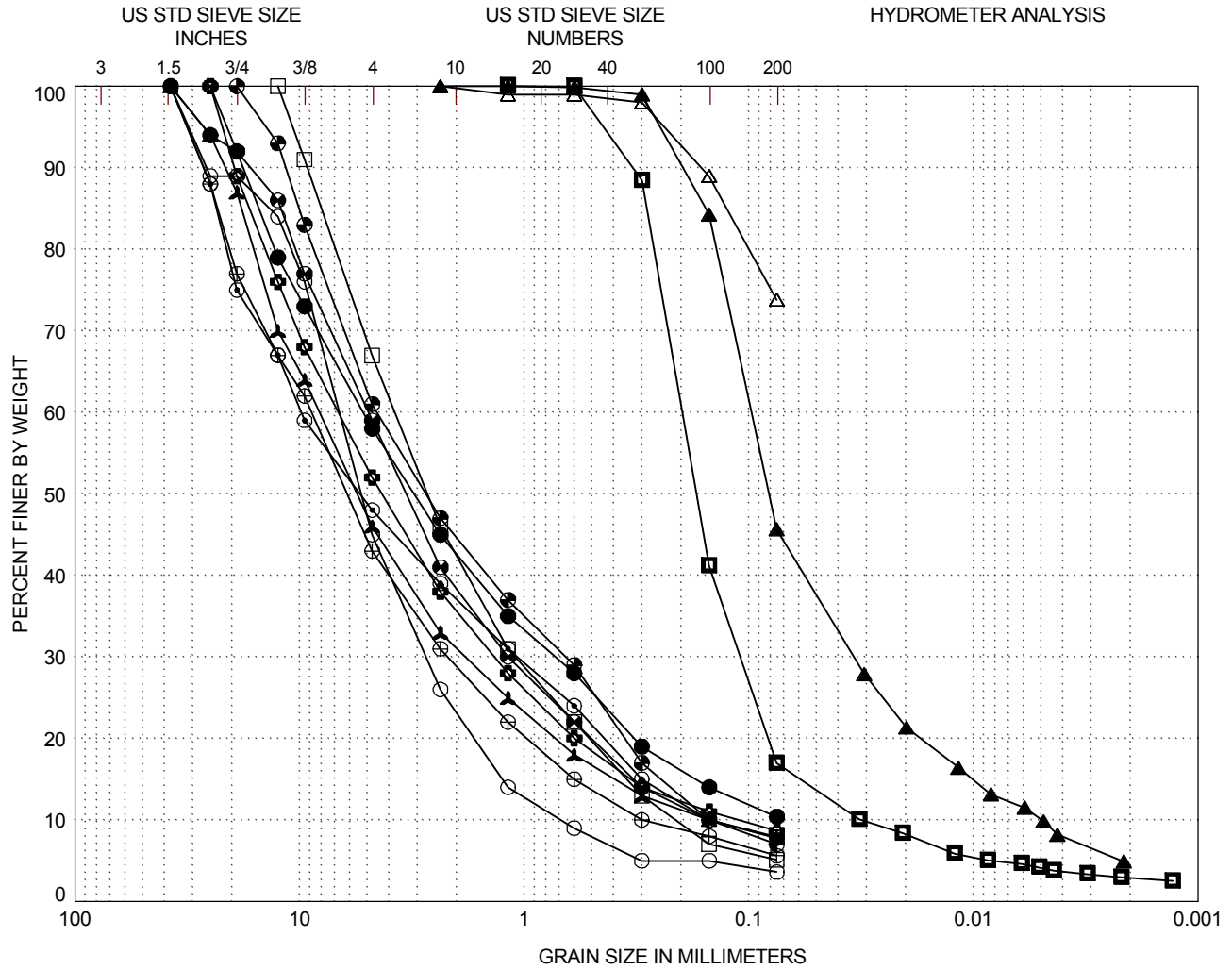
GRAIN SIZE CURVES
 Blue Lake Levee Evaluation
 Humboldt County, California



GRAVEL		SAND			SILT or CLAY
Coarse	Fine	Coarse	Medium	Fine	

LEGEND			CLASSIFICATION	C _c	C _u
	(location)	(depth,ft)			
○	D10RC	39.5	Well-graded GRAVEL with silt and sand (GW-GM)	2.2	80.2
●	D10RC	49.5	Silty SAND with gravel (SM)		
△	D10RL	9.5	Well-graded GRAVEL with silt and sand (GW-GM)	1.9	50.3
▲	D10RL	19.5	Well-graded SAND with silt and gravel (SW-SM)	2.3	26.1
⊙	D10RO	4.5	Silty SAND with gravel (SM)		
⊕	D10RO	9.5	Silty SAND with gravel (SM)		
▲	D10RW	10.0	Well-graded GRAVEL with silt and sand (GW-GM)	2.3	26.8
■	D10RW	20.0	Well-graded GRAVEL with silt and sand (GW-GM)	2.6	118.7
⊙	D20RC	24.5	Poorly-graded GRAVEL with silt and sand (GP-GM)	0.6	59.3
⊕	D20RC	34.5	Well-graded GRAVEL with silt and sand (GW-GM)	1.8	43.1
□	D20RL	4.5	Silty GRAVEL with sand (GM)		
⊕	D20RL	14.5	Well-graded GRAVEL with sand (GW)	2.4	41.1

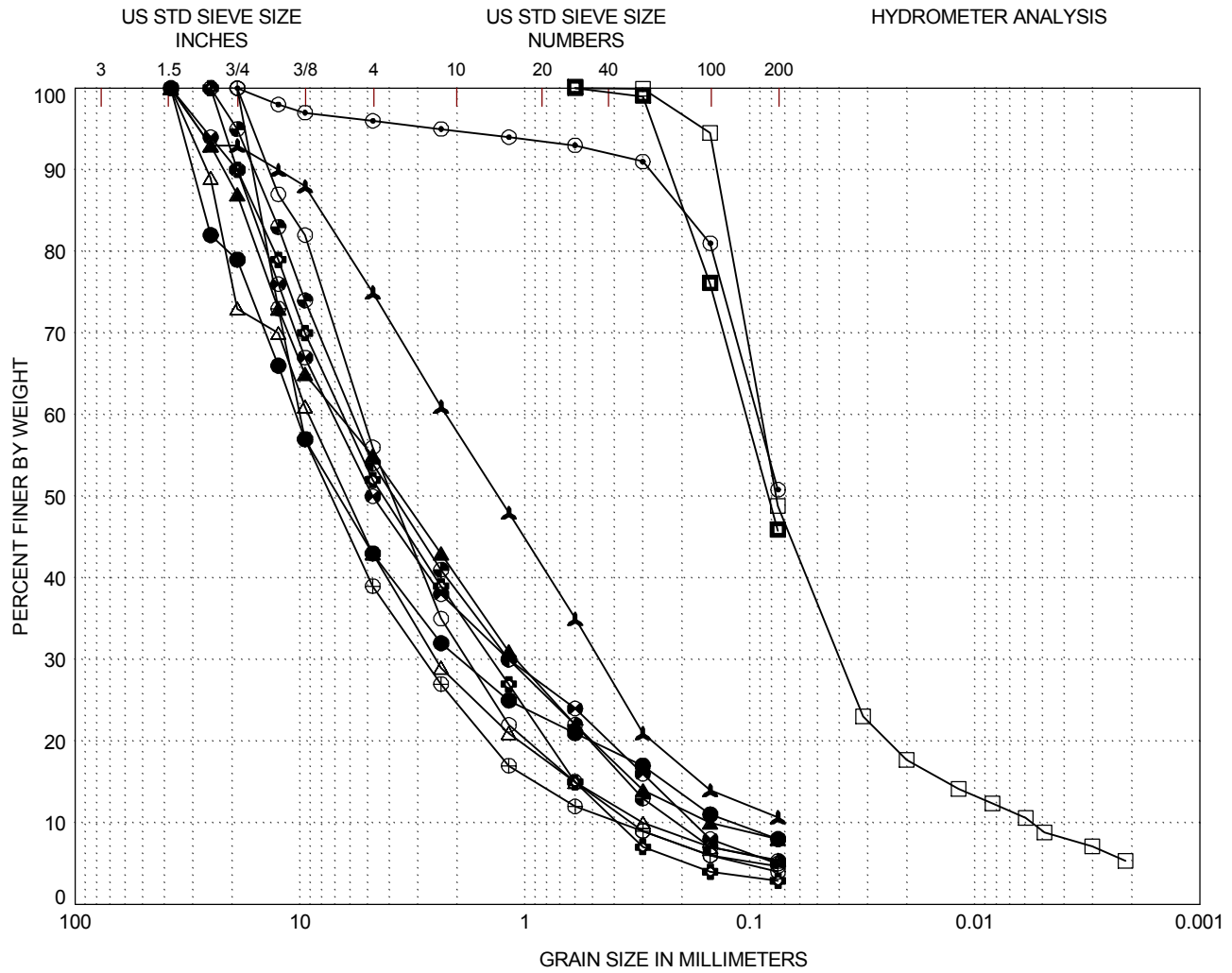
GRAIN SIZE CURVES
 Blue Lake Levee Evaluation
 Humboldt County, California



GRAVEL		SAND			SILT or CLAY
Coarse	Fine	Coarse	Medium	Fine	

LEGEND			CLASSIFICATION	Cc	Cu
(location)	(depth,ft)				
○	D20RO	14.5	Well-graded SAND with silt and gravel (SW-SM)	1.6	9.7
●	D30RC	4.5	Well-graded SAND with silt and gravel (SW-SM)	1.5	75.0
△	D30RC	20.0	SILT (ML)		
▲	D30RC	20.5	Silty SAND (SM)	2.4	19.6
⊙	D30RC	29.5	Poorly-graded GRAVEL with silt and sand (GP-GM)	0.8	65.5
⊕	D30RC	39.5	Poorly-graded GRAVEL with silt and sand (GP-GM)	2.5	60.5
⊖	D30RC	49.5	Poorly-graded GRAVEL with silt and sand (GP-GM)	2.7	54.3
⊗	D30RL	9.0	Silty SAND (SM)	1.9	6.2
⊘	D30RL	19.0	Well-graded SAND with clay (SW-SC)	1.9	32.9
⊕	D30RO	24.0	Well-graded GRAVEL with silt and sand (GW-GM)	1.8	29.4
□	D39RC	25.0	Well-graded SAND with silt and gravel (SW-SM)	1.5	17.7
⊕	D39RL	5.0	Poorly-graded SAND with silt and gravel (SP-SM)	0.6	30.1

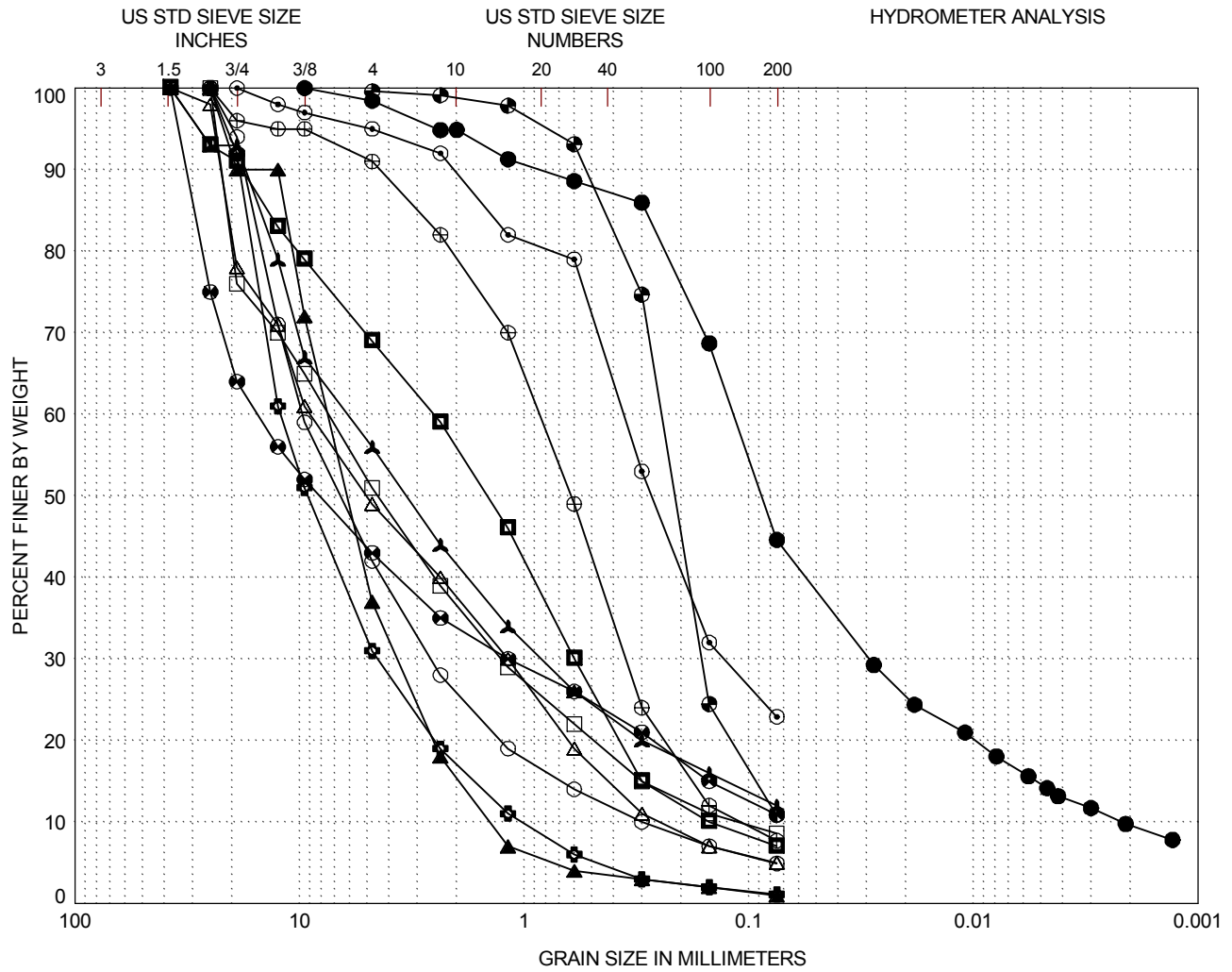
GRAIN SIZE CURVES
 Blue Lake Levee Evaluation
 Humboldt County, California



GRAVEL		SAND			SILT or CLAY
Coarse	Fine	Coarse	Medium	Fine	

LEGEND			CLASSIFICATION		C _c	C _u
(location)	(depth,ft)					
○	D39RL	15.0	Well-graded SAND gravel (SW)	1.8	15.7	
●	D39RL	25.0	Poorly-graded GRAVEL with silt and sand (GP-GM)	3.0	87.4	
△	D39RO	14.0	Well-graded GRAVEL with silt and sand (GW-GM)	2.2	30.5	
▲	D39RW	14.5	Poorly-graded SAND with silt and gravel (SP-SM)	1.2	44.8	
⊙	D49RC	10.0	Sandy SILT (ML)			
⊕	D49RC	20.0	Poorly-graded SAND with gravel (SP)	0.8	16.6	
▲	D49RC	30.0	Well-graded SAND with silt and gravel (SW-SM)	1.5	34.6	
■	D49RL	4.0	Silty SAND (SM)			
⊕	D49RL	9.0	Well-graded GRAVEL with silt and sand (GW-GM)	1.1	40.0	
⊕	D49RL	19.0	Well-graded GRAVEL with sand (GW)	2.1	26.5	
□	D49RO	4.5	Silty SAND (SM)	3.2	16.0	
⊕	D49RO	9.5	Well-graded SAND with silt and gravel (SW-SM)	1.1	27.6	

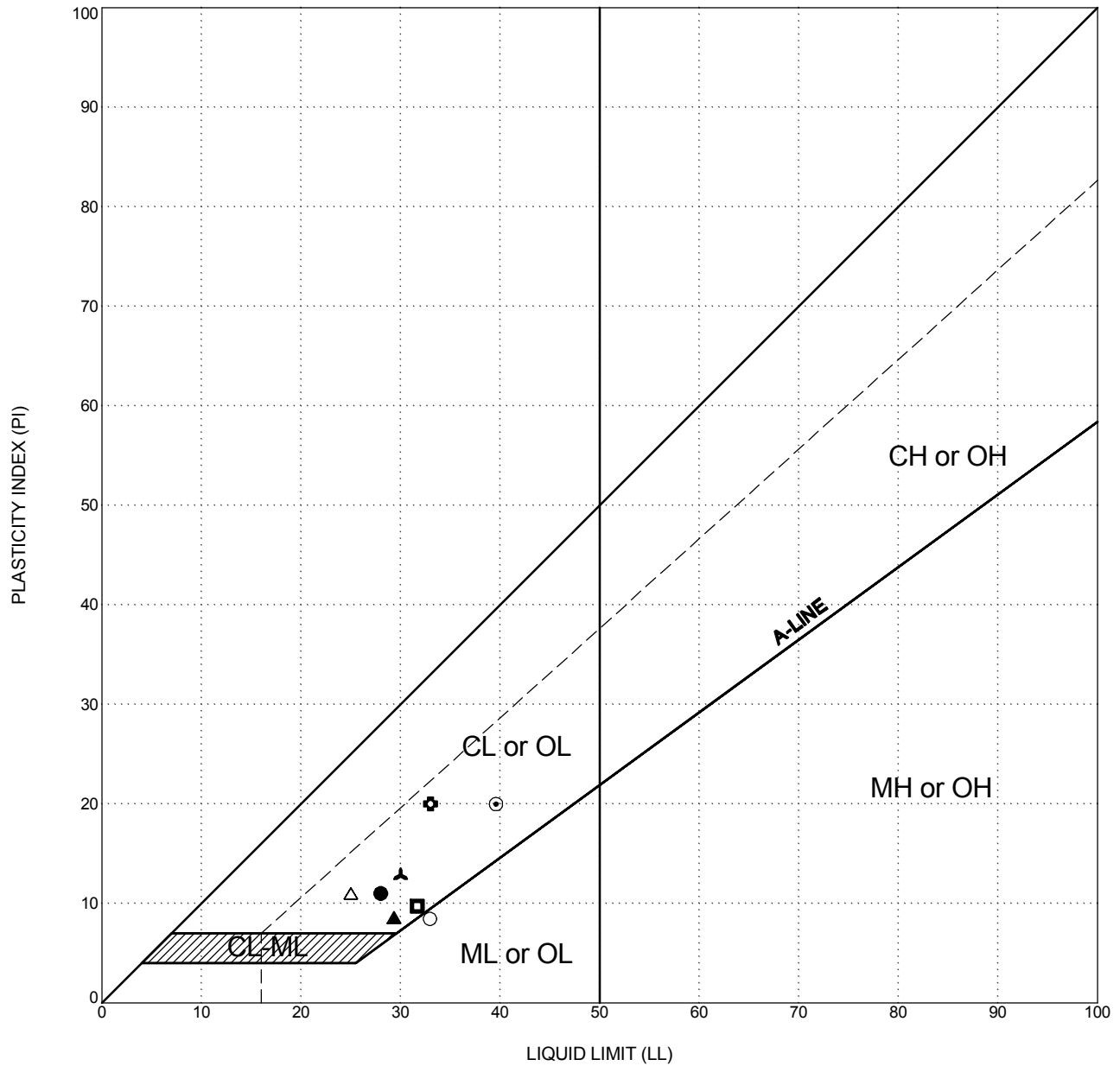
GRAIN SIZE CURVES
 Blue Lake Levee Evaluation
 Humboldt County, California



GRAVEL		SAND			SILT or CLAY
Coarse	Fine	Coarse	Medium	Fine	

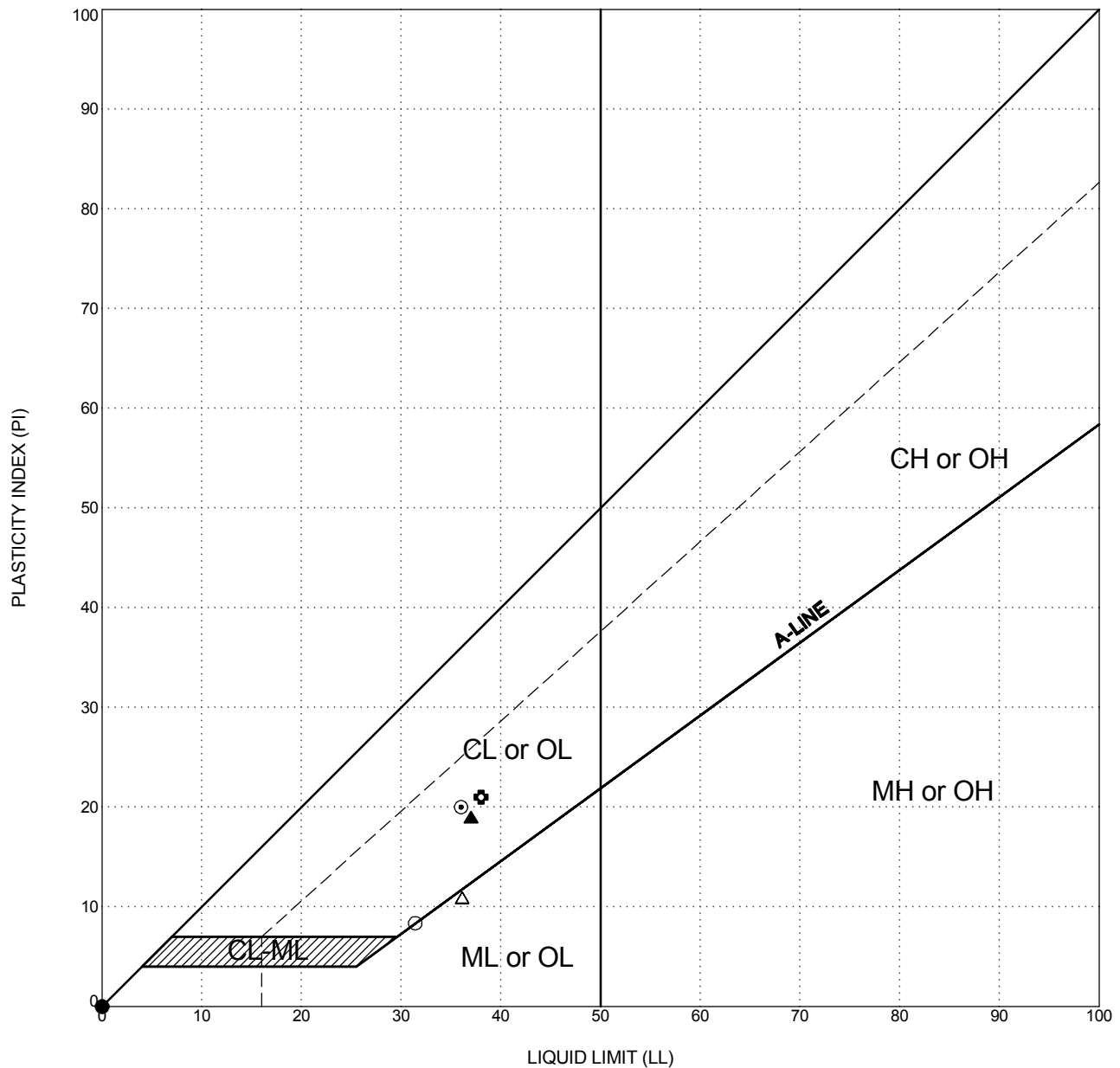
LEGEND			CLASSIFICATION	Cc	Cu
(location)	(depth,ft)				
○	D49RO	24.5	Well-graded GRAVEL with sand (GW)	2.3	32.4
●	D49RW	6.0	Clayey SAND (SC)	3.3	53.1
△	D49RW	9.5	Poorly-graded GRAVEL with silt and sand (GP-GM)	0.6	35.5
▲	D49RW	19.5	Well-graded GRAVEL with sand (GW)	1.3	5.3
⊙	D59RC	16.0	Silty SAND (SM)		
⊕	D59RC	20.0	Well-graded GRAVEL with sand (GW)	1.6	11.8
▲	D59RC	40.0	Well-graded SAND with silt and gravel (SW-SM)	2.2	115.2
■	D59RL	15.0	Poorly-graded SAND with silt and gravel (SP-SM)	0.9	16.9
⊙	D59RL	25.0	Well-graded GRAVEL with silt and sand (GW-GM)	1.4	239.2
⊕	D59RO	14.5	Well-graded SAND with silt (SW-SM)	1.4	7.9
□	D59RO	19.5	Well-graded GRAVEL with silt and sand (GW-GM)	1.9	66.0
⊕	D59RW	14.5	Poorly-graded SAND with SILT (SP-SM)	1.5	3.4

GRAIN SIZE CURVES
 Blue Lake Levee Evaluation
 Humboldt County, California




LEGEND			CLASSIFICATION			ATTERBERG LIMITS TEST RESULTS		
	location	depth, ft				LIQUID LIMIT(LL)	PLASTIC LIMIT(PL)	PLASTICITY INDEX (PI)
○	D1RC	9.5		Sandy SILT (ML)		33	24	9
●	D1RC	10.0		Sandy Lean CLAY with gravel (CL)		28	17	11
△	D1RW	5.0		Clayey SAND (SC)		25	14	11
▲	D10RC	10.0		Sandy Lean CLAY (CL)		29	21	8
⊙	D20RC	4.5		Sandy CLAY (CL)		40	20	20
⊕	D20RC	20.0		Sandy Lean CLAY with gravel (CL)		33	13	20
▲	D30RC	7.0		Sandy Lean CLAY with gravel (CL)		30	17	13
■	D39RC	11.0		Sandy Lean CLAY (CL)		32	22	10

PLASTICITY CHART
 Blue Lake Levee Evaluation
 Humboldt County, California




LEGEND			CLASSIFICATION			ATTERBERG LIMITS TEST RESULTS		
	location	depth, ft			LIQUID LIMIT(LL)	PLASTIC LIMIT(PL)	PLASTICITY INDEX(PI)	
○	D49RC	5.0	Sandy Lean CLAY with gravel (CL)		31	23	8	
●	D59RC	15.5	Silty SAND (SM)		NP	NP	NP	
△	D59RL	5.0	Sandy SILT (ML)		36	25	11	
▲	D59RW	4.5	Lean CLAY with sand (CL)		37	18	19	
⊙	D70RC	15.0	Lean CLAY (CL)		36	16	20	
⊕	D70RW	10.0	Lean CLAY (CL)		38	17	21	


PLASTICITY CHART
 Blue Lake Levee Evaluation
 Humboldt County, California

SAMPLE ID	Boring Number	D1RC		CLASSIFICATION	Sieve Size	% Passing	Other Parameters		
	Sample Number	3b			3/8-in. (9.5mm)	---	Liquid Limit	28	
Sample Depth, ft	10.0		#4 (4.75mm)		---	Plastic Limit	17		
Classification	Sandy CLAY w/ Gravel (CL) - Dark Yellowish Brown, Moist		#16 (1.18mm)		---	Plasticity Index	11		
SAMPLE PROPERTIES		Initial	Final		#30 (0.6mm)	---	Estimated Gs	2.6	
					#100 (0.150mm)	---			
	Mass, g	258.61	260.20		#200 (0.075mm)	---			
	Water Content, %	16.9%	17.6%				k_{avg} , 20°C, cm/s	3.8E-07	
	Dry Unit Weight, pcf	111.1	111.1				Sample Type	MCA	
	Saturation, %	95%	100%				Permeant	Deaired Tap-Water	
	Void Ratio	0.46	0.46			Pipette Area, cm ²	0.0314		
	Diameter, in	2.41	2.41			Annulus Area, cm ²	0.7671		
	Height, in	1.67	1.67			Tested By	AB		
	Area, in ²	4.54	4.54			REMARKS	Test Method: ASTM D5084 (Method F)		
Volume, in ³	7.59	7.59			Estimated Gs provides final saturation of 100%.				
PERMEATION DATA	Trial	Date	Time, sec	Temp _{Avg} , °C	σ' , ksf	μ , ksf	i_o	i_f	k_t , cm/s
	1	7/7/14	399	24.5	1.2	10.4	20.1	12.3	4.2E-07
	2	7/7/14	387	24.5	1.2	10.4	20.1	12.3	4.3E-07
	3	7/7/14	392	24.5	1.2	10.4	20.1	12.3	4.3E-07
	4								
	5								
	6								
SAMPLE IMAGES									

HYDRAULIC CONDUCTIVITY


Blue Lake Levee Evaluation
 Humboldt County, California

SAMPLE ID	Boring Number	D30RL		CLASSIFICATION	Sieve Size	% Passing	Other Parameters			
	Sample Number	2			#3/8-in. (9.5mm)	100	Liquid Limit	---		
Sample Depth, ft	9.0		#4 (4.75mm)	100	Plastic Limit	---				
Classification	Silty SAND (SM) - Dark Grayish Brown, Moist		#16 (1.18mm)	100	Plasticity Index	---				
			#30 (0.6mm)	99.9	Estimated Gs	2.6				
			#100 (0.150mm)	41.2						
			#200 (0.075mm)	16.9						
SAMPLE PROPERTIES		Initial	Final	TEST SUMMARY	k_{avg} 20°C, cm/s					1.3E-03
	Mass, g	405.07	428.81		Sample Type	MCA				
	Water Content, %	22.4%	29.5%		Permeant	Deaired Tap-Water				
	Dry Unit Weight, pcf	90.9	91.6		Pipette Area, cm ²	0.971				
	Saturation, %	74%	100%		Tested By	AB				
	Void Ratio	0.79	0.77	REMARKS	Test Method: ASTM D5084 (Method C)					
	Diameter, in	2.40	2.39		Estimated Gs provides final saturation of 100%.					
	Height, in	3.08	3.07							
	Area, in ²	4.51	4.49							
	Volume, in ³	13.88	13.77							
PERMEATION DATA	Trial	Date	Time, sec	Temp _{Avg} , °C	σ' , ksf	μ , ksf	i_o	i_f	k_t , cm/s	
	1	7/21/14	365	24.0	1.2	11.7	0.9	0.1	1.4E-03	
	2	7/21/14	350	24.0	1.2	11.7	0.9	0.1	1.5E-03	
	3	7/21/14	354	24.0	1.2	11.7	0.9	0.1	1.4E-03	
	4	7/21/14	355	24.0	1.2	11.7	0.9	0.1	1.5E-03	
	5									
	6									
SAMPLE IMAGES										

SAMPLE ID	Boring Number	D49RW		CLASSIFICATION	Sieve Size	% Passing	Other Parameters		
	Sample Number	1b			3/8-in. (9.5mm)	100	Liquid Limit	---	
Sample Depth, ft	6.0		#4 (4.75mm)	98.5	Plastic Limit	---			
Classification	Clayey SAND (SC) - Very Dark Grayish Brown, Moist		#16 (1.18mm)	91.3	Plasticity Index	---			
SAMPLE PROPERTIES		Initial	Final	#30 (0.6mm)	88.6	Estimated Gs	2.67		
				#100 (0.150mm)	68.7				
	Mass, g	429.86	432.85	#200 (0.075mm)	44.6				
	Water Content, %	22.3%	23.1%			k_{avg} , 20°C, cm/s	7.5E-07		
	Dry Unit Weight, pcf	101.7	102.8			Sample Type	MCA		
	Saturation, %	93%	100%			Permeant	Deaired Tap-Water		
	Void Ratio	0.64	0.62			Pipette Area, cm ²	0.0314		
	Diameter, in	2.40	2.39			Annulus Area, cm ²	0.7671		
	Height, in	2.92	2.90			Tested By	AB		
	Area, in ²	4.52	4.49			REMARKS	Test Method: ASTM D5084 (Method F)		
Volume, in ³	13.17	13.02				Estimated Gs provides final saturation of 100%.			
PERMEATION DATA	Trial	Date	Time, sec	Temp _{Avg} , °C	σ' , ksf	μ , ksf	i_o	i_f	k_t , cm/s
	1	7/30/14	425	24.5	0.7	11.5	20.1	11.2	8.4E-07
	2	7/30/14	325	24.5	0.7	11.5	20.1	13.0	8.2E-07
	3	7/30/14	322	24.5	0.7	11.5	20.1	13.0	8.3E-07
	4	7/30/14	315	24.5	0.7	11.5	20.1	13.0	8.4E-07
	5								
	6								
SAMPLE IMAGES									


HYDRAULIC CONDUCTIVITY

Blue Lake Levee Evaluation
 Humboldt County, California

SAMPLE ID	Boring Number	D59RW		CLASSIFICATION	Sieve Size	% Passing	Other Parameters		
	Sample Number	1			3/8-in. (9.5mm)	---	Liquid Limit	37	
Sample Depth, ft	4.5		#4 (4.75mm)	---	Plastic Limit	18			
Classification	Lean CLAY w/ Sand (CL) - Very Dark Grayish Brown, Moist		#16 (1.18mm)	---	Plasticity Index	18			
SAMPLE PROPERTIES		Initial	Final	#30 (0.6mm)	---	Estimated Gs	2.7		
				#100 (0.150mm)	---				
	Mass, g	230.97	232.85	#200 (0.075mm)	---				
	Water Content, %	25.8%	26.8%			k_{avg} , 20°C, cm/s	4.1E-08		
	Dry Unit Weight, pcf	97.2	97.8			Sample Type	MCA		
	Saturation, %	95%	100%			Permeant	Deaired Tap-Water		
	Void Ratio	0.73	0.72			Pipette Area, cm ²	0.0314		
	Diameter, in	2.41	2.41			Annulus Area, cm ²	0.7671		
	Height, in	1.58	1.58			Tested By	AB		
	Area, in ²	4.56	4.54			REMARKS	Test Method: ASTM D5084 (Method F)		
Volume, in ³	7.20	7.15				Estimated Gs provides final saturation of 100%.			
PERMEATION DATA									
	Trial	Date	Time, sec	Temp _{Avg} , °C	σ' , ksf	μ , ksf	i_o	i_f	k_t , cm/s
	1	7/30/14	921	25.0	0.7	11.6	30.1	26.5	4.5E-08
	2	7/30/14	823	25.0	0.7	11.6	30.1	26.8	4.6E-08
	3	7/30/14	804	25.0	0.7	11.6	30.1	26.8	4.7E-08
	4	7/30/14	828	25.0	0.7	11.6	30.1	26.8	4.5E-08
	5								
6									
SAMPLE IMAGES									


HYDRAULIC CONDUCTIVITY

Blue Lake Levee Evaluation
 Humboldt County, California

SAMPLE ID	Boring Number	D59RW		CLASSIFICATION	Sieve Size	% Passing	Other Parameters			
	Sample Number	3a			#3/8-in. (9.5mm)	100	Liquid Limit	---		
Sample Depth, ft	14.5		#4 (4.75mm)	99.6	Plastic Limit	---				
Classification	Poorly-Graded SAND w/ Silt (SP-SM) - Dark Grayish Brown, Moist		#16 (1.18mm)	97.8	Plasticity Index	---				
			#30 (0.6mm)	93.1	Estimated Gs	2.6				
			#100 (0.150mm)	24.5						
			#200 (0.075mm)	10.8						
SAMPLE PROPERTIES		Initial	Final	TEST SUMMARY	k_{avg} 20°C, cm/s					1.4E-04
	Mass, g	441.53	442.67		Sample Type	MCA				
	Water Content, %	26.4%	26.7%		Permeant	Deaired Tap-Water				
	Dry Unit Weight, pcf	95.9	95.9		Pipette Area, cm ²	0.971				
	Saturation, %	99%	100%		Tested By	AB				
	Void Ratio	0.69	0.69	REMARKS	Test Method: ASTM D5084 (Method C)					
	Diameter, in	2.40	2.40		Estimated Gs provides final saturation of 100%.					
	Height, in	3.08	3.08							
	Area, in ²	4.51	4.51							
	Volume, in ³	13.88	13.88							
PERMEATION DATA	Trial	Date	Time, sec	Temp _{Avg} , °C	σ' , ksf	μ , ksf	i_o	i_f	k_t , cm/s	
	1	7/21/14	652	24.0	1.7	10.3	0.9	0.7	1.4E-04	
	2	7/21/14	576	24.0	1.7	10.3	0.9	0.6	1.6E-04	
	3	7/21/14	575	24.0	1.7	10.3	0.9	0.6	1.6E-04	
	4	7/21/14	643	24.0	1.7	10.3	0.9	0.6	1.6E-04	
	5	7/21/14	581	24.0	1.7	10.3	0.9	0.6	1.6E-04	
	6									
SAMPLE IMAGES										

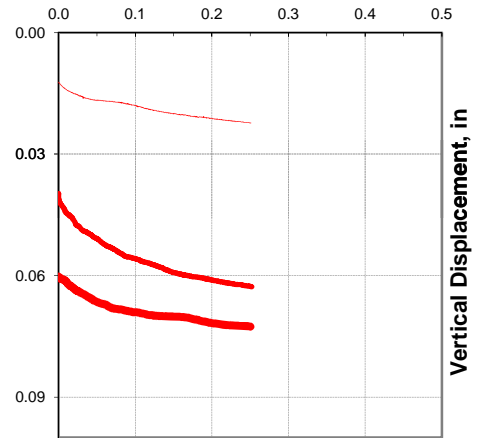
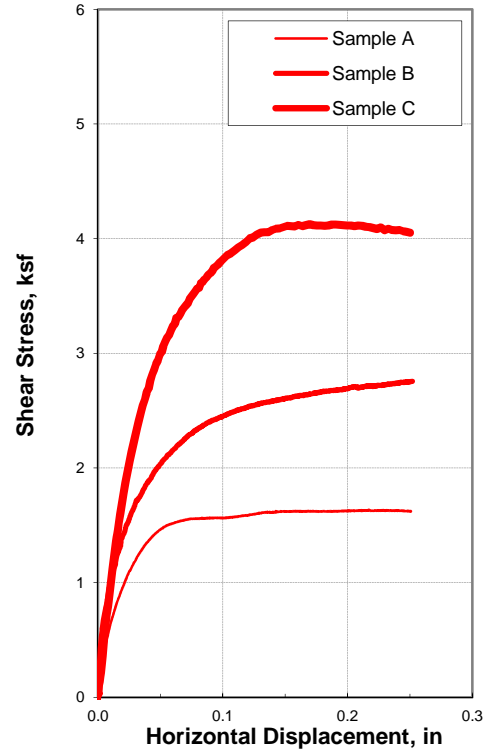
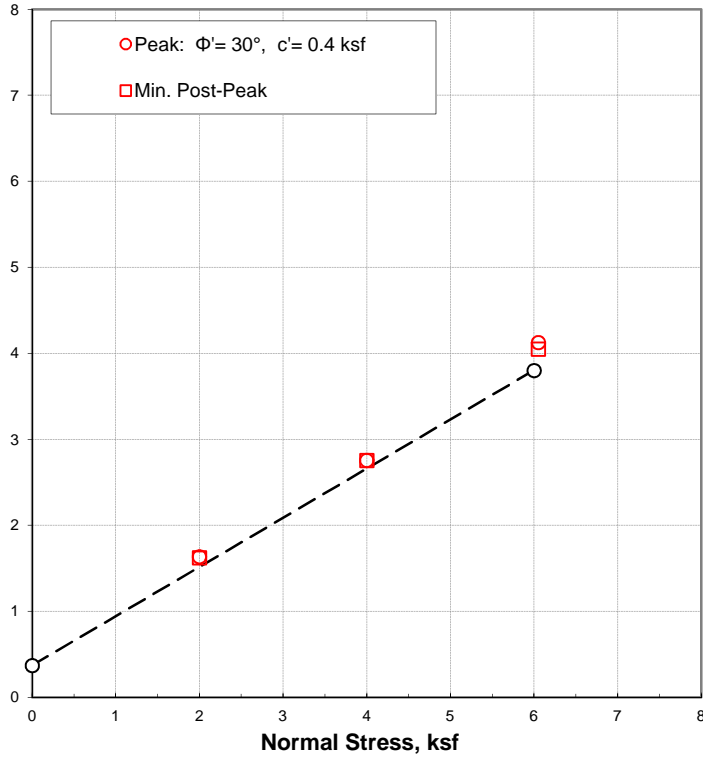
HYDRAULIC CONDUCTIVITY

Blue Lake Levee Evaluation
 Humboldt County, California

SAMPLE ID	Boring Number	D70RW		CLASSIFICATION	Sieve Size	% Passing	Other Parameters		
	Sample Number	2			3/8-in. (9.5mm)	---	Liquid Limit	38	
Sample Depth, ft	10.0		#4 (4.75mm)	---	Plastic Limit	17			
Classification	Lean CLAY (CL) - Dark Grayish Brown, Moist		#16 (1.18mm)	---	Plasticity Index	21			
			#30 (0.6mm)	---	Estimated Gs	2.7			
SAMPLE PROPERTIES		Initial	Final	#100 (0.150mm)	---				
	Mass, g	173.56	174.15	#200 (0.075mm)	---				
	Water Content, %	28.4%	28.8%			k_{avg} , 20°C, cm/s	9.3E-08		
	Dry Unit Weight, pcf	94.0	94.9			Sample Type	MCA		
	Saturation, %	97%	100%			Permeant	Deaired Tap-Water		
	Void Ratio	0.79	0.78			Pipette Area, cm ²	0.0314		
	Diameter, in	2.39	2.39			Annulus Area, cm ²	0.7671		
	Height, in	1.22	1.21			Tested By	AB		
	Area, in ²	4.49	4.49			REMARKS	Test Method: ASTM D5084 (Method F)		
	Volume, in ³	5.48	5.43				Estimated Gs provides final saturation of 100%.		
PERMEATION DATA									
	Trial	Date	Time, sec	Temp _{Avg} , °C	σ' , ksf	μ , ksf	i_o	i_f	k_t , cm/s
	1	7/7/14	822	24.5	1.2	10.2	29.8	21.3	1.0E-07
	2	7/7/14	864	24.5	1.2	10.2	29.8	21.3	9.9E-08
	3	7/7/14	811	24.5	1.2	10.2	29.8	21.3	1.1E-07
	4								
	5								
6									
SAMPLE IMAGES									

HYDRAULIC CONDUCTIVITY

Blue Lake Levee Evaluation
 Humboldt County, California

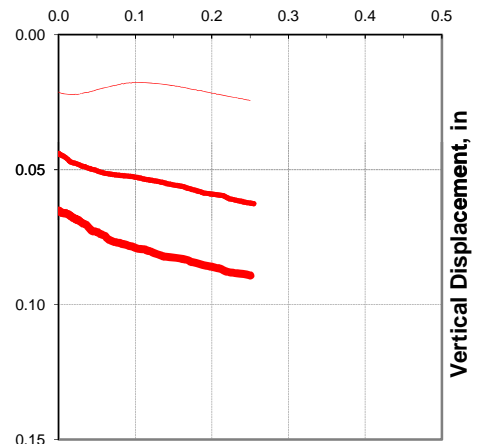
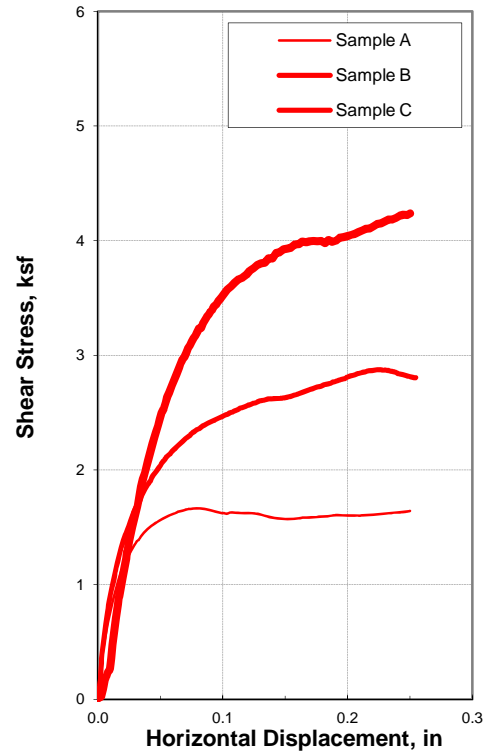
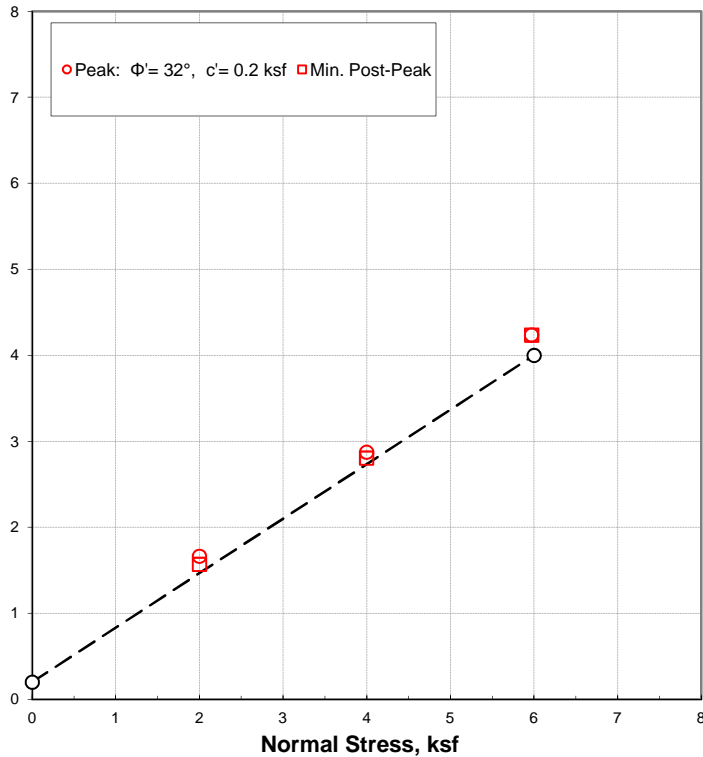


SAMPLE ID	Boring Number:	D20RC			
	Sample Number:	1			
	Sample Depth:	4.5 ft			
	USCS Classification:	Sandy CLAY (CL): yellowish brown, with few gravels			
INITIAL	Specimen	A	B	C	D
	Water Content, %	16.9%	16.9%	16.9%	
	Dry Unit Weight, pcf	104.0	107.1	108.3	
	Saturation, %	76%	83%	85%	
	Void Ratio	0.59	0.54	0.53	
	Diameter, in	2.42	2.42	2.42	
FINAL	Water Content, %	26.5%	21.0%	20.1%	
	Dry Unit Weight, pcf	97.2	106.4	108.0	
	Void Ratio	0.70	0.55	0.53	
TEST SUMMARY	Displacement at Peak, in	0.22	0.25	0.17	
	Displacement Rate, in/min	0.000	0.000	0.000	
	Normal Stress, ksf	2.0	4.0	6.1	
	Peak Shear Stress, ksf	1.64	2.76	4.13	
	Min. Post-Peak Stress, ksf	1.62	2.75	4.05	
	REMARKS	Test Method: ASTM D3080			

CLASSIFICATION	Sieve Size	% Passing
	3/8-in. (9.5mm)	---
	#4 (4.75mm)	---
	#16 (1.18mm)	---
	#30 (0.6mm)	---
	#100 (0.150mm)	---
	#200 (0.075mm)	---
Atterberg Limits		
Liquid Limit, %	---	
Plastic Limit, %	---	
Plasticity Index, %	---	
Estimated Gs	2.65	
k_{avg} 20°C, cm/sec	---	

DIRECT SHEAR TEST RESULTS

Blue Lake Levee Evaluation
 Humboldt County, California

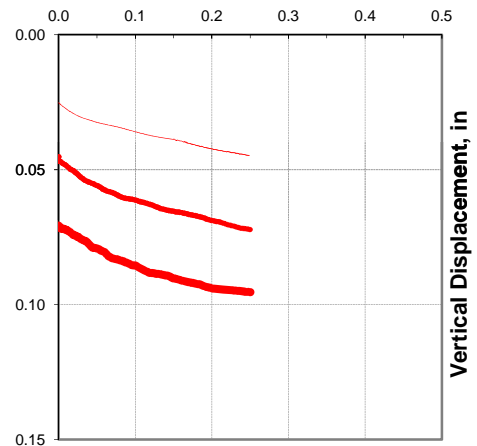
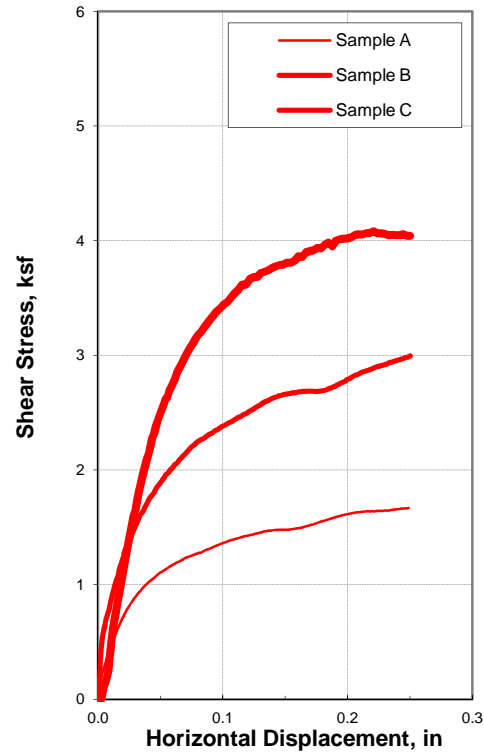
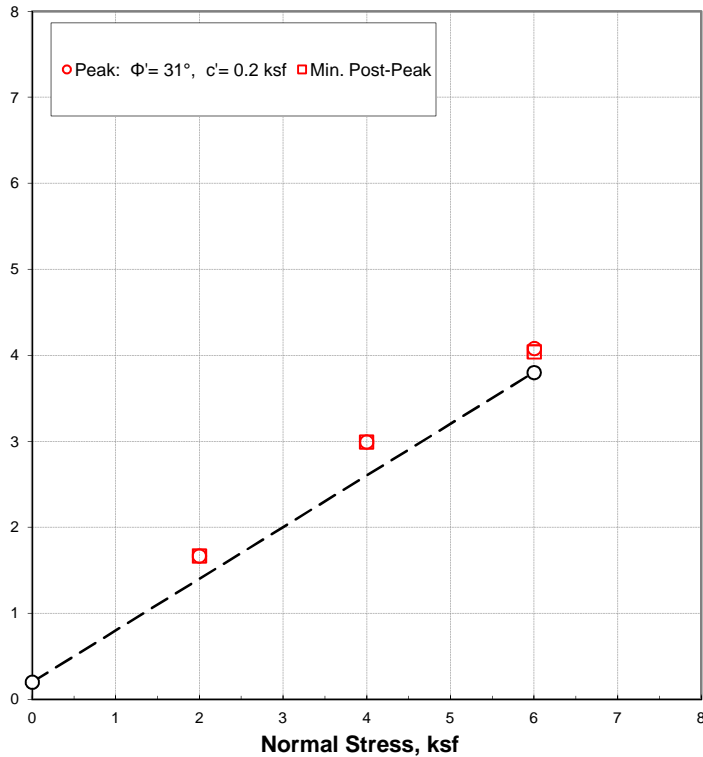


SAMPLE ID	Boring Number:	D30RC			
	Sample Number:	5b			
	Sample Depth:	20.5 ft			
	USCS Classification:	Silty SAND(SM);brown to grayish brown, moist			
INITIAL	Specimen	A	B	C	D
	Water Content, %	20.2%	20.2%	20.2%	
	Dry Unit Weight, pcf	99.7	100.3	99.1	
	Saturation, %	81%	82%	80%	
	Void Ratio	0.66	0.65	0.67	
FINAL	Water Content, %	26.9%	26.0%	25.8%	
	Dry Unit Weight, pcf	96.5	97.9	98.1	
	Void Ratio	0.71	0.69	0.69	
TEST SUMMARY	Displacement at Peak, in	0.08	0.22	0.25	
	Displacement Rate, in/min	0.002	0.002	0.002	
	Normal Stress, ksf	2.0	4.0	6.0	
	Peak Shear Stress, ksf	1.66	2.87	4.24	
	Min. Post-Peak Stress, ksf	1.57	2.81	4.24	
	Test Method: ASTM D3080				
REMARKS					

CLASSIFICATION	Sieve Size	% Passing
	3/8-in. (9.5mm)	---
#4 (4.75mm)	---	
#16 (1.18mm)	---	
#30 (0.6mm)	100	
#100 (0.150mm)	84	
#200 (0.075mm)	45.6	
Atterberg Limits		
Liquid Limit, %	---	
Plastic Limit, %	---	
Plasticity Index, %	---	
Estimated Gs	2.65	
k _{avg} 20°C, cm/sec	---	

DIRECT SHEAR TEST RESULTS

Blue Lake Levee Evaluation
 Humboldt County, California

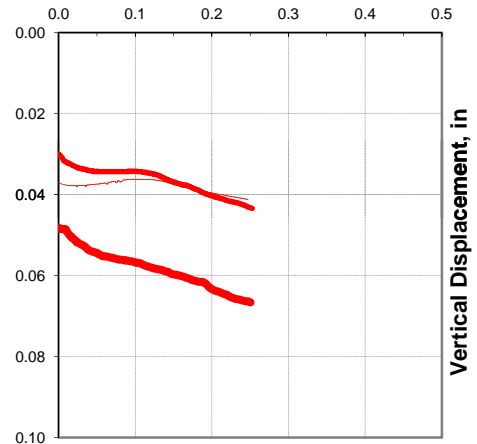
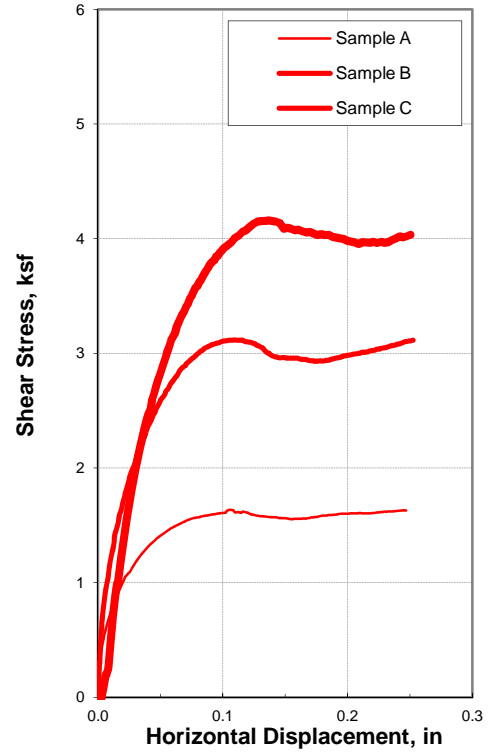
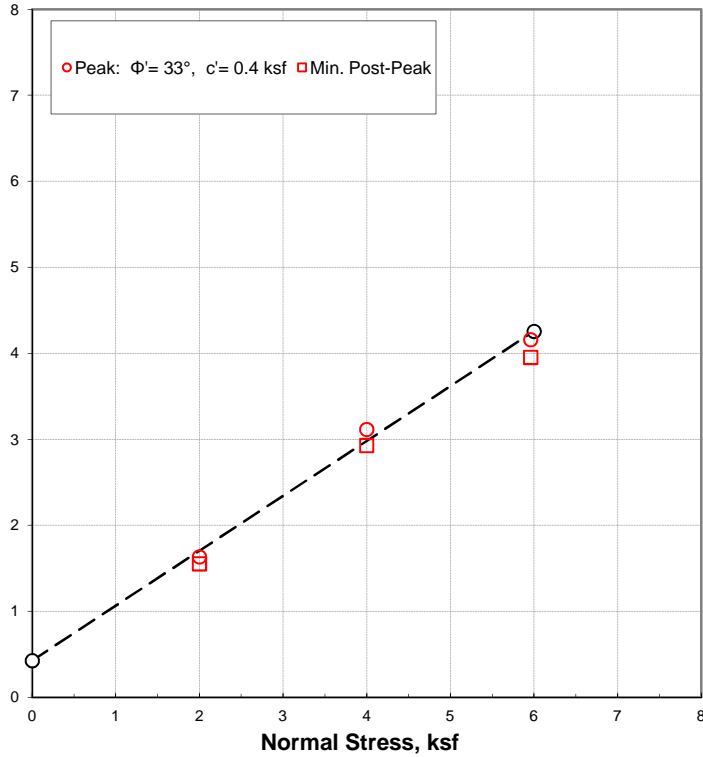


SAMPLE ID	Boring Number:	D49RO			
	Sample Number:	1			
	Sample Depth:	4.5 ft			
	USCS Classification:	Silty SAND(SM); very dark gray, slightly moist, with rootlets			
INITIAL	Specimen	A	B	C	D
	Water Content, %	18.1%	18.1%	18.1%	
	Dry Unit Weight, pcf	98.6	98.3	100.9	
	Saturation, %	71%	70%	75%	
	Void Ratio	0.68	0.68	0.64	
FINAL	Water Content, %	26.9%	25.0%	24.7%	
	Dry Unit Weight, pcf	96.4	99.5	100.0	
	Void Ratio	0.72	0.66	0.65	
TEST SUMMARY	Displacement at Peak, in	0.25	0.25	0.22	
	Displacement Rate, in/min	0.001	0.001	0.001	
	Normal Stress, ksf	2.0	4.0	6.0	
	Peak Shear Stress, ksf	1.67	2.99	4.08	
	Min. Post-Peak Stress, ksf	1.67	2.99	4.04	
	Test Method: ASTM D3080				
REMARKS					

CLASSIFICATION	Sieve Size	% Passing
	3/8-in. (9.5mm)	---
	#4 (4.75mm)	---
	#16 (1.18mm)	---
	#30 (0.6mm)	100
	#100 (0.150mm)	95
	#200 (0.075mm)	48.8
	Atterberg Limits	
Liquid Limit, %	---	
Plastic Limit, %	---	
Plasticity Index, %	---	
Estimated Gs	2.65	
k_{avg} 20°C, cm/sec	---	

DIRECT SHEAR TEST RESULTS

Blue Lake Levee Evaluation
 Humboldt County, California

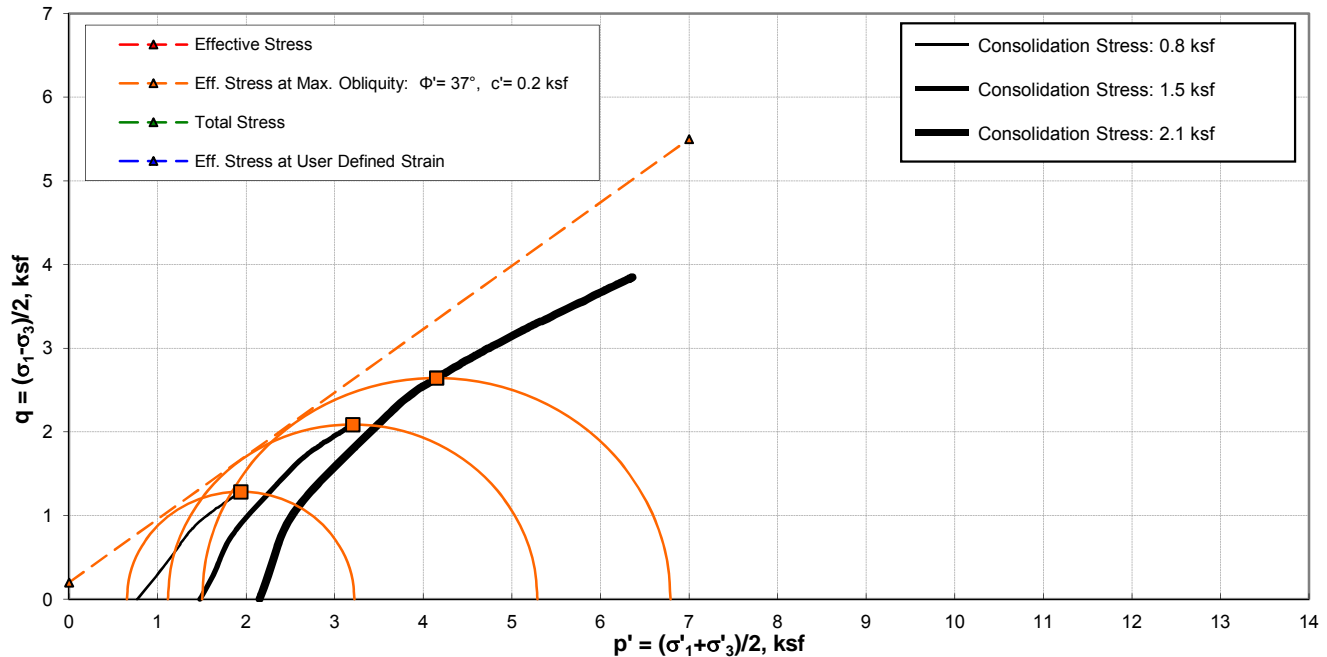


SAMPLE ID	Boring Number:	D59RC			
	Sample Number:	3a			
	Sample Depth:	15.5 ft			
	USCS Classification:	Silty SAND(SM);grayish brown, moist			
INITIAL	Specimen	A	B	C	D
	Water Content, %	16.3%	16.3%	16.3%	
	Dry Unit Weight, pcf	110.5	110.6	110.4	
	Saturation, %	87%	87%	87%	
	Void Ratio	0.50	0.50	0.50	
	Diameter, in	2.42	2.42	2.42	
FINAL	Water Content, %	18.1%	17.0%	16.9%	
	Dry Unit Weight, pcf	111.7	114.2	114.1	
	Void Ratio	0.48	0.45	0.45	
TEST SUMMARY	Displacement at Peak, in	0.11	0.11	0.14	
	Displacement Rate, in/min	0.001	0.001	0.001	
	Normal Stress, ksf	2.0	4.0	6.0	
	Peak Shear Stress, ksf	1.63	3.12	4.16	
	Min. Post-Peak Stress, ksf	1.55	2.93	3.95	
	REMARKS	Test Method: ASTM D3080			

CLASSIFICATION	Sieve Size	% Passing
	3/8-in. (9.5mm)	---
	#4 (4.75mm)	---
	#16 (1.18mm)	---
	#30 (0.6mm)	---
	#100 (0.150mm)	---
	#200 (0.075mm)	---
Atterberg Limits		
Liquid Limit, %	Non-plastic	
Plastic Limit, %	Non-plastic	
Plasticity Index, %	Non-plastic	
Estimated Gs	2.65	
k_{avg} 20°C, cm/sec	---	

DIRECT SHEAR TEST RESULTS

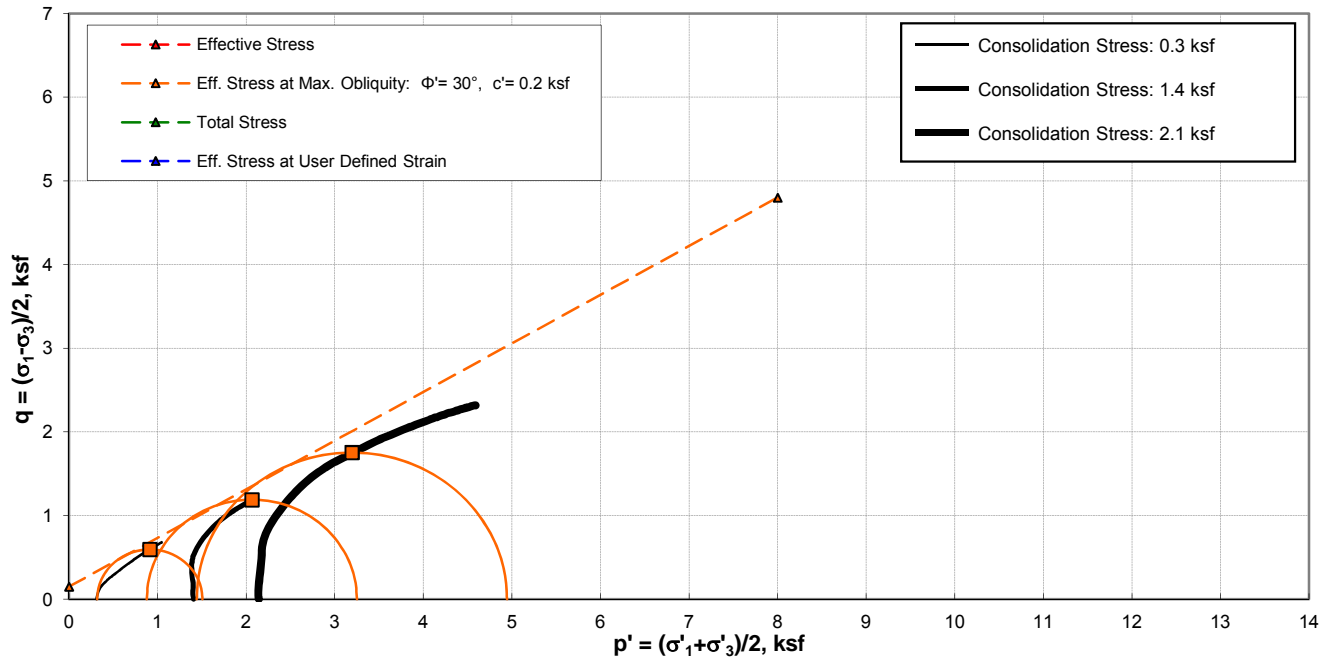
Blue Lake Levee Evaluation
 Humboldt County, California



SAMPLE ID	Boring Number D30RC			CLASSIFICATION	Trial ID	A	B	C	
	Sample Number	2a			Liquid Limit	30	---	---	
Specimen Depth	7.0 ft			Plastic Limit	17	---	---		
USCS Classification	Sandy CLAY w/ Gravel (SC) - Dark Yellowish Brown, Moist			Plastic Index	13	---	---		
				Passing #4 (4.75 mm)	76.0%	---	---		
				Passing #200 (0.075 mm)	33.0%	---	---		
				Estimated Gs	2.65	2.65	2.65		
INITIAL	Trial ID	A	B	C	TEST SUMMARY	Trial ID	A	B	C
	Water Content, %	17.2%	19.8%	19.5%		B-Parameter	0.95	0.95	0.95
	Dry Unit Weight, pcf	106.6	108.5	109.0		t ₅₀ , minutes	N/A	N/A	N/A
	Saturation, %	83%	100%	100%		Strain Rate, %/min	0.02	0.02	0.02
	Void Ratio	0.55	0.52	0.52		Cell Pressure, ksf	10.8	11.6	12.3
	Diameter, in	2.42	2.43	2.45		Back Pressure, ksf	10.1	10.1	10.1
	Height, in	4.91	4.80	4.71		Consolidation Stress, ksf	0.8	1.5	2.1
PRE-SHEAR	Water Content, %	19.8%	19.5%	19.2%		Deviator Stress @ Failure, ksf	2.5	4.1	5.2
	Dry Unit Weight, pcf	108.5	109.0	109.5		Axial Strain @ Failure, %	2.7	4.9	5.8
	Saturation, %	100%	100%	100%		σ'₁F, ksf	3.2	5.2	6.7
	Void Ratio	0.52	0.52	0.51		σ'₃F, ksf	0.7	1.1	1.5
REMARKS	Test Method: ASTM 4767 (modified for staged testing)			Tested By:		AB	AB	AB	
	Pocket Pen Reading (Qu in tsf) 4.50			Date Tested:		7/14/14	7/15/14	7/16/14	

ISOTROPICALLY CONSOLIDATED, UNDRAINED TRIAXIAL TEST WITH PORE WATER PRESSURE MEASUREMENTS

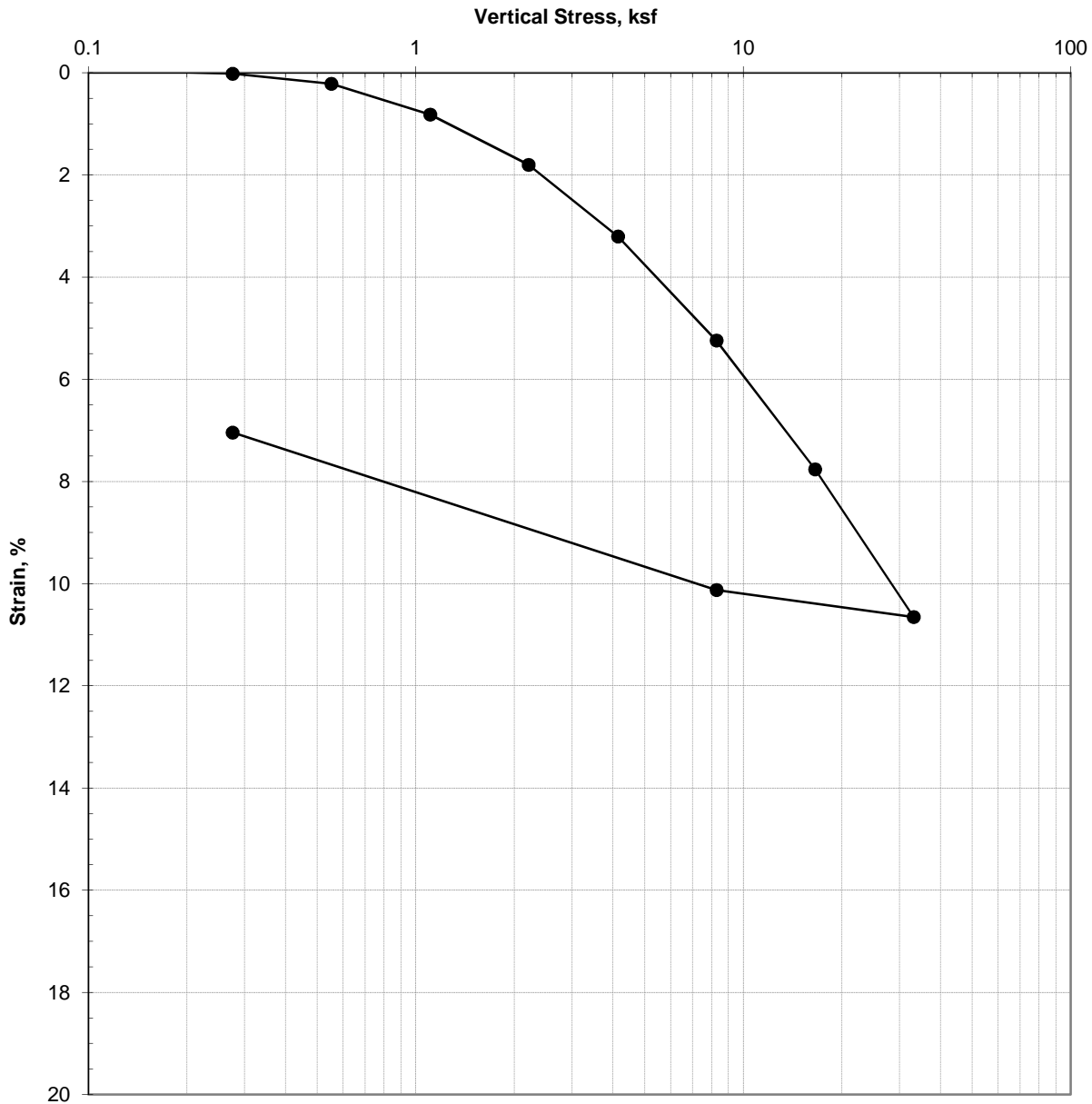
Blue Lake Levee Evaluation
 Humboldt County, California



SAMPLE ID	Boring Number D70RC			CLASSIFICATION	Trial ID	A	B	C
	Sample Number 3				Liquid Limit	30	---	---
Specimen Depth 15.0 ft			Plastic Limit	16	---	---		
USCS Classification Lean CLAY (CL) - Olive, Moist			Plastic Index	20	---	---		
			Passing #4 (4.75 mm)	---	---	---		
			Passing #200 (0.075 mm)	98.3%	---	---		
			Estimated Gs	2.70	2.70	2.70		
INITIAL	Trial ID			TEST SUMMARY	Trial ID	A	B	C
	Water Content, %				B-Parameter	0.95	0.95	0.95
	Dry Unit Weight, pcf				t ₅₀ , minutes	N/A	N/A	N/A
	Saturation, %				Strain Rate, %/min	0.00	0.02	0.02
	Void Ratio				Cell Pressure, ksf	11.1	11.6	12.4
	Diameter, in				Back Pressure, ksf	10.8	10.2	10.2
	Height, in				Consolidation Stress, ksf	0.3	1.4	2.1
PRE-SHEAR	Water Content, %				Deviator Stress @ Failure, ksf	1.2	2.3	3.5
	Dry Unit Weight, pcf				Axial Strain @ Failure, %	2.0	4.5	6.5
	Saturation, %				σ' _{1F} , ksf	1.5	3.2	4.9
	Void Ratio				σ' _{3F} , ksf	0.3	0.9	1.4
REMARKS	Test Method: ASTM 4767 (modified for staged testing)				Tested By:	AB	AB	AB
	Torvane Reading (Su in ksf)				Date Tested:	7/10/14	7/11/14	7/12/14
	Pocket Pen Reading (Qu in tsf)							

ISOTROPICALLY CONSOLIDATED, UNDRAINED TRIAXIAL TEST WITH PORE WATER PRESSURE MEASUREMENTS

Blue Lake Levee Evaluation
 Humboldt County, California



SAMPLE ID	Boring, Sample #, Depth	D59RL , #1 , 5.0 ft		SUMMARY	Preconsolidation Pressure, ksf	---
	USCS Classification:	Sandy SILT (ML): dark grayish brown, moist			Inundation Increment, ksf	0.10
PROPERTIES		Initial	Final		Liquid Limit	---
	Water Content, %	22.5%	18.9%		Plastic Limit	---
	Dry Unit Weight, pcf	103.3	111.1		Plasticity Index	---
	Saturation, %	99%	102%		Passing #200	---
	Void Ratio	0.60	0.49		Estimated Gs	2.65
	Diameter, in	2.42	2.42		REMARKS	Test Method: D2435
	Height, in	0.81	0.76			

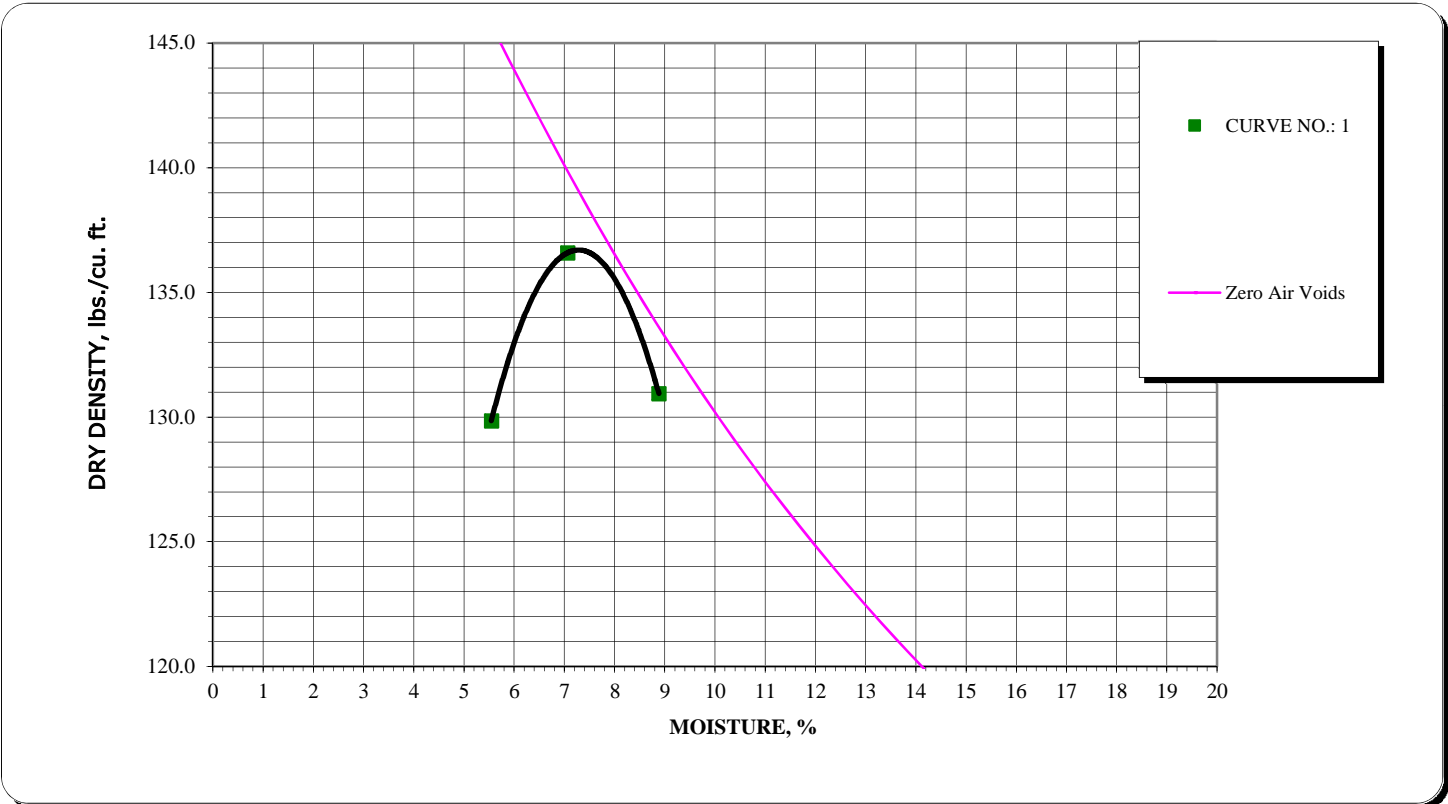
CONSOLIDATION TEST RESULTS
 Blue Lake Levee Evaluation
 Humboldt County, California

MOISTURE DENSITY RELATIONSHIP

Client: Humboldt County	Job No.: 14-1949.02
Project: Blue Lake Levee evaluation	Lab No.: 7604
Location: Blue Lake	
Material Description: Sand	CURVE NO.: 1
Material Supplier: NA	
Material Type: On-site	
Sample Location: D30RC BI @ 15-20	
Sampled By: JB	Date Sampled:
Received By: DL	Date Received:
Tested By: JFB	Date Tested: 16-Jul-14
Reviewed By: AB	Date Reviewed:
Test Procedure: ASTM	Method: D-1557

Oversized Material (%), +3/4": 2.3%

Correction Required: No



SPECIMEN	A	B	C	D
MOISTURE AT TEST, %	7.1	8.9	5.5	
DRY DENSITY	136.6	130.9	129.9	

Maximum Dry Density, PCF	136.8
With 10% Rock Correction	139.4
With 20% Rock Correction	142.1
With 30% Rock Correction	145.0

@ Optimum Moisture, %	7.2
Corrected Moisture Content	6.5
Corrected Moisture Content	5.8
Corrected Moisture Content	5.0

Form updated: 7/31/2013 jlh

APPENDIX D
GEOTECHNICAL ANALYSES

APPENDIX D SOIL PARAMETER SYNTHESIS

INTRODUCTION

This appendix presents a synthesis of soil property data and summarizes soil parameters used for evaluations. Parameters include unit weight, permeability, and shear strength. Parameters were developed from field exploration (drill holes, CPTs and pumping tests) and laboratory tests performed for the Blue Lake Levee Evaluation. This appendix should not be used independently from the geotechnical report.

Geotechnical design values for impervious and pervious (sand and gravel) materials were also included in the *Detailed Project Report* (USACE, 1962). Listed values include dry unit weights, moist weights, saturated weights, buoyed weights, and shear strength parameters. These values are presented on Plate A-8.

UNIT WEIGHT

Plate D-1 presents a plot of measured dry density versus elevation for pervious and impervious fill and foundation soils for selected samples from drill holes. Fill soils are composed of both granular, generally pervious material and fine-grained, generally impervious material.

Plate D-2 presents a plot of measured total unit weight versus elevation for pervious and impervious fill and foundation soils. Selected dry and total unit weight values are summarized on Plate D-3.

Based on a review of USACE (1962), we assumed the pervious fill material was sourced from local stream deposits. Although estimated unit weights for two existing fill samples tested by the USACE (1962) were approximately 101 and 113 pcf, we selected a value of 120 pcf based on the estimated density of sandy and gravelly materials encountered below the levee fill (i.e., pervious foundation materials).

PERMEABILITY

Fines Content and D_{10}

Fines content is the percentage of soil passing the No. 200 sieve (0.074 mm particle size). Measured values are plotted on Plate D-4 versus elevation. Most of the data are for pervious foundation soils between elevations +55 and +85 feet.

The D_{10} value is defined as the diameter where 10-percent of the grains are smaller in diameter. Measured values of D_{10} are plotted on Plate D-5 versus elevation. Most of the data are for sandy alluvial soils between elevations +55 and +85 feet.

As indicated on Plate D-4, fines content data for pervious foundation soils suggest those soils consist primarily of sand with silt and gravel, and gravel with silt and sand, with fines

content between 5- and 12-percent. As indicated on Plate D-5, D_{10} values for pervious foundation soils range from about 0.01 to 1.0 mm.

Saturated Permeability for Pervious Soil

Plate D-6 presents a plot of estimated permeability data for levee fill materials that includes laboratory testing estimates and empirical permeability estimates based on Chapuis (2004) using D_{10} and void ratio values. Plate D-7 presents a plot of estimated permeability data for levee foundation materials that includes empirical permeability estimates from D_{10} values and laboratory testing estimates from this study and USACE (1962).

Pertinent points about the data sets shown on Plates D-6 and D-7 include the following:

- Permeability estimates based on D_{10} values are primarily pertinent to pervious soils;
- Permeability values measured in laboratory on samples collected during field investigation are representative of vertical permeability; and
- Permeability estimates using D_{10} and void ratio are representative of vertical permeability

As shown on Plate D-6, limited data was collected for the levee fill materials. Plate D-7 shows permeability variations of about $3\frac{1}{2}$ orders of magnitude for primarily coarse-grained soils. Permeability of pervious soils is dependent on grain size variations and fines content; hence, variation over more than one order of magnitude is not uncommon.

Selected Saturated Permeability

Selected saturated permeability values for different materials anticipated for the levee project are summarized on Plate D-8. Both horizontal (k_h) and vertical permeability (k_v) values are required for numerical seepage modeling. Permeability values are assigned by inputting the saturated permeability in the horizontal direction, and the vertical to horizontal permeability ratio (k_v/k_h).

Unsaturated Permeability

For steady seepage conditions, unsaturated zones will occur within the levee fill. Seepage modeling of unsaturated zones requires variations of unsaturated permeability as a function of matric suction (air pressure minus pore pressure). Unsaturated permeability estimates are typically based on laboratory measured volumetric water content versus matric suction variations and theoretical/empirical derivations of unsaturated permeability.

Because no direct measurements of volumetric water content versus matric suction were performed, curves for volumetric water content and unsaturated permeability were estimated using generic curves programmed into SLIDE for anticipated levee fill and foundation materials.

SHEAR STRENGTH

Summary

Shear strength parameters are summarized on Plate D-9 for levee and foundation materials. Shear strength parameters were developed from field and laboratory data, and as described below.

For slope stability evaluations, different shear strength parameters are applied for different conditions, which include the following:

- Analyses for long-term, steady state seepage conditions apply drained shear strength (or effective stress) parameters for all soil types;
- Analyses for rapid drawdown conditions apply drained parameters for pervious soils and consolidated-undrained or R-envelope parameters for impervious soils; and
- Analyses for seismic conditions apply drained parameters for pervious soils and undrained parameters for impervious soils.

Drained Shear Strength for Foundation Soils

Pervious Materials. Direct shear testing was performed on selected samples of fill and coarse-grained alluvium. Individual tests results are presented in Appendix C. Based on a review of USACE (1962), we assumed the pervious fill material was sourced from local stream deposits. Thus, we assumed strength properties for both the pervious fill and foundation material are generally similar.

Plate D-10 presents a summary plot of direct shear data for pervious fill and foundation material. USACE (1962) lists three friction angles based on direct shear tests of undisturbed samples ranging between 27 and 30 degrees for the pervious materials. However, individual test data points were not provided and as a result, were not included on the summary plot. For this study, a friction angle of 33 degrees was interpreted. For slope stability analyses, zero cohesion was assumed for the pervious foundation material. An effective or “apparent” cohesion of 25 psf was assumed for the pervious fill material to approximate the low effective shear strength effects for unsaturated shear strength within the levee fill and surficial strength provided by vegetation.

The friction angle for pervious materials was compared to friction angle estimates based on CPT tip resistance. CPT-based friction angle estimates are generally higher than the value interpreted from direct shear data.

Impervious Materials. Direct shear tests and consolidated-undrained (CU) triaxial shear tests with pore pressure measurements were performed to develop strength parameters for impervious materials. Individual test results are presented in Appendix C. Based on a review of USACE (1962), we assumed the impervious fill material was imported from sources within 1½ to 3 miles of the site. Thus, we assumed strength properties for the impervious fill and foundation material are generally dissimilar.

Drained Shear Strength. Plates D-11 and D-12 present shear strength data used to develop drained strength parameters for impervious fill and impervious foundation material, respectively. Direct shear data and staged consolidated-undrained (CU) Mohr-circle data are plotted with final p-q values shown for each CU test stage. The q value is the maximum shear stress [$q=(\sigma_{1f}-\sigma_{3f})/2=(\sigma_{1f}'-\sigma_{3f}')/2$] and p' is the mean effective stress [$p'=(\sigma_{1f}'+\sigma_{3f}')/2$]. The estimated envelope shown was plotted to approximate a line tangent to CU Mohr-circle data and aligned with the general trend of direct shear data.

USACE (1962) lists two friction angles based on direct shear tests of remolded samples as 23 and 29 degrees for the impervious fill materials, with cohesion values of 300 psf and 80 psf, respectively. However, individual test data points were not provided and as a result, were not included on Plate D-11. A friction angle of 30 degrees and 300 psf cohesion was interpreted from drained shear strength results for impervious fill material.

In addition, USACE (1962) lists three friction angles based on direct shear tests of undisturbed samples ranging from 25 to 28 degrees for the impervious foundation materials with cohesion values ranging from zero to 300 psf, respectively. Individual test data points were not provided and as a result, were not included on Plate D-12. A friction angle of 31 degrees and 200 psf cohesion was interpreted from drained shear strength results for impervious foundation material.

Consolidated-Undrained Shear Strength. R-envelope shear strength parameters used for rapid drawdown slope stability analyses are plotted on Plates D-13 and D-14. The R-envelope is sometimes incorrectly referred to as a total stress envelope. The c_R and ϕ_R values are used by SLIDE (Rocscience, 2014) for rapid drawdown analyses. Plates D-13 and D-14 present plots developed with CU test data for impervious fill and foundation samples, respectively, along with interpreted c_R and ϕ_R values.

Undrained Shear Strength for Impervious Material

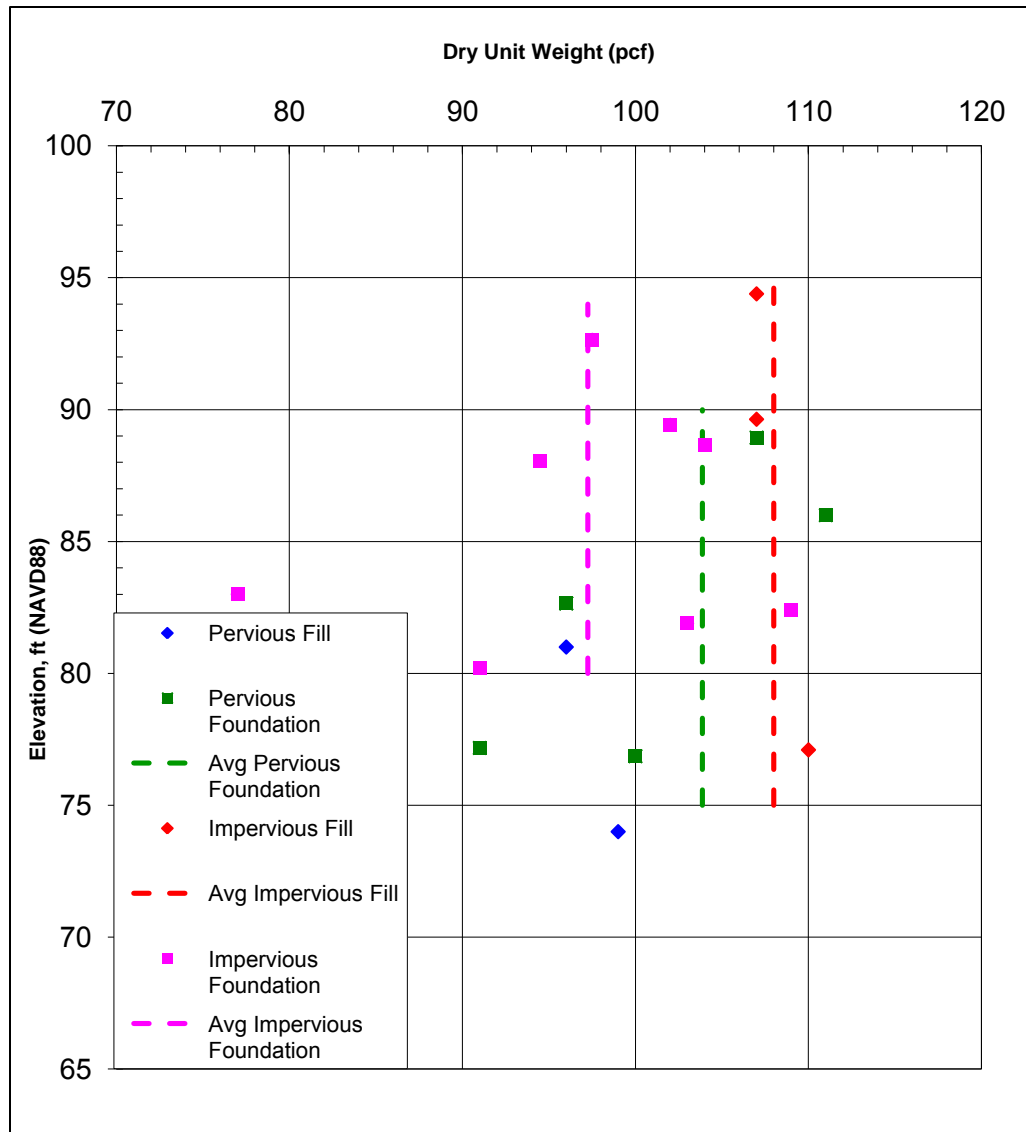
Undrained shear strength data is available for impervious fill and foundation material from field pocket penetrometer measurements, field torvane measurements, and CPT interpretations. Summary plots of undrained shear strength versus elevation are presented as Plates D-15 and D-16 for impervious fill and foundation material.

As shown on Plate D-15, limited data was collected for the impervious levee fill material. Pocket penetrometer and torvane data plotted on Plate D-16 generally correlate well with CPT-interpreted undrained shear strength for the impervious foundation material. Undrained shear strength values of 2,000 psf and 1,200 psf were selected for the impervious fill and foundation materials, respectively.

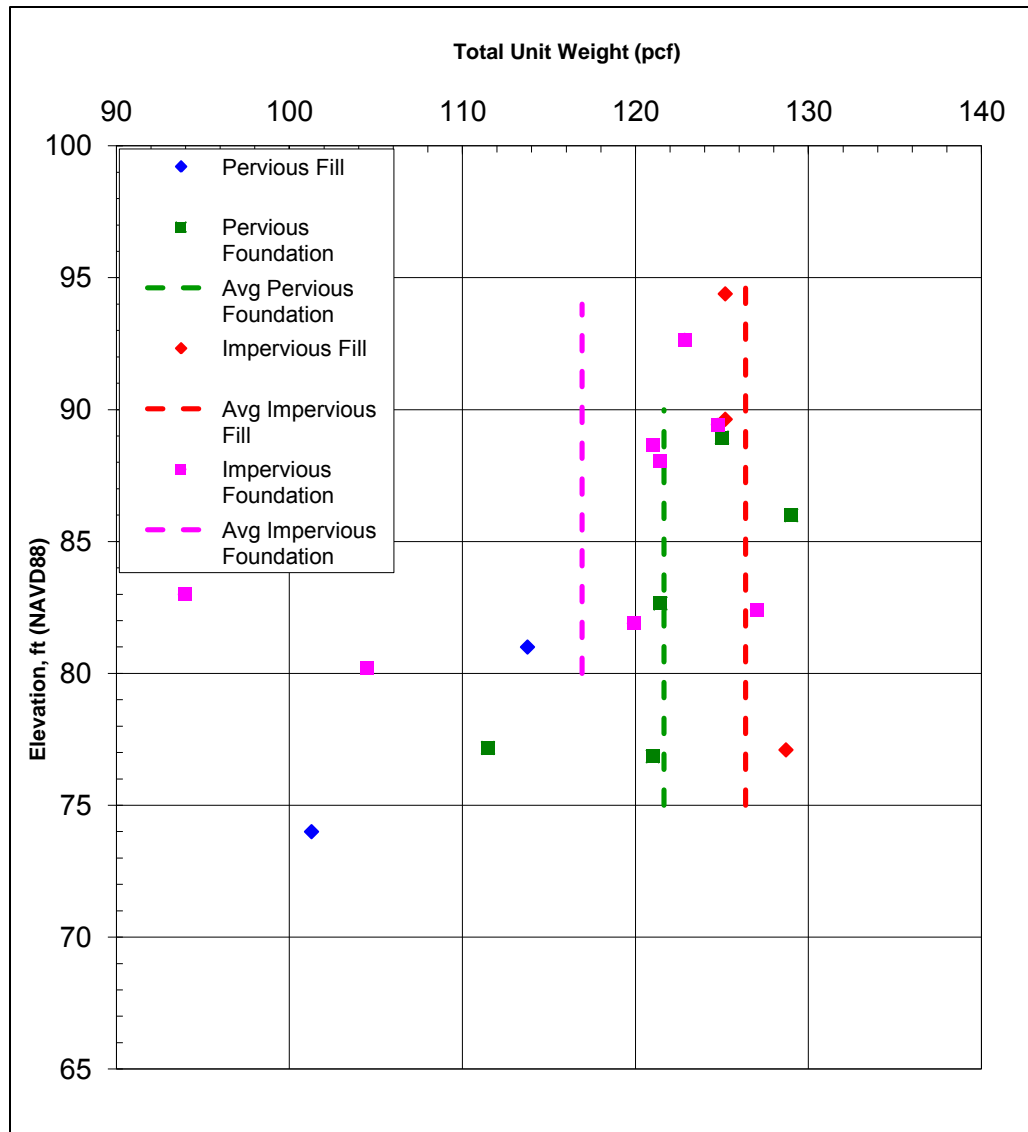
Undrained Residual Shear Strength for Pervious Foundation Material

Undrained residual shear strength values were estimated for potentially liquefiable strata according to the empirical correlations proposed by Seed and Harder (1990). The undrained residual shear strength values were estimated based on blow counts for each section evaluated

and ranged from 175 psf to 600 psf. Estimated undrained residual strength values for liquefiable strata are shown on slope stability output presented in Appendix E.



Dry Unit Weight versus Elevation

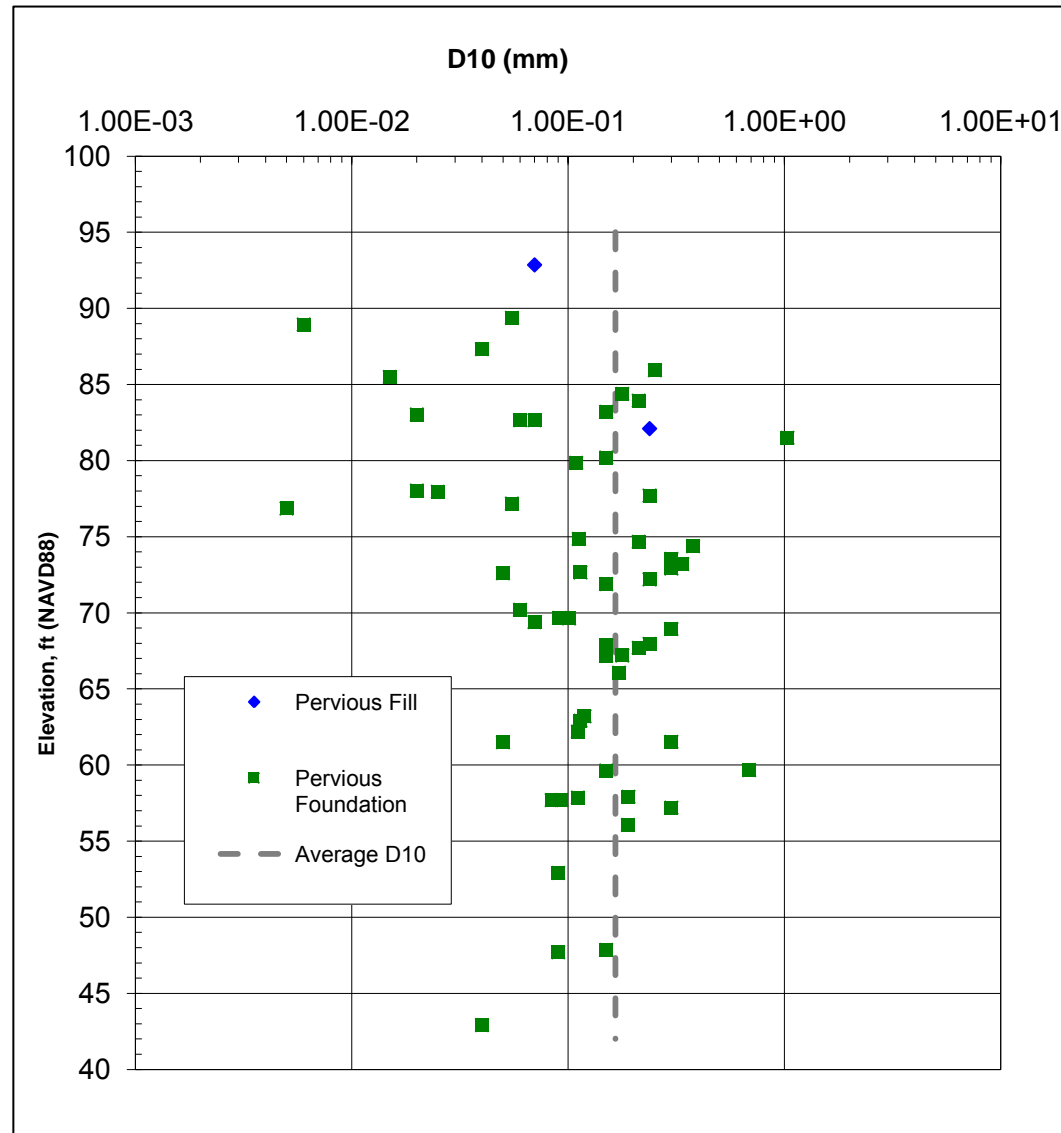


Total Unit Weight versus Elevation

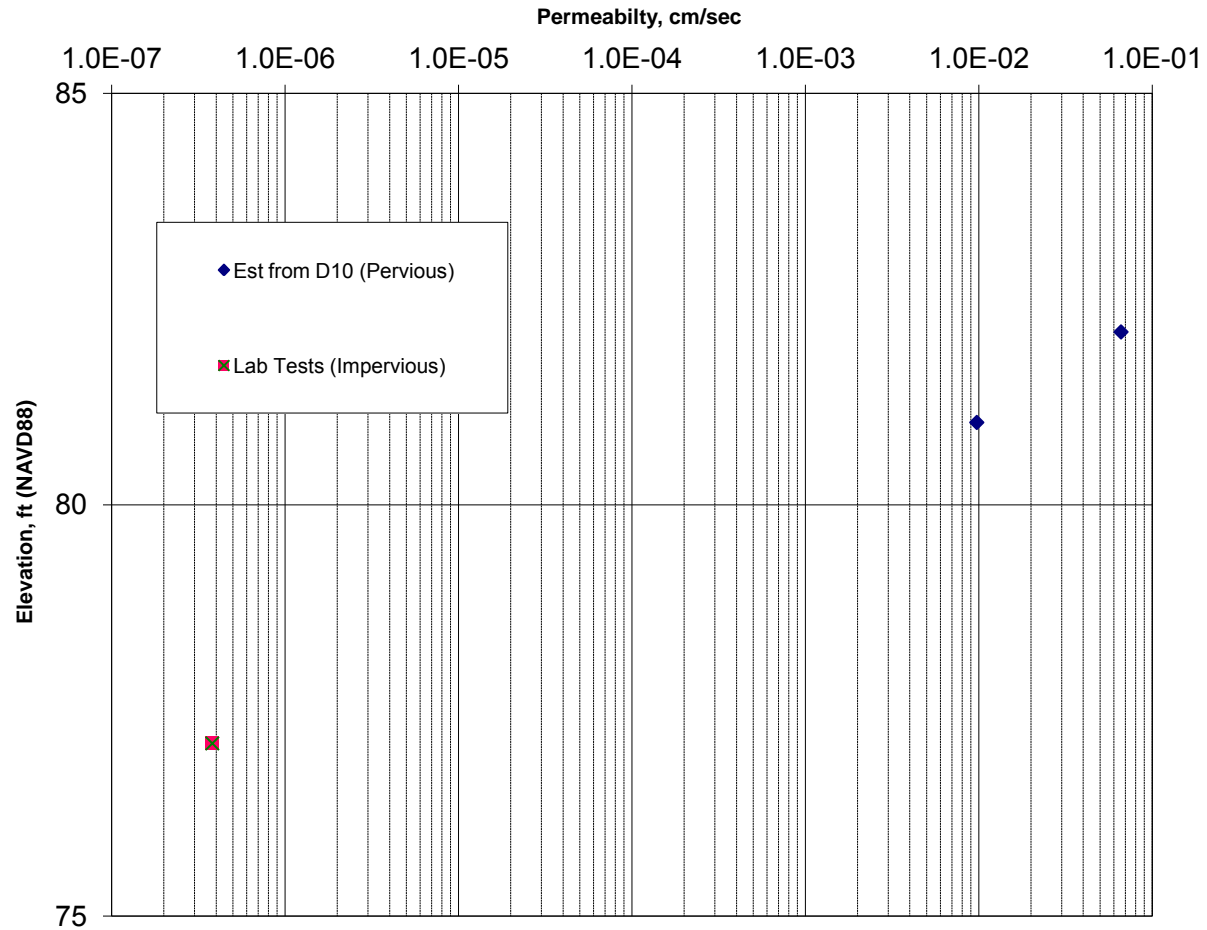


Unit	Selected Design Dry Unit Weight (pcf)	Selected Design Total Unit Weight (pcf)
Pervious Fill	100	120
Impervious Core	110	125
Impervious Foundation	100	120
Pervious Foundation	105	125

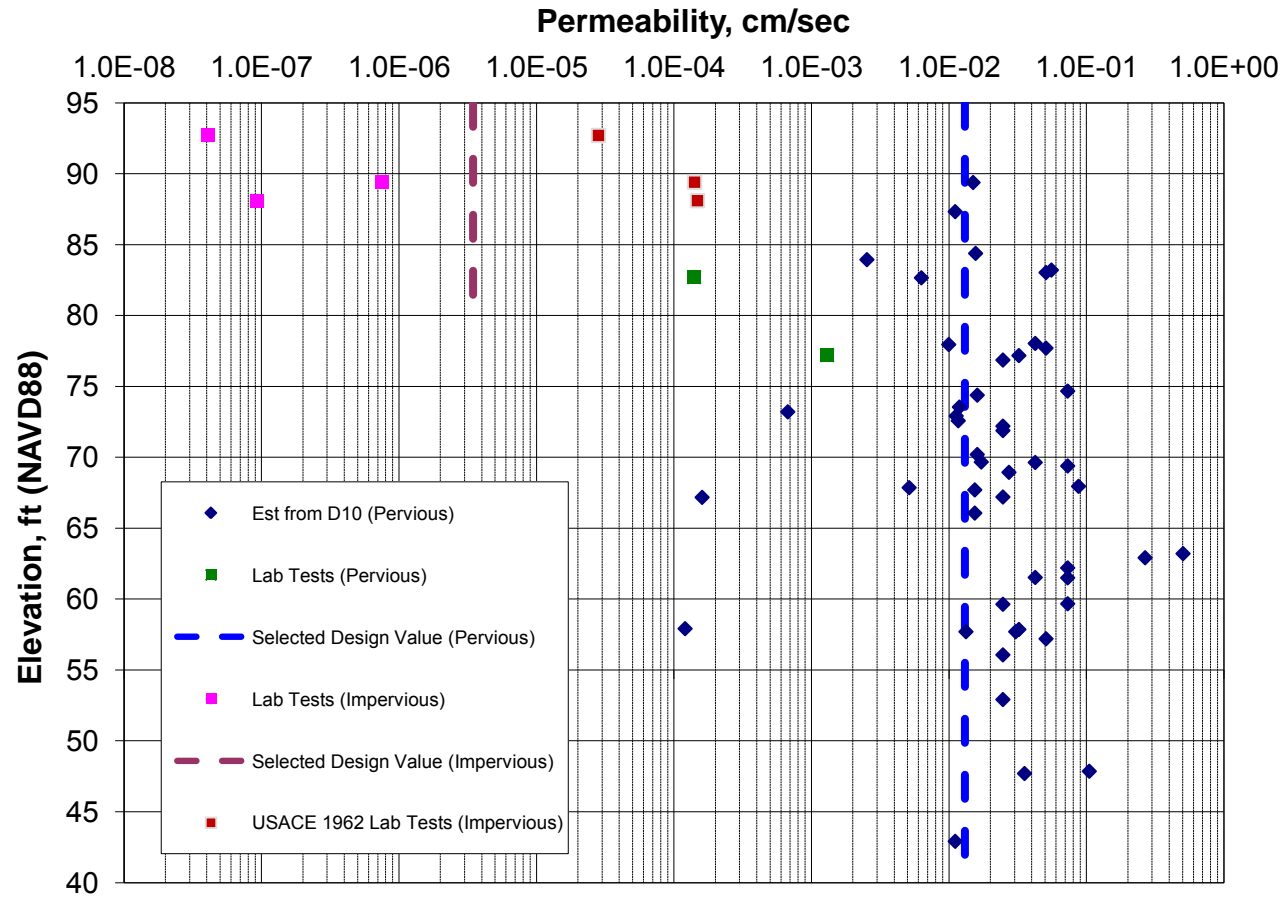
Summary of Unit Weight Data



D₁₀ versus Elevation for Pervious Material



Estimated Levee Fill Permeability versus Elevation



Estimated Foundation Permeability versus Elevation



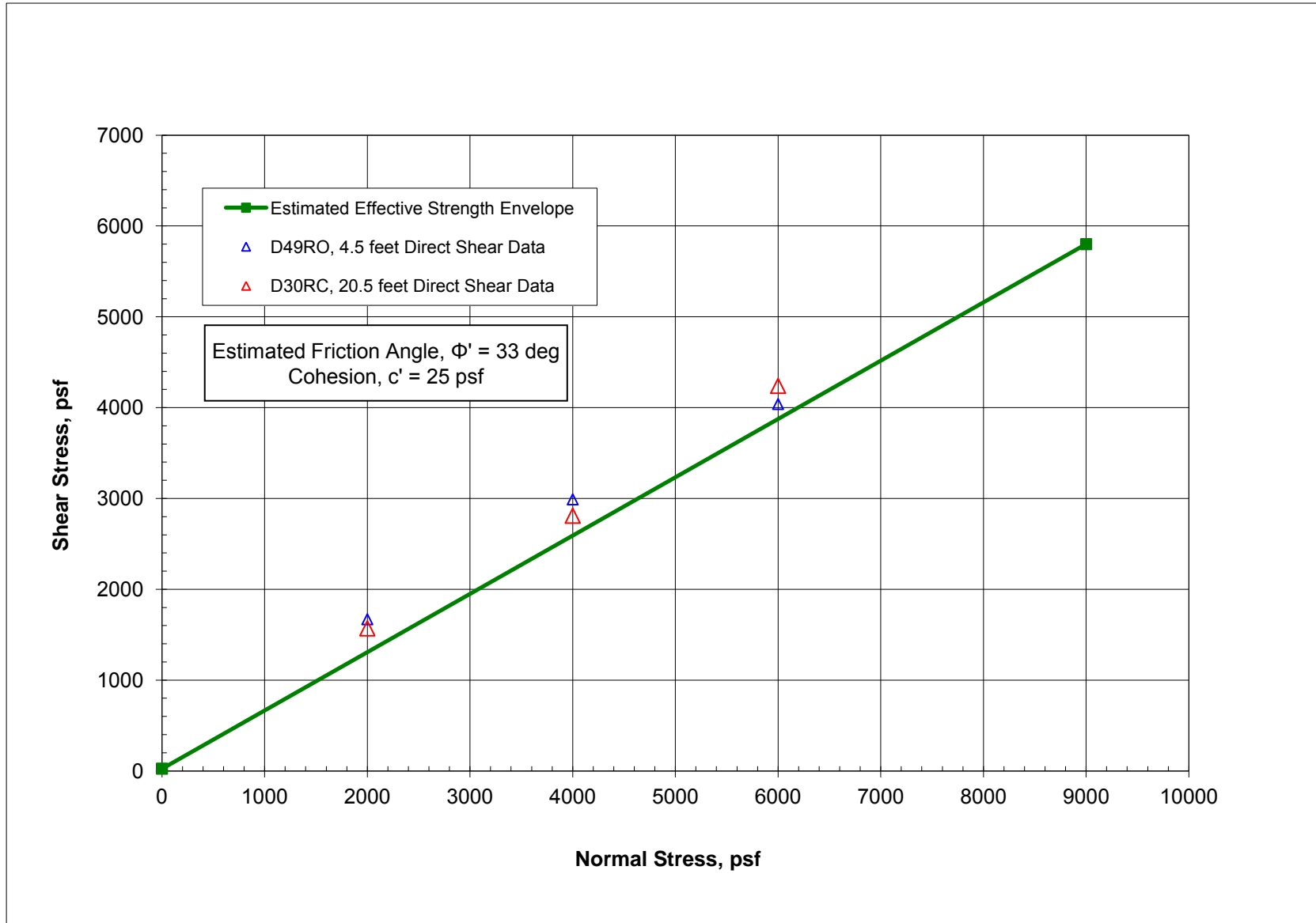
Unit	Horizontal Permeability, Kh		Vertical Permeability, Kv		Assumed Ratio
	ft/day	cm/s	ft/day	cm/s	Kv/Kh
Pervious Fill	144	0.050	72	0.025	0.50
Impervious Fill	0.004	1.5E-06	0.001	3.8E-07	0.25
Pervious Foundation	144	0.052	37	0.013	0.25
Impervious Foundation	0.04	1.4E-05	0.01	3.5E-06	0.25

Summary of Selected Saturated Permeability Values

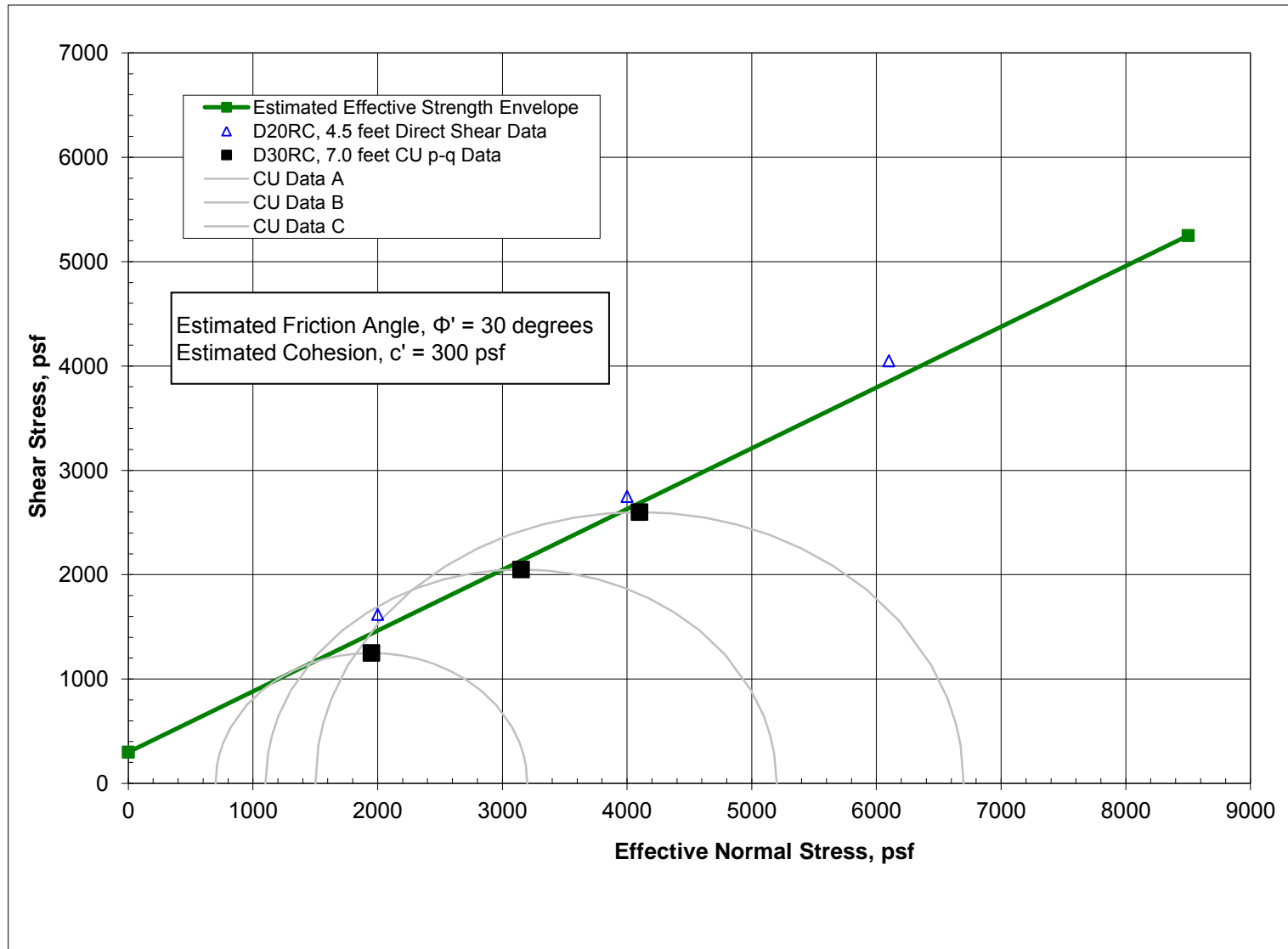


Unit	Total Unit Weight	Effective Stress/CD Conditions		R-Envelope/CU Conditions		Liquifaction/Undrained Conditions
	γ (pcf)	c' (psf)	ϕ' (deg)	c_R (psf)	ϕ_R (deg)	Su (psf)
Pervious Fill	120	25	33	--	--	Non-liquefiable (above water table)
Impervious Fill	125	300	30	130	35	2000
Impervious Foundation	120	200	31	120	28	1200
Pervious Foundation	125	0	33	--	--	Refer to Note Below

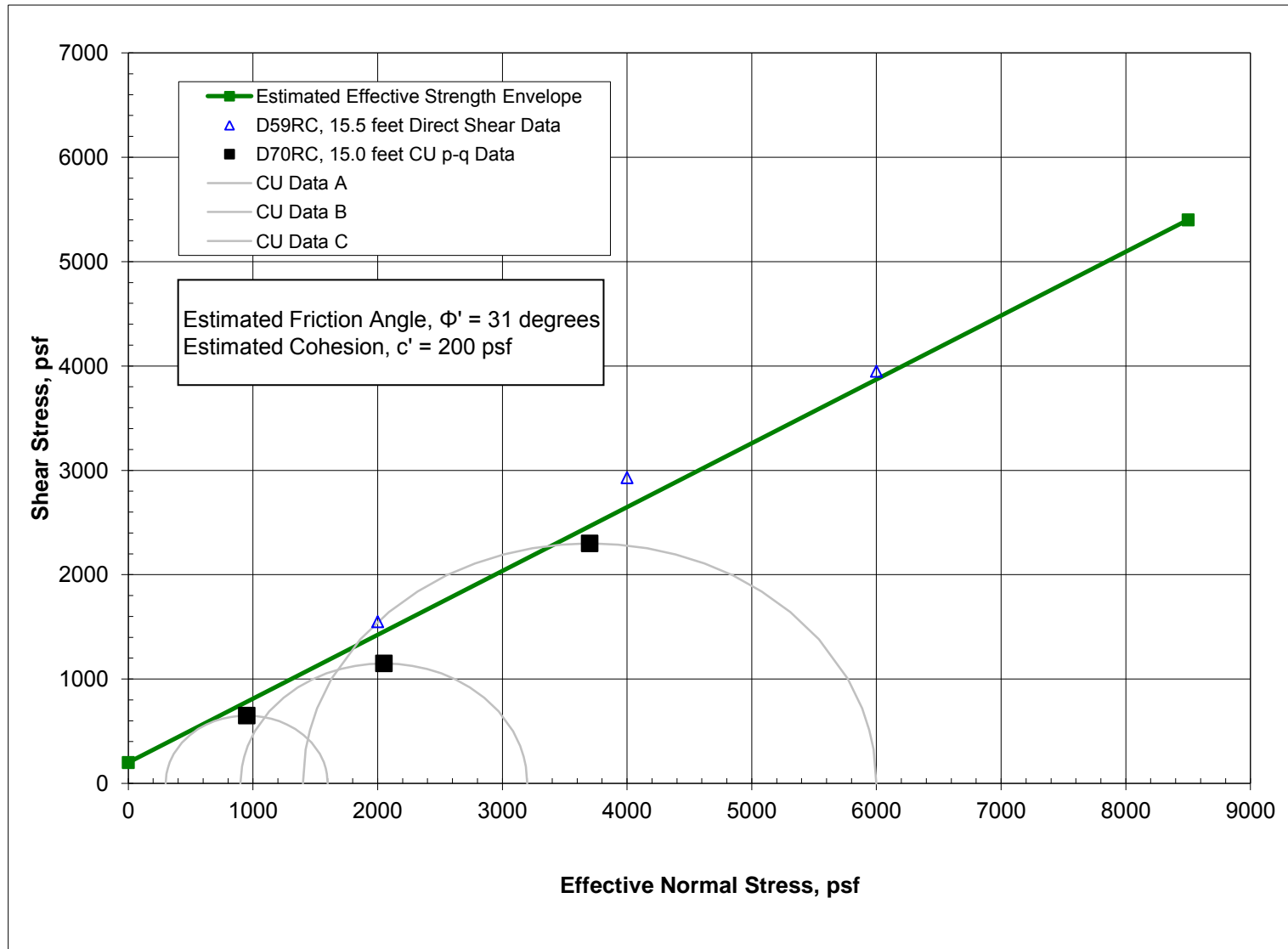
Note: Undrained Residual Strength varied for each section with potentially liquefiable Pervious Foundation material. Refer to Appendix E, SLIDE Output for parameters applied to each section.



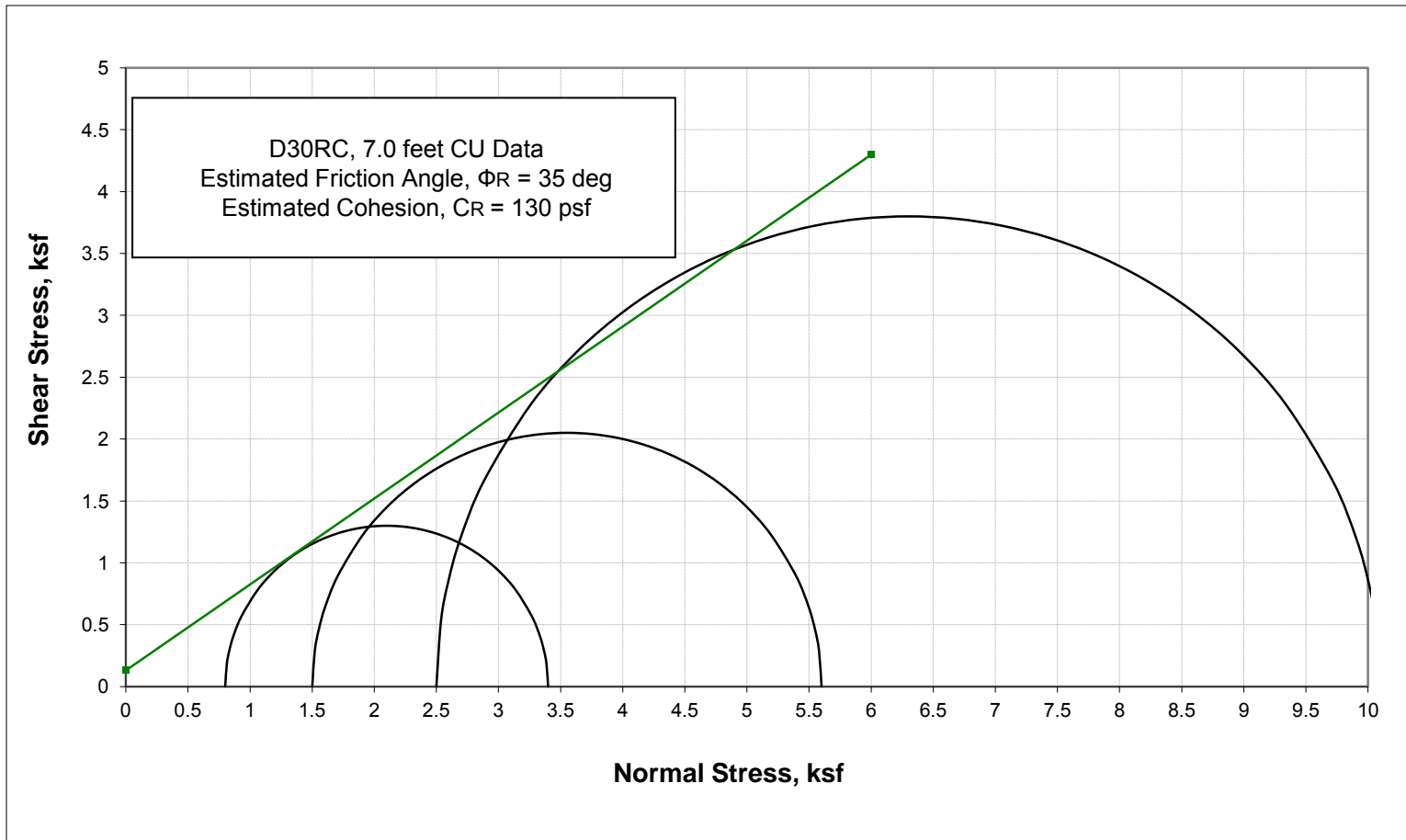
Effective Shear Strength Plot for Pervious Fill and Foundation Material



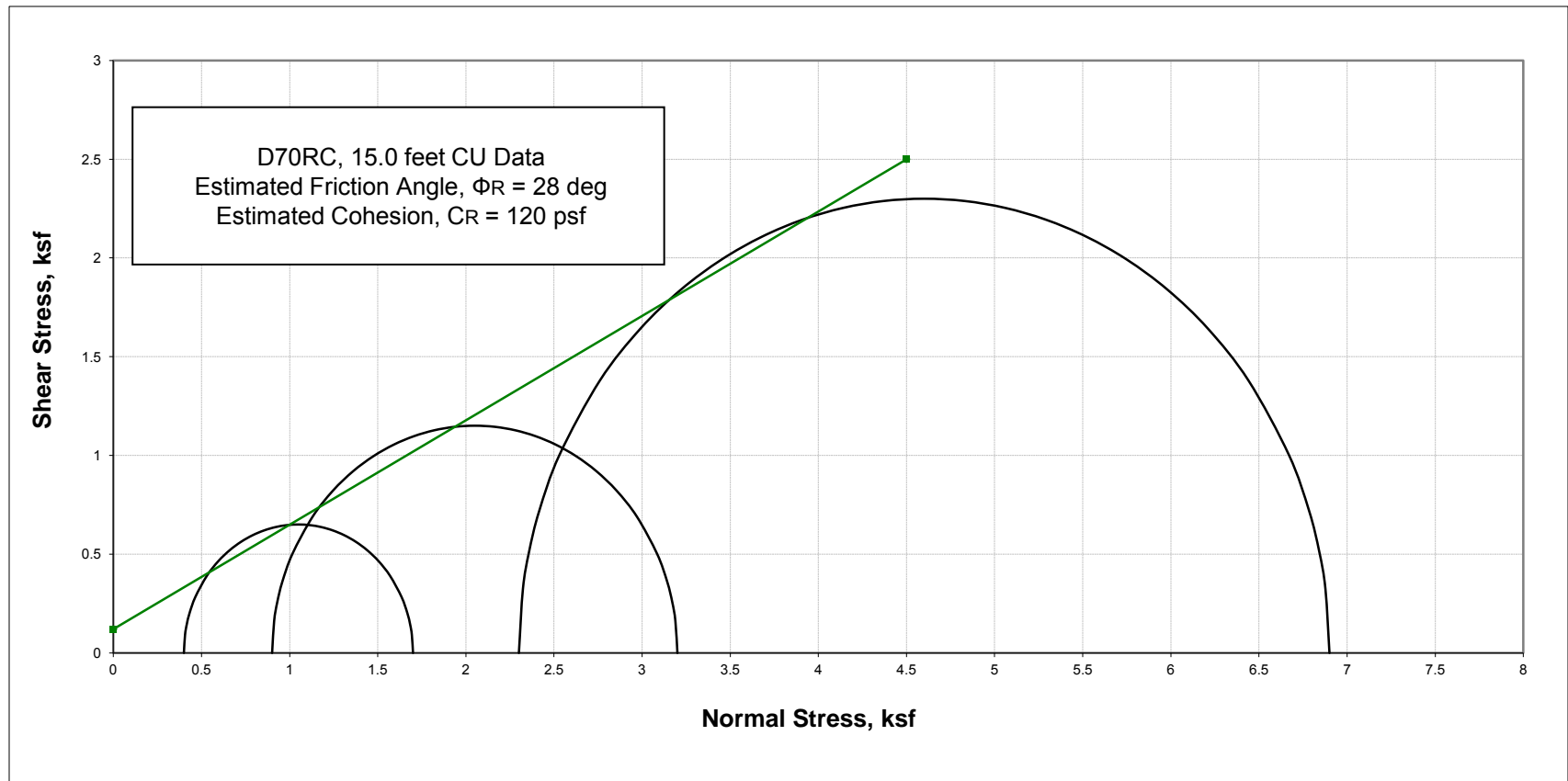
Effective Shear Strength Plot for Impervious Fill Material



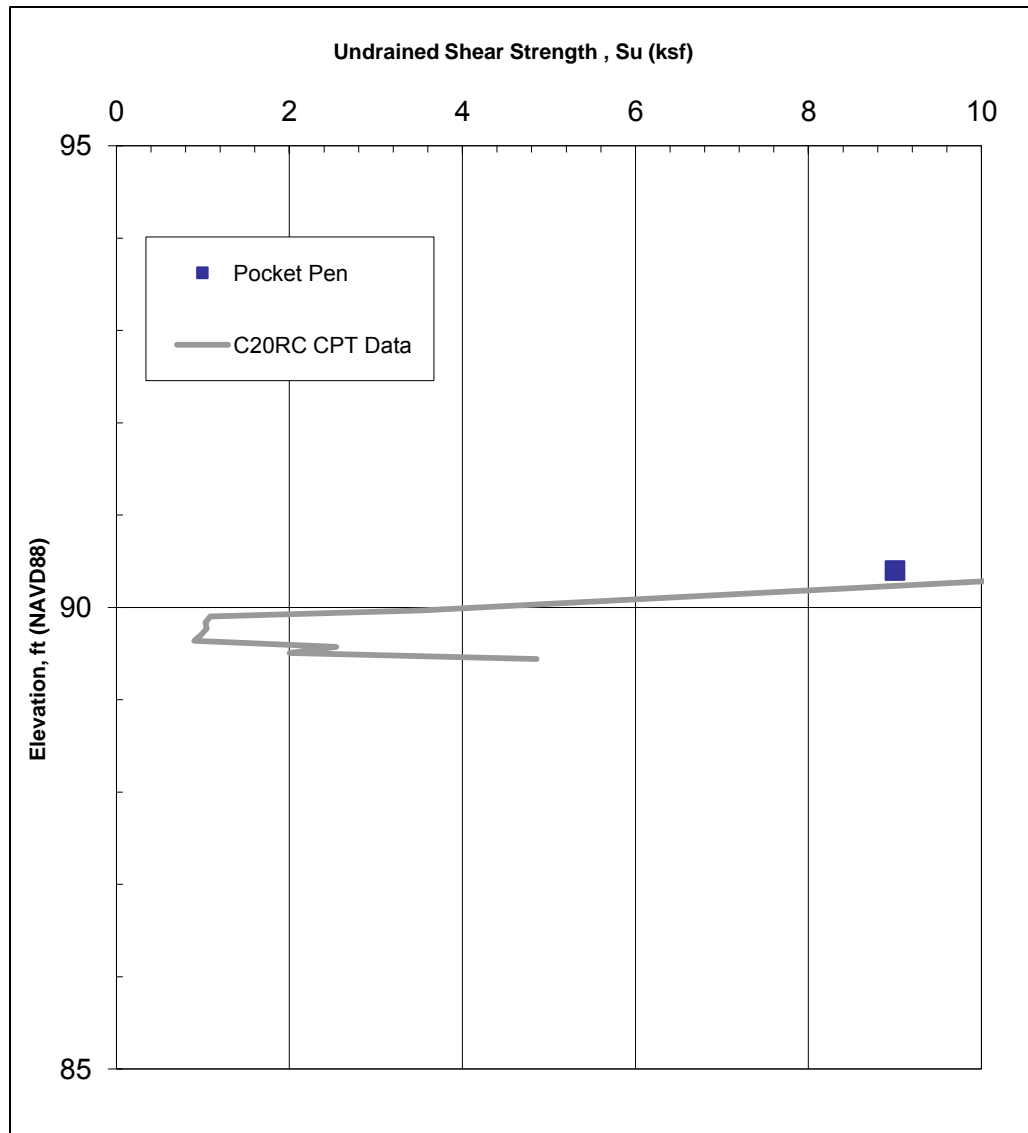
Effective Shear Strength Plot for Impervious Foundation Material



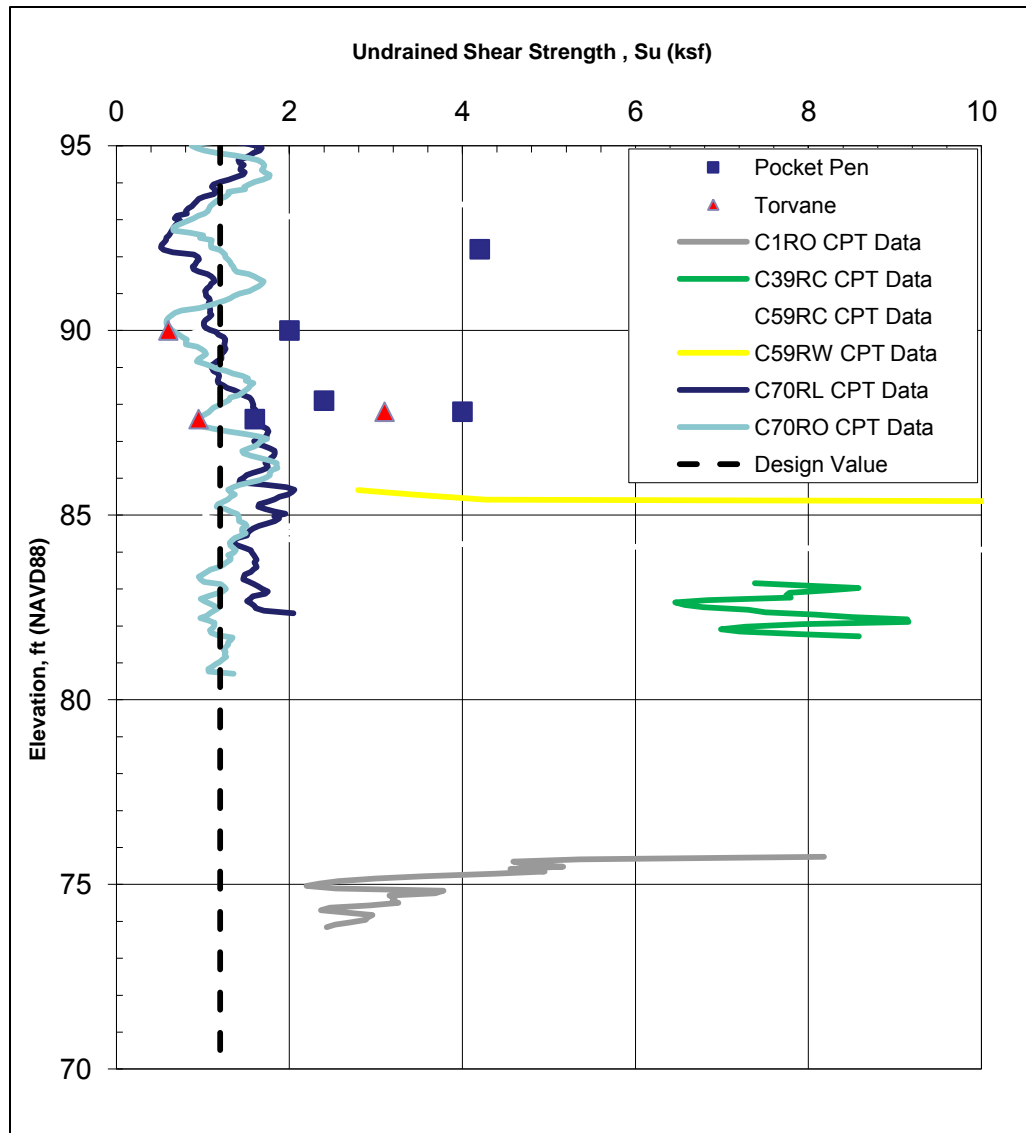
R Shear Strength Envelope Plot for Impervious Fill Material



R Shear Strength Envelope Plot for Impervious Foundation Material



Undrained Shear Strength versus Elevation for Impervious Fill Material



Undrained Shear Strength versus Elevation for Impervious Foundation Material

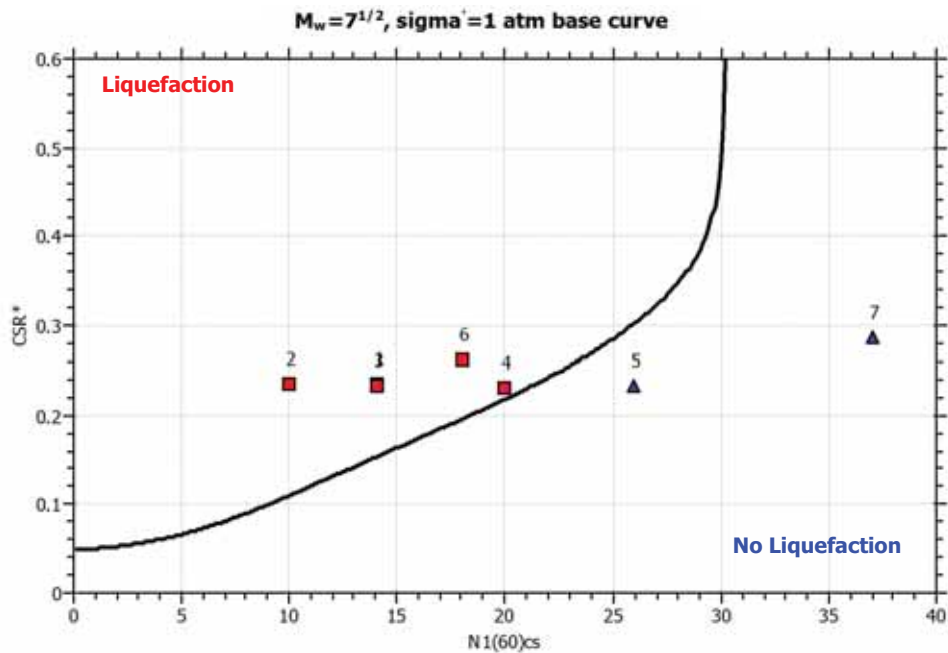
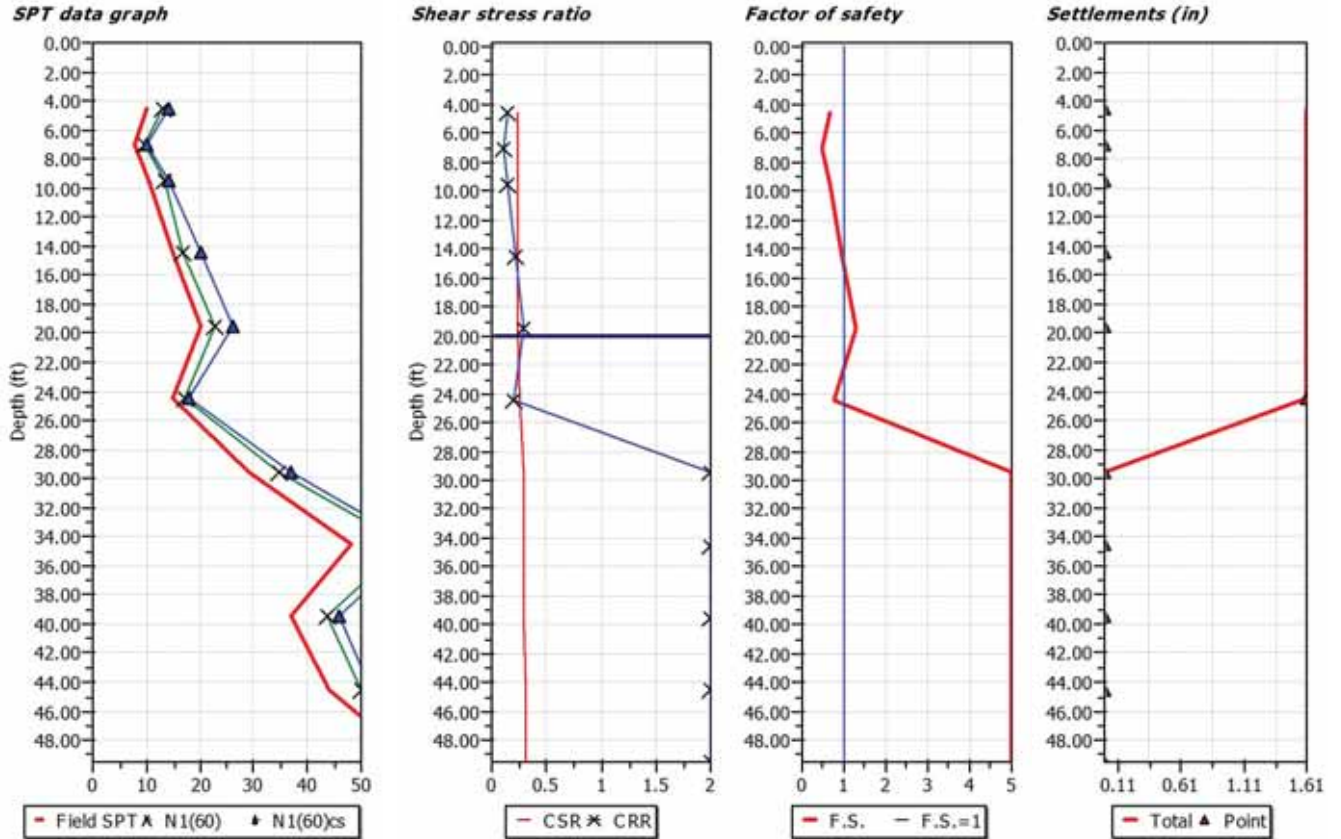
LIQUEFACTION ANALYSIS REPORT

Project title : Blue Lake Levee

Project subtitle : D1RC

Input parameters and analysis data

In-situ data type:	Standard Penetration Test	Depth to water table:	20.00 ft
Analysis type:	Deterministic	Earthquake magnitude M_w :	9.00
Analysis method:	NCEER 1998	Peak ground acceleration:	0.23 g
Fines correction method:	Idriss & Seed	User defined F.S.:	1.00



:: Field input data ::

Point ID	Depth (ft)	Field N_{SPT} (blows/feet)	Unit weight (pcf)	Fines content (%)
1	4.50	10.00	120.00	5.50
2	7.00	7.70	120.00	5.50
3	9.50	10.50	120.00	5.50
4	14.50	15.00	120.00	12.90
5	19.50	20.00	120.00	12.90
6	24.50	15.00	120.00	9.10
7	29.50	29.00	120.00	9.10
8	34.50	48.00	120.00	9.30
9	39.50	37.00	120.00	9.30
10	44.50	44.00	120.00	9.30
11	49.50	60.00	120.00	9.30

Depth : Depth from free surface, at which SPT was performed (ft)
 Field SPT : SPT blows measured at field (blows/feet)
 Unit weight : Bulk unit weight of soil at test depth (pcf)
 Fines content : Percentage of fines in soil (%)

:: Cyclic Stress Ratio calculation (CSR fully adjusted and normalized) ::

Point ID	Depth (ft)	Sigma (tsf)	u (tsf)	Sigma' (tsf)	r_d	CSR	MSF	$CSR_{eq,M=7.5}$	K_{σ}	CSR*
1	4.50	0.27	0.00	0.27	0.99	0.15	0.63	0.24	1.00	0.24
2	7.00	0.42	0.00	0.42	0.98	0.15	0.63	0.23	1.00	0.23
3	9.50	0.57	0.00	0.57	0.98	0.15	0.63	0.23	1.00	0.23
4	14.50	0.87	0.00	0.87	0.97	0.14	0.63	0.23	1.00	0.23
5	19.50	1.17	0.00	1.17	0.95	0.14	0.63	0.23	0.98	0.23
6	24.50	1.47	0.14	1.33	0.94	0.16	0.63	0.25	0.95	0.26
7	29.50	1.77	0.30	1.47	0.93	0.17	0.63	0.27	0.93	0.29
8	34.50	2.07	0.45	1.62	0.89	0.17	0.63	0.27	0.92	0.30
9	39.50	2.37	0.61	1.76	0.85	0.17	0.63	0.27	0.90	0.30
10	44.50	2.67	0.77	1.91	0.81	0.17	0.63	0.27	0.89	0.31
11	49.50	2.97	0.92	2.05	0.77	0.17	0.63	0.27	0.87	0.31

Depth : Depth from free surface, at which SPT was performed (ft)
 Sigma : Total overburden pressure at test point, during earthquake (tsf)
 u : Water pressure at test point, during earthquake (tsf)
 Sigma' : Effective overburden pressure, during earthquake (tsf)
 r_d : Nonlinear shear mass factor
 CSR : Cyclic Stress Ratio
 MSF : Magnitude Scaling Factor
 $CSR_{eq,M=7.5}$: CSR adjusted for M=7.5
 K_{σ} : Effective overburden stress factor
 CSR* : CSR fully adjusted

:: Cyclic Resistance Ratio calculation $CRR_{7.5}$::

Point ID	Field SPT	C_n	C_e	C_b	C_r	C_s	$N_{1(60)}$	DeltaN	$N_{1(60)CS}$	$CRR_{7.5}$
1	10.00	1.70	0.90	1.15	0.75	1.00	13.13	0.05	14.00	0.15
2	7.70	1.58	0.93	1.15	0.75	1.00	9.74	0.04	10.00	0.11
3	10.50	1.35	0.96	1.15	0.85	1.00	13.40	0.05	14.00	0.15
4	15.00	1.10	1.03	1.15	0.85	1.00	16.61	2.46	20.00	0.22
5	20.00	0.94	1.10	1.15	0.95	1.00	22.78	2.68	26.00	0.30
6	15.00	0.89	1.17	1.15	0.95	1.00	17.03	0.88	18.00	0.20
7	29.00	0.84	1.24	1.15	1.00	1.00	34.87	1.19	37.00	2.00
8	48.00	0.80	1.31	1.15	1.00	1.00	58.16	1.71	60.00	2.00
9	37.00	0.77	1.33	1.15	1.00	1.00	43.68	1.45	46.00	2.00
10	44.00	0.74	1.33	1.15	1.00	1.00	49.95	1.56	52.00	2.00
11	60.00	0.71	1.33	1.15	1.00	1.00	65.68	1.85	68.00	2.00

:: Cyclic Resistance Ratio calculation CRR_{7.5} ::

Point ID	Field SPT	C _n	C _e	C _b	C _r	C _s	N ₁₍₆₀₎	DeltaN	N _{1(60)cs}	CRR _{7.5}
C _n :	Overburden correction factor									
C _e :	Energy correction factor									
C _b :	Borehole diameter correction factor									
C _r :	Rod length correction factor									
C _s :	Liner correction factor									
N ₁₍₆₀₎ :	Corrected N _{SPT}									
DeltaN :	Addition to corrected N _{SPT} value due to the presence of fines									
N _{1(60)cs} :	Corrected N ₁₍₆₀₎ value for fines									
CRR _{7.5} :	Cyclic resistance ratio for M=7.5									

:: Settlements calculation for saturated sands ::

Point ID	N ₁₍₆₀₎	N ₁	FS _L	e _v (%)	Settle. (in)
1	14.00	11.67	0.65	3.21	0.00
2	10.00	8.33	0.47	3.88	0.00
3	14.00	11.67	0.65	3.21	0.00
4	20.00	16.67	0.94	2.35	0.00
5	26.00	21.67	1.30	0.16	0.00
6	18.00	15.00	0.75	2.68	1.61
7	37.00	30.83	5.00	0.00	0.00
8	60.00	50.00	5.00	0.00	0.00
9	46.00	38.33	5.00	0.00	0.00
10	52.00	43.33	5.00	0.00	0.00
11	68.00	56.67	5.00	0.00	0.00

Total settlement : 1.61

N ₁₍₆₀₎ :	Stress normalized and corrected SPT blow count
N ₁ :	Japanese equivalent corrected value
FS _L :	Calculated factor of safety
e _v :	Post-liquefaction volumetric strain (%)
Settle. :	Calculated settlement (in)

:: Liquefaction potential according to Iwasaki ::

Point ID	F	w _z	I _L
1	0.35	9.31	4.51
2	0.53	8.93	3.63
3	0.35	8.55	2.25
4	0.06	7.79	0.66
5	0.00	7.03	0.00
6	0.25	6.27	2.40
7	0.00	5.50	0.00
8	0.00	4.74	0.00
9	0.00	3.98	0.00
10	0.00	3.22	0.00
11	0.00	2.46	0.00

Overall potential I_L : 13.44

I _L = 0.00	- No liquefaction
I _L between 0.00 and 5	- Liquefaction not probable
I _L between 5 and 15	- Liquefaction probable
I _L > 15	- Liquefaction certain

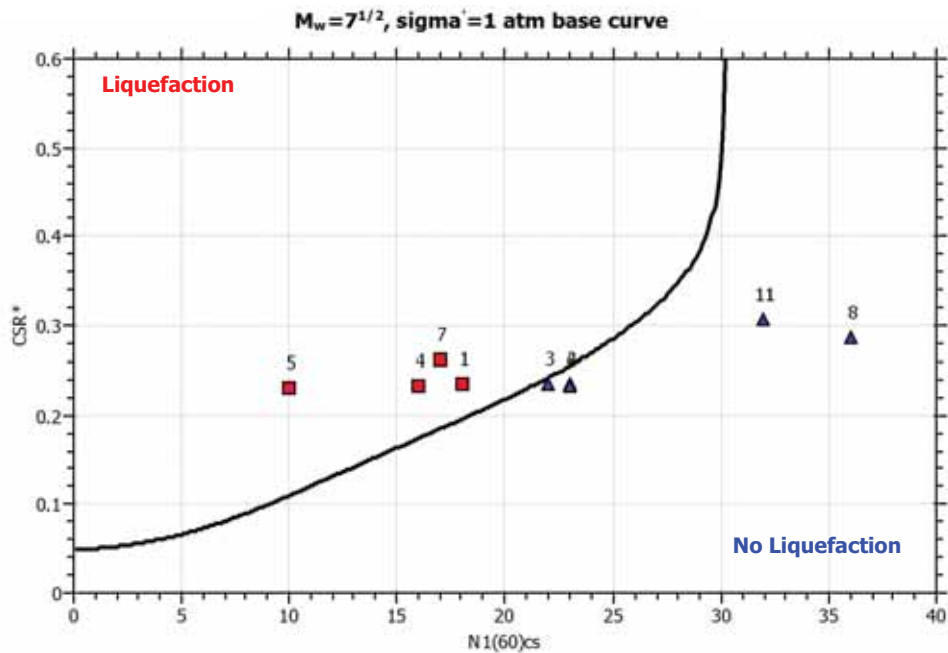
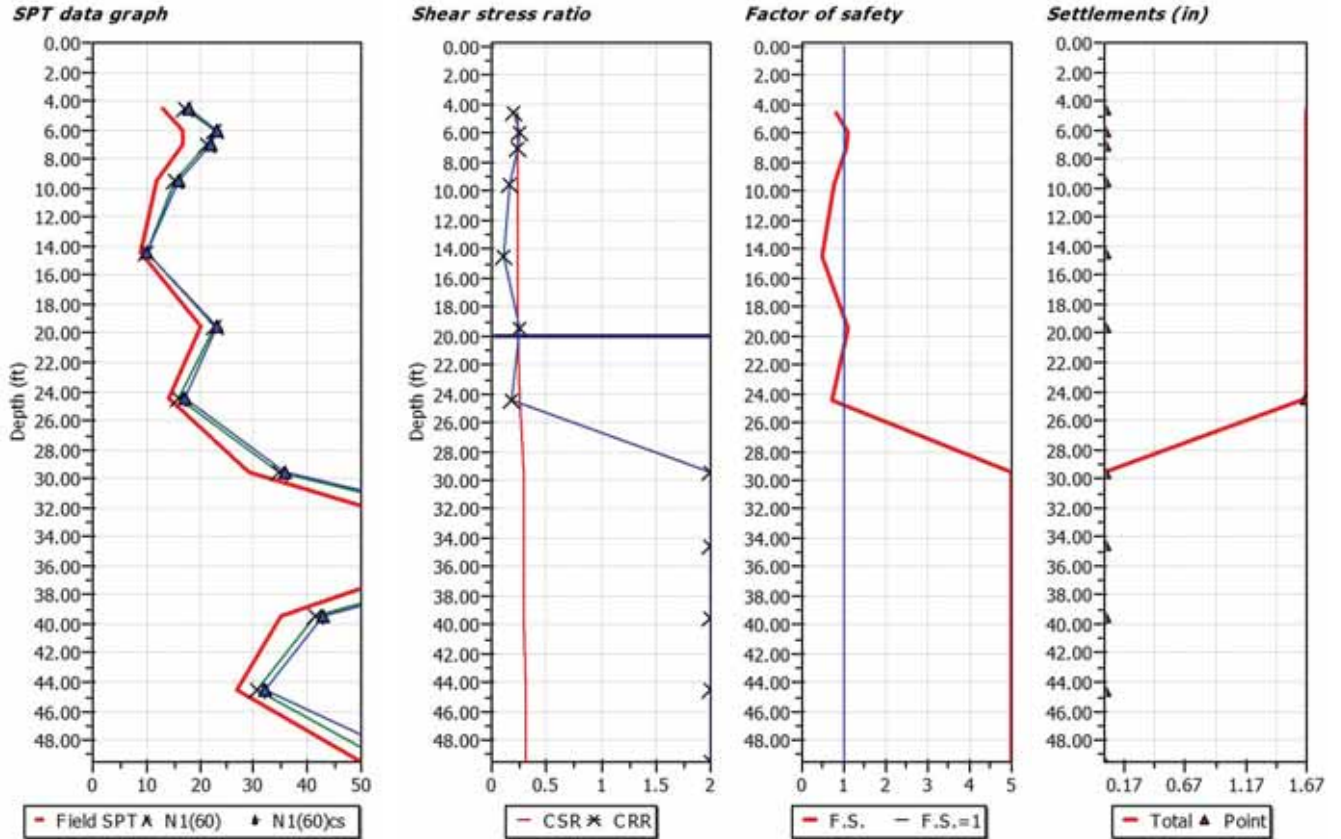
LIQUEFACTION ANALYSIS REPORT

Project title : Blue Lake Levee

Project subtitle : D10RC

Input parameters and analysis data

In-situ data type:	Standard Penetration Test	Depth to water table:	20.00 ft
Analysis type:	Deterministic	Earthquake magnitude M_w :	9.00
Analysis method:	NCEER 1998	Peak ground acceleration:	0.23 g
Fines correction method:	Idriss & Seed	User defined F.S.:	1.00



:: Field input data ::

Point ID	Depth (ft)	Field N_{SPT} (blows/feet)	Unit weight (pcf)	Fines content (%)
1	4.50	13.00	120.00	0.00
2	6.00	16.80	120.00	0.00
3	7.00	16.80	120.00	0.00
4	9.50	11.90	120.00	0.00
5	14.50	9.00	120.00	0.00
6	19.50	20.00	120.00	6.40
7	24.50	14.00	120.00	6.40
8	29.50	29.00	120.00	8.50
9	34.50	74.00	120.00	8.50
10	39.50	35.00	120.00	9.30
11	44.50	27.00	120.00	9.30
12	49.50	50.00	120.00	16.90

Depth : Depth from free surface, at which SPT was performed (ft)
 Field SPT : SPT blows measured at field (blows/feet)
 Unit weight : Bulk unit weight of soil at test depth (pcf)
 Fines content : Percentage of fines in soil (%)

:: Cyclic Stress Ratio calculation (CSR fully adjusted and normalized) ::

Point ID	Depth (ft)	Sigma (tsf)	u (tsf)	Sigma' (tsf)	r_d	CSR	MSF	$CSR_{eq,M=7.5}$	K_{sigma}	CSR*
1	4.50	0.27	0.00	0.27	0.99	0.15	0.63	0.24	1.00	0.24
2	6.00	0.36	0.00	0.36	0.99	0.15	0.63	0.24	1.00	0.24
3	7.00	0.42	0.00	0.42	0.98	0.15	0.63	0.23	1.00	0.23
4	9.50	0.57	0.00	0.57	0.98	0.15	0.63	0.23	1.00	0.23
5	14.50	0.87	0.00	0.87	0.97	0.14	0.63	0.23	1.00	0.23
6	19.50	1.17	0.00	1.17	0.95	0.14	0.63	0.23	0.98	0.23
7	24.50	1.47	0.14	1.33	0.94	0.16	0.63	0.25	0.95	0.26
8	29.50	1.77	0.30	1.47	0.93	0.17	0.63	0.27	0.93	0.29
9	34.50	2.07	0.45	1.62	0.89	0.17	0.63	0.27	0.92	0.30
10	39.50	2.37	0.61	1.76	0.85	0.17	0.63	0.27	0.90	0.30
11	44.50	2.67	0.77	1.91	0.81	0.17	0.63	0.27	0.89	0.31
12	49.50	2.97	0.92	2.05	0.77	0.17	0.63	0.27	0.87	0.31

Depth : Depth from free surface, at which SPT was performed (ft)
 Sigma : Total overburden pressure at test point, during earthquake (tsf)
 u : Water pressure at test point, during earthquake (tsf)
 Sigma' : Effective overburden pressure, during earthquake (tsf)
 r_d : Nonlinear shear mass factor
 CSR : Cyclic Stress Ratio
 MSF : Magnitude Scaling Factor
 $CSR_{eq,M=7.5}$: CSR adjusted for M=7.5
 K_{sigma} : Effective overburden stress factor
 CSR* : CSR fully adjusted

:: Cyclic Resistance Ratio calculation $CRR_{7.5}$::

Point ID	Field SPT	C_n	C_e	C_b	C_r	C_s	$N_{1(60)}$	DeltaN	$N_{1(60)cs}$	$CRR_{7.5}$
1	13.00	1.70	0.90	1.15	0.75	1.00	17.07	0.00	18.00	0.20
2	16.80	1.70	0.92	1.15	0.75	1.00	22.58	0.00	23.00	0.25
3	16.80	1.58	0.93	1.15	0.75	1.00	21.26	0.00	22.00	0.24
4	11.90	1.35	0.96	1.15	0.85	1.00	15.19	0.00	16.00	0.17
5	9.00	1.10	1.03	1.15	0.85	1.00	9.97	0.00	10.00	0.11
6	20.00	0.94	1.10	1.15	0.95	1.00	22.78	0.20	23.00	0.25
7	14.00	0.89	1.17	1.15	0.95	1.00	15.90	0.15	17.00	0.18
8	29.00	0.84	1.24	1.15	1.00	1.00	34.87	0.93	36.00	2.00
9	74.00	0.80	1.31	1.15	1.00	1.00	89.67	1.74	92.00	2.00
10	35.00	0.77	1.33	1.15	1.00	1.00	41.32	1.40	43.00	2.00

:: Cyclic Resistance Ratio calculation CRR_{7.5} ::

Point ID	Field SPT	C _n	C _e	C _b	C _r	C _s	N ₁₍₆₀₎	DeltaN	N _{1(60)cs}	CRR _{7.5}
11	27.00	0.74	1.33	1.15	1.00	1.00	30.65	1.21	32.00	2.00
12	50.00	0.71	1.33	1.15	1.00	1.00	54.73	6.24	61.00	2.00

C_n : Overburden correction factor
 C_e : Energy correction factor
 C_b : Borehole diameter correction factor
 C_r : Rod length correction factor
 C_s : Liner correction factor
 N₁₍₆₀₎ : Corrected N_{SPT}
 DeltaN : Addition to corrected N_{SPT} value due to the presence of fines
 N_{1(60)cs} : Corrected N₁₍₆₀₎ value for fines
 CRR_{7.5} : Cyclic resistance ratio for M=7.5

:: Settlements calculation for saturated sands ::

Point ID	N ₁₍₆₀₎	N ₁	FS _L	e _v (%)	Settle. (in)
1	18.00	15.00	0.83	2.66	0.00
2	23.00	19.17	1.08	0.58	0.00
3	22.00	18.33	1.03	0.98	0.00
4	16.00	13.33	0.75	2.91	0.00
5	10.00	8.33	0.48	3.88	0.00
6	23.00	19.17	1.09	0.53	0.00
7	17.00	14.17	0.71	2.78	1.67
8	36.00	30.00	5.00	0.00	0.00
9	92.00	76.67	5.00	0.00	0.00
10	43.00	35.83	5.00	0.00	0.00
11	32.00	26.67	5.00	0.00	0.00
12	61.00	50.83	5.00	0.00	0.00

Total settlement : 1.67

N₁₍₆₀₎ : Stress normalized and corrected SPT blow count
 N₁ : Japanese equivalent corrected value
 FS_L : Calculated factor of safety
 e_v : Post-liquefaction volumetric strain (%)
 Settle. : Calculated settlement (in)

:: Liquefaction potential according to Iwasaki ::

Point ID	F	w _z	I _L
1	0.17	9.31	2.19
2	0.00	9.09	0.00
3	0.00	8.93	0.00
4	0.25	8.55	1.65
5	0.52	7.79	6.23
6	0.00	7.03	0.00
7	0.29	6.27	2.79
8	0.00	5.50	0.00
9	0.00	4.74	0.00
10	0.00	3.98	0.00
11	0.00	3.22	0.00
12	0.00	2.46	0.00

Overall potential I_L : 12.86

I_L = 0.00 - No liquefaction
 I_L between 0.00 and 5 - Liquefaction not probable
 I_L between 5 and 15 - Liquefaction probable
 I_L > 15 - Liquefaction certain

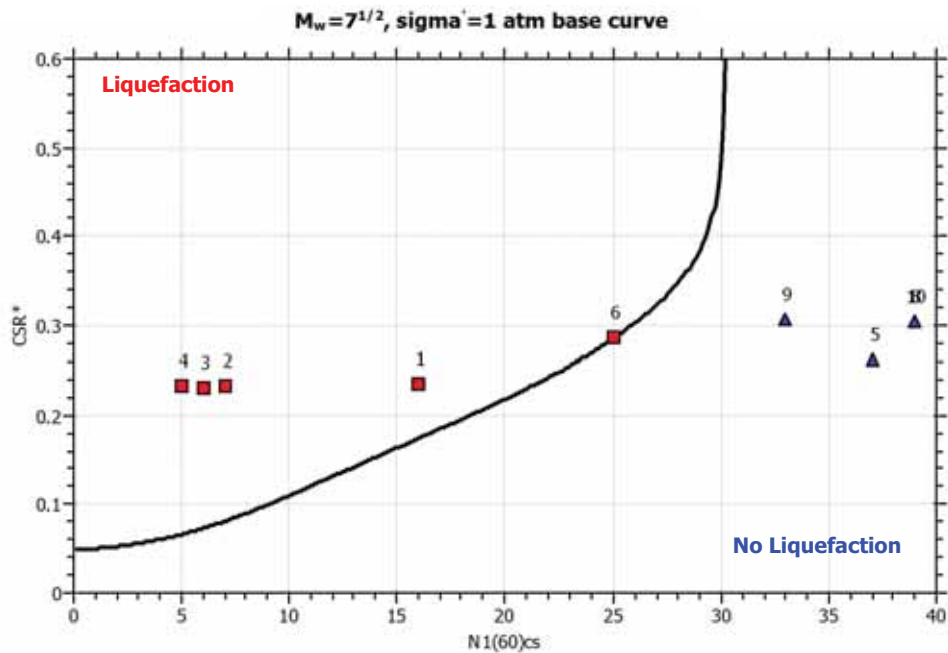
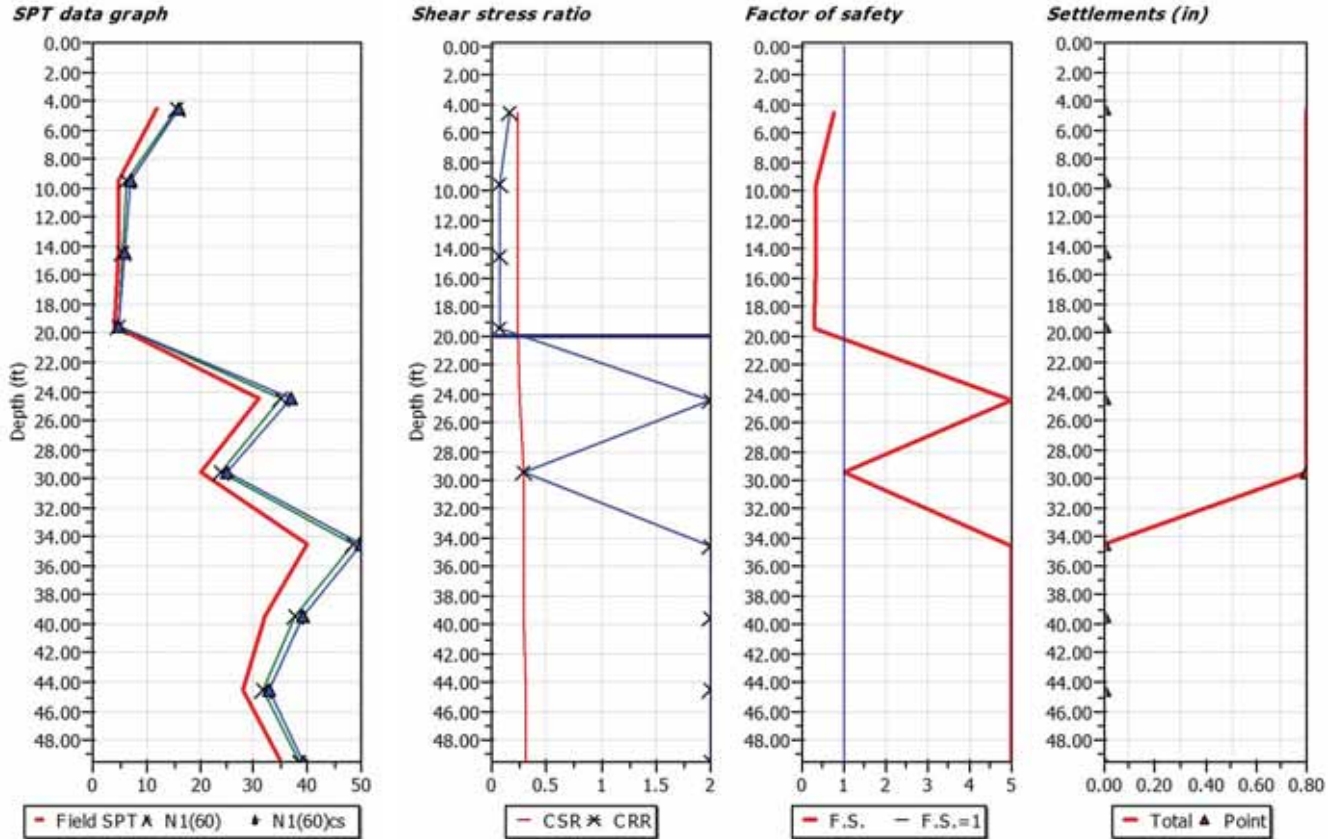
LIQUEFACTION ANALYSIS REPORT

Project title : Blue Lake Levee

Project subtitle : D20RC

Input parameters and analysis data

In-situ data type:	Standard Penetration Test	Depth to water table:	20.00 ft
Analysis type:	Deterministic	Earthquake magnitude M_w :	9.00
Analysis method:	NCEER 1998	Peak ground acceleration:	0.23 g
Fines correction method:	Idriss & Seed	User defined F.S.:	1.00



:: Field input data ::

Point ID	Depth (ft)	Field N_{SPT} (blows/feet)	Unit weight (pcf)	Fines content (%)
1	4.50	11.90	120.00	0.00
2	9.50	5.00	120.00	0.00
3	14.50	4.90	120.00	0.00
4	19.50	4.20	120.00	0.00
5	24.50	31.00	120.00	8.50
6	29.50	20.00	120.00	8.50
7	34.50	40.00	120.00	7.20
8	39.50	32.00	120.00	7.20
9	44.50	28.00	120.00	7.20
10	49.50	35.00	120.00	7.20

Depth : Depth from free surface, at which SPT was performed (ft)
 Field SPT : SPT blows measured at field (blows/feet)
 Unit weight : Bulk unit weight of soil at test depth (pcf)
 Fines content : Percentage of fines in soil (%)

:: Cyclic Stress Ratio calculation (CSR fully adjusted and normalized) ::

Point ID	Depth (ft)	Sigma (tsf)	u (tsf)	Sigma' (tsf)	r_d	CSR	MSF	$CSR_{eq,M=7.5}$	K_{σ}	CSR*
1	4.50	0.27	0.00	0.27	0.99	0.15	0.63	0.24	1.00	0.24
2	9.50	0.57	0.00	0.57	0.98	0.15	0.63	0.23	1.00	0.23
3	14.50	0.87	0.00	0.87	0.97	0.14	0.63	0.23	1.00	0.23
4	19.50	1.17	0.00	1.17	0.95	0.14	0.63	0.23	0.98	0.23
5	24.50	1.47	0.14	1.33	0.94	0.16	0.63	0.25	0.95	0.26
6	29.50	1.77	0.30	1.47	0.93	0.17	0.63	0.27	0.93	0.29
7	34.50	2.07	0.45	1.62	0.89	0.17	0.63	0.27	0.92	0.30
8	39.50	2.37	0.61	1.76	0.85	0.17	0.63	0.27	0.90	0.30
9	44.50	2.67	0.77	1.91	0.81	0.17	0.63	0.27	0.89	0.31
10	49.50	2.97	0.92	2.05	0.77	0.17	0.63	0.27	0.87	0.31

Depth : Depth from free surface, at which SPT was performed (ft)
 Sigma : Total overburden pressure at test point, during earthquake (tsf)
 u : Water pressure at test point, during earthquake (tsf)
 Sigma' : Effective overburden pressure, during earthquake (tsf)
 r_d : Nonlinear shear mass factor
 CSR : Cyclic Stress Ratio
 MSF : Magnitude Scaling Factor
 $CSR_{eq,M=7.5}$: CSR adjusted for M=7.5
 K_{σ} : Effective overburden stress factor
 CSR* : CSR fully adjusted

:: Cyclic Resistance Ratio calculation $CRR_{7.5}$::

Point ID	Field SPT	C_n	C_e	C_b	C_r	C_s	$N_{1(60)}$	DeltaN	$N_{1(60)CS}$	$CRR_{7.5}$
1	11.90	1.70	0.90	1.15	0.75	1.00	15.63	0.00	16.00	0.17
2	5.00	1.35	0.96	1.15	0.85	1.00	6.38	0.00	7.00	0.08
3	4.90	1.10	1.03	1.15	0.85	1.00	5.43	0.00	6.00	0.07
4	4.20	0.94	1.10	1.15	0.95	1.00	4.78	0.00	5.00	0.07
5	31.00	0.89	1.17	1.15	0.95	1.00	35.20	0.94	37.00	2.00
6	20.00	0.84	1.24	1.15	1.00	1.00	24.05	0.77	25.00	0.29
7	40.00	0.80	1.31	1.15	1.00	1.00	48.47	0.60	50.00	2.00
8	32.00	0.77	1.33	1.15	1.00	1.00	37.78	0.50	39.00	2.00
9	28.00	0.74	1.33	1.15	1.00	1.00	31.79	0.45	33.00	2.00
10	35.00	0.71	1.33	1.15	1.00	1.00	38.31	0.51	39.00	2.00

:: Cyclic Resistance Ratio calculation CRR_{7.5} ::

Point ID	Field SPT	C _n	C _e	C _b	C _r	C _s	N ₁₍₆₀₎	DeltaN	N _{1(60)cs}	CRR _{7.5}
C _n :	Overburden correction factor									
C _e :	Energy correction factor									
C _b :	Borehole diameter correction factor									
C _r :	Rod length correction factor									
C _s :	Liner correction factor									
N ₁₍₆₀₎ :	Corrected N _{SPT}									
DeltaN :	Addition to corrected N _{SPT} value due to the presence of fines									
N _{1(60)cs} :	Corrected N ₁₍₆₀₎ value for fines									
CRR _{7.5} :	Cyclic resistance ratio for M=7.5									

:: Settlements calculation for saturated sands ::

Point ID	N ₁₍₆₀₎	N ₁	FS _L	e _v (%)	Settle. (in)
1	16.00	13.33	0.74	2.91	0.00
2	7.00	5.83	0.35	4.46	0.00
3	6.00	5.00	0.32	4.77	0.00
4	5.00	4.17	0.28	5.07	0.00
5	37.00	30.83	5.00	0.00	0.00
6	25.00	20.83	1.00	1.34	0.80
7	50.00	41.67	5.00	0.00	0.00
8	39.00	32.50	5.00	0.00	0.00
9	33.00	27.50	5.00	0.00	0.00
10	39.00	32.50	5.00	0.00	0.00

Total settlement : 0.80

N ₁₍₆₀₎ :	Stress normalized and corrected SPT blow count
N ₁ :	Japanese equivalent corrected value
FS _L :	Calculated factor of safety
e _v :	Post-liquefaction volumetric strain (%)
Settle. :	Calculated settlement (in)

:: Liquefaction potential according to Iwasaki ::

Point ID	F	w _z	I _L
1	0.26	9.31	3.35
2	0.65	8.55	8.52
3	0.68	7.79	8.12
4	0.72	7.03	7.67
5	0.00	6.27	0.00
6	0.00	5.50	0.02
7	0.00	4.74	0.00
8	0.00	3.98	0.00
9	0.00	3.22	0.00
10	0.00	2.46	0.00

Overall potential I_L : 27.69

I _L = 0.00 - No liquefaction
I _L between 0.00 and 5 - Liquefaction not probable
I _L between 5 and 15 - Liquefaction probable
I _L > 15 - Liquefaction certain

LIQUEFACTION ANALYSIS REPORT

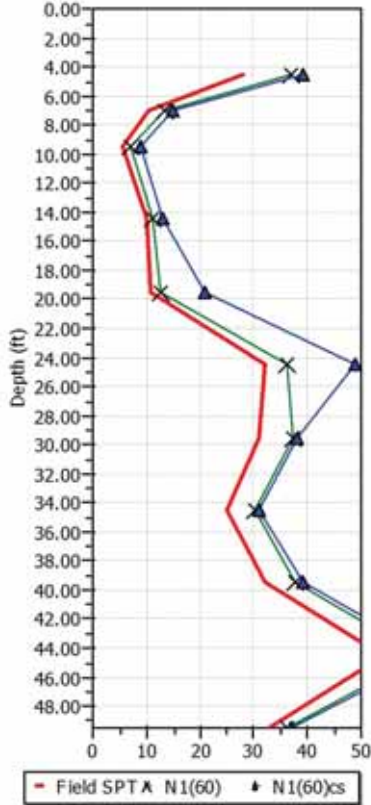
Project title : Blue Lake Levee

Project subtitle : D30RC

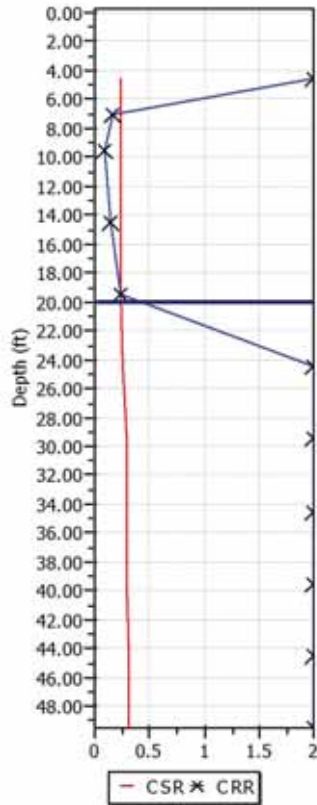
Input parameters and analysis data

In-situ data type:	Standard Penetration Test	Depth to water table:	20.00 ft
Analysis type:	Deterministic	Earthquake magnitude M_w :	9.00
Analysis method:	NCEER 1998	Peak ground acceleration:	0.23 g
Fines correction method:	Idriss & Seed	User defined F.S.:	1.00

SPT data graph



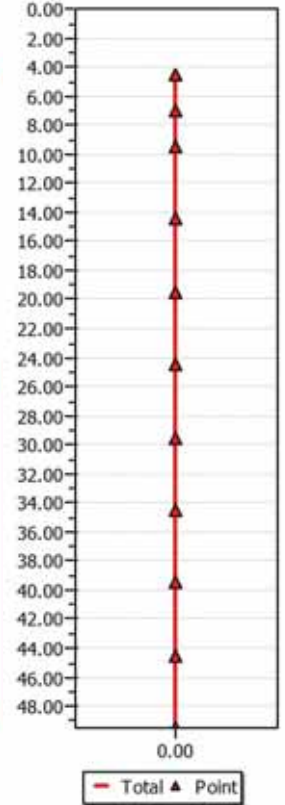
Shear stress ratio



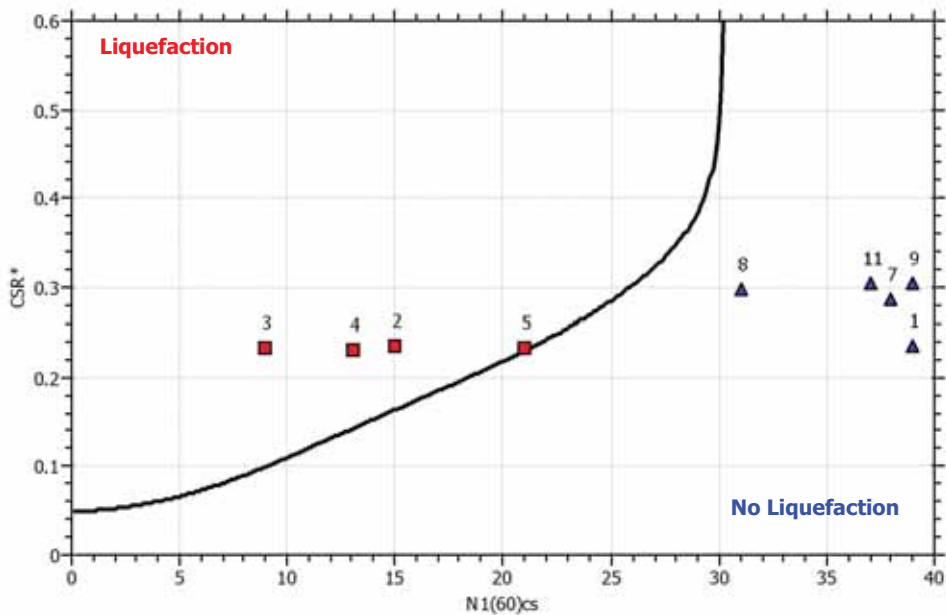
Factor of safety



Settlements (in)



$M_w=7^{1/2}$, $\sigma'_v=1$ atm base curve



:: Field input data ::

Point ID	Depth (ft)	Field N_{SPT} (blows/feet)	Unit weight (pcf)	Fines content (%)
1	4.50	28.00	120.00	10.40
2	7.00	10.50	120.00	10.40
3	9.50	5.60	120.00	10.40
4	14.50	10.00	120.00	10.40
5	19.50	11.00	120.00	73.80
6	24.50	32.00	120.00	73.80
7	29.50	31.00	120.00	7.80
8	34.50	25.00	120.00	7.80
9	39.50	32.00	120.00	8.70
10	44.50	54.00	120.00	8.70
11	49.50	33.00	120.00	7.80

Depth : Depth from free surface, at which SPT was performed (ft)
 Field SPT : SPT blows measured at field (blows/feet)
 Unit weight : Bulk unit weight of soil at test depth (pcf)
 Fines content : Percentage of fines in soil (%)

:: Cyclic Stress Ratio calculation (CSR fully adjusted and normalized) ::

Point ID	Depth (ft)	Sigma (tsf)	u (tsf)	Sigma' (tsf)	r_d	CSR	MSF	$CSR_{eq,M=7.5}$	K_{σ}	CSR*
1	4.50	0.27	0.00	0.27	0.99	0.15	0.63	0.24	1.00	0.24
2	7.00	0.42	0.00	0.42	0.98	0.15	0.63	0.23	1.00	0.23
3	9.50	0.57	0.00	0.57	0.98	0.15	0.63	0.23	1.00	0.23
4	14.50	0.87	0.00	0.87	0.97	0.14	0.63	0.23	1.00	0.23
5	19.50	1.17	0.00	1.17	0.95	0.14	0.63	0.23	0.98	0.23
6	24.50	1.47	0.14	1.33	0.94	0.16	0.63	0.25	0.95	0.26
7	29.50	1.77	0.30	1.47	0.93	0.17	0.63	0.27	0.93	0.29
8	34.50	2.07	0.45	1.62	0.89	0.17	0.63	0.27	0.92	0.30
9	39.50	2.37	0.61	1.76	0.85	0.17	0.63	0.27	0.90	0.30
10	44.50	2.67	0.77	1.91	0.81	0.17	0.63	0.27	0.89	0.31
11	49.50	2.97	0.92	2.05	0.77	0.17	0.63	0.27	0.87	0.31

Depth : Depth from free surface, at which SPT was performed (ft)
 Sigma : Total overburden pressure at test point, during earthquake (tsf)
 u : Water pressure at test point, during earthquake (tsf)
 Sigma' : Effective overburden pressure, during earthquake (tsf)
 r_d : Nonlinear shear mass factor
 CSR : Cyclic Stress Ratio
 MSF : Magnitude Scaling Factor
 $CSR_{eq,M=7.5}$: CSR adjusted for M=7.5
 K_{σ} : Effective overburden stress factor
 CSR* : CSR fully adjusted

:: Cyclic Resistance Ratio calculation $CRR_{7.5}$::

Point ID	Field SPT	C_n	C_e	C_b	C_r	C_s	$N_{1(60)}$	DeltaN	$N_{1(60)CS}$	$CRR_{7.5}$
1	28.00	1.70	0.90	1.15	0.75	1.00	36.77	1.87	39.00	2.00
2	10.50	1.58	0.93	1.15	0.75	1.00	13.28	1.32	15.00	0.16
3	5.60	1.35	0.96	1.15	0.85	1.00	7.15	1.17	9.00	0.10
4	10.00	1.10	1.03	1.15	0.85	1.00	11.08	1.26	13.00	0.14
5	11.00	0.94	1.10	1.15	0.95	1.00	12.53	7.51	21.00	0.23
6	32.00	0.89	1.17	1.15	0.95	1.00	36.34	12.27	49.00	2.00
7	31.00	0.84	1.24	1.15	1.00	1.00	37.28	0.70	38.00	2.00
8	25.00	0.80	1.31	1.15	1.00	1.00	30.29	0.61	31.00	2.00
9	32.00	0.77	1.33	1.15	1.00	1.00	37.78	1.06	39.00	2.00
10	54.00	0.74	1.33	1.15	1.00	1.00	61.30	1.43	63.00	2.00
11	33.00	0.71	1.33	1.15	1.00	1.00	36.12	0.68	37.00	2.00

:: Cyclic Resistance Ratio calculation CRR_{7.5} ::

Point ID	Field SPT	C _n	C _e	C _b	C _r	C _s	N ₁₍₆₀₎	DeltaN	N _{1(60)cs}	CRR _{7.5}
C _n :	Overburden correction factor									
C _e :	Energy correction factor									
C _b :	Borehole diameter correction factor									
C _r :	Rod length correction factor									
C _s :	Liner correction factor									
N ₁₍₆₀₎ :	Corrected N _{SPT}									
DeltaN :	Addition to corrected N _{SPT} value due to the presence of fines									
N _{1(60)cs} :	Corrected N ₁₍₆₀₎ value for fines									
CRR _{7.5} :	Cyclic resistance ratio for M=7.5									

:: Settlements calculation for saturated sands ::

Point ID	N ₁₍₆₀₎	N ₁	FS _L	e _v (%)	Settle. (in)
1	39.00	32.50	5.00	0.00	0.00
2	15.00	12.50	0.70	3.06	0.00
3	9.00	7.50	0.43	4.06	0.00
4	13.00	10.83	0.62	3.35	0.00
5	21.00	17.50	0.99	1.84	0.00
6	49.00	40.83	5.00	0.00	0.00
7	38.00	31.67	5.00	0.00	0.00
8	31.00	25.83	5.00	0.00	0.00
9	39.00	32.50	5.00	0.00	0.00
10	63.00	52.50	5.00	0.00	0.00
11	37.00	30.83	5.00	0.00	0.00

Total settlement : 0.00

N ₁₍₆₀₎ :	Stress normalized and corrected SPT blow count
N ₁ :	Japanese equivalent corrected value
FS _L :	Calculated factor of safety
e _v :	Post-liquefaction volumetric strain (%)
Settle. :	Calculated settlement (in)

:: Liquefaction potential according to Iwasaki ::

Point ID	F	w _z	I _L
1	0.00	9.31	0.00
2	0.30	8.93	2.07
3	0.57	8.55	3.74
4	0.38	7.79	4.56
5	0.01	7.03	0.16
6	0.00	6.27	0.00
7	0.00	5.50	0.00
8	0.00	4.74	0.00
9	0.00	3.98	0.00
10	0.00	3.22	0.00
11	0.00	2.46	0.00

Overall potential I_L : 10.53

I _L = 0.00	- No liquefaction
I _L between 0.00 and 5	- Liquefaction not probable
I _L between 5 and 15	- Liquefaction probable
I _L > 15	- Liquefaction certain

LIQUEFACTION ANALYSIS REPORT

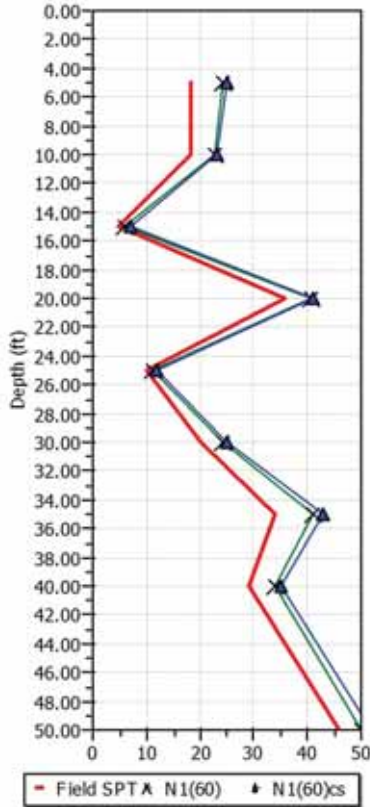
Project title : Blue Lake Levee

Project subtitle : D39RC

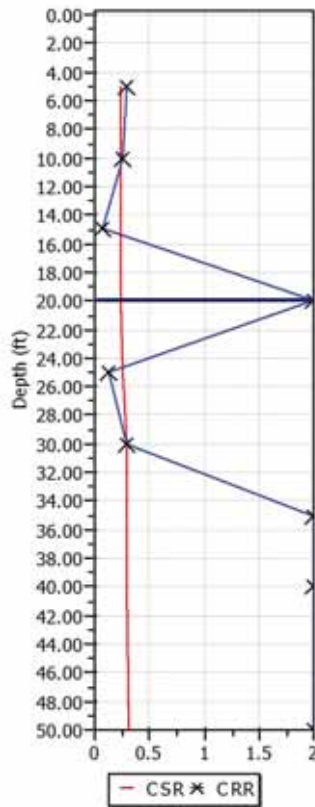
Input parameters and analysis data

In-situ data type:	Standard Penetration Test	Depth to water table:	20.00 ft
Analysis type:	Deterministic	Earthquake magnitude M_w :	9.00
Analysis method:	NCEER 1998	Peak ground acceleration:	0.23 g
Fines correction method:	Idriss & Seed	User defined F.S.:	1.00

SPT data graph



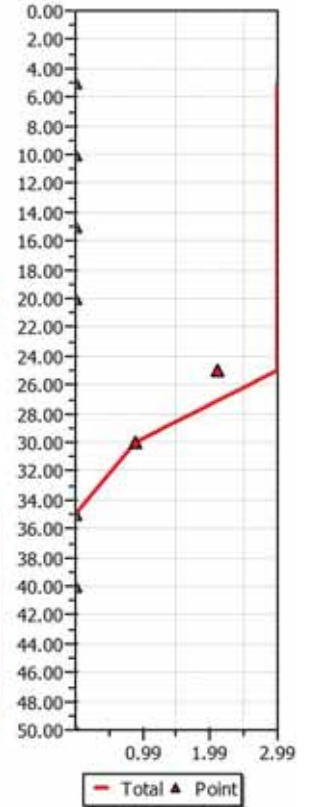
Shear stress ratio



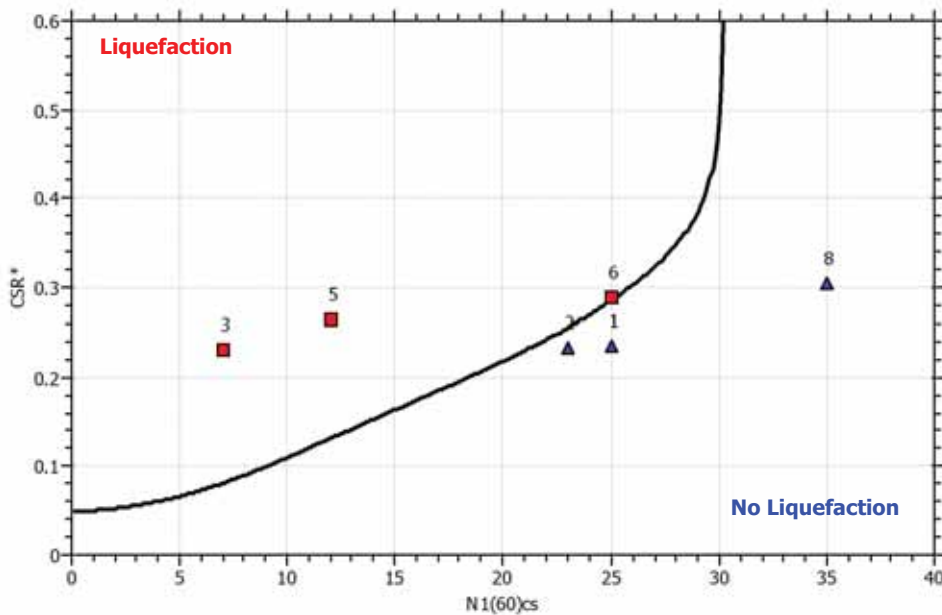
Factor of safety



Settlements (in)



$M_w = 7^{1/2}$, $\sigma'_v = 1$ atm base curve



:: Field input data ::

Point ID	Depth (ft)	Field N_{SPT} (blows/feet)	Unit weight (pcf)	Fines content (%)
1	5.00	18.20	120.00	0.00
2	10.00	18.20	120.00	0.00
3	15.00	4.90	120.00	0.00
4	20.00	36.00	120.00	0.00
5	25.00	10.00	120.00	5.10
6	30.00	20.00	120.00	5.10
7	35.00	34.00	120.00	8.00
8	40.00	29.00	120.00	8.00
9	50.00	46.00	120.00	8.00

Depth : Depth from free surface, at which SPT was performed (ft)
 Field SPT : SPT blows measured at field (blows/feet)
 Unit weight : Bulk unit weight of soil at test depth (pcf)
 Fines content : Percentage of fines in soil (%)

:: Cyclic Stress Ratio calculation (CSR fully adjusted and normalized) ::

Point ID	Depth (ft)	Sigma (tsf)	u (tsf)	Sigma' (tsf)	r_d	CSR	MSF	$CSR_{eq,M=7.5}$	K_{sigma}	CSR*
1	5.00	0.30	0.00	0.30	0.99	0.15	0.63	0.24	1.00	0.24
2	10.00	0.60	0.00	0.60	0.98	0.15	0.63	0.23	1.00	0.23
3	15.00	0.90	0.00	0.90	0.97	0.14	0.63	0.23	1.00	0.23
4	20.00	1.20	0.00	1.20	0.95	0.14	0.63	0.23	0.97	0.23
5	25.00	1.50	0.16	1.34	0.94	0.16	0.63	0.25	0.95	0.26
6	30.00	1.80	0.31	1.49	0.93	0.17	0.63	0.27	0.93	0.29
7	35.00	2.10	0.47	1.63	0.89	0.17	0.63	0.27	0.91	0.30
8	40.00	2.40	0.62	1.78	0.85	0.17	0.63	0.27	0.90	0.30
9	50.00	3.00	0.94	2.06	0.77	0.17	0.63	0.27	0.87	0.31

Depth : Depth from free surface, at which SPT was performed (ft)
 Sigma : Total overburden pressure at test point, during earthquake (tsf)
 u : Water pressure at test point, during earthquake (tsf)
 Sigma' : Effective overburden pressure, during earthquake (tsf)
 r_d : Nonlinear shear mass factor
 CSR : Cyclic Stress Ratio
 MSF : Magnitude Scaling Factor
 $CSR_{eq,M=7.5}$: CSR adjusted for M=7.5
 K_{sigma} : Effective overburden stress factor
 CSR* : CSR fully adjusted

:: Cyclic Resistance Ratio calculation $CRR_{7.5}$::

Point ID	Field SPT	C_n	C_e	C_b	C_r	C_s	$N_{1(60)}$	DeltaN	$N_{1(60)cs}$	$CRR_{7.5}$
1	18.20	1.70	0.90	1.15	0.75	1.00	24.09	0.00	25.00	0.29
2	18.20	1.32	0.97	1.15	0.85	1.00	22.81	0.00	23.00	0.25
3	4.90	1.08	1.04	1.15	0.95	1.00	6.00	0.00	7.00	0.08
4	36.00	0.93	1.11	1.15	0.95	1.00	40.74	0.00	41.00	2.00
5	10.00	0.88	1.18	1.15	0.95	1.00	11.36	0.02	12.00	0.13
6	20.00	0.84	1.25	1.15	1.00	1.00	24.07	0.04	25.00	0.29
7	34.00	0.80	1.32	1.15	1.00	1.00	41.23	0.82	43.00	2.00
8	29.00	0.77	1.33	1.15	1.00	1.00	34.10	0.73	35.00	2.00
9	46.00	0.71	1.33	1.15	1.00	1.00	50.18	0.93	52.00	2.00

C_n : Overburden correction factor
 C_e : Energy correction factor
 C_b : Borehole diameter correction factor
 C_r : Rod length correction factor
 C_s : Limer correction factor
 $N_{1(60)}$: Corrected N_{SPT}
 DeltaN : Addition to corrected N_{SPT} value due to the presence of fines
 $N_{1(60)cs}$: Corrected $N_{1(60)}$ value for fines
 $CRR_{7.5}$: Cyclic resistance ratio for M=7.5

:: Settlements calculation for saturated sands ::

Point ID	$N_{1(60)}$	N_1	FS_L	e_v (%)	Settle. (in)
1	25.00	20.83	1.21	0.25	0.00
2	23.00	19.17	1.09	0.54	0.00
3	7.00	5.83	0.35	4.46	0.00
4	41.00	34.17	5.00	0.00	0.00
5	12.00	10.00	0.50	3.50	2.10
6	25.00	20.83	0.99	1.49	0.89
7	43.00	35.83	5.00	0.00	0.00
8	35.00	29.17	5.00	0.00	0.00
9	52.00	43.33	5.00	0.00	0.00

Total settlement : 2.99

$N_{1(60)}$: Stress normalized and corrected SPT blow count
 N_1 : Japanese equivalent corrected value
 FS_L : Calculated factor of safety
 e_v : Post-liquefaction volumetric strain (%)
 Settle.: Calculated settlement (in)

:: Liquefaction potential according to Iwasaki ::

Point ID	F	w_z	I_L
1	0.00	9.24	0.00
2	0.00	8.48	0.00
3	0.65	7.71	7.63
4	0.00	6.95	0.00
5	0.50	6.19	4.75
6	0.01	5.43	0.09
7	0.00	4.67	0.00
8	0.00	3.90	0.00
9	0.00	2.38	0.00

Overall potential I_L : 12.46

$I_L = 0.00$ - No liquefaction
 I_L between 0.00 and 5 - Liquefaction not probable
 I_L between 5 and 15 - Liquefaction probable
 $I_L > 15$ - Liquefaction certain

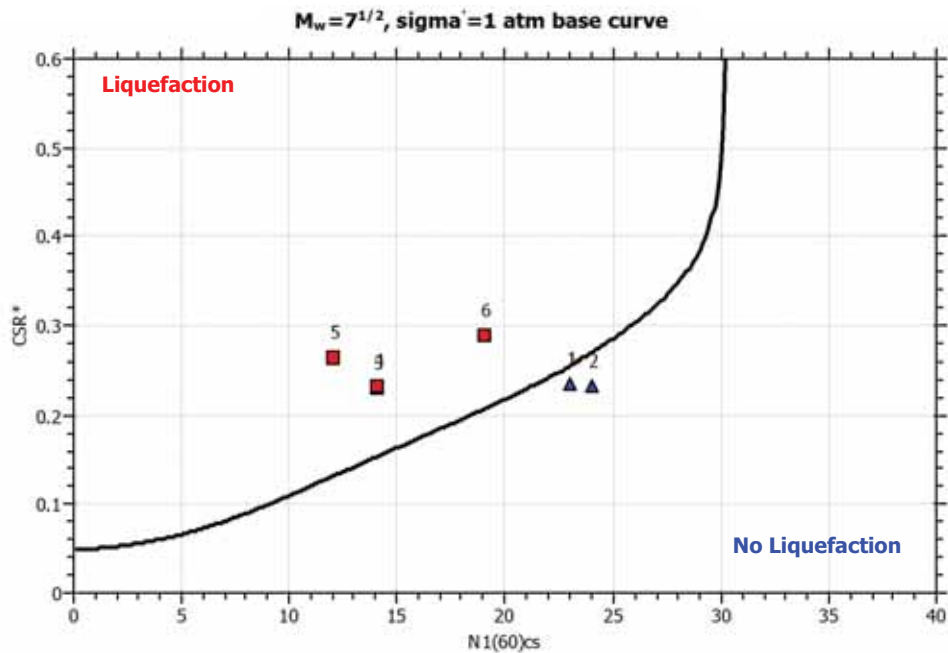
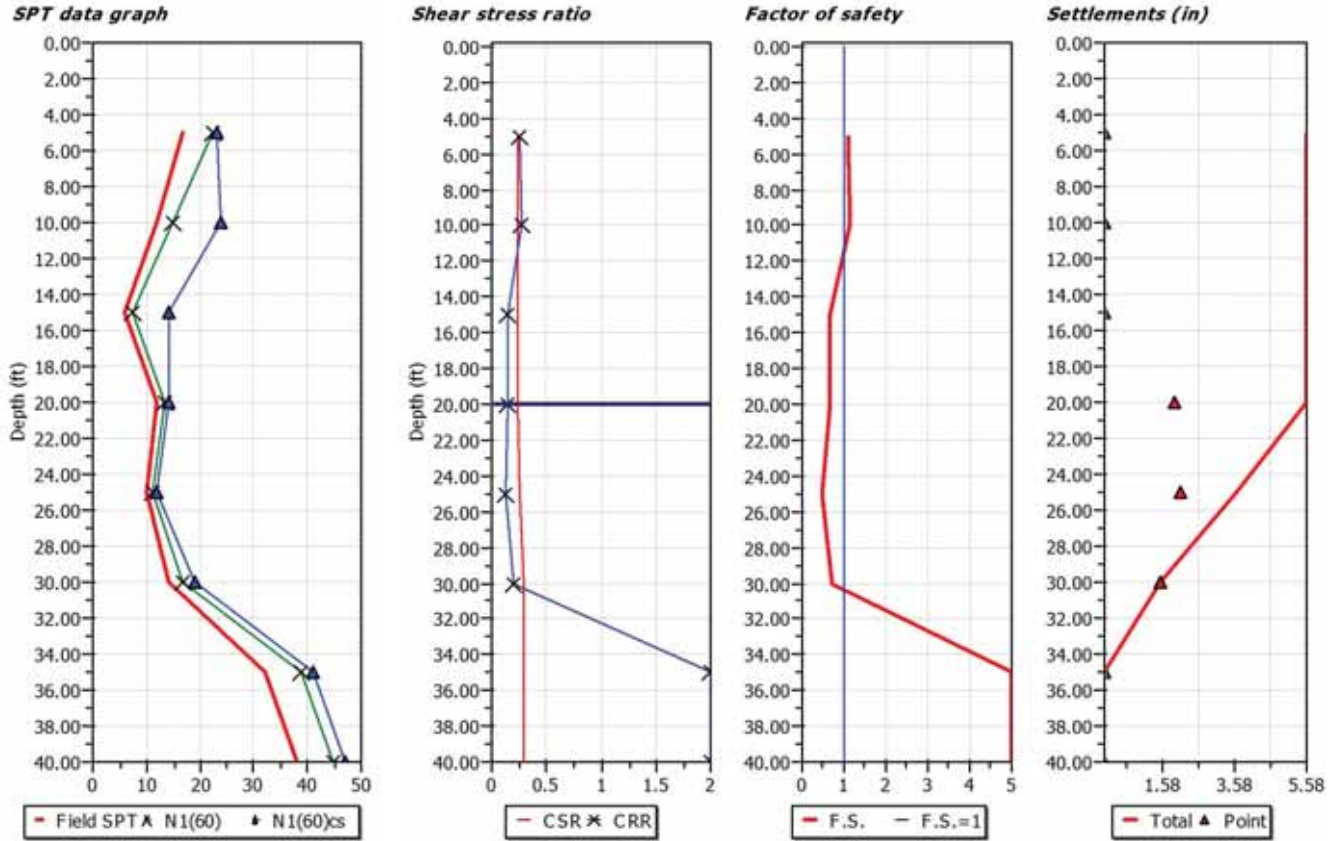
LIQUEFACTION ANALYSIS REPORT

Project title : Blue Lake Levee

Project subtitle : D49RC

Input parameters and analysis data

In-situ data type:	Standard Penetration Test	Depth to water table:	20.00 ft
Analysis type:	Deterministic	Earthquake magnitude M_w :	9.00
Analysis method:	NCEER 1998	Peak ground acceleration:	0.23 g
Fines correction method:	Idriss & Seed	User defined F.S.:	1.00



:: Field input data ::

Point ID	Depth (ft)	Field N_{SPT} (blows/feet)	Unit weight (pcf)	Fines content (%)
1	5.00	16.80	120.00	0.00
2	10.00	12.00	120.00	50.80
3	15.00	6.00	120.00	50.80
4	20.00	12.00	120.00	2.90
5	25.00	10.00	120.00	2.90
6	30.00	14.00	120.00	10.70
7	35.00	32.00	120.00	10.70
8	40.00	38.00	120.00	10.70

Depth : Depth from free surface, at which SPT was performed (ft)
 Field SPT : SPT blows measured at field (blows/feet)
 Unit weight : Bulk unit weight of soil at test depth (pcf)
 Fines content : Percentage of fines in soil (%)

:: Cyclic Stress Ratio calculation (CSR fully adjusted and normalized) ::

Point ID	Depth (ft)	Sigma (tsf)	u (tsf)	Sigma' (tsf)	r_d	CSR	MSF	$CSR_{eq,M=7.5}$	K_{sigma}	CSR*
1	5.00	0.30	0.00	0.30	0.99	0.15	0.63	0.24	1.00	0.24
2	10.00	0.60	0.00	0.60	0.98	0.15	0.63	0.23	1.00	0.23
3	15.00	0.90	0.00	0.90	0.97	0.14	0.63	0.23	1.00	0.23
4	20.00	1.20	0.00	1.20	0.95	0.14	0.63	0.23	0.97	0.23
5	25.00	1.50	0.16	1.34	0.94	0.16	0.63	0.25	0.95	0.26
6	30.00	1.80	0.31	1.49	0.93	0.17	0.63	0.27	0.93	0.29
7	35.00	2.10	0.47	1.63	0.89	0.17	0.63	0.27	0.91	0.30
8	40.00	2.40	0.62	1.78	0.85	0.17	0.63	0.27	0.90	0.30

Depth : Depth from free surface, at which SPT was performed (ft)
 Sigma : Total overburden pressure at test point, during earthquake (tsf)
 u : Water pressure at test point, during earthquake (tsf)
 Sigma' : Effective overburden pressure, during earthquake (tsf)
 r_d : Nonlinear shear mass factor
 CSR : Cyclic Stress Ratio
 MSF : Magnitude Scaling Factor
 $CSR_{eq,M=7.5}$: CSR adjusted for M=7.5
 K_{sigma} : Effective overburden stress factor
 CSR* : CSR fully adjusted

:: Cyclic Resistance Ratio calculation $CRR_{7.5}$::

Point ID	Field SPT	C_n	C_e	C_b	C_r	C_s	$N_{1(60)}$	DeltaN	$N_{1(60)cs}$	$CRR_{7.5}$
1	16.80	1.70	0.90	1.15	0.75	1.00	22.23	0.00	23.00	0.25
2	12.00	1.32	0.97	1.15	0.85	1.00	15.04	8.01	24.00	0.27
3	6.00	1.08	1.04	1.15	0.95	1.00	7.35	6.47	14.00	0.15
4	12.00	0.93	1.11	1.15	0.95	1.00	13.58	0.00	14.00	0.15
5	10.00	0.88	1.18	1.15	0.95	1.00	11.36	0.00	12.00	0.13
6	14.00	0.84	1.25	1.15	1.00	1.00	16.85	1.53	19.00	0.21
7	32.00	0.80	1.32	1.15	1.00	1.00	38.81	2.08	41.00	2.00
8	38.00	0.77	1.33	1.15	1.00	1.00	44.68	2.22	47.00	2.00

C_n : Overburden correction factor
 C_e : Energy correction factor
 C_b : Borehole diameter correction factor
 C_r : Rod length correction factor
 C_s : Liner correction factor
 $N_{1(60)}$: Corrected N_{SPT}
 DeltaN : Addition to corrected N_{SPT} value due to the presence of fines
 $N_{1(60)cs}$: Corrected $N_{1(60)}$ value for fines
 $CRR_{7.5}$: Cyclic resistance ratio for M=7.5

:: Settlements calculation for saturated sands ::

Point ID	$N_{1(60)}$	N_1	FS_L	e_v (%)	Settle. (in)
1	23.00	19.17	1.08	0.59	0.00
2	24.00	20.00	1.16	0.35	0.00
3	14.00	11.67	0.66	3.21	0.00
4	14.00	11.67	0.65	3.21	1.93
5	12.00	10.00	0.50	3.50	2.10
6	19.00	15.83	0.72	2.60	1.56
7	41.00	34.17	5.00	0.00	0.00
8	47.00	39.17	5.00	0.00	0.00

Total settlement : 5.58

$N_{1(60)}$: Stress normalized and corrected SPT blow count
 N_1 : Japanese equivalent corrected value
 FS_L : Calculated factor of safety
 e_v : Post-liquefaction volumetric strain (%)
 Settle.: Calculated settlement (in)

:: Liquefaction potential according to Iwasaki ::

Point ID	F	w_z	I_L
1	0.00	9.24	0.00
2	0.00	8.48	0.00
3	0.34	7.71	3.96
4	0.35	6.95	3.68
5	0.50	6.19	4.75
6	0.28	5.43	2.34
7	0.00	4.67	0.00
8	0.00	3.90	0.00

Overall potential I_L : 14.72

$I_L = 0.00$ - No liquefaction
 I_L between 0.00 and 5 - Liquefaction not probable
 I_L between 5 and 15 - Liquefaction probable
 $I_L > 15$ - Liquefaction certain

LIQUEFACTION ANALYSIS REPORT

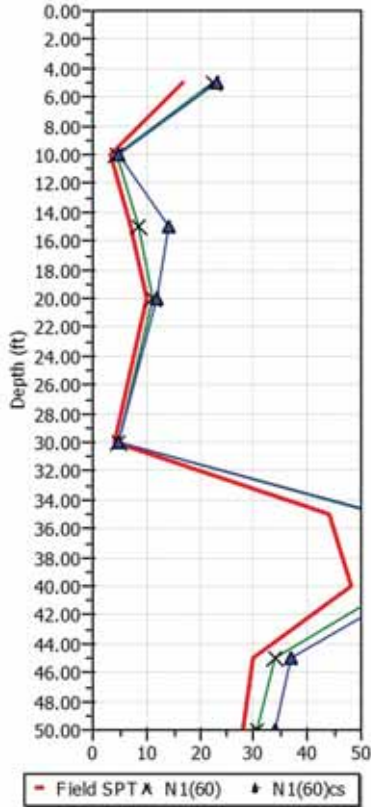
Project title : Blue Lake Levee

Project subtitle : D59RC

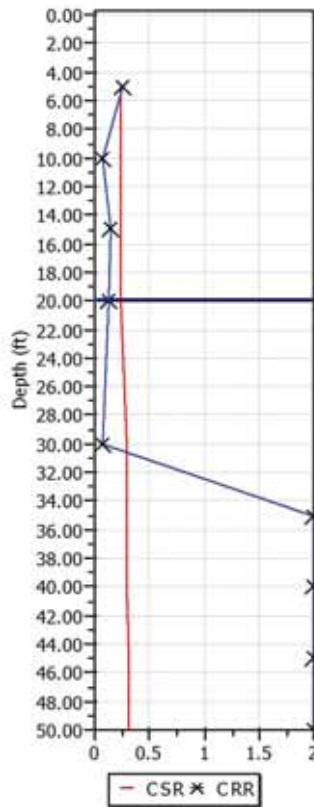
Input parameters and analysis data

In-situ data type:	Standard Penetration Test	Depth to water table:	20.00 ft
Analysis type:	Deterministic	Earthquake magnitude M_w :	9.00
Analysis method:	NCEER 1998	Peak ground acceleration:	0.23 g
Fines correction method:	Idriss & Seed	User defined F.S.:	1.00

SPT data graph



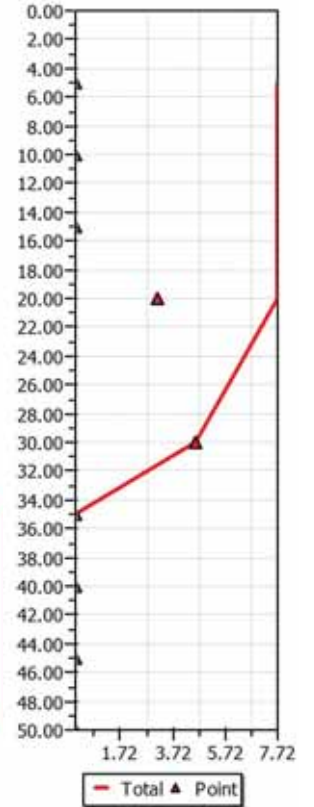
Shear stress ratio



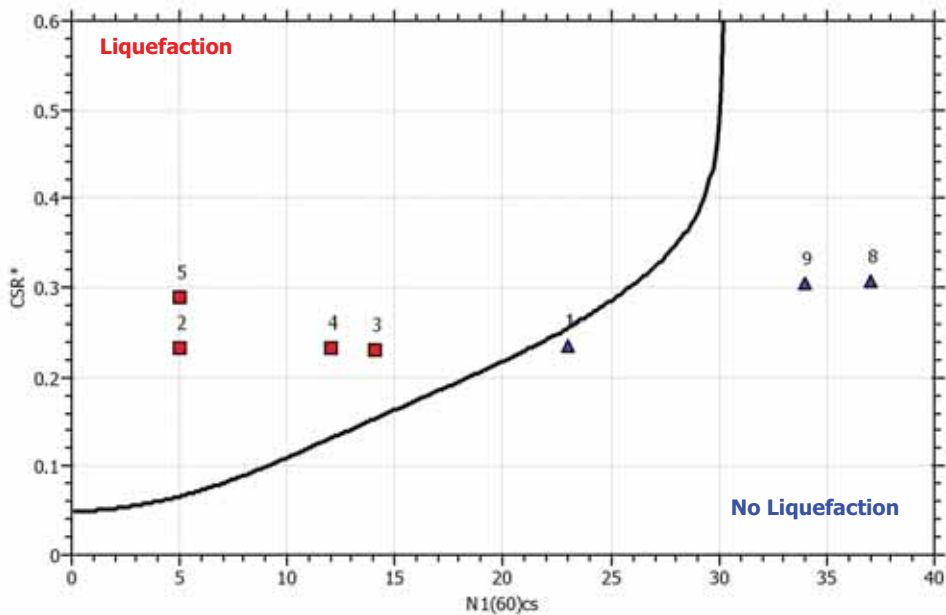
Factor of safety



Settlements (in)



$M_w = 7^{1/2}$, $\sigma'_v = 1$ atm base curve



:: Field input data ::

Point ID	Depth (ft)	Field N_{SPT} (blows/feet)	Unit weight (pcf)	Fines content (%)
1	5.00	16.80	120.00	0.00
2	10.00	3.50	120.00	0.00
3	15.00	7.00	120.00	22.90
4	20.00	10.00	120.00	1.10
5	30.00	4.00	120.00	1.10
6	35.00	44.00	120.00	1.10
7	40.00	48.00	120.00	12.00
8	45.00	30.00	120.00	12.00
9	50.00	28.00	120.00	12.00

Depth : Depth from free surface, at which SPT was performed (ft)
 Field SPT : SPT blows measured at field (blows/feet)
 Unit weight : Bulk unit weight of soil at test depth (pcf)
 Fines content : Percentage of fines in soil (%)

:: Cyclic Stress Ratio calculation (CSR fully adjusted and normalized) ::

Point ID	Depth (ft)	Sigma (tsf)	u (tsf)	Sigma' (tsf)	r_d	CSR	MSF	$CSR_{eq,M=7.5}$	K_{sigma}	CSR*
1	5.00	0.30	0.00	0.30	0.99	0.15	0.63	0.24	1.00	0.24
2	10.00	0.60	0.00	0.60	0.98	0.15	0.63	0.23	1.00	0.23
3	15.00	0.90	0.00	0.90	0.97	0.14	0.63	0.23	1.00	0.23
4	20.00	1.20	0.00	1.20	0.95	0.14	0.63	0.23	0.97	0.23
5	30.00	1.80	0.31	1.49	0.93	0.17	0.63	0.27	0.93	0.29
6	35.00	2.10	0.47	1.63	0.89	0.17	0.63	0.27	0.91	0.30
7	40.00	2.40	0.62	1.78	0.85	0.17	0.63	0.27	0.90	0.30
8	45.00	2.70	0.78	1.92	0.81	0.17	0.63	0.27	0.89	0.31
9	50.00	3.00	0.94	2.06	0.77	0.17	0.63	0.27	0.87	0.31

Depth : Depth from free surface, at which SPT was performed (ft)
 Sigma : Total overburden pressure at test point, during earthquake (tsf)
 u : Water pressure at test point, during earthquake (tsf)
 Sigma' : Effective overburden pressure, during earthquake (tsf)
 r_d : Nonlinear shear mass factor
 CSR : Cyclic Stress Ratio
 MSF : Magnitude Scaling Factor
 $CSR_{eq,M=7.5}$: CSR adjusted for M=7.5
 K_{sigma} : Effective overburden stress factor
 CSR* : CSR fully adjusted

:: Cyclic Resistance Ratio calculation $CRR_{7.5}$::

Point ID	Field SPT	C_n	C_e	C_b	C_r	C_s	$N_{1(60)}$	DeltaN	$N_{1(60)cs}$	$CRR_{7.5}$
1	16.80	1.70	0.90	1.15	0.75	1.00	22.23	0.00	23.00	0.25
2	3.50	1.32	0.97	1.15	0.85	1.00	4.39	0.00	5.00	0.07
3	7.00	1.08	1.04	1.15	0.95	1.00	8.58	4.90	14.00	0.15
4	10.00	0.93	1.11	1.15	0.95	1.00	11.32	0.00	12.00	0.13
5	4.00	0.84	1.25	1.15	1.00	1.00	4.81	0.00	5.00	0.07
6	44.00	0.80	1.32	1.15	1.00	1.00	53.36	0.00	54.00	2.00
7	48.00	0.77	1.33	1.15	1.00	1.00	56.44	3.34	60.00	2.00
8	30.00	0.74	1.33	1.15	1.00	1.00	33.93	2.62	37.00	2.00
9	28.00	0.71	1.33	1.15	1.00	1.00	30.54	2.52	34.00	2.00

C_n : Overburden correction factor
 C_e : Energy correction factor
 C_b : Borehole diameter correction factor
 C_r : Rod length correction factor
 C_s : Limer correction factor
 $N_{1(60)}$: Corrected N_{SPT}
 DeltaN : Addition to corrected N_{SPT} value due to the presence of fines
 $N_{1(60)cs}$: Corrected $N_{1(60)}$ value for fines
 $CRR_{7.5}$: Cyclic resistance ratio for M=7.5

:: Settlements calculation for saturated sands ::

Point ID	$N_{1(60)}$	N_1	FS_L	e_v (%)	Settle. (in)
1	23.00	19.17	1.08	0.59	0.00
2	5.00	4.17	0.28	5.07	0.00
3	14.00	11.67	0.66	3.21	0.00
4	12.00	10.00	0.56	3.50	3.15
5	5.00	4.17	0.23	5.07	4.57
6	54.00	45.00	5.00	0.00	0.00
7	60.00	50.00	5.00	0.00	0.00
8	37.00	30.83	5.00	0.00	0.00
9	34.00	28.33	5.00	0.00	0.00

Total settlement : 7.72

$N_{1(60)}$: Stress normalized and corrected SPT blow count
 N_1 : Japanese equivalent corrected value
 FS_L : Calculated factor of safety
 e_v : Post-liquefaction volumetric strain (%)
 Settle.: Calculated settlement (in)

:: Liquefaction potential according to Iwasaki ::

Point ID	F	w_z	I_L
1	0.00	9.24	0.00
2	0.72	8.48	9.26
3	0.34	7.71	3.96
4	0.44	6.95	4.66
5	0.77	5.43	12.75
6	0.00	4.67	0.00
7	0.00	3.90	0.00
8	0.00	3.14	0.00
9	0.00	2.38	0.00

Overall potential I_L : 30.62

$I_L = 0.00$ - No liquefaction
 I_L between 0.00 and 5 - Liquefaction not probable
 I_L between 5 and 15 - Liquefaction probable
 $I_L > 15$ - Liquefaction certain

LIQUEFACTION ANALYSIS REPORT

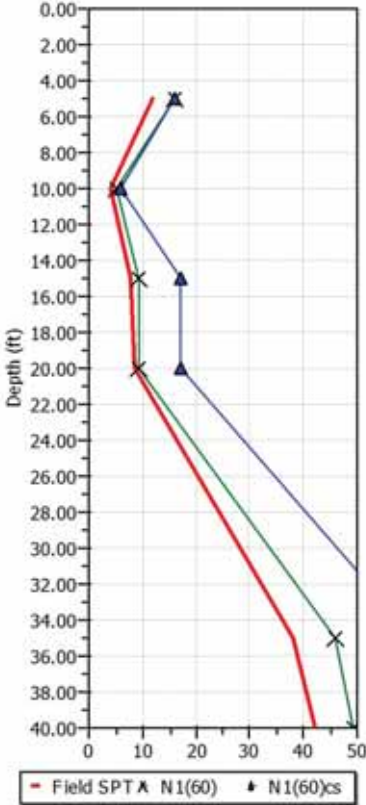
Project title : Blue Lake Levee

Project subtitle : D70RC

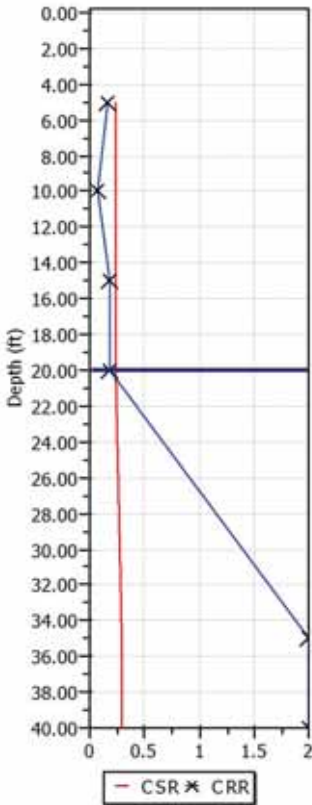
Input parameters and analysis data

In-situ data type:	Standard Penetration Test	Depth to water table:	20.00 ft
Analysis type:	Deterministic	Earthquake magnitude M_w :	9.00
Analysis method:	NCEER 1998	Peak ground acceleration:	0.23 g
Fines correction method:	Idriss & Seed	User defined F.S.:	1.00

SPT data graph



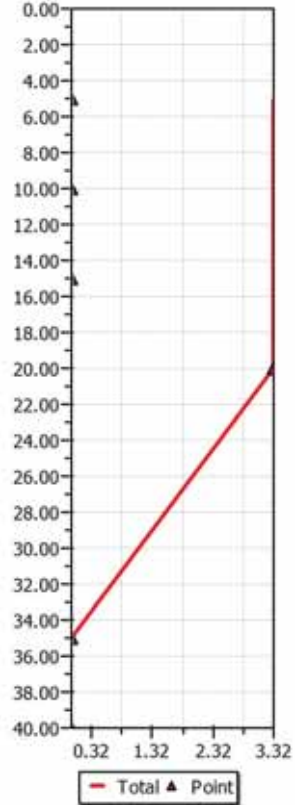
Shear stress ratio



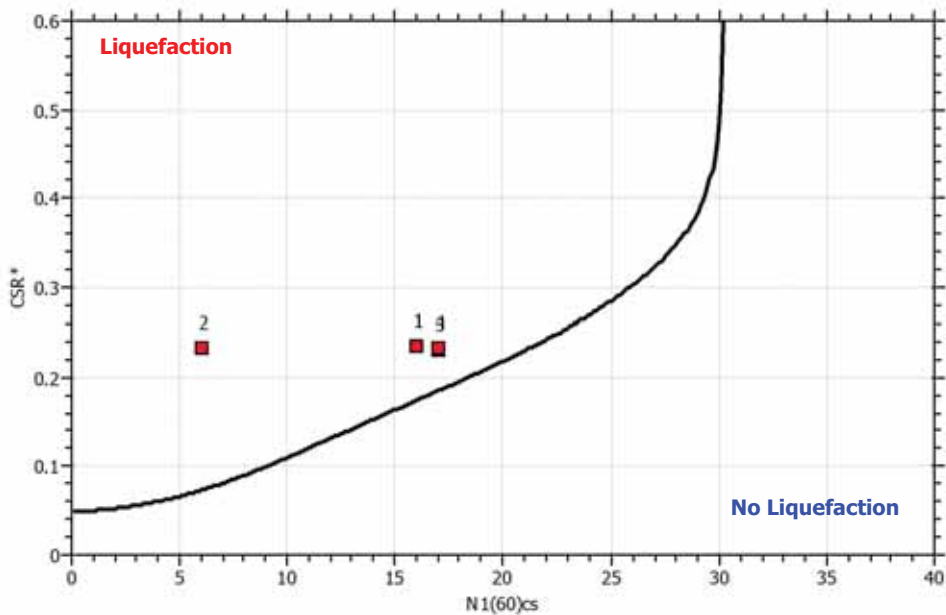
Factor of safety



Settlements (in)



$M_w=7^{1/2}$, $\sigma'_v=1$ atm base curve



:: Field input data ::

Point ID	Depth (ft)	Field N_{SPT} (blows/feet)	Unit weight (pcf)	Fines content (%)
1	5.00	12.00	120.00	0.00
2	10.00	4.20	120.00	0.00
3	15.00	7.70	120.00	50.00
4	20.00	8.40	120.00	50.00
5	35.00	38.00	120.00	50.00
6	40.00	42.00	120.00	50.00

Depth : Depth from free surface, at which SPT was performed (ft)
 Field SPT : SPT blows measured at field (blows/feet)
 Unit weight : Bulk unit weight of soil at test depth (pcf)
 Fines content : Percentage of fines in soil (%)

:: Cyclic Stress Ratio calculation (CSR fully adjusted and normalized) ::

Point ID	Depth (ft)	Sigma (tsf)	u (tsf)	Sigma' (tsf)	r_d	CSR	MSF	$CSR_{eq,M=7.5}$	K_{σ}	CSR'
1	5.00	0.30	0.00	0.30	0.99	0.15	0.63	0.24	1.00	0.24
2	10.00	0.60	0.00	0.60	0.98	0.15	0.63	0.23	1.00	0.23
3	15.00	0.90	0.00	0.90	0.97	0.14	0.63	0.23	1.00	0.23
4	20.00	1.20	0.00	1.20	0.95	0.14	0.63	0.23	0.97	0.23
5	35.00	2.10	0.47	1.63	0.89	0.17	0.63	0.27	0.91	0.30
6	40.00	2.40	0.62	1.78	0.85	0.17	0.63	0.27	0.90	0.30

Depth : Depth from free surface, at which SPT was performed (ft)
 Sigma : Total overburden pressure at test point, during earthquake (tsf)
 u : Water pressure at test point, during earthquake (tsf)
 Sigma' : Effective overburden pressure, during earthquake (tsf)
 r_d : Nonlinear shear mass factor
 CSR : Cyclic Stress Ratio
 MSF : Magnitude Scaling Factor
 $CSR_{eq,M=7.5}$: CSR adjusted for M=7.5
 K_{σ} : Effective overburden stress factor
 CSR' : CSR fully adjusted

:: Cyclic Resistance Ratio calculation $CRR_{7.5}$::

Point ID	Field SPT	C_n	C_e	C_b	C_r	C_s	$N_{1(60)}$	DeltaN	$N_{1(60)cs}$	$CRR_{7.5}$
1	12.00	1.70	0.90	1.15	0.75	1.00	15.88	0.00	16.00	0.17
2	4.20	1.32	0.97	1.15	0.85	1.00	5.26	0.00	6.00	0.07
3	7.70	1.08	1.04	1.15	0.95	1.00	9.43	6.89	17.00	0.18
4	8.40	0.93	1.11	1.15	0.95	1.00	9.51	6.90	17.00	0.18
5	38.00	0.80	1.32	1.15	1.00	1.00	46.08	14.22	61.00	2.00
6	42.00	0.77	1.33	1.15	1.00	1.00	49.39	14.88	65.00	2.00

C_n : Overburden correction factor
 C_e : Energy correction factor
 C_b : Borehole diameter correction factor
 C_r : Rod length correction factor
 C_s : Liner correction factor
 $N_{1(60)}$: Corrected N_{SPT}
 DeltaN : Addition to corrected N_{SPT} value due to the presence of fines
 $N_{1(60)cs}$: Corrected $N_{1(60)}$ value for fines
 $CRR_{7.5}$: Cyclic resistance ratio for M=7.5

:: Settlements calculation for saturated sands ::

Point ID	$N_{1(60)}$	N_1	FS_L	e_v (%)	Settle. (in)
1	16.00	13.33	0.74	2.91	0.00
2	6.00	5.00	0.31	4.77	0.00
3	17.00	14.17	0.80	2.76	0.00
4	17.00	14.17	0.79	2.77	3.32
5	61.00	50.83	5.00	0.00	0.00

:: Settlements calculation for saturated sands ::

Point ID	$N_{1(60)}$	N_1	FS_L	e_v (%)	Settle. (in)
6	65.00	54.17	5.00	0.00	0.00

Total settlement : 3.32

$N_{1(60)}$: Stress normalized and corrected SPT blow count
 N_1 : Japanese equivalent corrected value
 FS_L : Calculated factor of safety
 e_v : Post-liquefaction volumetric strain (%)
 Settle.: Calculated settlement (in)

:: Liquefaction potential according to Iwasaki ::

Point ID	F	w_z	I_L
1	0.26	9.24	3.68
2	0.69	8.48	8.88
3	0.20	7.71	2.32
4	0.21	6.95	2.22
5	0.00	4.67	0.00
6	0.00	3.90	0.00

Overall potential I_L : 17.10

$I_L = 0.00$ - No liquefaction
 I_L between 0.00 and 5 - Liquefaction not probable
 I_L between 5 and 15 - Liquefaction probable
 $I_L > 15$ - Liquefaction certain

APPENDIX E
SLIDE OUTPUT



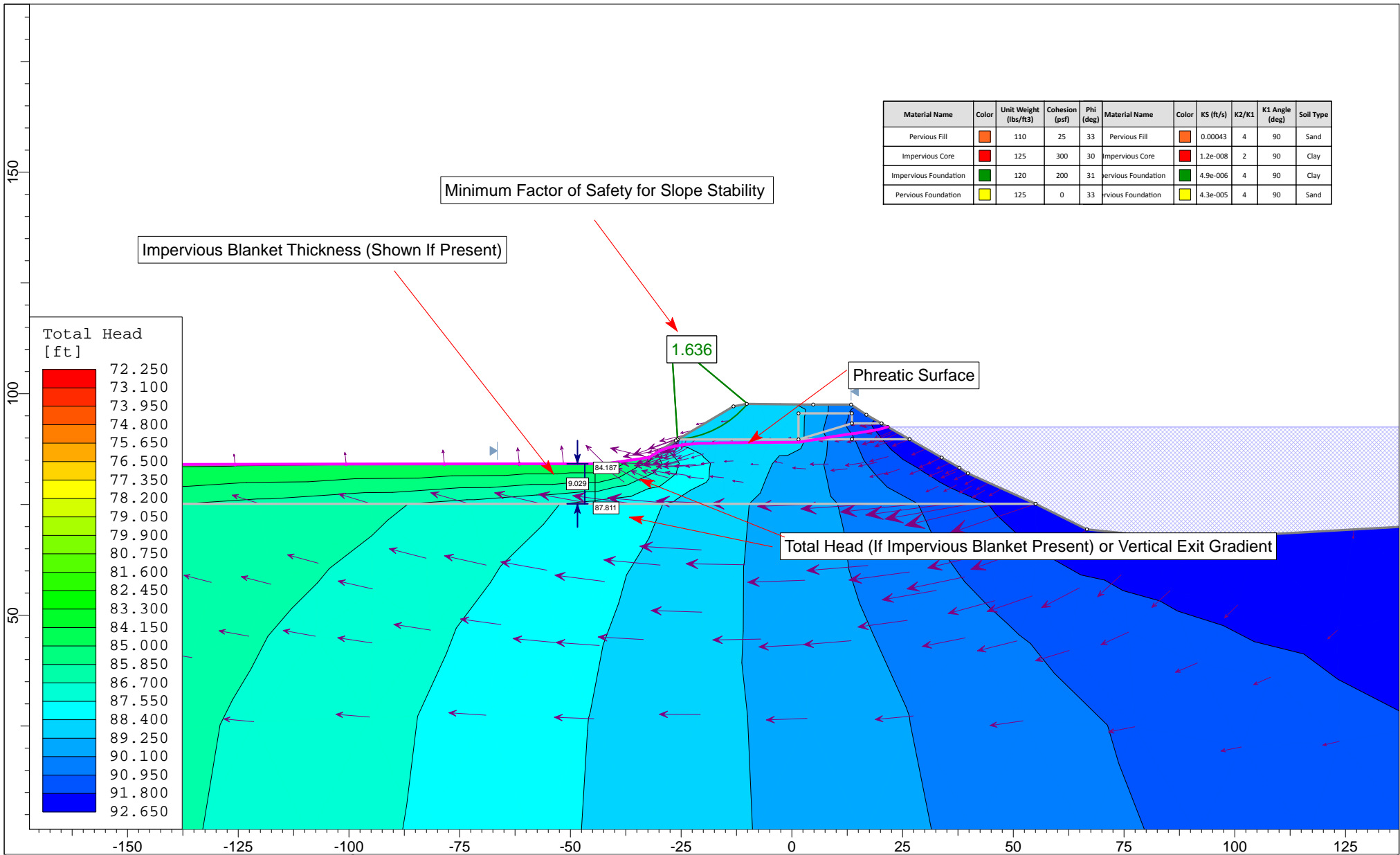
APPENDIX E - SLIDE OUTPUT

CONTENTS

Seepage Model	E-1
Slope Stability Model.....	E-2
STA 2+00, Existing Conditions, Landside	E-3
Existing Conditions, Waterside	E-4
Steady State Flood Conditions.....	E-5
Rapid Drawdown Conditions.....	E-6
Earthquake Conditions, Landside	E-7
Earthquake Conditions, Waterside.....	E-8
STA 11+00, Existing Conditions, Landside	E-9
Existing Conditions, Waterside	E-10
Steady State Flood Conditions.....	E-11
Rapid Drawdown Conditions.....	E-12
Earthquake Conditions, Landside	E-13
Earthquake Conditions, Waterside.....	E-14
STA 22+00, Existing Conditions, Landside	E-15
Existing Conditions, Waterside	E-16
Steady State Flood Conditions.....	E-17
Rapid Drawdown Conditions.....	E-18
Earthquake Conditions, Landside	E-19
Earthquake Conditions, Waterside.....	E-20
STA 34+00, Existing Conditions, Landside	E-21
Existing Conditions, Waterside	E-22
Steady State Flood Conditions.....	E-23
Rapid Drawdown Conditions.....	E-24
Earthquake Conditions, Landside	E-25
Earthquake Conditions, Waterside.....	E-26
STA 42+00, Existing Conditions, Landside	E-27
Existing Conditions, Waterside	E-28
Steady State Flood Conditions.....	E-29
Rapid Drawdown Conditions.....	E-30
Earthquake Conditions, Landside	E-31
Earthquake Conditions, Waterside.....	E-32
STA 50+00, Existing Conditions, Landside	E-33
Existing Conditions, Waterside	E-34
Steady State Flood Conditions.....	E-35
Rapid Drawdown Conditions.....	E-36
Earthquake Conditions, Landside	E-37
Earthquake Conditions, Waterside.....	E-38
STA 61+00, Existing Conditions, Landside	E-39
Existing Conditions, Waterside	E-40
Steady State Flood Conditions.....	E-41
Rapid Drawdown Conditions.....	E-42



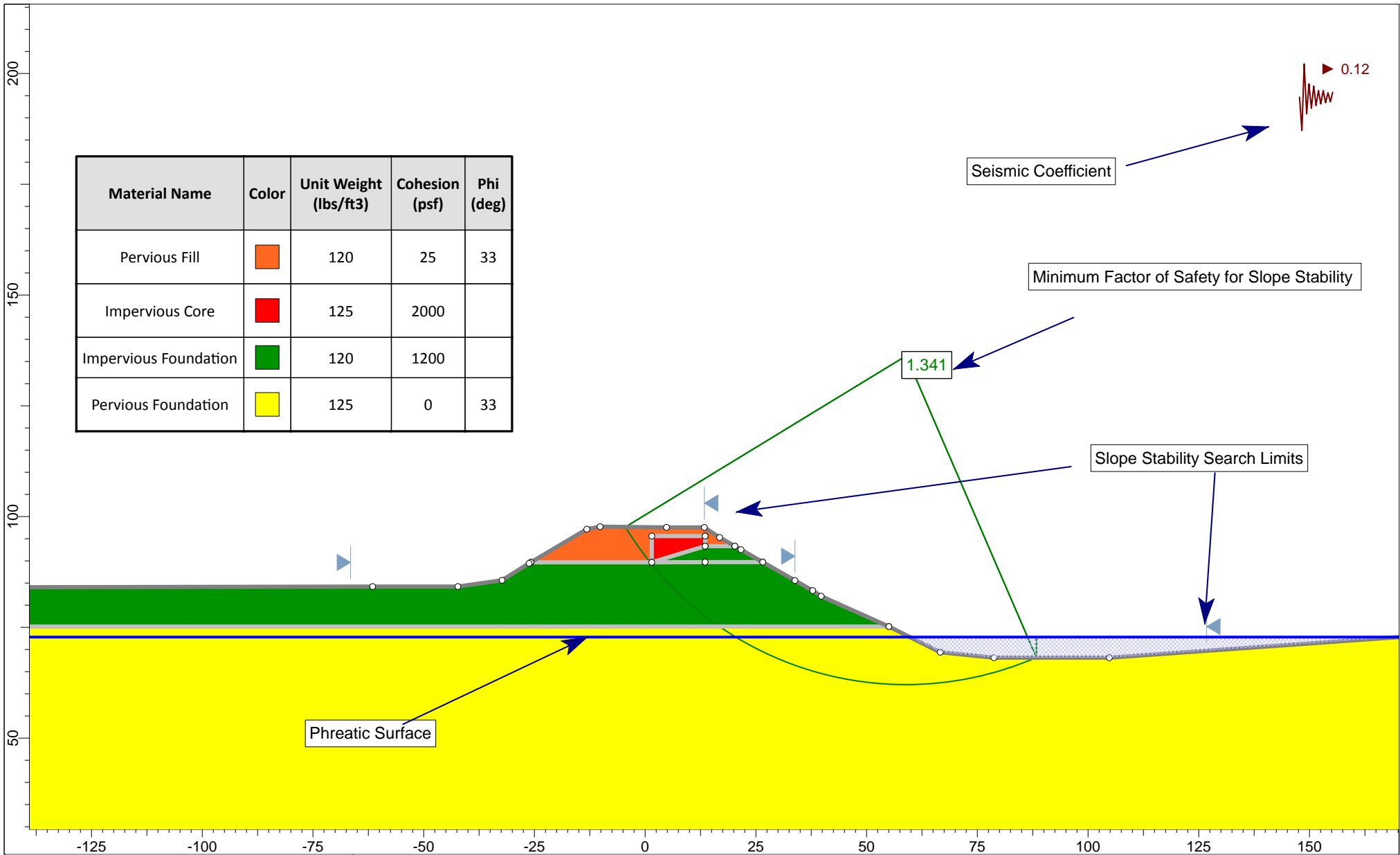
Earthquake Conditions, Landside	E-43
Earthquake Conditions, Waterside.....	E-44
STA 71+00, Existing Conditions, Landside	E-45
Existing Conditions, Waterside	E-46
Steady State Flood Conditions.....	E-47
Rapid Drawdown Conditions.....	E-48
Earthquake Conditions, Landside	E-49
Earthquake Conditions, Waterside.....	E-50




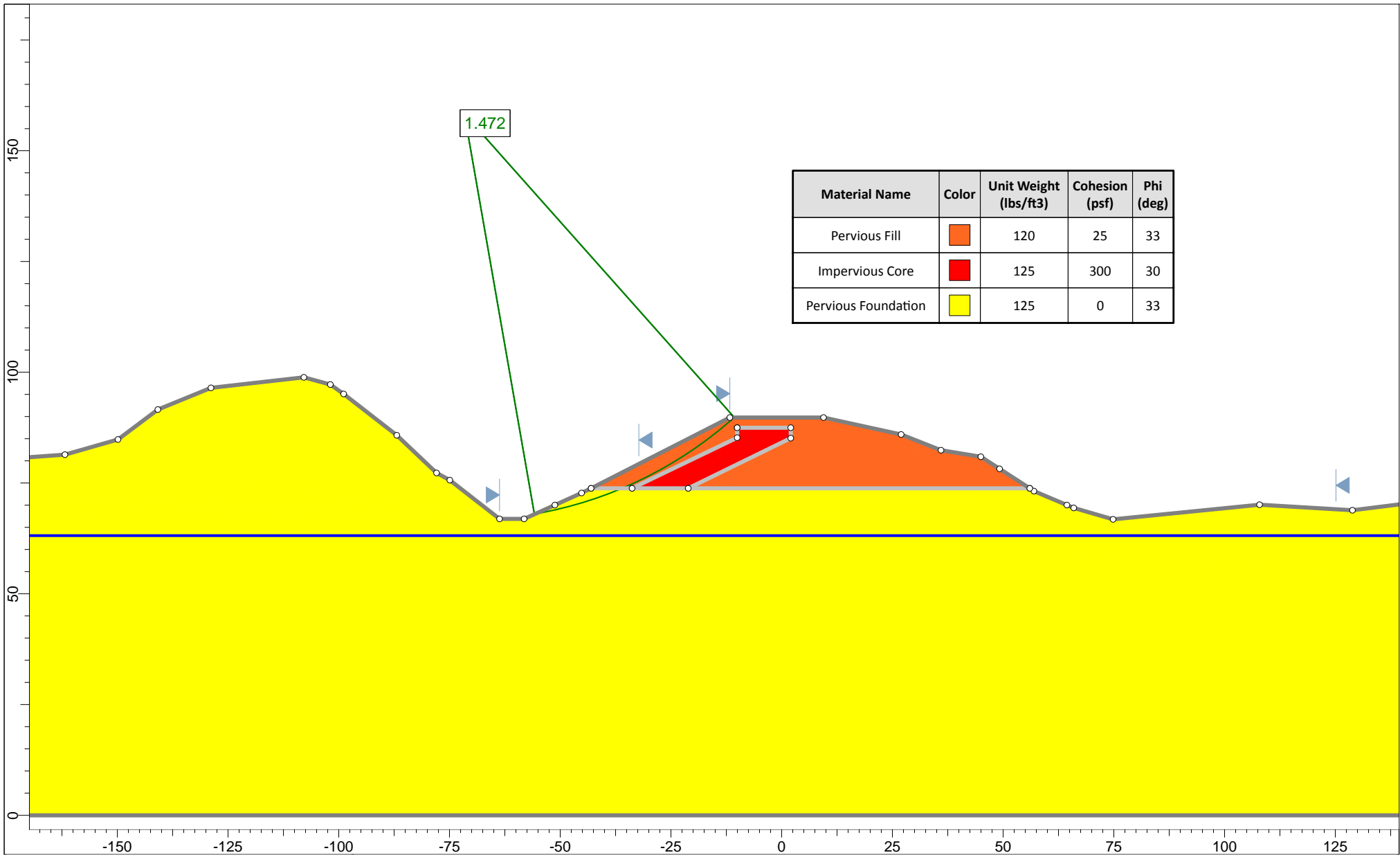
Material Name	Color	Unit Weight (lbs/ft ³)	Cohesion (psf)	Phi (deg)	Material Name	Color	KS (ft/s)	KZ/K1	K1 Angle (deg)	Soil Type
Pervious Fill	Orange	110	25	33	Pervious Fill	Orange	0.00043	4	90	Sand
Impervious Core	Red	125	300	30	Impervious Core	Red	1.2e-008	2	90	Clay
Impervious Foundation	Green	120	200	31	Impervious Foundation	Green	4.9e-006	4	90	Clay
Pervious Foundation	Yellow	125	0	33	Pervious Foundation	Yellow	4.3e-005	4	90	Sand

	Project			Blue Lake Levee Evaluation, Humboldt County, California		
	Analysis Description			Cross-section 34+00, Steady State Flood		
	Drawn By	GDE	Scale	1:360	Company	Fugro
	Date	8/26/2014, 3:35:26 PM		File Name	STA 34+00_S.State Flood_Plate Key.slim	


SLIDEINTERPRET 6.029



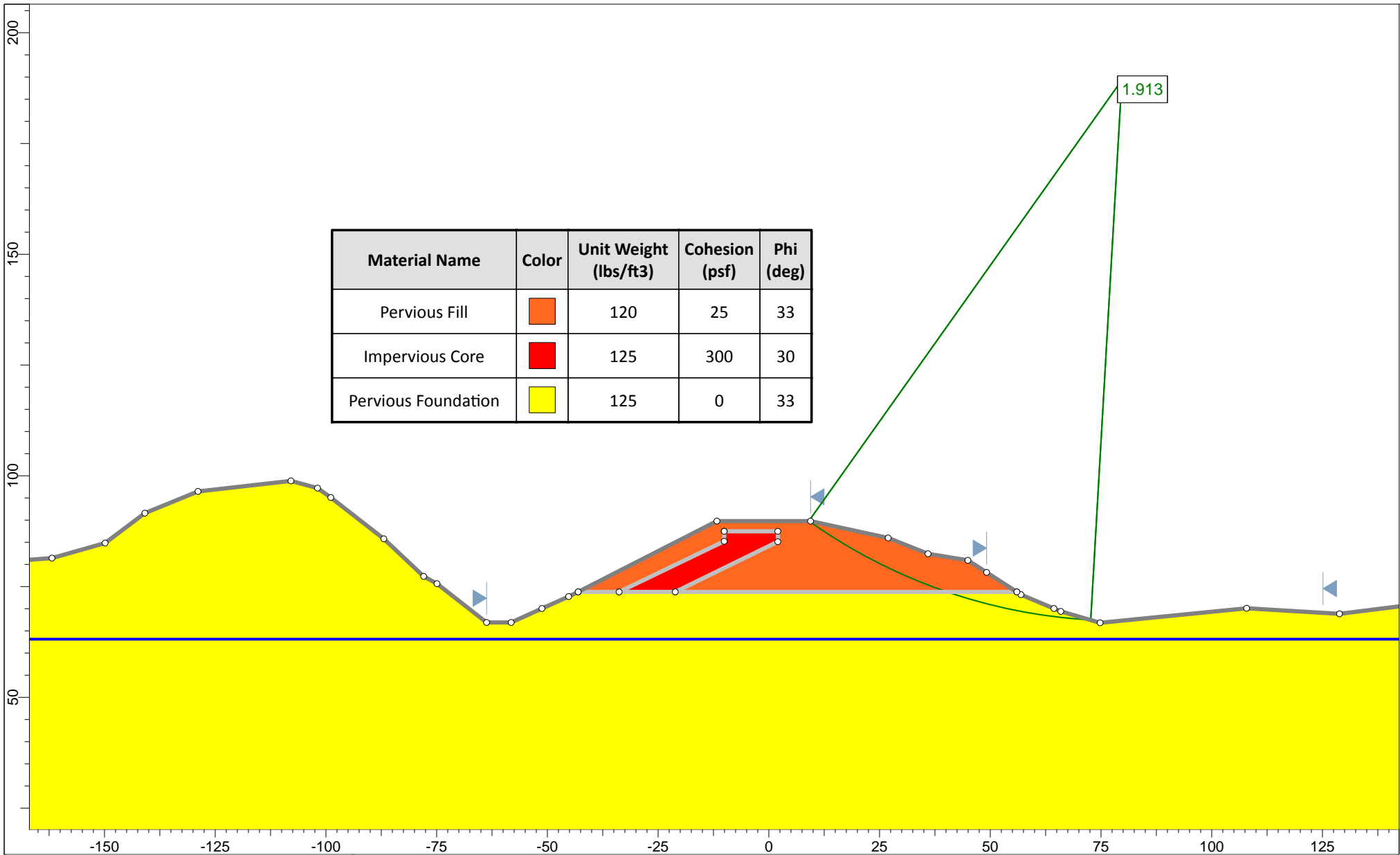
	Project			
	Blue Lake Levee Evaluation, Humboldt County, California			
	Analysis Description			
	Cross-section 34+00, Earthquake Conditions, Waterside			
Drawn By	GDE	Scale	1:360	Company
				Fugro
Date	8/26/2014, 8:09:01 PM		File Name	
			STA 34+00_EQ_Plate Key.slim	




Material Name	Color	Unit Weight (lbs/ft ³)	Cohesion (psf)	Phi (deg)
Pervious Fill	Orange	120	25	33
Impervious Core	Red	125	300	30
Pervious Foundation	Yellow	125	0	33

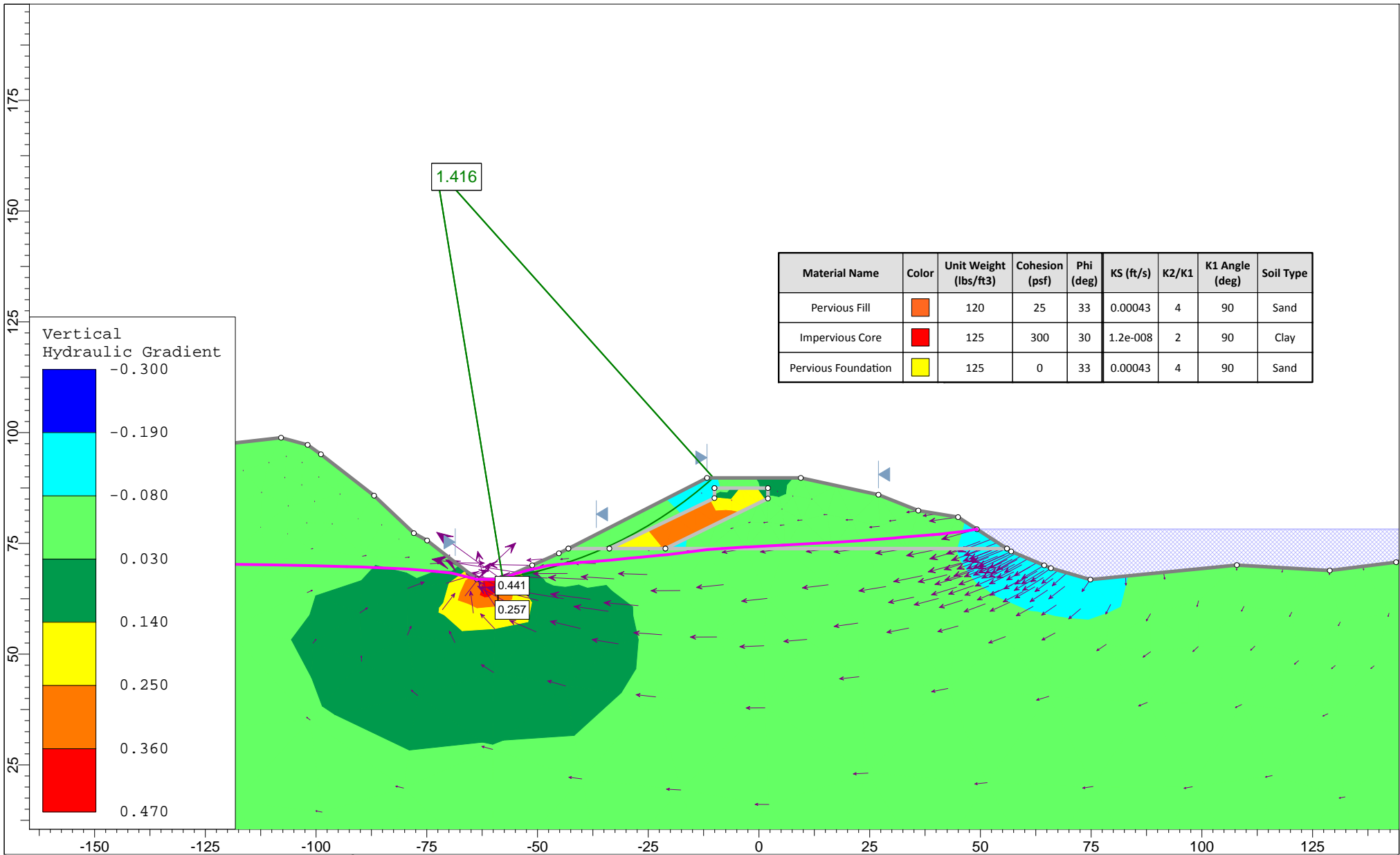
	Project			
	Blue Lake Levee Evaluation, Humboldt County, California			
	Analysis Description			
	Cross-section 2+00, Existing Conditions, Landside			
Drawn By	GDE	Scale	1:360	Company
				Fugro
Date	8/25/2014, 10:55:56 AM		File Name	
			STA 2+00_Existing.slim	


SLIDEINTERPRET 6.029



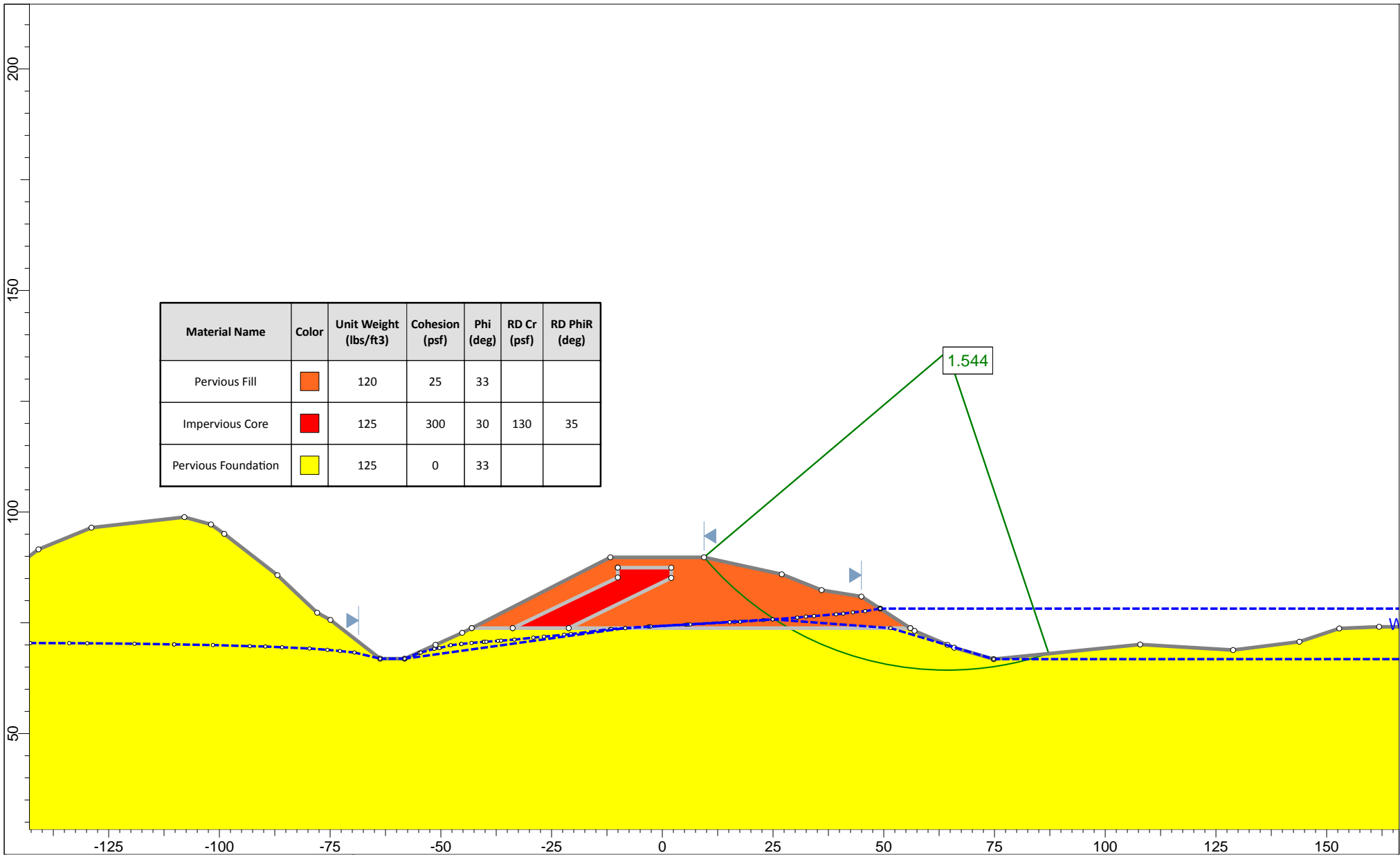
	Project			
	Blue Lake Levee Evaluation, Humboldt County, California			
	Analysis Description			
	Cross-section 2+00, Existing Conditions, Waterside			
Drawn By	GDE	Scale	1:360	Company
				Fugro
Date	8/25/2014, 10:55:56 AM		File Name	
			STA 2+00_Existing.slim	

SLIDEINTERPRET 6.029




	Project			Blue Lake Levee Evaluation, Humboldt County, California		
	Analysis Description			Cross-section 2+00, Steady State Flood		
	Drawn By	GDE	Scale	1:360	Company	Fugro
	Date	8/25/2014, 10:55:56 AM		File Name	STA 2+00_S.State Flood.slim	

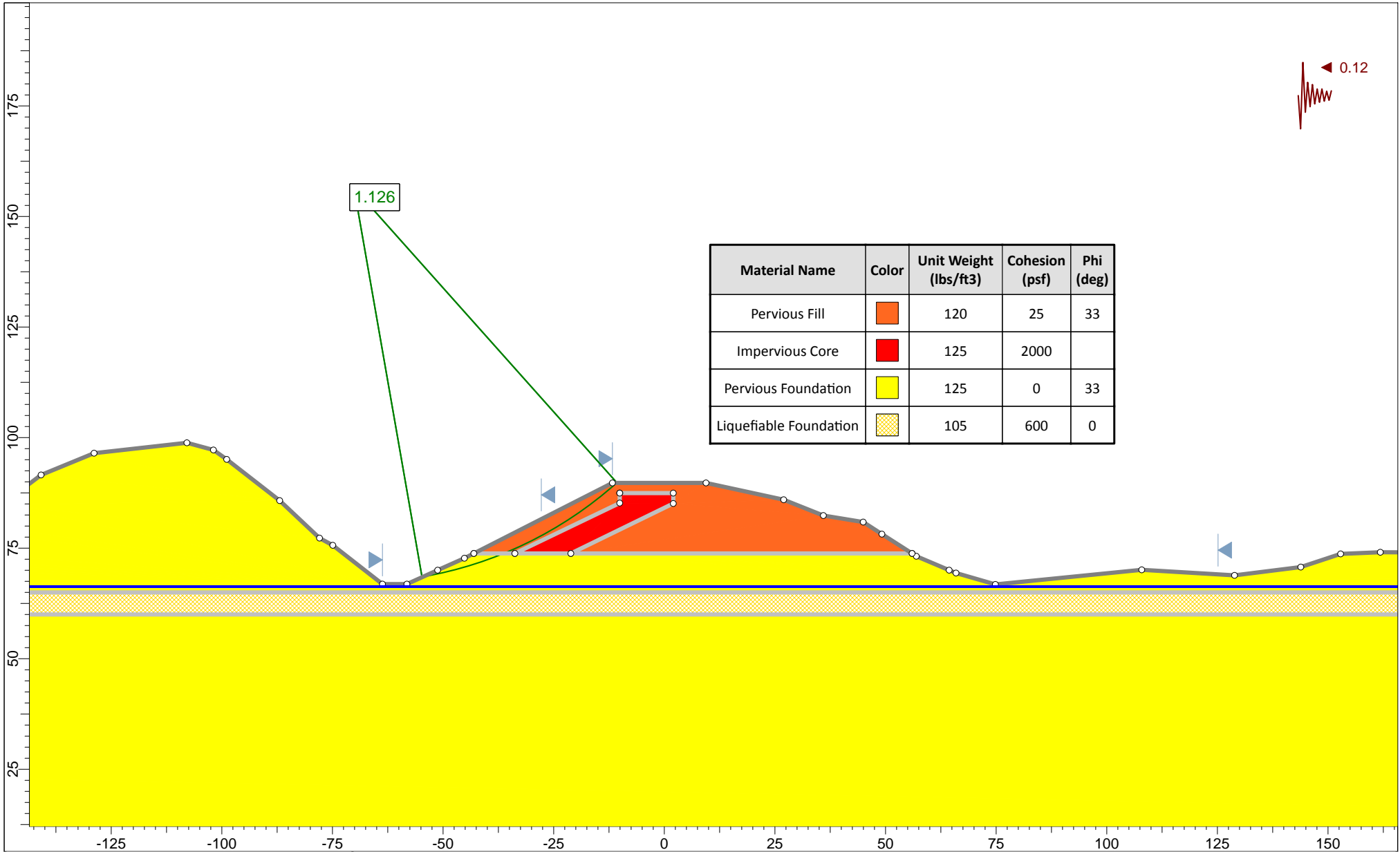
SLIDEINTERPRET 6.029




Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)	RD Cr (psf)	RD PhiR (deg)
Pervious Fill	Orange	120	25	33		
Impervious Core	Red	125	300	30	130	35
Pervious Foundation	Yellow	125	0	33		

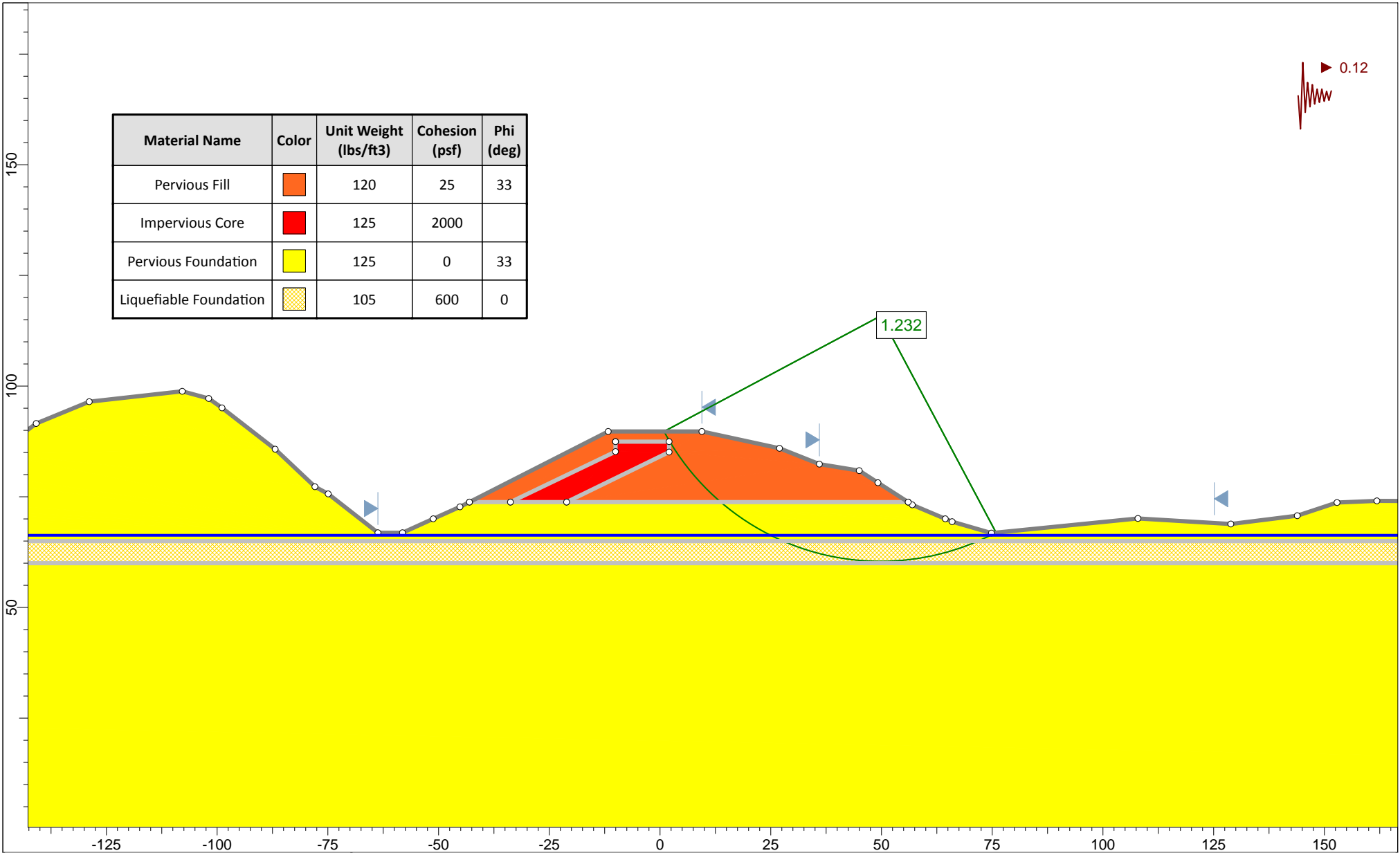
	Project						
	Blue Lake Levee Evaluation, Humboldt County, California						
	Analysis Description						
	Cross-section 2+00, Rapid Drawdown						
Drawn By		GDE		Scale		Company	
				1:360		Fugro	
Date				8/25/2014, 10:55:56 AM		File Name	
						STA 2+00_R.Drawdown.slim	


SLIDEINTERPRET 6.029



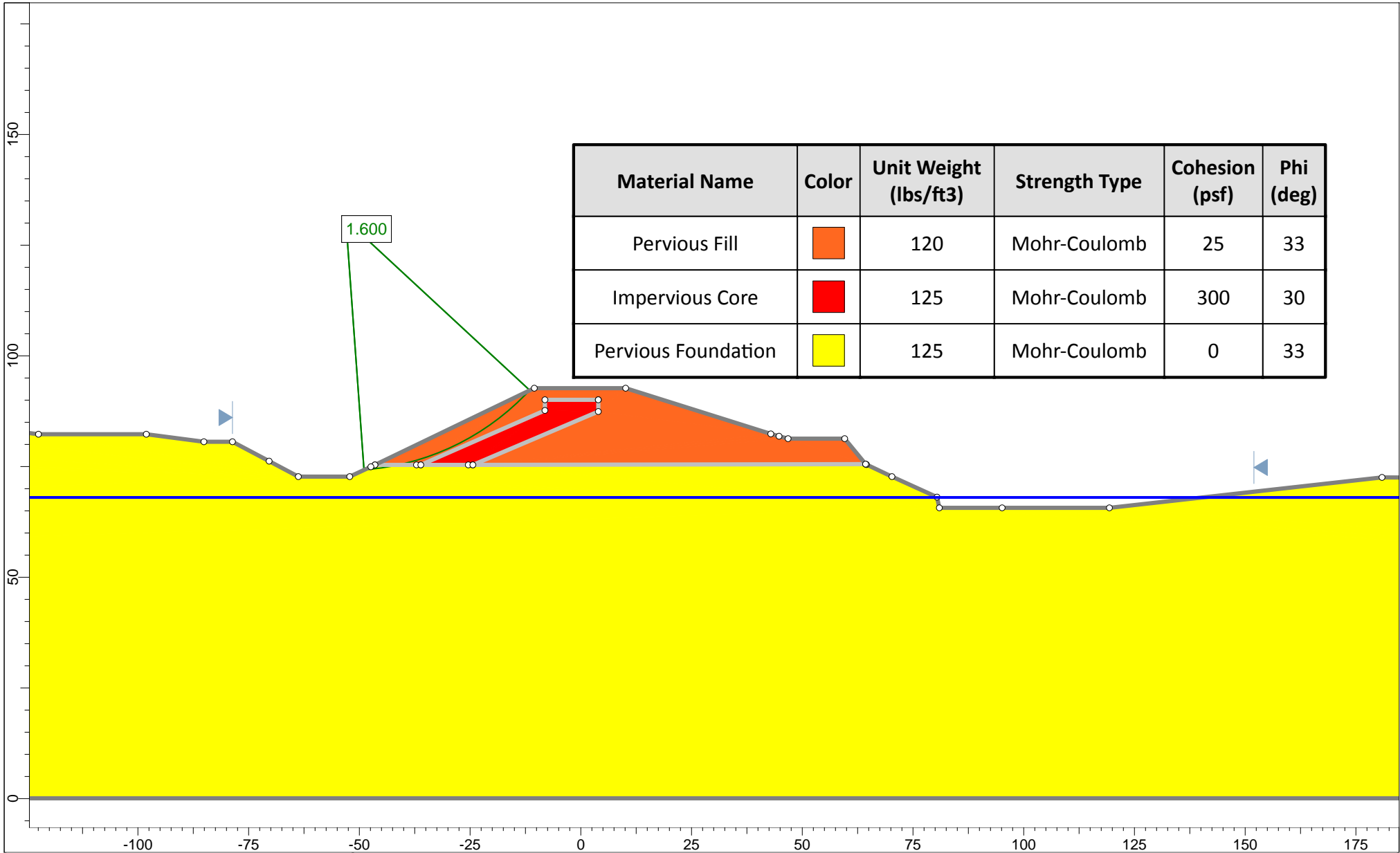
	<i>Project</i> Blue Lake Levee Evaluation, Humboldt County, California		
	<i>Analysis Description</i> Cross-section 2+00, Earthquake Conditions, Landside		
	<i>Drawn By</i> GDE	<i>Scale</i> 1:360	<i>Company</i> Fugro
	<i>Date</i> 8/25/2014, 10:55:56 AM	<i>File Name</i> STA 2+00_PostEQ.slim	

SLIDEINTERPRET 6.029



	Project			Blue Lake Levee Evaluation, Humboldt County, California		
	Analysis Description			Cross-section 2+00, Earthquake Conditions, Waterside		
	Drawn By	GDE	Scale	1:360	Company	Fugro
	Date	8/25/2014, 10:55:56 AM		File Name	STA 2+00_PostEQ.slim	

SLIDEINTERPRET 6.029






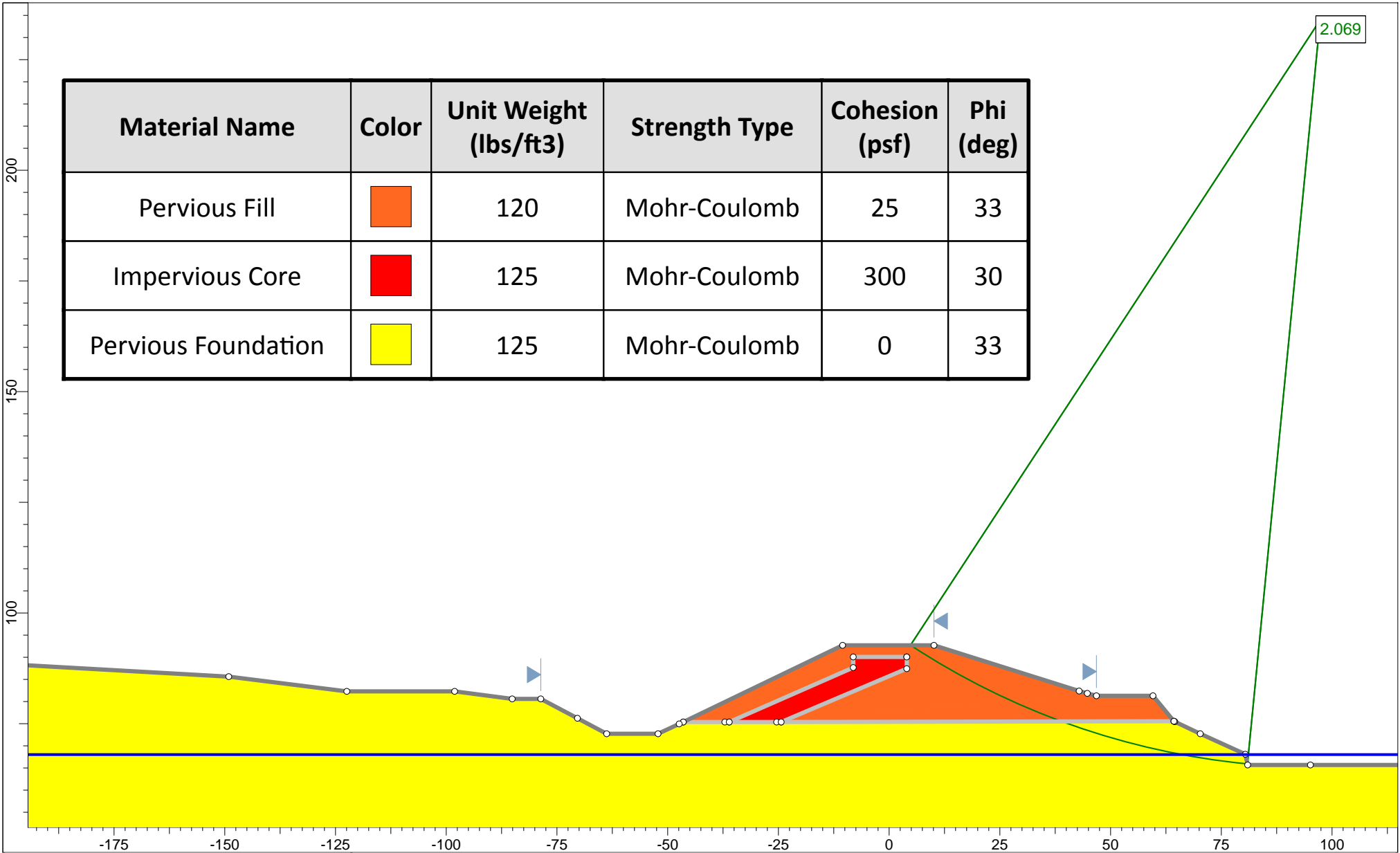
Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Pervious Fill	Orange	120	Mohr-Coulomb	25	33
Impervious Core	Red	125	Mohr-Coulomb	300	30
Pervious Foundation	Yellow	125	Mohr-Coulomb	0	33




SLIDEINTERPRET 6.029

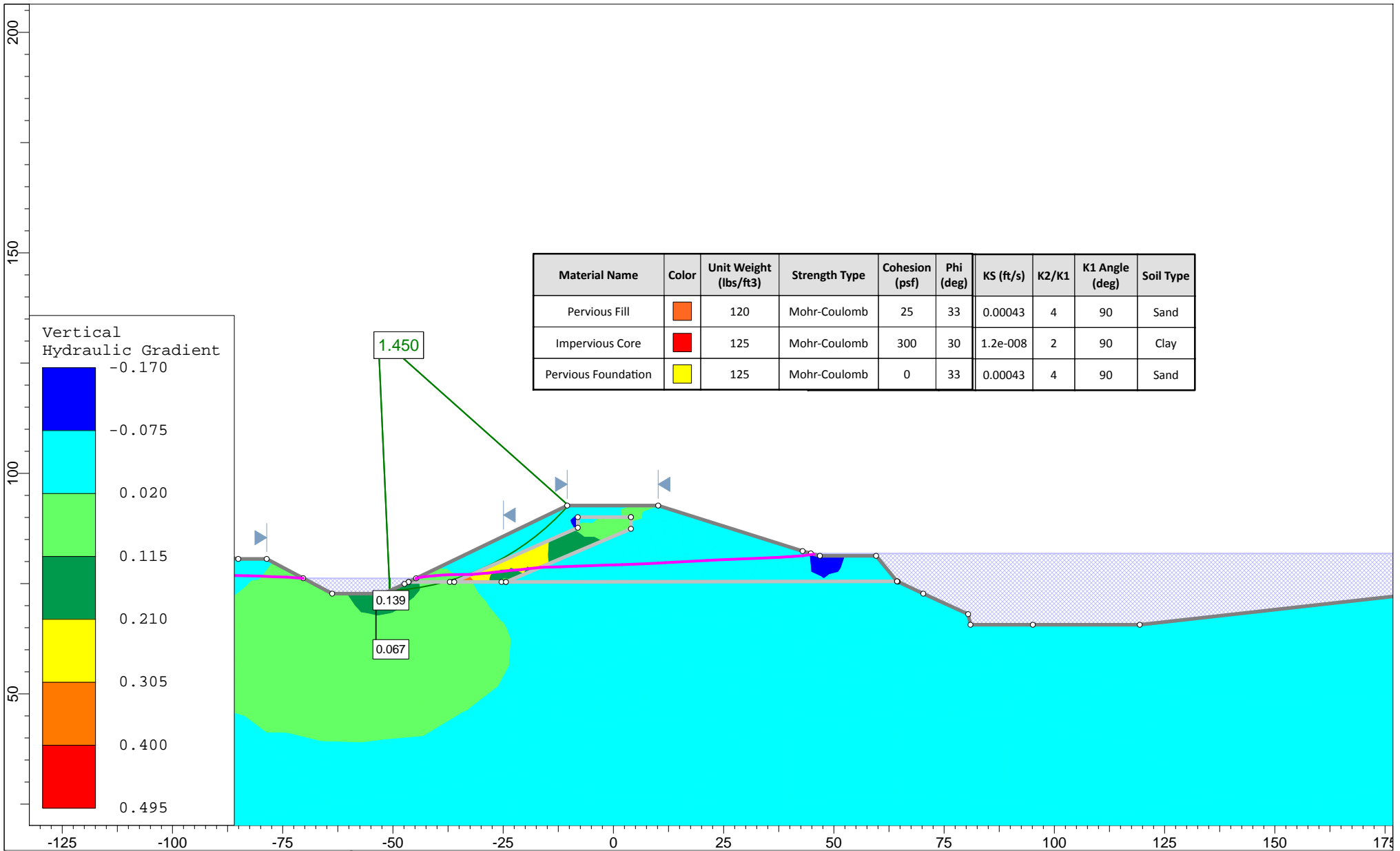
<i>Project</i>			
Blue Lake Levee Evaluation, Humboldt County, California			
<i>Analysis Description</i>			
Cross-section 11+00, Existing Conditions, Landside			
<i>Drawn By</i>	GDE	<i>Scale</i>	1:360
<i>Company</i>	Fugro		
<i>Date</i>	8/26/2014, 3:35:26 PM		<i>File Name</i>
			STA 11+00_Existing.slm

Material Name	Color	Unit Weight (lbs/ft ³)	Strength Type	Cohesion (psf)	Phi (deg)
Pervious Fill		120	Mohr-Coulomb	25	33
Impervious Core		125	Mohr-Coulomb	300	30
Pervious Foundation		125	Mohr-Coulomb	0	33



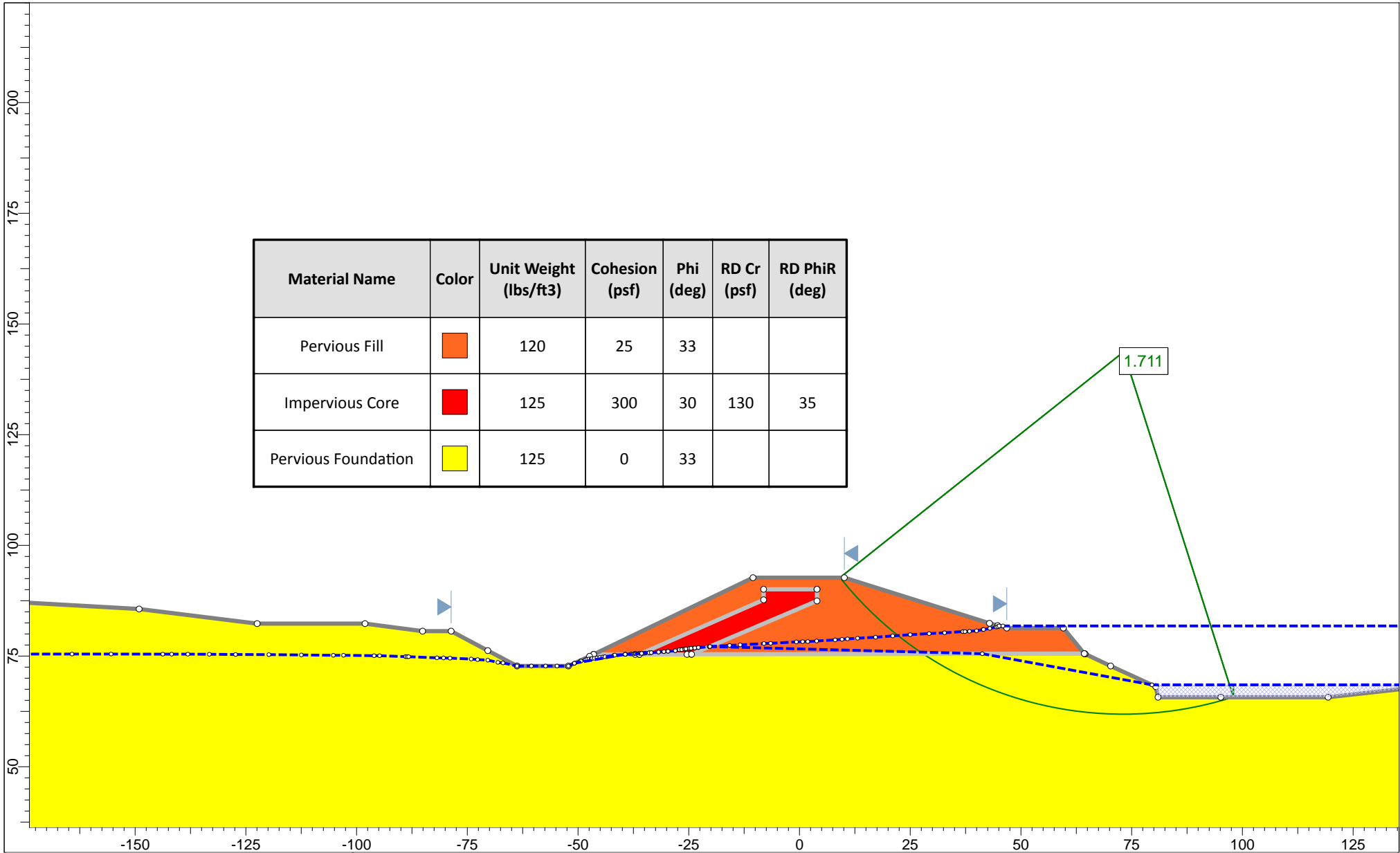
	Project				Blue Lake Levee Evaluation, Humboldt County, California	
	Analysis Description				Cross-section 11+00, Existing Conditions, Waterside	
	Drawn By		GDE	Scale		1:360
	Date		8/26/2014, 3:35:26 PM		Company	
File Name				STA 11+00_Existing.slim		

SLIDEINTERPRET 6.029



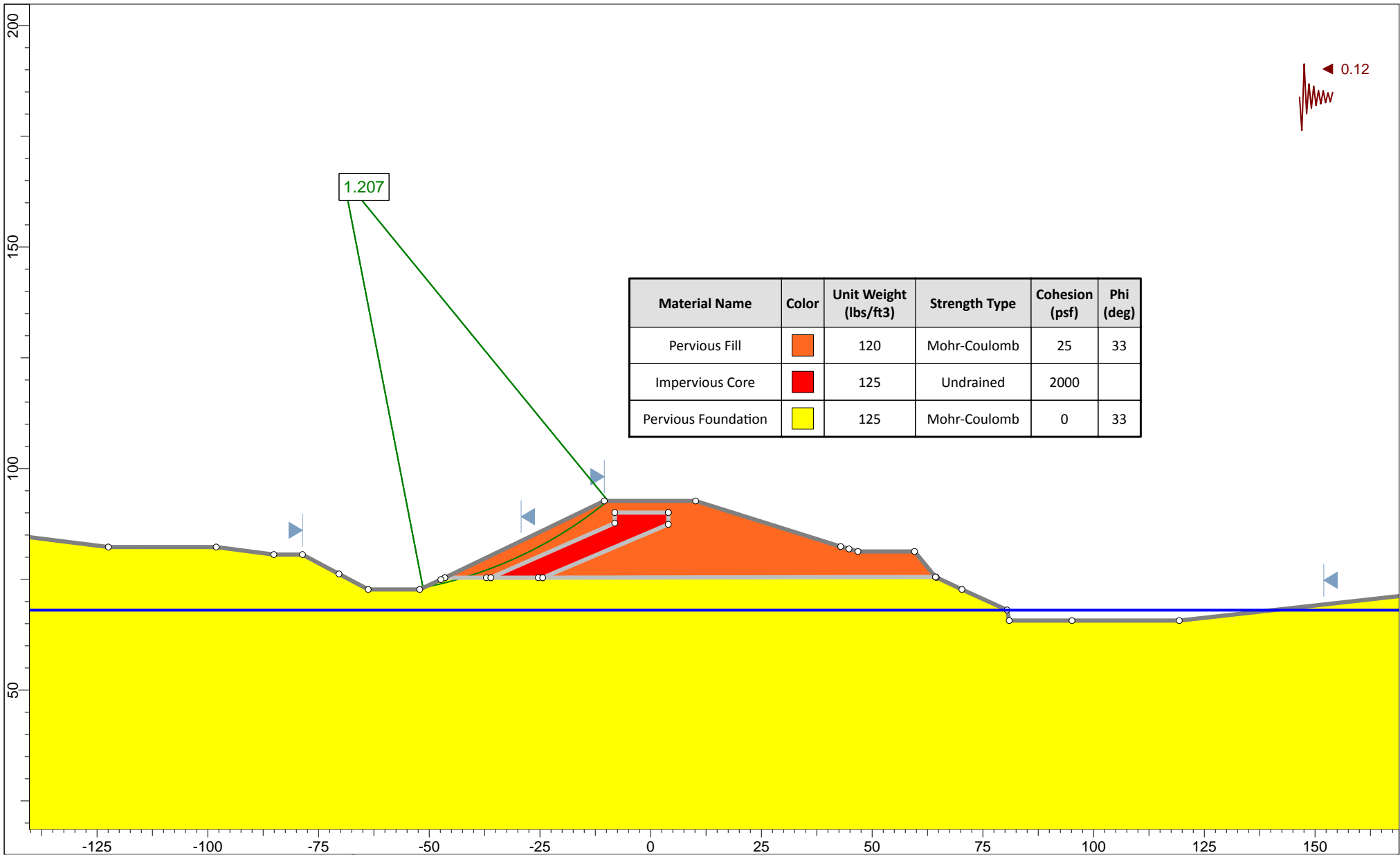
SLIDEINTERPRET 6.029

Project				Blue Lake Levee Evaluation, Humboldt County, California			
Analysis Description				Cross-section 11+00, Steady State Flood			
Drawn By		GDE		Scale		1:360	
Company				Fugro			
Date				8/26/2014, 3:35:26 PM		File Name	
				STA 11+00_S.State Flood.slim			



SLIDEINTERPRET 6.029

<i>Project</i>			
Blue Lake Levee Evaluation, Humboldt County, California			
<i>Analysis Description</i>			
Cross-section 11+00, Rapid Drawdown			
<i>Drawn By</i>	GDE	<i>Scale</i>	1:360
<i>Company</i>	Fugro		
<i>Date</i>	8/26/2014, 3:35:26 PM		<i>File Name</i>
		STA 11+00_R.Drawdown.slim	

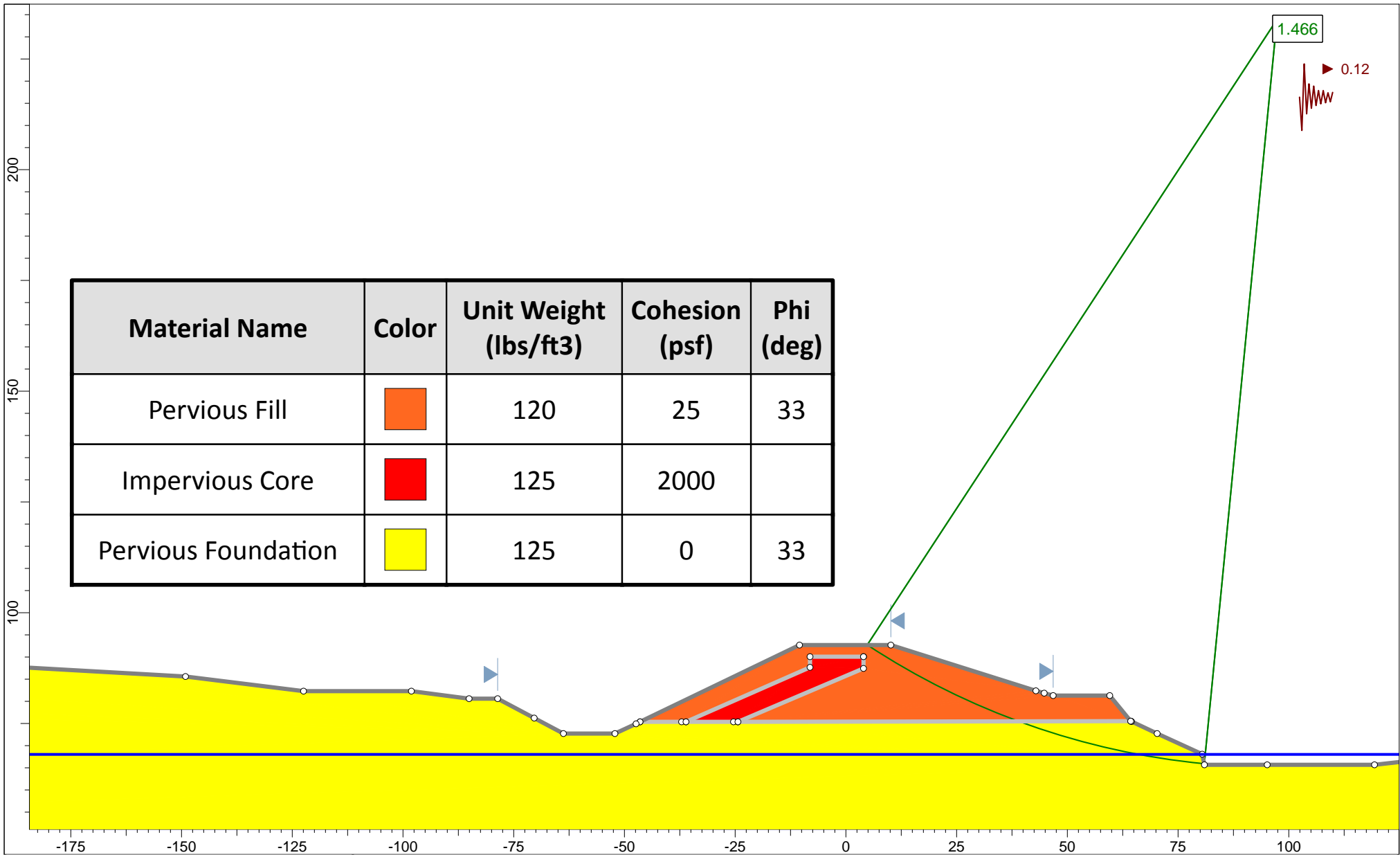


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Pervious Fill	Orange	120	Mohr-Coulomb	25	33
Impervious Core	Red	125	Undrained	2000	
Pervious Foundation	Yellow	125	Mohr-Coulomb	0	33



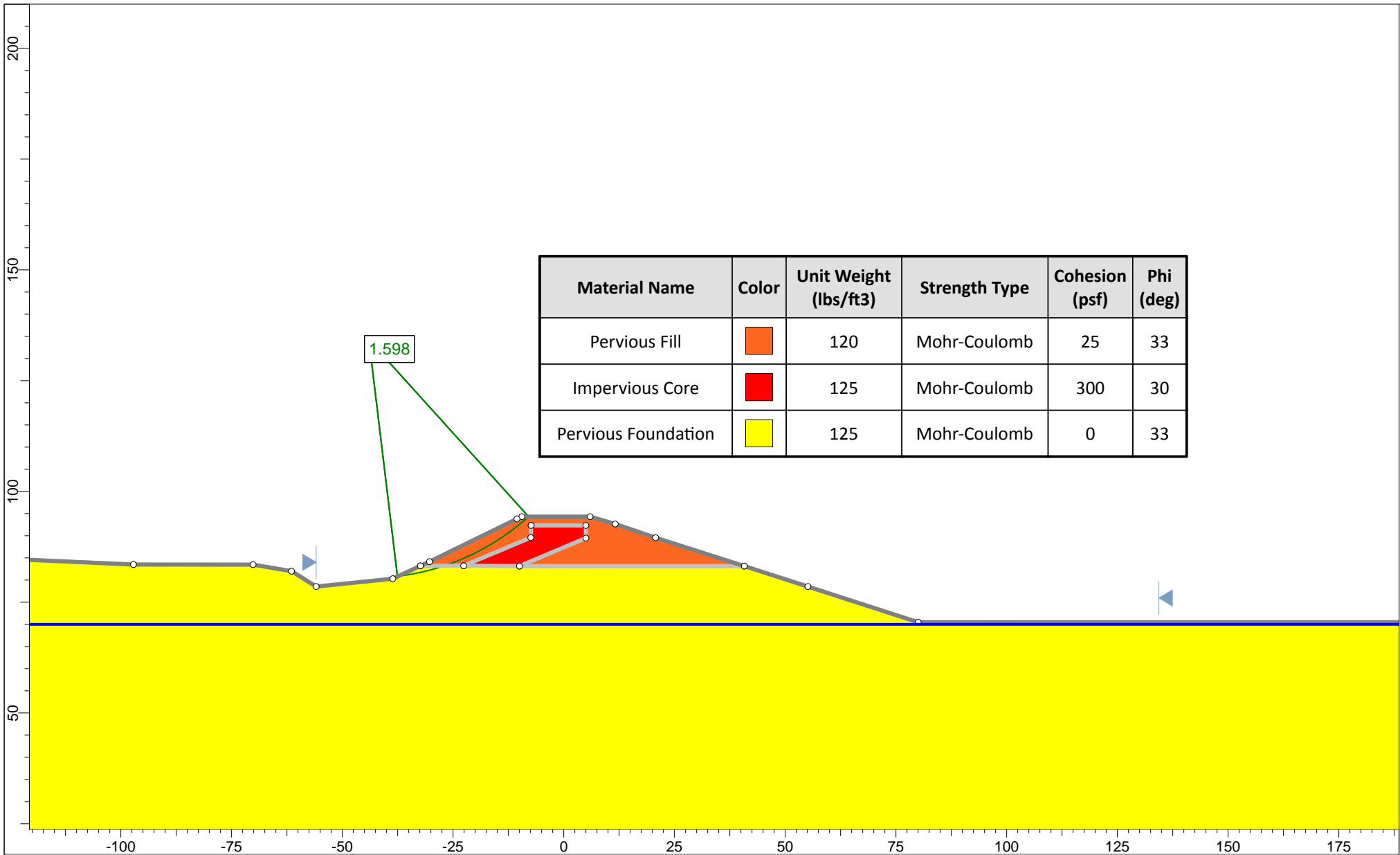
SLIDEINTERPRET 6.029

<i>Project</i>			
Blue Lake Levee Evaluation, Humboldt County, California			
<i>Analysis Description</i>			
Cross-section 11+00, Earthquake Conditions, Landside			
<i>Drawn By</i>	GDE	<i>Scale</i>	1:360
<i>Company</i>	Fugro		
<i>Date</i>	8/26/2014, 3:35:26 PM		<i>File Name</i>
	STA 11+00_PostEQ.slim		



SLIDEINTERPRET 6.029

<i>Project</i>			
Blue Lake Levee Evaluation, Humboldt County, California			
<i>Analysis Description</i>			
Cross-section 11+00, Earthquake Conditions, Waterside			
<i>Drawn By</i>	GDE	<i>Scale</i>	1:360
<i>Company</i>	Fugro		
<i>Date</i>	8/26/2014, 3:35:26 PM		<i>File Name</i>
			STA 11+00_PostEQ.slim

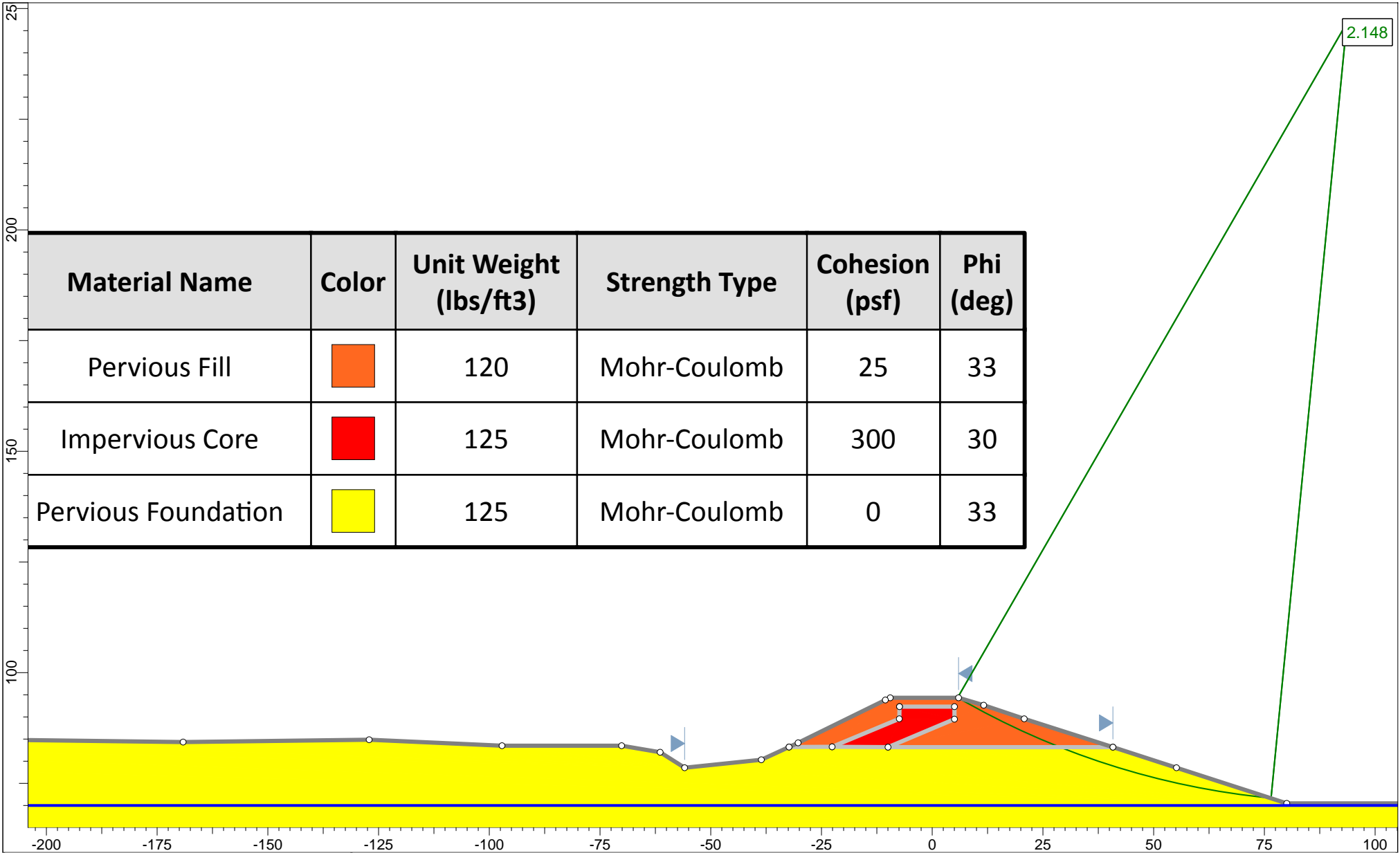



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Pervious Fill	Orange	120	Mohr-Coulomb	25	33
Impervious Core	Red	125	Mohr-Coulomb	300	30
Pervious Foundation	Yellow	125	Mohr-Coulomb	0	33



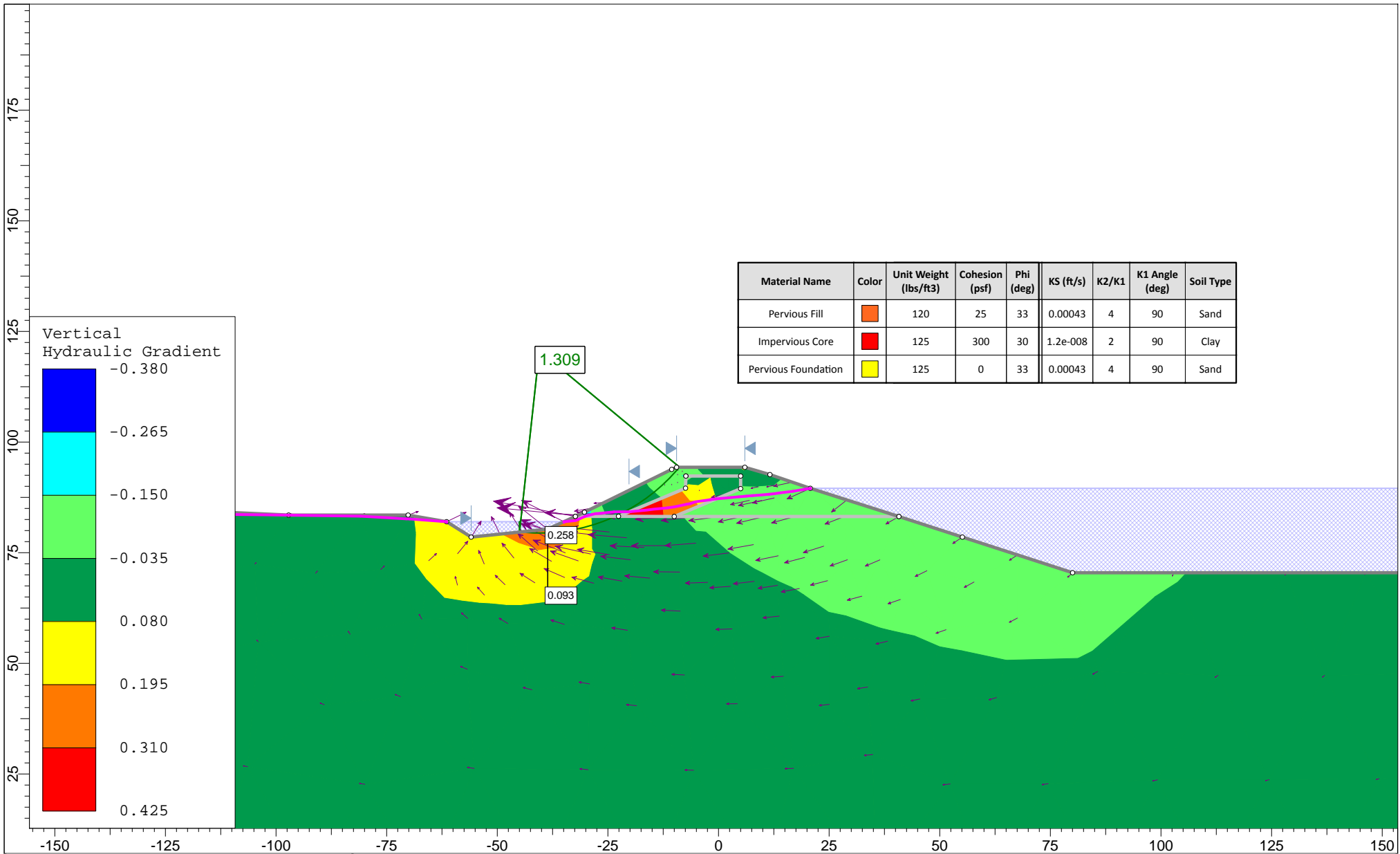
Project				Blue Lake Levee Evaluation, Humboldt County, California	
Analysis Description				Cross-section 22+00, Existing Conditions, Landside	
Drawn By	GDE	Scale	1:360	Company	Fugro
Date	8/28/2014, 12:01:34 PM			File Name	STA 22+00_Existing.slim

SLIDEINTERPRET 6.029




	<i>Project</i> Blue Lake Levee Evaluation, Humboldt County, California			
	<i>Analysis Description</i> Cross-section 22+00, Existing Conditions, Waterside			
	<i>Drawn By</i> GDE	<i>Scale</i> 1:360	<i>Company</i> Fugro	
	<i>Date</i> 8/28/2014, 12:01:34 PM		<i>File Name</i> STA 22+00_Existing.slm	

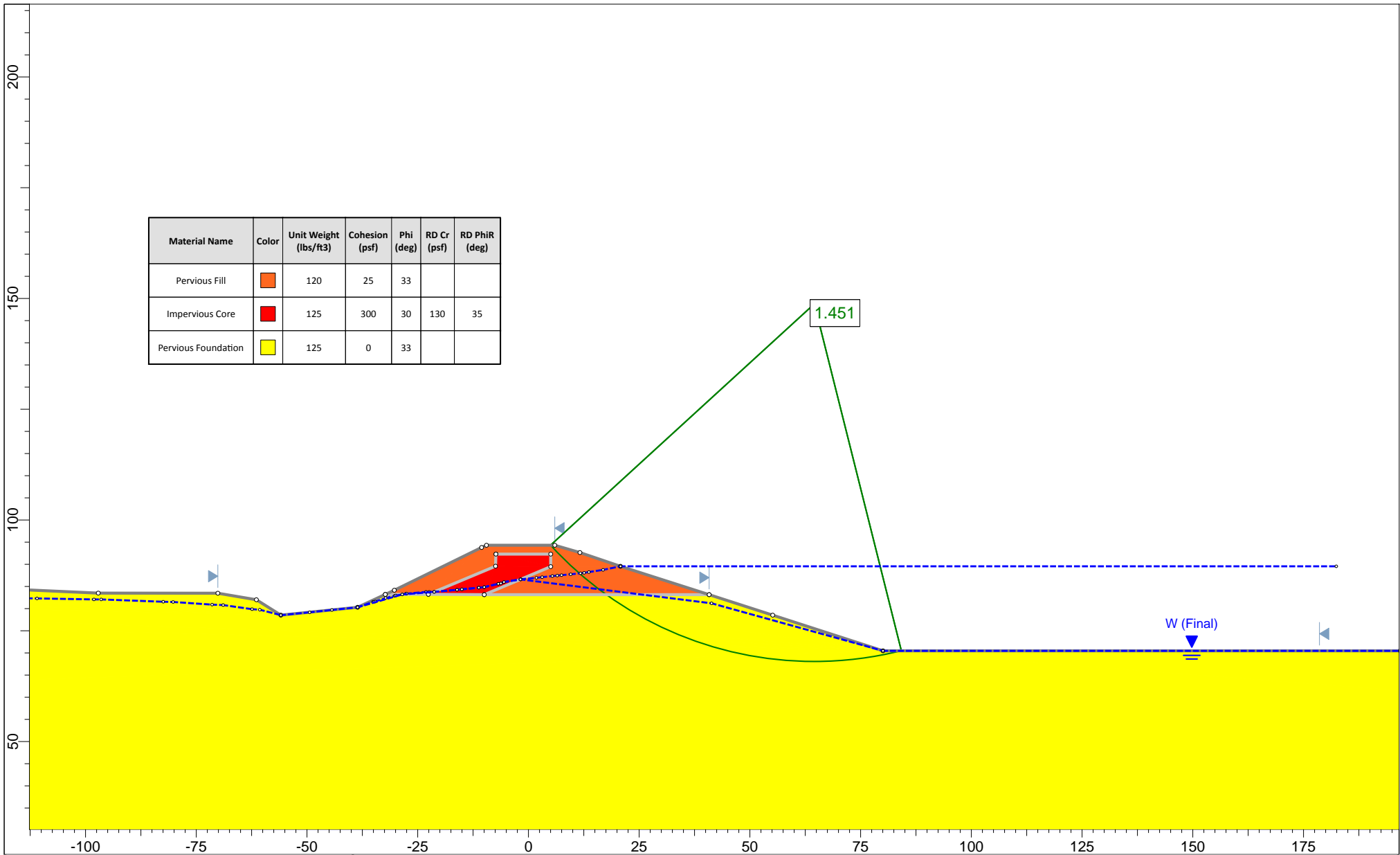
SLIDEINTERPRET 6.029




Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)	KS (ft/s)	K2/K1	K1 Angle (deg)	Soil Type
Pervious Fill	Orange	120	25	33	0.00043	4	90	Sand
Impervious Core	Red	125	300	30	1.2e-008	2	90	Clay
Pervious Foundation	Yellow	125	0	33	0.00043	4	90	Sand

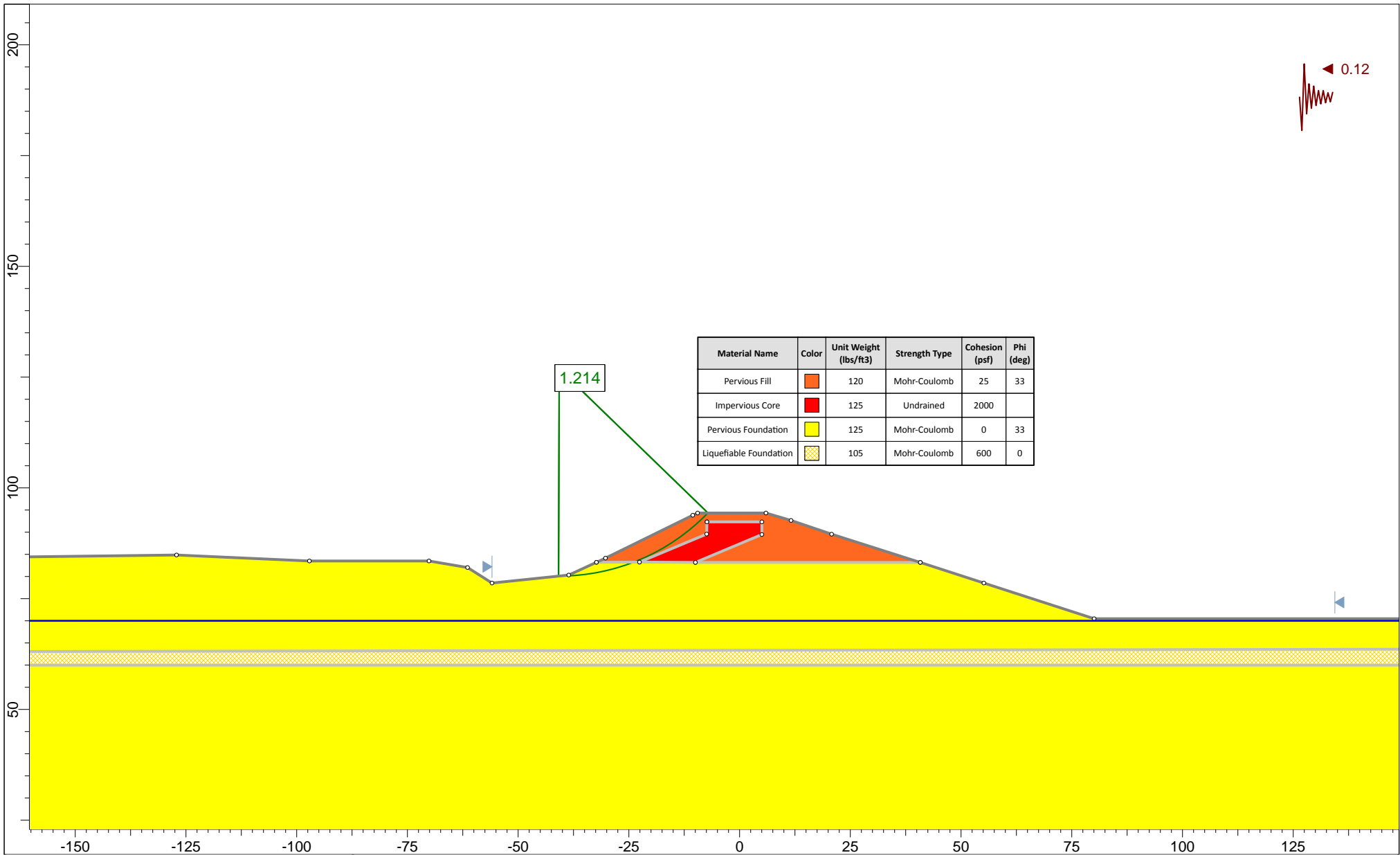
	Project			Blue Lake Levee Evaluation, Humboldt County, California		
	Analysis Description			Cross-section 22+00, Steady State Flood		
	Drawn By	GDE	Scale	1:360	Company	Fugro
	Date	8/26/2014, 3:35:26 PM		File Name	STA 22+00_S.State Flood.slim	


SLIDEINTERPRET 6.029



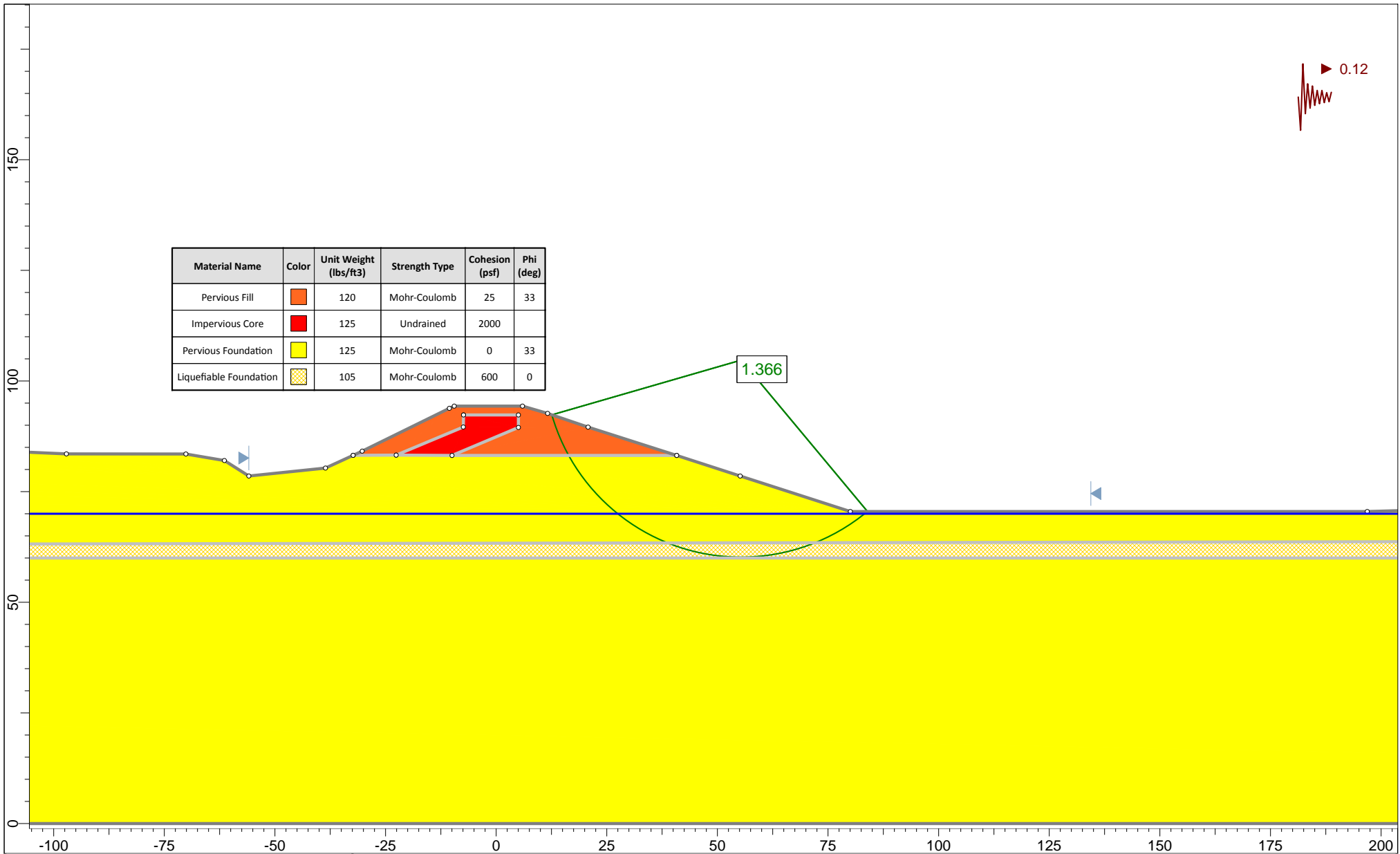
	Project			Blue Lake Levee Evaluation, Humboldt County, California		
	Analysis Description			Cross-section 22+00, Rapid Drawdown		
	Drawn By	GDE	Scale	1:360	Company	Fugro
	Date	8/26/2014, 3:35:26 PM		File Name	STA 22+00_R.Drawdown.slim	


SLIDEINTERPRET 6.029



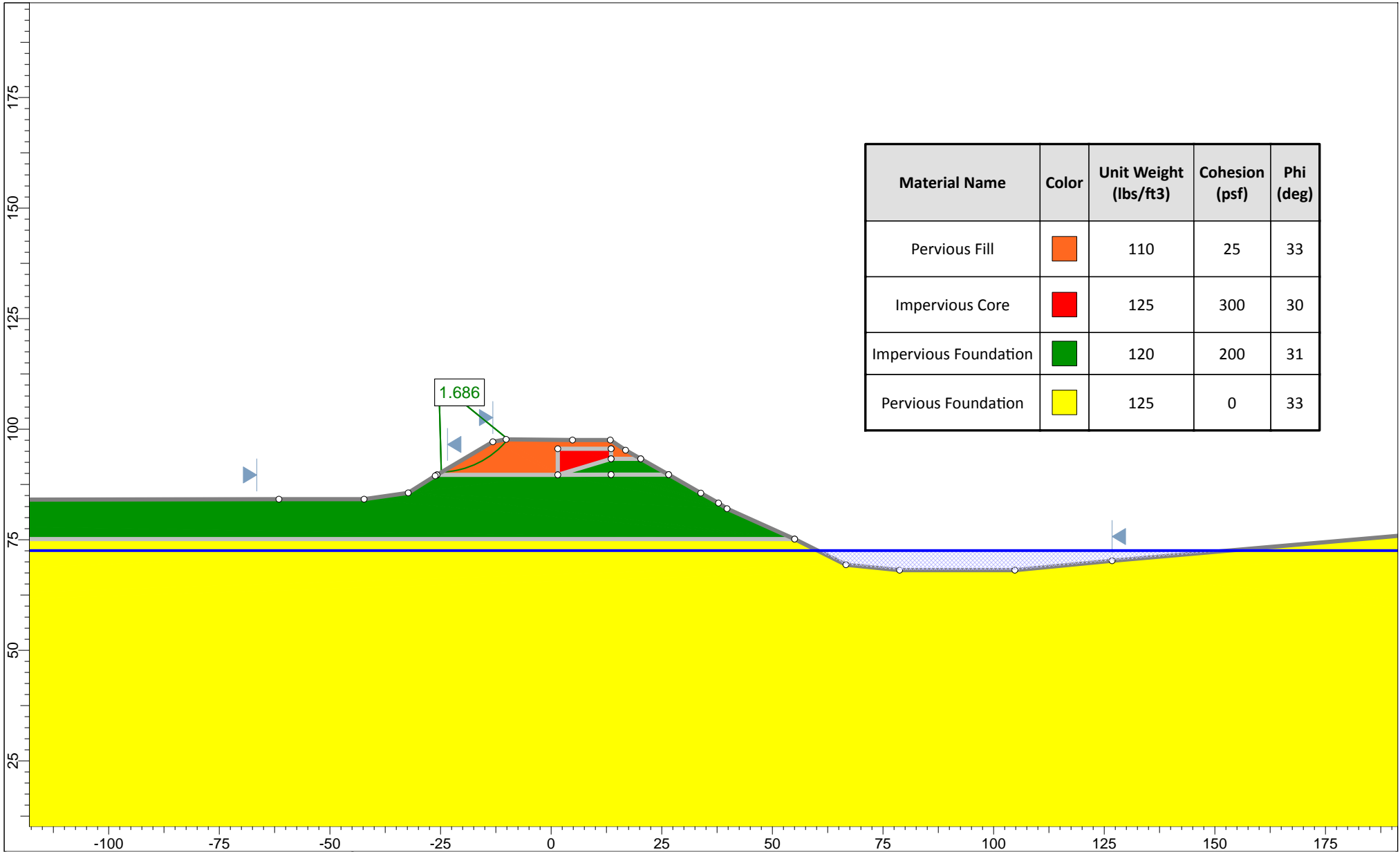
	Project			Blue Lake Levee Evaluation, Humboldt County, California		
	Analysis Description			Cross-section 22+00, Existing Conditions, Landside		
	Drawn By	GDE	Scale	1:360	Company	Fugro
	Date	8/28/2014, 12:01:34 PM		File Name	STA 22+00_PostEQ.slim	

SLIDEINTERPRET 6.029




	Project			Blue Lake Levee Evaluation, Humboldt County, California		
	Analysis Description			Cross-section 22+00, Existing Conditions, Waterside		
	Drawn By	GDE	Scale	1:360	Company	Fugro
	Date	8/28/2014, 12:01:34 PM			File Name	STA 22+00_PostEQ.slim

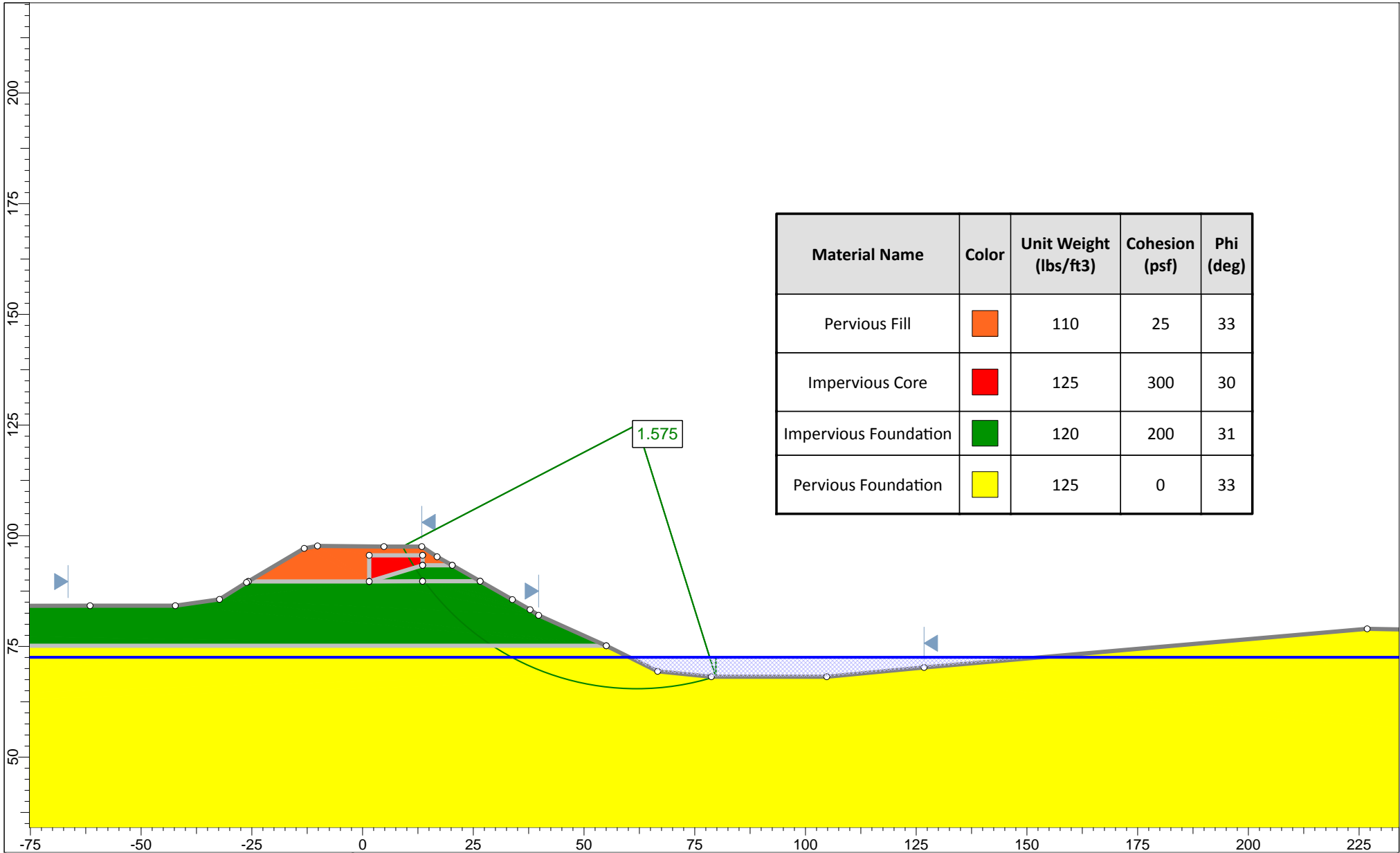
SLIDEINTERPRET 6.029




Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
Pervious Fill	Orange	110	25	33
Impervious Core	Red	125	300	30
Impervious Foundation	Green	120	200	31
Pervious Foundation	Yellow	125	0	33

	Project			
	Blue Lake Levee Evaluation, Humboldt County, California			
	Analysis Description			
	Cross-section 34+00, Existing Conditions, Landside			
Drawn By	GDE	Scale	1:360	Company
				Fugro
Date	8/26/2014, 8:09:01 PM		File Name	
			STA 34+00_Existing.slim	

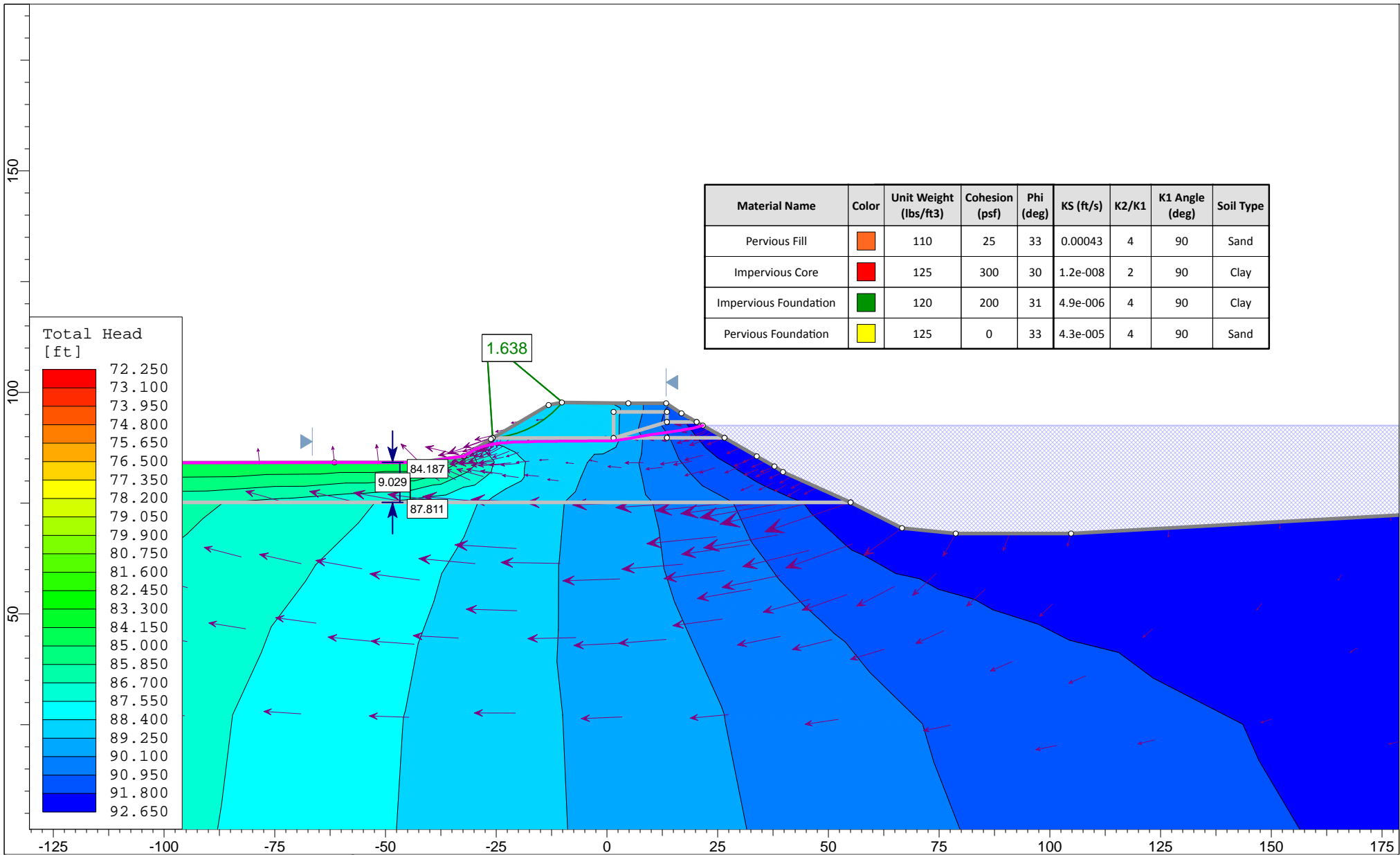
SLIDEINTERPRET 6.029




Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
Pervious Fill	Orange	110	25	33
Impervious Core	Red	125	300	30
Impervious Foundation	Green	120	200	31
Pervious Foundation	Yellow	125	0	33

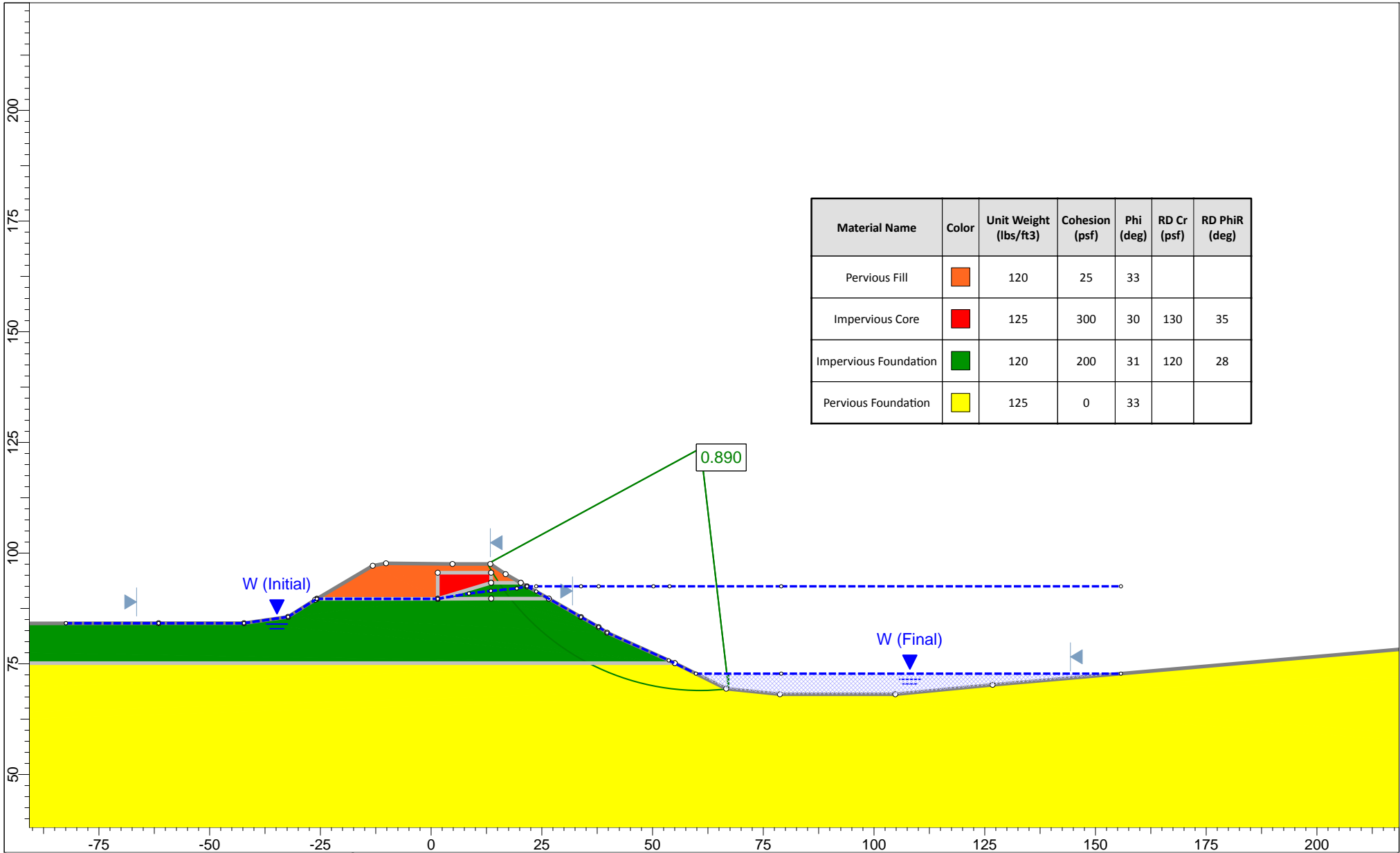
	Project			
	Blue Lake Levee Evaluation, Humboldt County, California			
	Analysis Description			
	Cross-section 34+00, Existing Conditions, Waterside			
Drawn By	GDE	Scale	1:360	Company
				Fugro
Date	8/26/2014, 8:09:01 PM		File Name	
			STA 34+00_Existing.slm	

SLIDEINTERPRET 6.029




	Project			Blue Lake Levee Evaluation, Humboldt County, California		
	Analysis Description			Cross-section 34+00, Steady State Flood		
	Drawn By	GDE	Scale	1:360	Company	Fugro
	Date	8/26/2014, 3:35:26 PM		File Name	STA 34+00_S.State Flood.slim	

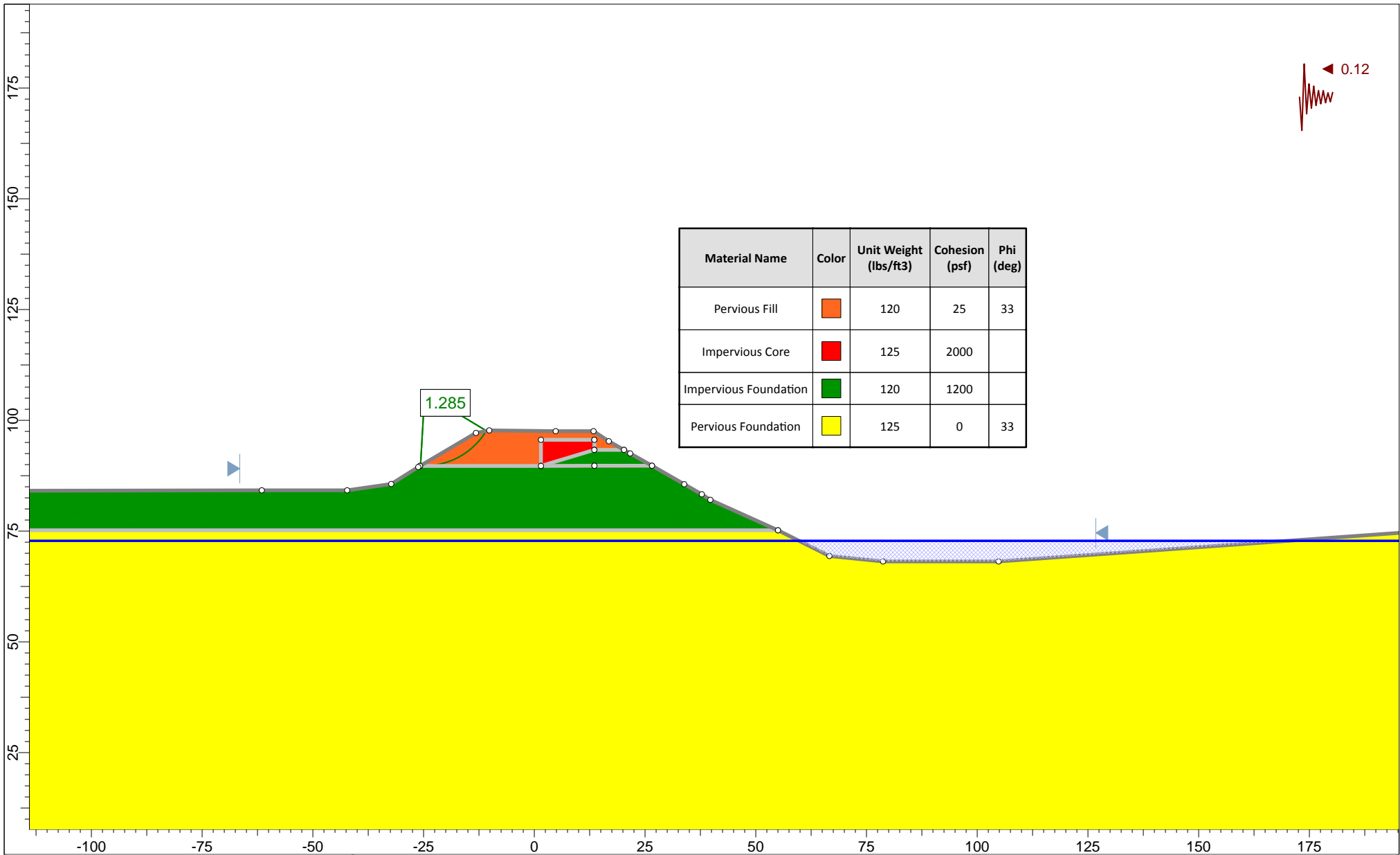
SLIDEINTERPRET 6.029




Material Name	Color	Unit Weight (lbs/ft ³)	Cohesion (psf)	Phi (deg)	RD Cr (psf)	RD PhiR (deg)
Pervious Fill	Orange	120	25	33		
Impervious Core	Red	125	300	30	130	35
Impervious Foundation	Green	120	200	31	120	28
Pervious Foundation	Yellow	125	0	33		

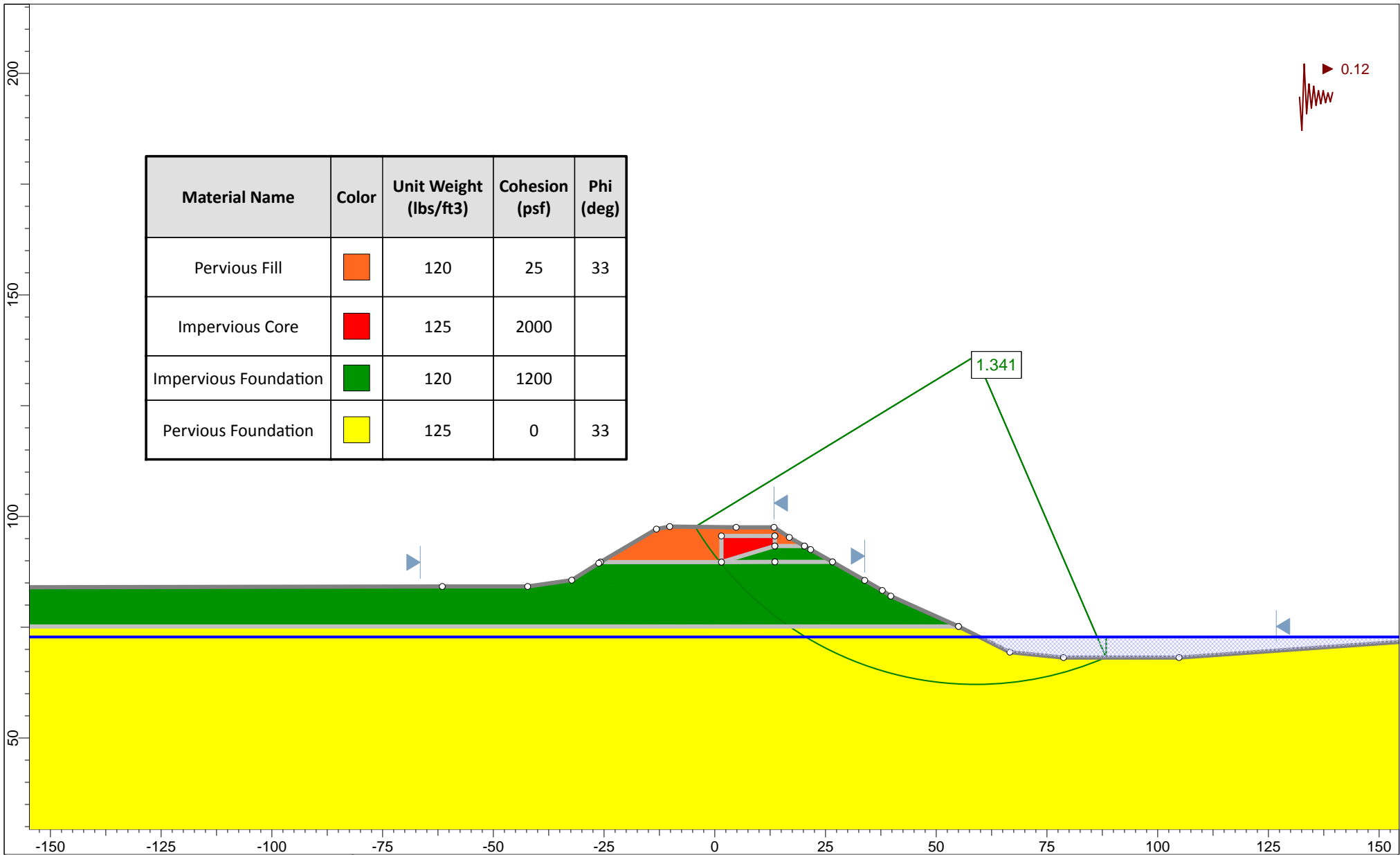
	Project										
	Blue Lake Levee Evaluation, Humboldt County, California										
	Analysis Description										
	Cross-section 34+00, Rapid Drawdown										
Drawn By		GDE		Scale		1:360		Company		Fugro	
Date		8/26/2014, 3:35:26 PM				File Name		STA 34+00_R.Drawdown.slim			


SLIDEINTERPRET 6.029



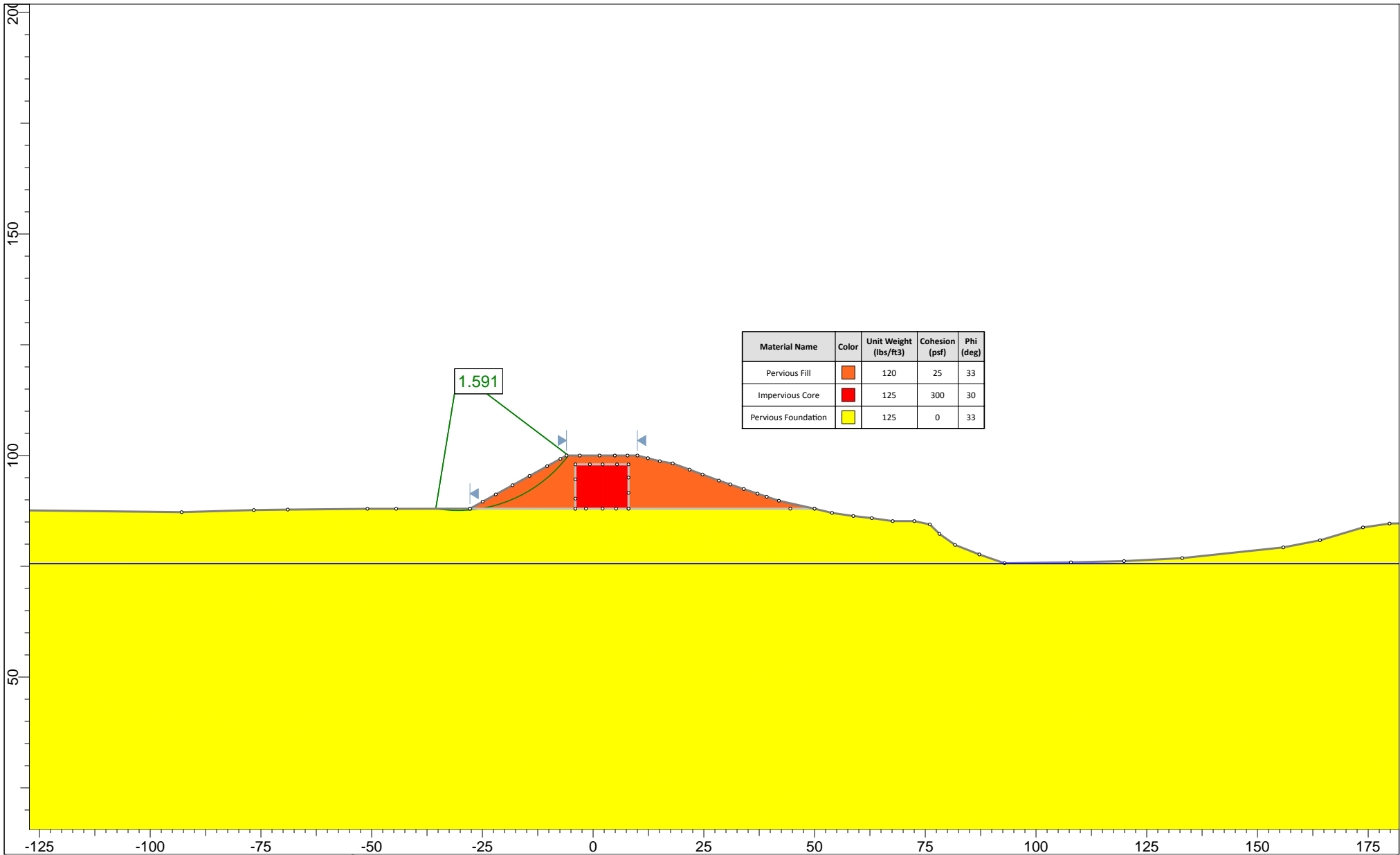
	<i>Project</i> Blue Lake Levee Evaluation, Humboldt County, California			
	<i>Analysis Description</i> Cross-section 34+00, Earthquake Conditions, Landside			
	<i>Drawn By</i> GDE	<i>Scale</i> 1:360	<i>Company</i> Fugro	
	<i>Date</i> 8/26/2014, 8:09:01 PM		<i>File Name</i> STA 34+00_EQ.slim	


SLIDEINTERPRET 6.029



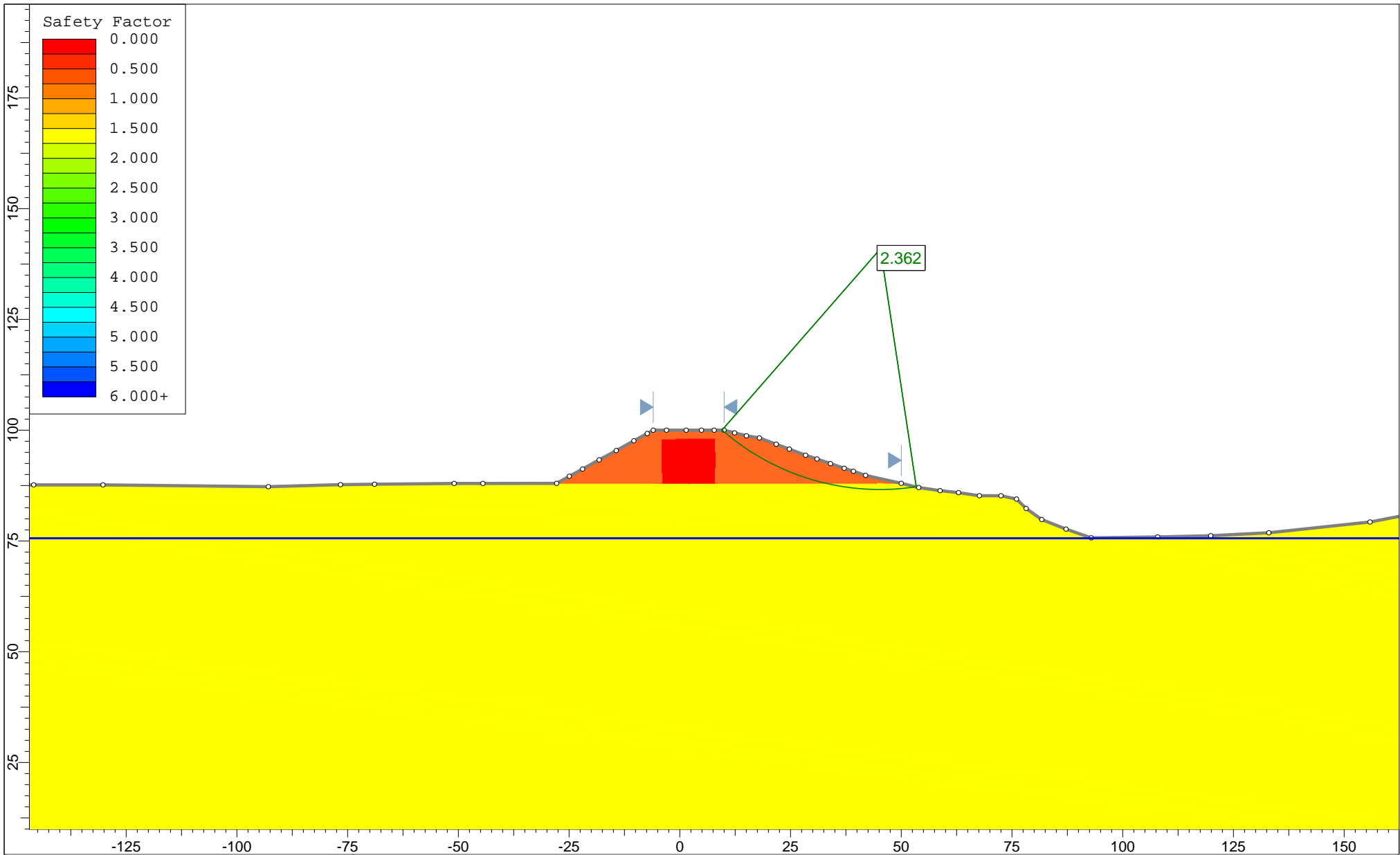
	<i>Project</i> Blue Lake Levee Evaluation, Humboldt County, California			
	<i>Analysis Description</i> Cross-section 34+00, Earthquake Conditions, Waterside			
	<i>Drawn By</i> GDE	<i>Scale</i> 1:360	<i>Company</i> Fugro	
	<i>Date</i> 8/26/2014, 8:09:01 PM	<i>File Name</i> STA 34+00_EQ.slim		


SLIDEINTERPRET 6.029



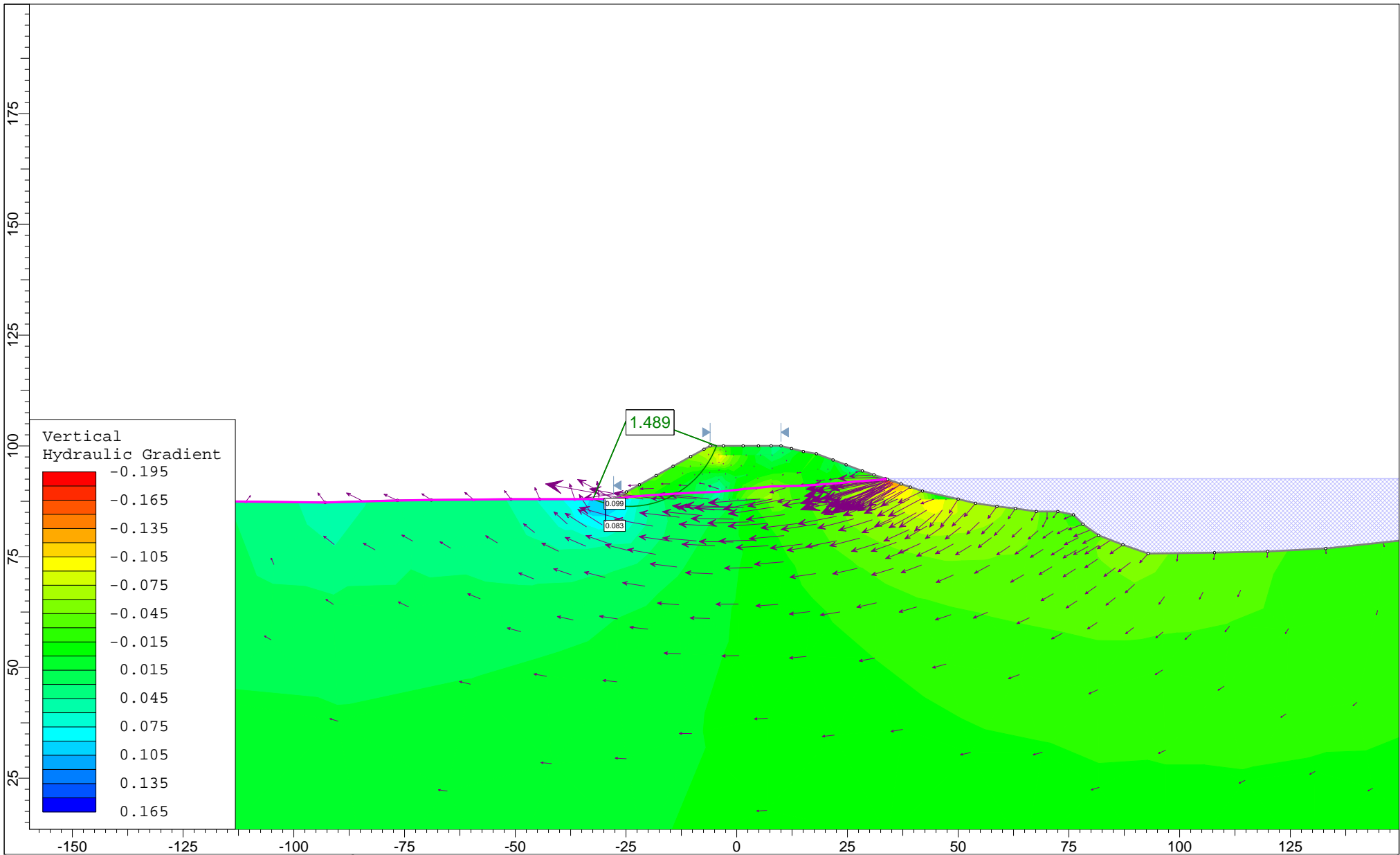
	<i>Project</i> Blue lake Levee Evaluation, Humboldt County, California		
	<i>Analysis Description</i> Cross Section 42+00, Existing Conditions, Landside		
	<i>Drawn By</i> AB/JB	<i>Scale</i> 1:360	<i>Company</i> CGI Technical Services Inc.
	<i>Date</i> 10/12/2014		<i>File Name</i> STA 42+00_Existing_Conditions, Median Annual WSE, Landside.slim


SLIDEINTERPRET 6.029



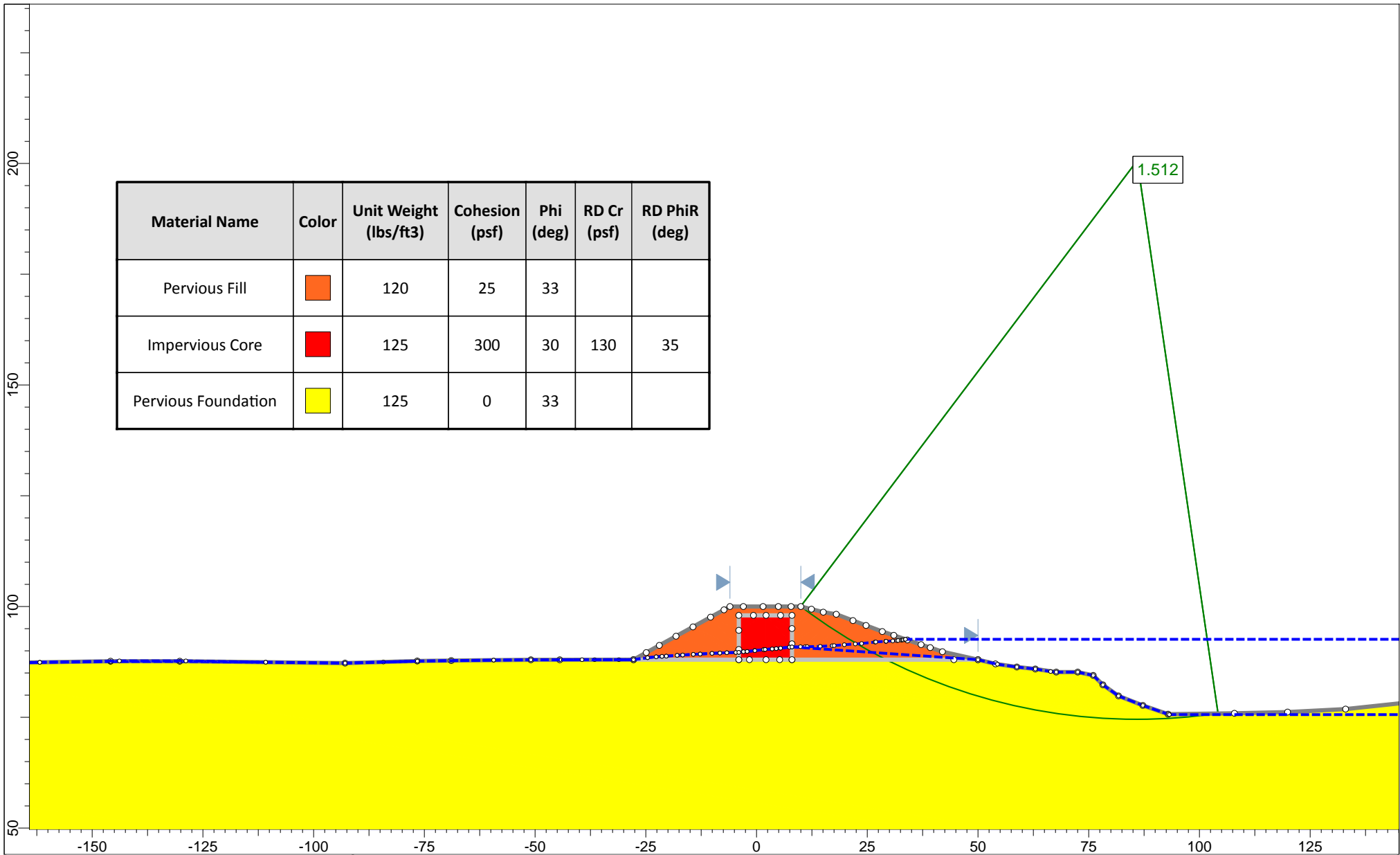
	<i>Project</i> Blue lake Levee Evaluation, Humboldt County, California		
	<i>Analysis Description</i> Existing Conditions, Median Annual WSE		
	<i>Drawn By</i> AB/JB	<i>Scale</i> 1:360	<i>Company</i> CGI Technical Services Inc.
	<i>Date</i> 10/12/2014		<i>File Name</i> STA 42+00_Existing_Conditions, Median Annual WSE, Waterside.slim

SLIDEINTERPRET 6.029




	<i>Project</i> Blue lake Levee Evaluation, Humboldt County, California		
	<i>Analysis Description</i> Flood Stage		
	<i>Drawn By</i> AB/JB	<i>Scale</i> 1:360	<i>Company</i>
	<i>Date</i> 10/12/2014		<i>File Name</i> STA 42+00_Flood_Stage_Conditions, 100-yr WSE, Landside.slim

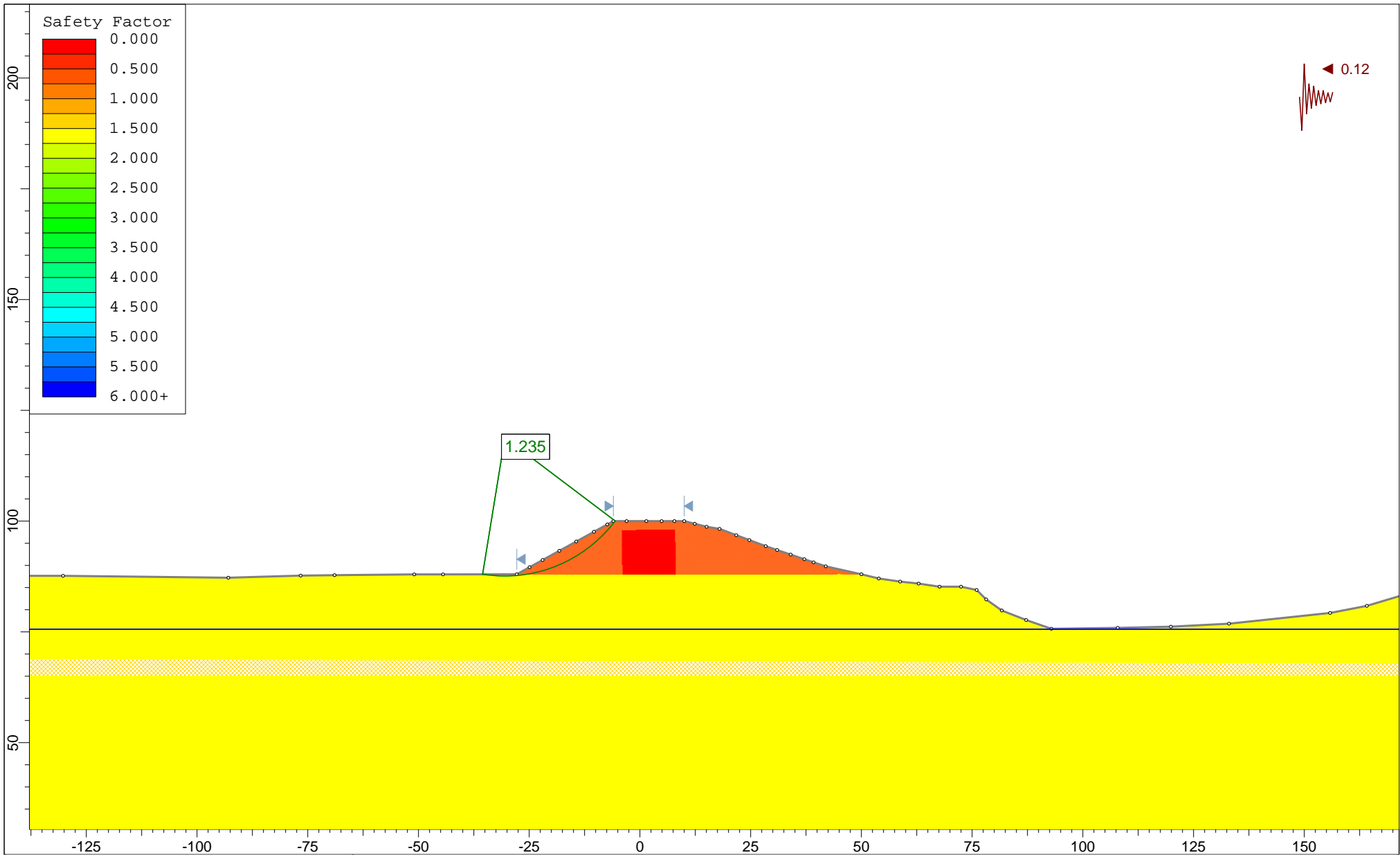
SLIDEINTERPRET 6.029




Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)	RD Cr (psf)	RD PhiR (deg)
Pervious Fill	Orange	120	25	33		
Impervious Core	Red	125	300	30	130	35
Pervious Foundation	Yellow	125	0	33		

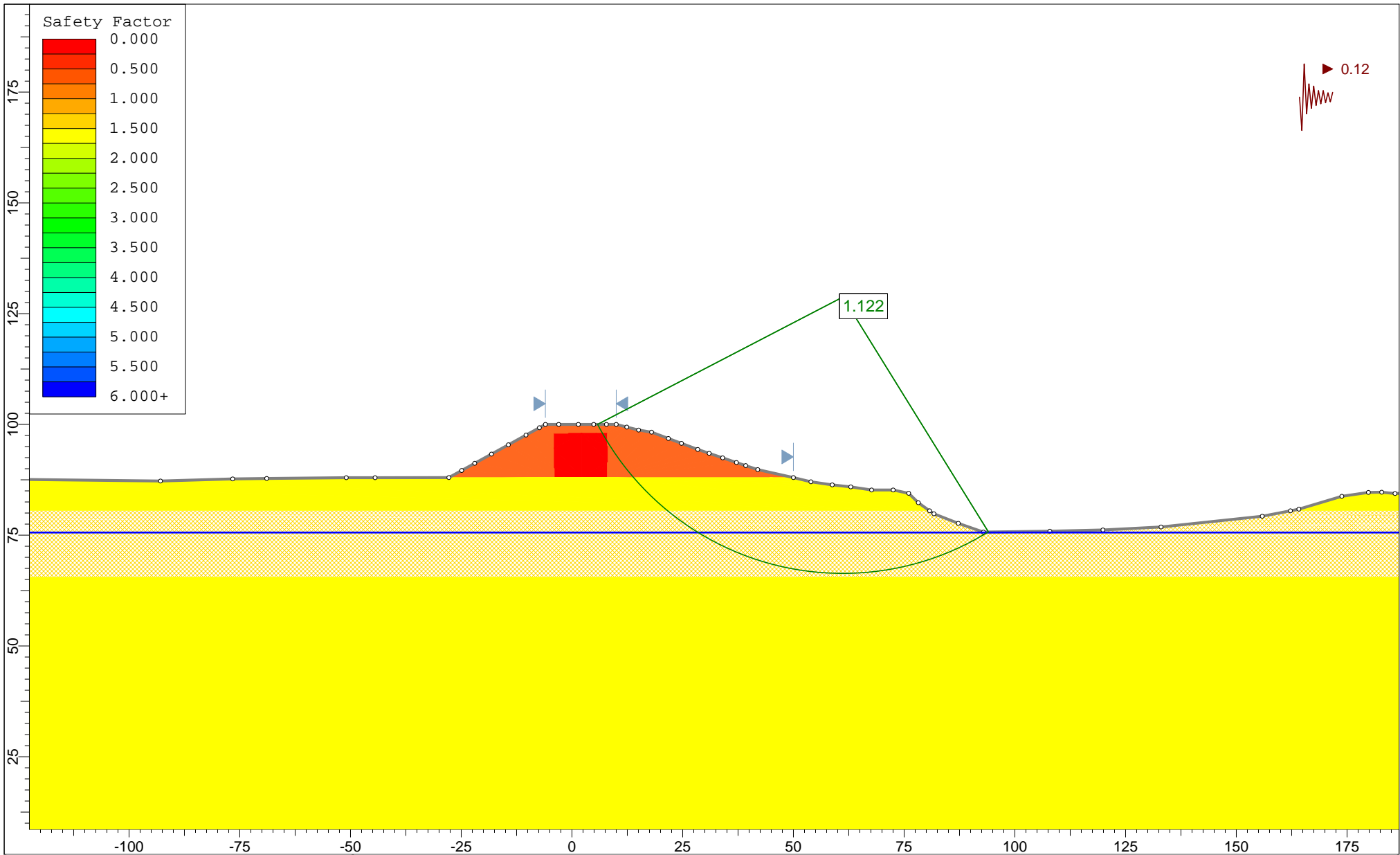
	Project			Blue lake Levee Evaluation, Humboldt County, California		
	Analysis Description			Cross-section 42+00, Rapid Drawdown		
	Drawn By	AB/JB	Scale	1:360	Company	
	Date		File Name	STA 42+00_Rapid Drawdown, Waterside.slim		


SLIDEINTERPRET 6.029



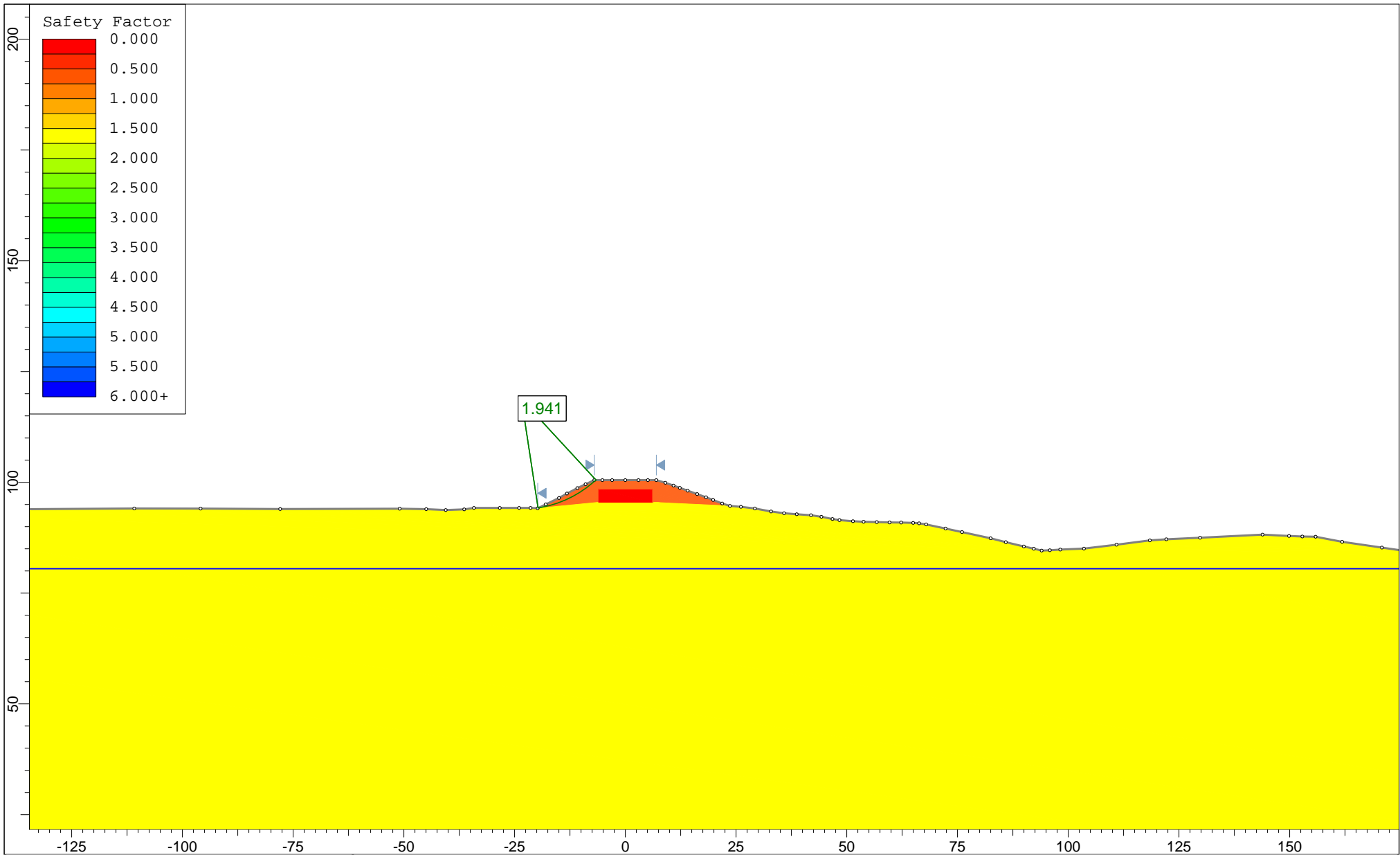
	<i>Project</i> Blue lake Levee Evaluation, Humboldt County, California		
	<i>Analysis Description</i> Cross Section 42+00, Landside		
	<i>Drawn By</i> AB/JB	<i>Scale</i> 1:360	<i>Company</i>
	<i>Date</i> 10/12/2014	<i>File Name</i> STA 42+00_EQ_Landside.slim	


SLIDEINTERPRET 6.029



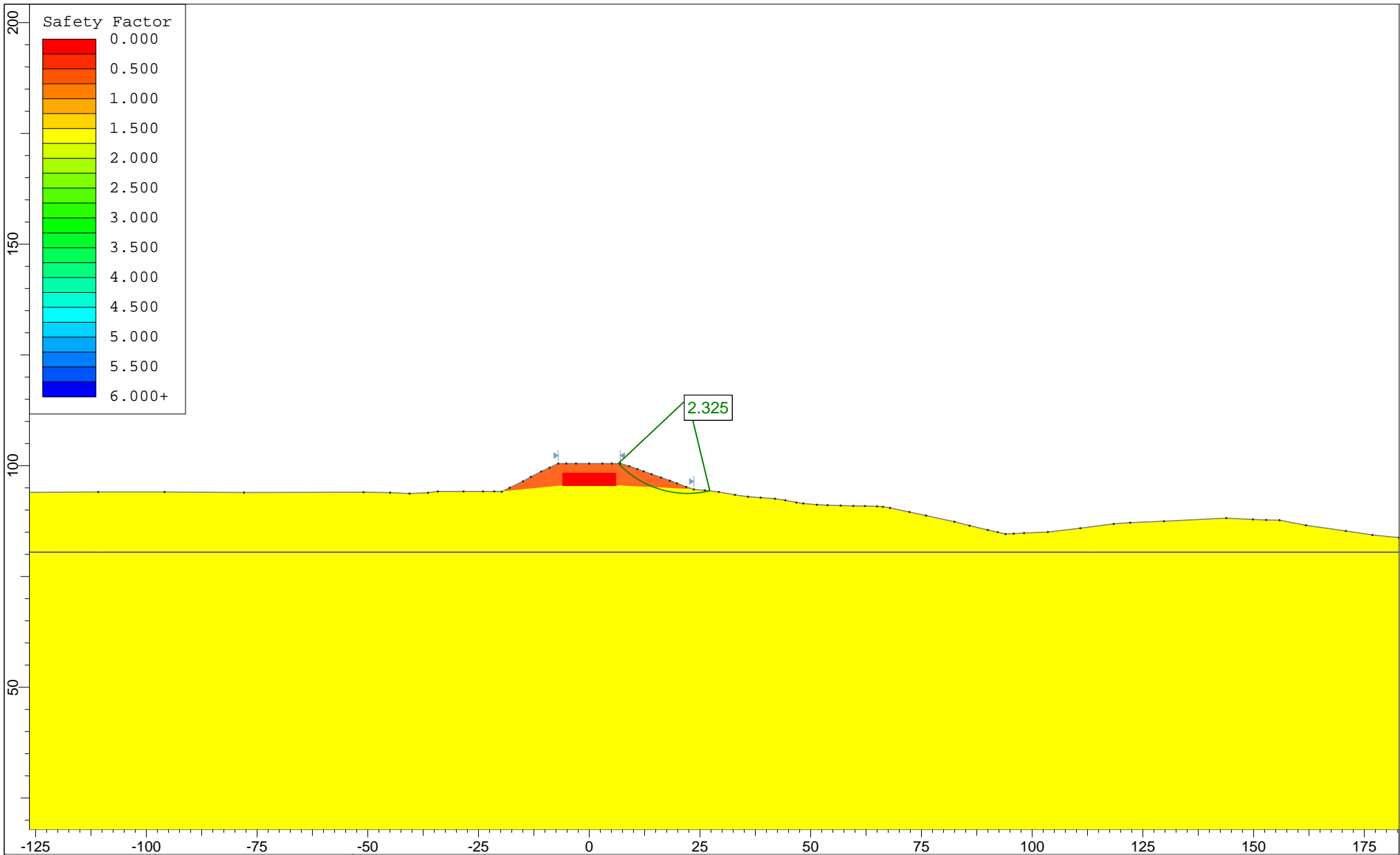
	<i>Project</i> Blue lake Levee Evaluation, Humboldt County, California		
	<i>Analysis Description</i> Cross Section 42+00, Waterside		
	<i>Drawn By</i> AB/JB	<i>Scale</i> 1:360	<i>Company</i>
	<i>Date</i> 10/12/2014	<i>File Name</i> STA 42+00_EQ_Waterside.slm	


SLIDEINTERPRET 6.029



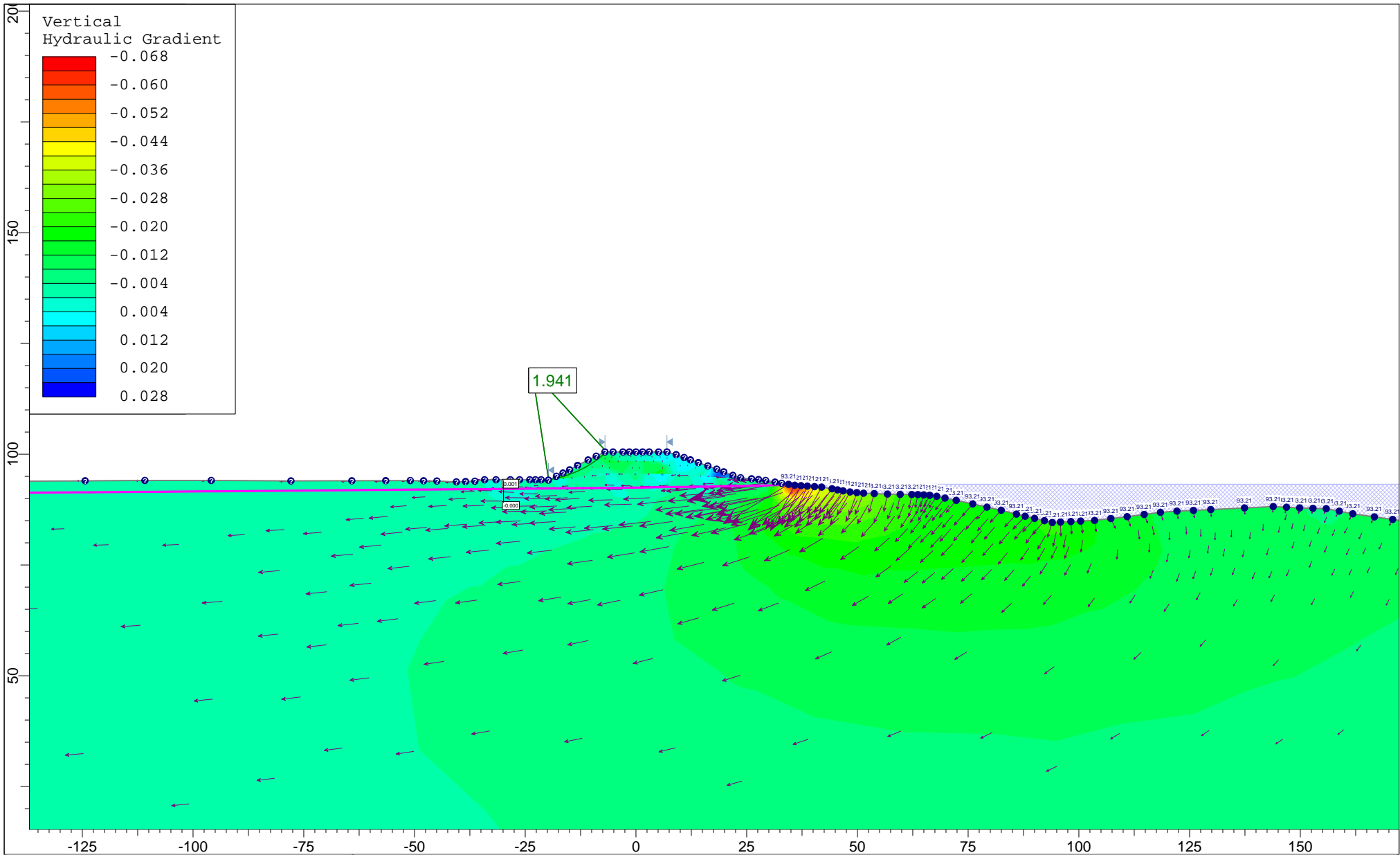
	<i>Project</i> Blue lake Levee		
	<i>Analysis Description</i>		
	<i>Drawn By</i>	<i>Scale</i> 1:360	<i>Company</i>
	<i>Date</i> 10/12/2014		<i>File Name</i> STA 50+00_Existing_Conditions, Median Annual WSE, Landside.slim


SLIDEINTERPRET 6.029



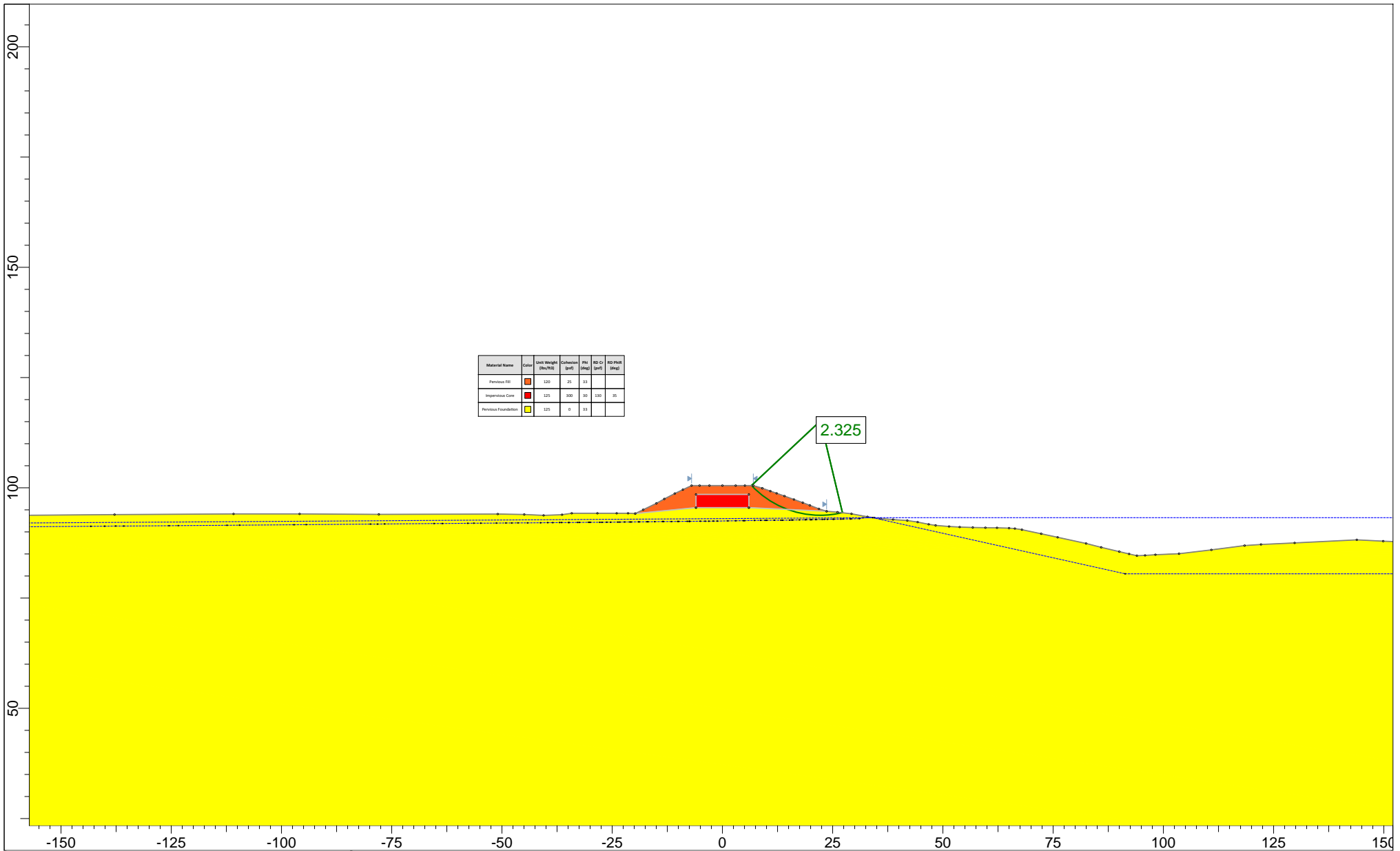
	<i>Project</i>		
	Blue lake Levee		
	<i>Analysis Description</i>		
	Waterside		
<i>Drawn By</i>	<i>Scale</i>	<i>Company</i>	
	1:360		
<i>Date</i>	<i>File Name</i>		
10/12/2014	STA 50+00_Existing_Conditions, Median Annual WSE, Waterside.slim		


SLIDEINTERPRET 6.029

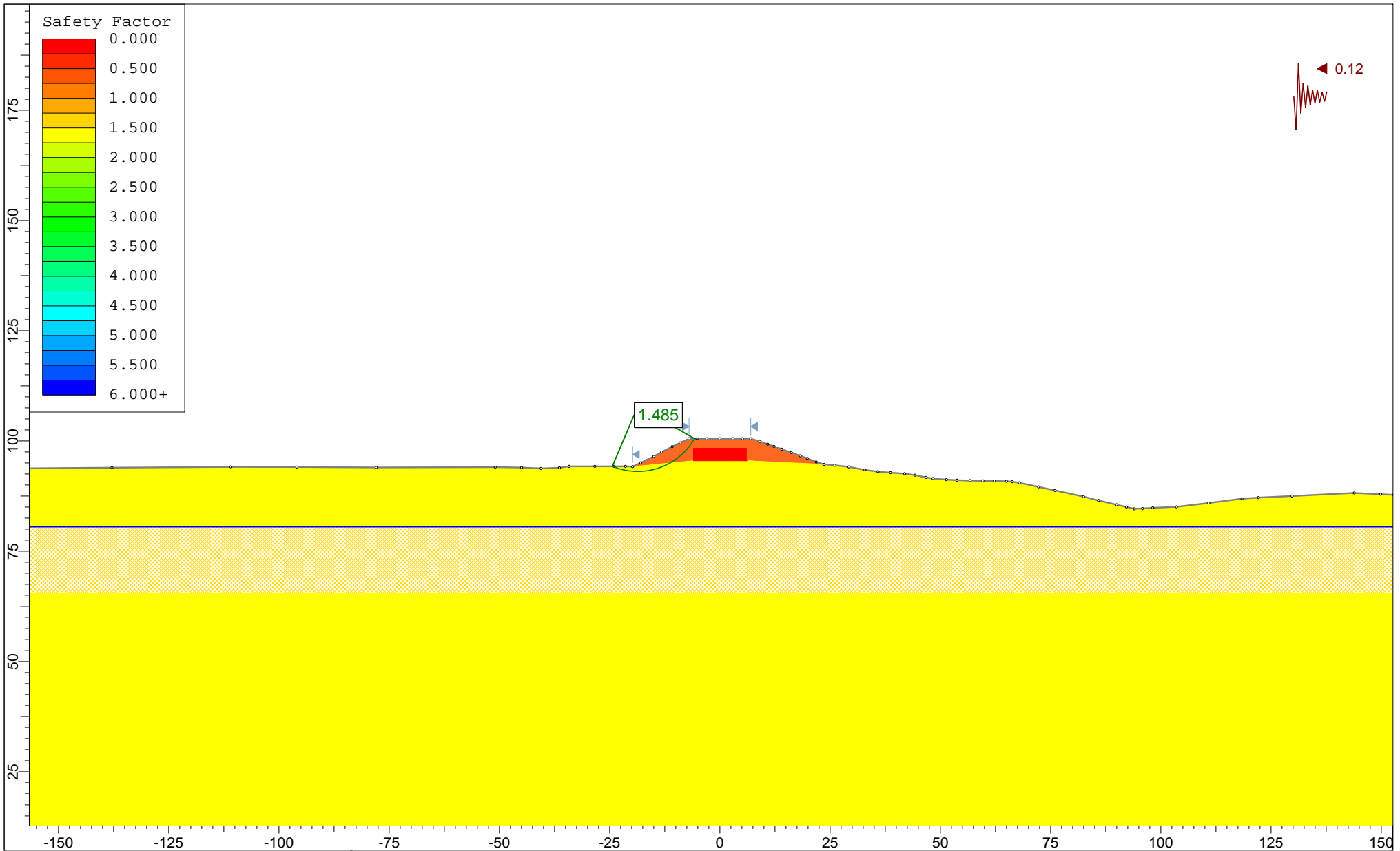



	Project			Blue lake Levee
	Analysis Description			Flood Stage
	Drawn By	Scale	Company	
	Date	10/12/2014	File Name	STA 50+00_Flood_Stage_Conditions, 100-yr WSE, Landside.slim

SLIDEINTERPRET 6.029

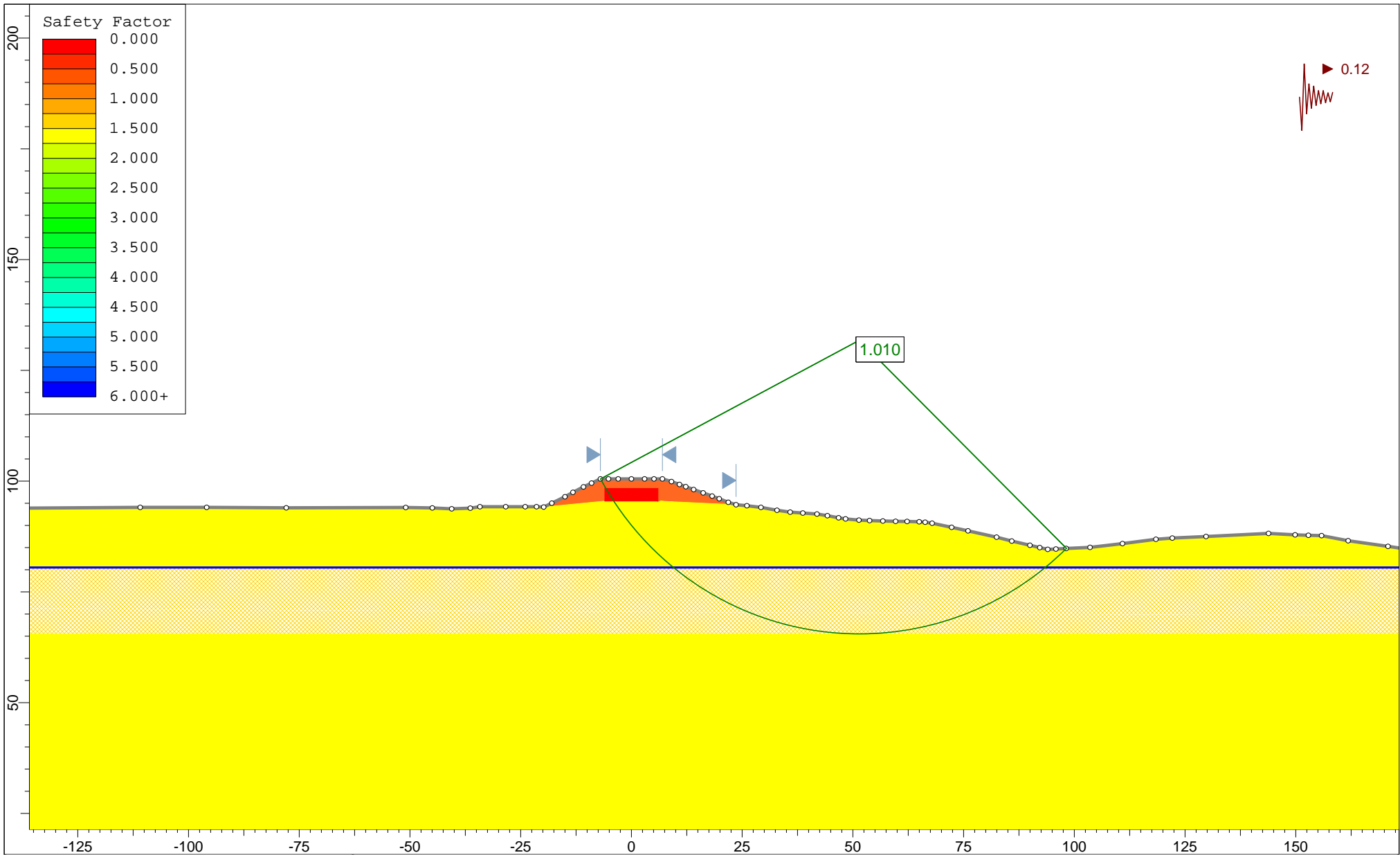



	Project										
	Blue lake Levee Evaluation										
	Analysis Description										
	Cross-section 50+00, Rapid Drawdown										
Drawn By		AB/JB		Scale		1:360		Company		CGI	
Date		8/28/2014, 10:04:51 AM						File Name		STA 50+00_Rapid Drawdown, Waterside.slim	



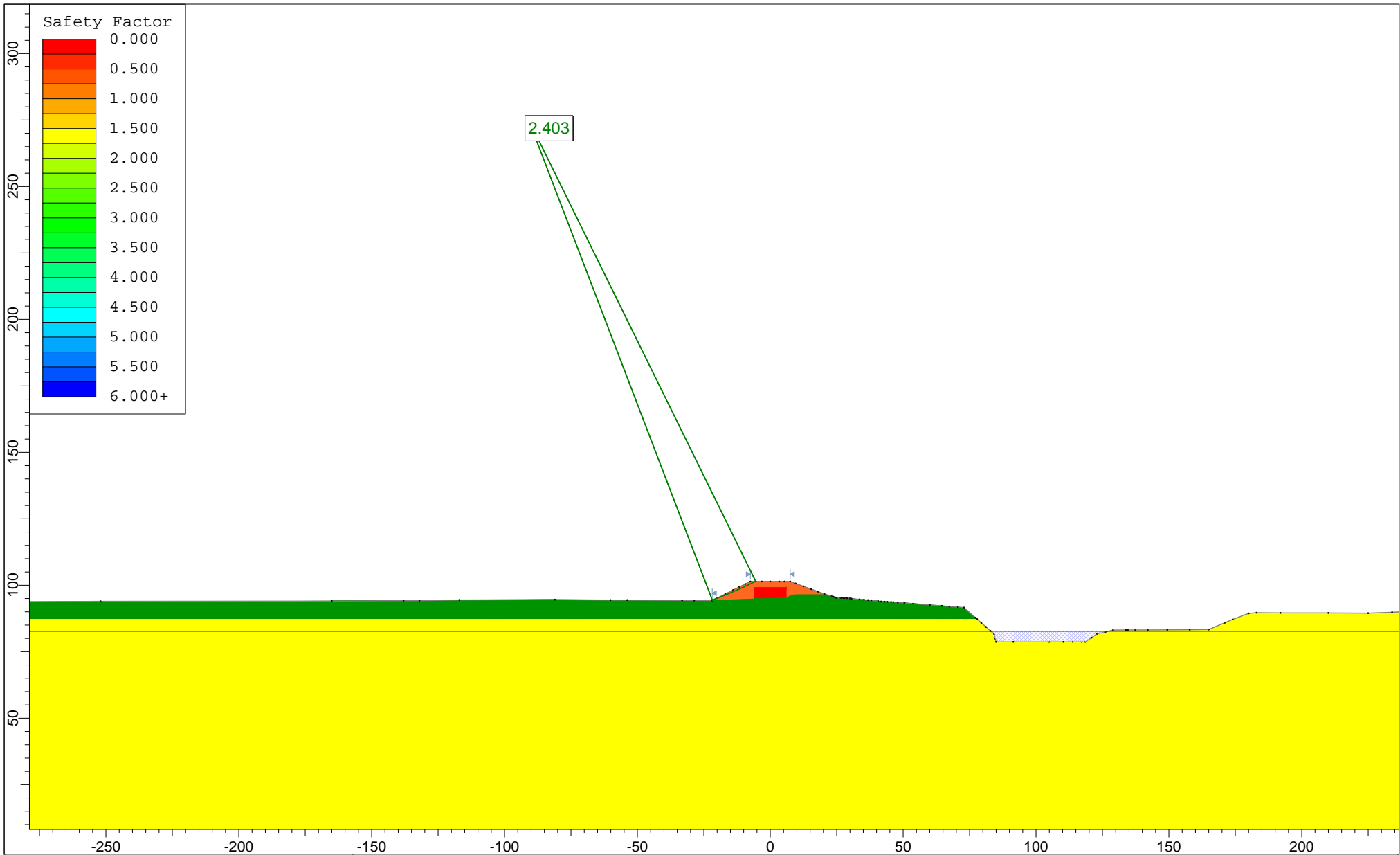
	<i>Project</i> Blue lake Levee Evaluation		
	<i>Analysis Description</i> Cross Section 50+00		
	<i>Drawn By</i> AB/JB	<i>Scale</i> 1:360	<i>Company</i>
	<i>Date</i> 10/12/2014	<i>File Name</i> STA 50+00_EQ_Landside.slim	


SLIDEINTERPRET 6.029



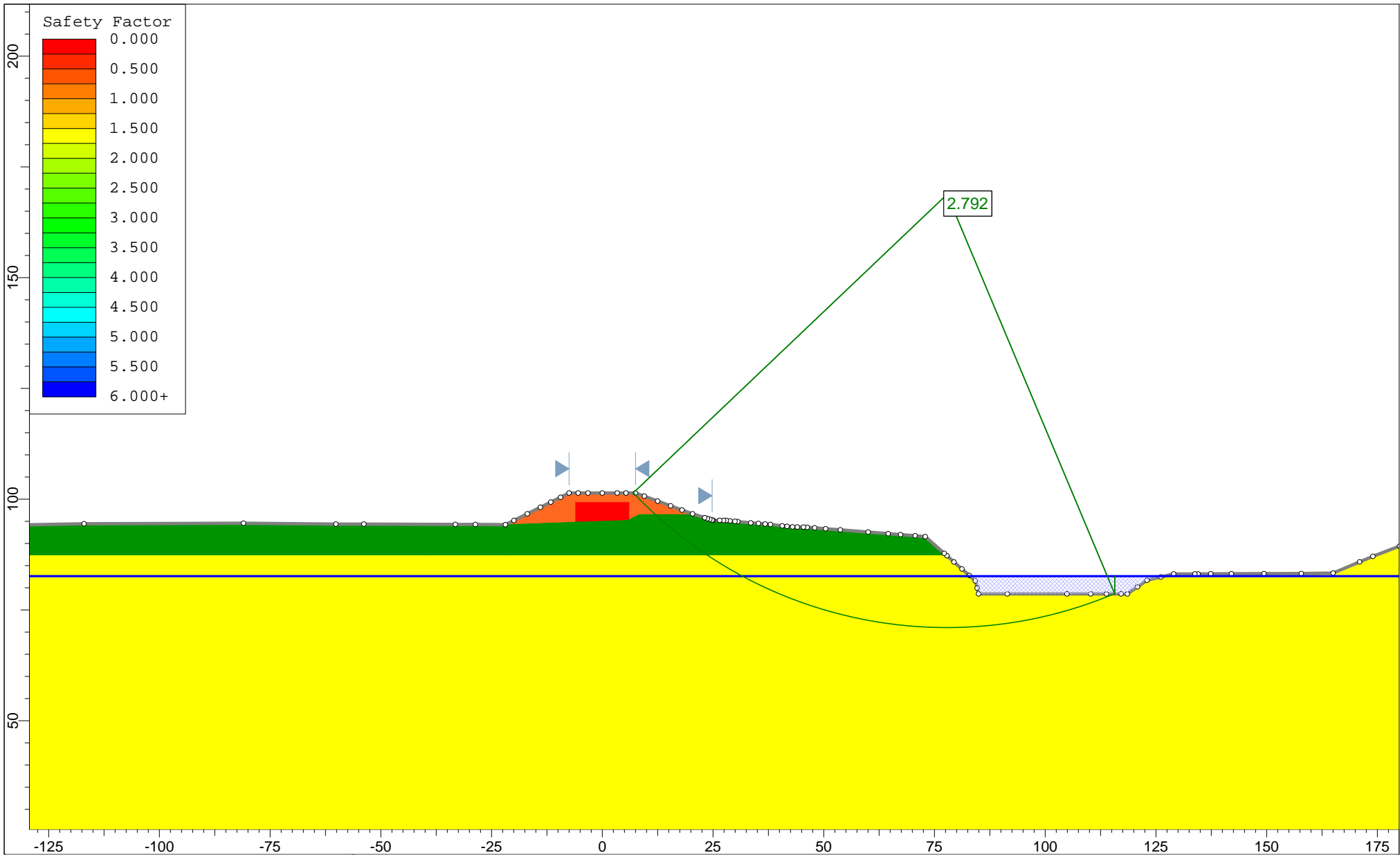
	<i>Project</i> Blue lake Levee		
	<i>Analysis Description</i>		
	<i>Drawn By</i>	<i>Scale</i> 1:360	<i>Company</i>
	<i>Date</i> 10/12/2014	<i>File Name</i> STA 50+00_EQ_Waterside.slim	


SLIDEINTERPRET 6.029

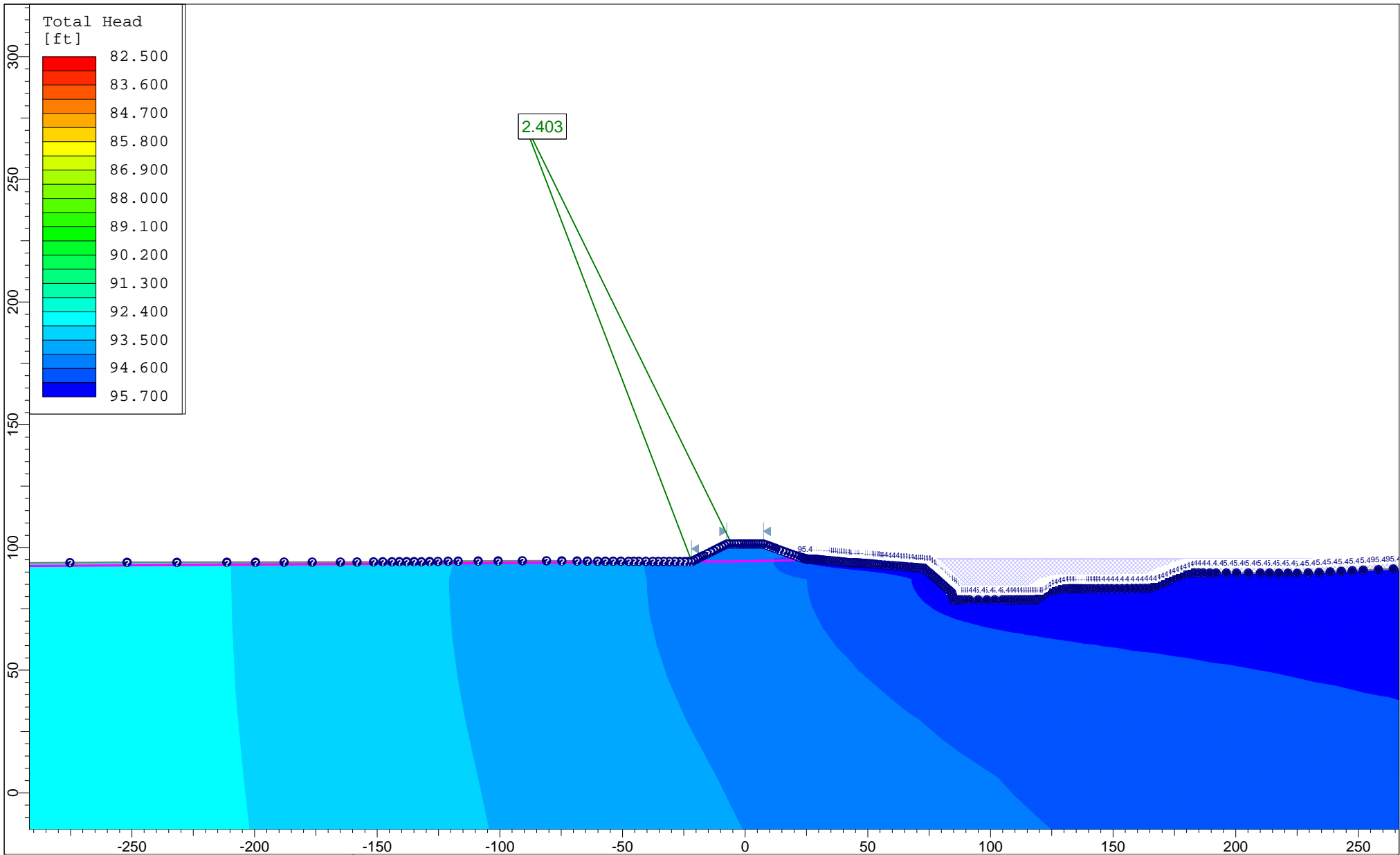



	<i>Project</i> Blue lake Levee		
	<i>Analysis Description</i> Landside		
	<i>Drawn By</i> AB/JB	<i>Scale</i> 1:600	<i>Company</i> CGI
	<i>Date</i> 10/12/2014		<i>File Name</i> STA 61+00_Existing_Conditions, Median Annual WSE, Landside.slim

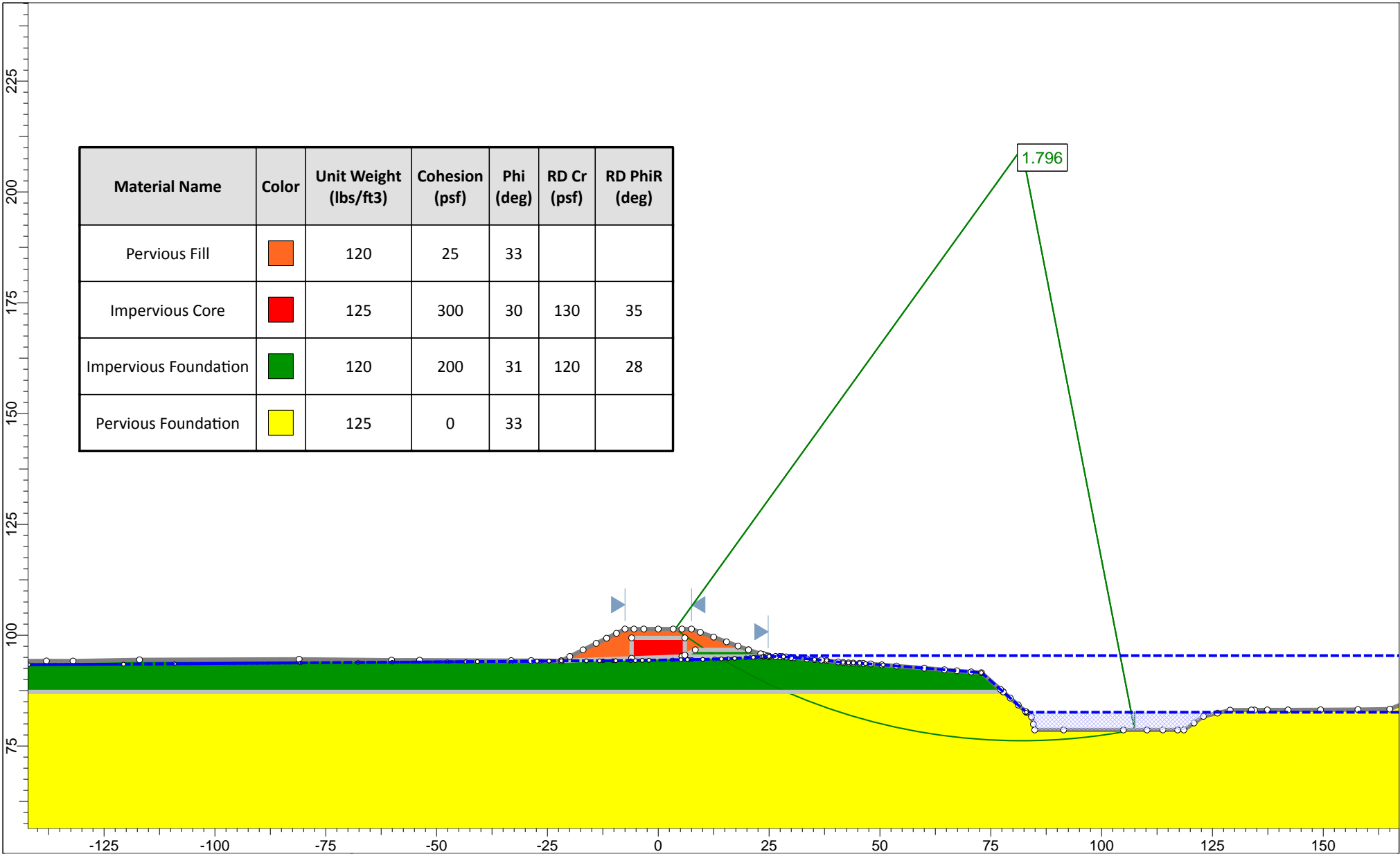
SLIDEINTERPRET 6.029




	<i>Project</i> Blue lake Levee		
	<i>Analysis Description</i> Waterside		
	<i>Drawn By</i> AB/JB	<i>Scale</i> 1:360	<i>Company</i> CGI
	<i>Date</i> 10/12/2014		<i>File Name</i> STA 61+00_Existing_Conditions, Median Annual WSE, Waterside.slim



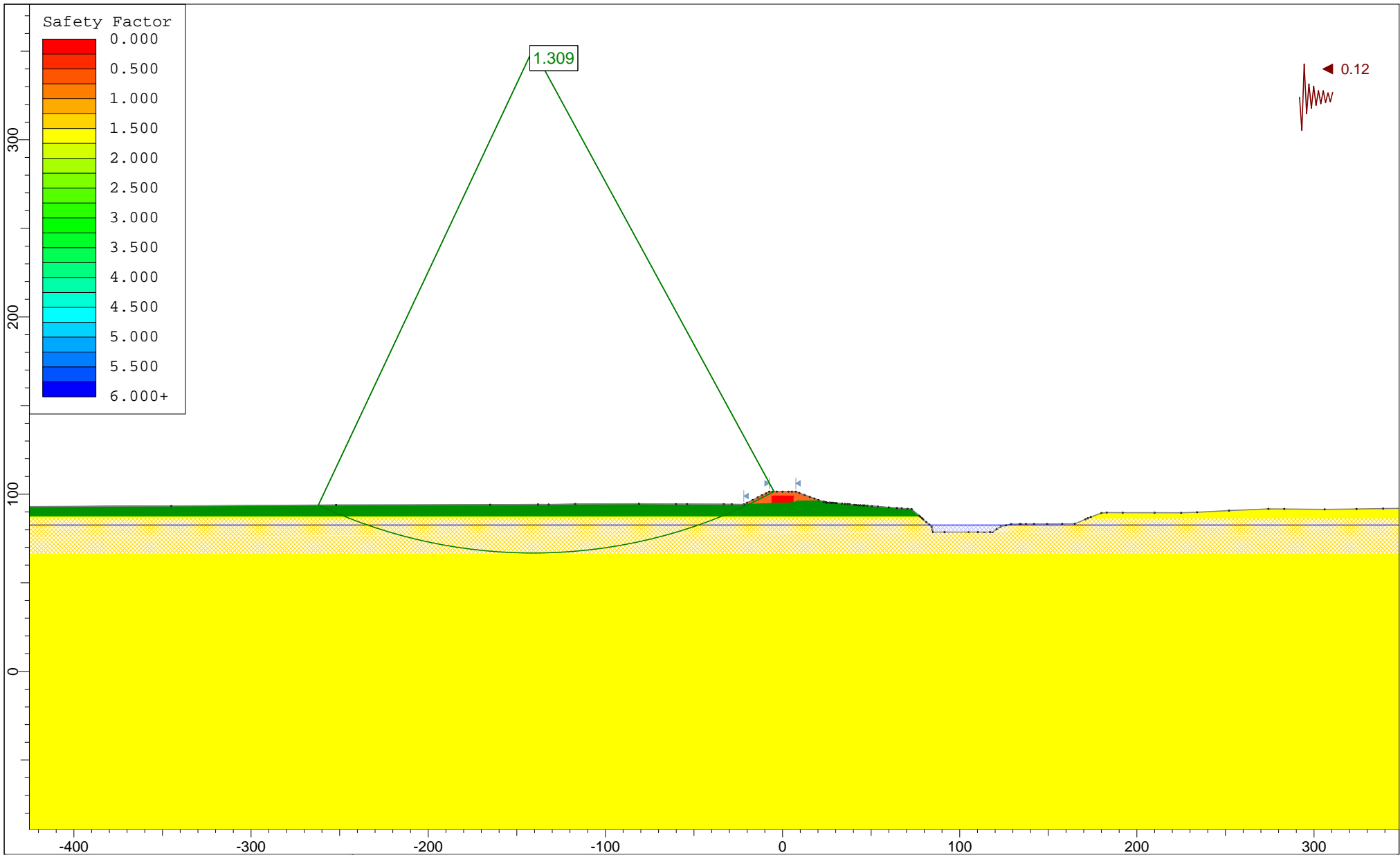
	Project			Blue lake Levee		
	Analysis Description			Flood Stage		
	Drawn By	AB/JB	Scale	1:650	Company	CGI
	Date	10/12/2014		File Name	STA 61+00_Flood_Stage_Conditions, 100-yr WSE, Landside.slim	




Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)	RD Cr (psf)	RD PhiR (deg)
Pervious Fill	Orange	120	25	33		
Impervious Core	Red	125	300	30	130	35
Impervious Foundation	Green	120	200	31	120	28
Pervious Foundation	Yellow	125	0	33		

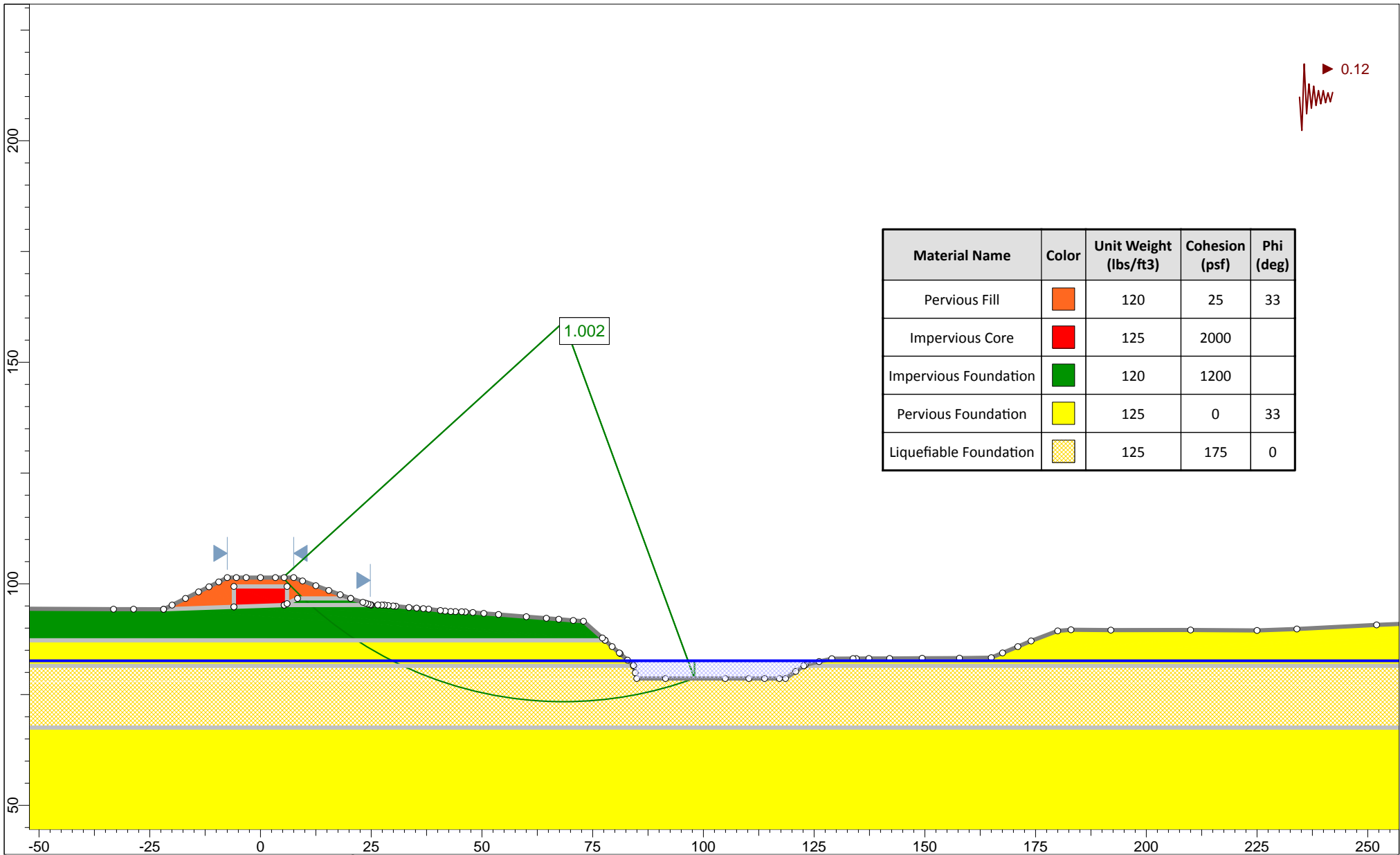
	Project			Blue lake Levee		
	Analysis Description			Cross-section 61+00, Rapid Drawdown		
	Drawn By	AB/JB	Scale	1:360	Company	CGI
	Date	8/28/2014, 10:04:51 AM		File Name	STA 61+00_Rapid Drawdown, Waterside.slim	

SLIDEINTERPRET 6.029




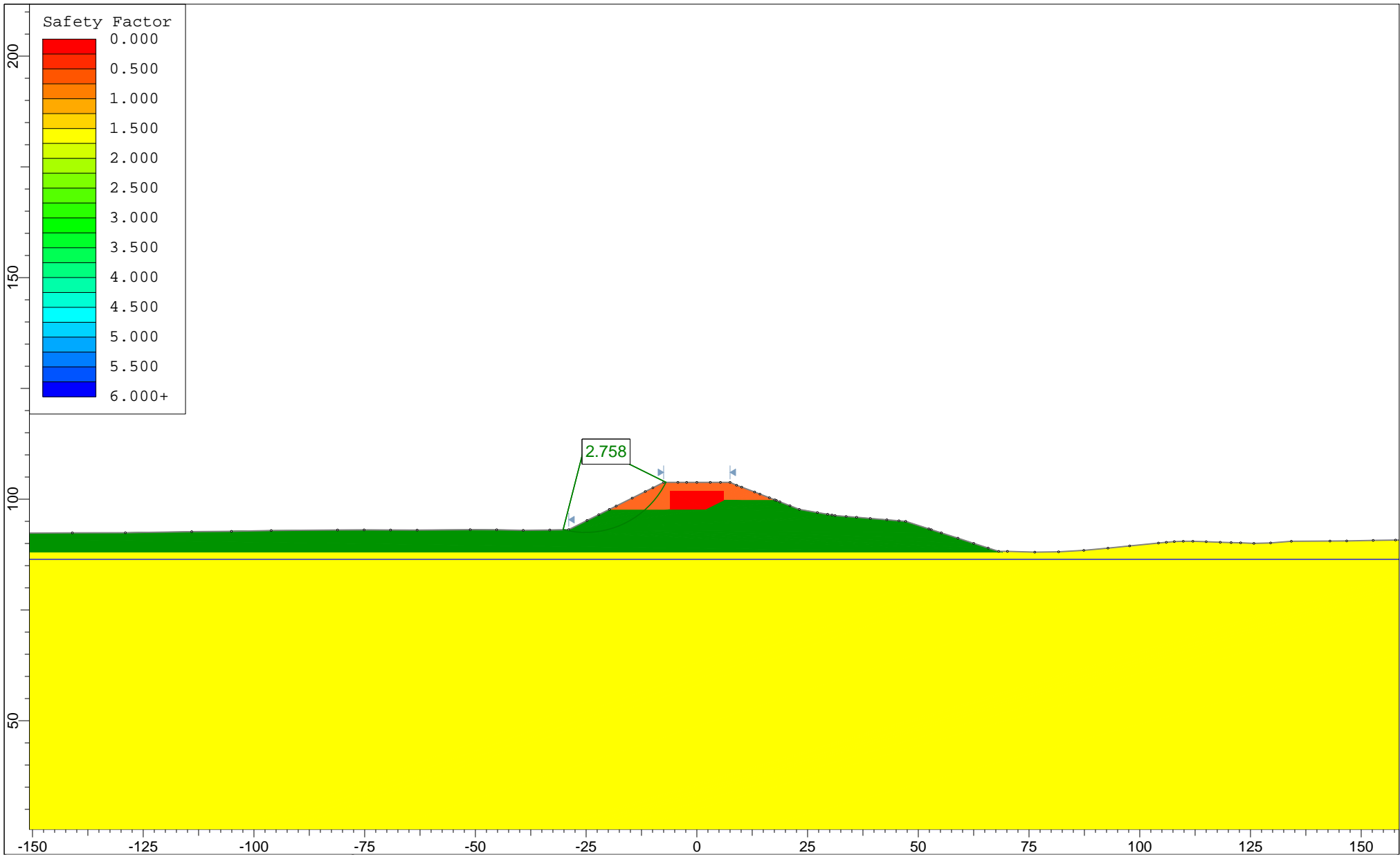
	Project			Blue lake Levee		
	Analysis Description			Landside		
	Drawn By	AB/JB	Scale	1:900	Company	CGI
	Date	10/12/2014		File Name	STA 61+00_EQ_Landside.slim	


SLIDEINTERPRET 6.029



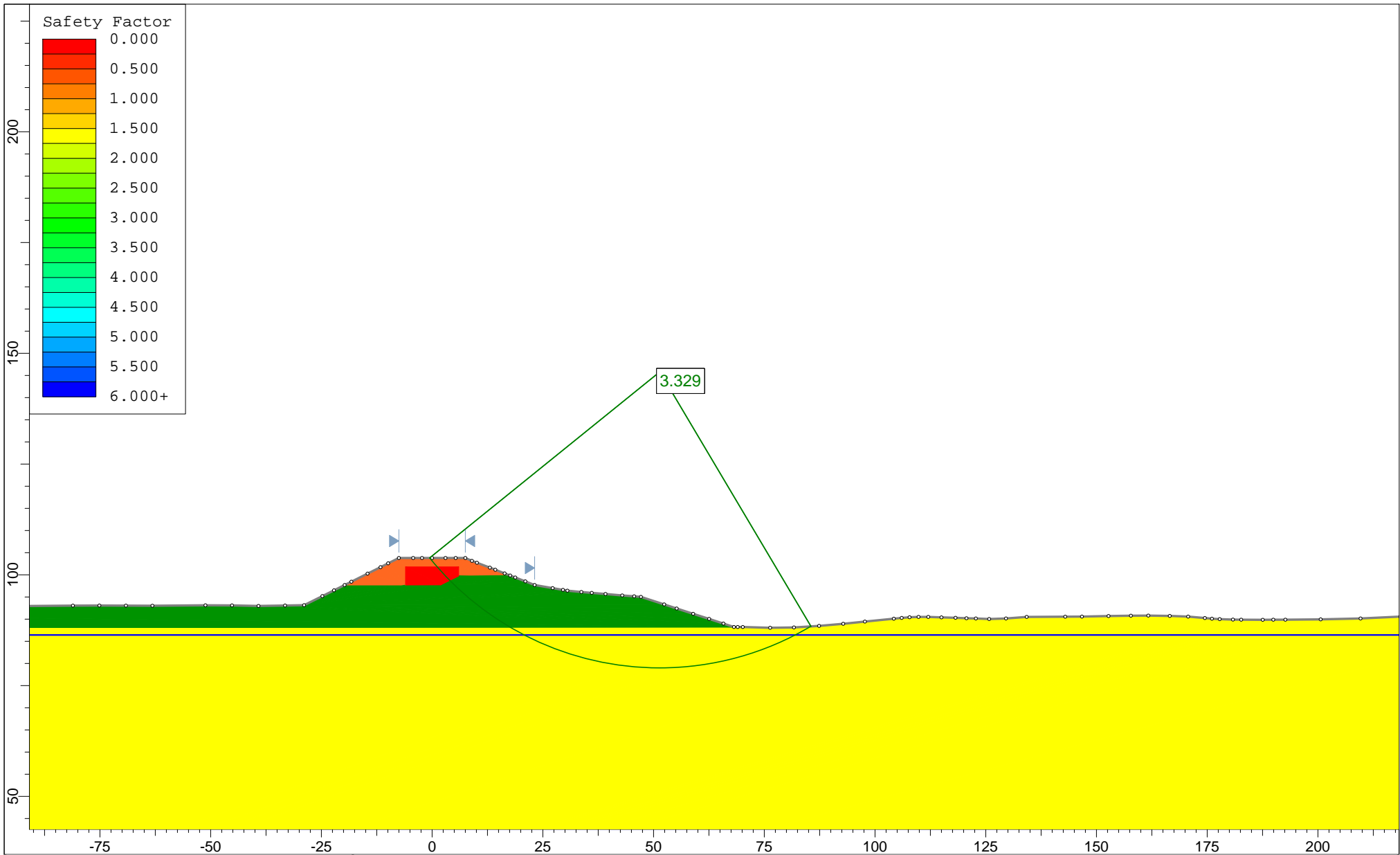
Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
Pervious Fill	Orange	120	25	33
Impervious Core	Red	125	2000	
Impervious Foundation	Green	120	1200	
Pervious Foundation	Yellow	125	0	33
Liquefiable Foundation	Hatched	125	175	0


	Project				Blue lake Levee	
	Analysis Description				Waterside	
	Drawn By		AB/JB	Scale		1:360
	Date		8/28/2014, 10:04:51 AM		Company	
SLIDEINTERPRET 6.029				File Name		STA 61+00_EQ_Waterside.slim



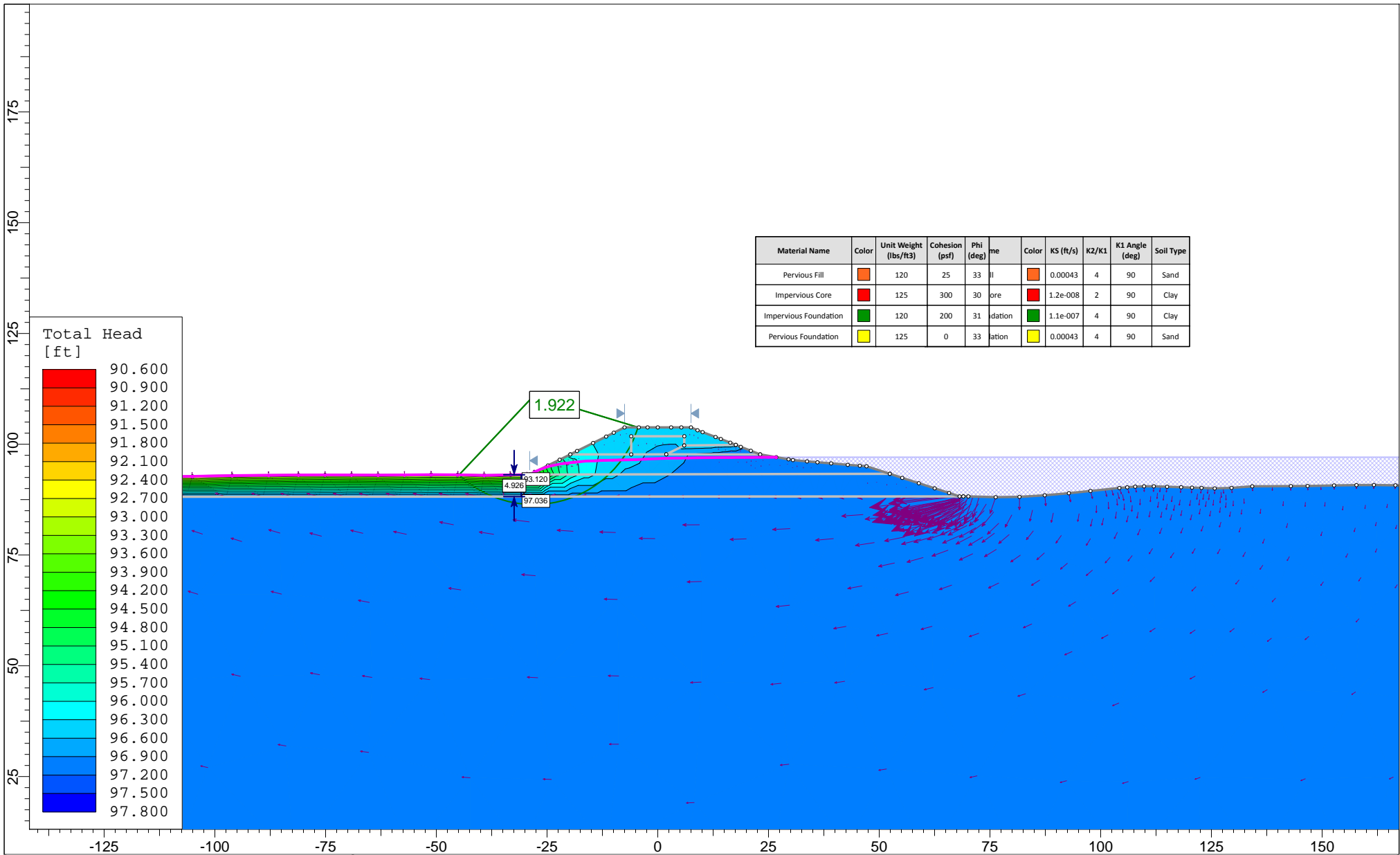
	<i>Project</i> Blue lake Levee		
	<i>Analysis Description</i> Landside		
	<i>Drawn By</i> AB/JB	<i>Scale</i> 1:360	<i>Company</i> CGI
	<i>Date</i> 10/12/2014		<i>File Name</i> STA 71+00_Existing_Conditions, Median Annual WSE, Landside.slim


SLIDEINTERPRET 6.029



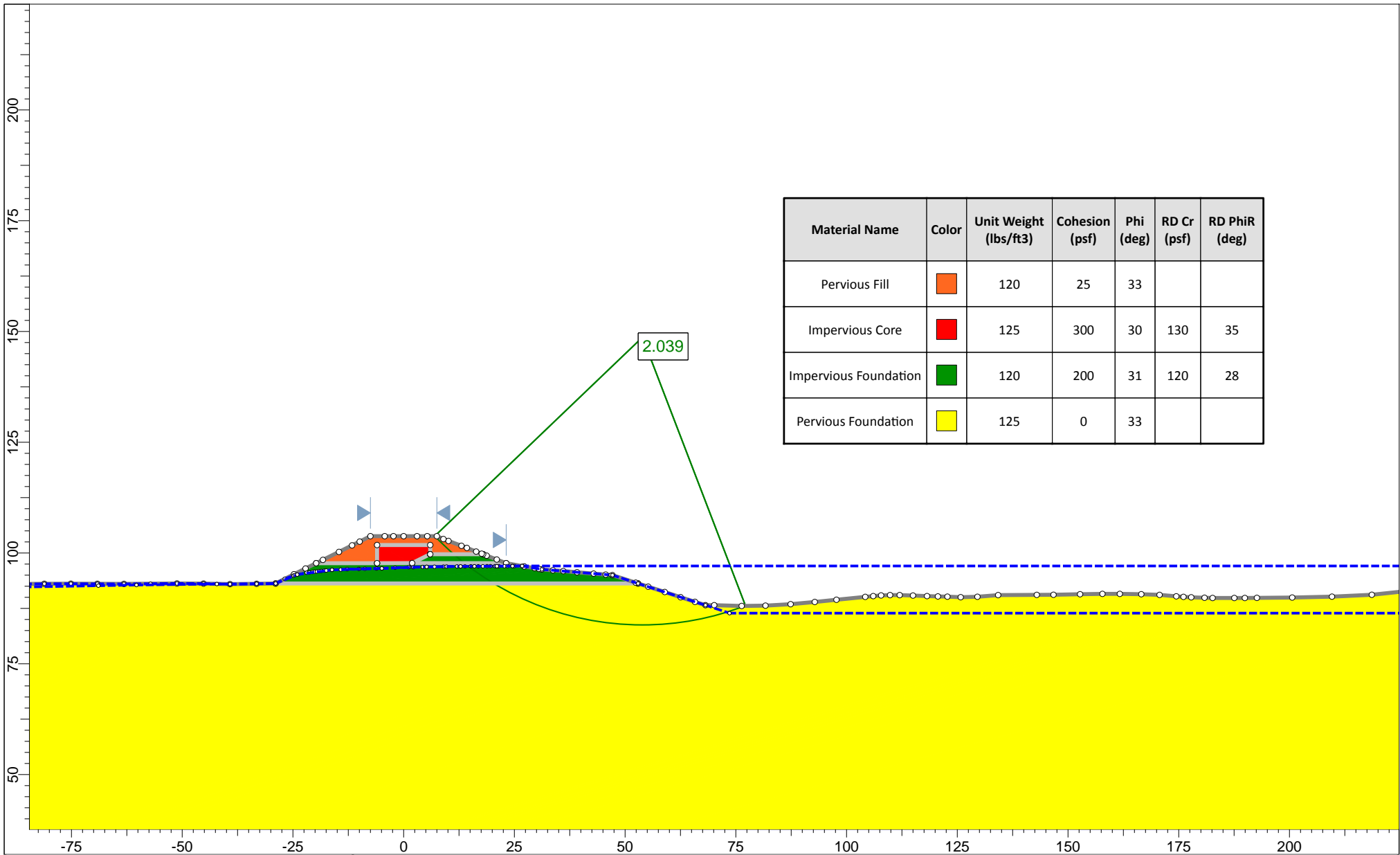
	Project			Blue lake Levee		
	Analysis Description			Waterside		
	Drawn By	AB/JB	Scale	1:360	Company	CGI
	Date	10/12/2014		File Name	STA 71+00_Existing_Conditions, Median Annual WSE, Waterside.slim	

SLIDEINTERPRET 6.029




	Project			Blue lake Levee		
	Analysis Description			Flood Stage		
	Drawn By	AB/JB	Scale	1:360	Company	CGI
	Date	8/28/2014, 10:04:51 AM		File Name	STA 71+00_Flood_Stage_Conditions, 100-yr WSE, Landside.slim	

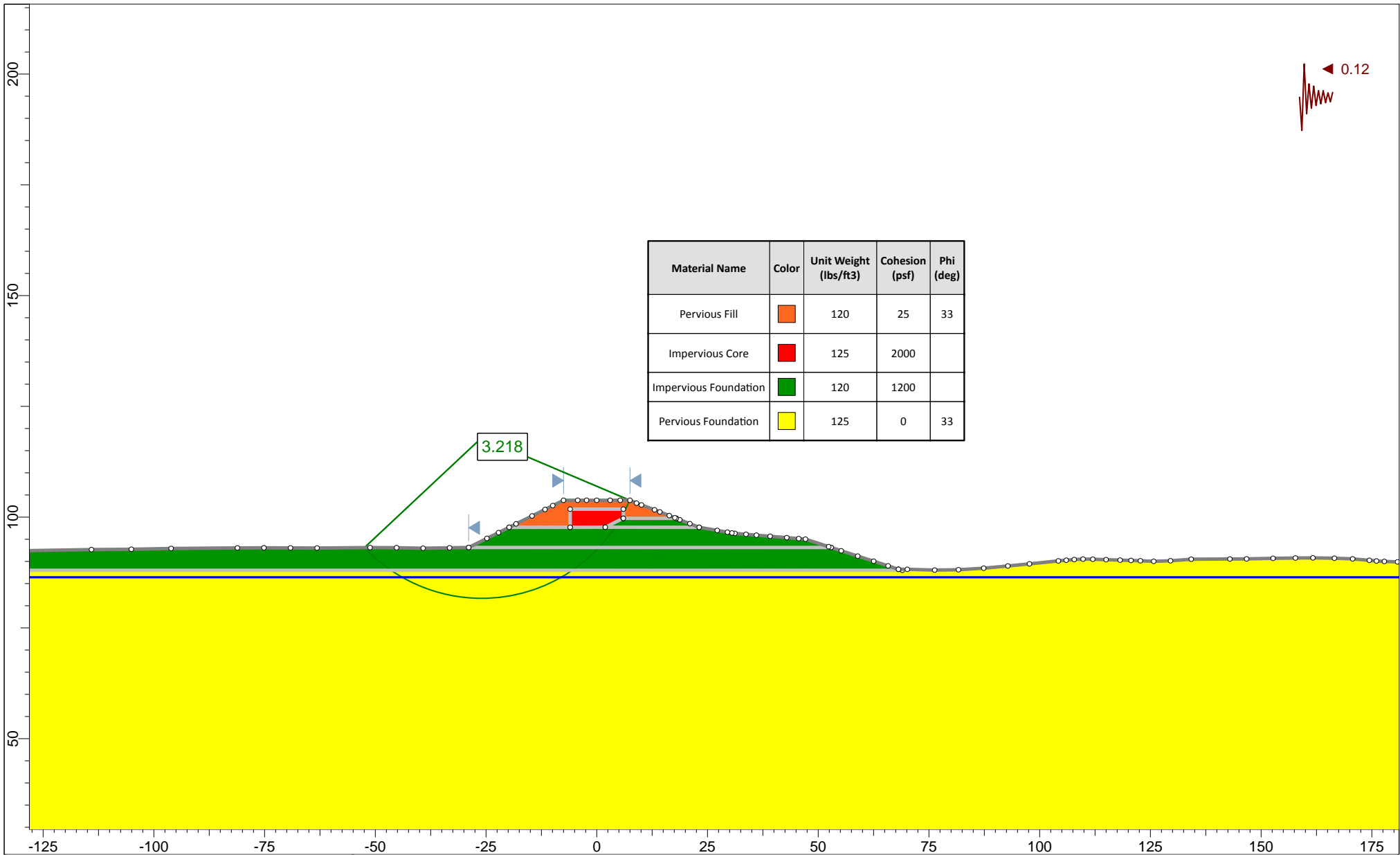
SLIDEINTERPRET 6.029




Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)	RD Cr (psf)	RD PhiR (deg)
Pervious Fill	Orange	120	25	33		
Impervious Core	Red	125	300	30	130	35
Impervious Foundation	Green	120	200	31	120	28
Pervious Foundation	Yellow	125	0	33		

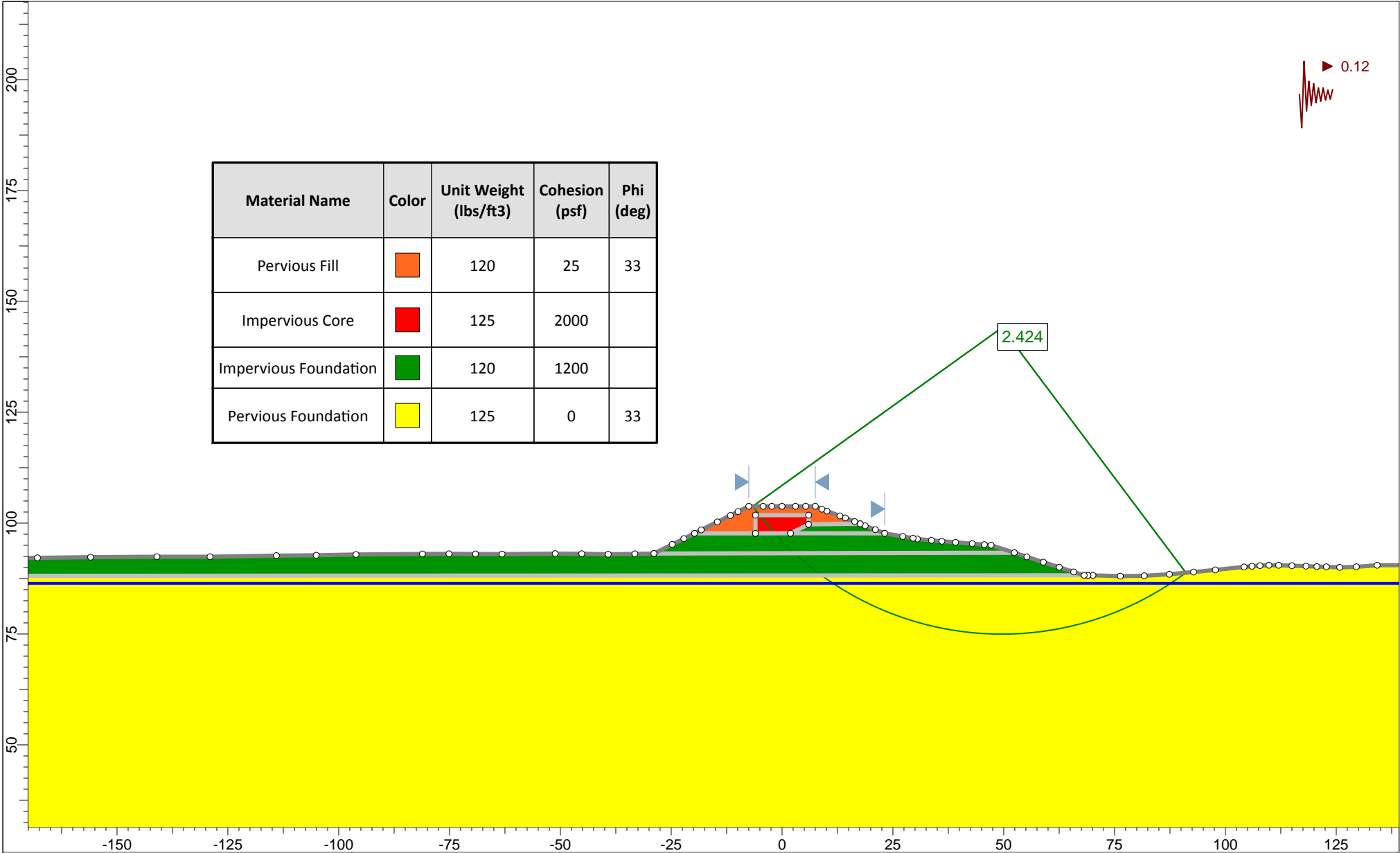
	Project			Blue lake Levee		
	Analysis Description			Cross-section 71+00, Rapid Drawdown		
	Drawn By	AB/JB	Scale	1:360	Company	CGI
	Date	8/28/2014, 10:04:51 AM		File Name	STA 71+00_Rapid Drawdown, Waterside.slim	


SLIDEINTERPRET 6.029



	<i>Project</i> Blue Lake Levee Evaluation, Humboldt County, California		
	<i>Analysis Description</i> Cross-section 71+00, Earthquake Conditions, Landside		
	<i>Drawn By</i> AB/JB	<i>Scale</i> 1:360	<i>Company</i> CGI
	<i>Date</i> 8/28/2014, 10:04:51 AM	<i>File Name</i> STA 71+00_EQ_Landside.slim	

SLIDEINTERPRET 6.029



	Project			Blue Lake Levee Evaluation, Humboldt County, California		
	Analysis Description			Cross-section 71+00, Earthquake Conditions, Waterside		
	Drawn By	AB/JB	Scale	1:360	Company	CGI
	Date	8/28/2014, 10:04:51 AM		File Name	STA 71+00_EQ_Waterside.slim	

SLIDEINTERPRET 6.029