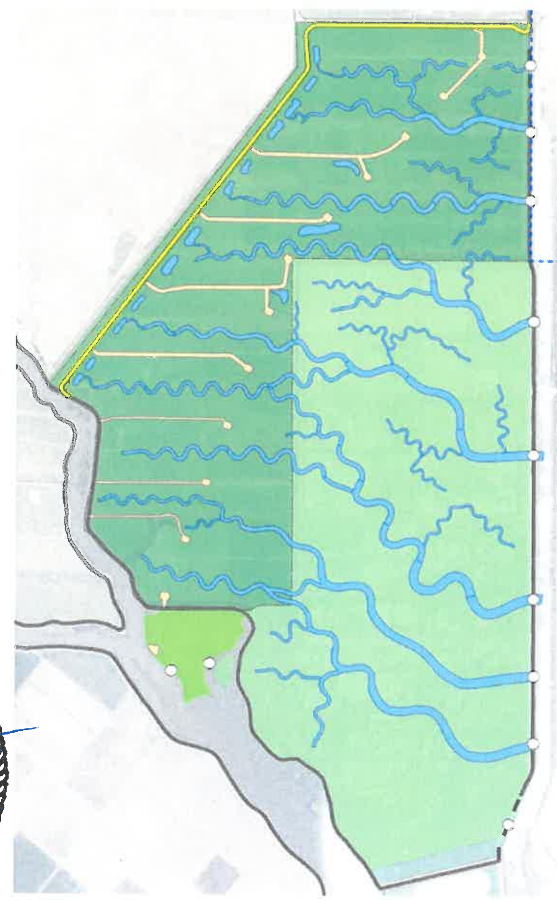
Appendix D – Lookout Slough Tidal Habitat Restoration and Flood Improvement Project: 65% Basis of Design Report, Wood Rodgers 2019.

This page intentionally left blank.

LOOKOUT SLOUGH TIDAL HABITAT RESTORATION AND FLOOD IMPROVEMENT PROJECT

65% DESIGN BASIS OF DESIGN REPORT



Prepared For:

Ecosystem Investment Partners
5550 Newbury St.
Baltimore, Maryland 21209

Contact: David Urban
david@ecosystempartners.com

Prepared By:

Wood Rodgers, Inc.
3301 C Street, Suite 100
Sacramento, CA 95816

Contact: Jesse Patchett
jpatchett@woodrodgers.com

Date: December 2, 2019

REGISTERED PROFESSIONAL ENGINEER
JESSE J. PATCHETT
No. [illegible]48
Exp. 3/30/20
CIVIL
STATE OF CALIFORNIA
12/2/19

The findings and recommendations in this report are draft, intended for 65%-level design, and should not be relied on for final design or construction. Findings and recommendations may change as design progresses. Subsequent 90% and/or 100% updates of this report prepared by Wood Rodgers will contain findings and recommendations for final design and construction.

Ecosystem Investment Partners

WOOD RODGERS
BUILDING RELATIONSHIPS ONE PROJECT AT A TIME

This Page Intentionally Left Blank

TABLE OF CONTENTS

TABLES

FIGURES

APPENDICES

This Page Intentionally Left Blank

1.0 INTRODUCTION

1.1 Document Purpose and Scope

The Lookout Slough Tidal Habitat Restoration and Flood Improvement Project (Project) has been initiated by EIP III Credit Co, LLC (EIP) and the California Department of Water Resources (DWR) to evaluate the restoration of tidal hydrology to more than 3,000 acres within the Sacramento-San Joaquin Delta (Delta) and to increase flood system resiliency.

As part of the Project, the west levee of Shag Slough will be partially degraded and breached in several locations. The west levee of Shag Slough currently serves as the west levee of the Yolo Bypass in this area. Therefore, a new setback levee, Duck Slough Setback Levee (DSSL), will be constructed to maintain flood protection to areas west and north of the Project that would otherwise be impacted by these breaches.

The purpose of this Basis of Design Report (BODR) is to document the basis for design for the flood protection elements of the Project. Project features relating to the habitat restoration elements of the Project are provided in a separate document.

1.2 Project Location

The Project Site is a 15-parcel, approximately 3,395-acre area located in unincorporated Solano County, California, with a small portion of work extending into unincorporated Yolo County. The Project is located approximately 20 miles southwest of the city of Sacramento and 50 miles northeast of the city of San Francisco.

The Project Site is wholly within Reclamation District (RD) 2098 and includes the three properties known as Bowlsbey Property, Liberty Farms, and Vogel Properties. It is bordered on the northwest by Duck Slough and on the east by Shag Slough. The southwestern boundary of the Project Site is formed by Cache Slough and its tributary, Hass Slough. The southern border of the Project Site consists of the Cross Levee, and the northern boundary of the Project Site is Liberty Island Road. Refer to **Figure 1** (attached) for a graphical depiction of the Project location.

1.3 Background Information

EIP and DWR are undertaking the Project to work towards fulfilling DWR's obligation to restore 8,000 acres of tidal marsh under Reasonable and Prudent Alternative (RPA) 4 of the United States Fish and Wildlife Service (USFWS) Delta Smelt Biological Opinion (BiOp) and consistent with RPA I.6.1 of the National Marine Fisheries Service Salmonid BiOp for long-term coordinated operations of the California State Water Project (SWP) and the federal Central Valley Project (CVP).

1.4 Project Goals and Objectives

The Project is designed to achieve the goals and objectives identified below.

Goal 1: Create and maintain a diverse landscape of intertidal habitat and associated subtidal habitat that will support habitat elements for native species and improved food productivity within the Project area.

Objectives:

- Improve primary and secondary productivity and food availability for Delta Smelt and other native fish within the Project boundaries and the immediate tidal sloughs surrounding the Project.
- Improve the rearing habitat for Delta Smelt, salmonids, and other native fish.
- Promote a suitable spawning habitat with appropriate water velocities and depths that are accessible for Delta Smelt within the Project and the immediate tidal sloughs surrounding the Project.
- Increase on-site diversity of foraging, breeding, and refuge habitat conditions for aquatic and terrestrial wetland-dependent species.
- To the greatest extent practicable, preserve existing topographic variability to allow for habitat succession and resilience against future climate change.
- To the greatest extent practicable, avoid promoting conditions that are adverse to Project biological objectives, such as those that would favor the establishment or spread of invasive exotic species.

Goal 2: Design and, if approved, implement a Project that also supports viable populations of special status aquatic and terrestrial species.

Objectives:

- Minimize temporary effects to special status aquatic and terrestrial species when implementing Project activities (*e.g.*, earth disturbance and vegetation management activities).
- Include habitat elements for special status aquatic and terrestrial species.

Goal 3: Provide additional flood storage within the Yolo Bypass to reduce the chance of catastrophic flooding and protect existing nearby infrastructure (*e.g.*, agriculture, power, and human habitation).

Objectives:

- Protect existing nearby infrastructure surrounding the Project and avoid any adverse flood-related impacts in the region.
- Provide flood management benefits by reducing flood stages in the lower part of the Yolo Bypass.

1.5 Project Description

The Project would restore more than 3,000 acres of floodplain, tidal marsh, and subtidal habitats within the Project Site. This would be accomplished by reintroducing tidal hydrology to the Project Site through breaching of the Yolo Bypass West Levee (YBWL) (a.k.a Shag Slough Levee), and the Vogel Levee, and with the creation of new tidal channels through these properties. Upon completion, the proposed Project would protect approximately 3,400 acres of open space, including more than 3,000 acres of floodplain, tidal, and subtidal marsh habitat that would provide suitable habitat for special-status fish species, including but not limited to, Delta Smelt, long-fin smelt, winter and spring-run Chinook Salmon, and steelhead. Additionally, the Project would create over 40,000 acre-feet of transitory flood storage at the Delta confluence.

The Project consists of levee modifications, grading to achieve suitable elevation for tidal inundation, and ecosystem restoration and monitoring. A graphical overview of the primary Project features is shown on Figure 1. The various elements of the Project are described in the following sections.

1.5.1 YBWL Degrade and Breaches

The YBWL (a.k.a Shag Slough Levee) would be breached at nine locations. Breaches along the YBWL would be between 300 feet and 600 feet wide. The purpose of the levee breaches is to reconnect the Project Site to the Cache Slough Complex, restoring tidal historical tidal exchange and ecosystem functions on the Project Site.

Outside of the proposed breach areas, the YBWL will have two 1500-foot-long sections degraded to provide flood benefits. In large flood events, the degraded segments would provide additional conveyance to allow floodwaters from the Yolo Bypass to flow into the Project Site and providing transitory flood storage. Erosion/scour protection is not provided to the majority degraded portion because the design intent is to allow scour and natural processes to modify these over time. The exception is the section of the remnant Shag Slough Levee embankment north of the northernmost breach since that area will need to be protected to allow access to a proposed agency boat ramp. The agency boat ramp is anticipated to be armored with articulated concrete block, turf reinforcing mat, rock slope protection, or other suitable armoring material. The design on this feature will be developed as the design progresses. Additionally, the northern segment of the northern breach and southern segment of the southern breach will be armored to maintain the integrity of the existing levees to remain north and south of the Project.

1.5.2 Cache Slough/Hass Slough (Cache/Hass Slough Training Levees)

The Hass Slough East and Cache Slough East Levees (a.k.a. Cache/Hass Slough Training Levees) will be graded to one foot above the 0.01 annual exceedance probability (AEP) water surface elevation (WSE) (or one foot above the 1957 WSE, whichever is higher). It is noted that the existing crowns of the Cache Slough East and Hass Slough East Levees are less than two feet above the 1957 WSE in many locations. A 16-foot-wide crest will be established atop the remnant embankment. The project-side slope will be flattened to 4H:1V down to an elevation of eight feet. At the eight-foot elevation, a 12-foot-wide operation and maintenance (O&M) corridor will be constructed. The project-side slope will continue down at 4H:1V to the landside ground surface.

The crown and upper three feet of the waterside and project-side slopes include overtopping protection. Overtopping protection may consist of rock slope protection (RSP), an articulated concrete block, a turf reinforcing mat, or other similar measures. The specific measure to provide armoring will be developed in coordination with the US Army Corps of Engineers (USACE), DWR, and the design team as the design progresses. The extent of the overtopping protection will encompass the entire width of the crown and will extend down both slopes for three vertical feet.

Finally, existing encroachments and one existing "up and over" pipe penetration will be removed where they occur within the Cache/Hass Slough Training Levee. Approximately seven pipe penetrations (one abandoned Pacific Gas and Electric (PG&E) gas line and six irrigation pipes) through the Cache/Hass Slough Training Levee will be abandoned in place by cutting, capping, and grouting them in accordance with Title 23 standards.

An assessment of Project's impacts on the Cache/Hass Slough Levees is included in **Appendix E** (attached).

1.5.3 Vogel Levee Breaches

The Vogel Levee would be breached at two locations to provide hydraulic connectivity with Cache Slough, provide habitat connectivity to Cache Slough, and restore normal tidal exchange to the interior of this property. In large flood events, the remnant levee segments will continue to overtop as they do today.

1.5.4 Duck Slough Setback Levee

A new setback levee known as the Duck Slough Setback Levee (DSSL) would be constructed along Malcolm Lane (which runs parallel to Duck Slough) and Liberty Island Road. The DSSL will become the new west levee of the Yolo Bypass, providing protection to areas north and east of the Project.

1.5.5 Tidal Channels and Ponds

The Project includes a number of tidal channels and ponds that facilitate tidal exchange into the site interior. These elements also serve as borrow sources for the DSSL and PG&E access roads.

1.5.6 PG&E Access Roads

The Project Site is traversed by electrical transmission lines with 13 towers from the northeast corner to the southwest corner of the Project Site. These transmission lines are owned and operated by PG&E and will remain in place. Access roads meeting the design criteria provided by PG&E will be provided to the base of each transmission tower.

1.5.7 Cross Levee

The Cross Levee is the levee that connects the Cache Slough East Levee to the Shag Slough/YBWL Levee along the southern border of the Project. This levee will remain unaltered as part of the Project.

1.6 Existing Land Use

The site is comprised of three properties: Bowlsbey Ranch, Liberty Farms, and Vogel Properties. All three properties sit at elevations that would be submerged during daily high tide events were it not for man-made dikes and levees that preclude inundation. This is consistent with other properties in the Delta, where 90 percent of historic tidal marsh habitats have been converted to other uses through human activity. While these properties historically supported tidal marsh habitat, they currently support agriculture and recreation. The Bowlsbey Ranch Property is used for irrigated pasture. The Liberty Farms Property is managed and operated for duck hunting. The Vogel Property was originally designed for duck hunting but is currently unmanaged.

The Bowlsbey Ranch Property is prime farmland used largely as grazing land for cattle and sheep. It is divided into nine agricultural fields, which are separated by earthen access roads and irrigation canals. Concrete ditches bisect each field. The Bowlsbey Ranch Property was graded and infrastructure was constructed there to provide irrigation for pastureland. Irrigation systems include pumps located along the Cache, Hass, and Duck Sloughs; storage ponds; concrete ditches for distributing irrigation water; and a series of collection ditches and toe drains to collect and pump excess irrigation water into the Cache and Hass Sloughs.

The Liberty Farms Property contains several residential structures and buildings related to operation of the Duck Club. The Liberty Farms Property also contains water management infrastructure that is used to flood and drain the wetland areas for duck hunting. The components of the water management system include a gravity gate at the junction between the Cache and Lookout Sloughs, a series of gravity gates along Lookout Slough, water distribution channels and gates throughout the Liberty Farms Property, toe drains, and pumps to drain water from the site.

In general, water enters the site from Cache Slough into Lookout Slough, moves through the site from west to east to flood selected fields, and is then pumped into Shag Slough. The wetland areas within the Liberty Farms Property are flooded in late summer and drained in early spring. Duck Club operations include growing corn cover crops to provide supplemental food that will attract ducks during hunting season.

The Vogel Property was designed as a location for hunting ducks. A flood gate that connects to Cache Slough can be opened and closed to flood or drain these areas. The property has not been used for duck hunting for at least five years.

1.7 Topography

The existing topography within the Bowlsbey Ranch and Liberty Farms Properties varies from approximately -2.0 feet North American Vertical Datum of 1988 (NAVD 88) in the southeast to an approximate 9.0 feet NAVD 88 along the northern boundary and the northwest corner of the Bowlsbey Ranch Property. The elevations within the Vogel Property vary from approximately 3.0 feet to 6.0 feet NAVD 88. The majority of the Project Site is below the natural high tide elevations (6.5 feet NAVD 88) in the surrounding sloughs and would be subject to daily flooding if it was not protected by the Shag Slough, the Cross Levee, the Cache Slough and Hass Slough Levees.

The Bowlsbey Ranch and Liberty Farms properties are bordered by existing levees along Shag Slough, along Cache and Hass Sloughs, and the Cross Levee. The elevation of the top of these levees varies between approximately 21 feet and 25 feet NAVD 88. The Vogel Property is protected from tidal inundation by an agricultural levee. The elevation of the top of this levee is approximately 9.0 feet NAVD 88.

1.8 Existing Infrastructure

The Project Site is traversed from the northeast corner to the southwest corner by electrical transmission lines with 13 towers. These transmission lines are owned and operated by PG&E and will remain in place and be protected from tidal action corresponding to events with a return period of five years or less.

Electrical distribution lines also owned and operated by PG&E provide local service to the buildings and pumps within the Project Site. These local service lines consist of overhead conductors and wood poles that would be mostly removed along with the infrastructure they serve as part of the Project. The only exceptions to this would be the local distribution lines serving the pump at the confluence of Duck Slough and Cache Slough (which would remain in place), and the distribution line along Liberty Island Road at the northern end of the Project (which would be relocated north of the road to avoid conflicts with the proposed DSSL).

1.9 Surveying and Mapping

1.9.1 Project Datum

The horizontal datum for the Project is referenced to the North American Datum of 1983 (NAD 83) and the California State Plane Zone 2 (feet) coordinate system. The vertical datum for the Project is NAVD 88.

1.9.2 Topographic Information

The aerial topography and ortho-imagery for the Project were prepared by Wood Rodgers, Inc. (Wood Rodgers) and Aerotech Mapping, Inc. (dated September 8, 2017). Some bathymetric data was also collected for use in ecosystem restoration analyses and flood modeling. The horizontal accuracy of the post-processed LiDAR data is 3.5 feet at the

95-percent confidence level. Vertical accuracy is 0.6 foot at the 95-percent confidence level. This accuracy is sufficient for developing one-foot contour mapping.

1.9.3 Parcel Boundary Information

Parcel boundary mapping for the Project was prepared by Wood Rodgers between November and December of 2017. The resolved boundary was established from found survey monuments, record documents and maps, and information within the provided preliminary title reports.

2.0 DESIGN CRITERIA

Flood risk reduction criteria used for the Project are based on published federal and state regulations and technical guidance documents. For levees to be accredited by the Federal Emergency Management Agency (FEMA), evidence must be provided substantiating that adequate design and O&M systems are in place to provide reasonable assurance that protection from the base flood with a 1-percent annual chance of exceedance (i.e.: 100-year flood) exists. These requirements are outlined in the Code of Federal Regulations (44 CFR 65.10). California Code of Regulations (CCR) Title 23 requirements for levees in the Central Valley have general provisions similar in intent to those in 44 CFR 65.10.

In general, the USACE criteria are employed for the design of levees based on the requirements of 44 CFR 65.10. These include design criteria for levee geometry, seepage, slope stability, levee settlement and levee construction materials, as well as requirements for geotechnical site investigations, seepage analyses, slope stability analyses and settlement analyses.

The following design criteria were established for the DSSL and are discussed in the following sections:

- Hydraulics
  - Design Water Surface Elevation (DWSE)
  - Top-of-Levee Height
- General levee cross-section geometry
- Geotechnical criteria for the levee and foundation in regards to:
  - Steady-state underseepage and through-seepage
  - Steady-state slope stability
  - Rapid drawdown slope stability
  - End-of-construction slope stability
  - Previous levee performance
  - Liquefaction and seismic stability
  - Levee settlement
  - Levee embankment materials

Additionally, there are requirements in regards to Project features or facilities on or near the levee embankment that include:

- Pipeline and conduit penetrations
- Penetration by utility poles and supports and other structures
- Levee vegetation and encroachments
- Erosion protection

Additional criteria are required for the design of internal drainage and irrigation water conveyance from the protected side of the levee, including adjacent roadways.

2.1 Hydraulic Criteria

Hydraulic analyses include criteria for developing the DWSE and top-of-levee height. Criteria specific to these elements are described below.

2.1.1 Design Water Surface Elevation

The Design Water Surface Elevation for the proposed DSSL was set at the USACE Authorized Design Flow (i.e.: 1957 Profile) or the with-Project 100-year (i.e.: 1% AEP) water surface profile, whichever was determined to be higher. Additional information on the DWSE and hydraulic criteria used for the Project are described in the *Hydrologic and Hydraulic System Analysis* included in **Appendix A**.

2.1.2 Adjustment Factors/Top-of-Levee Height

Adjustments are typically made to the DWSE to account for uncertainty, climate change, sea-level rise, and to accommodate the potential for wind setup and wave runup. These adjustments provide an additional factor of safety in the design and allow for additional system resiliency. These adjustments are collectively referred to as freeboard.

In determining a recommended top-of-levee height, other similar bypass projects were reviewed. One such project is the Lower Elkhorn Basin Levee Setback (LEBLS), a project currently in design and led by DWR. This project is located along the east levee of the Yolo Bypass north of West Sacramento. The LEBLS DWSE incorporated six feet of freeboard and one additional foot to account for uncertainty in hydraulic analyses and to provide resilience to climate change. This adjustment was reviewed by the Project team and was deemed appropriate for this Project.

Additionally, the O&M Manual for the Yolo Bypass West Levee indicates that the existing levee was originally designed and constructed to have a crown elevation that is six feet above the 1957 Profile. Therefore, after taking freeboard and uncertainty adjustments into consideration, the Project was designed to have a total of seven feet of freeboard above the 1957 Profile. This is consistent with the freeboard being incorporated at the LEBLS and other regional projects at the YBWL.

Finally, an adjustment for anticipated settlement has also been incorporated into the post-construction top-of-levee elevation. As outlined in the *Draft 65% Geotechnical Basis of Design Report* (Blackburn Consulting), included as **Appendix B**, long-term settlement is expected to be approximately one foot or less. Therefore, the current design crown elevation is set eight feet above the 1957 Profile so that at least seven feet of freeboard above the 1957 Profile will be maintained after long-term settlement.

2.2 General Levee Cross-Sectional Geometry

The minimum levee cross section is based on a review of the following documents (see the Reference list of Section 7.0 for additional details):

- USACE, Design & Construction of Levees, EM 1110-2-1913
- USACE, Design Guidance for Levee Under-Seepage, Engineering Technical Letter (ETL) 1110-2-569
- USACE, Sacramento District Geotechnical Levee Practice (GLP)
- Central Valley Flood Protection Board (CVFPB) Regulations, CCR Title 23

The following geometric standards have been identified for the design of the DSSL:

- Levee crown width: 20 feet
- Waterside slope: 4H:1V
- Landside slope: 4H:1V

It is noted that the design slopes are flatter that the standards to which the YBWL was originally designed. The proposed flatter criteria is in accordance with the special construction details noted in the CVFPB design standards, Title 23, Section 120 Levees, (a) (12).

2.3 Geotechnical Criteria

Geotechnical criteria for designing new levee embankments are identified in Appendix B.

2.4 Penetrations and Encroachments

Penetrations and encroachments are points of potential weaknesses in levees and are generally not allowed under CVFPB and USACE regulations.

The levee prism is defined as the area of the levee embankment that is equal to the DWSE plus design freeboard (a top width of 20 feet), and side slopes projected downward at a slope of 4H:1V at the levee landside slope and 4:1 at the levee waterside slope. Where utility penetrations or other encroachments into the levee prism cannot be avoided on the Project, they will be incorporated into the Project as outlined below.

2.4.1 Pipes and Conduits

There are eight pipe penetrations within the Cache/Hass Slough Training Levee and four within the DSSL. The four existing pipes under the DSSL will be removed. One existing "up and over" irrigation pipe penetration across the Cache/Hass Slough Training Levee will be completely removed.

Approximately seven pipe penetrations (one abandoned PG&E gas line and six irrigation pipes) through the Cache/Hass Slough Training Levee will be abandoned in place by cutting, capping, and grouting them in accordance with Title 23 standards.

2.4.2 Utility Poles and Supports

Utility pole foundations within the levee prism and within twenty (20) feet of the landside toe-of-levee and within fifteen (15) feet of the waterside levee toe will be relocated (or will be removed if they are no longer needed). Overhead utilities must meet the minimum clearance requirements outlined in Title 23, including a clearance of twenty-five (25) feet for lines carrying 750 volts or more, unless the utility owner has more stringent requirements. PG&E requires a minimum of 40 feet of clearance below the existing 500-kilovolt (kv) transmission lines. Therefore, the DSSL alignment was located to achieve at least 40 feet of clearance from the existing 500 kv transmission lines. The proposed levee geometry and proposed surface features were provided to PG&E for review, and PG&E confirmed that the proposed Project maintains adequate clearance from their transmission lines on May 3, 2019.

2.4.3 Transportation Encroachments

Access to a private residence north of the Project will be maintained along a proposed access road at the landside toe of the DSSL east of the intersection of Liberty Island Road and Malcolm Lane. Other than this access, the levee will not be open to public vehicular traffic and the Liberty Island Road right-of-way adjacent to the Project is proposed to be vacated as part of the Project. Access ramps up the levee landside embankment and down the waterside embankment will be provided to facilitate patrolling by RD 2098 and for PG&E's access to transmission towers. Additionally, an agency boat ramp will be provided at the northern-most breach in the Shag Slough Levee for DWR's long-term monitoring access.

2.4.4 Levee Vegetation

The USACE requires a "vegetation-free zone" as detailed in ETL 1110-2-583. The vegetation-free zone encompasses the levee crown, the side slopes, and a 20-foot setback from the landside and waterside toes. For the Project, grasses free of invasive species will be planted on the new levee. Woody vegetation used to create riparian habitat will be placed at least 20 feet from the proposed levee toes.

2.5 Erosion Protection

The need for erosion protection was assessed for the proposed DSSL, the Cache/Hass Slough Training Levee, and the YBWL just upstream of the Project. With-Project velocities and shear stresses were evaluated in Appendix A. The criteria in **Table 1** (on the following page) was used as the basis for selection of erosion protection measures.

Table 1 – Erosion Protection Criteria		
Boundary Type	**Maximum Permissible Velocity (fps)**	**Maximum Permissible Shear Stress (psf)**
Vegetated Slopes	3	0.7
6-inch Riprap	5	2.5
9-inch Riprap	7	3.8
12-inch Riprap	10	5.1

Erosion protection was not assessed for the segment of the Shag Slough Levee that is being degraded and breached because this remnant segment will not serve a flood protection purpose in the future and, therefore, does not need to be protected against erosion. Similarly, erosion protection was not provided for the on-site channels because the design intent is to allow scour and natural processes to modify these channels over time.

3.0 PROJECT DESIGN

3.1 Hydraulic Design

3.1.1 Water Surface Elevations

The DWSE is based upon the 1957 water surface profile. Refer to Appendix A for more information on the DWSE for the Project.

3.1.2 Duck Slough Setback Levee Crown Elevation

The DSSL was designed to have a crown elevation located seven feet above the 1957 Profile after long-term settlement occurs. A 6-inch-thick, 16-foot-wide aggregate base road with 3H:1V shoulders is proposed on top of the 20-foot-wide levee crown.

3.1.3 Yolo Bypass West Levee/Shag Slough Levee Degrade Elevation

The Shag Slough Levee will be breached in nine locations to provide hydraulic connectivity from Shag Slough to the Project Site, and two 1,500-foot-long portions of the Shag Slough Levee within the Project will be degraded to provide flood benefits. As described in Appendix A, these actions reduce the with-Project 100-year flood event water stages between six and twelve inches in the Yolo Bypass upstream of the Project.

3.1.4 Cache/Hass Slough Training Levee

The Hass Slough and Cache Slough East Levees (a.k.a the Cache/Hass Slough Training Levee) will be degraded to 1 foot above the 0.01 AEP WSE (or 1 foot above the 1957 WSE, whichever is higher). A 16-foot-wide crest will be established atop the remnant embankment. The Project-side slope will be flattened to 4H:1V down to an elevation of eight feet. At elevation 8, a 12-foot-wide O&M corridor will be constructed. Finally, the Project-side slope will continue down at 4H:1V to the landside ground surface.

3.1.5 Erosion and Scour

With-Project velocities and shear stresses at key locations were extracted from the data presented in Appendix A and are presented graphically on **Figures 2** and **3** (attached) and below in Table 2.

Table 2 – Erosion Protection Measures

Location	With-Project Velocity	With-Project Shear Stress	Erosion Protection Measures Selected
Waterside Slope of Shag Slough Levee Upstream of the Project	3.3 fps (Increase of 0.6 fps)	0.2 psf (Increase of 0.1 psf)	Existing mix of vegetation and riprap will remain. *
Shag Slough Channel Upstream of the Project (Approximately 60’ from the waterside slope)	4.6 fps (Increase of 2.1 fps)	1.5 psf (Increase of 0.1 psf)	Existing riprap at the waterside slope below elevation 8’± will remain.
Waterside Slope of the DSSL	1.8 fps	0.3 psf	Native grasses

Table 2 – Erosion Protection Measures			
Location	**With-Project Velocity**	**With-Project Shear Stress**	**Erosion Protection Measures Selected**
Cache/Hass Slough Training Levee	N/A (armoring is protected to guard against wave action)	N/A (armoring is protected to guard against wave action)	RSP, turf reinforcing mat, articulated concrete block, or other similar measure.

**Proposed project increases are considered negligible above existing condition.*

3.1.6 Wind Setup and Wave Runup Analysis

Historically, waves generated by wind can grow to four feet or more during large storm events due to the combination of long fetch lengths in the Yolo Bypass and strong sustained winds (DWR, 2016).

Wood Rodgers conducted a wind setup and wave runup analysis using wind data collected at the Sacramento Executive Airport in Sacramento County. Refer to the *Lookout Slough Setback Levee Wave Runup and Wind Setup Analysis* in **Appendix C** for more information on the wind setup and wave runup evaluation.

3.2 Geotechnical Design

3.2.1 Underseepage

Blackburn Consulting (BCI) completed evaluations for steady-state underseepage, steady-state slope stability, rapid drawdown slope stability and end-of-construction slope stability at four cross-sections along the DSSL alignment. BCI's evaluations considered the DSSL with and without the recommended cutoff wall discussed below. The proposed levee fill consisting of lean-to fat clay will mitigate through-seepage.

Between Station 3+50 and Station 32+00 and from Station 53+00 to Station 152+00, the steady-state underseepage and steady-state slope stability, rapid drawdown slope stability and end-of-construction slope stability all met geotechnical criteria. BCI encountered intermittent, discontinuous layers of material (predominantly sandy clay) in some of the exploratory borings that have a higher permeability than the overlying and underlying soil (generally fat to lean clay). BCI also encountered relatively shallow groundwater within some of these explorations near the higher permeable layers. To reduce the potential for nuisance seepage to adjacent properties, BCI recommends a relatively impervious, relatively shallow cutoff wall along the center of the planned levee alignment from Station 3+50 to Station 32+00 and from Station 53+00 to Station 152+00, extending from the ground surface to Elevation -15 feet mean sea level (MSL). The cutoff wall will intersect the intermittent, discontinuous higher permeable soil layers in the upper 20 feet.

Between Station 32+00 and Station 53+00, BCI recommends a relatively impervious, relatively shallow cutoff wall extending from the ground surface to Elevation -40 feet, through the permeable sand and gravel layers, and into the underlying clay. The cutoff wall will mitigate uncontrolled underseepage through the near-surface permeable layers from the waterside to the landside of the planned DSSL.

The cutoff wall along the levee alignment will also cut off flow through unidentified old ditches and channel deposits that might pass below the planned levee alignment and mitigate associated constructability issues (such as backfilling over wet, unstable soil conditions).

Between Station 3+50 and Station 152+00, the cutoff wall will also eliminate the need for an inspection trench. An inspection trench will be necessary from Station 2+00 to Station 3+50 where there is no cutoff wall.

Table 3 (below) provides details of each mitigation measure by section. The specific methodology and results of underseepage analyses are included in Appendix B.

Table 3 – Geotechnical Mitigation Measures

Reach	Start Station	End Station	Length (feet)	Geotechnical Mitigation Measure
1	3+50	32+00	2,850	Cutoff Wall to Elevation -15 MSL (i.e.: Approx. 25' Deep)
2	32+00	53+00	2,100	Cutoff Wall to Elevation -40 MSL (i.e.: Approx. 50' Deep)
3	53+00	152+00	9,900	Cutoff Wall to Elevation -15 MSL (i.e.: Approx. 25' Deep)

NOTE: Transition between cutoff wall depths will be done at a 2H:1V slope.

3.2.2 Through-Seepage

For through-seepage, the emergence of the phreatic line on the landside levee slope and the composition of the levee materials to be used in construction were evaluated. Levees shown to have a phreatic line emerging on the landside levee slope at the DWSE should be evaluated for piping potential and for the potential of through-seepage-induced sloughing of the landside slope.

Because the proposed levee will be constructed primarily from fine-grained soil that is resistant to erosion, and because the levee slopes will be constructed no steeper than 4H:1V (landside) and 4H:1V (waterside), through-seepage was determined to be a non-issue. The specific methodology and results of through-seepage analyses are included in Appendix B.

3.2.3 Slope Stability

The proposed waterside slope of 4H:1V and the proposed landside slope of 4H:1V have both been shown to be stable for steady-state slope stability, rapid drawdown slope stability and end-of-construction slope stability, according to the recommendations in Appendix B. (Refer to Appendix B for additional details on the slope stability analysis and recommendations.)

3.2.4 Seepage Cutoff Walls

Soil-Bentonite (SB) cutoff walls are recommended for the DSSL, as shown above in Table 3. Cutoff walls would mitigate potential nuisance seepage and underseepage by providing a seepage barrier within the levee foundation. The proposed cutoff walls range in depth from approximately 25 to 50 feet below the existing ground surface.

The cutoff wall depth will allow the use of a conventional excavation method, although other methods could be used. Conventional cutoff walls are constructed using an excavator with a long stick excavator boom capable of digging a trench to the specified depth. The trench width is typically 36 inches (3 feet).

To construct a cutoff wall, the existing ground is cleared, grubbed, and stripped of vegetation. After stripping, the existing ground beneath the DSSL footprint will be over-excavated to a depth of one foot. The foundation of the DSSL will be scarified to a depth of eight inches and then recompacted. Once this work is complete, the proposed cutoff wall will be constructed, centered along the DSSL alignment. During the cutoff wall trench excavation, a bentonite slurry will be used to fill the trench as it is excavated to prevent caving the trench sidewalls while the backfill material is mixed. The excavated soil is then mixed with the bentonite slurry to achieve the required cutoff wall permeability, and then it is placed back into the trench. After the initial set of the soil-bentonite backfill and a three-week settlement monitoring period (or shorter, based on BCI's recommendations after reviewing post-construction settlement data), the levee embankment is constructed with levee embankment material that meets the requirements specified in Appendix B.

3.2.5 Tie-In to Existing Levees

For the levee tie-ins at Hass Slough East Levee and YBWL, the outer three feet (measured vertical to the ground surface) of material will be removed from the existing levee crowns. The material removed will be replaced by material free of debris and heavy concentrations of vegetation or from on-site borrows. The reconstructed and new fill will be keyed/benched into the existing embankment a minimum of one foot vertically for every one foot (measured horizontally) of fill placed. Additional details on tie-ins can be found in Appendix B. The current 65% design reflects the soil-bentonite shallow cutoff wall to extend from Station 3+50 to Station 152+00 of the DSSL alignment and will not, therefore, tie into the existing levees.

3.3 Civil Design

The following sections discuss various civil and construction-related considerations in preparing the 65% Design Plans and Specifications.

3.3.1 Patrol Access

A 16-foot-wide patrol road with 2-foot-wide shoulders will be located along the entire DSSL crown. The patrol road will consist of 6-inch-thick aggregate surfacing. Aggregate base from the Shag Slough Levee will be stripped and salvaged for re-use on the DSSL patrol road.

3.3.2 Pipe Crossings

There are no proposed pipe crossings across the proposed DSSL. The four existing irrigation and gas pipelines will be removed where they occur within 100-feet of the DSSL footprint.

3.3.3 Adjacent Canals

Existing irrigation canals within the Project Site that are used by Liberty Island, Bowlsbey Ranch, and Vogel Properties will be filled in. Where these canals are located within 50 feet of the DSSL, they will be mucked out, filled in with material meeting levee embankment specifications, and appropriately compacted.

3.3.4 Electrical Transmission Towers, Power Poles and Overhead Utilities

As previously discussed, PG&E requires a minimum of 40 feet of clearance below the existing 500-kv transmission lines. This requirement is more stringent than the 25-foot clearance outlined in Title 23 for lines carrying 750 volts or more. Therefore, the DSSL alignment was located to achieve a clearance of at least 40 feet with the existing 500-kv transmission lines.

Electrical distribution poles along Liberty Island Road will be relocated because they are currently situated within 15 feet of the landside levee toe. These poles will be moved to a location at least 20 feet from the proposed landside levee toe.

The design of power pole and overhead crossing relocations will be completed by PG&E. The Project construction contractor will be required to coordinate work with PG&E as needed during construction.

3.3.5 Roadway Crossings and Access Ramps

Two existing roadways will be impacted by the new levee alignment: Liberty Island Road (public, paved) and Malcolm Lane (private, gravel). The Liberty Island Road right-of-way will be vacated where it adjoins or crosses the Project and will be replaced with a private gravel access serving an existing residence north of the Project. Beyond the residence, the gravel road will serve as a patrol road. Malcolm Lane will be removed as part of the Project and will not be replaced. Access to the south along the Project will be via proposed access ramps that will only be accessible by DWR, CDFW, RD 2098, and PG&E.

3.3.6 Demolition of Existing Structures

Various structures that lie within the Project Site require demolition. Barns, irrigation canals, fences, and other appurtenant structures that are located within the Project Site will be removed.

3.3.7 Tree and Vegetation Removal

All trees and vegetation located within the DSSL footprint and within forty (40) feet of the landside and waterside levee toes will be marked for removal as part of the clearing and grubbing operations.

3.3.8 Construction Limits and Staging Areas

Construction staging will be contained entirely within the land owned by EIP at the Project Site. The construction limits are shown on the 65% plans.

The SB cutoff wall construction will require a batch plant and materials staging area ranging from two to three acres in size. The area will generate and supply trench stabilization fluid to the work areas. Water storage tanks, bulk bag supplies of bentonite, a cyclone mixer, pumps, and generators will be located adjacent to the slurry generation ponds. The exact locations of the temporary staging areas will be dependent on the contractor's means and methods.

3.3.9 Construction Water Source

Construction water will be obtained from existing on-site irrigation ditches and pumps. Typical water requirements for cutoff wall construction include:

- A pH of 7.0, plus or minus 1.0
- Total dissolved solids of 500 parts per million (ppm), or less
- Hardness less than 50 ppm (recommendation only)
- Oil, organics, acids, alkali, or other deleterious substances less than 50 ppm

The proposed water supply facilities should be tested to ensure that supplied water can meet these requirements.

3.3.10 Site Access

Access to the Project construction site will be provided by state and county roadways including County Road (CR) 104, Bulkley Road, Midway Road, King Road, and Liberty Island Road. Stabilized construction entrances will be constructed at the roadway entrances as part of the Project's stormwater pollution prevention plans and/or best management practices.

3.3.11 Borrow Sources

Approximately 1,573,000 cubic yards of fill will be necessary for the DSSL construction. This material is expected to come from on-site ecosystem restoration channels and other excavations located waterward of the new levee (~861,000 CY) and from tidal channel excavations where they are in close proximity to the new levee (~712,000 CY).

Embankment materials for the new DSSL are required to meet specific geotechnical criteria. Geotechnical investigations were completed and identified on-site borrow areas with soil that would be suitable for the construction of the DSSL. These borrow areas have been designed and configured in such a way that they yield the necessary materials for the new levee and with the final configuration being consistent with the ecological goals of the Project.

Refer to the *Draft 65% Borrow Report* included in **Appendix D** for more information on the borrow materials.

3.3.12 Quantity Calculations

Quantity estimates were determined based on the Project design presented in the 65% plans. Earthwork quantities were calculated using AutoCAD Civil 3D modeling of the proposed levee geometry within the terrain model. Quantities of other Project features such as tidal channels, PG&E access roads, and spoil piles, were also developed to compare surfaces for these elements to the existing surface in AutoCAD Civil 3D. The 65% quantity estimates are presented in **Appendix F**.

3.4 Schedule

Hazardous material abatement is expected to begin in 2019, with construction of the primary Project features starting the spring after permit approval. The DSSL and on-site features will be constructed first. Earthwork operations, including tie-in of the DSSL to the Shag Slough Levee and Cache Slough Levee, will take place during the typical non-rain season (April through November), and outside of the CVFPB-designated flood season (November 1 to April 15). Other construction activities, such as levee crown surfacing, site cleanup and demobilization may take place during the flood season as necessary and subject to approval by the CVFPB.

Once those improvements are complete, the Shag Slough Levee degrade and breaches will be constructed. This work is expected to be completed by the end of 2022. Finally, revegetation and plantings are expected to be completed by the end of 2023.

4.0 OPERATIONS AND MAINTENANCE

4.1 Duck Slough Setback Levee

Operations and maintenance of the DSSL will be in accordance with the *Supplement to Standard Operation and Maintenance Manual Sacramento River Flood Control Project Unit No. 109 West Levee of the Yolo Bypass East Levee of Cache Slough* (Supplement Manual). The Supplement Manual will be updated to reflect the improvements and modifications made within Unit No. 109 and will be submitted to the USACE for review and approval once construction is complete.

4.2 Remnant Shag Slough Levee Embankment

The majority of the remnant Shag Slough Levee embankment within the Project limits will not be maintained as it will no longer serve its authorized purpose. The exception is the section of the remnant Shag Slough Levee embankment north of the northernmost breach since that area will need to be protected to allow access to the agency boat ramp and the southernmost portion of the southern breach. The specific measures that will be used to armor this section will be developed as the design progresses.

4.3 Cache/Hass Slough Training Levee

The proposed Project will result in water being on both sides of the existing Cache Slough and Hass Slough Levees. However, stakeholders in the region will continue to rely on the Cache/Hass Slough Training Levee within the Project limits to limit water surface increases in Cache and Hass Sloughs.

Therefore, the Cache/Hass Slough Training Levee within the Project limits will be operated and maintained by DWR in accordance with the *Supplement to Standard Operation and Maintenance Manual Sacramento River Flood Control Project Unit No. 109 West Levee of the Yolo Bypass East Levee of Cache Slough* (Supplement Manual). The Supplement Manual will be updated to reflect the improvements and modifications made within Unit No. 109 and will be submitted to the USACE for review and approval once construction is complete.

5.0 REGULATORY COMPLIANCE

5.1 Environmental Impact Report

An Environmental Impact Report (EIR) is required to provide California Environmental Quality Act (CEQA) compliance for the Project. This work is being performed by WRA, Inc. (WRA). On March 21, 2019, the lead agency (DWR) filed a Notice of Preparation (NOP) and Initial Study for the EIR document. The Project's EIR (State Clearinghouse No. is 2019039136) is scheduled to be circulated in the winter of 2019/2020.

5.2 Agency Approvals and Permits

Several permits and authorizations are required for the Project. These include:

- USACE
  - Section 404 of the Clean Water Act and Section 10 of the Rivers and Harbors Act
  - Section 408 of the Clean Water Act
- United States Fish and Wildlife Service and National Marine Fisheries Service
  - Federal Endangered Species Act
- California Department of Fish and Wildlife
  - California Endangered Species Act
  - California Fish and Game Code Section 1602
- California State Office of Historic Preservation
  - Section 106 of the National Historic Preservation Act
- Central Valley Flood Protection Board
  - Encroachment permit
- Central Valley Regional Water Quality Control Board (Region 5)
  - Section 401 of the Clean Water Act, water quality certification
  - Section 402 of the Clean Water Act, National Pollutant Discharge Elimination System (NPDES)
- California Department of Water Resources
  - State Plan of Flood Control acceptance

6.0 REFERENCES

6.1 Design Criteria Documents

6.1.1 US Army Corps of Engineers (USACE)

Engineer Technical Letters (ETL)

USACE, Design Guidelines for Levee Under-seepage, ETL 1110-2-569, May 1, 2005

USACE, Guidelines for Landscape Planting and Vegetation Management at Levees, Floodwalls, Embankment Dams, and Appurtenant Structures, ETL 1110-2-571, April 10, 2009

Engineer Regulations (ER)

USACE, Quality Management, ER 1110-1-12, September 30, 2006.

USACE, Planning Guidance Notebook, ER 1105-2-100, June 30, 2004.

USACE, Flood Control Operations & Maintenance Policies, ER 1130-2-530, October 30, 1996.

USACE, Engineering and Design for Civil Works Projects, ER 1110-2-1150, August 31, 1999.

Engineer Manuals (EM)

USACE, Geotechnical Investigations, EM 1110-1-1804, January 1, 2001.

USACE, Seepage Analysis and Control for Dams, EM 1110-2-1901, April 30, 1993.

USACE, Slope Stability, EM 1110-2-1902, October 31, 2003.

USACE, Instrumentation of Embankment Dams and Levees, EM 1110-2-1908, June 30, 1995.

USACE, Design & Construction of Levees, EM 1110-2-1913, April 30, 2000.

USACE, Design, Construction, and Maintenance of Relief Wells, EM 1110-2-1914, May 29, 1992.

USACE, Conduits, Culverts, and Pipes, EM 1110-2-2909, March 31, 1998.

Other

USACE, Sacramento District, Geotechnical Levee Practice, April 11, 2008

6.1.2 Other Federal Agencies

Federal Emergency Management Agency, Requirements of 44 CFR Section 65.10: Mapping of Areas Protected by Levee Systems, March 2007

Federal Emergency Management Agency, Title 44 Emergency Management and Assistance. Chapter 1, Federal Emergency Management Agency Part 65 – Identification and Mapping of Special Hazard Areas, October 1, 2002.

Federal Emergency Management Agency, Guidance on Levee Certification for the National Flood Insurance Program, March 25, 1997.

6.1.3 State/County Agencies

California Code of Regulation, Title 23 Waters, Division 1 Central Valley Flood Protection Board, Chapter 1 Organization, Powers, and Standards

6.2 Other Reference Documents

Environmental Science Associates, Inc., *Hydrologic and Hydraulic System Analysis,* November 2019

Blackburn Consulting, Inc., *Draft 65% Design Geotechnical Basis of Design Report*, September 2019.

Blackburn Consulting, Inc., *Draft 65% Design Geotechnical Data Report*, September 2019.

Blackburn Consulting, Inc. *Draft 65% Design Geotechnical Borrow Report*, September 2019.

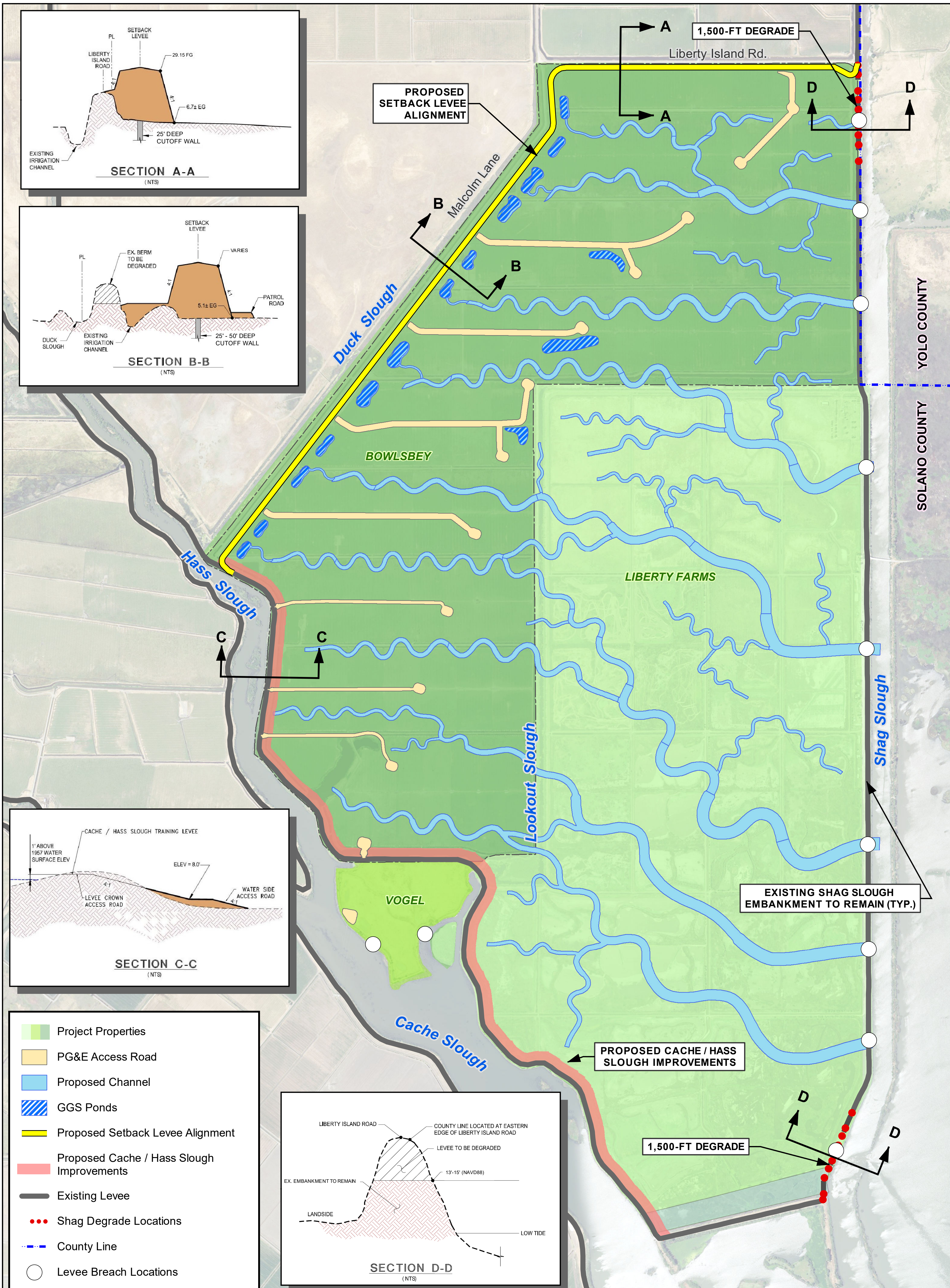
Wood Rodgers, Inc., *Lookout Slough Setback Levee Wave Runup and Wind Setup Analysis*, December 2019

WRA, Inc., *Draft Environmental Impact Report – Lookout Slough Restoration Project,* November 2019

WRA, Inc., *Restoration Plan, Lookout Slough Restoration Project,* November 2019

Wood Rodgers, Inc., *Cache/Hass Slough Levee Impact Analysis*, December 2019

FIGURES



Overall Project Exhibit

N
W E
S

0 0.25 0.5 1
Miles

Lookout Slough Tidal Habitat
Restoration and Flood Improvement Project

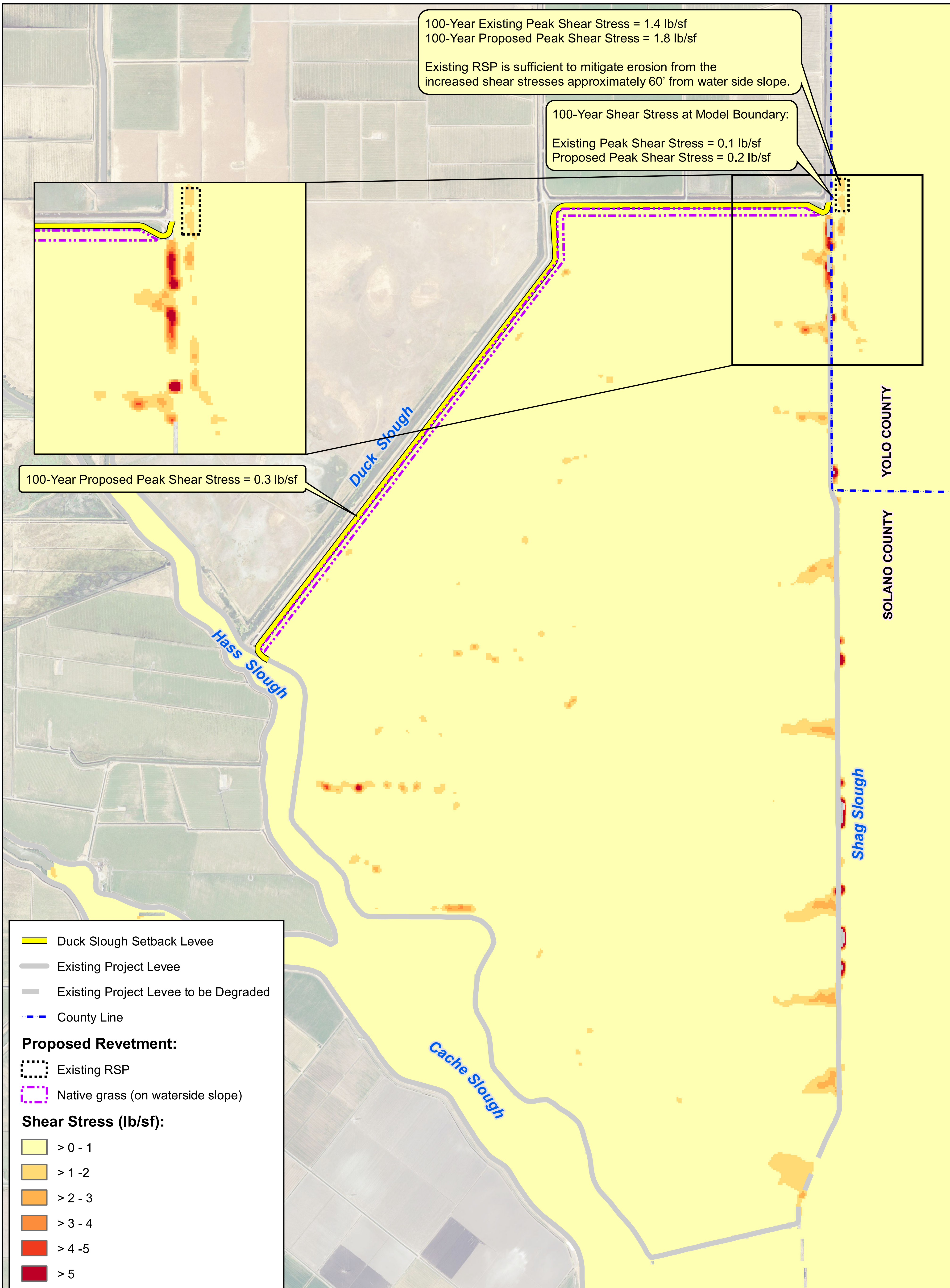
Ecosystem Investment Partners

Map Prepared Date: 11/14/2019
Map Prepared By: clopez
Base Source: Wood Rogers
Base Date: 10/24/17
Data Source(s):

Prepared by:
WOOD RODGERS

Path: J:\3000-s\3487_Ecosystem_Invest_Partners\3487003 Lookout Slough Preliminary Design\GIS\Tasks\draft_\Overall_Project_Exhibit_20191103.mxd

FIGURE 1



Project Shear Stress Exhibit

N
W E
S

0 0.25 0.5 1
Miles

Lookout Slough Tidal Habitat
Restoration and Flood Improvement Project

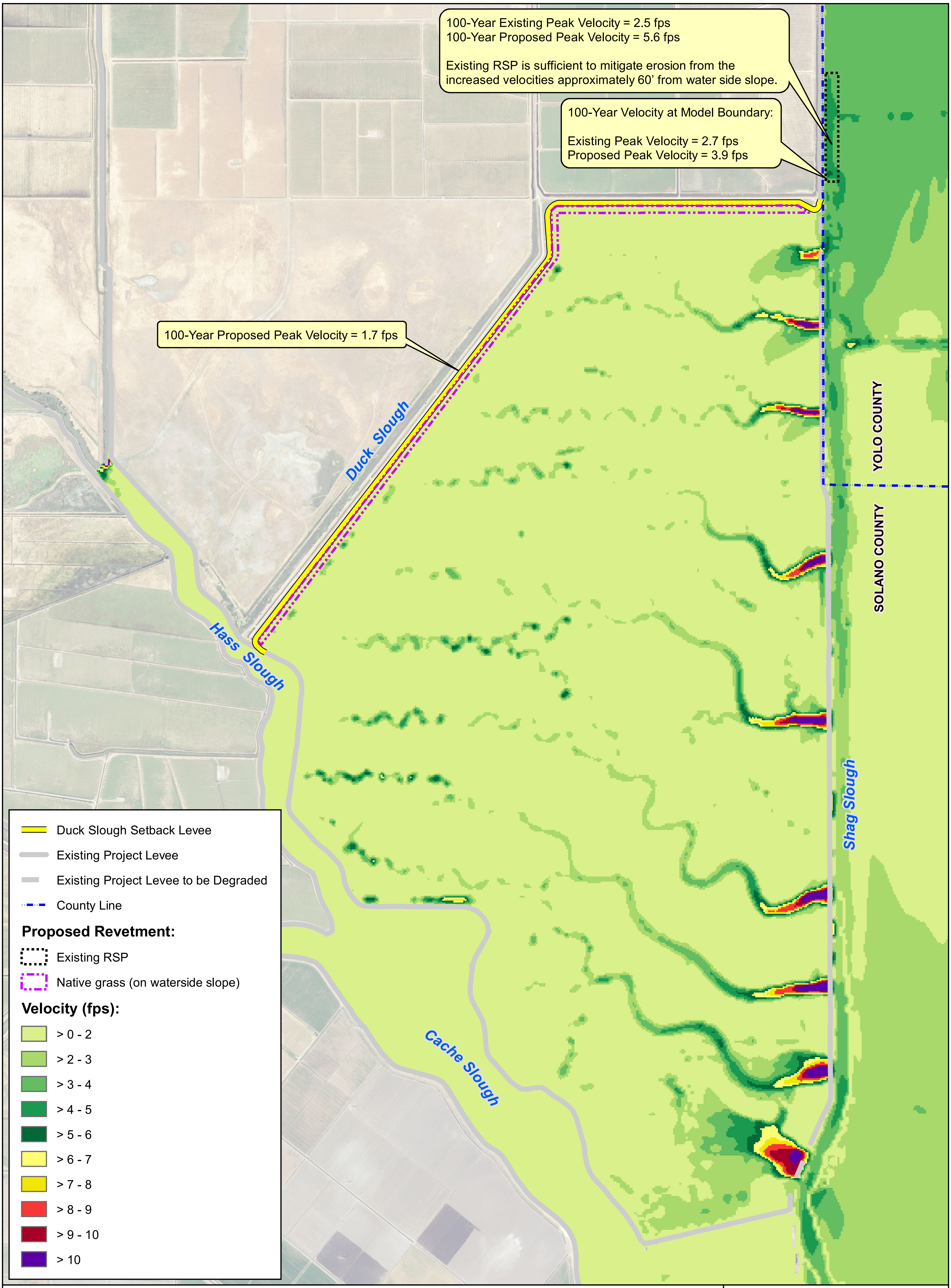
Ecosystem Investment Partners

Map Prepared Date: 11/6/2019
Map Prepared By: cmilligan
Base Source: Wood Rogers
Base Date: 10/24/17
Data Source(s):

Prepared by:
WOOD RODGERS

Path: J:\3000-s\3487_Ecosystem_Invest_Partners\3487002 Lookout Slough Prelim Hydraulic Analysis\GIS\Tasks\20191105_BODR_Figures\Shear_Stress_Erosion_Protection_Exhibit_20191105_V1.mxd

FIGURE 2



Project Velocity Exhibit

Lookout Slough Tidal Habitat Restoration and Flood Improvement Project

N W E S

0 0.25 0.5 1 Miles

Ecosystem Investment Partners

Map Prepared Date: 11/6/2019
Map Prepared By: cmilligan
Base Source: Wood Rogers
Base Date: 10/24/17
Data Source(s):

Prepared by: WOOD RODGERS

Path: J:\3000-s\3487_Ecosystem_Invest_Partners\3487002 Lookout Slough Prelim Hydraulic Analysis\GIS\Tasks\20191105_BODR_Figures\Velocity_Erosion_Protection_Exhibit_20191105_V1.mxd

FIGURE 3

This Page Intentionally Left Blank

APPENDICES

Appendix A – Draft Hydrologic and Hydraulic System Analysis – Lookout Slough Tidal Habitat Restoration and Flood Improvement Project (Environmental Science Associates – May 2019)

Appendix B.1 – Draft 60% Geotechnical Data Report (Blackburn Consulting – May 2019)

Appendix B.2 – Draft 60% Geotechnical Basis of Design Report (Blackburn Consulting – May 2019)

Appendix C – Lookout Slough setback Levee Wave Runup and Wind Setup Analysis TM (Wood Rodgers, March 11, 2019)

Appendix D – Draft 60% Geotechnical Borrow Report (Blackburn Consulting – May 2019)

Appendix E – 60% Progress Design Earthwork Estimates

This Page Intentionally Left Blank

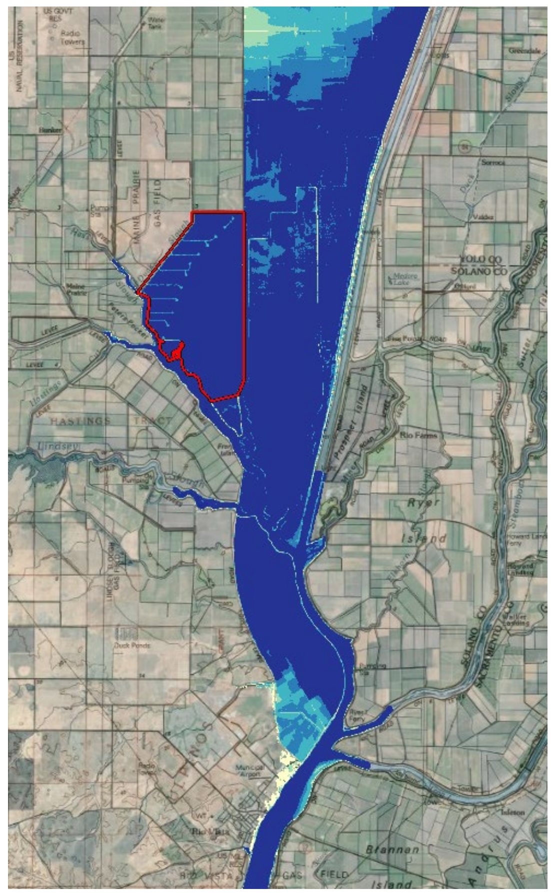
Appendix A

Draft Hydrologic and Hydraulic System Analysis

This Page Intentionally Left Blank

DRAFT HYDROLOGIC AND HYDRAULIC SYSTEM ANALYSIS

LOOKOUT SLOUGH TIDAL HABITAT RESTORATION AND FLOOD IMPROVEMENT PROJECT



Prepared for:

Reclamation District 2098
7178 Yolano Rd.
Dixon, CA 95620

On behalf of:

Ecosystem Investment Partners
5550 Newbury St.
Baltimore, MD 21209

Contact: David Urban
david@ecosystempartners.com

Prepared by:

Environmental Science Associates
2600 Capitol Ave., Suite 200
Sacramento, CA 95816

Contact: John Pritchard

Date: December 2019

Ecosystem Investment Partners

ESA

DRAFT HYDROLOGIC AND HYDRAULIC SYSTEM ANALYSIS

Lookout Slough Tidal Habitat Restoration and Flood Improvement Project

Prepared for:

Reclamation District 2098
7178 Yolano Rd.
Dixon, CA 95620

On behalf of:

Ecosystem Investment Partners
5550 Newbury St.
Baltimore, MD 21209
Contact: David Urban
david@ecosystempartners.com

Prepared by:

Environmental Science Associates
2600 Capitol Ave., Suite 200
Sacramento, CA 95816

Contact: John Pritchard

December 2019

TABLE OF CONTENTS

Lookout Slough Tidal Habitat Restoration and Flood Improvement Project Draft Hydrologic and Hydraulic System Analysis

Page

Page

Appendices

A. Downstream Boundary Conditions Hydrology
B. Bridge Form Loss Calculation Summary

List of Figures

Page

List of Tables

This page intentionally left blank

LOOKOUT SLOUGH TIDAL HABITAT RESTORATION AND FLOOD IMPROVEMENT PROJECT

Draft Hydrologic and Hydraulic System Analysis

Executive Summary

The Lookout Slough Tidal Habitat Restoration and Flood Improvement Project (Project), if approved, will create approximately 3,000 acres of natural freshwater tidal marsh in the Cache Slough Complex in the northern Sacramento-San Joaquin Delta (**Figure ES-1**) and increase the regional flood conveyance capacity of the Yolo Bypass. The Project is being funded by the California Department of Water Resources (DWR) to meet multiple objectives:

- To meet goals outlined in the State of California's Bay Delta Conservation Plan (BDCP) as well as the U.S. Fish and Wildlife Service's (FWS) Biological Opinion (BiOp) issued as part of the Long-Term Operational Criteria and Plan (OCAP) for coordination of the Central Valley Project and State Water Project. The Project is within the priority habitat restoration areas delineated in the 2008 FWS BiOp Delta Smelt Crediting Decision Model, and will create creditable acres for Delta Smelt that will satisfy DWR's obligations under the Delta Smelt BiOp and salmonids under the Salmonid BiOp.

- To meet regional flood management objectives to increase the conveyance capacity of the Yolo Bypass in a manner that is consistent with the 2017 DWR Sacramento Basin-Wide Feasibility Study (BWFS). By setting back the existing State-Federal levee along the west side of the Yolo Bypass, the Project will provide flood storage and reduce upstream flood stages in the Yolo Bypass.

This report documents the methods, data, and assumptions used to establish the design water surface elevation and identify potential impacts associated with the Project. The Project has been determined to create no adverse increases to stage or channel velocity, while providing localized reductions in stage within the Yolo Bypass.

The existing system and future hydraulic performance of the project and its alterations have been described in this report. The analysis establishes that the 1957 authorized design water surface profile shall be used as the basis for design for the Project's setback levee. The design top of levee shall include six feet of freeboard, plus one additional foot of freeboard for climate resiliency. Analysis of the Future Cumulative Condition also indicates that the Project will achieve superior hydraulic performance relative to the preferred concept plan (Yolo Bypass Option 3) identified in the BWFS.

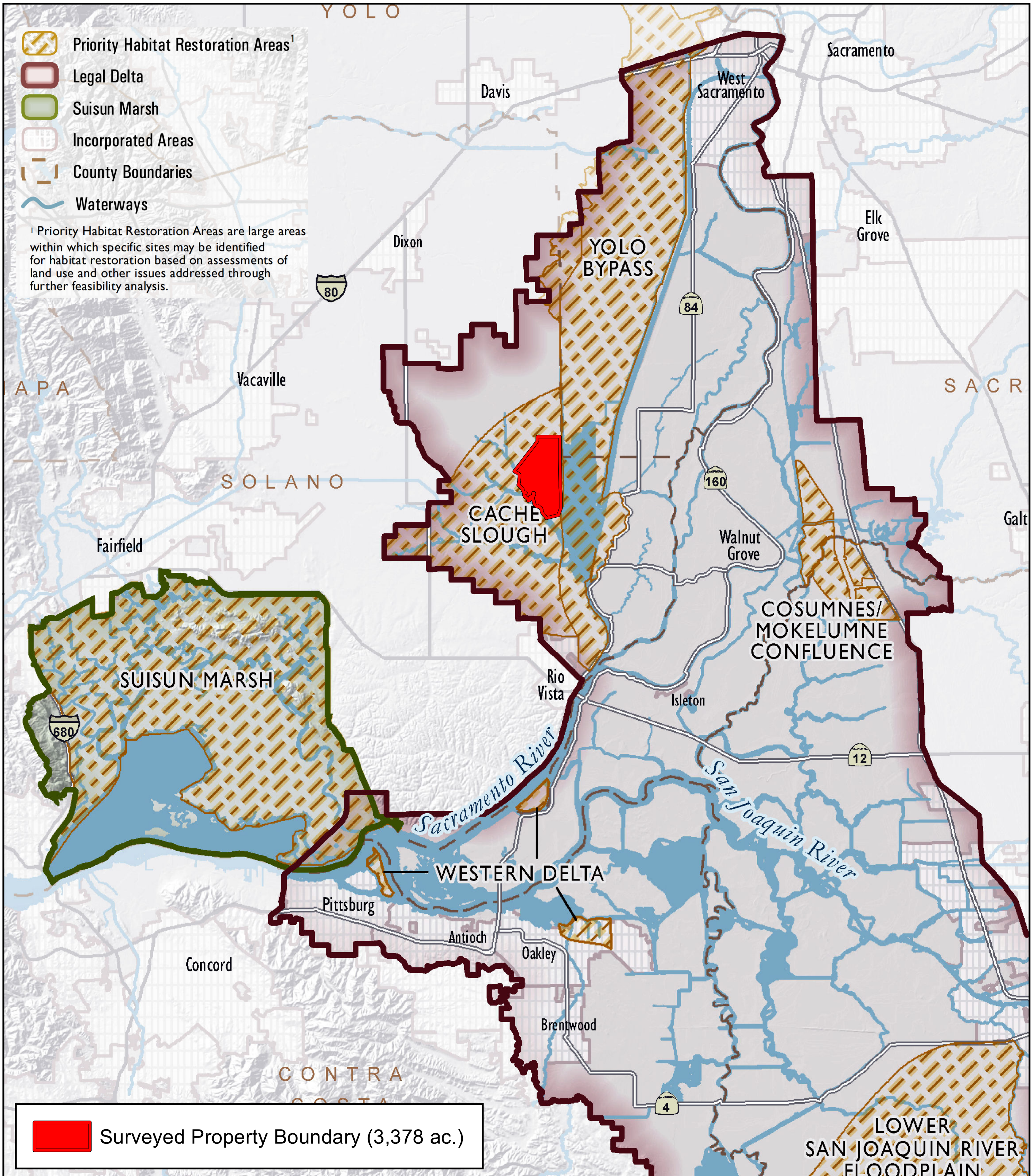


Figure ES-1
Location Map

Lookout Slough Tidal Habitat Restoration and Flood Improvement Project

Ecosystem Investment Partners

Prepared by: ESA

Map Prepared Date: 4/8/2019
Map Prepared By: JPritchard
Base Source: Wood Rodgers
Base Date: 10/24/2017
Data Source(s):
Delta Stewardship Council, 2013

Path: U:\GIS\GIS\Projects\18xxxx\D181197_00_Lookout_Slough_Restoration_1\03_MXDs_Projects\02_Flood_Task_System_HandH\F01_Location_Map.mxd

The Project alterations would result in no adverse impacts to flood stages within the system for the range of hydrologic loadings analyzed. The region-wide system models have also been reviewed to verify that no significant change in the flow distribution at Fremont Weir or the Sacramento Weir would occur as a result of the Project. As the hydraulic impacts of the Project are localized, and generally result in stage decreases for the design events under consideration (including the 1957 authorized design flow), the Project's potential to transfer risk from one part of the system to another is considered to be negligible. Consequently, a detailed system performance calculation using HEC-FDA is not considered to be warranted. The deterministic analysis conducted for the Project is considered sufficient for describing the overall system performance for the without- and with-Project conditions and verifies that the reduction in assurance posed by the Project is negligible.

This page intentionally left blank

LOOKOUT SLOUGH TIDAL HABITAT RESTORATION AND FLOOD IMPROVEMENT PROJECT

Hydrologic and Hydraulic System Analysis

Introduction

The Lookout Slough Tidal Habitat Restoration and Flood Improvement Project (Project) will create approximately 3,000 acres of natural freshwater tidal marsh in the Cache Slough Complex in the northern Sacramento-San Joaquin Delta (**Figure 1**), and increase the regional flood conveyance capacity of the Yolo Bypass. The Project is being funded by the California Department of Water Resources (DWR) to meet multiple objectives:

- To meet goals outlined in the State of California's Bay Delta Conservation Plan (BDCP) as well as the U.S. Fish and Wildlife Service's (FWS) Biological Opinion (BiOp) issued as part of the Long-Term Operational Criteria and Plan (OCAP) for coordination of the Central Valley Project and State Water Project. The Project is within the priority habitat restoration areas delineated in the 2008 FWS BiOp Delta Smelt Crediting Decision Model, and will create creditable acres for Delta Smelt that will satisfy DWR's obligations under the Delta Smelt BiOp and salmonids under the Salmonid BiOp.

- To meet regional flood management objectives to increase the conveyance capacity of the Yolo Bypass in a manner that is consistent with the 2017 DWR Sacramento Basin-Wide Feasibility Study (BWFS). By setting back the existing State-Federal levee along the west side of the Yolo Bypass, the Project will provide flood storage and reduce upstream flood stages in the Yolo Bypass.

DWR contracted EIP III Credit Co., LLC (EIP) to develop and, if approved, implement the Project as a multi-benefit project targeting both habitat restoration and flood risk reduction. Environmental Science Associates (ESA) is a subconsultant to EIP responsible for hydraulic analyses on the Project. This report provides the hydrologic and hydraulic basis of design for the flood management features of the Project, and documents changes in hydrology and hydraulic performance that would result from implementation of the Project. Hydrologic and hydraulic analysis of the habitat restoration components of the Project are documented in a separate report (ESA, 2019).

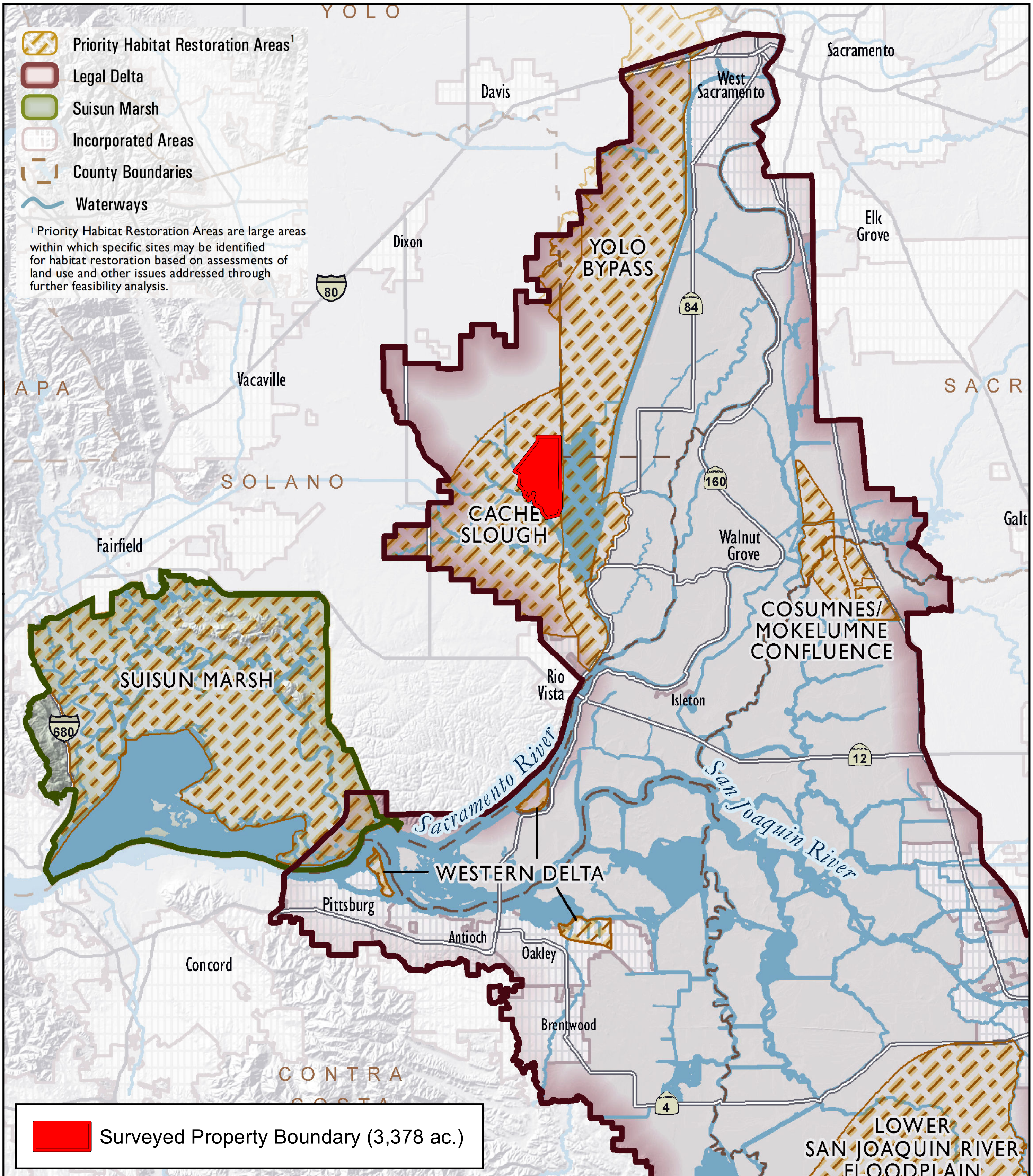


Figure 1
Location Map

Lookout Slough Tidal Habitat Restoration and Flood Improvement Project

Ecosystem Investment Partners

Map Prepared Date: 4/8/2019
Map Prepared By: JPritchard
Base Source: Wood Rodgers
Base Date: 10/24/2017
Data Source(s):
Delta Stewardship Council, 2013

Prepared by:
ESA

Path: U:\GIS\GIS\Projects\18xxxx\D181197_00_Lookout_Slough_Restoration_1\03_MXDs_Projects\02_Flood_Task_System_HandH\F01_Location_Map.mxd

Background

The Project is located within the Cache Slough Complex, in the northwest corner of the Sacramento-San Joaquin Delta in Solano and Yolo Counties. The Cache Slough Complex is considered ideal for tidal restoration by federal and state wildlife agencies as a result of its "connectivity to the Yolo Bypass floodplain, suitable elevations, high turbidity, high primary and secondary productivity, and use by Delta smelt, Chinook salmon, and other native fishes" (CDFW, 2017).

The Project is bounded to the north by Liberty Island Road, to the east by the Yolo Bypass, to the south by Cache Slough, and to the west by Duck Slough. With the exception of the levee system, land on the Project site ranges between El. -2.0 feet (NAVD 88) and El. 9.0 feet (NAVD 88), and generally slopes from west to east. Precipitation at the site is derived from frontal storms originating from the Pacific Ocean during the primary wet season between the months of October and April. The site receives a mean annual rainfall of approximately 17 inches (Solano County, 1999) and is characterized by poorly drained clay soils, with high runoff potential (USDA, 2018).

Historic Landscape

Up to the early 20th century, the majority of the site was part of the historic tidal tule marsh complex (**Figure 2**) that formed the low-lying southern portion of the Yolo Basin. The upper portions of the Yolo Basin were formed by Holocene basin deposits laid down by the Sacramento River and the two major west side tributaries, Cache Creek and Putah Creek (**Figure 3**). These deposits grade basin-ward into the plains of the north Delta, which is characterized by peat-rich muds (Helley and Harwood, 1983). Flood-basin deposits in this region are typically firm to stiff silty clay, clayey silt, and silt (Atwater, 1982).

The Yolo Basin was largely cutoff from the Sacramento River, except in times when the natural levees along the banks of the river overtopped, similar to flows cresting Fremont Weir today (Opperman et al., 2017). The Yolo Basin received seasonal runoff from the west side tributaries, including Cache Creek and Putah Creek, as well as groundwater seepage from the Sacramento River. These sources combined with freshwater tidal inundation, fed the historic freshwater tidal marsh and channels where the Project is located (PWA, 2008).

The Project is located in what is understood to have been part of the historic tidally-inundated marsh above Cache Slough. Vegetation on the majority of the Project site was tules (*Scirpus acutus,* also known as Hardstem Bulrush), a dense perennial wetland plant species which historically dominated the marshplains of the region. The density of tules and willows in the region are considered to be one of the reasons that these areas were not carefully surveyed prior to reclamation (Atwater, 1982). The site would have been relatively level, gradually draining southward into Cache Slough, with the marshplain edge dictated by elevation of the highest tides (PWA, 2008). As shown on Figure 2, a network of blind tidal channels formed along the banks of Cache Slough.

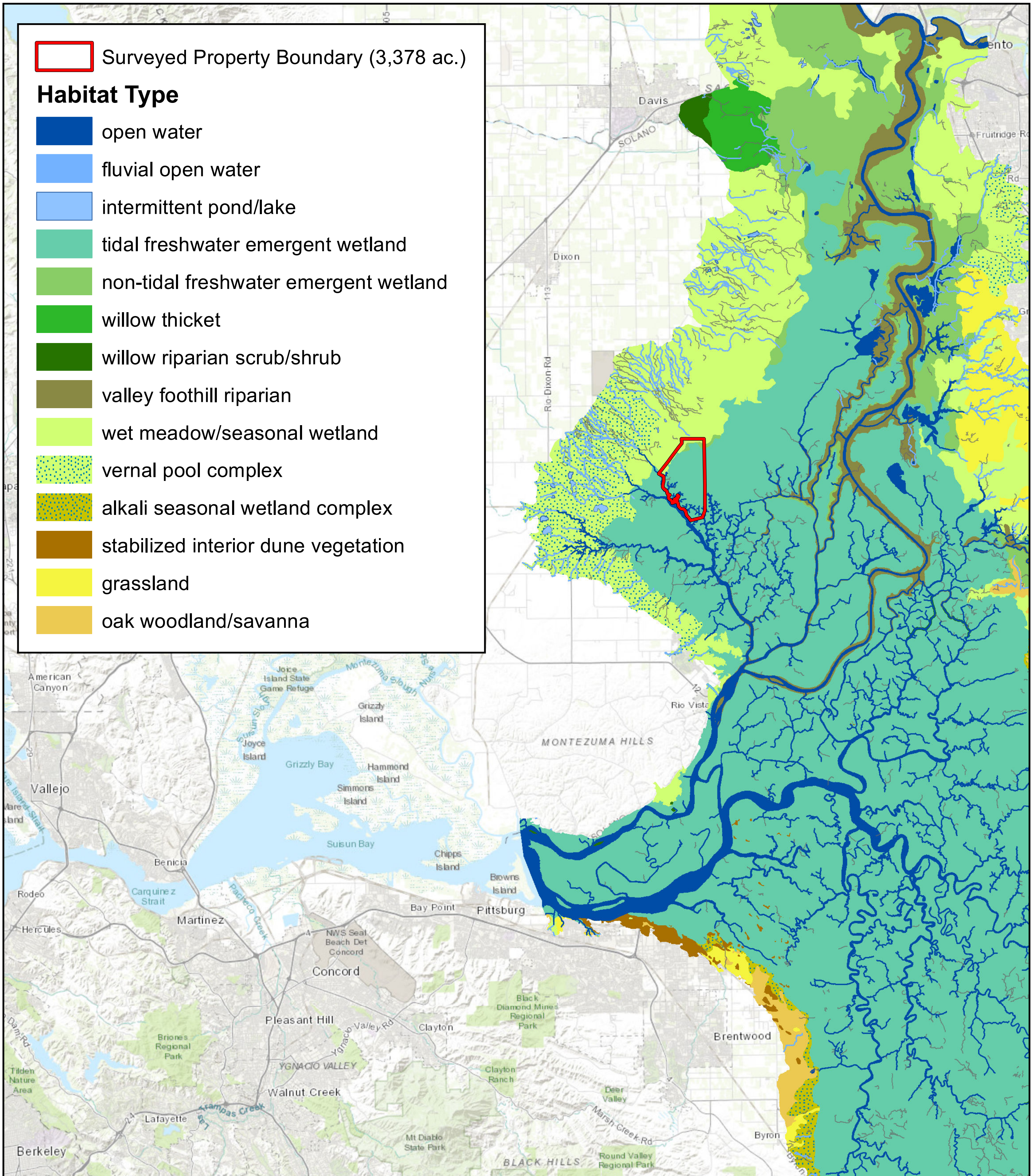


Figure 2
Historical Ecology

Lookout Slough Tidal Habitat Restoration and Flood Improvement Project

Ecosystem Investment Partners

Map Prepared Date: 4/8/2019
Map Prepared By: JPritchard
Base Source: Wood Rodgers
Base Date: 10/24/2017
Data Source(s):
SFEI, 2012

Prepared by:
ESA

Path: U:\GIS\GIS\Projects\18xxxx\D181197_00_Lookout_Slough_Restoration_1\03_MXDs_Projects\02_Flood_Task_System_HandH\F02_Historical_Ecology_R2.mxd

Surveyed Property Boundary (3,378 ac.)

Description of Map Units:

Qop: older alluvium of Putah Creek (upper Pleistocene)
Qyp: younger alluvium of Putah Creek (Holocene and/or upper Pleistocene)
Qb: flood-basin deposits (Holocene)
Qpm: peat and mud of tidal wetlands and waterways (Holocene)
Ql: natural levee deposits (Holocene)

Figure 3
Geologic Map of Sacramento-San Joaquin Delta, California

Lookout Slough Tidal Habitat Restoration and Flood Improvement Project

0 0.5 1 2
Miles

Ecosystem Investment Partners

Prepared by: ESA

Map Prepared Date: 4/8/2019
Map Prepared By: JPritchard
Base Source: Wood Rodgers
Base Date: 10/24/2017
Data Source(s):
Atwater, 1982

Path: U:\GIS\GIS\Projects\18xxxx\D181197_00_Lookout_Slough_Restoration_1\03_MXDs_Projects\02_Flood_Task_System_HandH\F03_USGS_Geologic_Mapping.mxd

Existing Conditions

Beginning in the 1930's and continuing through the 1960's, a series of levee improvements were constructed along the east side of Cache Slough and the west side Yolo Bypass as part of the Sacramento River Flood Control Project (SRFCP) to develop and protect approximately 13,000 acres of agricultural land and associated structures and roads (U.S. Army Corps of Engineers [USACE], 1962). Following repairs in 1962, the southern portion of the original levee system experienced significant subsidence, and in 1986 a plan for a cross levee was finalized and then constructed by the USACE (URS, 2011 and USACE, 1986). The remnant levee system south of the cross levee was subsequently abandoned and breached in May 1992 by the USACE to create the Cache Slough mitigation area south of the Project (Stevens & Rejmankova, 1995). The existing levee system bounding the Project (**Figure 4**) is currently maintained and operated by Reclamation District (RD) No. 2098.

Until recently, the Project site was managed separately by three primary land owners (**Figure 5**):

- The Vogel Island portion of the project was originally purchased for use as a duck club. Historically, the island drained by gravity through a gated outfall structure into Cache Slough. During winter flood season the berms forming the perimeter of Vogel Island often overtop, flooding the property. These same berms prevent flood waters from draining once the island is inundated, creating a condition where water and potentially fish are trapped inside a temporary lake.

- The Bowlsbey Ranch property north and west of Lookout Slough has been operated and managed as irrigated pasture for livestock. The land is irrigated using water pumped from Hass Slough and drains generally from west to east through a network of agricultural ditches to a toe drain that runs parallel to western and northern sides of Lookout Slough, which collects in the southeast corner of the site before ultimately being pumped back to Hass Slough.

- The Liberty Farms property was used for agricultural production for many years before being converted to a duck club circa 2005. Although the northern portion of the property continues to be used for agricultural production, the majority of the site is seasonally flooded and drained through a series of artificial channels to manage vegetation on the duck club. The property is seasonally flooded using water sourced from Cache Slough and is drained via pumping to Shag Slough.

The State-Federal levee system ensures that the Project land is currently inaccessible to fishes, including Delta smelt, green sturgeon, Central Valley Spring Run Chinook salmon, Sacramento River Winter-run Chinook salmon, Central Valley steelhead, and longfin smelt, except during winter runoff events which periodically flood the Vogel Island tract.

The Project will establish tidal hydraulic connectivity to all three pieces of land by breaching the berms at Vogel Island, the west (right) levee of the Yolo Bypass along Shag Slough. The existing pumping and irrigation channel network will be decommissioned and replaced with a network of tidal channels which will allow the site to flood and drain by gravity with the tides. In doing so, the Project will have a continuous supply of fresh water and suspended sediment which will promote establishment of a mosaic of subtidal, intertidal, and uplands habitat types.

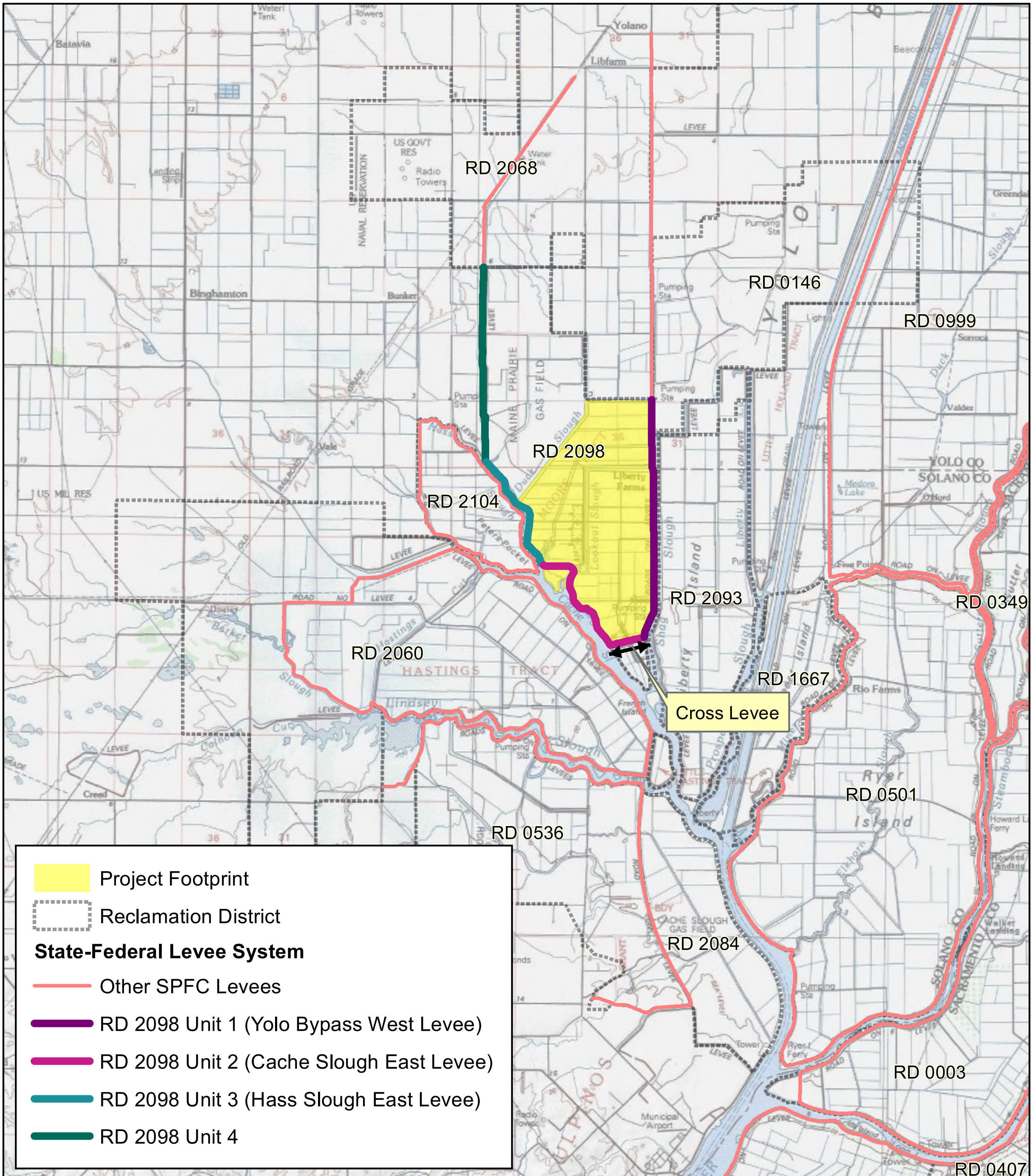


Figure 4
Existing Levee System

Lookout Slough Tidal Habitat Restoration and Flood Improvement Project

Ecosystem Investment Partners

Map Prepared Date: 8/25/2019
Map Prepared By: Brent Davis
Base Source: Wood Rodgers
Base Date: 10/24/2017
Data Source(s):
CA Levee Database, CBI, DWR
ESRI Surface Layers

Prepared by:
ESA

Path: U:\GIS\GIS\Projects\18xxxx\D181197_00_Lookout_Slough_Restoration_1\03_MXDs_Projects\02_Flood_Task_System_HandH\F04_Existing_Levees.mxd

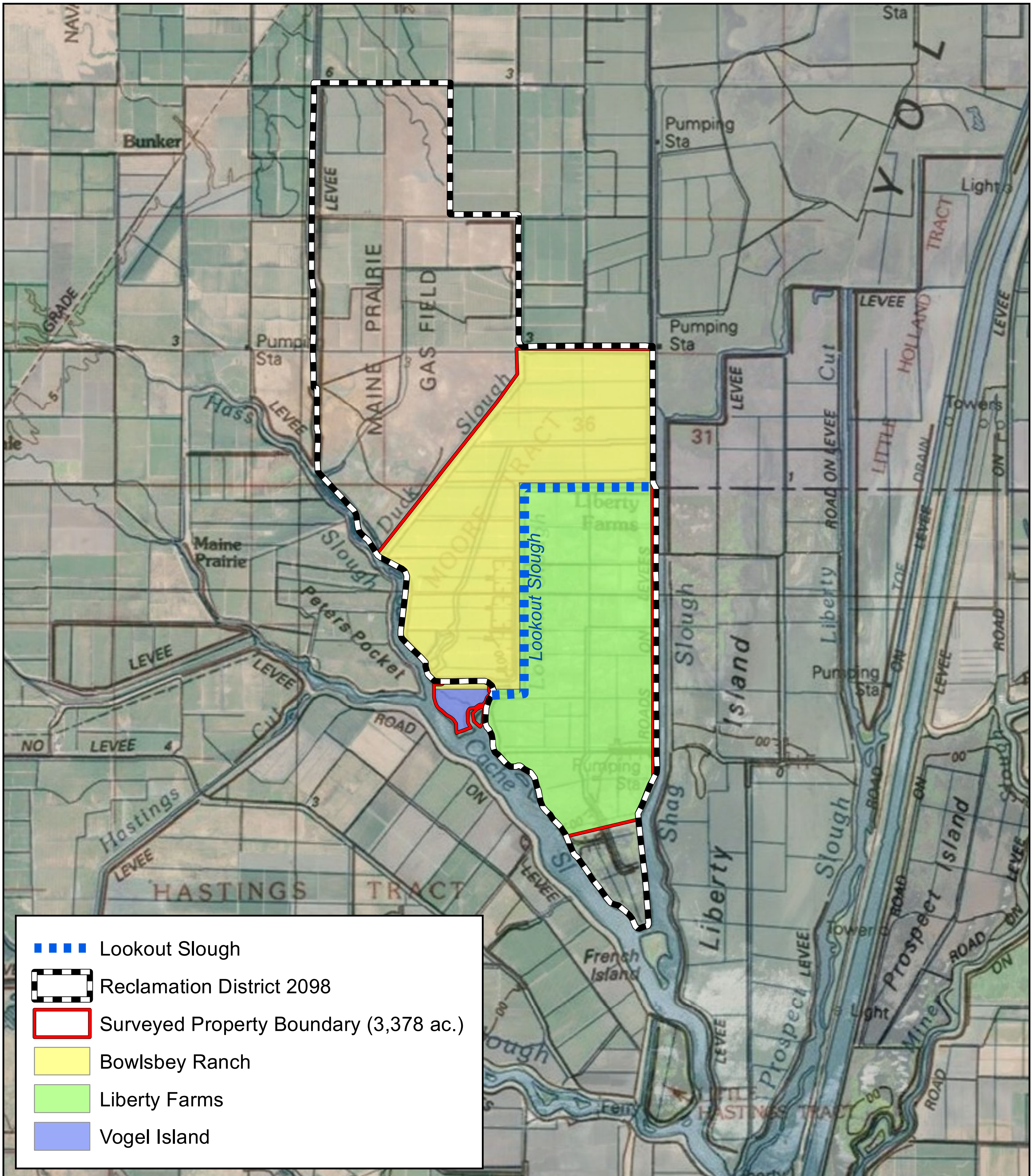


Figure 5
Land Ownership

Lookout Slough Tidal Habitat Restoration and Flood Improvement Project

0 0.25 0.5 1
Miles

Ecosystem Investment Partners

Prepared by:
ESA

Map Prepared Date: 4/28/2019
Map Prepared By: JPritchard
Base Source: Wood Rogers
Base Date: 10/24/2017
Data Source(s):

Path: U:\GIS\GIS\Projects\18xxxx\D181197_00_Lookout_Slough_Restoration_1\03_MXDs_Projects\02_Flood_Task_System_HandH\F05_Property_Boundaries.mxd

Construction of the habitat restoration components of the Project necessitates alteration of the State-Federal levee system. To maintain the existing level of flood protection for lands north of the Project (RD 2068) and lands west of the Project (RD 2098), a new setback levee will be constructed along the northern and western boundaries of the project. The Project will also increase the conveyance capacity in this part of the Yolo Bypass, consistent with DWR's regional planning objectives (DWR, 2016).

Engineering Circular 1165-2-220 (USACE, 2018) states that any project proposing to alter a federal project in any way "*must not be injurious to the public interest or affect the USACE project's ability to meet its authorized purpose*." If that can be shown, then the Project can receive a Section 408 Permit before construction begins.

Two of the alterations to be made as part of the Project classify the Project as falling under jurisdiction of Section 408:

1. Breaching and degrading the existing west (right) levee of the Yolo Bypass between Liberty Island Road and the southern end of Liberty Farms, and construction of a new setback levee parallel to Duck Slough and Liberty Island Road.

2. Improvements to the existing east (left) levee of Cache Slough and Hass Slough on the western side of the Project.

Project Datums

All data for the project is referenced to the North American Datum of 1983 (NAD 83) and the California State Plane II (feet) coordinate system. All vertical elevations described in this report are referenced to the North American Vertical Datum of 1988 (NAVD 88) and are reported in units of feet.

Hydraulic Design Criteria

The project design concept was developed iteratively through engagement between EIP's project delivery team, DWR staff, and members of the Lower Sacramento River/Delta North Regional Flood Management Plan Workgroup including the Sacramento Area Flood Control Agency (SAFCA), Solano County, the Solano County Water Agency (SCWA), RD 2060, RD 2068, and RD 2098. A summary of the criteria used for designing and modifying the Project flood management features follows below.

Existing State-Federal Project Levee System

The existing State-Federal levee system bounding the Project includes the West Levee of the Yolo Bypass (RD 2098 Unit 1) bordering Shag Slough, the cross levee and East Levee of Cache Slough (both of which compose RD 2098 Unit 2), and the East Levee of Hass Slough (RD 2098 Unit 3). With the exception of the cross levee (USACE, 1986), the existing system was designed and constructed in 1961 by the USACE as part of the Sacramento River Flood Control Project (SRFCP [USACE, 1962]). The West Levee of the Yolo Bypass was originally designed and constructed with a crest six feet above the 1957 design water surface profile (1957 Profile), and the levees along Cache Slough and Hass Slough were constructed with a crest at least three feet above the 1957 design water surface profile (USACE, 1962). The 1957 Profile is based on specified design discharges (not tied to a recurrence frequency) and adopted concurrent conditions at confluences of study streams (USACE, 1993). The 1957 Profile reflects revisions made up to and during design of the SRFCP, as agreed upon by the Reclamation Board (now the Central Valley Flood Protection Board), the State of California, and the USACE, as published in "Levee and Channel Profiles, Sacramento River Flood Control Project," dated March 15, 1957. In this portion of the Yolo Bypass, the 1957 profile was scaled from the 1907 and 1909 floods (DWR, 2016), based upon the authorized design flow of 490,000 cfs.

The six-foot freeboard criterion along the West Levee of the Yolo Bypass provides a factor of safety for both flood stage and run-up from wind-generated waves in the Yolo Bypass. Historically, wind waves can grow to four feet or more during large storm events due to the combination of long fetch lengths in the Yolo Bypass and strong sustained winds (DWR, 2016).

Levee Design Height

The Project design will conform to the latest Central Valley Flood Protection Board (CVFPB), USACE, and Federal Emergency Management Agency (FEMA) standards, methods, procedures, and policies for levee design including the following:

- *California Code of Regulations, Title 23, § 120 – Levees*
- *USACE Engineering Manual No. 1110-2-1913 – Engineering and Design – Design and Construction of Levees*
- *USACE, Design Guidance for Levee Under-Seepage, ETL 1110-2-569, May 1, 2005*
- *Code of Federal Regulations, Title 44. § 65.10 – Mapping of Areas Protected by Levee Systems*

In 2007, the California Legislature passed several bills adding to and amending State flood management and land use laws. As part of this legislation, cities and counties within the Sacramento-San Joaquin Valley are required to make a Finding related either to an urban level of flood protection (defined as a 1-in-200 chance event) or to the FEMA standard of flood protection before: (1) entering into a development agreement within a flood hazard zone; (2) approving a discretionary permit or entitlement of any property development or use that is located in a flood hazard zone; or (3) approving a tentative map/parcel map for a subdivision that is located in a flood hazard zone (California Government Code Sections 65865.5, 65962, and 66474.5). These requirements apply to protecting "urban or urbanizing" areas as defined by California Government Code Section 65007 paragraphs (j) and (k). "Urban" and "urbanizing" areas are defined as those areas with a population greater than 10,000, or that will have a population greater than 10,000 within 10 years, respectively (DWR, 2012). Since the alterations proposed by the Project will not affect any urban or urbanizing areas, this criterion does not apply. Outside of urban or urbanizing areas within the Central Valley, the 1% ACE (100-year) water surface elevation is generally used as the basis for design. The Project will use the 1% ACE (100-year) water surface elevation or the authorized 1957 design profile, whichever is higher.

Adjustments are typically made to the design water surface elevation in order to provide factors of safety to account for uncertainty, climate change and sea-level rise, as well as to provide system resiliency.

Design Water Surface Profile

Wood Rodgers, Inc. (Wood Rodgers) is preparing the civil design of the Project and has reviewed criteria being used by DWR for the design of the Lower Elkhorn Basin Levee Setback (LEBLS) Project, a similar non-urban setback levee proposed along the east levee of the Yolo Bypass north of the confluence with the Sacramento Bypass. The design water surface used in the LEBLS project is based on a 100-year design water surface computed using Central Valley Hydrology Study (CVHS) hydrology (1997 storm pattern with 95% scaling) developed during the Basin-Wide Feasibility Study (BWFS) for the Sacramento River Basin recently prepared by DWR as part of the 2017 Central Valley Flood Protection Plan (CVFPP). For the LEBLS Project, DWR has also provided six feet of freeboard, consistent with the levee design in the Sutter and Yolo Bypasses. As part of the LEBLS design, DWR added an additional one foot of freeboard for resiliency to address future effects of climate change, for a total of seven feet of freeboard above the design water surface elevation. For purposes of the current Project, the 1957 authorized design or the 1% ACE (100-year) water surface will be used as the basis for design, whichever is higher. In addition to the minimum required six feet of freeboard, an additional 1 foot of freeboard will be included for climate resiliency. Although this is a more conservative approach than required by the CVFPB and the USACE, it is consistent with DWR flood planning objectives for the region.

Authorized Design Flow (1957 Profile)

The 1957 authorized design capacity of this portion of the Yolo Bypass is 490,000 cfs (USACE, 1957). The resultant design water surface profile establishes the minimum design height of the Project levee system. At the northeastern corner of the Project, the design water surface of the 1957 Profile at the west (right) bank levee of the Yolo Bypass is approximately El. 20.6 feet (NAVD 88) (USACE, 1957 and Atkins, 2013). At the southeastern corner of the project, the design water surface at the west (right) bank of the Yolo Bypass is approximately El. 18.6 feet (USACE, 1957 and Atkins, 2013).

1% ACE (100-year) Design Water Surface Elevation

To establish the design height of the levee, the Project performance for the 1% ACE (100-year) design flow was evaluated. The resultant water surface elevation was compared with the authorized design (1957 Profile), and the higher of the two was used to establish the design height for the Project flood management features. This approach is conservative and ensures consistency with DWR's planning objectives for rural and non-urban areas (DWR, 2017a).

0.5% ACE (200-year) Design Water Surface Elevation

Although not used for setting the design height of any of the Project features, analysis of the 0.5% ACE (200-year) design flow was performed. The 0.5% ACE (200-year) design flow is of interest to DWR as it relates to informing long term planning activities within the Yolo Bypass.

Channel Stability and Erosion

The Project alterations will result in localized changes in velocity and bed shear stress. To ensure that these changes do not adversely impact the performance of the State-Federal levee system, modeling results from the 1% ACE (100-year) design storm will be used as the basis for assessing bank stability and formulating recommendations for selection of lining materials if necessary. For purposes of the Project, stability threshold values shown in **Table 1** will be used as reference.

TABLE 1
PERMISSIBLE SHEAR AND VELOCITY FOR SELECTED LINING MATERIALS

Boundary Category	Boundary Type	Permissible Shear Stress (psf)	Permissible Velocity (fps)
Soils	Fine colloidal sand	0.02 – 0.03	1.5
	Sandy loam (noncolloidal)	0.03 – 0.04	1.75
	Alluvial silt (noncolloidal)	0.045 – 0.05	2
	Silty loam (noncolloidal)	0.045 – 0.05	1.75 – 2.25
	Firm loam	0.075	2.5
	Fine gravels	0.075	2.5
	Stiff clay	0.26	3 – 4.5
	Alluvial silt (colloidal)	0.26	3.75
	Graded loam to cobbles	0.38	3.75
	Graded silts to cobbles	0.43	4
	Shales and hardpan	0.67	6
Gravel/Cobble	1-in.	0.33	2.5 – 5
	2-in.	0.67	3 – 6
	6-in.	2.0	4 – 7.5
	12-in.	4.0	5.5 – 12
Vegetation	Class A turf	3.7	6 – 8
	Class B turf	2.1	4 – 7
	Class C turf	1.0	3.5
	Long native grasses	1.2 – 1.7	4 – 6
	Short native and bunch grasses	0.70 – 0.95	3 – 4
	Reed plantings	0.10 – 0.60	N/A
	Hardwood tree plantings	0.41 – 2.50	N/A
Temporary Degradable RECPs	Jute net	0.45	1 – 2.5
	Straw with net	1.50 – 1.65	1 – 3
	Coconut fiber with net	2.25	3 – 4
	Fiberglass roving	2.0	2.5 – 7
Non-Degradable RECPs	Unvegetated	3.0	5 – 7
	Partially established	4.0 - 6.0	7.5 – 15
	Fully vegetated	8.0	8 – 21

TABLE 1
PERMISSIBLE SHEAR AND VELOCITY FOR SELECTED LINING MATERIALS

Boundary Category	Boundary Type	Permissible Shear Stress (psf)	Permissible Velocity (fps)
Riprap	6-in. d50	2.5	5 – 10
	9-in. d50	3.8	7 – 11
	12-in. d50	5.1	10 – 13
	18-in. d50	7.6	12 – 16
	24-in. d50	10.1	14 – 18
Soil Bioengineering	Wattles	0.2 – 1.0	3
	Reed fascine	0.6 – 1.25	5
	Coir roll	3 – 5	8
	Vegetated coir mat	4 – 8	9.5
	Live brush mattress (initial)	0.4 – 4.1	4
	Live brush mattress (grown)	3.9 – 8.2	12
	Brush layering (initial/grown)	0.40 – 6.25	12
	Live fascine	1.25 – 3.10	6 – 8
	Live willow stakes	2.10 – 3.10	3 – 10
Hard surfacing	Gabions	10.0	14 – 19
	Concrete	12.5	> 18

SOURCE: Fischenich, 2001

Wind Setup and Wave Run Up

The effects of potential wind setup and wave run up related to the Project have been analyzed by Wood Rodgers and have been documented in a separate stand-alone appendix to the Project's overall basis of design report.

Hydraulic Impact Considerations

If approved, alteration of the State-Federal levee system would change hydrologic and hydraulic conditions in the Yolo Bypass and Cache Slough Complex. Recognizing this, the analysis includes considerations to ensure that any increases to water surface elevation, velocity, wind-wave, or other hydraulic effects are negligible. Areas identified as sensitive to the Project performance during flood conditions are identified below.

Impacts to the Yolo Bypass

The Project seeks to reduce flood stages in the Yolo Bypass by setting back the existing west (right) bank levee of the Yolo Bypass between Liberty Island Road and the southern boundary of the Project, thereby increasing the overall conveyance corridor width and floodplain storage during large flood events. The Project seeks to maximize resultant stage reductions in this part of the Yolo Bypass without adversely impacting other parts of the system.

Impacts to Cache Slough and Hass Slough

The adjacent levee systems along the west banks of Cache Slough and Hass Slough lack freeboard and suffer from deferred maintenance. This makes them particularly vulnerable to increases in water level, erosion, or wind-wave run-up. One important component of the habitat enhancement objectives of the Project includes establishing hydraulic connectivity between the restored marsh habitat and the Yolo Bypass. The Project seeks to avoid raising water levels in Cache Slough and Hass Slough more than 0.01 feet.

Impacts to Downstream Areas, including Rio Vista

The city of Rio Vista is vulnerable to flooding from the Sacramento River and the Yolo Bypass. The City receives modest flood protection from an existing floodwall that extends from the dock at the end of Montezuma Street to just north of Main Street. This floodwall was overtopped in 1986 and was subsequently raised. Since the raising, the floodwall has not been overtopped by a flood event. However, downtown Rio Vista regularly experiences flooding from minor storm events and high tides (Flood Protect, 2014).

Elevated water stages resulting from a 6-year flood event in the Sacramento River also overtop the west bank of the Sacramento River upstream of State Highway 12 and flow through the highway underpass, thereby effectively flanking the existing floodwall and flooding downtown Rio Vista. During these high water events, businesses upstream of State Highway 12 are forced to close until floodwaters recede, since flooding along State Highway 84 makes the businesses inaccessible.

The project will alter the hydraulics of the Cache Slough Complex during a large flood. Although these changes are assumed to be beneficial due to attenuation of the flood wave in the overbank areas of the Project site, care must be taken to keep water levels from increasing in the vicinity of Rio Vista.

Alteration of State-Federal Project – Concept Plan

The conceptual site design (**Figure 6**) was developed by Wood Rodgers, WRA, Inc. (WRA) and Beaver Creek Hydrology, LLC (Beaver Creek Hydrology) to restore the full tidal range to as much of the site as is practical, and to connect the site hydraulically to the Yolo Bypass during high water events. The project concept seeks to meet flood management objectives using the criteria outlined above, while also supporting habitat function. In addition to alterations to the levee system, a number of functional design components, such as a training levee and refugia areas, have been incorporated into the design. Many of these features are intended to address DWR's obligations in the respective Biological Opinions, and offer dual benefits in the form of enhanced flood risk reduction. The major project features and their intended functions are described below (WRA, 2019a).

Duck Slough Setback Levee Improvements

A new setback levee is proposed on the northwestern and northern sides of the Project site. If approved, this levee would become part of the State-Federal levee system, protecting lands within

RD 2098, north and west of the Project. The proposed levee would begin near the confluence of Hass Slough and Duck Slough; run parallel to Duck Slough on the northwestern side of the project; and upon reaching the northwestern corner of the Project, turn east and run parallel to the south side of Liberty Island Road; eventually tying into the West Levee of the Yolo Bypass system at the northeast corner of the Project site. The segment of levee running parallel to Duck Slough would be offset from the property line to provide a refugia habitat buffer on the land side for the endangered Giant Garter Snake (*Thamnophis gigas*).

Alteration of Cache Slough and Yolo Bypass Levees

Prior to being developed for agriculture, the majority of the Bowlsbey Ranch and Liberty Farms parcels were covered in tidal freshwater emergent wetlands, which drained to Cache Sough (Whipple et al., 2012). Today, the existing State-Federal levee system currently prevents the site from flooding and draining with normal tides. Breaching the levee system is necessary to restore tidal exchange on the Project site.

Alteration of the State-Federal levees requires careful consideration to ensure that risk is not transferred from one part of the system to another, and constrains what modifications can be made to re-establish tidal processes on the site. Tidal marsh considerations have been analyzed in parallel with the flood management design, and have been documented in a separate report (ESA, 2019). A brief description of the proposed modifications of the East Levee of Cache Slough and West Levee of the Yolo Bypass follows below.

West Levee of Yolo Bypass Alteration

The Project proposes to breach the west (right bank) levee of the Yolo Bypass along Shag Slough at nine locations to provide hydraulic connectivity between the site and Shag Slough and the Yolo Bypass. This alteration would restore regular tidal exchange to the majority of the site and create habitat connectivity to Shag Slough. Two 1,500-foot long segments of the remainder of the existing levee would be degraded to provide flood benefits. The first of these would be located near the northern end of the Project, and act as an inlet during high flow events to divert additional water onto the site. This inlet section would be degraded to approximately elevation El. 14.0 feet (NAVD 88). The second segment would be located near the southern end of the Project, and act as an outlet during high flow events, and would be degraded to approximately El. 11.8 feet (NAVD 88). This would allow floodwaters during a significant flood event to be conveyed across the Project Site.

Rock slope protection would be included at the northern and southern portions of the degraded sections of the Shag Slough Levee. The rock slope protection would provide additional protection from erosion for the adjacent levees including the adjacent unmodified section of the Shag Slough Levee in the north and the adjacent section of the Cross Levee in the south.

East Levee of Cache Slough Alteration

Proposed modifications to the West Levee of the Yolo Bypass would hydraulically connect the Project site to the Yolo Bypass. During less frequent, high flow flood events this will create a condition where the water levels on the Project site will be slightly higher than those inside of

Cache Slough. Significant increases to flood levels in Cache Slough and Hass Slough are considered to be unacceptable to RD 2060, RD 2068, and RD 2098 as portions of the levee systems maintained by these entities do not currently meet minimum freeboard requirements and suffer from years of deferred maintenance. Recognizing this, the Project seeks to avoid increasing stage in Cache and Hass Slough.

Historically, wind waves can grow to four feet or more during large storm events due to the combination of long fetch lengths in the Yolo Bypass and strong sustained winds (DWR, 2016). The Project proposes to connect the site to the Yolo Bypass floodplain during high flow events, which will increase fetch lengths against the remnant Cache Slough levee. The remnant embankment along Cache Slough would act as a wind-wave buffer providing an additional layer of safety for levees on the opposite sides of Hass Slough and Cache Slough. Wind-wave assessment analysis of the Project and its potential impacts are summarized by Wood Rodgers in a separate appendix to the Project's overall Basis of Design Report.

The levee along Cache and Hass Sloughs would be retained as a training levee to prevent increased water surface elevations in Cache and Hass Sloughs during Yolo Bypass flood events. The Cache/Hass Slough Training Levee would be improved to reduce subsidence, increase slope stability, increase resilience to wind-wave forces, and improve maintenance access. Material would be removed from the levee to reduce the extent of future levee subsidence and standardize the crest height to either the 1957 water surface profile or 1% ACE water surface elevation, whichever is higher, plus one foot of freeboard. Removing material from the levee top is proposed to relieve weight and consequently reduce potential for subsidence, which has historically been a maintenance issue. Removed levee material would be used to flatten the Project-side levee slope to a maximum of 4H:1V and construct an operations and maintenance roadway at the waterside toe of the slope. The levee crown and upper portion of the slope would be made more uniform in width (minimum of 16-feet wide) and include a maintenance road with an improved road surface.

Erosion protection would be added to the crown of the Cache/Hass Slough Training Levee to provide protection from potential erosion due to overtopping caused by wind wave splash. Erosion protection could be in the form of rock or bio-geotechnical methods. In addition, riparian vegetation may be planted at appropriate elevations along portions of the Project-side slope.

Breach of Vogel Island Levees

The Project proposes to breach the uncertified agricultural levees that form the perimeter of Vogel Island at two locations to provide hydraulic connectivity to Cache Slough. This alteration would restore normal tidal exchange to the island and habitat connectivity to Cache Slough. In large flood events, the remnant levee segments would continue to overtop as they do today.

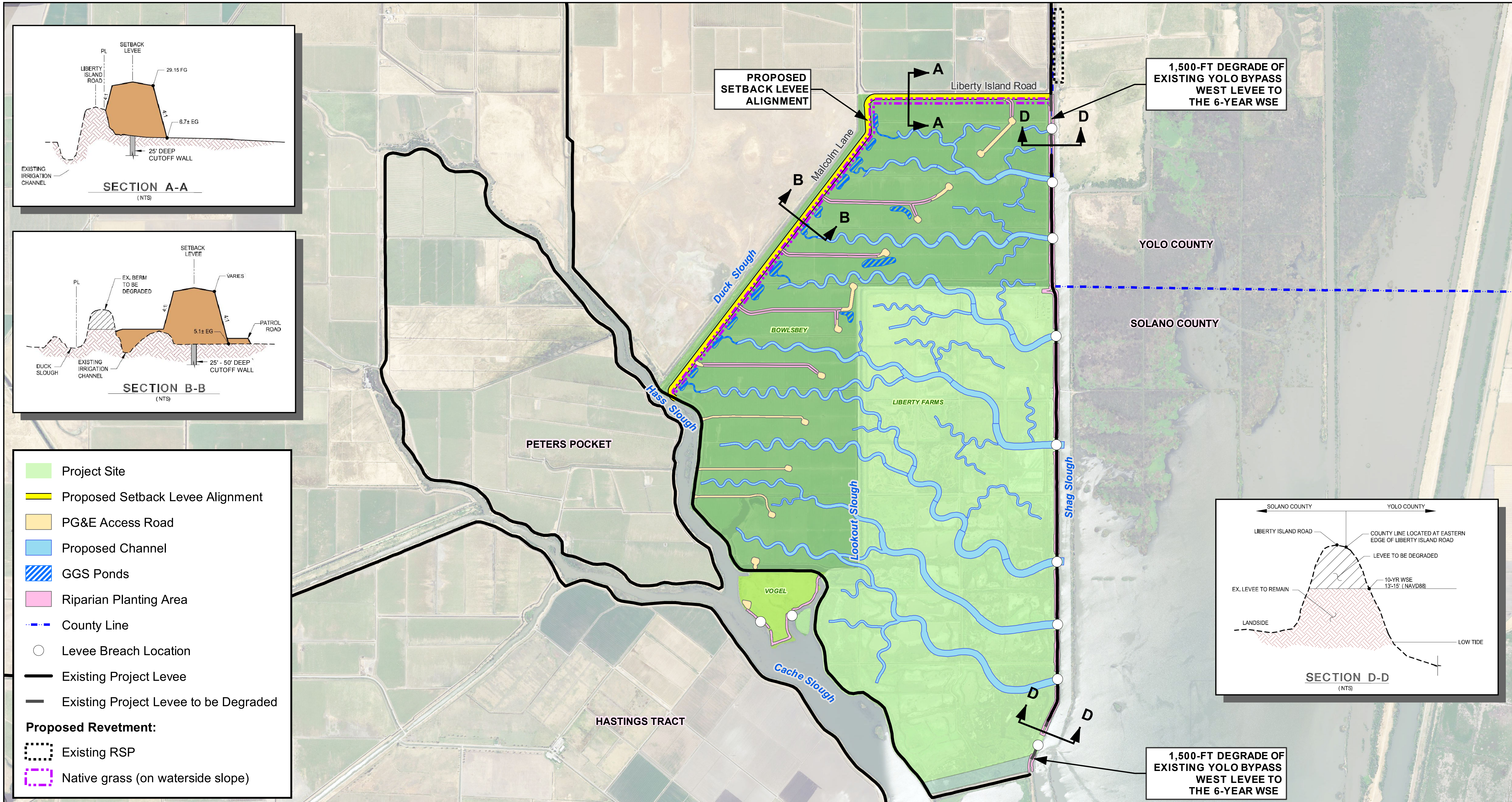


Figure 6
Conceptual Site Design

Lookout Slough Tidal Habitat
Restoration and Flood Improvement Project

0 0.25 0.5 1
Miles

Ecosystem Investment Partners

Map Prepared Date: 8/6/2019
Map Prepared By: cmilligan
Base Source: Wood Rogers
Base Date: 10/24/17
Data Source(s):

Prepared by:
WOOD RODGERS

Path: J:\3000-s\3487_Ecosystem_Invest_Partners\3487003 Lookout Slough Preliminary Design\GIS\Tasks\WRA_TEMPLATES\Overall_Project_Exhibit_Landscape_20190806.mxd

This page intentionally left blank

Tidal Channel Network

Tidal channel networks provide important low resistance pathways for distributing material and energy between the marsh habitat and adjacent bodies of water (Mitsch & Gosselink, 2015). In general, width and depth of the channel decrease between the channel inlets at Cache Slough and Shag Slough and the back of the site. Constructed channel top widths will range from 60 feet to 250 feet, with channel invert elevations ranging between 1.0 and -1.0 feet (NAVD 88) to limit growth of emergent vegetation. Constructed channel side slopes would vary, but be set to a maximum of 3:1. Additional site grading will be performed to remove man-made berms and existing drainage canals (including the previously realigned Lookout Slough) throughout the site to prevent short-circuiting of the new channel network. The proposed network has been laid out to take advantage of the existing topography which drains primarily from west to east towards Shag Slough, with additional provisions to provide connectivity to Cache Slough. The performance of the Project channel network and marsh plain grading plan was tested and further refined by WRA and Beaver Creek Hydrology (WRA and Beaver Creek Hydrology, 2019) using results from the tidal restoration hydrodynamic modeling analysis (ESA, 2019).

As the proposed tidal channel network has only been sized for daily tidal exchange, the hydraulic capacity of the channels is not anticipated to have a significant effect on flood routing during high water events in the Yolo Bypass. The overbanks and adjacent floodplains of the tidal channel network are anticipated to be covered with tule marsh vegetation. Although dense stands of tules provide significant hydraulic resistance during normal tidal conditions, their influence will be reduced significantly during high water conditions in the Yolo Bypass where depths of flooding on the site will exceed 10 feet or more.

Analysis

The USACE Sacramento District is responsible for determining whether a hydrologic and hydraulic system analysis is needed and, if so, also determining the appropriate scope of analysis based on the complexity of the proposed alteration. Based on pre-coordination meeting with the USACE Sacramento District on January 15, 2019, it was determined that if deterministic analysis of without- and with-Project conditions was conducted for a range of hydrologic loading scenarios (16% ACE, 1% ACE, and 0.5% ACE), and the Project implementation was demonstrated to have only localized effects, and would not result in increased water levels of more than 0.1 feet at key index points within the system, then more detailed performance computations at the index points would not be required.

System Performance Assumptions

The proposed project alterations are being evaluated relative to the Baseline Condition, as well as the Future Cumulative Condition Baseline scenarios described below. Per USACE EC 1165-2-220, Appendix F, Section F-3.f (USACE, 2018) all project features are assumed to be stable and functional to the top of containment (USACE, 2018) in this analysis. Levees are not assumed to breach or otherwise malfunction in the analysis of pre- and post-project conditions. Levees are allowed to overtop and spill water to storage areas adjacent to levees, without failing. The Project also is assumed to be stabilized to the authorized condition, and based on this assumption, fragility curves are not required.

Levees of the SPFC that do not meet the minimum project standard have been modeled as meeting the minimum authorized height (i.e., the 1957 design profile). Where existing top of levee heights exceed the authorized height, they are modeled as such (DWR, 2017c). These assumptions reflect the ability of upstream projects to engage in maintenance and provide a conservative estimate of flow delivery in the area of interest. This approach is consistent with the assumptions used for LEBLS and similar projects in the region.

Baseline Condition

The Baseline Condition modeling assumes the following Early Implementation Projects (DWR, 2017c):

- American River Common Features Project WRDA 96/99 sites
- Folsom Dam Joint Federal Project (JFP) – including water control manual updated considering forecast-based operations as of August 19, 2016
- Marysville Ring Levee
- Sutter Basin Project – Feather River West Levee Project
- Three Rivers Levee Improvement Project (TRLIA)
- Natomas Levee Improvement Project (NLIP)
- West Sacramento 2016 sites (Southport Levee Improvement Project)
- Hamilton City – Phase 1
- Star Bend (SBFCA)
- Bear River

Future Cumulative Condition

The Future Cumulative Condition scenario builds upon the assumptions in the Baseline Condition, and reflects full build-out of the elements of the recommended Yolo Bypass expansion option (Yolo Bypass Option 3) described in the BWFS (DWR, 2016) and reproduced on **Figure 7**. This includes implementation of the following features:

- **Upper Elkhorn and Fremont Weir Expansion** – a one-mile expansion of the Upper Elkhorn Basin with a corresponding expansion of Fremont Weir
- **Lower Elkhorn Expansion** – a 3,500-feet levee setback along the Lower Elkhorn Basin
- **Sacramento Weir and Bypass Expansion** – a 1,500-feet expansion of the Sacramento Weir and Bypass

- **Cache Creek Settling Basin** – measures to extend useful life of the Cache Creek Settling Basin and address concerns regarding mercury in its sediment
- **Levee Setback Near Willow Slough Bypass** – a 4,000-feet levee setback on the west side of the bypass north of Willow Slough and south of I-80
- **Levee Setback Near Putah Creek** – a 5,000-feet levee setback on the west side of the Yolo Bypass north of Putah Creek
- **Tie-in to Sacramento River Deep Water Ship Channel** – a gated weir to tie into the Sacramento River Deep Water Ship Channel and a closure structure to prevent high stages from reaching West Sacramento
- **Degradation of Step Levees and Lower Egbert Track Levees** – degrading remaining levee segments in the lower Yolo Bypass at the north end of Little Holland Tract and Liberty Island and degrading portions of the Lower Egbert Track (RD 2084) levees.
- **Lower Yolo Bypass Setback** – levee setback south of RD 2068 to Rio Vista, including removal of cross levee at southern boundary of RD 2098)
- **Build Weirs on Prospect Island Levee** – build weirs along portions of the Prospect Island west levee
- **Improved Flood Protection for Rio Vista and Highway 84** – flood protection improvements for the city of Rio Vista to address potential hydraulic impacts of Yolo Bypass capacity improvements
- **Fix-in-place Levee Improvements** – provide six feet of freeboard over the estimated 200-year flood flows (represented by the 110-percent scaling of the 1997 storm pattern)
- **Geotechnical Levee Improvements** – fix any remaining geotechnical inadequacies for urban areas unaddressed in the future baseline condition and fix known critical geotechnical deficiencies for rural and small communities.

Index Points

A total of eleven index points were selected as locations to review the hydraulic impacts of the Project in both a Baseline and Future Cumulative Conditions scenarios. Shown on **Figure 8**, the following locations were identified during preliminary hydraulic analysis in close coordination with DWR and local interests:

1. West (left) bank of Yolo Bypass at County Road 155
2. Hass Slough at western boundary of RD 2098
3. Cache Slough near Hastings Cut
4. West (left) bank of Yolo Bypass at northern boundary of the Project
5. West (left) bank of Yolo Bypass at Yolo County/Solano County Line
6. Cache Slough at Confluence with Yolo Bypass
7. Lindsey Slough approximately 1 mile upstream of Hastings Island Road Bridge

8. Cache Slough at northern end of Little Egbert Tract
9. Cache Slough at Ryer Island
10. Cache Slough at southern end of Little Egbert Tract
11. Sacramento River at Rio Vista

Hydrology

Hydrologic input data for the hydraulic modeling was developed using data previously prepared by the USACE and DWR for regional planning studies. This includes historic flow record data used for calibration and validation of the hydraulic model parameters, as well as design storm hydrology suitable for analyzing the 16% ACE (6-year), 1% ACE (100-year), and 0.5% ACE (200-year) storm events. The sources of hydrology data used for these analyses are described in the following sections.

Calibration and Validation Hydrology

The objective of the model calibration effort is to test and refine the hydraulic model's simplified geometric elements and empirical parameters so that the model will as faithfully as reasonably possible reproduce the behavior of the system during an observed event. The quality of the calibration can be significantly influenced by the quality of its data inputs and observations, particularly with respect to the hydrology which drives the model boundary conditions.

The Baseline Condition hydraulic model has been calibrated using records from the January 1997 flood event and validated using the records from the January 2006 flood event. The calibration and validation time series flow data and high water mark survey data used in this study was compiled by USACE Sacramento District (USACE, 2013). All calibration data prepared by the USACE has been subject to quality control review and is reported in the NAVD 88 vertical datum, consistent with the Project datum. This dataset has been used extensively for calibrating other regional hydraulic models, including those used by DWR in the BWFS and LEBLS projects. For purposes of this project, outputs extracted from DWR's calibration and validation analysis (Wood Rodgers, 2015) were used to define boundary conditions for the Project's baseline two-dimensional hydraulic model calibration analysis and validation analysis.
A summary of the flow inputs used in the calibration and validation analysis is provided in the subsequent hydraulic model boundary conditions discussion.

CVHS Historic Patterns and Design Storm Scalings

Input time series data for evaluating the 16% ACE (6-year), 1% ACE (100-year), and 0.5% (200-year) design storms for existing conditions and future cumulative conditions were developed using information previously prepared by DWR for the LEBLS project (DWR, 2017c) and BWFS (DWR, 2016), respectively. These hydrology datasets were prepared using data and tools originally developed for the Central Valley Hydrology Study (CVHS) completed by the USACE and DWR in 2013. The CVHS-based hydrology uses historic storm patterns, scaled to correspond to statistically-determined return period flows. As part of the BWFS, DWR analyzed 120 scaled event simulations, and identified the 1997 storm pattern as being the dominant pattern in this part

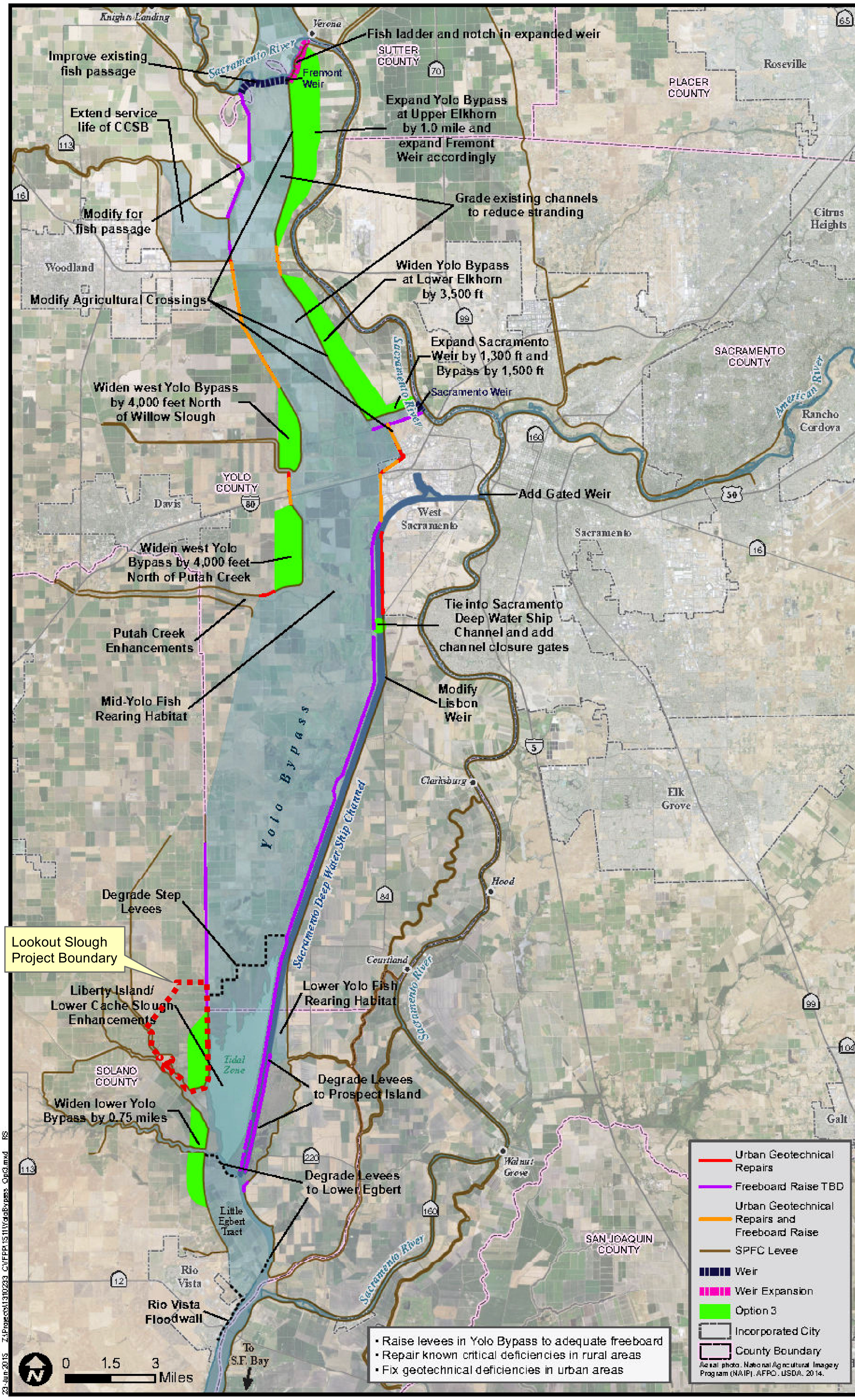


Figure 7
Future Cumulative Condition (BWFS Yolo Bypass Option 3)

Lookout Slough Tidal Habitat Restoration and Flood Improvement Project

Ecosystem Investment Partners

Prepared by: ESA

Map Prepared Date: 8/25/2019
Map Prepared By: JPritchard
Base Source: Wood Rogers
Base Date: 10/24/17
Data Source(s): DWR, 2016

Path: U:\GIS\GIS\Projects\18xxxx\D181197_00_Lookout_Slough_Restoration_1\03_MXDs_Projects\02_Flood_Task_System_HandH\F07_BWFS_YB3.mxd

This page intentionally left blank

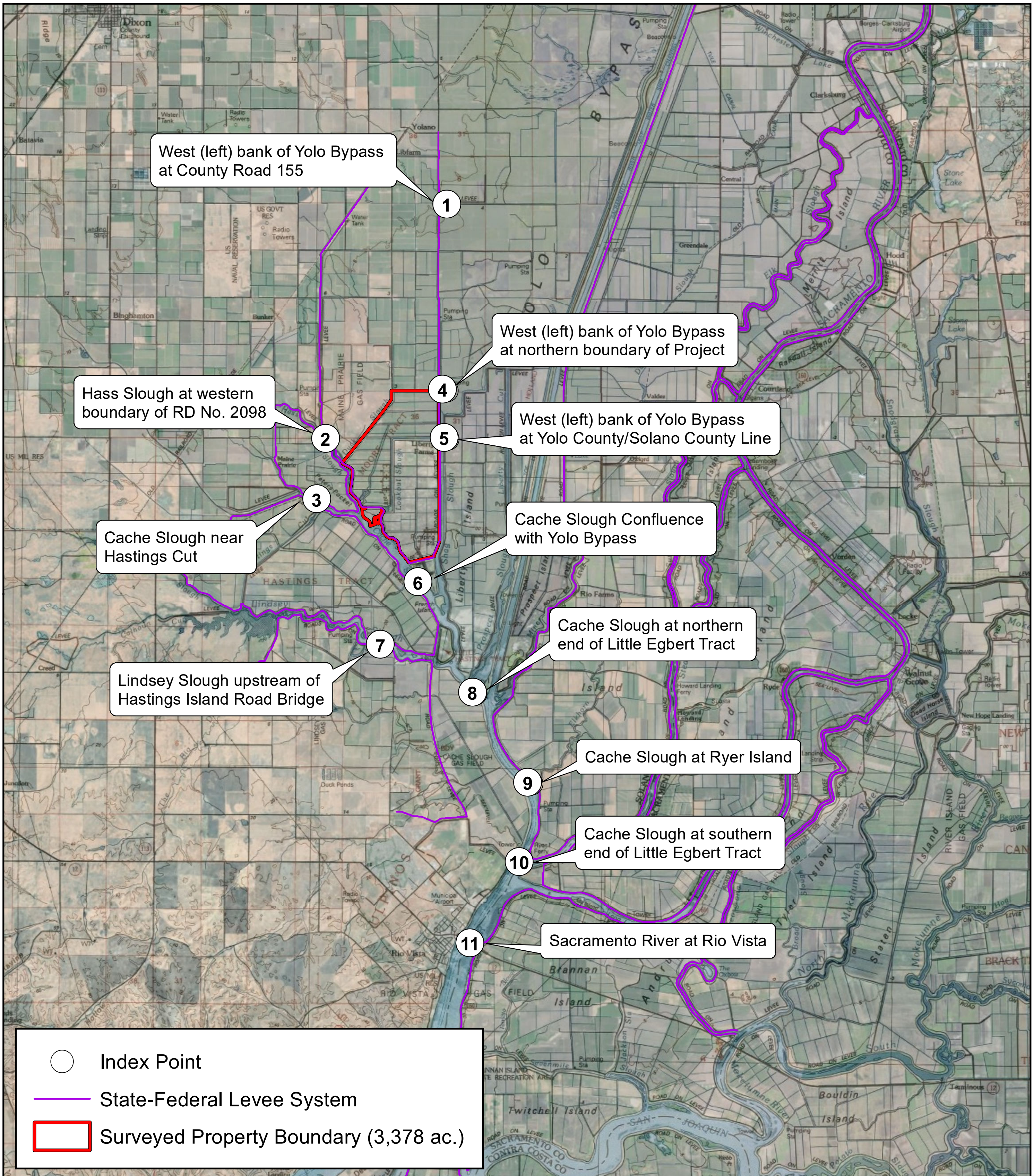


Figure 8
Index Points

Lookout Slough Tidal Habitat Restoration and Flood Improvement Project

0 7,500 15,000
Feet

Ecosystem Investment Partners

Prepared by:
ESA

Map Prepared Date: 4/8/2019
Map Prepared By: JPritchard
Base Source: Wood Rogers
Base Date: 10/24/2017
Data Source(s):

Path: U:\GIS\GIS\Projects\18xxxx\D181197_00_Lookout_Slough_Restoration_1\03_MXDs_Projects\02_Flood_Task_System_HandH\F08_Index_Points.mxd of the system. That effort was also used to identify the appropriate event scalings for the 16% ACE (6-year), 1% ACE (100-year), and 0.5% (200-year) design storms for application to the Yolo Bypass (**Table 2**).

TABLE 2
CVHS SCALED EVENTS USED FOR ANALYSIS (DWR, 2016 AND DWR, 2017B)

	ACE	Frequency	SAC 15 Yolo Bypass Downstream of Knights Landing Ridge Cut	SAC 35 Yolo Bypass Upstream of Sacramento Bypass	SAC 17A Yolo Bypass Downstream of I-80 Bridge
Combined Regulated Frequency Curve Peak Flows (cfs)	16%	6-year	176,034	186,957	208,737
	1%	100-year	389,277	407,333	501,046
	0.5%	200-year	426,163	446,532	549,582
CVHS Scale Factor (1997 Event Pattern)	16%	6-year	0.40	0.40	0.40
	1%	100-year	0.95	0.95	0.95
	0.5%	200-year	1.10	1.10	1.10
Event Based Peak Flows (cfs)	16%	6-year	176,032	178,600	209,286
	1%	100-year	390,720	406,613	505,024
	0.5%	200-year	431,324	446,800	561,626

A summary of the flow inputs used in the hydraulic design analysis is provided in the subsequent hydraulic model boundary conditions discussion.

Hydraulic Analysis

To address the complex interaction between Yolo Bypass flood flows and the tidal influences of the north Sacramento-San Joaquin Delta, a two-dimensional hydraulic model is necessary for supporting design of the Project. A description of the modeling approach, tools, supporting data, and system impacts assessment are provided in the following sections.

Parent-Child Model Nesting Concept

One cost-effective and computationally efficient technique that has been deployed successfully in numerical modeling applications is splitting computations between coarse, large scale region-wide models (parent models) and localized high-resolution subdomain areas (child models). It can often be useful to deploy this technique in series, whereby results from the parent model are used to define boundary conditions for the child model, particularly when the child model domain is defined appropriately so as to avoid erroneous biasing at the boundary conditions.

This report documents the development and analysis performed using a child model prepared specifically for design of the Project. Documentation associated with development and deployment of the parent model for establishing boundary conditions in the child model have been referenced where applicable.

Parent Hydraulic Model

One-dimensional HEC-RAS system models prepared previously by DWR were utilized as the parent models for this study. Data from the BWFS, incorporating downstream tidal dynamics was used for representing the Baseline Condition (DWR, 2016). Data from the BWFS recommended alternative for expanding the Yolo Bypass (Yolo Bypass Option 3) was utilized to represent the Future Cumulative Condition (DWR, 2016). The Baseline Conditions modeling of the Sacramento River system extends from Hamilton City to Collinsville, and includes the major tributary systems (Feather River and American River). The future cumulative conditions model is truncated above the Sutter Bypass and Tisdale Bypass systems, but otherwise covers the same geographic area as the existing conditions system model. The geographic coverage and quality of calibration make these models well suited as a source for establishing boundary conditions for a localized site-specific model.

Child Hydraulic Model

For on-site design, a high resolution two-dimensional child model was developed using the TUFLOW commercial software package. The child model builds upon and expands the calibrated two-dimensional model previously developed for analyzing and supporting design of the Project's tidal restoration components. This approach was reviewed during pre-coordination with the Hydraulics Section of the USACE Sacramento District, and is considered appropriate for advancing the Project through the USACE Section 408 Permit process. TUFLOW was approved for use and added to the USACE Hydrology, Hydraulics, and Coastal Software List in 2012, and both DWR and the USACE Sacramento District have expert staff trained in use and review of the software. For this project, the TUFLOW HPC (Heavily Parallelized Compute) finite volume solver has been used, allowing the software to run in simulation on NVidia GPU hardware. All modeling prepared for the Project utilizes the latest software version of TUFLOW (Build: 2018-03-AD-iSP-w64).

The relative extents of the parent and child models are shown on **Figure 9** and **Figure 10**. The child model boundaries are located at appropriate handoff points correlating with cross-sections in the respective one-dimensional HEC-RAS parent models. Boundary locations in the child model were selected to minimize distortions in the area of interest, and at locations where flow and stage could be discretized appropriately to avoid misrepresenting data received from the parent model. Upstream flows routed through the respective parent models are compiled at each of these locations and used as inputs to the TUFLOW model. Likewise, the modeled stage time series data output from the HEC-RAS system is used to define the downstream stage boundary of the TUFLOW model.

Hydraulic Model Development

The following section describes the model extents, general construction of the TUFLOW hydraulic model and input data sources, calibration and validation of the model to observed data, and application of the model for evaluating the project design.

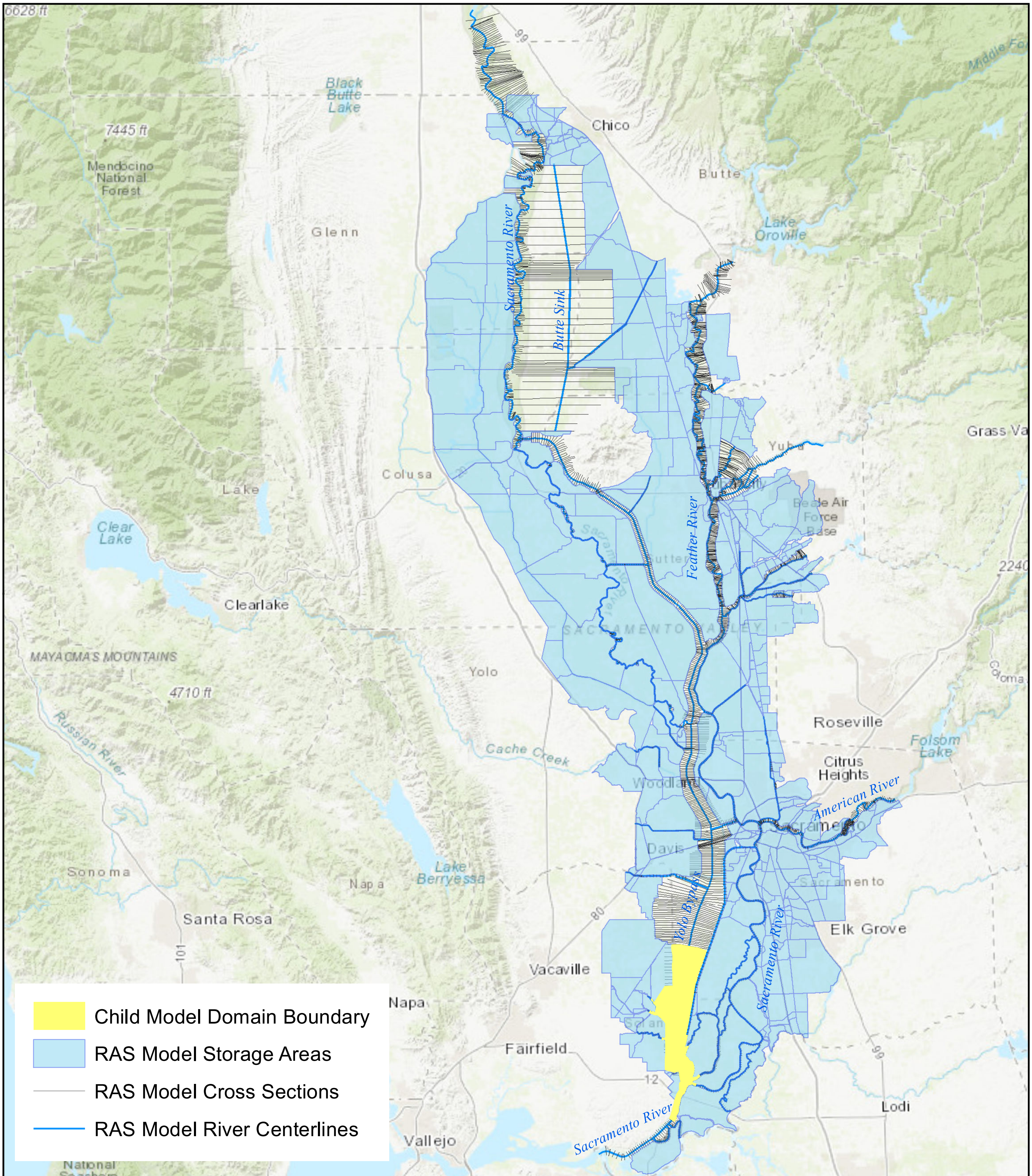


Figure 9
Parent-Child Model Schematic (Baseline Condition)

Lookout Slough Tidal Habitat Restoration and Flood Improvement Project

0 7.5 15
Miles

Ecosystem Investment Partners

Map Prepared Date: 4/8/2019
Map Prepared By: JPritchard
Base Source: Wood Rodgers
Base Date: 10/24/2017
Data Source(s):
DWR
ESRI Service Layers

Prepared by:
ESA

Path: U:\GIS\GIS\Projects\18xxxx\D181197_00_Lookout_Slough_Restoration_1\03_MXDs_Projects\02_Flood_Task_System_HandH\F09_Parent_Child_Schematic_Baseline.mxd

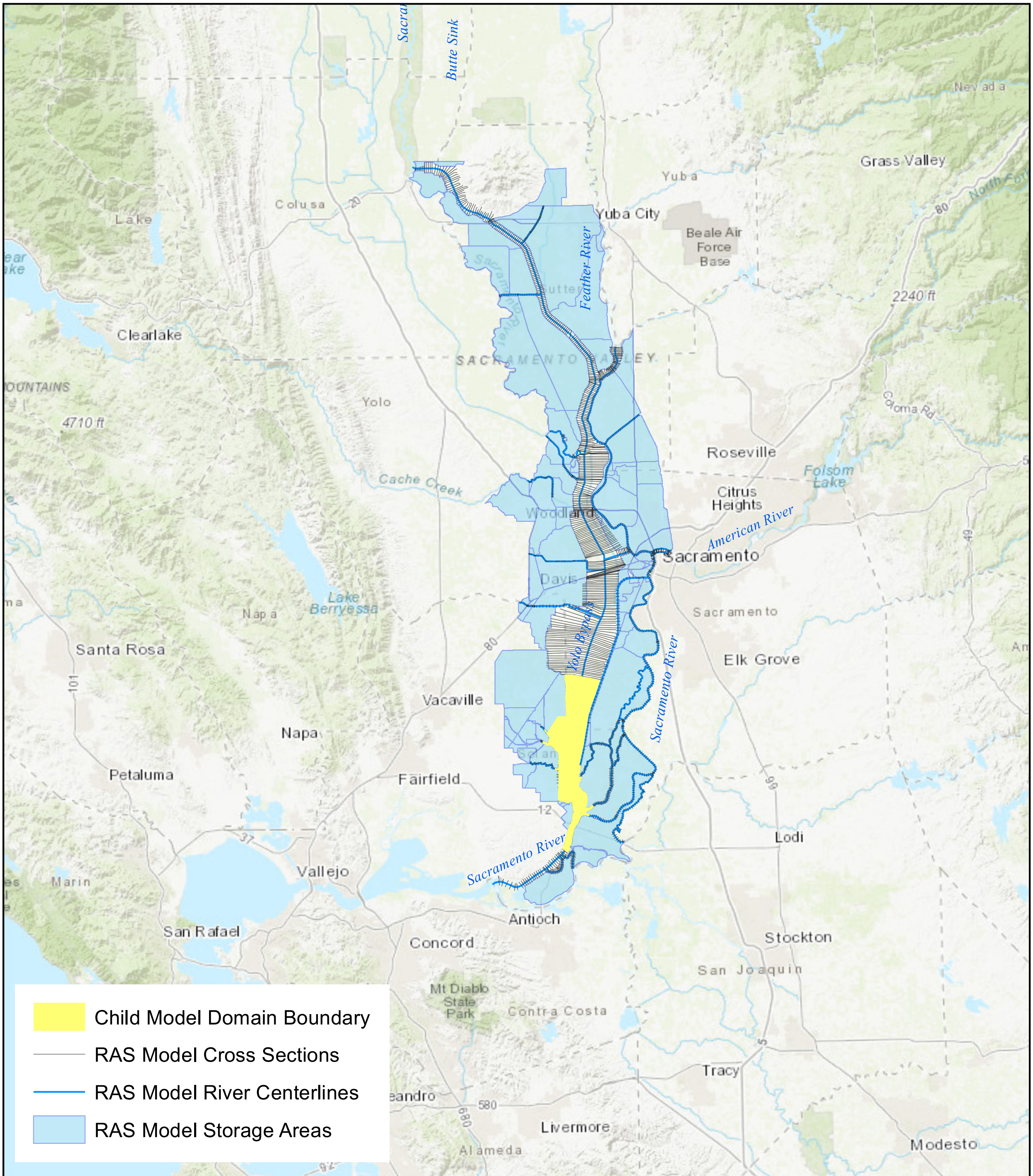


Figure 10
Parent-Child Model Schematic (Future Cumulative Condition)

Lookout Slough Tidal Habitat Restoration and Flood Improvement Project

0 7.5 15
Miles

Ecosystem Investment Partners

Map Prepared Date: 4/8/2019
Map Prepared By: Brent Davis
Base Source: Wood Rodgers
Base Date: 10/24/2017
Data Source(s):
DWR
ESRI Service Layers

Prepared by:
ESA

Path: U:\GIS\GIS\Projects\18xxxx\D181197_00_Lookout_Slough_Restoration_1\03_MXDs_Projects\02_Flood_Task_System_HandH\F10_Parent_Child_Schematic_Future_Cumulative_Condition.mxd

The TUFLOW hydraulic model utilizes a grid resolution of 60 feet, which was selected based on sensitivity and solution-convergence testing. The grid resolution has been optimized to balance output requirements with computational efficiency and model stability. Quality assurance checks have been conducted to ensure that the model performs within recommended tolerances for numerical stability and mass balance for all simulations.

Geographic Extents

The TUFLOW model domain boundary is shown in **Figure 11**. The northern boundary of the model domain is located on the Yolo Bypass, approximately 5 miles north of Liberty Island Road (the northern boundary of the Project). The eastern edge of the model domain is bounded by the east levee of the Yolo Bypass, and wraps around to include the lower end of the Sacramento River Deep Water Ship Channel, and tracks southward to intercept the confluences with Miner Slough, Steamboat Slough, and the Sacramento River near Rio Vista. The western edge of the model domain covers the Project boundary up to Duck Slough; lower Hass Slough and Cache Slough above where these streams form a confluence at the southeastern tip of the Peters Pocket track; and also includes the lower portion of Lindsey Slough beginning approximately 1 mile above Hastings Island Bridge. The southern (downstream) boundary is located upstream of the Sacramento River's confluence with Three Mile Slough.

The model domain extents have been defined sufficiently far from the area of interest to avoid the influence of numerical artifacts at the model domain boundaries. Care has been taken to avoid setting the model domain boundary beyond the extents of regional parent models and to avoid excessively complicating the model boundary set up by reaching further than necessary into the overall system.

Boundary Conditions

Figure 12 shows the locations of the TUFLOW model boundary conditions. The model boundaries can be generally summarized as follows:

- Tidal boundary at the Sacramento River above Three Mile Slough
- Flow at Yolo Bypass near Yolano
- Flow at Sacramento River Deep Water Ship Channel
- Flow at Hass Slough
- Flow at Cache Slough
- Flow at Miner Slough
- Flow at Lindsey Slough
- Flow at Steamboat Slough
- Flow at Sacramento River

All flow time-series data at the boundary conditions locations was sourced from the respective HEC-RAS parent model output (provided by DWR in *.dss database format).

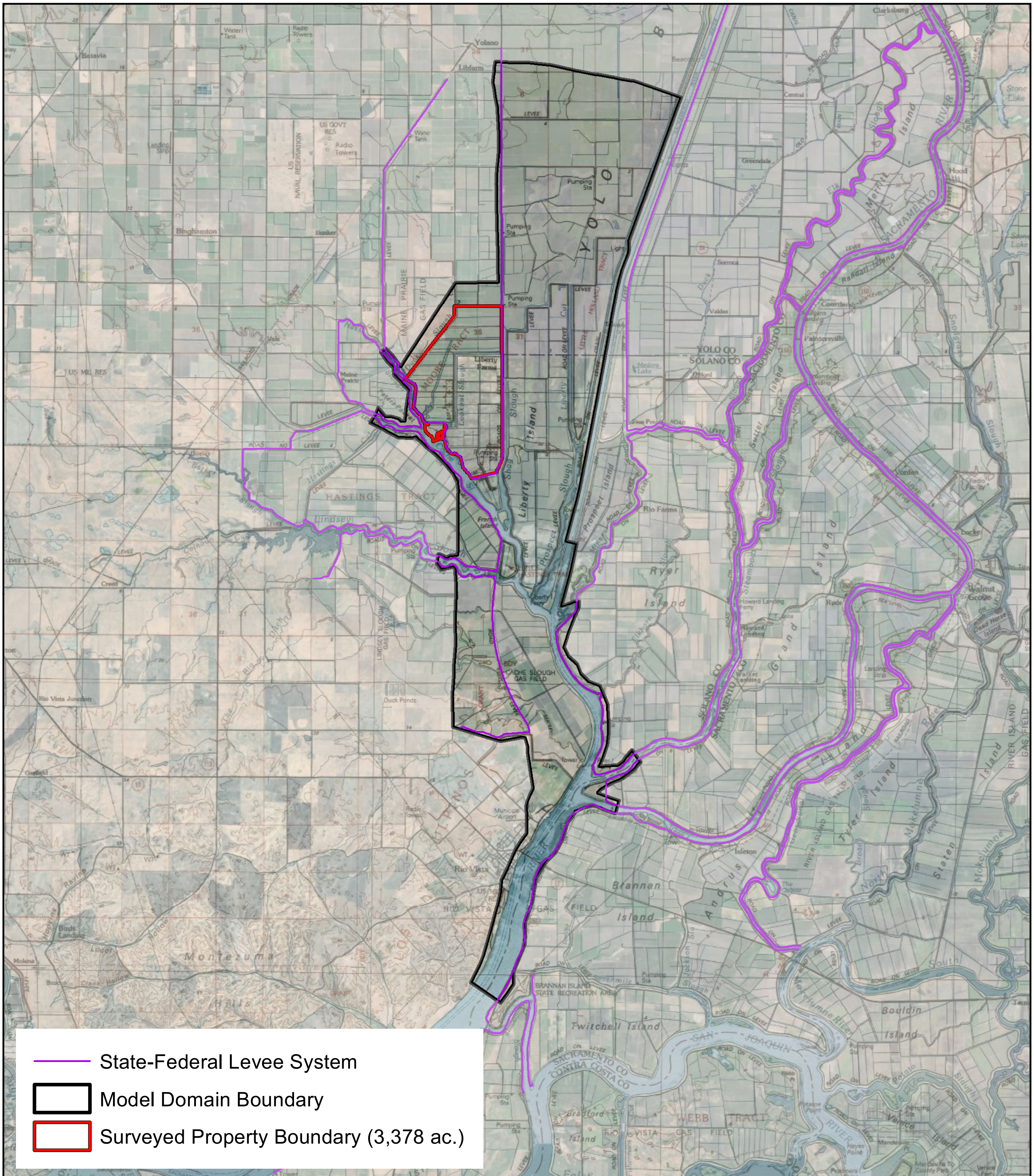


Figure 11
TUFLOW Model Boundary Extents

Lookout Slough Tidal Habitat Restoration and Flood Improvement Project

0 7,500 15,000
Feet

Ecosystem Investment Partners

Prepared by:
ESA

Map Prepared Date: 4/8/2019
Map Prepared By: JPritchard
Base Source: Wood Rogers
Base Date: 10/24/2017
Data Source(s):

Path: U:\GIS\GIS\Projects\18xxxx\D181197_00_Lookout_Slough_Restoration_1\03_MXDs_Projects\02_Flood_Task_System_HandH\F11_TUFLOW_Boundary.mxd

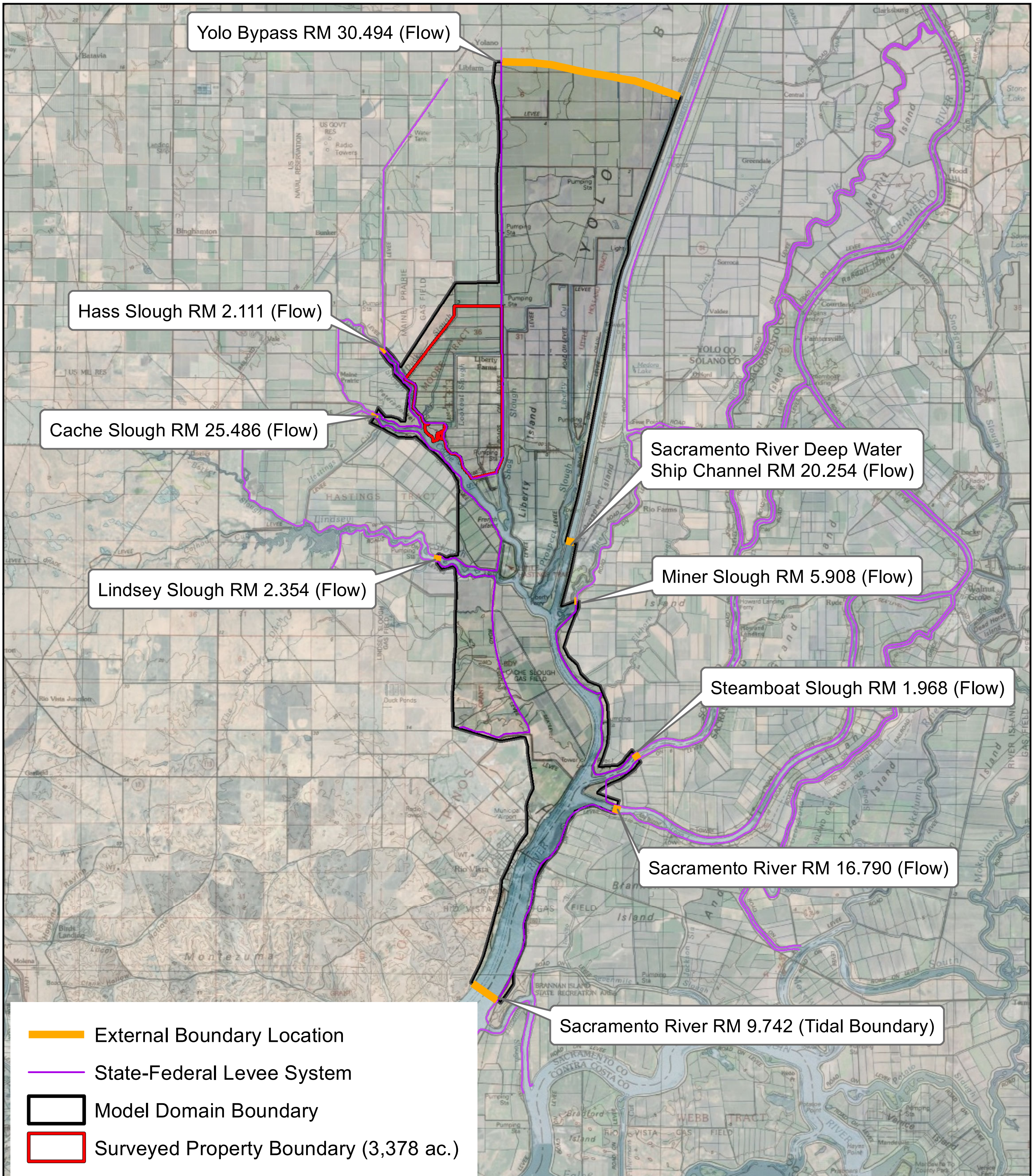


Figure 12
TUFLOW Model Boundary Conditions

Lookout Slough Tidal Habitat Restoration and Flood Improvement Project

Ecosystem Investment Partners

Prepared by:
ESA

Map Prepared Date: 4/8/2019
Map Prepared By: JPritchard
Base Source: Wood Rogers
Base Date: 10/24/2017
Data Source(s):

Path: U:\GIS\GIS\Projects\18xxxx\D181197_00_Lookout_Slough_Restoration_1\03_MXDs_Projects\02_Flood_Task_System_HandH\F12_TUFLOW_BC_Locations.mxd

For modeling downstream tidal boundary conditions in the calibration and validation simulations, historic records from the 1997 and 2006 storm periods were used to define dynamic stage time series at the extremities of the HEC-RAS parent model.

For the design storm events, two approaches were utilized for representing the tidal boundary conditions at the downstream end of the system. The 1% ACE (100-year) and 0.5% ACE (200-year) events were modeled using a dynamic tidal time series derived from routing the CVHS hydrology through the RMA Delta model (DWR, 2016). For the 16% ACE (6-year) simulations, a dynamic stage boundary was not provided, and a fixed water surface was used at each of the tidal boundaries instead. The simulated 16% ACE stage was derived from stage-frequency analysis of the respective gages at the Sacramento River at Collinsville, Georgiana Slough at Mokelumne River, and Three Mile Slough at San Joaquin River (**Appendix A**). For ease of interpretation, the 10% (10-year) downstream stage was used as the basis for analyzing the 16% ACE (6-year) storm event. Although this assumption is somewhat conservative, it only results in differences of approximately 0.5 feet at the downstream boundaries, and is not anticipated to have a significant effect on the results in the vicinity of the Project. The peak stages in the dynamic time series for the 1% ACE (100-year) and 0.5% ACE (200-year) were also reviewed and found to be in close agreement with the corresponding stage-frequency relationships computed at each of the downstream boundary locations.

Modeling of the 1957 authorized design condition in the TUFLOW child model did not require use of the parent model for boundary conditions. To establish a downstream boundary for the authorized design condition, a static water surface was interpolated from the authorized 1957 design profile on the Sacramento River downstream of Rio Vista.

Table 3 summarizes the peak flow or stage values at each boundary location for the respective hydrology scenarios.

This Page Intentionally Left Blank

TABLE 3
BOUNDARY CONDITION SUMMARY (PEAK FLOW AND STAGE SUMMARY)

			Calibration and Validation		Baseline Condition			Future Cumulative Condition		
Source	**HEC-RAS Cross-Section Handoff Designation**	**1957 Authorized Design Flow and Profile**	**1997 Historic Storm Calibration Simulation**	**2006 Historic Storm Validation Simulation**	**1997 Pattern 40% Scaling 16% ACE (6-year)**	**1997 Pattern 95% Scaling 1% ACE (100-year)**	**1997 Pattern 110% Scaling 0.5% ACE (200-year)**	**1997 Pattern 40% Scaling 16% ACE (6-year)**	**1997 Pattern 95% Scaling 1% ACE (100-year)**	**1997 Pattern 110% Scaling 0.5% ACE (200-year)**
Yolo Bypass	YOL R03 RM 30.494	490,000 cfs	458,781 cfs	272,026 cfs	206,944 cfs	489,525 cfs	544,481 cfs	242,064 cfs	472,014 cfs	521,124 cfs
Sacramento River Deep Water Ship Channel	SAD R01 RM 20.254	N/A	15,219 cfs	16,881 cfs	1,063 cfs	14,984 cfs	12,420 cfs	1,935 cfs	18,255 cfs	19,257 cfs
Hass Slough	HAS R01 RM 2.111	N/A	2,524 cfs	840 cfs	169 cfs	1,965 cfs	2,057 cfs	177 cfs	2,546 cfs	1,896 cfs
Cache Slough	CAS R04 RM 25.486	N/A	2,363 cfs	522 cfs	118 cfs	2,535 cfs	2,545 cfs	129 cfs	993 cfs	1,952 cfs
Miner Slough	MIN R01 RM 5.908	10,000 cfs	18,681 cfs	14,422 cfs	10,687 cfs	18,125 cfs	19,119 cfs	10,627 cfs	12,559 cfs	12,879 cfs
Lindsey Slough	LIN R01 RM 2.354	N/A	3,691 cfs	4,292 cfs	541 cfs	2,826 cfs	2,799 cfs	569 cfs	4,713 cfs	3,226 cfs
Steamboat Slough	STM R01 RM 1.968	43,500 cfs	34,002 cfs	27,216 cfs	25,657 cfs	35,508 cfs	37,400 cfs	25,801 cfs	30,970 cfs	32,645 cfs
Sacramento River (Inflow)	SAC R05 RM 16.790	35,900 cfs	46,101 cfs	42,430 cfs	40,444 cfs	47,130 cfs	48,655 cfs	40,596 cfs	41,490 cfs	42,504 cfs
Sacramento River (Downstream Stage, NAVD 88)	SAC R04 RM 9.742	11.51 feet	9.82 feet	9.39 feet	9.13 feet	10.11 feet	10.43 feet	8.94 feet	10.24 feet	10.60 feet

This page intentionally left blank.

Topographic and Bathymetric Survey Data

Terrain data for this project is based on the following data sources, which are layered in the hydraulic model input to build a composite bathymetric and terrain surface:

- The primary terrain data source representing existing terrain for the southern portion of the model domain is based on the DWR *San Francisco Bay and Sacramento-San Joaquin Delta DEM* (Wang & Ateljevich, 2012) which aggregates a number of data sources. In the vicinity of the Project, coverage consists primarily of Delta Risk Management Strategy (DRMS) LiDAR data (Dudas, 2010) and the Liberty Island single beam bathymetric surveys prepared by cbec/EDS in 2006, 2009, and 2010. Elevation data was prepared by DWR in 10m DEM format (Esri Grid) in units of centimeters, referenced to NAVD 88. For purposes of preparing the model input, the elevation data was converted to units of feet and re-projected to California State Plane II FIPS 0402 (US Feet) for consistency with the Project datum, and clipped to a smaller extent to reduce the overall data footprint and terrain processing overhead.

- The DRMS LiDAR dataset (Dudas, 2010) was used to fill in gaps in some of the low confidence marsh areas on Liberty Island. Wood Rodgers utilized DRMS tiles which were post-processed as part of DWR's CVFED Program to create "patch" areas to improve the terrain representation in these areas. The CVFED post-processed tiles incorporate breaklines to enforce edges of water bodies and avoid undesired interpolation across large flat areas.

- The DRMS and CVFED LiDAR datasets were also used to provide a continuous surface inside the Yolo Bypass north of Liberty Island and west of the Toe Drain.

- USGS conducted bathymetric surveys of the Little Holland Tract area in 2015 (Snyder et al., 2016). Data was provided in NAD 83 UTM Zone 10 coordinates in units of meters. Elevations were provided in units of meters referenced to NAVD 88. Wood Rodgers re-projected the data to California State Plane II FIPS 0402 (US Feet) using ArcGIS. Elevation values were converted using the ArcGIS Spatial Analyst extension (vertical metric conversion to feet using ArcGIS Times function: 1m = 3.28084 feet).

- DWR's North Central Regional Office (NCRO) provided bathymetric survey data collected in 2015 along the northern "steps" of Liberty Island. This data was provided in NAD83, California State Plane II FIPS 0402 (US Feet) coordinates and referenced to NAVD 88 in units of feet. No additional processing was required.

- To correct for isolated issues identified in the *San Francisco Bay and Sacramento-San Joaquin Delta DEM* surface, some locations were replaced with data from the DWR Bay-Delta Office Cross Section Development Program (CSDP).

- At the project site, new topographic surveys flown by Wood Rodgers were used to define without-Project conditions. This data was collected and mapped in NAD 83, California State Plane II FIPS 0402 (US Feet) and referenced to NAVD 88 in units of feet, consistent with the Project datums. Field surveys were also performed to rectify aerial survey data in marsh areas within the Liberty Farms tract.

The TUFLOW topographic layering hierarchy was input as follows (layers listed in order from the "top" of the stack, to "bottom"):

1. San Francisco Bay and Sacramento-San Joaquin Delta DEM (Wang & Ateljevich, 2012)
2. DRMS LiDAR DEM (Dudas, 2010)
3. Little Holland Tract DEM (Snyder et al., 2016).
4. Liberty Cut bathymetry survey DEM (DWR NCRO, 2015)
5. CSDP Bathymetry for localized bathymetry corrections (DWR Bay-Delta Office, 2001)
6. On-site topography (aerial and bathymetry) collected in Fall 2017 by Wood Rodgers. For the with-Project scenarios, a preliminary grading surface reflecting the proposed marsh grading plan and tidal channel network replaces the onsite topography.

The geographic distribution of the respective terrain layer datasets is shown on **Figure 13**.

Terrain Enforcement

The DWR Delta DEM surface exhibits areas with erroneous elevations or missing data. These areas are filled/cleaned using TUFLOW's topographic layering tools to generate TIN surfaces which eliminate gaps and clean up erroneous data values in the terrain.

Using the 3D breaklines prepared previously as part of DWR's CVFED LiDAR surveying efforts and data contained in the DWR California Levee Database (DWR, 2010) as a base, a comprehensive breakline dataset was developed to enforce the tops of levees and embankments within the domain area. In some cases, manual edits were made to better align the line work with tops of embankments considered hydraulically significant. The California Levee Database line work was then densified to intervals of 30 feet (roughly half the cell size of the computational grid) and converted to points using ArcGIS, which were then assigned elevations using the SF Bay SJ Delta DEM surface. The CVFED 3D breaklines already contained elevation values and were converted to points accordingly. The respective breakline datasets used to enforce terrain in the model are shown on Figure 12. The resultant composite terrain and bathymetry surface utilized in the respective model scenarios is shown on **Figure 14** through **Figure 17**.

Bed Roughness

Land use classifications derived from mapping prepared by the California Department of Fish and Game (now Fish and Wildlife, CDFW) in 2007 were aggregated into general land cover (materials) types for input into the baseline hydraulic model: subtidal, mudflats, low and middle marsh, upland, cropland, and riparian plantings proposed as part of the Project (WRA, 2019b). With the exception of cropland, these are generally associated with vegetation densities and depths that will be associated with different portions of the tidal prism (**Figure 18**), which are expected to be representative of conditions in the north Delta and lower Yolo Bypass. The crosswalk between CDFW vegetation and the model material type reclassification scheme used is summarized in **Table 4**.

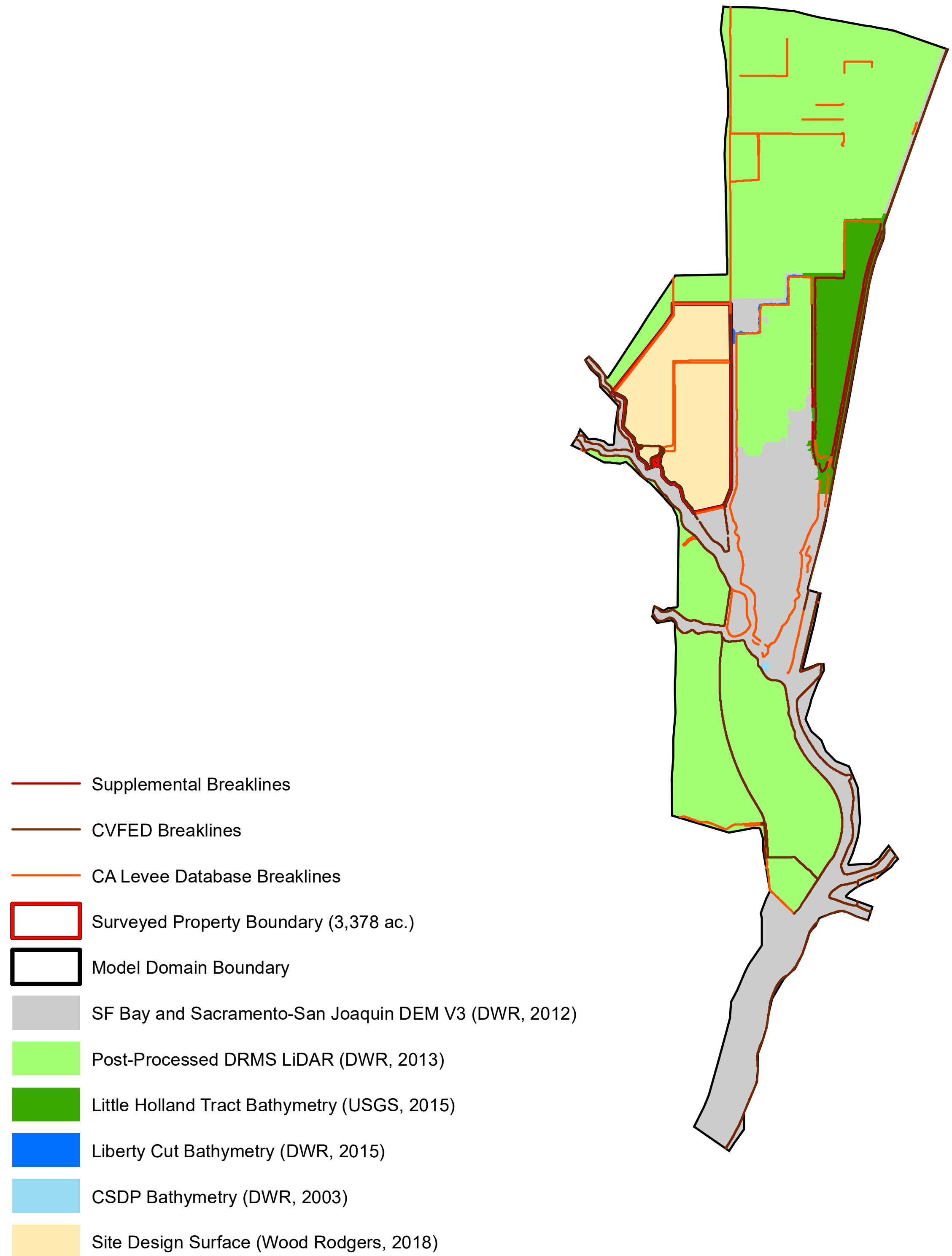


Figure 13
Topographic and Bathymetric Data Sources and Coverage

N W E S

0 7,500 15,000
Feet

Lookout Slough Tidal Habitat Restoration and Flood Improvement Project

Ecosystem Investment Partners

Prepared by:
ESA

Map Prepared Date: 4/8/2019
Map Prepared By: JPritchard
Base Source: Wood Rodgers
Base Date: 10/24/2017
Data Source(s):
Esri Service Layers (2018)

Path: U:\GIS\GIS\Projects\18xxxx\D181197_00_Lookout_Slough_Restoration_1\03_MXDs_Projects\02_Flood_Task_System_HandH\F13_TUFLOW_Terrain_Sources.mxd

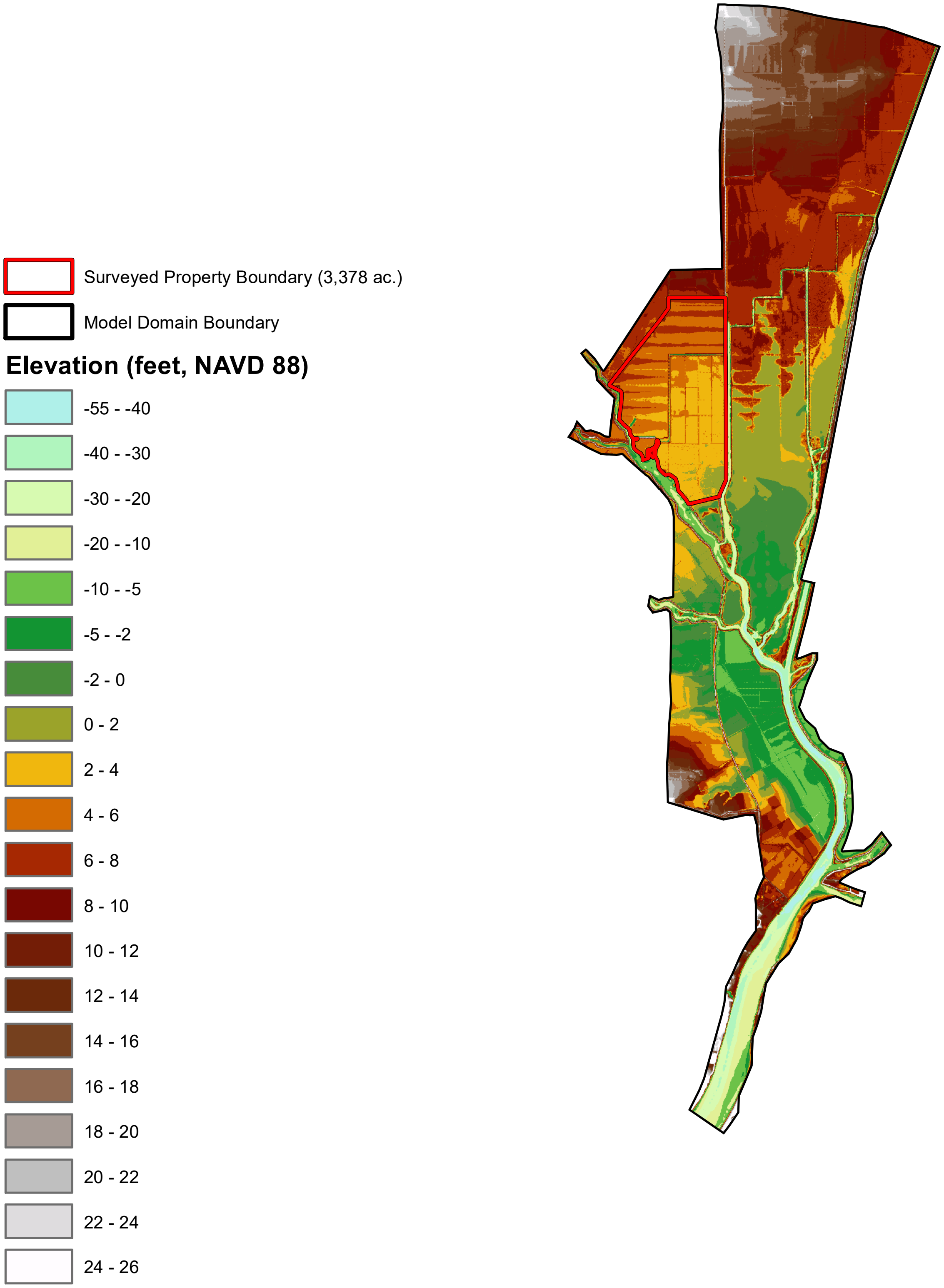


Figure 14
TUFLOW Composite Digital Elevation Model
Baseline Condition Without-Project

Lookout Slough Tidal Habitat Restoration
and Flood Improvement Project

Ecosystem Investment Partners

Map Prepared Date: 4/8/2019
Map Prepared By: JPritchard
Base Source: Wood Rodgers
Base Date: 10/24/2017
Data Source(s):
USGS, DWR, Wood Rodgers

Prepared by:
ESA

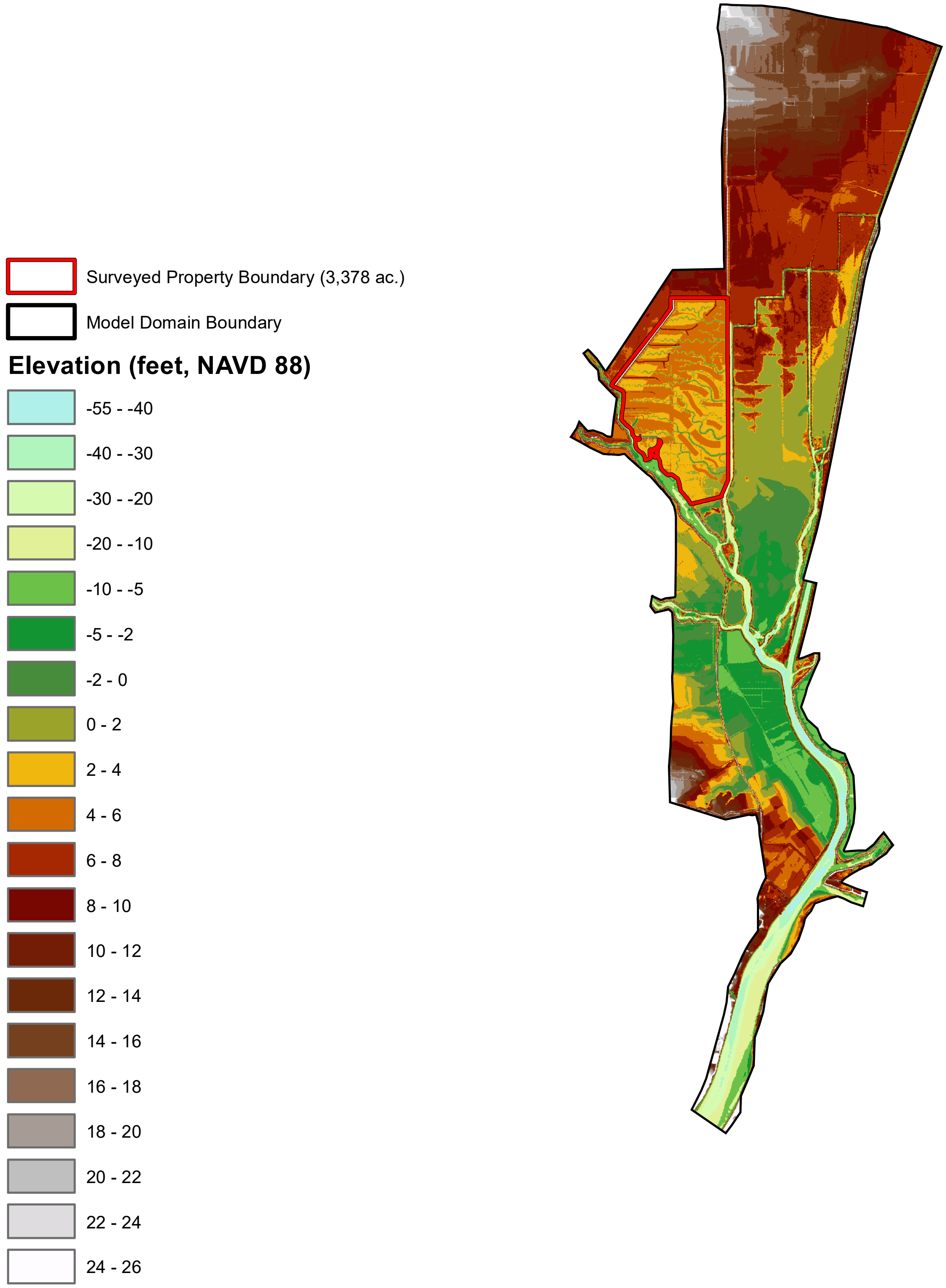


Figure 15
TUFLOW Composite Digital Elevation Model
Baseline Condition With-Project

N
W E
S

Ecosystem Investment Partners

Lookout Slough Tidal Habitat Restoration
and Flood Improvement Project

0 7,500 15,000
Feet

Map Prepared Date: 8/25/2019
Map Prepared By: JPritchard
Base Source: Wood Rodgers
Base Date: 10/24/2017
Data Source(s):
USGS, DWR, Wood Rodgers

Prepared by:
ESA

Path: U:\GIS\GIS\Projects\18xxxx\D181197_00_Lookout_Slough_Restoration_1\03_MXDs_Projects\02_Flood_Task_System_HandH\F15_TUFLOW_Terrain_Baseline_w_Project.mxd

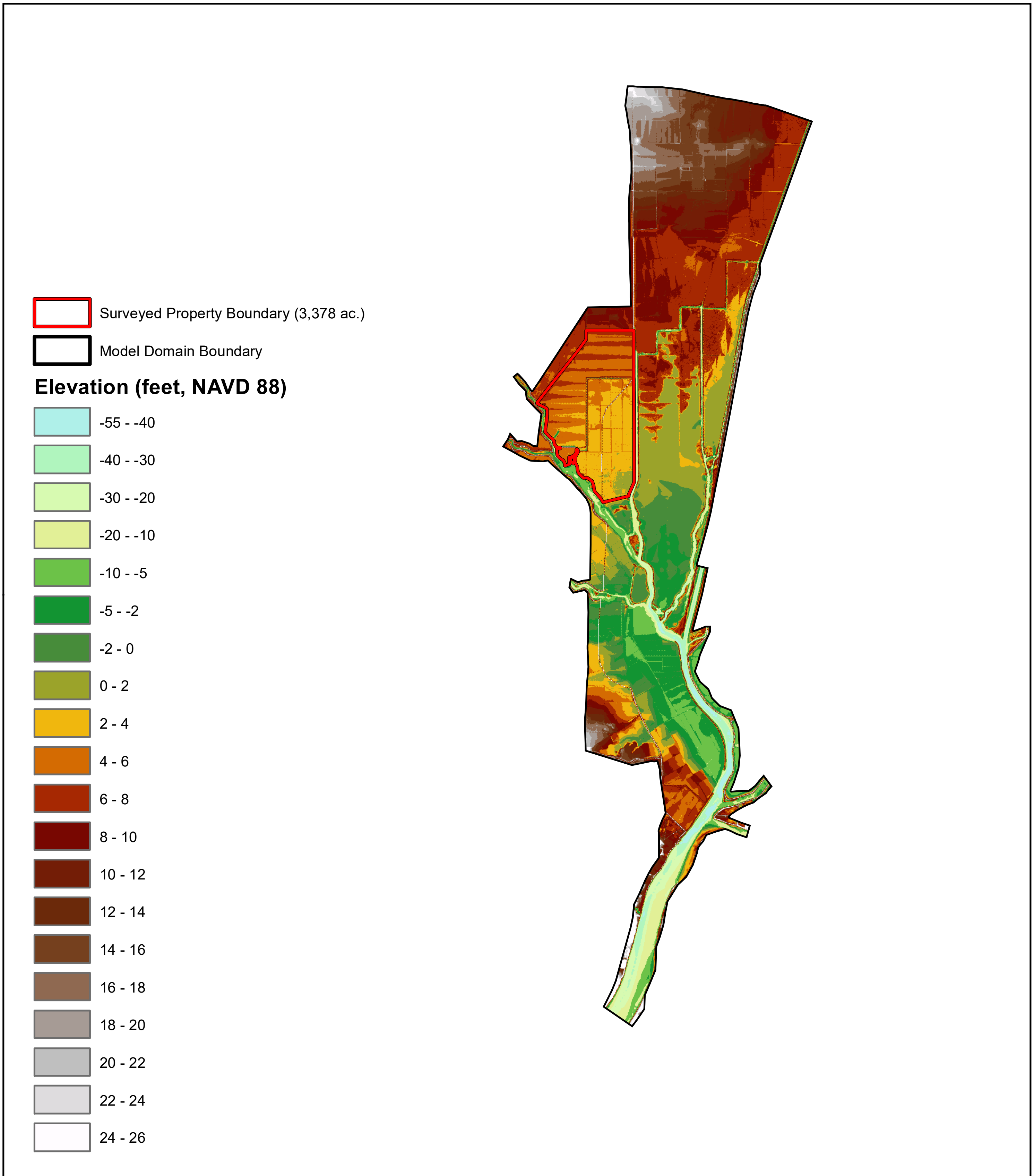


Figure 16
TUFLOW Composite Digital Elevation Model
Future Cumulative Condition Without-Project

Lookout Slough Tidal Habitat Restoration and Flood Improvement Project

Ecosystem Investment Partners

Prepared by: ESA

Map Prepared Date: 4/8/2019
Map Prepared By: JPritchard
Base Source: Wood Rodgers
Base Date: 10/24/2017
Data Source(s):
USGS, DWR, Wood Rodgers

Path: U:\GIS\GIS\Projects\18xxxx\D181197_00_Lookout_Slough_Restoration_1\03_MXDs_Projects\02_Flood_Task_System_HandH\F16_TUFLOW_Terrain_FCC_wo_Project.mxd

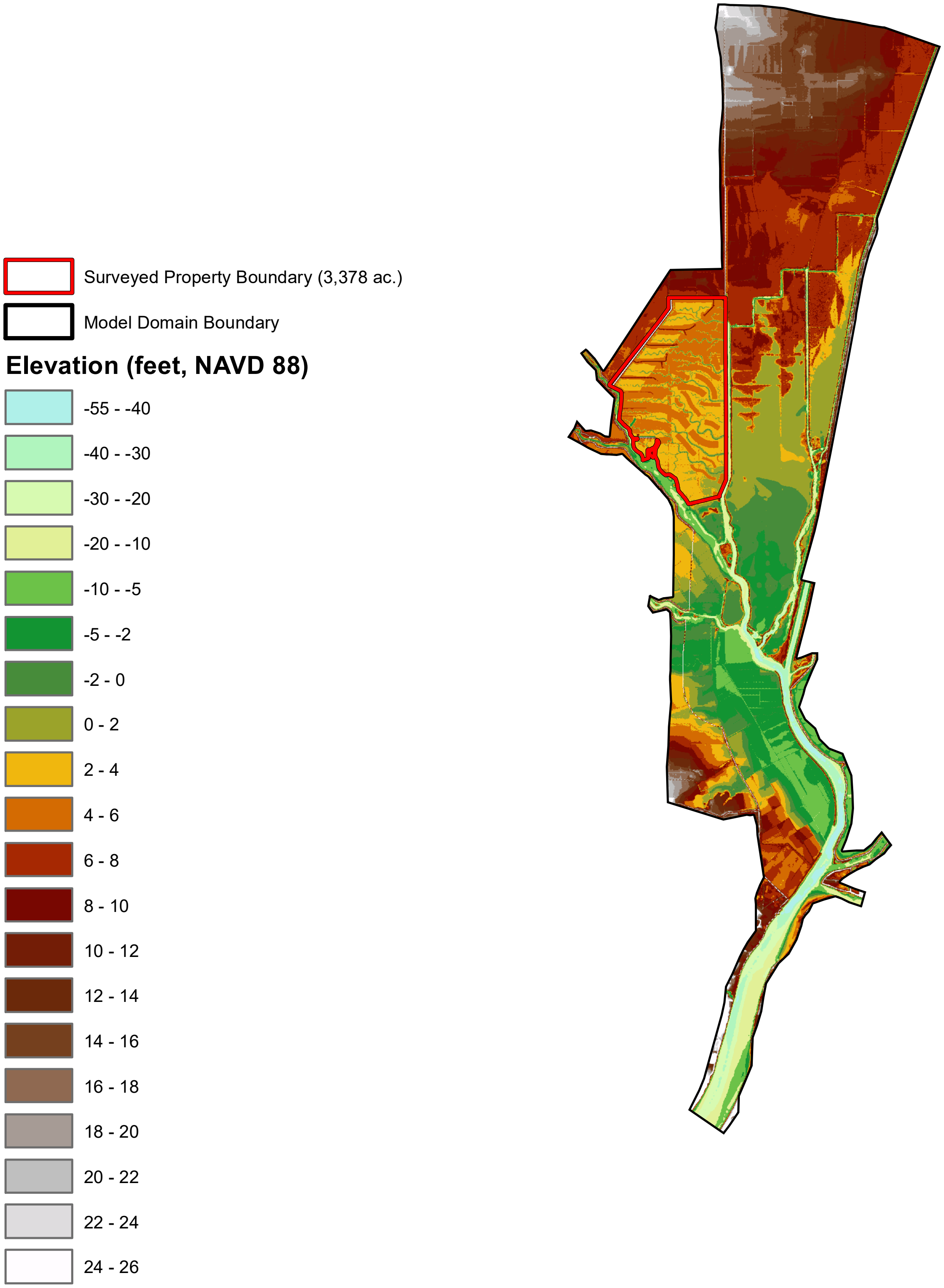


Figure 17
TUFLOW Composite Digital Elevation Model
Future Cumulative Condition With-Project

N
W E
S

Ecosystem Investment Partners

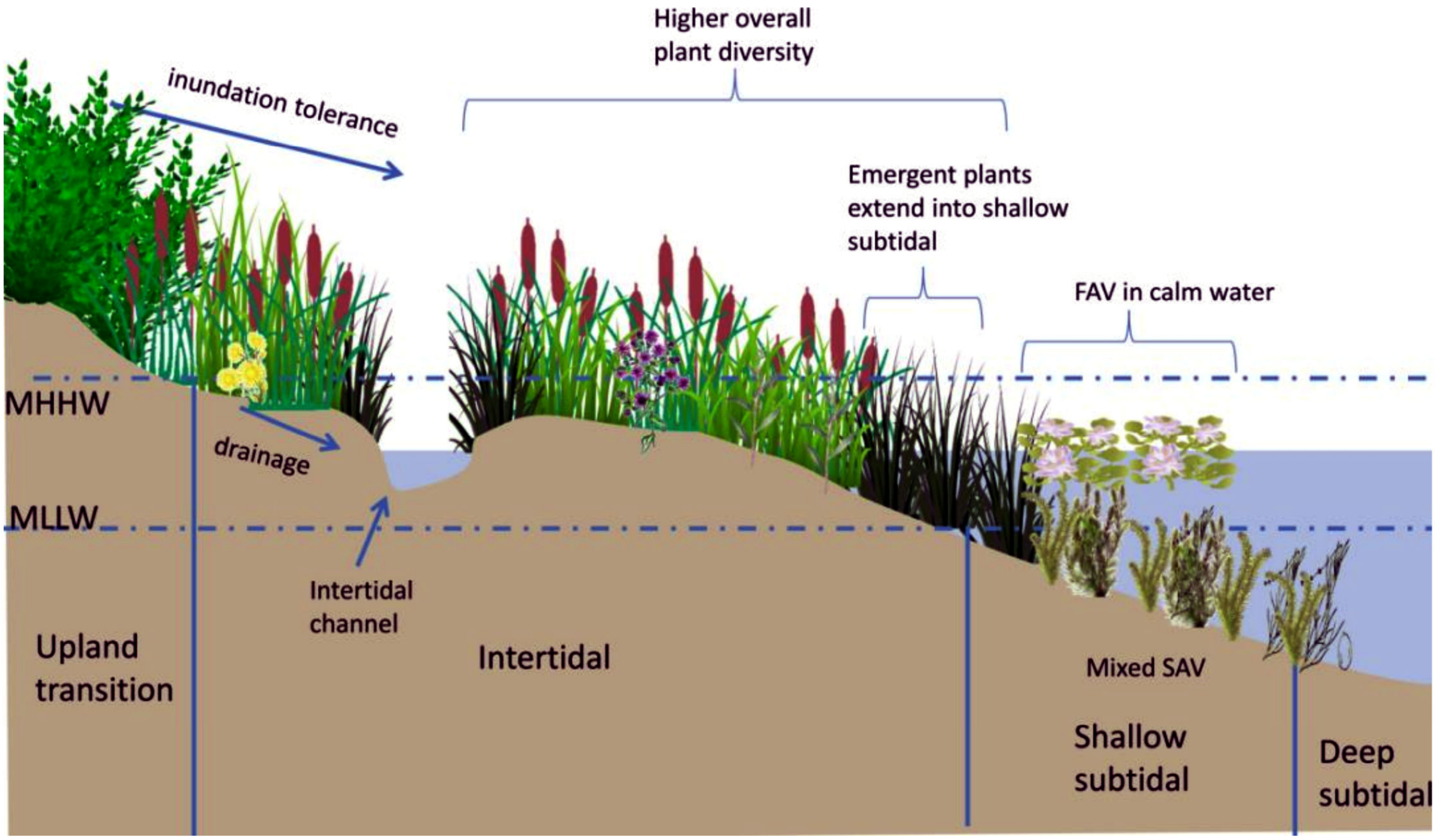
Lookout Slough Tidal Habitat Restoration and Flood Improvement Project

0 7,500 15,000
Feet

Map Prepared Date: 4/8/2019
Map Prepared By: JPritchard
Base Source: Wood Rodgers
Base Date: 10/24/2017
Data Source(s):
USGS, DWR, Wood Rodgers

Prepared by:
ESA

Path: U:\GIS\GIS\Projects\18xxxx\D181197_00_Lookout_Slough_Restoration_1\03_MXDs_Projects\02_Flood_Task_System_HandH\F17_TUFLOW_Terrain_FCC_w_Project.mxd



Note: FAV denotes floating aquatic vegetation, SAV denotes submerged aquatic vegetation.

Figure 18
General Factors Controlling Vegetation Zonation in Freshwater Marshes (Sherman et al, 2017)

Lookout Slough Tidal Habitat Restoration and Flood Improvement Project

Ecosystem Investment Partners

Map Prepared Date: 4/8/2019
Map Prepared By: JPritchard
Data Source(s):
Sherman et al (2017)

Prepared by:
ESA

Path: U:\GIS\GIS\Projects\18xxxx\D181197_00_Lookout_Slough_Restoration_1\03_MXDs_Projects\02_Flood_Task_System_HandH\F18_MarshProfile.mxd

TABLE 4
MODEL MATERIAL CLASSIFICATION KEY

California Wildlife Habitat Relationship[1]	TUFLOW Model Material Type
Unclassified	Upland
Annual Grassland	Mudflat/Grassland
Barren	Mudflat/Grassland
Coastal Oak Woodland	Upland
Coastal Scrub	Low and Middle Marsh
Cropland	Cropland
Deciduous Orchard	Cropland
Eucalyptus	Upland
Fresh Emergent Wetland	Low and Middle Marsh
Riverine	Riverine
Saline Emergent Wetland	Low and Middle Marsh
Urban	Upland
Valley Foothill Riparian	Upland
Vineyard	Cropland

1 SOURCE: CDFW, 2007.

In the hydraulic model, the default material assignment to the 2D domain is Open Water, representing a roughness coefficient of 0.023 to 0.027 (consistent with the HEC-RAS parent model, and refined during model calibration). Roughness coefficient values for the Mudflat and Grassland, Low and Middle Marsh, Upland, Cropland, and Riparian materials types were estimated using the procedure for floodplains described in USGS Water Supply Paper No. 2339 (USGS, 1989). **Table 5** summarizes the respective material classification scheme and associated roughness coefficient estimates.

TABLE 5
MANNING'S ROUGHNESS CLASSIFICATIONS

Vegetation Complex Type	Typical Vegetation	Manning's Roughness[1]	Elevation Range (feet, NAVD 88)
Open Water	Negligible (primarily open water)	0.023 – 0.027	< 2.0 (MLLW)
Mudflat and Grassland	Minor	0.035	2.0 – 3.5 (MTL)
Low and Middle Marsh	Perennial vegetation, dense stands of bulrushes (tules and cattails)	0.045 (*assumes marsh vegetation lies down during flood conditions*)	3.5 – 7.0 (MHHW)
Upland	Riparian vegetation	0.060	> 7.0 (Maximum Tide)
Cropland	Rice, field crops	0.030	> 7.0
Riparian Planting	Riparian trees and scrub	0.140	7.0 – 9.0

NOTES:
1 Manning's roughness coefficients estimated using USGS, 1989 and base values computed previously by RMA, 2013.

The resultant materials input file representing the Baseline without-Project condition is shown on **Figure 19**. This dataset is also used for the 2006 event validation analysis.

Prior to the January 1997 storm, land use on Liberty Island was primarily agriculture cover. For the 1997 event calibration analysis, the base land use classification input was modified to reflect this historic land cover condition, as shown on **Figure 20**.

For the with-Project condition, the Lookout Slough Restoration site will be converted from agricultural use to a mix of tule marsh and subtidal habitat. For the with-Project analysis, the base land use classification input was modified to reflect the proposed land cover condition, as shown on **Figure 21**.

Bridge Hydraulics

The only major bridge crossing included explicitly in the model is the State Route 12 bridge crossing the Sacramento River at Rio Vista. Results from the parent model indicate that losses through the bridge are generally minor (0.2 feet or less), and that the bridge will not go under pressure or overtop for the range of flows being evaluated. For purposes of this analysis, the standard TUFLOW layered bridge approach (BMT WBM, n.d.) was applied to reflect form losses at the bridge piers. Form losses for bridge piers were estimated based on pier shape and blockage area using standard bridge pier backwater computation procedures (FHWA, 1978). During model testing, head losses through the bridge were compared with results from the parent model and found to be similar for each of the studied design storm return frequencies.

The Liberty Island Road bridge crossing near the project site is also within the model domain, however it has been omitted from the modeling for purposes of this study. Although in the area of interest, the bridge occupies a very small portion of the floodplain (less than 4% of the total width of the Yolo Bypass), and is not considered hydraulically significant with respect to analyzing flood impacts of the project.

The Hastings Island Road bridge crossing Lindsey Slough is also located within the model domain. This bridge is located on a backwater reach and is not considered to be hydraulically significant with respect to analyzing the flood impacts of the project.

The bridge pier form loss coefficients used in this study are summarized in **Appendix B**.

Model Calibration and Validation

The hydraulic model was calibrated to record data from the January 1997 storm and validated using record data from the January 2006 storm, consistent with work done by DWR for the Sacramento River system (Wood Rodgers, 2015). In general, more data is available for the 1997 event in the form of high water mark observations. However, levee failures that occurred at Little Egbert Tract and on Liberty Island during the January 1997 storm introduce significant uncertainties in timing and routing of flows in the Cache Slough Complex.

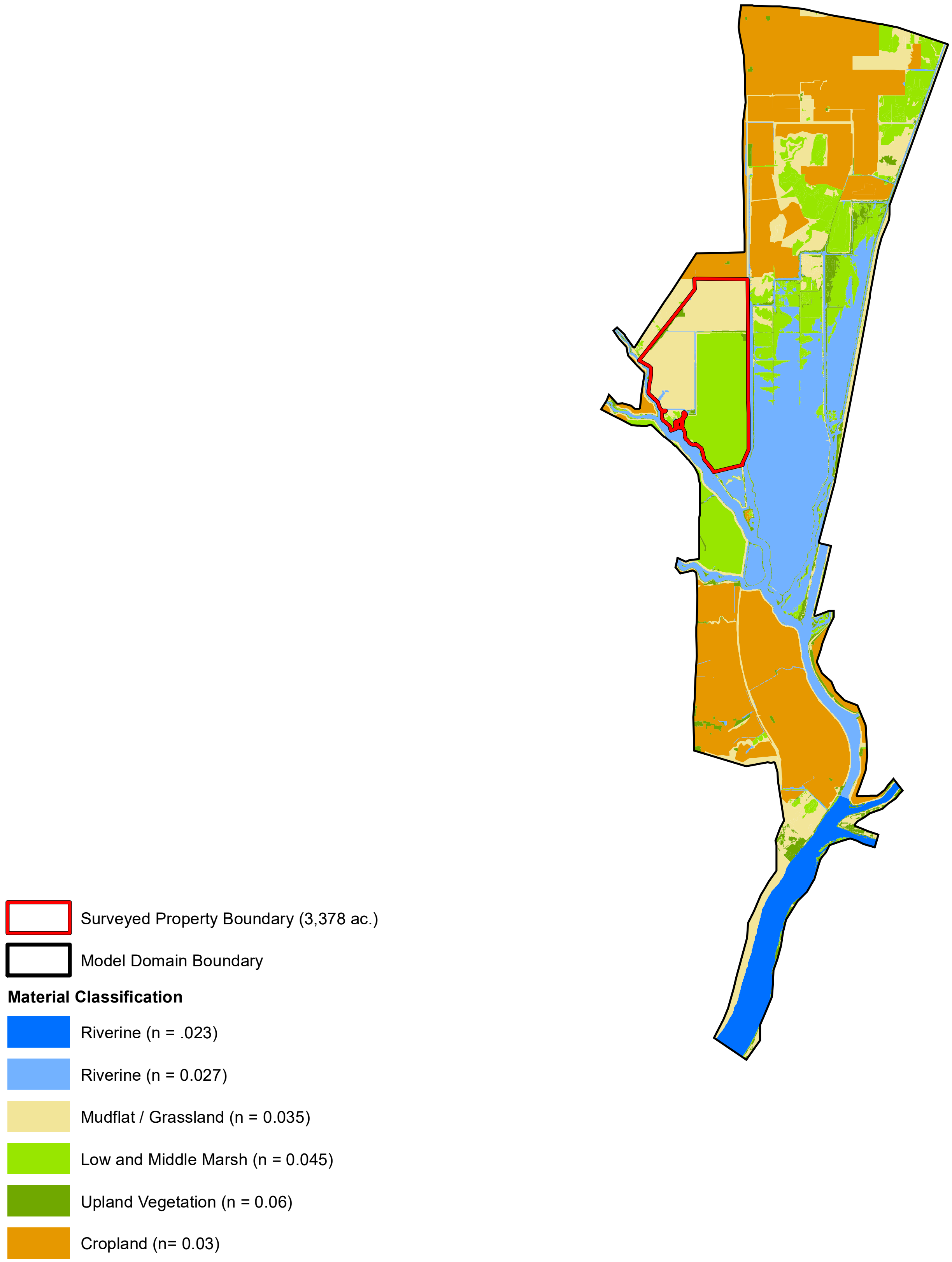


Figure 19
TUFLOW Without-Project Materials File

N
W E
S

Lookout Slough Tidal Habitat Restoration and Flood Improvement Project

0 7,500 15,000
Feet

Ecosystem Investment Partners

Map Prepared Date: 9/1/2019
Map Prepared By: JPritchard
Base Source: Wood Rodgers
Base Date: 10/24/2017
Data Source(s):
USGS, DWR, Wood Rodgers

Prepared by:
ESA

Path: U:\GIS\GIS\Projects\18xxxx\D181197_00_Lookout_Slough_Restoration_1\03_MXDs_Projects\02_Flood_Task_System_HandH\F19_TUFLOW_Materials_wo_Project.mxd

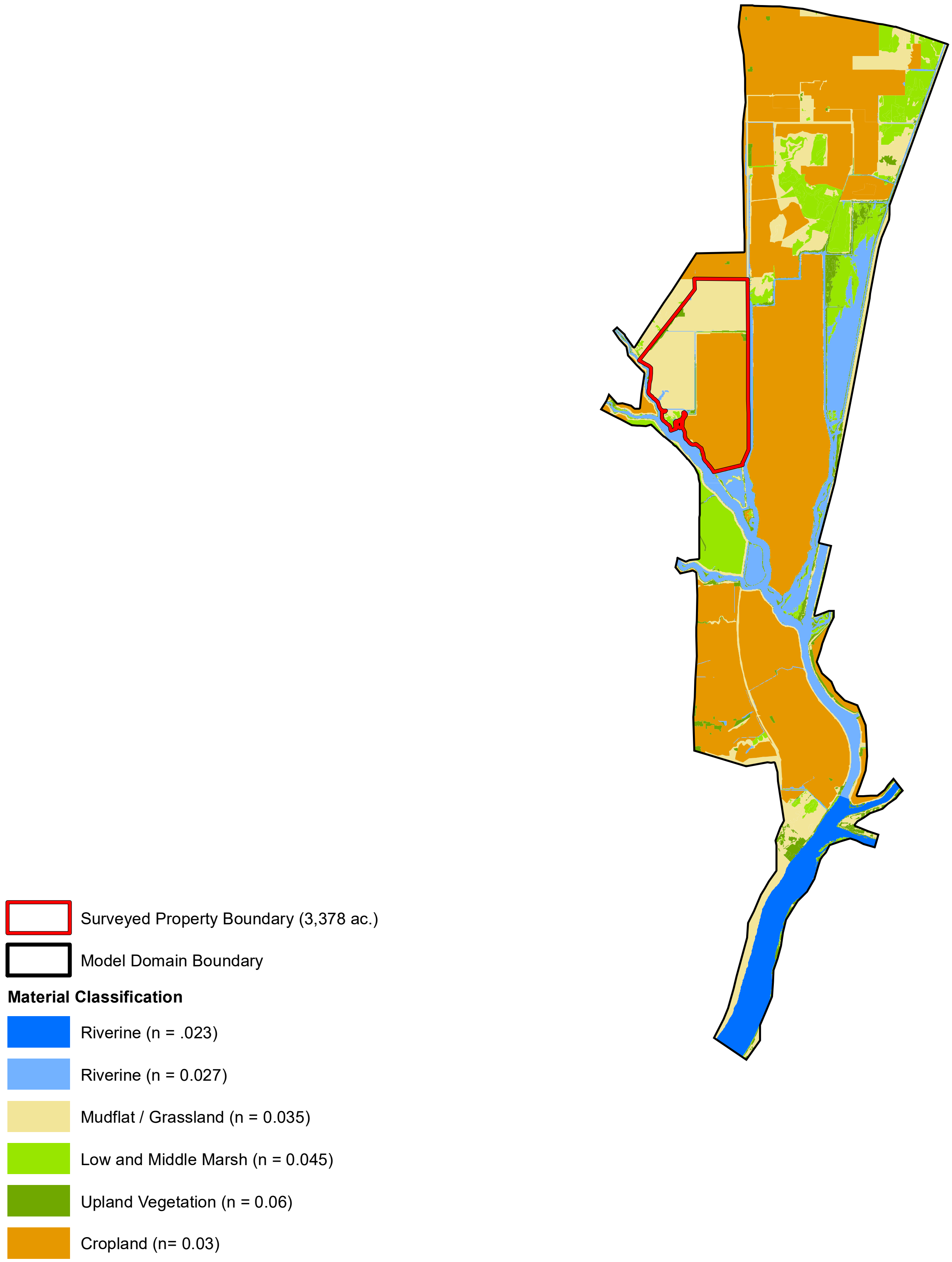


Figure 20
TUFLOW 1997 Historic Conditions Materials File

Lookout Slough Tidal Habitat Restoration and Flood Improvement Project

0 7,500 15,000
Feet

Ecosystem Investment Partners

Map Prepared Date: 9/1/2019
Map Prepared By: JPritchard
Base Source: Wood Rodgers
Base Date: 10/24/2017
Data Source(s):
USGS, DWR, Wood Rodgers

Prepared by:
ESA

Path: U:\GIS\GIS\Projects\18xxxx\D181197_00_Lookout_Slough_Restoration_1\03_MXDs_Projects\02_Flood_Task_System_HandH\F20_TUFLOW_Materials_1997_Historic.mxd

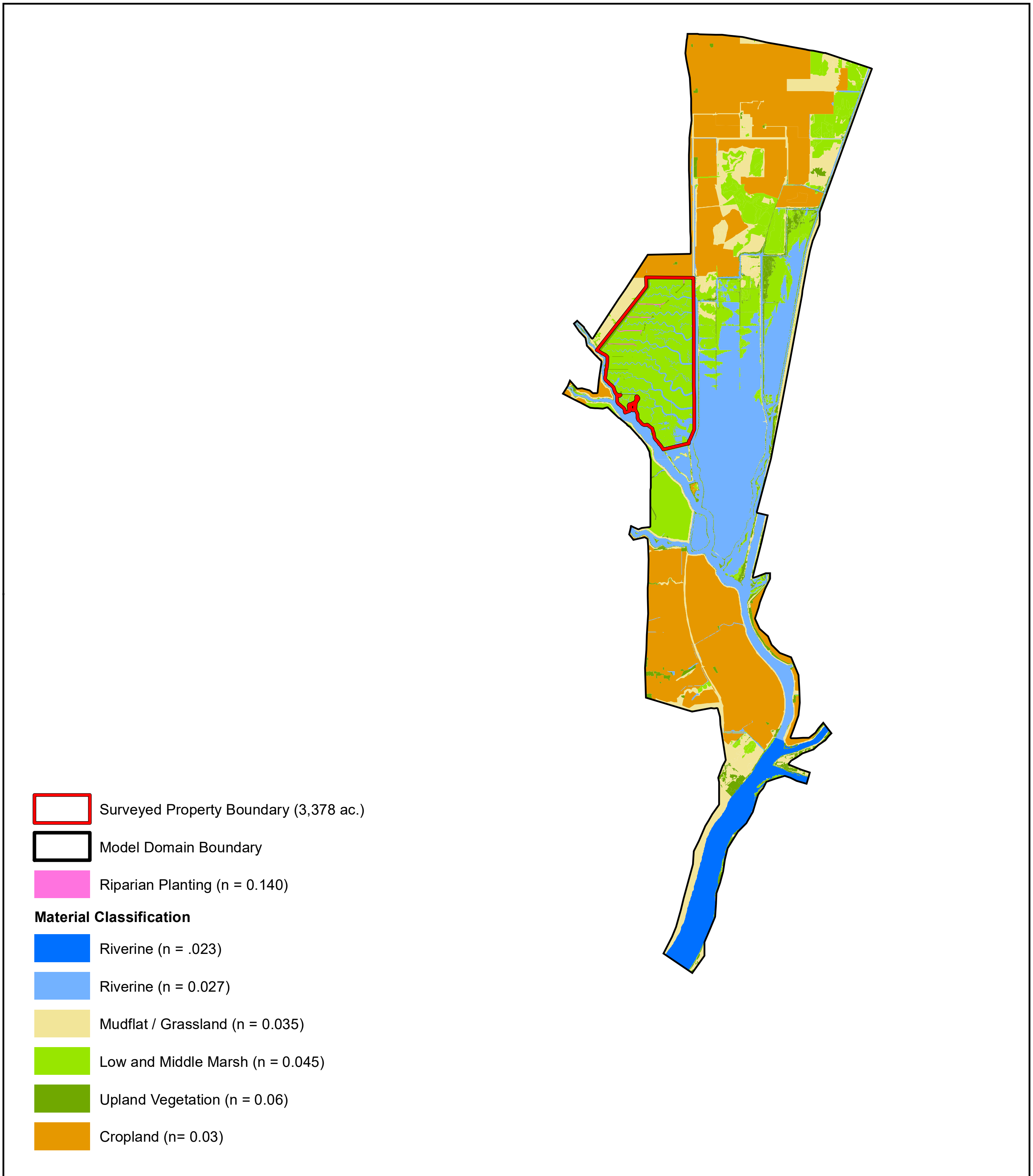


Figure 21
TUFLOW With-Project Materials File

Lookout Slough Tidal Habitat Restoration and Flood Improvement Project

0 7,500 15,000
Feet

Ecosystem Investment Partners

Map Prepared Date: 9/1/2019
Map Prepared By: JPritchard
Base Source: Wood Rodgers
Base Date: 10/24/2017
Data Source(s):
USGS, DWR, Wood Rodgers

Prepared by:
ESA

Path: U:\GIS\GIS\Projects\18xxxx\D181197_00_Lookout_Slough_Restoration_1\03_MXDs_Projects\02_Flood_Task_System_HandH\F21_TUFLOW_Materials_w_Project.mxd

Geometry Modifications for Calibration Analysis (1997 Storm)

Prior to the January 1997 flood, Liberty Island was a productive agriculture tract protected by levees. Despite attempts to protect the tract, Liberty Island flooded 27 times in the years between 1918 and 1973 (Liberty Farms Company, n.d.). Following the levee failures during the 1997 storm, the area was eventually sold to the Trust for Public Land (TPL) in 1999 and natural processes took over, returning the farm land to a naturalized state. To properly reflect conditions during the 1997 calibration simulation, the following modifications were made to the model geometry and material parameters:

- During the 1997 storm, ten breaches occurred along the west Cache Slough Levee protecting RD 2084 (Little Egbert Tract), ranging from 100 to 850 feet in length. These have been included in the calibration analysis using information provided by MBK in a memo addressed to the Reclamation Board and dated February 10, 1997 (**Figure 22**). Although the timing and sequence of the levee failures during the 1997 event is uncertain, it is likely that the majority occurred prior or during the peak of the flood.

  For purposes of this analysis, two scenarios were evaluated to understand the sensitivity of the model results to the breaches on Little Egbert Tract. The first scenario assumed that all of the known 1997 failures were fully formed prior to the beginning of the simulation. Although a simplification of the actual beach formation and timing, this is considered to represent the maximum conveyance that might have been possible in the Cache Slough Complex during the peak of the storm. The second scenario assumed that none of the breaches on Little Egbert Tract formed. Although the second scenario is not representative of what actually occurred, it is consistent with the assumptions used to calibrate the parent HEC-RAS system model and will provide a useful comparison with the parent model results.

- In the time since Liberty Island was sold to the TPL, natural processes have been acting to passively restore the site to its current state. To reflect the historic condition in the calibration analysis, the land cover (materials) file was modified to reflect Liberty Island as agricultural land use (whereas today it is predominantly open water and tidal marsh, as depicted in Figure 19).

Model Calibration and Validation Approach

The following data hierarchy was used to assess the quality of the calibration and validation results:

1. Stream gage records, including:
   - Yolo Bypass near Liberty Island (LIY)
   - Cache Slough at Ryer Island (RYI)
   - Sacramento River at Rio Vista (SRV)
2. High water marks
3. Comparison with the HEC-RAS parent model results

Locations of stream gages and high water mark observations are shown on **Figure 23**. The primary approach for calibrating the model was refinement of breakline definitions and bathymetry, particularly in the vicinity of Liberty Island where the step levees act as a hydraulic control which significantly influences the flow distribution in the vicinity of the LIY stream gage.

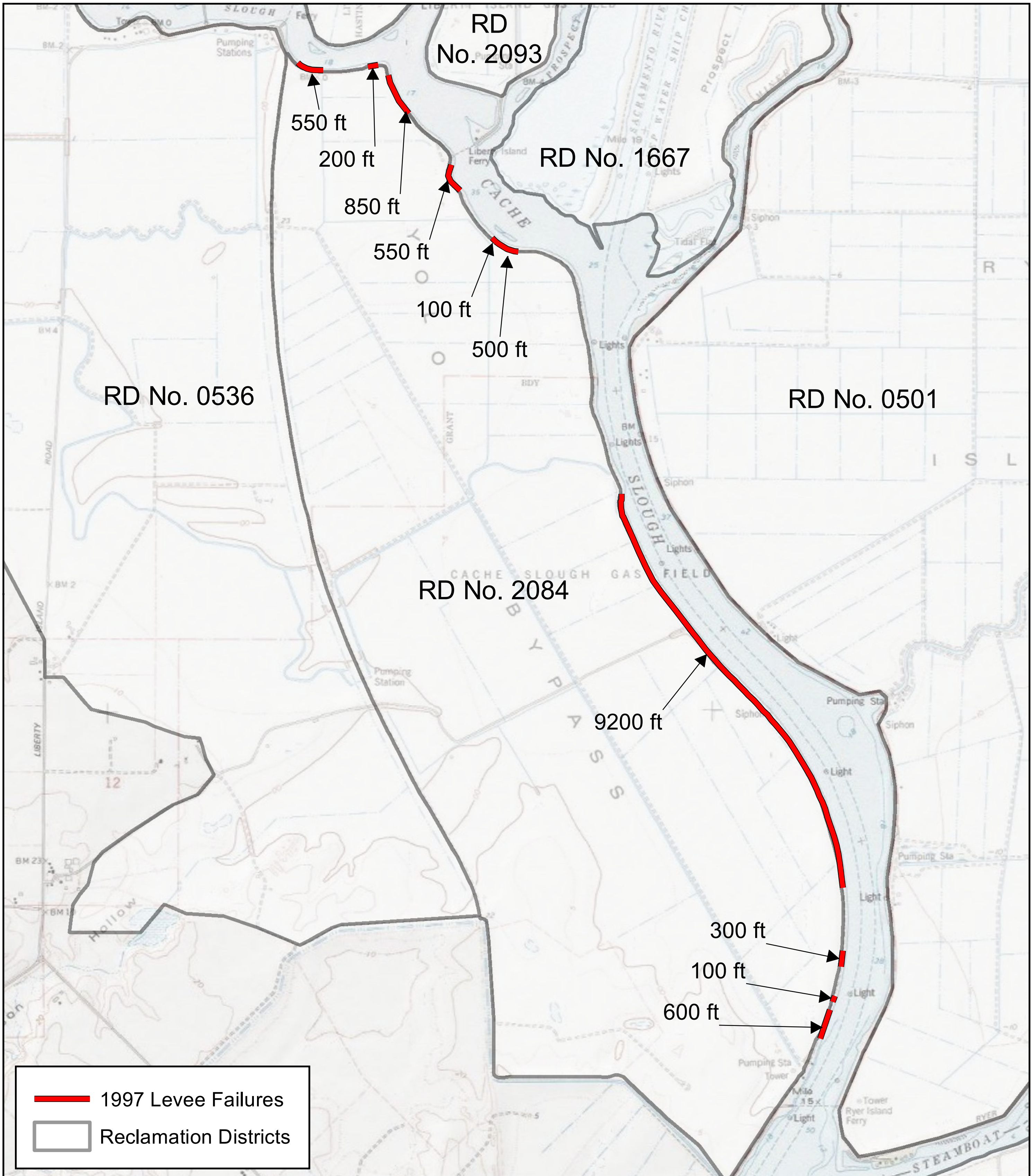


Figure 22
1997 Levee Failures along Cache Slough into Little Egbert Tract

Lookout Slough Tidal Habitat Restoration and Flood Improvement Project

0 0.25 0.5
Miles

Ecosystem Investment Partners

Map Prepared Date: 3/6/2019
Map Prepared By: Brent Davis
Base Source: Wood Rodgers
Base Date: 10/24/2017
Data Source(s):
DWR, ESRI Service Layers,
MBK (1997)

Prepared by:
ESA

Path: U:\GIS\GIS\Projects\18xxxx\D181197_00_Lookout_Slough_Restoration_1\03_MXDs_Projects\02_Flood_Task_System_HandH\F22_1997_Levee_Failures.mxd

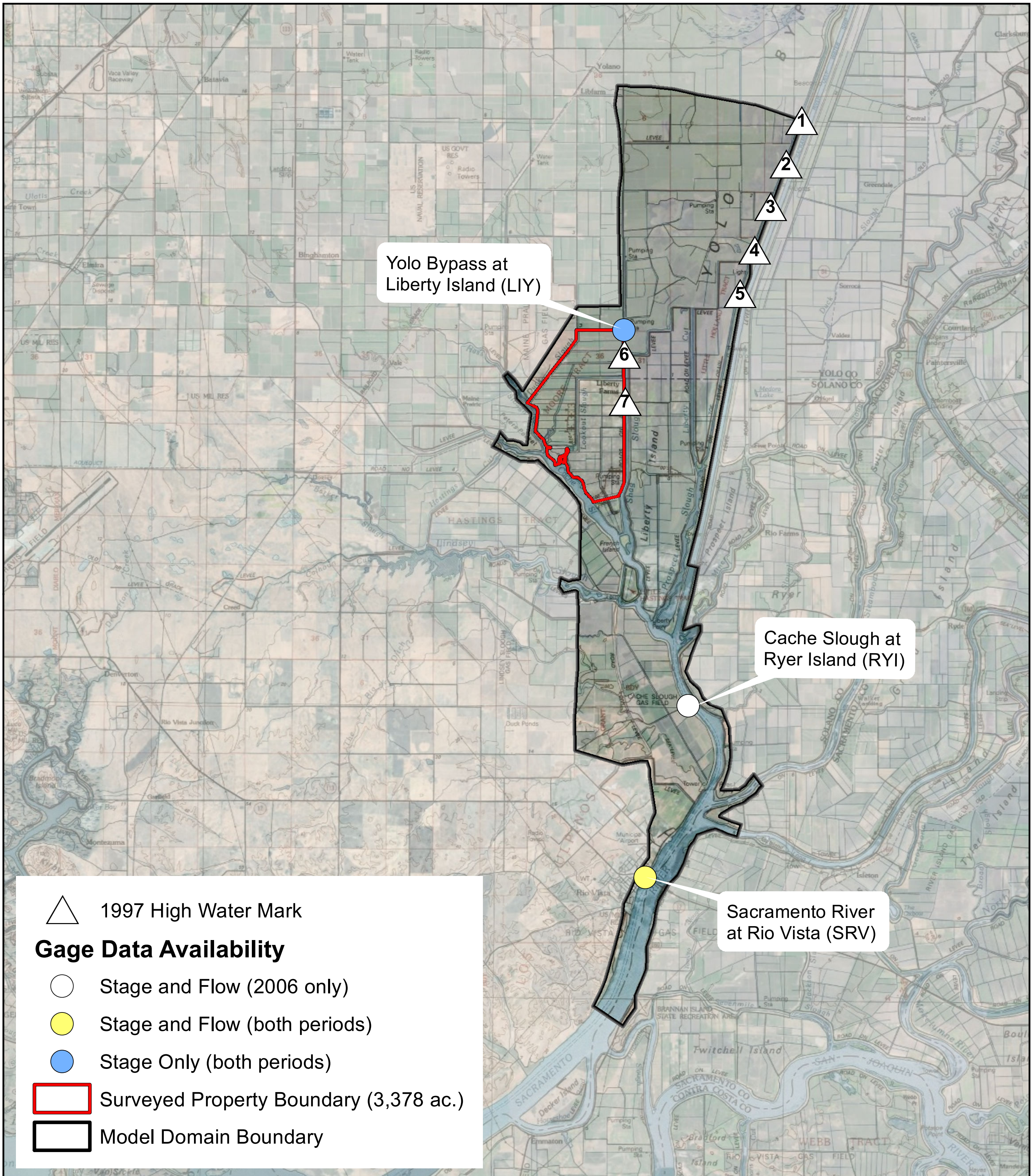


Figure 23
Calibration and Validation Data Observation Locations

Lookout Slough Tidal Habitat Restoration and Flood Improvement Project

0 7,500 15,000
Feet

Ecosystem Investment Partners

Map Prepared Date: 4/8/2019
Map Prepared By: JPritchard
Base Source: Wood Rodgers
Base Date: 10/24/2017
Data Source(s):
DWR, ESA PWA, MWD, SCWA

Prepared by:
ESA

Path: U:\GIS\GIS\Projects\18xxxx\D181197_00_Lookout_Slough_Restoration_1\03_MXDs_Projects\02_Flood_Task_System_HandH\F23_Calibration_Data.mxd

Model Calibration Results (1997 Storm)

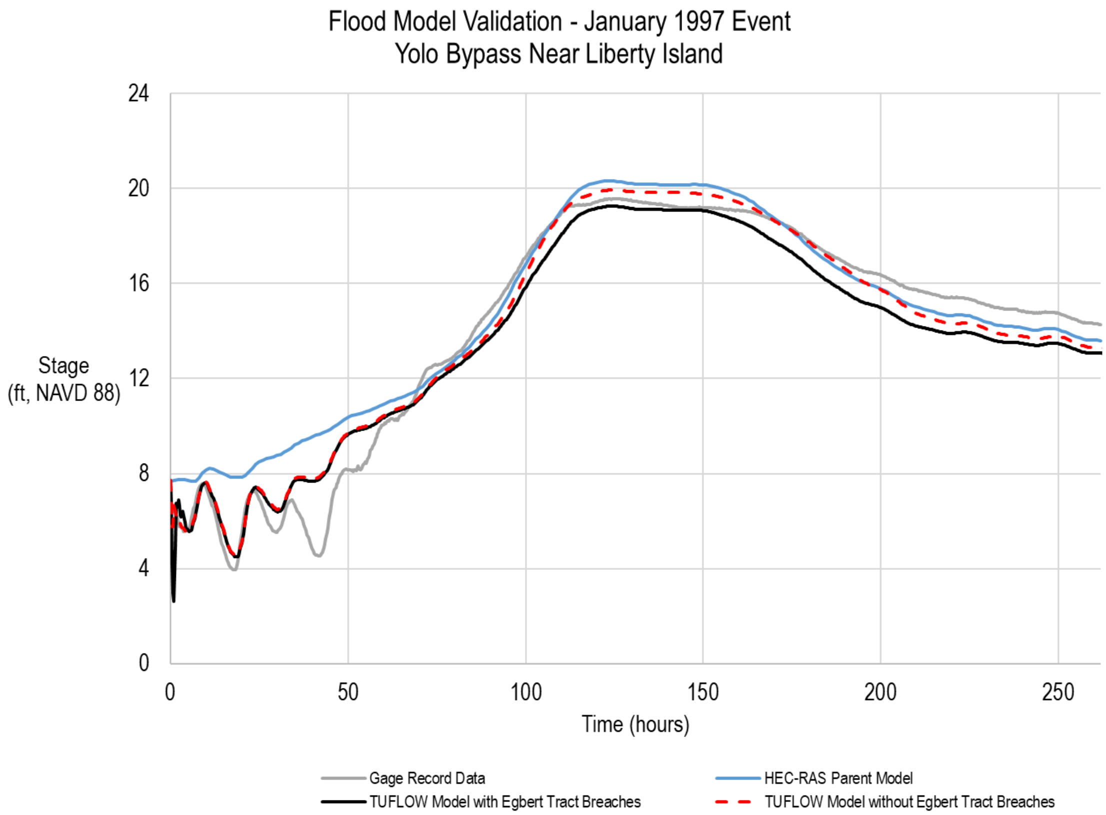
The model provides reasonable results for the validation simulation event, and is generally consistent with the results of the parent HEC-RAS model (**Figure 24** through **Figure 26**). At the LIY gage, the validation model results align much closer with the observed data for the 1997 event than in the parent HEC-RAS model. This is likely due to the incorporation of the levee breaches at Little Egbert Tract, which were omitted in the parent model calibration analysis. **Table 6** summarizes comparisons of the validation analysis with high water mark observations during the 1997 event.

TABLE 6
COMPARISON OF 1997 CALIBRATION SIMULATION WITH OBSERVED HIGH WATER MARKS

Location ID	River Mile Station	Observed High Water Elevation (feet, NAVD 88)	Computed High Water Elevation (feet, NAVD 88)	Difference (feet)
1	30.494	24.8	23.8	-1.0
2[a]	29.709	26.2	23.1	-3.1
3[a]	28.423	23.6	22.0	-1.6
4	27.421	21.2	21.2	0.0
5[a]	26.655	18.7	20.1	+1.4
6	25.211	19.7	18.7	-1.0
7	24.090	19.3	18.1	-1.2

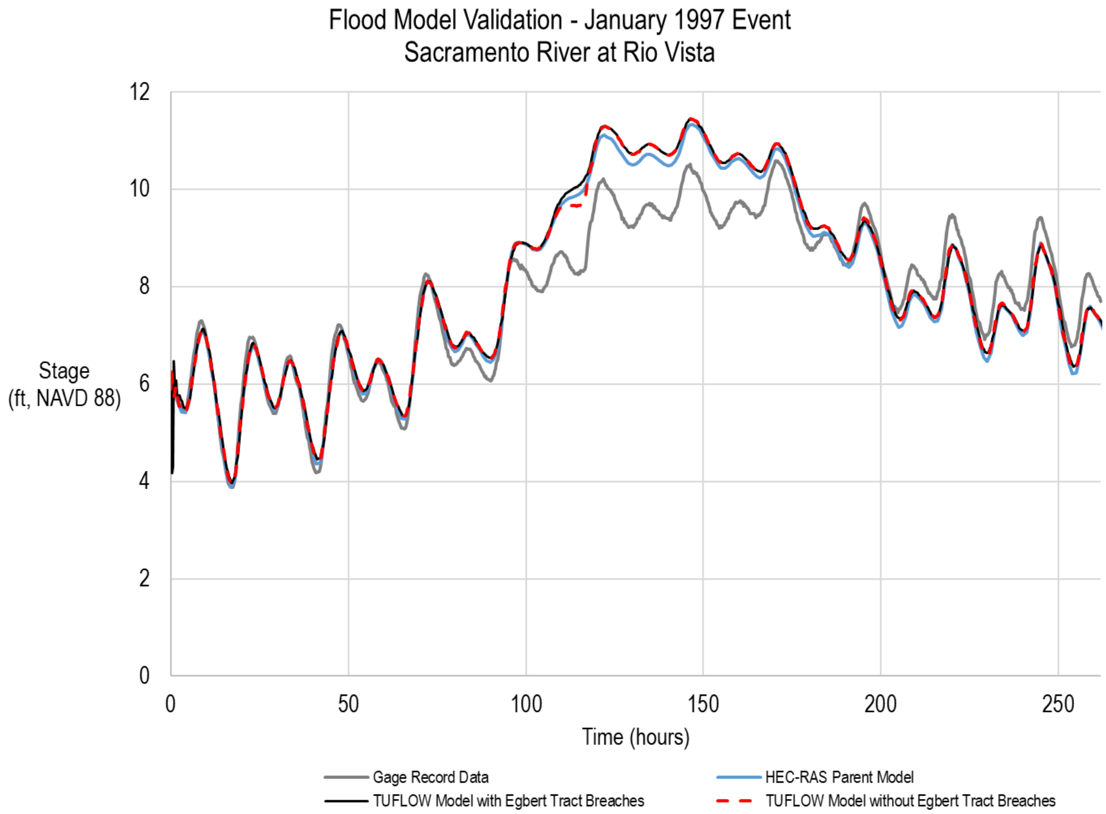
NOTES:
a The 1997 observed high water marks are not monotonically increasing from downstream to upstream, possibly a result of wind-wave action influencing the disposition of the debris line. In many cases this results in an observation that is higher than the actual water surface. The specific high water marks noted here have been flagged by DWR has excessively deviating from the trend and are not considered reliable. They are presented for documentation purposes only, and are presented in a lighter font for de-emphasis.
b Results are shown reflect levee failures simulated at Little Egbert Tract

Figure 24 Calibration Results, Liberty Island at Yolo Bypass Gage (Stage)



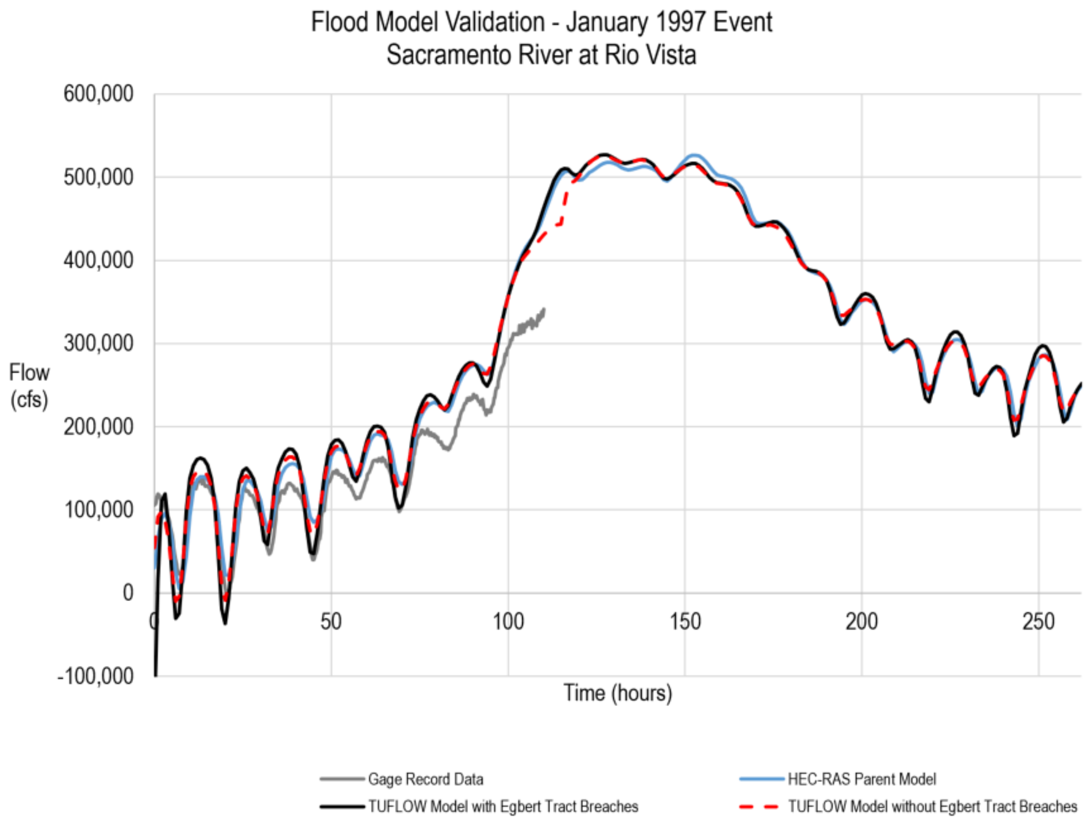
TUFLOW two-dimensional model results correlate well with observed peak data when the historic downstream levee failures at Little Egbert Tract are included. The HEC-RAS parent model appears to over-predict maximum water levels at the peak, likely due to the omission of levee failures at Little Egbert Track and changes on Liberty Island.

Figure 25 Calibration Results, Sacramento River at Rio Vista Gage (Stage)



Both the parent and child models are in close agreement with one another, but appear to over-predict flood stages during the peak, possibly a result of uncertainties in the 1997 event simulation datasets. The model results at this location do not appear to be sensitive to the breach hydraulics at Little Egbert Tract except for a short period on the rising limb of the flood wave (beginning around Hour 110 and ending around Hour 118 in the simulation).

Figure 26 Calibration Results, Sacramento River at Rio Vista Gage (Flow)



The stream flow instrumentation failed at approximately Hour 110. Both the parent and child models are in close agreement with one another, but appear to over-predict stages compared to the measured data during the rising limb, possibly a result of uncertainties in the 1997 event simulation datasets. The model results at this location do not appear to be sensitive to the breach hydraulics at Little Egbert Tract except for a short period on the rising limb of the flood wave (beginning around Hour 110 and ending around Hour 118 in the simulation).

Model Validation Results (2006 Storm)

In general, the calibration model produces peak water level results that are consistent with the observed data and the parent model (**Figure 27** through **Figure 31**). One location where the model produces water levels that are noticeably higher than the regional HEC-RAS model is in the lower reach of Cache Slough as it approaches its confluences with Steamboat Slough and the Sacramento River. In this location the 1D model appears to underestimate the hydraulic grade line. This is considered a product of the limitations in the one-dimensional model schematization at this location, as momentum is not transferred through the storage areas used to represent the junctions at Steamboat Slough and the Sacramento River. The child model in this case is considered to provide a more reasonable estimation of water levels at this location.

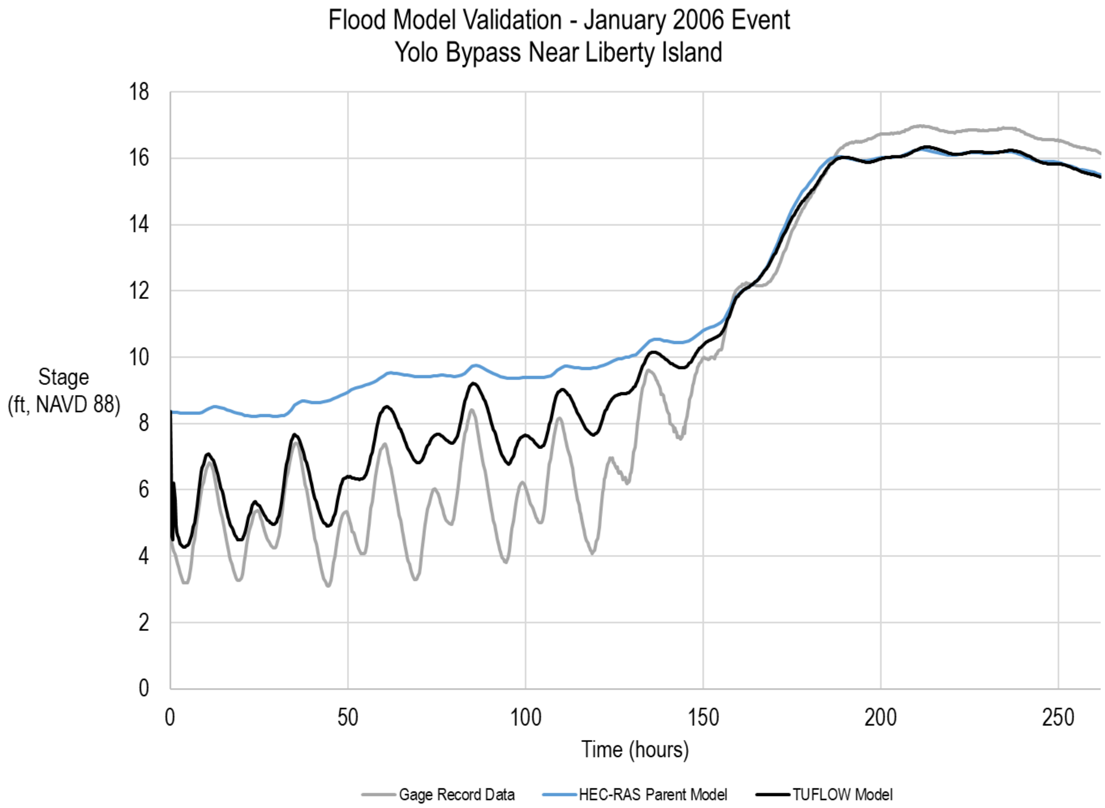
In the vicinity of the Project, the model provides good correlation with the results at the LIY stream gage, coming within 0.6 feet of the observed peak stage. This correlates well with the results shown in the parent model.

Calibration and Validation Summary

In general, the calibration and validation results appear to be within accepted tolerances. Although some deviation occurs between the modeled and measured data, comparisons between the TUFLOW HPC child model and HEC-RAS parent model indicate that both models are performing similarly within the region of interest, and that the flood peak is well represented in both models, particularly when historic levee breaches are taken into consideration.

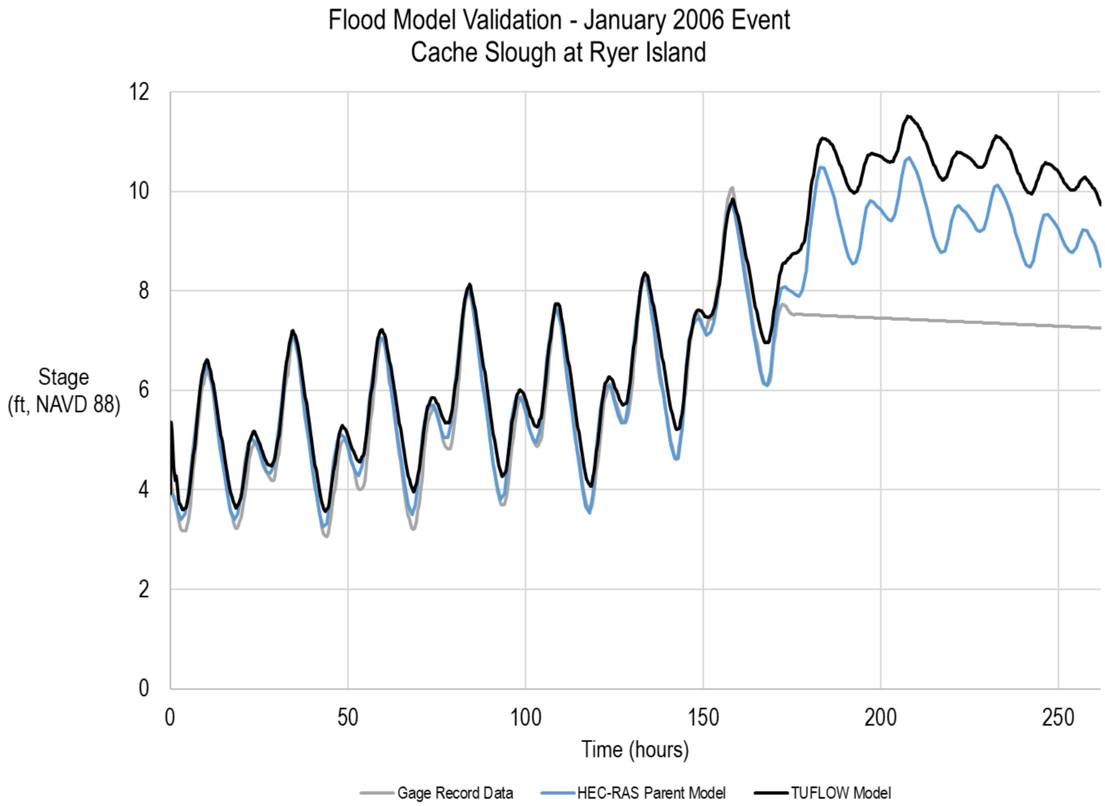
In general, the modeling predicts water surfaces that are generally lower than high water marks surveys collected after the 1997 storm. Given the general uncertainty in the high water mark survey dataset as a whole, these deviations are not considered to reflect poor model performance and may simply reflect the effects of wind-wave run-up in the Yolo Bypass that are not captured explicitly in the model simulation.

Figure 37 Validation Results, Liberty Island at Yolo Bypass Gage (Stage)



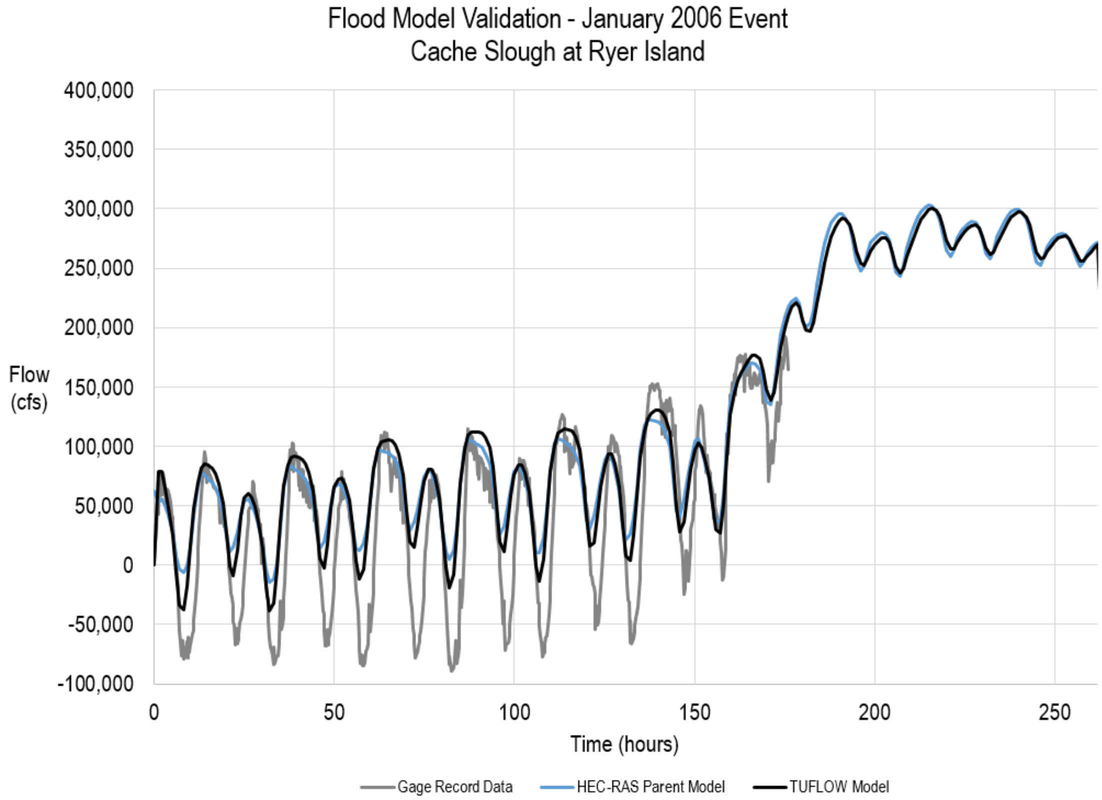
Although the TUFLOW two-dimensional model results are slightly lower than peak stage recorded at the gage (approximately 0.6 feet), they are consistent with the calibrated and validated one-dimensional HEC-RAS parent model during the peak of the storm event. Differences between the models in the initial run up of the simulation (hours 0 to 150) are likely due to limitations of the parent model's one-dimensional representation of the Cache Slough Complex.

Figure 28 Validation Results, Cache Slough at Ryer Island Gage (Stage)



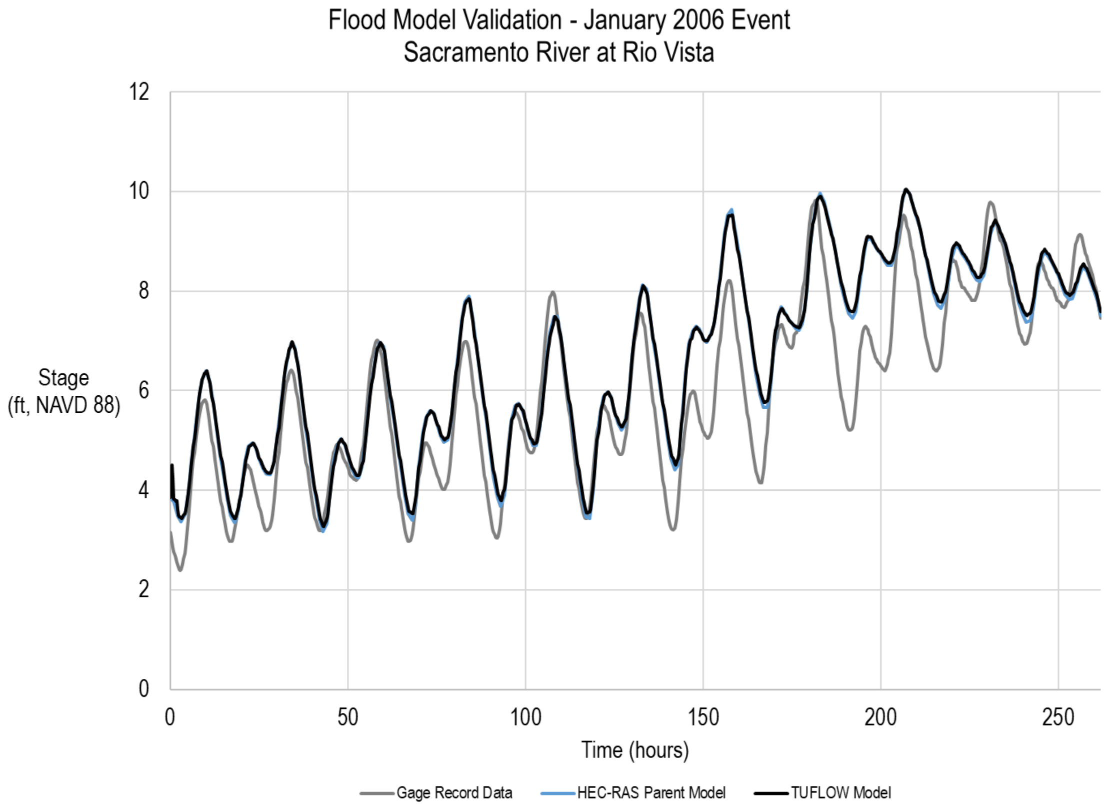
The gage records appear to be erroneous beginning around hour 170, suggesting instrument failure occurred on the rising limb of the flood hydrograph (this is corroborated by flow records shown on Figure 29). Both the one-dimensional and two-dimensional models appear to provide good correlation with the measured data up to that point that it is available. Differences between the models at the peak appear linked to the manner in which the one-dimensional model is defined at the series of junctions between Cache Slough, Steamboat Slough, and the Sacramento River near Rio Vista. At these locations, the one-dimensional hydraulic model computes a relatively flat hydraulic grade line through a series of junctions, likely under-predicting the stage during periods of higher flow.

Figure 29 Validation Results, Cache Slough at Ryer Island Gage (Flow)



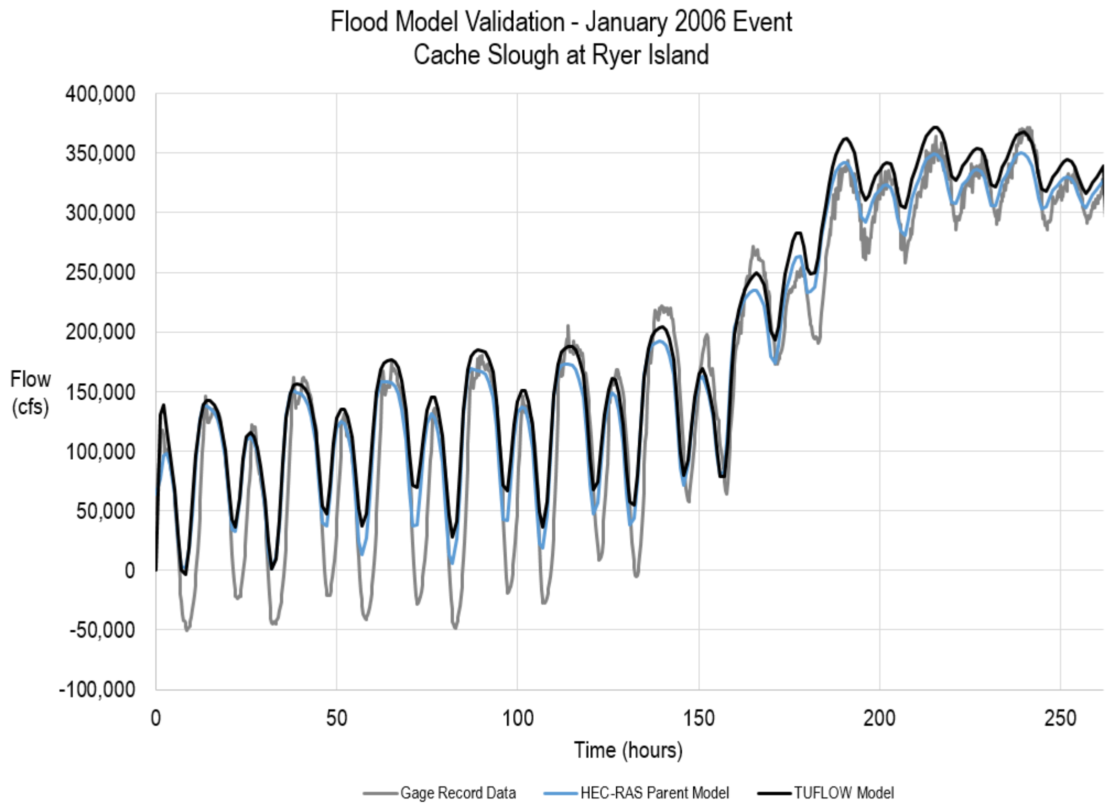
Gage records terminate around hour 170, suggesting instrument failure on the rising limb of the flood hydrograph. Both the one-dimensional and two-dimensional models appear to provide good correlation with the measured data up on the high tide portions of the tidal signal. The ebb tide correlation is much poorer, likely due to limitations of the one-dimensional parent model's ability to represent the tidal exchange through this part of the system. This appears to also be supported by the more pronounced muting of the tidal signal in the one-dimensional model results at this location.

Figure 30 Validation Results, Sacramento River at Rio Vista Gage (Stage)



Both models appear to provide reasonable results at this location. Both models provide relatively similar results due to the proximity of this location to the downstream stage boundary handoff from the parent HEC-RAS model to the TUFLOW child model.

Figure 31 Validation Results, Sacramento River at Rio Vista Gage (Flow)



Both models provide similar results that appear to be reasonable at this location. Both models provide relatively similar results due to the proximity of this location to the downstream stage boundary handoff from the parent HEC-RAS model to the TUFLOW child model; however, the child model appears to provide results which more closely follow the peaks in the observed data. Performance within the tidal range could probably be further improved by deriving the downstream boundary from observed data or another hydrodynamic model of the Delta (i.e., RMA Delta model).

Uncertainty in Stages for Computed Water Surface Profiles

Uncertainty is the result of imperfect knowledge concerning the present or future state of a system, event, situation, or (sub) population under consideration (USACE, 2017). Known sources of uncertainty relevant to the current analysis include (USACE, 1996):

- Uncertainty about future hydrologic events, including climate change. Recognizing this, the Project has incorporated an additional 1 foot of freeboard in the levee design.
- Uncertainty related to structural and geotechnical performance of water-control measures when these are subjected to rare stresses and loads caused by floods. For purposes of assessing the Project performance, the system is assumed to be stable up to the top of containment (no breaching) in accordance with USACE Section 408 guidance (USACE, 2018). This is anticipated to provide the most conservative estimate of flow deliveries and flood stages within the area of interest.
- Uncertainty arising from the use of simplified models to describe complex phenomena. Although the hydraulic models used to support this study have been calibrated and validated using historic flood records, residual uncertainty in parameters such as Manning's roughness coefficients is inevitable.

For purposes of assessing stage uncertainty in the current study, a sensitivity analysis was performed to assess the upper and lower bounds of Manning's roughness for the given design discharges (16%, 1%, and 0.5% ACE). Per discussion with the USACE Sacramento District, Manning's roughness coefficients were adjusted globally by +/-20% relative to the calibrated values. This resultant range of stages is assumed reflect 95% of the error range in the Manning's roughness parameter, or two standard deviations above and below the mean. The standard deviation is assumed to be the total range of these values divided by four (USACE, 1996).

Figure 32 through **Figure 35** depict the spatial distribution of the standard deviation in stage based on adjusting the Manning's roughness coefficient +/-20% for the respective without- and with-Project conditions assessments for the Baseline and Future Cumulative Conditions. The Manning's roughness value reliability was assessed based on the ranges recommended by the USACE for cross-sections based on field surveys or aerial spot elevation (USACE, 1996) as summarized in **Table 7** below.

TABLE 7
MINIMUM STANDARD DEVIATION OF ERROR IN STAGE

Manning's n Value Reliability	Standard Deviation (in feet) for Cross Section Based on Field Survey or Aerial Spot Elevation
Good	0.3
Fair	0.7
Poor	1.3

SOURCE: USACE, 1996

Review of the standard deviation maps for the respective geometry conditions and design flow rates indicates that the reliability of the model's Manning's roughness coefficients can be characterized as good to fair in all cases. All of the maps exhibit a small standard deviation in the downstream portion of model domain inside of the Sacramento River and Cache Slough corridors. This effect is most prominent in the lower flow events (i.e., 16% ACE), and is likely due to the influence the tidal boundary exerts on these zones. In tidal zones, the inertia terms are more influential than the friction terms, reducing the model sensitivity to the bed roughness coefficient in these locations.

In the 16% ACE comparisons, a small portion in the northwestern portion of the model domain exhibits a standard deviation in excess of 1.3 feet (shown in orange on Figure 11 through Figure 14). This area is located west of a small agricultural berm within the Yolo Bypass which overtops in the 16% ACE event only as higher roughness coefficients are applied. During higher flow events this area is completely inundated and the model is less sensitive to changes in roughness, resulting in a lower standard deviation for the 1% ACE and 0.5% ACE events. The increased uncertainty in this localized portion of the model domain during the 16% ACE event is not considered to have a significant impact on the overall quality of the model results as it relates to describing the performance of the system without- and with-Project.

Impacts of Proposed Project Alteration

As described in the preceding section on model calibration and validation, the simulation modeling conducted for the analysis of conditions without the project reasonably reproduces the drivers of flood risk within the child model domain, peak flow and peak stage. While the simulation results may imperfectly reflect measured conditions, the analysis of impacts will focus on the *differences* between the with- and without-project conditions. The differences in predicted peak stage and peak flow due to project-induced changes are typically more accurate than the absolute results of the models may be. Thus, it is entirely reasonable to rely on the differences in modeled results to evaluate the impact of the project.

The hydraulic performance analysis consisted of analyzing the Baseline Condition and Future Cumulative Condition both without- and with-Project using a range of hydraulic loadings (16%, 1%, and 0.5% ACE) in unsteady state. In addition to this, Baseline Condition was analyzed for without- and with-Project conditions to verify that the Project would not adversely impact the performance of the system using the authorized 1957 design flow. For purposes of this Project, increases in water surface elevation are reflected as a reduction in assurance (conditional non-exceedance probability [CNP]).

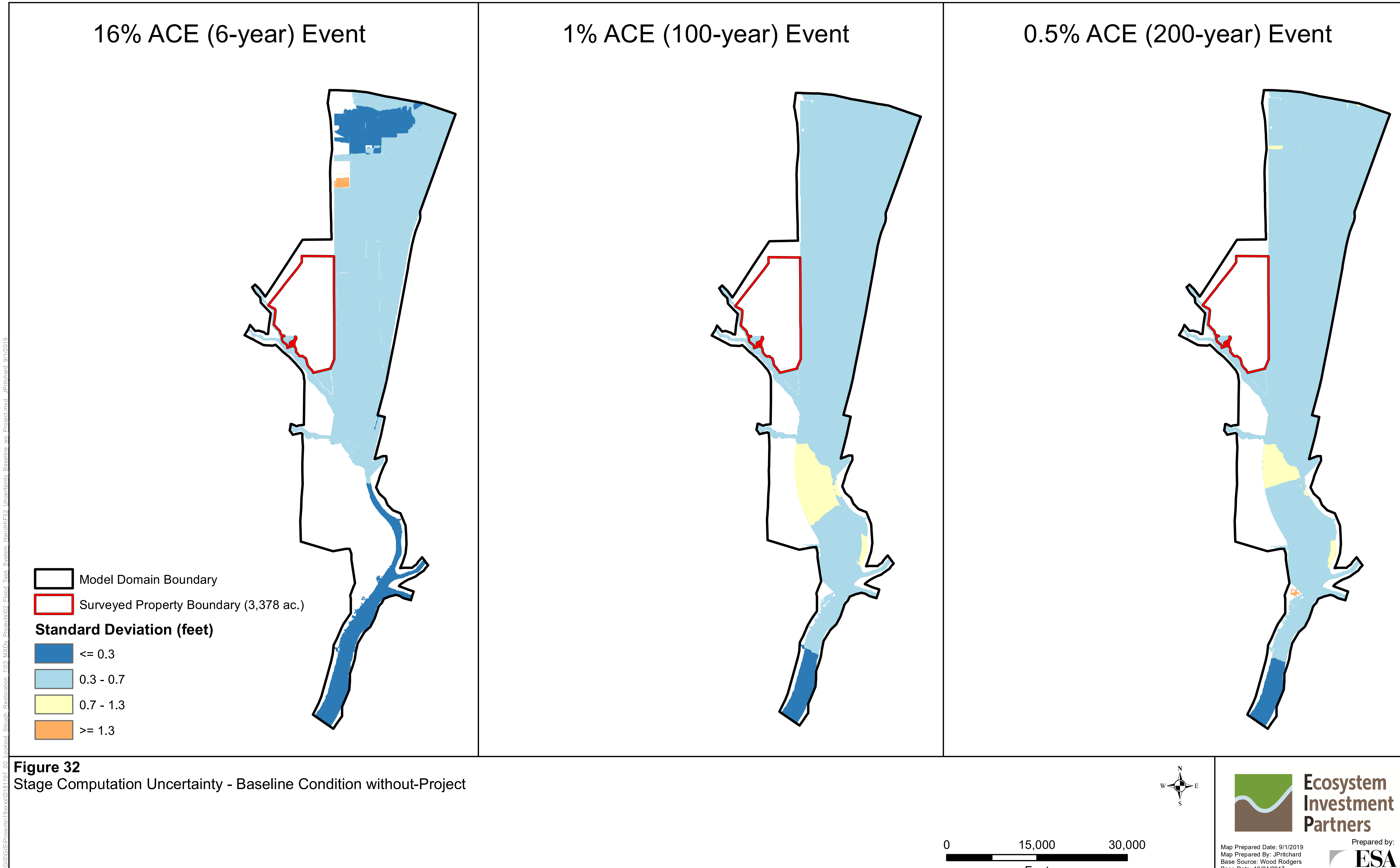


Figure 32
Stage Computation Uncertainty - Baseline Condition without-Project

Lookout Slough Tidal Habitat Restoration and Flood Improvement Project

Ecosystem Investment Partners

Map Prepared Date: 9/1/2019
Map Prepared By: JPritchard
Base Source: Wood Rodgers
Base Date: 10/24/2017
Data Source(s):

Prepared by: ESA

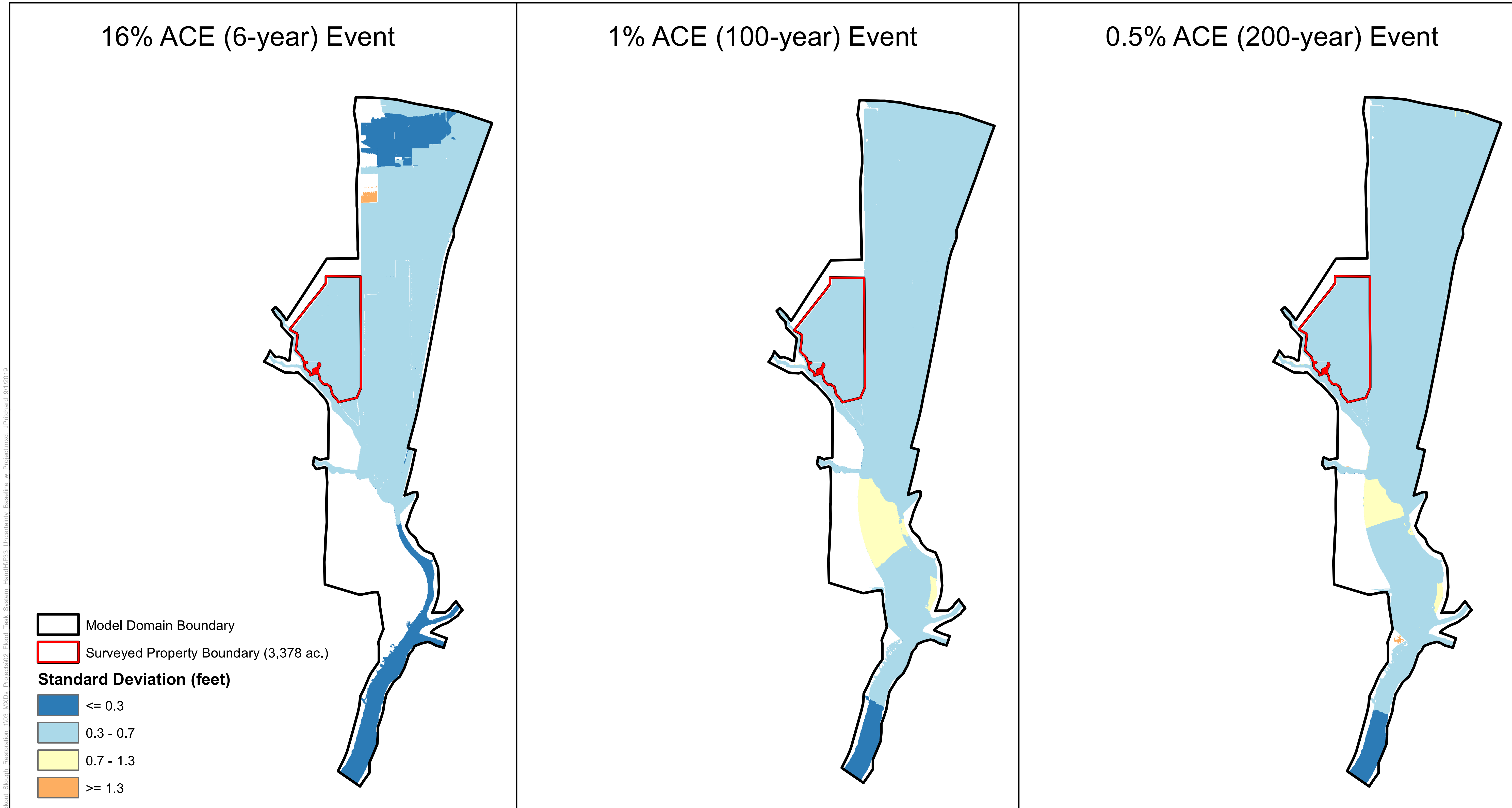


Figure 33
Stage Computation Uncertainty - Baseline Condition with-Project

Lookout Slough Tidal Habitat Restoration and Flood Improvement Project

Ecosystem Investment Partners

Map Prepared Date: 9/1/2019
Map Prepared By: JPritchard
Base Source: Wood Rodgers
Base Date: 10/24/2017
Data Source(s):

Prepared by:
ESA

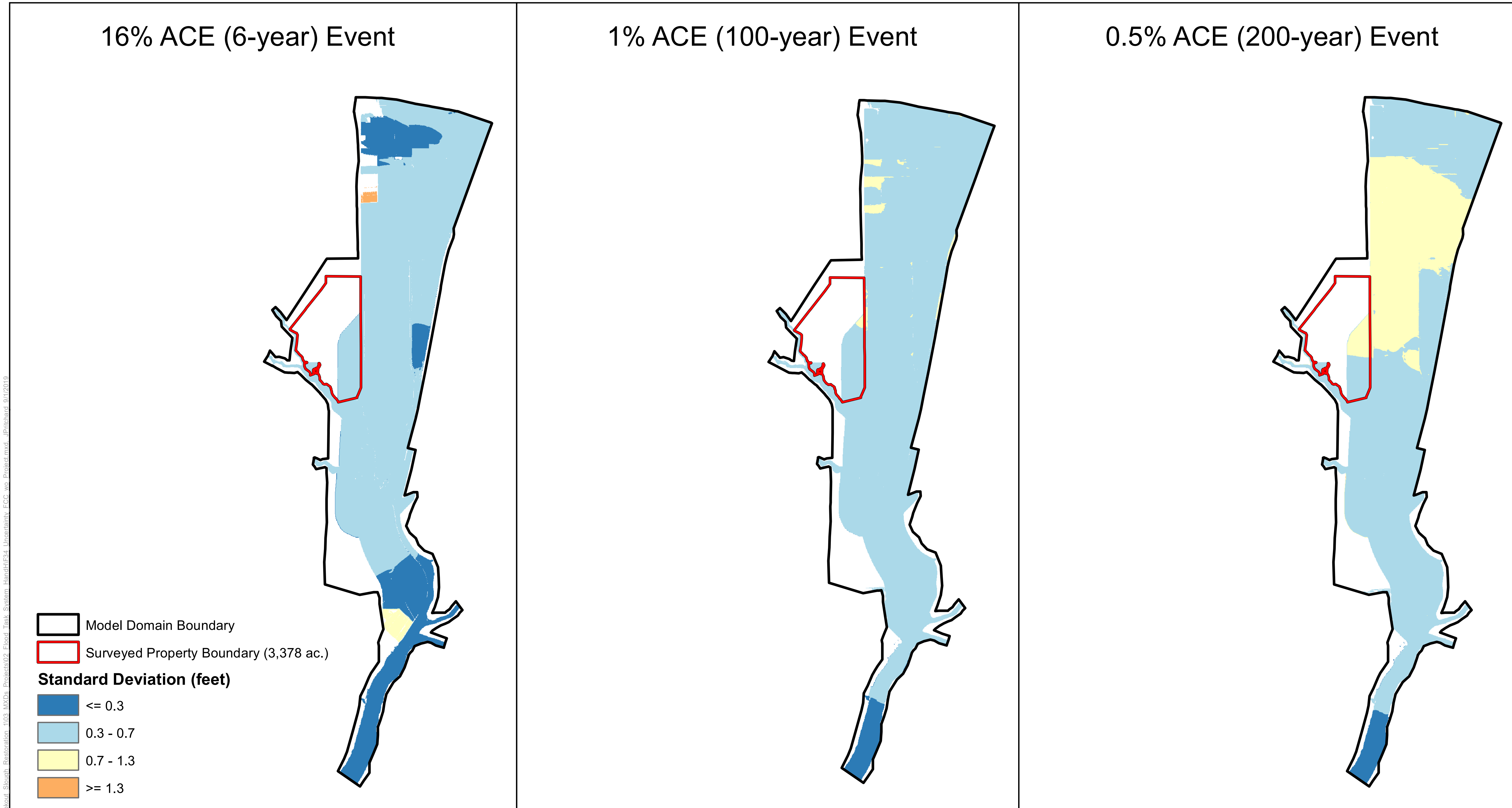


Figure 34
Stage Computation Uncertainty - Future Cumulative Condition without-Project

Lookout Slough Tidal Habitat Restoration and Flood Improvement Project

Ecosystem Investment Partners

Map Prepared Date: 9/1/2019
Map Prepared By: JPritchard
Base Source: Wood Rodgers
Base Date: 10/24/2017
Data Source(s):

Prepared by:
ESA

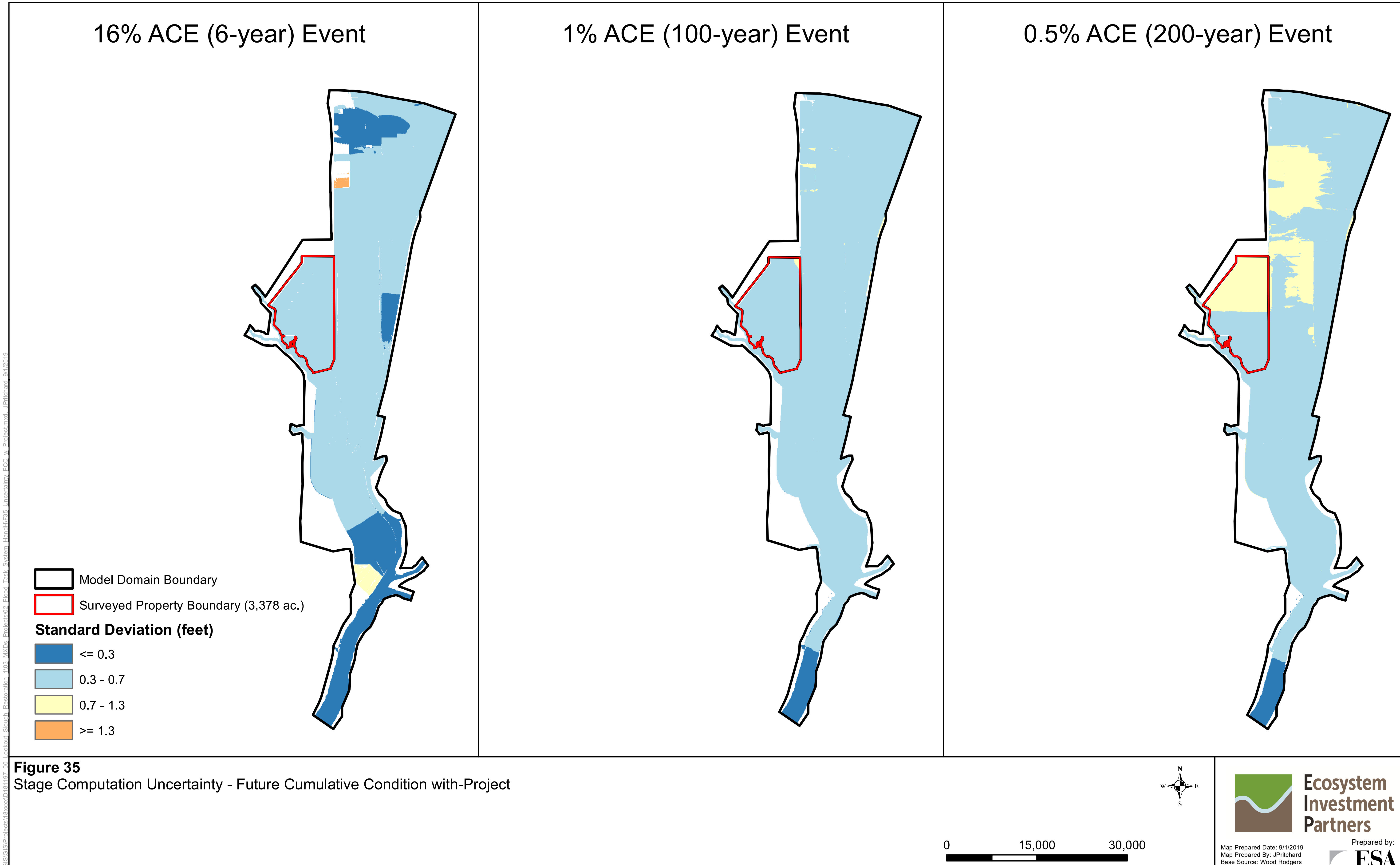


Figure 35
Stage Computation Uncertainty - Future Cumulative Condition with-Project

Lookout Slough Tidal Habitat Restoration and Flood Improvement Project

Ecosystem Investment Partners

Map Prepared Date: 9/1/2019
Map Prepared By: JPritchard
Base Source: Wood Rodgers
Base Date: 10/24/2017
Data Source(s):

Prepared by:
ESA

As shown on **Figure 36** and **Table 8**, the proposed Project alterations result in no adverse impacts to assurance (expressed as flood stage) at the identified index locations for the range of hydrologic loadings analyzed. The parent HEC-RAS system models have also been reviewed to verify that no significant change in the flow distribution at Fremont Weir or the Sacramento Weir occurs as a result of the Project (**Table 9**). As the hydraulic impacts of the Project are localized, and generally result in stage decreases for the design events under consideration (including the 1957 authorized design flow), the Project's potential to transfer risk from one part of the system to another is considered to be negligible. These changes are not considered significant enough to warrant a detailed system performance calculation using HEC-FDA. The deterministic analysis conducted for the Project is considered sufficient for describing the overall system performance for the without- and with-Project conditions and verifies that the reduction in assurance is negligible.

Authorized Design Flow Performance Assessment

The Project proposes to alter the west (right) levee of the Yolo Bypass and the east (left) levee of Cache Slough, both of which are part of the SRFCP. The Project is also in close proximity to other SRFCP levees along the Yolo Bypass, Cache Slough, Hass Slough, Miner Slough, Lindsey Slough, Steamboat Slough, and the Sacramento River. The design capacities of the majority of these facilities are documented in the individual project O&M Manuals, and on the 1957 Levee and Channel profile exhibits (USACE, 1957). There are no published design flows for Hass Slough, Cache Slough, and Lindsey Slough. This is perhaps because the flooding in these reaches is governed by backwater within the Cache Slough Complex, which is driven by a combination of Yolo Bypass flood flows and interaction with the tides. The authorized design flows for the reaches within the model domain and stage at the downstream boundary of the model are summarized in Table 3.

To analyze the effects of the Project for the authorized design flow condition, a quasi-steady state simulation was developed using the authorized design flows for this part of the system. The relative changes in stage and velocity without- and with-Project are described below.

Stage Impacts

The Baseline Condition was simulated for without- and with-Project conditions using the authorized design flows. The resultant change in water surface at the respective index point locations is summarized in **Table 10**. The resultant floodplain extents, depth, and computed maximum water surface for the without- and with-Project simulations are shown on **Figure 37**. Figure 37 also depicts the change in maximum stage between the without- and with-Project conditions.

In general, the Project results in localized stage reductions in the Yolo Bypass. That the geographic extent of these increases appear to be slightly less than what is shown in the analysis of the ACE storms (with comparable flow rates) is most likely attributable to the quasi-steady state nature of the analysis, where the transient effects (timing and volume) of the flood wave are not accounted for. The higher downstream stage boundary defined by the 1957 authorized design profile may also be contributing to these differences.

TABLE 8
SUMMARY OF CHANGE IN ASSURANCE AT RESPECTIVE INDEX POINTS

Index Point	1957 Design WSEL (ft, NAVD 88)	Design Freeboard (feet)	Existing Top of Levee Elevation (ft, NAVD 88)	Condition	CNP	% ACE	WSEL (ft, NAVD 88) Without-Project	With-Project	Change
1	22.83	6	28.65	Baseline	0.160	16%	19.74	19.72	-0.02
					0.010	1%	23.85	23.74	-0.11
					0.005	0.5%	24.63	24.49	-0.14
				Future Cumulative	0.160	16%	20.16	20.15	-0.01
					0.010	1%	23.26	23.20	-0.06
					0.005	0.5%	23.92	23.83	-0.09
2	17.88	3	20.86	Baseline	0.160	16%	13.01	13.00	-0.01
					0.010	1%	18.65	18.63	-0.02
					0.005	0.5%	19.58	19.53	-0.05
				Future Cumulative	0.160	16%	11.98	11.97	-0.01
					0.010	1%	17.02	16.99	-0.03
					0.005	0.5%	18.12	18.11	-0.01
3	17.88	3	20.86	Baseline	0.160	16%	13.01	13.00	-0.01
					0.010	1%	18.65	18.63	-0.02
					0.005	0.5%	19.56	19.51	-0.05
				Future Cumulative	0.160	16%	11.98	11.97	-0.01
					0.010	1%	17.00	16.97	-0.03
					0.005	0.5%	18.12	18.11	-0.01
4	20.46	6	24.88	Baseline	0.160	16%	14.81	14.36	-0.45
					0.010	1%	20.80	20.28	-0.52
					0.005	0.5%	21.77	21.22	-0.55
				Future Cumulative	0.160	16%	14.28	13.92	-0.36
					0.010	1%	19.24	18.74	-0.50
					0.005	0.5%	20.22	19.73	-0.49
5	19.71	6	25.34	Baseline	0.160	16%	13.68	13.57	-0.11
					0.010	1%	19.86	19.59	-0.27
					0.005	0.5%	20.84	20.55	-0.29
				Future Cumulative	0.160	16%	13.12	12.95	-0.17
					0.010	1%	18.09	17.90	-0.19
					0.005	0.5%	19.10	18.95	-0.15
6	17.86	3	20.59	Baseline	0.160	16%	13.01	13.00	-0.01
					0.010	1%	18.65	18.63	-0.02
					0.005	0.5%	19.54	19.52	-0.02
				Future Cumulative	0.160	16%	11.94	11.94	0.00
					0.010	1%	16.98	16.96	-0.02
					0.005	0.5%	18.07	18.06	-0.01

TABLE 8
SUMMARY OF CHANGE IN ASSURANCE AT RESPECTIVE INDEX POINTS

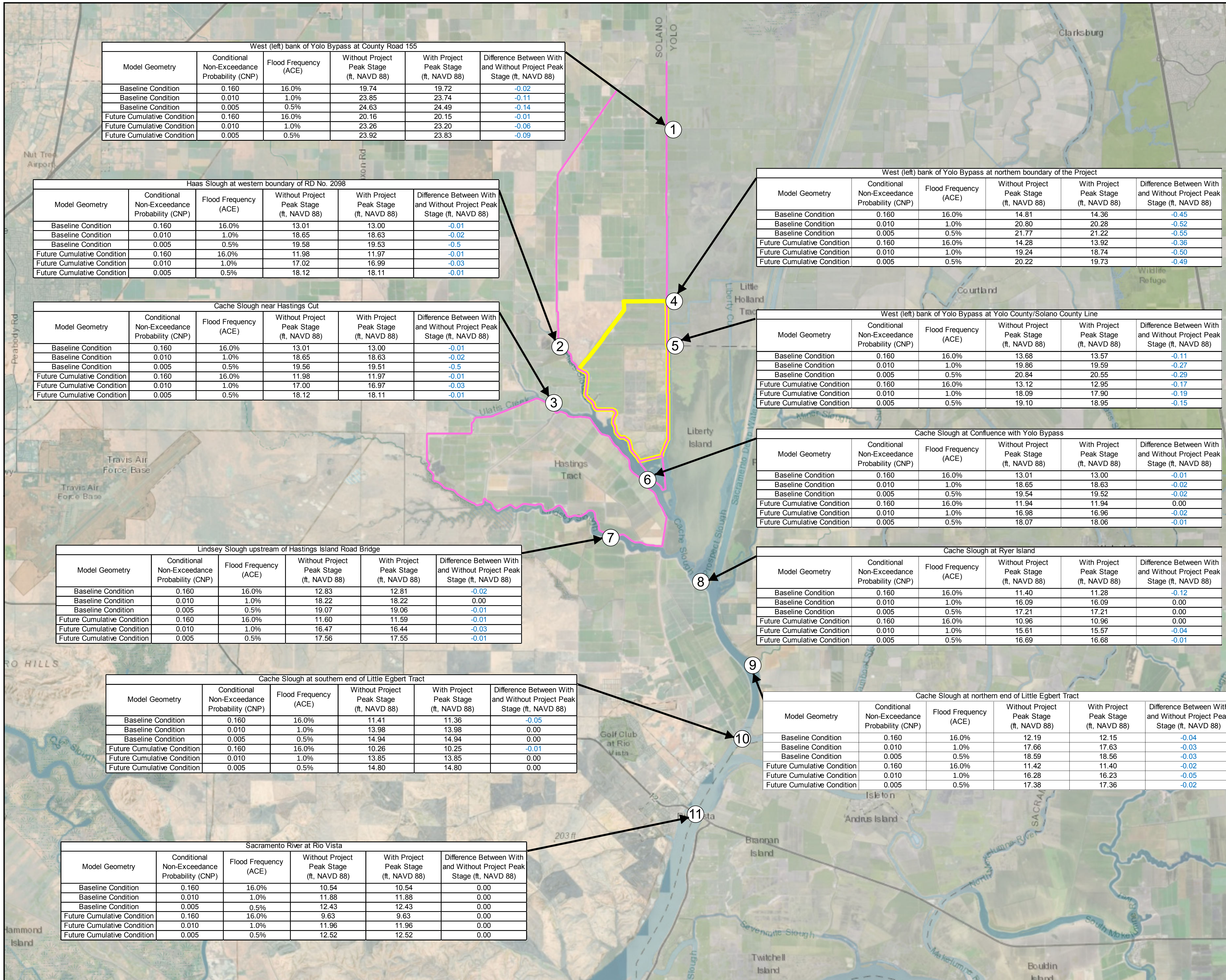
Index Point	1957 Design WSEL (ft, NAVD 88)	Design Freeboard (feet)	Existing Top of Levee Elevation (ft, NAVD 88)	Condition	CNP	% ACE	WSEL (ft, NAVD 88) Without-Project	With-Project	Change
7	17.85	3	19.57	Baseline	0.160	16%	12.83	12.81	-0.02
					0.010	1%	18.22	18.22	0.00
					0.005	0.5%	19.07	19.06	-0.01
				Future Cumulative	0.160	16%	11.60	11.59	-0.01
					0.010	1%	16.47	16.44	-0.03
					0.005	0.5%	17.56	17.55	-0.01
8	17.82	3	20.82	Baseline	0.160	16%	12.19	12.15	-0.04
					0.010	1%	17.66	17.63	-0.03
					0.005	0.5%	18.59	18.56	-0.03
				Future Cumulative	0.160	16%	11.42	11.40	-0.02
					0.010	1%	16.28	16.23	-0.05
					0.005	0.5%	17.38	17.36	-0.02
9	15.08	3	21.71	Baseline	0.160	16%	11.40	11.28	-0.12
					0.010	1%	16.09	16.09	0.00
					0.005	0.5%	17.21	17.21	0.00
				Future Cumulative	0.160	16%	10.96	10.96	0.00
					0.010	1%	15.61	15.57	-0.04
					0.005	0.5%	16.69	16.68	-0.01
10	12.42	3	11.85 (Restricted Height Levee El.)	Baseline	0.160	16%	11.41	11.36	-0.05
					0.010	1%	13.98	13.98	0.00
					0.005	0.5%	14.94	14.94	0.00
				Future Cumulative	0.160	16%	10.26	10.25	-0.01
					0.010	1%	13.85	13.85	0.00
					0.005	0.5%	14.80	14.80	0.00
11	12.01	3	22.99	Baseline	0.160	16%	10.54	10.54	0.00
					0.010	1%	11.88	11.88	0.00
					0.005	0.5%	12.43	12.43	0.00
				Future Cumulative	0.160	16%	9.63	9.63	0.00
					0.010	1%	11.96	11.96	0.00
					0.005	0.5%	12.52	12.52	0.00

This Page Intentionally Left Blank

TABLE 9
SUMMARY OF CHANGE IN FLOWS DOWNSTREAM OF FREMONT WEIR AND SACRAMENTO WEIR

Location	Design Flow (cfs)	Condition	CNP	% ACE	Peak Flow (cfs)			Volume (acre-feet)		
					Without-Project	With-Project	% Change	Without-Project	With-Project	% Change
Yolo Bypass Downstream of Fremont Weir	343,000	Baseline	0.160	16%	177,900	177,900	0.00%	4,037,500	4,037,500	0.00%
			0.010	1%	380,500	380,500	0.00%	5,787,100	5,787,000	0.00%
			0.005	0.5%	419,300	419,300	0.00%	6,785,400	6,785,200	0.00%
		Future Cumulative	0.160	16%	206,000	206,000	0.00%	3,926,800	3,926,800	0.00%
			0.010	1%	390,500	390,500	0.00%	4,437,000	4,436,800	0.00%
			0.005	0.5%	430,200	430,200	0.00%	5,111,900	5,111,700	0.00%
Sacramento Bypass Downstream of Sacramento Weir	112,000	Baseline	0.160	16%	31,800	31,800	0.00%	224,000	224,000	0.00%
			0.010	1%	109,300	109,300	0.00%	1,363,400	1,363,500	0.01%
			0.005	0.5%	122,600	122,600	0.00%	1,643,900	1,644,200	0.02%
		Future Cumulative	0.160	16%	39,800	39,800	0.00%	247,300	247,300	0.00%
			0.010	1%	114,500	114,500	0.00%	1,160,500	1,161,000	0.04%
			0.005	0.5%	128,800	128,900	0.08%	1,392,100	1,392,800	0.05%

This page intentionally left blank.



West (left) bank of Yolo Bypass at County Road 155

Model Geometry	Conditional Non-Exceedance Probability (CNP)	Flood Frequency (ACE)	Without Project Peak Stage (ft, NAVD 88)	With Project Peak Stage (ft, NAVD 88)	Difference Between With and Without Project Peak Stage (ft, NAVD 88)
Baseline Condition	0.160	16.0%	19.74	19.72	-0.02
Baseline Condition	0.010	1.0%	23.85	23.74	-0.11
Baseline Condition	0.005	0.5%	24.63	24.49	-0.14
Future Cumulative Condition	0.160	16.0%	20.16	20.15	-0.01
Future Cumulative Condition	0.010	1.0%	23.26	23.20	-0.06
Future Cumulative Condition	0.005	0.5%	23.92	23.83	-0.09

Haas Slough at western boundary of RD No. 2098

Model Geometry	Conditional Non-Exceedance Probability (CNP)	Flood Frequency (ACE)	Without Project Peak Stage (ft, NAVD 88)	With Project Peak Stage (ft, NAVD 88)	Difference Between With and Without Project Peak Stage (ft, NAVD 88)
Baseline Condition	0.160	16.0%	13.01	13.00	-0.01
Baseline Condition	0.010	1.0%	18.65	18.63	-0.02
Baseline Condition	0.005	0.5%	19.58	19.53	-0.5
Future Cumulative Condition	0.160	16.0%	11.98	11.97	-0.01
Future Cumulative Condition	0.010	1.0%	17.02	16.99	-0.03
Future Cumulative Condition	0.005	0.5%	18.12	18.11	-0.01

Cache Slough near Hastings Cut

Model Geometry	Conditional Non-Exceedance Probability (CNP)	Flood Frequency (ACE)	Without Project Peak Stage (ft, NAVD 88)	With Project Peak Stage (ft, NAVD 88)	Difference Between With and Without Project Peak Stage (ft, NAVD 88)
Baseline Condition	0.160	16.0%	13.01	13.00	-0.01
Baseline Condition	0.010	1.0%	18.65	18.63	-0.02
Baseline Condition	0.005	0.5%	19.56	19.51	-0.5
Future Cumulative Condition	0.160	16.0%	11.98	11.97	-0.01
Future Cumulative Condition	0.010	1.0%	17.00	16.97	-0.03
Future Cumulative Condition	0.005	0.5%	18.12	18.11	-0.01

West (left) bank of Yolo Bypass at northern boundary of the Project

Model Geometry	Conditional Non-Exceedance Probability (CNP)	Flood Frequency (ACE)	Without Project Peak Stage (ft, NAVD 88)	With Project Peak Stage (ft, NAVD 88)	Difference Between With and Without Project Peak Stage (ft, NAVD 88)
Baseline Condition	0.160	16.0%	14.81	14.36	-0.45
Baseline Condition	0.010	1.0%	20.80	20.28	-0.52
Baseline Condition	0.005	0.5%	21.77	21.22	-0.55
Future Cumulative Condition	0.160	16.0%	14.28	13.92	-0.36
Future Cumulative Condition	0.010	1.0%	19.24	18.74	-0.50
Future Cumulative Condition	0.005	0.5%	20.22	19.73	-0.49

West (left) bank of Yolo Bypass at Yolo County/Solano County Line

Model Geometry	Conditional Non-Exceedance Probability (CNP)	Flood Frequency (ACE)	Without Project Peak Stage (ft, NAVD 88)	With Project Peak Stage (ft, NAVD 88)	Difference Between With and Without Project Peak Stage (ft, NAVD 88)
Baseline Condition	0.160	16.0%	13.68	13.57	-0.11
Baseline Condition	0.010	1.0%	19.86	19.59	-0.27
Baseline Condition	0.005	0.5%	20.84	20.55	-0.29
Future Cumulative Condition	0.160	16.0%	13.12	12.95	-0.17
Future Cumulative Condition	0.010	1.0%	18.09	17.90	-0.19
Future Cumulative Condition	0.005	0.5%	19.10	18.95	-0.15

Cache Slough at Confluence with Yolo Bypass

Model Geometry	Conditional Non-Exceedance Probability (CNP)	Flood Frequency (ACE)	Without Project Peak Stage (ft, NAVD 88)	With Project Peak Stage (ft, NAVD 88)	Difference Between With and Without Project Peak Stage (ft, NAVD 88)
Baseline Condition	0.160	16.0%	13.01	13.00	-0.01
Baseline Condition	0.010	1.0%	18.65	18.63	-0.02
Baseline Condition	0.005	0.5%	19.54	19.52	-0.02
Future Cumulative Condition	0.160	16.0%	11.94	11.94	0.00
Future Cumulative Condition	0.010	1.0%	16.98	16.96	-0.02
Future Cumulative Condition	0.005	0.5%	18.07	18.06	-0.01

Lindsey Slough upstream of Hastings Island Road Bridge

Model Geometry	Conditional Non-Exceedance Probability (CNP)	Flood Frequency (ACE)	Without Project Peak Stage (ft, NAVD 88)	With Project Peak Stage (ft, NAVD 88)	Difference Between With and Without Project Peak Stage (ft, NAVD 88)
Baseline Condition	0.160	16.0%	12.83	12.81	-0.02
Baseline Condition	0.010	1.0%	18.22	18.22	0.00
Baseline Condition	0.005	0.5%	19.07	19.06	-0.01
Future Cumulative Condition	0.160	16.0%	11.60	11.59	-0.01
Future Cumulative Condition	0.010	1.0%	16.47	16.44	-0.03
Future Cumulative Condition	0.005	0.5%	17.56	17.55	-0.01

Cache Slough at Ryer Island

Model Geometry	Conditional Non-Exceedance Probability (CNP)	Flood Frequency (ACE)	Without Project Peak Stage (ft, NAVD 88)	With Project Peak Stage (ft, NAVD 88)	Difference Between With and Without Project Peak Stage (ft, NAVD 88)
Baseline Condition	0.160	16.0%	11.40	11.28	-0.12
Baseline Condition	0.010	1.0%	16.09	16.09	0.00
Baseline Condition	0.005	0.5%	17.21	17.21	0.00
Future Cumulative Condition	0.160	16.0%	10.96	10.96	0.00
Future Cumulative Condition	0.010	1.0%	15.61	15.57	-0.04
Future Cumulative Condition	0.005	0.5%	16.69	16.68	-0.01

Cache Slough at northern end of Little Egbert Tract

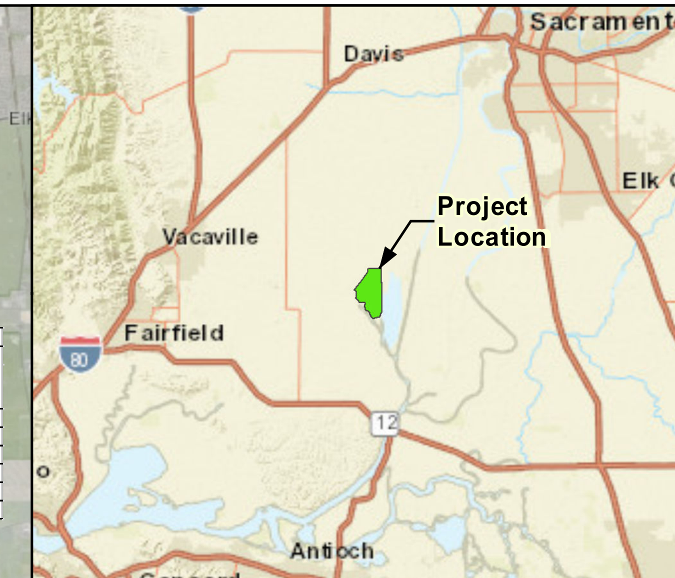
Model Geometry	Conditional Non-Exceedance Probability (CNP)	Flood Frequency (ACE)	Without Project Peak Stage (ft, NAVD 88)	With Project Peak Stage (ft, NAVD 88)	Difference Between With and Without Project Peak Stage (ft, NAVD 88)
Baseline Condition	0.160	16.0%	12.19	12.15	-0.04
Baseline Condition	0.010	1.0%	17.66	17.63	-0.03
Baseline Condition	0.005	0.5%	18.59	18.56	-0.03
Future Cumulative Condition	0.160	16.0%	11.42	11.40	-0.02
Future Cumulative Condition	0.010	1.0%	16.28	16.23	-0.05
Future Cumulative Condition	0.005	0.5%	17.38	17.36	-0.02

Cache Slough at southern end of Little Egbert Tract

Model Geometry	Conditional Non-Exceedance Probability (CNP)	Flood Frequency (ACE)	Without Project Peak Stage (ft, NAVD 88)	With Project Peak Stage (ft, NAVD 88)	Difference Between With and Without Project Peak Stage (ft, NAVD 88)
Baseline Condition	0.160	16.0%	11.41	11.36	-0.05
Baseline Condition	0.010	1.0%	13.98	13.98	0.00
Baseline Condition	0.005	0.5%	14.94	14.94	0.00
Future Cumulative Condition	0.160	16.0%	10.26	10.25	-0.01
Future Cumulative Condition	0.010	1.0%	13.85	13.85	0.00
Future Cumulative Condition	0.005	0.5%	14.80	14.80	0.00

Sacramento River at Rio Vista

Model Geometry	Conditional Non-Exceedance Probability (CNP)	Flood Frequency (ACE)	Without Project Peak Stage (ft, NAVD 88)	With Project Peak Stage (ft, NAVD 88)	Difference Between With and Without Project Peak Stage (ft, NAVD 88)
Baseline Condition	0.160	16.0%	10.54	10.54	0.00
Baseline Condition	0.010	1.0%	11.88	11.88	0.00
Baseline Condition	0.005	0.5%	12.43	12.43	0.00
Future Cumulative Condition	0.160	16.0%	9.63	9.63	0.00
Future Cumulative Condition	0.010	1.0%	11.96	11.96	0.00
Future Cumulative Condition	0.005	0.5%	12.52	12.52	0.00



Ecosystem Investment Partners

LOOKOUT SLOUGH TIDAL HABITAT RESTORATION AND FLOOD IMPROVEMENT PROJECT

PROJECT IMPACTS AT INDEX POINTS

SOLANO COUNTY, CALIFORNIA
AUGUST, 2019

NORTH

0 6,000 12,000 24,000
FEET

Project Location

RD 2060 and RD 2068 Levees

① Index Point

Sources: Esri Service Layers 2018 (World Imagery, World Topographic Map, World Street Map).

Notes:
1. Hydrology input data adapted from "Basin-Wide Feasibility Studies - Sacramento River Basin" prepared by California Departmentof Water Resources in 2017. Event hydrology is based on the Central Valley Hydrology Study (USACE, 2015) methodology. 10% ACE uses the 1997 pattern with 0.40 scale factor. 1% ACE uses the 1997 pattern with 0.95 scale factor, and 0.5% ACE uses the 1997 pattern with 1.10 scale factor.

2. Future Cumulative Condition represents full build-out of the Yolo Bypass Option 3 concept presented in "Basin-Wide Feasibility Studies - Sacramento River Basin" prepared by DWR in 2017.

PRELIMINARY

WOOD RODGERS

J:\3000-s\3487_Ecosystem_Invest_Partners\3487002 Lookout Slough Prelim Hydraulic Analysis\GIS\Tasks\20190807_Comparison_Point_Map\FXX_Overall_Project_Impacts_Map_20190807_V1.mxd 8/7/2019 4:23:25 PM cmilligan

FIGURE 36

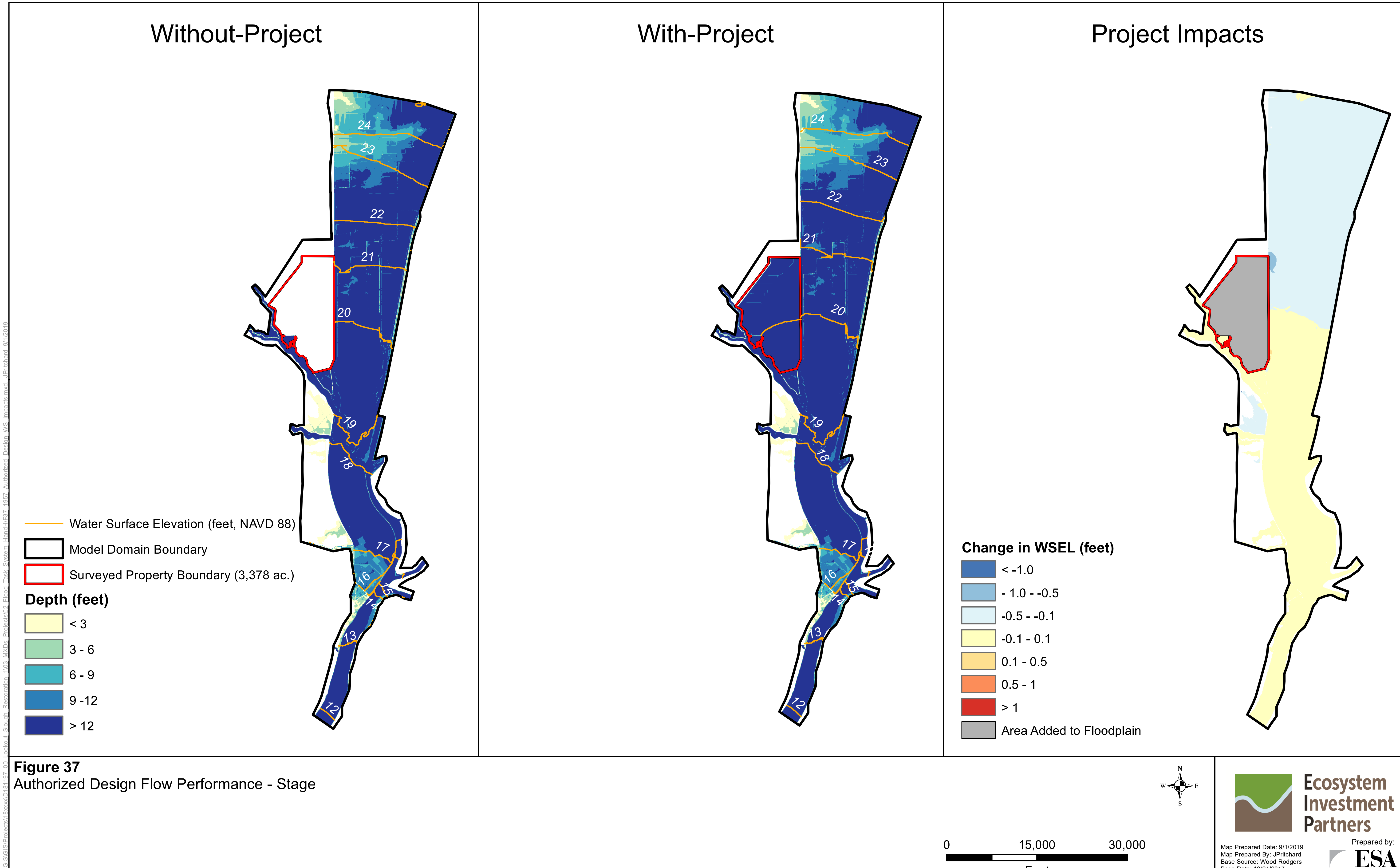


Figure 37
Authorized Design Flow Performance - Stage

Lookout Slough Tidal Habitat Restoration and Flood Improvement Project

Ecosystem Investment Partners

Map Prepared Date: 9/1/2019
Map Prepared By: JPritchard
Base Source: Wood Rodgers
Base Date: 10/24/2017
Data Source(s):

Prepared by:
ESA

TABLE 10
SUMMARY OF AUTHORIZED DESIGN FLOW COMPUTED WATER SURFACE ELEVATIONS (FEET, NAVD 88)
BASELINE CONDITION

Index Point	Location	Without-Project	With-Project	Change
1	West (left) bank of Yolo Bypass at County Road 155	24.05	23.92	-0.13
2	Hass Slough at western boundary of RD 2098	19.36	19.35	-0.01
3	Cache Slough near Hastings Cut	19.36	19.35	-0.01
4	West (left) levee of Yolo Bypass at northern boundary of the Project	21.29	20.76	-0.53
5	West (left) bank of Yolo Bypass at Yolo County/Solano County Line	20.43	20.20	-0.23
6	Cache Slough at Confluence with Yolo Bypass	19.35	19.34	-0.01
7	Lindsey Slough upstream of Hastings Island Road Bridge	18.94	18.94	0.00
8	Cache Slough at northern end of Little Egbert Tract	18.51	18.51	0.00
9	Cache Slough at Ryer Island	17.33	17.33	0.00
10	Cache Slough at southern end of Little Egbert Tract	15.49	15.49	0.00
11	Sacramento River at Rio Vista	13.19	13.19	0.00

Velocity Impacts

The resultant computed maximum velocity for the without- and with-Project simulations are shown on **Figure 38**. Figure 38 also depicts the change in maximum velocity between the without- and with-Project conditions. Although the Project results in localized increases in velocity in some locations, the maximum velocities remain low enough that channel erosion and scour potential along the SRFCP facilities are not considered to be significant.

Baseline Condition Performance Assessment

The Baseline Condition was analyzed without- and with-Project to identify hydraulic changes that would result from the proposed alteration. The assessment included hydraulic analysis of the authorized design flow capacity, and assessment of the respective 16% ACE (6-year), 1% ACE (100-year), and 0.5% ACE (200-year) design storm events. The following section describes the changes in the hydraulic performance of the system created by the Project.

Stage Impacts

The resultant change in the Baseline Condition water surfaces at the respective index point locations is summarized in on Figure 36 as well as in Table 8. The resultant floodplain extents, depth, and computed maximum water surface for the 16% ACE (6-year), 1% ACE (100-year), and 0.5% ACE (200-year) design flows for the without- and with-Project simulations are shown on **Figure 39** through **Figure 41**, respectively. Figure 39 through Figure 41 also depict the change in maximum stage between the without- and with-Project conditions for the respective design storm events. In general, the Project results in localized stage reductions in the Yolo Bypass and does not increase stages in other parts of the system.

Velocity Impacts

The resultant change in the Baseline Condition velocities for the 16% ACE (6-year), 1% ACE (100-year), and 0.5% ACE (200-year) design flows for the without- and with-Project simulations are shown on **Figure 42** through **Figure 44**, respectively. Figure 42 through Figure 44 also depict the change in the Baseline Condition maximum velocity between the without- and with-Project conditions for the respective design storm events. Although the Project results in localized increases in velocity in some locations, the maximum velocities remain low enough that channel erosion and scour potential along existing and proposed SRFCP facilities are not considered to be significant during the 1% ACE (100-year) storm event.

The Wood Rodgers civil design team has determined that planting native grasses will be adequate for protecting the waterside of the new setback levee. A detailed discussion of the erosion countermeasures design is included in the main body of the overall Basis of Design Report.

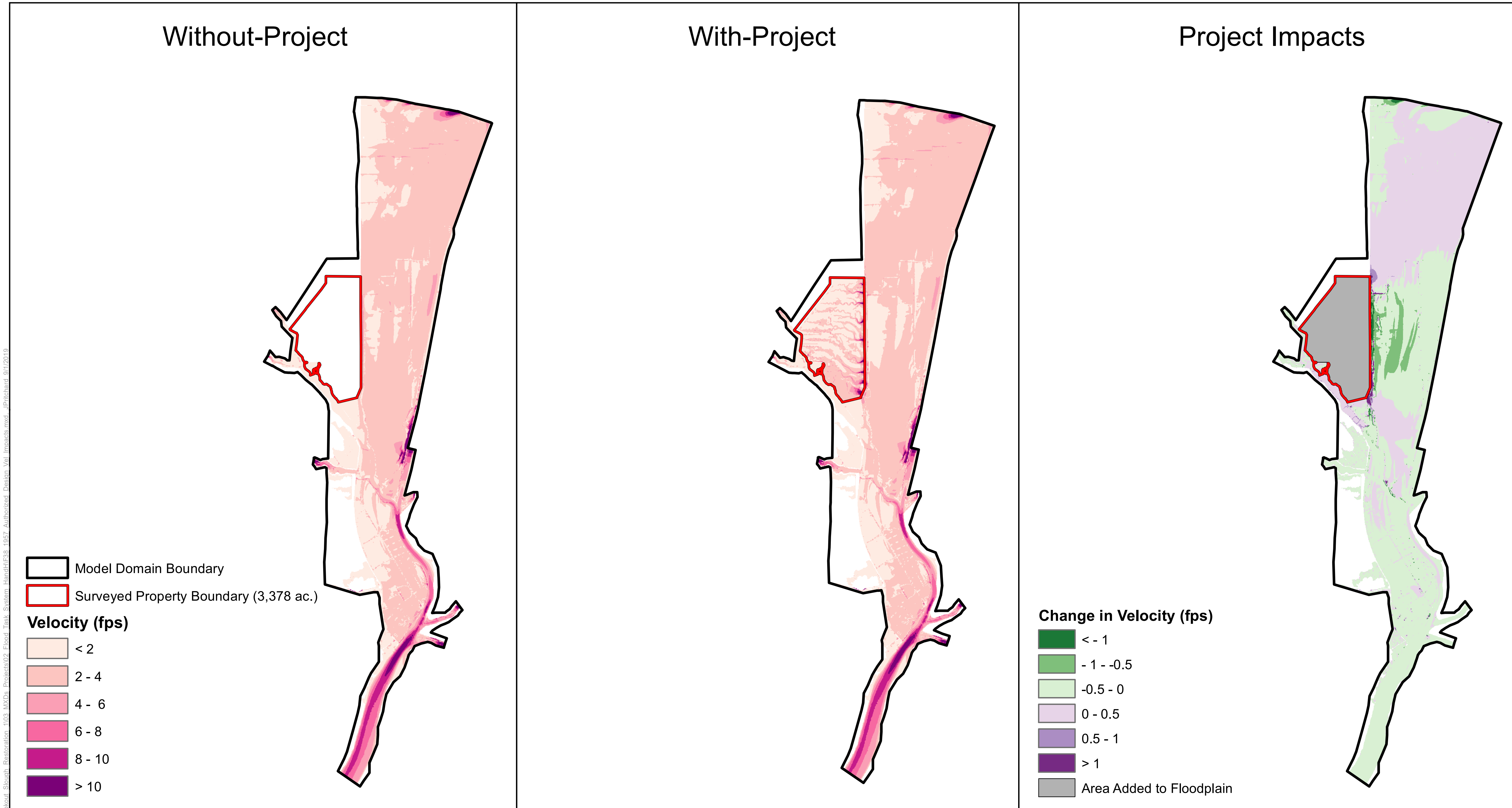


Figure 38
Authorized Design Flow Performance - Velocity

Lookout Slough Tidal Habitat Restoration and Flood Improvement Project

0 15,000 30,000
Feet

Ecosystem Investment Partners

Map Prepared Date: 9/1/2019
Map Prepared By: JPritchard
Base Source: Wood Rodgers
Base Date: 10/24/2017
Data Source(s):

Prepared by:
ESA

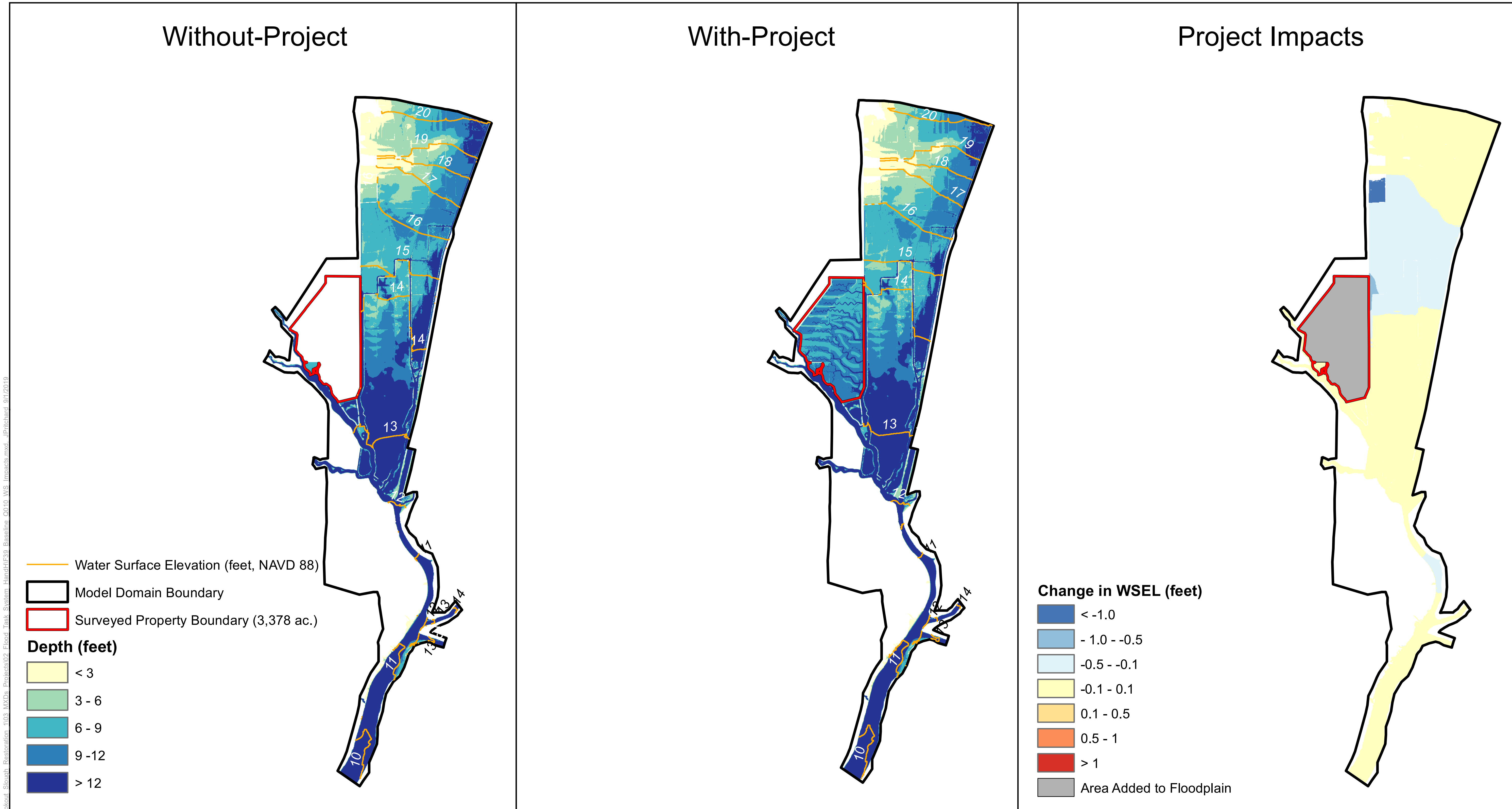


Figure 39
Baseline Condition Performance 16% ACE (6-year) - Stage

0 15,000 30,000
Feet

Lookout Slough Tidal Habitat Restoration and Flood Improvement Project

Ecosystem Investment Partners

Map Prepared Date: 9/1/2019
Map Prepared By: JPritchard
Base Source: Wood Rodgers
Base Date: 10/24/2017
Data Source(s):

Prepared by:
ESA

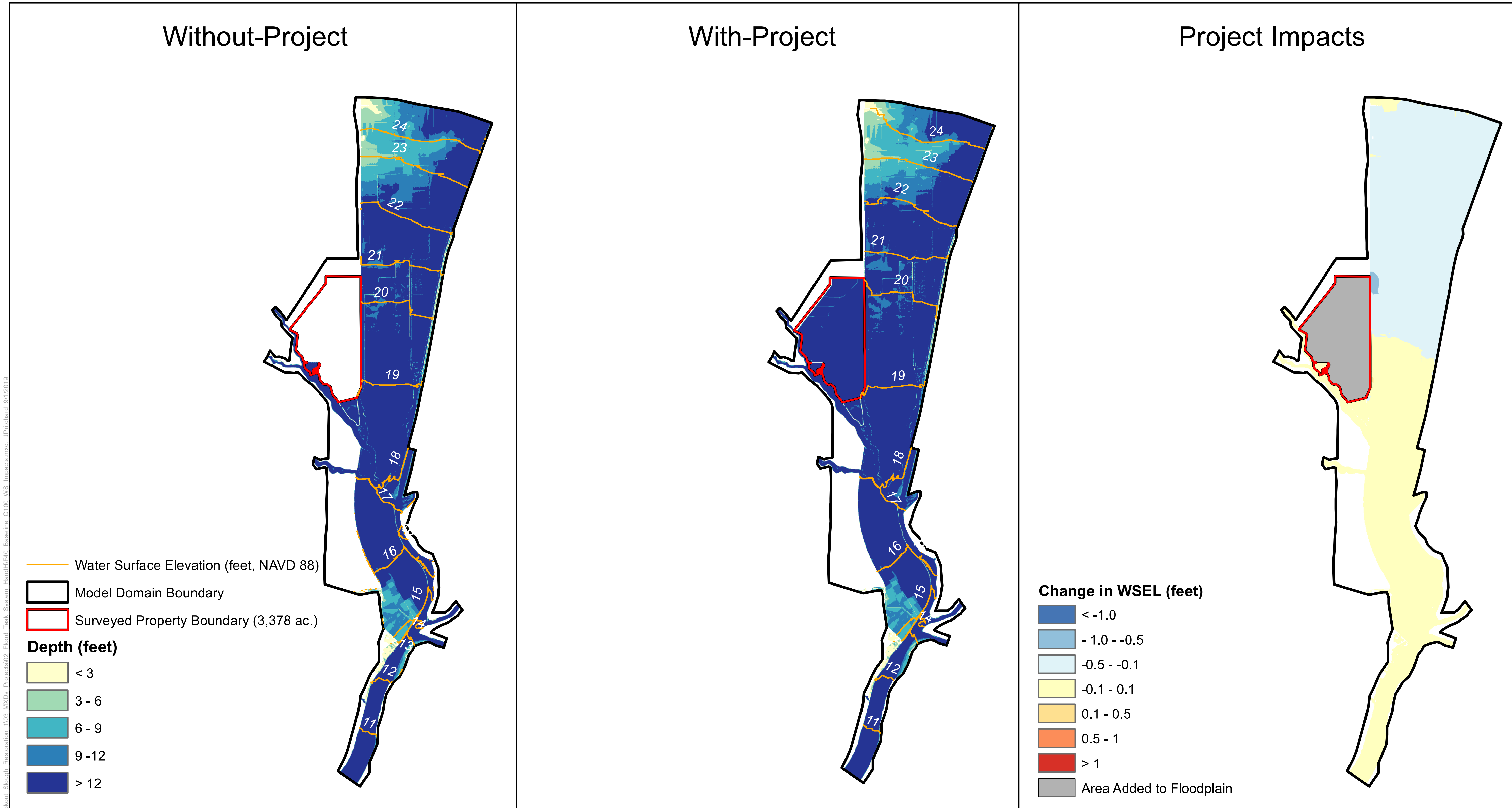


Figure 40
Baseline Condition Performance 1% ACE (100-year) - Stage

0 15,000 30,000
Feet

Lookout Slough Tidal Habitat Restoration and Flood Improvement Project

Ecosystem Investment Partners

Map Prepared Date: 9/1/2019
Map Prepared By: JPritchard
Base Source: Wood Rodgers
Base Date: 10/24/2017
Data Source(s):

Prepared by: ESA

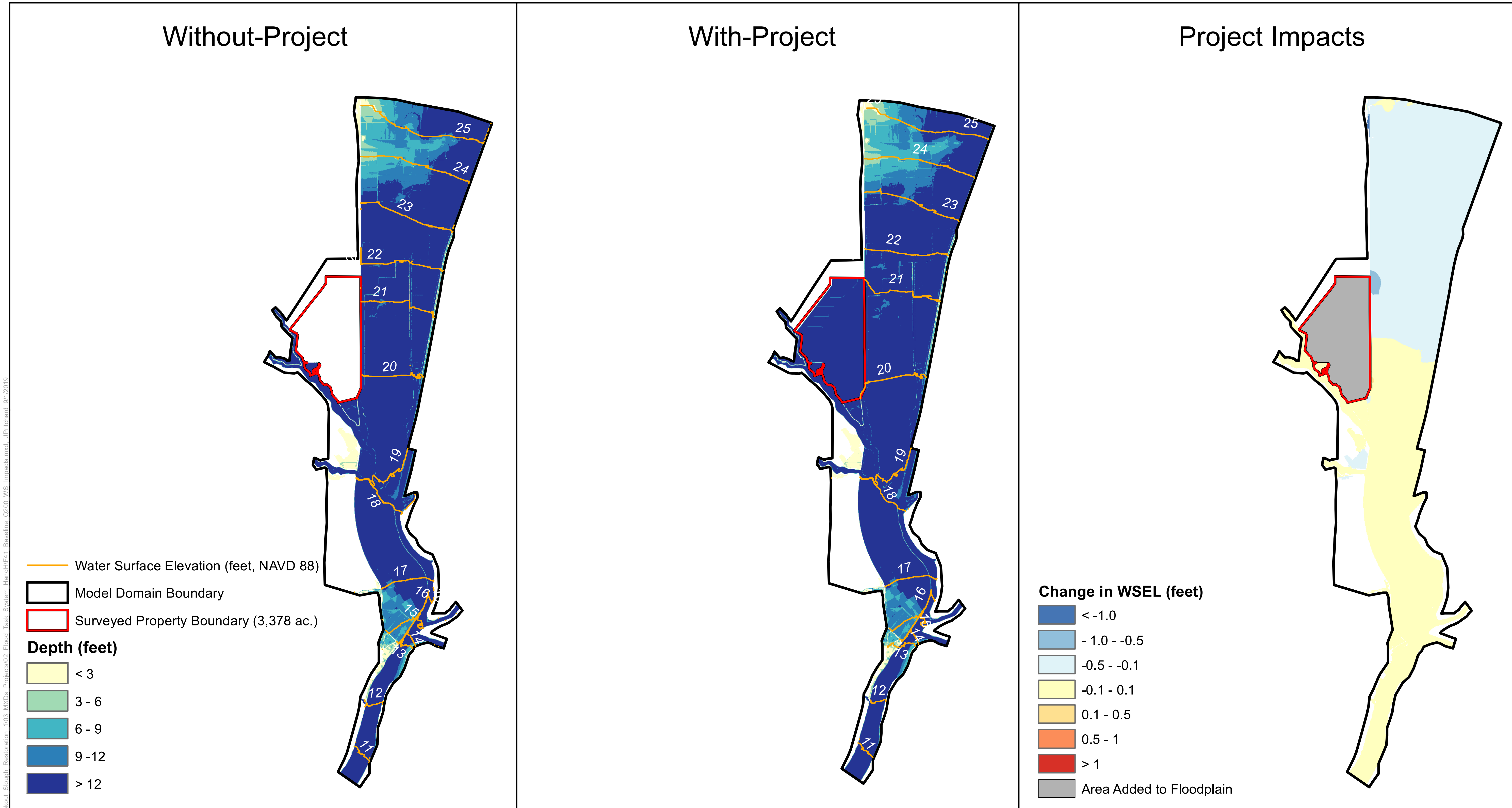


Figure 41
Baseline Condition Performance 0.5% ACE (200-year) - Stage

0 15,000 30,000
Feet

Lookout Slough Tidal Habitat Restoration and Flood Improvement Project

Ecosystem Investment Partners

Map Prepared Date: 9/1/2019
Map Prepared By: JPritchard
Base Source: Wood Rodgers
Base Date: 10/24/2017
Data Source(s):

Prepared by:
ESA

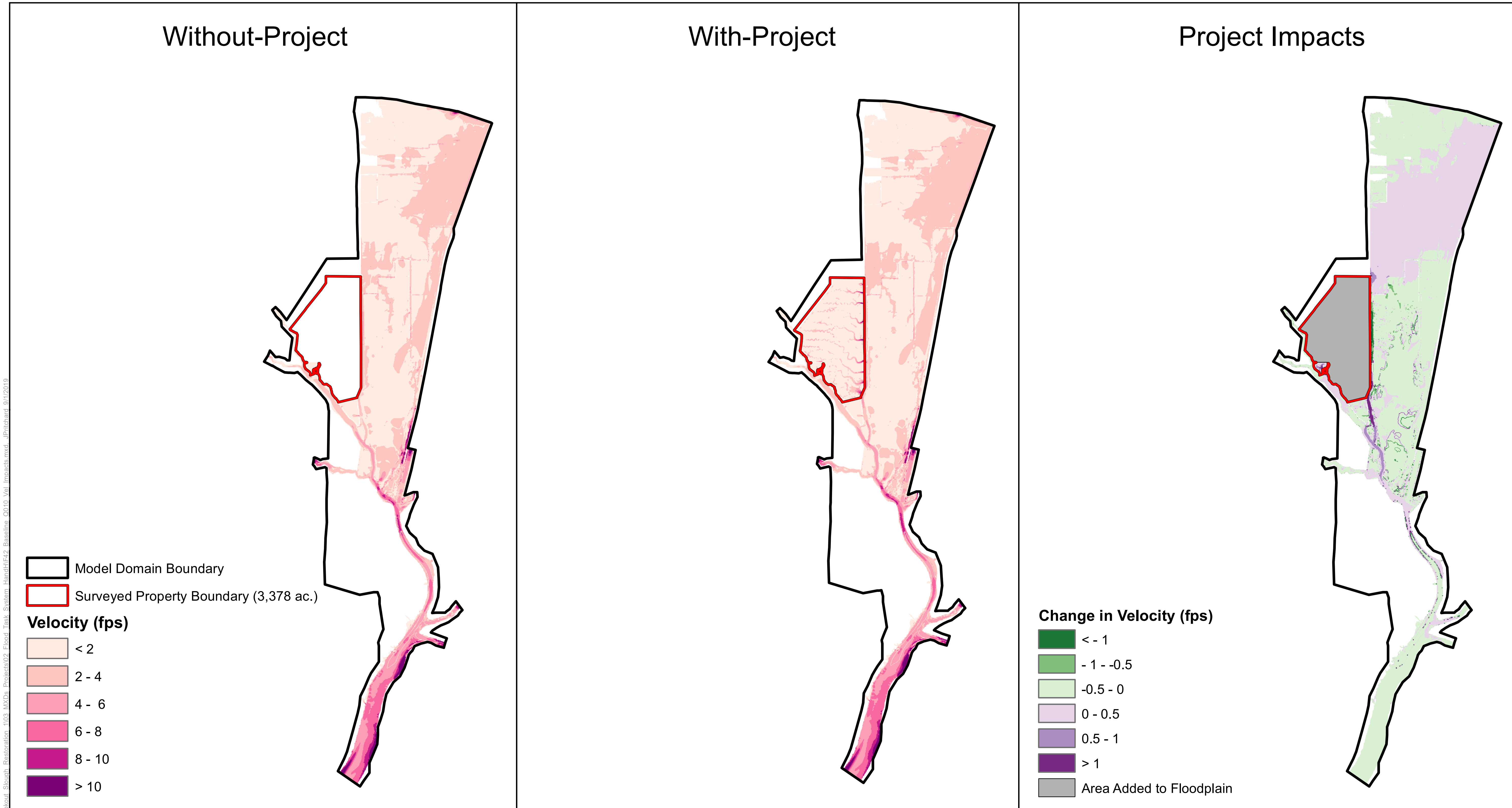


Figure 42
Baseline Condition Performance 16% ACE (6-year) - Velocity

Lookout Slough Tidal Habitat Restoration and Flood Improvement Project

0 15,000 30,000
Feet

Ecosystem Investment Partners

Map Prepared Date: 9/1/2019
Map Prepared By: JPritchard
Base Source: Wood Rodgers
Base Date: 10/24/2017
Data Source(s):

Prepared by:
ESA

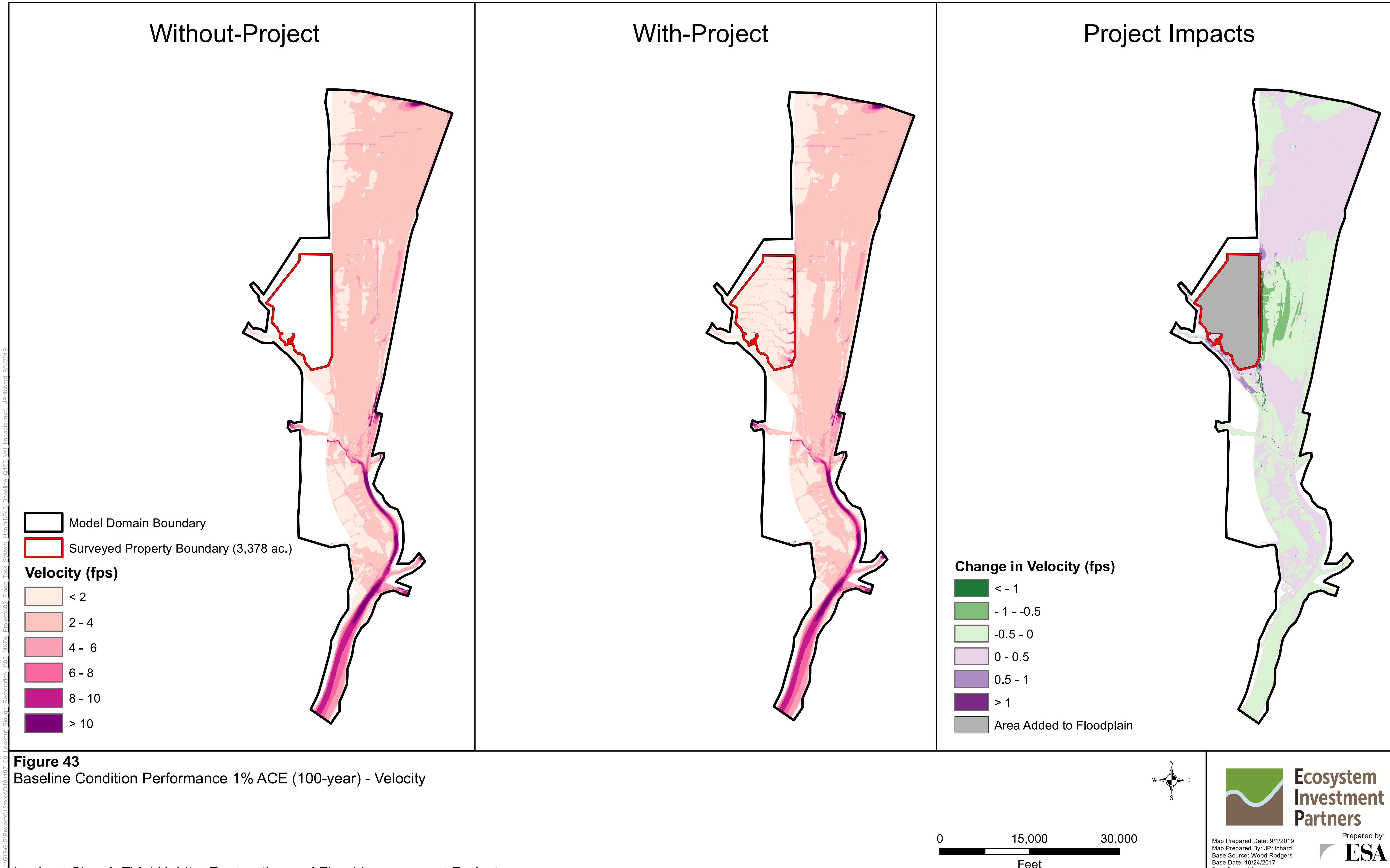


Figure 43
Baseline Condition Performance 1% ACE (100-year) - Velocity

Lookout Slough Tidal Habitat Restoration and Flood Improvement Project

Ecosystem Investment Partners

Map Prepared Date: 9/1/2019
Map Prepared By: JPritchard
Base Source: Wood Rodgers
Base Date: 10/24/2017
Data Source(s):

Prepared by: ESA

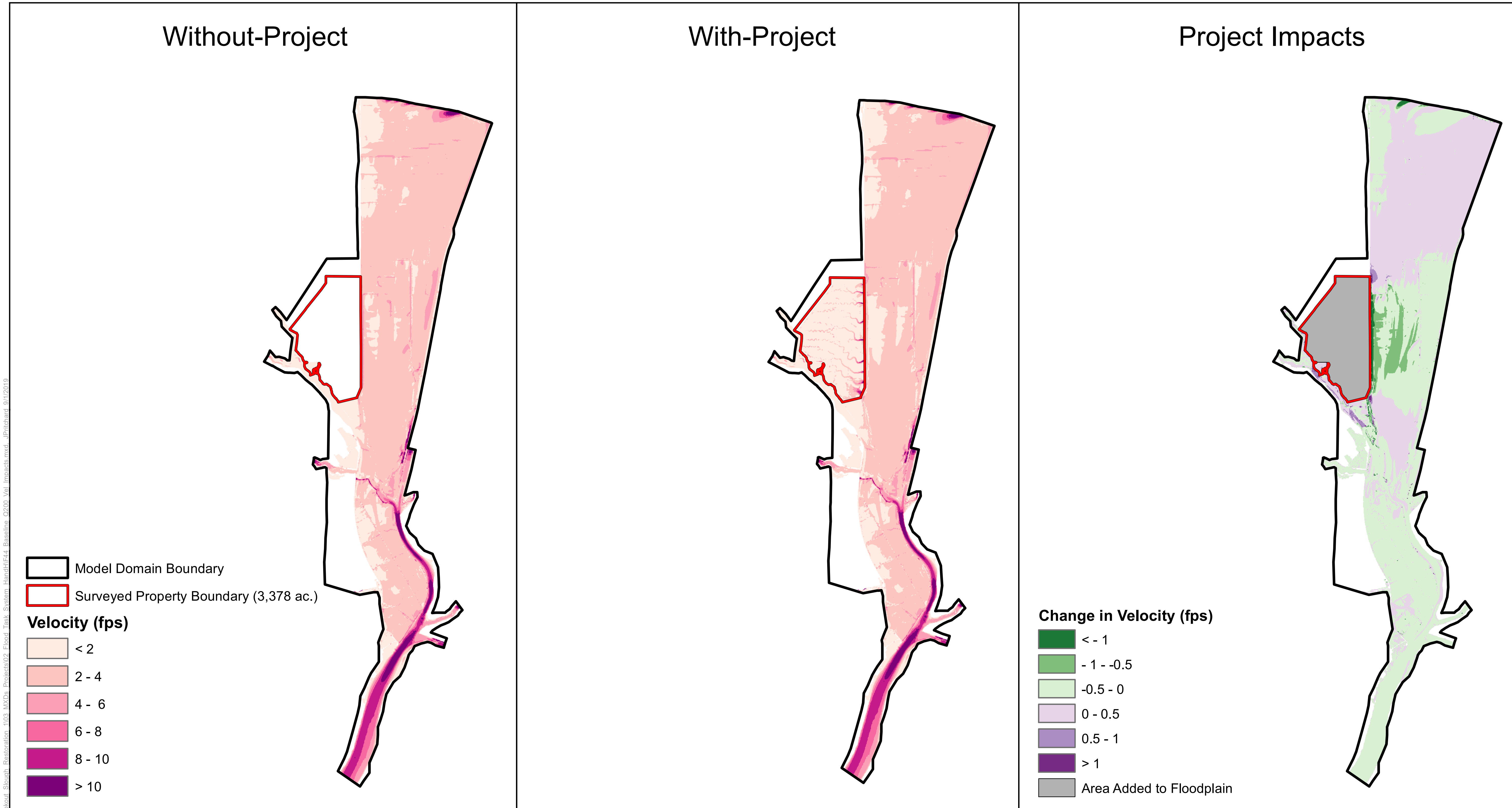


Figure 44
Baseline Condition Performance 0.5% ACE (200-year) - Velocity

0 15,000 30,000
Feet

Ecosystem Investment Partners

Map Prepared Date: 9/1/2019
Map Prepared By: JPritchard
Base Source: Wood Rodgers
Base Date: 10/24/2017
Data Source(s):

Prepared by: ESA

Lookout Slough Tidal Habitat Restoration and Flood Improvement Project

This page intentionally left blank

Future Cumulative Condition Performance Assessment

The Future Cumulative Condition was analyzed without- and with-Project to identify hydraulic changes that would result from the proposed alteration relative to the preferred Yolo Bypass expansion concept (Yolo Bypass Option 3) identified in the BWFS. The assessment included hydraulic analysis of the authorized design flow capacity, and assessment of the respective 16% ACE (6-year), 1% ACE (100-year), and 0.5% ACE (200-year) design storm events. The following section describes the changes in the hydraulic performance of the system created by the Project.

Stage Impacts

The resultant change in the Future Cumulative Condition water surfaces at the respective index point locations is summarized on Figure 36 as well as in Table 8. The resultant floodplain extents, depth, and computed maximum water surface for the 16% ACE (6-year), 1% ACE (100-year), and 0.5% ACE (200-year) design flows for the without- and with-Project simulations are shown on **Figure 45** through **Figure 47**, respectively. Figure 45 through Figure 47 also depict the change in maximum stage between the without- and with-Project conditions for the respective design storm events. In general, the Project results in localized stage reductions in the Yolo Bypass and does not increase stages in other parts of the system for any of the frequency intervals analyzed.

Velocity Impacts

The resultant change in the Future Cumulative Condition velocities for the 16% ACE (6-year), 1% ACE (100-year), and 0.5% ACE (200-year) design flows for the without- and with-Project simulations are shown on **Figure 48** through **Figure 50**, respectively. Figure 48 through Figure 50 also depict the change in the Baseline Condition maximum velocity between the without- and with-Project conditions for the respective design storm events. Although the Project results in localized increases in velocity in some locations, the maximum velocities remain low enough that channel erosion and scour potential along existing and proposed SRFCP facilities are not considered to be significant during the 1% ACE (100-year) storm event.

As noted previously, a detailed discussion of the erosion countermeasures design is included in the main body of the overall Basis of Design Report.

Design Water Surface Elevation

Figure 51 shows the With-Project 1% ACE (100-year) design water surface profile along the Project's proposed setback levee alignment plotted relative to the 1957 authorized design profile (projected westward, perpendicular from the existing levee alignment). Although the flow rates in this part of the Yolo Bypass are comparable, the authorized 1957 design water surface profile is generally higher than the computed 1% ACE (100-year) design profile. The differences seen here are considered to be the product of the stage reductions in the Yolo Bypass created by the Project in conjunction with higher downstream stage assumptions in the 1957 authorized design profile (see Table 3).

The 1957 Profile is based on specified design discharges (not tied to a recurrence frequency) and adopted concurrent conditions at confluences of study streams (USACE, 1993). In this portion of the Yolo Bypass, the 1957 profile was based on flow extents and durations from the 1907 and

1909 floods (DWR, 2016, U.S. House, 1917). For the purposes of designing a new setback levee, the 1957 profile will provide a slightly more conservative design water surface elevation and should generally be used as the basis of design except at locations where the 1% ACE (100-year) stage provides a higher elevation.

Summary and Conclusion

This report documents the methods, data, and assumptions used to establish the design water surface elevation and potential impacts associated with a multi-benefit project that meets the objectives of habitat restoration while also improving flood conveyance in the Yolo Bypass. The Project as proposed, has been determined to create no adverse impacts to stage or channel velocity, while providing localized reductions in stage within the Yolo Bypass.

The existing system and future hydraulic performance of the project have been described in this report. A fundamental precept of the analysis is that the 1957 authorized design water surface profile shall be used as the basis for design for the Project's setback levee. The design top of levee shall include 6 feet of freeboard, plus 1 additional foot of freeboard for climate resiliency. Analysis of the Future Cumulative Condition also indicates that the Project will achieve superior hydraulic performance relative to the preferred concept plan (Yolo Bypass Option 3) identified in the BWFS.

The analysis described in this report shows that the proposed Project alterations would result in negligible adverse impacts to flood stages in the system. The region-wide system models have also been reviewed to verify that no significant change in the flow distribution at Fremont Weir or the Sacramento Weir would occur as a result of the Project. As the hydraulic impacts of the Project are localized, and generally result in stage decreases for the design events under consideration (including the 1957 authorized design flow), the Project's potential to transfer risk from one part of the system to another is considered to be negligible. The deterministic analysis conducted for the Project is considered sufficient for describing the overall system performance for the without- and with-Project conditions and verifies that the reduction in assurance is negligible.

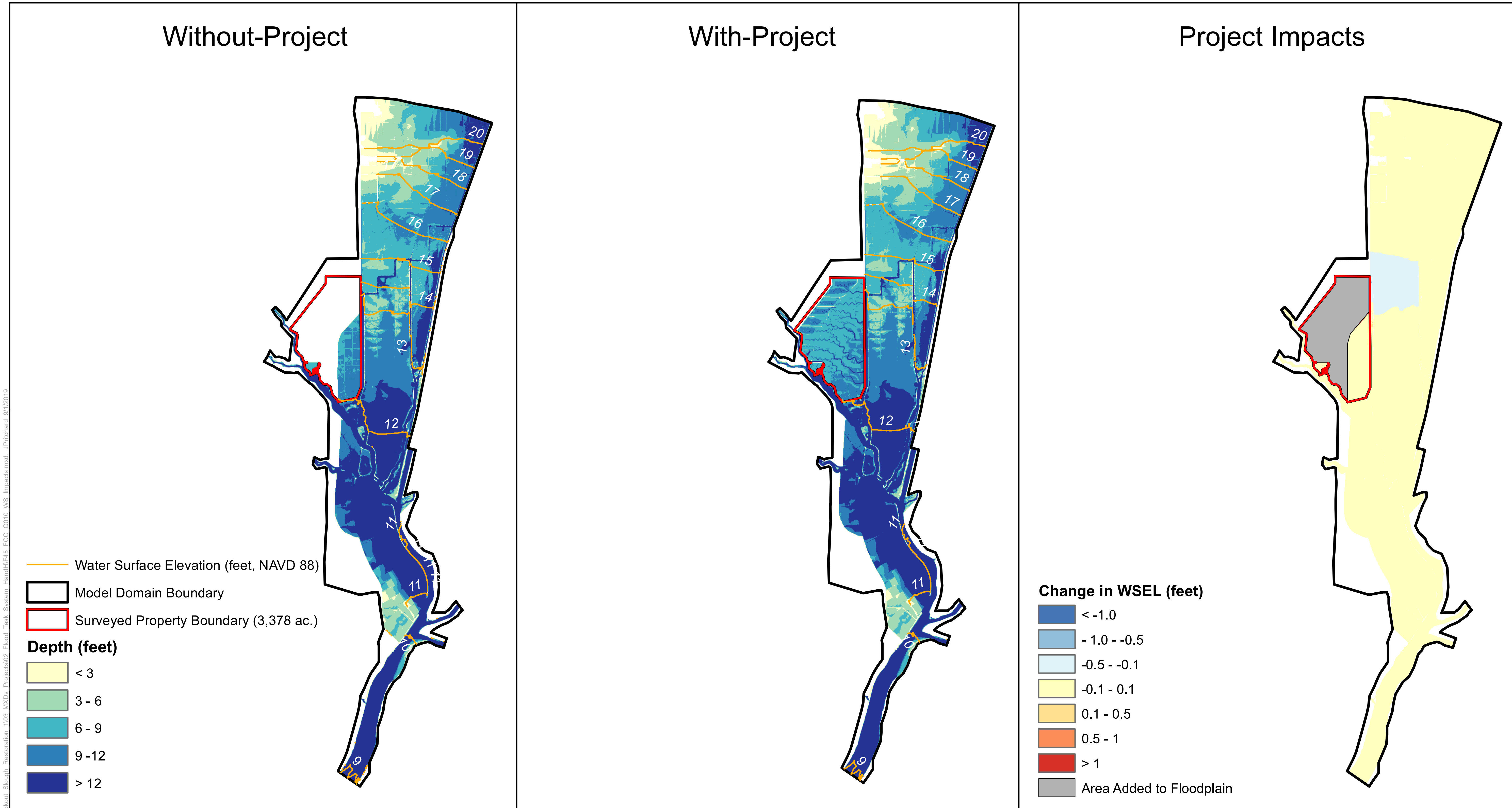


Figure 45
Future Cumulative Condition Performance 16% ACE (6-year) - Stage

0 15,000 30,000
Feet

Lookout Slough Tidal Habitat Restoration and Flood Improvement Project

Ecosystem Investment Partners

Map Prepared Date: 9/1/2019
Map Prepared By: JPritchard
Base Source: Wood Rodgers
Base Date: 10/24/2017
Data Source(s):

Prepared by:
ESA

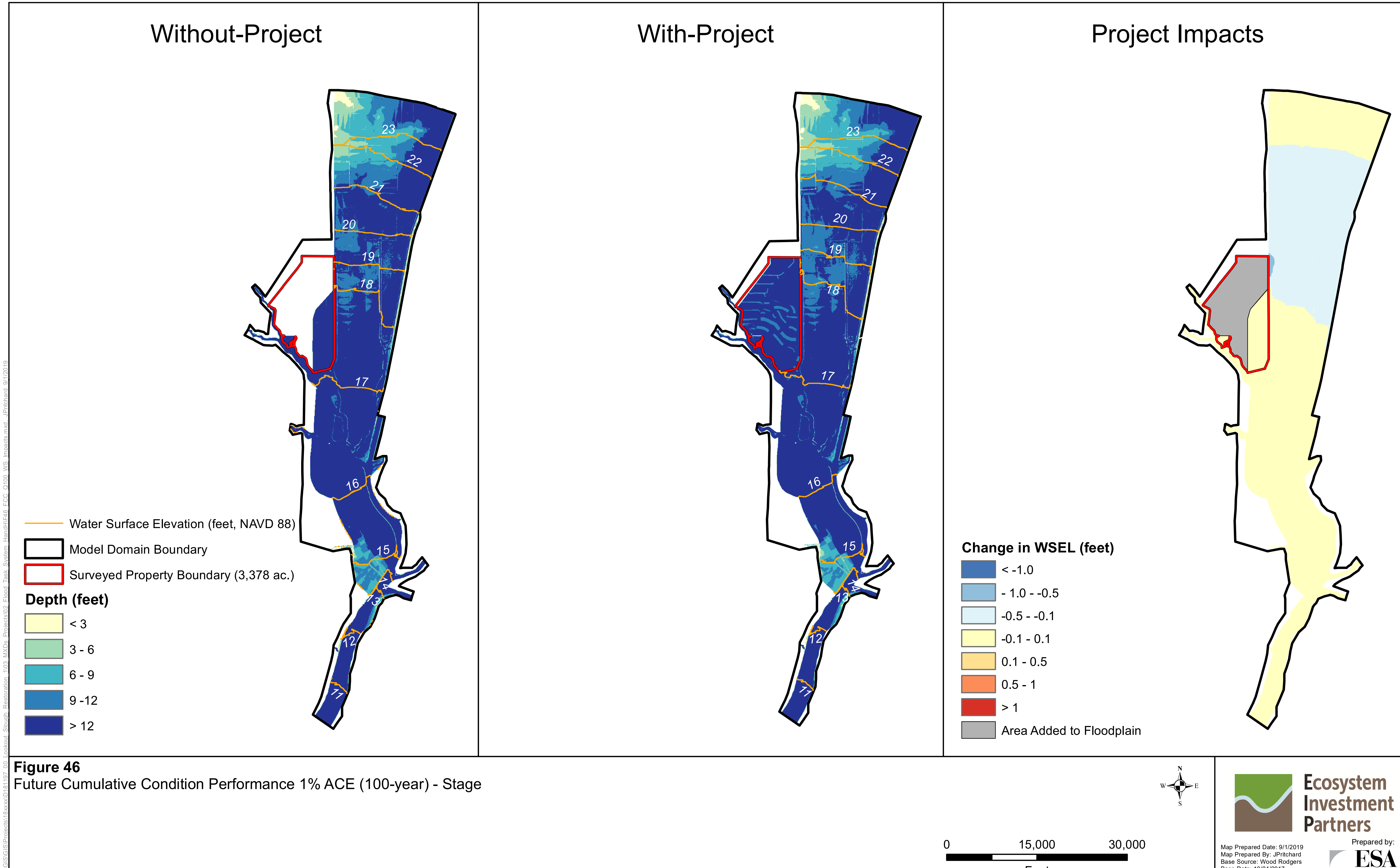


Figure 46
Future Cumulative Condition Performance 1% ACE (100-year) - Stage

Lookout Slough Tidal Habitat Restoration and Flood Improvement Project

Ecosystem Investment Partners

Map Prepared Date: 9/1/2019
Map Prepared By: JPritchard
Base Source: Wood Rodgers
Base Date: 10/24/2017
Data Source(s):

Prepared by: ESA

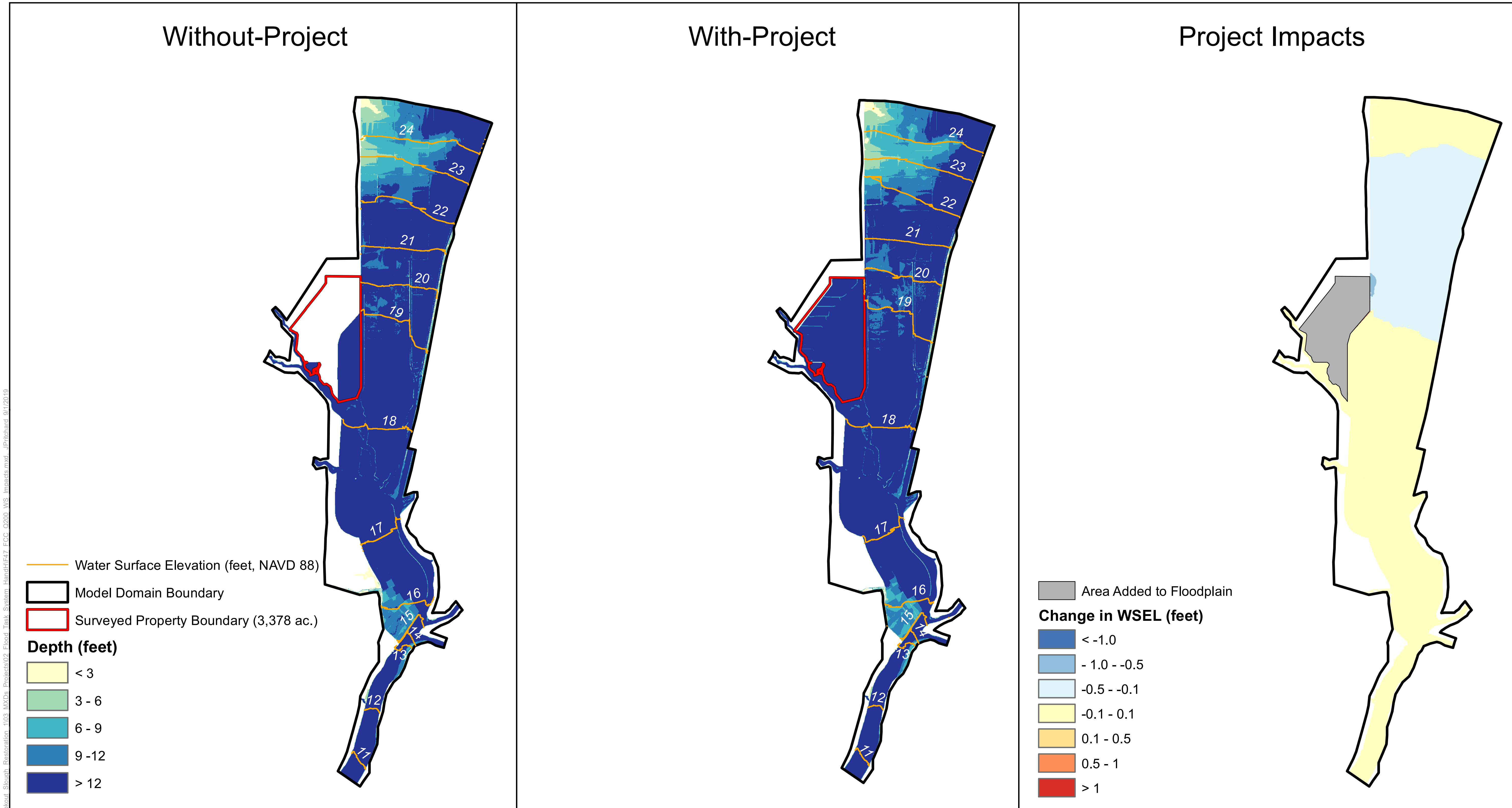


Figure 47
Future Cumulative Condition Performance 0.5% ACE (200-year) - Stage

Lookout Slough Tidal Habitat Restoration and Flood Improvement Project

Ecosystem Investment Partners

Map Prepared Date: 9/1/2019
Map Prepared By: JPritchard
Base Source: Wood Rodgers
Base Date: 10/24/2017
Data Source(s):

Prepared by:
ESA

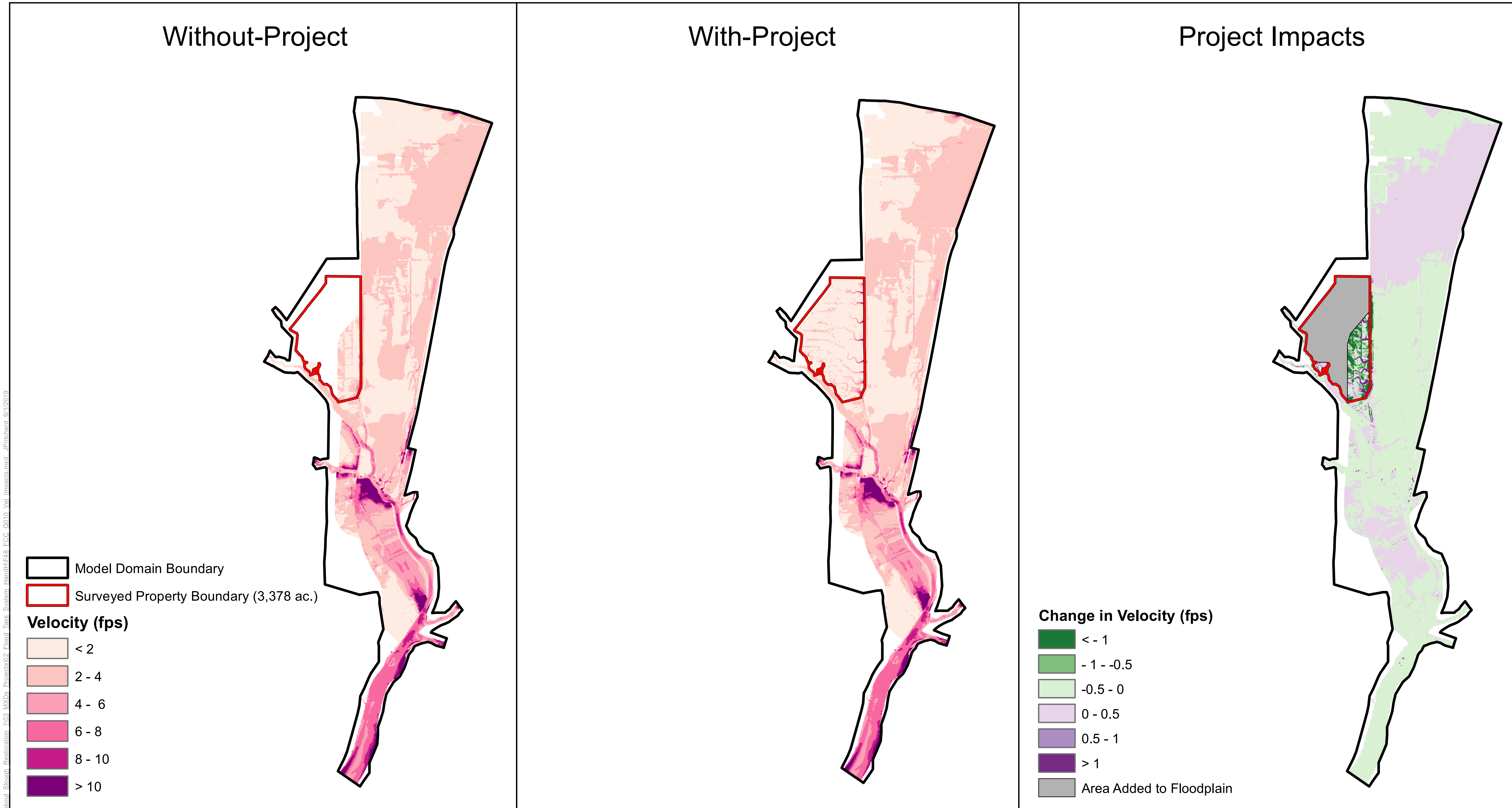


Figure 48
Future Cumulative Condition Performance 16% ACE (6-year) - Velocity

0 15,000 30,000
Feet

Ecosystem Investment Partners

Map Prepared Date: 9/1/2019
Map Prepared By: JPritchard
Base Source: Wood Rodgers
Base Date: 10/24/2017
Data Source(s):

Prepared by: ESA

Lookout Slough Tidal Habitat Restoration and Flood Improvement Project

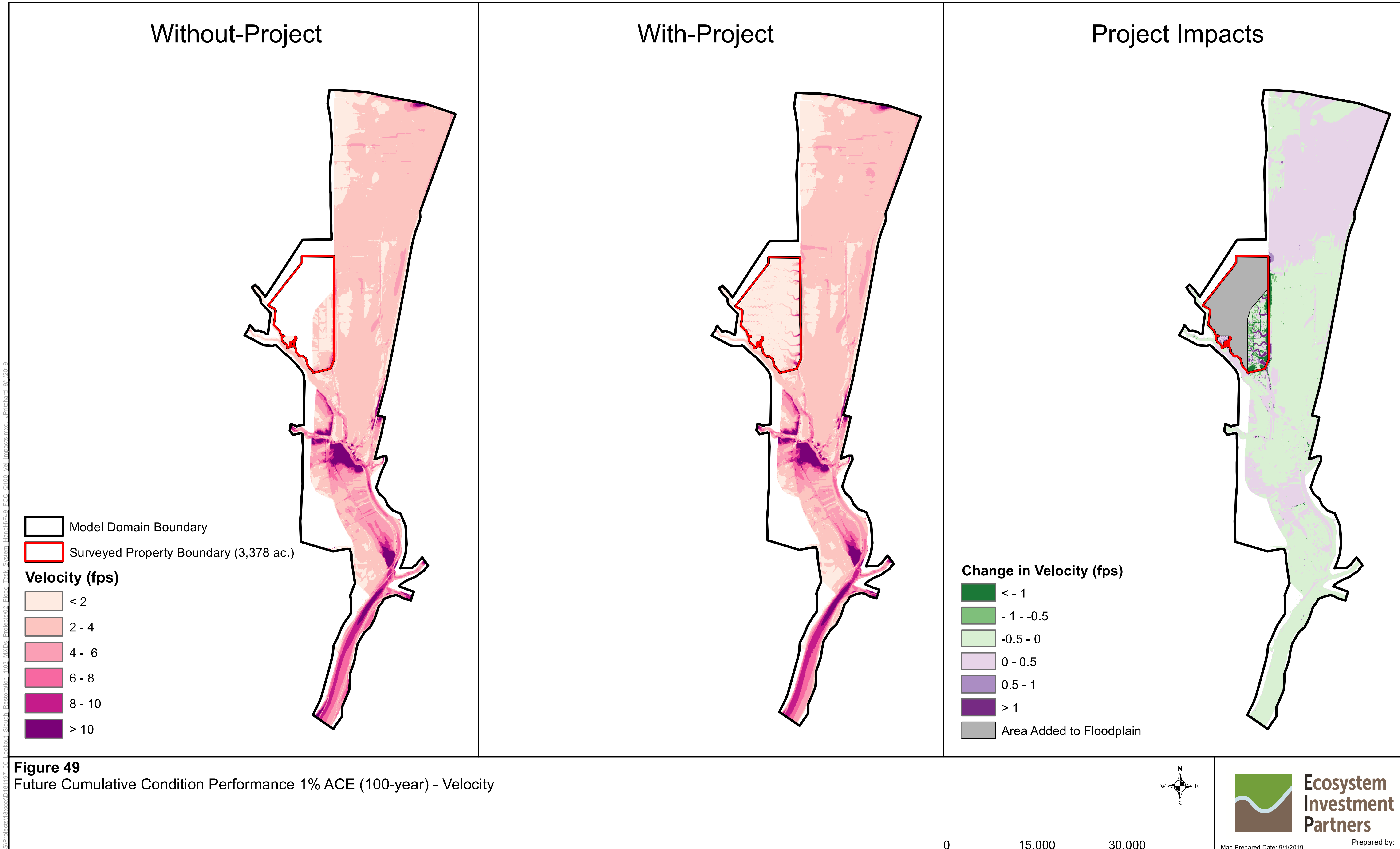


Figure 49
Future Cumulative Condition Performance 1% ACE (100-year) - Velocity

Lookout Slough Tidal Habitat Restoration and Flood Improvement Project

Ecosystem Investment Partners

Map Prepared Date: 9/1/2019
Map Prepared By: JPritchard
Base Source: Wood Rodgers
Base Date: 10/24/2017
Data Source(s):

Prepared by: ESA

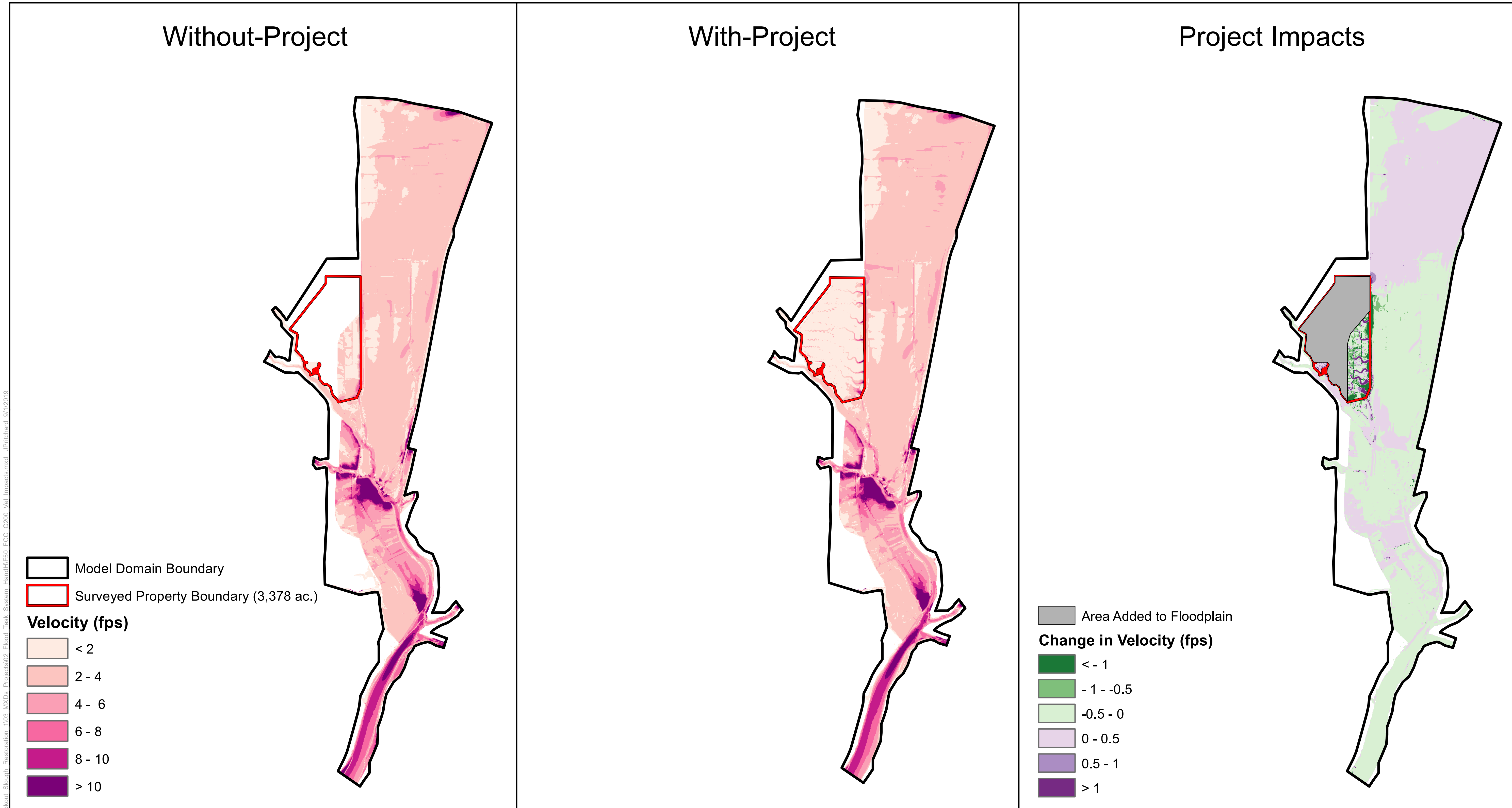


Figure 50
Future Cumulative Condition Performance 0.5% ACE (200-year) - Velocity

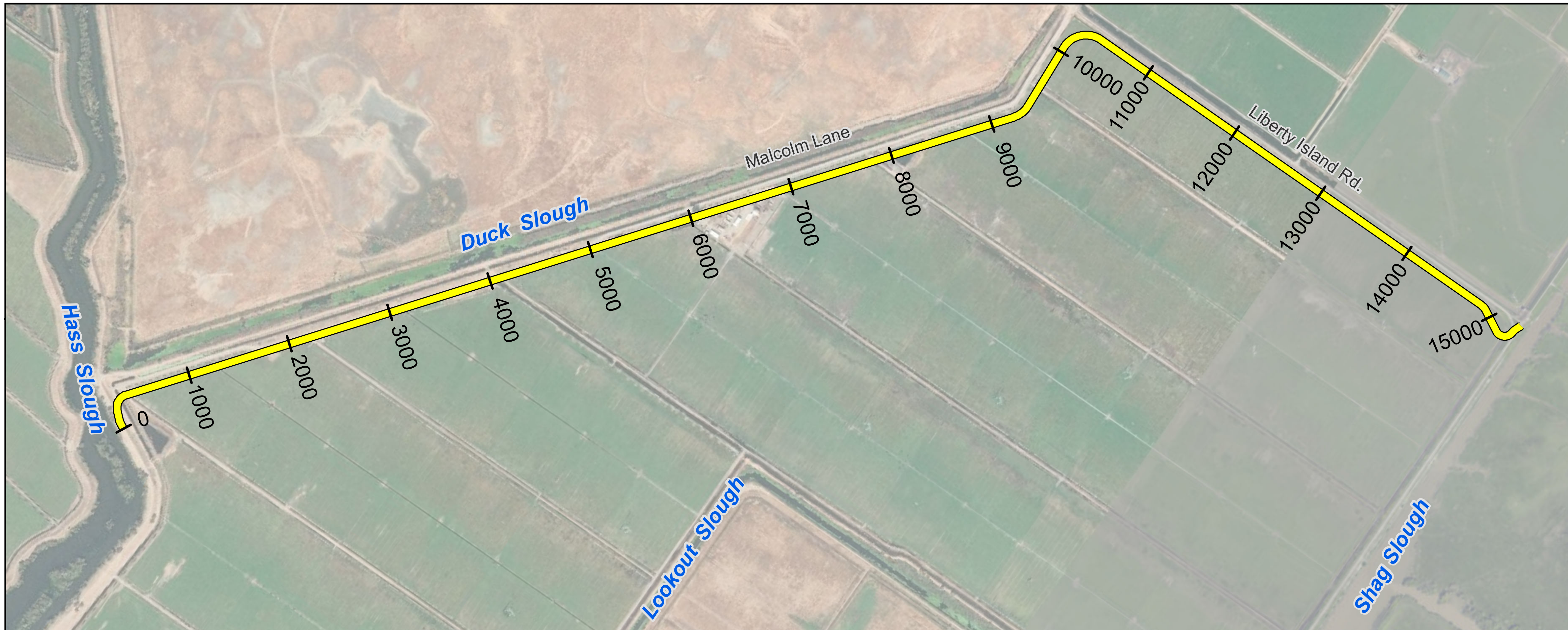
0 15,000 30,000
Feet

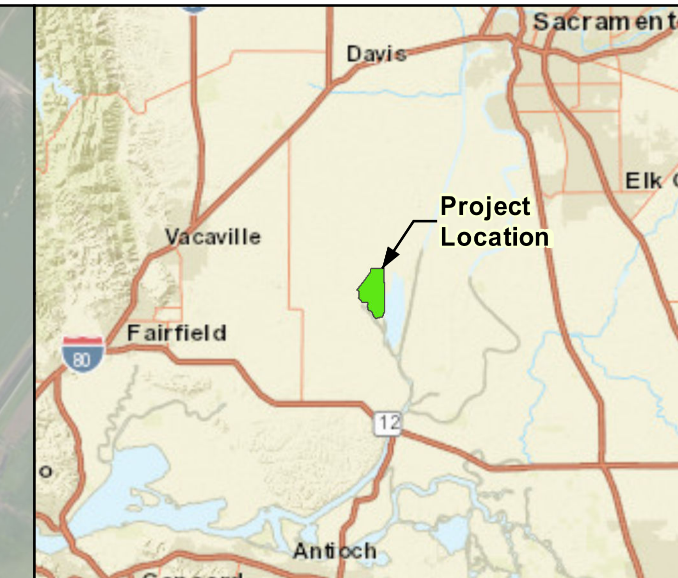
Ecosystem Investment Partners

Map Prepared Date: 9/1/2019
Map Prepared By: JPritchard
Base Source: Wood Rodgers
Base Date: 10/24/2017
Data Source(s):

Prepared by:
ESA

Lookout Slough Tidal Habitat Restoration and Flood Improvement Project





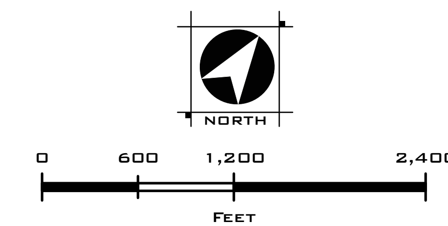
Ecosystem Investment Partners

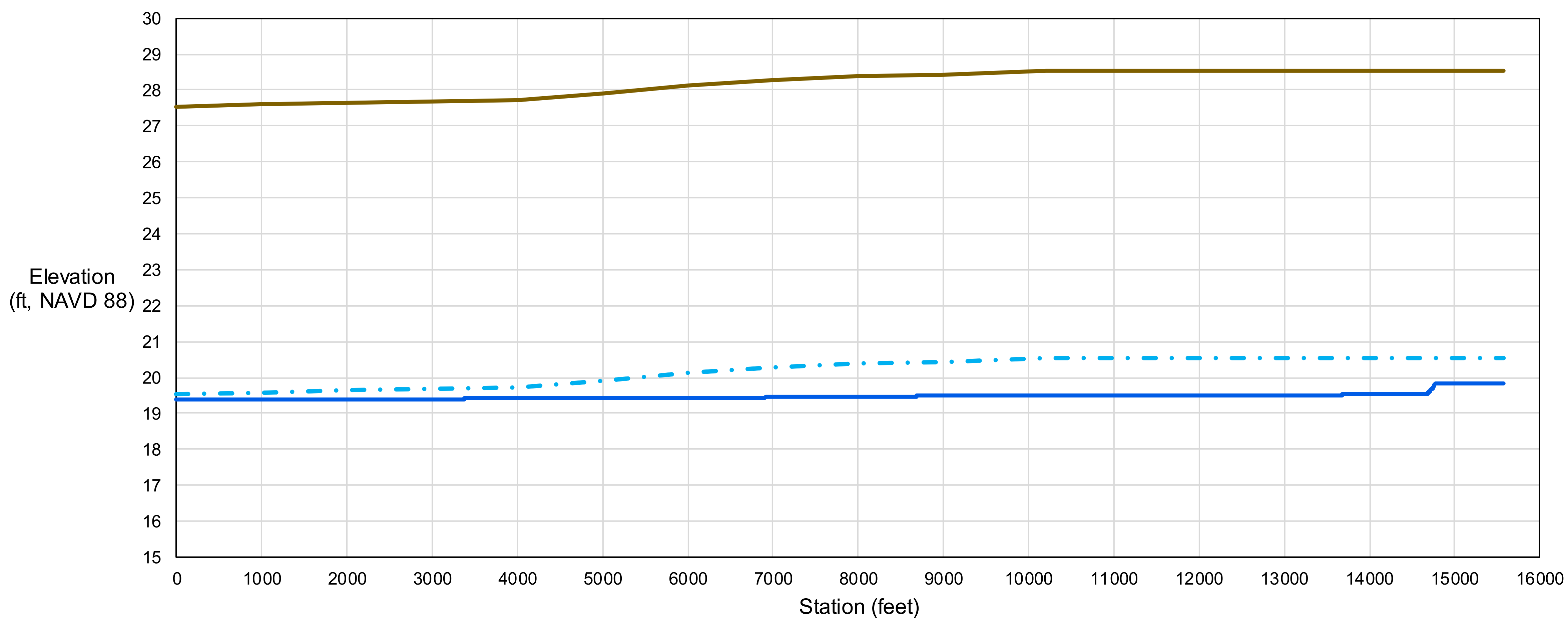
LOOKOUT SLOUGH SETBACK LEVEE

ALTERNATIVE 17 OVERALL PROJECT EXHIBIT

SOLANO COUNTY, CALIFORNIA

AUGUST, 2019





Proposed Setback Levee Alignment

Proposed Top of Levee

1% AEP (100-year) Baseline Condition with-Project Water Surface Elevation

1957 Authorized Design Water Surface Profile

PRELIMINARY

WOOD RODGERS

J:\3000-s\3487_Ecosystem_Invest_Partners\3487002 Lookout Slough Prelim Hydraulic Analysis\GIS\Tasks\20190807_DWSE_Exhibit\FXX_100YR_Design_WSE_Exhibit_20190807.mxd 8/7/2019 5:05:31 PM cmilligan

FIGURE 51

This page intentionally left blank

References

Atkins. 2013. CVFED 1955/1957 Profiles and ULOP Levee Elevations – Draft Report.

Atwater, B. 1982. *Geologic Maps of the Sacramento-San Joaquin Delta California. U.S. Geological Survey*; MF-1401.

BMT WBM. n.d. Modelling Bridge Piers and Afflux in TUFLOW. Retrieved February 2019 from: https://www.tuflow.com/Download/Technical_Memos/Modelling%20Bridge%20Piers%20in%202D%20using%20TUFLOW.pdf.

California Department of Fish and Game (CDFG). 2007. *Vegetation and Land Use Classification and Map of the Sacramento-San Joaquin River Delta.* CDFG: Sacramento, CA.

California Department of Fish and Wildlife (CDFW). 2017. *Delta Conservation Framework 2017-2050 (Public Draft)*. Retrieved July 2018 from: https://www.wildlife.ca.gov/conservation/watersheds/dcf.

California Department of Water Resources (DWR), Bay-Delta Office. 2001. *Cross-Section Development Program (CDSP) Version 2.4d*. DWR: Sacramento, CA. Available: http://baydeltaoffice.water.ca.gov/modeling/deltamodeling/models/csdp/csdp.cfm.

California Department of Water Resources (DWR). 2010. California Levee Database. DWR: Sacramento, CA.

California Department of Water Resources (DWR). 2012. *Urban Level of Flood Protection*. DWR: Sacramento, CA.

California Department of Water Resources (DWR). 2015. North Central Region Office. *Bathymetric Surveys of Liberty Island Step*. DWR: Sacramento, CA.

California Department of Water Resources (DWR). 2016. *Basin-Wide Feasibility Studies – Sacramento River Basin – Draft*. DWR: Sacramento, CA.

California Department of Water Resources (DWR). 2017a. *Central Valley Flood Protection Plan 2017 Update*. DWR: Sacramento, CA.

California Department of Water Resources (DWR). 2017b. *Central Valley Flood Protection Plan 2017 Update, Technical Analyses Summary Expanded Report, Appendix D: Flow and Stage Frequency Curves*. DWR: Sacramento, CA.

California Department of Water Resources (DWR). 2017c. *Lower Elkhorn Basin Levee Setback Project Design Documentation Report – 65% Submittal*. DWR: Sacramento, CA.

Delta Stewardship Council. 2013. *The Delta Plan: Ensuring a reliable water supply for California, a healthy Delta ecosystem, and a place of enduring value.*

Dudas, J. 2010. *LiDAR data for the Delta Area of California*. DWR: Sacramento, CA.

Environmental Science Associates (ESA). 2019. Lookout Slough Restoration Project, Basis of Design Report – Tidal Hydrology and Hydraulic Analysis. Prepared on behalf of Ecosystem Investment Partners.

Fischenich, C. 2001. "Stability Thresholds for Stream Restoration Materials," EMRRP Technical Notes Collection (ERDC TN-EMRRP-SR-29), U.S. Army Engineer Research and Development Center, Vicksburg, MS.

Flood Protect. 2014. Lower Sacramento River/Delta North Regional Flood Management Plan.

Helley, E.J., Harwood, D.S. 1985. Geologic map of late Cenozoic deposits of the Sacramento Valley and northern Sierran foothills, California: U.S. Geological Survey Miscellaneous Field Studies Map MF-1790.

Liberty Farms Company. n.d. *Liberty Farms Company Archives, 1916-1970*. From UC Davis Special Collections: Available: http://www.oac.cdlib.org/findaid/ark:/13030/kt4870205h/admin/#bioghist-1.8.3.

MBK Engineers. 1997. *Letter to Reclamation Board re: PL 84-99 Assistance for Reclamation District No. 2084*.

Mitsch, W.J., & Gosselink, J.G. 2015. *Wetlands*. Hoboken, NJ: John Wiley and Sons.

Opperman, J.J., Moyle, P.B., Larsen, E.W., Florsheim, J.L., & Manfree, A.D. 2017. *Floodplains: processes and management for ecosystem services*. Oakland, CA: University of California Press.

Philip Williams & Associates, Ltd. (PWA). 2008. Liberty Island Restoration Phase 1: Restoration Concept and Basis of Design. Prepared for Wildlands, Inc.

Resource Management Associates (RMA). 2013. *Lower Sacramento Bypass 2-D Model Calibration and Validation – Technical Memorandum*. Prepared for the California Department of Water Resources.

Sherman, S., Hartman, R., and Contreras, D., editors. 2017. Effects of Tidal Wetland Restoration on Fish: A Suite of Conceptual Models. IEP Technical Report 91. Department of Water Resources, Sacramento, California.

Snyder, A.G., Lacy, J.R., Stevens, A.W., and Carlson, E.M. 2016. Bathymetric survey and digital elevation model of Little Holland Tract, Sacramento-San Joaquin Delta, California: U.S. Geological Survey Open-File Report 2016-1093, 14 p.

Solano County Water Agency (Solano County). 1999. *Hydrology Manual, Appendix A – Design Rainfall for Solano County*. Prepared by James D. Goodridge.

Stevens, M. and Rejmankova, E. 1995. *Wetland Research Program Technical Report WRP-RE-11: Cache Slough/Yolo Bypass Ecosystem Monitoring Study to Determine Wetland Mitigation Success.* Prepared on behalf of the U.S. Army Corps of Engineers.

URS. 2011. *Non-Urban Levee Evaluations Project: Geotechnical Assessment Report, North NULE Project Study Area, Volume 6 of 6: Appendix G, Area 5 Levee Segments*. Prepared on behalf of the California Department of Water Resources.

U.S. House. 62nd Congress, 1st Session. (1917). *House Document No. 81: Flood Control – Sacramento and San Joaquin River Systems, California*.

U.S. Department of Agriculture (USDA) Natural Resources Conservation Service. 2018. *Web Soil Survey*. Available: https://websoilsurvey.sc.egov.usda.gov/. Accessed August 2018.

U.S. Army Corps of Engineers (USACE), Sacramento District. 1957. *Sacramento River Flood Control Project – Levee and Channel Profiles.* USACE SPK: Sacramento, CA.

U.S. Army Corps of Engineers (USACE), Sacramento District. 1962. Supplement to Standard Operation and Maintenance Manual Sacramento River Flood Control Project. Unit No. 109, West Levee of Yolo Bypass and East Levee of Cache Slough.

U.S. Army Corps of Engineers (USACE), Sacramento District. 1986. Sacramento River Flood Control Project, California – Right Bank Yolo Bypass and Left Bank Cache Slough near Junction Yolo Bypass and Cache Slough, Levee Construction, General Design.

U.S. Army Corps of Engineers (USACE), Sacramento District. 1993. *Sacramento River Flood Control System Evaluation – Initial Appraisal Report – Lower Sacramento Area.* USACE SPK: Sacramento, CA.

U.S. Army Corps of Engineers (USACE). 1996. *Engineering Manual No.1110-2-1619:Risk-Based Analysis for Flood Damage Reduction Studies*. USACE: Washington, DC.

U.S. Army Corps of Engineers (USACE), Sacramento District. 2013. *Memorandum for File: American River Common Features GRR Feasibility Study, Sacramento River System Hydrologic Inputs for Calibration.* USACE SPK: Sacramento, CA.

U.S. Army Corps of Engineers (USACE), Hydrologic Engineering Center. 2016. HEC-RAS River Analysis System User's Manual Version 5.0.

U.S. Army Corps of Engineers (USACE). 2017. *Engineering Regulation 1105-2-101: Risk Assessment for Flood Risk Management Studies*. USACE: Washington, DC.

U.S. Army Corps of Engineers (USACE). 2018. *Engineering Circular No.1165-2-220: Policy and Procedural Guidance for Processing Requests to Alter U.S. Army Corps of Engineers Civil Works Projects Pursuant to 33 USC 408*. USACE: Washington, DC.

U.S. Department of Transportation, Federal Highway Administration (FHWA). 1978. *Hydraulic Design Series No. 1 – Hydraulics of Bridge Waterways.*

U.S. Geological Survey (USGS). 1989. *Water Supply Paper No. 2339: Guide for selecting Manning's roughness coefficients for natural channels and flood plains.*

Wang, R. & Ateljevich, E. 2012. A Continuous Surface Elevation Map for Modeling (Chapter 6). In *Methodology for Flow and Salinity Estimates in the Sacramento-San Joaquin Delta and*

Suisun Marsh, 23rd Annual Progress Report to the State Water Resources Control Board. California Department of Water Resources, Bay-Delta Office, Delta Modeling Section.

Whipple A.A., Grossinger R.M., Rankin D., Stanford B., Askevold R.A. 2012. *Sacramento-San Joaquin Delta Historical Ecology Investigation: Exploring Pattern and Process*. Prepared for the California Department of Fish and Game and Ecosystem Restoration Program. A Report of SFEI-ASC's Historical Ecology Program, Publication No. 672, San Francisco Estuary Institute-Aquatic Science Center, Richmond, CA.

Wood Rodgers, Inc. 2015. *Refine/Recalibrate Combined Sacramento River and San Joaquin River Systems - Sacramento River System Study Area Report*.

WRA, Inc. 2019a. Restoration Plan, Adaptive Management and Monitoring Plan. Prepared for Ecosystem Investment Partners on behalf of DWR.

WRA, Inc. 2019b. Lookout Slough Riparian Mitigation Plan. Prepared for Ecosystem Investment Partners on behalf of DWR.

WRA, Inc. and Beaver Creek Hydrology. 2019. Basis of Design Report – Tidal Marsh and Channel Design. Prepared for Ecosystem Investment Partners on behalf of DWR.

Appendix A

Downstream Boundary Conditions Hydrology

TECHNICAL MEMORANDUM

TO: Mr. David Urban, P.E., Ecosystem Investment Partners

FROM: Mr. Mitch Berggren, EIT, Wood Rodgers, Inc.
Mr. Cody L. Milligan, P.E., CFM, Wood Rodgers, Inc.

DATE: February 28, 2019

SUBJECT: Lookout Slough Restoration Project North Delta Boundary Stage-Frequency Analysis

INTRODUCTION

Ecosystem Investment Partners (EIP) and the California Department of Water Resources (DWR) are in the process of creating more than 3,000 acres of habitat for listed and vulnerable native species as part of the Lookout Slough Restoration Project (Project). When completed, the Project will provide upland, tidal, subtidal, and floodplain habitat for Delta Smelt, Longfin Smelt, Steelhead Salmon, Splittail, Giant Garter Snake, and other species. In addition to the habitat created, the Project will create between 40,000 and 50,000 acre-feet of seasonal floodplain storage.

The Project is located west of the Yolo Bypass within the north Sacramento-San Joaquin Delta. Once constructed, the Project will be hydraulically connected to the Yolo Bypass and subject to a complex combination of seasonal flood flows and tidal hydrodynamic effects. Decisions related to design of the Project's flood control components are linked to protection levels associated with flood frequency. The Project design flow hydrology is based on information developed by DWR using data and tools developed as part of the Central Valley Hydrology Study (CVHS). Although dynamic tidal boundaries were previously developed by DWR for the 1% ACE (100-year) and 0.5% ACE (200-year) CVHS-based design floods using the RMA Delta Model, similar data was not readily available for the 10% ACE (10-year) design event. A stage-frequency analysis of stream gages located at the downstream boundaries of the regional HEC-RAS hydraulic system models will ensure that a statistically valid design water surface is used for the 10% ACE (10-year) event at the downstream end of the system and used to validate boundary conditions computed for other design frequencies.

PURPOSE

Regional HEC-RAS hydraulic models used to assist in the design of the Project contain three downstream stage boundaries:

1. Georgiana Slough at Mokelumne River
2. Threemile Slough at San Joaquin River
3. Sacramento River at Collinsville

The purpose of this Technical Memorandum is to document the data sources, methods, assumptions, and findings of the stage-frequency analysis conducted for gages at the locations listed above.

ANALYSIS

Modeling Tools

The United States Army Corps of Engineers (USACE) HEC-SSP software (version 2.1.1) was used to conduct the analysis. Annual peak stages for each water year were plotted on a semi-log chart using Weibull plotting positions. The Weibull equation is as follows:

$$P = \frac{M}{N+1}$$

Where:
P = exceedance probability
M = sequence rank
N = number of years in data set

Stage-frequency curves were then computed graphically to fit the data. As curves were extrapolated beyond available data, the peak stages were compared with levee heights at their respective locations to ensure that they did not exceed the height of the adjacent levee crown.

Available Data

The USACE conducted a stage-frequency analysis in 1992 for many gages in the Sacramento-San Joaquin Delta including the gages of interest for this analysis. This study included data between the date each gage was installed up to 1988. For the current analysis, annual maximum gage stages for water years prior to 1988 were taken from the USACE 1992 study. For water years after 1988, annual maximum gage stages were taken from the best available data. This included data from DWR’s Water Data Library (WDL) and the California Data Exchange Center (CDEC).

Datum

The datum at all three gages analyzed has changed two or more times of during the period of record. Therefore, for the purposes of this analysis, all values were adjusted to the North American Vertical Datum of 1988 (NAVD 88). The values and methods used varied at each gage location and are discussed below.

Georgiana Slough at Mokelumne River

At this gage location, data from the USACE's 1992 study was available non-continuously for water years 1943 to 1988. Maximum gage stages for this time period were reported using the National Geodetic Vertical Datum of 1929 (NGVD 29). For water years subsequent to 1988, published data from WDL was used. Maximum gage stages for water years 1989 to 2006 were reported using gage datum. Metadata from the USACE's calibrated 1997 HEC-RAS model documents the conversion factors from NGVD 29 to NAVD 88 and from the gage datum to NAVD 88 and these values were used. The reported maximum gage stage was reported in NAVD 88 starting in water year 2007. **Figure 1** shows the results from HEC-SSP and **Table 1** shows the data source, datum, adjustment, and values used in the analysis for this gage.

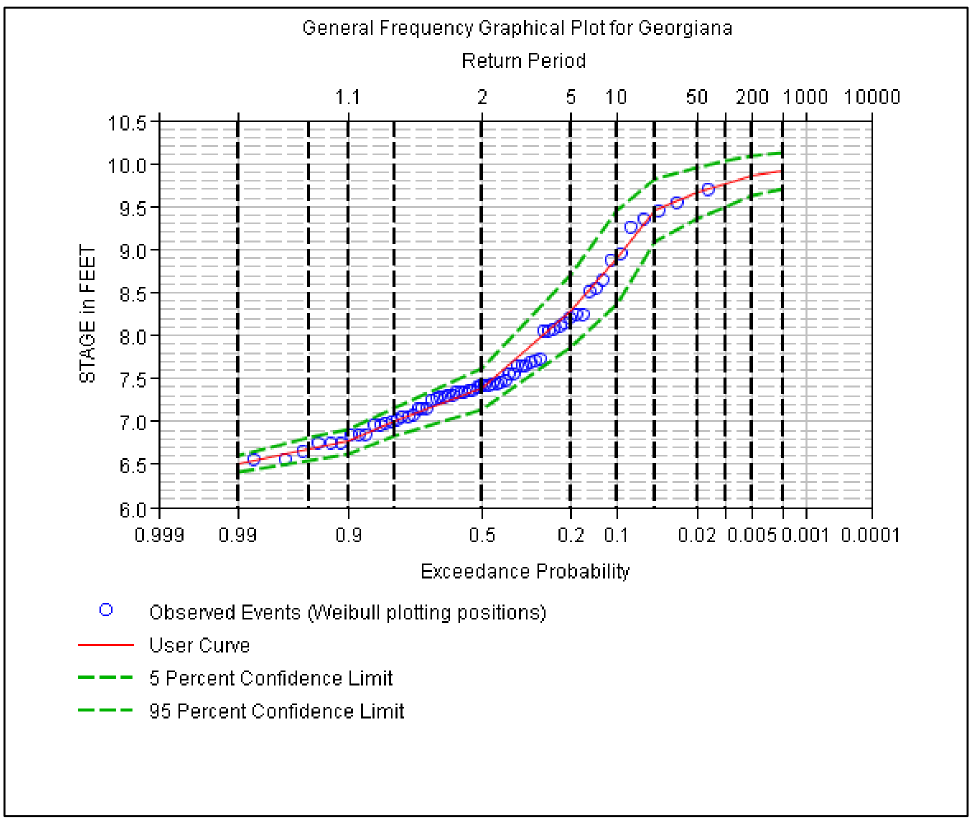


Figure 1 – Frequency plot for Georgiana Slough at Mokelumne River

Table 1 - Georgiana Slough at Mokelumne River Annual Maximum Gage Stages

Water Year	Peak Stage (ft)	Data Source	Datum	Correction (ft)	Peak Stage (ft, NAVD88)
1943	4.30	USACE Report	NVGD29	2.54	6.84
1947	4.50	USACE Report	NVGD29	2.54	7.04
1948	4.30	USACE Report	NVGD29	2.54	6.84
1949	4.20	USACE Report	NVGD29	2.54	6.74
1950	4.20	USACE Report	NVGD29	2.54	6.74
1951	6.00	USACE Report	NVGD29	2.54	8.54
1952	5.60	USACE Report	NVGD29	2.54	8.14
1954	4.60	USACE Report	NVGD29	2.54	7.14
1955	4.40	USACE Report	NVGD29	2.54	6.94
1956	6.70	USACE Report	NVGD29	2.54	9.24
1957	4.50	USACE Report	NVGD29	2.54	7.04
1958	6.40	USACE Report	NVGD29	2.54	8.94
1959	4.80	USACE Report	NVGD29	2.54	7.34
1960	4.70	USACE Report	NVGD29	2.54	7.24
1961	4.20	USACE Report	NVGD29	2.54	6.74
1962	4.90	USACE Report	NVGD29	2.54	7.44
1963	5.10	USACE Report	NVGD29	2.54	7.64
1964	4.10	USACE Report	NVGD29	2.54	6.64
1965	5.50	USACE Report	NVGD29	2.54	8.04
1966	4.40	USACE Report	NVGD29	2.54	6.94
1974	5.00	USACE Report	NVGD29	2.54	7.54
1975	4.60	USACE Report	NVGD29	2.54	7.14
1976	4.00	USACE Report	NVGD29	2.54	6.54
1977	4.00	USACE Report	NVGD29	2.54	6.54
1978	5.10	USACE Report	NVGD29	2.54	7.64
1979	4.60	USACE Report	NVGD29	2.54	7.14
1980	6.10	USACE Report	NVGD29	2.54	8.64
1981	4.30	USACE Report	NVGD29	2.54	6.84
1982	5.50	USACE Report	NVGD29	2.54	8.04
1983	6.90	USACE Report	NVGD29	2.54	9.44
1984	5.70	USACE Report	NVGD29	2.54	8.24
1985	4.80	USACE Report	NVGD29	2.54	7.34
1986	7.00	USACE Report	NVGD29	2.54	9.54
1987	5.15	USACE Report	NVGD29	2.54	7.69
1988	5.00	USACE Report	NVGD29	2.54	7.54
1989	7.42	WDL	NVGD29 + 3.0 ft	-0.46	6.96
1990	7.75	WDL	NVGD29 + 3.0 ft	-0.46	7.29
1991	7.44	WDL	NVGD29 + 3.0 ft	-0.46	6.98
1992	7.87	WDL	NVGD29 + 3.0 ft	-0.46	7.41
1993	8.14	WDL	NVGD29 + 3.0 ft	-0.46	7.68
1994	7.74	WDL	NVGD29 + 3.0 ft	-0.46	7.28
1995	8.96	WDL	NVGD29 + 3.0 ft	-0.46	8.50
1996	8.10	WDL	NVGD29 + 3.0 ft	-0.46	7.64
1997	9.80	WDL	NVGD29 + 3.0 ft	-0.46	9.34

Table 1 - Georgiana Slough at Mokelumne River Annual Maximum Gage Stages

Water Year	Peak Stage (ft)	Data Source	Datum	Correction (ft)	Peak Stage (ft, NAVD88)
1998	10.15	WDL	NVGD29 + 3.0 ft	-0.46	9.69
1999	7.89	WDL	NVGD29 + 3.0 ft	-0.46	7.43
2000	8.56	WDL	NVGD29 + 3.0 ft	-0.46	8.10
2001	7.47	WDL	NVGD29 + 3.0 ft	-0.46	7.01
2002	7.87	WDL	NVGD29 + 3.0 ft	-0.46	7.41
2003	8.65	WDL	NVGD29 + 3.0 ft	-0.46	8.19
2004	8.18	WDL	NVGD29 + 3.0 ft	-0.46	7.72
2005	8.51	WDL	NVGD29 + 3.0 ft	-0.46	8.05
2006	9.33	WDL	NVGD29 + 3.0 ft	-0.46	8.87
2007	7.25	WDL	NAVD88	0.00	7.25
2008	7.46	WDL	NAVD88	0.00	7.46
2009	7.35	WDL	NAVD88	0.00	7.35
2010	7.42	WDL	NAVD88	0.00	7.42
2011	8.24	WDL	NAVD88	0.00	8.24
2012	7.07	WDL	NAVD88	0.00	7.07
2013	7.38	WDL	NAVD88	0.00	7.38
2014	7.35	WDL	NAVD88	0.00	7.35
2015	7.34	WDL	NAVD88	0.00	7.34
2016	7.30	WDL	NAVD88	0.00	7.30
2017	7.41	WDL	NAVD88	0.00	7.41

Threemile Slough at San Joaquin River

At this gage location, data from the USACE's 1992 study was available non-continuously for water years 1939 to 1988. Maximum gage stages for this time period were reported using NGVD 29. For water years subsequent to 1988, published data from WDL was used. Maximum gage stages for water years 1989 to 2005 were reported using a gage datum. Metadata from the USACE's calibrated 1997 HEC-RAS model documents the conversion factors from NGVD 29 to NAVD 88 and from the gage datum to NAVD 88, and these values were used. The reported maximum gage stage was reported in NAVD 88 starting in water year 2006. **Figure 2** shows the results from HEC-SSP, and **Table 2** shows the data source, datum, adjustment, and values used in the analysis for this gage.

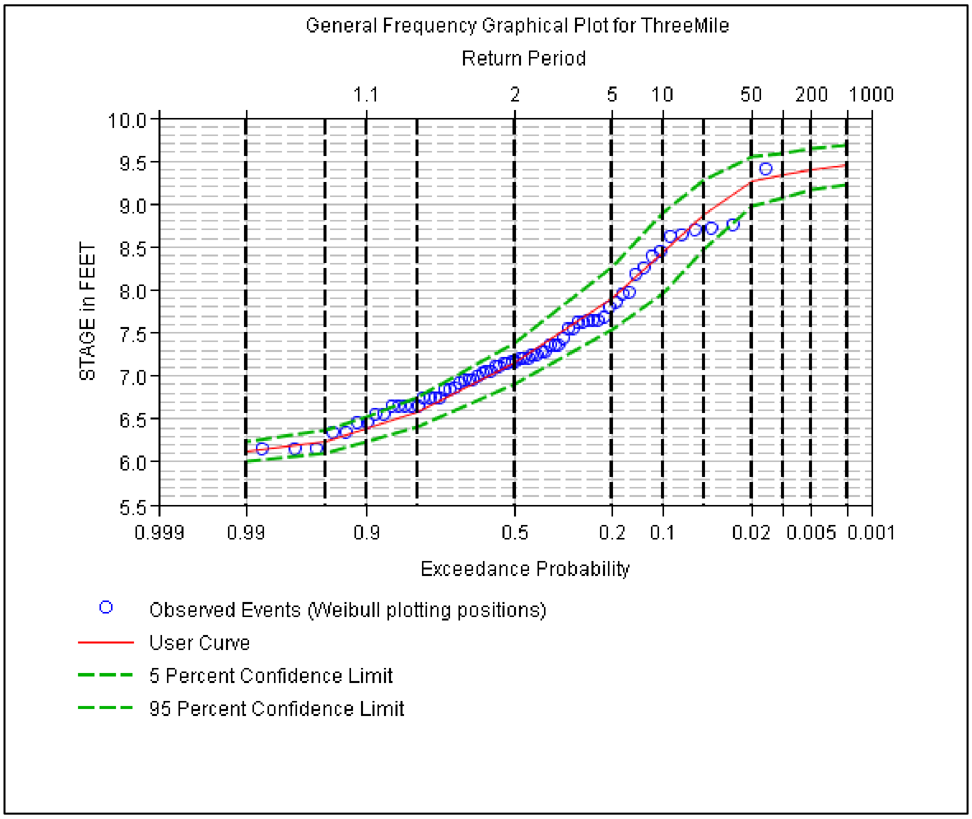


Figure 2 – Frequency plot for Threemile Slough at San Joaquin River

Table 2 - Threemile Slough at San Joaquin River Annual Maximum Gage Stages					
Water Year	**Peak Stage (ft)**	**Data Source**	**Datum**	**Correction (ft)**	**Peak Stage (ft, NAVD88)**
1939	4.30	USACE Report	NVGD29	2.34	6.64
1944	4.60	USACE Report	NVGD29	2.34	6.94
1945	4.40	USACE Report	NVGD29	2.34	6.74
1947	4.40	USACE Report	NVGD29	2.34	6.74
1948	4.40	USACE Report	NVGD29	2.34	6.74
1949	4.30	USACE Report	NVGD29	2.34	6.64
1950	4.90	USACE Report	NVGD29	2.34	7.24
1951	5.60	USACE Report	NVGD29	2.34	7.94
1952	5.30	USACE Report	NVGD29	2.34	7.64
1954	5.90	USACE Report	NVGD29	2.34	8.24
1955	4.30	USACE Report	NVGD29	2.34	6.64
1957	4.10	USACE Report	NVGD29	2.34	6.44
1960	4.50	USACE Report	NVGD29	2.34	6.84
1961	4.00	USACE Report	NVGD29	2.34	6.34
1962	4.60	USACE Report	NVGD29	2.34	6.94
1963	4.60	USACE Report	NVGD29	2.34	6.94
1964	4.10	USACE Report	NVGD29	2.34	6.44

Table 2 - Threemile Slough at San Joaquin River Annual Maximum Gage Stages					
Water Year	**Peak Stage (ft)**	**Data Source**	**Datum**	**Correction (ft)**	**Peak Stage (ft, NAVD88)**
1965	5.00	USACE Report	NVGD29	2.34	7.34
1966	4.30	USACE Report	NVGD29	2.34	6.64
1967	5.20	USACE Report	NVGD29	2.34	7.54
1968	4.20	USACE Report	NVGD29	2.34	6.54
1969	5.30	USACE Report	NVGD29	2.34	7.64
1970	5.00	USACE Report	NVGD29	2.34	7.34
1971	4.40	USACE Report	NVGD29	2.34	6.74
1972	3.80	USACE Report	NVGD29	2.34	6.14
1974	4.70	USACE Report	NVGD29	2.34	7.04
1975	4.30	USACE Report	NVGD29	2.34	6.64
1976	3.80	USACE Report	NVGD29	2.34	6.14
1977	3.80	USACE Report	NVGD29	2.34	6.14
1978	4.90	USACE Report	NVGD29	2.34	7.24
1979	4.20	USACE Report	NVGD29	2.34	6.54
1980	5.50	USACE Report	NVGD29	2.34	7.84
1981	4.00	USACE Report	NVGD29	2.34	6.34
1982	5.00	USACE Report	NVGD29	2.34	7.34
1983	6.30	USACE Report	NVGD29	2.34	8.64
1984	6.10	USACE Report	NVGD29	2.34	8.44
1985	4.50	USACE Report	NVGD29	2.34	6.84
1986	6.40	USACE Report	NVGD29	2.34	8.74
1987	4.70	USACE Report	NVGD29	2.34	7.04
1988	4.80	USACE Report	NVGD29	2.34	7.14
1989	7.85	WDL	NAVD88 + 0.66 ft	-0.66	7.19
1990	7.51	WDL	NAVD88 + 0.66 ft	-0.66	6.85
1991	7.94	WDL	NAVD88 + 0.66 ft	-0.66	7.28
1992	8.20	WDL	NAVD88 + 0.66 ft	-0.66	7.54
1993	7.81	WDL	NAVD88 + 0.66 ft	-0.66	7.15
1994	8.83	WDL	NAVD88 + 0.66 ft	-0.66	8.17
1995	8.09	WDL	NAVD88 + 0.66 ft	-0.66	7.43
1996	9.34	WDL	NAVD88 + 0.66 ft	-0.66	8.68
1997	10.06	WDL	NAVD88 + 0.66 ft	-0.66	9.40
1998	7.82	WDL	NAVD88 + 0.66 ft	-0.66	7.16
1999	9.05	WDL	NAVD88 + 0.66 ft	-0.66	8.39
2000	7.68	WDL	NAVD88 + 0.66 ft	-0.66	7.02
2001	8.33	WDL	NAVD88 + 0.66 ft	-0.66	7.67
2002	8.62	WDL	NAVD88 + 0.66 ft	-0.66	7.96
2003	8.30	WDL	NAVD88 + 0.66 ft	-0.66	7.64
2004	8.27	WDL	NAVD88 + 0.66 ft	-0.66	7.61
2005	9.28	WDL	NAVD88 + 0.66 ft	-0.66	8.62
2006	7.28	WDL	NAVD 88	0.00	7.28
2007	7.62	WDL	NAVD 88	0.00	7.62
2008	7.14	WDL	NAVD 88	0.00	7.14
2009	6.99	WDL	NAVD 88	0.00	6.99

Table 2 - Threemile Slough at San Joaquin River Annual Maximum Gage Stages					
Water Year	**Peak Stage (ft)**	**Data Source**	**Datum**	**Correction (ft)**	**Peak Stage (ft, NAVD88)**
2010	7.79	WDL	NAVD 88	0.00	7.79
2011	6.91	WDL	NAVD 88	0.00	6.91
2012	7.19	WDL	NAVD 88	0.00	7.19
2013	7.10	WDL	NAVD 88	0.00	7.10
2014	7.19	WDL	NAVD 88	0.00	7.19
2015	7.10	WDL	NAVD 88	0.00	7.10
2016	7.10	WDL	NAVD 88	0.00	7.10
2017	8.70	WDL	NAVD 88	0.00	8.70

Sacramento River at Collinsville

At this gage location, data from the USACE’s 1992 study was available non-continuously for water years 1945 to 1988. Maximum gage stages for this time period were reported using NGVD 29. Gage data was unavailable for water years from 1989 to 2008. Beginning in water year 2009, gage data was available from CDEC. This data was downloaded and the maximum value was determined for each water year. Data flagged as “erroneous” or that had excessively high values (such as values above the top-of-levee) were excluded from the analysis. All gage data from CDEC was reported in NAVD 88. Metadata from the USACE’s calibrated 1997 HEC-RAS model did not contain any information on a conversion factor from NGVD 29 to NAVD 88; thus, the National Oceanic and Atmospheric Administration’s (NOAA) VERTCON program was used to convert from NGVD 29 to NAVD 88. **Figure 3** shows the results from HEC-SSP and **Table 3** shows the data source, datum, adjustment, and values used in the analysis for this gage.

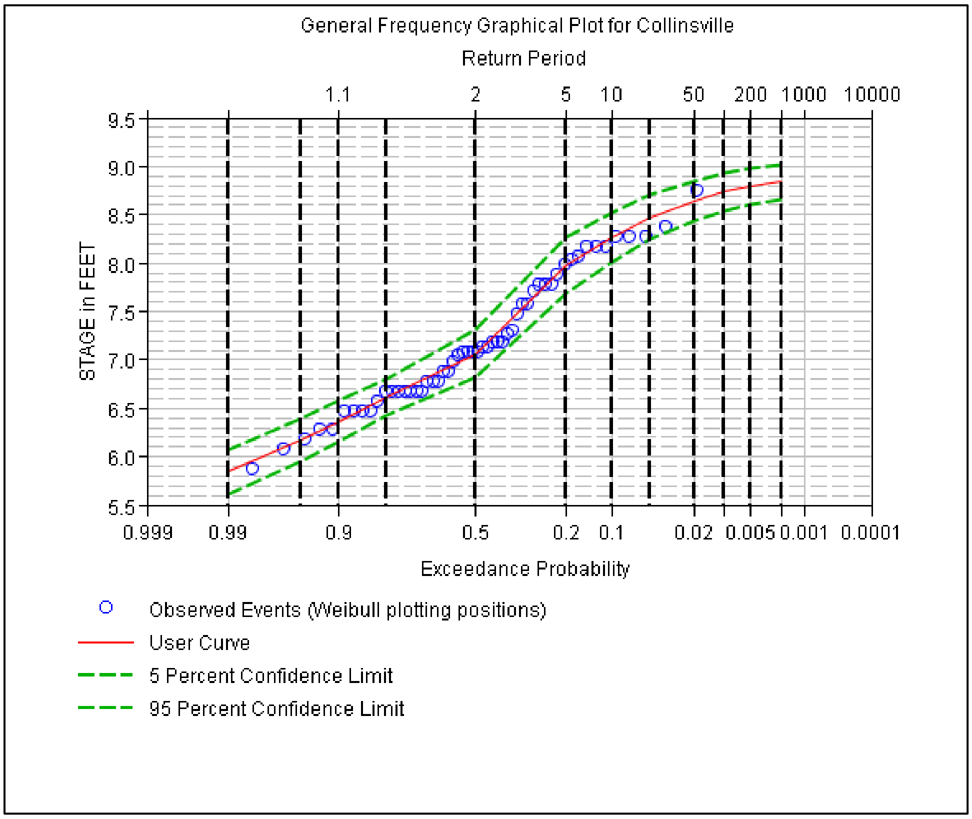


Figure 3 – Frequency Plot for Sacramento River at Collinsville

Table 3 - Collinsville at Sacramento River Annual Maximum Gage Stages					
Water Year	**Peak Stage (ft)**	**Data Source**	**Datum**	**Correction (ft)**	**Peak Stage (ft, NAVD88)**
1945	4.00	USACE Report	NVGD29	2.47	6.47
1946	4.40	USACE Report	NVGD29	2.47	6.87
1947	4.00	USACE Report	NVGD29	2.47	6.47
1948	4.30	USACE Report	NVGD29	2.47	6.77
1949	4.20	USACE Report	NVGD29	2.47	6.67
1950	5.70	USACE Report	NVGD29	2.47	8.17
1951	5.40	USACE Report	NVGD29	2.47	7.87
1952	5.70	USACE Report	NVGD29	2.47	8.17
1953	5.10	USACE Report	NVGD29	2.47	7.57
1954	4.30	USACE Report	NVGD29	2.47	6.77
1955	4.40	USACE Report	NVGD29	2.47	6.87
1956	5.80	USACE Report	NVGD29	2.47	8.27
1957	4.20	USACE Report	NVGD29	2.47	6.67
1958	5.70	USACE Report	NVGD29	2.47	8.17
1959	4.80	USACE Report	NVGD29	2.47	7.27
1960	4.20	USACE Report	NVGD29	2.47	6.67
1961	4.00	USACE Report	NVGD29	2.47	6.47
1962	4.20	USACE Report	NVGD29	2.47	6.67

Table 3 - Collinsville at Sacramento River Annual Maximum Gage Stages

Water Year	Peak Stage (ft)	Data Source	Datum	Correction (ft)	Peak Stage (ft, NAVD88)
1963	4.70	USACE Report	NVGD29	2.47	7.17
1964	3.80	USACE Report	NVGD29	2.47	6.27
1965	5.30	USACE Report	NVGD29	2.47	7.77
1966	4.30	USACE Report	NVGD29	2.47	6.77
1967	5.10	USACE Report	NVGD29	2.47	7.57
1968	4.20	USACE Report	NVGD29	2.47	6.67
1969	5.30	USACE Report	NVGD29	2.47	7.77
1970	5.00	USACE Report	NVGD29	2.47	7.47
1971	4.50	USACE Report	NVGD29	2.47	6.97
1972	4.10	USACE Report	NVGD29	2.47	6.57
1973	5.80	USACE Report	NVGD29	2.47	8.27
1974	4.60	USACE Report	NVGD29	2.47	7.07
1975	4.00	USACE Report	NVGD29	2.47	6.47
1976	3.40	USACE Report	NVGD29	2.47	5.87
1977	3.60	USACE Report	NVGD29	2.47	6.07
1978	4.70	USACE Report	NVGD29	2.47	7.17
1979	3.80	USACE Report	NVGD29	2.47	6.27
1980	5.30	USACE Report	NVGD29	2.47	7.77
1981	3.70	USACE Report	NVGD29	2.47	6.17
1982	4.60	USACE Report	NVGD29	2.47	7.07
1983	5.90	USACE Report	NVGD29	2.47	8.37
1984	5.80	USACE Report	NVGD29	2.47	8.27
1985	4.20	USACE Report	NVGD29	2.47	6.67
1986	5.60	USACE Report	NVGD29	2.47	8.07
1987	4.20	USACE Report	NVGD29	2.47	6.67
1988	5.50	USACE Report	NVGD29	2.47	7.97
2009	8.03	CDEC	NAVD88	0.00	8.03
2010	7.07	CDEC	NAVD88	0.00	7.07
2011	7.70	CDEC	NAVD88	0.00	7.70
2012	7.13	CDEC	NAVD88	0.00	7.13
2013	7.18	CDEC	NAVD88	0.00	7.18
2014	7.13	CDEC	NAVD88	0.00	7.13
2015	7.08	CDEC	NAVD88	0.00	7.08
2016	7.04	CDEC	NAVD88	0.00	7.04
2017	8.75	CDEC	NAVD88	0.00	8.75

SUMMARY OF RESULTS

A summary of the results of this analysis for selected storm events are presented in **Table 4**.

Table 4 – Stage-Frequency Analysis Results

Gage Location	10% ACE (10-year) Peak Stage (ft, NAVD 88)	1% ACE (100-year) Peak Stage (ft, NAVD 88)	0.5% ACE (200-year) Peak Stage (ft, NAVD 88)
Georgiana Slough at Mokelumne River	8.91	9.86	9.92
Threemile Slough at San Joaquin River	8.43	9.34	9.40
Collinsville at Sacramento River	8.27	8.74	8.79

REFERENCES

1. California Department of Water Resources, Water Data Library website accessed from: http://wdl.water.ca.gov/waterdatalibrary/index.cfm
2. California Department of Water Resources, California Data Exchange Center website accessed from: http://cdec.water.ca.gov/
3. National Oceanic and Atmospheric Administration, National Geodetic Survey. (2017). VERTCON website accessed from: https://www.ngs.noaa.gov/TOOLS/Vertcon/vertcon.html
4. United States Army Corps of Engineers, Sacramento District. (February 1992) *Sacramento-San Joaquín Delta California Hydrology - Special Study*.
5. United States Army Corps of Engineers. (2012). Common Features HEC-RAS Model

Appendix B
Bridge Form Loss Calculation Summary

ESA 50 YEARS 1969-2019

2600 Capitol Avenue
Suite 200
Sacramento, CA 95816
916.564.4500 phone
916.564.4501 fax

esassoc.com

technical memorandum

date	September 1, 2019
to	Ecosystem Investment Partners, LLC
cc	
from	John Pritchard, PE, CFM
subject	Lookout Slough Tidal Habitat Restoration and Flood Improvement Project (D181197.00), SR 12 Bridge Crossing at Sacramento River near Rio Vista, TUFLOW modeling input summary

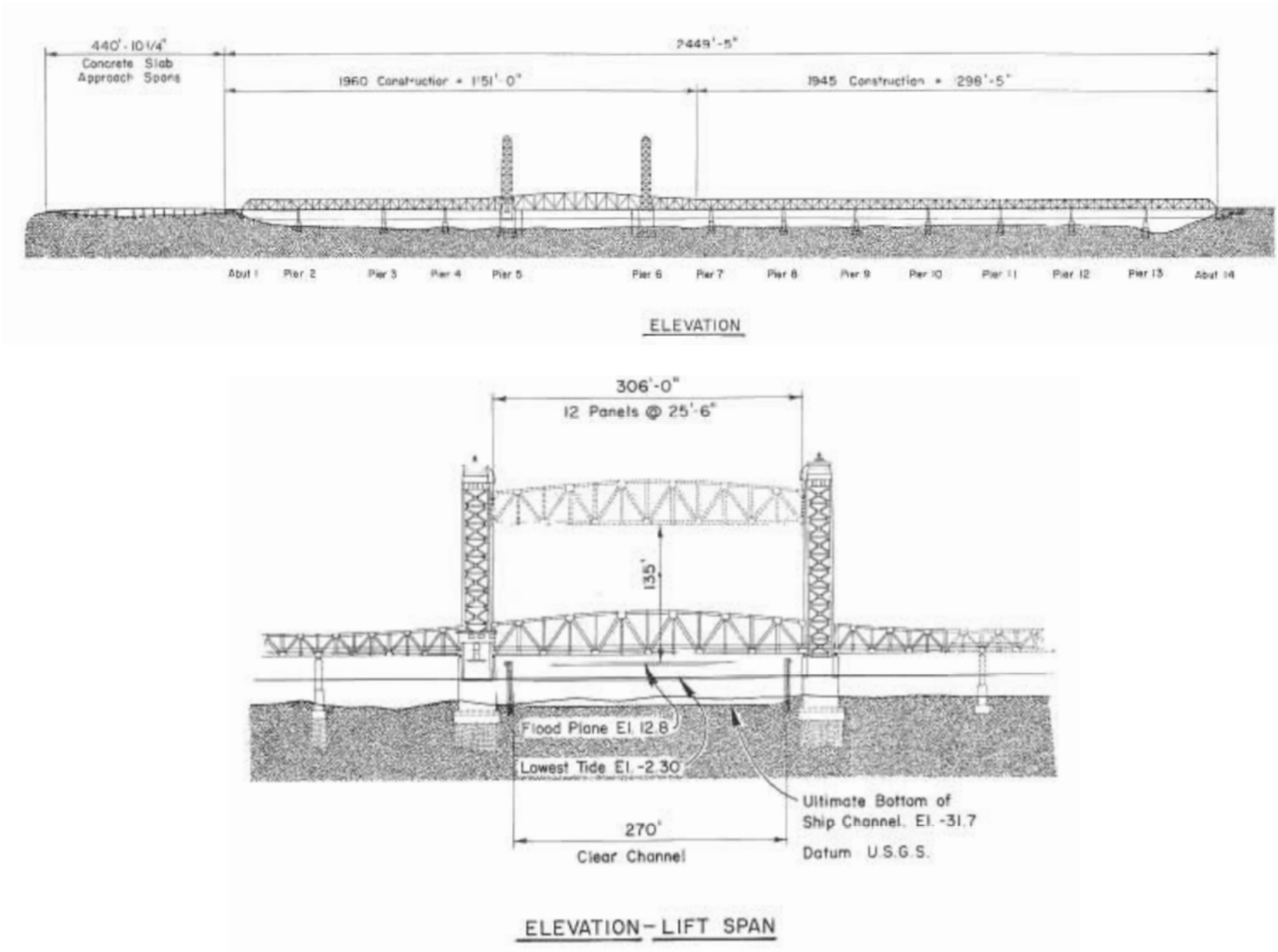
A TUFLOW HPC two-dimensional hydraulic model has been developed to support analysis of flood management alternatives and potential impacts associated with the Lookout Slough Tidal Habitat Restoration and Flood Improvement Project. The purpose of this document is to summarize the modeling approach used to simulate energy losses through the State Route 12 crossing the Sacramento River at Rio Vista (**Figure 1**). As shown on **Figure 2**, the existing structure is a moveable vertical-lift bridge, constructed in 1960 (Smith et al, 1960).

The hydraulic analysis supporting the Lookout Slough Restoration Project is investigating flood performance in the system for events up a 0.5% ACE (200-year) storm frequency. Based on review of existing one-dimensional modeling studies by DWR and the USACE (DWR, 2017 and USACE, 2014), the bridge will not be subject to pressure flow or overtopping during these conditions, and hydraulic analysis through the bridge can therefore be simplified to focus on form losses at the bridge piers and abutments. Drag forces from the piers are also anticipated to create 0.2 feet of head loss or less through the structure for the events being studied.

There are several approaches for modeling form losses at bridge piers in a two-dimensional hydraulic model, including disabling model grid elements, addition of pier drag forces (form losses), and increasing flow resistance (Manning’s n) (FHWA, 2012). The authors of the TUFLOW software have examined several approaches, and recommend using the form loss approach in conjunction with procedures outlined in industry standard publications (WBM BMT, n.d.). For purposes of this study, the Federal Highway Administration (FHWA) *Hydraulic Design Series No. 1 – Hydraulics of Bridge Waterways* manual (FHWA, 1978) has been referenced for estimating losses at the bridge piers.

Source: Google Earth, 2019

Figure 1
Location Map



Source: Smith et al, 1960.

Figure 2
Bridge Cross-Sections Facing Downstream

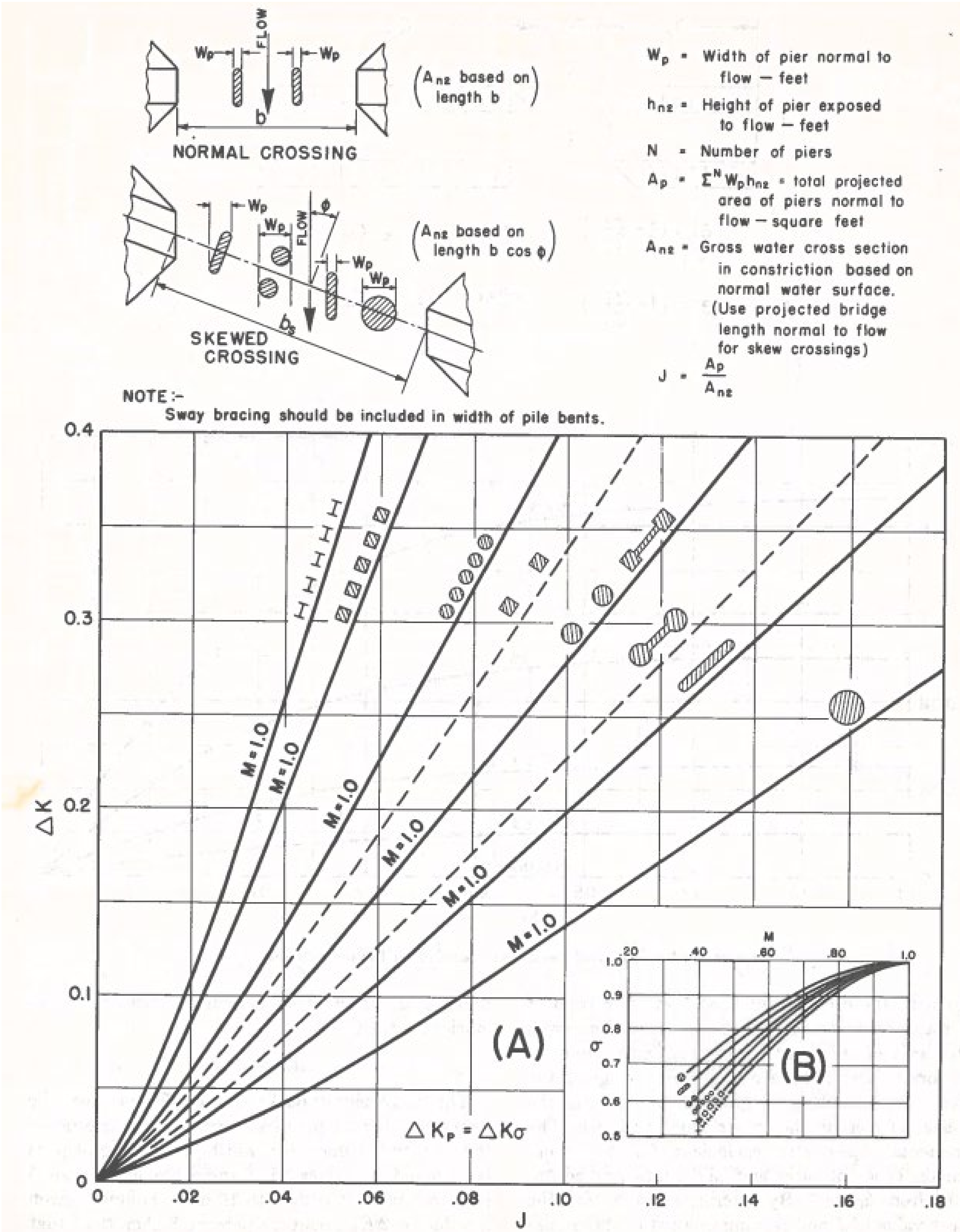
Given that the structure is several miles downstream of the Project, a detailed assessment of the local hydraulics at individual bridge piers is not required. Therefore, the bridge pier losses have been lumped together within a single flow constriction shape across the entire waterway, rather than entered individually at each pier location. This approach simplifies the geometric representation of the bridge and averages losses through the structure across the entire span of the bridge (more akin to a one-dimensional representation). This approach does replicate the anticipated losses through the bridge, and provides results that are consistent with other one-dimensional modeling methods.

Computation of form losses at bridge piers was performed using the incremental backwater approach for computing the effect of piers at normal crossings (FHWA, 1978). This approach computes a backwater coefficient ΔK_p, which is assigned to the form loss shape in the model input. To determine ΔK_p, a ratio of the blockage area of the piers to the gross water cross-section of the channel is computed (*J*). This value is then referenced against nomographs developed by FHWA which account for the pier shape (**Figure 3**) and the ratio (*M*) of the flow which can pass unimpeded through the bridge constriction to the total flow of the river. In this manner, bridge pier form losses can be computed individually, or applied as a weighted average of the blocked area across the entire span of the bridge.

A Microsoft Excel spreadsheet was developed to compute the blocked area of the piers based on regional one-dimensional HEC-RAS modeling geometry (**Figure 4**). The resultant J values were then computed and a weighted average ΔK_p value of 0.17 was determined for the entire structure (**Table 1**).

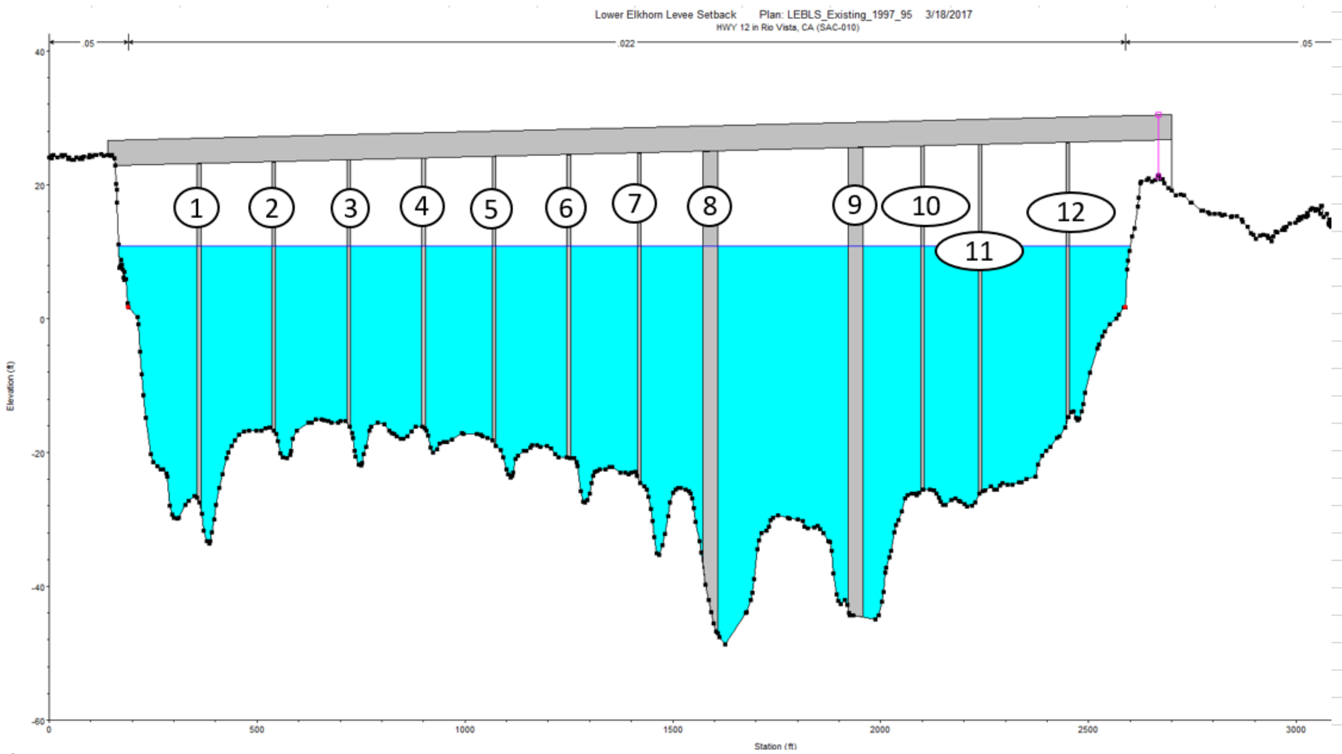
TABLE 1
BRIDGE PIER FORM LOSS CALCULATIONS

Pier Number	Width of Pier (feet)	Area of Pier Blockage, A_p (feet^2)	Gross Water Section, A_{n2} (feet)	J	ΔK_p
1	8.6	327	8,513	0.04	0.08
2	8.6	238	5,197	0.05	0.1
3	8.6	234	4,884	0.05	0.1
4	8.6	233	4,974	0.05	0.1
5	8.6	254	5,299	0.05	0.1
6	8.6	276	5,706	0.05	0.1
7	8.6	299	6,275	0.05	0.1
8	36	1942	12,379	0.16	0.34
9	36	2002	12,403	0.16	0.34
10	8.6	317	5,801	0.05	0.1
11	8.6	322	6,329	0.05	0.1
12	8.6	227	5,800	0.04	0.08



Source: FHWA, 1978.

Figure 3
Incremental Backwater Coefficient for Piers



Source: DWR, 2017.

Figure 4
DWR HEC-RAS Bridge Geometry at State Route 12

References

California Department of Water Resources (DWR). 2017. *Lower Elkhorn Basin Levee Setback Project Design Documentation Report – 65% Submittal*. DWR: Sacramento, CA.

Smith, G.W.; Gilbert, G.D.; Van Zee, E.F.; Robinson, S.J.; Fuller, R.T. (May–June 1960). "Rio Vista Bridge: Modern Lift Structure Spans Lower Sacramento." *California Highways and Public Works*. California Department of Public Works. 39 (5–6): 51–57.

U.S. Army Corps of Engineers (USACE). (2014). *Memorandum for File: American River Common Features GRR Sacramento River Basin HEC-RAS Model Release – Sacramento River Basin HEC-RAS Model Release 5*. USACE: Sacramento, CA.

U.S. Department of Transportation, Federal Highway Administration (FHWA). 1978. Hydraulic Design Series No. 1 – Hydraulics of Bridge Waterways. FHWA Division of Hydraulic Research: Washington, DC.

U.S. Department of Transportation, Federal Highway Administration (FHWA). 2012. Publication No. FHWA-HIF-12-018, Hydraulic Design Series No. 7 – Hydraulic Design of Safe Bridges. National Highway Institute and FHWA: Washington, DC.

WBM BMT, Pty Ltd. n.d. *Modelling Bridge Piers and Afflux in TUFLOW*. Retrieved February 2019 from: https://www.tuflow.com/Download/Technical_Memos/Modelling%20Bridge%20Piers%20in%202D%20using%20TUFLOW.pdf.

Appendix B.1

Draft 65% Geotechnical Data Report

This Page Intentionally Left Blank

DRAFT GEOTECHNICAL DATA REPORT
65% DESIGN

LOOKOUT SLOUGH TIDAL HABITAT RESTORATION AND FLOOD IMPROVEMENT PROJECT

Prepared For:

Ecosystem Investment Partners
5550 Newbury St.
Baltimore, Maryland 21209

Contact: David Urban
david@ecosystempartners.com

Prepared By:

Blackburn Consulting
2491 Boatman Ave
West Sacramento, CA 95691

Contact: Nicole Hart
nicoleh@blackburnconsulting.com

Date: September 2019

Ecosystem Investment Partners

blackburn consulting

This Page Intentionally Left Blank

West Sacramento Office: (916) 375-8706
2491 Boatman Ave
West Sacramento, CA 95691

blackburn consulting

Main Auburn Office: (530) 887-1494
Fresno Office: (559) 438-8411

Geotechnical ▪ Geo-Environmental ▪ Construction Services ▪ Forensics

BCI File No. 3195.x
September 26, 2019

Mr. David Urban
Director of Operations
Ecosystem Investment Partners
5550 Newbury Street
Baltimore, MD 21209

Subject: **DRAFT GEOTECHNICAL DATA REPORT – 65% Design**
Lookout Slough Tidal Habitat Restoration and Flood Improvement Project
Solano County, California

Dear Mr. Urban,

Blackburn Consulting (BCI) is pleased to submit this Draft Geotechnical Data Report (Draft GDR) for 65% Levee Design of the Lookout Slough Tidal Habitat Restoration and Flood Improvement Project in Solano County, California. This DRAFT GDR replaces BCI's May 2019 Draft 60% GDR.

The findings in this report are draft, intended for 65%-level design, and should not be relied on for final design or construction. Findings may change as design progresses. Subsequent 90% and/or 100% updates of this report prepared by BCI will contain final design and construction.

Thank you for including BCI on your team for this important project. Please call if you have questions or require additional information.

Sincerely,

BLACKBURN CONSULTING

Prepared by:

Nicole C. Hart, P.E.
Senior Project Engineer

Reviewed by:

REGISTERED PROFESSIONAL ENGINEER
ROBERT B. LOKTEFF
No. 2589
GEOTECHNICAL
STATE OF CALIFORNIA

Robert B. Lokteff, G.E., P.E.
Principal

Copies: 1 to Addressee (PDF)

This Page Intentionally Left Blank

TABLE OF CONTENTS

TABLE OF CONTENTS (cont.)

1 INTRODUCTION

1.1 Project Overview

The Lookout Slough Tidal Habitat Restoration and Flood Improvement Project (Lookout Slough THRFIP) in Solano County, California will create more than 3,000 acres of habitat for listed and vulnerable native species within a portion of Reclamation District 2068 (RD 2068) including upland, tidal, subtidal, and floodplain habitat for Delta Smelt, Longfin Smelt, Steelhead Salmon, Splittail, Giant Garter Snake, and other species. In addition to habitat creation, the Lookout Slough THRFIP will provide 40,000 to 50,000 acre-feet of seasonal floodplain storage. A Lookout Slough THRFIP Vicinity Map is presented as Figure 1.

To create tidal, subtidal, and floodplain habitat, the Lookout Slough THRFIP would breach the Shag Slough Levee (SSL) at several locations and construct the new Duck Slough Setback Levee (DSSL) to maintain flood protection to areas outside of the Lookout Slough THRFIP area. Ecosystem Investment Partners (EIP) retained Blackburn Consulting (BCI) to perform geotechnical engineering services for DSSL design, borrow material evaluation within the restoration area, and design of PG&E tower access roads that extends to electrical distribution towers located in the site area. Geotechnical recommendations for the PG&E towers are presented in separate Technical Memorandums prepared by the design-build team. The design-build team is also preparing a separate Hass and Cache Slough Levee Technical Memorandum that provides an evaluation of possible impacts the Project may have on the existing levee systems and neighboring properties. Figure 2 presents the Lookout Slough THRFIP Site Limits and includes the DSSL alignment, PG&E distribution tower alignment with proposed access road locations, and proposed SSL breach areas.

1.2 Purpose and Scope

BCI prepared this Draft Geotechnical Data Report (Draft GDR) for 65% Levee Design of the Lookout Slough THRFIP. BCI prepared this report for EIP to support the design-build team's 65% design of the project. This report updates and replaces the May 2019 Draft 60% Draft GDR prepared by BCI.

BCI is currently performing geotechnical evaluations for the following aspects of the new DSSL associated with the project:

- Geometry.
- Underseepage, through-seepage, settlement, slope stability and seismic vulnerability.
- Tie-in considerations at the SSL and Hass Slough East Levee.
- Use of on-site borrow.

BCI has completed subsurface explorations and laboratory testing programs for the above evaluations except for the tie-in locations, which are expected to be complete by the end of September 2019. Findings from the additional explorations will be included in the 90% and/or 100% GDR.

2 TOPOGRAPHY, GEOLOGY, GEOMORPHOLOGY, AND GROUND WATER

2.1 Topography

The April 2011 *Geotechnical Assessment Report, North NULE Project Study Area, Volume 1 of 6, Non-Urban Levee Evaluations Project Contract 4600008101, Task Order U104,* (2011 NULE) prepared by URS describes the Area 5, West Delta Levees as located within the low-lying portion of the southwestern Sacramento Valley. Within the Lookout Slough THRFIP area and surrounding sites, small and large canals with associated levees were constructed to aid in irrigation, prevent flooding, and drain the previously saturated, low-lying deposits. Current ground elevations near the proposed DSSL range from Elevation 8 feet to Elevation 6 feet.

BCI reviewed the following available historical topographic maps within the Lookout Slough THRFIP area to identify if historical sloughs or drainage areas crossed the proposed DSSL alignment:

- Courtland Quadrangle Topography, March 1908 Edition, Reprinted in 1914.
- Cache Slough Quadrangle Topography, 1916 Edition.
- Liberty Island Quadrangle Topography, 1952, Photo revised 1968.

A pond feature is identified on both the 1908 and the 1916 topographic maps. This pond feature aligns with the water feature identified on the geomorphology map, discussed below in Section 3.3. BCI did not identify any other historical sloughs or drainage/irrigation channels crossing the proposed DSSL alignment. Appendix A presents the topographic maps overlain with the Lookout Slough THRFIP limits and the proposed DSSL alignment.

2.2 Geology

The Lookout Slough THRFIP area is located within the northwestern portion of the approximately 50-mile-wide and 400-mile-long Great Valley Geomorphic Province. The Great Valley province is a depositional basin bounded by the Sierra Nevada to the east, the Coast Ranges to the west, and the Klamath Mountains and Cascade Range to the north. The basin is a broad, elongated, northwest trending, structural trough that has been filled with a thick sequence of sediments as much as 20,000 to 40,000 feet thick.

BCI reviewed both the *Geologic Maps of the Sacramento -San Joaquin Delta,* California, Brian F. Atwater, 1982 (1982 Geologic Map), and the *Geologic Map of the Late Cenozoic Deposits of the Sacramento Valley, Sheet 1,* Edward J. Helley and David S. Harwood, USGS Publication MF-1790, 1985 (1985 Geologic Map). Both Geologic Maps indicate the site as generally underlain by Basin Deposits, Undivided/Flood-basin deposits (Holocene) (Qb). This material consists of fine grained silt and clay. Both maps also identify two localized areas are mapped as Lower Member, Modesto Formation (Qml) (1985 Geologic Map) and Alluvium of Putah Creek, Older Alluvium (Pleistocene) Qop near the proposed DSSL alignment and borrow areas. The Qml formation consists of unconsolidated, slightly weathered gravel, sand, silt and clay. These areas are near the water features identified in the geomorphology map discussed below in Section 3.3.

The 1982 Geology Map identifies the northern border of the property as Younger Alluvium of Putah Creek (Holocene and Pleistocene) (Qyp). The border of Qyp closely follows the border between Basin Deposits and Marsh Deposits identified on the geomorphology map. Peat Deposits (Qp/Qpm) extend into the very lower southeast section of the project site on both geology maps. The southern cross levee is located within this deposit. Peat deposits consist of decaying fresh-water plant remains with minor amounts of silt and clay.

Figure 4 presents the site Geologic Map using the 1982 Geology Map. This map more closely aligns with features identified in the geomorphology map and is more specific to the Delta area.

2.3 Geomorphology

URS prepared the January 2011, *Final Geomorphology Technical Memoranda and Maps, North NULE Area Geomorphic Assessments, Non-Urban Levee Evaluations Project, Contract 4600008101,* (2011 Geomorphology TM. The 2011 Geomorphology TM describes the geology of the Lookout Slough THRFIP area as the Yolo Flood Basin. During times of flood, slow moving inland seas covered this basin. Referenced reports describe deposition in such flood basins resulted from slow moving/standing water, with primary sediments consisting of silt and clay. Higher permeability deposits may be locally interbedded, as well as alluvial fan sediments from west or east flowing streams.

The Delta geomorphic domain generally consists of fluvial channels and tidal sloughs. Delta island deposits are late Holocene, unconsolidated and fine-grained organic-rich silt and clay with high water content and peat. Directly adjacent to watercourses, Sacramento River supratidal alluvium and sloughs overlie Delta islands of peat and mud. Natural levee deposits and peat and mud deposits interfinger in the subsurface and create vertical interbedded layers of silt and sand with organic-rich material. The deposits in the Delta are moderately permeable.

The geomorphology underlying the proposed DSSL alignment and extending into the proposed borrow areas generally consists of Basin Deposits (Hn) comprised of fine sand, silt and clay. A localized water area is mapped generally between Station 38+00 to Station 48+00 of the proposed DSSL alignment, and localized Alluvial Fan deposits (Pf) are mapped in the northern portion of the site, generally waterside of the proposed levee alignment. A Holocene Slough Deposit (Hsl) is mapped to extend into the upper northeast corner of the site.

The remainder of the site is generally mapped as Marsh Deposits (Hs) which consist of silt and clay and possible organic rich deposits. Similar to the mapped Qp of the Helley and Harwood Geologic Map, Peat and Muck (Qpm) is mapped in the very lower southwest section of the Lookout Slough THRFIP, near the southern cross levee, but not under the proposed new DSSL alignment. This material consists of interbedded peat and organic-rich silt and clay. Both Historical and Holocene Slough Deposits (Rsl and Hsl respectively) which consist of silt, clay and sand, low-energy channel deposits extend into the Lookout Slough THRFIP predominantly along the western border, apparently originating from Hass and Cache Slough. Refer to Figures 3A and 3B.

2.4 Ground Water

BCI determined local ground water elevations from subsurface explorations (borings and test pits) performed to date. BCI encountered ground water from 3 to 20 feet below the existing ground surface (bgs) (approximate Elevation 3 feet to Elevation -7 feet) near the proposed DSSL alignment within the explorations. In some explorations, it appears that the water was seeping from within the clay blanket layer, while in others, the water appeared to be within discontinuous, thin clayey sand lenses. During test pit excavations, BCI observed ground water seeping from the side walls into the test pit, fluctuating between 5.5 feet to 9 feet bgs. Therefore, the ground water could be perched water from heavy winter rains and the continual irrigation flooding from ranching operations.

3 SUBSURFACE EXPLORATION PROGRAM

To date, BCI has performed a total of 39 exploratory borings, 5 cone penetrometer tests and 47 test pits for the Lookout Slough THRFIP to support up to 65% design. BCI spaced the explorations to meet the USACE criteria regarding the number of explorations needed for levee design evaluation.

Figure 3 shows the locations of BCI's subsurface explorations completed to date. Figures 5A through Figures 5G present the Lookout Slough THRFIP Plan and Geotechnical Profile Figures. These figures present the subsurface soil conditions along the entire DSSL alignment.

BCI located the explorations along the proposed DSSL alignment, and slightly landside and waterside of the proposed levee toe. BCI worked closely with the design team prior to the initiation of each field exploration program and performed the following tasks:

- Prepared an exploration program with exploration locations and proposed exploration depths for review and comment from the design team.
- Contacted the lessee to discuss the exploration procedures and timeline.
- Acquired permits including Solano County Environmental Health Department permits.
- Marked each location for Underground Service Alert (USA) and notified USA.
- Contacted subcontractors to discuss schedule, procedures and obtain insurance certificates as applicable.

As part of the Lookout Slough THRFIP, BCI also performed test pits within the proposed borrow areas identified by the design-build team. Findings from the test pits are presented in the September 2019 DRAFT 65% Design Borrow Report prepared by BCI for the project. The Borrow Report contains test pit logs and laboratory test results for the borrow evaluation.

Four additional explorations are planned for the new DSSL evaluation at the tie-ion locations to existing levees; two explorations in the Hass Slough East Levee at the southern tie-in location, and two explorations within the SSL at the northern tie-in location. These explorations are planned mid-August 2019 with the recent receipt of the signed DPP.

3.1 Exploratory Boring Field Procedures

BCI completed the following exploratory borings for the Lookout Slough THRFIP:

- August and September 2017: Eight (8) auger/mud rotary wash borings as part of a feasibility study to evaluate the subsurface conditions along a preliminary DSSL alignment.
- November and December 2017: Twelve (12) auger/mud rotary wash borings to account for a slight modification to the levee alignment and to confirm variable subsurface conditions encountered within the project area.
- June 2018: Eight (8) auger/mud rotary borings to confirm continuity of subsurface conditions observed during previous field exploration programs.
- December 2018: Four (4) auger borings along Liberty Island Road that extended through the roadway embankment. BCI performed these explorations to evaluate the condition of the roadway embankment because the new DSSL alignment landside levee slope will tie into the embankment.
- March and April 2019: Seven (7) auger borings along the DSSL alignment between existing explorations and near the tie-in locations at Hass Slough East Levee and the SSL.

Taber Drilling (Taber) of West Sacramento, California drilled all the auger/mud rotary borings for BCI with a CME 55 HD crawler drill rig and a CME 75 Truck Rig, both equipped with 6-inch diameter solid-stem auger and a 94-mm wire-line system to obtain soil samples at selected intervals. Below ground water, Taber switched to mud rotary with a 94-mm drill pipe attached to a 12-tooth carbide bit to advance the borings.

At BCI's direction, the drillers obtained relatively "undisturbed" soil samples of fine-grained soil with a hydraulically-pushed, piston-type 3-inch diameter Shelby sampler. These samples were supplemented with 1.4-inch inside diameter (I.D.) Standard Penetration Test (SPT) samples and 2.4-inch I.D. Modified California samples, driven with a standard 140-pound automatic trip hammer falling 30 inches. The SPT blow counts shown on BCI's boring logs are uncorrected "field" values. The blow count N-value represents the number of hammer blows required to drive the sampler the last 12 inches of an 18-inch run. Taber obtained hammer energy measurements during the field exploration programs. The energy efficiency measurements and reports are presented in Appendix B.

3.2 Exploratory Cone Penetrometer Test Field Procedures

BCI performed five (5) cone penetrometer tests (CPTs) for the Lookout Slough THRFIP in April 2018. Middle Earth Geo Testing, Inc. (MEGT, Inc.) of Orange County, California performed the CPT probes with a 25-ton truck-mounted CPT rig.

The truck-mounted computer-based data acquisition and presentation system performed CPT data processing. The computer-generated graphical logs include cone resistance (qt), friction resistance (fs), friction ratio, and pore pressure (u) ratio versus depth. The Soil Behavior Type (SBT) interpretations are based on Robertson, P.K. and Campanella, R.C., 1998, "Guidelines for Geotechnical Design Using the Cone Penetrometer Test and CPT with Pore Pressure Measurement," Soil Mechanics Series NO. 120, Civil Engineering Department, University of British Columbia, Vancouver, B.C., V6T 1Z4, September 1989. The interpretation of the SBT based solely on qt, fs, and u is not always possible. Therefore, experience, judgment and correlations with nearby borings are also used to infer SBT in CPT probes.

3.3 Exploratory Logging

For the auger/mud rotary wash borings, a BCI engineer/geologist logged the soils consistent with the Unified Soil Classification System (USCS) and obtained pocket penetrometer measurements on fine-grained soil samples obtained from the borings. Appendix B presents the Lookout Slough THRFIP boring logs completed by BCI. The boring logs present corrected soil descriptions based on laboratory test results.

For the CPT probes, the subsurface stratigraphy is presented as the soil behavior type (SBT), based on qt, fs, and u data recorded at the time of the CPT probe exploration. The CPT logs are presented in Appendix B.

BCI made ground water observations in the borings during drilling operations. The CPT logs presented in Appendix B also include the estimated ground water depth based on pore pressure readings.

3.4 Exploratory Locations

BCI's field engineer/geologist located the explorations with a hand-held GPS unit, and used LIDAR data provided by the design team to determine the ground surface elevations for each exploration. The elevations are provided in the NAVD 88 vertical datum. Figures 5A through 5G present the ground surface elevations for each exploration. The coordinates are presented on the boring logs in Appendix B.

3.5 Backfill and Soil Cuttings Disposal

At the completion of field work, the drilling subcontractor backfilled the explorations and probes with cement-grout, placed by tremie-method into the borehole. For the auger/mud-rotary wash borings, soil cuttings and circulating mud used in the drilling operations were spread near the exploration location. No significant soil cuttings were generated in the CPT probes.

4 LABORATORY TESTING PROGRAM

BCI performed the following laboratory tests on representative soil samples obtained from the exploratory borings. Tests included:

- Moisture Content and Unit Weight (56 tests) (ASTM D2216-10) for design parameter development and correlation.
- Sieve Analysis (ASTM D422-63 and ASTM D1140-00) (167 tests) and Atterberg Limits (ASTM D4318-10) (153 tests) for soil classification, hydraulic conductivity and strength correlations, liquefaction analysis, and seismic slope stability evaluation.
- Optimum moisture and maximum density compaction curves (ASTM D698) (7 tests) to determine parameters for remolded test specimens and cut-to-fill volume change evaluation.
- Direct Shear tests (ASTM D3080) (5 tests), Unconsolidated Undrained Triaxial Compression (ASTM D2850) (7 tests), and Consolidated Undrained with pore-water pressure measurements Triaxial Compression (ASTM D4767) (3 tests) on native relatively "undisturbed" and remolded specimens for slope stability analysis.
- Hydraulic Conductivity (ASTM D5084-10 Method C) (10 tests) on native relatively "undisturbed" and remolded specimens for seepage analysis.

- Consolidation tests (D2435/D2435M-11) (8 tests) for settlement analysis.
- Organic Matter Tests (13 tests)

BCI performed laboratory tests in accordance with current ASTM test methods. Appendix C contains a summary table of BCI's test results. Appendix C also contains the lab test result reports. The exploration logs presented in Appendix B and the stick logs presented in Figures 5A through 5G also contain the #200 sieve analysis results and the Atterberg Limit test results.

4.1 Index, Grain Size, Moisture Content and Dry Density Tests

BCI performed index, grain size, moisture content and dry density tests to classify the subsurface soil underlying the proposed levee alignment, and in the near-field both landside and waterside of the alignment. BCI performed these tests on samples collected during the subsurface exploration program described in Section 4. These tests include:

- Sieve analysis (ASTM D422-63) for particle size distribution determination.
- Percent material finer than the No. 200 sieve (ASTM D1140-00) to determine the percent fines.
- Atterberg limits test (ASTM D4318-10) to determine the liquid limit, plastic limit and plasticity index, and
- Moisture content and dry unit weight (ASTM D2216-10) to determine the in-situ moisture content and unit weight.

The September 2019 DRAFT 65% Borrow Report presents Index Property test results for samples obtained during the borrow area evaluations.

4.2 Hydraulic Conductivity Tests

BCI performed hydraulic conductivity tests on relatively "undisturbed" soil samples obtained with a hydraulically-pushed, piston-type 3-inch diameter Shelby sampler. BCI performed the tests in accordance with ASTM D5084-10 Method C to assist in the determination of the hydraulic conductivity parameters for underseepage analysis. The September 2019 DRAFT 65% Borrow Report presents remolded hydraulic conductivity test results for samples obtained during the borrow area evaluations.

4.3 Strength Tests

BCI performed strength tests on relatively "undisturbed" soil samples to determine parameters for slope stability analysis. The September 2019 DRAFT 65% Borrow Report presents the remolded triaxial compression test results for samples obtained during the borrow area evaluations.

With regards to CU w/pp triaxial compression tests, BCI evaluated the total and effective friction angle and cohesion at the maximum principal strength ratio, 5% strain, and the maximum deviator stress (if less than 5%). The strength values at 5% strain provided the most reasonable results on specimens of in-situ clay and were therefore used for analysis.

BCI performed strength tests on Shelby tube samples to test relatively undisturbed in-situ soil samples. Three, 3-inch x 6-inch samples of the same material type are needed for CU w/pp triaxial compression tests to obtain reasonable results. The clay blanket layer along the DSSL alignment consists of varying layers of lean-to fat clay to sandy clay, with discontinuous, relatively thin zones of higher permeability clayey sand, silt and silty sand. It was therefore difficult to obtain a continuous 1.5 foot sample of similar material that would produce reasonable CU w/pp triaxial compression test results to obtain both total and effective strengths. BCI performed two CU w/pp triaxial compression tests on specimens of in-situ soil in an attempt to obtain both effective and total strength tests. However, due to sample variability, BCI could not produce reasonable Mohr circles to determine effective strengths from these test results.

4.4 Consolidation Tests

BCI performed One-Dimensional Consolidation Tests on Soils Using Incremental Loading (D2435/D2435M-11) on relatively undisturbed samples collected during the field exploration program. BCI performed these tests to evaluate settlement potential, time-rate settlement and to estimate the maximum past effective overburden pressures of the soil layers.

4.5 Organic Matter Tests

BCI performed Organic Matter tests on select soil samples along the levee alignment. The test results ranged from 4.4% to 12.6%. Of the 13 organic content tests result, 7 were less than 6%, three were less than 8%, two were less than 10% and one was greater than 10% at 12.6% (BCI-17-10.2)

Organic CLAY is defined under ASTM D2487-06 as a clay with sufficient organic content to influence soil properties. BCI performed an additional evaluation on sample BCI-17-10.2 to confirm this material did not classify as Organic CLAY. BCI performed liquid limit tests both with and without oven drying. The liquid limit after oven drying was greater than 75% of the liquid limit before oven drying; therefore, this material is classified as a Fat CLAY (CH), not an Organic CLAY (OH).

5 LIMITATIONS

BCI prepared this Draft GDR for EIP and the design team for the Lookout Slough THRFIP. This Draft GDR should not be used by others or for other projects without BCI's written permission.

BCI prepared this report in accordance with the generally accepted geotechnical standard of practice currently being used in this area.

BCI based this Draft GDR on the current site and Lookout Slough THRFIP conditions. We assumed the soil/ground water conditions encountered in our explorations are representative of the subsurface conditions across the site. Actual conditions between explorations could be different. Ground water may be higher in other locations and at other times than measured in the explorations.

The interface between soil types on the logs is approximate. The transition between soil types may be abrupt or gradual. We based our recommendations on the final logs, which represent our interpretation of the field logs and general knowledge of the site and geologic conditions.

GEOTECHNICAL DATA REPORT

65% Design

Lookout Slough Tidal Habitat Restoration and Flood Improvement Project

Solano County, California

FIGURES

Lookout Slough THRFIP Vicinity Map
Lookout Slough THRFIP Site Limits
Exploration Site Plan
Geologic Map
Plan and Profile Sheets

This Page Intentionally Left Blank

FIGURE 1, PROJECT VICINITY MAP
Geotechnical Data Report - 65% Design
September 2019

N
W E
S

0 10,000
SCALE: 1" = 10,000'

Lookout Slough THRFIP

Ecosystem Investment Partners

Prepared by:

Map Prepared Date: 09/01/19
Map Prepared By: M.D.R.
Checked By: N.C.H.
Job No.: 3195.x

BLACKBURN CONSULTING

Path: \\FS-01\Common\Active Projects\3195.P DWR Lookout Slough Restoration Project\CAD\3195.x Fig1 LSRP 65%.dwg

This Page Intentionally Left Blank

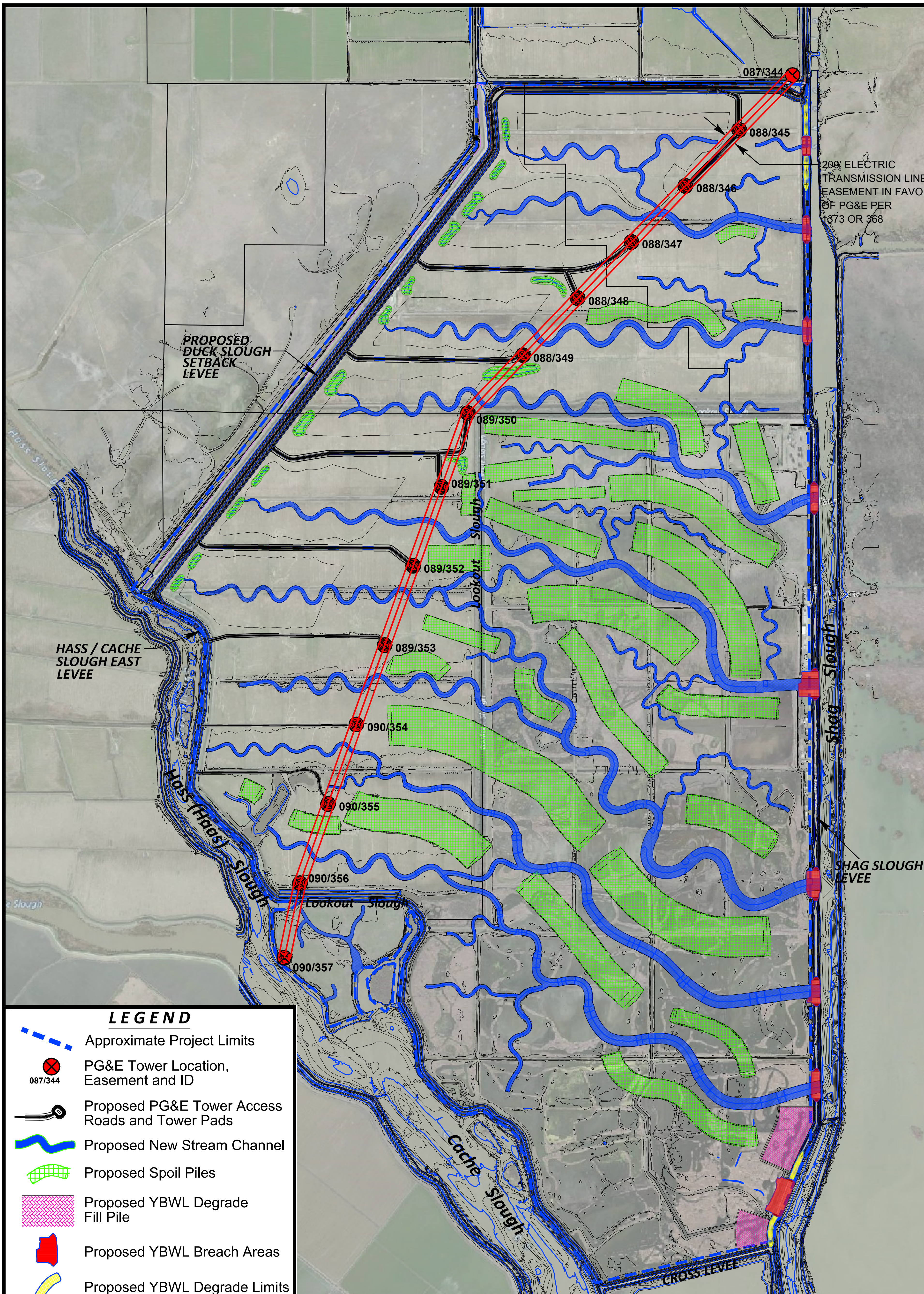


FIGURE 2, PROJECT SITE LIMITS
Geotechnical Data Report - 65% Design
September 2019

N
W E
S

Drawing References: Lookout Slough boundary lines and easements provided by Wood Rodgers, Inc., 12/08/2017. Proposed levee alignment, stream channels, and topography updated 7/30/2019.

0 1500
SCALE: 1 " = 1500'

Lookout Slough THRFIP

Ecosystem Investment Partners

Map Prepared Date: 09/01/19
Map Prepared By: M.D.R.
Checked By: N.C.H.
Job No.: 3195.x

Prepared by:
BLACKBURN CONSULTING

Path: \\FS-01\Common\Active Projects\3195.P DWR Lookout Slough Restoration Project\CAD\3195.x Fig2 LSRP 65%.dwg

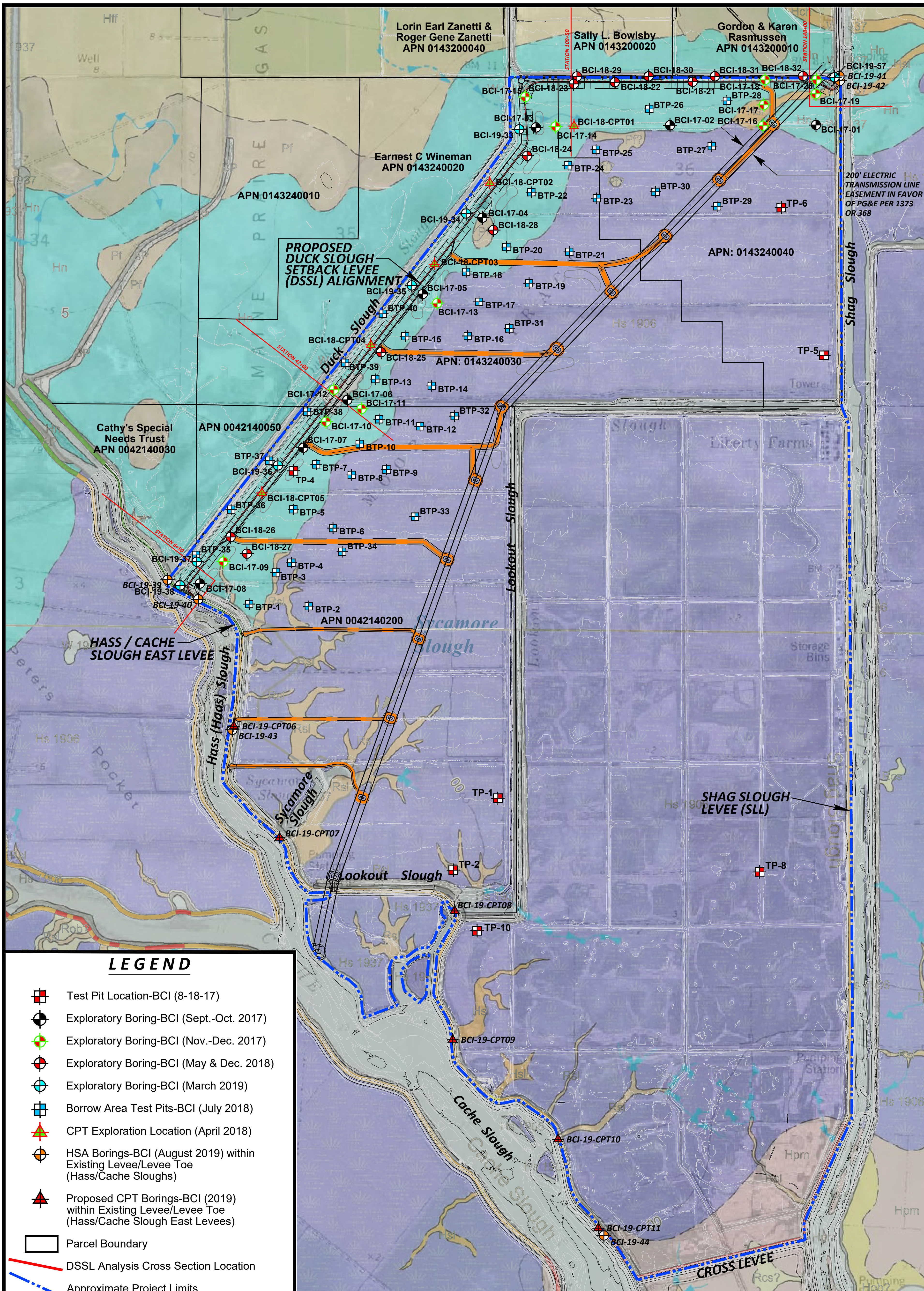


FIGURE 3A, EXPLORATION SITE PLAN
Geotechnical Data Report - 65% Design
September 2019

Lookout Slough THRFIP

Drawing References: Lookout Slough boundary lines and easements provided by Wood Rodgers, Inc., 12/08/2017. Proposed levee alignment updated 2/1/2019 and topography updated11/12/2018.

0 1500
SCALE: 1 " = 1500'

Ecosystem Investment Partners

Map Prepared Date: 09/01/19
Map Prepared By: M.D.R.
Checked By: N.C.H.
Job No.: 3195.x

Prepared by:
BLACKBURN CONSULTING

Path: \\FS-01\Common\Active Projects\3195.P DWR Lookout Slough Restoration Project\CAD\3195.x Fig3 LSRP 65%.dwg

This map shows surficial geologic deposits and levees as they existed in 1937. Map units and boundaries are drawn by interpretation of historical aerial photography supplemented by data from historical maps and surveys. For reference, the mapping is superimposed on modern U.S. Geological Survey 7.5' topographic base maps (individual maps referenced below).
Screened back semi-transparent mapping shown on this plate is from Deep Water Ship Channel study area, which is not assessed in this investigation. For clarity, only the surficial geologic map units of this study appear in the explanation.
See accompanying technical memorandum for complete descriptions of map units, process descriptions and methodology.
Adjacent polygons that have identical map unit symbols are employed to delineate sequences of sedimentation and landscape evolution.

Explanation

Underseepage Susceptibility Along Non-Urban Levee Alignment

Very High | High | Moderate | Low

?

Geologic contact; dashed where approximate, dotted where concealed, queried where uncertain. Solid contacts accurate to within 100' of line shown on map; dashed contacts accurate to within about 250' on either side of the line.

Narrow channel, generally <100 ft in width. Dashed where approximate, dotted where concealed.

Narrow, tidally influenced channel (<100 ft in width), commonly connected to a larger slough channel.

Canal

Levee; artificial fill prism, generally <70 ft in width.

Borrow pit, generally <70 ft in width.

W 1937 — Water; date indicates year of historical dataset.

BP — Borrow pit present in 1937.

Geologic Units

HISTORICAL

- AF — Artificial fill, circa 1937.
- L — Levee (made of artificial fill), circa 1937.
- Rob — Overbank deposits; silt, sand, and lesser clay; deposited during high-stage water flow, overtopping channel banks.
- Rcs — Crevasse splay deposits; fine sand and silt with clay deposited from breaching of natural or artificial levees.
- Rch — Channel deposits; well sorted sand and trace fine gravel.
- Rsl — Slough deposits; silt, clay, and sand, fining upward facies, low-energy channel deposits.
- Ril 1906 — Intermittent lake; seasonal lake shown on historical topographic maps. Date indicates source data set.

HOLOCENE

- Hob — Overbank deposits; silt, sand, and clay; deposited during high-stage water flow, overtopping channel banks.
- Hcs — Crevasse splay deposits; fine sand and silt with clay deposited from breaching of natural levees.
- Hff — Fine-grained alluvial fan deposits; silt and clay with sand.
- Hch — Channel deposits; well sorted sand and trace fine gravel.
- Hsl — Slough deposits; silt, clay, and sand, fining upward facies, low-energy channel deposits.
- Ha — Alluvial deposits, undifferentiated; sand, silt, clay and minor lenses of gravel.
- Hpm — Peat and muck; interbedded peat and organic-rich silt and clay, former tidal marsh deposits, mostly now leveed, drained, and farmed.
- Hn — Basin deposits; fine sand, silt and clay.
- Hs 1937 — Marsh deposits; silt and clay, possibly with organic-rich beds; perennially or seasonally submerged. Date indicates year of historical dataset used to map the marsh.

PLEISTOCENE

- Pf — Alluvial fan deposits; semi-consolidated silt, sand, sandy clay and fine to coarse subrounded gravel.
- Pf (m) — Alluvial fan deposits of the Montezuma Hills; semi-consolidated sandy silt, sandy clayey silt, clay, sand and minor pebble gravel eroded from the early Pleistocene Montezuma Formation

Stratigraphic Correlation Chart

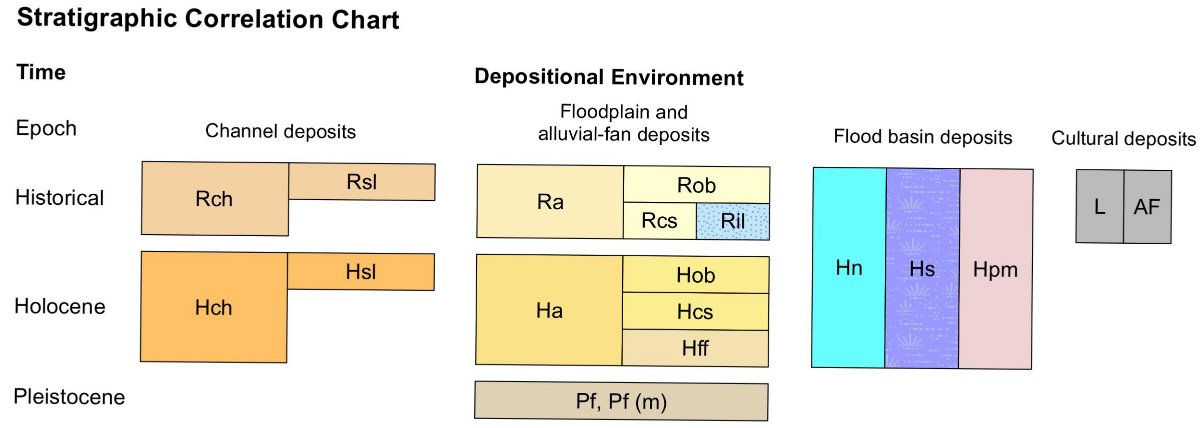


FIGURE 3B, LEGEND, EXPLORATION SITE PLAN
Geotechnical Data Report - 65% Design
September 2019

Source: Surficial Geologic Map of the West Delta Study Area, Plate 1 for the North Non-Urban Levee Evaluations. Produced by Department of Water Resources, Division of Flood Management, Levee Evaluations Branch in association with URS and Fugro, Scale is 1"=2000'.

Lookout Slough THRFIP

Ecosystem Investment Partners

Prepared by:

Map Prepared Date: 09/01/19
Map Prepared By: M.D.R.
Checked By: N.C.H.
Job No.: 3195.x

BLACKBURN CONSULTING

Path: \\FS-01\Common\Active Projects\3195.P DWR Lookout Slough Restoration Project\CAD\3195.x Fig3 LSRP 65%.dwg

FIGURE 4, GEOLOGIC MAP
Geotechnical Data Report - 65% Design
September 2019

Lookout Slough boundary lines and easements provided by Wood Rodgers, Inc., 12/08/2017. Proposed levee alignment and topography updated 02/01/2019. Liberty Island, Geologic Map of the Sacramento-San Joaquin Delta, California, by Brian F. Atwater, 1982.

0 1500
SCALE: 1 " = 1500'

Ecosystem Investment Partners

Map Prepared Date: 09/01/19
Map Prepared By: M.D.R.
Checked By: N.C.H.
Job No.: 3195.x

Prepared by:
BLACKBURN CONSULTING

Lookout Slough THRFIP

Path: \\FS-01\Common\Active Projects\3195.P DWR Lookout Slough Restoration Project\CAD\3195.x Fig4 LSRP 65%.dwg

GROUP SYMBOLS AND NAMES

Graphic/Symbol	Group Names
GW	Well-graded GRAVEL Well-graded GRAVEL with SAND
GP	Poorly-graded GRAVEL Poorly-graded GRAVEL with SAND
GW-GM	Well-graded GRAVEL with SILT Well-graded GRAVEL with SILT and SAND
GW-GC	Well-graded GRAVEL with CLAY (or SILTY CLAY) Well-graded GRAVEL with CLAY and SAND (or SILTY CLAY and SAND)
GP-GM	Poorly-graded GRAVEL with SILT Poorly-graded GRAVEL with SILT and SAND
GP-GC	Poorly-graded GRAVEL with CLAY (or SILTY CLAY) Poorly-graded GRAVEL with CLAY and SAND (or SILTY CLAY and SAND)
GM	SILTY GRAVEL SILTY GRAVEL with SAND
GC	CLAYEY GRAVEL CLAYEY GRAVEL with SAND
GC-GM	SILTY, CLAYEY GRAVEL SILTY, CLAYEY GRAVEL with SAND
SW	Well-graded SAND Well-graded SAND with GRAVEL
SP	Poorly-graded SAND Poorly-graded SAND with GRAVEL
SW-SM	Well-graded SAND with SILT Well-graded SAND with SILT and GRAVEL
SW-SC	Well-graded SAND with CLAY (or SILTY CLAY) Well-graded SAND with CLAY and GRAVEL (or SILTY CLAY and GRAVEL)
SP-SM	Poorly-graded SAND with SILT Poorly-graded SAND with SILT and GRAVEL
SP-SC	Poorly-graded SAND with CLAY (or SILTY CLAY) Poorly-graded SAND with CLAY and GRAVEL (or SILTY CLAY and GRAVEL)
SM	SILTY SAND SILTY SAND with GRAVEL
SC	CLAYEY SAND CLAYEY SAND with GRAVEL
SC-SM	SILTY, CLAYEY SAND SILTY, CLAYEY SAND with GRAVEL
PT	PEAT
	COBBLES COBBLES and BOULDERS BOULDERS

Graphic/Symbol	Group Names
CL	Lean CLAY Lean CLAY with SAND Lean CLAY with GRAVEL SANDY lean CLAY SANDY lean CLAY with GRAVEL GRAVELLY lean CLAY GRAVELLY lean CLAY with SAND
CL-ML	SILTY CLAY SILTY CLAY with SAND SILTY CLAY with GRAVEL SANDY SILTY CLAY SANDY SILTY CLAY with GRAVEL GRAVELLY SILTY CLAY GRAVELLY SILTY CLAY with SAND
ML	SILT SILT with SAND SILT with GRAVEL SANDY SILT SANDY SILT with GRAVEL GRAVELLY SILT GRAVELLY SILT with SAND
OL	ORGANIC lean CLAY ORGANIC lean CLAY with SAND ORGANIC lean CLAY with GRAVEL SANDY ORGANIC lean CLAY SANDY ORGANIC lean CLAY with GRAVEL GRAVELLY ORGANIC lean CLAY GRAVELLY ORGANIC lean CLAY with SAND
OL	ORGANIC SILT ORGANIC SILT with SAND ORGANIC SILT with GRAVEL SANDY ORGANIC SILT SANDY ORGANIC SILT with GRAVEL GRAVELLY ORGANIC SILT GRAVELLY ORGANIC SILT with SAND
CH	Fat CLAY Fat CLAY with SAND Fat CLAY with GRAVEL SANDY fat CLAY SANDY fat CLAY with GRAVEL GRAVELLY fat CLAY GRAVELLY fat CLAY with SAND
MH	Elastic SILT Elastic SILT with SAND Elastic SILT with GRAVEL SANDY elastic SILT SANDY elastic SILT with GRAVEL GRAVELLY elastic SILT GRAVELLY elastic SILT with SAND
OH	ORGANIC fat CLAY ORGANIC fat CLAY with SAND ORGANIC fat CLAY with GRAVEL SANDY ORGANIC fat CLAY SANDY ORGANIC fat CLAY with GRAVEL GRAVELLY ORGANIC fat CLAY GRAVELLY ORGANIC fat CLAY with SAND
OH	ORGANIC elastic SILT ORGANIC elastic SILT with SAND ORGANIC elastic SILT with GRAVEL SANDY ORGANIC elastic SILT SANDY ORGANIC elastic SILT with GRAVEL GRAVELLY ORGANIC elastic SILT GRAVELLY ORGANIC elastic SILT with SAND
OL/OH	ORGANIC SOIL ORGANIC SOIL with SAND ORGANIC SOIL with GRAVEL SANDY ORGANIC SOIL SANDY ORGANIC SOIL with GRAVEL GRAVELLY ORGANIC SOIL GRAVELLY ORGANIC SOIL with SAND

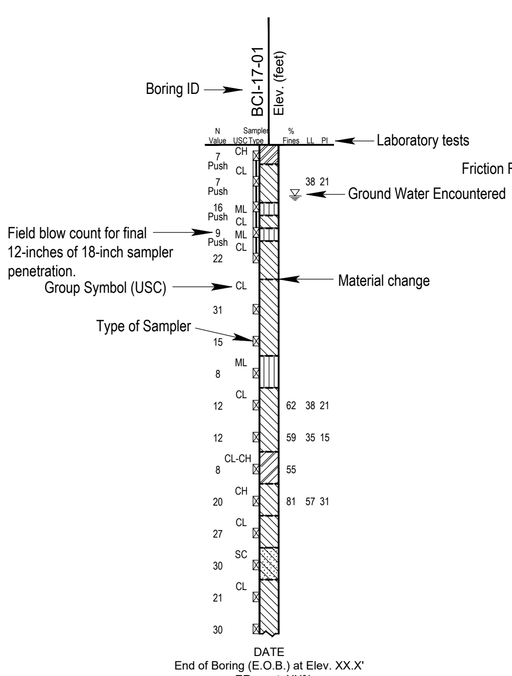
SAMPLER GRAPHIC SYMBOLS

- Standard Penetration Test (1.4 in ID)
- Modified California (2.5 in ID)
- Standard California (2.0 in ID)
- Shelby Tube (2.38 or 2.87 in ID)
- Punch Core
- Dry Core
- Sonic Core or Grab Sample
- Bag Sample

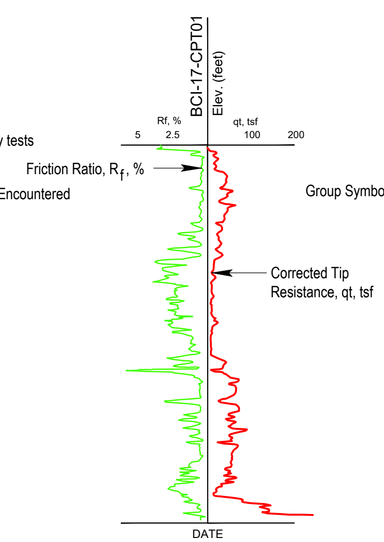
BLACKBURN BORINGS AND TEST PITS

- BCI-YEAR-ID — Exploratory Boring (September-October 2017)
- BCI-YEAR-ID — Exploratory Boring (May and December 2018)
- BCI-YEAR-ID — Exploratory Boring (November-December 2017)
- BCI-YEAR-ID — Exploratory Boring (March 2019)
- TP-ID — Approximate Test Pit Location (8-18-17)
- BTP-ID — Borrow Area Test Pits (July 2018)
- BTP-ID — Duck Slough Embankment Test Pits (July 2018) (Not in Profile View)
- BCI-YEAR-ID — CPT Exploration Location (April 2018)
- HSA Boring (August 2019) Existing Levee/Levee Toe (Hass/Cache & Skag Sloughs)
- 5 — Proposed Duck Slough Setback Levee Centerline
- Parcel Boundary
- STA 42+00 — Geotechnical Analysis
- Approximate Project Limits

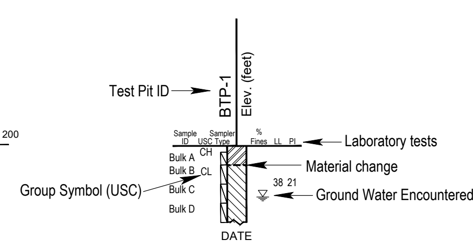
Boring Information



CPT Information



Test Pit Information



NOTES:

1. Boring locations and elevations shown are approximate and based on various levels of certainty according to available data.
2. Boring logs represent soil conditions at the point of exploration on the date indicated.
3. Lines separating strata on boring logs represent approximate boundaries.
4. No warranty is provided as to the continuity of soil conditions between individual boring locations.
5. Geomorphology overlay source: Surficial Geologic Map of the West Delta Study Area, Plate 1 for the North Non-Urban Levee Evaluations. Produced by Department of Water Resources, Division of Flood Management, Levee Evaluations Branch in association with URS and Fugro, Scale is 1"=2000'. This is a color figure. black and white reproductions should not be relied upon as data will be lost.
6. Base drawings for the levee profiles are based on topography terrain model data provided by Wood Rodgers, Inc. 4-10-2019.
7. Boring locations on plan and profile sheets are referenced to 60% design levee alignment received 4-29-2019.
8. Base drawings for the levee plan and profiles are based on topography terrain model data and drawings provided by Wood Rodgers, Inc. September 2019.

This map shows surficial geologic deposits and levees as they existed in 1937. Map units and boundaries are drawn by interpretation of historical aerial photography supplemented by data from historical maps and surveys. For reference, the mapping is superimposed on modern U.S. Geological Survey 7.5' topographic base maps (individual maps referenced below).
Screened back semi-transparent mapping shown on this plate is from Deep Water Ship Channel study area, which is not assessed in this investigation. For clarity, only the surficial geologic map units of this study appear in the explanation.
See accompanying technical memorandum for complete descriptions of map units, process descriptions and methodology.
Adjacent polygons that have identical map unit symbols are employed to delineate sequences of sedimentation and landscape evolution.

Explanation

- Geologic contact; dashed where approximate, dotted where concealed, queried where uncertain. Solid contacts accurate to within 100' of line shown on map; dashed contacts accurate to within about 250' on either side of the line.
- Narrow channel, generally <100 ft in width. Dashed where approximate, dotted where concealed.
- Narrow, tidally influenced channel (<100 ft in width), commonly connected to a larger slough channel.
- Canal
- Levee; artificial fill prism, generally <70 ft in width.
- Borrow pit, generally <70 ft in width.

- W 1937 — Water; date indicates year of historical dataset.
- BP — Borrow pit present in 1937.

Geologic Units

HISTORICAL

- AF — Artificial fill, circa 1937.
- L — Levee (made of artificial fill), circa 1937.
- Rob — Overbank deposits; silt, sand, and lesser clay; deposited during high-stage water flow, overtopping channel banks.
- Rcs — Crevasse splay deposits; fine sand and silt with clay deposited from breaching of natural or artificial levees.
- Rch — Channel deposits; well sorted sand and trace fine gravel.
- Rsl — Slough deposits; silt, clay, and sand, fining upward facies, low-energy channel deposits.
- Ril 1906 — Intermittent lake; seasonal lake shown on historical topographic maps. Date indicates source data set.

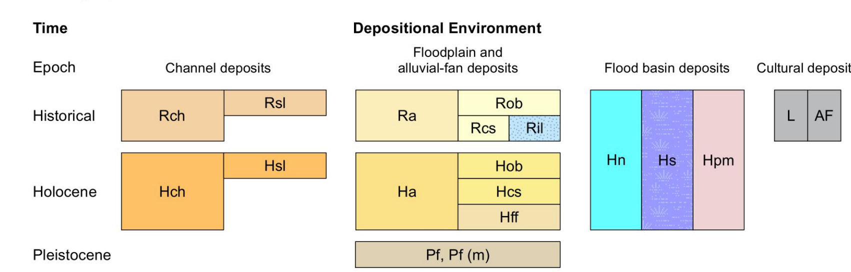
HOLOCENE

- Hob — Overbank deposits; silt, sand, and clay; deposited during high-stage water flow, overtopping channel banks.
- Hcs — Crevasse splay deposits; fine sand and silt with clay deposited from breaching of natural levees.
- Hff — Fine-grained alluvial fan deposits; silt and clay with sand.
- Hch — Channel deposits; well sorted sand and trace fine gravel.
- Hsl — Slough deposits; silt, clay, and sand, fining upward facies, low-energy channel deposits.
- Ha — Alluvial deposits, undifferentiated; sand, silt, clay and minor lenses of gravel.
- Hpm — Peat and muck; interbedded peat and organic-rich silt and clay, former tidal marsh deposits, mostly now leveed, drained, and farmed.
- Hn — Basin deposits; fine sand, silt and clay.
- Hs 1937 — Marsh deposits; silt and clay, possibly with organic-rich beds; perennially or seasonally submerged. Date indicates year of historical dataset used to map the marsh.

PLEISTOCENE

- Pf — Alluvial fan deposits; semi-consolidated silt, sand, sandy clay and fine to coarse subrounded gravel.
- Pf (m) — Alluvial fan deposits of the Montezuma Hills; semi-consolidated sandy silt, sandy clayey silt, clay, sand and minor pebble gravel eroded from the early Pleistocene Montezuma Formation

Stratigraphic Correlation Chart



REV.	DATE	BY	CHK.	APPR.	DESCRIPTION

DESIGNED BY: ROBERT B. LOKTEFF, P.E.,G.E.
DRAWN BY: MIKE ROBERTSON
CHECKED BY: NICOLE C. HART, P.E.
IN CHARGE: JONATHAN KORS, P.E.
DATE: 09/02/2019

REGISTERED PROFESSIONAL ENGINEER — ROBERT B. LOKTEFF — GEOTECHNICAL — STATE OF CALIFORNIA
PRELIMINARY

Prepared by:
BLACKBURN CONSULTING
2491 BOATMAN AVENUE
WEST SACRAMENTO, CA 95691
www.blackburnconsulting.com
JOB NO.: 3195.x

SUBMITTED
APPROVED

Ecosystem Investment Partners

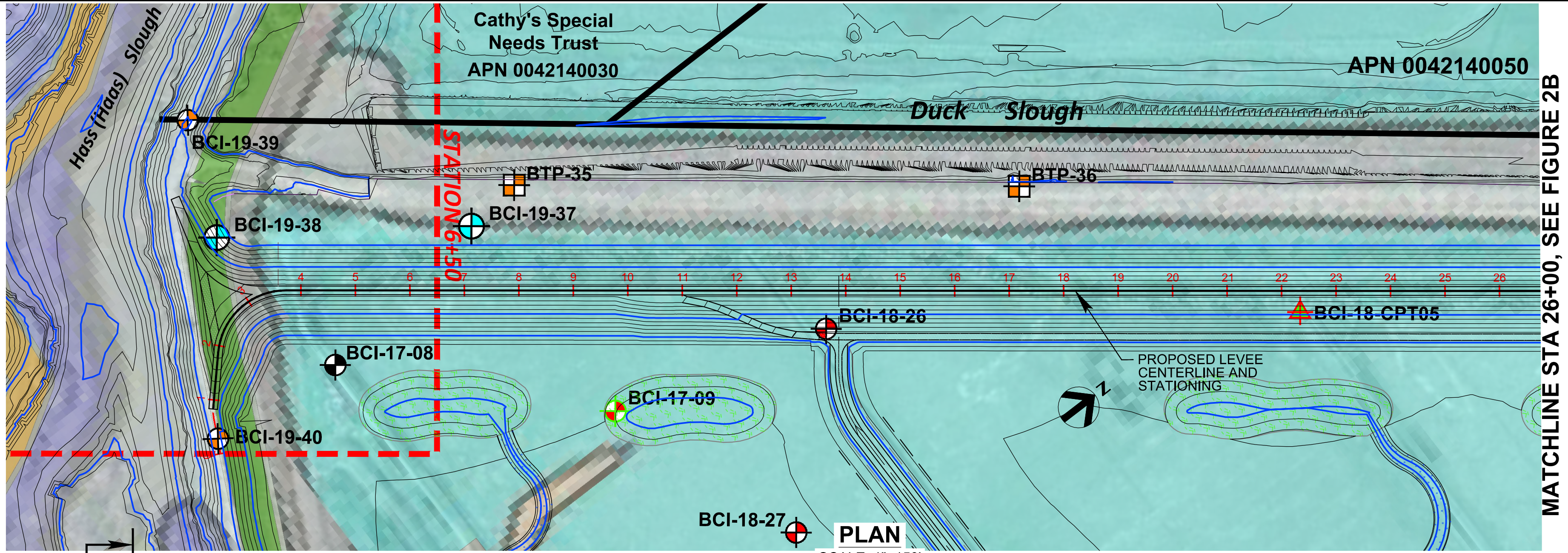
ECOSYSTEM INVESTMENT PARTNERS

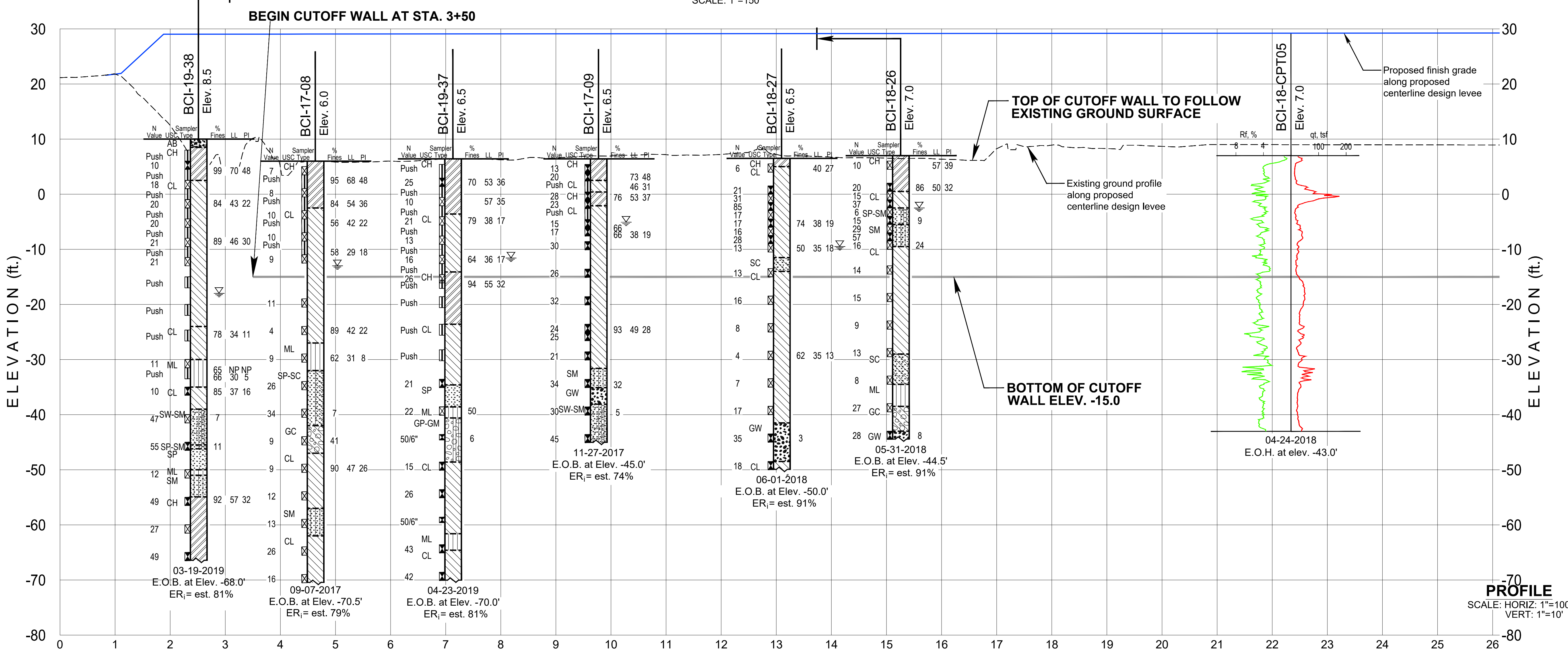
LOOKOUT SLOUGH THRFIP
Geotechnical Data Report - 65% Design
PLAN AND PROFILE LEGEND

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING, ADJUST SCALES FOR REDUCED PLOTS
0 1"

FIGURE NO. 5
SHEET A

\\FS-01\Common\Active Projects\3195.P DWR Lookout Slough Restoration Project\CAD\3195.x Figs LSRP 65%.dwg 9/26/2019 3:59 PM Mike Robertson





REV.	DATE	BY	CHK.	APPR.	DESCRIPTION

DESIGNED BY: ROBERT B. LOKTEFF, P.E.,G.E.
DRAWN BY: MIKE ROBERTSON
CHECKED BY: NICOLE C. HART, P.E.
IN CHARGE: JONATHAN KORS, P.E.
DATE: 09/02/2019

PRELIMINARY

Prepared by:
BLACKBURN CONSULTING
2491 BOATMAN AVENUE
WEST SACRAMENTO, CA 95691
www.blackburnconsulting.com
JOB NO.: 3195.x

SUBMITTED | APPROVED

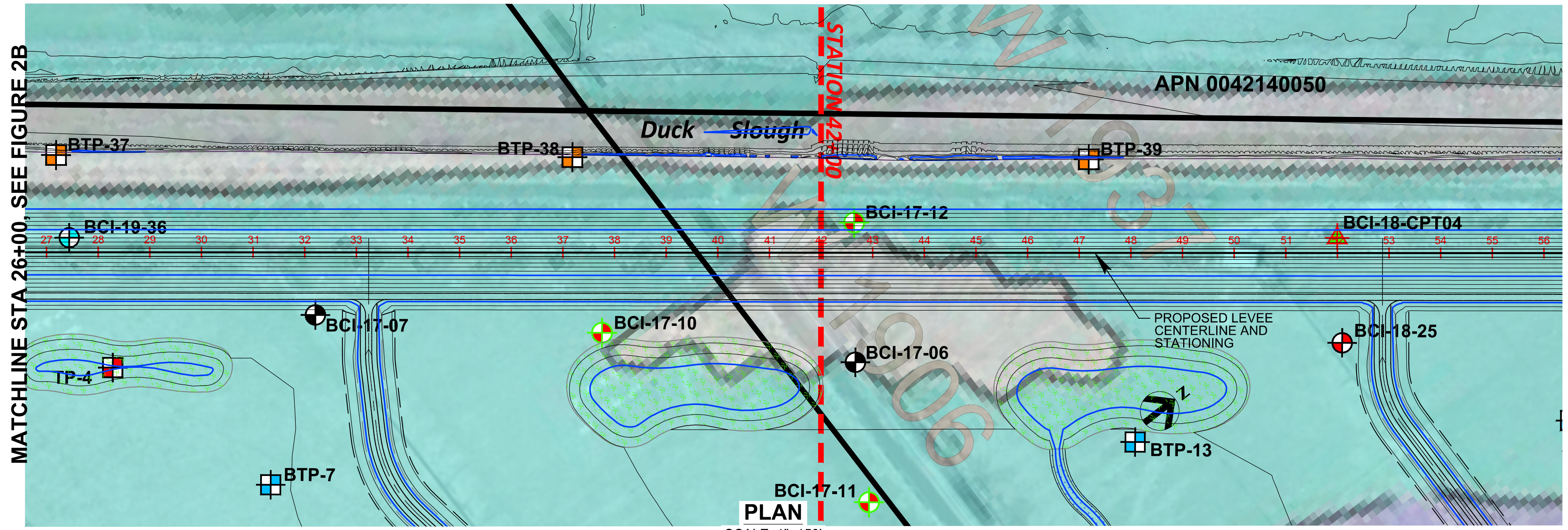
Ecosystem Investment Partners

ECOSYSTEM INVESTMENT PARTNERS

LOOKOUT SLOUGH THRFIP
Geotechnical Data Report - 65% Design
PLAN AND PROFILE STA. 0+00 to 30+00

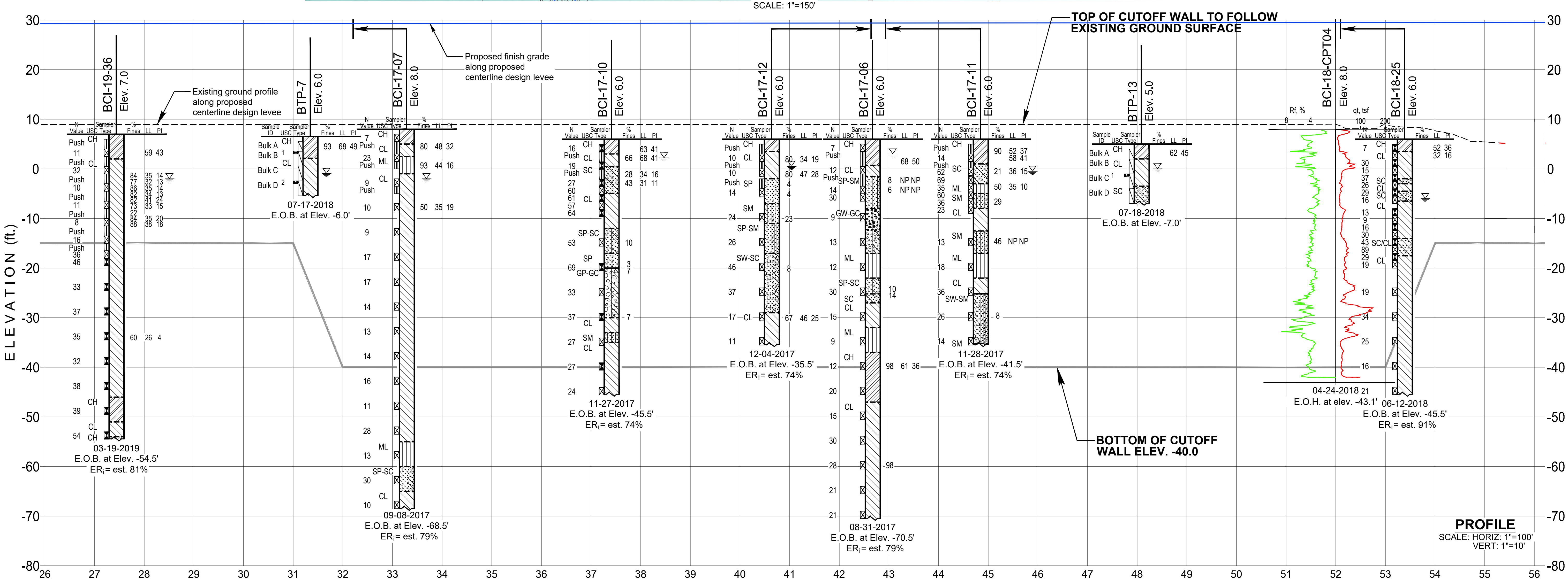
VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING, ADJUST SCALES FOR REDUCED PLOTS

FIGURE NO. 5 | SHEET B



PLAN

SCALE: 1"=150'



REV.	DATE	BY	CHK.	APPR.	DESCRIPTION

DESIGNED BY: ROBERT B. LOKTEFF, P.E.,G.E.
DRAWN BY: MIKE ROBERTSON
CHECKED BY: NICOLE C. HART, P.E.
IN CHARGE: JONATHAN KORS, P.E.
DATE: 09/02/2019

PRELIMINARY

Prepared by: BLACKBURN CONSULTING
2491 BOATMAN AVENUE
WEST SACRAMENTO, CA 95691
www.blackburnconsulting.com
JOB NO.: 3195.x

SUBMITTED
APPROVED

Ecosystem Investment Partners

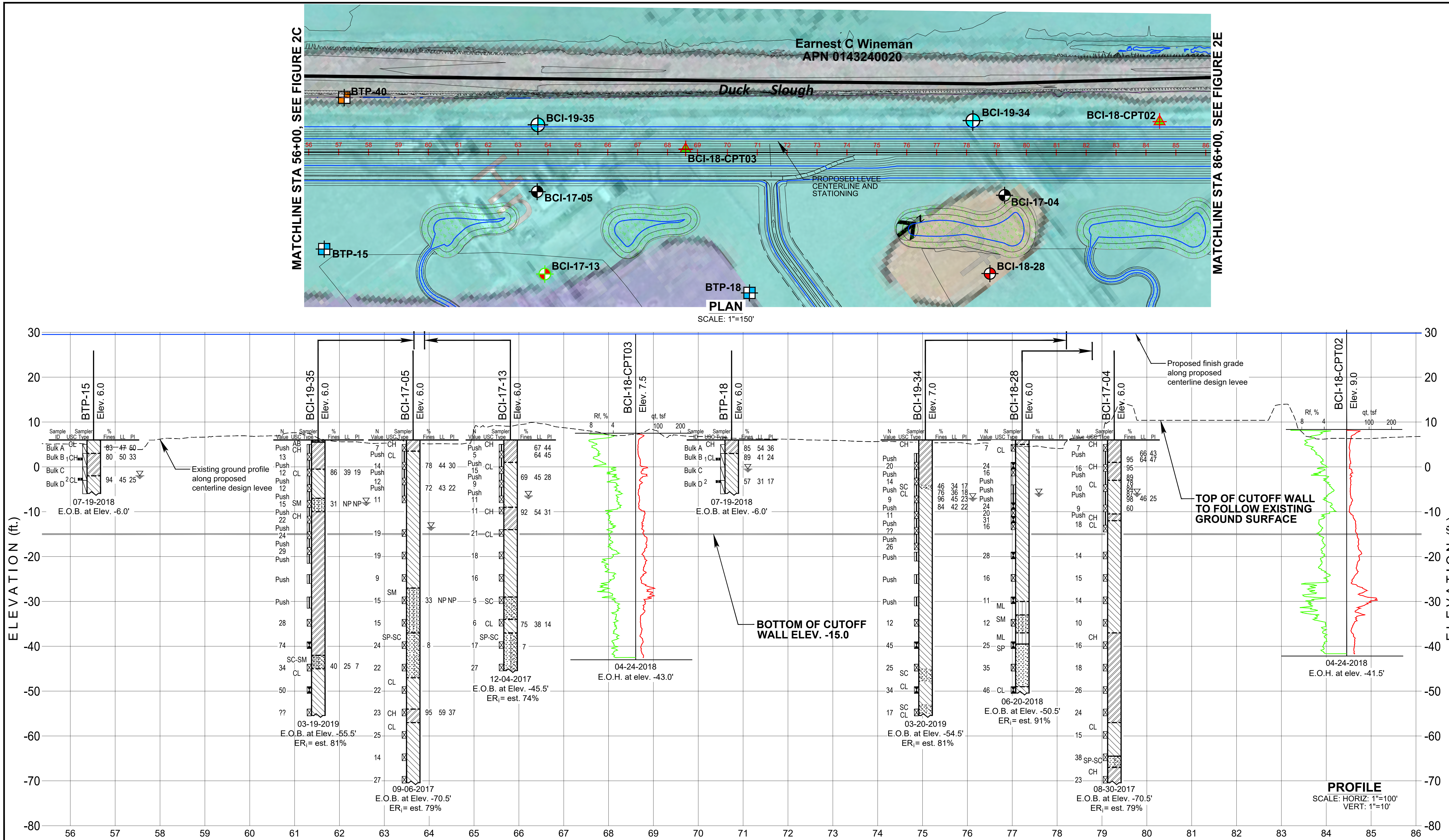
ECOSYSTEM INVESTMENT PARTNERS

LOOKOUT SLOUGH THRFIP
Geotechnical Data Report - 60% Design

PLAN AND PROFILE STA. 30+00 to 60+00

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING, ADJUST SCALES FOR REDUCED PLOTS

FIGURE NO. 5
SHEET C



REV.	DATE	BY	CHK.	APPR.	DESCRIPTION

DESIGNED BY: ROBERT B. LOKTEFF, P.E.,G.E.
DRAWN BY: MIKE ROBERTSON
CHECKED BY: NICOLE C. HART, P.E.
IN CHARGE: JONATHAN KORS, P.E.
DATE: 09/02/2019

PRELIMINARY

Prepared by:
BLACKBURN CONSULTING
2491 BOATMAN AVENUE
WEST SACRAMENTO, CA 95691
www.blackburnconsulting.com
JOB NO.: 3195.x

SUBMITTED
APPROVED

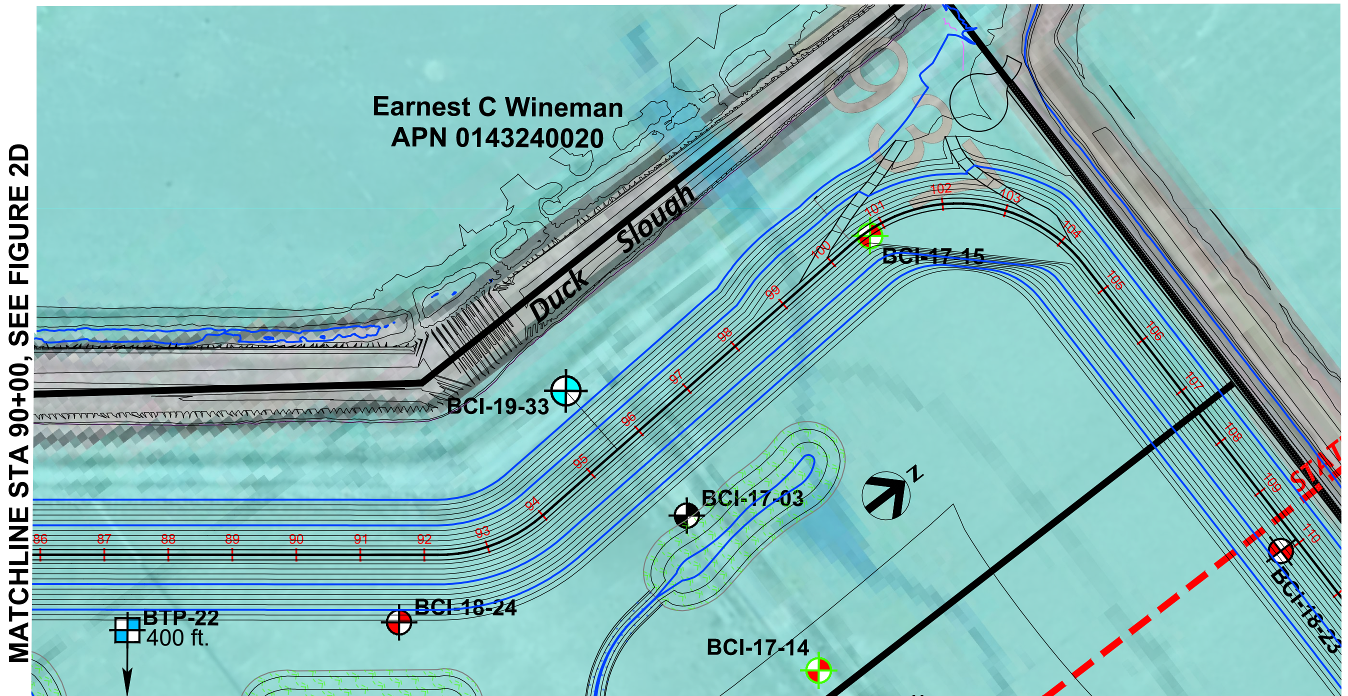
Ecosystem Investment Partners

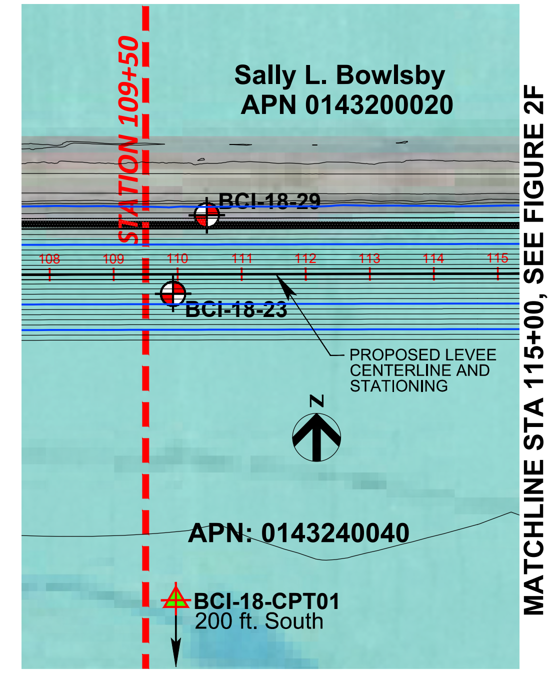
ECOSYSTEM INVESTMENT PARTNERS

LOOKOUT SLOUGH THRFIP
Geotechnical Data Report - 65% Design
PLAN AND PROFILE STA. 60+00 to 90+00

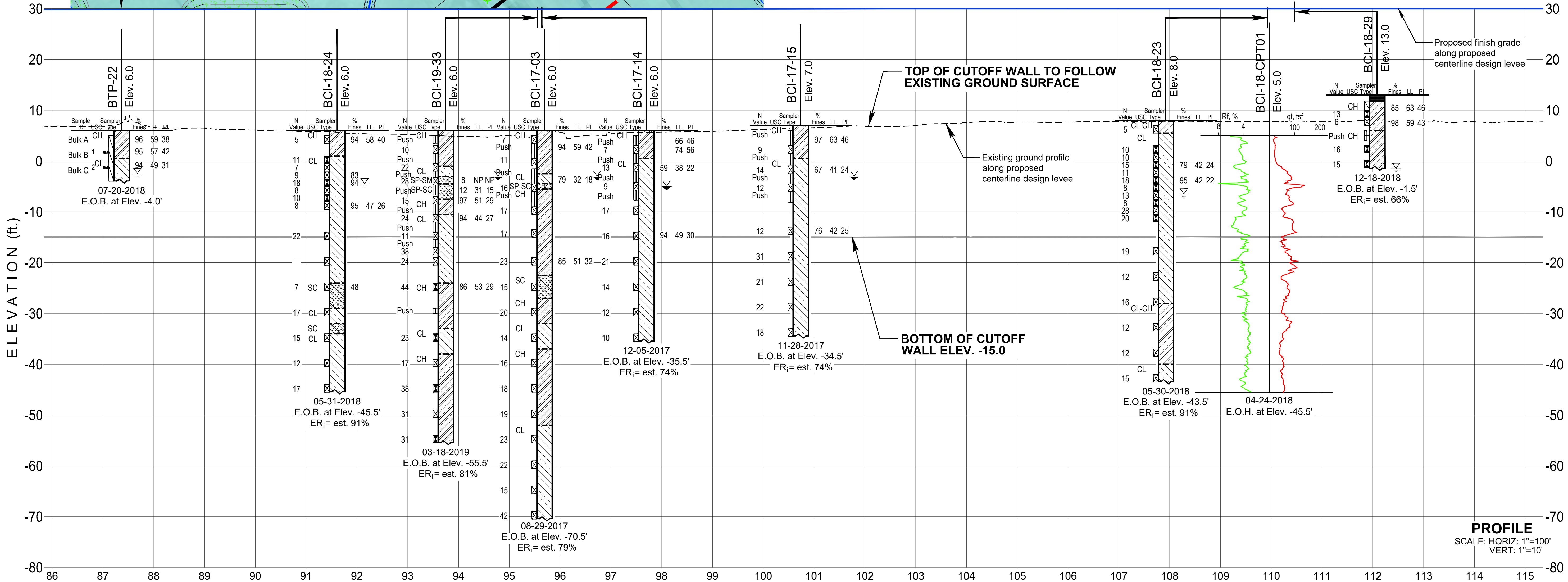
VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING, ADJUST SCALES FOR REDUCED PLOTS
0 1"

FIGURE NO. 5
SHEET D





PLAN
SCALE: 1"=150'



REV.	DATE	BY	CHK.	APPR.	DESCRIPTION

DESIGNED BY: ROBERT B. LOKTEFF, P.E.,G.E.
DRAWN BY: MIKE ROBERTSON
CHECKED BY: NICOLE C. HART, P.E.
IN CHARGE: JONATHAN KORS, P.E.
DATE: 09/02/2019

PRELIMINARY

Prepared by:
BLACKBURN CONSULTING
2491 BOATMAN AVENUE
WEST SACRAMENTO, CA 95691
www.blackburnconsulting.com
JOB NO.: 3195.X

SUBMITTED
APPROVED

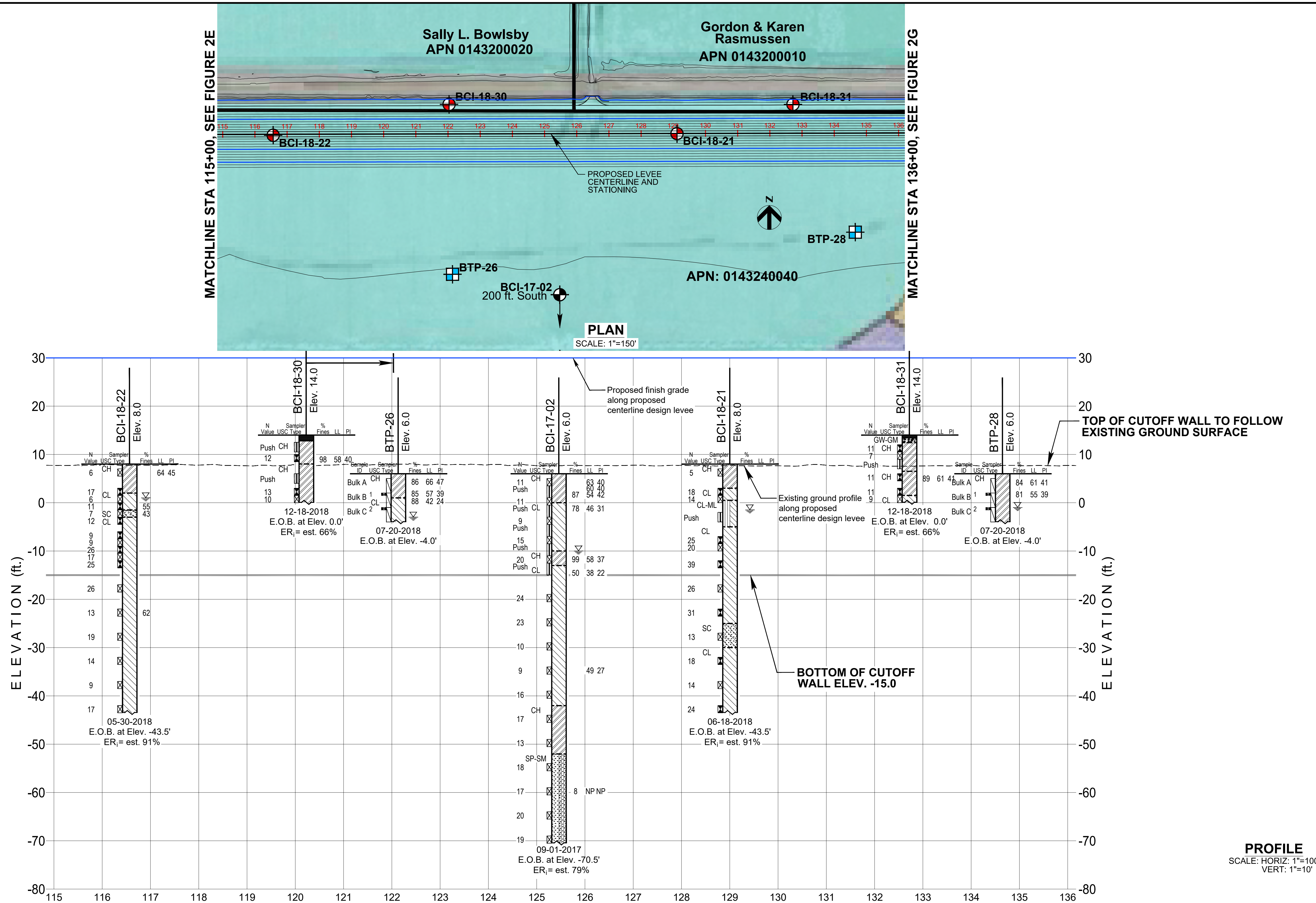
Ecosystem Investment Partners

ECOSYSTEM INVESTMENT PARTNERS

LOOKOUT SLOUGH THRFIP
Geotechnical Data Report - 65% Design
PLAN AND PROFILE STA. 90+00 to 119+00

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING, ADJUST SCALES FOR REDUCED PLOTS

FIGURE NO. 5
SHEET E



REV.	DATE	BY	CHK.	APPR.	DESCRIPTION

DESIGNED BY: ROBERT B. LOKTEFF, P.E.,G.E.
DRAWN BY: MIKE ROBERTSON
CHECKED BY: NICOLE C. HART, P.E.
IN CHARGE: JONATHAN KORS, P.E.
DATE: 09/02/2019

PRELIMINARY

Prepared by:
BLACKBURN CONSULTING
2491 BOATMAN AVENUE
WEST SACRAMENTO, CA 95691
www.blackburnconsulting.com
JOB NO.: 3195.x

SUBMITTED
APPROVED

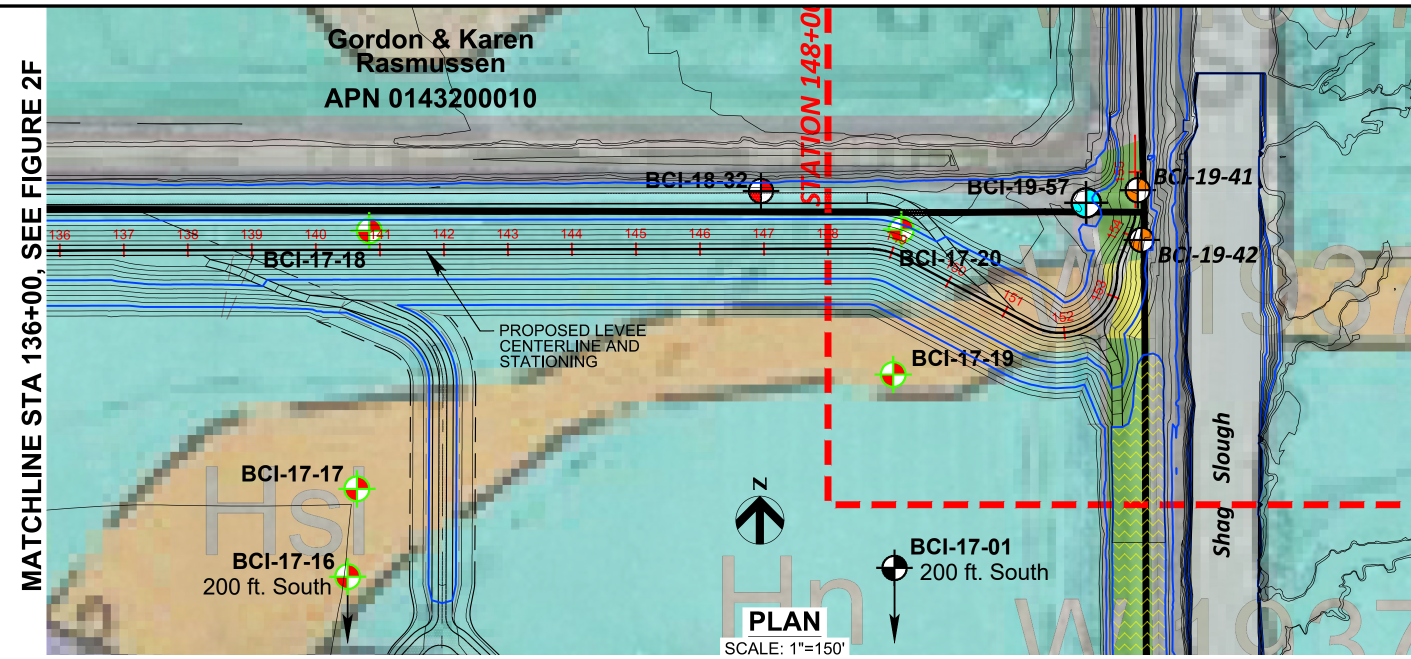
Ecosystem Investment Partners

ECOSYSTEM INVESTMENT PARTNERS

LOOKOUT SLOUGH THRFIP
Geotechnical Data Report - 65% Design
PLAN AND PROFILE STA. 119+00 to 135+50

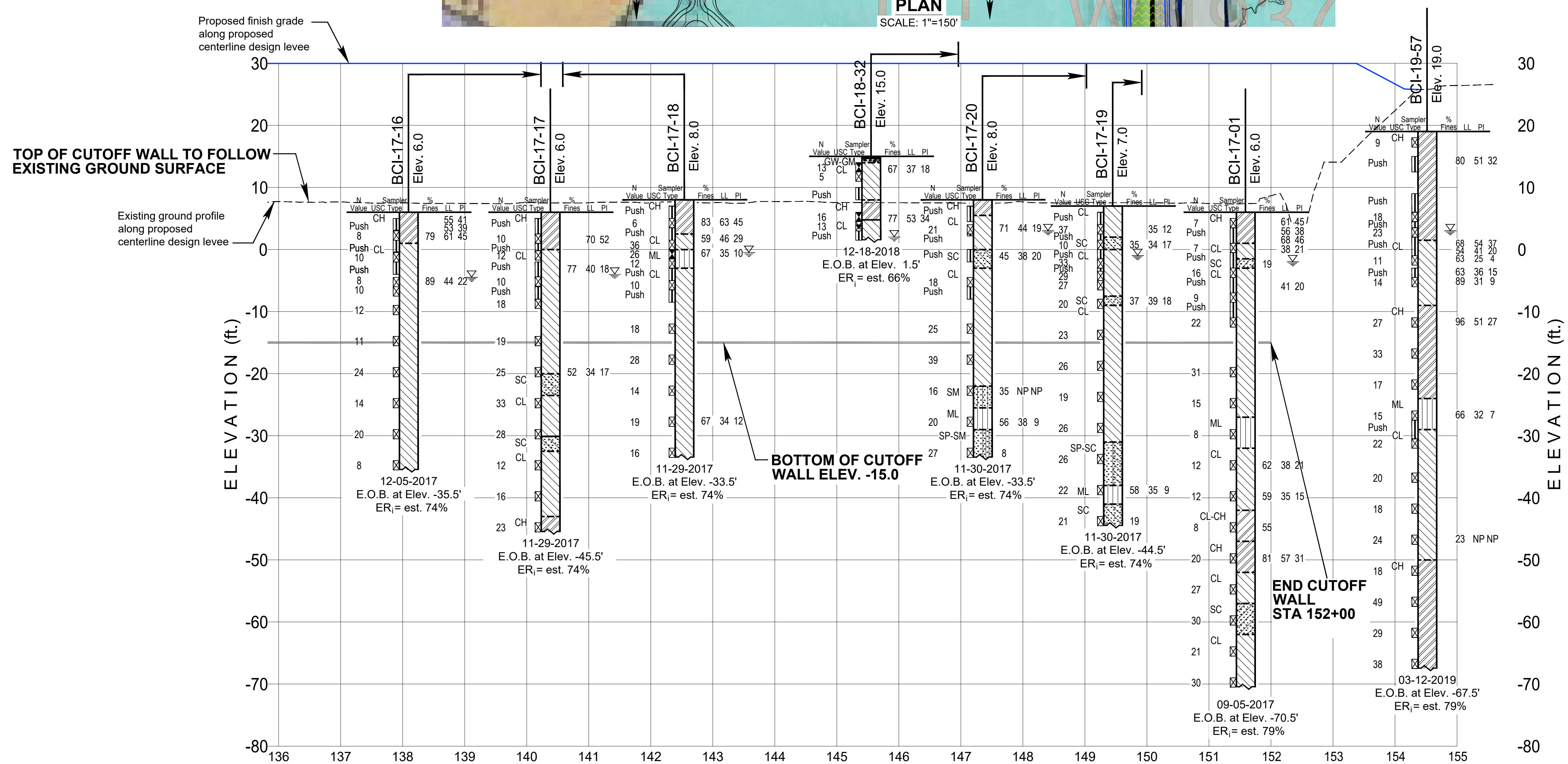
VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING, ADJUST SCALES FOR REDUCED PLOTS

FIGURE NO. 5
SHEET F



PLAN

SCALE: 1"=150'



PROFILE

SCALE: HORIZ: 1"=100'
VERT: 1"=10'

REV.	DATE	BY	CHK.	APPR.	DESCRIPTION

DESIGNED BY: ROBERT B. LOKTEFF, P.E.,G.E.
DRAWN BY: MIKE ROBERTSON
CHECKED BY: NICOLE C. HART, P.E.
IN CHARGE: JONATHAN KORS, P.E.
DATE: 09/02/2019

PRELIMINARY

Prepared by:
BLACKBURN CONSULTING
2491 BOATMAN AVENUE
WEST SACRAMENTO, CA 95691
www.blackburnconsulting.com
JOB NO.: 3195.x

SUBMITTED | APPROVED

Ecosystem Investment Partners

ECOSYSTEM INVESTMENT PARTNERS

LOOKOUT SLOUGH THRFIP
Geotechnical Data Report - 65% Design

PLAN AND PROFILE STA. 135+00 to 155+00

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING, ADJUST SCALES FOR REDUCED PLOTS

FIGURE NO. 5
SHEET G

\\VFS-01\Common\Active Projects\3195.P DWR Lookout Slough Restoration Project\CAD\3195.x Fig5 LSRP 65%.dwg 9/19/2019 12:19 PM Mike Robertson

This Page Intentionally Left Blank

GEOTECHNICAL DATA REPORT

65% Design

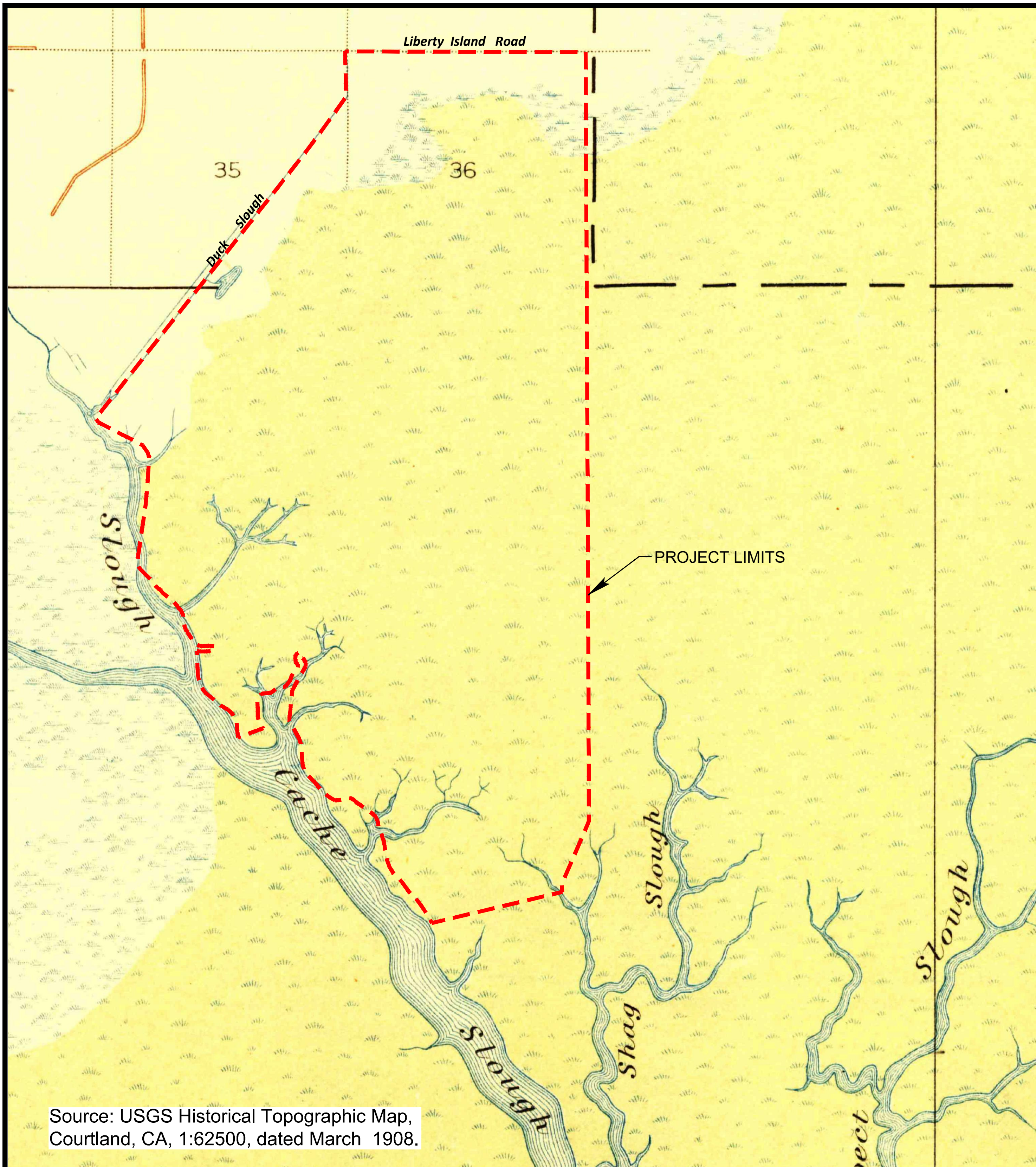
Lookout Slough Tidal Habitat Restoration and Flood Improvement Project

Solano County, California

APPENDIX A

Historical Topographic Maps

This Page Intentionally Left Blank



APPENDIX A-1, TOPOGRAPHIC MAP 1908
Geotechnical Data Report - 65% Design
September 2019

N W E S

0 3000
SCALE: 1" = 3000'

Lookout Slough THRFIP

Ecosystem Investment Partners

Map Prepared Date: 09/01/19
Map Prepared By: M.D.R.
Checked By: N.C.H.
Job No.: 3195.x

Prepared by:
BLACKBURN CONSULTING

Path: \\FS-01\Common\Active Projects\3195.P DWR Lookout Slough Restoration Project\CAD\65% GDR REPORT\3195.x LSRP GDR 65% AppA-1.dwg

Source: USGS Historical Topographic Map, Cache Slough, CA, 1:31680, dated March 17, 1916.

APPENDIX A-2, TOPOGRAPHIC MAP 1916
Geotechnical Data Report - 65% Design
September 2019

Lookout Slough THRFIP

N
W E
S

0 3000

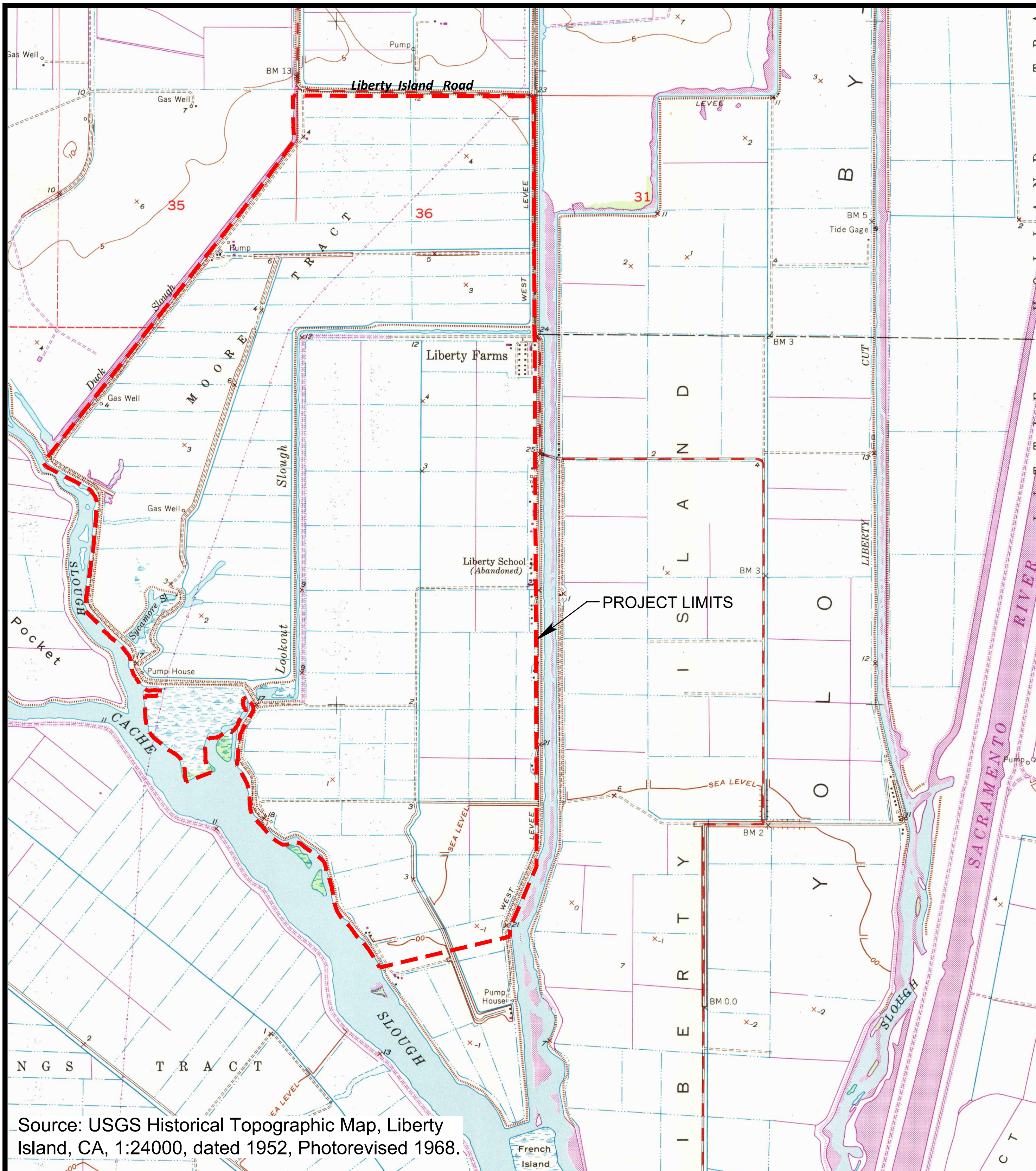
SCALE: 1" = 3000'

Ecosystem Investment Partners

Map Prepared Date: 09/01/19
Map Prepared By: M.D.R.
Checked By: N.C.H.
Job No.: 3195.x

Prepared by:
BLACKBURN CONSULTING

Path: \\FS-01\Common\Active Projects\3195.P DWR Lookout Slough Restoration Project\CAD\65% GDR REPORT\3195.x LSRP GDR 65% AppA-2.dwg



Source: USGS Historical Topographic Map, Liberty Island, CA, 1:24000, dated 1952, Photorevised 1968.

APPENDIX A-3, TOPOGRAPHIC MAP 1952
Geotechnical Data Report - 65% Design
September 2019

Lookout Slough THRFIP

N W E S

0 3000
SCALE: 1" = 3000'

Ecosystem Investment Partners

Map Prepared Date: 09/01/19
Map Prepared By: M.D.R.
Checked By: N.C.H.
Job No.: 3195.x

Prepared by:
BLACKBURN CONSULTING

Path: \\FS-01\Common\Active Projects\3195.P DWR Lookout Slough Restoration Project\CAD\65% GDR REPORT\3195.x LSRP GDR 65% AppA-3.dwg

This Page Intentionally Left Blank

GEOTECHNICAL DATA REPORT

65% Design

Lookout Slough Tidal Habitat Restoration and Flood Improvement Project

Solano County, California

APPENDIX B

BCI Exploratory Borings
SPT-Hammer Energy Measurement Report
BCI Cone Penetration Test Reports

This Page Intentionally Left Blank

GROUP SYMBOLS AND NAMES

Graphic / Symbol	Group Names
GW	Well-graded GRAVEL Well-graded GRAVEL with SAND
GP	Poorly graded GRAVEL Poorly graded GRAVEL with SAND
GW-GM	Well-graded GRAVEL with SILT Well-graded GRAVEL with SILT and SAND
GW-GC	Well-graded GRAVEL with CLAY (or SILTY CLAY) Well-graded GRAVEL with CLAY and SAND (or SILTY CLAY and SAND)
GP-GM	Poorly graded GRAVEL with SILT Poorly graded GRAVEL with SILT and SAND
GP-GC	Poorly graded GRAVEL with CLAY (or SILTY CLAY) Poorly graded GRAVEL with CLAY and SAND (or SILTY CLAY and SAND)
GM	SILTY GRAVEL SILTY GRAVEL with SAND
GC	CLAYEY GRAVEL CLAYEY GRAVEL with SAND
GC-GM	SILTY, CLAYEY GRAVEL SILTY, CLAYEY GRAVEL with SAND
SW	Well-graded SAND Well-graded SAND with GRAVEL
SP	Poorly graded SAND Poorly graded SAND with GRAVEL
SW-SM	Well-graded SAND with SILT Well-graded SAND with SILT and GRAVEL
SW-SC	Well-graded SAND with CLAY (or SILTY CLAY) Well-graded SAND with CLAY and GRAVEL (or SILTY CLAY and GRAVEL)
SP-SM	Poorly graded SAND with SILT Poorly graded SAND with SILT and GRAVEL
SP-SC	Poorly graded SAND with CLAY (or SILTY CLAY) Poorly graded SAND with CLAY and GRAVEL (or SILTY CLAY and GRAVEL)
SM	SILTY SAND SILTY SAND with GRAVEL
SC	CLAYEY SAND CLAYEY SAND with GRAVEL
SC-SM	SILTY, CLAYEY SAND SILTY, CLAYEY SAND with GRAVEL
PT	PEAT
	COBBLES COBBLES and BOULDERS BOULDERS

Graphic / Symbol	Group Names
CL	Lean CLAY Lean CLAY with SAND Lean CLAY with GRAVEL SANDY lean CLAY SANDY lean CLAY with GRAVEL GRAVELLY lean CLAY GRAVELLY lean CLAY with SAND
CL-ML	SILTY CLAY SILTY CLAY with SAND SILTY CLAY with GRAVEL SANDY SILTY CLAY SANDY SILTY CLAY with GRAVEL GRAVELLY SILTY CLAY GRAVELLY SILTY CLAY with SAND
ML	SILT SILT with SAND SILT with GRAVEL SANDY SILT SANDY SILT with GRAVEL GRAVELLY SILT GRAVELLY SILT with SAND
OL	ORGANIC lean CLAY ORGANIC lean CLAY with SAND ORGANIC lean CLAY with GRAVEL SANDY ORGANIC lean CLAY SANDY ORGANIC lean CLAY with GRAVEL GRAVELLY ORGANIC lean CLAY GRAVELLY ORGANIC lean CLAY with SAND
OL	ORGANIC SILT ORGANIC SILT with SAND ORGANIC SILT with GRAVEL SANDY ORGANIC SILT SANDY ORGANIC SILT with GRAVEL GRAVELLY ORGANIC SILT GRAVELLY ORGANIC SILT with SAND
CH	Fat CLAY Fat CLAY with SAND Fat CLAY with GRAVEL SANDY fat CLAY SANDY fat CLAY with GRAVEL GRAVELLY fat CLAY GRAVELLY fat CLAY with SAND
MH	Elastic SILT Elastic SILT with SAND Elastic SILT with GRAVEL SANDY elastic SILT SANDY elastic SILT with GRAVEL GRAVELLY elastic SILT GRAVELLY elastic SILT with SAND
OH	ORGANIC fat CLAY ORGANIC fat CLAY with SAND ORGANIC fat CLAY with GRAVEL SANDY ORGANIC fat CLAY SANDY ORGANIC fat CLAY with GRAVEL GRAVELLY ORGANIC fat CLAY GRAVELLY ORGANIC fat CLAY with SAND
OH	ORGANIC elastic SILT ORGANIC elastic SILT with SAND ORGANIC elastic SILT with GRAVEL SANDY elastic ELASTIC SILT SANDY ORGANIC elastic SILT with GRAVEL GRAVELLY ORGANIC elastic SILT GRAVELLY ORGANIC elastic SILT with SAND
OL/OH	ORGANIC SOIL ORGANIC SOIL with SAND ORGANIC SOIL with GRAVEL SANDY ORGANIC SOIL SANDY ORGANIC SOIL with GRAVEL GRAVELLY ORGANIC SOIL GRAVELLY ORGANIC SOIL with SAND

FIELD AND LABORATORY TESTS

C	Consolidation (ASTM D 2435)
CL	Collapse Potential (ASTM D 5333)
CP	Compaction Curve (ASTM D 698 & 1557, CTM 216)
CR	Corrosion, Sulfates, Chlorides (CTM 643, CTM 417, CTM 422)
CU	Consolidated Undrained Triaxial (ASTM D 4767)
DS	Direct Shear (ASTM D 3080)
EI	Expansion Index (ASTM D 4829)
M	Moisture Content (ASTM D 2216)
OC	Organic Content (ASTM D 2974)
P	Permeability (ASTM D 5084)
PA	Particle Size Analysis (ASTM D 6913 & 7928)
PI	Liquid Limit, Plastic Limit, Plasticity Index (ASTM D 4318)
PL	Point Load Index (ASTM D 5731)
PM	Pressure Meter
PP	Pocket Penetrometer
R	R-Value (CTM 301)
SE	Sand Equivalent (CTM 217)
SG	Specific Gravity (AASHTO T100)
SL	Shrinkage Limit (ASTM D 4943)
SW	Swell Potential (ASTM D 4546)
TV	Pocket Torvane
UC	Unconfined Compression - Soil (ASTM D 2166) Unconfined Compression - Rock (ASTM D 7012)
UU	Unconsolidated Undrained Triaxial (ASTM D 2850)
UW	Unit Weight (ASTM D 7263)
VS	Vane Shear (AASHTO T223 / ASTM D 2573)

SAMPLER GRAPHIC SYMBOLS

- Standard Penetration Test (SPT)
- California Sampler (2" ID)
- Modified California Sampler (2.4" ID)
- Shelby Tube
- Piston Sampler
- NX Rock Core
- HQ Rock Core
- Bulk Sample
- Other (see remarks)

DRILLING METHOD SYMBOLS

- Auger Drilling
- Rotary Drilling
- Dynamic Cone or Hand Driven
- Diamond Core

WATER LEVEL SYMBOLS

- First Water Level Reading (during drilling)
- Static Water Level Reading (short-term)
- Static Water Level Reading (long-term)

BLACKBURN CONSULTING

BORING RECORD LEGEND

CONSISTENCY OF COHESIVE SOILS				
Descriptor	**Unconfined Compressive Strength (tsf)**	**Pocket Penetrometer (tsf)**	**Torvane (tsf)**	**Field Approximation**
Very Soft	< 0.25	< 0.25	< 0.12	Extrudes between fingers when squeezed
Soft	0.25 - 0.50	0.25 - 0.50	0.12 - 0.25	Easily penetrated several inches by thumb
Medium Stiff	0.50 - 1.0	0.50 - 1.0	0.25 - 0.50	Can be penetrated several inches by thumb with moderate effort
Stiff	1.0 - 2.0	1.0 - 2.0	0.50 - 1.0	Readily indented by thumb but penetrated only with great effort
Very Stiff	2.0 - 4.0	2.0 - 4.0	1.0 - 2.0	Readily indented by thumbnail
Hard	> 4.0	> 4.0	> 2.0	Indented by thumbnail with difficulty

APPARENT DENSITY OF COHESIONLESS SOILS	
Descriptor	**SPT N_{60} - Value (blows / foot)**
Very Loose	0 - 4
Loose	5 - 10
Medium Dense	11 - 30
Dense	31 - 50
Very Dense	> 50

MOISTURE	
Descriptor	**Criteria**
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, usually soil is below water table

PERCENT OR PROPORTION OF SOILS	
Descriptor	**Criteria**
Trace	Particles are present but estimated to be less than 5%
Few	5 to 10%
Little	15 to 25%
Some	30 to 45%
Mostly	50 to 100%

SOIL PARTICLE SIZE		
Descriptor		**Size**
Boulder		> 12 inches
Cobble		3 to 12 inches
Gravel	Coarse	3/4 inch to 3 inches
	Fine	No. 4 Sieve to 3/4 inch
Sand	Coarse	No. 10 Sieve to No. 4 Sieve
	Medium	No. 40 Sieve to No. 10 Sieve
	Fine	No. 200 Sieve to No. 40 Sieve
Silt and Clay		Passing No. 200 Sieve

PLASTICITY OF FINE-GRAINED SOILS	
Descriptor	**Criteria**
Nonplastic	A 1/8-inch thread cannot be rolled at any water content.
Low	The thread can barely be rolled, and the lump cannot be formed when drier than the plastic limit.
Medium	The thread is easy to roll, and not much time is required to reach the plastic limit; it cannot be rerolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit.
High	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be rerolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit.

CEMENTATION	
Descriptor	**Criteria**
Weak	Crumbles or breaks with handling or little finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

NOTE: This legend sheet provides descriptors and associated criteria for required soil description components only. Refer to Caltrans Soil and Rock Logging, Classification, and Presentation Manual (2010), Section 2, for tables of additional soil description components and discussion of soil description and identification.

BLACKBURN CONSULTING

BORING RECORD LEGEND

LOGGED BY	BEGIN DATE	COMPLETION DATE	LOCATION (Lat/Long or North/East and Datum)	HOLE ID
RMS	**9-5-17**	**9-5-17**	**38.326948° / -121.695364°**	**BCI-17-01**

CONTRACTOR	LOCATION (Offset, Station, Line)	SURFACE ELEVATION
Taber		**6.0 ft**

OPERATOR'S NAME	HELPER'S NAME	EQUIPMENT	TOTAL DEPTH
Chad	**Kevin**	**CME 55 Truck Rig**	**76.5 ft**

EXCAVATION METHOD	DRILLING ROD TYPE AND DIAMETER / BUCKET WIDTH	BOREHOLE DIAMETER
Rotary Wash		**6 in**

SAMPLER TYPE(S) AND SIZE(S) (ID)	HAMMER TYPE	HAMMER EFFICIENCY, ERi
Shelby (2.87") and SPT (1.4")	**Safety semi-automatic drop (140#/ 30")**	**79%**

BACKFILL AND COMPLETION	GROUND WATER READINGS	DURING	AFTER (DATE)	CASING TYPE AND DIAMETER(in)
Tremie Grout Backfill		**8.0 ft**	**2.0 ft on 9-5-17**	

ELEVATION (ft)	DEPTH (ft)	Material Graphics	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Laboratory Data: Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests	Drilling Method
	0		Fat CLAY (CH), Medium Stiff, Brown, Moist, High Plasticity														
4.00	1–2				1	2 3 4	7	100				61	45				
2.00	3–5		With SAND, Very Stiff, Approximately 15-20% Fine SAND		2	900 psi		80	3.4			56	38				
	5											68	46		DS		
0.00	5.5–7		Lean CLAY with SAND (CL), Very Stiff, Brown, Moist, Approximately 25% Fine SAND		3	2 3 4	7	100	1.0			38	21				
	7								1.5								
-2.00	8		CLAYEY SAND (SC), Dense, Brown, Moist		4	800 psi		90						19			
-4.00	9–10		Lean CLAY (CL), Very Stiff, Yellowish Brown, Moist, Low Plasticity		5	6 6 10	16	100	3.75								
-6.00	11–12		Switched to mud rotary at 10.5 ft bgs With SAND, Hard, Approximately 15-20% Fine SAND		6	800 psi		50	3.75 4.5			41	20				
-8.00	13–14				7	3 4 5	9	100									
-10.00	14.5–16		Lean CLAY (CL), Hard, Brown, Moist, Medium Plasticity		8	750 psi		87	4.5	25	96					C	
-12.00	17–18		Wet		9	5 9 13	22	100	>4.5								
-14.00	19–20																
-16.00	21–22		Sandy Lean CLAY (CL), Very Stiff, Yellowish Brown, Wet, Low Plasiticity, Approximately 35% SAND														
-18.00	23–25																

(continued)

blackburn consulting

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	**3195.X**	**BCI-17-01**

COUNTY	ROUTE	POSTMILE
SOL		

CLIENT		
Ecosystems Investment Partners		

PREPARED BY	CHECKED BY	SHEET
RMS	**NCH**	**1 of 3**

ELEVATION (ft)	DEPTH (ft)	Material Graphics	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Laboratory Data: Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests	Drilling Method
	25		SANDY Lean CLAY (CL) *(continued)*.		10	9 13 18	31	100									
-20.00	26																
	27																
-22.00	28		Lean CLAY (CL), Hard, Grayish Brown, Moist, Medium Plasticity, Medium Cementation														
	29																
-24.00	30				11	3 7 8	15	100	>4.5								
	31																
-26.00	32																
	33		SILT (ML), Soft, Dark Yellowish Brown, Wet, Low Plasticity, Weak Cementation														
-28.00	34																
	35				12	3 3 5	8	100									
-30.00	36																
	37																
-32.00	38		SANDY Lean CLAY (CL), Medium Stiff, Dark Greenish Gray, Wet														
	39																
-34.00	40				13	4 6 6	12	100	1.0	37		38	21	62			
	41																
-36.00	42																
	43																
-38.00	44																
	45		Brown, Moist		14	4 5 7	12	100	1.0	30		35	15	59			
-40.00	46																
	47																
-42.00	48		SANDY Lean/Fat CLAY (CL/CH), Medium Stiff, Dark Gray, Moist, Fine SAND														
	49																
-44.00	50				15	3 4 4	8	100	1.1	34				55			
	51																
-46.00	52																
	53		Fat CLAY with SAND (CH), Medium Stiff, Very Dark Greenish Gray, Moist														
-48.00	54																
	55																

(continued)

blackburn consulting

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	3195.X	BCI-17-01
COUNTY: SOL	ROUTE:	POSTMILE:
CLIENT: Ecosystems Investment Partners		
PREPARED BY: RMS	CHECKED BY: NCH	SHEET: 2 of 3

ELEVATION (ft)	DEPTH (ft)	Material Graphics	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests	Drilling Method
	55		Fat CLAY with SAND (CH) *(continued)*.														
-50.00	56			X	16	8 9 11	20	100	2.75	25		57	31	81			
	57																
-52.00	58		Lean CLAY (CL), Hard, Brown, Moist, Medium to High Plasticity														
	59																
-54.00	60																
	61			X	17	9 12 15	27	100	>4.5								
-56.00	62																
	63		CLAYEY SAND (SC), Dense, Dark Yellowish Brown, Wet, Lean CLAY														
-58.00	64																
	65																
-60.00	66			X	18	11 15 15	30	100									
	67																
-62.00	68		Lean CLAY (CL), Very Stiff, Yellowish Brown, Wet, Low to Medium Plasticity, Weak Cementation														
	69																
-64.00	70																
	71			X	19	9 10 11	21	100	3.25								
-66.00	72																
	73																
-68.00	74																
	75		Hard														
-70.00	76			X	20	10 14 16	30	100	>4.5								
	77		Bottom of exploration at 76.5 ft below ground surface (bgs)														
-72.00	78		Tremie Grout Backfill Ground water initially encountered at 8.0 ft bgs, rose to 2.0 ft bgs after drilling														
	79																
-74.00	80																
	81																
-76.00	82																
	83																
-78.00	84																
	85																

Laboratory Data

blackburn consulting

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME **Lookout Slough THRFIP**		FILE NO. **3195.X**	HOLE ID **BCI-17-01**
COUNTY **SOL**	ROUTE		POSTMILE
CLIENT **Ecosystems Investment Partners**			
PREPARED BY **RMS**	CHECKED BY **NCH**	SHEET **3 of 3**	

LOGGED BY	BEGIN DATE	COMPLETION DATE	LOCATION (Lat/Long or North/East and Datum)	HOLE ID
RMS	**9-1-17**	**9-1-17**	**38.326953° / -121.703579°**	**BCI-17-02**
CONTRACTOR **Taber**			LOCATION (Offset, Station, Line)	SURFACE ELEVATION **6.0 ft**
OPERATOR'S NAME **Chad**	HELPER'S NAME **Kevin**		EQUIPMENT **CME 55 Truck Rig**	TOTAL DEPTH **76.5 ft**
EXCAVATION METHOD **Rotary Wash**			DRILLING ROD TYPE AND DIAMETER / BUCKET WIDTH	BOREHOLE DIAMETER **6 in**
SAMPLER TYPE(S) AND SIZE(S) (ID) **Shelby (2.87") and SPT (1.4")**			HAMMER TYPE **Safety semi-automatic drop (140#/ 30")**	HAMMER EFFICIENCY, ERi **79%**
BACKFILL AND COMPLETION **Tremie Grout Backfill**			GROUND WATER READINGS — DURING **16.0 ft** — AFTER (DATE) **16.0 ft on 9-1-17**	CASING TYPE AND DIAMETER(in)

ELEVATION (ft)	DEPTH (ft)	Material Graphics	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests	Drilling Method
	0		Fat CLAY (CH), Very Stiff, Dark Gray, Moist, High Plasticity														
4.00	1–2			SPT	1	3 6 5	11	100	2.0			63	40				
2.00	3–4			Shelby	2	600 psi		73	2.5	26	97	60 / 54	40 / 42	87			
0.00	5–6			SPT	3	4 5 6	11	100	1.3								
	6		Lean CLAY with SAND (CL), Stiff to Very Stiff, Yellowish Brown, Moist, Sand Lenses														
-2.00	7–8		Greenish Brown Lenses	Shelby	4	550 psi		90	2.5 1.75 2.25 2.0	25	97	46	31	78			
-4.00	9–10		Light Olive Brown	SPT	5	3 4 5	9	100	1.75	26	99						
-6.00	11–12		Yellowish Brown, Very Weak Cementation	Shelby	6	750 psi		90	1.5 2.0	22	127				UU		
-8.00	13–14		No Cementation	SPT	7	5 6 9	15	100	3.0								
-10.00	15–16			Shelby	8	800 psi		90	3.0								
	16		Fat CLAY (CH), Very Stiff, Olive Brown, Moist, Weak Cementation														
-12.00	17–18			SPT	9	5 8 12	20	100	4.0	25		58	37	99			
	18.5		Switched to mud rotary at 18.5 ft bgs														
-14.00	19–20		SANDY Lean CLAY (CL), Very Stiff to Hard, Dark Yellowish Brown, Moist to Wet	Shelby	10	1050 psi		90	4.25 2.25			38	22	50	UU		
-16.00	21–22																
-18.00	23–24		Lean CLAY (CL), Very Stiff, Yellowish Brown, Moist, Medium Plasticity														
	25																

(continued)

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	**3195.X**	**BCI-17-02**
COUNTY **SOL**	ROUTE	POSTMILE
CLIENT **Ecosystems Investment Partners**		
PREPARED BY **RMS**	CHECKED BY **NCH**	SHEET **1 of 3**

ELEVATION (ft)	DEPTH (ft)	Material Graphics	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests	Drilling Method
	25		Lean CLAY (CL) *(continued)*.		11	6 12 12	24	100	>4.5								
-20.00	26																
	27																
-22.00	28																
	29																
-24.00	30				12	7 10 13	23	100									
	31																
-26.00	32																
	33																
-28.00	34																
	35		Medium to High Plasticity		13	3 4 6	10	100									
-30.00	36																
	37																
-32.00	38																
	39																
-34.00	40		Yellowish Brown		14	4 4 5	9	100	3.5	31	93	49	27				
	41																
-36.00	42																
	43																
-38.00	44																
	45				15	6 8 8	16	100	3.5								
-40.00	46																
	47																
-42.00	48		Fat CLAY (CH), Stiff, Olive Brown Mottled with Brown, Moist, Medium to High Plasticity														
	49																
-44.00	50				16	4 7 10	17	100									
	51																
-46.00	52																
	53																
-48.00	54																
	55																

Laboratory Data (column group: Moisture Content through Additional Lab Tests)

(continued)

blackburn consulting

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	3195.X	BCI-17-02

COUNTY	ROUTE	POSTMILE
SOL		

CLIENT
Ecosystems Investment Partners

PREPARED BY	CHECKED BY	SHEET
RMS	NCH	2 of 3

BCI LOG FOR SOIL BORINGS.GPJ LIBRARY_3195.GLB 8/28/19

ELEVATION (ft)	DEPTH (ft)	Material Graphics	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests	Drilling Method
	55		Fat CLAY (CH) (continued), Light Brown		17	5 6 7	13	100									
-50.00	56																
	57																
-52.00	58		Poorly-graded SAND with SILT (SP-SM), Medium Dense, Yellowish Brown, Wet														
	59																
-54.00	60				18	5 8 10	18	100									
	61																
-56.00	62																
	63																
-58.00	64																
	65				19	7 8 9	17	100		25		NP	NP	8			
-60.00	66																
	67																
-62.00	68																
	69																
-64.00	70				20	8 10 10	20	100									
	71																
-66.00	72																
	73																
-68.00	74																
	75				21	9 9 10	19	0									
-70.00	76																
	77		Bottom of exploration at 76.5 ft below ground surface (bgs)														
-72.00	78		Tremie Grout Backfill Ground water encountered at 16.0 ft bgs														
	79																
-74.00	80																
	81																
-76.00	82																
	83																
-78.00	84																
	85																

Laboratory Data: Moisture Content (%), Dry Density (pcf), Liquid Limit, Plasticity Index, % <#200, Shear Strength Test, Additional Lab Tests

blackburn consulting

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	3195.X	BCI-17-02
COUNTY: SOL	ROUTE:	POSTMILE:
CLIENT: Ecosystems Investment Partners		
PREPARED BY: RMS	CHECKED BY: NCH	SHEET: 3 of 3

LOGGED BY RMS / BEGIN DATE 8-29-17 / COMPLETION DATE 8-29-17	LOCATION (Lat/Long or North/East and Datum) 38.326876° / -121.711124°	HOLE ID BCI-17-03
CONTRACTOR Taber	LOCATION (Offset, Station, Line)	SURFACE ELEVATION 6.0 ft
OPERATOR'S NAME Chad / HELPER'S NAME Kevin	EQUIPMENT CME 55 Truck Rig	TOTAL DEPTH 76.5 ft
EXCAVATION METHOD Rotary Wash	DRILLING ROD TYPE AND DIAMETER / BUCKET WIDTH	BOREHOLE DIAMETER 6 in
SAMPLER TYPE(S) AND SIZE(S) (ID) Shelby (2.87") and SPT (1.4")	HAMMER TYPE Safety semi-automatic drop (140#/ 30")	HAMMER EFFICIENCY, ERi 79%
BACKFILL AND COMPLETION Tremie Grout Backfill	GROUND WATER READINGS DURING 9.0 ft / AFTER (DATE) 9.0 ft on 8-29-17	CASING TYPE AND DIAMETER(in)

ELEVATION (ft)	DEPTH (ft)	DESCRIPTION	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests
	0	Fat CLAY (CH), Very Stiff, Dark Brown, Moist, High Plasticity												
4.00	1–2		1	2 3 4	7	100	2.0							
2.00	3–5	Olive Brown, Moist	2	700 psi		67	2.75	24	100	59	42	94		C
0.00	6–7	Brown	3	3 4 7	11	100	4.0							
-2.00 / -4.00	8–10	Lean CLAY with SAND (CL), Very Stiff, Olive Brown, Moist	4	>1500 psi		94				32	14	79		
	11	Poorly-graded SAND with CLAY (SP-SC), Medium Dense, Dark Yellowish Brown, Moist, Fine SAND	5	6 8 8	16	100								
-6.00 / -8.00	12–14	Lean CLAY (CL), Hard, Light Olive Brown, Wet, Some Weak Cementation Switched to mud rotary at 12 ft bgs	6	1250 psi		100	4.0						UU	
-10.00	15–16	Moist	7	5 7 10	17	100	4.2							
-14.00	19–20	Stiff, Yellowish Brown	8	3 5 12	17	100	1.75	24	101					
-16.00 / -18.00	21–25													

(continued)

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME Lookout Slough THRFIP		FILE NO. 3195.X	HOLE ID BCI-17-03
COUNTY SOL	ROUTE		POSTMILE
CLIENT Ecosystems Investment Partners			
PREPARED BY RMS	CHECKED BY NCH	SHEET 1 of 3	

ELEVATION (ft)	DEPTH (ft)	DESCRIPTION	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests
	25	Fat CLAY with SAND (CH), Hard, Yellowish Brown, Moist	9	5 10 13	23	100	>4.5			51	32	85		
-20.00	26													
	27													
-22.00	28													
	29	SILTY SAND (SM), Medium Dense, Yellowish Brown, Moist, Fine SAND, Approximately 30% SILT												
-24.00	30		10	3 7 8	15	100		22	104					
	31													
-26.00	32													
	33	Fat CLAY (CH), Hard, Dark Yellowish Brown, Moist to Wet, High Plasticity												
-28.00	34													
	35		11	6 8 12	20	100	>4.5							
-30.00	36													
	37													
-32.00	38	Lean CLAY (CL), Very Stiff, Dark Yellowish Brown, Moist to Wet, Medium Plasticity												
	39													
-34.00	40		12	2 6 8	14	100	2.25	32	90					
	41													
-36.00	42													
	43	Fat CLAY (CH), Hard, Dark Grayish Brown, Wet, High Plasticity												
-38.00	44													
	45		13	5 7 9	16	100	4.1							
-40.00	46													
	47													
-42.00	48													
	49													
-44.00	50	Dark Brown	14	7 9 9	18	100	>4.5							
	51													
-46.00	52													
	53													
-48.00	54													
	55													

Laboratory Data columns: Moisture Content (%), Dry Density (pcf), Liquid Limit, Plasticity Index, % <#200, Shear Strength Test, Additional Lab Tests. Other columns: Material Graphics, Sample Location, Drilling Method.

(continued)

blackburn consulting

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	3195.X	BCI-17-03
COUNTY: SOL	ROUTE:	POSTMILE:
CLIENT: Ecosystems Investment Partners		
PREPARED BY: RMS	CHECKED BY: NCH	SHEET: 2 of 3

ELEVATION (ft)	DEPTH (ft)	DESCRIPTION	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests
	55	Fat CLAY (CH) *(continued)*, Yellowish Brown	15	4 7 12	19	100	4.0	26	104					
-50.00	56													
	57													
-52.00	58	Lean CLAY (CL), Very Stiff, Brown Mottled with Light Brown, Wet, Medium to High Plasticity, Approximately 95% Fines												
	59													
-54.00	60		16	6 11 12	23	100	3.5							
	61													
-56.00	62													
	63													
-58.00	64													
	65		17	8 10 12	22	100	4.0							
-60.00	66													
	67													
-62.00	68													
	69													
-64.00	70	Hard, Medium Plasticity, Approximately 90% Fines	18	6 7 8	15	100	>4.5							
	71													
-66.00	72													
	73													
-68.00	74													
	75	Very Stiff	19	14 18 24	42	100								
-70.00	76													
	77	Bottom of exploration at 76.5 ft below ground surface (bgs) Tremie Grout Backfill Ground water encountered at 9.0 ft bgs												
-72.00	78													
	79													
-74.00	80													
	81													
-76.00	82													
	83													
-78.00	84													
	85													

Laboratory Data

blackburn consulting

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	3195.X	BCI-17-03
COUNTY: SOL	ROUTE	POSTMILE
CLIENT: Ecosystems Investment Partners		
PREPARED BY: RMS	CHECKED BY: NCH	SHEET: 3 of 3

LOGGED BY	BEGIN DATE	COMPLETION DATE	LOCATION (Lat/Long or North/East and Datum)	HOLE ID
RMS	**8-30-17**	**8-30-17**	**38.322881° / -121.714157°**	**BCI-17-04**

CONTRACTOR **Taber**	LOCATION (Offset, Station, Line)	SURFACE ELEVATION **6.0 ft**
OPERATOR'S NAME **Chad** / HELPER'S NAME **Kevin**	EQUIPMENT **CME 55 Truck Rig**	TOTAL DEPTH **76.5 ft**
EXCAVATION METHOD **Rotary Wash**	DRILLING ROD TYPE AND DIAMETER / BUCKET WIDTH	BOREHOLE DIAMETER **6 in**
SAMPLER TYPE(S) AND SIZE(S) (ID) **Shelby (2.87") and SPT (1.4")**	HAMMER TYPE **Safety semi-automatic drop (140#/ 30")**	HAMMER EFFICIENCY, ERi **79%**
BACKFILL AND COMPLETION **Tremie Grout Backfill**	GROUND WATER READINGS — DURING **12.0 ft** — AFTER (DATE) **12.0 ft on 8-30-17**	CASING TYPE AND DIAMETER(in)

ELEVATION (ft)	DEPTH (ft)	DESCRIPTION	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests
	0	Fat CLAY (CH), Stiff, Dark Brown, Moist												
4.00	2		1	3 3 4	7	100	1.8							
2.00	3–4	Very Stiff, Brown	2	600 psi		53	2.75	25	98	66 64	43 47	95		
0.00	5–6	Fat CLAY (CH), Very Stiff to Hard, Olive Brown, Moist	3	4 8 8	16	100	3.5					95		
-2.00	8	Organics, Shells, Vegetation, Roots, Apparent Fill	4	850 psi		67	4.5					89 78	DS	
-4.00	9–11	Lean CLAY with SAND (CL), Hard, Olive Brown, Moist	5	4 5 5	10	100	4.0	26	99			84		
-6.00 / -8.00	12–14	Wet	6	900 psi		81	4.0			46	25	87 98	UU	
	15	Stiff, Lenses of SAND	7	3 4 5	9	100	1.25	26	96			60		
-10.00	16	Switched to mud rotary at 16 ft bgs												
	16–17	Fat CLAY (CH), Very Stiff, Yellowish Brown, Moist to Wet, High Plasticity	8	1200 psi		64	3.75							
-12.00	18	Lean CLAY (CL), Hard, Yellowish Brown, Moist												
-14.00	19–20		9	7 8 10	18	100	>4.5							
-16.00 / -18.00	21–25	Lean CLAY with SAND (CL), Very Stiff, Yellowish Brown, Moist, Medium to Low Plasticity, Fine SAND												

(continued)

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	**3195.X**	**BCI-17-04**
COUNTY **SOL**	ROUTE	POSTMILE
CLIENT **Ecosystems Investment Partners**		
PREPARED BY **RMS**	CHECKED BY **NCH**	SHEET **1 of 3**

ELEVATION (ft)	DEPTH (ft)	Material Graphics	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests	Drilling Method
	25		Lean CLAY with SAND (CL) *(continued)*.														
-20.00	26				10	4 7 7	14	100	2.25	23	106						
	27																
-22.00	28																
	29																
-24.00	30		Approximately 25% Fine SAND														
	31				11	7 7 8	15	100	3.2								
-26.00	32																
	33		Lean CLAY (CL), Very Stiff to Hard, Yellowish Brown, Moist, Low Plasticity														
-28.00	34																
	35																
-30.00	36				12	5 7 7	14	100	4.0	25	102						
	37																
-32.00	38		Light Brown,Medium Plasticity														
	39																
-34.00	40																
	41				13	4 4 6	10	100	3.75								
-36.00	42																
	43		Fat CLAY (CH), Very Stiff to Hard, Dark Yellowish Brown, Moist, High Plasticity														
-38.00	44																
	45																
-40.00	46				14	5 7 9	16	100	4.5	27	96						
	47																
-42.00	48																
	49																
-44.00	50																
	51				15	6 8 10	18	100	3.75								
-46.00	52																
	53																
-48.00	54																
	55																

Laboratory Data: Moisture Content through Additional Lab Tests.

(continued)

blackburn consulting
Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	3195.X	BCI-17-04
COUNTY: SOL	ROUTE	POSTMILE
CLIENT: Ecosystems Investment Partners		
PREPARED BY: RMS	CHECKED BY: NCH	SHEET: 2 of 3

ELEVATION (ft)	DEPTH (ft)	DESCRIPTION	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests
	55	Fat CLAY (CH) *(continued)*, Hard	16	9 11 15	26	100	>4.5							
-50.00	56													
	57													
-52.00	58													
	59													
-54.00	60		17	8 10 14	24	100	>4.5							
	61													
-56.00	62													
	63	Lean CLAY (CL), Hard, Yellowish Brown, Moist, Medium Plasticity												
-58.00	64													
	65		18	5 6 9	15	100	>4.5							
-60.00	66													
	67													
-62.00	68													
	69													
-64.00	70	Poorly-graded SAND with CLAY (SP-SC), Dense, Dark Yellowish Brown, Fine SAND, Lean CLAY	19	10 16 22	38	100								
	71													
-66.00	72													
	73	Fat CLAY (CH), Hard, Brown, Moist, High Plasticity												
-68.00	74													
	75		20	7 10 13	23	100	>4.5							
-70.00	76													
	77	Bottom of exploration at 76.5 ft below ground surface (bgs)												
-72.00	78	Tremie Grout Backfill Ground water encountered at 12.0 ft bgs												
	79													
-74.00	80													
	81													
-76.00	82													
	83													
-78.00	84													
	85													

Laboratory Data columns: Moisture Content (%), Dry Density (pcf), Liquid Limit, Plasticity Index, % <#200, Shear Strength Test, Additional Lab Tests. Other columns: Material Graphics, Sample Location, Drilling Method.

blackburn consulting

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	3195.X	BCI-17-04
COUNTY: SOL	ROUTE:	POSTMILE:
CLIENT: Ecosystems Investment Partners		
PREPARED BY: RMS	CHECKED BY: NCH	SHEET: 3 of 3

LOGGED BY	BEGIN DATE	COMPLETION DATE	LOCATION (Lat/Long or North/East and Datum)	HOLE ID
RMS	9-6-17	9-6-17	38.319509° / -121.717528°	BCI-17-05

CONTRACTOR: Taber	LOCATION (Offset, Station, Line)	SURFACE ELEVATION: 6.0 ft
OPERATOR'S NAME: Chad — HELPER'S NAME: Kevin	EQUIPMENT: CME 55 Truck Rig	TOTAL DEPTH: 76.5 ft
EXCAVATION METHOD: Rotary Wash	DRILLING ROD TYPE AND DIAMETER / BUCKET WIDTH	BOREHOLE DIAMETER: 6 in
SAMPLER TYPE(S) AND SIZE(S) (ID): Shelby (2.87") and SPT (1.4")	HAMMER TYPE: Safety semi-automatic drop (140#/ 30")	HAMMER EFFICIENCY, ERi: 79%
BACKFILL AND COMPLETION: Tremie Grout Backfill	GROUND WATER READINGS — DURING: 19.5 ft — AFTER (DATE): 19.5 ft on 9-6-17	CASING TYPE AND DIAMETER(in)

ELEVATION (ft)	DEPTH (ft)	DESCRIPTION	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests
	0	Fat CLAY (CH), Medium Stiff, Dark Brown, Moist, High Plasticity												
4.00	1–2		1	2 3 4	7	100								
2.00	3–4	Fat CLAY (CH), Very Stiff, Dark Gray, Moist	2	600 psi		67	3.5	19	106					
0.00	5–6	Lean CLAY with SAND (CL), Very Stiff to Hard, Yellowish Brown, Moist, Weak cementation	3	4 6 8	14	100	2.8	20		44	30	78		
-2.00	7–8		4	1300 psi		100	>4.5							
-4.00	9–10	Dark Yellowish Brown, Medium Plasticity	5	5 5 7	12	100								
-6.00	11–12		6	800 psi		90	3.5	22	108	43	22	72		
-8.00	13–14		7	3 5 6	11	100	3.0							
-10.00 to -12.00	15–19													
-14.00	20–21	Switched to mud rotary at 20 ft bgs Mottled with Greenish Gray, Weak Cementation	8	6 6 13	19	100	>4.5							
-16.00 to -18.00	22–25													

(continued)

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	3195.X	BCI-17-05

COUNTY	ROUTE	POSTMILE
SOL		

CLIENT: Ecosystems Investment Partners

PREPARED BY	CHECKED BY	SHEET
RMS	NCH	1 of 3

ELEVATION (ft)	DEPTH (ft)	Material Graphics	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests	Drilling Method
	25		Lean CLAY (CL), Very Stiff to Hard, Dark Yellowish Brown, Moist, No Mottling, Medium Cementation		9	7 8 11	19	100	>4.5	22 21	108 108						
-20.00	26																
	27																
-22.00	28																
	29																
-24.00	30				10	3 4 5	9	100	3.2								
	31																
-26.00	32																
	33		SILTY SAND (SM), Medium Dense, Brown, Wet, Fine SAND														
-28.00	34																
	35				11	2 7 9	16	100		34		NP	NP	33			
-30.00	36																
	37																
-32.00	38																
	39																
-34.00	40		Mottled with Greenish Gray, Moist		12	6 6 9	15	100									
	41																
-36.00	42																
	43		Poorly-graded SAND with CLAY (SP-SC), Medium Dense, Dark Brown, Wet, Fine SAND														
-38.00	44																
	45				13	9 11 13	24	100						8			
-40.00	46																
	47																
-42.00	48																
	49																
-44.00	50		Dark Yellowish Brown		14	7 8 14	22	100	1.6								
	51																
-46.00	52																
	53		Lean CLAY (CL), Hard, Dark Yellowish Brown, Moist, Medium Plasticity, Weak Cementation														
-48.00	54																
	55																

(continued)

blackburn consulting

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	3195.X	BCI-17-05
COUNTY: SOL	ROUTE:	POSTMILE:
CLIENT: Ecosystems Investment Partners		
PREPARED BY: RMS	CHECKED BY: NCH	SHEET: 2 of 3

ELEVATION (ft)	DEPTH (ft)	Material Graphics	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests	Drilling Method
	55		Lean CLAY (CL) *(continued)*.	X		8											
-50.00	56				15	10	22	100	4.5								
						12											
	57																
-52.00	58																
	59																
-54.00	60		Fat CLAY (CH), Hard, Dark Yellowish Brown, Moist	X		7											
	61				16	10	23	100	4.5	32		59	37	95			
						13											
-56.00	62																
	63		Lean CLAY with SAND (CL), Hard, Yellowish Brown, Moist, Approximately 20% Fine SAND, Low Plasticity, Weak Cementation														
-58.00	64																
	65			X		7											
-60.00	66				17	12	25	100	>4.5								
						13											
	67																
-62.00	68																
	69																
-64.00	70		Approximately 15% SAND, Medium Plasticity, No Cementation	X		7											
	71				18	6	14	100	4.0								
						8											
-66.00	72																
	73		Lean CLAY (CL), Stiff, Dark Yellowish Brown, Wet, Medium Plasticity														
-68.00	74																
	75			X		9											
-70.00	76				19	13	27	100	1.1								
						14											
	77		Bottom of exploration at 76.5 ft below ground surface (bgs)														
-72.00	78		Tremie Grout Backfill Ground water encountered at 19.5 ft bgs														
	79																
-74.00	80																
	81																
-76.00	82																
	83																
-78.00	84																
	85																

blackburn consulting

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME		FILE NO.	HOLE ID
Lookout Slough THRFIP		**3195.X**	**BCI-17-05**
COUNTY **SOL**	ROUTE		POSTMILE
CLIENT **Ecosystems Investment Partners**			
PREPARED BY **RMS**	CHECKED BY **NCH**		SHEET **3 of 3**

LOGGED BY	BEGIN DATE	COMPLETION DATE	LOCATION (Lat/Long or North/East and Datum)	HOLE ID
RMS	8-31-17	8-31-17	38.314824° / -121.721789°	BCI-17-06

CONTRACTOR: Taber	LOCATION (Offset, Station, Line)	SURFACE ELEVATION: 6.0 ft
OPERATOR'S NAME: Chad / HELPER'S NAME: Kevin	EQUIPMENT: CME 55 Truck Rig	TOTAL DEPTH: 76.5 ft
EXCAVATION METHOD: Rotary Wash	DRILLING ROD TYPE AND DIAMETER / BUCKET WIDTH	BOREHOLE DIAMETER: 6 in
SAMPLER TYPE(S) AND SIZE(S) (ID): Shelby (2.87") and SPT (1.4")	HAMMER TYPE: Safety semi-automatic drop (140#/ 30")	HAMMER EFFICIENCY, ERi: 79%
BACKFILL AND COMPLETION: Tremie Grout Backfill	GROUND WATER READINGS: DURING 3.0 ft; AFTER (DATE) 3.0 ft on 8-31-17	CASING TYPE AND DIAMETER(in)

ELEVATION (ft)	DEPTH (ft)	DESCRIPTION	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests
	0	Fat CLAY (CH), Stiff, Dark Brown, Moist, High Plasticity												
4.00	1–2		1	3 3 4	7	100	1.8							
2.00	3.5	Fat CLAY with SAND (CH), Very Stiff, Dark Yellowish Brown, Moist, Medium Plasticity, Medium Cementation	2	700 psi		67	2.75	25	99	68	50		UU	
0.00	5.3	SANDY Lean CLAY (CL), Very Stiff to Hard, Dark Yellowish Brown, Moist	3	9 7 5	12	100	>4.5	17	107					
	7	Switched to mud rotary @ 7 ft bgs												
-2.00	7.5	Poorly-graded SAND with SILT (SP-SM), Medium Dense, Dark Yellowish Brown, Moist, Fine SAND	4	800 psi		90		11	113	NP	NP	8		
-4.00	10	Yellowish Brown, Wet	5	3 6 8	14	100		17	109	NP	NP	6		
-6.00	11	Dense	6	11 20 10	30	100								
-8.00	14	Well-graded GRAVEL with CLAY (GW-GC), Medium Dense, Yellowish Brown, Wet, Approximately 30% SAND, Approximately 5-10% CLAY												
-10.00	15–16		7	4 4 5	9	100		21	121					
-14.00	20–21		8	6 6 7	13	100								
-18.00	23	SANDY SILT (ML), Very Stiff, Yellowish Brown, Moist, Low Plasticity												

Groundwater symbol at 3 ft.

(continued)

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME: Lookout Slough THRFIP	FILE NO.: 3195.X	HOLE ID: BCI-17-06	
COUNTY: SOL	ROUTE	POSTMILE	
CLIENT: Ecosystems Investment Partners			
PREPARED BY: RMS	CHECKED BY: NCH	SHEET: 1 of 3	

ELEVATION (ft)	DEPTH (ft)	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests	Drilling Method
	25	SANDY SILT (ML) *(continued)*.		9	4 6 6	12	100	3.5	26	99						
-20.00	26															
	27															
-22.00	28	Poorly-graded SAND with CLAY (SP-SC), Dense, Yellowish Brown, Moist - Wet														
	29															
-24.00	30			10	12 13 17	30	100		14	121			10 14			
	31	CLAYEY SAND (SC); Dense; Yellowish Brown; Moist - Wet														
-26.00	32															
	33	Lean CLAY (CL), Hard, Reddish Brown, Moist, Low Plasticity, SAND Lenses														
-28.00	34															
	35			11	4 6 9	15	100	>4.5								
-30.00	36															
	37															
-32.00	38	SILT (ML), Medium Stiff, Reddish Brown, Moist, Low Plasticity, SAND Lenses														
	39															
-34.00	40			12	4 4 5	9	100	1.3								
	41															
-36.00	42															
	43	Fat CLAY (CH), Very Stiff, Yellowish Brown, Wet														
-38.00	44															
	45			13	4 5 7	12	100	2.4			61	36	98			
-40.00	46															
	47															
-42.00	48															
	49															
-44.00	50			14	6 8 12	20	100	2.5								
	51															
-46.00	52															
	53	SANDY Lean CLAY (CL), Very Stiff, Dark Yellowish Brown, Moist, Medium Plasticity														
-48.00	54															
	55															

(continued)

blackburn consulting

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME		FILE NO.	HOLE ID
Lookout Slough THRFIP		3195.X	BCI-17-06
COUNTY: SOL	ROUTE		POSTMILE
CLIENT: Ecosystems Investment Partners			
PREPARED BY: RMS	CHECKED BY: NCH	SHEET: 2 of 3	

ELEVATION (ft)	DEPTH (ft)	DESCRIPTION	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests
	55	SANDY Lean CLAY (CL) *(continued)*.	15	5 7 8	15	100	3.5	23	103					
-50.00	56													
	57													
-52.00	58													
	59	Lean CLAY (CL), Hard, Dark Yellowish Brown, Wet												
-54.00	60		16	10 12 18	30	100	4.3							
	61													
-56.00	62													
	63													
-58.00	64													
	65		17	1 10 18	28	100	>4.5					98		
-60.00	66													
	67													
-62.00	68													
	69													
-64.00	70	Very Stiff, Medium Cementation	18	10 10 11	21	100	3.75							
	71													
-66.00	72													
	73													
-68.00	74													
	75		19	5 6 15	21	100	3.1							
-70.00	76													
	77	Bottom of exploration at 76.5 ft below ground surface (bgs)												
-72.00	78	Tremie Grout Backfill Ground water encountered at 3.0 ft bgs												
	79													
-74.00	80													
	81													
-76.00	82													
	83													
-78.00	84													
	85													

Laboratory Data

blackburn consulting

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	3195.X	BCI-17-06
COUNTY: SOL	ROUTE	POSTMILE
CLIENT: Ecosystems Investment Partners		
PREPARED BY: RMS	CHECKED BY: NCH	SHEET: 3 of 3

LOGGED BY	BEGIN DATE	COMPLETION DATE	LOCATION (Lat/Long or North/East and Datum)	HOLE ID
RMS	**9-8-17**	**9-8-17**	**38.312708° / -121.724274°**	**BCI-17-07**

Field	Value
CONTRACTOR	**Taber**
LOCATION (Offset, Station, Line)	
SURFACE ELEVATION	**8.0 ft**
OPERATOR'S NAME	**Chad**
HELPER'S NAME	**Kevin**
EQUIPMENT	**CME 55 Truck Rig**
TOTAL DEPTH	**76.5 ft**
EXCAVATION METHOD	**Rotary Wash**
DRILLING ROD TYPE AND DIAMETER / BUCKET WIDTH	
BOREHOLE DIAMETER	**6 in**
SAMPLER TYPE(S) AND SIZE(S) (ID)	**Shelby (2.87") and SPT (1.4")**
HAMMER TYPE	**Safety semi-automatic drop (140#/ 30")**
HAMMER EFFICIENCY, ERi	**79%**
BACKFILL AND COMPLETION	**Tremie Grout Backfill**
GROUND WATER READINGS — DURING	**10.0 ft**
GROUND WATER READINGS — AFTER (DATE)	**10.0 ft on 9-8-17**
CASING TYPE AND DIAMETER(in)	

ELEVATION (ft)	DEPTH (ft)	DESCRIPTION	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests
	0	Fat CLAY (CH), Very Stiff, Moist, High Plasticity												
6.00	1–2		1	2 3 4	7	100	2.6							
4.00	3–4	Lean CLAY with SAND (CL), Very Stiff, Dark Yellowish Brown, Moist	2	750 psi		87	2.25	18	110	48	32	80	DS	
2.00	5.5–6	SILT (ML), Very stiff to Hard, Yellowish Brown, Moist, Weak Cementation	3	3 8 15	23	100	>4.5							
0.00	7–8	Strong Cementation	4	1300 psi		100	3.8			44	16	93		
	9	Lean CLAY with SAND (CL), Very Stiff to Hard, Dark Yellowish Brown, Moist												
-2.00	10–11		5	4 4 5	9	100	3.5	24	101					
-4.00	11.5–13	Switched to mud rotary at 11.5 ft bgs	6	1300 psi		94	>4.5							
-6.00	14	SANDY Lean CLAY (CL), Stiff, Yellowish Brown, Wet												
-8.00	15–16		7	3 4 6	10	100	2.0	23		35	19	50		
-10.00	18	Lean CLAY (CL), Hard, Dark Yellowish Brown, Wet, Medium Plasticity, Weak Cementation												
-12.00	20–21		8	2 3 6	9	100	>4.5							
-14.00	22													
-16.00	24													
	25													

(continued)

blackburn consulting

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	**3195.X**	**BCI-17-07**

COUNTY	ROUTE	POSTMILE
SOL		

CLIENT: **Ecosystems Investment Partners**

PREPARED BY	CHECKED BY	SHEET
RMS	**NCH**	**1 of 3**

ELEVATION (ft)	DEPTH (ft)	DESCRIPTION	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests
	25	Lean CLAY (CL) *(continued)*, Moist, Moderate Cementation	9	6 8 9	17	100	>4.5	22	106					
-18.00	26													
	27													
-20.00	28													
	29													
-22.00	30	Stiff, Weak Cementation	10	6 8 9	17	100	1.0							
	31													
-24.00	32													
	33													
-26.00	34													
	35	Very Stiff, Yellowish Brown	11	3 6 8	14	100	2.2							
-28.00	36													
	37													
-30.00	38	Lean CLAY with SAND (CL), Very Stiff, Dark Yellowish Brown, Moist, Low Plasticity, Approximately 20% Fine SAND												
	39													
-32.00	40		12	3 6 7	13	100	3.3							
	41													
-34.00	42													
	43	Lean CLAY (CL), Very Stiff, Dark Yellowish Brown Mottled with Dark Brown, Wet, Weak Cementation												
-36.00	44													
	45		13	4 6 8	14	100	2.8							
-38.00	46													
	47													
-40.00	48													
	49													
-42.00	50	Grayish Brown, Moist	14	5 7 9	16	100	3.5							
	51													
-44.00	52													
	53													
-46.00	54													
	55													

Column headers also printed: Material Graphics, Sample Location, Laboratory Data, Drilling Method.

(continued)

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	3195.X	BCI-17-07
COUNTY: SOL	ROUTE	POSTMILE
CLIENT: Ecosystems Investment Partners		
PREPARED BY: RMS	CHECKED BY: NCH	SHEET: 2 of 3

ELEVATION (ft)	DEPTH (ft)	DESCRIPTION	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests
	55	Lean CLAY (CL) *(continued)*, Hard, Dark Yellowish Brown, No Cementation	15	3 5 6	11	100	4.5							
-48.00	56													
	57													
-50.00	58													
	59													
-52.00	60	Low Plasticity, Medium Cementation	16	8 12 16	28	100	>4.5							
	61													
-54.00	62													
	63	SILT with SAND (ML), Medium Stiff, Yellowish Brown, Wet, Low to No Plasticity, Approximately 15% Fine SAND												
-56.00	64													
	65		17	4 6 7	13	100	0.8							
-58.00	66													
	67													
-60.00	68	SILTY SAND (SM), Dense, Reddish Brown, Moist, Fine SAND, Interbedded lenses of SANDY SILT (ML)												
	69													
-62.00	70		18	10 10 20	30	100	1.75	23	108					
	71													
-64.00	72													
	73	Lean CLAY (CL), Stiff, Olive Brown, Wet												
-66.00	74													
	75		19	4 4 6	10	100	2.5							
-68.00	76													
	77	Bottom of exploration at 76.5 ft below ground surface (bgs)												
-70.00	78	Tremie Grout Backfill Ground water encountered at 10.0 ft bgs												
	79													
-72.00	80													
	81													
-74.00	82													
	83													
-76.00	84													
	85													

blackburn consulting

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	3195.X	BCI-17-07
COUNTY: SOL	ROUTE	POSTMILE
CLIENT: Ecosystems Investment Partners		
PREPARED BY: RMS	CHECKED BY: NCH	SHEET: 3 of 3

LOGGED BY	BEGIN DATE	COMPLETION DATE	LOCATION (Lat/Long or North/East and Datum)	HOLE ID
RMS	**9-7-17**	**9-7-17**	**38.306699° / -121.730121°**	**BCI-17-08**
CONTRACTOR			LOCATION (Offset, Station, Line)	SURFACE ELEVATION
Taber				**6.0 ft**
OPERATOR'S NAME	HELPER'S NAME		EQUIPMENT	TOTAL DEPTH
Andy	**Trevor**		**CME 55 Truck Rig**	**76.5 ft**
EXCAVATION METHOD			DRILLING ROD TYPE AND DIAMETER / BUCKET WIDTH	BOREHOLE DIAMETER
Rotary Wash				**6 in**
SAMPLER TYPE(S) AND SIZE(S) (ID)			HAMMER TYPE	HAMMER EFFICIENCY, ERi
Shelby (2.87") and SPT (1.4")			**Safety semi-automatic drop (140#/ 30")**	**79%**
BACKFILL AND COMPLETION			GROUND WATER READINGS — DURING **19.0 ft** — AFTER (DATE) **15.0 ft on 9-7-17**	CASING TYPE AND DIAMETER(in)
Tremie Grout Backfill				

ELEVATION (ft)	DEPTH (ft)	DESCRIPTION	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests
	0	Fat CLAY (CH), Stiff, Dark Gray, Moist												
	1													
4.00	2		1	3 3 4	7	100	1.75							
	3													
2.00	4	Very Stiff	2	300 psi		80	2.75	30	86	68	48	95	DS	C
	5													
0.00	6		3	2 4 4	8	100	3.0							
	7	Fat CLAY with SAND (CH), Very Stiff, Dark Gray, Moist												
-2.00	8		4	500 psi		87	4.0	23	90	54	36	84		
	9	SANDY Lean CLAY (CL), Stiff to Hard, Brown, Moist												
-4.00	10		5	3 5 5	10	100	1.5							
	11	Yellowish Brown												
-6.00	12		6	500 psi		67	>4.5	17	107	35	22	56		
	13													
-8.00	14		7	3 5 5	10	100	3.5							
	15													
-10.00	16		8	500 psi		83	3.75			29	18	58		
	17													
-12.00	18		9	4 4 5	9	100	>4.5							
	19													
-14.00	20	Switched to mud rotary at 20 ft bgs												
	21													
-16.00	22													
	23													
-18.00	24													
	25													

Laboratory Data

Material Graphics | Sample Location | Drilling Method

(continued)

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	**3195.X**	**BCI-17-08**
COUNTY **SOL**	ROUTE	POSTMILE
CLIENT **Ecosystems Investment Partners**		
PREPARED BY **RMS**	CHECKED BY **NCH**	SHEET **1 of 3**

ELEVATION (ft)	DEPTH (ft)	Material Graphics	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests	Drilling Method
	25		Lean CLAY (CL), Very Stiff, Light Oliver Brown, Moist														
-20.00	26				10	3 5 6	11	100	3.5	26	100						
	27																
-22.00	28																
	29																
-24.00	30		Medium Stiff, Wet														
	31				11	2 2 2	4	100	<1.0	35		42	22	89			
-26.00	32																
	33		SANDY SILT (ML), Stiff, Brown, Wet, Low Plasticity														
-28.00	34																
	35																
-30.00	36				12	3 4 5	9	100	1.5	33		31	8	62			
	37																
-32.00	38		Poorly-graded SAND with SILT (SP-SM), Dense, Olive Gray, Moist														
	39																
-34.00	40																
	41				13	8 12 14	26	100		13	124						
-36.00	42																
	43		With GRAVEL, Dark Brown, Wet														
-38.00	44																
	45																
-40.00	46				14	6 16 18	34	100						7		GS	
	47																
-42.00	48		CLAYEY GRAVEL with SAND (GC), Medium Dense, Brown, Wet														
	49																
-44.00	50																
	51				15	5 4 5	9	100						41		GS	
-46.00	52																
	53		Lean CLAY (CL), Hard, Yellowish Brown, Moist														
-48.00	54																
	55																

Laboratory Data

(continued)

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME: **Lookout Slough THRFIP**		FILE NO. **3195.X**	HOLE ID **BCI-17-08**
COUNTY **SOL**	ROUTE		POSTMILE
CLIENT **Ecosystems Investment Partners**			
PREPARED BY **RMS**	CHECKED BY **NCH**		SHEET **2 of 3**

ELEVATION (ft)	DEPTH (ft)	Material Graphics	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests	Drilling Method
	55		Lean CLAY (CL) *(continued)*.														
-50.00	56				16	3 3 6	9	100	4.4	25		47	26	90			
	57																
-52.00	58																
	59																
-54.00	60		Medium Cementation														
	61				17	4 4 8	12	100	>4.5								
-56.00	62																
	63		SILTY SAND (SM), Medium Dense, Olive Brown, Wet, Low to No Plasticity, Fine SAND, Approximately 25% SILT														
-58.00	64																
	65																
-60.00	66				18	4 5 8	13	100									
	67																
-62.00	68		Lean CLAY (CL), Hard, Grayish Brown, Moist, Medium Plasticity, Medium Cementation														
	69																
-64.00	70																
	71				19	7 16 10	26	100	>4.5								
-66.00	72																
	73																
-68.00	74																
	75		Olive Brown, Wet, Traces of SAND, No Cementation														
-70.00	76				20	4 6 10	16	100	4.3								
	77		Bottom of exploration at 76.5 ft below ground surface (bgs) Tremie Grout Backfill Ground water initially encountered at 19.0 ft bgs, rose to 15.0 ft bgs after drilling														
-72.00	78																
	79																
-74.00	80																
	81																
-76.00	82																
	83																
-78.00	84																
	85																

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	3195.X	BCI-17-08
COUNTY: SOL	ROUTE:	POSTMILE:
CLIENT: Ecosystems Investment Partners		
PREPARED BY: RMS	CHECKED BY: NCH	SHEET: 3 of 3

LOGGED BY	BEGIN DATE	COMPLETION DATE	LOCATION (Lat/Long or North/East and Datum)	HOLE ID
RMS	**11-27-17**	**11-27-17**	**38.307672° / -121.728791°**	**BCI-17-09**

CONTRACTOR **Taber**	LOCATION (Offset, Station, Line)	SURFACE ELEVATION **6.5 ft**
OPERATOR'S NAME **Andy** / HELPER'S NAME **Stephen**	EQUIPMENT **CME 55 Crawler**	TOTAL DEPTH **51.5 ft**
EXCAVATION METHOD **Rotary Wash**	DRILLING ROD TYPE AND DIAMETER / BUCKET WIDTH	BOREHOLE DIAMETER **6 in**
SAMPLER TYPE(S) AND SIZE(S) (ID) **Shelby (2.87") and Mod Cal (2.4")**	HAMMER TYPE **Safety semi-automatic drop (140#/ 30")**	HAMMER EFFICIENCY, ERi **74%**
BACKFILL AND COMPLETION **Tremie Grout Backfill**	GROUND WATER READINGS — DURING **11.5 ft** — AFTER (DATE)	CASING TYPE AND DIAMETER(in)

ELEVATION (ft)	DEPTH (ft)	DESCRIPTION	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests
	0	Fat CLAY with SAND (CH), Medium Stiff to Stiff, Olive Brown, Moist												
	1													
4.50	2		1	3 5 8	13	33	.75							
	3		2	4 8 12	20	61	1.5	31	89	73	48			
2.50	4	Lean CLAY with SAND (CL), Stiff, Yellowish Brown, Moist												
	5		3	300 psi		83	1.5			46	31			
0.50	6	Fat CLAY with SAND (CH), Stiff to Very Stiff, Yellowish Brown, Moist												
	7		4	14 14 14	28	100	2.2	24		53	37	76		
-1.50	8		5	6 9 14	23	100	1.5							
	9	Lean CLAY with SAND (CL), Medium Stiff to Stiff, Olive Brown, Moist												
-3.50	10		6	500 psi		88	1.0						UU	
	11													
-5.50	12		7	7 7 8	15	100	1.75							
	13	SANDY Lean CLAY (CL), Very Stiff, Olive Brown, Moist	8	4 7 10	17	100	2.1	34 32		38	19	66 66		
-7.50	14	Switched to mud rotary at 14 ft bgs Lean CLAY (CL), Very Stiff, Olive Brown, Moist												
	15													
-9.50	16		9	9 12 18	30	100	2.7							
	17													
-11.50	18													
	19													
-13.50	20													
	21		10	7 11 15	26	100	3.1							
-15.50	22													
	23													
-17.50	24													
	25													

(continued)

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	**3195.X**	**BCI-17-09**
COUNTY **SOL**	ROUTE	POSTMILE
CLIENT **Ecosystems Investment Partners**		
PREPARED BY **DWC**	CHECKED BY **NCH**	SHEET **1 of 2**

ELEVATION (ft)	DEPTH (ft)	DESCRIPTION	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests
	25	Lean CLAY (CL) *(continued)*.												
-19.50	26		11	10 15 17	32	100	3.25							
	27													
-21.50	28													
	29													
-23.50	30	Medium Stiff, Yellowish Brown, Wet												
	31		12	11 11 13	24	78	0.75	32		49	28	93		C
-25.50	32		13	8 11 14	25	100	1.0							
	33													
-27.50	34													
	35	Moist												
-29.50	36		14	7 10 11	21	100	1.0							
	37													
-31.50	38	SILTY SAND (SM), Dense, Yellowish Brown, Wet, Fine SAND												
	39													
-33.50	40													
	41		15	9 16 18	34	100		30	96			32		
-35.50	42	Well-graded GRAVEL (GW), Medium Dense to Dense, Dark Gray, Wet, Fine SAND												
	43													
-37.50	44													
	45	Well-graded SAND with SILT and GRAVEL (SW-SM), Dense, Dark Yellowish Brown, Wet												
-39.50	46		16	10 11 19	30	100		21				5		
	47													
-41.50	48													
	49													
-43.50	50													
	51		17	15 21 24	45	100								
-45.50	52	Bottom of exploration at 51.5 ft below ground surface (bgs)												
	53	Tremie Grout Backfill Ground water encountered at 11.5 ft bgs												
-47.50	54													
	55													

blackburn consulting

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	**3195.X**	**BCI-17-09**

COUNTY	ROUTE	POSTMILE
SOL		

CLIENT
Ecosystems Investment Partners

PREPARED BY	CHECKED BY	SHEET
DWC	**NCH**	**2 of 2**

LOGGED BY	BEGIN DATE	COMPLETION DATE	LOCATION (Lat/Long or North/East and Datum)	HOLE ID
DWC	**11-27-17**	**11-27-17**	**38.313855° / -121.722994°**	**BCI-17-10**
CONTRACTOR			LOCATION (Offset, Station, Line)	SURFACE ELEVATION
Taber				**6.0 ft**
OPERATOR'S NAME	HELPER'S NAME		EQUIPMENT	TOTAL DEPTH
Andy	**Stephen**		**CME 55 Crawler**	**51.5 ft**
EXCAVATION METHOD			DRILLING ROD TYPE AND DIAMETER / BUCKET WIDTH	BOREHOLE DIAMETER
Rotary Wash				**6 in**
SAMPLER TYPE(S) AND SIZE(S) (ID)			HAMMER TYPE	HAMMER EFFICIENCY, ERi
Shelby (2.87") and SPT (1.4") and Mod Cal (2.4")			**Safety semi-automatic drop (140#/ 30")**	**74%**
BACKFILL AND COMPLETION			GROUND WATER READINGS — DURING **3.8 ft** — AFTER (DATE)	CASING TYPE AND DIAMETER(in)
Tremie Grout Backfill				

ELEVATION (ft)	DEPTH (ft)	Material Graphics	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests	Drilling Method
	0		Fat CLAY (CH), Medium Stiff, Very Dark Brown, Moist														
4.00	1–2				1	4 6 10	16		2.25			63	41				
2.00	3–4		Lean CLAY with SAND (CL), Stiff to Very Stiff, Very Dark Gray, Moist		2				1.5	46	72	68	41	66			
	5				3	5 9 10	19		2.5	28	99						
0.00	6–7		CLAYEY SAND (SC), Medium Dense, Olive Brown, Moist Switched to mud rotary at 6 ft bgs		4	550 psi						34	16	28			
-2.00	8–9				5	5 12 15	27			30		31	11	43			
-4.00	10		Very Dense		6	16 27 33	60										
-6.00	11–12		Lean CLAY with SAND (CL), Hard, Brown, Moist		7	12 27 34	61										
	13				8	14 26 31	57										
-8.00	14–15		Lean CLAY (CL), Hard, Brown, Moist, Some Strong Induration		9	21 30 34	64										
-10.00	16–17																
-12.00	18–19		Poorly-graded SAND with CLAY (SP-SC), Very Dense, Brown, Wet, Fine to Medium Grain SAND														
-14.00	20–21				10	19 23 30	53							10			
-16.00	22																
-18.00	23–25		Poorly-graded SAND with GRAVEL (SP), Very Dense, Dark Olive Brown, Wet														

(continued)

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME		FILE NO.	HOLE ID
Lookout Slough THRFIP		**3195.X**	**BCI-17-10**
COUNTY	ROUTE		POSTMILE
SOL			
CLIENT			
Ecosystems Investment Partners			
PREPARED BY	CHECKED BY	SHEET	
DWC	**NCH**	**1 of 2**	

ELEVATION (ft)	DEPTH (ft)	DESCRIPTION	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests
	25	Poorly Graded SAND with GRAVEL (SP) *(continued)*.	11	24 31 38	69							3 7		
-20.00	26	Poorly-graded GRAVEL with CLAY and SAND (GP-GC), Very Dense, Dark Olive Brown, Wet, Fine to Coarse SAND, Fine GRAVEL												
-24.00	30	Dense, Fine to Coarse GRAVEL	12	9 12 21	33									
	33	Less SAND												
	35		13	9 16 21	37		3.25					7		
-30.00	36	Lean CLAY (CL), Very Stiff, Olive Brown, Moist												
	39	SILTY SAND (SM), Dense, Olive, Moist, Very Fine SAND												
-34.00	40		14	10 11 16	27									
	41	Lean CLAY (CL), Very Stiff, Olive and Mottled Reddish Brown, Moist												
	45		15	7 12 15	27		1.0							
-40.00	46	Medium Stiff												
	49	Dark Olive Gray, Very Stiff												
-44.00	50		16	9 10 14	24		4.0							

Elevation scale: -20.00 to -48.00; Depth scale: 25 to 55 ft. Drilling Method: as shown.

Bottom of exploration at 51.5 ft below ground surface (bgs)

Tremie Grout Backfill
Ground water encountered at 3.8 ft bgs

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	3195.X	BCI-17-10
COUNTY: SOL	ROUTE	POSTMILE
CLIENT: Ecosystems Investment Partners		
PREPARED BY: DWC	CHECKED BY: NCH	SHEET: 2 of 2

LOGGED BY	BEGIN DATE	COMPLETION DATE	LOCATION (Lat/Long or North/East and Datum)	HOLE ID
DWC	**11-28-17**	**11-28-17**	**38.314425° / -121.720986°**	**BCI-17-11**

Field	Value	Field	Value	Field	Value
CONTRACTOR	**Taber**	LOCATION (Offset, Station, Line)		SURFACE ELEVATION	**6.0 ft**
OPERATOR'S NAME / HELPER'S NAME	**Andy** / **Stephen**	EQUIPMENT	**CME 55 Crawler**	TOTAL DEPTH	**41.5 ft**
EXCAVATION METHOD	**Rotary Wash**	DRILLING ROD TYPE AND DIAMETER / BUCKET WIDTH		BOREHOLE DIAMETER	**6 in**
SAMPLER TYPE(S) AND SIZE(S) (ID)	**Shelby (2.87") and SPT (1.4")**	HAMMER TYPE	**Safety semi-automatic drop (140#/ 30")**	HAMMER EFFICIENCY, ERi	**74%**
BACKFILL AND COMPLETION	**Tremie Grout Backfill**	GROUND WATER READINGS	DURING **6.5 ft**; AFTER (DATE)	CASING TYPE AND DIAMETER(in)	

ELEVATION (ft)	DEPTH (ft)	DESCRIPTION	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests
6.00	0	Fat CLAY (CH), Medium Stiff, Dark Grayish Brown, Moist												
4.00	1–3		1				.75			52	37	90		
2.00	3–4.5	Stiff	2	4, 6, 8	14		1.5			58	41			
1.00	5	CLAYEY SAND with GRAVEL (SC), Very Dense, Dark Yellowish Brown, Moist, Fine SAND	3	700 psi										
0.00	6–7.5		4	14, 25, 37	62			18	101	36	15	21		
-2.00	7.5–9	Switched to mud rotary at 7.5 ft bgs	5	19, 29, 40	69									
-4.00	9–10.5	SANDY SILT (ML), Very Stiff, Olive Gray, Moist, Fine SAND, Some Weak Cementation	6	12, 15, 20	35			30	95	35	10	50		
-6.00	11–12	SILTY SAND (SM), Dense, Dark Brown, Wet	7	14, 28, 32	60									
	12–13.5		8	9, 18, 18	36			27	99			29		
-8.00	13.5–15	Lean CLAY with SAND (CL), Hard, Dark Yellowish Brown, Moist	9	6, 11, 12	23		4.0							
-13.00	19	SILTY SAND (SM), Medium Dense, Olive Brown, Wet, Very Fine SAND												
-14.00	20–21.5		10	3, 4, 9	13			29	97	NP	NP	46		
-17.00	23	SANDY SILT (ML), Medium Stiff, Olive Brown, Moist												
-19.00	25													

(continued)

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	**3195.X**	**BCI-17-11**
COUNTY: **SOL**	ROUTE	POSTMILE
CLIENT: **Ecosystems Investment Partners**		
PREPARED BY: **DWC**	CHECKED BY: **NCH**	SHEET: **1 of 2**

ELEVATION (ft)	DEPTH (ft)	DESCRIPTION	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests
	25	SANDY SILT (ML) *(continued)*.	11	5 7 11	18									
-22.00	28	Lean CLAY (CL), Soft, Olive, Moist												
-24.00	30		12	3 12 24	36		0							
	31	Well-graded SAND with SILT and GRAVEL (SW-SM), Dense, Dark Olive Brown, Wet, Fine to Medium Grain GRAVEL												
	35		13	10 14 12	26							8		
-34.00	40		14	6 7 7	14									
	41	SILTY SAND (SM), Medium Dense, Dark Olive Gray, Moist, Medium Grain SAND												

Bottom of exploration at 41.5 ft below ground surface (bgs)

Tremie Grout Backfill
Ground water encountered at 6.5 ft bgs

Elevation scale: -20.00, -22.00, -24.00, -26.00, -28.00, -30.00, -32.00, -34.00, -36.00, -38.00, -40.00, -42.00, -44.00, -46.00, -48.00

Depth scale: 25–55

BCI LOG FOR SOIL BORINGS.GPJ LIBRARY_3195.GLB 8/28/19

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	3195.X	BCI-17-11
COUNTY: SOL	ROUTE:	POSTMILE:
CLIENT: Ecosystems Investment Partners		
PREPARED BY: DWC	CHECKED BY: NCH	SHEET: 2 of 2

LOGGED BY	BEGIN DATE	COMPLETION DATE	LOCATION (Lat/Long or North/East and Datum)	HOLE ID
RMS	**12-4-17**	**12-4-17**	**38.315274° / -121.72254°**	**BCI-17-12**

CONTRACTOR **Taber**	LOCATION (Offset, Station, Line)	SURFACE ELEVATION **6.0 ft**
OPERATOR'S NAME **Chad** HELPER'S NAME	EQUIPMENT **CME 55 Crawler**	TOTAL DEPTH **41.5 ft**
EXCAVATION METHOD **Rotary Wash**	DRILLING ROD TYPE AND DIAMETER / BUCKET WIDTH	BOREHOLE DIAMETER **6 in**
SAMPLER TYPE(S) AND SIZE(S) (ID) **Shelby (2.87") and SPT (1.4")**	HAMMER TYPE **Safety semi-automatic drop (140#/ 30")**	HAMMER EFFICIENCY, ERi **74%**
BACKFILL AND COMPLETION **Tremie Grout Backfill**	GROUND WATER READINGS — DURING **5.5 ft** — AFTER (DATE)	CASING TYPE AND DIAMETER(in)

ELEVATION (ft)	DEPTH (ft)	Material Graphics	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests	Drilling Method
	0		Fat CLAY (CH), Stiff, Dark Brown, Moist														
	1																
4.00	2				1	600 psi		92	1.25								
	3		Lean CLAY with SAND (CL),Stiff to Very Stiff, Brown, Moist														
2.00	4				2	5 3 7	10	100				34	19	80			
	5			▽	3	800 psi		100	1.5	25	101						
0.00	6																
	7				4	3 5 5	10	100				47	28	80			
-2.00	8		Switched to mud rotary at 7.5 ft bgs Poorly-graded SAND with GRAVEL (SP), Dense, Very Dark Gray, Wet, Fine GRAVEL, Fine SAND														
	9				5	800 psi		100						4			
-4.00	10		Poorly-graded SAND (SP), Medium Dense, Dark Brown, Wet														
	11				6	5 6 8	14	100						4			
-6.00	12																
	13		SILTY SAND (SM), Medium Dense, Very Dark Olive Brown, Moist														
-8.00	14																
	15																
-10.00	16				7	2 10 14	24	100		24	101			23			
	17		Poorly-graded SAND with SILT and GRAVEL (SP-SM), Dense, Very Dark Olive Brown, Moist, Fine SAND														
-12.00	18																
	19																
-14.00	20																
	21				8	5 16 10	26	100									
-16.00	22																
	23		Well-graded SAND with CLAY and GRAVEL (SW-SC), Very Dense, Dark Olive Brown, Wet														
-18.00	24																
	25																

(continued)

blackburn consulting

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	**3195.X**	**BCI-17-12**
COUNTY **SOL**	ROUTE	POSTMILE
CLIENT **Ecosystems Investment Partners**		
PREPARED BY **DWC**	CHECKED BY **NCH**	SHEET **1 of 2**

ELEVATION (ft)	DEPTH (ft)	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests	Drilling Method
	25	Well Graded SAND with CLAY and GRAVEL (SW-SC) *(continued)*.	X	9	13 22 24	46	100		13	117			8			
	30		X	10	9 18 19	37	100									
	35	SANDY Lean CLAY (CL), Stiff, Olive Brown, Wet, Fine to Coarse SAND	X	11	5 8 9	17	100				46	25	67			
	38	Lean CLAY (CL), Stiff, Olive Brown, Moist														
	40		X	12	5 4 7	11	100									

Elevation scale: -20.00 (26), -22.00 (28), -24.00 (30), -26.00 (32), -28.00 (34), -30.00 (36), -32.00 (38), -34.00 (40), -36.00 (42), -38.00 (44), -40.00 (46), -42.00 (48), -44.00 (50), -46.00 (52), -48.00 (54); depth 25–55 ft.

Bottom of exploration at 41.5 ft below ground surface (bgs)

Tremie Grout Backfill
Ground water encountered at 5.5 ft bgs

blackburn consulting
Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	3195.X	BCI-17-12
COUNTY: SOL	ROUTE:	POSTMILE:
CLIENT: Ecosystems Investment Partners		
PREPARED BY: DWC	CHECKED BY: NCH	SHEET: 2 of 2

LOGGED BY: RMS	BEGIN DATE: 12-4-17	COMPLETION DATE: 12-4-17
LOCATION (Lat/Long or North/East and Datum): 38.319101° / -121.716715°		HOLE ID: BCI-17-13
CONTRACTOR: Taber	LOCATION (Offset, Station, Line):	SURFACE ELEVATION: 6.0 ft
OPERATOR'S NAME: Chad / HELPER'S NAME:	EQUIPMENT: CME 55 Crawler	TOTAL DEPTH: 51.5 ft
EXCAVATION METHOD: Rotary Wash	DRILLING ROD TYPE AND DIAMETER / BUCKET WIDTH:	BOREHOLE DIAMETER: 6 in
SAMPLER TYPE(S) AND SIZE(S) (ID): Shelby (2.87") and SPT (1.4")	HAMMER TYPE: Safety semi-automatic drop (140#/ 30")	HAMMER EFFICIENCY, ERi: 74%
BACKFILL AND COMPLETION: Tremie Grout Backfill	GROUND WATER READINGS: DURING 12.5 ft; AFTER (DATE)	CASING TYPE AND DIAMETER(in)

ELEVATION (ft)	DEPTH (ft)	DESCRIPTION	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests
	0	Fat CLAY with SAND (CH), Medium Stiff, Dark Grayish Brown, Moist												
4.00	1–2.5		1	650 psi		100	1.0			67	44			
2.00	2.5–4	Stiff	2	4 3 2	5	100	2.0			64	45			
0.00	5	Lean CLAY (CL), Hard, Dark Yellowish Brown, Moist	3	750 psi		100	>4.5							
	6–7.5		4	5 6 9	15	100								
-2.00	7.5	SANDY Lean CLAY (CL), Very Stiff, Light Olive Brown, Moist, Weak to Moderate Induration	5	850 psi		100	3.0	21		45	28	69		
	9–10		6	3 4 5	9	100								
-4.00	10	Lean CLAY (CL), Very Stiff, Yellowish Brown, Moist												
-6.00	11–12.5		7	800 psi		100	3.75							
	12.5–14	Trace Fine SAND	8	4 5 6	11	100								
-8.00	14	Switched to mud rotary at 14 ft bgs												
-10.00	15	Fat CLAY (CH), Very Stiff, Olive Brown, Moist	9	3 4 7	11	100	2.5	31	94	54	31	92		
-12.00	18													
-14.00	20	Lean CLAY (CL), Very Stiff, Olive Brown, Moist	10	4 10 11	21	100								
-16.00	22													
-18.00	24													
	25													

(continued)

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME: Lookout Slough THRFIP		FILE NO.: 3195.X	HOLE ID: BCI-17-13
COUNTY: SOL	ROUTE:		POSTMILE:
CLIENT: Ecosystems Investment Partners			
PREPARED BY: DWC	CHECKED BY: NCH	SHEET: 1 of 2	

ELEVATION (ft)	DEPTH (ft)	Material Graphics	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests	Drilling Method
										Laboratory Data							
	25		Lean CLAY (CL) *(continued)*.		11	6 8 10	18	100	2.0								
-20.00	26																
	27																
-22.00	28																
	29																
-24.00	30				12	5 7 9	16	100									
	31																
-26.00	32																
	33																
-28.00	34		Soft, Wet														
	35		CLAYEY SAND (SC), Loose, Olive Brown, Fine SAND		13	3 2 3	5	100									
-30.00	36																
	37																
-32.00	38																
	39																
-34.00	40		Lean CLAY with SAND (CL), Medium Stiff, Olive Brown		14	2 3 3	6	100				38	14	75			
	41																
-36.00	42																
	43		Poorly-graded SAND with CLAY (SP-SC), Medium Dense to Dense, Dark Olive Brown, Wet, Fine SAND														
-38.00	44																
	45				15	6 8 9	17	100						7			
-40.00	46																
	47																
-42.00	48																
	49																
-44.00	50				16	8 13 14	27	50									
	51																
-46.00	52		Bottom of exploration at 51.5 ft below ground surface (bgs) Tremie Grout Backfill Ground water encountered at 12.5 ft bgs														
	53																
-48.00	54																
	55																

blackburn consulting

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME **Lookout Slough THRFIP**		FILE NO. **3195.X**	HOLE ID **BCI-17-13**
COUNTY **SOL**	ROUTE		POSTMILE
CLIENT **Ecosystems Investment Partners**			
PREPARED BY **DWC**	CHECKED BY **NCH**	SHEET **2 of 2**	

LOGGED BY	BEGIN DATE	COMPLETION DATE	LOCATION (Lat/Long or North/East and Datum)	HOLE ID
RMS	12-5-17	12-5-17	38.326916° / -121.710018°	BCI-17-14

Field	Value
CONTRACTOR	Taber
LOCATION (Offset, Station, Line)	
SURFACE ELEVATION	6.0 ft
OPERATOR'S NAME	Chad
HELPER'S NAME	
EQUIPMENT	CME 55 Crawler
TOTAL DEPTH	41.5 ft
EXCAVATION METHOD	Rotary Wash
DRILLING ROD TYPE AND DIAMETER / BUCKET WIDTH	
BOREHOLE DIAMETER	6 in
SAMPLER TYPE(S) AND SIZE(S) (ID)	Shelby (2.87") and SPT (1.4")
HAMMER TYPE	Safety semi-automatic drop (140#/ 30")
HAMMER EFFICIENCY, ERi	74%
BACKFILL AND COMPLETION	Tremie Grout Backfill
GROUND WATER READINGS	DURING: 11.0 ft; AFTER (DATE):
CASING TYPE AND DIAMETER(in)	

ELEVATION (ft)	DEPTH (ft)	DESCRIPTION
6.00	0	Fat CLAY (CH), Stiff, Very Dark Gray, Moist
	3.3	Dark Olive Brown
0.50	5.5	SANDY Lean CLAY (CL), Hard, Olive Brown, Moist
-2.00	8	Lean CLAY (CL), Stiff to Very Stiff, Olive Brown, Moist
	13.3	Wet
	13.5	Switched to mud rotary at 13.5 ft bgs
	20.3	Hard, Weak Induration

Sample Number	Sample Type	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests
1	Shelby	600 psi		75	1.5			66	46			
2	SPT	2 3 4	7	100				74	56			
3	Shelby	700 psi		75	4.0							
4	SPT	4 6 7	13	100		23		38	22	59		
5	Shelby	800 psi		100	1.75							
6	SPT	3 4 5	9	100								
7	Shelby	800 psi		100	2.0							
8	SPT	3 7 10	17	100								
9	SPT	5 7 9	16	100	4.5	22		49	30	94		

(continued)

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	3195.X	BCI-17-14

COUNTY	ROUTE	POSTMILE
SOL		

CLIENT: Ecosystems Investment Partners

PREPARED BY	CHECKED BY	SHEET
DWC	NCH	1 of 2

BCI LOG FOR SOIL BORINGS.GPJ LIBRARY_3195.GLB 8/28/19

ELEVATION (ft)	DEPTH (ft)	Material Graphics	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests	Drilling Method
	25		Lean CLAY (CL) *(continued)*.		10	5 8 13	21	100									
-20.00	26																
	27																
-22.00	28		SANDY Lean CLAY (CL), Very Stiff, Dark Olive Brown, Moist, Fine SAND														
	29																
-24.00	30				11	5 6 8	14	100	3.0								
	31																
-26.00	32																
	33		Lean CLAY (CL), Stiff, Olive Brown, Moist, Weak Induration														
-28.00	34																
	35				12	3 5 7	12	100									
-30.00	36																
	37																
-32.00	38																
	39																
-34.00	40		Very Stiff, No Induration		13	4 4 6	10	100	2.5								
	41																
-36.00	42		Bottom of exploration at 41.5 ft below ground surface (bgs) Tremie Grout Backfill Ground water encountered at 11.0 ft bgs														
	43																
-38.00	44																
	45																
-40.00	46																
	47																
-42.00	48																
	49																
-44.00	50																
	51																
-46.00	52																
	53																
-48.00	54																
	55																

Laboratory Data: Moisture Content (%), Dry Density (pcf), Liquid Limit, Plasticity Index, % <#200, Shear Strength Test, Additional Lab Tests

blackburn consulting

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME **Lookout Slough THRFIP**		FILE NO. **3195.X**	HOLE ID **BCI-17-14**
COUNTY **SOL**	ROUTE		POSTMILE
CLIENT **Ecosystems Investment Partners**			
PREPARED BY **DWC**	CHECKED BY **NCH**	SHEET **2 of 2**	

LOGGED BY	BEGIN DATE	COMPLETION DATE	LOCATION (Lat/Long or North/East and Datum)	HOLE ID
DWC	11-28-17	11-28-17	38.328232° / -121.711717°	BCI-17-15
CONTRACTOR: Taber			LOCATION (Offset, Station, Line)	SURFACE ELEVATION: 7.0 ft
OPERATOR'S NAME: Andy	HELPER'S NAME: Stephen		EQUIPMENT: CME 55 Crawler	TOTAL DEPTH: 41.5 ft
EXCAVATION METHOD: Rotary Wash			DRILLING ROD TYPE AND DIAMETER / BUCKET WIDTH	BOREHOLE DIAMETER: 6 in
SAMPLER TYPE(S) AND SIZE(S) (ID): Shelby (2.87") and SPT (1.4")			HAMMER TYPE: Safety semi-automatic drop (140#/ 30")	HAMMER EFFICIENCY, ERi: 74%
BACKFILL AND COMPLETION: Tremie Grout Backfill			GROUND WATER READINGS — DURING: 10.0 ft; AFTER (DATE):	CASING TYPE AND DIAMETER(in)

ELEVATION (ft)	DEPTH (ft)	DESCRIPTION	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests
	0	Fat CLAY (CH), Medium Stiff, Very Dark Gray, Moist												
5.00	2		1	400 psi			1.25			63	46	97		
3.00	4		2	2 4 5	9									
1.00	6		3	600 psi			1.5 4.5							
	6.5	SANDY Lean CLAY (CL), Very Stiff to Hard, Olive Brown, Moist												
-1.00	8		4	5 6 8	14		2.0	23		41	24	67		
-3.00	10	Lean CLAY (CL), Very Stiff, Olive Brown, Moist	5	700 psi			2.0							
-5.00	12	Switched to mud rotary at 13 ft bgs	6	5 5 7	12		2.25							
-7.00	14		7	600 psi			3.5							
	19	Lean CLAY with SAND (CL), Stiff to Very Stiff, Light Olive Brown, Moist												
-13.00	20		8	5 5 7	12		1.75	29	96	42	25	76		
-15.00	22													
-17.00	24													
	25													

Laboratory Data

(continued)

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	3195.X	BCI-17-15
COUNTY: SOL	ROUTE	POSTMILE
CLIENT: Ecosystems Investment Partners		
PREPARED BY: DWC	CHECKED BY: NCH	SHEET: 1 of 2

ELEVATION (ft)	DEPTH (ft)	Material Graphics	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests	Drilling Method
	25		Lean CLAY with SAND (CL) *(continued)*.		9	8 15 16	31		3.0								
-19.00	26																
	27																
-21.00	28																
	29		Lean CLAY (CL), Very Stiff, Olive Brown, Moist														
-23.00	30				10	7 10 11	21		3.25								
	31																
-25.00	32																
	33																
-27.00	34																
	35		Olive Gray		11	6 8 14	22		3.5								
-29.00	36																
	37																
-31.00	38																
	39																
-33.00	40				12	7 8 10	18		2.5								
	41																
-35.00	42		Bottom of exploration at 41.5 ft below ground surface (bgs) Tremie Grout Backfill Ground water encountered at 10.0 ft bgs														
	43																
-37.00	44																
	45																
-39.00	46																
	47																
-41.00	48																
	49																
-43.00	50																
	51																
-45.00	52																
	53																
-47.00	54																
	55																

Laboratory Data

blackburn consulting

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	**3195.X**	**BCI-17-15**
COUNTY **SOL**	ROUTE	POSTMILE
CLIENT **Ecosystems Investment Partners**		
PREPARED BY **DWC**	CHECKED BY **NCH**	SHEET **2 of 2**

LOGGED BY: RMS; BEGIN DATE: 12-5-17; COMPLETION DATE: 12-5-17	LOCATION (Lat/Long or North/East and Datum): 38.326918° / -121.698342°	HOLE ID: BCI-17-16
CONTRACTOR: Taber	LOCATION (Offset, Station, Line)	SURFACE ELEVATION: 6.0 ft
OPERATOR'S NAME: Chad; HELPER'S NAME	EQUIPMENT: CME 55 Crawler	TOTAL DEPTH: 41.5 ft
EXCAVATION METHOD: Rotary Wash	DRILLING ROD TYPE AND DIAMETER / BUCKET WIDTH	BOREHOLE DIAMETER: 6 in
SAMPLER TYPE(S) AND SIZE(S) (ID): Shelby (2.87") and SPT (1.4")	HAMMER TYPE: Safety semi-automatic drop (140#/ 30")	HAMMER EFFICIENCY, ERi: 74%
BACKFILL AND COMPLETION: Tremie Grout Backfill	GROUND WATER READINGS: DURING 10.5 ft; AFTER (DATE)	CASING TYPE AND DIAMETER(in)

ELEVATION (ft)	DEPTH (ft)	DESCRIPTION	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests
	0	Fat CLAY with SAND (CH), Medium Stiff, Dark Brown, Moist												
	1													
4.00	2		1	500 psi		96	2.0			55 / 53	41 / 39			
	3													
2.00	4		2	2 4 4	8	100				61	45	79		
	5	Lean CLAY (CL), Stiff to Very Stiff, Brown, Moist												
0.00	6		3	550 psi		96	2.5							
	7		4	3 4 6	10	100								
-2.00	8	No recovery/Refusal												
	9		5			0								
-4.00	10													
	11	Wet	6	3 3 5	8	100				44	22	89		
-6.00	12	Switched to mud rotary at 12 ft bgs												
	13		7	2 4 6	10	100	3.75							
-8.00	14													
	15	Weak Induration												
-10.00	16		8	3 5 7	12	100	3.0							
	17													
-12.00	18													
	19													
-14.00	20	Traces of SAND												
	21		9	3 5 6	11	100								
-16.00	22													
	23	Lean CLAY with SAND (CL), Very Stiff, Olive Brown, Moist, Fine SAND, Moderate Induration												
-18.00	24													
	25													

(continued)

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME: Lookout Slough THRFIP		FILE NO.: 3195.X	HOLE ID: BCI-17-16
COUNTY: SOL	ROUTE		POSTMILE
CLIENT: Ecosystems Investment Partners			
PREPARED BY: DWC	CHECKED BY: NCH	SHEET: 1 of 2	

ELEVATION (ft)	DEPTH (ft)	Material Graphics	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Laboratory Data: Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests	Drilling Method
	25		Lean CLAY with SAND (CL) *(continued)*.		10	8 10 14	24	100	3.75								
-20.00	26																
	27																
-22.00	28																
	29																
-24.00	30		Calcite Lensing		11	6 6 8	14	100									
	31																
-26.00	32																
	33																
-28.00	34																
	35		Hard, No Calcite, No Induration		12	6 9 11	20	100	>4.5								
-30.00	36																
	37																
-32.00	38		Lean CLAY (CL), Medium Stiff, Olive Brown, Moist														
	39																
-34.00	40				13	3 3 5	8	100									
	41																
-36.00	42		Bottom of exploration at 41.5 ft below ground surface (bgs) Tremie Grout Backfill Ground water encountered at 10.5 ft bgs														
	43																
-38.00	44																
	45																
-40.00	46																
	47																
-42.00	48																
	49																
-44.00	50																
	51																
-46.00	52																
	53																
-48.00	54																
	55																

blackburn consulting

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME		FILE NO.	HOLE ID
Lookout Slough THRFIP		3195.X	BCI-17-16
COUNTY: SOL	ROUTE		POSTMILE
CLIENT: Ecosystems Investment Partners			
PREPARED BY: DWC	CHECKED BY: NCH	SHEET: 2 of 2	

LOGGED BY	BEGIN DATE	COMPLETION DATE	LOCATION (Lat/Long or North/East and Datum)	HOLE ID
DWC	11-29-17	11-29-17	38.327844° / -121.698288°	BCI-17-17

CONTRACTOR **Taber**	LOCATION (Offset, Station, Line)	SURFACE ELEVATION **6.0 ft**
OPERATOR'S NAME **Andy** HELPER'S NAME **Ra**	EQUIPMENT **CME 55 Crawler**	TOTAL DEPTH **51.5 ft**
EXCAVATION METHOD **Rotary Wash**	DRILLING ROD TYPE AND DIAMETER / BUCKET WIDTH	BOREHOLE DIAMETER **6 in**
SAMPLER TYPE(S) AND SIZE(S) (ID) **Shelby (2.87") and SPT (1.4")**	HAMMER TYPE **Safety semi-automatic drop (140#/ 30")**	HAMMER EFFICIENCY, ERi **74%**
BACKFILL AND COMPLETION **Tremie Grout Backfill**	GROUND WATER READINGS — DURING **10.0 ft** — AFTER (DATE)	CASING TYPE AND DIAMETER(in)

ELEVATION (ft)	DEPTH (ft)	DESCRIPTION	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests
	0	Fat CLAY (CH), Medium Stiff to Stiff, Dark Gray, Moist												
4.00	2		1	300 psi		50	1.25							
2.00	4	Olive Brown	2	2 4 6	10					70	52			
	5		3	700 psi										
0.00	6	Lean CLAY with SAND (CL), Very Stiff, Yellowish Brown, Moist	4	5 5 7	12									
-2.00	8													
	9		5	700 psi			3.75							
-4.00	10													
	11		6	3 5 5	10		3.0			40	18	77		
-6.00	12	Lean CLAY (CL), Very Stiff to Hard, Olive Brown, Moist Switched to mud rotary at 12 ft bgs												
	13		7	600 psi			2.5							
-8.00	14		8	7 7 11	18		>4.5							
-10.00	16													
-12.00	18	Lean CLAY with SAND (CL), Hard, Olive Brown, Moist												
-14.00	20		9	6 8 11	19		>4.5							
-16.00	22													
	23	SANDY Lean CLAY (CL), Stiff, Olive Brown, Moist												
-18.00	24													
	25													

(continued)

blackburn consulting

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	3195.X	BCI-17-17

COUNTY	ROUTE	POSTMILE
SOL		

CLIENT
Ecosystems Investment Partners

PREPARED BY	CHECKED BY	SHEET
DWC	NCH	1 of 2

Elevation (ft)	Depth (ft)	Description	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests
	25	SANDY Lean CLAY (CL) *(continued)*.	10	7 11 14	25		2.0	23		34	17	52		
	26.5	CLAYEY SAND (SC), Dense, Olive Brown, Moist												
	29.5	Lean CLAY (CL), Very Stiff, Olive Brown, Moist, Moderate Induration												
	30		11	11 15 18	33		3.75							
	35		12	6 12 16	28									
	36	CLAYEY SAND (SC), Dense, Brown, Moist												
	38.5	Lean CLAY (CL), Very Stiff, Olive Brown, Moist												
	40		13	3 4 8	12		2.25							
	45		14	5 7 9	16		2.25							
	49	Fat CLAY (CH), Very Stiff, Olive Gray, Moist												
	50		15	6 10 13	23		3.25							

Elevation scale: -20.00 (26), -22.00 (28), -24.00 (30), -26.00 (32), -28.00 (34), -30.00 (36), -32.00 (38), -34.00 (40), -36.00 (42), -38.00 (44), -40.00 (46), -42.00 (48), -44.00 (50), -46.00 (52), -48.00 (54)

Bottom of exploration at 51.5 ft below ground surface (bgs)

Tremie Grout Backfill
Ground water encountered at 10.0 ft bgs

blackburn consulting

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	3195.X	BCI-17-17
COUNTY: SOL	ROUTE:	POSTMILE:
CLIENT: Ecosystems Investment Partners		
PREPARED BY: DWC	CHECKED BY: NCH	SHEET: 2 of 2

LOGGED BY	BEGIN DATE	COMPLETION DATE	LOCATION (Lat/Long or North/East and Datum)	HOLE ID
DWC	11-29-17	11-29-17	38.328951° / -121.698216°	BCI-17-18
CONTRACTOR: Taber			LOCATION (Offset, Station, Line)	SURFACE ELEVATION: 8.0 ft
OPERATOR'S NAME: Andy	HELPER'S NAME: Ra		EQUIPMENT: CME 55 Crawler	TOTAL DEPTH: 41.5 ft
EXCAVATION METHOD: Rotary Wash			DRILLING ROD TYPE AND DIAMETER / BUCKET WIDTH	BOREHOLE DIAMETER: 6 in
SAMPLER TYPE(S) AND SIZE(S) (ID): Shelby (2.87") and SPT (1.4") and Mod Cal (2.4")			HAMMER TYPE: Safety semi-automatic drop (140#/ 30")	HAMMER EFFICIENCY, ERi: 74%
BACKFILL AND COMPLETION: Tremie Grout Backfill			GROUND WATER READINGS — DURING: 8.5 ft; AFTER (DATE):	CASING TYPE AND DIAMETER(in)

ELEVATION (ft)	DEPTH (ft)	DESCRIPTION	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests
	0	Fat CLAY with SAND (CH), Stiff, Dark Gray, Moist												
6.00	2		1	300 psi										
4.00	4		2	2 2 4	6		1.75	27		63	45	83		
2.00	6	Lean CLAY with SAND (CL), Dense, Yellowish Brown, Moist	3	600 psi			2.25 2.25			46	29	59		
	7		4	7 17 19	36		3.0							
0.00	8	SANDY SILT (ML), Very Stiff, Brown, Moist	5	6 14 12	26		3.5	36	90	35	10	67		
-2.00	10	Switched to mud rotary at 9.5 ft bgs	6	2 5 7	12		2.25							
-4.00	12	Lean CLAY (CL), Stiff to Very Stiff, Olive Brown, Moist	7	500 psi			3.0							
-6.00	14		8	3 5 5	10		1.0							
-8.00	16	Yellowish Brown	9	400 psi			2.75							
-10.00	18													
-12.00	20		10	5 8 10	18		2.75 1.25							
-14.00	22	SANDY Lean CLAY (CL), Stiff, Brown, Moist, Fine SAND												
-16.00	24	Lean CLAY (CL), Hard, Dark Yellowish Brown, Moist												
	25													

Laboratory Data

(continued)

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	3195.X	BCI-17-18
COUNTY: SOL	ROUTE	POSTMILE
CLIENT: Ecosystems Investment Partners		
PREPARED BY: DWC	CHECKED BY: NCH	SHEET: 1 of 2

ELEVATION (ft)	DEPTH (ft)	Material Graphics	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests	Drilling Method
	25		Lean CLAY (CL) *(continued)*.		11	7 11 17	28		4.25								
-18.00	26																
	27																
-20.00	28																
	29																
-22.00	30				12	4 6 8	14		>4.5								
	31																
-24.00	32																
	33		SANDY Lean CLAY (CL), Stiff, Brown to Olive, Moist, Very Fine SAND														
-26.00	34																
	35				13	6 9 10	19			30		34	12	67			
-28.00	36																
	37																
-30.00	38																
	39																
-32.00	40				14	3 7 9	16		1.75								
	41																
-34.00	42		Bottom of exploration at 41.5 ft below ground surface (bgs) Tremie Grout Backfill Ground water encountered at 8.5 ft bgs														
	43																
-36.00	44																
	45																
-38.00	46																
	47																
-40.00	48																
	49																
-42.00	50																
	51																
-44.00	52																
	53																
-46.00	54																
	55																

Laboratory Data: Moisture Content through Additional Lab Tests.

blackburn consulting

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	**3195.X**	**BCI-17-18**
COUNTY: **SOL**	ROUTE:	POSTMILE:
CLIENT: **Ecosystems Investment Partners**		
PREPARED BY: **DWC**	CHECKED BY: **NCH**	SHEET: **2 of 2**

LOGGED BY	BEGIN DATE	COMPLETION DATE	LOCATION (Lat/Long or North/East and Datum)	HOLE ID
RMS	11-30-17	11-30-17	38.328327° / -121.695365°	BCI-17-19

Field	Value	Field	Value	Field	Value
CONTRACTOR	Taber	LOCATION (Offset, Station, Line)		SURFACE ELEVATION	7.0 ft
OPERATOR'S NAME	Andy	EQUIPMENT	CME 55 Crawler	TOTAL DEPTH	51.5 ft
HELPER'S NAME					
EXCAVATION METHOD	Rotary Wash	DRILLING ROD TYPE AND DIAMETER / BUCKET WIDTH		BOREHOLE DIAMETER	6 in
SAMPLER TYPE(S) AND SIZE(S) (ID)	Shelby (2.87") and SPT (1.4")	HAMMER TYPE	Safety semi-automatic drop (140#/ 30")	HAMMER EFFICIENCY, ERi	74%
BACKFILL AND COMPLETION	Tremie Grout Backfill	GROUND WATER READINGS	DURING 8.0 ft; AFTER (DATE)	CASING TYPE AND DIAMETER(in)	

ELEVATION (ft)	DEPTH (ft)	DESCRIPTION	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests
	0	Lean CLAY (CL), Stiff, Very Dark Gray, Moist												
5.00	2		1	700 psi		96	1.5							
3.00	4		2	15 18 19	37	100				35	12			
	5	CLAYEY SAND (SC), Medium Dense, Dark Yellowish Brown, Moist, Fine SAND	3	700 psi		100	4.0							
1.00	6		4	4 4 6	10	100				34	17	35		
	7	SANDY Lean CLAY (CL), Stiff, Dark Yellowish Brown, Moist, Fine SAND												
-1.00	8		5	700 psi		0								
	9		6	5 14 19	33	100	>4.5							
-3.00	10	Hard Switched to mud rotary at 10 ft bgs	7			100								
	11	Lean CLAY (CL), Hard, Dark Yellowish Brown, Moist	8	700 psi 10 14 15	29	100	4.5							
-5.00	12		9	6 12 15	27	100								
	13	Wet												
-7.00	14													
	15	CLAYEY SAND (SC), Dense, Olive Brown, Moist												
-9.00	16		10	9 9 11	20	100	3.5	28	93	39	18	37		
	16	Lean CLAY (CL), Very Stiff, Olive Brown, Moist												
	17													
-11.00	18													
	19													
-13.00	20													
	21		11	7 7 16	23	100								
-15.00	22													
	23													
-17.00	24													
	25													

(continued)

blackburn consulting

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	3195.X	BCI-17-19
COUNTY: SOL	ROUTE:	POSTMILE:
CLIENT: Ecosystems Investment Partners		
PREPARED BY: DWC	CHECKED BY: NCH	SHEET: 1 of 2

ELEVATION (ft)	DEPTH (ft)	Material Graphics	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Laboratory Data: Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests	Drilling Method
	25		Lean CLAY (CL) *(continued)*, Hard, Weak Induration		12	8 10 16	26	100	>4.5								
-19.00	26																
	27																
-21.00	28																
	29																
-23.00	30		No Induration		13	11 8 11	19	100									
	31																
-25.00	32																
	33																
-27.00	34																
	35				14	9 10 16	26	100	2.8								
-29.00	36																
	37																
-31.00	38		Poorly-graded SAND with CLAY (SP-SC), Dense, Olive Brown, Moist, Fine SAND														
	39																
-33.00	40				15	7 12 14	26	100									
	41																
-35.00	42																
	43																
-37.00	44																
	45		SANDY SILT (ML), Medium Stiff, Olive Brown, Moist		16	9 10 12	22	100				35	9	58			
-39.00	46																
	47																
-41.00	48		CLAYEY SAND (SC), Medium Dense, Dark Yellowish Brown, Wet, Fine SAND														
	49																
-43.00	50				17	9 9 12	21	100						19			
	51																
-45.00	52		Bottom of exploration at 51.5 ft below ground surface (bgs)														
	53		Tremie Grout Backfill Ground water encountered at 8.0 ft bgs														
-47.00	54																
	55																

blackburn consulting

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	3195.X	BCI-17-19

COUNTY	ROUTE	POSTMILE
SOL		

CLIENT
Ecosystems Investment Partners

PREPARED BY	CHECKED BY	SHEET
DWC	NCH	2 of 2

LOGGED BY	BEGIN DATE	COMPLETION DATE	LOCATION (Lat/Long or North/East and Datum)	HOLE ID
RMS	**11-30-17**	**11-30-17**	**38.328948° / -121.695318°**	**BCI-17-20**

CONTRACTOR **Taber**	LOCATION (Offset, Station, Line)	SURFACE ELEVATION **8.0 ft**
OPERATOR'S NAME **Andy** HELPER'S NAME	EQUIPMENT **CME 55 Crawler**	TOTAL DEPTH **41.5 ft**
EXCAVATION METHOD **Rotary Wash**	DRILLING ROD TYPE AND DIAMETER / BUCKET WIDTH	BOREHOLE DIAMETER **6 in**
SAMPLER TYPE(S) AND SIZE(S) (ID) **Shelby (2.87") and SPT (1.4")**	HAMMER TYPE **Safety semi-automatic drop (140#/ 30")**	HAMMER EFFICIENCY, ERi **74%**
BACKFILL AND COMPLETION **Tremie Grout Backfill**	GROUND WATER READINGS DURING **5.0 ft** AFTER (DATE)	CASING TYPE AND DIAMETER(in)

ELEVATION (ft)	DEPTH (ft)	DESCRIPTION	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests
	0	Fat CLAY (CH), Very Stiff, Very Dark Gray, Moist												
	1													
6.00	2		1	500 psi		100	3.25 2.25							
	3	Lean CLAY with SAND (CL), Very Stiff, Olive Brown, Moist												
4.00	4		2	3 6 15	21	100				44	19	71		
	5													
2.00	6	Hard, Strongly Cemented Switched to mud rotary at 6 ft bgs	3	700 psi		44	>4.5							
	7													
0.00	8	CLAYEY SAND with GRAVEL (SC), Dense, Yellowish Brown, Moist												
	9		4	700 psi		100	2.25			38	20	45		
-2.00	10													
	11	Lean CLAY (CL), Stiff, Yellowish Brown, Moist												
-4.00	12													
	13		5	4 8 10	18	100								
-6.00	14													
	15		6	700 psi		100	2.0							
-8.00	16													
	17													
-10.00	18													
	19													
-12.00	20													
	21		7	7 11 14	25									
-14.00	22													
	23													
-16.00	24													
	25													

(continued)

blackburn consulting

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	**3195.X**	**BCI-17-20**
COUNTY **SOL**	ROUTE	POSTMILE
CLIENT **Ecosystems Investment Partners**		
PREPARED BY **DWC**	CHECKED BY **NCH**	SHEET **1 of 2**

ELEVATION (ft)	DEPTH (ft)	DESCRIPTION	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests
-18.00	25–30	SANDY Lean CLAY (CL), Stiff, Yellowish Brown, Moist, Medium to Coarse Grain SAND	8	10 18 21	39									
-22.00	30–33.5	SILTY SAND (SM), Medium Dense, Light Brown, Wet	9	6 7 9	16	100				NP	NP	35		
-26.00	33.5–37	SANDY SILT (ML), Medium Stiff, Gray, Moist	10	4 6 14	20	100				38	9	56		
-29.00	37–41.5	Poorly-graded SAND with SILT (SP-SM), Dense, Brown, Wet	11	10 13 14	27	100						8		

Bottom of exploration at 41.5 ft below ground surface (bgs)

Tremie Grout Backfill
Ground water encountered at 5.0 ft bgs

Elevation scale: -18.00 (26), -20.00 (28), -22.00 (30), -24.00 (32), -26.00 (34), -28.00 (36), -30.00 (38), -32.00 (40), -34.00 (42), -36.00 (44), -38.00 (46), -40.00 (48), -42.00 (50), -44.00 (52), -46.00 (54); Depth 25–55 ft

blackburn consulting
Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	3195.X	BCI-17-20
COUNTY: SOL	ROUTE	POSTMILE
CLIENT: Ecosystems Investment Partners		
PREPARED BY: DWC	CHECKED BY: NCH	SHEET: 2 of 2

LOGGED BY	BEGIN DATE	COMPLETION DATE	LOCATION (Lat/Long or North/East and Datum)	HOLE ID
DWC	6-18-18	6-18-18	38.328876° / -121.7023°	BCI-18-21
CONTRACTOR			LOCATION (Offset, Station, Line)	SURFACE ELEVATION
Taber				8.0 ft
OPERATOR'S NAME	HELPER'S NAME		EQUIPMENT	TOTAL DEPTH
Toby			CME 55 Crawler	51.5 ft
EXCAVATION METHOD			DRILLING ROD TYPE AND DIAMETER / BUCKET WIDTH	BOREHOLE DIAMETER
Rotary Wash				6 in
SAMPLER TYPE(S) AND SIZE(S) (ID)			HAMMER TYPE	HAMMER EFFICIENCY, ERi
Shelby (2.87") and SPT (1.4") and Mod Cal (2.4")			Safety semi-automatic drop (140#/ 30")	91%
BACKFILL AND COMPLETION			GROUND WATER READINGS: DURING 9.5 ft; AFTER (DATE)	CASING TYPE AND DIAMETER(in)
Tremie Grout Backfill				

ELEVATION (ft)	DEPTH (ft)	DESCRIPTION	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests
	0	Fat CLAY (CH), Medium Stiff, Very Dark Grayish Brown, Moist												
6.00	1–2		1	3 2 3	5									
4.00	4													
2.00	5–6	Lean CLAY (CL), Very Stiff, Mottled Dark Brown and Bluish Gray, Moist, Some Strong Cementation	2	5 7 11	18		2.25							
	6.5–7.5		3	6 7 7	14		3.25							
0.00	7.5–8	SILTY CLAY (CL-ML), Very Stiff, Dark Yellowish Brown, Moist, Some Moderate Cementation												
-2.00	10–12		4	650 psi										
-4.00	12	Switched to mud rotary at 12 ft bgs												
-6.00	13–14	Lean CLAY (CL), Very Stiff to Hard, Dark Yellowish Brown, Moist												
-8.00	15–16.5		5	7 10 15	25		3.5							
	16.5–18		6	7 8 12	20		>4.5							
-10.00	18													
-12.00	20–21.5	Hard, Olive Brown, Moist, Medium to High Plasticity	7	7 17 22	39		>4.5							
-14.00	22													
-16.00	24–25													

(continued)

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	3195.X	BCI-18-21
COUNTY: SOL	ROUTE	POSTMILE
CLIENT: Ecosystems Investment Partners		
PREPARED BY: DWC	CHECKED BY: NCH	SHEET: 1 of 2

ELEVATION (ft)	DEPTH (ft)	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests	Drilling Method
	25	Lean CLAY (CL) *(continued)*, Dark Yellowish Brown, Medium Plasticity		8	8 12 14	26		>4.5								
-18.00	26															
	27															
-20.00	28															
	29															
-22.00	30	Very Stiff, Some Weak Cementation		9	10 13 18	31		3.5								
	31															
-24.00	32															
	33	CLAYEY SAND (SC), Medium Dense, Dark Yellowish Brown, Wet, Approximately 35% Fines, Fine SAND														
-26.00	34															
	35			10	4 6 7	13										
-28.00	36															
	37															
-30.00	38	Lean CLAY (CL), Very Stiff to Hard, Olive Brown, Moist														
	39															
-32.00	40			11	8 9 9	18		3.5								
	41															
-34.00	42															
	43															
-36.00	44															
	45			12	4 6 8	14		4.25								
-38.00	46															
	47															
-40.00	48															
	49															
-42.00	50			13	7 10 14	24		3.75								
	51															
-44.00	52	Bottom of exploration at 51.5 ft below ground surface (bgs) Tremie Grout Backfill Ground water encountered at 9.5 ft bgs														
	53															
-46.00	54															
	55															

blackburn consulting
Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	3195.X	BCI-18-21
COUNTY: SOL	ROUTE:	POSTMILE:
CLIENT: Ecosystems Investment Partners		
PREPARED BY: DWC	CHECKED BY: NCH	SHEET: 2 of 2

LOGGED BY: DWC	BEGIN DATE: 5-30-18	COMPLETION DATE: 5-30-18	LOCATION (Lat/Long or North/East and Datum): 38.328871° / -121.706676°	HOLE ID: BCI-18-22
CONTRACTOR: Taber			LOCATION (Offset, Station, Line)	SURFACE ELEVATION: 8.0 ft
OPERATOR'S NAME: Toby	HELPER'S NAME		EQUIPMENT: CME 55 Crawler	TOTAL DEPTH: 51.5 ft
EXCAVATION METHOD: Rotary Wash			DRILLING ROD TYPE AND DIAMETER / BUCKET WIDTH	BOREHOLE DIAMETER: 6 in
SAMPLER TYPE(S) AND SIZE(S) (ID): SPT (1.4") and Cal Mod (2.4")			HAMMER TYPE: Safety semi-automatic drop (140#/ 30")	HAMMER EFFICIENCY, ERi: 91%
BACKFILL AND COMPLETION: Tremie Grout Backfill			GROUND WATER READINGS — DURING: 7.0 ft; AFTER (DATE)	CASING TYPE AND DIAMETER(in)

ELEVATION (ft)	DEPTH (ft)	DESCRIPTION	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests
	0	Fat CLAY (CH), Medium Stiff, Very dark gray, Moist												
6.00	2		1	2 3 3	6					64	45			
4.00	4													
2.00	6		2	5 9 8	17		2.0							
	6	Lean CLAY with SAND (CL), Stiff, Dark yellowish brown, Moist												
	7	SANDY Lean CLAY (CL), Very Stiff, Dark yellowish brown, Wet	3	5 3 3	6		2.25							
0.00	8		4	3 4 7	11							55		
-2.00	10	CLAYEY SAND (SC), Loose, Dark yellowish brown, Wet Switched to mud rotary at 8 ft bgs	5	3 3 4	7							43		
-4.00	11	Lean CLAY (CL), Medium Stiff, Dark yellowish brown, Wet, Moderate cementation	6	4 6 6	12									
-6.00	14		7	3 3 6	9		2.25							
-8.00	16	Very Stiff to Hard	8	3 4 5	9									
-10.00	18		9	5 10 16	26		>4.5							
	19		10	7 8 9	17									
-12.00	20		11	9 11 14	25									
-14.00	22													
-16.00	24													
	25													

(continued)

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME: Lookout Slough THRFIP		FILE NO.: 3195.X	HOLE ID: BCI-18-22
COUNTY: SOL	ROUTE		POSTMILE
CLIENT: Ecosystems Investment Partners			
PREPARED BY: DWC	CHECKED BY: NCH	SHEET: 1 of 2	

ELEVATION (ft)	DEPTH (ft)	Material Graphics	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests	Drilling Method
	25		Lean CLAY (CL) *(continued)*.		12	7 12 14	26		>4.5								
-18.00	26																
	27																
-20.00	28																
	29		SANDY Lean CLAY (CL), Very Stiff, Brown, Moist														
-22.00	30				13	5 4 9	13		2.75					62			
	31																
-24.00	32																
	33																
-26.00	34																
	35				14	9 10 9	19		2.5								
-28.00	36		Lean CLAY (CL), Very Stiff, Brown, Moist														
	37																
-30.00	38																
	39																
-32.00	40				15	4 6 8	14										
	41																
-34.00	42																
	43																
-36.00	44																
	45		Hard		16	4 4 5	9		>4.5								
-38.00	46																
	47																
-40.00	48																
	49																
-42.00	50				17	5 7 10	17										
	51																
-44.00	52		Bottom of exploration at 51.5 ft below ground surface (bgs)														
	53		Tremie Grout Backfill Ground water encountered at 7.0 ft bgs														
-46.00	54																
	55																

Laboratory Data

blackburn consulting

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	3195.X	BCI-18-22
COUNTY: SOL	ROUTE:	POSTMILE:
CLIENT: Ecosystems Investment Partners		
PREPARED BY: DWC	CHECKED BY: NCH	SHEET: 2 of 2

LOGGED BY	BEGIN DATE	COMPLETION DATE	LOCATION (Lat/Long or North/East and Datum)	HOLE ID
DWC	**5-30-18**	**5-30-18**	**38.328798° / -121.70899°**	**BCI-18-23**
CONTRACTOR **Taber**			LOCATION (Offset, Station, Line)	SURFACE ELEVATION **8.0 ft**
OPERATOR'S NAME **Toby**	HELPER'S NAME		EQUIPMENT **CME 55 Crawler**	TOTAL DEPTH **51.5 ft**
EXCAVATION METHOD **Rotary Wash**			DRILLING ROD TYPE AND DIAMETER / BUCKET WIDTH	BOREHOLE DIAMETER **6 in**
SAMPLER TYPE(S) AND SIZE(S) (ID) **SPT (1.4") and Cal Mod (2.4")**			HAMMER TYPE **Safety semi-automatic drop (140#/ 30")**	HAMMER EFFICIENCY, ERi **91%**
BACKFILL AND COMPLETION **Tremie Grout Backfill**			GROUND WATER READINGS DURING **14.5 ft** AFTER (DATE)	CASING TYPE AND DIAMETER(in)

ELEVATION (ft)	DEPTH (ft)	DESCRIPTION	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests
	0	Lean to Fat CLAY (CL/CH), Soft, Dark brown, Moist												
6.00	1–2		1	2 2 3	5									
	2.5	Lean CLAY (CL), Med Stiff, Light brown, Moist, moderate cementation												
2.00	5–6		2	3 4 6	10									
	6.5–8		3	2 4 6	10									
0.00	8–9.5	Some organics, Trace SAND, Dark yellowish brown	4	5 7 8	15									
-2.00	9.5–11	Lean CLAY with SAND (CL), Stiff, Brown, Moist	5	3 5 6	11		1.25			42	24	79		
	10.5	Lean CLAY (CL), Stiff, Brown, Moist, Trace SAND												
-4.00	11–12.5		6	4 8 10	18									
	12.5–14		7	3 4 4	8		1.25			42	22	95		
-6.00	14–15.5		8	4 6 7	13									
-8.00	15.5–17	Switched to mud rotary at 15.5 ft bgs	9	2 4 4	8									
-10.00	17–18.5	Very Stiff to Hard	10	9 12 16	28		4.0							
	18.5–20		11	5 8 12	20									
-12.00	20													
-14.00	22													
-16.00	24													
	25													

(continued)

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	**3195.X**	**BCI-18-23**
COUNTY **SOL**	ROUTE	POSTMILE
CLIENT **Ecosystems Investment Partners**		
PREPARED BY **DWC**	CHECKED BY **NCH**	SHEET **1 of 2**

ELEVATION (ft)	DEPTH (ft)	DESCRIPTION	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests
	25	Lean CLAY (CL) *(continued)*, Hard, Some Organics, Weak Cementation	12	7 9 10	19									
-18.00	26													
	27													
-20.00	28													
	29													
-22.00	30	More SAND	13	4 6 6	12		2.0							
	31	Very Stiff, Weak to moderate cementation												
-24.00	32													
	33													
-26.00	34													
	35		14	6 7 9	16		1.25							
-28.00	36	Lean to Fat CLAY (CL/CH), Stiff, Brown, Moist												
	37													
-30.00	38													
	39													
-32.00	40	Mottled orange brown	15	4 5 7	12									
	41													
-34.00	42													
	43													
-36.00	44													
	45		16	4 5 7	12									
-38.00	46													
	47													
-40.00	48	Lean CLAY (CL), Medium Stiff, Dark yellowish brown, Moist												
	49													
-42.00	50		17	6 6 9	15									
	51													
-44.00	52	Bottom of exploration at 51.5 ft below ground surface (bgs)												
	53	Tremie Grout Backfill Ground water encountered at 14.5 ft bgs												
-46.00	54													
	55													

Columns also include Material Graphics, Sample Location and Drilling Method (graphic only). Laboratory Data.

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	3195.X	BCI-18-23
COUNTY: SOL	ROUTE	POSTMILE
CLIENT: Ecosystems Investment Partners		
PREPARED BY: DWC	CHECKED BY: NCH	SHEET: 2 of 2

LOGGED BY	BEGIN DATE	COMPLETION DATE	LOCATION (Lat/Long or North/East and Datum)	HOLE ID
NCH	**5-31-18**	**5-31-18**	**38.325621° / -121.711625°**	**BCI-18-24**
CONTRACTOR **Taber**			LOCATION (Offset, Station, Line)	SURFACE ELEVATION **6.0 ft**
OPERATOR'S NAME **Toby**	HELPER'S NAME		EQUIPMENT **CME 55 Crawler**	TOTAL DEPTH **51.5 ft**
EXCAVATION METHOD **Rotary Wash**			DRILLING ROD TYPE AND DIAMETER / BUCKET WIDTH	BOREHOLE DIAMETER **6 in**
SAMPLER TYPE(S) AND SIZE(S) (ID) **SPT (1.4") and Cal Mod (2.4")**			HAMMER TYPE **Safety semi-automatic drop (140#/ 30")**	HAMMER EFFICIENCY, ERi **91%**
BACKFILL AND COMPLETION **Tremie Grout Backfill**			GROUND WATER READINGS DURING **10.5 ft** AFTER (DATE)	CASING TYPE AND DIAMETER(in)

ELEVATION (ft)	DEPTH (ft)	DESCRIPTION	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests
	0	Fat CLAY (CH), Medium Stiff, Dark brown, Moist												
4.00	1–2		1	2 2 3	5		1.0			58	40	94		
2.00	3–4													
0.00	5	Lean CLAY (CL), Stiff, Light brown, Moist	2	4 6 5	11									
	6.5		3	2 4 3	7		1.5							
-2.00	8	Lean CLAY with SAND (CL), Medium Stiff, Light brown with gray streaks, Moist	4	3 4 5	9		1.0					83		
-4.00	9.5	Lean CLAY (CL), Stiff to Very Stiff, Light brown, Moist to wet	5	4 9 9	18		2.5					94		
-6.00	11		6	3 4 4	8		1.75							
	12.5	Switched to mud rotary at 12.5 ft bgs Wet	7	3 4 6	10									
-8.00	14		8	3 4 4	8		1.25			47	26	95		
-10.00 / -12.00	16–18													
-14.00	19	Lean CLAY with SAND (CL), Very Stiff, Light brown with gray mottling, Moist, Approximately 30% fines												
	20		9	6 12 10	22		4.0							
-16.00 / -18.00	22–25													

(continued)

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	**3195.X**	**BCI-18-24**
COUNTY **SOL**	ROUTE	POSTMILE
CLIENT **Ecosystems Investment Partners**		
PREPARED BY **NCH**	CHECKED BY **DWC**	SHEET **1 of 2**

ELEVATION (ft)	DEPTH (ft)	Material Graphics	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests	Drilling Method
	25		Lean CLAY with SAND (CL) *(continued)*, With cementation	X	10	8 13 14	27		4.5								
-20.00	26																
	27																
-22.00	28																
	29																
-24.00	30		CLAYEY SAND (SC), Loose, Light brown with gray mottling, Moist	X	11	3 4 3	7							48			
	31																
-26.00	32																
	33																
-28.00	34																
	35		SANDY Lean CLAY (CL), Stiff, Light brown, Moist, Some cementation	X	12	7 9 8	17										
-30.00	36																
	37																
-32.00	38		CLAYEY SAND (SC), Medium Dense, Dark brown, Wet														
	39																
-34.00	40		SANDY Lean CLAY (CL), Stiff, Light brown with gray mottling, Moist	X	13	5 7 8	15		1.25								
	41																
-36.00	42																
	43																
-38.00	44		Lean CLAY with SAND (CL), Stiff, Grey with brown mottling, Moist, Little weak cementation														
	45			X	14	3 6 6	12		2.0								
-40.00	46																
	47																
-42.00	48																
	49																
-44.00	50			X	15	6 7 10	17										
	51																
-46.00	52		Bottom of exploration at 51.5 ft below ground surface (bgs) Tremie Grout Backfill Ground water encountered at 10.5 ft bgs														
	53																
-48.00	54																
	55																

Laboratory Data: Moisture Content (%), Dry Density (pcf), Liquid Limit, Plasticity Index, % <#200, Shear Strength Test, Additional Lab Tests

blackburn consulting

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	3195.X	BCI-18-24
COUNTY: SOL	ROUTE:	POSTMILE:
CLIENT: Ecosystems Investment Partners		
PREPARED BY: NCH	CHECKED BY: DWC	SHEET: 2 of 2

LOGGED BY	BEGIN DATE	COMPLETION DATE	LOCATION (Lat/Long or North/East and Datum)	HOLE ID
DWC	**6-12-18**	**6-12-18**	**38.316932° / -121.71988°**	**BCI-18-25**

CONTRACTOR	LOCATION (Offset, Station, Line)	SURFACE ELEVATION
Taber		**6.0 ft**

OPERATOR'S NAME	HELPER'S NAME	EQUIPMENT	TOTAL DEPTH
Toby		**CME 55 Crawler**	**51.5 ft**

EXCAVATION METHOD	DRILLING ROD TYPE AND DIAMETER / BUCKET WIDTH	BOREHOLE DIAMETER
Rotary Wash		**6 in**

SAMPLER TYPE(S) AND SIZE(S) (ID)	HAMMER TYPE	HAMMER EFFICIENCY, ERi
SPT (1.4") and Cal Mod (2.4")	**Safety semi-automatic drop (140#/ 30")**	**91%**

BACKFILL AND COMPLETION	GROUND WATER READINGS	DURING	AFTER (DATE)	CASING TYPE AND DIAMETER(in)
Tremie Grout Backfill		**12.0 ft**		

ELEVATION (ft)	DEPTH (ft)	Material Graphics	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Laboratory Data: Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests	Drilling Method
	0		Fat CLAY (CH), Medium Stiff, Dark brown, Moist														
	1																
4.00	2				1	4 4 3	7					52	36				
	3		SANDY Lean CLAY (CL), Stiff, Yellowish brown, Moist, 35% Sand		2							32	16				
2.00	4																
	5				3	10 14 16	30										
0.00	6				4	5 7 8	15										
	7																
-2.00	8		CLAYEY SAND (SC), Dense, Brown, Moist, Moderate to strong cementation		5	6 12 25	37										
	9		Lean CLAY (CL), Hard, Olive brown, Moist		6	12 13 13	26		>4.5								
-4.00	10																
	11		CLAYEY SAND (SC), Medium Dense, Brown, Moist to wet		7	5 15 14	29										
-6.00	12				8	3 7 9	16		>4.5								
	13		Lean CLAY (CL), Hard, Brown, Moist Switched to mud rotary at 13 ft bgs														
-8.00	14																
	15				9	5 5 8	13										
-10.00	16		SANDY Lean CLAY (CL), Stiff, Brown, Wet		10	3 4 5	9		1.75								
	17				11	4 7 9	16										
-12.00	18		Lenses of CLAYEY SAND														
	19				12	6 14 16	30										
-14.00	20		CLAYEY SAND/ SANDY Lean CLAY (SC/CL), Dense/ Very Stiff, Brown, Moist, Moderately cemented		13	11 20 23	43										
	21																
-16.00	22		Very Dense/ Hard		14	11 39 50	89										
	23																
-18.00	24		Lean CLAY with SAND (CL), Hard, Yellowish brown, Moist		15	9 13 16	29										
	25				16		19		4.0								

(continued)

blackburn consulting

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	**3195.X**	**BCI-18-25**

COUNTY	ROUTE	POSTMILE
SOL		

CLIENT
Ecosystems Investment Partners

PREPARED BY	CHECKED BY	SHEET
LDM	**DWC**	**1 of 2**

ELEVATION (ft)	DEPTH (ft)	Material Graphics	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests	Drilling Method
	25		Lean CLAY with SAND (CL) *(continued)*.		16	5 9 10	19		4.0								
-20.00	26																
	27																
-22.00	28																
	29																
-24.00	30				17	6 8 11	19		>4.5								
	31																
-26.00	32																
	33		Lean CLAY (CL), Hard, Olive gray, Moist														
-28.00	34																
	35				18	7 15 19	34		>4.5								
-30.00	36																
	37																
-32.00	38																
	39		SANDY Lean CLAY (CL), Soft, Brown, Wet, Very fine SAND														
-34.00	40				19	5 10 15	25										
	41																
-36.00	42																
	43																
-38.00	44		Lean CLAY (CL); [Medium Stiff]; Olive brown; Moist														
	45				20	6 8 8	16										
-40.00	46																
	47																
-42.00	48		Hard, Gray, Moist														
	49																
-44.00	50				21	7 9 12	21		4.0								
	51																
-46.00	52		Bottom of exploration at 51.5 ft below ground surface (bgs)														
	53		Tremie Grout Backfill Ground water encountered at 12.0 ft bgs														
-48.00	54																
	55																

Laboratory Data

blackburn consulting

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	3195.X	BCI-18-25

COUNTY	ROUTE	POSTMILE
SOL		

CLIENT
Ecosystems Investment Partners

PREPARED BY	CHECKED BY	SHEET
LDM	DWC	2 of 2

LOGGED BY	BEGIN DATE	COMPLETION DATE	LOCATION (Lat/Long or North/East and Datum)	HOLE ID
NCH	**5-31-18**	**5-31-18**	**38.308766° / -121.728381°**	**BCI-18-26**

CONTRACTOR **Taber**	LOCATION (Offset, Station, Line)	SURFACE ELEVATION **7.0 ft**
OPERATOR'S NAME **Toby** / HELPER'S NAME	EQUIPMENT **CME 55 Crawler**	TOTAL DEPTH **51.5 ft**
EXCAVATION METHOD **Rotary Wash**	DRILLING ROD TYPE AND DIAMETER / BUCKET WIDTH	BOREHOLE DIAMETER **6 in**
SAMPLER TYPE(S) AND SIZE(S) (ID) **SPT (1.4") and Cal Mod (2.4")**	HAMMER TYPE **Safety semi-automatic drop (140#/ 30")**	HAMMER EFFICIENCY, ERi **91%**
BACKFILL AND COMPLETION **Tremie Grout Backfill**	GROUND WATER READINGS DURING **9.5 ft** AFTER (DATE) **5'**	CASING TYPE AND DIAMETER(in)

ELEVATION (ft)	DEPTH (ft)	DESCRIPTION	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests
	0	Fat CLAY (CH), Very Stiff, Dark brown, Moist, Some minor roots												
5.00	1–2		1	4 5 5	10		2.5			57	39			
3.00	3	Fat CLAY with SAND (CH), Very Stiff, Dark brown, Moist												
1.00	5–6		2	4 8 12	20		2.75			50	32	86		
	6–7	SANDY Lean CLAY (CL), Stiff, Brown with gray mottling, Dry to moist	3	6 8 7	15									
-1.00	8–9	Hard, Strong cementation	4	25 26 11	37									
-3.00	9.5	▽												
	9–10	Poorly-graded SAND with SILT (SP-SM), Loose to Medium Dense, Dark brown, Moist to wet Switched to mud rotary at 9.5 ft bgs	5	2 3 3	6									
-5.00	11–12		6	3 5 10	15							9		
	12–13	SILTY SAND (SM), Dense, Brown with gray mottling, Moist	7	3 12 17	29									
-7.00	14–15	Cementation, with GRAVEL	8	24 27 30	57									
-9.00	15–16		9	7 9 7	16							24		
-11.00	17	SANDY Lean CLAY (CL), Stiff, Light brown with gray mottling, Moist												
-13.00	20–21		10	5 7 7	14									
-15.00	22													
-17.00	24													
	25													

(continued)

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	**3195.X**	**BCI-18-26**
COUNTY **SOL**	ROUTE	POSTMILE
CLIENT **Ecosystems Investment Partners**		
PREPARED BY **NCH**	CHECKED BY **DWC**	SHEET **1 of 2**

ELEVATION (ft)	DEPTH (ft)	Material Graphics	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests	Drilling Method
	25		Lean CLAY (CL), Stiff, Light brown with gray mottling, Moist		11	6 6 9	15										
-19.00	26																
	27																
-21.00	28																
	29																
-23.00	30				12	3 4 5	9										
	31																
-25.00	32		Lean CLAY with SAND (CL), Medium Stiff, Light brown, Moist to wet														
	33																
-27.00	34																
	35				13	3 5 8	13										
-29.00	36		CLAYEY SAND (SC), Medium Dense, Brown, Moist to wet														
	37																
-31.00	38																
	39																
-33.00	40				14	2 3 5	8										
	41		SANDY SILT (ML), Medium Stiff, Light brown with gray mottling, Moist to wet														
-35.00	42																
	43																
-37.00	44																
	45		CLAYEY GRAVEL (GC), Medium Dense, Brown, Wet		15	3 10 17	27										
-39.00	46																
	47																
-41.00	48																
	49																
-43.00	50		Well Graded GRAVEL with SAND (GW), Medium Dense, Brown, Wet		16	12 16 12	28							8			
	51																
-45.00	52		Bottom of exploration at 51.5 ft below ground surface (bgs) Tremie Grout Backfill Ground water encountered at 9.5 ft bgs, rose to 5 ft bgs														
	53																
-47.00	54																
	55																

blackburn consulting

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME Lookout Slough THRFIP	FILE NO. 3195.X	HOLE ID BCI-18-26
COUNTY SOL	ROUTE	POSTMILE
CLIENT Ecosystems Investment Partners		
PREPARED BY NCH	CHECKED BY DWC	SHEET 2 of 2

LOGGED BY	BEGIN DATE	COMPLETION DATE	LOCATION (Lat/Long or North/East and Datum)	HOLE ID
DWC	6-1-18	6-1-18	38.308019° / -121.727468°	BCI-18-27
CONTRACTOR: Taber			LOCATION (Offset, Station, Line)	SURFACE ELEVATION: 6.5 ft
OPERATOR'S NAME: Toby	HELPER'S NAME		EQUIPMENT: CME 55 Crawler	TOTAL DEPTH: 56.5 ft
EXCAVATION METHOD: Rotary Wash			DRILLING ROD TYPE AND DIAMETER / BUCKET WIDTH	BOREHOLE DIAMETER: 6 in
SAMPLER TYPE(S) AND SIZE(S) (ID): SPT (1.4") and Cal Mod (2.4")			HAMMER TYPE: Safety semi-automatic drop (140#/ 30")	HAMMER EFFICIENCY, ERi: 91%
BACKFILL AND COMPLETION: Tremie Grout Backfill			GROUND WATER READINGS — DURING: 16.0 ft; AFTER (DATE)	CASING TYPE AND DIAMETER(in)

ELEVATION (ft)	DEPTH (ft)	DESCRIPTION	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests
	0	Fat CLAY (CH), Medium Stiff, black, Moist												
4.50	2	Lean CLAY (CL), Medium Stiff, Dark yellowish brown, Moist	1	3 3 3	6					40	27			
0.50	6	Lean CLAY with SAND (CL), Hard, Dark yellowish brown, Moist	2	4 8 13	21									
	7		3	6 11 20	31		>4.5							
	9	Strong cementation	4	24 39 46	85		4.5							
-3.50	10	Very Stiff; Weak cementation	5	7 8 9	17		3.5							
-5.50	12		6	5 8 9	17					38	19	74		
	13		7	5 6 10	16		>4.5							
-7.50	14	SANDY Lean CLAY (CL), Hard, Dark yellowish brown, Moist to Wet, Strong cementation	8	7 13 15	28									
-9.50	16		9	4 6 7	13		1.0			35	18	50		
-11.50	18	CLAYEY SAND (SC), Medium Dense, Dark yellowish brown, Moist, Strong cementation												
-13.50	20	Lean CLAY (CL), Hard, Dark yellowish brown, Moist	10	8 7 6	13		4.0							
-15.50	22	Switched to mud rotary at 22 ft bgs												
-17.50	24													
	25													

(continued)

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	3195.X	BCI-18-27
COUNTY: SOL	ROUTE	POSTMILE
CLIENT: Ecosystems Investment Partners		
PREPARED BY: DWC	CHECKED BY: NCH	SHEET: 1 of 3

ELEVATION (ft)	DEPTH (ft)	Material Graphics	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests	Drilling Method
										Laboratory Data							
	25		Lean CLAY (CL) *(continued)*.		11	4 7 9	16		4.25								
-19.50	26																
	27																
-21.50	28																
	29																
-23.50	30		Stiff		12	4 4 4	8		1.75								
	31																
-25.50	32																
	33																
-27.50	34																
	35		SANDY Lean CLAY (CL), Very Soft, Brown, Wet		13	2 2 2	4		0			35	13	62			
-29.50	36																
	37																
-31.50	38																
	39																
-33.50	40				14	3 4 3	7										
	41																
-35.50	42																
	43																
-37.50	44																
	45		SANDY Lean CLAY (CL), Soft to Medium Stiff, Brown, Wet		15	4 7 10	17		0.5								
-39.50	46																
	47																
-41.50	48		Well graded GRAVEL with SAND (GW), Dense, Brown, Wet														
	49																
-43.50	50				16	8 15 20	35							3			
	51																
-45.50	52																
	53																
-47.50	54																
	55																

(continued)

blackburn consulting

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME **Lookout Slough THRFIP**		FILE NO. **3195.X**	HOLE ID **BCI-18-27**
COUNTY **SOL**	ROUTE		POSTMILE
CLIENT **Ecosystems Investment Partners**			
PREPARED BY **DWC**	CHECKED BY **NCH**	SHEET **2 of 3**	

ELEVATION (ft)	DEPTH (ft)	Material Graphics	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests	Drilling Method
	55		SANDY Lean CLAY (CL), Stiff, Brown, Moist		17	9 9 9	18		1.75								
-49.50	56																
	57		Bottom of exploration at 56.5 ft below ground surface (bgs) Tremie Grout Backfill Ground water encountered at 16 ft bgs														
-51.50	58																
	59																
-53.50	60																
	61																
-55.50	62																
	63																
-57.50	64																
	65																
-59.50	66																
	67																
-61.50	68																
	69																
-63.50	70																
	71																
-65.50	72																
	73																
-67.50	74																
	75																
-69.50	76																
	77																
-71.50	78																
	79																
-73.50	80																
	81																
-75.50	82																
	83																
-77.50	84																
	85																

Laboratory Data: Moisture Content through Additional Lab Tests

blackburn consulting

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	3195.X	BCI-18-27
COUNTY: SOL	ROUTE	POSTMILE
CLIENT: Ecosystems Investment Partners		
PREPARED BY: DWC	CHECKED BY: NCH	SHEET: 3 of 3

LOGGED BY	BEGIN DATE	COMPLETION DATE	LOCATION (Lat/Long or North/East and Datum)	HOLE ID
DWC	6-20-18	6-20-18	38.322334° / -121.713541°	BCI-18-28
CONTRACTOR			LOCATION (Offset, Station, Line)	SURFACE ELEVATION
Taber				6.0 ft
OPERATOR'S NAME	HELPER'S NAME		EQUIPMENT	TOTAL DEPTH
Toby			CME 55 Crawler	56.5 ft
EXCAVATION METHOD			DRILLING ROD TYPE AND DIAMETER / BUCKET WIDTH	BOREHOLE DIAMETER
Rotary Wash				6 in
SAMPLER TYPE(S) AND SIZE(S) (ID)			HAMMER TYPE	HAMMER EFFICIENCY, ERi
Shelby (2.87") and SPT (1.4") and Mod Cal (2.4")			Safety semi-automatic drop (140#/ 30")	91%
BACKFILL AND COMPLETION			GROUND WATER READINGS: DURING 12.0 ft; AFTER (DATE)	CASING TYPE AND DIAMETER(in)
Tremie Grout Backfill				

ELEVATION (ft)	DEPTH (ft)	DESCRIPTION	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests
	0	Lean/Fat CLAY (CL/CH), Stiff, Dark brown, Moist												
	1	Lean CLAY (CL), Very Stiff, Dark olive brown, Moist	1	2 3 4	7		3.75							
4.00	2													
	3													
2.00	4													
	5	Dark yellowish brown	2	6 11 13	24		3.75							
0.00	6													
	7	Moderate cementation	3	4 8 8	16		2.75							
-2.00	8	Lean CLAY with SAND (CL), Very Stiff, Dark yellowish brown, Moist	4	450 psi										
	9													
-4.00	10		5	500 psi			3.25							
	11													
-6.00	12		6	650 psi			3.5							
	13	Wet												
-8.00	14	Lean CLAY (CL), Hard, Dark yellowish brown, moist, Some strong cementation Switched to mud rotary at 14 ft bgs	7	5 9 15	24		4.5							
	15													
-10.00	16		8	6 9 11	20		>4.5							
	17		9	6 13 18	31		>4.5							
-12.00	18													
	19	Very Stiff	10	6 8 8	16		3.5							
-14.00	20													
	21													
-16.00	22													
	23													
-18.00	24													
	25													

(continued)

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	3195.X	BCI-18-28
COUNTY: SOL	ROUTE	POSTMILE
CLIENT: Ecosystems Investment Partners		
PREPARED BY: LDM	CHECKED BY: DWC	SHEET: 1 of 3

ELEVATION (ft)	DEPTH (ft)	DESCRIPTION	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests
	25	Lean CLAY (CL) *(continued)*.	11	10 13 15	28		>4.5							
-20.00	26													
	27													
-22.00	28													
	29													
-24.00	30	Lean CLAY with SAND (CL), Hard, Dark yellowish brown, Moist, Moderate to strong cementation, 15-20 % SAND	12	7 8 8	16		4.25							
	31													
-26.00	32													
	33													
-28.00	34													
	35		13	4 5 6	11		0.5							
-30.00	36	SANDY SILT (ML), Soft, Dark brown, Wet, 40% Fine SAND												
	37													
-32.00	38													
	39	SILTY SAND (SM), Medium dense, Mottled brown and gray, Wet, 40% SILT, Fine SAND												
-34.00	40		14	3 4 8	12									
	41													
-36.00	42													
	43	SILT with SAND (ML), Medium Stiff, Olive gray, Moist, Low PI												
-38.00	44													
	45	Poorly-graded SAND (SP), Medium Dense to Dense, Dark olive gray, Wet, Fine SAND	15	6 12 13	25									
-40.00	46													
	47													
-42.00	48													
	49													
-44.00	50	Dense	16	13 19 16	35									
	51													
-46.00	52													
	53													
-48.00	54													
	55													

(continued)

ELEVATION (ft)	DEPTH (ft)	Material Graphics	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests	Drilling Method
	55		Lean CLAY (CL), Hard, Olive brown, Moist		17	9 20 26	46		>4.5								
-50.00	56																
	57		Bottom of exploration at 56.5 ft below ground surface (bgs) Tremie Grout Backfill Ground water encountered at 12 ft bgs														
-52.00	58																
	59																
-54.00	60																
	61																
-56.00	62																
	63																
-58.00	64																
	65																
-60.00	66																
	67																
-62.00	68																
	69																
-64.00	70																
	71																
-66.00	72																
	73																
-68.00	74																
	75																
-70.00	76																
	77																
-72.00	78																
	79																
-74.00	80																
	81																
-76.00	82																
	83																
-78.00	84																
	85																

Laboratory Data: Moisture Content (%), Dry Density (pcf), Liquid Limit, Plasticity Index, % <#200, Shear Strength Test, Additional Lab Tests

blackburn consulting

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	3195.X	BCI-18-28
COUNTY: SOL	ROUTE:	POSTMILE:
CLIENT: Ecosystems Investment Partners		
PREPARED BY: LDM	CHECKED BY: DWC	SHEET: 3 of 3

LOGGED BY DWC	BEGIN DATE 12-18-18	COMPLETION DATE 12-18-18	LOCATION (Lat/Long or North/East and Datum) 38.329132° / -121.708805°	HOLE ID BCI-18-29
CONTRACTOR Taber			LOCATION (Offset, Station, Line)	SURFACE ELEVATION 13.0 ft
OPERATOR'S NAME Chad	HELPER'S NAME		EQUIPMENT CME 75	TOTAL DEPTH 14.5 ft
EXCAVATION METHOD Solid-Stem Auger			DRILLING ROD TYPE AND DIAMETER / BUCKET WIDTH	BOREHOLE DIAMETER 4 in
SAMPLER TYPE(S) AND SIZE(S) (ID) Shelby (2.87") and Mod Cal (2.4")			HAMMER TYPE Safety semi-automatic drop (140#/ 30")	HAMMER EFFICIENCY, ERi 66%
BACKFILL AND COMPLETION Tremie Grout Backfill			GROUND WATER READINGS: DURING 14.5 ft; AFTER (DATE)	CASING TYPE AND DIAMETER(in)

ELEVATION (ft)	DEPTH (ft)	DESCRIPTION	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests
	0	ASPHALT CONCRETE (14")												
11.00	1–3	Fat CLAY (CH) (Fill); Stiff; Mottled Dark Olive Gray and Brown; Moist	Bulk			100				63	46	85		
9.00	3–4.5		1	4 5 8	13	100	1.75							
7.00	4.5–6		2	1 2 4	6	50	1.5			59	43	98		
5.00	7–9	Fat CLAY (CH); Stiff; Dark Olive Gray; Moist	3	250 psi		67	1.75							
3.00	10–11.5	Very Stiff, Olive Brown	4	5 7 9	16	100	2.25							
-1.00	13–14.5	Very Weak Cementation	5	5 7 8	15	100	3.25							

Bottom of exploration at 14.5 ft below ground surface (bgs)

Tremie Grout Backfill
Ground water encountered at 14.5 ft bgs

Elevation scale: 11.00, 9.00, 7.00, 5.00, 3.00, 1.00, -1.00, -3.00, -5.00; Depth scale: 0–20

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME Lookout Slough THRFIP		FILE NO. 3195.X	HOLE ID BCI-18-29
COUNTY SOL	ROUTE		POSTMILE
CLIENT Ecosystems Investment Partners			
PREPARED BY DWC	CHECKED BY NCH	SHEET 1 of 1	

LOGGED BY **DWC**	BEGIN DATE **12-18-18**	COMPLETION DATE **12-18-18**	LOCATION (Lat/Long or North/East and Datum) **38.329127° / -121.70477°**	HOLE ID **BCI-18-30**
CONTRACTOR **Taber**			LOCATION (Offset, Station, Line)	SURFACE ELEVATION **14.0 ft**
OPERATOR'S NAME **Chad**	HELPER'S NAME		EQUIPMENT **CME 75**	TOTAL DEPTH **14.0 ft**
EXCAVATION METHOD **Solid-Stem Auger**			DRILLING ROD TYPE AND DIAMETER / BUCKET WIDTH	BOREHOLE DIAMETER **4 in**
SAMPLER TYPE(S) AND SIZE(S) (ID) **Shelby (2.87") and Mod Cal (2.4")**			HAMMER TYPE **Safety semi-automatic drop (140#/ 30")**	HAMMER EFFICIENCY, ERi **66%**
BACKFILL AND COMPLETION **Tremie Grout Backfill**			GROUND WATER READINGS DURING AFTER (DATE)	CASING TYPE AND DIAMETER(in)

ELEVATION (ft)	DEPTH (ft)	DESCRIPTION	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests
	0	ASPHALT CONCRETE (12")												
	1	Fat CLAY (CH) (Fill); Very Stiff; Mottled Black and Brown; Moist												
12.00	2–3		1	300 psi		100	2.5							
10.00	4–5	Stiff; Olive	2	4 5 7	12	100	1.25			58	40	98		
8.00	6	Fat CLAY (CH); Stiff; Black; Moist												
6.00	8–9		3	325 psi		75								
4.00	10													
2.00	11–12	Stiff to Very Stiff; Olive	4	3 5 8	13	89	2.5							
	13		5	3 4 6	10		2.0							
0.00	14	Bottom of exploration at 14.0 ft below ground surface (bgs) Tremie Grout Backfill No ground water encountered												
	15													
-2.00	16													
	17													
-4.00	18													
	19													
	20													

Laboratory Data

blackburn consulting
Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME **Lookout Slough THRFIP**		FILE NO. **3195.X**	HOLE ID **BCI-18-30**
COUNTY **SOL**	ROUTE		POSTMILE
CLIENT **Ecosystems Investment Partners**			
PREPARED BY **DWC**	CHECKED BY **NCH**	SHEET **1 of 1**	

LOGGED BY: **DWC**	BEGIN DATE: **12-18-18**	COMPLETION DATE: **12-18-18**
LOCATION (Lat/Long or North/East and Datum): **38.329117° / -121.701045°**		HOLE ID: **BCI-18-31**
CONTRACTOR: **Taber**	LOCATION (Offset, Station, Line)	SURFACE ELEVATION: **14.0 ft**
OPERATOR'S NAME: **Chad**	HELPER'S NAME	
EQUIPMENT: **CME 75**		TOTAL DEPTH: **14.0 ft**
EXCAVATION METHOD: **Solid-Stem Auger**	DRILLING ROD TYPE AND DIAMETER / BUCKET WIDTH	BOREHOLE DIAMETER: **4 in**
SAMPLER TYPE(S) AND SIZE(S) (ID): **Shelby (2.87") and Mod Cal (2.4")**	HAMMER TYPE: **Safety semi-automatic drop (140#/ 30")**	HAMMER EFFICIENCY, ERi: **66%**
BACKFILL AND COMPLETION: **Tremie Grout Backfill**	GROUND WATER READINGS: DURING / AFTER (DATE)	CASING TYPE AND DIAMETER(in)

ELEVATION (ft)	DEPTH (ft)	DESCRIPTION	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests
	0	ASPHALT CONCRETE (7")												
	0.6	AGGREGATE BASE (12")												
12.00	1.6	Fat CLAY (CH) (Fill); Stiff; Mottled Black and Brown; Moist												
	2–3.5		1	2, 3, 8	11	50	1.5							
10.00	3.5–5		2	2, 3, 4	7	50	1.75							
8.00	5–7		3	300 psi										
6.00	7.5	Fat CLAY (CH); Stiff; Dark Olive Gray; Moist												
	8–9.5		4	3, 4, 7	11	75	1.5			61	41	89		
2.00	11–12.5		5	3, 4, 7	11	100	1.5							
	12.5	Lean CLAY with SAND (CL); Very Stiff; Olive Brown; Moist												
	12.5–14		6	2, 4, 5	9	100	2.75							
0.00	14	Bottom of exploration at 14.0 ft below ground surface (bgs)												

Tremie Grout Backfill
No ground water encountered

blackburn consulting
Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME: **Lookout Slough THRFIP**		FILE NO.: **3195.X**	HOLE ID: **BCI-18-31**
COUNTY: **SOL**	ROUTE		POSTMILE
CLIENT: **Ecosystems Investment Partners**			
PREPARED BY: **DWC**	CHECKED BY: **NCH**	SHEET: **1 of 1**	

LOGGED BY	BEGIN DATE	COMPLETION DATE	LOCATION (Lat/Long or North/East and Datum)	HOLE ID
DWC	**12-18-18**	**12-18-18**	**38.329115° / -121.696082°**	**BCI-18-32**

CONTRACTOR **Taber**	LOCATION (Offset, Station, Line)	SURFACE ELEVATION **14.0 ft**
OPERATOR'S NAME **Chad** / HELPER'S NAME	EQUIPMENT **CME 75**	TOTAL DEPTH **13.5 ft**
EXCAVATION METHOD **Solid-Stem Auger**	DRILLING ROD TYPE AND DIAMETER / BUCKET WIDTH	BOREHOLE DIAMETER **4 in**
SAMPLER TYPE(S) AND SIZE(S) (ID) **Shelby (2.87") and Mod Cal (2.4")**	HAMMER TYPE **Safety semi-automatic drop (140#/ 30")**	HAMMER EFFICIENCY, ERi **66%**
BACKFILL AND COMPLETION **Tremie Grout Backfill**	GROUND WATER READINGS DURING **13.0 ft** AFTER (DATE)	CASING TYPE AND DIAMETER(in)

ELEVATION (ft)	DEPTH (ft)	DESCRIPTION	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests
	0	ASPHALT CONCRETE (4")												
		AGGREGATE BASE (8")												
	1	SANDY Lean CLAY (CL) (Fill); Very Stiff to Hard; Dark Yellowish Brown Mottled with Black; Moist; [FILL]	1	5 6 7	13	89	1.75			37	18	67		
12.00	2													
	3		2	2 2 3	5									
10.00	4													
	5													
8.00	6		3	275 psi		58	1.75							
	7	Fat CLAY with SAND (CH); Hard; Olive Brown; Moist												
6.00	8													
	9		4	4 6 10	16	100	4.5			53	34	77		
4.00	10	Lean CLAY with SAND (CL); Hard; Olive Brown; Moist												
	11		5	4 4 9	13		4.5							
2.00	12		6	800 psi		100	4.5							
	13	Becomes Wet; Cemented												
0.00	14	Bottom of exploration at 13.5 ft below ground surface (bgs) Tremie Grout Backfill Ground water encountered at 13.0 ft bgs												
	15													
-2.00	16													
	17													
-4.00	18													
	19													
	20													

blackburn consulting

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	**3195.X**	**BCI-18-32**
COUNTY **SOL**	ROUTE	POSTMILE
CLIENT **Ecosystems Investment Partners**		
PREPARED BY **DWC**	CHECKED BY **NCH**	SHEET **1 of 1**

LOGGED BY: **DWC**	BEGIN DATE: **3-18-19**	COMPLETION DATE: **3-18-19**	LOCATION (Lat/Long or North/East and Datum): **38.32677° / -121.71211°**
HOLE ID: **BCI-19-33**			
CONTRACTOR: **Taber**			LOCATION (Offset, Station, Line):
SURFACE ELEVATION: **8.0 ft**			
OPERATOR'S NAME: **Rick**	HELPER'S NAME: **Derrick/Adam**		EQUIPMENT: **Diedrich D120**
TOTAL DEPTH: **61.5 ft**			
EXCAVATION METHOD: **Solid-Stem Auger/ Mud Rotary**			DRILLING ROD TYPE AND DIAMETER / BUCKET WIDTH:
BOREHOLE DIAMETER: **4 in**			
SAMPLER TYPE(S) AND SIZE(S) (ID): **Shelby (2.87") and SPT (1.4") and Mod Cal (2.4")**			HAMMER TYPE: **Safety semi-automatic drop (140#/ 30")**
HAMMER EFFICIENCY, ERi: **81%**			
BACKFILL AND COMPLETION: **Tremie Grout Backfill**			GROUND WATER READINGS — DURING: **9.0 ft**; AFTER (DATE): **1.5 ft on 3-18-19**
CASING TYPE AND DIAMETER(in):			

ELEVATION (ft)	DEPTH (ft)	Material Graphics	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests	Drilling Method
	0		Fat CLAY (CH); Stiff to Very Stiff; Dark Yellowish Brown; Moist														
	1																
6.00	2				1	200 PSI		86	1.75								
	3																
4.00	4		Mottled Dark Yellowish Brown and Gray; Some Moderate Cementation		2	3 4 6	10	100	3.25								
	5				3	800 PSI		88	2.75								
2.00	6		Trace Very Fine SAND														
	7		SANDY Lean CLAY (CL); Very Stiff; Dark Yellowish Brown; Moist; Some Fine to Medium SAND		4	4 7 15	22	100	2.5								
0.00	8				5	1000 PSI		100									
	9		Poorly-Graded SAND with SILT (SP-SM); Medium Dense; Grayish Brown; Wet; Some Fines; Fine to Medium SAND; Little GRAVEL														
-2.00	10				6	13 13 15	28	100				NP	NP	8			
	11		Poorly-Graded SAND with CLAY (SP-SC); Medium Dense; Grayish Brown; Wet									31	15	12			
-4.00	12				7	500 PSI		100									
	13		Switched to Mud Rotary at 12.5 ft bgs														
-6.00	14		Fat CLAY (CH); Stiff; Olive Brown; Moist; Some Strong Cementation		8	5 6 9	15	100	1.25			51	29	97			
	15		SANDY Fat CLAY (CH); Stiff; Light Olive Brown; Moist									50	30	55			
-8.00	16				9	500 PSI		100	1.25								
	17		Lean CLAY (CL); Very Stiff to Hard; Yellowish Brown; Moist		10	6 10 14	24	100	>4.5			44	27	94			
-10.00	18																
	19				11	800 PSI		100	3.25								
-12.00	20																
	21				12	3 4 7	11	100	2.25								
-14.00	22				13	800 PSI		100	>4.5								
	23																
-16.00	24				14	11 15 23	38	100	>4.5								
	25																

Laboratory Data: Moisture Content (%), Dry Density (pcf), Liquid Limit, Plasticity Index, % <#200, Shear Strength Test, Additional Lab Tests

(continued)

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME: **Lookout Slough THRFIP**		FILE NO.: **3195.X**	HOLE ID: **BCI-19-33**
COUNTY: **SOL**	ROUTE:		POSTMILE:
CLIENT: **Ecosystems Investment Partners**			
PREPARED BY: **LDM**	CHECKED BY: **DWC**		SHEET: **1 of 3**

ELEVATION (ft)	DEPTH (ft)	Material Graphics	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests	Drilling Method
	25		Lean CLAY (CL) *(continued)*.		15	4 9 15	24	100									
-18.00	26																
	27																
-20.00	28		Loss of Circulation @ 28 ft bgs														
	29																
-22.00	30		Fat CLAY (CH); Hard; Dark Yellowish Brown; Moist; Some Fine SAND		16	14 21 23	44	100	4.5			53	29	86			
	31																
-24.00	32																
	33																
-26.00	34																
	35				17	900 PSI		100									
-28.00	36																
	37																
-30.00	38																
	39		Lean CLAY (CL); Very Stiff; Dark Yellowish Brown; Moist; Little Very Fine SAND														
-32.00	40				18	10 11 12	23	90	2.25								
	41																
-34.00	42																
	43																
-36.00	44		Fat CLAY (CH); Stiff to Very Stiff; Mottled Olive Gray and Brown; Moist														
	45				19	5 7 10	17	100	1.75								
-38.00	46																
	47																
-40.00	48																
	49																
-42.00	50		Dark Yellowish Brown		20	15 17 21	38	100	3.75								
	51																
-44.00	52																
	53																
-46.00	54																
	55																

(continued)

blackburn consulting

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	3195.X	BCI-19-33
COUNTY: SOL	ROUTE	POSTMILE
CLIENT: Ecosystems Investment Partners		
PREPARED BY: LDM	CHECKED BY: DWC	SHEET: 2 of 3

ELEVATION (ft)	DEPTH (ft)	Material Graphics	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests	Drilling Method
	55		Fat CLAY (CH) *(continued)*.														
-48.00	56		Some Strong Cementation		21	10 14 17	31	100									
	57																
-50.00	58																
	59																
-52.00	60																
	61				22	12 15 16	31	80	1.75								
-54.00	62		Bottom of exploration at 61.5 ft below ground surface (bgs)														
	63		Tremie Grout Backfill Ground water encountered at 9.0 ft bgs, rose to 1.5 ft bgs														
-56.00	64																
	65																
-58.00	66																
	67																
-60.00	68																
	69																
-62.00	70																
	71																
-64.00	72																
	73																
-66.00	74																
	75																
-68.00	76																
	77																
-70.00	78																
	79																
-72.00	80																
	81																
-74.00	82																
	83																
-76.00	84																
	85																

Laboratory Data: Moisture Content (%), Dry Density (pcf), Liquid Limit, Plasticity Index, % <#200, Shear Strength Test, Additional Lab Tests

blackburn consulting

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	3195.X	BCI-19-33
COUNTY: SOL	ROUTE	POSTMILE
CLIENT: Ecosystems Investment Partners		
PREPARED BY: LDM	CHECKED BY: DWC	SHEET: 3 of 3

LOGGED BY **DWC**	BEGIN DATE **3-20-19**	COMPLETION DATE **3-20-19**	LOCATION (Lat/Long or North/East and Datum) **38.32307° / -121.71507°**	HOLE ID **BCI-19-34**
CONTRACTOR **Taber**			LOCATION (Offset, Station, Line)	SURFACE ELEVATION **7.0 ft**
OPERATOR'S NAME **Rick**	HELPER'S NAME **Derrick/Adam**		EQUIPMENT **Diedrich D120**	TOTAL DEPTH **61.5 ft**
EXCAVATION METHOD **Solid-Stem Auger/ Mud Rotary**			DRILLING ROD TYPE AND DIAMETER / BUCKET WIDTH	BOREHOLE DIAMETER **4 in**
SAMPLER TYPE(S) AND SIZE(S) (ID) **Shelby (2.87") and SPT (1.4") and Mod Cal (2.4")**			HAMMER TYPE **Safety semi-automatic drop (140#/ 30")**	HAMMER EFFICIENCY, ERi **81%**
BACKFILL AND COMPLETION **Tremie Grout Backfill**			GROUND WATER READINGS — DURING **13.0 ft** — AFTER (DATE) **3.5 ft on 3-20-19**	CASING TYPE AND DIAMETER(in)

ELEVATION (ft)	DEPTH (ft)	DESCRIPTION	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests
	0	Fat CLAY (CH); Very Stiff; Black; Moist												
5.00	2													
	3	Dark Yellowish Brown												
3.00	4		1	500 PSI		67	3.0							
1.00	6		2	6 8 12	20	90	4.0							
-1.00	8		3	800 PSI		67	3.75							
	9	More SAND	4	5 6 8	14	100								
-3.00	10	CLAYEY SAND (SC); Dense; Yellowish Brown; Moist								34	17	46		
	11	Lean CLAY with SAND (CL); Medium Stiff; Dark Yellowish Brown; Moist	5	400 PSI		100	0.75			36	18	76		
	12.5	Lean CLAY (CL); Stiff to Hard; Light Olive Brown; Moist	6	3 4 5	9	100				45	23	96		
-7.00	14	Switched to mud rotary at 14 ft bgs	7	300 PSI		100	1.5	26	93	42	22	84		
-9.00	16		8	4 5 9	14	100	>4.5							
-11.00	18		9	600 PSI		100	2.75							
-13.00	20		10			100								
-15.00	22		11	400 PSI		100	1.25							
-17.00	24		12	9 11 15	26	100	4.5							
	25													

(continued)

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME **Lookout Slough THRFIP**		FILE NO. **3195.X**	HOLE ID **BCI-19-34**
COUNTY **SOL**	ROUTE		POSTMILE
CLIENT **Ecosystems Investment Partners**			
PREPARED BY **LDM**	CHECKED BY **DWC**	SHEET **1 of 3**	

ELEVATION (ft)	DEPTH (ft)	DESCRIPTION	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests
	25	Lean CLAY (CL) *(continued)*.												
-19.00	26		13	800 PSI		100	2.5							
	27													
-21.00	28													
	29													
-23.00	30													
	31		14	900 PSI		100	3.5							
-25.00	32													
	33													
-27.00	34													
	35	Mottled Olive Gray and Brown; Little Moderate Cementation												
-29.00	36		15	700 PSI		100	2.5							
	37													
-31.00	38													
	39													
-33.00	40													
	41		16	4 5 7	12	100	1.75							
-35.00	42													
	43													
-37.00	44													
	45													
-39.00	46		17	12 20 25	45	90	>4.5							
	47													
-41.00	48													
	49													
-43.00	50		18	7 11 14	25	75								
	51	CLAYEY SAND (SC); Medium Dense; Dark Yellowish Brown; Moist; some Fines; Fine to Medium SAND												
-45.00	52													
	53													
-47.00	54	Lean CLAY (CL); Hard; Dark Yellowish Brown; Moist												
	55													

(continued)

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	3195.X	BCI-19-34

COUNTY	ROUTE	POSTMILE
SOL		

CLIENT: Ecosystems Investment Partners

PREPARED BY	CHECKED BY	SHEET
LDM	DWC	2 of 3

ELEVATION (ft)	DEPTH (ft)	Material Graphics	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests	Drilling Method
	55		Lean CLAY (CL) *(continued)*.		19	14 14 20	34	100	>4.5								
-49.00	56																
	57																
-51.00	58																
	59		CLAYEY SAND (SC); Medium Dense; Dark Yellowish Brown; Moist														
-53.00	60				20	8 7 10	17	100	2.5								
	61		Lean CLAY (CL); Very Stiff; Dark Yellowish Brown; Moist														
-55.00	62		Bottom of exploration at 61.5 ft below ground surface (bgs) Tremie Grout Backfill Ground water encountered at 13 ft bgs, rose to 3.5 ft bgs														
	63																
-57.00	64																
	65																
-59.00	66																
	67																
-61.00	68																
	69																
-63.00	70																
	71																
-65.00	72																
	73																
-67.00	74																
	75																
-69.00	76																
	77																
-71.00	78																
	79																
-73.00	80																
	81																
-75.00	82																
	83																
-77.00	84																
	85																

Laboratory Data (columns Moisture Content through Additional Lab Tests)

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	3195.X	BCI-19-34
COUNTY: SOL	ROUTE	POSTMILE
CLIENT: Ecosystems Investment Partners		
PREPARED BY: LDM	CHECKED BY: DWC	SHEET: 3 of 3

LOGGED BY	BEGIN DATE	COMPLETION DATE	LOCATION (Lat/Long or North/East and Datum)	HOLE ID
DWC	3-19-19	3-19-19	38.31989° / -121.71814°	BCI-19-35
CONTRACTOR			LOCATION (Offset, Station, Line)	SURFACE ELEVATION
Taber				6.0 ft
OPERATOR'S NAME	HELPER'S NAME		EQUIPMENT	TOTAL DEPTH
Rick	Derrick/Adam		Diedrich D120	61.5 ft
EXCAVATION METHOD			DRILLING ROD TYPE AND DIAMETER / BUCKET WIDTH	BOREHOLE DIAMETER
Solid-Stem Auger/ Mud Rotary				4 in
SAMPLER TYPE(S) AND SIZE(S) (ID)			HAMMER TYPE	HAMMER EFFICIENCY, ERi
Shelby (2.87") and SPT (1.4") and Mod Cal (2.4")			Safety semi-automatic drop (140#/ 30")	81%
BACKFILL AND COMPLETION			GROUND WATER READINGS — DURING: 14.0 ft; AFTER (DATE): 6.0 ft on 3-19-19	CASING TYPE AND DIAMETER(in)
Tremie Grout Backfill				

ELEVATION (ft)	DEPTH (ft)	DESCRIPTION	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests
	0	Aggregate Base (AB)												
	0–6	Fat CLAY (CH); Very Stiff; Dark Brown; Moist												
4.00	2		1	200 PSI		67	2.5							
2.00	4	Mottled Dark Yellowish Brown and gray and white	2	3 5 8	13	100	3.0							
0.00	6	Some Strong Cementation	3	400 PSI		67	3.5							
-2.00	6–13	Lean CLAY (CL); Very Stiff; Dark Yellowish Brown; Moist; Little Fine SAND	4	6 6 6	12	100	2.25			39	19	86		
-4.00	9		5	500 PSI		100	2.75							
	11		6	4 5 7	12	100								
-6.00	12		7	400 PSI		92								
-8.00	13–16	SILTY SAND (SM); Medium Dense; Dark Yellowish Brown; Moist to Wet; Little Fines; Fine SAND	8	5 6 9	15	100				NP	NP	31		
	15	Switched to mud rotary at 15 ft bgs												
-10.00	16	Fat CLAY (CH); Stiff to Hard; Dark Yellowish Brown; Moist; Black Spots	9	600 PSI		100	2.5							
-12.00	18		10	5 8 14	22	100	>4.5							
-14.00	20		11	800 PSI		92								
-16.00	21		12	6 9 15	24	100	3.0							
-18.00	23		13	800 PSI		100	3.0							
	24–25		14	11	29	100								

(continued)

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	3195.X	BCI-19-35
COUNTY: SOL	ROUTE	POSTMILE
CLIENT: Ecosystems Investment Partners		
PREPARED BY: LDM	CHECKED BY: DWC	SHEET: 1 of 3

ELEVATION (ft)	DEPTH (ft)	DESCRIPTION	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests
	25	Fat CLAY (CH) *(continued)*.	14	12 17	29	100								
-20.00	26		15	850 PSI		88	4.25							
	27													
-22.00	28													
	29													
-24.00	30													
	31		16	500 PSI		100	1.25							
-26.00	32													
	33													
-28.00	34													
	35													
-30.00	36		17	800 PSI		93	1.25							
	37													
-32.00	38													
	39													
-34.00	40													
	41		18	10 12 16	28	100								
-36.00	42													
	43													
-38.00	44													
	45	Some Weak to Moderate Cementation												
-40.00	46		19	23 32 42	74	100	>4.5							
	47													
-42.00	48	SILTY, CLAYEY SAND (SC-SM); Medium Dense; Very Dark Gray; Moist; Fine SAND												
	49													
-44.00	50		20	14 17 17	34	80	2.75			25	7	40		
	51	Lean CLAY (CL); Very Stiff; Very Dark Gray; Moist												
-46.00	52													
	53													
-48.00	54													
	55													

(continued)

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	3195.X	BCI-19-35
COUNTY: SOL	ROUTE:	POSTMILE:
CLIENT: Ecosystems Investment Partners		
PREPARED BY: LDM	CHECKED BY: DWC	SHEET: 2 of 3

ELEVATION (ft)	DEPTH (ft)	Material Graphics	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests	Drilling Method
	55		Lean CLAY (CL) *(continued)*.		21	13 23 27	50	100	>4.5								
-50.00	56		Dark Yellowish Brown; Black Spots														
	57																
-52.00	58																
	59																
-54.00	60		Grayish Brown		22			100									
	61																
-56.00	62		Bottom of exploration at 61.5 ft below ground surface (bgs) Tremie Grout Backfill Ground water encountered at 14.0 ft bgs, rose to 6 ft bgs														
	63																
-58.00	64																
	65																
-60.00	66																
	67																
-62.00	68																
	69																
-64.00	70																
	71																
-66.00	72																
	73																
-68.00	74																
	75																
-70.00	76																
	77																
-72.00	78																
	79																
-74.00	80																
	81																
-76.00	82																
	83																
-78.00	84																
	85																

Laboratory Data columns: Moisture Content (%), Dry Density (pcf), Liquid Limit, Plasticity Index, % <#200, Shear Strength Test, Additional Lab Tests.

blackburn consulting

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	3195.X	BCI-19-35
COUNTY: SOL	ROUTE:	POSTMILE:
CLIENT: Ecosystems Investment Partners		
PREPARED BY: LDM	CHECKED BY: DWC	SHEET: 3 of 3

LOGGED BY	BEGIN DATE	COMPLETION DATE	LOCATION (Lat/Long or North/East and Datum)	HOLE ID
DWC	3-21-19	3-21-19	38.31193° / -121.72571°	BCI-19-36

CONTRACTOR: **Taber**	LOCATION (Offset, Station, Line):	SURFACE ELEVATION: **7.0 ft**
OPERATOR'S NAME: **Rick** — HELPER'S NAME: **Derrick/Adam**	EQUIPMENT: **Diedrich D120**	TOTAL DEPTH: **61.5 ft**
EXCAVATION METHOD: **Solid-Stem Auger/ Mud Rotary**	DRILLING ROD TYPE AND DIAMETER / BUCKET WIDTH:	BOREHOLE DIAMETER: **4 in**
SAMPLER TYPE(S) AND SIZE(S) (ID): **Shelby (2.87") and SPT (1.4") and Mod Cal (2.4")**	HAMMER TYPE: **Safety semi-automatic drop (140#/ 30")**	HAMMER EFFICIENCY, ERi: **81%**
BACKFILL AND COMPLETION: **Tremie Grout Backfill**	GROUND WATER READINGS — DURING: **9.0 ft** — AFTER (DATE): **2.5 ft on 3-21-19**	CASING TYPE AND DIAMETER(in)

ELEVATION (ft)	DEPTH (ft)	DESCRIPTION	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests
	0	Fat CLAY (CH); Stiff to Hard; Mottled Dark Gray; Moist												
	1													
5.00	2		1	300 PSI		58	1.75							
	3	Dark Yellowish Brown												
3.00	4		2	3 4 7	11	78	>4.5			59	43			
	5	Lean CLAY with SAND (CL); Stiff; Dark Yellowish Brown; Moist; Moderate Cementation												
1.00	6		3	900 PSI		71	>4.5							
	7		4	10 15 17	32	100	3.25							
-1.00	8													
	9		5	500 PSI		100	1.5			35 32	14 13	84 77		
-3.00	10													
	11		6	4 3 7	10	100	>4.5			35	14	86		
-5.00	12	Switched to mud rotary at 11.5 ft bgs								34	13	82		
	13		7	600 PSI		96	2.5			41	24	82		
-7.00	14		8	5 5 6	11	100				33	15	73		
	15													
-9.00	16	Lense of CLAYEY SAND (SC)	9	400 PSI		100	1.75					22		
	17									35	20	84		
	17	Lean CLAY (CL); Stiff to Hard; Dark Yellowish Brown; Moist; Some Moderate Cemenation	10	4 4 4	8	100	0.75			38	18	88		
-11.00	18													
	19													
-13.00	20		11	300 PSI		100	1.5							
	21		12	4 7 9	16	100								
-15.00	22													
	23		13	500 PSI		100	3.75							
-17.00	24		14	10 15 21	36	100								
	25													

(continued)

blackburn consulting

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	3195.X	BCI-19-36
COUNTY: SOL	ROUTE:	POSTMILE:
CLIENT: Ecosystems Investment Partners		
PREPARED BY: LDM	CHECKED BY: DWC	SHEET: 1 of 3

ELEVATION (ft)	DEPTH (ft)	Material Graphics	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests	Drilling Method
	25		Lean CLAY (CL) *(continued)*.														
-19.00	26				15	11 19 27	46	100	>4.5								
	27																
-21.00	28																
	29																
-23.00	30																
	31				16	10 14 19	33	100	4.5								
-25.00	32																
	33																
-27.00	34																
	35																
-29.00	36				17	8 15 22	37	100	>4.5								
	37																
-31.00	38																
	39																
-33.00	40																
	41		Lense of SANDY SILTY CLAY (CL-ML)		18	9 15 20	35	100	2.0			26	4	60			
-35.00	42																
	43																
-37.00	44																
	45																
-39.00	46				19	4 14 18	32	100	3.5								
	47																
-41.00	48																
	49																
-43.00	50																
	51				20	10 16 22	38	100	2.25								
-45.00	52																
	53		Fat CLAY (CH); Very Stiff; Olive; Moist														
-47.00	54																
	55																

(continued)

blackburn consulting

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	3195.X	BCI-19-36
COUNTY: SOL	ROUTE	POSTMILE
CLIENT: Ecosystems Investment Partners		
PREPARED BY: LDM	CHECKED BY: DWC	SHEET: 2 of 3

ELEVATION (ft)	DEPTH (ft)	Material Graphics	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests	Drilling Method
	55		Fat CLAY (CH) *(continued)*.		21	11 15 24	39	100	3.5								
-49.00	56																
	57																
-51.00	58		Lean CLAY (CL); Hard; Mottled Orange Brown; Moist														
	59																
-53.00	60				22	14 24 30	54	100									
	61		Fat CLAY (CH); Very Stiff; Olive; Moist; Some Strong Cementation														
-55.00	62		Bottom of exploration at 61.5 ft below ground surface (bgs) Tremie Grout Backfill Ground water encountered at 9.0 ft bgs, rose to 2.5 ft bgs														
	63																
-57.00	64																
	65																
-59.00	66																
	67																
-61.00	68																
	69																
-63.00	70																
	71																
-65.00	72																
	73																
-67.00	74																
	75																
-69.00	76																
	77																
-71.00	78																
	79																
-73.00	80																
	81																
-75.00	82																
	83																
-77.00	84																
	85																

Laboratory Data

blackburn consulting

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	**3195.X**	**BCI-19-36**
COUNTY **SOL**	ROUTE	POSTMILE
CLIENT **Ecosystems Investment Partners**		
PREPARED BY **LDM**	CHECKED BY **DWC**	SHEET **3 of 3**

LOGGED BY	BEGIN DATE	COMPLETION DATE	LOCATION (Lat/Long or North/East and Datum)	HOLE ID
DWC	4-23-19	4-23-19	38.30767° / -121.73029°	BCI-19-37

CONTRACTOR: Taber	LOCATION (Offset, Station, Line)	SURFACE ELEVATION: 6.5 ft
OPERATOR'S NAME: Rick / HELPER'S NAME: Derrick/Nick	EQUIPMENT: Diedrich D120	TOTAL DEPTH: 76.5 ft
EXCAVATION METHOD: Solid-Stem Auger/ Mud Rotary	DRILLING ROD TYPE AND DIAMETER / BUCKET WIDTH	BOREHOLE DIAMETER: 4 in
SAMPLER TYPE(S) AND SIZE(S) (ID): Shelby (2.87") and SPT (1.4") and Mod Cal (2.4")	HAMMER TYPE: Safety semi-automatic drop (140#/ 30")	HAMMER EFFICIENCY, ERi: 81%
BACKFILL AND COMPLETION: Tremie Grout Backfill	GROUND WATER READINGS: DURING 18.0 ft; AFTER (DATE) 17.0 ft on 4-23-19	CASING TYPE AND DIAMETER(in)

ELEVATION (ft)	DEPTH (ft)	DESCRIPTION	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests
	0	Fat CLAY (CH); Stiff; Dark Brown; Moist												
4.50	2		1	400 PSI		50	1.5							
2.50	4	Hard; Dry	2	11 12 13	25	60	>4.5							
0.50	6		3	300 psi		79	2.5							
-1.50	8	Very Stiff; Moist; Mottled Blueish Gray	4	4 4 6	10	100	3.0							
-3.50	10		5	600 psi		88	>4.5							
	10	Lean CLAY (CL); Hard; Dark Yellowish Brown; Moist; Mottled Light Gray; Some Weak Cementation	6	6 9 12	21	90	>4.5							
-5.50	12													
	13	Very Stiff	7	500 psi		92	2.75							
-7.50	14		8	4 6 7	13	100	3.0							
-9.50	16		9	600 psi		100	4.5							
	17	SANDY Lean CLAY (CL); Hard; Dark Yellowish Brown; Moist; Fine SAND												
-11.50	18		10	8 8 8	16	65								
	19	Switched to mud rotary at 19 ft bgs												
-13.50	20		11	600 psi		100	>4.5							
	21	Fat CLAY (CH); Hard; Dark yellowish Brown; Moist; Some Moderate Cementation												
-15.50	22		12	8 10 16	26	90	>4.5							
	23		13	800 psi		100	4.5							
-17.50	24													
	25													

(continued)

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	3195.X	BCI-19-37
COUNTY: SOL	ROUTE	POSTMILE
CLIENT: Ecosystems Investment Partners		
PREPARED BY: NCH	CHECKED BY: DWC	SHEET: 1 of 3

ELEVATION (ft)	DEPTH (ft)	Material Graphics	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests	Drilling Method
	25		Very Stiff; Moderate to Strong Cementation Fat CLAY (CH) *(continued)*.														
-19.50	26				14	300 psi		100	2.75								
	27																
-21.50	28																
	29																
-23.50	30		Lean CLAY (CL); Stiff; Dark Yellow Brown; Moist														
	31				15	300 psi		100	1.5								
-25.50	32																
	33		SANDY Lean CLAY (CL); Medium Stiff; Moist; Dark Yellow Brown; Some Very Fine SAND														
-27.50	34																
	35																
-29.50	36				16	200 psi		100	0.75								
	37																
-31.50	38																
	39																
-33.50	40		More SAND		17	5 6 15	21	100									
	41		Poorly-Graded SAND (SP); Medium Dense; Moist; Dark Gray Brown; Fine SAND														
-35.50	42																
	43																
-37.50	44																
	45		SILTY SAND (SM); Medium Dense; Dark Gray Brown; Mottled Blue Gray; Wet; Some Fine to Coarse Gravel in Shoe; Some Moderate to Strong Cementation - From Cuttings		18	7 13 9	22	0									
-39.50	46																
	47		Well-Graded GRAVEL with SAND (GW); Very Dense; Dark Gray; Wet; Fine to Coarse GRAVEL; Some Fine to Coarse SAND; +1-inch GRAVEL in shoe														
-41.50	48																
	49																
-43.50	50				19	21 50/6	50/6	100									
	51																
-45.50	52																
	53																
-47.50	54																
	55																

(continued)

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	3195.X	BCI-19-37
COUNTY: SOL	ROUTE	POSTMILE
CLIENT: Ecosystems Investment Partners		
PREPARED BY: NCH	CHECKED BY: DWC	SHEET: 2 of 3

ELEVATION (ft)	DEPTH (ft)	Material Graphics	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests	Drilling Method
	55		Lean CLAY (CL); Stiff; Olive Brown; Moist; Trace GRAVEL		20	9 6 9	15	50	1.5								
-49.50	56																
	57																
-51.50	58		No GRAVEL														
	59																
-53.50	60		Very Stiff		21	8 12 14	26	70	2								
	61																
-55.50	62																
	63																
-57.50	64																
	65		Hard, Some Strong Cementation		22	27 50/6	50/6	100	>4.5								
-59.50	66																
	67																
-61.50	68		SANDY SILT (ML); Hard; Olive Gray; Moist; Some Very Fine SAND; Some Moderate to Strong Cementation; Trace GRAVEL														
	69																
-63.50	70				23	11 16 27	43	80	4.25								
	71		Lean CLAY (CL); Very Stiff to Hard; Mottled Olive Brown; Moist														
-65.50	72																
	73																
-67.50	74																
	75		Lenses of CLAYEY SAND with GRAVEL		24	8 19 23	42	90	3.75								
-69.50	76																
	77		Bottom of exploration at 76.5 ft below ground surface (bgs)														
-71.50	78		Tremie Grout Backfill Ground water encountered at 18.0 ft bgs, rose to 17.0 ft bgs														
	79																
-73.50	80																
	81																
-75.50	82																
	83																
-77.50	84																
	85																

Laboratory Data

blackburn consulting

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	3195.X	BCI-19-37
COUNTY: SOL	ROUTE:	POSTMILE:
CLIENT: Ecosystems Investment Partners		
PREPARED BY: NCH	CHECKED BY: DWC	SHEET: 3 of 3

LOGGED BY	BEGIN DATE	COMPLETION DATE	LOCATION (Lat/Long or North/East and Datum)	HOLE ID
DWC	3-19-19	3-19-19	38.30662° / -121.73123°	BCI-19-38

CONTRACTOR **Taber**	LOCATION (Offset, Station, Line)	SURFACE ELEVATION **8.5 ft**
OPERATOR'S NAME **Rick** HELPER'S NAME **Derrick/Adam**	EQUIPMENT **Diedrich D120**	TOTAL DEPTH **76.5 ft**
EXCAVATION METHOD **Solid-Stem Auger/ Mud Rotary**	DRILLING ROD TYPE AND DIAMETER / BUCKET WIDTH	BOREHOLE DIAMETER **4 in**
SAMPLER TYPE(S) AND SIZE(S) (ID) **Shelby (2.87") and SPT (1.4") and Mod Cal (2.4")**	HAMMER TYPE **Safety semi-automatic drop (140#/ 30")**	HAMMER EFFICIENCY, ERi **81%**
BACKFILL AND COMPLETION **Tremie Grout Backfill**	GROUND WATER READINGS — DURING **28.0 ft** — AFTER (DATE) **6.0 ft on 3-19-19**	CASING TYPE AND DIAMETER(in)

ELEVATION (ft)	DEPTH (ft)	DESCRIPTION	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests
	0	AGGREGATE BASE (AB)												
6.50	2	Fat CLAY (CH); Stiff to Very Stiff; Black; Moist												
	3		1	500 PSI		63	3.5							
	5		2	3 5 5	10	100	1.25			70	48	99		
2.50	6	Orangish Gray Mottled with Gray	3	300 PSI		75	2.5							
0.50	8	Lean CLAY with SAND (CL); Very Stiff to Hard; Yellowish Brown; Moist; Some Weak Cementation	4	5 8 10	18	100	2.75							
-1.50	10		5	900 PSI		83	>4.5							
-3.50	12	Mottled Yellowish Brown and Orange; Black Spots	6	7 8 12	20	60				43	22	84		
	13		7	600 PSI		75	2.25							
	15		8	5 9 11	20	90	3.75							
-7.50	16	Lean CLAY (CL); Very Stiff to Hard; Mottled Blueish Gray and Orangish Brown and light Gray and white; Moist												
	17	Mottled Blueish Gray and Orangish Brown	9	700 PSI		100	4.0							
-9.50	18		10	6 8 13	21	100	>4.5			46	30	89		
-11.50	20	Mottled Blueish Gray and Orangish Brown and White	11	800 PSI		92	>4.5							
-13.50	22		12	8 10 11	21	90								
-15.50	24													
	25													

(continued)

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	3195.X	BCI-19-38
COUNTY: SOL	ROUTE	POSTMILE
CLIENT: Ecosystems Investment Partners		
PREPARED BY: LDM	CHECKED BY: DWC	SHEET 1 of 3

ELEVATION (ft)	DEPTH (ft)	Material Graphics	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests	Drilling Method
	25		Lean CLAY (CL) *(continued)*.														
-17.50	26				13	500 PSI		100	>4.5								
	27																
-19.50	28																
	29																
-21.50	30		Switched to Mud Rotary at 30 ft bgs														
	31				14	400 PSI		100	1.75								
-23.50	32																
	33																
-25.50	34		Lean CLAY with SAND (CL); Medium Stiff to Stiff; Orange Yellowish Brown; Moist														
	35																
-27.50	36				15	300 PSI		100	1.0			34	11	78			
	37																
-29.50	38																
	39																
-31.50	40		SANDY SILT (ML); Medium Stiff to Stiff; Orange Yellowish Brown; Moist No Recovery														
	41				16	3 4 7	11	0									
-33.50	42				17	200 PSI		100	1.25			NP 30	NP 5	65 66			
	43																
-35.50	44																
	45		Lean CLAY (CL); Soft; Dark Olive Brown; Moist														
-37.50	46				18	5 4 6	10	90	0.25			37	16	85			
	47																
-39.50	48																
	49		Well-Graded SAND with SILT and GRAVEL (SW-SM); Dense; Orangish Gray; Moist to Wet; Fine to Coarse SAND; Some Fine to Medium GRAVEL														
-41.50	50																
	51				19	23 23 24	47	100						7			
-43.50	52																
	53																
-45.50	54																
	55																

(continued)

blackburn consulting

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	3195.X	BCI-19-38
COUNTY: SOL	ROUTE:	POSTMILE:
CLIENT: Ecosystems Investment Partners		
PREPARED BY: LDM	CHECKED BY: DWC	SHEET: 2 of 3

ELEVATION (ft)	DEPTH (ft)	DESCRIPTION	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests
	55	Well Graded SAND with SILT and GRAVEL (SW-SM) *(continued)*.	20	16 26 29	55	80						11		
-47.50	56	Poorly-graded SAND with SILT (SP-SM); Dense; Orangish Grayish Brown; Moist; Fine SAND												
	57	Poorly-graded SAND (SP); Dense; Orangish Gray; Moist; Fine to Medium SAND												
-49.50	58													
	59													
-51.50	60	SANDY SILT (ML); Soft; Orangish Yellowish Brown; Moist to Wet; Some Fine SAND	21	5 4 8	12	75								
	61	SILTY SAND (SM); Loose; Orangish Grayish Brown; Moist to Wet; Some Fines; Fine SAND												
-53.50	62													
	63													
-55.50	64													
	65	Fat CLAY (CH); Very Stiff to Hard; Mottled Olive Gray and Brown; Moist; (Brown Material Appears to be SC)	22	17 21 28	49	90	4.25			57	32	92		
-57.50	66													
	67													
-59.50	68													
	69													
-61.50	70		23	12 12 15	27	0								
	71													
-63.50	72													
	73													
-65.50	74													
	75		24	13 23 26	49	100	2.25							
-67.50	76													
	77	Bottom of exploration at 76.5 ft below ground surface (bgs)												
-69.50	78	Tremie Grout Backfill Ground water encountered at 28.0 ft bgs, rose to 6.0 ft bgs												
	79													
-71.50	80													
	81													
-73.50	82													
	83													
-75.50	84													
	85													

Laboratory Data

Columns also: Material Graphics, Sample Location, Drilling Method

BCI LOG FOR SOIL BORINGS.GPJ LIBRARY_3195.GLB 8/28/19

blackburn consulting

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	3195.X	BCI-19-38
COUNTY: SOL	ROUTE:	POSTMILE:
CLIENT: Ecosystems Investment Partners		
PREPARED BY: LDM	CHECKED BY: DWC	SHEET: 3 of 3

LOGGED BY	BEGIN DATE	COMPLETION DATE	LOCATION (Lat/Long or North/East and Datum)	HOLE ID
LDM	**3-12-19**	**3-12-19**	**38.32906° / -121.69431°**	**BCI-19-57**

Field	Value
CONTRACTOR	**Taber**
LOCATION (Offset, Station, Line)	
SURFACE ELEVATION	**19.0 ft**
OPERATOR'S NAME	**Bob**
HELPER'S NAME	**David/ Jeff**
EQUIPMENT	**CME 55 Truck**
TOTAL DEPTH	**86.5 ft**
EXCAVATION METHOD	**Solid-Stem Auger/ Mud Rotary**
DRILLING ROD TYPE AND DIAMETER / BUCKET WIDTH	
BOREHOLE DIAMETER	**4 in**
SAMPLER TYPE(S) AND SIZE(S) (ID)	**Shelby (2.87") and SPT (1.4")**
HAMMER TYPE	**Safety semi-automatic drop (140#/ 30")**
HAMMER EFFICIENCY, ERi	**79%**
BACKFILL AND COMPLETION	**Tremie Grout Backfill**
GROUND WATER READINGS — DURING	**16.0 ft**
GROUND WATER READINGS — AFTER (DATE)	
CASING TYPE AND DIAMETER(in)	

ELEVATION (ft)	DEPTH (ft)	DESCRIPTION	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests
	0	Fat CLAY (CH); Medium Stiff to Stiff; Grayish Brown; Moist												
17.00	1–2.5		1	2 4 5	9	75								
15.00	4													
13.00	5–7.5		2	700 PSI		70	1.5			51	32	80		
11.00	8													
	9	Dark Gray												
9.00 / 7.00	10–13		3	600 PSI		80	2.0							
5.00	13–14.5		4	4 7 9	16	100								
	14.5–15.5		5	900 PSI		100	>4.5							
3.00	15.5–17	Hard; Wet	6	8 11 12	23	100								
	17	Switched to Mud Rotary at 17 ft bgs								54	37	68		
1.00	17–20	SANDY Lean CLAY (CL); Very Stiff; Olive Brown; Wet; Fine SAND	7	300 PSI		100		23	100	41	20	54		
	19	Thin layer of SANDY SILTY CLAY (CL-ML)						22	90	25	4	63		
-1.00	20–21.5		8	4 5 6	11	100	4.0	29	97					
-3.00	22–23.5		9	800 PSI		100				36	15	63		
	23	Lean CLAY (CL); Stiff to Very Stiff; Mottled Strong Brown and Light Brown; Wet. Shelby Disturbed Due to High Pressures.												
-5.00	23.5–25		10	6 7 7	14	100		30	93	31	9	89		

(continued)

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	**3195.X**	**BCI-19-57**

COUNTY	ROUTE	POSTMILE
SOL		

CLIENT: **Ecosystems Investment Partners**

PREPARED BY	CHECKED BY	SHEET
LDM	**NCH**	**1 of 4**

ELEVATION (ft)	DEPTH (ft)	Material Graphics	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests	Drilling Method
	25		Lean CLAY (CL) *(continued)*.														
-7.00	26																
	27																
-9.00	28		Fat CLAY (CH); Hard; Strong Brown; Wet														
	29																
-11.00	30				11	6 11 16	27	100	4.5			51	27	96			
	31																
-13.00	32																
	33																
-15.00	34																
	35				12	10 15 18	33	100	4.0								
-17.00	36																
	37																
-19.00	38																
	39																
-21.00	40		Little Recovery		13	6 8 9	17	10									
	41																
-23.00	42																
	43		SANDY SILT (ML); Stiff; Strong Brown; Wet; approximately 30-40% Fine SAND														
-25.00	44																
	45				14	5 6 9	15	10				32	7	66			
-27.00	46																
	47		Some SAND		15	800 PSI		100	>4.5								
-29.00	48		Lean CLAY (CL); Hard; Black; Wet														
	49																
-31.00	50		Dark Olive Brown		16	9 10 12	22	80									
	51																
-33.00	52																
	53		SANDY Lean CLAY (CL); Medium Stiff; Dark Olive Brown; Wet														
-35.00	54																
	55																

(continued)

blackburn consulting

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	3195.X	BCI-19-57
COUNTY: SOL	ROUTE	POSTMILE
CLIENT: Ecosystems Investment Partners		
PREPARED BY: LDM	CHECKED BY: NCH	SHEET: 2 of 4

ELEVATION (ft)	DEPTH (ft)	DESCRIPTION	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests
	55	SANDY Lean CLAY (CL) *(continued)*. No Recovery; Sand Catcher Redone for Sample	17	8 9 11	20	80	1.0							
-37.00	56													
	57													
-39.00	58													
	59													
-41.00	60	Soft; Dark Gray; Sand Catcher	18	4 8 10	18	70								
	61													
-43.00	62													
	63													
-45.00	64													
	65	SILTY SAND (SM); Dense; Grayish Brown; Moist	19	9 11 13	24	25				NP	NP	23		
-47.00	66													
	67													
-49.00	68													
	69	Fat CLAY (CH); Very Stiff; Grayish Brown; Wet												
-51.00	70	Sand Catcher Used	20	5 7 11	18	80	2.5							
	71													
-53.00	72													
	73													
-55.00	74													
	75	Hard; Dark Gray	21	15 21 28	49	100	>4.5							
-57.00	76													
	77													
-59.00	78													
	79													
-61.00	80	Little Recovery	22	10 13 16	29	10								
	81													
-63.00	82													
	83													
-65.00	84													
	85													

Laboratory Data columns: Moisture Content (%), Dry Density (pcf), Liquid Limit, Plasticity Index, % <#200, Shear Strength Test, Additional Lab Tests. Other columns: Material Graphics, Sample Location, Drilling Method.

(continued)

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	3195.X	BCI-19-57
COUNTY: SOL	ROUTE:	POSTMILE:
CLIENT: Ecosystems Investment Partners		
PREPARED BY: LDM	CHECKED BY: NCH	SHEET: 3 of 4

ELEVATION (ft)	DEPTH (ft)	Material Graphics	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests	Drilling Method
-67.00	85 86		Very Stiff; Grayish Brown; Sand Catcher Fat CLAY (CH) *(continued)*.		23	13 16 22	38	80	3.0								

Bottom of exploration at 86.5 ft below ground surface (bgs)

Tremie Grout Backfill
Ground water encountered at 16.0 ft bgs

ELEVATION (ft)	DEPTH (ft)
	87
-69.00	88
	89
-71.00	90
	91
-73.00	92
	93
-75.00	94
	95
-77.00	96
	97
-79.00	98
	99
-81.00	100
	101
-83.00	102
	103
-85.00	104
	105
-87.00	106
	107
-89.00	108
	109
-91.00	110
	111
-93.00	112
	113
-95.00	114
	115

blackburn consulting

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME **Lookout Slough THRFIP**		FILE NO. **3195.X**	HOLE ID **BCI-19-57**
COUNTY **SOL**	ROUTE		POSTMILE
CLIENT **Ecosystems Investment Partners**			
PREPARED BY **LDM**	CHECKED BY **NCH**	SHEET **4 of 4**	

Taber
EXPLORATION & TESTING
536 Galveston Street
West Sacramento, CA 95691-2116
Office **(916) 371-8234**
Fax (916) 371-8283

January 30, 2018

Blackburn Consulting
2491 Boatman Avenue
West Sacramento, CA 95691

Subject: SPT – Hammer Energy Measurements
CME 55 Track Rig
Lookout Slough Habitat, Boring B11
Solano County, CA

Greetings:

This letter transmits the Standard Penetration Test (SPT) hammer energy efficiency in boring B11 for your Lookout Slough Habitat Project on November 28, 2017 using a CME 55 Track-Mounted Drill Rig equipped with our Blue automatic hammer. Energy measurements for this hammer were obtained in a manner consistent with ASTM D4633-10 using an SPT Analyzer manufactured by Pile Dynamics, Inc. The purpose was to obtain hammer energy measurements and determine hammer efficiency (normalized for 60% efficiency) during sampling.

Dynamic strain and acceleration measurements were obtained through two strain bridge pairs and two accelerometers affixed on a 2-foot long section of AWJ rod. The AWJ rod was mounted on top of the string of rods and below the hammer. Strain and acceleration signals were conditioned and converted to force and velocity measurements using the SPT Analyzer.

The dynamic force and velocity data was converted to maximum transferred energy using the EFV method: $EFV = \int F(t) \bullet V(t) \bullet dt$. The integration is performed from when energy transfer begins to when the maximum energy occurs. This method is theoretically appropriate regardless of rod length, wave travel time, and the number of non-uniform rod connections. Energy transfer is then calculated as ETR = EFV/PE, where ETR is the energy transfer ratio, EVF is the energy transferred to the sampling rods, and PE is the theoretical potential energy.

The average hammer efficiency (ETR) on November 28, 2017, was **74%** (based on an EFV of 260 ft-lbs). The results via the SPT Analyzer are presented in the attached table (Summary of Field Results, SPT Energy Measurements), graphical data plots, and data sheets.

We appreciate the opportunity to be of service.

Very Truly Yours,
Taber Drilling

REGISTERED PROFESSIONAL ENGINEER
FRANKLIN P. TABER
No. 816
GEOTECHNICAL
STATE OF CALIFORNIA

Franklin Taber

Frank Taber
GE 816

Attachments: Summary of Field Results, SPT Energy Measurements
SPT Analyzer Data, Per Drive Depth

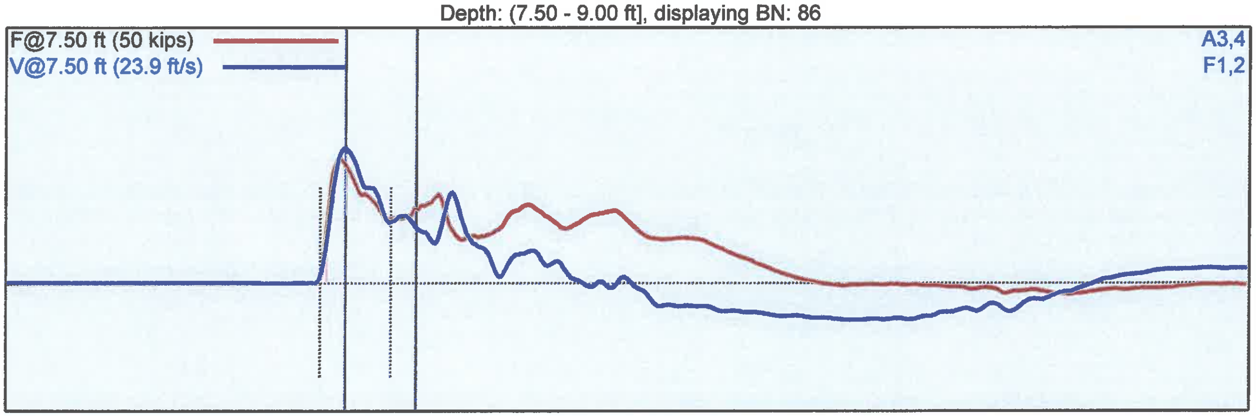
cme 55 11-28-17
Tim

7.5
Test date: 11/28/2017

AR: 1.17 in^2
LE: 7.50 ft
WS: 16807.9 ft/s

SP: 0.492 k/ft3
EM: 30000 ksi

Depth: (7.50 - 9.00 ft], displaying BN: 86



FMX: Maximum Force
VMX: Maximum Velocity
BPM: Blows/Minute

EFV: Maximum Energy
ETR: Energy Transfer Ratio - Rated

BL#	LP	FMX	VMX	BPM	EFV	ETR
	ft	kips	ft/s	bpm	ft-lb	(%)
1	7.53	25	15.0	1.9	234	66.9
2	7.55	25	13.2	28.1	250	71.4
3	7.58	25	13.3	28.4	253	72.2
4	7.61	25	13.2	28.4	264	75.3
5	7.63	25	13.0	28.5	264	75.3
6	7.66	25	12.4	28.5	260	74.2
7	7.68	25	12.5	28.1	263	75.1
8	7.71	25	12.3	28.6	259	74.0
9	7.74	25	12.6	28.6	261	74.6
10	7.76	25	12.6	28.6	260	74.4
11	7.79	25	12.7	28.6	262	74.9
12	7.82	25	13.0	28.3	267	76.3
13	7.84	25	12.7	27.8	260	74.4
14	7.87	25	12.9	28.1	261	74.7
15	7.89	25	13.0	28.4	264	75.4
16	7.92	25	12.6	28.6	265	75.6
17	7.95	25	12.5	28.7	258	73.6
18	7.97	25	12.6	28.7	261	74.5
19	8.00	25	12.7	28.3	260	74.3
20	8.02	25	12.7	28.7	259	74.1
21	8.03	25	12.8	28.6	254	72.6
22	8.05	25	12.8	28.6	257	73.5
23	8.07	25	12.2	28.6	248	70.9
24	8.09	25	12.8	28.5	247	70.5
25	8.10	25	12.8	28.3	240	68.7
26	8.12	25	12.5	28.6	230	65.8
27	8.14	25	12.1	28.7	257	73.5
28	8.16	25	12.7	28.9	267	76.3
29	8.17	25	12.2	28.8	246	70.4
30	8.19	25	12.6	28.5	254	72.5
31	8.21	25	12.6	28.6	254	72.5
32	8.22	25	12.3	28.8	257	73.4
33	8.24	25	12.3	28.9	256	73.1

34	8.26	25	12.5	28.8	248	70.8
35	8.28	25	12.1	28.8	254	72.5
36	8.29	25	12.0	28.1	267	76.3
37	8.31	25	12.3	29.0	260	74.2
38	8.33	25	12.7	28.8	243	69.5
39	8.34	25	12.0	28.8	249	71.2
40	8.36	25	12.6	28.8	257	73.5
41	8.38	25	12.4	28.8	265	75.7
42	8.40	25	13.1	28.2	267	76.3
43	8.41	25	11.8	29.0	258	73.8
44	8.43	25	12.6	28.9	252	72.0
45	8.45	25	12.2	28.9	261	74.6
46	8.47	25	12.5	28.9	275	78.5
47	8.48	25	12.0	29.0	253	72.2
48	8.50	25	12.8	28.3	268	76.7
49	8.51	25	12.2	29.1	248	71.0
50	8.53	25	12.5	28.9	262	74.7
51	8.54	25	12.5	28.9	252	71.9
52	8.55	25	12.7	28.9	266	76.1
53	8.56	25	12.6	29.0	272	77.8
54	8.58	25	12.8	28.3	261	74.5
55	8.59	25	12.4	29.1	235	67.0
56	8.60	25	12.3	28.9	235	67.1
57	8.61	25	12.7	29.0	250	71.5
58	8.63	25	12.8	28.9	254	72.6
59	8.64	25	12.7	28.9	261	74.4
60	8.65	25	12.0	28.3	273	77.9
61	8.66	25	12.7	29.0	254	72.6
62	8.68	25	12.4	28.9	251	71.8
63	8.69	25	12.8	28.9	280	80.1
64	8.70	25	12.4	29.0	236	67.4
65	8.71	25	12.3	28.9	253	72.2
66	8.73	25	12.3	28.3	286	81.8
67	8.74	25	12.1	29.0	275	78.7
68	8.75	25	12.7	28.9	273	77.9
69	8.76	25	12.5	29.0	258	73.7
70	8.78	25	12.7	28.9	261	74.5
71	8.79	25	13.0	29.0	263	75.2
72	8.80	25	12.3	28.3	256	73.0
73	8.81	25	12.6	29.1	260	74.4
74	8.83	24	12.6	29.0	257	73.5
75	8.84	25	12.9	29.0	264	75.6
76	8.85	24	12.1	29.0	258	73.8
77	8.86	25	12.2	29.0	259	73.9
78	8.88	24	12.2	28.3	253	72.4
79	8.89	24	12.7	29.1	257	73.5
80	8.90	24	12.2	29.0	252	72.0
81	8.91	24	12.6	29.0	261	74.6
82	8.93	25	12.4	29.0	253	72.3
83	8.94	24	12.6	29.0	258	73.6
84	8.95	25	12.2	28.4	264	75.6
85	8.96	24	13.0	29.1	258	73.8
86	8.98	24	12.7	29.0	254	72.6
87	8.99	25	13.0	29.0	253	72.2
88	9.00	25	13.0	29.0	257	73.4
	Average	25	12.5	28.8	257	73.4
	Std Dev	0	0.3	0.3	10	2.9
	Maximum	25	13.1	29.1	286	81.8
	Minimum	24	11.8	28.1	230	65.8

N-value: 69

Sample Interval Time: 181.80 seconds.

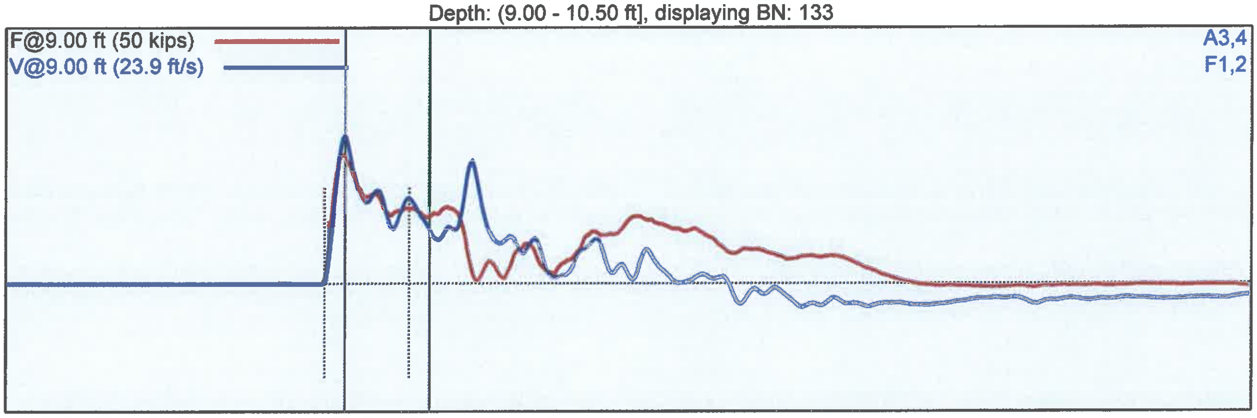
cme 55 11-28-17
Tim

7.5
Test date: 11/28/2017

AR: 1.17 in^2
LE: 9.00 ft
WS: 16807.9 ft/s

SP: 0.492 k/ft3
EM: 30000 ksi

Depth: (9.00 - 10.50 ft], displaying BN: 133



BL#	LP	FMX	VMX	BPM	EFV	ETR
	ft	kips	ft/s	bpm	ft-lb	(%)
89	9.04	25	13.6	1.9	235	67.2
90	9.08	25	13.6	25.7	247	70.4
91	9.13	25	13.9	28.0	250	71.4
92	9.17	25	14.1	29.7	257	73.5
93	9.21	26	14.1	29.8	263	75.2
94	9.25	25	14.1	29.8	256	73.0
95	9.29	25	14.2	29.4	268	76.7
96	9.33	26	14.1	29.9	262	74.9
97	9.38	26	14.2	29.9	258	73.8
98	9.42	26	14.3	29.9	260	74.2
99	9.46	26	14.3	29.9	264	75.3
100	9.50	26	14.3	30.0	264	75.5
101	9.53	26	14.1	29.5	268	76.6
102	9.57	26	14.1	30.0	265	75.7
103	9.60	26	14.3	29.9	268	76.5
104	9.63	26	14.2	30.0	266	75.9
105	9.67	26	14.4	30.0	265	75.8
106	9.70	26	14.5	29.2	266	76.1
107	9.73	25	14.1	30.2	261	74.6
108	9.77	26	14.2	30.0	266	76.0
109	9.80	25	14.1	30.0	261	74.6
110	9.83	25	13.9	30.0	263	75.2
111	9.87	25	14.0	30.0	259	73.9
112	9.90	25	14.2	29.6	259	74.0
113	9.93	26	14.1	30.0	263	75.0
114	9.97	25	13.8	30.0	258	73.7
115	10.00	25	14.0	30.1	263	75.2
116	10.03	25	13.9	30.0	266	76.1
117	10.05	26	14.4	30.1	272	77.7
118	10.08	26	14.2	29.6	263	75.2
119	10.10	25	13.8	30.0	263	75.1
120	10.13	25	13.5	30.1	251	71.7
121	10.15	26	14.0	30.1	259	73.9
122	10.18	25	13.5	30.0	255	72.9
123	10.20	26	13.9	30.1	263	75.3
124	10.23	25	13.6	29.6	216	61.7

125	10.25	25	13.9	30.0	216	61.8
126	10.28	25	13.5	30.0	193	55.2
127	10.30	25	14.1	30.1	278	79.5
128	10.33	25	13.9	30.1	281	80.2
129	10.35	26	14.2	29.3	279	79.7
130	10.38	25	13.8	30.2	257	73.3
131	10.40	25	13.9	30.1	263	75.0
132	10.43	26	14.3	30.0	262	75.0
133	10.45	25	13.9	30.1	268	76.5
134	10.48	25	13.6	30.1	332	94.8
135	10.50	25	13.6	29.6	210	59.9
	Average	25	14.0	29.9	260	74.3
	Std Dev	0	0.3	0.2	23	6.5
	Maximum	26	14.5	30.2	332	94.8
	Minimum	25	13.5	29.2	193	55.2

N-value: 35

Sample Interval Time: 92.77 seconds.

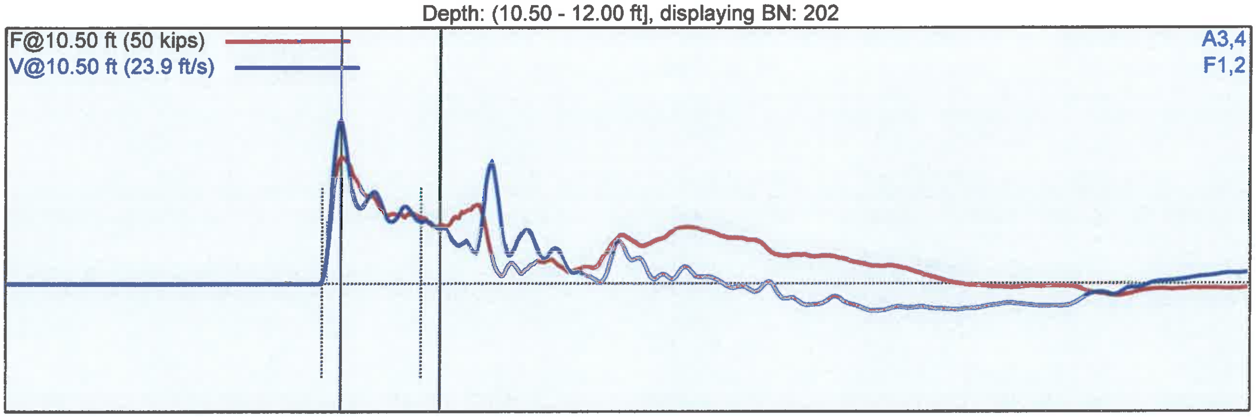
cme 55 11-28-17
Tim

7.5
Test date: 11/28/2017

AR: 1.17 in^2
LE: 10.50 ft
WS: 16807.9 ft/s

SP: 0.492 k/ft3
EM: 30000 ksi

Depth: (10.50 - 12.00 ft], displaying BN: 202



BL#	LP ft	FMX kips	VMX ft/s	BPM bpm	EFV ft-lb	ETR (%)
136	10.53	24	14.8	1.9	243	69.4
137	10.55	25	14.8	25.2	255	72.8
138	10.58	25	15.4	29.2	264	75.4
139	10.61	25	15.2	29.3	300	85.7
140	10.63	25	15.3	29.3	266	75.9
141	10.66	25	15.2	28.9	321	91.6
142	10.68	25	15.3	29.3	259	74.0
143	10.71	25	15.2	29.4	288	82.2
144	10.74	25	15.5	29.3	272	77.6
145	10.76	25	15.1	29.5	185	52.9
146	10.79	24	16.0	28.7	194	55.4
147	10.82	25	15.9	29.5	261	74.6
148	10.84	25	16.2	29.4	272	77.6
149	10.87	25	16.0	29.2	209	59.6
150	10.89	25	16.0	29.2	213	60.9
151	10.92	25	16.4	29.0	322	91.9
152	10.95	25	16.2	28.8	276	78.8
153	10.97	25	16.4	29.3	311	88.9
154	11.00	25	16.1	29.5	275	78.5
155	11.02	24	15.2	29.4	208	59.3
156	11.04	24	15.0	29.4	241	68.8
157	11.05	24	15.1	28.7	270	77.3
158	11.07	25	15.6	29.7	259	73.9
159	11.09	25	15.8	29.5	263	75.0
160	11.11	25	15.9	29.5	267	76.2
161	11.13	25	15.6	29.5	252	72.1
162	11.14	25	15.6	29.5	264	75.5
163	11.16	24	14.9	29.2	259	74.1
164	11.18	25	15.2	29.5	256	73.0
165	11.20	25	15.6	29.5	273	78.0
166	11.21	25	15.5	29.5	253	72.2
167	11.23	24	14.6	29.6	259	73.9
168	11.25	24	15.2	29.5	270	77.1
169	11.27	25	15.6	29.0	268	76.7
170	11.29	24	15.4	29.5	263	75.1
171	11.30	24	14.9	29.5	263	75.0

172	11.32	25	15.4	29.6	254	72.5
173	11.34	24	14.7	29.5	261	74.6
174	11.36	25	15.5	28.8	274	78.3
175	11.38	24	15.1	29.7	261	74.6
176	11.39	25	15.6	29.5	268	76.6
177	11.41	25	15.5	29.6	259	74.0
178	11.43	24	14.8	29.5	258	73.6
179	11.45	24	15.1	29.5	260	74.2
180	11.46	24	14.9	29.1	259	74.1
181	11.48	24	15.4	29.6	260	74.2
182	11.50	24	14.9	29.5	260	74.3
183	11.52	25	15.5	29.5	266	76.0
184	11.55	24	15.4	29.6	258	73.8
185	11.57	24	15.1	29.3	260	74.4
186	11.59	25	15.5	29.3	264	75.3
187	11.61	25	15.8	29.5	269	76.9
188	11.64	25	15.5	29.5	264	75.3
189	11.66	24	15.3	29.6	263	75.0
190	11.68	25	15.0	29.6	264	75.4
191	11.70	25	15.8	28.9	269	76.7
192	11.73	25	15.7	29.6	268	76.7
193	11.75	25	15.2	29.5	267	76.2
194	11.77	25	15.7	29.6	260	74.2
195	11.80	25	15.3	29.6	250	71.5
196	11.82	25	15.5	29.6	255	72.9
197	11.84	25	15.9	29.2	380	108.6
198	11.86	25	15.2	29.5	272	77.8
199	11.89	25	15.5	29.5	269	76.9
200	11.91	24	15.1	29.6	267	76.2
201	11.93	25	15.7	29.6	269	76.8
202	11.95	25	15.3	29.5	264	75.4
203	11.98	25	15.4	29.2	270	77.1
204	12.00	25	15.4	29.5	262	74.9
	Average	25	15.3	29.4	264	75.4
	Std Dev	0	0.3	0.2	19	5.5
	Maximum	25	15.9	29.7	380	108.6
	Minimum	24	14.6	28.7	208	59.3

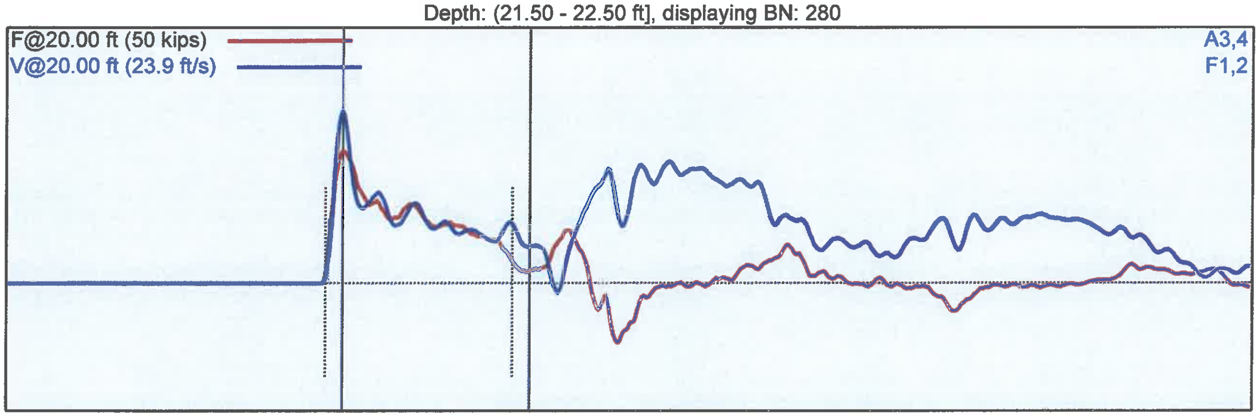
N-value: 50

Sample Interval Time: 139.23 seconds.

cme 55 11-28-17 7.5
Tim Test date: 11/28/2017

AR: 1.17 in^2 SP: 0.492 k/ft3
LE: 20.00 ft EM: 30000 ksi
WS: 16807.9 ft/s

Depth: (21.50 - 22.50 ft], displaying BN: 280



BL#	LP	FMX	VMX	BPM	EFV	ETR
	ft	kips	ft/s	bpm	ft-lb	(%)
276	22.00	25	15.7	30.8	257	73.5
277	22.50	25	16.3	30.0	281	80.2
278	22.50	25	15.7	31.2	251	71.8
279	22.50	26	15.9	30.8	337	96.3
280	22.50	26	16.1	30.9	274	78.3
281	22.50	26	16.8	30.9	353	100.8
282	22.50	25	15.7	30.9	257	73.4
	Average	26	16.0	30.8	287	82.0
	Std Dev	0	0.4	0.3	38	10.9
	Maximum	26	16.8	31.2	353	100.8
	Minimum	25	15.7	30.0	251	71.8

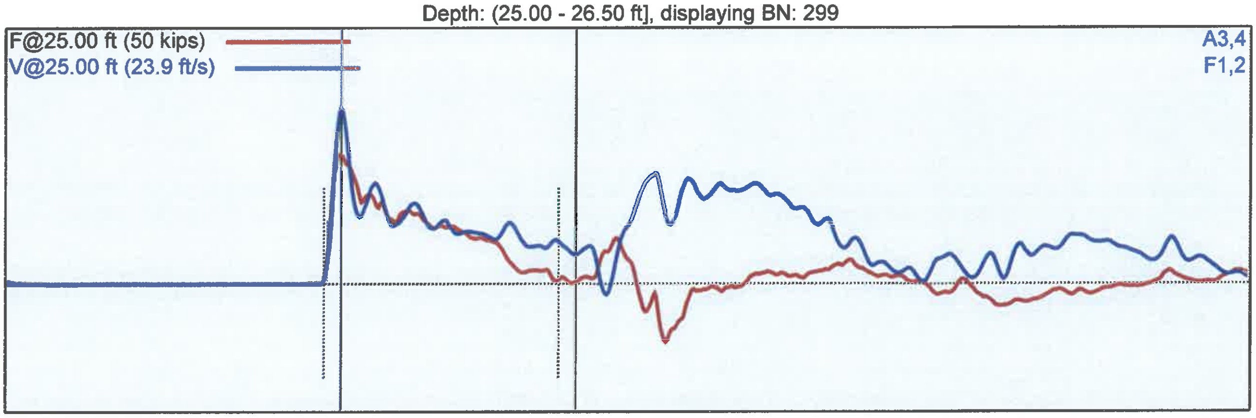
N-value: 7

Sample Interval Time: 11.75 seconds.

cme 55 11-28-17 7.5
Tim Test date: 11/28/2017

AR: 1.17 in^2 SP: 0.492 k/ft3
LE: 25.00 ft EM: 30000 ksi
WS: 16807.9 ft/s

Depth: (25.00 - 26.50 ft], displaying BN: 299



BL#	LP	FMX	VMX	BPM	EFV	ETR
	ft	kips	ft/s	bpm	ft-lb	(%)
283	25.17	25	15.2	1.9	257	73.5
284	25.33	25	16.0	30.4	252	72.0
285	25.50	25	15.5	30.7	256	73.0
286	25.60	25	16.3	30.7	252	72.1
287	25.70	25	16.6	30.8	250	71.3
288	25.80	25	15.7	30.8	239	68.2
289	25.90	25	15.9	30.4	248	71.0
290	26.00	26	16.0	30.8	256	73.0
291	26.05	26	16.3	30.8	262	75.0
292	26.09	26	16.1	30.8	281	80.3
293	26.14	26	15.7	30.8	237	67.7
294	26.18	26	16.1	30.1	263	75.0
295	26.23	25	16.4	31.1	284	81.2
296	26.27	25	16.4	30.9	249	71.3
297	26.32	25	16.5	30.9	264	75.4
298	26.36	26	16.6	30.9	258	73.7
299	26.41	25	16.5	30.9	251	71.9
300	26.45	25	16.4	30.5	266	76.1
301	26.50	25	16.5	30.9	278	79.6
	Average	25	16.2	30.8	259	73.9
	Std Dev	0	0.3	0.2	13	3.9
	Maximum	26	16.6	31.1	284	81.2
	Minimum	25	15.7	30.1	237	67.7

N-value: 16

Sample Interval Time: 35.18 seconds.

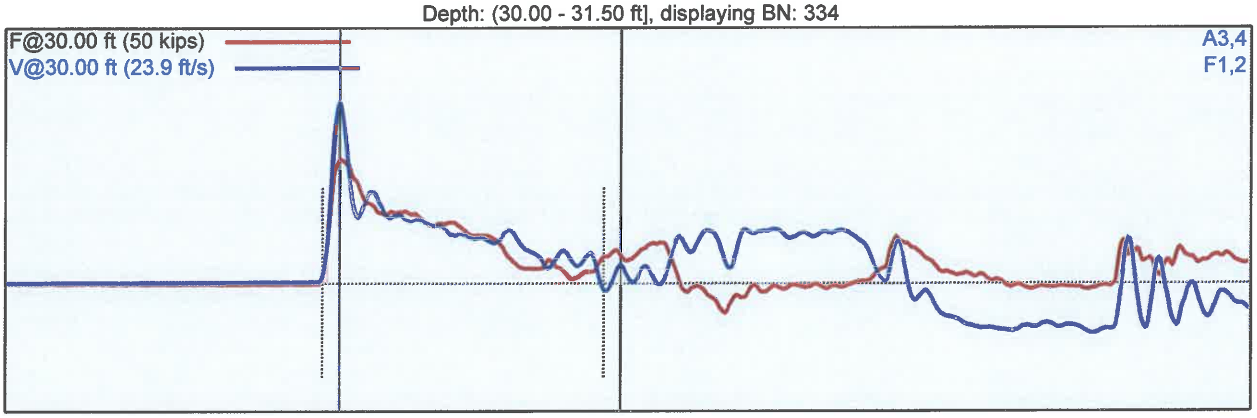
cme 55 11-28-17
Tim

7.5
Test date: 11/28/2017

AR: 1.17 in^2
LE: 30.00 ft
WS: 16807.9 ft/s

SP: 0.492 k/ft3
EM: 30000 ksi

Depth: (30.00 - 31.50 ft], displaying BN: 334



BL#	LP ft	FMX kips	VMX ft/s	BPM bpm	EFV ft-lb	ETR (%)
302	30.25	25	15.4	1.9	252	72.1
303	30.50	25	15.9	29.7	288	82.2
304	30.56	25	16.3	29.9	260	74.3
305	30.61	25	15.8	29.2	285	81.4
306	30.67	25	15.3	30.1	229	65.4
307	30.72	25	15.8	30.0	208	59.5
308	30.78	25	16.1	29.9	265	75.7
309	30.83	25	16.4	30.1	266	76.0
310	30.89	25	15.9	29.9	262	74.9
311	30.94	25	16.5	29.7	268	76.6
312	31.00	25	16.1	30.0	270	77.0
313	31.02	25	16.7	30.0	232	66.2
314	31.04	25	15.8	30.0	237	67.8
315	31.06	25	16.3	30.0	292	83.4
316	31.08	25	17.7	29.7	383	109.4
317	31.10	25	15.1	30.0	258	73.6
318	31.13	25	15.9	30.0	256	73.2
319	31.15	25	16.6	30.1	266	75.9
320	31.17	24	15.9	30.0	245	70.0
321	31.19	25	16.7	29.6	187	53.4
322	31.21	25	16.3	30.0	209	59.8
323	31.23	25	16.6	30.0	284	81.0
324	31.25	25	17.0	30.1	248	70.9
325	31.27	25	16.9	30.1	276	78.7
326	31.29	25	16.8	29.7	298	85.0
327	31.31	25	16.7	30.0	259	74.0
328	31.33	25	16.7	30.1	246	70.4
329	31.35	25	16.6	30.1	269	76.8
330	31.38	24	16.4	30.2	273	78.1
331	31.40	25	16.5	29.2	278	79.5
332	31.42	25	16.9	30.3	259	73.9
333	31.44	25	16.8	30.1	235	67.2
334	31.46	24	17.0	30.2	246	70.4
335	31.48	24	15.3	30.0	255	73.0
336	31.50	24	15.1	29.4	275	78.4

Average	25	16.3	29.9	260	74.3
Std Dev	0	0.6	0.3	32	9.2
Maximum	25	17.7	30.3	383	109.4
Minimum	24	15.1	29.2	187	53.4

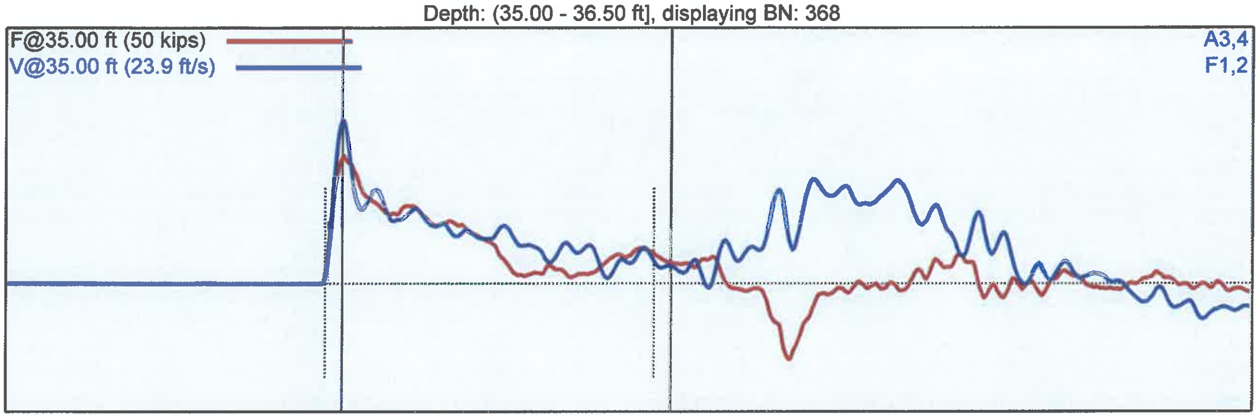
N-value: 33

Sample Interval Time: 68.17 seconds.

cme 55 11-28-17 7.5
Tim Test date: 11/28/2017

AR: 1.17 in^2 SP: 0.492 k/ft3
LE: 35.00 ft EM: 30000 ksi
WS: 16807.9 ft/s

Depth: (35.00 - 36.50 ft], displaying BN: 368



BL#	LP	FMX	VMX	BPM	EFV	ETR
	ft	kips	ft/s	bpm	ft-lb	(%)
337	35.06	26	15.1	1.9	227	65.0
338	35.13	25	15.4	28.2	212	60.6
339	35.19	25	15.1	29.7	265	75.8
340	35.25	25	15.2	29.5	320	91.5
341	35.31	25	15.0	29.6	262	74.9
342	35.38	25	14.8	29.5	260	74.2
343	35.44	25	15.6	29.2	253	72.2
344	35.50	25	14.9	29.6	262	75.0
345	35.54	25	15.7	29.7	260	74.2
346	35.57	25	15.7	29.7	202	57.8
347	35.61	24	15.3	29.2	214	61.1
348	35.64	25	19.0	29.7	196	55.9
349	35.68	25	16.0	29.7	254	72.5
350	35.71	25	16.9	29.7	290	82.9
351	35.75	25	16.2	29.3	261	74.7
352	35.79	25	16.8	29.8	188	53.7
353	35.82	25	16.6	29.8	261	74.7
354	35.86	25	16.7	29.8	274	78.3
355	35.89	25	17.0	29.4	270	77.3
356	35.93	26	16.9	29.7	264	75.5
357	35.96	26	16.8	29.8	267	76.3
358	36.00	26	17.0	29.7	260	74.2
359	36.04	25	16.2	29.4	252	72.1
360	36.08	25	16.7	29.8	287	82.1
361	36.13	25	15.9	29.8	251	71.7
362	36.17	25	15.7	29.8	262	74.8
363	36.21	24	15.2	29.4	260	74.1
364	36.25	25	14.9	29.8	244	69.6
365	36.29	25	15.7	29.8	282	80.6
366	36.33	25	14.4	29.9	249	71.1
367	36.38	25	15.5	29.4	220	62.9
368	36.42	25	15.3	29.9	255	72.7
369	36.46	25	15.0	29.8	257	73.5
370	36.50	24	14.9	29.9	256	73.2

Average	25	16.1	29.7	251	71.8
Std Dev	0	1.0	0.2	26	7.4
Maximum	26	19.0	29.9	290	82.9
Minimum	24	14.4	29.2	188	53.7

N-value: 26

Sample Interval Time: 66.85 seconds.

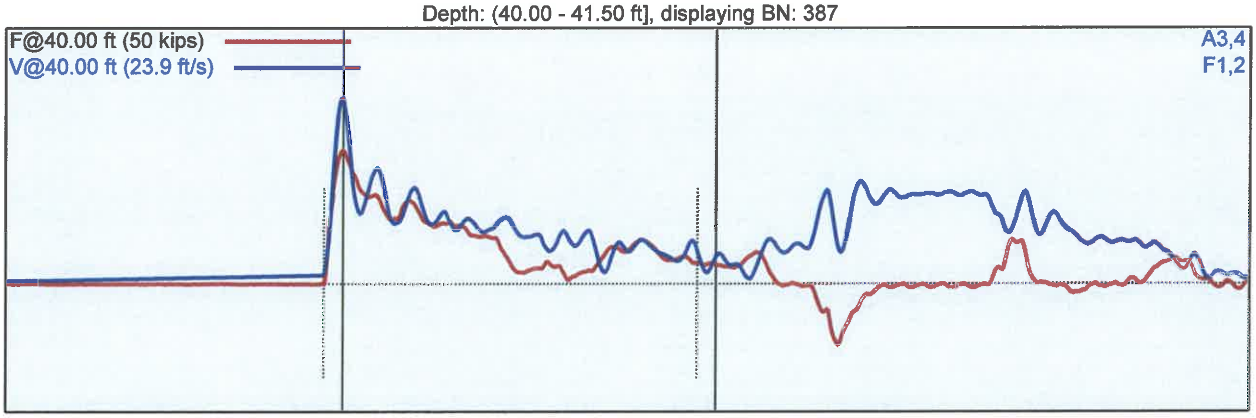
cme 55 11-28-17
Tim

7.5
Test date: 11/28/2017

AR: 1.17 in^2
LE: 40.00 ft
WS: 16807.9 ft/s

SP: 0.492 k/ft3
EM: 30000 ksi

Depth: (40.00 - 41.50 ft], displaying BN: 387



BL#	LP	FMX	VMX	BPM	EFV	ETR
	ft	kips	ft/s	bpm	ft-lb	(%)
371	40.10	25	15.5	1.9	228	65.0
372	40.20	25	15.0	29.8	260	74.2
373	40.30	25	15.2	29.5	262	74.8
374	40.40	25	15.5	30.1	271	77.5
375	40.50	25	15.8	30.1	255	72.9
376	40.57	25	16.2	30.1	244	69.7
377	40.64	25	15.7	29.6	244	69.8
378	40.71	25	15.8	30.1	255	72.8
379	40.79	25	15.9	30.1	256	73.2
380	40.86	25	15.9	30.1	236	67.5
381	40.93	25	16.2	30.0	237	67.6
382	41.00	25	16.0	29.7	248	70.9
383	41.07	26	16.7	30.1	274	78.2
384	41.14	26	16.9	30.2	274	78.3
385	41.21	26	16.8	30.2	284	81.2
386	41.29	25	16.1	29.7	276	79.0
387	41.36	26	17.4	30.2	332	94.9
388	41.43	26	16.6	30.2	278	79.3
389	41.50	26	16.4	30.2	281	80.2
	Average	25	16.3	30.0	266	75.9
	Std Dev	0	0.5	0.2	25	7.0
	Maximum	26	17.4	30.2	332	94.9
	Minimum	25	15.7	29.6	236	67.5

N-value: 14

Sample Interval Time: 36.05 seconds.

This Page Intentionally Left Blank

Summary of SPT Test Results

Project: cme 55 11-28-17, Test Date: 11/28/2017

FMX: Maximum Force
VMX: Maximum Velocity
BPM: Blows/Minute

EFV: Maximum Energy
ETR: Energy Transfer Ratio - Rated

Instr. Length ft	Start Depth ft	Final Depth ft	N Value	N60 Value	Average FMX kips	Average VMX ft/s	Average BPM bpm	Average EFV ft-lb	Average ETR (%)
7.50	7.50	9.00	**69**	**85**	25	12.5	28.8	257	73.4
9.00	9.00	10.50	**35**	**43**	25	14.0	29.9	260	74.3
10.50	10.50	12.00	**50**	**61**	25	15.3	29.4	264	75.4
20.00	21.50	22.50	**0**	**0**	26	16.0	30.8	287	82.0
25.00	25.00	26.50	**16**	**19**	25	16.2	30.8	259	73.9
30.00	30.00	31.50	**33**	**40**	25	16.3	29.9	260	74.3
35.00	35.00	36.50	**26**	**32**	25	16.1	29.7	251	71.8
40.00	40.00	41.50	**14**	**17**	25	16.3	30.0	266	75.9
			Overall Average Values:		25	14.7	29.6	260	74.3
			Standard Deviation:		0	1.6	0.6	22	6.4
			Overall Maximum Value:		26	19.0	31.2	383	109.4
			Overall Minimum Value:		24	11.8	28.1	187	53.4

This page intentionally left blank.

Taber
EXPLORATION & TESTING

536 Galveston Street
West Sacramento, CA 95691-2116
Office **(916) 371-8234**
Fax (916) 371-8283

January 30, 2018

Blackburn Consulting
2491 Boatman Avenue
West Sacramento , CA 95691

Subject: <u>SPT – Hammer Energy Measurements</u>
CME 55 Truck Rig
Yolo County, CA

Greetings:

This letter transmits the Standard Penetration Test (SPT) hammer energy efficiency on December 6, 2017 using a CME 55 Truck-Mounted Drill Rig equipped with an automatic hammer. Energy measurements for this hammer were obtained in a manner consistent with ASTM D4633-10 using an SPT Analyzer manufactured by Pile Dynamics, Inc. The purpose was to obtain hammer energy measurements and determine hammer efficiency (normalized for 60% efficiency) during sampling.

Dynamic strain and acceleration measurements were obtained through two strain bridge pairs and two accelerometers affixed on a 2-foot long section of AWJ rod. The AWJ rod was mounted on top of the string of rods and below the hammer. Strain and acceleration signals were conditioned and converted to force and velocity measurements using the SPT Analyzer.

The dynamic force and velocity data was converted to maximum transferred energy using the EFV method: $EFV = \int F(t) \bullet V(t) \bullet dt$. The integration is performed from when energy transfer begins to when the maximum energy occurs. This method is theoretically appropriate regardless of rod length, wave travel time, and the number of non-uniform rod connections. Energy transfer is then calculated as ETR = EFV/PE, where ETR is the energy transfer ratio, EVF is the energy transferred to the sampling rods, and PE is the theoretical potential energy.

The average hammer efficiency (ETR) on December 6, 2017, was **79%** (based on an EFV of 276 ft-lbs). The results via the SPT Analyzer are presented in the attached table (Summary of Field Results, SPT Energy Measurements), graphical data plots, and data sheets.

We appreciate the opportunity to be of service.

Very Truly Yours,
Taber Drilling

Franklin Taber

REGISTERED PROFESSIONAL ENGINEER
FRANKLIN P. TABER
No. 816
GEOTECHNICAL
STATE OF CALIFORNIA

Frank Taber
GE 816

Attachments: Summary of Field Results, SPT Energy Measurements
SPT Analyzer Data, Per Drive Depth

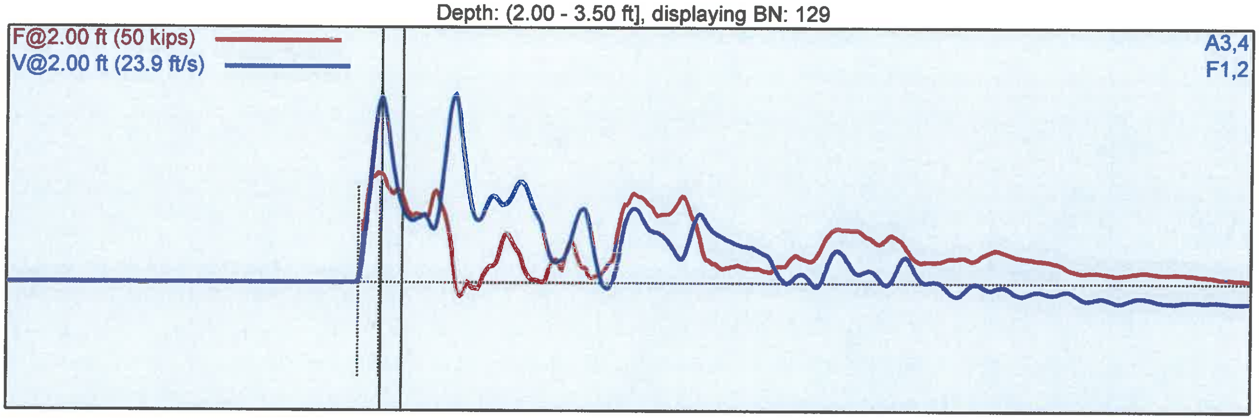
cme 55 12-6-17
Tim

2
Test date: 12/6/2017

AR: 1.17 in^2
LE: 2.00 ft
WS: 16807.9 ft/s

SP: 0.492 k/ft3
EM: 30000 ksi

Depth: (2.00 - 3.50 ft], displaying BN: 129



FMX: Maximum Force
VMX: Maximum Velocity
BPM: Blows/Minute
EFV: Maximum Energy
ETR: Energy Transfer Ratio - Rated

BL#	LP	FMX	VMX	BPM	EFV	ETR
	ft	kips	ft/s	bpm	ft-lb	(%)
1	2.01	25	20.4	1.9	282	80.5
2	2.02	26	19.8	33.4	285	81.5
3	2.03	26	19.7	33.6	282	80.6
4	2.04	26	20.0	33.8	278	79.5
5	2.05	26	20.6	33.6	271	77.3
6	2.06	26	20.4	33.5	280	80.1
7	2.07	26	20.4	33.5	281	80.2
8	2.08	26	20.5	33.7	283	80.9
9	2.09	26	20.3	33.7	285	81.4
10	2.10	26	20.4	33.6	291	83.1
11	2.11	26	20.3	33.5	270	77.2
12	2.12	26	20.4	33.5	276	78.9
13	2.13	25	20.7	33.6	280	80.1
14	2.14	25	20.5	33.6	283	80.8
15	2.15	25	20.4	33.7	279	79.8
16	2.16	25	20.3	33.5	280	79.9
17	2.17	25	20.1	33.6	281	80.4
18	2.18	25	20.0	33.6	282	80.4
19	2.19	24	19.9	33.7	283	80.9
20	2.20	24	19.9	33.5	285	81.3
21	2.21	24	19.9	33.4	285	81.4
22	2.22	25	19.7	33.6	280	79.9
23	2.23	24	19.5	33.6	280	79.9
24	2.24	24	19.6	33.6	285	81.3
25	2.26	24	19.3	33.7	282	80.6
26	2.27	24	19.3	33.4	285	81.4
27	2.28	24	18.9	33.6	281	80.2
28	2.29	25	19.0	33.7	266	75.9
29	2.30	24	19.0	33.6	258	73.8
30	2.31	25	18.5	33.5	261	74.6
31	2.32	25	19.1	33.5	314	89.8
32	2.33	24	18.8	33.5	309	88.4
33	2.34	24	18.7	33.7	280	79.9

34	2.35	25	18.6	33.6	281	80.2
35	2.36	24	18.5	33.5	280	80.0
36	2.37	24	18.5	33.4	278	79.3
37	2.38	24	18.3	33.5	280	79.9
38	2.39	24	18.3	33.8	274	78.2
39	2.40	24	18.5	33.5	278	79.3
40	2.41	24	18.3	33.6	277	79.1
41	2.42	25	18.2	33.5	282	80.5
42	2.43	24	18.2	33.5	277	79.1
43	2.44	25	18.5	33.8	283	80.8
44	2.45	25	17.9	33.6	281	80.2
45	2.46	25	18.0	33.5	281	80.4
46	2.47	25	18.1	33.5	281	80.4
47	2.48	24	18.3	33.7	279	79.6
48	2.49	25	17.8	33.6	279	79.9
49	2.50	24	17.8	33.5	281	80.3
50	2.51	24	18.0	33.5	281	80.2
51	2.52	25	18.2	33.3	286	81.8
52	2.53	24	17.8	33.8	276	78.9
53	2.54	25	17.8	33.6	283	80.8
54	2.55	24	17.8	33.6	283	80.7
55	2.56	24	18.0	33.4	282	80.7
56	2.57	24	17.8	33.6	281	80.4
57	2.58	25	18.0	33.5	288	82.3
58	2.58	24	18.0	33.7	281	80.4
59	2.59	24	17.9	33.5	284	81.3
60	2.60	24	17.9	33.4	285	81.5
61	2.61	25	18.1	33.6	286	81.6
62	2.62	24	18.1	33.7	283	80.8
63	2.63	24	17.7	33.7	285	81.6
64	2.64	25	17.7	33.4	285	81.4
65	2.65	24	17.7	33.6	282	80.7
66	2.66	24	18.1	33.6	286	81.6
67	2.67	24	18.1	33.6	284	81.1
68	2.68	25	17.8	33.6	285	81.4
69	2.69	24	18.1	33.4	286	81.8
70	2.70	24	17.9	33.4	287	81.9
71	2.71	24	17.7	33.7	286	81.7
72	2.72	24	17.9	33.6	282	80.5
73	2.73	24	18.0	33.4	284	81.2
74	2.74	24	18.1	33.4	285	81.3
75	2.75	24	18.0	33.6	278	79.5
76	2.75	24	18.5	33.7	279	79.7
77	2.76	24	18.5	33.5	277	79.1
78	2.77	24	18.6	33.6	281	80.2
79	2.78	24	18.6	33.4	282	80.4
80	2.79	24	18.5	33.5	275	78.5
81	2.80	24	18.6	33.7	278	79.3
82	2.81	25	18.2	33.6	273	77.9
83	2.82	24	18.8	33.6	271	77.5
84	2.83	24	18.8	33.3	274	78.4
85	2.84	24	18.7	33.6	256	73.3
86	2.85	24	18.9	33.6	278	79.4
87	2.86	24	18.5	33.5	254	72.5
88	2.87	24	19.1	33.5	277	79.2
89	2.88	24	19.0	33.4	258	73.7
90	2.89	24	19.5	33.7	277	79.0
91	2.90	23	18.0	33.5	267	76.3
92	2.91	23	19.2	33.6	266	76.0
93	2.92	23	19.3	33.4	269	76.8
94	2.92	23	19.4	33.5	286	81.7

95	2.93	23	19.4	33.5	295	84.3
96	2.94	23	19.1	33.7	291	83.3
97	2.95	23	18.1	33.5	280	80.0
98	2.96	23	19.2	33.4	291	83.2
99	2.97	23	19.1	33.5	279	79.7
100	2.98	23	19.5	33.5	292	83.6
101	2.99	23	19.1	33.7	286	81.7
102	3.00	23	18.4	33.5	283	80.8
103	3.02	22	19.3	33.5	286	81.8
104	3.03	22	19.0	33.5	282	80.6
105	3.05	23	19.0	33.6	282	80.5
106	3.07	22	19.0	33.6	287	82.1
107	3.09	23	18.8	10.7	269	76.7
108	3.10	23	17.9	33.3	267	76.3
109	3.12	22	18.9	33.6	269	76.8
110	3.14	23	18.6	33.4	274	78.4
111	3.16	22	18.8	33.4	285	81.4
112	3.17	22	18.5	33.8	281	80.3
113	3.19	22	18.6	33.6	282	80.6
114	3.21	22	18.8	33.5	288	82.4
115	3.22	22	18.1	33.3	282	80.6
116	3.24	22	18.8	33.6	286	81.8
117	3.26	22	18.2	33.7	286	81.8
118	3.28	22	18.1	33.5	281	80.3
119	3.29	22	18.2	33.4	286	81.8
120	3.31	22	17.9	33.4	285	81.5
121	3.33	22	18.2	33.5	291	83.1
122	3.34	21	17.7	33.7	285	81.5
123	3.36	22	17.9	33.5	288	82.4
124	3.38	22	18.1	33.5	292	83.5
125	3.40	22	17.9	33.4	282	80.6
126	3.41	21	18.0	33.6	283	80.8
127	3.43	22	18.0	33.6	287	81.9
128	3.45	21	18.2	33.5	283	80.8
129	3.47	21	17.6	33.4	281	80.4
130	3.48	22	18.1	33.5	291	83.3
131	3.50	22	17.8	33.6	286	81.8
	Average	23	18.4	33.3	281	80.3
	Std Dev	1	0.5	2.5	8	2.2
	Maximum	25	19.5	33.8	295	84.3
	Minimum	21	17.6	10.7	254	72.5

N-value: 82

Sample Interval Time: 236.34 seconds.

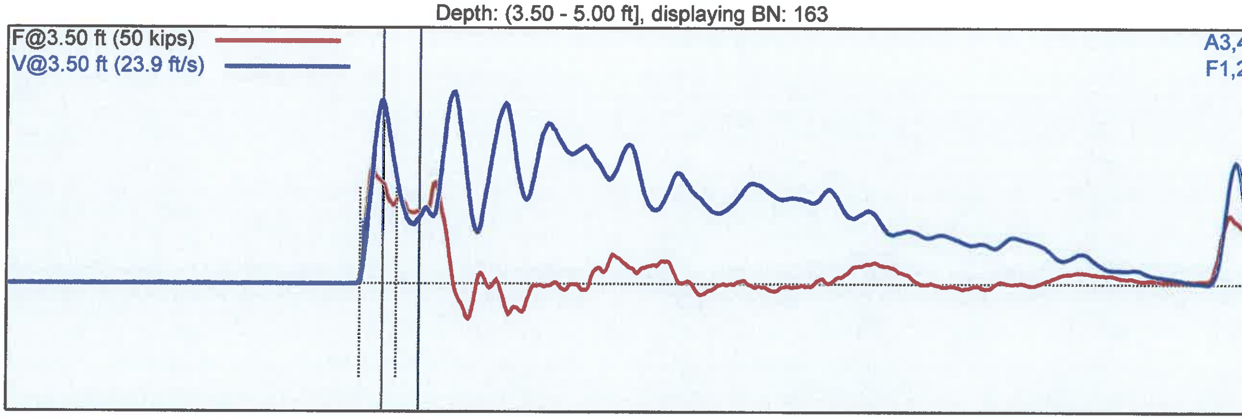
cme 55 12-6-17
Tim

2
Test date: 12/6/2017

AR: 1.17 in^2
LE: 3.50 ft
WS: 16807.9 ft/s

SP: 0.492 k/ft3
EM: 30000 ksi

Depth: (3.50 - 5.00 ft], displaying BN: 163



BL#	LP ft	FMX kips	VMX ft/s	BPM bpm	EFV ft-lb	ETR (%)
132	3.53	22	18.1	1.9	288	82.2
133	3.56	23	17.9	33.2	288	82.2
134	3.59	21	18.2	33.6	273	78.0
135	3.62	21	17.9	33.5	274	78.2
136	3.65	22	17.7	33.5	266	75.9
137	3.68	22	18.4	33.4	275	78.5
138	3.71	22	18.4	33.6	273	78.1
139	3.74	22	18.1	33.7	275	78.5
140	3.76	22	17.9	33.6	272	77.7
141	3.79	22	18.0	33.3	282	80.5
142	3.82	21	17.8	33.5	278	79.5
143	3.85	22	18.7	33.7	281	80.4
144	3.88	22	18.1	33.5	283	81.0
145	3.91	23	18.1	33.4	284	81.3
146	3.94	23	17.9	33.5	270	77.2
147	3.97	23	18.1	33.4	270	77.3
148	4.00	21	18.1	33.8	269	76.8
149	4.04	21	17.5	33.5	278	79.3
150	4.08	23	18.1	33.5	276	79.0
151	4.13	22	18.2	33.4	274	78.4
152	4.17	22	18.2	33.6	275	78.5
153	4.21	21	18.0	33.5	272	77.8
154	4.25	22	18.3	33.6	276	78.8
155	4.29	21	18.3	33.3	260	74.4
156	4.33	21	18.3	33.4	265	75.7
157	4.38	21	18.4	33.8	266	76.1
158	4.42	21	18.4	33.5	267	76.3
159	4.46	21	18.1	14.8	264	75.5
160	4.50	23	18.2	33.2	288	82.4
161	4.60	21	18.1	33.6	266	76.0
162	4.70	23	18.2	33.5	266	76.1
163	4.80	23	17.9	33.4	264	75.6
164	4.90	21	18.0	33.4	256	73.3
165	5.00	21	18.2	33.6	262	74.8

Average	22	18.1	32.4	269	76.9
Std Dev	1	0.2	4.4	8	2.2
Maximum	23	18.4	33.8	288	82.4
Minimum	21	17.5	14.8	256	73.3

N-value: 17

Sample Interval Time: 61.28 seconds.

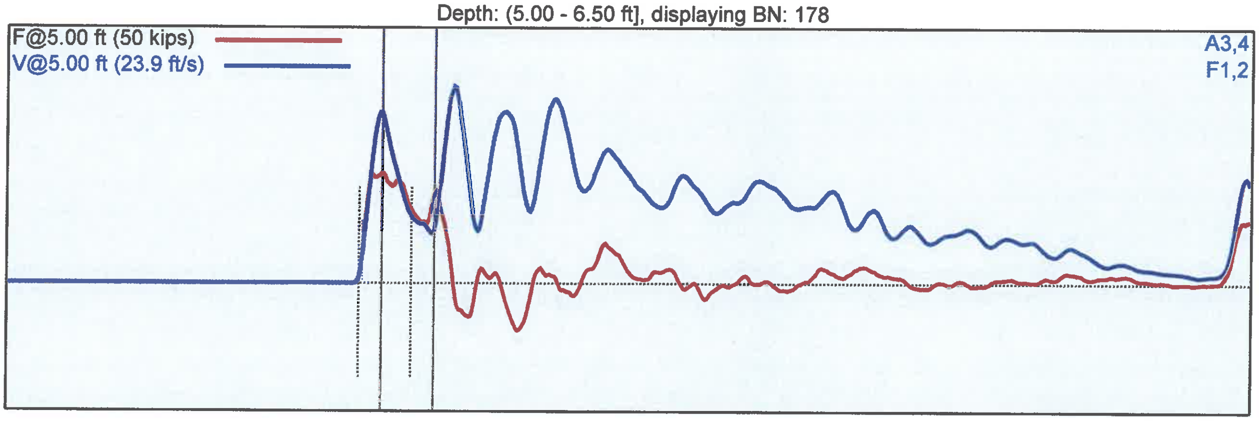
cme 55 12-6-17
Tim

2
Test date: 12/6/2017

AR: 1.17 in^2
LE: 5.00 ft
WS: 16807.9 ft/s

SP: 0.492 k/ft3
EM: 30000 ksi

Depth: (5.00 - 6.50 ft], displaying BN: 178



BL#	LP ft	FMX kips	VMX ft/s	BPM bpm	EFV ft-lb	ETR (%)
166	5.10	21	18.0	1.9	263	75.2
167	5.20	21	17.9	33.1	261	74.6
168	5.30	21	18.3	33.4	262	74.8
169	5.40	21	18.4	33.5	270	77.0
170	5.50	21	18.1	33.6	263	75.3
171	5.63	21	18.7	33.6	269	77.0
172	5.75	21	18.3	33.3	259	74.1
173	5.88	21	18.7	33.4	274	78.1
174	6.00	21	18.0	33.8	268	76.6
175	6.08	21	17.8	33.4	264	75.4
176	6.17	22	18.7	33.4	277	79.2
177	6.25	21	18.3	33.5	269	77.0
178	6.33	22	18.4	33.5	267	76.2
179	6.42	21	18.5	33.6	269	76.9
180	6.50	22	18.8	33.5	271	77.4
	Average	21	18.4	33.5	269	76.8
	Std Dev	0	0.3	0.1	5	1.3
	Maximum	22	18.8	33.8	277	79.2
	Minimum	21	17.8	33.3	259	74.1

N-value: 10

Sample Interval Time: 25.10 seconds.

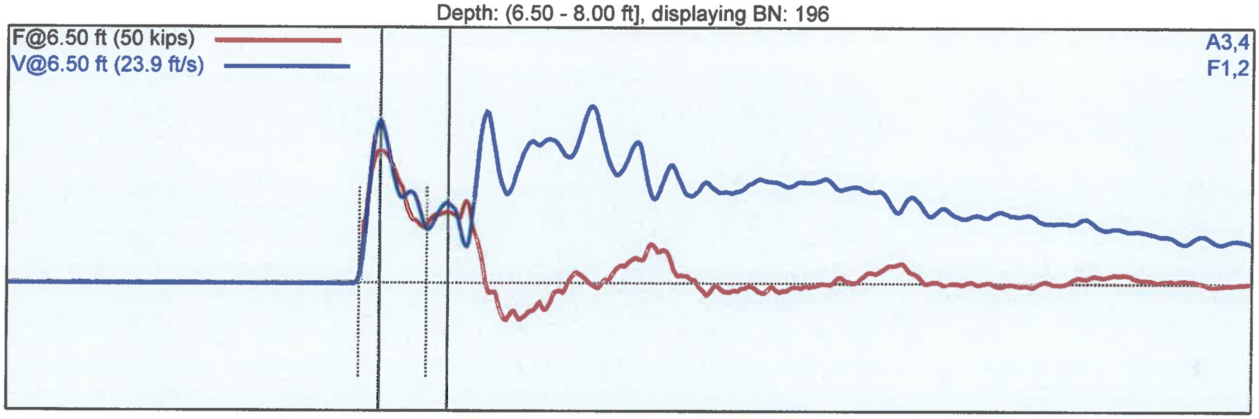
cme 55 12-6-17
Tim

2
Test date: 12/6/2017

AR: 1.17 in^2
LE: 6.50 ft
WS: 16807.9 ft/s

SP: 0.492 k/ft3
EM: 30000 ksi

Depth: (6.50 - 8.00 ft], displaying BN: 196



BL#	LP ft	FMX kips	VMX ft/s	BPM bpm	EFV ft-lb	ETR (%)
181	6.58	25	15.3	1.9	272	77.6
182	6.67	25	16.6	33.2	275	78.6
183	6.75	25	16.5	33.6	267	76.3
184	6.83	26	16.0	33.5	270	77.1
185	6.92	26	16.2	33.5	271	77.5
186	7.00	26	15.8	33.3	265	75.8
187	7.10	26	15.9	33.5	269	76.8
188	7.20	26	16.2	33.5	262	74.9
189	7.30	26	16.2	33.4	267	76.3
190	7.40	26	15.7	33.5	268	76.6
191	7.50	26	15.7	33.4	272	77.8
192	7.57	26	16.5	33.5	273	78.0
193	7.64	26	16.1	22.6	264	75.5
194	7.71	26	16.1	33.1	276	78.9
195	7.79	26	15.9	33.4	270	77.2
196	7.86	26	16.6	33.7	262	74.9
197	7.93	26	16.5	33.4	264	75.5
198	8.00	26	17.4	33.6	270	77.2
	Average	26	16.2	32.5	268	76.7
	Std Dev	0	0.4	3.0	4	1.2
	Maximum	26	17.4	33.7	276	78.9
	Minimum	26	15.7	22.6	262	74.9

N-value: 12

Sample Interval Time: 31.48 seconds.

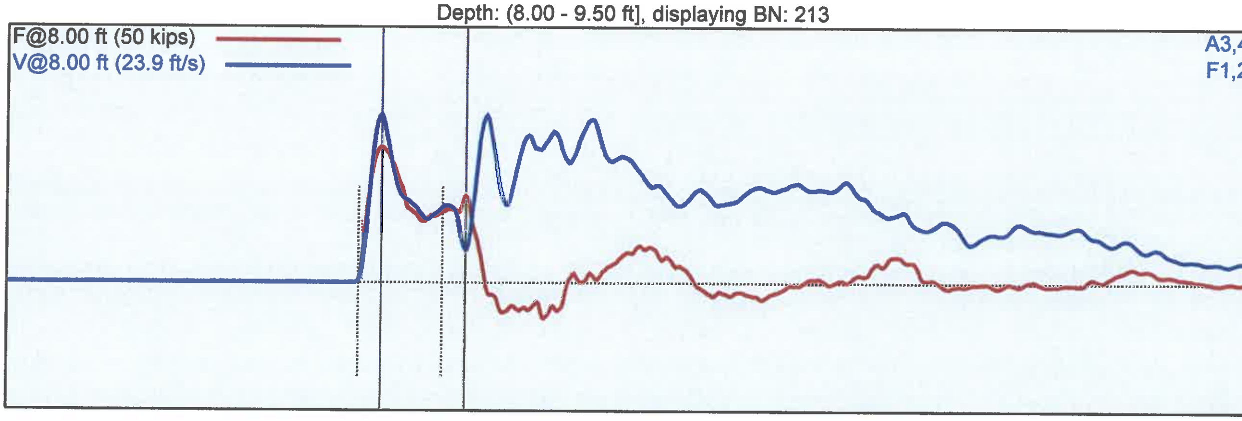
cme 55 12-6-17
Tim

2
Test date: 12/6/2017

AR: 1.17 in^2
LE: 8.00 ft
WS: 16807.9 ft/s

SP: 0.492 k/ft3
EM: 30000 ksi

Depth: (8.00 - 9.50 ft], displaying BN: 213



BL#	LP ft	FMX kips	VMX ft/s	BPM bpm	EFV ft-lb	ETR (%)
199	8.10	26	15.6	1.9	267	76.3
200	8.20	26	16.3	33.4	271	77.5
201	8.30	26	16.5	33.4	265	75.6
202	8.40	26	16.5	33.3	269	76.9
203	8.50	26	16.7	33.7	265	75.7
204	8.58	26	16.1	33.5	271	77.3
205	8.67	26	16.3	33.4	266	76.1
206	8.75	26	16.6	33.3	266	76.0
207	8.83	26	16.5	33.5	268	76.6
208	8.92	26	16.7	33.6	265	75.8
209	9.00	26	15.8	33.6	265	75.7
210	9.08	26	16.4	33.2	274	78.2
211	9.17	26	16.1	33.4	274	78.2
212	9.25	27	15.9	33.7	264	75.5
213	9.33	26	15.8	33.5	271	77.5
214	9.42	27	16.1	33.3	271	77.5
215	9.50	27	15.8	33.3	267	76.3
	Average	26	16.2	33.4	269	76.7
	Std Dev	0	0.3	0.1	3	0.9
	Maximum	27	16.7	33.7	274	78.2
	Minimum	26	15.8	33.2	264	75.5

N-value: 12

Sample Interval Time: 28.81 seconds.

This Page Intentionally Left Blank

Summary of SPT Test Results

Project: cme 55 12-6-17, Test Date: 12/6/2017

FMX: Maximum Force
VMX: Maximum Velocity
BPM: Blows/Minute

EFV: Maximum Energy
ETR: Energy Transfer Ratio - Rated

Instr. Length ft	Start Depth ft	Final Depth ft	N Value	N60 Value	Average FMX kips	Average VMX ft/s	Average BPM bpm	Average EFV ft-lb	Average ETR (%)
2.00	2.00	3.50	**82**	**107**	23	18.4	33.3	281	80.3
3.50	3.50	5.00	**17**	**22**	22	18.1	32.4	269	76.9
5.00	5.00	6.50	**10**	**13**	21	18.4	33.5	269	76.8
6.50	6.50	8.00	**12**	**15**	26	16.2	32.5	268	76.7
8.00	8.00	9.50	**12**	**15**	26	16.2	33.4	269	76.7
			Overall Average Values:		23	18.0	33.1	276	79.0
			Standard Deviation:		2	1.0	2.7	9	2.6
			Overall Maximum Value:		27	19.5	33.8	295	84.3
			Overall Minimum Value:		21	15.7	10.7	254	72.5

This page intentionally left blank.

Taber
EXPLORATION & TESTING

536 Galveston Street
West Sacramento, CA 95691-2116
Office **(916) 371-8234**
Fax (916) 371-8283

June 7, 2018

Taber Drilling
536 Galveston Street
West Sacramento, CA 95691

Subject: <u>SPT – Hammer Energy Measurements</u>
CME 75 Hammer
Yolo County, CA

Greetings:

This letter transmits the Standard Penetration Test (SPT) hammer energy efficiency on May 21, 2018 using a automatic hammer. Energy measurements for this hammer were obtained in a manner consistent with ASTM D4633-10 using an SPT Analyzer manufactured by Pile Dynamics, Inc. The purpose was to obtain hammer energy measurements and determine hammer efficiency (normalized for 60% efficiency) during sampling.

Dynamic strain and acceleration measurements were obtained through two strain bridge pairs and two accelerometers affixed on a 2-foot long section of NWJ rod. The NWJ rod was mounted on top of the string of rods and below the hammer. Strain and acceleration signals were conditioned and converted to force and velocity measurements using the SPT Analyzer.

The dynamic force and velocity data was converted to maximum transferred energy using the EFV method: $EFV = \int F(t) \bullet V(t) \bullet dt$. The integration is performed from when energy transfer begins to when the maximum energy occurs. This method is theoretically appropriate regardless of rod length, wave travel time, and the number of non-uniform rod connections. Energy transfer is then calculated as ETR = EFV/PE, where ETR is the energy transfer ratio, EVF is the energy transferred to the sampling rods, and PE is the theoretical potential energy.

The average hammer efficiency (ETR) on May 21, 2018, was **66%** (based on an EFV of 230 ft-lbs). The results via the SPT Analyzer are presented in the attached table (Summary of Field Results, SPT Energy Measurements), graphical data plots, and data sheets.

We appreciate the opportunity to be of service.

Very Truly Yours,
Taber Drilling

Franklin Taber

Frank Taber
GE 816

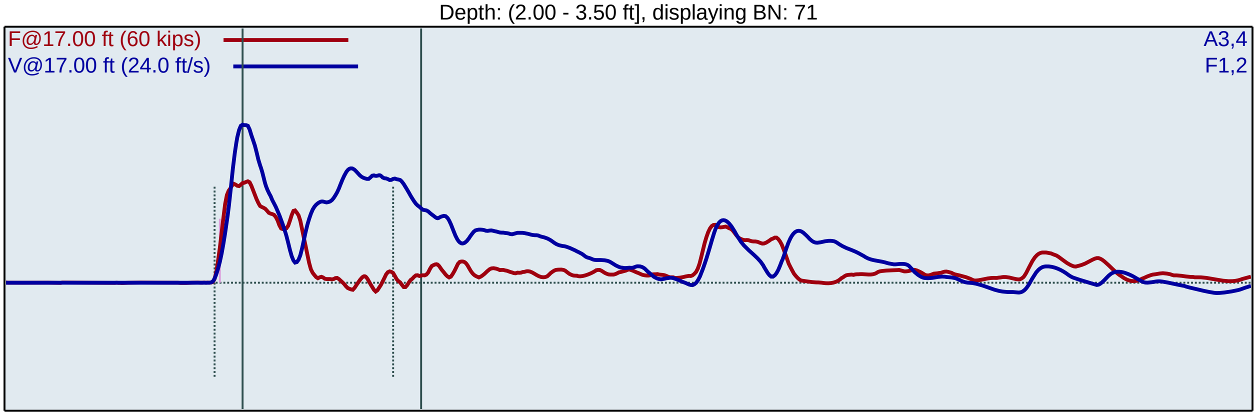
REGISTERED PROFESSIONAL ENGINEER
FRANKLIN P. TABER
No. 816
GEOTECHNICAL
STATE OF CALIFORNIA

Attachments: Summary of Field Results, SPT Energy Measurements
SPT Analyzer Data, Per Drive Depth

cme 75 5-21-18 2
Tim Test date: 5/21/2018

AR: 1.40 in^2 SP: 0.492 k/ft3
LE: 17.00 ft EM: 30000 ksi
WS: 16807.9 ft/s

Depth: (2.00 - 3.50 ft], displaying BN: 71



FMX: Maximum Force
VMX: Maximum Velocity
BPM: Blows/Minute
EFV: Maximum Energy
ETR: Energy Transfer Ratio - Rated

BL#	LP	FMX	VMX	BPM	EFV	ETR
	ft	kips	ft/s	bpm	ft-lb	(%)
1	2.02	31	12.9	1.9	222	63.4
2	2.03	30	13.5	25.5	229	65.3
3	2.05	30	13.9	30.7	238	68.1
4	2.06	30	13.7	34.6	232	66.2
5	2.08	30	13.8	34.3	233	66.7
6	2.09	30	13.7	34.3	229	65.3
7	2.11	30	13.8	34.2	233	66.6
8	2.12	30	13.9	34.2	239	68.2
9	2.14	30	13.8	34.1	232	66.2
10	2.15	29	13.8	34.1	234	66.8
11	2.17	29	13.9	33.9	237	67.8
12	2.18	29	13.8	34.0	229	65.4
13	2.20	29	13.9	33.9	232	66.4
14	2.21	29	14.0	33.8	236	67.4
15	2.23	29	14.1	33.8	235	67.0
16	2.24	28	14.3	33.7	234	66.7
17	2.26	28	14.2	33.6	232	66.4
18	2.27	28	14.5	33.6	233	66.7
19	2.29	28	14.5	33.5	239	68.2
20	2.30	28	14.8	33.3	243	69.5
21	2.32	27	14.9	33.3	244	69.6
22	2.33	27	14.9	33.2	243	69.3
23	2.35	27	14.7	33.1	240	68.4
24	2.36	27	14.7	33.1	240	68.5
25	2.38	26	14.6	32.9	237	67.7
26	2.39	26	14.7	32.8	239	68.2
27	2.41	26	14.8	32.6	235	67.0
28	2.42	26	14.9	32.5	232	66.4
29	2.44	26	14.8	32.3	236	67.3
30	2.45	26	14.8	32.1	227	65.0
31	2.47	26	14.8	31.9	231	66.0
32	2.48	26	15.1	31.8	231	65.9
33	2.50	26	14.8	31.6	230	65.7

34	2.53	26	15.2	31.3	237	67.6
35	2.55	26	15.0	31.1	229	65.5
36	2.58	26	15.2	30.6	243	69.4
37	2.60	26	14.9	29.9	223	63.6
38	2.63	26	15.0	29.2	234	66.9
39	2.65	25	14.7	28.8	226	64.5
40	2.68	25	14.9	28.6	230	65.7
41	2.70	25	14.7	28.4	230	65.8
42	2.73	25	14.7	28.2	229	65.4
43	2.75	25	14.6	28.1	231	66.0
44	2.78	24	14.6	28.1	227	64.8
45	2.80	24	14.7	28.1	228	65.3
46	2.83	24	14.7	28.0	228	65.2
47	2.85	24	14.8	28.0	232	66.2
48	2.88	25	14.9	27.8	232	66.3
49	2.90	24	14.8	27.7	230	65.8
50	2.93	24	14.7	27.7	227	65.0
51	2.95	25	14.8	27.7	229	65.5
52	2.98	24	14.7	27.6	227	64.8
53	3.00	24	14.6	27.6	224	64.1
54	3.03	25	14.6	27.6	228	65.2
55	3.05	25	14.7	27.5	228	65.2
56	3.08	25	14.8	27.6	224	64.0
57	3.10	25	14.7	27.5	226	64.6
58	3.13	24	14.8	27.4	223	63.8
59	3.15	25	15.1	27.4	239	68.4
60	3.18	24	14.8	27.3	234	66.8
61	3.20	24	14.9	27.3	234	67.0
62	3.23	24	15.0	27.2	235	67.2
63	3.25	24	15.1	27.1	235	67.2
64	3.28	24	14.9	27.1	234	66.9
65	3.30	24	14.8	27.1	232	66.2
66	3.33	24	14.9	27.1	235	67.0
67	3.35	24	15.2	27.0	237	67.7
68	3.38	24	14.9	26.9	235	67.2
69	3.40	24	15.0	27.0	239	68.3
70	3.43	24	14.8	26.9	237	67.8
71	3.45	24	14.8	26.9	233	66.7
72	3.48	24	15.0	26.9	237	67.7
73	3.50	0	0.3	1.9	1	0.2
	Average	24	14.5	27.3	226	64.5
	Std Dev	4	2.3	4.2	36	10.4
	Maximum	26	15.2	31.3	243	69.4
	Minimum	0	0.3	1.9	1	0.2

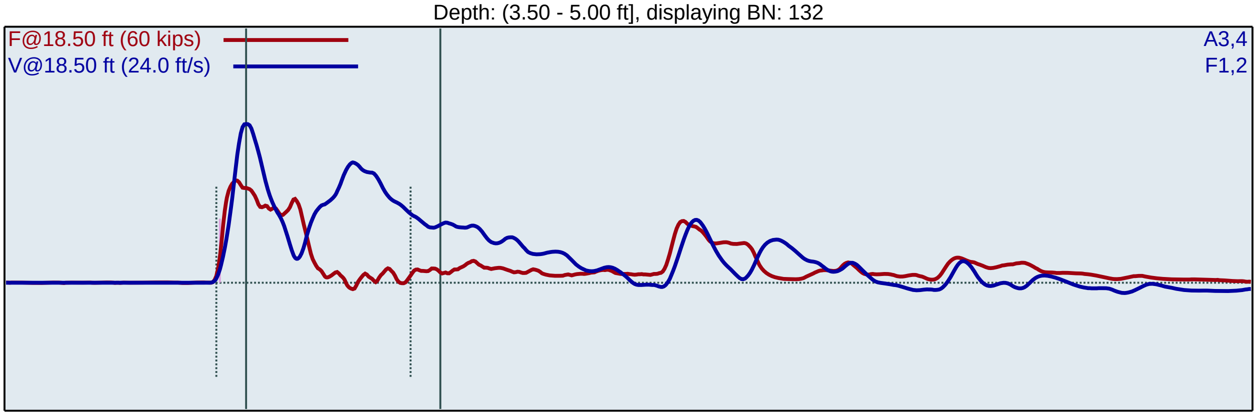
N-value: 40

Sample Interval Time: 148.47 seconds.

cme 75 5-21-18 | 2
Tim | Test date: 5/21/2018

AR: 1.40 in^2 | SP: 0.492 k/ft3
LE: 18.50 ft | EM: 30000 ksi
WS: 16807.9 ft/s

Depth: (3.50 - 5.00 ft], displaying BN: 132



BL#	LP	FMX	VMX	BPM	EFV	ETR
	ft	kips	ft/s	bpm	ft-lb	(%)
74	3.52	24	14.4	1.9	232	66.2
75	3.54	24	14.9	26.6	235	67.2
76	3.57	24	14.8	26.7	232	66.4
77	3.59	24	14.7	26.7	231	65.9
78	3.61	24	14.6	26.6	232	66.4
79	3.63	24	14.7	26.7	231	66.0
80	3.65	23	14.7	26.9	234	66.8
81	3.67	24	14.5	26.9	230	65.8
82	3.70	24	14.7	26.9	238	67.9
83	3.72	24	14.7	26.9	235	67.1
84	3.74	24	14.8	26.9	236	67.5
85	3.76	24	14.7	26.9	233	66.7
86	3.78	23	14.6	26.9	234	67.0
87	3.80	23	14.9	26.8	237	67.6
88	3.83	24	14.9	26.8	238	68.0
89	3.85	23	14.9	26.8	237	67.7
90	3.87	24	14.8	26.9	237	67.6
91	3.89	24	15.0	26.9	236	67.6
92	3.91	23	14.9	26.8	239	68.3
93	3.93	24	15.0	26.8	238	68.1
94	3.96	23	15.0	26.8	233	66.6
95	3.98	23	14.9	26.8	236	67.3
96	4.00	23	15.1	26.8	238	67.9
97	4.03	23	15.2	26.8	236	67.4
98	4.06	24	15.0	26.7	236	67.4
99	4.08	23	14.9	26.8	230	65.7
100	4.11	24	15.0	26.7	234	66.7
101	4.14	24	15.0	26.7	236	67.3
102	4.17	24	14.9	26.8	232	66.3
103	4.19	23	14.8	26.7	231	65.9
104	4.22	24	14.9	26.7	231	66.0
105	4.25	23	14.7	26.7	231	65.9
106	4.28	23	14.8	26.8	233	66.6
107	4.31	23	14.7	26.8	230	65.7
108	4.33	23	14.7	26.7	228	65.0
109	4.36	24	14.8	26.7	231	66.1

110	4.39	23	14.7	26.7	229	65.5
111	4.42	23	14.7	26.7	227	64.9
112	4.44	23	14.8	26.7	228	65.1
113	4.47	23	14.7	26.6	229	65.3
114	4.50	23	14.7	26.7	226	64.6
115	4.53	23	14.7	26.7	224	63.9
116	4.55	23	14.7	26.6	228	65.2
117	4.58	23	14.7	26.6	226	64.7
118	4.60	23	15.0	26.7	231	66.1
119	4.63	23	14.8	26.7	229	65.6
120	4.65	24	14.8	26.7	223	63.6
121	4.68	23	14.8	26.7	220	62.9
122	4.70	23	14.8	26.7	226	64.7
123	4.73	24	15.1	26.7	239	68.2
124	4.75	24	14.8	26.7	226	64.6
125	4.78	24	14.8	26.7	224	64.0
126	4.80	24	14.7	26.7	226	64.6
127	4.83	24	14.9	26.8	222	63.3
128	4.85	24	14.8	26.7	224	64.1
129	4.88	24	14.8	26.8	230	65.7
130	4.90	24	14.9	26.7	235	67.0
131	4.93	24	14.8	26.7	226	64.7
132	4.95	24	14.9	26.7	235	67.1
133	4.98	24	14.8	26.7	235	67.1
134	5.00	24	14.8	26.7	233	66.5
	Average	23	14.8	26.7	229	65.6
	Std Dev	0	0.1	0.0	4	1.2
	Maximum	24	15.2	26.8	239	68.2
	Minimum	23	14.7	26.6	220	62.9

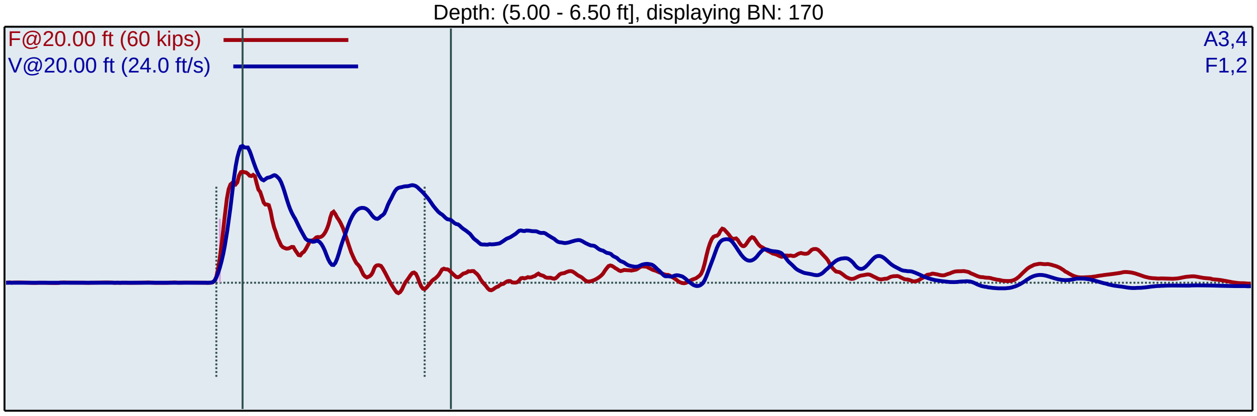
N-value: 38

Sample Interval Time: 134.64 seconds.

cme 75 5-21-18 2
Tim Test date: 5/21/2018

AR: 1.40 in^2 SP: 0.492 k/ft3
LE: 20.00 ft EM: 30000 ksi
WS: 16807.9 ft/s

Depth: (5.00 - 6.50 ft], displaying BN: 170



BL#	LP	FMX	VMX	BPM	EFV	ETR
	ft	kips	ft/s	bpm	ft-lb	(%)
135	5.05	26	12.4	1.9	228	65.0
136	5.09	26	12.0	26.5	223	63.8
137	5.14	26	12.3	26.6	231	66.1
138	5.18	26	12.0	26.6	221	63.1
139	5.23	26	12.0	26.6	223	63.6
140	5.27	26	12.0	26.6	225	64.3
141	5.32	26	12.0	26.5	225	64.4
142	5.36	26	12.1	26.6	222	63.4
143	5.41	26	12.1	26.5	223	63.6
144	5.45	26	12.3	26.6	229	65.4
145	5.50	27	12.5	26.6	233	66.5
146	5.54	27	12.4	26.6	230	65.7
147	5.58	27	12.4	26.7	234	67.0
148	5.62	27	11.9	26.6	221	63.1
149	5.65	27	12.3	26.7	229	65.5
150	5.69	27	12.3	26.6	228	65.2
151	5.73	26	12.3	26.6	226	64.5
152	5.77	26	12.4	26.6	233	66.6
153	5.81	26	12.3	26.6	231	65.9
154	5.85	27	12.5	26.6	231	66.1
155	5.88	26	12.4	26.6	231	66.1
156	5.92	26	12.4	26.5	227	64.9
157	5.96	27	12.3	26.6	230	65.8
158	6.00	26	12.4	26.5	233	66.5
159	6.04	26	12.3	26.5	230	65.7
160	6.07	27	12.6	26.6	242	69.1
161	6.11	26	12.6	26.6	235	67.0
162	6.14	26	12.4	26.6	234	66.8
163	6.18	26	12.4	26.6	232	66.4
164	6.21	26	12.5	26.5	233	66.7
165	6.25	26	12.4	26.5	231	65.9
166	6.29	26	12.4	26.6	231	66.1
167	6.32	26	12.9	26.6	232	66.2
168	6.36	26	12.6	26.5	228	65.0
169	6.39	26	12.6	26.6	230	65.8
170	6.43	26	12.8	26.6	229	65.5

171	6.46	26	12.9	26.5	229	65.3
172	6.50	26	13.3	26.6	238	67.9
	Average	26	12.5	26.6	231	66.0
	Std Dev	0	0.3	0.0	4	1.1
	Maximum	27	13.3	26.7	242	69.1
	Minimum	26	11.9	26.5	221	63.1

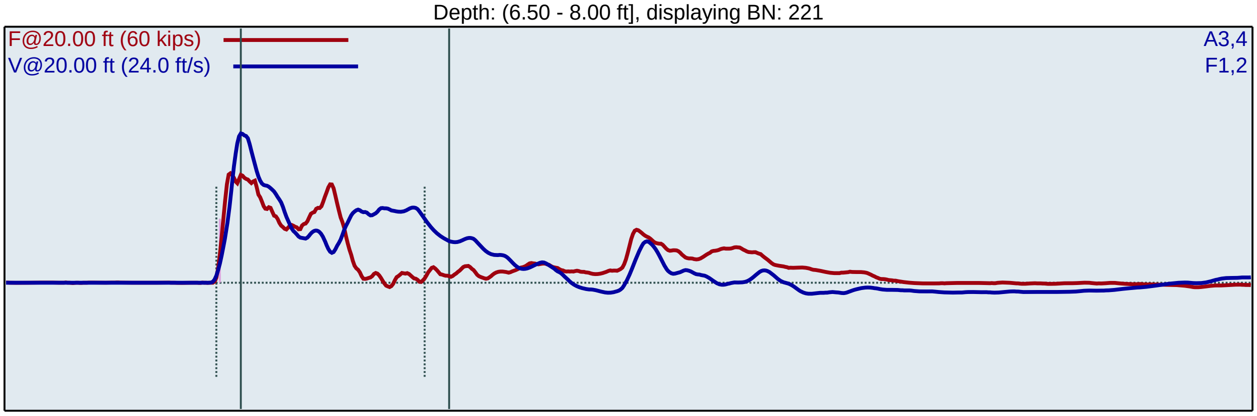
N-value: 27

Sample Interval Time: 83.52 seconds.

cme 75 5-21-18 2
Tim Test date: 5/21/2018

AR: 1.40 in^2 SP: 0.492 k/ft3
LE: 20.00 ft EM: 30000 ksi
WS: 16807.9 ft/s

Depth: (6.50 - 8.00 ft], displaying BN: 221



BL#	LP	FMX	VMX	BPM	EFV	ETR
	ft	kips	ft/s	bpm	ft-lb	(%)
173	6.53	27	12.4	1.9	234	66.9
174	6.56	26	12.8	25.9	235	67.1
175	6.58	26	13.1	26.7	232	66.4
176	6.61	26	13.0	26.5	232	66.2
177	6.64	26	12.8	26.6	231	65.9
178	6.67	26	13.0	26.6	235	67.1
179	6.69	26	12.9	26.5	230	65.8
180	6.72	26	12.8	26.6	230	65.7
181	6.75	26	13.1	26.5	234	66.8
182	6.78	27	13.0	26.6	234	66.8
183	6.81	27	13.1	26.5	235	67.3
184	6.83	26	12.9	26.6	231	65.9
185	6.86	27	12.9	26.6	229	65.4
186	6.89	27	13.0	26.6	233	66.5
187	6.92	27	13.3	26.6	236	67.4
188	6.94	26	13.1	26.5	233	66.6
189	6.97	27	13.1	26.7	235	67.0
190	7.00	26	13.2	26.6	233	66.6
191	7.04	26	13.1	26.6	232	66.3
192	7.07	26	13.3	26.6	236	67.3
193	7.11	26	13.4	26.6	237	67.6
194	7.14	26	13.6	26.6	237	67.6
195	7.18	26	14.0	26.6	240	68.7
196	7.21	26	14.1	26.6	240	68.6
197	7.25	26	14.0	26.6	237	67.8
198	7.29	26	14.2	26.6	244	69.6
199	7.32	26	14.2	26.6	245	70.0
200	7.36	25	14.1	26.6	240	68.5
201	7.39	25	14.1	26.6	240	68.5
202	7.43	25	14.0	26.6	236	67.5
203	7.46	26	14.1	26.6	237	67.7
204	7.50	26	14.3	26.7	242	69.3
205	7.53	26	14.3	26.7	237	67.6
206	7.55	26	14.3	26.6	236	67.3
207	7.58	25	14.0	26.7	232	66.3
208	7.61	26	14.1	26.7	236	67.3

209	7.63	25	14.0	26.7	235	67.2
210	7.66	25	14.0	26.7	235	67.2
211	7.68	26	13.9	26.7	233	66.6
212	7.71	26	14.1	26.6	236	67.5
213	7.74	26	14.0	26.6	234	66.9
214	7.76	25	14.0	26.7	233	66.6
215	7.79	26	13.9	26.6	233	66.6
216	7.82	25	13.9	26.7	232	66.4
217	7.84	26	13.7	26.7	230	65.8
218	7.87	25	13.8	26.6	231	66.1
219	7.89	26	13.7	26.7	238	68.1
220	7.92	26	13.9	26.6	233	66.5
221	7.95	26	14.0	26.8	235	67.2
222	7.97	26	13.8	26.7	234	66.7
223	8.00	26	13.8	26.7	234	67.0
	Average	26	13.9	26.7	236	67.5
	Std Dev	0	0.3	0.0	4	1.0
	Maximum	26	14.3	26.8	245	70.0
	Minimum	25	13.1	26.6	230	65.8

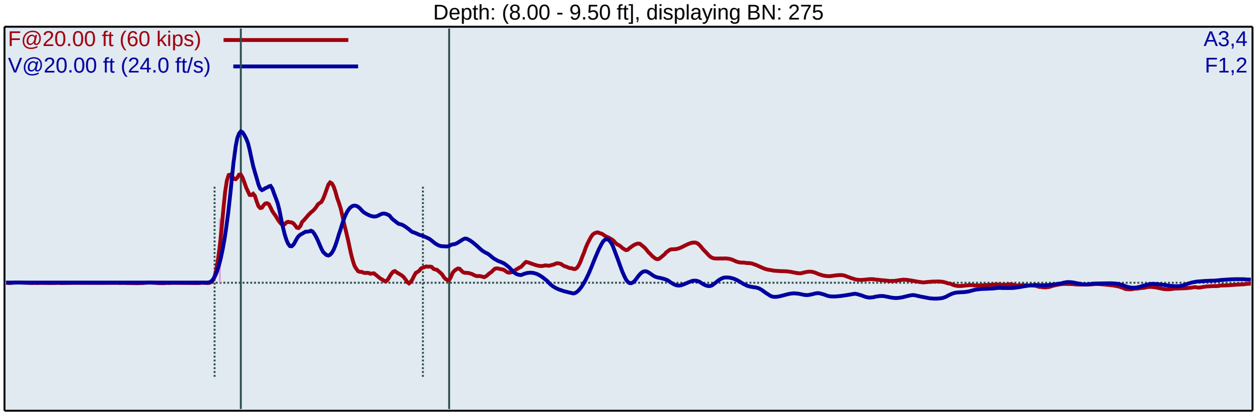
N-value: 33

Sample Interval Time: 112.77 seconds.

cme 75 5-21-18 2
Tim Test date: 5/21/2018

AR: 1.40 in^2 SP: 0.492 k/ft3
LE: 20.00 ft EM: 30000 ksi
WS: 16807.9 ft/s

Depth: (8.00 - 9.50 ft], displaying BN: 275



BL#	LP	FMX	VMX	BPM	EFV	ETR
	ft	kips	ft/s	bpm	ft-lb	(%)
224	8.04	25	13.7	1.9	235	67.1
225	8.07	26	13.8	26.6	236	67.5
226	8.11	25	14.0	26.5	235	67.1
227	8.14	25	14.0	26.5	232	66.4
228	8.18	26	14.1	26.6	237	67.6
229	8.21	26	14.3	26.5	237	67.8
230	8.25	26	14.1	26.6	236	67.5
231	8.29	25	14.0	26.6	233	66.5
232	8.32	25	13.8	26.6	233	66.5
233	8.36	25	13.7	26.6	234	66.9
234	8.39	25	13.7	26.6	232	66.4
235	8.43	25	13.7	26.6	233	66.6
236	8.46	25	13.6	26.6	235	67.2
237	8.50	25	13.6	26.6	235	67.1
238	8.53	26	13.6	26.6	232	66.3
239	8.57	26	13.8	26.7	234	67.0
240	8.60	26	13.9	26.6	238	68.0
241	8.63	26	13.3	26.6	233	66.7
242	8.67	26	13.4	26.6	231	66.0
243	8.70	26	13.3	26.6	232	66.2
244	8.73	26	13.5	26.7	232	66.2
245	8.77	26	13.2	26.6	231	65.9
246	8.80	26	13.0	26.7	228	65.3
247	8.83	26	13.0	26.6	226	64.5
248	8.87	26	13.2	26.6	228	65.3
249	8.90	26	13.3	26.6	231	66.0
250	8.93	25	13.2	26.7	227	64.7
251	8.97	26	13.5	26.7	231	66.0
252	9.00	25	12.8	26.7	223	63.8
253	9.02	25	13.3	26.7	223	63.6
254	9.04	25	13.2	26.7	224	64.1
255	9.06	24	13.3	26.7	222	63.3
256	9.08	25	13.3	26.7	221	63.1
257	9.10	24	13.5	26.7	224	64.1
258	9.12	25	13.4	26.6	226	64.5
259	9.14	24	13.5	26.8	223	63.6

260	9.16	25	13.4	26.6	224	63.9
261	9.18	25	13.4	26.8	221	63.3
262	9.20	25	13.4	26.6	223	63.8
263	9.22	25	13.5	26.7	225	64.3
264	9.24	25	13.6	26.7	230	65.7
265	9.26	25	13.5	26.8	222	63.4
266	9.28	25	13.8	26.7	227	64.8
267	9.30	25	13.9	26.7	228	65.3
268	9.32	25	13.8	26.7	222	63.5
269	9.34	25	14.0	26.6	224	64.0
270	9.36	25	14.0	26.7	222	63.5
271	9.38	25	14.1	26.6	226	64.5
272	9.40	26	14.1	26.7	224	64.1
273	9.42	26	14.1	26.6	226	64.7
274	9.44	25	13.9	26.7	223	63.6
275	9.46	25	14.2	26.8	225	64.2
276	9.48	26	14.3	26.7	229	65.4
277	9.50	26	14.6	26.7	232	66.4
	Average	25	13.6	26.7	227	64.8
	Std Dev	0	0.4	0.1	4	1.2
	Maximum	26	14.6	26.8	238	68.0
	Minimum	24	12.8	26.6	221	63.1

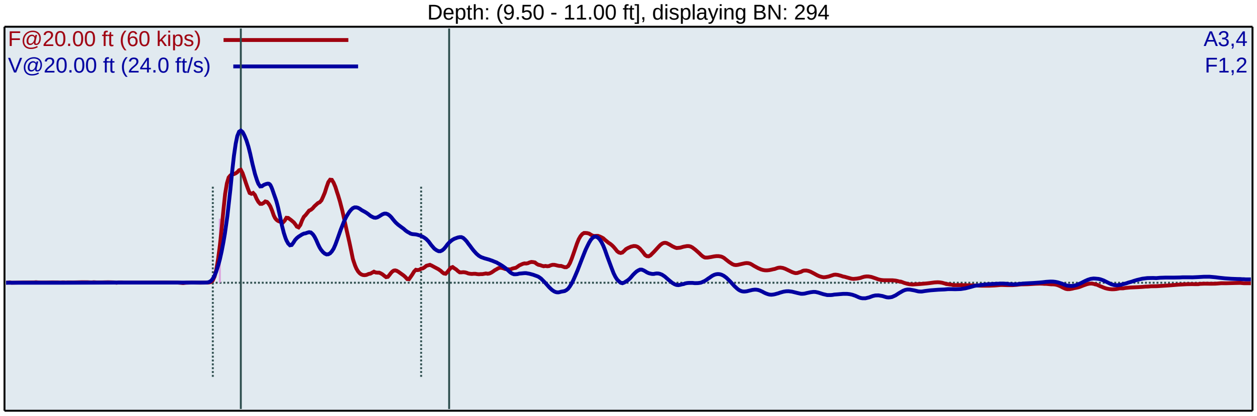
N-value: 40

Sample Interval Time: 119.22 seconds.

cme 75 5-21-18 | 2
Tim | Test date: 5/21/2018

AR: 1.40 in^2 | SP: 0.492 k/ft3
LE: 20.00 ft | EM: 30000 ksi
WS: 16807.9 ft/s

Depth: (9.50 - 11.00 ft], displaying BN: 294



BL#	LP	FMX	VMX	BPM	EFV	ETR
	ft	kips	ft/s	bpm	ft-lb	(%)
278	9.60	26	13.8	1.9	242	69.0
279	9.70	26	14.3	26.6	248	71.0
280	9.80	26	14.1	26.6	246	70.4
281	9.90	26	14.2	26.6	242	69.1
282	10.00	26	14.1	26.6	237	67.8
283	10.08	26	14.2	26.6	240	68.5
284	10.17	26	14.2	26.7	241	68.8
285	10.25	26	14.3	26.7	241	68.9
286	10.33	26	14.2	26.8	240	68.6
287	10.42	26	14.3	26.6	246	70.2
288	10.50	26	14.3	26.3	240	68.7
289	10.56	26	14.3	26.8	239	68.3
290	10.63	26	14.2	26.7	239	68.4
291	10.69	26	14.1	26.7	234	66.9
292	10.75	26	14.3	26.8	236	67.5
293	10.81	26	14.2	26.7	231	66.0
294	10.88	26	14.3	26.7	238	67.9
295	10.94	26	14.2	26.7	233	66.5
296	11.00	26	14.2	26.7	238	68.0
	Average	26	14.2	26.7	238	68.1
	Std Dev	0	0.1	0.1	4	1.1
	Maximum	26	14.3	26.8	246	70.2
	Minimum	26	14.1	26.3	231	66.0

N-value: 14

Sample Interval Time: 40.54 seconds.

Summary of SPT Test Results

Project: cme 75 5-21-18, Test Date: 5/21/2018

FMX: Maximum Force
VMX: Maximum Velocity
BPM: Blows/Minute
EFV: Maximum Energy
ETR: Energy Transfer Ratio - Rated

Instr. Length ft	Start Depth ft	Final Depth ft	**N Value**	**N60 Value**	Average FMX kips	Average VMX ft/s	Average BPM bpm	Average EFV ft-lb	Average ETR (%)
17.00	2.00	3.50	**40**	**43**	24	14.5	27.3	226	64.5
18.50	3.50	5.00	**38**	**41**	23	14.8	26.7	229	65.6
20.00	5.00	6.50	**27**	**29**	26	12.5	26.6	231	66.0
20.00	6.50	8.00	**33**	**36**	26	13.9	26.7	236	67.5
20.00	8.00	9.50	**40**	**43**	25	13.6	26.7	227	64.8
20.00	9.50	11.00	**14**	**15**	26	14.2	26.7	238	68.1
				Overall Average Values:	25	14.0	26.8	230	65.7
				Standard Deviation:	2	1.3	1.9	17	5.0
				Overall Maximum Value:	27	15.2	31.3	246	70.2
				Overall Minimum Value:	0	0.3	1.9	1	0.2

This page intentionally left blank.

Taber
EXPLORATION & TESTING

536 Galveston Street
West Sacramento, CA 95691-2116
Office **(916) 371-8234**
Fax (916) 371-8283

July 16, 2019

Taber Drilling
536 Galveston Street
West Sacramento , CA 95691

Subject: SPT – Hammer Energy Measurements
Diedrich D 120
West Sacramento, CA

Greetings:

This letter transmits the Standard Penetration Test (SPT) hammer energy efficiency on June 17, 2019 using a Diedrich D-120 Truck-Mounted Drill Rig equipped with our Gray automatic hammer. Energy measurements for this hammer were obtained in a manner consistent with ASTM D4633-10 using an SPT Analyzer manufactured by Pile Dynamics, Inc. The purpose was to obtain hammer energy measurements and determine hammer efficiency (normalized for 60% efficiency) during sampling.

Dynamic strain and acceleration measurements were obtained through two strain bridge pairs and two accelerometers affixed on a 2-foot long section of AWJ rod. The AWJ rod was mounted on top of the string of rods and below the hammer. Strain and acceleration signals were conditioned and converted to force and velocity measurements using the SPT Analyzer.

The dynamic force and velocity data was converted to maximum transferred energy using the EFV method: $EFV = \int F(t) \bullet V(t) \bullet dt$. The integration is performed from when energy transfer begins to when the maximum energy occurs. This method is theoretically appropriate regardless of rod length, wave travel time, and the number of non-uniform rod connections. Energy transfer is then calculated as ETR = EFV/PE, where ETR is the energy transfer ratio, EVF is the energy transferred to the sampling rods, and PE is the theoretical potential energy.

The average hammer efficiency (ETR) on June 17, 2019 was **81%** (based on an EFV of 285 ft-lbs). Note, in accordance with the ASTM testing protocols employed, these results of energy measurement are specific to this hammer, on this date, at this location. A more general use and application of this data should only be made when based on specific professional engineering judgement.

We appreciate the opportunity to be of service.

Very Truly Yours,
Taber Drilling

Franklin Taber

REGISTERED PROFESSIONAL ENGINEER
FRANKLIN P. TABER
No. 816
GEOTECHNICAL
STATE OF CALIFORNIA

Frank Taber
GE 816

Attachments: Summary of Field Results, SPT Energy Measurements
SPT Analyzer Data, Per Drive Depth

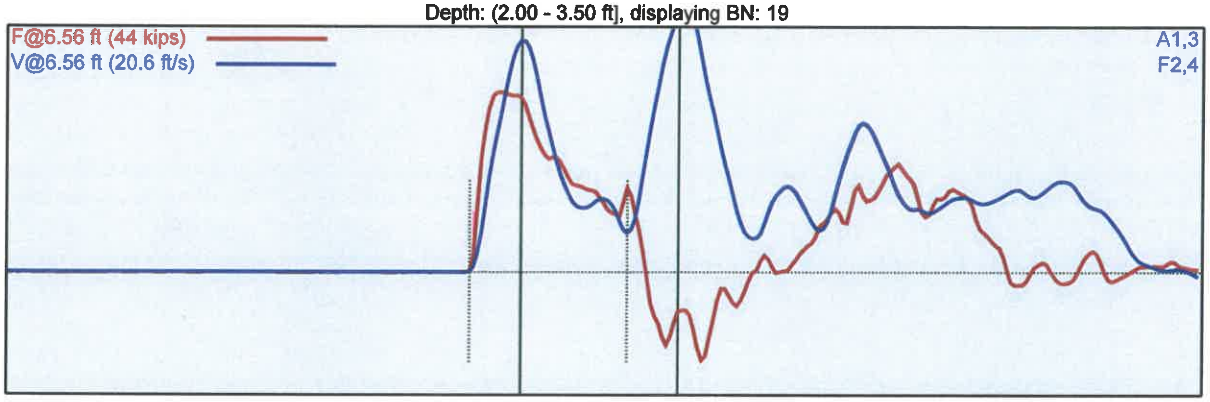
d120 gray6-17-19
tad
SHOP

2
Test date: 6/17/2019

AR: 1.20 in^2
LE: 6.56 ft
WS: 16807.9 ft/s

SP: 0.492 k/ft3
EM: 30000 ksi

Depth: (2.00 - 3.50 ft], displaying BN: 19



F2 : [202AWJ1] 207.18 PDICAL (1) FF1
F4 : [202AWJ2] 207.8 PDICAL (1) FF1

A1 (PR): [K6179] 380 mv/6.4v/5000g (1) VF1
A3 (PR): [K1510] 342 mv/6.4v/5000g (1) VF1

FMX: Maximum Force
VMX: Maximum Velocity
BPM: Blows/Minute

EFV: Maximum Energy
ETR: Energy Transfer Ratio - Rated

BL#	BC /6"	FMX kips	VMX ft/s	BPM bpm	EFV ft-lb	ETR %
1	7	31	22.1	1.9	255	72.8
2	7	32	22.7	30.6	280	79.9
3	7	32	22.9	30.6	271	77.5
4	7	32	23.0	30.4	272	77.8
5	7	32	23.2	30.6	268	76.5
6	7	32	23.1	30.4	270	77.1
7	7	32	23.2	30.7	269	77.0
8	7	32	23.1	30.5	269	76.8
9	7	32	23.0	30.6	271	77.5
10	7	32	22.9	30.4	270	77.0
11	7	32	22.4	30.6	277	79.1
12	7	32	22.9	30.5	273	78.0
13	7	32	22.4	30.6	273	78.0
14	7	32	22.4	30.6	277	79.2
15	7	32	22.5	30.5	282	80.5
16	7	32	22.4	30.5	274	78.4
17	7	32	22.2	30.7	276	78.8
18	7	32	22.4	30.5	280	80.0
19	7	32	22.2	30.6	281	80.2
20	7	32	21.9	30.5	285	81.3
21	7	32	21.6	30.6	285	81.5
	Average	32	22.5	30.6	277	79.0
	Std Dev	0	0.4	0.1	5	1.4
	Maximum	32	23.1	30.7	285	81.5
	Minimum	32	21.6	30.4	269	76.8

N-value: 14

Sample Interval Time: 39.28 seconds.

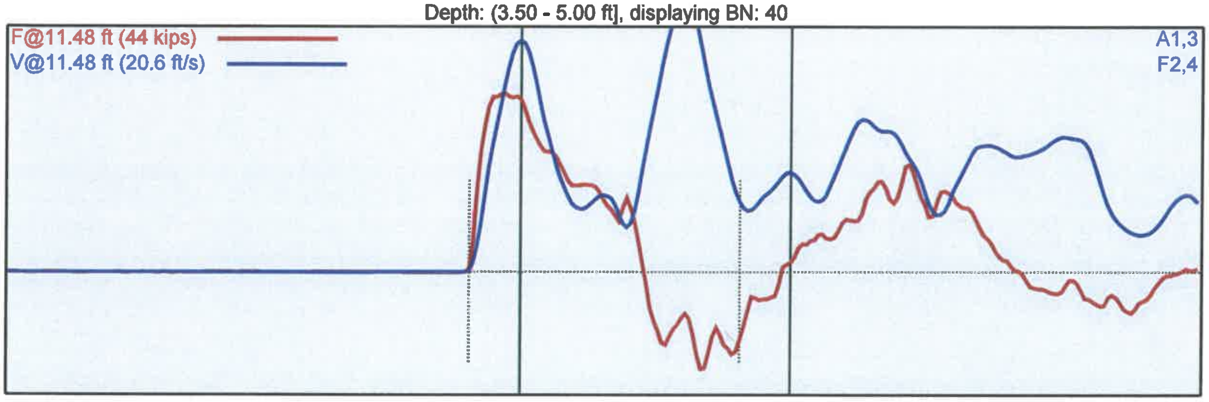
d120 gray6-17-19
tad
SHOP

2
Test date: 6/17/2019

AR: 1.20 in^2
LE: 11.48 ft
WS: 16807.9 ft/s

SP: 0.492 k/ft3
EM: 30000 ksi

Depth: (3.50 - 5.00 ft], displaying BN: 40



F2 : [202AWJ1] 207.18 PDICAL (1) FF1
F4 : [202AWJ2] 207.8 PDICAL (1) FF1

A1 (PR): [K6179] 380 mv/6.4v/5000g (1) VF1
A3 (PR): [K1510] 342 mv/6.4v/5000g (1) VF1

BL#	BC /6"	FMX kips	VMX ft/s	BPM bpm	EFV ft-lb	ETR %
22	7	33	21.9	1.9	295	84.2
23	7	33	21.9	30.8	288	82.4
24	7	32	21.5	30.5	290	83.0
25	7	33	21.8	30.6	290	82.8
26	7	32	21.1	30.6	288	82.3
27	7	33	21.9	30.6	291	83.2
28	7	33	22.0	30.6	279	79.6
29	7	33	22.2	30.5	282	80.5
30	7	33	22.0	14.3	272	77.7
31	7	33	22.4	30.4	287	82.0
32	7	32	22.2	30.5	283	80.8
33	7	33	22.5	30.7	276	78.8
34	7	33	22.7	30.5	272	77.8
35	7	32	22.6	30.6	282	80.6
36	7	32	22.8	30.6	284	81.1
37	7	33	22.9	30.4	279	79.7
38	7	32	22.7	30.7	277	79.0
39	7	32	21.9	30.7	281	80.3
40	7	32	22.4	30.7	279	79.7
41	7	32	22.1	30.6	283	80.9
42	7	33	22.7	30.6	283	80.9
	Average	32	22.4	29.4	280	80.0
	Std Dev	0	0.3	4.2	4	1.2
	Maximum	33	22.9	30.7	287	82.0
	Minimum	32	21.9	14.3	272	77.7

N-value: 14

Sample Interval Time: 41.51 seconds.

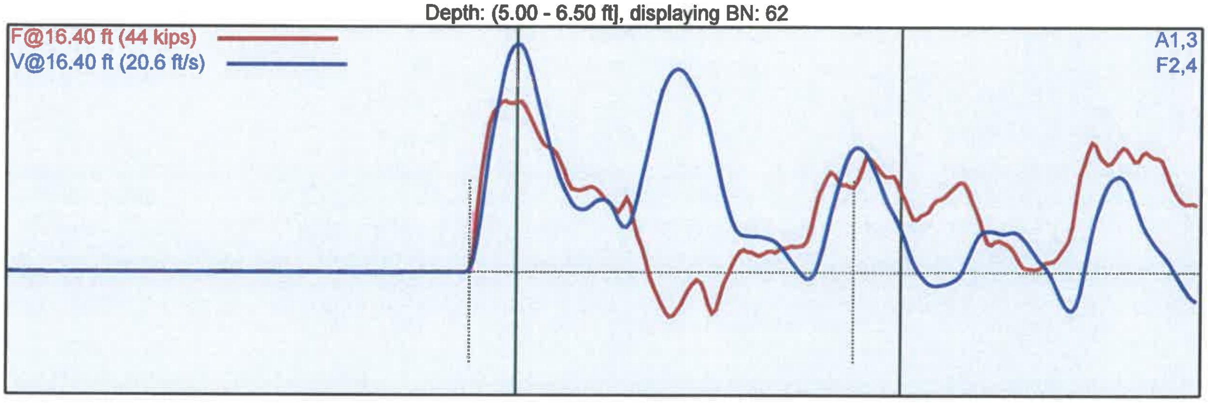
d120 gray6-17-19
tad
SHOP

2
Test date: 6/17/2019

AR: 1.20 in^2
LE: 16.40 ft
WS: 16807.9 ft/s

SP: 0.492 k/ft3
EM: 30000 ksi

Depth: (5.00 - 6.50 ft], displaying BN: 62



F2 : [202AWJ1] 207.18 PDICAL (1) FF1
F4 : [202AWJ2] 207.8 PDICAL (1) FF1

A1 (PR): [K6179] 380 mv/6.4v/5000g (1) VF1
A3 (PR): [K1510] 342 mv/6.4v/5000g (1) VF1

BL#	BC /6"	FMX kips	VMX ft/s	BPM bpm	EFV ft-lb	ETR %
43	8	32	21.2	1.9	280	80.0
44	8	31	21.4	30.6	290	82.8
45	8	33	22.1	30.5	287	82.1
46	8	31	21.5	30.7	287	81.9
47	8	32	22.5	30.5	293	83.6
48	8	30	21.6	30.7	283	80.8
49	8	31	22.5	30.6	282	80.7
50	8	29	19.5	31.5	230	65.9
51	7	29	18.9	30.0	248	71.0
52	7	31	18.9	30.2	257	73.5
53	7	31	18.9	30.6	263	75.1
54	7	31	18.8	30.6	264	75.4
55	7	31	18.8	30.7	267	76.2
56	7	31	18.7	30.7	280	80.0
57	7	31	18.9	30.8	272	77.7
58	7	31	18.7	30.6	277	79.2
59	7	31	19.0	30.6	278	79.5
60	7	31	19.0	30.7	278	79.5
61	7	31	19.1	30.8	278	79.3
62	7	31	19.1	30.5	275	78.6
63	7	31	19.3	30.6	281	80.4
64	7	31	19.4	30.7	282	80.5
	Average	31	19.0	30.6	271	77.6
	Std Dev	1	0.2	0.2	10	2.8
	Maximum	31	19.4	30.8	282	80.5
	Minimum	29	18.7	30.0	248	71.0

N-value: 14

Sample Interval Time: 41.12 seconds.

Pile Dynamics, Inc.
SPT Analyzer Results

PDA-S Ver. 2018.30 - Printed: 7/15/2019

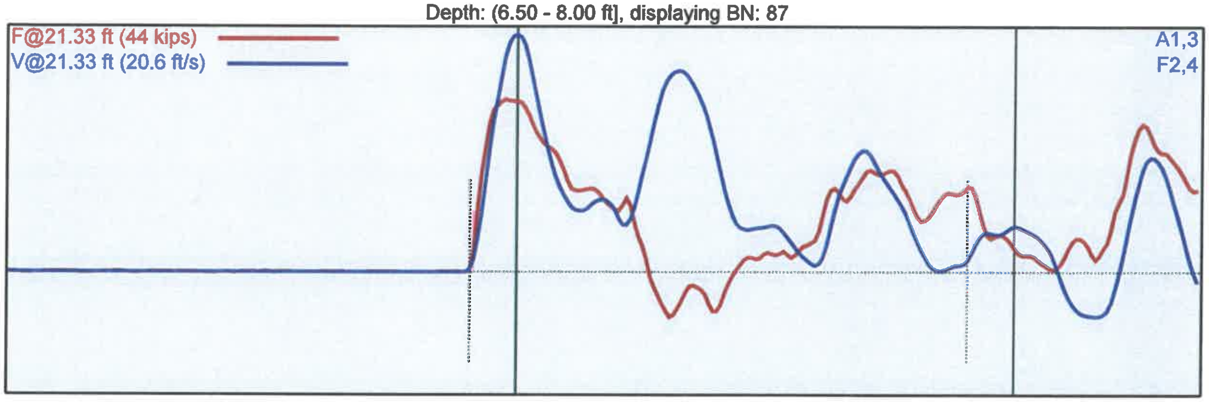
d120 gray6-17-19
tad
SHOP

2
Test date: 6/17/2019

AR: 1.20 in^2
LE: 21.33 ft
WS: 16807.9 ft/s

SP: 0.492 k/ft3
EM: 30000 ksi

Depth: (6.50 - 8.00 ft], displaying BN: 87



F2 : [202AWJ1] 207.18 PDICAL (1) FF1
F4 : [202AWJ2] 207.8 PDICAL (1) FF1

A1 (PR): [K6179] 380 mv/6.4v/5000g (1) VF1
A3 (PR): [K1510] 342 mv/6.4v/5000g (1) VF1

BL#	BC /6"	FMX kips	VMX ft/s	BPM bpm	EFV ft-lb	ETR %
65	9	31	19.2	1.9	280	79.9
66	9	31	19.4	30.8	278	79.4
67	9	31	19.5	30.7	281	80.2
68	9	31	19.5	30.7	282	80.5
69	9	31	19.6	30.7	284	81.2
70	9	31	19.5	30.7	280	80.0
71	9	31	19.8	30.6	286	81.6
72	9	31	19.7	30.7	288	82.3
73	9	31	19.5	30.7	284	81.2
74	**8**	**31**	**19.7**	**30.8**	**283**	**81.0**
75	**8**	**31**	**19.7**	**30.6**	**286**	**81.8**
76	**8**	**31**	**19.7**	**30.8**	**287**	**81.9**
77	**8**	**31**	**19.7**	**30.7**	**287**	**82.1**
78	**8**	**31**	**19.8**	**30.7**	**287**	**82.0**
79	**8**	**31**	**19.5**	**30.7**	**286**	**81.8**
80	**8**	**31**	**19.7**	**30.7**	**287**	**81.9**
81	**8**	**31**	**19.7**	**30.7**	**287**	**81.9**
82	**8**	**31**	**19.7**	**30.7**	**284**	**81.3**
83	**8**	**30**	**19.7**	**30.8**	**284**	**81.1**
84	**8**	**31**	**19.7**	**30.6**	**287**	**81.9**
85	**8**	**31**	**19.9**	**30.7**	**286**	**81.7**
86	**8**	**31**	**19.9**	**30.8**	**289**	**82.5**
87	**8**	**31**	**19.9**	**30.9**	**288**	**82.3**
88	**8**	**31**	**20.0**	**30.6**	**290**	**82.8**
89	**8**	**31**	**19.9**	**30.7**	**288**	**82.3**
	Average	**31**	**19.8**	**30.7**	**287**	**81.9**
	Std Dev	**0**	**0.1**	**0.1**	**2**	**0.5**
	Maximum	**31**	**20.0**	**30.9**	**290**	**82.8**
	Minimum	**30**	**19.5**	**30.6**	**283**	**81.0**

N-value: 16

Sample Interval Time: 46.89 seconds.

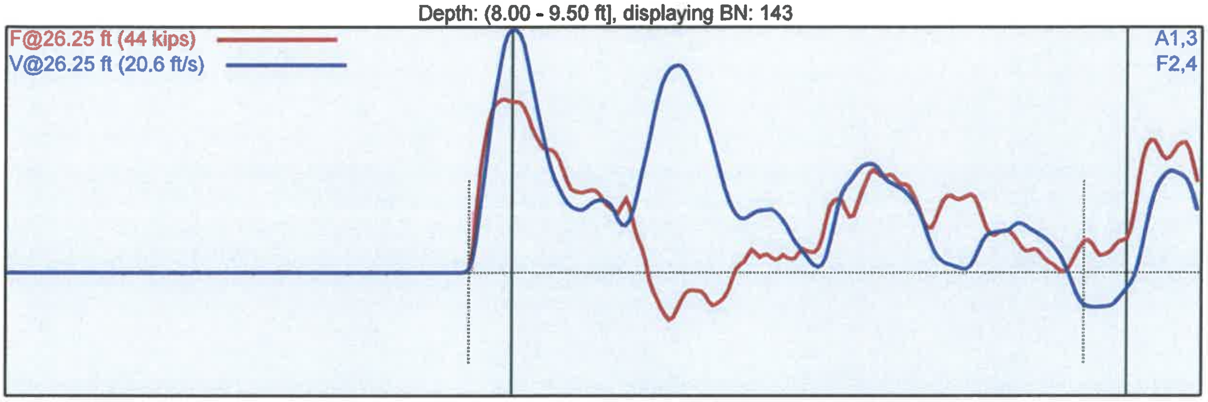
d120 gray6-17-19
tad
SHOP

2
Test date: 6/17/2019

AR: 1.20 in^2
LE: 26.25 ft
WS: 16807.9 ft/s

SP: 0.492 k/ft3
EM: 30000 ksi

Depth: (8.00 - 9.50 ft], displaying BN: 143



F2 : [202AWJ1] 207.18 PDICAL (1) FF1
F4 : [202AWJ2] 207.8 PDICAL (1) FF1

A1 (PR): [K6179] 380 mv/6.4v/5000g (1) VF1
A3 (PR): [K1510] 342 mv/6.4v/5000g (1) VF1

BL#	BC	FMX	VMX	BPM	EFV	ETR
	/6"	kips	ft/s	bpm	ft-lb	%
90	20	31	20.0	1.9	293	83.6
91	20	31	19.9	30.7	286	81.8
92	20	31	20.0	30.8	287	82.1
93	20	31	20.1	30.8	290	82.8
94	20	31	19.9	30.8	287	82.1
95	20	31	19.8	30.8	284	81.3
96	20	31	20.0	30.8	286	81.8
97	20	31	19.9	30.8	283	80.8
98	20	31	20.0	30.8	290	82.9
99	20	31	20.1	30.7	286	81.8
100	**18**	**31**	**20.1**	**30.9**	**288**	**82.3**
101	**18**	**31**	**20.1**	**30.6**	**289**	**82.5**
102	**18**	**31**	**20.1**	**30.7**	**288**	**82.2**
103	**18**	**31**	**20.0**	**30.7**	**288**	**82.2**
104	**18**	**31**	**20.1**	**30.8**	**292**	**83.4**
105	**18**	**31**	**20.1**	**30.7**	**287**	**82.1**
106	**18**	**31**	**20.0**	**30.7**	**289**	**82.6**
107	**18**	**31**	**20.1**	**30.7**	**293**	**83.8**
108	**18**	**31**	**20.1**	**30.8**	**290**	**82.9**
109	**18**	**31**	**20.1**	**30.9**	**289**	**82.6**
110	**18**	**31**	**20.1**	**30.7**	**289**	**82.6**
111	**18**	**31**	**19.8**	**30.7**	**290**	**82.9**
112	**18**	**31**	**20.2**	**30.7**	**290**	**83.0**
113	**18**	**31**	**20.2**	**30.7**	**287**	**82.1**
114	**18**	**31**	**20.3**	**30.7**	**290**	**82.8**
115	**18**	**31**	**20.4**	**30.8**	**300**	**85.6**
116	**18**	**31**	**20.5**	**30.8**	**301**	**86.1**
117	**18**	**31**	**20.4**	**30.8**	**301**	**86.1**
118	20	31	20.0	1.9	293	83.6
119	20	31	19.9	30.7	286	81.8
120	20	31	20.0	30.8	287	82.1

121	20	31	20.1	30.8	290	82.8
122	20	31	19.9	30.8	287	82.1
123	20	31	19.8	30.8	284	81.3
124	20	31	20.0	30.8	286	81.8
125	20	31	19.9	30.8	283	80.8
126	20	31	20.0	30.8	290	82.9
127	20	31	20.1	30.7	286	81.8
128	**18**	**31**	**20.1**	**30.9**	**288**	**82.3**
129	**18**	**31**	**20.1**	**30.6**	**289**	**82.5**
130	**18**	**31**	**20.1**	**30.7**	**288**	**82.2**
131	**18**	**31**	**20.0**	**30.7**	**288**	**82.2**
132	**18**	**31**	**20.1**	**30.8**	**292**	**83.4**
133	**18**	**31**	**20.1**	**30.7**	**287**	**82.1**
134	**18**	**31**	**20.0**	**30.7**	**289**	**82.6**
135	**18**	**31**	**20.1**	**30.7**	**293**	**83.8**
136	**18**	**31**	**20.1**	**30.8**	**290**	**82.9**
137	**18**	**31**	**20.1**	**30.9**	**289**	**82.6**
138	**18**	**31**	**20.1**	**30.7**	**289**	**82.6**
139	**18**	**31**	**19.8**	**30.7**	**290**	**82.9**
140	**18**	**31**	**20.2**	**30.7**	**290**	**83.0**
141	**18**	**31**	**20.2**	**30.7**	**287**	**82.1**
142	**18**	**31**	**20.3**	**30.7**	**290**	**82.8**
143	**18**	**31**	**20.4**	**30.8**	**300**	**85.6**
144	**18**	**31**	**20.5**	**30.8**	**301**	**86.1**
145	**18**	**31**	**20.4**	**30.8**	**301**	**86.1**
	Average	**31**	**20.2**	**30.7**	**291**	**83.2**
	Std Dev	**0**	**0.2**	**0.1**	**5**	**1.3**
	Maximum	**31**	**20.5**	**30.9**	**301**	**86.1**
	Minimum	**31**	**19.8**	**30.6**	**287**	**82.1**

N-value: 36

Sample Interval Time: 52.71 seconds.

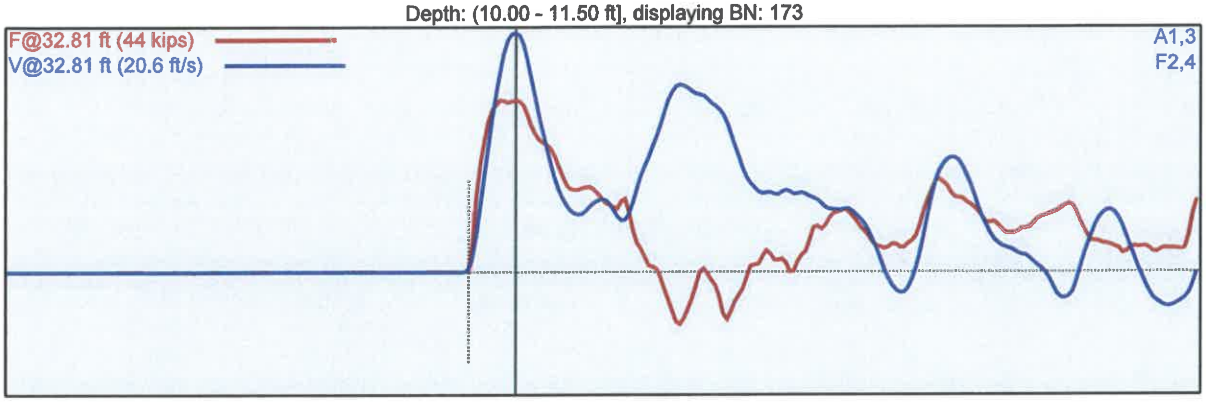
d120 gray6-17-19
tad
SHOP

2
Test date: 6/17/2019

AR: 1.20 in^2
LE: 32.81 ft
WS: 16807.9 ft/s

SP: 0.492 k/ft3
EM: 30000 ksi

Depth: (10.00 - 11.50 ft], displaying BN: 173



F2 : [202AWJ1] 207.18 PDICAL (1) FF1
F4 : [202AWJ2] 207.8 PDICAL (1) FF1

A1 (PR): [K6179] 380 mv/6.4v/5000g (1) VF1
A3 (PR): [K1510] 342 mv/6.4v/5000g (1) VF1

BL#	BC /6"	FMX kips	VMX ft/s	BPM bpm	EFV ft-lb	ETR %
146	10	31	20.3	1.9	293	83.7
147	10	31	20.5	30.6	305	87.1
148	10	31	20.4	30.8	300	85.6
149	10	31	20.5	30.8	303	86.5
150	10	31	20.4	30.8	304	86.8
151	10	31	20.4	30.6	300	85.7
152	10	31	20.3	30.7	304	86.9
153	10	31	20.4	30.7	303	86.5
154	10	31	20.3	30.9	303	86.5
155	10	31	20.4	30.6	302	86.3
156	10	31	20.2	30.6	303	86.6
157	10	31	20.2	30.8	295	84.3
158	10	31	20.0	30.7	293	83.6
159	10	31	20.3	30.7	293	83.7
160	10	31	20.1	30.7	285	81.5
161	10	31	20.3	30.7	293	83.6
162	10	31	20.2	30.9	287	82.0
163	10	31	20.2	30.7	284	81.3
164	10	31	20.2	30.6	293	83.8
165	10	31	20.1	30.7	288	82.3
166	10	31	20.1	30.8	289	82.7
167	10	31	20.2	30.8	289	82.4
168	10	31	20.2	30.7	291	83.0
169	10	31	20.3	30.7	291	83.3
170	10	31	20.2	30.8	283	80.8
171	10	31	20.2	30.8	285	81.4
172	10	31	20.3	30.8	288	82.2
173	10	31	20.1	30.7	288	82.3
174	10	31	20.3	30.8	286	81.8
175	10	31	20.1	30.8	285	81.4

Average	31	20.2	30.8	289	82.7
Std Dev	0	0.1	0.1	5	1.3
Maximum	31	20.3	30.9	303	86.6
Minimum	31	20.0	30.6	283	80.8

N-value: 20

Sample Interval Time: 56.57 seconds.

This Page Intentionally Left Blank

Summary of SPT Test Results

Project: d120 gray6-17-19, Test Date: 6/17/2019

FMX: Maximum Force
VMX: Maximum Velocity
BPM: Blows/Minute
EFV: Maximum Energy
ETR: Energy Transfer Ratio - Rated

Instr. Length ft	Blows Applied /6"	**N Value**	**N60 Value**	Average FMX kips	Average VMX ft/s	Average BPM bpm	Average EFV ft-lb	Average ETR %
6.56	**7-7-7**	**14**	**18**	32	22.5	30.6	277	79.0
11.48	**7-7-7**	**14**	**18**	32	22.4	29.4	280	80.0
16.40	**8-7-7**	**14**	**18**	31	19.0	30.6	271	77.6
21.33	**9-8-8**	**16**	**21**	31	19.8	30.7	287	81.9
26.25	**20-18-18**	**36**	**48**	31	20.2	30.7	291	83.2
32.81	**10-10-10**	**20**	**27**	31	20.2	30.8	289	82.7
			Overall Average Values:	31	20.5	30.5	285	81.3
			Standard Deviation:	1	1.2	1.5	9	2.5
			Overall Maximum Value:	33	23.1	30.9	303	86.6
			Overall Minimum Value:	29	18.7	14.3	248	71.0

This page intentionally left blank.

Taber DRILLING

Taber Drilling
536 Galveston Street
West Sacramento, CA 95691-2116
Office **(916) 371-8234**
Fax (916) 371-8283
Tim d'Arcy Cell (916) 952-8546

June 29, 2018

Blackburn Consulting
2491 Boatman Avenue
West Sacramento, CA 95691

Subject: <u>SPT and Cal Mod – Hammer Energy Measurements</u>
Lookout Slough
Red Hammer
Solano County, CA

Greetings:

This letter transmits the Standard Penetration Test (SPT) hammer energy efficiency on June 20, 2018 using a red automatic hammer. Energy measurements for this hammer were obtained in a manner consistent with ASTM D4633-10 using an SPT Analyzer manufactured by Pile Dynamics, Inc. The purpose was to obtain hammer energy measurements and determine hammer efficiency (normalized for 60% efficiency) during sampling.

Dynamic strain and acceleration measurements were obtained through two strain bridge pairs and two accelerometers affixed on a 2-foot long section of AWJ rod. The AWJ rod was mounted on top of the string of rods and below the hammer. Strain and acceleration signals were conditioned and converted to force and velocity measurements using the SPT Analyzer.

The dynamic force and velocity data was converted to maximum transferred energy using the EFV method: $EFV = \int F(t) \bullet V(t) \bullet dt$. The integration is performed from when energy transfer begins to when the maximum energy occurs. This method is theoretically appropriate regardless of rod length, wave travel time, and the number of non-uniform rod connections. Energy transfer is then calculated as ETR = EFV/PE, where ETR is the energy transfer ratio, EVF is the energy transferred to the sampling rods, and PE is the theoretical potential energy.

The average hammer efficiency (ETR) on June22, 2018, was **91%** (based on an EFV of 320 ft-lbs). The results via the SPT Analyzer are presented in the attached table (Summary of Field Results, SPT Energy Measurements), graphical data plots, and data sheets.

We appreciate the opportunity to be of service.

Very Truly Yours,
Taber Drilling

Franklin Taber

Frank Taber
GE 816

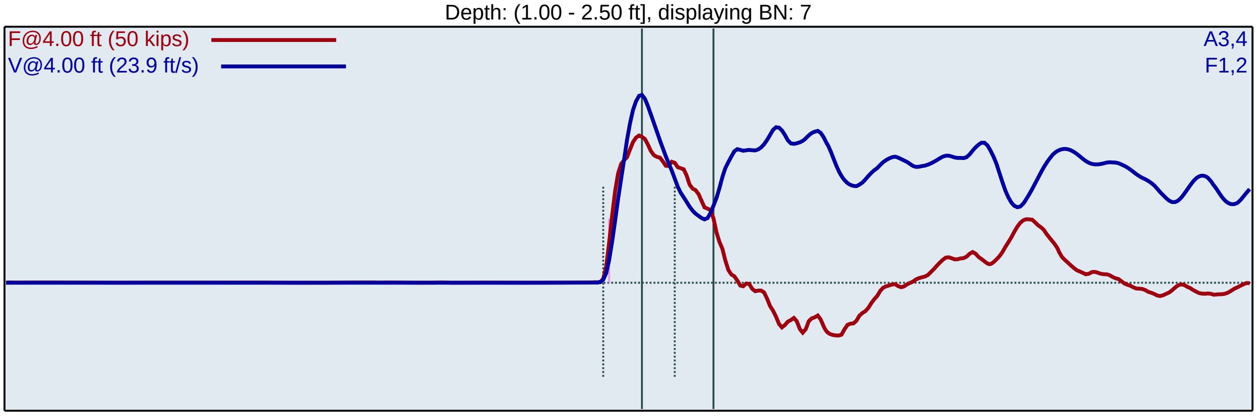
REGISTERED PROFESSIONAL ENGINEER FRANKLIN P. TABER No. 816 GEOTECHNICAL STATE OF CALIFORNIA

Attachments: Summary of Field Results, SPT Energy Measurements
SPT Analyzer Data, Per Drive Depth

cme55 6.20.2018 1
lawrence Test date: 6/20/2018

AR: 1.17 in^2 SP: 0.492 k/ft3
LE: 4.00 ft EM: 30000 ksi
WS: 16807.9 ft/s

Depth: (1.00 - 2.50 ft], displaying BN: 7



FMX: Maximum Force
VMX: Maximum Velocity
BPM: Blows/Minute

EFV: Maximum Energy
ETR: Energy Transfer Ratio - Rated

BL#	LP	FMX	VMX	BPM	EFV	ETR
	ft	kips	ft/s	bpm	ft-lb	(%)
1	1.25	29	15.5	1.9	313	89.4
2	1.50	31	17.3	38.2	314	89.7
3	1.67	28	16.2	37.2	276	78.7
4	1.83	27	16.8	36.4	291	83.2
5	2.00	28	17.1	41.0	291	83.0
6	2.13	28	17.2	38.7	298	85.2
7	2.25	29	17.6	41.2	309	88.2
8	2.38	29	18.0	38.5	331	94.5
9	2.50	30	18.7	39.9	341	97.4
	Average	29	17.3	39.0	305	87.2
	Std Dev	1	0.8	1.7	22	6.2
	Maximum	30	18.7	41.2	341	97.4
	Minimum	27	16.2	36.4	276	78.7

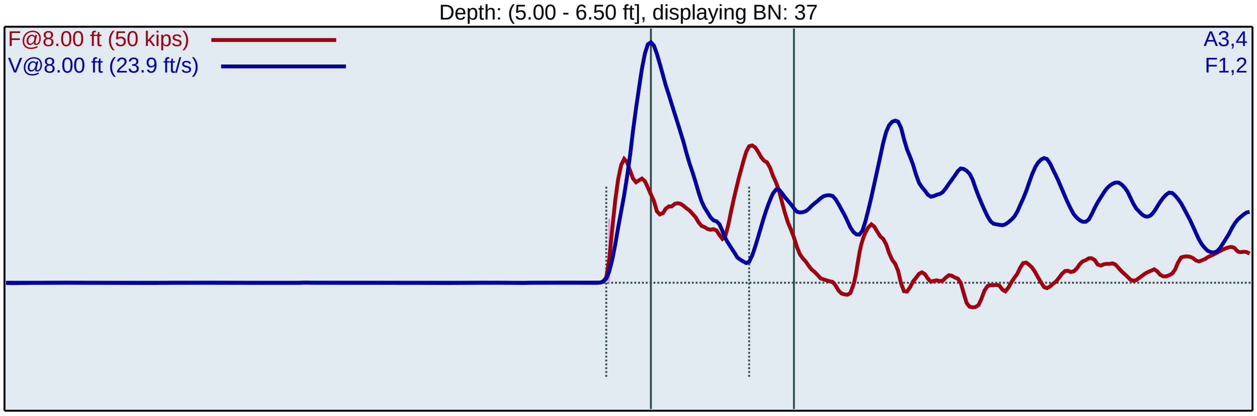
N-value: 7

Sample Interval Time: 12.39 seconds.

cme55 6.20.2018 1
lawrence Test date: 6/20/2018

AR: 1.17 in^2 SP: 0.492 k/ft3
LE: 8.00 ft EM: 30000 ksi
WS: 16807.9 ft/s

Depth: (5.00 - 6.50 ft], displaying BN: 37



BL#	LP	FMX	VMX	BPM	EFV	ETR
	ft	kips	ft/s	bpm	ft-lb	(%)
10	5.08	29	21.9	1.9	347	99.2
11	5.17	29	21.1	38.9	343	98.0
12	5.25	29	21.3	38.0	328	93.7
13	5.33	29	21.5	38.3	337	96.4
14	5.42	29	21.7	37.7	339	96.9
15	5.50	28	21.2	37.7	334	95.4
16	5.55	28	21.1	37.3	321	91.6
17	5.59	26	20.7	36.5	318	90.9
18	5.64	27	20.8	37.7	298	85.0
19	5.68	25	20.1	37.3	282	80.6
20	5.73	25	20.4	37.7	292	83.6
21	5.77	25	20.7	38.0	302	86.2
22	5.82	24	19.7	36.9	290	82.7
23	5.86	25	20.9	38.1	289	82.5
24	5.91	25	20.6	38.7	293	83.7
25	5.95	24	20.2	39.0	284	81.1
26	6.00	25	21.5	39.7	296	84.5
27	6.04	25	20.9	37.2	295	84.1
28	6.08	27	22.2	39.4	302	86.3
29	6.12	27	22.1	38.9	306	87.3
30	6.15	26	21.5	39.9	308	88.0
31	6.19	26	22.8	39.0	312	89.0
32	6.23	26	22.4	39.4	320	91.4
33	6.27	27	23.5	39.3	336	96.1
34	6.31	27	23.1	39.6	327	93.4
35	6.35	26	21.3	40.1	310	88.6
36	6.38	27	23.6	39.7	340	97.2
37	6.42	27	22.5	40.0	333	95.2
38	6.46	26	22.2	40.3	325	92.9
39	6.50	27	23.0	40.5	334	95.6
	Average	26	21.6	38.8	309	88.2
	Std Dev	1	1.1	1.2	17	4.9
	Maximum	28	23.6	40.5	340	97.2
	Minimum	24	19.7	36.5	282	80.6

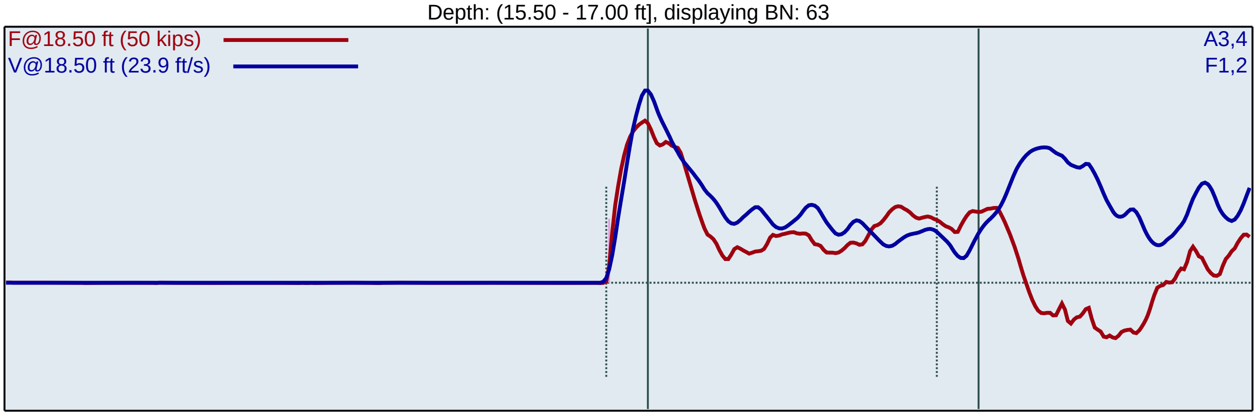
N-value: 24

Sample Interval Time: 45.12 seconds.

cme55 6.20.2018 1
lawrence Test date: 6/20/2018

AR: 1.17 in^2 SP: 0.492 k/ft3
LE: 18.50 ft EM: 30000 ksi
WS: 16807.9 ft/s

Depth: (15.50 - 17.00 ft], displaying BN: 63



BL#	LP	FMX	VMX	BPM	EFV	ETR
	ft	kips	ft/s	bpm	ft-lb	(%)
40	15.63	31	16.7	1.9	320	91.4
41	15.75	31	17.2	38.7	335	95.8
42	15.88	31	17.2	37.9	337	96.3
43	16.00	31	17.4	38.0	343	98.1
44	16.10	31	17.6	38.1	339	96.8
45	16.20	31	17.5	38.0	326	93.2
46	16.30	31	17.5	37.8	333	95.0
47	16.40	31	18.2	37.5	339	96.8
48	16.50	31	17.8	37.6	332	95.0
49	16.53	30	17.3	37.4	322	91.9
50	16.56	31	17.7	38.7	317	90.7
51	16.59	30	17.3	38.0	309	88.2
52	16.62	30	17.0	39.0	303	86.6
53	16.65	30	17.2	37.5	302	86.3
54	16.68	30	17.5	38.9	315	89.9
55	16.71	30	17.3	38.5	308	87.9
56	16.74	30	16.9	40.5	289	82.5
57	16.76	30	17.6	38.1	319	91.2
58	16.79	31	17.9	38.8	321	91.7
59	16.82	30	16.9	39.4	325	92.9
60	16.85	31	17.4	39.3	328	93.7
61	16.88	32	18.0	39.2	339	96.8
62	16.91	31	17.8	39.4	344	98.4
63	16.94	32	18.0	39.1	344	98.3
64	16.97	31	17.9	39.3	351	100.2
65	17.00	32	18.2	39.8	354	101.2
	Average	31	17.6	38.6	325	93.0
	Std Dev	1	0.4	0.8	17	4.7
	Maximum	32	18.2	40.5	354	101.2
	Minimum	30	16.9	37.4	289	82.5

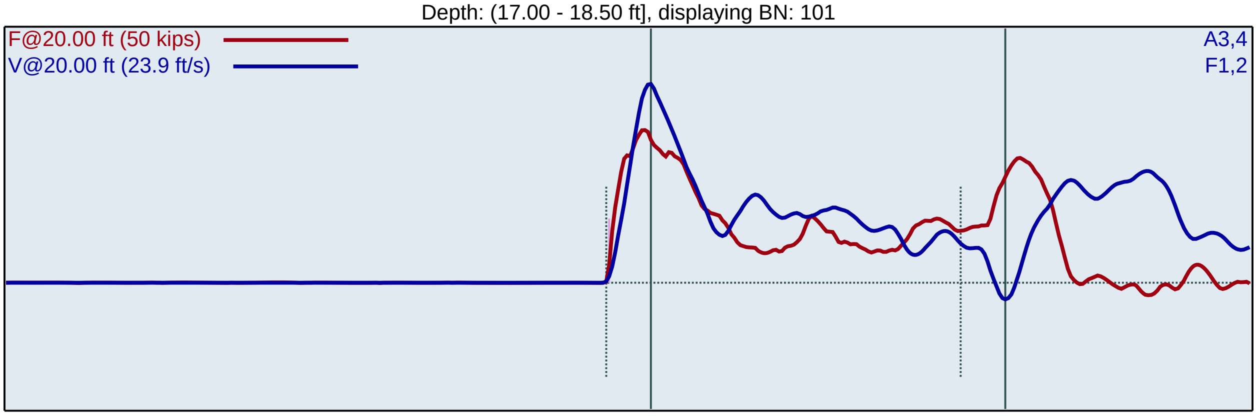
N-value: 22

Sample Interval Time: 38.94 seconds.

cme55 6.20.2018 1
lawrence Test date: 6/20/2018

AR: 1.17 in^2 SP: 0.492 k/ft3
LE: 20.00 ft EM: 30000 ksi
WS: 16807.9 ft/s

Depth: (17.00 - 18.50 ft], displaying BN: 101



BL#	LP	FMX	VMX	BPM	EFV	ETR
	ft	kips	ft/s	bpm	ft-lb	(%)
66	17.07	31	17.9	1.9	349	99.7
67	17.14	30	18.0	37.7	335	95.7
68	17.21	31	18.3	37.2	341	97.5
69	17.29	24	14.6	38.8	224	64.1
70	17.36	30	18.1	36.6	329	93.9
71	17.43	30	17.9	36.5	327	93.5
72	17.50	28	16.8	37.7	301	86.0
73	17.54	27	16.0	37.1	265	75.7
74	17.58	29	17.8	37.2	328	93.6
75	17.62	29	17.6	37.1	306	87.5
76	17.65	29	18.0	37.2	315	90.1
77	17.69	28	17.0	36.7	287	82.0
78	17.73	28	17.2	36.6	286	81.8
79	17.77	28	17.3	36.8	293	83.6
80	17.81	28	17.2	37.8	295	84.2
81	17.85	26	16.7	36.5	283	80.8
82	17.88	27	17.4	37.7	294	84.0
83	17.92	27	17.6	38.3	300	85.7
84	17.96	28	17.7	38.1	306	87.4
85	18.00	27	17.3	37.9	301	86.1
86	18.03	28	18.5	37.2	316	90.3
87	18.06	27	17.0	37.8	303	86.6
88	18.08	29	18.5	38.8	315	90.0
89	18.11	27	16.7	39.3	279	79.7
90	18.14	28	18.5	38.2	317	90.7
91	18.17	28	17.7	37.3	319	91.0
92	18.19	28	18.0	38.5	320	91.3
93	18.22	29	18.7	38.3	330	94.3
94	18.25	29	18.7	38.4	326	93.3
95	18.28	29	18.4	38.5	325	93.0
96	18.31	29	18.4	39.0	318	90.9
97	18.33	29	18.2	38.8	319	91.1
98	18.36	30	18.7	39.0	331	94.5
99	18.39	30	18.8	38.8	335	95.7
100	18.42	30	18.8	38.9	331	94.6
101	18.44	30	18.6	38.9	332	94.8

102	18.47	30	18.3	38.2	331	94.7
103	18.50	30	18.7	39.2	333	95.0
	Average	28	17.9	38.0	311	88.8
	Std Dev	1	0.7	0.8	18	5.2
	Maximum	30	18.8	39.3	335	95.7
	Minimum	26	16.0	36.5	265	75.7

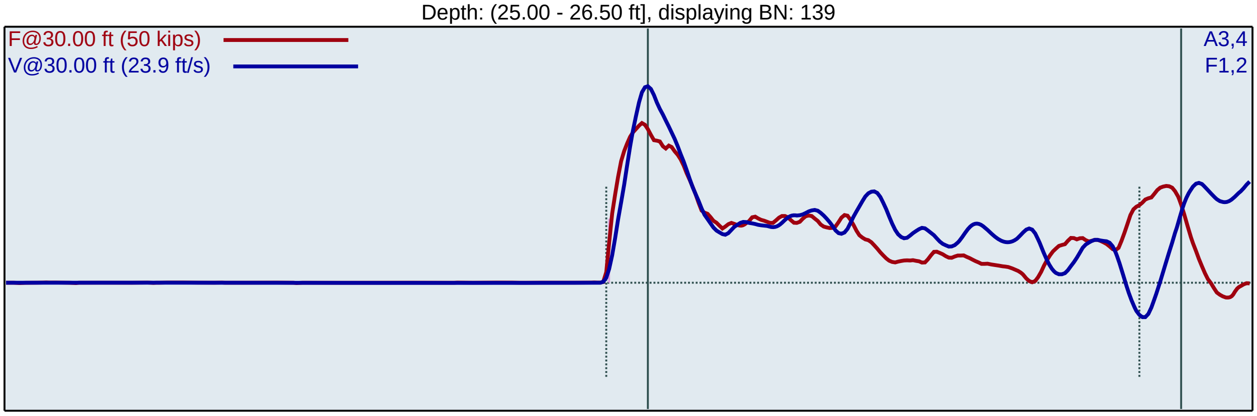
N-value: 31

Sample Interval Time: 58.53 seconds.

cme55 6.20.2018 1
lawrence Test date: 6/20/2018

AR: 1.17 in^2 SP: 0.492 k/ft3
LE: 30.00 ft EM: 30000 ksi
WS: 16807.9 ft/s

Depth: (25.00 - 26.50 ft], displaying BN: 139



BL#	LP	FMX	VMX	BPM	EFV	ETR
	ft	kips	ft/s	bpm	ft-lb	(%)
104	25.05	30	17.0	1.9	328	93.6
105	25.09	30	18.0	38.9	337	96.2
106	25.14	30	17.7	38.1	333	95.1
107	25.18	29	17.8	38.0	329	94.0
108	25.23	30	17.9	37.8	335	95.7
109	25.27	29	17.3	38.4	313	89.3
110	25.32	30	18.1	38.1	330	94.4
111	25.36	29	17.6	38.1	315	90.1
112	25.41	30	18.3	37.8	330	94.4
113	25.45	30	18.3	37.7	330	94.3
114	25.50	30	18.2	38.2	332	94.9
115	25.54	28	16.6	38.4	284	81.1
116	25.58	30	17.9	37.6	327	93.5
117	25.62	29	17.0	38.1	318	90.9
118	25.65	29	17.1	38.4	296	84.6
119	25.69	28	16.6	38.1	304	87.0
120	25.73	29	16.9	38.4	301	85.9
121	25.77	27	15.9	37.8	283	80.9
122	25.81	28	16.3	38.3	299	85.4
123	25.85	27	16.0	38.3	300	85.8
124	25.88	28	16.4	38.2	304	87.0
125	25.92	27	15.9	38.7	300	85.7
126	25.96	30	17.6	38.2	321	91.6
127	26.00	30	17.8	38.5	326	93.1
128	26.04	30	17.6	39.0	322	91.9
129	26.07	29	17.0	38.6	320	91.5
130	26.11	30	18.2	39.1	323	92.3
131	26.14	30	18.0	38.8	333	95.0
132	26.18	30	18.0	39.0	335	95.8
133	26.21	30	18.1	39.0	336	96.0
134	26.25	30	17.9	39.2	336	96.0
135	26.29	30	17.7	39.2	333	95.2
136	26.32	30	17.6	39.3	319	91.2
137	26.36	31	18.0	39.1	340	97.3
138	26.39	31	18.5	39.5	346	98.7
139	26.43	31	18.4	39.2	343	97.9

140	26.46	31	18.3	39.5	342	97.6
141	26.50	32	18.6	39.2	347	99.2
	Average	30	17.4	38.7	320	91.4
	Std Dev	1	0.8	0.5	19	5.3
	Maximum	32	18.6	39.5	347	99.2
	Minimum	27	15.9	37.6	283	80.9

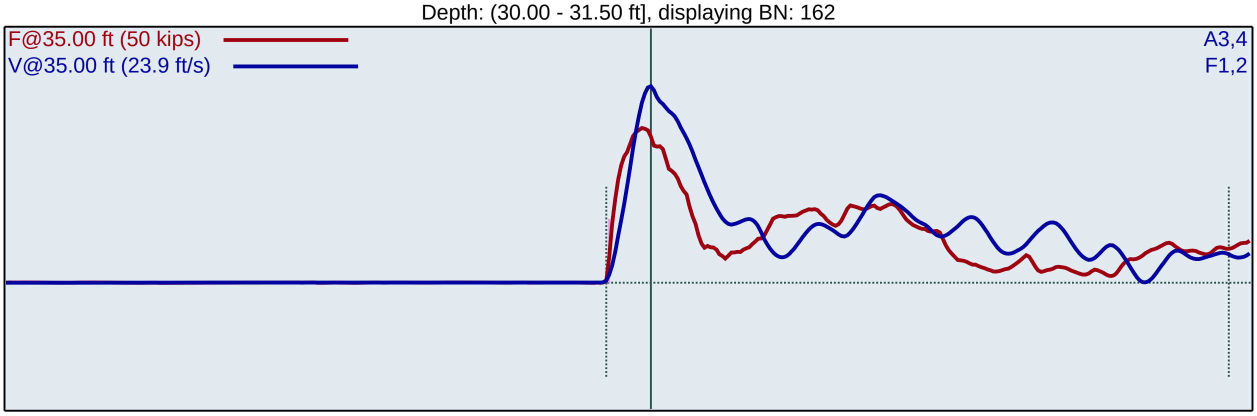
N-value: 27

Sample Interval Time: 57.72 seconds.

cme55 6.20.2018 — 1
lawrence — Test date: 6/20/2018

AR: 1.17 in^2 — SP: 0.492 k/ft3
LE: 35.00 ft — EM: 30000 ksi
WS: 16807.9 ft/s

Depth: (30.00 - 31.50 ft], displaying BN: 162



BL#	LP	FMX	VMX	BPM	EFV	ETR
	ft	kips	ft/s	bpm	ft-lb	(%)
142	30.06	30	17.8	1.9	315	90.0
143	30.13	29	16.5	39.2	325	92.8
144	30.19	31	18.4	37.7	346	98.8
145	30.25	31	18.6	38.6	350	99.9
146	30.31	30	18.0	38.2	331	94.7
147	30.38	31	18.3	37.9	342	97.8
148	30.44	31	17.9	38.4	332	94.9
149	30.50	30	17.9	38.3	327	93.3
150	30.56	29	16.7	38.9	293	83.7
151	30.63	29	17.3	37.9	310	88.5
152	30.69	28	16.3	38.2	291	83.2
153	30.75	29	17.3	37.9	307	87.6
154	30.81	29	17.2	38.9	302	86.4
155	30.88	28	17.1	37.6	301	86.0
156	30.94	29	17.7	39.7	308	88.1
157	31.00	30	18.3	38.7	324	92.6
158	31.07	30	18.2	38.6	328	93.7
159	31.14	30	18.1	39.3	327	93.6
160	31.21	30	18.4	39.1	336	96.1
161	31.29	30	18.7	39.0	339	96.8
162	31.36	30	18.4	39.3	334	95.6
163	31.43	30	18.5	39.2	340	97.2
164	31.50	31	18.7	39.6	342	97.8
	Average	30	17.8	38.8	319	91.1
	Std Dev	1	0.7	0.6	17	5.0
	Maximum	31	18.7	39.7	342	97.8
	Minimum	28	16.3	37.6	291	83.2

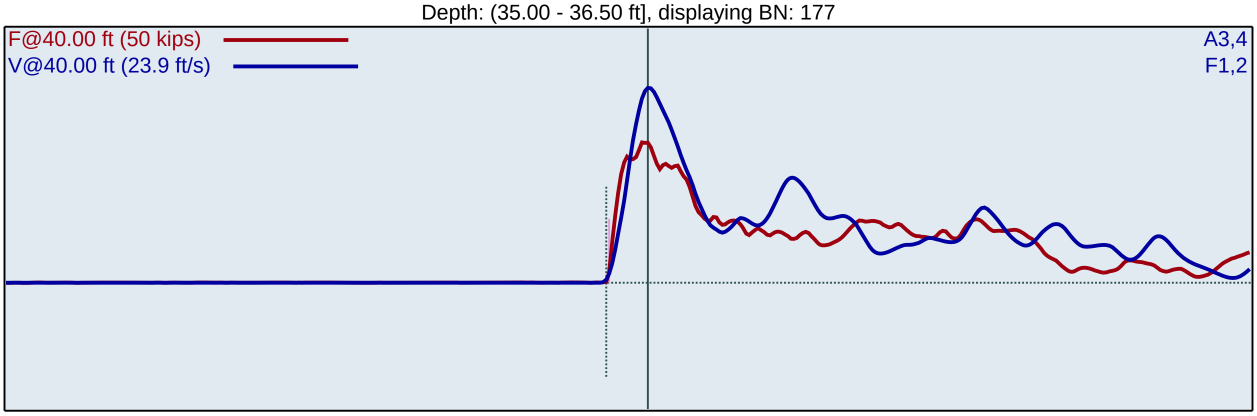
N-value: 15

Sample Interval Time: 34.26 seconds.

cme55 6.20.2018 1
lawrence Test date: 6/20/2018

AR: 1.17 in^2 SP: 0.492 k/ft3
LE: 40.00 ft EM: 30000 ksi
WS: 16807.9 ft/s

Depth: (35.00 - 36.50 ft], displaying BN: 177



BL#	LP	FMX	VMX	BPM	EFV	ETR
	ft	kips	ft/s	bpm	ft-lb	(%)
165	35.13	20	13.7	1.9	207	59.1
166	35.25	28	18.7	37.4	320	91.5
167	35.38	29	18.8	38.8	328	93.6
168	35.50	28	18.2	38.6	322	92.0
169	35.60	27	18.4	39.3	313	89.5
170	35.70	26	17.7	39.4	291	83.1
171	35.80	26	18.1	39.0	306	87.5
172	35.90	26	17.6	38.2	298	85.1
173	36.00	27	18.0	39.4	311	88.8
174	36.08	27	17.3	39.3	294	83.9
175	36.17	28	18.1	39.7	307	87.6
176	36.25	27	18.2	39.4	310	88.7
177	36.33	27	18.2	39.6	322	91.9
178	36.42	28	18.5	39.2	321	91.6
179	36.50	27	18.5	39.8	324	92.7
	Average	27	18.1	39.3	309	88.2
	Std Dev	1	0.4	0.4	11	3.1
	Maximum	28	18.5	39.8	324	92.7
	Minimum	26	17.3	38.2	291	83.1

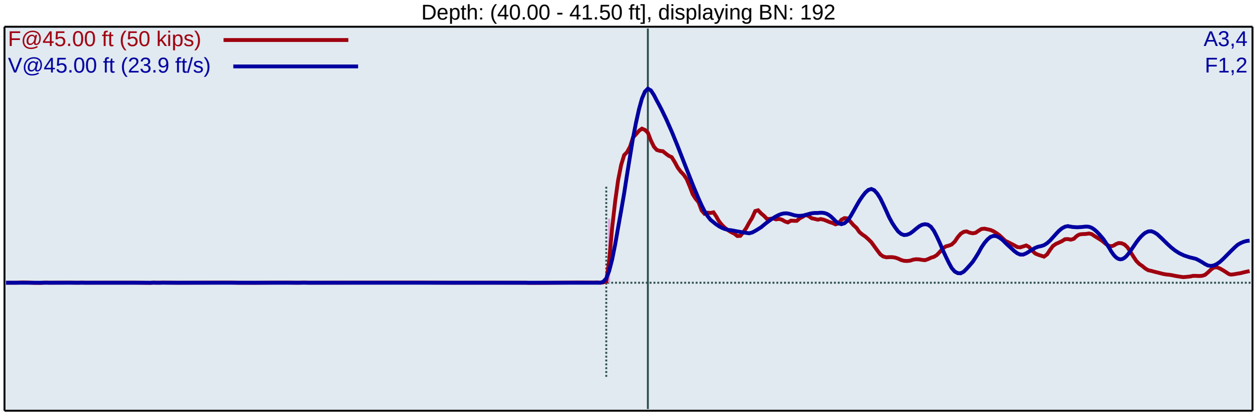
N-value: 11

Sample Interval Time: 21.54 seconds.

cme55 6.20.2018 1
lawrence Test date: 6/20/2018

AR: 1.17 in^2 SP: 0.492 k/ft3
LE: 45.00 ft EM: 30000 ksi
WS: 16807.9 ft/s

Depth: (40.00 - 41.50 ft], displaying BN: 192



BL#	LP	FMX	VMX	BPM	EFV	ETR
	ft	kips	ft/s	bpm	ft-lb	(%)
180	40.17	31	17.7	1.9	340	97.2
181	40.33	31	18.9	39.1	342	97.7
182	40.50	31	18.8	37.3	341	97.5
183	40.63	31	18.4	38.4	333	95.1
184	40.75	28	16.8	37.7	304	86.9
185	40.88	28	16.9	38.2	303	86.7
186	41.00	28	16.9	38.1	305	87.0
187	41.06	30	18.3	39.1	324	92.4
188	41.13	28	17.0	39.8	293	83.6
189	41.19	29	17.9	38.8	325	92.8
190	41.25	30	17.9	39.0	330	94.3
191	41.31	30	18.0	39.3	329	94.0
192	41.38	30	18.1	39.2	332	94.9
193	41.44	30	18.1	39.3	333	95.2
194	41.50	31	18.5	39.4	341	97.4
	Average	29	17.7	38.9	321	91.7
	Std Dev	1	0.6	0.6	15	4.2
	Maximum	31	18.5	39.8	341	97.4
	Minimum	28	16.8	37.7	293	83.6

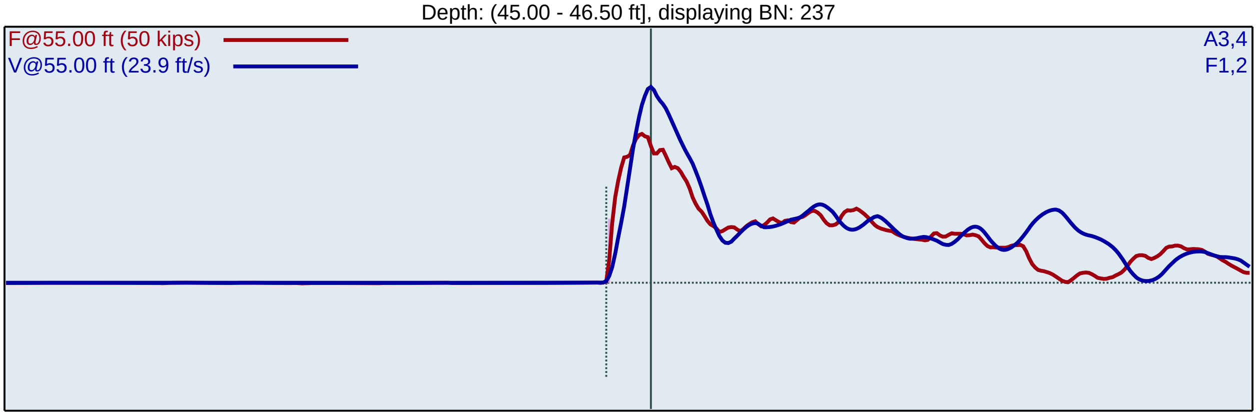
N-value: 12

Sample Interval Time: 21.62 seconds.

cme55 6.20.2018 1
lawrence Test date: 6/20/2018

AR: 1.17 in^2 SP: 0.492 k/ft3
LE: 50.00 ft EM: 30000 ksi
WS: 16807.9 ft/s

Depth: (45.00 - 46.50 ft], displaying BN: 237



BL#	LP	FMX	VMX	BPM	EFV	ETR
	ft	kips	ft/s	bpm	ft-lb	(%)
195	45.08	29	17.2	1.9	322	92.1
196	45.17	30	19.2	38.2	345	98.4
197	45.25	29	18.1	38.4	326	93.2
198	45.33	30	20.2	38.1	364	104.0
199	45.42	29	18.4	38.1	337	96.3
200	45.50	23	15.5	40.3	250	71.5
201	45.54	30	20.0	37.0	348	99.4
202	45.58	29	19.0	37.9	338	96.5
203	45.62	28	18.7	38.2	318	90.9
204	45.65	28	19.2	37.9	330	94.2
205	45.69	26	17.3	38.2	293	83.7
206	45.73	26	17.5	38.1	294	84.0
207	45.77	26	18.1	38.1	301	86.1
208	45.81	27	19.1	38.2	318	90.8
209	45.85	26	17.7	38.2	304	86.9
210	45.88	26	18.1	37.7	308	88.0
211	45.92	27	18.7	38.9	309	88.3
212	45.96	27	17.9	38.0	311	88.9
213	46.00	28	19.1	38.6	316	90.4
214	46.04	27	18.9	38.6	319	91.2
215	46.08	27	18.1	38.7	317	90.7
216	46.12	28	19.6	38.7	329	94.0
217	46.15	28	19.5	39.1	336	95.9
218	46.19	28	19.5	38.8	333	95.2
219	46.23	29	19.4	39.2	339	96.8
220	46.27	29	18.9	38.8	342	97.7
221	46.31	28	19.7	39.2	337	96.4
222	46.35	29	19.1	39.0	340	97.0
223	46.38	30	19.5	39.2	352	100.5
224	46.42	30	19.6	38.7	351	100.2
225	46.46	31	19.9	39.2	357	102.0
226	46.50	30	19.0	40.0	341	97.4
227	3.57	29	17.2	1.9	321	91.8

Average	28	18.9	38.5	326	93.2
Std Dev	1	0.7	0.6	18	5.1
Maximum	31	20.0	40.0	357	102.0
Minimum	26	17.3	37.0	293	83.7

N-value: 26

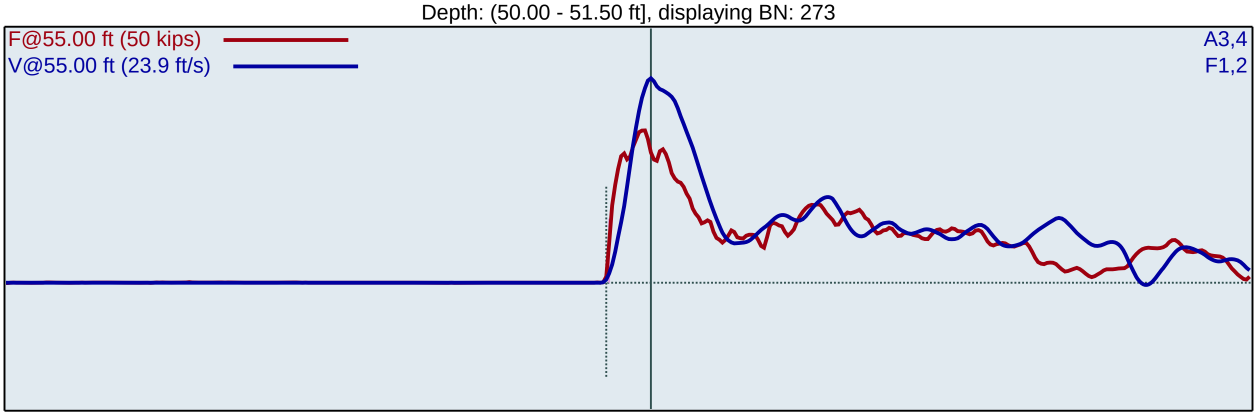
Sample Interval Time: 1086.59 seconds.

cme55 6.20.2018 1
lawrence Test date: 6/20/2018

AR: 1.17 in^2
LE: 55.00 ft
WS: 16807.9 ft/s

SP: 0.492 k/ft3
EM: 30000 ksi

Depth: (50.00 - 51.50 ft], displaying BN: 273



BL#	LP	FMX	VMX	BPM	EFV	ETR
	ft	kips	ft/s	bpm	ft-lb	(%)
241	50.53	29	18.3	38.5	337	96.2
242	50.55	29	18.3	38.5	335	95.9
243	50.58	29	17.8	38.7	328	93.8
244	50.61	29	18.4	38.6	330	94.4
245	50.63	26	16.1	37.8	297	84.9
246	50.66	27	16.8	38.4	300	85.8
247	50.68	27	17.0	38.8	298	85.2
248	50.71	28	17.8	38.3	316	90.3
249	50.74	28	16.9	38.4	306	87.5
250	50.76	27	16.7	38.5	295	84.2
251	50.79	26	16.7	39.0	287	82.0
252	50.82	26	16.4	38.8	283	80.9
253	50.84	27	17.1	38.6	315	89.9
254	50.87	28	17.7	38.2	312	89.2
255	50.89	28	17.3	38.5	315	90.1
256	50.92	29	17.6	39.7	318	90.9
257	50.95	27	16.9	37.9	314	89.7
258	50.97	28	17.3	38.8	316	90.2
259	51.00	29	17.4	39.3	332	95.0
260	51.03	27	16.9	38.9	312	89.1
261	51.06	30	19.1	39.2	349	99.6
262	51.09	28	16.7	39.2	319	91.1
263	51.13	28	17.8	39.9	318	90.8
264	51.16	29	17.7	38.5	338	96.6
265	51.19	29	18.6	39.3	338	96.7
266	51.22	29	18.3	39.1	345	98.5
267	51.25	29	18.4	39.2	346	98.9
268	51.28	30	18.7	39.2	348	99.6
269	51.31	30	18.9	39.8	351	100.2
270	51.34	29	18.0	39.6	335	95.6
271	51.38	30	19.1	39.4	351	100.3
272	51.41	30	18.7	39.2	342	97.6
273	51.44	30	19.1	39.5	346	98.9
274	51.47	31	18.9	39.6	352	100.6
275	51.50	30	18.8	39.7	351	100.4

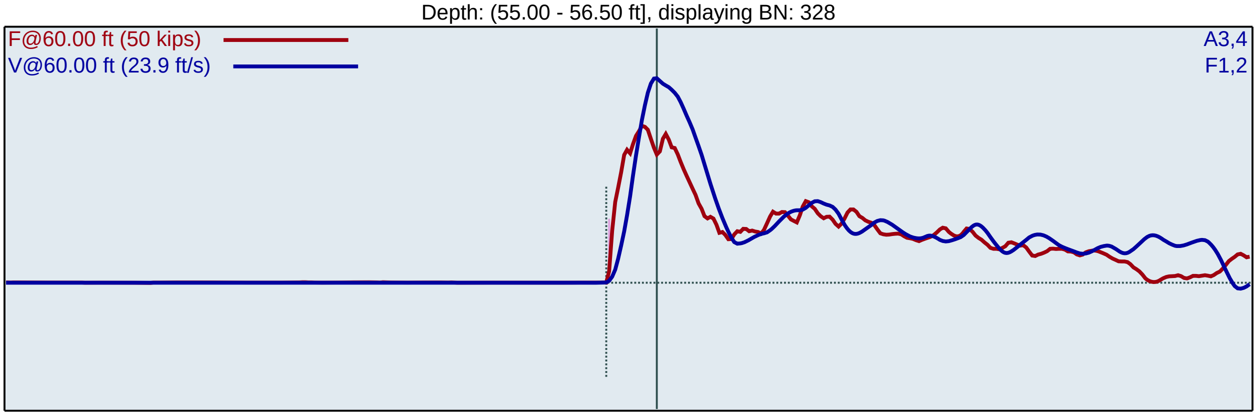
Average	28	17.8	38.9	325	92.9
Std Dev	1	0.9	0.5	20	5.7
Maximum	31	19.1	39.9	352	100.6
Minimum	26	16.1	37.8	283	80.9

N-value: 35

Sample Interval Time: 52.38 seconds.

cme55 6.20.2018 1
lawrence Test date: 6/20/2018

AR: 1.17 in^2 SP: 0.492 k/ft3
LE: 60.00 ft EM: 30000 ksi
WS: 16807.9 ft/s



BL#	LP	FMX	VMX	BPM	EFV	ETR
	ft	kips	ft/s	bpm	ft-lb	(%)
276	55.06	30	17.2	1.9	334	95.3
277	55.11	31	18.8	39.3	353	100.9
278	55.17	30	17.4	38.9	345	98.7
279	55.22	31	19.0	38.5	359	102.4
280	55.28	30	18.2	38.3	349	99.7
281	55.33	30	18.2	38.6	340	97.3
282	55.39	31	18.4	38.4	348	99.4
283	55.44	31	18.1	38.4	340	97.1
284	55.50	30	17.9	38.7	331	94.5
285	55.53	30	18.3	38.4	333	95.2
286	55.55	30	18.0	38.2	331	94.5
287	55.58	30	17.9	38.6	332	94.8
288	55.60	27	16.6	37.7	270	77.3
289	55.63	30	18.4	38.8	322	91.9
290	55.65	29	17.1	38.2	299	85.4
291	55.68	28	17.4	38.6	301	86.1
292	55.70	30	18.4	38.4	326	93.2
293	55.73	30	17.8	38.2	321	91.6
294	55.75	27	17.1	38.6	287	82.1
295	55.78	29	17.5	38.3	306	87.5
296	55.80	29	18.0	38.3	318	90.7
297	55.83	29	17.5	37.6	313	89.4
298	55.85	28	16.5	38.8	299	85.4
299	55.88	29	17.7	38.6	318	91.0
300	55.90	28	16.7	37.8	295	84.3
301	55.93	29	17.3	39.6	315	90.1
302	55.95	29	17.3	38.3	309	88.2
303	55.98	28	17.4	38.9	315	89.9
304	56.00	29	18.2	38.8	330	94.2
305	56.02	29	17.6	38.6	325	92.7
306	56.04	29	17.5	39.0	322	92.0
307	56.06	29	17.5	38.8	329	94.1
308	56.08	29	17.7	38.7	327	93.4
309	56.10	30	17.8	39.7	331	94.6
310	56.12	29	17.6	38.8	329	93.9
311	56.13	29	17.8	38.4	332	94.7

312	56.15	30	18.2	38.7	332	95.0
313	56.17	29	17.4	39.1	324	92.6
314	56.19	30	17.6	39.0	336	95.9
315	56.21	29	17.6	39.1	331	94.5
316	56.23	30	18.2	39.0	336	95.9
317	56.25	30	18.1	39.0	337	96.2
318	56.27	30	18.3	39.1	339	96.9
319	56.29	30	18.7	39.3	344	98.4
320	56.31	30	18.0	39.0	327	93.5
321	56.33	30	17.9	39.1	336	96.0
322	56.35	31	17.8	39.3	334	95.4
323	56.37	30	18.5	39.1	343	98.0
324	56.38	31	18.7	39.2	352	100.6
325	56.40	29	17.4	39.5	333	95.0
326	56.42	31	19.0	39.2	349	99.6
327	56.44	30	18.2	39.4	341	97.4
328	56.46	31	19.1	39.3	359	102.7
329	56.48	30	18.7	39.6	364	103.9
330	56.50	30	18.7	39.4	366	104.7
	Average	29	17.8	38.8	326	93.3
	Std Dev	1	0.6	0.5	19	5.3
	Maximum	31	19.1	39.7	366	104.7
	Minimum	27	16.5	37.6	270	77.3

N-value: 46

Sample Interval Time: 83.55 seconds.

Summary of SPT Test Results

Project: cme55 6.20.2018, Test Date: 6/20/2018

FMX: Maximum Force
VMX: Maximum Velocity
BPM: Blows/Minute
EFV: Maximum Energy
ETR: Energy Transfer Ratio - Rated

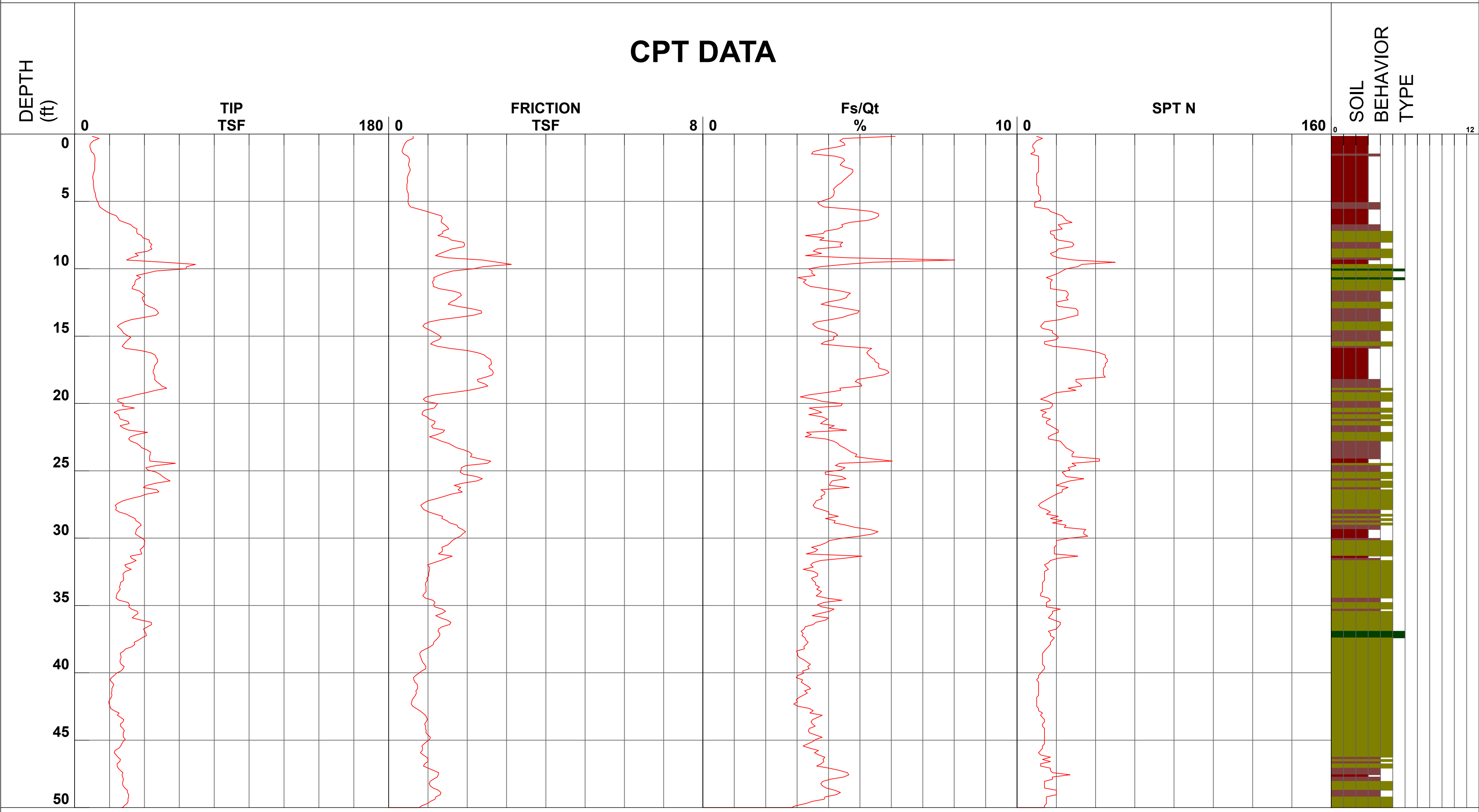
Instr. Length ft	Start Depth ft	Final Depth ft	**N Value**	**N60 Value**	Average FMX kips	Average VMX ft/s	Average BPM bpm	Average EFV ft-lb	Average ETR (%)
4.00	1.00	2.50	**7**	**10**	29	17.3	39.0	305	87.2
8.00	5.00	6.50	**24**	**36**	26	21.6	38.8	309	88.2
18.50	15.50	17.00	**22**	**33**	31	17.6	38.6	325	93.0
20.00	17.00	18.50	**31**	**47**	28	17.9	38.0	311	88.8
30.00	25.00	26.50	**27**	**41**	30	17.4	38.7	320	91.4
35.00	30.00	31.50	**15**	**22**	30	17.8	38.8	319	91.1
40.00	35.00	36.50	**11**	**16**	27	18.1	39.3	309	88.2
45.00	40.00	41.50	**12**	**18**	29	17.7	38.9	321	91.7
50.00	45.00	46.50	**26**	**39**	28	18.9	38.5	326	93.2
55.00	50.00	51.50	**35**	**53**	28	17.8	38.9	325	92.9
60.00	55.00	56.50	**46**	**70**	29	17.8	38.8	326	93.3
				Overall Average Values:	29	18.2	38.7	320	91.4
				Standard Deviation:	2	1.4	2.4	19	5.5
				Overall Maximum Value:	32	23.6	41.2	366	104.7
				Overall Minimum Value:	24	15.9	36.4	265	75.7

Blackburn Consulting

Project	Lookout Slough	Operator	RB-JM	Filename	SDF(019).cpt
Job Number	3195.X	Cone Number	DDG1418	GPS	
Hole Number	CPT-01	Date and Time	4/24/2018 11:20:21 AM	Maximum Depth	50.52 ft
EST GW Depth During Test		3.00 ft			

Net Area Ratio .8

CPT DATA



1 - sensitive fine grained	4 - silty clay to clay	7 - silty sand to sandy silt	10 - gravelly sand to sand
2 - organic material	5 - clayey silt to silty clay	8 - sand to silty sand	11 - very stiff fine grained (*)
3 - clay	6 - sandy silt to clayey silt	9 - sand	12 - sand to clayey sand (*)

Cone Size 10cm squared

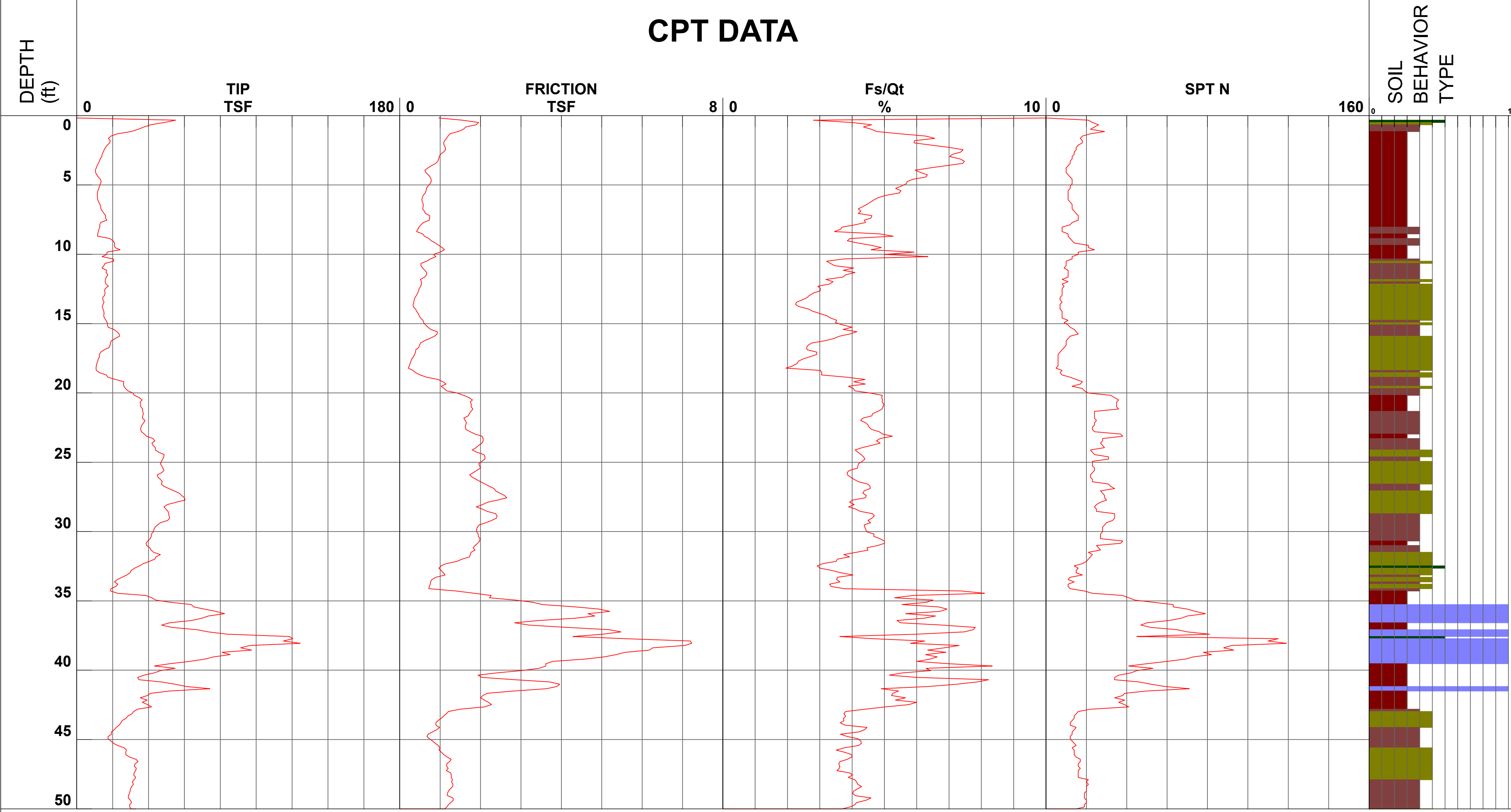
S*Soil behavior type and SPT based on data from UBC-1983

Blackburn Consulting

Project	Lookout Slough	Operator	RB-JM	Filename	SDF(018).cpt
Job Number	3195.X	Cone Number	DDG1418	GPS	
Hole Number	CPT-02	Date and Time	4/24/2018 10:29:54 AM	Maximum Depth	50.52 ft
EST GW Depth During Test		5.00 ft			

Net Area Ratio .8

CPT DATA



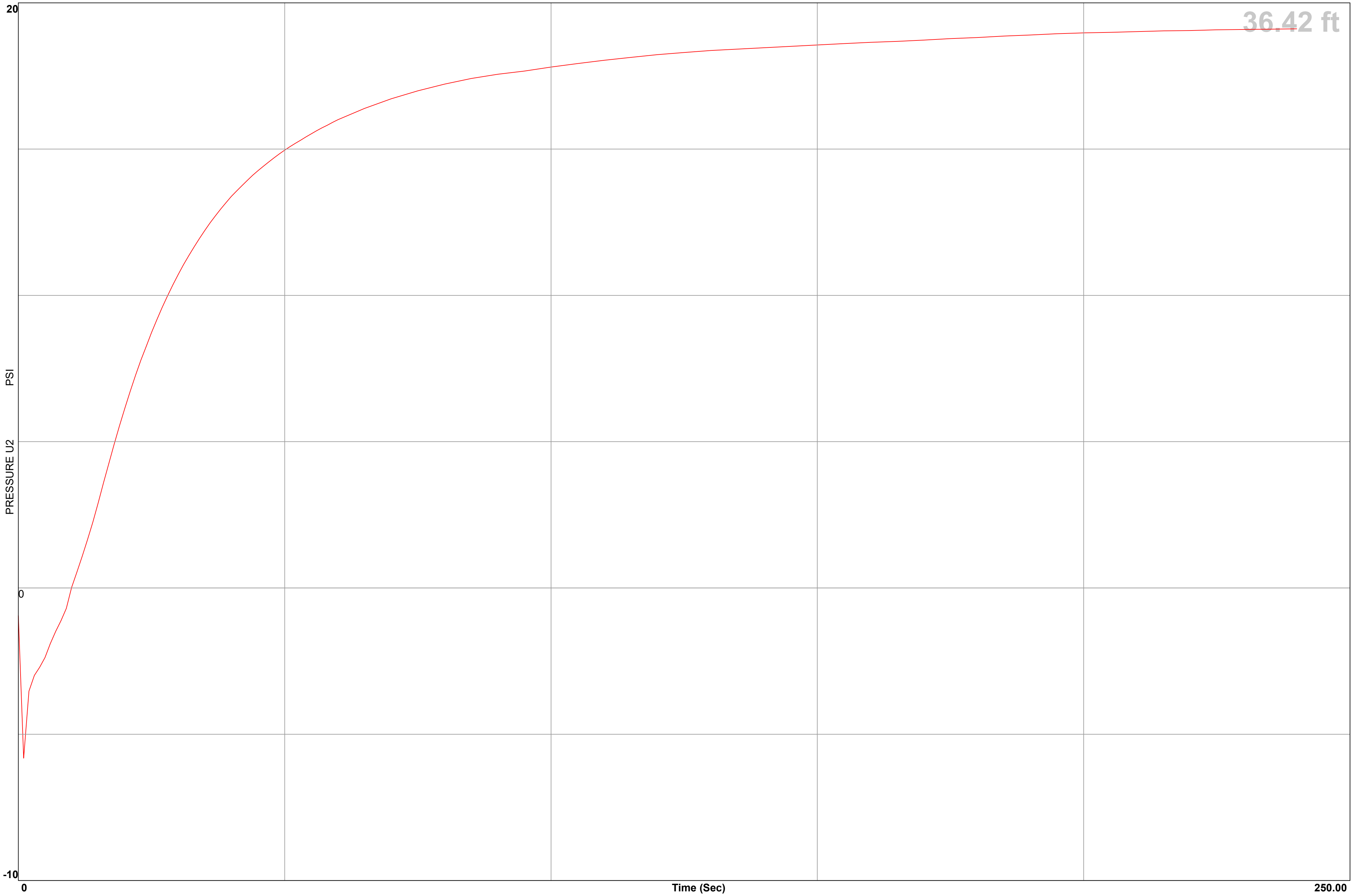
- 1 - sensitive fine grained
- 2 - organic material
- 3 - clay
- 4 - silty clay to clay
- 5 - clayey silt to silty clay
- 6 - sandy silt to clayey silt
- 7 - silty sand to sandy silt
- 8 - sand to silty sand
- 9 - sand
- 10 - gravelly sand to sand
- 11 - very stiff fine grained (*)
- 12 - sand to clayey sand (*)

Cone Size 10cm squared

S*Soil behavior type and SPT based on data from UBC-1983

Blackburn Consulting

Location	Lookout Slough	Operator	RB-JM		
Job Number	3195.X	Cone Number	DDG1418	GPS	
Hole Number	CPT-02	Date and Time	4/24/2018 10:29:54 AM		
Equilized Pressure	19.0	EST GW Depth During Test	+7.6 Incomplete Test		

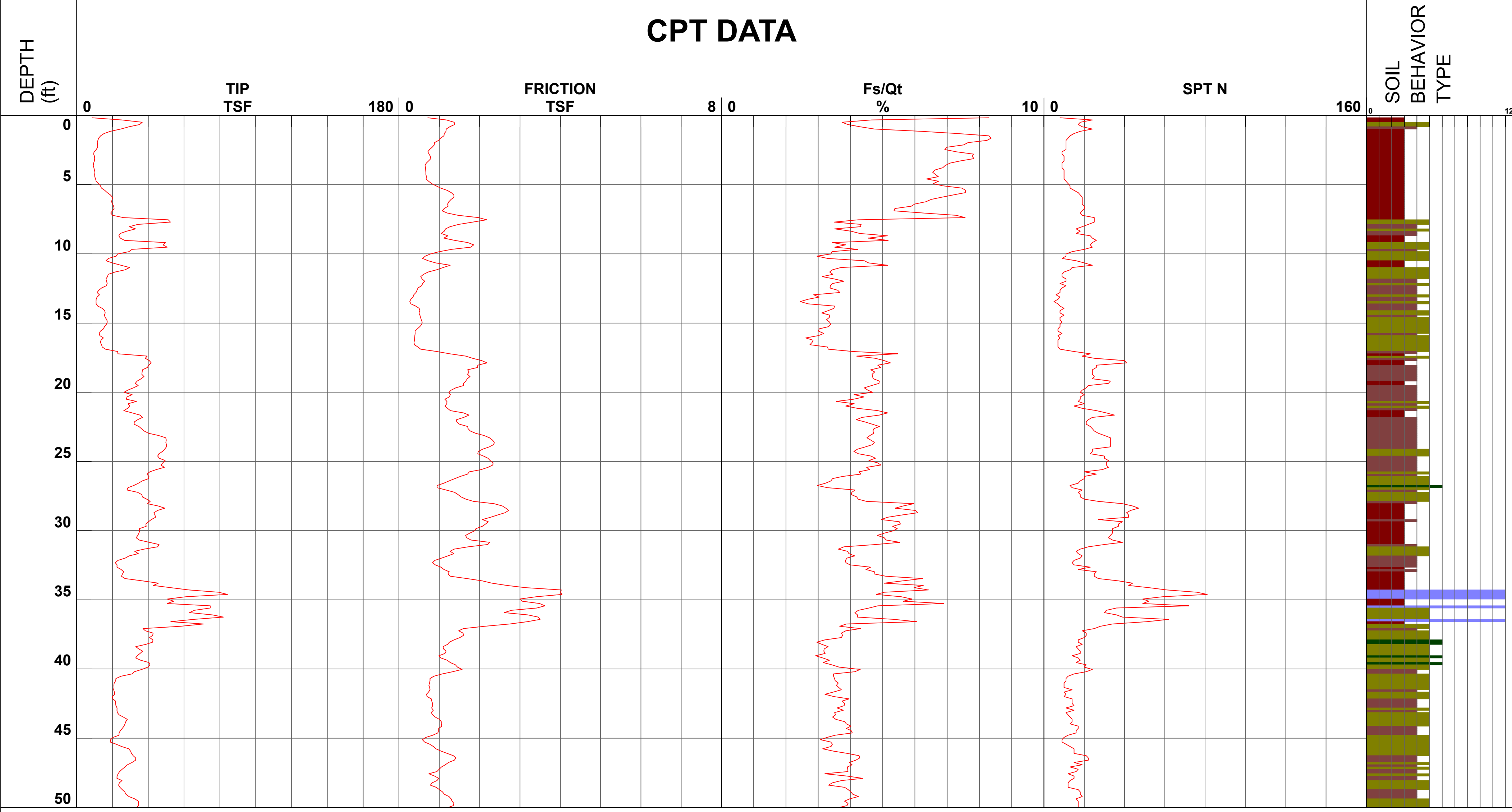


Blackburn Consulting

Project	Lookout Slough	Operator	RB-JM	Filename	SDF(017).cpt
Job Number	3195.X	Cone Number	DDG1418	GPS	
Hole Number	CPT-03	Date and Time	4/24/2018 9:46:03 AM	Maximum Depth	50.52 ft
EST GW Depth During Test		5.00 ft			

Net Area Ratio .8

CPT DATA



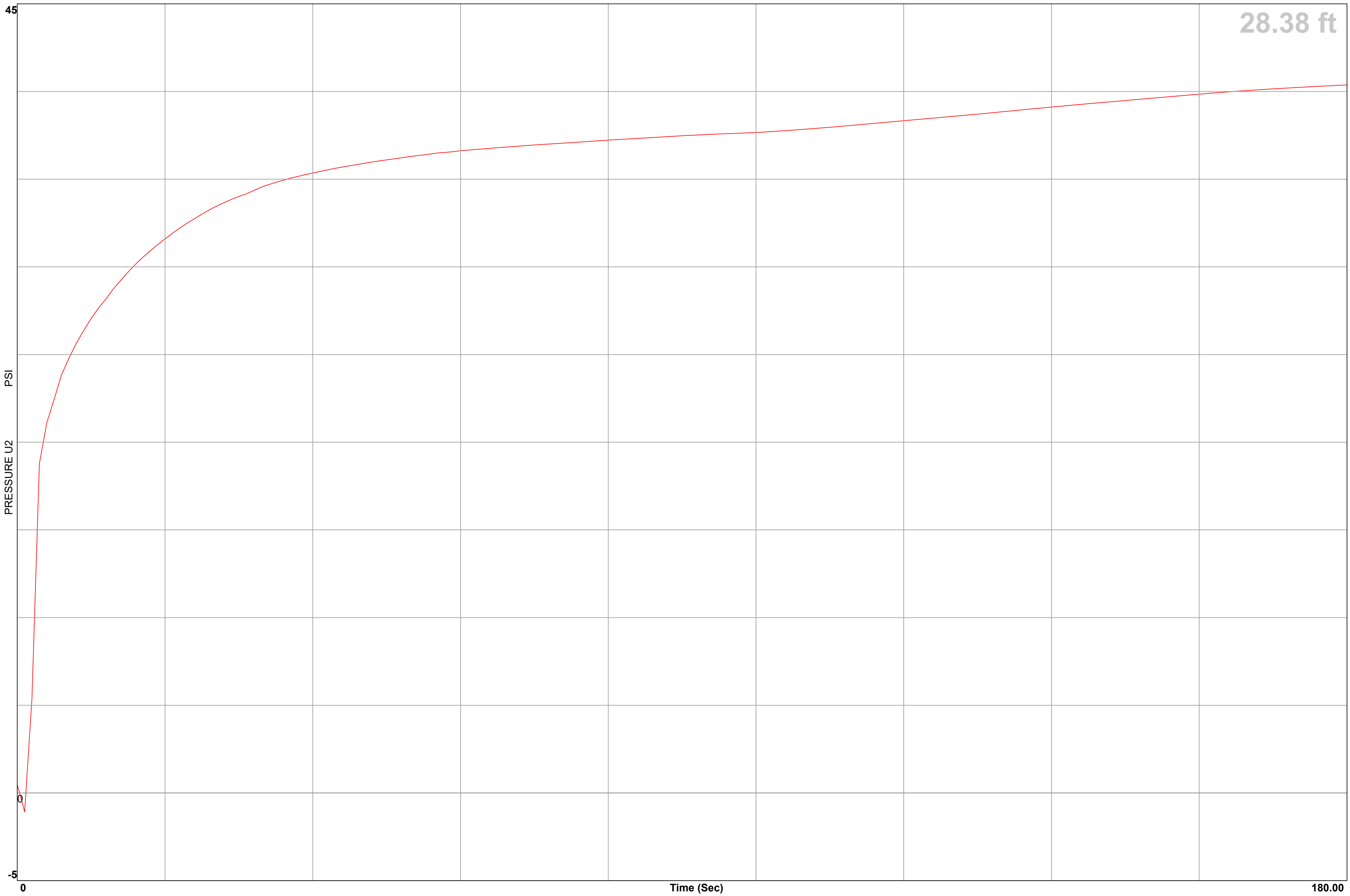
1 - sensitive fine grained
2 - organic material
3 - clay
4 - silty clay to clay
5 - clayey silt to silty clay
6 - sandy silt to clayey silt
7 - silty sand to sandy silt
8 - sand to silty sand
9 - sand
10 - gravelly sand to sand
11 - very stiff fine grained (*)
12 - sand to clayey sand (*)

Cone Size 10cm squared

S*Soil behavior type and SPT based on data from UBC-1983

Blackburn Consulting

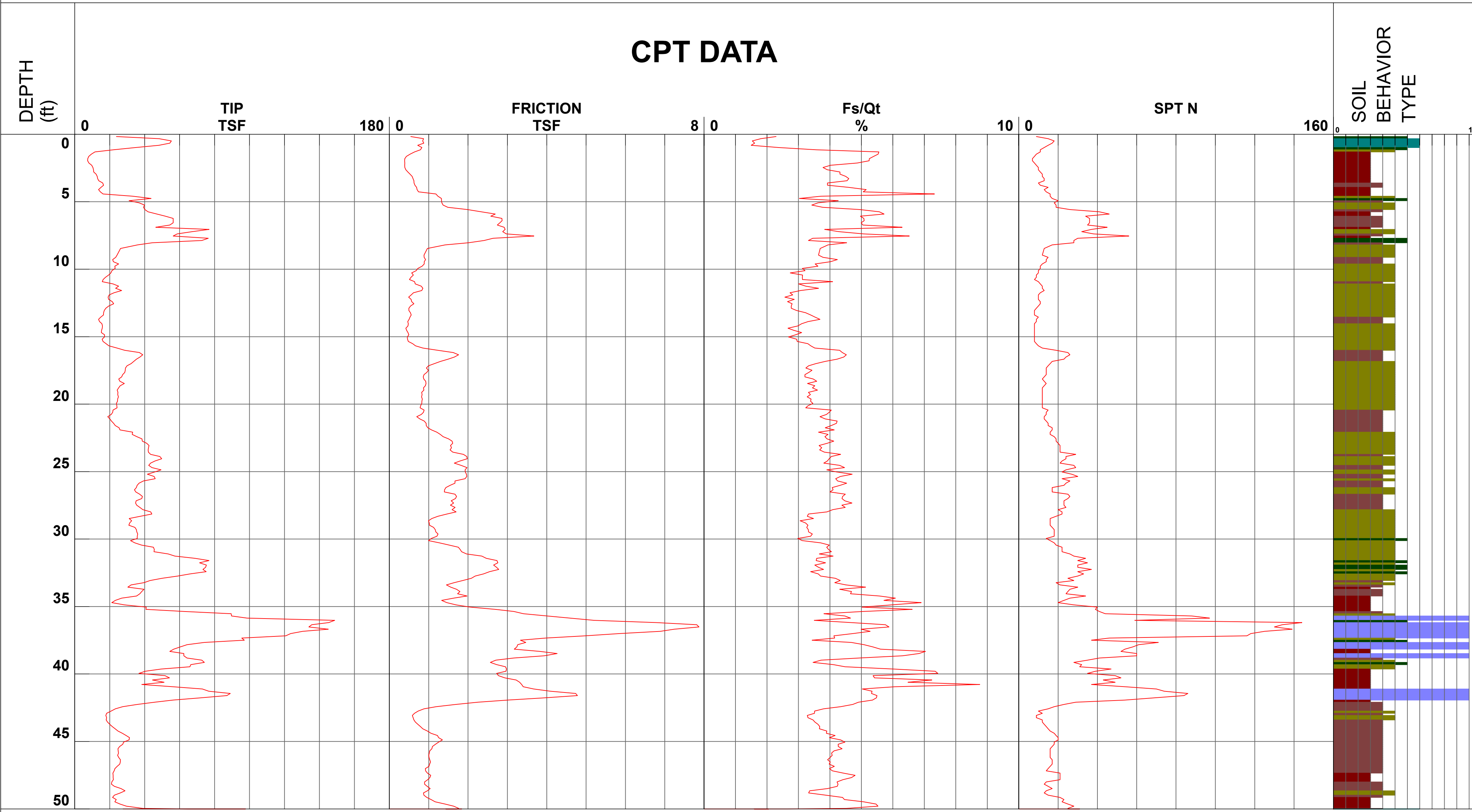
Location	Lookout Slough	Operator	RB-JM		
Job Number	3195.X	Cone Number	DDG1418	GPS	
Hole Number	CPT-03	Date and Time	4/24/2018 9:46:03 AM		
Equilized Pressure	40.4	EST GW Depth During Test	+64.94 Incomplete Test		



Blackburn Consulting

Project	Lookout Slough	Operator	RB-JM	Filename	SDF(016).cpt
Job Number	3195.X	Cone Number	DDG1418	GPS	
Hole Number	CPT-04	Date and Time	4/24/2018 8:59:48 AM	Maximum Depth	51.11 ft
EST GW Depth During Test		3.00 ft			

Net Area Ratio .8



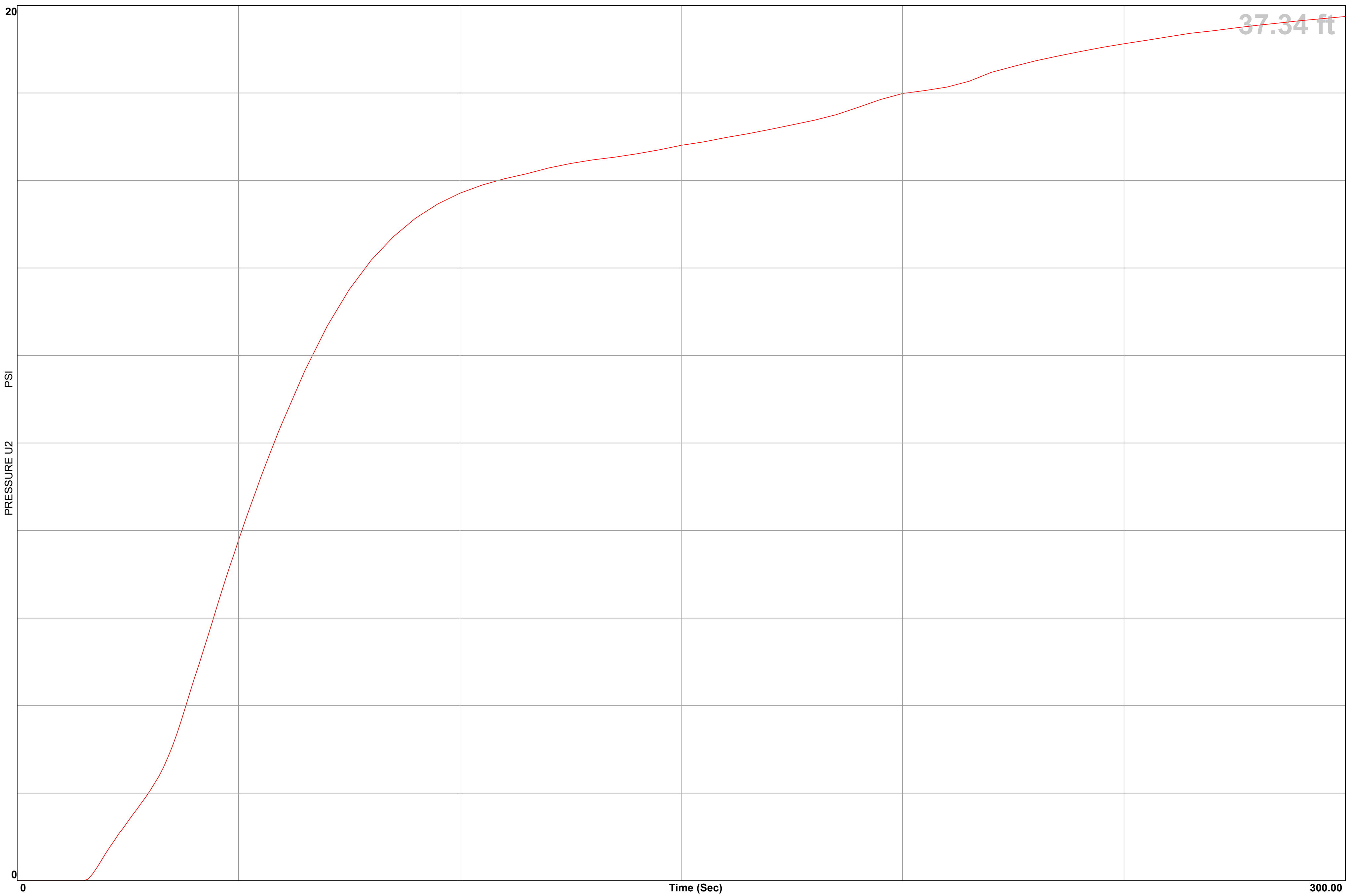
1 - sensitive fine grained	4 - silty clay to clay	7 - silty sand to sandy silt	10 - gravelly sand to sand
2 - organic material	5 - clayey silt to silty clay	8 - sand to silty sand	11 - very stiff fine grained (*)
3 - clay	6 - sandy silt to clayey silt	9 - sand	12 - sand to clayey sand (*)

Cone Size 10cm squared

S*Soil behavior type and SPT based on data from UBC-1983

Blackburn Consulting

Location	Lookout Slough	Operator	RB-JM		
Job Number	3195.X	Cone Number	DDG1418	GPS	
Hole Number	CPT-04	Date and Time	4/24/2018 8:59:48 AM		
Equilized Pressure	19.7	EST GW Depth During Test	+8.2 Incomplete Test		

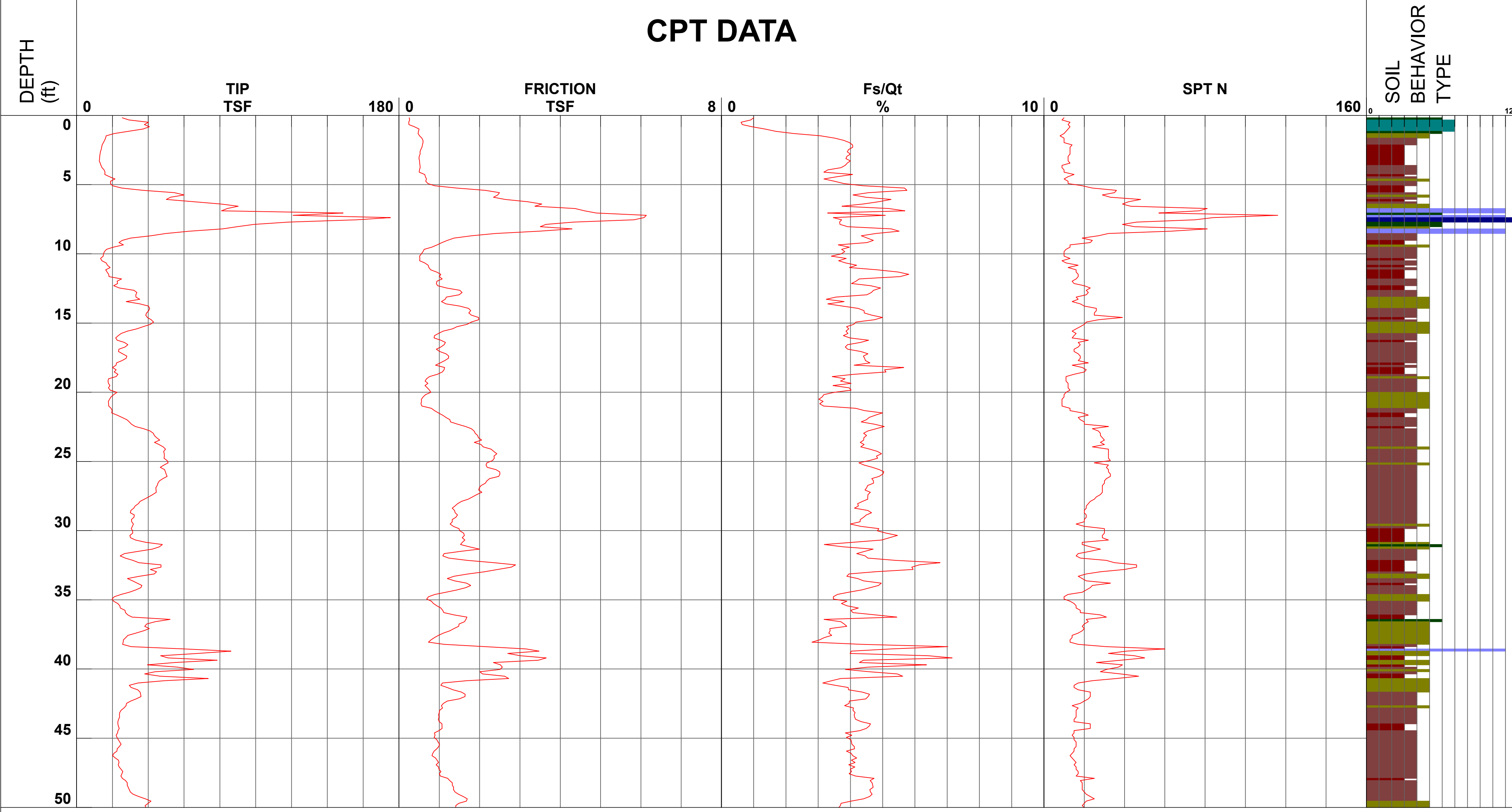


Blackburn Consulting

Project	Lookout Slough	Operator	RB-JM	Filename	SDF(015).cpt
Job Number	3195.X	Cone Number	DDG1418	GPS	
Hole Number	CPT-05	Date and Time	4/24/2018 8:06:44 AM	Maximum Depth	50.03 ft
EST GW Depth During Test		5.00 ft			

Net Area Ratio .8

CPT DATA



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 (*)
12 - sand to clayey sand (*)

Cone Size 10cm squared

S*Soil behavior type and SPT based on data from UBC-1983

This page intentionally left blank.

GEOTECHNICAL DATA REPORT

65% Design

Lookout Slough Tidal Habitat Restoration and Flood Improvement Project

Solano County, California

APPENDIX C

BCI Laboratory Testing Summary Table
BCI Laboratory Test Results

This Page Intentionally Left Blank

Lookout Slough Tidal Habitat Restoration and Flood Improvement Project Exploration Laboratory Testing Summary Table

Exploration/ Sample I.D.	Depth (feet)	Sample Type	USCS Classification (ASTM D2487)	Field Pocket Penetrometer (tsf)	N Value (field) / Pressure Shelby Tube Sampling	Water Content (%) (ASTM D2216)	Wet Density, g_{wet} (pcf) (ASTM D7263)	Dry Density, g_{dry} (pcf) (ASTM D7263)	Percent Passing #200 (ASTM D1140)	Liquid Limit (ASTM D4318)	Plasticity Index (ASTM D4318)	Triaxial Data - CU (ASTM D4767)				Triaxial Data - UU (ASTM D2850)	Direct Shear (ASTM D3080)		Hydraulic Conductivity (ASTM D5084) k_v (cm/sec)	Sieve Analysis Performed (ASTM D6913)	Consolidation Test Performed (ASTM D2435)	Organic Matter (%) (ASTM D2974)
												Effective Friction Angle, ϕ' (deg)	Effective Cohesion, C^{total} (psf)	Total Friction Angle, ϕ^{total} (deg)	Total Cohesion, C' (psf)	Total Cohesion, C^{total} (psf)	Effective Friction Angle, ϕ' (deg)	Effective Cohesion, C' (psf)				
BCI-17-1-1	1.0-2.5	SPT	CH		7					61	45											
BCI-17-1-2	2.5-3.5	Shelby	CH		900 psi					56	38											
BCI-17-1-2	4.0-5.0	Shelby	CH	0.40	900 psi					68	46						41	382				4.0
BCI-17-1-2	4.5-4.9	Shelby	CH	0.40	900 psi					68	46						41	382				4.0
BCI-17-1-3	5.0-6.5	SPT	CL	1.00	7					38	21											9.7
BCI-17-1-4	8.0-8.5	Shelby	SC		800 psi				19											X		
BCI-17-1-6	12.0-12.5	Shelby	CL						95	41	20								9.94×10^{-6}			
BCI-17-1-8	16.0-16.5	Shelby	CL	4.50	750 psi	25	121	96													X	
BCI-17-1-13	40.0-41.5	SPT	CL	1.00	12	37			62	38	21											
BCI-17-1-14	46.0-46.5	SPT	CL	1.00	12	30			59	35	15											
BCI-17-1-15	50.0-51.5	SPT	CL/CH	1.10	8	34			55													
BCI-17-1-16	55.0-56.5	SPT	CH	2.75	20	25			81	57	31											
BCI-17-2-1	1.0-2.5	SPT	CH	2.00						63	40											
BCI-17-2-2	2.5-3.0	Shelby	CH	2.50	600 psi					60	40											
BCI-17-2-2	4.0-5.0	Shelby	CH	2.50	600 psi	26	122	97	87	54	42						34	95				6.8
BCI-17-2-4	8.0-8.5	Shelby	CL	1.75	550 psi	25	122	97	78	46	31											5.9
BCI-17-2-5	10.0-10.25	SPT	CL	1.75	9	26	125	99														
BCI-17-2-6	11.5-12.5	Shelby	CL	2.00	750 psi	22	127	104								3924						
BCI-17-2-9	17.0-18.5	SPT	CH	4.00	20	25			99	58	37											
BCI-17-2-10	20.0-20.5	Shelby	CL	4.25	1050 psi				50	38	22					2570						
BCI-17-2-14	40.75-41.5	SPT	CL	3.50	9	31	121	93		49	27											
BCI-17-2-19	65.5-66.5	SPT	SP-SM		17	25			8	NP												
BCI-17-3-2	3.8-4.2	Shelby	CH	2.75	700 psi	24	124	100	94	59	42										X	6.3
BCI-17-3-4	9.0-9.5	Shelby	CL						79	32	14								1.45×10^{-5}			
BCI-17-3-6	12.3-12.8	Shelby	CL	4.00	1250 psi											4664						
BCI-17-3-8	20.0-20.25	SPT	CL	1.75	17	24	125	101														
BCI-17-3-9	26.0-26.5	SPT	CH	>4.5	23				85	51	32											
BCI-17-3-10	31.0-31.25	SPT	SM	2.25	15	22	126	104														
BCI-17-3-12	41.25-41.5	SPT	CL	2.25	14	32	118	90														
BCI-17-3-15	56.0-56.25	SPT	CH	4.00	19	26	131	104														
BCI-17-4-2	2.0-2.5	Shelby	CH	2.75	600 psi					66	43											
BCI-17-4-2	4.2-5.1	Shelby	CH	2.75	600 psi	25	123	98	95	64	47											5.5
BCI-17-4-3	6.5-6.75	SPT	CH						95													
BCI-17-4-4	8.0-8.5	Shelby	CH	4.50	850 psi				89													
BCI-17-4-4	8.7-9.1	Shelby	CL		850 psi				78													
BCI-17-4-4	8.7-9.3	Shelby	CL														34	420				
BCI-17-4-5	11.0-11.5	SPT	CL	4.00	10	26	125	99	84													
BCI-17-4-6	12.25-12.5	Shelby	CL	4.00	900 psi				87													
BCI-17-4-6	12.75-13.0	Shelby	CL		900 psi				98													
BCI-17-4-6	13.0-13.5	Shelby	CL	4.00	900 psi					46	25					2411						
BCI-17-4-7	15.75	SPT	CL	1.25	9	26	121	96	60													
BCI-17-4-10	26.25-26.5	SPT	CL	2.25	14	23	130	106														
BCI-17-4-12	35.75-36.0	SPT	CL	4.00	14	25	128	102														
BCI-17-4-14	46.0-46.25	SPT	CH	4.50	16	27	122	96														
BCI-17-5-2	3.75-4.25	Shelby	CH	3.50	600 psi	19	126	106														
BCI-17-5-3	5.0-6.5	SPT	CL	2.80	14	20			78	44	30											
BCI-17-5-6	10.7-11.3	Shelby	CL	3.50	800 psi	22	133	109	72	43	22											5.6

Lookout Slough Tidal Habitat Restoration and Flood Improvement Project Exploration Laboratory Testing Summary Table

Exploration/ Sample I.D.	Depth (feet)	Sample Type	USCS Classification (ASTM D2487)	Field Pocket Penetrometer (tsf)	N Value (field) / Pressure Shelby Tube Sampling	Water Content (%) (ASTM D2216)	Wet Density, g_{wet} (pcf) (ASTM D7263)	Dry Density, g_{dry} (pcf) (ASTM D7263)	Percent Passing #200 (ASTM D1140)	Liquid Limit (ASTM D4318)	Plasticity Index (ASTM D4318)	Triaxial Data - CU (ASTM D4767): Effective Friction Angle, ϕ' (deg)	Triaxial Data - CU (ASTM D4767): Effective Cohesion, C^{total} (psf)	Triaxial Data - CU (ASTM D4767): Total Friction Angle, ϕ^{total} (deg)	Triaxial Data - CU (ASTM D4767): Total Cohesion, C' (psf)	Triaxial Data - UU (ASTM D2850): Total Cohesion, C^{total} (psf)	Direct Shear (ASTM D3080): Effective Friction Angle, ϕ' (deg)	Direct Shear (ASTM D3080): Effective Cohesion, C' (psf)	Hydraulic Conductivity (ASTM D5084) k_v (cm/sec)	Sieve Analysis Performed (ASTM D6913)	Consolidation Test Performed (ASTM D2435)	Organic Matter (%) (ASTM D2974)
BCI-17-5-9	26.0-26.5	SPT	CL	>4.5	19	21/22	132	108														
BCI-17-5-11	35.0-36.5	SPT	SM		16	34			33	NP												
BCI-17-5-13	45.0-46.5	SPT	SP-SC		24				8											X		
BCI-17-5-16	60.0-61.5	SPT	CH	4.50	23	32			95	59	37											
BCI-17-6-2	4.3-4.8	Shelby	CH	2.75	700 psi					68	50					2684						
BCI-17-6-2	4.8-5.2	Shelby	CH	2.75	700 psi	25	124	99														
BCI-17-6-3	6.5-6.75	SPT	CL	>4.5	12	17	124	107														
BCI-17-6-4	8.5-9.0	Shelby	SP-SM		800 psi	11	125	114	8	NP												
BCI-17-6-5	9.5-11.0	SPT	SP-SM		14	17	127	109	6	NP												
BCI-17-6-7	16.25-16.5	SPT	GW-GC		9	21	146	121														
BCI-17-6-9	26.0-26.25	SPT	ML	3.50	12	26	125	99														
BCI-17-6-10	31.0-31.25	SPT	SP-SC		30	14	138	121	10													
BCI-17-6-10	31.25-31.5	SPT	SC		30				14													
BCI-17-6-13	45.0-46.5	SPT	CH	2.40	12				98	61	36											
BCI-17-6-15	56.0-56.25	SPT	CL	3.50	158	23	127	103														
BCI-17-6-17	65.0-66.5	SPT	CL	>4.5	28				98													
BCI-17-7-2	3.7-4.3	Shelby	CL	2.25	750 psi	18	130	110	80	48	32						17	690				5.1
BCI-17-7-4	7.5-8.0	Shelby	ML	3.80	1300 psi				93	44	16											7.3
BCI-17-7-5	11.25-11.5	SPT	CL	3.50	9	24	126	101														
BCI-17-7-7	15.0-16.5	SPT	CL	2.00	10	23			50	35	19											
BCI-17-7-9	26.0-26.25	SPT	CL	>4.5	17	22	130	106														
BCI-17-7-18	71.0-71.25	SPT	SM		30	23	133	108														
BCI-17-8-2	3.7-4.2	Shelby	CH	2.75	300 psi	30	112	86,4	95	68	48						25	648	2.80×10^{-7}		X	9.2
BCI-17-8-4	7.7-8.2	Shelby	CH	4.00	500 psi	23	110	90	84	54	36											5.0
BCI-17-8-6	11.3-11.7	Shelby	CL	>4.5	500 psi	17	125	107	56	35	22								4.19×10^{-7}			5.1
BCI-17-8-8	16.0-16.5	Shelby	CL	3.75	500 psi				58	29	18											
BCI-17-8-10	26.25-26.5	SPT	CL	3.50	11	26	127	100														
BCI-17-8-11	30.0-31.5	SPT	CL	<1	4	35			89	42	22											
BCI-17-8-12	35.0-36.5	SPT	ML	1.50	9	33			62	31	8											
BCI-17-8-13	41.25-41.5	SPT	SP-SM		26	13	140	124														
BCI-17-8-14	45.0-46.5	SPT	SP-SM		34				7											X		
BCI-17-8-15	50.0-51.5	SPT	GC		9				41											X		
BCI-17-8-16	55.0-56.5	SPT	CL	4.40	9	25			90	47	26											
BCI-17-9-2	3.0-3.5	MCAL	CH	1.50	20					73	48											
BCI-17-9-2	3.5-4.0	MCAL	CH	1.50	20	31	124	95														
BCI-17-9-3	4.0-5.0	Shelby	CL	1.50	300 psi					46	31											
BCI-17-9-4	6.5-7.0	MCAL	CH	2.20	28	24			76	53	37											
BCI-17-9-6	9.8-10.3	Shelby	CL	1.00	500 psi											1817						
BCI-17-9-8	13.0-13.5	MCAL	CL	2.10	17	34			66													
BCI-17-9-8	13.5-14.0	MCAL	CL	2.10	17	32			66	38	19											
BCI-17-9-12	31.0-31.5	MCAL	CL	0.75	24	32	117	89	93	49	28										X	
BCI-17-9-15	40.5-41.0	MCAL	SM		34	30	125	96	32													
BCI-17-9-16	45.5-46.0	MCAL	SW-SM		30	21			5													
BCI-17-10-1	1.5-2.0	MCAL	CH	2.25	16					63	41											
BCI-17-10-2	2.0-4.5	Shelby	CH	1.50		46	105	72	66	68	41											12.6
BCI-17-10-3	5.0-5.5	MCAL	CL	2.50	19	28	127	99														
BCI-17-10-4	6.5-7.0	MCAL	SC						28	34	16								9.92×10^{-6}			

Lookout Slough Tidal Habitat Restoration and Flood Improvement Project Exploration Laboratory Testing Summary Table

Exploration/ Sample I.D.	Depth (feet)	Sample Type	USCS Classification (ASTM D2487)	Field Pocket Penetrometer (tsf)	N Value (field) / Pressure Shelby Tube Sampling	Water Content (%) (ASTM D2216)	Wet Density, g_{wet} (pcf) (ASTM D7263)	Dry Density, g_{dry} (pcf) (ASTM D7263)	Percent Passing #200 (ASTM D1140)	Liquid Limit (ASTM D4318)	Plasticity Index (ASTM D4318)	Triaxial Data - CU (ASTM D4767)				Triaxial Data - UU (ASTM D2850)	Direct Shear (ASTM D3080)		Hydraulic Conductivity (ASTM D5084) k_v (cm/sec)	Sieve Analysis Performed (ASTM D6913)	Consolidation Test Performed (ASTM D2435)	Organic Matter (%) (ASTM D2974)
												Effective Friction Angle, ϕ' (deg)	Effective Cohesion, C^{total} (psf)	Total Friction Angle, ϕ^{total} (deg)	Total Cohesion, C' (psf)	Total Cohesion, C^{total} (psf)	Effective Friction Angle, ϕ' (deg)	Effective Cohesion, C' (psf)				
BCI-17-10-5	9.0-9.5	MCAL	SC		27	30			43	31	11											
BCI-17-10-10	20.0-21.5	SPT	SP-SC		53				10													
BCI-17-10-11	25.5-26.0	MCAL	SP		69				3											X		
BCI-17-10-11	26.0-26.5	MCAL	GP-GC		69				7													
BCI-17-10-13	35.5-36.0	MCAL	GP-GC		37				7											X		
BCI-17-11-1	2.5-3.0	Shelby	CH						90	52	37								2.72×10^{-8}			
BCI-17-11-4	3.5-4.0	SPT	CH	1.50	14					58	41											
BCI-17-11-4	6.5-7.0	SPT	SC		62	18	119	101														
BCI-17-11-4&5	7.0-8.5	SPT	SC		62				21	36	15									X		
BCI-17-11-6	9.5-10.5	SPT	ML		35	30	124	95	50	35	10											
BCI-17-11-8	12.5-13.0	SPT	SM		36	27	125	99	29													
BCI-17-11-10	20.5-21.5	SPT	SM		13	29	125	97	46	NP												
BCI-17-11-13	35.0-36.5	SPT	SW-SM		26				8													
BCI-17-12-2	3.0-4.5	SPT	CL		10				80	34	19											
BCI-17-12-3	4.9-5.3	Shelby	CL	1.50		25	127	101														
BCI-17-12-4	6.0-7.5	SPT	CL		10				80	47	28											
BCI-17-12-5	9.0-10.0	Shelby	SP		800 psi				4											X		
BCI-17-12-6	10.0-11.5	SPT	SP		14				4											X		
BCI-17-12-7	15.0-16.5	SPT	SM		24	24	125	101	23													
BCI-17-12-9	25.5-26.0	SPT	SW-SC		46	13	133	118	8													
BCI-17-12-11	35.0-36.5	SPT	CL		17				67	46	25											
BCI-17-13-1	1.0-2.5	Shelby	CH	1.0-2.0	650 psi					67	44											
BCI-17-13-2	2.5-4.0	SPT	CH		5					64	45											
BCI-17-13-5	7.5-9.0	Shelby	CL	3.00	850 psi	21			69	45	28											
BCI-17-13-9	15.0-16.5	SPT	CH	2.50	11	31	123	94	92	54	31											
BCI-17-13-14	40.0-41.5	SPT	CL		6				75	38	14											
BCI-17-13-15	45.0-46.5	SPT	SP-SC						7													
BCI-17-14-1	1.0-2.0	Shelby	CH	1.50	600 psi					66	46											
BCI-17-14-2	3.0-4.5	SPT	CH		7					74	56											
BCI-17-14-3	4.5-6.0	Shelby	CL	4.00	700 psi							31	391	21*	288*							
BCI-17-14-4	6.5-8.0	SPT	CL		13	23			59	38	22											
BCI-17-14-9	20.5-21.0	SPT	CL	4.50	16	22			94	49	30											
BCI-17-15-1	1.5-2.0	SPT	CH						97	63	46								4.34×10^{-7}			
BCI-17-15-4	8.0-9.5	SPT	CL	2.00	14	27			67	41	24											
BCI-17-15-8	20.5-21.0	SPT	CL	1.75	12	29	123	96	76	42	25											
BCI-17-16-1	1.0-2.0	Shelby	CH	2.00	500 psi					55	41											
BCI-17-16-1	2.0-3.0	SPT	CH	2.00	500 psi					53	39											
BCI-17-16-2	3.0-4.5	SPT	CH		8				79	61	45											
BCI-17-16-6	10.5-12.0	SPT	CL		8				89	44	22											
BCI-17-17-1	2.0-3.5	Shelby	CH	1.25	300									25.8*	335*				1.59×10^{-6}			
BCI-17-17-2	4.0-5.0	SPT	CH		10					70	52											
BCI-17-17-6	10.2-11.7	SPT	CL	3.00	10				77	40	18											
BCI-17-17-10	25.0-26.5	SPT	CL	2.00	25	23			52	34	17											
BCI-17-18-2	3.0-4.5	SPT	CH	1.75	6	27			83	63	45											
BCI-17-18-3	5.5-6.5	Shelby	CL		600 psi				59	46	29								2.86×10^{-7}			
BCI-17-18-5	8.5-9.0	MCAL	ML	3.50	26	36	122	90	67	35	10											

Lookout Slough Tidal Habitat Restoration and Flood Improvement Project Exploration Laboratory Testing Summary Table

Exploration/ Sample I.D.	Depth (feet)	Sample Type	USCS Classification (ASTM D2487)	Field Pocket Penetrometer (tsf)	N Value (field) / Pressure Shelby Tube Sampling	Water Content (%) (ASTM D2216)	Wet Density, g_{wet} (pcf) (ASTM D7263)	Dry Density, g_{dry} (pcf) (ASTM D7263)	Percent Passing #200 (ASTM D1140)	Liquid Limit (ASTM D4318)	Plasticity Index (ASTM D4318)	Triaxial Data - CU (ASTM D4767) Effective Friction Angle, ϕ' (deg)	Triaxial Data - CU (ASTM D4767) Effective Cohesion, C^{total} (psf)	Triaxial Data - CU (ASTM D4767) Total Friction Angle, ϕ^{total} (deg)	Triaxial Data - CU (ASTM D4767) Total Cohesion, C' (psf)	Triaxial Data - UU (ASTM D2850) Total Cohesion, C^{total} (psf)	Direct Shear (ASTM D3080) Effective Friction Angle, ϕ' (deg)	Direct Shear (ASTM D3080) Effective Cohesion, C' (psf)	Hydraulic Conductivity (ASTM D5084) k_v (cm/sec)	Sieve Analysis Performed (ASTM D6913)	Consolidation Test Performed (ASTM D2435)	Organic Matter (%) (ASTM D2974)
BCI-17-18-13	35.0-36.5	SPT	CL		19	30			67	34	12											
BCI-17-19-1	1.0-2.5	Shelby	CL	1.50	700									24.2*	331.9*							
BCI-17-19-2	3.0-4.5	SPT	CL		37					35	12											
BCI-17-19-4	5.5-7.0	SPT	SC		10				35	34	17											
BCI-17-19-10	15.5-16.0	SPT	SC	3.50	20	28	118	93	37	39	18											
BCI-17-19-16	45.5-46.0	SPT	ML		22				58	35	9											
BCI-17-19-17	50.0-51.5	SPT	SC		21				19													
BCI-17-20-2	4.0-5.5	SPT	CL		21				71	44	19											
BCI-17-20-04	9.0-9.5	Shelby	SC		700 psi				45	38	20								2.51×10^{-6}			
BCI-17-20-9	30.5-31.0	SPT	SM		16				35	NP												
BCI-17-20-10	35.0-36.5	SPT	ML		20				56	38	9											
BCI-17-20-11	40.5-41.0	SPT	SP-SM		27				8													
BCI-18-22-1	1.0-2.5	SPT	CH		6					64	45											
BCI-18-22-4	8.0-9.5	MCAL	CL		11				55													
BCI-18-22-5	9.5-11.0	SPT	SC		7				43													
BCI-18-22-13	30.0-31.5	SPT	CL	2.75	13				62													
BCI-18-23-5	9.5-11.0	SPT	CL	1.25	11				79	42	24											
BCI-18-23-7	12.5-14.0	MCAL	CL	1.25	8				95	42	22											
BCI-18-24-1	1.0-2.5	SPT	CH	1.00	5				94	58	40											
BCI-18-24-4	8.0-9.5	SPT	CL	1.00	9				83													
BCI-18-24-5	9.5-11.0	MCAL	CL	2.50	18				94													
BCI-18-24-8	14.0-15.5	SPT	CL	1.25	8				95	47	26											
BCI-18-24-11	30.0-31.5	SPT	SC		7				48													
BCI-18-25-1	1.0-2.5	MCAL	CH		7					52	36											
BCI-18-25-2	2.5-4.0	SPT	CL							32	16											
BCI-18-26-1	1.0-2.5	SPT	CH	2.50	10					57	39											
BCI-18-26-2	5.0-6.5	MCAL	CH	2.75	20				86	50	32											
BCI-18-26-6	11.0-12.5	MCAL	SP-SM		15				9													
BCI-18-26-9	15.5-17.0	SPT	SM		16				24											X		
BCI-18-26-16	50.0-51.5	MCAL	GW						8											X		
BCI-18-27-1	1.0-2.5	SPT	CL		6					40	27											
BCI-18-27-6	11.0-12.5	MCAL	CL		17				74	38	19											
BCI-18-27-9	15.5-17.0	SPT	CL	1.00	13				50	35	18											
BCI-18-27-13	35.0-36.5	SPT	CL	0.00	4				62	35	13											
BCI-18-27-16	50.0-51.5	MCAL	GW		35				3													
BCI-18-29-A	1.2-3.0	Bulk	CH						85	63	46											
BCI-18-29-2	4.5-6.0	MCAL	CH						98	59	43											
BCI-18-30-2	4.5-6.0	MCAL	CH						98	58	40											
BCI-18-31-4	9.0-9.5	MCAL	CH						89	61	41											
BCI-18-32-1	2.0-2.5	MCAL	CL						67	37	18											
BCI-18-32-4	10.0-1.05	MCAL	CH						77	53	34											
BCI-19-33-6B	9.5-10.0	SPT	SP-SM		28				8	NP												
BCI-19-33-7	11.0-11.5	Shelby	SP-SC		500 psi				12	31	15											
BCI-19-33-8B	13.5-14.0	SPT	CH	1.25	15				97	51	29											
BCI-19-33-9	14.5-15	Shelby	CH	1.25	500 psi				55	50	30											
BCI-19-33-10B	17.0-17.5	SPT	CL	>4.5	24				94	44	27											

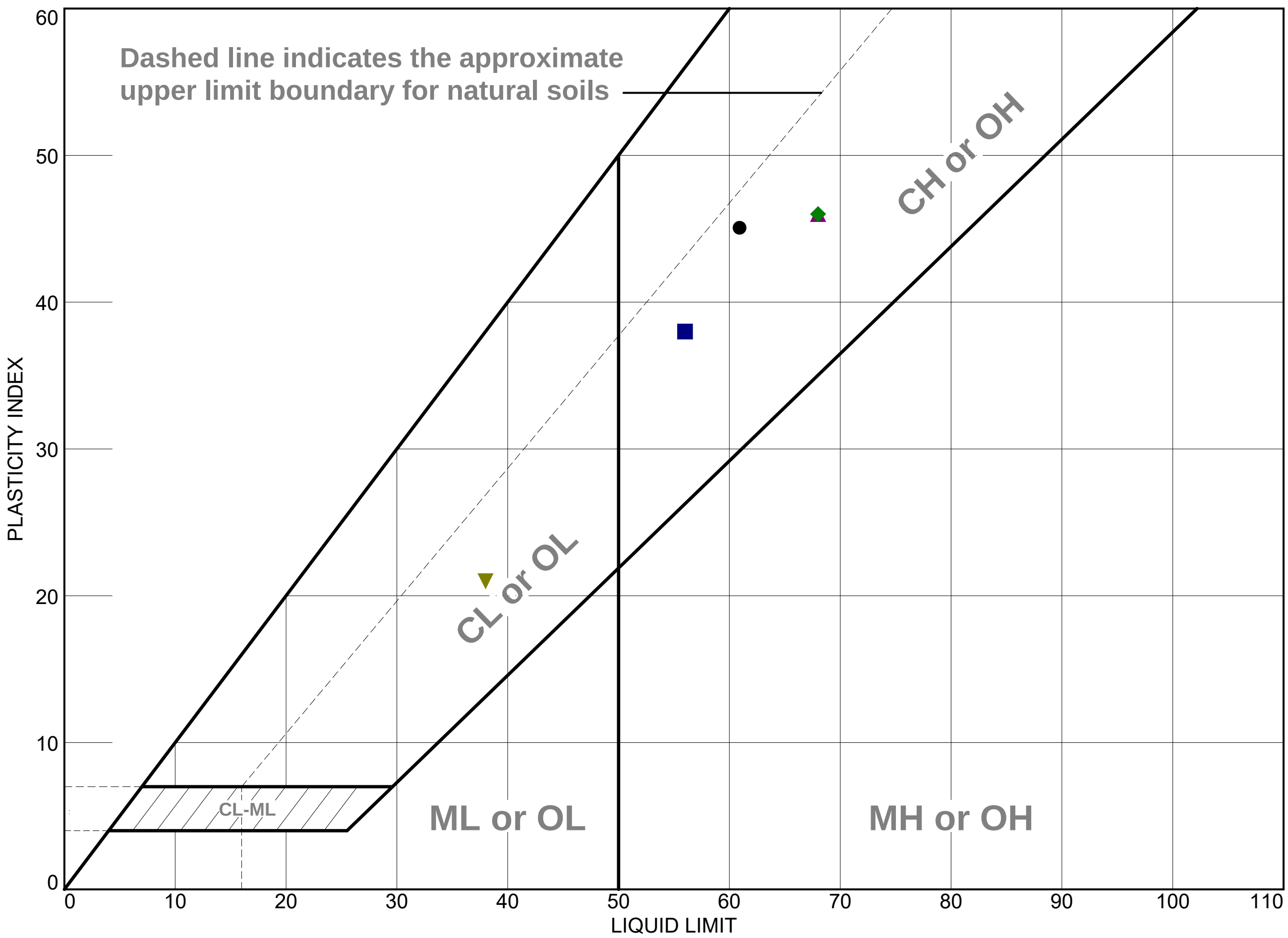
Lookout Slough Tidal Habitat Restoration and Flood Improvement Project Exploration Laboratory Testing Summary Table

Exploration/ Sample I.D.	Depth (feet)	Sample Type	USCS Classification (ASTM D2487)	Field Pocket Penetrometer (tsf)	N Value (field) / Pressure Shelby Tube Sampling	Water Content (%) (ASTM D2216)	Wet Density, g_{wet} (pcf) (ASTM D7263)	Dry Density, g_{dry} (pcf) (ASTM D7263)	Percent Passing #200 (ASTM D1140)	Liquid Limit (ASTM D4318)	Plasticity Index (ASTM D4318)	Triaxial Data - CU (ASTM D4767)				Triaxial Data - UU (ASTM D2850)	Direct Shear (ASTM D3080)		Hydraulic Conductivity (ASTM D5084) k_v (cm/sec)	Sieve Analysis Performed (ASTM D6913)	Consolidation Test Performed (ASTM D2435)	Organic Matter (%) (ASTM D2974)
												Effective Friction Angle, φ' (deg)	Effective Cohesion, C^{total} (psf)	Total Friction Angle, ϕ^{total} (deg)	Total Cohesion, C' (psf)	Total Cohesion, C^{total} (psf)	Effective Friction Angle, φ' (deg)	Effective Cohesion, C' (psf)				
BCI-19-33-16B	30.5-31.0	MCAL	CH	4.50	44				86	53	29											
BCI-19-34-5	10.5-11	Shelby	SC		400 psi				46	34	17											
BCI-19-34-5	11.5-12.0	Shelby	CL	0.75	400 psi				76	36	18											
BCI-19-34-6	12.5-14	SPT	CL		9				96	45	23											
BCI-19-34-7	14.2-14.7	Shelby	CL	1.50	300 psi	26	117	93	84	42	22										x	
BCI-19-35-4C	7.5-8.0	SPT	CL	2.25	12				86	39	19											
BCI-19-34-8C	14.5-15.0	SPT	SM		15				31	NP												
BCI-19-34-20	50.0-51.5	SPT	SC-SM		34				40	25	7											
BCI-19-36-2C	4.0-4.5	SPT	CH	>4.5	11					59	43											
BCI-19-36-5	9.0-9.5	Shelby	CL	1.50	500 psi				84	35	14											
BCI-19-36-5	9.5-10.3	Shelby	CL	1.50	500 psi				77	32	13											
BCI-19-36-6B	10.5-11	SPT	CL	1.50	10				86	35	14											
BCI-19-36-7	11.5-12	Shelby	CL	2.50	600 psi				82	34	13											
BCI-19-36-7	12.5-13.0	Shelby	CL	2.50	600 psi				82	41	24											
BCI-19-36-8	13.5-15.0	SPT	CL		11				73	33	15											
BCI-19-36-9	15.5-15.75	Shelby	CL	1.75	400 psi				22													
BCI-19-36-9	16.5-17.1	Shelby	CL	1.75	400 psi				84	35	20											
BCI-19-36-10	17.0-18.5	SPT	CL	0.75	8				88	38	18											
BCI-19-36-18C	41.0-41.5	MCAL	CL-ML	2.00	35				60	26	4											
BCI-19-37-2C	4.5-5.0	CalMod	CH	>4.5	25				70	53	36											
BCI-19-37-4C	7.0-8.5	SPT	CH	3.00	10					57	35											
BCI-19-37-6B	10.5-12.0	SPT	CL	>4.5	21				79	38	17											
BCI-19-37-10C	17.5-19.0	SPT	CL		16				64	36	17											
BCI-19-37-13	23.5-24.0	Shelby	CH	4.50	800				94	55	32											
BCI-19-37-18C	46.0-46.5	CalMod	ML		22				50													
BCI-19-37-19	50.0-51.0	CalMod	GP-GM		71/12				6													
BCI-19-38-2C	5.0-5.5	SPT	CH	1.25	10				99	70	48											
BCI-19-38-6C	12.0-12.5	SPT	CL		20				84	43	22											
BCI-19-38-10C	19.0-19.5	SPT	CL	>4.5	21				89	46	30											
BCI-19-38-15	35.5-36.0	Shelby	CL	1.00	300				78	34	11										x	
BCI-19-38-17	42.0-42.5	Shelby	ML	1.25	200 psi				65	NP												
BCI-19-38-17	42.5-43.0	Shelby	ML	1.25	200 psi				66	30	5											
BCI-19-38-18C	46.0-46.5	MCAL	CL	0.25	10				85	37	16											
BCI-19-38-19C	51.0-51.5	SPT	SW-SM		47				7													
BCI-19-38-20C	56.0-56.5	MCAL	SP-SM		55				11													
BCI-19-38-22C	66.0-66.5	MCAL	CH	4.25	49				92	57	32											
BCI-19-57-2	5.0-5.5	Shelby	CH	1.50	700 psi				80	51	32					1039						
BCI-19-57-7	17.0-17.4	Shelby	CH		300 psi				68	54	37											
BCI-19-57-7	17.5-17.9	Shelby	CL		300 psi	23	123	100	54	41	20										x	
BCI-19-57-7	18.4-18.6	Shelby	CL-ML		300 psi	22	110	90	63	25	4										x	
BCI-19-57-9	22.0-22.4	Shelby	CL		800 psi				63	36	15											
BCI-19-57-10C	24.0-24.5	SPT	CL		14				89	31	9											
BCI-19-57-11	30.0-31.5	SPT	CH	4.50	27				96	51	27											
BCI-19-57-14	45.0-46.5	SPT	ML		15				66	32	7											
BCI-19-57-19	65.0-66.5	SPT	SM		24				23	NP												

* BCI performed the Consolidated Undrained Triaxial Test taking pore water pressures to obtain both Total Strength Values and Effective Strength Values. However, BCI could only obtain Total Strength Values due to the sample variability and inability to obtain reasonalbe Effective Strength Mohr Circles.

This Page Intentionally Left Blank

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Fat CLAY, olive brown	61	16	45			CH
■	Fat CLAY, light yellowish brown	56	18	38			CH
▲	Fat CLAY, light yellowish brown	68	22	46			CH
◆	Fat CLAY with SAND, light yellowish brown	68	22	46			CH
▼	Lean CLAY with SAND, dark yellowish brown	38	17	21			CL

Project No. 3195.P **Client:** EIP

Project: Lookout Slough THRFP

● **Source of Sample:** BCI-17-1 **Depth:** 1.0-2.5' **Sample Number:** 1
■ **Source of Sample:** BCI-17-1 **Depth:** 2.5-3.5' **Sample Number:** 2
▲ **Source of Sample:** BCI-17-1 **Depth:** 4.0-5.0' **Sample Number:** 2
◆ **Source of Sample:** BCI-17-1 **Depth:** 4.5-4.9' **Sample Number:** 2
▼ **Source of Sample:** BCI-17-1 **Depth:** 5.0-6.5' **Sample Number:** 3

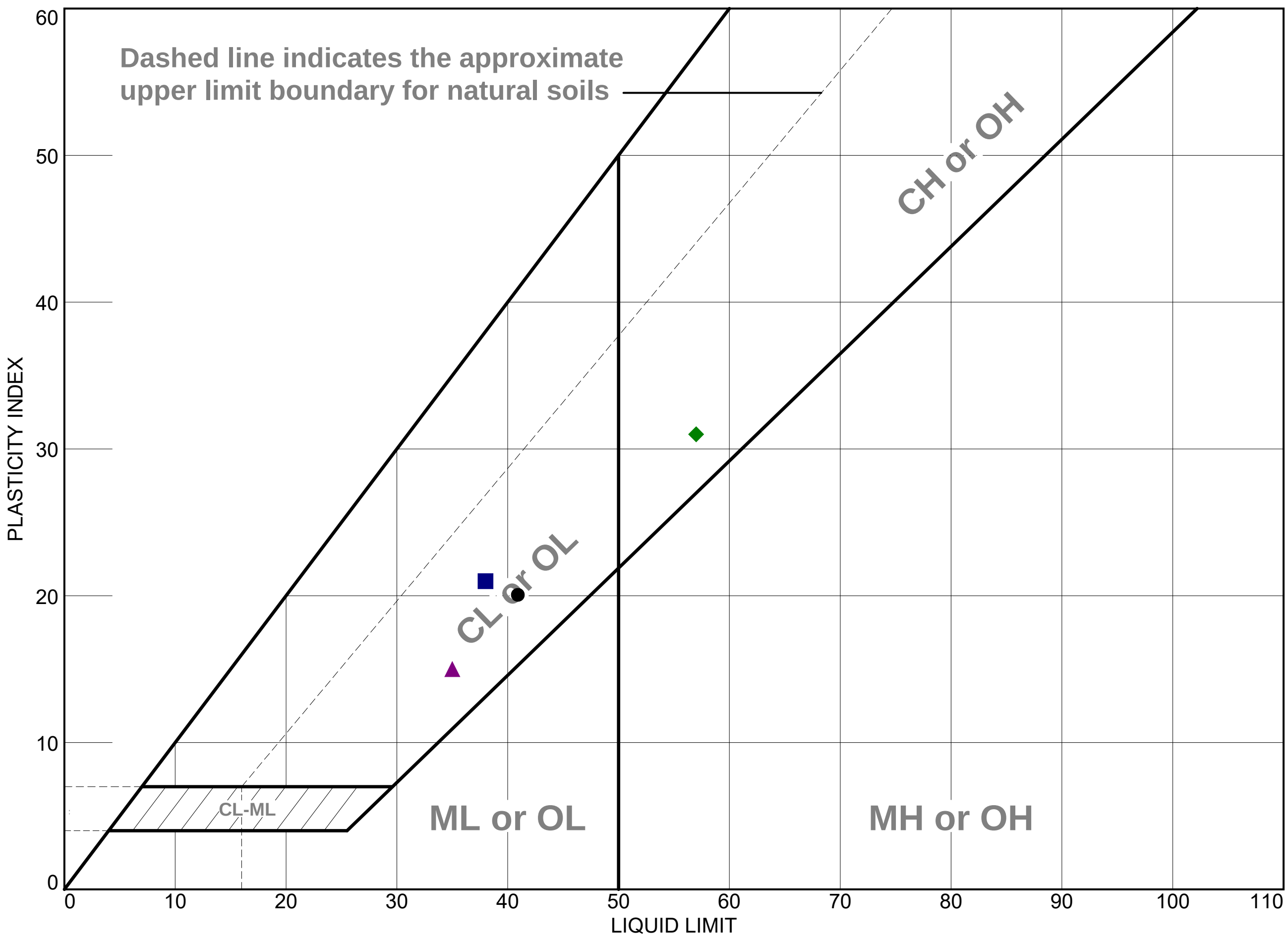
Remarks:

Blackburn Consulting

W. Sacramento, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Lean CLAY, brown	41	21	20		95	CL
■	SANDY Lean CLAY, dark greensih gray	38	17	21		62	CL
▲	SANDY Lean CLAY, brown	35	20	15		59	CL
◆	Fat CLAY with SAND, brownish yellow	57	26	31		81	CH

Project No. 3195.P **Client:** EIP

Project: Lookout Slough THRFP

●**Source of Sample:** BCI-17-1 **Depth:** 12.0-12.5' **Sample Number:** 6
■**Source of Sample:** BCI-17-1 **Depth:** 40.0-41.5' **Sample Number:** 13
▲**Source of Sample:** BCI-17-1 **Depth:** 46.0-46.5' **Sample Number:** 14
◆**Source of Sample:** BCI-17-1 **Depth:** 55.0-56.5' **Sample Number:** 16

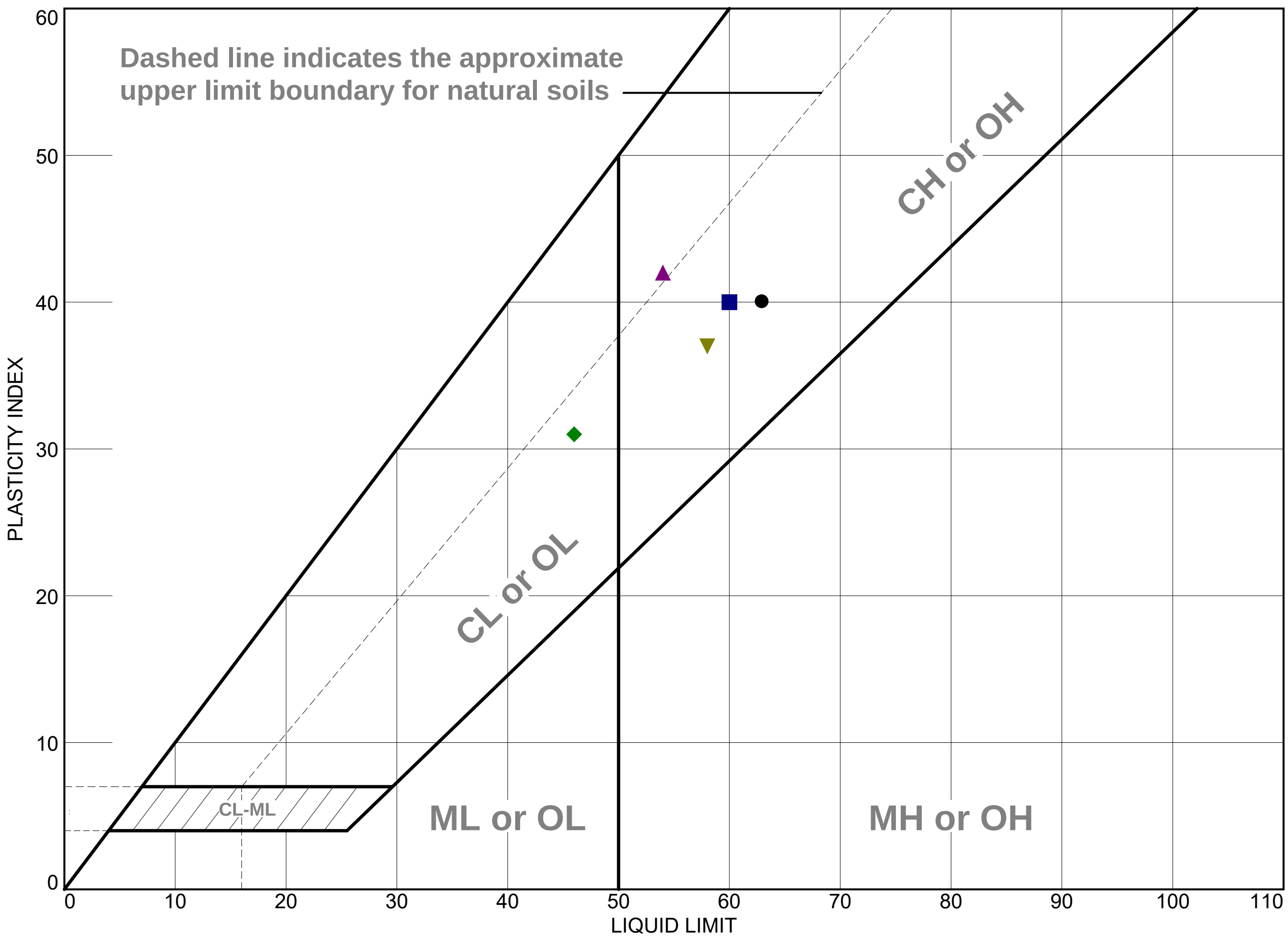
Remarks:

Blackburn Consulting

W. Sacramento, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Fat CLAY, very dark gray	63	23	40			CH
■	Fat CLAY, dark olive brown	60	20	40			CH
▲	Fat CLAY, dark gray	54	12	42		87	CH
◆	Lean CLAY with SAND, olive brown	46	15	31		78	CL
▼	Fat CLAY, olive brown	58	21	37		99	CH

Project No. 3195.P **Client:** EIP

Project: Lookout Slough THRFP

●**Source of Sample:** BCI-17-2 **Depth:** 1.0-2.5' **Sample Number:** 1
■**Source of Sample:** BCI-17-2 **Depth:** 2.5-3.0' **Sample Number:** 2
▲**Source of Sample:** BCI-17-2 **Depth:** 4.0-5.0' **Sample Number:** 2
◆**Source of Sample:** BCI-17-2 **Depth:** 8.0-8.5' **Sample Number:** 4
▼**Source of Sample:** BCI-17-2 **Depth:** 17.0-18.5' **Sample Number:** 9

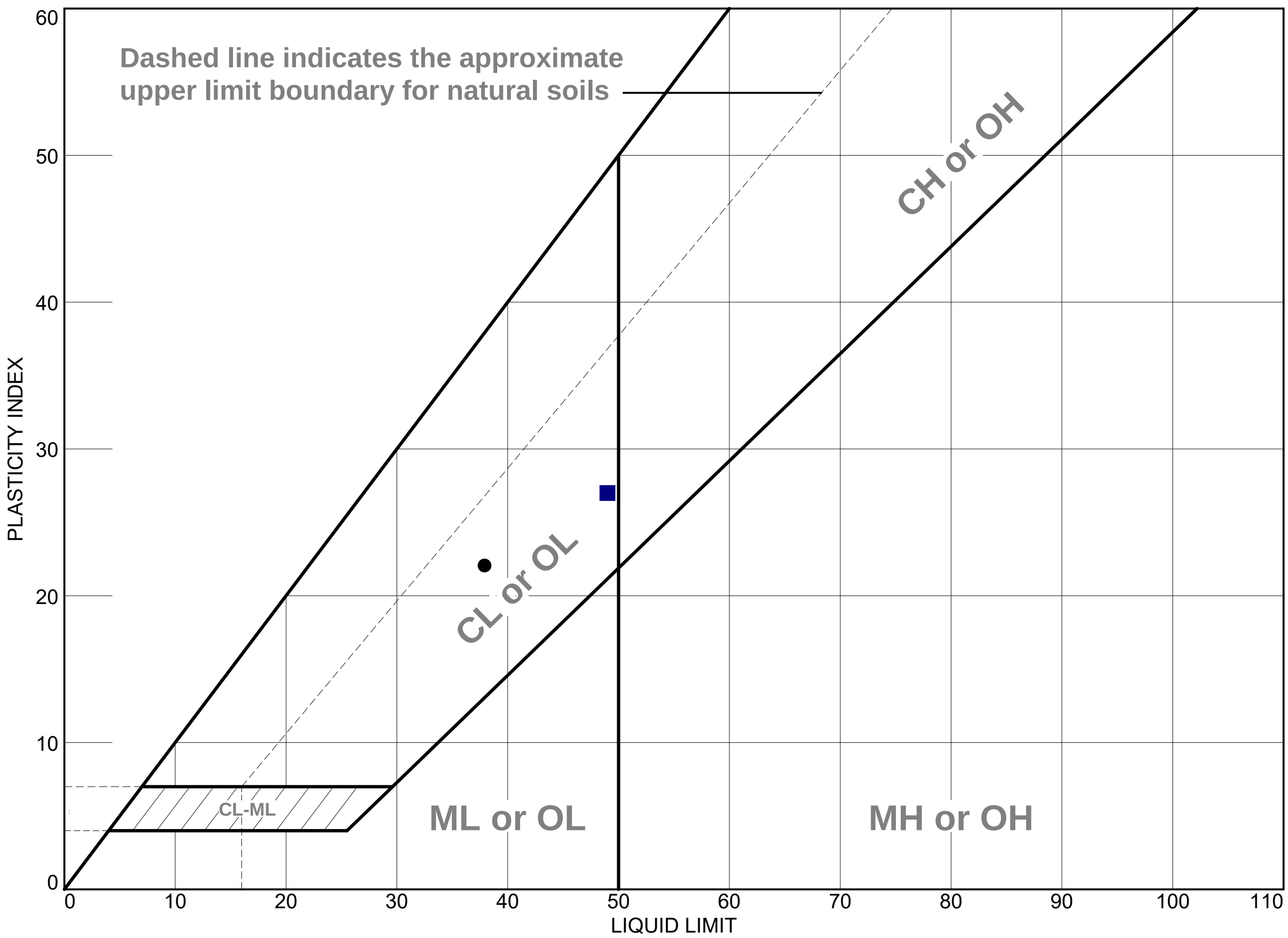
Remarks:

Blackburn Consulting

W. Sacramento, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	SANDY Lean CLAY, brown	38	16	22		50	CL
■	Lean CLAY, yellowish brown	49	22	27			CL
▲	Poorly-graded SAND with SILT, yellowish brown	NP	NP	NP		8	SP-SM

Project No. 3195.P **Client:** EIP

Project: Lookout Slough THRFP

● **Source of Sample:** BCI-17-2 **Depth:** 20'-20.5' **Sample Number:** 10
■ **Source of Sample:** BCI-17-2 **Depth:** 40.75-41.50' **Sample Number:** 14
▲ **Source of Sample:** BCI-17-2 **Depth:** 65.5-66.5' **Sample Number:** 19

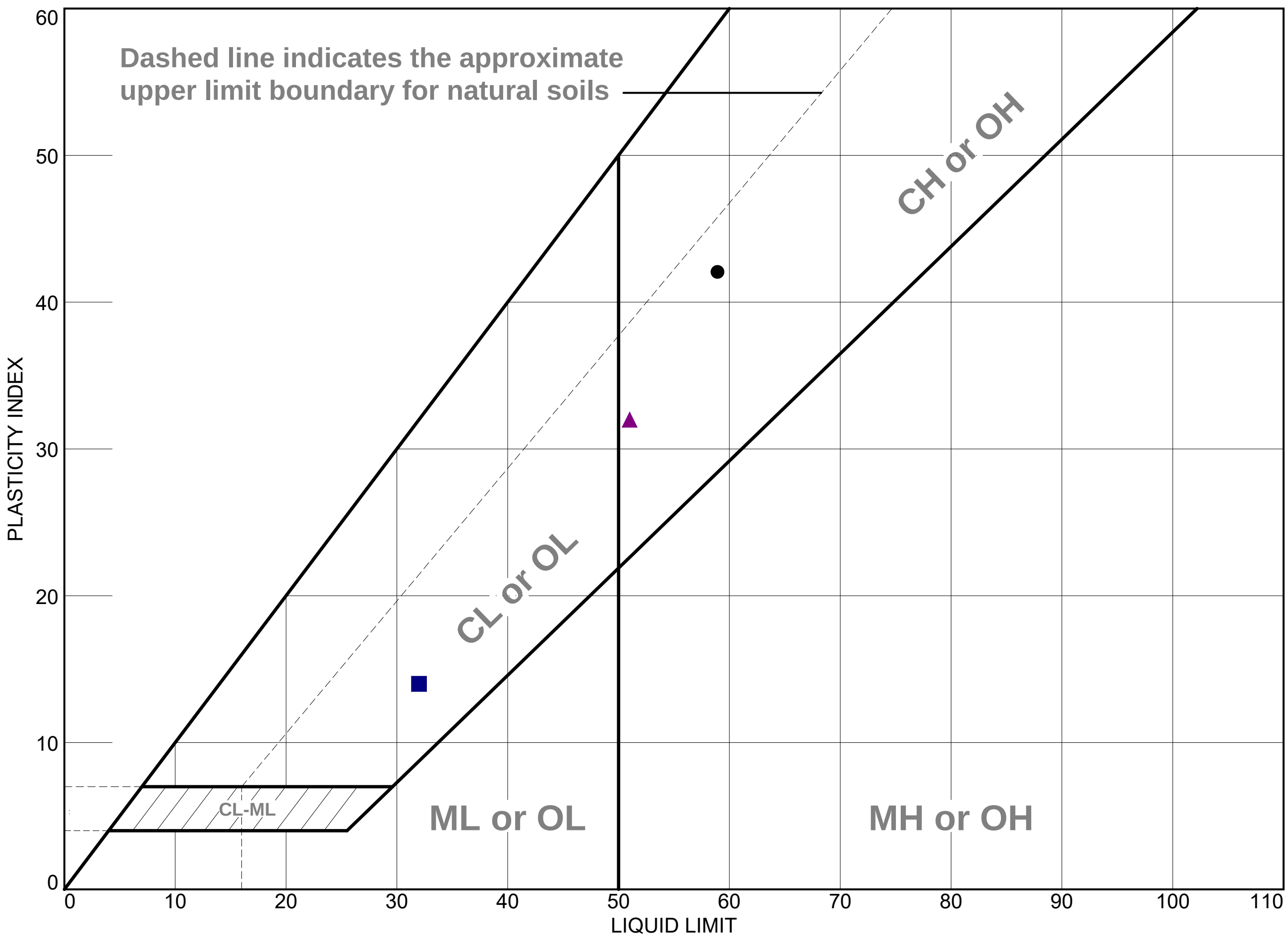
Remarks:

Blackburn Consulting

W. Sacramento, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Fat CLAY, olive brown	59	17	42		94	CH
■	Lean CLAY with SAND, olive brown	32	18	14		79	CL
▲	Fat CLAY with SAND, yellowish brown	51	19	32		85	CH

Project No. 3195.P **Client:** EIP

Project: Lookout Slough THRFP

●**Source of Sample:** BCI-17-3 **Depth:** 3.8-4.2' **Sample Number:** 2

■**Source of Sample:** BCI-17-3 **Depth:** 9.0-9.5' **Sample Number:** 4

▲**Source of Sample:** BCI-17-3 **Depth:** 26.0-26.5' **Sample Number:** 9

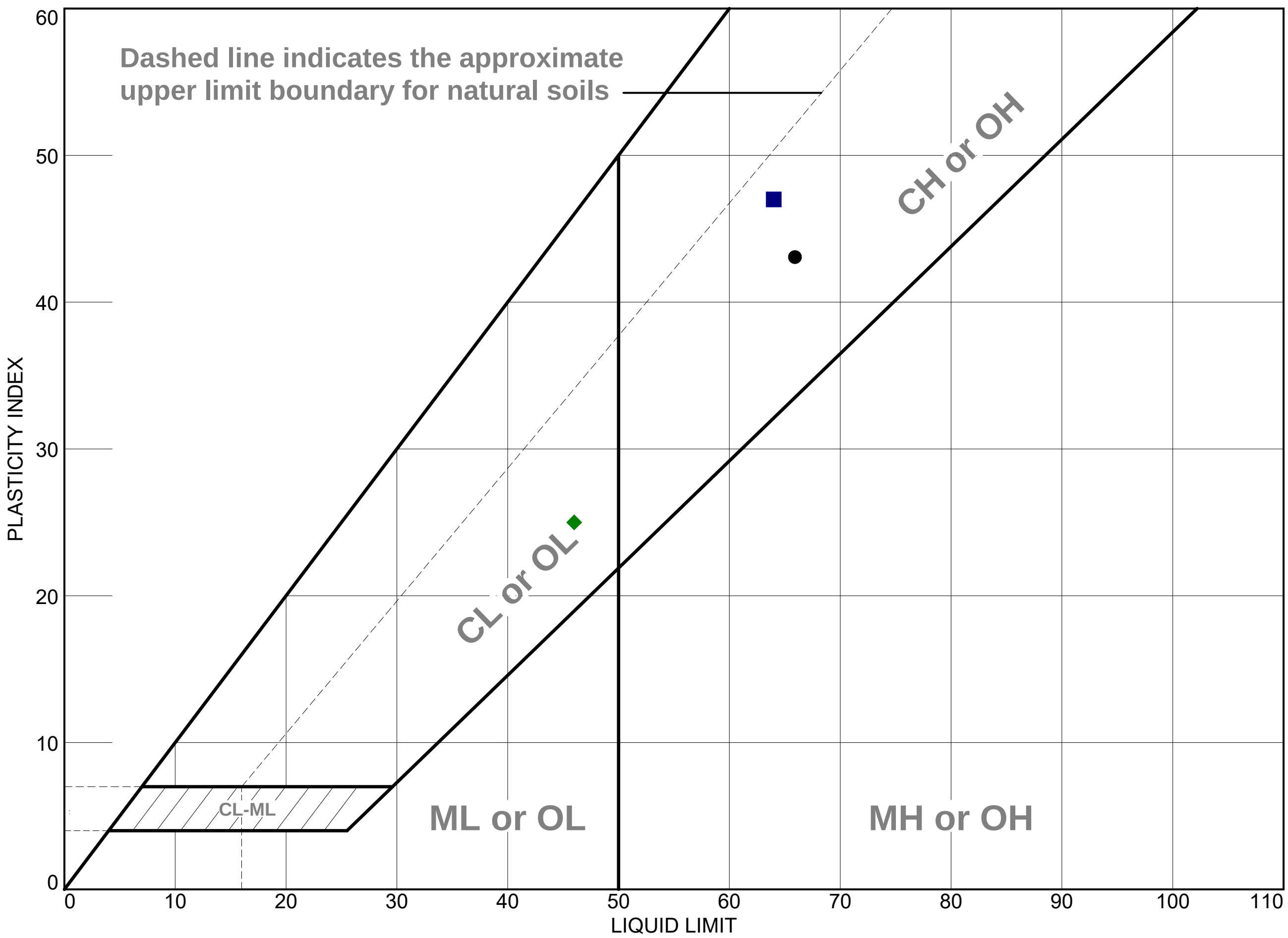
Remarks:

Blackburn Consulting

W. Sacramento, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Fat CLAY, very dark grayish brown	66	23	43			CH
■	Fat CLAY, dark grayish brown	64	17	47		95	CH
▲	Fat CLAY with SAND, yellowish brown					78	CH
◆	Lean CLAY, yellowish brown	46	21	25			CL

Project No. 3195.P **Client:** EIP

Project: Lookout Slough THRFP

●**Source of Sample:** BCI-17-4 **Depth:** 2-2.5' **Sample Number:** 1
■**Source of Sample:** BCI-17-4 **Depth:** 4.7-5.1' **Sample Number:** 2
▲**Source of Sample:** BCI-17-4 **Depth:** 8.7-9.1' **Sample Number:** 4
◆**Source of Sample:** BCI-17-4 **Depth:** 13.0-13.5' **Sample Number:** 6

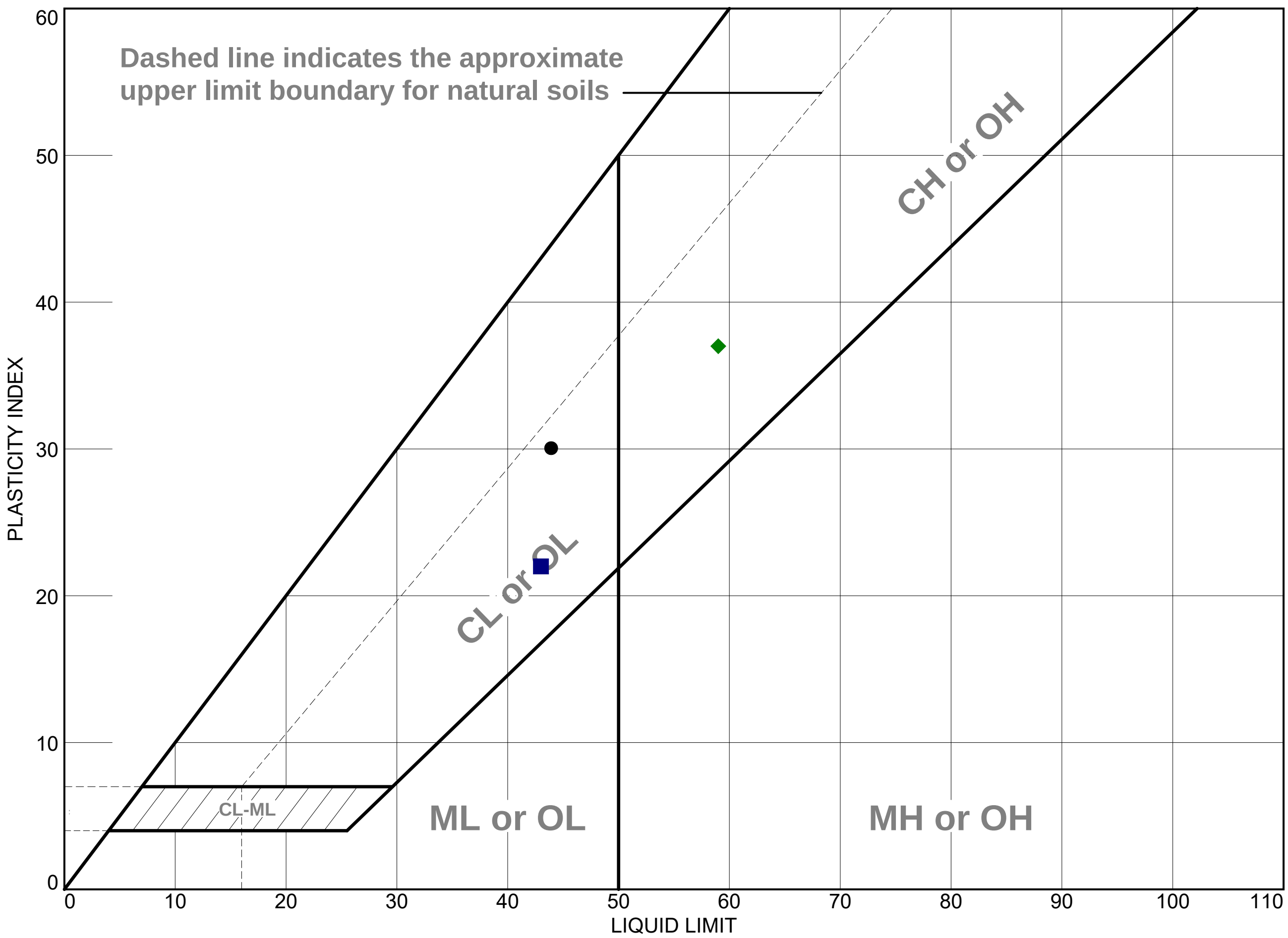
Remarks:

Blackburn Consulting

W. Sacramento, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Lean CLAY with SAND, yellowish brown	44	14	30		78	CL
■	Lean CLAY with SAND, yellowish brown	43	21	22		72	CL
▲	SILTY SAND, brown	NP	NP	NP		33	SM
◆	Fat CLAY, yellowish brown	59	22	37		95	CH

Project No. 3195.P **Client:** EIP

Project: Lookout Slough THRFP

●**Source of Sample:** BCI-17-5 **Depth:** 5.0-6.5' **Sample Number:** 3
■**Source of Sample:** BCI-17-5 **Depth:** 10.7-11.2' **Sample Number:** 6
▲**Source of Sample:** BCI-17-5 **Depth:** 35.0-36.5' **Sample Number:** 11
◆**Source of Sample:** BCI-17-5 **Depth:** 60.0-61.5' **Sample Number:** 16

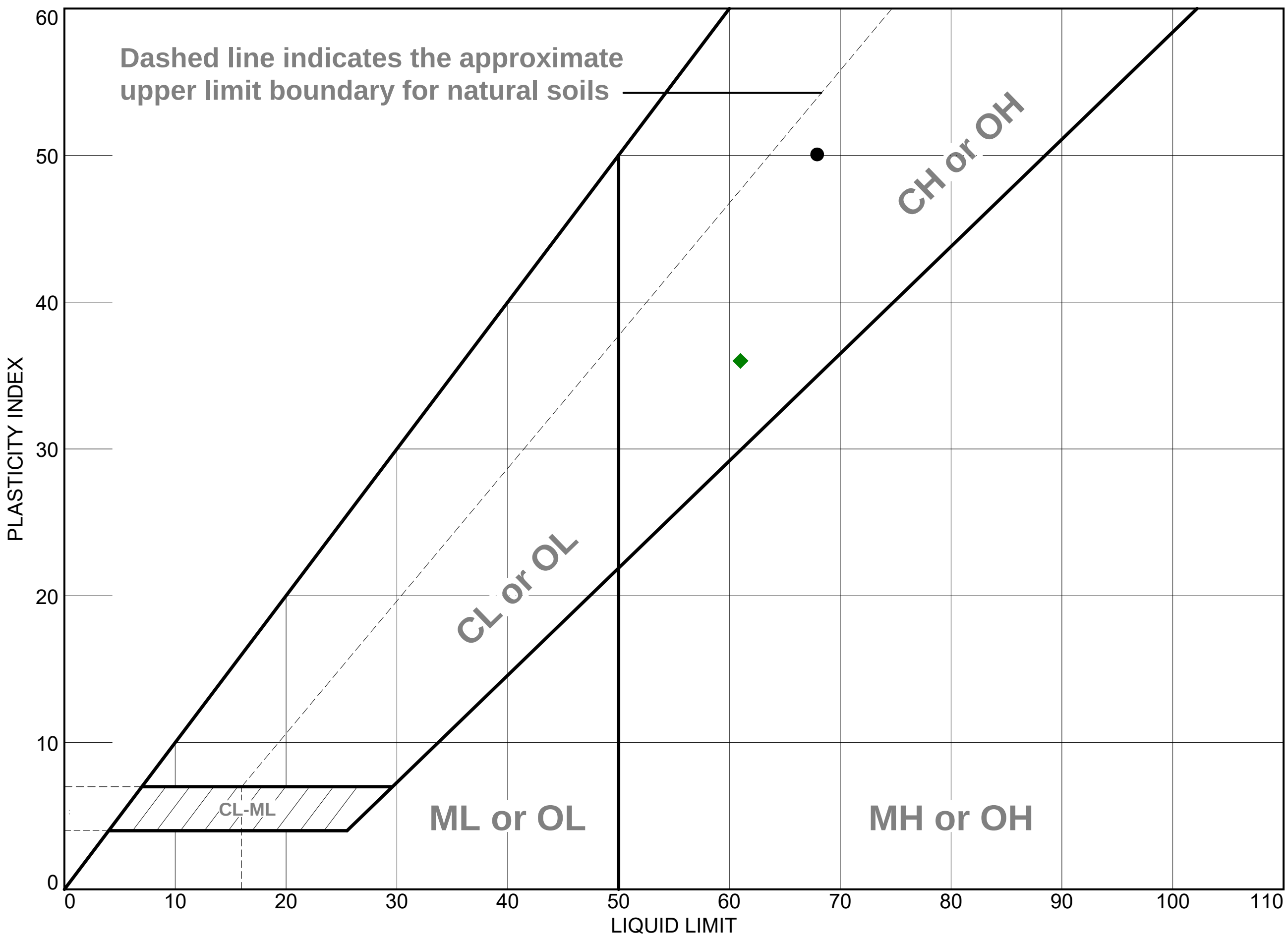
Remarks:

Blackburn Consulting

W. Sacramento, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Fat CLAY with SAND, dark brown	68	18	50			CH
■	Poorly-graded SAND with SILT, dark yellowish brown	NP	NP	NP		8	SP-SM
▲	Poorly-graded SAND with SILT, yellowish brown	NP	NP	NP		6	SP-SM
◆	Fat CLAY, dark yellowish brown	61	25	36		98	CH

Project No. 3195.P **Client:** EIP

Project: Lookout Slough THRFP

●**Source of Sample:** BCI-17-6 **Depth:** 4.3-4.8' **Sample Number:** 2
■**Source of Sample:** BCI-17-6 **Depth:** 8.5-9.0' **Sample Number:** 4
▲**Source of Sample:** BCI-17-6 **Depth:** 10.25-11.0' **Sample Number:** 5
◆**Source of Sample:** BCI-17-6 **Depth:** 45.0-46.5' **Sample Number:** 13

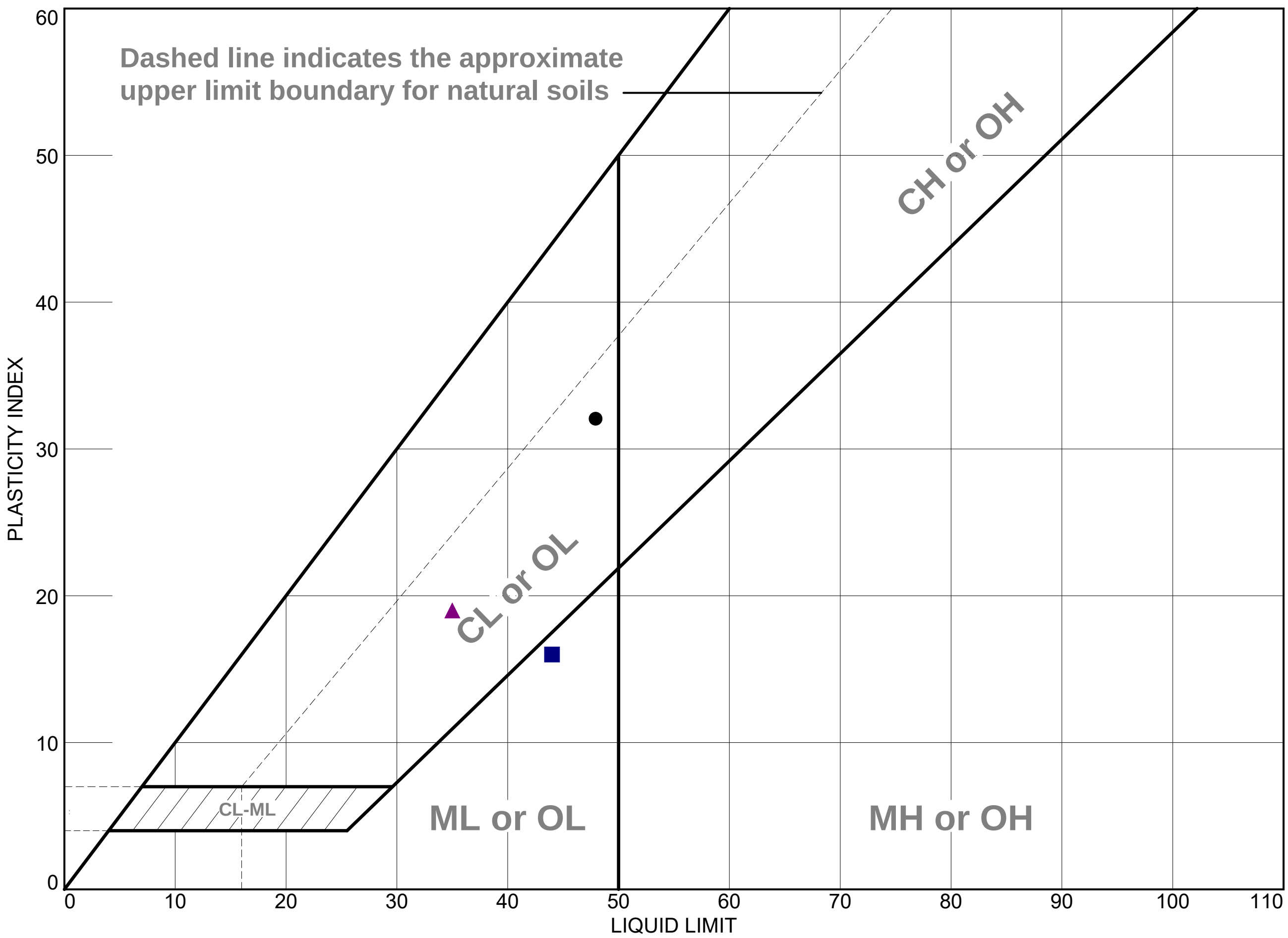
Remarks:

Blackburn Consulting

W. Sacramento, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Lean CLAY with SAND, dark yellowish brown	48	16	32		80	CL
■	SILT, yellowish brown	44	28	16		93	ML
▲	SANDY Lean CLAY, yellowish brown	35	16	19		50	CL

Project No. 3195.P **Client:** EIP

Project: Lookout Slough THRFP

● **Source of Sample:** BCI-17-7 **Depth:** 3.8-4.2' **Sample Number:** 2
■ **Source of Sample:** BCI-17-7 **Depth:** 7.5-8.0' **Sample Number:** 4
▲ **Source of Sample:** BCI-17-7 **Depth:** 15.0-16.5' **Sample Number:** 7

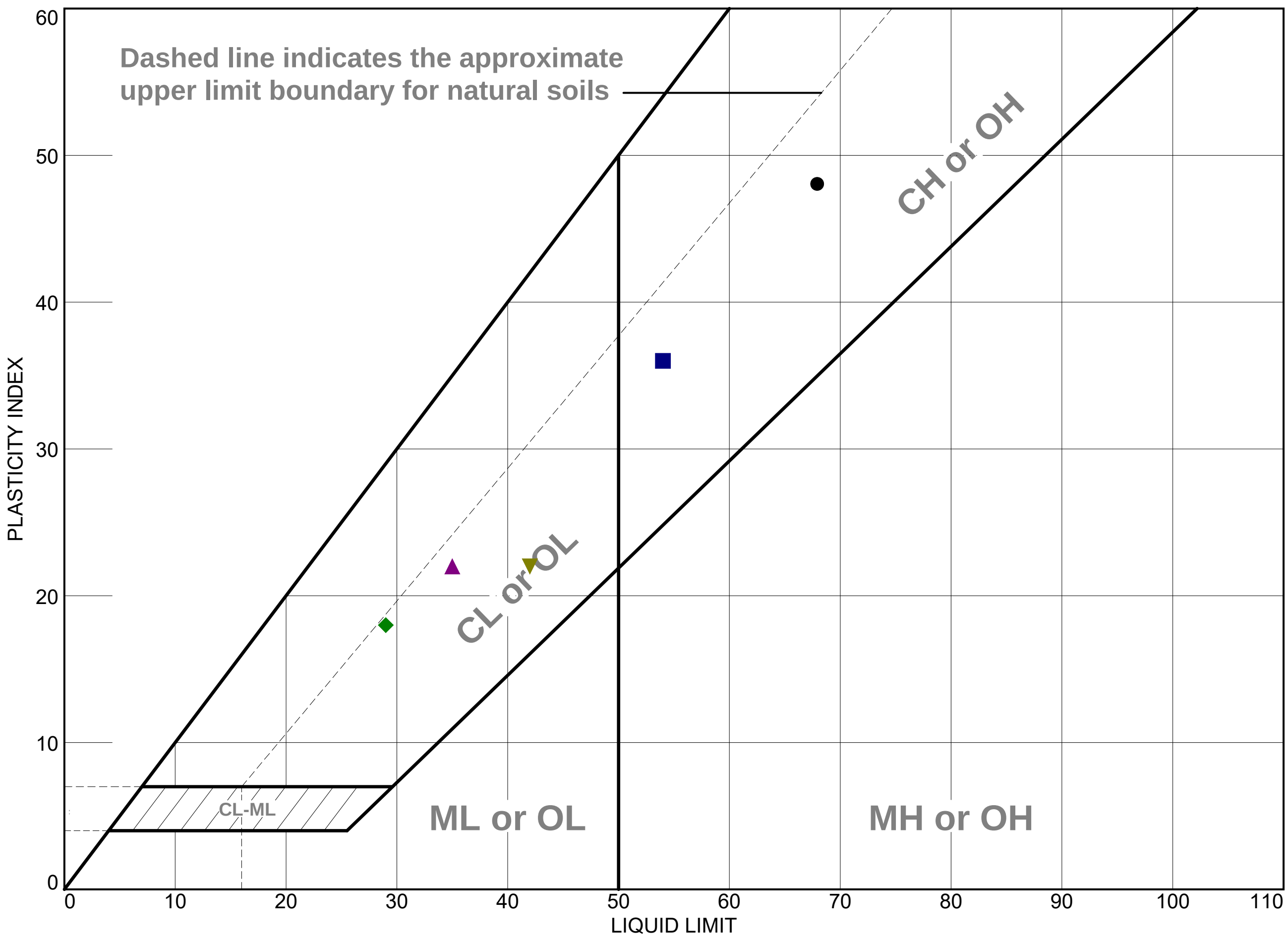
Remarks:

Blackburn Consulting

W. Sacramento, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Fat CLAY, very dark gray	68	20	48		95	CH
■	Fat CLAY with SAND, light olive brown	54	18	36		84	CH
▲	SANDY Lean CLAY, yellowish brown	35	13	22		56	CL
◆	SANDY Lean CLAY, yellowish brown	29	11	18		58	CL
▼	Lean CLAY, light olive brown	42	20	22		89	CL

Project No. 3195.P **Client:** EIP

Project: Lookout Slough THRFP

●**Source of Sample:** BCI-17-8 **Depth:** 3.8-4.2' **Sample Number:** 2
■**Source of Sample:** BCI-17-8 **Depth:** 7.7-8.2' **Sample Number:** 4
▲**Source of Sample:** BCI-17-8 **Depth:** 11.3-11.7' **Sample Number:** 6
◆**Source of Sample:** BCI-17-8 **Depth:** 16.0-16.5' **Sample Number:** 8
▼**Source of Sample:** BCI-17-8 **Depth:** 30.0-31.5' **Sample Number:** 11

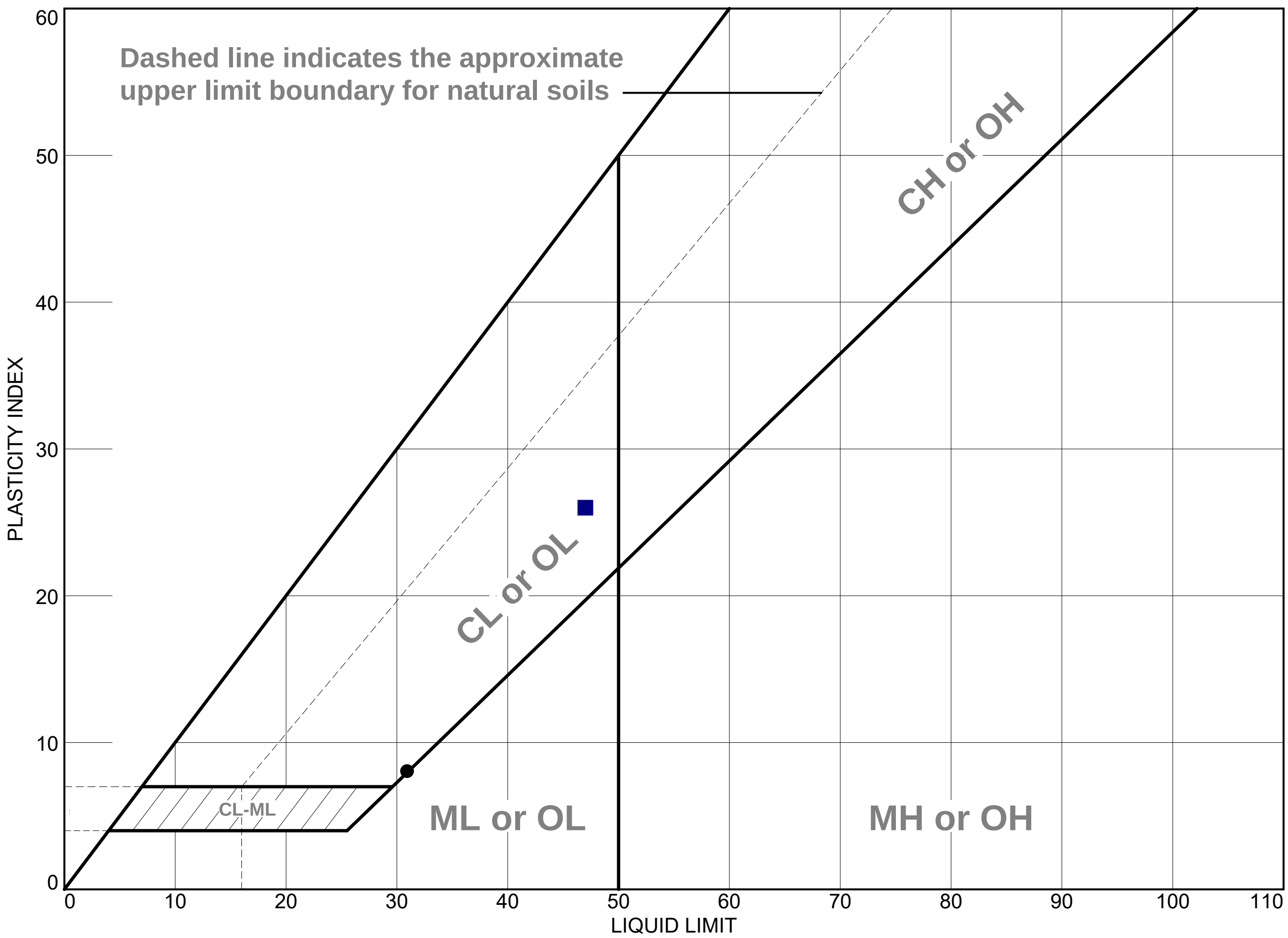
Remarks:

Blackburn Consulting

W. Sacramento, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	SANDY SILT, brown	31	23	8		62	ML
■	Lean CLAY, yellowish brown	47	21	26		90	CL

Project No. 3195.P **Client:** EIP

Project: Lookout Slough THRFP

● **Source of Sample:** BCI-17-8 **Depth:** 35.0-36.5' **Sample Number:** 12

■ **Source of Sample:** BCI-17-8 **Depth:** 55.0-56.5' **Sample Number:** 16

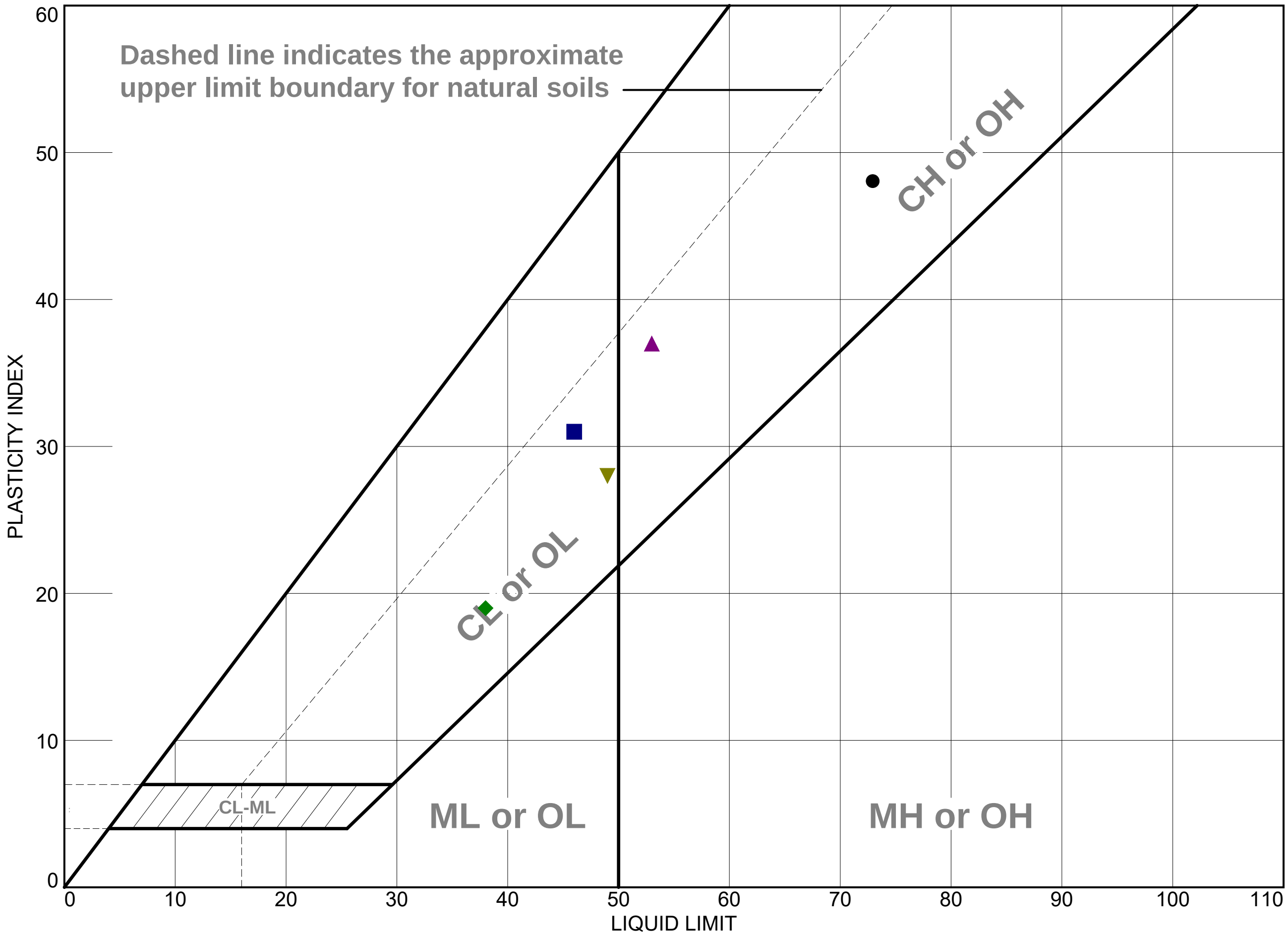
Remarks:

Blackburn Consulting

W. Sacramento, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Fat CLAY, very dark gray	73	25	48			CH
■	Lean CLAY, olive brown	46	15	31			CL
▲	Fat CLAY with SAND, yellowish brown	53	16	37		76	CH
◆	SANDY Lean CLAY, olive brown	38	19	19		66	CL
▼	Lean CLAY, yellowish brown	49	21	28		93	CL

Project No. 3195.P **Client:** EIP

Project: Lookout Slough THRFP

●**Source of Sample:** BCI-17-9 **Depth:** 3.0-3.5' **Sample Number:** 2B
■**Source of Sample:** BCI-17-9 **Depth:** 4.0-5.0' **Sample Number:** 3
▲**Source of Sample:** BCI-17-9 **Depth:** 6.5-7.0' **Sample Number:** 4B
◆**Source of Sample:** BCI-17-9 **Depth:** 13.5-14.0' **Sample Number:** 8C
▼**Source of Sample:** BCI-17-9 **Depth:** 31.0-31.5' **Sample Number:** 12C

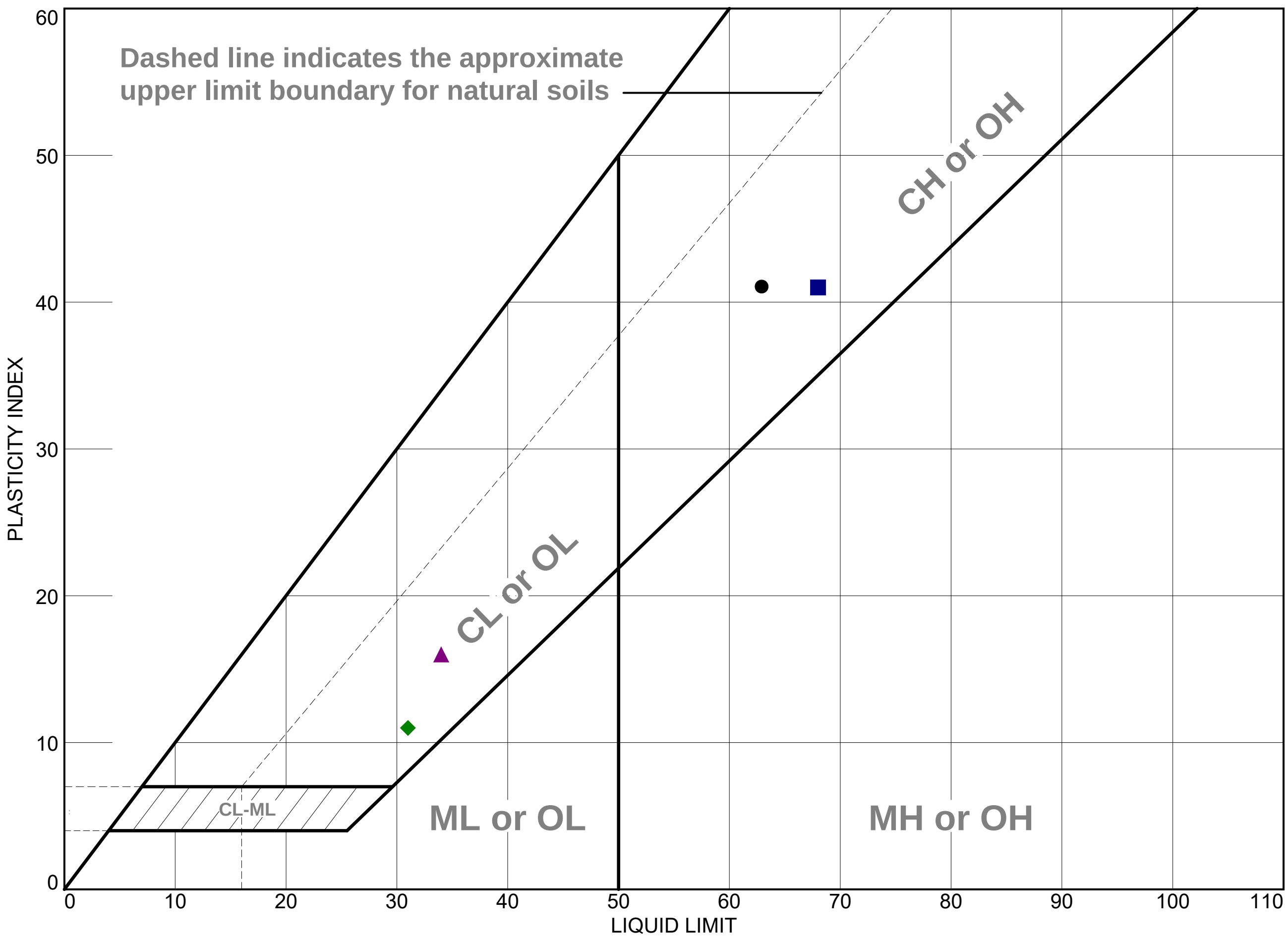
Remarks:

Blackburn Consulting

W. Sacramento, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Fat CLAY, very dark brown	63	22	41			CH
■	SANDY Fat CLAY, very dark gray	68	27	41		66	CH
▲	CLAYEY SAND, brown	34	18	16		28	SC
◆	CLAYEY SAND, olive brown	31	20	11		43	SC

Project No. 3195.P **Client:** EIP

Project: Lookout Slough THRFP

● **Source of Sample:** BCI-17-10 **Depth:** 1.5-2.0' **Sample Number:** 1B
■ **Source of Sample:** BCI-17-10 **Depth:** 2.0-2.5' **Sample Number:** 2
▲ **Source of Sample:** BCI-17-10 **Depth:** 6.5-7.0' **Sample Number:** 4
◆ **Source of Sample:** BCI-17-10 **Depth:** 9.0-9.5' **Sample Number:** 5C

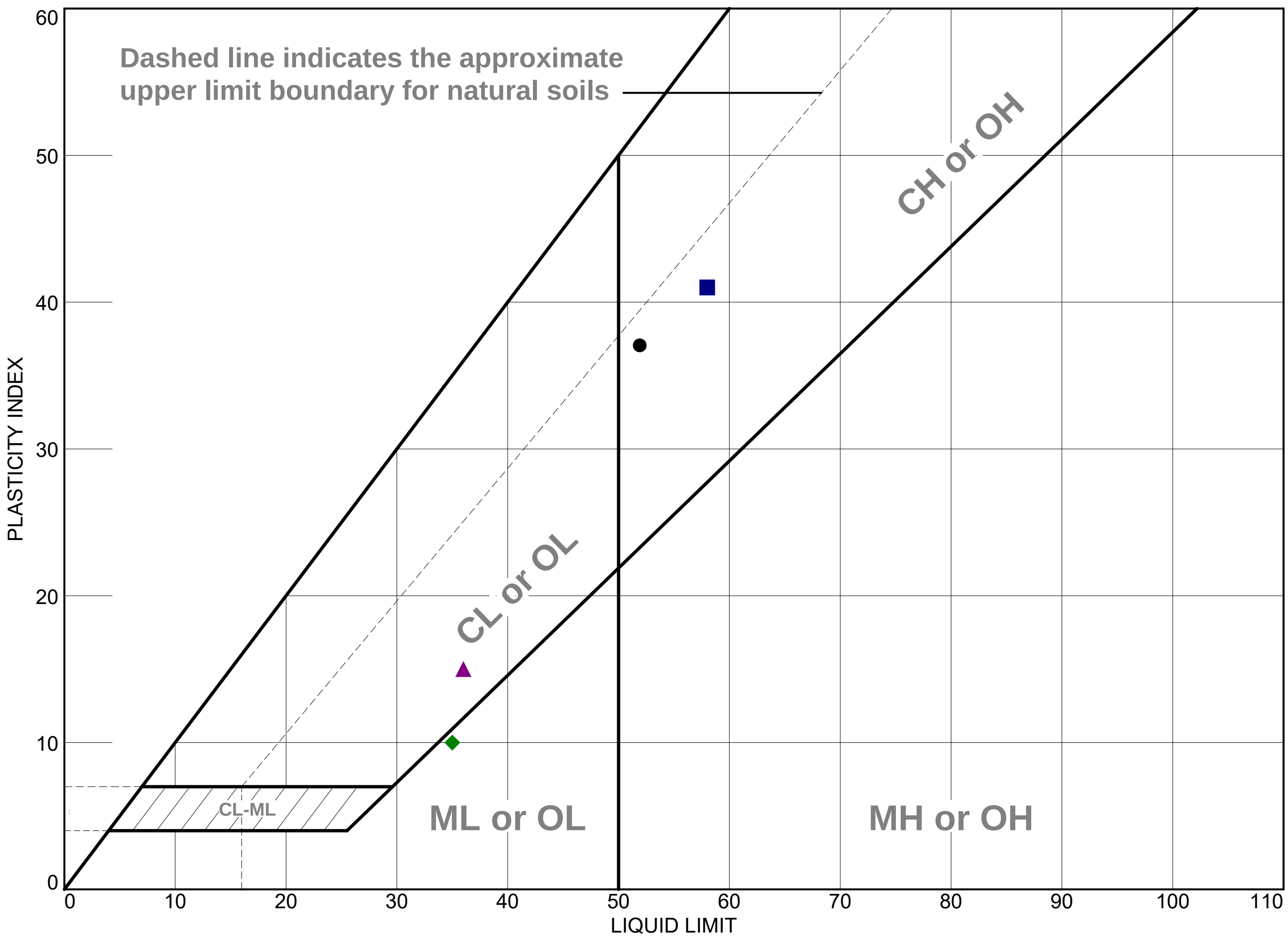
Remarks:

Blackburn Consulting

W. Sacramento, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Fat CLAY, very dark brown	52	15	37		90	CH
■	Fat CLAY, light olive brown	58	17	41			CH
▲	CLAYEY SAND with GRAVEL, dark yellowish brown	36	21	15	43	21	SC
◆	SANDY SILT, dark yellowish brown	35	25	10		50	ML
▼	SILTY SAND, olive brown	NP	NP	NP		46	SM

Project No. 3195.P **Client:** EIP

Project: Lookout Slough THRFP

●**Source of Sample:** BCI-17-11 **Depth:** 2.5-3.0' **Sample Number:** 1
■**Source of Sample:** BCI-17-11 **Depth:** 3.5-4.0' **Sample Number:** 2B
▲**Source of Sample:** BCI-17-11 **Depth:** 7.0-8.5' **Sample No.:** 4C&5B
◆**Source of Sample:** BCI-17-11 **Depth:** 9.5-10.0' **Sample Number:** 6B
▼**Source of Sample:** BCI-17-11 **Depth:** 20.5-21.5 **Sample No.:** 10B&10C

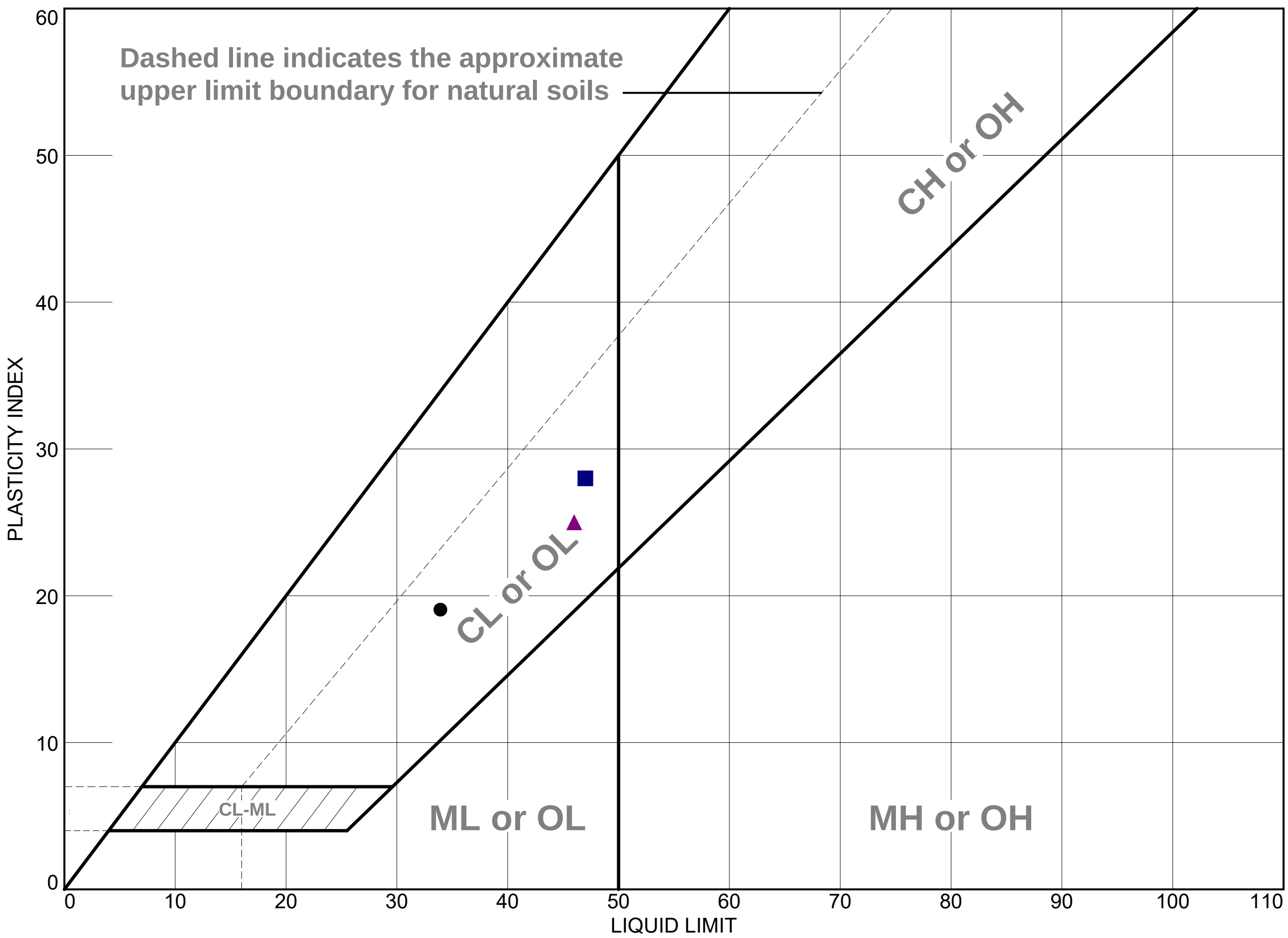
Blackburn Consulting

W. Sacramento, CA

Remarks:

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Lean CLAY with SAND, brown	34	15	19		80	CL
■	Lean CLAY with SAND, bluish gray	47	19	28		80	CL
▲	SANDY Lean CLAY, olive brown	46	21	25		67	CL

Project No. 3195.P **Client:** EIP

Project: Lookout Slough THRFP

● **Source of Sample:** BCI-17-12 **Depth:** 3.0-4.5 **Sample Number:** 2

■ **Source of Sample:** BCI-17-12 **Depth:** 6.0-7.5 **Sample Number:** 4

▲ **Source of Sample:** BCI-17-12 **Depth:** 35.0-36.5 **Sample Number:** 11

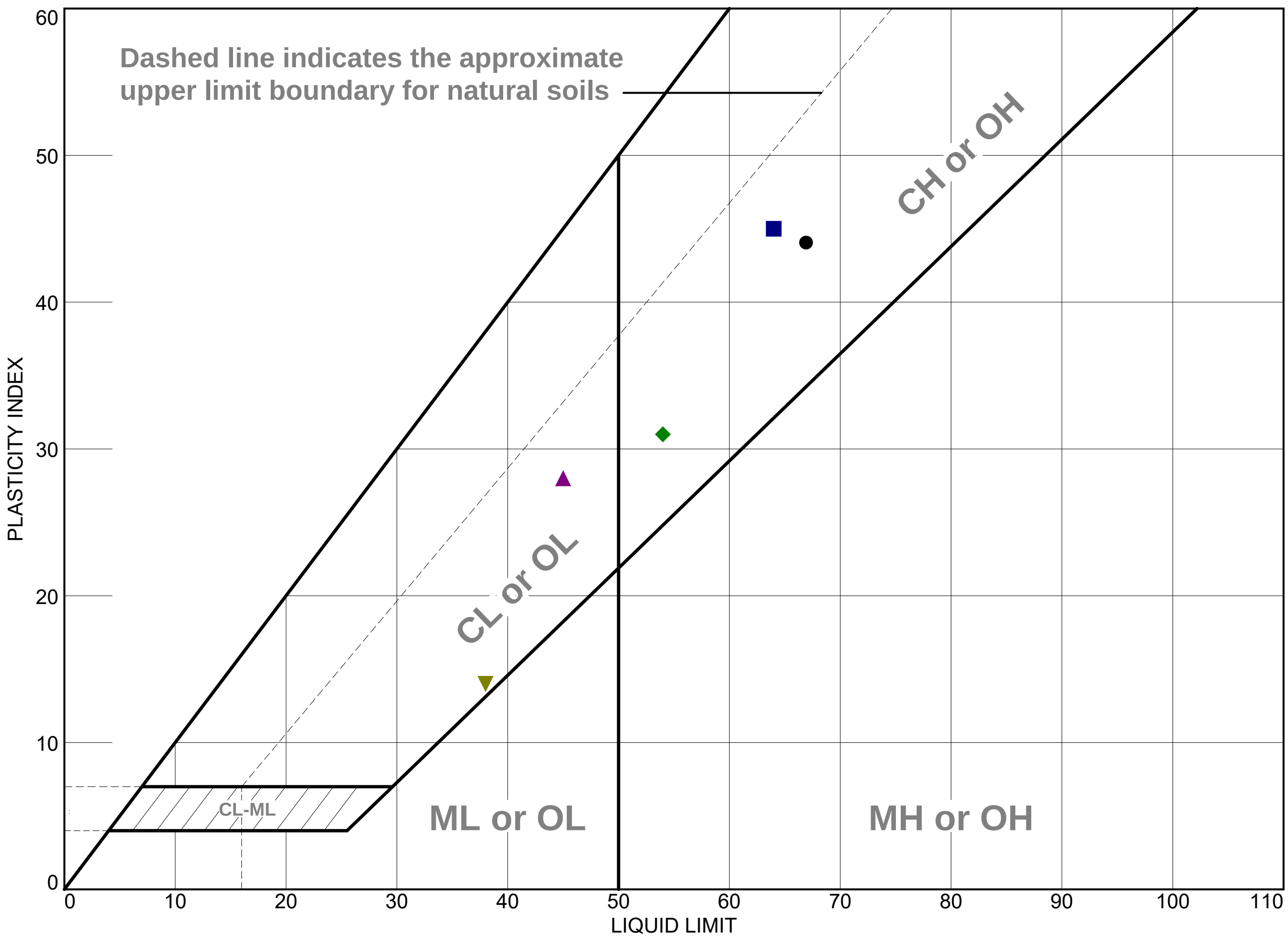
Remarks:

Blackburn Consulting

W. Sacramento, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Fat CLAY, very dark grayish brown	67	23	44			CH
■	Fat CLAY, dark olive brown	64	19	45			CH
▲	SANDY Lean CLAY, dark olive brown	45	17	28		69	CL
◆	Fat CLAY, olive brown	54	23	31		92	CH
▼	Lean CLAY with SAND, olive brown	38	24	14		75	CL

Project No. 3195.P **Client:** EIP

Project: Lookout Slough THRFP

●**Source of Sample:** BCI-17-13 **Depth:** 1-2.5' **Sample Number:** 1

■**Source of Sample:** BCI-17-13 **Depth:** 2.5-4.0' **Sample Number:** 2

▲**Source of Sample:** BCI-17-13 **Depth:** 7.5-9.0' **Sample Number:** 5

◆**Source of Sample:** BCI-17-13 **Depth:** 16.0-16.5' **Sample Number:** 9C

▼**Source of Sample:** BCI-17-13 **Depth:** 40-41.5' **Sample Number:** 14

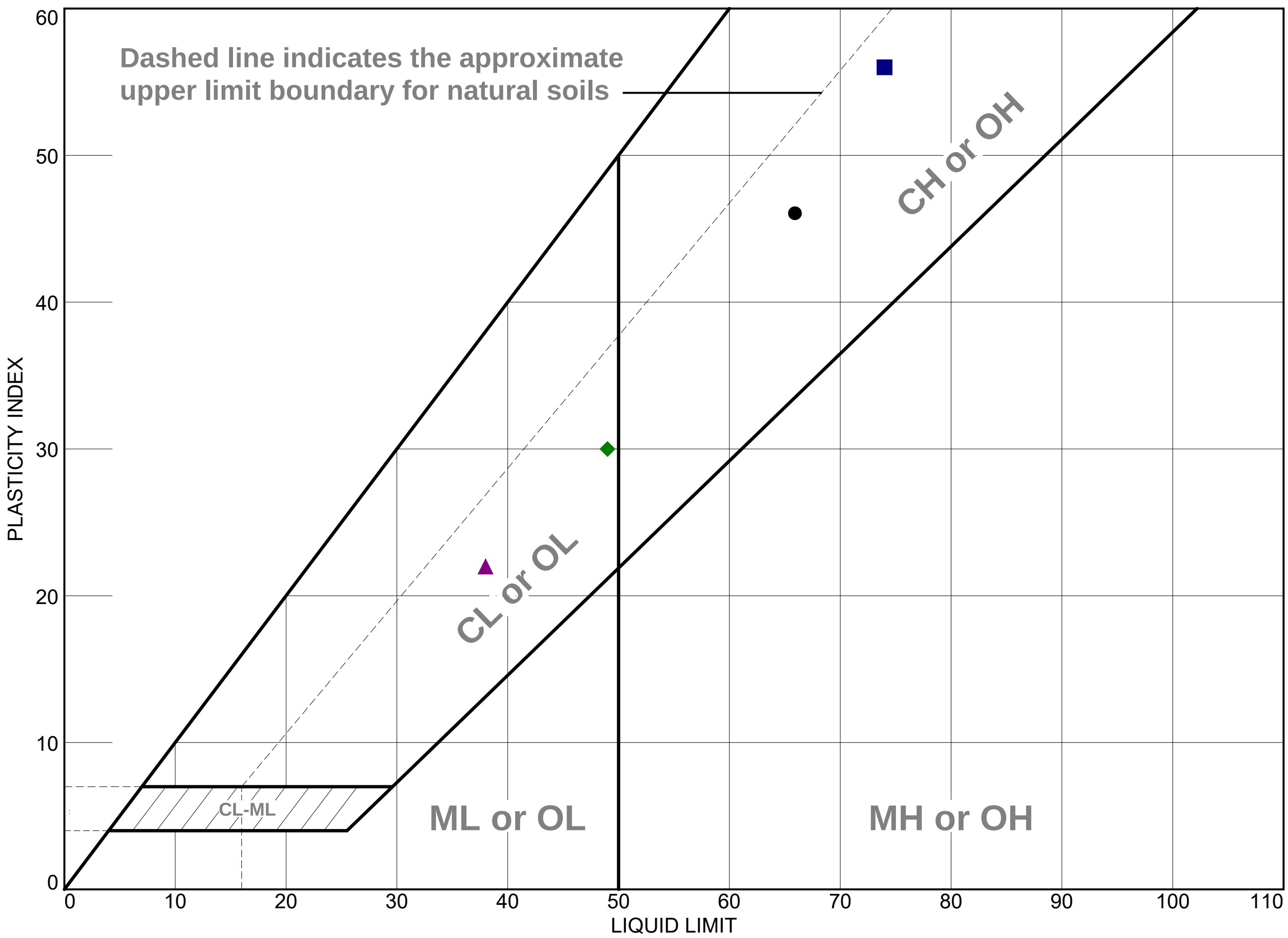
Remarks:

Blackburn Consulting

W. Sacramento, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Fat CLAY, very dark gray	66	20	46			CH
■	Fat CLAY, dark grayish brown	74	18	56			CH
▲	SANDY Lean CLAY, olive brown	38	16	22		59	CL
◆	Lean CLAY, olive brown	49	19	30		94	CL

Project No. 3195.P **Client:** EIP

Project: Lookout Slough THRFP

●**Source of Sample:** BCI-17-14 **Depth:** 1.0-2.0' **Sample Number:** 1
■**Source of Sample:** BCI-17-14 **Depth:** 3-4.5' **Sample Number:** 2
▲**Source of Sample:** BCI-17-14 **Depth:** 6.5-8.0' **Sample Number:** 4
◆**Source of Sample:** BCI-17-14 **Depth:** 20.5-21.0' **Sample Number:** 9B

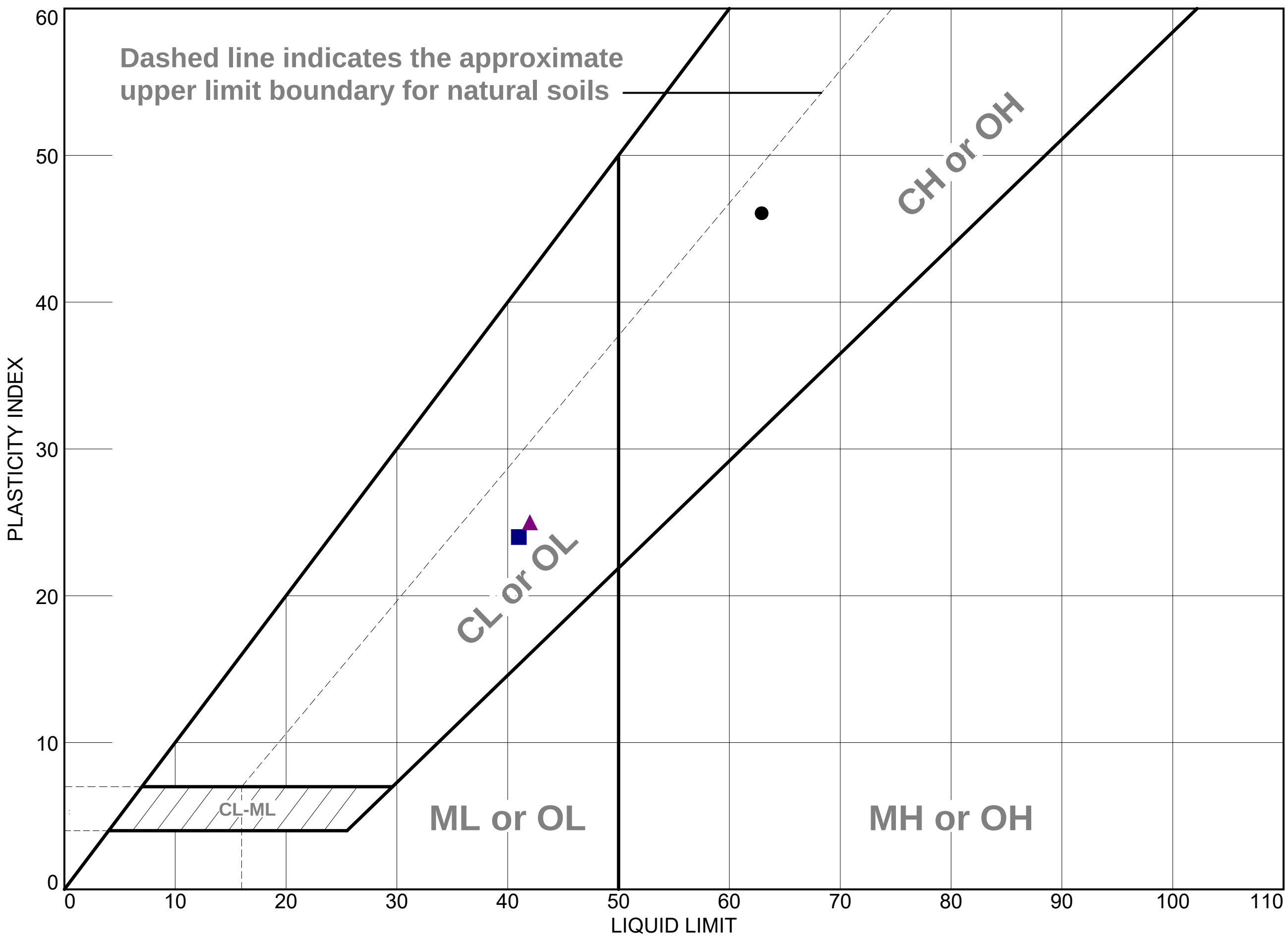
Remarks:

Blackburn Consulting

W. Sacramento, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Fat CLAY, very dark gray	63	17	46		97	CH
■	SANDY Lean CLAY, olive brown	41	17	24		67	CL
▲	Lean CLAY with SAND, olive brown	42	17	25		76	CL

Project No. 3195.P **Client:** EIP

Project: Lookout Slough THRFP

●**Source of Sample:** BCI-17-15 **Depth:** 1.5-2.0' **Sample Number:** 1
■**Source of Sample:** BCI-17-15 **Depth:** 8-9.5' **Sample Number:** 4
▲**Source of Sample:** BCI-17-15 **Depth:** 20.5-21' **Sample Number:** 8B

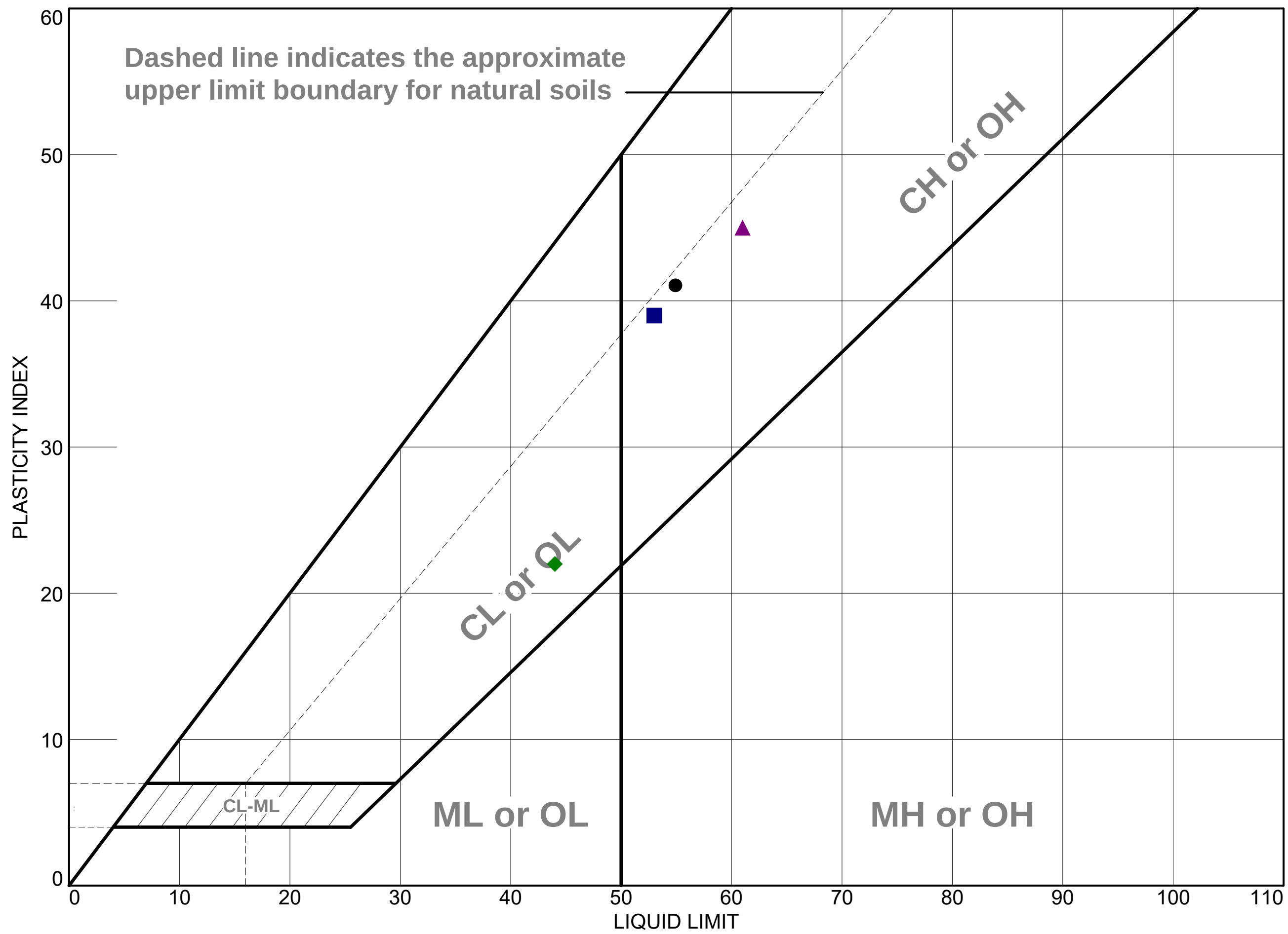
Remarks:

Blackburn Consulting

W. Sacramento, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Fat CLAY, dark olive gray	55	14	41			CH
■	Fat CLAY, dark olive gray	53	14	39			CH
▲	Fat CLAY with SAND, olive brown	61	16	45		79	CH
◆	Lean CLAY, olive brown	44	22	22		89	CL

Project No. 3195.P **Client:** EIP

Project: Lookout Slough THRFP

●**Source of Sample:** BCI-17-16 **Depth:** 1-2' **Sample Number:** 1
■**Source of Sample:** BCI-17-16 **Depth:** 2-3' **Sample Number:** 1
▲**Source of Sample:** BCI-17-16 **Depth:** 3-4.5' **Sample Number:** 2
◆**Source of Sample:** BCI-17-16 **Depth:** 10.5-12' **Sample Number:** 6

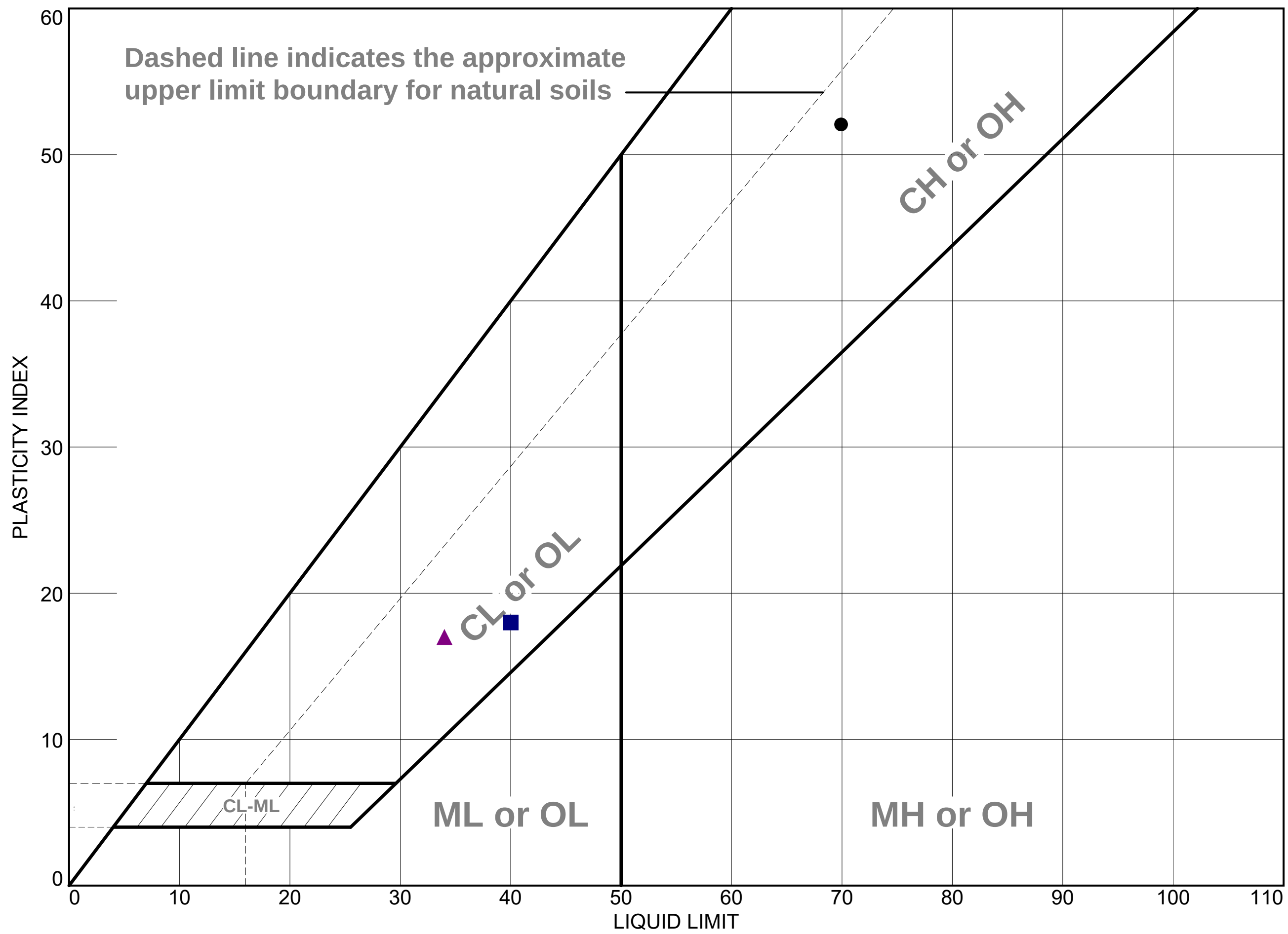
Remarks:

Blackburn Consulting

W. Sacramento, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Fat CLAY, light olive brown	70	18	52			CH
■	Lean CLAY with SAND, olive brown	40	22	18		77	CL
▲	SANDY Lean CLAY, olive brown	34	17	17		52	CL

Project No. 3195.P **Client:** EIP

Project: Lookout Slough THRFP

●**Source of Sample:** BCI-17-17 **Depth:** 4.0-5.0' **Sample Number:** 2

■**Source of Sample:** BCI-17-17 **Depth:** 10.2-11.7 **Sample Number:** 6

▲**Source of Sample:** BCI-17-17 **Depth:** 25-26.5 **Sample Number:** 10

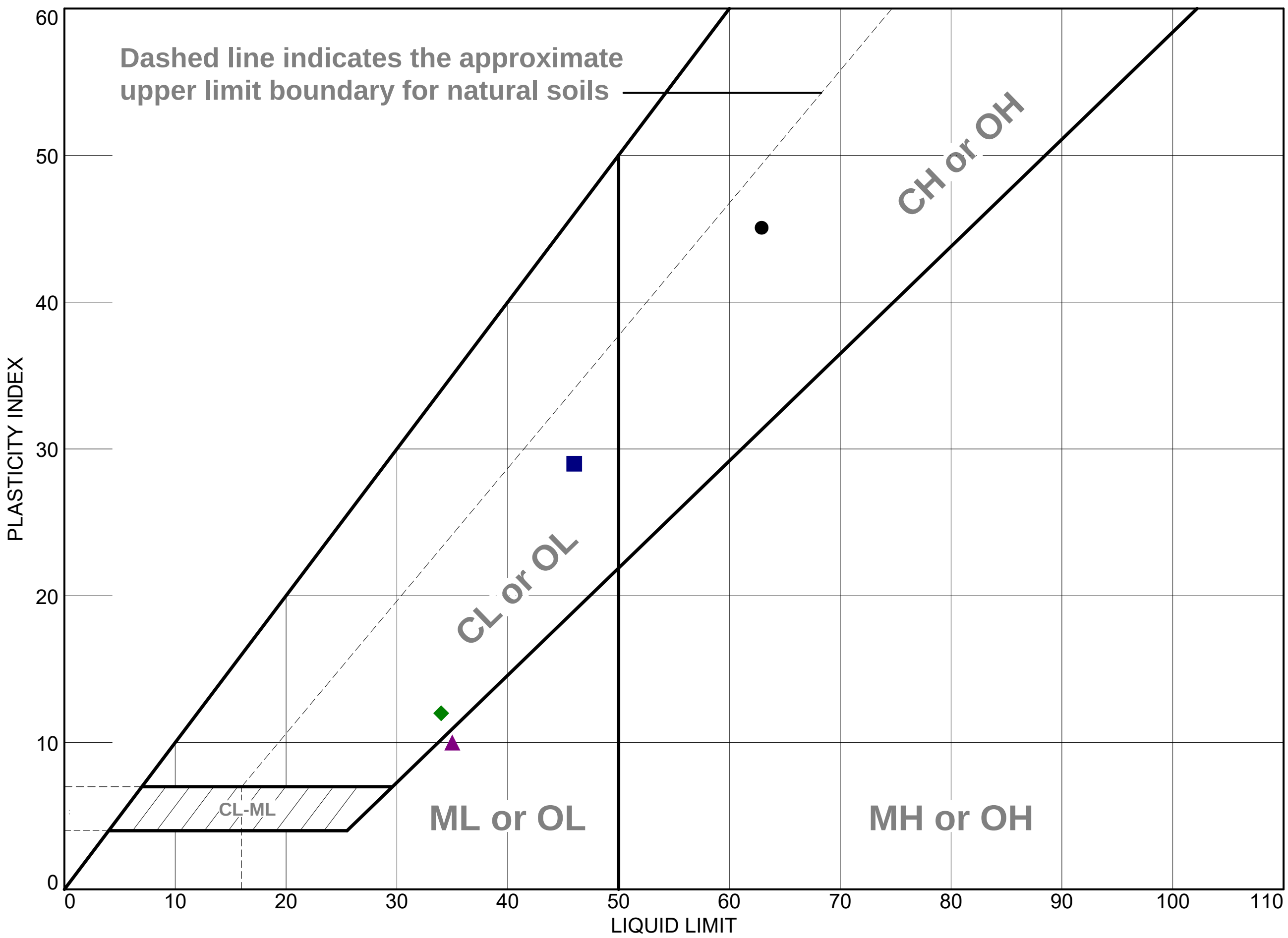
Remarks:

Blackburn Consulting

W. Sacramento, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Fat CLAY with SAND, dark grayish brown	63	18	45		83	CH
■	SANDY Lean CLAY, yellowish brown	46	17	29		59	CL
▲	SANDY SILT, dark olive brown	35	25	10		67	ML
◆	SANDY lean CLAY, dark olive brown	34	22	12		67	CL

Project No. 3195.P **Client:** EIP

Project: Lookout Slough THRFP

●**Source of Sample:** BCI-17-18 **Depth:** 3-4.5' **Sample Number:** 2
■**Source of Sample:** BCI-17-18 **Depth:** 6-6.5' **Sample Number:** 3
▲**Source of Sample:** BCI-17-18 **Depth:** 8.5-9' **Sample Number:** 5B
◆**Source of Sample:** BCI-17-18 **Depth:** 35-36.5' **Sample Number:** 13

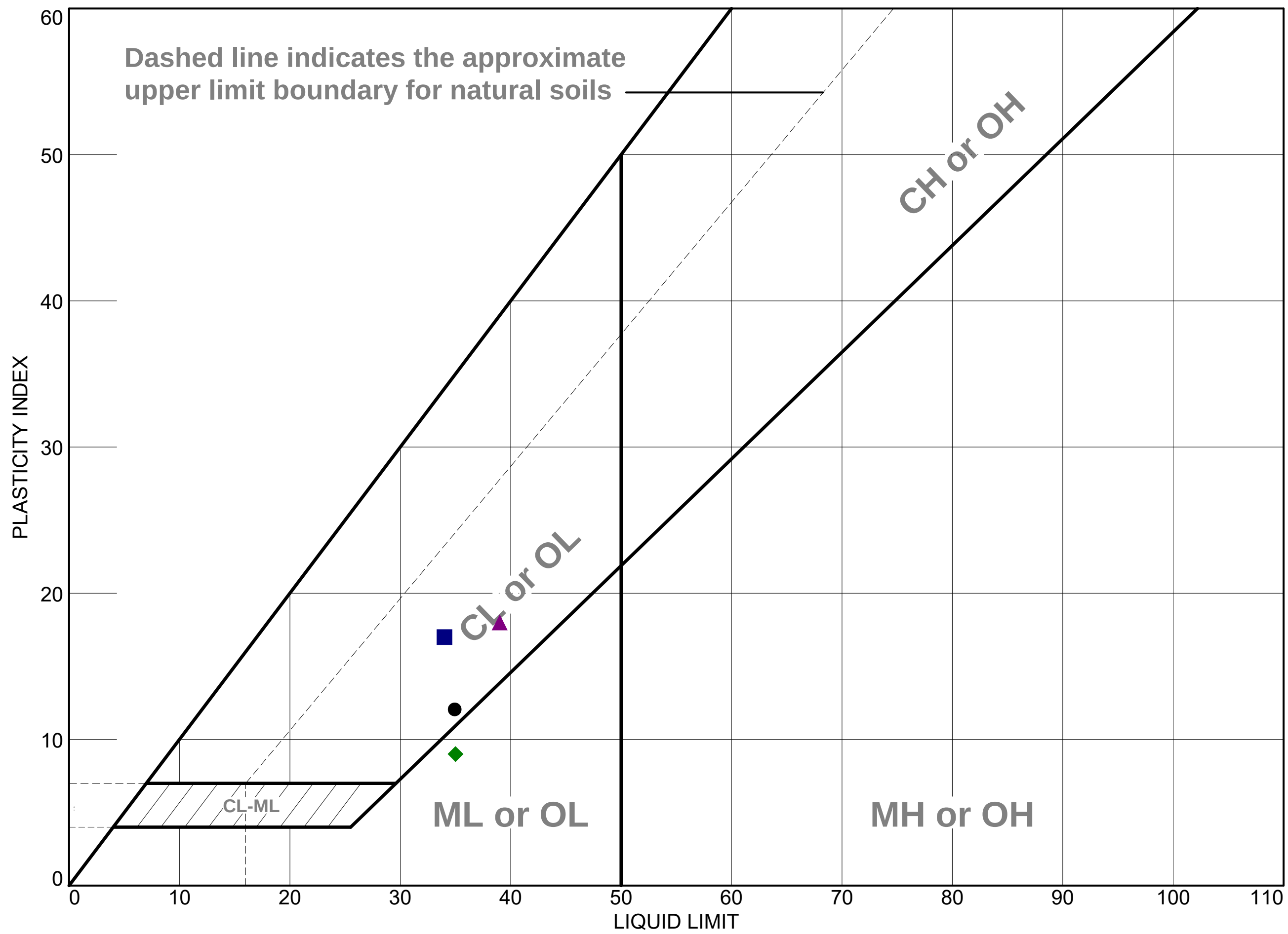
Remarks:

Blackburn Consulting

W. Sacramento, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Lean CLAY, dark yellowish brown	35	23	12			CL
■	CLAYEY SAND, dark brown	34	17	17		35	SC
▲	CLAYEY SAND. very dark olive brown	39	21	18		37	SC
◆	SANDY SILT, olive brown	35	26	9		58	ML

Project No. 3195.P **Client:** EIP

Project: Lookout Slough THRFP

● **Source of Sample:** BCI-17-19 **Depth:** 3.0-4.5' **Sample Number:** 2
■ **Source of Sample:** BCI-17-19 **Depth:** 5.5-7' **Sample Number:** 4
▲ **Source of Sample:** BCI-17-19 **Depth:** 15.5-16' **Sample Number:** 10B
◆ **Source of Sample:** BCI-17-19 **Depth:** 45.5-46' **Sample Number:** 16B

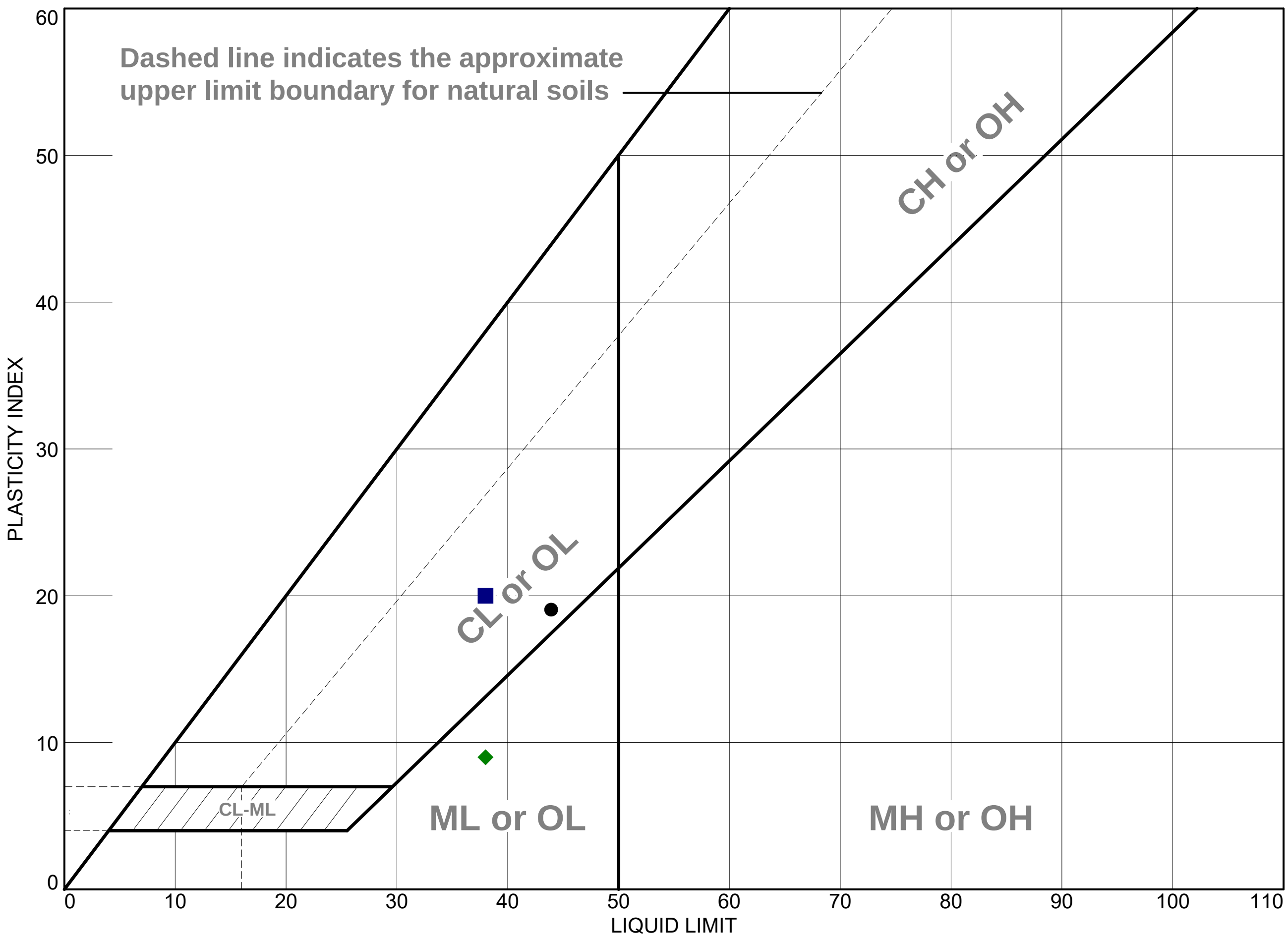
Remarks:

Blackburn Consulting

W. Sacramento, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Lean CLAY with SAND, olive brown	44	25	19		71	CL
■	CLAYEY SAND, dark yellowish brown	38	18	20		45	SC
▲	SILTY SAND, olive brown	NP	NP	NP		35	SM
◆	SANDY SILT, olive brown	38	29	9		56	ML

Project No. 3195.P **Client:** EIP

Project: Lookout Slough THRFP

● **Source of Sample:** BCI-17-20 **Depth:** 4-5.5' **Sample Number:** 2
■ **Source of Sample:** BCI-17-20 **Depth:** 9.-9.5' **Sample Number:** 4
▲ **Source of Sample:** BCI-17-20 **Depth:** 30.5-31 **Sample Number:** 9B
◆ **Source of Sample:** BCI-17-20 **Depth:** 35-36.5' **Sample Number:** 10

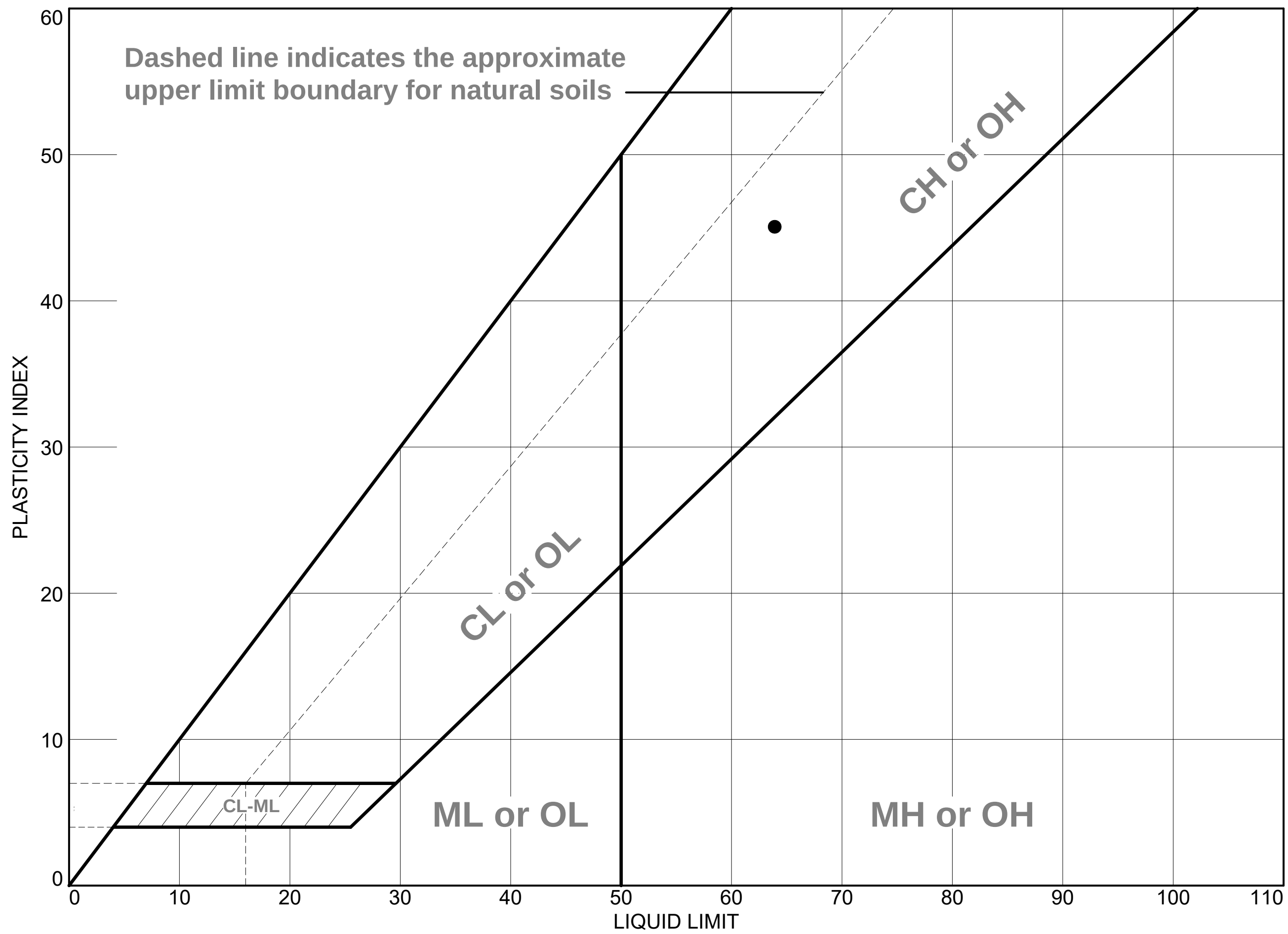
Blackburn Consulting

W. Sacramento, CA

Remarks:

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Fat CLAY, very dark gray	64	19	45	---	---	CH

Project No. 3195.P **Client:** EIP

Project: Lookout Slough THRFP

● **Source of Sample:** BCI-18-22 **Depth:** 1.0-2.5' **Sample Number:** 1

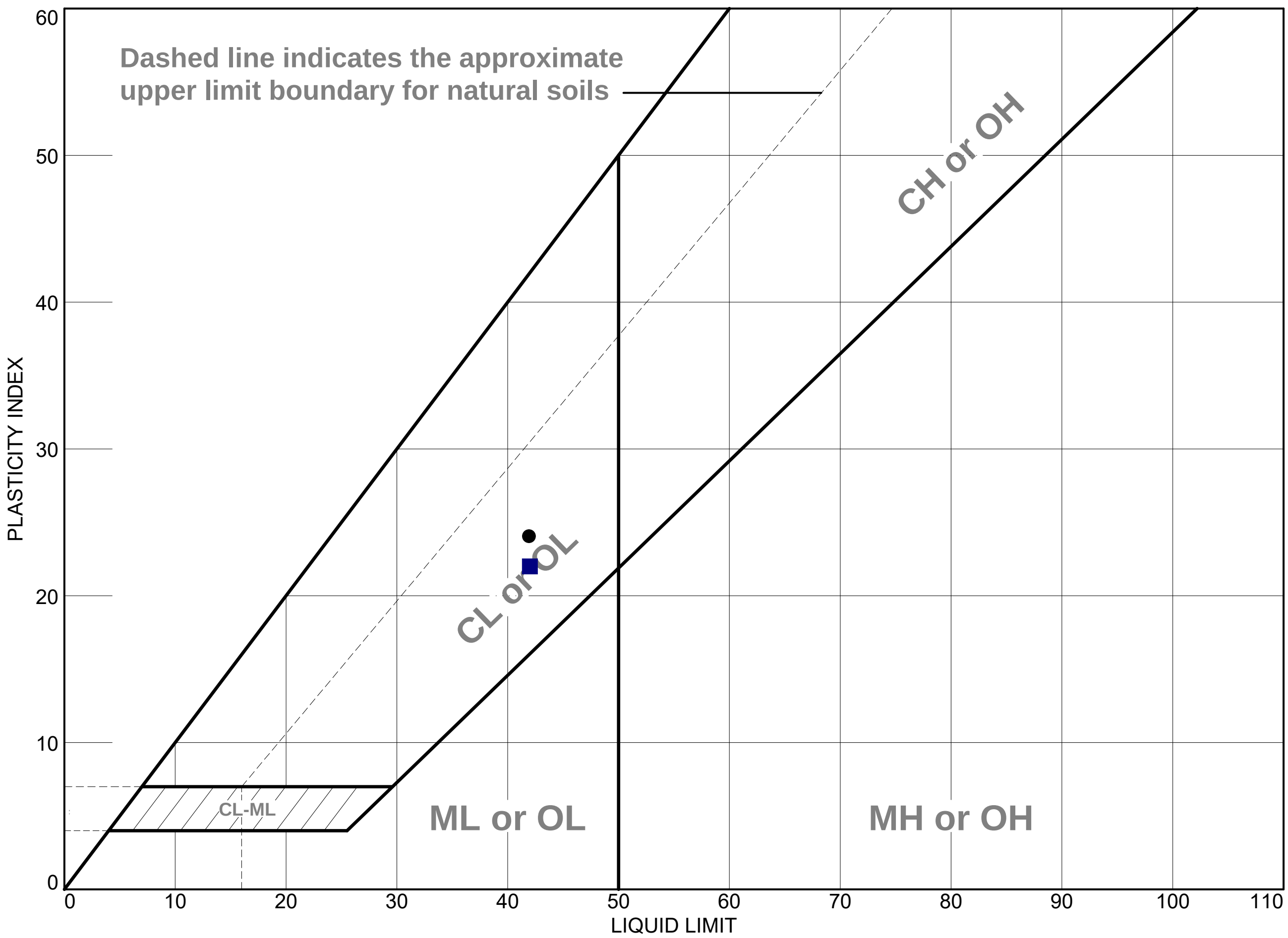
Remarks:

Blackburn Consulting

W. Sacramento, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Lean CLAY with SAND, olive brown	42	18	24	---	79	CL
■	Lean CLAY, olive brown	42	20	22	---	95	CL

Project No. 3195.P **Client:** EIP

Project: Lookout Slough THRFP

● **Source of Sample:** BCI-18-23 **Depth:** 9.5-11.0' **Sample Number:** 5

■ **Source of Sample:** BCI-18-23 **Depth:** 12.5-14.0' **Sample Number:** 7

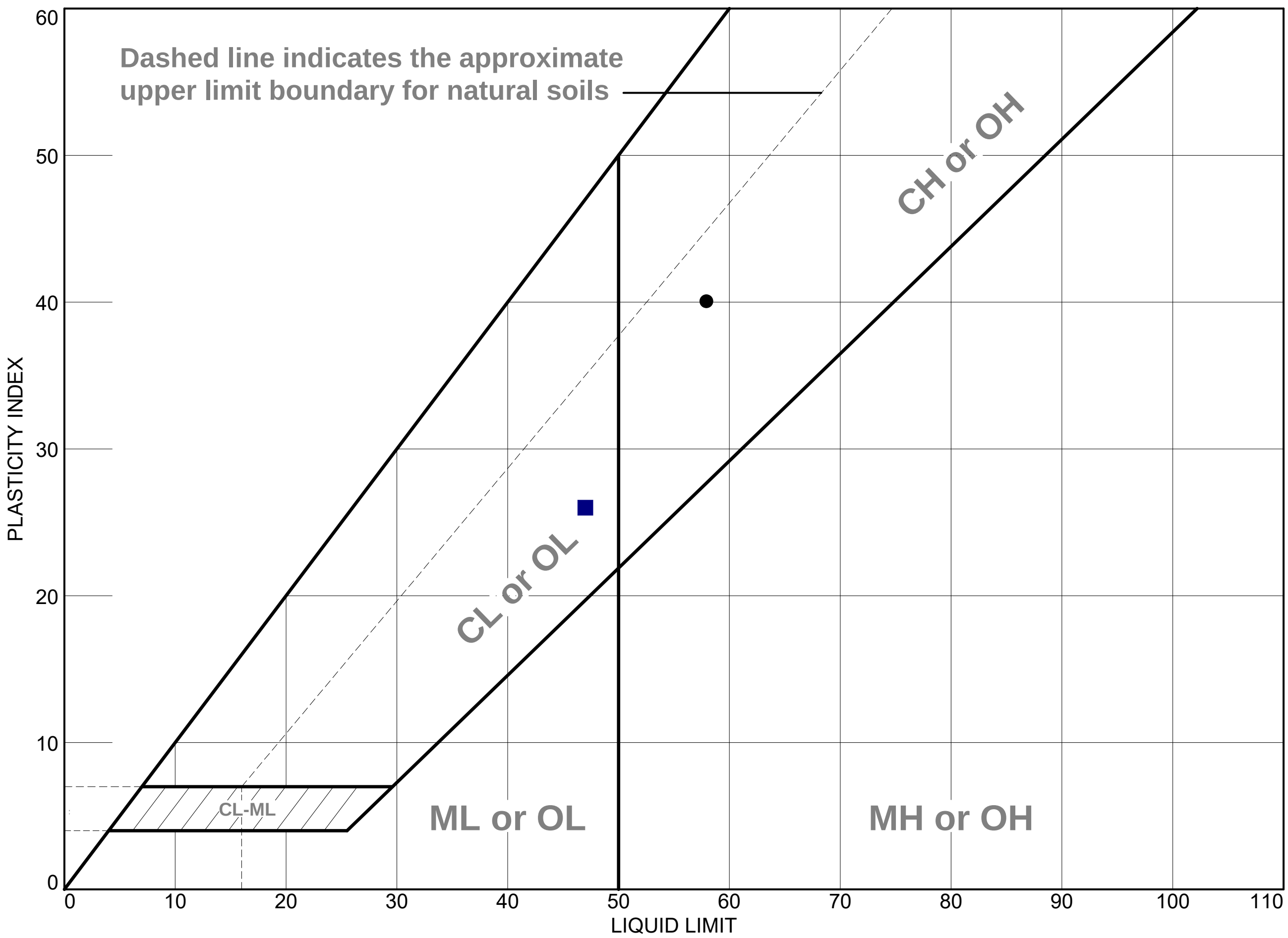
Remarks:

Blackburn Consulting

W. Sacramento, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Fat CLAY, very dark gray	58	18	40	---	94	CH
■	Lean CLAY, olive brown	47	21	26	---	95	CL

Project No. 3195.P **Client:** EIP

Project: Lookout Slough THRFP

● **Source of Sample:** BCI-18-24 **Depth:** 1.0-2.5' **Sample Number:** 1

■ **Source of Sample:** BCI-18-24 **Depth:** 14.0-15.5' **Sample Number:** 8

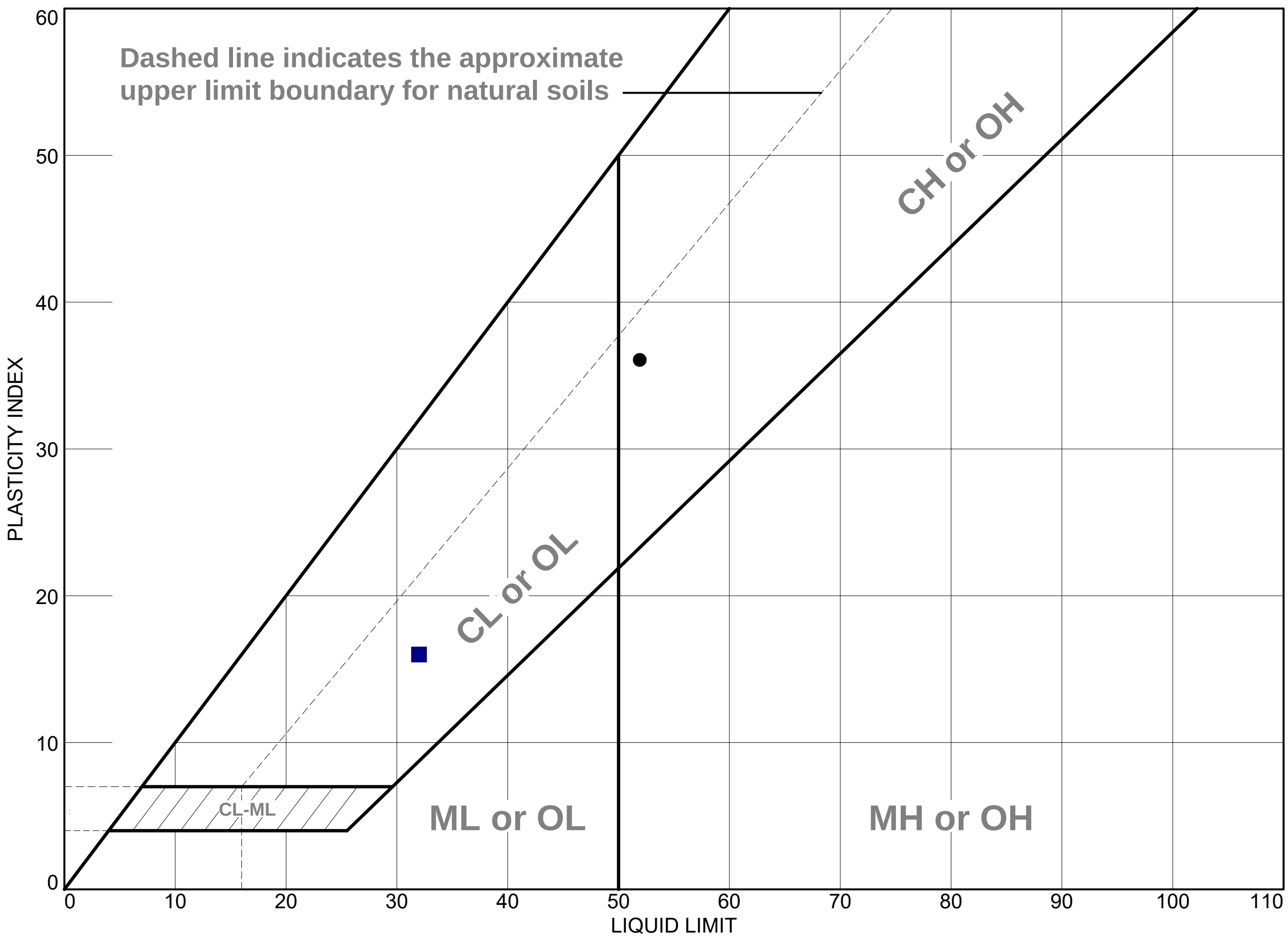
Remarks:

Blackburn Consulting

W. Sacramento, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Fat CLAY, yellowish brown	52	16	36			CH
■	Lean CLAY, yellowish brown	32	16	16			CL

Project No. 3195.P **Client:** EIP

Project: Lookout Slough THRFP

● **Source of Sample:** BCI-18-25 **Depth:** 1.0-2.5' **Sample Number:** 1

■ **Source of Sample:** BCI-18-25 **Depth:** 2.5-4.0' **Sample Number:** 2

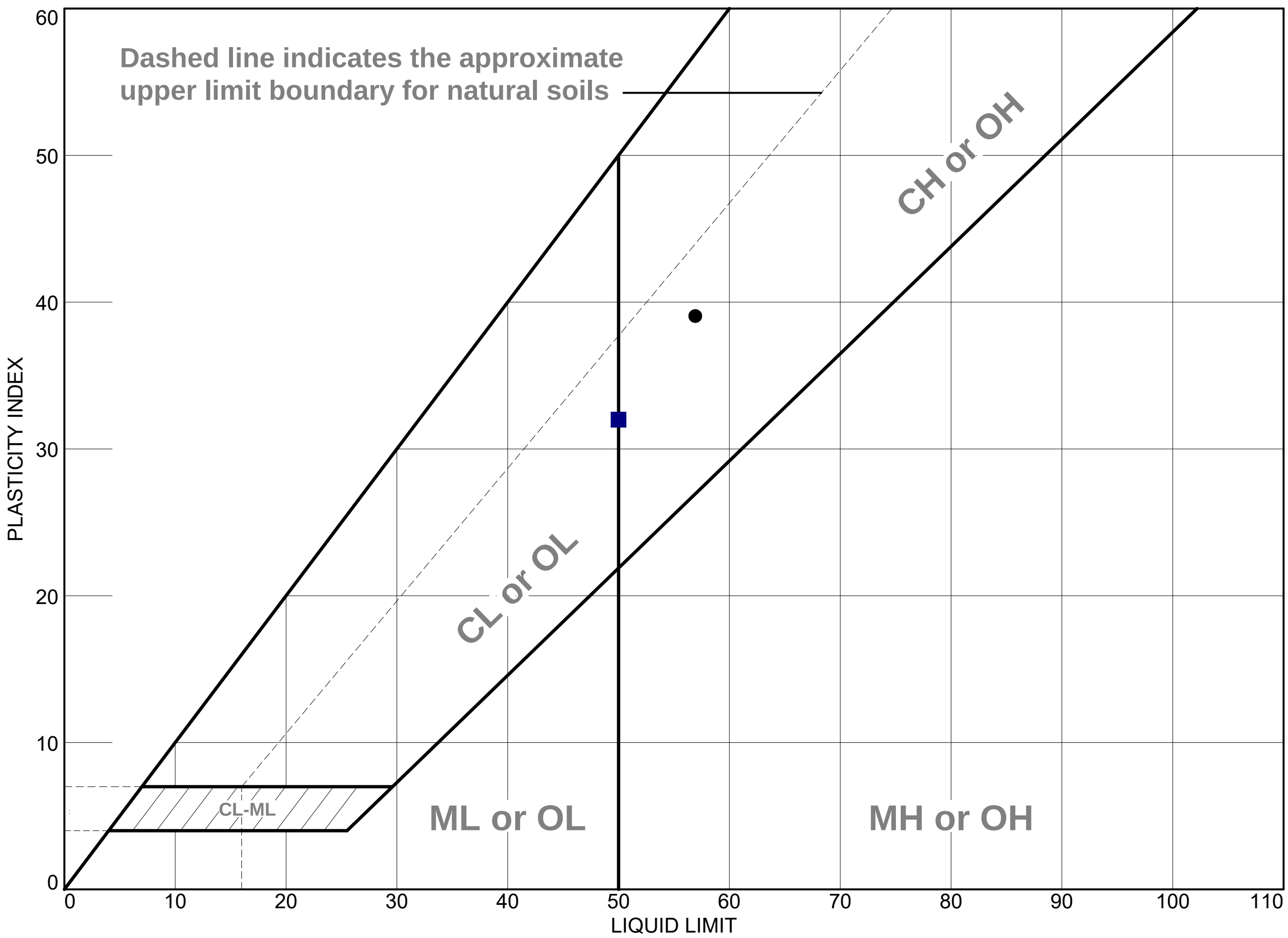
Remarks:

Blackburn Consulting

W. Sacramento, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Fat CLAY, very dark brown	57	18	39			CH
■	Fat CLAY, olive brown	50	18	32	---	86	CH

Project No. 3195.P **Client:** EIP

Project: Lookout Slough THRFP

● **Source of Sample:** BCI-18-26 **Depth:** 1.0-2.5' **Sample Number:** 1

■ **Source of Sample:** BCI-18-26 **Depth:** 5.0-6.5' **Sample Number:** 2

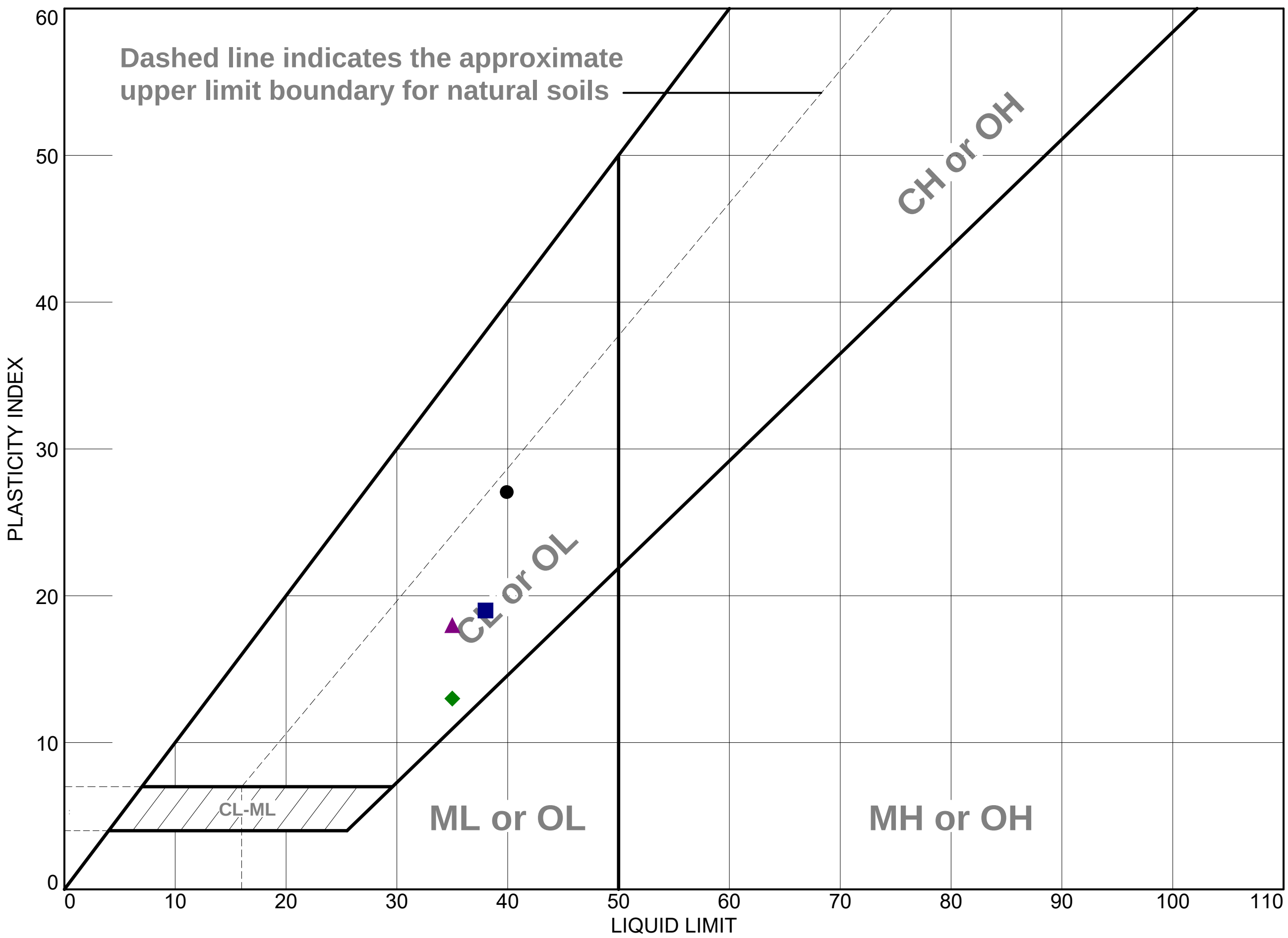
Remarks:

Blackburn Consulting

W. Sacramento, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Lean CLAY, dark olive brown	40	13	27			CL
■	Lean CLAY with SAND, dark yellowish brown	38	19	19		74	CL
▲	SANDY lean CLAY, dark yellowish brown	35	17	18		50	CL
◆	SANDY lean CLAY, olive brown	35	22	13	---	62	CL

Project No. 3195.P **Client:** EIP

Project: Lookout Slough THRFP

●**Source of Sample:** BCI-18-27 **Depth:** 1.0-2.5' **Sample Number:** 1
■**Source of Sample:** BCI-18-27 **Depth:** 11.0-12.5' **Sample Number:** 6
▲**Source of Sample:** BCI-18-27 **Depth:** 15.5-17.0' **Sample Number:** 9
◆**Source of Sample:** BCI-18-27 **Depth:** 35.0-36.5' **Sample Number:** 13

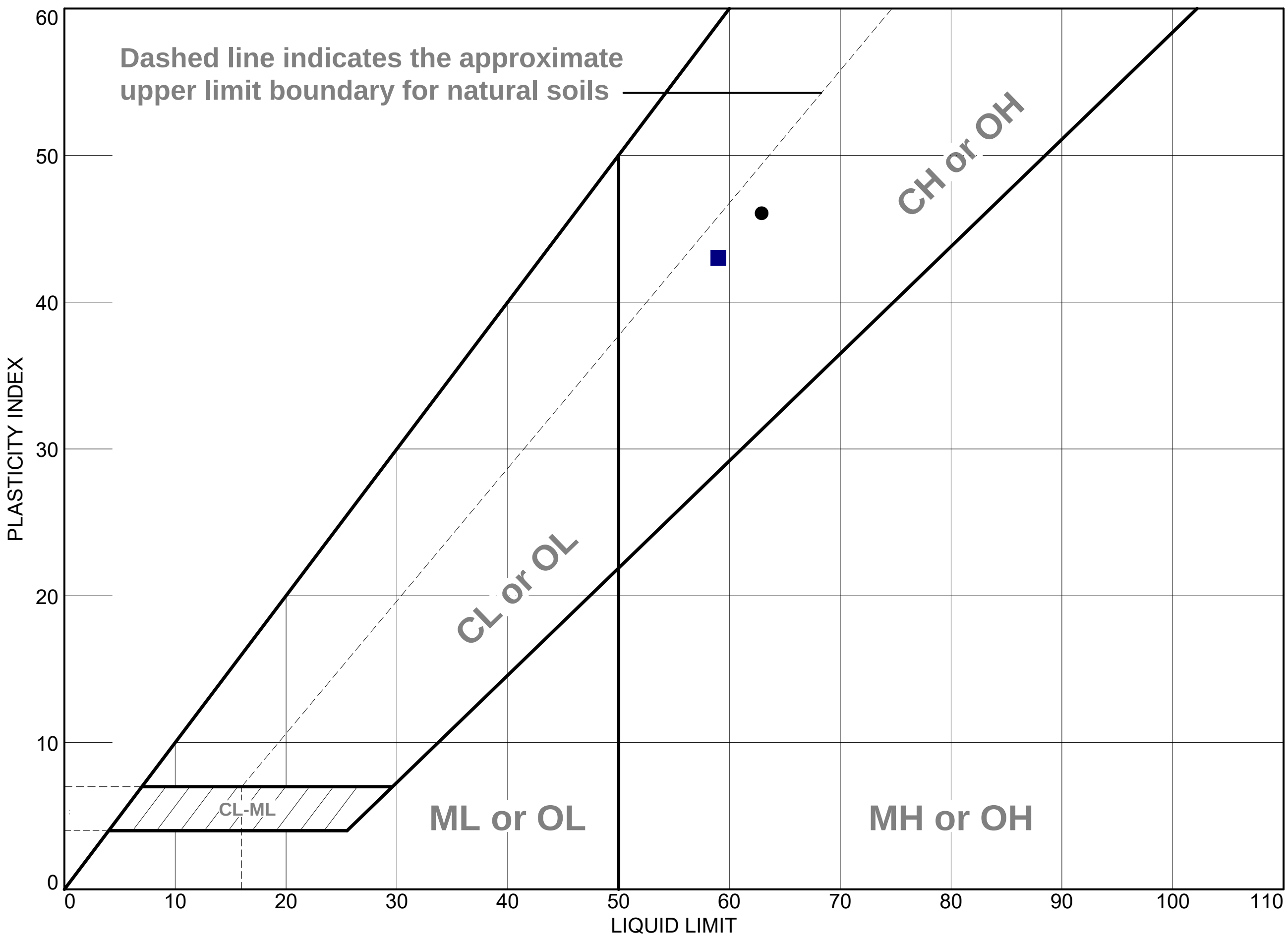
Remarks:

Blackburn Consulting

W. Sacramento, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Fat CLAY with SAND,dark olive gray	63	17	46		85	CH
■	Fat CLAY,dark yellowish brown and black	59	16	43		98	CH

Project No. 3195.P **Client:** EIP

Project: Lookout Slough THRFP

● **Source of Sample:** BCI-18-29 **Depth:** 1-3' **Sample Number:** Bulk A

■ **Source of Sample:** BCI-18-29 **Depth:** 4.5-6' **Sample Number:** 2

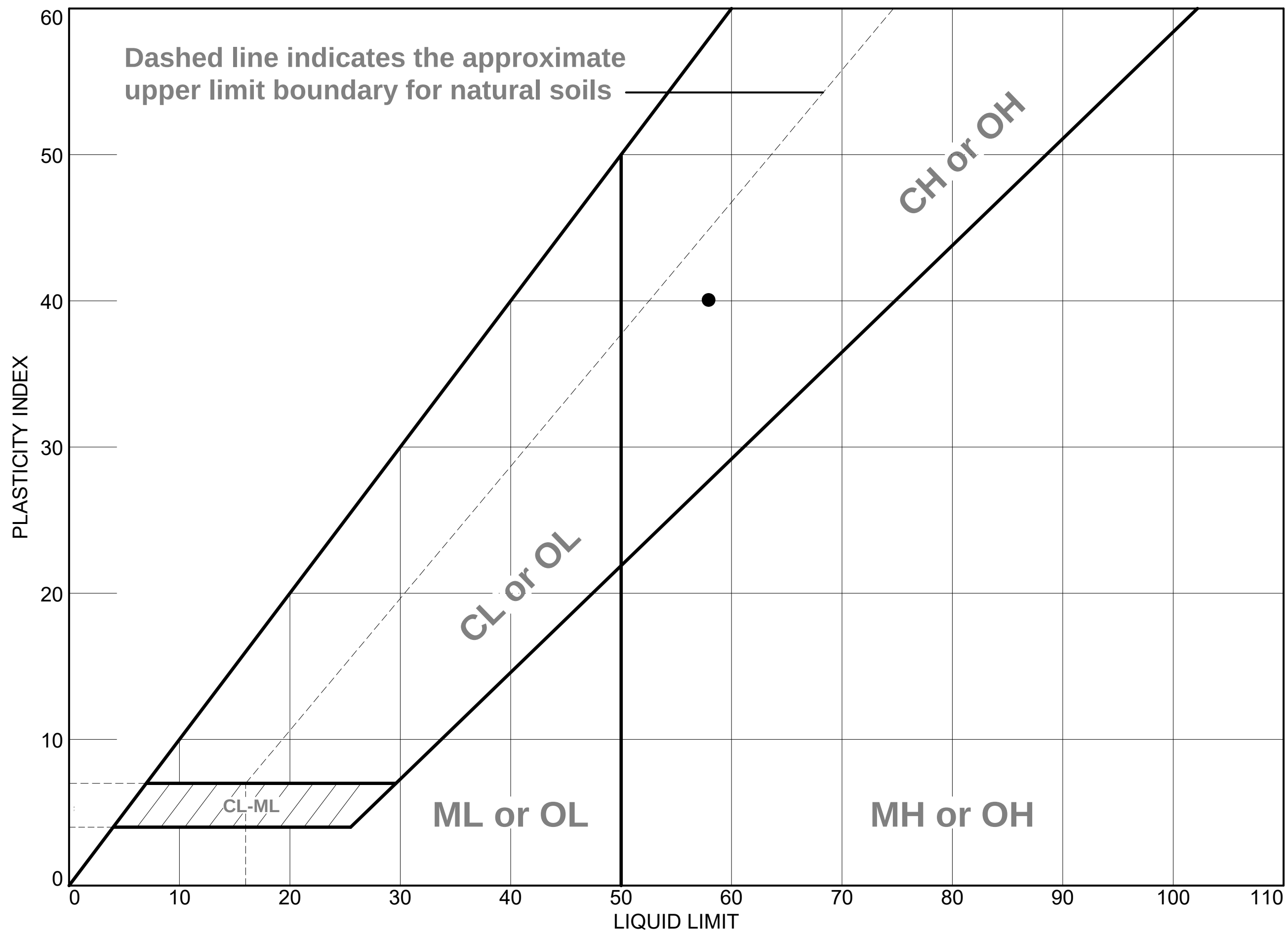
Remarks:

Blackburn Consulting

W. Sacramento, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Fat CLAY, dark grayish brown	58	18	40		98	CH

Project No. 3195.P **Client:** EIP

Project: Lookout Slough THRFP

● **Source of Sample:** BCI-18-30 **Depth:** 4.5-5.0' **Sample Number:** 2B

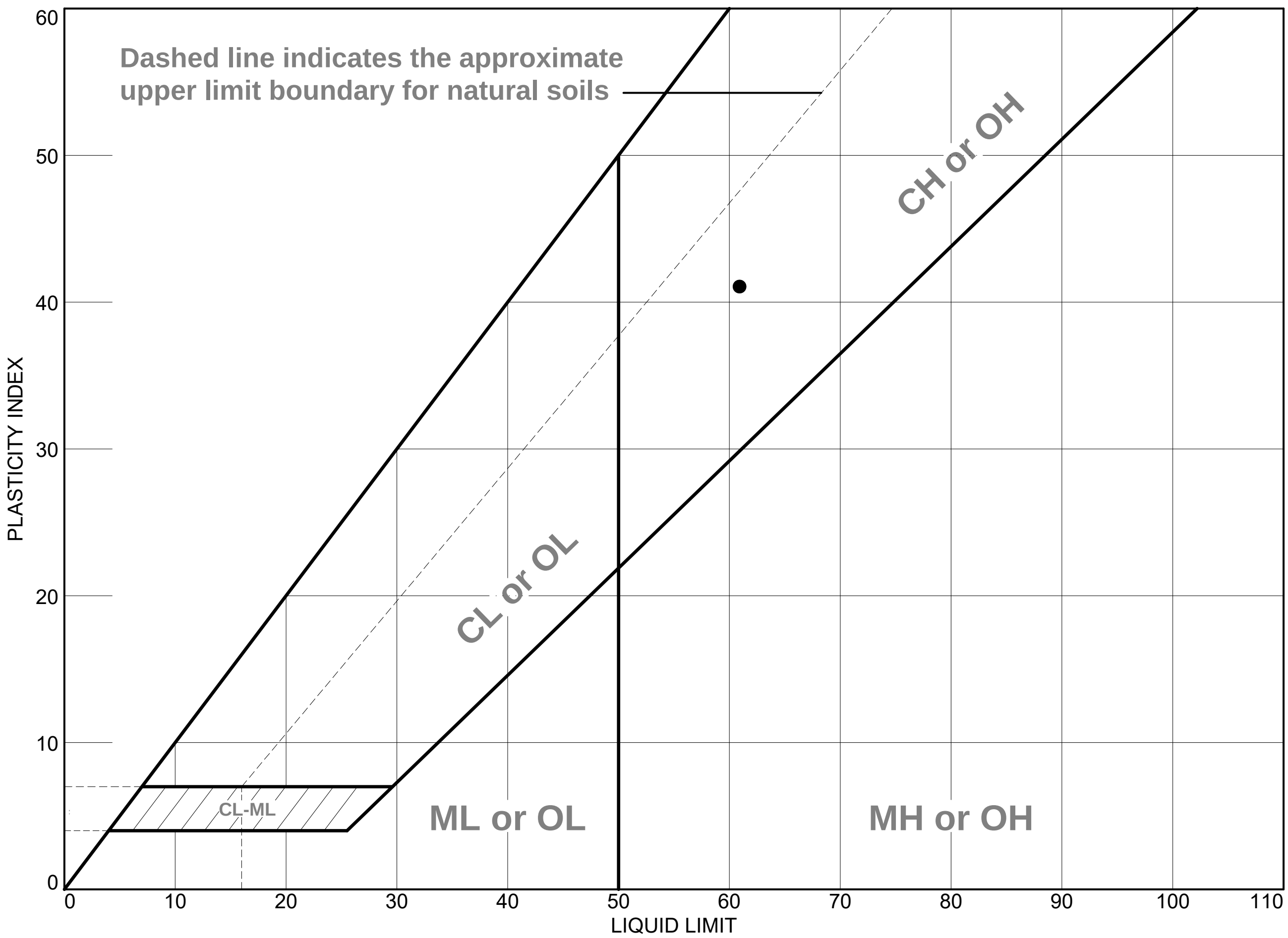
Remarks:

Blackburn Consulting

W. Sacramento, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Fat CLAY, very dark grayish brown	61	20	41		89	CH

Project No. 3195.P **Client:** EIP

Project: Lookout Slough THRFP

● **Source of Sample:** BCI-18-31 **Depth:** 9-9.5' **Sample Number:** 4C

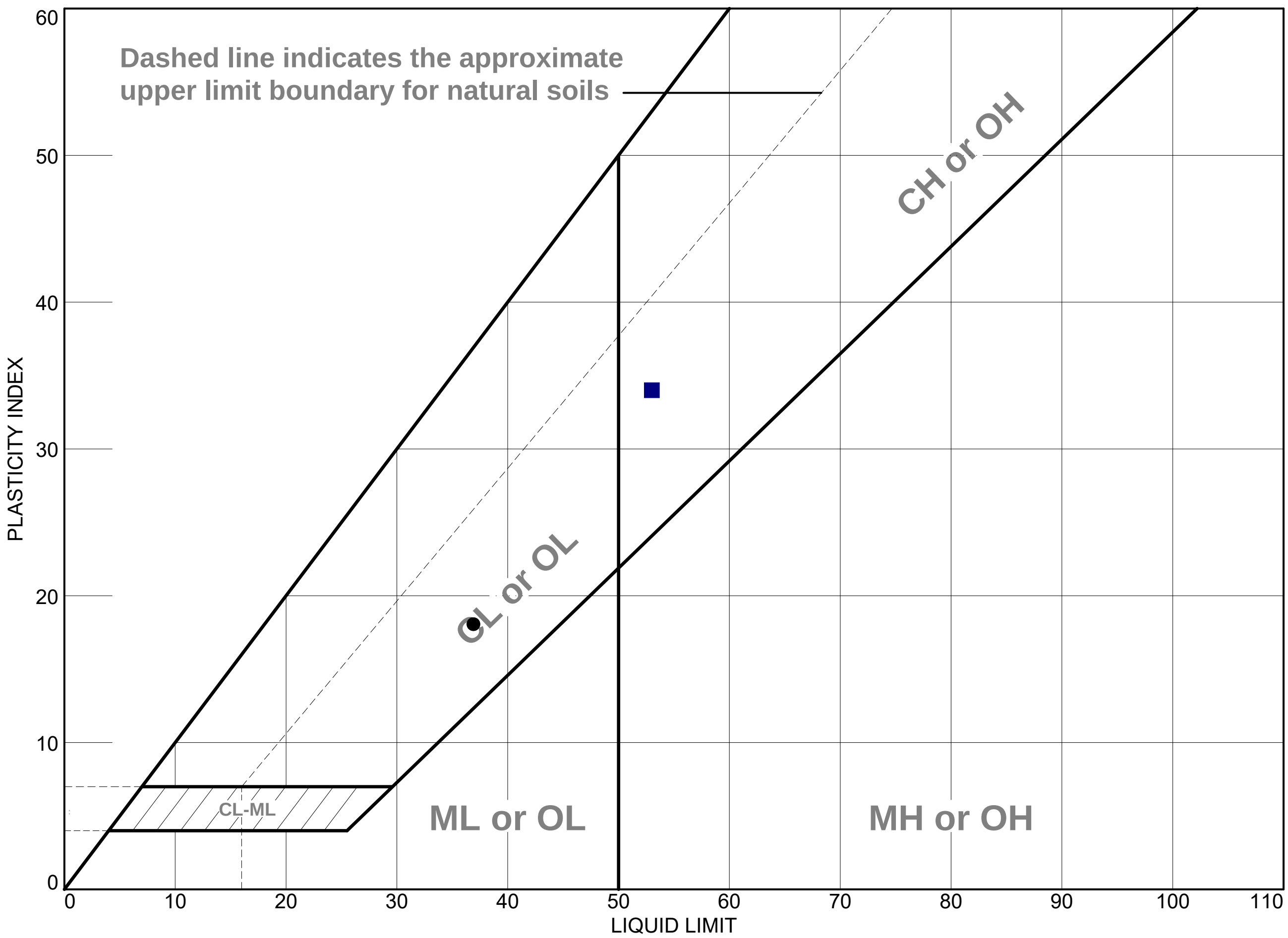
Blackburn Consulting

W. Sacramento, CA

Remarks:

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	SANDY lean CLAY, dark yellowish brown	37	19	18		67	CL
■	Fat CLAY with SAND, dark yellowish brown	53	19	34		77	CH

Project No. 3195.P **Client:** EIP

Project: Lookout Slough THRFP

● **Source of Sample:** BCI-18-32 **Depth:** 2-2.5' **Sample Number:** 1C

■ **Source of Sample:** BCI-18-32 **Depth:** 10-10.5' **Sample Number:** 4C

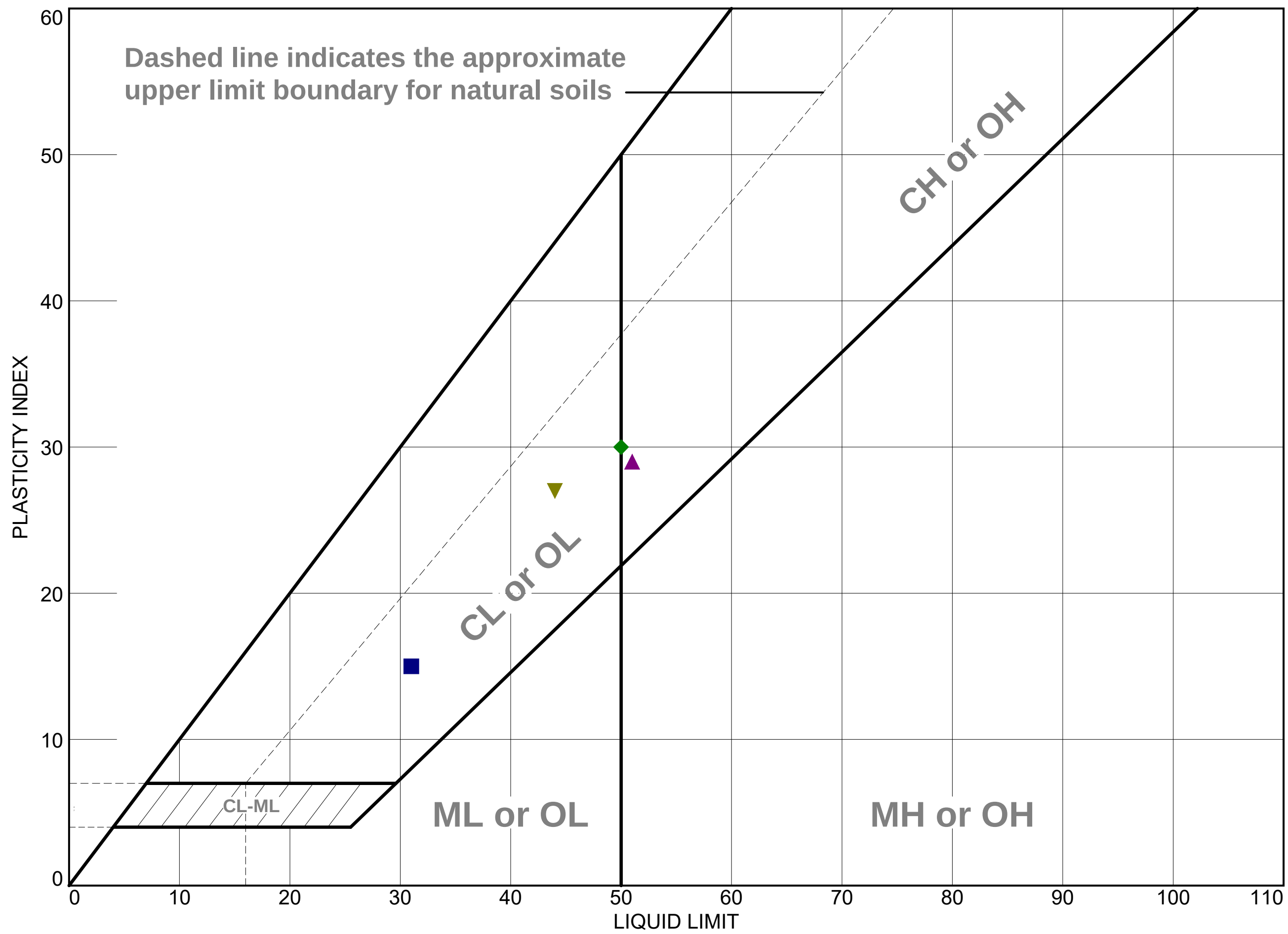
Remarks:

Blackburn Consulting

W. Sacramento, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Poorly-graded SAND with SILT, olive brown	NP	NP	NP		8	SP-SM
■	Poorly-graded SAND with CLAY, olive brown	31	16	15		12	SP-SC
▲	Fat CLAY, olive brown	51	22	29		97	CH
◆	SANDY Fat CLAY, light olive brown	50	20	30	63	55	CH
▼	Lean CLAY, yellowish brown	44	17	27	100	94	CL

Project No. 3195.P **Client:** EIP

Project: Lookout Slough THRFP

● **Source of Sample:** BCI-19-33 **Depth:** 9.5-10' **Sample Number:** 6B
■ **Source of Sample:** BCI-19-33 **Depth:** 11-11.5' **Sample Number:** 7
▲ **Source of Sample:** BCI-19-33 **Depth:** 13.5-14' **Sample Number:** 8B
◆ **Source of Sample:** BCI-19-33 **Depth:** 14.5-15' **Sample Number:** 9
▼ **Source of Sample:** BCI-19-33 **Depth:** 17-17.5' **Sample Number:** 10B

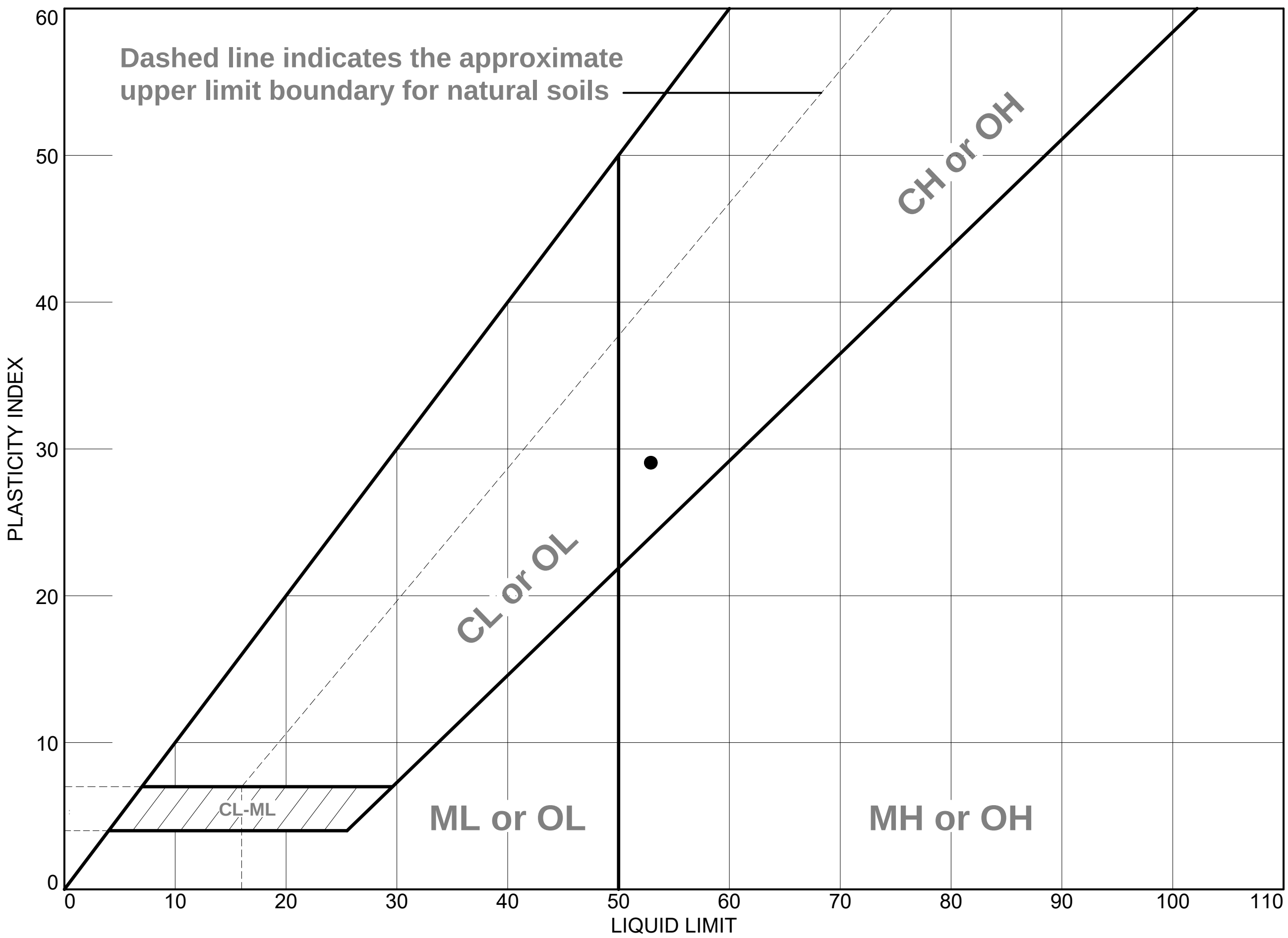
Remarks:

Blackburn Consulting

W. Sacramento, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Fat CLAY, light olive brown	53	24	29		86	CH

Project No. 3195.P **Client:** EIP

Project: Lookout Slough THRFP

● **Source of Sample:** BCI-19-33 **Depth:** 30.5-31' **Sample Number:** 16B

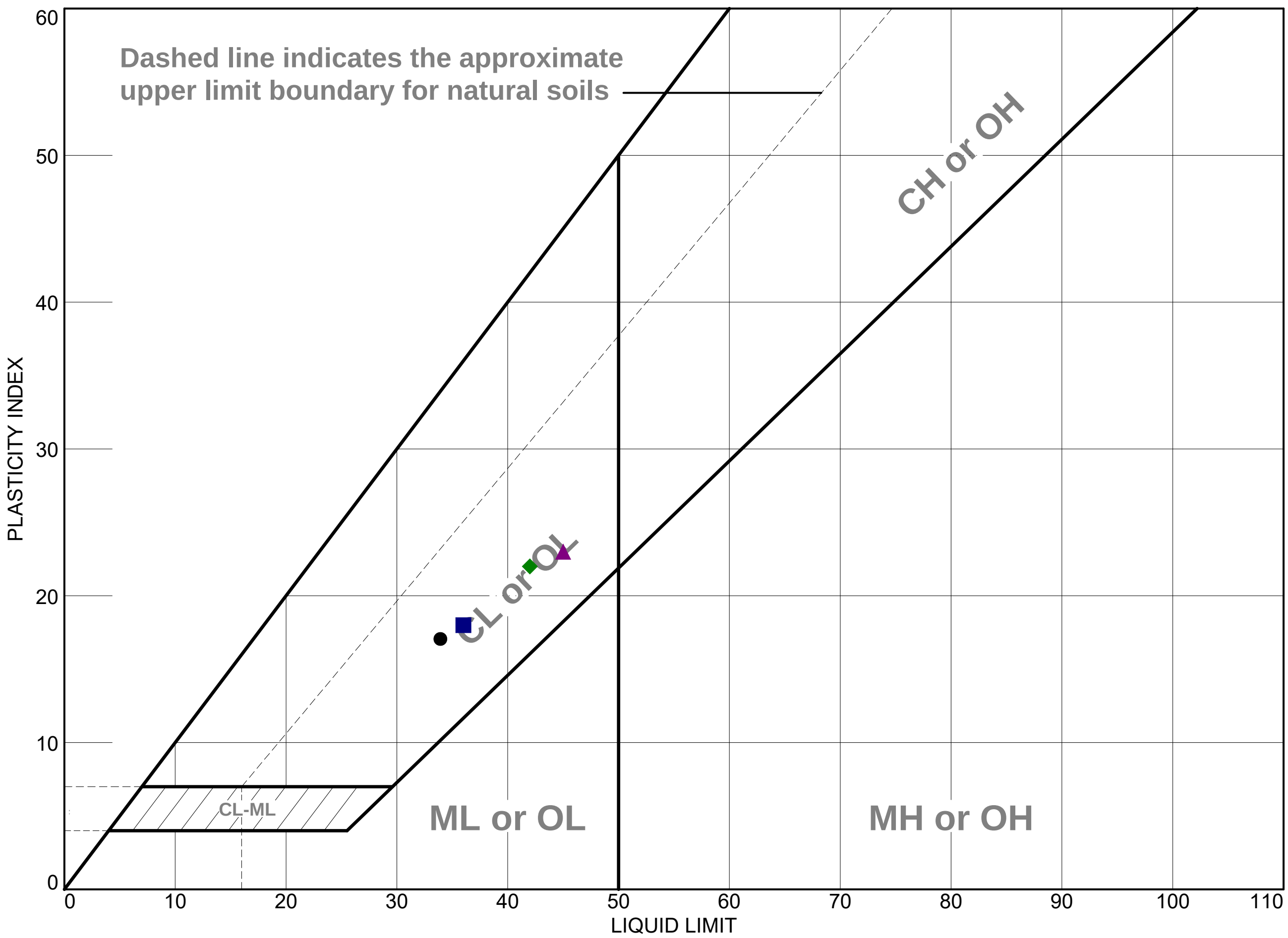
Remarks:

Blackburn Consulting

W. Sacramento, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	CLAYEY SAND, yellowish brown	34	17	17		46	SC
■	Lean CLAY with SAND, light olive brown	36	18	18		76	CL
▲	Lean CLAY, light olive brown	45	22	23		96	CL
◆	Lean CLAY with SAND, light olive brown	42	20	22		84	CL

Project No. 3195.P **Client:** EIP

Project: Lookout Slough THRFP

● **Source of Sample:** BCI-19-34 **Depth:** 10.5-11' **Sample Number:** 5
■ **Source of Sample:** BCI-19-34 **Depth:** 11.5-12' **Sample Number:** 5
▲ **Source of Sample:** BCI-19-34 **Depth:** 12.5-14' **Sample Number:** 6
◆ **Source of Sample:** BCI-19-34 **Depth:** 14.2-14.7' **Sample Number:** 7

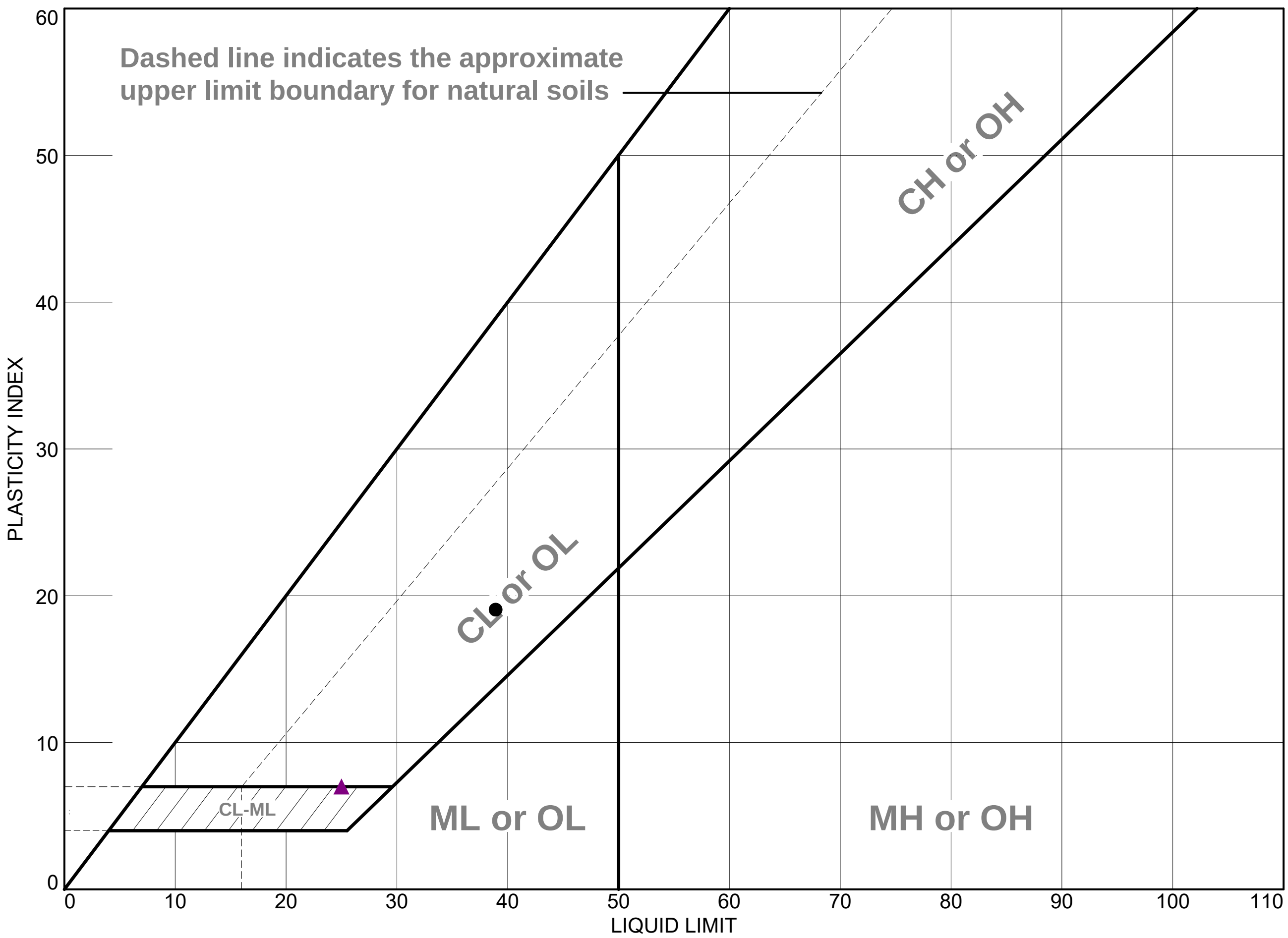
Remarks:

Blackburn Consulting

W. Sacramento, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Lean CLAY, light olive brown	39	20	19		86	CL
■	SILTY SAND, olive brown	NP	NP	NP		31	SM
▲	SILTY CLAYEY SAND, very dark gray	25	18	7		40	SC-SM

Project No. 3195.P **Client:** EIP

Project: Lookout Slough THRFP

●**Source of Sample:** BCI-19-35 **Depth:** 7.5-8' **Sample Number:** 4C
■**Source of Sample:** BCI-19-35 **Depth:** 14.5-15' **Sample Number:** 8C
▲**Source of Sample:** BCI-19-35 **Depth:** 50-51.5' **Sample Number:** 20

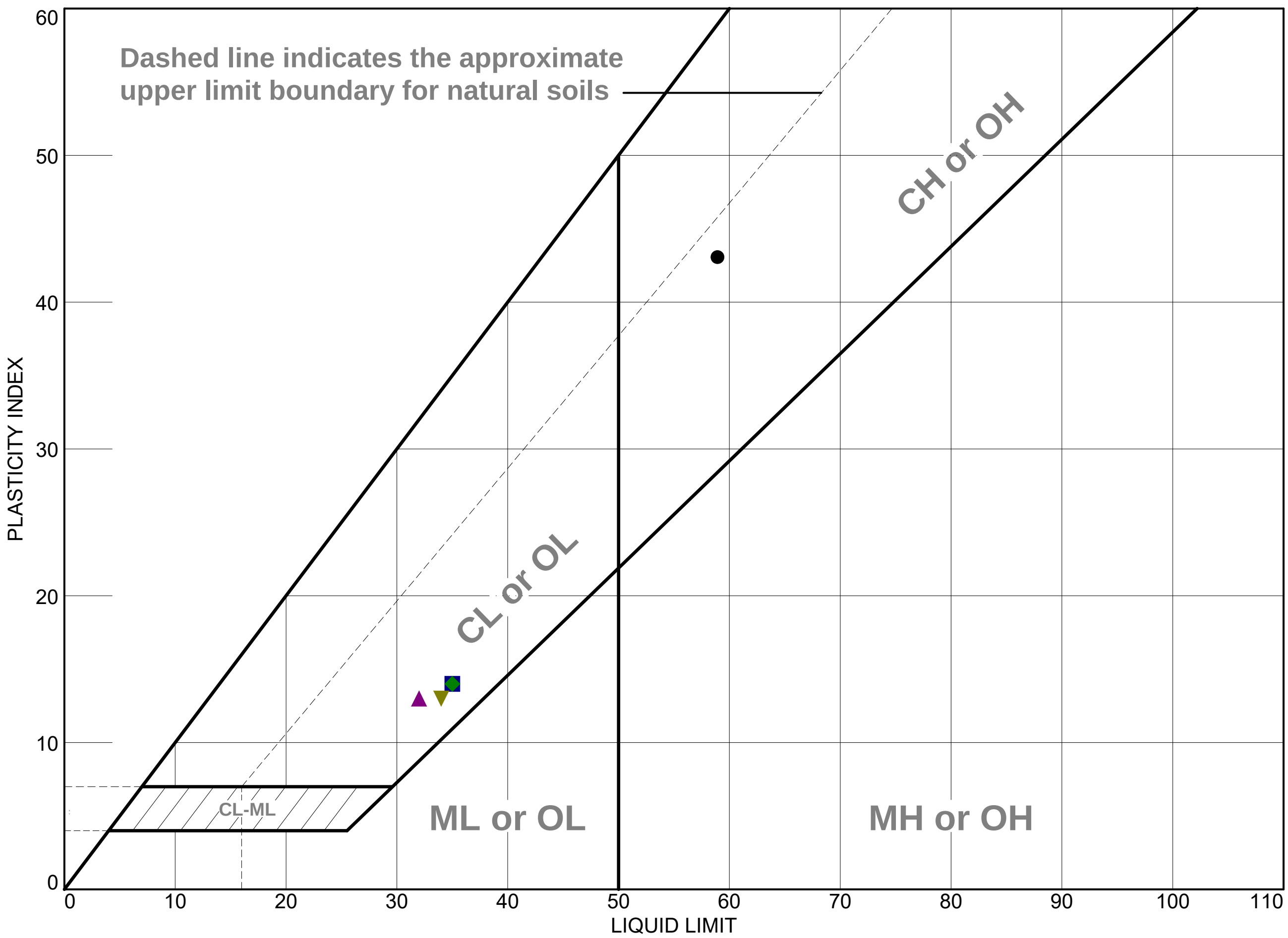
Remarks:

Blackburn Consulting

W. Sacramento, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Fat CLAY, light olive brown	59	16	43			CH
■	Lean CLAY with SAND, yellowish brown	35	21	14		84	CL
▲	Lean CLAY with SAND, light olive brown	32	19	13		77	CL
◆	Lean CLAY, olive brown	35	21	14		86	CL
▼	Lean CLAY with SAND, light olive brown	34	21	13		82	CL

Project No. 3195.P **Client:** EIP

Project: Lookout Slough THRFP

● **Source of Sample:** BCI-19-36 **Depth:** 4-4.5 **Sample Number:** 2C
■ **Source of Sample:** BCI-19-36 **Depth:** 9-9.5' **Sample Number:** 5
▲ **Source of Sample:** BCI-19-36 **Depth:** 9.5-10.3 **Sample Number:** 5
◆ **Source of Sample:** BCI-19-36 **Depth:** 10.5-11' **Sample Number:** 6B
▼ **Source of Sample:** BCI-19-36 **Depth:** 11.5-12' **Sample Number:** 7

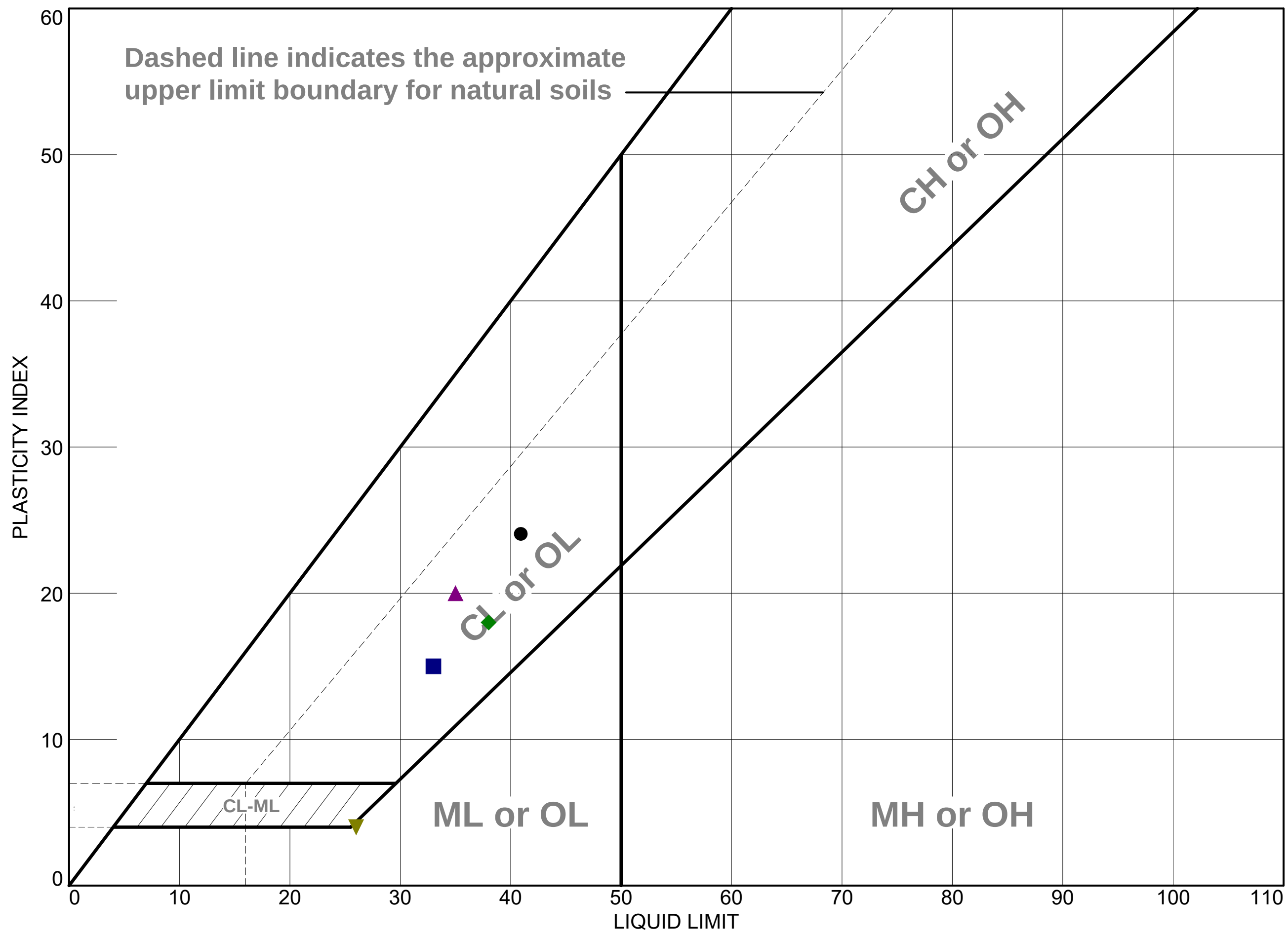
Remarks:

Blackburn Consulting

W. Sacramento, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Lean CLAY with SAND, yellowish brown	41	17	24		82	CL
■	Lean CLAY with SAND, olive yellow	33	18	15		73	CL
▲	Lean CLAY with SAND, light olive brown	35	15	20		84	CL
◆	Lean CLAY, yellowish brown	38	20	18		88	CL
▼	SANDY SILTY CLAY, dark yellowish brown	26	22	4		60	CL-ML

Project No. 3195.P **Client:** EIP

Project: Lookout Slough THRFP

● **Source of Sample:** BCI-19-36 **Depth:** 12.5-13' **Sample Number:** 7
■ **Source of Sample:** BCI-19-36 **Depth:** 13.5-15' **Sample Number:** 8
▲ **Source of Sample:** BCI-19-36 **Depth:** 16.5-17.1' **Sample Number:** 9
◆ **Source of Sample:** BCI-19-36 **Depth:** 17-18.5' **Sample Number:** 10
▼ **Source of Sample:** BCI-19-36 **Depth:** 41-41.5' **Sample Number:** 18C

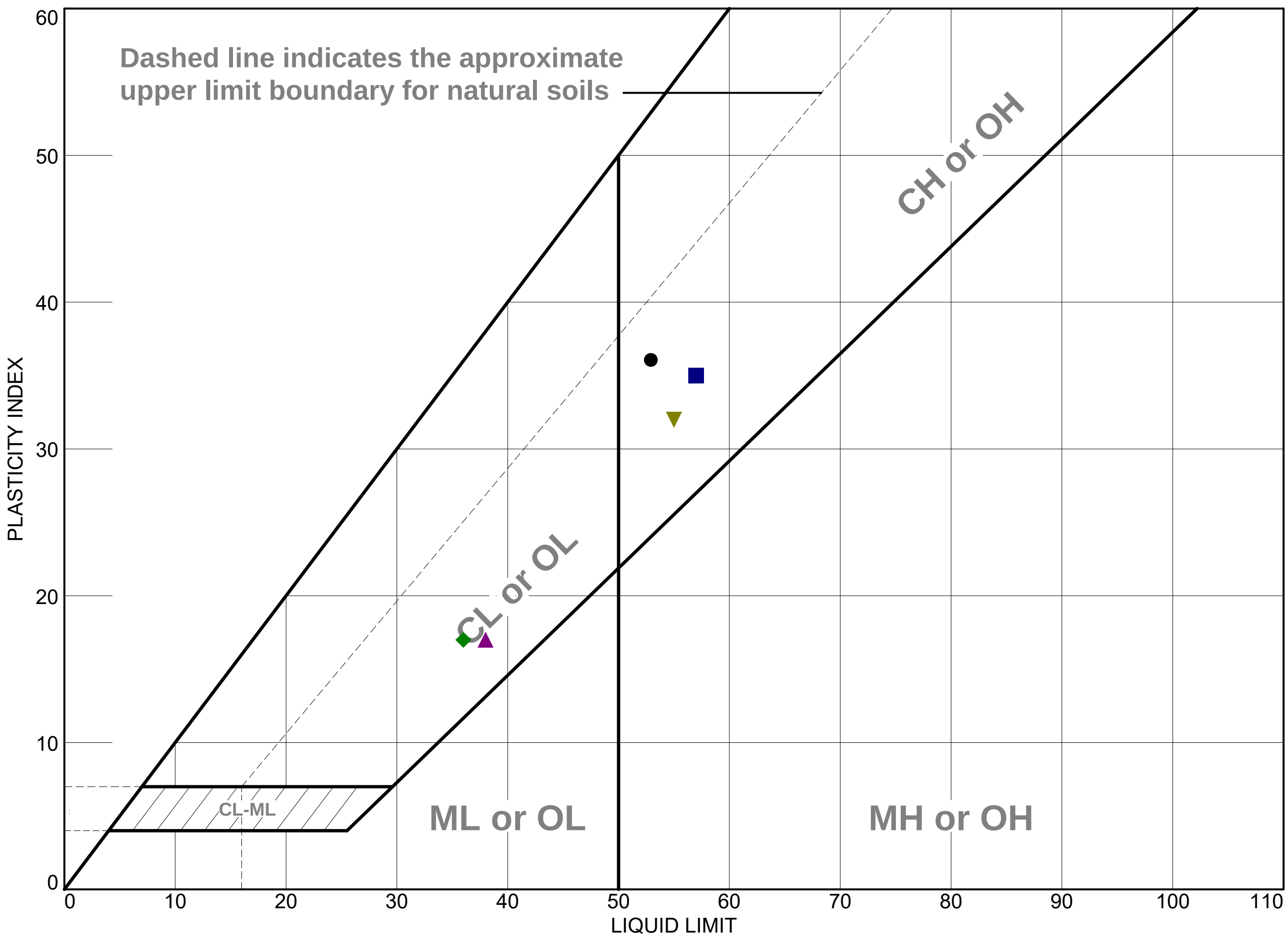
Remarks:

Blackburn Consulting

W. Sacramento, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	SANDY FAT CLAY, dark olive gray	53	17	36		70	CH
■	Fat CLAY, light olive brown	57	22	35			CH
▲	Lean CLAY with SAND, light olive brown	38	21	17		79	CL
◆	SANDY lean CLAY, light olive brown	36	19	17		64	CL
▼	Fat CLAY, light olive brown	55	23	32		94	CH

Project No. 3195.P **Client:** EIP

Project: Lookout Slough THRFP

●**Source of Sample:** BCI-19-37 **Depth:** 4.5-5' **Sample Number:** 2C
■**Source of Sample:** BCI-19-37 **Depth:** 7-8.5' **Sample Number:** 4C
▲**Source of Sample:** BCI-19-37 **Depth:** 10.5-12' **Sample Number:** 6B
◆**Source of Sample:** BCI-19-37 **Depth:** 17.5-19' **Sample Number:** 10C
▼**Source of Sample:** BCI-19-37 **Depth:** 23.5-24' **Sample Number:** 13

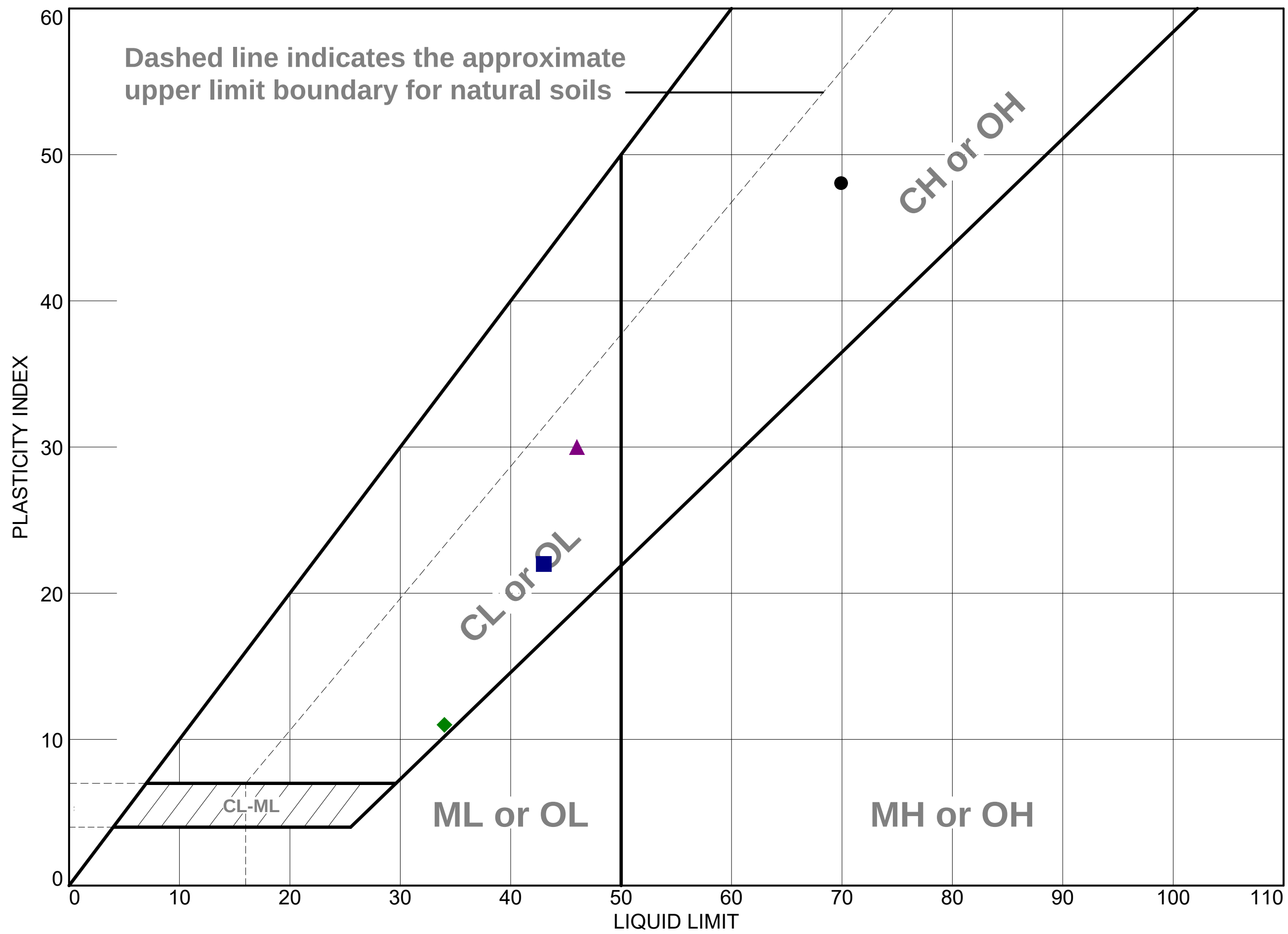
Remarks:

Blackburn Consulting

W. Sacramento, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Fat CLAY, dark olive gray	70	22	48		99	CH
■	Lean CLAY with SAND, yellowish brown	43	21	22		84	CL
▲	Lean CLAY, light olive brown	46	16	30		89	CL
◆	Lean CLAY with SAND, olive brown	34	23	11		78	CL

Project No. 3195.P **Client:** EIP

Project: Lookout Slough THRFP

●**Source of Sample:** BCI-19-38 **Depth:** 5-5.5' **Sample Number:** 2C
■**Source of Sample:** BCI-19-38 **Depth:** 12-12.5' **Sample Number:** 6C
▲**Source of Sample:** BCI-19-38 **Depth:** 19-19.5' **Sample Number:** 10C
◆**Source of Sample:** BCI-19-38 **Depth:** 35.5-36' **Sample Number:** 15

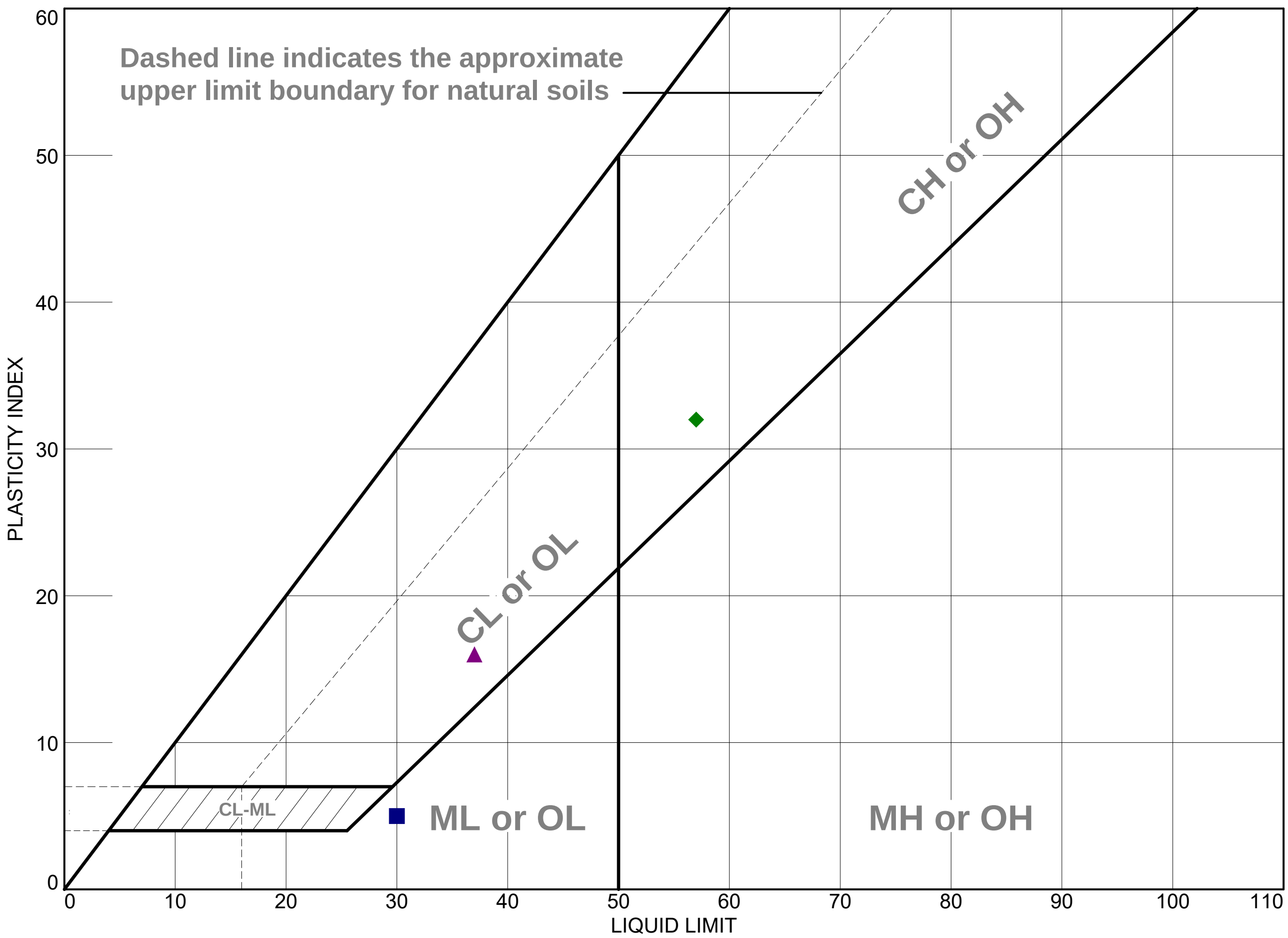
Remarks:

Blackburn Consulting

W. Sacramento, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	SANDY SILT, yellowish brown	NP	NP	NP		65	ML
■	SANDY SILT, dark yellowish brown	30	25	5		66	ML
▲	Lean CLAY with SAND, dark olive brown	37	21	16		85	CL
◆	Fat CLAY, light olive brown	57	25	32		92	CH

Project No. 3195.P **Client:** EIP

Project: Lookout Slough THRFP

●**Source of Sample:** BCI-19-38 **Depth:** 42-42.5' **Sample Number:** 17
■**Source of Sample:** BCI-19-38 **Depth:** 42.5-43' **Sample Number:** 17
▲**Source of Sample:** BCI-19-38 **Depth:** 46-46.5' **Sample Number:** 18C
◆**Source of Sample:** BCI-19-38 **Depth:** 66-66.5' **Sample Number:** 22C

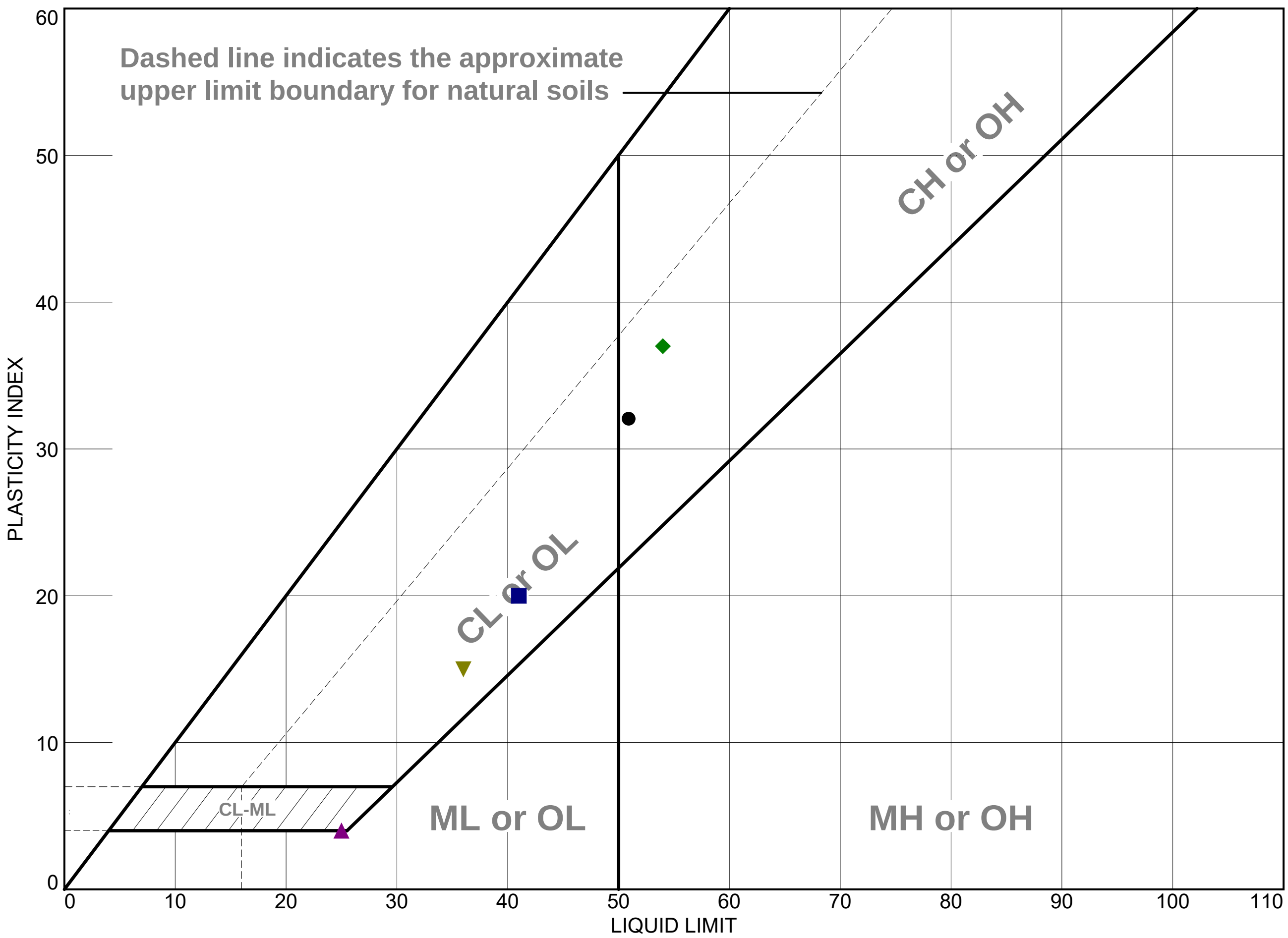
Remarks:

Blackburn Consulting

W. Sacramento, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Fat CLAY with SAND, olive brown	51	19	32		80	CH
■	SANDY lean CLAY, olive brown & blueish gray	41	21	20		54	CL
▲	SANDY SILTY CLAY, yellowish brown	25	21	4		63	CL-ML
◆	SANDY Fat CLAY, yellowish brown	54	17	37		68	CH
▼	SANDY Lean CLAY, olive brown	36	21	15		63	CL

Project No. 3195.P **Client:** EIP

Project: Lookout Slough THRFP

●**Source of Sample:** BCI-19-57 **Depth:** 5-5.5' **Sample Number:** 2
■**Source:** BCI-19-57 **Depth:** 17.5-17.9' **Sample No.:** 7-soft
▲**Source:** BCI-19-57 **Depth:** 18.4-18.6 **Sample No.:** 7-firm
◆**Source:** BCI-19-57 **Depth:** 17-17.4' **Sample No.:** 7-slough
▼**Source of Sample:** BCI-19-57 **Depth:** 22-22.4' **Sample Number:** 9

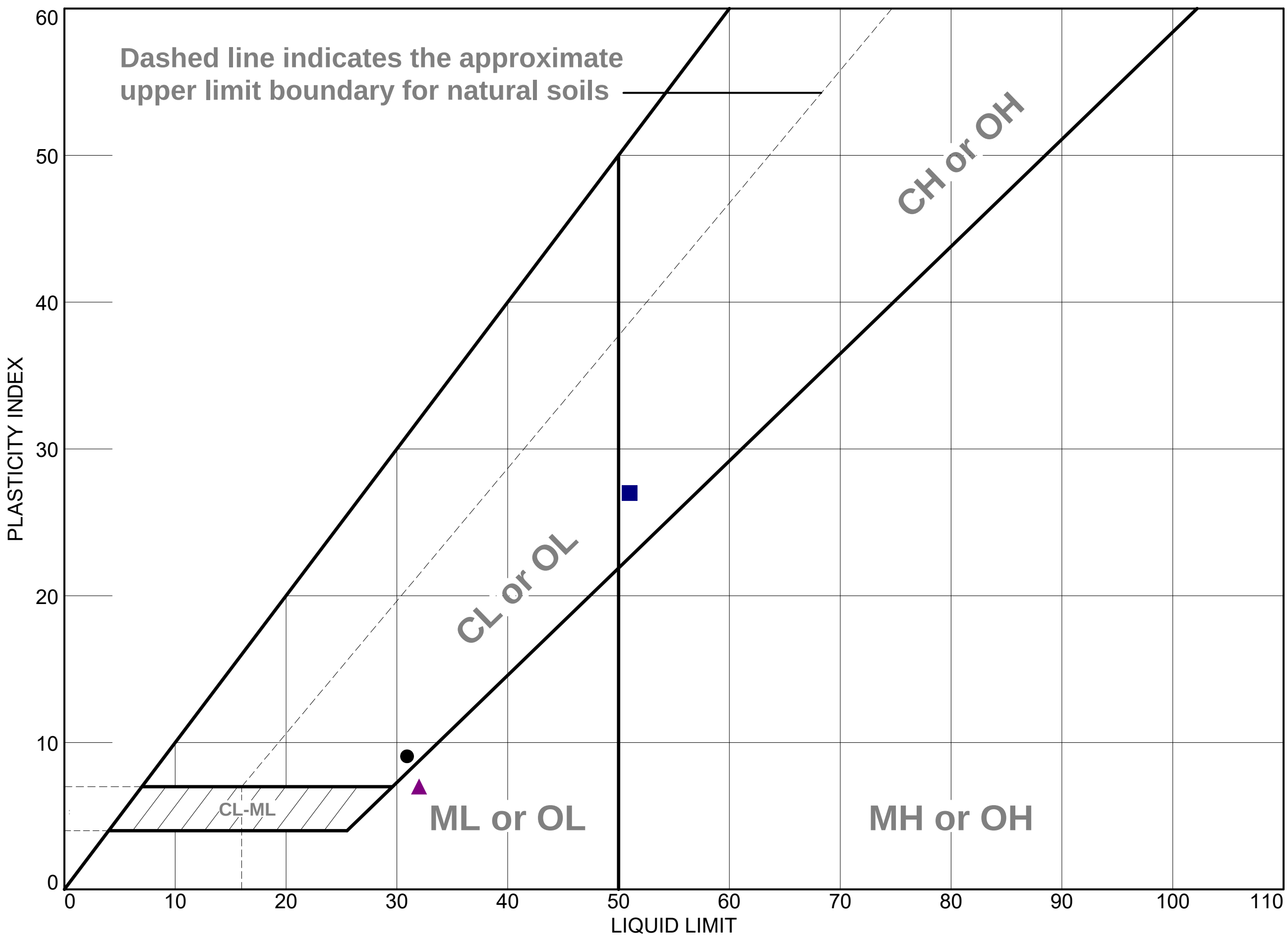
Remarks:

Blackburn Consulting

W. Sacramento, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Lean CLAY, light olive brown	31	22	9		89	CL
■	Fat CLAY, olive brown	51	24	27		96	CH
▲	SANDY SILT, dark olive brown	32	25	7		66	ML
◆	SILTY SAND, dark olive brown	NP	NP	NP		23	SM

Project No. 3195.P **Client:** EIP

Project: Lookout Slough THRFP

●**Source of Sample:** BCI-19-57 **Depth:** 24-24.5' **Sample Number:** 10C
■**Source of Sample:** BCI-19-57 **Depth:** 30-31.5' **Sample Number:** 11
▲**Source of Sample:** BCI-19-57 **Depth:** 45-46.5' **Sample Number:** 14
◆**Source of Sample:** BCI-19-57 **Depth:** 65-66.5 **Sample Number:** 19

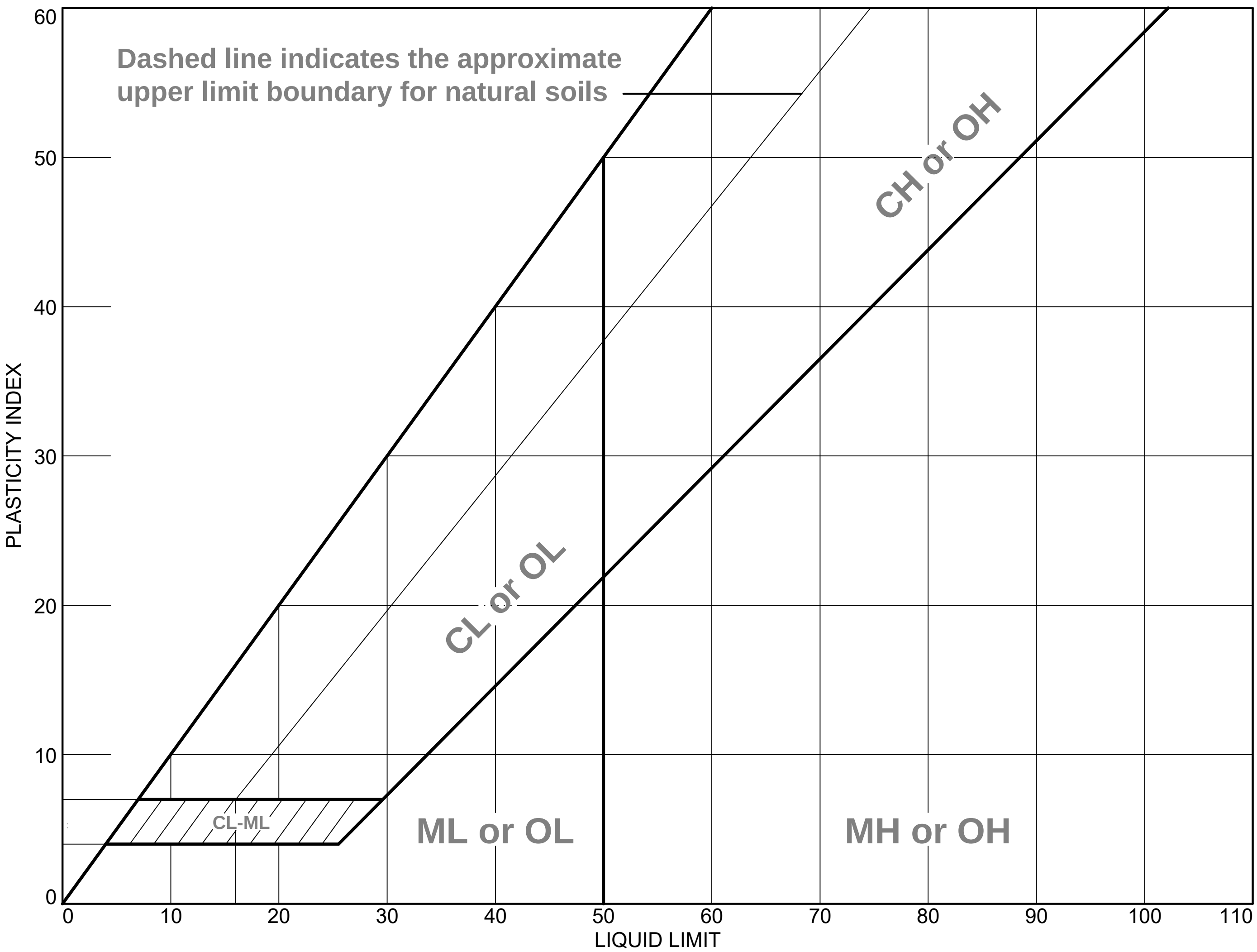
Blackburn Consulting

W. Sacramento, CA

Remarks:

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Fat CLAY, very dark gray	62					
■	Fat CLAY, very dark gray	56					

Project No. 3195.P **Client:** EIP

Project: Lookout Slough THRFP

● **Source of Sample:** BCI-17-17 **Sample Number:** 2-rerun

■ **Source of Sample:** BCI-17-17 **Sample Number:** 2-oven dried

Remarks:

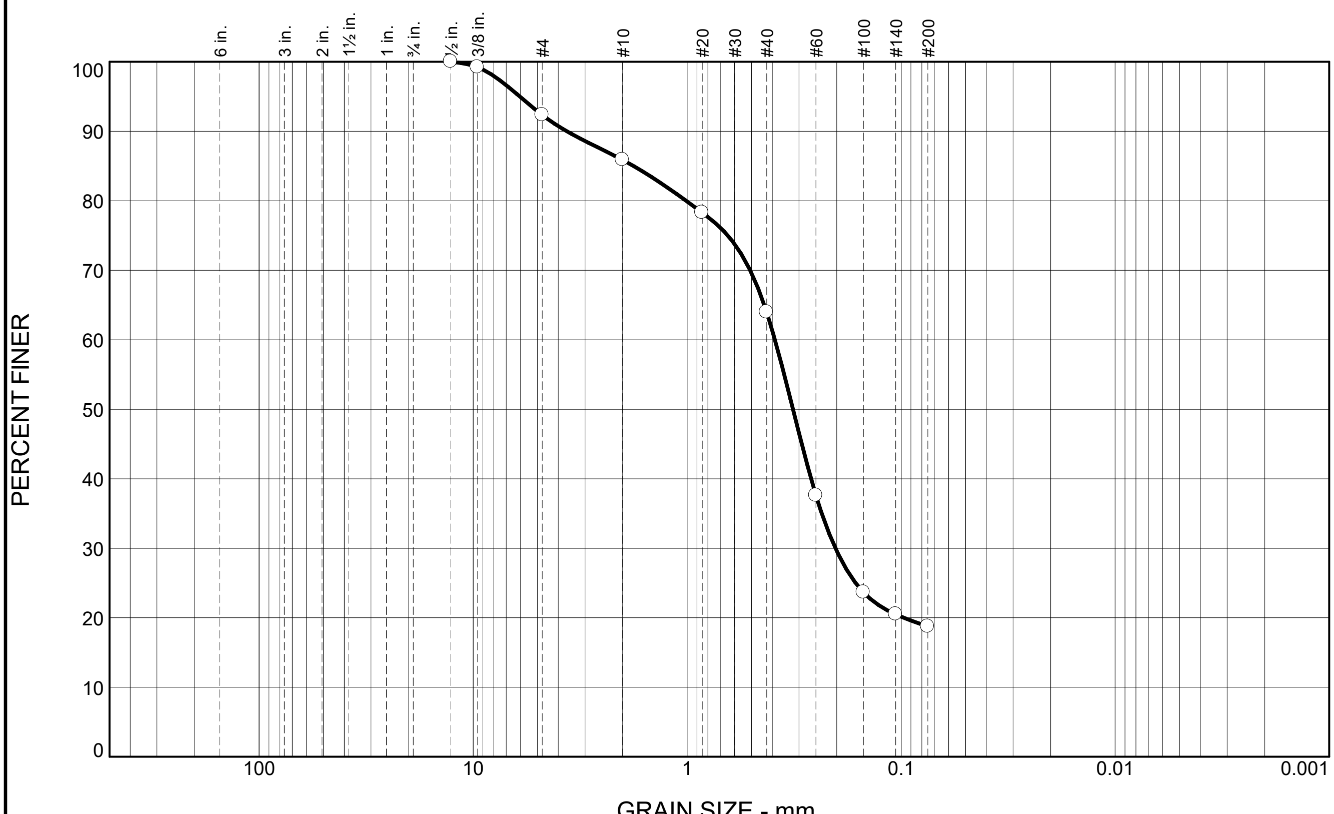
■ Sample checked for organic matter influence. Oven dried LL was closer than 75% of regular LL, therefore this sample is not an Organic CLAY.

Blackburn Consulting

W. Sacramento, CA

Figure

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0	0	8	6	22	45	19	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1/2"	100		
3/8"	99		
#4	92		
#10	86		
#20	78		
#40	64		
#60	38		
#100	24		
#140	20		
#200	19		

* (no specification provided)

Material Description

CLAYEY SAND, brown

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 3.6503 D_{85}= 1.7807 D_{60}= 0.3887
D_{50}= 0.3202 D_{30}= 0.2028 D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= SC AASHTO=

Remarks

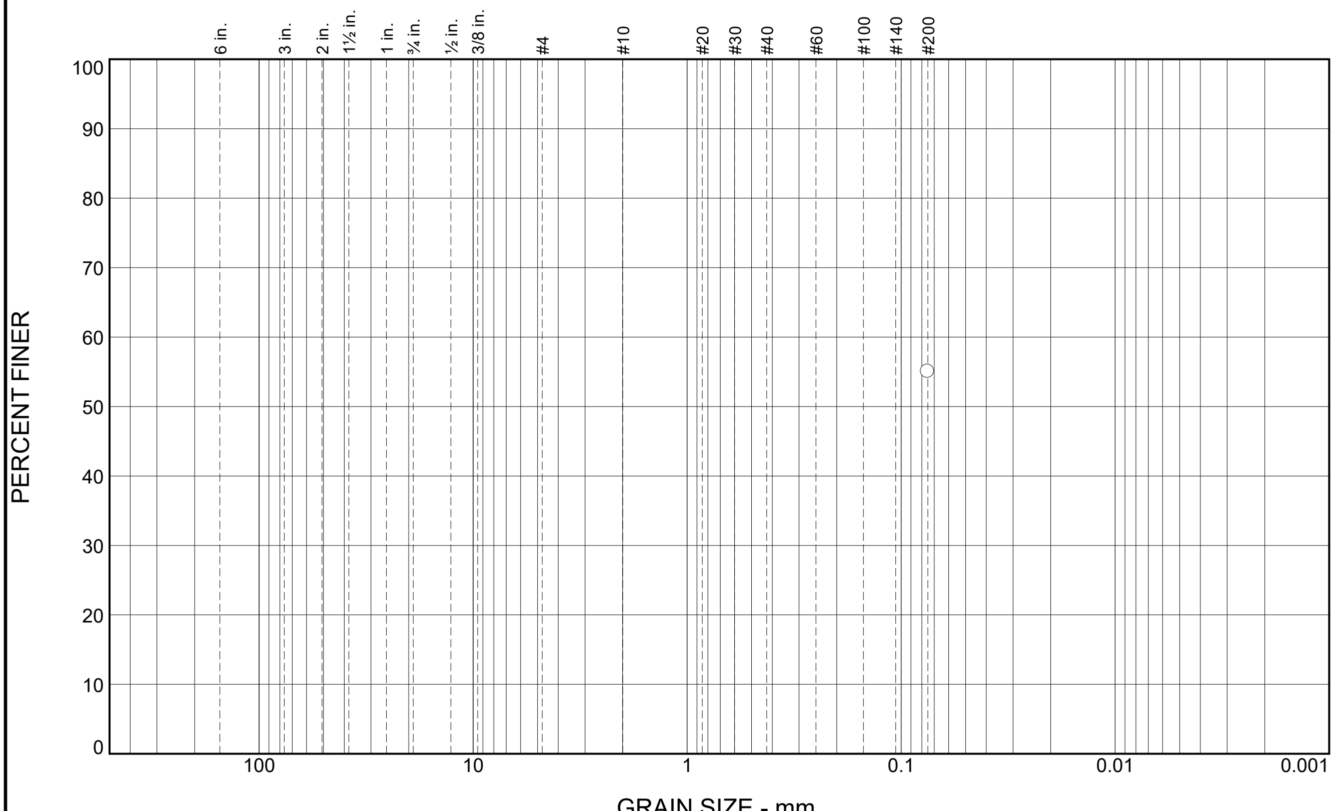
Source of Sample: BCI-17-1 **Depth:** 8.0-8.5'
Sample Number: 4 **Date:**

Blackburn Consulting

W. Sacramento, CA

Client: EIP
Project: Lookout Slough THRFP
Project No: 3195.P **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
						55	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#200	55		

* (no specification provided)

Material Description

SANDY Lean CLAY, yellowish brown

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= D_{85}= D_{60}=
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= CL AASHTO=

Remarks

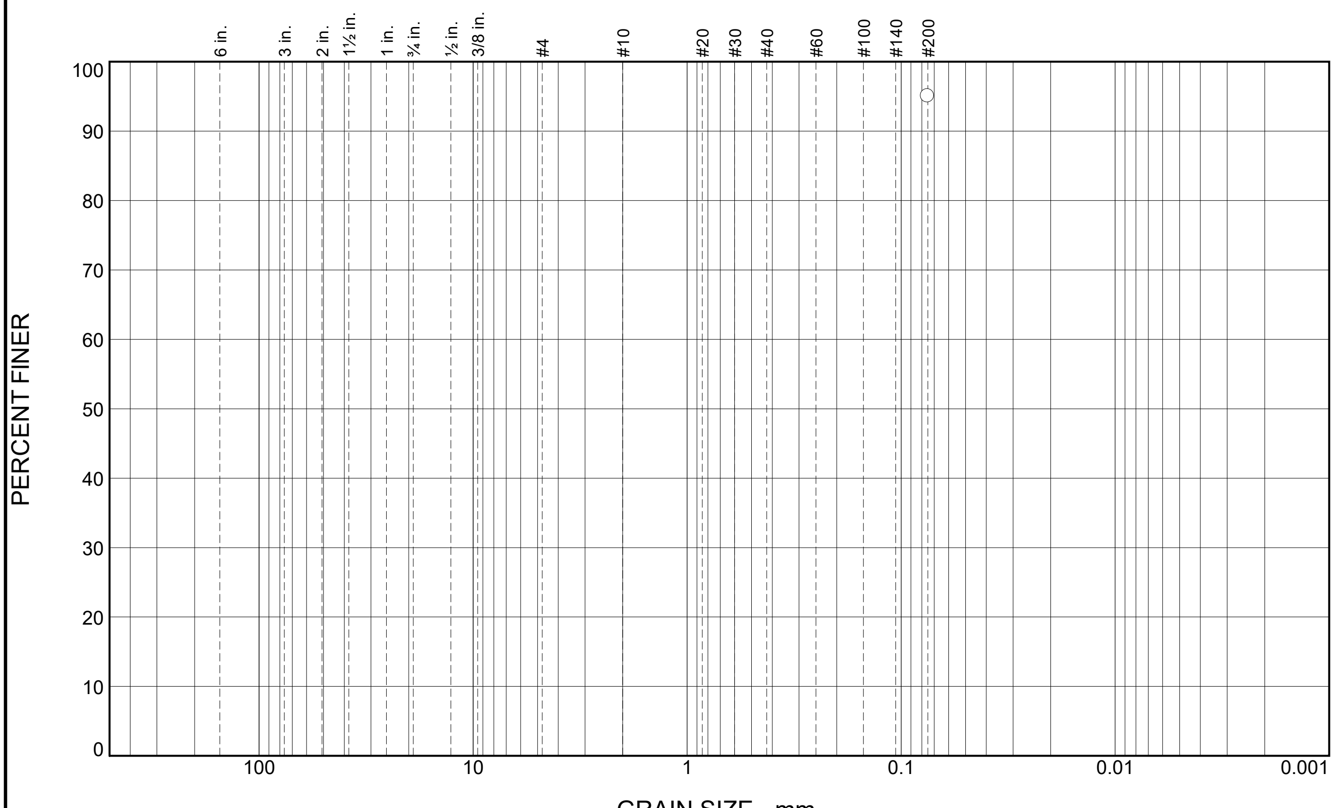
Source of Sample: BCI-17-1 **Depth:** 50.0-51.5'
Sample Number: 15 **Date:**

Blackburn Consulting

W. Sacramento, CA

Client: EIP
Project: Lookout Slough THRFP
Project No: 3195.P **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
						95	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#200	95		

* (no specification provided)

Material Description

Fat CLAY, yellowish brown

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= D_{85}= D_{60}=
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= AASHTO=

Remarks

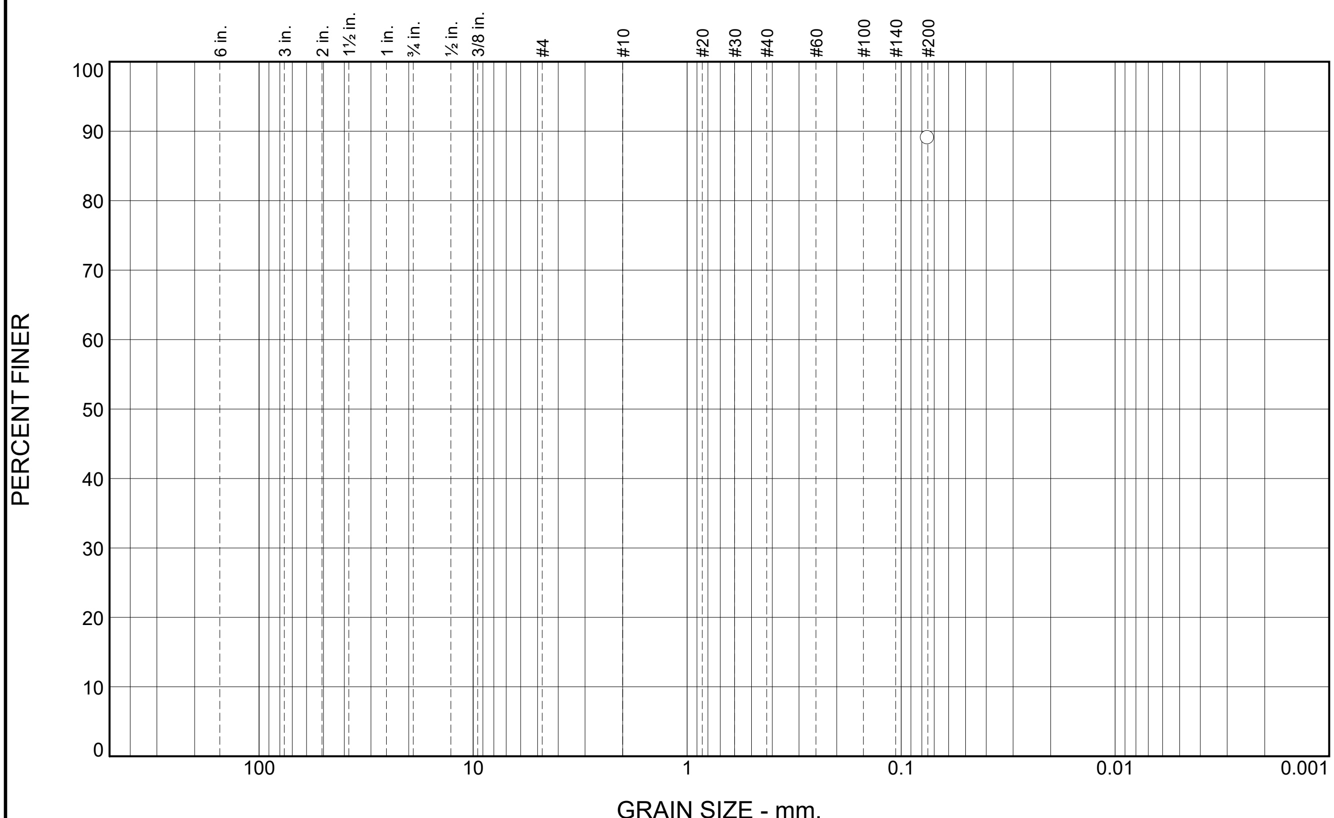
Source of Sample: BCI-17-4 **Depth:** 6.5-6.75'
Sample Number: 3B **Date:**

Blackburn Consulting

W. Sacramento, CA

Client: EIP
Project: Lookout Slough THRFP
Project No: 3195.P **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
						89	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#200	89		

* (no specification provided)

Material Description

Lean CLAY, black

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= D_{85}= D_{60}=
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= AASHTO=

Remarks

Sample contains rocks and shells and organic debris

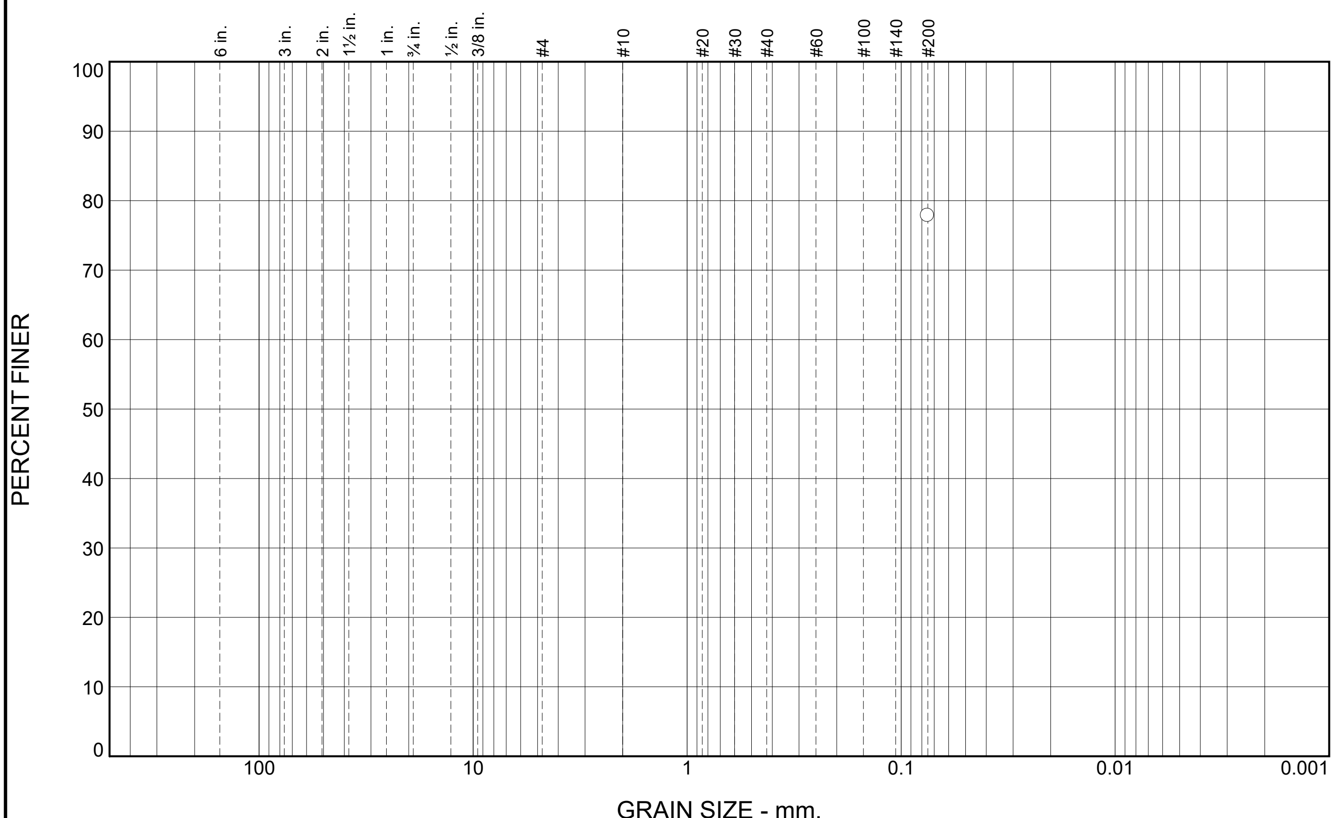
Source of Sample: BCI-17-4 **Depth:** 8.0-8.5'
Sample Number: 4 **Date:**

Blackburn Consulting

W. Sacramento, CA

Client: EIP
Project: Lookout Slough THRFP
Project No: 3195.P **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
						78	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#200	78		

* (no specification provided)

Material Description

Fat CLAY with SAND, yellowish brown

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= D_{85}= D_{60}=
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= CH AASHTO=

Remarks

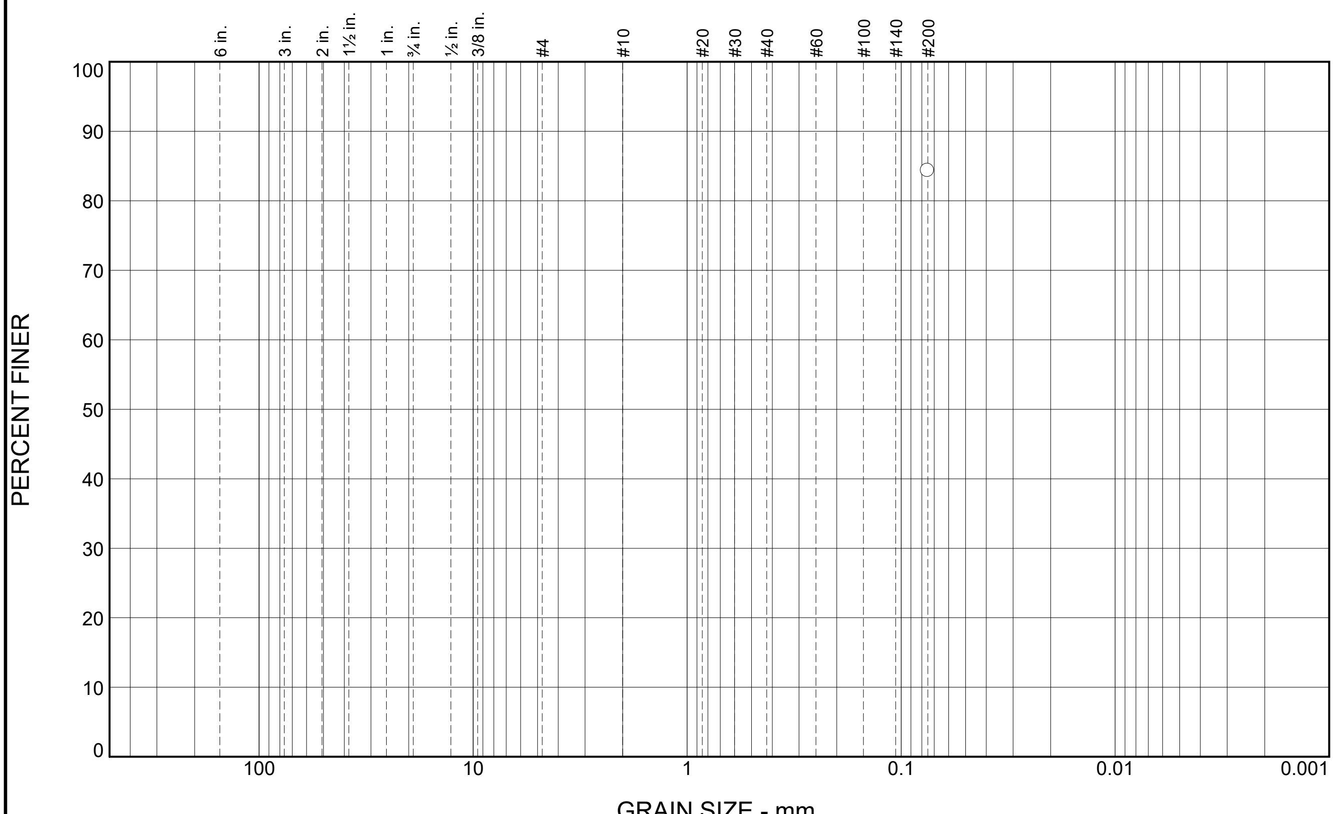
Source of Sample: BCI-17-4 **Depth:** 8.7-9.1'
Sample Number: 4 **Date:**

Blackburn Consulting

W. Sacramento, CA

Client: EIP
Project: Lookout Slough THRFP
Project No: 3195.P **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
						84	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#200	84		

* (no specification provided)

Material Description

Lean CLAY with SAND, yellowish brown

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= D_{85}= D_{60}=
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= AASHTO=

Remarks

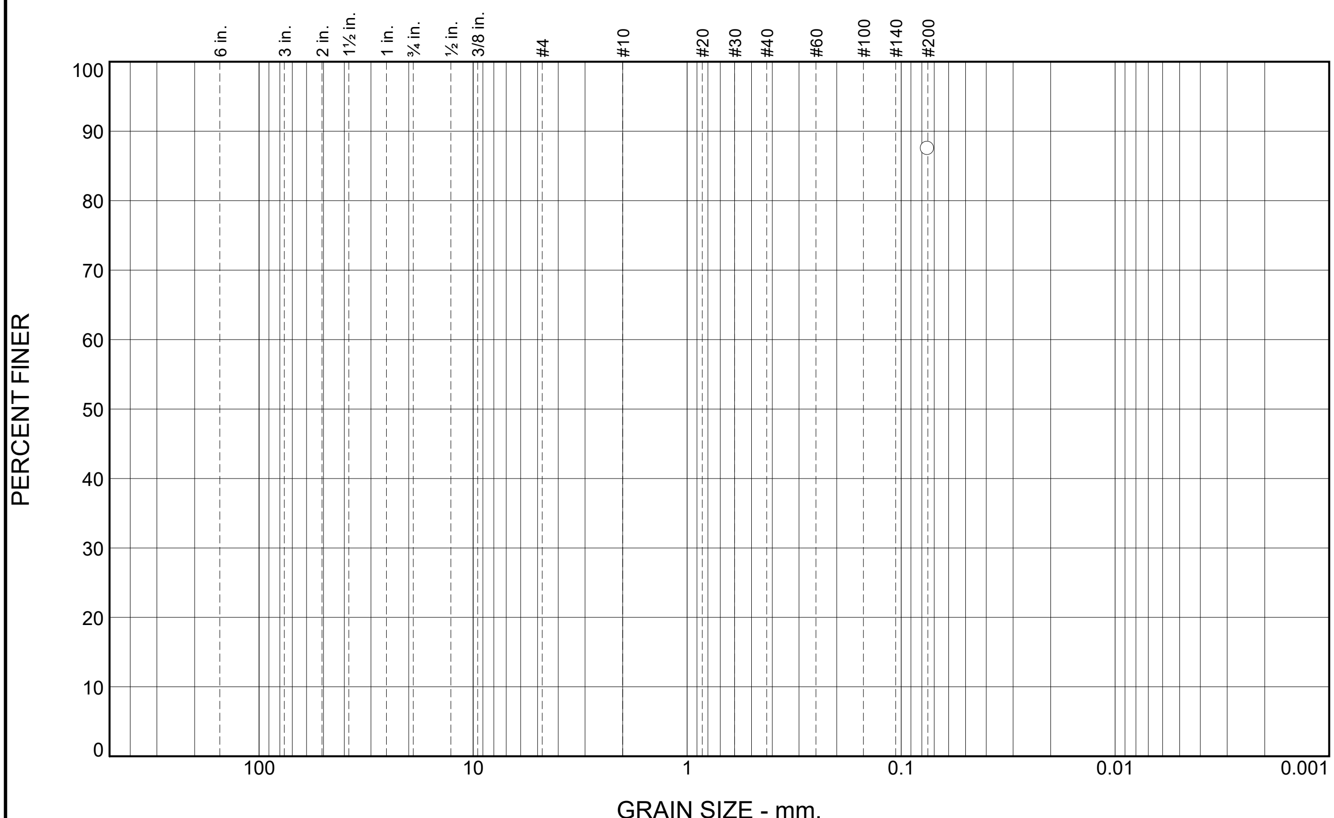
Source of Sample: BCI-17-4 **Depth:** 11.0-11.25'
Sample Number: 5B **Date:**

Blackburn Consulting

W. Sacramento, CA

Client: EIP
Project: Lookout Slough THRFP
Project No: 3195.P **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
						87	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#200	87		

* (no specification provided)

Material Description
Lean CLAY, yellowish brown

Atterberg Limits
PL= LL= PI=

Coefficients
D_{90}= D_{85}= D_{60}=
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification
USCS= AASHTO=

Remarks

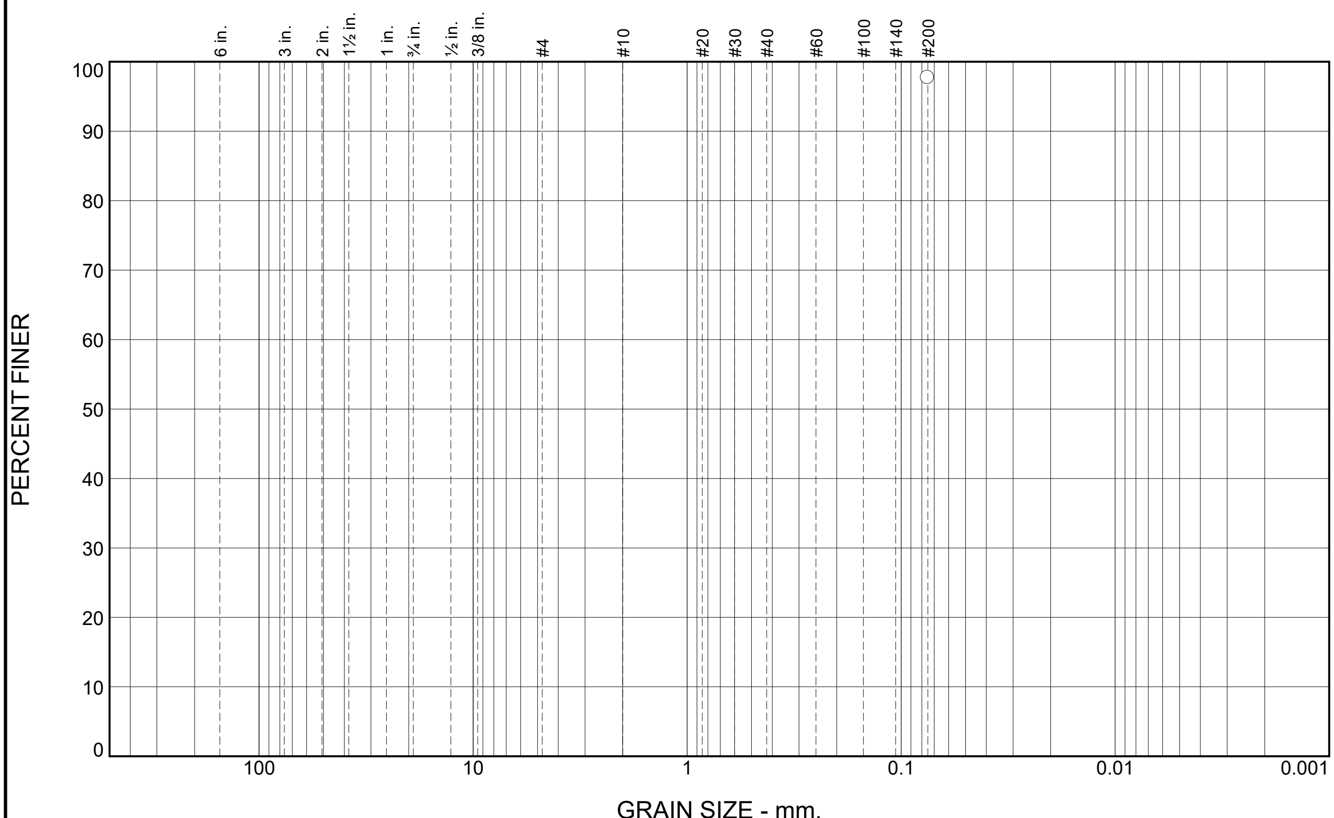
Source of Sample: BCI-17-4 **Depth:** 12.25-12.5'
Sample Number: 6
Date:

Blackburn Consulting

W. Sacramento, CA

Client: EIP
Project: Lookout Slough THRFP
Project No: 3195.P **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
						98	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#200	98		

* (no specification provided)

Material Description

Lean CLAY, yellowish brown

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= D_{85}= D_{60}=
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= AASHTO=

Remarks

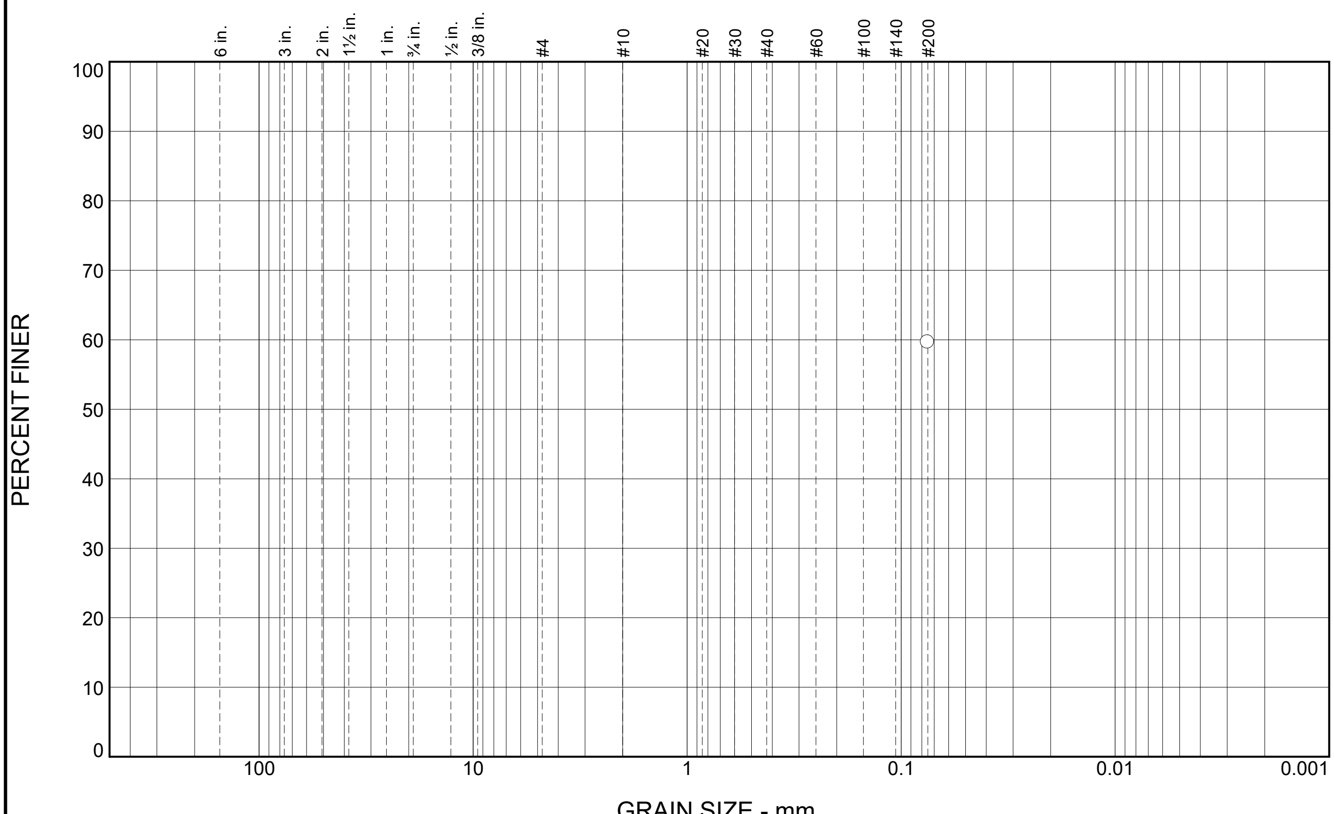
Source of Sample: BCI-17-4 **Depth:** 12.75-13.0'
Sample Number: 6 **Date:**

Blackburn Consulting

W. Sacramento, CA

Client: EIP
Project: Lookout Slough THRFP
Project No: 3195.P **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
						60	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#200	60		

* (no specification provided)

Material Description

SANDY Lean CLAY, yellowish brown

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= D_{85}= D_{60}=
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= AASHTO=

Remarks

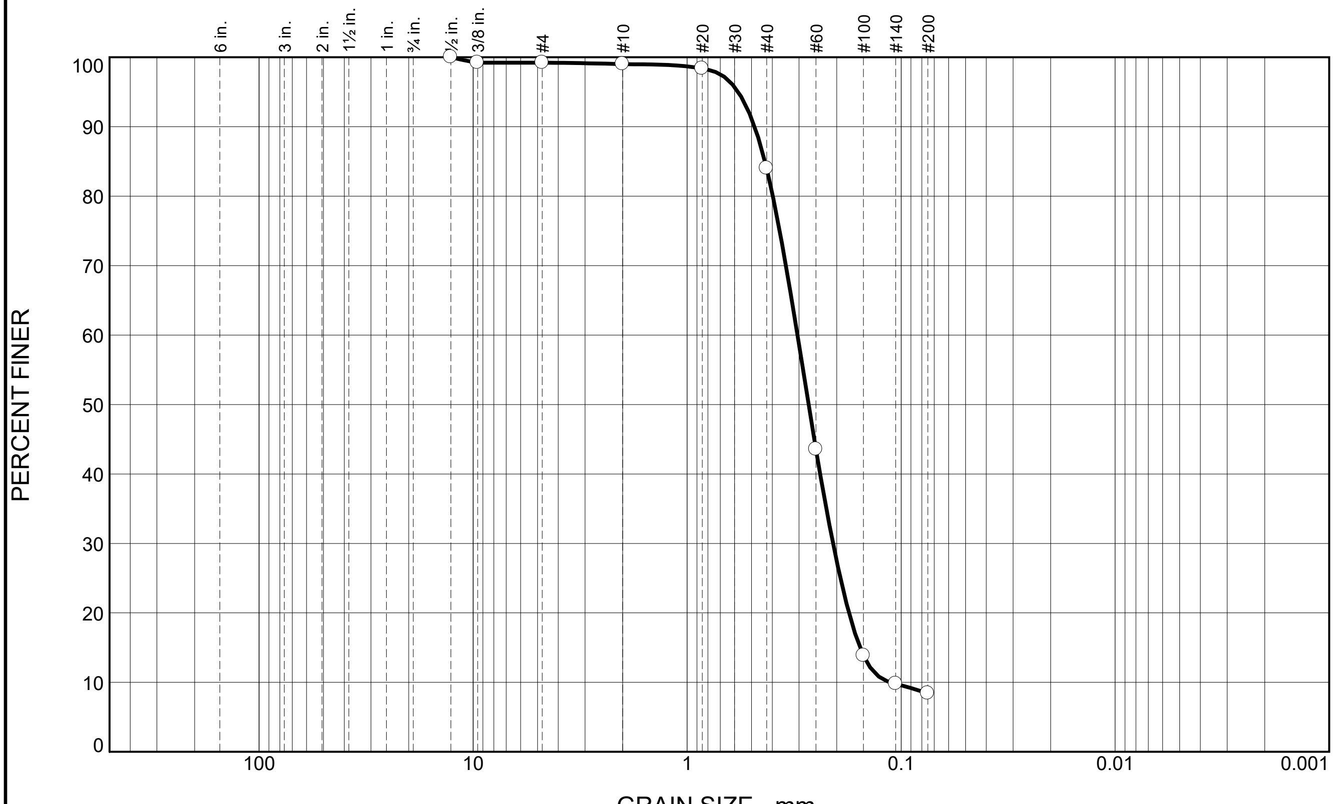
Source of Sample: BCI-17-4 **Depth:** 15.25-15.5'
Sample Number: 7B **Date:**

Blackburn Consulting

W. Sacramento, CA

Client: EIP
Project: Lookout Slough THRFP
Project No: 3195.P **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0	0	1	0	15	76	8	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1/2"	100		
3/8"	99		
#4	99		
#10	99		
#20	98		
#40	84		
#60	44		
#100	14		
#140	10		
#200	8		

* (no specification provided)

Material Description

Poorly-graded SAND with CLAY, dark brown

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 0.4840 D_{85}= 0.4330 D_{60}= 0.3052
D_{50}= 0.2706 D_{30}= 0.2081 D_{15}= 0.1556
D_{10}= 0.1121 C_u= 2.72 C_c= 1.27

Classification

USCS= SP-SC AASHTO=

Remarks

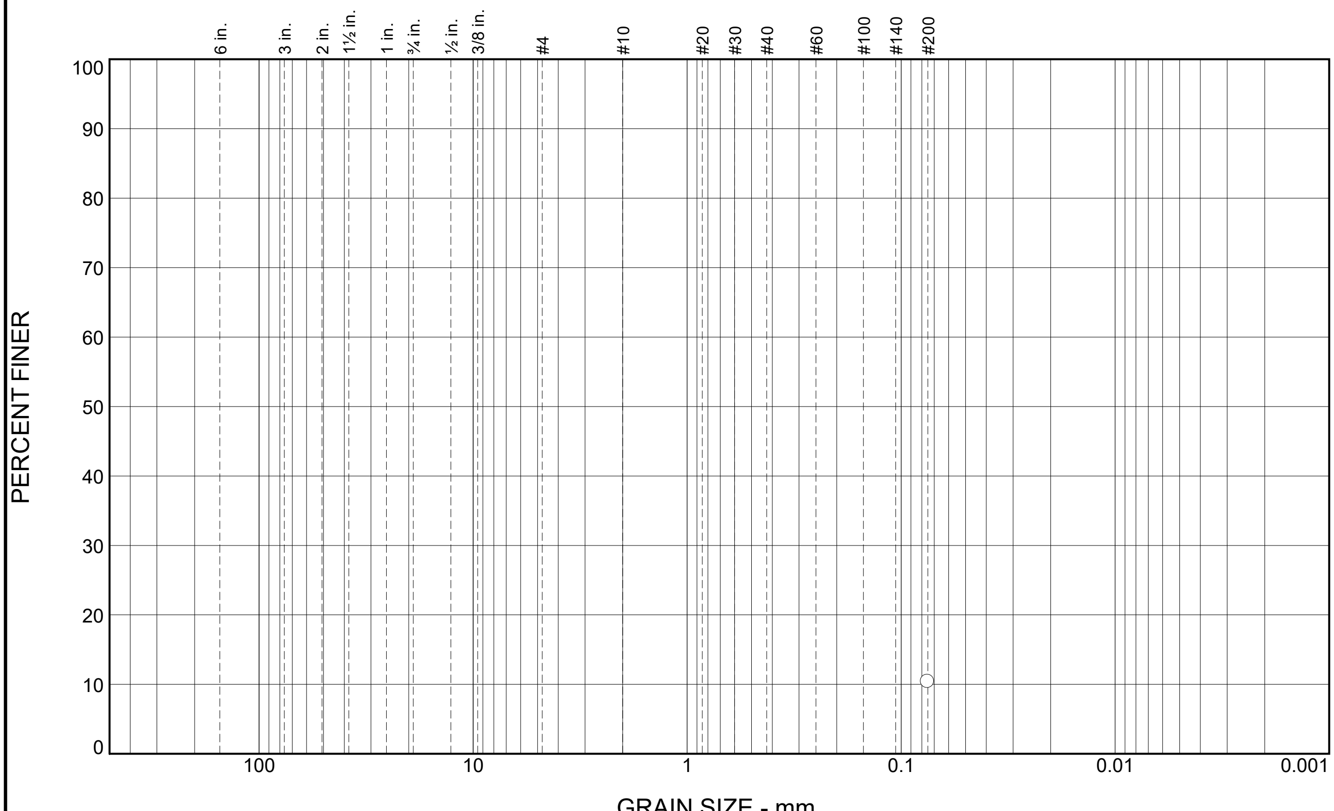
Source of Sample: BCI-17-5 **Depth:** 45.0-46.5'
Sample Number: 13 **Date:** 12/12/17

Blackburn Consulting

W. Sacramento, CA

Client: EIP
Project: Lookout Slough THRFP
Project No: 3195.P **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
						10	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#200	10		

* (no specification provided)

Material Description

Poorly-graded SAND with CLAY, yellowish brown

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= D_{85}= D_{60}=
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= SP-SC AASHTO=

Remarks

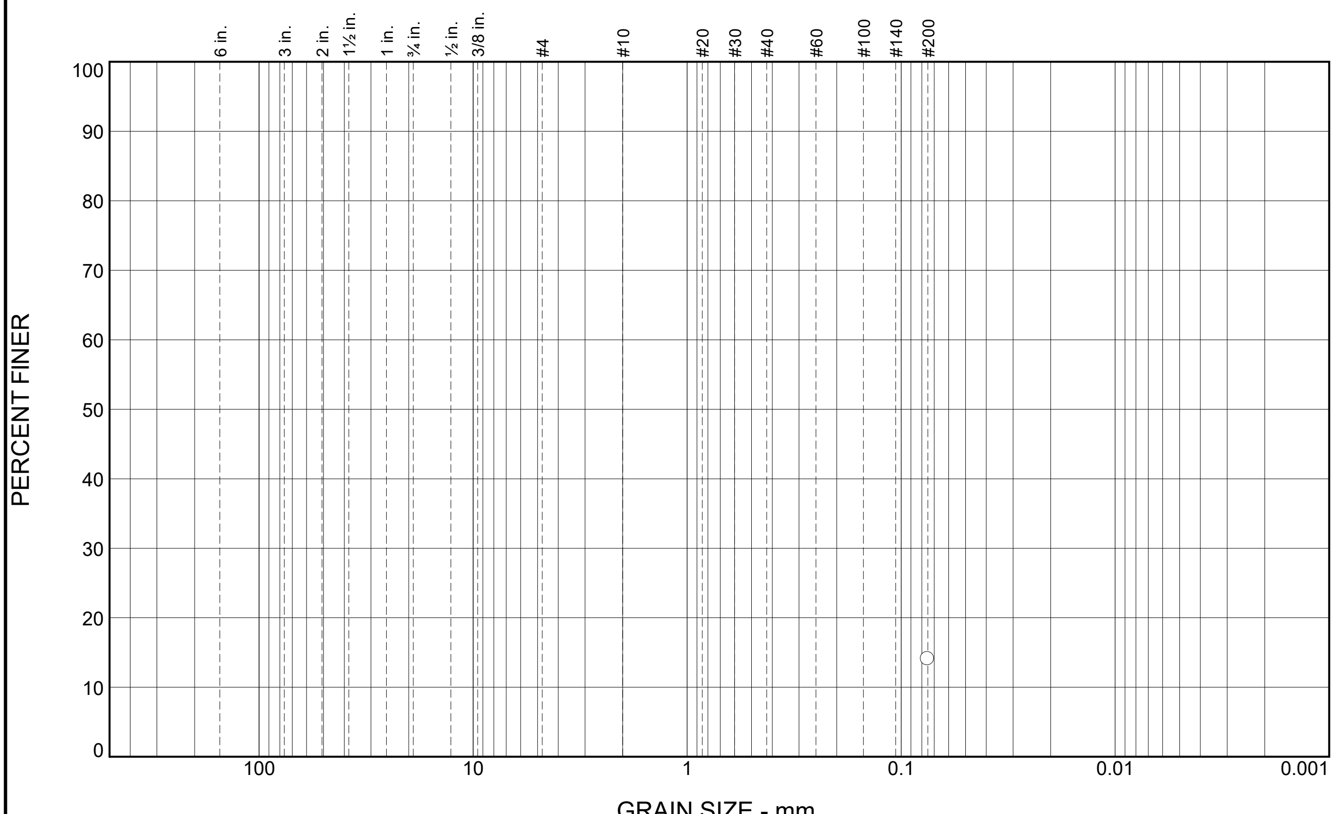
Source of Sample: BCI-17-6 **Depth:** 31.0-31.25'
Sample Number: 10B **Date:**

Blackburn Consulting

W. Sacramento, CA

Client: EIP
Project: Lookout Slough THRFP
Project No: 3195.P **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
						14	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#200	14		

* (no specification provided)

Material Description

CLAYEY SAND, yellowish brown

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= D_{85}= D_{60}=
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= SC AASHTO=

Remarks

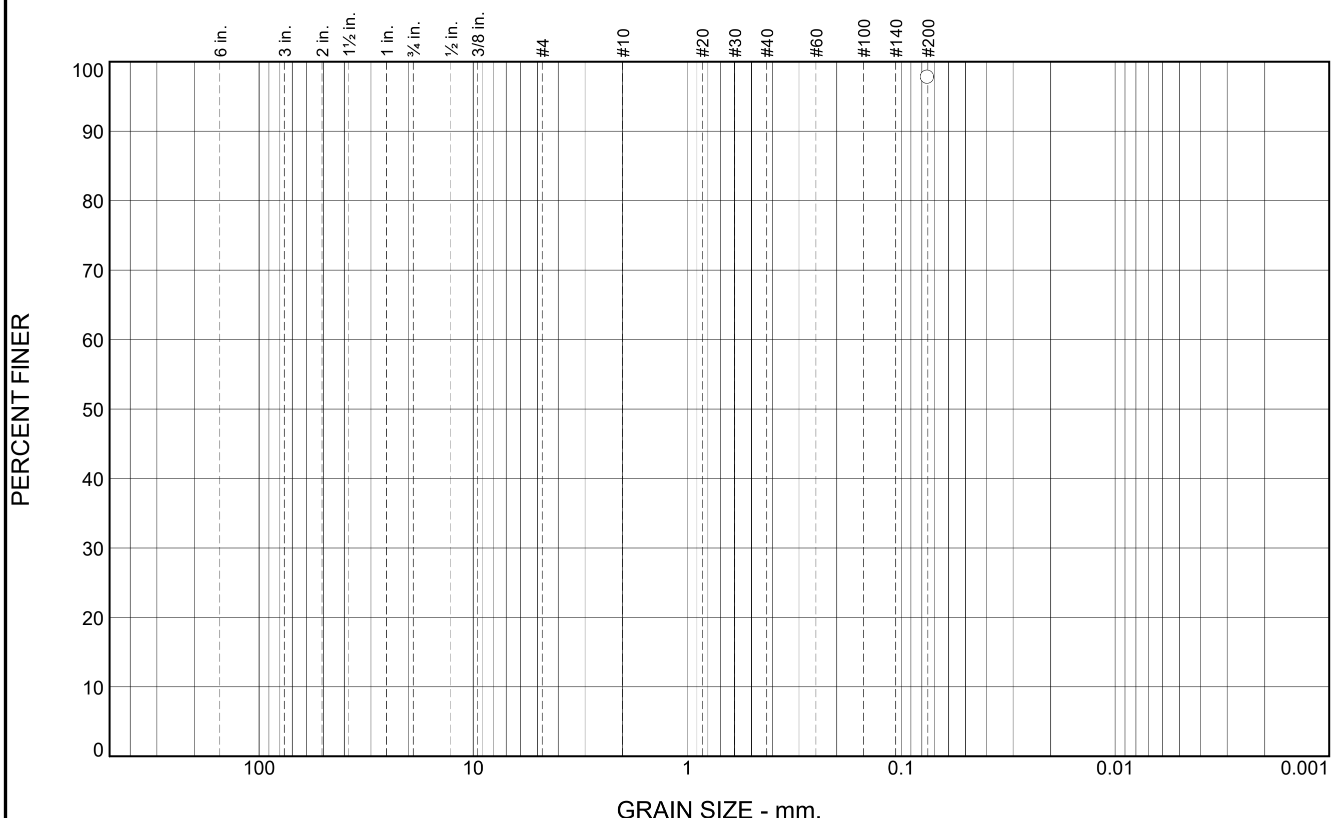
Source of Sample: BCI-17-6 **Depth:** 31.25-31.5'
Sample Number: 10C **Date:**

Blackburn Consulting

W. Sacramento, CA

Client: EIP
Project: Lookout Slough THRFP
Project No: 3195.P **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
						98	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#200	98		

* (no specification provided)

Material Description

Lean CLAY, dark yellowish brown

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= D_{85}= D_{60}=
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= CL AASHTO=

Remarks

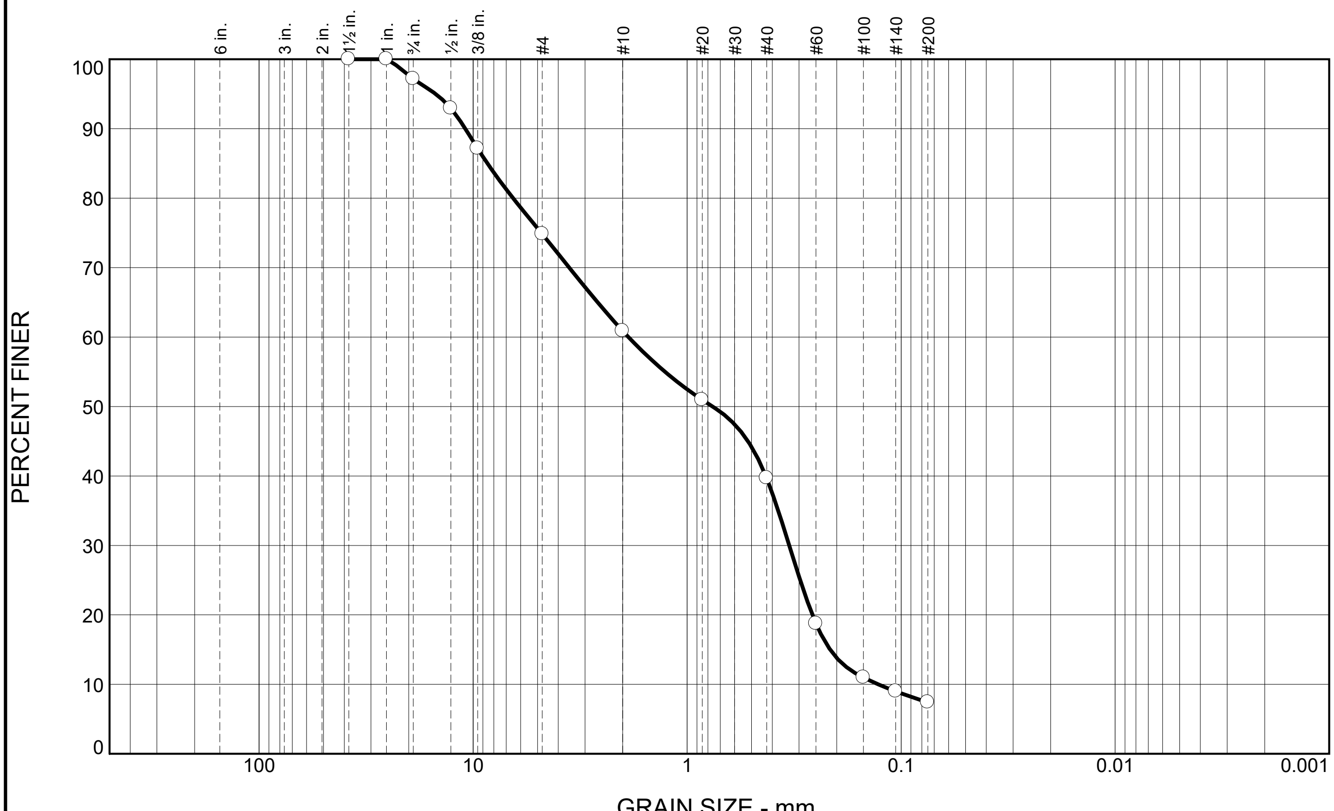
Source of Sample: BCI-17-6 **Depth:** 65.0-66.5'
Sample Number: 17 **Date:**

Blackburn Consulting

W. Sacramento, CA

Client: EIP
Project: Lookout Slough THRFP
Project No: 3195.P **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0	3	22	14	21	33	7	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1.5"	100		
1"	100		
3/4"	97		
1/2"	93		
3/8"	87		
#4	75		
#10	61		
#20	51		
#40	40		
#60	19		
#100	11		
#140	9		
#200	7		

* (no specification provided)

Material Description

Poorly-graded SAND with CLAY and GRAVEL, dark brown

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 10.8852 D_{85}= 8.5730 D_{60}= 1.8808
D_{50}= 0.7607 D_{30}= 0.3333 D_{15}= 0.2146
D_{10}= 0.1279 C_u= 14.71 C_c= 0.46

Classification

USCS= SP-SC AASHTO=

Remarks

ASTM D6913 sample mass reqs. not met due to large particle size

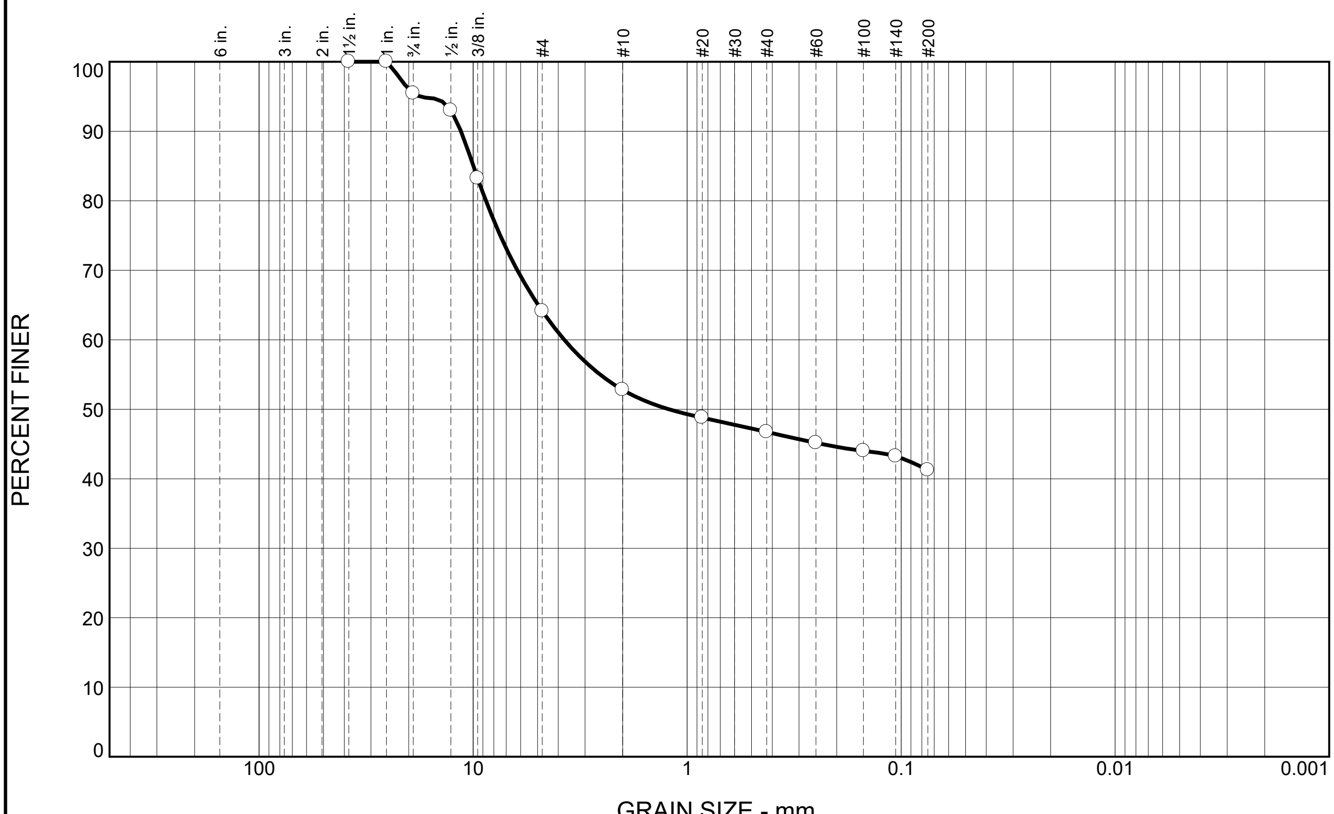
Source of Sample: BCI-17-8 **Depth:** 45.0-46.5'
Sample Number: 14 **Date:** 12/12/17

Blackburn Consulting

W. Sacramento, CA

Client: EIP
Project: Lookout Slough THRFP
Project No: 3195.P **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0	5	31	11	6	6	41	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1.5"	100		
1"	100		
3/4"	95		
1/2"	93		
3/8"	83		
#4	64		
#10	53		
#20	49		
#40	47		
#60	45		
#100	44		
#140	43		
#200	41		

* (no specification provided)

Material Description

CLAYEY GRAVEL with SAND, brown

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 11.3987 D_{85}= 9.9713 D_{60}= 3.7507
D_{50}= 1.2171 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= GC AASHTO=

Remarks

ASTM D6913 sample mass reqs. not met due to large particle size

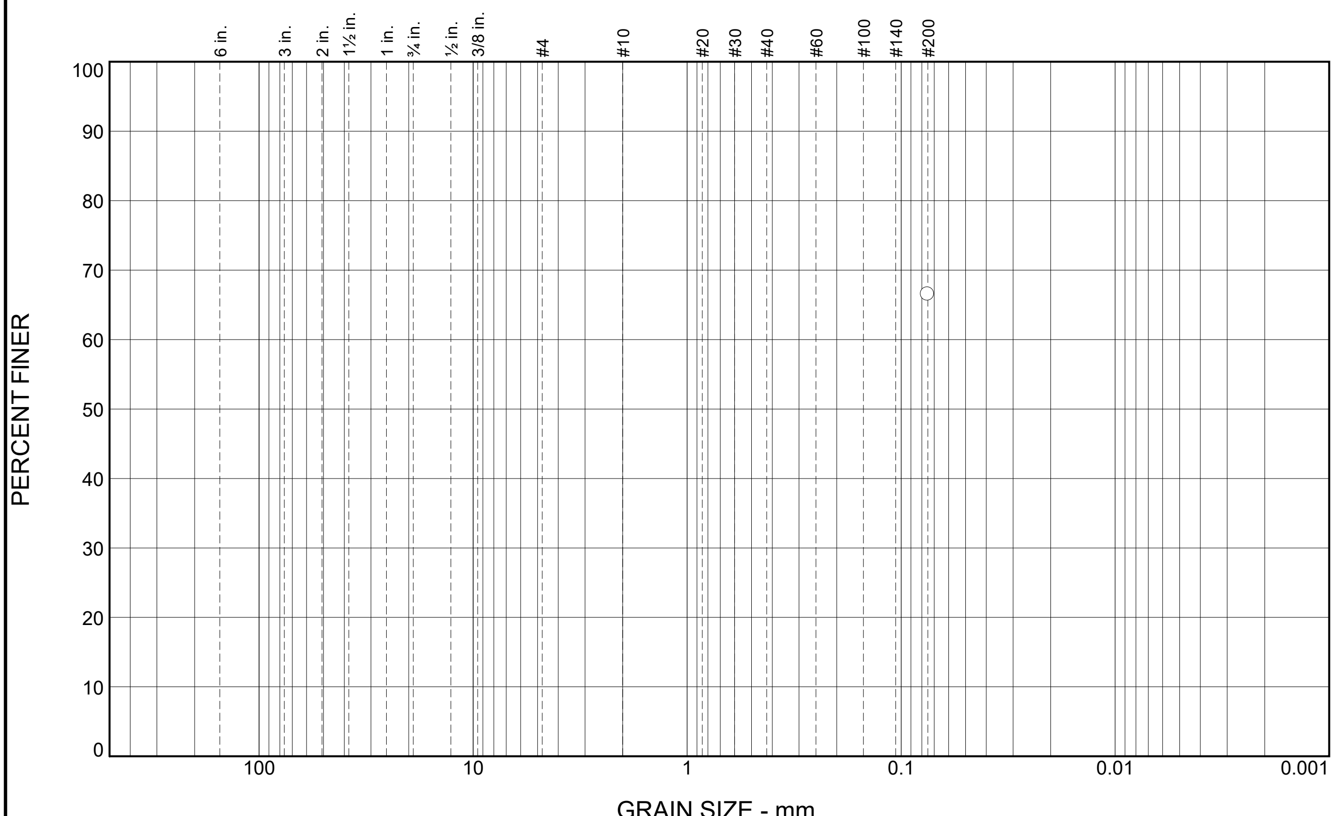
Source of Sample: BCI-17-8 **Depth:** 50.0-51.5'
Sample Number: 15 **Date:** 12/12/17

Blackburn Consulting

W. Sacramento, CA

Client: EIP
Project: Lookout Slough THRFP
Project No: 3195.P **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
						66	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#200	66		

* (no specification provided)

Material Description

SANDY Lean CLAY, olive brown

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= D_{85}= D_{60}=
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= CL AASHTO=

Remarks

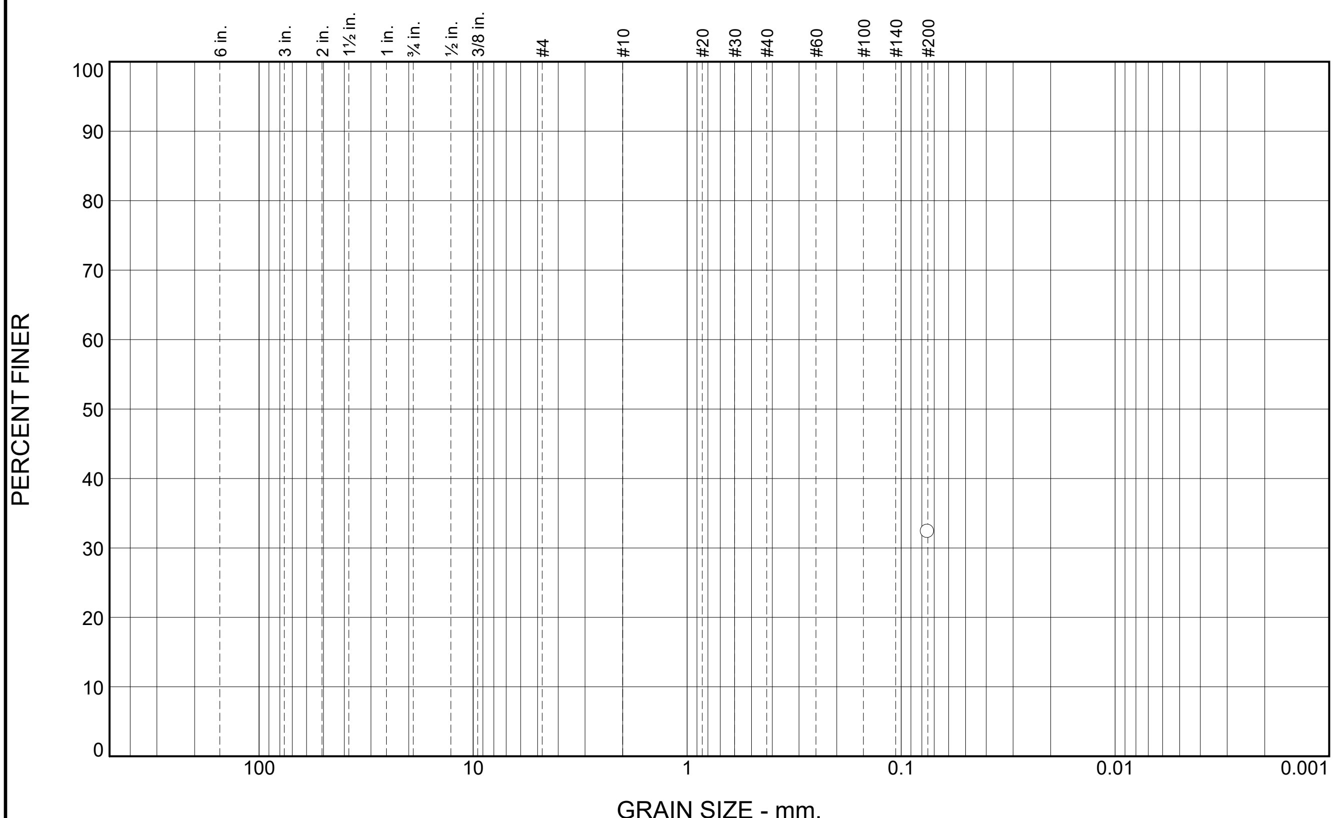
Source of Sample: BCI-17-9 **Depth:** 13.0-13.5'
Sample Number: 8B **Date:** 1/22/18

Blackburn Consulting

W. Sacramento, CA

Client: EIP
Project: Lookout Slough THRFP
Project No: 3195.P **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
						32	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#200	32		

* (no specification provided)

Material Description

SILTY SAND, yellowish brown

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= D_{85}= D_{60}=
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= SM AASHTO=

Remarks

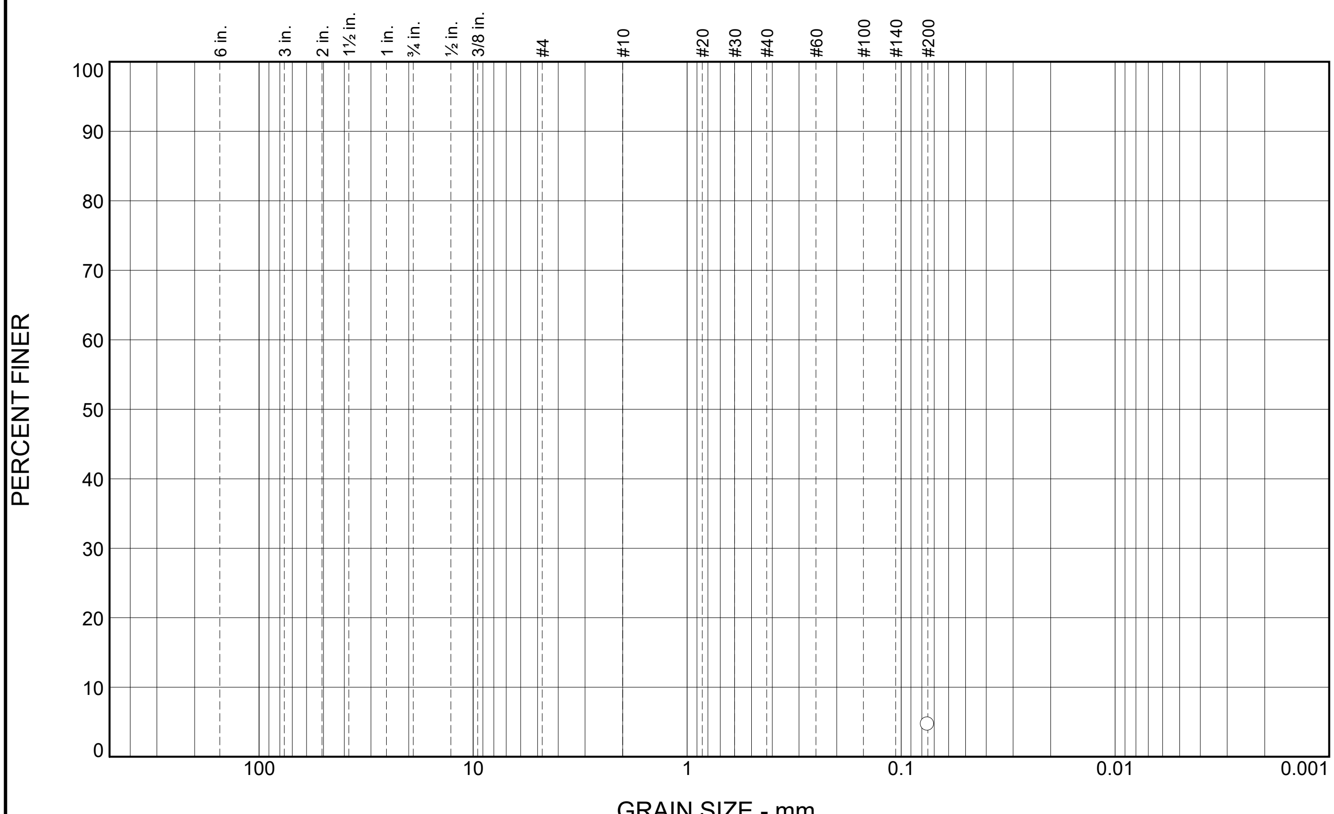
Source of Sample: BCI-17-9 **Depth:** 40.5-41.0
Sample Number: 15B **Date:**

Blackburn Consulting

W. Sacramento, CA

Client: EIP
Project: Lookout Slough THRFP
Project No: 3195.P **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
						5	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#200	5		

* (no specification provided)

Material Description

Well-graded SAND with SILT and GRAVEL, dark yellowish brown

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= D_{85}= D_{60}=
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= SW-SM AASHTO=

Remarks

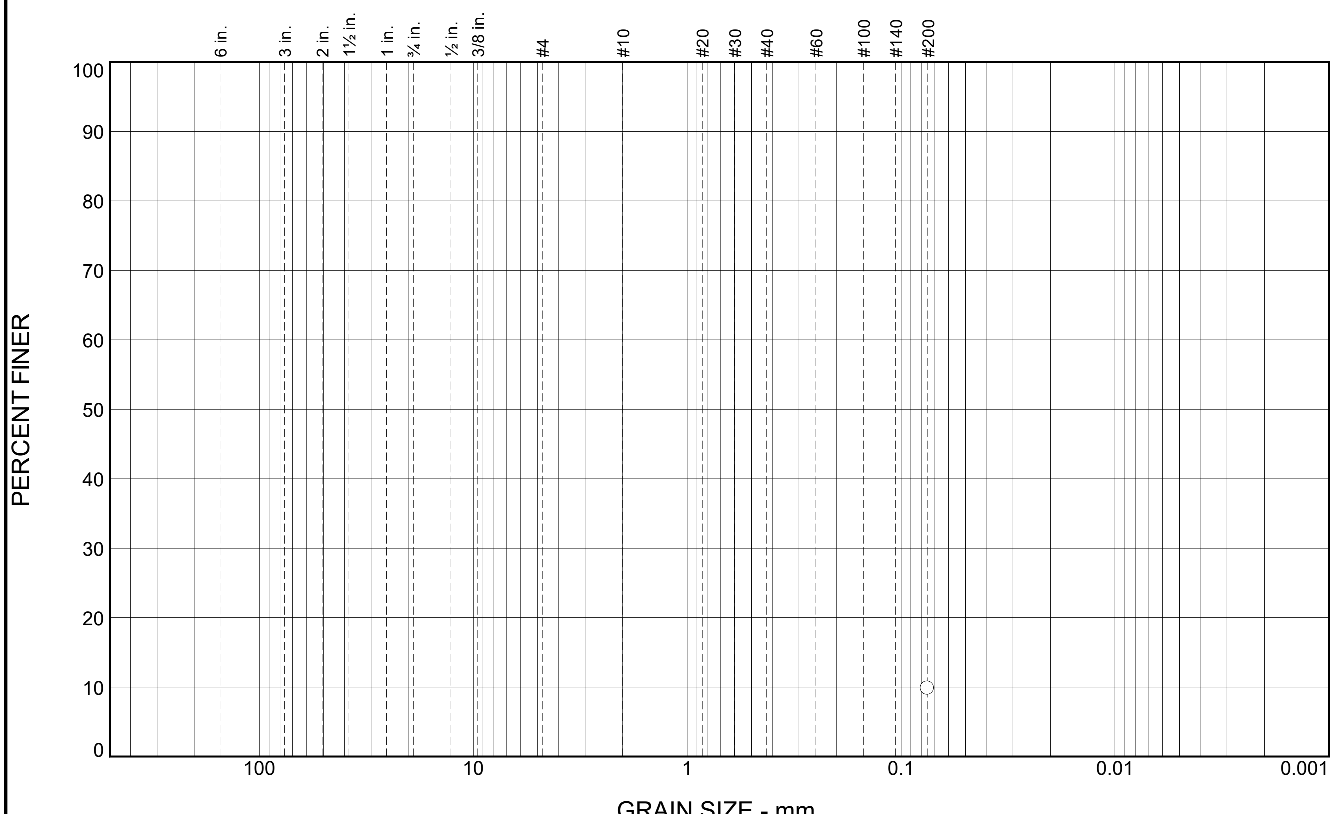
Source of Sample: BCI-17-9 **Depth:** 45.5-46.0
Sample Number: 16B **Date:**

Blackburn Consulting

W. Sacramento, CA

Client: EIP
Project: Lookout Slough THRFP
Project No: 3195.P **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
						10	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#200	10		

* (no specification provided)

Material Description

Poorly-graded SAND with CLAY, olive brown

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= D_{85}= D_{60}=
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= SP-SC AASHTO=

Remarks

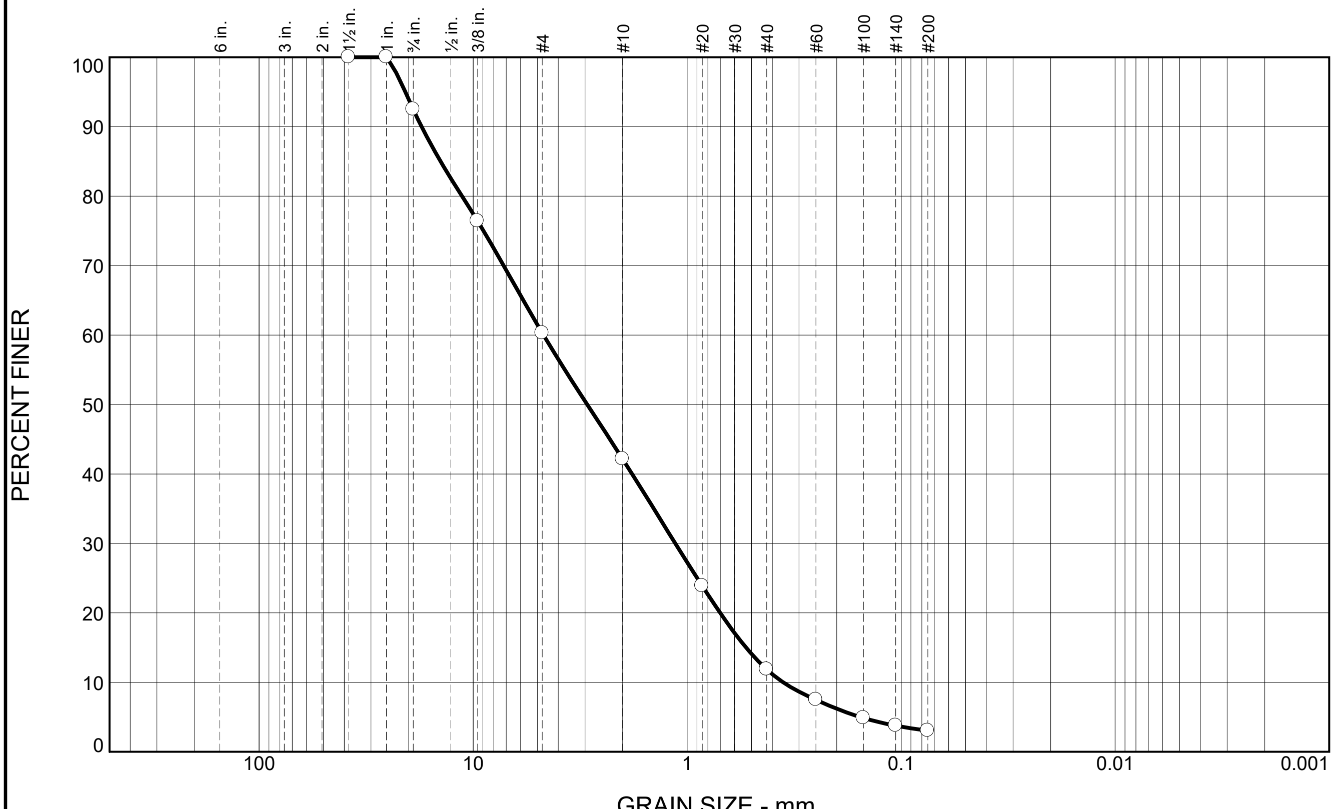
Source of Sample: BCI-17-10 **Depth:** 20.0-21.5'
Sample Number: 10 **Date:**

Blackburn Consulting

W. Sacramento, CA

Client: EIP
Project: Lookout Slough THRFP
Project No: 3195.P **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0	8	32	18	30	9	3	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1.5"	100		
1"	100		
3/4"	92		
3/8"	76		
#4	60		
#10	42		
#20	24		
#40	12		
#60	7		
#100	5		
#140	4		
#200	3		

* (no specification provided)

Material Description

Poorly-graded SAND with GRAVEL, dark olive brown

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 17.4117 D_{85}= 14.1911 D_{60}= 4.6895
D_{50}= 2.9296 D_{30}= 1.1355 D_{15}= 0.5300
D_{10}= 0.3556 C_u= 13.19 C_c= 0.77

Classification

USCS= SP AASHTO=

Remarks

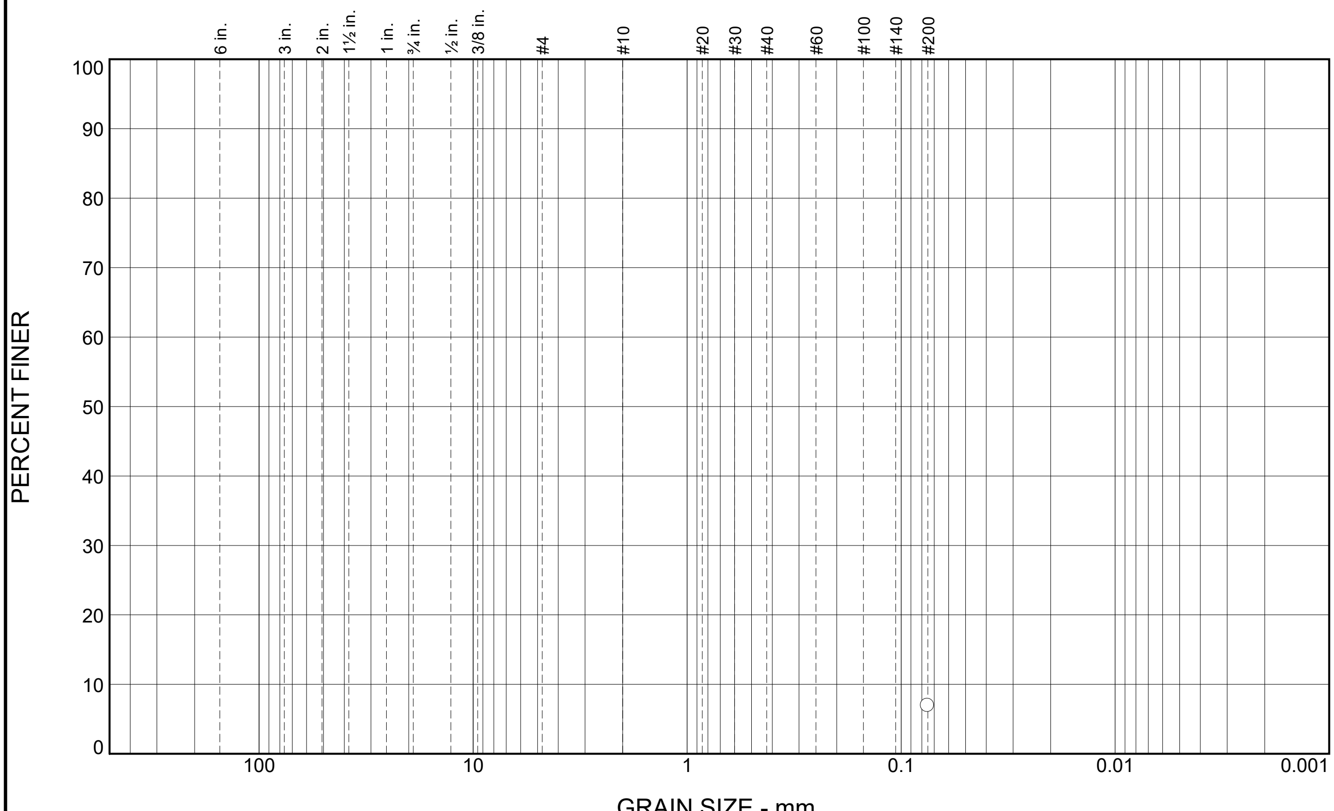
Source of Sample: BCI-17-10 **Depth:** 25.5-26.0'
Sample Number: 11B
Date: 1/22/18

Blackburn Consulting

W. Sacramento, CA

Client: EIP
Project: Lookout Slough THRFP
Project No: 3195.P **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
						7	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#200	7		

* (no specification provided)

Material Description

Poorly-graded GRAVEL with CLAY and SAND, dark olive brown

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= D_{85}= D_{60}=
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= GP-GC AASHTO=

Remarks

Source of Sample: BCI-17-10 **Depth:** 26.0-26.5'
Sample Number: 11C

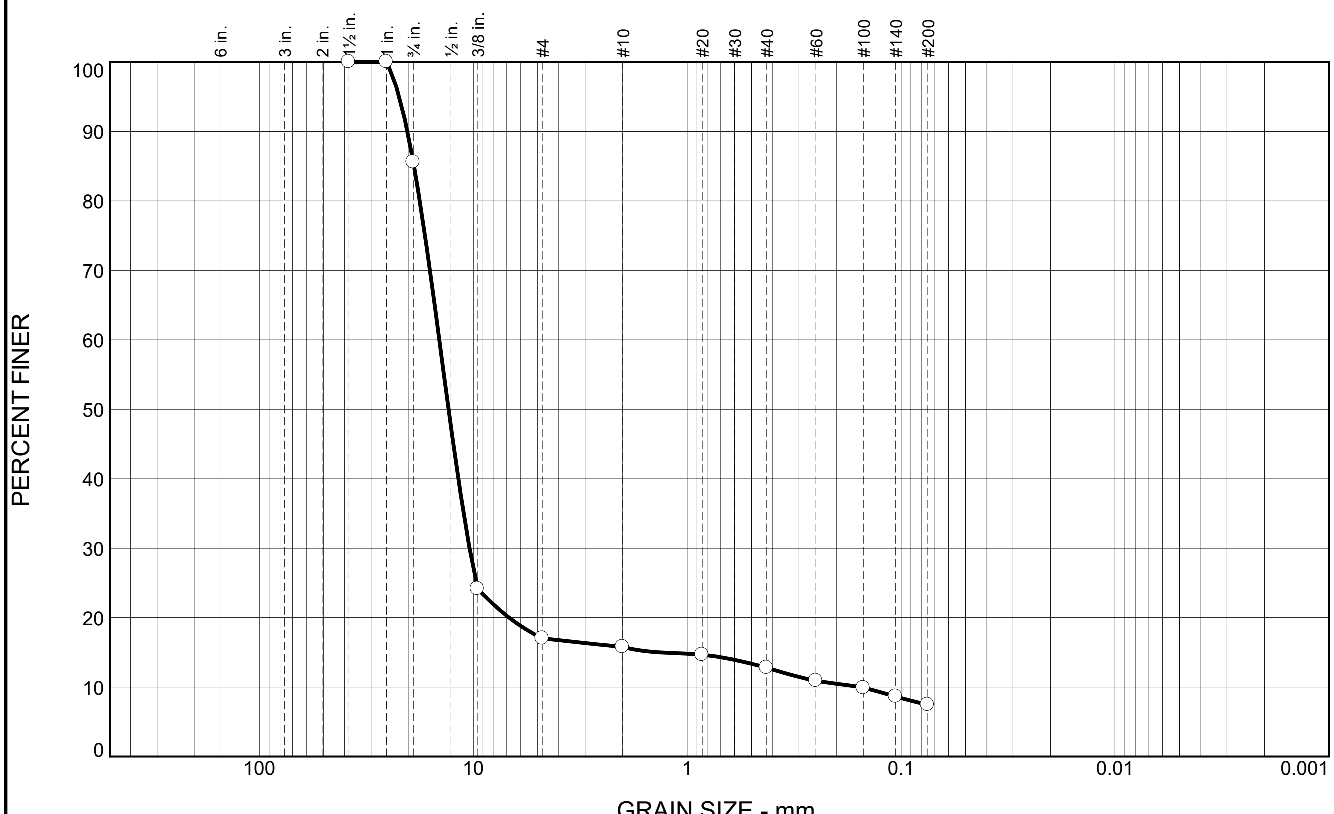
Date: 1/22/18

Blackburn Consulting

W. Sacramento, CA

Client: EIP
Project: Lookout Slough THRFP
Project No: 3195.P **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0	14	69	1	3	6	7	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1.5"	100		
1"	100		
3/4"	86		
3/8"	24		
#4	17		
#10	16		
#20	15		
#40	13		
#60	11		
#100	10		
#140	9		
#200	7		

* (no specification provided)

Material Description

Poorly-graded GRAVEL with CLAY, dark olive brown

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 20.2997 D_{85}= 18.9063 D_{60}= 14.3988
D_{50}= 13.0282 D_{30}= 10.4051 D_{15}= 1.3430
D_{10}= 0.1563 C_u= 92.10 C_c= 48.09

Classification

USCS= GP-GC AASHTO=

Remarks

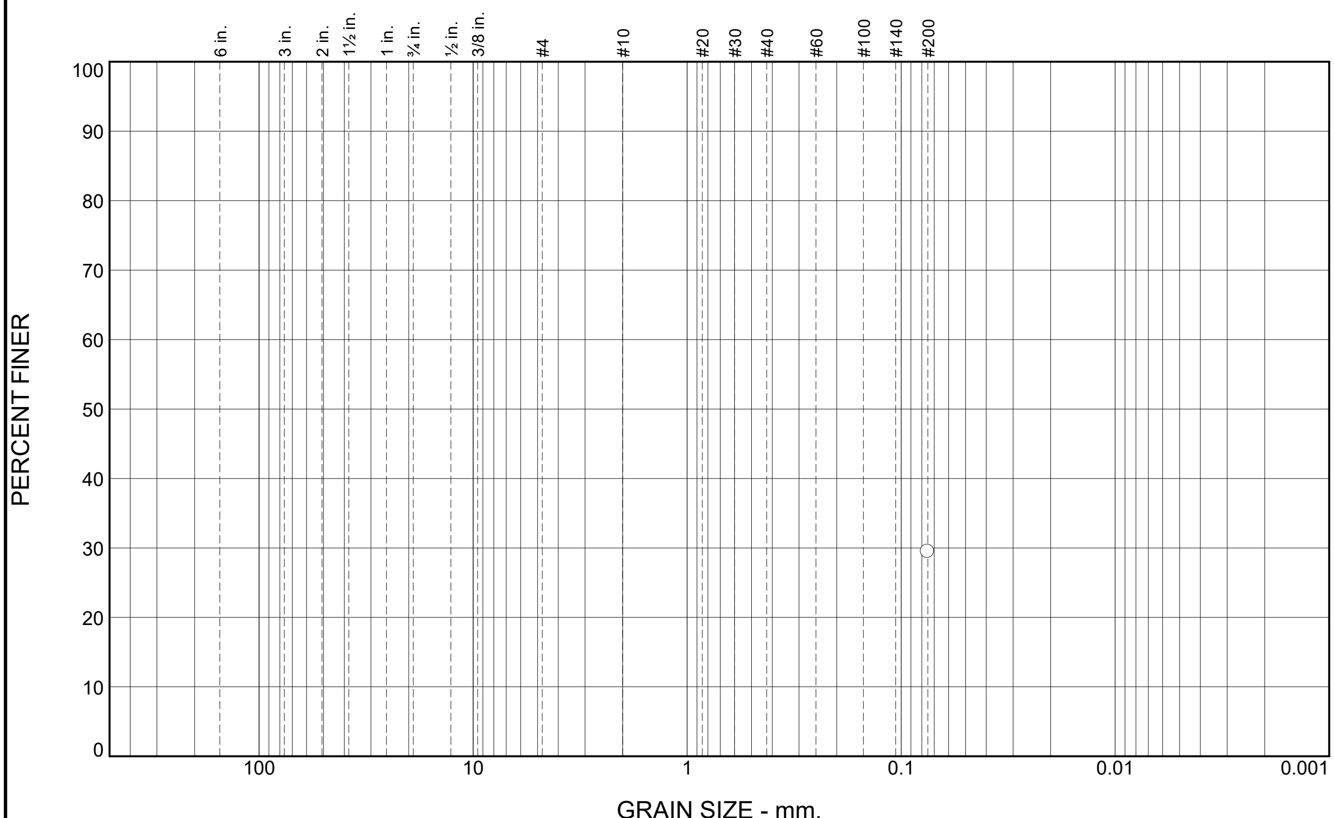
Source of Sample: BCI-17-10 **Depth:** 35.5-36.0'
Sample Number: 13B **Date:** 1/22/18

Blackburn Consulting

W. Sacramento, CA

Client: EIP
Project: Lookout Slough THRFP
Project No: 3195.P **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
						29	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#200	29		

* (no specification provided)

Material Description

SILTY SAND, olive brown

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= D_{85}= D_{60}=
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= SM AASHTO=

Remarks

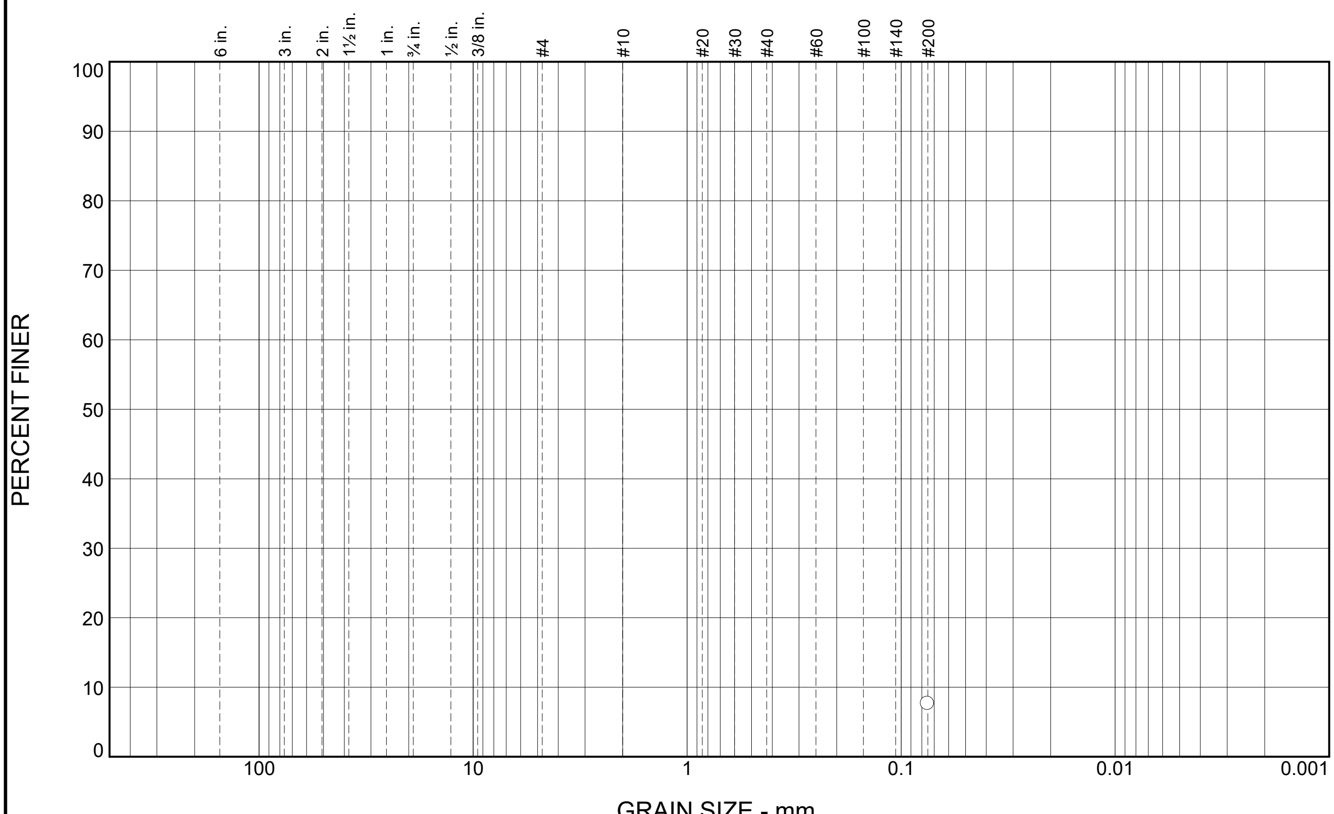
Source of Sample: BCI-17-11 **Depth:** 12.5-13.0'
Sample Number: 8B **Date:**

Blackburn Consulting

W. Sacramento, CA

Client: EIP
Project: Lookout Slough THRFP
Project No: 3195.P **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
						8	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#200	8		

* (no specification provided)

Material Description

Well-graded SAND with SILT and GRAVEL, dark olive brown

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= D_{85}= D_{60}=
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= SW-SM AASHTO=

Remarks

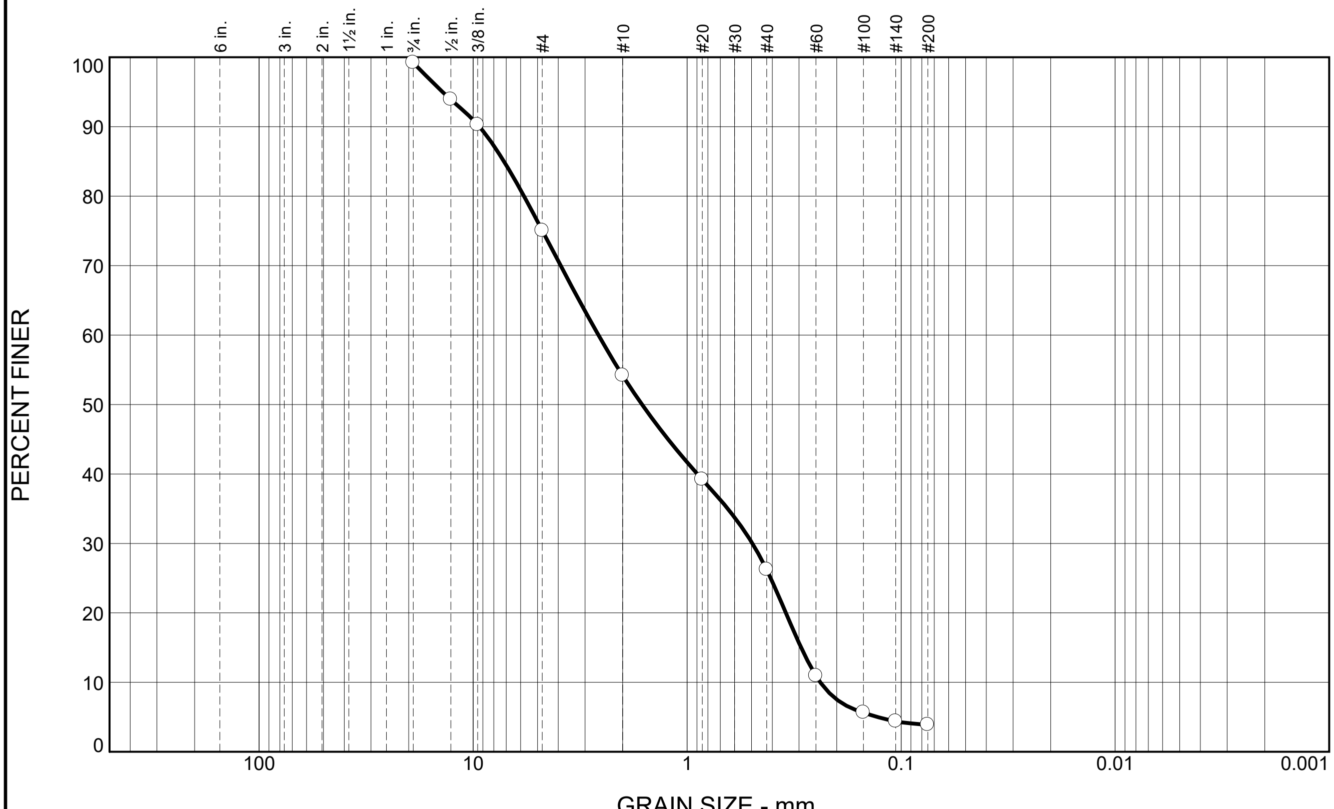
Source of Sample: BCI-17-11 **Depth:** 35.0-36.5'
Sample Number: 13 **Date:**

Blackburn Consulting

W. Sacramento, CA

Client: EIP
Project: Lookout Slough THRFP
Project No: 3195.P **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
		24	21	28	22	4	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.75	99		
.5	94		
.375	90		
#4	75		
#10	54		
#20	39		
#40	26		
#60	11		
#100	6		
#140	4		
#200	4		

* (no specification provided)

Material Description

Poorly-graded SAND with GRAVEL, dark brown

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 9.3548 D_{85}= 7.1742 D_{60}= 2.5966
D_{50}= 1.6245 D_{30}= 0.4956 D_{15}= 0.2934
D_{10}= 0.2385 C_u= 10.89 C_c= 0.40

Classification

USCS= SP AASHTO=

Remarks

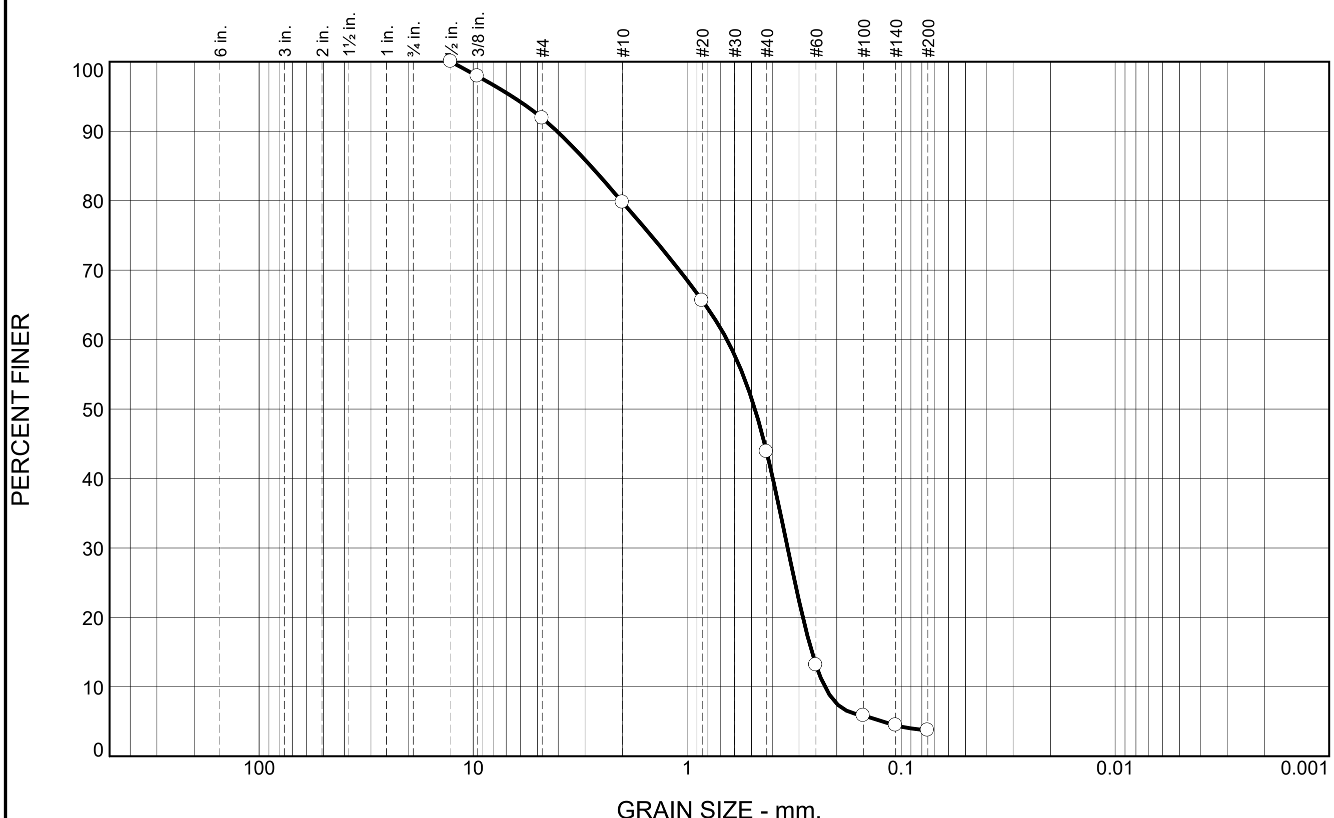
Source of Sample: BCI-17-12 **Depth:** 9.0-10.0
Sample Number: 5 **Date:**

Blackburn Consulting

W. Sacramento, CA

Client: EIP
Project: Lookout Slough THRFP
Project No: 3195.P **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0	0	8	12	36	40	4	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1/2"	100		
3/8"	98		
#4	92		
#10	80		
#20	66		
#40	44		
#60	13		
#100	6		
#140	4		
#200	4		

* (no specification provided)

Material Description

Poorly-graded SAND, dark brown

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 4.0615 D_{85}= 2.8253 D_{60}= 0.6518
D_{50}= 0.4823 D_{30}= 0.3391 D_{15}= 0.2612
D_{10}= 0.2270 C_u= 2.87 C_c= 0.78

Classification

USCS= SP AASHTO=

Remarks

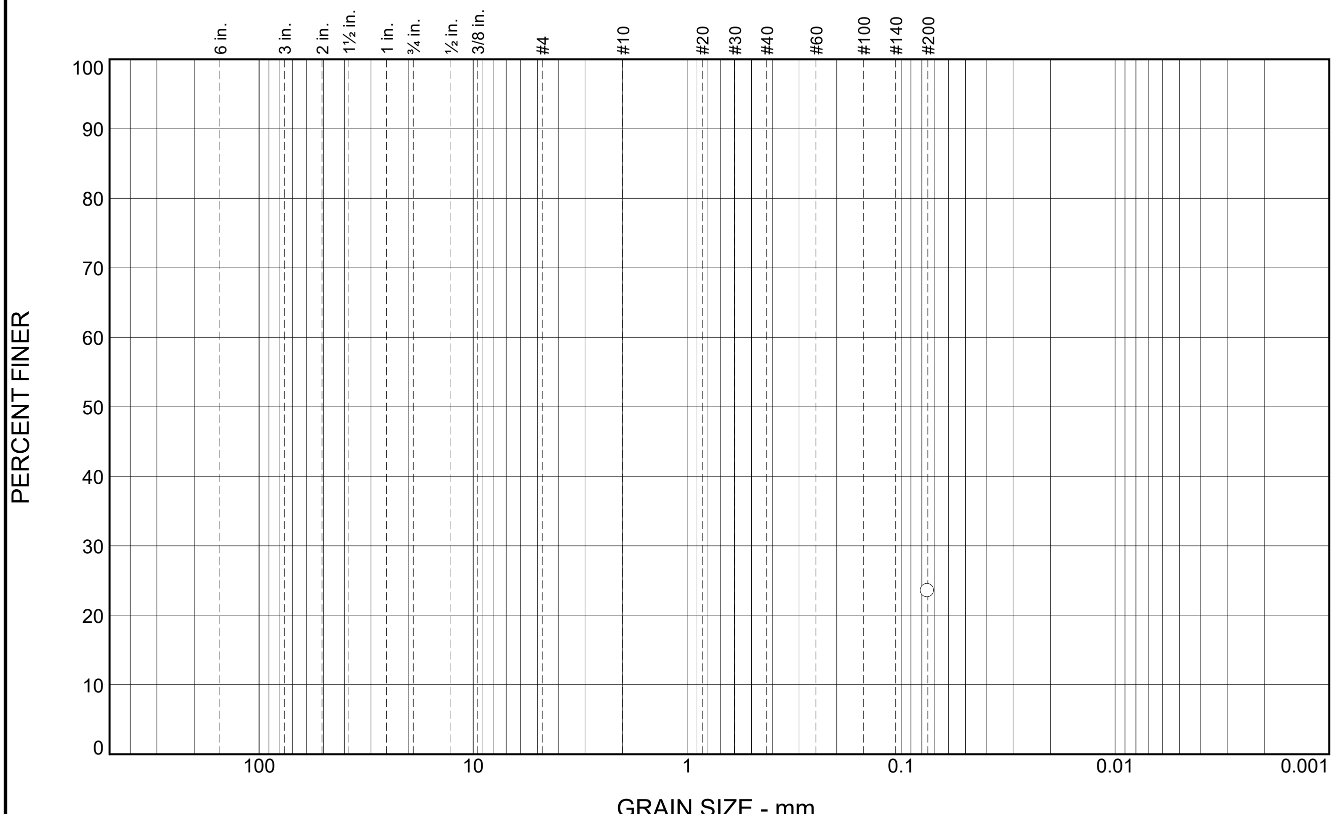
Source of Sample: BCI-17-12 **Depth:** 10.0-11.5
Sample Number: 6 **Date:**

Blackburn Consulting

W. Sacramento, CA

Client: EIP
Project: Lookout Slough THRFP
Project No: 3195.P **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
						23	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#200	23		

* (no specification provided)

Material Description

SILTY SAND, very dark olive brown

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= D_{85}= D_{60}=
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= SM AASHTO=

Remarks

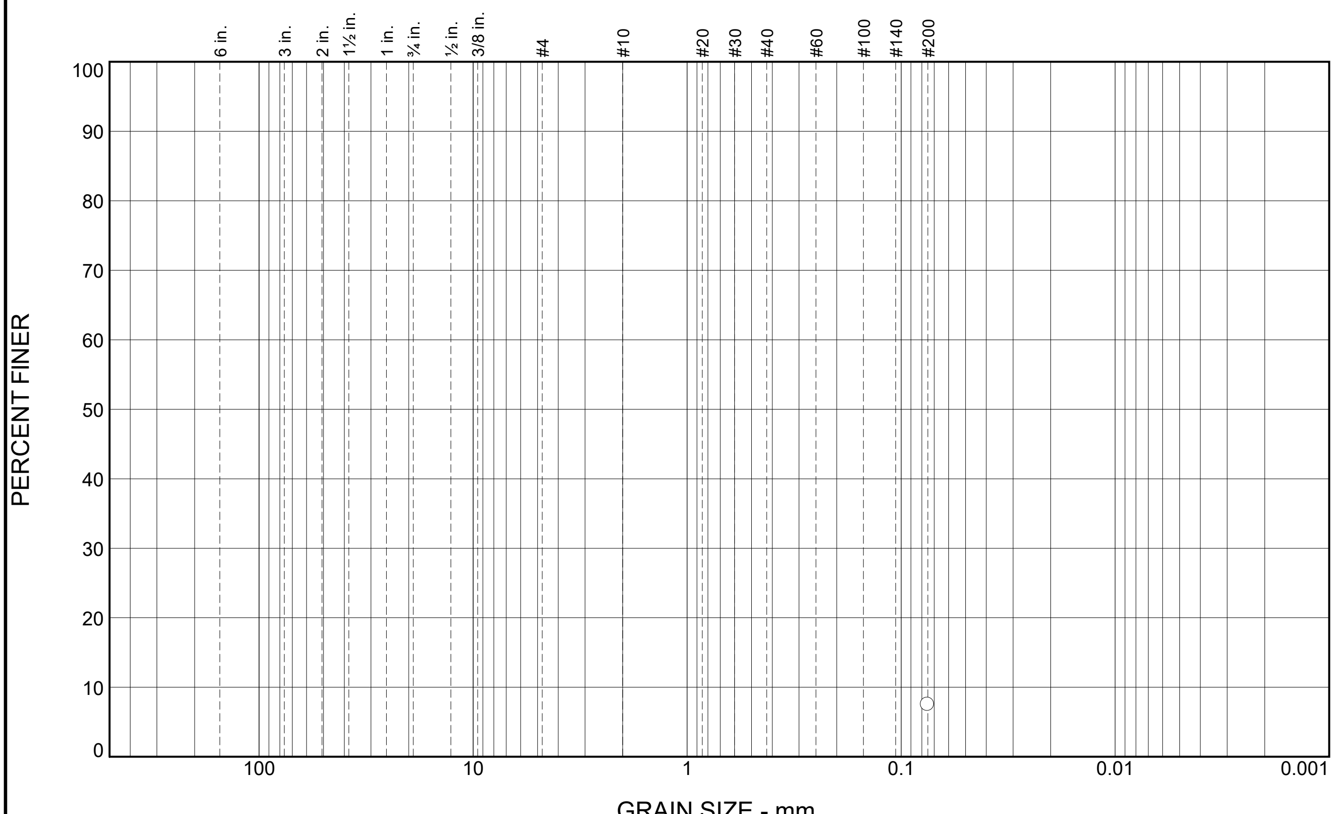
Source of Sample: BCI-17-12 **Depth:** 16.0-16.5
Sample Number: 7C **Date:**

Blackburn Consulting

W. Sacramento, CA

Client: EIP
Project: Lookout Slough THRFP
Project No: 3195.P **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
						8	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#200	8		

* (no specification provided)

Material Description

Well-graded SAND with CLAY and GRAVEL, dark grayish brown

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= D_{85}= D_{60}=
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= SW-SC AASHTO=

Remarks

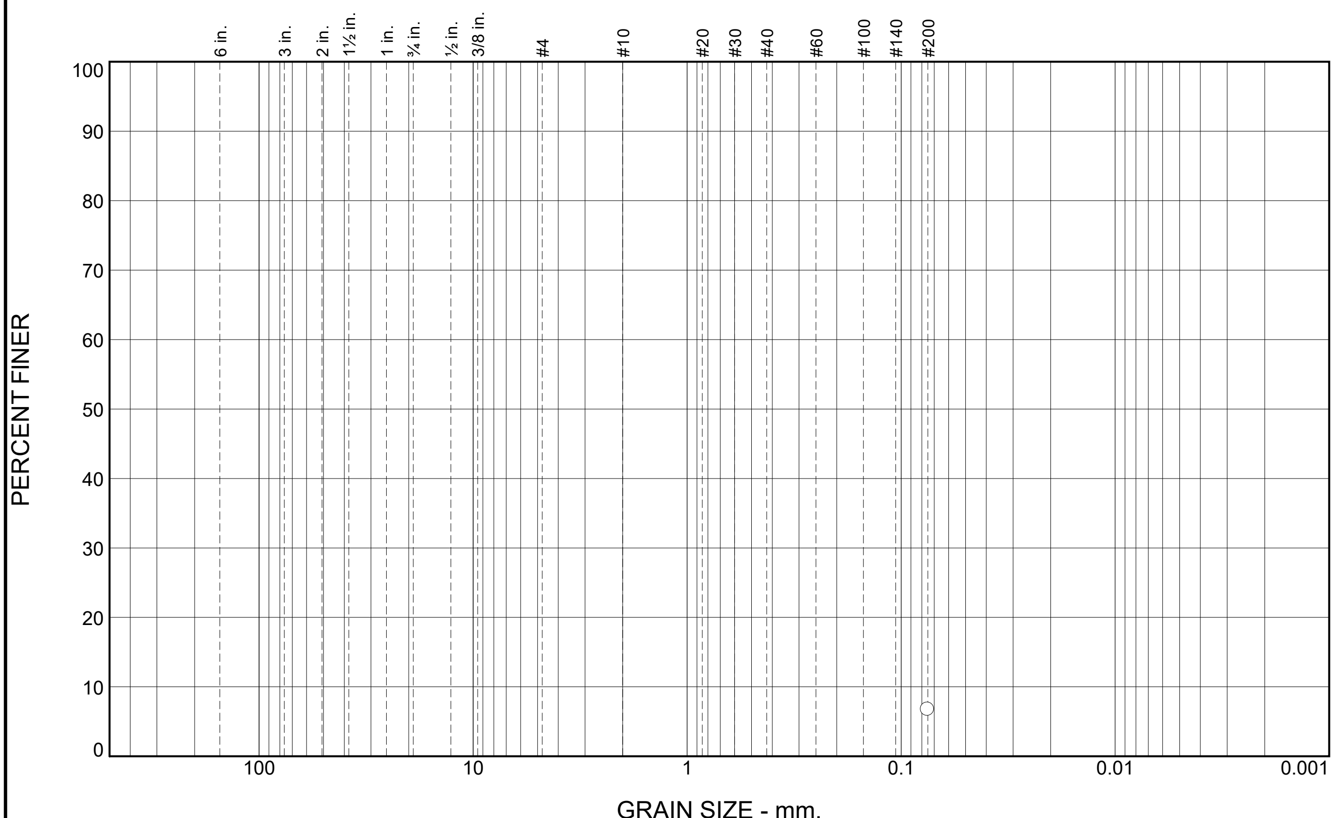
Source of Sample: BCI-17-12 **Depth:** 25.5-26.0
Sample Number: 9B **Date:**

Blackburn Consulting

W. Sacramento, CA

Client: EIP
Project: Lookout Slough THRFP
Project No: 3195.P **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
						7	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#200	7		

* (no specification provided)

Material Description
Poorly-graded SAND with CLAY, dark brown

Atterberg Limits
PL= LL= PI=

Coefficients
D_{90}= D_{85}= D_{60}=
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification
USCS= SP-SC AASHTO=

Remarks

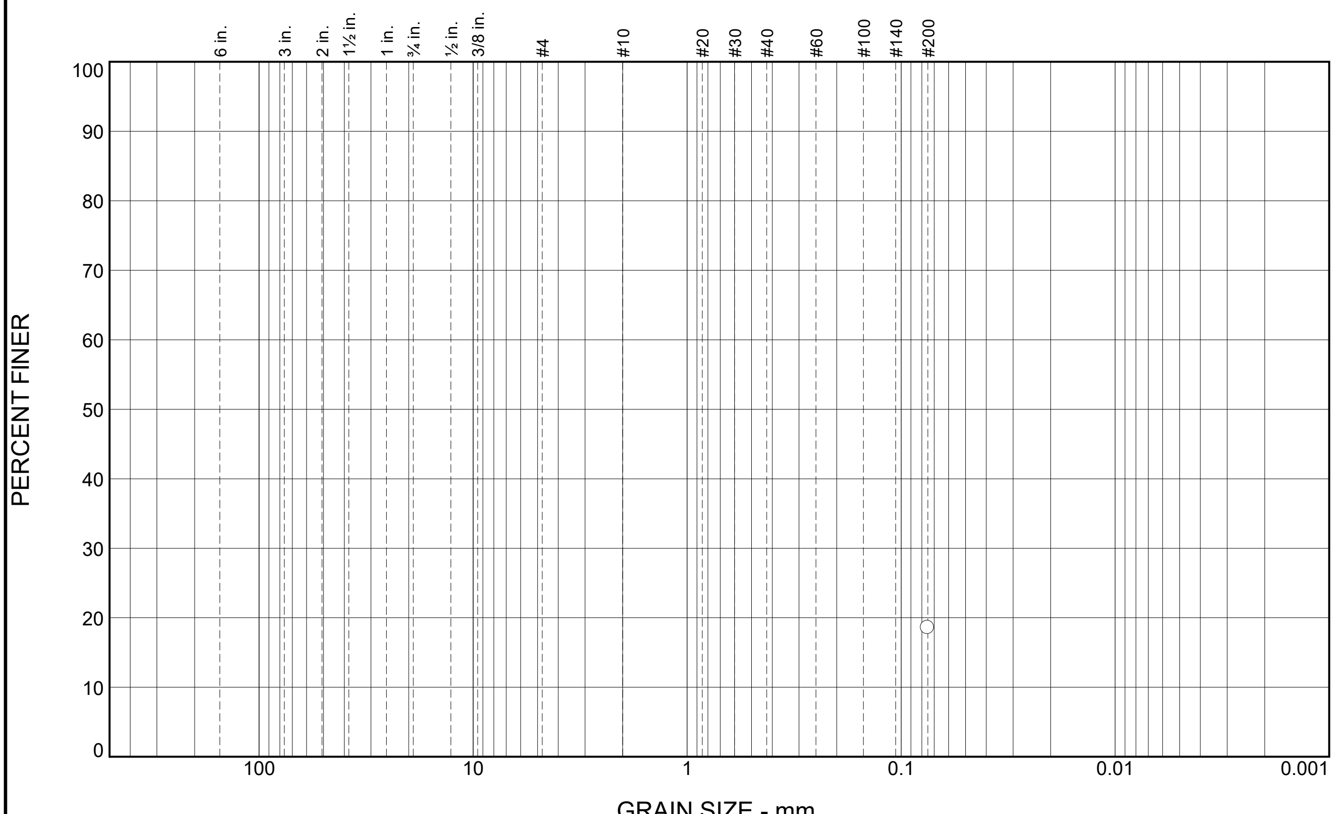
Source of Sample: BCI-17-13 **Depth:** 46.0-46.5'
Sample Number: 15C **Date:**

Blackburn Consulting

W. Sacramento, CA

Client: EIP
Project: Lookout Slough THRFP
Project No: 3195.P **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
						19	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#200	19		

* (no specification provided)

Material Description

CLAYEY SAND, very dark olive brown

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= D_{85}= D_{60}=
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= SC AASHTO=

Remarks

Source of Sample: BCI-17-19 **Depth:** 50-51.5'
Sample Number: 17 **Date:**

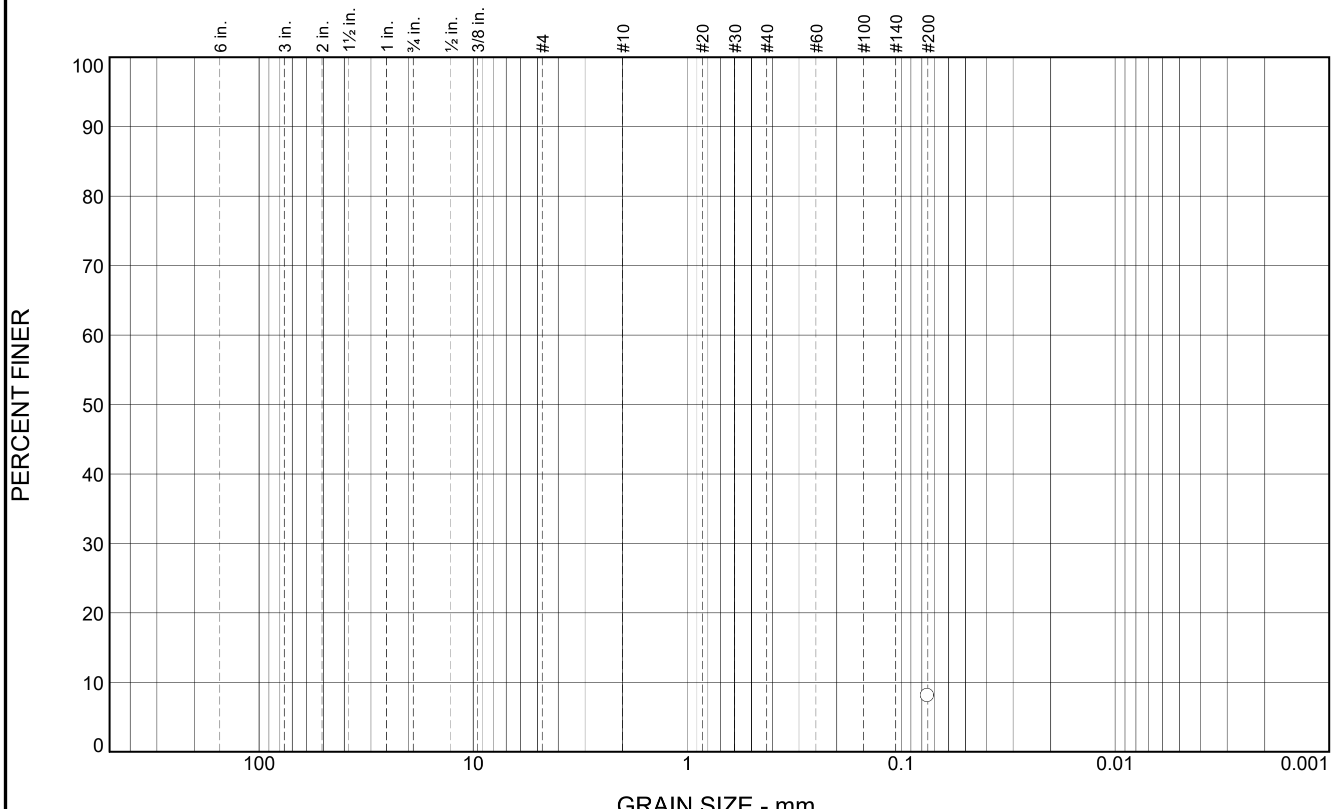
Blackburn Consulting

W. Sacramento, CA

Client: EIP
Project: Lookout Slough THRFP

Project No: 3195.P **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
						8	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#200	8		

* (no specification provided)

Material Description

Poorly-graded SAND with SILT, dark brown

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= D_{85}= D_{60}=
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= SP-SM AASHTO=

Remarks

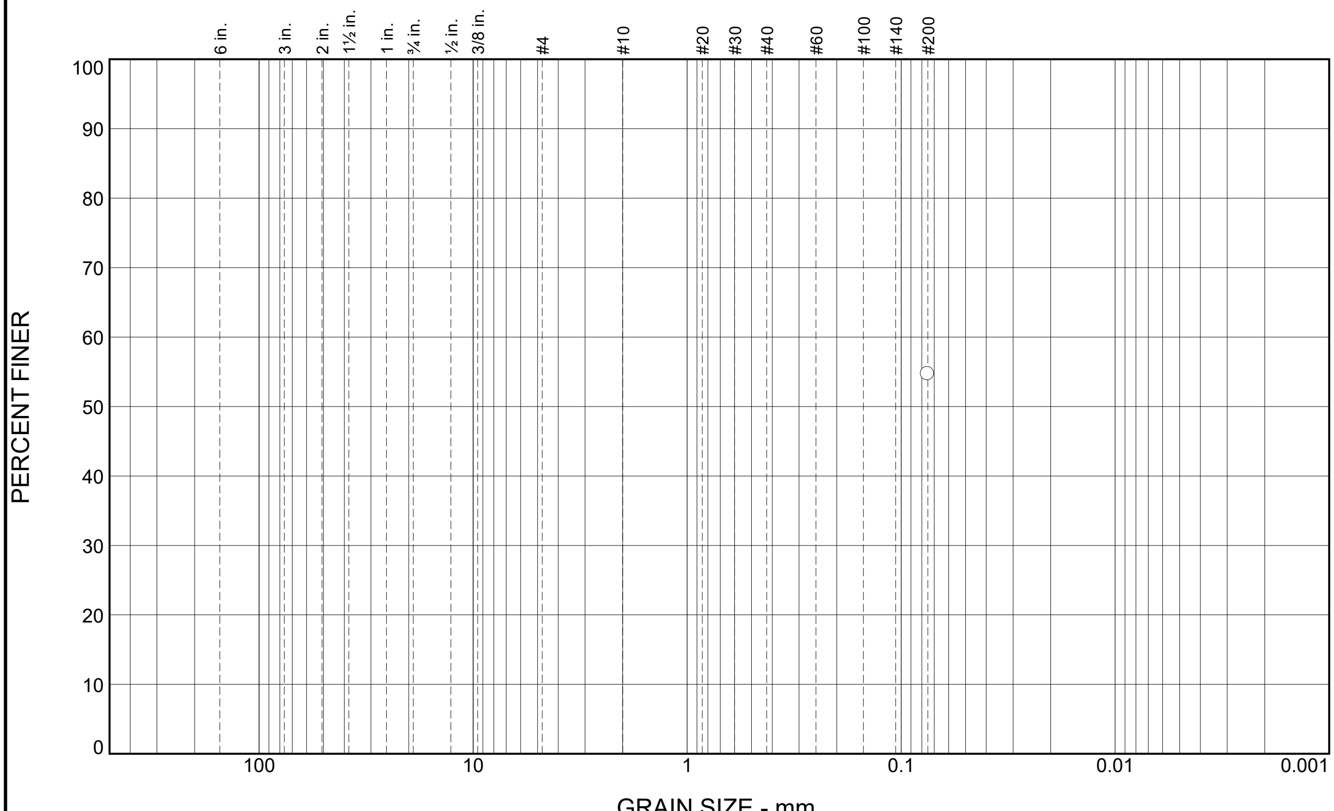
Source of Sample: BCI-17-20 **Depth:** 40.5-41'
Sample Number: 11B **Date:**

Blackburn Consulting

W. Sacramento, CA

Client: EIP
Project: Lookout Slough THRFP
Project No: 3195.P **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
						55	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#200	55		

* (no specification provided)

Material Description

SANDY Lean CLAY, olive brown

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= D_{85}= D_{60}=
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= CL AASHTO=

Remarks

Source of Sample: BCI-18-22 **Depth:** 8.0-9.5'
Sample Number: 4

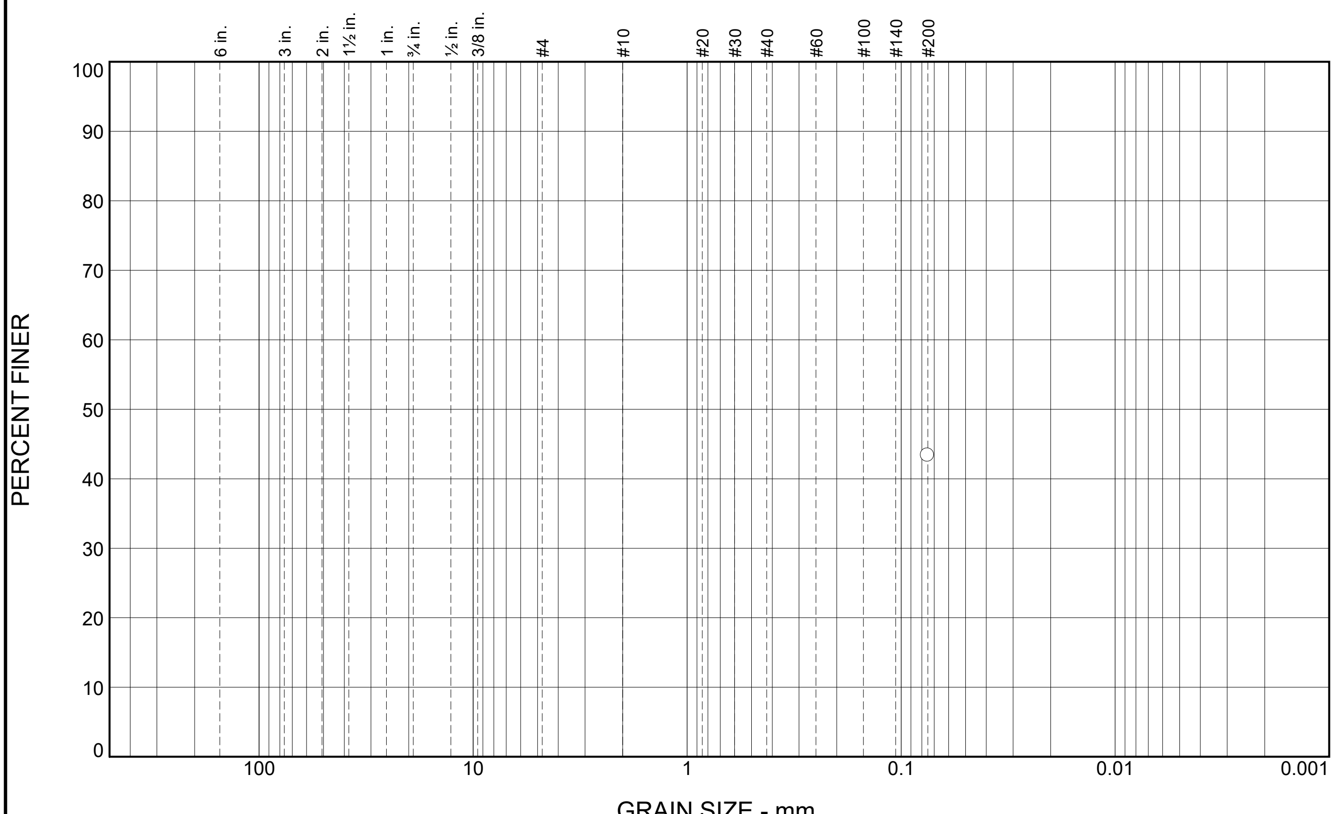
Date: 6/14/18

Blackburn Consulting

W. Sacramento, CA

Client: EIP
Project: Lookout Slough THRFP
Project No: 3195.P **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
						43	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#200	43		

* (no specification provided)

Material Description

CLAYEY SAND, olive brown

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= D_{85}= D_{60}=
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= SC AASHTO=

Remarks

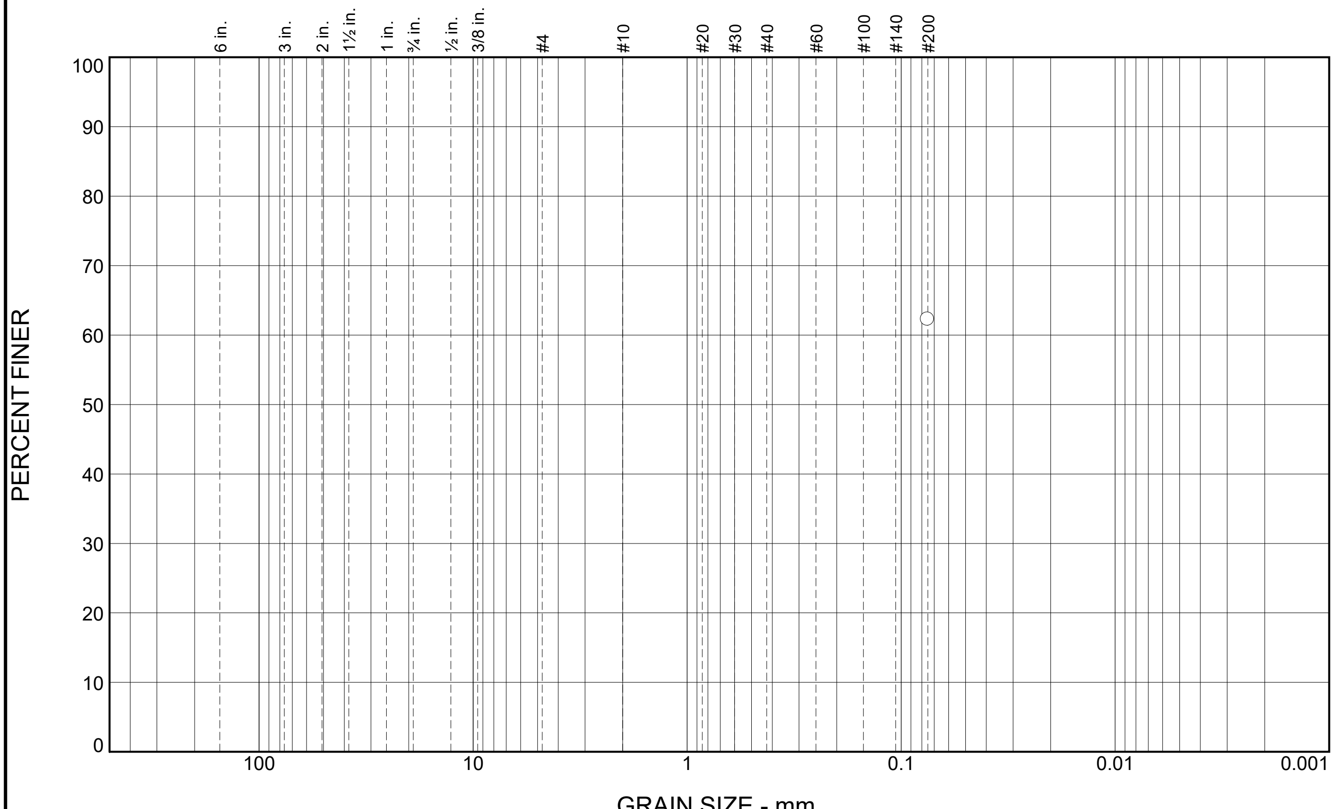
Source of Sample: BCI-18-22 **Depth:** 9.5-11.0'
Sample Number: 5 **Date:** 6/14/18

Blackburn Consulting

W. Sacramento, CA

Client: EIP
Project: Lookout Slough THRFP
Project No: 3195.P **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
						62	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#200	62		

* (no specification provided)

Material Description

SANDY Lean CLAY, olive brown

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= D_{85}= D_{60}=
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= CL AASHTO=

Remarks

Source of Sample: BCI-18-22 **Depth:** 30.0-31.5'
Sample Number: 13

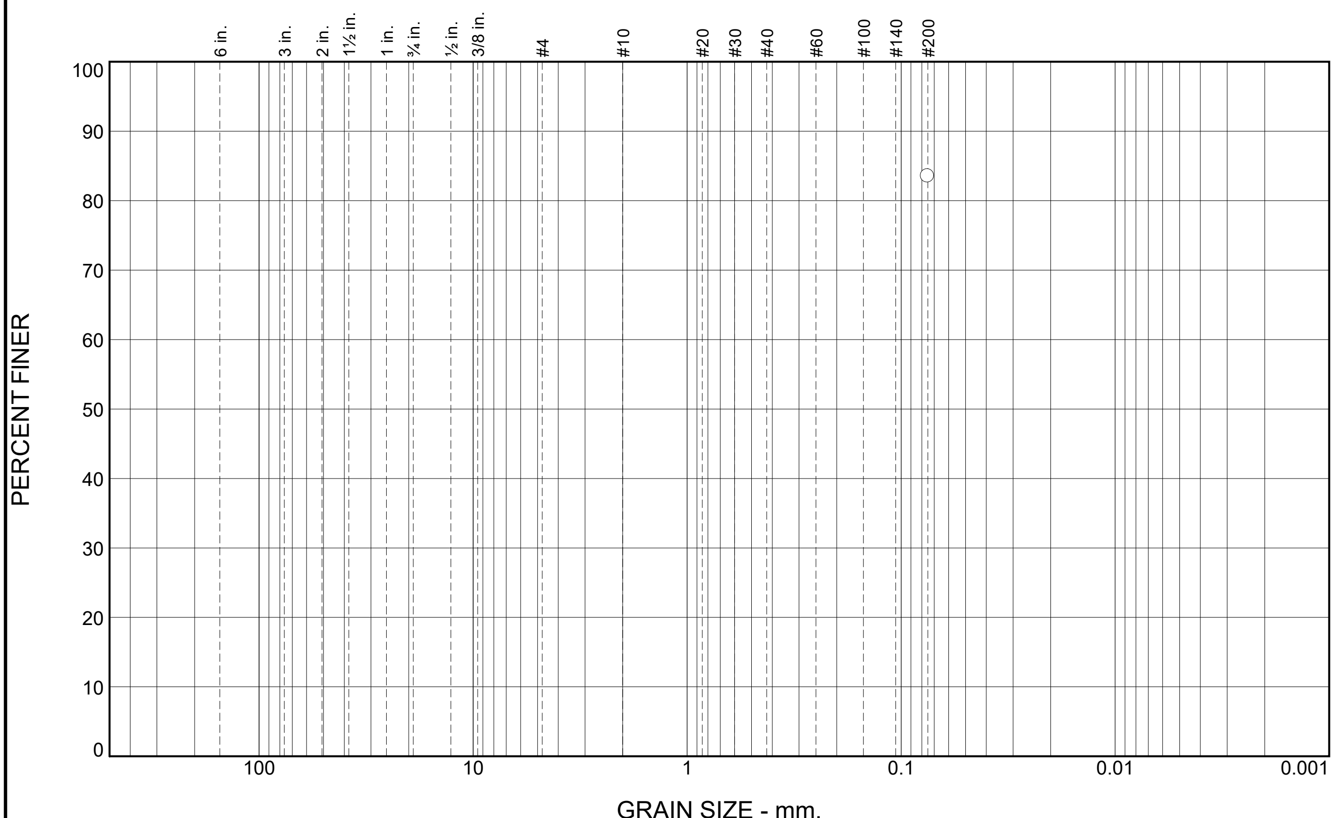
Date: 6/14/18

Blackburn Consulting

W. Sacramento, CA

Client: EIP
Project: Lookout Slough THRFP
Project No: 3195.P **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
						83	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#200	83		

* (no specification provided)

Material Description

Lean CLAY with SAND, olive brown

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= D_{85}= D_{60}=
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= CL AASHTO=

Remarks

Source of Sample: BCI-18-24 **Depth:** 8.0-9.5'
Sample Number: 4

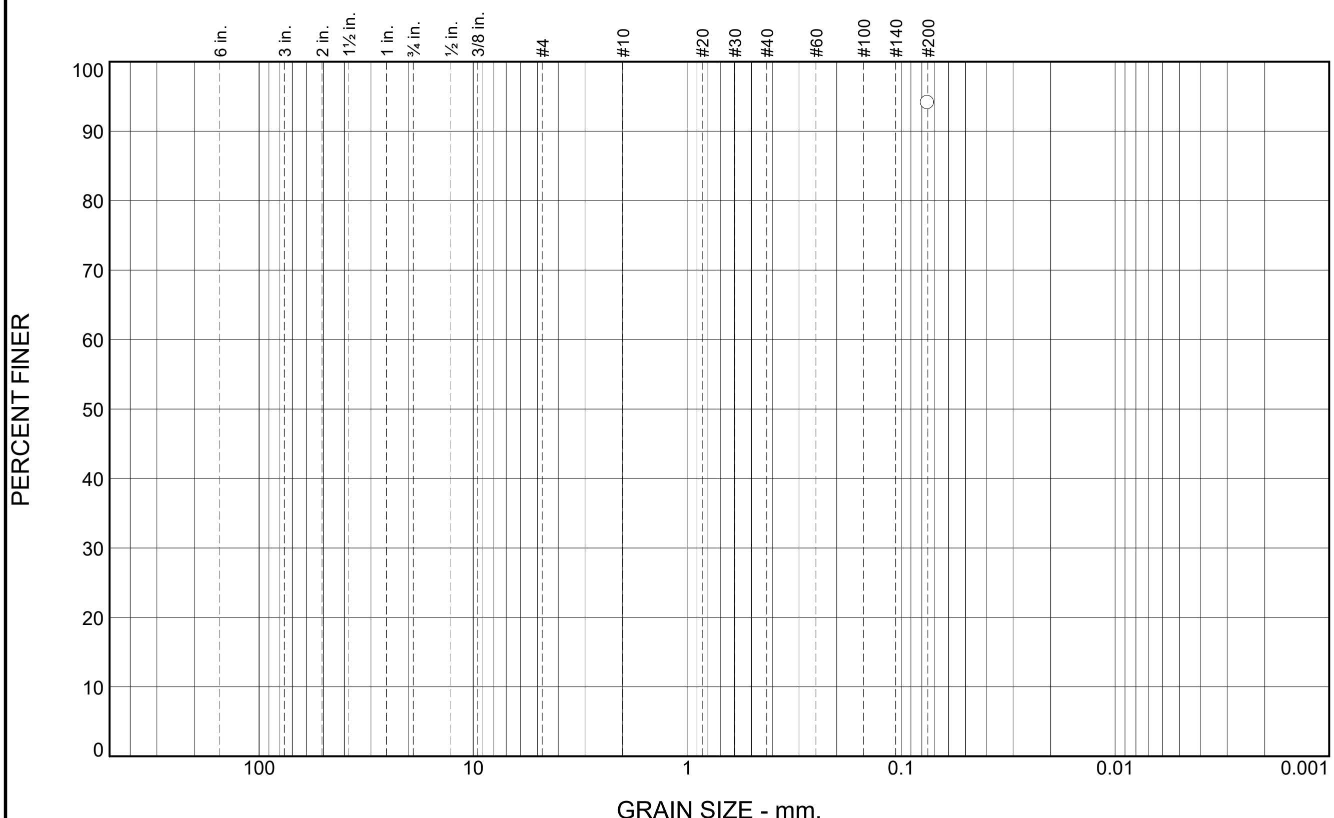
Date: 6/17/18

Blackburn Consulting

W. Sacramento, CA

Client: EIP
Project: Lookout Slough THRFP
Project No: 3195.P **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
						94	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#200	94		

* (no specification provided)

Material Description

Lean CLAY, olive brown

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= D_{85}= D_{60}=
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= CL AASHTO=

Remarks

Source of Sample: BCI-18-24 **Depth:** 9.5-11.0'
Sample Number: 5

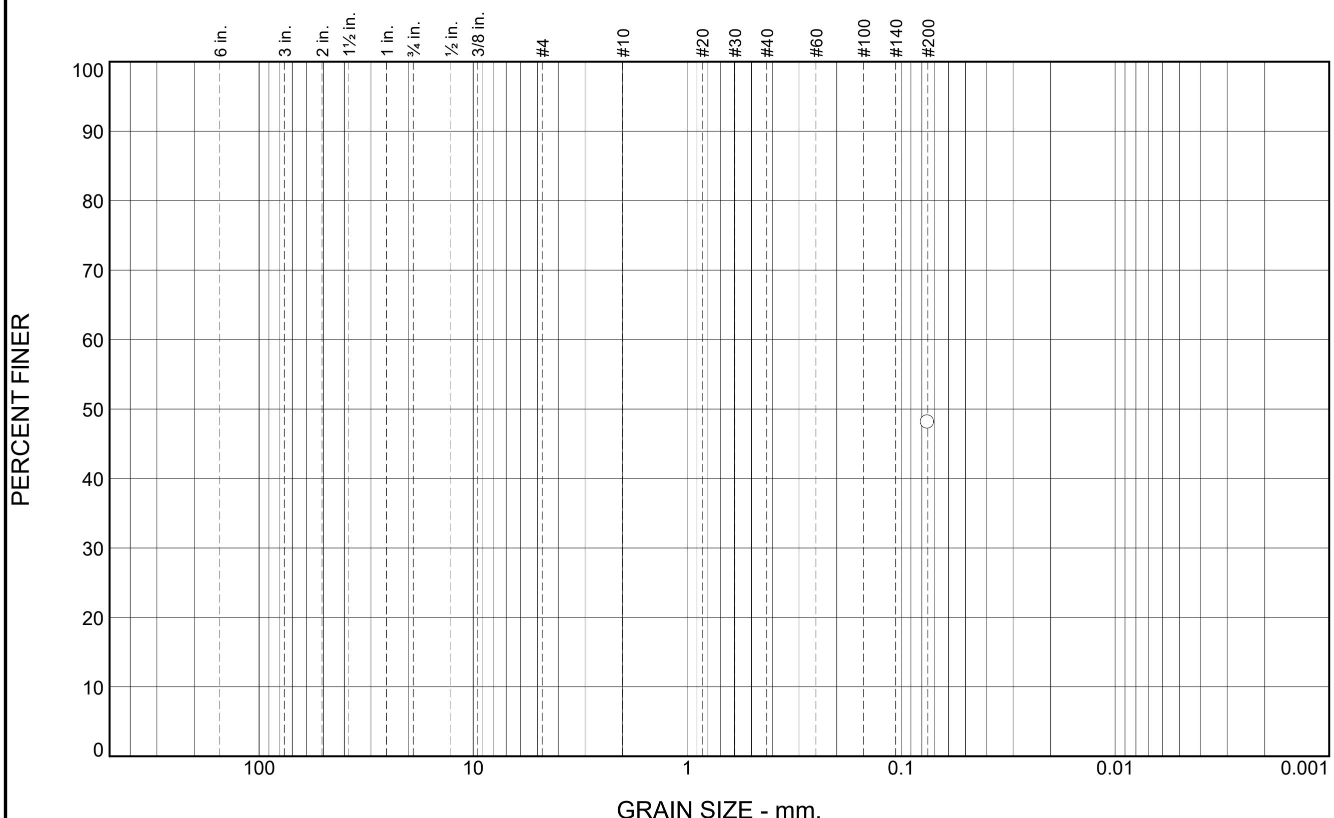
Date: 6/14/18

Blackburn Consulting

W. Sacramento, CA

Client: EIP
Project: Lookout Slough THRFP
Project No: 3195.P **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
						48	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#200	48		

* (no specification provided)

Material Description

CLAYEY SAND, olive brown

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= D_{85}= D_{60}=
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= SC AASHTO=

Remarks

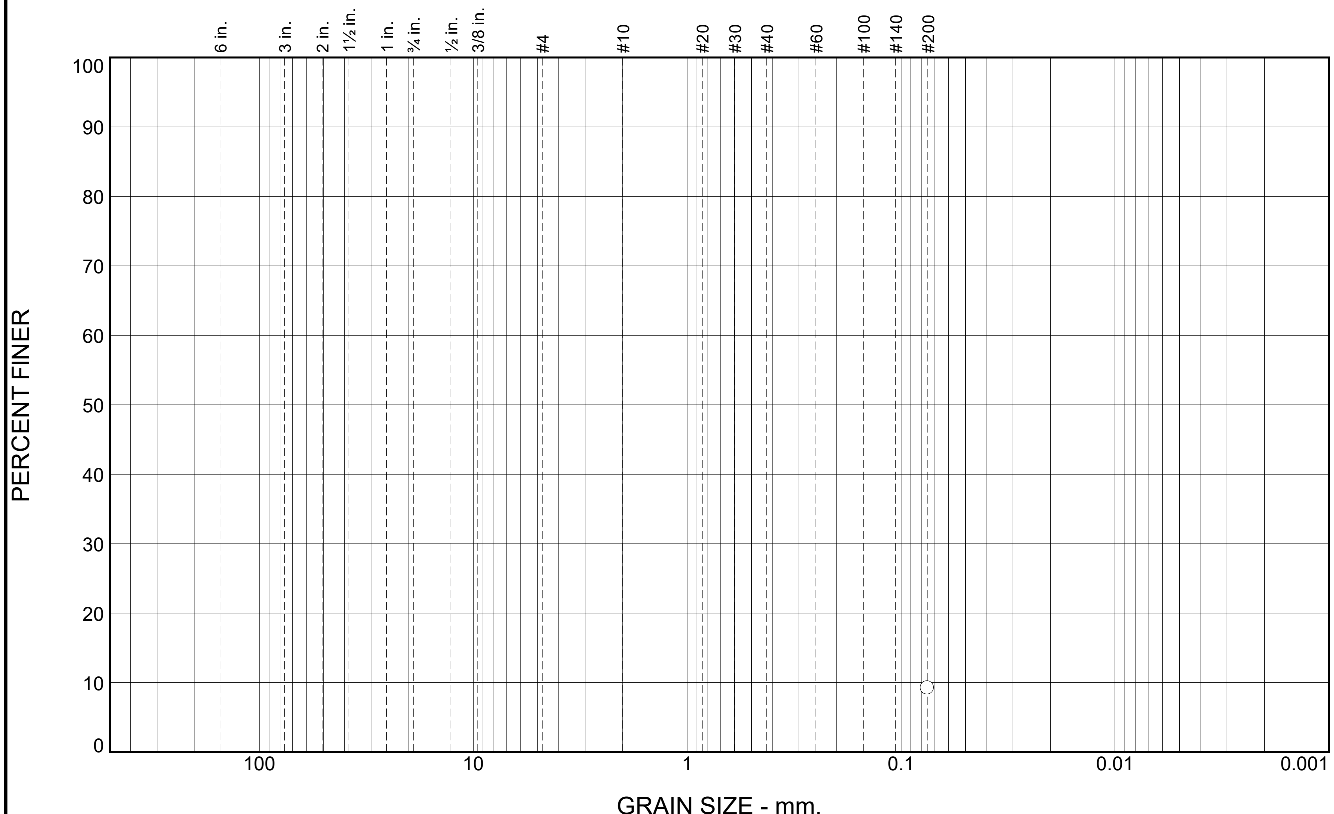
Source of Sample: BCI-18-24 **Depth:** 30.0-31.5'
Sample Number: 11 **Date:** 6/14/18

Blackburn Consulting

W. Sacramento, CA

Client: EIP
Project: Lookout Slough THRFP
Project No: 3195.P **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
						9	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#200	9		

* (no specification provided)

Material Description

Poorly-graded SAND with SILT, very dark grayish brown

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= D_{85}= D_{60}=
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= SP-SM AASHTO=

Remarks

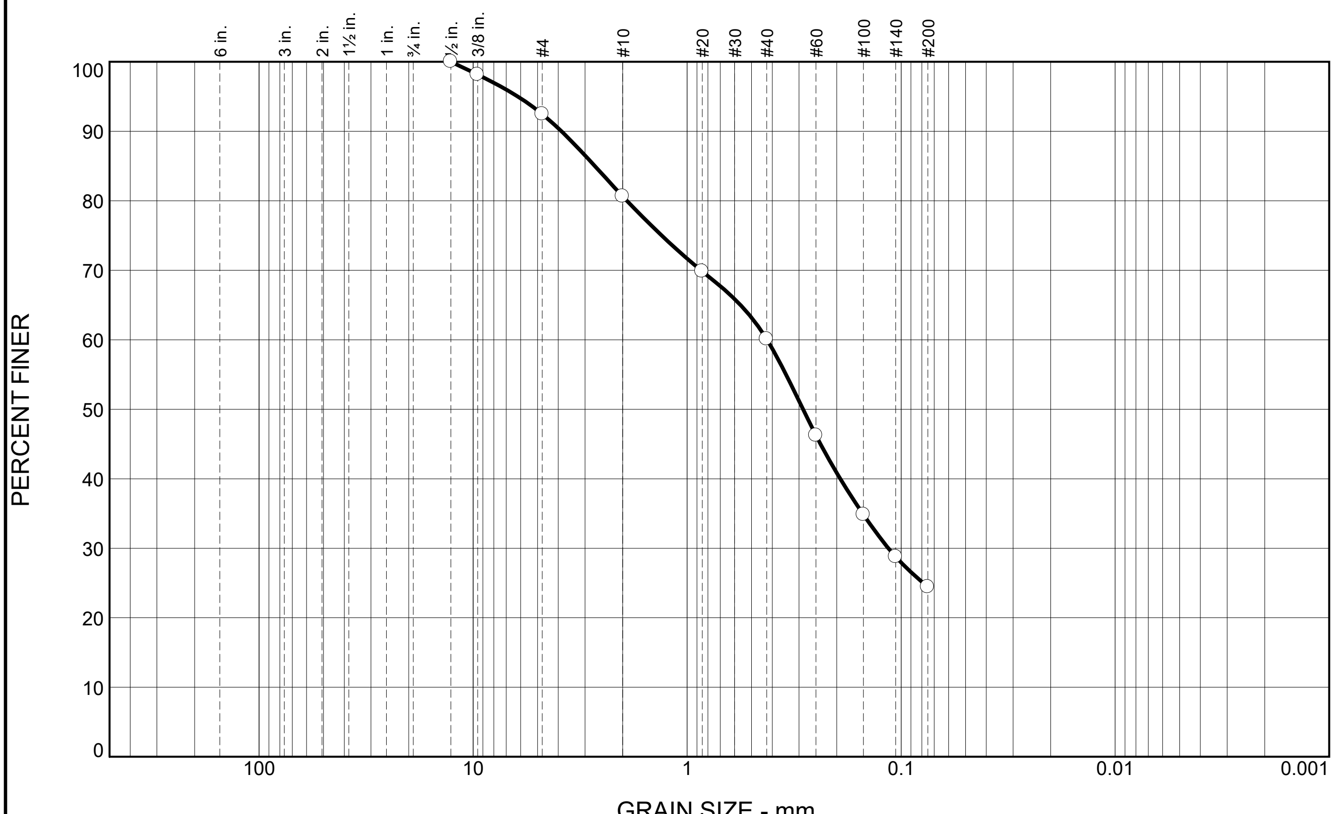
Source of Sample: BCI-18-26 **Depth:** 11.0-12.5'
Sample Number: 6
Date: 6/14/18

Blackburn Consulting

W. Sacramento, CA

Client: EIP
Project: Lookout Slough THRFP
Project No: 3195.P **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0	0	8	11	21	36	24	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1/2"	100		
3/8"	98		
#4	92		
#10	81		
#20	70		
#40	60		
#60	46		
#100	35		
#140	29		
#200	24		

* (no specification provided)

Material Description

SILTY SAND, dark yellowish brown

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 3.8689 D_{85}= 2.7005 D_{60}= 0.4231
D_{50}= 0.2874 D_{30}= 0.1147 D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= SM AASHTO=

Remarks

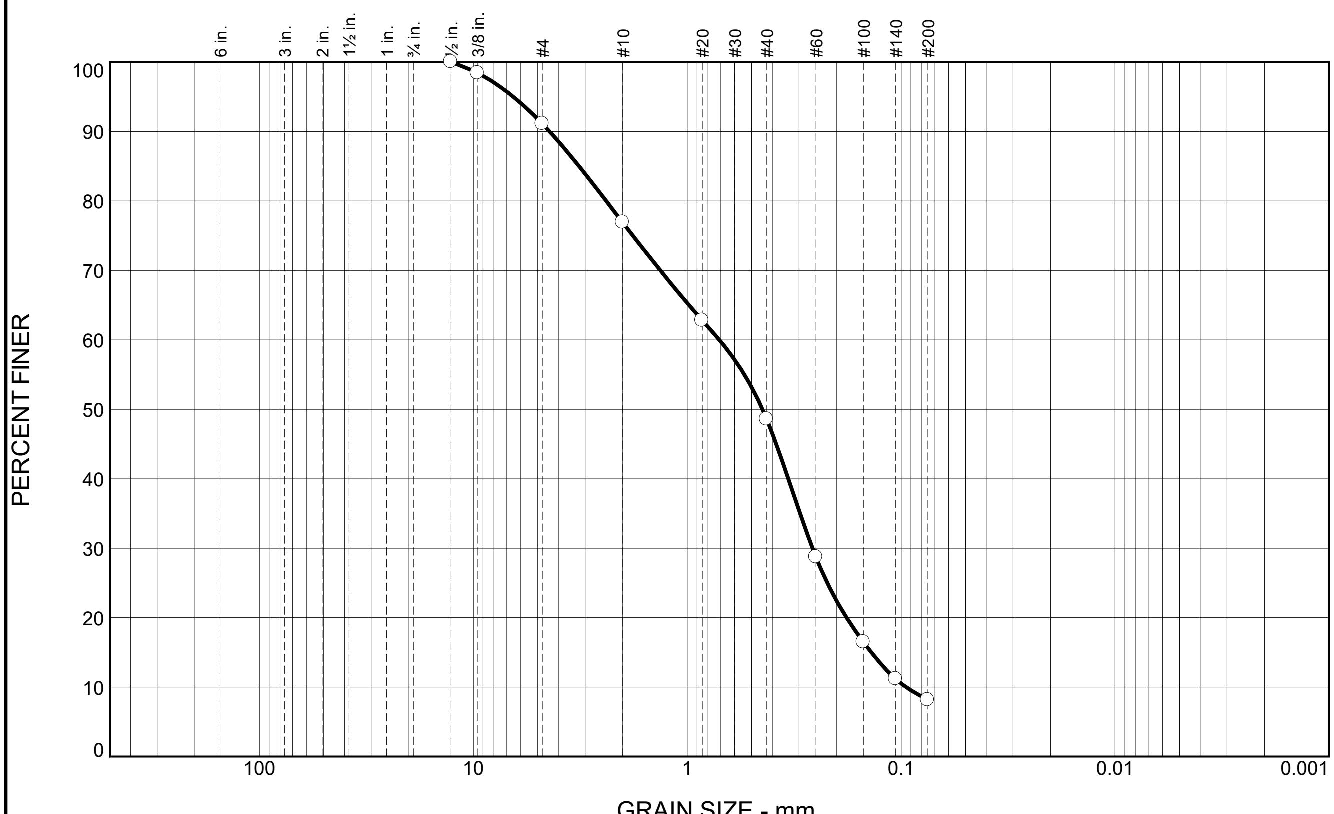
Source of Sample: BCI-18-26 **Depth:** 15.5-17.0'
Sample Number: 9 **Date:** 6/15/18

Blackburn Consulting

W. Sacramento, CA

Client: EIP
Project: Lookout Slough THRFP
Project No: 3195.P **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0	0	9	14	28	41	8	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1/2"	100		
3/8"	98		
#4	91		
#10	77		
#20	63		
#40	49		
#60	29		
#100	16		
#140	11		
#200	8		

* (no specification provided)

Material Description

Well-graded SAND with SILT, dark grayish brown

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 4.4001 D_{85}= 3.2025 D_{60}= 0.7083
D_{50}= 0.4447 D_{30}= 0.2596 D_{15}= 0.1378
D_{10}= 0.0947 C_u= 7.48 C_c= 1.00

Classification

USCS= SW-SM AASHTO=

Remarks

Source of Sample: BCI-18-26 **Depth:** 50.0-51.5'
Sample Number: 16

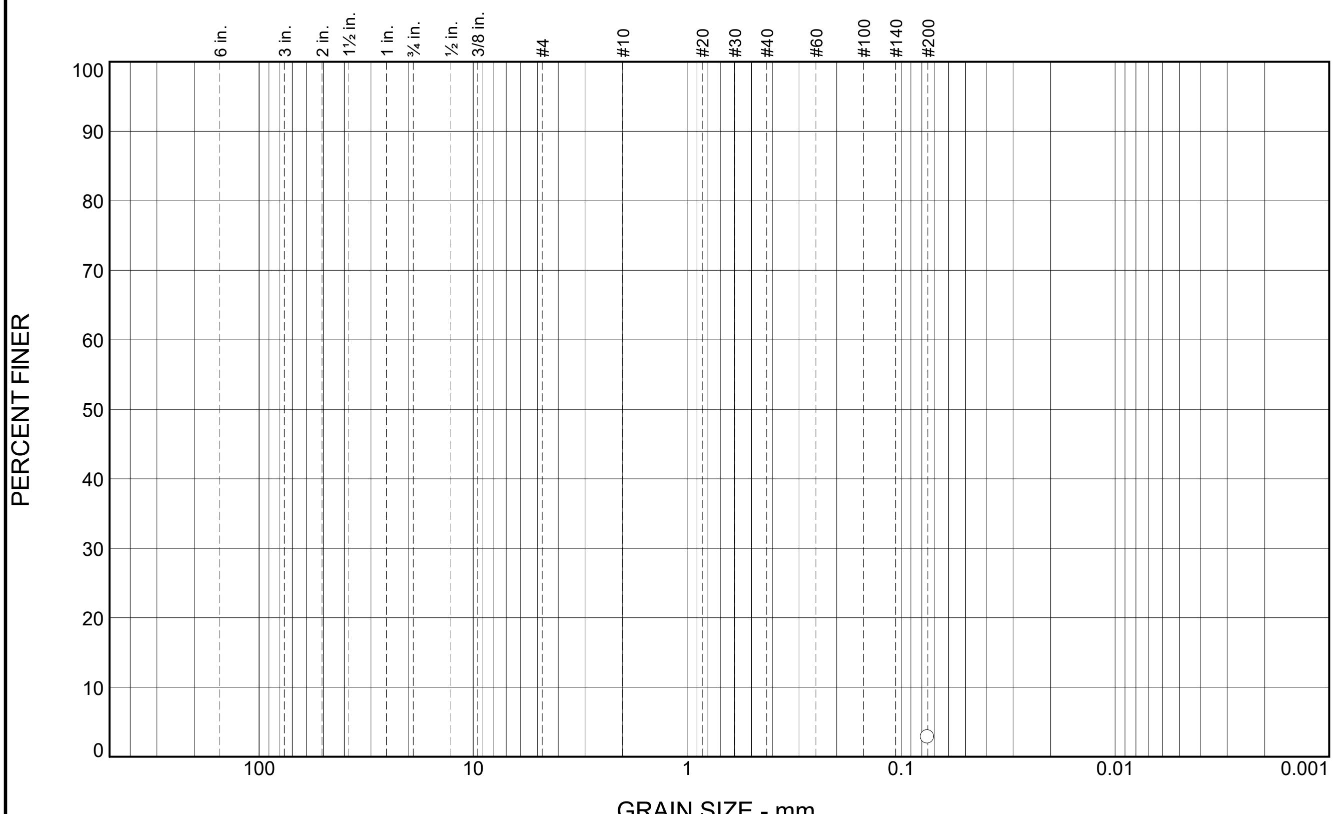
Date: 6/15/18

Blackburn Consulting

W. Sacramento, CA

Client: EIP
Project: Lookout Slough THRFP
Project No: 3195.P **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
						3	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#200	3		

* (no specification provided)

Material Description

Well-graded SAND, dark gray

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= D_{85}= D_{60}=
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= SW AASHTO=

Remarks

Source of Sample: BCI-18-27 **Depth:** 50.0-51.5'
Sample Number: 16

Date: 6/14/18

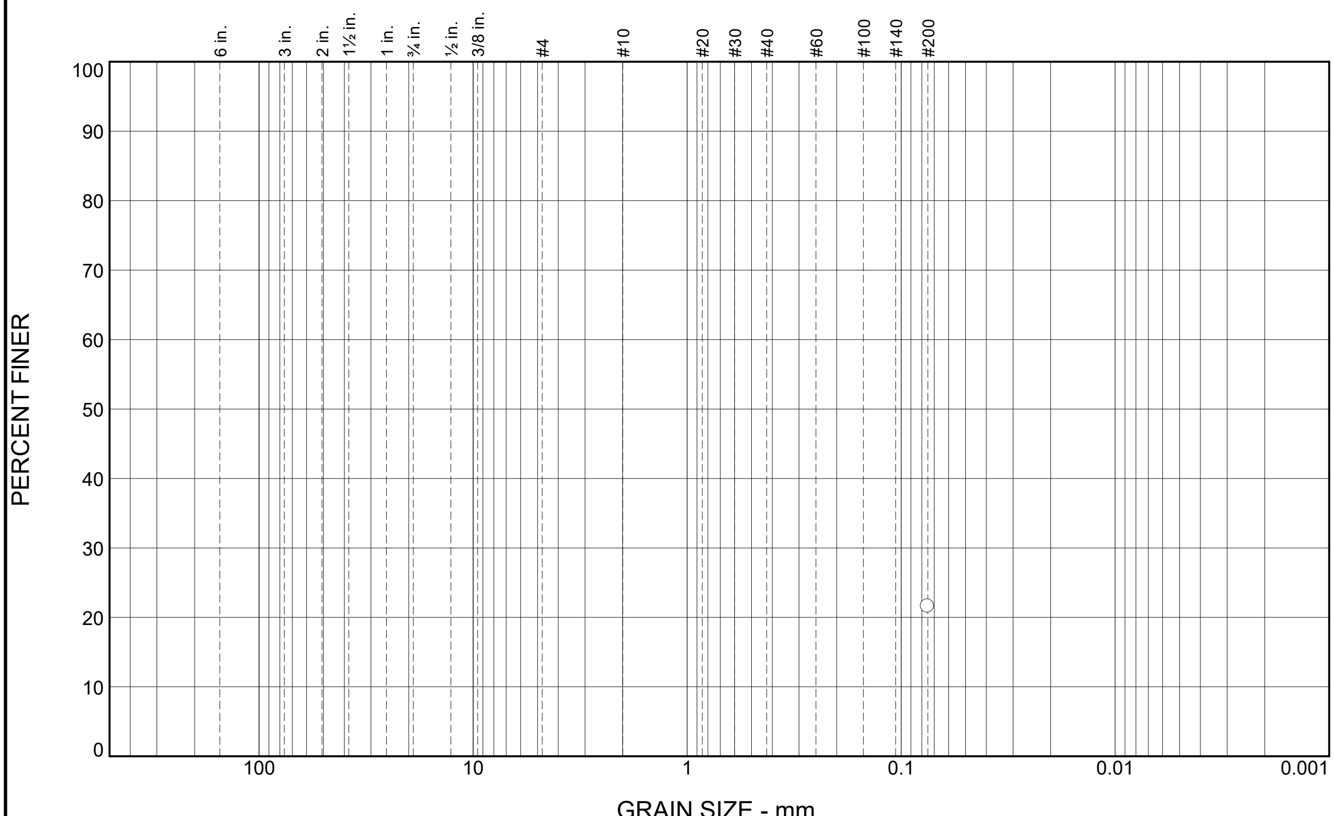
Blackburn Consulting

W. Sacramento, CA

Client: EIP
Project: Lookout Slough THRFP

Project No: 3195.P **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
						22	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#200	22		

* (no specification provided)

Material Description

CLAYEY SAND, olive brown

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= D_{85}= D_{60}=
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= SC AASHTO=

Remarks

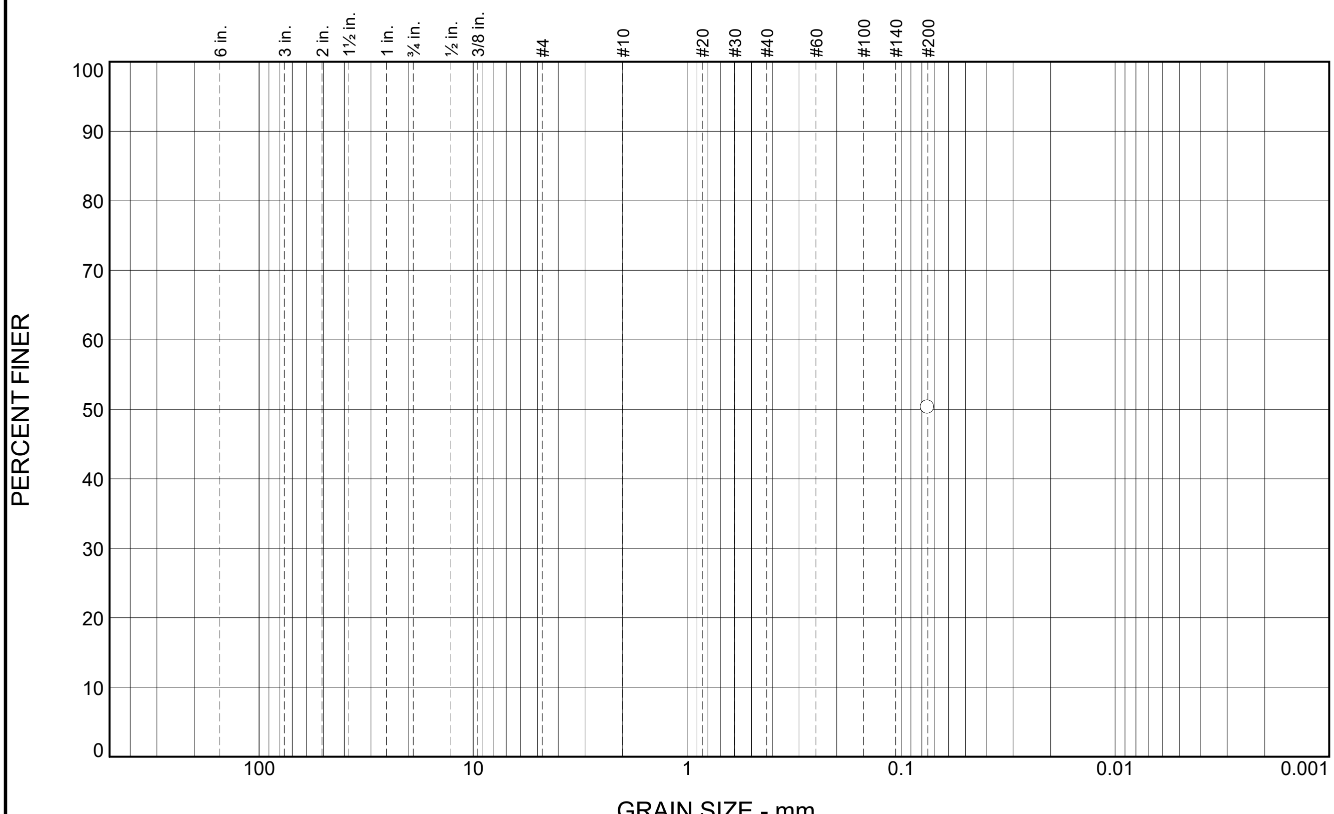
Source of Sample: BCI-19-36 **Depth:** 15.5-15.75'
Sample Number: 9 **Date:**

Blackburn Consulting

W. Sacramento, CA

Client: EIP
Project: Lookout Slough THRFP
Project No: 3195.P **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
						50	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#200	50		

* (no specification provided)

Material Description

SANDY SILT, olive gray

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= D_{85}= D_{60}=
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= ML AASHTO=

Remarks

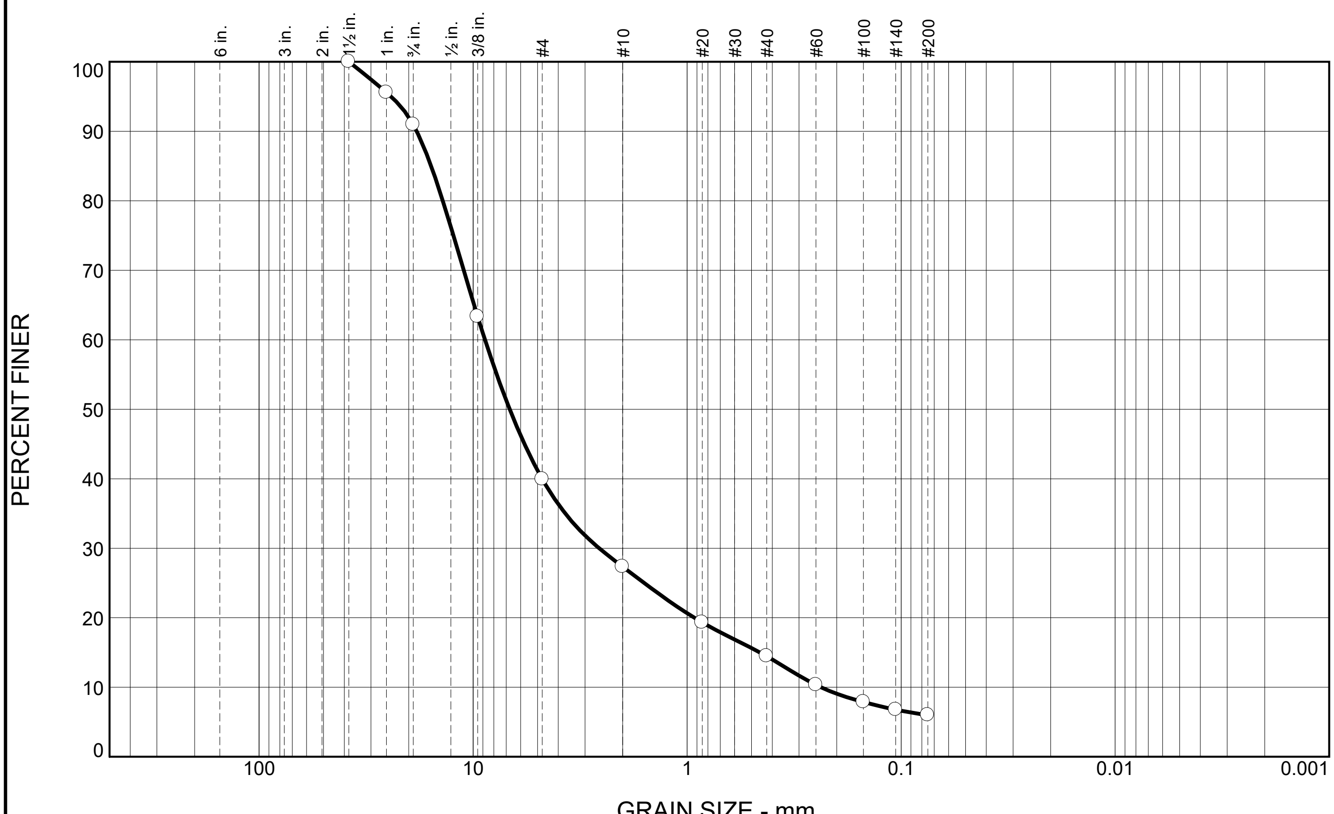
Source of Sample: BCI-19-37 **Depth:** 46-46.5'
Sample Number: 18C **Date:**

Blackburn Consulting

W. Sacramento, CA

Client: EIP
Project: Lookout Slough THRFP
Project No: 3195.P **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0	9	51	13	13	8	6	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1.5"	100		
1"	96		
3/4"	91		
3/8"	63		
#4	40		
#10	27		
#20	19		
#40	14		
#60	10		
#100	8		
#140	7		
#200	6		

* (no specification provided)

Material Description

Poorly-graded GRAVEL with SILT and SAND, brown

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 18.3525 D_{85}= 15.7167 D_{60}= 8.8016
D_{50}= 6.7427 D_{30}= 2.5750 D_{15}= 0.4567
D_{10}= 0.2369 C_u= 37.15 C_c= 3.18

Classification

USCS= GP-GM AASHTO=

Remarks

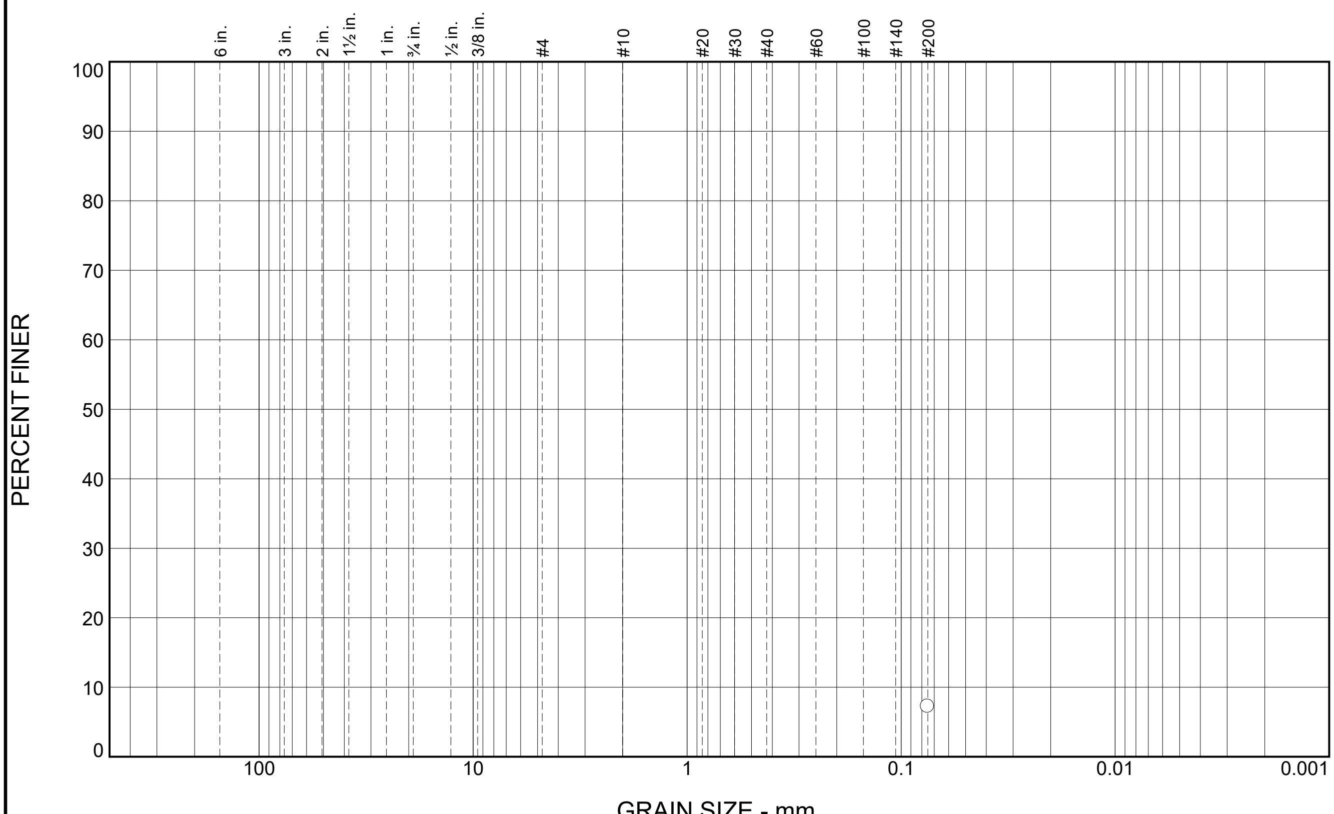
Source of Sample: BCI-19-37 **Depth:** 50-51'
Sample Number: 19 **Date:**

Blackburn Consulting

W. Sacramento, CA

Client: EIP
Project: Lookout Slough THRFP
Project No: 3195.P **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
						7	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#200	7		

* (no specification provided)

Material Description

Poorly-graded SAND with SILT, olive brown

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= D_{85}= D_{60}=
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= SP-SM AASHTO=

Remarks

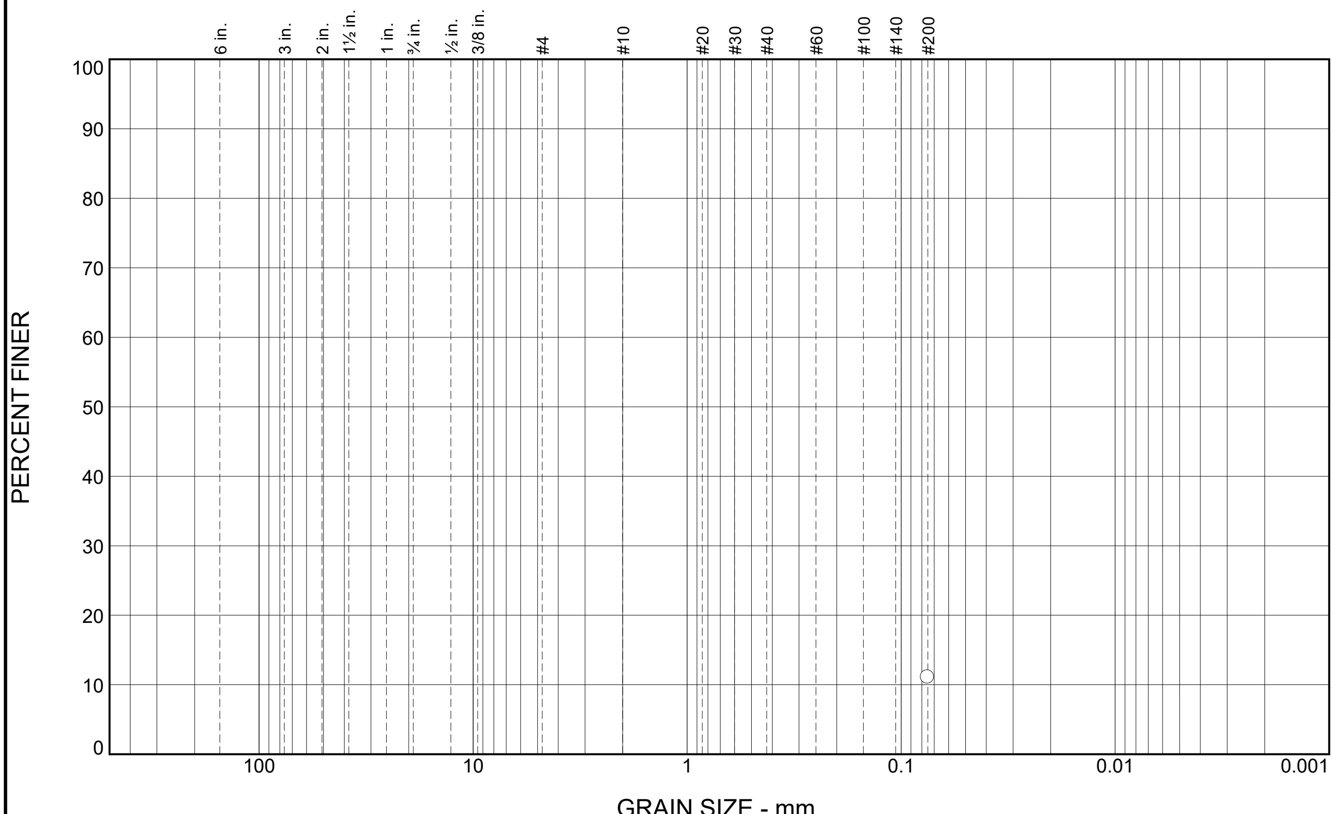
Source of Sample: BCI-19-38 **Depth:** 51-51.5'
Sample Number: 19C **Date:**

Blackburn Consulting

W. Sacramento, CA

Client: EIP
Project: Lookout Slough THRFP
Project No: 3195.P **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
						11	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#200	11		

* (no specification provided)

Material Description

Poorly-graded SAND with SILT, brown

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= D_{85}= D_{60}=
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= SP-SM AASHTO=

Remarks

Source of Sample: BCI-19-38 **Depth:** 56-56.5'
Sample Number: 20C

Date:

Blackburn Consulting

W. Sacramento, CA

Client: EIP
Project: Lookout Slough THRFP
Project No: 3195.P **Figure**

Sunland Analytical
11419 Sunrise Gold Circle, #10
Rancho Cordova, CA 95742
(916) 852-8557

Date Reported 02/07/2018
Date Submitted 02/02/2018

To: Nicole Hart
Blackburn Consulting
2491 Boatman Ave
W. Sacramento, CA 95691

From: Gene Oliphant, Ph.D. \ Randy Horney
General Manager \ Lab Manager

The following is analysis requested on SUN Order 76123.

Thank you for your business.

SOIL ANALYSIS

SUN#	Sample Source	Samp ID	Organic Matter
158742	3195.X LOOKOUT SLOUG	B1-17-3	9.7 %
158743	3195.X LOOKOUT SLOUG	B1-17-2	4.4 %
158744	3195.X LOOKOUT SLOUG	B2-17-2	6.8 %
158745	3195.X LOOKOUT SLOUG	B2-17-4	5.9 %
158746	3195.X LOOKOUT SLOUG	B3-17-2	6.3 %
158747	3195.X LOOKOUT SLOUG	B4-17-2	5.5 %
158748	3195.X LOOKOUT SLOUG	B5-17-6	5.6 %

METHOD: LOI

Sunland Analytical

11419 Sunrise Gold Circle, #10
Rancho Cordova, CA 95742
(916) 852-8557

Date Reported 02/07/2018
Date Submitted 02/02/2018

To: Nicole Hart
Blackburn Consulting
2491 Boatman Ave
W. Sacramento, CA 95691

From: Gene Oliphant, Ph.D. \ Randy Horney
General Manager \ Lab Manager

The following is analysis requested on SUN Order 76124.

Thank you for your business.

SOIL ANALYSIS

SUN#	Sample Source	Samp ID	Organic Matter
158749	3195.X LOOKOUT SLOUG	B7-17-2	5.1 %
158750	3195.X LOOKOUT SLOUG	B7-17-4	7.3 %
158751	3195.X LOOKOUT SLOUG	B8-17-2	9.2 %
158752	3195.X LOOKOUT SLOUG	B8-17-4	5.0 %
158753	3195.X LOOKOUT SLOUG	B8-17-6	5.1 %
158754	3195.X LOOKOUT SLOUG	B10-17-2	12.6 %

METHOD: LOI

Hydraulic Conductivity of Saturated Porous Material
ASTM D 5084 (Method C)

Project: Lookout Slough THRFIP
Project Number: 3195.x
Date: 10/30/2018

Sample Number: BCI-17-1-06 **Depth: 12'-12.5'**
Material Description: Lean CLAY, LL = 41, PI = 20
Sample Collection Date: 09/05/17

Sample Data:

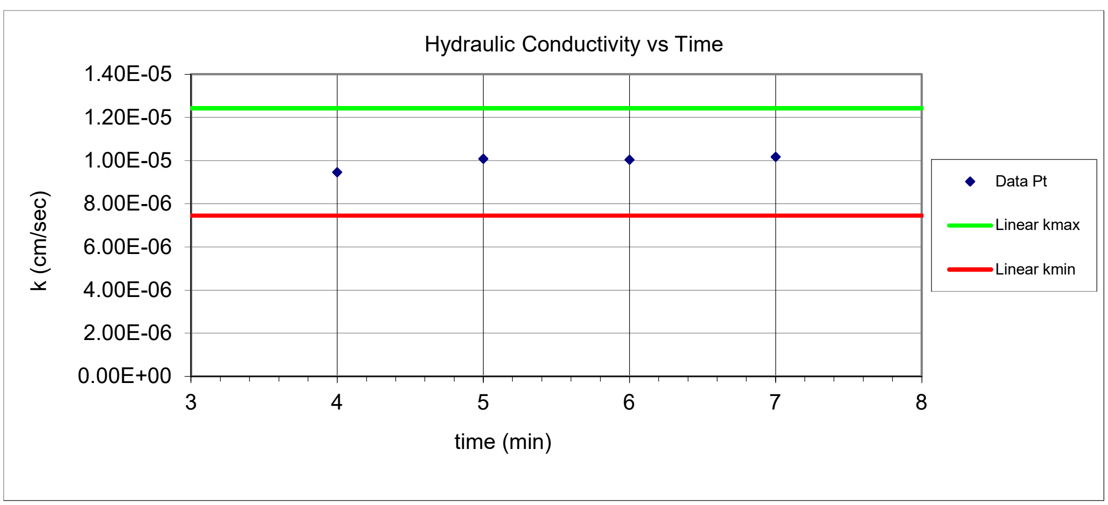
Type of Sample = Shelby

Initial Data:			**Final Data:**		
Sample Length =	9.1	cm	Sample Length =	9.1	cm
Sample Diameter =	7.21	cm	Sample Diameter =	7.19	cm
Area =	40.8	cm^2	Area =	40.6	cm^2
Volume =	372.4	cm^3	Volume =	370.3	cm^3
Wet Weight=	665.8	g	Wet Weight=	689.9	g
Moisture =	29.6	%	Moisture =	34.3	%
Dry Density =	1.38	g/cm^3	Dry Density =	1.39	g/cm^3
Dry Density =	86.1	pcf	Dry Density =	86.6	pcf
Saturation =	85.3	%	Saturation =	100.0	%
Specific Gravity =	2.65	(assumed)	Specific Gravity =	2.65	(assumed)

Testing Parameters:

B Value =		0.95				
Cell Pressure	P_C=	60	psi	Permeant:	Deaired Water	
Base Pressure	P_b=	51	psi	Aver. Temp=	73.6	°F
Top Pressure	P_T=	50	psi	Burette Area=	0.194	cm^2
Consolidation	=	10	psi	Initial Hydraulic Gradient=	13.22	
Confining Pressure	=	1440	psf	Final Hydraulic Gradient=	10.53	

Results: **Average k (cm/sec)= 9.94E-06 cm/sec**

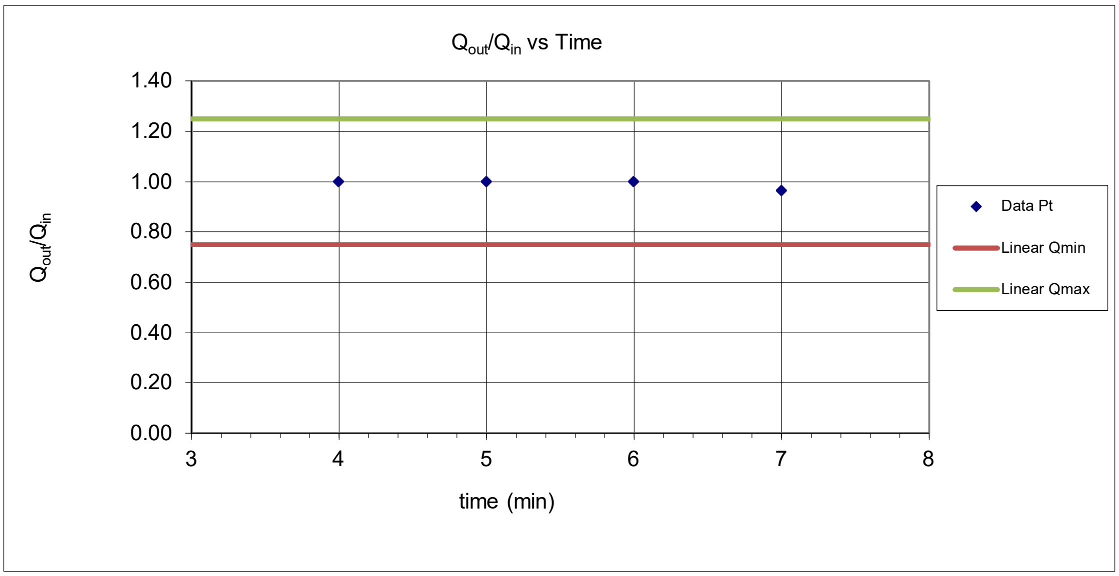


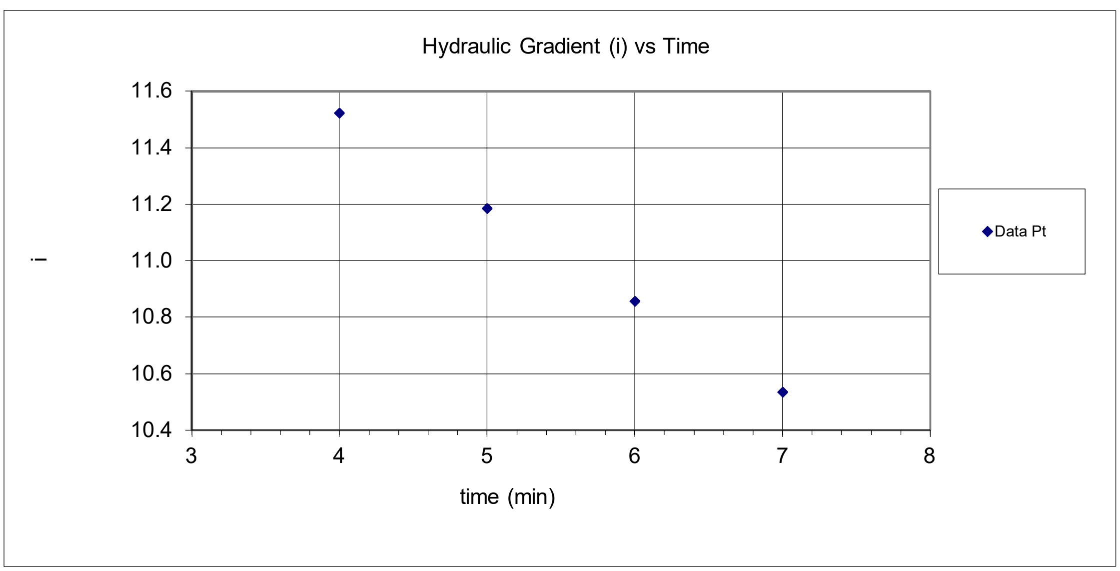
Hydraulic Conductivity of Saturated Porous Material
ASTM D 5084 (Method C)

Project: **Lookout Slough THRFIP**
Project Number: **3195.x**
Date: **10/30/2018**

Sample Number: **BCI-17-1-06** **Depth:** **12'-12.5'**
Material Description: **Lean CLAY, LL = 41, PI = 20**
Sample Collection Date: 09/05/17

Average k (cm/sec): 9.94E-06 cm/sec





Hydraulic Conductivity of Saturated Porous Material
ASTM D 5084 (Method C)

Project: Lookout Slough THRFIP
Project Number: 3195.x
Date: 10/30/2018

Sample Number: BCI-17-3-04 **Depth: 9'-9.5'**
Material Description: Lean CLAY with SAND, LL = 32, PI = 14
Sample Collection Date: 08/29/17

Sample Data:

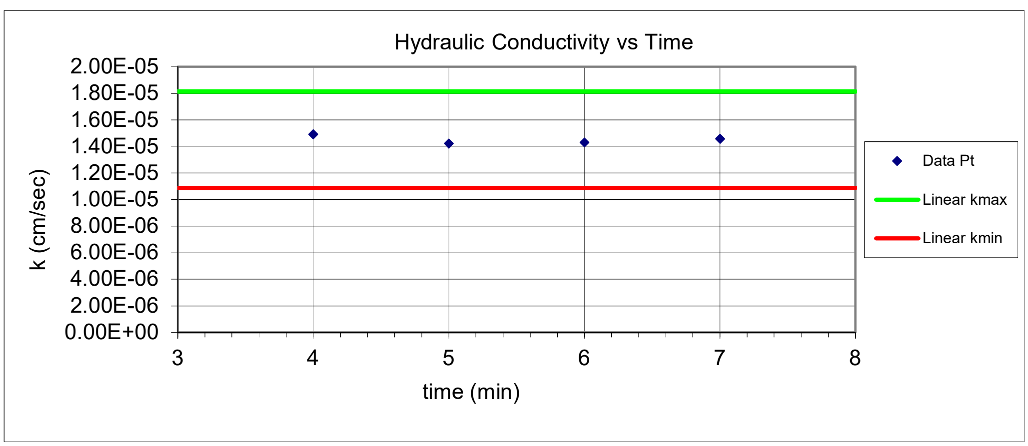
Type of Sample = Shelby

Initial Data:			**Final Data:**		
Sample Length =	8.7	cm	Sample Length =	8.7	cm
Sample Diameter =	7.17	cm	Sample Diameter =	7.15	cm
Area =	40.3	cm^2	Area =	40.2	cm^2
Volume =	351.5	cm^3	Volume =	350.3	cm^3
Wet Weight=	656.5	g	Wet Weight=	707.5	g
Moisture =	14.8	%	Moisture =	23.7	%
Dry Density =	1.63	g/cm^3	Dry Density =	1.63	g/cm^3
Dry Density =	101.6	pcf	Dry Density =	102.0	pcf
Saturation =	73.4	%	Saturation =	100.8	%
Specific Gravity =	2.65	(assumed)	Specific Gravity =	2.65	(assumed)

Testing Parameters:

B Value* =		0.54				
Cell Pressure	P_C=	60	psi	Permeant:	Deaired Water	
Base Pressure	P_b=	51	psi	Aver. Temp=	73.6	°F
Top Pressure	P_T=	50	psi	Burette Area=	0.194	cm^2
Consolidation	=	10	psi	Initial Hydraulic Gradient=	13.93	
Confining Pressure	=	1440	psf	Final Hydraulic Gradient=	9.95	

Results: **Average k (cm/sec)= 1.45E-05 cm/sec**



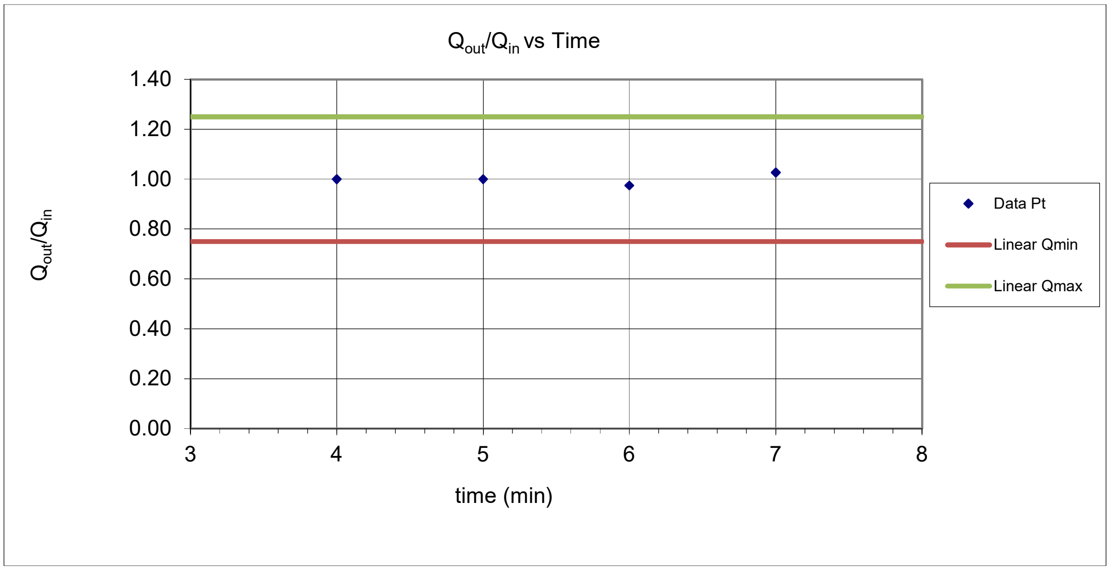
* B Value 0.95 could not be attained; however, 100% saturation was achieved during test.

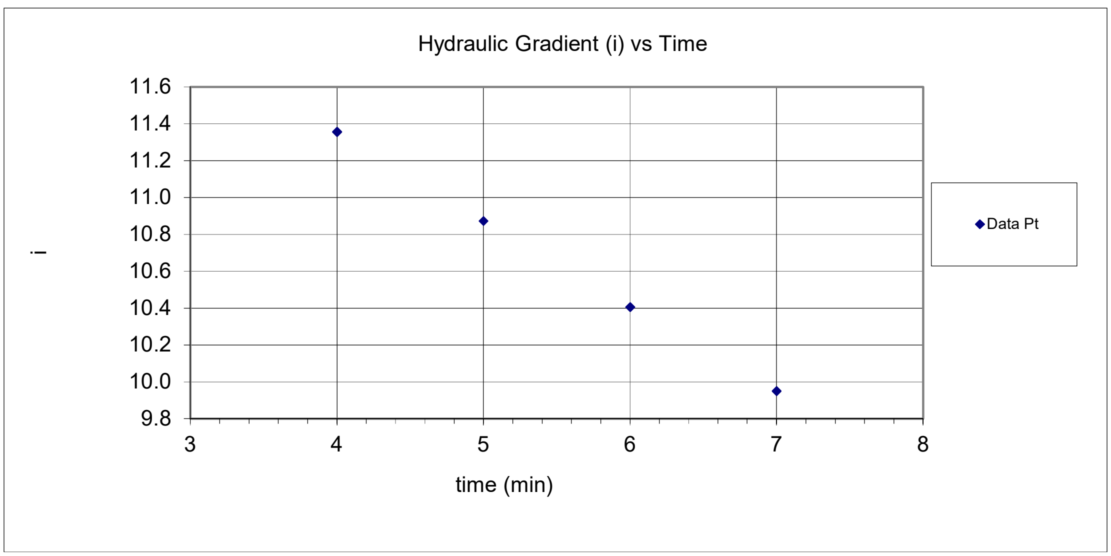
Hydraulic Conductivity of Saturated Porous Material
ASTM D 5084 (Method C)

Project: Lookout Slough THRFIP
Project Number: 3195.x
Date: 10/30/2018

Sample Number: BCI-17-3-04 **Depth:** 9'-9.5'
Material Description: Lean CLAY with SAND, LL = 32, PI = 14
Sample Collection Date: 08/29/17

Average k (cm/sec): **1.45E-05** **cm/sec**





Hydraulic Conductivity of Saturated Porous Material
ASTM D 5084 (Method C)

Project: Lookout Slough THRFIP
Project Number: 3195.x
Date: 1/9/2018

Sample Number: BCI-17-8-02 **Depth** 3'8" - 4'2"
Material Description: Fat CLAY LL = 68, PI = 48
Sample Collection Date: 09/07/17

Sample Data:

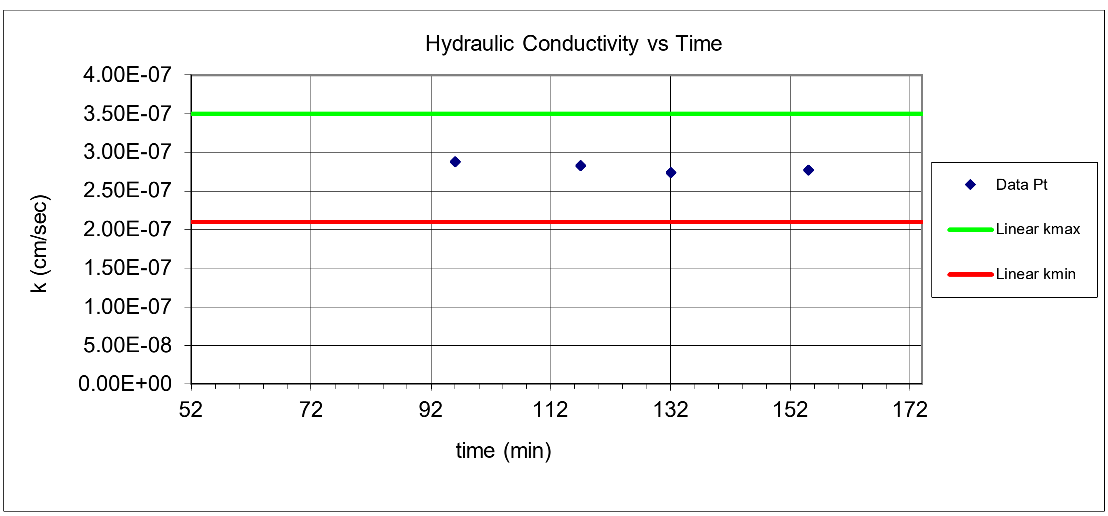
Type of Sample = Shelby

Initial Data:			**Final Data:**		
Sample Length =	11.2	cm	Sample Length =	10.6	cm
Sample Diameter =	7.20	cm	Sample Diameter =	7.29	cm
Area =	40.7	cm^2	Area =	41.7	cm^2
Volume =	454.3	cm^3	Volume =	442.9	cm^3
Wet Weight=	820.7	g	Wet Weight=	836.3	g
Moisture =	30.2	%	Moisture =	32.4	%
Dry Density =	1.39	g/cm^3	Dry Density =	1.43	g/cm^3
Dry Density =	86.6	pcf	Dry Density =	89.0	pcf
Saturation =	88.0	%	Saturation =	100.2	%
Specific Gravity =	2.65	(assumed)	Specific Gravity =	2.65	(assumed)

Testing Parameters:

B Value =		0.99				
Cell Pressure	P_C=	47	psi	Permeant:	Deaired Water	
Base Pressure	P_b=	45	psi	Aver. Temp=	69.0	°F
Top Pressure	P_T=	42	psi	Burette Area=	0.194	cm^2
Consolidation	=	5	psi	Initial Hydraulic Gradient=	23.33	
Confining Pressure	=	720	psf	Final Hydraulic Gradient=	21.23	

Results: **Average k (cm/sec)= 2.80E-07 cm/sec**



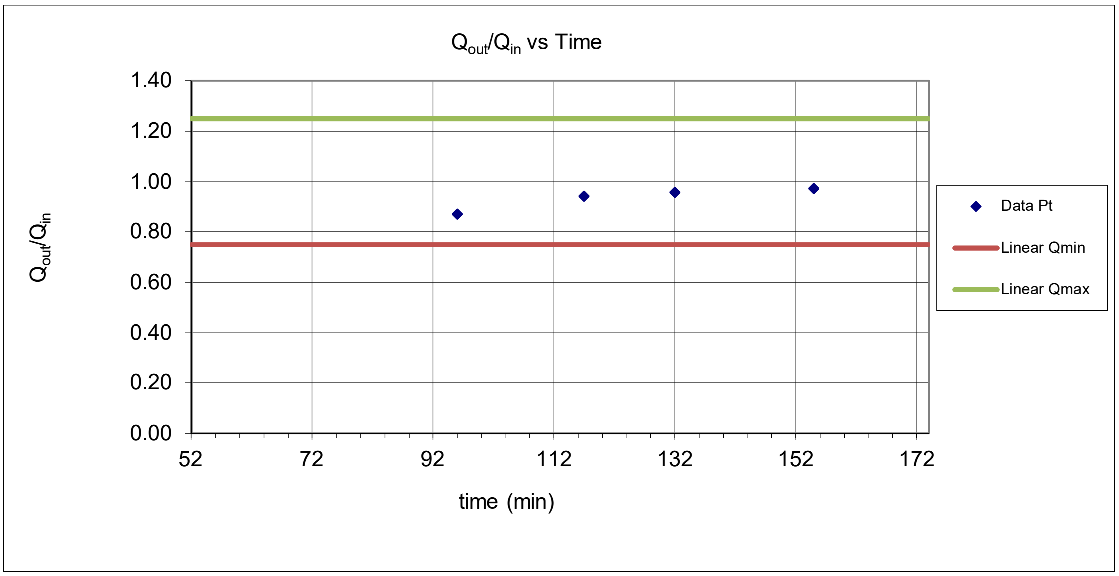
blackburn consulting

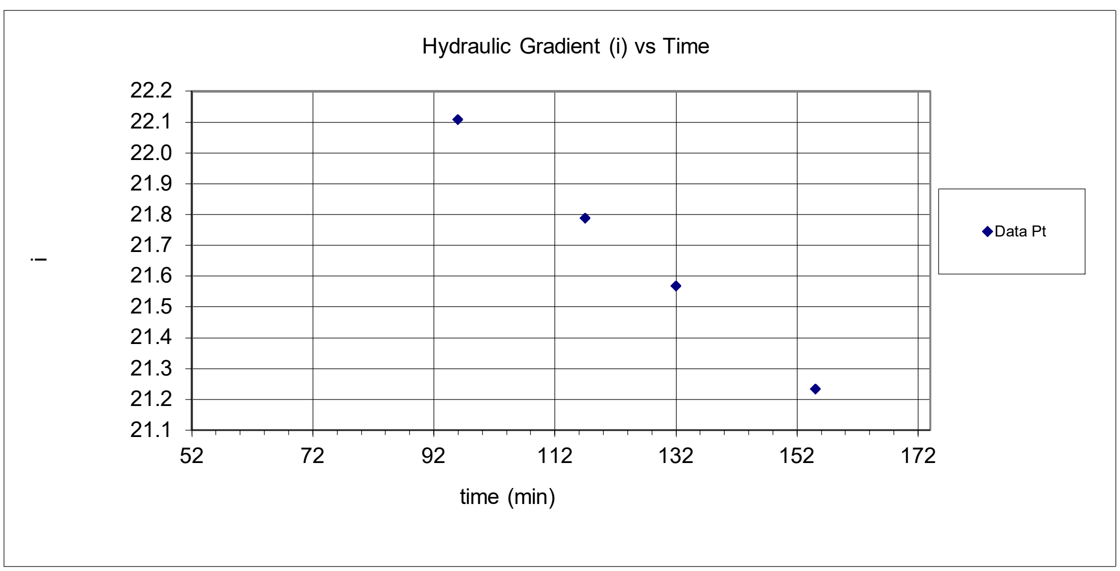
Hydraulic Conductivity of Saturated Porous Material
ASTM D 5084 (Method C)

Project: **Lookout Slough THRFIP**
Project Number: **3195.x**
Date: **1/9/2018**

Sample Number: **BCI-17-8-02** **Depth** **3'8" - 4'2"**
Material Description: **Fat CLAY LL = 68, PI = 48**
Sample Collection Date: 09/07/17

Average k (cm/sec): 2.80E-07 **cm/sec**





Hydraulic Conductivity of Saturated Porous Material
ASTM D 5084 (Method C)

Project: Lookout Slough THRFIP
Project Number: 3195.x
Date: 1/9/2018

Sample Number: BCI-17-8-06 **Depth** 11'4" - 11'8"
Material Description: Sandy Lean CLAY, LL = 35, PI = 22
Sample Collection Date: 09/07/17

Sample Data:

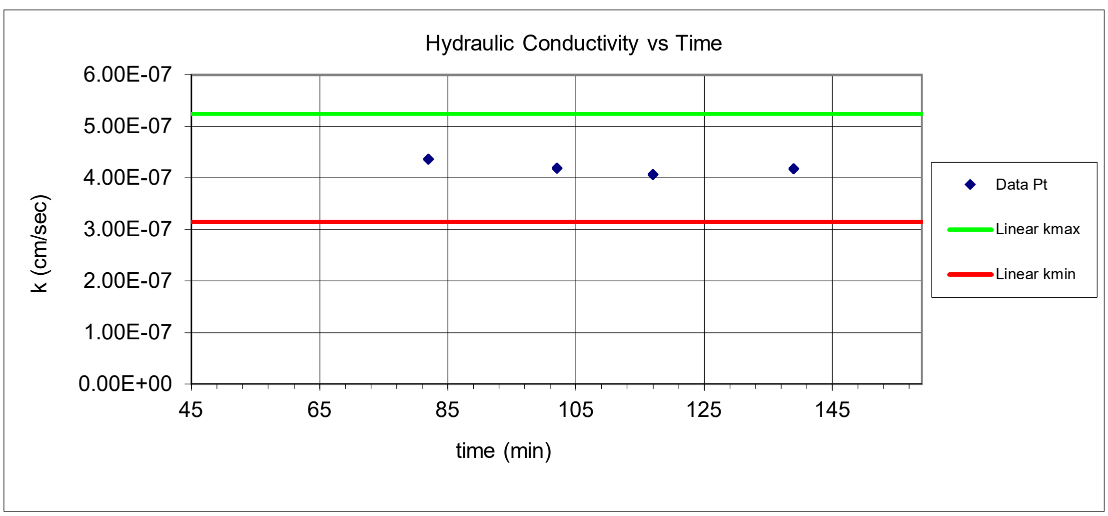
Type of Sample = Shelby

Initial Data:			Final Data:		
Sample Length =	8.7	cm	Sample Length =	8.5	cm
Sample Diameter =	7.23	cm	Sample Diameter =	7.28	cm
Area =	41.0	cm^2	Area =	41.6	cm^2
Volume =	358.3	cm^3	Volume =	354.4	cm^3
Wet Weight=	722.6	g	Wet Weight=	729.9	g
Moisture =	17.0	%	Moisture =	21.1	%
Dry Density =	1.72	g/cm^3	Dry Density =	1.70	g/cm^3
Dry Density =	107.6	pcf	Dry Density =	106.1	pcf
Saturation =	84.1	%	Saturation =	100.4	%
Specific Gravity =	2.65	(assumed)	Specific Gravity =	2.65	(assumed)

Testing Parameters:

B Value =		0.96				
Cell Pressure	P_C=	52	psi	Permeant:	Deaired Water	
Base Pressure	P_b=	44	psi	Aver. Temp=	69.0	°F
Top Pressure	P_T=	42	psi	Burette Area=	0.194	cm^2
Consolidation	=	10	psi	Initial Hydraulic Gradient=	22.30	
Confining Pressure	=	1440	psf	Final Hydraulic Gradient=	18.45	

Results: **Average k (cm/sec)= 4.19E-07 cm/sec**

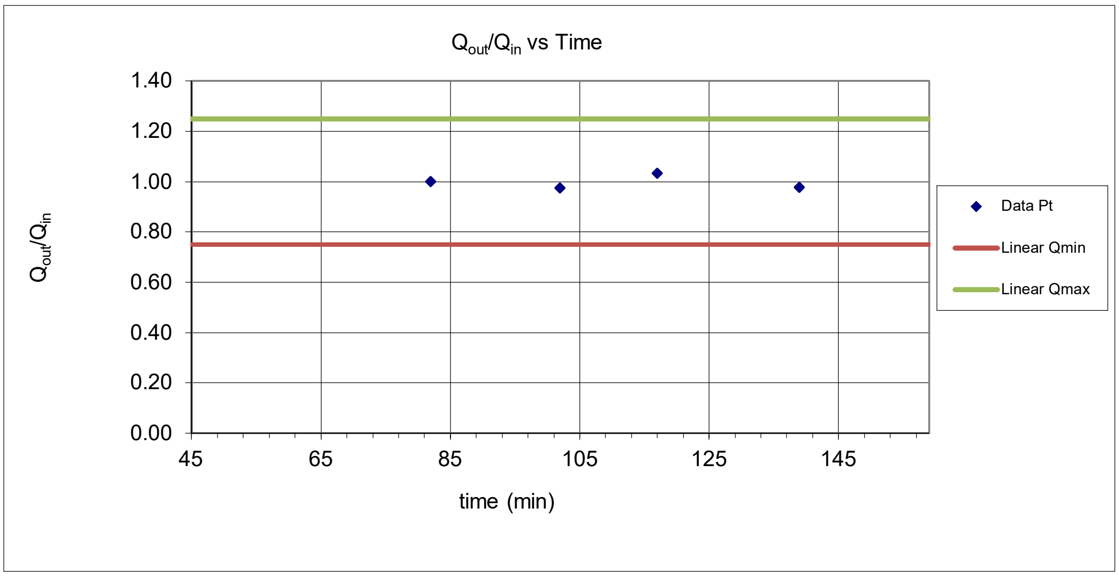


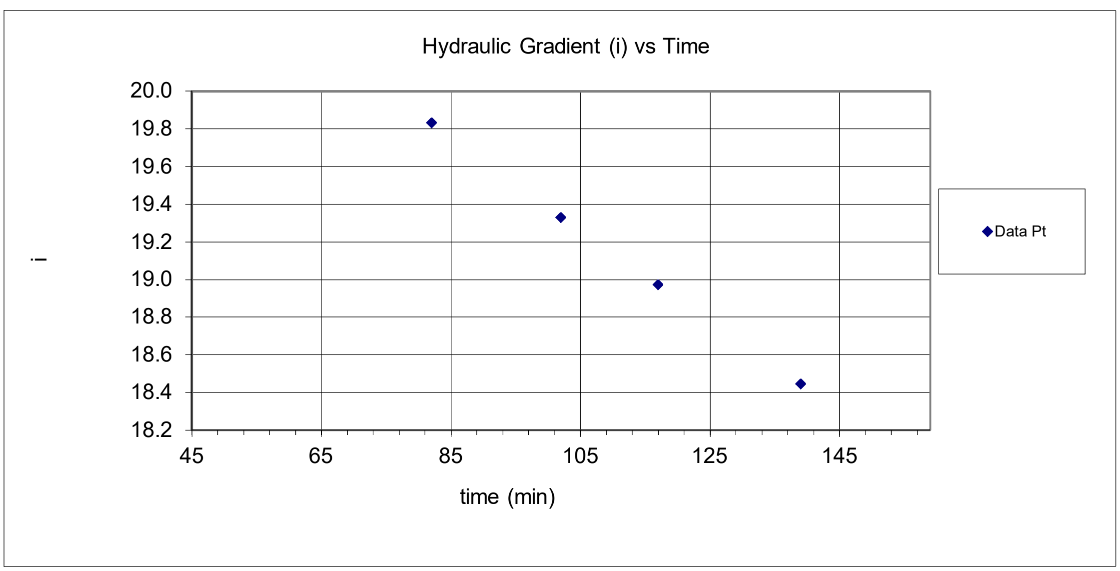
Hydraulic Conductivity of Saturated Porous Material
ASTM D 5084 (Method C)

Project: **Lookout Slough THRFIP**
Project Number: **3195.x**
Date: **1/9/2018**

Sample Number: **BCI-17-8-06** **Depth** **11'4" - 11'8"**
Material Description: **Sandy Lean CLAY, LL = 35, PI = 22**
Sample Collection Date: 09/07/17

Average k (cm/sec): **4.19E-07** **cm/sec**





Hydraulic Conductivity of Saturated Porous Material
ASTM D 5084 (Method C)

Project: **Lookout Slough THRFIP**
Project Number: **3195.x**
Date: **10/30/2018**

Sample Number: **BCI-17-10-04** **Depth:** **6.5'-7'**
Material Description: **Clayey SAND, LL=34, PI=16, 28% Fines**
Sample Collection Date: 11/27/17

Sample Data:

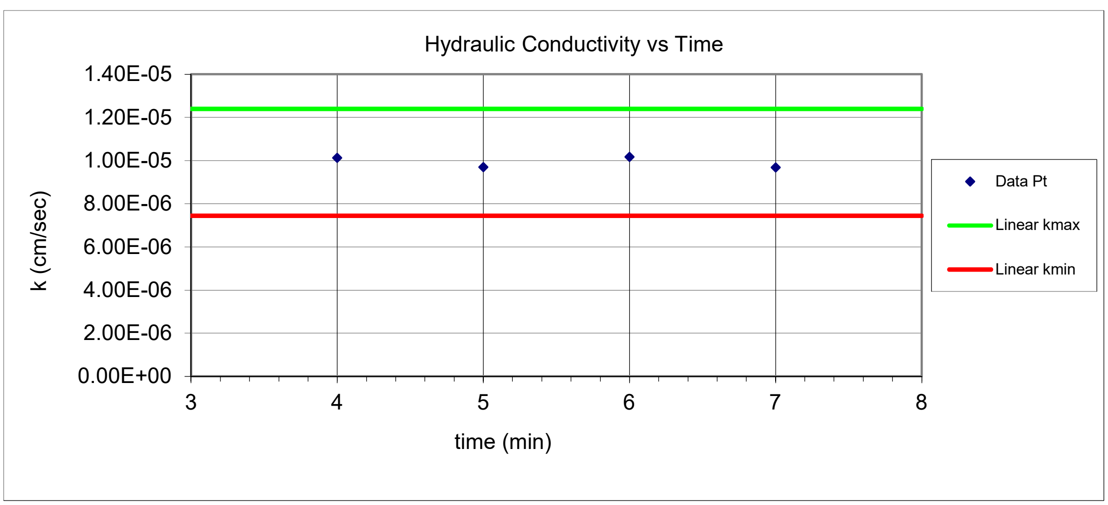
Type of Sample = Shelby

Initial Data:			**Final Data:**		
Sample Length =	8.3	cm	Sample Length =	8.3	cm
Sample Diameter =	7.24	cm	Sample Diameter =	7.21	cm
Area =	41.2	cm^2	Area =	40.8	cm^2
Volume =	342.8	cm^3	Volume =	339.7	cm^3
Wet Weight=	707.2	g	Wet Weight=	712.3	g
Moisture =	19.6	%	Moisture =	20.4	%
Dry Density =	1.73	g/cm^3	Dry Density =	1.74	g/cm^3
Dry Density =	106.8	pcf	Dry Density =	108.7	pcf
Saturation =	94.5	%	Saturation =	103.9	%
Specific Gravity =	2.65	(assumed)	Specific Gravity =	2.65	(assumed)

Testing Parameters:

B Value =	0.97					
Cell Pressure P_C=	60	psi	Permeant:	Deaired Water		
Base Pressure P_b=	51	psi	Aver. Temp=	73.6	°F	
Top Pressure P_T=	50	psi	Burette Area=	0.194	cm^2	
Consolidation =	10	psi	Initial Hydraulic Gradient=	14.56		
Confining Pressure =	1440	psf	Final Hydraulic Gradient=	11.38		

Results: **Average k (cm/sec)= 9.92E-06 cm/sec**

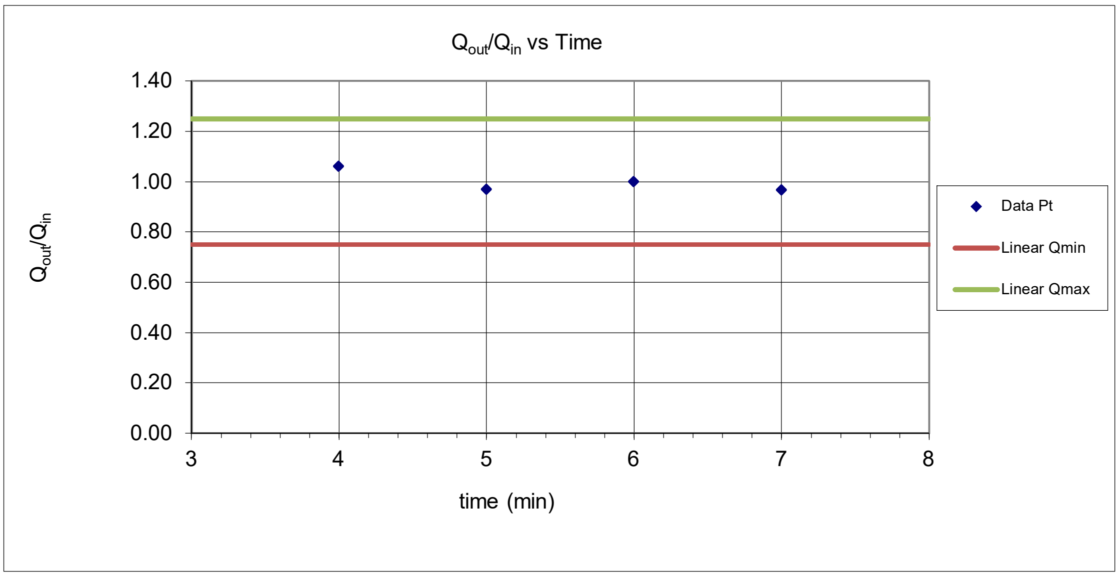


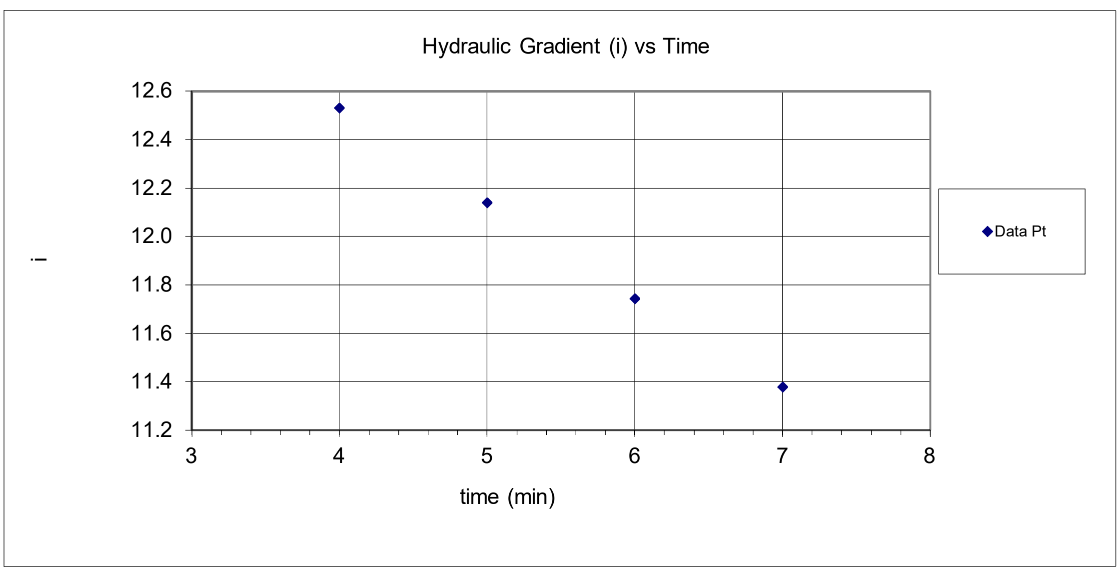
Hydraulic Conductivity of Saturated Porous Material
ASTM D 5084 (Method C)

Project: **Lookout Slough THRFIP**
Project Number: **3195.x**
Date: **10/30/2018**

Sample Number: **BCI-17-10-04** **Depth:** **6.5'-7'**
Material Description: **Clayey SAND, LL=34, PI=16, 28% Fines**
Sample Collection Date: 11/27/17

Average k (cm/sec): **9.92E-06** **cm/sec**





Hydraulic Conductivity of Saturated Porous Material
ASTM D 5084 (Method C)

blackburn consulting

Project: **Lookout Slough THRFIP**
Project Number: **3195.x**
Date: **10/24/2018**

Sample Number: **BCI-17-11-01** **Depth:** **2.5'-3'**
Material Description: **Fat CLAY, LL=52, PI=37**
Sample Collection Date: 11/28/17

Sample Data:

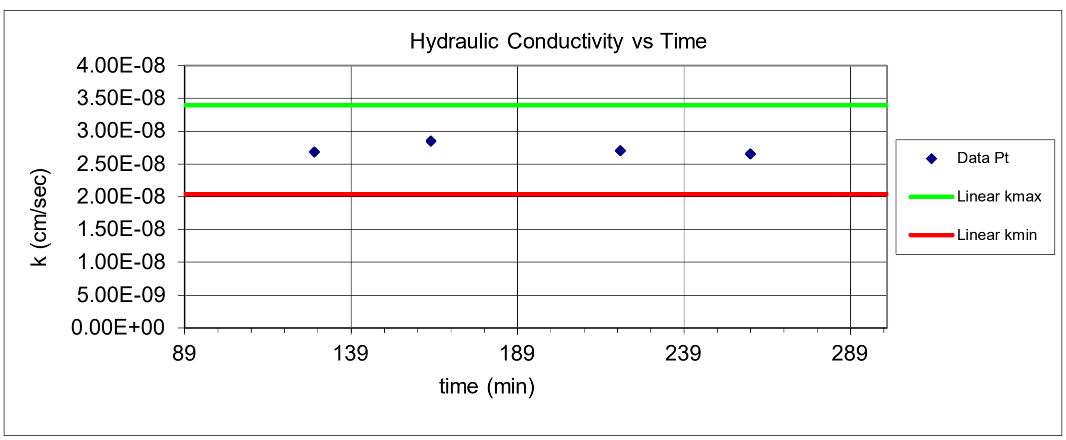
Type of Sample = Shelby

Initial Data:			**Final Data:**		
Sample Length =	7.8	cm	Sample Length =	7.8	cm
Sample Diameter =	7.11	cm	Sample Diameter =	7.11	cm
Area =	39.7	cm^2	Area =	39.7	cm^2
Volume =	310.3	cm^3	Volume =	310.6	cm^3
Wet Weight=	639.5	g	Wet Weight=	641.6	g
Moisture =	20.6	%	Moisture =	21.0	%
Dry Density =	1.71	g/cm^3	Dry Density =	1.71	g/cm^3
Dry Density =	106.7	pcf	Dry Density =	106.6	pcf
Saturation =	99.3	%	Saturation =	100.9	%
Specific Gravity =	2.65	(assumed)	Specific Gravity =	2.65	(assumed)

Testing Parameters:

B Value =		0.95				
Cell Pressure	P_C=	60	psi	Permeant:	Deaired Water	
Base Pressure	P_b=	58	psi	Aver. Temp=	73.3	°F
Top Pressure	P_T=	50	psi	Burette Area=	0.194	cm^2
Consolidation	=	10	psi	Initial Hydraulic Gradient*=	79.42	
Confining Pressure	=	1440	psf	Final Hydraulic Gradient*=	75.79	

Results: **Average k (cm/sec)= 2.72E-08 cm/sec**



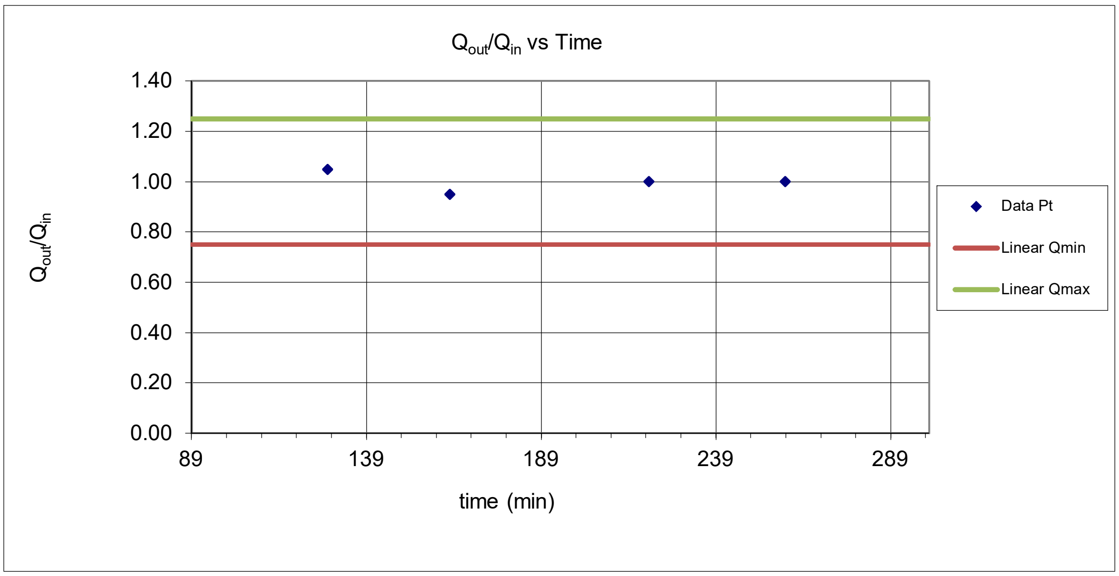
* Used a gradient higher than 20 in accordance with ASTM D 5084 due to the inability to achieve flow using a gradient of 20.

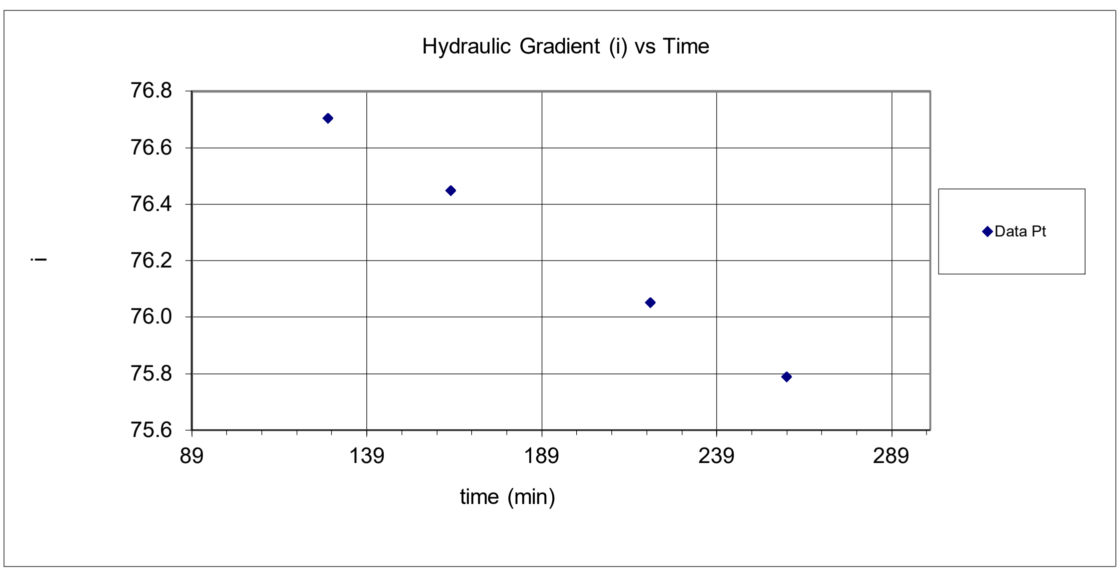
Hydraulic Conductivity of Saturated Porous Material
ASTM D 5084 (Method C)

Project: **Lookout Slough THRFIP**
Project Number: **3195.x**
Date: **10/24/2018**

Sample Number: **BCI-17-11-01** **Depth:** **2.5'-3'**
Material Description: **Fat CLAY, LL=52, PI=37**
Sample Collection Date: 11/28/17

Average k (cm/sec): 2.72E-08 cm/sec





blackburn consulting

Hydraulic Conductivity of Saturated Porous Material
ASTM D 5084 (Method C)

Project: Lookout Slough THRFIP
Project Number: 3195.x
Date: 10/23/2018

Sample Number: BCI-17-15-01 **Depth: 1.5'-2'**
Material Description: Fat CLAY, LL=63, PI=46
Sample Collection Date: 11/29/17

Sample Data:

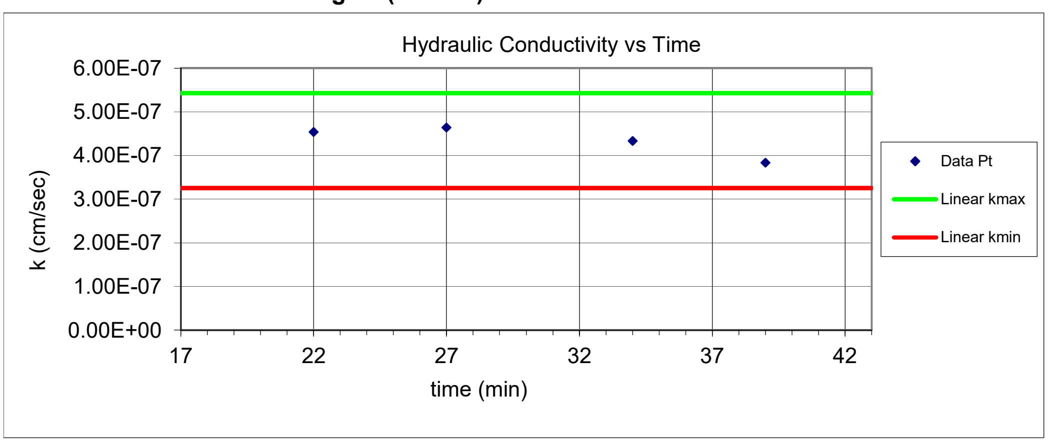
Type of Sample = Shelby

Initial Data:			**Final Data:**		
Sample Length =	8.5	cm	Sample Length =	8.5	cm
Sample Diameter =	7.20	cm	Sample Diameter =	7.20	cm
Area =	40.8	cm^2	Area =	40.8	cm^2
Volume =	347.9	cm^3	Volume =	347.9	cm^3
Wet Weight=	661.0	g	Wet Weight=	672.5	g
Moisture =	29.3	%	Moisture =	31.5	%
Dry Density =	1.47	g/cm^3	Dry Density =	1.47	g/cm^3
Dry Density =	91.8	pcf	Dry Density =	91.8	pcf
Saturation =	96.7	%	Saturation =	104.1	%
Specific Gravity =	2.65	(assumed)	Specific Gravity =	2.65	(assumed)

Testing Parameters:

B Value =		0.97				
Cell Pressure	P_C=	60	psi	Permeant:	Deaired Water	
Base Pressure	P_b=	56	psi	Aver. Temp=	72.9	°F
Top Pressure	P_T=	50	psi	Burette Area=	0.194	cm^2
Consolidation	=	10	psi	Initial Hydraulic Gradient*=	55.29	
Confining Pressure	=	1440	psf	Final Hydraulic Gradient*=	52.11	

Results: **Average k (cm/sec)= 4.34E-07 cm/sec**



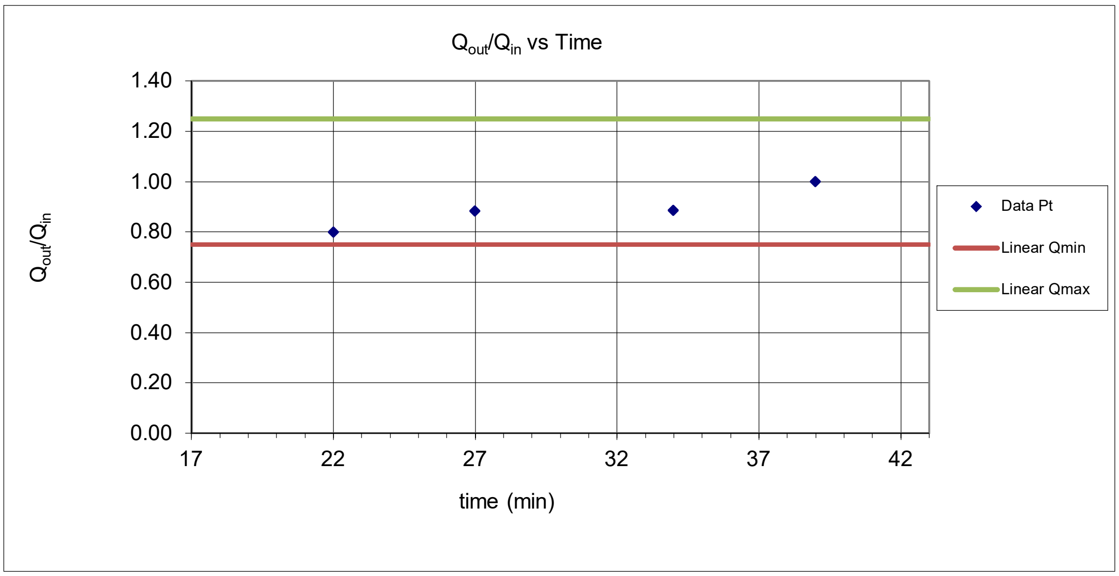
* Used a gradient higher than 20 in accordance with ASTM D 5084 due to the inability to achieve flow using a gradient of 20.

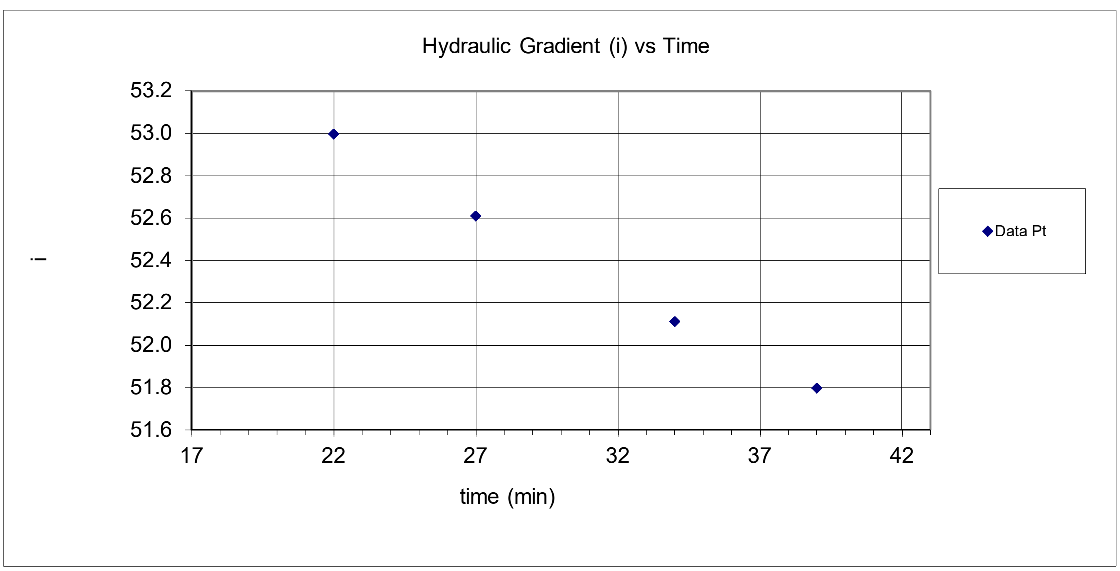
Hydraulic Conductivity of Saturated Porous Material
ASTM D 5084 (Method C)

Project: **Lookout Slough THRFIP**
Project Number: **3195.x**
Date: **10/23/2018**

Sample Number: **BCI-17-15-01** **Depth:** **1.5'-2'**
Material Description: **Fat CLAY, LL=63, PI=46**
Sample Collection Date: 11/29/17

Average k (cm/sec): **4.34E-07** **cm/sec**





Hydraulic Conductivity of Saturated Porous Material
ASTM D 5084 (Method C)

Project: Lookout Slough THRFIP
Project Number: 3195.x
Date: 1/2/2019

Sample Number: BCI-17-17-01 **Depth** 2.5-3
Material Description: Fat CLAY
Sample Collection Date: 11/29/17

Sample Data:

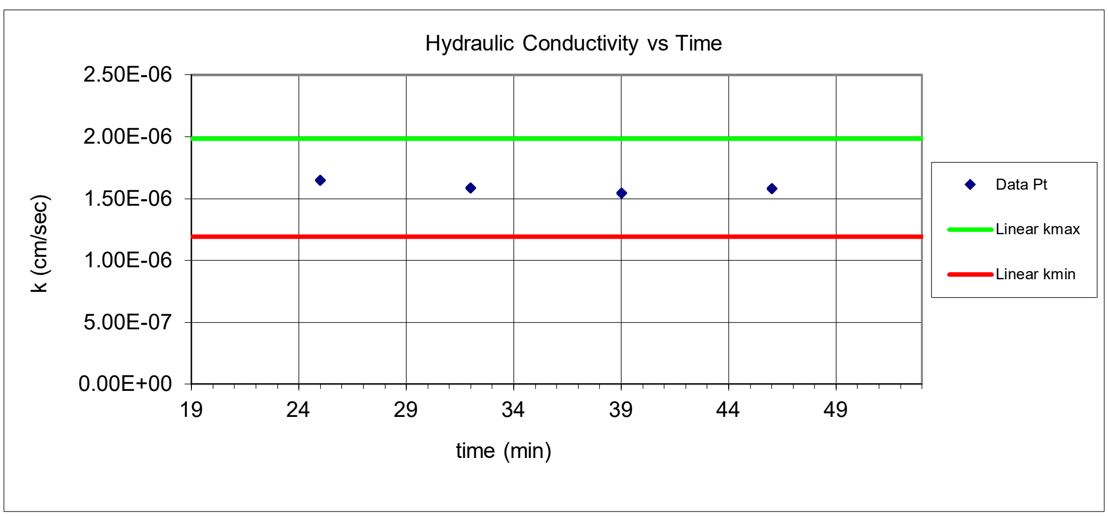
Type of Sample = Shelby

Initial Data:			Final Data:		
Sample Length =	12.8	cm	Sample Length =	12.8	cm
Sample Diameter =	7.25	cm	Sample Diameter =	7.33	cm
Area =	41.3	cm^2	Area =	42.1	cm^2
Volume =	528.0	cm^3	Volume =	539.2	cm^3
Wet Weight=	1032.6	g	Wet Weight=	1040.4	g
Moisture =	28.8	%	Moisture =	29.1	%
Dry Density =	1.52	g/cm^3	Dry Density =	1.49	g/cm^3
Dry Density =	94.8	pcf	Dry Density =	93.3	pcf
Saturation =	102.5	%	Saturation =	99.8	%
Specific Gravity =	2.65	(assumed)	Specific Gravity =	2.65	(assumed)

Testing Parameters:

B Value =		0.98				
Cell Pressure	P_C=	52.8	psi	Permeant:	Deaired Water	
Base Pressure	P_b=	51	psi	Aver. Temp=	65.5	°F
Top Pressure	P_T=	50	psi	Burette Area=	0.194	cm^2
Consolidation	=	3	psi	Initial Hydraulic Gradient=	9.12	
Confining Pressure	=	403.2	psf	Final Hydraulic Gradient=	7.89	

Results: **Average k (cm/sec)= 1.59E-06 cm/sec**

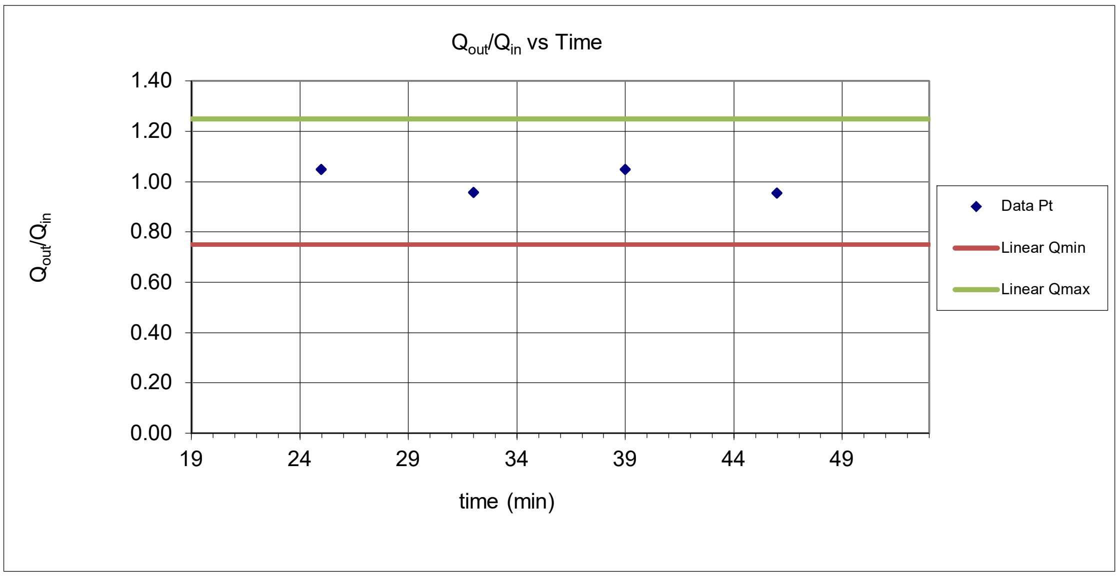


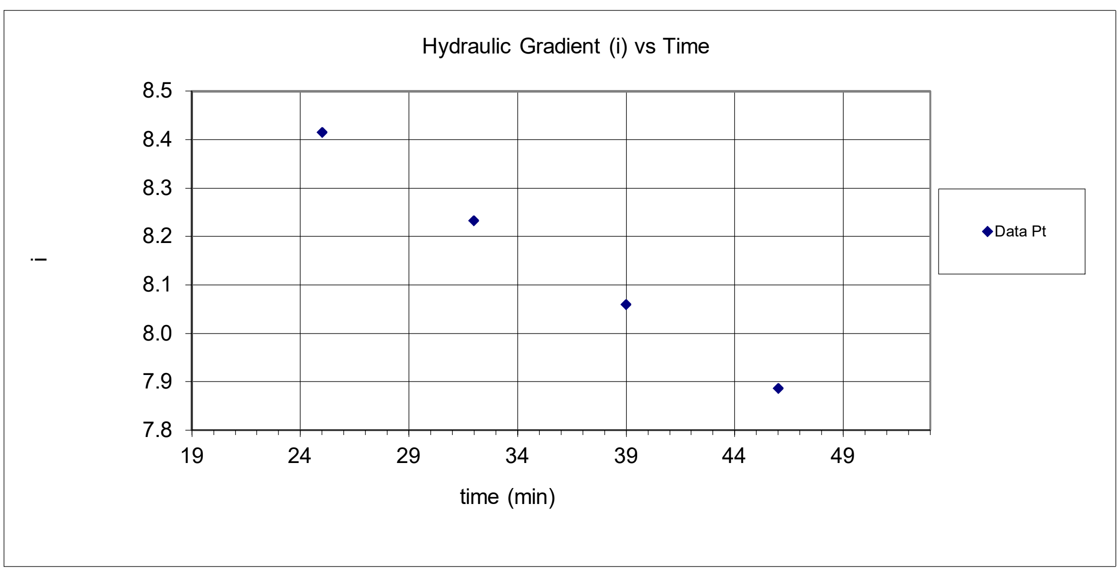
Hydraulic Conductivity of Saturated Porous Material
ASTM D 5084 (Method C)

Project: **Lookout Slough THRFIP**
Project Number: **3195.x**
Date: **1/2/2019**

Sample Number: **BCI-17-17-01** **Depth** **2.5-3**
Material Description: **Fat CLAY**
Sample Collection Date: 11/29/17

Average k (cm/sec): **1.59E-06** **cm/sec**





Hydraulic Conductivity of Saturated Porous Material
ASTM D 5084 (Method C)

blackburn consulting

Project: Lookout Slough THRFIP
Project Number: 3195.x
Date: 10/24/2018

Sample Number: BCI-17-18-03 **Depth: 5.5'-6'**
Material Description: Fat CLAY, LL=46, PI=29
Sample Collection Date: 11/29/17

Sample Data:

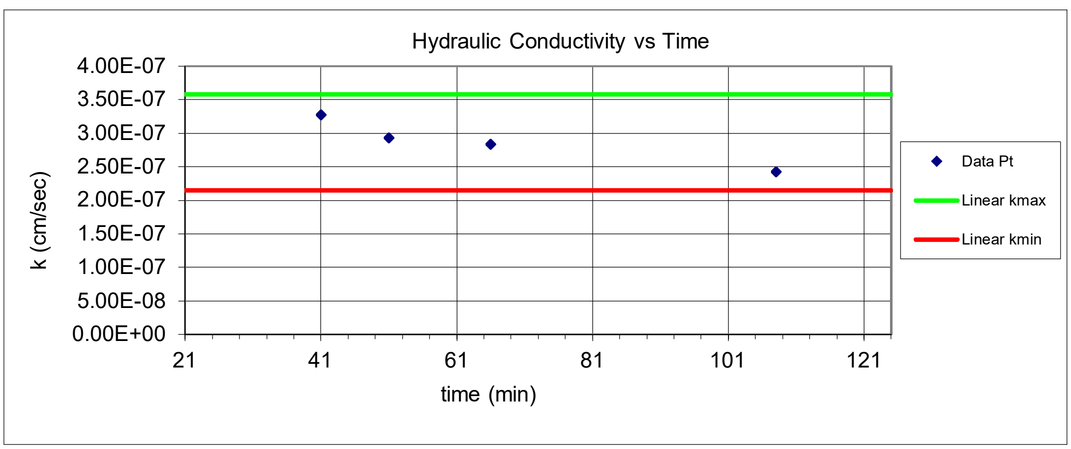
Type of Sample = Shelby

Initial Data:			Final Data:		
Sample Length =	8.7	cm	Sample Length =	8.7	cm
Sample Diameter =	7.26	cm	Sample Diameter =	7.26	cm
Area =	41.4	cm^2	Area =	41.4	cm^2
Volume =	358.3	cm^3	Volume =	358.3	cm^3
Wet Weight=	712.9	g	Wet Weight=	717.9	g
Moisture =	24.6	%	Moisture =	25.5	%
Dry Density =	1.60	g/cm^3	Dry Density =	1.60	g/cm^3
Dry Density =	99.7	pcf	Dry Density =	99.7	pcf
Saturation =	98.9	%	Saturation =	102.5	%
Specific Gravity =	2.65	(assumed)	Specific Gravity =	2.65	(assumed)

Testing Parameters:

B Value =		1				
Cell Pressure	P_C=	60	psi	Permeant:	Deaired Water	
Base Pressure	P_b=	56	psi	Aver. Temp=	73.3	°F
Top Pressure	P_T=	50	psi	Burette Area=	0.194	cm^2
Consolidation	=	10	psi	Initial Hydraulic Gradient*=	54.94	
Confining Pressure	=	1440	psf	Final Hydraulic Gradient*=	48.91	

Results: **Average k (cm/sec)= 2.86E-07 cm/sec**



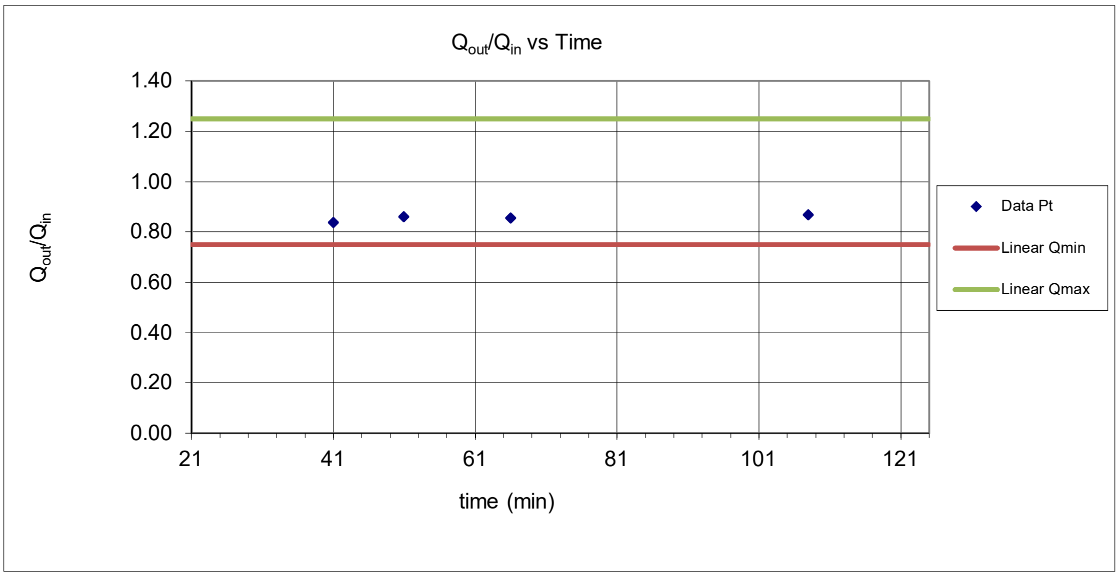
* Used a gradient higher than 20 in accordance with ASTM D 5084 due to the inability to achieve flow using a gradient of 20.

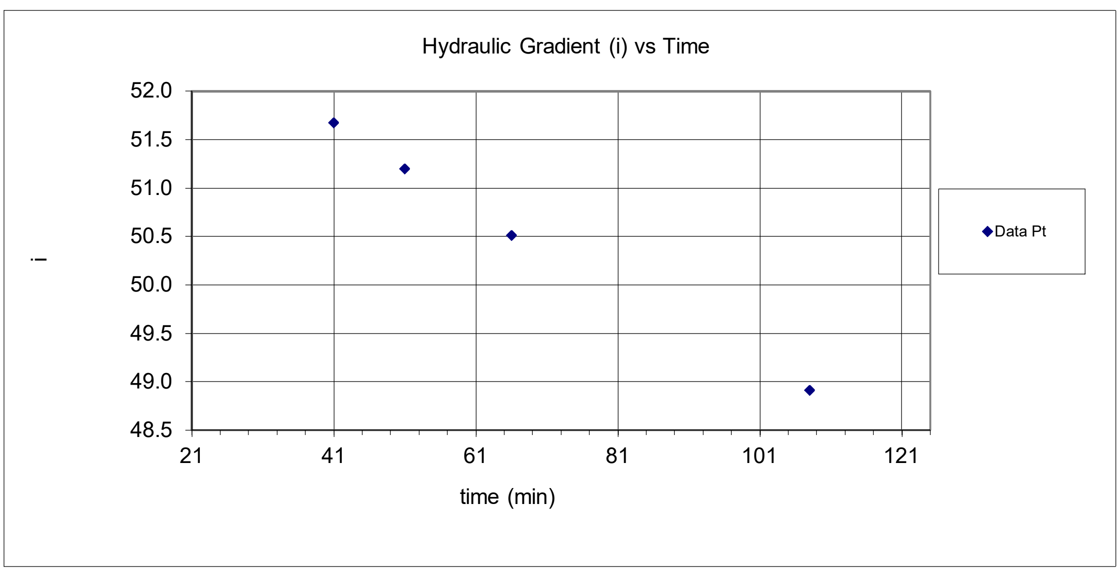
Hydraulic Conductivity of Saturated Porous Material
ASTM D 5084 (Method C)

Project: **Lookout Slough THRFIP**
Project Number: **3195.x**
Date: **10/24/2018**

Sample Number: **BCI-17-18-03** **Depth:** **5.5'-6'**
Material Description: **Fat CLAY, LL=46, PI=29**
Sample Collection Date: 11/29/17

Average k (cm/sec): **2.86E-07** **cm/sec**





Hydraulic Conductivity of Saturated Porous Material
ASTM D 5084 (Method C)

Project: Lookout Slough THRFIP
Project Number: 3195.x
Date: 10/30/2018

Sample Number: BCI-17-20-04 **Depth:** 9'-9.5'
Material Description: Clayey SAND, LL=38, PI=20, 45% Fines
Sample Collection Date: 11/30/17

Sample Data:

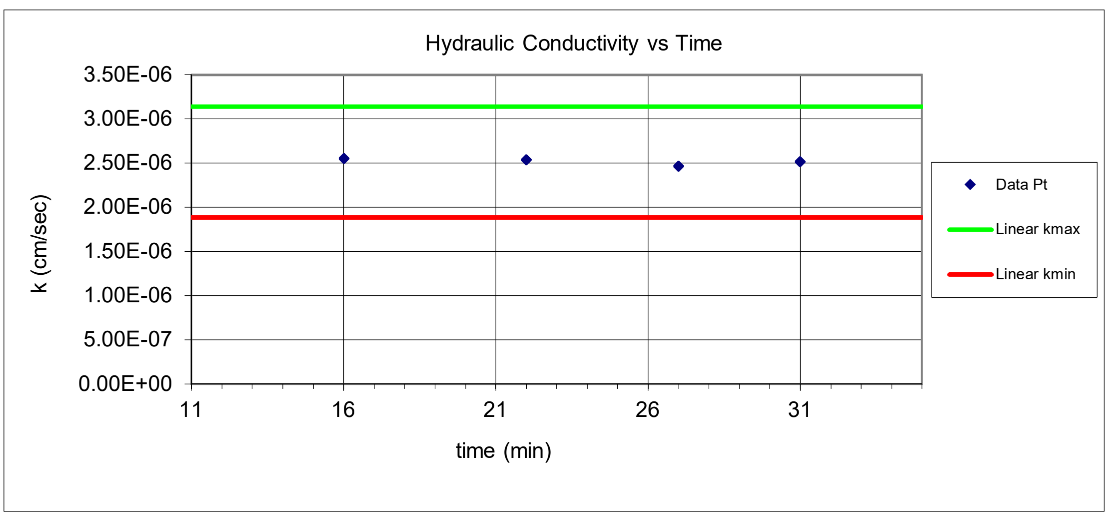
Type of Sample = Shelby

Initial Data:			Final Data:		
Sample Length =	9.3	cm	Sample Length =	9.3	cm
Sample Diameter =	7.12	cm	Sample Diameter =	7.12	cm
Area =	39.8	cm^2	Area =	39.8	cm^2
Volume =	370.6	cm^3	Volume =	370.6	cm^3
Wet Weight=	736.9	g	Wet Weight=	735.5	g
Moisture =	25.2	%	Moisture =	25.0	%
Dry Density =	1.59	g/cm^3	Dry Density =	1.59	g/cm^3
Dry Density =	99.1	pcf	Dry Density =	99.1	pcf
Saturation =	100.1	%	Saturation =	99.2	%
Specific Gravity =	2.65	(assumed)	Specific Gravity =	2.65	(assumed)

Testing Parameters:

B Value =		0.98				
Cell Pressure	P_C=	60	psi	Permeant:	Deaired Water	
Base Pressure	P_b=	51	psi	Aver. Temp=	73.6	°F
Top Pressure	P_T=	50	psi	Burette Area=	0.194	cm^2
Consolidation	=	10	psi	Initial Hydraulic Gradient=	12.84	
Confining Pressure	=	1440	psf	Final Hydraulic Gradient=	10.09	

Results: **Average k (cm/sec)= 2.51E-06 cm/sec**

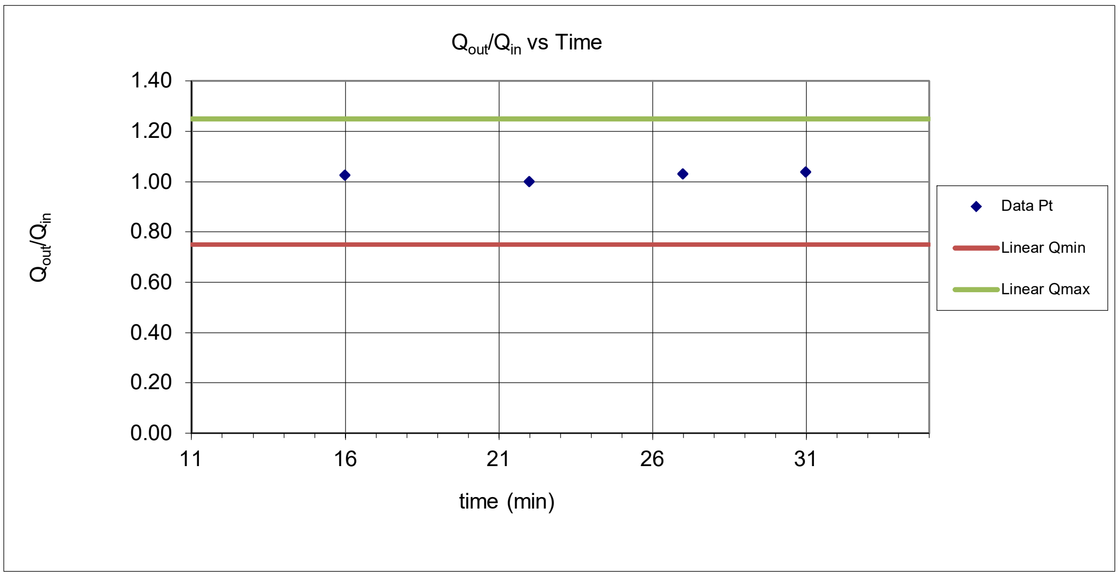


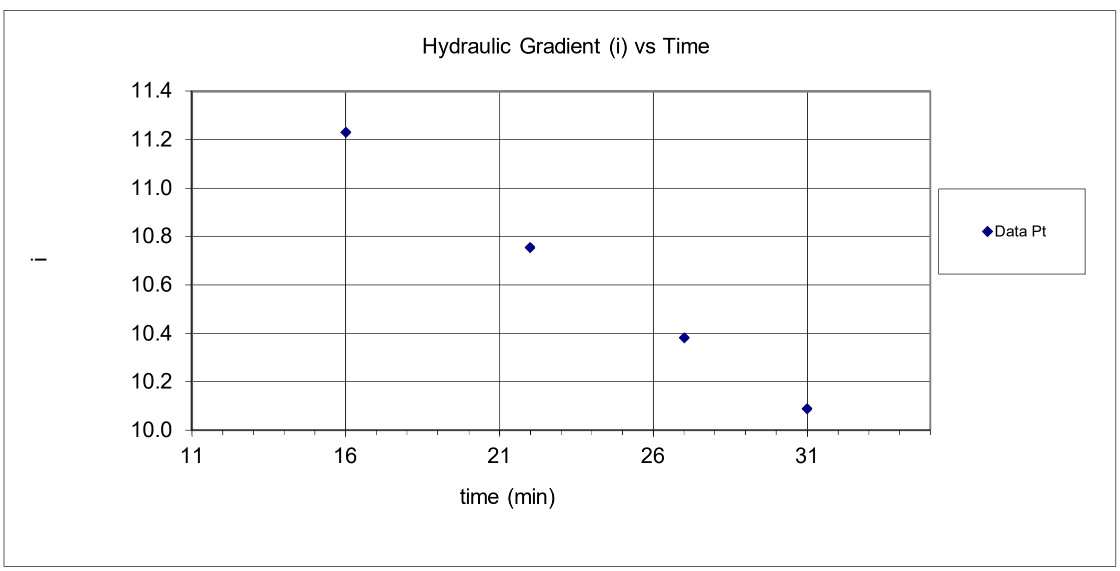
Hydraulic Conductivity of Saturated Porous Material
ASTM D 5084 (Method C)

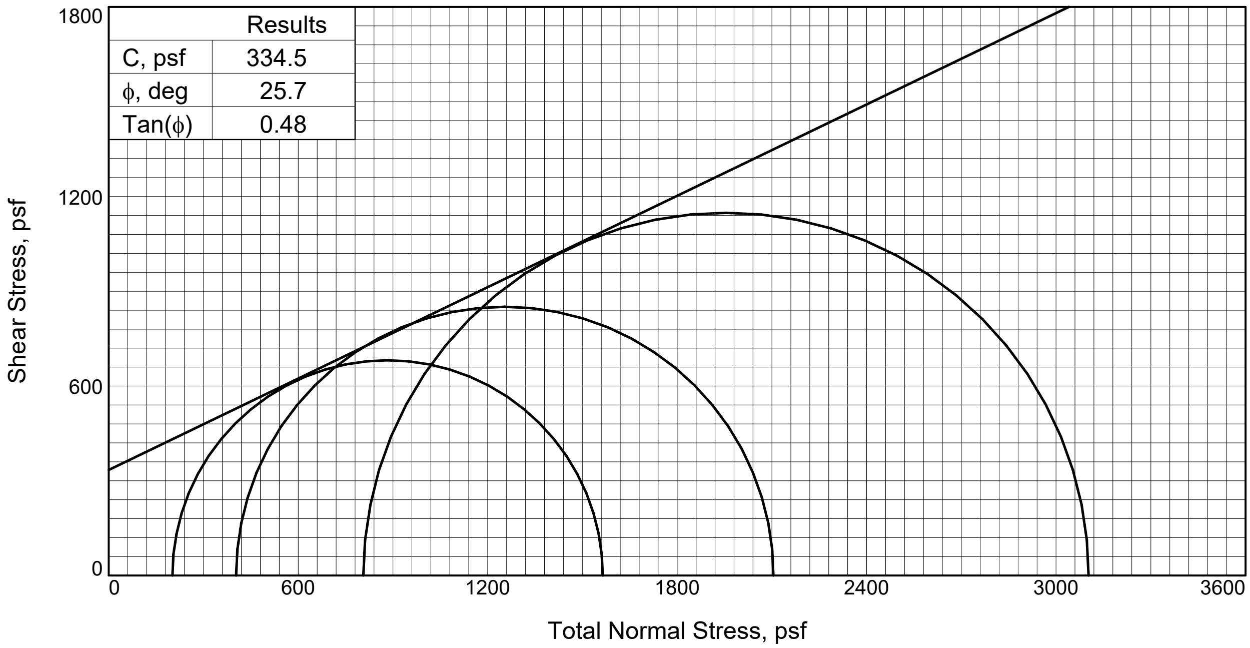
Project: Lookout Slough THRFIP
Project Number: 3195.x
Date: 10/30/2018

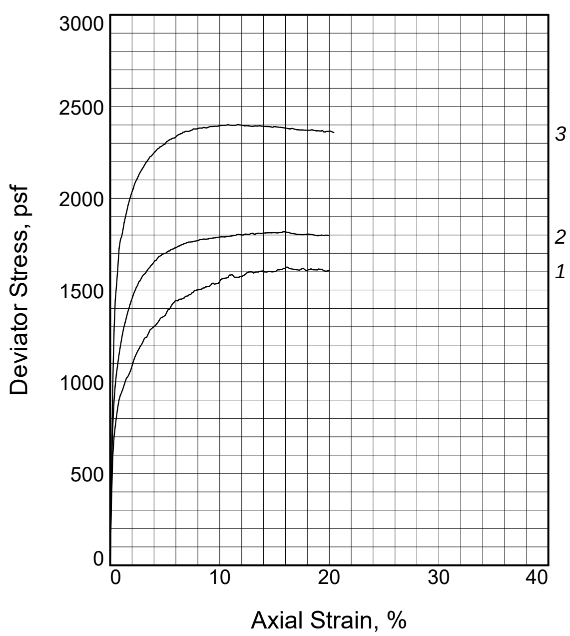
Sample Number: BCI-17-20-04 **Depth:** 9'-9.5'
Material Description: Clayey SAND, LL=38, PI=20, 45% Fines
Sample Collection Date: 11/30/17

Average k (cm/sec): 2.51E-06 **cm/sec**









Sample No.		1	2	3
Initial	Water Content, %	28.1	27.8	28.1
	Dry Density, pcf	93.4	95.5	95.6
	Saturation, %	96.6	100.7	101.9
	Void Ratio	0.7710	0.7319	0.7309
	Diameter, in.	2.852	2.854	2.845
	Height, in.	4.987	5.037	4.886
At Test	Water Content, %	30.4	29.1	29.0
	Dry Density, pcf	91.6	93.4	93.5
	Saturation, %	100.0	100.0	100.0
	Void Ratio	0.8056	0.7711	0.7685
	Diameter, in.	2.882	2.887	2.876
	Height, in.	4.980	5.035	4.884
Strain rate, in./min.		0.002	0.002	0.002
Eff. Cell Pressure, psf		201.6	403.2	806.4
Fail. Stress, psf		1362.7	1701.7	2296.4
Excess Pore Pr., psf		28.8	129.6	604.8
Strain, %		5.0	5.1	5.0
Ult. Stress, psf				
Excess Pore Pr., psf				
Strain, %				
$\bar{\sigma}_1$ Failure, psf		1535.5	1975.3	2498.0
$\bar{\sigma}_3$ Failure, psf		172.8	273.6	201.6

Type of Test:
CU with Pore Pressures

Sample Type: 2.8" Shelby

Description: Fat CLAY, very dark gray

Assumed Specific Gravity= 2.65

Remarks:

Figure ________

Client: EIP

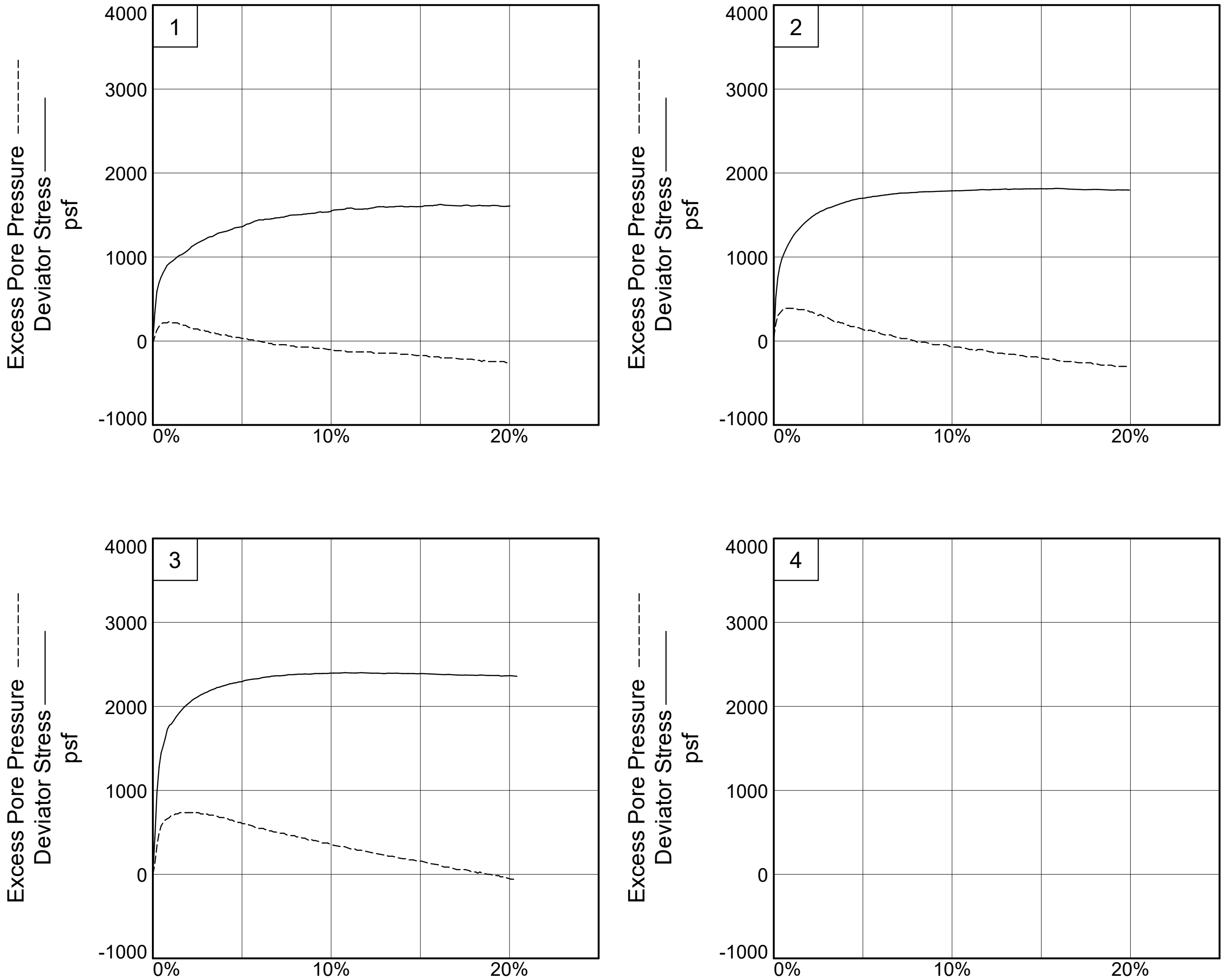
Project: Lookout Slough Restoration Project

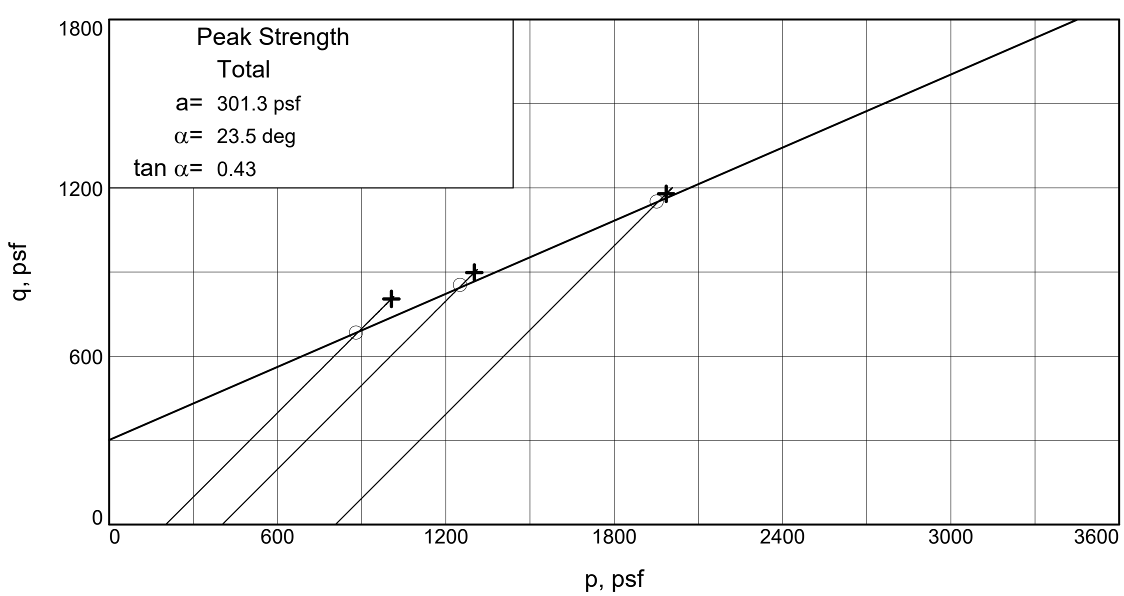
Source of Sample: BCI-17-17 **Depth:** 2.0-3.5'

Sample Number: 1- total

Proj. No.: 3195.P **Date Sampled:**

TRIAXIAL SHEAR TEST REPORT
Blackburn Consulting
W. Sacramento, CA





Stress Paths: o indicates peak + indicates end

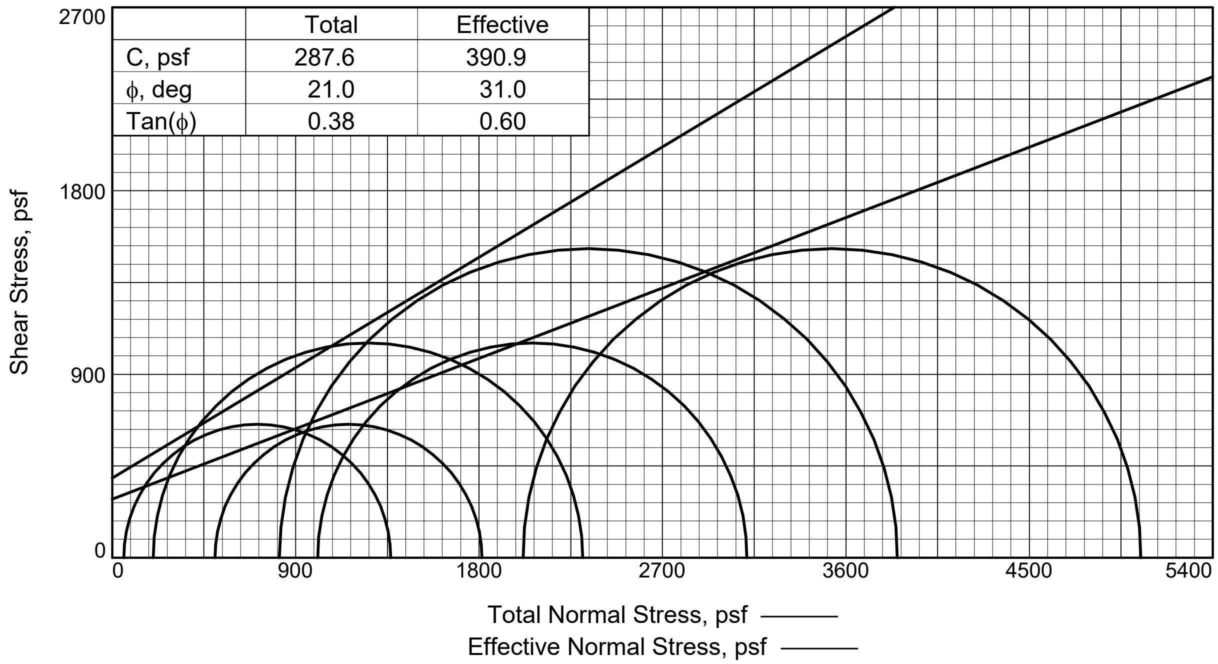
Client: EIP

Project: Lookout Slough Restoration Project

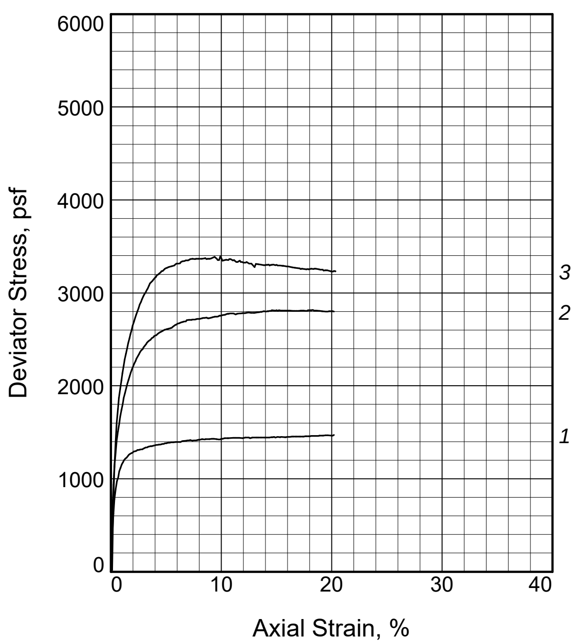
Source of Sample: BCI-17-17 **Depth:** 2.0-3.5' **Sample Number:** 1- total

Project No.: 3195.P **Figure** ________

Blackburn Consulting



	Total	Effective
C, psf	287.6	390.9
ϕ, deg	21.0	31.0
Tan(ϕ)	0.38	0.60



Sample No.		1	2	3
Initial	Water Content, %	25.8	25.8	25.8
	Dry Density, pcf	97.5	100.9	97.0
	Saturation, %	98.0	106.9	96.9
	Void Ratio	0.6973	0.6397	0.7054
	Diameter, in.	2.836	2.821	2.849
	Height, in.	5.306	5.452	5.563
At Test	Water Content, %	24.3	22.2	23.5
	Dry Density, pcf	100.6	104.1	101.9
	Saturation, %	100.0	100.0	100.0
	Void Ratio	0.6440	0.5895	0.6235
	Diameter, in.	2.806	2.792	2.803
	Height, in.	5.250	5.396	5.473
Strain rate, in./min.		0.002	0.002	0.002
Eff. Cell Pressure, psf		504.0	1008.0	2016.0
Fail. Stress, psf		1309.3	2106.6	3031.5
Excess Pore Pr., psf		446.4	806.4	1195.2
Strain, %		2.4	1.7	3.2
Ult. Stress, psf				
Excess Pore Pr., psf				
Strain, %				
$\mp_1$ Failure, psf		1366.9	2308.2	3852.3
$\mp_3$ Failure, psf		57.6	201.6	820.8

Type of Test:
CU with Pore Pressures

Sample Type: 2.8" Shelby

Description: Lean CLAY, dark yellowish brown/ dark grayish brown

Assumed Specific Gravity= 2.65

Remarks:

Figure ________

Client: EIP

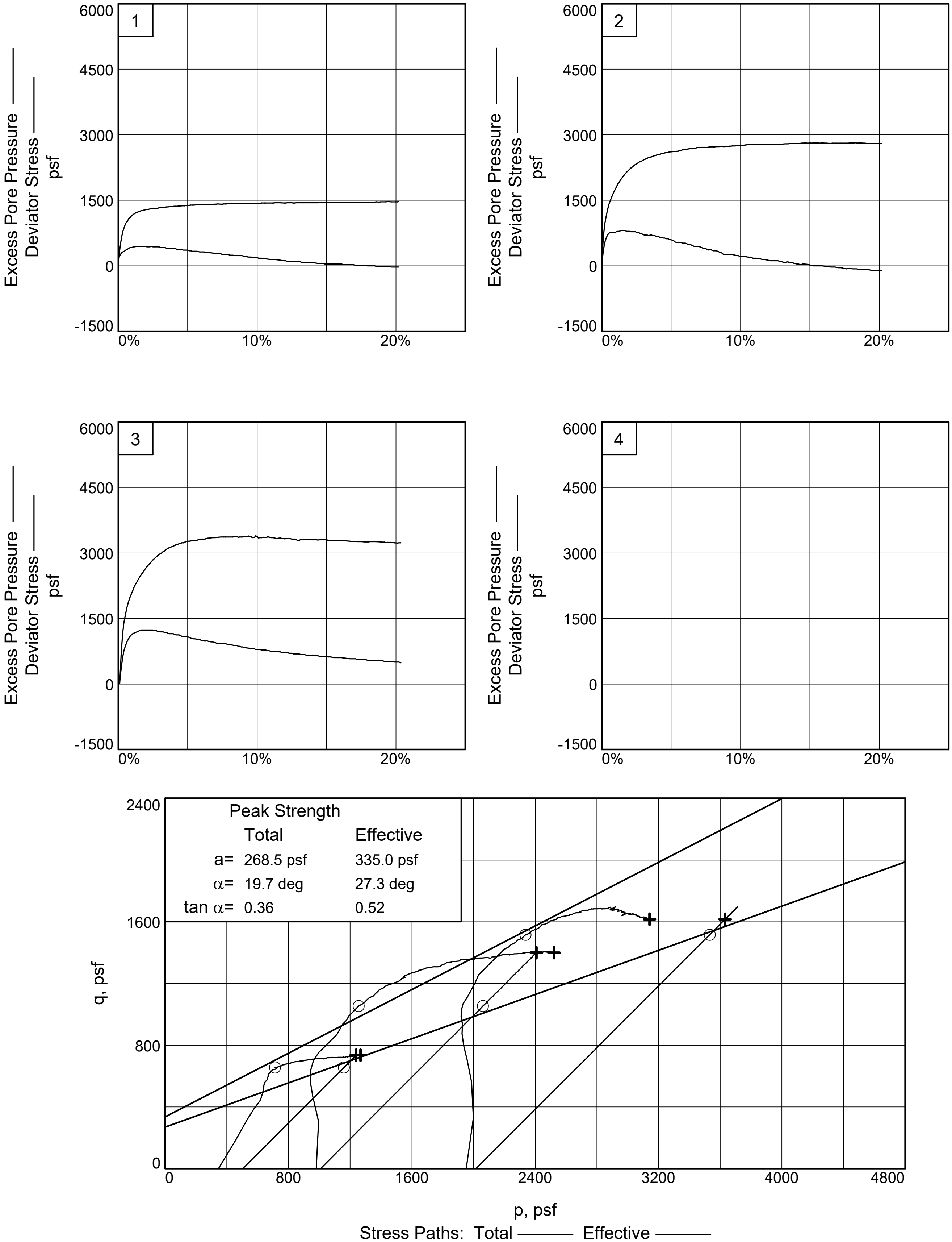
Project: Lookout Slough Restoration Project

Source of Sample: BCI-17-14 **Depth:** 4.5-6.0'

Sample Number: 3

Proj. No.: 3195.P **Date Sampled:**

TRIAXIAL SHEAR TEST REPORT
Blackburn Consulting
W. Sacramento, CA



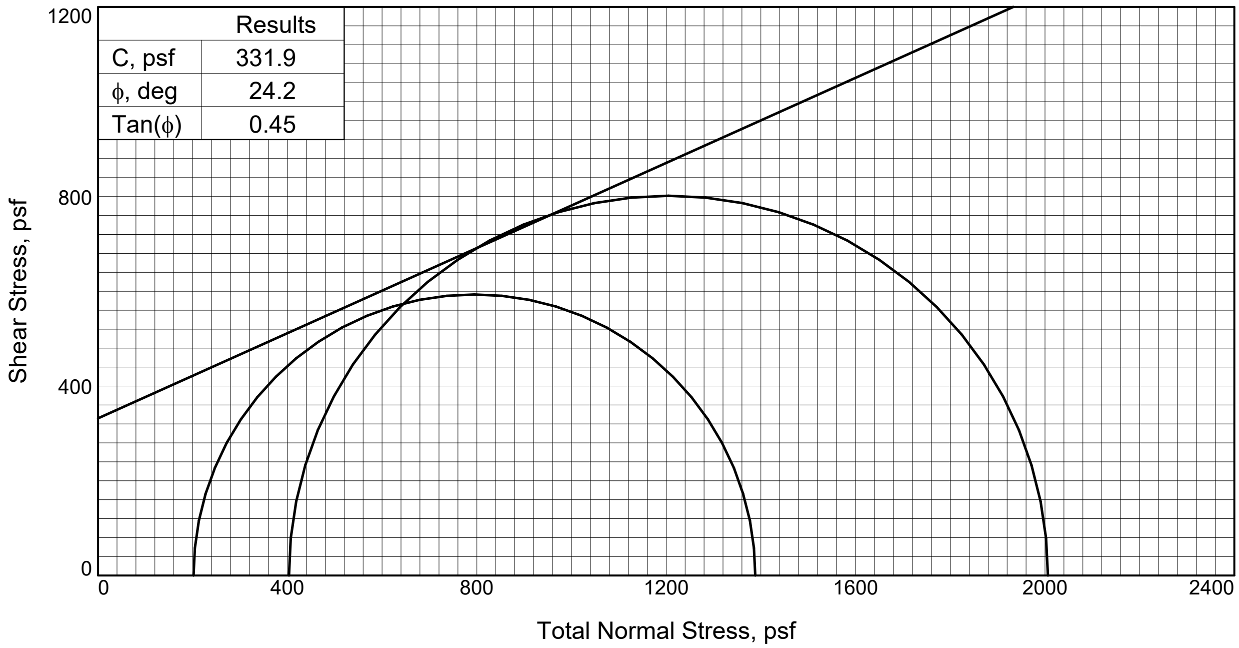
Client: EIP

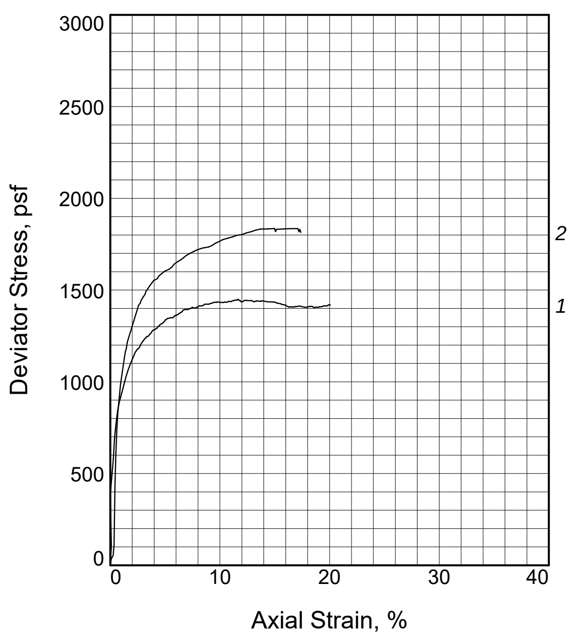
Project: Lookout Slough Restoration Project

Source of Sample: BCI-17-14 **Depth:** 4.5-6.0' **Sample Number:** 3

Project No.: 3195.P **Figure** ________

Blackburn Consulting





Sample No.		1	2
Initial	Water Content, %	27.9	26.7
	Dry Density, pcf	95.4	98.0
	Saturation, %	100.7	102.9
	Void Ratio	0.7339	0.6876
	Diameter, in.	2.852	2.857
	Height, in.	6.034	5.949
At Test	Water Content, %	29.1	27.4
	Dry Density, pcf	93.4	95.8
	Saturation, %	100.0	100.0
	Void Ratio	0.7711	0.7261
	Diameter, in.	2.887	2.891
	Height, in.	6.016	5.942
Strain rate, in./min.		0.002	0.002
Eff. Cell Pressure, psf		201.6	403.2
Fail. Stress, psf		1186.5	1603.1
Excess Pore Pr., psf		187.2	388.8
Strain, %		2.7	5.0
Ult. Stress, psf			
Excess Pore Pr., psf			
Strain, %			
$\bar{\sigma}_1$ Failure, psf		1200.9	1617.5
$\bar{\sigma}_3$ Failure, psf		14.4	14.4

Type of Test:
CU with Pore Pressures

Sample Type: 2.8" Shelby

Description: Lean CLAY, dark grayish brown

Assumed Specific Gravity= 2.65

Remarks:

Figure ________

Client: EIP

Project: Lookout Slough Restoration Project

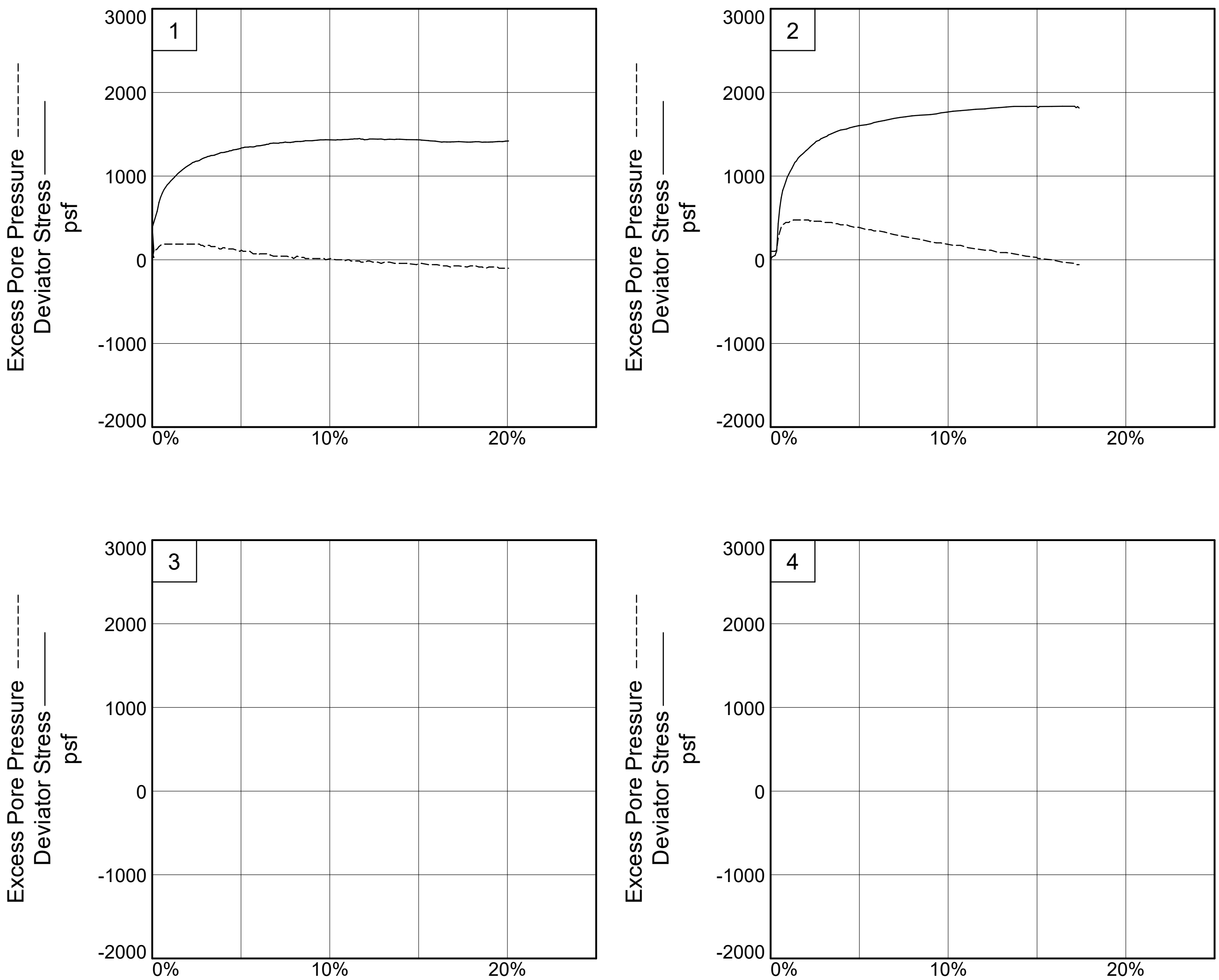
Source of Sample: BCI-17-19 **Depth:** 1.0-2.5'

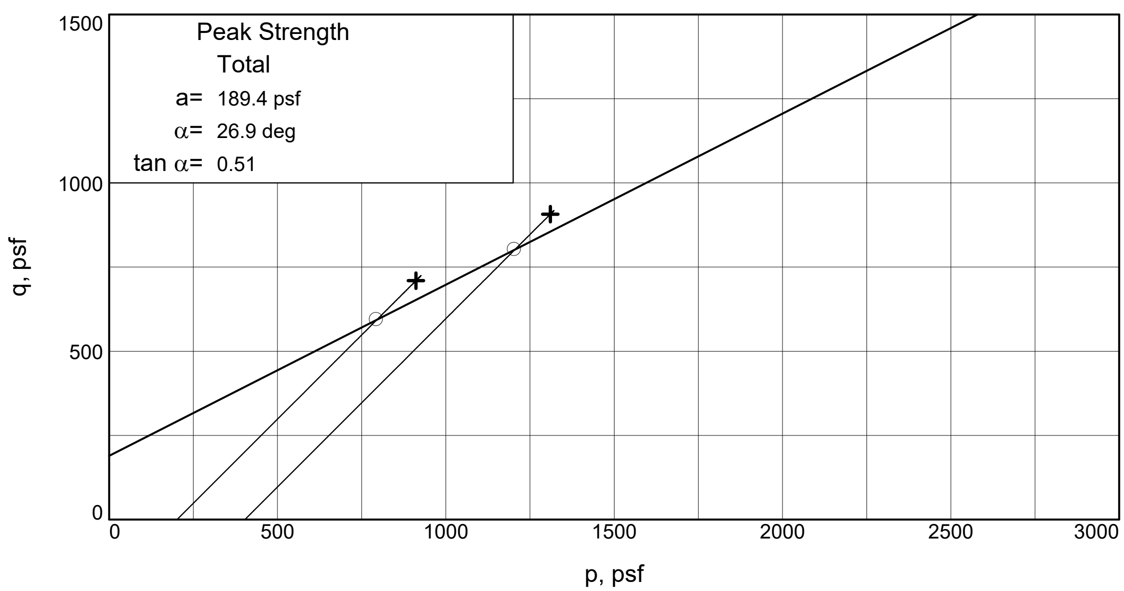
Sample Number: 1-total max 1:3

Proj. No.: 3195.P **Date Sampled:**

TRIAXIAL SHEAR TEST REPORT

Blackburn Consulting
W. Sacramento, CA





Stress Paths: o indicates peak + indicates end

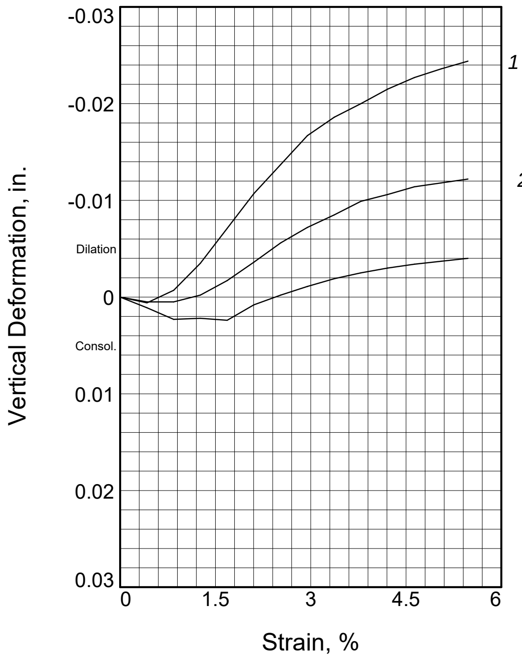
Client: EIP

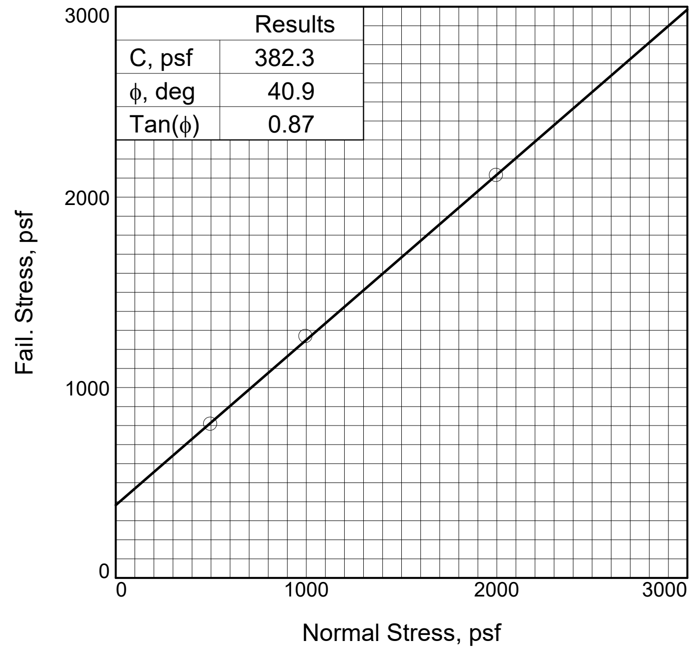
Project: Lookout Slough Restoration Project

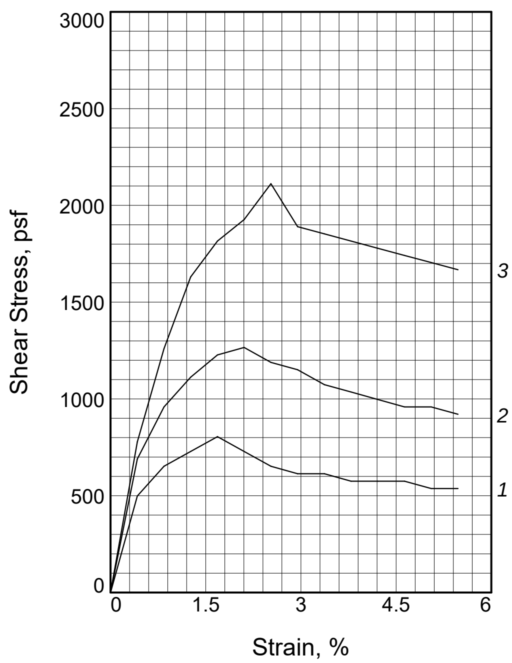
Source of Sample: BCI-17-19 **Depth:** 1.0-2.5' **Sample Number:** 1-total max 1:3

Project No.: 3195.P **Figure** ________

Blackburn Consulting







	Sample No.	1	2	3
Initial	Water Content, %	22.2	21.5	24.1
	Dry Density, pcf	95.7	95.4	93.4
	Saturation, %	78.6	75.8	80.8
	Void Ratio	0.7609	0.7667	0.8038
	Diameter, in.	2.375	2.375	2.375
	Height, in.	0.945	0.945	0.945
At Test	Water Content, %	27.1	27.1	28.6
	Dry Density, pcf	96.2	96.0	95.2
	Saturation, %	97.2	96.8	100.0
	Void Ratio	0.7520	0.7553	0.7713
	Diameter, in.	2.375	2.375	2.375
	Height, in.	0.940	0.939	0.928
	Normal Stress, psf	500.0	1000.0	2000.0
	Fail. Stress, psf	805.5	1265.7	2112.2
	Strain, %	1.7	2.1	2.5
	Ult. Stress, psf			
	Strain, %			
	Strain rate, in./min.	0.002	0.002	0.002

Sample Type: 3" Shelby

Description: Fat CLAY with SAND, light yellowish brown

LL= 68 **PL=** 22 **PI=** 46

Assumed Specific Gravity= 2.7

Remarks:

Figure ________

Client: EIP

Project: Lookout Slough Restoration Project

Source of Sample: BCI-17-1 **Depth:** 4.5-4.9'

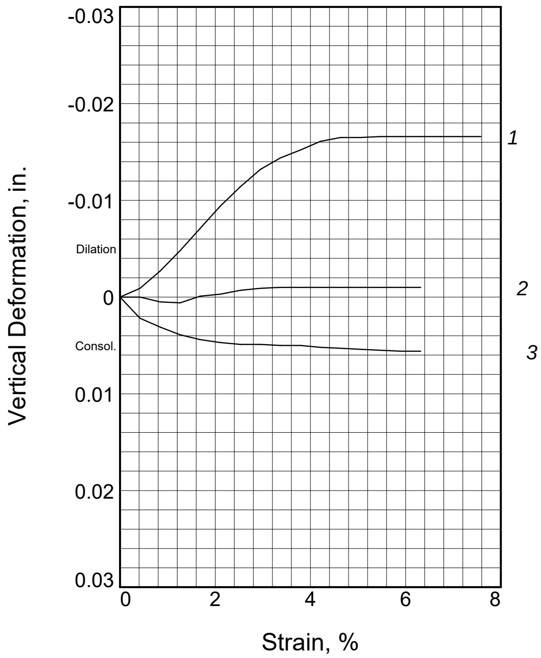
Sample Number: 2

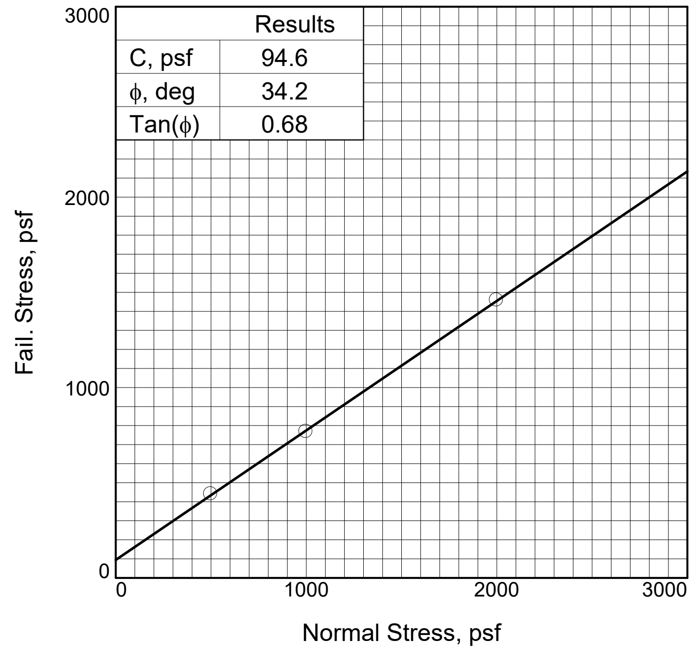
Proj. No.: 3195.P **Date Sampled:**

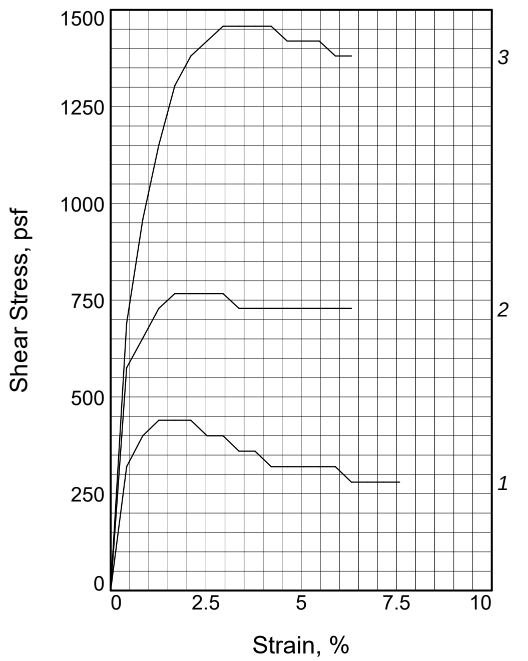
DIRECT SHEAR TEST REPORT

Blackburn Consulting

W. Sacramento, CA







	Sample No.	1	2	3
Initial	Water Content, %	24.1	21.5	22.3
	Dry Density, pcf	94.0	98.0	97.8
	Saturation, %	82.2	80.6	83.1
	Void Ratio	0.7926	0.7200	0.7236
	Diameter, in.	2.375	2.375	2.375
	Height, in.	0.945	0.945	0.945
At Test	Water Content, %	29.3	24.4	25.3
	Dry Density, pcf	93.9	98.3	99.9
	Saturation, %	99.8	92.2	99.2
	Void Ratio	0.7943	0.7140	0.6880
	Diameter, in.	2.375	2.375	2.375
	Height, in.	0.946	0.942	0.925
	Normal Stress, psf	500.0	1000.0	2000.0
	Fail. Stress, psf	439.8	767.1	1457.5
	Strain, %	1.3	1.7	2.9
	Ult. Stress, psf			
	Strain, %			
	Strain rate, in./min.	0.002	0.002	0.002

Sample Type: 3.0" Shelby
Description: Fat CLAY, dark gray

LL= 54 **PL=** 12 **PI=** 42
Assumed Specific Gravity= 2.7
Remarks:

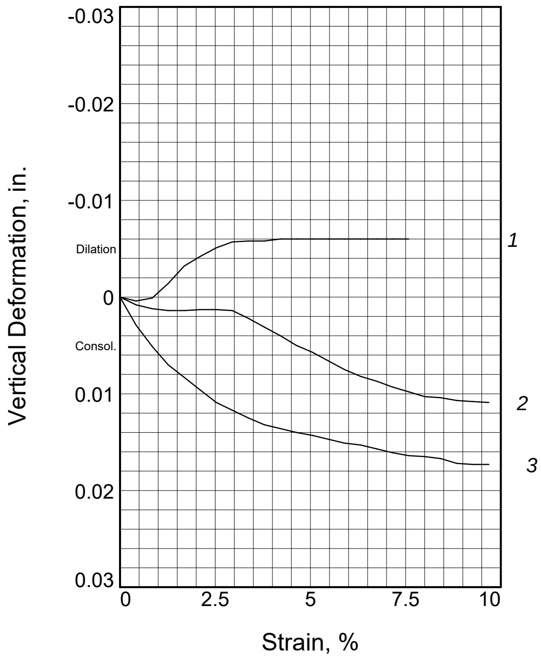
Figure ________

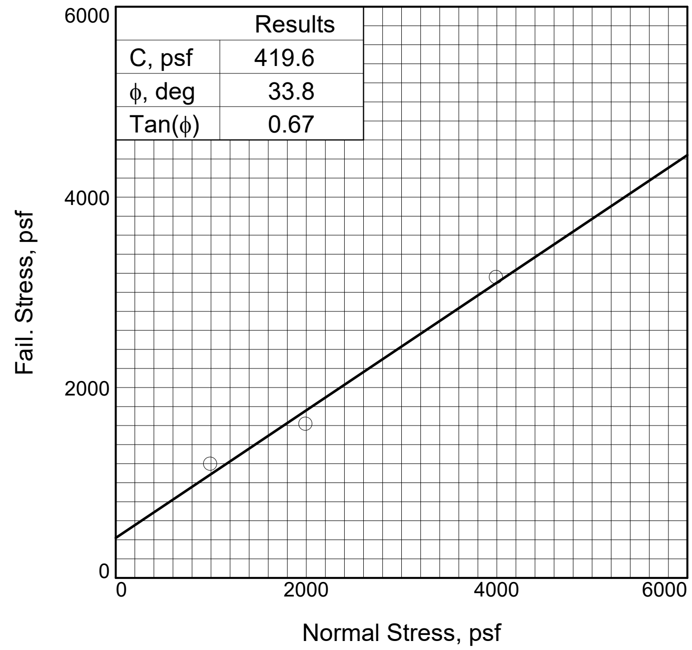
Client: EIP

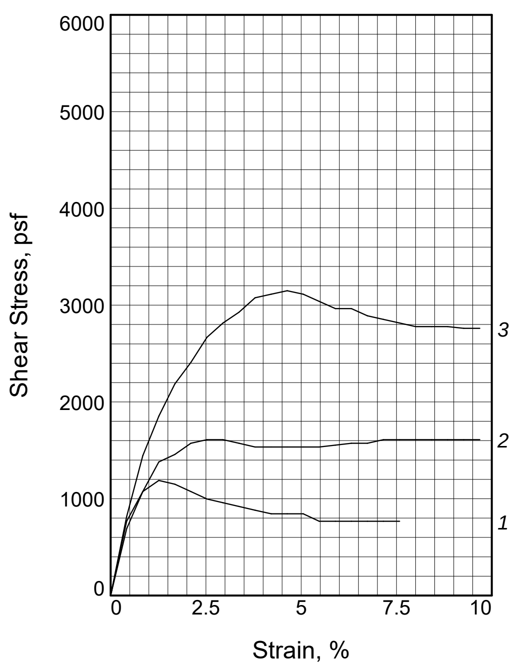
Project: Lookout Slough Restoration Project

Source of Sample: BCI-17-2 **Depth:** 4.0-5.0'
Sample Number: 2
Proj. No.: 3195.P **Date Sampled:**

DIRECT SHEAR TEST REPORT
Blackburn Consulting
W. Sacramento, CA







	Sample No.	1	2	3
Initial	Water Content, %	21.8	23.2	22.3
	Dry Density, pcf	95.2	91.5	94.0
	Saturation, %	76.5	74.5	75.9
	Void Ratio	0.7707	0.8418	0.7926
	Diameter, in.	2.375	2.375	2.375
	Height, in.	0.945	0.945	0.945
At Test	Water Content, %	28.1	29.8	26.2
	Dry Density, pcf	95.8	93.3	98.6
	Saturation, %	99.8	100.0	99.6
	Void Ratio	0.7590	0.8059	0.7090
	Diameter, in.	2.375	2.375	2.375
	Height, in.	0.939	0.927	0.901
Normal Stress, psf		1000.0	2000.0	4000.0
Fail. Stress, psf		1189.0	1610.9	3149.7
Strain, %		1.3	2.5	4.6
Ult. Stress, psf				
Strain, %				
Strain rate, in./min.		0.000	0.000	0.000

Sample Type: 3.0" Shelby

Description: Lean CLAY, brown

Assumed Specific Gravity= 2.70

Remarks:

Figure ________

Client: EIP

Project: Lookout Slough Restoration Project

Source of Sample: BCI-17-4 **Depth:** 8.7-9.3'

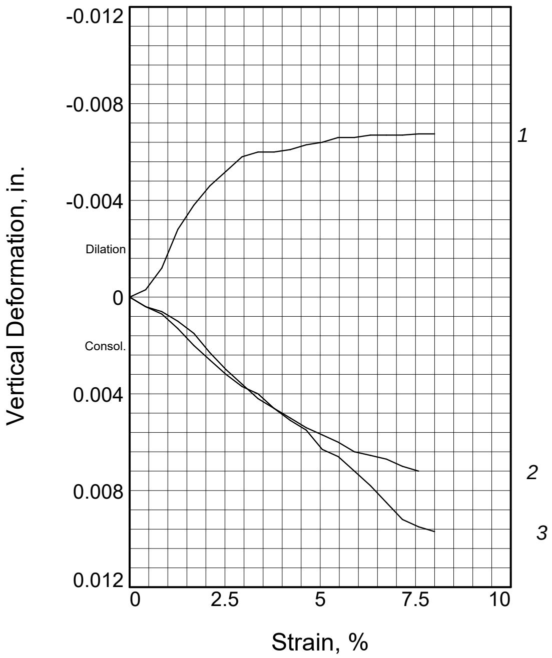
Sample Number: 4

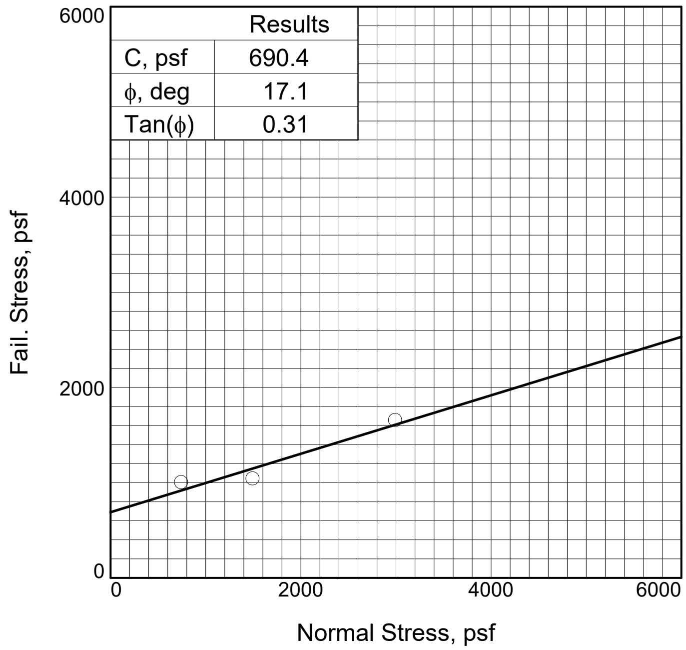
Proj. No.: 3195.P **Date Sampled:**

DIRECT SHEAR TEST REPORT

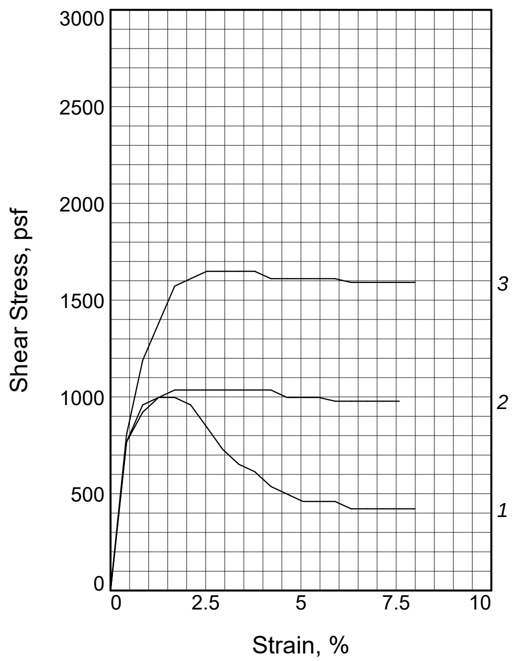
Blackburn Consulting

W. Sacramento, CA





Results	
C, psf	690.4
ϕ, deg	17.1
Tan(ϕ)	0.31



	Sample No.	1	2	3
Initial	Water Content, %	21.1	21.6	22.4
	Dry Density, pcf	102.5	100.5	100.8
	Saturation, %	88.6	86.1	90.1
	Void Ratio	0.6439	0.6769	0.6723
	Diameter, in.	2.375	2.375	2.375
	Height, in.	0.945	0.945	0.945
At Test	Water Content, %	24.2	24.3	23.7
	Dry Density, pcf	101.9	101.8	102.6
	Saturation, %	99.8	100.0	99.8
	Void Ratio	0.6538	0.6563	0.6424
	Diameter, in.	2.375	2.375	2.375
	Height, in.	0.951	0.933	0.928
	Normal Stress, psf	750.0	1500.0	3000.0
	Fail. Stress, psf	997.2	1035.6	1649.3
	Strain, %	1.3	1.7	2.5
	Ult. Stress, psf			
	Strain, %			
	Strain rate, in./min.	0.000	0.000	0.000

Sample Type: 3.0" Shelby
Description: Lean CLAY with SAND, dark yellowish brown
LL= 48 **PL=** 16 **PI=** 32
Assumed Specific Gravity= 2.70
Remarks:

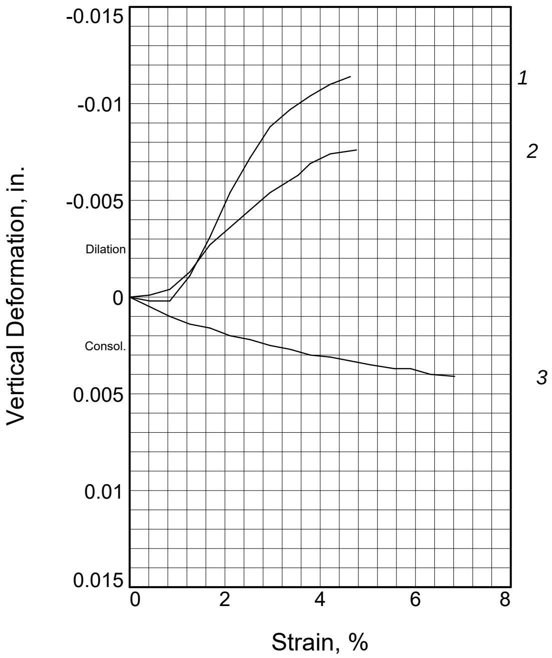
Figure ________

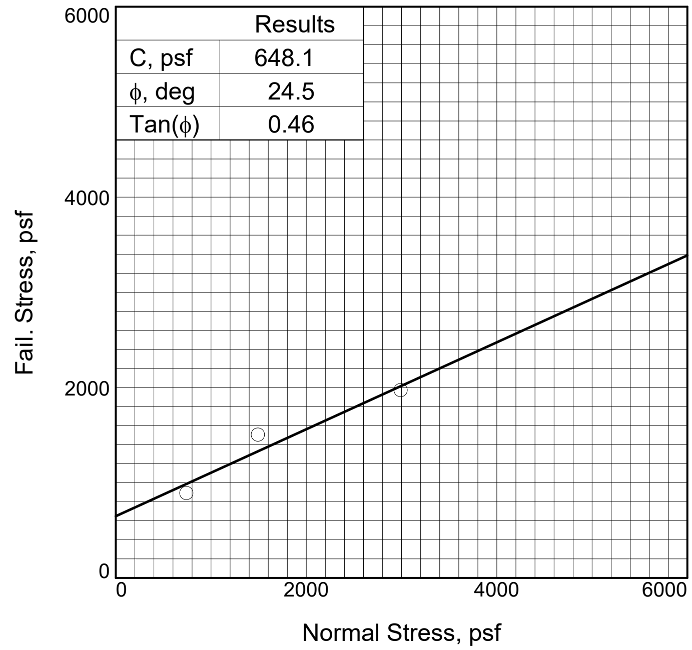
Client: EIP

Project: Lookout Slough Restoration Project

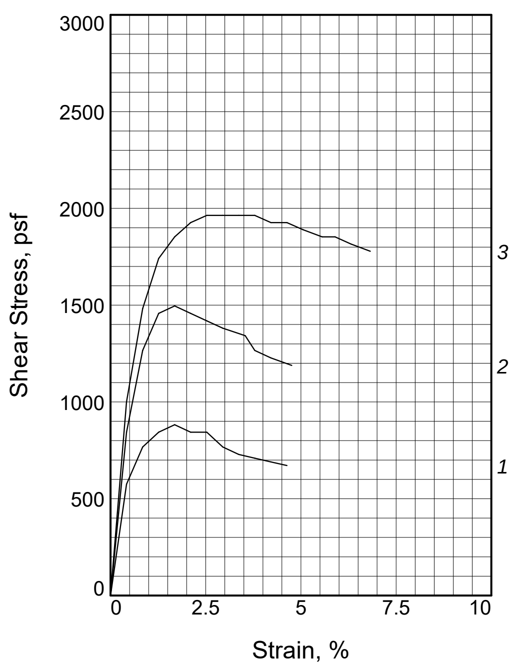
Source of Sample: BCI-17-7 **Depth:** 3.8-4.2'
Sample Number: 2
Proj. No.: 3195.P **Date Sampled:**

DIRECT SHEAR TEST REPORT
Blackburn Consulting
W. Sacramento, CA





Results	
C, psf	648.1
ϕ, deg	24.5
Tan(ϕ)	0.46



	Sample No.	1	2	3
Initial	Water Content, %	30.8	29.1	30.7
	Dry Density, pcf	88.2	91.7	86.5
	Saturation, %	91.1	93.9	87.5
	Void Ratio	0.9119	0.8373	0.9477
	Diameter, in.	2.375	2.375	2.375
	Height, in.	0.945	0.945	0.945
At Test	Water Content, %	33.7	30.8	31.2
	Dry Density, pcf	88.2	92.0	88.6
	Saturation, %	99.8	99.8	93.5
	Void Ratio	0.9115	0.8324	0.9019
	Diameter, in.	2.375	2.375	2.375
	Height, in.	0.945	0.943	0.923
	Normal Stress, psf	750.0	1500.0	3000.0
	Fail. Stress, psf	882.2	1495.9	1963.9
	Strain, %	1.7	1.7	2.5
	Ult. Stress, psf			
	Strain, %			
	Strain rate, in./min.	0.000	0.000	0.000

Sample Type: 3.0" Shelby

Description: Fat CLAY, very dark gray

LL= 68 **PL=** 20 **PI=** 48

Assumed Specific Gravity= 2.70

Remarks:

Figure ________

Client: EIP

Project: Lookout Slough Restoration Project

Source of Sample: BCI-17-8 **Depth:** 3.8-4.2'

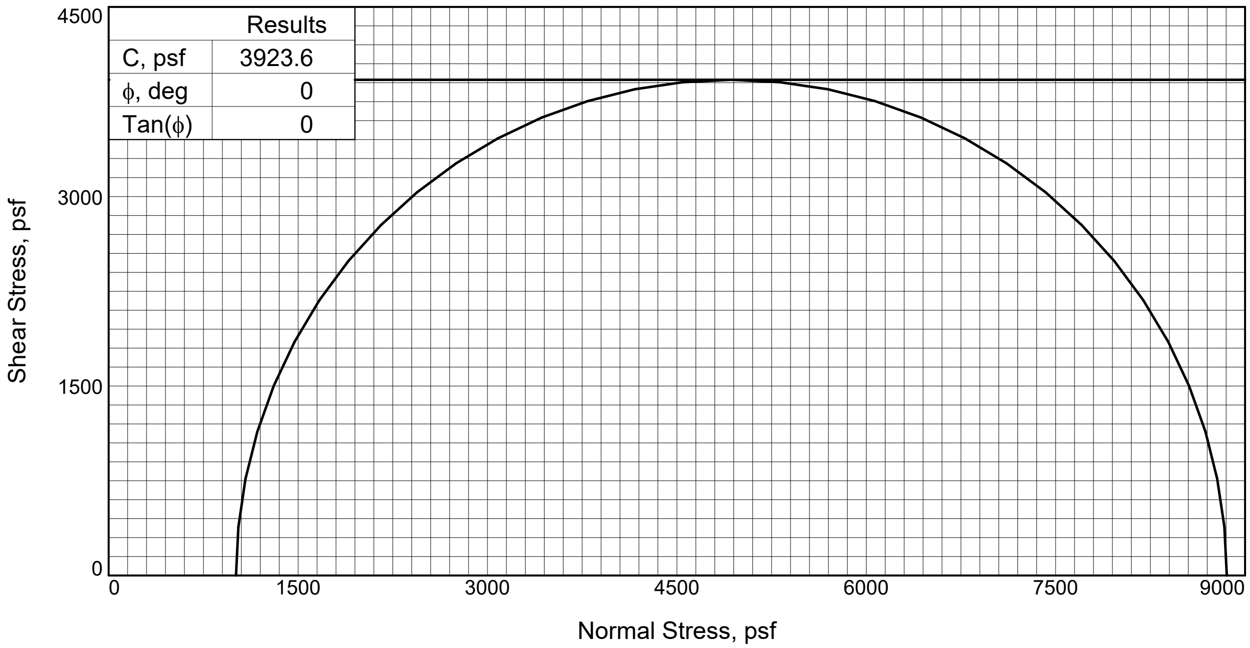
Sample Number: 2

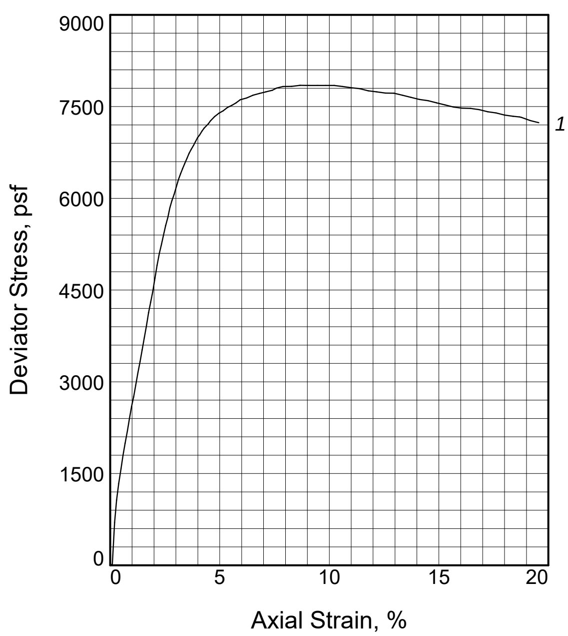
Proj. No.: 3195.P **Date Sampled:**

DIRECT SHEAR TEST REPORT

Blackburn Consulting

W. Sacramento, CA





Sample No.		1
Initial	Water Content, %	21.3
	Dry Density, pcf	103.5
	Saturation, %	91.6
	Void Ratio	0.6293
	Diameter, in.	2.869
	Height, in.	6.175
At Test	Water Content, %	21.3
	Dry Density, pcf	103.5
	Saturation, %	91.6
	Void Ratio	0.6293
	Diameter, in.	2.869
	Height, in.	6.175
Strain rate, in./min.		0.062
Back Pressure, psf		0.0
Cell Pressure, psf		1008.0
Fail. Stress, psf		7847.1
Strain, %		8.7
Ult. Stress, psf		
Strain, %		
σ_1 Failure, psf		8855.1
σ_3 Failure, psf		1008.0

Type of Test:
Unconsolidated Undrained

Sample Type: 3.0" Shelby

Description: Lean CLAY with SAND, yellowish brown

Assumed Specific Gravity= 2.70

Remarks:

Figure ________

Client: EIP

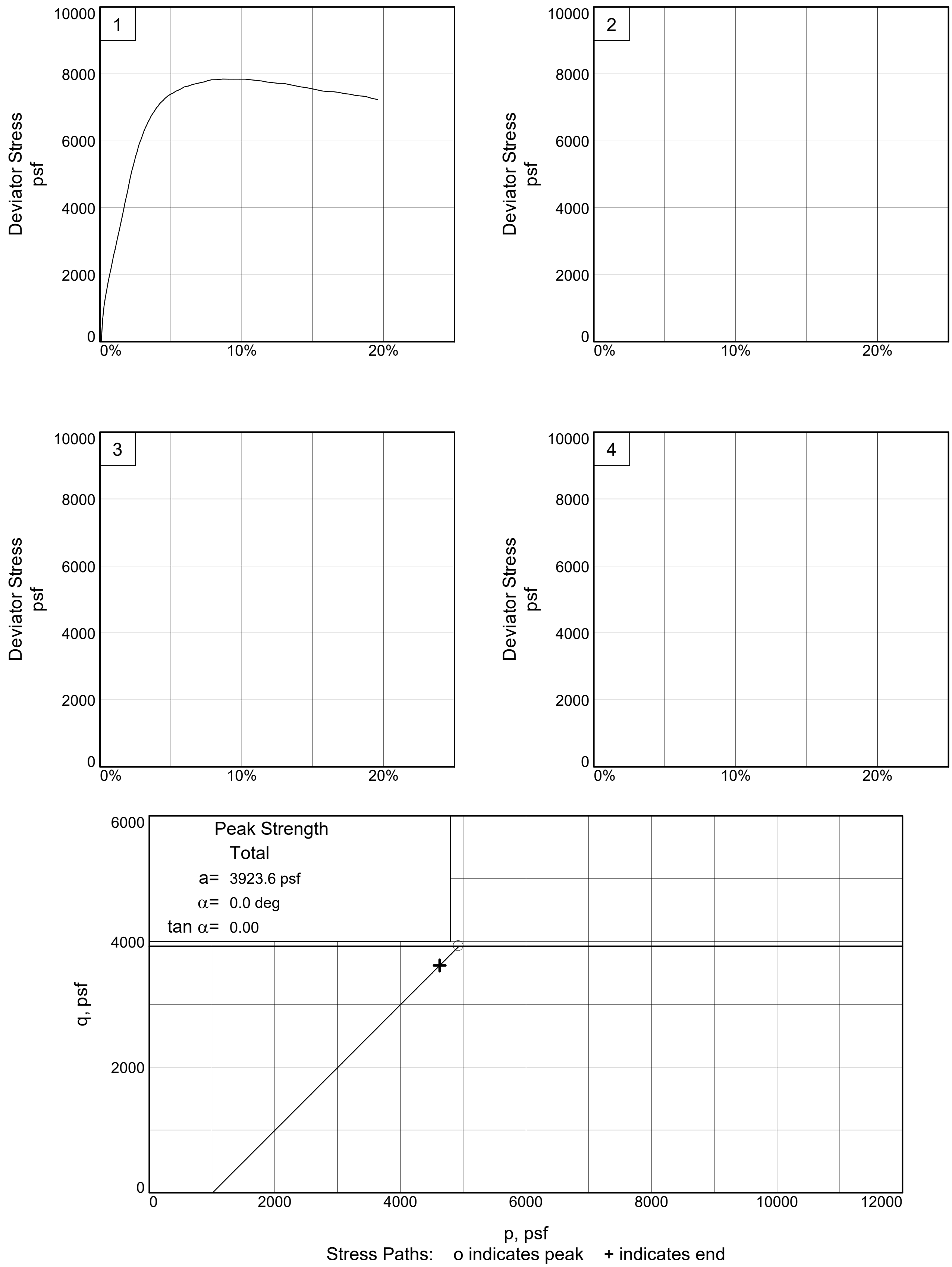
Project: Lookout Slough Restoration Project

Source of Sample: BCI-17-2 **Depth:** 11.5-12.0'

Sample Number: 6

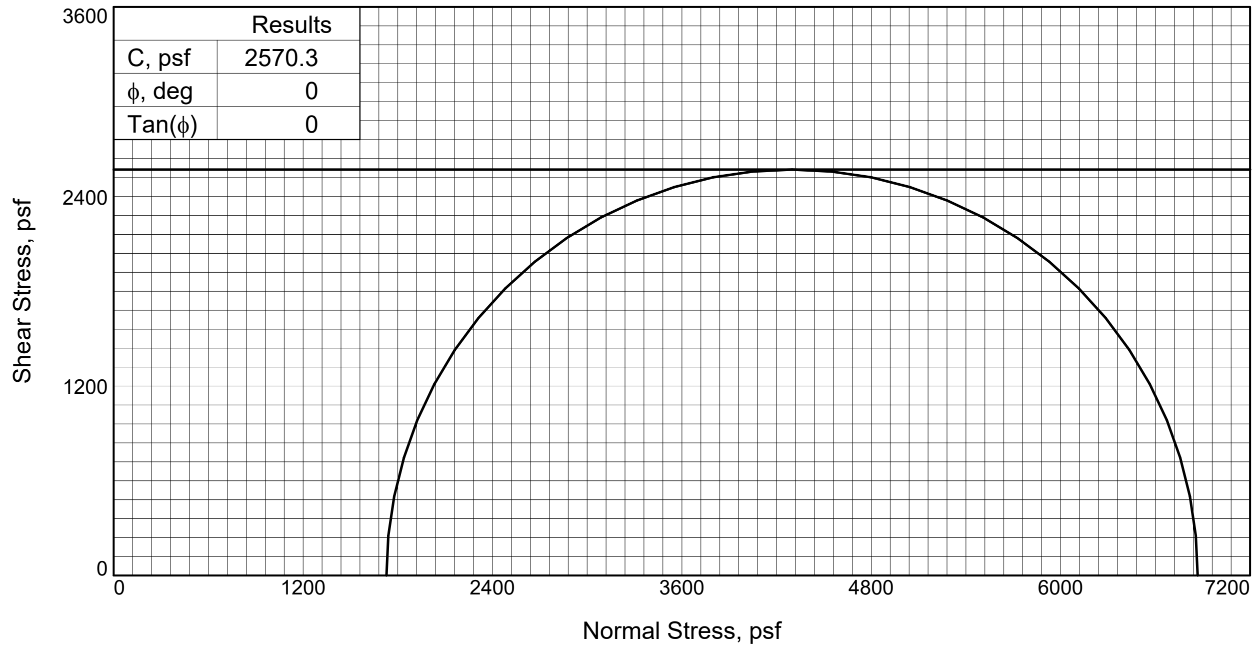
Proj. No.: 3195.P **Date Sampled:**

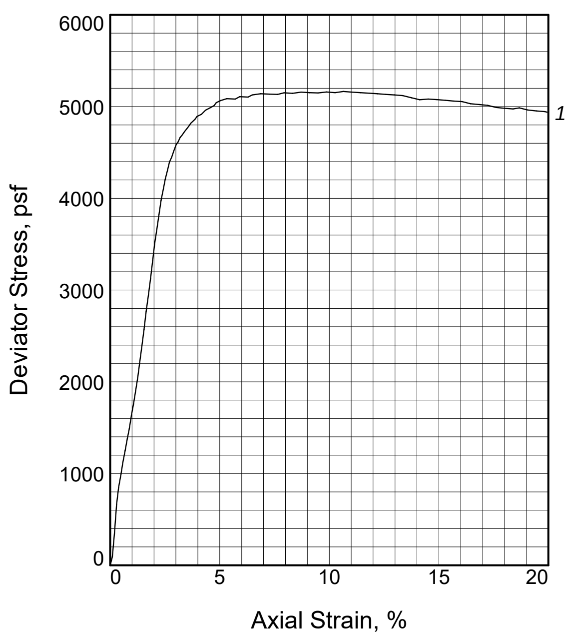
TRIAXIAL SHEAR TEST REPORT
Blackburn Consulting
W. Sacramento, CA



Client: EIP
Project: Lookout Slough Restoration Project
Source of Sample: BCI-17-2 **Depth:** 11.5-12.0' **Sample Number:** 6
Project No.: 3195.P **Figure** ________

Blackburn Consulting





Sample No.		1
Initial	Water Content, %	17.4
	Dry Density, pcf	108.0
	Saturation, %	83.8
	Void Ratio	0.5613
	Diameter, in.	2.862
	Height, in.	6.211
At Test	Water Content, %	17.4
	Dry Density, pcf	108.0
	Saturation, %	83.8
	Void Ratio	0.5613
	Diameter, in.	2.862
	Height, in.	6.211
Strain rate, in./min.		0.062
Back Pressure, psf		0.0
Cell Pressure, psf		1728.0
Fail. Stress, psf		5140.6
Strain, %		6.9
Ult. Stress, psf		
Strain, %		
σ_1 Failure, psf		6868.6
σ_3 Failure, psf		1728.0

Type of Test:
Unconsolidated Undrained

Sample Type: 3.0" Shelby

Description: SANDY lean CLAY, brown

LL= 38 **PL=** 16 **PI=** 22

Assumed Specific Gravity= 2.70

Remarks:

Figure ________

Client: EIP

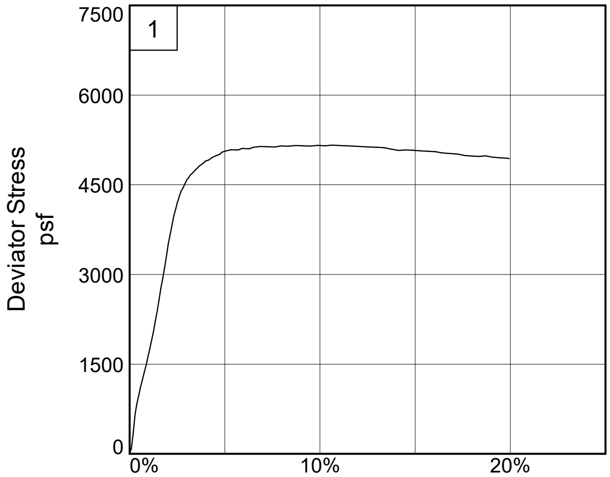
Project: Lookout Slough Restoration Project

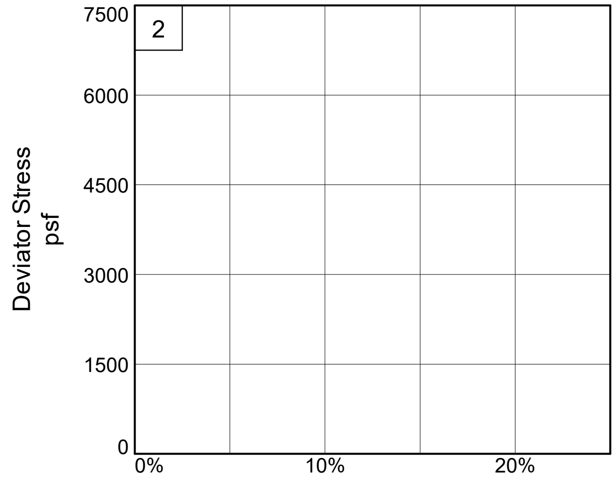
Source of Sample: BCI-17-2 **Depth:** 20'-20.5'

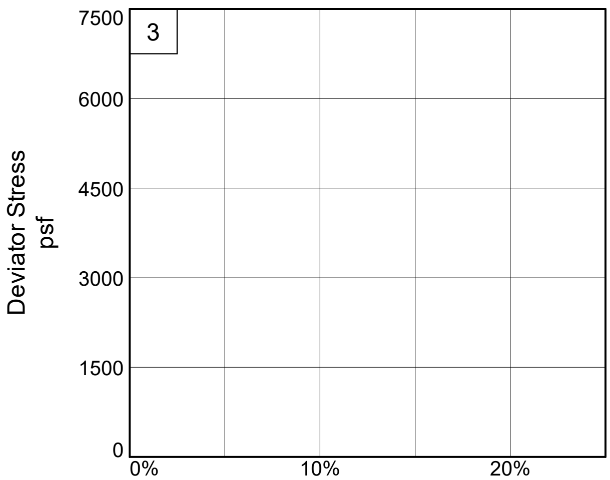
Sample Number: 10

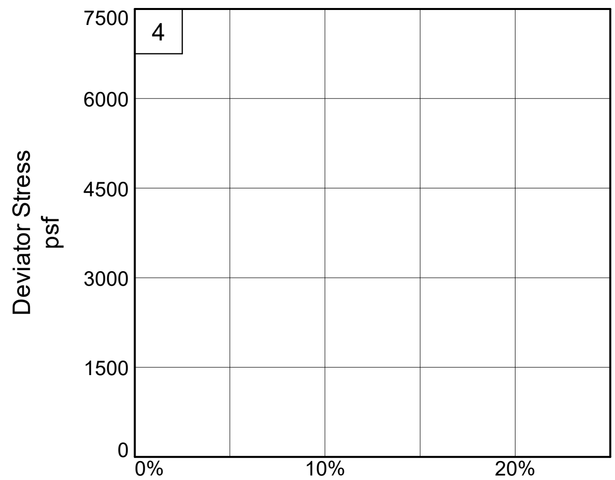
Proj. No.: 3195.P **Date Sampled:**

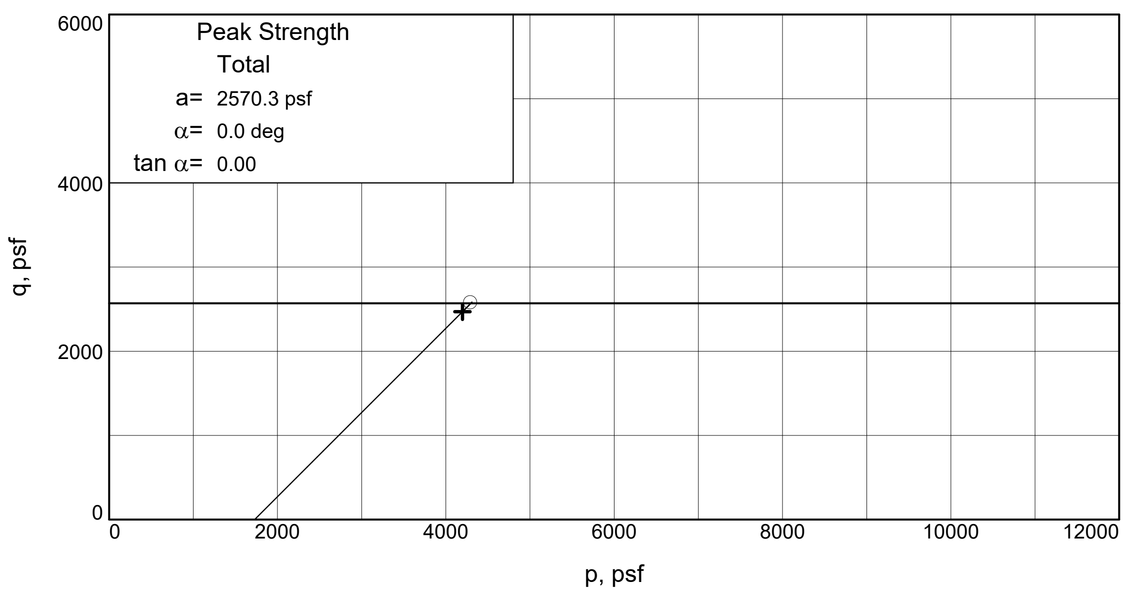
TRIAXIAL SHEAR TEST REPORT
Blackburn Consulting
W. Sacramento, CA











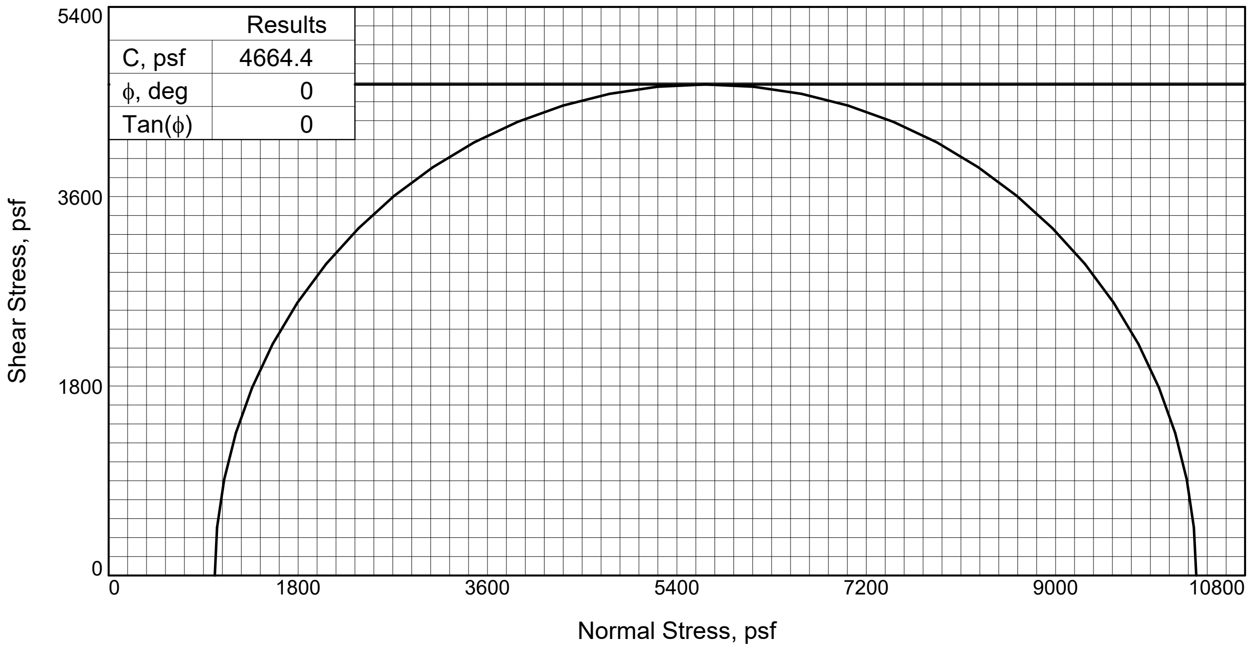
Stress Paths: o indicates peak + indicates end

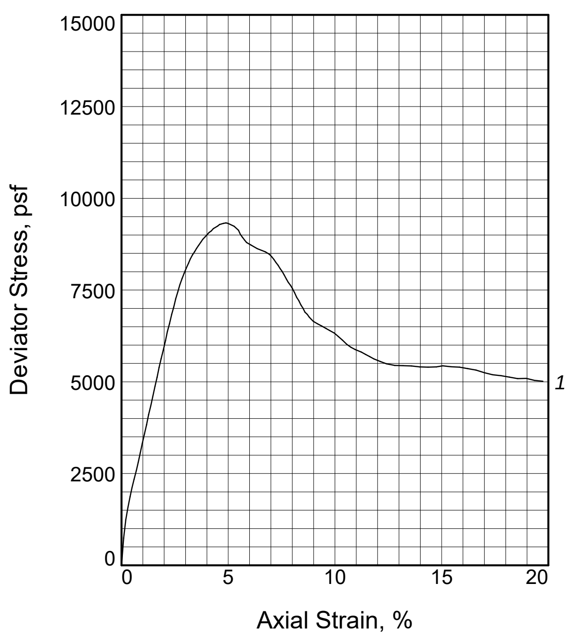
Client: EIP

Project: Lookout Slough Restoration Project

Source of Sample: BCI-17-2 **Depth:** 20'-20.5' **Sample Number:** 10

Project No.: 3195.P **Figure** ________ **Blackburn Consulting**





Sample No.		1
Initial	Water Content, %	19.8
	Dry Density, pcf	106.7
	Saturation, %	92.2
	Void Ratio	0.5803
	Diameter, in.	2.861
	Height, in.	6.151
At Test	Water Content, %	19.8
	Dry Density, pcf	106.7
	Saturation, %	92.2
	Void Ratio	0.5803
	Diameter, in.	2.861
	Height, in.	6.151
Strain rate, in./min.		0.062
Back Pressure, psf		0.0
Cell Pressure, psf		1008.0
Fail. Stress, psf		9328.7
Strain, %		4.9
Ult. Stress, psf		
Strain, %		
σ_1 Failure, psf		10336.7
σ_3 Failure, psf		1008.0

Type of Test:
Unconsolidated Undrained

Sample Type: 3.0" Shelby

Description: Fat CLAY, yellowish brown

Assumed Specific Gravity= 2.70

Remarks: Stiff/Very Stiff

Figure ________

Client: EIP

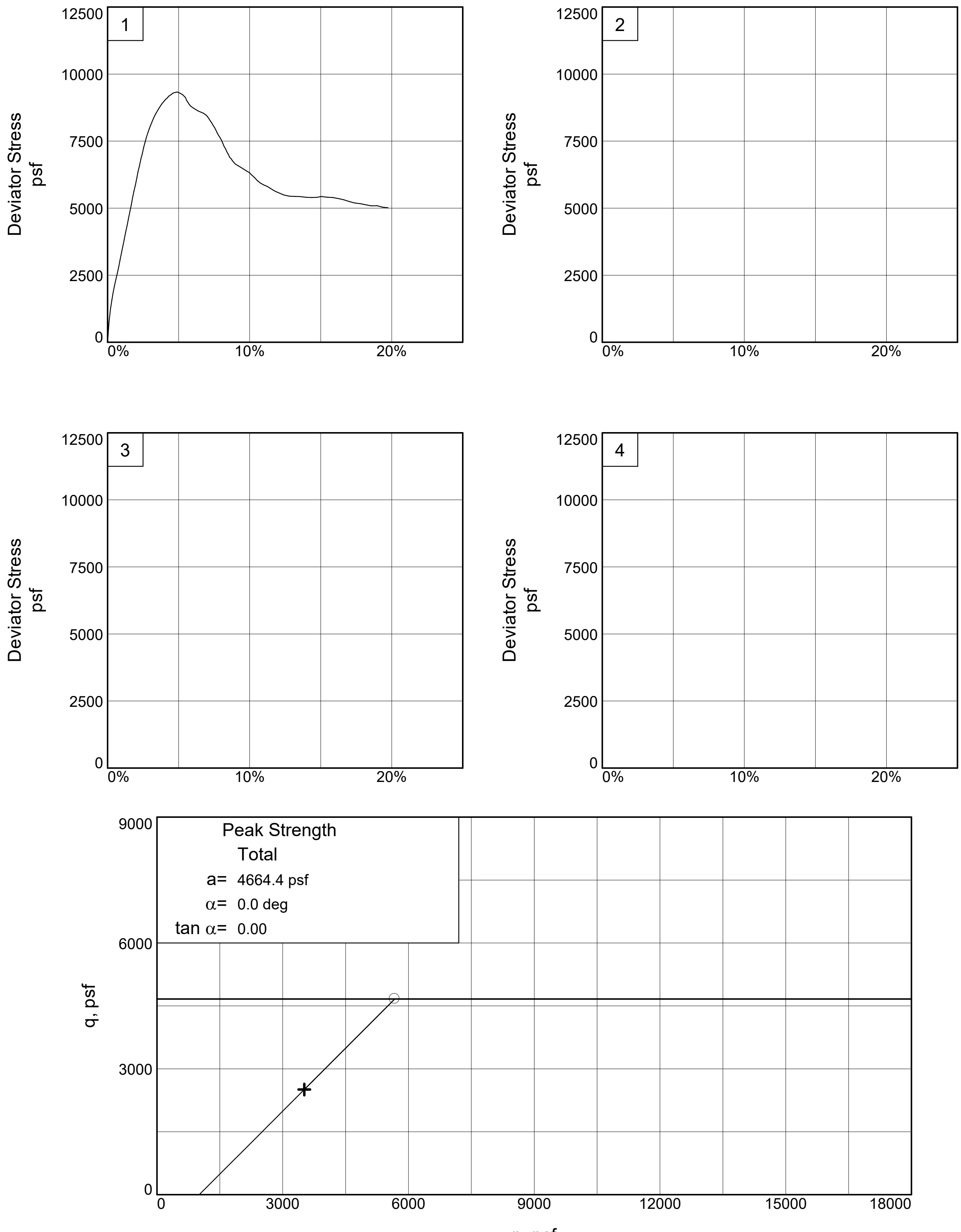
Project: Lookout Slough Restoration Project

Source of Sample: BCI-17-3 **Depth:** 12.3-12.8'

Sample Number: 6

Proj. No.: 3195.P **Date Sampled:**

TRIAXIAL SHEAR TEST REPORT
Blackburn Consulting
W. Sacramento, CA



Stress Paths: o indicates peak + indicates end

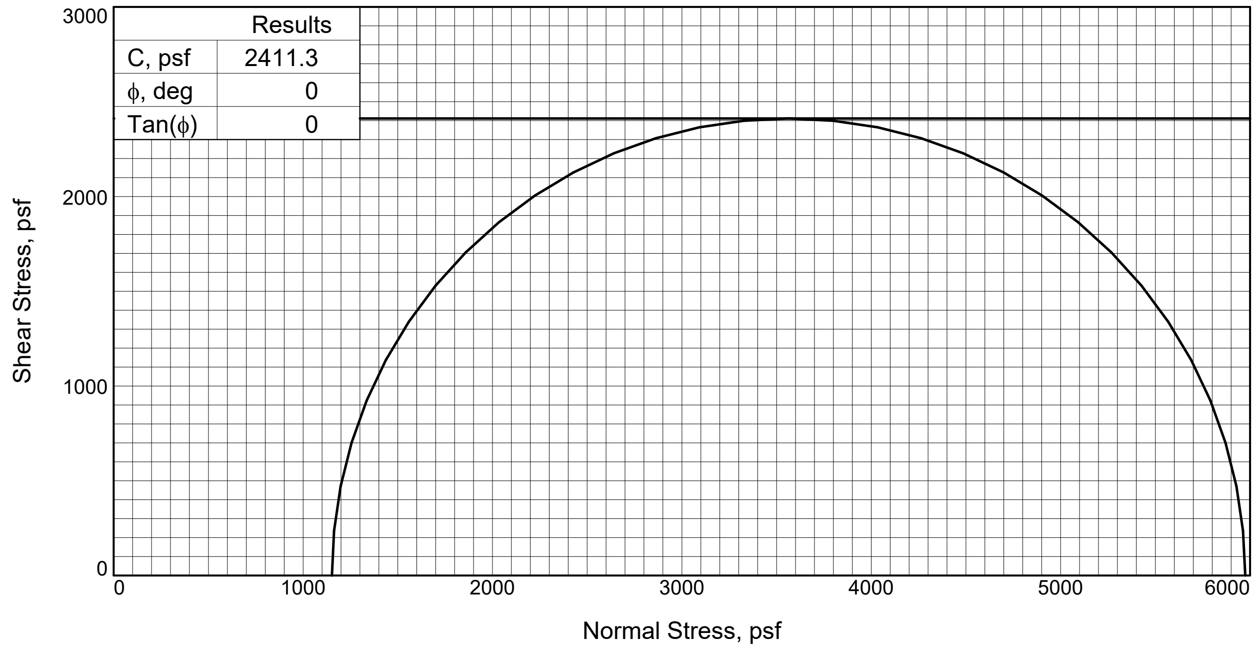
Client: EIP

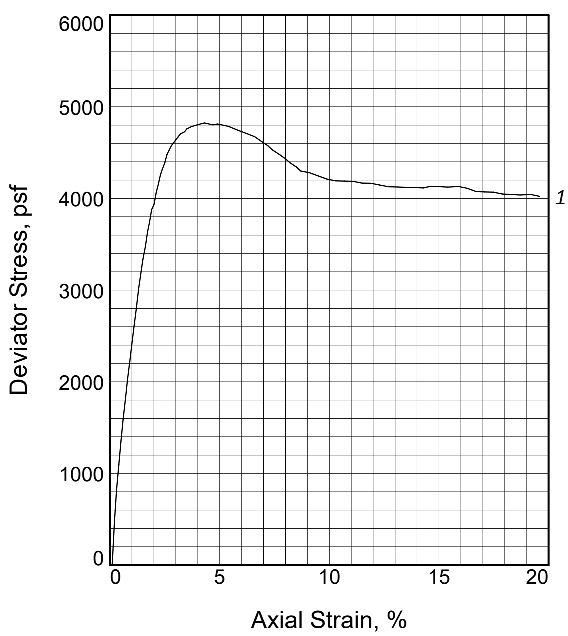
Project: Lookout Slough Restoration Project

Source of Sample: BCI-17-3 **Depth:** 12.3-12.8' **Sample Number:** 6

Project No.: 3195.P **Figure** ________

Blackburn Consulting





Sample No.		1
Initial	Water Content, %	24.3
	Dry Density, pcf	96.3
	Saturation, %	87.5
	Void Ratio	0.7508
	Diameter, in.	2.872
	Height, in.	5.089
At Test	Water Content, %	24.3
	Dry Density, pcf	96.3
	Saturation, %	87.5
	Void Ratio	0.7508
	Diameter, in.	2.872
	Height, in.	5.089
Strain rate, in./min.		0.051
Back Pressure, psf		0.0
Cell Pressure, psf		1152.0
Fail. Stress, psf		4822.6
Strain, %		4.3
Ult. Stress, psf		
Strain, %		
σ_1 Failure, psf		5974.6
σ_3 Failure, psf		1152.0

Type of Test:
Unconsolidated Undrained

Sample Type: 3.0" Shelby

Description: Lean CLAY, yellowish brown

LL= 46 **PL=** 21 **PI=** 25

Assumed Specific Gravity= 2.70

Remarks:

Figure ________

Client: EIP

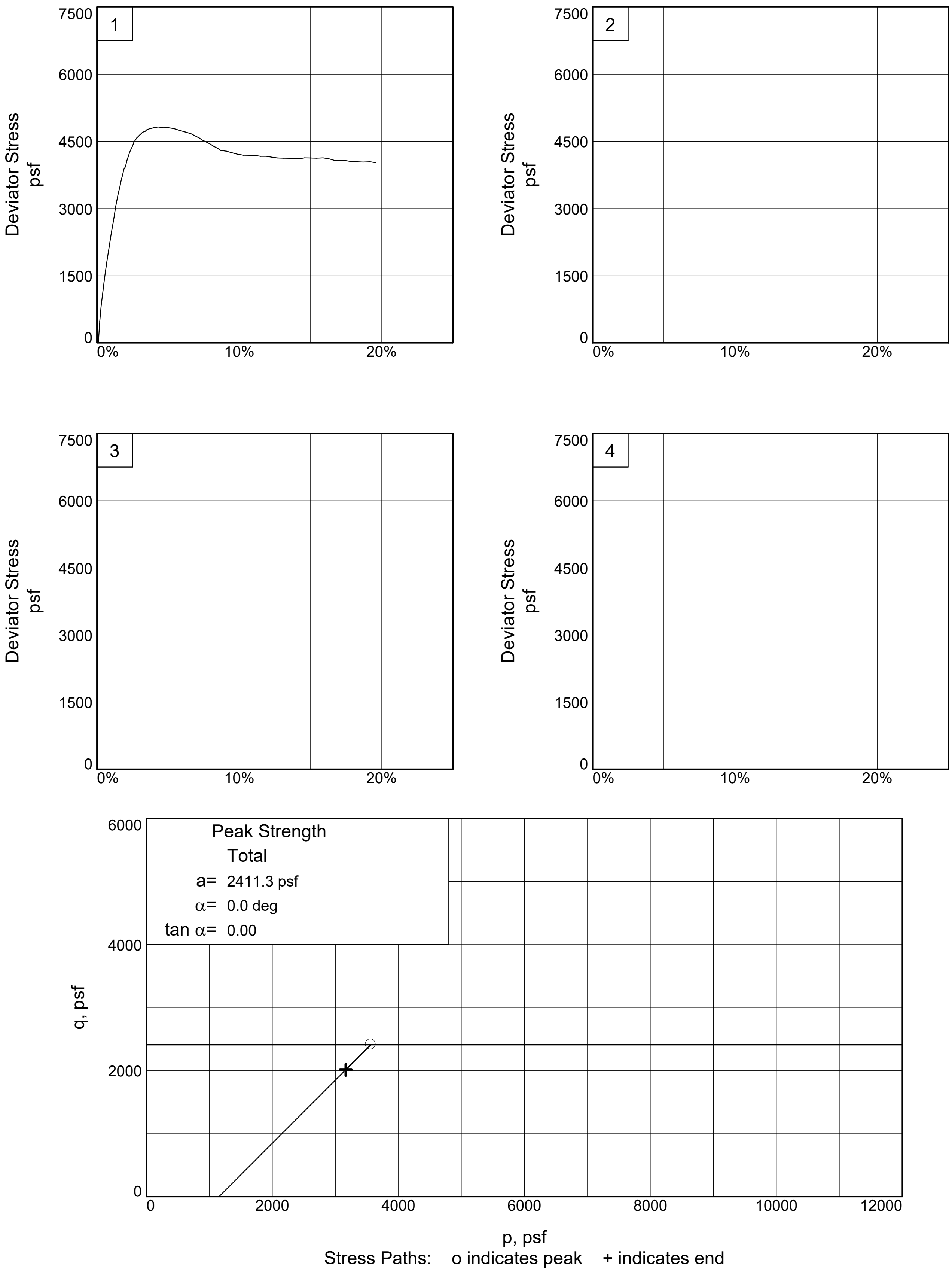
Project: Lookout Slough Restoration Project

Source of Sample: BCI-17-4 **Depth:** 13.0-13.5'

Sample Number: 6

Proj. No.: 3195.P **Date Sampled:**

TRIAXIAL SHEAR TEST REPORT
Blackburn Consulting
W. Sacramento, CA

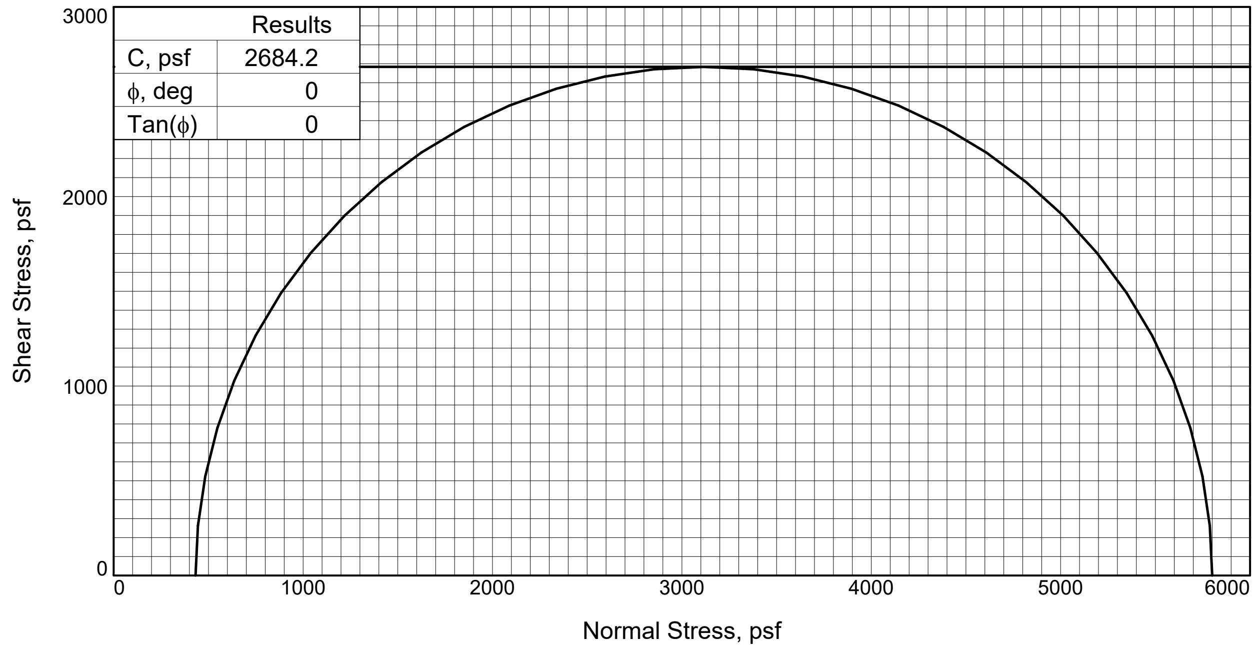


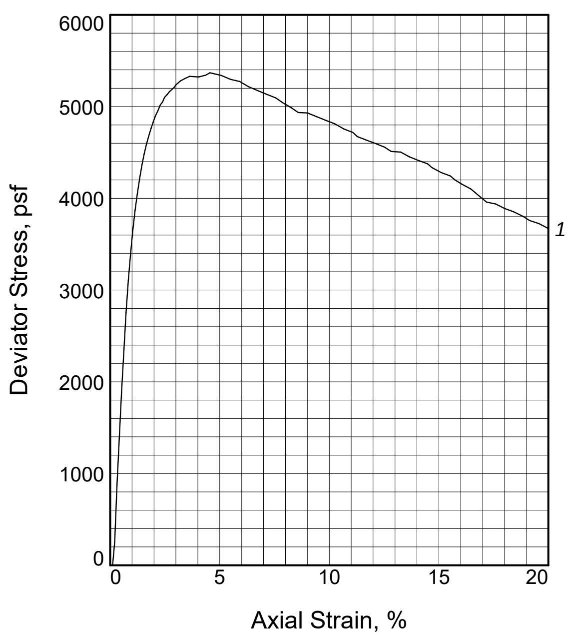
Client: EIP

Project: Lookout Slough Restoration Project

Source of Sample: BCI-17-4 **Depth:** 13.0-13.5' **Sample Number:** 6

Project No.: 3195.P **Figure** ________ **Blackburn Consulting**





Sample No.		1
Initial	Water Content, %	20.7
	Dry Density, pcf	102.7
	Saturation, %	87.2
	Void Ratio	0.6409
	Diameter, in.	2.845
	Height, in.	5.808
At Test	Water Content, %	20.7
	Dry Density, pcf	102.7
	Saturation, %	87.2
	Void Ratio	0.6409
	Diameter, in.	2.845
	Height, in.	5.808
Strain rate, in./min.		0.058
Back Pressure, psf		0.0
Cell Pressure, psf		432.0
Fail. Stress, psf		5368.5
Strain, %		4.6
Ult. Stress, psf		
Strain, %		
σ_1 Failure, psf		5800.5
σ_3 Failure, psf		432.0

Type of Test:
Unconsolidated Undrained

Sample Type: 3.0" Shelby

Description: Fat CLAY with SAND, dark brown

LL= 68 **PL=** 18 **PI=** 50

Assumed Specific Gravity= 2.70

Remarks: Stiff

Figure ________

Client: EIP

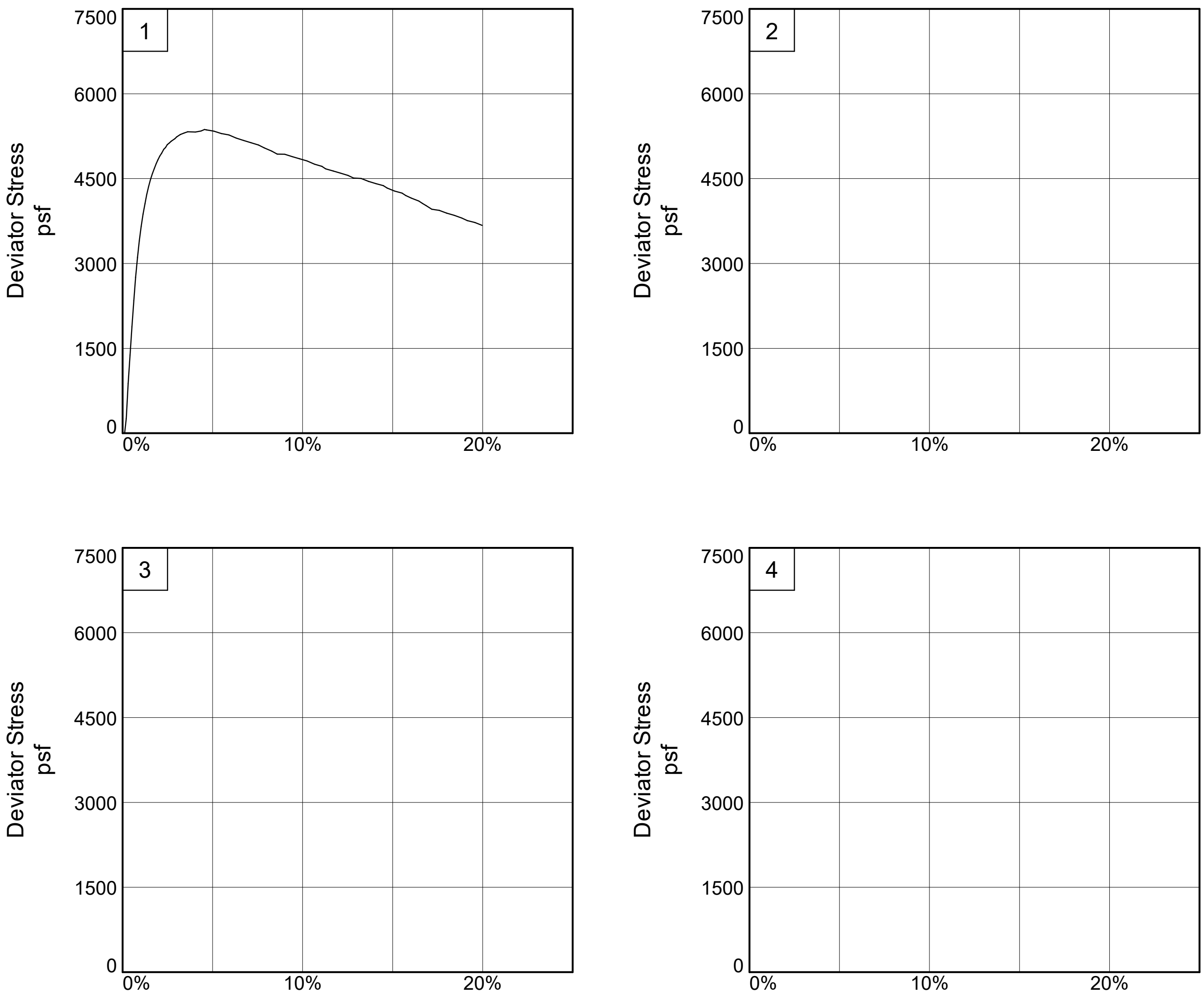
Project: Lookout Slough Restoration Project

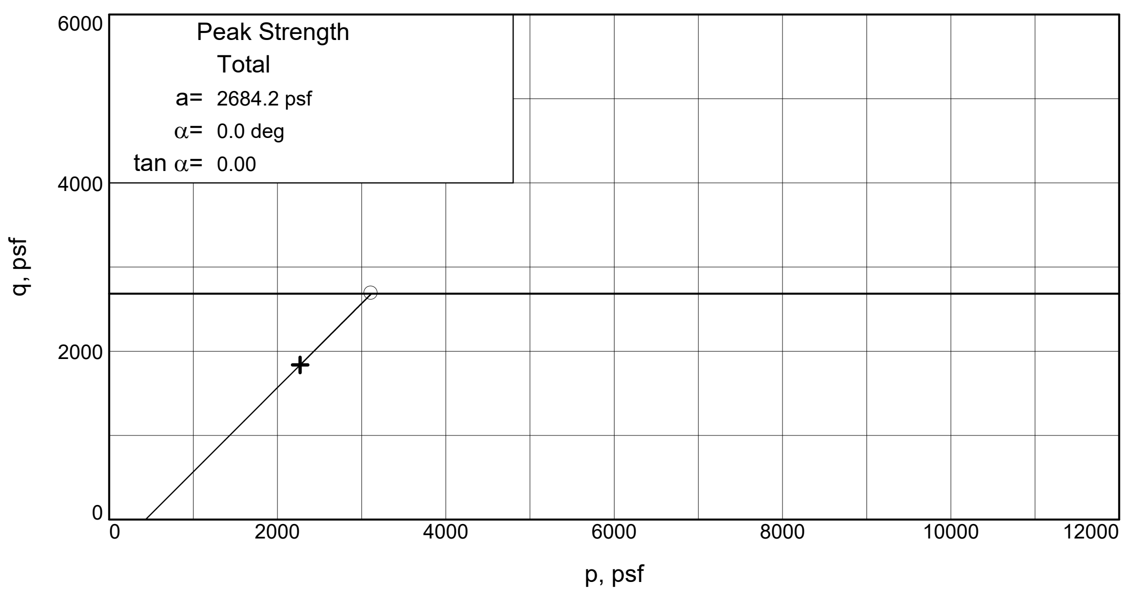
Source of Sample: BCI-17-6 **Depth:** 4.3-4.8'

Sample Number: 2

Proj. No.: 3195.P **Date Sampled:**

TRIAXIAL SHEAR TEST REPORT
Blackburn Consulting
W. Sacramento, CA





Stress Paths: o indicates peak + indicates end

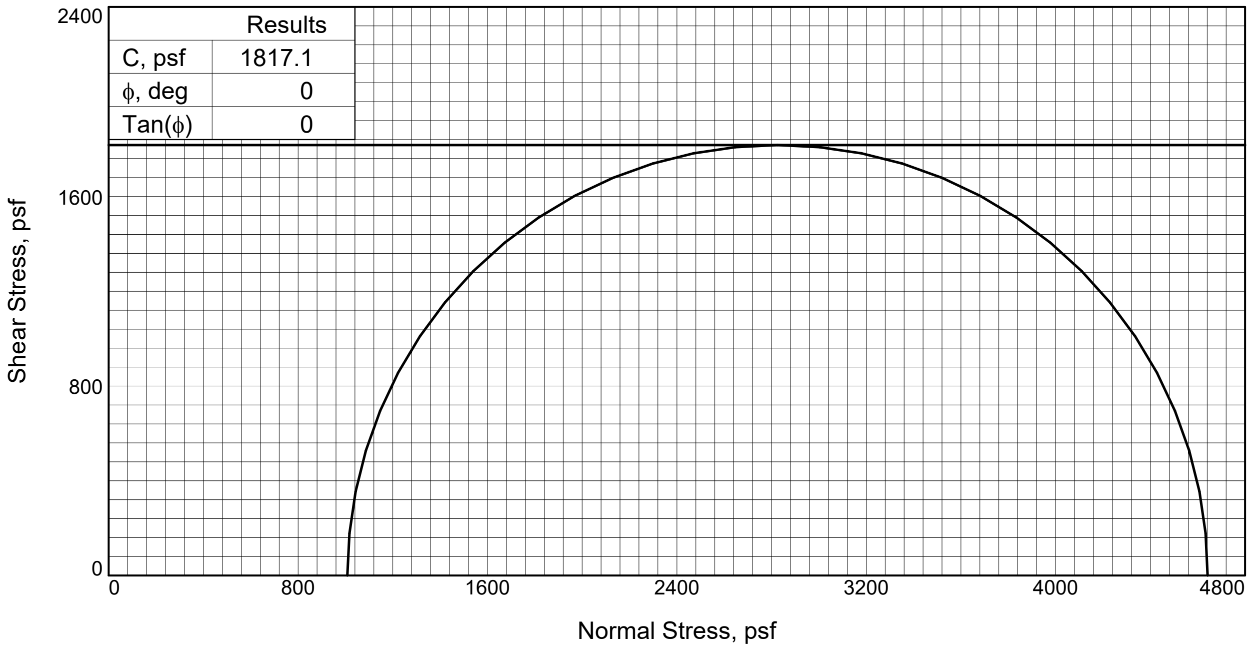
Client: EIP

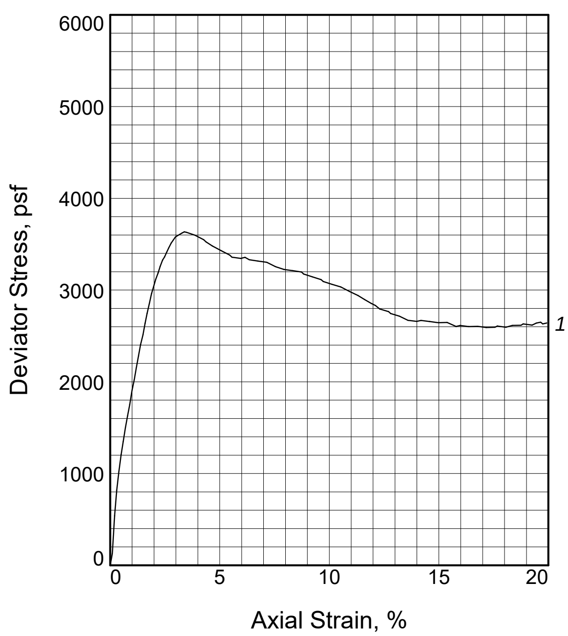
Project: Lookout Slough Restoration Project

Source of Sample: BCI-17-6 **Depth:** 4.3-4.8' **Sample Number:** 2

Project No.: 3195.P **Figure** ________

Blackburn Consulting





Sample No.		1
Initial	Water Content, %	26.4
	Dry Density, pcf	95.9
	Saturation, %	94.0
	Void Ratio	0.7570
	Diameter, in.	2.854
	Height, in.	6.058
At Test	Water Content, %	26.4
	Dry Density, pcf	95.9
	Saturation, %	94.0
	Void Ratio	0.7570
	Diameter, in.	2.854
	Height, in.	6.058
Strain rate, in./min.		0.061
Back Pressure, psf		0.0
Cell Pressure, psf		1008.0
Fail. Stress, psf		3634.2
Strain, %		3.4
Ult. Stress, psf		
Strain, %		
σ_1 Failure, psf		4642.2
σ_3 Failure, psf		1008.0

Type of Test:
Unconsolidated Undrained

Sample Type: 3.0" Shelby

Description: Lean CLAY with SAND, olive brown

Assumed Specific Gravity= 2.70

Remarks:

Figure ________

Client: EIP

Project: Lookout Slough Restoration Project

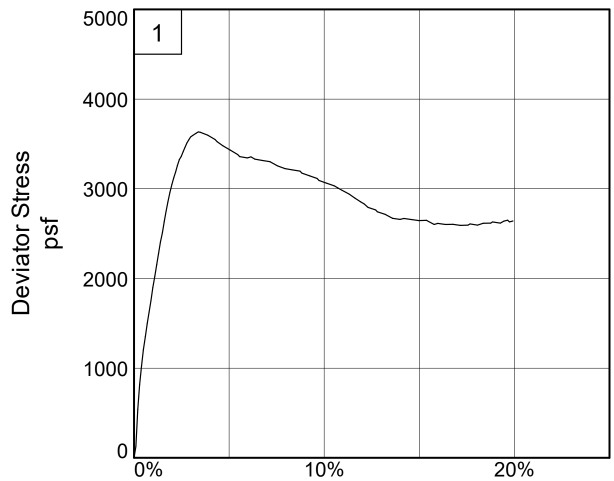
Source of Sample: BCI-17-9 **Depth:** 9.8-10.3'

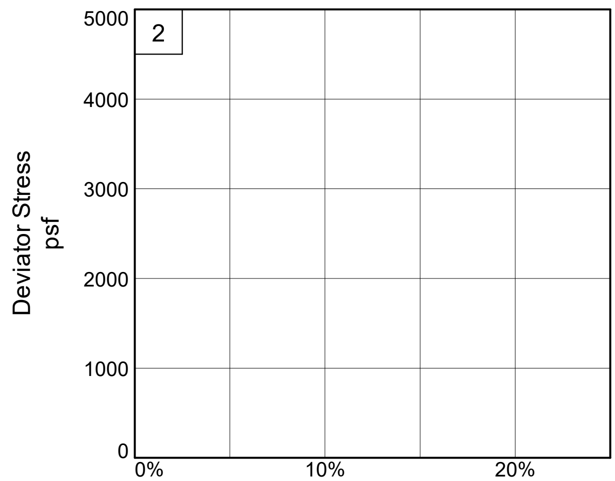
Sample Number: 6

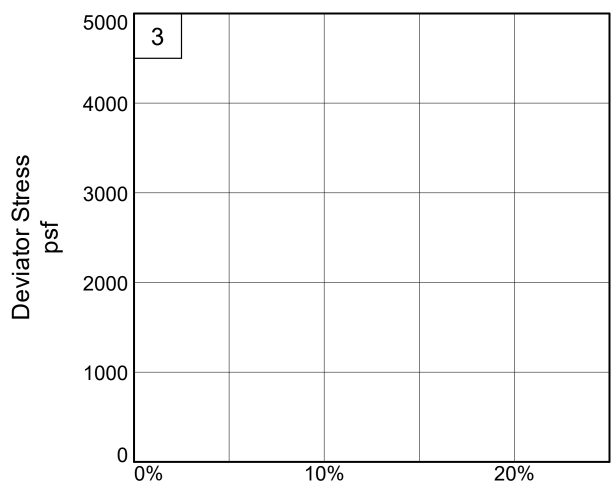
Proj. No.: 3195.P **Date Sampled:**

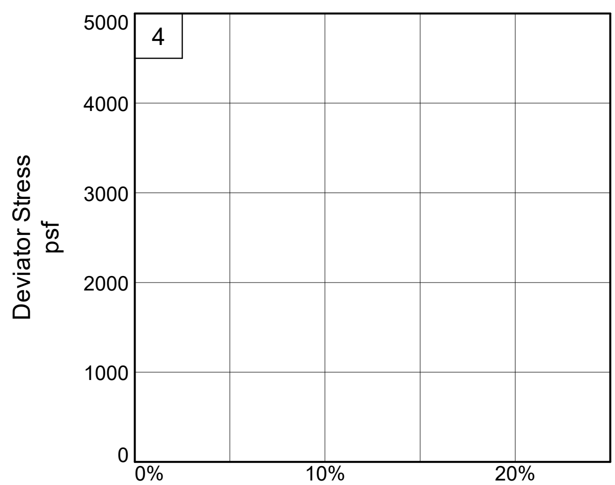
TRIAXIAL SHEAR TEST REPORT

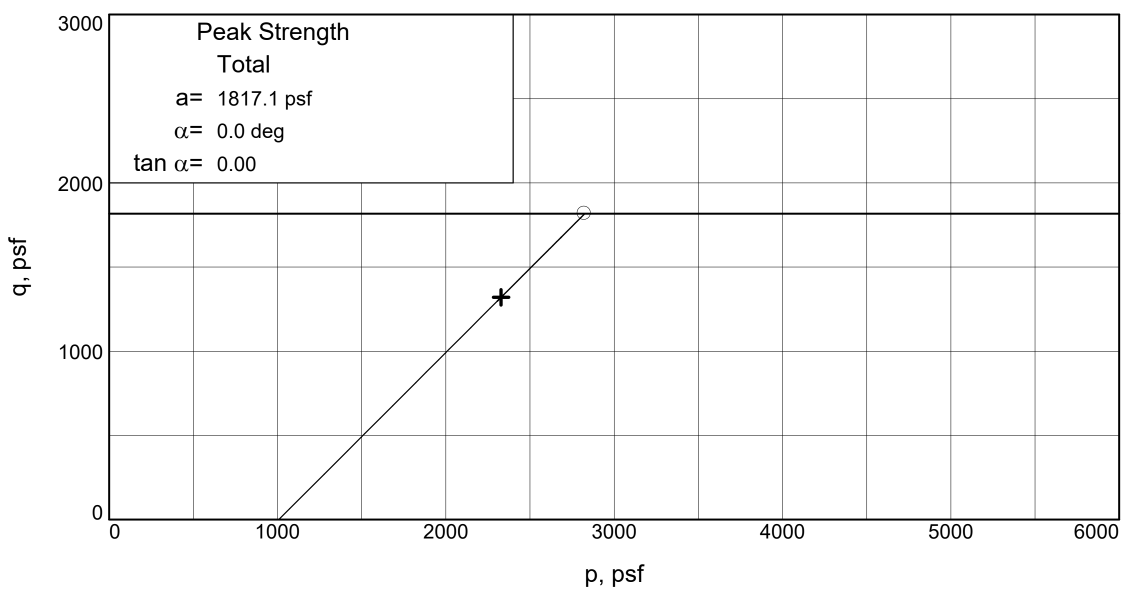
Blackburn Consulting
W. Sacramento, CA











Stress Paths: o indicates peak + indicates end

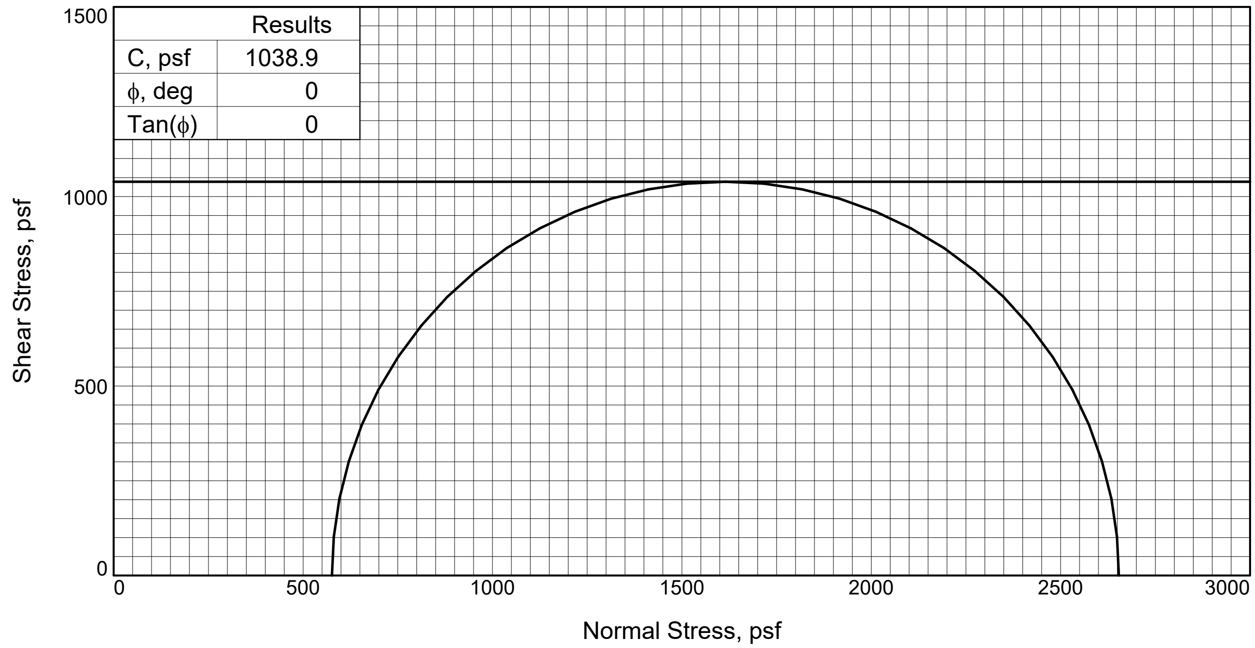
Client: EIP

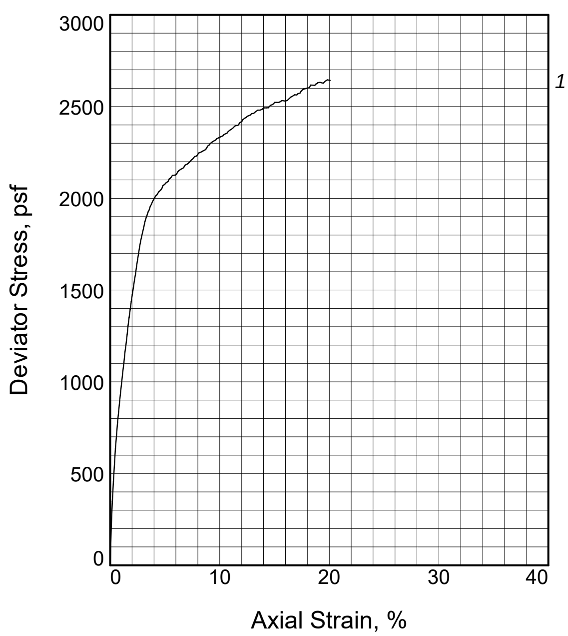
Project: Lookout Slough Restoration Project

Source of Sample: BCI-17-9 **Depth:** 9.8-10.3' **Sample Number:** 6

Project No.: 3195.P **Figure** ________

Blackburn Consulting





Sample No.		1
Initial	Water Content, %	23.0
	Dry Density, pcf	103.8
	Saturation, %	99.5
	Void Ratio	0.6239
	Diameter, in.	2.850
	Height, in.	5.926
At Test	Water Content, %	23.0
	Dry Density, pcf	103.8
	Saturation, %	99.5
	Void Ratio	0.6239
	Diameter, in.	2.850
	Height, in.	5.926
Strain rate, in./min.		0.030
Back Pressure, psf		0.0
Cell Pressure, psf		576.0
Fail. Stress, psf		2077.8
Strain, %		5.0
Ult. Stress, psf		
Strain, %		
σ_1 Failure, psf		2653.8
σ_3 Failure, psf		576.0

Type of Test:
Unconsolidated Undrained

Sample Type: 2.8" Shelby

Description: Fat CLAY with SAND, olive brown

LL= 51 **PL=** 19 **PI=** 32

Assumed Specific Gravity= 2.7

Remarks:

Figure ________

Client: EIP

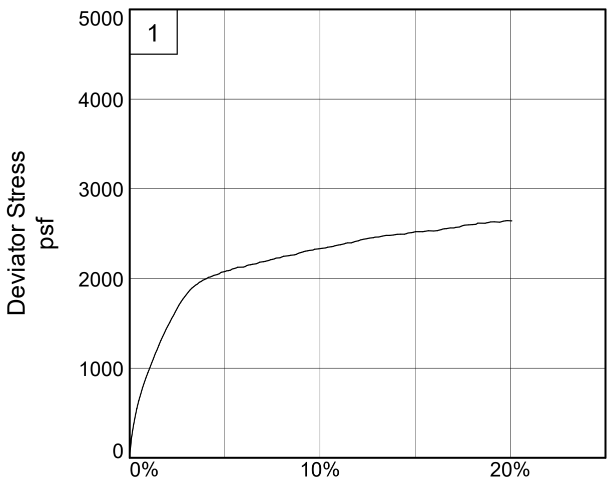
Project: Lookout Slough THRFP

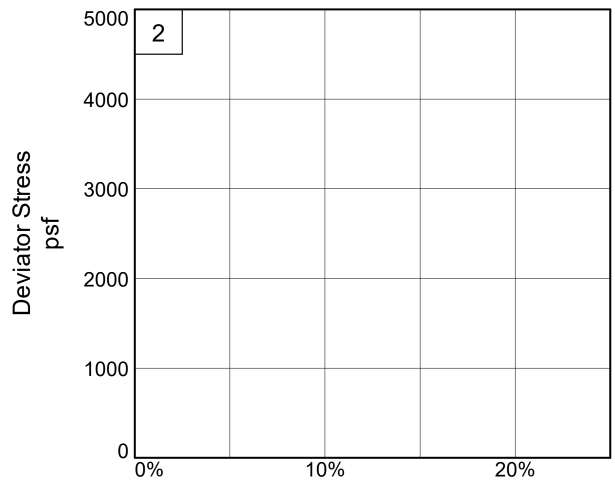
Source of Sample: BCI-19-57 **Depth:** 5-5.5'

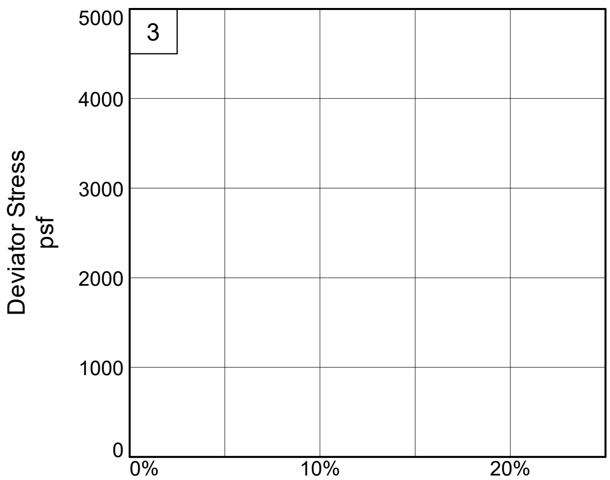
Sample Number: 2

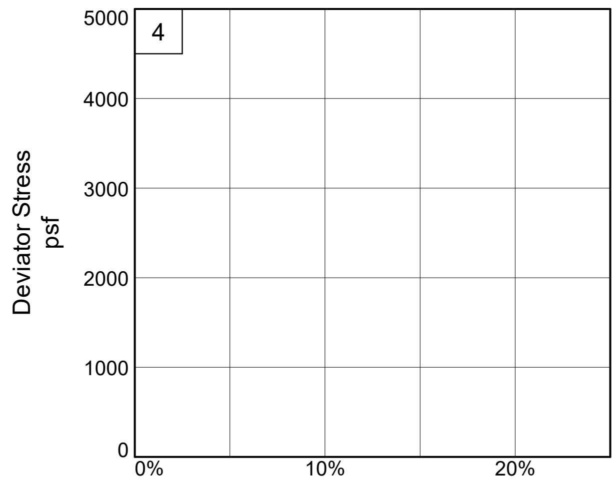
Proj. No.: 3195.P **Date Sampled:**

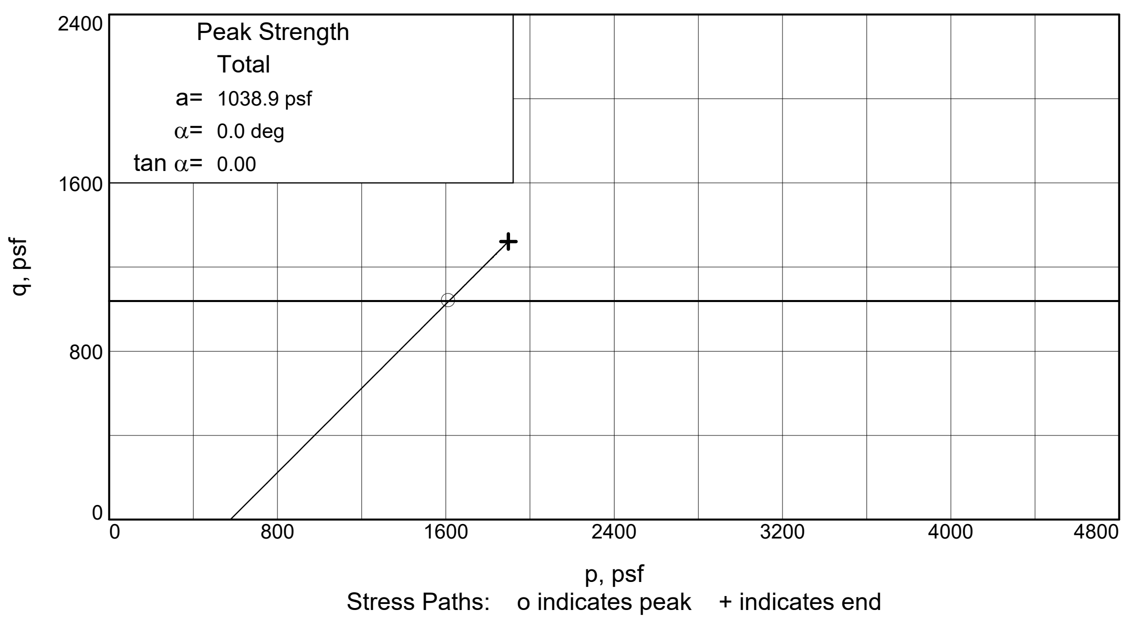
TRIAXIAL SHEAR TEST REPORT
Blackburn Consulting
W. Sacramento, CA











Client: EIP

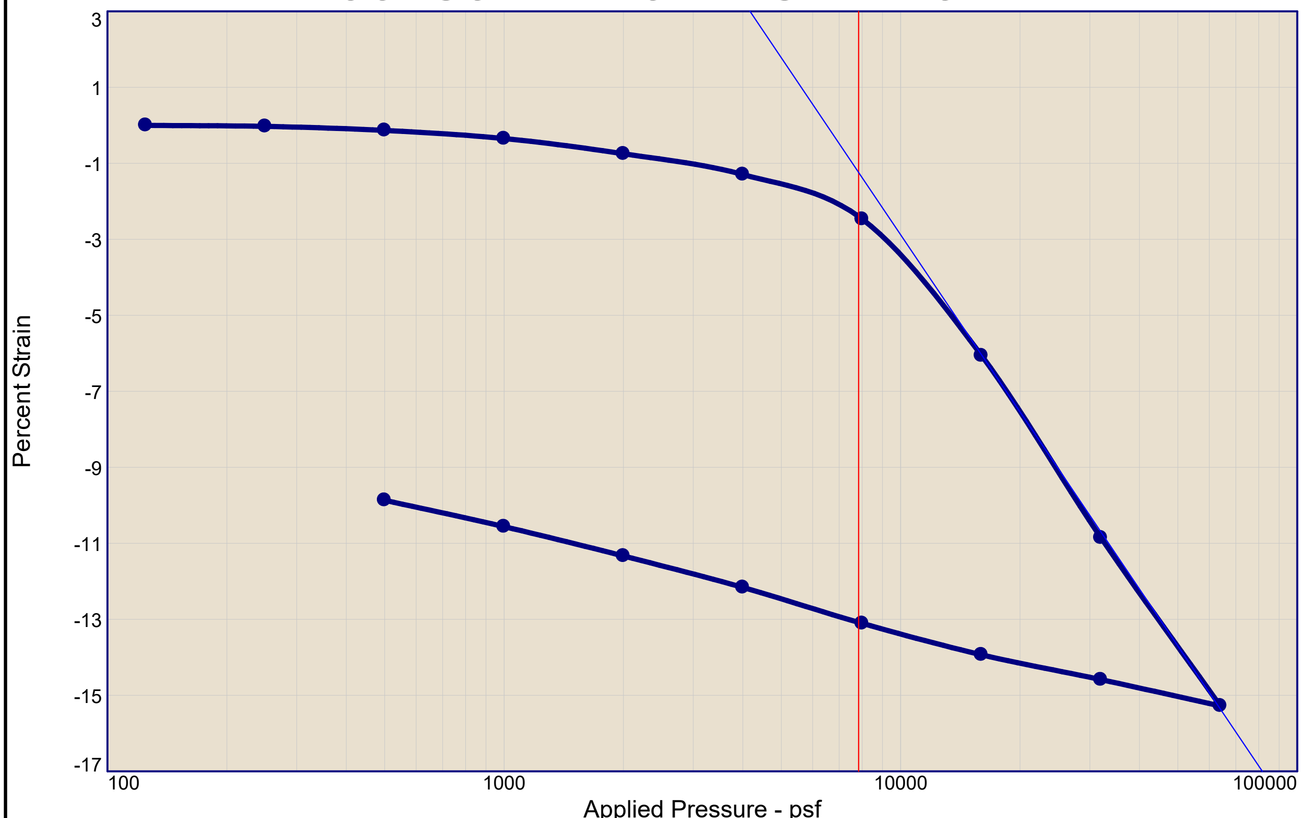
Project: Lookout Slough THRFP

Source of Sample: BCI-19-57 **Depth:** 5-5.5' **Sample Number:** 2

Project No.: 3195.P **Figure** ________

Blackburn Consulting

CONSOLIDATION TEST REPORT



Coefficients of Consolidation and Secondary Consolidation											
No.	Load (psf)	C_v (ft.^{2}/day)	C_α	No.	Load (psf)	C_v (ft.^{2}/day)	C_α	No.	Load (psf)	C_v (ft.^{2}/day)	C_α
3	500.00	0.435		10	64000	0.179					
4	1000.00	0.255		11	32000	0.140					
5	2000	0.885		12	16000	0.062					
6	4000	0.113		13	8000	0.028					
7	8000	0.236									
8	16000	0.482									
9	32000	0.197									

Natural		Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (psf)	P_c (psf)	C_c	C_r	Initial Void Ratio
Saturation	Moisture									
90.9 %	25.2 %	96.4			2.70	922	9815	0.27	0.05	0.748

MATERIAL DESCRIPTION	USCS	AASHTO
Lean CLAY, brownish yellow	CL	

Project No. 3195.P **Client:** EIP

Project: Lookout Slough Restoration Project

Source of Sample: BCI-17-1 **Depth:** 16.0-16.5' **Sample Number:** 8

Blackburn Consulting

W. Sacramento, CA

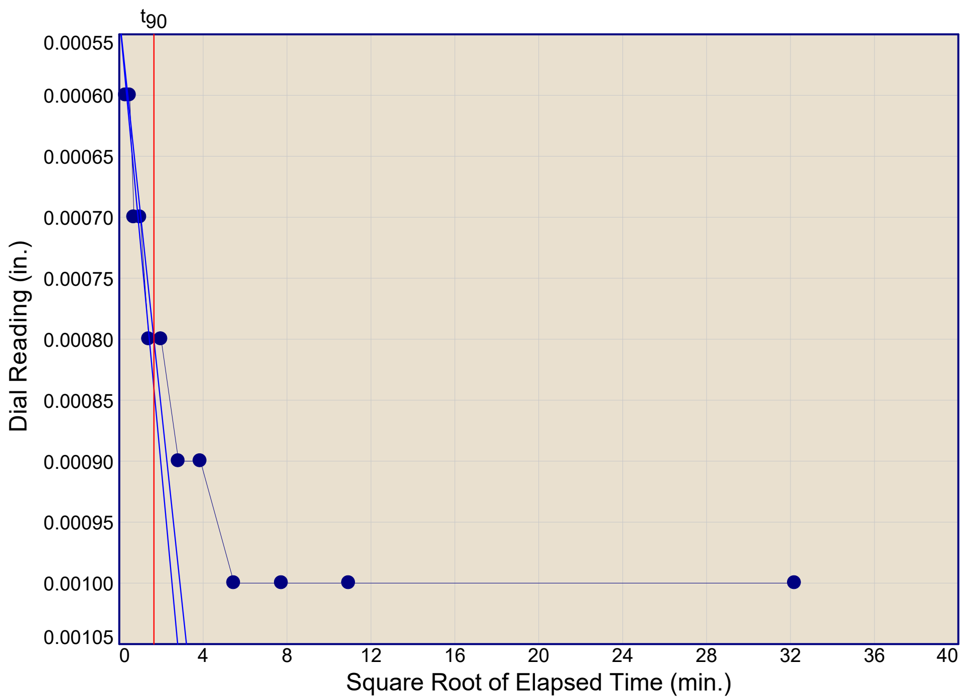
Remarks:

Figure

Dial Reading vs. Time

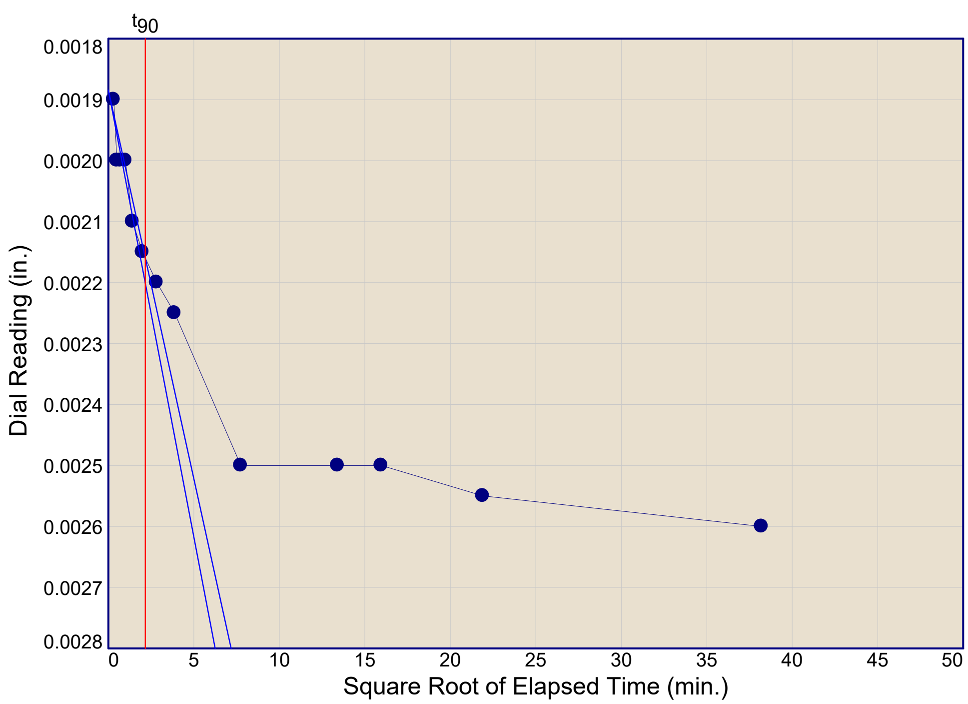
Project No.: 3195.P
Project: Lookout Slough Restoration Project

Source of Sample: BCI-17-1 Depth: 16.0-16.5' Sample Number: 8



Load No.= 3
Load= 500.00 psf
D_0 = 0.0005
D_{90} = 0.0008
D_{100} = 0.0008
T_{90} = 2.74 min.

C_v @ T_{90}
0.435 $ft.^2$/day



Load No.= 4
Load= 1000.00 psf
D_0 = 0.0019
D_{90} = 0.0022
D_{100} = 0.0022
T_{90} = 4.65 min.

C_v @ T_{90}
0.255 $ft.^2$/day

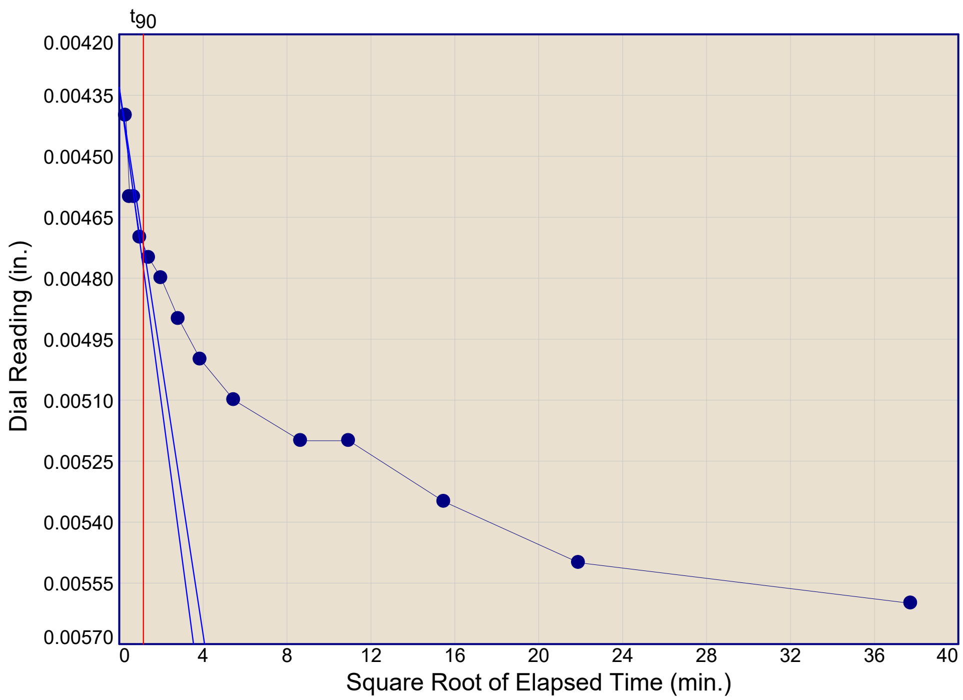
Figure

Blackburn Consulting

Dial Reading vs. Time

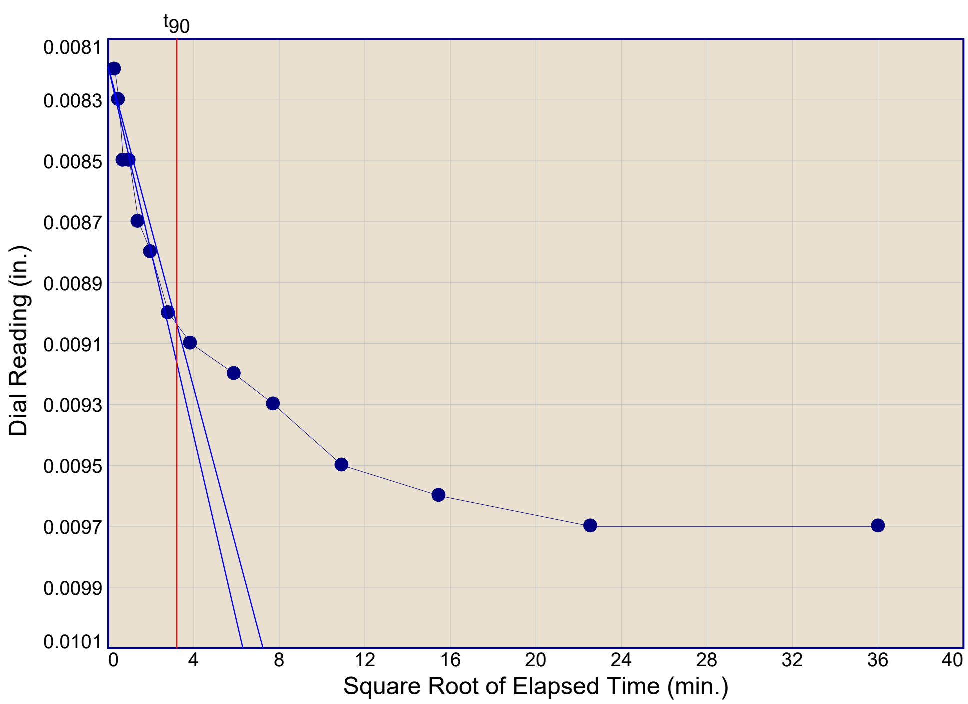
Project No.: 3195.P
Project: Lookout Slough Restoration Project

Source of Sample: BCI-17-1 Depth: 16.0-16.5' Sample Number: 8



Load No.= 5
Load= 2000 psf
D_0 = 0.0043
D_{90} = 0.0047
D_{100} = 0.0048
T_{90} = 1.33 min.

C_v @ T_{90}
0.885 $ft.^2$/day



Load No.= 6
Load= 4000 psf
D_0 = 0.0082
D_{90} = 0.0090
D_{100} = 0.0091
T_{90} = 10.30 min.

C_v @ T_{90}
0.113 $ft.^2$/day

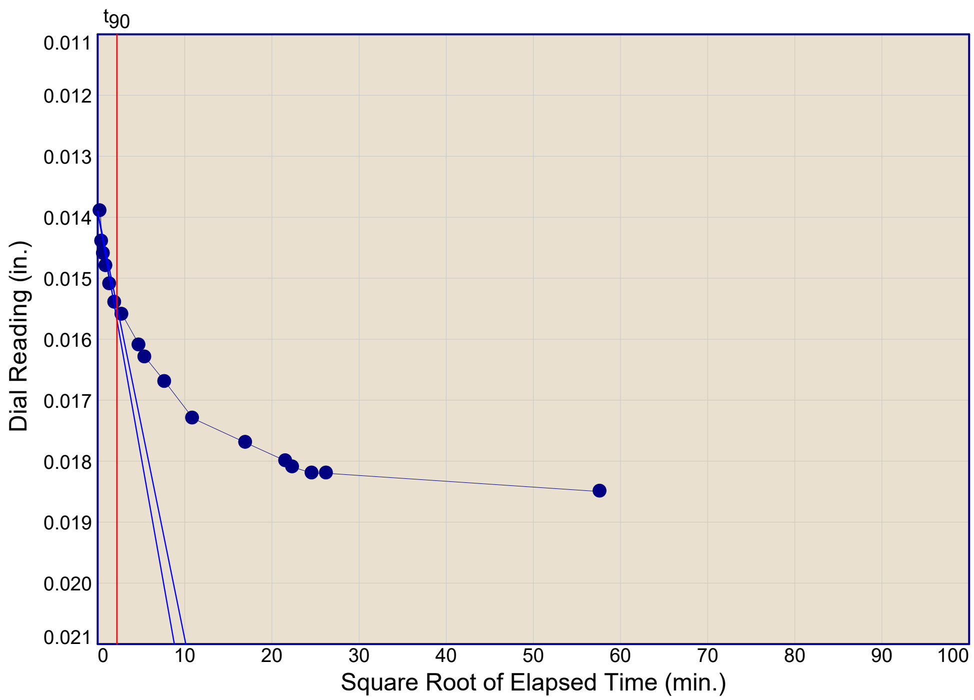
Figure

Blackburn Consulting

Dial Reading vs. Time

Project No.: 3195.P
Project: Lookout Slough Restoration Project

Source of Sample: BCI-17-1 Depth: 16.0-16.5' Sample Number: 8



Load No.= 7

Load= 8000 psf

D_0 = 0.0139

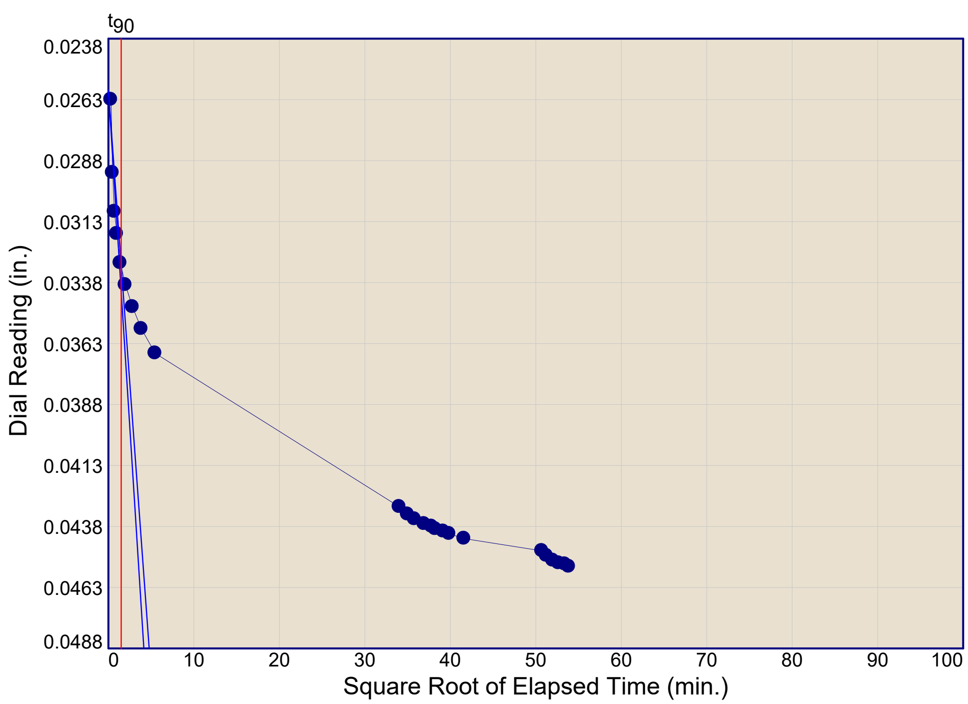
D_{90} = 0.0155

D_{100} = 0.0156

T_{90} = 4.87 min.

C_v @ T_{90}

0.236 ft.^{2}/day



Load No.= 8

Load= 16000 psf

D_0 = 0.0259

D_{90} = 0.0331

D_{100} = 0.0339

T_{90} = 2.27 min.

C_v @ T_{90}

0.482 ft.^{2}/day

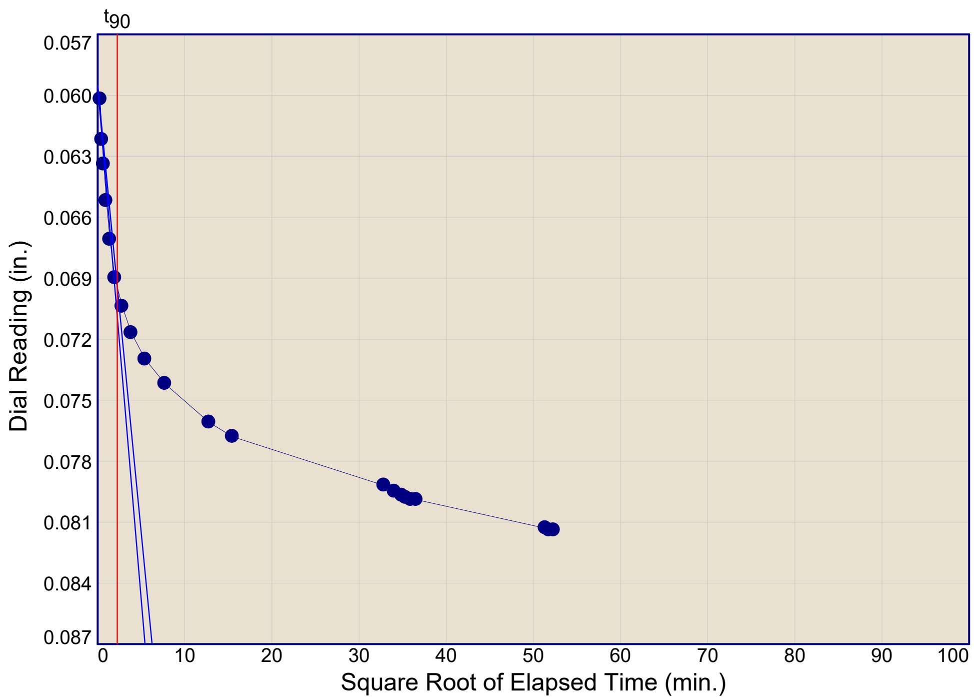
Figure

Blackburn Consulting

Dial Reading vs. Time

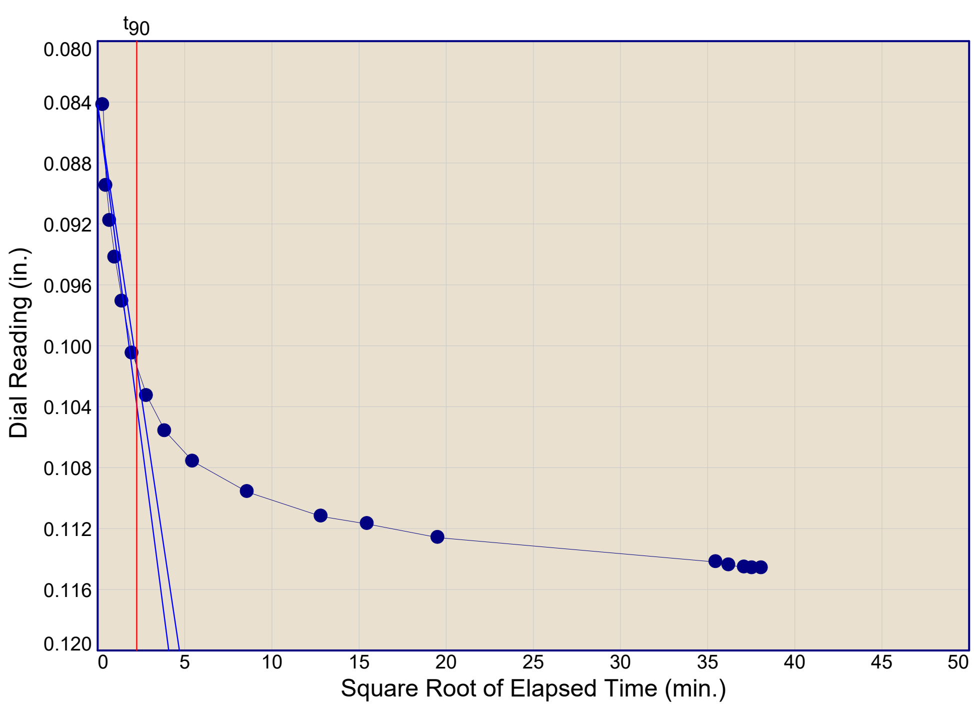
Project No.: 3195.P
Project: Lookout Slough Restoration Project

Source of Sample: BCI-17-1 Depth: 16.0-16.5' Sample Number: 8



Load No.= 9
Load= 32000 psf
D_0 = 0.0595
D_{90} = 0.0694
D_{100} = 0.0705
T_{90} = 5.08 min.

C_v @ T_{90}
0.197 ft.^{2}/day



Load No.= 10
Load= 64000 psf
D_0 = 0.0842
D_{90} = 0.1013
D_{100} = 0.1032
T_{90} = 5.04 min.

C_v @ T_{90}
0.179 ft.^{2}/day

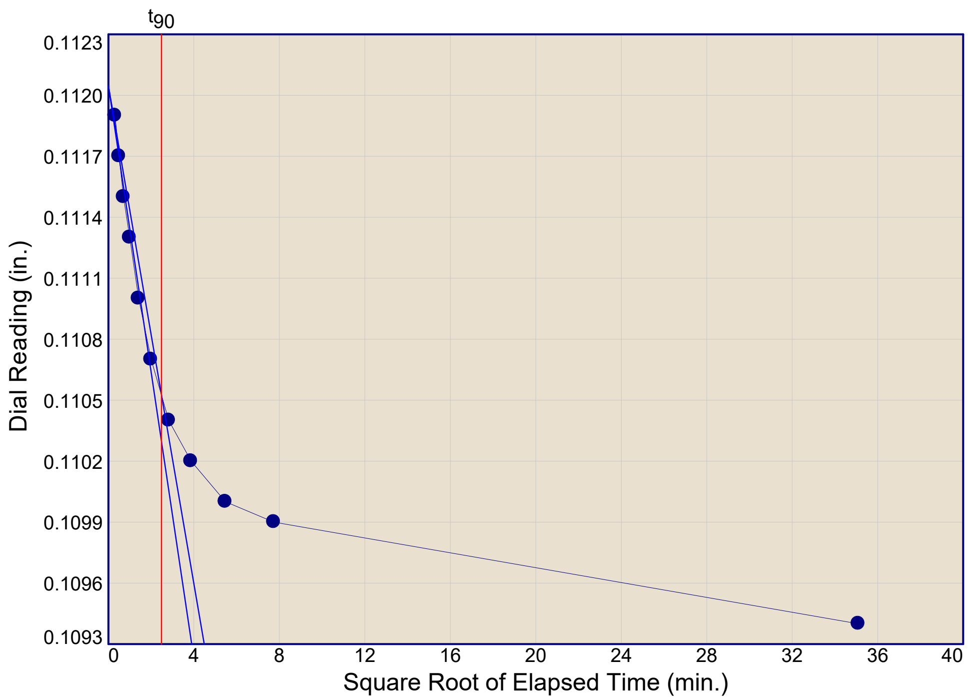
Figure

Blackburn Consulting

Dial Reading vs. Time

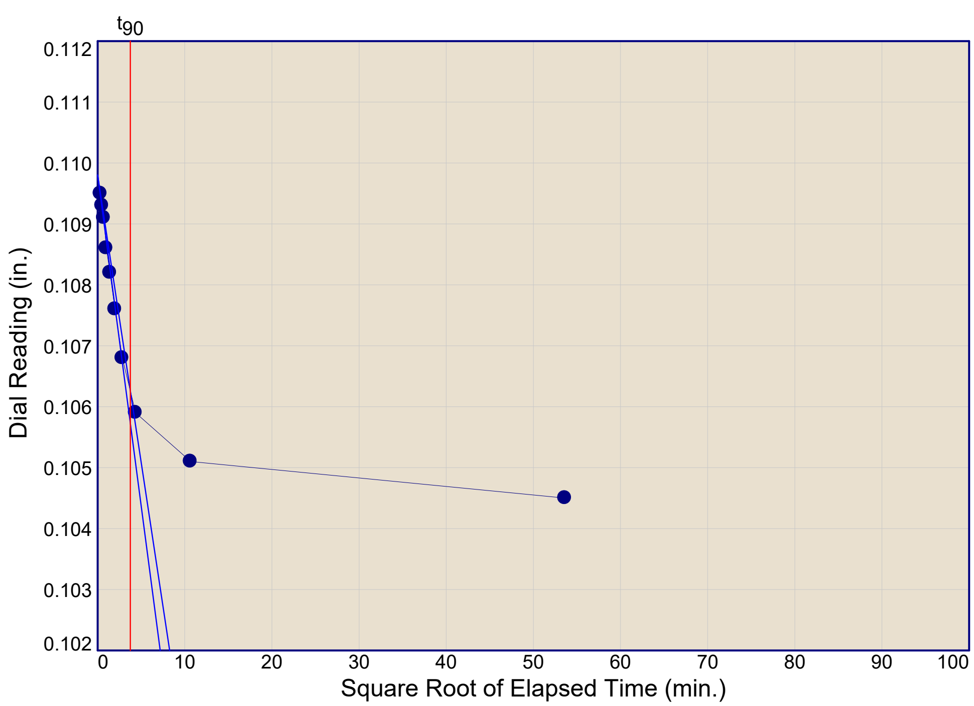
Project No.: 3195.P
Project: Lookout Slough Restoration Project

Source of Sample: BCI-17-1 Depth: 16.0-16.5' Sample Number: 8



Load No.= 11
Load= 32000 psf
D_0 = 0.1120
D_{90} = 0.1105
D_{100} = 0.1104
T_{90} = 6.18 min.

C_v @ T_{90}
0.140 $ft.^2$/day



Load No.= 12
Load= 16000 psf
D_0 = 0.1098
D_{90} = 0.1063
D_{100} = 0.1059
T_{90} = 14.13 min.

C_v @ T_{90}
0.062 $ft.^2$/day

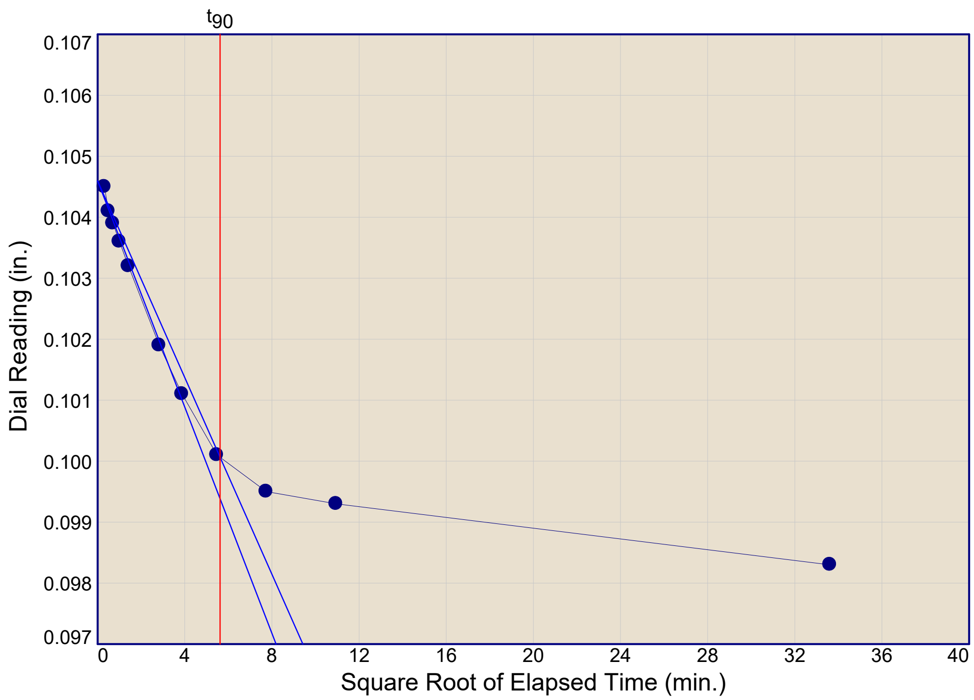
Figure

Blackburn Consulting

Dial Reading vs. Time

Project No.: 3195.P
Project: Lookout Slough Restoration Project

Source of Sample: BCI-17-1 Depth: 16.0-16.5' Sample Number: 8



Load No.= 13

Load= 8000 psf

D_0 = 0.1046

D_{90} = 0.1001

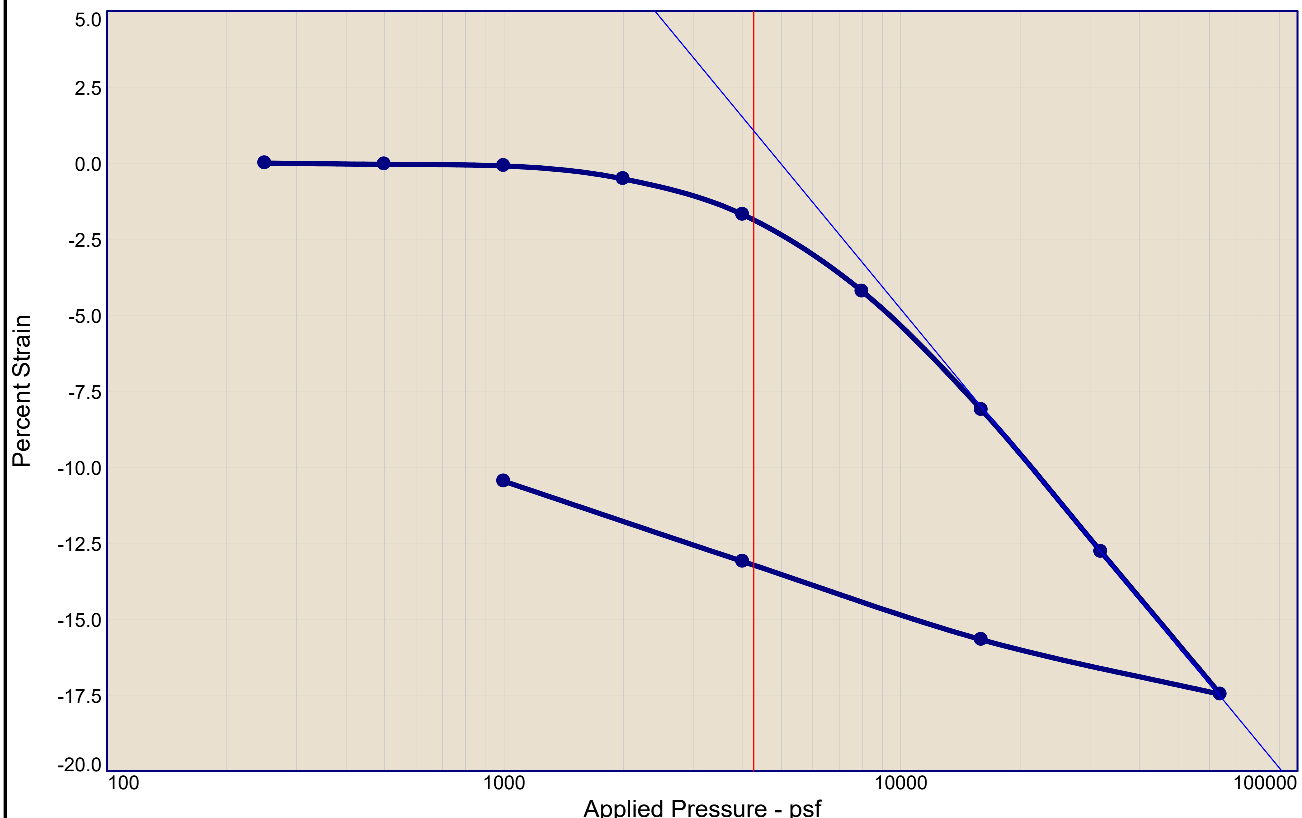
D_{100} = 0.0996

T_{90} = 31.60 min.

C_v @ T_{90}

0.028 ft.^{2}/day

CONSOLIDATION TEST REPORT



Coefficients of Consolidation and Secondary Consolidation											
No.	Load (psf)	C_v (ft.^{2}/day)	C_α	No.	Load (psf)	C_v (ft.^{2}/day)	C_α	No.	Load (psf)	C_v (ft.^{2}/day)	C_α
4	2000	0.226		11	4000	0.005					
5	4000	0.111		12	1000.00	0.002					
6	8000	0.106									
7	16000	0.028									
8	32000	0.021									
9	64000	0.012									
10	16000	0.013									

Natural		Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (psf)	P_c (psf)	C_c	C_r	Initial Void Ratio
Saturation	Moisture									
96.4 %	28.8 %	93.3	59	42	2.70	480	7258	0.29	0.07	0.807

MATERIAL DESCRIPTION	USCS	AASHTO
Fat CLAY, olive brown	CH	

Project No. 3195.P **Client:** EIP

Project: Lookout Slough Restoration Project

Source of Sample: BCI-17-3 **Depth:** 3.8-4.2' **Sample Number:** 2

Blackburn Consulting

W. Sacramento, CA

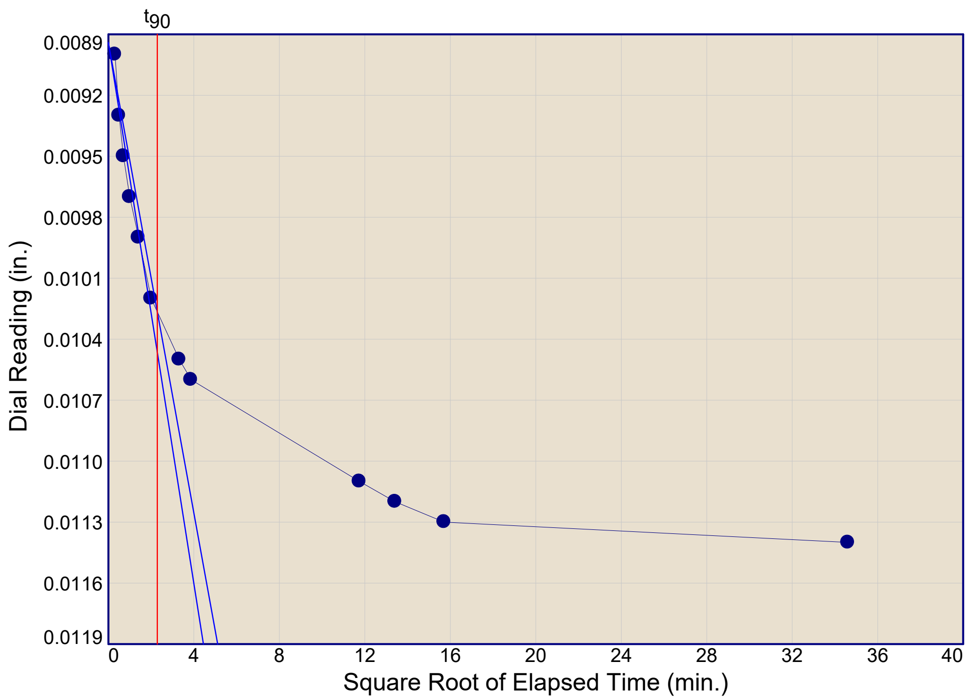
Remarks:

Figure

Dial Reading vs. Time

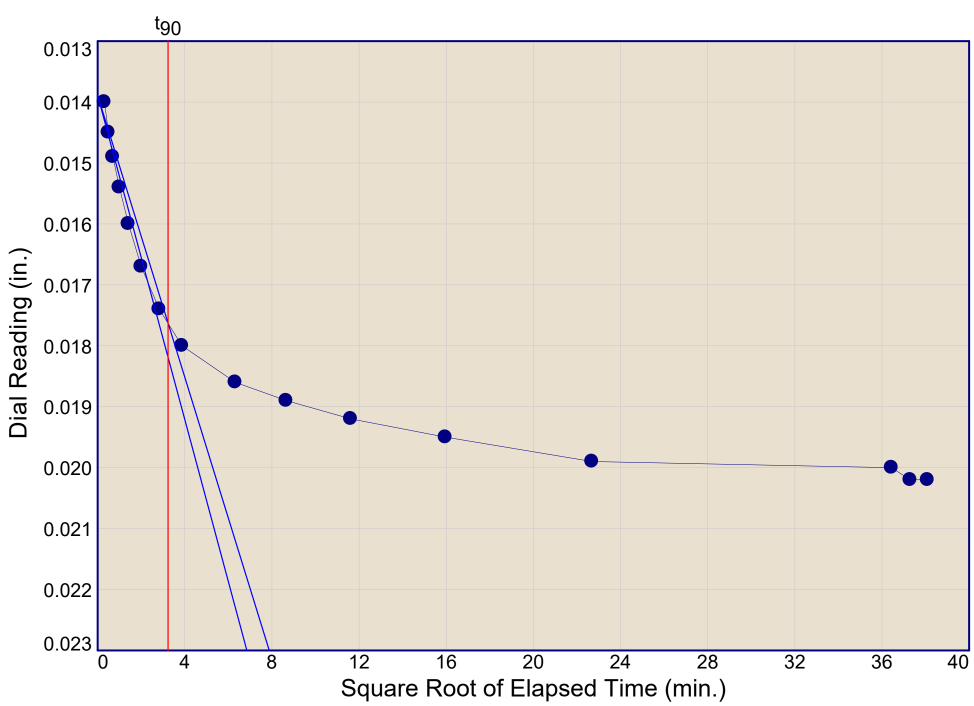
Project No.: 3195.P
Project: Lookout Slough Restoration Project

Source of Sample: BCI-17-3 Depth: 3.8-4.2' Sample Number: 2



Load No.= 4
Load= 2000 psf
D_0 = 0.0089
D_{90} = 0.0103
D_{100} = 0.0104
T_{90} = 5.25 min.

C_v @ T_{90}
0.226 ft.^{2}/day



Load No.= 5
Load= 4000 psf
D_0 = 0.0139
D_{90} = 0.0176
D_{100} = 0.0180
T_{90} = 10.46 min.

C_v @ T_{90}
0.111 ft.^{2}/day

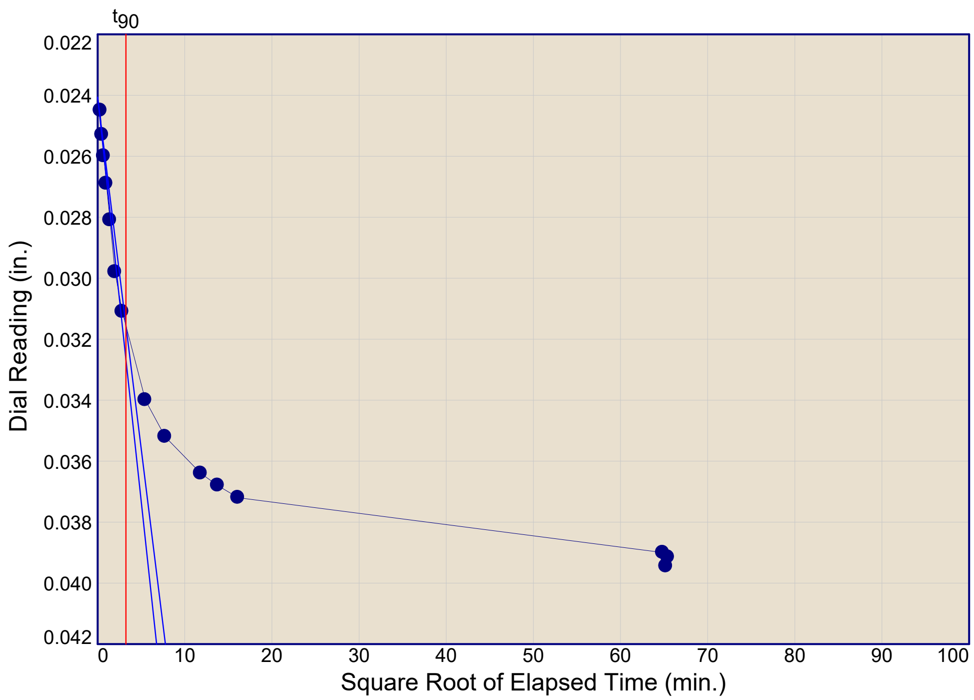
Figure

Blackburn Consulting

Dial Reading vs. Time

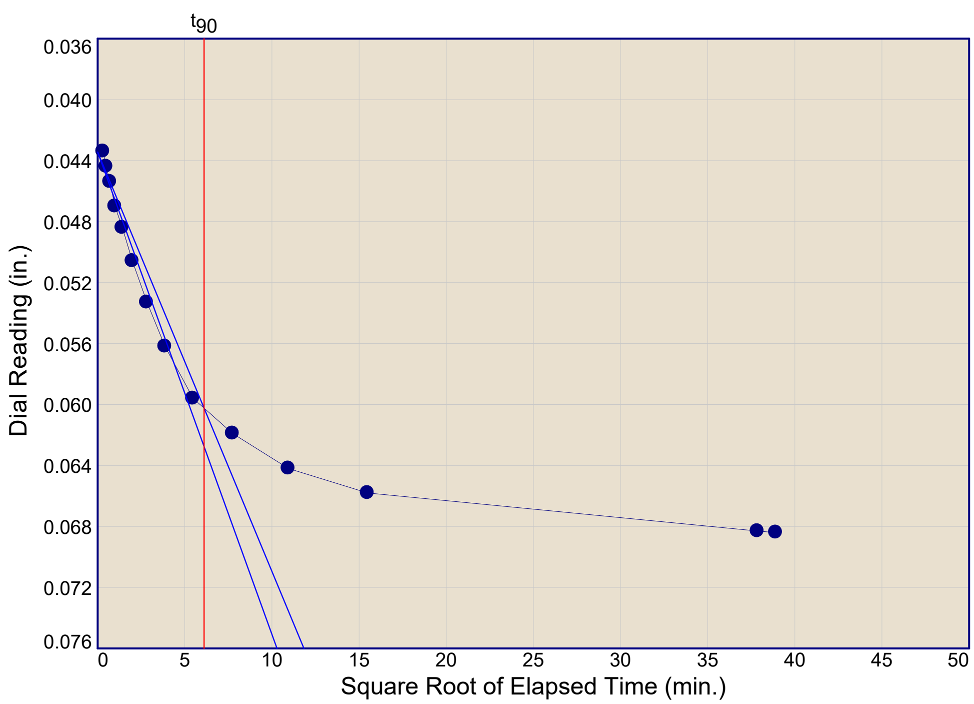
Project No.: 3195.P
Project: Lookout Slough Restoration Project

Source of Sample: BCI-17-3 Depth: 3.8-4.2' Sample Number: 2



Load No.= 6
Load= 8000 psf
D_0 = 0.0241
D_{90} = 0.0316
D_{100} = 0.0324
T_{90} = 10.57 min.

C_v @ T_{90}
0.106 ft.^{2}/day



Load No.= 7
Load= 16000 psf
D_0 = 0.0434
D_{90} = 0.0602
D_{100} = 0.0621
T_{90} = 37.26 min.

C_v @ T_{90}
0.028 ft.^{2}/day

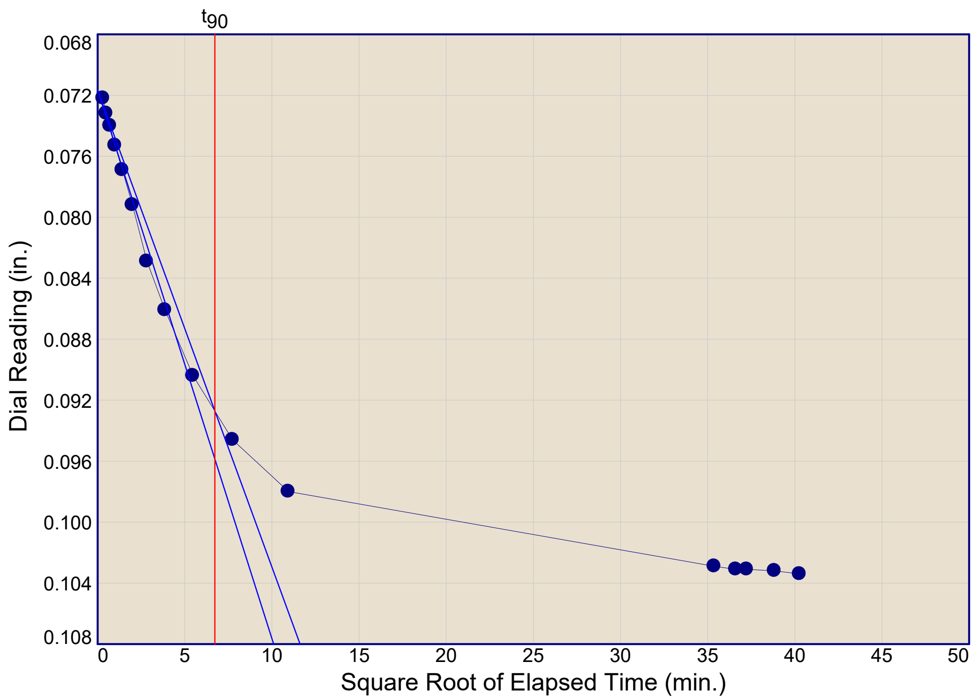
Figure

Blackburn Consulting

Dial Reading vs. Time

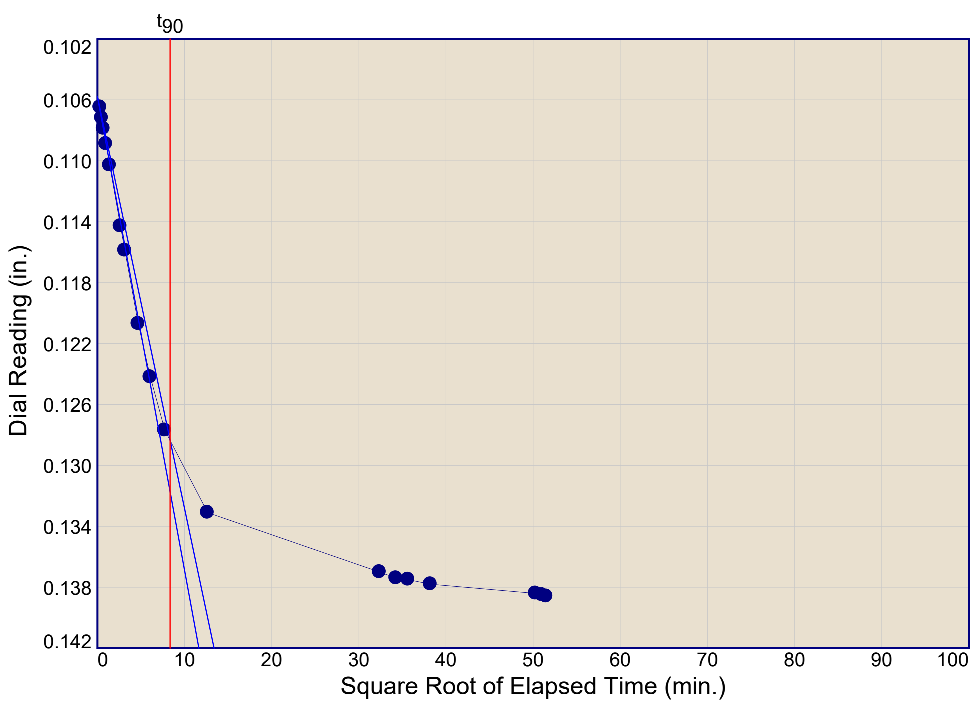
Project No.: 3195.P
Project: Lookout Slough Restoration Project

Source of Sample: BCI-17-3 Depth: 3.8-4.2' Sample Number: 2



Load No.= 8
Load= 32000 psf
D_0 = 0.0717
D_{90} = 0.0927
D_{100} = 0.0951
T_{90} = 45.24 min.

C_v @ T_{90}
0.021 ft.^{2}/day



Load No.= 9
Load= 64000 psf
D_0 = 0.1058
D_{90} = 0.1284
D_{100} = 0.1309
T_{90} = 69.64 min.

C_v @ T_{90}
0.012 ft.^{2}/day

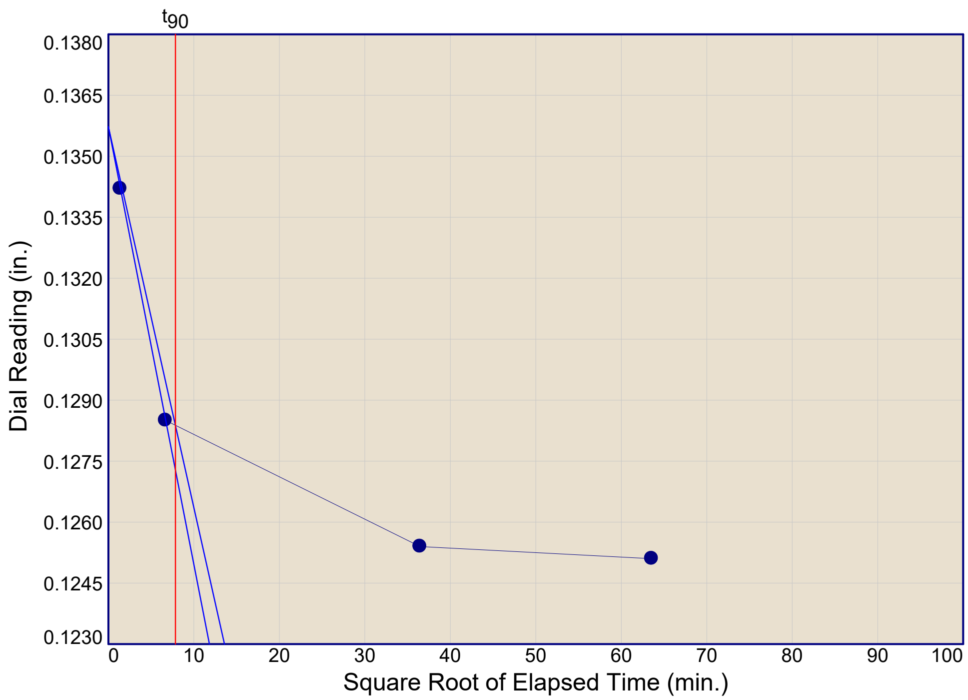
Figure

Blackburn Consulting

Dial Reading vs. Time

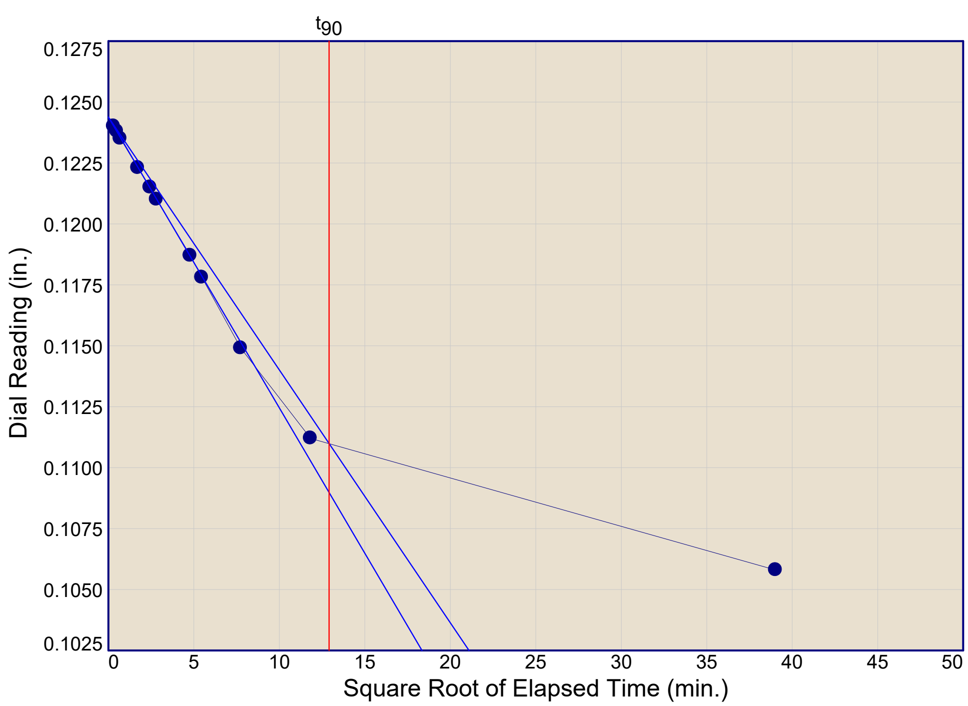
Project No.: 3195.P
Project: Lookout Slough Restoration Project

Source of Sample: BCI-17-3 Depth: 3.8-4.2' Sample Number: 2



Load No.= 10
Load= 16000 psf
D_0 = 0.1357
D_{90} = 0.1284
D_{100} = 0.1276
T_{90} = 61.47 min.

C_v @ T_{90}
0.013 ft.^{2}/day



Load No.= 11
Load= 4000 psf
D_0 = 0.1244
D_{90} = 0.1110
D_{100} = 0.1095
T_{90} = 166.75 min.

C_v @ T_{90}
0.005 ft.^{2}/day

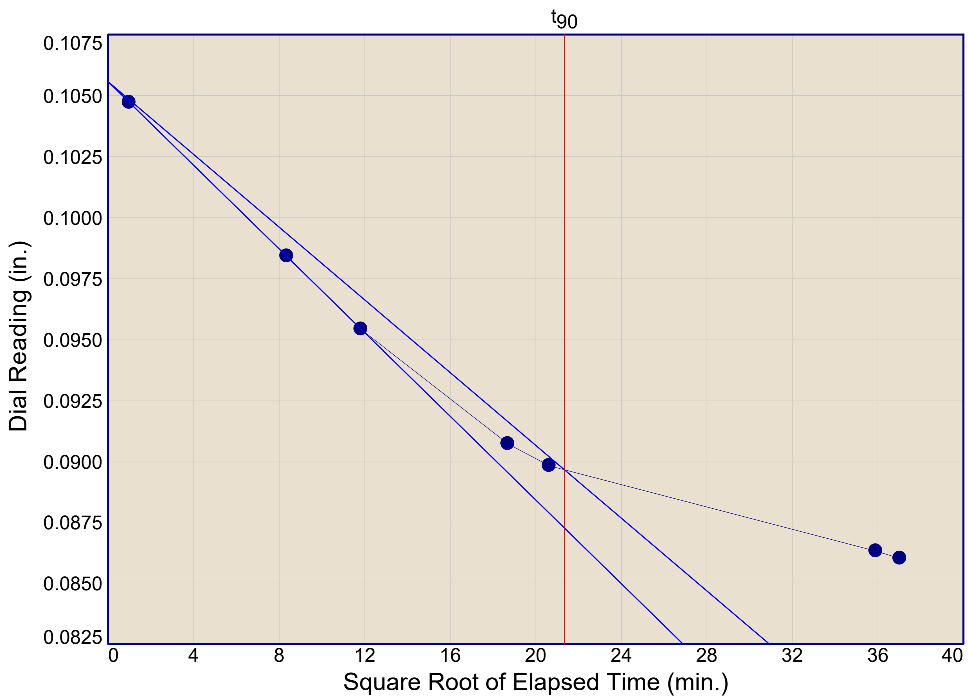
Figure

Blackburn Consulting

Dial Reading vs. Time

Project No.: 3195.P
Project: Lookout Slough Restoration Project

Source of Sample: BCI-17-3 Depth: 3.8-4.2' Sample Number: 2



Load No.= 12

Load= 1000.00 psf

D_0 = 0.1056

D_{90} = 0.0896

D_{100} = 0.0879

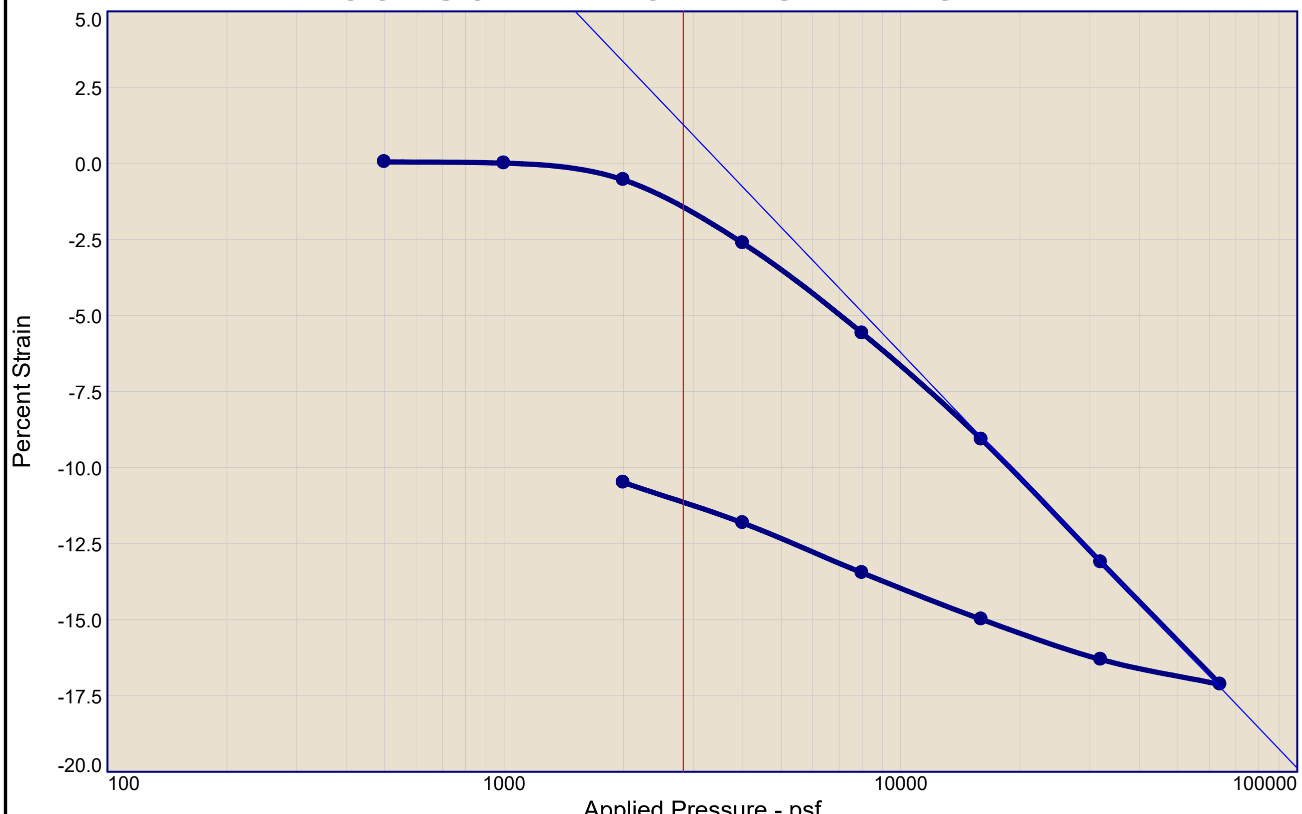
T_{90} = 455.53 min.

C_v @ T_{90}
0.002 $ft.^2$/day

Blackburn Consulting

Figure

CONSOLIDATION TEST REPORT



Coefficients of Consolidation and Secondary Consolidation

No.	Load (psf)	C_v (ft.^{2}/day)	C_α	No.	Load (psf)	C_v (ft.^{2}/day)	C_α	No.	Load (psf)	C_v (ft.^{2}/day)	C_α
3	2000	0.320									
4	4000	0.035									
5	8000	0.027									
6	16000	0.023									
7	32000	0.015									
8	64000	0.005									
10	16000	0.004									

Natural		Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (psf)	P_c (psf)	C_c	C_r	Initial Void Ratio
Saturation	Moisture									
93.5 %	28.4 %	92.6	68	48	2.70	440	5215	0.25	0.08	0.820

MATERIAL DESCRIPTION	USCS	AASHTO
Fat CLAY, very dark gray	CH	

Project No. 3195.P **Client:** EIP

Project: Lookout Slough Restoration Project

Source of Sample: BCI-17-8 **Depth:** 3.8-4.2' **Sample Number:** 2

Blackburn Consulting

W. Sacramento, CA

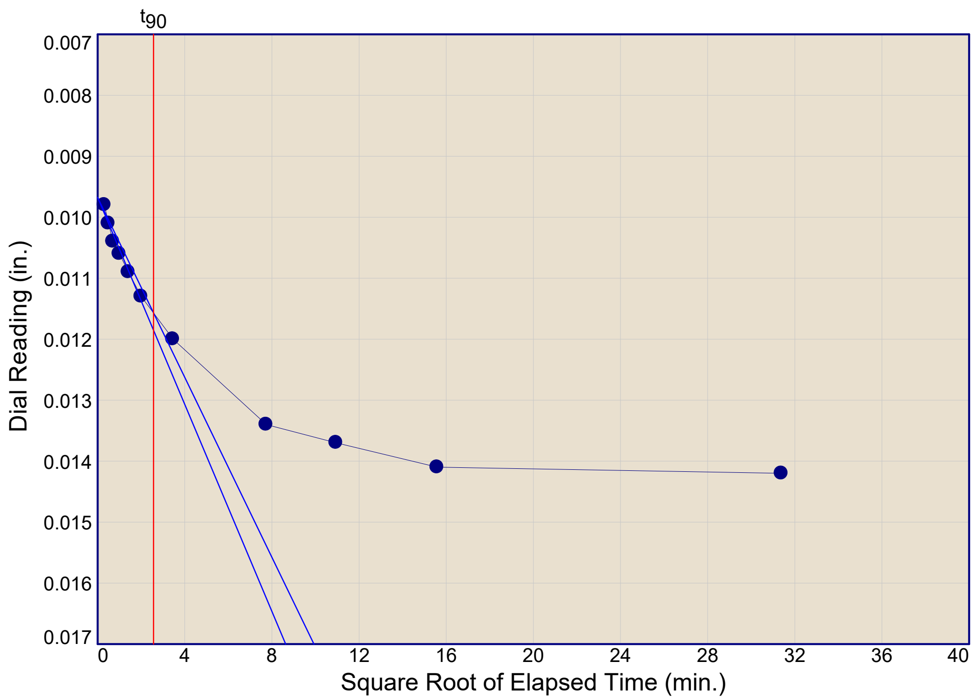
Remarks:

Figure

Dial Reading vs. Time

Project No.: 3195.P
Project: Lookout Slough Restoration Project

Source of Sample: BCI-17-8 Depth: 3.8-4.2' Sample Number: 2



Load No.= 3

Load= 2000 psf

D_0 = 0.0097

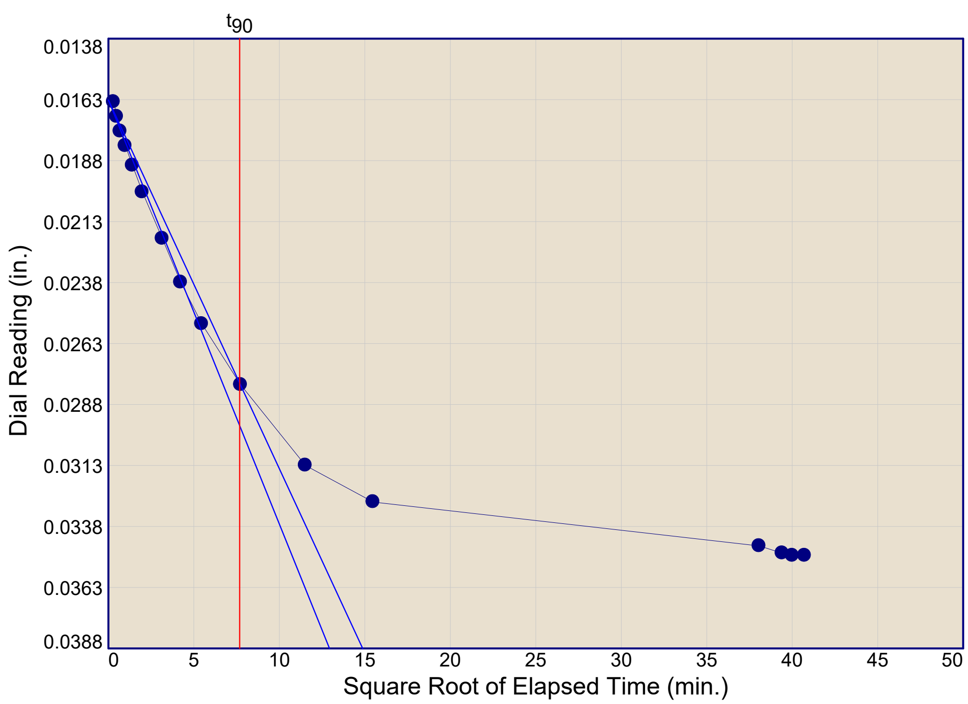
D_{90} = 0.0116

D_{100} = 0.0118

T_{90} = 6.58 min.

C_v @ T_{90}

0.320 ft.^{2}/day



Load No.= 4

Load= 4000 psf

D_0 = 0.0163

D_{90} = 0.0279

D_{100} = 0.0292

T_{90} = 58.93 min.

C_v @ T_{90}

0.035 ft.^{2}/day

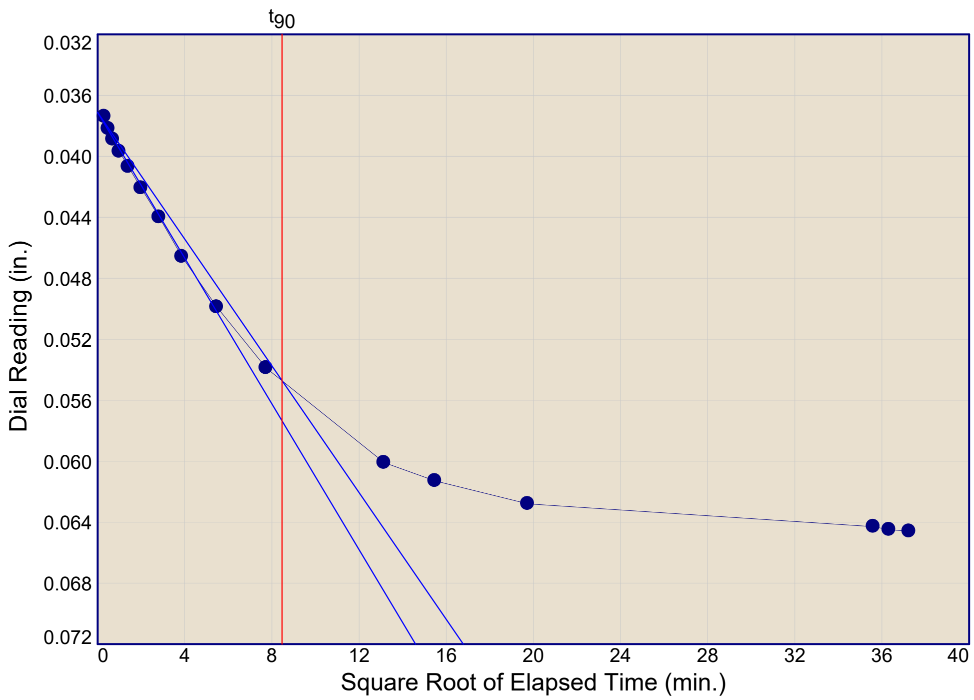
Figure

Blackburn Consulting

Dial Reading vs. Time

Project No.: 3195.P
Project: Lookout Slough Restoration Project

Source of Sample: BCI-17-8 Depth: 3.8-4.2' Sample Number: 2



Load No.= 5

Load= 8000 psf

D_0 = 0.0371

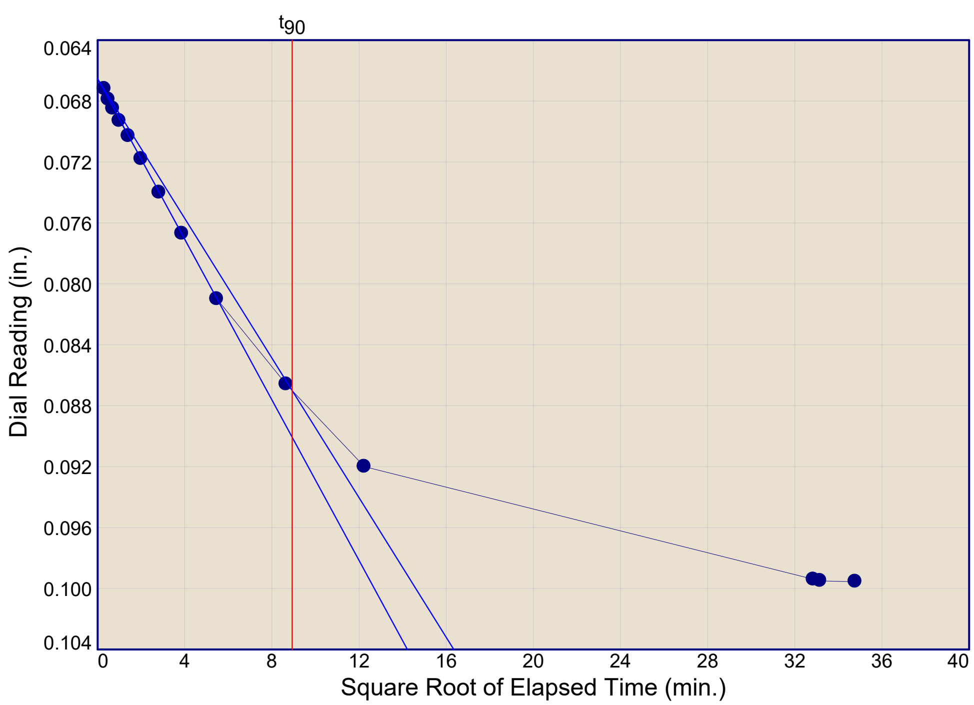
D_{90} = 0.0547

D_{100} = 0.0567

T_{90} = 71.68 min.

C_v @ T_{90}

0.027 ft.^{2}/day



Load No.= 6

Load= 16000 psf

D_0 = 0.0666

D_{90} = 0.0870

D_{100} = 0.0893

T_{90} = 79.73 min.

C_v @ T_{90}

0.023 ft.^{2}/day

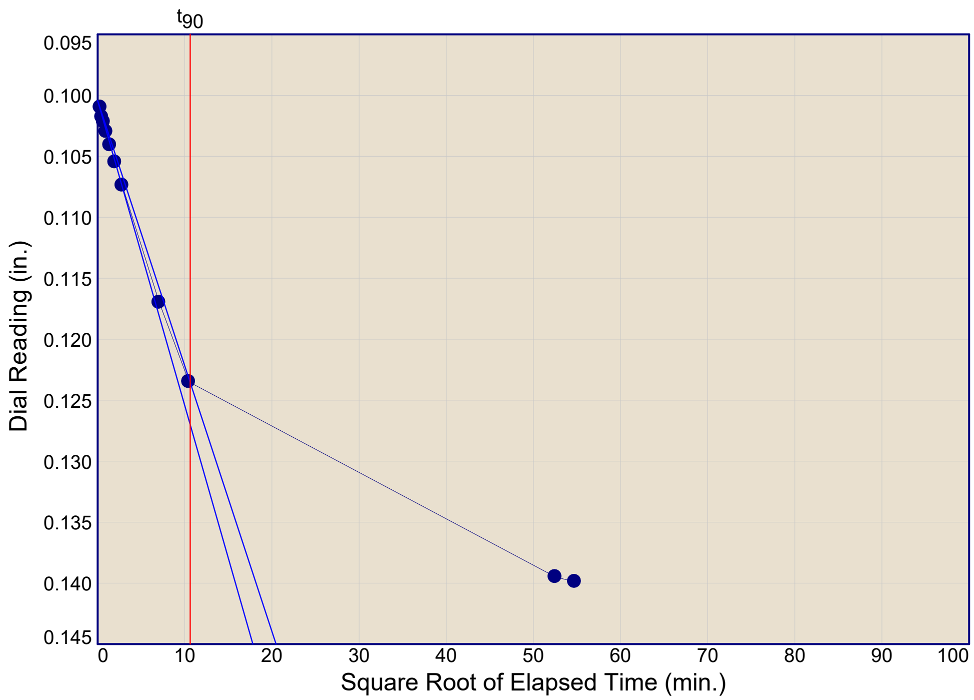
Figure

Blackburn Consulting

Dial Reading vs. Time

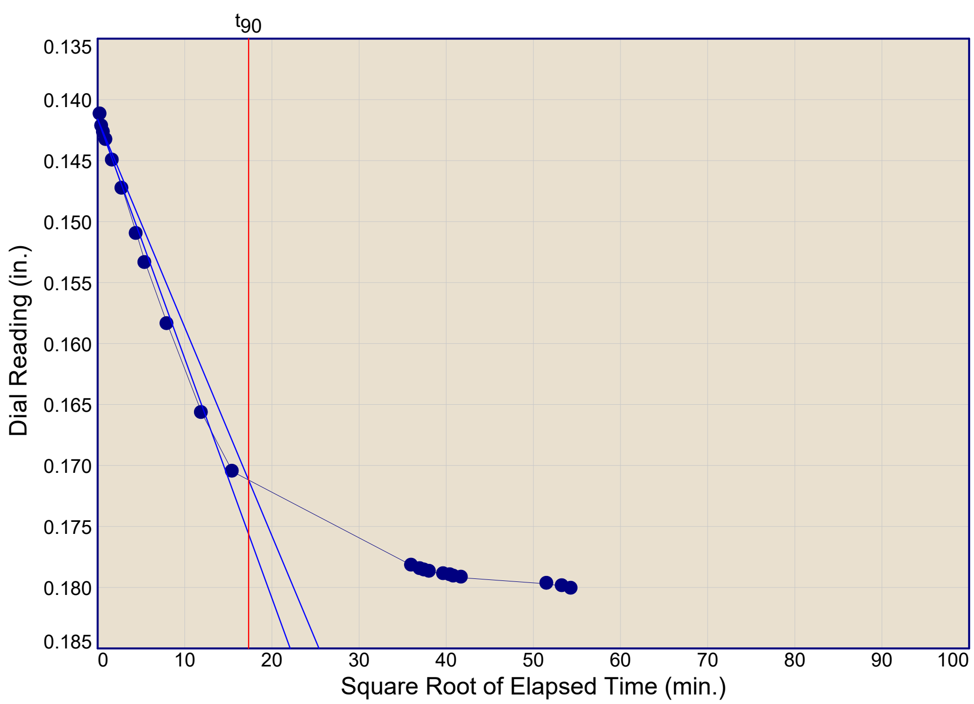
Project No.: 3195.P
Project: Lookout Slough Restoration Project

Source of Sample: BCI-17-8 Depth: 3.8-4.2' Sample Number: 2



Load No.= 7
Load= 32000 psf
D_0 = 0.1004
D_{90} = 0.1236
D_{100} = 0.1261
T_{90} = 112.81 min.

C_v @ T_{90}
0.015 ft.^{2}/day



Load No.= 8
Load= 64000 psf
D_0 = 0.1416
D_{90} = 0.1712
D_{100} = 0.1745
T_{90} = 299.86 min.

C_v @ T_{90}
0.005 ft.^{2}/day

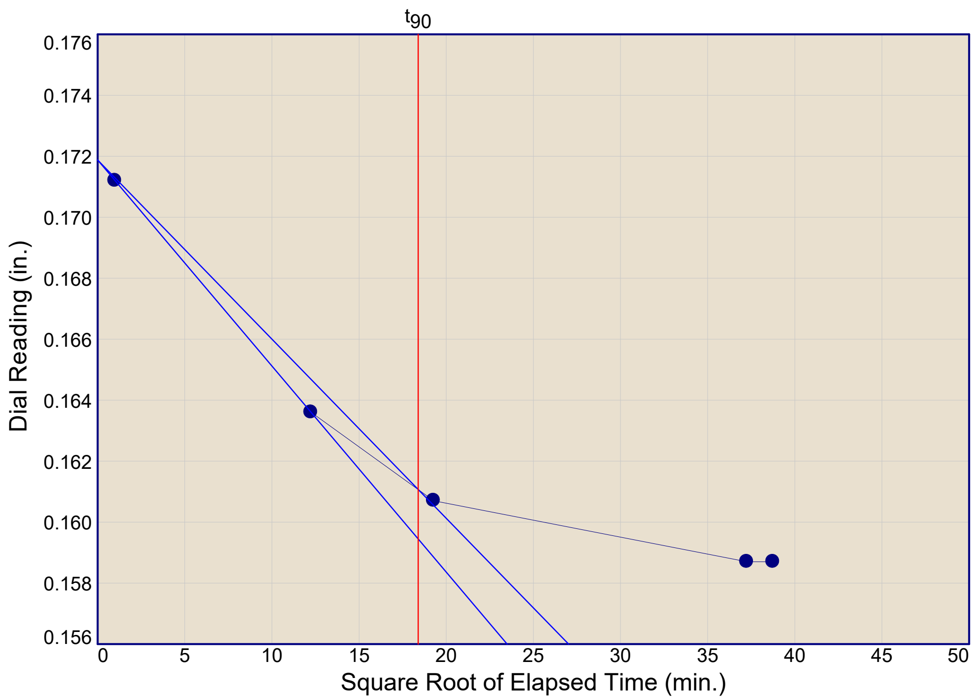
Figure

Blackburn Consulting

Dial Reading vs. Time

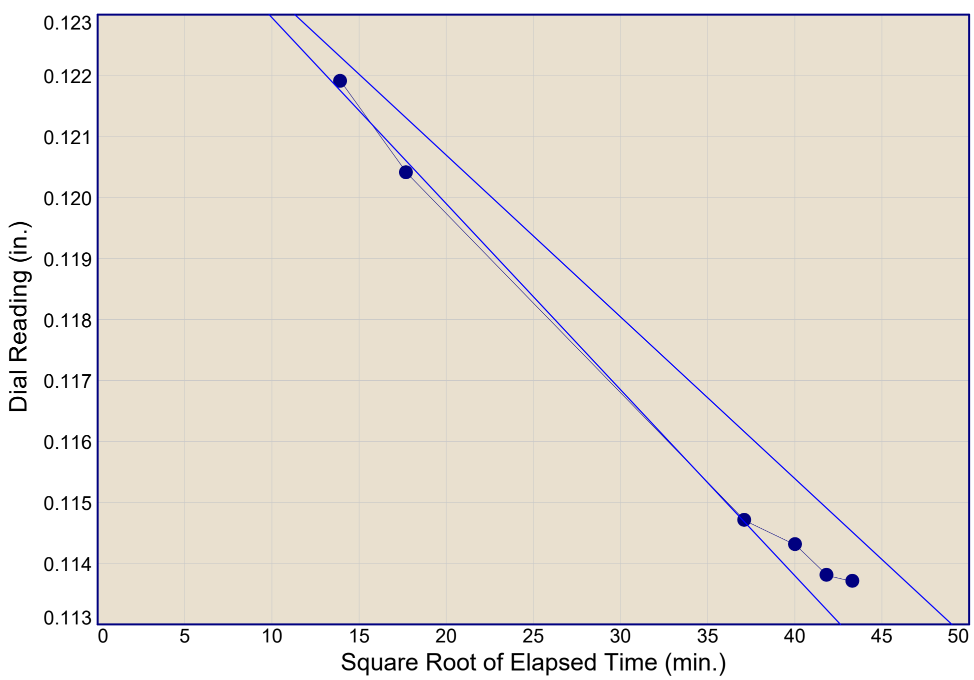
Project No.: 3195.P
Project: Lookout Slough Restoration Project

Source of Sample: BCI-17-8 Depth: 3.8-4.2' Sample Number: 2



Load No.= 10
Load= 16000 psf
D_0 = 0.1719
D_{90} = 0.1611
D_{100} = 0.1599
T_{90} = 338.33 min.

C_v @ T_{90}
0.004 ft.^{2}/day

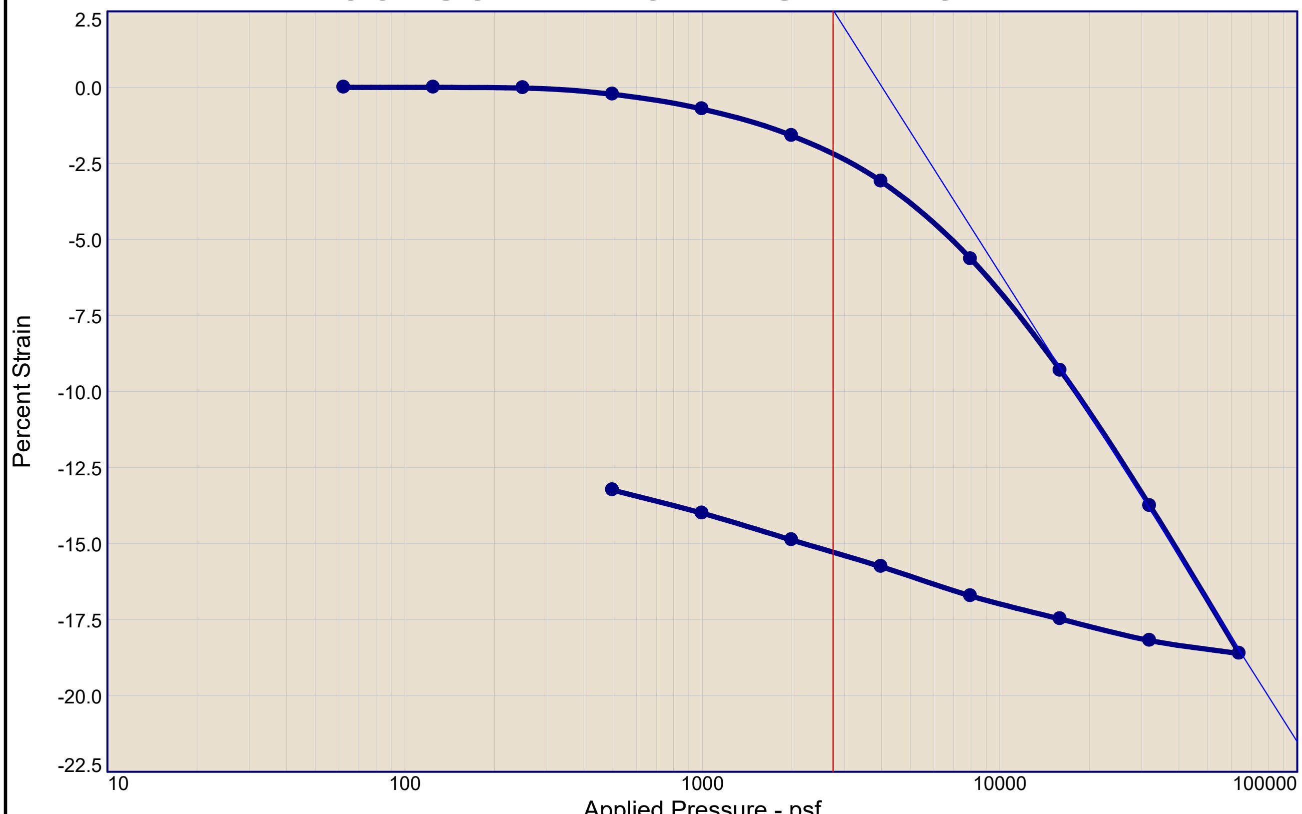


Load No.= 13
Load= 2000 psf
D_0 =
D_{90} =
D_{100} =
T_{90} =

Figure

Blackburn Consulting

CONSOLIDATION TEST REPORT



Coefficients of Consolidation and Secondary Consolidation											
No.	Load (psf)	C_v (ft.^{2}/day)	C_α	No.	Load (psf)	C_v (ft.^{2}/day)	C_α	No.	Load (psf)	C_v (ft.^{2}/day)	C_α
3	250.00	0.116		10	32000	0.159					
4	500.00	0.409		11	64000	0.059					
5	1000.00	0.866		12	32000	0.202					
6	2000	0.476		13	16000	0.117					
7	4000	0.768		14	8000	0.050					
8	8000	0.430									
9	16000	0.324									

Natural		Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (psf)	P_c (psf)	C_c	C_r	Initial Void Ratio
Saturation	Moisture									
95.0 %	31.5 %	88.9	49	28	2.70	2414	6347	0.29	0.06	0.895

MATERIAL DESCRIPTION	USCS	AASHTO
Lean CLAY, yellowish brown	CL	

Project No. 3195.P **Client:** EIP

Project: Lookout Slough Restoration Project

Source of Sample: BCI-17-9 **Depth:** 31.0-31.5' **Sample Number:** 12C

Blackburn Consulting

W. Sacramento, CA

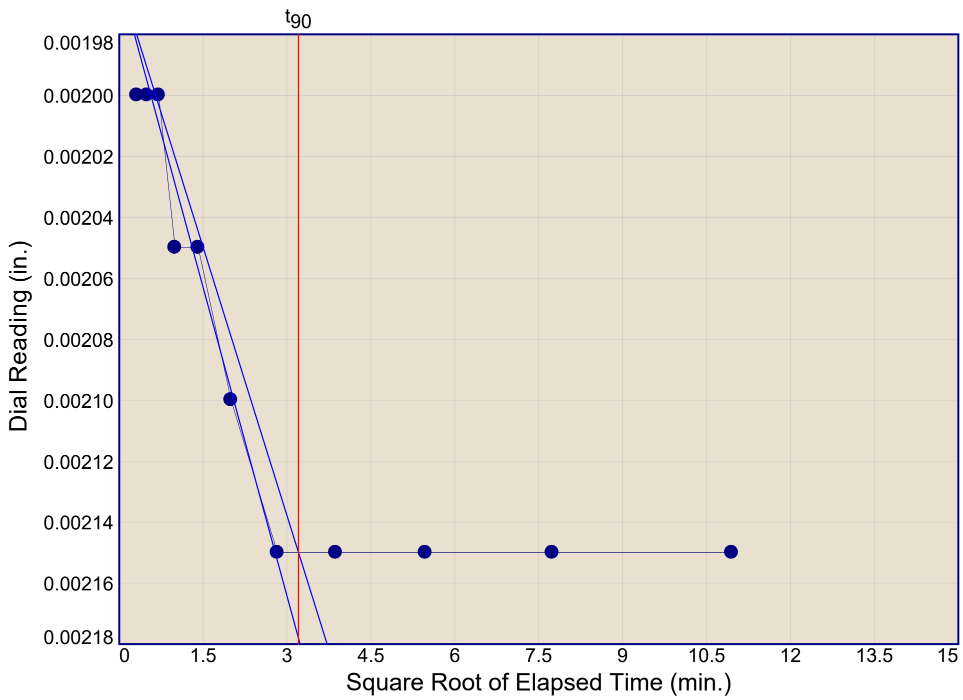
Remarks:

Figure

Dial Reading vs. Time

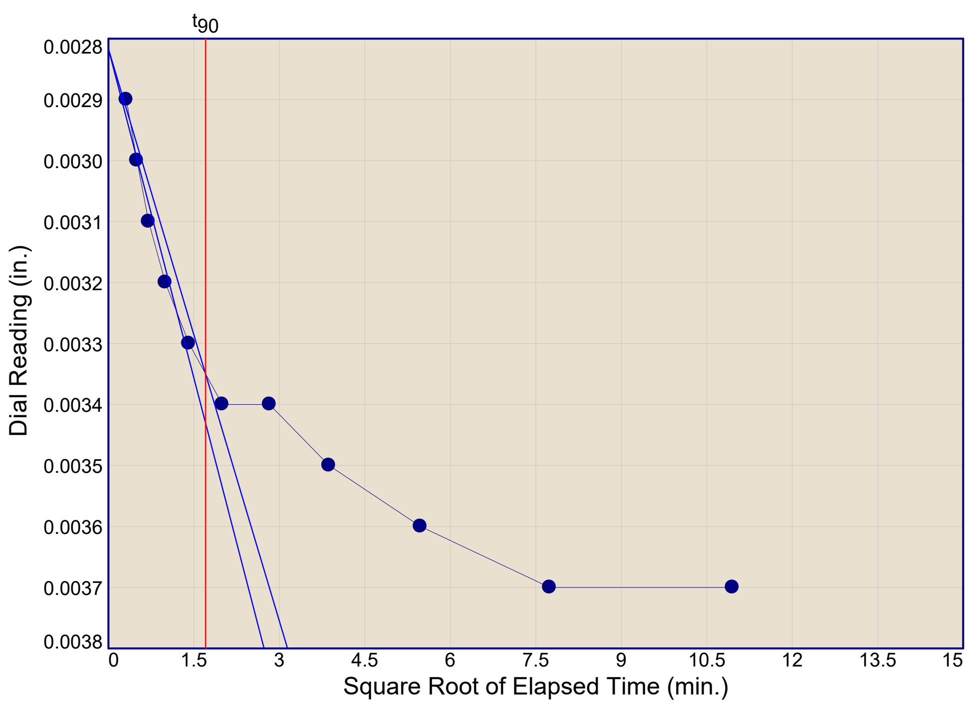
Project No.: 3195.P
Project: Lookout Slough Restoration Project

Source of Sample: BCI-17-9 Depth: 31.0-31.5' Sample Number: 12C



Load No.= 3
Load= 250.00 psf
D_0 = 0.0020
D_{90} = 0.0022
D_{100} = 0.0022
T_{90} = 10.27 min.

C_v @ T_{90}
0.116 ft.^{2}/day



Load No.= 4
Load= 500.00 psf
D_0 = 0.0028
D_{90} = 0.0033
D_{100} = 0.0034
T_{90} = 2.91 min.

C_v @ T_{90}
0.409 ft.^{2}/day

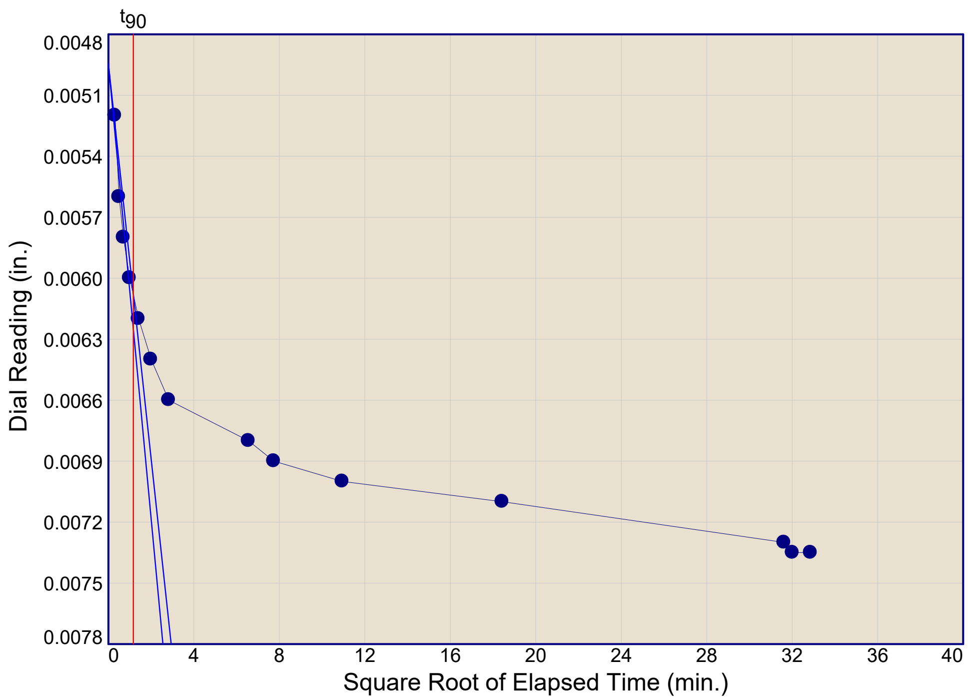
Figure

Blackburn Consulting

Dial Reading vs. Time

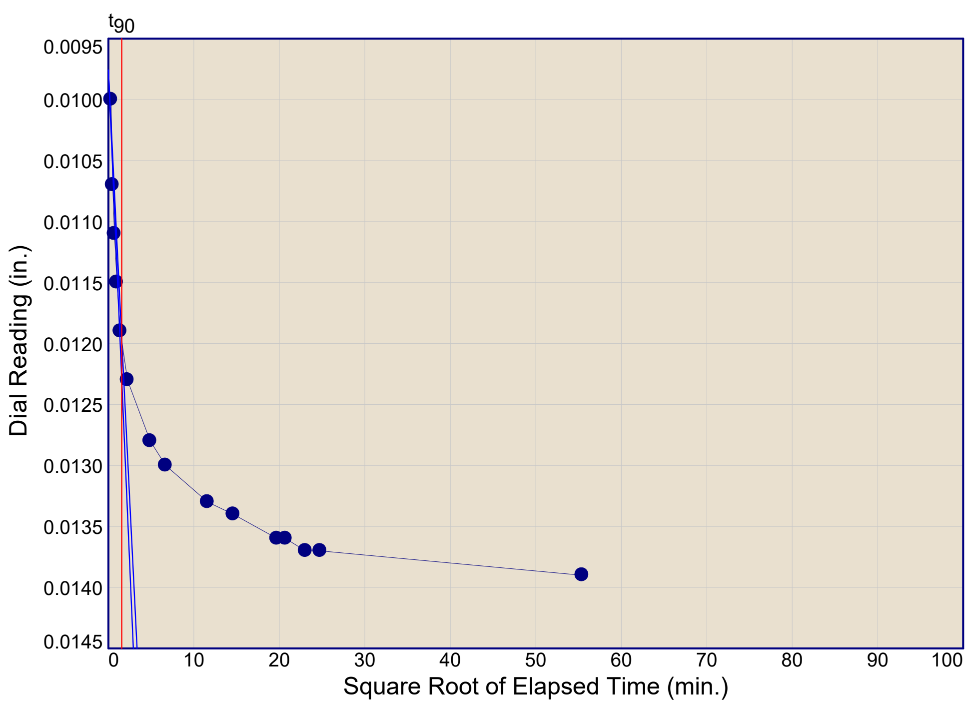
Project No.: 3195.P
Project: Lookout Slough Restoration Project

Source of Sample: BCI-17-9 Depth: 31.0-31.5' Sample Number: 12C



Load No.= 5
Load= 1000.00 psf
D_0 = 0.0049
D_{90} = 0.0061
D_{100} = 0.0062
T_{90} = 1.36 min.

C_v @ T_{90}
0.866 ft.^{2}/day



Load No.= 6
Load= 2000 psf
D_0 = 0.0098
D_{90} = 0.0120
D_{100} = 0.0122
T_{90} = 2.45 min.

C_v @ T_{90}
0.476 ft.^{2}/day

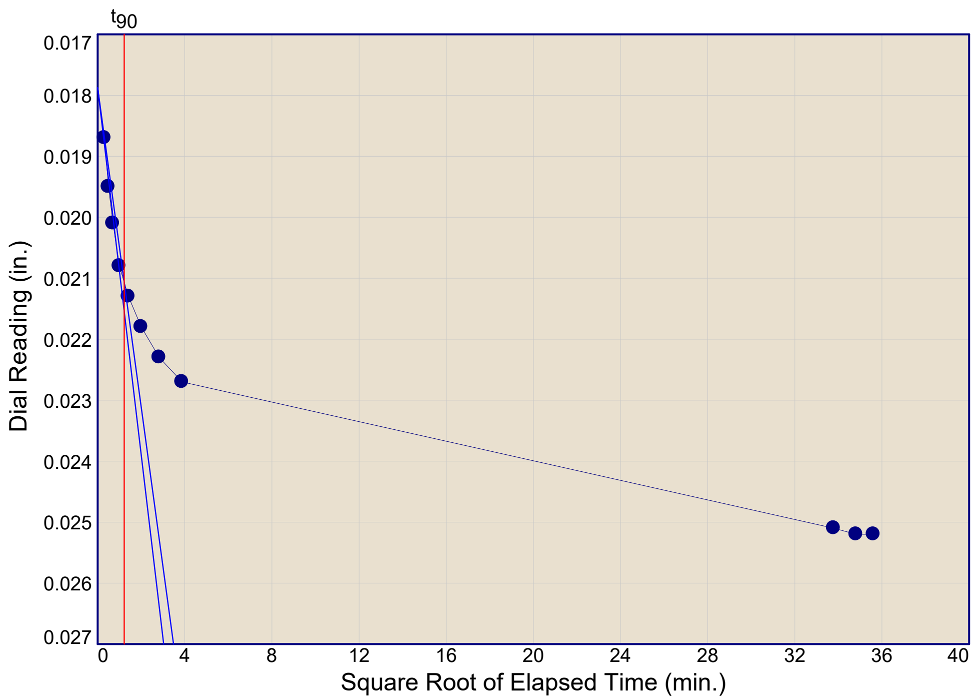
Figure

Blackburn Consulting

Dial Reading vs. Time

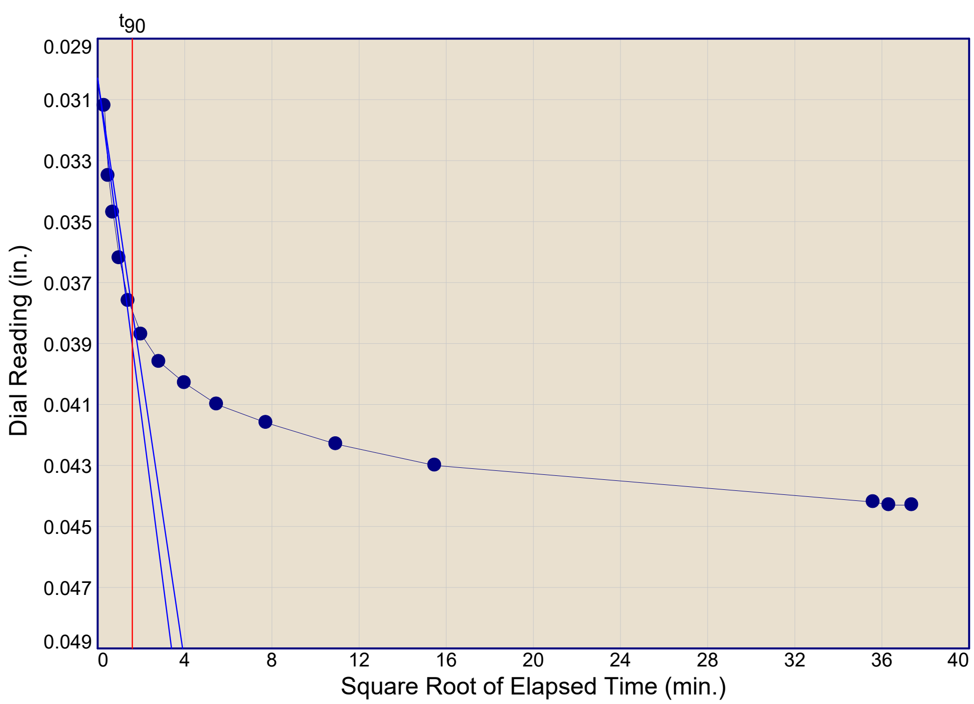
Project No.: 3195.P
Project: Lookout Slough Restoration Project

Source of Sample: BCI-17-9 Depth: 31.0-31.5' Sample Number: 12C



Load No.= 7
Load= 4000 psf
D_0 = 0.0179
D_{90} = 0.0211
D_{100} = 0.0214
T_{90} = 1.48 min.

C_v @ T_{90}
0.768 ft.^{2}/day



Load No.= 8
Load= 8000 psf
D_0 = 0.0303
D_{90} = 0.0379
D_{100} = 0.0388
T_{90} = 2.54 min.

C_v @ T_{90}
0.430 ft.^{2}/day

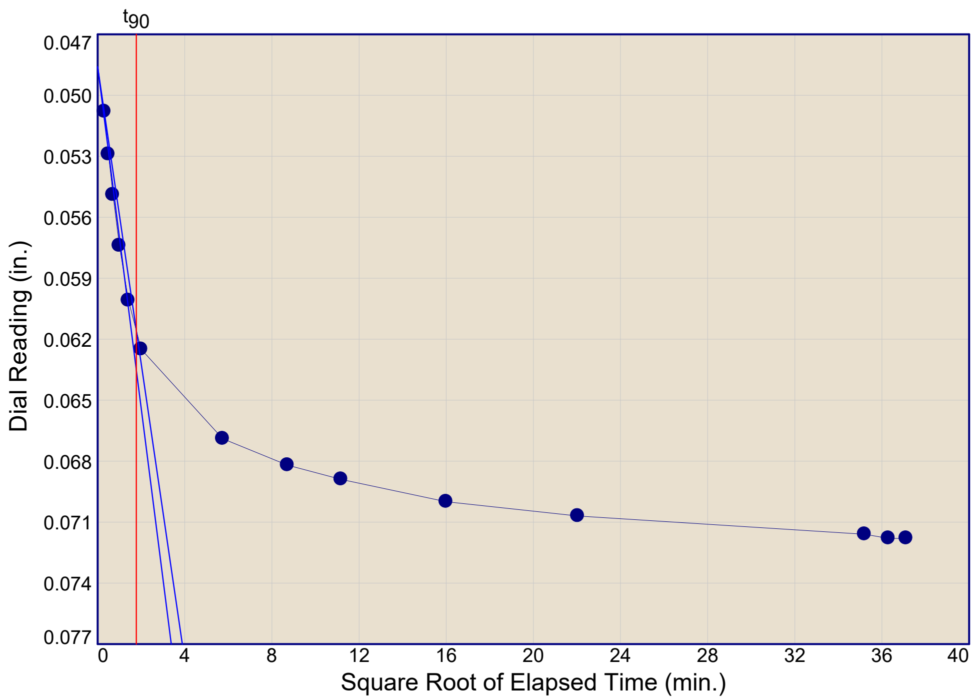
Figure

Blackburn Consulting

Dial Reading vs. Time

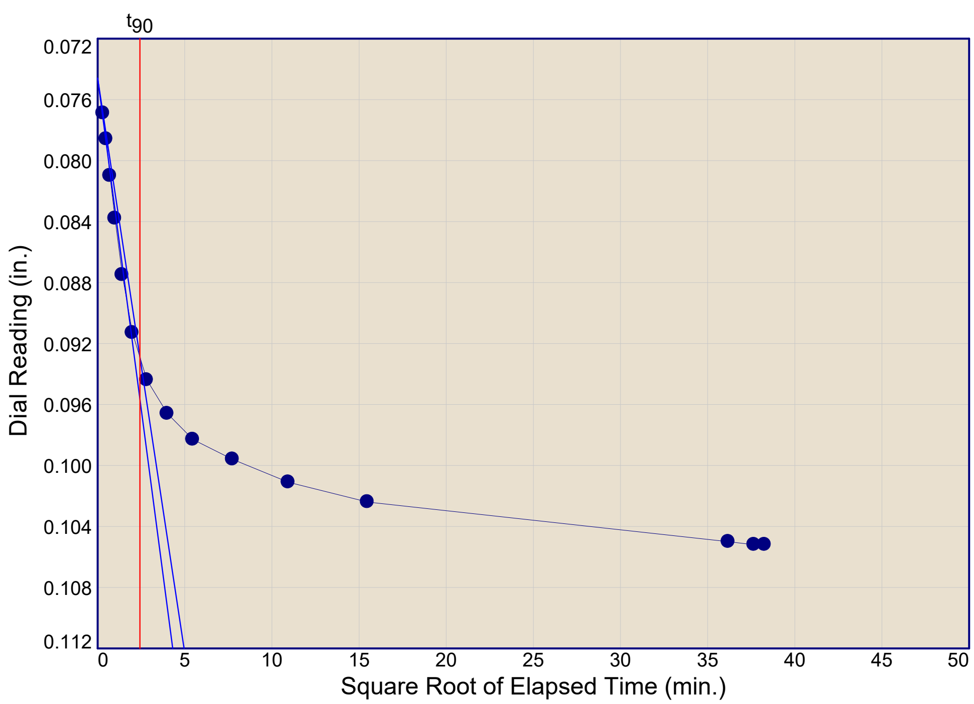
Project No.: 3195.P
Project: Lookout Slough Restoration Project

Source of Sample: BCI-17-9 Depth: 31.0-31.5' Sample Number: 12C



Load No.= 9
Load= 16000 psf
D_0 = 0.0486
D_{90} = 0.0616
D_{100} = 0.0630
T_{90} = 3.16 min.

C_v @ T_{90}
0.324 ft.^{2}/day



Load No.= 10
Load= 32000 psf
D_0 = 0.0746
D_{90} = 0.0929
D_{100} = 0.0949
T_{90} = 5.88 min.

C_v @ T_{90}
0.159 ft.^{2}/day

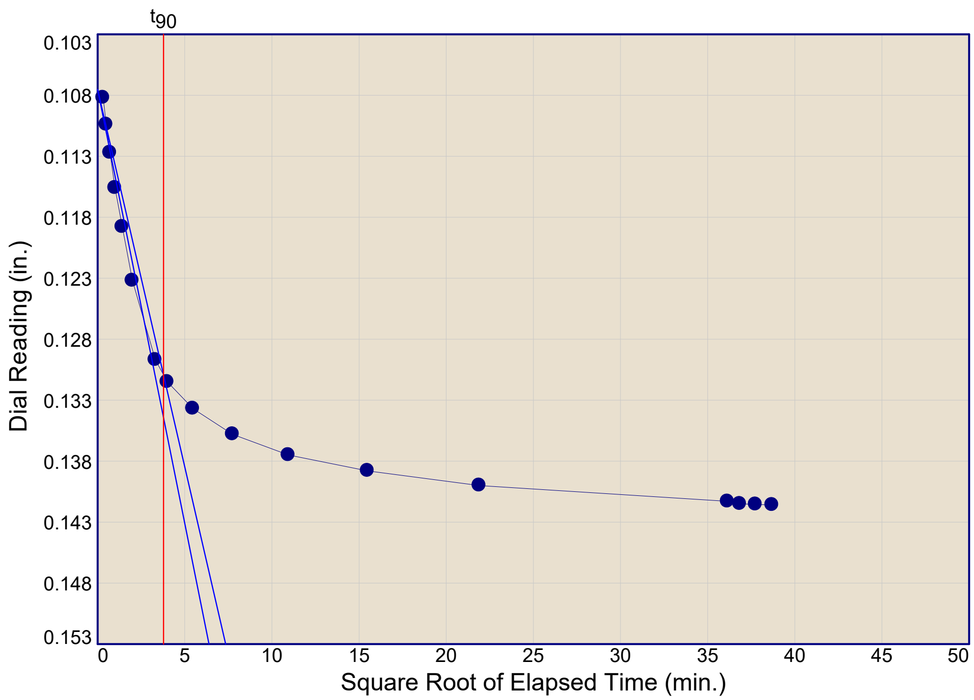
Figure

Blackburn Consulting

Dial Reading vs. Time

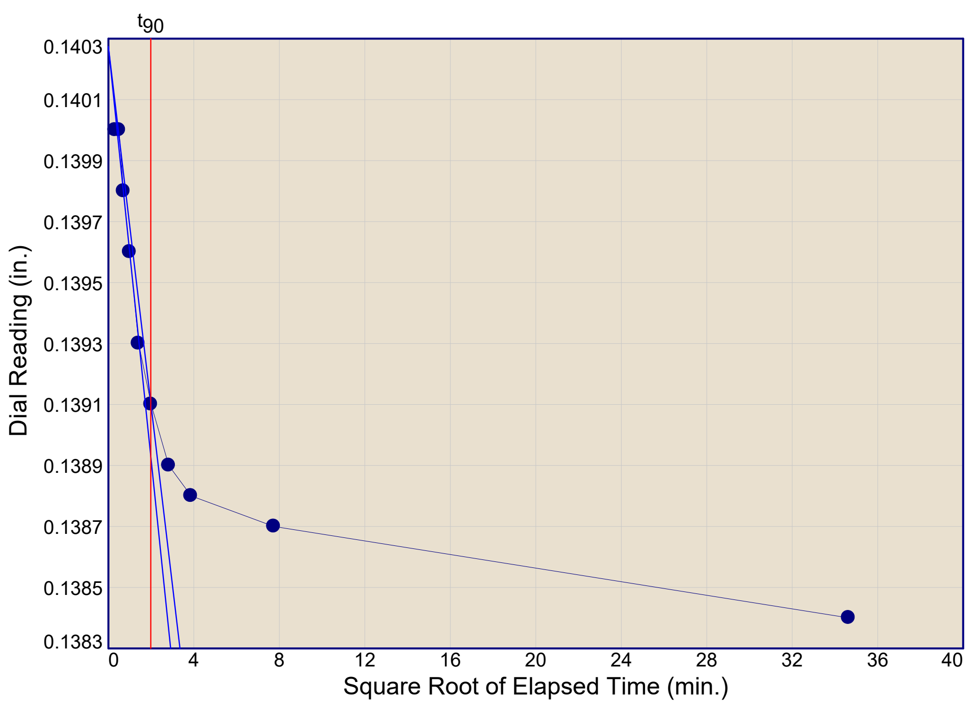
Project No.: 3195.P
Project: Lookout Slough Restoration Project

Source of Sample: BCI-17-9   Depth: 31.0-31.5'   Sample Number: 12C



Load No.= 11
Load= 64000 psf
D_0 = 0.1075
D_{90} = 0.1309
D_{100} = 0.1335
T_{90} = 14.28 min.

C_v @ T_{90}
0.059 ft.^{2}/day



Load No.= 12
Load= 32000 psf
D_0 = 0.1403
D_{90} = 0.1391
D_{100} = 0.1390
T_{90} = 3.94 min.

C_v @ T_{90}
0.202 ft.^{2}/day

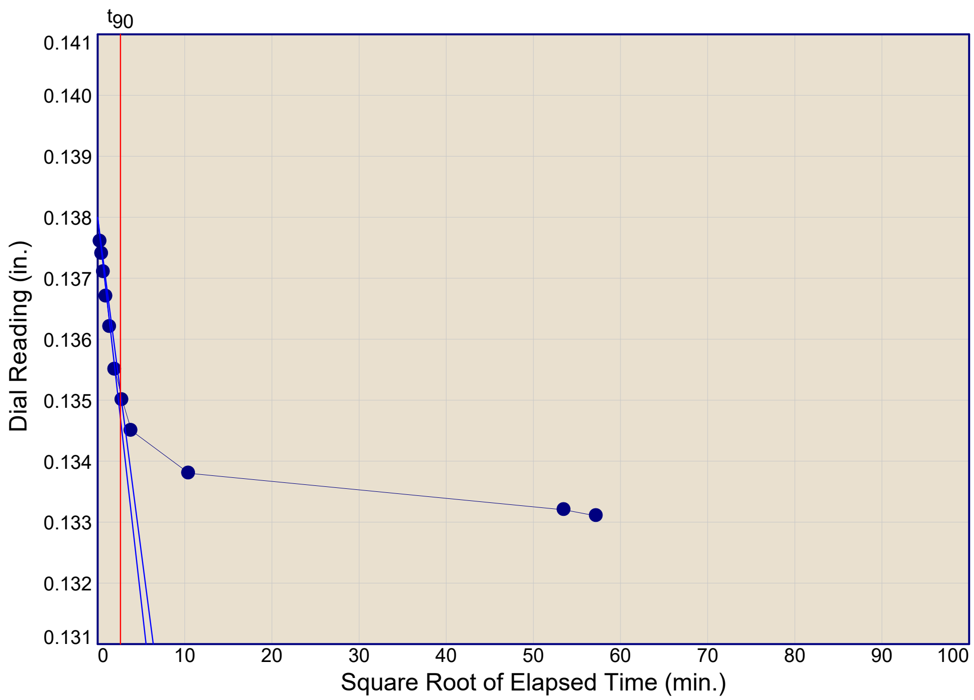
Figure

Blackburn Consulting

Dial Reading vs. Time

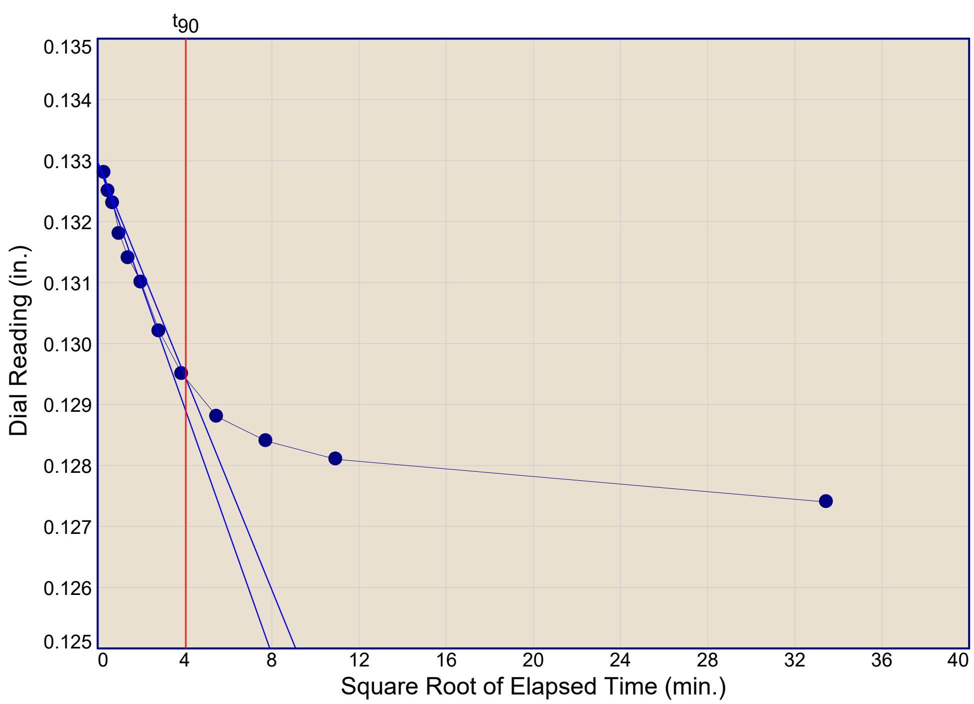
Project No.: 3195.P
Project: Lookout Slough Restoration Project

Source of Sample: BCI-17-9 Depth: 31.0-31.5' Sample Number: 12C



Load No.= 13
Load= 16000 psf
D_0 = 0.1380
D_{90} = 0.1351
D_{100} = 0.1348
T_{90} = 6.87 min.

C_v @ T_{90}
0.117 ft.^{2}/day



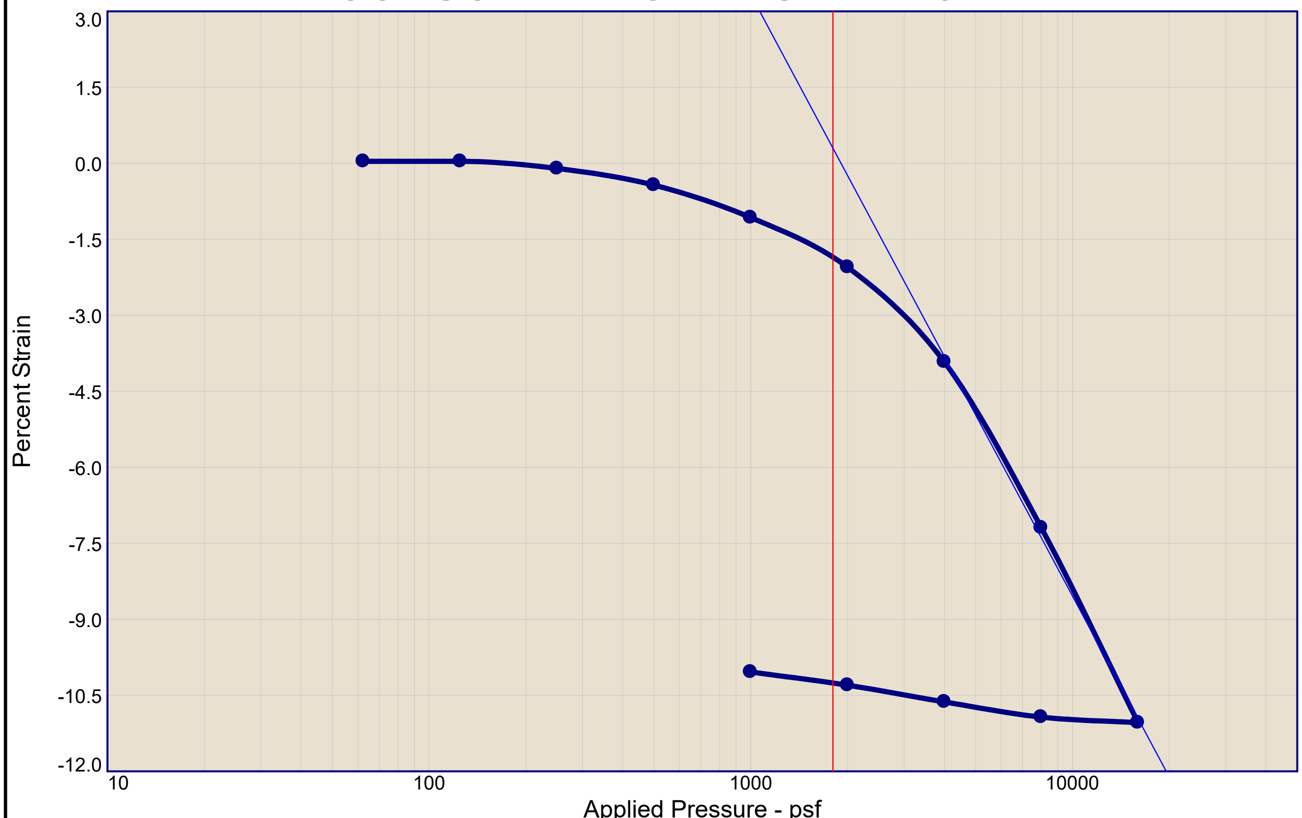
Load No.= 14
Load= 8000 psf
D_0 = 0.1330
D_{90} = 0.1294
D_{100} = 0.1290
T_{90} = 16.40 min.

C_v @ T_{90}
0.050 ft.^{2}/day

Figure

Blackburn Consulting

CONSOLIDATION TEST REPORT



Coefficients of Consolidation and Secondary Consolidation											
No.	Load (psf)	C_v (ft.^{2}/day)	C_α	No.	Load (psf)	C_v (ft.^{2}/day)	C_α	No.	Load (psf)	C_v (ft.^{2}/day)	C_α
4	500.00	0.215									
5	1000.00	0.849									
6	2000	0.763									
7	4000	0.835									
8	8000	1.566									
9	16000	1.528									

Natural		Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (psf)	P_c (psf)	C_c	C_r	Initial Void Ratio
Saturation	Moisture									
86.7 %	26.1 %	93.0			2.70	1680	2974	0.22	0.02	0.813

MATERIAL DESCRIPTION	USCS	AASHTO
Lean CLAY, yellowish brown		

Project No. 3195.P **Client:** EIP

Project: Lookout Slough THRFP

Source of Sample: BCI-19-34 **Depth:** 14' **Sample Number:** 7

Remarks:

Blackburn Consulting

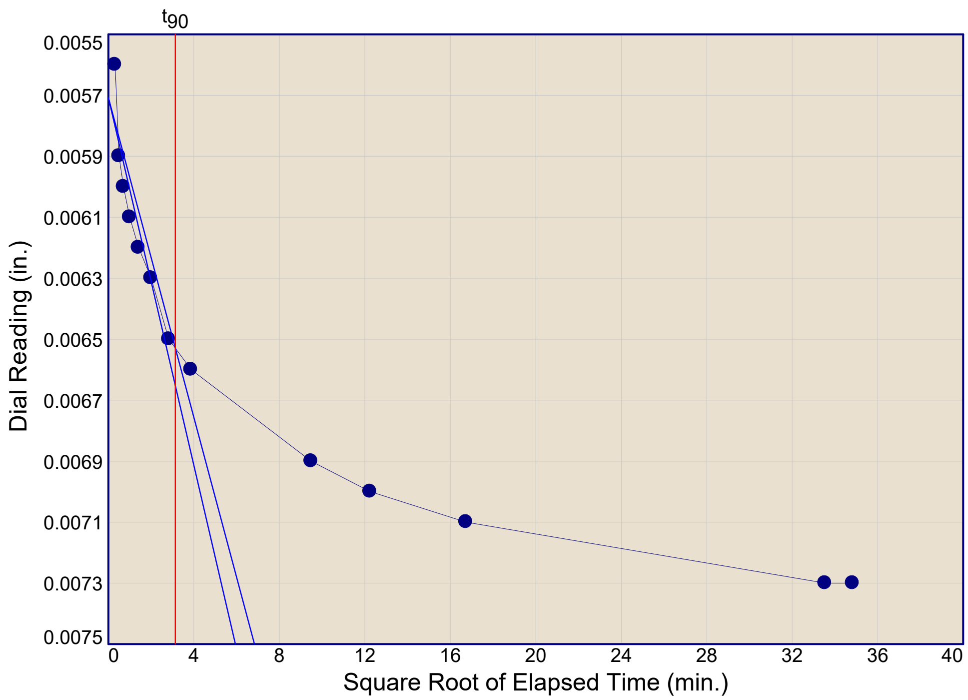
W. Sacramento, CA

Figure

Dial Reading vs. Time

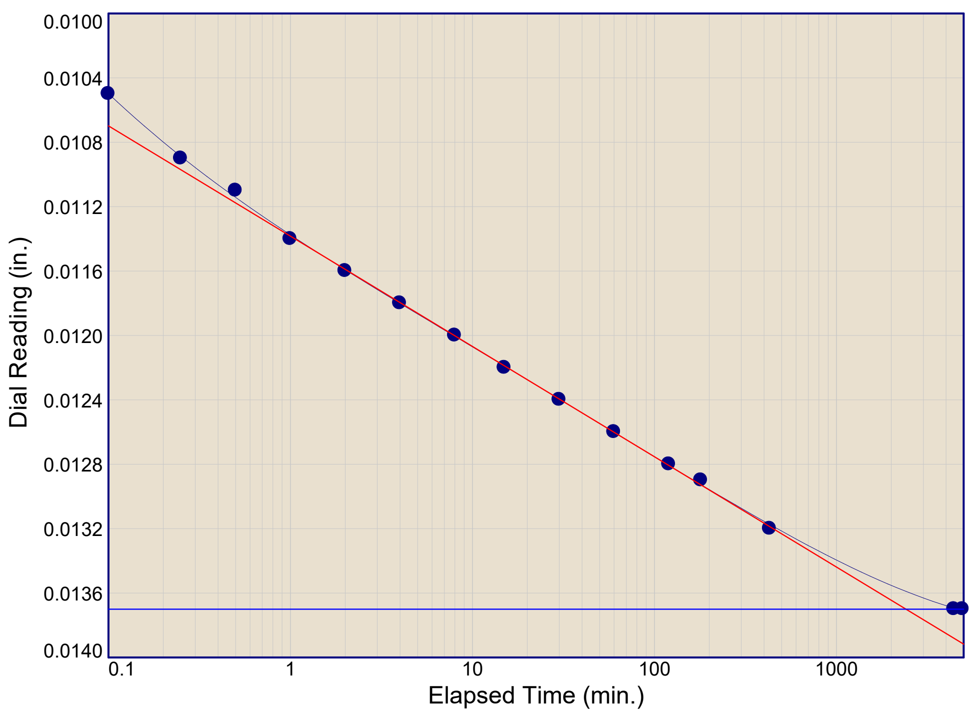
Project No.: 3195.P
Project: Lookout Slough THRFP

Source of Sample: BCI-19-34 Depth: 14' Sample Number: 7



Load No.= 4
Load= 500.00 psf
D_0 = 0.0057
D_{90} = 0.0065
D_{100} = 0.0066
T_{90} = 9.81 min.

C_v @ T_{90}
0.215 $ft.^2$/day



Load No.= 5
Load= 1000.00 psf
D_0 = 0.0073
D_{50} = 0.0105
D_{100} = 0.0137
T_{50} = 0.10 min.

C_v @ T_{50}
4.826 $ft.^2$/day

C_α = 0.000

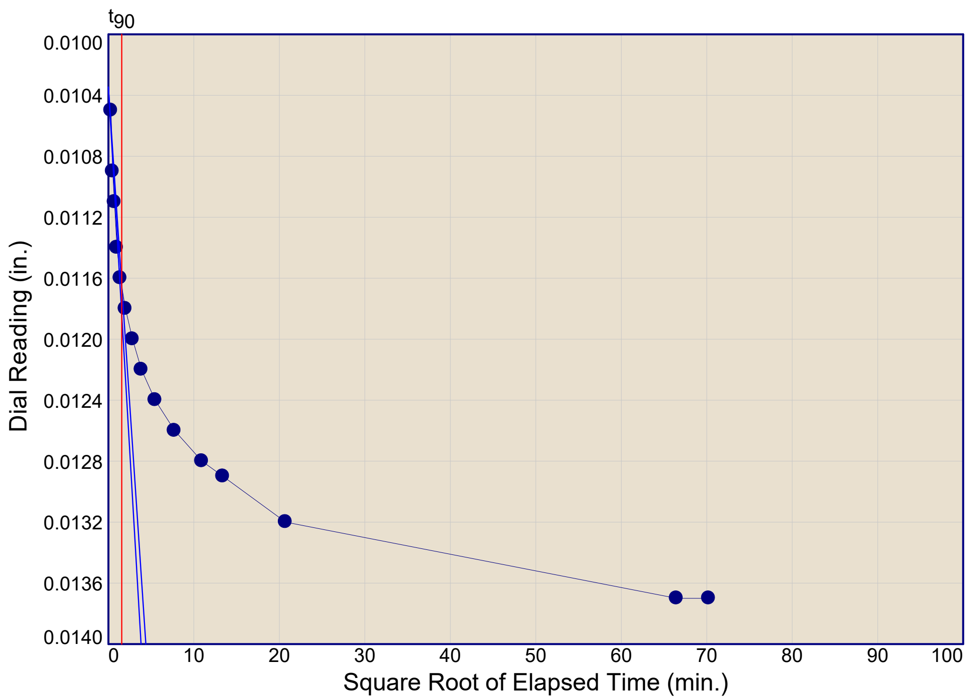
Figure

Blackburn Consulting

Dial Reading vs. Time

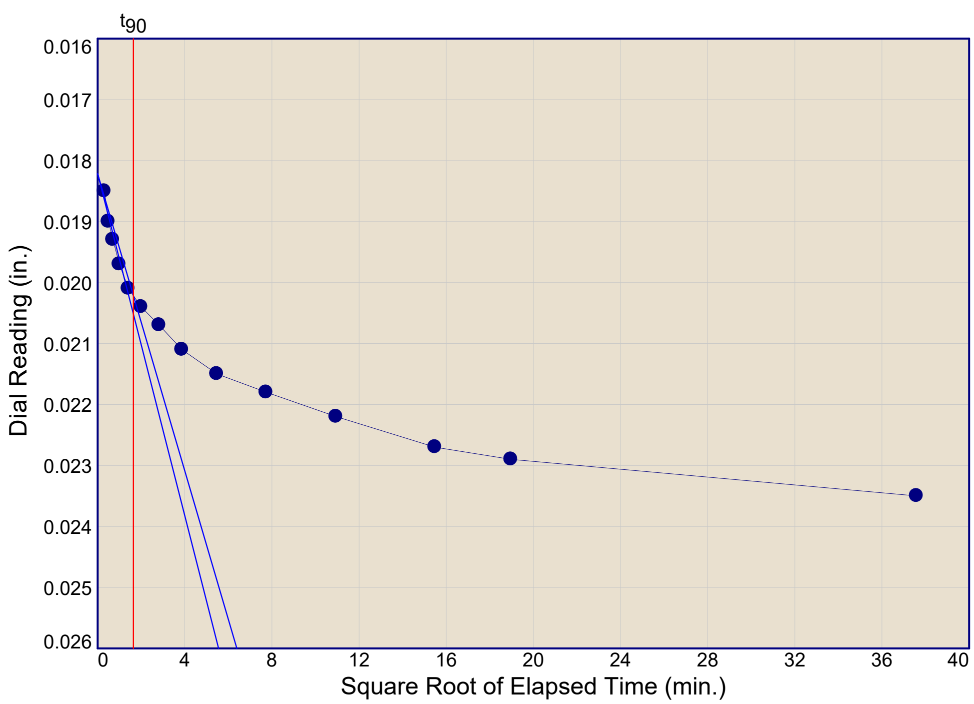
Project No.: 3195.P
Project: Lookout Slough THRFP

Source of Sample: BCI-19-34 Depth: 14' Sample Number: 7



Load No.= 5
Load= 1000.00 psf
D_0 = 0.0103
D_{90} = 0.0117
D_{100} = 0.0118
T_{90} = 2.46 min.

C_v @ T_{90}
0.849 ft.^{2}/day



Load No.= 6
Load= 2000 psf
D_0 = 0.0182
D_{90} = 0.0202
D_{100} = 0.0204
T_{90} = 2.69 min.

C_v @ T_{90}
0.763 ft.^{2}/day

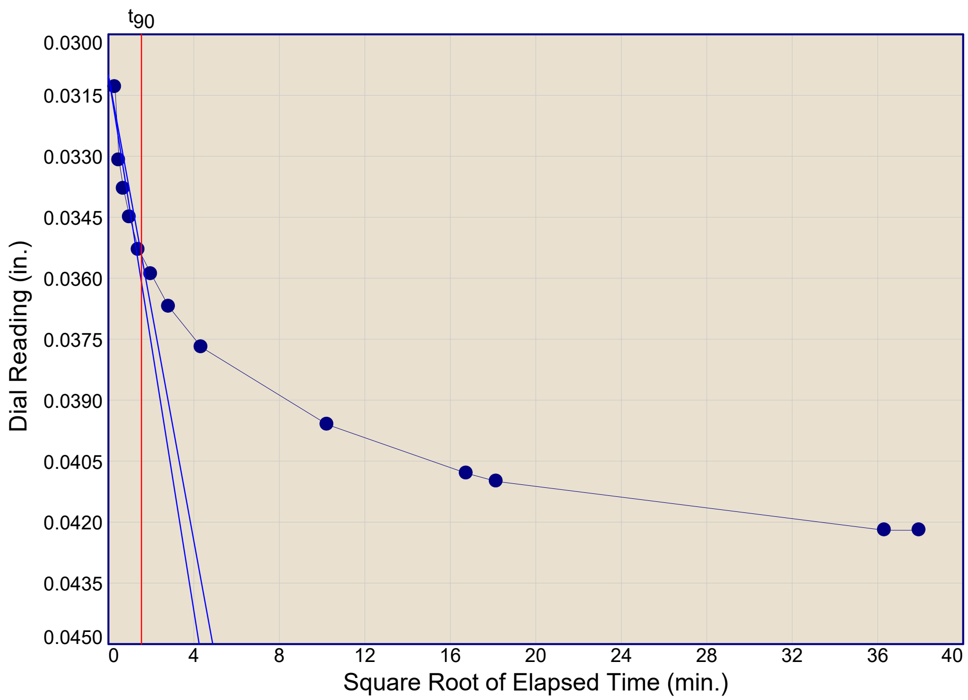
Figure

Blackburn Consulting

Dial Reading vs. Time

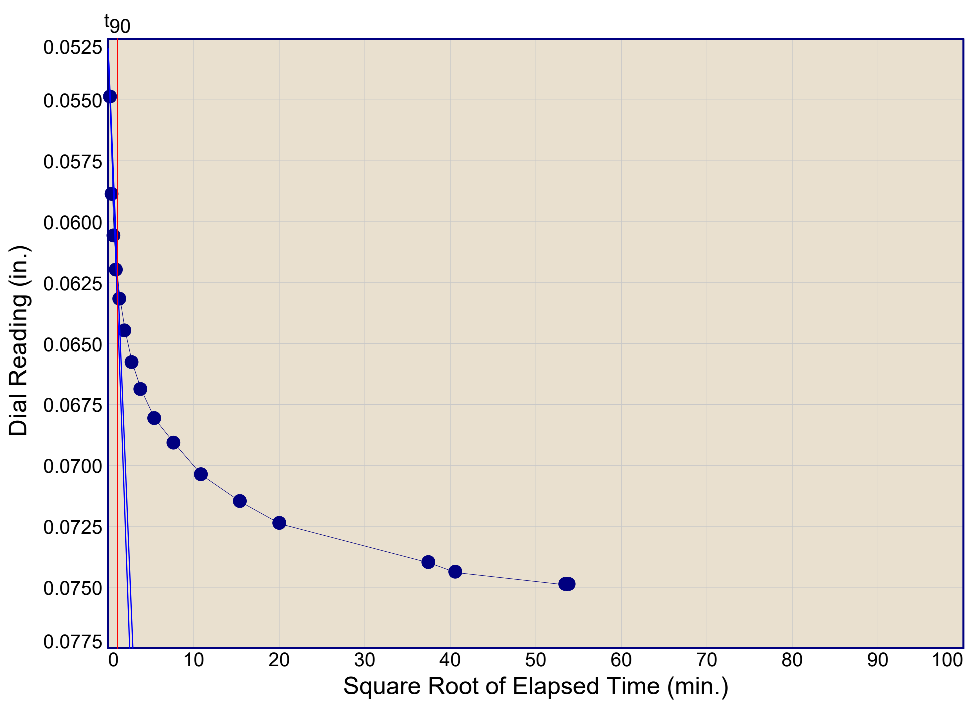
Project No.: 3195.P
Project: Lookout Slough THRFP

Source of Sample: BCI-19-34 Depth: 14' Sample Number: 7



Load No.= 7
Load= 4000 psf
D_0 = 0.0310
D_{90} = 0.0354
D_{100} = 0.0359
T_{90} = 2.39 min.

C_v @ T_{90}
0.835 ft.^{2}/day



Load No.= 8
Load= 8000 psf
D_0 = 0.0529
D_{90} = 0.0623
D_{100} = 0.0633
T_{90} = 1.21 min.

C_v @ T_{90}
1.566 ft.^{2}/day

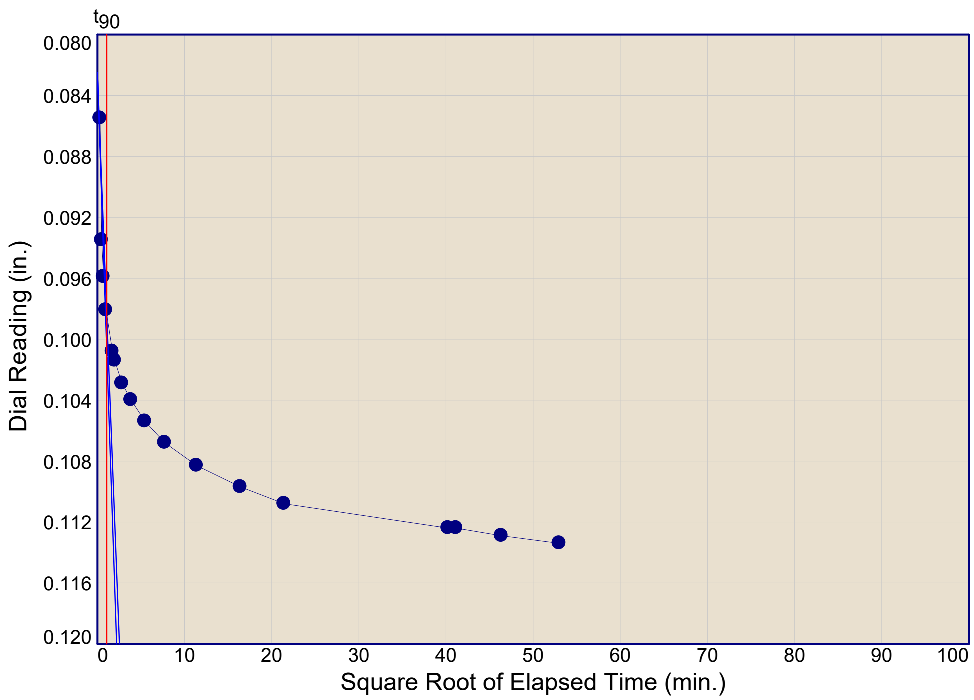
Figure

Blackburn Consulting

Dial Reading vs. Time

Project No.: 3195.P
Project: Lookout Slough THRFP

Source of Sample: BCI-19-34 Depth: 14' Sample Number: 7



Load No.= 9

Load= 16000 psf

D_0 = 0.0825

D_{90} = 0.0984

D_{100} = 0.1001

T_{90} = 1.15 min.

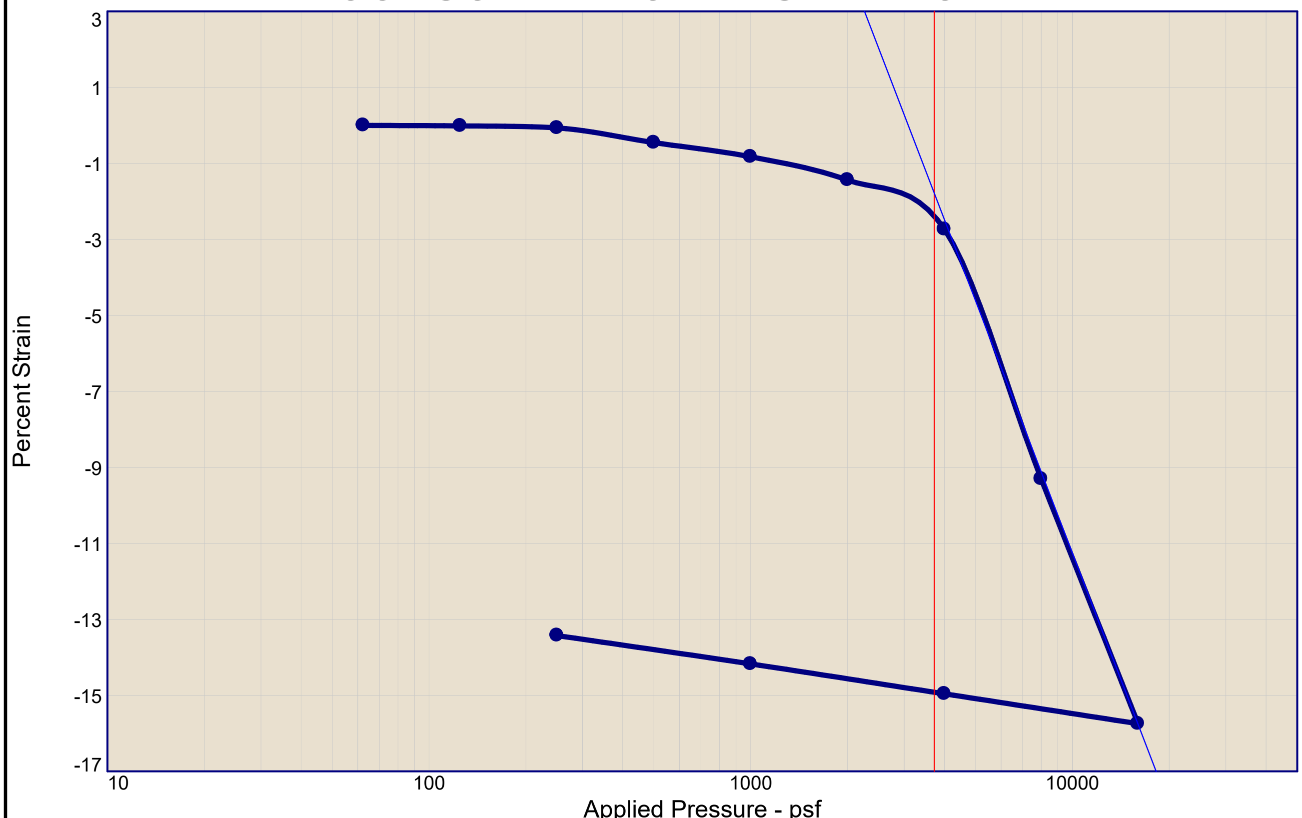
C_v @ T_{90}

1.528 ft.^{2}/day

Figure

Blackburn Consulting

CONSOLIDATION TEST REPORT



Coefficients of Consolidation and Secondary Consolidation											
No.	Load (psf)	C_v (ft.^{2}/day)	C_α	No.	Load (psf)	C_v (ft.^{2}/day)	C_α	No.	Load (psf)	C_v (ft.^{2}/day)	C_α
5	1000.00	0.222									
6	2000	0.197									
7	4000	0.110									
8	8000	2.992									
9	16000	1.500									

Natural		Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (psf)	P_c (psf)	C_c	C_r	Initial Void Ratio
Saturation	Moisture									
93.7 %	31.6 %	88.2	34	11	2.70		4025	0.42	0.02	0.912

MATERIAL DESCRIPTION	USCS	AASHTO
SANDY lean CLAY, olive brown	CL	

Project No. 3195.P **Client:** EIP
Project: Lookout Slough THRFP

Source of Sample: BCI-19-38 **Depth:** 35.5-36' **Sample Number:** 15

Blackburn Consulting

W. Sacramento, CA

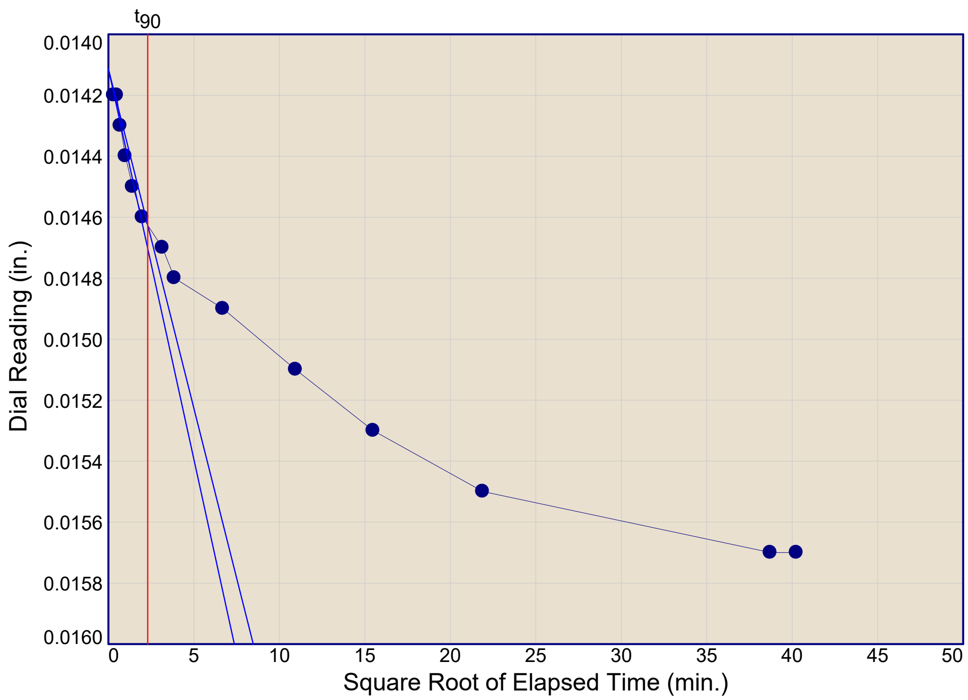
Remarks:

Figure

Dial Reading vs. Time

Project No.: 3195.P
Project: Lookout Slough THRFP

Source of Sample: BCI-19-38 Depth: 35.5-36' Sample Number: 15



Load No.= 5

Load= 1000.00 psf

D_0 = 0.0141

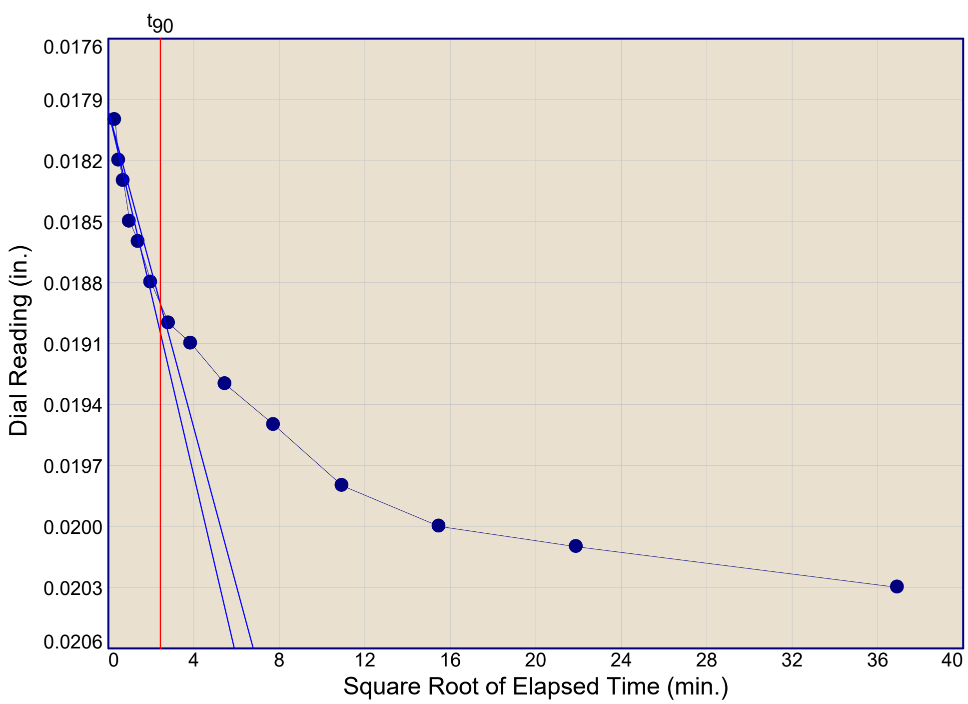
D_{90} = 0.0146

D_{100} = 0.0147

T_{90} = 5.31 min.

C_v @ T_{90}

0.222 ft.^{2}/day



Load No.= 6

Load= 2000 psf

D_0 = 0.0180

D_{90} = 0.0189

D_{100} = 0.0190

T_{90} = 5.91 min.

C_v @ T_{90}

0.197 ft.^{2}/day

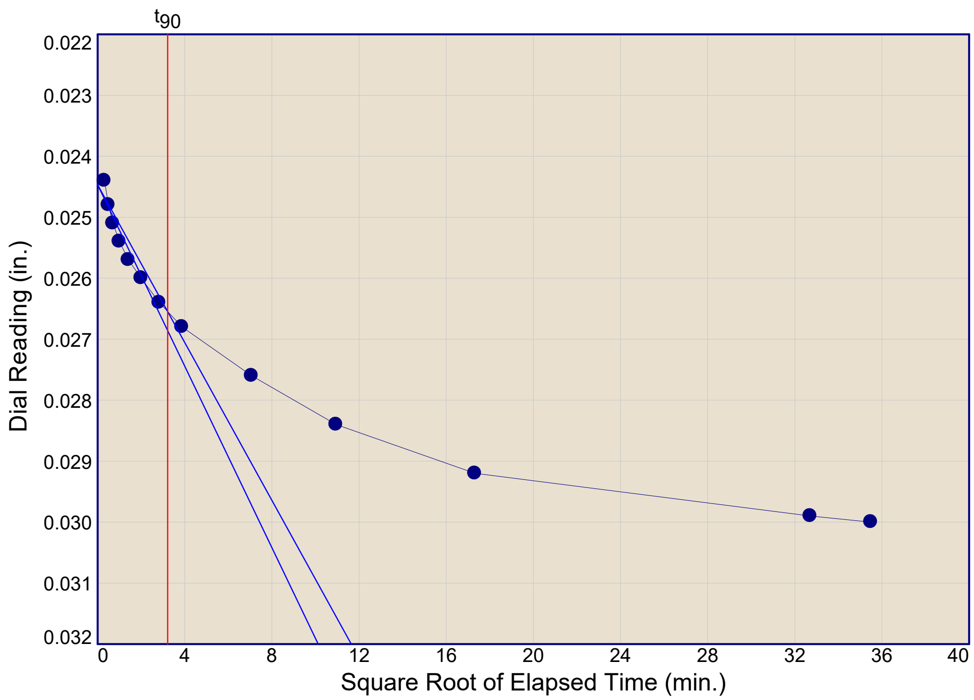
Figure

Blackburn Consulting

Dial Reading vs. Time

Project No.: 3195.P
Project: Lookout Slough THRFP

Source of Sample: BCI-19-38 Depth: 35.5-36' Sample Number: 15



Load No.= 7

Load= 4000 psf

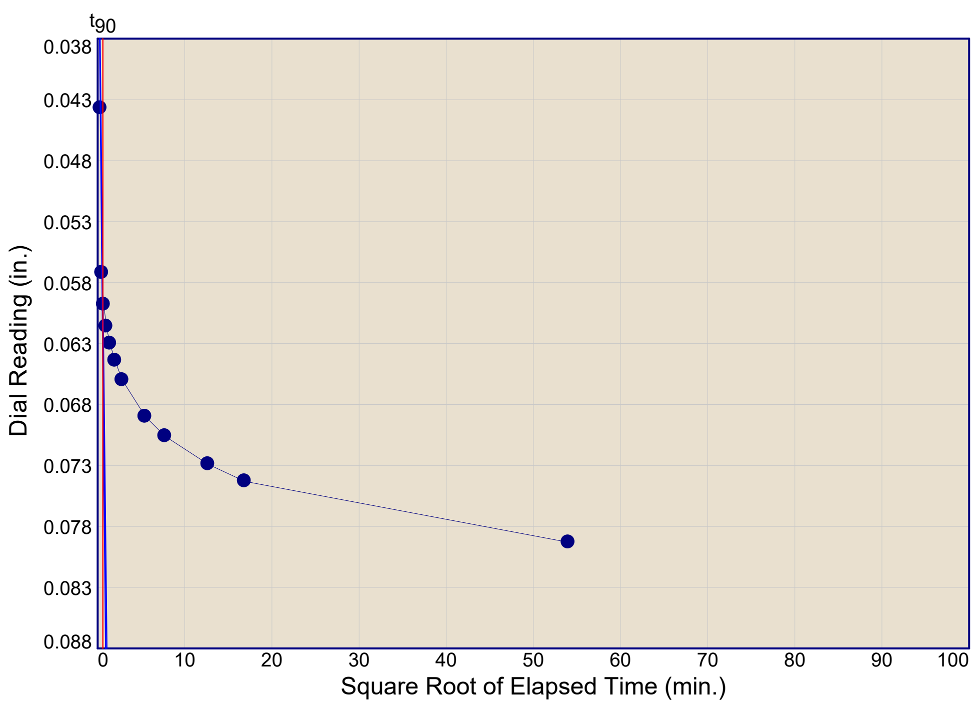
D_0 = 0.0245

D_{90} = 0.0265

D_{100} = 0.0268

T_{90} = 10.35 min.

C_v @ T_{90}
0.110 ft.^{2}/day



Load No.= 8

Load= 8000 psf

D_0 = 0.0205

D_{90} = 0.0584

D_{100} = 0.0626

T_{90} = 0.35 min.

C_v @ T_{90}
2.992 ft.^{2}/day

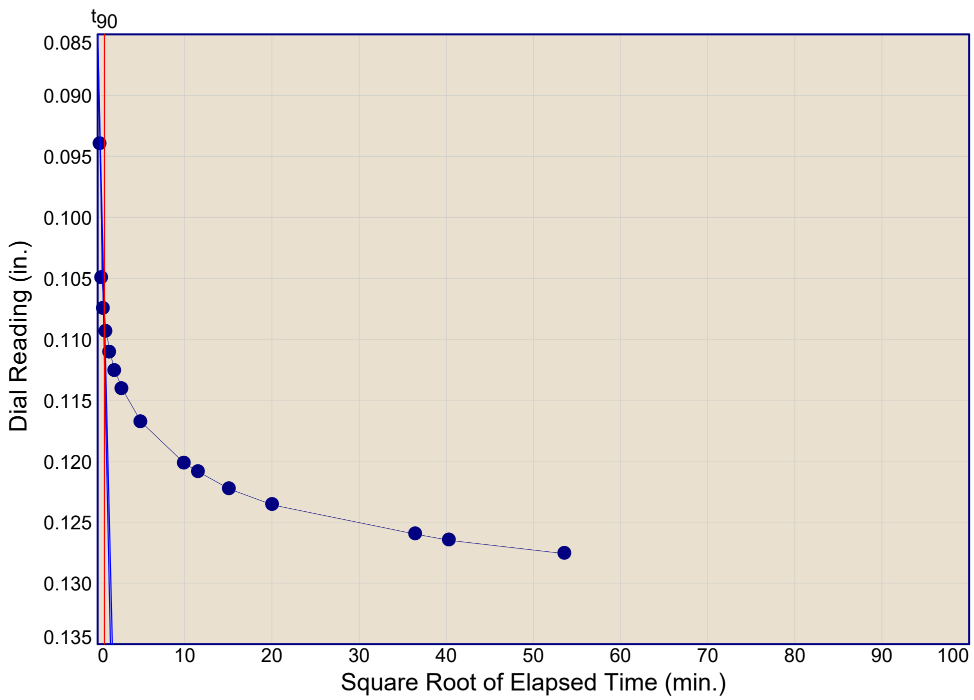
Figure

Blackburn Consulting

Dial Reading vs. Time

Project No.: 3195.P
Project: Lookout Slough THRFP

Source of Sample: BCI-19-38 Depth: 35.5-36' Sample Number: 15



Load No.= 9

Load= 16000 psf

D_0 = 0.0849

D_{90} = 0.1080

D_{100} = 0.1105

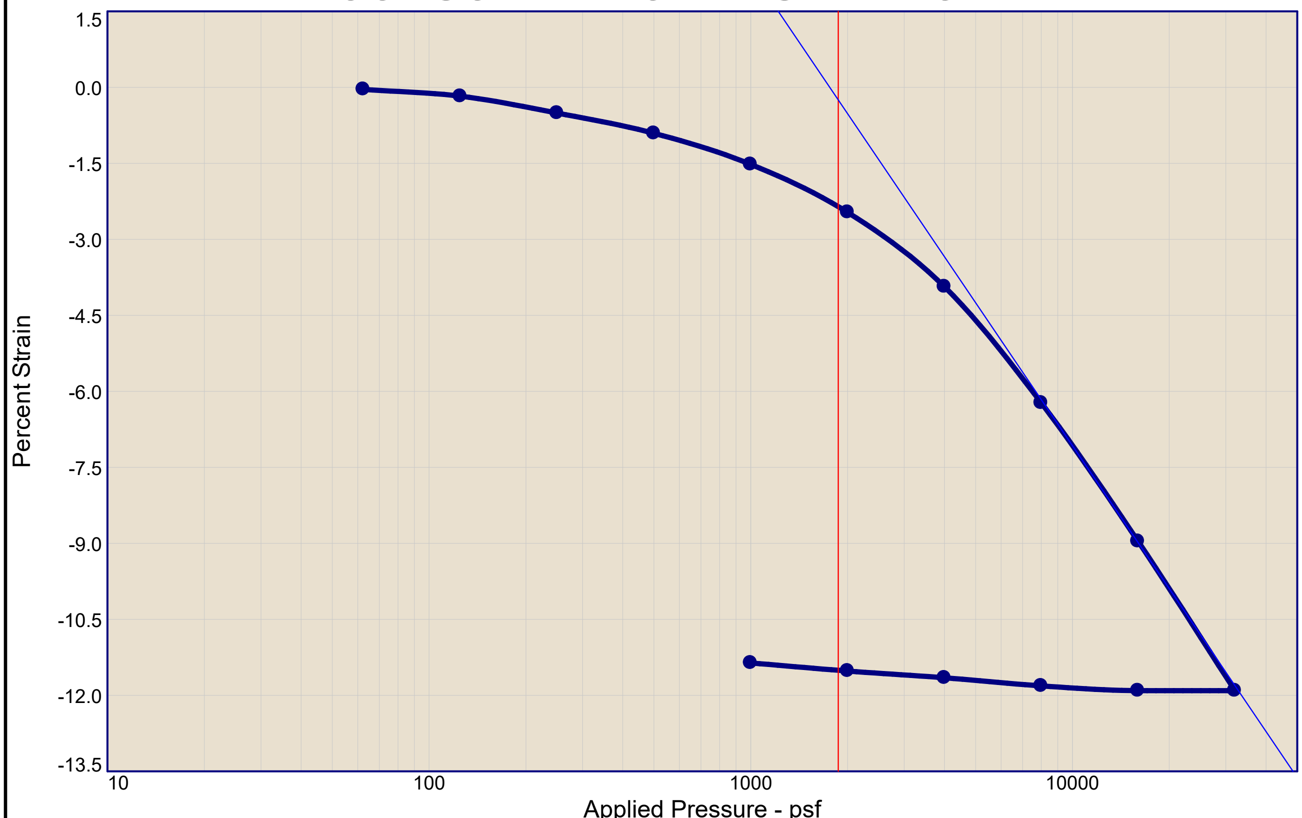
T_{90} = 0.61 min.

C_v @ T_{90}
1.500 ft.^{2}/day

Figure

Blackburn Consulting

CONSOLIDATION TEST REPORT



Coefficients of Consolidation and Secondary Consolidation

No.	Load (psf)	C_v ($ft.^2$/day)	C_α	No.	Load (psf)	C_v ($ft.^2$/day)	C_α	No.	Load (psf)	C_v ($ft.^2$/day)	C_α
4	500.00	0.445									
5	1000.00	3.224									
6	2000	1.755									
7	4000	3.078									
8	8000	0.728									
9	16000	0.437									
10	32000	1.435									

Natural		Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (psf)	P_c (psf)	C_c	C_r	Initial Void Ratio
Saturation	Moisture									
91.4 %	23.3 %	99.9	41	20	2.70	2050	3563	0.16	0.01	0.688

MATERIAL DESCRIPTION	USCS	AASHTO
SANDY lean CLAY, olive brown & blueish gray	CL	

Project No. 3195.P **Client:** EIP

Project: Lookout Slough THRFP

Source of Sample: BCI-19-57 **Depth:** 17.5-17.9' **Sample Number:** 7-soft

Blackburn Consulting

W. Sacramento, CA

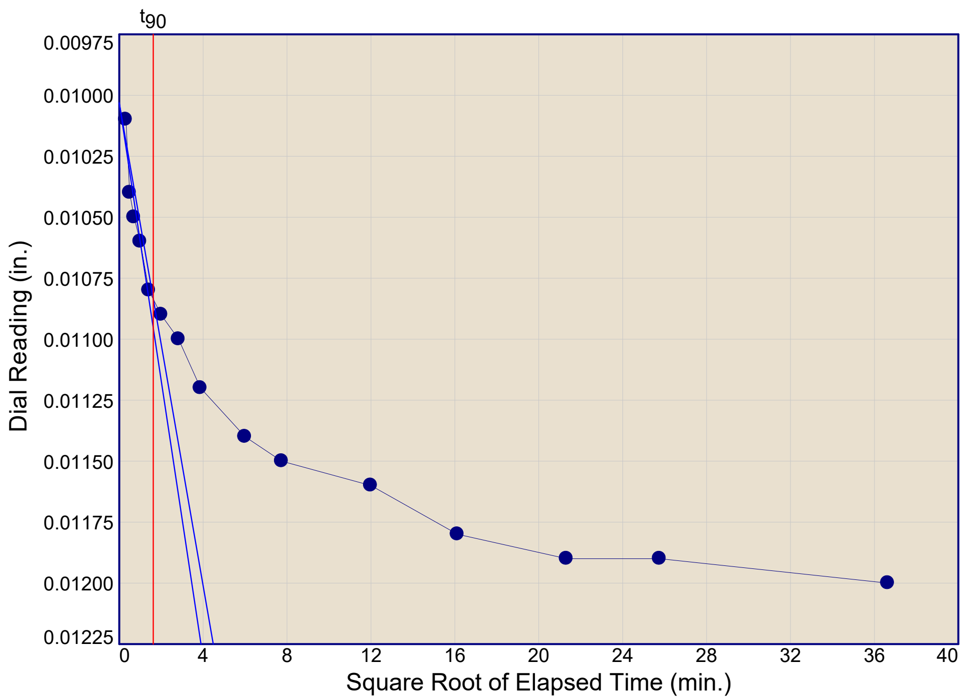
Remarks:

Figure

Dial Reading vs. Time

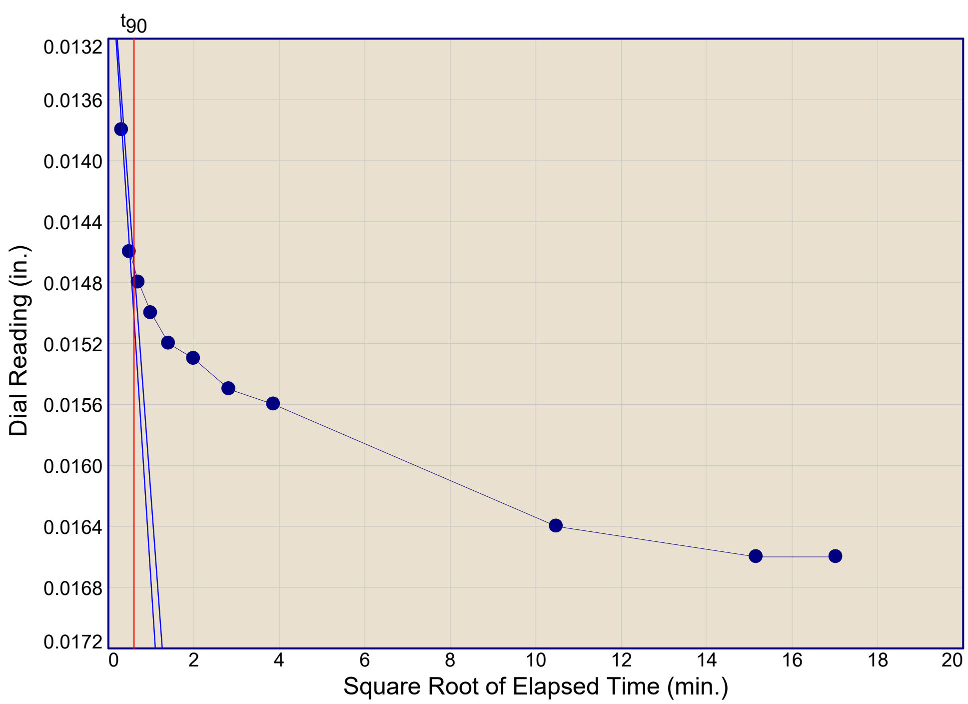
Project No.: 3195.P
Project: Lookout Slough THRFP

Source of Sample: BCI-19-57 Depth: 17.5-17.9' Sample Number: 7-soft



Load No.= 4
Load= 500.00 psf
D_0 = 0.0100
D_{90} = 0.0108
D_{100} = 0.0109
T_{90} = 2.64 min.

C_v @ T_{90}
0.445 ft.^{2}/day



Load No.= 5
Load= 1000.00 psf
D_0 = 0.0124
D_{90} = 0.0147
D_{100} = 0.0150
T_{90} = 0.36 min.

C_v @ T_{90}
3.224 ft.^{2}/day

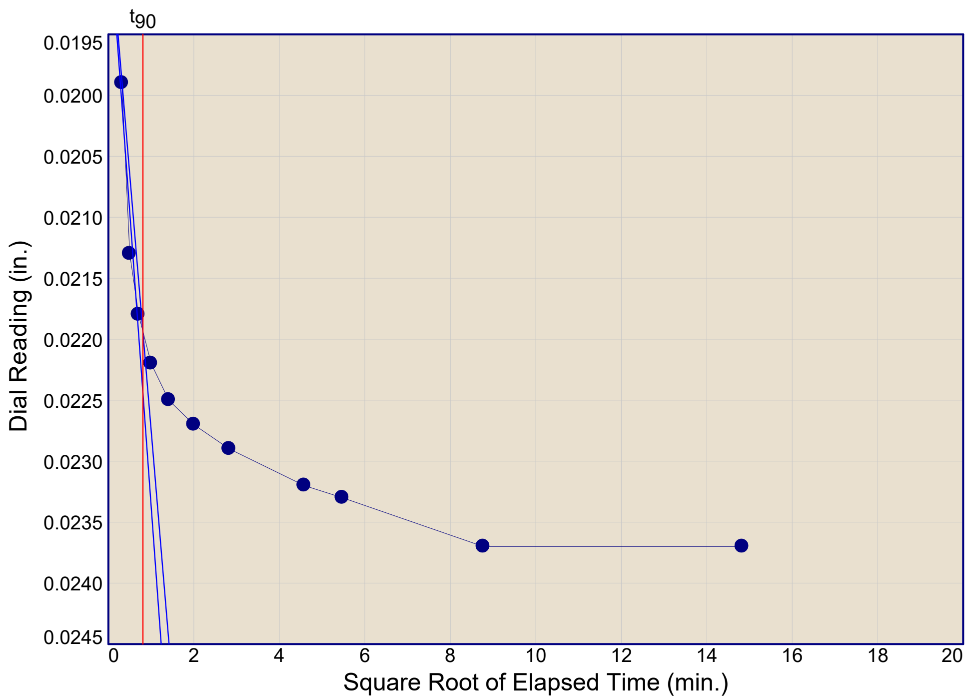
Figure

Blackburn Consulting

Dial Reading vs. Time

Project No.: 3195.P
Project: Lookout Slough THRFP

Source of Sample: BCI-19-57 Depth: 17.5-17.9' Sample Number: 7-soft



Load No.= 6

Load= 2000 psf

D_0 = 0.0186

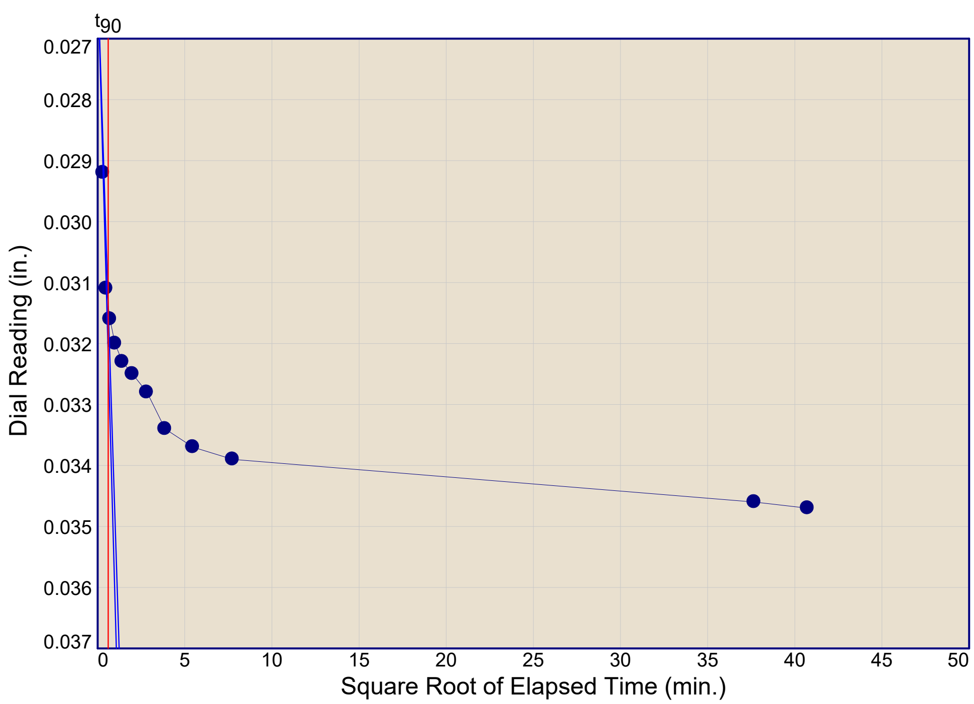
D_{90} = 0.0219

D_{100} = 0.0223

T_{90} = 0.65 min.

C_v @ T_{90}

1.755 ft.^{2}/day



Load No.= 7

Load= 4000 psf

D_0 = 0.0259

D_{90} = 0.0313

D_{100} = 0.0319

T_{90} = 0.36 min.

C_v @ T_{90}

3.078 ft.^{2}/day

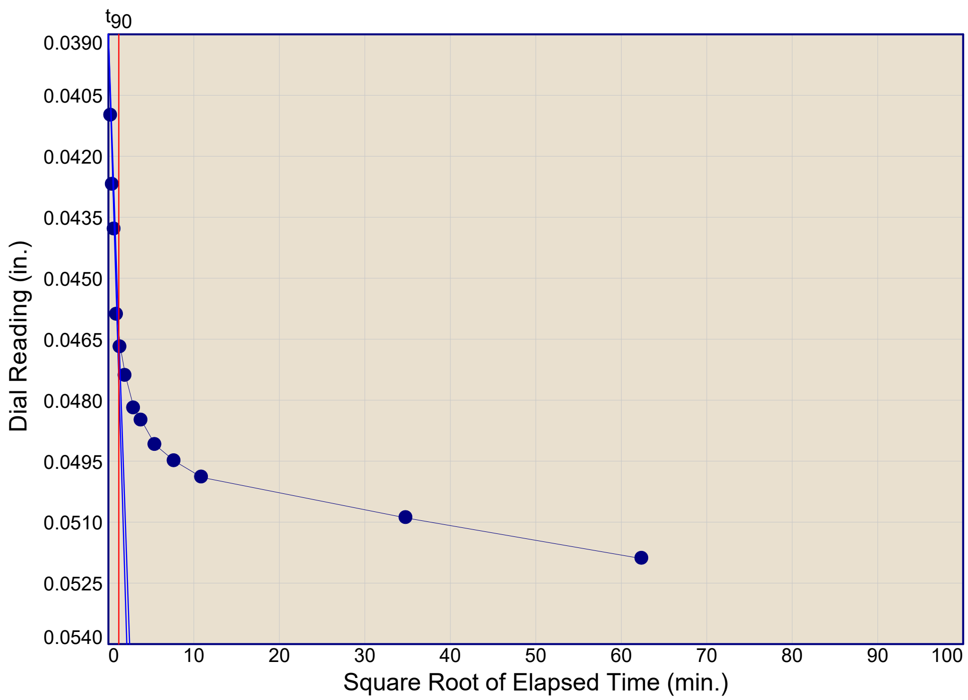
Figure

Blackburn Consulting

Dial Reading vs. Time

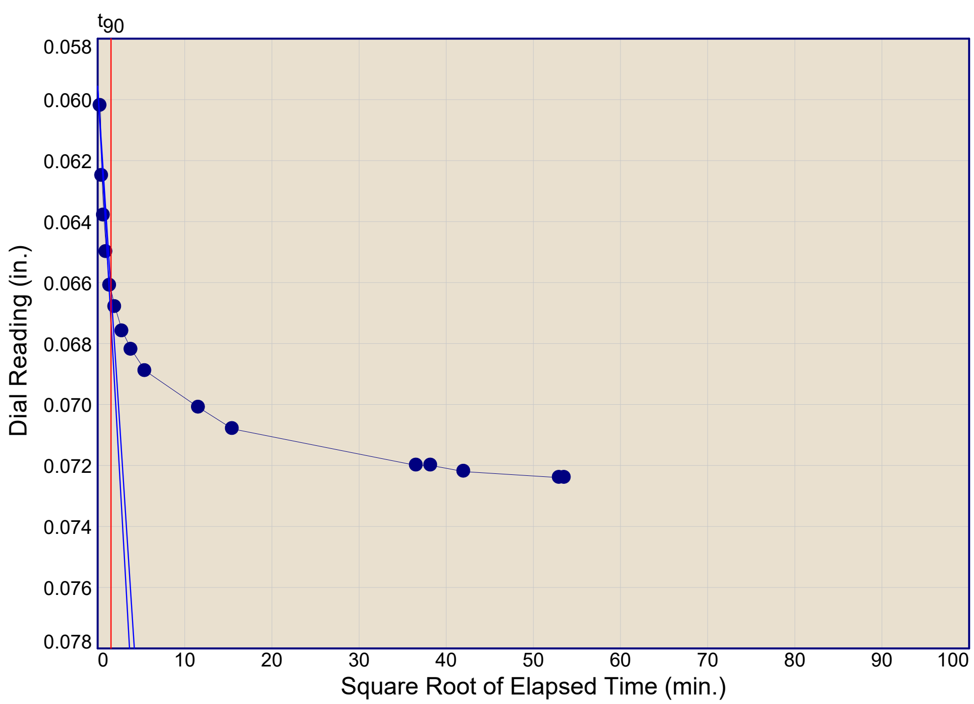
Project No.: 3195.P
Project: Lookout Slough THRFP

Source of Sample: BCI-19-57 Depth: 17.5-17.9' Sample Number: 7-soft



Load No.= 8
Load= 8000 psf
D_0 = 0.0390
D_{90} = 0.0463
D_{100} = 0.0471
T_{90} = 1.48 min.

C_v @ T_{90}
0.728 ft.^{2}/day



Load No.= 9
Load= 16000 psf
D_0 = 0.0596
D_{90} = 0.0662
D_{100} = 0.0670
T_{90} = 2.33 min.

C_v @ T_{90}
0.437 ft.^{2}/day

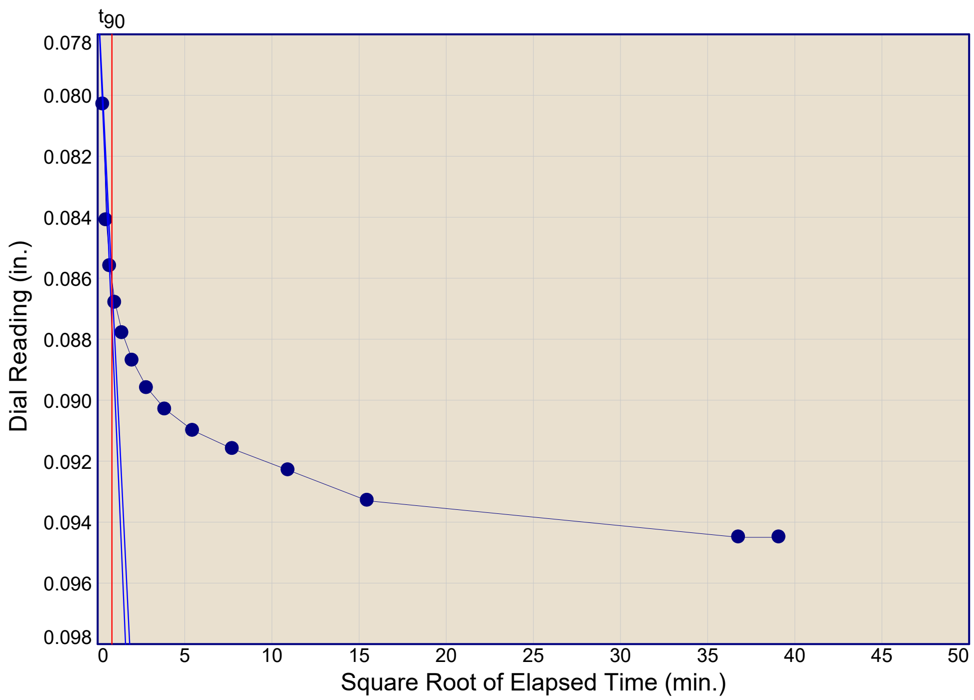
Figure

Blackburn Consulting

Dial Reading vs. Time

Project No.: 3195.P
Project: Lookout Slough THRFP

Source of Sample: BCI-19-57 Depth: 17.5-17.9' Sample Number: 7-soft



Load No.= 10

Load= 32000 psf

D_0 = 0.0765

D_{90} = 0.0860

D_{100} = 0.0871

T_{90} = 0.67 min.

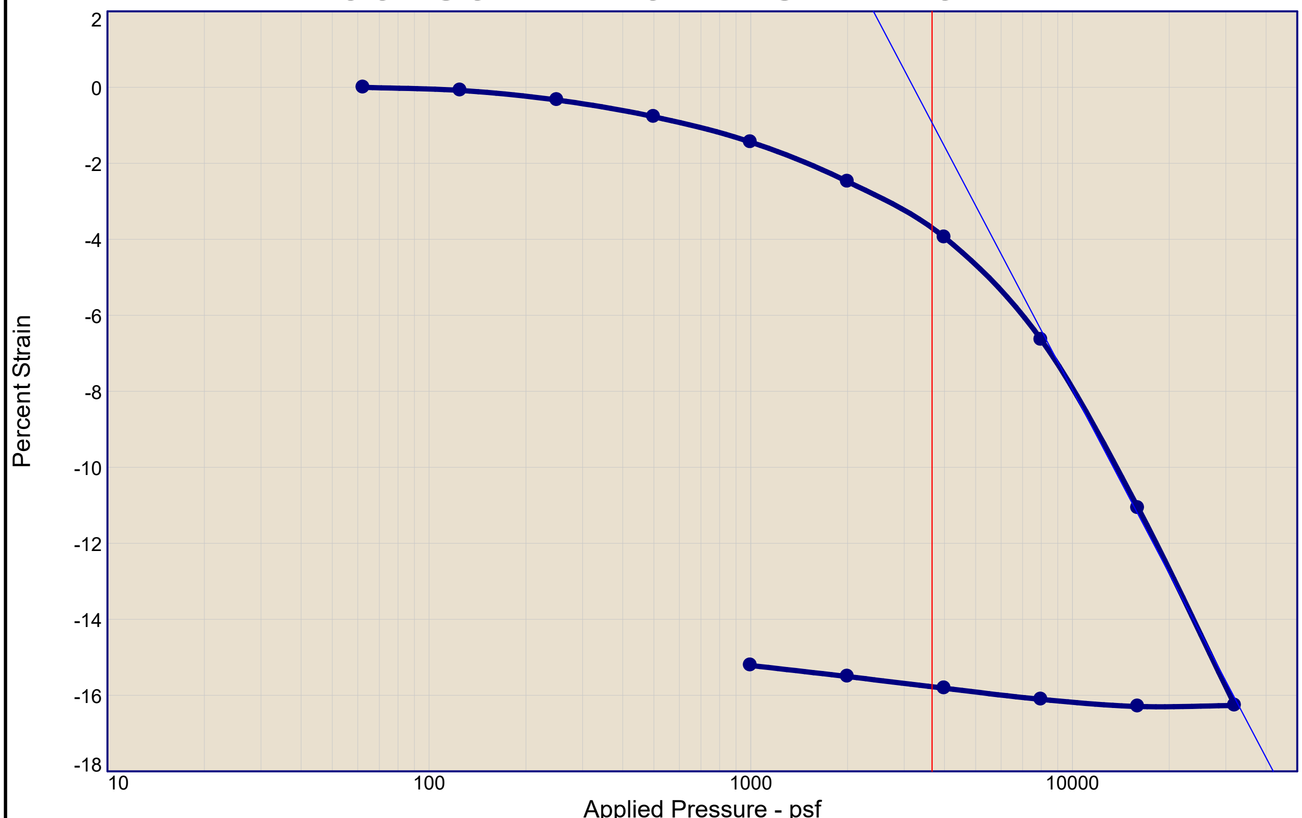
C_v @ T_{90}

1.435 ft.^{2}/day

Figure

Blackburn Consulting

CONSOLIDATION TEST REPORT



Coefficients of Consolidation and Secondary Consolidation											
No.	Load (psf)	C_v (ft.^{2}/day)	C_α	No.	Load (psf)	C_v (ft.^{2}/day)	C_α	No.	Load (psf)	C_v (ft.^{2}/day)	C_α
4	500.00	0.070									
5	1000.00	0.125									
6	2000	0.177									
7	4000	0.117									
8	8000	0.422									
9	16000	1.530									
10	32000	0.734									

Natural		Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (psf)	P_c (psf)	C_c	C_r	Initial Void Ratio
Saturation	Moisture									
67.2 %	21.7 %	90.1	25	4	2.70	2100	5955	0.30	0.02	0.871

MATERIAL DESCRIPTION	USCS	AASHTO
SANDY SILTY CLAY, yellowish brown	CL-ML	

Project No. 3195.P **Client:** EIP

Project: Lookout Slough THRFP

Source of Sample: BCI-19-57 **Depth:** 18.4-18.6 **Sample Number:** 7-firm

Blackburn Consulting

W. Sacramento, CA

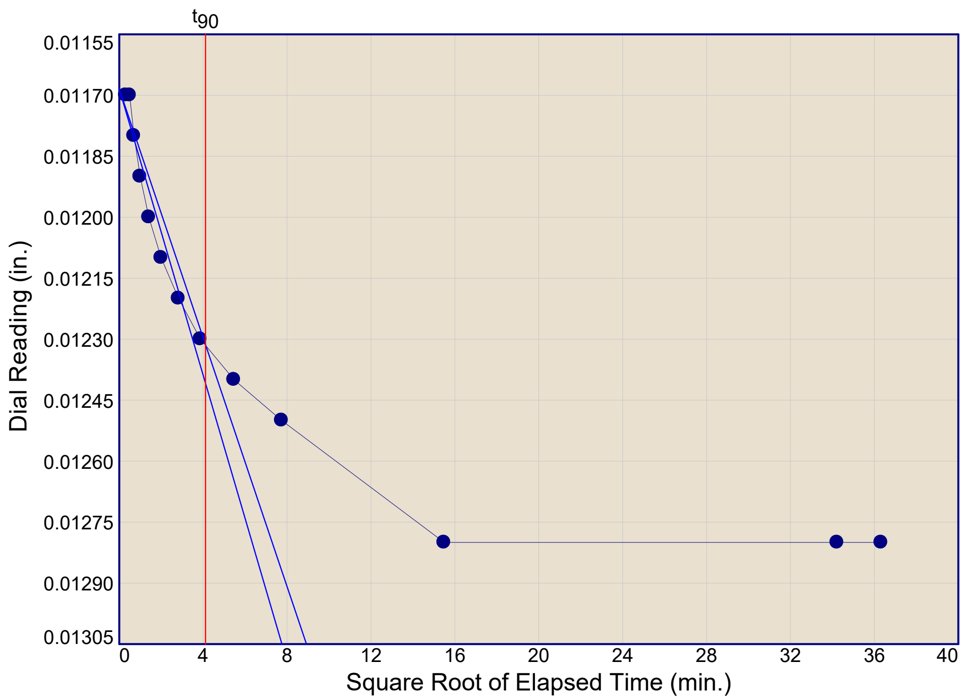
Remarks:

Figure

Dial Reading vs. Time

Project No.: 3195.P
Project: Lookout Slough THRFP

Source of Sample: BCI-19-57 Depth: 18.4-18.6 Sample Number: 7-firm



Load No.= 4

Load= 500.00 psf

D_0 = 0.0117

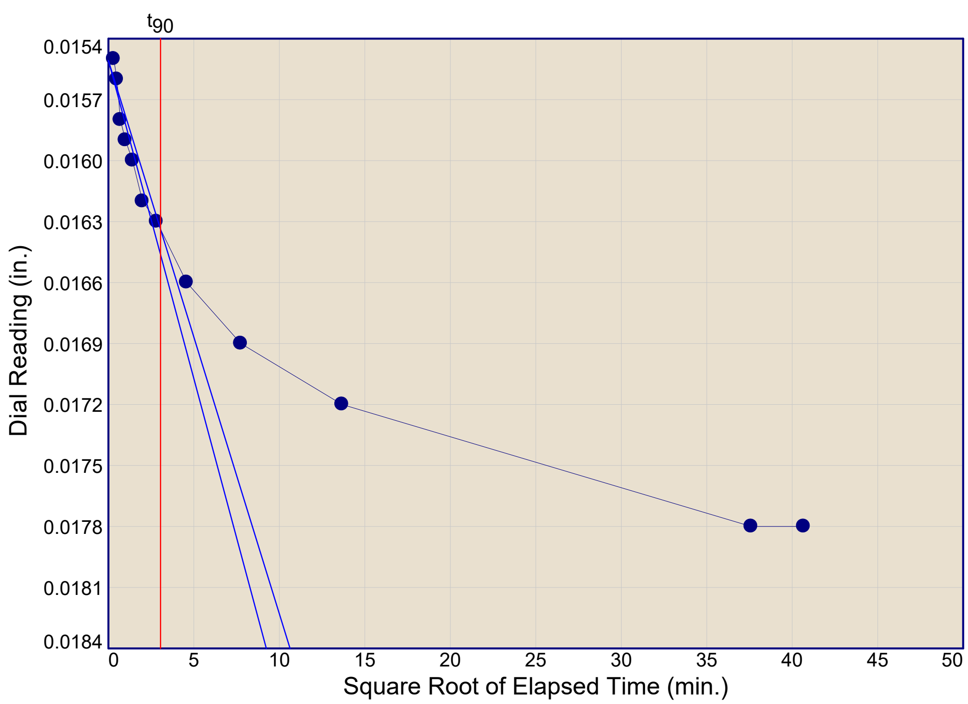
D_{90} = 0.0123

D_{100} = 0.0124

T_{90} = 16.95 min.

C_v @ T_{90}

0.070 ft.^{2}/day



Load No.= 5

Load= 1000.00 psf

D_0 = 0.0155

D_{90} = 0.0163

D_{100} = 0.0164

T_{90} = 9.29 min.

C_v @ T_{90}

0.125 ft.^{2}/day

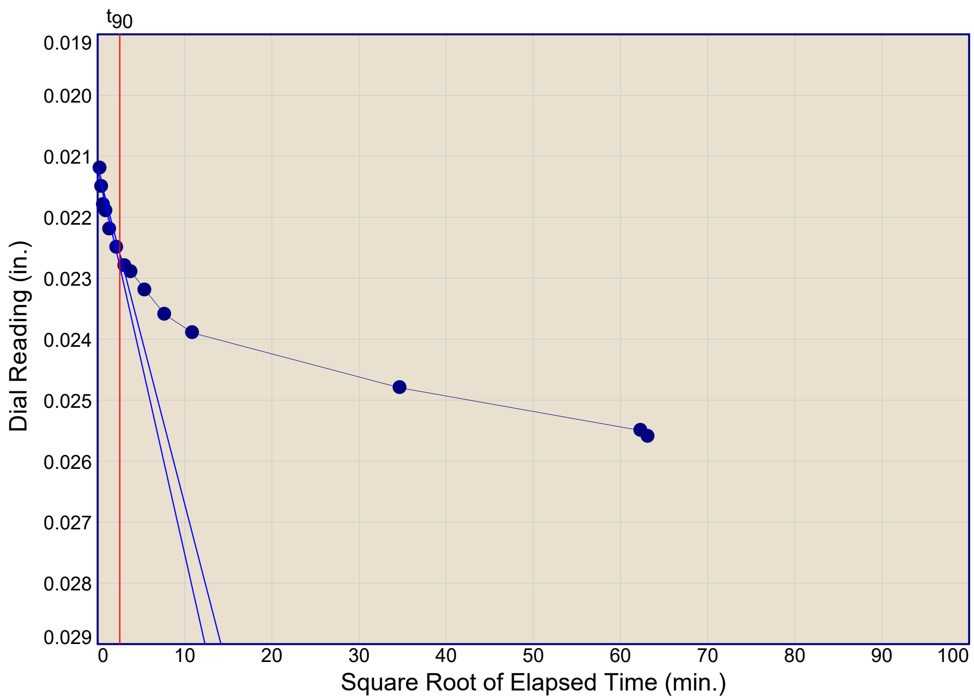
Figure

Blackburn Consulting

Dial Reading vs. Time

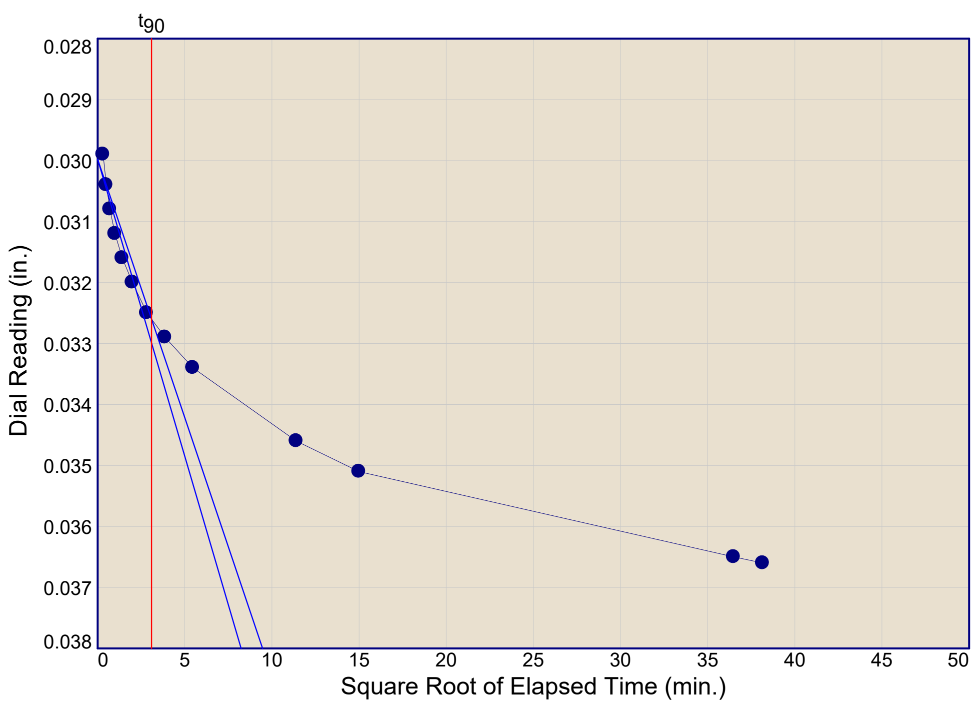
Project No.: 3195.P
Project: Lookout Slough THRFP

Source of Sample: BCI-19-57 Depth: 18.4-18.6 Sample Number: 7-firm



Load No.= 6
Load= 2000 psf
D_0 = 0.0212
D_{90} = 0.0226
D_{100} = 0.0228
T_{90} = 6.47 min.

C_v @ T_{90}
0.177 $ft.^2$/day



Load No.= 7
Load= 4000 psf
D_0 = 0.0300
D_{90} = 0.0326
D_{100} = 0.0329
T_{90} = 9.57 min.

C_v @ T_{90}
0.117 $ft.^2$/day

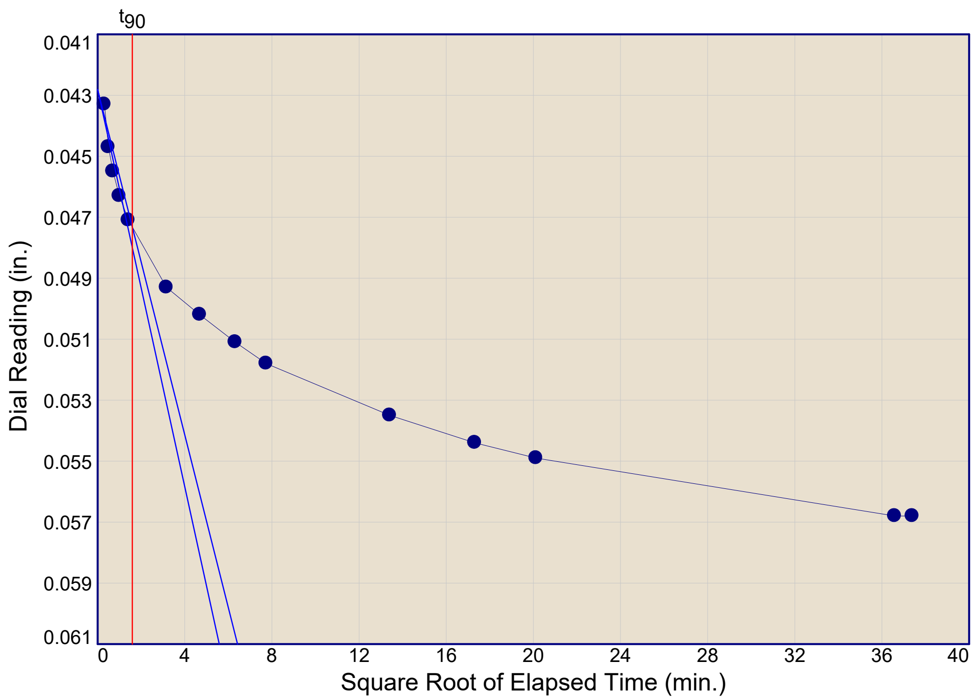
Figure

Blackburn Consulting

Dial Reading vs. Time

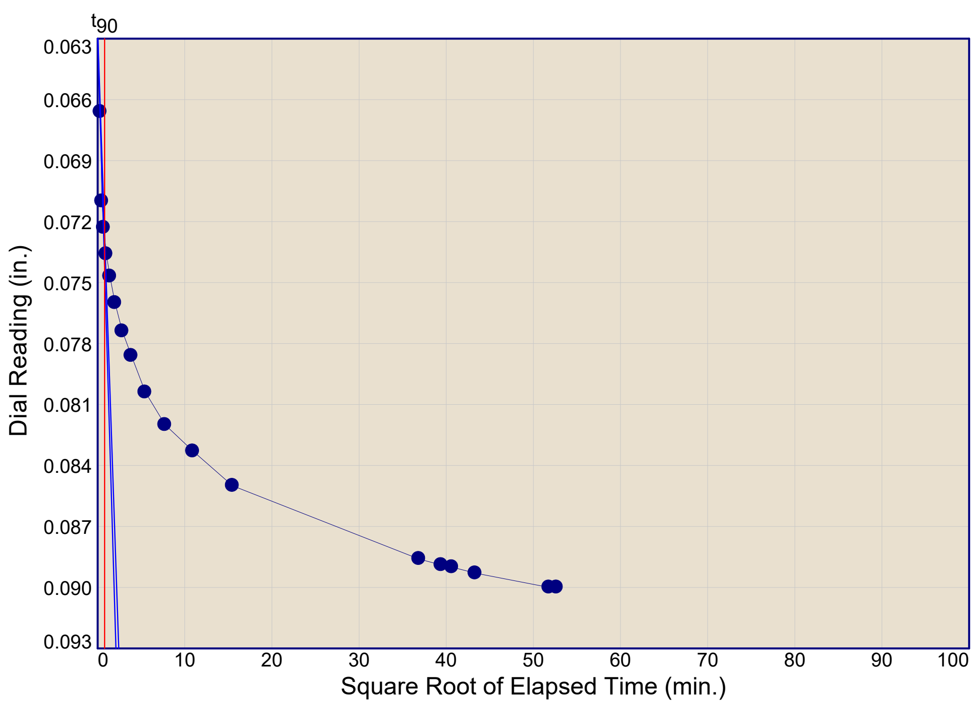
Project No.: 3195.P
Project: Lookout Slough THRFP

Source of Sample: BCI-19-57 Depth: 18.4-18.6 Sample Number: 7-firm



Load No.= 8
Load= 8000 psf
D_0 = 0.0428
D_{90} = 0.0473
D_{100} = 0.0478
T_{90} = 2.54 min.

C_v @ T_{90}
0.422 ft.^{2}/day



Load No.= 9
Load= 16000 psf
D_0 = 0.0627
D_{90} = 0.0727
D_{100} = 0.0739
T_{90} = 0.65 min.

C_v @ T_{90}
1.530 ft.^{2}/day

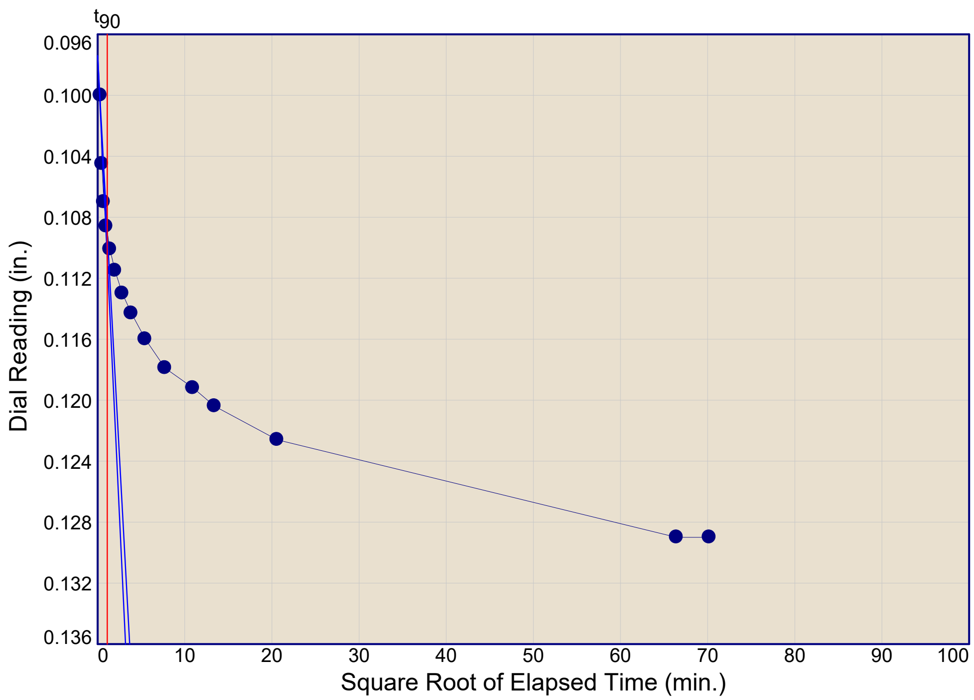
Figure

Blackburn Consulting

Dial Reading vs. Time

Project No.: 3195.P
Project: Lookout Slough THRFP

Source of Sample: BCI-19-57 Depth: 18.4-18.6 Sample Number: 7-firm



Load No.= 10

Load= 32000 psf

D_0 = 0.0974

D_{90} = 0.1090

D_{100} = 0.1102

T_{90} = 1.21 min.

C_v @ T_{90}

0.734 ft.^{2}/day

Figure

Blackburn Consulting

Appendix B.2

Draft 65% Geotechnical Basis of Design Report

This Page Intentionally Left Blank

DRAFT GEOTECHNICAL BASIS OF DESIGN REPORT 65% DESIGN

LOOKOUT SLOUGH TIDAL HABITAT RESTORATION AND FLOOD IMPROVEMENT PROJECT

Prepared For:

Ecosystem Investment Partners
5550 Newbury St.
Baltimore, Maryland 21209

Contact: David Urban
david@ecosystempartners.com

Prepared By:

Blackburn Consulting
2491 Boatman Ave
West Sacramento, CA 95691

Contact: Nicole Hart
nicoleh@blackburnconsulting.com

Date: September 2019

Ecosystem Investment Partners

blackburn consulting

This Page Intentionally Left Blank

West Sacramento Office: (916) 375-8706
2491 Boatman Ave
West Sacramento, CA 95691

blackburn consulting

Main Auburn Office: (530) 887-1494
Fresno Office: (559) 438-8411

Geotechnical ▪ Geo-Environmental ▪ Construction Services ▪ Forensics

BCI File No. 3195.x
September 26, 2019

Mr. David Urban
Director of Operations
Ecosystem Investment Partners
5550 Newbury Street
Baltimore, MD 21209

Subject: **DRAFT GEOTECHNICAL BASIS OF DESIGN REPORT – 65% Design**
Lookout Slough Tidal Habitat Restoration and Flood Improvement Project
Solano County, California

Dear Mr. Urban,

Blackburn Consulting (BCI) is pleased to submit this Draft Geotechnical Basis of Design Report (Draft GBODR) for 65% Levee Design associated with the Lookout Slough Tidal Habitat Restoration and Flood Improvement Project in Solano County, California. This Draft GBODR replaces BCI's May 2019 Draft 60% GBODR for the Project.

The findings and recommendations in this report are draft, intended for 65%-level design, and should not be relied on for final design or construction. Findings and recommendations may change as design progresses. Subsequent 90% and/or 100% updates of this report prepared by BCI will contain findings and recommendations for final design and construction.

Thank you for including BCI on your team for this important project. Please call if you have questions or require additional information.

Sincerely,

BLACKBURN CONSULTING

Prepared by:

Nicole C. Hart, P.E.
Senior Project Engineer

Reviewed by:

REGISTERED PROFESSIONAL ENGINEER
ROBERT B. LOKTEFF
No. 2589
GEOTECHNICAL
STATE OF CALIFORNIA

Robert B. Lokteff, G.E., P.E.
Principal

Copies: 1 to Addressee (PDF)

This Page Intentionally Left Blank

TABLE OF CONTENTS

TABLE OF CONTENTS (cont.)

1 INTRODUCTION

1.1 Purpose and Scope

Blackburn Consulting (BCI) prepared this Draft Geotechnical Basis of Design Report (Draft GBODR) for 65% Levee Design associated with the Lookout Slough Tidal Habitat Restoration and Flood Improvement Project (Lookout Slough THRFIP) in Solano County, California. BCI prepared this Draft GBODR for Ecosystems Investment Partners (EIP) to support the design-build team's 65% design of the Lookout Slough THRFIP. This report updates and replaces the May 2019 DRAFT 60% Design GBODR BCI prepared for the Lookout Slough THRFIP.

This 65% Draft GBODR contains relevant information and analysis results from the May 2019 DRAFT 60% GBODR and updated information and analysis results based on the following:

- The September 2019 Draft Geotechnical Data Report (GDR) prepared by BCI that contains site topography, geology and geomorphology, historical explorations, and BCI's exploration and laboratory testing program for the Duck Slough Setback Levee (DSSL) completed to date.
- Review of geotechnical evaluations prepared by others including descriptions of the existing levees within the project area, past performance and levee improvements to those levees, and explorations and laboratory tests performed by others that are relevant to the Lookout Slough THRFIP.
- Several meetings with EIP and the design-build team to discuss and obtain consensus regarding 65% geotechnical design parameters and methodology.
- Preliminary comments provided by the USACE, the Safety Assurance Panel (SAR), and the Department of Water Resources (DWR) on the Draft 30% GBODR.
- Preliminary comments provided by the SAR panel and the DWR on the Draft 60% GBODR.
- The April 2019 Draft Hydrologic and Hydraulic System Analysis, Lookout Slough Tidal Habitat Restoration and Flood Improvement Project (H&H Analysis), prepared by Environmental Science Associates (ESA).
- The September 2019 Draft Geotechnical Borrow Report (Borrow Report) prepared by BCI and submitted under separate cover. The Draft Borrow Report presents a summary of BCI's evaluation of on-site borrow performed to date for the Lookout Slough THRFIP.
- Updated Geotechnical Plan and Profile sheets that reflect the new 65% design centerline location and stationing, levee geometry, and information from exploratory borings and laboratory tests.
- Seepage, slope stability and settlement analysis updated with 65% design information.
- Seismic vulnerability evaluation for the DSSL.
- Preliminary information from explorations drilled in August 2019 at the DSSL tie-in locations (laboratory testing in progress).

1.2 Project Overview

The Lookout Slough THRFIP will create more than 3,000 acres of habitat for listed and vulnerable native species within a portion of Reclamation District 2068 (RD 2068) including upland, tidal, subtidal, and floodplain habitat for Delta Smelt, Longfin Smelt, Steelhead Salmon, Splittail, Giant Garter Snake, and other species. In addition to habitat creation, the Lookout Slough THRFIP would provide 40,000 to

50,000 acre-feet of seasonal floodplain storage. A Lookout Slough THRFIP Vicinity Map is presented as Figure 1.

To create tidal, subtidal, and floodplain habitat, the Lookout Slough THRFIP will breach the Shag Slough Levee (SSL) at several locations and construct the new DLLS to maintain Yolo Bypass flood protection to areas outside of the Lookout Slough THRFIP area. EIP retained BCI to perform geotechnical engineering services associated with DSSL design, borrow material evaluation within the site area, and design of PG&E tower access roads that extend to the distribution towers located within the site area. Geotechnical recommendations for the PG&E towers are presented in separate Technical Memorandums prepared by the design-build team. In addition, the design-build team is preparing a separate Hass and Cache Slough Levee Technical Memorandum that provides an evaluation of possible impacts the Lookout Slough THRFIP may have on the existing Hass and Cache Slough levees. Figure 2 presents the Lookout Slough THRFIP site limits and includes the DSSL alignment, PG&E distribution tower alignment with proposed access road locations, and proposed SSL breach areas.

1.3 Project Datum

BCI references the Elevations in this report in feet based on the North America Vertical Datum of 1988 (NAVD88). The horizontal datum is based on California State Plane Zone 2.

1.4 Geotechnical Data

The 65% Draft GDR contains the geotechnical data compiled to date to support the Lookout Slough THRFIP geotechnical levee analysis and recommendations. The data includes information from BCI's subsurface evaluations, field explorations, and laboratory tests. To date, BCI has completed forty-three (43) exploratory borings and five (5) cone penetrometer tests to support design and meet the USACE criteria regarding the number of explorations needed for levee design evaluation.

The USACE and Central Valley Flood Protection Board (CVFPB) approved the 408 permit on August 8, 2019, which included the Drilling Program Plan (DPP) to drill explorations on the SSL and the Hass and Cache Slough East Levees. After approval, BCI drilled four exploratory borings in August 2019 for DSSL tie-in analysis; two explorations on the Hass Slough East Levee at the southern tie-in, and two explorations on the SSL at the northern tie-in. BCI also drilled two exploratory borings on the Hass and Cache Slough East Levee to obtain information for the Hass and Cache Slough Levee Technical Memorandum. Additional CPTs are planned along the Hass and Cache Slough East Levee in early October 2019. Laboratory testing for the above exploratory borings is in progress. Test results will be included in subsequent GDR reports completed for the project.

2 RELEVANT EVALUATIONS BY OTHERS

2.1 Available Reports

BCI obtained relevant information regarding the existing levees within the Lookout Slough THRFIP area from the following available reports:

- April 2011 *Geotechnical Assessment Report, North NULE Project Study Area, Volume 1 of 6, Non-Urban Levee Evaluations Project Contract 4600008101, Task Order U104,* (2011 NULE) prepared by URS;

- August 2011, *Remedial Alternatives and Cost Estimates Report (RACER), North NULE Study Area, Non-Urban Levee Evaluations Project, Contract 4600008101, Task Order U107,* (2011 RACER), prepared by URS;
- January 2011, *Final Geomorphology Technical Memoranda and Maps, North NULE Area Geomorphic Assessments, Non-Urban Levee Evaluations Project, Contract 4600008101,* (2011 Geomorphology TM), prepared by URS.
- May 1986, *Right Bank Yolo Bypass and Left Bank Cache Slough near Junction Yolo Bypass and Cache Slough, Levee Construction, General Design, Supplement No. 1 to Design Memorandum No. 13*, prepared by the USACE.
- November 1988, *Levee Construction Right Bank Yolo Bypass & Left Bank Cache Slough,* prepared by the USACE, Sacramento District.
- February 1993, *Attachment B Basis of Design Geotechnical Evaluation of Levees for Sacramento River Flood Control System Evaluation, Lower Sacramento River Area, Phase IV,* (1993 USACE BODR Attachment B), prepared by the USACE. Attachment B contains the Initial Appraisal Report – Lower Sacramento Area. BCI could not obtain a copy of the full 1993 USACE BODR.

The above reports refer to Hass Slough as Haas Slough. We have therefore kept consistent with this nomenclature when referring to the historical information.

2.2 Existing Levee Information for the Lookout Slough THRFIP Area

The 2011 NULE presents information with sub-area segments. Area 5, West Delta Levees, includes the levees within the Lookout Slough THRFIP area. These levee segments include:

- Levee Segment 153, located along the right bank of the Yolo Bypass (or Shag Slough),
- Levee Segment 313, located along the left bank of Cache Slough, and
- Levee Segment 312, located along left bank of Haas Slough (the southern end within the Lookout Slough THRFIP Area).

Based on the 2011 NULE, limited information exists on levee construction and assumes that soil adjacent to the levee segments was used for levee construction. The 2011 NULE infers that the subsurface stratigraphy below the levee segments consists of fine-grained material, interbedded in localized areas, with Delta peat and mud.

The 1986 USACE Levee Construction report addressed the 2.4-mile section of the southern tip of the Liberty Farm mitigation measures. This report refers to a departure from the original project plan, which had proposed mitigating the 2.4-mile southern tip. Instead, the selected alternative included a new cross levee connecting the SSL to the Cache Slough East Levee. The 1988 plans show this alternative.

The 1993 USACE BODR Attachment B provides subsurface information collected at the site with an evaluation of pre-1986 borings, and borings performed in 1990 and 1991. Within this report, the USACE states that the levee and foundation systems are extremely complex.

It is important to note that the 2011 NULE report includes the cross levee presented on the 1988 USACE plans in Levee Segment 153 (Right Bank Shag Slough) as discussed below in Sections 2.2.1. However, the USACE National Levee Database (NLD) instead places this levee segment in RD 2098 – Cache Slough-Haas Slough – Unit 2, Cache Slough. BCI therefore provides a separate section for the Cross Levee in

Section 2.2.4 below and includes the cross levee in the SSL section as it pertains to information provided in the 2011 NULE.

BCI summarizes the information provided in the 2011 NULE and the USACE reports and plans in Sections 2.2.1 through 2.2.4 below. Where available, specific Levee Segment information is provided. Appendix A of this report contains figures extracted from the 2011 NULE that show the respective levee mile identifications for each Segment discussed below. Appendix A also contains a Past Performance Map that presents Reported Levee Performance Events summarized in the 2011 NULE.

2.2.1 SSL

The 2011 NULE describes the SSL as Levee Segment 153, which extends from Liberty Island Road, south for 3.6 miles. From levee mile (LM) 3.6 to LM 4.43, the 2011 NULE states that a new levee mile system was implemented with the construction of a new cross levee. The new levee mile system begins at the Yolo Bypass, and extends west for 0.55 miles to the intersection with Cache Slough. The 2011 NULE separates this segment into Reach 1, from LM 0.0 to LM 3.18, and Reach 2, from LM 3.18 to LM 3.6 and LM 0.0 to LM 0.55. Reach 2 is the Cross Levee, described in Section 2.2.4.

The 2011 NULE further states that historical documents indicate that Segment 153 levees were originally constructed in the 1900s predominantly of organic clay and clay dredged from adjacent sloughs and channels. Levee geometry included 3H:1V riverside and 2H:1V landside slopes. USACE widened and raised the levees in 1961 with borrow material dredged from the Deep-Water Ship Channel and borrow along Cache Slough. New levee geometry included 3H:1V landslide and waterside slopes with a 40-foot berm on each side. Due to several failed PL 84-99 repair attempts, USACE reconstructed this levee in 1976. For several years, construction repair work continued to bring the Lookout Slough THRFIP levee to design grade.

The 2011 NULE states that historical performance included multiple erosion sites, and significant subsidence and stability problems during construction of the Reach 2 levee system (Cross Levee). Foundation material consists of clay, silt and sand within Reach 1 and compressible peat and organic material within Reach 2.

The 2011 NULE presents subsurface information from the USACE borings extending 25 feet below the ground surface conducted in 1959 and 30- to 40-feet deep borings along Reach 2. These explorations confirm relatively stiff clay within the northern portion of Reach 1 and organic clay up to 30 feet deep in the southern portion of this Segment.

The USACE drilled four explorations, 2 F-91-9, 9A and 2F-91-10, 10A, along this levee segment in 1991. These explorations indicate the levee and foundation materials consist of fat clay and organic clay.

2.2.2 Cache Slough East Levee

The 2011 NULE describes the Cache Slough East Levee as Levee Segment 313, which extends from Reach 2 of Levee Segment 153 (LM 7.2) to the confluence of Haas Slough and Cache Slough to the north (LM 5.3). As discussed above, the NLD reports the Cross Levee as part of the Left Bank Cache Slough Levee. See Section 2.2.4 for a discussion on the Cross Levee based on information from the USACE reports.

Original construction of these levees occurred in the early 1900s with soil most likely obtained from adjacent sloughs. The 2011 NULE states that the original levees were deficient in grade and did not include patrol roads. Similar to Levee Segment 153, sometime between the 1930s and 1960s, USACE improved this levee segment with borrow material generated from the Deep-Water Ship Channel and local borrow areas along Cache Slough. The 2011 NULE LiDAR survey data indicated that the landside slopes vary from 2H:1V to 3.2H:1V. The waterside slopes vary from 1.3H:1V to 3H:1V.

The 2011 NULE reported that, similar to Reach 2 of Levee Segment 153, these improved levees experienced significant distress and subsidence including erosion and landside slumps. Continuous repairs from 1974 to 1980 resulted in similar distress. Some of the landside slumps involved the entire landside slope and, at times, the levee crown.

The USACE drilled five explorations, 2F-91-13, 2F-91-14, 2F-91-15, 5F-62-7, and 5F-62-8, along this levee stretch. The explorations indicate the levee and foundation material generally consist of lean- to fat clay with some interbedded peat layers.

2.2.3 Haas Slough East Levee

The 2011 NULE describes Haas Slough East Levee as Levee Segment 312, which extends along the left bank of Haas Slough from the confluence of Cache Slough then continues north 1.9 miles along Haas Slough, north of the Lookout Slough THRFIP. The section adjacent to the Lookout Slough THRFIP extends from the confluence of Cache Slough to the confluence with Duck Slough. Segment 312 levees were constructed in the early 1900s using dredge material from adjacent sloughs, so the levee likely consist of lean- to fat clay and organic clay. The subsurface conditions below the levees also consists of lean- to fat clay.

Similar to other levees in the area described above, the USACE improved this levee system in the 1930s and 1960s using borrow from dredging operations in the Deep-Water Ship Channel and borrow areas near Cache Slough. The 2011 NULE LiDAR indicates landside slopes from 2H:1V to 5H:1V, with the majority being 2.5H:1V or flatter. Waterside slopes vary but are as steep as 1.5H:1V.

The 2011 NULE states that this levee section experienced landside sloughing at multiple locations during the 1997-1998 flood, both along the waterside and landside slopes.

The USACE drilled three explorations, 2F-91-11,11A, and 2F-91-12, within this levee segment adjacent to the Lookout Slough THRFIP. The explorations indicate the levee and foundation material generally consists of lean- to fat clay with some interbedded peat layers, similar to that encountered in Levee Segment 313.

2.2.4 Cross Levee

The 1986 USACE report presents project background and history that led to the construction of the cross levee at the southern end of the Lookout Slough THRFIP. The southern end of Liberty Farm, along the SSL, experienced substantial subsidence and sloughing both during and after construction improvements in 1961. Through 1973, remedial repair and upgrade construction occurred annually. Repair continued until 1981 when the USACE decided to design a more permanent fix along this levee stretch.

The 1986 report concentrates on the initial selected plan which included 6-feet of freeboard by improving and enhancing the existing levee. Due to cost considerations, the USACE deviated from the proposed plan and selected an alternative plan to construct a cross levee to join Shag Slough to Cache Slough. The existing levees north of the remediation location were also to be widened and/or modified to provide a 20-foot-wide levee crown, 3(H):1(V) waterside levee slopes and 2(H):1(V) landside levee slopes.

The 1988 USACE plans for the Cross Levee show a 20-foot-wide levee crown and 3(H):1(V) waterside and landside slopes with rip rap protection along the waterside slopes to Elevation 7 feet. It appears that the Cross Levee crest elevations were designed to meet the SSL elevation at the tie-in with Shag Slough and slope down to meet the elevation of the Cache Slough East Levee. Based on information provided in the USACE *Supplement to Standard Operation and Maintenance Manual, Sacramento River Flood Control Project, Unit No. 109, West Levee of Yolo Bypass and East Levee of Cache Slough*, the construction of the Cross Levee was completed on November 1, 1989.

3 TOPOGRAPHY, GEOLOGY, GEOMORPHOLOGY, GROUND WATER AND SUBSURFACE SOIL CONDITIONS

3.1 Topography

The 2011 NULE describes the Area 5, West Delta Levees as located within the low-lying portion of the southwestern Sacramento Valley. Within the project area and surrounding sites, small and large canals with associated levees were constructed to aid in irrigation, prevent flooding, and drain the previously saturated, low-lying deposits. Current ground elevations near the proposed DSSL range from Elevation 8 feet to Elevation 6 feet.

BCI reviewed the following available historical topographic maps within the Lookout Slough THRFIP area to identify if historical sloughs or drainage areas crossed the proposed DSSL alignment:

- Courtland Quadrangle Topography, March 1908 Edition, Reprinted in 1914.
- Cache Slough Quadrangle Topography, 1916 Edition.
- Liberty Island Quadrangle Topography, 1952, Photo revised 1968.

A pond feature is identified on both the 1908 and the 1916 topographic maps. This pond feature aligns with the water feature identified on the geomorphology map, discussed below in Section 3.3. BCI did not identify any other historical sloughs or drainage/irrigation channels crossing the proposed DSSL alignment. Appendix A presents the topographic maps overlain with the project limits and the proposed DSSL alignment.

3.2 Geology

The Lookout Slough THRFIP area is located within the northwestern portion of the approximately 50-mile-wide and 400-mile-long Great Valley Geomorphic Province. The Great Valley province is a depositional basin bounded by the Sierra Nevada to the east, the Coast Ranges to the west, and the Klamath Mountains and Cascade Range to the north. The basin is a broad, elongated, northwest trending, structural trough that has been filled with a thick sequence of sediments as much as 20,000 to 40,000 feet thick.

BCI reviewed both the *Geologic Maps of the Sacramento -San Joaquin Delta,* California, Brian F. Atwater, 1982 (1982 Geologic Map), and the *Geologic Map of the Late Cenozoic Deposits of the Sacramento Valley, Sheet 1,* Edward J. Helley and David S. Harwood, USGS Publication MF-1790, 1985 (1985 Geologic Map). Both Geologic Maps indicate the site as generally underlain by Basin Deposits, Undivided/Flood-basin deposits (Holocene) (Qb). This material consists of fine grained silt and clay. Both maps also identify two localized areas are mapped as Lower Member, Modesto Formation (Qml) (1985 Geologic Map) and Alluvium of Putah Creek, Older Alluvium (Pleistocene) Qop near the proposed DSSL alignment and borrow areas. The Qml formation consists of unconsolidated, slightly weathered gravel, sand, silt and clay. These areas are near the water features identified in the geomorphology map discussed below in Section 3.3.

The 1982 Geology Map identifies the northern border of the property as Younger Alluvium of Putah Creek (Holocene and Pleistocene) (Qyp). The border of Qyp closely follows the border between Basin Deposits and Marsh Deposits identified on the geomorphology map. Peat Deposits (Qp/Qpm) extend into the very lower southeast section of the project site on both geology maps. The southern cross levee is located within this deposit. Peat deposits consist of decaying fresh-water plant remains with minor amounts of silt and clay.

Figure 4 presents the site Geologic Map using the 1982 Geology Map. This map more closely aligns with features identified in the geomorphology map and is more specific to the Delta area.

3.3 Geomorphology

The 2011 Geomorphology TM describes the geology of the project area as the Yolo Flood Basin. During times of flood, slow moving inland seas covered this basin. In the existing information listed in Section 2.1, URS describes deposition in such flood basins resulted from slow moving/standing water, with primary sediments consisting of silt and clay. Higher permeability deposits may be locally interbedded, as well as alluvial fan sediments from west or east flowing streams.

The Delta geomorphic domain generally consists of fluvial channels and tidal sloughs. Delta island deposits are late Holocene, unconsolidated and fine-grained organic-rich silt and clay with high water content and peat. Directly adjacent to watercourses, Sacramento River supratidal alluvium and sloughs overlie Delta islands of peat and mud. Natural levee deposits and peat and mud deposits interfinger in the subsurface and create vertical interbedded layers of silt and sand with organic-rich material. The deposits in the Delta are moderately permeable.

The geomorphology underlying the proposed DSSL alignment and extending into the proposed borrow areas generally consists of Basin Deposits (Hn) comprised of fine sand, silt and clay. A localized water area is mapped generally between Station 38+00 to Station 48+00 of the proposed DSSL alignment, and localized Alluvial Fan deposits (Pf) are mapped in the northern portion of the site, generally waterside of the proposed levee alignment. A Holocene Slough Deposit (Hsl) is mapped to extend into the upper northeast corner of the site.

The remainder of the site is generally mapped as Marsh Deposits (Hs) which consist of silt and clay and possible organic rich deposits. Similar to the mapped Qp of the Helley and Harwood Geologic Map, Peat and Muck (Qpm) is mapped in the very lower southwest section of the Lookout Slough THRFIP, near the southern cross levee, but not under the proposed new DSSL alignment. This material consists of interbedded peat and organic-rich silt and clay. Both Historical and Holocene Slough Deposits (Rsl and Hsl respectively) which consist of silt, clay and sand, low-energy channel deposits extend into the Lookout Slough THRFIP predominantly along the western border, apparently originating from Hass and Cache Slough. Refer to Figures 3A and 3B.

3.4 Ground Water

Ground water elevations encountered during recent subsurface explorations are shown on the exploratory borings and test pits logs in the GDR and Borrow Report prepared for this project. This information indicates free ground water from 3 to 20 feet below the existing ground surface (bgs) (approximate Elevation 3 feet to Elevation -7 feet) near the proposed DSSL alignment and landside borrow area. In some explorations, it appears that water was seeping from within the clay blanket layer, while in others, the water appeared to be within discontinuous, thin clayey sand lenses. During test pit excavations, BCI observed ground water seeping from the side walls into the test pit, fluctuating between 5.5 feet to 9 feet bgs. We interpret that the ground water we encountered is a combination of perched water from heavy winter rains, irrigation flooding from ranching operations, and seepage from the nearby canals, sloughs, ditches and the bypass within disconnected sandy clay layers that are more pervious than the overlying and underlying clay.

3.5 Subsurface Conditions Underlying the DSSL Alignment

In general, from Station 0+00 to Station 32+00 and from Station 53+00 to Station 152+00, BCI's subsurface explorations to date indicate that the soil conditions underlying the DSSL alignment consist of a relatively thick (about 35 feet) layer of medium stiff to hard lean-to fat clay to sandy clay, overlying a variable dense to medium dense sand, gravel, silty sand, clayey sand aquifer. We generally encountered the top of the aquifer at an elevation of -30 feet MSL or deeper. In some explorations, we did not encounter an aquifer to the depth explored; and in other explorations, the relatively thick surface clay layer contains variable, discontinuous, relatively thin (less than 5-foot-thick) zones of higher permeability dense to very dense clayey sand, sand with silt and clay, silt and silty sand within the upper 20 feet.

Between Station 32+00 to Station 53+00, the subsurface conditions generally consist of a 5-foot-thick layer of medium stiff to hard lean-to fat clay to sandy clay underlain by relatively permeable layers of medium dense to very dense poorly-to well-graded sand with silt and clay, silty sand, and poorly-to well-graded gravel with sand and clay, up to depths of about 32 feet. The depth to the top of the permeable layers varies. BCI encountered ground water at a depth of about 3 to 7 feet below the surface within this area.

Figures 5A through Figures 5G present the Lookout Slough THRFIP Plan and Geotechnical Profile Figures. These figures present the subsurface soil conditions along the entire levee alignment.

4 DESIGN DSSL WATER SURFACE ELEVATIONS, GEOMETRY AND COMPOSITION

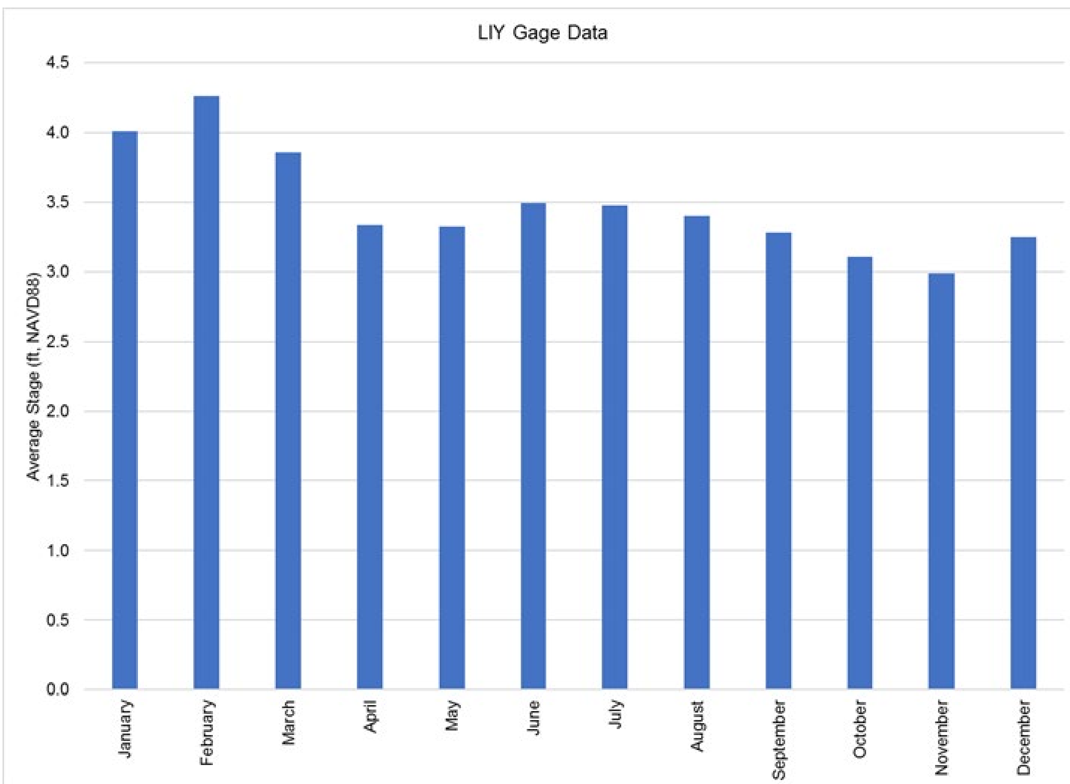
4.1 Design Water Surface Elevations for Steady-State Analysis and Water Surface Elevations for End-of-Construction Analysis

ESA prepared the April 2019 Draft H&H Analysis for the Lookout Slough THRFIP. The H&H Analysis presents a discussion on the Design Water Surface Profile and associated Design Water Surface

Elevations (DWSEs). The analysis compares the 1957 authorized design water surface profile (1957 Profile) with the 100-year design water surface profile along the new DSSL alignment. The H&H Analysis recommends the 1957 Profile for the basis of design water surface elevation for the Lookout Slough THRFIP because it is generally higher than the 100-year profile.

Based on the H&H Analysis, the proposed water surface elevations (WSEs) for geotechnical design include:

- Design Water Surface Elevation (DWSE) for steady-state underseepage and steady-state slope stability analyses equal to the 1957 Profile plus one-foot. The 1-foot adjustment accounts for uncertainties associated with climate change and sea-level rise.
- Average of the Winter and Summer WSE for end-of-construction (EOC) stability analyses. Regulatory design documents do not specify what WSE to use for EOC; however, based on our experience, the standard of care in the area typically evaluates EOC based on the average winter and summer WSEs.
- The design-build team provided BCI with average stage WSEs accessed through http://wdl.water.ca.gov/waterdatalibrary/docs/Hydstra/index.cfm?site=B91510&source=map. Stage daily mean values were taken from the website for each year available between 1995 and 2018, and then grouped by month.



Based on the gage data presented above, BCI used an average WSE = 3.5 feet for EOC analysis. In addition, BCI evaluated one model for the EOC slope stability using the DWSE. The SAR panel suggested we also evaluate EOC at the DWSE because new regulations may include this requirement.

4.2 Levee Composition and Geometry

The California Code of Regulations, Regulations of the Central Valley Flood Protection Board, Title 23, Waters, December 2009 (Title 23) recommends the following for levee construction of a bypass levee:

- At least 20% passing the No. 200 sieve
- Liquid Limit less than 50
- Plasticity Index greater than 8
- 3(H):1(V) landside slope
- 4(H):1(V) waterside slope
- 4-foot to 6-foot freeboard

Title 23 further states that “special construction details (e.g., 4:1 slopes) may be substituted where the soil properties are not easily attainable”. In addition, Title 23 also states “Where the design of a new levee structure utilizes zones of various materials or soil types, the requirements of this subdivision do not apply.”

BCI worked closely with the design-build team to evaluate on-site soil that would be generated from the habitat restoration component of the Lookout Slough THRFIP for DSSL fill. Our evaluation consisted of test pits within the proposed on-site restoration areas located near the proposed DSSL and laboratory tests on representative samples obtained from the test pits. The findings from the test pits and laboratory tests are contained in the 65% Draft Geotechnical Borrow Report prepared by BCI for the Lookout Slough THRFIP and submitted under separate cover.

Based on our Borrow Report findings, the on-site soil meets Title 23 percent passing the #200 sieve and Plasticity Index criteria but does not consistently meet the Liquid Limit criteria. Based on our tests in the borrow pits, the Liquid Limit of the soil from the proposed excavation lateral extents and excavation depths ranges from 31 to 80 with an average of 56. When used for levee fill, cyclical wetting and drying of fat clay (clay with a Liquid Limit of 50 or greater) can result in shrinkage (desiccation) cracks and softening of the clay along the exterior of the levee, which can lead to surficial slumps when the softened soil becomes near-saturated from rainfall. This phenomenon is generally restricted to within about 6 feet (measured perpendicular) of the slope face, and for slopes steeper than about 4(H):1(V).

Considering the potential for softening and slumps, the project design consists of 4(H):1(V) landside slope and 4(H):1(V) waterside slope. The 4(H):1(V) landside and waterside slope is flat enough to account for material with Liquid Limits that exceed 50 and will help mitigate surficial slumping. Desiccation cracks should be expected, but, due to the relative flat 4(H):1(V) slopes, should not result in significant surficial slumps that would impact the performance of the levee.

The design build team set freeboard at 8 feet above the DWSE which includes 6 feet of freeboard above the 1957 Profile, 1-foot for climate change and future adjustments to the DWSE, and 1-foot for anticipated settlement. This design freeboard relates closely to the original design freeboard for the SSL and other similar DSSL projects in the area. The current DSSL crest is set between Elevation 28 feet to Elevation 29.4 feet.

5 GEOTECHNICAL CROSS-SECTION AND DESIGN PARAMETER SELECTION

5.1 Geotechnical Analysis Cross-Section Selection

For 65% design, BCI evaluated DSSL subsurface conditions along the entire alignment to determine cross-sections for steady-state underseepage, steady-state slope stability, rapid drawdown slope stability and end-of-construction slope stability evaluations. To select the cross-sections for analysis, BCI:

- Reviewed the subsurface soil and ground water conditions in explorations completed by BCI near the centerline levee alignment, and both waterside and landside of the planned DSSL alignment.
- Reviewed laboratory test results performed by BCI on soil samples obtained from the exploratory explorations.
- Reviewed geologic and geomorphic mapping of the area.
- Divided the planned levee alignment into sections with similar subsurface conditions based on the information obtained from the above bullet points.
- Developed subsurface stratigraphy models for the different stations.
- Developed and analyzed cross-sections for the different stations.

Based on the above information, BCI developed cross-sections at the following four locations to represent subsurface soil conditions along the entire DSSL alignment:

- Station 6+50
- Station 42+00
- Station 109+50
- Station 148+00

5.2 Unit Weight Selection

For steady-state underseepage evaluation, the average exit gradient criteria is based on the assumption that the saturated unit weights of the "in situ" landside blanket soils are at or above 112 pounds per cubic foot. BCI performed moisture content and density tests on relatively undisturbed samples of the underlying blanket soil obtained from our exploratory borings and test pits. The results indicate that the average dry density ranges from 97 pounds per cubic foot (pcf) to 103.1 pcf (depending on the range of sample depth) and average in-situ moisture content ranges from 23.7% to 28.3% for the CL, CH blanket layer. This results in an average total unit weight range of about 122 pcf to 128 pcf depending on depth below the ground surface. Assuming a specific gravity of 2.65, the saturation of the samples is close to 100% saturation. Therefore, the in-situ blanket layer material exhibits saturated unit weights greater than 112 pcf.

BCI estimated saturated unit weights for each stability analyses cross-section based on laboratory test results presented in the 65% Draft GDR for explorations included in the cross-section stratigraphy.

5.3 Hydraulic Conductivity and Strength Parameter Selection

The steady-state underseepage evaluation requires hydraulic conductivity parameter input, and each individual slope stability evaluation requires strength parameter input. Selection of these parameters considers both the soil properties encountered within the Lookout Slough THRFIP area as well as the specific subsurface soil layering within each cross-section. BCI assigned the soil layer classification for each layer based on the exploration data encountered within a specified cross-section, as well as surrounding explorations within the cross-section area and considered the variable nature of the soil. We took into consideration the varying soil types and non-continuous nature of the soil layering.

BCI presents the rationale used to determine the input parameters for analysis below.

5.3.1 Hydraulic Conductivity Parameter Selection Rationale

To determine the hydraulic conductivity values for steady-state underseepage analyses, BCI performed an evaluation of existing data and laboratory hydraulic conductivity test results obtained by BCI on soil samples obtained at the Lookout Slough THRFIP site. The evaluation included:

- Review of hydraulic conductivity values proposed by BCI and others for nearby projects.
- Laboratory hydraulic conductivity tests on samples of various soil types from the Lookout Slough THRFIP site at in-situ-estimated confining pressures.
- Review of laboratory test results with respect to sample depth and material type.
- Comparison of the laboratory test results with previous and recently reported hydraulic conductivity values proposed by others for nearby projects including the Lower Elkhorn project, which is entering final design.
- Comparison of the proposed parameters with the hydraulic conductivity tests proposed in the April 2015 Guidance Document for Geotechnical Analyses, Urban Levee Evaluations Project, Contract 4600008101, URS.

BCI considered the hydraulic conductivity values determined for the Southport EIP located in West Sacramento, California. The soil types within the Southport EIP Project area are somewhat similar to those that exist within the Lookout Slough THRFIP. BCI determined the Southport EIP values based on an in-depth review of hydraulic conductivity values used by others in the surrounding areas, as well as a detailed evaluation of numerous hydraulic conductivity test results for samples obtained within the Southport project area.

BCI compared the laboratory test values obtained during this evaluation (presented in Table 1) with the values from Southport EIP, the Lower Elkhorn project and the 2015 Guidance Document (shown in Table 2) and made a final determination of the proposed hydraulic conductivity values presented in Table 3 based on soil types encountered within the Lookout Slough THRFIP area.

BCI considered the following in the final determination of the proposed hydraulic conductivity values for 65%-Design:

- Laboratory hydraulic conductivity tests performed by BCI on samples of various soil types from the Lookout Slough THRFIP site at in-situ-estimated confining pressures to confirm parameters used by others in nearby projects.
- The average laboratory test result on the remolded samples for the new DSSL is $K_v = 3.87 \times 10^{-9}$ cm/s. BCI used the more conservative value of $K_v = 2.5 \times 10^{-7}$ cm/s to align with parameters used in similar nearby projects.
- The average laboratory test result for the Lean CLAY, Fat CLAY blanket layer is $K_v = 1.85 \times 10^{-6}$ cm/s. BCI used a more conservative value of $K_v = 2.5 \times 10^{-7}$ cm/s.

5.3.2 Strength Parameter Selection Rationale

To determine strength parameter values for each slope stability analysis, BCI evaluated published data and laboratory strength test results including direct shear and triaxial tests performed by BCI on samples obtained from the Lookout Slough THRFIP site. The evaluation included:

- Review of strength parameter values used by BCI for nearby projects including the Southport EIP. BCI determined the Southport EIP values based on a review of strength parameter values used by others in the surrounding areas, as well as an evaluation of strength test results from samples obtained within the Southport EIP project area.
- Review of strength parameters used by others for nearby projects including the Lower Elkhorn Basin Levee Setback project.
- BCI laboratory strength parameter test results on various soil types at various depths on samples obtained within the Lookout Slough THRFIP area.
- Evaluation of laboratory test results with respect to sample depth and material type.
- Comparison of the proposed parameters with the strength parameters proposed in the April 2015 Guidance Document for Geotechnical Analyses, Urban Levee Evaluations Project, Contract 4600008101, URS.

BCI strength tests performed for the Lookout Slough THRFIP on both in-situ and remolded samples included direct shear tests and triaxial compression tests including Consolidated Undrained with pore-water pressure measurements (CU w/pp). These tests were performed on Shelby tube samples. With a diameter of approximately 3-inches, three, 3-inch by 6-inch samples of the same material type are required for CU w/pp triaxial compression tests. As discussed in Section 3.5, the thick clay layer consists of varying layers of lean-to fat clay to sandy clay, with discontinuous, relatively thin zones of higher permeability clayey sand, silt and silty sand. It was therefore difficult to obtain a continuous 1.5 foot sample of similar material that would produce reasonable CU w/pp triaxial compression test results to obtain both total and effective strengths. BCI performed three CU w/pp triaxial compression tests on specimens of in-situ soil in an attempt to obtain both effective and total strength tests. However, due to sample variability, BCI could not produce reasonable Mohr circles to determine effective strengths from two of the three test results. We therefore considered the total strength parameters from these tests for the Rapid Drawdown slope stability evaluation. For the steady-state slope stability analysis, we considered the effective strength parameters from the one CU w/pp and the direct shear results as well as typical values from previous studies and values obtained and recommended by others.

With regards to CU w/pp triaxial compression tests, BCI evaluated the total and effective friction angle and cohesion at the maximum principal strength ratio, 5% strain, and the maximum deviator stress (if less than 5%). Based on this evaluation, the strength values at the maximum principal strength ratio generally provided the most reasonable results for the remolded specimens and were therefore used for analysis. The strength values at 5% strain provided the most reasonable results on specimens of in-situ clay and were therefore used for analysis.

5.3.2.1 Undrained Shear Strength for Native Clay

To determine the undrained strength of the clay underlying the DSSL for end-of-construction slope stability analysis, BCI reviewed the undrained shear strength data from the BCI CU w/pp triaxial tests at confining pressures similar to the in-situ vertical stress, as well as the Unconsolidated Undrained (UU) triaxial tests. The test results indicate that the undrained shear strength ranges from about 1,039 psf to 4,650 psf with an average undrained strength of about 2,730 psf and are appropriate for design. BCI confirmed these values with the values obtained from the CPT soundings. For analysis, BCI used a conservative value of 1,000 psf in the slope stability models for 65% design. Higher undrained strengths, such as the average values presented in Table 4, would also be appropriate and may be used for final design.

5.3.2.2 Drained/Effective Strength Parameters for Native Clay

BCI's effective strength test results (direct shear) on samples of the clay underlying the DSSL alignment indicate friction angles from about 17 to 34 degrees with an outlier test exhibiting about 41 degrees, and cohesion values from 382 psf to 690 psf with one outlier test result indicating a cohesion of 94.6 psf. The average effective strength parameters from the direct shear tests are a friction angle of about 27 degrees and 463 psf cohesion. One CU w/pp test indicated a drained friction angle of about 31 degrees and cohesion of 391 psf. Based on these results a friction angle of about 29 degrees and cohesion of about 400 psf are appropriate for design. However, based on initial comments provided by DWR, BCI modeled the clay layer using effective and total cohesion values from URS presumptive values document of a friction angle of 30 to 32 degrees and 150 psf cohesion. The cohesion value is significantly conservative and higher effective and total cohesion values may be used for final design.

5.3.2.3 Remolded Strength Parameters for Compacted Levee Fill

BCI's CU w/pp tests on remolded soil samples obtained from the borrow areas indicated total/undrained strength parameters ranging from a friction angle of about 13 to 21 degrees and 165 to 600 psf cohesion with average values of about 16 degrees and 375 psf. These tests also indicated effective/drained strength parameters ranging from a friction angle of about 19 to 27 degrees and 400 to 550 psf cohesion with an average of about 24 degrees and 475 psf. Based on these results total strength parameters of about 16 degree and 375 psf and effective strength parameter of about 27 degrees and 475 psf are reasonable values for design. Based on our review of the test results, we used total strength parameters of 13 degrees and 450 psf and effective strength parameters of 22 degrees and 400 psf in our analysis. DWR indicated a concern using the results of the remolded CU w/pp triaxial compression tests for the analysis; specifically, the use of a cohesion value greater than 200 psf. BCI therefore performed a slope stability sensitivity analysis with a reduced/conservative cohesion value significantly lower than those obtained from the remolded test values. The sensitivity analysis is discussed in Section 7 and presented in Appendix E.

5.3.2.4 Remolded Fully Softened Strength Parameters

BCI performed two remolded Fully Softened Direct Shear tests on material obtained from the borrow area to determine the drained, fully softened friction angle for evaluation of long-term stability of the surficial clay levee soil, which can lose significant strength over cyclical periods of wetting and drying. BCI followed the procedures outlined in the February 20, 2014, *Use and Measurement of Fully Softened Shear Strength*, Bernardo A. Castellanos. The tests indicate a fully softened friction angle of about 19 degrees and no cohesion, which we used in our preliminary analysis for slopes steeper than 4(H):1(V).

6 GEOTECHNICAL ANALYSIS GUIDANCE DOCUMENTS, CRITERIA AND MODEL DEVELOPMENT

6.1 Seepage and Slope Stability Criteria Guidance Documents

BCI developed geotechnical design criteria for steady-state underseepage, steady-state slope stability, rapid drawdown slope stability and end-of-construction slope stability for this Draft GBODR from the following guideline documents:

- California Code of Regulations, Regulations of the Central Valley Flood Protection Board, Title 23, Waters, December 2009.
- USACE, Engineer Manual, EM 1110-2-1913, Design and Construction of Levees, 30 April 2000.
- USACE, Recommendations for Seepage Design Criteria, Evaluation and Design Practices, prepared by the 2003 CESPK Levee Task Force, 15 July 2003.
- USACE, Engineer Manual, EM 1110-2-1902, Engineering and Design, Slope Stability, 31 October 2003.
- USACE, Engineer Technical Letter ETL 1110-2-569, Design Guidance for Levee Underseepage, May 1, 2005.
- USACE, Geotechnical Levee Practice Standard Operating Procedure, Revision 2, 11 April 2008.

6.2 Steady-State Underseepage Criteria

BCI evaluated the average exit gradients for each cross-section under steady-state conditions at DWSE water levels. The average exit gradient is defined as the average head loss per foot traveling upward through the blanket. Elevated average exit gradients may result in sand boils and piping and may potentially lead to levee failure.

For water levels at the DWSE, the average hydraulic exit gradient criteria for steady-state underseepage design include:

Location	Average Exit Gradient
Landside levee toe:	≤ 0.5
Bottom of empty ditch or depression at landside levee toe:	≤ 0.5
Bottom of empty ditch or depression 150 feet to 300 feet from landside levee toe:	≤ 0.8

For ditches between the landside levee toe and 150 feet from the landside levee toe, the acceptable average exit gradient is determined through linear interpolation of the maximum allowable average exit gradient between 0.5 and 0.8.

The average exit gradient criteria summarized above are based on the assumption that the saturated unit weights of the in- situ landside blanket soils and seepage berm (if present) must be at or above 112 pounds per cubic foot, which is applicable to the Lookout Slough THRFIP analyses (see Section 5.5 of this report).

6.3 Slope Stability Criteria

BCI evaluated steady-state slope stability, rapid drawdown slope stability and end-of-construction slope stability analyses at each cross-section. Based on the guidance documents listed above, the required minimum acceptable slope stability factors of safety are:

Condition	Minimum Factor of Safety
Steady-State DWSE:	1.4
Rapid Drawdown:	1.0 to 1.2
End of Construction:	1.3

In some cases where it can be conclusively shown that the levee embankment is composed of impervious soils, or a cutoff wall/impervious core is used, a lower phreatic line through the levee may be justified and used in the steady state analyses and designs per USACE allowances. For this Draft GBODR, BCI used the unadjusted phreatic line determined by the steady-state underseepage analysis for the steady-state slope stability analysis.

6.4 Geotechnical Analysis Model Development

BCI used the following information provided by the design-build team to create each cross-section model:

- Surface topography and bathymetry provided by the design-build team. BCI prepared models for each cross-section to extend landward a minimum of 2,000 feet, and waterside a minimum of 1,000 feet from the levee.
- Cross-section geometry provided by the design-build team including final grading waterside of the DSSL within the habitat area. BCI did not include an inspection trench in the developed models. Currently, for 65% design, BCI recommends a conventional cutoff wall along the levee alignment. The cutoff wall provides the same engineering benefits as an inspection trench and therefore eliminates the need for an inspection trench, which is required by Title 23.
- Historical Yolo Bypass WSEs provided by the design-build team to determine the end-of-construction slope stability WSE considering both the average winter WSE and average summer WSE.
- DWSE provided by the design-build team based on the evaluation presented in the H&H Analysis. The following table presents a summary of the DWSEs provided by the design-build team and used in BCI's analyses.

Design Water Surface Elevations (NAVD D88 ft)		
Station	**1957 WSE (feet)**	**DWSE (1957 WSE + 1 foot) (feet)**
6+50	19.6	20.6
42+00	19.8	20.8
109+50	20.6	21.6
148+00	20.6	21.6

6.4.1 Through-Seepage and Steady-State Underseepage

6.4.1.1 Through-Seepage

If completed, the new DSSL would be constructed of on-site clay with a relatively low permeability that will restrict through-seepage during high water events.

6.4.1.2 Steady-State Underseepage

For 65% design, BCI evaluated steady-state underseepage at the DWSE for each cross-section with and without the recommended cutoff walls.

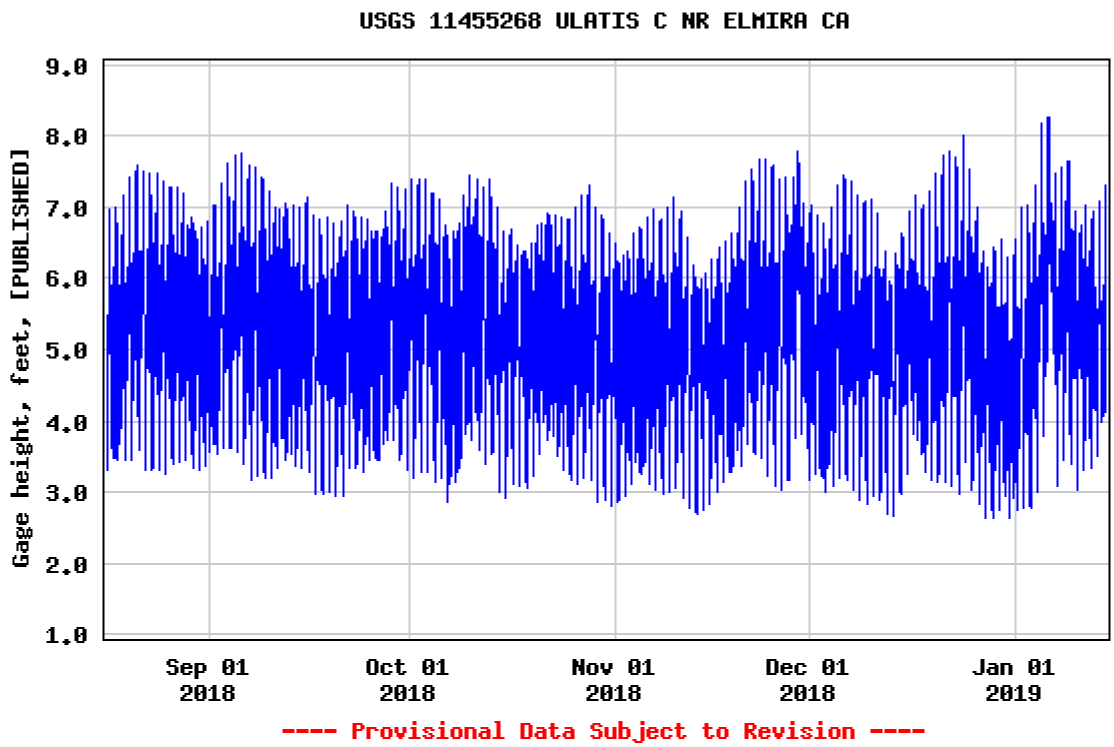
To perform the analysis, BCI used the program SEEP/W, Version 2019, 10.1.0.18696, with the proposed hydraulic conductivity values presented in Table 3 as input parameters. BCI then applied the following boundary conditions to each model:

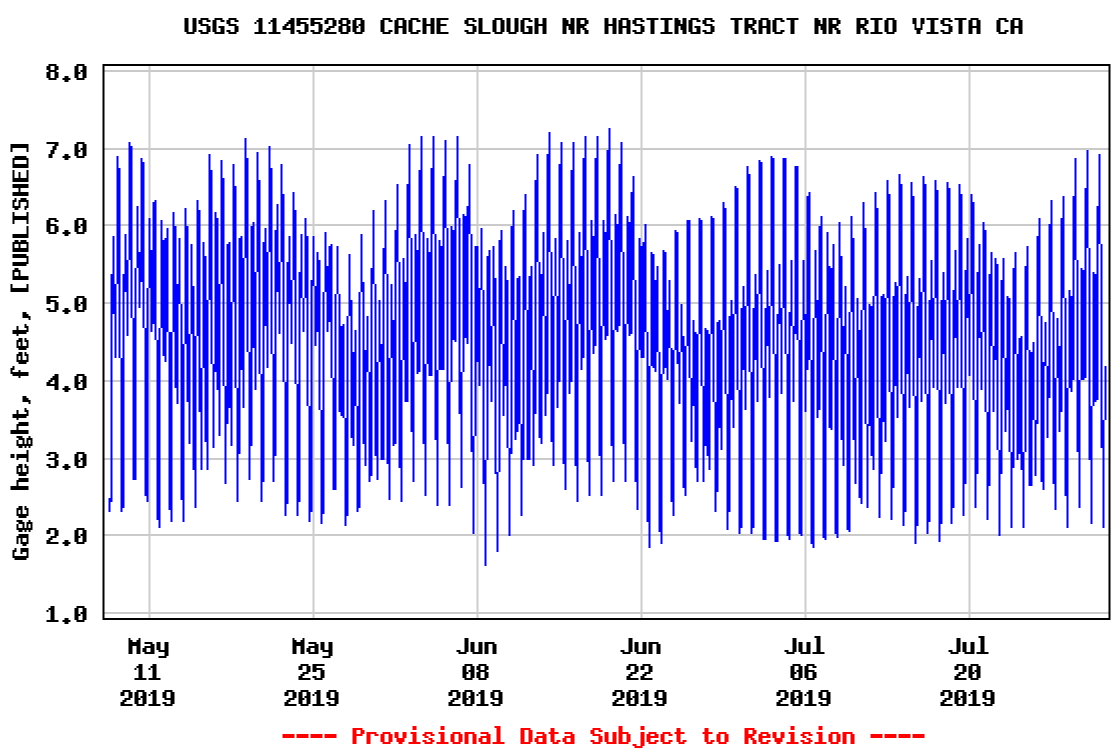
- Fixed-head set to the river stage along the boundary nodes of the waterside levee slope and river bottom.
- Potential seepage surface for nodes on the landside levee slope and landside ground surface.
- No-flow condition along the bottom of the model, and along the waterside vertical edge of the model.
- Total head boundary along the landside vertical edge set to the lower elevation of the landside ground surface elevation at the landside edge, the bottom of the slough landside of the new DSSL or the landside levee toe elevation.

The above boundary conditions are similar to those applied in previous nearby projects by both BCI and the USACE and are recommended in the April 2015 URS Guidance Document.

BCI evaluated Duck Slough, parallel to Lookout Slough along Malcolm Lane, with and without water and the Liberty Island irrigation ditch north of Liberty Island Road without water. BCI spoke with the current lessee of the project area who also leases the property to the north of the project site that includes Duck Slough and will continue to use this property after construction of the Lookout Slough THRFIP. The lessee explained that he uses water within Duck Slough for pasture irrigation and that the Slough always has water, with elevations close to the elevations within Hass Slough as they are hydraulically connected via a gate. In the summer, the gate opens to allow Hass Slough water to enter into Duck Slough and in the winter the gate opens to discharge water from Duck Slough into Hass Slough to reduce flooding potential of the pastures.

To evaluate a reasonable and relatively conservative water surface elevation within Duck Slough, BCI evaluated available gage data in the area. The USGS Water Data for the Nation website, https://waterdata.usgs.gov/nwis, provides gage data at Cache Slough along Hastings Tract and at Ulatis Creek. The data presented for the Cache Slough gage would be more representative of water surface elevations anticipated for Duck Slough. The following graphs were provided by the USGS website:


USGS 11455268 ULATIS C NR ELMIRA CA
Gage height, feet, [PUBLISHED]
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
Sep 01 2018
Oct 01 2018
Nov 01 2018
Dec 01 2018
Jan 01 2019
---- Provisional Data Subject to Revision ----


USGS 11455280 CACHE SLOUGH NR HASTINGS TRACT NR RIO VISTA CA
Gage height, feet, [PUBLISHED]
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
May 11 2019
May 25 2019
Jun 08 2019
Jun 22 2019
Jul 06 2019
Jul 20 2019
---- Provisional Data Subject to Revision ----

Based on the above, a conservative WSE of 4 feet is a reasonable WSE to use within Duck Slough during the year. For steady-state underseepage analysis, at flood levels, this WSE is most likely higher than 4 feet.

6.4.2 Steady-State Slope Stability and End-of-Construction Slope Stability

BCI performed steady-state slope stability and end-of-construction slope stability analyses at each cross-section with and without the recommended cutoff walls.

BCI used the program SLOPE/W, Version 2019, 10.1.0.18696, and the proposed strength parameter values presented in Table 5. BCI's slope stability analyses used the following:

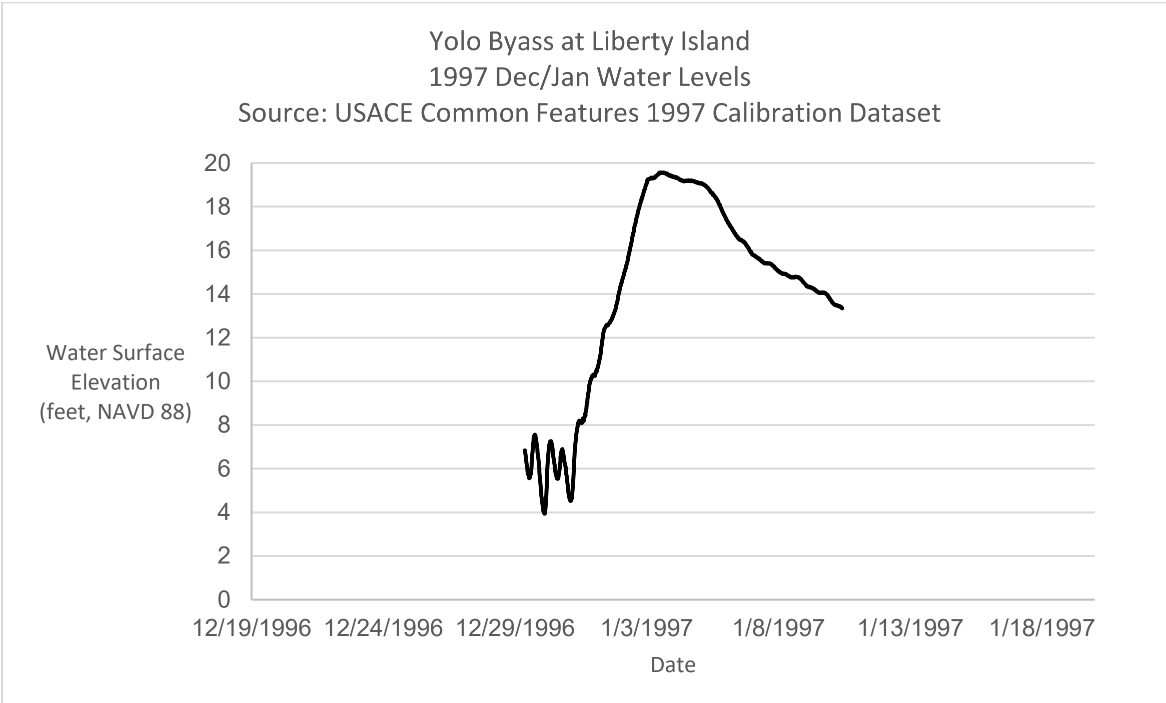
- Spencer's Method, a limit-equilibrium method of analysis.
- A tension crack zone along the levee crest assumed to be 6-feet deep for the steady-state slope stability analyses.
- Effective shear strengths shown in Table 5 and pore water pressures imported from the SEEP/W model for the steady-state slope stability models at the DWSE.
- End-of-construction (EOC) slope stability using the WSE as 3.5 feet (NAVD88) considering average winter and summer WSEs and one model at the DWSE. BCI input undrained shear strengths from Table 5 for slow-draining, fine-grained soil types CL, CH and interbedded layers containing CL and CH. For free-draining material, BCI used the effective strengths presented in Table 5.

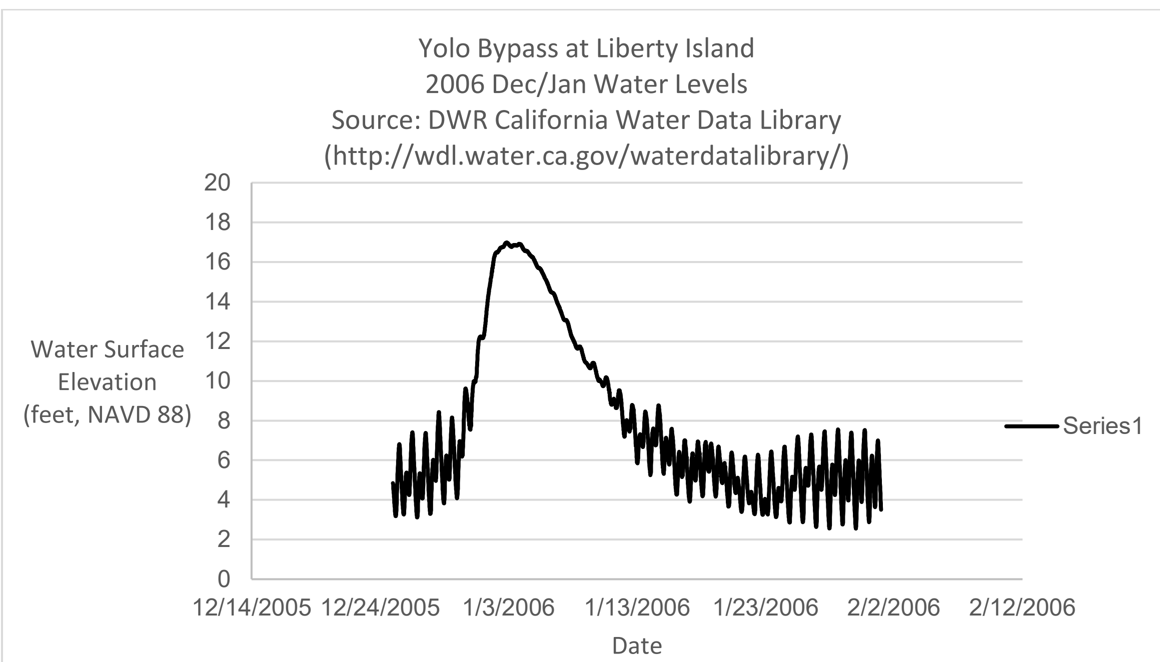
6.4.3 Rapid Drawdown Slope Stability

BCI evaluated the potential for rapid drawdown slope stability to occur along the new DSSL waterside slope. BCI based the analysis on available stage hydrographs provided by the design-build team, drainage properties of native soil underlying the new DSSL alignment, compacted levee fill, past waterside slope performance on existing levees in the area, and duration of pre-drawdown water levels.

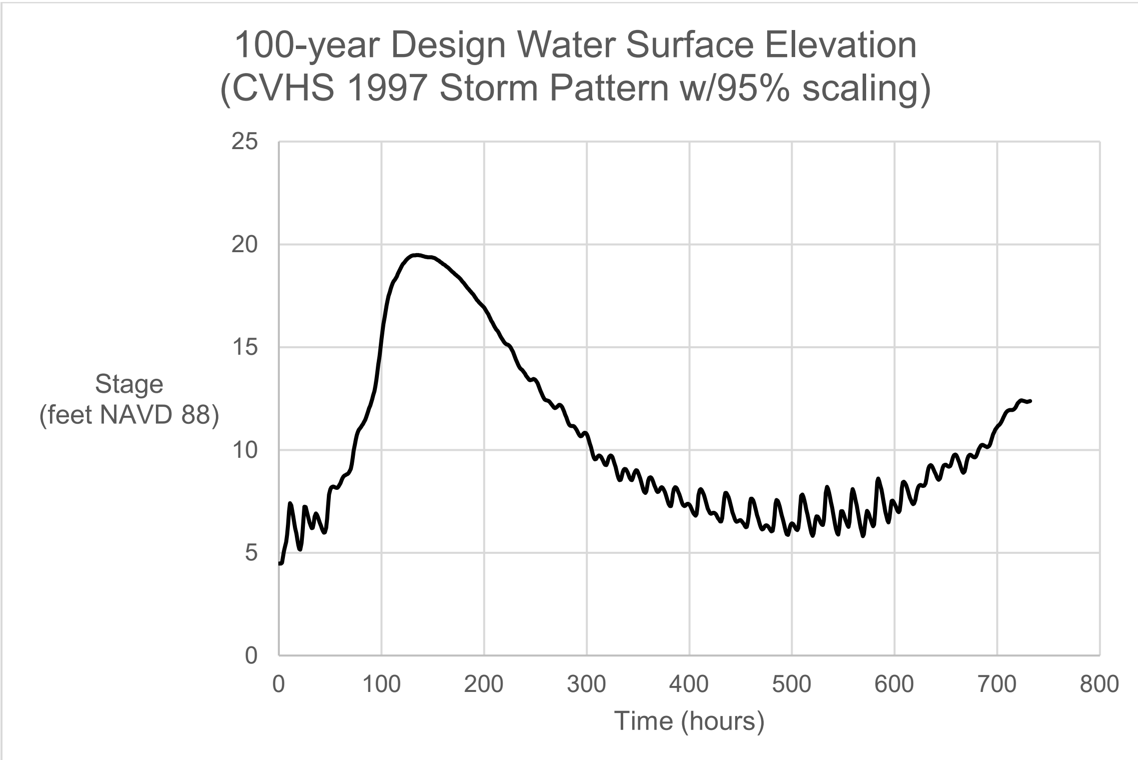
As discussed in Section 2.1, historical erosion sites were identified along the SSL waterside slopes after storm events. This instability may occur when water recedes after storm events, which in turn, may produce a rapid drawdown condition. If completed, the new DSSL would be constructed of clay, which is susceptible to rapid drawdown failures. BCI therefore recommends a rapid drawdown slope stability evaluation of the new DSSL.

Stage Hydrographs
The design-build team provided data from the 1997 flood and 2006 flood events, two of the larger flood events in the past 20 years. This data was collected for Liberty Island at the Yolo Bypass stream gage. The design-build team extracted the 1997 flood data from the USACE's Common Features calibration datasets, and obtained the 2006 flood data from DWR's California Water Data Library to generate the following hydrographs:





BCI then evaluated the simulated 1-in-100-year stage hydrograph provided by the design-build team. To generate the hydrograph, the design-build team scaled the 1997 storm pattern with 95% scaling to prepare the following hydrograph based on the 1957 "design flow", which is a steady-state number.



The hydrographs indicate slightly more than one-foot-per-day drop can be expected after a flood event, with a typical 10-foot drawdown for the 100-year DWSE.

Soil Drainage Properties

In general, clay soil requires a slow drawdown rate to create drained conditions, in the order of less than one-foot-per-day. As information extracted from the hydrographs discussed above indicates drawdowns of up to one-foot-per-day, the clay layers underlying the new DSSL should be modeled as undrained. In addition, the new compacted clay levee fill should also be modeled as undrained after drawdown.

Analysis

BCI used the program SLOPE/W, Version 2019, 10.1.0.18696, and the proposed effective and total strength parameter values presented in Table 5. BCI's rapid drawdown slope stability analyses used the following:

- Spencer's Method, a limit-equilibrium method of analysis, for each stability analysis.
- A 6-foot-deep tension crack zone along the levee crest.
- The rapid drawdown slope stability analysis method in SLOPE/W, which uses the three-stage method developed by Duncan, Wright, and Wong[1]. BCI input the pre-drawdown WSE equal to the DWSE and a drawdown of 10 feet. The analysis used both effective and total shear strengths shown in Table 5 as input into the program. For free-draining material, the analyses use only effective strengths. BCI evaluated waterside stability analysis for each cross-section.

[1] Duncan, J.M., Wright, S.G, and Wong, K.S. (1990), "Slope Stability during Rapid Drawdown". H. Bolton Seed Memorial Symposium, Vol. 2, University of California at Berkeley.

6.4.4 Long-Term Fully Softened Stability of Surficial Clay Levee

BCI performed preliminary stability analysis of the surficial clay levee using fully softened strength parameters. This evaluation indicated unacceptable factors of safety for 3(H):1(V) slopes. We therefore recommend waterside and landside slopes no steeper than 4(H):1(V).

7 GEOTECHNICAL EVALUATIONS AND RECOMMENDATIONS FOR 65% DESIGN

7.1 Through-Seepage, Steady-State Underseepage, Steady-State Slope Stability, Rapid Drawdown Slope Stability, and End-of-Construction Slope Stability

BCI completed steady-state underseepage, steady-state slope stability, rapid drawdown slope stability and end-of-construction slope stability evaluations for each of the cross-sections determined through the process outlined in Section 5.1 of this report. BCI's evaluations considered the DSSL with and without the recommended cutoff wall discussed below. As discussed in Section 6.4.1, the proposed levee fill consisting of lean-to fat clay will mitigate through-seepage.

Between Station 3+50 and Station 32+00 and from Station 53+00 to Station 152+00, the steady-state underseepage and steady-state slope stability, rapid drawdown slope stability and end-of-construction slope stability all met criteria. As discussed above, BCI encountered intermittent, discontinuous layers of material (predominantly sandy clay) in some of the exploratory borings that have a higher permeability than the overlying and underlying soil (generally fat to lean clay). BCI also encountered relatively shallow ground water within some of these explorations near these higher permeable layers. To reduce the potential for nuisance seepage to adjacent properties, BCI recommends a relatively impervious, relatively shallow cutoff wall along the center of the planned levee alignment from Station 3+50 to Station 32+00 and from Station 53+00 to Station 152+00, extending from the ground surface to Elevation -15 feet MSL. The cutoff wall will intersect the intermittent, discontinuous higher permeable soil layers in the upper 20 feet.

Between Station 32+00 to Station 53+00, BCI recommends a relatively impervious, relatively shallow cutoff wall extending from the ground surface to Elevation -40 feet, through the permeable sand and gravel layers and into the underlying clay. The cutoff wall will mitigate uncontrolled underseepage through the near-surface permeable layers from the waterside to the landside of the planned DSSL.

The cutoff wall along the levee alignment will also cut off flow through unidentified old ditches and channel deposits that might pass below the planned levee alignment and mitigate associated constructability issues such as backfilling over wet, unstable soil conditions.
Between Station 3+50 to Station 152+00, the cutoff wall will also eliminate the need for an inspection trench. An inspection trench will be necessary from Station 0+00 to Station 3+50 where there is no cutoff wall.

BCI presents a discussion of the geotechnical analyses for each analyzed cross-section below.

7.1.1 Evaluation Cross-Section at Station 6+50

BCI evaluated the DSSL at Station 6+50 to account for potential hydraulic influences from Hass Slough. The cross-section angles from the existing Hass Slough levee alignment to the DSSL alignment to maintain the shortest path perpendicular to both the existing levee and the DSSL. BCI's evaluation included a waterside pond feature for the Tidal Habitat Restoration and filling in the drainage ditch located landside of the new DSSL based on the direction of the design-build team. The drainage ditch is located between Duck Slough and the new DSSL.

In general, this cross-section represents similar subsurface soil conditions from Station 0+00 to Station 32+00. Our explorations encountered a relatively thick blanket layer of lean-to fat clay to sandy clay from the ground surface to approximate Elevation -32 feet near the new DSSL alignment. An aquifer layer underlies the blanket and generally consists of interbedded relatively permeable soil layers, including poorly-graded sand with clay, clayey gravel, well-graded gravel and well-graded sand with silt.

BCI's steady-state underseepage and steady-state slope stability analyses both with and without the shallow wall indicate that the average exit gradients and slope stability factors of safety meet criteria under the DWSE.

Station 6+50 reflects the model where the new DSSL ties into the Hass Slough East Levee, which may potentially result in an exit gradient higher than that determined with the 2-dimensional model. BCI evaluated the 3-dimensional effects using the recommendations in the 2015 ULE Guidance Document. The 2015 ULE Guidance Document recommends increasing the required average exit gradient calculated by the 2-dimensional model by a range of percentages based on the levee angle created. The tie-in at the Hass Slough East Levee creates an approximate 90-degree angle. The recommended range of increase for a 90-degree angle is from 15 to 25 percent. Considering the high end of this range, 25 percent, the average exit gradients meet criteria with and without the soil-bentonite cutoff wall to Elevation -15 feet (NAVD88). Table 6 presents the results of the 3-dimensional consideration.

Appendix B presents the steady-state underseepage and individual slope stability analysis result exhibits. Tables 6 and 7 present a summary of the results. BCI's analyses at Station 6+50 indicate that the cutoff wall to Elevation -15 feet (NAVD88) satisfy the average exit gradient criteria and slope stability factors of safety criteria.

7.1.2 Evaluation Cross-Section at Station 42+00

BCI analyzed the DSSL at Station 42+00 to evaluate the subsurface soil conditions within the area marked "Water" on the geomorphology map presented in the 2011 Geomorphology TM. The explorations in this area encountered subsurface soil conditions different than elsewhere along the proposed levee alignment. BCI's evaluation included filling in the drainage ditch located landside of the new DSSL based on the direction of the design-build team, similar to the cross-section at Station 6+50 analyses. BCI also included a waterside pond in this analysis, based on the location of the proposed pond near Station 40+00 as shown in Figure 2.

In general, this cross-section represents similar subsurface soil conditions from Station 32+00 to Station 53+00. Our explorations encountered a relatively thin layer of lean-to fat clay overlying an aquifer layer, with the top of the aquifer as shallow as Elevation -2 feet. The aquifer generally consists of interbedded relatively permeable soil layers, including poorly-graded sand, poorly-graded sand with silt, well-graded sand with clay, and well-graded gravel with sand and with clay and extends to Elevation -30 feet to -35 feet under the levee alignment. Lean clay underlies the aquifer.

BCI's steady-state underseepage analysis and steady-state slope stability analysis without the cutoff wall meet criteria at the landside levee toe. The steady-state underseepage analysis exceeds criteria at the Duck Slough toe with and without a soil-bentonite slurry wall when Duck Slough is conservatively modeled empty as discussed above. With the soil-bentonite slurry wall, each slope stability analysis and the steady-state underseepage analysis with a WSE of 4 feet in Duck Slough meet criteria. BCI recommends a relatively impervious shallow soil-bentonite cutoff wall to Elevation -40 feet MSL, through the permeable layers and into the underlying clay.

Appendix B presents the steady-state underseepage and individual slope stability analysis result exhibits. Tables 6 and 7 present a summary of the results. BCI's analyses for Station 42+00 indicate that the cutoff wall to Elevation -40 feet (NAVD88) satisfy the average exit gradient criteria and slope stability factors of safety criteria.

7.1.3 Evaluation Cross-Section at Station 109+50

BCI analyzed the DSSL at Station 109+50 to evaluate the general subsurface conditions along the levee alignment and the close proximity of the landside levee toe with the irrigation ditch north of Liberty Island Road. The subsurface soil conditions past Station 53+00 are similar to those encountered and modeled at Station 6+50. The 65% design indicates the new DSSL with be constructed partially on the existing Liberty Island Road embankment along the northern edge of the property.

At cross-section Station 109+50, the subsurface conditions generally consist of lean clay, with one possible 10-foot thick clayey sand water bearing zone at Elevation -24 feet MSL (NAVD88), interbedded within lean clay. The dashed lines on the subsurface profile indicate this layer is discontinuous.

BCI's steady-state underseepage analysis and steady-state slope stability analysis without the cutoff wall indicate that the average exit gradients and slope stability factors of safety meet criteria under the DWSE water levels.

Appendix B presents the steady-state underseepage and individual slope stability analysis result exhibits. Tables 6 and 7 present a summary of the results. For this cross-section, BCI evaluated the EOC at the DWSE. BCI's analyses at Station 109+50 indicate that the cutoff wall to Elevation -15 feet (NAVD88) satisfy the average exit gradient criteria and slope stability factors of safety criteria.

7.1.4 Evaluation Cross-Section at Station 148+00

BCI evaluated the DSSL at Station 148+00 to account for potential hydraulic influences from the Yolo Bypass. The cross-section angles from the existing SSL alignment to the DSSL alignment to maintain the shortest path perpendicular to both the existing levee and the DSSL.

In general, this cross-section represents similar subsurface soil conditions as those presented on the cross-sections at Stations 6+50 and 109+50. Our explorations near Station 148+00 encountered the top of the aquifer at approximately Elevation -20 feet. The aquifer generally consists of discontinuous layers of poorly-graded sand with silt and with clay, interbedded with the clay. Some explorations did not encounter this aquifer layer. The subsurface soil layer overlying the aquifer consists of a relatively thick blanket layer of lean-to fat clay to sandy clay.

BCI's steady-state underseepage analysis and steady-state slope stability analysis without the cutoff wall indicate that the average exit gradient and slope stability factor of safety meet criteria under the DWSE.

Appendix B presents the steady-state underseepage and individual slope stability analysis result exhibits. Tables 6 and 7 present a summary of the results. BCI's analyses at Station 148+00 indicate that the cutoff wall to Elevation -15 feet (NAVD88) satisfy the average exit gradient criteria and slope stability factors of safety criteria.

Station 148+00 reflects the model where the new DSSL ties into the SSL, which may potentially result in an exit gradient higher than that determined with the 2-dimensional model. BCI evaluated the 3-dimensional effects using the recommendations in the 2015 ULE Guidance Document. As discussed above, the 2015 ULE Guidance Document recommend increasing the average exit gradient calculated by the 2-dimensional model by a range of percentages based on the levee angle created. The tie-in at the SSL creates an approximate 90-degree angle. The recommended range of increase for a 90-degree angle is from 15 to 25 percent. Considering the high end of this range, the exit gradients meet criteria with the soil-bentonite cutoff wall to Elevation -15 feet (NAVD88). Table 6 presents the results of the 3-dimensional consideration.

7.2 Settlement Analysis

BCI performed immediate (elastic) and long-term (consolidation) settlement analyses for the Lookout Slough THRFIP cross-sections. BCI used FoSSA 2.0 Foundation Stress & Settlement Analysis software to determine the magnitude of settlement. BCI used consolidation parameters obtained from consolidation tests conducted for the Lookout Slough THRFIP on samples obtained from the site using Shelby tube sampling methods to minimize disturbance.

BCI used over-consolidation ratios (OCRs) from the consolidation test results and compared the values with CPT data obtained in nearby explorations. BCI's evaluation indicates the clay layers underlying the levee alignment are generally over-consolidated with OCR's ranging from 3 to 10. The CPT data confirms these OCRs. BCI encountered relatively soft clay layers between 14 to 20 feet bgs and from 30 to 33 feet bgs. Although these layers are interbedded with stiffer clay lenses, BCI modeled a continuous clay subsurface profile to evaluate consolidation settlement using the consolidation test results from various samples as presented in the September 2019 GDR.

Our analysis results indicate 1 to 5 inches of elastic settlement could occur during construction, and up to 6 inches of primary consolidation settlement could occur after construction. As discussed, the clay underlying the new DSSL is over-consolidated. Secondary consolidation settlement occurs in sensitive clays, normally consolidated clays, and organic clays. Several sources including Das and Sobhan (2012), and Lambe and Whitman (1969), state that the Rate of Secondary Compression index is negligible for overly-consolidated clays. BCI estimates 5 to 6 inches of settlement could occur after construction at some locations. For 65% design, the design-build team assumed 1-foot of total long-term settlement. Future designs may reduce this value based on BCI's analysis.

Table 8 presents the consolidation parameters used in BCI's analysis. Appendix C contains the settlement results.

7.3 Underseepage Effects at the DSSL Tie-In Locations to the Hass Slough East Levee and the Yolo Bypass West Levee

The new DSSL will tie into the Hass Slough East Levee and the Yolo Bypass West Levee, which will create a condition where water will be introduced against the new levee and immediate adjacent existing levee. This can lead to increased underseepage potential landside of the tie-in caused by the dual seepage sources. To help evaluate this condition, BCI drilled one exploration in August 2019, BCI-19-39, north of the tie-in on the Hass Slough East Levee and one exploration, BCI -19-41, north of the tie-in on the SSL.

Visual classification of the subsurface conditions within BCI-19-39 indicate a 36-foot-thick blanket consisting of 31 feet of lean to fat clay underlain by 5 feet of sandy silt below the Hass Slough East Levee. The blanket is underlain by a poorly-graded sand with silt and poorly-graded sand with silt and gravel aquifer. These subsurface conditions are similar to the subsurface conditions encountered in the cross-section at Station 6+50, and indicate that increased underseepage or elevated seepage gradients should not occur landside of the tie-in and property north of Duck Slough because:

- As discussed in Section 7.1.1, considering a 25 percent increase in exit gradient due to dual direction underseepage at the cross-section at Station 6+50, the average exit gradients at the landside levee toe and at the Duck Slough ditch toe continued to meet criteria without a soil-bentonite cutoff wall.
- A relatively thick clay blanket underlies the Hass Slough East Levee near the tie-in location. We encountered a minimum 36-feet-thick blanket based on visual classification and preliminary laboratory results. BCI-19-38, located just south of BCI-19-39 indicated a 48-thick clay blanket.
- The new DSSL crest is approximately 300-feet minimum from the nearest Hass Slough East Levee toe at the property to the north.

Visual classification of the subsurface conditions within BCI-19-41 indicate lean to fat clay below the SSL. BCI did not encounter an aquifer to the 76.5-foot depth explored. These subsurface conditions reflect the subsurface conditions encountered in the explorations near the cross-section at Station 148+00; and indicate that increased underseepage or elevated seepage gradients should not occur landside of the tie-in because:

- We did not encounter an aquifer in either BCI-19-41 or in BCI-19-57, located just south of BCI-19-41, to the maximum depth of over 75 feet below the existing levee. Therefore, no measurable exit gradient exists in this area.
- The new DSSL crest is greater than 300-feet from the Yolo Bypass West Levee toe at the property to the north.

7.4 Settlement Evaluation at the DSSL Tie-In Locations to the Hass Slough East Levee and the Yolo Bypass West Levee

The new DSSL will tie into the Hass Slough East Levee and the Yolo Bypass West Levee, which may induce settlement of the existing levees. BCI performed a preliminary immediate (elastic) and long-term (consolidation) settlement analyses on cross-sections provided by Wood Rodgers at the two tie-in locations to estimate the magnitude of the settlement and if it could have detrimental impacts on the existing levee at the tie-in locations. BCI will update these evaluations once laboratory tests are complete.

To perform the preliminary analysis, BCI considered the following:

- The subsurface soil condition encountered within BCI-19-39 and BCI-19-40 for the tie-in at the Hass Slough East Levee.
- The subsurface soil conditions encountered within BCI-19-41 and BCI-19-42 for the tie-in at the Yolo Bypass West Levee.
- Comparison of the pocket pen data and pressure required for the Shelby samples within the new explorations with data from the explorations used in the analysis for the DSSL
- The previous consolidation test results performed for the DSSL design by BCI.

Based on the above, BCI created two preliminary models to evaluate immediate and primary consolidation settlement using FoSSA 2.0 Foundation Stress & Settlement Analysis software. The results indicate minimal immediate and primary consolidation settlement at the tie-in locations, which indicates special construction considerations due to settlement may not be required. Final findings and recommendations will be developed following BCI's on-going laboratory testing program and will be included in the 90% GBODR.

7.5 Slope Stability Evaluation at the DSSL Tie-In Locations to the Hass Slough East Levee and the Yolo Bypass West Levee

BCI performed preliminary rapid drawdown and EOC slope stability analyses on cross-sections provided by Wood Rodgers to check stability at the Hass Slough East Levee and Yolo Bypass West Levee (YBEL) tie-ins. We used the strength values used in this GBODR in the analysis. The preliminary Hass Slough East Levee tie-in analysis indicated an EOC FS of 2.04 and a rapid drawdown FS of 1.53. Both of these safety factors meet criteria. The preliminary YBEL tie-in analysis indicated an EOC FS of 1.53 and a rapid drawdown FS of 1.37. Both of these safety factors also meet criteria.

BCI is performing strength tests on relatively undisturbed soil samples obtained in the explorations in both the Hass Slough East Levee and the SSL at the tie-in locations to check these preliminary analyses. BCI will update these evaluations once laboratory tests are complete and provide final findings in the in the 90% GBODR.

7.6 Seismic Analysis

BCI completed a seismic analysis to evaluate the seismic vulnerability of the proposed new DSSL. BCI generally followed the methodology presented in ETL 1110-2-580, *Guidelines for Seismic Evaluation of Levees,* Expires 1 March 2018, USACE. BCI verified with the USACE that these Guidelines are still valid and have not been updated.

To evaluate levee seismic vulnerability, BCI:

- Used an approximate return period of 100 years, defined as 50% probability of exceedance in 75 years.
- Determined site specific Peak Ground Acceleration (PGA) and earthquake Magnitude (M) for an earthquake with a 100-year return period. BCI obtained the PGA from the United States Geological Survey (USGS) website https://earthquake.usgs.gov/hazards/interactive/. BCI determined an average PGA for the levee segment and used an average value where the evaluated PGA is within ±10% of the average value. BCI used a weighted average of major

source contributions as determined from the USGS deaggregation (i.e. all individual seismic sources contributing greater than 2% of the mean hazard).

- Completed liquefaction triggering and seismically induced settlement analysis at select subsurface data locations. BCI used Youd et al., 2001, *Liquefaction Resistance of Soils: Summary Report from the 1996 NCEER and 1998 NCEER/NSF Workshops on Evaluation of Liquefaction Resistance of Soils*, Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Vol. 127, No. 10., pp 817-833. BCI based fine-grained soil susceptibility on Seed et al, 2003, and used a water level, as defined in the USACE Draft publication *Guidelines for Seismic Stability Evaluation of USACE Levees*, equal to the average water level for the wettest month of the year, typically in February.

7.6.1 Site Specific Ground Motion

An estimate of ground motion parameters such as peak horizontal ground acceleration (PGA) and earthquake moment magnitude (M) are necessary for liquefaction analysis. BCI used the USGS Unified Hazards Tool website (https://earthquake.usgs.gov/hazards/interactive/) to complete a probabilistic analysis and develop the peak horizontal ground acceleration (PGA) for an earthquake with a 100-year return period. The USGS 2008 Interactive Deaggregations program is based on source and attenuation models as presented in Petersen, M. and others, 2008, "*Documentation for the 2008 Update of the National Seismic Hazard Maps, USGS OFR 08–1128*," available on the web at http://pubs.usgs.gov/of/2008/1128/.

To estimate the ground motion parameters for the Lookout Slough THRFIP, BCI checked the PGA near the center of the Lookout Slough THRFIP. BCI used Vs_{30} equal to 259 meters per second (mps, approximately 850 feet per second). This velocity is based on the general soil conditions logged in geotechnical borings completed for the Lookout Slough THRFIP by BCI. The 259 mps velocity is the value for Site Class D (Stiff Soil site).

To determine the PGA for an earthquake with a 100-year return period, BCI used the USGS Unified Hazards Tool which determined the PGA for several return periods and plotted the results as a hazard curve. From the hazard curve, the tool calculated a PGA equal to 0.17 for a 108-year return period. A "most likely" earthquake moment magnitude (M) for the event that will cause the PGA of interest is necessary for liquefaction analysis. Deaggregation within the USGS Unified Hazards Tool website allows for determination of the magnitude with the most significant contribution to the ground motion.

For the 100-year return period, the mean M is 6.6; modal M is approximately 6.7. Listed below are the faults that contribute most significantly to the PGA hazard with percent contribution and magnitude shown (from deaggregation at the 108-year return period level).

Fault Name	Contribution (%)	Magnitude
Green Valley	5.11%	6.83
Great Valley 5 Pittsburg – Kirby Hills alt1	4.05%	6.34
Great Valley 4b, Gordon Valley	2.83%	6.65
Rodgers Creek – Healdsburg	2.53%	7.34

A weighted average of the four largest percent contributing faults results in M equal to 6.75. We select an applicable M equal to 6.7 for use in Lookout Slough THRFIP analysis.

The Regional Fault map (Appendix D) shows the locations of these faults and others in the region is attached. The locations of faults shown on the Exhibit are based on the U.S. Geological Survey and California Geological Survey, 2006, Quaternary fault and fold database for the United States (USGS web site: http//earthquake.usgs.gov/hazards/qfaults/).

7.6.2 Liquefaction

Liquefaction is a phenomenon in which granular material can transform from a solid to a liquefied state as a result of increased pore-water pressure and reduced effective stress. Ground shaking can induce an increase in pore-water pressure and granular materials can compact when subjected to the cyclic shear deformations. Liquefaction is most likely to occur in lower relative density granular soils, but some non-to- low plasticity fine-grained soils are also susceptible to liquefaction and/or strength loss via cyclical softening.

In loose materials, a loss of shear strength can occur that may lead to ground deformation or lateral movement (lateral spread) under foundation loading or on sloping ground. Loose soils can also compact following liquefaction and reconsolidation, which can result in ground settlement. For a levee, deformation and volume change can result in settlement at the ground surface, lateral migration (lateral spreading) of liquefied and overlying soils, and ground cracking at the surface. Strength loss within soils following a seismic event can result in slope failure.

BCI performed liquefaction analyses to evaluate potential liquefaction of the soils underlying the planned levee locations during a 100-year earthquake event with methods that include: Liquefaction Resistance of Soils: Summary Report from the 1996 NCEER and 1998 NCEER/NSF Workshop on Evaluation of Liquefaction Resistance of Soils by T. L. Youd and I. M. Idriss (Youd et al, 2001); Standard Penetration Test-Based Probabilistic and Deterministic Assessment of Seismic Soil Liquefaction Potential by K. Onder Cetin and Raymond B. Seed (Cetin et al, 2004); and Soil Liquefaction During Earthquakes by I. M. Idriss and R. W. Boulanger (Idriss and Boulanger, 2008).

BCI used the liquefaction analyses results to estimate the post-earthquake strengths of the foundation materials. The post-earthquake strengths are used to evaluate seismic stability and potential levee deformation due to slope failure and/or settlement.

Liquefaction Triggering
BCI completed liquefaction analyses in general accordance with Youd et al, (2001); Cetin et al, (2004); and Idriss and Bourlanger, (2008). In determining the soils Factor of Safety against liquefaction, all three methods use a similar approach where they compare the cyclic stress ratio (CSR), which is the seismic demand on a soil layer, versus the cyclic resistance ratio (CRR), which is the capacity of the soil to resist liquefaction. BCI's analysis considered fine grained soils with Plasticity Index (PI)<10 and Liquid Limit (LL) <35 as potentially liquefiable, consistent with USACE guidelines.

For this evaluation, BCI completed liquefaction triggering analysis at BCI borings BCI-17-B05, BCI-17-B06, BCI-17-B11 through B17 and BCI-18-B28. These borings are located along the proposed levee alignment. BCI also considered the information contained in the CPT data for the five CPTs drilled at the site.

BCI used the following parameters for liquefaction triggering analysis:

- Earthquake magnitude of M=6.7
- PGA of 0.17g
- Design ground water elevation equal to an assumed nominal winter water surface elevation (WSE) of Elevation 4 feet (NAVD88) as the most critical condition when compared to the lower nominal summer WSE

Our analysis indicates that only two, isolated, thin soil zones in two separate borings show the potential for strength loss under the design seismic event; specifically, the thin gravel layer beginning at Elevation -9 feet in BCI-17-B06, and the thin clayey sand layer beginning at Elevation -30 feet in BCI-17-B13. Analysis of nearby explorations confirm that these layers are isolated and not continuous.

Based on this information, post-earthquake slope stability analyses and deformation are not required, and levee settlement due to seismic loading (horizontal and vertical displacement due to slope failure) is not anticipated.

Appendix D presents the liquefaction triggering sheets for each exploration.

8 ADDITIONAL GEOTECHNICAL CONSIDERATIONS

This section addresses additional geotechnical considerations with respect to the DSSL construction.

8.1 Irrigation Ditch, Pond and Existing Slough Fill Recommendations

This section addresses fill recommendations associated with irrigation ditches, ponds and sloughs that currently exist within the new DSSL alignment footprint, and a minimum 20-feet beyond the new DSSL footprint.

All water bearing features (irrigation ditches, ponds and sloughs, etc.) underlying the new DSSL footprint or landside of the levee toe within the Lookout Slough THRFIP area that will receive fill shall be dewatered and mucked out until competent material is encountered. At a minimum, remove one-foot of material after dewatering. Scarify the base of the feature to a depth of 8”, moisture condition to within 3% of optimum, and compact to a minimum 90% relative compaction. If the subgrade is too wet/unstable to achieve compaction, follow recommendations in Section 8.3 of this report. Place fill in maximum 8” thick loose lifts and compact to a minimum 97% relative compaction within the levee footprint and within 20 feet of the landside toe. Compact all other fill to a minimum 90% relative compaction. Bench fill into the side of the feature a minimum of 1’ horizontally for every 1’ of vertical fill or as needed to remove loose material along the side of the feature.

8.2 DSSL Tie-Ins

The new DSSL will tie into existing levees and roadway embankments at points along the levee alignment and at DSSL termination points. This includes a tie-in at the intersection with the Hass Slough East Levee, a tie-in into Malcolm Lane, tie-in into Liberty Island Road and tie-in into the SSL. BCI understands that Liberty Island Road will be reconstructed landside of the new DSSL.

8.2.1 Roadway Tie-In Earthwork Recommendations

Where the new levee ties into Malcom Lane, remove the roadway aggregate base, scarify the soil underlying the aggregate base at to a depth of at least 8-inches, and compact to a minimum 97% of maximum density (ASTM D698) at a moisture content within 2% of optimum. Where the new levee ties into Liberty Road along the north side of the project, remove the pavement section including the asphalt concrete, aggregate base, and underlying roadway embankment soil to a depth of 3 feet. Reconstruct the road to design grade using on-site borrow material. The removed material may be used as fill provided it is free from debris and concentrations of vegetation. Key the rebuilt slope and new levee fill a minimum of 1 foot vertically for every 1 foot (measured horizontally) of fill placed.

8.2.2 Hass Slough East Levee and the SSL Tie-In Earthwork Recommendations

Where the new DSSL ties into the Hass Slough East Levee and SSL, remove the upper 3 feet (measured vertical to the ground surface) of soil within the existing levees. Reconstruct the levees with over-excavated material free of debris and concentrations of vegetation or from on-site borrow. Key the reconstructed and new fill a minimum of 1 foot vertically for every 1 foot (measured horizontally) of fill placed.

8.3 Unstable Subgrade Mitigation

Significant wet weather conditions, high, localized ground water conditions, and conditions encountered at the bottom of dewatered depressions including ditches and ponds may result in challenges to obtain compaction per the project plans and specifications. BCI therefore prepared this section to address these conditions if encountered.

The Contractor should clear, grub and strip per the Lookout Slough THRFIP specifications. If elevated soil moisture and ground pumping prevent the contractor from achieving the specified original ground compaction after stripping and scarification, the Contractor should perform additional scarification to a depth of 12-inches and recompact the upper 6-inches in accordance with the Lookout Slough THRFIP specifications. If compaction still cannot be achieved, or the subgrade pumps significantly, BCI proposes the following mitigation with geogrid. Stabilization with geogrid has been evaluated and used successfully on other levee projects for similar applications within the regional area.

For minimally unstable areas where minor flexing with no pumping is observed, place geogrid (BX 1200 biaxial or equivalent) at the surface of the unstable soil, leaving a 6-foot-wide (± 6 inches) gap centered along the levee alignment for cutoff wall construction, as necessary, prior to placing the first lift of levee fill. If large areas of minimally unstable areas are observed, a test section should be performed to verify mitigation measures will address the instability prior to placement of geogrid over the entire area to be stabilized.

For significantly unstable areas where significant pumping and rutting is observed, mitigate these areas as follows:

- Over-excavate the unstable soil to a depth of up to 18-inches (actual depth will depend on the severity of instability as determined by BCI).
- Place geogrid (BX 1200 or equivalent) on the surface of the excavated area, leaving a gap for cutoff wall construction, as necessary.

- Place and compact (at 90% relative compaction of ASTM D698) on-site borrow material, or the previously excavated, dried out material, in a 12-inch-thick lift to within 6-inches of the original ground surface.
- Place and compact (per Lookout Slough THRFIP specifications) on-site borrow material, or the previously excavated, dried out material, in the upper 6-inches of subgrade.
- If excessively unstable conditions exist, a second layer of geogrid may be warranted prior to replacement and compaction of the upper 6-inches. If instability persists that prevents the ability to achieve the specified compaction, additional layers of geogrid may be required to continue into the levee embankment. In this case, BCI will perform additional analyses to evaluate the effect on Lookout Slough THRFIP design.

If large areas of significantly unstable areas are observed, a test section shall be performed to verify mitigation measures will address the instability prior to excavation and placement of geogrid over the entire area.

The Contractor shall comply with the Lookout Slough THRFIP specifications regarding geogrid. In addition, the Contractor shall perform the following:

- Minimize subgrade disturbance prior to geotextile placement.
- Consideration to unrolling geogrid transversely or perpendicular to the embankment alignment to reduce lateral spreading or overlap separation.
- Overlap adjacent rolls along their sides and ends with a 3-feet overlap.
- Consider the use of nylon cable ties or zip ties to help maintain overlap dimensions.
- At the beginning of a roll, consider anchoring the beginning and the corners to the underlying surface using a washer and pin, or heavy-gauge staples.
- Use a lightweight, low ground pressure dozer to evenly push out the fill over the exposed geogrid.

9 FUTURE GEOTECHNICAL CONSIDERATIONS

Future geotechnical evaluations include the following:

- An updated evaluation, as necessary, at the two tie-in locations based on completed laboratory test results.
- Updated analyses as required based on refined design of the DSSL model and alignment, borrow sites and channels designed for the restoration habitat.

10 LIMITATIONS

BCI prepared this Draft GBODR for EIP and the design-build team for the Lookout Slough Tidal Habitat Restoration and Flood Improvement Project. This Draft GBODR should not be used by others or for other projects without BCI’s written permission.

BCI prepared this report in accordance with the generally accepted geotechnical standard of practice currently being used in this area. BCI based this Draft GBODR on the current site and project conditions.

11 GUIDANCE DOCUMENTS

BCI reviewed the following documents to help determine the findings and conclusions of this Draft GBODR:

- California Code of Regulations, December 2009, Regulations of the Central Valley Flood Protection Board, Title 23, Waters.
- State of California, The Natural Resources Agency, Department of Water Resources, May 2012 Urban Levee Design Criteria.
- URS January 2011, Final Geomorphology Technical Memoranda and Maps, North NULE Area, Geomorphic Assessments, Non-Urban Levee Evaluations Project Contract 46000008101, prepared for the Department of Water Resources, Division of Flood Management.
- URS April 2011, Geotechnical Assessment Report, North NULE Project Study Area, Non-Urban Levee Evaluations Project Contract 46000008101, prepared for the Department of Water Resources, Division of Flood Management.
- URS August 2011, Remedial Alternatives and Cost Estimates Report (RACER), North NULE Study Area, Non-Urban Levee Evaluations Project Contract 46000008101, prepared for the Department of Water Resources, Division of Flood Management.
- URS April 2015, Guidance Document for Geotechnical Analyses, Urban Levee Evaluations Project, Contract 4600008101, (URS Guidance Document), prepared for Department of Water Resources, Division of Flood Management (DWR).
- USACE, EM 1110-2-1913, Design and Construction of Levees, 30 April 2000.
- USACE, EM 1110-2-1902, Engineering and Design, Slope Stability, 31 October 2003.
- USACE, Recommendations for Seepage Design Criteria, Evaluation and Design Practices, prepared by the 2003 CESPK Levee Task Force, 15 July 2003.
- USACE, ETL 1110-2-569, Design Guidance for Levee Underseepage, 1 May 2005.
- USACE, Geotechnical Levee Practice Standard Operating Procedure, Revision 2, 11 April 2008.
- USACE, ETL 1110-2-580, Guidelines for Seismic Evaluation of Levees, Expires 1 March 2018 (no update available).

TABLES

This Page Intentionally Left Blank

TABLE 1									
Lookout Slough THRFIP Hydraulic Conductivity Laboratory Test Results									
Segment	**Boring**	**Depth (ft)**	**USCS Soil Type**	**Hydraulic Conductivity**		**% Fines**	**LL**	**PI**	**Comments**
				Laboratory Kv (cm/sec)	**Kh a=0.25**				
	BCI-17-B10.4	6.5’-7’	SC	9.92E-06	3.97E-05	28	34	16	
	BCI-17-B20.4	9’-9.5’	SC	2.51E-06	1.00E-05	45	38	20	
		Average:	**SC**	**6.22E-06**	**2.49E-05**				
	BCI-17-B01.6	12’-12.5’	CL	9.94E-06	3.98E-06		41	20	
	BCI-17-B03.4	9’-9.5’	CL	1.45E-05	5.80E-05	79	32	14	Outlier
	BCI-17-B08.6	11’4”-11’8”	CL	4.19E-07	1.68E-06	56	35	22	
	BCI-17-B18.3	5.5-6’	CL	2.86E-07	1.14E-06	59	46	29	
	BCI-17-B08.2	3’8”-4’2”	CH	2.80E-07	1.12E-06	95	68	48	
	BCI-17-B11.1	2.5’-3’	CH	2.72E-08	1.09E-07	90	52	37	
	BCI-17-B15.1	1.5’-2’	CH	4.34E-07	1.74E-06	97	63	46	
	BCI-17-B17.1	2.5’-3.0’	CH	1.59E-06	6.36E-06				
		Average:	**CL, CH**	**1.85-06**	**2.30E-06**				
	TP4	1’-3’	CH	2.78E-09	1.11E-08		50	33	New Levee Fill
	BTP15-B	3’-6’	CH	4.24E-09	1.70E-08		50	33	
	BTP20-A	1’-3’	CL	4.60E-09	1.84E-08		43	29	
		Average:	**CL, CH**	**3.87E-09**	**1.55E-08**				

TABLE 2															
Hydraulic Conductivity Values Used By Others for Lookout Slough THRFIP Soil Layers															
Material Type	**USCS Designation**	**Soil Description**	**Southport EIP**				**Lower Elkhorn Basin Levee**			**USACE West Sacramento**			**URS Presumptive HC Values**		
			Kh (ft/day)	**Kh (cm/s)**	**Kv/Kh**	**Kv (cm/s)**	**Kh (cm/s)**	**Kv/Kh**	**Kv (cm/s)**	**Kh (cm/s)**	**Kv/Kh**	**Kv (cm/s)**	**Kh (cm/s)**	**Kv/Kh**	**Kv (cm/s)**
Cutoff Wall	NA	SCB, SB	0.0028	1.0×10^{-6}	1.0	1.0×10^{-6}	--	--	--	1.0×10^{-6}	1.0	1.0×10^{-6}	1.0×10^{-6} to 1.0×10^{-7}	1.0	1.0×10^{-6} to 1.0×10^{-7}
New Levee Soil, Embankment	CL, CH	New Levee Lean CLAY and Fat CLAY	0.0028	1.0×10^{-6}	0.25	2.5×10^{-7}	1.0×10^{-6}	0.25	2.5×10^{-7}	--	--	--	1.0×10^{-6} to 1.0×10^{-8}	.25-1.0	varies
Lean CLAY, Fat CLAY,	CL, CH	Layers of medium stiff to hard Lean and Fat CLAY	0.0028	1.0×10^{-6}	0. 25	2.5×10^{-7}	4.0×10^{-6}	0.25	1.0×10^{-6}	1×10^{-5}	0.25	2.5×10^{-6}	5.0×10^{-6} to 5.0×10^{-8}	.25-1.0	varies
Lean CLAY	CL	Soft to Medium Stiff Lean CLAY	0.016	5.6×10^{-6}	0. 25	1.4×10^{-6}	--	--	--	--	--	--			
Clayey SAND, Sandy Lean CLAY	SC, CL	Interbedded layers of SC and CL	--	--	--	--	1×10^{-4}	0.25	2.5×10^{-5}	1×10^{-4}	0.25	2.5×10^{-5}	1.0×10^{-4} to 1.0×10^{-5}	.25-1.0	varies
Interbedded Poorly-graded SAND/Sand with Silt/SAND with Clay	SP, SP-SM	Interbedded layers of SP and SP-SM	22.68	8.0×10^{-3}	0. 25	2.0×10^{-3}	(SP-SM) 1×10^{-2}	0.50	(SP-SM) 5.0×10^{-3}	--	--	--	--	--	--
	SP-SM, SP-SC	Interbedded layers of SP-SM and SP-SC predominantly	(SP-SM) 14.74	(SP-SM) 5.2×10^{-3}	0.25	(SP-SM) 1.3×10^{-3}	1.0×10^{-2} to 4.0×10^{-4}	0.50	5.0×10^{-3} to 2.0×10^{-4}	5×10^{-3}	0.25	1.3×10^{-3}	--	--	--
Interbedded Clayey GRAVEL and Poorly-graded SAND with Clay	GC, SP-SC	Interbedded layers of GC and SP-SC	--	--	--	--	(GM 26-49%) 2.0×10^{-3}	0. 25	(GM 26-49%) 5.0×10^{-4}	--	--	--	--	--	--
Well-graded SAND with Silt, Poorly-graded GRAVEL with SILT	GP-GC, SW-SM	Interbedded layers of SW-SM and GP-GC	(SP-SM) 14.74	(SP-SM) 5.2×10^{-3}	0.25	(SP-SM) 1.3×10^{-3}	(GM 13-25%) 4.0×10^{-3}	0.25	(GM 13-25%) 1.0×10^{-3}	--	--	--	--	--	--

TABLE 3

Lookout Slough THRFIP Hydraulic Conductivity Values For 65%-Design

Material Type	USCS Designation	Soil Description	Kh (ft/day)	Kh (cm/s)	Kv/Kh	Kv (cm/s)
Cutoff Wall	NA	SCB, SB	0.0028	1.0×10^{-6}	1.0	1.0×10^{-6}
New Levee Soil, Embankment	CL, CH	New Levee Lean CLAY and Fat CLAY	0.0028	1.0×10^{-6}	0.25	2.5×10^{-7}
Lean CLAY, Fat CLAY, Interbedded SILT/CLAY	CL, CH	Layers of medium stiff to hard Lean and Fat CLAY	0.0028	1.0×10^{-6}	0. 25	2.5×10^{-7}
	CL	Soft to Medium Stiff Lean CLAY	0.0057	2.0×10^{-6}	0. 25	5.0×10^{-7}
Clayey SAND, Sandy Lean CLAY	SC, CL	Interbedded layers of SC and CL	0.057	2.0×10^{-5}	0.25	5.0×10^{-6}
Interbedded Poorly-graded SAND/Sand with Silt/SAND with Clay	SP, SP-SM	Interbedded layers of SP and SP-SM	22.68	8.0×10^{-3}	0. 25	2.0×10^{-3}
	SP-SM, SP-SC	Interbedded layers of SP-SM and SP-SC predominantly	14.74	5.2×10^{-3}	0. 25	1.3×10^{-3}
Interbedded Clayey GRAVEL and Poorly-graded SAND with Clay	GC, SP-SC	Interbedded layers of GC and SP-SC	5.67	2.0×10^{-3}	0. 25	5.0×10^{-4}
Well-graded SAND with Silt, Poorly-graded GRAVEL with SILT	GP-GC, SW-SM	Interbedded layers of SW-SM and GP-GC	14.74	5.2×10^{-3}	0.25	1.3×10^{-3}

TABLE 4

Lookout Slough THRFIP Strength Parameter Laboratory Test Results

USCS	BCI Boring/Test Pit	Effective Strength		Total Strength		Undrained Shear Strength (Su)		Remarks	Averages
		ϕ' (deg)	c' (psf)	ϕ^{total} (deg)	c^{total} (psf)	Su (psf)	Cell Pressure (psf)		
CL	BCI-17-B1 (4.5'-4.9')	40.9[2]	382.3[2]					Lean CLAY with Sand (LL = 38, PI = 21)	Average Values: **ϕ' = 27 deg** **c' = 463 psf** Average values did not include BCI-17-B1 ϕ' = 40.9 deg **Average Undrained Shear Strength** **Su = 2730 psf**
CH	BCI-17-B2 (4.0'-5.0')	34.2[2]	94.6[2]					Fat CLAY (LL = 54, PI = 42)	
CL	BCI-17-B2 (11.5'-12.0'					3923.6	1008	Lean CLAY with Sand	
CL	BCI-17-B2 (20' – 20.5')					2570.3	1728	Sandy Lean CLAY (LL = 38, PI = 22)	
CH	BCI-17-B3 (12.3' – 12.8')					4664.4	1008	Fat CLAY	
CL	BCI-17-B4 (8.7' – 9.3')	33.8[2]	419.6[2]					Lean CLAY, Brown	
CL	BCI-17-B7 (3.8' – 4.2')	17.1[2]	690.4[2]					Lean CLAY with Sand (LL = 48, PI = 32)	
CL	BCI-17-B4 (13.0' – 13.5')					2411.3	1152.0	Lean CLAY (LL = 46, PI = 25)	
CH	BCI-17-B6 (4.3' – 4.8')					2684.2	432	Fat CLAY (LL = 68, PI = 50)	
CH	BCI-17-B8 (3.8' – 4.2')	24.5[2]	648.1[2]					Fat CLAY (LL = 68, PI = 48)	
CL	BCI-17-B9 (9.8' – 10.3')					1817.1	1008	Lean CLAY with Sand	
CH	BCI-19-57 (5.0'-5.5')					1039	576	Fat CLAY with Sand (LL = 51, PI = 32)	
CL	BCI-17-14 (4.5' – 6.0')	31[3]	390.9[3]	21[3]	287.6[3]			Lean CLAY	Average Total Strength Values for Upper CL/CH Layer **ϕ^{total} = 24 deg, c^{total} = 318.6 psf**
CH	BCI-17-17-1 (2.0'- 3.5')			25.8[4]	336.2[4]			Fat CLAY	
CL	BCI-17-19-1 (1.0' – 2.5')			24.2[4]	331.9[4]			Lean CLAY	
CH	TP4 Bulk[1] (1.0' - 3.0')	24.4[3]	462.0[3]	20.9[3]	165.3[3]	1996.5	750.2	Fat CLAY with Sand (LL = 59, PI = 44)	Average for New DSSL Fill **ϕ' = 23.6 deg, c' = 475 psf** **ϕ^{total} = 16 deg, c^{total} = 375.6 psf**
CH	TP6 Bulk[1] (1.0' – 3.0')	27.4[3]	538.1[3]	13.2[3]	579.6[3]	1758.3	748.8	Fat CLAY with Sand (LL = 51, PI = 13)	
CH	BTP24 Bulk[1] (4.0' – 7.0')	19.0[3]	424.1[3]	13.8[3]	381.8[3]			Fat CLAY (LL = 56, PI = 38)	
CH	BTP4 Bulk[5] (1.0' – 3.0')	18.3[5]	0[5]						
CH	BTP12 Bulk[5] (1.0' – 3.0')	19.8[5]	0[5]						
CH	BTP3 Bulk[1] (1.0' – 3.0')					1298.5	720		Average for New DSSL Fill **Su = 1676 psf**
CH	BTP15[1] (3.0' – 6.0')					1566.9	720		
CH	BTP26[1] (4.0' – 7.0')					1583.6	720		
CH	BTP29[1] (1.0' – 4.0')					1930.9	720		
CH	BTP31[1] (1.0' – 3.0')					1598.6	720		

[1] Specimens remolded to 97% relative compaction (ASTM D698)
[2] Direct Shear Test (ASTM D3080)
[3] Consolidated Undrained with pore-water pressure measurements Triaxial Compression Tests (ASTM D4767)
[4] Consolidated Undrained with pore-water pressure measurements Triaxial Compression Tests (ASTM D4767). However, due to sample variability, BCI could not produce reasonable Mohr circles to determine effective strengths.
[5] Fully-Softened Direct Shear Test following the procedures outlined in the February 20, 2014, *Use and Measurement of Fully Softened Shear Strength*, Bernardo A. Castellanos

TABLE 5

Lookout Slough THRFIP Soil Strength Parameters for 65%-Design

Type (USCS)	BCI Recommended Strength Values					Southport EIP					Lower Elkhorn Basin Levee				URS Presumptive Values	
	φ' (deg)	c' (psf)	ϕ^{total} (deg)	c^{total} (psf)	Su (psf)	φ' (deg)	c' (psf)	ϕ^{total} (deg)	c^{total} (psf)	Su (psf)	φ' (deg)	c' (psf)	ϕ^{total} (deg)	c^{total} (psf)	φ' (deg)	c' (psf)
Slurry Wall (SB)	0	50			20	0	50	0	20	20	-	-	-	-	-	-
New Levee (CL, CH)	22	400	13	450	1500	22[1]	240[1]	13[1]	250[1]	1500[1]	23	160	11	230	≤32	≤150
Lean CLAY/Fat CLAY (CL, CH)	30	150	15	175	1000	28-30	75-200	15	150-400	600-1000	30/23	100/150	17/10	180/250	-	-
Lean CLAY (CL)	32	150	16	175	1000						30	100	17	180	≤35	≤200
Clayey SAND, Sandy Lean CLAY (SC, CL)	32	100	16	115	-	-	-	-	-	-	-	-	-	-		
Poorly-graded SAND, Poorly-graded SAND with SILT (SP, SP-SM)	32	0	-	-	-	34	0	-	-	-	-	-	-	-		
Poorly-graded SAND with SILT, Poorly-graded SAND with CLAY (SP-SM/SP-SC)	30	0	-	-	-	30	0	-	-	-	-	-	-	-	≥32 to ≤35	0
Clayey GRAVEL/Poorly-graded SAND with CLAY (GC, SP-SC)	34	0	-	-	-	-	-	-	-	-	-	-	-	-		
Poorly-graded GRAVEL with CLAY, Well-graded SAND with SILT (GP-GC, SW-SM)	34	0	-	-	-	-	-	-	-	-	-	-	-	-		

[1] Based on New Levee Deep Core (CL, CH)

TABLE 6

Lookout Slough THRFIP 65%-Design Steady-State Underseepage Analysis Results

BCI Cross-Section	Levee Improvement Measure	Underseepage Mitigation Measure	Steady-State Underseepage Analysis Results, $i_{exit\ avg}$ at Landside Levee Toe			Steady-State Underseepage Analysis Results, $i_{exit\ avg}$ at Landside Ditch (Duck Slough or Irrigation Canal)		
		Cutoff Wall Toe Elev. (ft) NAVD88	DWSE $i_{exit\ avg}$	DWSE $i_{exit\ avg}$* 1.25 3-D effect	Meets Criteria ($i_{exit\ avg} \leq 0.5$)	DWSE $i_{exit\ avg}$	DWSE $i_{exit\ avg}$* 1.25 3-D effect	Meets Criteria ($i_{exit\ avg}$ varies)
Station 6+50	DSSL	---	<0.05	<0.1	Yes	0.22	0.28	Yes ($i_{exit\ avg}$ 0.8)
	DSSL w/wall	-15	<0.05	<0.1	Yes	0.22	0.28	Yes
Station 42+00	DSSL	---	<0.05		Yes	3.85		No ($i_{exit\ avg}$ 0.77)
	DSSL w/wall	-40	<0.05		Yes	2.31		No ($i_{exit\ avg}$ 0.77)
	DSSL w/wall[1]	-40	<0.05		Yes	0.59		Yes
Station 109+50	DSSL	---	<0.05		Yes	0.24		Yes ($i_{exit\ avg}$ 0.61)
	DSSL w/wall	-15	<0.05		Yes	0.24		Yes
Station 148+00	DSSL	---	<0.05	<0.1	Yes	0.29	0.36	Yes
	DSSL w/wall	-15	<0.05	<0.1	Yes	0.29	0.36	Yes

[1] With water surface elevation set at 4 feet in Duck Slough

TABLE 7

Lookout Slough THRFIP 65%-Design Steady-State Slope Stability Analysis Results

BCI Cross-Section	Levee Improvement Measure	Mitigation Measure	Steady-State Slope Stability Analysis Results, Minimum Factor of Safety					
		Cutoff Wall Toe Elev. (ft) NAVD88	SS DWSE	Meets Criteria (FS≥1.4)	Rapid DD	Meets Criteria (FS≥1.2)	EOC WSE	Meets Criteria (FS≥1.3)
Station 6+50	DSSL	---	2.89	Yes	---	---	---	---
	DSSL w/wall	-15	2.89	Yes	1.88	Yes	2.40	Yes
Station 42+00	DSSL	---	3.11	Yes	---	---	---	---
	DSSL w/wall	-40	3.16	Yes	2.88	Yes	3.46	Yes
Station 109+50	DSSL	---	2.49	Yes	---	---	---	---
	DSSL w/wall	-15	2.49	Yes	1.84	Yes	2.38/2.42[1]	Yes
Station 148+00	DSSL	---	2.75	Yes	---	---	---	---
	DSSL w/wall	-15	2.87	Yes	1.87	Yes	2.35	Yes

[1] With water at the Design Water Surface Elevations

TABLE 8

Lookout Slough THRFIP Settlement Analysis Parameters

Consolidation Settlement at Levee Centerline

Layer No.	Soil Description	Depth Below Levee Base (ft)	Unit Weight (pcf)	Elastic Soil Modulus, Es (ksf)	Poisson's Ratio (U)	C_c	C_r	OCR	C_v (ft^2/day)	e_o	Results
1	New Levee Fill	--	125	--	--	--	--	--	--	--	
2	Med. Stiff to Hard Fat CLAY (CH)	0-5	120	500	0.30	--	--	--	--	--	
3	Hard Lean CLAY (CL)	5-14	120	500	0.40	0.27	0.075	10.00	0.123	0.810	
4	Soft to Med. Stiff Lean CLAY (CL)	14-20	118	310	0.40	0.24	0.020	3.00	0.554	0.780	Elastic Settlement: 0.21 feet (2.5 inches)
5	Hard Lean CLAY (CL)	20-30	125	1000	0.40	--	--	--	--	--	Consolidation Settlement: 0.50 feet (6.0 inches)
6	Med. Stiff Lean CLAY (CL)	30-33	117	250	0.40	0.29	0.060	3.00	0.218	0.895	
7	Stiff Lean CLAY (CL)	33-40	120	1000	0.40	0.30	0.060	10.00	0.218	0.895	
8	Stiff Lean Clay (SC)	40-55	120	625	0.40	0.30	0.060	4.00	0.231	0.895	
9	Hard Fat to Lean CLAY (CH, CL)	55-80	120	1000	0.40	--		--	--	--	

BCI-17-06

Layer No.	Soil Description	Depth Below Levee Base (ft)	Unit Weight (pcf)	Elastic Soil Modulus, Es (ksf)	Poisson's Ratio (U)	C_c	C_r	OCR	C_v (ft^2/day)	e_o	Notes
1	New Levee Fill	--	125	--	--	--	--	--	--	--	
2	Stiff to Hard Fat to Lean CLAY (CH, CL)	0-5	120	1500	0.40	--	--	--	--	--	
3	Stiff Lean CLAY, Clayey SAND (SC, CL)	5-10	120	250	0.30	--	--	--	--	--	
4	Poorly-graded SAND (SP)	10-15	105	450	0.30	--	--	--	--	--	Elastic Settlement: 0.43 feet (5.2 inches)
5	Well-graded GRAVEL (GW)	15-25	115	250	0.30	--	--	--	--	--	
6	Firm Sandy SILT, Lean CLAY (ML, CL)	25-45	115	150	0.30	--	--	--	--	--	
7	Firm Fat CLAY (CH)	45-55	120	500	0.40	--	--	--	--	--	
8	Very Hard Lean CLAY (CL)	55-75	125	2000	0.40	--	--	--	--	--	

BCI-17-02, 03, 04, 05

Layer No.	Soil Description	Depth Below Levee Base (ft)	Unit Weight (pcf)	Elastic Soil Modulus, Es (ksf)	Poisson's Ratio (U)	C_c	C_r	OCR	C_v (ft^2/day)	e_o	Notes
1	New Levee Fill	--	125	--	--	--	--	--	--	--	
2	Stiff Fat to Lean CLAY (CH, CL)	0-5	120	1000	0.40	--	--	--	--	--	Elastic Settlement: 0.07 feet (0.8 inches)
3	Hard to Very Hard Lean CLAY (CL)	5-40	125	2000	0.40	--	--	--	--	--	

GEOTECHNICAL BASIS OF DESIGN REPORT

65% Design

Lookout Slough THRFIP

Solano County, California

FIGURES

Project Vicinity Map
Project Site Limits
Exploration Site Plan
Geologic Map
Plan and Profile Sheets

This Page Intentionally Left Blank

FIGURE 1, PROJECT VICINITY MAP
Geotechnical Basis of Design Report - 65% Design
September 2019

N
W E
S

0 10,000

SCALE: 1" = 10,000'

Ecosystem Investment Partners

Prepared by:

Map Prepared Date: 09/01/19
Map Prepared By: M.D.R.
Checked By: N.C.H.
Job No.: 3195.x

BLACKBURN CONSULTING

Lookout Slough THRFIP

Path: \\FS-01\Common\Active Projects\3195.P DWR Lookout Slough Restoration Project\CAD\3195.x Fig1 LSRP 65%.dwg

This Page Intentionally Left Blank

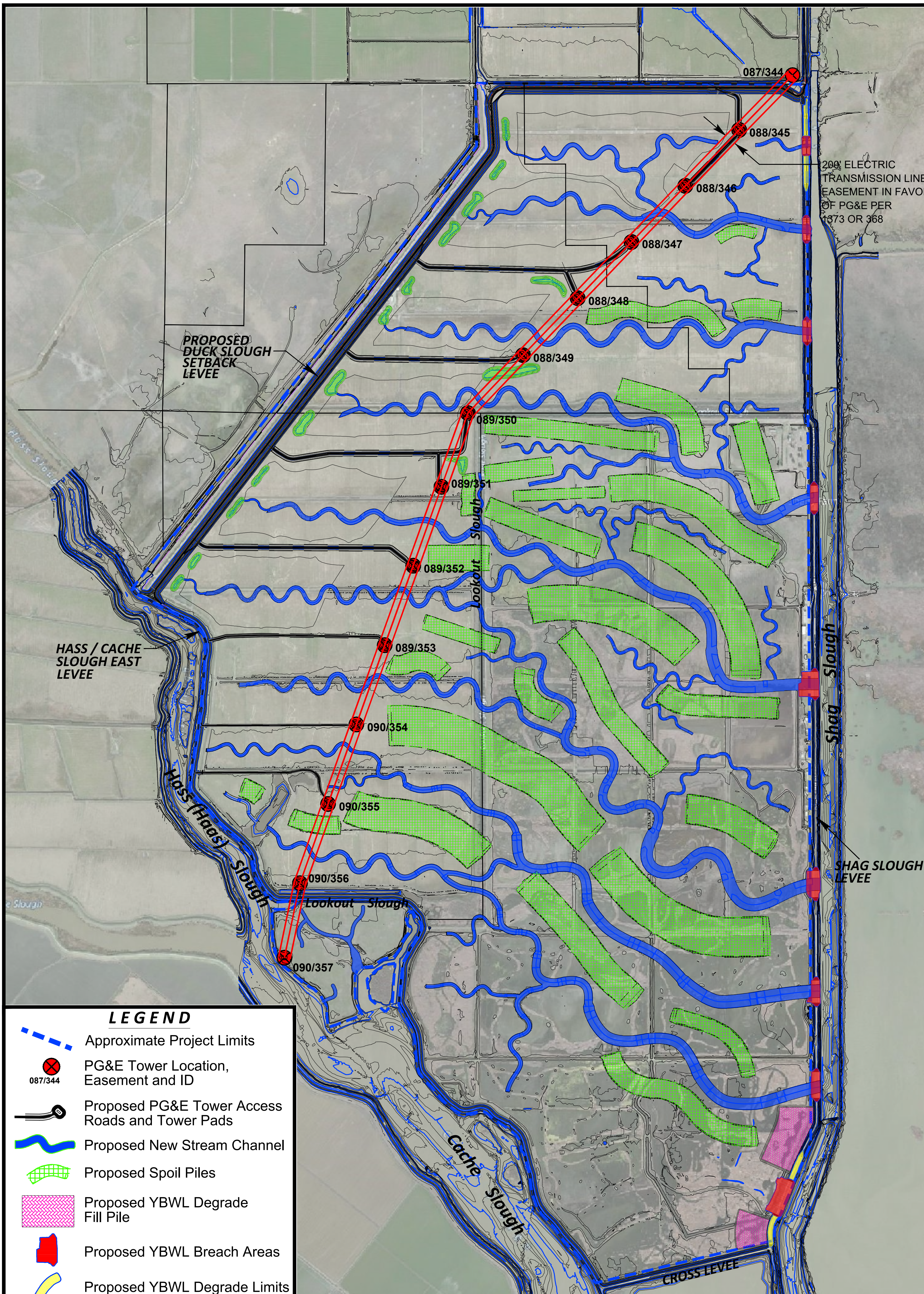


FIGURE 2, PROJECT SITE LIMITS
Geotechnical Basis of Design Report - 65% Design
September 2019

N W E S

Drawing References: Lookout Slough boundary lines and easements provided by Wood Rodgers, Inc., 12/08/2017. Proposed levee alignment, stream channels, and topography updated 7/30/2019.

0 1500
SCALE: 1 " = 1500'

Lookout Slough THRFIP

Ecosystem Investment Partners

Map Prepared Date: 09/01/19
Map Prepared By: M.D.R.
Checked By: N.C.H.
Job No.: 3195.x

Prepared by:
BLACKBURN CONSULTING

Path: \\FS-01\Common\Active Projects\3195.P DWR Lookout Slough Restoration Project\CAD\3195.x Fig2 LSRP 65%.dwg

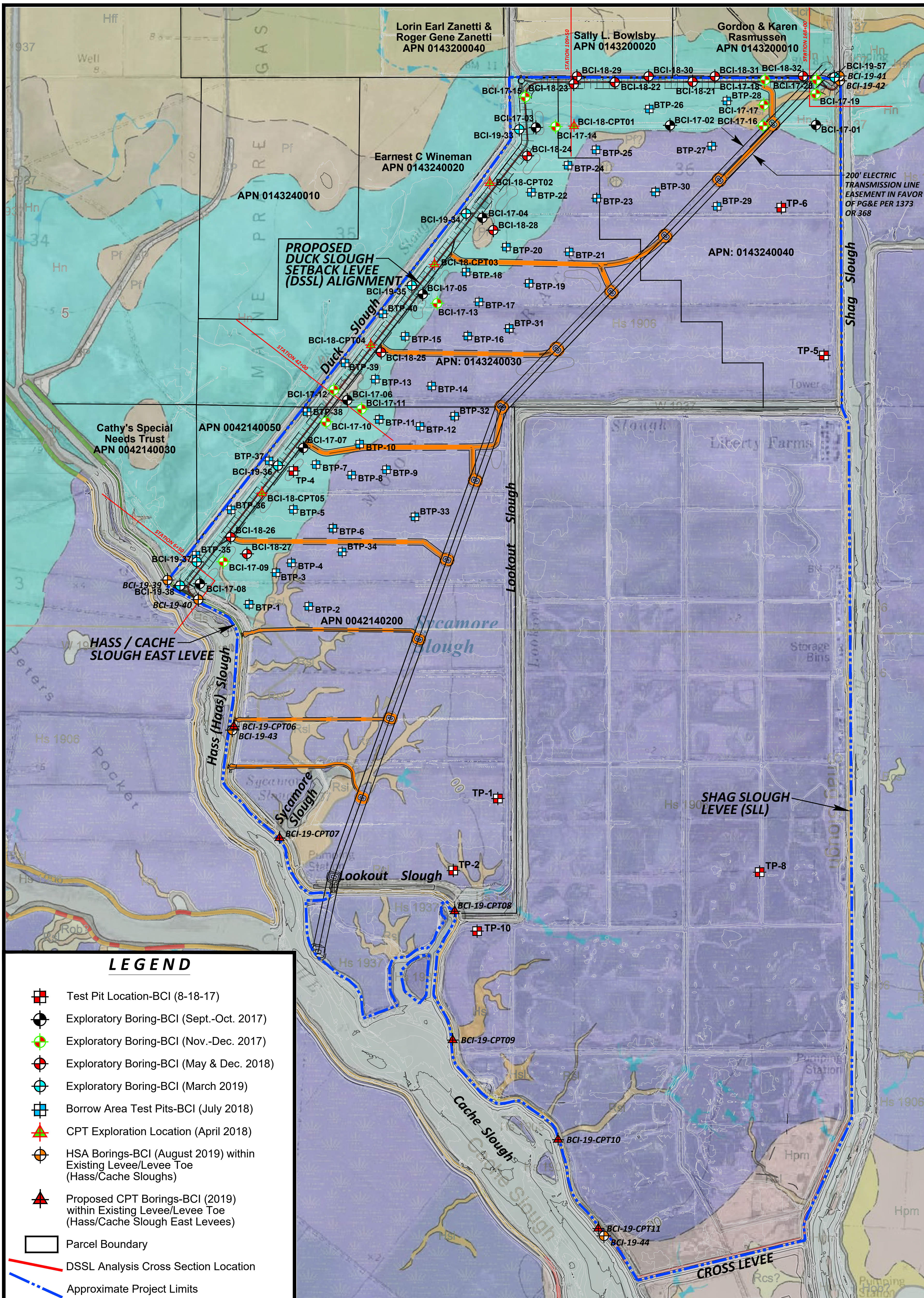


FIGURE 3A, EXPLORATION SITE PLAN

Geotechnical Basis of Design Report - 65% Design
September 2019

Drawing References: Lookout Slough boundary lines and easements provided by Wood Rodgers, Inc., 12/08/2017. Proposed levee alignment updated 2/1/2019 and topography updated11/12/2018.

0 1500
SCALE: 1 " = 1500'

N W E S

Lookout Slough THRFIP

Ecosystem Investment Partners

Map Prepared Date: 09/01/19
Map Prepared By: M.D.R.
Checked By: N.C.H.
Job No.: 3195.x

Prepared by:
BLACKBURN CONSULTING

Path: \\FS-01\Common\Active Projects\3195.P DWR Lookout Slough Restoration Project\CAD\3195.x Fig3 LSRP 65%.dwg

This map shows surficial geologic deposits and levees as they existed in 1937. Map units and boundaries are drawn by interpretation of historical aerial photography supplemented by data from historical maps and surveys. For reference, the mapping is superimposed on modern U.S. Geological Survey 7.5' topographic base maps (individual maps referenced below).
Screened back semi-transparent mapping shown on this plate is from Deep Water Ship Channel study area, which is not assessed in this investigation. For clarity, only the surficial geologic map units of this study appear in the explanation.
See accompanying technical memorandum for complete descriptions of map units, process descriptions and methodology.
Adjacent polygons that have identical map unit symbols are employed to delineate sequences of sedimentation and landscape evolution.

Explanation

Underseepage Susceptibility Along Non-Urban Levee Alignment

Very High | High | Moderate | Low

Geologic contact; dashed where approximate, dotted where concealed, queried where uncertain. Solid contacts accurate to within 100' of line shown on map; dashed contacts accurate to within about 250' on either side of the line.

Narrow channel, generally <100 ft in width. Dashed where approximate, dotted where concealed.

Narrow, tidally influenced channel (<100 ft in width), commonly connected to a larger slough channel.

Canal

Levee; artificial fill prism, generally <70 ft in width.

Borrow pit, generally <70 ft in width.

Symbol	Description
W 1937	Water; date indicates year of historical dataset.
BP	Borrow pit present in 1937.

Geologic Units

	Unit	Description
HISTORICAL	AF	Artificial fill, circa 1937.
	L	Levee (made of artificial fill), circa 1937.
	Rob	Overbank deposits; silt, sand, and lesser clay; deposited during high-stage water flow, overtopping channel banks.
	Rcs	Crevasse splay deposits; fine sand and silt with clay deposited from breaching of natural or artificial levees.
	Rch	Channel deposits; well sorted sand and trace fine gravel.
	Rsl	Slough deposits; silt, clay, and sand, fining upward facies, low-energy channel deposits.
	Ril 1906	Intermittent lake; seasonal lake shown on historical topographic maps. Date indicates source data set.
HOLOCENE	Hob	Overbank deposits; silt, sand, and clay; deposited during high-stage water flow, overtopping channel banks.
	Hcs	Crevasse splay deposits; fine sand and silt with clay deposited from breaching of natural levees.
	Hff	Fine-grained alluvial fan deposits; silt and clay with sand.
	Hch	Channel deposits; well sorted sand and trace fine gravel.
	Hsl	Slough deposits; silt, clay, and sand, fining upward facies, low-energy channel deposits.
	Ha	Alluvial deposits, undifferentiated; sand, silt, clay and minor lenses of gravel.
	Hpm	Peat and muck; interbedded peat and organic-rich silt and clay, former tidal marsh deposits, mostly now leveed, drained, and farmed.
	Hn	Basin deposits; fine sand, silt and clay.
	Hs 1937	Marsh deposits; silt and clay, possibly with organic-rich beds; perennially or seasonally submerged. Date indicates year of historical dataset used to map the marsh.
PLEISTOCENE	Pf	Alluvial fan deposits; semi-consolidated silt, sand, sandy clay and fine to coarse subrounded gravel.
	Pf (m)	Alluvial fan deposits of the Montezuma Hills; semi-consolidated sandy silt, sandy clayey silt, clay, sand and minor pebble gravel eroded from the early Pleistocene Montezuma Formation

Stratigraphic Correlation Chart

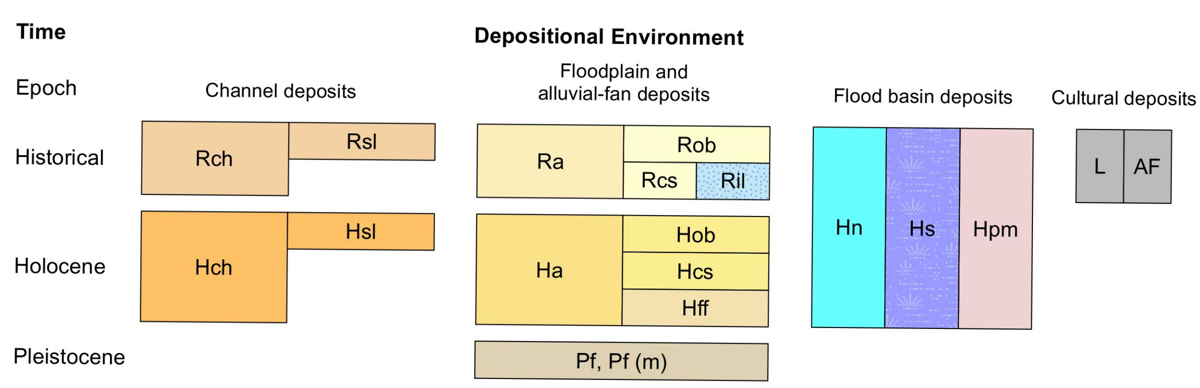


FIGURE 3B, LEGEND, EXPLORATION SITE PLAN
Geotechnical Basis of Design Report - 65% Design
September 2019

Source: Surficial Geologic Map of the West Delta Study Area, Plate 1 for the North Non-Urban Levee Evaluations. Produced by Department of Water Resources, Division of Flood Management, Levee Evaluations Branch in association with URS and Fugro, Scale is 1"=2000'.

Lookout Slough THRFIP

Ecosystem Investment Partners

Prepared by:

Map Prepared Date: 09/01/19
Map Prepared By: M.D.R.
Checked By: N.C.H.
Job No.: 3195.x

BLACKBURN CONSULTING

Path: \\FS-01\Common\Active Projects\3195.P DWR Lookout Slough Restoration Project\CAD\3195.x Fig3 LSRP 65%.dwg

FIGURE 4, GEOLOGIC MAP
Geotechnical Basis of Design Report - 65% Design
September 2019

Lookout Slough boundary lines and easements provided by Wood Rodgers, Inc., 12/08/2017. Proposed levee alignment and topography updated 02/01/2019. Liberty Island, Geologic Map of the Sacramento-San Joaquin Delta, California, by Brian F. Atwater, 1982.

0 1500
SCALE: 1 " = 1500'

Lookout Slough THRFIP

Ecosystem Investment Partners

Map Prepared Date: 09/01/19
Map Prepared By: M.D.R.
Checked By: N.C.H.
Job No.: 3195.x

Prepared by:
BLACKBURN CONSULTING

Path: \\FS-01\Common\Active Projects\3195.P DWR Lookout Slough Restoration Project\CAD\3195.x Fig4 LSRP 65%.dwg

GROUP SYMBOLS AND NAMES

Graphic/Symbol	Group Names
GW	Well-graded GRAVEL Well-graded GRAVEL with SAND
GP	Poorly-graded GRAVEL Poorly-graded GRAVEL with SAND
GW-GM	Well-graded GRAVEL with SILT Well-graded GRAVEL with SILT and SAND
GW-GC	Well-graded GRAVEL with CLAY (or SILTY CLAY) Well-graded GRAVEL with CLAY and SAND (or SILTY CLAY and SAND)
GP-GM	Poorly-graded GRAVEL with SILT Poorly-graded GRAVEL with SILT and SAND
GP-GC	Poorly-graded GRAVEL with CLAY (or SILTY CLAY) Poorly-graded GRAVEL with CLAY and SAND (or SILTY CLAY and SAND)
GM	SILTY GRAVEL SILTY GRAVEL with SAND
GC	CLAYEY GRAVEL CLAYEY GRAVEL with SAND
GC-GM	SILTY, CLAYEY GRAVEL SILTY, CLAYEY GRAVEL with SAND
SW	Well-graded SAND Well-graded SAND with GRAVEL
SP	Poorly-graded SAND Poorly-graded SAND with GRAVEL
SW-SM	Well-graded SAND with SILT Well-graded SAND with SILT and GRAVEL
SW-SC	Well-graded SAND with CLAY (or SILTY CLAY) Well-graded SAND with CLAY and GRAVEL (or SILTY CLAY and GRAVEL)
SP-SM	Poorly-graded SAND with SILT Poorly-graded SAND with SILT and GRAVEL
SP-SC	Poorly-graded SAND with CLAY (or SILTY CLAY) Poorly-graded SAND with CLAY and GRAVEL (or SILTY CLAY and GRAVEL)
SM	SILTY SAND SILTY SAND with GRAVEL
SC	CLAYEY SAND CLAYEY SAND with GRAVEL
SC-SM	SILTY, CLAYEY SAND SILTY, CLAYEY SAND with GRAVEL
PT	PEAT
	COBBLES COBBLES and BOULDERS BOULDERS

Graphic/Symbol	Group Names
CL	Lean CLAY Lean CLAY with SAND Lean CLAY with GRAVEL SANDY lean CLAY SANDY lean CLAY with GRAVEL GRAVELLY lean CLAY GRAVELLY lean CLAY with SAND
CL-ML	SILTY CLAY SILTY CLAY with SAND SILTY CLAY with GRAVEL SANDY SILTY CLAY SANDY SILTY CLAY with GRAVEL GRAVELLY SILTY CLAY GRAVELLY SILTY CLAY with SAND
ML	SILT SILT with SAND SILT with GRAVEL SANDY SILT SANDY SILT with GRAVEL GRAVELLY SILT GRAVELLY SILT with SAND
OL	ORGANIC lean CLAY ORGANIC lean CLAY with SAND ORGANIC lean CLAY with GRAVEL SANDY ORGANIC lean CLAY SANDY ORGANIC lean CLAY with GRAVEL GRAVELLY ORGANIC lean CLAY GRAVELLY ORGANIC lean CLAY with SAND
0L	ORGANIC SILT ORGANIC SILT with SAND ORGANIC SILT with GRAVEL SANDY ORGANIC SILT SANDY ORGANIC SILT with GRAVEL GRAVELLY ORGANIC SILT GRAVELLY ORGANIC SILT with SAND
CH	Fat CLAY Fat CLAY with SAND Fat CLAY with GRAVEL SANDY fat CLAY SANDY fat CLAY with GRAVEL GRAVELLY fat CLAY GRAVELLY fat CLAY with SAND
MH	Elastic SILT Elastic SILT with SAND Elastic SILT with GRAVEL SANDY elastic SILT SANDY elastic SILT with GRAVEL GRAVELLY elastic SILT GRAVELLY elastic SILT with SAND
OH	ORGANIC fat CLAY ORGANIC fat CLAY with SAND ORGANIC fat CLAY with GRAVEL SANDY ORGANIC fat CLAY SANDY ORGANIC fat CLAY with GRAVEL GRAVELLY ORGANIC fat CLAY GRAVELLY ORGANIC fat CLAY with SAND
OH	ORGANIC elastic SILT ORGANIC elastic SILT with SAND ORGANIC elastic SILT with GRAVEL SANDY ORGANIC elastic SILT SANDY ORGANIC elastic SILT with GRAVEL GRAVELLY ORGANIC elastic SILT GRAVELLY ORGANIC elastic SILT with SAND
OL/OH	ORGANIC SOIL ORGANIC SOIL with SAND ORGANIC SOIL with GRAVEL SANDY ORGANIC SOIL SANDY ORGANIC SOIL with GRAVEL GRAVELLY ORGANIC SOIL GRAVELLY ORGANIC SOIL with SAND

SAMPLER GRAPHIC SYMBOLS

- Standard Penetration Test (1.4 in ID)
- Modified California (2.5 in ID)
- Standard California (2.0 in ID)
- Shelby Tube (2.38 or 2.87 in ID)
- Punch Core
- Dry Core
- Sonic Core or Grab Sample
- Bag Sample

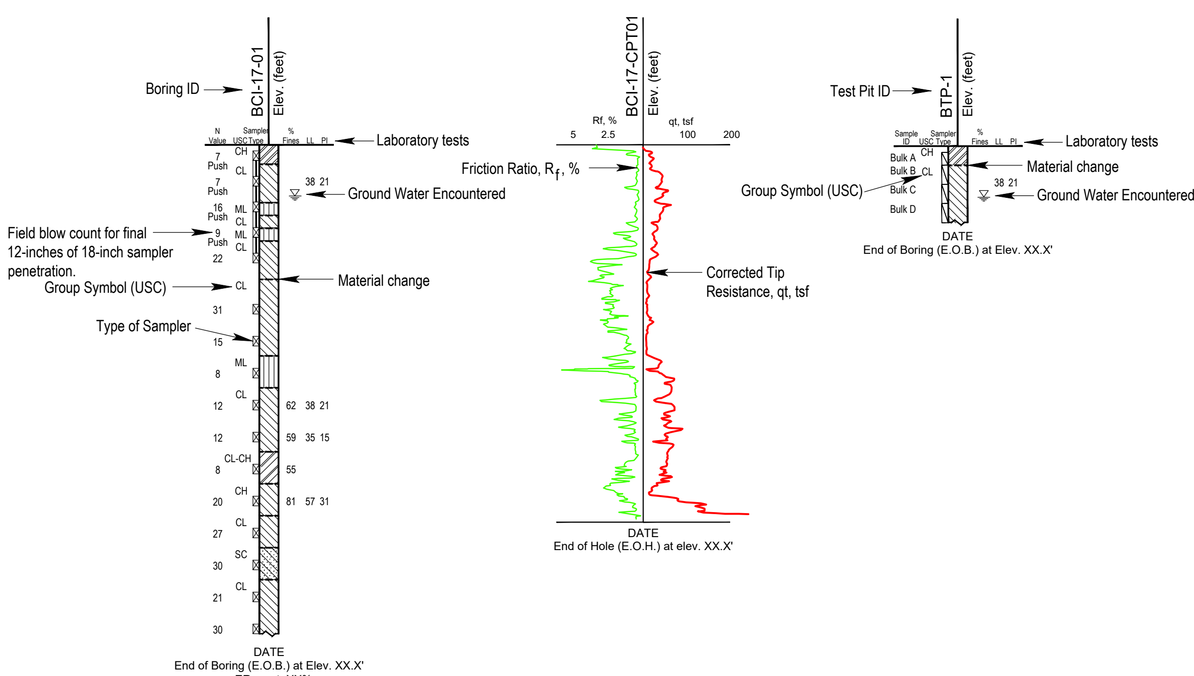
BLACKBURN BORINGS AND TEST PITS

- BCI-YEAR-ID — Exploratory Boring (September-October 2017)
- BCI-YEAR-ID — Exploratory Boring (May and December 2018)
- BCI-YEAR-ID — Exploratory Boring (November-December 2017)
- BCI-YEAR-ID — Exploratory Boring (March 2019)
- TP-ID — Approximate Test Pit Location (8-18-17)
- BTP-ID — Borrow Area Test Pits (July 2018)
- BTP-ID — Duck Slough Embankment Test Pits (July 2018) (Not in Profile View)
- BCI-YEAR-ID — CPT Exploration Location (April 2018)
- HSA Boring (August 2019) Existing Levee/Levee Toe (Hass/Cache & Skag Sloughs)
- 5 — Proposed Duck Slough Setback Levee Centerline
- Parcel Boundary
- STA 42+00 — Geotechnical Analysis
- Approximate Project Limits

Boring Information

CPT Information

Test Pit Information



NOTES:

1. Boring locations and elevations shown are approximate and based on various levels of certainty according to available data.
2. Boring logs represent soil conditions at the point of exploration on the date indicated.
3. Lines separating strata on boring logs represent approximate boundaries.
4. No warranty is provided as to the continuity of soil conditions between individual boring locations.
5. Geomorphology overlay source: Surficial Geologic Map of the West Delta Study Area, Plate 1 for the North Non-Urban Levee Evaluations. Produced by Department of Water Resources, Division of Flood Management, Levee Evaluations Branch in association with URS and Fugro, Scale is 1"=2000'. This is a color figure. black and white reproductions should not be relied upon as data will be lost.
6. Base drawings for the levee profiles are based on topography terrain model data provided by Wood Rodgers, Inc. 4-10-2019.
7. Boring locations on plan and profile sheets are referenced to 60% design levee alignment received 4-29-2019.
8. Base drawings for the levee plan and profiles are based on topography terrain model data and drawings provided by Wood Rodgers, Inc. September 2019.

This map shows surficial geologic deposits and levees as they existed in 1937. Map units and boundaries are drawn by interpretation of historical aerial photography supplemented by data from historical maps and surveys. For reference, the mapping is superimposed on modern U.S. Geological Survey 7.5' topographic base maps (individual maps referenced below).
Screened back semi-transparent mapping shown on this plate is from Deep Water Ship Channel study area, which is not assessed in this investigation. For clarity, only the surficial geologic map units of this study appear in the explanation.
See accompanying technical memorandum for complete descriptions of map units, process descriptions and methodology.
Adjacent polygons that have identical map unit symbols are employed to delineate sequences of sedimentation and landscape evolution.

Explanation

- Geologic contact; dashed where approximate, dotted where concealed, queried where uncertain. Solid contacts accurate to within 100' of line shown on map; dashed contacts accurate to within about 250' on either side of the line.
- Narrow channel, generally <100 ft in width. Dashed where approximate, dotted where concealed.
- Narrow, tidally influenced channel (<100 ft in width), commonly connected to a larger slough channel.
- Canal
- Levee; artificial fill prism, generally <70 ft in width.
- Borrow pit, generally <70 ft in width.

- W 1937 — Water; date indicates year of historical dataset.
- BP — Borrow pit present in 1937.

Geologic Units

HISTORICAL

- AF — Artificial fill, circa 1937.
- L — Levee (made of artificial fill), circa 1937.
- Rob — Overbank deposits; silt, sand, and lesser clay; deposited during high-stage water flow, overtopping channel banks.
- Rcs — Crevasse splay deposits; fine sand and silt with clay deposited from breaching of natural or artificial levees.
- Rch — Channel deposits; well sorted sand and trace fine gravel.
- Rsl — Slough deposits; silt, clay, and sand, fining upward facies, low-energy channel deposits.
- Ril 1906 — Intermittent lake; seasonal lake shown on historical topographic maps. Date indicates source data set.

HOLOCENE

- Hob — Overbank deposits; silt, sand, and clay; deposited during high-stage water flow, overtopping channel banks.
- Hcs — Crevasse splay deposits; fine sand and silt with clay deposited from breaching of natural levees.
- Hff — Fine-grained alluvial fan deposits; silt and clay with sand.
- Hch — Channel deposits; well sorted sand and trace fine gravel.
- Hsl — Slough deposits; silt, clay, and sand, fining upward facies, low-energy channel deposits.
- Ha — Alluvial deposits, undifferentiated; sand, silt, clay and minor lenses of gravel.
- Hpm — Peat and muck; interbedded peat and organic-rich silt and clay, former tidal marsh deposits, mostly now leveed, drained, and farmed.
- Hn — Basin deposits; fine sand, silt and clay.
- Hs 1937 — Marsh deposits; silt and clay, possibly with organic-rich beds; perennially or seasonally submerged. Date indicates year of historical dataset used to map the marsh.

PLEISTOCENE

- Pf — Alluvial fan deposits; semi-consolidated silt, sand, sandy clay and fine to coarse subrounded gravel.
- Pf (m) — Alluvial fan deposits of the Montezuma Hills; semi-consolidated sandy silt, sandy clayey silt, clay, sand and minor pebble gravel eroded from the early Pleistocene Montezuma Formation

Stratigraphic Correlation Chart

Time: Epoch	Depositional Environment: Channel deposits	Floodplain and alluvial-fan deposits	Flood basin deposits	Cultural deposits
Historical	Rch, Rsl	Ra, Rob, Rcs, Ril	Hn, Hs, Hpm	L, AF
Holocene	Hch, Hsl	Ha, Hob, Hcs, Hff		
Pleistocene		Pf, Pf (m)		

REV.	DATE	BY	CHK.	APPR.	DESCRIPTION

DESIGNED BY: ROBERT B. LOKTEFF, P.E.,G.E.
DRAWN BY: MIKE ROBERTSON
CHECKED BY: NICOLE C. HART, P.E.
IN CHARGE: JONATHAN KORS, P.E.
DATE: 09/02/2019

PRELIMINARY — REGISTERED PROFESSIONAL ENGINEER, ROBERT B. LOKTEFF, GEOTECHNICAL, STATE OF CALIFORNIA

Prepared by:
BLACKBURN CONSULTING
2491 BOATMAN AVENUE
WEST SACRAMENTO, CA 95691
www.blackburnconsulting.com
JOB NO.: 3195.x

SUBMITTED
APPROVED

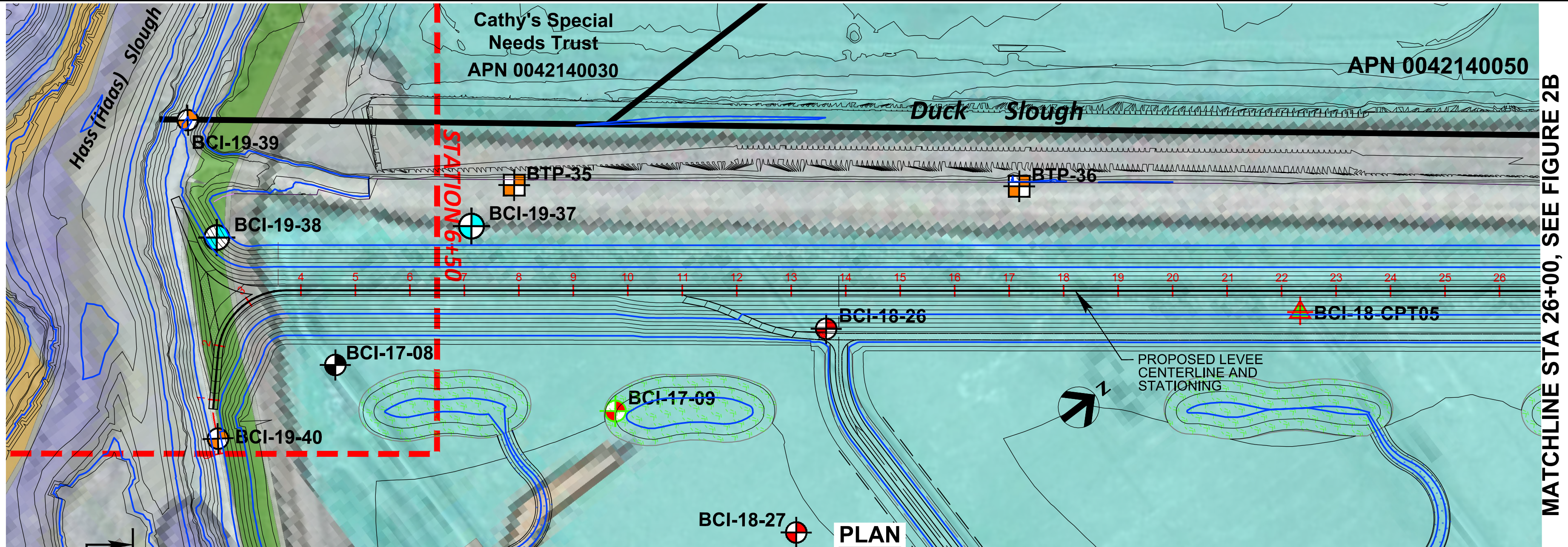
Ecosystem Investment Partners

ECOSYSTEM INVESTMENT PARTNERS

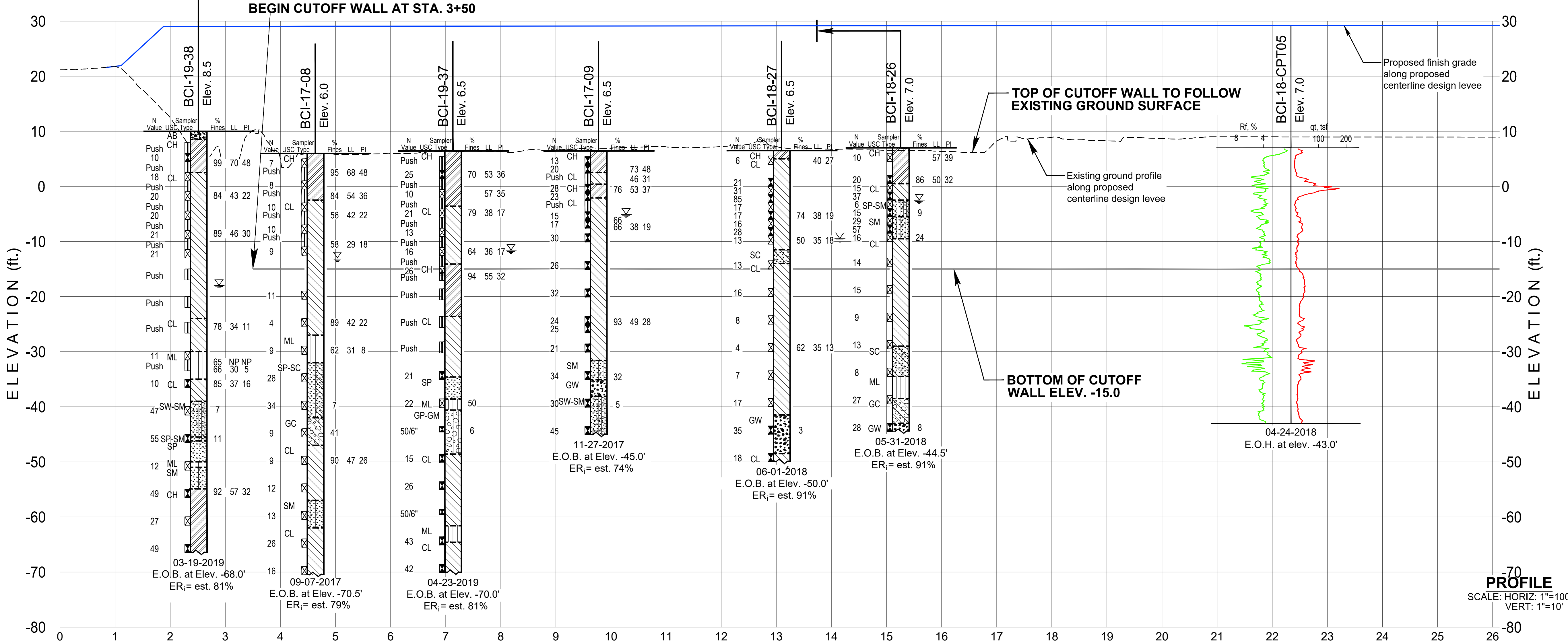
LOOKOUT SLOUGH THRFIP
Geotechnical Basis of Design Report - 65% Design
PLAN AND PROFILE LEGEND

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING, ADJUST SCALES FOR REDUCED PLOTS
0 1"

FIGURE NO. 5
SHEET A



PLAN
SCALE: 1"=150'



PROFILE
SCALE: HORIZ: 1"=100'
VERT: 1"=10'

REV.	DATE	BY	CHK.	APPR.	DESCRIPTION

DESIGNED BY: ROBERT B. LOKTEFF, P.E.,G.E.
DRAWN BY: MIKE ROBERTSON
CHECKED BY: NICOLE C. HART, P.E.
IN CHARGE: JONATHAN KORS, P.E.
DATE: 09/02/2019

PRELIMINARY

Prepared by:
BLACKBURN CONSULTING
2491 BOATMAN AVENUE
WEST SACRAMENTO, CA 95691
www.blackburnconsulting.com
JOB NO.: 3195.x

SUBMITTED
APPROVED

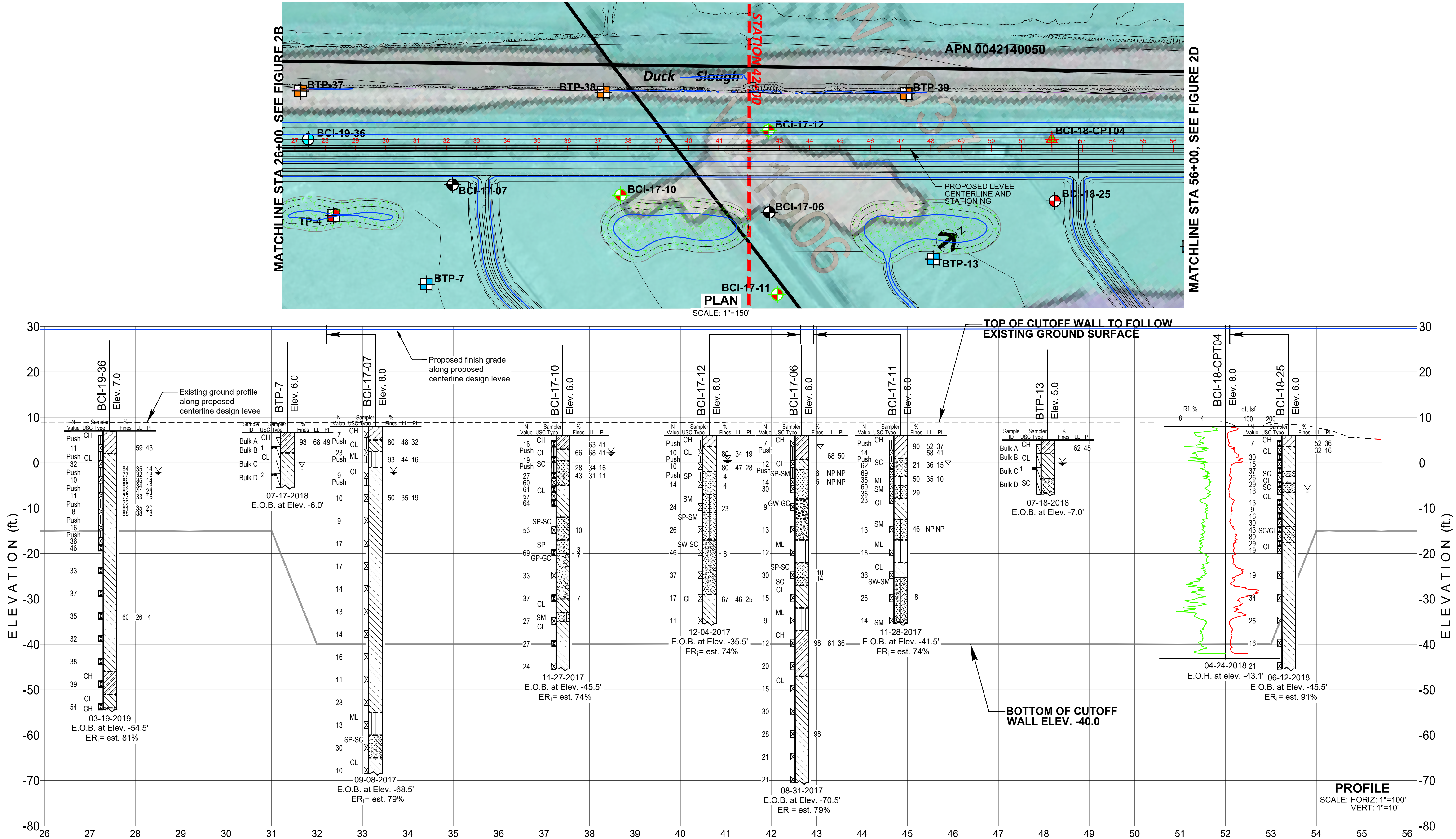
Ecosystem Investment Partners

ECOSYSTEM INVESTMENT PARTNERS

LOOKOUT SLOUGH THRFIP
Geotechnical Basis of Design Report - 65% Design
PLAN AND PROFILE STA. 0+00 to 26+00

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING, ADJUST SCALES FOR REDUCED PLOTS

FIGURE NO. 5
SHEET B



REV.	DATE	BY	CHK.	APPR.	DESCRIPTION

DESIGNED BY: ROBERT B. LOKTEFF, P.E., G.E.
DRAWN BY: MIKE ROBERTSON
CHECKED BY: NICOLE C. HART, P.E.
IN CHARGE: JONATHAN KORS, P.E.
DATE: 09/02/2019

PRELIMINARY

Prepared by:
BLACKBURN CONSULTING
2491 BOATMAN AVENUE
WEST SACRAMENTO, CA 95691
www.blackburnconsulting.com
JOB NO.: 3195.x

SUBMITTED
APPROVED

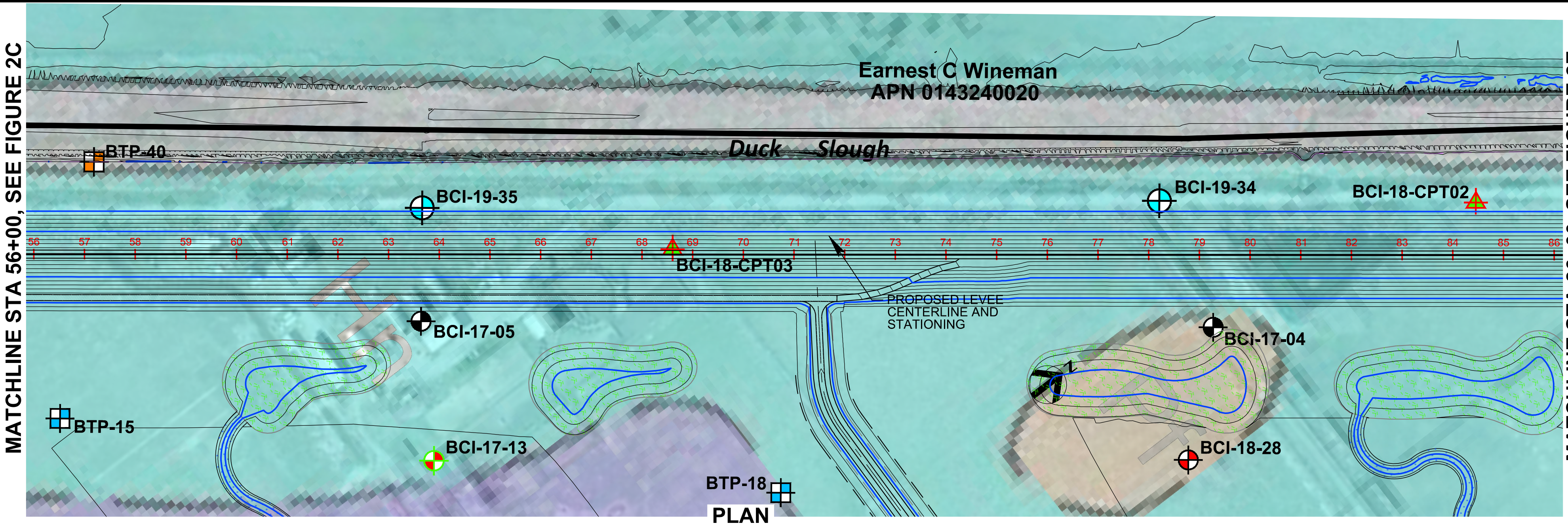
Ecosystem Investment Partners

ECOSYSTEM INVESTMENT PARTNERS

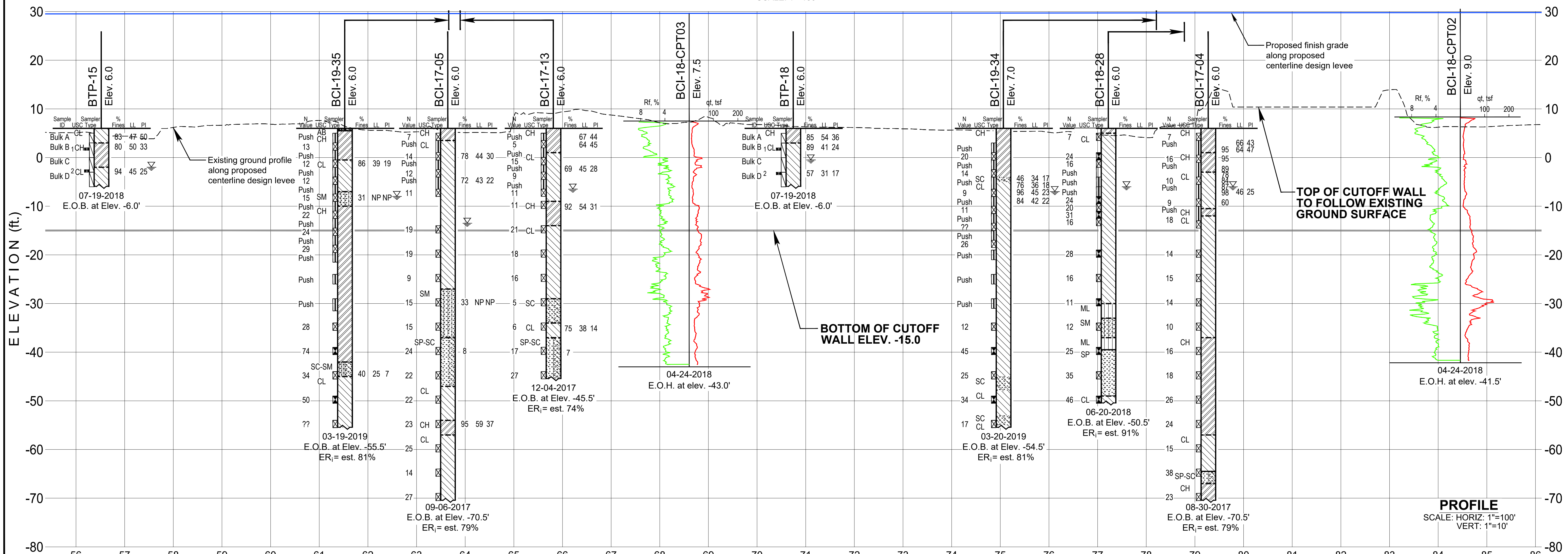
LOOKOUT SLOUGH THRFIP
Geotechnical Basis of Design Report - 65% Design
PLAN AND PROFILE STA. 26+00 to 56+00

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING, ADJUST SCALES FOR REDUCED PLOTS

FIGURE NO. 5
SHEET C



PLAN
SCALE: 1"=150'



PROFILE
SCALE: HORIZ: 1"=100'
VERT: 1"=10'

REV.	DATE	BY	CHK.	APPR.	DESCRIPTION

DESIGNED BY: ROBERT B. LOKTEFF, P.E.,G.E.
DRAWN BY: MIKE ROBERTSON
CHECKED BY: NICOLE C. HART, P.E.
IN CHARGE: JONATHAN KORS, P.E.
DATE: 09/02/2019

PRELIMINARY

Prepared by:
BLACKBURN CONSULTING
2491 BOATMAN AVENUE
WEST SACRAMENTO, CA 95691
www.blackburnconsulting.com
JOB NO.: 3195.x

SUBMITTED
APPROVED

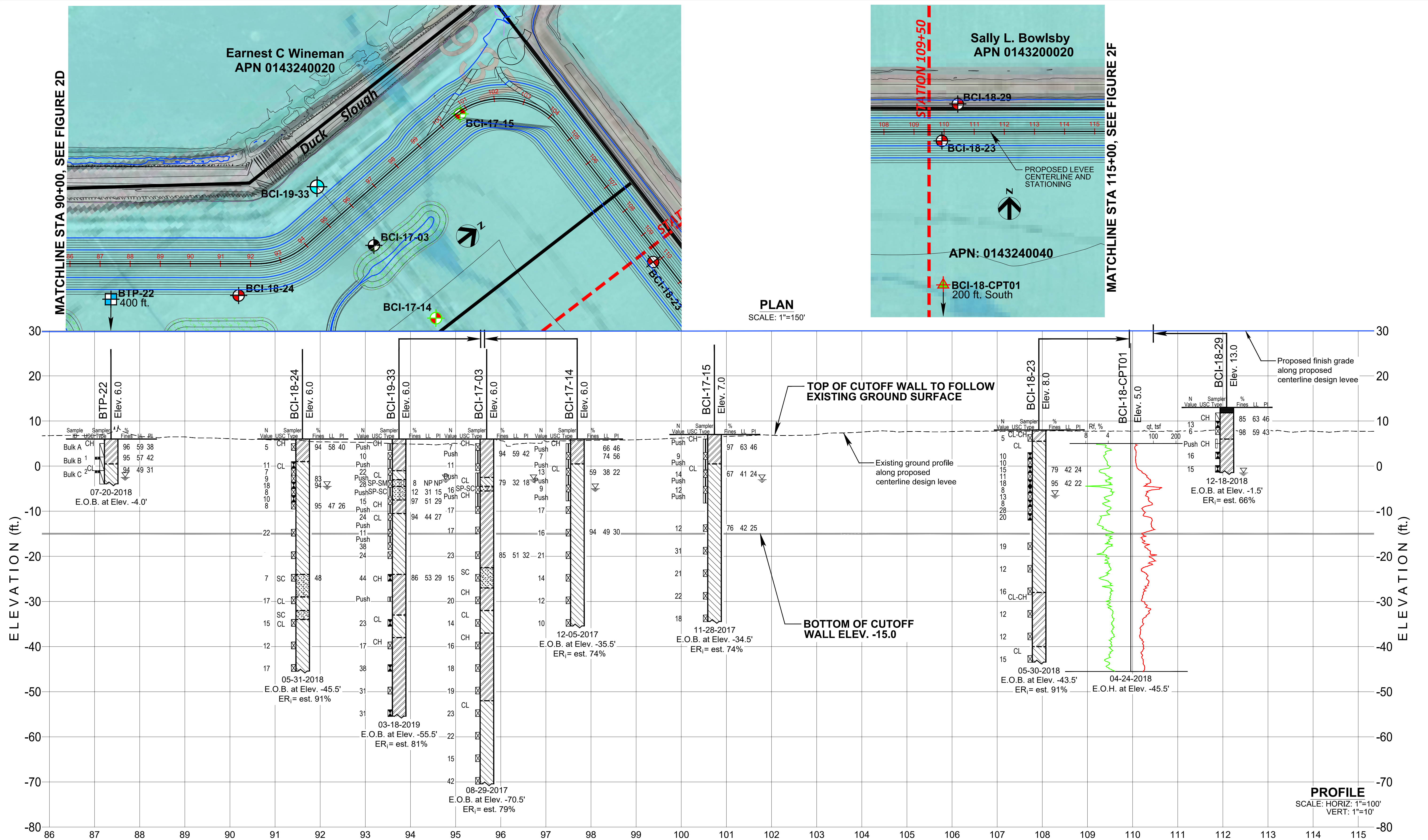
Ecosystem Investment Partners

ECOSYSTEM INVESTMENT PARTNERS

LOOKOUT SLOUGH THRFIP
Geotechnical Basis of Design Report - 65% Design
PLAN AND PROFILE STA. 56+00 to 86+00

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING, ADJUST SCALES FOR REDUCED PLOTS

FIGURE NO. 5
SHEET D



REV.	DATE	BY	CHK.	APPR.	DESCRIPTION

DESIGNED BY: ROBERT B. LOKTEFF, P.E.,G.E.
DRAWN BY: MIKE ROBERTSON
CHECKED BY: NICOLE C. HART, P.E.
IN CHARGE: JONATHAN KORS, P.E.
DATE: 09/02/2019

PRELIMINARY

Prepared by:
BLACKBURN CONSULTING
2491 BOATMAN AVENUE
WEST SACRAMENTO, CA 95691
www.blackburnconsulting.com
JOB NO.: 3195.x

SUBMITTED
APPROVED

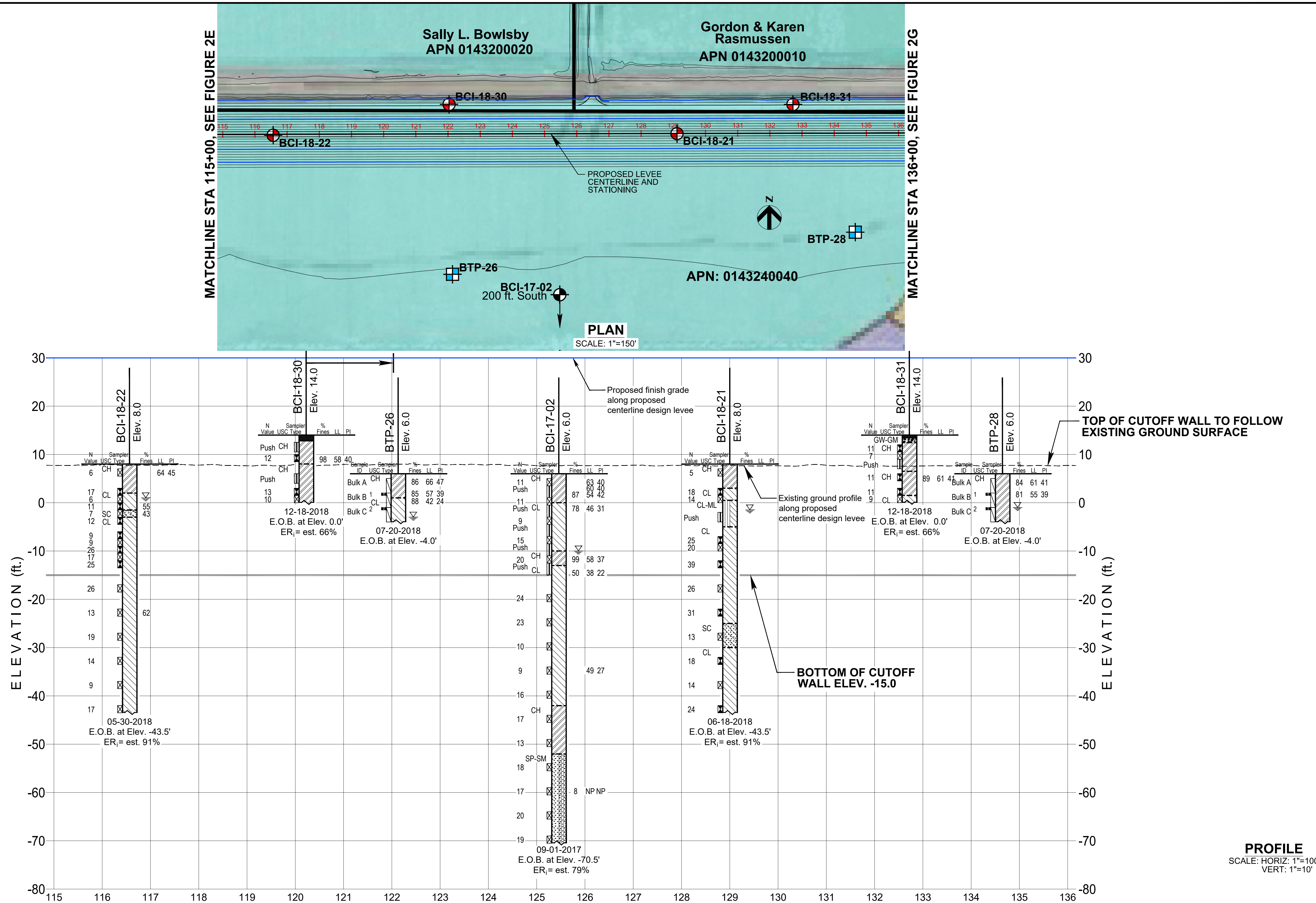
Ecosystem Investment Partners

ECOSYSTEM INVESTMENT PARTNERS

LOOKOUT SLOUGH THRFIP
Geotechnical Basis of Design Report - 65% Design
PLAN AND PROFILE STA. 86+00 to 115+00

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING, ADJUST SCALES FOR REDUCED PLOTS

FIGURE NO. 5
SHEET E



REV.	DATE	BY	CHK.	APPR.	DESCRIPTION

DESIGNED BY: ROBERT B. LOKTEFF, P.E.,G.E.
DRAWN BY: MIKE ROBERTSON
CHECKED BY: NICOLE C. HART, P.E.
IN CHARGE: JONATHAN KORS, P.E.
DATE: 09/02/2019

PRELIMINARY

Prepared by:
BLACKBURN CONSULTING
2491 BOATMAN AVENUE
WEST SACRAMENTO, CA 95691
www.blackburnconsulting.com
JOB NO.: 3195.x

SUBMITTED
APPROVED

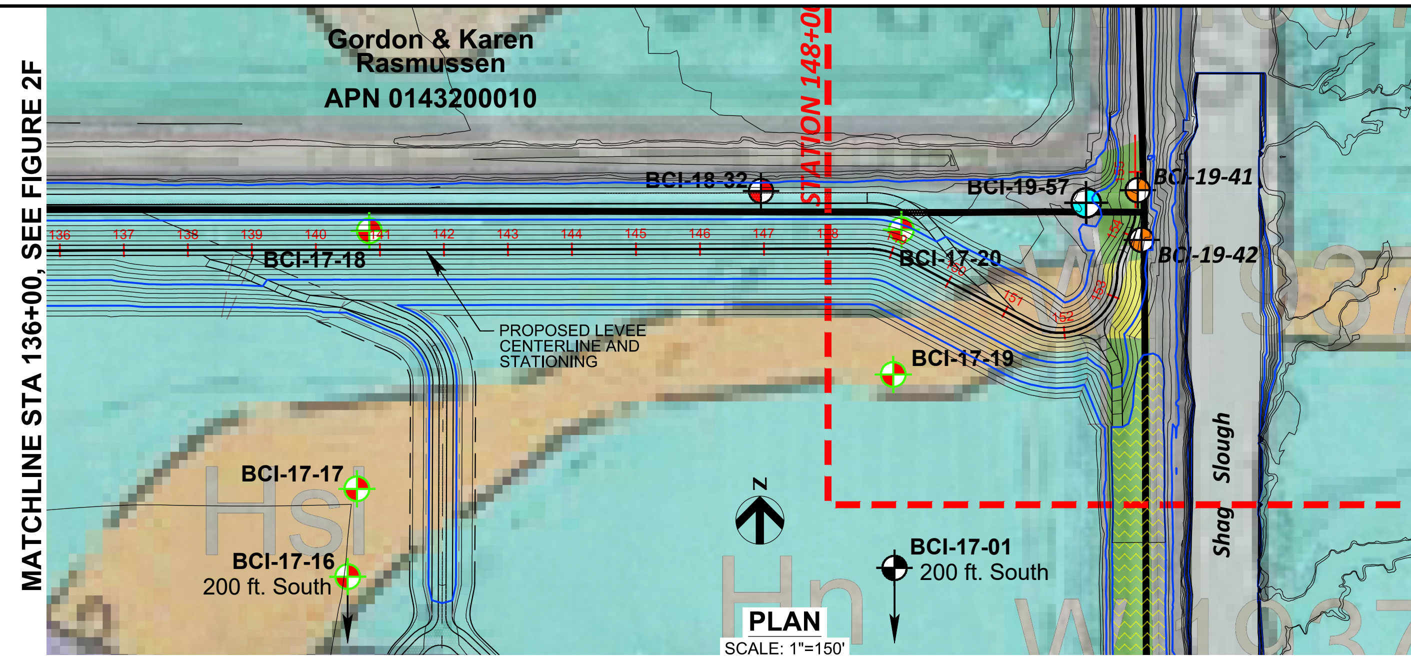
Ecosystem Investment Partners

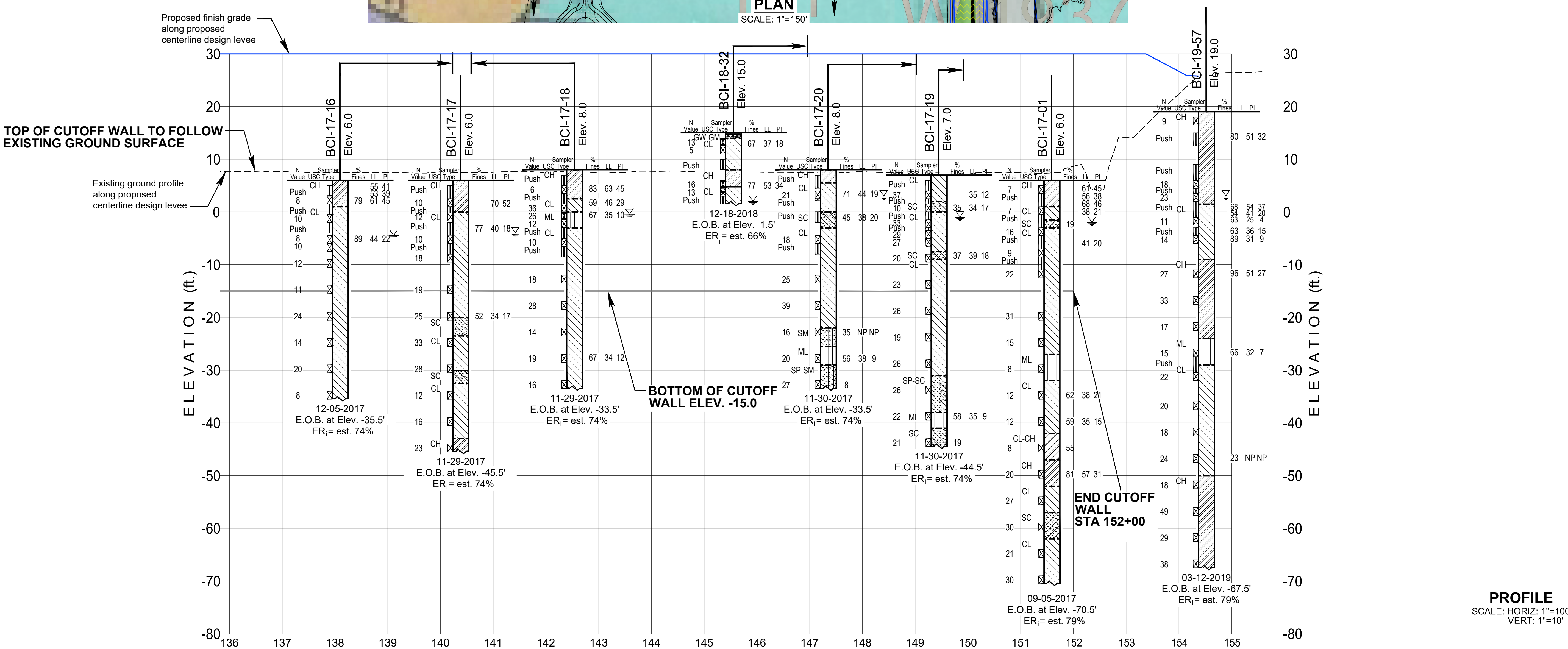
ECOSYSTEM INVESTMENT PARTNERS

LOOKOUT SLOUGH THRFIP
Geotechnical Basis of Design Report - 65% Design
PLAN AND PROFILE STA. 115+00 to 136+00

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING, ADJUST SCALES FOR REDUCED PLOTS

FIGURE NO. 5
SHEET F





REV.	DATE	BY	CHK.	APPR.	DESCRIPTION

DESIGNED BY: ROBERT B. LOKTEFF, P.E.,G.E.
DRAWN BY: MIKE ROBERTSON
CHECKED BY: NICOLE C. HART, P.E.
IN CHARGE: JONATHAN KORS, P.E.
DATE: 09/02/2019

PRELIMINARY

Prepared by:
BLACKBURN CONSULTING
2491 BOATMAN AVENUE
WEST SACRAMENTO, CA 95691
www.blackburnconsulting.com
JOB NO.: 3195.x

SUBMITTED
APPROVED

Ecosystem Investment Partners

ECOSYSTEM INVESTMENT PARTNERS

LOOKOUT SLOUGH THRFIP
Geotechnical Basis of Design Report - 65% Design
PLAN AND PROFILE STA. 136+00 to 155+00

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING, ADJUST SCALES FOR REDUCED PLOTS
0 1"

FIGURE NO. 5
SHEET G

This Page Intentionally Left Blank

GEOTECHNICAL BASIS OF DESIGN REPORT

65% Design

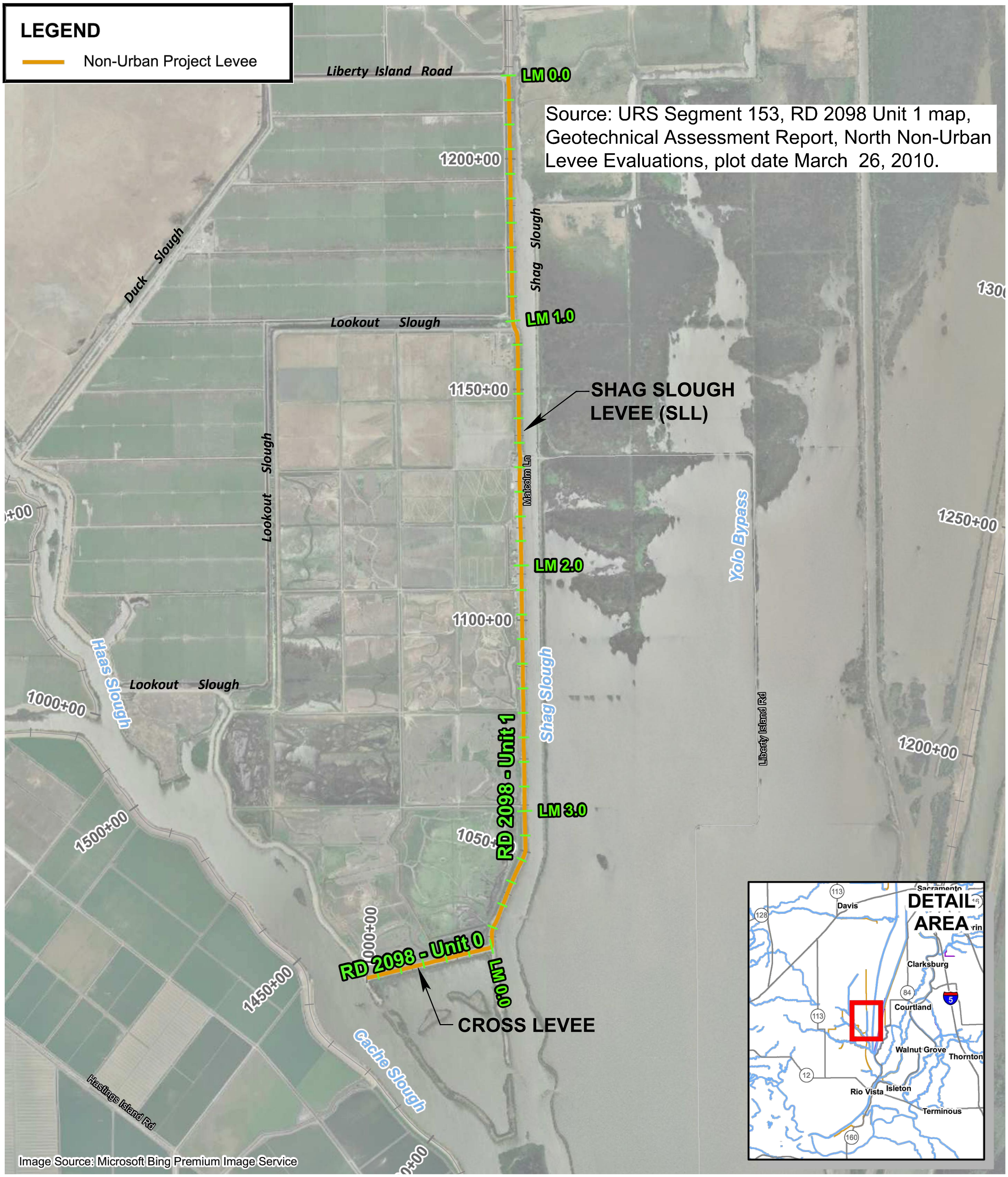
Lookout Slough THRFIP

Solano County, California

APPENDIX A

Historical Documents

This Page Intentionally Left Blank



APPENDIX A-1, SEGMENT 153, RD 2098 Unit 1
Geotechnical Basis of Design Report - 65% Design
September 2019

N
W E
S

0 3000
SCALE: 1" = 3000'

Lookout Slough THRFIP

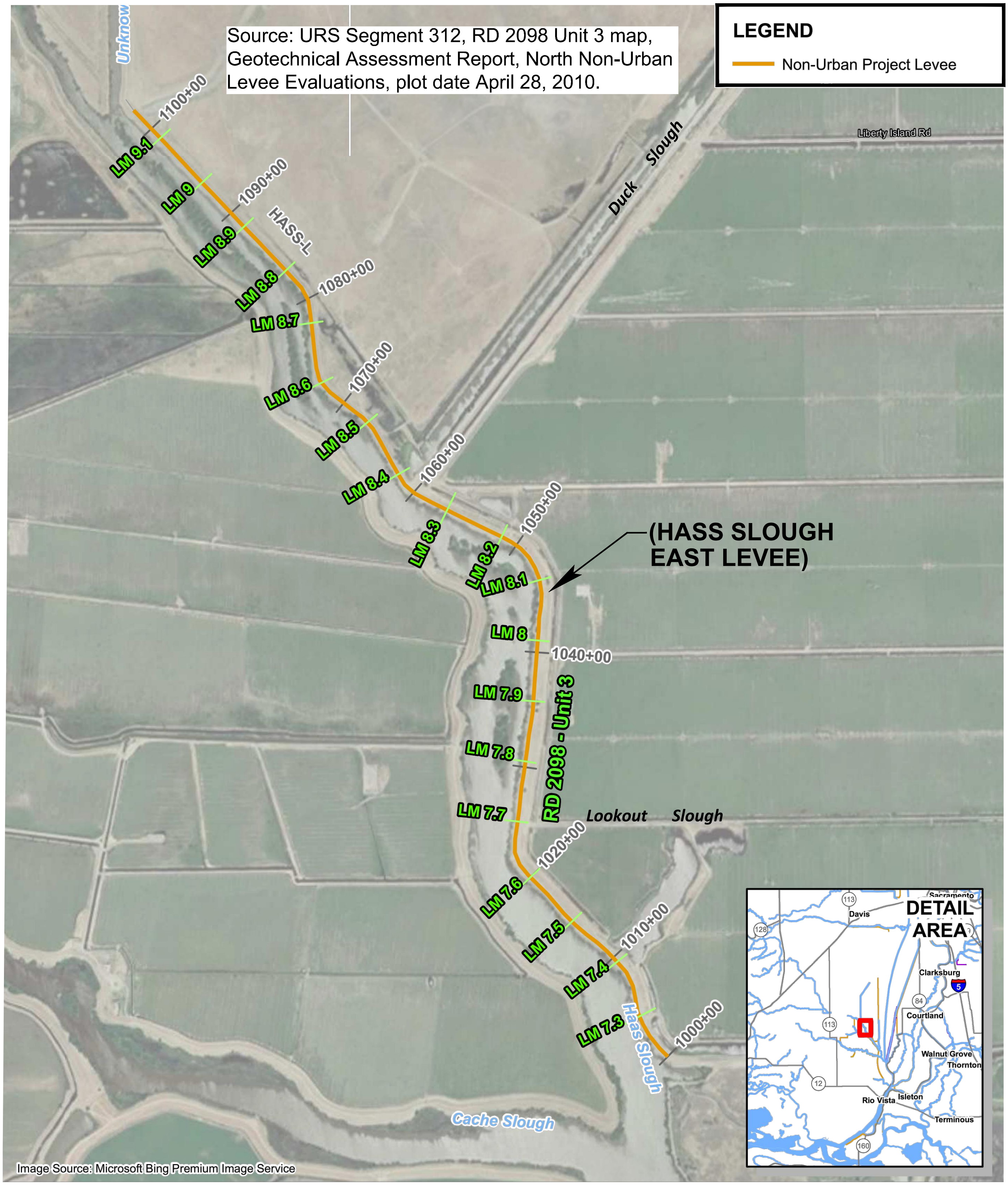
Ecosystem Investment Partners

Prepared by:

Map Prepared Date: 09/01/19
Map Prepared By: M.D.R.
Checked By: N.C.H.
Job No.: 3195.x

BLACKBURN CONSULTING

Path: \\FS-01\Common\Active Projects\3195.P DWR Lookout Slough Restoration Project\CAD\3195.x LSRP GBOD 65% AppA-1.dwg



APPENDIX A-2, SEGMENT 312, RD 2098 Unit 3
Geotechnical Basis of Design Report - 65% Design
September 2019

Lookout Slough THRFIP

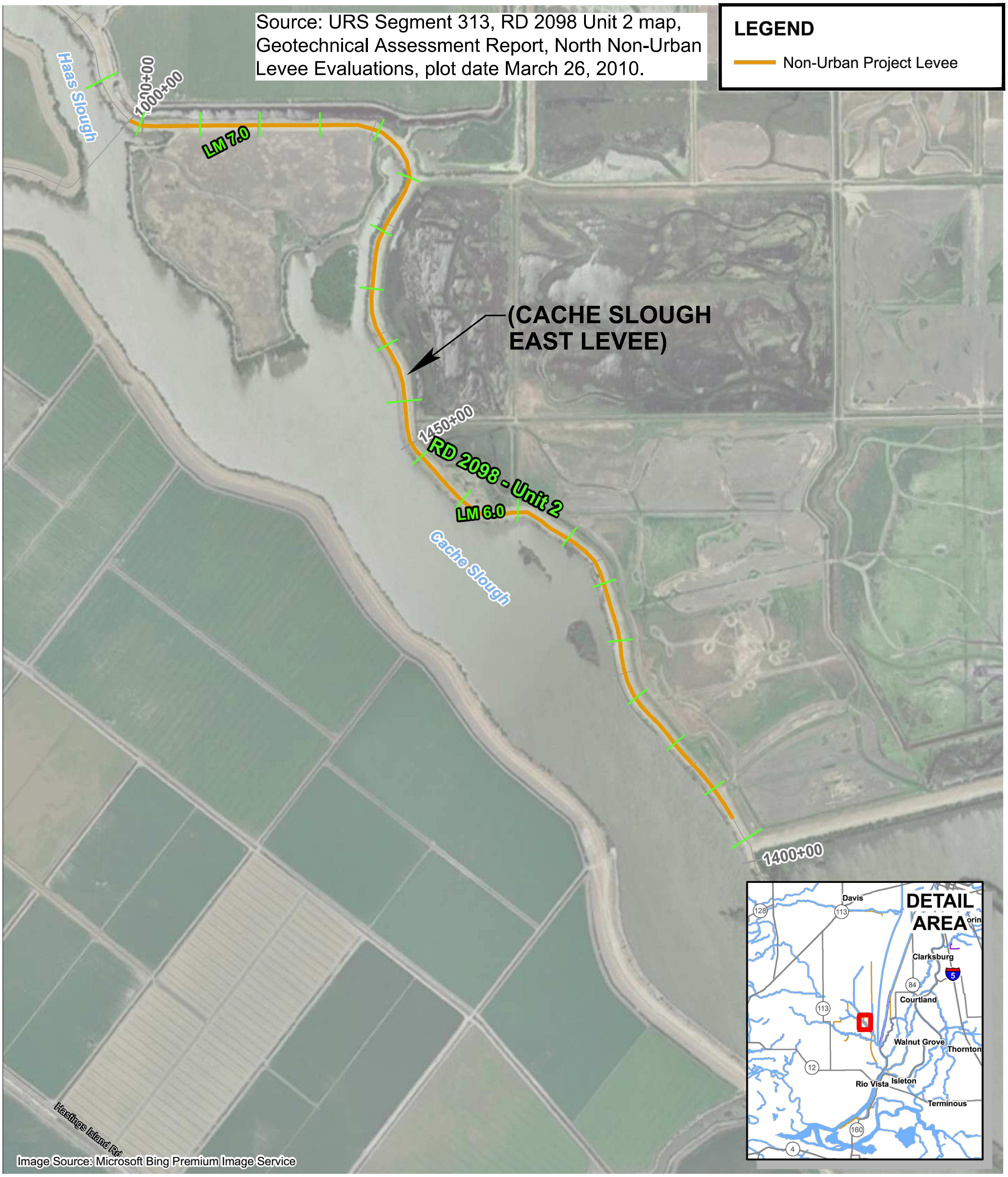
0 1200
SCALE: 1" = 1200'

Ecosystem Investment Partners

Prepared by:
Map Prepared Date: 09/01/19
Map Prepared By: M.D.R.
Checked By: N.C.H.
Job No.: 3195.x

BLACKBURN CONSULTING

Path: \\FS-01\Common\Active Projects\3195.P DWR Lookout Slough Restoration Project\CAD\3195.x LSRP GBOD 65% AppA-2.dwg



APPENDIX A-3, SEGMENT 313, RD 2098 Unit 2
Geotechnical Basis of Design Report - 65% Design
September 2019

N W E S

0 1200
SCALE: 1" = 1200'

Lookout Slough THRFIP

Ecosystem Investment Partners

Prepared by:

Map Prepared Date: 09/01/19
Map Prepared By: M.D.R.
Checked By: N.C.H.
Job No.: 3195.x

BLACKBURN CONSULTING

Path: \\FS-01\Common\Active Projects\3195.P DWR Lookout Slough Restoration Project\CAD\3195.x LSRP GBOD 65% AppA-3.dwg

APPENDIX A-4, TOPOGRAPHIC MAP 1908
Geotechnical Basis of Design Report - 65% Design
September 2019

N W E S

0 3000
SCALE: 1" = 3000'

Lookout Slough THRFIP

Ecosystem Investment Partners

Prepared by:

Map Prepared Date: 09/01/19
Map Prepared By: M.D.R.
Checked By: N.C.H.
Job No.: 3195.x

BLACKBURN CONSULTING

Path: \\FS-01\Common\Active Projects\3195.P DWR Lookout Slough Restoration Project\CAD\3195.x LSRP GBOD 65% AppA-4.dwg

Source: USGS Historical Topographic Map, Cache Slough, CA, 1:31680, dated March 17, 1916.

APPENDIX A-5, TOPOGRAPHIC MAP 1916
Geotechnical Basis of Design Report - 65% Design
September 2019

Lookout Slough THRFIP

0 3000

SCALE: 1" = 3000'

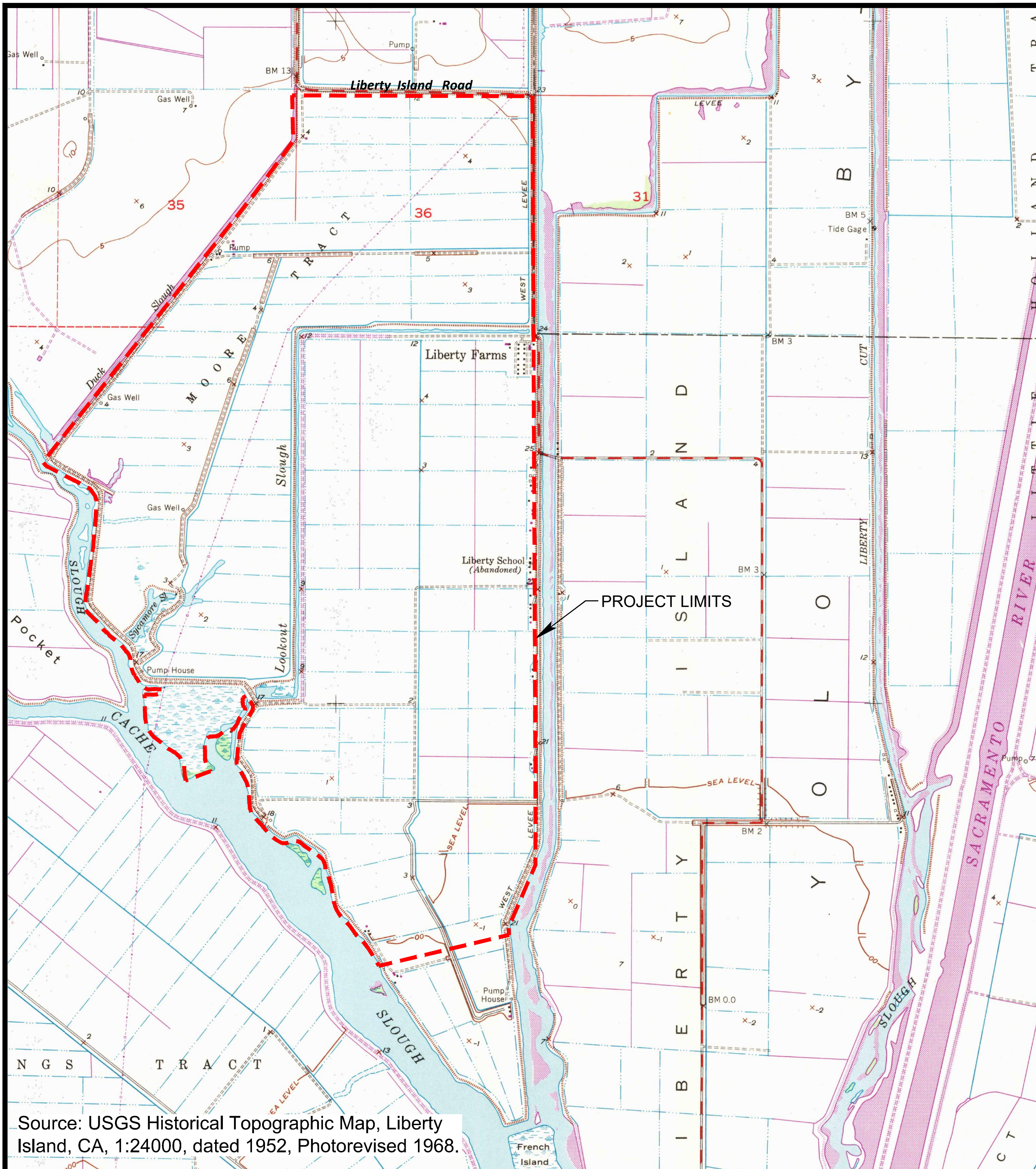
Ecosystem Investment Partners

Prepared by:

Map Prepared Date: 09/01/19
Map Prepared By: M.D.R.
Checked By: N.C.H.
Job No.: 3195.x

BLACKBURN CONSULTING

Path: \\FS-01\Common\Active Projects\3195.P DWR Lookout Slough Restoration Project\CAD\3195.x LSRP GBOD 65% AppA-5.dwg



Source: USGS Historical Topographic Map, Liberty Island, CA, 1:24000, dated 1952, Photorevised 1968.

APPENDIX A-6, TOPOGRAPHIC MAP 1952
Geotechnical Basis of Design Report - 65% Design
September 2019

Lookout Slough THRFIP

Ecosystem Investment Partners

Prepared by:

Map Prepared Date: 09/01/19
Map Prepared By: M.D.R.
Checked By: N.C.H.
Job No.: 3195.x

BLACKBURN CONSULTING

Path: \\FS-01\Common\Active Projects\3195.P DWR Lookout Slough Restoration Project\CAD\3195.x LSRP GBOD 65% AppA-6.dwg

GEOTECHNICAL BASIS OF DESIGN REPORT

65% Design

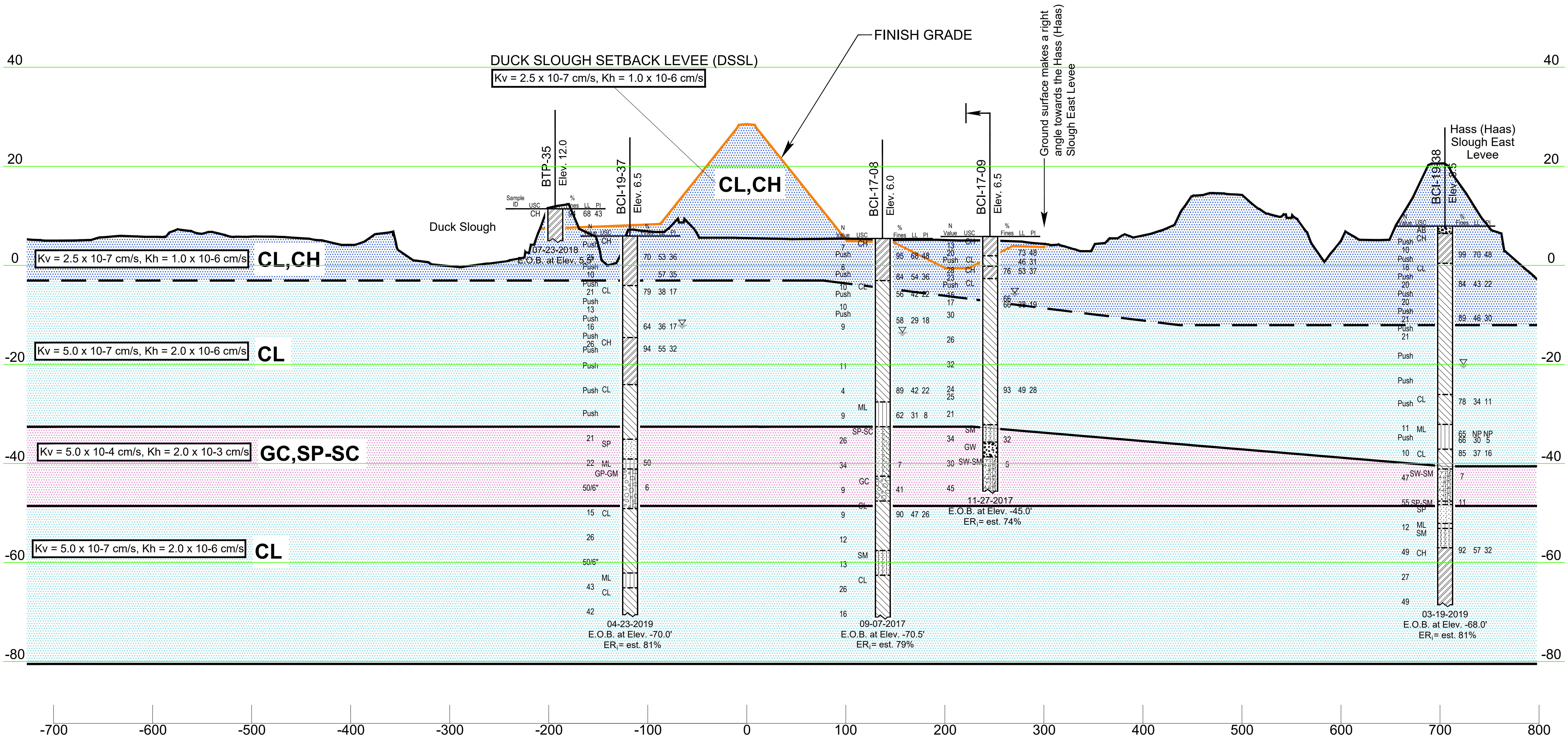
Lookout Slough THRFIP

Solano County, California

APPENDIX B

SEEP/W and SLOPE/W Analytical Results

This Page Intentionally Left Blank



APPENDIX B-1, STA 6+50
GEOTECHNICAL BASIS OF DESIGN REPORT - 65% DESIGN
SUBSURFACE PROFILE USED IN ANALYSIS
September 2019

LEGEND

Kv, Kh = - Hydraulic Conductivity Values for Soil Layers

NOTES:
Cross section updated 05-14-19. Levee shifted to centerline of new alignment. Boring logs updated 5-8-19.

SCALE: 1 inch = 100 ft Hor.
1 inch = 20 ft Vert.

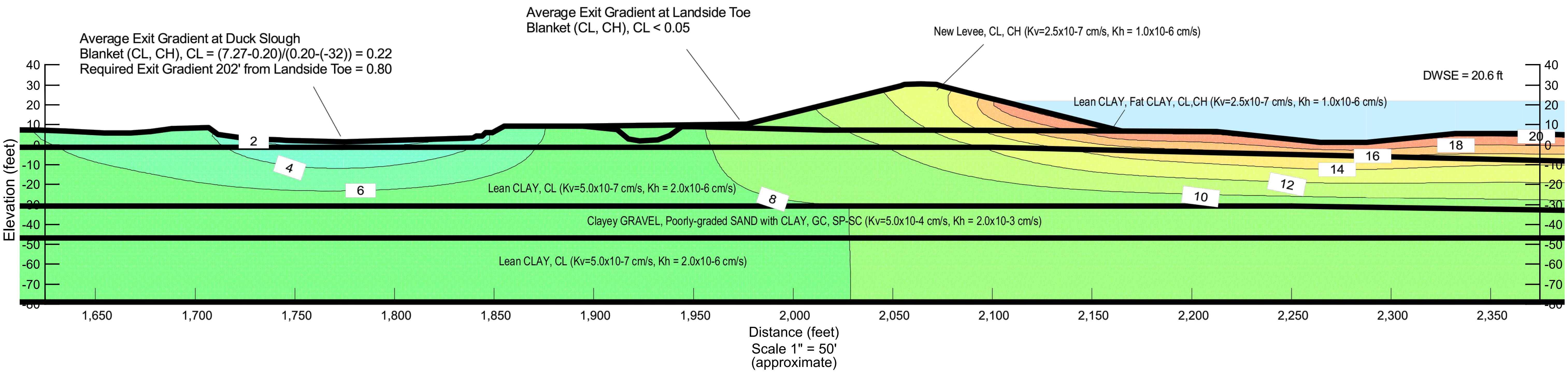
Ecosystem Investment Partners

Lookout Slough THRFIP

Map Prepared Date: 09/01/19
Map Prepared By: M.D.R.
Checked By: N.C.H.
Job No.: 3195.x

Prepared by:
BLACKBURN CONSULTING

Path: \\FS-01\Common\Active Projects\3195.P DWR Lookout Slough Restoration Project\CAD\CROSS SECTIONS NEW 06_20_2019\3195.x LSRP BDR 65% 06+50 AppB.dwg



Material ID and Type, Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

Clayey GRAVEL, Poorly-Graded SAND with CLAY, GC, SP-SC	Kh=5.67 ft/day	(=2.0x10-3 cm/s)	0.25
Lean CLAY, CL	Kh=0.0057 ft/day	(=2.0x10-6 cm/s)	0.25
Lean CLAY, Fat CLAY, CL, CH	Kh=0.0028 ft/day	(=1.0x10-6 cm/s)	0.25
New Levee, CL, CH	Kh=0.0028 ft/day	(=1.0x10-6 cm/s)	0.25

APPENDIX B-2, STA 6+50
GEOTECHNICAL BASIS OF DESIGN REPORT - 65% DESIGN
DWSE Steady-State Seepage Analysis
Setback Levee with No Cutoff Wall
September 2019

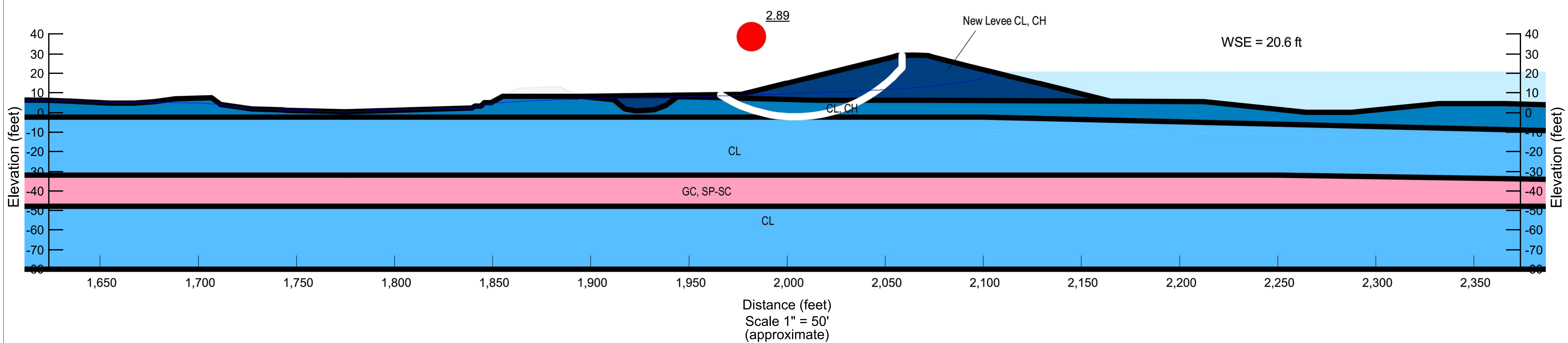
Lookout Slough THRFIP

Ecosystem Investment Partners

Map Prepared Date: 09/01/19
Map Prepared By: M.D.R.
Checked By: N.C.H.
Job No.: 3195.x

Prepared by:
BLACKBURN CONSULTING

Path: \\FS-01\Common\Active Projects\3195.P DWR Lookout Slough Restoration Project\CAD\65%
GBOD REPORT\3195.x LSRP GBOD 65% AppB 6+50.dwg



Material ID and Type, Unit Weight, Effective Cohesion, Effective Friction Angle

Material	Kh		(pcf)	(psf)	(°)
Clayey GRAVEL, Poorly-Graded SAND with CLAY, GC, SP-SC	Kh=5.67 ft/day	(=2.0x10-3 cm/s)	125	0	34
Lean CLAY, CL	Kh=0.0057 ft/day	(=2.0x10-6 cm/s)	115	150	32
Lean CLAY, Fat CLAY, CL, CH	Kh=0.0028 ft/day	(=1.0x10-6 cm/s)	115	150	30
New Levee, CL, CH	Kh=0.0028 ft/day	(=1.0x10-6 cm/s)	125	400	22

APPENDIX B-3, STA 6+50
GEOTECHNICAL BASIS OF DESIGN REPORT - 65% DESIGN
DWSE Steady-State Slope Stability Analysis
Setback Levee with No Cutoff Wall
September 2019

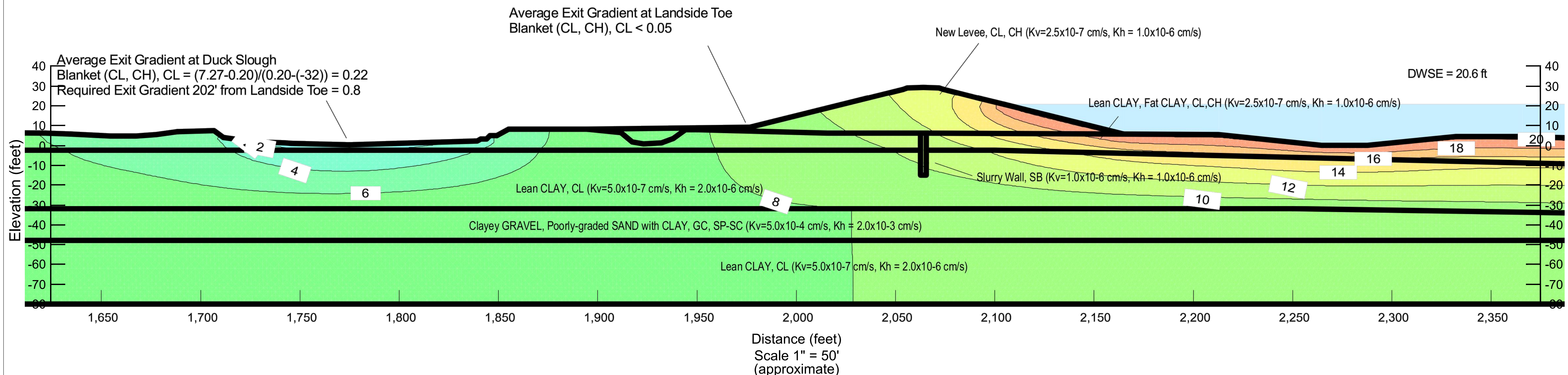
Lookout Slough THRFIP

Ecosystem Investment Partners

Map Prepared Date: 09/01/19
Map Prepared By: M.D.R.
Checked By: N.C.H.
Job No.: 3195.x

Prepared by:
BLACKBURN CONSULTING

Path: \\FS-01\Common\Active Projects\3195.P DWR Lookout Slough Restoration Project\CAD\65% GBOD REPORT\3195.x LSRP GBOD 65% AppB 6+50.dwg



Material ID and Type, Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

Clayey GRAVEL, Poorly-Graded SAND with CLAY, GC, SP-SC	Kh=5.67 ft/day	(=2.0x10-3 cm/s)	0.25
Lean CLAY, CL	Kh=0.0057 ft/day	(=2.0x10-6 cm/s)	0.25
Lean CLAY, Fat CLAY, CL, CH	Kh=0.0028 ft/day	(=1.0x10-6 cm/s)	0.25
New Levee, CL, CH	Kh=0.0028 ft/day	(=1.0x10-6 cm/s)	0.25
Slurry Wall, SB	Kh=0.0028 ft/day	(=1.0x10-6 cm/s)	1

APPENDIX B-4, STA 6+50
GEOTECHNICAL BASIS OF DESIGN REPORT - 65% DESIGN
DWSE Steady-State Seepage Analysis
Setback Levee with Shallow Cutoff Wall
September 2019

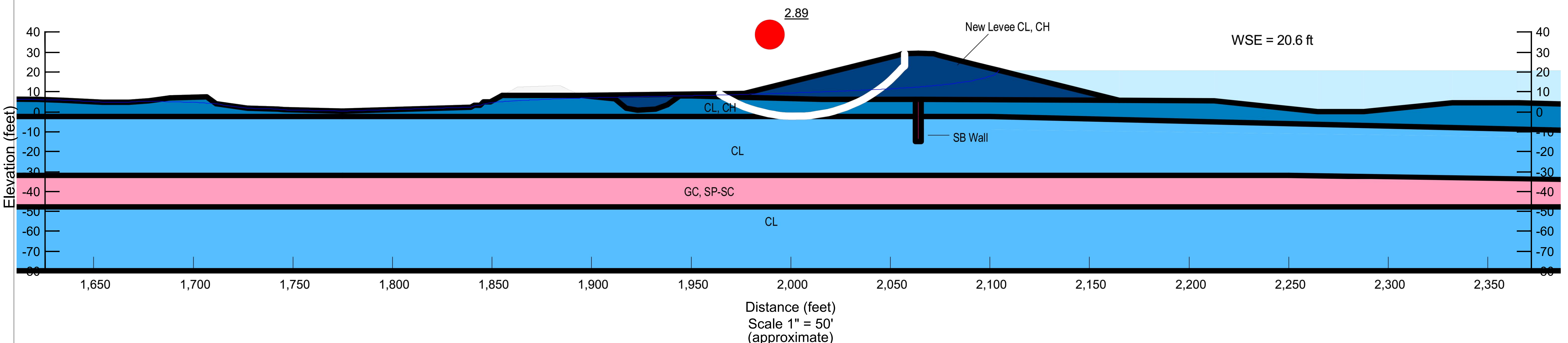
Lookout Slough THRFIP

Ecosystem Investment Partners

Map Prepared Date: 09/01/19
Map Prepared By: M.D.R.
Checked By: N.C.H.
Job No.: 3195.x

Prepared by:
BLACKBURN CONSULTING

Path: \\FS-01\Common\Active Projects\3195.P DWR Lookout Slough Restoration Project\CAD\65% GBOD REPORT\3195.x LSRP GBOD 65% AppB 6+50.dwg



Material ID and Type, Unit Weight, Effective Cohesion, Effective Friction Angle

Material	Kh		(pcf)	(psf)	(°)
Clayey GRAVEL, Poorly-Graded SAND with CLAY, GC, SP-SC	Kh=5.67 ft/day	(=2.0x10-3 cm/s)	125	0	34
Lean CLAY, CL	Kh=0.0057 ft/day	(=2.0x10-6 cm/s)	115	150	32
Lean CLAY, Fat CLAY, CL, CH	Kh=0.0028 ft/day	(=1.0x10-6 cm/s)	115	150	30
New Levee, CL, CH	Kh=0.0028 ft/day	(=1.0x10-6 cm/s)	125	400	22
Slurry Wall, SB	Kh=0.0028 ft/day	(=1.0x10-6 cm/s)	100	50	0

APPENDIX B-5, STA 6+50
GEOTECHNICAL BASIS OF DESIGN REPORT - 65% DESIGN
DWSE Steady-State Slope Stability Analysis
Setback Levee with Shallow Cutoff Wall
September 2019

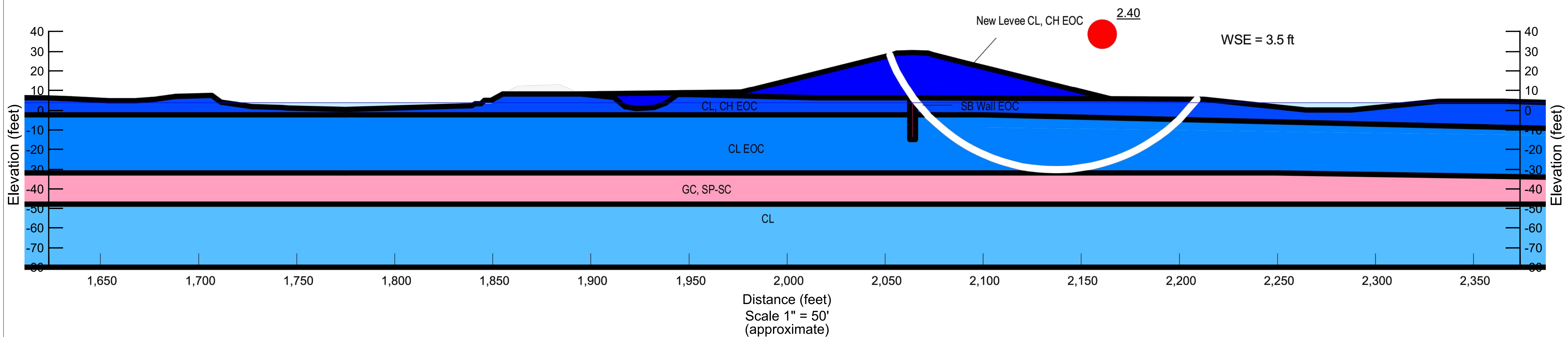
Lookout Slough THRFIP

Ecosystem Investment Partners

Map Prepared Date: 09/01/19
Map Prepared By: M.D.R.
Checked By: N.C.H.
Job No.: 3195.x

Prepared by:
BLACKBURN CONSULTING

Path: \\FS-01\Common\Active Projects\3195.P DWR Lookout Slough Restoration Project\CAD\65% GBOD REPORT\3195.x LSRP GBOD 65% AppB 6+50.dwg



Material ID and Type, Unit Weight, Undrained Shear Strength, Effective Cohesion, Effective Friction Angle

Material	Kh		(pcf)	(psf)	(psf)	(°)
Clayey GRAVEL, Poorly-Graded SAND with CLAY, GC, SP-SC	Kh=5.67 ft/day	(=2.0x10-3 cm/s)	125		0	34
Lean CLAY, CL	Kh=0.0057 ft/day	(=2.0x10-6 cm/s)	115		150	32
Lean CLAY, CL EOC	Kh=0.0057 ft/day	(=2.0x10-6 cm/s)	115	1,000		
Lean CLAY, Fat CLAY, CL, CH	Kh=0.0028 ft/day	(=1.0x10-6 cm/s)	115		150	30
Lean CLAY, Fat CLAY, CL, CH EOC	Kh=0.0028 ft/day	(=1.0x10-6 cm/s)	115	1,000		
New Levee, CL, CH EOC	Kh=0.0028 ft/day	(=1.0x10-6 cm/s)	125	1,500		
Slurry Wall, SB, EOC	Kh=0.0028 ft/day	(=1.0x10-6 cm/s)	100	20		

APPENDIX B-6, STA 6+50

GEOTECHNICAL BASIS OF DESIGN REPORT - 65% DESIGN

End-of-Construction Slope Stability Analysis
Setback Levee with Shallow Cutoff Wall
September 2019

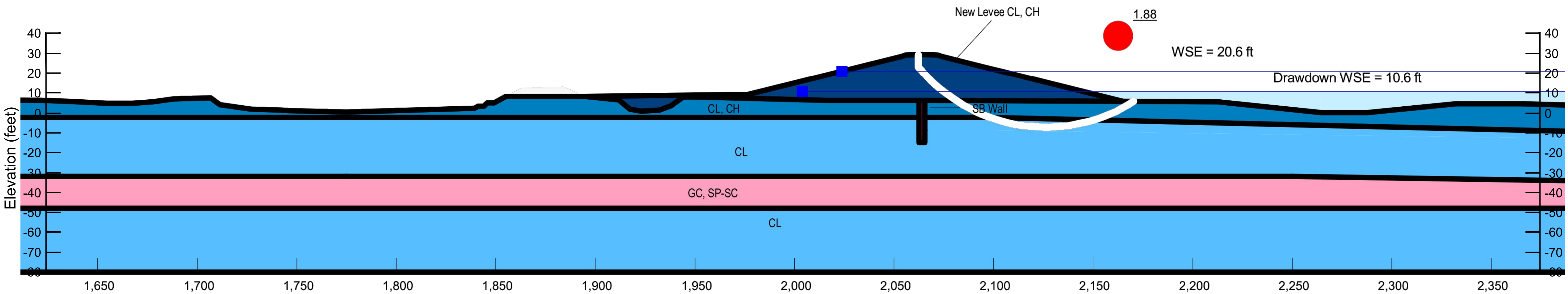
Lookout Slough THRFIP

Ecosystem Investment Partners

Map Prepared Date: 09/01/19
Map Prepared By: M.D.R.
Checked By: N.C.H.
Job No.: 3195.x

Prepared by:
BLACKBURN CONSULTING

Path: \\FS-01\Common\Active Projects\3195.P DWR Lookout Slough Restoration Project\CAD\65% GBOD REPORT\3195.x LSRP GBOD 65% AppB 6+50.dwg



Scale 1" = 50'
(approximate)

Material ID and Type, Unit Weight, Effective Cohesion, Effective Friction Angle, Total Cohesion, Total Friction Angle

Material	Kh		(pcf)	(psf)	(°)	(psf)	(°)
Clayey GRAVEL, Poorly-Graded SAND with CLAY, GC, SP-SC	Kh=5.67 ft/day	(=2.0x10-3 cm/s)	125	0	34	0	0
Lean CLAY, CL	Kh=0.0057 ft/day	(=2.0x10-6 cm/s)	115	150	32	175	16
Lean CLAY, Fat CLAY, CL, CH	Kh=0.0028 ft/day	(=1.0x10-6 cm/s)	115	150	30	175	15
New Levee, CL, CH	Kh=0.0028 ft/day	(=1.0x10-6 cm/s)	125	400	22	450	13
Slurry Wall, SB	Kh=0.0028 ft/day	(=1.0x10-6 cm/s)	100	50	0	0	0

APPENDIX B-7, STA 6+50
GEOTECHNICAL BASIS OF DESIGN REPORT - 60% DESIGN
Rapid Drawdown Slope Stability Analysis, 10 ft. Drawdown
Setback Levee with Shallow Cutoff Wall
September 2019

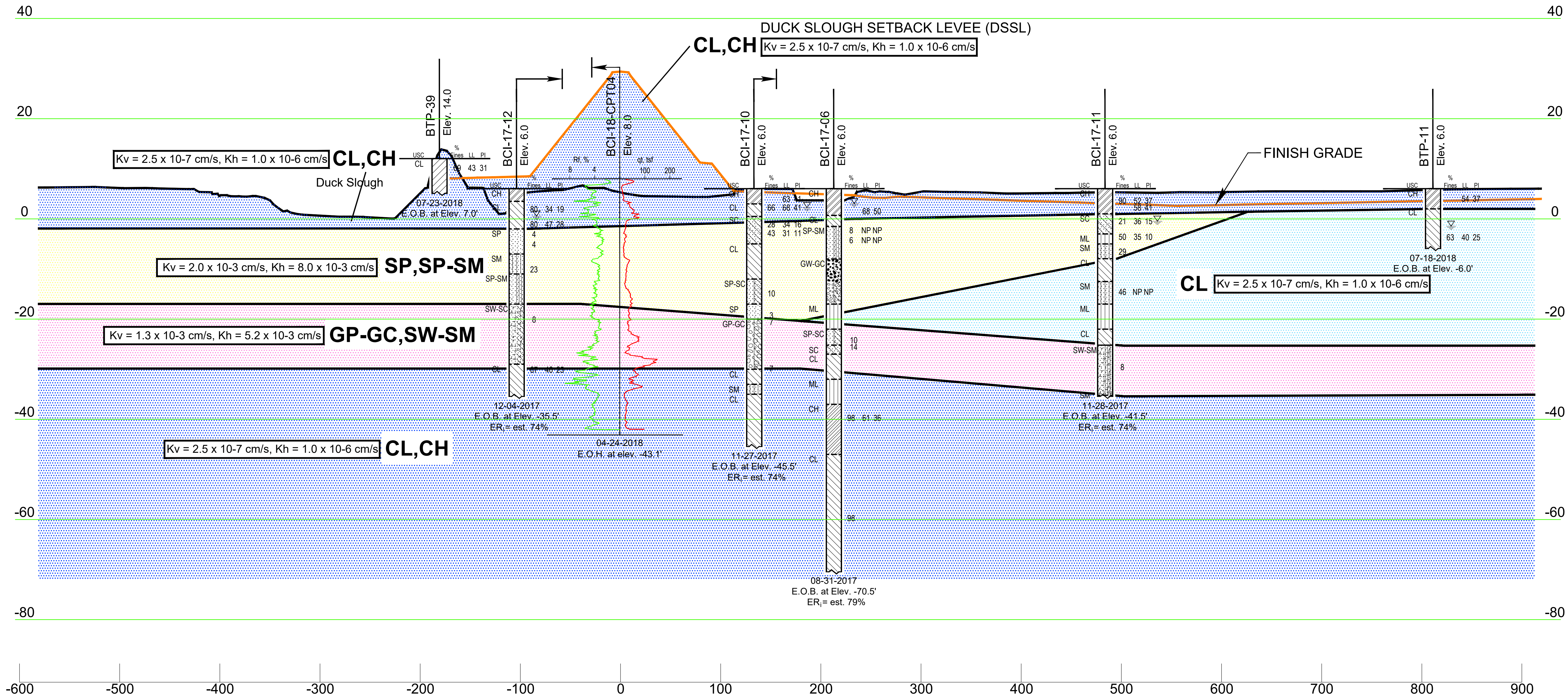
Lookout Slough THRFIP

Ecosystem Investment Partners

Map Prepared Date: 09/01/19
Map Prepared By: M.D.R.
Checked By: N.C.H.
Job No.: 3195.x

Prepared by:
BLACKBURN CONSULTING

Path: \\FS-01\Common\Active Projects\3195.P DWR Lookout Slough Restoration Project\CAD\65% GBOD REPORT\3195.x LSRP GBOD 65% AppB 6+50.dwg



APPENDIX B-8, STA 42+00
GEOTECHNICAL BASIS OF DESIGN REPORT - 65% DESIGN
SUBSURFACE PROFILE USED IN ANALYSIS
September 2019

Lookout Slough THRFIP

LEGEND

Kv, Kh = - Hydraulic Conductivity Values for Soil Layers

NOTES:
Cross section updated 05-14-19. Levee shifted to centerline of new alignment. Boring logs updated 5-8-19.

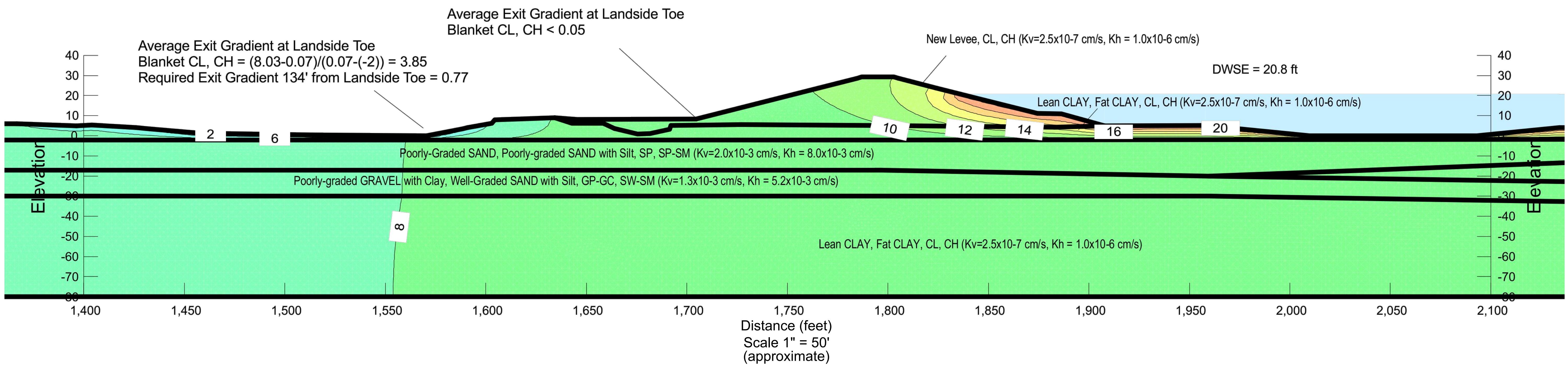
SCALE: 1 inch = 100 ft Hor.
1 inch = 20 ft Vert.

Ecosystem Investment Partners

Prepared by:
BLACKBURN CONSULTING

Map Prepared Date: 09/01/19
Map Prepared By: M.D.R.
Checked By: N.C.H.
Job No.: 3195.x

Path: \\FS-01\Common\Active Projects\3195.P DWR Lookout Slough Restoration Project\CAD\CROSS SECTIONS NEW 06_20_2019\3195.x LSRP BDR 65% 42+00 AppB.dwg



Material ID and Type, Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

Lean CLAY, CL	Kh=0.0057 ft/day	(=2.0x10-6 cm/s)	0.25
Lean CLAY, Fat CLAY, CL, CH	Kh=0.0028 ft/day	(=1.0x10-6 cm/s)	0.25
New Levee, CL, CH	Kh=0.0028 ft/day	(=1.0x10-6 cm/s)	0.25
Poorly-Graded GRAVEL with Clay, Well-Graded SAND with Silt, GP-GC, SW-SM	Kh=14.74 ft/day	(=5.2x10-3 cm/s)	0.25
Poorly-graded SAND, Poorly-graded SAND with Silt, SP, SP-SM	Kh=22.68 ft/day	(=8.0x10-3 cm/s)	0.25

APPENDIX B-9, STA 42+00
GEOTECHNICAL BASIS OF DESIGN REPORT - 65% DESIGN
DWSE Steady-State Seepage Analysis
Setback Levee with No Cutoff Wall
September 2019

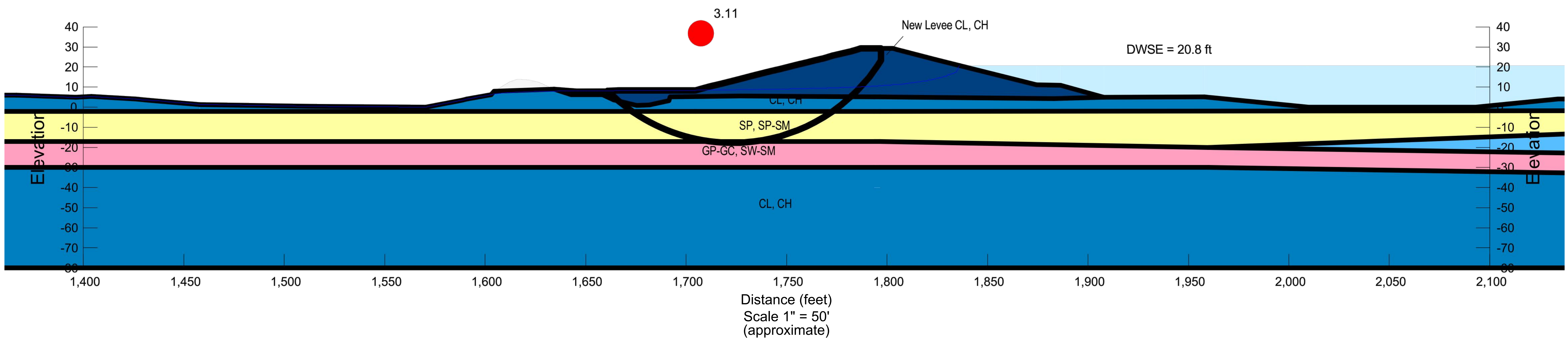
Lookout Slough THRFIP

Ecosystem Investment Partners

Map Prepared Date: 09/01/19
Map Prepared By: M.D.R.
Checked By: N.C.H.
Job No.: 3195.x

Prepared by:
BLACKBURN CONSULTING

Path: \\FS-01\Common\Active Projects\3195.P DWR Lookout Slough Restoration Project\CAD\65% GBOD REPORT\3195.x LSRP GBOD 65% AppB 42+00.dwg



Material ID and Type, Hydraulic Conductivity (Kh), Unit Weight, Effective Cohesion, Effective Friction Angle

Material	Kh		Model	(pcf)	(psf)	(°)
Lean CLAY, CL	Kh=0.0057 ft/day	(=2.0x10-6 cm/s)	Mohr-Coulomb	115	150	32
Lean CLAY, Fat CLAY, CL, CH	Kh=0.0028 ft/day	(=1.0x10-6 cm/s)	Mohr-Coulomb	115	150	30
New Levee, CL, CH	Kh=0.0028 ft/day	(=1.0x10-6 cm/s)	Mohr-Coulomb	125	400	22
Poorly-Graded GRAVEL with Clay, Well-Graded SAND with Silt, GP-GC, SW-SM	Kh=14.74 ft/day	(=5.2x10-3 cm/s)	Mohr-Coulomb	125	0	34
Poorly-graded SAND, Poorly-graded SAND with Silt, SP, SP-SM	Kh=22.68 ft/day	(=8.0x10-3 cm/s)	Mohr-Coulomb	120	0	32

APPENDIX B-10, STA 42+00
GEOTECHNICAL BASIS OF DESIGN REPORT - 65% DESIGN
DWSE Steady-State Slope Stability Analysis
Setback Levee with No Cutoff Wall
September 2019

Lookout Slough THRFIP

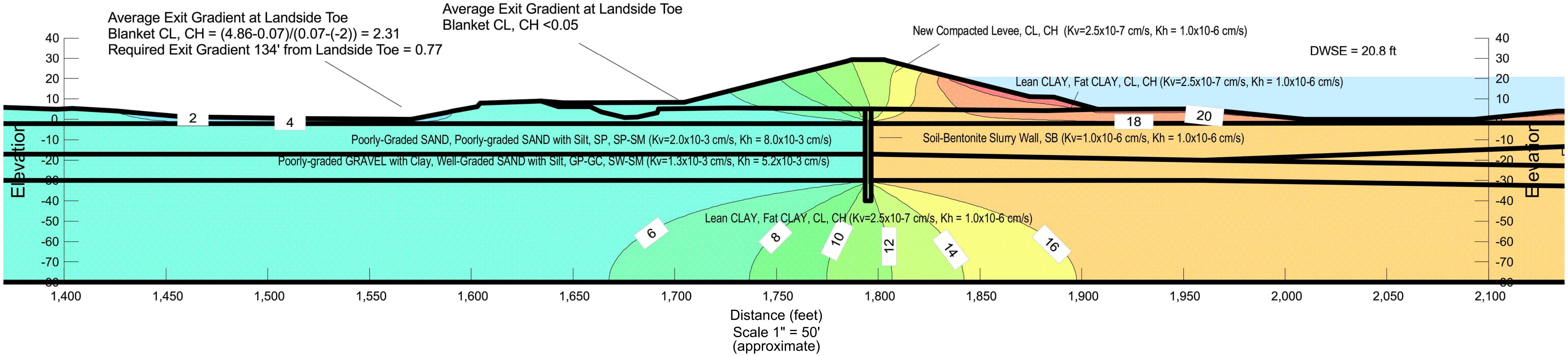
Ecosystem Investment Partners

Prepared by:

Map Prepared Date: 09/01/19
Map Prepared By: M.D.R.
Checked By: N.C.H.
Job No.: 3195.x

BLACKBURN CONSULTING

Path: \\FS-01\Common\Active Projects\3195.P DWR Lookout Slough Restoration Project\CAD\65% GBOD REPORT\3195.x LSRP GBOD 65% AppB 42+00.dwg



Material ID and Type, Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

Lean CLAY, CL	Kh=0.0057 ft/day	(=2.0x10-6 cm/s)	0.25
Lean CLAY, Fat CLAY, CL, CH	Kh=0.0028 ft/day	(=1.0x10-6 cm/s)	0.25
New Levee, CL, CH	Kh=0.0028 ft/day	(=1.0x10-6 cm/s)	0.25
Poorly-Graded GRAVEL with Clay, Well-Graded SAND with Silt, GP-GC, SW-SM	Kh=14.74 ft/day	(=5.2x10-3 cm/s)	0.25
Poorly-graded SAND, Poorly-graded SAND with Silt, SP, SP-SM	Kh=22.68 ft/day	(=8.0x10-3 cm/s)	0.25
Slurry Wall, SB	Kh=0.0028 ft/day	(=1.0x10-6 cm/s)	1

APPENDIX B-11, STA 42+00
GEOTECHNICAL BASIS OF DESIGN REPORT - 65% DESIGN
DWSE Steady-State Seepage Analysis
Setback Levee with Shallow Cutoff Wall
September 2019

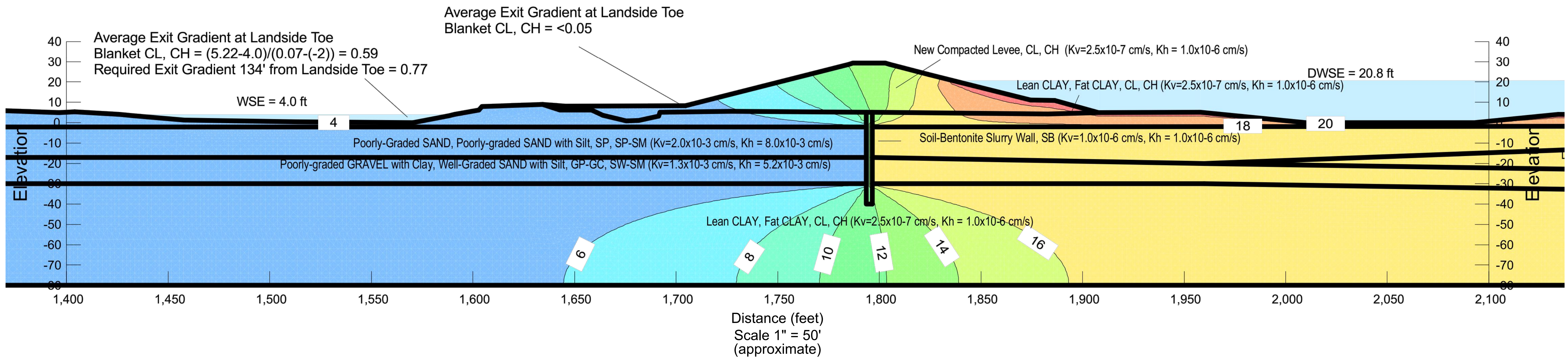
Lookout Slough THRFIP

Ecosystem Investment Partners

Prepared by:
BLACKBURN CONSULTING

Map Prepared Date: 09/01/19
Map Prepared By: M.D.R.
Checked By: N.C.H.
Job No.: 3195.x

Path: \\FS-01\Common\Active Projects\3195.P DWR Lookout Slough Restoration Project\CAD\65% GBOD REPORT\3195.x LSRP GBOD 65% AppB 42+00.dwg



Material ID and Type, Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

Lean CLAY, CL	Kh=0.0057 ft/day	(=2.0x10-6 cm/s)	0.25
Lean CLAY, Fat CLAY, CL, CH	Kh=0.0028 ft/day	(=1.0x10-6 cm/s)	0.25
New Levee, CL, CH	Kh=0.0028 ft/day	(=1.0x10-6 cm/s)	0.25
Poorly-Graded GRAVEL with Clay, Well-Graded SAND with Silt, GP-GC, SW-SM	Kh=14.74 ft/day	(=5.2x10-3 cm/s)	0.25
Poorly-graded SAND, Poorly-graded SAND with Silt, SP, SP-SM	Kh=22.68 ft/day	(=8.0x10-3 cm/s)	0.25
Slurry Wall, SB	Kh=0.0028 ft/day	(=1.0x10-6 cm/s)	1

APPENDIX B-12, STA 42+00
GEOTECHNICAL BASIS OF DESIGN REPORT - 65% DESIGN
DWSE Steady-State Seepage Analysis with Water in Duck Slough
September 2019

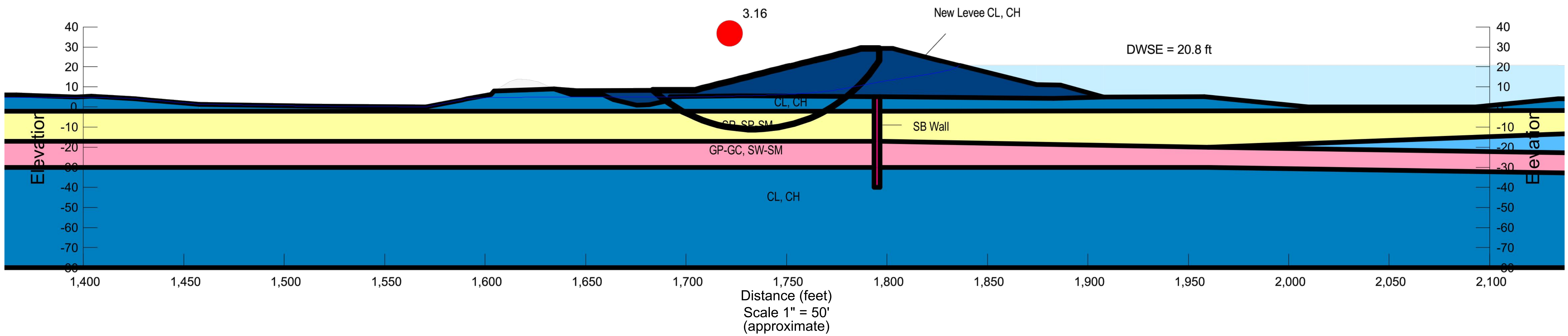
Lookout Slough THRFIP

Ecosystem Investment Partners

Prepared by: BLACKBURN CONSULTING

Map Prepared Date: 09/01/19
Map Prepared By: M.D.R.
Checked By: N.C.H.
Job No.: 3195.x

Path: \\FS-01\Common\Active Projects\3195.P DWR Lookout Slough Restoration Project\CAD\65% GBOD REPORT\3195.x LSRP GBOD 65% AppB 42+00.dwg



Material ID and Type, Hydraulic Conductivity (Kh), Unit Weight, Effective Cohesion, Effective Friction Angle

Material	Kh		Model	(pcf)	(psf)	(°)
Lean CLAY, CL	Kh=0.0057 ft/day	(=2.0x10-6 cm/s)	Mohr-Coulomb	115	150	32
Lean CLAY, Fat CLAY, CL, CH	Kh=0.0028 ft/day	(=1.0x10-6 cm/s)	Mohr-Coulomb	115	150	30
New Levee, CL, CH	Kh=0.0028 ft/day	(=1.0x10-6 cm/s)	Mohr-Coulomb	125	400	22
Poorly-Graded GRAVEL with Clay, Well-Graded SAND with Silt, GP-GC, SW-SM	Kh=14.74 ft/day	(=5.2x10-3 cm/s)	Mohr-Coulomb	125	0	34
Poorly-graded SAND, Poorly-graded SAND with Silt, SP, SP-SM	Kh=22.68 ft/day	(=8.0x10-3 cm/s)	Mohr-Coulomb	120	0	32
Slurry Wall, SB	Kh=0.0028 ft/day	(=1.0x10-6 cm/s)	Mohr-Coulomb	100	50	0

APPENDIX B-13, STA 42+00
GEOTECHNICAL BASIS OF DESIGN REPORT - 65% DESIGN
DWSE Steady-State Slope Stability Analysis
Setback Levee with Shallow Cutoff Wall
September 2019

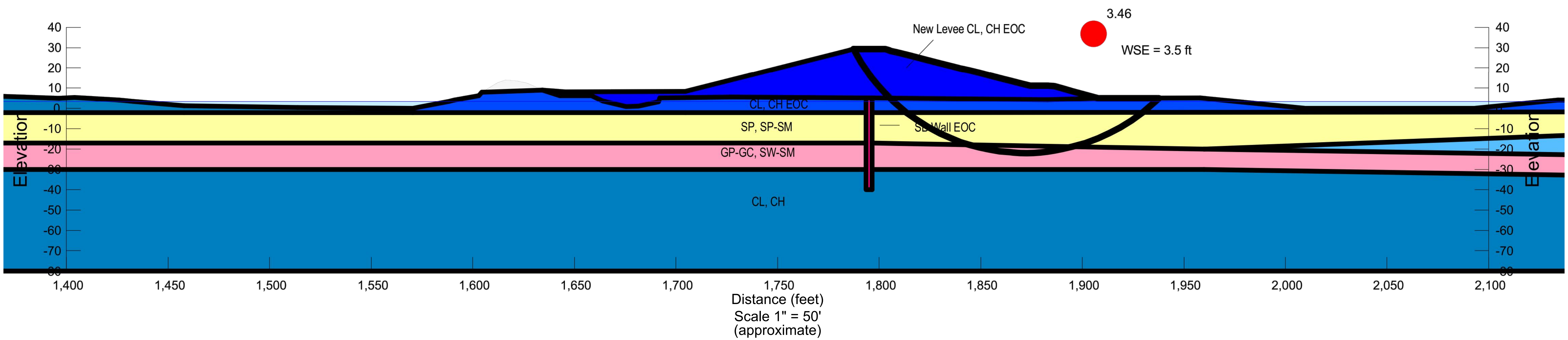
Lookout Slough THRFIP

Ecosystem Investment Partners

Map Prepared Date: 09/01/19
Map Prepared By: M.D.R.
Checked By: N.C.H.
Job No.: 3195.x

Prepared by:
BLACKBURN CONSULTING

Path: \\FS-01\Common\Active Projects\3195.P DWR Lookout Slough Restoration Project\CAD\65% GBOD REPORT\3195.x LSRP GBOD 65% AppB 42+00.dwg



Material ID and Type, Hydraulic Conductivity (Kh), Unit Weight, Undrained Shear Strength, Effective Cohesion, Effective Friction Angle

Material	Kh		(pcf)	(psf)	(psf)	(°)
Lean CLAY, CL	Kh=0.0057 ft/day	(=2.0x10-6 cm/s)	115		150	32
Lean CLAY, Fat CLAY, CL, CH	Kh=0.0028 ft/day	(=1.0x10-6 cm/s)	115		150	30
Lean CLAY, Fat CLAY, CL, CH EOC	Kh=0.0028 ft/day	(=1.0x10-6 cm/s)	115	1,000		
New Levee, CL, CH EOC	Kh=0.0028 ft/day	(=1.0x10-6 cm/s)	125	1,500		
Poorly-Graded GRAVEL with Clay, Well-Graded SAND with Silt, GP-GC, SW-SM	Kh=14.74 ft/day	(=5.2x10-3 cm/s)	125		0	34
Poorly-graded SAND, Poorly-graded SAND with Silt, SP, SP-SM	Kh=22.68 ft/day	(=8.0x10-3 cm/s)	120		0	32
Slurry Wall, SB, EOC	Kh=0.0028 ft/day	(=1.0x10-6 cm/s)	100	20		

APPENDIX B-14, STA 42+00
GEOTECHNICAL BASIS OF DESIGN REPORT - 65% DESIGN
End-of-Construction Slope Stability Analysis
Setback Levee with Shallow Cutoff Wall
September 2019

Lookout Slough THRFIP

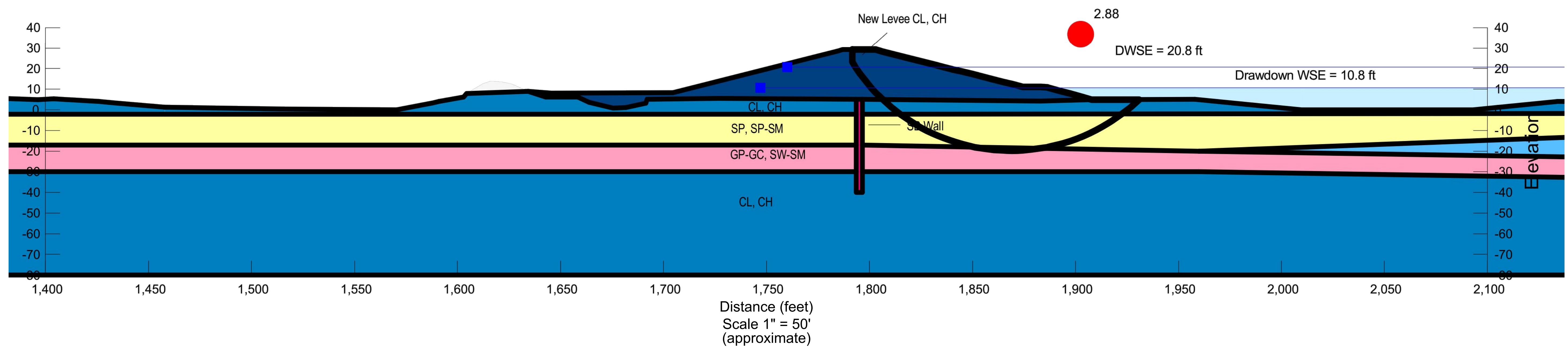
Ecosystem Investment Partners

Prepared by:

Map Prepared Date: 09/01/19
Map Prepared By: M.D.R.
Checked By: N.C.H.
Job No.: 3195.x

BLACKBURN CONSULTING

Path: \\FS-01\Common\Active Projects\3195.P DWR Lookout Slough Restoration Project\CAD\65% GBOD REPORT\3195.x LSRP GBOD 65% AppB 42+00.dwg



Material ID and Type, Hydraulic Conductivity (Kh), Unit Weight, Effective Cohesion, Effective Friction Angle, Total Cohesion, Total Friction Angle

Material	Kh		(pcf)	(psf)	(°)	(psf)	(°)
Lean CLAY, CL	Kh=0.0057 ft/day	(=2.0x10-6 cm/s)	115	150	32	175	16
Lean CLAY, Fat CLAY, CL, CH	Kh=0.0028 ft/day	(=1.0x10-6 cm/s)	115	150	30	175	15
New Levee, CL, CH	Kh=0.0028 ft/day	(=1.0x10-6 cm/s)	125	400	22	450	13
Poorly-Graded GRAVEL with Clay, Well-Graded SAND with Silt, GP-GC, SW-SM	Kh=14.74 ft/day	(=5.2x10-3 cm/s)	125	0	34	0	0
Poorly-graded SAND, Poorly-graded SAND with Silt, SP, SP-SM	Kh=22.68 ft/day	(=8.0x10-3 cm/s)	120	0	32	0	0
Slurry Wall, SB	Kh=0.0028 ft/day	(=1.0x10-6 cm/s)	100	50	0	0	0

APPENDIX B-15, STA 42+00
GEOTECHNICAL BASIS OF DESIGN REPORT - 65% DESIGN
Rapid Drawdown Slope Stability Analysis, 10 ft. Drawdown
Setback Levee with Shallow Cutoff Wall
September 2019

Lookout Slough THRFIP

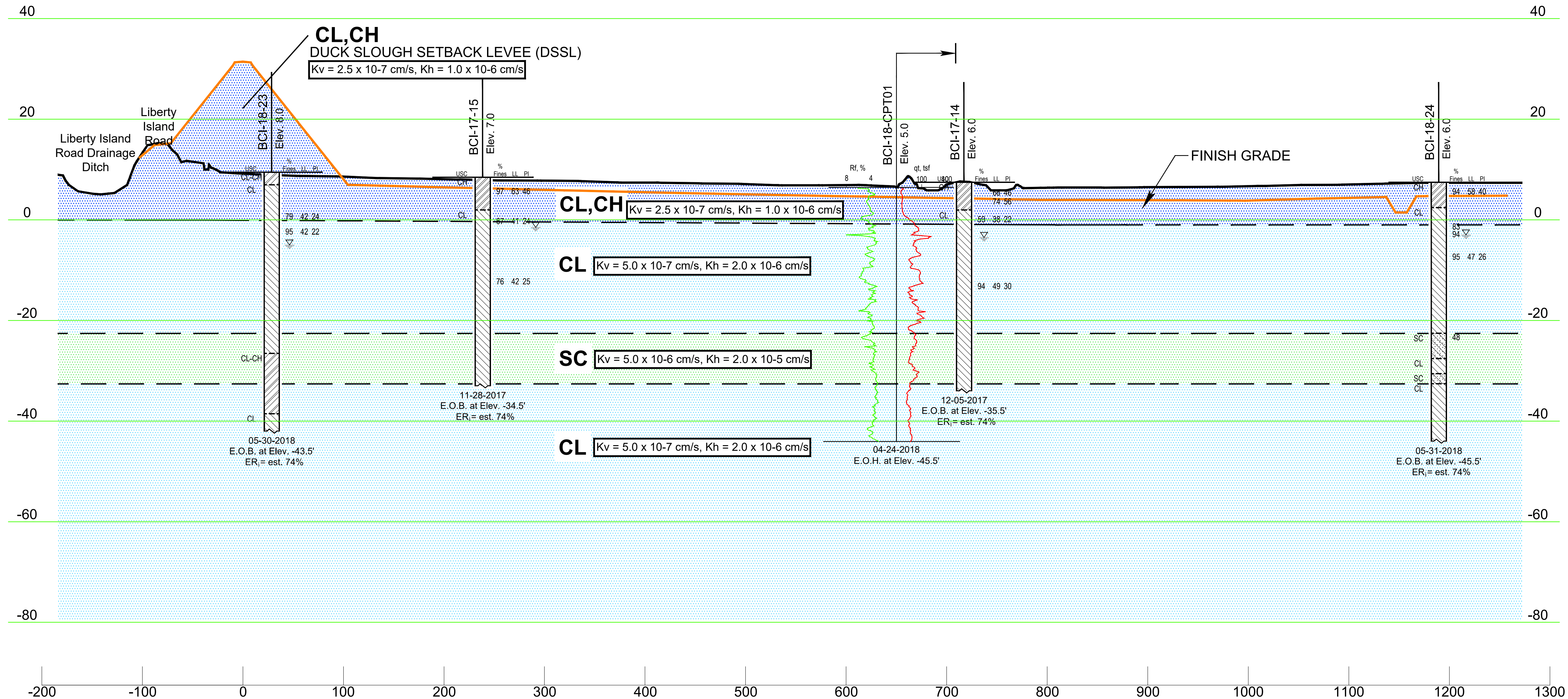
Ecosystem Investment Partners

Prepared by:

Map Prepared Date: 09/01/19
Map Prepared By: M.D.R.
Checked By: N.C.H.
Job No.: 3195.x

BLACKBURN CONSULTING

Path: \\FS-01\Common\Active Projects\3195.P DWR Lookout Slough Restoration Project\CAD\65% GBOD REPORT\3195.x LSRP GBOD 65% AppB 42+00.dwg



APPENDIX B-16, STA 109+50
GEOTECHNICAL BASIS OF DESIGN REPORT - 65% DESIGN
SUBSURFACE PROFILE USED IN ANALYSIS
September 2019

LEGEND

Kv, Kh = - Hydraulic Conductivity Values for Soil Layers

NOTES:
Cross section updated 05-14-19. Levee shifted to centerline of new alignment. Boring logs updated 5-8-19.

SCALE: 1 inch = 100 ft Hor.
1 inch = 20 ft Vert.

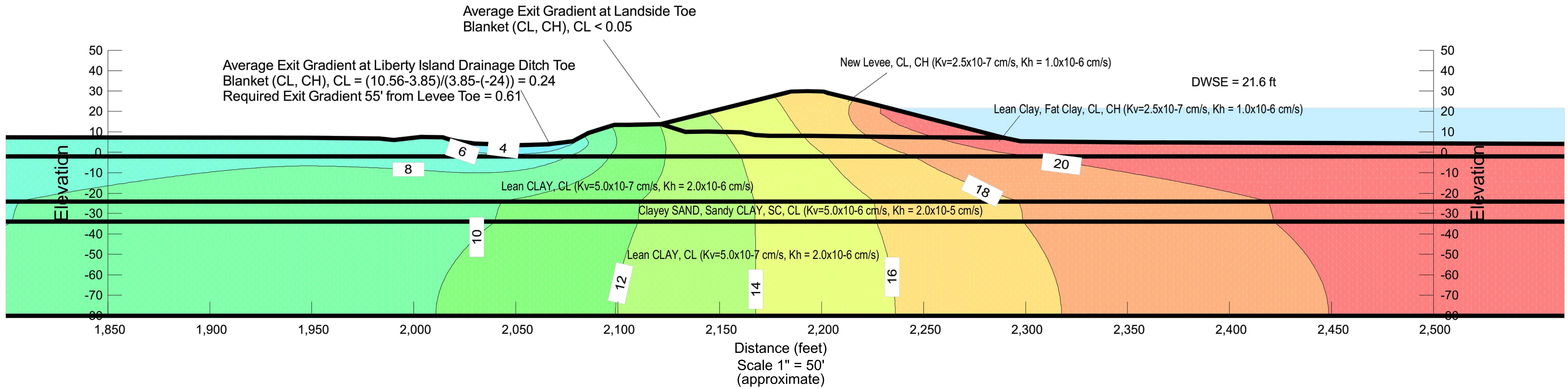
Ecosystem Investment Partners

Map Prepared Date: 09/01/19
Map Prepared By: M.D.R.
Checked By: N.C.H.
Job No.: 3195.x

Prepared by:
BLACKBURN CONSULTING

Lookout Slough THRFIP

Path: \\FS-01\Common\Active Projects\3195.P DWR Lookout Slough Restoration Project\CAD\CROSS SECTIONS NEW 06_20_2019\3195.x LSRP BDR 65% 109+50 AppB.dwg



Material ID and Type, Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

Clayey SAND, Sandy Lean CLAY, SC, CL	Kh=0.057 ft/d	(=2.0x10-5 cm/s)	0.25
Lean CLAY, CL	Kh=0.0057 ft/day	(=2.0x10-6 cm/s)	0.25
Lean CLAY, Fat CLAY, CL, CH	Kh=0.0028 ft/day	(=1.0x10-6 cm/s)	0.25
New Levee, CL, CH	Kh=0.0028 ft/day	(=1.0x10-6 cm/s)	0.25

APPENDIX B-17, STA 109+50
GEOTECHNICAL BASIS OF DESIGN REPORT - 65% DESIGN
DWSE Steady-State Seepage Analysis
Setback Levee with No Cutoff Wall
September 2019

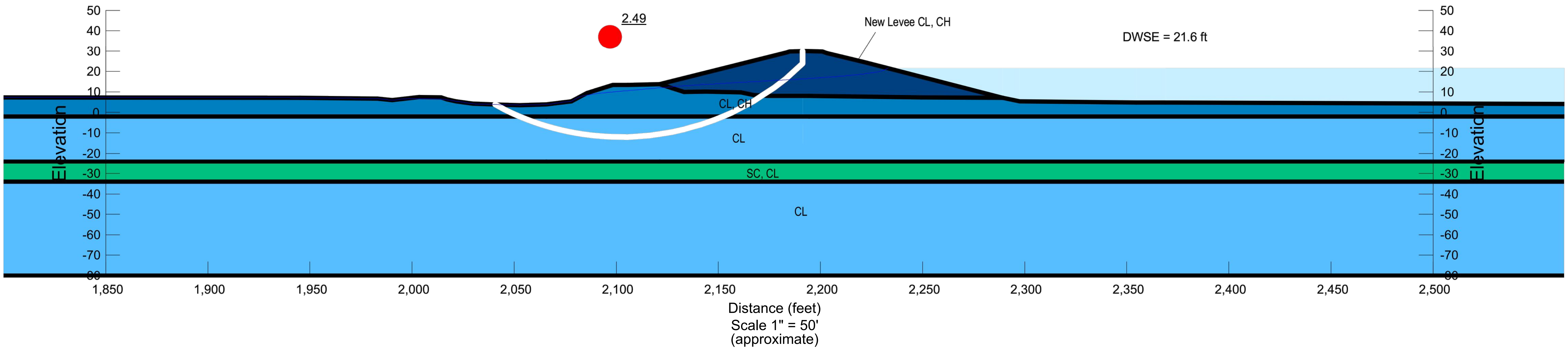
Lookout Slough THRFIP

Ecosystem Investment Partners

Map Prepared Date: 09/01/19
Map Prepared By: M.D.R.
Checked By: N.C.H.
Job No.: 3195.x

Prepared by:
BLACKBURN CONSULTING

Path: \\FS-01\Common\Active Projects\3195.P DWR Lookout Slough Restoration Project\CAD\65%
GBOD REPORT\3195.x LSRP GBOD 65% AppB 109+50.dwg



Material ID and Type,Unit Weight, Effective Cohesion, Effective Friction Angle

			(pcf)	(psf)	(°)
Clayey SAND, Sandy Lean CLAY, SC, CL	Kh=0.057 ft/d	(=2.0x10-5 cm/s)	115	100	32
Lean CLAY, CL	Kh=0.0057 ft/day	(=2.0x10-6 cm/s)	115	150	32
Lean CLAY, Fat CLAY, CL, CH	Kh=0.0028 ft/day	(=1.0x10-6 cm/s)	115	150	30
New Levee, CL, CH	Kh=0.0028 ft/day	(=1.0x10-6 cm/s)	125	400	22

APPENDIX B-18, STA 109+50
GEOTECHNICAL BASIS OF DESIGN REPORT - 65% DESIGN
DWSE Steady-State Slope Stability Analysis
Setback Levee with No Cutoff Wall
September 2019

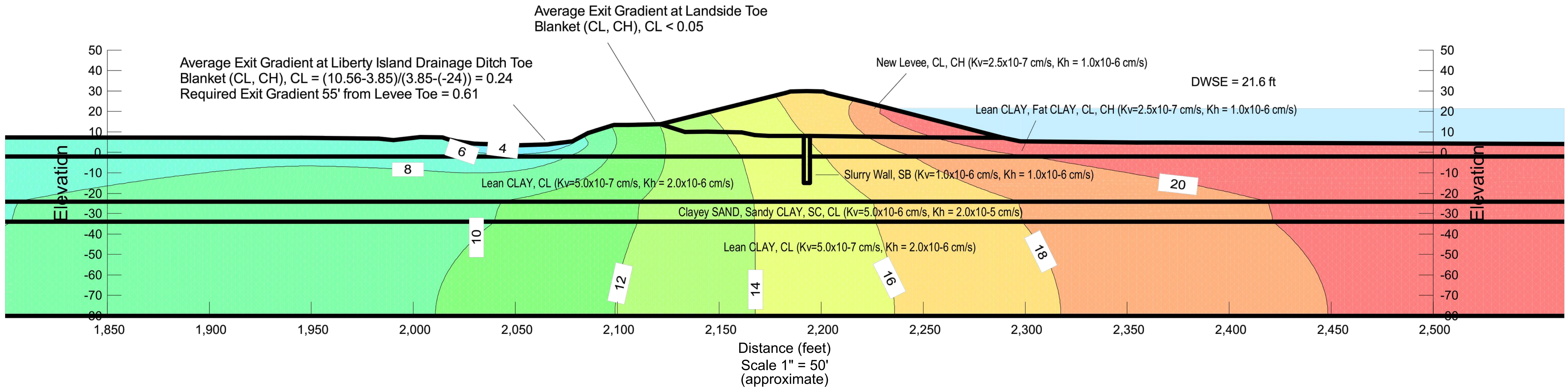
Lookout Slough THRFIP

Ecosystem Investment Partners

Map Prepared Date: 09/01/19
Map Prepared By: M.D.R.
Checked By: N.C.H.
Job No.: 3195.x

Prepared by:
BLACKBURN CONSULTING

Path: \\FS-01\Common\Active Projects\3195.P DWR Lookout Slough Restoration Project\CAD\65% GBOD REPORT\3195.x LSRP GBOD 65% AppB 109+50.dwg



Material ID and Type, Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

Clayey SAND, Sandy Lean CLAY, SC, CL	Kh=0.057 ft/d	(=2.0x10-5 cm/s)	0.25
Lean CLAY, CL	Kh=0.0057 ft/day	(=2.0x10-6 cm/s)	0.25
Lean CLAY, Fat CLAY, CL, CH	Kh=0.0028 ft/day	(=1.0x10-6 cm/s)	0.25
New Levee, CL, CH	Kh=0.0028 ft/day	(=1.0x10-6 cm/s)	0.25
Slurry Wall, SB	Kh=0.0028 ft/day	(=1.0x10-6 cm/s)	1

APPENDIX B-19, STA 109+50
GEOTECHNICAL BASIS OF DESIGN REPORT - 65% DESIGN
DWSE Steady-State Seepage Analysis
Setback Levee with Shallow Cutoff Wall
September 2019

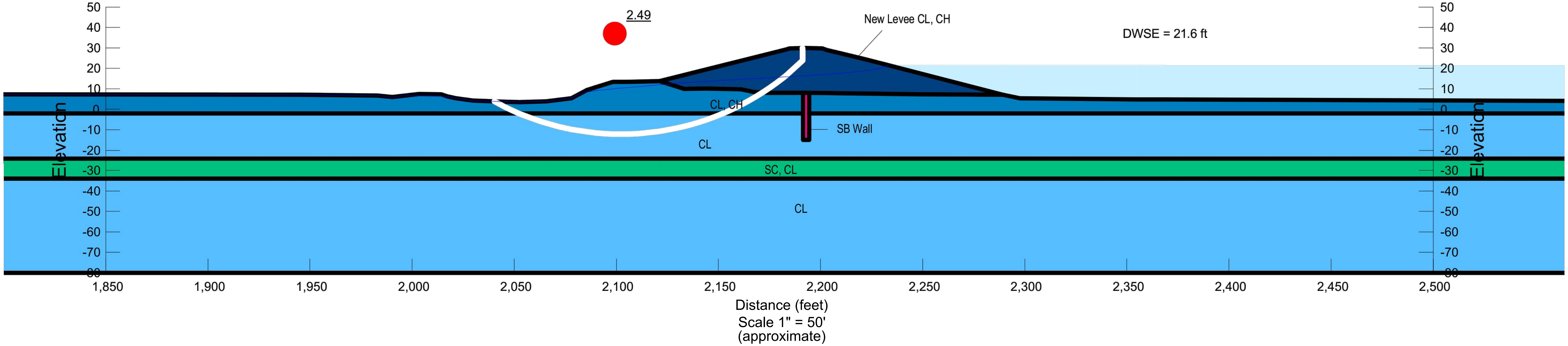
Lookout Slough THRFIP

Ecosystem Investment Partners

Map Prepared Date: 09/01/19
Map Prepared By: M.D.R.
Checked By: N.C.H.
Job No.: 3195.x

Prepared by:
BLACKBURN CONSULTING

Path: \\FS-01\Common\Active Projects\3195.P DWR Lookout Slough Restoration Project\CAD\65% GBOD REPORT\3195.x LSRP GBOD 65% AppB 109+50.dwg



Material ID and Type, Unit Weight, Effective Cohesion, Effective Friction Angle

Material	Kh		(pcf)	(psf)	(°)
Clayey SAND, Sandy Lean CLAY, SC, CL	Kh=0.057 ft/d	(=2.0x10-5 cm/s)	115	100	32
Lean CLAY, CL	Kh=0.0057 ft/day	(=2.0x10-6 cm/s)	115	150	32
Lean CLAY, Fat CLAY, CL, CH	Kh=0.0028 ft/day	(=1.0x10-6 cm/s)	115	150	30
New Levee, CL, CH	Kh=0.0028 ft/day	(=1.0x10-6 cm/s)	125	400	22
Slurry Wall, SB	Kh=0.0028 ft/day	(=1.0x10-6 cm/s)	100	50	0

APPENDIX B-20, STA 109+50
GEOTECHNICAL BASIS OF DESIGN REPORT - 65% DESIGN
DWSE Steady-State Slope Stability Analysis
Setback Levee with Shallow Cutoff Wall
September 2019

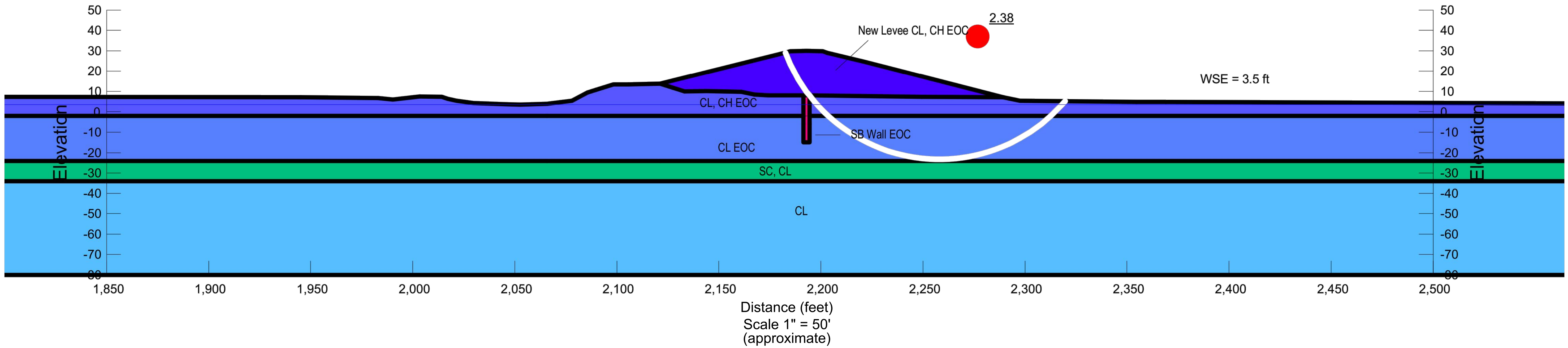
Lookout Slough THRFIP

Ecosystem Investment Partners

Map Prepared Date: 09/01/19
Map Prepared By: M.D.R.
Checked By: N.C.H.
Job No.: 3195.x

Prepared by:
BLACKBURN CONSULTING

Path: \\FS-01\Common\Active Projects\3195.P DWR Lookout Slough Restoration Project\CAD\65%
GBOD REPORT\3195.x LSRP GBOD 65% AppB 109+50.dwg



Material ID and Type, Unit Weight, Undrained Shear Strength, Effective Cohesion, Effective Friction Angle

Material	Kh		(pcf)	(psf)	(psf)	(°)
Clayey SAND, Sandy Lean CLAY, SC, CL	Kh=0.057 ft/d	(=2.0x10-5 cm/s)	115		100	32
Lean CLAY, CL	Kh=0.0057 ft/day	(=2.0x10-6 cm/s)	115		150	32
Lean CLAY, CL EOC	Kh=0.0057 ft/day	(=2.0x10-6 cm/s)	115	1,000		
Lean CLAY, Fat CLAY, CL, CH EOC	Kh=0.0028 ft/day	(=1.0x10-6 cm/s)	115	1,000		
New Levee, CL, CH EOC	Kh=0.0028 ft/day	(=1.0x10-6 cm/s)	125	1,500		
Slurry Wall, SB, EOC	Kh=0.0028 ft/day	(=1.0x10-6 cm/s)	100	20		

APPENDIX B-21, STA 109+50

GEOTECHNICAL BASIS OF DESIGN REPORT - 65% DESIGN

End-of-Construction Slope Stability Analysis
Setback Levee with Shallow Cutoff Wall
September 2019

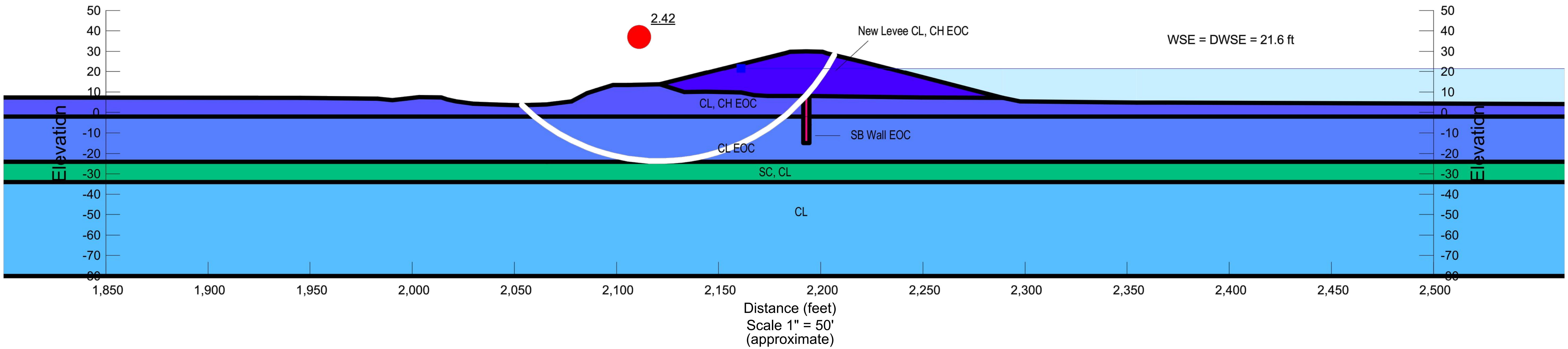
Lookout Slough THRFIP

Ecosystem Investment Partners

Map Prepared Date: 09/01/19
Map Prepared By: M.D.R.
Checked By: N.C.H.
Job No.: 3195.x

Prepared by:
BLACKBURN CONSULTING

Path: \\FS-01\Common\Active Projects\3195.P DWR Lookout Slough Restoration Project\CAD\65%
GBOD REPORT\3195.x LSRP GBOD 65% AppB 109+50.dwg



Material ID and Type, Unit Weight, Undrained Shear Strength, Effective Cohesion, Effective Friction Angle

			(pcf)	(psf)	(psf)	(°)
Clayey SAND, Sandy Lean CLAY, SC, CL	Kh=0.057 ft/d	(=2.0x10-5 cm/s)	115		100	32
Lean CLAY, CL	Kh=0.0057 ft/day	(=2.0x10-6 cm/s)	115		150	32
Lean CLAY, CL EOC	Kh=0.0057 ft/day	(=2.0x10-6 cm/s)	115	1,000		
Lean CLAY, Fat CLAY, CL, CH EOC	Kh=0.0028 ft/day	(=1.0x10-6 cm/s)	115	1,000		
New Levee, CL, CH EOC	Kh=0.0028 ft/day	(=1.0x10-6 cm/s)	125	1,500		
Slurry Wall, SB, EOC	Kh=0.0028 ft/day	(=1.0x10-6 cm/s)	100	20		

APPENDIX B-22, STA 109+50

GEOTECHNICAL BASIS OF DESIGN REPORT - 65% DESIGN

End-of-Construction Slope Stability Analysis at DWSE
Setback Levee with Shallow Cutoff Wall
September 2019

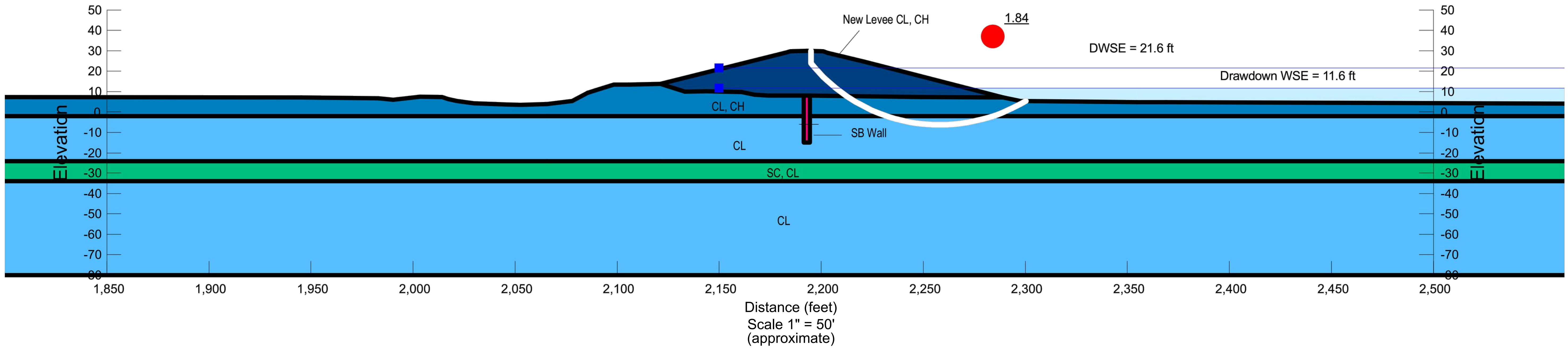
Lookout Slough THRFIP

Ecosystem Investment Partners

Map Prepared Date: 09/01/19
Map Prepared By: M.D.R.
Checked By: N.C.H.
Job No.: 3195.x

Prepared by:
BLACKBURN CONSULTING

Path: \\FS-01\Common\Active Projects\3195.P DWR Lookout Slough Restoration Project\CAD\65% GBOD REPORT\3195.x LSRP GBOD 65% AppB 109+50.dwg



Material ID and Type, Unit Weight, Effective Cohesion, Effective Friction Angle, Total Cohesion, Total Friction Angle

Material	Kh	Kh (cm/s)	(pcf)	(psf)	(°)	(psf)	(°)
Clayey SAND, Sandy Lean CLAY, SC, CL	Kh=0.057 ft/d	(=2.0x10-5 cm/s)	115	100	32	115	16
Lean CLAY, CL	Kh=0.0057 ft/day	(=2.0x10-6 cm/s)	115	150	32	175	16
Lean CLAY, Fat CLAY, CL, CH	Kh=0.0028 ft/day	(=1.0x10-6 cm/s)	115	150	30	175	15
New Levee, CL, CH	Kh=0.0028 ft/day	(=1.0x10-6 cm/s)	125	400	22	450	13
Slurry Wall, SB	Kh=0.0028 ft/day	(=1.0x10-6 cm/s)	100	50	0	0	0

APPENDIX B-23, STA 109+50
GEOTECHNICAL BASIS OF DESIGN REPORT - 65% DESIGN
Rapid Drawdown Slope Stability Analysis, 5 ft. Drawdown
Setback Levee with Shallow Cutoff Wall
September 2019

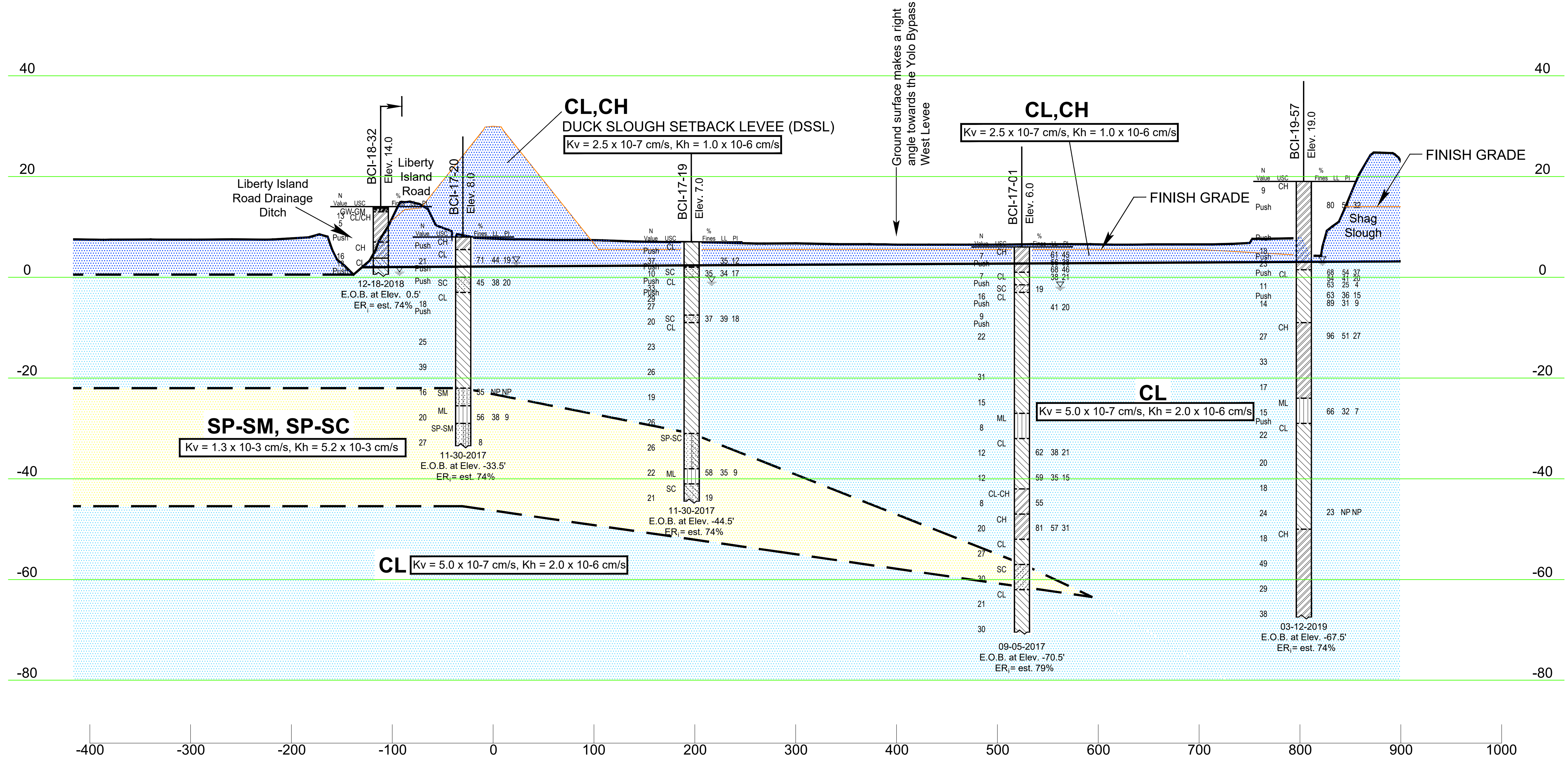
Lookout Slough THRFIP

Ecosystem Investment Partners

Map Prepared Date: 09/01/19
Map Prepared By: M.D.R.
Checked By: N.C.H.
Job No.: 3195.x

Prepared by:
BLACKBURN CONSULTING

Path: \\FS-01\Common\Active Projects\3195.P DWR Lookout Slough Restoration Project\CAD\65% GBOD REPORT\3195.x LSRP GBOD 65% AppB 109+50.dwg



APPENDIX B-24, STA 148+00
GEOTECHNICAL BASIS OF DESIGN REPORT - 65% DESIGN
SUBSURFACE PROFILE USED IN ANALYSIS
September 2019

LEGEND

Kv, Kh = - Hydraulic Conductivity Values for Soil Layers

NOTES:
Cross section updated 05-14-19. Levee shifted to centerline of new alignment. Boring logs updated 5-8-19.

SCALE: 1 inch = 100 ft Hor.
1 inch = 20 ft Vert.

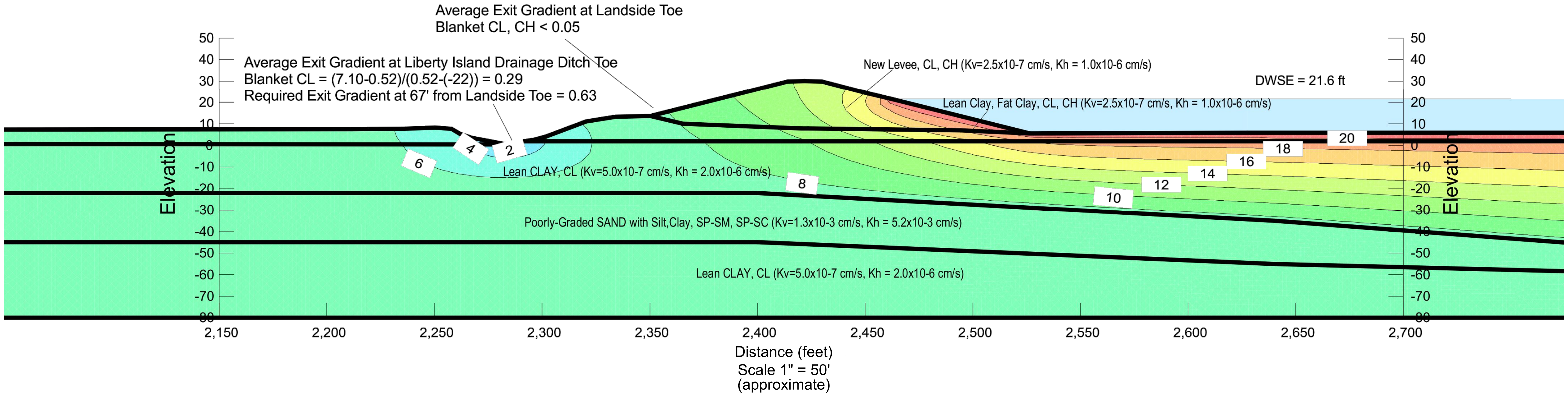
Ecosystem Investment Partners

Lookout Slough THRFIP

Map Prepared Date: 09/01/19
Map Prepared By: M.D.R.
Checked By: N.C.H.
Job No.: 3195.x

Prepared by:
BLACKBURN CONSULTING

Path: \\FS-01\Common\Active Projects\3195.P DWR Lookout Slough Restoration Project\CAD\CROSS SECTIONS NEW 06_20_2019\3195.x LSRP BDR 65% 148+00 AppB.dwg



Material ID and Type, Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

Lean CLAY, CL	Kh=0.0057 ft/day	(=2.0x10-6 cm/s)	0.25
Lean CLAY, Fat CLAY, CL, CH	Kh=0.0028 ft/day	(=1.0x10-6 cm/s)	0.25
New Levee, CL, CH	Kh=0.0028 ft/day	(=1.0x10-6 cm/s)	0.25
Poorly-graded SAND with Silt, Clay SP-SM, SP-SC	Kh=14.74 ft/day	(=5.2x10-3 cm/s)	0.25

APPENDIX B-25, STA 148+00
GEOTECHNICAL BASIS OF DESIGN REPORT - 65% DESIGN
DWSE Steady-State Seepage Analysis
Setback Levee with No Cutoff Wall
September 2019

Lookout Slough THRFIP

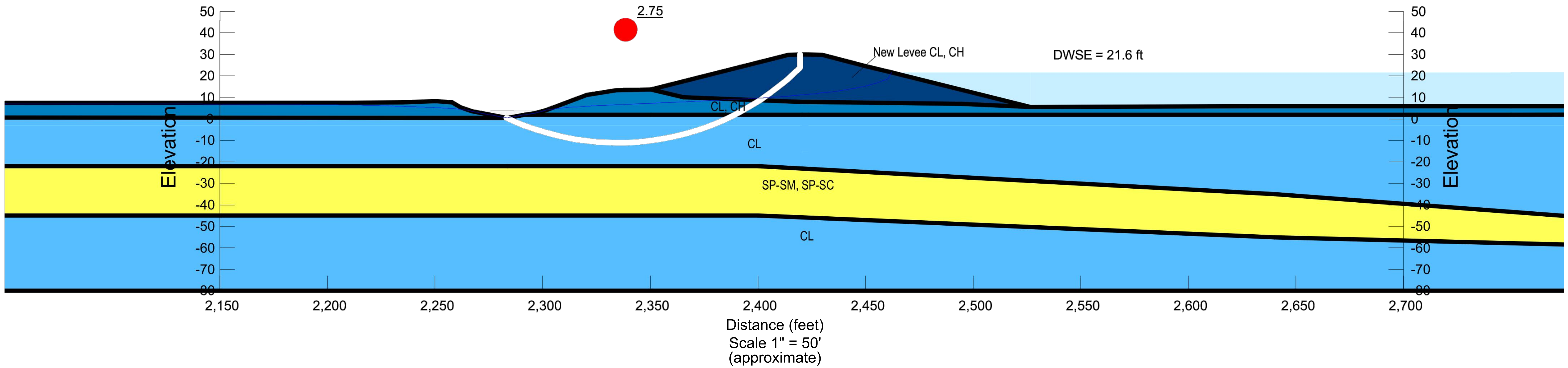
Ecosystem Investment Partners

Prepared by:

Map Prepared Date: 09/01/19
Map Prepared By: M.D.R.
Checked By: N.C.H.
Job No.: 3195.x

BLACKBURN CONSULTING

Path: \\FS-01\Common\Active Projects\3195.P DWR Lookout Slough Restoration Project\CAD\65% GBOD REPORT\3195.x LSRP GBOD 65% AppB 148+00.dwg



Material ID and Type, Unit Weight, Effective Cohesion, Effective Friction Angle

Material	Kh		(pcf)	(psf)	(°)
Lean CLAY, CL	Kh=0.0057 ft/day	(=2.0x10-6 cm/s)	115	150	32
Lean CLAY, Fat CLAY, CL, CH	Kh=0.0028 ft/day	(=1.0x10-6 cm/s)	115	150	30
New Levee, CL, CH	Kh=0.0028 ft/day	(=1.0x10-6 cm/s)	125	400	22
Poorly-graded SAND with Silt, Clay SP-SM, SP-SC	Kh=14.74 ft/day	(=5.2x10-3 cm/s)	120	0	30

APPENDIX B-26, STA 148+00
GEOTECHNICAL BASIS OF DESIGN REPORT - 65% DESIGN
DWSE Steady-State Slope Stability Analysis
Setback Levee with No Cutoff Wall
September 2019

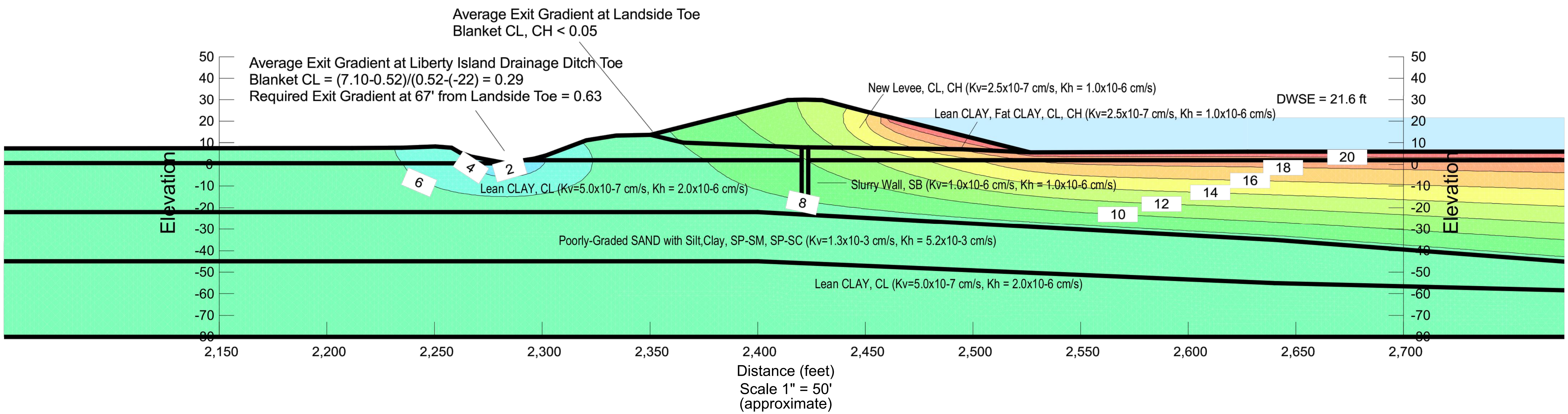
Lookout Slough THRFIP

Ecosystem Investment Partners

Map Prepared Date: 09/01/19
Map Prepared By: M.D.R.
Checked By: N.C.H.
Job No.: 3195.x

Prepared by:
BLACKBURN CONSULTING

Path: \\FS-01\Common\Active Projects\3195.P DWR Lookout Slough Restoration Project\CAD\65% GBOD REPORT\3195.x LSRP GBOD 65% AppB 148+00.dwg



Material ID and Type, Hydraulic Conductivity (Kh), Anisotropic Ratio (Kv/Kh)

	Lean CLAY, CL	Kh=0.0057 ft/day	(=2.0x10-6 cm/s)	0.25
	Lean CLAY, Fat CLAY, CL, CH	Kh=0.0028 ft/day	(=1.0x10-6 cm/s)	0.25
	New Levee, CL, CH	Kh=0.0028 ft/day	(=1.0x10-6 cm/s)	0.25
	Poorly-graded SAND with Silt, Clay SP-SM, SP-SC	Kh=14.74 ft/day	(=5.2x10-3 cm/s)	0.25
	Slurry Wall, SB	Kh=0.0028 ft/day	(=1.0x10-6 cm/s)	1

APPENDIX B-27, STA 148+00
GEOTECHNICAL BASIS OF DESIGN REPORT - 65% DESIGN
DWSE Steady-State Seepage Analysis
Setback Levee with Shallow Cutoff Wall
September 2019

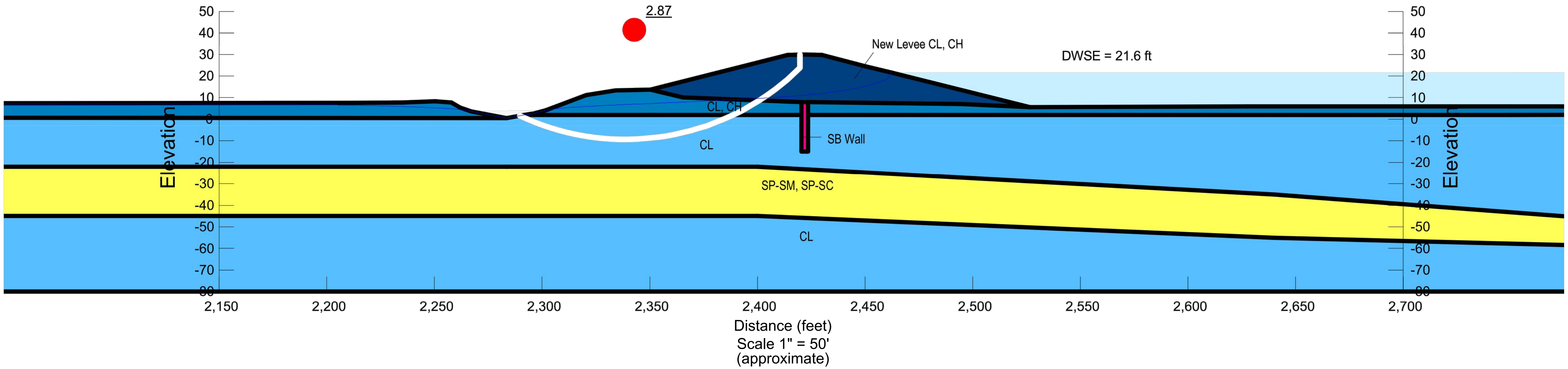
Lookout Slough THRFIP

Ecosystem Investment Partners

Map Prepared Date: 09/01/19
Map Prepared By: M.D.R.
Checked By: N.C.H.
Job No.: 3195.x

Prepared by:
BLACKBURN CONSULTING

Path: \\FS-01\Common\Active Projects\3195.P DWR Lookout Slough Restoration Project\CAD\65% GBOD REPORT\3195.x LSRP GBOD 65% AppB 148+00.dwg



Material ID and Type, Unit Weight, Effective Cohesion, Effective Friction Angle

			(pcf)	(psf)	(°)
Lean CLAY, CL	Kh=0.0057 ft/day	(=2.0x10-6 cm/s)	115	150	32
Lean CLAY, Fat CLAY, CL, CH	Kh=0.0028 ft/day	(=1.0x10-6 cm/s)	115	150	30
New Levee, CL, CH	Kh=0.0028 ft/day	(=1.0x10-6 cm/s)	125	400	22
Poorly-graded SAND with Silt, Clay SP-SM, SP-SC	Kh=14.74 ft/day	(=5.2x10-3 cm/s)	120	0	30
Slurry Wall, SB	Kh=0.0028 ft/day	(=1.0x10-6 cm/s)	100	50	0

APPENDIX B-28, STA 148+00
GEOTECHNICAL BASIS OF DESIGN REPORT - 65% DESIGN
DWSE Steady-State Slope Stability Analysis
Setback Levee with Shallow Cutoff Wall
September 2019

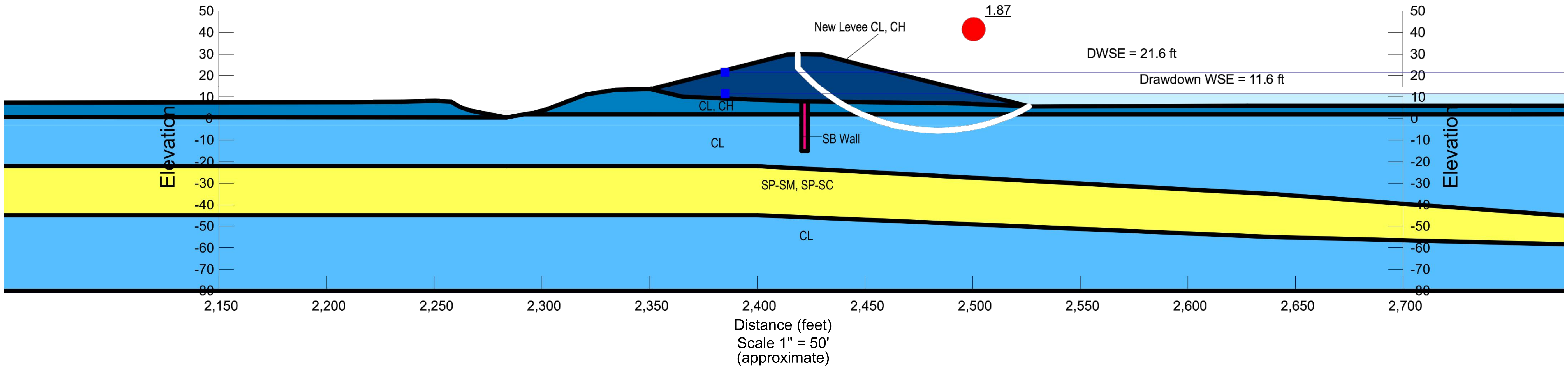
Lookout Slough THRFIP

Ecosystem Investment Partners

Map Prepared Date: 09/01/19
Map Prepared By: M.D.R.
Checked By: N.C.H.
Job No.: 3195.x

Prepared by:
BLACKBURN CONSULTING

Path: \\FS-01\Common\Active Projects\3195.P DWR Lookout Slough Restoration Project\CAD\65% GBOD REPORT\3195.x LSRP GBOD 65% AppB 148+00.dwg



Material ID and Type, Unit Weight, Effective Cohesion, Effective Friction Angle, Total Cohesion, Total Friction Angle

Color	Name			Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Cohesion R (psf)	Phi R (°)
	Lean CLAY, CL	Kh=0.0057 ft/day	(=2.0x10-6 cm/s)	115	150	32	175	16
	Lean CLAY, Fat CLAY, CL, CH	Kh=0.0028 ft/day	(=1.0x10-6 cm/s)	115	150	30	175	15
	New Levee, CL, CH	Kh=0.0028 ft/day	(=1.0x10-6 cm/s)	125	400	22	450	13
	Poorly-graded SAND with Silt, Clay SP-SM, SP-SC	Kh=14.74 ft/day	(=5.2x10-3 cm/s)	120	0	30	0	0
	Slurry Wall, SB	Kh=0.0028 ft/day	(=1.0x10-6 cm/s)	100	50	0	0	0

APPENDIX B-29, STA 148+00
GEOTECHNICAL BASIS OF DESIGN REPORT - 65% DESIGN
Rapid Drawdown Slope Stability Analysis, 10 ft. Drawdown
Setback Levee with Shallow Cutoff Wall
September 2019

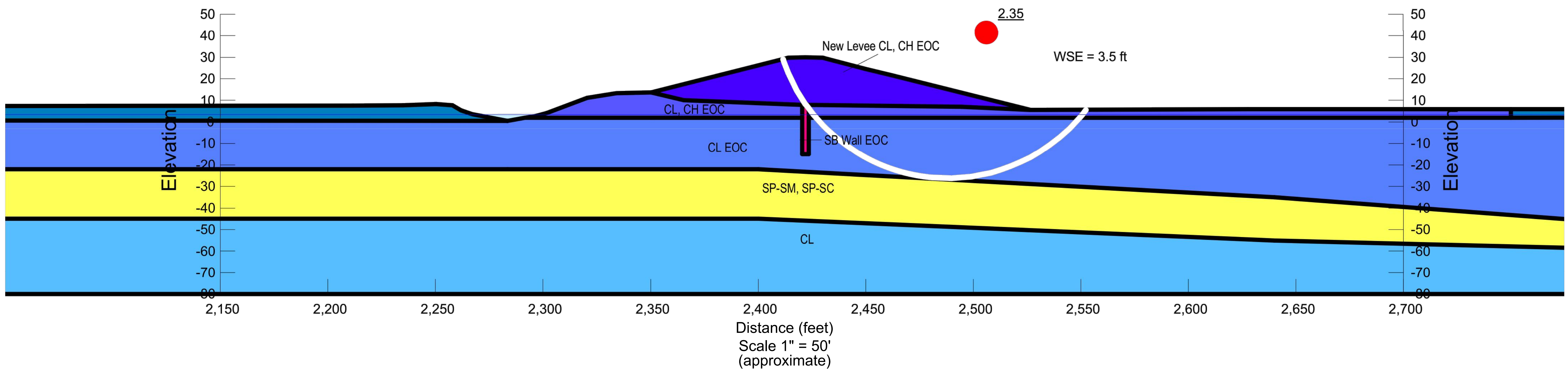
Lookout Slough THRFIP

Ecosystem Investment Partners

Map Prepared Date: 09/01/19
Map Prepared By: M.D.R.
Checked By: N.C.H.
Job No.: 3195.x

Prepared by:
BLACKBURN CONSULTING

Path: \\FS-01\Common\Active Projects\3195.P DWR Lookout Slough Restoration Project\CAD\65% GBOD REPORT\3195.x LSRP GBOD 65% AppB 148+00.dwg



Material ID and Type, Unit Weight, Undrained Shear Strength, Effective Cohesion, Effective Friction Angle

Color	Name			Unit Weight (pcf)	Cohesion (psf)	Cohesion' (psf)	Phi' (°)
	Lean CLAY, CL	Kh=0.0057 ft/day	(=2.0x10-6 cm/s)	115		150	32
	Lean CLAY, CL EOC	Kh=0.0057 ft/day	(=2.0x10-6 cm/s)	115	1,000		
	Lean CLAY, Fat CLAY, CL, CH	Kh=0.0028 ft/day	(=1.0x10-6 cm/s)	115		150	30
	Lean CLAY, Fat CLAY, CL, CH EOC	Kh=0.0028 ft/day	(=1.0x10-6 cm/s)	115	1,000		
	New Levee, CL, CH EOC	Kh=0.0028 ft/day	(=1.0x10-6 cm/s)	125	1,500		
	Poorly-graded SAND with Silt, Clay SP-SM, SP-SC	Kh=14.74 ft/day	(=5.2x10-3 cm/s)	120		0	30
	Slurry Wall, SB, EOC	Kh=0.0028 ft/day	(=1.0x10-6 cm/s)	100	20		

APPENDIX B-30, STA 148+00

GEOTECHNICAL BASIS OF DESIGN REPORT - 65% DESIGN

End-of-Construction Slope Stability Analysis
Setback Levee with Shallow Cutoff Wall
September 2019

Lookout Slough THRFIP

Ecosystem Investment Partners

Map Prepared Date: 09/01/19
Map Prepared By: M.D.R.
Checked By: N.C.H.
Job No.: 3195.x

Prepared by:
BLACKBURN CONSULTING

Path: \\FS-01\Common\Active Projects\3195.P DWR Lookout Slough Restoration Project\CAD\65%
GBOD REPORT\3195.x LSRP GBOD 65% AppB 148+00.dwg

GEOTECHNICAL BASIS OF DESIGN REPORT

65% Design

Lookout Slough THRFIP

Solano County, California

APPENDIX C

Settlement Evaluations

This Page Intentionally Left Blank

Lookout Slough THRFIP

PROJECT IDENTIFICATION

Title: Lookout Slough THRFIP
Project Number: 3195.x -
Client: Ecosystem Investment Partners
Designer: David J. Morrell
Station Number:

Description:

Borings BCI-17-02, BCI-17-03, BCI-17-04, BCI-17-05 Soil Profile

Company's information:

Name: Blackburn Consulting
Street: 2491 Boatman Avenue
West Sacramento, CA 95691
Telephone #:
Fax #:
E-Mail:

Original file path and name: Z:\Active ..... Settlement Analysis\(B2-B3-B4-B5) Soil Profile.2ST
Original date and time of creating this file: Fri Nov 03 15:12:26 2017

GEOMETRY: Analysis of a 2D geometry

INPUT DATA – FOUNDATION LAYERS – 2 layers

	Wet Unit Weight, γ [lb/ft³]	Poisson's Ratio μ	Description of Soil
1	120.00	0.40	
2	125.00	0.40	

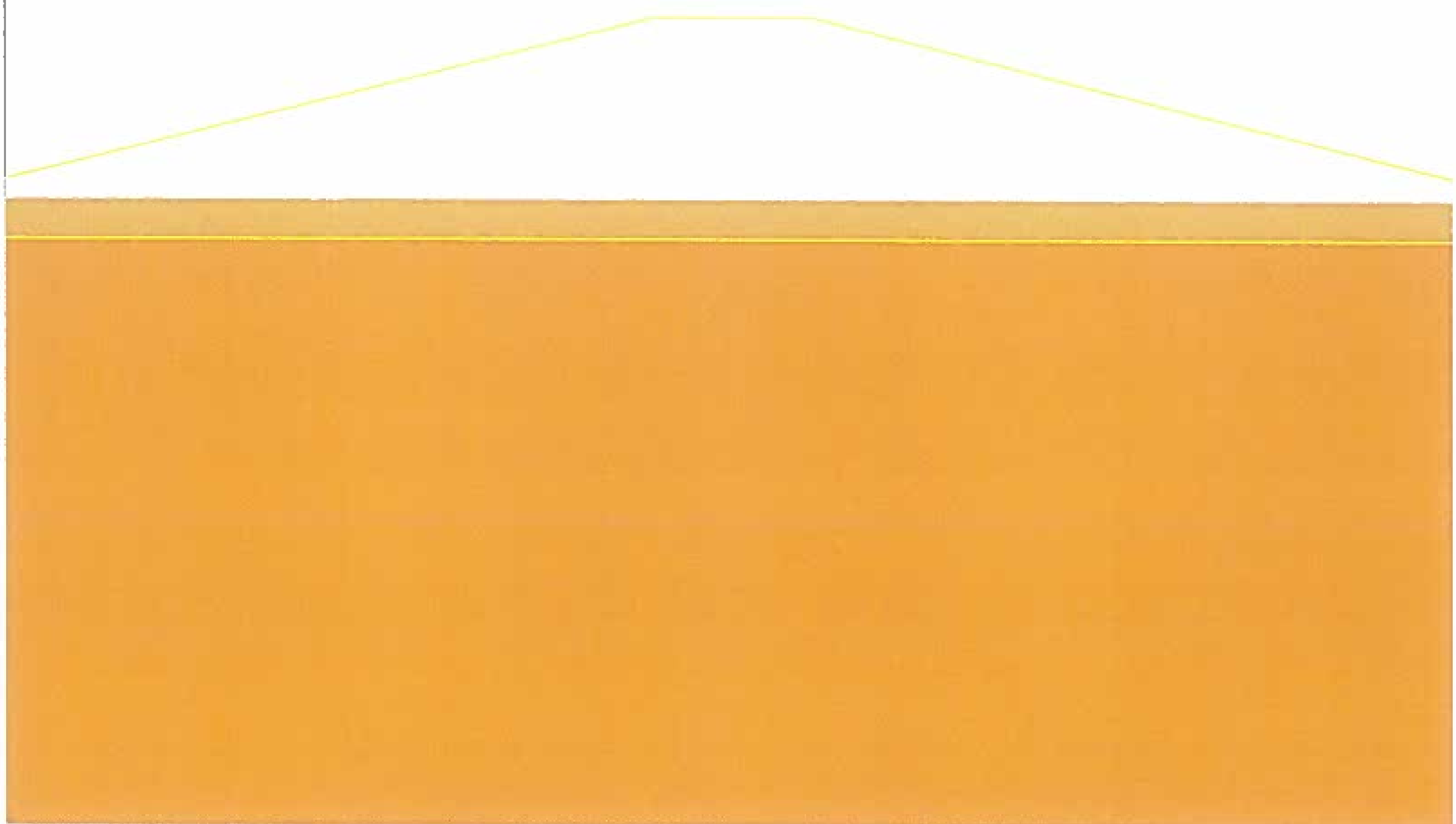
INPUT DATA – EMBANKMENT LAYERS – 1 layers

	Wet Unit Weight, γ [lb/ft³]	Description of Soil
1	125.00	

INPUT DATA OF WATER

Point #	Coordinates (X, Z) : (X) [ft.]	(Z) [ft.]
1	-500.00	95.00
2	-250.00	95.00
3	0.00	95.00
4	250.00	95.00
5	500.00	95.00

DRAWING OF SPECIFIED GEOMETRY



IMMEDIATE SETTLEMENT, Si

Node #	Settlement along section: X [ft.]	Y [ft.]	Layer (k)	Young's Modulus, E [lb/ft ²]	Poisson's Ratio, μ	Settlement of each layer, Si(k) [ft.]	Initial Z [ft.]	Final Z * [ft.]	Total Settlement Sum of Si(k), [ft.]
1	0.00	0.00	1	1000000	0.4000	0.0054	100.00	99.93	0.07
			2	2000000	0.4000	0.0676			

*Note: Final Z is calculated assuming only 'Immediate Settlement' exists.

TABULATED GEOMETRY: INPUT OF FOUNDATION SOILS

Found. Soil #	Point #	Coordinates (X, Z) : (X) [ft.]	(Z) [ft.]	DESCRIPTION
1	1	0.00	100.00	
2	1	0.00	95.00	

TABULATED GEOMETRY: INPUT OF EMBANKMENT SOILS

Embankment footprint width = 204.00 [ft]. Side slope of embakment: 14.04 degrees.

Embank. Soil #	Coordinates (X, Z) of center line : (X) [ft.]	(Z) [ft.]	DESCRIPTION
1	0.00	123.00	

Lookout Slough THRFIP

PROJECT IDENTIFICATION

Title: Lookout Slough THRFIP
Project Number: 3195.x -
Client: Ecosystem Investment Partners
Designer: David J. Morrell
Station Number:

Description:
Borings BCI-17--06 Soil Profile

Company's information:

Name: Blackburn Consulting
Street: 2491 Boatman Avenue
West Sacramento, CA 95691
Telephone #:
Fax #:
E-Mail:

Original file path and name: Z:\Active ..... Analysis\Settlement Analysis\(B6) Soil Profile.2ST
Original date and time of creating this file: Fri Nov 03 15:12:26 2017

GEOMETRY: Analysis of a 2D geometry

INPUT DATA -- FOUNDATION LAYERS -- 7 layers

	Wet Unit Weight, γ [lb/ft³]	Poisson's Ratio μ	Description of Soil
1	120.00	0.40	
2	120.00	0.30	
3	105.00	0.30	
4	115.00	0.30	
5	115.00	0.30	
6	120.00	0.40	
7	125.00	0.40	

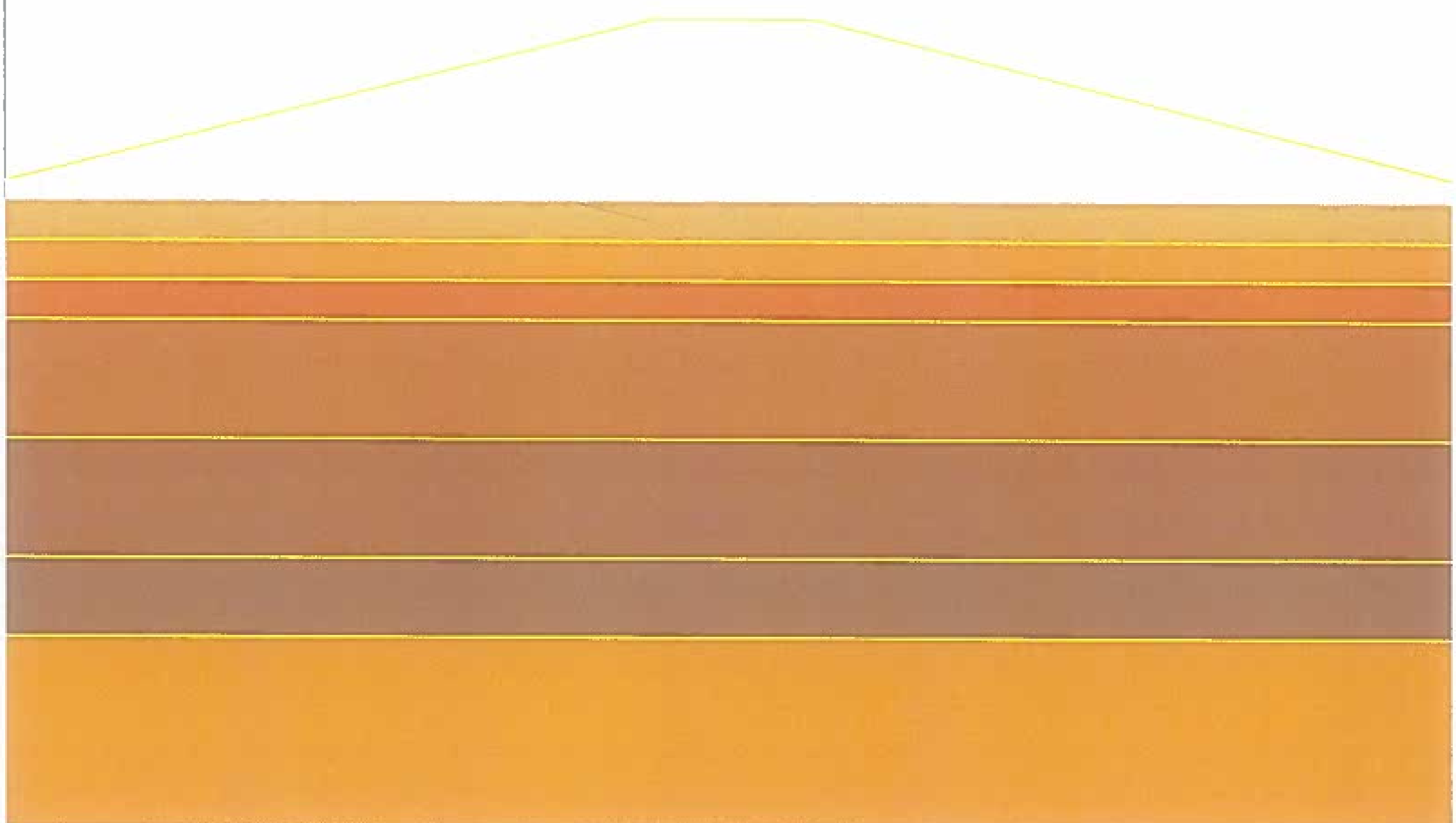
INPUT DATA -- EMBANKMENT LAYERS -- 1 layers

	Wet Unit Weight, γ [lb/ft³]	Description of Soil
1	125.00	

INPUT DATA OF WATER

Point #	Coordinates (X, Z) : (X) [ft.]	(Z) [ft.]
1	-500.00	95.00
2	-250.00	95.00
3	0.00	95.00
4	250.00	95.00
5	500.00	95.00

DRAWING OF SPECIFIED GEOMETRY



IMMEDIATE SETTLEMENT, Si

Node #	Settlement along section: X [ft.]	Y [ft.]	Layer (k)	Young's Modulus, E [lb/ft ²]	Poisson's Ratio, μ	Settlement of each layer, Si(k) [ft.]	Initial Z [ft.]	Final Z * [ft.]	Total Settlement Sum of Si(k), [ft.]
1	0.00	0.00	1	1500000	0.4000	0.0036	100.00	99.57	0.43
			2	250000	0.3000	0.0367			
			3	450000	0.3000	0.0214			
			4	250000	0.3000	0.1144			
			5	150000	0.3000	0.1876			
			6	500000	0.4000	0.0311			
			7	2000000	0.4000	0.0311			

*Note: Final Z is calculated assuming only 'Immediate Settlement' exists.

TABULATED GEOMETRY: INPUT OF FOUNDATION SOILS

Found. Soil #	Point #	Coordinates (X, Z) : (X) [ft.]	(Z) [ft.]	DESCRIPTION
1	1	0.00	100.00	
2	1	0.00	95.00	
3	1	0.00	90.00	
4	1	0.00	85.00	
5	1	0.00	70.00	
6	1	0.00	55.00	
7	1	0.00	45.00	

TABULATED GEOMETRY: INPUT OF EMBANKMENT SOILS

Embankment footprint width = 204.00 [ft]. Side slope of embakment: 14.04 degrees.

Embank. Soil #	Coordinates (X, Z) of center line : (X) [ft.]	(Z) [ft.]	DESCRIPTION
1	0.00	123.00	

Lookout Slough THRFIP

PROJECT IDENTIFICATION

Title:	Lookout Slough THRFIP
Project Number:	3195.x -
Client:	Ecosystem Investment Partners
Designer:	David J. Morrell
Station Number:	

Description:

SETTLEMENT AT LEVEE CENTERLINE; 4:1 Levee Side Slopes with Updated Soil Profile

Company's information:

Name:	Blackburn Consulting
Street:	2491 Boatman Avenue West Sacramento, CA 95691
Telephone #:	
Fax #:	
E-Mail:	

Original file path and name: Z:\Active ..... alysis\4 to 1 Side Slopes Updated Soil Profile.2ST
Original date and time of creating this file: Fri Nov 03 15:12:26 2017

GEOMETRY: Analysis of a 2D geometry

INPUT DATA – FOUNDATION LAYERS – 8 layers

	Wet Unit Weight, γ [lb/ft³]	Poisson's Ratio μ	Description of Soil
1	120.00	0.30	
2	120.00	0.40	
3	118.00	0.40	
4	125.00	0.40	
5	117.00	0.40	
6	120.00	0.40	
7	120.00	0.40	
8	120.00	0.40	

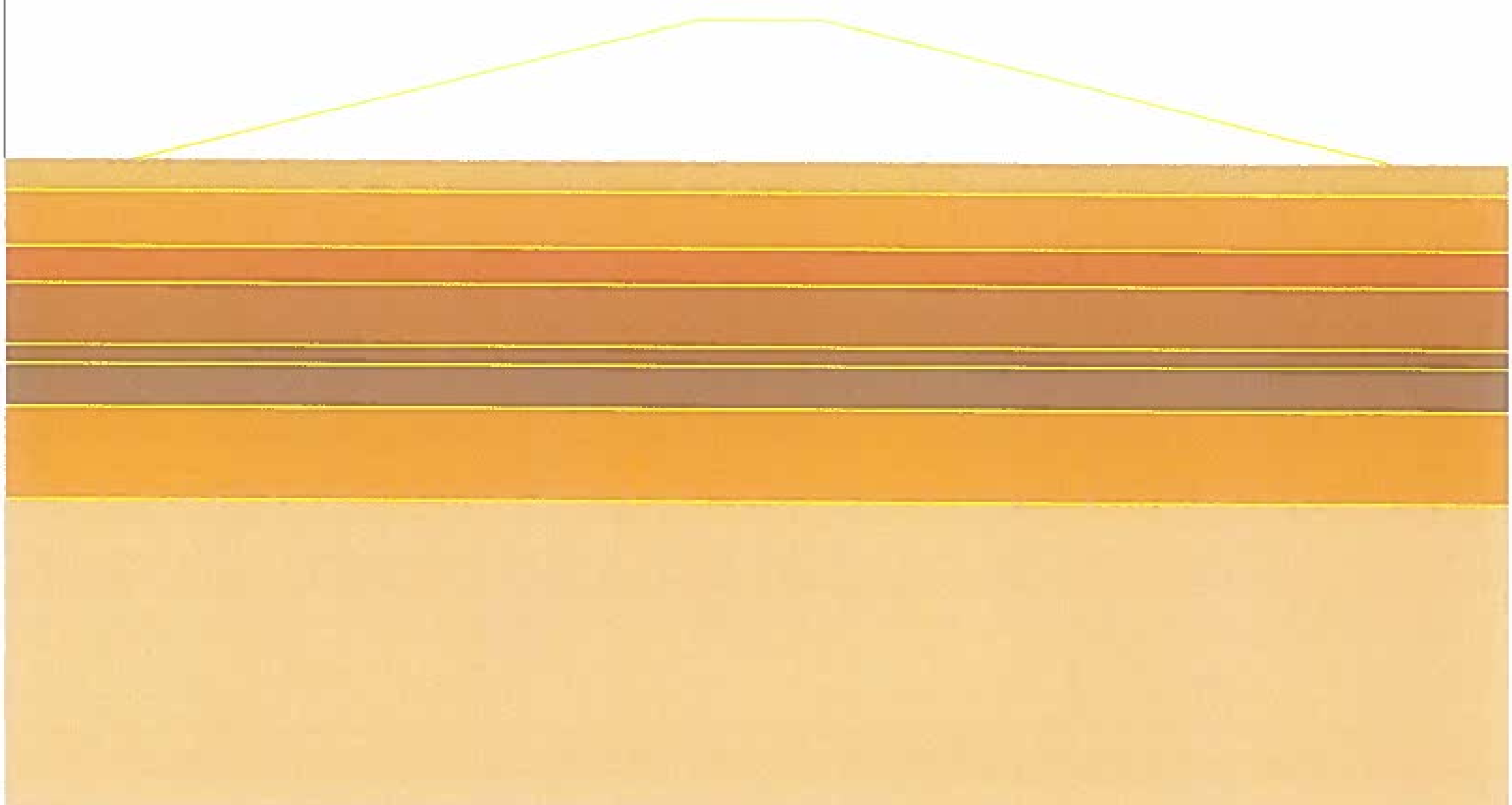
INPUT DATA – EMBANKMENT LAYERS – 1 layers

	Wet Unit Weight, γ [lb/ft³]	Description of Soil
1	125.00	

INPUT DATA OF WATER

Point #	Coordinates (X, Z) : (X) [ft.]	(Z) [ft.]
1	-500.00	95.00
2	-250.00	95.00
3	0.00	95.00
4	250.00	95.00
5	500.00	95.00

DRAWING OF SPECIFIED GEOMETRY



INPUT DATA FOR CONSOLIDATION — $\alpha = 1/2$

Layer #	Underging Consolidation [Yes/No]	OCR = Pc / Po	Cc	Cr	e0	Cv [ft ²/day]	Drains at :
1	No	N/A	N/A	N/A	N/A	N/A	N/A
2	Yes	10.00	0.270	0.075	0.810	0.1230	Top
3	Yes	3.00	0.240	0.020	0.780	0.5540	Top
4	No	N/A	N/A	N/A	N/A	N/A	N/A
5	Yes	3.00	0.290	0.060	0.895	0.2180	Bottom
6	Yes	10.00	0.300	0.060	0.895	0.2180	Bottom
7	Yes	4.00	0.300	0.060	0.895	0.2310	Bottom
8	No	N/A	N/A	N/A	N/A	N/A	N/A

IMMEDIATE SETTLEMENT, Si

Node #	Settlement along section: X [ft.]	Y [ft.]	Layer (k)	Young's Modulus, E [lb/ft ²]	Poisson's Ratio, μ	Settlement of each layer, Si(k) [ft.]	Initial Z [ft.]	Final Z * [ft.]	Total Settlement Sum of Si(k), [ft.]
1	0.00	0.00	1	500000	0.3000	0.0174	100.00	99.79	0.21
			2	500000	0.4000	0.0231			
			3	310000	0.4000	0.0285			
			4	1000000	0.4000	0.0153			
			5	250000	0.4000	0.0202			
			6	1000000	0.4000	0.0112			
			7	625000	0.4000	0.0370			
			8	1000000	0.4000	0.0622			

*Note: Final Z is calculated assuming only 'Immediate Settlement' exists.

ULTIMATE SETTLEMENT, Sc

Node #	X [ft.]	Y [ft.]	Original Z [ft.]	Settlement Sc [ft.]	Final Z * [ft.]
1	0.00	0.00	100.00	0.50	99.50

*Note: Final Z is calculated assuming only 'Ultimate Settlement' exists.

TABULATED GEOMETRY: INPUT OF FOUNDATION SOILS

Found. Soil #	Point #	Coordinates (X, Z) : (X) [ft.]	(Z) [ft.]	DESCRIPTION
1	1	0.00	100.00	
2	1	0.00	95.00	
3	1	0.00	86.00	
4	1	0.00	80.00	
5	1	0.00	70.00	
6	1	0.00	67.00	
7	1	0.00	60.00	
8	1	0.00	45.00	

TABULATED GEOMETRY: INPUT OF EMBANKMENT SOILS

Embankment footprint width = 204.00 [ft]. Side slope of embakment: 14.04 degrees.

Embank. Soil #	Coordinates (X, Z) of center line : (X) [ft.]	(Z) [ft.]	DESCRIPTION
1	0.00	123.00	

GEOTECHNICAL BASIS OF DESIGN REPORT

65% Design

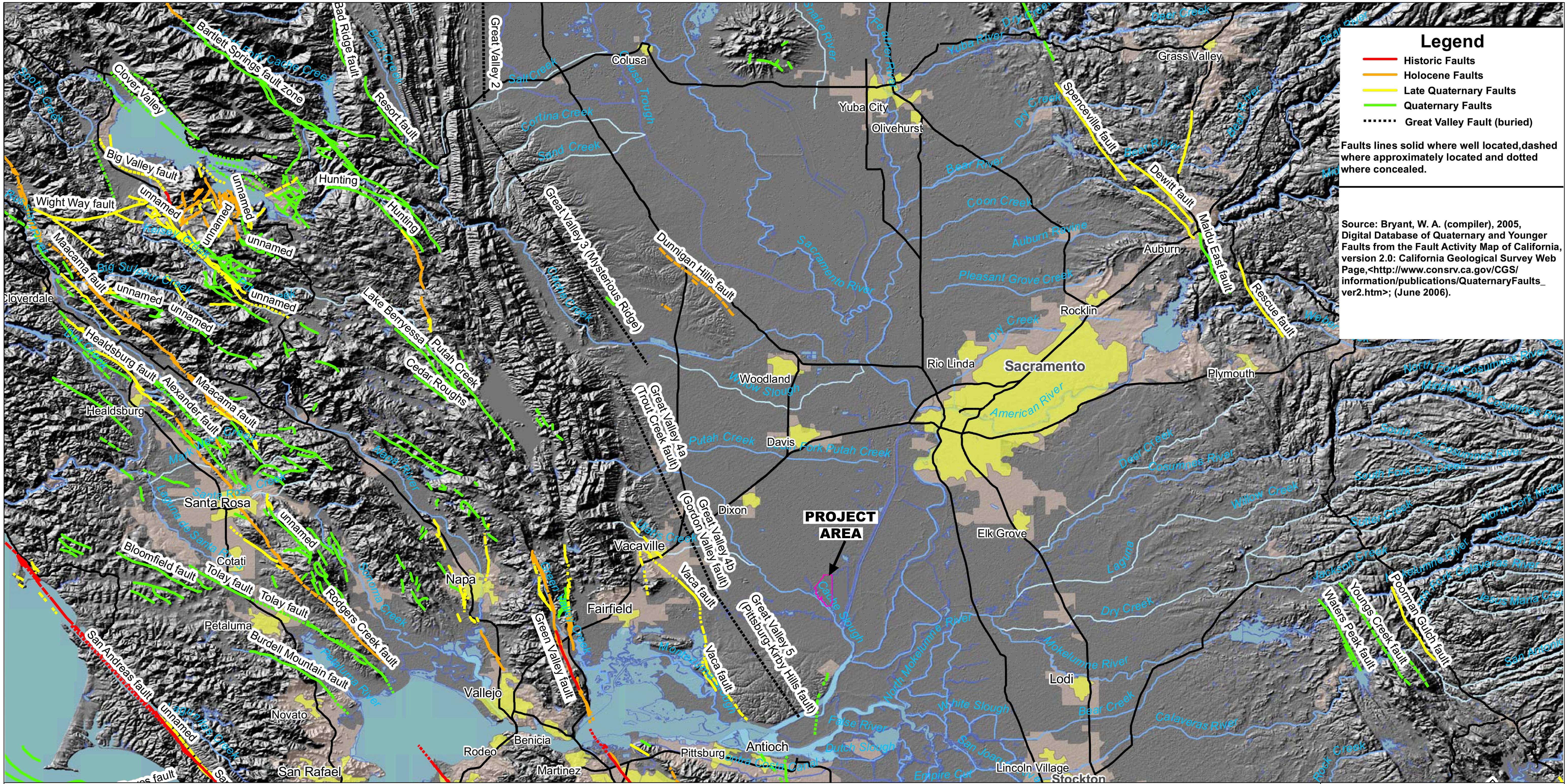
Lookout Slough THRFIP

Solano County, California

APPENDIX D

Seismic Information

This Page Intentionally Left Blank



APPENDIX D, REGIONAL FAULT MAP
GEOTECHNICAL BASIS OF DESIGN REPORT - 65% DESIGN
September 2019

Lookout Slough THRFIP

N
W E
S

0 60,000

SCALE: 1" = 60,000'

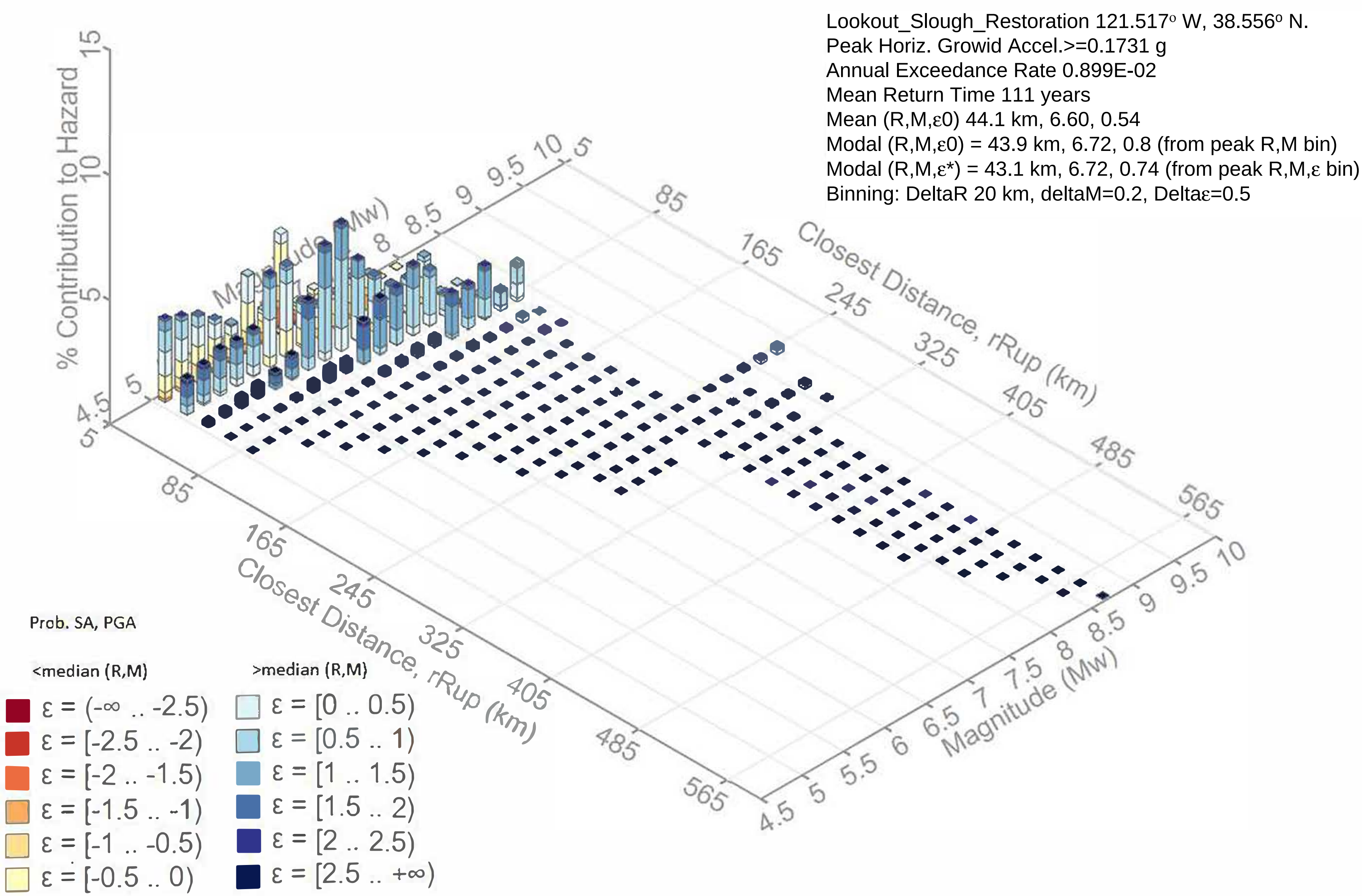
Ecosystem Investment Partners

Map Prepared Date: 09/01/19
Map Prepared By: M.D.R.
Checked By: N.C.H.
Job No.: 3195.x

Prepared by:
BLACKBURN CONSULTING

Path: \\FS-01\Common\Active Projects\3195.P DWR Lookout Slough Restoration Project\CAD\3195.x LSRP GBOD 65% AppD.dwg

This Page Intentionally Left Blank



Lookout_Slough_Restoration 121.517° W, 38.556° N.
Peak Horiz. Growid Accel.>=0.1731 g
Annual Exceedance Rate 0.899E-02
Mean Return Time 111 years
Mean (R,M,ε0) 44.1 km, 6.60, 0.54
Modal (R,M,ε0) = 43.9 km, 6.72, 0.8 (from peak R,M bin)
Modal (R,M,ε*) = 43.1 km, 6.72, 0.74 (from peak R,M,ε bin)
Binning: DeltaR 20 km, deltaM=0.2, Deltaε=0.5
% Contribution to Hazard
Closest Distance, rRup (km)
Magnitude (Mw)
Prob. SA, PGA
<median (R,M)
>median (R,M)
ε = (-∞ .. -2.5)
ε = [-2.5 .. -2)
ε = [-2 .. -1.5)
ε = [-1.5 .. -1)
ε = [-1 .. -0.5)
ε = [-0.5 .. 0)
ε = [0 .. 0.5)
ε = [0.5 .. 1)
ε = [1 .. 1.5)
ε = [1.5 .. 2)
ε = [2 .. 2.5)
ε = [2.5 .. +∞)

This Page Intentionally Left Blank

Summary -- Liquefaction Analysis

Lookout Slough

BCI-17-05 (Near Station 63+00)

Project: Lookout Slough
BCI No.: 3195.X
Date: 8/13/2018
Location: BCI-17-05 (Near Station 63+00)
By: DWC

Boring Elevation:	6	feet
Ground Water Elevation:	4.3	feet (For Liquefaction Analysis)
Hammer Energy (ER):	79	%
Ground Water Depth:	19.0	feet (At Time of Drilling)
Ground Water Depth:	1.8	feet (For Liquefaction Analysis)
Distance to Fault (R) =	27.6	miles
Moment Magnitude, M_w =	6.7	
PGA =	0.17	g
Liquefaction Factor of Safety (FS):	1.2	

Soil Layer

Granular	(yellow)
Cohesive	(green)

Input Data										Overburden Stress			Liquefaction Analysis						Strength Parameters	
Sample Number	Sample Depth (feet)	Depth to Bottom of Layer (feet)	Layer Thickness (feet)	Soil Type (USCS)	Total Unit Weight (pcf)	Field N (bpf)	Fines %	PI %	Average Mean Grain Size D50 (mm)	Total Stress (psf)	Effective Stress at Time of Drilling (psf)	Effective Stress for Liquefaction Analysis (psf)	N_{SPT} (bpf)	$(N_1)_{60}$ NCEER $(N_1)_{60}$ Boulanger (bpf)	$(N_1)_{60}$ Cetin (bpf)	$(N_1)_{60CS}$ NCEER (bpf)	$(N_1)_{60CS}$ Boulanger (bpf)	$(N_1)_{60CS}$ Cetin (bpf)	$(N_1)_{60}$ (bpf)	Effective Friction Angle (φ') (degrees)
1	1.0	5.0	5.0	CH	126	7	90	--	--	126	126	126	7	12	12	12	12	12	18	32
3	5.0	7.5	2.5	CL	125	14	78	30	--	631	631	428	14	25	23	25	25	23	26	34
5	8.5	11.5	4.0	CL	125	12	80	--	--	1068	1068	647	12	19	18	19	19	18	19	32
7	12.5	17.0	5.5	CL	132	11	72	22	--	1575	1575	904	11	14	14	14	14	14	16	31
8	20.0	23.0	6.0	CL	125	19	75	--	--	2543	2480	1404	19	22	22	22	22	22	23	33
9	25.0	28.0	5.0	CL	131	19	90	--	--	3179	2805	1728	19	21	21	21	21	21	22	33
10	30.0	33.0	5.0	CL	130	9	90	--	--	3831	3145	2068	9	9	9	9	9	9	10	30
11	35.0	38.0	5.0	SM	125	16	33	0	--	4471	3473	2396	16	16	16	24	22	20	17	32
12	40.0	43.0	5.0	SM	125	15	33	--	--	5096	3786	2709	15	15	14	22	20	18	16	31
13	45.0	48.0	5.0	SP-SC	125	24	10	--	--	5721	4099	3022	24	23	22	24	24	24	24	34
14	50.0	53.0	5.0	SP-SC	125	22	10	--	--	6346	4412	3335	22	20	20	21	21	21	21	33
15	55.0	60.0	7.0	CL	125	22	90	--	--	6971	4725	3648	22	19	19	19	19	19	21	32
16	60.0	63.0	3.0	CH	125	23	95	37	--	7596	5038	3961	23	20	20	20	20	20	21	32
17	65.0	68.5	5.5	CL	125	25	90	--	--	8221	5351	4274	25	21	21	21	21	21	22	33
18	70.0	73.0	4.5	CL	125	14	90	--	--	8846	5664	4587	14	11	11	11	11	11	12	31
19	75.0	76.5	3.5	CL	125	27	90	--	--	9471	5977	4900	27	21	21	21	21	21	23	33

	Liquefaction Factor of Safety: Factor of Safety (FS)						Residual Shear Strength (Sr)										
Sample Number	NCEES (FS)	FS ≤ 1.2	Cetin (FS)	FS ≤ 1.2	Boulanger (FS)	FS ≤ 1.2	$(N_1)_{60CS\text{-}Sr}$ (bpf)	Idriss and Boulanger 2008 [1] Case 1 (psf)	Idriss and Boulanger 2008 [1] Case 2 (psf)	Idriss and Boulanger 2007 [2] (psf)	Seed & Harder 1990 w/ NCEER FS [3] Lower Bound (psf)	Seed & Harder 1990 w/ NCEER FS [3] Upper Bound (psf)	Seed & Harder 1990 w/ NCEER FS [3] Average (psf)	Seed & Harder 1990 w/ NCEER FS [3] Bound plus 1/3 (psf)	Idriss 1998 (psf)	Olson & Stark 2002 [4] (psf)	Sr. Kramer and Wang 2007 (psf)
1	unsaturated	--	unsaturated	--	unsaturated	--	12	--	--	--	--	--	--	--	--	--	--
3	NL	--	NL	--	NL	--	25	--	--	--	--	--	--	--	--	--	--
5	12.12	--	11.39	--	11.31	--	19	404	148	977	1310	1870	1590	1496	992	NA	415
7	NL	--	NL	--	NL	--	14	--	--	--	--	--	--	--	--	--	--
8	8.29	--	7.30	--	8.06	--	22	912	432	1723	--	--	--	--	1674	NA	870
9	6.71	--	5.77	--	6.69	--	21	1122	470	1364	--	--	--	--	1358	NA	841
10	2.67	--	2.25	--	2.73	--	9	379	251	225	360	810	585	509	219	205	267
11	1.90	--	1.17	x	1.66	--	24	1497	378	2682	750	1270	1010	923	2429	NA	634
12	1.68	--	1.01	x	1.52	--	22	950	385	1837	560	1050	805	723	1770	NA	565
13	1.87	--	1.37	--	1.96	--	24	2039	695	2571	1310	1870	1590	1496	2348	NA	1426
14	1.62	--	1.17	x	1.69	--	21	2166	628	1550	1090	1630	1360	1269	1524	NA	1129
15	4.59	--	3.26	--	4.55	--	19	2280	887	1099	--	--	--	--	1110	NA	1104
16	NL	--	NL	--	NL	--	20	--	--	--	--	--	--	--	--	--	--
17	4.99	--	2.78	--	4.75	--	21	2776	1167	1378	--	--	--	--	1370	NA	1395
18	2.77	--	1.46	--	2.56	--	11	1385	631	307	560	1050	805	723	303	525	520
19	5.35	--	2.64	--	4.77	--	21	3182	1396	1493	--	--	--	--	1473	NA	1586

[1] Idriss, I. M. and Boulanger, R. W., "Soil Liquefaction During Earthquakes," Earthquake Engineering Research Institute, pages 140-142 and 152-158, 2008.

[2] Idriss, I. M. and Boulanger, R. W., "Residual Shear Strength of Liquified Soils," Proceedings, 27th USSD Annual Meeting and Conference, Modernization and Optimization of Existing Dams and Reservoirs, Philadelphia, Pennsylvania, March 5-9, 2007, where, Sr = exp[((N1)60CS-Sr/5.1 - ((N1)60CS-Sr/16.5)2 + ((N1)60CS-Sr/21.4)3 + 0.8]/0.0479 (psf)

[3] Seed, R.B. and Harder, L.F., "SPT-based Analysis of Cyclic Pore Pressure Generation and Undrained Residual Strength", Proceedings of the H.B. Seed Memorial Symposium, BiTech Publishers Ltd., Vancouver,

[4] Olson and Stark (2002), where, $S_u(LIQ) = \sigma'_{v0}[0.03+(0.0075(N_1)_{60})]$; valid for $(N_1)_{60} \leq 12$

Summary -- Liquefaction Analysis

Lookout Slough

BCI-17-06 (Near Station 42+00)

Project: **Lookout Slough**
BCI No.: **3195.X**
Date: **8/13/2018**
Location: **BCI-17-06 (Near Station 42+00)**
By: **DWC**

Soil Layer	
Granular	(yellow)
Cohesive	(green)

Boring Elevation:	6	feet
Ground Water Elevation:	4.3	feet (For Liquefaction Analysis)
Hammer Energy (ER):	79	%
Ground Water Depth:	3.0	feet (At Time of Drilling)
Ground Water Depth:	1.8	feet (For Liquefaction Analysis)
Distance to Fault (R) =	27.6	miles
Moment Magnitude, M_w =	6.7	
PGA =	0.17	g
Liquefaction Factor of Safety (FS):	1.2	

Input Data / Overburden Stress

Sample Number	Sample Depth (feet)	Depth to Bottom of Layer (feet)	Layer Thickness (feet)	Soil Type (USCS)	Total Unit Weight (pcf)	Field N (bpf)	Fines %	PI %	Average Mean Grain Size D50 (mm)	Total Stress (psf)	Effective Stress at Time of Drilling (psf)	Effective Stress for Liquefaction Analysis (psf)
1	1.0	5.0	5.0	CH	124	7	80	50	--	124	124	124
3	5.5	7.5	2.5	CL	125	12	65	--	--	681	525	447
5	9.5	11.0	3.5	SP-SM	128	14	6	0	--	1187	781	703
6	11.0	14.0	3.0	SP-SM	128	30	6	--	--	1378	879	801
7	15.0	19.0	5.0	GW-GC	146	9	10	--	--	1908	1160	1082
8	20.0	23.0	4.0	GW-GC	150	13	10	--	--	2644	1583	1505
9	25.0	28.0	5.0	ML	125	12	60	--	--	3344	1971	1893
10	30.0	33.0	5.0	SP-SC	138	30	12	--	--	3994	2309	2231
11	35.0	38.0	5.0	CL	125	15	80	--	--	4658	2661	2583
12	40.0	43.0	5.0	ML	125	9	80	--	--	5283	2974	2896
13	45.0	47.5	4.5	CH	125	12	98	36	--	5908	3287	3209
14	50.0	53.0	5.5	CH	125	20	98	35	--	6533	3600	3522
15	55.0	59.0	6.0	CL	127	15	60	--	--	7161	3916	3838
16	60.0	62.5	3.5	CL	125	30	98	--	--	7793	4236	4158
17	65.0	67.5	5.0	CL	125	28	98	--	--	8418	4549	4471
18	70.0	72.5	5.0	CL	125	21	98	--	--	9043	4862	4784
19	75.0	76.5	4.0	CL	125	21	98	--	--	9668	5175	5097

Liquefaction Analysis / Strength Parameter / Liquefaction Factor of Safety

Sample Number	N_{SPT} (bpf)	$(N_1)_{60}$ NCEER $(N_1)_{60}$ Boulanger (bpf)	$(N_1)_{60}$ Cetin (bpf)	$(N_1)_{60CS}$ NCEER (bpf)	$(N_1)_{60CS}$ Boulanger (bpf)	$(N_1)_{60CS}$ Cetin (bpf)	$(N_1)_{60}$ (bpf)	Effective Friction Angle (φ') (degrees)	Factor of Safety (FS): NCEES (FS)	FS ≤ 1.2	Cetin (FS)	FS ≤ 1.2	Boulanger (FS)	FS ≤ 1.2
1	7	12	12	12	12	12	18	32	unsaturated	--	unsaturated	--	unsaturated	--
3	12	21	20	21	21	20	23	33	18.86	--	18.09	--	17.48	--
5	14	25	23	26	26	24	24	34	NL	--	NL	--	NL	--
6	30	52	48	52	52	49	50	43	NL	--	NL	--	14.63	--
7	9	14	14	15	15	15	14	31	1.10	x	1.03	x	1.10	x
8	13	19	18	20	20	20	18	32	1.53	--	1.32	--	1.48	--
9	12	16	16	16	16	16	16	31	4.03	--	3.47	--	4.02	--
10	30	36	37	39	38	39	38	36	NL	--	NL	--	14.35	--
11	15	18	17	18	18	17	18	32	3.83	--	3.09	--	3.91	--
12	9	10	10	10	10	10	10	30	2.12	--	1.64	--	2.16	--
13	12	13	12	13	13	12	13	31	NL	--	NL	--	NL	--
14	20	20	20	20	20	20	21	33	NL	--	NL	--	NL	--
15	15	15	14	15	15	14	15	31	3.05	--	2.18	--	3.02	--
16	30	28	28	28	28	28	30	35	5.94	--	4.10	--	5.78	--
17	28	25	25	25	25	25	27	34	5.45	--	3.05	--	5.19	--
18	21	18	18	18	18	18	19	32	4.06	--	2.14	--	3.76	--
19	21	18	18	18	18	18	19	32	4.08	--	2.01	--	3.64	--

Residual Shear Strength (Sr)

Sample Number	$(N_1)_{60CS-Sr}$ (bpf)	Idriss and Boulanger 2008 [1] Case 1 (psf)	Idriss and Boulanger 2008 [1] Case 2 (psf)	Idriss and Boulanger 2007 [2] (psf)	Seed & Harder 1990 w/ NCEER FS [3] Lower Bound (psf)	Upper Bound (psf)	Average (psf)	Bound plus 1/3 (psf)	Idriss 1998 (psf)	Olson & Stark 2002 [4] (psf)	Sr. Kramer and Wang 2007 (psf)
1	12	--	--	--	--	--	--	--	--	--	--
3	21	291	116	1493	--	--	--	--	1473	NA	457
5	26	--	--	--	--	--	--	--	--	--	--
6	52	--	--	--	--	--	--	--	--	--	--
7	15	214	134	524	360	810	585	509	531	NA	307
8	20	941	260	1236	850	1390	1120	1029	1240	NA	640
9	16	1137	321	592	850	1390	1120	1029	601	NA	507
10	39	--	--	--	--	--	--	--	--	--	--
11	18	1614	545	821	1190	1740	1465	1373	836	NA	750
12	10	627	368	253	360	810	585	509	247	304	348
13	13	--	--	--	--	--	--	--	--	--	--
14	20	--	--	--	--	--	--	--	--	--	--
15	15	2306	609	504	750	1270	1010	923	510	NA	668
16	28	2911	2693	5827	--	--	--	--	4349	NA	3015
17	25	3016	1971	3193	--	--	--	--	2790	NA	2323
18	18	2989	1059	909	1310	1870	1590	1496	925	NA	1139
19	18	3185	1081	830	1190	1740	1465	1373	845	NA	1112

[1] Idriss, I. M. and Boulanger, R. W., "Soil Liquefaction During Earthquakes," Earthquake Engineering Research Institute, pages 140-142 and 152-158, 2008.

[2] Idriss, I. M. and Boulanger, R. W., "Residual Shear Strength of Liquified Soils," Proceedings, 27th USSD Annual Meeting and Conference, Modernization and Optimization of Existing Dams and Reservoirs, Philadelphia, Pennsylvania, March 5-9, 2007, where, Sr = exp[((N1)60CS-Sr/5.1 - ((N1)60CS-Sr/16.5)2 + ((N1)60CS-Sr/21.4)3 + 0.8]/0.0479 (psf)

[3] Residual Strength", Proceedings of the H.B. Seed Memorial Symposium, BiTech Publishers Ltd., Vancouver, B.C., Canada, Vol. 2, pp. 351-376, 1990.

[4] Olson and Stark (2002), where, $S_u(LIQ) = \sigma'_{v0}[0.03+(0.0075(N_1)_{60})]$; valid for $(N_1)_{60} \leq 12$

Project: Lookout Slough
BCI No.: 3195.X
Date: 8/13/2018
Location: BCI-17-11 (Near Station 42+20)
By: DWC

Boring Elevation:	6	feet
Ground Water Elevation:	4.3	feet (For Liquefaction Analysis)
Hammer Energy (ER):	74	%
Ground Water Depth:	6.5	feet (At Time of Drilling)
Ground Water Depth:	1.8	feet (For Liquefaction Analysis)
Distance to Fault (R) =	27.6	miles
Moment Magnitude, M_w =	6.7	
PGA =	0.17	g
Liquefaction Factor of Safety (FS):	1.2	

Soil Layer	
Granular	
Cohesive	

Input Data										Overburden Stress		
Sample Number	Sample Depth (feet)	Depth to Bottom of Layer (feet)	Layer Thickness (feet)	Soil Type (USCS)	Total Unit Weight (pcf)	Field N (bpf)	Fines %	PI %	Average Mean Grain Size D50 (mm)	Total Stress (psf)	Effective Stress at Time of Drilling (psf)	Effective Stress for Liquefaction Analysis (psf)
2	3.0	5.0	5.0	CL	125	14	90	--	--	375	375	297
4	5.5	7.5	2.5	SC	119	62	21	15	--	685	685	451
5	7.5	9.0	1.5	SC	120	69	21	--	--	923	861	564
6	9.0	10.5	1.5	SM	124	35	50	10	--	1103	947	651
7	10.5	12.0	1.5	SM	124	60	40	--	--	1288	1039	742
8	12.0	13.5	1.5	SM	126	36	29	--	--	1474	1131	835
9	13.5	18.5	5.0	CL	125	23	80	--	--	1663	1226	930
10	20.0	23.0	4.5	SM	125	13	46	0	--	2475	1633	1337
11	25.0	28.0	5.0	ML	125	18	60	--	--	3101	1946	1650
12	30.0	31.0	3.0	CL	120	36	90	--	--	3716	2249	1953
13	35.0	40.0	9.0	SW-SM	125	26	8	--	--	4336	2557	2261
14	40.0	41.5	1.5	SM	125	14	20	--	--	4961	2870	2574

	Liquefaction Analysis						Strength Parameters		Liquefaction Factor of Safety: Factor of Safety (FS)					
Sample Number	N_{SPT} (bpf)	$(N_1)_{60}$ NCEER $(N_1)_{60}$ Boulanger (bpf)	$(N_1)_{60}$ Cetin (bpf)	$(N_1)_{60CS}$ NCEER (bpf)	$(N_1)_{60CS}$ Boulanger (bpf)	$(N_1)_{60CS}$ Cetin (bpf)	$(N_1)_{60}$ (bpf)	Effective Friction Angle (φ') (degrees)	NCEES (FS)	FS ≤ 1.2	Cetin (FS)	FS ≤ 1.2	Boulanger (FS)	FS ≤ 1.2
2	14	23	22	23	23	22	27	34	37.23	--	36.32	--	34.34	--
4	62	102	96	115	107	105	104	43	NL	--	NL	--	NL	--
5	69	112	105	126	117	115	109	43	NL	--	NL	--	15.11	--
6	35	52	48	52	52	48	54	43	32.10	--	30.07	--	30.00	--
7	60	90	80	113	95	93	90	43	NL	--	NL	--	14.46	--
8	36	52	49	64	57	56	53	43	NL	--	NL	--	14.33	--
9	23	32	32	32	32	32	33	36	14.14	--	12.89	--	13.41	--
10	13	17	17	26	23	21	17	32	2.07	--	1.36	--	1.74	--
11	18	22	22	22	22	22	22	33	6.10	--	5.23	--	6.08	--
12	36	41	42	41	41	42	43	37	10.32	--	8.66	--	10.56	--
13	26	29	28	30	30	30	29	35	3.09	--	2.41	--	3.20	--
14	14	15	14	20	19	17	15	31	1.43	--	0.92	x	1.42	--

	Residual Shear Strength (Sr)										
Sample Number	$(N_1)_{60CS\text{-}Sr}$ (bpf)	Idriss and Boulanger 2008 [1] Case 1 (psf)	Idriss and Boulanger 2008 [1] Case 2 (psf)	Idriss and Boulanger 2007 [2] (psf)	Seed & Harder 1990 w/ NCEER FS [3] Lower Bound (psf)	Seed & Harder 1990 w/ NCEER FS [3] Upper Bound (psf)	Seed & Harder 1990 w/ NCEER FS [3] Average (psf)	Seed & Harder 1990 w/ NCEER FS [3] Bound plus 1/3 (psf)	Idriss 1998 (psf)	Olson & Stark 2002 [4] (psf)	Sr. Kramer and Wang 2007 (psf)
2	23	200	103	2140	--	--	--	--	2017	NA	470
4	115	--	--	--	--	--	--	--	--	--	--
5	126	--	--	--	--	--	--	--	--	--	--
6	52	607	607	80915248	--	--	--	--	192963	NA	15072
7	113	--	--	--	--	--	--	--	--	--	--
8	64	--	--	--	--	--	--	--	--	--	--
9	32	675	675	14874	--	--	--	--	7935	NA	2039
10	26	835	224	3663	850	1390	1120	1029	3102	NA	513
11	22	1072	463	1736	--	--	--	--	1684	NA	950
12	41	1472	1472	327380	--	--	--	--	34762	NA	8172
13	30	1583	886	9218	--	--	--	--	5910	NA	2459
14	20	687	345	1144	460	940	700	619	1152	NA	553

[1] Idriss, I. M. and Boulanger, R. W., "Soil Liquefaction During Earthquakes," Earthquake Engineering Research Institute, pages 140-142 and 152-158, 2008.

[2] Idriss, I. M. and Boulanger, R. W., "Residual Shear Strength of Liquified Soils," Proceedings, 27th USSD Annual Meeting and Conference, Modernization and Optimization of Existing Dams and Reservoirs, Philadelphia, Pennsylvania, March 5-9, 2007, where, Sr = exp[((N1)60CS-Sr/5.1 - ((N1)60CS-Sr/16.5)2 + ((N1)60CS-Sr/21.4)3 + 0.8]/0.0479 (psf)

[3] Residual Strength", Proceedings of the H.B. Seed Memorial Symposium, BiTech Publishers Ltd., Vancouver, B.C., Canada, Vol. 2, pp. 351-376, 1990.

[4] Olson and Stark (2002), where, $S_u(LIQ) = \sigma'_{v0}[0.03+(0.0075(N_1)_{60})]$; valid for $(N_1)_{60} \leq 12$

Summary -- Liquefaction Analysis

Lookout Slough

BCI-17-12 (Near Station 42+00)

Project: **Lookout Slough**
BCI No.: **3195.X**
Date: **8/13/2018**
Location: **BCI-17-12 (Near Station 42+00)**
By: **DWC**

Boring Elevation:	6	feet
Ground Water Elevation:	4.3	feet (For Liquefaction Analysis)
Hammer Energy (ER):	74	%
Ground Water Depth:	5.5	feet (At Time of Drilling)
Ground Water Depth:	1.8	feet (For Liquefaction Analysis)
Distance to Fault (R) =	27.6	miles
Moment Magnitude, M_w =	6.7	
PGA =	0.17	g
Liquefaction Factor of Safety (FS):	1.2	

Soil Layer	
Granular	(yellow)
Cohesive	(green)

Input Data										Overburden Stress			Liquefaction Analysis							Strength Parameter
Sample Number	Sample Depth (feet)	Depth to Bottom of Layer (feet)	Layer Thickness (feet)	Soil Type (USCS)	Total Unit Weight (pcf)	Field N (bpf)	Fines %	PI %	Average Mean Grain Size D50 (mm)	Total Stress (psf)	Effective Stress at Time of Drilling (psf)	Effective Stress for Liquefaction Analysis (psf)	N_{SPT} (bpf)	$(N_1)_{60}$ NCEER $(N_1)_{60}$ Boulanger (bpf)	$(N_1)_{60}$ Cetin (bpf)	$(N_1)_{60CS}$ NCEER (bpf)	$(N_1)_{60CS}$ Boulanger (bpf)	$(N_1)_{60CS}$ Cetin (bpf)	$(N_1)_{60}$ (bpf)	Effective Friction Angle (φ') (degrees)
2	3.0	5.5	5.5	CL	126	10	80	19	--	379	379	301	10	17	16	17	17	16	19	32
4	6.0	8.0	2.5	CL	125	10	80	28	--	757	726	492	10	17	16	17	17	16	17	32
6	10.0	13.0	5.0	SP	125	14	4	--	--	1257	977	743	14	21	20	21	21	20	21	33
7	15.0	17.0	4.0	SM	125	24	23	--	--	1883	1290	1056	24	32	34	40	37	38	34	36
8	20.0	23.0	6.0	SP-SM	125	26	10	--	--	2508	1604	1370	26	35	34	37	36	36	34	36
9	25.0	28.0	5.0	SW-SC	132	46	8	--	--	3148	1931	1697	46	56	57	57	57	59	58	43
10	30.0	35.0	7.0	SW-SC	130	37	8	--	--	3804	2276	2042	37	42	43	43	42	44	44	37
11	35.0	38.0	3.0	CL	125	17	67	25	--	4454	2614	2380	17	19	18	19	19	18	19	32
12	40.0	41.5	3.5	CL	120	11	90	--	--	5069	2917	2683	11	12	11	12	12	11	12	30

	Liquefaction Factor of Safety — Factor of Safety (FS)						Residual Shear Strength (Sr)											
							$(N_1)_{60}$ CS-Sr	Idriss and Boulanger 2008 [1]		Idriss and Boulanger 2007 [7]	Seed & Harder 1990 w/ NCEER FS [5]				Idriss 1998	Olson & Stark 2002 [6]	Sr. Kramer and Wang 2007 (psf)
Sample Number	NCEES (FS)	FS ≤ 1.2	Cetin (FS)	FS ≤ 1.2	Boulanger (FS)	FS ≤ 1.2	(bpf)	Case 1 (psf)	Case 2 (psf)	(psf)	Lower Bound (psf)	Upper Bound (psf)	Average (psf)	Bound plus 1/3 (psf)	(psf)	(psf)	(psf)
2	NL	--	NL	--	NL	--	17	--	--	--	--	--	--	--	--	--	--
4	NL	--	NL	--	NL	--	17	--	--	--	--	--	--	--	--	--	--
6	1.67	--	1.44	--	1.65	--	21	482	143	1546	1090	1630	1360	1269	1520	NA	593
7	NL	--	NL	--	12.99	--	40	--	--	--	--	--	--	--	--	--	--
8	NL	--	NL	--	10.35	--	37	--	--	--	--	--	--	--	--	--	--
9	NL	--	NL	--	14.41	--	57	--	--	--	--	--	--	--	--	--	--
10	NL	--	NL	--	14.16	--	43	--	--	--	--	--	--	--	--	--	--
11	NL	--	NL	--	NL	--	19	--	--	--	--	--	--	--	--	--	--
12	2.53	--	1.98	--	2.57	--	12	882	376	321	560	1050	805	723	317	313	396

[1] Idriss, I. M. and Boulanger, R. W., "Soil Liquefaction During Earthquakes," Earthquake Engineering Research Institute, pages 140-142 and 152-158, 2008.

[2] Idriss, I. M. and Boulanger, R. W., "Residual Shear Strength of Liquified Soils," Proceedings, 27th USSD Annual Meeting and Conference, Modernization and Optimization of Existing Dams and Reservoirs, Philadelphia, Pennsylvania, March 5-9, 2007, where, Sr = exp[((N1)60CS-Sr/5.1 - ((N1)60CS-Sr/16.5)2 + ((N1)60CS-Sr/21.4)3 + 0.8]/0.0479 (psf)

[3] Strength", Proceedings of the H.B. Seed Memorial Symposium, BiTech Publishers Ltd., Vancouver, B.C., Canada, Vol. 2, pp. 351-376, 1990.

[4] Olson and Stark (2002), where, $S_u(LIQ) = \sigma'_{v0}[0.03+(0.0075(N_1)_{60})]$; valid for $(N_1)_{60} \le 12$

Summary -- Liquefaction Analysis

Lookout Slough

BCI-17-13 (Near Station 63+20)

Project: **Lookout Slough**
BCI No.: **3195.X**
Date: **8/13/2018**
Location: **BCI-17-13 (Near Station 63+20)**
By: **DWC**

Soil Layer	
Granular	
Cohesive	

Boring Elevation:	6	feet
Ground Water Elevation:	4.3	feet (For Liquefaction Analysis)
Hammer Energy (ER):	74	%
Ground Water Depth:	12.5	feet (At Time of Drilling)
Ground Water Depth:	1.8	feet (For Liquefaction Analysis)
Distance to Fault (R) =	27.6	miles
Moment Magnitude, M_w =	6.7	
PGA =	0.17	g
Liquefaction Factor of Safety (FS):	1.2	

Input Data										**Overburden Stress**			**Liquefaction Analysis**						**Strength Parameters**	
Sample Number	**Sample Depth**	**Depth to Bottom of Layer**	**Layer Thickness**	**Soil Type**	**Total Unit Weight**	**Field N**	**Fines**	**PI**	**Average Mean Grain Size D50**	**Total Stress**	**Effective Stress at Time of Drilling**	**Effective Stress for Liquefaction Analysis**	**N_{SPT}**	**$(N_1)_{60}$ NCEER $(N_1)_{60}$ Boulanger**	**$(N_1)_{60}$ Cetin**	**$(N_1)_{60CS}$ NCEER**	**$(N_1)_{60CS}$ Boulanger**	**$(N_1)_{60CS}$ Cetin**	**$(N_1)_{60}$**	**Effective Friction Angle (φ')**
	(feet)	**(feet)**	**(feet)**	**(USCS)**	**(pcf)**	**(bpf)**	**%**	**%**	**(mm)**	**(psf)**	**(psf)**	**(psf)**	**(bpf)**	**(bpf)**	**(bpf)**	**(bpf)**	**(bpf)**	**(bpf)**	**(bpf)**	**(degrees)**
2	3.0	5.0	5.0	CH	115	5	90	--	--	345	345	267	5	8	8	8	8	8	10	29
4	6.0	7.5	2.5	CL	120	15	90	--	--	695	695	430	15	25	23	25	25	23	25	34
6	9.0	11.0	3.5	CL	120	9	69	28	--	1055	1055	603	9	13	12	13	13	12	13	31
8	12.5	15.0	4.0	CL	125	11	90	--	--	1483	1483	812	11	14	13	14	14	13	15	31
9	15.0	20.0	5.0	CH	123	11	92	31	--	1795	1639	968	11	13	14	13	13	14	14	31
10	20.0	23.0	3.0	CL	125	21	90	--	--	2411	1943	1272	21	26	25	26	26	25	26	34
11	25.0	28.0	5.0	CL	125	18	90	--	--	3036	2256	1585	18	20	21	20	20	21	21	33
12	30.0	35.0	7.0	CL	125	16	90	--	--	3661	2569	1898	16	17	17	17	17	17	18	32
13	35.0	40.0	5.0	SC	115	5	40	--	--	4286	2882	2211	5	5	5	11	11	8	5	28
14	40.0	43.0	3.0	CL	120	6	75	14	--	4861	3145	2474	6	6	6	6	6	6	6	28
15	45.0	48.0	5.0	SP-SC	125	17	7	--	--	5471	3443	2772	17	16	16	17	17	17	17	32
16	50.0	51.5	3.5	SP-SC	125	27	7	--	--	6096	3756	3085	27	25	25	25	25	26	26	34

	Liquefaction Factor of Safety						**Residual Shear Strength (Sr)**										
	Factor of Safety (FS)						**$(N_1)_{60CS\text{-}Sr}$**	**Idriss and Boulanger 2008 [1]**		**Idriss and Boulanger 2007 [7]**	**Seed & Harder 1990 w/ NCEER FS [5]**				**Idriss 1998**	**Olson & Stark 2002 [6]**	**Sr. Kramer and Wang 2007 (psf)**
Sample Number	**NCEES (FS)**	**FS ≤ 1.2**	**Cetin (FS)**	**FS ≤ 1.2**	**Boulanger (FS)**	**FS ≤ 1.2**	**(bpf)**	**Case 1 (psf)**	**Case 2 (psf)**	**(psf)**	**Lower Bound (psf)**	**Upper Bound (psf)**	**Average (psf)**	**Bound plus 1/3 (psf)**	**(psf)**	**(psf)**	**(psf)**
2	14.45	--	14.13	--	13.33	--	8	41	30	193	290	740	515	439	187	25	89
4	21.68	--	20.81	--	20.11	--	25	290	181	2957	--	--	--	--	2627	NA	665
6	NL	--	NL	--	NL	--	13	--	--	--	--	--	--	--	--	--	--
8	7.57	--	7.04	--	7.15	--	14	488	131	450	750	1270	1010	923	453	NA	271
9	NL	--	NL	--	NL	--	13	--	--	--	--	--	--	--	--	--	--
10	9.05	--	8.23	--	8.81	--	26	858	600	3567	--	--	--	--	3039	NA	1242
11	6.24	--	5.64	--	6.22	--	20	1029	422	1314	--	--	--	--	1312	NA	785
12	4.65	--	4.23	--	4.76	--	17	1186	383	746	1190	1740	1465	1373	760	NA	595
13	0.85	x	0.56	x	0.87	x	11	166	162	311	20	360	190	133	307	154	180
14	NL	--	NL	--	NL	--	6	--	--	--	--	--	--	--	--	--	--
15	1.22	--	1.08	x	1.24	--	17	880	386	709	560	1050	805	723	722	NA	686
16	2.03	--	1.79	--	2.16	--	25	2081	791	3316	--	--	--	--	2874	NA	1851

[1] Idriss, I. M. and Boulanger, R. W., "Soil Liquefaction During Earthquakes," Earthquake Engineering Research Institute, pages 140-142 and 152-158, 2008.

[2]

Idriss, I. M. and Boulanger, R. W., "Residual Shear Strength of Liquified Soils," Proceedings, 27th USSD Annual Meeting and Conference, Modernization and Optimization of Existing Dams and Reservoirs, Philadelphia, Pennsylvania, March 5-9, 2007, where, Sr = exp[((N1)60CS-Sr/5.1 - ((N1)60CS-Sr/16.5)2 + ((N1)60CS-Sr/21.4)3 + 0.8]/0.0479 (psf)

[3] Seed, R.B. and Harder, L.F., "SPT-based Analysis of Cyclic Pore Pressure Generation and Undrained Residual Strength", Proceedings of the H.B. Seed Memorial Symposium, BiTech Publishers Ltd., Vancouver, B.C., Canada, Vol. 2, pp. 351-

[4] Olson and Stark (2002), where, $S_u(LIQ) = \sigma'_{v0}[0.03+(0.0075(N_1)_{60})]$; valid for $(N_1)_{60} \leq 12$

Summary -- Liquefaction Analysis

Lookout Slough

BCI-18-28 (Near Station 78+00)

SEGMENT B

Project: Lookout Slough
BCI No.: 3195.X
Date: 8/13/2018
Location: BCI-18-28 (Near Station 78+00)
By: DWC

Boring Elevation:	6	feet
Ground Water Elevation:	4.3	feet (For Liquefaction Analysis)
Hammer Energy (ER):	74	%
Ground Water Depth:	12.0	feet (At Time of Drilling)
Ground Water Depth:	1.8	feet (For Liquefaction Analysis)
Distance to Fault (R) =	27.6	miles
Moment Magnitude, M_w =	6.7	
PGA =	0.17	g
Liquefaction Factor of Safety (FS):	1.2	

Soil Layer	
Granular	
Cohesive	

Input Data											Overburden Stress			Liquefaction Analysis						Strength Parameters	
Sample Number	Sample Depth (feet)	Depth to Bottom of Layer (feet)	Layer Thickness (feet)	Soil Type (USCS)	Total Unit Weight (pcf)	Field N (bpf)	Fines %	PI %	Average Mean Grain Size D50 (mm)	Total Stress (psf)	Effective Stress at Time of Drilling (psf)	Effective Stress for Liquefaction Analysis (psf)	N_{SPT} (bpf)	$(N_1)_{60}$ NCEER $(N_1)_{60}$ Boulanger (bpf)	$(N_1)_{60}$ Cetin (bpf)	$(N_1)_{60CS}$ NCEER (bpf)	$(N_1)_{60CS}$ Boulanger (bpf)	$(N_1)_{60CS}$ Cetin (bpf)	$(N_1)_{60}$ (bpf)	Effective Friction Angle (φ') (degrees)
1	1.0	4.0	4.0	CL	120	7	90	--	--	120	120	120	7	12	11	12	12	11	17	32
2	5.0	6.5	2.5	CL	125	24	90	--	--	605	605	402	16	26	24	26	26	24	27	34
3	6.5	11.0	4.5	CL	125	16	85	--	--	793	793	496	16	25	25	25	25	25	26	34
7	14.0	15.5	4.5	CL	125	24	80	--	--	1730	1605	966	16	19	19	19	19	19	21	32
8	15.5	17.0	1.5	CL	125	20	90	--	--	1918	1699	1060	20	23	25	23	23	25	26	34
9	17.0	18.5	1.5	CL	125	31	90	--	--	2105	1793	1153	20	23	24	23	23	24	26	34
10	18.5	23.0	4.5	CL	125	16	90	--	--	2293	1887	1247	16	20	19	20	20	19	20	32
11	25.0	30.0	7.0	CL	125	28	90	--	--	3105	2294	1654	18	20	21	20	20	21	21	33
12	30.0	35.0	5.0	CL	125	16	80	--	--	3730	2607	1967	16	17	17	17	17	17	18	32
13	35.0	39.0	4.0	ML	120	11	60	--	--	4355	2920	2280	7	8	7	8	8	7	8	29
14	40.0	45.0	6.0	SM	125	12	40	--	--	4960	3213	2573	12	12	12	19	18	15	12	31
15	45.0	48.0	3.0	SP	125	25	5	--	--	5585	3526	2886	16	16	15	16	16	16	16	32
16	50.0	55.0	7.0	SP	130	35	5	--	--	6220	3849	3209	35	32	32	32	32	32	34	36
17	55.0	56.5	1.5	CL	125	46	90	--	--	6870	4187	3547	30	26	26	26	26	26	28	34

	Liquefaction Factor of Safety: Factor of Safety (FS)						Residual Shear Strength (Sr)										
Sample Number	NCEES (FS)	FS ≤ 1.2	Cetin (FS)	FS ≤ 1.2	Boulanger (FS)	FS ≤ 1.2	$(N_1)_{60}$ CS-Sr (bpf)	Idriss and Boulanger 2008 [1] Case 1 (psf)	Idriss and Boulanger 2008 [1] Case 2 (psf)	Idriss and Boulanger 2007 [7] (psf)	Seed & Harder 1990 w/ NCEER FS [5] Lower Bound (psf)	Seed & Harder 1990 w/ NCEER FS [5] Upper Bound (psf)	Seed & Harder 1990 w/ NCEER FS [5] Average (psf)	Seed & Harder 1990 w/ NCEER FS [5] Bound plus 1/3 (psf)	Idriss 1998 (psf)	Olson & Stark 2002 [6] (psf)	Sr: Kramer and Wang 2007 (psf)
1	unsaturated	--	unsaturated	--	unsaturated	--	12	--	--	--	--	--	--	--	--	--	--
2	25.84	--	24.86	--	23.92	--	26	271	192	3626	--	--	--	--	3078	NA	718
3	20.30	--	19.34	--	18.85	--	25	335	226	3361	--	--	--	--	2903	NA	760
7	9.23	--	8.40	--	8.77	--	19	603	223	993	1310	1870	1590	1496	1007	NA	509
8	10.72	--	9.67	--	10.23	--	23	715	380	2259	--	--	--	--	2110	NA	883
9	9.87	--	8.83	--	9.48	--	23	778	394	2074	--	--	--	--	1963	NA	877
10	7.22	--	6.41	--	6.98	--	20	779	316	1190	--	--	--	--	1196	NA	651
11	6.16	--	5.30	--	6.14	--	20	1074	443	1327	--	--	--	--	1323	NA	807
12	4.57	--	3.85	--	4.68	--	17	1229	393	731	1090	1630	1360	1269	745	NA	598
13	1.83	--	1.47	--	1.86	--	8	269	231	172	150	590	370	296	166	197	233
14	1.42	--	0.85	x	1.29	--	19	451	307	1105	360	810	585	509	1115	NA	407
15	1.15	x	0.88	x	1.19	x	16	712	379	590	460	940	700	619	599	NA	635
16	NL	--	NL	--	4.67	--	32	--	--	--	--	--	--	--	--	--	--
17	5.93	--	4.22	--	5.87	--	26	2393	1798	3996	--	--	--	--	3312	NA	2287

[1] Idriss, I. M. and Boulanger, R. W., "Soil Liquefaction During Earthquakes," Earthquake Engineering Research Institute, pages 140-142 and 152-158, 2008.

[2] Idriss, I. M. and Boulanger, R. W., "Residual Shear Strength of Liquified Soils," Proceedings, 27th USSD Annual Meeting and Conference, Modernization and Optimization of Existing Dams and Reservoirs, Philadelphia, Pennsylvania, March 5-9, 2007, where, Sr = exp[((N1)60CS-Sr/5.1 - ((N1)60CS-Sr/16.5)2 + ((N1)60CS-Sr/21.4)3 + 0.8]/0.0479 (psf)

[3] Undrained Residual Strength", Proceedings of the H.B. Seed Memorial Symposium, BiTech Publishers Ltd., Vancouver, B.C., Canada, Vol. 2, pp. 351-376, 1990.

[4] Olson and Stark (2002), where, $S_u(LIQ) = \sigma'_{v0}[0.03+(0.0075(N_1)_{60})]$; valid for $(N_1)_{60} \leq 12$

Appendix C

Lookout Slough setback Levee Wave Runup and Wind Setup Analysis TM

This Page Intentionally Left Blank

TECHNICAL MEMORANDUM

TO: Mr. David Urban, P.E., Ecosystem Investment Partners

FROM: Mr. Mitch Berggren, EIT, Wood Rodgers, Inc.
Mr. Cody L. Milligan, P.E., CFM, Wood Rodgers, Inc.

DATE: December 5, 2019

SUBJECT: Lookout Slough Tidal Habitat Restoration and Flood Improvement Project: Wave Runup and Wind Setup Analysis

---

INTRODUCTION

Ecosystem Investment Partners (EIP) and the California Department of Water Resources (DWR) are in the process of creating more than 3,000 acres of habitat for listed and vulnerable native species as part of the Lookout Slough Tidal Habitat Restoration and Flood Improvement Project (Project). The Project is located in Solano and Yolo Counties, within the north Sacramento-San Joaquin Delta. When completed, the Project will provide upland, tidal, subtidal, and floodplain habitat for Delta Smelt, Longfin Smelt, Steelhead Salmon, Splittail, Giant Garter Snake, and other species. In addition to the habitat created, the Project will create between 40,000 and 50,000 acre-feet of seasonal floodplain storage. This habitat and flood storage created through implementation of the Project will be accomplished by degrading portions of the west levee of the Yolo Bypass along Shag Slough located at the north and south ends of the Project by breaching the same levee in several locations and by constructing a new levee, which will be called the Duck Slough Setback Levee (DSSL).

The Project will result in a new hydraulic connection between the restoration area and the Yolo Bypass that could result in significant wind-generated waves. Typically, due to the combination of long fetch lengths within the Yolo Bypass and strong sustained winds, waves in the Yolo Bypass can be generated that exceed four feet in height (DWR 2016). Therefore, this Technical Memorandum (TM) has been prepared to estimate the potential wind setup and wave runup impacts on the following Project levees:

1. DSSL
2. Cache/Hass Training Levee
3. Cross Levee
4. Yolo Bypass East Levee (YBEL)

Wave runup and wind setup were analyzed for both the without-Project and with-Project conditions in order to identify the increase in potential total runup resulting from the Project. A graphical overview of the Project location and levees noted above are shown on **Figure 1** (attached).

METHODS

The total runup for each fetch site selected was estimated in accordance with the procedures outlined in the US Army Corps of Engineers' (USACE's) *Coastal Engineering Manual (EM 1110-2-1100)* (USACE 2008) and *Shore Protection Manual* (SPM) (USACE 1984). Furthermore, the methods used in this TM are consistent with the procedures used in prior wave runup and wind setup studies conducted in the region, such as the *Wave Runup and Erosion Analysis for West Sacramento Levee System General Reevaluation Report* (GRR) (Northwest Hydraulics Consultants 2012) and the *Lower Elkhorn Basin Levee Setback Project* (LEBLS) (DWR 2017).

Below is the procedure used to estimate total runup at each location:

1. Select fetch sites so that the transect delineated for each site aligns with the proposed breach locations in the Shag Slough Levee and maximizes fetch properties.
2. Calculate length, average water depth, and angle of incidence at each fetch site.
3. Select location of existing wind gage to use in collecting historical wind speed data.
4. Compare maximum wind speeds during historic flood events (1986, 1997, 2006) to the maximum wind speed for the period of record at the selected wind gage.
5. Determine the maximum 1-hour wind speed based on the selected wind speed in the direction of the fetch site.
6. Estimate wind stress (U_A).
7. Determine if the site is duration limited, t_{lim} < 1hr; if so, estimate the effective fetch (F_e) length.
8. Determine significant wave height (H_s) and peak wave period (T_p) using F_e or F.
9. Determine wave runup ($R_{u2\%}$) reduction factors.
10. Estimate wave runup ($R_{u2\%}$) as a function of H_s and T_p and reduction factors.
11. Estimate wind setup, S_{wind}.
12. Sum $R_{u2\%}$ and S_{wind} to estimate total runup.

ANALYSIS DATA

Hydraulic Data

Hydraulic modeling results from the TUFLOW model used for the hydrologic and hydraulic design of the Project (the 1997 flood event scaled at 95 percent) were the basis for this analysis. This is considered representative of a 1-percent Annual Chance Exceedance (ACE) or 100-year event.

Wind Data and Wind Data Adjustments

Wind data from two different stations close to the Project site were reviewed. The first station with data that was reviewed was located at the Rio Vista Municipal Airport, approximately eight miles to the south of the Project. Available data from this station was available dating back to 1999. However, this station only recorded data for the hours between 7:00 a.m. and 7:00 p.m. The available data from this station was reviewed and it was noted that, because the data had not gone through a quality control check, it therefore included many unreasonable wind speeds (speeds exceeding Category 5 hurricane wind speeds).

The second station with data that was reviewed was located approximately 16 miles to the northeast of the Project at the Sacramento Executive Airport. The data available from this station was available dating back to 1931. Wind roses displaying the frequency of wind by direction for both the Sacramento Executive Airport and the Rio Vista Airport were compared and found to demonstrate similar patterns.

Due to the longer, continuous-period record of data available at the Sacramento Executive Airport, the similarities in wind patterns exhibited by the data when compared, and the dubious nature of values from the Rio Vista Municipal Airport, data from the Sacramento Executive Airport was used for this analysis. The location of each airport in proximity to the Project as well as wind roses displaying the wind patterns for each airport are presented in **Figure 2**.

To determine the wind speed to use in this analysis, wind data for this analysis was separated into four cardinal directions (N, S, E, and W) and four ordinal directions (NE, SE, SW, and NW) depending on the readings of the recordings. All missing data for either wind speed or direction was removed from the analysis, as was any data that was reported as negative or that was unrealistic (higher than Category 5 hurricane wind speeds). The wind speeds were assumed to be reported at the standard elevation of ten meters above local ground, and no adjustments for observation height were made. The data from the Sacramento Executive Airport represents the two-minute average prior to the observation time. Maximum two-minute wind speeds were converted to the one-hour wind speeds following procedures in the *Coastal Engineering Manual* (USACE 2008). The duration adjustment factor was found to be 1.169.

Once the available wind data had been converted to maximum hourly wind speeds, a comparison was made between maximum wind speed for the period of record for the Sacramento Executive Airport and the wind speeds observed during historic storm events in 1986, 1997, and 2006. Additionally, the maximum wind speed was compared to the peak wind speed observed during "winter flood months" (defined as October through April). These comparisons were made to ensure that the wind speeds used in this analysis did not under-represent the peak wind speeds that could occur during a flood event. Peak hourly wind speeds by direction are summarized below in **Table 1**.

Table 1 – Maximum Wind Speed During Historical Storm Events						
Wind Direction	**Wind Direction (Compass Degrees)**	**1986 Storm Maximum Hourly Wind Speed (mph)**	**1997 Storm Maximum Hourly Wind Speed (mph)**	**2006 Storm Maximum Hourly Wind Speed (mph)**	**Winter Flood Months Maximum Hourly Wind Speed (mph)**	**Maximum Hourly Wind Speed (mph)**
North (N)	$337.5 \leq \theta \leq 360$ and $0 < \theta < 22.5$	15.7	18.7	17.7	34.4	49.2
Northeast (NE)	$22.5 \leq \theta < 67.5$	5.9	8.9	6.9	24.6	49.2
East (E)	$67.5 \leq \theta < 112.5$	13.8	23.0	7.9	49.2	49.2
Southeast (SE)	$112.5 \leq \theta < 157.5$	24.6	40.2	29.5	53.1	53.1
South (S)	$157.5 \leq \theta < 202.5$	27.5	20.7	21.6	60.1	60.1
Southwest (SW)	$202.5 \leq \theta < 247.5$	16.7	14.8	18.7	50.2	50.2
West (W)	$247.5 \leq \theta < 292.5$	14.8	14.8	16.7	46.3	49.2
Northwest (NW)	$292.5 \leq \theta < 337.5$	18.7	42.1	17.7	54.1	64.9

Based on the values in **Table 1**, the maximum wind speed for the period of record is greater than any wind observed during the 1986, 1997, and 2006 storm events, and is either equal to or greater than the wind observed during the winter flood months. While the Urban Levee Design Criteria (ULDC) specifies using a wind speed with a 72.6-year return period for design calculations, this analysis adopted a conservative approach to use the maximum wind speed reported over the 88-year period of record as the basis for wind setup and wave runup estimations. The approach of using the maximum value for the period of record is consistent with the wave runup and wind setup analyses conducted by the GRR as well as LEBLS.

ANALYSIS

Fetch Site Selection and Properties

Fetch is the distance over which wind travels without obstruction and with a fairly uniform speed and direction. For this analysis, fetch sites along the DSSL, Cache/Hass Slough Training Levee, Cross Levee, and YBEL were selected to maximize the fetch length. Fetch parameters with an effect on maximum total runup at the impacted levee include the fetch length, the average water depth along the fetch, the maximum wind speed in the direction of the fetch, and the angle of incidence to the impacted levee.

Guidelines for calculating fetch length from the SPM (1984) were used at each selected fetch site. At each site, nine radials at 3-degree intervals (four on each side of the central radial) were drawn, and the average of the nine radials was taken and used as the final fetch length at each site.

Fetch depth is the average depth of water along a transect. For this analysis, depth was based on hydraulic modeling results from the model described under the Hydraulic Analysis section above, and is considered to be representative of a 1-percent ACE event.

Upon completion of the Project, the Project site will become extensively covered by hardstem bulrush. Hardstem bulrush, commonly referred to as tules, can grow up to 10 feet in height and form very dense stands (Tilley, 2012). Field observations made by team members of restoration projects in the Gulf Coast have noted that these dense tule stands will dampen the effects of wind blowing across them which, in turn, reduces the effective depth of water over which the wind travels. Due to the fact that the Project is designed so that tules will establish themselves across a vast majority of the Project site, it was considered reasonable to lower Project site depth values. While tules can grow up to 10 feet, to be conservative, an average tule height of 6 feet was assumed across the Project site, and with-Project depth values were reduced by this value within the footprint of the Project.

The fetch alignments used in this analysis for the without-Project conditions are shown in **Figure 3**, and for the with-Project conditions are shown in **Figure 4**. The angles of incidence and direction were determined from the orientation of the fetch alignments, and **Table 2** below summarizes the fetch properties for each fetch site.

Table 2 – Summary of Fetch Lengths and Average Fetch Depth

Levee	Fetch Site	Fetch Length (mi)	Average Fetch Water Depth (ft)	Fetch Direction	Angle of Incidence (deg from normal)
YBEL	EX01	2.6	13.8	SW	33.7
	EX02	2.0	16.1	W	13.7
	EX03	2.1	17.6	NW	27.5
	PR01	4.8	8.8	SW	33.7
	PR02	3.9	8.3	W	13.7
	PR03	4.2	8.8	NW	27.5
DSSL	PR04	5.8	9.1	SE	26.1
	PR05	6.1	8.9	S	16.1

Table 2 – Summary of Fetch Lengths and Average Fetch Depth

Levee	Fetch Site	Fetch Length (mi)	Average Fetch Water Depth (ft)	Fetch Direction	Angle of Incidence (deg from normal)
Cache/Hass Slough Training Levee	PR06	3.9	10.0	E	7.0
	PR07	13.5	8.9	NE	30.1
	PR08	3.9	9.7	NE	3.1
	PR09	5.0	8.7	NE	14.0
Cross Levee	PR10	3.6	9.3	N	5.0

Wind Stress

The maximum hourly wind speeds selected from Table 1 were used to estimate the wind stress (U_A) for each fetch location using the following equation from the SPM (1984):

$$U_A = 0.589U^{1.23} \tag{1}$$

Where,

U is the maximum hourly wind speed in mph, U_A is the wind stress in mph.

Wave Forecasting

Wave runup is a product of the wave forecasting parameters, significant wave height (H_s), and peak wave period (T_p) using equations from Hurdle and Stive (1989). Wave forecasts can be either fetch-limited or duration-limited. If the fetch length is short, it is considered to be fetch-limited. Waves fail to reach a steady state condition where full waves are developed over the total length of the fetch and impart maximum energy. When fetch lengths are longer, maximum wind speed duration is shorter than the time required to develop full waves, and the waves are duration-limited. The first step in wave forecasting is to calculate the limiting duration (t_{lim}) for the fetch. For this study, waves were considered duration limited when t_{lim} was greater than one hour. This assumption is consistent with wave runup and wind setup analyses conducted by the GRR as well as LEBLS. Equation 2, shown below, was used to estimate t_{lim}:

$$\frac{gt_{\text{lim}}}{U_A} = 65.9\left(\frac{gF}{U_A^2}\right)^{\frac{2}{3}} \tag{2}$$

Where,

t_{lim} is the limiting duration in seconds, g is the gravitational constant 32.2 ft^2/s, U_A is the wind stress in mph, F is the fetch length in feet.

In the case where $t_{lim} > 1$hr, Equation 2 was solved for F using $t_{lim} = 1$hr to determine an effective fetch length, F_e. The actual fetch length F, if fetch limited, or effective fetch length, if duration limited, was then used in equations 3 and 4 (Hurdle and Stive (1989)) to determine the peak period and significant wave height:

$$\frac{gT_p}{U_A} = 8.3\tanh\left[0.76\left(\frac{gd}{U_A^2}\right)^{0.375}\right]\tanh^{\frac{1}{3}}\left[\frac{4.1\times10^{-5}\frac{gF}{U_A^2}}{\tanh^3\left(0.6\left(\frac{gd}{U_A^2}\right)^{0.375}\right)}\right] \quad (3)$$

Where,

T_p is the peak wave period in sec, g is the gravitational constant 32.2 ft^2/s, U_A is the wind stress in mph, F is the fetch length in ft, d is the average depth in ft.

$$\frac{gH_s}{U_A^2} = 0.25\tanh\left[0.6\left(\frac{gd}{U_A^2}\right)^{0.75}\right]\tanh^{\frac{1}{2}}\left[\frac{4.3\times10^{-5}\frac{gF}{U_A^2}}{\tanh^2\left(0.6\left(\frac{gd}{U_A^2}\right)^{0.75}\right)}\right] \quad (4)$$

Where,

H_s is the significant wave height in ft, g is the gravitational constant 32.2 ft^2/s, U_A is the wind stress in mph, F is the fetch length in ft, d is the average depth in ft.

Wave Runup Estimation

Wave runup on a sloped structure is considered to be the maximum vertical elevation above the still water level to which the water level can rise under the influence of waves. Wave runup is dependent upon the wave characteristics estimated in the previous section, as well as upon the type of wave breaking through a parameter called the surf similarity factor, ξ_{op}. The surf similarity factor, ξ_{op}, is used to relate peak wave period and significant wave height to wave runup based on the foreshore slope. Following guidelines presented in the ULDC for bypass levees, levee slopes were assumed to be 4H:1V for the YBEL. The Project design proposes to grade the DSSL and Cache/Hass Slough Training Levee to 4H:1V slopes, while the Cross Levee will retain its existing 3:1 slope. Equation 5 below was used to estimate ξ_{op}:

$$\xi_{op} = \frac{\tan(\alpha)}{\sqrt{\frac{2\pi H_s}{gT_p^2}}} \quad (5)$$

Where,

ξ_{op} is the surf similarity factor in ft, H_s is the significant wave height in ft, g is the gravitational constant 32.2 ft^2/s, and $\tan(\alpha)$ is the inverse of the levee side slope.

The de Waal and van der Meer formula (USACE, 2008) was used for two-percent wave runup ($R_{u2\%}$) estimation. The two-percent wave runup is the wave runup level exceeded by only two percent of the runup waves:

$$\frac{R_{u2\%}}{H_S} = \begin{Bmatrix} 1.6\xi_{op}\left(\gamma_r\gamma_b\gamma_h\gamma_\beta\gamma_v\right) & \text{for } 0.5 < \xi_{op} < 2 \\ 3.2\xi_{op}\left(\gamma_r\gamma_b\gamma_h\gamma_\beta\gamma_v\right) & \text{for } 2 < \xi_{op} \leq 4 \end{Bmatrix} \quad (6)$$

Wave runup is influenced by a variety of factors: presence of a berm (γ_b), shallow water conditions (γ_h), angle of incidence of the waves (γ_β), surface roughness (γ_r) and vegetation (γ_v).

For this analysis, a value of 1.0 was used for the berm reduction factor (γ_b) and the shallow water reduction factor (γ_h) since there are no berms intersecting the transects delineated for this analysis and the shallow water reduction is used for much more gradual foreshore slopes.

The angle of incidence reduction factor (γ_β) was estimated using the following equation for short crested-waves (USACE, 2008):

$$\gamma_\beta = 1 - 0.0022 * |\beta| \quad (7)$$

Where,

β is the angle of incidence to the levee measured in degrees from normal.

The reduction factors for incidence angles varied from 0.91 to 0.97. For reference, a parallel fetch would indicate a reduction factor of 0.8.

The various levees surrounding the Project will have different materials on their respective waterside slopes. The DSSL will have native grasses planted on the waterside slope, while the existing YBEL and Cross Levee were observed to be covered in grass, which will not change as a result of the Project. The Cache/Hass Slough Training Levee will be armored to protect against wave action and overtopping. Values of 0.6 and 0.9 were used for the surface roughness reduction factor (γ_r) for riprap/turf reinforcing mat (or other similar measures) and grass-covered slopes, respectively. These values are within the recommended range outlined in the *Coastal Engineering Manual* (USACE, 2008) and are consistent with wave runup and wind setup analyses conducted by the GRR as well as LEBLS.

Finally, vegetation such as trees or shrubs on or near a levee can also affect wave runup. The DSSL and Cross Levee will not have any major vegetation besides native grasses on the waterside immediately after construction; thus, Transects PR04, PR05, and PR10 were assigned a value of 0.9. A review of aerial photography taken over the past 10 years shows that the existing YBEL has multiple columns of dense trees and shrubs growing along the toe drains that border the levee.

As part of the Project, the Cache/Hass Slough Training Levee will have riparian trees planted along it. A value of 0.6 for vegetation reduction was assigned for these fetch sites, which is consistent with wave runup and wind setup analyses conducted by the GRR as well as LEBLS. The estimated wave runup parameters and results are summarized below in **Table 3** and **Table 4** for without-Project and with-Project conditions.

Table 3 – Without-Project Conditions Wave Runup Results

Levee	Fetch Site	Wind Stress, UA (mph)	Effective Fetch Length, F (mi)	Average Depth, d (ft)	Wave Height, H_s (ft)	Peak Wave Period, T_p (sec)	Total Runup Reduction	Wave Runup, $R_{u2\%}$ (ft)
YBEL	EX01	72.7	2.63	13.84	3.43	4.02	0.50	3.37
	EX02	71.0	2.03	16.11	3.05	3.67	0.52	3.04
	EX03	99.9	2.08	17.57	4.29	4.16	0.51	3.96

Table 4 – With-Project Condition Wave Runup Results

Levee	Fetch Site	Wind Stress, UA (mph)	Effective Fetch Length, F (mi)	Average Depth, d (ft)	Wave Height, H_s (ft)	Peak Wave Period, T_p (sec)	Total Runup Reduction	Wave Runup, $R_{u2\%}$ (ft)
YBEL	PR01	72.7	3.70	8.80	3.21	4.35	0.50	3.52
	PR02	71.0	3.66	8.32	3.05	4.28	0.52	3.54
	PR03	99.9	4.23	8.84	3.89	4.96	0.51	4.49
DSSL	PR04	78.0	3.83	9.12	3.43	4.50	0.76	5.76
	PR05	90.7	4.13	8.90	3.70	4.79	0.78	6.53
Cache/Hass Slough Training Levee	PR06	71.0	3.66	9.97	3.37	4.34	0.35	2.56
	PR07	71.0	3.66	8.88	3.17	4.30	0.34	2.33
	PR08	71.0	3.66	9.73	3.33	4.33	0.36	2.56
	PR09	71.0	3.66	8.74	3.14	4.30	0.35	2.41
Cross Levee	PR10	71.0	3.63	9.33	3.25	4.31	0.80	7.52

Wind Setup Estimation

Wind setup is the vertical rise of the water level above still water level on the leeward side of a body of water and is caused by shear stresses resulting from the wind blowing on the surface of the large bodies of water. Wind setup is estimated using the Zuider Zee equation (USACE, 1997)

$$S_{\text{wind}} = \frac{U^2 F}{1400d} \tag{8}$$

Where,

U is the maximum hourly wind speed in mph, F is the fetch length in miles, d is the average water depth along the fetch in feet.

The analysis determined that PR03 and PR10 were fetch limited and the remaining fetch sites were duration limited. For duration limited sites, the effective fetch length was used for wind setup estimations. This approach was also used in the *Sutter Basin Wave Runup Analysis* (Sutter Study) (USACE, 2011) as well as LEBLS. According to a design criteria memorandum (DCM-2) developed by USACE, the South Florida Water Management District (SFWMD), and the Florida Department of Environmental Protection, the Zuider Zee equation may be inaccurate for shallower bodies of water. DCM-2 noted that the Zuider Zee equation is commonly used when determining wind setup at reservoirs and, thus, can overestimate wind setup when applied to water bodies with shallower depths. DCM-2 recommends using the average of the Zuider Zee equation and the Sibul equation (Brater and King, 1976) for depths under 16 feet:

$$\frac{S}{d} = 2.44 \times 10^{-5} \left(\frac{F}{d}\right)^{1.66} \left(\frac{U^2}{Fg}\right)^{2.02\left(\frac{5}{d}\right)^{-0.0768}} \tag{9}$$

For fetch sites with an average depth of less than 16 feet, the average of the two equations was taken. This approach is consistent with the approach used in the Sutter Study and LEBLS. The wind setup parameters estimated and the results are summarized below in **Table 5** and **Table 6**.

Table 5 – Without-Project Conditions Wind Setup Results

Levee	Fetch Site	Maximum Hourly Wind Speed (mph)	Effective Fetch Length, F (mi)	Average Depth, d (ft)	Wind Setup, Zuider (ft)	Wind Setup, Sibul (ft)	Wind Setup (ft)
YBEL	EX01	50.2	2.63	13.84	0.34	0.07	0.21
	EX02	49.2	2.03	16.11	0.22	0.04	0.22
	EX03	64.9	2.08	17.57	0.36	0.08	0.36

Table 6 – With-Project Conditions Wind Setup Results

Levee	Fetch Site	Maximum Hourly Wind Speed (mph)	Effective Fetch Length, F (mi)	Average Depth, d (ft)	Wind Setup, Zuider (ft)	Wind Setup, Sibul (ft)	Wind Setup (ft)
YBEL	PR01	50.2	3.70	8.80	0.76	0.16	0.46
	PR02	49.2	3.66	8.32	0.76	0.16	0.46
	PR03	64.9	4.23	8.84	1.44	0.32	0.88
DSSL	PR04	53.1	3.83	9.12	0.85	0.18	0.51
	PR05	60.1	4.13	8.90	1.20	0.27	0.73
Cache/Hass Slough Training Levee	PR06	49.2	3.66	9.97	0.63	0.13	0.38
	PR07	49.2	3.66	8.88	0.71	0.15	0.43
	PR08	49.2	3.66	9.73	0.65	0.14	0.39
	PR09	49.2	3.66	8.74	0.72	0.15	0.44
Cross Levee	PR10	49.2	3.63	9.33	0.67	0.14	0.41

RESULTS

Total Runup Results

The wind setup and wave runup values estimated for this analysis, as well as the total runup for each fetch site, are summarized below in **Table 7** and **Table 8**.

Table 7 – Without-Project Conditions Total Runup

Levee	Fetch Site	Wind Stress, UA (mph)	Fetch Length, F (mi)	Average Depth, d (ft)	Wave Height, H_s (ft)	Peak Wave Period, T_p (sec)	Wave Runup, $R_{u2\%}$ (ft)	Wind Setup (ft)	Total Runup (ft)
YBEL	EX01	72.7	2.63	13.84	3.43	4.02	3.37	0.21	3.6
	EX02	71.0	2.03	16.11	3.05	3.67	3.04	0.22	3.3
	EX03	99.9	2.08	17.57	4.29	4.16	3.96	0.36	4.3

Table 8 – With-Project Conditions Total Runup

Levee	Fetch Site	Wind Stress, UA (mph)	Fetch Length, F (mi)	Average Depth, d (ft)	Wave Height, H_s (ft)	Peak Wave Period, T_p (sec)	Wave Runup, $R_{u2\%}$ (ft)	Wind Setup (ft)	Total Runup (ft)
YBEL	PR01	72.7	3.70	8.80	3.21	4.35	3.52	0.46	4.0
	PR02	71.0	3.66	8.32	3.05	4.28	3.54	0.46	4.0
	PR03	99.9	4.23	8.84	3.89	4.96	4.49	0.88	5.4
DSSL	PR04	78.0	3.83	9.12	3.43	4.50	5.76	0.51	6.3
	PR05	90.7	4.13	8.90	3.70	4.79	6.53	0.73	7.3
Cache/ Hass Slough Training Levee	PR06	71.0	3.66	9.97	3.37	4.34	2.56	0.38	2.9
	PR07	71.0	3.66	8.88	3.17	4.30	2.33	0.43	2.8
	PR08	71.0	3.66	9.73	3.33	4.33	2.56	0.39	3.0
	PR09	71.0	3.66	8.74	3.14	4.30	2.41	0.44	2.8
Cross Levee	PR10	71.0	3.63	9.33	3.25	4.31	7.52	0.41	7.9

Yolo Bypass East Levee

The Operations and Maintenance (O&M) Manual for the YBEL (USACE 1966) states that the YBEL provides six feet of freeboard. However, in a 2014 evaluation of the YBEL titled *Geotechnical Evaluation Report Volume 1, Existing Conditions: South West Sacramento Deep Water Ship Channel Study Area* (URS, 2014), it was concluded that the YBEL did not meet freeboard requirements and has the potential to be overtopped from wind setup and wave runup in the without-Project conditions. **Table 9** and **Table 10** below show without-Project and with-Project freeboard calculations for the YBEL.

Table 9 – Without-Project Conditions YBEL Freeboard

Levee	Fetch Site	Levee Elevation (ft)	WSEL (ft)	Levee Freeboard (ft)	Total Runup (ft)	Freeboard – Total Runup (ft)
YBEL	EX01	27.8	21.1	7.0	3.6	3.4
	EX02	27.2	19.8	7.9	3.3	4.6
	EX03	19.0	18.8	0.2	4.3	-4.1

Table 10 – With-Project Conditions YBEL Freeboard						
Levee	**Fetch Site**	**Levee Elevation (ft)**	**WSEL (ft)**	**Levee Freeboard (ft)**	**Total Runup (ft)**	**Freeboard – Total Runup (ft)**
YBEL	PR01	27.8	20.8	7.0	4.0	3.0
	PR02	27.2	19.6	7.9	4.0	3.9
	PR03	19.0	18.8	0.6	5.4	-4.8

A comparison of the maximum total runup between without-Project conditions and with-Project conditions is summarized below in **Table 11**.

Table 11 – Maximum Total Runup Comparison				
Levee	**Fetch Site**	**Without Project Conditions Maximum Total Runup (ft)**	**With Project Conditions Maximum Total Runup (ft)**	**Difference (ft)**
YBEL	EX01 / PR01	3.6	4.0	0.4
	EX02 / PR02	3.3	4.0	0.7
	EX03 / PR03	4.3	5.4	1.1

Duck Slough Setback Levee

The DSSL will be designed with a minimum of six feet of freeboard above the design water surface elevation in areas with an excess of six feet. **Table 12** shows with-Project freeboard calculations for the DSSL.

Table 12 – With-Project Conditions DSSL Freeboard						
Levee	**Fetch Site**	**Levee Elevation (ft)**	**WSEL (ft)**	**Levee Freeboard (ft)**	**Total Runup (ft)**	**Freeboard – Maximum Total Runup (ft)**
DSSL	PR04	27.7	19.4	8.3	6.3	2.0
	PR05	28.2	19.5	8.7	7.3	1.4

Cache/Hass Slough Training Levee

With the implementation of the Project, water will be introduced to the current landside levee slopes for the Cache/Hass Slough East Levees. This effectively change the purpose of the Cache/Hass Slough East Levees from their current purpose of protecting neighboring lands within from elevated water stages in Cache and Hass Sloughs to preventing flood stages inside the Yolo Bypass within the Project site from raising water surfaces in Cache/Hass Sloughs. As such, the Cache/Hass Slough East Levees becomes a training levee, and is referred to as the Cache/Hass Slough Training Levee. The training levee will be degraded to one foot above the 1957 Authorized Design Flow water surface elevation, or the 100-year water surface elevation, whichever is higher. The training levee will also be reconstructed to have a wider levee crown and uniform 4H:1V side slopes. These measures will make the Cache/Hass Slough Training Levee more resilient to a variety of factors including the potential for larger wind-generated waves. The with-Project total runup ranges from 2.8 to 3.0 feet and, therefore, the Cache/Hass Slough Training Levee will continue to have insufficient freeboard to completely contain total runup. It will, however, be armored over the entire width of the crown, and the armoring will extend three vertical feet down both side slopes. This armoring may consist of rock slope protection, articulated concrete block, a turf reinforcing mat, or other similar erosion control measures. The specific erosion control measure will be developed in coordination with USACE, DWR, and the design team as the design of the Project progresses. Due to the fact that the difference in water surface elevation (WSEL) between the two sides of the Cache/Hass Slough Training Levee will be approximately 0.7 foot, any splash-over that occurs will land on the proposed crest armoring and not on native soil. Additionally, this armoring will effectively break all waves emanating from the Project site so that waves will not continue to propagate towards the Cache Slough and Hass Slough West Levees. The landside toe of the Cache/Hass Training Levee will be graded to between elevation 3.5 and 5.5. As discussed in the *Fetch Site Selection and Properties* section of this TM, the dense stands of tules that will establish themselves on the Project site will dampen the effects of wind, making armoring below the elevation of the tules unnecessary. While tule stands can grow up to 10 feet (Tilley, 2012) a conservative approach based on engineering judgement and field observations made by team members of restoration projects in Gulf Coast was used and a maximum tule height of 8 feet was estimated. Based on this estimation, it is recommended that native grasses be placed on the Cache/Hass Training Levee starting at elevation 11 and extend up to where the crown armoring begins. **Table 13** below shows with-Project freeboard calculations for the Cache/Hass Slough Training Levee.

Table 13 – With-Project Conditions Cache/Hass Slough Training Levee Freeboard

Levee	Fetch Site	Levee Elevation (ft)	WSEL (ft)	Levee Freeboard (ft)	Total Runup (ft)	Freeboard – Maximum Total Runup (ft)
Cache/Hass Slough Training Levee	PR06	19.9	18.9	1.0	2.9	-1.9
	PR07	19.7	18.7	1.0	2.8	-1.8
	PR08	19.6	18.6	1.0	3.0	-2.0
	PR09	21.2	20.2	1.0	2.8	-1.8

Cross Levee

The Cross Levee was designed and built with a varying amount freeboard, ranging from 3 feet to 6.5 feet across the levee. While the maximum recorded wind speed from the north is high and results in a higher amount of total runup, it should be noted that this direction is not the dominant wind direction. While the total runup is greater than the freeboard on the Cross Levee for the selected fetch site, erosion protection beyond existing native grasses is not considered necessary due to the limited overtopping duration and planned operation and maintenance. The Cross Levee will effectively break all waves emanating from the Project site so that waves will not continue to propagate past the levee. **Table 14** shows with-Project freeboard calculations for the Cross Levee.

Table 14 – With Project Conditions Cross Levee Freeboard

Levee	Fetch Site	Levee Elevation (ft)	WSEL (ft)	Levee Freeboard (ft)	Total Runup (ft)	Freeboard – Maximum Total Runup (ft)
Cross Levee	PR10	25.4	19.2	6.2	7.9	-1.7

FINDINGS AND RECOMMENDATIONS

Based on the results of this analysis, adjacent properties will not be subject to increased wave runup and wind setup action from the proposed Project beyond the Cache/Hass Training Levee and the new Duck Slough Setback Levee. Based on the findings of this TM, the following revetment and erosion protection measures are recommended:

Table 15 – Recommendations

Location	Erosion Protection Measures Selected
Waterside Slope of the DSSL	Native grasses
Project-side Slope of the Cache/Hass Slough Training Levee	Crown armoring that extents down both side slopes three vertical feet, native grasses above elevation 11
Waterside Slope of the YBEL	Existing native grasses
Cross Levee	Existing native grasses

REFERENCES

1. California Department of Water Resources (2012). *Urban Levee Design Criteria*. FloodSAFE California, May 2012
2. California Department of Water Resources. (2016). *Basin-Wide Feasibility Studies – Sacramento River Basin – Draft.* DWR: Sacramento, CA.
3. California Department of Water Resources. (2017). *Lower Elkhorn Basin Levee Setback – Wave Runup and Wind Setup Analysis - Draft.* DWR: Sacramento, CA.
4. Hurdle, D.P. and Stive, R.J.H. (1989). *Revision of SPM 1984 Wave Hindcast Model to Avoid Inconsistences in Engineering Applications,* Coastal Engineering, 12:339-351
5. National Oceanic and Atmospheric Administration. (1998). *Automated Surface Observing System User's Guide*. NOAA: Washington D.C. (March 1998)
6. Northwest Hydraulic Consultants (2012). *Wave Runup and Erosion Analysis for West Sacramento Levee System General Reevaluation Report.* Prepared for HDR on the behalf of West Sacramento Area Flood Control Agency (March 2012).
7. South Florida Water Management District (2006). *DCM-2 Wind and Precipitation Design Criteria for Freeboard*. SFWMD (February 2006).
8. Tilley, D. (2012). *Plant Guide for Hardstem Bulrush (Schoenoplectus acutus)*. USDA-Natural Resources Conservation Service, Idaho Plant Materials Center. Aberdeen, ID.
9. United States Army Corps of Engineers. (1962). *Supplement to Standard Operation and Maintenance Manual - Sacramento River Flood Control Project, Unit No. 109. West Levee of Yolo Bypass, East Levee of Cache Slough.* USACE: Sacramento, CA (April 1962)
10. United States Army Corps of Engineers. (1966). *Supplement to Standard Operation and Maintenance Manual - Sacramento River Flood Control Project, Unit No. 113 (Revised).*

East Levee of Yolo Bypass, North Levee of Miner Slough, West Levees of Sutter Slough, Elkhorn Slough and Sacramento River, All Bordering Reclamation District No. 999. USACE: Sacramento, CA (August 1966)

11. United States Army Corps of Engineers (1984) *Shore Protection Manual.* USACE: Waterways Experiment Station, Vicksburg, Mississippi.
12. United States Army Corps of Engineers (1997). *Hydrologic Engineering Requirements for Reservoirs EM 1110-2-1420.* USACE: Washington D.C.
13. United State Army Corps of Engineers (2008). *Coastal Engineering Manual EM 1110-2-1100.* USACE: Washington D.C.
14. United States Army Corps of Engineers (2011) *Sutter Basin Wave Runup Analysis.* USACE: Sacramento District
15. URS (2014). *Geotechnical Evaluation Report Volume 1, Existing Conditions: South West Sacramento Deep Water Ship Channel Study Area.* Prepared on the behalf of the California Department of Water Resources.

ATTACHMENTS

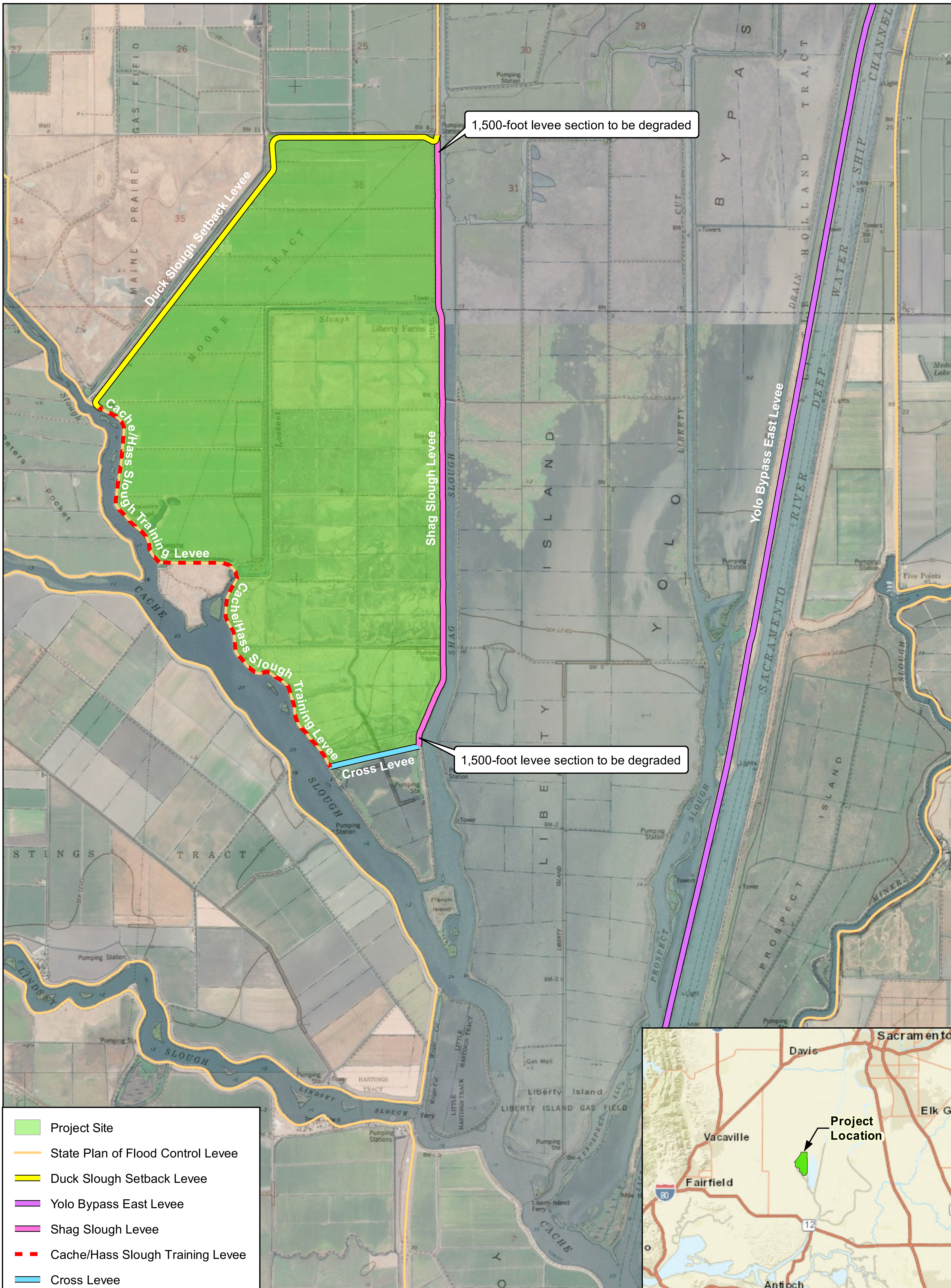
Figure 1: Location Map

Figure 2: Wind Data Location Map

Figure 3: Without-Project Conditions Fetch Site Location Map

Figure 4: With-Project Conditions Fetch Site Location Map

This Page Intentionally Left Blank



Location Map

Lookout Slough Tidal Habitat Restoration and Flood Improvement Project

0 0.25 0.5 1
Miles

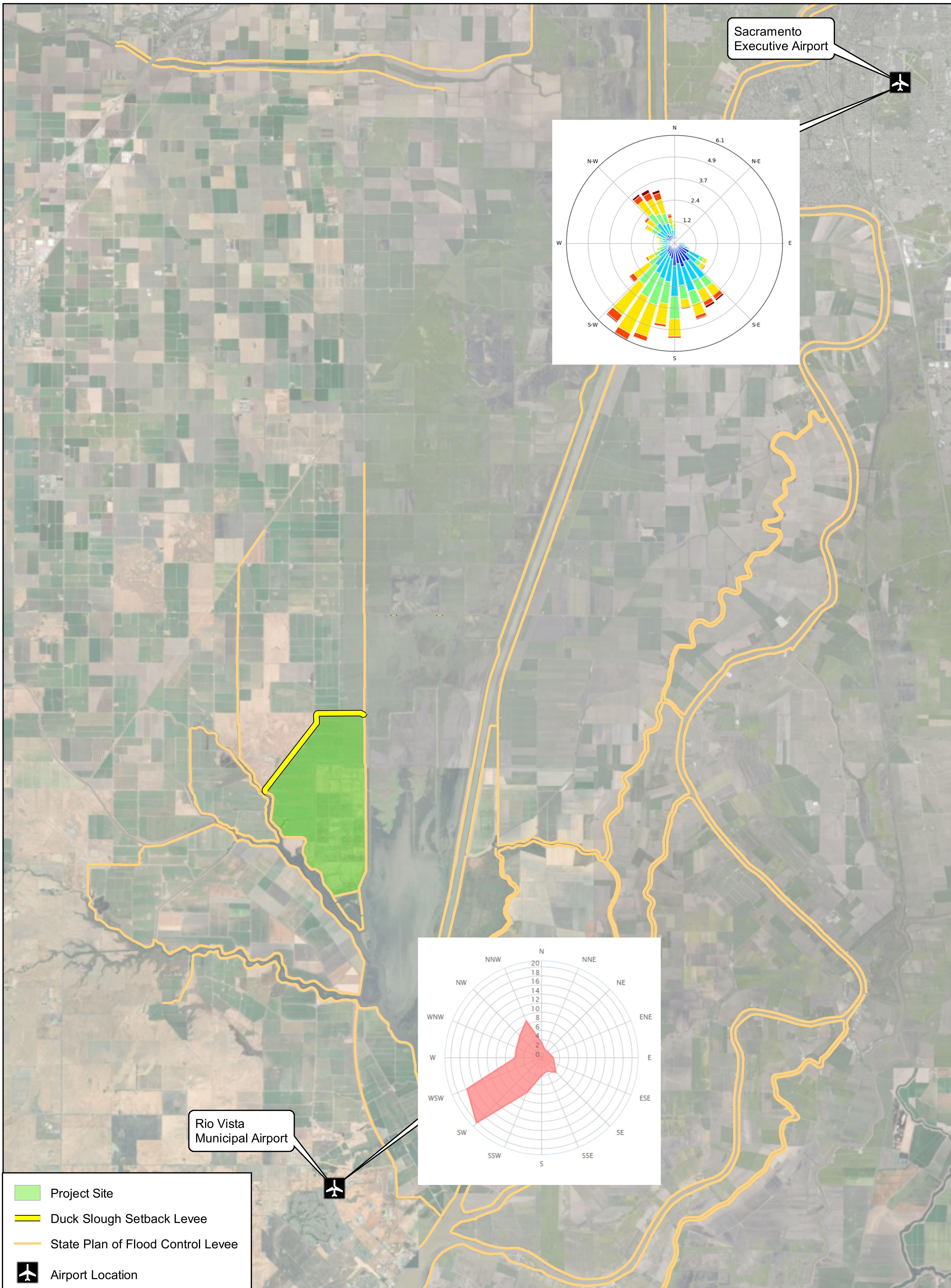
Ecosystem Investment Partners

Map Prepared Date: 9/25/2019
Map Prepared By: cmilligan
Base Source: Wood Rodgers
Base Date: 10/24/17
Data Source(s):

Prepared by:
WOOD RODGERS

Path: J:\3000-s\3487_Ecosystem_Invest_Partners\3487002 Lookout Slough Prelim Hydraulic Analysis\GIS\Tasks\20190828_Wind_Wave_TM_Exhibits\F01_Project_Location_Map_20190924_V1.mxd

Figure 1



Wind Data Location Map

N
W E
S

Ecosystem Investment Partners

Lookout Slough Tidal Habitat Restoration and Flood Improvement Project

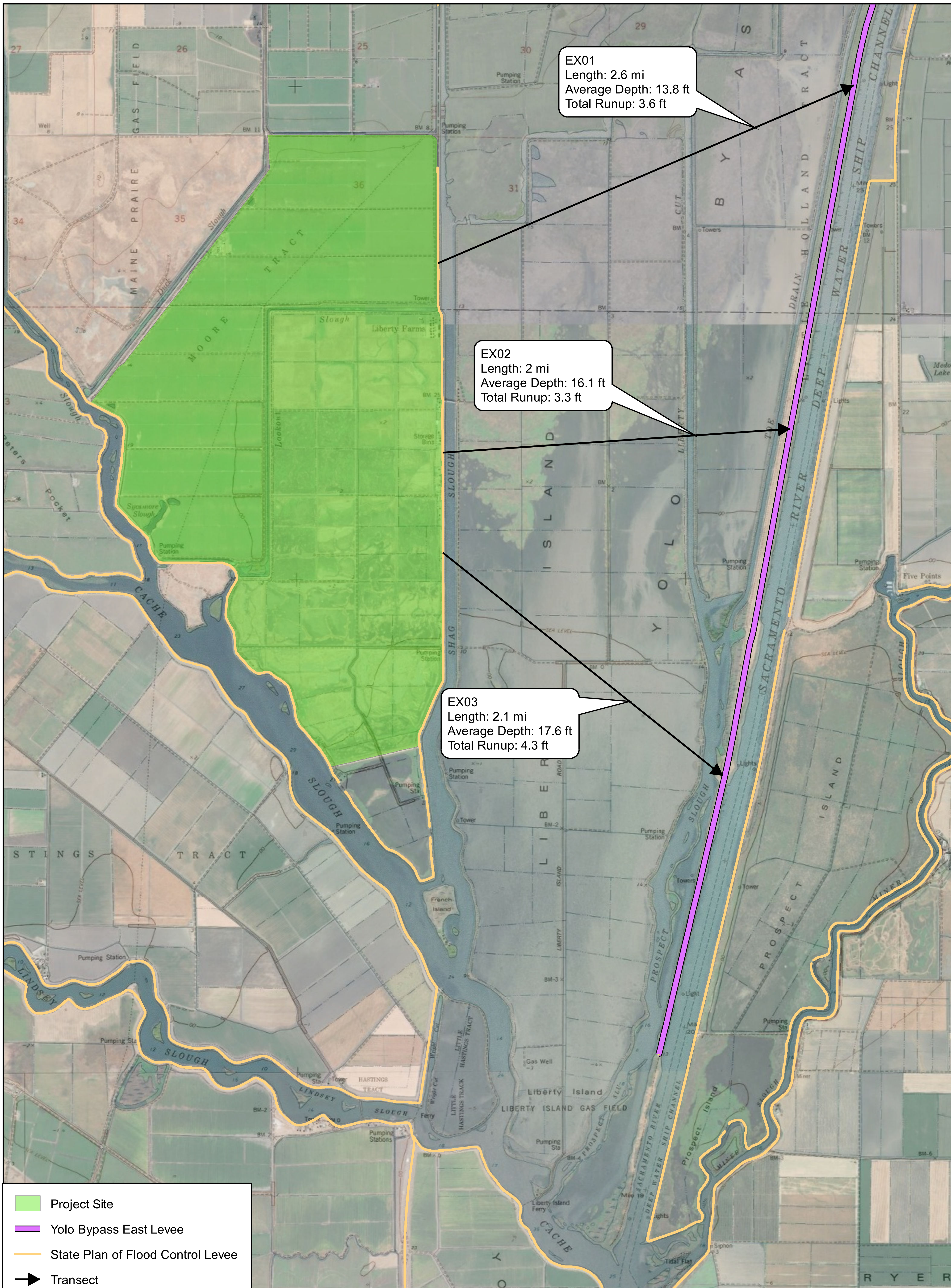
0 1.5 3 6
Miles

Map Prepared Date: 9/18/2019
Map Prepared By: cmilligan
Base Source: Wood Rodgers
Base Date: 10/24/17
Data Source(s):

Prepared by:
WOOD RODGERS

Path: J:\3000-s\3487_Ecosystem_Invest_Partners\3487002 Lookout Slough Prelim Hydraulic Analysis\GIS\Tasks\20190828_Wind_Wave_TM_Exhibits\F02_Wind_Data_Location_Map_20190924_V1.mxd

Figure 2



Without-Project Conditions
Fetch Site Location Map

Lookout Slough Tidal Habitat Restoration
and Flood Improvement Project

N W E S

0 0.25 0.5 1
Miles

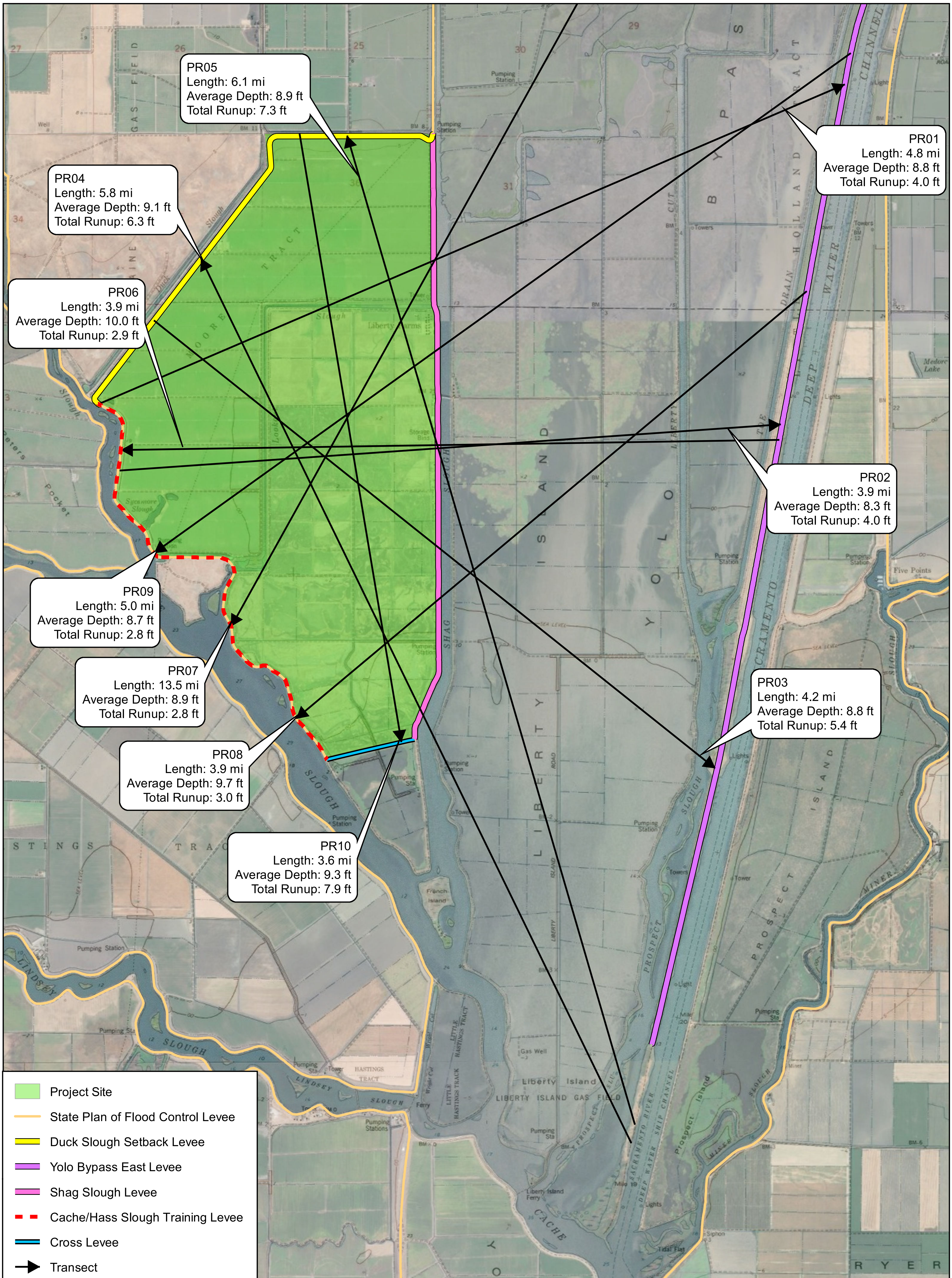
Ecosystem Investment Partners

Map Prepared Date: 12/3/2019
Map Prepared By: mberggren
Base Source: Wood Rodgers
Base Date: 10/24/17
Data Source(s):

Prepared by:
WOOD RODGERS

Path: J:\3000-s\3487_Ecosystem_Invest_Partners\3487002 Lookout Slough Prelim Hydraulic Analysis\GIS\Tasks\20190828_Wind_Wave_With_Tules_TM_Exhibits\F03_Existing_Fetch_Site_Location_Map_20190924_V1.mxd

Figure 3



With-Project Condtions
Fetch Site Location Map

Lookout Slough Tidal Habitat Restoration and Flood Improvement Project

Ecosystem Investment Partners

Map Prepared Date: 12/3/2019
Map Prepared By: mberggren
Base Source: Wood Rodgers
Base Date: 10/24/17
Data Source(s):

Prepared by:
WOOD RODGERS

Path: J:\3000-s\3487_Ecosystem_Invest_Partners\3487002 Lookout Slough Prelim Hydraulic Analysis\GIS\Tasks\20190828_Wind_Wave_With_Tules_TM_Exhibits\F04_Proposed_Fetch_Site_Location_Map_20190924_V1.mxd

Figure 4

Appendix D
Draft 65% Geotechnical Borrow Report

This Page Intentionally Left Blank

DRAFT GEOTECHNICAL BORROW REPORT
65% DESIGN

LOOKOUT SLOUGH TIDAL HABITAT RESTORATION AND FLOOD IMPROVEMENT PROJECT

Prepared For:

Ecosystem Investment Partners
5550 Newbury St.
Baltimore, Maryland 21209

Contact: David Urban
david@ecosystempartners.com

Prepared By:

Blackburn Consulting
2491 Boatman Ave
West Sacramento, CA 95691

Contact: Nicole Hart
nicoleh@blackburnconsulting.com

Date: September 2019

Ecosystem Investment Partners

blackburn consulting

West Sacramento Office: (916) 375-8706
2491 Boatman Ave
West Sacramento, CA 95691

blackburn consulting

Main Auburn Office: (530) 887-1494
Fresno Office: (559) 438-8411

Geotechnical ▪ Geo-Environmental ▪ Construction Services ▪ Forensics

BCI File No. 3195.x
September 26, 2019

Mr. David Urban
Director of Operations
Ecosystem Investment Partners
5550 Newbury Street
Baltimore, MD 21209

Subject: **DRAFT GEOTECHNICAL BORROW REPORT – 65% Design**
Lookout Slough Tidal Habitat Restoration and Flood Improvement Project
Solano County, California

Dear Mr. Urban,

Blackburn Consulting (BCI) is pleased to submit this Draft Geotechnical Borrow Report (Draft Borrow Report) for 65% Levee Design of the Lookout Slough Tidal Habitat Restoration and Flood Improvement Project located in Solano County, California. This Draft Borrow Report provides the geotechnical investigation and evaluation compiled to date by BCI to support BCI's Geotechnical Basis of Design Report (GBODR) geotechnical analyses and recommendations.

The findings and recommendations in this report are draft, intended for 65%-level design, and should not be relied on for final design or construction. Findings and recommendations may change as design progresses. Subsequent 90% and/or 100% updates of this report prepared by BCI will contain final design and construction.

Thank you for selecting BCI to be on your design-build team. Please call if you have questions or require additional information.

Sincerely,

BLACKBURN CONSULTING

Prepared by:

Nicole C. Hart, P.E.
Senior Project Engineer

Reviewed by:

REGISTERED PROFESSIONAL ENGINEER
ROBERT B. LOKTEFF
No. 2589
GEOTECHNICAL
STATE OF CALIFORNIA

Robert B. Lokteff, G.E., P.E.
Principal

Copies: 1 to Addressee (PDF)

This Page Intentionally Left Blank

TABLE OF CONTENTS

TABLE OF CONTENTS (cont.)

1 INTRODUCTION

1.1 Project Overview

The Lookout Slough Restoration Tidal Habitat Restoration and Flood Improvement Project (Lookout Slough THRFIP) will create more than 3,000 acres of habitat for listed and vulnerable native species within a portion of Reclamation District 2068 (RD 2068) including upland, tidal, subtidal, and floodplain habitat for Delta Smelt, Longfin Smelt, Steelhead Salmon, Splittail, Giant Garter Snake, and other species. In addition to habitat creation, the Lookout Slough THRFIP will provide 40,000 to 50,000 acre-feet of seasonal floodplain storage. A Lookout Slough THRFIP Vicinity Map is presented as Figure 1.

To create tidal, subtidal, and floodplain habitat; the Lookout Slough THRFIP would breach the Shag Slough Levee (SLL), at several locations and construct the new Duck Slough Setback Levee (DSSL) to maintain flood protection for areas outside of the Lookout Slough THRFIP area. Ecosystem Investment Partners (EIP) retained Blackburn Consulting (BCI) to perform geotechnical engineering services for DSSL design, borrow material evaluation in the restoration area, and design of PG&E tower access roads that extend to electrical distribution towers in the site area.

Geotechnical recommendations for the PG&E towers are presented in separate Technical Memorandums prepared by the design-build team. The design-build team is also preparing a separate Hass and Cache Slough Levee Technical Memorandum that provides an evaluation of possible impacts the Project may have on the existing levee systems and neighboring properties. Figure 2 presents the Lookout Slough THRFIP Site Limits and includes the DSSL alignment, PG&E distribution tower alignment with proposed access road locations, and proposed SSL breach areas.

1.2 Purpose and Content

BCI prepared this Draft Borrow Report for 65% Levee Design to support the design-build team's 65% design of the Lookout Slough THRFIP. This Draft Borrow Report summarizes BCI's 65%-design investigation and evaluation of potential on-site borrow material for use as fill for the new DSSL. Figures 3A and 3B present the Exploration Site Plan.

2 TOPOGRAPHY, GEOLOGY AND GEOMORPHOLOGY

2.1 Topography

The April 2011 *Geotechnical Assessment Report, North NULE Project Study Area, Volume 1 of 6, Non-Urban Levee Evaluations Project Contract 4600008101, Task Order U104,* (2011 NULE) prepared by URS describes the Area 5, West Delta Levees as located within the low-lying portion of the southwestern Sacramento Valley. Within the project area and surrounding sites, small and large canals with associated levees were constructed to aid in irrigation, prevent flooding, and drain the previously saturated, low-lying deposits. Current ground elevations near the proposed DSSL range from Elevation 8 feet to Elevation 6 feet.

BCI reviewed the following available historical topographic maps within the Lookout Slough THRFIP area to identify if historical sloughs or drainage areas crossed the proposed DSSL alignment:

- Courtland Quadrangle Topography, March 1908 Edition, Reprinted in 1914.
- Cache Slough Quadrangle Topography, 1916 Edition.
- Liberty Island Quadrangle Topography, 1952, Photo revised 1968.

A pond feature is identified on both the 1908 and the 1916 topographic maps. This pond feature aligns with the water feature identified on the geomorphology map, discussed below in Section 2.3. BCI did not identify any other historical sloughs or drainage/irrigation channels crossing the proposed DSSL alignment. Appendix A presents the topographic maps overlain with the Lookout Slough THRFIP limits and the proposed DSSL alignment.

2.2 Geology

The Lookout Slough THRFIP area is located within the northwestern portion of the approximately 50-mile-wide and 400-mile-long Great Valley Geomorphic Province. The Great Valley province is a depositional basin bounded by the Sierra Nevada to the east, the Coast Ranges to the west, and the Klamath Mountains and Cascade Range to the north. The basin is a broad, elongated, northwest trending, structural trough that has been filled with a thick sequence of sediments as much as 20,000 to 40,000 feet thick.

BCI reviewed both the *Geologic Maps of the Sacramento -San Joaquin Delta,* California, Brian F. Atwater, 1982 (1982 Geologic Map), and the *Geologic Map of the Late Cenozoic Deposits of the Sacramento Valley, Sheet 1,* Edward J. Helley and David S. Harwood, USGS Publication MF-1790, 1985 (1985 Geologic Map). Both Geologic Maps indicate the site as generally underlain by Basin Deposits, Undivided/Flood-basin deposits (Holocene) (Qb). This material consists of fine grained silt and clay. Both maps also identify two localized areas are mapped as Lower Member, Modesto Formation (Qml) (1985 Geologic Map) and Alluvium of Putah Creek, Older Alluvium (Pleistocene) Qop near the proposed DSSL alignment and borrow areas. The Qml formation consists of unconsolidated, slightly weathered gravel, sand, silt and clay. These areas are near the water feature identified in the geomorphology map discussed below in Section 2.3.

The 1982 Geology Map identifies the northern border of the property as Younger Alluvium of Putah Creek (Holocene and Pleistocene) (Qyp). The border of Qyp closely follows the border between Basin Deposits and Marsh Deposits identified on the geomorphology map. Peat Deposits (Qp/Qpm) extend into the very lower southeast section of the project site on both geology maps. The southern cross levee is located within this deposit. Peat deposits consist of decaying fresh-water plant remains with minor amounts of silt and clay.

Figure 4 presents the site Geologic Map using the 1982 Geology Map. This map more closely aligns with features identified in the geomorphology map and is more specific to the Delta area.

2.3 Geomorphology

URS prepared the January 2011, *Final Geomorphology Technical Memoranda and Maps, North NULE Area Geomorphic Assessments, Non-Urban Levee Evaluations Project, Contract 4600008101,* (2011 Geomorphology TM. The 2011 Geomorphology TM describes the geology of the Lookout Slough THRFIP area as the Yolo Flood Basin. During times of flood, slow moving inland seas covered this basin. In the existing information listed in Section 2.1, URS describes deposition in such flood basins resulted from slow moving/standing water, with primary sediments consisting of silt and clay. Higher permeability deposits may be locally interbedded, as well as alluvial fan sediments from west or east flowing streams.

The Delta geomorphic domain generally consists of fluvial channels and tidal sloughs. Delta island deposits are late Holocene, unconsolidated and fine-grained organic-rich silt and clay with high water content and peat. Directly adjacent to watercourses, Sacramento River supratidal alluvium and sloughs overlie Delta islands of peat and mud. Natural levee deposits and peat and mud deposits interfinger in the subsurface and create vertical interbedded layers of silt and sand with organic-rich material. The deposits in the Delta are moderately permeable.

The geomorphology underlying the proposed DSSL alignment and extending into the proposed borrow areas generally consists of Basin Deposits (Hn) comprised of fine sand, silt and clay. A localized water area is mapped generally between Station 38+00 to Station 48+00 of the proposed DSSL alignment, and localized Alluvial Fan deposits (Pf) are mapped in the northern portion of the site, generally waterside of the proposed levee alignment. A Holocene Slough Deposit (Hsl) is mapped to extend into the upper northeast corner of the site.

The remainder of the site is generally mapped as Marsh Deposits (Hs) which consist of silt and clay and possible organic rich deposits. Similar to the mapped Qp of the Helley and Harwood Geologic Map, Peat and Muck (Qpm) is mapped in the very lower southwest section of the Lookout Slough THRFIP, near the southern cross levee, but not under the proposed new DSSL alignment. This material consists of interbedded peat and organic-rich silt and clay. Both Historical and Holocene Slough Deposits (Rsl and Hsl respectively) extend into the Lookout Slough THRFIP predominantly along the western border, apparently originating from Hass and Cache Slough. These deposits consist of silt, clay and sand, low-energy channel deposits. Refer to Figures 3A and 3B.

3 SUBSURFACE EXPLORATION PROGRAM

3.1 Surface Conditions

The potential borrow area is waterside of the new DSSL alignment and is typically covered with a dense growth of seasonal grasses and irrigated by flooding for cattle grazing. Several dirt/gravel roads and concrete-lined irrigation ditches cross the borrow area.

3.2 Field Explorations

BCI's field engineer coordinated with the property lessee to gain site access based on cattle grazing and irrigation schedules. In summer and fall, BCI could access the borrow area with a backhoe several days after flooding, when no standing water was present.

BCI logged a total of 47 backhoe-excavated test pits in the proposed on-site borrow area to evaluate soil conditions and obtain samples for laboratory testing as follows:

- As part of a preliminary subsurface evaluation for the Lookout Slough THRFIP, Hanford ARC used a 430E backhoe equipped with a 24-inch-wide bucket to excavate test pits to depths of 5 feet bgs throughout the Lookout Slough THRFIP area on September 18, 2017. BCI observed subsurface conditions within 7 of these test pits; TP-1, TP-2, TP-4, TP-5, TP-6, TP-8 and TP-10. TP-4 and TP-6 were located near the current planned borrow area, as shown on Figure 3A.
- After coordination with the design-build team regarding potential borrow areas, Hanford ARC used a CAT 316E backhoe equipped with a 24-inch-wide bucket to excavate 40 additional test pits within the borrow areas to depths of up to 12.5 bgs between June 17 and June 24, 2018.

At the completion of field work, Hanford ARC backfilled the test pits with excavated material. Hanford ARC tamped each approximate one-foot-loose backfill layer with the back of the bucket up to the existing ground surface.

BCI's field engineer located the explorations with a hand-held GPS unit, and used LiDAR data provided by the design team to determine the ground surface elevations for each test pit. The elevations are provided in the NAVD 88 vertical datum. Figures 5A through 5G present the ground surface elevations for each test pit. The coordinates are presented on the test pit logs in Appendix A.

BCI's field engineer logged soils encountered in the test pits consistent with the Unified Soil Classification System (USCS). BCI collected both bulk and relatively "undisturbed" tube samples from the test pits. The relatively "undisturbed" tube samples were obtained with either a hand auger and a hand driven sampler or the back of the backhoe bucket gently pushing the tube into the excavation surface. BCI performed pocket penetrometer measurements on fine-grained (silt and clay) soil on the relatively "undisturbed" samples obtained from the test pits.

BCI assigned laboratory tests to evaluate suitability of the material for levee fill and to obtain seepage and strength parameters to support the geotechnical design analysis presented in the Draft 65% Geotechnical Basis of Design Report. Section 4.0 of this report presents BCI's Laboratory Testing Program.

3.3 Subsurface Conditions

The test pits generally indicate interbedded layers of lean- to fat- clay from the ground surface to the full depth of the test pit. The only variance was observed in BTP-13 where we encountered silty sand approximately 8 feet bgs.

Appendix A presents the Lookout Slough THRFIP test pit logs completed by BCI. The test pit logs present corrected soil descriptions based on laboratory test results. Figures 5A through 5G present the Borrow Area Geotechnical Plan and Profiles that show the test pit stick logs. Refer to BCI's 65% Draft Geotechnical Data Report and/or BCI's Draft 65% Geotechnical Basis of Design Report Plan and Profile sheets for the boring and CPT stick logs.

3.4 Ground Water

During test pit excavation, BCI observed ground water seeping from the clay sidewalls between 5.5 feet to 9 feet bgs. The ground water continued to seep to form shallow puddles at the bottom of the test pits when left open. BCI did not observe water bearing soil layers within or at the bottom of the test pits. The ground water could be perched water from the heavy winter rains and the continual irrigation flooding from ranching operations.

4 LABORATORY TESTING PROGRAM

BCI performed laboratory tests on representative soil samples obtained from the test pits.
Tests included:

- Moisture Content and Unit Weight (ASTM D2216-10) for design parameter development / correlation.
- Sieve Analysis (ASTM D1140-00) and Atterberg Limits (ASTM D4318-10) for soil classification, hydraulic conductivity and strength correlations, and slope stability evaluation.
- Optimum moisture and maximum density compaction curves (ASTM D698) to determine parameters for remolded test specimens and cut-to-fill volume change evaluation.
- Remolded Unconsolidated Undrained (ASTM D2850), and Consolidated Undrained with pore-water pressure measurements (ASTM D4767) triaxial compression tests for slope stability analysis.
- Remolded Hydraulic Conductivity (ASTM D5084-10 Method C) for seepage analysis.
- Fully Softened Direct Shear tests following the procedures outlined in the February 20, 2014, *Use and Measurement of Fully Softened Shear Strength*, Bernardo A. Castellanos.

BCI performed laboratory tests in accordance with current ASTM test methods. Appendix B contains a summary table of BCI's test results and lab result reports. The test pit logs presented in Appendix A and the stick logs presented in Figures 5A through 5G show the #200 sieve analysis and Atterberg Limit test results.

4.1 Moisture Content

BCI performed 36 moisture content tests on soil samples collected from the test pits in accordance with ASTM D2216. The moisture content ranges from approximately 20% to 34% and indicate the in-situ moisture content at the time of sampling.

4.2 Moisture-Density Relationship

BCI performed moisture-density tests on 36 generally "undisturbed" soil samples collected within the test pits in accordance with ASTM D7263. BCI also performed 9 compaction curves in accordance with ASTM D698 on bulk soil samples obtained from the test pits to evaluate the optimum moisture content and maximum dry density of the borrow material anticipated for levee fill. Based on the test results, the in-situ dry density ranges from approximately 86 pounds per cubic foot (pcf) to 107 pcf. The ASTM D 698 maximum density and optimum moisture test results ranged from 93 pcf with an optimum moisture of 27%, to 110 pcf with an optimum moisture of 17%.

4.3 Index Properties

BCI performed index tests to classify the proposed levee fill material. BCI performed these tests on samples collected during the subsurface exploration program described in Section 3. These tests included:

- 37 Percent material finer than the No. 200 sieve (ASTM D1140-00) to determine the percent fines.
- 77 Atterberg limits test (ASTM D4318-10) to determine the liquid limit, plastic limit and plasticity index.

The sieve analysis test results generally indicate fines content greater than 80 percent for the material in the upper 4 to 5 feet from ground surface. Of the 73 test results (not including the outlier test results obtained from BTP10), 48 indicate Liquid Limits less than 60, 17 indicate Liquid Limits between 60 to 70, and 7 indicate Liquid Limits between 70 to 80. All tests indicate a Plasticity Index less than 60.

4.4 Remolded Hydraulic Conductivity Tests

BCI performed three hydraulic conductivity tests on soil samples remolded to approximately 97% of the maximum dry density based on ASTM D698. BCI performed the tests in accordance with ASTM D5084-10 Method C to assist in the determination of the hydraulic conductivity parameters for underseepage analysis. Hydraulic Conductivity Test results are shown in the summary table in Appendix B.

4.5 Strength Tests

BCI performed triaxial compression tests on soil samples remolded to approximately 97% of the maximum dry density based on ASTM D698 to help determine strength parameters for slope stability analysis.

The tests included:

- Seven remolded Unconsolidated Undrained (UU) Triaxial Compression Tests on Cohesive Soils (ASTM D2850-03a).
- Three remolded Consolidated Undrained (CU) Triaxial Compression Tests for Cohesive Soils (ASTM D4767-11).
- Two Direct Shear Tests to determine fully softened shear strength following the procedures presented in *Use and Measurement of Fully Softened Shear Strength*, Bernardo A. Castellanos, February 20, 2014.

Strength test results are shown in the summary table in Appendix B.

5 CONCLUSIONS AND RECOMMENDATIONS

5.1 Material Suitability

The California Code of Regulations, Regulations of the Central Valley Flood Protection Board, Title 23, Waters, December 2009 (Title 23) recommends the following for levee construction of a bypass levee:

- At least 20% passing the No. 200 sieve
- Liquid Limit less than 50
- Plasticity Index greater than 8
- 3(H):1(V) landside slope
- 4(H):1(V) waterside slope
- 4-foot to 6-foot freeboard

Title 23 further states that "special construction details (e.g., 4:1 slopes) may be substituted where the soil properties are not easily attainable". Title 23 also states that "Where the design of a new levee structure utilizes zones of various materials or soil types, the requirements of this subdivision do not apply".

BCI worked closely with the design-build team to evaluate on-site soil that would be generated from the habitat restoration component of the Lookout Slough THRFIP for DSSL fill. The on-site soil meets Title 23 percent passing the #200 sieve and Plasticity Index criteria but does not consistently meet the Liquid Limit criteria. Based on our tests, the Liquid Limit of the soil from the potential borrow area ranges from 31 to 80 with an average of 56. (We did not include the outlier test results from BTP10, which indicated Liquid Limits greater than 80.).

When used for levee fill, cyclical wetting and drying of fat clay (clay with a Liquid Limit of 50 or greater) can result in shrinkage (desiccation) cracks and softening of the clay along the exterior of the levee, which can lead to surficial slumps when the softened soil becomes near-saturated from rainfall. This phenomenon is generally restricted to within about 6 feet (measured perpendicular) of the slope face, and for slopes steeper than about 4(H):1(V).

The project design consists of 4(H):1(V) landside and waterside slopes, to account for material with Liquid Limits that exceed 50 and will help mitigate surficial slumping.

5.2 Borrow Material Volume Change Evaluation

BCI evaluated cut-to-fill volume change of the proposed borrow material by comparing the in-situ dry densities to the maximum dry densities obtained using ASTM D698. We looked at various depth ranges and relative compaction between 97% and 100%. Based on our evaluation, the Contractor should anticipate a maximum cut-to-fill volume decrease of 7%. The design-build team will adjust this value and add a factor-of-safety based on levee construction and earthwork experience.

5.3 Construction Considerations

Due to concentrations of surficial organics, BCI recommends the Contractor remove the upper 12 inches of soil prior to excavating material for levee fill. We understand that the upper 12 inches of soil can be used in other areas of the Lookout Slough THRFIP. Soil removal may need to extend deeper than 12 inches in isolated areas if excavations encounter vegetation after removal of the upper 12 inches.

If construction commences in early spring after a wet winter, earthmoving activities may encounter unstable, saturated soil within the borrow areas. In addition, unstable soil may be encountered due to the relatively shallow ground water observed in the explorations and the test pits. The contractor may need to implement dewatering measures if ground water enters the excavation area.

Depending on the time of year, the moisture content of the excavated borrow material may either be greater or less than optimum moisture and therefore require moisture conditioning by the addition of water or air drying. In addition, high plasticity clays require more-than-typical processing due to the cohesive and blocky nature of the excavated soil. The excavated soil should be broken down to less than 3-inch-diameter fragments prior to compaction for levee embankment.

6 LIMITATIONS

BCI prepared this Draft Borrow Report for EIP and the design team for the Lookout Slough THRFIP. This Draft Borrow Report should not be used by others or for other projects without BCI's written permission.

BCI prepared this report in accordance with the generally accepted geotechnical standard of practice currently being used in this area.

BCI based this Draft Borrow Report on the current site and project conditions. We assumed the soil/ground water conditions encountered in our test pits are representative of the subsurface conditions across the site. Actual conditions between test pits could be different. Ground water may be higher in other locations and at other times than measured in the explorations.

The interface between soil types on the logs is approximate. The transition between soil types may be abrupt or gradual. We based our recommendations on the final logs, which represent our interpretation of the field logs and general knowledge of the site and geologic conditions.

GEOTECHNICAL BORROW REPORT

65% Design

Lookout Slough THRFIP

Solano County, California

FIGURES

blackburn consulting

FIGURE 1, PROJECT VICINITY MAP
Borrow Report - 65% Design
September 2019

N
W E
S

0 10,000
SCALE: 1" = 10,000'

Lookout Slough THRFIP

Ecosystem Investment Partners

Prepared by:

Map Prepared Date: 09/01/19
Map Prepared By: M.D.R.
Checked By: N.C.H.
Job No.: 3195.x

BLACKBURN CONSULTING

Path: \\FS-01\Common\Active Projects\3195.P DWR Lookout Slough Restoration Project\CAD\3195.x Fig1 LSRP 65%.dwg

This Page Intentionally Left Blank

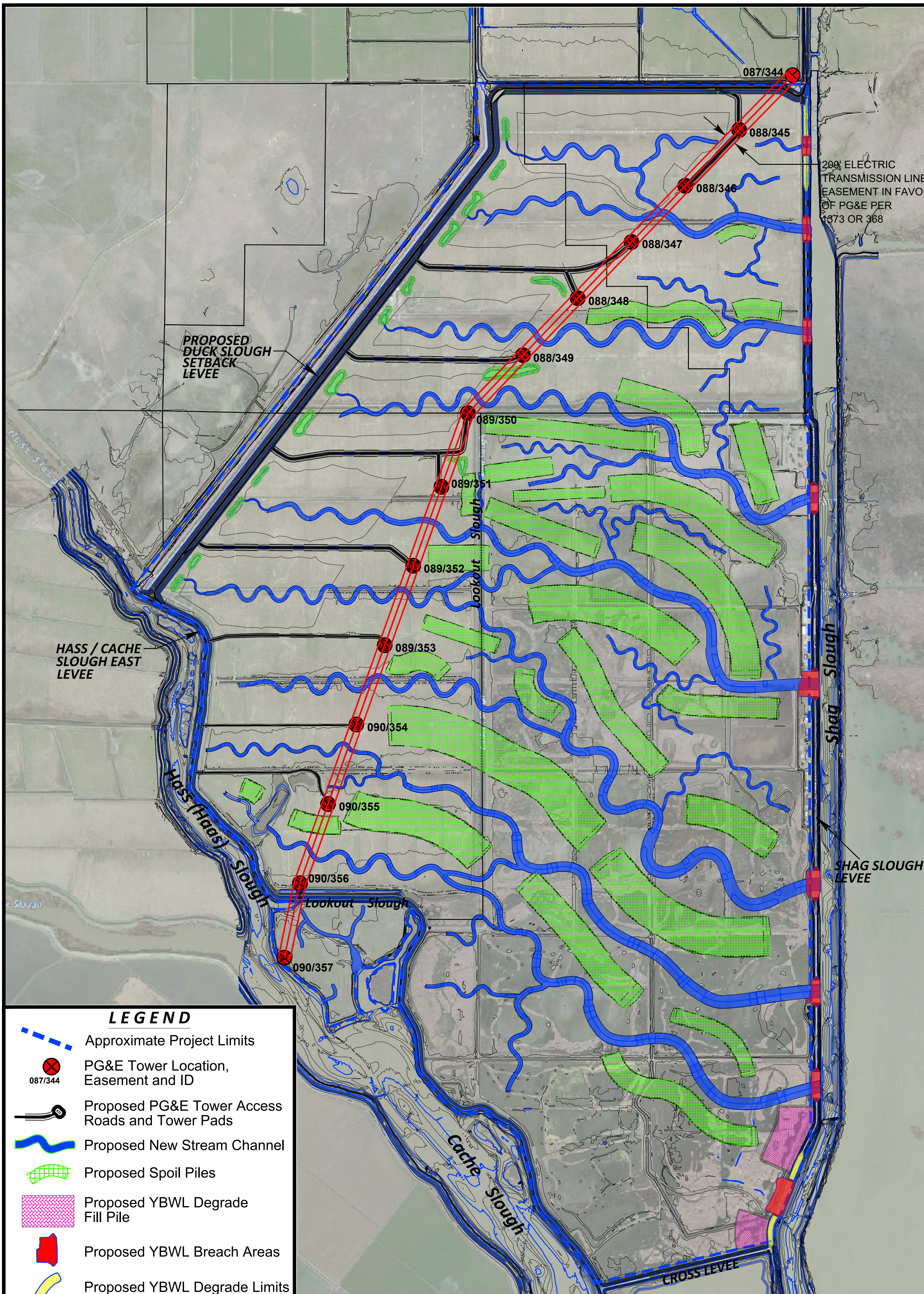


FIGURE 2, PROJECT SITE LIMITS
Borrow Report - 65% Design
September 2019

N
W E
S

Drawing References: Lookout Slough boundary lines and easements provided by Wood Rodgers, Inc., 12/08/2017. Proposed levee alignment, stream channels, and topography updated 7/30/2019.

0 1500
SCALE: 1 " = 1500'

Lookout Slough THRFIP

Ecosystem Investment Partners

Map Prepared Date: 09/01/19
Map Prepared By: M.D.R.
Checked By: N.C.H.
Job No.: 3195.x

Prepared by:
BLACKBURN CONSULTING

Path: \\FS-01\Common\Active Projects\3195.P DWR Lookout Slough Restoration Project\CAD\3195.x Fig2 LSRP 65%.dwg

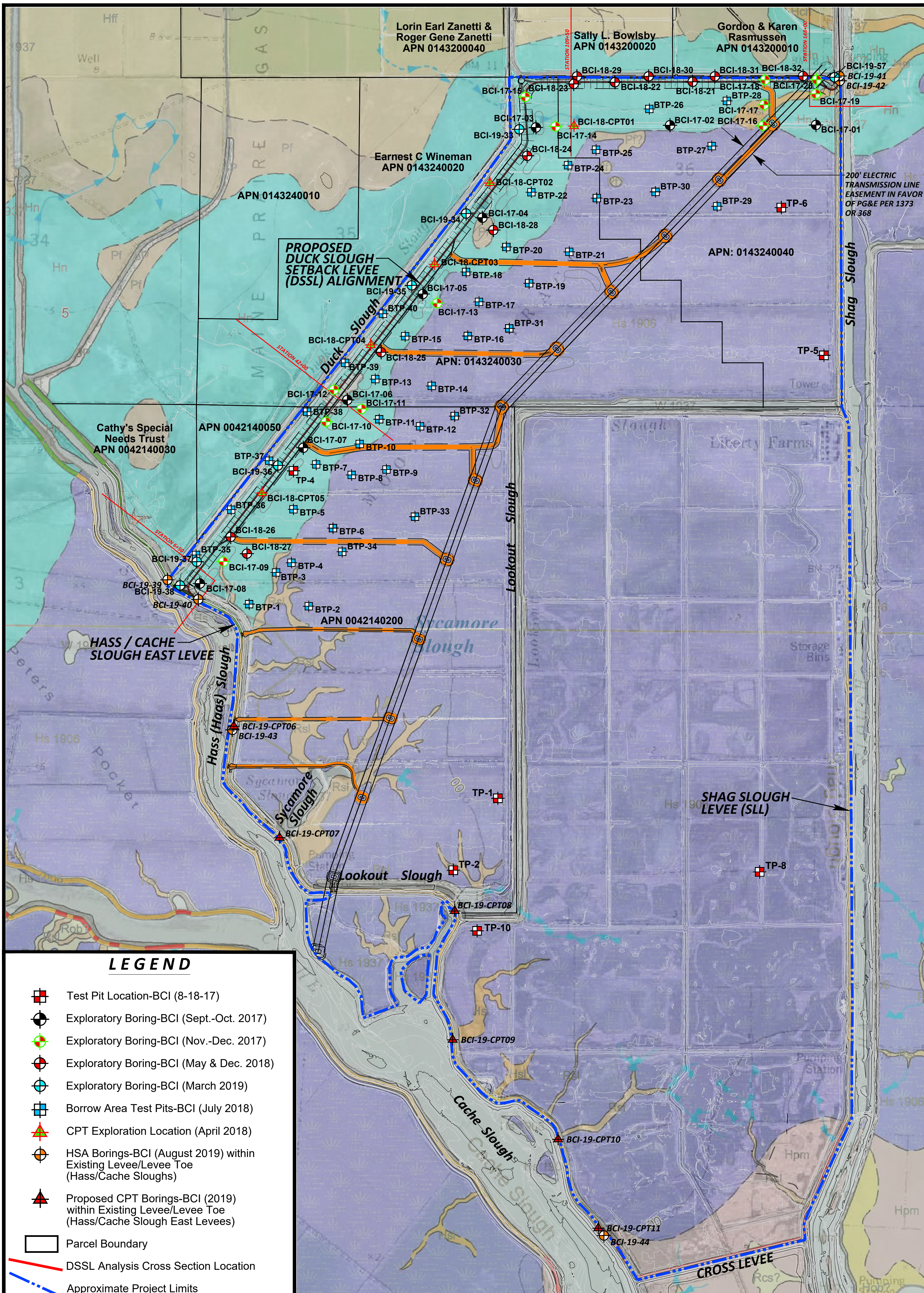


FIGURE 3A, EXPLORATION SITE PLAN
Borrow Report - 65% Design
September 2019

Drawing References: Lookout Slough boundary lines and easements provided by Wood Rodgers, Inc., 12/08/2017. Proposed levee alignment updated 2/1/2019 and topography updated11/12/2018.

0 1500
SCALE: 1 " = 1500'

Lookout Slough THRFIP

Ecosystem Investment Partners

Map Prepared Date: 09/01/19
Map Prepared By: M.D.R.
Checked By: N.C.H.
Job No.: 3195.x

Prepared by:
BLACKBURN CONSULTING

Path: \\FS-01\Common\Active Projects\3195.P DWR Lookout Slough Restoration Project\CAD\3195.x Fig3 LSRP 65%.dwg

This map shows surficial geologic deposits and levees as they existed in 1937. Map units and boundaries are drawn by interpretation of historical aerial photography supplemented by data from historical maps and surveys. For reference, the mapping is superimposed on modern U.S. Geological Survey 7.5' topographic base maps (individual maps referenced below).
Screened back semi-transparent mapping shown on this plate is from Deep Water Ship Channel study area, which is not assessed in this investigation. For clarity, only the surficial geologic map units of this study appear in the explanation.
See accompanying technical memorandum for complete descriptions of map units, process descriptions and methodology.
Adjacent polygons that have identical map unit symbols are employed to delineate sequences of sedimentation and landscape evolution.

Explanation

Underseepage Susceptibility Along Non-Urban Levee Alignment

Very High | High | Moderate | Low

— — ? ········ Geologic contact; dashed where approximate, dotted where concealed, queried where uncertain. Solid contacts accurate to within 100' of line shown on map; dashed contacts accurate to within about 250' on either side of the line.

Narrow channel, generally <100 ft in width. Dashed where approximate, dotted where concealed.

Narrow, tidally influenced channel (<100 ft in width), commonly connected to a larger slough channel.

Canal

Levee; artificial fill prism, generally <70 ft in width.

Borrow pit, generally <70 ft in width.

W 1937 — Water; date indicates year of historical dataset.

BP — Borrow pit present in 1937.

Geologic Units

HISTORICAL

- AF — Artificial fill, circa 1937.
- L — Levee (made of artificial fill), circa 1937.
- Rob — Overbank deposits; silt, sand, and lesser clay; deposited during high-stage water flow, overtopping channel banks.
- Rcs — Crevasse splay deposits; fine sand and silt with clay deposited from breaching of natural or artificial levees.
- Rch — Channel deposits; well sorted sand and trace fine gravel.
- Rsl — Slough deposits; silt, clay, and sand, fining upward facies, low-energy channel deposits.
- Ril 1906 — Intermittent lake; seasonal lake shown on historical topographic maps. Date indicates source data set.

HOLOCENE

- Hob — Overbank deposits; silt, sand, and clay; deposited during high-stage water flow, overtopping channel banks.
- Hcs — Crevasse splay deposits; fine sand and silt with clay deposited from breaching of natural levees.
- Hff — Fine-grained alluvial fan deposits; silt and clay with sand.
- Hch — Channel deposits; well sorted sand and trace fine gravel.
- Hsl — Slough deposits; silt, clay, and sand, fining upward facies, low-energy channel deposits.
- Ha — Alluvial deposits, undifferentiated; sand, silt, clay and minor lenses of gravel.
- Hpm — Peat and muck; interbedded peat and organic-rich silt and clay, former tidal marsh deposits, mostly now leveed, drained, and farmed.
- Hn — Basin deposits; fine sand, silt and clay.
- Hs 1937 — Marsh deposits; silt and clay, possibly with organic-rich beds; perennially or seasonally submerged. Date indicates year of historical dataset used to map the marsh.

PLEISTOCENE

- Pf — Alluvial fan deposits; semi-consolidated silt, sand, sandy clay and fine to coarse subrounded gravel.
- Pf (m) — Alluvial fan deposits of the Montezuma Hills; semi-consolidated sandy silt, sandy clayey silt, clay, sand and minor pebble gravel eroded from the early Pleistocene Montezuma Formation

Stratigraphic Correlation Chart

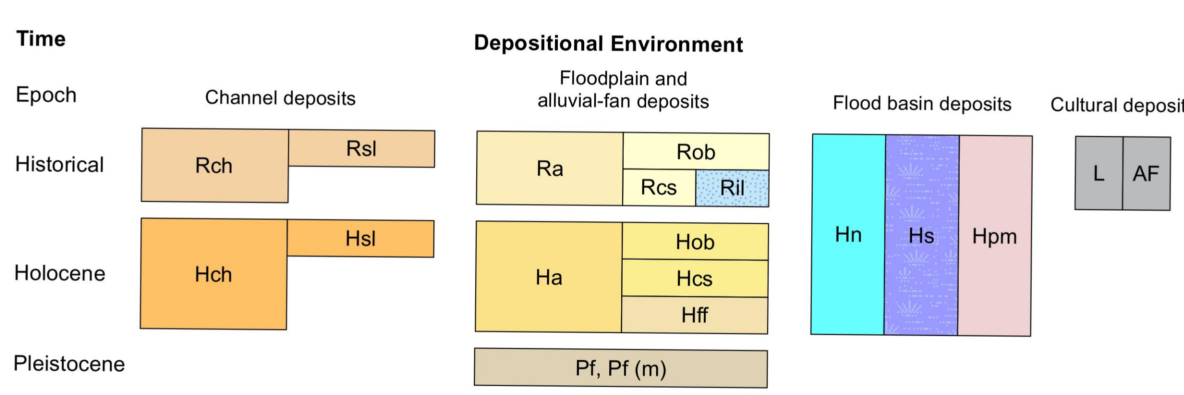


FIGURE 3B, LEGEND, EXPLORATION SITE PLAN
Borrow Report - 65% Design
September 2019

Source: Surficial Geologic Map of the West Delta Study Area, Plate 1 for the North Non-Urban Levee Evaluations. Produced by Department of Water Resources, Division of Flood Management, Levee Evaluations Branch in association with URS and Fugro, Scale is 1"=2000'.

Lookout Slough THRFIP

Ecosystem Investment Partners

Prepared by:

Map Prepared Date: 09/01/19
Map Prepared By: M.D.R.
Checked By: N.C.H.
Job No.: 3195.x

BLACKBURN CONSULTING

Path: \\FS-01\Common\Active Projects\3195.P DWR Lookout Slough Restoration Project\CAD\3195.x Fig3 LSRP 65%.dwg

FIGURE 4, GEOLOGIC MAP
Borrow Report - 65% Design
September 2019

Lookout Slough THRFIP

Lookout Slough boundary lines and easements provided by Wood Rodgers, Inc., 12/08/2017. Proposed levee alignment and topography updated 02/01/2019. Liberty Island, Geologic Map of the Sacramento-San Joaquin Delta, California, by Brian F. Atwater, 1982.

0 1500
SCALE: 1 " = 1500'

Ecosystem Investment Partners

Map Prepared Date: 09/01/19
Map Prepared By: M.D.R.
Checked By: N.C.H.
Job No.: 3195.x

Prepared by:
BLACKBURN CONSULTING

Path: \\FS-01\Common\Active Projects\3195.P DWR Lookout Slough Restoration Project\CAD\3195.x Fig4 LSRP 65%.dwg

GROUP SYMBOLS AND NAMES

Graphic/Symbol	Group Names
GW	Well-graded GRAVEL Well-graded GRAVEL with SAND
GP	Poorly-graded GRAVEL Poorly-graded GRAVEL with SAND
GW-GM	Well-graded GRAVEL with SILT Well-graded GRAVEL with SILT and SAND
GW-GC	Well-graded GRAVEL with CLAY (or SILTY CLAY) Well-graded GRAVEL with CLAY and SAND (or SILTY CLAY and SAND)
GP-GM	Poorly-graded GRAVEL with SILT Poorly-graded GRAVEL with SILT and SAND
GP-GC	Poorly-graded GRAVEL with CLAY (or SILTY CLAY) Poorly-graded GRAVEL with CLAY and SAND (or SILTY CLAY and SAND)
GM	SILTY GRAVEL SILTY GRAVEL with SAND
GC	CLAYEY GRAVEL CLAYEY GRAVEL with SAND
GC-GM	SILTY, CLAYEY GRAVEL SILTY, CLAYEY GRAVEL with SAND
SW	Well-graded SAND Well-graded SAND with GRAVEL
SP	Poorly-graded SAND Poorly-graded SAND with GRAVEL
SW-SM	Well-graded SAND with SILT Well-graded SAND with SILT and GRAVEL
SW-SC	Well-graded SAND with CLAY (or SILTY CLAY) Well-graded SAND with CLAY and GRAVEL (or SILTY CLAY and GRAVEL)
SP-SM	Poorly-graded SAND with SILT Poorly-graded SAND with SILT and GRAVEL
SP-SC	Poorly-graded SAND with CLAY (or SILTY CLAY) Poorly-graded SAND with CLAY and GRAVEL (or SILTY CLAY and GRAVEL)
SM	SILTY SAND SILTY SAND with GRAVEL
SC	CLAYEY SAND CLAYEY SAND with GRAVEL
SC-SM	SILTY, CLAYEY SAND SILTY, CLAYEY SAND with GRAVEL
PT	PEAT
	COBBLES COBBLES and BOULDERS BOULDERS

Graphic/Symbol	Group Names
CL	Lean CLAY Lean CLAY with SAND Lean CLAY with GRAVEL SANDY lean CLAY SANDY lean CLAY with GRAVEL GRAVELLY lean CLAY GRAVELLY lean CLAY with SAND
CL-ML	SILTY CLAY SILTY CLAY with SAND SILTY CLAY with GRAVEL SANDY SILTY CLAY SANDY SILTY CLAY with GRAVEL GRAVELLY SILTY CLAY GRAVELLY SILTY CLAY with SAND
ML	SILT SILT with SAND SILT with GRAVEL SANDY SILT SANDY SILT with GRAVEL GRAVELLY SILT GRAVELLY SILT with SAND
OL	ORGANIC lean CLAY ORGANIC lean CLAY with SAND ORGANIC lean CLAY with GRAVEL SANDY ORGANIC lean CLAY SANDY ORGANIC lean CLAY with GRAVEL GRAVELLY ORGANIC lean CLAY GRAVELLY ORGANIC lean CLAY with SAND
0L	ORGANIC SILT ORGANIC SILT with SAND ORGANIC SILT with GRAVEL SANDY ORGANIC SILT SANDY ORGANIC SILT with GRAVEL GRAVELLY ORGANIC SILT GRAVELLY ORGANIC SILT with SAND
CH	Fat CLAY Fat CLAY with SAND Fat CLAY with GRAVEL SANDY fat CLAY SANDY fat CLAY with GRAVEL GRAVELLY fat CLAY GRAVELLY fat CLAY with SAND
MH	Elastic SILT Elastic SILT with SAND Elastic SILT with GRAVEL SANDY elastic SILT SANDY elastic SILT with GRAVEL GRAVELLY elastic SILT GRAVELLY elastic SILT with SAND
OH	ORGANIC fat CLAY ORGANIC fat CLAY with SAND ORGANIC fat CLAY with GRAVEL SANDY ORGANIC fat CLAY SANDY ORGANIC fat CLAY with GRAVEL GRAVELLY ORGANIC fat CLAY GRAVELLY ORGANIC fat CLAY with SAND
OH	ORGANIC elastic SILT ORGANIC elastic SILT with SAND ORGANIC elastic SILT with GRAVEL SANDY ORGANIC elastic SILT SANDY ORGANIC elastic SILT with GRAVEL GRAVELLY ORGANIC elastic SILT GRAVELLY ORGANIC elastic SILT with SAND
OL/OH	ORGANIC SOIL ORGANIC SOIL with SAND ORGANIC SOIL with GRAVEL SANDY ORGANIC SOIL SANDY ORGANIC SOIL with GRAVEL GRAVELLY ORGANIC SOIL GRAVELLY ORGANIC SOIL with SAND

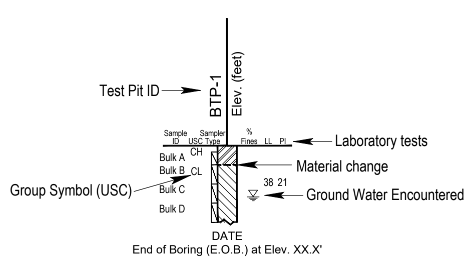
SAMPLER GRAPHIC SYMBOLS

- Standard Penetration Test (1.4 in ID)
- Modified California (2.5 in ID)
- Standard California (2.0 in ID)
- Shelby Tube (2.38 or 2.87 in ID)
- Punch Core
- Dry Core
- Sonic Core or Grab Sample
- Bag Sample

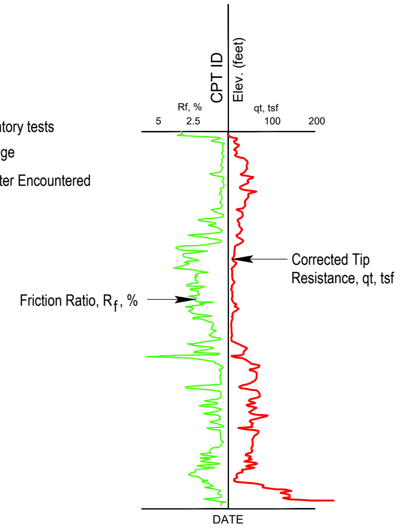
BLACKBURN BORINGS AND TEST PITS

- BCI-YEAR-ID — Exploratory Boring (September-October 2017)
- BCI-YEAR-ID — Exploratory Boring (May and December 2018)
- BCI-YEAR-ID — Exploratory Boring (November-December 2017)
- BCI-YEAR-ID — Exploratory Boring (March 2019)
- TP-ID — Approximate Test Pit Location (8-18-17)
- BTP-ID — Borrow Area Test Pits (July 2018)
- BTP-ID — Duck Slough Embankment Test Pits (July 2018) (Not in Profile View)
- BCI-YEAR-ID — CPT Exploration Location (April 2018)
- BCI-YEAR-ID — HSA Boring (August 2019) within Existing Levee/Levee Toe (Hass/Cache Sloughs)
- 5 — Proposed Duck Slough Setback Levee Centerline
- Parcel Boundary
- STA 42+00 — Geotechnical Analysis

Test Pit Information



CPT Information



NOTES:

1. Borrow area test pit locations and elevations shown are approximate and based on various levels of certainty according to available data.
2. Test pit logs represent soil conditions at the point of exploration on the date indicated.
3. Lines separating strata on boring logs represent approximate boundaries.
4. No warranty is provided as to the continuity of soil conditions between individual boring locations.
5. Geomorphology overlay source: Surficial Geologic Map of the West Delta Study Area, Plate 1 for the North Non-Urban Levee Evaluations. Produced by Department of Water Resources, Division of Flood Management, Levee Evaluations Branch in association with URS and Fugro, Scale is 1"=2000'. This is a color figure. black and white reproductions should not be relied upon as data will be lost.
6. Levee profiles are based on data provided by Wood Rodgers, Inc. 04-29-2019.
7. Borrow area test pit locations on plan and profile sheets are referenced to 60% design levee alignment received 4-10-2019.
8. Base drawings for the levee plan and profiles are based on topography terrain model data and drawings provided by Wood Rodgers, Inc. 2019.

Explanation

- Geologic contact; dashed where approximate, dotted where concealed, queried where uncertain. Solid contacts accurate to within 100' of line shown on map; dashed contacts accurate to within about 250' on either side of the line.
- Narrow channel, generally <100 ft in width. Dashed where approximate, dotted where concealed.
- Narrow, tidally influenced channel (<100 ft in width), commonly connected to a larger slough channel.
- Canal
- Levee; artificial fill prism, generally <70 ft in width.
- Borrow pit, generally <70 ft in width.

- W 1937 — Water; date indicates year of historical dataset.
- BP — Borrow pit present in 1937.

Geologic Units

HISTORICAL

- AF — Artificial fill, circa 1937.
- L — Levee (made of artificial fill), circa 1937.
- Rob — Overbank deposits; silt, sand, and lesser clay; deposited during high-stage water flow, overtopping channel banks.
- Rcs — Crevasse splay deposits; fine sand and silt with clay deposited from breaching of natural or artificial levees.
- Rch — Channel deposits; well sorted sand and trace fine gravel.
- Rsl — Slough deposits; silt, clay, and sand, fining upward facies, low-energy channel deposits.
- Ril 1906 — Intermittent lake; seasonal lake shown on historical topographic maps. Date indicates source data set.

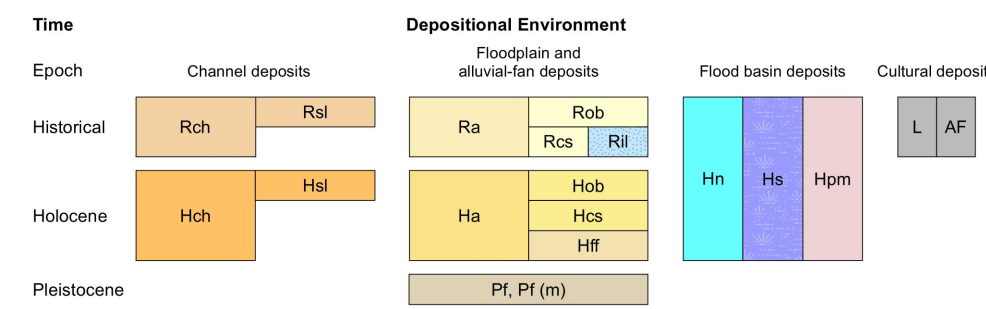
HOLOCENE

- Hob — Overbank deposits; silt, sand, and clay; deposited during high-stage water flow, overtopping channel banks.
- Hcs — Crevasse splay deposits; fine sand and silt with clay deposited from breaching of natural levees.
- Hff — Fine-grained alluvial fan deposits; silt and clay with sand.
- Hch — Channel deposits; well sorted sand and trace fine gravel.
- Hsl — Slough deposits; silt, clay, and sand, fining upward facies, low-energy channel deposits.
- Ha — Alluvial deposits, undifferentiated; sand, silt, clay and minor lenses of gravel.
- Hpm — Peat and muck; interbedded peat and organic-rich silt and clay, former tidal marsh deposits, mostly now leveed, drained, and farmed.
- Hn — Basin deposits; fine sand, silt and clay.
- Hs 1937 — Marsh deposits; silt and clay, possibly with organic-rich beds; perennially or seasonally submerged. Date indicates year of historical dataset used to map the marsh.

PLEISTOCENE

- Pf — Alluvial fan deposits; semi-consolidated silt, sand, sandy clay and fine to coarse subrounded gravel.
- Pf (m) — Alluvial fan deposits of the Montezuma Hills; semi-consolidated sandy silt, sandy clayey silt, clay, sand and minor pebble gravel eroded from the early Pleistocene Montezuma Formation

Stratigraphic Correlation Chart



REV.	DATE	BY	CHK.	APPR.	DESCRIPTION

DESIGNED BY: ROBERT B. LOKTEFF, P.E.,G.E.
DRAWN BY: MIKE ROBERTSON
CHECKED BY: NICOLE C. HART, P.E.
IN CHARGE: JONATHAN KORS, P.E.
DATE: 09/02/2019

PRELIMINARY

Prepared by: BLACKBURN CONSULTING
2491 BOATMAN AVENUE
WEST SACRAMENTO, CA 95691
www.blackburnconsulting.com
JOB NO.: 3195.x

SUBMITTED
APPROVED

Ecosystem Investment Partners

ECOSYSTEM INVESTMENT PARTNERS

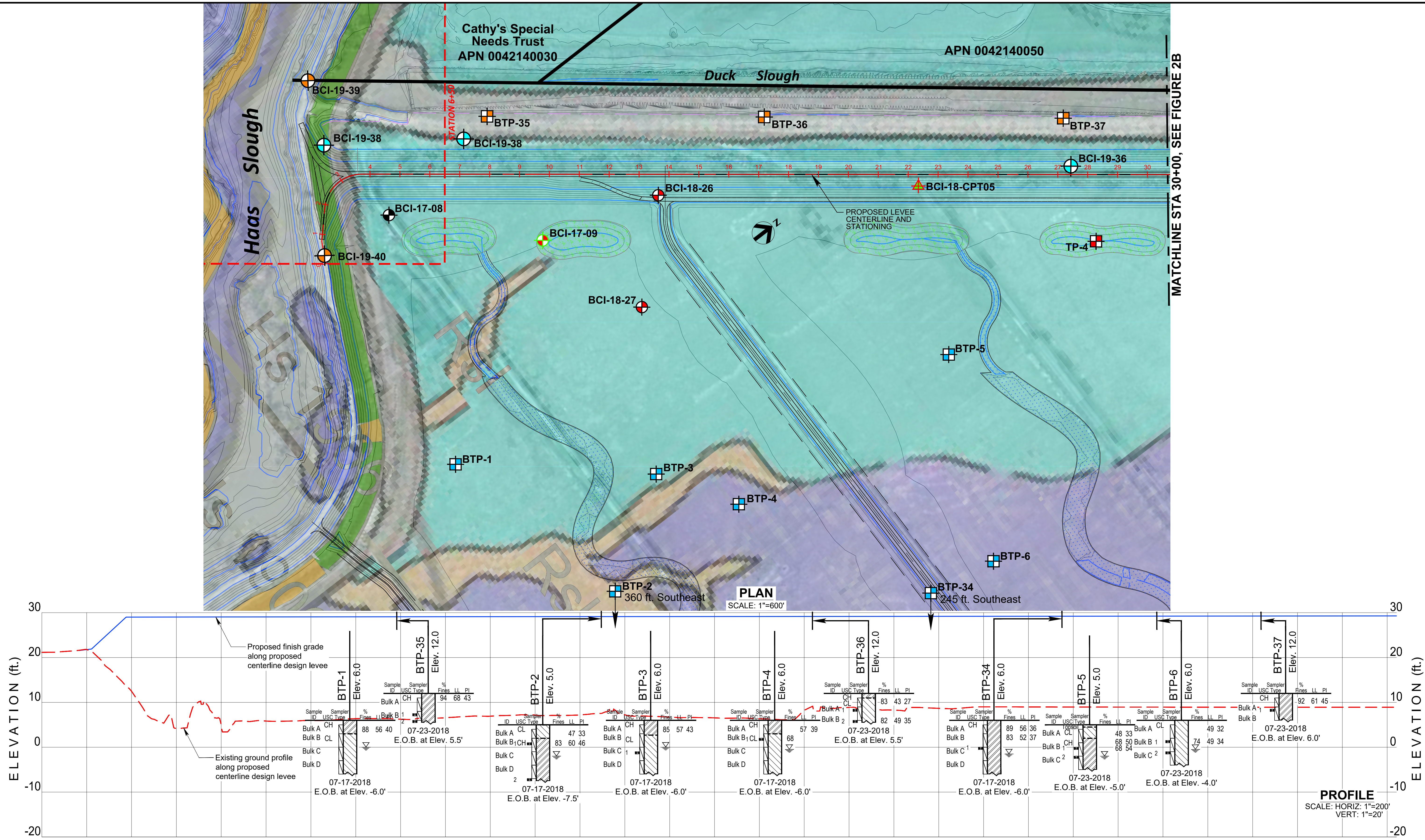
LOOKOUT SLOUGH THRFIP BORROW REPORT - 65% DESIGN

PLAN AND PROFILE LEGEND

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING, ADJUST SCALES FOR REDUCED PLOTS
0 — 1"

FIGURE NO. 5
SHEET A

\\FS-01\Common\Active Projects\3195.P DWR Lookout Slough Restoration Project\CAD\3195.x Fig5 LSRP BORROW 65%.dwg 9/26/2019 12:02 PM Mike Robertson



REV.	DATE	BY	CHK.	APPR.	DESCRIPTION

DESIGNED BY: ROBERT B. LOKTEFF, P.E.,G.E.
DRAWN BY: MIKE ROBERTSON
CHECKED BY: NICOLE C. HART, P.E.
IN CHARGE: JONATHAN KORS, P.E.
DATE: 09/02/2019

PRELIMINARY

Prepared by:
BLACKBURN CONSULTING
2491 BOATMAN AVENUE
WEST SACRAMENTO, CA 95691
www.blackburnconsulting.com
JOB NO.: 3195.x

SUBMITTED
APPROVED

Ecosystem Investment Partners

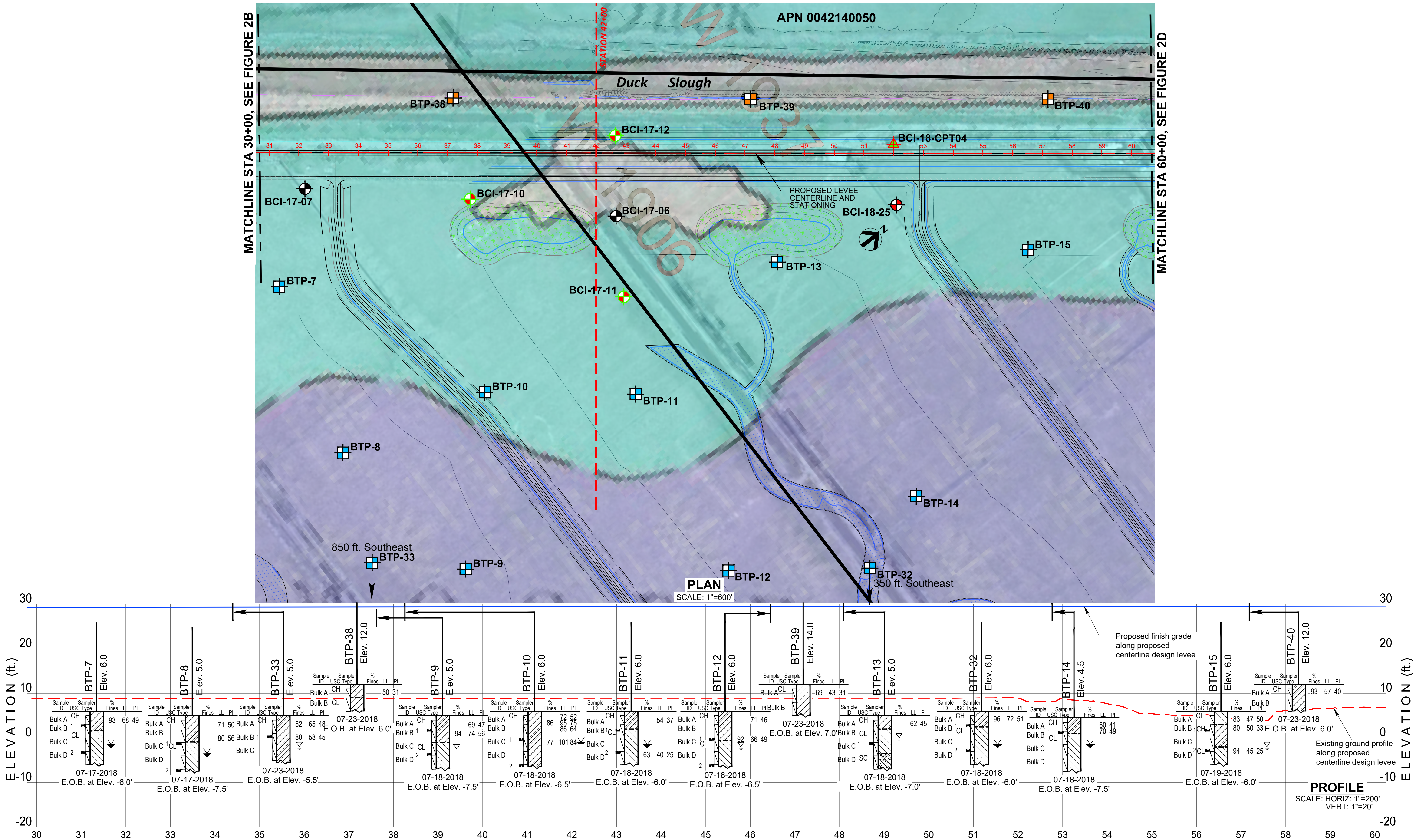
ECOSYSTEM INVESTMENT PARTNERS

LOOKOUT SLOUGH THRFIP
BORROW REPORT - 65% DESIGN

PLAN AND PROFILE STA. 0+00 to 30+00

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING, ADJUST SCALES FOR REDUCED PLOTS

FIGURE NO. 5
SHEET B



REV.	DATE	BY	CHK.	APPR.	DESCRIPTION

DESIGNED BY: ROBERT B. LOKTEFF, P.E.,G.E.
DRAWN BY: MIKE ROBERTSON
CHECKED BY: NICOLE C. HART, P.E.
IN CHARGE: JONATHAN KORS, P.E.
DATE: 09/02/2019

PRELIMINARY

Prepared by:
BLACKBURN CONSULTING
2491 BOATMAN AVENUE
WEST SACRAMENTO, CA 95691
www.blackburnconsulting.com
JOB NO.: 3195.x

SUBMITTED
APPROVED

Ecosystem Investment Partners

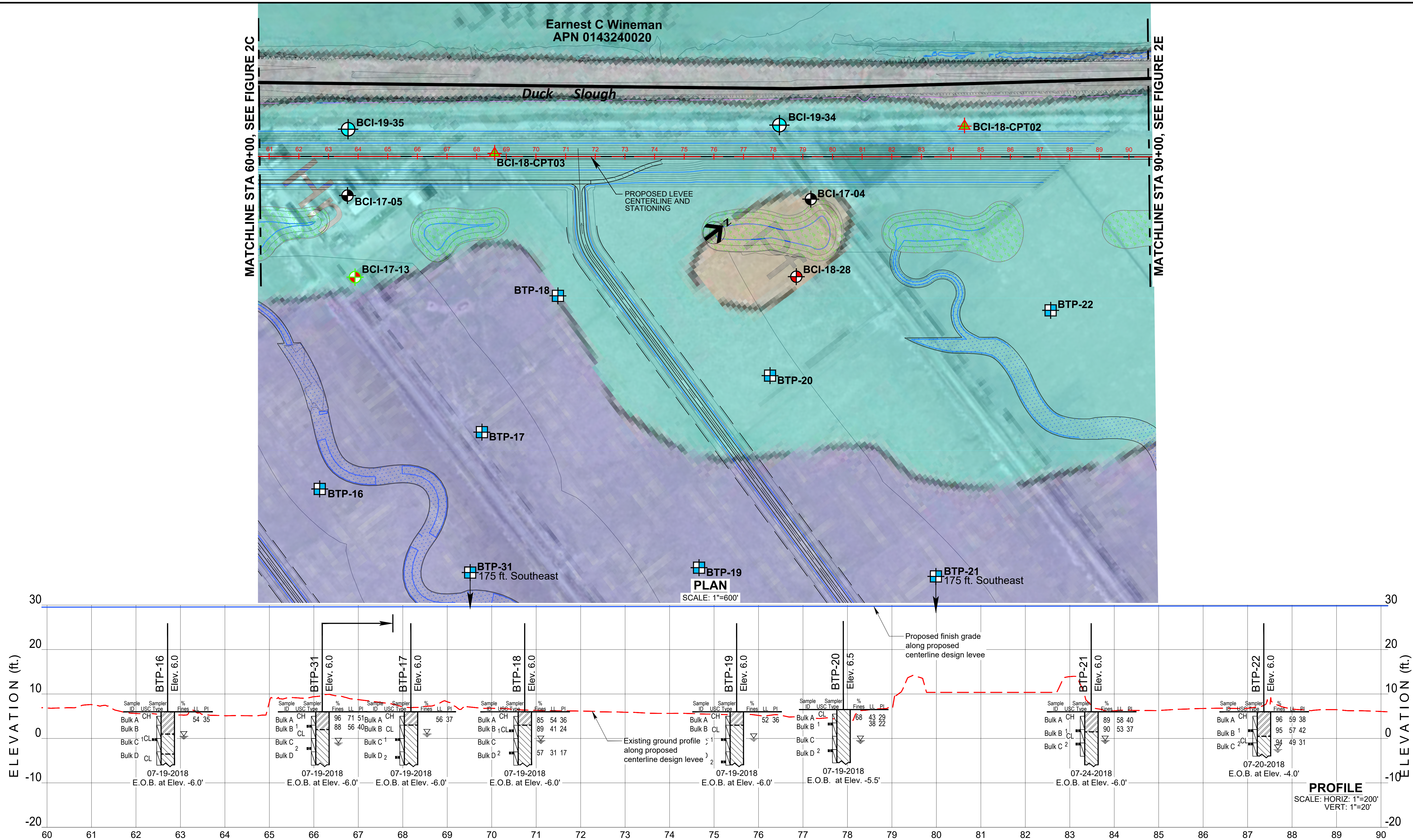
ECOSYSTEM INVESTMENT PARTNERS

LOOKOUT SLOUGH THRFIP
BORROW REPORT - 65% DESIGN

PLAN AND PROFILE STA. 30+00 to 60+00

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING, ADJUST SCALES FOR REDUCED PLOTS

FIGURE NO. 5
SHEET C



REV.	DATE	BY	CHK.	APPR.	DESCRIPTION

DESIGNED BY: ROBERT B. LOKTEFF, P.E.,G.E.
DRAWN BY: MIKE ROBERTSON
CHECKED BY: NICOLE C. HART, P.E.
IN CHARGE: JONATHAN KORS, P.E.
DATE: 09/02/2019

PRELIMINARY

Prepared by:
BLACKBURN CONSULTING
2491 BOATMAN AVENUE
WEST SACRAMENTO, CA 95691
www.blackburnconsulting.com
JOB NO.: 3195.x

SUBMITTED
APPROVED

Ecosystem Investment Partners

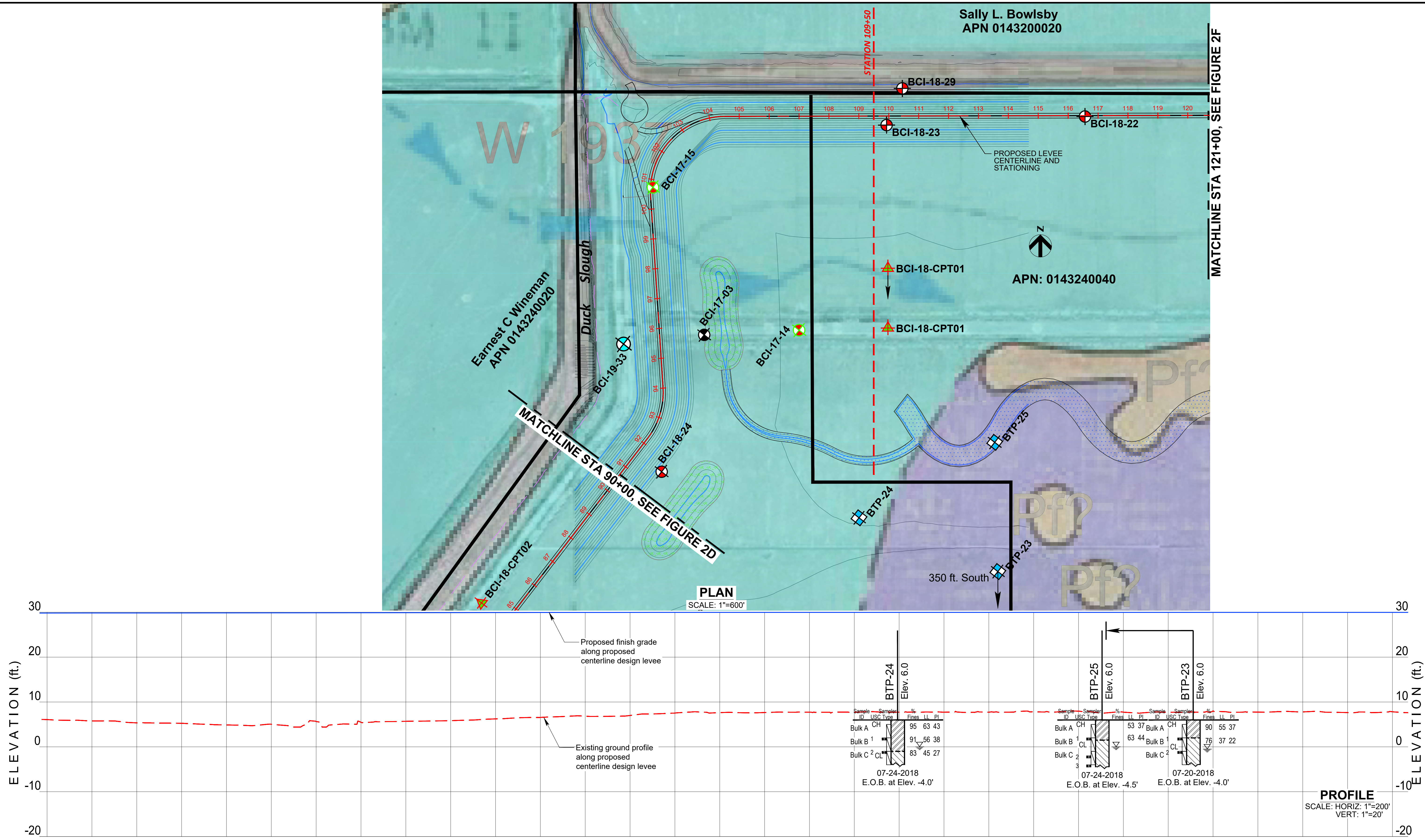
ECOSYSTEM INVESTMENT PARTNERS

LOOKOUT SLOUGH THRFIP
BORROW REPORT - 65% DESIGN

PLAN AND PROFILE STA. 60+00 to 90+00

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING, ADJUST SCALES FOR REDUCED PLOTS

FIGURE NO. 5
SHEET D



REV.	DATE	BY	CHK.	APPR.	DESCRIPTION

DESIGNED BY: ROBERT B. LOKTEFF, P.E.,G.E.
DRAWN BY: MIKE ROBERTSON
CHECKED BY: NICOLE C. HART, P.E.
IN CHARGE: JONATHAN KORS, P.E.
DATE: 09/02/2019

PRELIMINARY

Prepared by:
BLACKBURN CONSULTING
2491 BOATMAN AVENUE
WEST SACRAMENTO, CA 95691
www.blackburnconsulting.com
JOB NO.: 3195.x

SUBMITTED
APPROVED

Ecosystem Investment Partners

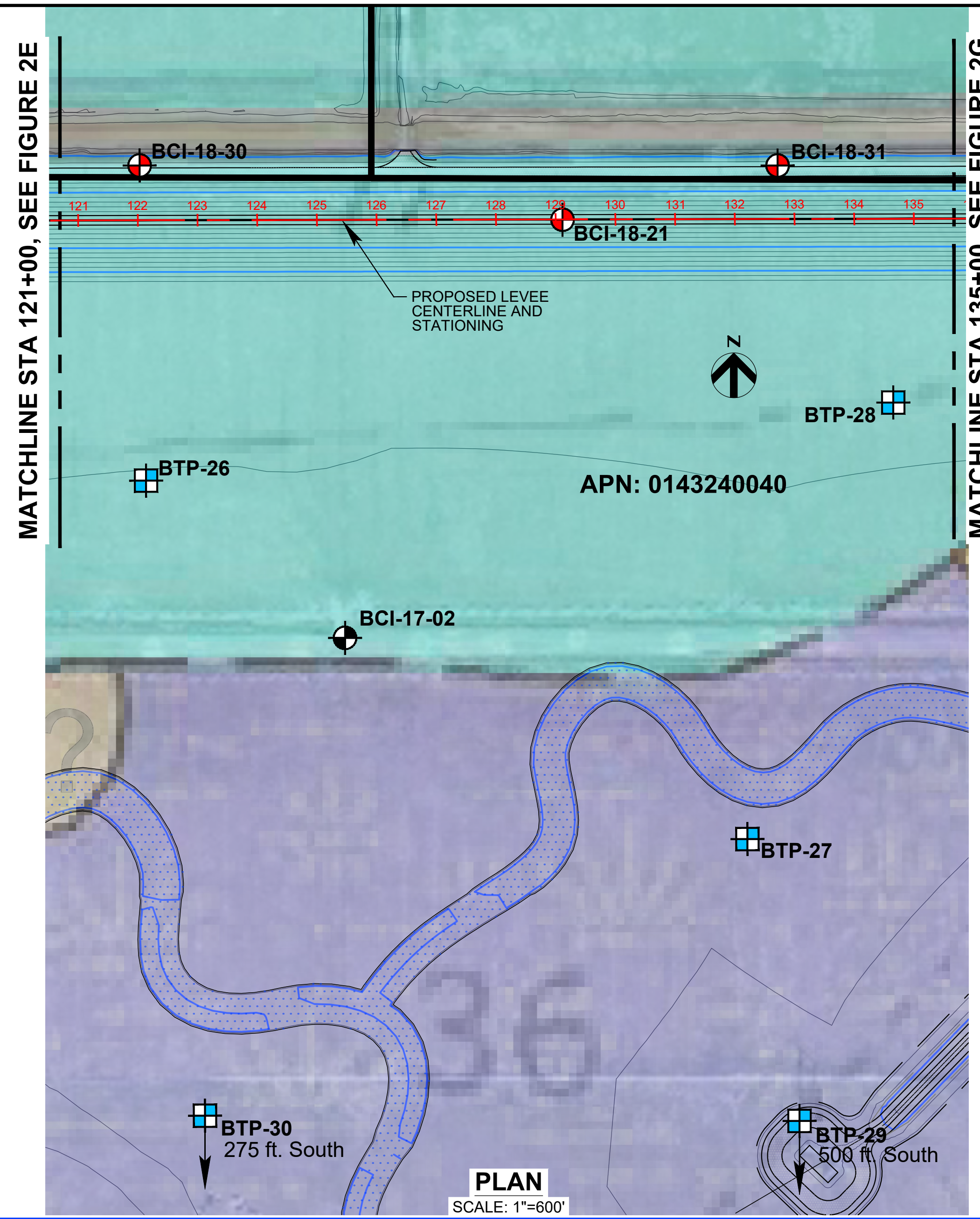
ECOSYSTEM INVESTMENT PARTNERS

LOOKOUT SLOUGH THRFIP
BORROW REPORT - 65% DESIGN

PLAN AND PROFILE STA. 90+00 to 120+00

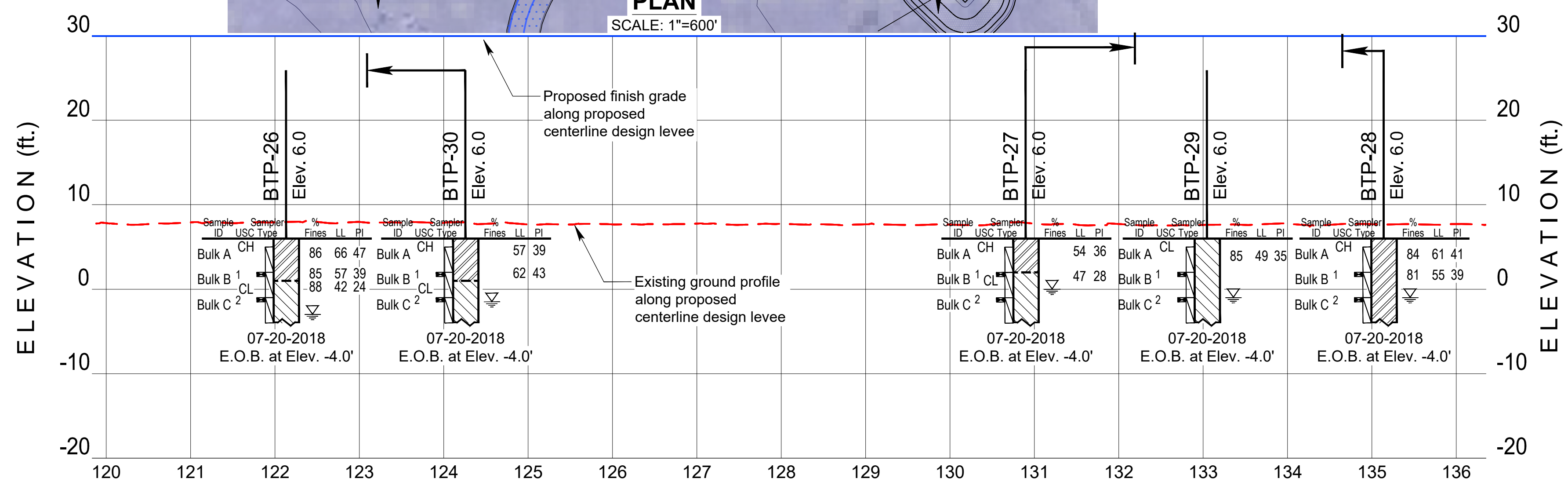
VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING, ADJUST SCALES FOR REDUCED PLOTS

FIGURE NO. 5
SHEET E



PLAN

SCALE: 1"=600'



PROFILE

SCALE: HORIZ: 1"=200'
VERT: 1"=20'

REV.	DATE	BY	CHK.	APPR.	DESCRIPTION

DESIGNED BY: ROBERT B. LOKTEFF, P.E.,G.E.
DRAWN BY: MIKE ROBERTSON
CHECKED BY: NICOLE C. HART, P.E.
IN CHARGE: JONATHAN KORS, P.E.
DATE: 09/02/2019

PRELIMINARY

Prepared by:
BLACKBURN CONSULTING
2491 BOATMAN AVENUE
WEST SACRAMENTO, CA 95691
www.blackburnconsulting.com
JOB NO.: 3195.x

SUBMITTED
APPROVED

Ecosystem Investment Partners

ECOSYSTEM INVESTMENT PARTNERS

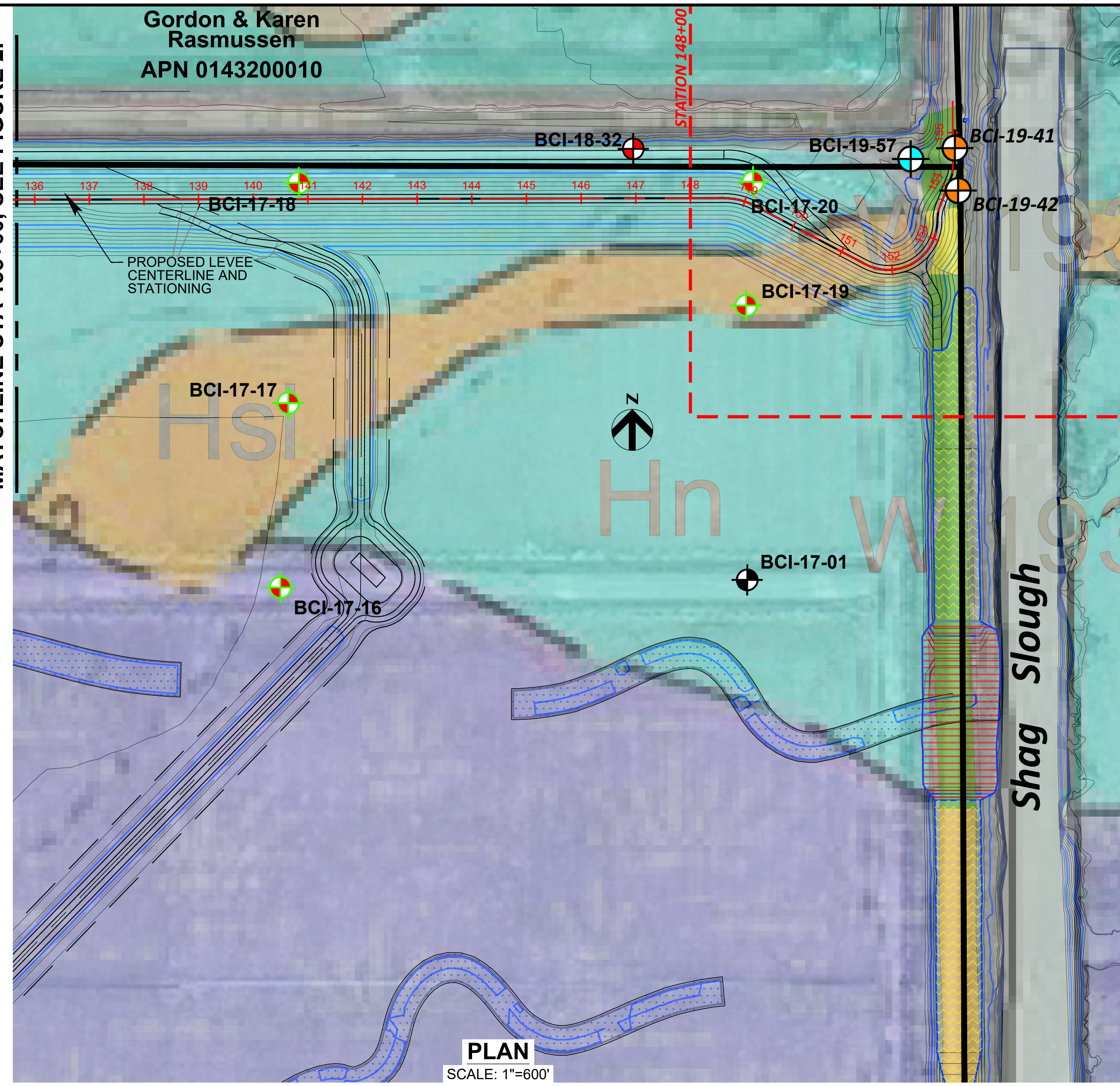
LOOKOUT SLOUGH THRFIP
BORROW REPORT - 65% DESIGN

PLAN AND PROFILE STA. 120+00 to 135+00

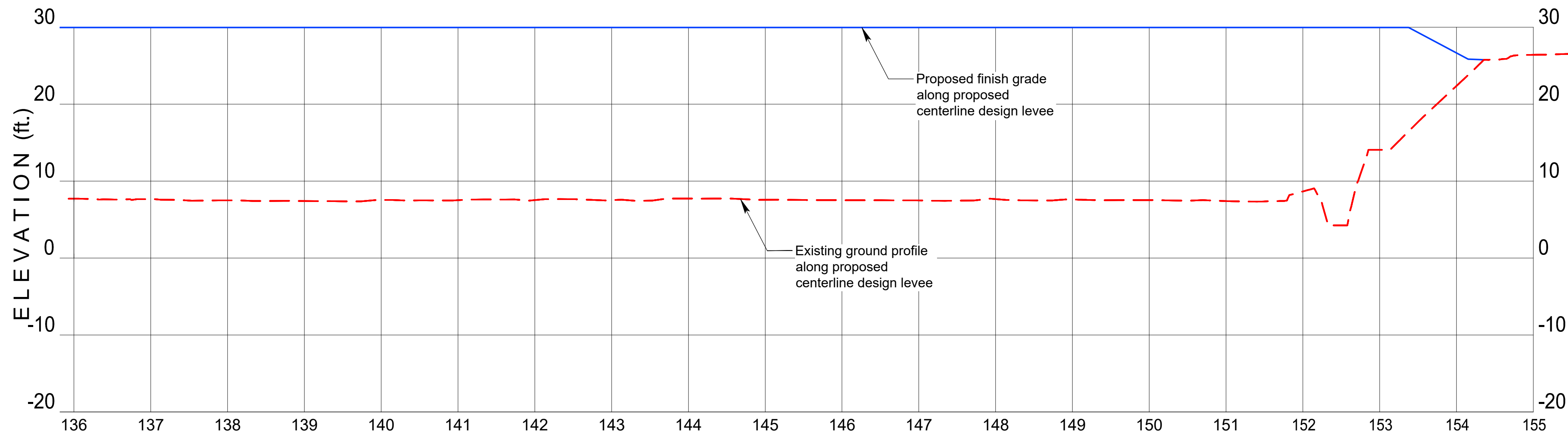
VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING, ADJUST SCALES FOR REDUCED PLOTS
0 1"

FIGURE NO. 5
SHEET F

\\VFS-01\Common\Active Projects\3195.P DWR Lookout Slough Restoration Project\CAD\3195.x Fig5 LSRP BORROW 65%.dwg 9/12/2019 3:21 PM Mike Robertson



PLAN
SCALE: 1"=600'



PROFILE
SCALE: HORIZ: 1"=200'
VERT: 1"=20'

REV.	DATE	BY	CHK.	APPR.	DESCRIPTION

DESIGNED BY: ROBERT B. LOKTEFF, P.E.,G.E.
DRAWN BY: MIKE ROBERTSON
CHECKED BY: NICOLE C. HART, P.E.
IN CHARGE: JONATHAN KORS, P.E.
DATE: 09/02/2019

PRELIMINARY

Prepared by:
BLACKBURN CONSULTING
2491 BOATMAN AVENUE
WEST SACRAMENTO, CA 95691
www.blackburnconsulting.com
JOB NO.: 3195.x

SUBMITTED
APPROVED

Ecosystem Investment Partners

ECOSYSTEM INVESTMENT PARTNERS

LOOKOUT SLOUGH THRFIP
BORROW REPORT - 65% DESIGN

PLAN AND PROFILE STA. 135+00 to 155+00

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING, ADJUST SCALES FOR REDUCED PLOTS
0 1"

FIGURE NO. 5
SHEET G

This Page Intentionally Left Blank

GEOTECHNICAL BORROW REPORT

65% Design

Lookout Slough THRFIP

Solano County, California

APPENDIX A

BCI Exploratory Test Pit Logs

This Page Intentionally Left Blank

GROUP SYMBOLS AND NAMES

Graphic / Symbol	Group Names
GW	Well-graded GRAVEL Well-graded GRAVEL with SAND
GP	Poorly graded GRAVEL Poorly graded GRAVEL with SAND
GW-GM	Well-graded GRAVEL with SILT Well-graded GRAVEL with SILT and SAND
GW-GC	Well-graded GRAVEL with CLAY (or SILTY CLAY) Well-graded GRAVEL with CLAY and SAND (or SILTY CLAY and SAND)
GP-GM	Poorly graded GRAVEL with SILT Poorly graded GRAVEL with SILT and SAND
GP-GC	Poorly graded GRAVEL with CLAY (or SILTY CLAY) Poorly graded GRAVEL with CLAY and SAND (or SILTY CLAY and SAND)
GM	SILTY GRAVEL SILTY GRAVEL with SAND
GC	CLAYEY GRAVEL CLAYEY GRAVEL with SAND
GC-GM	SILTY, CLAYEY GRAVEL SILTY, CLAYEY GRAVEL with SAND
SW	Well-graded SAND Well-graded SAND with GRAVEL
SP	Poorly graded SAND Poorly graded SAND with GRAVEL
SW-SM	Well-graded SAND with SILT Well-graded SAND with SILT and GRAVEL
SW-SC	Well-graded SAND with CLAY (or SILTY CLAY) Well-graded SAND with CLAY and GRAVEL (or SILTY CLAY and GRAVEL)
SP-SM	Poorly graded SAND with SILT Poorly graded SAND with SILT and GRAVEL
SP-SC	Poorly graded SAND with CLAY (or SILTY CLAY) Poorly graded SAND with CLAY and GRAVEL (or SILTY CLAY and GRAVEL)
SM	SILTY SAND SILTY SAND with GRAVEL
SC	CLAYEY SAND CLAYEY SAND with GRAVEL
SC-SM	SILTY, CLAYEY SAND SILTY, CLAYEY SAND with GRAVEL
PT	PEAT
	COBBLES COBBLES and BOULDERS BOULDERS

Graphic / Symbol	Group Names
CL	Lean CLAY Lean CLAY with SAND Lean CLAY with GRAVEL SANDY lean CLAY SANDY lean CLAY with GRAVEL GRAVELLY lean CLAY GRAVELLY lean CLAY with SAND
CL-ML	SILTY CLAY SILTY CLAY with SAND SILTY CLAY with GRAVEL SANDY SILTY CLAY SANDY SILTY CLAY with GRAVEL GRAVELLY SILTY CLAY GRAVELLY SILTY CLAY with SAND
ML	SILT SILT with SAND SILT with GRAVEL SANDY SILT SANDY SILT with GRAVEL GRAVELLY SILT GRAVELLY SILT with SAND
OL	ORGANIC lean CLAY ORGANIC lean CLAY with SAND ORGANIC lean CLAY with GRAVEL SANDY ORGANIC lean CLAY SANDY ORGANIC lean CLAY with GRAVEL GRAVELLY ORGANIC lean CLAY GRAVELLY ORGANIC lean CLAY with SAND
OL	ORGANIC SILT ORGANIC SILT with SAND ORGANIC SILT with GRAVEL SANDY ORGANIC SILT SANDY ORGANIC SILT with GRAVEL GRAVELLY ORGANIC SILT GRAVELLY ORGANIC SILT with SAND
CH	Fat CLAY Fat CLAY with SAND Fat CLAY with GRAVEL SANDY fat CLAY SANDY fat CLAY with GRAVEL GRAVELLY fat CLAY GRAVELLY fat CLAY with SAND
MH	Elastic SILT Elastic SILT with SAND Elastic SILT with GRAVEL SANDY elastic SILT SANDY elastic SILT with GRAVEL GRAVELLY elastic SILT GRAVELLY elastic SILT with SAND
OH	ORGANIC fat CLAY ORGANIC fat CLAY with SAND ORGANIC fat CLAY with GRAVEL SANDY ORGANIC fat CLAY SANDY ORGANIC fat CLAY with GRAVEL GRAVELLY ORGANIC fat CLAY GRAVELLY ORGANIC fat CLAY with SAND
OH	ORGANIC elastic SILT ORGANIC elastic SILT with SAND ORGANIC elastic SILT with GRAVEL SANDY elastic ELASTIC SILT SANDY ORGANIC elastic SILT with GRAVEL GRAVELLY ORGANIC elastic SILT GRAVELLY ORGANIC elastic SILT with SAND
OL/OH	ORGANIC SOIL ORGANIC SOIL with SAND ORGANIC SOIL with GRAVEL SANDY ORGANIC SOIL SANDY ORGANIC SOIL with GRAVEL GRAVELLY ORGANIC SOIL GRAVELLY ORGANIC SOIL with SAND

FIELD AND LABORATORY TESTS

C	Consolidation (ASTM D 2435)
CL	Collapse Potential (ASTM D 5333)
CP	Compaction Curve (ASTM D 698 & 1557, CTM 216)
CR	Corrosion, Sulfates, Chlorides (CTM 643, CTM 417, CTM 422)
CU	Consolidated Undrained Triaxial (ASTM D 4767)
DS	Direct Shear (ASTM D 3080)
EI	Expansion Index (ASTM D 4829)
M	Moisture Content (ASTM D 2216)
OC	Organic Content (ASTM D 2974)
P	Permeability (ASTM D 5084)
PA	Particle Size Analysis (ASTM D 6913 & 7928)
PI	Liquid Limit, Plastic Limit, Plasticity Index (ASTM D 4318)
PL	Point Load Index (ASTM D 5731)
PM	Pressure Meter
PP	Pocket Penetrometer
R	R-Value (CTM 301)
SE	Sand Equivalent (CTM 217)
SG	Specific Gravity (AASHTO T100)
SL	Shrinkage Limit (ASTM D 4943)
SW	Swell Potential (ASTM D 4546)
TV	Pocket Torvane
UC	Unconfined Compression - Soil (ASTM D 2166) Unconfined Compression - Rock (ASTM D 7012)
UU	Unconsolidated Undrained Triaxial (ASTM D 2850)
UW	Unit Weight (ASTM D 7263)
VS	Vane Shear (AASHTO T223 / ASTM D 2573)

SAMPLER GRAPHIC SYMBOLS

- Standard Penetration Test (SPT)
- California Sampler (2" ID)
- Modified California Sampler (2.4" ID)
- Shelby Tube
- Piston Sampler
- NX Rock Core
- HQ Rock Core
- Bulk Sample
- Other (see remarks)

DRILLING METHOD SYMBOLS

- Auger Drilling
- Rotary Drilling
- Dynamic Cone or Hand Driven
- Diamond Core

WATER LEVEL SYMBOLS

- First Water Level Reading (during drilling)
- Static Water Level Reading (short-term)
- Static Water Level Reading (long-term)

BLACKBURN CONSULTING

BORING RECORD LEGEND

8/5/2019 Boring Legend for Reports 2019.dwg

CONSISTENCY OF COHESIVE SOILS				
Descriptor	**Unconfined Compressive Strength (tsf)**	**Pocket Penetrometer (tsf)**	**Torvane (tsf)**	**Field Approximation**
Very Soft	< 0.25	< 0.25	< 0.12	Extrudes between fingers when squeezed
Soft	0.25 - 0.50	0.25 - 0.50	0.12 - 0.25	Easily penetrated several inches by thumb
Medium Stiff	0.50 - 1.0	0.50 - 1.0	0.25 - 0.50	Can be penetrated several inches by thumb with moderate effort
Stiff	1.0 - 2.0	1.0 - 2.0	0.50 - 1.0	Readily indented by thumb but penetrated only with great effort
Very Stiff	2.0 - 4.0	2.0 - 4.0	1.0 - 2.0	Readily indented by thumbnail
Hard	> 4.0	> 4.0	> 2.0	Indented by thumbnail with difficulty

APPARENT DENSITY OF COHESIONLESS SOILS	
Descriptor	**SPT N_{60} - Value (blows / foot)**
Very Loose	0 - 4
Loose	5 - 10
Medium Dense	11 - 30
Dense	31 - 50
Very Dense	> 50

MOISTURE	
Descriptor	**Criteria**
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, usually soil is below water table

PERCENT OR PROPORTION OF SOILS	
Descriptor	**Criteria**
Trace	Particles are present but estimated to be less than 5%
Few	5 to 10%
Little	15 to 25%
Some	30 to 45%
Mostly	50 to 100%

SOIL PARTICLE SIZE		
Descriptor		**Size**
Boulder		> 12 inches
Cobble		3 to 12 inches
Gravel	Coarse	3/4 inch to 3 inches
	Fine	No. 4 Sieve to 3/4 inch
Sand	Coarse	No. 10 Sieve to No. 4 Sieve
	Medium	No. 40 Sieve to No. 10 Sieve
	Fine	No. 200 Sieve to No. 40 Sieve
Silt and Clay		Passing No. 200 Sieve

PLASTICITY OF FINE-GRAINED SOILS	
Descriptor	**Criteria**
Nonplastic	A 1/8-inch thread cannot be rolled at any water content.
Low	The thread can barely be rolled, and the lump cannot be formed when drier than the plastic limit.
Medium	The thread is easy to roll, and not much time is required to reach the plastic limit; it cannot be rerolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit.
High	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be rerolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit.

CEMENTATION	
Descriptor	**Criteria**
Weak	Crumbles or breaks with handling or little finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

<u>**NOTE**</u>: This legend sheet provides descriptors and associated criteria for required soil description components only. Refer to Caltrans Soil and Rock Logging, Classification, and Presentation Manual (2010), Section 2, for tables of additional soil description components and discussion of soil description and identification.

8/5/2019 Boring Legend for Reports 2019.dwg

BLACKBURN
CONSULTING

BORING RECORD LEGEND

LOGGED BY	BEGIN DATE	COMPLETION DATE	LOCATION (Lat/Long or North/East and Datum)	HOLE ID
DWC	7-17-18	7-17-18	38.305781° / -121.72735°	BTP01

CONTRACTOR Hanford ARC	LOCATION (Offset, Station, Line)	SURFACE ELEVATION 6.0 ft
OPERATOR'S NAME Emilio / HELPER'S NAME	EQUIPMENT CAT 316E excavator	TOTAL DEPTH 12.0 ft
EXCAVATION METHOD Test Pit	DRILLING ROD TYPE AND DIAMETER / BUCKET WIDTH 2'	BOREHOLE DIAMETER
SAMPLER TYPE(S) AND SIZE(S) (ID) 2.4"-diameter	HAMMER TYPE	HAMMER EFFICIENCY, ERi
BACKFILL AND COMPLETION Backfill Native Soil	GROUND WATER READINGS — DURING: 6.0 ft; AFTER (DATE):	CASING TYPE AND DIAMETER(in)

ELEVATION (ft)	DEPTH (ft)	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests	Drilling Method
	0	Fat CLAY (CH); medium stiff; black; moist														
4.00	1–3			Bulk A							56	40	88			
2.00	3–6	Lean CLAY (CL); medium stiff; olive brown; moist		Bulk B												
0.00	6–9	becomes wet		Bulk C												
-2.00 to -6.00	9–12			Bulk D												

Bottom of exploration at 12.0 ft below ground surface (bgs)

Backfill Native Soil
Ground water encountered at 6 ft bgs
Bulk A 1-3 ft bgs
Bulk B 3-6 ft bgs
Bulk C 6-9 ft bgs
Bulk D 9-12 ft bgs

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	3195.X	BTP01
COUNTY: SOL	ROUTE	POSTMILE
CLIENT: Ecosystems Investment Partners		
PREPARED BY: LDM	CHECKED BY: DWC	SHEET: 1 of 1

LOGGED BY	BEGIN DATE	COMPLETION DATE	LOCATION (Lat/Long or North/East and Datum)	HOLE ID
DWC	7-17-18	7-17-18	38.305679° / -121.723995°	BTP02

CONTRACTOR Hanford ARC	LOCATION (Offset, Station, Line)	SURFACE ELEVATION 5.0 ft
OPERATOR'S NAME Emilio HELPER'S NAME	EQUIPMENT CAT 316E excavator	TOTAL DEPTH 12.5 ft
EXCAVATION METHOD Test Pit	DRILLING ROD TYPE AND DIAMETER / BUCKET WIDTH 2'	BOREHOLE DIAMETER
SAMPLER TYPE(S) AND SIZE(S) (ID) 2.4"-diameter	HAMMER TYPE	HAMMER EFFICIENCY, ERi
BACKFILL AND COMPLETION Backfill Native Soil	GROUND WATER READINGS — DURING: 7.0 ft; AFTER (DATE):	CASING TYPE AND DIAMETER(in)

ELEVATION (ft)	DEPTH (ft)	Material Graphics	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests	Drilling Method
	0		Lean CLAY (CL); medium stiff; dark grayish brown; moist														
	1											47	33				
3.00	2				Bulk A												
	3		Fat CLAY with SAND (CH); very stiff; light olive brown; moist														
1.00	4				1				2.25	23	100	60	46	83			
	5				Bulk B												
-1.00	6																
	7		wet		Bulk C												
-3.00	8																
	9																
-5.00	10				Bulk D												
	11																
-7.00	12				2												
	13		Bottom of exploration at 12.5 ft below ground surface (bgs)														
-9.00	14																
	15																
-11.00	16																
	17																
-13.00	18																
	19																
-15.00	20																
	21																
-17.00	22																
	23																
-19.00	24																
	25																

Backfill Native Soil
Ground water encountered at 7 ft bgs
Bulk A 1-3 ft bgs
Bulk B 3-6 ft bgs
Bulk C 6-9 ft bgs
Bulk D 9-12 ft bgs

blackburn consulting
Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	3195.X	BTP02
COUNTY: SOL	ROUTE	POSTMILE
CLIENT: Ecosystems Investment Partners		
PREPARED BY: LDM	CHECKED BY: DWC	SHEET: 1 of 1

LOGGED BY	BEGIN DATE	COMPLETION DATE	LOCATION (Lat/Long or North/East and Datum)	HOLE ID
DWC	7-17-18	7-17-18	38.307182° / -121.725828°	BTP03

CONTRACTOR Hanford ARC		LOCATION (Offset, Station, Line)	SURFACE ELEVATION 6.0 ft
OPERATOR'S NAME Emilio	HELPER'S NAME	EQUIPMENT CAT 316E excavator	TOTAL DEPTH 12.0 ft
EXCAVATION METHOD Test Pit		DRILLING ROD TYPE AND DIAMETER / BUCKET WIDTH 2'	BOREHOLE DIAMETER
SAMPLER TYPE(S) AND SIZE(S) (ID) 2.4"-diameter		HAMMER TYPE	HAMMER EFFICIENCY, ERi
BACKFILL AND COMPLETION Backfill Native Soil		GROUND WATER READINGS — DURING: 6.0 ft; AFTER (DATE):	CASING TYPE AND DIAMETER(in)

ELEVATION (ft)	DEPTH (ft)	Material Graphics	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests	Drilling Method
	0		Fat CLAY (CH); medium stiff; very dark grayish brown; moist														
4.00	1–3				Bulk A							57	43	85			
2.00	3		Lean CLAY (CL); medium stiff; mottled olive gray and brown; moist														
	5		brown		Bulk B												
0.00	6		some strong cementation, wet														
-2.00	7–9				1 Bulk C												
-4.00	9–12				Bulk D												
-6.00	12		Bottom of exploration at 12.0 ft below ground surface (bgs)														

Backfill Native Soil
Ground water encountered at 6 ft bgs
Bulk A 1-3 ft bgs
Bulk B 3-6 ft bgs
Bulk C 6-9 ft bgs
Bulk D 9-12 ft bgs

Elevation scale: 4.00, 2.00, 0.00, -2.00, -4.00, -6.00, -8.00, -10.00, -12.00, -14.00, -16.00, -18.00; Depth scale 0–25

blackburn consulting

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	3195.X	BTP03
COUNTY: SOL	ROUTE	POSTMILE
CLIENT: Ecosystems Investment Partners		
PREPARED BY: LDM	CHECKED BY: DWC	SHEET: 1 of 1

LOGGED BY	BEGIN DATE	COMPLETION DATE	LOCATION (Lat/Long or North/East and Datum)	HOLE ID
DWC	**7-17-18**	**7-17-18**	**38.307613° / -121.72496°**	**BTP04**
CONTRACTOR **Hanford ARC**			LOCATION (Offset, Station, Line)	SURFACE ELEVATION **6.0 ft**
OPERATOR'S NAME **Emilio**	HELPER'S NAME		EQUIPMENT **CAT 316E excavator**	TOTAL DEPTH **12.0 ft**
EXCAVATION METHOD **Test Pit**			DRILLING ROD TYPE AND DIAMETER / BUCKET WIDTH **2'**	BOREHOLE DIAMETER
SAMPLER TYPE(S) AND SIZE(S) (ID) **2.4"-diameter**			HAMMER TYPE	HAMMER EFFICIENCY, ERi
BACKFILL AND COMPLETION **Backfill Native Soil**			GROUND WATER READINGS — DURING **6.5 ft** — AFTER (DATE)	CASING TYPE AND DIAMETER(in)

ELEVATION (ft)	DEPTH (ft)	Material Graphics	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests	Drilling Method
	0		Fat CLAY (CH); medium stiff; black; moist														
	1											57	39				
4.00	2				Bulk A												
	3		SANDY Lean CLAY (CL); hard; dark yellowish brown; moist														
2.00	4				1				4.0	23	97			68			
	5				Bulk B												
0.00	6		some cementation														
	7		wet		Bulk C												
-2.00	8																
	9																
-4.00	10				Bulk D												
	11																
-6.00	12		Bottom of exploration at 12.0 ft below ground surface (bgs)														
	13		Backfill Native Soil Ground water encountered at 6.5 ft bgs Bulk A 1-3 ft bgs Bulk B 3-6 ft bgs Bulk C 6-9 ft bgs Bulk D 9-12 ft bgs														
-8.00	14																
	15																
-10.00	16																
	17																
-12.00	18																
	19																
-14.00	20																
	21																
-16.00	22																
	23																
-18.00	24																
	25																

Laboratory Data

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME		FILE NO.	HOLE ID
Lookout Slough THRFIP		**3195.X**	**BTP04**
COUNTY **SOL**	ROUTE		POSTMILE
CLIENT **Ecosystems Investment Partners**			
PREPARED BY **LDM**	CHECKED BY **DWC**	SHEET **1 of 1**	

LOGGED BY **DWC**	BEGIN DATE **7-23-18**	COMPLETION DATE **7-23-18**	LOCATION (Lat/Long or North/East and Datum) **38.309979° / -121.72484°**	HOLE ID **BTP05**
CONTRACTOR **Hanford ARC**			LOCATION (Offset, Station, Line)	SURFACE ELEVATION **5.0 ft**
OPERATOR'S NAME **Emilio**	HELPER'S NAME		EQUIPMENT **CAT 316E excavator**	TOTAL DEPTH **10.0 ft**
EXCAVATION METHOD **Test Pit**			DRILLING ROD TYPE AND DIAMETER / BUCKET WIDTH **2'**	BOREHOLE DIAMETER
SAMPLER TYPE(S) AND SIZE(S) (ID) **2.4"-diameter**			HAMMER TYPE	HAMMER EFFICIENCY, ERi
BACKFILL AND COMPLETION **Backfill Native Soil**			GROUND WATER READINGS DURING **7.0 ft** AFTER (DATE)	CASING TYPE AND DIAMETER(in)

ELEVATION (ft)	DEPTH (ft)	DESCRIPTION	Sample Number	Liquid Limit	Plasticity Index
	0	Topsoil			
	0.5	Lean CLAY (CL); medium stiff; olive brown; moist			
	1			48	33
3.00	2		Bulk A		
	3	Fat CLAY (CH); medium stiff, black, moist		68	50
1.00	4	olive gray		68	54
	5		1		
-1.00	6		Bulk B		
	7	wet	2		
-3.00	8		Bulk C		
	9				
-5.00	10	Bottom of exploration at 10.0 ft below ground surface (bgs)			

Laboratory Data columns (Moisture Content (%), Dry Density (pcf), % <#200, Shear Strength Test, Additional Lab Tests), Sample Location, Blows per 6 in., Blows per foot, Recovery (%), Pocket Penetrometer, Drilling Method: no entries.

Backfill Native Soil
Ground water encountered at 7 ft bgs
Bulk A 1-4 ft bgs
Bulk B 4-7 ft bgs
Bulk C 7-10 ft bgs

Elevation / Depth scale: -7.00 / 12, -9.00 / 14, -11.00 / 16, -13.00 / 18, -15.00 / 20, -17.00 / 22, -19.00 / 24, 25

blackburn consulting

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME **Lookout Slough THRFIP**		FILE NO. **3195.X**	HOLE ID **BTP05**
COUNTY **SOL**	ROUTE		POSTMILE
CLIENT **Ecosystems Investment Partners**			
PREPARED BY **LDM**	CHECKED BY **DWC**	SHEET **1 of 1**	

LOGGED BY	BEGIN DATE	COMPLETION DATE	LOCATION (Lat/Long or North/East and Datum)	HOLE ID
DWC	**7-23-18**	**7-23-18**	**38.309141° / -121.722617°**	**BTP06**
CONTRACTOR **Hanford ARC**			LOCATION (Offset, Station, Line)	SURFACE ELEVATION **6.0 ft**
OPERATOR'S NAME **Emilio**	HELPER'S NAME		EQUIPMENT **CAT 316E excavator**	TOTAL DEPTH **10.0 ft**
EXCAVATION METHOD **Test Pit**			DRILLING ROD TYPE AND DIAMETER / BUCKET WIDTH **2'**	BOREHOLE DIAMETER
SAMPLER TYPE(S) AND SIZE(S) (ID) **2.4"-diameter**			HAMMER TYPE	HAMMER EFFICIENCY, ERi
BACKFILL AND COMPLETION **Backfill Native Soil**			GROUND WATER READINGS — DURING **6.5 ft** — AFTER (DATE)	CASING TYPE AND DIAMETER(in)

ELEVATION (ft)	DEPTH (ft)	Material Graphics	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests	Drilling Method
	0		Lean CLAY (CL); medium stiff; very dark grayish brown; moist; some organics														
	1											49	32				
4.00	2				Bulk A												
	3																
2.00	4		Lean CLAY with SAND (CL); very stiff; dark yellowish brown; moist; trace cementation														
	5				1				3.0	22	95	49	34	74			
0.00	6				Bulk B												
	7		some cementation; wet		2												
-2.00	8				Bulk C												
	9																
-4.00	10		Bottom of exploration at 10.0 ft below ground surface (bgs)														

Laboratory Data

Backfill Native Soil
Ground water encountered at 6.5 ft bgs
Bulk A 1-4 ft bgs
Bulk B 4-7 ft bgs
Bulk C 7-10 ft bgs

Elevation scale: -6.00 (12), -8.00 (14), -10.00 (16), -12.00 (18), -14.00 (20), -16.00 (22), -18.00 (24); depth to 25

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	**3195.X**	**BTP06**
COUNTY **SOL**	ROUTE	POSTMILE
CLIENT **Ecosystems Investment Partners**		
PREPARED BY **LDM**	CHECKED BY **DWC**	SHEET **1 of 1**

LOGGED BY	BEGIN DATE	COMPLETION DATE	LOCATION (Lat/Long or North/East and Datum)	HOLE ID
LDM	**7-17-18**	**7-17-18**	**38.311967° / -121.723553°**	**BTP07**

CONTRACTOR **Hanford ARC**	LOCATION (Offset, Station, Line)	SURFACE ELEVATION **6.0 ft**
OPERATOR'S NAME **Emilio** / HELPER'S NAME	EQUIPMENT **CAT 316E excavator**	TOTAL DEPTH **12.0 ft**
EXCAVATION METHOD **Test Pit**	DRILLING ROD TYPE AND DIAMETER / BUCKET WIDTH **2'**	BOREHOLE DIAMETER
SAMPLER TYPE(S) AND SIZE(S) (ID) **2.4"-diameter**	HAMMER TYPE	HAMMER EFFICIENCY, ERi
BACKFILL AND COMPLETION **Backfill Native Soil**	GROUND WATER READINGS — DURING **7.5 ft** — AFTER (DATE)	CASING TYPE AND DIAMETER(in)

ELEVATION (ft)	DEPTH (ft)	DESCRIPTION	Sample Number	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200
	0	Fat CLAY (CH); stiff; very dark grayish brown; moist							
4.00	1–3		Bulk A				68	49	93
	3		1	1.7	28	92			
2.00	4	Lean CLAY (CL); medium stiff; grayish brown; moist	Bulk B						
0.00	6		Bulk C						
-2.00	8	some cementation							
		wet							
	9		2						
-4.00	10		Bulk D						
-6.00	12	Bottom of exploration at 12.0 ft below ground surface (bgs)							

Backfill Native Soil
Ground water encountered at 7.5 ft bgs
Bulk A 1-3 ft bgs
Bulk B 3-6 ft bgs
Bulk C 6-9 ft bgs
Bulk D 9-12 ft bgs

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	**3195.X**	**BTP07**
COUNTY **SOL**	ROUTE	POSTMILE
CLIENT **Ecosystems Investment Partners**		
PREPARED BY **LDM**	CHECKED BY **DWC**	SHEET **1 of 1**

LOGGED BY	BEGIN DATE	COMPLETION DATE	LOCATION (Lat/Long or North/East and Datum)	HOLE ID
LDM	7-17-18	7-17-18	38.311494° / -121.72156°	BTP08

CONTRACTOR **Hanford ARC**	LOCATION (Offset, Station, Line)	SURFACE ELEVATION **5.0 ft**
OPERATOR'S NAME **Emilio** — HELPER'S NAME	EQUIPMENT **CAT 316E excavator**	TOTAL DEPTH **12.5 ft**
EXCAVATION METHOD **Test Pit**	DRILLING ROD TYPE AND DIAMETER / BUCKET WIDTH **2'**	BOREHOLE DIAMETER
SAMPLER TYPE(S) AND SIZE(S) (ID) **2.4"-diameter**	HAMMER TYPE	HAMMER EFFICIENCY, ERi
BACKFILL AND COMPLETION **Backfill Native Soil**	GROUND WATER READINGS — DURING **8.5 ft** — AFTER (DATE)	CASING TYPE AND DIAMETER(in)

ELEVATION (ft)	DEPTH (ft)	Material Graphics	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests	Drilling Method
	0		Fat CLAY (CH); medium stiff; dark olive gray; moist														
3.00	1–3				Bulk A							71	50				
1.00	3–6		grayish brown		Bulk B							80	56				
-1.00	6		Lean CLAY (CL); medium stiff; dark grayish brown; moist		1												
-3.00	6–9				Bulk C												
-5.00	9–12		some cementation wet		Bulk D												
-7.00	12				2												

Laboratory Data

Bottom of exploration at 12.5 ft below ground surface (bgs)

Backfill Native Soil
Ground water encountered at 8.5 ft bgs
Bulk A 1-3 ft bgs
Bulk B 3-6 ft bgs
Bulk C 6-9 ft bgs
Bulk D 9-12 ft bgs

Elevation scale: 3.00, 1.00, -1.00, -3.00, -5.00, -7.00, -9.00, -11.00, -13.00, -15.00, -17.00, -19.00; Depth scale: 0–25

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	3195.X	BTP08
COUNTY: SOL	ROUTE	POSTMILE
CLIENT: Ecosystems Investment Partners		
PREPARED BY: LDM	CHECKED BY: DWC	SHEET: 1 of 1

LOGGED BY	BEGIN DATE	COMPLETION DATE	LOCATION (Lat/Long or North/East and Datum)	HOLE ID
LDM	**7-18-18**	**7-18-18**	**38.31173° / -121.7196°**	**BTP09**

CONTRACTOR	LOCATION (Offset, Station, Line)	SURFACE ELEVATION
Hanford ARC		**5.0 ft**
OPERATOR'S NAME: **Emilio** / HELPER'S NAME:	EQUIPMENT: **CAT 316E excavator**	TOTAL DEPTH: **12.0 ft**
EXCAVATION METHOD: **Test Pit**	DRILLING ROD TYPE AND DIAMETER / BUCKET WIDTH: **2'**	BOREHOLE DIAMETER:
SAMPLER TYPE(S) AND SIZE(S) (ID): **2.4"-diameter**	HAMMER TYPE:	HAMMER EFFICIENCY, ERi:
BACKFILL AND COMPLETION: **Backfill Native Soil**	GROUND WATER READINGS — DURING: **7.5 ft**; AFTER (DATE):	CASING TYPE AND DIAMETER(in):

ELEVATION (ft)	DEPTH (ft)	Material Graphics	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests	Drilling Method
	0		Fat CLAY (CH); stiff; dark grayish brown; moist														
3.00	1–3				Bulk A							69	47				
	3				1				1.75	32	88	74	56	94			
1.00	3–6				Bulk B												
-1.00	6		Lean CLAY (CL); medium stiff; dark yellowish brown; moist														
-3.00	6–9		some cementation		Bulk C												
	9		wet		2												
-5.00	9–12				Bulk D												
-7.00	12		Bottom of exploration at 12.0 ft below ground surface (bgs)														

Elevation scale: 3.00, 1.00, -1.00, -3.00, -5.00, -7.00, -9.00, -11.00, -13.00, -15.00, -17.00, -19.00; Depth scale 0–25 ft.

Backfill Native Soil
Ground water encountered at 7.5 ft bgs
Bulk A 1-3 ft bgs
Bulk B 3-6 ft bgs
Bulk C 6-9 ft bgs
Bulk D 9-12 ft bgs

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	**3195.X**	**BTP09**
COUNTY: **SOL**	ROUTE:	POSTMILE:
CLIENT: **Ecosystems Investment Partners**		
PREPARED BY: **LDM**	CHECKED BY: **DWC**	SHEET: **1 of 1**

LOGGED BY	BEGIN DATE	COMPLETION DATE	LOCATION (Lat/Long or North/East and Datum)	HOLE ID
LDM	**7-18-18**	**7-18-18**	**38.31287° / -121.7211°**	**BTP10**

CONTRACTOR **Hanford ARC**	LOCATION (Offset, Station, Line)	SURFACE ELEVATION **6.0 ft**
OPERATOR'S NAME **Emilio** / HELPER'S NAME	EQUIPMENT **CAT 316E excavator**	TOTAL DEPTH **12.5 ft**
EXCAVATION METHOD **Test Pit**	DRILLING ROD TYPE AND DIAMETER / BUCKET WIDTH **2'**	BOREHOLE DIAMETER
SAMPLER TYPE(S) AND SIZE(S) (ID) **2.4"-diameter**	HAMMER TYPE	HAMMER EFFICIENCY, ERi
BACKFILL AND COMPLETION **Backfill Native Soil**	GROUND WATER READINGS — DURING **7.0 ft** — AFTER (DATE)	CASING TYPE AND DIAMETER(in)

ELEVATION (ft)	DEPTH (ft)	Material Graphics	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests	Drilling Method
										Laboratory Data							
	0		Fat CLAY (CH); medium stiff; dark grayish brown; moist														
	1				Bulk A							72	52				
4.00	2																
	3											95	75	86			
2.00	4				Bulk B							86	64				
	5		Fat CLAY with SAND (CH); stiff; mottled dark yellowish brown and grayish brown; moist														
0.00	6				1				1.25	30	93	101	84	77			
	7				Bulk C												
-2.00	8		some medium to strong cementation wet														
	9		dark yellowish brown														
-4.00	10				Bulk D												
	11																
-6.00	12				2												
	13		Bottom of exploration at 12.5 ft below ground surface (bgs) Backfill Native Soil Ground water encountered at 7 ft bgs Bulk A 1-3 ft bgs Bulk B 3-6 ft bgs Bulk C 6-9 ft bgs Bulk D 9-12 ft bgs														
-8.00	14																
	15																
-10.00	16																
	17																
-12.00	18																
	19																
-14.00	20																
	21																
-16.00	22																
	23																
-18.00	24																
	25																

blackburn consulting

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	**3195.X**	**BTP10**
COUNTY **SOL**	ROUTE	POSTMILE
CLIENT **Ecosystems Investment Partners**		
PREPARED BY **LDM**	CHECKED BY **DWC**	SHEET **1 of 1**

LOGGED BY	BEGIN DATE	COMPLETION DATE	LOCATION (Lat/Long or North/East and Datum)	HOLE ID
LDM	7-18-18	7-18-18	38.31396° / -121.72°	BTP11

CONTRACTOR **Hanford ARC**	LOCATION (Offset, Station, Line)	SURFACE ELEVATION **6.0 ft**
OPERATOR'S NAME **Emilio** HELPER'S NAME	EQUIPMENT **CAT 316E excavator**	TOTAL DEPTH **12.0 ft**
EXCAVATION METHOD **Test Pit**	DRILLING ROD TYPE AND DIAMETER / BUCKET WIDTH **2'**	BOREHOLE DIAMETER
SAMPLER TYPE(S) AND SIZE(S) (ID) **2.4"-diameter**	HAMMER TYPE	HAMMER EFFICIENCY, ERi
BACKFILL AND COMPLETION **Backfill Native Soil**	GROUND WATER READINGS — DURING **7.5 ft** — AFTER (DATE)	CASING TYPE AND DIAMETER(in)

ELEVATION (ft)	DEPTH (ft)	Material Graphics	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests	Drilling Method
	0		Fat CLAY (CH); medium stiff; dark grayish brown; moist														
	1											54	37				
4.00	2				Bulk A												
	3																
2.00	4		SANDY Lean CLAY (CL); medium stiff; dark yellowish brown; moist		1												
	5		some cementation		Bulk B												
0.00	6																
	7				Bulk C												
-2.00	8		some moderate cementation														
	9		soft, wet		2				0.25	31	92	40	25	63			
-4.00	10				Bulk D												
	11																
-6.00	12		Bottom of exploration at 12.0 ft below ground surface (bgs)														

Laboratory Data

Backfill Native Soil
Ground water encountered at 7.5 ft bgs
Bulk A 1-3 ft bgs
Bulk B 3-6 ft bgs
Bulk C 6-9 ft bgs
Bulk D 9-12 ft bgs

Elevation/depth scale: 13, -8.00 14, 15, -10.00 16, 17, -12.00 18, 19, -14.00 20, 21, -16.00 22, 23, -18.00 24, 25

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	3195.X	BTP11
COUNTY: SOL	ROUTE	POSTMILE
CLIENT: Ecosystems Investment Partners		
PREPARED BY: LDM	CHECKED BY: DWC	SHEET: 1 of 1

LOGGED BY	BEGIN DATE	COMPLETION DATE	LOCATION (Lat/Long or North/East and Datum)	HOLE ID
LDM	7-18-18	7-18-18	38.31364° / -121.7177°	BTP12

CONTRACTOR Hanford ARC	LOCATION (Offset, Station, Line)	SURFACE ELEVATION 6.0 ft
OPERATOR'S NAME Emilio HELPER'S NAME	EQUIPMENT CAT 316E excavator	TOTAL DEPTH 12.5 ft
EXCAVATION METHOD Test Pit	DRILLING ROD TYPE AND DIAMETER / BUCKET WIDTH 2'	BOREHOLE DIAMETER
SAMPLER TYPE(S) AND SIZE(S) (ID) 2.4"-diameter	HAMMER TYPE	HAMMER EFFICIENCY, ERi
BACKFILL AND COMPLETION Backfill Native Soil	GROUND WATER READINGS — DURING: 8.0 ft; AFTER (DATE):	CASING TYPE AND DIAMETER(in)

ELEVATION (ft)	DEPTH (ft)	Material Graphics	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests	Drilling Method
										Laboratory Data							
	0		Fat CLAY (CH); stiff; dark gray; moist														
	1				Bulk A							71	46				
4.00	2																
	3				Bulk B												
2.00	4																
	5																
0.00	6				1				1.25	32	91	66	49	92			
	7		Lean CLAY (CL); medium stiff; mottled grayish brown and dark yellowish brown; moist		Bulk C												
-2.00	8		some cementation wet														
	9				Bulk D												
-4.00	10		some strong cementation														
	11																
-6.00	12				2												
	13		Bottom of exploration at 12.5 ft below ground surface (bgs) Backfill Native Soil Ground water encountered at 8 ft bgs Bulk A 1-3 ft bgs Bulk B 3-6 ft bgs Bulk C 6-9 ft bgs Bulk D 9-12 ft bgs														
-8.00	14																
	15																
-10.00	16																
	17																
-12.00	18																
	19																
-14.00	20																
	21																
-16.00	22																
	23																
-18.00	24																
	25																

blackburn consulting

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME Lookout Slough THRFIP		FILE NO. 3195.X	HOLE ID BTP12
COUNTY SOL	ROUTE		POSTMILE
CLIENT Ecosystems Investment Partners			
PREPARED BY LDM	CHECKED BY DWC	SHEET 1 of 1	

LOGGED BY LDM	BEGIN DATE 7-18-18	COMPLETION DATE 7-18-18	LOCATION (Lat/Long or North/East and Datum) 38.31574° / -121.720207°	HOLE ID BTP13
CONTRACTOR Hanford ARC			LOCATION (Offset, Station, Line)	SURFACE ELEVATION 5.0 ft
OPERATOR'S NAME Emilio	HELPER'S NAME		EQUIPMENT CAT 316E excavator	TOTAL DEPTH 12.0 ft
EXCAVATION METHOD Test Pit			DRILLING ROD TYPE AND DIAMETER / BUCKET WIDTH 2'	BOREHOLE DIAMETER
SAMPLER TYPE(S) AND SIZE(S) (ID) 2.4"-diameter			HAMMER TYPE	HAMMER EFFICIENCY, ERi
BACKFILL AND COMPLETION Backfill Native Soil			GROUND WATER READINGS DURING 5.0 ft AFTER (DATE)	CASING TYPE AND DIAMETER(in)

ELEVATION (ft)	DEPTH (ft)	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests	Drilling Method
	0–3	Fat CLAY (CH); medium stiff; dark olive brown; moist		Bulk A (1–3)							62	45				
	3–9	Lean CLAY (CL); medium stiff; grayish brown; moist dark yellowish brown some cementation (ground water at 5 ft) wet		Bulk B (3–6); 1 (6); Bulk C (6–9)												
	9–12	CLAYEY SAND (SC); medium dense; olive brown; wet; well-graded SAND		Bulk D (9–12)												

Elevation scale: 3.00 (2 ft), 1.00 (4 ft), -1.00 (6 ft), -3.00 (8 ft), -5.00 (10 ft), -7.00 (12 ft), -9.00 (14 ft), -11.00 (16 ft), -13.00 (18 ft), -15.00 (20 ft), -17.00 (22 ft), -19.00 (24 ft). Depth scale 0–25 ft.

Laboratory Data

Bottom of exploration at 12.0 ft below ground surface (bgs)

Backfill Native Soil
Ground water encountered at 5 ft bgs
Bulk A 1-3 ft bgs
Bulk B 3-6 ft bgs
Bulk C 6-9 ft bgs
Bulk D 9-12 ft bgs

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME Lookout Slough THRFIP		FILE NO. 3195.X	HOLE ID BTP13
COUNTY SOL	ROUTE		POSTMILE
CLIENT Ecosystems Investment Partners			
PREPARED BY LDM	CHECKED BY DWC	SHEET 1 of 1	

LOGGED BY	BEGIN DATE	COMPLETION DATE	LOCATION (Lat/Long or North/East and Datum)	HOLE ID
LDM	**7-18-18**	**7-18-18**	**38.31543° / -121.71704°**	**BTP14**

CONTRACTOR **Hanford ARC**	LOCATION (Offset, Station, Line)	SURFACE ELEVATION **4.5 ft**
OPERATOR'S NAME **Emilio** / HELPER'S NAME	EQUIPMENT **CAT 316E excavator**	TOTAL DEPTH **12.0 ft**
EXCAVATION METHOD **Test Pit**	DRILLING ROD TYPE AND DIAMETER / BUCKET WIDTH **2'**	BOREHOLE DIAMETER
SAMPLER TYPE(S) AND SIZE(S) (ID) **2.4"-diameter**	HAMMER TYPE	HAMMER EFFICIENCY, ERi
BACKFILL AND COMPLETION **Backfill Native Soil**	GROUND WATER READINGS — DURING **6.0 ft** — AFTER (DATE)	CASING TYPE AND DIAMETER(in)

ELEVATION (ft)	DEPTH (ft)	Material Graphics	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests	Drilling Method
	0		Fat CLAY (CH); medium stiff; dark olive gray; moist														
2.50	1–3				Bulk A							60	41				
	3				1							70	49				
0.50	3.5		Lean CLAY (CL); medium stiff; dark grayish brown; moist some cementation		Bulk B												
-1.50	6																
-3.50	6–9		dark yellowish brown wet		Bulk C												
-5.50	9–12				Bulk D												
-7.50	12		Bottom of exploration at 12.0 ft below ground surface (bgs)														

Backfill Native Soil
Ground water encountered at 6 ft bgs
Bulk A 1-3 ft bgs
Bulk B 3-6 ft bgs
Bulk C 6-9 ft bgs
Bulk D 9-12 ft bgs

Elevation scale: 2.50, 0.50, -1.50, -3.50, -5.50, -7.50, -9.50, -11.50, -13.50, -15.50, -17.50, -19.50; Depth scale: 0–25

blackburn consulting

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	**3195.X**	**BTP14**
COUNTY **SOL**	ROUTE	POSTMILE
CLIENT **Ecosystems Investment Partners**		
PREPARED BY **LDM**	CHECKED BY **DWC**	SHEET **1 of 1**

LOGGED BY	BEGIN DATE	COMPLETION DATE	LOCATION (Lat/Long or North/East and Datum)	HOLE ID
LDM	**7-19-18**	**7-19-18**	**38.31764° / -121.71852°**	**BTP15**

CONTRACTOR **Hanford ARC**	LOCATION (Offset, Station, Line)	SURFACE ELEVATION **6.0 ft**
OPERATOR'S NAME **Emilio** HELPER'S NAME	EQUIPMENT **CAT 316E excavator**	TOTAL DEPTH **12.0 ft**
EXCAVATION METHOD **Test Pit**	DRILLING ROD TYPE AND DIAMETER / BUCKET WIDTH **2'**	BOREHOLE DIAMETER
SAMPLER TYPE(S) AND SIZE(S) (ID) **2.4"-diameter**	HAMMER TYPE	HAMMER EFFICIENCY, ERi
BACKFILL AND COMPLETION **Backfill Native Soil**	GROUND WATER READINGS DURING **8.0 ft** AFTER (DATE)	CASING TYPE AND DIAMETER(in)

ELEVATION (ft)	DEPTH (ft)	DESCRIPTION	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests	Drilling Method
	0	Lean CLAY with SAND (CL); stiff; olive brown; moist													
4.00	1–3		Bulk A							47	30	83			
2.00	3	Fat CLAY with SAND (CH); stiff; mottled dark yellowish brown and grayish brown; moist								50	33	80			
	4		1				1.50	26	98						
	5	some strong cementation	Bulk B												
0.00	6–8		Bulk C												
-2.00	8	Lean CLAY (CL); very stiff; mottled dark yellowish brown and grayish brown; wet													
	9	dark yellowish brown wet	2				2.25	33	86	45	25	94			
-4.00	10–12		Bulk D												
-6.00	12	Bottom of exploration at 12.0 ft below ground surface (bgs) Backfill Native Soil Ground water encountered at 8 ft bgs Bulk A 1-3 ft bgs Bulk B 3-6 ft bgs Bulk C 6-9 ft bgs Bulk D 9-12 ft bgs													

Elevation scale: -8.00, -10.00, -12.00, -14.00, -16.00, -18.00; Depth scale: 13–25

blackburn consulting

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	**3195.X**	**BTP15**
COUNTY **SOL**	ROUTE	POSTMILE
CLIENT **Ecosystems Investment Partners**		
PREPARED BY **LDM**	CHECKED BY **DWC**	SHEET **1 of 1**

LOGGED BY	BEGIN DATE	COMPLETION DATE	LOCATION (Lat/Long or North/East and Datum)	HOLE ID
LDM	**7-19-18**	**7-19-18**	**38.31764° / -121.715°**	**BTP16**

CONTRACTOR **Hanford ARC**	LOCATION (Offset, Station, Line)	SURFACE ELEVATION **6.0 ft**
OPERATOR'S NAME **Emilio** HELPER'S NAME	EQUIPMENT **CAT 316E excavator**	TOTAL DEPTH **12.0 ft**
EXCAVATION METHOD **Test Pit**	DRILLING ROD TYPE AND DIAMETER / BUCKET WIDTH **2'**	BOREHOLE DIAMETER
SAMPLER TYPE(S) AND SIZE(S) (ID) **2.4"-diameter**	HAMMER TYPE	HAMMER EFFICIENCY, ERi
BACKFILL AND COMPLETION **Backfill Native Soil**	GROUND WATER READINGS DURING **5.5 ft** AFTER (DATE)	CASING TYPE AND DIAMETER(in)

ELEVATION (ft)	DEPTH (ft)	Material Graphics	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests	Drilling Method
	0		Fat CLAY (CH); medium stiff; very dark grayish brown; moist														
	1																
4.00	2				Bulk A							54	35				
	3																
2.00	4				Bulk B												
	5		Lean CLAY (CL); medium stiff; mottled grayish brown and dark yellowish brown; moist														
0.00	6		some strong cementation		1												
	7		dark yellowish brown wet		Bulk C												
-2.00	8																
	9																
-4.00	10		SANDY Lean CLAY (CL); medium stiff; dark olive brown; wet; approximately 30-40% fine SAND		Bulk D												
	11																
-6.00	12		Bottom of exploration at 12.0 ft below ground surface (bgs)														

Backfill Native Soil
Ground water encountered at 5.5 ft bgs
Bulk A 1-3 ft bgs
Bulk B 3-6 ft bgs
Bulk C 6-9 ft bgs
Bulk D 9-12 ft bgs

ELEVATION (ft)	DEPTH (ft)
	13
-8.00	14
	15
-10.00	16
	17
-12.00	18
	19
-14.00	20
	21
-16.00	22
	23
-18.00	24
	25

BCI LOG FOR SOIL BORROW TEST PITS.GPJ LIBRARY_3195.GLB 8/6/19

blackburn consulting

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	**3195.X**	**BTP16**

COUNTY	ROUTE	POSTMILE
SOL		

CLIENT
Ecosystems Investment Partners

PREPARED BY	CHECKED BY	SHEET
LDM	**DWC**	**1 of 1**

LOGGED BY	BEGIN DATE	COMPLETION DATE	LOCATION (Lat/Long or North/East and Datum)	HOLE ID
LDM	7-19-18	7-19-18	38.31915° / -121.71436°	BTP17

CONTRACTOR Hanford ARC	LOCATION (Offset, Station, Line)	SURFACE ELEVATION 6.0 ft
OPERATOR'S NAME Emilio HELPER'S NAME	EQUIPMENT CAT 316E excavator	TOTAL DEPTH 12.0 ft
EXCAVATION METHOD Test Pit	DRILLING ROD TYPE AND DIAMETER / BUCKET WIDTH 2'	BOREHOLE DIAMETER
SAMPLER TYPE(S) AND SIZE(S) (ID) 2.4"-diameter	HAMMER TYPE	HAMMER EFFICIENCY, ERi
BACKFILL AND COMPLETION Backfill Native Soil	GROUND WATER READINGS: DURING 5.0 ft; AFTER (DATE)	CASING TYPE AND DIAMETER(in)

ELEVATION (ft)	DEPTH (ft)	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests	Drilling Method
	0	Fat CLAY (CH); medium stiff; dark olive gray; moist														
4.00	1–3			Bulk A							56	37				
	3	Lean CLAY(CL); medium stiff; dark grayish brown; moist														
2.00	4	dark yellowish brown, some strong cementation		Bulk B												
	5	▽														
0.00	6	wet		1												
-2.00	6–9			Bulk C												
-4.00	10	some moderate cementation		2												
	9–12			Bulk D												
-6.00	12	Bottom of exploration at 12.0 ft below ground surface (bgs)														

Backfill Native Soil
Ground water encountered at 5 ft bgs
Bulk A 1-3 ft bgs
Bulk B 3-6 ft bgs
Bulk C 6-9 ft bgs
Bulk D 9-12 ft bgs

blackburn consulting

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	3195.X	BTP17

COUNTY	ROUTE	POSTMILE
SOL		

CLIENT: Ecosystems Investment Partners

PREPARED BY	CHECKED BY	SHEET
LDM	DWC	1 of 1

LOGGED BY	BEGIN DATE	COMPLETION DATE	LOCATION (Lat/Long or North/East and Datum)	HOLE ID
LDM	**7-19-18**	**7-19-18**	**38.32048° / -121.71508°**	**BTP18**

CONTRACTOR **Hanford ARC**	LOCATION (Offset, Station, Line)	SURFACE ELEVATION **6.0 ft**
OPERATOR'S NAME **Emilio** / HELPER'S NAME	EQUIPMENT **CAT 316E excavator**	TOTAL DEPTH **12.0 ft**
EXCAVATION METHOD **Test Pit**	DRILLING ROD TYPE AND DIAMETER / BUCKET WIDTH **2'**	BOREHOLE DIAMETER
SAMPLER TYPE(S) AND SIZE(S) (ID) **2.4"-diameter**	HAMMER TYPE	HAMMER EFFICIENCY, ERi
BACKFILL AND COMPLETION **Backfill Native Soil**	GROUND WATER READINGS DURING **6.5 ft** AFTER (DATE)	CASING TYPE AND DIAMETER(in)

ELEVATION (ft)	DEPTH (ft)	Material Graphics	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests	Drilling Method
	0		Fat CLAY (CH); medium stiff; dark grayish brown; moist														
4.00	1–3				Bulk A							54	36	85			
	3		Lean CLAY (CL); medium stiff; dark yellowish brown; moist									41	24	89			
2.00	4		some cementation		1												
	4–6				Bulk B												
0.00	6–9		wet		Bulk C												
-2.00	8		SANDY Lean CLAY (CL); soft; dark yellowish brown; wet;														
	9				2					30	91	31	17	57			
-4.00	10–12				Bulk D												
-6.00	12		Bottom of exploration at 12.0 ft below ground surface (bgs)														

Backfill Native Soil
Ground water encountered at 6.5 ft bgs
Bulk A 1-3 ft bgs
Bulk B 3-6 ft bgs
Bulk C 6-9 ft bgs
Bulk D 9-12 ft bgs

blackburn consulting
Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	**3195.X**	**BTP18**
COUNTY **SOL**	ROUTE	POSTMILE
CLIENT **Ecosystems Investment Partners**		
PREPARED BY **LDM**	CHECKED BY **DWC**	SHEET **1 of 1**

LOGGED BY LDM	BEGIN DATE 7-19-18	COMPLETION DATE 7-19-18	LOCATION (Lat/Long or North/East and Datum) 38.31998° / -121.71154°	HOLE ID BTP19
CONTRACTOR Hanford ARC			LOCATION (Offset, Station, Line)	SURFACE ELEVATION 6.0 ft
OPERATOR'S NAME Emilio	HELPER'S NAME		EQUIPMENT CAT 316E excavator	TOTAL DEPTH 12.0 ft
EXCAVATION METHOD Test Pit			DRILLING ROD TYPE AND DIAMETER / BUCKET WIDTH 2'	BOREHOLE DIAMETER
SAMPLER TYPE(S) AND SIZE(S) (ID) 2.4"-diameter			HAMMER TYPE	HAMMER EFFICIENCY, ERi
BACKFILL AND COMPLETION Backfill Native Soil			GROUND WATER READINGS DURING 6.0 ft AFTER (DATE)	CASING TYPE AND DIAMETER(in)

ELEVATION (ft)	DEPTH (ft)	Material Graphics	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests	Drilling Method
	0		Fat CLAY (CH); medium stiff; dark olive gray; moist														
	1				Bulk A							52	36				
4.00	2																
	3		Lean CLAY (CL); medium stiff; dark grayish brown; moist		Bulk B												
2.00	4		some cementation														
	5		dark yellowish brown														
0.00	6				1												
	7		wet		Bulk C												
-2.00	8																
	9				Bulk D												
-4.00	10																
	11				2												
-6.00	12		Bottom of exploration at 12.0 ft below ground surface (bgs)														
	13		Backfill Native Soil Ground water encountered at 6 ft bgs Bulk A 1-3 ft bgs Bulk B 3-6 ft bgs Bulk C 6-9 ft bgs Bulk D 9-12 ft bgs														
-8.00	14																
	15																
-10.00	16																
	17																
-12.00	18																
	19																
-14.00	20																
	21																
-16.00	22																
	23																
-18.00	24																
	25																

blackburn consulting

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME Lookout Slough THRFIP		FILE NO. 3195.X	HOLE ID BTP19
COUNTY SOL	ROUTE		POSTMILE
CLIENT Ecosystems Investment Partners			
PREPARED BY LDM	CHECKED BY DWC	SHEET 1 of 1	

LOGGED BY **LDM**	BEGIN DATE **7-19-18**	COMPLETION DATE **7-19-18**	LOCATION (Lat/Long or North/East and Datum) **38.32158° / -121.71281°**	HOLE ID **BTP20**
CONTRACTOR **Hanford ARC**			LOCATION (Offset, Station, Line)	SURFACE ELEVATION **6.5 ft**
OPERATOR'S NAME **Emilio**	HELPER'S NAME		EQUIPMENT **CAT 316E excavator**	TOTAL DEPTH **12.0 ft**
EXCAVATION METHOD **Test Pit**			DRILLING ROD TYPE AND DIAMETER / BUCKET WIDTH **2'**	BOREHOLE DIAMETER
SAMPLER TYPE(S) AND SIZE(S) (ID) **2.4"-diameter**			HAMMER TYPE	HAMMER EFFICIENCY, ERi
BACKFILL AND COMPLETION **Backfill Native Soil**			GROUND WATER READINGS DURING **7.0 ft** AFTER (DATE)	CASING TYPE AND DIAMETER(in)

ELEVATION (ft)	DEPTH (ft)	Material Graphics	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests	Drilling Method
	0		SANDY Lean CLAY (CL); medium stiff; dark yellowish brown; moist														
4.50	1–3				Bulk A							43	29	68			
	3		some cementation		1							38	22				
2.50	3–6				Bulk B												
0.50 / -1.50	6–9		wet (ground water at 7 ft)		Bulk C												
	9		Lean CLAY (CL); medium stiff; dark yellowish brown; moist		2												
-3.50	9–12				Bulk D												
-5.50	12		Bottom of exploration at 12.0 ft below ground surface (bgs)														

Elevation scale: 4.50 (2), 2.50 (4), 0.50 (6), -1.50 (8), -3.50 (10), -5.50 (12), -7.50 (14), -9.50 (16), -11.50 (18), -13.50 (20), -15.50 (22), -17.50 (24); depth 0–25 ft.

Bottom of exploration at 12.0 ft below ground surface (bgs)

Backfill Native Soil
Ground water encountered at 7 ft bgs
Bulk A 1-3 ft bgs
Bulk B 3-6 ft bgs
Bulk C 6-9 ft bgs
Bulk D 9-12 ft bgs

blackburn consulting
Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME **Lookout Slough THRFIP**		FILE NO. **3195.X**	HOLE ID **BTP20**
COUNTY **SOL**	ROUTE		POSTMILE
CLIENT **Ecosystems Investment Partners**			
PREPARED BY **LDM**	CHECKED BY **DWC**	SHEET **1 of 1**	

LOGGED BY **DWC**	BEGIN DATE **7-24-18**	COMPLETION DATE **7-24-18**	LOCATION (Lat/Long or North/East and Datum) **38.321356° / -121.70927°**	HOLE ID **BTP21**
CONTRACTOR **Hanford ARC**			LOCATION (Offset, Station, Line)	SURFACE ELEVATION **6.0 ft**
OPERATOR'S NAME **Emilio**	HELPER'S NAME		EQUIPMENT **CAT 316E excavator**	TOTAL DEPTH **12.0 ft**
EXCAVATION METHOD **Test Pit**			DRILLING ROD TYPE AND DIAMETER / BUCKET WIDTH **2'**	BOREHOLE DIAMETER
SAMPLER TYPE(S) AND SIZE(S) (ID) **2.4"-diameter**			HAMMER TYPE	HAMMER EFFICIENCY, ERi
BACKFILL AND COMPLETION **Backfill Native Soil**			GROUND WATER READINGS — DURING **6.5 ft** — AFTER (DATE)	CASING TYPE AND DIAMETER(in)

ELEVATION (ft)	DEPTH (ft)	Material Graphics	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests	Drilling Method
	0		Fat CLAY (CH); stiff; very dark grayish brown; moist														
	1											58	40	89			
4.00	2				Bulk A												
	3																
2.00	4				1				1.25	26	90	53	37	90			
	5		Lean CLAY (CL); dark yellowish brown; moist; some cementation		Bulk B												
0.00	6																
	7				2												
-2.00	8		wet		Bulk C												
	9																
-4.00	10																
	11																
-6.00	12		Bottom of exploration at 12.0 ft below ground surface (bgs) Backfill Native Soil Ground water encountered at 6.5 ft bgs Bulk A 1-4 ft bgs Bulk B 4-7 ft bgs Bulk C 7-10 ft bgs														
	13																
-8.00	14																
	15																
-10.00	16																
	17																
-12.00	18																
	19																
-14.00	20																
	21																
-16.00	22																
	23																
-18.00	24																
	25																

blackburn consulting

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME **Lookout Slough THRFIP**		FILE NO. **3195.X**	HOLE ID **BTP21**
COUNTY **SOL**	ROUTE		POSTMILE
CLIENT **Ecosystems Investment Partners**			
PREPARED BY **LDM**	CHECKED BY **DWC**	SHEET **1 of 1**	

LOGGED BY	BEGIN DATE	COMPLETION DATE	LOCATION (Lat/Long or North/East and Datum)	HOLE ID
RMS	**7-20-18**	**7-20-18**	**38.324005° / -121.711396°**	**BTP22**
CONTRACTOR **Hanford ARC**			LOCATION (Offset, Station, Line)	SURFACE ELEVATION **6.0 ft**
OPERATOR'S NAME **Emilio**	HELPER'S NAME		EQUIPMENT **CAT 316E excavator**	TOTAL DEPTH **10.0 ft**
EXCAVATION METHOD **Test Pit**			DRILLING ROD TYPE AND DIAMETER / BUCKET WIDTH **2'**	BOREHOLE DIAMETER
SAMPLER TYPE(S) AND SIZE(S) (ID) **2.4"-diameter**			HAMMER TYPE	HAMMER EFFICIENCY, ERi
BACKFILL AND COMPLETION **Backfill Native Soil**			GROUND WATER READINGS — DURING **8.5 ft** — AFTER (DATE)	CASING TYPE AND DIAMETER(in)

ELEVATION (ft)	DEPTH (ft)	Material Graphics	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests	Drilling Method
	0		Fat CLAY (CH); very stiff; brown; moist														
	1				Bulk A							59	38	96			
4.00	2																
	3																
2.00	4				1				2.25	24	100	57	42	95			
	5				Bulk B												
0.00	6		Lean CLAY (CL); stiff; olive brown; moist														
	7				2				1.50	27	87	49	31	94			
-2.00	8				Bulk C												
	9																
-4.00	10		wet														

Bottom of exploration at 10.0 ft below ground surface (bgs)

Backfill Native Soil
Ground water encountered at 8.5 ft bgs
Bulk A 1-4 ft bgs
Bulk B 4-7 ft bgs
Bulk C 7-10 ft bgs

ELEVATION (ft)	DEPTH (ft)
	11
-6.00	12
	13
-8.00	14
	15
-10.00	16
	17
-12.00	18
	19
-14.00	20
	21
-16.00	22
	23
-18.00	24
	25

BCI LOG FOR SOIL BORROW TEST PITS.GPJ LIBRARY_3195.GLB 8/6/19

blackburn consulting
Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	**3195.X**	**BTP22**
COUNTY **SOL**	ROUTE	POSTMILE
CLIENT **Ecosystems Investment Partners**		
PREPARED BY **LDM**	CHECKED BY **DWC**	SHEET **1 of 1**

LOGGED BY	BEGIN DATE	COMPLETION DATE	LOCATION (Lat/Long or North/East and Datum)	HOLE ID
RMS	**7-20-18**	**7-20-18**	**38.323732° / -121.707713°**	**BTP23**

CONTRACTOR	LOCATION (Offset, Station, Line)	SURFACE ELEVATION
Hanford ARC		**6.0 ft**
OPERATOR'S NAME **Emilio** / HELPER'S NAME	EQUIPMENT **CAT 316E excavator**	TOTAL DEPTH **10.0 ft**
EXCAVATION METHOD **Test Pit**	DRILLING ROD TYPE AND DIAMETER / BUCKET WIDTH **2'**	BOREHOLE DIAMETER
SAMPLER TYPE(S) AND SIZE(S) (ID) **2.4"-diameter**	HAMMER TYPE	HAMMER EFFICIENCY, ERi
BACKFILL AND COMPLETION **Backfill Native Soil**	GROUND WATER READINGS — DURING **6.5 ft** — AFTER (DATE)	CASING TYPE AND DIAMETER(in)

ELEVATION (ft)	DEPTH (ft)	DESCRIPTION	Sample Number	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200
6.00	0	Fat CLAY (CH); stiff; blackish brown; moist							
	1		Bulk A				55	37	90
	3	dark brown							
2.00	4	Lean CLAY with SAND (CL); medium stiff; brown; moist	1	1.50	20	107	37	22	76
	5	medium stiff; brown	Bulk B						
	7	wet, some weak cementation	2						
	8		Bulk C						
-4.00	10	Bottom of exploration at 10.0 ft below ground surface (bgs)							

Other columns (Sample Location, Blows per 6 in., Blows per foot, Recovery (%), Shear Strength Test, Additional Lab Tests, Drilling Method) contain no values. Laboratory Data.

Backfill Native Soil
Ground water encountered at 6.5 ft bgs
Bulk A 1-4 ft bgs
Bulk B 4-7 ft bgs
Bulk C 7-10 ft bgs

blackburn consulting
Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	**3195.X**	**BTP23**
COUNTY **SOL**	ROUTE	POSTMILE
CLIENT **Ecosystems Investment Partners**		
PREPARED BY **LDM**	CHECKED BY **DWC**	SHEET **1 of 1**

LOGGED BY	BEGIN DATE	COMPLETION DATE	LOCATION (Lat/Long or North/East and Datum)	HOLE ID
DWC	7-24-18	7-24-18	38.32519° / -121.709325°	BTP24

CONTRACTOR: Hanford ARC	LOCATION (Offset, Station, Line)
SURFACE ELEVATION: 6.0 ft	
OPERATOR'S NAME: Emilio	HELPER'S NAME
EQUIPMENT: CAT 316E excavator	TOTAL DEPTH: 10.0 ft
EXCAVATION METHOD: Test Pit	DRILLING ROD TYPE AND DIAMETER / BUCKET WIDTH: 2'
BOREHOLE DIAMETER	
SAMPLER TYPE(S) AND SIZE(S) (ID): 2.4"-diameter	HAMMER TYPE
HAMMER EFFICIENCY, ERi	
BACKFILL AND COMPLETION: Backfill Native Soil	GROUND WATER READINGS — DURING: 6.0 ft; AFTER (DATE)
CASING TYPE AND DIAMETER(in)	

ELEVATION (ft)	DEPTH (ft)	DESCRIPTION	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests	Drilling Method
	0	Fat CLAY (CH); stiff; very dark grayish brown; moist													
	1–4		Bulk A							63	43	95			
2.00	4	as above, olive brown	1				1.75	28	94	56	38	91			
0.00	4–7		Bulk B												
	7	wet													
	7	Lean CLAY with SAND (CL); olive brown; wet	2							45	27	83			
-2.00	7–10		Bulk C												
-4.00	10	Bottom of exploration at 10.0 ft below ground surface (bgs)													

Backfill Native Soil
Ground water encountered at 6 ft bgs
Bulk A 1-4 ft bgs
Bulk B 4-7 ft bgs
Bulk C 7-10 ft bgs

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	3195.X	BTP24
COUNTY: SOL	ROUTE	POSTMILE
CLIENT: Ecosystems Investment Partners		
PREPARED BY: LDM	CHECKED BY: DWC	SHEET: 1 of 1

LOGGED BY **DWC**	BEGIN DATE **7-24-18**	COMPLETION DATE **7-24-18**	LOCATION (Lat/Long or North/East and Datum) **38.32588° / -121.707741°**	HOLE ID **BTP25**
CONTRACTOR **Hanford ARC**			LOCATION (Offset, Station, Line)	SURFACE ELEVATION **6.0 ft**
OPERATOR'S NAME **Emilio**	HELPER'S NAME		EQUIPMENT **CAT 316E excavator**	TOTAL DEPTH **10.5 ft**
EXCAVATION METHOD **Test Pit**			DRILLING ROD TYPE AND DIAMETER / BUCKET WIDTH **2'**	BOREHOLE DIAMETER
SAMPLER TYPE(S) AND SIZE(S) (ID) **2.4"-diameter**			HAMMER TYPE	HAMMER EFFICIENCY, ERi
BACKFILL AND COMPLETION **Backfill Native Soil**			GROUND WATER READINGS — DURING **6.0 ft** — AFTER (DATE)	CASING TYPE AND DIAMETER(in)

ELEVATION (ft)	DEPTH (ft)	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests	Drilling Method
	0	Fat CLAY (CH); very dark grayish brown; moist														
	1		Bulk	Bulk A							53	37				
4.00	2															
	3															
2.00	4			1							63	44				
	5	Lean CLAY (CL); dark yellowish brown; moist	Bulk	Bulk B												
0.00	6	▽														
	7	wet, some cementation														
-2.00	8			2												
	9		Bulk	Bulk C												
-4.00	10			3												

Bottom of exploration at 10.5 ft below ground surface (bgs)

Backfill Native Soil
Ground water encountered at 6 ft bgs
Bulk A 1-4 ft bgs
Bulk B 4-7 ft bgs
Bulk C 7-10 ft bgs

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME **Lookout Slough THRFIP**		FILE NO. **3195.X**	HOLE ID **BTP25**
COUNTY **SOL**	ROUTE		POSTMILE
CLIENT **Ecosystems Investment Partners**			
PREPARED BY **LDM**	CHECKED BY **DWC**	SHEET **1 of 1**	

LOGGED BY **RMS**	BEGIN DATE **7-20-18** / COMPLETION DATE **7-20-18**	LOCATION (Lat/Long or North/East and Datum) **38.327679° / -121.704738°**	HOLE ID **BTP26**
CONTRACTOR **Hanford ARC**		LOCATION (Offset, Station, Line)	SURFACE ELEVATION **6.0 ft**
OPERATOR'S NAME **Emilio**	HELPER'S NAME	EQUIPMENT **CAT 316E excavator**	TOTAL DEPTH **10.0 ft**
EXCAVATION METHOD **Test Pit**		DRILLING ROD TYPE AND DIAMETER / BUCKET WIDTH **2'**	BOREHOLE DIAMETER
SAMPLER TYPE(S) AND SIZE(S) (ID) **2.4"-diameter**		HAMMER TYPE	HAMMER EFFICIENCY, ERi
BACKFILL AND COMPLETION **Backfill Native Soil**		GROUND WATER READINGS — DURING **9.0 ft** — AFTER (DATE)	CASING TYPE AND DIAMETER(in)

ELEVATION (ft)	DEPTH (ft)	Material Graphics	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Laboratory Data: Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests	Drilling Method
	0		Fat CLAY (CH); stiff; dark reddish brown; moist; high plasticity														
	1				Bulk A							66	47	86			
4.00	2																
	3																
2.00	4		medium stiff, brown, weak cemented particles		1				1.75	29	91	57	39	85			
	5		Lean CLAY (CL); medium stiff; dark yellowish brown; moist		Bulk B							42	24	88			
0.00	6																
	7				2				1.25	34	98						
-2.00	8				Bulk C												
	9																
-4.00	10		wet														

Bottom of exploration at 10.0 ft below ground surface (bgs)

Backfill Native Soil
Ground water encountered at 9 ft bgs
Bulk A 1-4 ft bgs
Bulk B 4-7 ft bgs
Bulk C 7-10 ft bgs

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME **Lookout Slough THRFIP**		FILE NO. **3195.X**	HOLE ID **BTP26**
COUNTY **SOL**	ROUTE		POSTMILE
CLIENT **Ecosystems Investment Partners**			
PREPARED BY **LDM**	CHECKED BY **DWC**	SHEET **1 of 1**	

LOGGED BY	BEGIN DATE	COMPLETION DATE	LOCATION (Lat/Long or North/East and Datum)	HOLE ID
RMS	**7-20-18**	**7-20-18**	**38.326022° / -121.701234°**	**BTP27**

CONTRACTOR **Hanford ARC**	LOCATION (Offset, Station, Line)	SURFACE ELEVATION **6.0 ft**
OPERATOR'S NAME **Emilio** HELPER'S NAME	EQUIPMENT **CAT 316E excavator**	TOTAL DEPTH **10.0 ft**
EXCAVATION METHOD **Test Pit**	DRILLING ROD TYPE AND DIAMETER / BUCKET WIDTH **2'**	BOREHOLE DIAMETER
SAMPLER TYPE(S) AND SIZE(S) (ID) **2.4"-diameter**	HAMMER TYPE	HAMMER EFFICIENCY, ERi
BACKFILL AND COMPLETION **Backfill Native Soil**	GROUND WATER READINGS DURING **6.0 ft** AFTER (DATE)	CASING TYPE AND DIAMETER(in)

ELEVATION (ft)	DEPTH (ft)	Material Graphics	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%) (Laboratory Data)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests	Drilling Method
	0		Fat CLAY (CH); medium stiff; blackish brown; moist to wet														
	1											54	36				
4.00	2				Bulk A												
	3																
2.00	4		Lean CLAY (CL); medium stiff; brown; wet; medium to high plasticity weak cemented particles		1							47	28				
	5				Bulk B												
0.00	6		▽														
	7				2												
-2.00	8				Bulk C												
	9																
-4.00	10		Bottom of exploration at 10.0 ft below ground surface (bgs) Backfill Native Soil Ground water encountered at 6 ft bgs Bulk A 1-4 ft bgs Bulk B 4-7 ft bgs Bulk C 7-10 ft bgs														
	11																
-6.00	12																
	13																
-8.00	14																
	15																
-10.00	16																
	17																
-12.00	18																
	19																
-14.00	20																
	21																
-16.00	22																
	23																
-18.00	24																
	25																

blackburn consulting

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME		FILE NO.	HOLE ID
Lookout Slough THRFIP		**3195.X**	**BTP27**
COUNTY **SOL**	ROUTE		POSTMILE
CLIENT **Ecosystems Investment Partners**			
PREPARED BY **LDM**	CHECKED BY **DWC**	SHEET **1 of 1**	

LOGGED BY	BEGIN DATE	COMPLETION DATE	LOCATION (Lat/Long or North/East and Datum)	HOLE ID
RMS	**7-20-18**	**7-20-18**	**38.328027° / -121.700374°**	**BTP28**

CONTRACTOR	LOCATION (Offset, Station, Line)	SURFACE ELEVATION
Hanford ARC		**6.0 ft**

OPERATOR'S NAME	HELPER'S NAME	EQUIPMENT	TOTAL DEPTH
Emilio		**CAT 316E excavator**	**10.0 ft**

EXCAVATION METHOD	DRILLING ROD TYPE AND DIAMETER / BUCKET WIDTH	BOREHOLE DIAMETER
Test Pit	**2'**	

SAMPLER TYPE(S) AND SIZE(S) (ID)	HAMMER TYPE	HAMMER EFFICIENCY, ERi
2.4"-diameter		

BACKFILL AND COMPLETION	GROUND WATER READINGS	DURING	AFTER (DATE)	CASING TYPE AND DIAMETER(in)
Backfill Native Soil		**7.0 ft**		

ELEVATION (ft)	DEPTH (ft)	Material Graphics	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Laboratory Data: Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests	Drilling Method
	0		Fat CLAY with SAND (CH); stiff; dark grayish brown; moist														
	1											61	41	84			
4.00	2				Bulk A												
	3																
2.00	4				1				1.50	26	97	55	39	81			
	5				Bulk B												
0.00	6																
	7				2												
-2.00	8		wet		Bulk C												
	9																
-4.00	10		Bottom of exploration at 10.0 ft below ground surface (bgs)														
	11																
-6.00	12																
	13																
-8.00	14																
	15																
-10.00	16																
	17																
-12.00	18																
	19																
-14.00	20																
	21																
-16.00	22																
	23																
-18.00	24																
	25																

Backfill Native Soil
Ground water encountered at 7 ft bgs
Bulk A 1-4 ft bgs
Bulk B 4-7 ft bgs
Bulk C 7-10 ft bgs

BCI LOG FOR SOIL BORROW TEST PITS.GPJ LIBRARY_3195.GLB 8/6/19

blackburn consulting
Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	**3195.X**	**BTP28**

COUNTY	ROUTE	POSTMILE
SOL		

CLIENT
Ecosystems Investment Partners

PREPARED BY	CHECKED BY	SHEET
LDM	**DWC**	**1 of 1**

LOGGED BY **RMS**	BEGIN DATE **7-20-18**	COMPLETION DATE **7-20-18**	LOCATION (Lat/Long or North/East and Datum) **38.323352° / -121.700941°**	HOLE ID **BTP29**
CONTRACTOR **Hanford ARC**			LOCATION (Offset, Station, Line)	SURFACE ELEVATION **6.0 ft**
OPERATOR'S NAME **Emilio**	HELPER'S NAME		EQUIPMENT **CAT 316E excavator**	TOTAL DEPTH **10.0 ft**
EXCAVATION METHOD **Test Pit**			DRILLING ROD TYPE AND DIAMETER / BUCKET WIDTH **2'**	BOREHOLE DIAMETER
SAMPLER TYPE(S) AND SIZE(S) (ID) **2.4"-diameter**			HAMMER TYPE	HAMMER EFFICIENCY, ERi
BACKFILL AND COMPLETION **Backfill Native Soil**			GROUND WATER READINGS — DURING **7.0 ft** — AFTER (DATE)	CASING TYPE AND DIAMETER(in)

ELEVATION (ft)	DEPTH (ft)	Material Graphics	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests	Drilling Method
	0		Lean CLAY (CL); stiff; very dark grayish brown; moist														
	1				Bulk A							49	35	85			
4.00	2																
	3																
2.00	4				1				2.00	23	102						
	5				Bulk B												
0.00	6		medium stiff; brown; wet; weak cemented particles														
	7				2												
-2.00	8				Bulk C												
	9																
-4.00	10		Bottom of exploration at 10.0 ft below ground surface (bgs)														

Laboratory Data

Backfill Native Soil
Ground water encountered at 7 ft bgs
Bulk A 1-4 ft bgs
Bulk B 4-7 ft bgs
Bulk C 7-10 ft bgs

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME **Lookout Slough THRFIP**		FILE NO. **3195.X**	HOLE ID **BTP29**
COUNTY **SOL**	ROUTE		POSTMILE
CLIENT **Ecosystems Investment Partners**			
PREPARED BY **LDM**	CHECKED BY **DWC**	SHEET **1 of 1**	

LOGGED BY	BEGIN DATE	COMPLETION DATE	LOCATION (Lat/Long or North/East and Datum)	HOLE ID
RMS	**7-20-18**	**7-20-18**	**38.324003° / -121.704409°**	**BTP30**

CONTRACTOR	LOCATION (Offset, Station, Line)	SURFACE ELEVATION
Hanford ARC		**6.0 ft**
OPERATOR'S NAME: **Emilio** / HELPER'S NAME:	EQUIPMENT: **CAT 316E excavator**	TOTAL DEPTH: **10.0 ft**
EXCAVATION METHOD: **Test Pit**	DRILLING ROD TYPE AND DIAMETER / BUCKET WIDTH: **2'**	BOREHOLE DIAMETER
SAMPLER TYPE(S) AND SIZE(S) (ID): **2.4"-diameter**	HAMMER TYPE	HAMMER EFFICIENCY, ERi
BACKFILL AND COMPLETION: **Backfill Native Soil**	GROUND WATER READINGS — DURING: **7.5 ft** / AFTER (DATE):	CASING TYPE AND DIAMETER(in)

ELEVATION (ft)	DEPTH (ft)	Material Graphics	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests	Drilling Method
	0		Fat CLAY (CH); stiff; blackish brown; moist														
	1				Bulk A							57	39				
4.00	2																
	3		dark brown														
2.00	4				1							62	43				
	5		Lean CLAY (CL); medium stiff; brown; moist; medium plasticity		Bulk B												
0.00	6																
	7				2												
-2.00	8		wet		Bulk C												
	9																
-4.00	10		Bottom of exploration at 10.0 ft below ground surface (bgs)														
	11		Backfill Native Soil Ground water encountered at 7.5 ft bgs Bulk A 1-4 ft bgs Bulk B 4-7 ft bgs Bulk C 7-10 ft bgs														
-6.00	12																
	13																
-8.00	14																
	15																
-10.00	16																
	17																
-12.00	18																
	19																
-14.00	20																
	21																
-16.00	22																
	23																
-18.00	24																
	25																

blackburn consulting

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	**3195.X**	**BTP30**
COUNTY: **SOL**	ROUTE	POSTMILE
CLIENT: **Ecosystems Investment Partners**		
PREPARED BY: **LDM**	CHECKED BY: **DWC**	SHEET: **1 of 1**

LOGGED BY	BEGIN DATE	COMPLETION DATE	LOCATION (Lat/Long or North/East and Datum)	HOLE ID
LDM	**7-19-18**	**7-19-18**	**38.31797° / -121.71266°**	**BTP31**

CONTRACTOR **Hanford ARC**	LOCATION (Offset, Station, Line)	SURFACE ELEVATION **6.0 ft**
OPERATOR'S NAME **Emilio** / HELPER'S NAME	EQUIPMENT **CAT 316E excavator**	TOTAL DEPTH **12.0 ft**
EXCAVATION METHOD **Test Pit**	DRILLING ROD TYPE AND DIAMETER / BUCKET WIDTH **2'**	BOREHOLE DIAMETER
SAMPLER TYPE(S) AND SIZE(S) (ID) **2.4"-diameter**	HAMMER TYPE	HAMMER EFFICIENCY, ERi
BACKFILL AND COMPLETION **Backfill Native Soil**	GROUND WATER READINGS — DURING **7.0 ft** — AFTER (DATE)	CASING TYPE AND DIAMETER(in)

ELEVATION (ft)	DEPTH (ft)	Material Graphics	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests	Drilling Method
	0		Fat CLAY (CH); stiff; very dark grayish brown; moist														
	1				Bulk A							71	51	96			
4.00	2																
	3				1				1.50	28	94	56	40	88			
2.00	4		Lean CLAY (CL); medium stiff; dark yellowish brown; moist; weakly cemented		Bulk B												
	5																
0.00	6				Bulk C												
	7																
-2.00	8		wet		2												
	9				Bulk D												
-4.00	10																
	11																
-6.00	12		Bottom of exploration at 12.0 ft below ground surface (bgs) Backfill Native Soil Ground water encountered at 7 ft bgs Bulk A 1-3 ft bgs Bulk B 3-6 ft bgs Bulk C 6-9 ft bgs Bulk D 9-12 ft bgs														
	13																
-8.00	14																
	15																
-10.00	16																
	17																
-12.00	18																
	19																
-14.00	20																
	21																
-16.00	22																
	23																
-18.00	24																
	25																

Laboratory Data

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	**3195.X**	**BTP31**
COUNTY **SOL**	ROUTE	POSTMILE
CLIENT **Ecosystems Investment Partners**		
PREPARED BY **LDM**	CHECKED BY **DWC**	SHEET **1 of 1**

LOGGED BY	BEGIN DATE	COMPLETION DATE	LOCATION (Lat/Long or North/East and Datum)	HOLE ID
LDM	7-18-18	7-18-18	38.31409° / -121.71575°	BTP32

CONTRACTOR: **Hanford ARC**	LOCATION (Offset, Station, Line)	SURFACE ELEVATION: **6.0 ft**
OPERATOR'S NAME: **Emilio** / HELPER'S NAME	EQUIPMENT: **CAT 316E excavator**	TOTAL DEPTH: **12.0 ft**
EXCAVATION METHOD: **Test Pit**	DRILLING ROD TYPE AND DIAMETER / BUCKET WIDTH: **2'**	BOREHOLE DIAMETER
SAMPLER TYPE(S) AND SIZE(S) (ID): **2.4"-diameter**	HAMMER TYPE	HAMMER EFFICIENCY, ERi
BACKFILL AND COMPLETION: **Backfill Native Soil**	GROUND WATER READINGS — DURING: **7.5 ft**; AFTER (DATE)	CASING TYPE AND DIAMETER(in)

ELEVATION (ft)	DEPTH (ft)	Material Graphics	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests	Drilling Method
	0		Fat CLAY (CH); stiff; dark gray; moist														
4.00	1–3			Bulk	Bulk A							72	51	96			
	3			Tube	1				1.75	29	94						
2.00	3.5		Lean CLAY (CL); medium stiff; dark grayish brown; moist														
0.00	4–6			Bulk	Bulk B												
	6		dark yellowish brown														
-2.00	6–9			Bulk	Bulk C												
	8		some strong cementation														
	9		wet	Tube	2												
-4.00	9–12			Bulk	Bulk D												
-6.00	12		Bottom of exploration at 12.0 ft below ground surface (bgs)														

Backfill Native Soil
Ground water encountered at 7.5 ft bgs
Bulk A 1-3 ft bgs
Bulk B 3-6 ft bgs
Bulk C 6-9 ft bgs
Bulk D 9-12 ft bgs

Elevation scale: 4.00, 2.00, 0.00, -2.00, -4.00, -6.00, -8.00, -10.00, -12.00, -14.00, -16.00, -18.00; Depth scale 0–25 ft.

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	3195.X	BTP32
COUNTY: SOL	ROUTE	POSTMILE
CLIENT: Ecosystems Investment Partners		
PREPARED BY: LDM	CHECKED BY: DWC	SHEET: 1 of 1

LOGGED BY	BEGIN DATE	COMPLETION DATE	LOCATION (Lat/Long or North/East and Datum)	HOLE ID
DWC	7-23-18	7-23-18	38.309637° / -121.718005°	BTP33

CONTRACTOR Hanford ARC	LOCATION (Offset, Station, Line)	SURFACE ELEVATION 5.0 ft
OPERATOR'S NAME Emilio HELPER'S NAME	EQUIPMENT CAT 316E excavator	TOTAL DEPTH 10.5 ft
EXCAVATION METHOD Test Pit	DRILLING ROD TYPE AND DIAMETER / BUCKET WIDTH 2'	BOREHOLE DIAMETER
SAMPLER TYPE(S) AND SIZE(S) (ID) 2.4"-diameter	HAMMER TYPE	HAMMER EFFICIENCY, ERi
BACKFILL AND COMPLETION Backfill Native Soil	GROUND WATER READINGS — DURING: 7.0 ft; AFTER (DATE):	CASING TYPE AND DIAMETER(in)

ELEVATION (ft)	DEPTH (ft)	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests	Drilling Method
	0	Fat CLAY with SAND (CH); medium stiff; very dark grayish brown; moist; some organics														
3.00	1–4		Bulk	Bulk A							65	48	82			
1.00	4	very stiff; dark olive brown; moist														
	5		Drive	1				2.50	24	100	58	45	80			
-1.00	4–7		Bulk	Bulk B												
-3.00	7	some weak to moderate cementation	Bulk	Bulk C												
-5.00	10															

Bottom of exploration at 10.5 ft below ground surface (bgs)

Backfill Native Soil
Ground water encountered at 7 ft bgs
Bulk A 1-4 ft bgs
Bulk B 4-7 ft bgs
Bulk C 7-10 ft bgs

blackburn consulting
Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	3195.X	BTP33
COUNTY: SOL	ROUTE	POSTMILE
CLIENT: Ecosystems Investment Partners		
PREPARED BY: LDM	CHECKED BY: DWC	SHEET: 1 of 1

LOGGED BY	BEGIN DATE	COMPLETION DATE	LOCATION (Lat/Long or North/East and Datum)	HOLE ID
DWC	7-17-18	7-17-18	38.30809° / -121.7221°	BTP34

CONTRACTOR **Hanford ARC**	LOCATION (Offset, Station, Line)	SURFACE ELEVATION **6.0 ft**
OPERATOR'S NAME **Emilio** HELPER'S NAME	EQUIPMENT **CAT 316E excavator**	TOTAL DEPTH **12.0 ft**
EXCAVATION METHOD **Test Pit**	DRILLING ROD TYPE AND DIAMETER / BUCKET WIDTH **2'**	BOREHOLE DIAMETER
SAMPLER TYPE(S) AND SIZE(S) (ID) **2.4"-diameter**	HAMMER TYPE	HAMMER EFFICIENCY, ERi
BACKFILL AND COMPLETION **Backfill Native Soil**	GROUND WATER READINGS — DURING **7.5 ft** — AFTER (DATE)	CASING TYPE AND DIAMETER(in)

ELEVATION (ft)	DEPTH (ft)	Material Graphics	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests	Drilling Method
	0		Fat CLAY (CH); stiff black to dark brown; moist														
4.00	1–3				Bulk A							56	36	89			
2.00	3–6		Fat CLAY with SAND (CH); very stiff; dark yellowish brown		Bulk B							52	37	83			
0.00	6		some cementation		1				2.75	24	105						
	6–9		some organics (groundwater 7.5 ft)		Bulk C												
-2.00	8		wet														
-4.00	9–12				Bulk D												
-6.00	12		Bottom of exploration at 12.0 ft below ground surface (bgs)														

Elevation scale: -8.00 (14), -10.00 (16), -12.00 (18), -14.00 (20), -16.00 (22), -18.00 (24); depth to 25.

Backfill Native Soil
Ground water encountered at 7.5 ft bgs
Bulk A 1-3 ft bgs
Bulk B 3-6 ft bgs
Bulk C 6-9 ft bgs
Bulk D 9-12 ft bgs

blackburn consulting
Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	3195.X	BTP34
COUNTY: SOL	ROUTE	POSTMILE
CLIENT: Ecosystems Investment Partners		
PREPARED BY: LDM	CHECKED BY: DWC	SHEET 1 of 1

LOGGED BY	BEGIN DATE	COMPLETION DATE	LOCATION (Lat/Long or North/East and Datum)	HOLE ID
DWC	**7-23-18**	**7-23-18**	**38.307812° / -121.730491°**	**BTP35**
CONTRACTOR **Hanford ARC**			LOCATION (Offset, Station, Line)	SURFACE ELEVATION **12.0 ft**
OPERATOR'S NAME **Emilio**	HELPER'S NAME		EQUIPMENT **CAT 316E excavator**	TOTAL DEPTH **6.5 ft**
EXCAVATION METHOD **Test Pit**			DRILLING ROD TYPE AND DIAMETER / BUCKET WIDTH **2'**	BOREHOLE DIAMETER
SAMPLER TYPE(S) AND SIZE(S) (ID) **2.4"-diameter**			HAMMER TYPE	HAMMER EFFICIENCY, ERi
BACKFILL AND COMPLETION **Backfill Native Soil**			GROUND WATER READINGS DURING AFTER (DATE)	CASING TYPE AND DIAMETER(in)

ELEVATION (ft)	DEPTH (ft)	Material Graphics	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Laboratory Data: Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests	Drilling Method
	0		Fat CLAY (CH); medium stiff; black; dry; [Fill]														
	1				Bulk A							68	43	94			
10.00	2																
	3																
8.00	4																
	5				1												
			moist		Bulk B												
6.00	6				2												

Bottom of exploration at 6.5 ft below ground surface (bgs)

Backfill Native Soil
No ground water encountered
Bulk A 1-4 ft bgs
Bulk B 4-6 ft bgs

ELEVATION (ft)	DEPTH (ft)
	7
4.00	8
	9
2.00	10
	11
0.00	12
	13
-2.00	14
	15
-4.00	16
	17
-6.00	18
	19
-8.00	20
	21
-10.00	22
	23
-12.00	24
	25

BCI LOG FOR SOIL BORROW TEST PITS.GPJ LIBRARY_3195.GLB 8/6/19

blackburn consulting

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	**3195.X**	**BTP35**
COUNTY **SOL**	ROUTE	POSTMILE
CLIENT **Ecosystems Investment Partners**		
PREPARED BY **LDM**	CHECKED BY **DWC**	SHEET **1 of 1**

LOGGED BY DWC	BEGIN DATE 7-23-18	COMPLETION DATE 7-23-18	LOCATION (Lat/Long or North/East and Datum) 38.309975° / -121.728346°	HOLE ID BTP36
CONTRACTOR Hanford ARC			LOCATION (Offset, Station, Line)	SURFACE ELEVATION 12.0 ft
OPERATOR'S NAME Emilio	HELPER'S NAME		EQUIPMENT CAT 316E excavator	TOTAL DEPTH 6.5 ft
EXCAVATION METHOD Test Pit			DRILLING ROD TYPE AND DIAMETER / BUCKET WIDTH 2'	BOREHOLE DIAMETER
SAMPLER TYPE(S) AND SIZE(S) (ID) 2.4"-diameter			HAMMER TYPE	HAMMER EFFICIENCY, ERi
BACKFILL AND COMPLETION Backfill Native Soil			GROUND WATER READINGS DURING AFTER (DATE)	CASING TYPE AND DIAMETER(in)

ELEVATION (ft)	DEPTH (ft)	Material Graphics	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Laboratory Data: Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests	Drilling Method
	0		Fat CLAY (CH); medium stiff; black; dry; [Fill]														
	1		Lean CLAY with SAND (CL); medium stiff; dark yellowish brown mottled with black; dry; [Fill]		Bulk A							43	27	83			
10.00	2																
	3																
8.00	4				1												
	5		dry to moist, more black		Bulk B												
6.00	6				2					15	104	49	35	82			
	7		Bottom of exploration at 6.5 ft below ground surface (bgs)														
4.00	8		Backfill Native Soil No ground water encountered Bulk A 1-3 ft bgs Bulk B 3-6 ft bgs														
	9																
2.00	10																
	11																
0.00	12																
	13																
-2.00	14																
	15																
-4.00	16																
	17																
-6.00	18																
	19																
-8.00	20																
	21																
-10.00	22																
	23																
-12.00	24																
	25																

blackburn consulting
Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME Lookout Slough THRFIP		FILE NO. 3195.X	HOLE ID BTP36
COUNTY SOL	ROUTE		POSTMILE
CLIENT Ecosystems Investment Partners			
PREPARED BY LDM	CHECKED BY DWC		SHEET 1 of 1

LOGGED BY	BEGIN DATE	COMPLETION DATE	LOCATION (Lat/Long or North/East and Datum)	HOLE ID
DWC	7-23-18	7-23-18	38.312139° / -121.7262°	BTP37
CONTRACTOR			LOCATION (Offset, Station, Line)	SURFACE ELEVATION
Hanford ARC				12.0 ft
OPERATOR'S NAME	HELPER'S NAME		EQUIPMENT	TOTAL DEPTH
Emilio			CAT 316E excavator	6.0 ft
EXCAVATION METHOD			DRILLING ROD TYPE AND DIAMETER / BUCKET WIDTH	BOREHOLE DIAMETER
Test Pit			2'	
SAMPLER TYPE(S) AND SIZE(S) (ID)			HAMMER TYPE	HAMMER EFFICIENCY, ERi
2.4"-diameter				
BACKFILL AND COMPLETION			GROUND WATER READINGS DURING AFTER (DATE)	CASING TYPE AND DIAMETER(in)
Backfill Native Soil				

ELEVATION (ft)	DEPTH (ft)	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests	Drilling Method
	0	Fat CLAY (CH); hard; mottled dark yellowish brown and black; dry to moist; [Fill]														
	1			Bulk A							61	45	92			
10.00	2															
	3			1				>4.5	15	107						
8.00	4	some cementation		Bulk B												
	5															
6.00	6	Bottom of exploration at 6.0 ft below ground surface (bgs) Backfill Native Soil No ground water encountered Bulk A 1-3 ft bgs Bulk B 3-6 ft bgs														
	7															
4.00	8															
	9															
2.00	10															
	11															
0.00	12															
	13															
-2.00	14															
	15															
-4.00	16															
	17															
-6.00	18															
	19															
-8.00	20															
	21															
-10.00	22															
	23															
-12.00	24															
	25															

Laboratory Data

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME		FILE NO.	HOLE ID
Lookout Slough THRFIP		3195.X	BTP37
COUNTY	ROUTE		POSTMILE
SOL			
CLIENT			
Ecosystems Investment Partners			
PREPARED BY	CHECKED BY	SHEET	
LDM	DWC	1 of 1	

LOGGED BY	BEGIN DATE	COMPLETION DATE	LOCATION (Lat/Long or North/East and Datum)	HOLE ID
DWC	7-23-18	7-23-18	38.314302° / -121.724053°	BTP38

CONTRACTOR Hanford ARC	LOCATION (Offset, Station, Line)	SURFACE ELEVATION 12.0 ft
OPERATOR'S NAME Emilio HELPER'S NAME	EQUIPMENT CAT 316E excavator	TOTAL DEPTH 6.0 ft
EXCAVATION METHOD Test Pit	DRILLING ROD TYPE AND DIAMETER / BUCKET WIDTH 2'	BOREHOLE DIAMETER
SAMPLER TYPE(S) AND SIZE(S) (ID) 2.4"-diameter	HAMMER TYPE	HAMMER EFFICIENCY, ERi
BACKFILL AND COMPLETION Backfill Native Soil	GROUND WATER READINGS DURING AFTER (DATE)	CASING TYPE AND DIAMETER(in)

ELEVATION (ft)	DEPTH (ft)	Material Graphics	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests	Drilling Method
	0		Fat CLAY (CH) (Fill); medium stiff; olive brown; moist														
10.00	1–3				Bulk A							50	31				
8.00	3–6		Lean CLAY (CL) (Fill); mottled dark yellowish brown and black; dry to moist		Bulk B												
6.00	6		Bottom of exploration at 6.0 ft below ground surface (bgs) Backfill Native Soil No ground water encountered Bulk A 1-3 ft bgs Bulk B 3-6 ft bgs														

Elevation scale: 10.00, 8.00, 6.00, 4.00, 2.00, 0.00, -2.00, -4.00, -6.00, -8.00, -10.00, -12.00

Depth scale: 0–25

blackburn consulting

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	3195.X	BTP38

COUNTY	ROUTE	POSTMILE
SOL		

CLIENT
Ecosystems Investment Partners

PREPARED BY	CHECKED BY	SHEET
LDM	DWC	1 of 1

LOGGED BY **DWC** / BEGIN DATE **7-23-18** / COMPLETION DATE **7-23-18**	LOCATION (Lat/Long or North/East and Datum) **38.316466° / -121.721907°**	HOLE ID **BTP39**
CONTRACTOR **Hanford ARC**	LOCATION (Offset, Station, Line)	SURFACE ELEVATION **14.0 ft**
OPERATOR'S NAME **Emilio** / HELPER'S NAME	EQUIPMENT **CAT 316E excavator**	TOTAL DEPTH **7.0 ft**
EXCAVATION METHOD **Test Pit**	DRILLING ROD TYPE AND DIAMETER / BUCKET WIDTH **2'**	BOREHOLE DIAMETER
SAMPLER TYPE(S) AND SIZE(S) (ID) **2.4"-diameter**	HAMMER TYPE	HAMMER EFFICIENCY, ERi
BACKFILL AND COMPLETION **Backfill Native Soil**	GROUND WATER READINGS / DURING / AFTER (DATE)	CASING TYPE AND DIAMETER(in)

ELEVATION (ft)	DEPTH (ft)	Material Graphics	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Laboratory Data: Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests	Drilling Method
	0		SANDY Lean CLAY (CL); medium stiff; mottled dark yellowish brown and black; dry to moist; [Fill]														
	1–4				Bulk A							43	31	69			
12.00	2																
10.00	4–7		mottled black and dark yellowish brown		Bulk B												
8.00	6																
	7		Bottom of exploration at 7.0 ft below ground surface (bgs)														

Backfill Native Soil
No ground water encountered
Bulk A 1-4 ft bgs
Bulk B 4-7 ft bgs

Elevation scale: 12.00, 10.00, 8.00, 6.00, 4.00, 2.00, 0.00, -2.00, -4.00, -6.00, -8.00, -10.00; Depth scale: 0–25

blackburn consulting
Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME **Lookout Slough THRFIP**		FILE NO. **3195.X**	HOLE ID **BTP39**
COUNTY **SOL**	ROUTE		POSTMILE
CLIENT **Ecosystems Investment Partners**			
PREPARED BY **LDM**	CHECKED BY **DWC**	SHEET **1 of 1**	

LOGGED BY **DWC**	BEGIN DATE **7-23-18**	COMPLETION DATE **7-23-18**	LOCATION (Lat/Long or North/East and Datum) **38.318638° / -121.719774°**	HOLE ID **BTP40**
CONTRACTOR **Hanford ARC**			LOCATION (Offset, Station, Line)	SURFACE ELEVATION **12.0 ft**
OPERATOR'S NAME **Emilio**	HELPER'S NAME		EQUIPMENT **CAT 316E excavator**	TOTAL DEPTH **6.0 ft**
EXCAVATION METHOD **Test Pit**			DRILLING ROD TYPE AND DIAMETER / BUCKET WIDTH **2'**	BOREHOLE DIAMETER
SAMPLER TYPE(S) AND SIZE(S) (ID) **2.4"-diameter**			HAMMER TYPE	HAMMER EFFICIENCY, ERi
BACKFILL AND COMPLETION **Backfill Native Soil**			GROUND WATER READINGS DURING AFTER (DATE)	CASING TYPE AND DIAMETER(in)

ELEVATION (ft)	DEPTH (ft)	Material Graphics	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests	Drilling Method
	0		Fat CLAY (CH) (Fill); medium stiff; mottled dark grayish brown and black; dry to moist														
10.00	1–3				Bulk A							57	40	93			
8.00	3–6				Bulk B												
6.00	6		Bottom of exploration at 6.0 ft below ground surface (bgs)														

Laboratory Data

Backfill Native Soil
No ground water encountered
Bulk A 1-3 ft bgs
Bulk B 3-6 ft bgs

Depth scale 0–25 ft; elevation scale 10.00, 8.00, 6.00, 4.00, 2.00, 0.00, -2.00, -4.00, -6.00, -8.00, -10.00, -12.00

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME **Lookout Slough THRFIP**		FILE NO. **3195.X**	HOLE ID **BTP40**
COUNTY **SOL**	ROUTE		POSTMILE
CLIENT **Ecosystems Investment Partners**			
PREPARED BY **LDM**	CHECKED BY **DWC**	SHEET **1 of 1**	

LOGGED BY	BEGIN DATE	COMPLETION DATE	LOCATION (Lat/Long or North/East and Datum)	HOLE ID
MDR	8-18-17	8-18-17		TP01
CONTRACTOR Hanford ARC			LOCATION (Offset, Station, Line)	SURFACE ELEVATION
OPERATOR'S NAME Jesse	HELPER'S NAME		EQUIPMENT CAT 420E backhoe	TOTAL DEPTH 5.0 ft
EXCAVATION METHOD Test Pit			DRILLING ROD TYPE AND DIAMETER / BUCKET WIDTH 2'	BOREHOLE DIAMETER
SAMPLER TYPE(S) AND SIZE(S) (ID) 2.4"-diameter			HAMMER TYPE	HAMMER EFFICIENCY, ERi
BACKFILL AND COMPLETION Backfill Native Soil			GROUND WATER READINGS DURING 2.8 ft AFTER (DATE)	CASING TYPE AND DIAMETER(in)

ELEVATION (ft)	DEPTH (ft)	Material Graphics	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests	Drilling Method
	0		Lean CLAY (CL); stiff; mottled dark gray and black; moist; organics														
	1		Fat CLAY (CH); stiff; mottled dark gray and brown and yellowish brown; moist; no organics		Bulk G							76	53	91			
	2				1				1.25	51	70						
	3		very dark gray, wet		2				1.5	36	85						
	4				Bulk H												
	5				3				1.75	35	87						

Bottom of exploration at 5.0 ft below ground surface (bgs)

Backfill Native Soil
Ground water encountered at 2.8 ft bgs
Bulk G 1.0-2.0 ft
Bulk H 3.0-4.5 ft
Test Results (Liquid Limit, Plasticity Index and % <#200) at 1.0 ft from Combined Bulk G and Bulk H

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	3195.X	TP01
COUNTY SOL	ROUTE	POSTMILE
CLIENT Ecosystems Investment Partners		
PREPARED BY NCH	CHECKED BY DWC	SHEET 1 of 1

LOGGED BY: MDR	BEGIN DATE: 8-18-17	COMPLETION DATE: 8-18-17
LOCATION (Lat/Long or North/East and Datum):		HOLE ID: TP02
CONTRACTOR: Hanford ARC	LOCATION (Offset, Station, Line):	SURFACE ELEVATION:
OPERATOR'S NAME: Jesse / HELPER'S NAME:	EQUIPMENT: CAT 420E backhoe	TOTAL DEPTH: 4.5 ft
EXCAVATION METHOD: Test Pit	DRILLING ROD TYPE AND DIAMETER / BUCKET WIDTH: 2'	BOREHOLE DIAMETER:
SAMPLER TYPE(S) AND SIZE(S) (ID): 2.4"-diameter	HAMMER TYPE:	HAMMER EFFICIENCY, ERi:
BACKFILL AND COMPLETION: Backfill Native Soil	GROUND WATER READINGS: DURING 3.0 ft; AFTER (DATE):	CASING TYPE AND DIAMETER(in):

ELEVATION (ft)	DEPTH (ft)	Material Graphics	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests	Drilling Method
	0		Fat CLAY (CH); soft; mottled dark gray and black; moist; some rootlets														
	1		mottled very dark brown and yellowish red and dark gray		1 Bulk F												
	3				2												
	4.5		Lean CLAY (CL); stiff; very dark grayish brown; wet		3												

Bottom of exploration at 4.5 ft below ground surface (bgs)

Backfill Native Soil
Ground water encountered at 3.0 ft bgs
Bulk F 1.0-3.0 ft

blackburn consulting
Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME: Lookout Slough THRFIP		FILE NO.: 3195.X	HOLE ID: TP02
COUNTY: SOL	ROUTE:		POSTMILE:
CLIENT: Ecosystems Investment Partners			
PREPARED BY: NCH	CHECKED BY: DWC		SHEET: 1 of 1

LOGGED BY	BEGIN DATE	COMPLETION DATE	LOCATION (Lat/Long or North/East and Datum)	HOLE ID
MDR	**8-18-17**	**8-18-17**		**TP04**

CONTRACTOR **Hanford ARC**	LOCATION (Offset, Station, Line)	SURFACE ELEVATION
OPERATOR'S NAME **Jesse** / HELPER'S NAME	EQUIPMENT **CAT 420E backhoe**	TOTAL DEPTH **4.3 ft**
EXCAVATION METHOD **Test Pit**	DRILLING ROD TYPE AND DIAMETER / BUCKET WIDTH **2'**	BOREHOLE DIAMETER
SAMPLER TYPE(S) AND SIZE(S) (ID) **2.4"-diameter**	HAMMER TYPE	HAMMER EFFICIENCY, ERi
BACKFILL AND COMPLETION **Backfill Native Soil**	GROUND WATER READINGS DURING **3.2 ft** AFTER (DATE)	CASING TYPE AND DIAMETER(in)

ELEVATION (ft)	DEPTH (ft)	Material Graphics	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests	Drilling Method
	0		Fat CLAY with SAND (CH); soft; dark gray and black; moist to wet; rootlets														
	1		stiff; mottled dark yellowish brown and yellowish brown; no rootlets		1				1.75	26	97	59	44	75			
	2				Bulk E												
	3		SANDY SILT (ML); dark yellowish brown; wet; some cementation														

Bottom of exploration at 4.3 ft below ground surface (bgs)

Backfill Native Soil
Ground water encountered at 3.2 ft bgs
Perched ground water at 1.0 ft
Test Results (Liquid Limit, Plasticity Index and % <#200) at 1 ft from Bulk E
Bulk E 1.0-3.0 ft

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	**3195.X**	**TP04**
COUNTY **SOL**	ROUTE	POSTMILE
CLIENT **Ecosystems Investment Partners**		
PREPARED BY **NCH**	CHECKED BY **DWC**	SHEET **1 of 1**

LOGGED BY	BEGIN DATE	COMPLETION DATE	LOCATION (Lat/Long or North/East and Datum)	HOLE ID
MDR	**8-18-17**	**8-18-17**		**TP05**

CONTRACTOR **Hanford ARC**	LOCATION (Offset, Station, Line)	SURFACE ELEVATION
OPERATOR'S NAME **Jesse** / HELPER'S NAME	EQUIPMENT **CAT 420E backhoe**	TOTAL DEPTH **4.5 ft**
EXCAVATION METHOD **Test Pit**	DRILLING ROD TYPE AND DIAMETER / BUCKET WIDTH **2'**	BOREHOLE DIAMETER
SAMPLER TYPE(S) AND SIZE(S) (ID) **2.4"-diameter**	HAMMER TYPE	HAMMER EFFICIENCY, ERi
BACKFILL AND COMPLETION **Backfill Native Soil**	GROUND WATER READINGS — DURING **2.5 ft** — AFTER (DATE)	CASING TYPE AND DIAMETER(in)

ELEVATION (ft)	DEPTH (ft)	Material Graphics	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests	Drilling Method
	0		Fat CLAY (CH); soft; very dark gray; moist; rootlets														
	1		stiff; mottled very dark gray to black and dark yellowish brown; no rootlets		1				1.5	37	81	68	50	93			
	2				Bulk C												
	3		black; wet		2				1.5	30	90						
					Bulk D												
	4		very dark grayish brown		3				1.25	29	92						

Laboratory Data

Bottom of exploration at 4.5 ft below ground surface (bgs)

Backfill Native Soil
Ground water encountered at 2.5 ft bgs
Bulk C 1.0-3.0 ft
Bulk D 3.0-4.0 ft
Test Results (Liquid Limit, Plasticity Index and % <#200) at 1.0 ft from Combined Bulk C and Bulk D

BCI LOG FOR SOIL BORROW TEST PITS.GPJ LIBRARY_3195.GLB 8/6/19

blackburn consulting

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	**3195.X**	**TP05**
COUNTY **SOL**	ROUTE	POSTMILE
CLIENT **Ecosystems Investment Partners**		
PREPARED BY **NCH**	CHECKED BY **DWC**	SHEET **1 of 1**

LOGGED BY	BEGIN DATE	COMPLETION DATE	LOCATION (Lat/Long or North/East and Datum)	HOLE ID
MDR	**8-18-17**	**8-18-17**		**TP06**

CONTRACTOR **Hanford ARC**	LOCATION (Offset, Station, Line)	SURFACE ELEVATION
OPERATOR'S NAME **Jesse** HELPER'S NAME	EQUIPMENT **CAT 420E backhoe**	TOTAL DEPTH **4.5 ft**
EXCAVATION METHOD **Test Pit**	DRILLING ROD TYPE AND DIAMETER / BUCKET WIDTH **2'**	BOREHOLE DIAMETER
SAMPLER TYPE(S) AND SIZE(S) (ID) **2.4"-diameter**	HAMMER TYPE	HAMMER EFFICIENCY, ERi
BACKFILL AND COMPLETION **Backfill Native Soil**	GROUND WATER READINGS DURING **3.5 ft** AFTER (DATE)	CASING TYPE AND DIAMETER(in)

ELEVATION (ft)	DEPTH (ft)	Material Graphics	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests	Drilling Method
	0		Fat CLAY with SAND (CH); soft; dark gray; moist; rootlets														
	1		mottled very dark gray and dark gray and dark yellowish brown; very moist; no rootlets									51	38	85			
	2				1				1.5	24	100						
					Bulk A												
	3		Lean CLAY (CL); stiff; yellowish brown; wet		2				2.25	23	103						
	4				Bulk B												
					3				0.5/2.0	24	100						

Bottom of exploration at 4.5 ft below ground surface (bgs)

Backfill Native Soil
Ground water encountered at 3.5 ft bgs
Bulk A 1.0-3.0 ft
Bulk B 3.0-4.0 ft
Test Results (Liquid Limit, Plasticity Index and % <#200) at 1.0 ft from Combined Bulk A and Bulk B

blackburn consulting
Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME	FILE NO.	HOLE ID
Lookout Slough THRFIP	**3195.X**	**TP06**
COUNTY **SOL**	ROUTE	POSTMILE
CLIENT **Ecosystems Investment Partners**		
PREPARED BY **NCH**	CHECKED BY **DWC**	SHEET **1 of 1**

LOGGED BY **MDR**	BEGIN DATE **8-18-17**	COMPLETION DATE **8-18-17**	LOCATION (Lat/Long or North/East and Datum)	HOLE ID **TP08**
CONTRACTOR **Hanford ARC**			LOCATION (Offset, Station, Line)	SURFACE ELEVATION
OPERATOR'S NAME **Jesse**	HELPER'S NAME		EQUIPMENT **CAT 420E backhoe**	TOTAL DEPTH **5.0 ft**
EXCAVATION METHOD **Test Pit**			DRILLING ROD TYPE AND DIAMETER / BUCKET WIDTH **2'**	BOREHOLE DIAMETER
SAMPLER TYPE(S) AND SIZE(S) (ID) **2.4"-diameter**			HAMMER TYPE	HAMMER EFFICIENCY, ERi
BACKFILL AND COMPLETION **Backfill Native Soil**			GROUND WATER READINGS / DURING / AFTER (DATE)	CASING TYPE AND DIAMETER(in)

ELEVATION (ft)	DEPTH (ft)	Material Graphics	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests	Drilling Method
	0		Lean CLAY (CL); stiff; very dark gray; dry; organics														
					Bulk I												
	1				1												
	2		very stiff; some organics		2												
	3				Bulk J												
					3												
	4		stiff; mottled dark gray and brown and yellowish brown; moist		4												
	5		Bottom of exploration at 5.0 ft below ground surface (bgs)														

Backfill Native Soil
No ground water encountered
Bulk I 0.5-1.0 ft
Bulk J 1.5 -3.5 ft

Laboratory Data

blackburn consulting

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME **Lookout Slough THRFIP**		FILE NO. **3195.X**	HOLE ID **TP08**
COUNTY **SOL**	ROUTE		POSTMILE
CLIENT **Ecosystems Investment Partners**			
PREPARED BY **NCH**	CHECKED BY **DWC**	SHEET **1 of 1**	

LOGGED BY	BEGIN DATE	COMPLETION DATE	LOCATION (Lat/Long or North/East and Datum)	HOLE ID
MDR	**8-18-17**	**8-18-17**		**TP10**

CONTRACTOR **Hanford ARC**	LOCATION (Offset, Station, Line)	SURFACE ELEVATION
OPERATOR'S NAME **Jesse** HELPER'S NAME	EQUIPMENT **CAT 420E backhoe**	TOTAL DEPTH **5.0 ft**
EXCAVATION METHOD **Test Pit**	DRILLING ROD TYPE AND DIAMETER / BUCKET WIDTH **2'**	BOREHOLE DIAMETER
SAMPLER TYPE(S) AND SIZE(S) (ID) **2.4"-diameter**	HAMMER TYPE	HAMMER EFFICIENCY, ERi
BACKFILL AND COMPLETION **Backfill Native Soil**	GROUND WATER READINGS DURING AFTER (DATE)	CASING TYPE AND DIAMETER(in)

ELEVATION (ft)	DEPTH (ft)	Material Graphics	DESCRIPTION	Sample Location	Sample Number	Blows per 6 in.	Blows per foot	Recovery (%)	Pocket Penetrometer	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% <#200	Shear Strength Test	Additional Lab Tests	Drilling Method
	0		Fat CLAY (CH); soft to medium stiff; mottled dark gray and dark brown; dry to slightly moist; rootlets														
	1				1												
	2		SANDY Lean CLAY (CL); stiff; mottled dark brown and dark gray; dry; rootlets														
	3				2												
	4		very dark gray; very moist		Bulk K												
	5				3												

Laboratory Data

Bottom of exploration at 5.0 ft below ground surface (bgs)

Backfill Native Soil
No ground water encountered
Bulk K 2-4.5 ft

BCI LOG FOR SOIL BORROW TEST PITS.GPJ LIBRARY_3195.GLB 8/6/19

blackburn consulting

Blackburn Consulting
2491 Boatman Avenue
West Sacramento CA, 95691
Phone: (916) 375-8706
Fax: (916) 375-8709

PROJECT NAME **Lookout Slough THRFIP**		FILE NO. **3195.X**	HOLE ID **TP10**
COUNTY **SOL**	ROUTE		POSTMILE
CLIENT **Ecosystems Investment Partners**			
PREPARED BY **NCH**	CHECKED BY **DWC**		SHEET **1 of 1**

This Page Intentionally Left Blank

GEOTECHNICAL BORROW REPORT

65% Design

Lookout Slough THRFIP

Solano County, California

APPENDIX B

BCI Laboratory Testing Summary Table
BCI Laboratory Test Results

Lookout Slough Tidal Habitat Restoration and Flood Improvement Project Test Pit Laboratory Testing Summary Table

Exploration/ Sample I.D.	Depth (feet)	Sample Type	USCS Classification (ASTM D2487)	Field Pocket Penetrometer (tsf)	Water Content (%) (ASTM D2216)	Wet Density, g_{wet} (pcf) (ASTM D7263)	Dry Density, g_{dry} (pcf) (ASTM D7263)	Compaction Curve (ASTM D698-12 Method A)		Percent Passing #200 (ASTM D1140)	Liquid Limit (ASTM D4318)	Plasticity Index (ASTM D4318)	Triaxial Data - CU (ASTM D4767)				Fully Softened Friction Angle (deg)	Triaxial Data - UU (ASTM D2850)	Hydraulic Conductivity, (ASTM D5084) k_v (cm/sec)
								Maximum Density (pcf)	Optimumm Moisture Content (%)				Effective Friction Angle (ϕ')	Effective Cohesion, C' (psf)	Total Friction Angle (ϕ')	Total Cohesion, C (psf)		Total Cohesion, C (psf)	
TP1	1.0-4.5	Bulk	CH							91	76	53							
TP1-1	2.8-3.3	Tube	CH	1.5	36	115	85												
TP1-2	2.8-3.3	Tube	CH	1.5	36	115	85												
TP1-3	4.5-5	Tube	CH	1.75	35	117	87												
TP4	1.0-3.0	Bulk	CH							75	59	44	22	404	14	399		1997	2.78×10^{-09}
TP4-1	1.0-1.5	Tube	CL	1.75	26	121	97												
TP5	1.0-4.0	Bulk	CH							93	68	50							
TP5-1	1.0-1.5	Tube	CH	1.5	37	111	81												
TP5-2A	3.0-3.5	Tube	CH	1.5	30	117	90												
TP5-3A	4.0-4.5	Tube	CH	1.25	29	119	93												
TP6	1.0-4.0	Bulk	CH							85	51	38	27	540	13	591		1758	
TP6-1	1.5-2.0	Tube	CH	1.5	24	123	100												
TP6-2	3.0-3.5	Tube	CL	2.25	23	127	103												
TP6-3	4.0-4.5	Tube	CL	0.5-2.0	24	124	100												
BTP01-A	1.0-3.0	Bulk	CH							88	56	40							
BTP02-A	1.0-3.0	Bulk	CL								47	33							
BTP02-1	4.0	Tube	CH	2.25	23	123	100			83	60	46							
BTP03-A	1.0-3.0	Bulk	CH							85	57	43						1299	
BTP04-A	1.0-3.0	Bulk	CH								57	39					18		
BTP04-1	4.0	Tube	CL	4.0	23	119	97			68									
BTP05- A	1.0-4.0	Bulk	CL								48	33							
BTP05-2A	3.0-3.5	Bulk	CH								68	50							
BTP05-3A	4.0-4.5	Bulk	CH								68	54							
BTP06-A	1.0-4.0	Bulk	CL								49	32							
BTP06-1	4.5	Tube	CL	3.0	22	116	95			74	49	34							
BTP07-A	1.0-3.0	Bulk	CH					95	24	93	68	49							
BTP07-1	3.0	Tube	CL/CH	1.7	28	118	92												
BTP08-A	1.0-4.0	Bulk	CH								71	50							
BTP08-4A	4.5-5.0	Bulk	CH								80	56							
BTP09-A	1.0-3.0	Bulk	CH								69	47							
BTP09-1	3.0	Tube	CH	1.75	32	116	88			94	74	56							
BTP10-1A	1.0-1.5	Bulk	CH								72	52							
BTP10-A	1.0-3.0	Bulk	CH								95	75							
BTP10-1	6.0	Tube	CH	1.25	30	121	93			77	101	84							
BTP10-2A	4.5-5.0	Bulk	CH								86	64							
BTP11-1A	1.0-3.0	Bulk	CH								54	37							
BTP11-2	9.0	Tube	CL	0.25	31	120	92			63	40	25							
BTP12-A	1.0-3.0	Bulk	CH								71	46					20		
BTP12-1	6.0	Tube	CH	1.25	32	119	91			92	66	49							
BTP13-A	1.0-3.0	Bulk	CH								62	45							
BTP14-A	1.0-3.0	Bulk	CH								60	41							

Lookout Slough Tidal Habitat Restoration and Flood Improvement Project Test Pit Laboratory Testing Summary Table

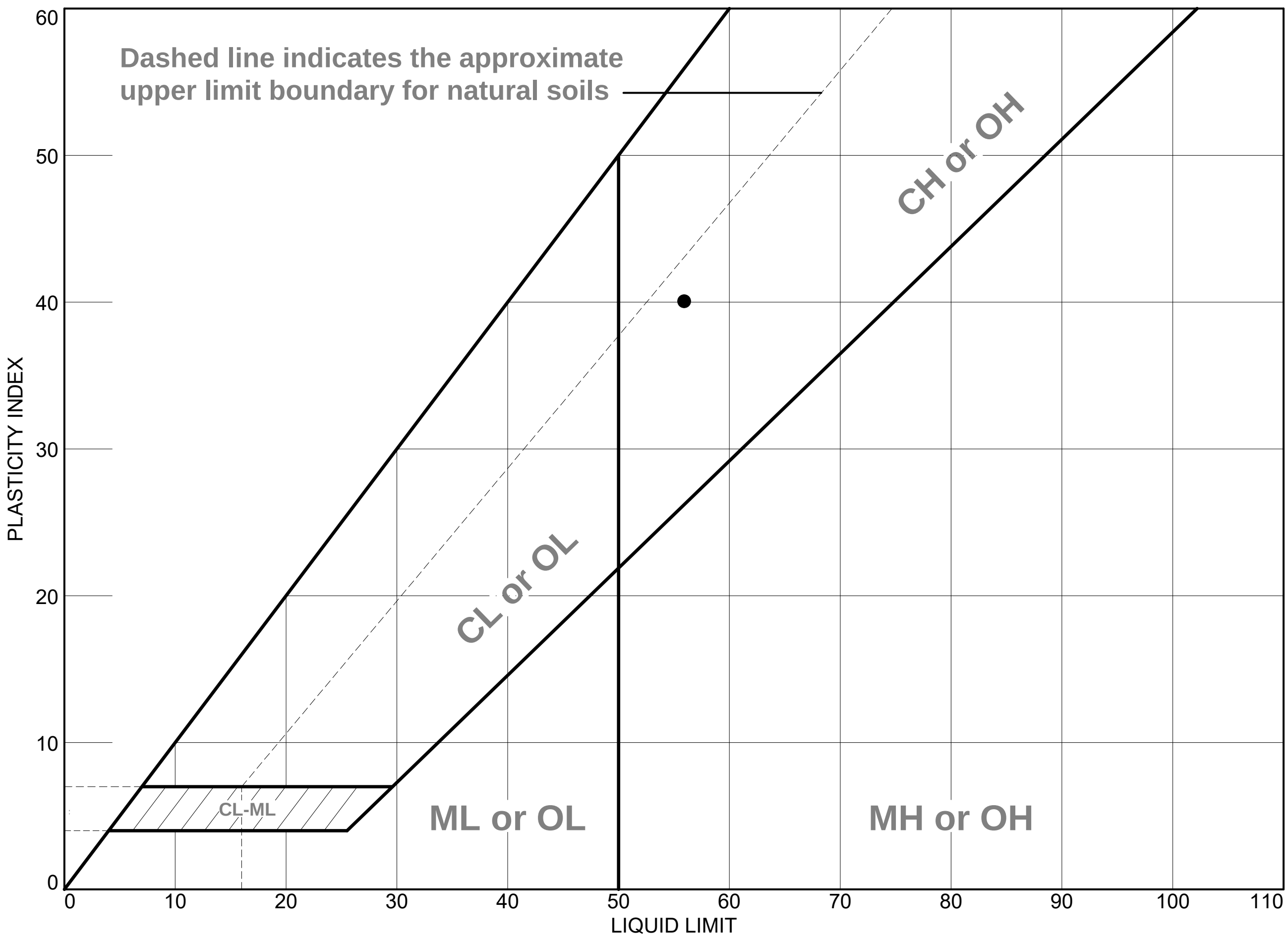
Exploration/ Sample I.D.	Depth (feet)	Sample Type	USCS Classification (ASTM D2487)	Field Pocket Penetrometer (tsf)	Water Content (%) (ASTM D2216)	Wet Density, g_{wet} (pcf) (ASTM D7263)	Dry Density, g_{dry} (pcf) (ASTM D7263)	Compaction Curve (ASTM D698-12 Method A)		Percent Passing #200 (ASTM D1140)	Liquid Limit (ASTM D4318)	Plasticity Index (ASTM D4318)	Triaxial Data - CU (ASTM D4767)				Fully Softened Friction Angle (deg)	Triaxial Data - UU (ASTM D2850)	Hydraulic Conductivity, (ASTM D5084) k_v (cm/sec)
								Maximum Density (pcf)	Optimumm Moisture Content (%)				Effective Friction Angle (ϕ')	Effective Cohesion, C' (psf)	Total Friction Angle (ϕ')	Total Cohesion, C (psf)		Total Cohesion, C (psf)	
BTP14-1	3.0-3.5	Tube	CH								70	49							
BTP15-A	1.0-3.0	Bulk	CL								47	30						1567	4.24×10^{-09}
BTP15-B	3.0-6.0	Bulk	CH					104	21	80	50	33							
BTP15-1	4.0	Tube	CL	1.5	26	124	98												
BTP15-2	8.5	Tube	CL	2.25	33	115	86			94	45	25							
BTP16-A	1.0-3.0	Bulk	CH								54	35							
BTP17-A	1.0-3.0	Bulk	CH								56	37							
BTP18-A	1.0-3.0	Bulk	CH								54	36							
BTP18-B	3.0-6.0	Bulk	CL							89	41	24							
BTP18-2	9.0	Tube	CL		30	118	91			57	31	17							
BTP19-A	1.0-3.0	Bulk	CL								52	36							
BTP20-A	1.0-3.0	Bulk	CL					110	17	68	43	29							4.60×10^{-09}
BTP20-1	3.0-3.5	Tube	CL								38	22							
BTP21-A	1.0-4.0	Bulk	CH								58	40							
BTP21-1	4.0	Tube	CH	1.25	26	113	90			90	53	37							
BTP22-A	1.0-4.0	Bulk	CH								59	38							
BTP22-1	4.0	Tube	CH	2.25	24	125	101			95	57	42							
BTP22-2	7.0	Tube	CL	1.5	27	110	87			94	49	31							
BTP23-A	1.0-4.0	Bulk	CH								55	37							
BTP23-1	4.0	Tube	CL	1.5	20	129	107			76	37	22							
BTP24-A	1.0-4.0	Bulk	CH								63	43							
BTP24-B	4.0-7.0	Bulk	CH					103	20	91	56	38	19	424	14	382			
BTP24-C	7.0-10.0	Bulk	CL							83	45	27							
BTP24-1	4.0	Tube	CL	1.75	28	121	94												
BTP25-A	1.0-3.0	Bulk	CH								53	37							
BTP25-1	4.0-4.5	Tube	CH								63	44							
BTP26-A	1.0-4.0	Bulk	CH								66	47							
BTP26-B	4.0-7.0	Bulk	CL					102	21	88	42	24						1584	
BTP26-1	4.0	Tube	CH	1.75	29	117	91			85	57	39							
BTP26-2	7.0	Tube	CL	1.25	34	131	98												
BTP27-A	1.0-4.0	Bulk	CH								54	36							
BTP27-1	4.0-4.5	Tube	CL								47	28							
BTP28-A	1.0-4.0	Bulk	CH								61	41							
BTP28-1	4.0	Tube	CH	1.5	26	123	97			81	55	39							
BTP29-A	1.0-4.0	Bulk	CL					107	19	85	49	35						1931	
BTP29-1	4.0	Tube	CH	2	23	126	103												
BTP30-A	1.0-4.0	Bulk	CH								57	39							
BTP30-1	4.0-4.5	Tube	CH								62	43							
BTP31-A	1.0-3.0	Bulk	CH							96	71	51						1599	
BTP31-1	3.0	Tube	CH	1.5	28	120	94			88	56	40							
BTP32-A	1.0-3.0	Bulk	CH					93	27	96	72	51							
BTP32-1	3.0	Tube	CH	1.75	29	121	94												

Lookout Slough Tidal Habitat Restoration and Flood Improvement Project Test Pit Laboratory Testing Summary Table

Exploration/ Sample I.D.	Depth (feet)	Sample Type	USCS Classification (ASTM D2487)	Field Pocket Penetrometer (tsf)	Water Content (%) (ASTM D2216)	Wet Density, g_{wet} (pcf) (ASTM D7263)	Dry Density, g_{dry} (pcf) (ASTM D7263)	Compaction Curve (ASTM D698-12 Method A)		Percent Passing #200 (ASTM D1140)	Liquid Limit (ASTM D4318)	Plasticity Index (ASTM D4318)	Triaxial Data - CU (ASTM D4767)				Fully Softened Friction Angle (deg)	Triaxial Data - UU (ASTM D2850)	Hydraulic Conductivity, (ASTM D5084) k_v (cm/sec)
								Maximum Density (pcf)	Optimumm Moisture Content (%)				Effective Friction Angle (ϕ')	Effective Cohesion, C' (psf)	Total Friction Angle (ϕ')	Total Cohesion, C (psf)		Total Cohesion, C (psf)	
BTP33-A	1.0-4.0	Bulk	CH								65	48							
BTP33-1	4.5	Tube	CH	2.5	24	124	100			80	58	45							
BTP34-A	1.0-3.0	Bulk	CH								56	36							
BTP34-B	3.0-6.0	Bulk	CH					105	19	83	52	37			16	254			
BTP34-1	6.0	Tube	CL	2.75	24	131	105												
BTP35-A	1.0-4.0	Bulk	CH								68	43							
BTP36-A	1.0-4.0	Bulk	CL								43	27							
BTP36-2	6.0	Tube	CL		15	120	104			82	49	35							
BTP37-A	1.0-3.0	Bulk	CH					100	20	92	61	45							
BTP37-1	3.0	Tube	CL	>4.5	15	122	107												
BTP38-A	1.0-3.0	Bulk	CH								50	31							
BTP39-A	1.0-4.0	Bulk	CL								43	31							
BTP40-A	1.0-3.0	Bulk	CH							93	57	40							

This Page Intentionally Left Blank

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Fat CLAY, dark grayish brown	56	16	40		87.9	CH

Project No. 3195.X **Client:** EIP

Project: Lookout Slough THRFP - Borrow Analysis

● **Source of Sample:** BTP 1 **Depth:** 1-3' **Sample Number:** A

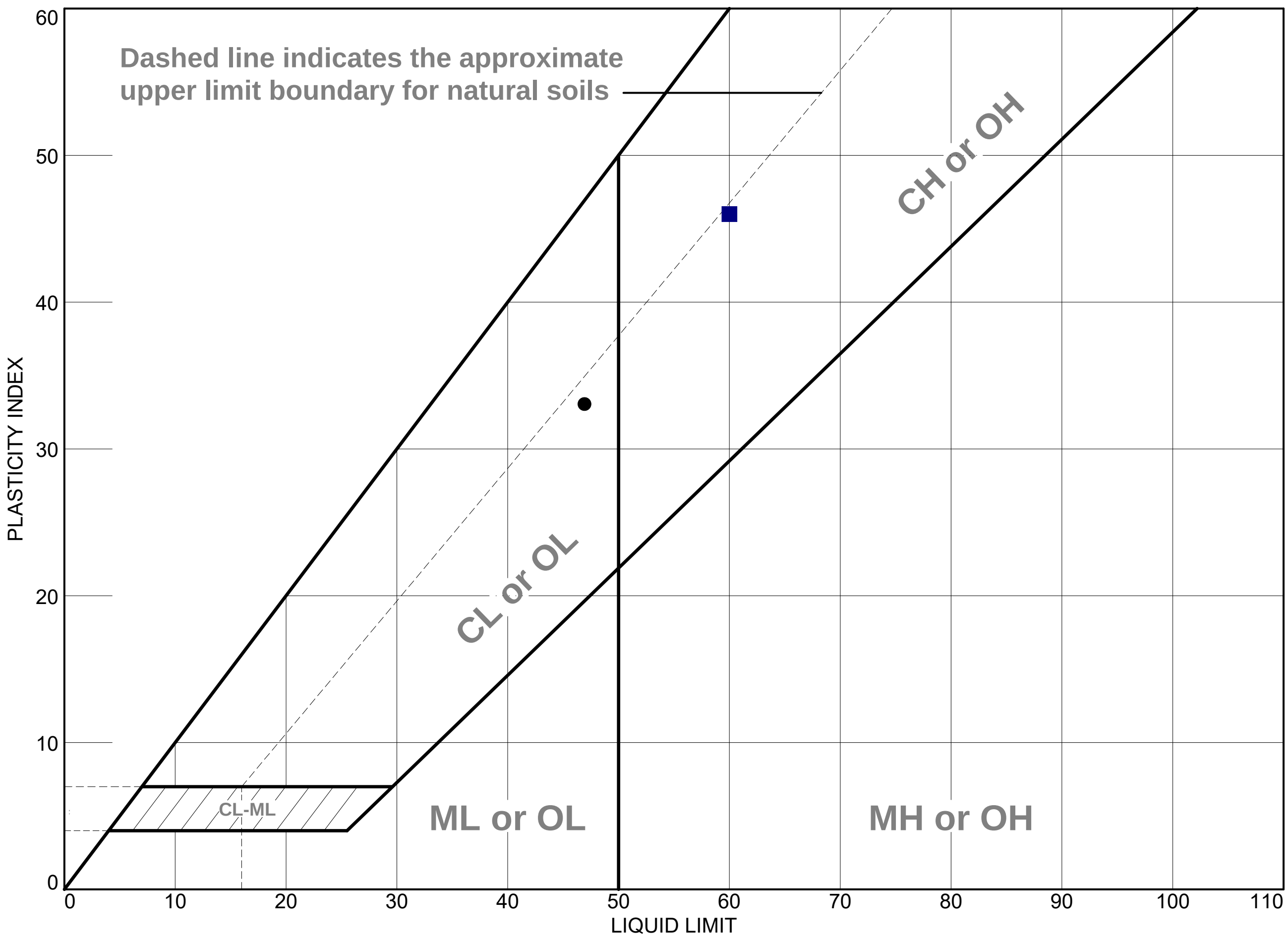
Remarks:

Blackburn Consulting

W. Sacramento, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Lean CLAY, dark grayish brown	47	14	33			CL
■	Fat CLAY with SAND, light olive brown	60	14	46		83.0	CH

Project No. 3195.X **Client:** EIP

Project: Lookout Slough THRFP - Borrow Analysis

●**Source of Sample:** BTP 2 **Depth:** 1-3' **Sample Number:** A

■**Source of Sample:** BTP 2 **Depth:** 4' **Sample Number:** 1

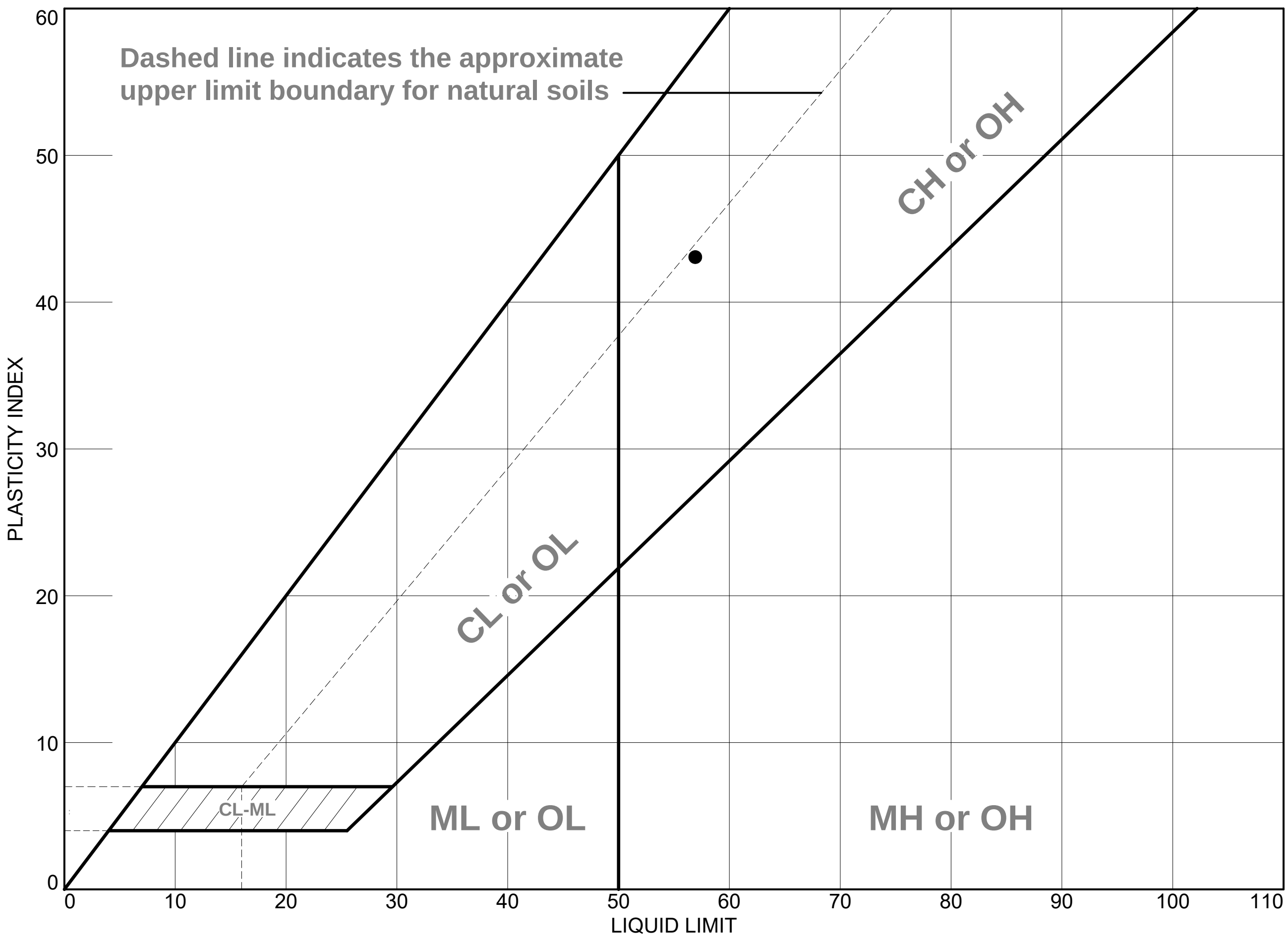
Remarks:

Blackburn Consulting

W. Sacramento, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Fat CLAY, very dark grayish brown	57	14	43		85.3	CH

Project No. 3195.X **Client:** EIP

Project: Lookout Slough THRFP - Borrow Analysis

● **Source of Sample:** BTP 3 **Depth:** 1-3' **Sample Number:** A

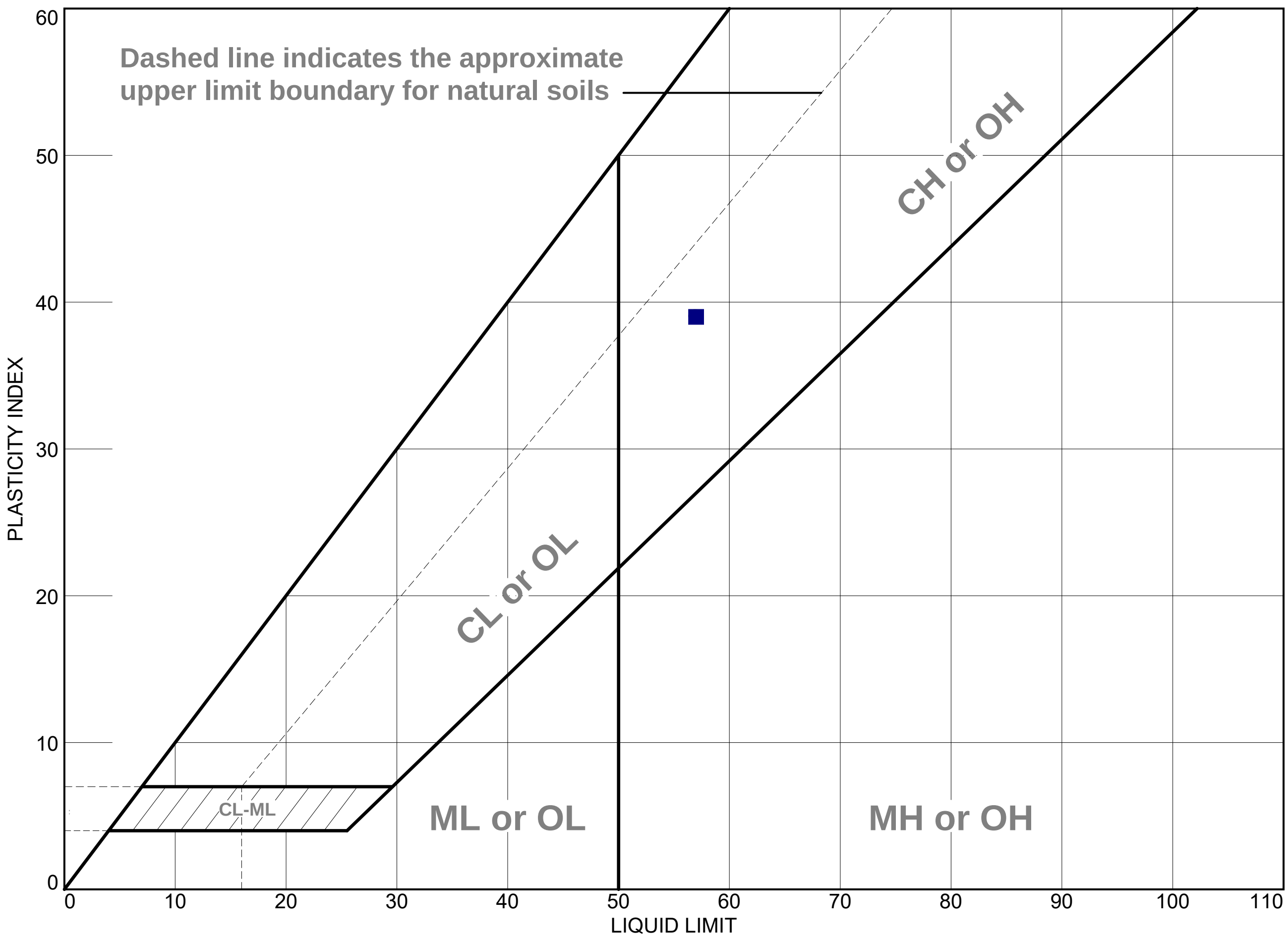
Remarks:

Blackburn Consulting

W. Sacramento, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Fat CLAY, brownish gray	57	18	39			CH

Project No. 3195.X **Client:** EIP

Project: Lookout Slough THRFP - Borrow Analysis

● **Source of Sample:** BTP 4 **Depth:** 1-3' **Sample Number:** A

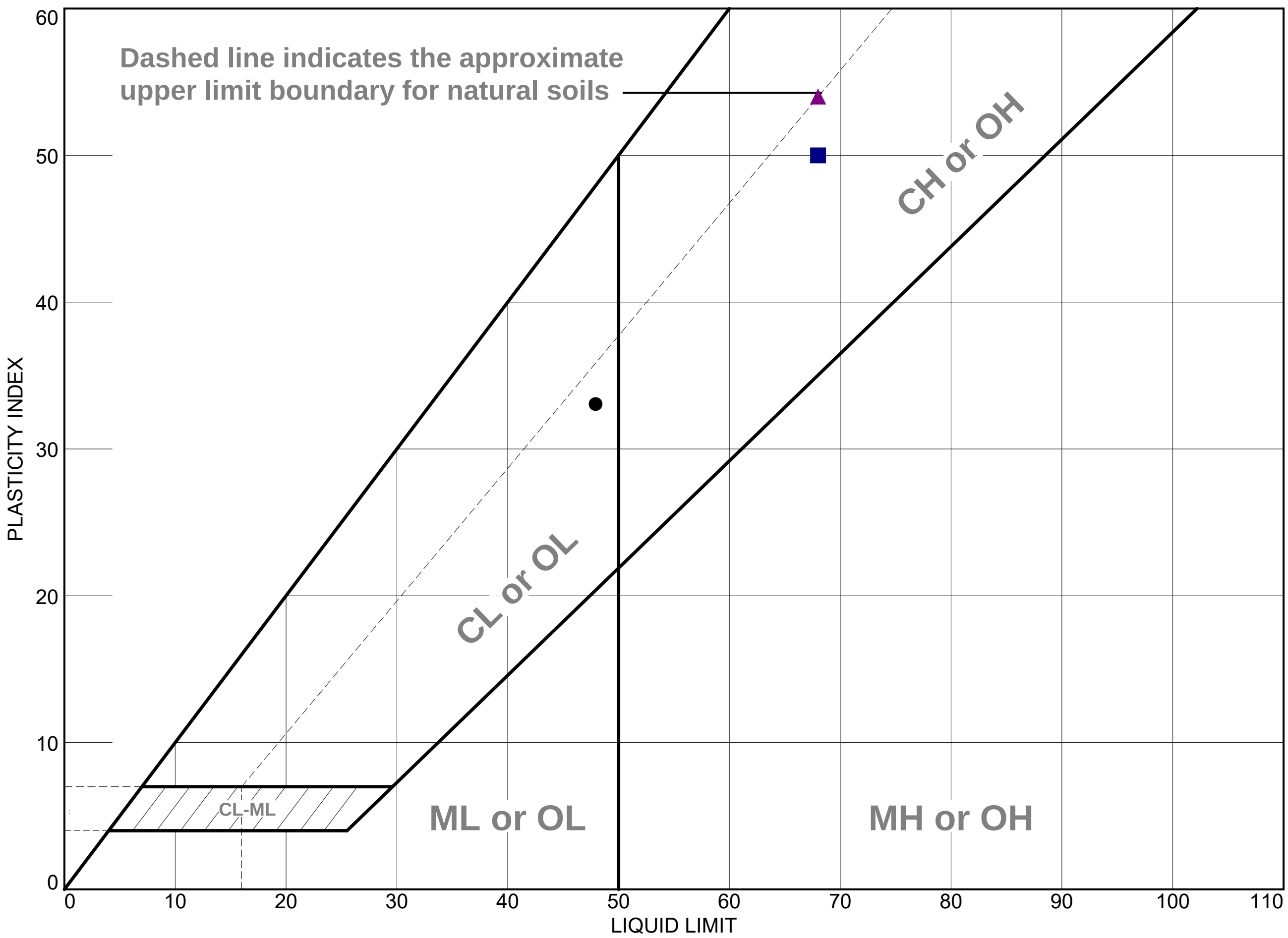
Remarks:

Blackburn Consulting

W. Sacramento, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Lean CLAY, olive brown	48	15	33			CL
■	Fat CLAY, black	68	18	50			CH
▲	Fat CLAY, dark olive gray	68	14	54			CH

Project No. 3195.X **Client:** EIP

Project: Lookout Slough THRFP - Borrow Analysis

●**Source of Sample:** BTP 5 **Depth:** 1-4' **Sample Number:** A

■**Source of Sample:** BTP 5 **Depth:** 3-3.5' **Sample Number:** 2A

▲**Source of Sample:** BTP 5 **Depth:** 4-4.5' **Sample Number:** 3A

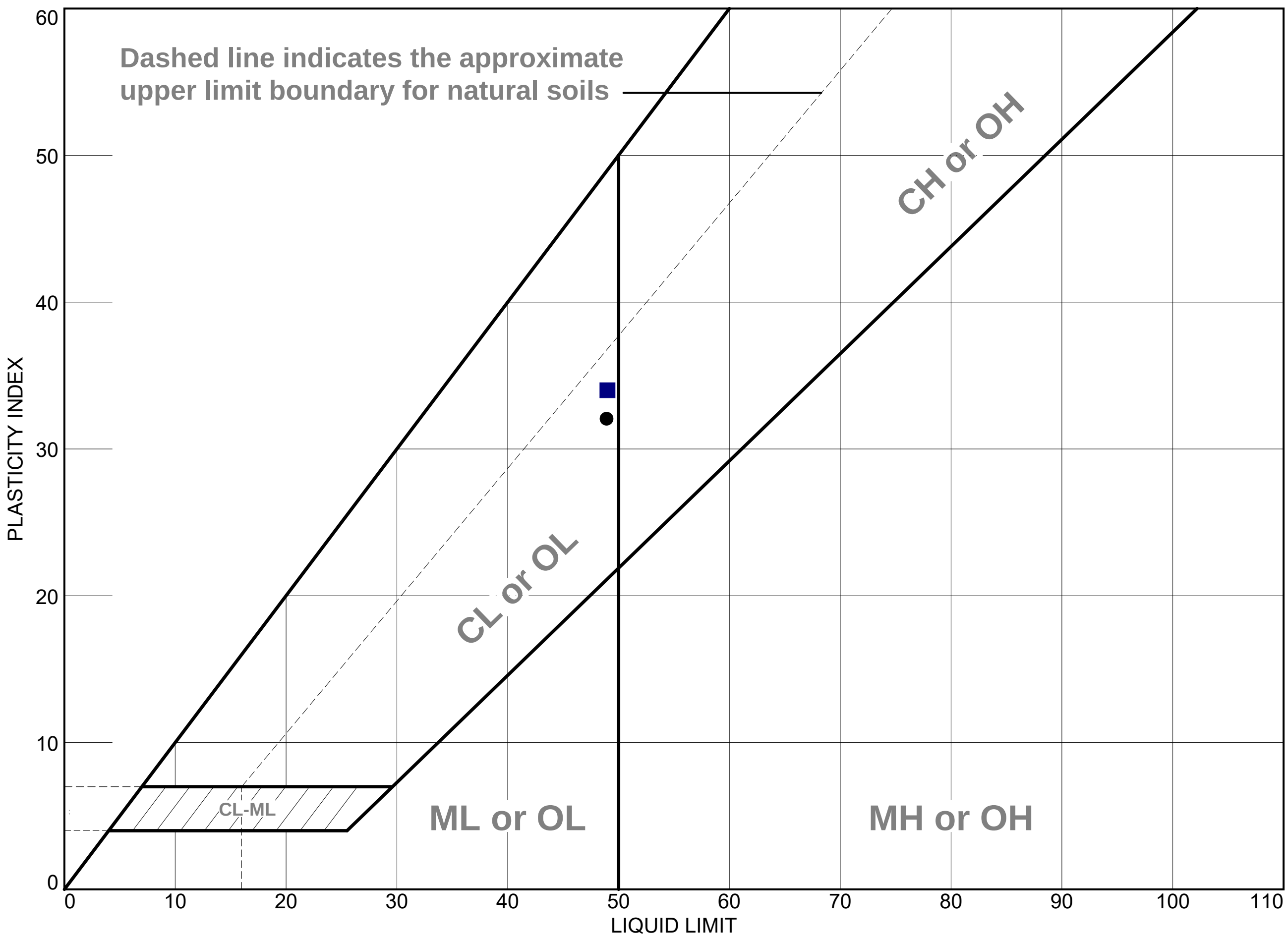
Remarks:

Blackburn Consulting

W. Sacramento, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Lean CLAY, very dark grayish brown	49	17	32			CL
■	Lean CLAY with SAND, dark yellowish brown	49	15	34		73.9	CL

Project No. 3195.X **Client:** EIP

Project: Lookout Slough THRFP - Borrow Analysis

● **Source of Sample:** BTP 6 **Depth:** 1-4' **Sample Number:** A

■ **Source of Sample:** BTP 6 **Depth:** 4.5' **Sample Number:** 1

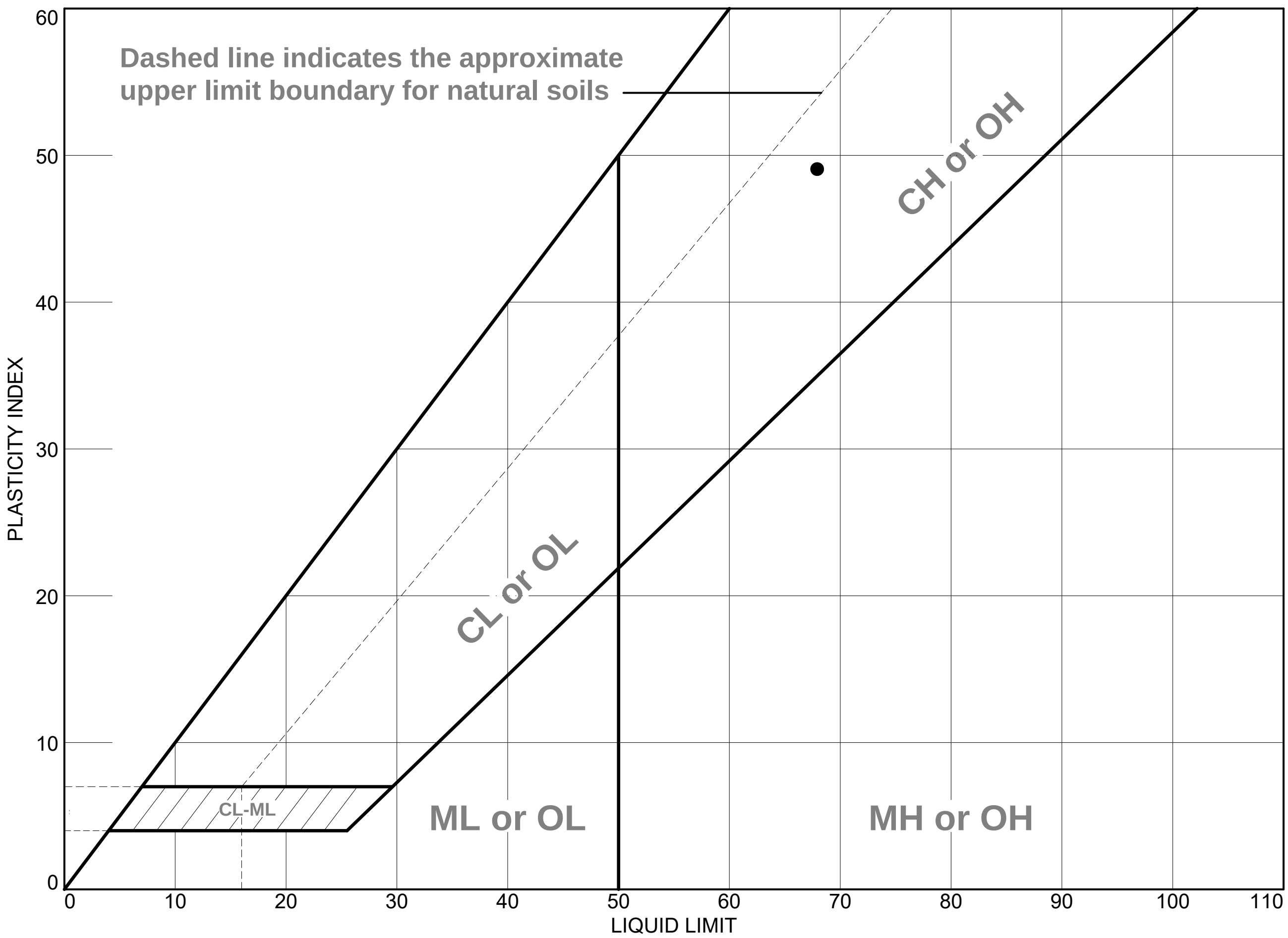
Remarks:

Blackburn Consulting

W. Sacramento, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Fat CLAY, very dark grayish brown	68	19	49		93.2	CH

Project No. 3195.X **Client:** EIP

Project: Lookout Slough THRFP - Borrow Analysis

●**Source of Sample:** BTP 7 **Depth:** 1-3' **Sample Number:** A

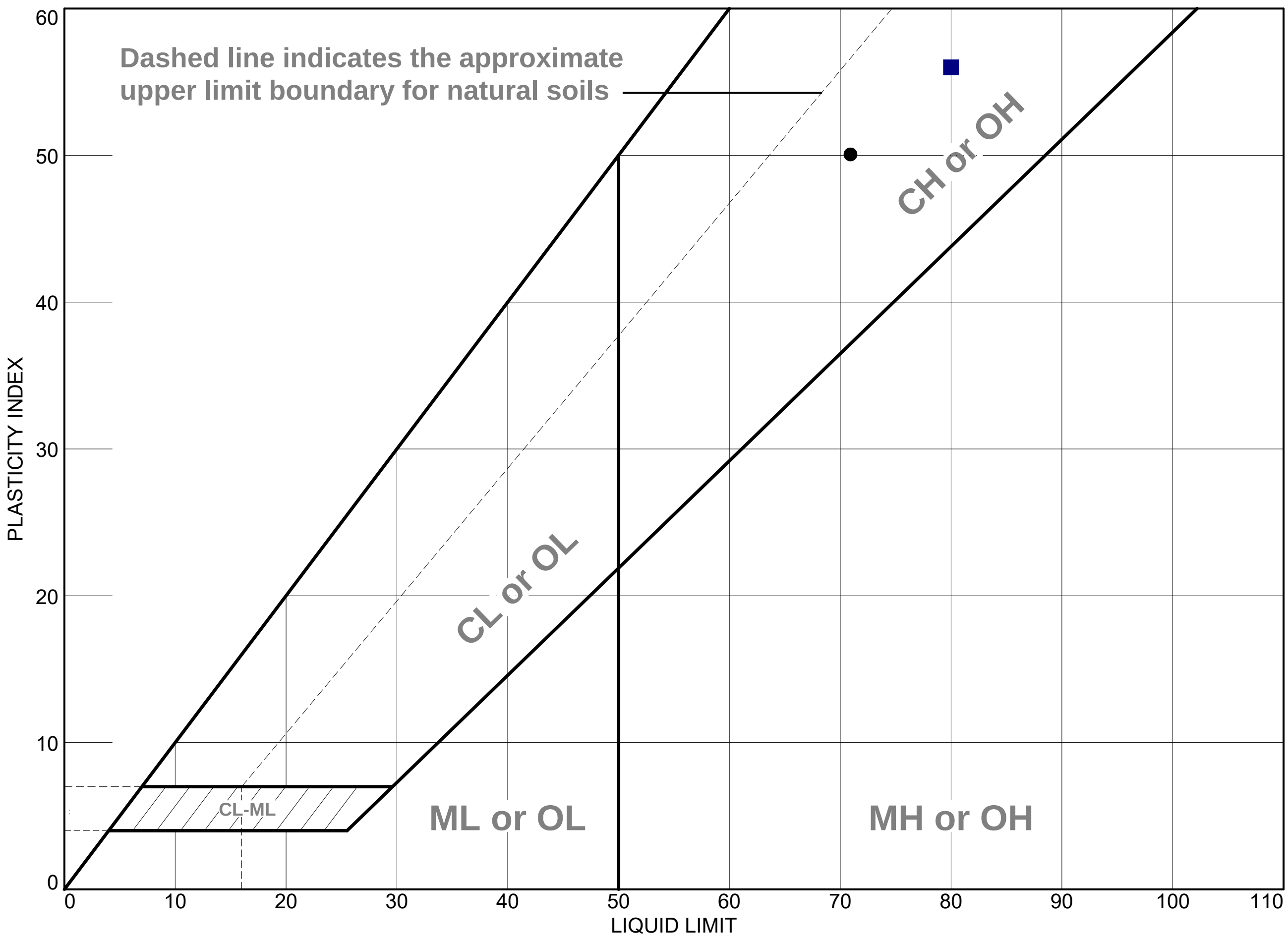
Remarks:

Blackburn Consulting

W. Sacramento, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Fat CLAY, dark olive gray	71	21	50			CH
■	Fat CLAY, very dark brown	80	24	56			CH

Project No. 3195.X **Client:** EIP

Project: Lookout Slough THRFP - Borrow Analysis

● **Source of Sample:** BTP 8 **Depth:** 1-4' **Sample Number:** A

■ **Source of Sample:** BTP 8 **Depth:** 4.5-5' **Sample Number:** 4A

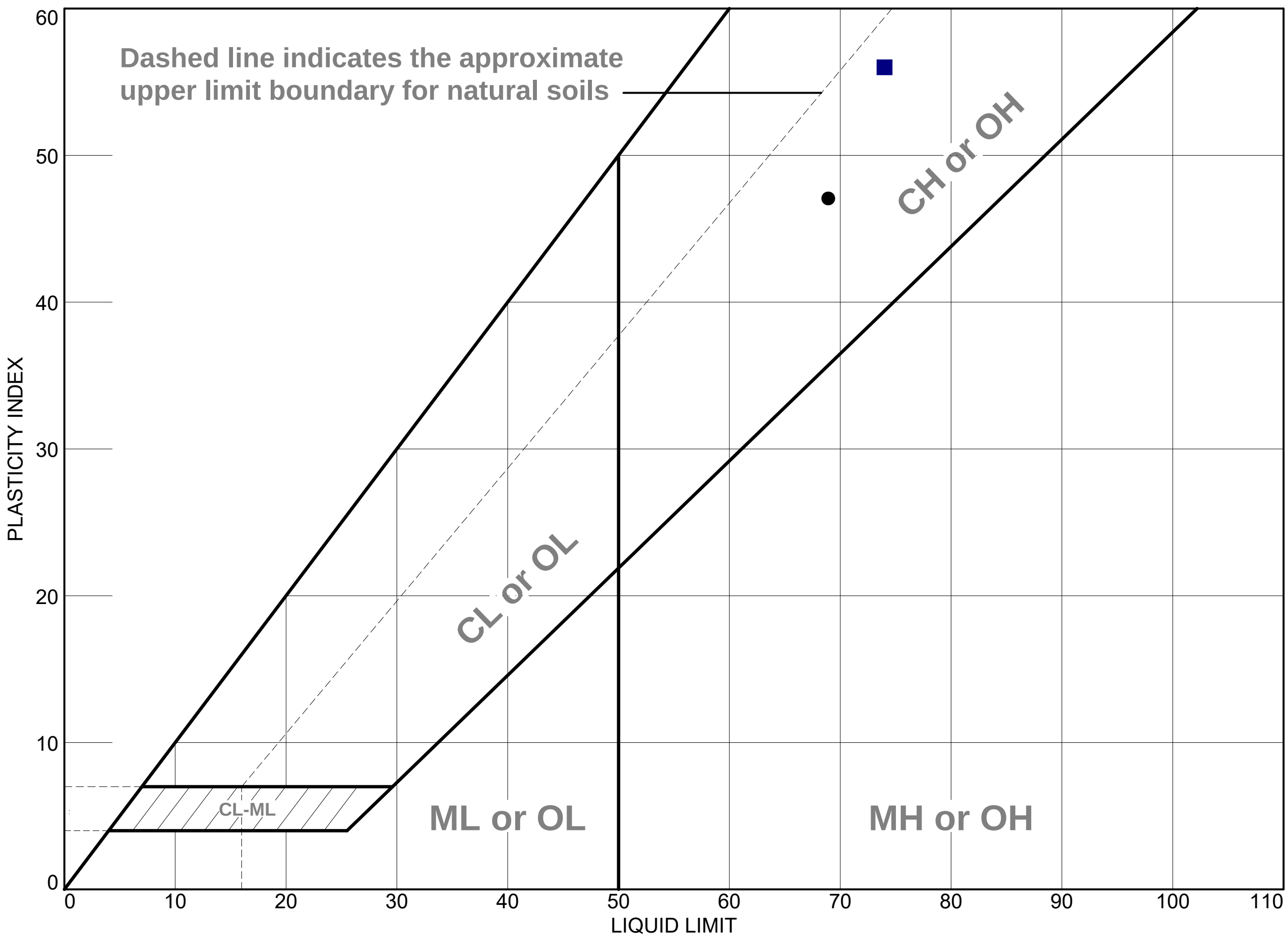
Remarks:

Blackburn Consulting

W. Sacramento, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Fat CLAY, very dark grayish brown	69	22	47			CH
■	Fat CLAY, black	74	18	56		93.5	CH

Project No. 3195.X **Client:** EIP

Project: Lookout Slough THRFP - Borrow Analysis

●**Source of Sample:** BTP 9 **Depth:** 1-3' **Sample Number:** A

■**Source of Sample:** BTP 9 **Depth:** 3' **Sample Number:** 1

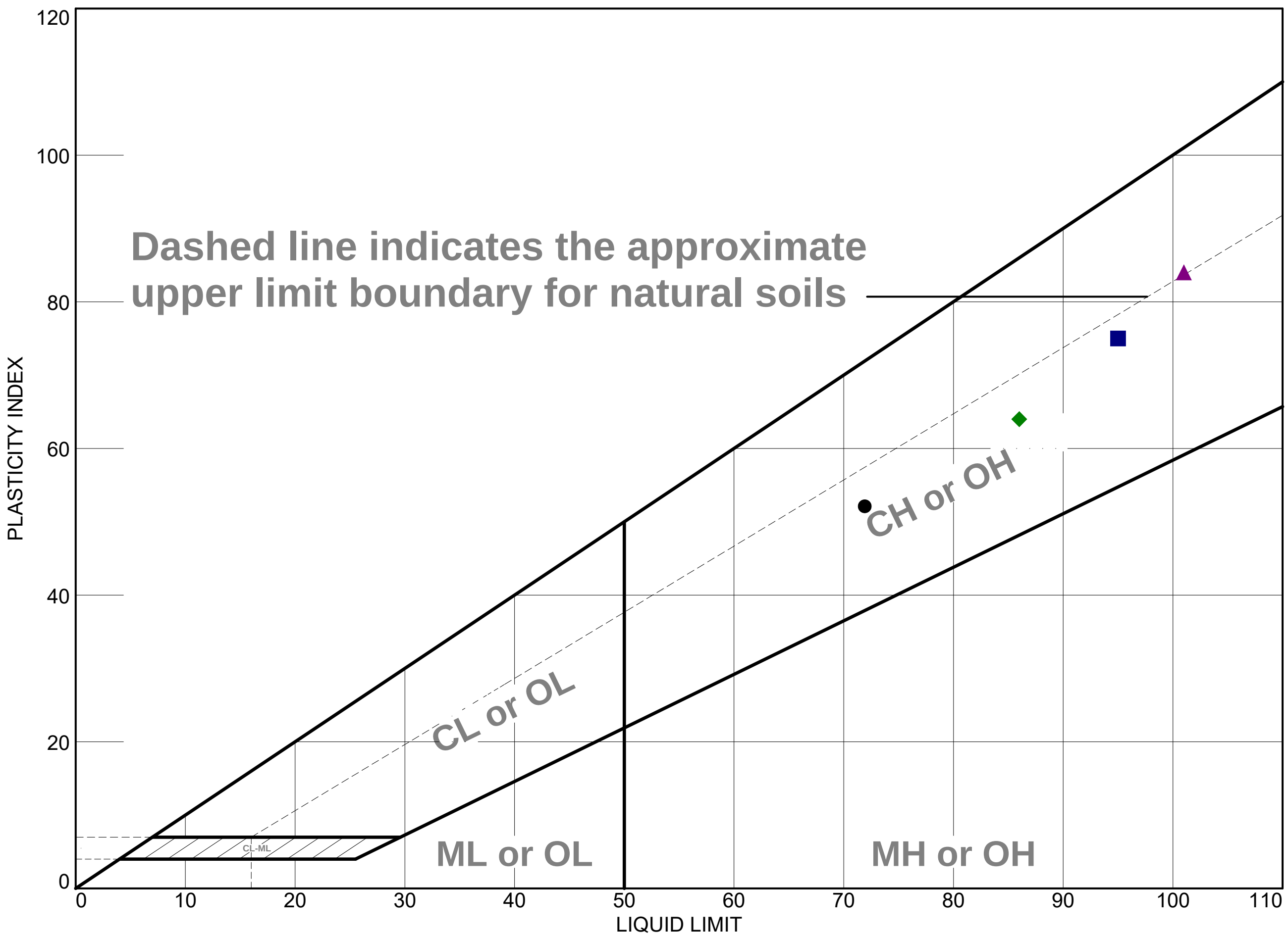
Remarks:

Blackburn Consulting

W. Sacramento, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Fat CLAY, black	72	20	52			CH
■	Fat CLAY, very dark brown	95	20	75		86.0	CH
▲	Fat CLAY with SAND, olive brown	101	17	84		77.0	CH
◆	Fat CLAY, black	86	22	64			CH

Project No. 3195.X **Client:** EIP

Project: Lookout Slough THRFP - Borrow Analysis

●**Source of Sample:** BTP 10 **Depth:** 1-1.5' **Sample Number:** 1A
■**Source of Sample:** BTP 10 **Depth:** 1-3' **Sample Number:** A
▲**Source of Sample:** BTP 10 **Depth:** 6' **Sample Number:** 1
◆**Source of Sample:** BTP 10 **Depth:** 4.5-5' **Sample Number:** 2A

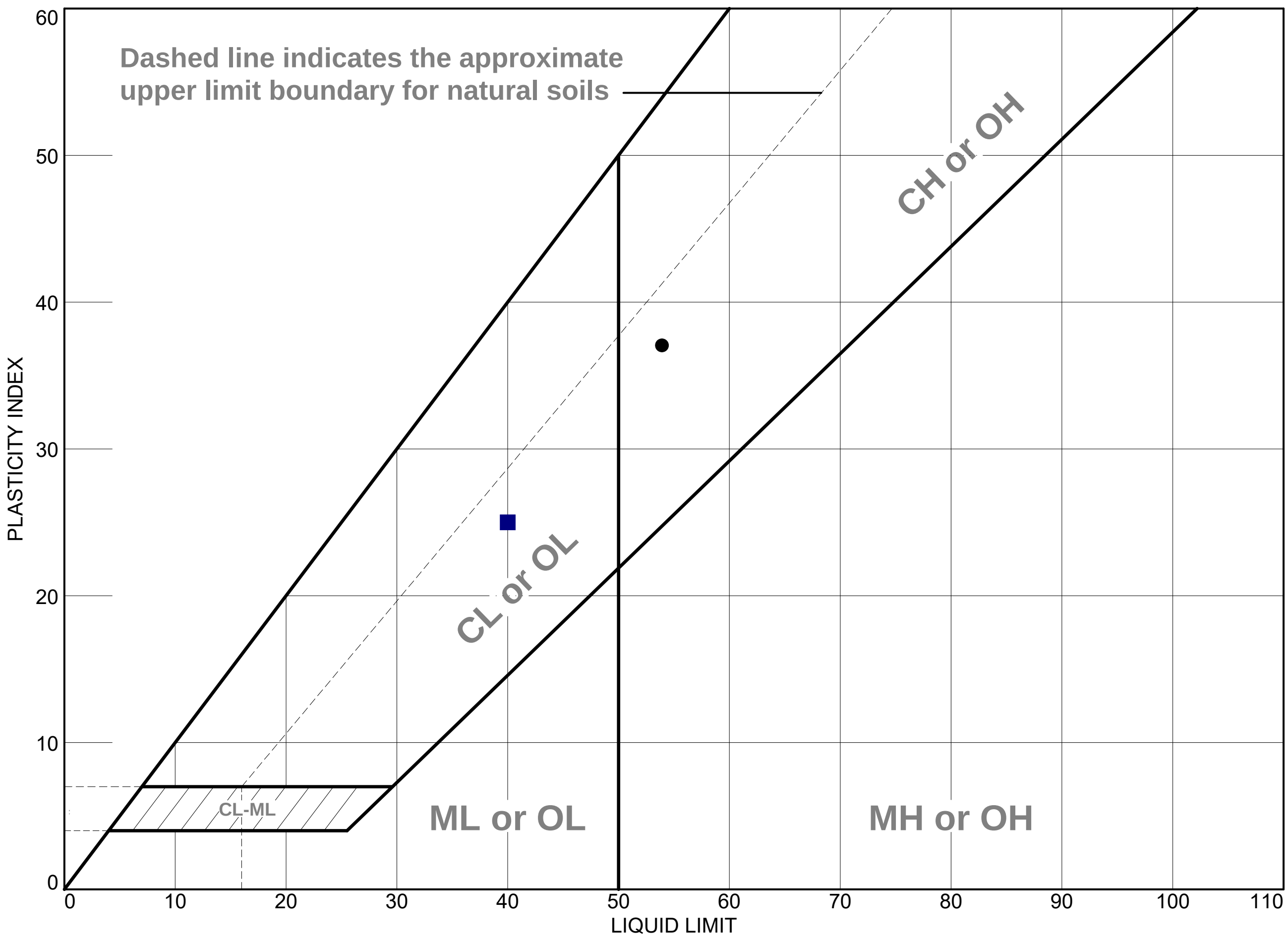
Remarks:

Blackburn Consulting

W. Sacramento, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Fat CLAY, olive brown	54	17	37			CH
■	SANDY Lean CLAY, dark yellowish brown	40	15	25		62.6	CL

Project No. 3195.X **Client:** EIP

Project: Lookout Slough THRFP - Borrow Analysis

● **Source of Sample:** BTP 11 **Depth:** 1-3' **Sample Number:** A

■ **Source of Sample:** BTP 11 **Depth:** 9' **Sample Number:** 2

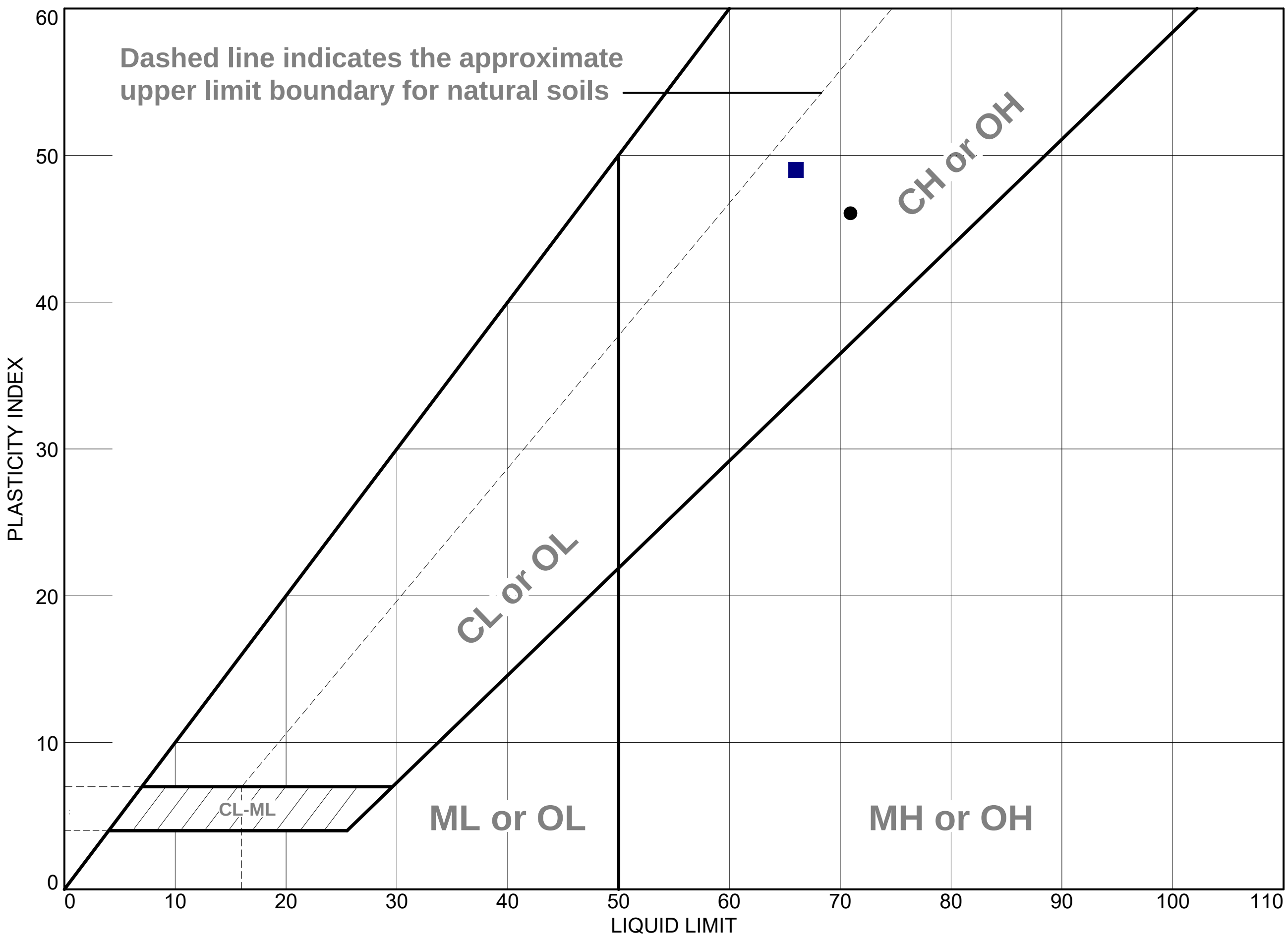
Remarks:

Blackburn Consulting

W. Sacramento, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Fat CLAY, very dark gray	71	25	46			CH
■	Fat CLAY, very dark grayish brown	66	17	49		92.4	CH

Project No. 3195.X **Client:** EIP

Project: Lookout Slough THRFP - Borrow Analysis

●**Source of Sample:** BTP 12 **Depth:** 1-3' **Sample Number:** A

■**Source of Sample:** BTP 12 **Depth:** 6' **Sample Number:** 1

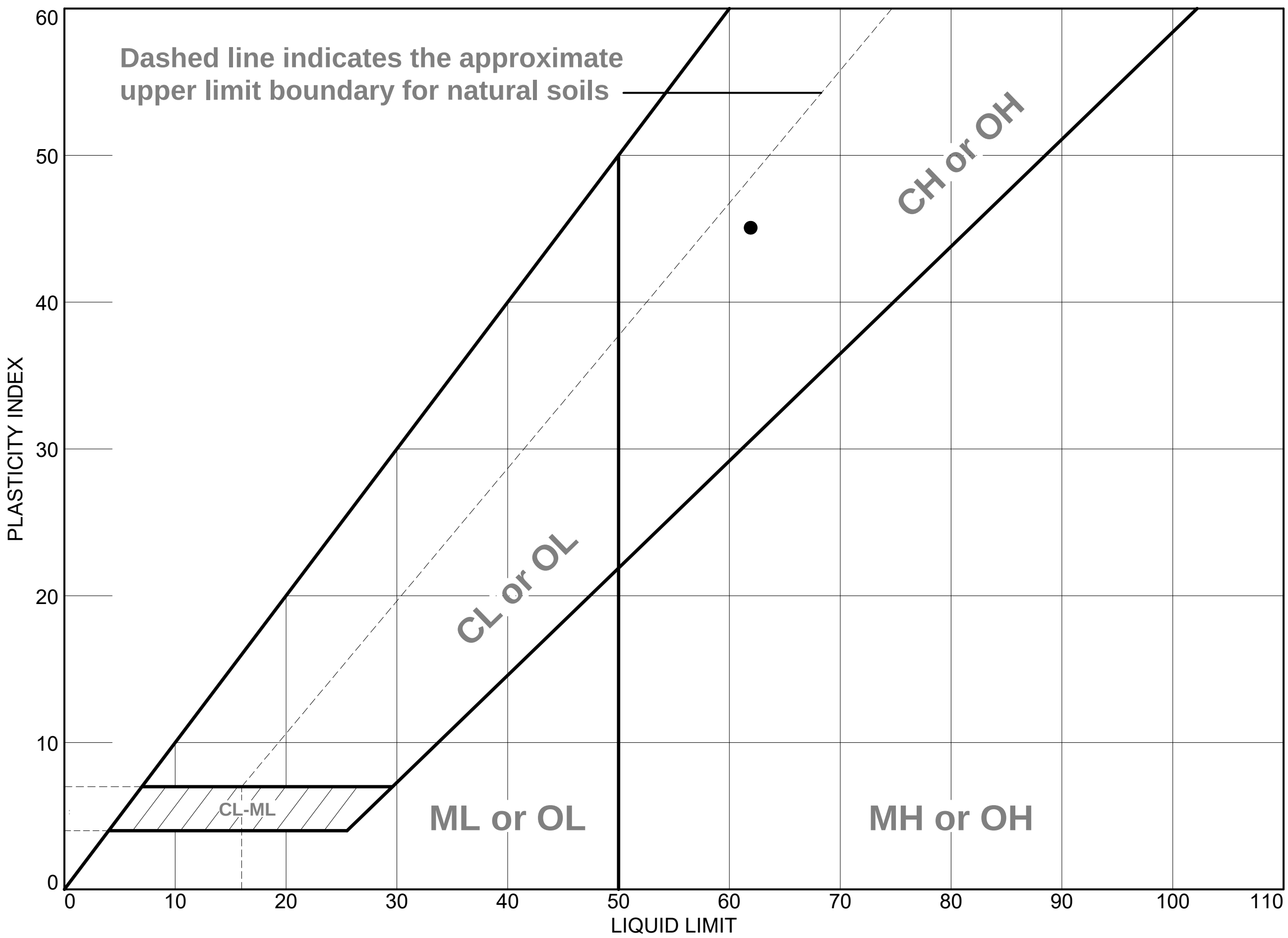
Remarks:

Blackburn Consulting

W. Sacramento, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Fat CLAY, dark olive brown	62	17	45			CH

Project No. 3195.X **Client:** EIP

Project: Lookout Slough THRFP - Borrow Analysis

● **Source of Sample:** BTP 13 **Depth:** 1-3' **Sample Number:** A

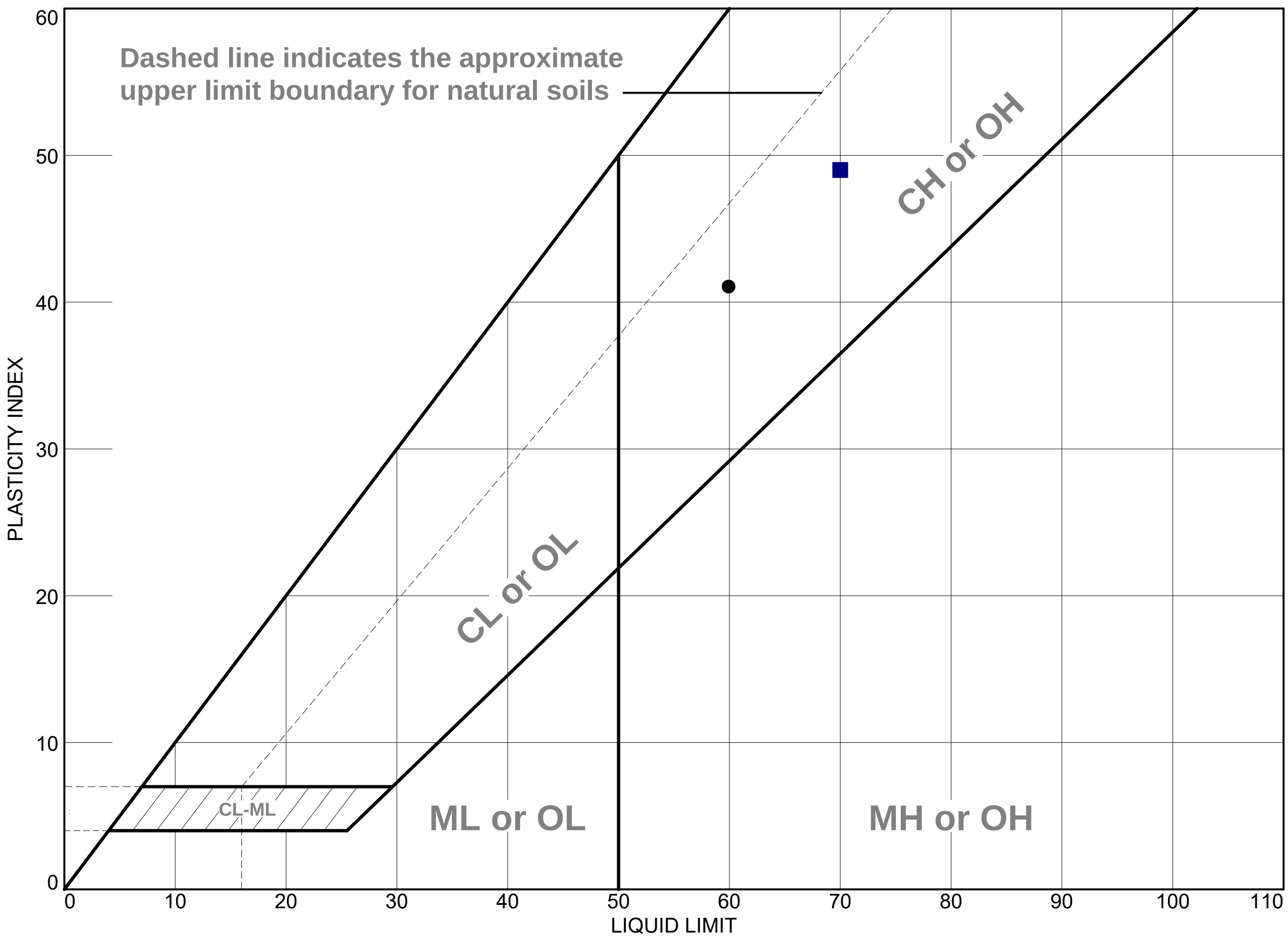
Remarks:

Blackburn Consulting

W. Sacramento, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Fat CLAY, dark olive gray	60	19	41			CH
■	Fat CLAY, very dark gray	70	21	49			CL

Project No. 3195.X **Client:** EIP

Project: Lookout Slough THRFP - Borrow Analysis

●**Source of Sample:** BTP 14 **Depth:** 1-3' **Sample Number:** A

■**Source of Sample:** BTP 14 **Depth:** 3-3.5'

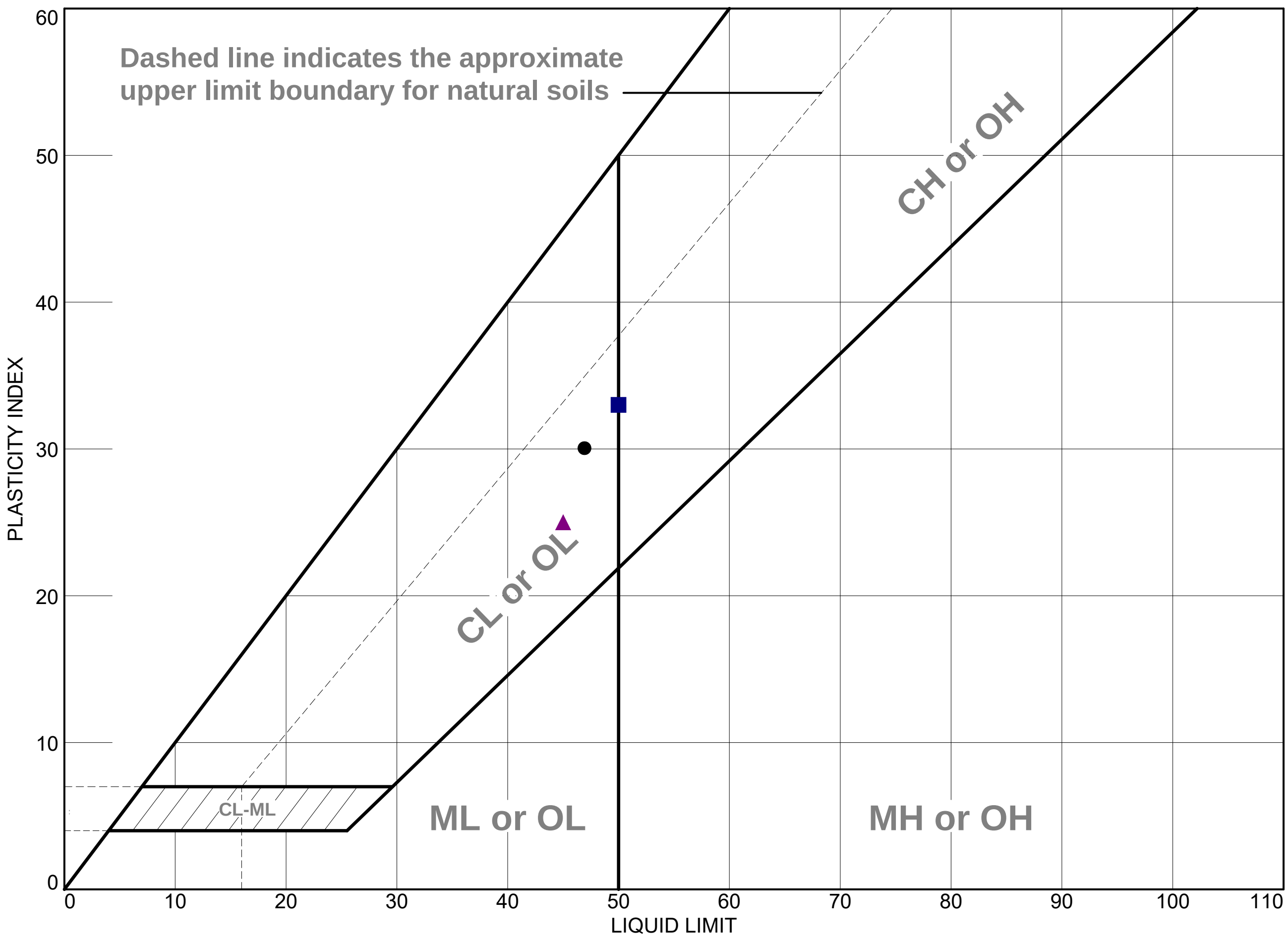
Remarks:

Blackburn Consulting

W. Sacramento, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Lean CLAY with SAND, olive brown	47	17	30		83.3	CL
■	Fat CLAY with SAND, dark yellowish brown	50	17	33		80.2	CH
▲	Lean CLAY, olive brown	45	20	25		94.3	CL

Project No. 3195.X **Client:** EIP

Project: Lookout Slough THRFP - Borrow Analysis

●**Source of Sample:** BTP 15 **Depth:** 1-3' **Sample Number:** A
■**Source of Sample:** BTP 15 **Depth:** 3-6' **Sample Number:** B
▲**Source of Sample:** BTP 15 **Depth:** 8.5' **Sample Number:** 2

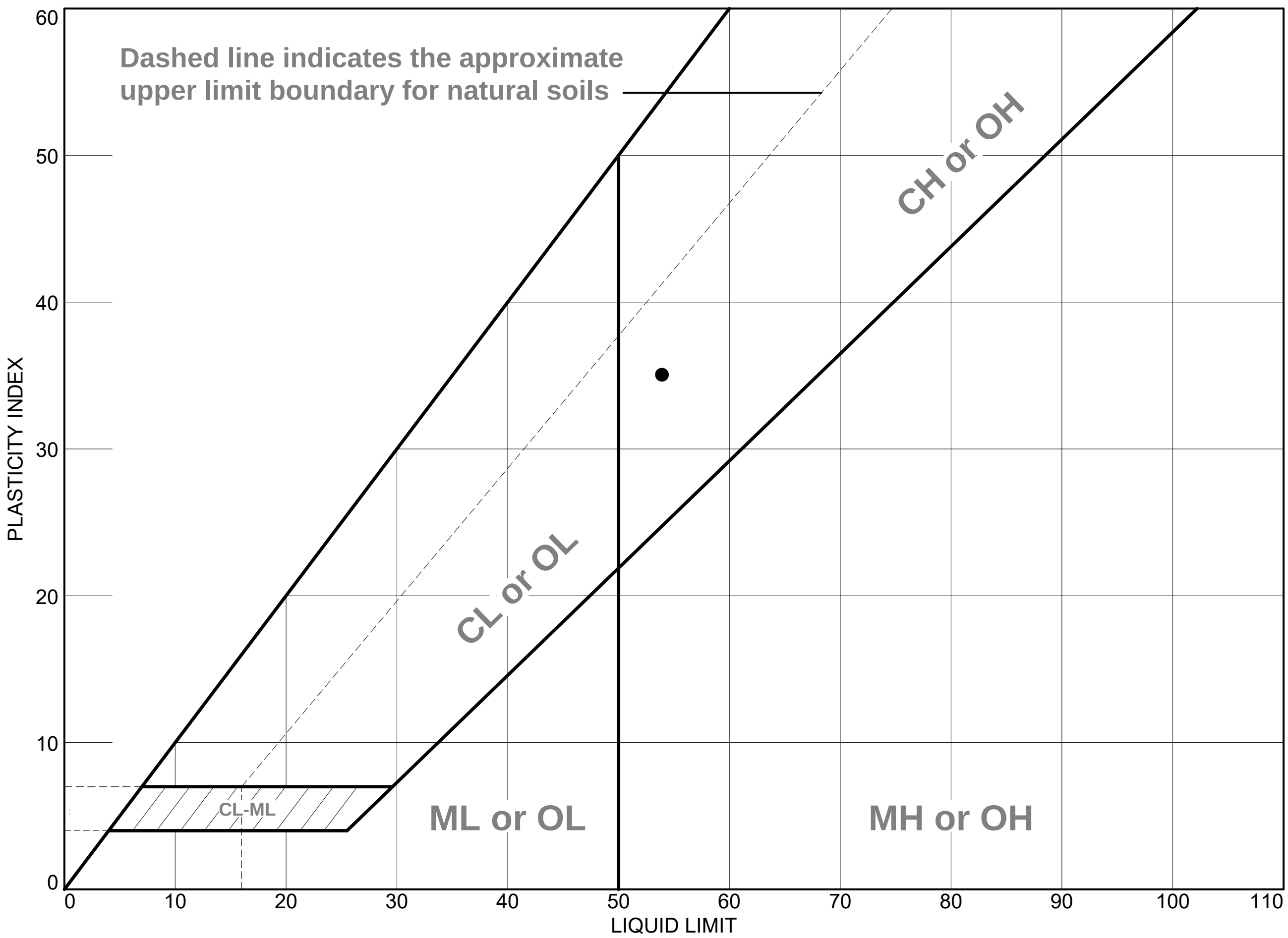
Remarks:

Blackburn Consulting

W. Sacramento, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Fat CLAY, dark olive gray	54	19	35			CH

Project No. 3195.X **Client:** EIP

Project: Lookout Slough THRFP - Borrow Analysis

● **Source of Sample:** BTP 16 **Depth:** 1-3' **Sample Number:** A

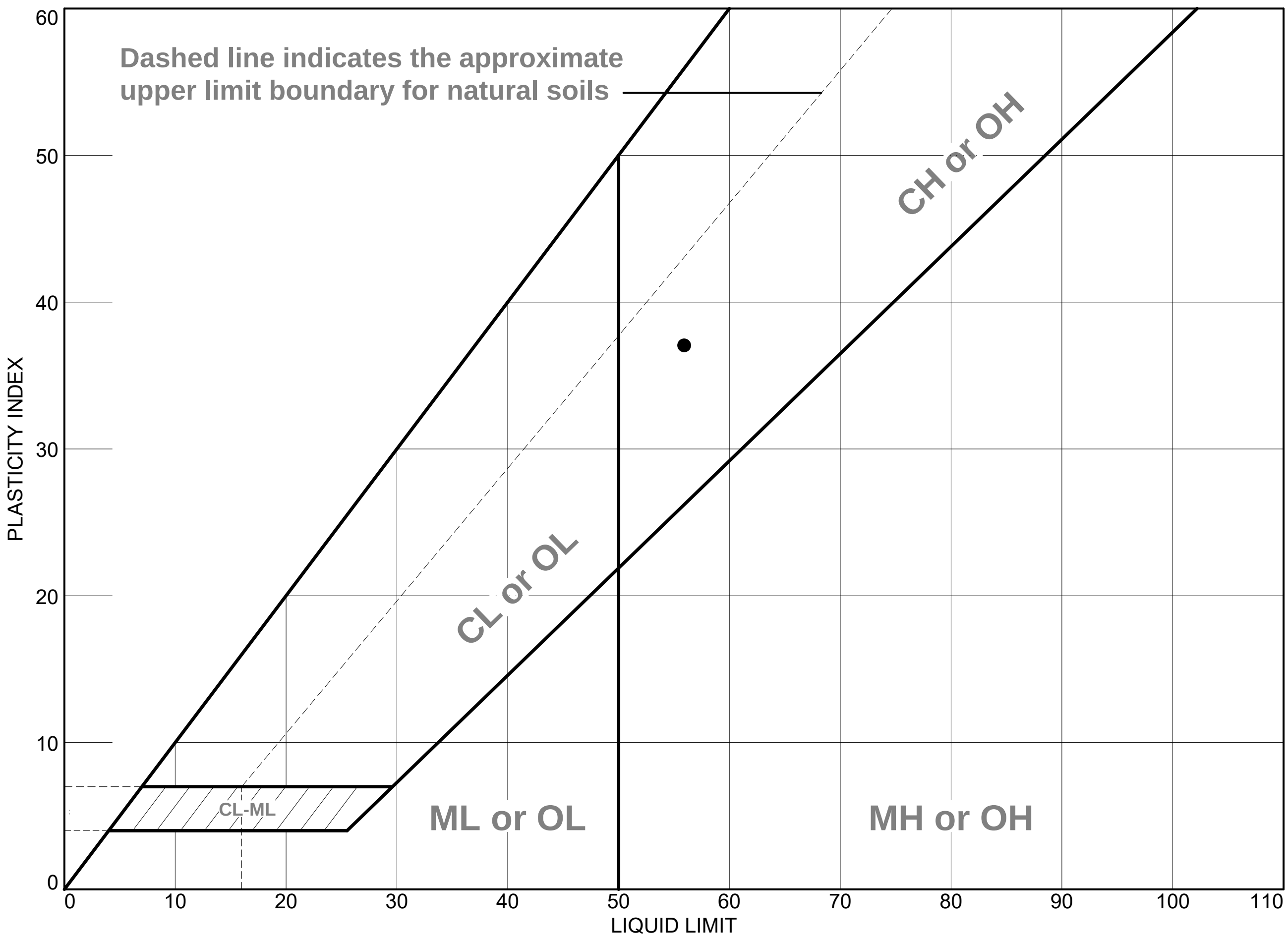
Remarks:

Blackburn Consulting

W. Sacramento, CA

Figure

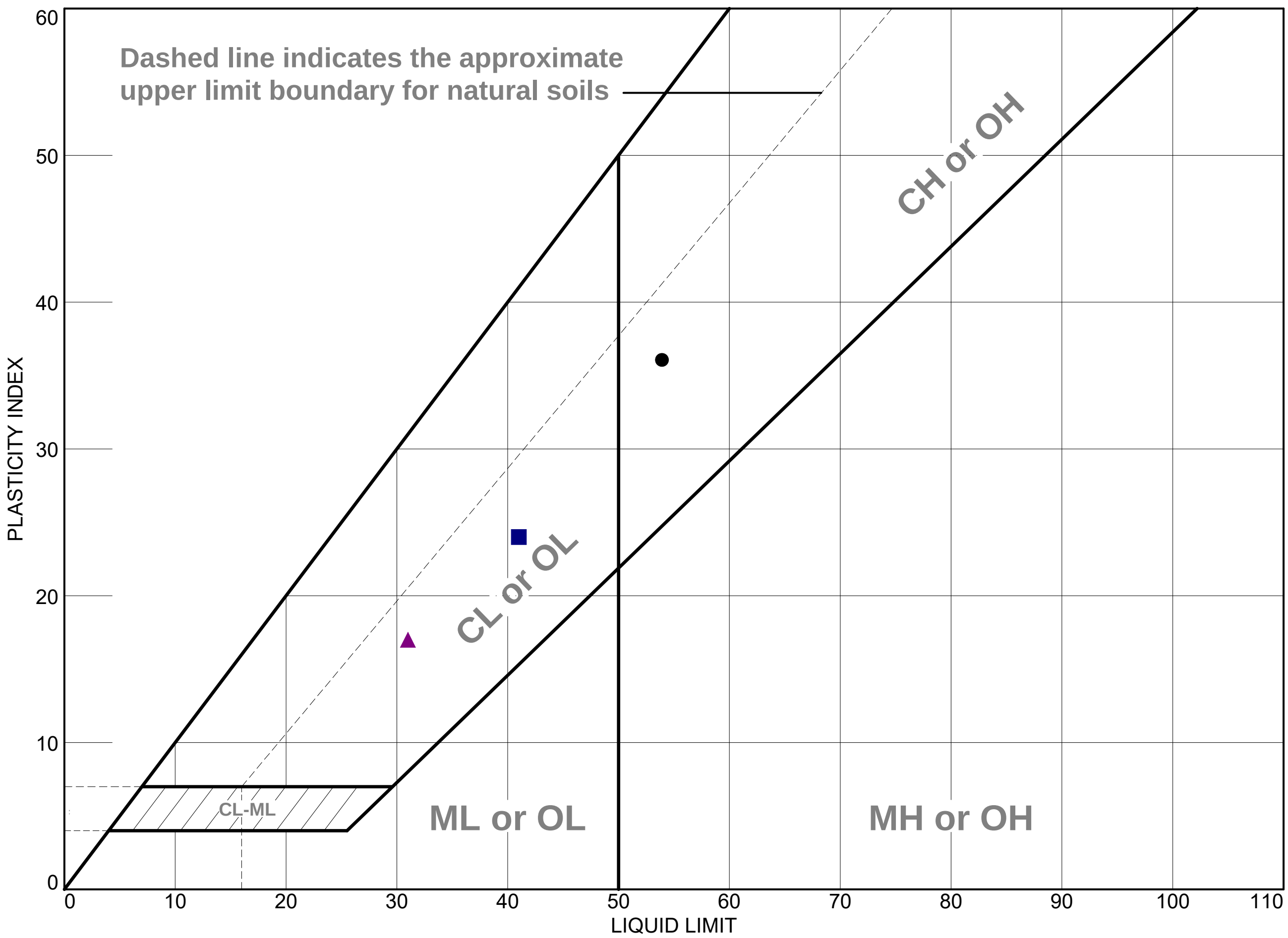
LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Fat CLAY, dark olive gray	56	19	37			CH

Project No. 3195.X **Client:** EIP **Project:** Lookout Slough THRFP - Borrow Analysis ● **Source of Sample:** BTP 17 **Depth:** 1-3' **Sample Number:** A	**Remarks:**
Blackburn Consulting **W. Sacramento, CA**	**Figure**

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Fat CLAY with SAND, olive brown	54	18	36		84.5	CH
■	Lean CLAY, olive brown	41	17	24		88.5	CL
▲	SANDY lean CLAY, dark yellowish brown	31	14	17		57.0	CL

Project No. 3195.X **Client:** EIP

Project: Lookout Slough THRFP - Borrow Analysis

● **Source of Sample:** BTP 18 **Depth:** 1-3' **Sample Number:** A

■ **Source of Sample:** BTP 18 **Depth:** 3-6' **Sample Number:** B

▲ **Source of Sample:** BTP 18 **Depth:** 9' **Sample Number:** 2

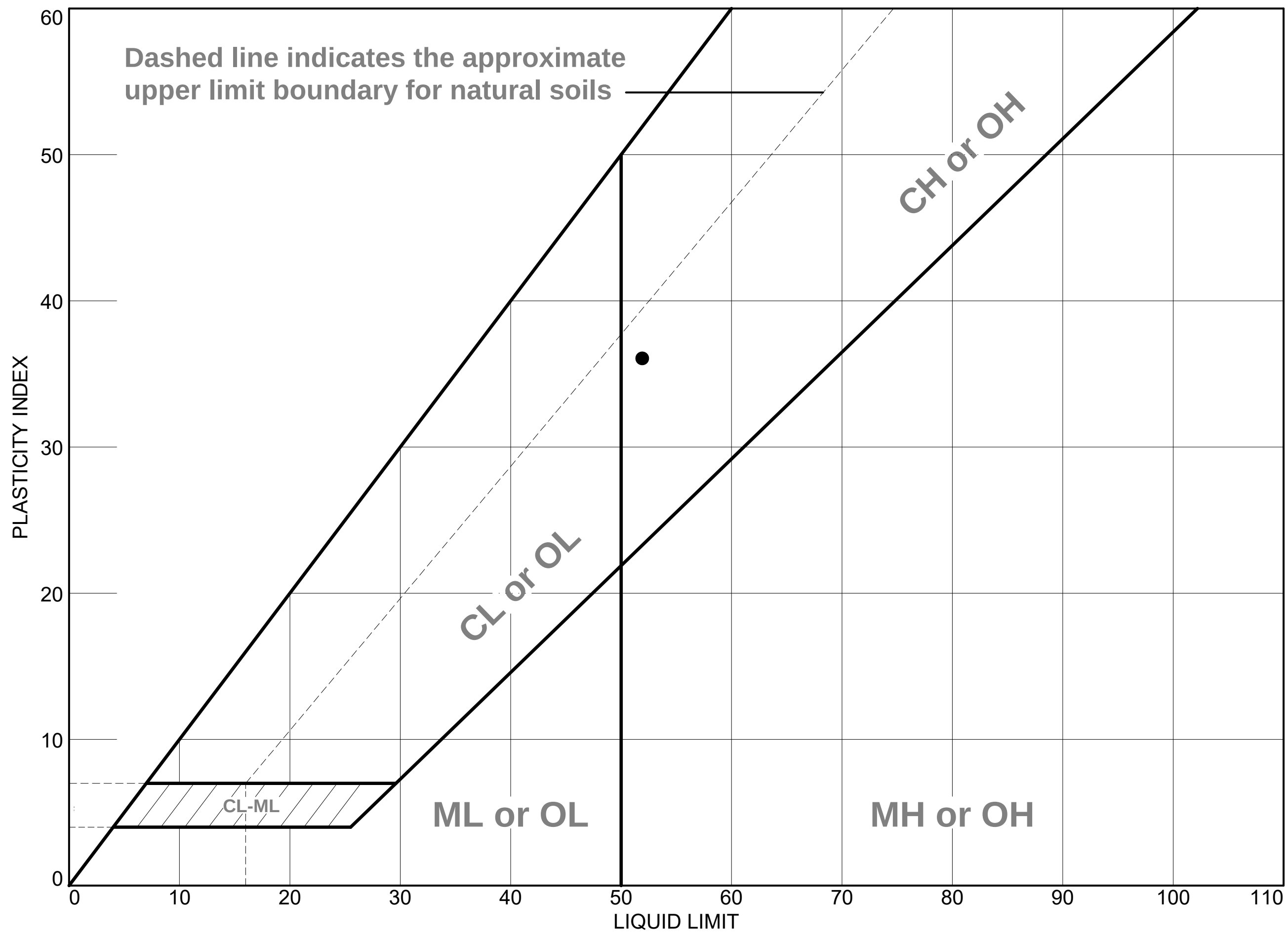
Remarks:

Blackburn Consulting

W. Sacramento, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Fat CLAY, dark olive gray	52	16	36			CH

Project No. 3195.X **Client:** EIP

Project: Lookout Slough THRFP - Borrow Analysis

● **Source of Sample:** BTP 19 **Depth:** 1-3' **Sample Number:** A

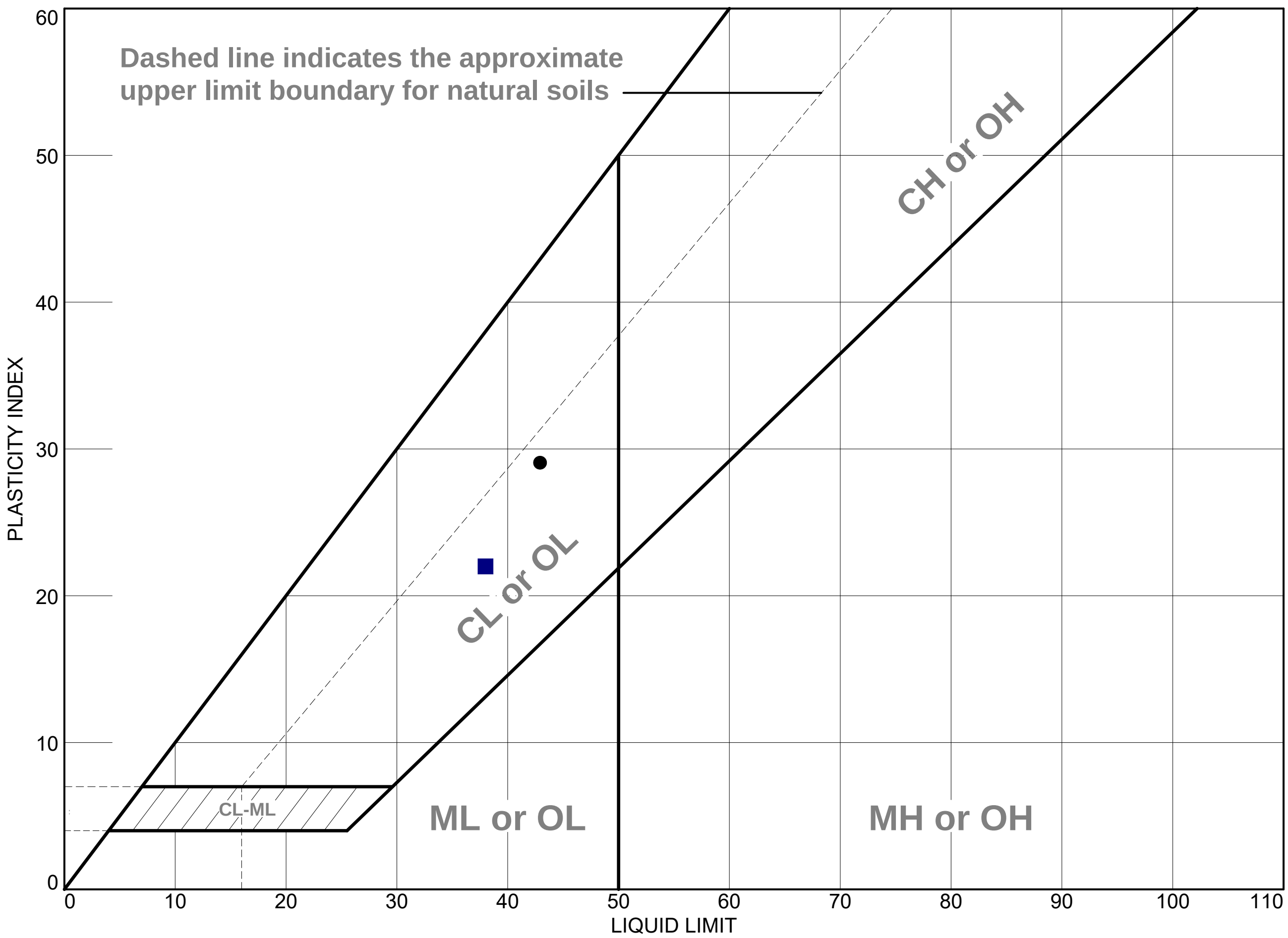
Remarks:

Blackburn Consulting

W. Sacramento, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	SANDY Lean CLAY, olive brown	43	14	29		68.4	CL
■	Lean CLAY, dark yellowish brown	38	16	22			CL

Project No. 3195.X **Client:** EIP

Project: Lookout Slough THRFP - Borrow Analysis

●**Source of Sample:** BTP 20 **Depth:** 1-3' **Sample Number:** A

■**Source of Sample:** BTP 20 **Depth:** 3-3.5'

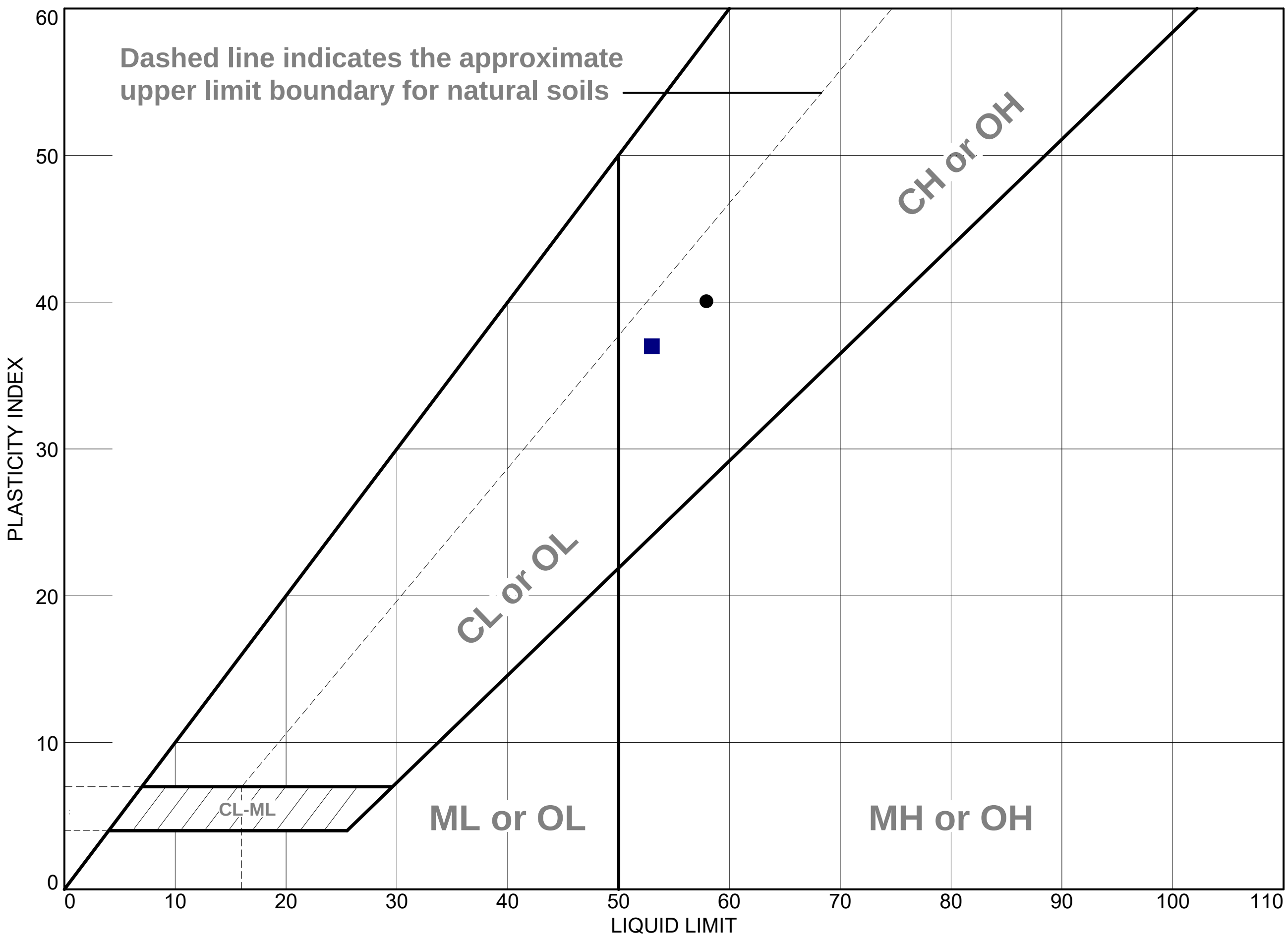
Remarks:

Blackburn Consulting

W. Sacramento, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Fat CLAY, dark olive gray	58	18	40		88.7	CH
■	Fat CLAY, very dark grayish brown	53	16	37		89.8	CH

Project No. 3195.X **Client:** EIP

Project: Lookout Slough THRFP - Borrow Analysis

● **Source of Sample:** BTP 21 **Depth:** 1-4' **Sample Number:** A

■ **Source of Sample:** BTP 21 **Depth:** 4' **Sample Number:** 1

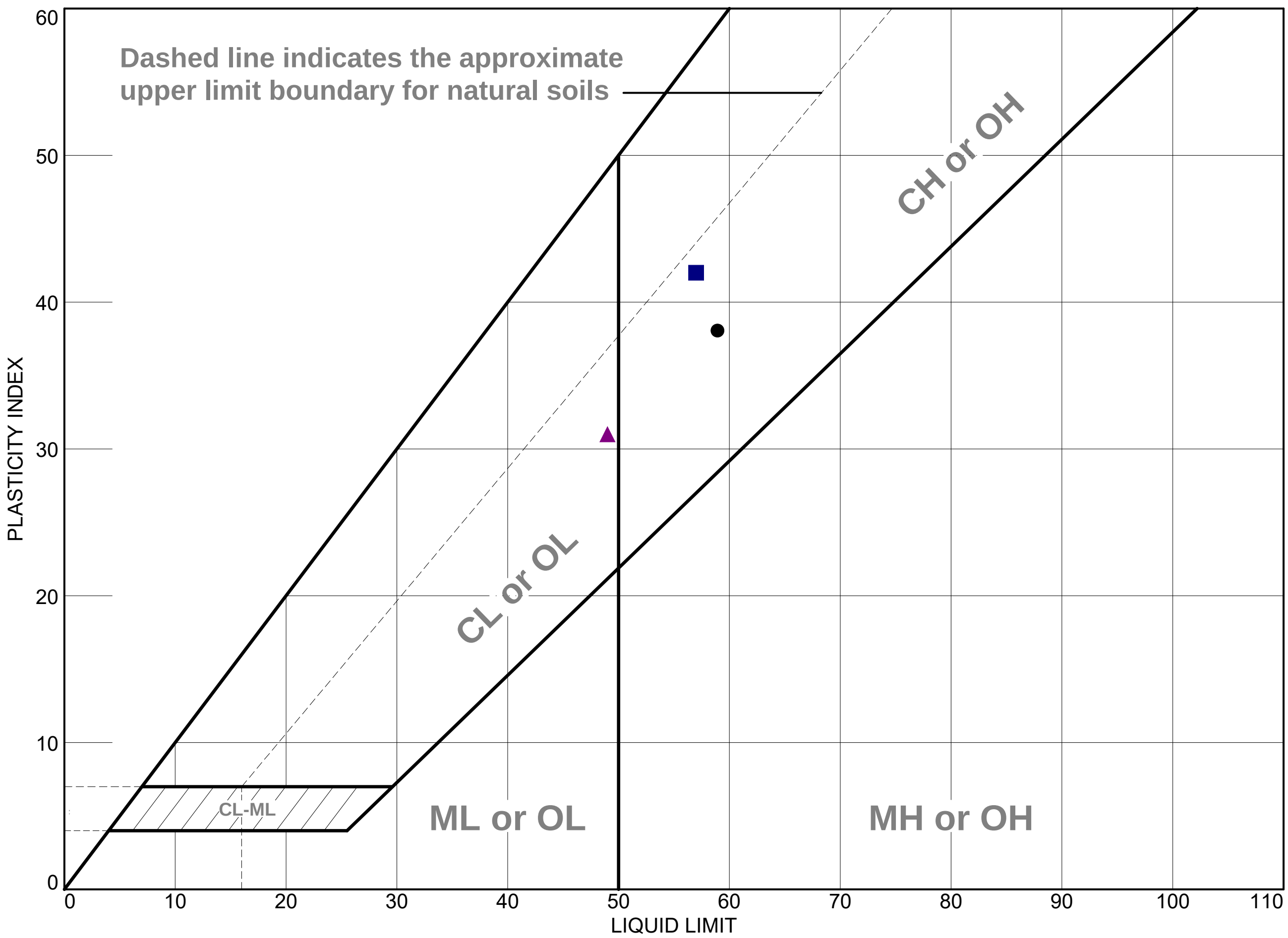
Remarks:

Blackburn Consulting

W. Sacramento, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Fat CLAY, light olive brown	59	21	38		95.5	CH
■	Fat CLAY, brown	57	15	42		95.1	CH
▲	Lean CLAY, olive brown	49	18	31		93.7	CL

Project No. 3195.X **Client:** EIP

Project: Lookout Slough THRFP - Borrow Analysis

●**Source of Sample:** BTP 22 **Depth:** 1-4' **Sample Number:** A
■**Source of Sample:** BTP 22 **Depth:** 4' **Sample Number:** 1
▲**Source of Sample:** BTP 22 **Depth:** 7' **Sample Number:** 2

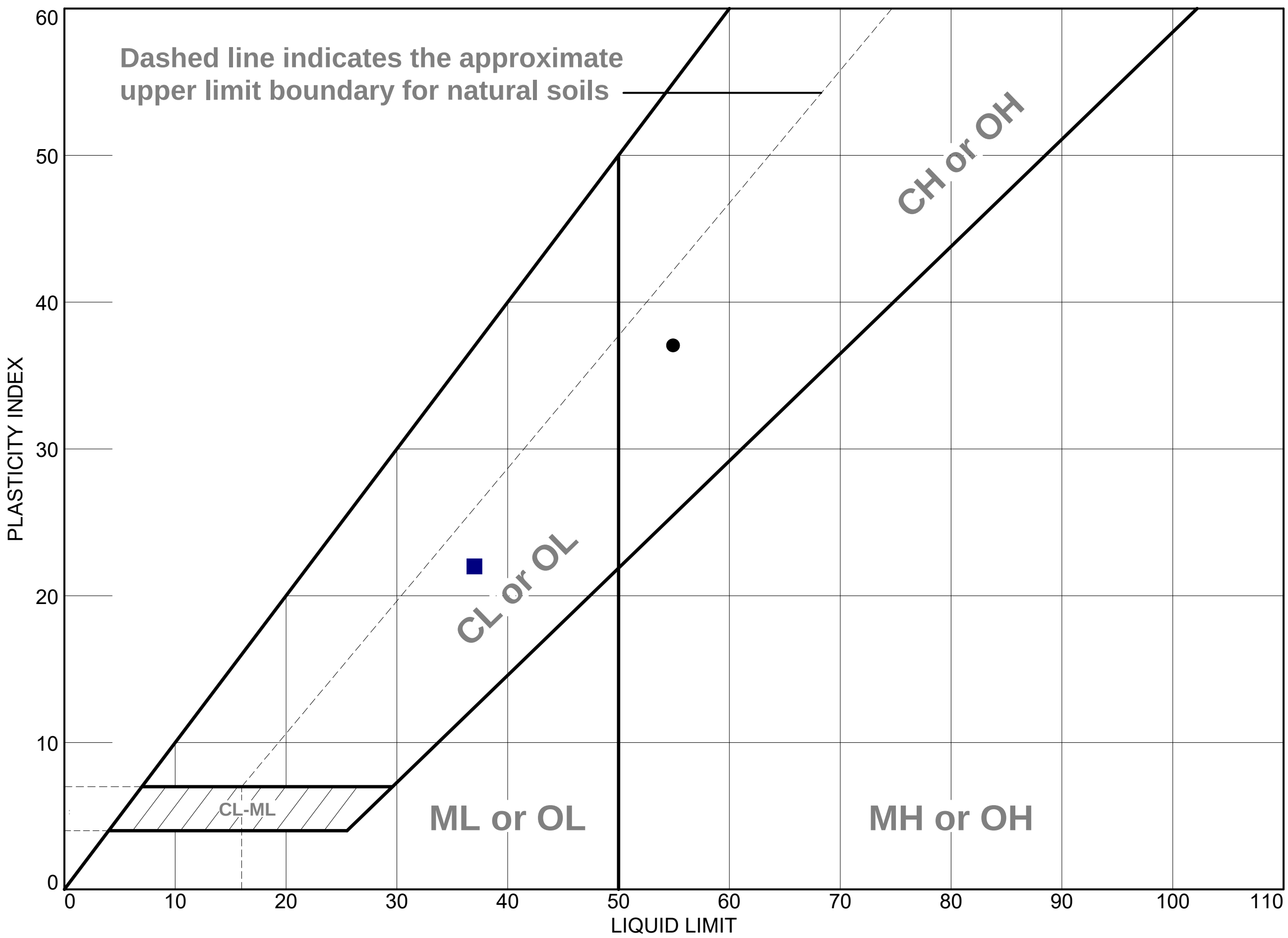
Remarks:

Blackburn Consulting

W. Sacramento, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Fat CLAY, light olive brown	55	18	37		90.4	CH
■	Lean CLAY wiwth SAND, dark yellowish brown	37	15	22		75.8	CL

Project No. 3195.X **Client:** EIP

Project: Lookout Slough THRFP - Borrow Analysis

● **Source of Sample:** BTP 23 **Depth:** 1-4' **Sample Number:** A

■ **Source of Sample:** BTP 23 **Depth:** 4' **Sample Number:** 1

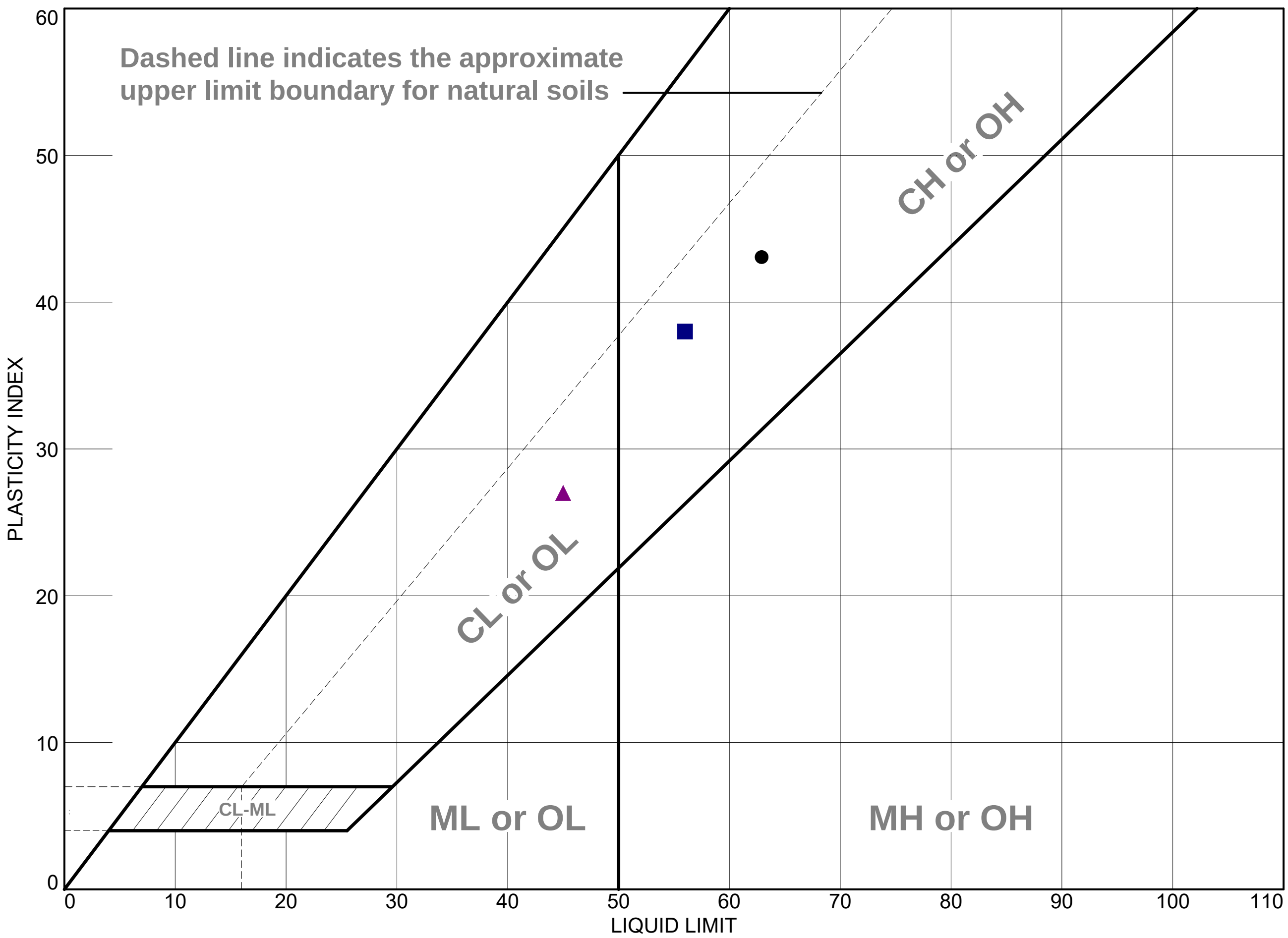
Remarks:

Blackburn Consulting

W. Sacramento, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Fat CLAY, very dark grayish brown	63	20	43		94.6	CH
■	Fat CLAY, olive brown	56	18	38		91.3	CH
▲	Lean CLAY with SAND, olive brown	45	18	27		83.1	CL

Project No. 3195.X **Client:** EIP

Project: Lookout Slough THRFP - Borrow Analysis

● **Source of Sample:** BTP 24 **Depth:** 1-4' **Sample Number:** A

■ **Source of Sample:** BTP 24 **Depth:** 4-7' **Sample Number:** B

▲ **Source of Sample:** BTP 24 **Depth:** 7-10' **Sample Number:** C

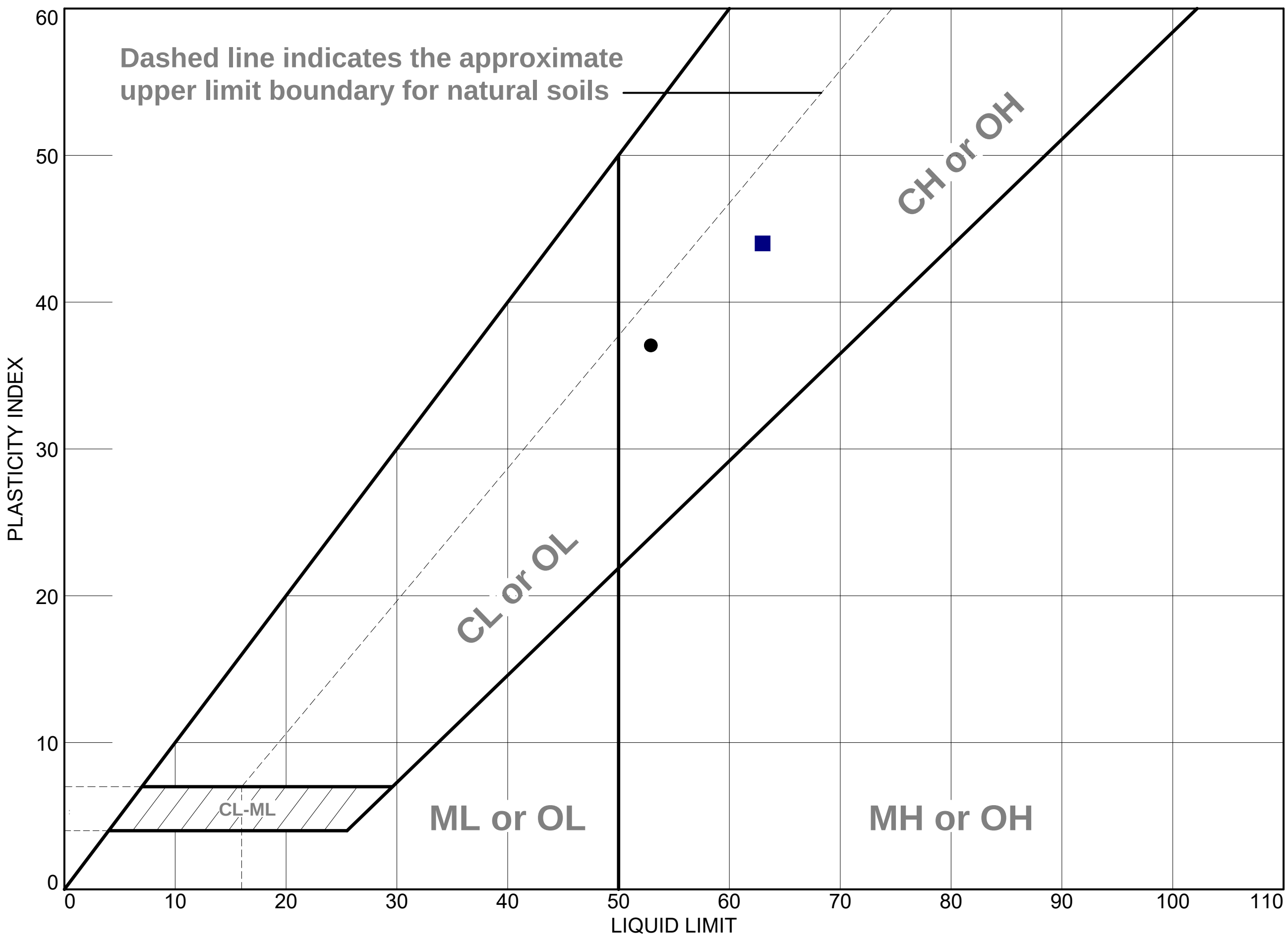
Remarks:

Blackburn Consulting

W. Sacramento, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Fat CLAY, light brownish gray	53	16	37			CH
■	Fat CLAY, olive brown	63	19	44			CL

Project No. 3195.X **Client:** EIP

Project: Lookout Slough THRFP - Borrow Analysis

● **Source of Sample:** BTP 25 **Depth:** 1-3' **Sample Number:** A

■ **Source of Sample:** BTP 25 **Depth:** 4-4.5'

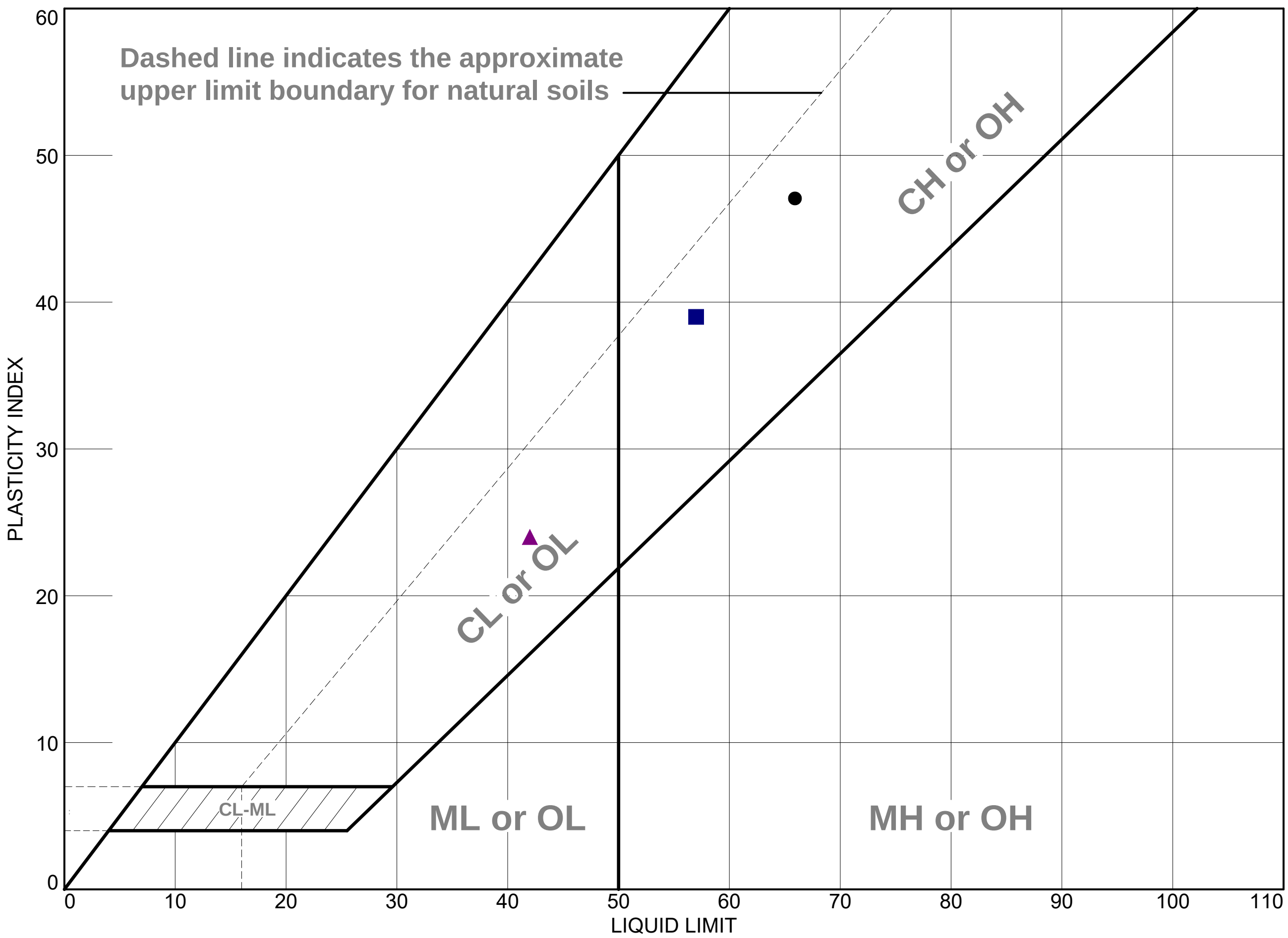
Remarks:

Blackburn Consulting

W. Sacramento, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Fat CLAY, dark olive brown	66	19	47		86.4	CH
■	Fat CLAY, dark reddish brown	57	18	39		85.4	CH
▲	Lean CLAY, dark yellowish brown	42	18	24		88.0	CL

Project No. 3195.X **Client:** EIP

Project: Lookout Slough THRFP - Borrow Analysis

● **Source of Sample:** BTP 26 **Depth:** 1-4' **Sample Number:** A
■ **Source of Sample:** BTP 26 **Depth:** 4' **Sample Number:** 1
▲ **Source of Sample:** BTP 26 **Depth:** 4-7' **Sample Number:** B

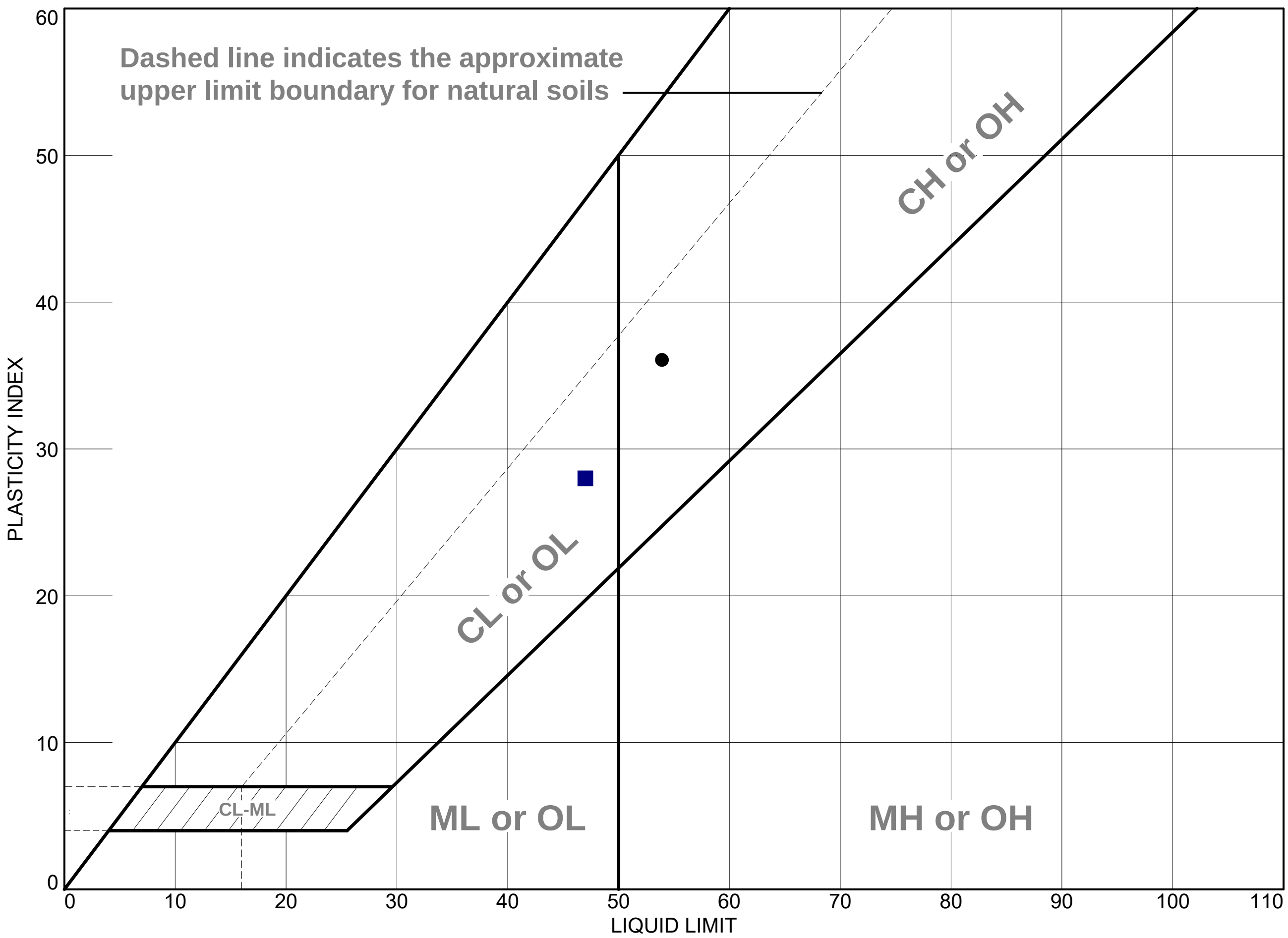
Blackburn Consulting

W. Sacramento, CA

Remarks:

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Fat CLAY, light olive brown	54	18	36			CH
■	Lean CLAY, yellowish brown	47	19	28			CL

Project No. 3195.X **Client:** EIP

Project: Lookout Slough THRFP - Borrow Analysis

● **Source of Sample:** BTP 27 **Depth:** 1-4' **Sample Number:** A
■ **Source of Sample:** BTP 27 **Depth:** 4-4.5'

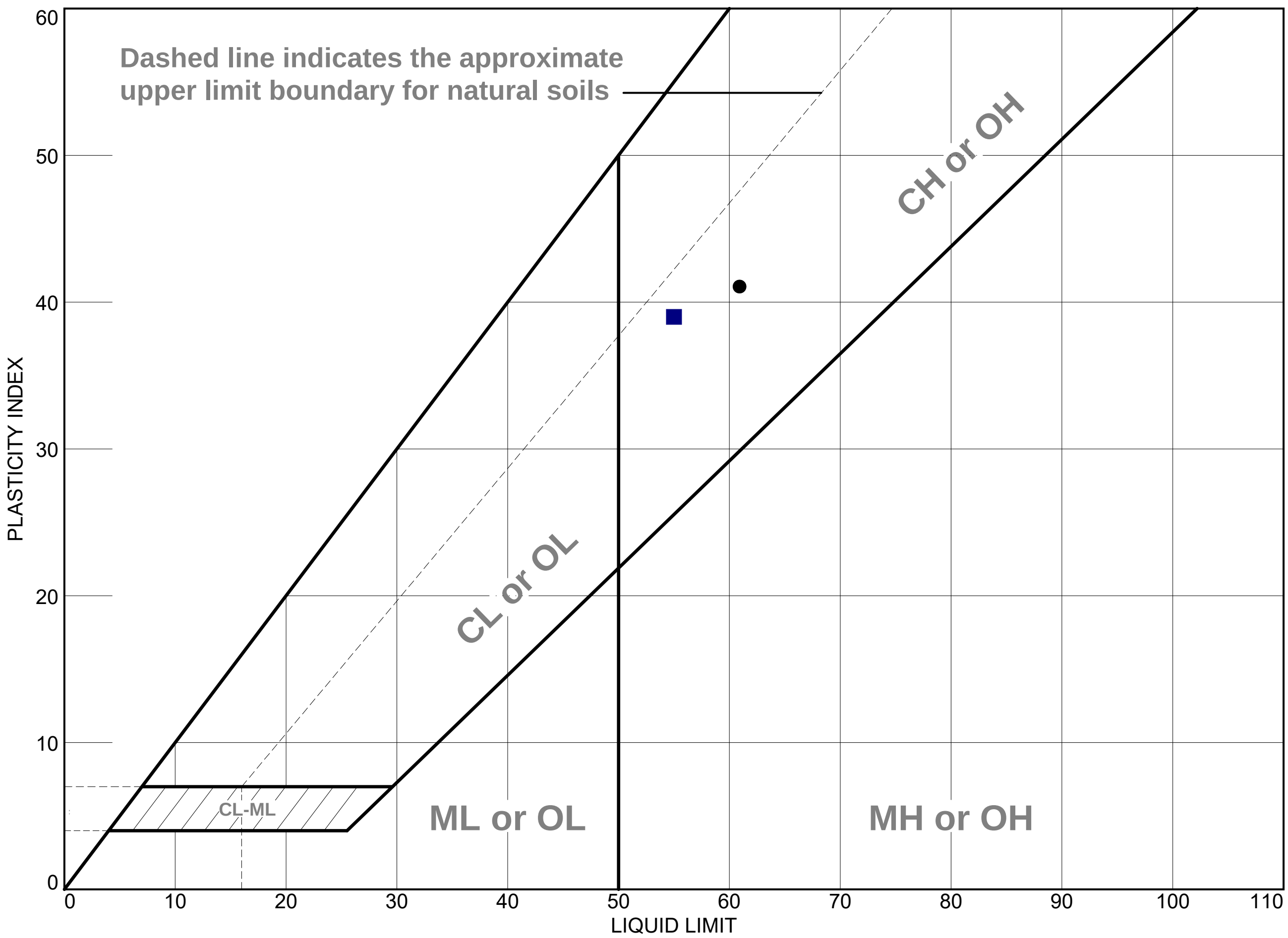
Remarks:

Blackburn Consulting

W. Sacramento, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Fat CLAY with SAND, very dark graysih brown	61	20	41		84.3	CH
■	Fat CLAY with SAND, dark grayish brown	55	16	39		81.3	CH

Project No. 3195.X **Client:** EIP

Project: Lookout Slough THRFP - Borrow Analysis

● **Source of Sample:** BTP 28 **Depth:** 1-4' **Sample Number:** A

■ **Source of Sample:** BTP 28 **Depth:** 4' **Sample Number:** 1

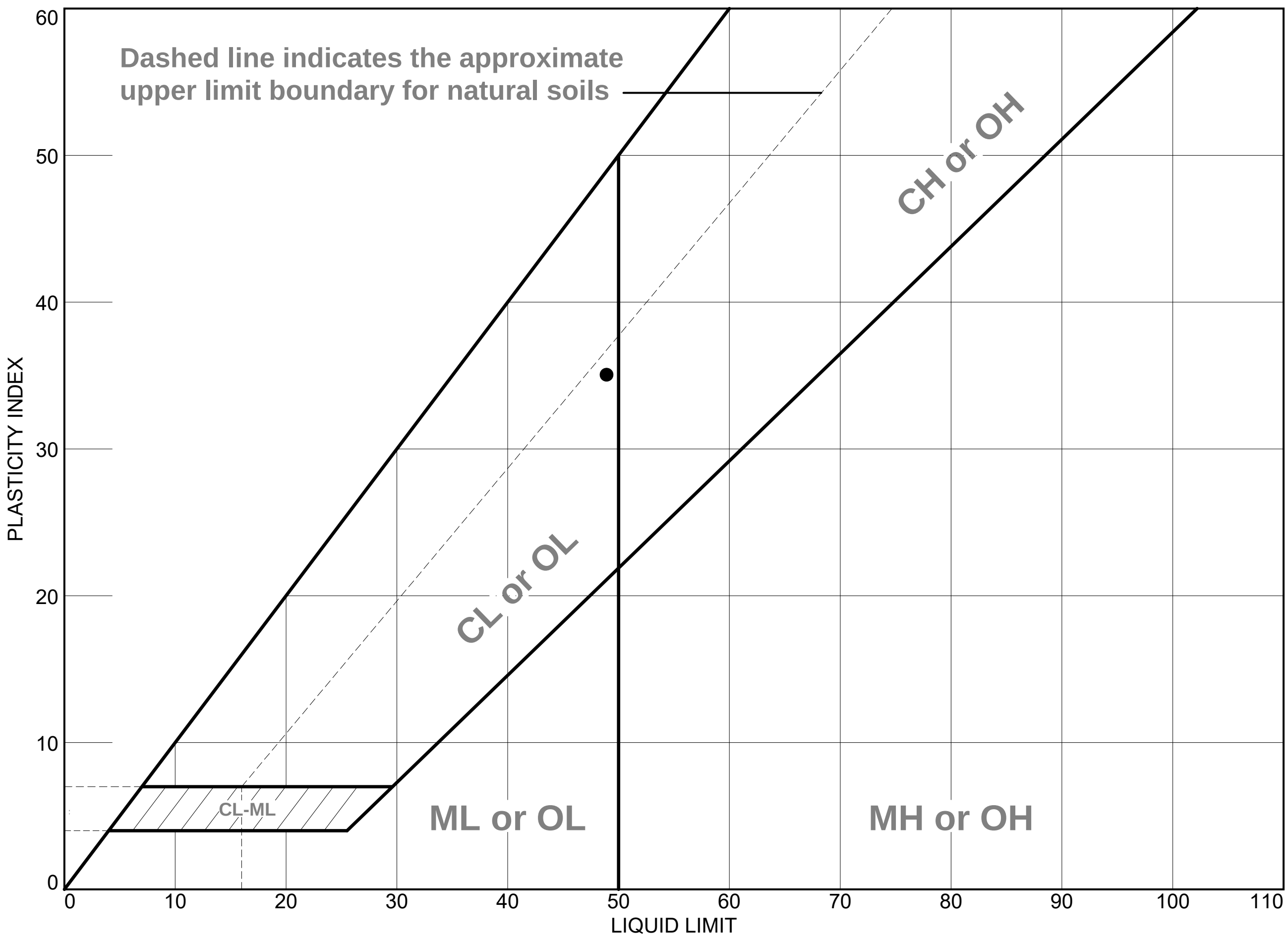
Remarks:

Blackburn Consulting

W. Sacramento, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Lean CLAY, very dark grayish brown	49	14	35		85.3	CL

Project No. 3195.X **Client:** EIP

Project: Lookout Slough THRFP - Borrow Analysis

●**Source of Sample:** BTP 29 **Depth:** 1-4' **Sample Number:** A

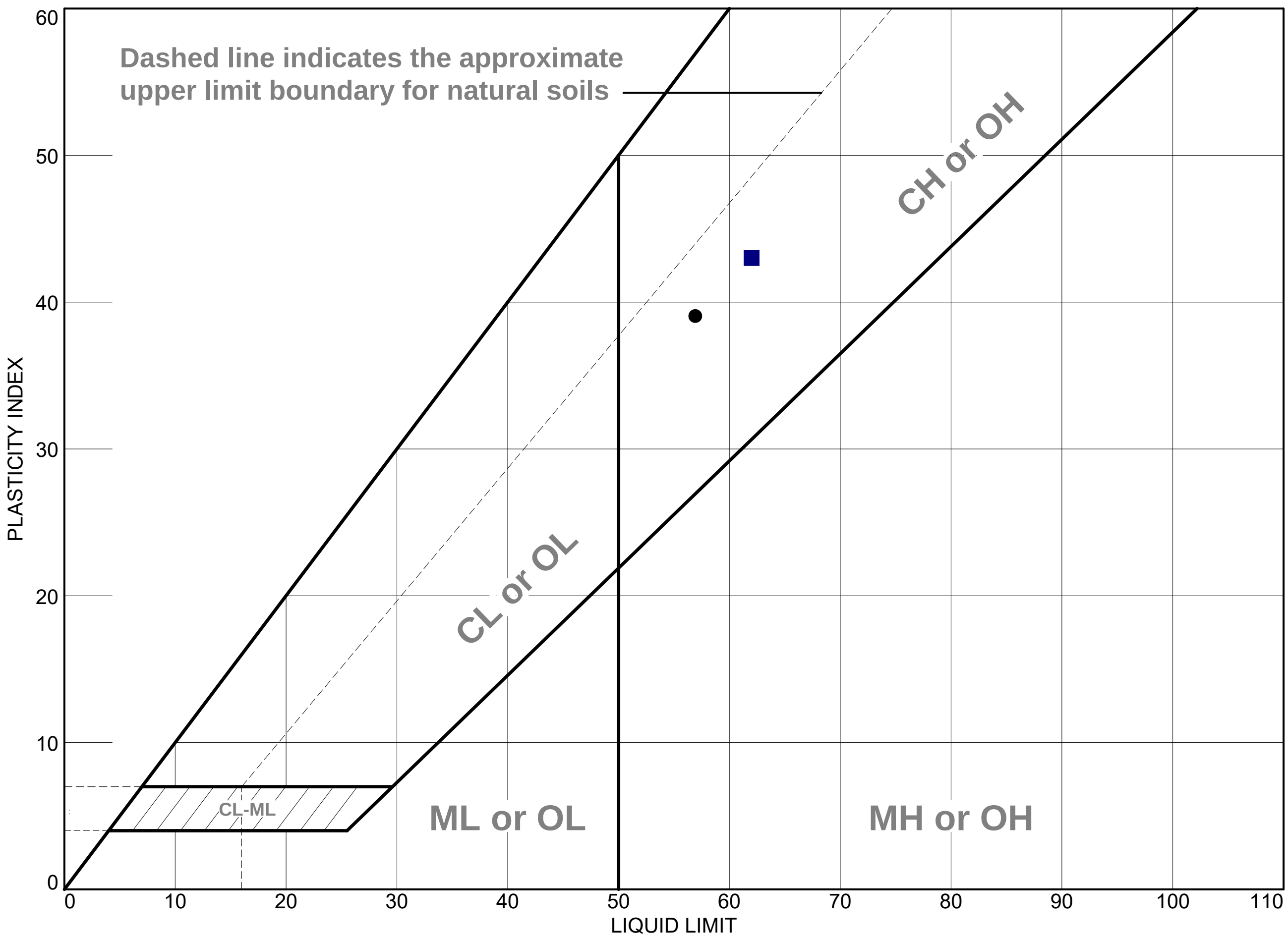
Remarks:

Blackburn Consulting

W. Sacramento, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Fat CLAY, dark grayish brown	57	18	39			CH
■	Fat CLAY, olive brown	62	19	43			CH

Project No. 3195.X **Client:** EIP

Project: Lookout Slough THRFP - Borrow Analysis

●**Source of Sample:** BTP 30 **Depth:** 1-4' **Sample Number:** A

■**Source of Sample:** BTP 30 **Depth:** 4-4.5'

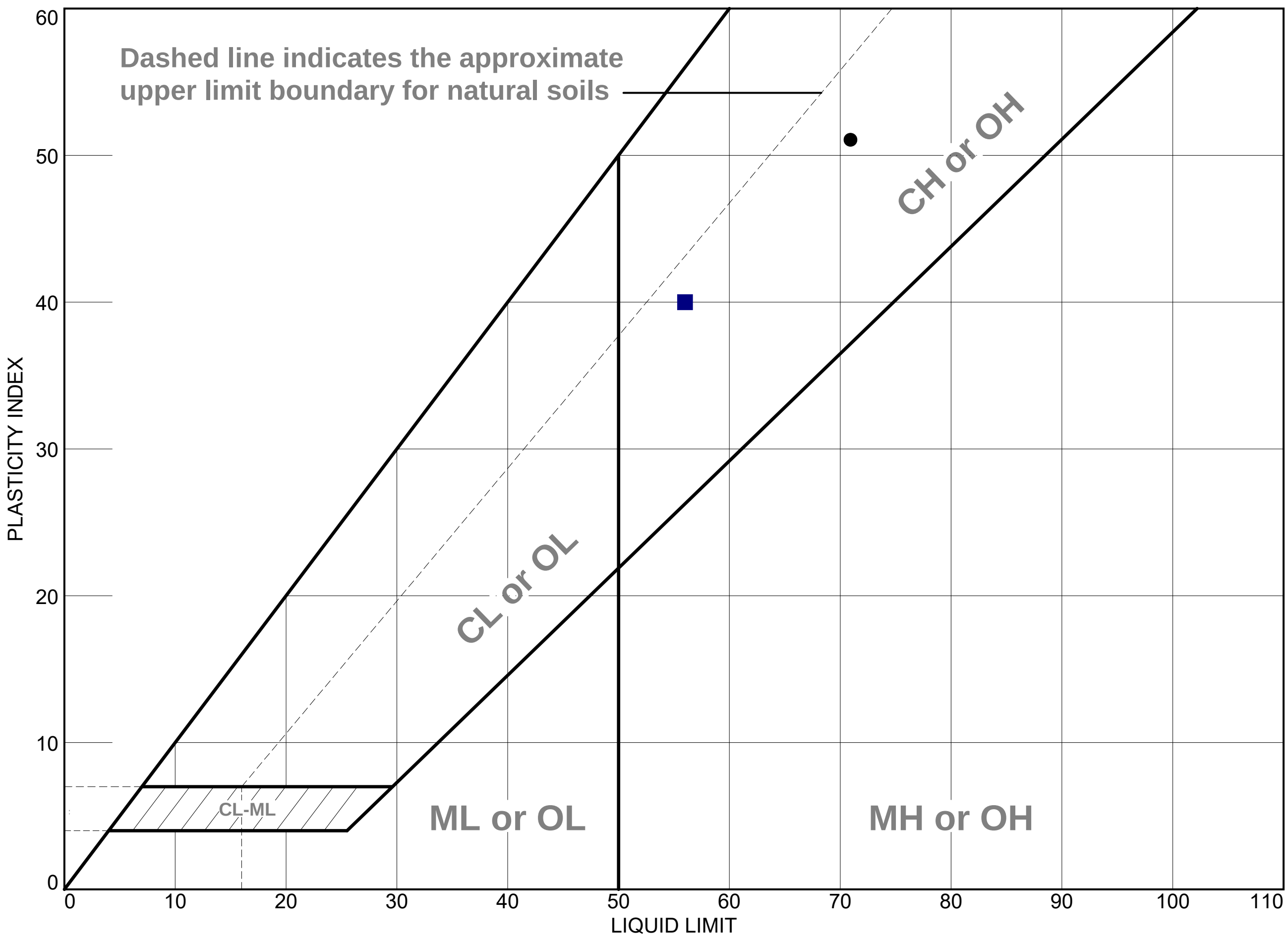
Remarks:

Blackburn Consulting

W. Sacramento, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Fat CLAY, black	71	20	51		96.1	CH
■	Fat CLAY, very dark grayish brown	56	16	40		87.8	CH

Project No. 3195.X **Client:** EIP

Project: Lookout Slough THRFP - Borrow Analysis

●**Source of Sample:** BTP 31 **Depth:** 1-3' **Sample Number:** A

■**Source of Sample:** BTP 31 **Depth:** 3' **Sample Number:** 1

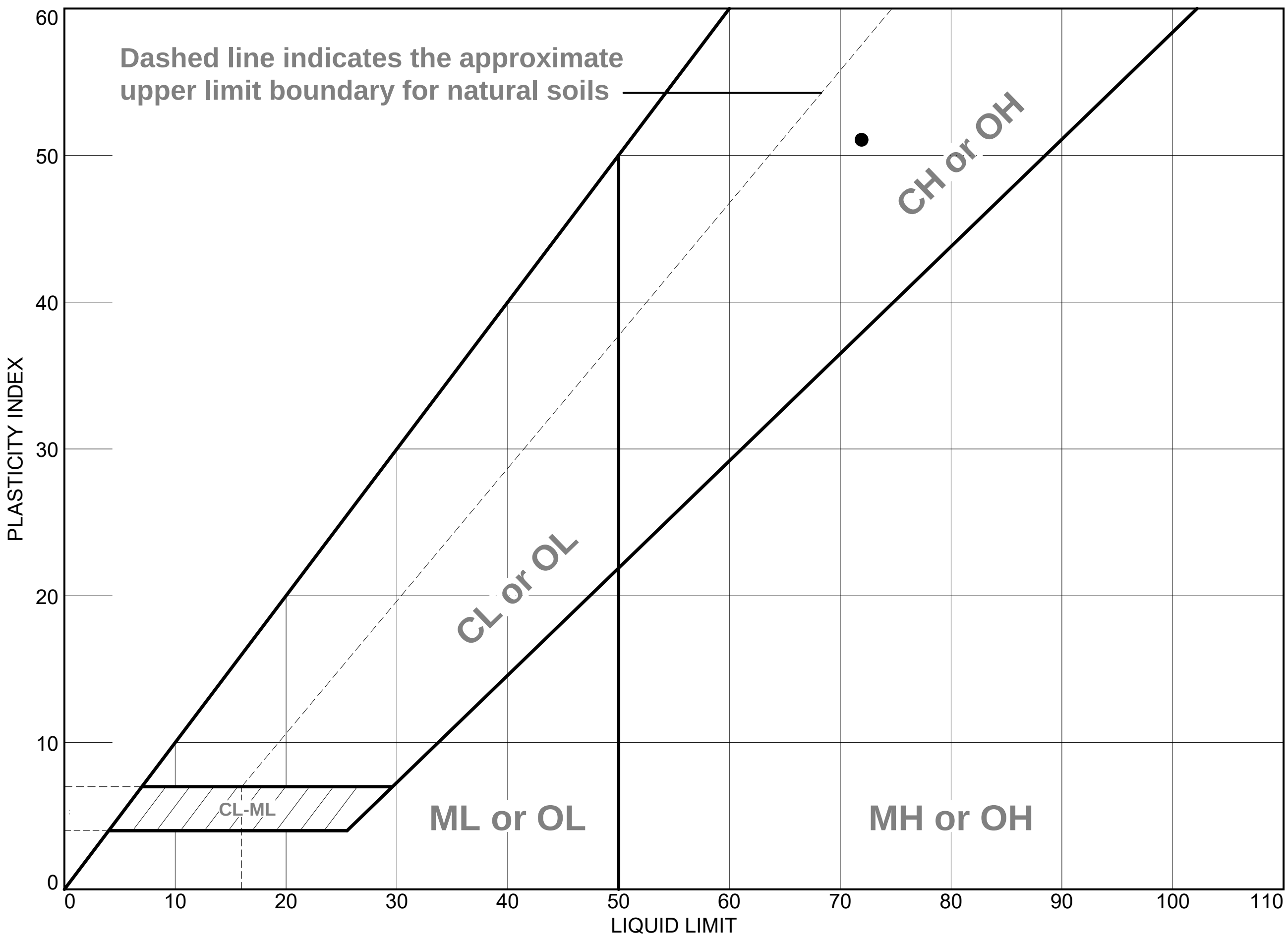
Remarks:

Blackburn Consulting

W. Sacramento, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Fat CLAY, Black	72	21	51		96.4	CH

Project No. 3195.X **Client:** EIP

Project: Lookout Slough THRFP - Borrow Analysis

● **Source of Sample:** BTP 32 **Depth:** 1-3' **Sample Number:** A

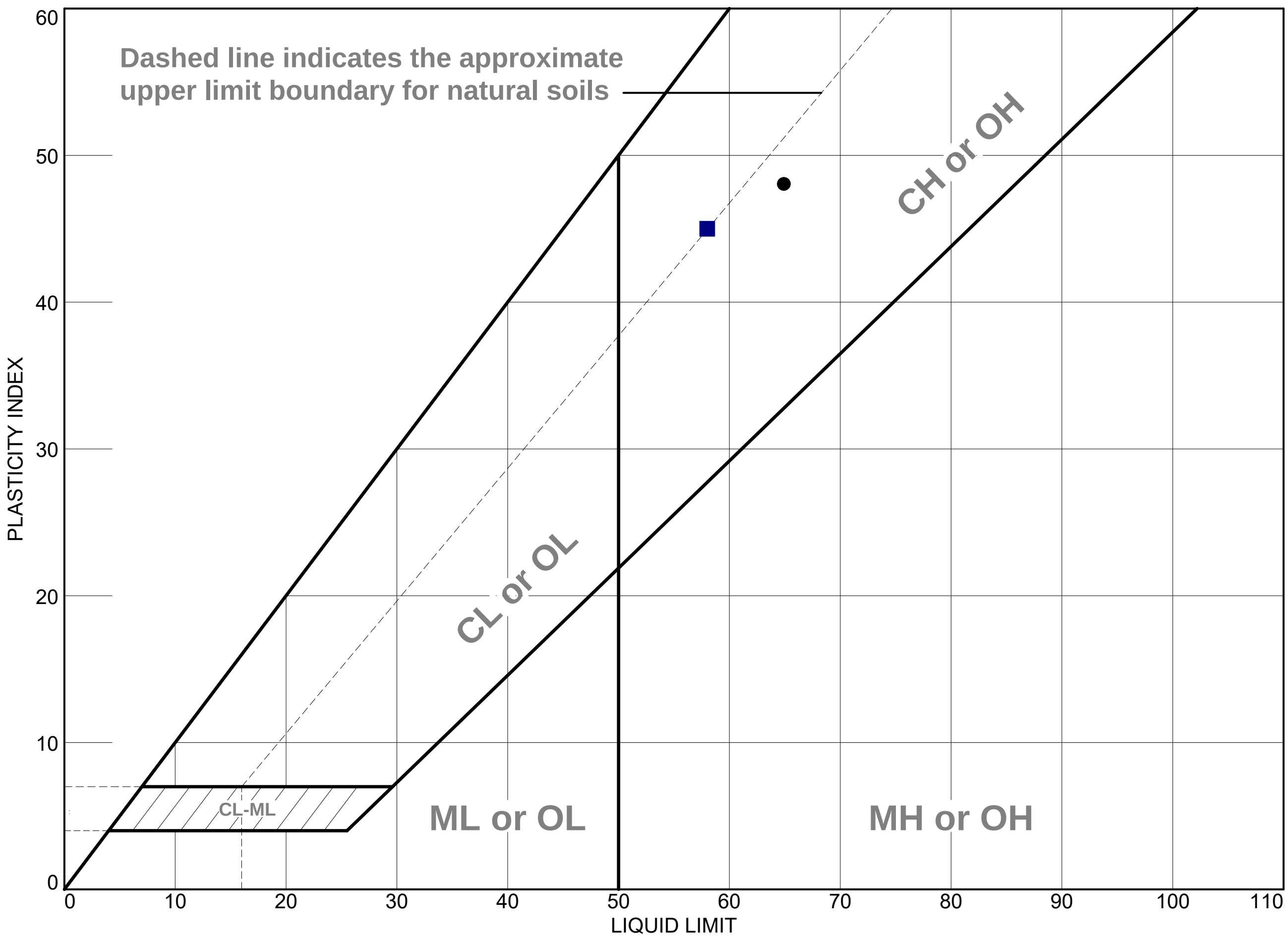
Remarks:

Blackburn Consulting

W. Sacramento, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Fat CLAY with SAND, dark olive brown	65	17	48		82.4	CH
■	Fat CLAY with SAND, dark olive brown	58	13	45		80.0	CH

Project No. 3195.X **Client:** EIP

Project: Lookout Slough THRFP - Borrow Analysis

●**Source of Sample:** BTP 33 **Depth:** 1-4' **Sample Number:** A

■**Source of Sample:** BTP 33 **Depth:** 4.5' **Sample Number:** 1

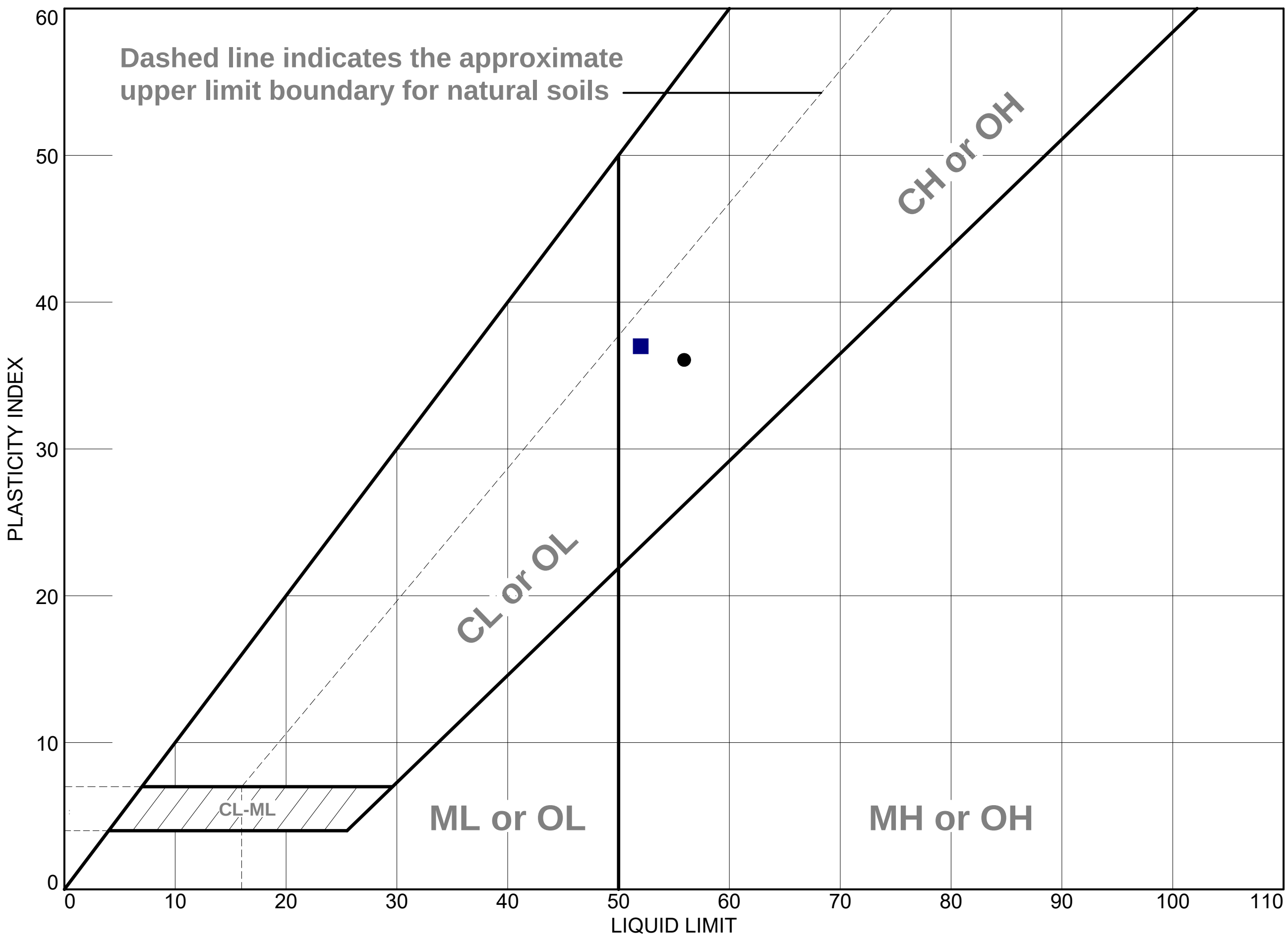
Blackburn Consulting

W. Sacramento, CA

Remarks:

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Fat CLAY, dark brown	56	20	36		88.5	CH
■	Fat CLAY with SAND, dark yellowish brown	52	15	37		82.8	CH

Project No. 3195.X **Client:** EIP

Project: Lookout Slough THRFP - Borrow Analysis

●**Source of Sample:** BTP 34 **Depth:** 1-3' **Sample Number:** A

■**Source of Sample:** BTP 34 **Depth:** 3-6' **Sample Number:** B

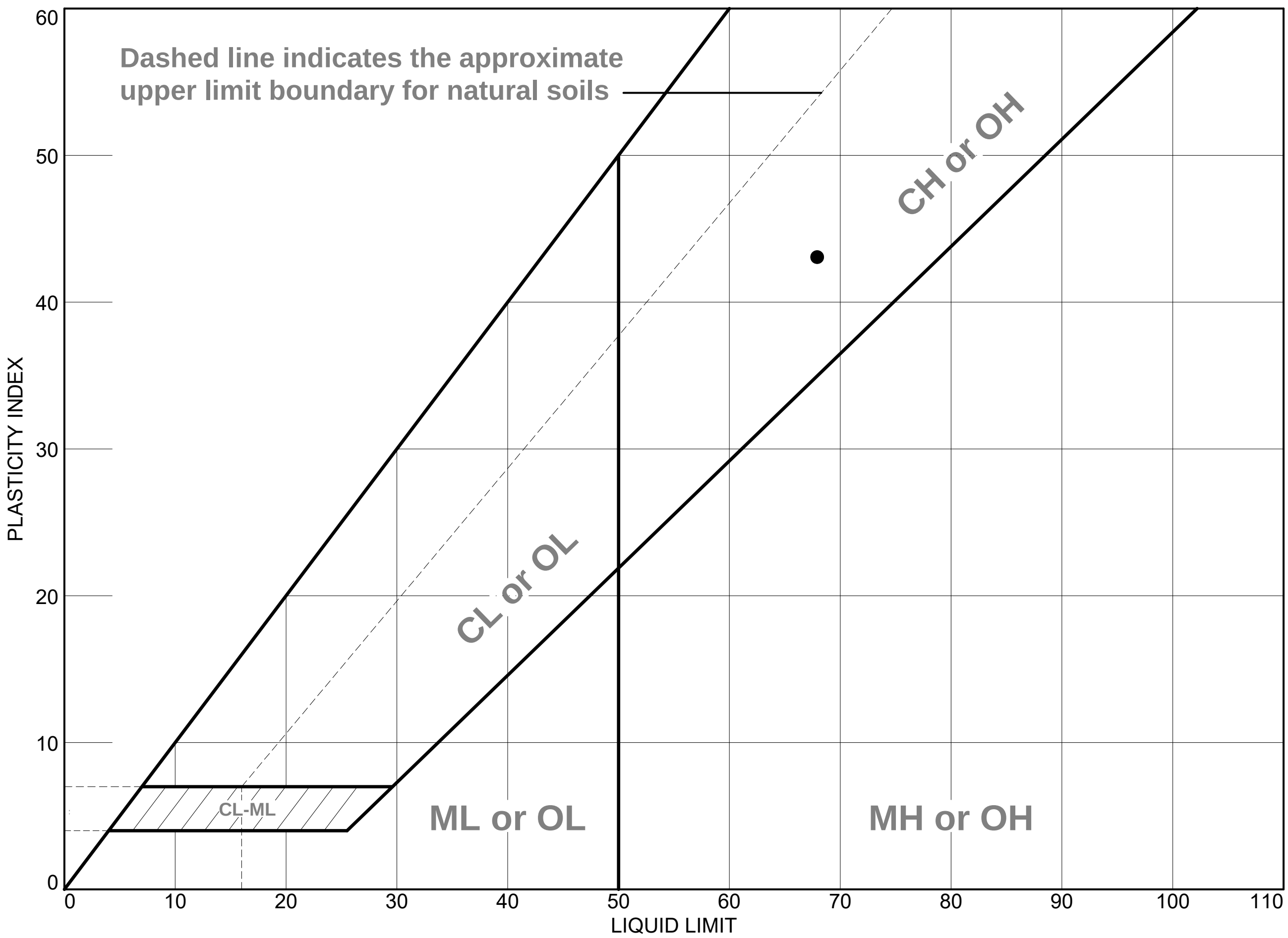
Remarks:

Blackburn Consulting

W. Sacramento, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Fat CLAY, very dark brown	68	25	43		94.3	CH

Project No. 3195.X **Client:** EIP

Project: Lookout Slough THRFP - Borrow Analysis

● **Source of Sample:** BTP 35 **Depth:** 1-4' **Sample Number:** A

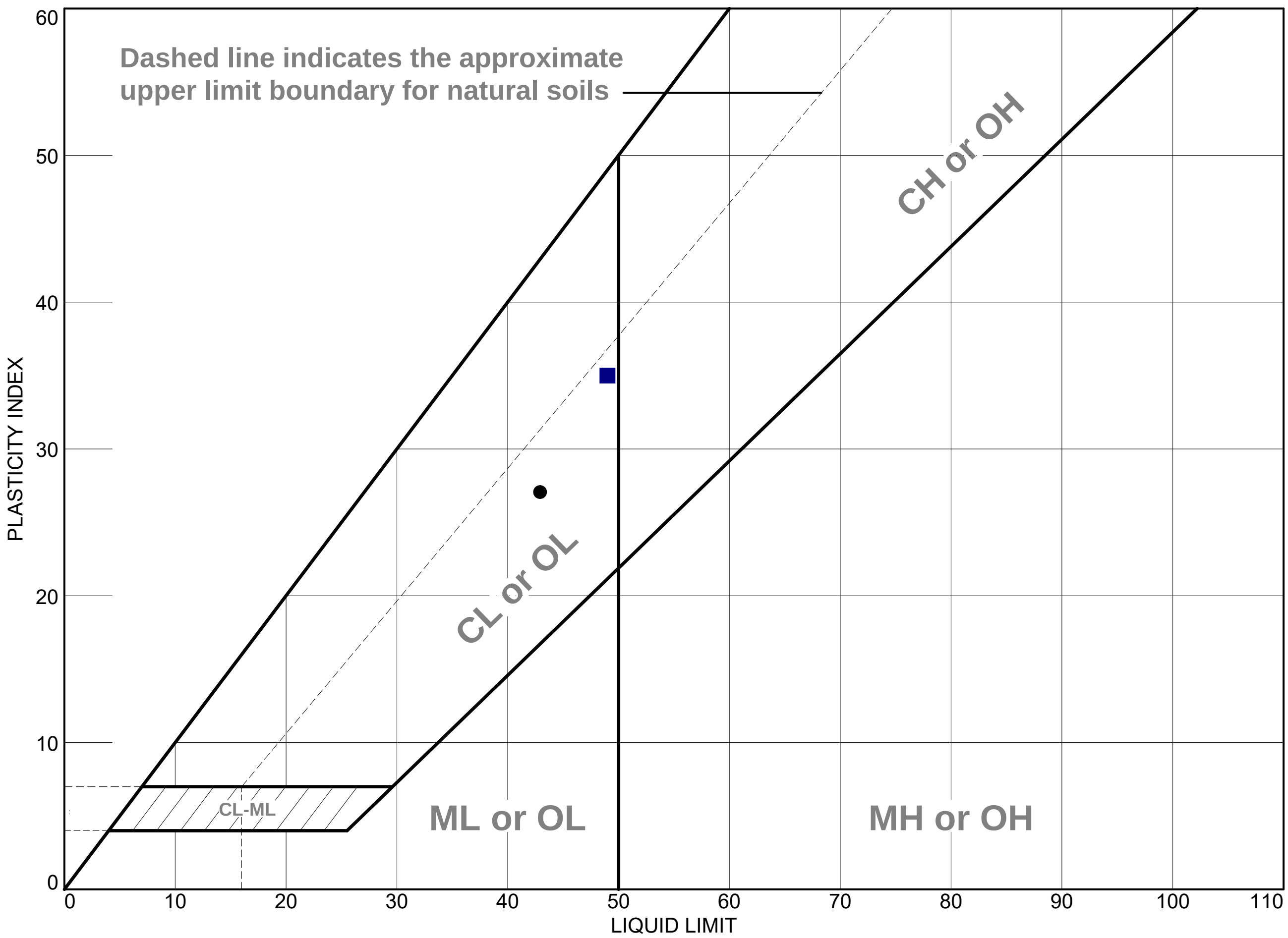
Remarks:

Blackburn Consulting

W. Sacramento, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Lean CLAY with SAND, dark olive brown	43	16	27		82.6	CL
■	Lean CLAY with SAND, olive brown	49	14	35		81.6	CL

Project No. 3195.X **Client:** EIP

Project: Lookout Slough THRFP - Borrow Analysis

● **Source of Sample:** BTP 36 **Depth:** 1-4' **Sample Number:** A

■ **Source of Sample:** BTP 36 **Depth:** 6' **Sample Number:** 2

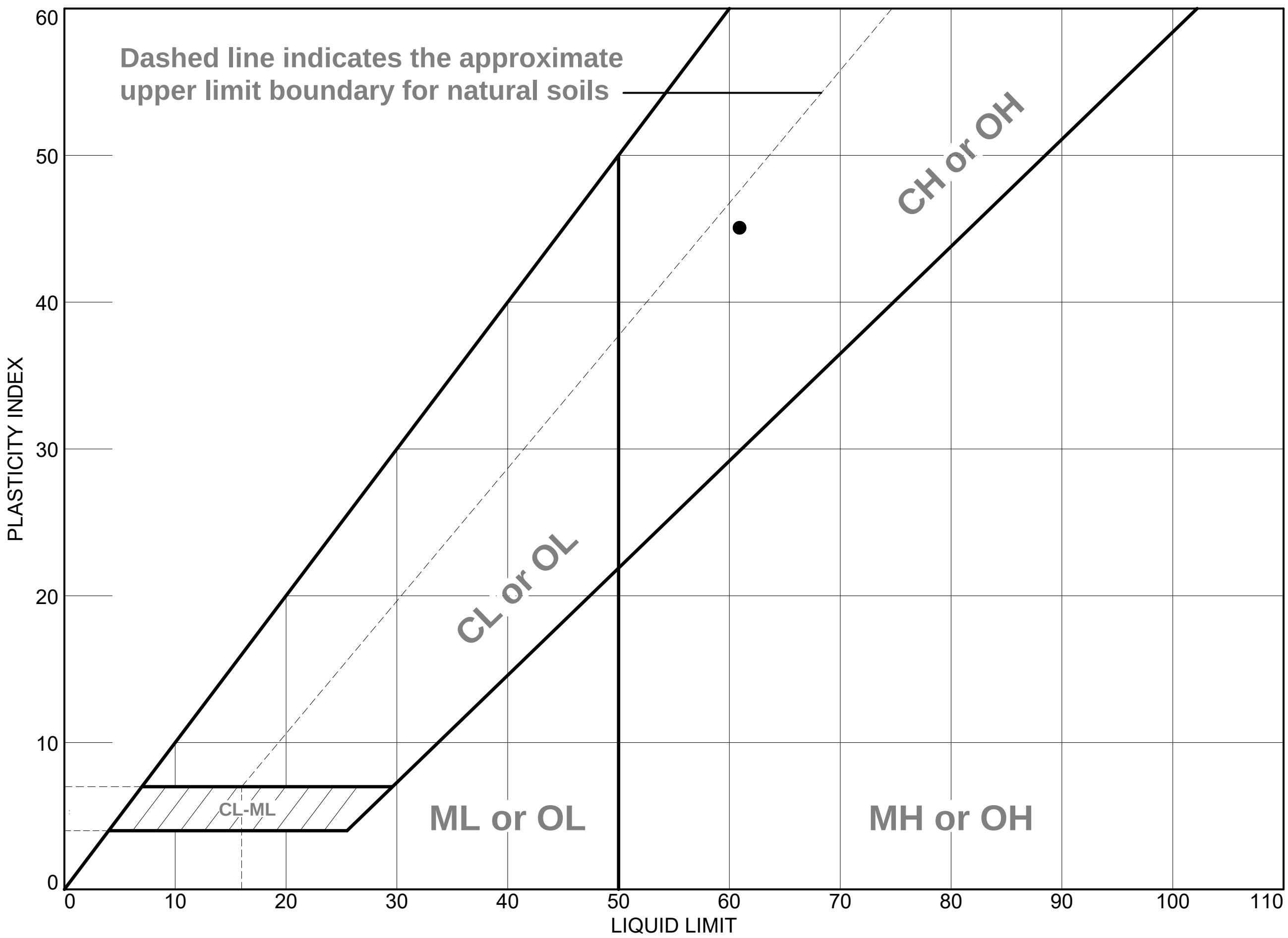
Remarks:

Blackburn Consulting

W. Sacramento, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Fat CLAY, very dark grayish brown	61	16	45		92.4	CH

Project No. 3195.X **Client:** EIP

Project: Lookout Slough THRFP - Borrow Analysis

●**Source of Sample:** BTP 37 **Depth:** 1-3' **Sample Number:** A

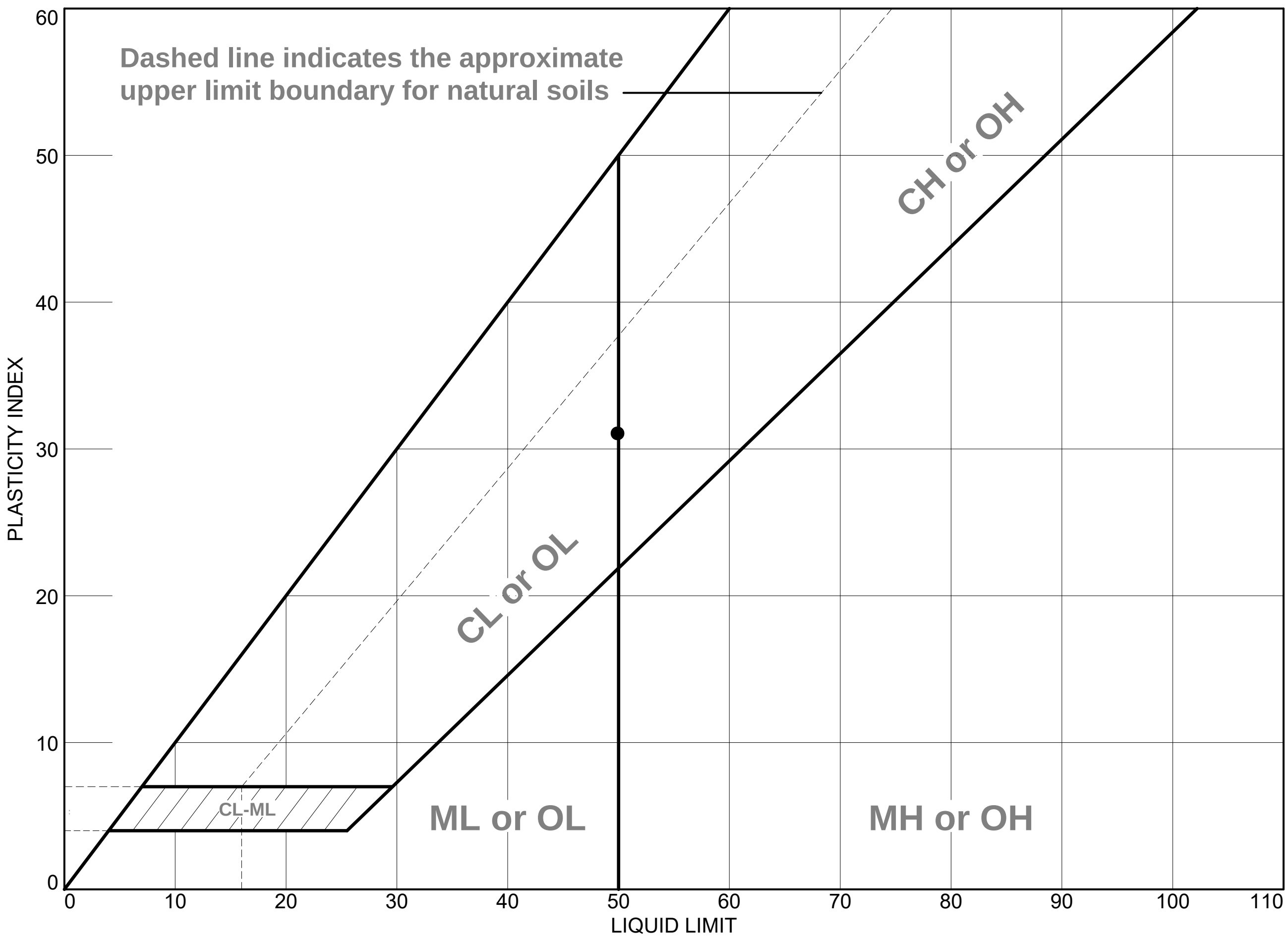
Remarks:

Blackburn Consulting

W. Sacramento, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Fat CLAY, olive brown	50	19	31			CH

Project No. 3195.X **Client:** EIP

Project: Lookout Slough THRFP - Borrow Analysis

● **Source of Sample:** BTP 38 **Depth:** 1-3' **Sample Number:** A

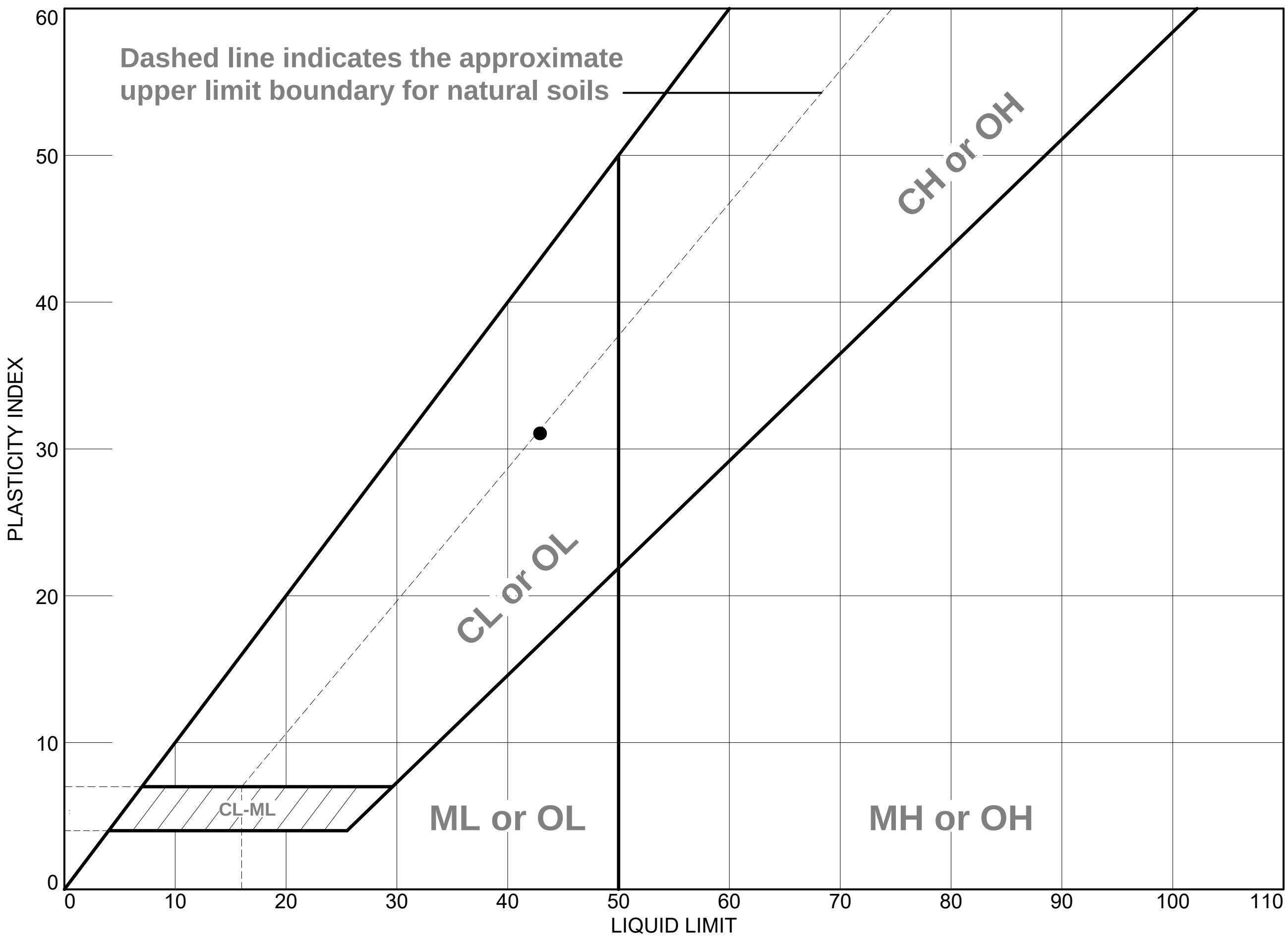
Remarks:

Blackburn Consulting

W. Sacramento, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	SANDY lean CLAY, dark yellowish brown	43	12	31		69.2	CL

Project No. 3195.X **Client:** EIP

Project: Lookout Slough THRFP - Borrow Analysis

● **Source of Sample:** BTP 39 **Depth:** 1-4' **Sample Number:** A

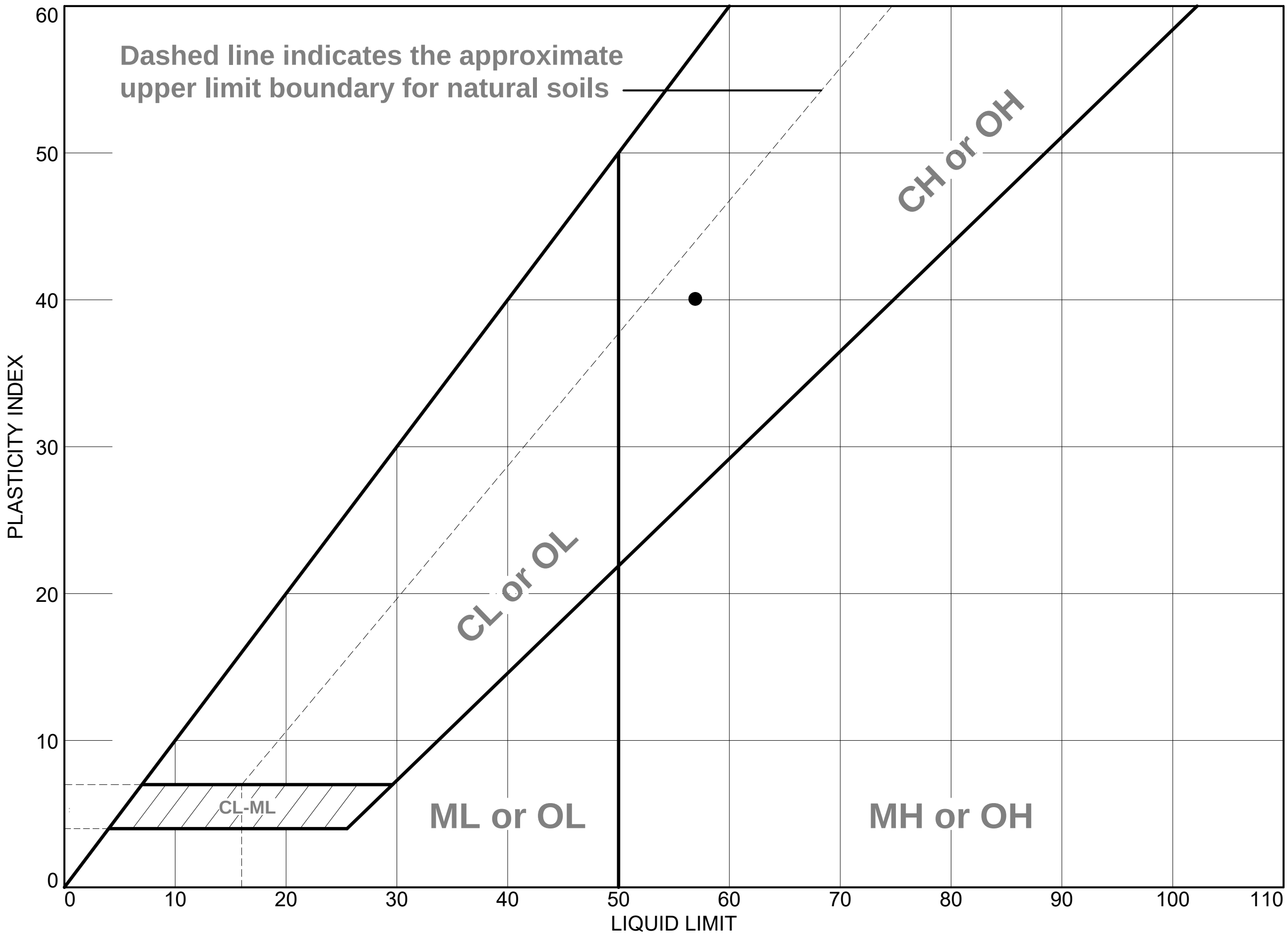
Remarks:

Blackburn Consulting

W. Sacramento, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Fat CLAY, dark grayish brown	57	17	40		93.3	CH

Project No. 3195.X **Client:** EIP

Project: Lookout Slough THRFP - Borrow Analysis

● **Source of Sample:** BTP 40 **Depth:** 1-3' **Sample Number:** A

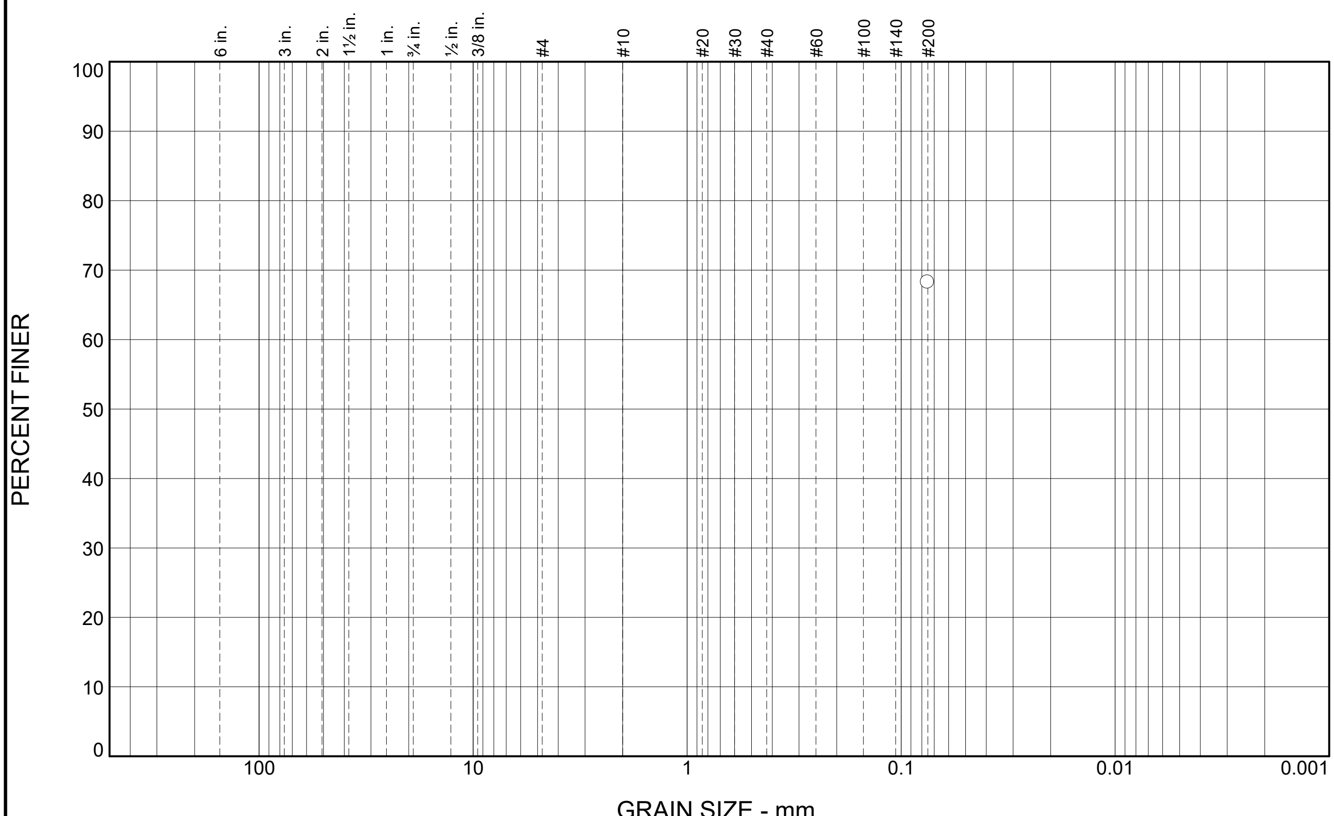
Remarks:

Blackburn Consulting

W. Sacramento, CA

Figure

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
						68.2	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#200	68.2		

* (no specification provided)

Material Description

SANDY fat CLAY, brownish gray

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= D_{85}= D_{60}=
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= AASHTO=

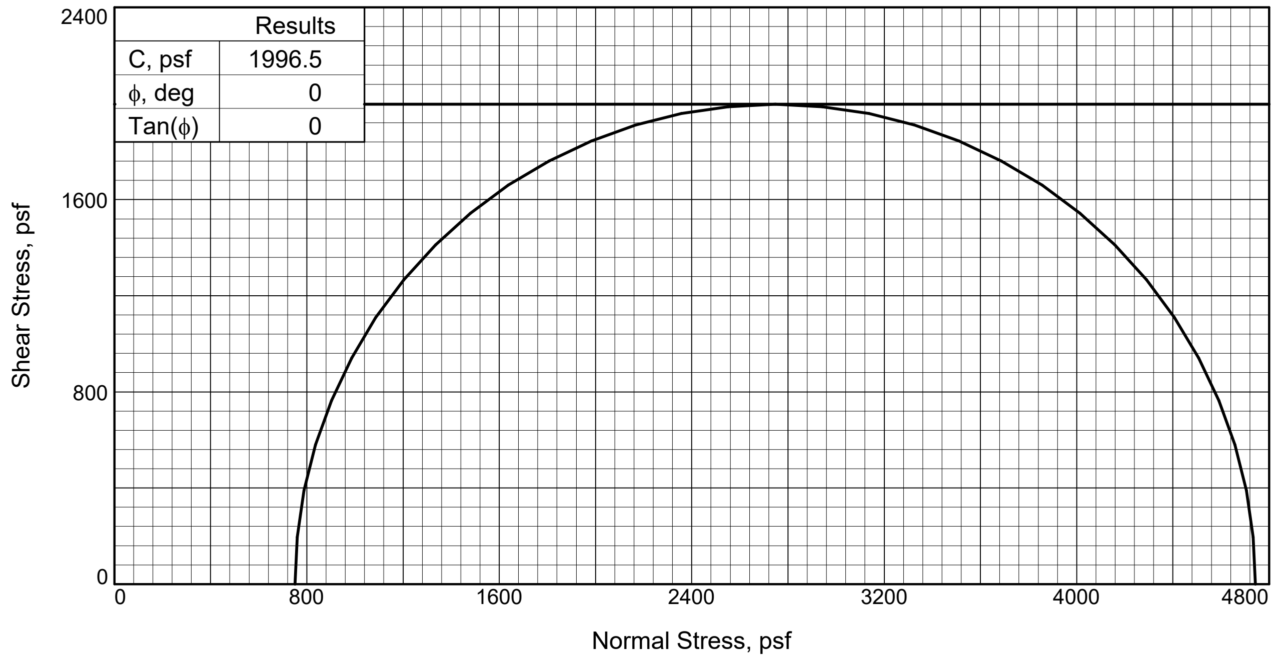
Remarks

Source of Sample: BTP 4 **Depth:** 4'
Sample Number: 1 **Date:**

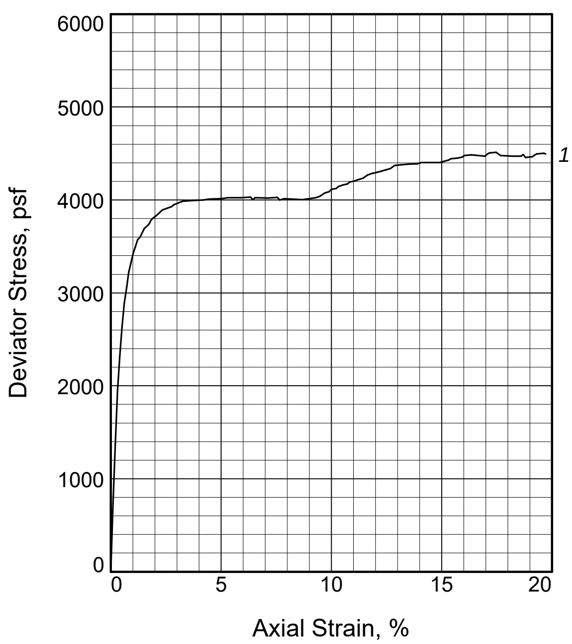
Blackburn Consulting

W. Sacramento, CA

Client: EIP
Project: Lookout Slough THRFP - Borrow Analysis
Project No: 3195.X **Figure**



	Results
C, psf	1996.5
ϕ, deg	0
Tan(ϕ)	0



Sample No.		1
Initial	Water Content, %	21.6
	Dry Density, pcf	99.5
	Saturation, %	84.1
	Void Ratio	0.6937
	Diameter, in.	2.397
	Height, in.	4.975
At Test	Water Content, %	21.5
	Dry Density, pcf	99.5
	Saturation, %	83.6
	Void Ratio	0.6937
	Diameter, in.	2.397
	Height, in.	4.975
Strain rate, in./min.		0.050
Back Pressure, psf		0.0
Cell Pressure, psf		750.2
Fail. Stress, psf		3993.1
Strain, %		3.7
Ult. Stress, psf		
Strain, %		
$\pm_1$ Failure, psf		4743.3
$\pm_3$ Failure, psf		750.2

Type of Test:
Unconsolidated Undrained

Sample Type: 2.4" Remold

Description: Fat CLAY with SAND, dark reddish brown

Assumed Specific Gravity= 2.70

Remarks: Remolded to 97% of maximum dry dentisy per ASTM D698 @ 2% over optimum

Figure ________

Client: EIP

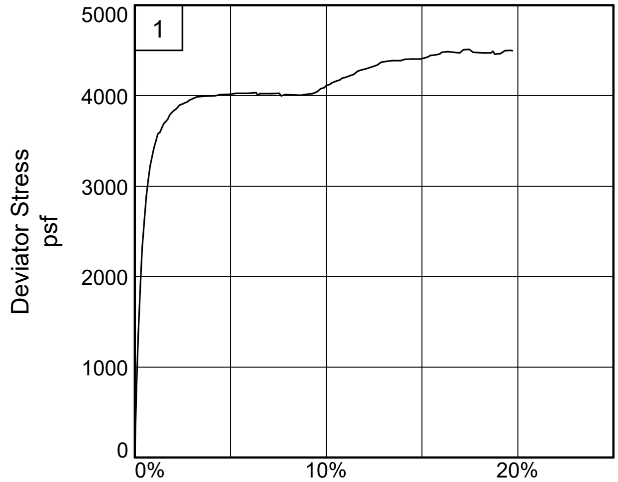
Project: Lookout Slough Restoration Project

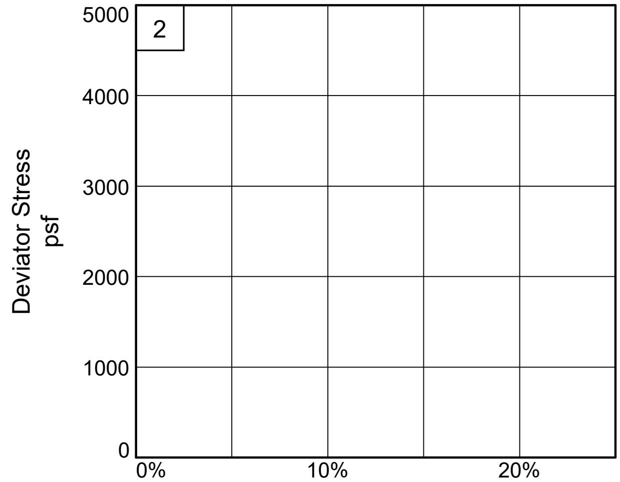
Source of Sample: TP4 **Depth:** 1.0-3.0'

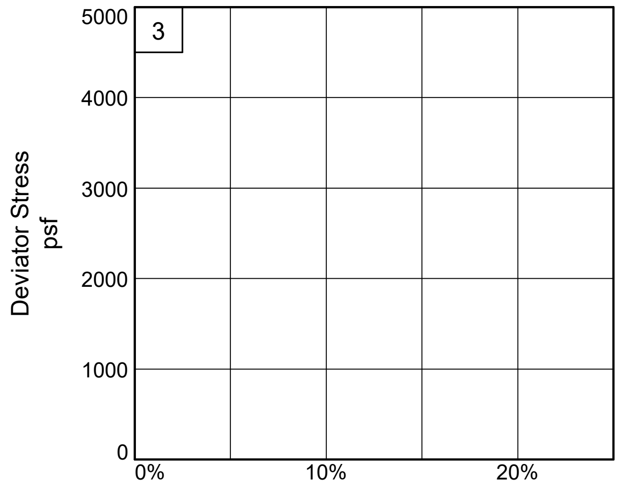
Sample Number: Bulk 1

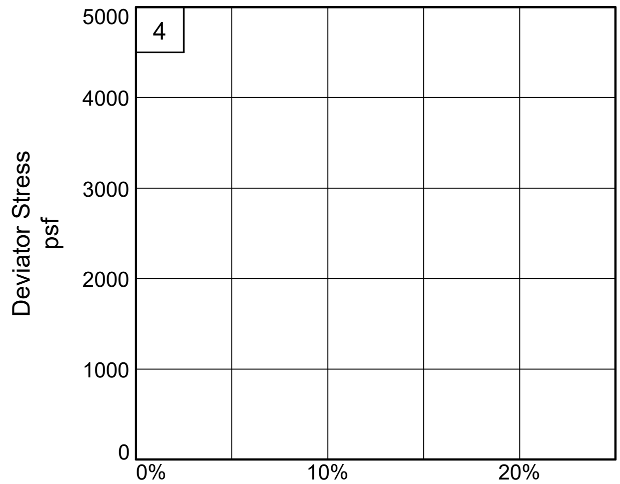
Proj. No.: 3195.P **Date Sampled:** 9/17

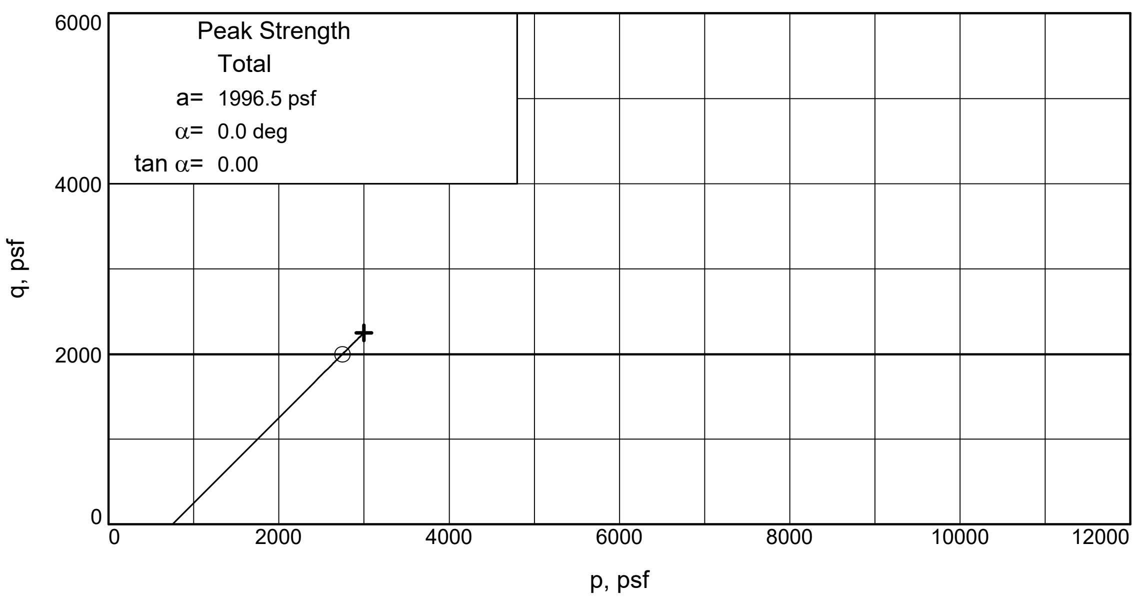
TRIAXIAL SHEAR TEST REPORT
Blackburn Consulting
W. Sacramento, CA











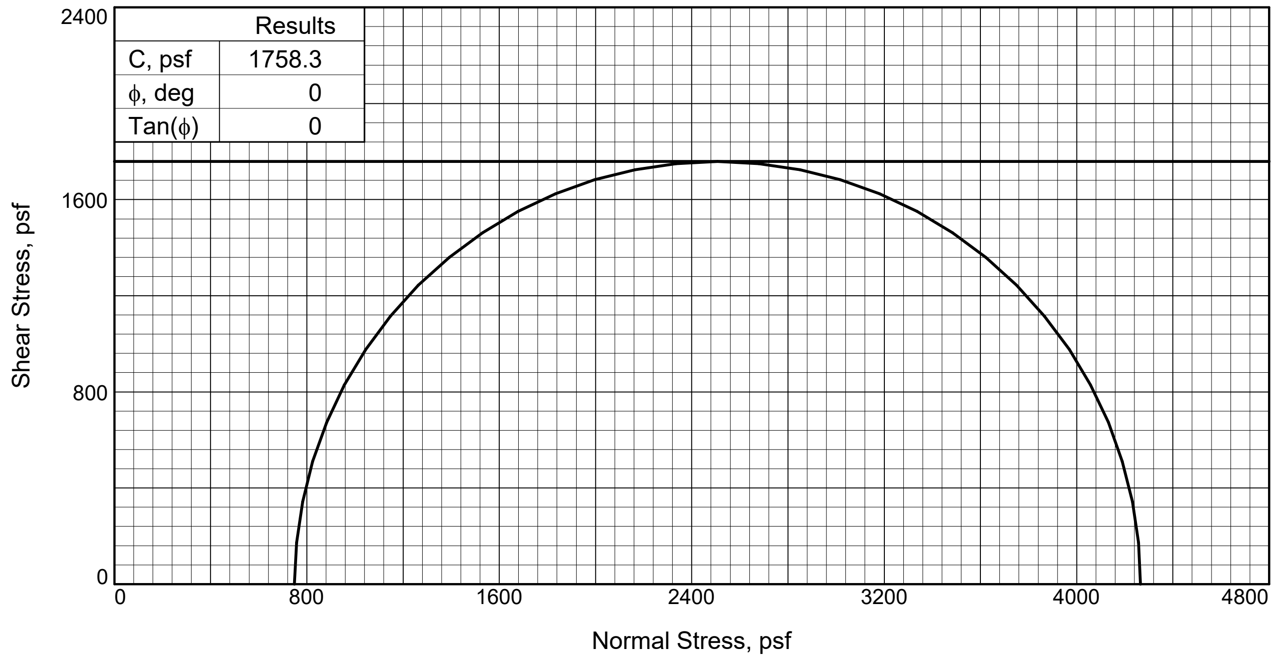
Stress Paths: o indicates peak + indicates end

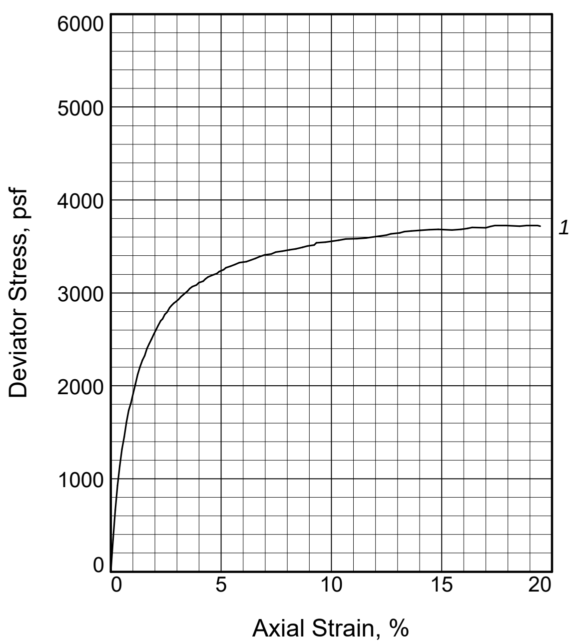
Client: EIP

Project: Lookout Slough Restoration Project

Source of Sample: TP4 **Depth:** 1.0-3.0' **Sample Number:** Bulk 1

Project No.: 3195.P **Figure** ________ **Blackburn Consulting**





Sample No.		1
Initial	Water Content, %	21.2
	Dry Density, pcf	101.7
	Saturation, %	87.0
	Void Ratio	0.6579
	Diameter, in.	2.396
	Height, in.	4.972
At Test	Water Content, %	24.0
	Dry Density, pcf	102.3
	Saturation, %	100.0
	Void Ratio	0.6479
	Diameter, in.	2.391
	Height, in.	4.962
Strain rate, in./min.		0.050
Back Pressure, psf		0.0
Cell Pressure, psf		748.8
Fail. Stress, psf		3516.7
Strain, %		9.2
Ult. Stress, psf		
Strain, %		
$\pm_1$ Failure, psf		4265.5
$\pm_3$ Failure, psf		748.8

Type of Test:
Unconsolidated Undrained

Sample Type: 2.4" Remold

Description: Fat CLAY with SAND, dark grayish brown

Assumed Specific Gravity= 2.70

Remarks: Remolded to 97% of maximum dry density per ASTM D698 @ 2% over optimum

Figure ________

Client: EIP

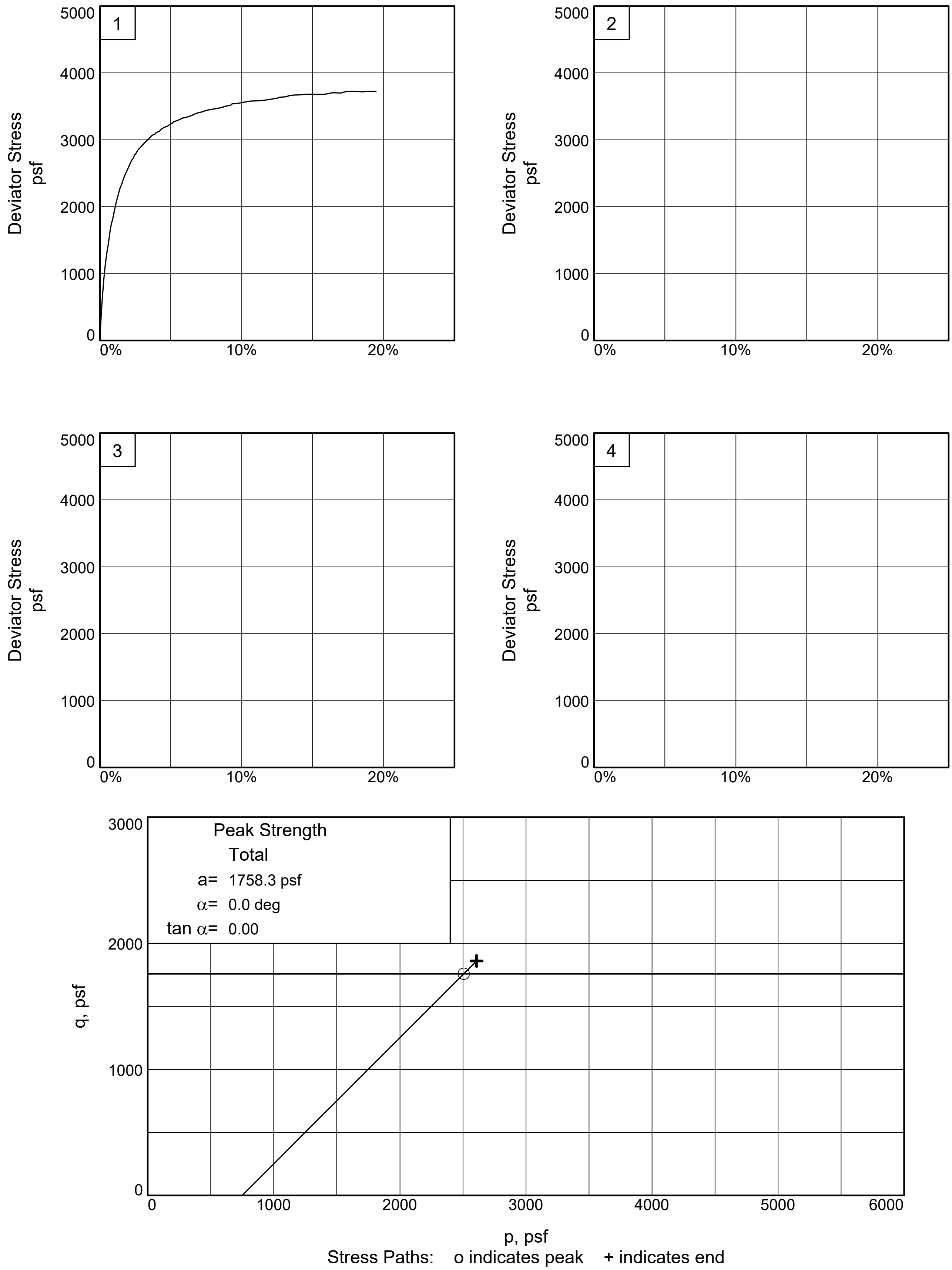
Project: Lookout Slough Restoration Project

Source of Sample: TP6 **Depth:** 1.0-4.0'

Sample Number: Bulks 1&2

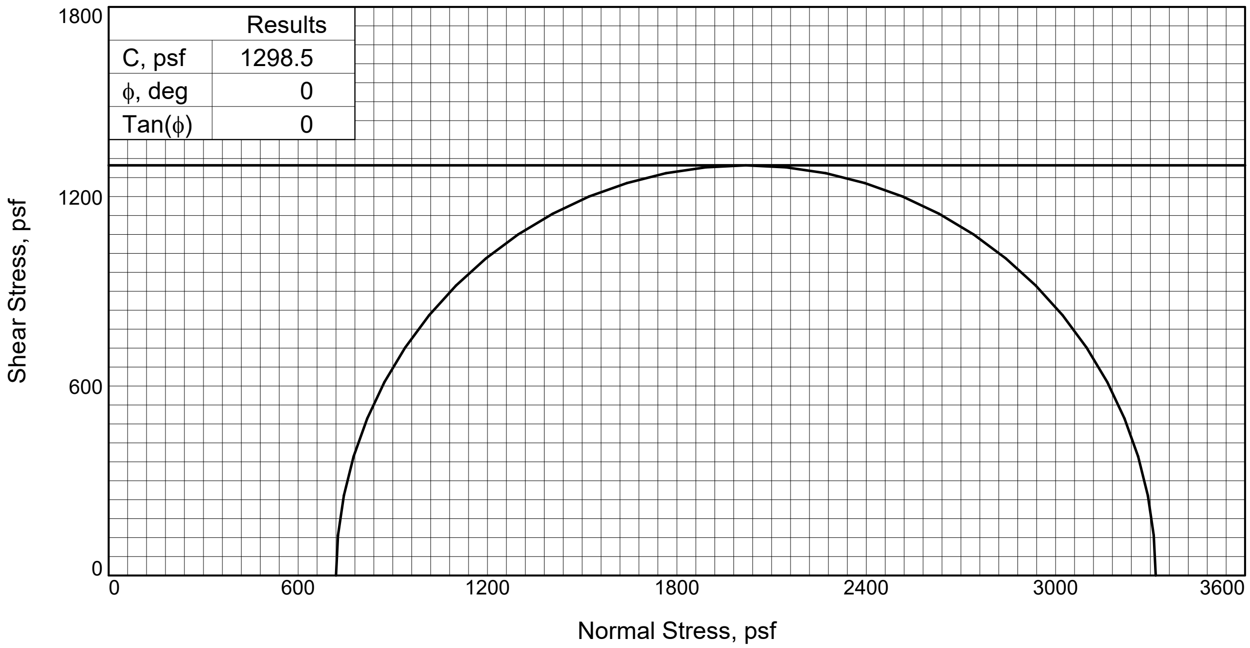
Proj. No.: 3195.P **Date Sampled:** 9/17

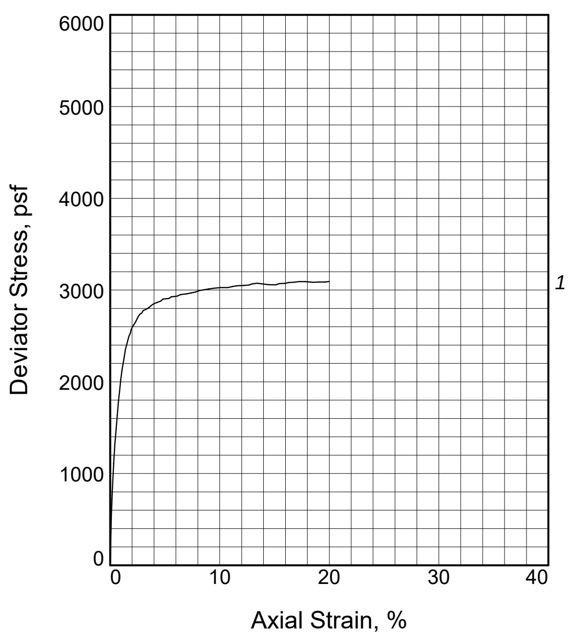
TRIAXIAL SHEAR TEST REPORT
Blackburn Consulting
W. Sacramento, CA



Client: EIP
Project: Lookout Slough Restoration Project
Source of Sample: TP6 **Depth:** 1.0-4.0' **Sample Number:** Bulks 1&2
Project No.: 3195.P **Figure** ________

Blackburn Consulting





Sample No.		1
Initial	Water Content, %	22.1
	Dry Density, pcf	100.1
	Saturation, %	89.8
	Void Ratio	0.6523
	Diameter, in.	2.393
	Height, in.	4.744
At Test	Water Content, %	22.1
	Dry Density, pcf	100.1
	Saturation, %	89.8
	Void Ratio	0.6523
	Diameter, in.	2.393
	Height, in.	4.744
Strain rate, in./min.		0.047
Back Pressure, psf		0.0
Cell Pressure, psf		720.0
Fail. Stress, psf		2597.1
Strain, %		2.0
Ult. Stress, psf		
Strain, %		
σ_1 Failure, psf		3317.1
σ_3 Failure, psf		720.0

Type of Test:
Unconsolidated Undrained

Sample Type: 2.4" Remold

Description: Fat CLAY, very dark grayish brown

LL= 57 **PL=** 14 **PI=** 43

Assumed Specific Gravity= 2.65

Remarks:

Figure ________

Client: EIP

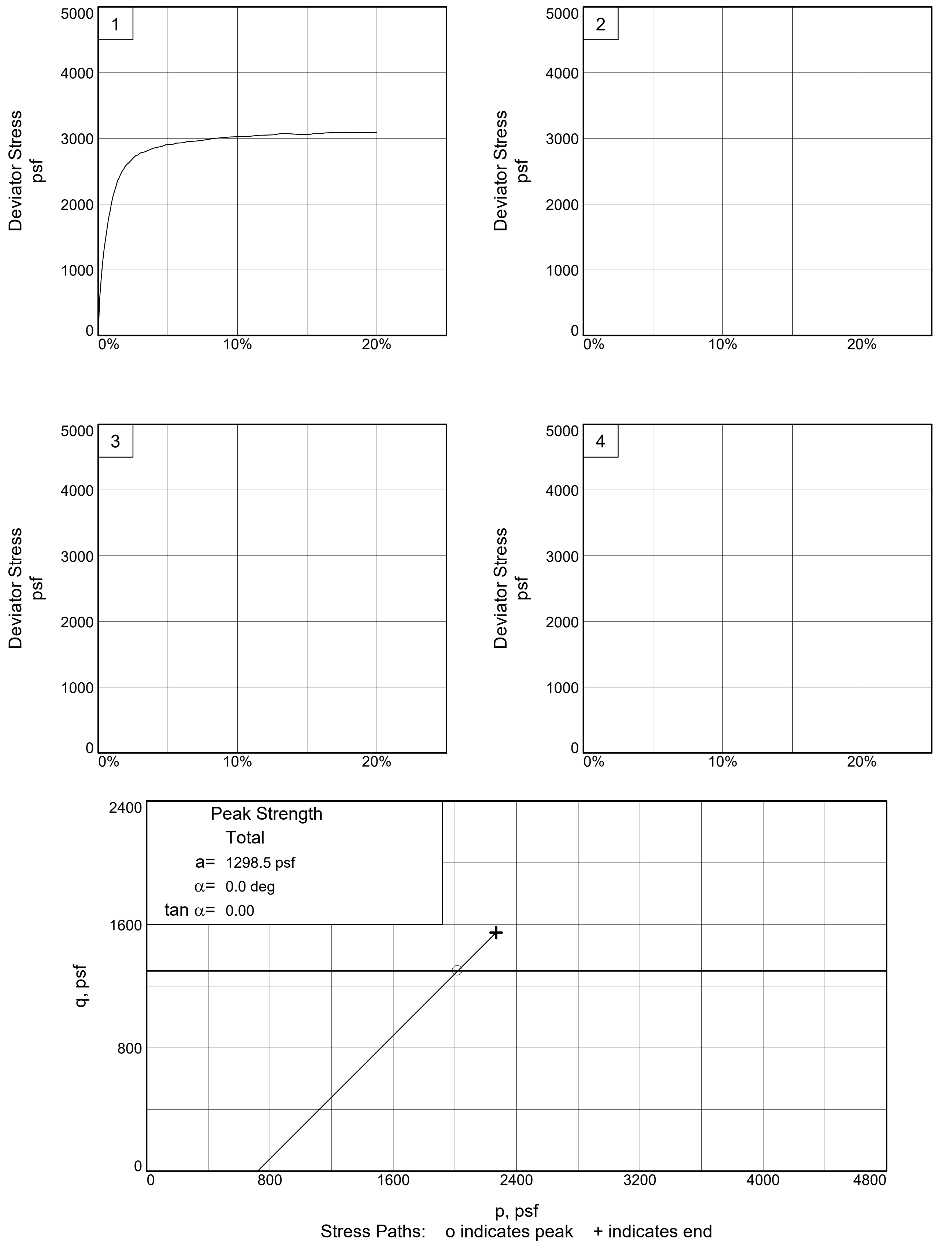
Project: Lookout Slough Restoration Project - Borrow Analysis

Source of Sample: BTP 3 **Depth:** 1-3'

Sample Number: A

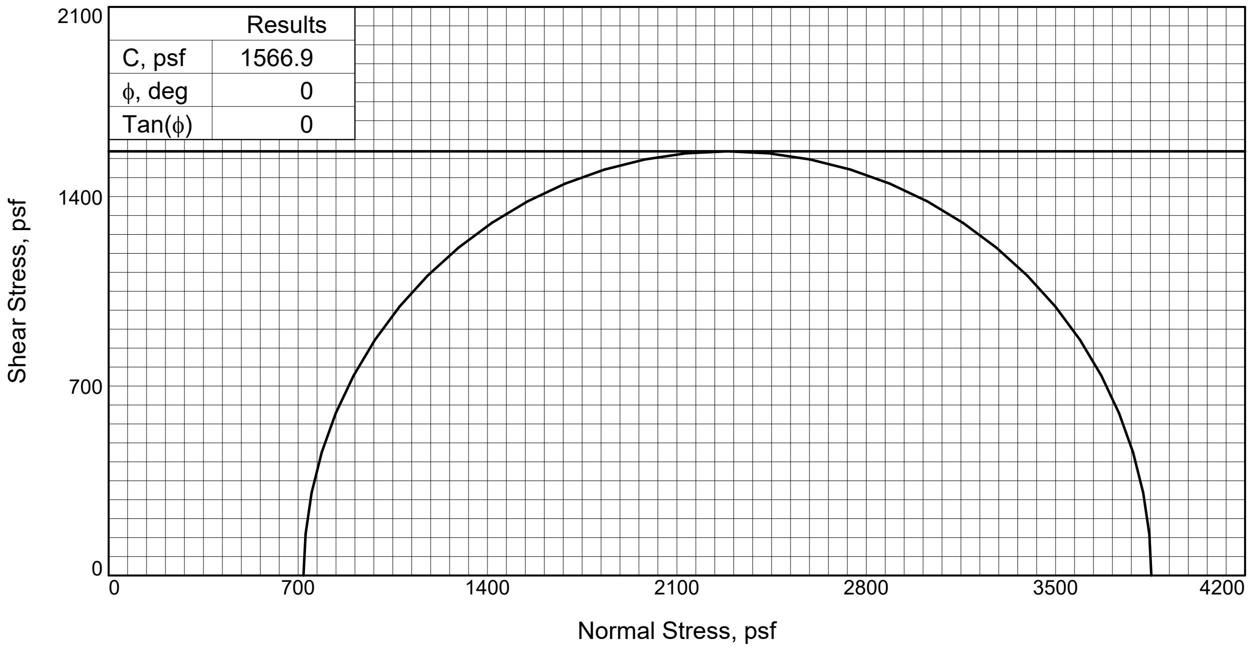
Proj. No.: 3195.X **Date Sampled:**

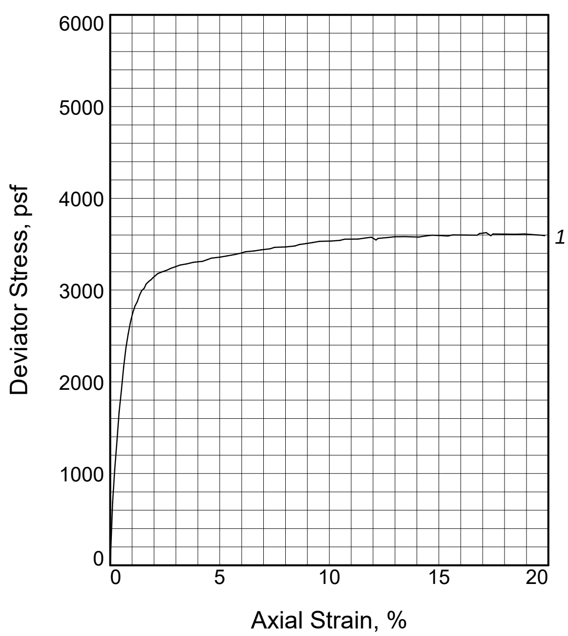
TRIAXIAL SHEAR TEST REPORT
Blackburn Consulting
W. Sacramento, CA



Client: EIP
Project: Lookout Slough Restoration Project - Borrow Analysis
Source of Sample: BTP 3 **Depth:** 1-3' **Sample Number:** A
Project No.: 3195.X **Figure** ________

Blackburn Consulting





Sample No.		1
Initial	Water Content, %	23.1
	Dry Density, pcf	99.4
	Saturation, %	92.2
	Void Ratio	0.6641
	Diameter, in.	2.407
	Height, in.	4.948
At Test	Water Content, %	23.1
	Dry Density, pcf	99.4
	Saturation, %	92.2
	Void Ratio	0.6641
	Diameter, in.	2.407
	Height, in.	4.948
Strain rate, in./min.		0.049
Back Pressure, psf		0.0
Cell Pressure, psf		720.0
Fail. Stress, psf		3133.9
Strain, %		2.0
Ult. Stress, psf		
Strain, %		
σ_1 Failure, psf		3853.9
σ_3 Failure, psf		720.0

Type of Test:
Unconsolidated Undrained

Sample Type: 2.4" Remold

Description: Fat CLAY with SAND, dark yellowish brown

LL= 50 **PL=** 17 **PI=** 33

Assumed Specific Gravity= 2.65

Remarks:

Figure ________

Client: EIP

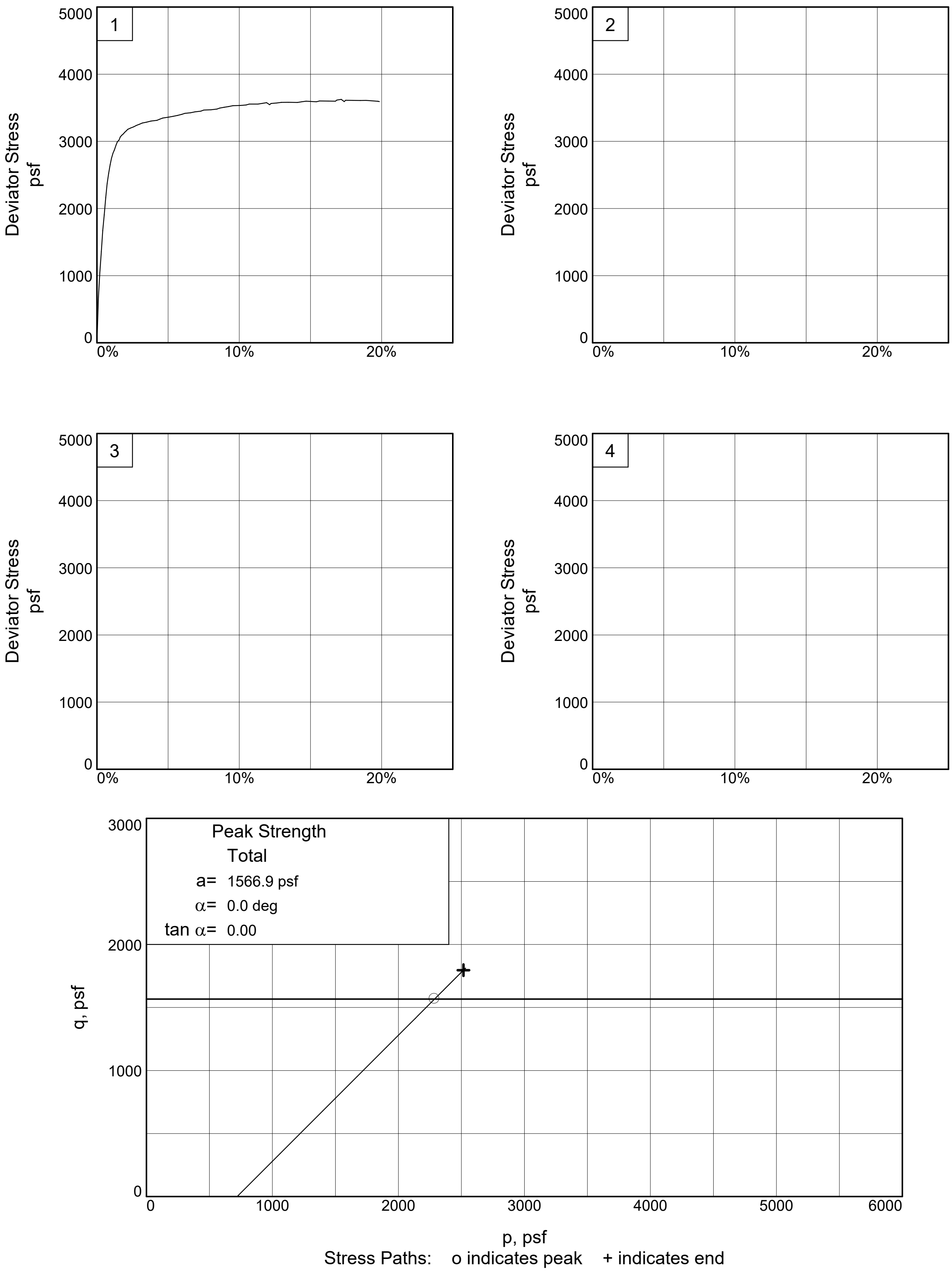
Project: Lookout Slough Restoration Project - Borrow Analysis

Source of Sample: BTP 15 **Depth:** 3-6'

Sample Number: B

Proj. No.: 3195.X **Date Sampled:**

TRIAXIAL SHEAR TEST REPORT
Blackburn Consulting
W. Sacramento, CA



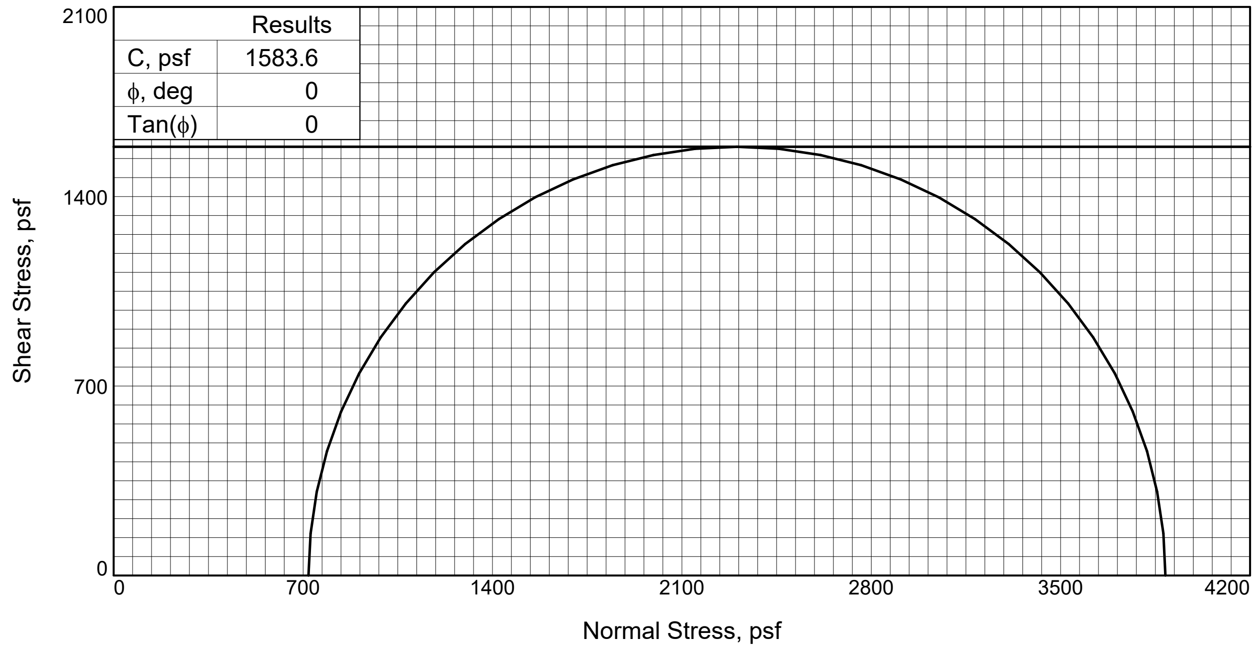
Client: EIP

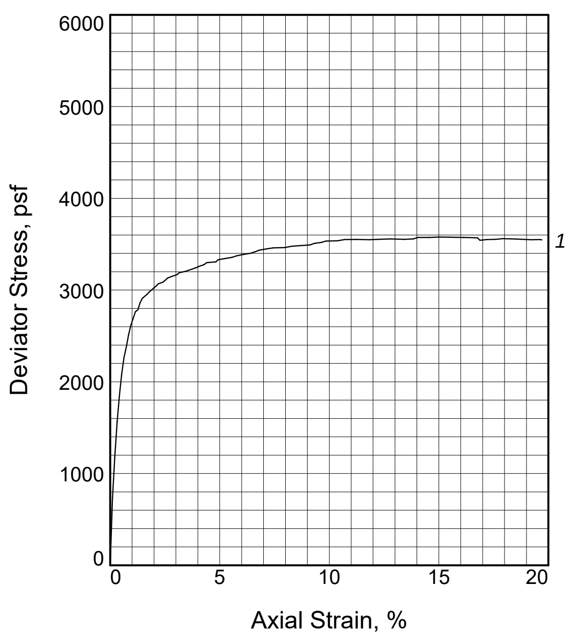
Project: Lookout Slough Restoration Project - Borrow Analysis

Source of Sample: BTP 15 **Depth:** 3-6' **Sample Number:** B

Project No.: 3195.X **Figure** ________

Blackburn Consulting





Sample No.		1
Initial	Water Content, %	22.6
	Dry Density, pcf	98.8
	Saturation, %	88.9
	Void Ratio	0.6736
	Diameter, in.	2.409
	Height, in.	4.853
At Test	Water Content, %	22.6
	Dry Density, pcf	98.8
	Saturation, %	88.9
	Void Ratio	0.6736
	Diameter, in.	2.409
	Height, in.	4.853
Strain rate, in./min.		0.049
Back Pressure, psf		0.0
Cell Pressure, psf		720.0
Fail. Stress, psf		3167.2
Strain, %		3.0
Ult. Stress, psf		
Strain, %		
σ_1 Failure, psf		3887.2
σ_3 Failure, psf		720.0

Type of Test:
Unconsolidated Undrained

Sample Type: 2.4" Remold

Description: Lean CLAY, dark yellowish brown

LL= 42 **PL=** 18 **PI=** 24

Assumed Specific Gravity= 2.65

Remarks:

Figure ________

Client: EIP

Project: Lookout Slough Restoration Project - Borrow Analysis

Source of Sample: BTP 26 **Depth:** 4-7'

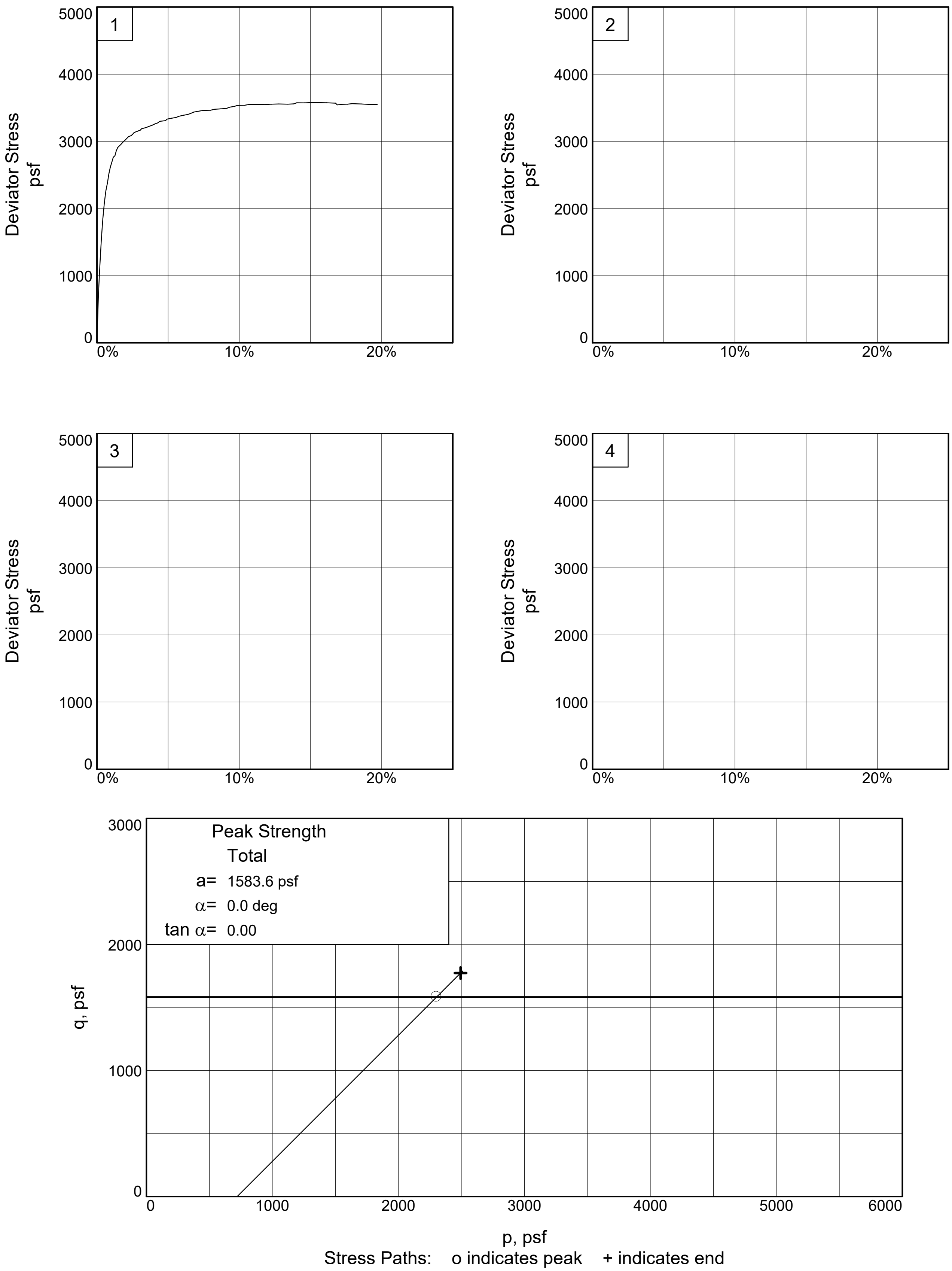
Sample Number: B

Proj. No.: 3195.X **Date Sampled:**

TRIAXIAL SHEAR TEST REPORT

Blackburn Consulting

W. Sacramento, CA



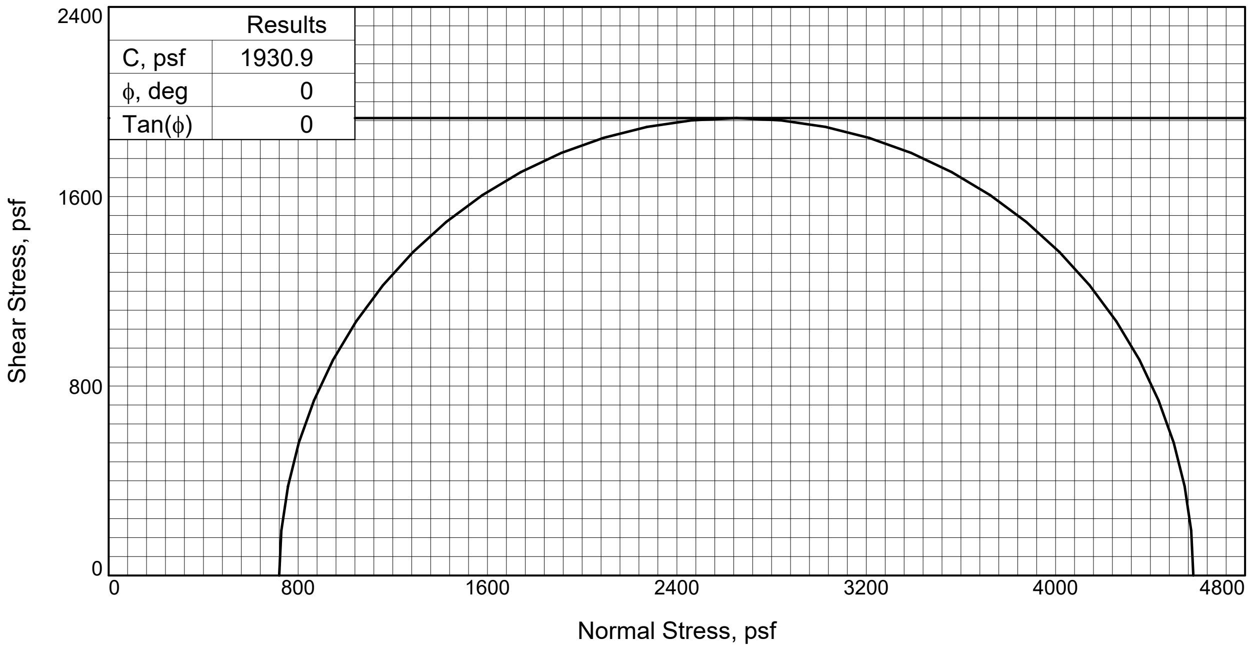
Client: EIP

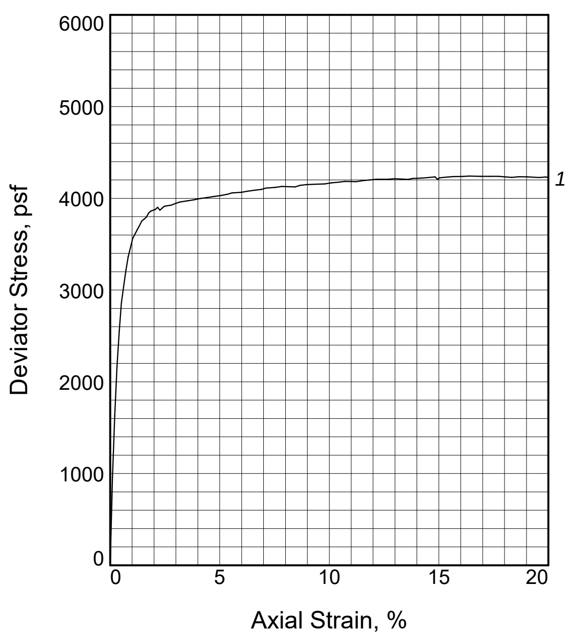
Project: Lookout Slough Restoration Project - Borrow Analysis

Source of Sample: BTP 26 **Depth:** 4-7' **Sample Number:** B

Project No.: 3195.X **Figure** ________

Blackburn Consulting





Sample No.		1
Initial	Water Content, %	20.0
	Dry Density, pcf	103.6
	Saturation, %	88.8
	Void Ratio	0.5971
	Diameter, in.	2.421
	Height, in.	4.937
At Test	Water Content, %	20.0
	Dry Density, pcf	103.6
	Saturation, %	88.8
	Void Ratio	0.5971
	Diameter, in.	2.421
	Height, in.	4.937
Strain rate, in./min.		0.049
Back Pressure, psf		0.0
Cell Pressure, psf		720.0
Fail. Stress, psf		3861.8
Strain, %		1.9
Ult. Stress, psf		
Strain, %		
σ_1 Failure, psf		4581.8
σ_3 Failure, psf		720.0

Type of Test:
Unconsolidated Undrained

Sample Type: 2.4" Remold

Description: Lean CLAY, very dark grayish brown

LL= 49 **PL=** 14 **PI=** 35

Assumed Specific Gravity= 2.65

Remarks:

Figure ________

Client: EIP

Project: Lookout Slough Restoration Project - Borrow Analysis

Source of Sample: BTP 29 **Depth:** 1-4'

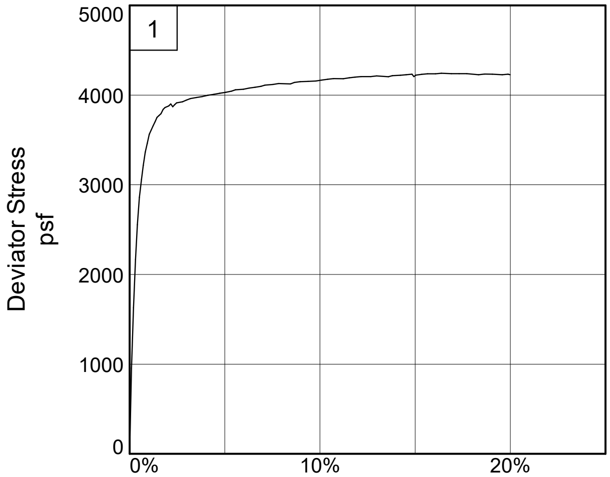
Sample Number: A

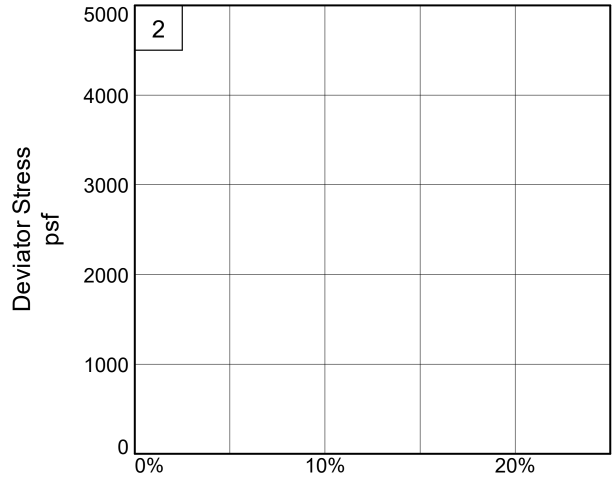
Proj. No.: 3195.X **Date Sampled:**

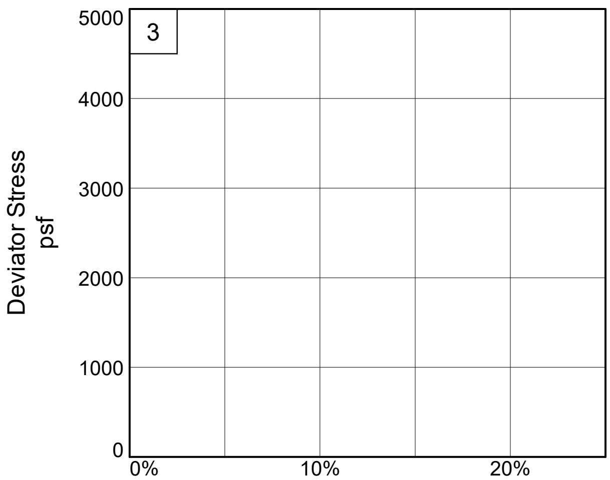
TRIAXIAL SHEAR TEST REPORT

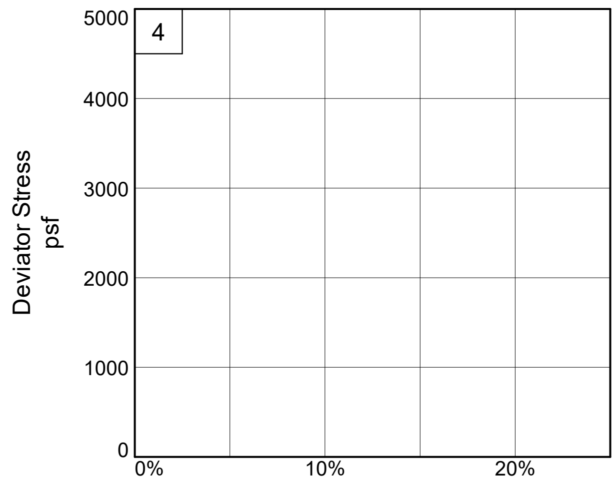
Blackburn Consulting

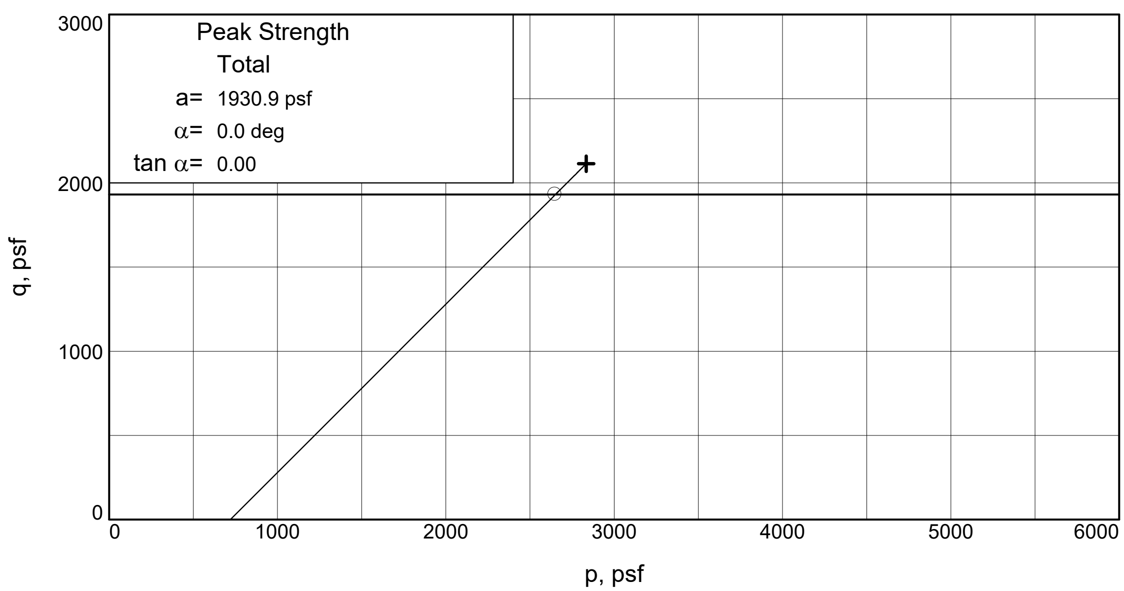
W. Sacramento, CA











Stress Paths: o indicates peak + indicates end

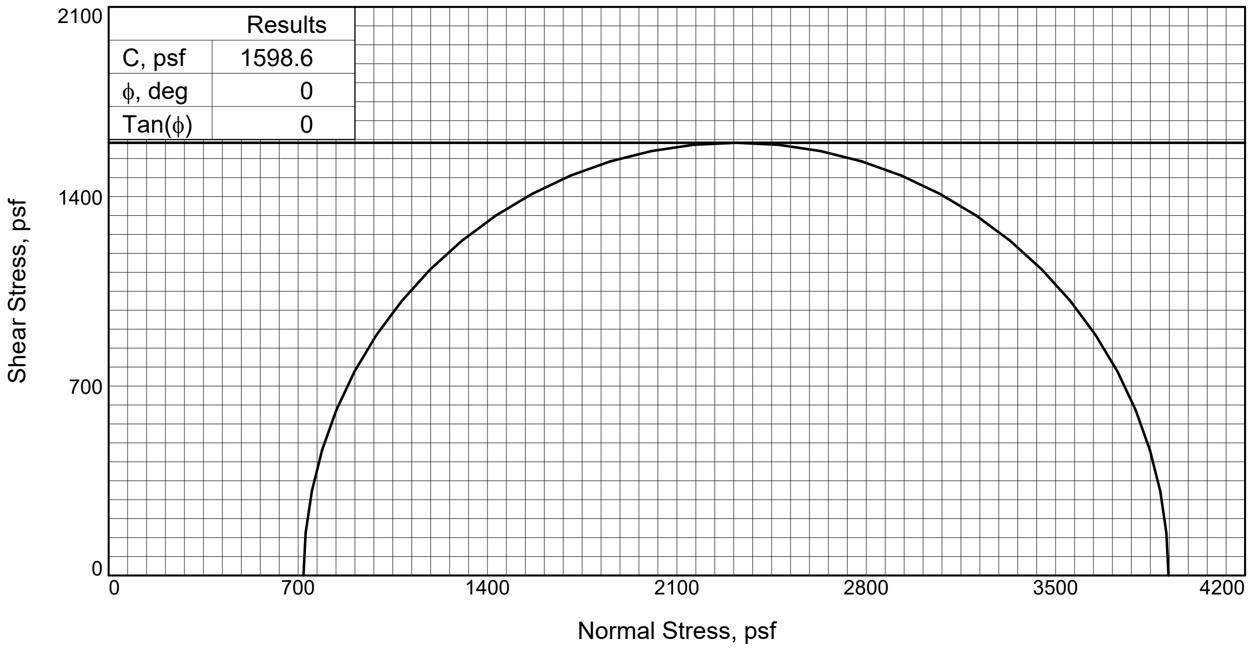
Client: EIP

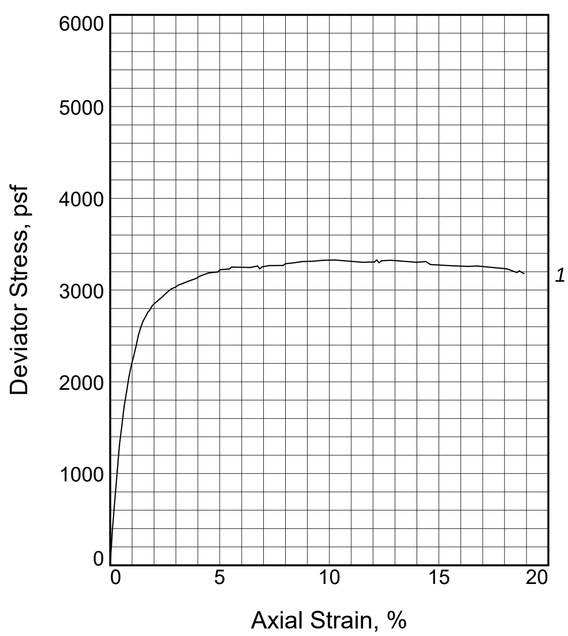
Project: Lookout Slough Restoration Project - Borrow Analysis

Source of Sample: BTP 29 **Depth:** 1-4' **Sample Number:** A

Project No.: 3195.X **Figure** ________

Blackburn Consulting





Sample No.		1
Initial	Water Content, %	28.7
	Dry Density, pcf	91.7
	Saturation, %	94.6
	Void Ratio	0.8041
	Diameter, in.	2.394
	Height, in.	4.766
At Test	Water Content, %	28.7
	Dry Density, pcf	91.7
	Saturation, %	94.6
	Void Ratio	0.8041
	Diameter, in.	2.394
	Height, in.	4.766
Strain rate, in./min.		0.048
Back Pressure, psf		0.0
Cell Pressure, psf		720.0
Fail. Stress, psf		3197.2
Strain, %		4.9
Ult. Stress, psf		
Strain, %		
σ_1 Failure, psf		3917.2
σ_3 Failure, psf		720.0

Type of Test:
Unconsolidated Undrained

Sample Type: 2.4" Remold

Description: Fat CLAY, black

LL= 71 **PL=** 20 **PI=** 51

Assumed Specific Gravity= 2.65

Remarks:

Figure ________

Client: EIP

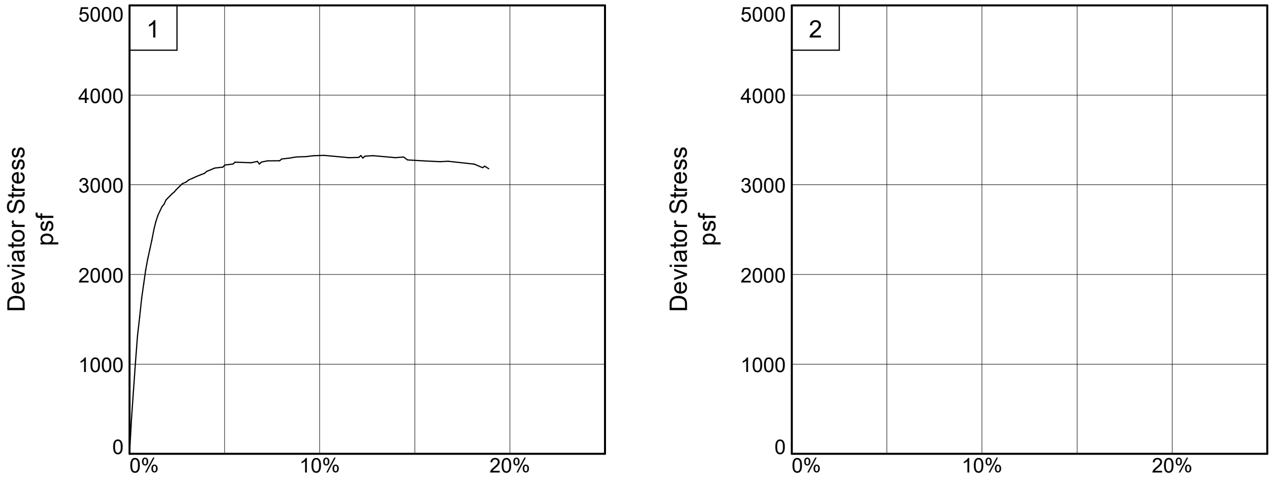
Project: Lookout Slough Restoration Project - Borrow Analysis

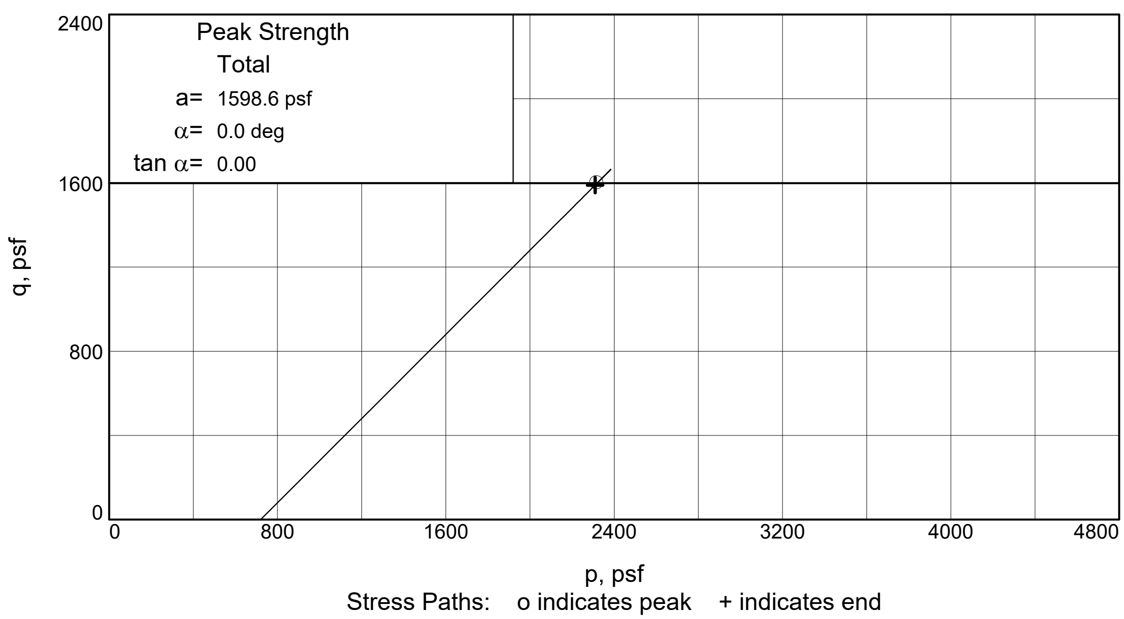
Source of Sample: BTP 31 **Depth:** 1-3'

Sample Number: A

Proj. No.: 3195.X **Date Sampled:**

TRIAXIAL SHEAR TEST REPORT
Blackburn Consulting
W. Sacramento, CA





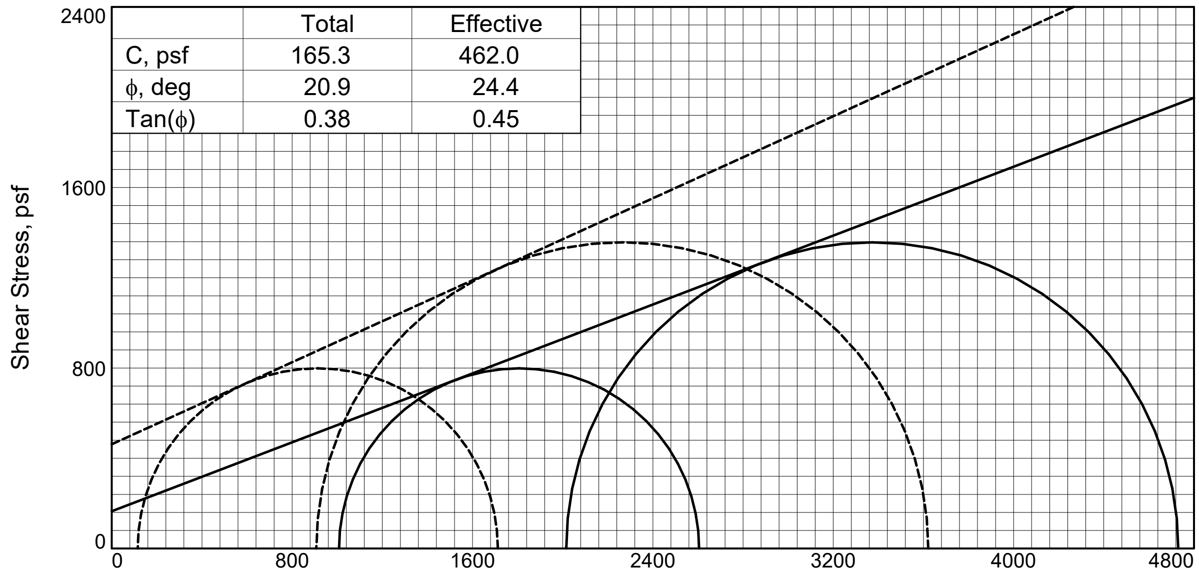
Client: EIP

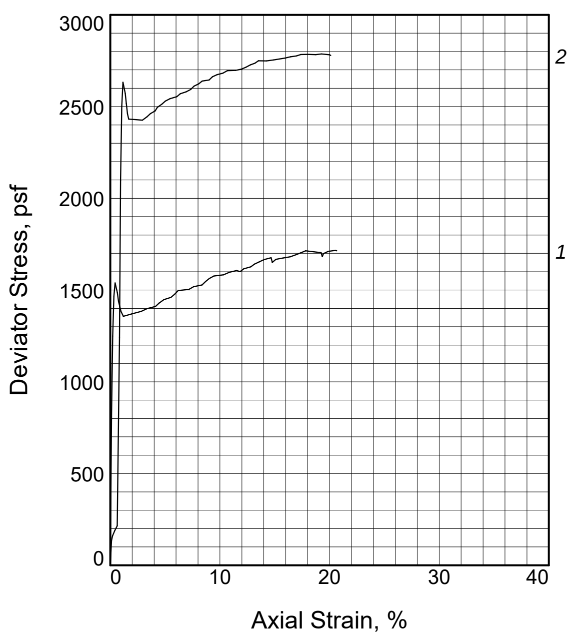
Project: Lookout Slough Restoration Project - Borrow Analysis

Source of Sample: BTP 31 **Depth:** 1-3' **Sample Number:** A

Project No.: 3195.X **Figure** ________

Blackburn Consulting





Sample No.		1	2
Initial	Water Content, %	21.2	21.6
	Dry Density, pcf	102.6	100.4
	Saturation, %	91.7	88.3
	Void Ratio	0.6130	0.6479
	Diameter, in.	2.394	2.390
	Height, in.	4.850	4.916
At Test	Water Content, %	25.6	22.3
	Dry Density, pcf	98.6	104.0
	Saturation, %	100.0	100.0
	Void Ratio	0.6784	0.5909
	Diameter, in.	2.486	2.363
	Height, in.	4.680	4.856
Strain rate, in./min.		0.002	0.002
Eff. Cell Pressure, psf		1008.0	2016.0
Fail. Stress, psf		1597.2	2714.3
Excess Pore Pr., psf		892.8	1108.8
Strain, %		10.9	12.4
Ult. Stress, psf			
Excess Pore Pr., psf			
Strain, %			
$\bar{\sigma}_1$ Failure, psf		1712.4	3621.5
$\bar{\sigma}_3$ Failure, psf		115.2	907.2

Type of Test:
CU with Pore Pressures

Sample Type: 2.4" Remold

Description: Fat CLAY with SAND, dark reddish brown

LL= 59 **PL=** 15 **PI=** 44

Assumed Specific Gravity= 2.65

Remarks: Remolded to 97% of max dry density @ 2% over optimum per ASTM D698
Failure picked at max principal stress ratio
First point removed due to inconsistent result

Figure ________

Client: EIP

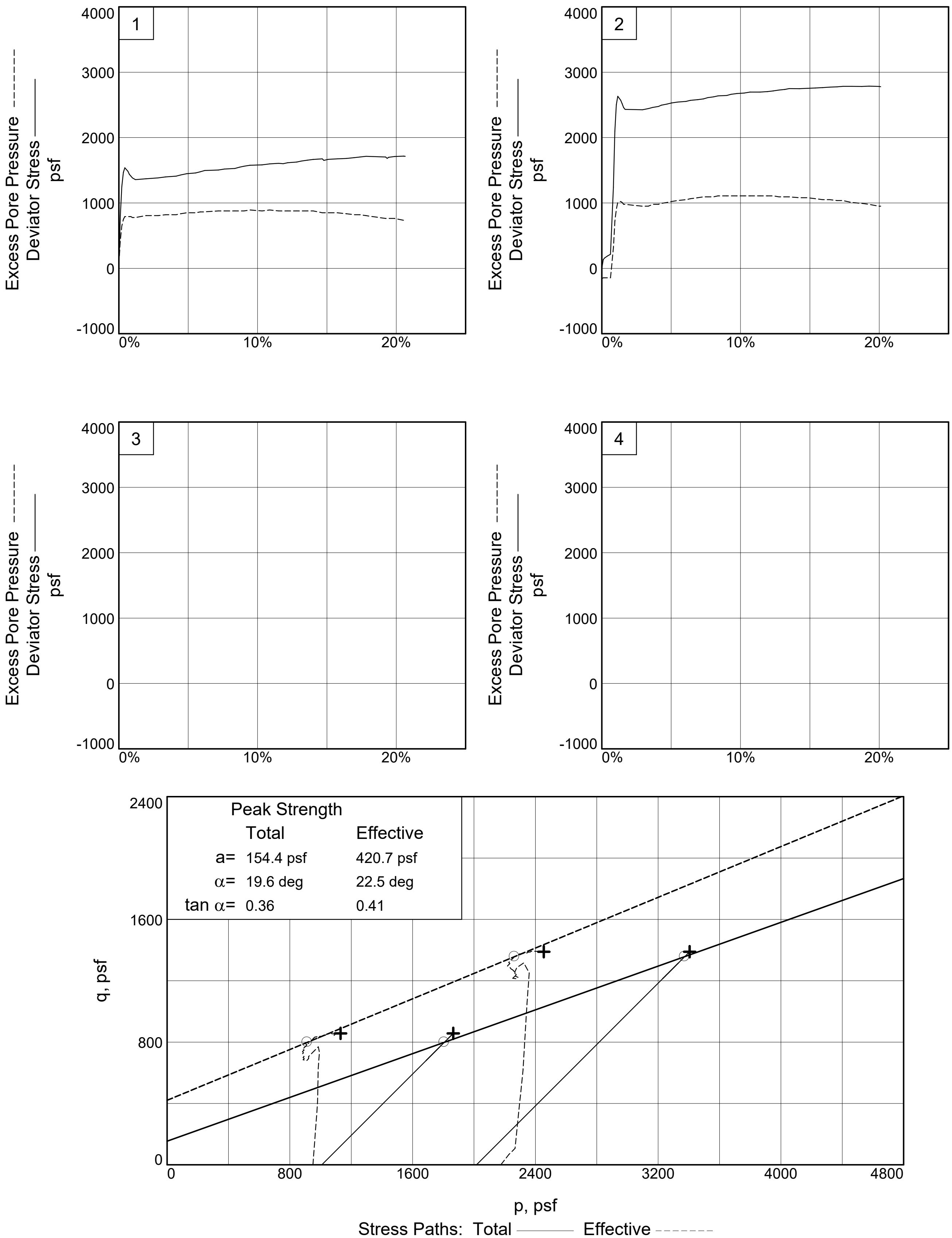
Project: Lookout Slough Restoration Project

Source of Sample: TP4 **Depth:** 1.0-3.0'

Sample Number: Bulk 1

Proj. No.: 3195.P **Date Sampled:** 9/17

TRIAXIAL SHEAR TEST REPORT
Blackburn Consulting
W. Sacramento, CA



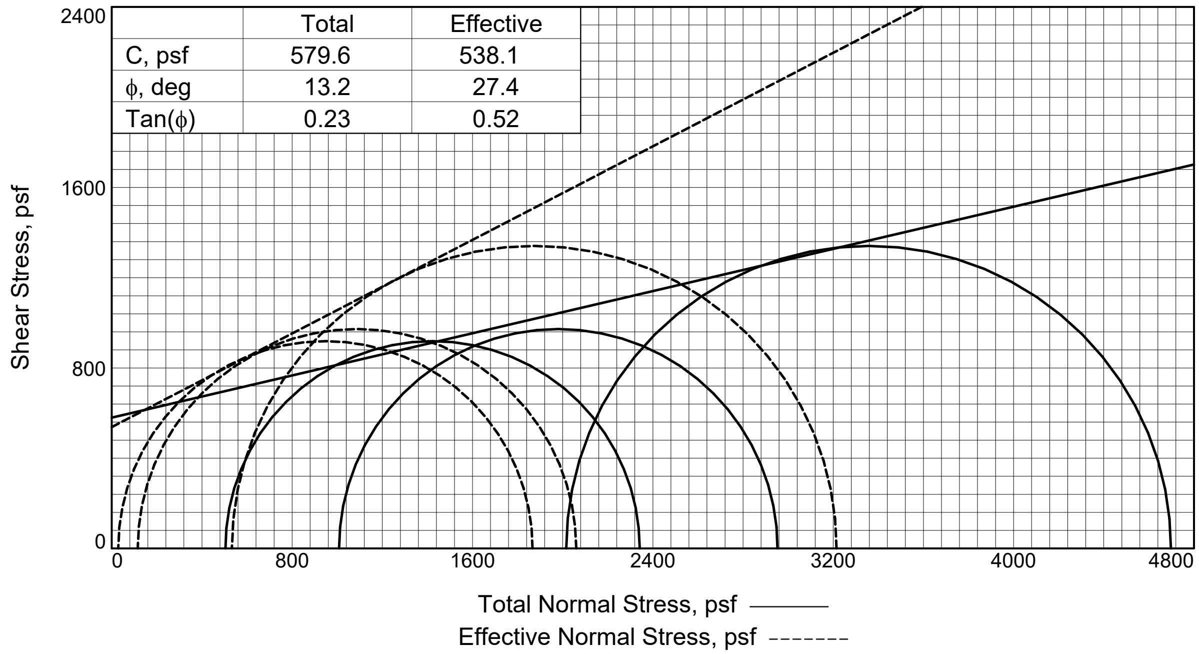
Client: EIP

Project: Lookout Slough Restoration Project

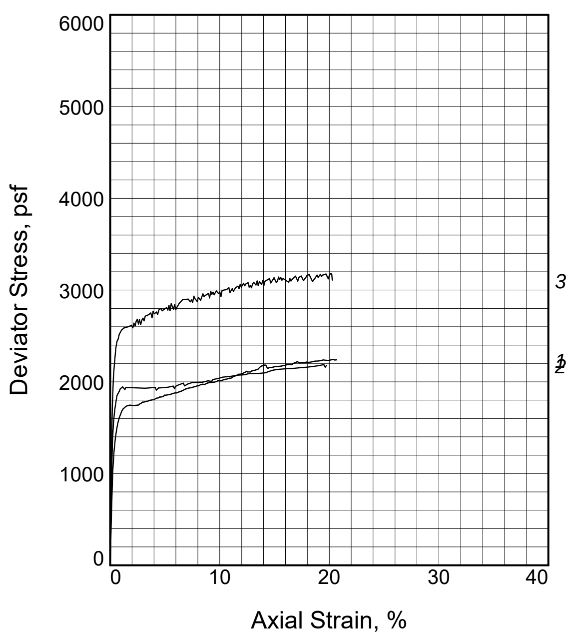
Source of Sample: TP4 **Depth:** 1.0-3.0' **Sample Number:** Bulk 1

Project No.: 3195.P **Figure** ________

Blackburn Consulting



	Total	Effective
C, psf	579.6	538.1
φ, deg	13.2	27.4
Tan(φ)	0.23	0.52



Sample No.		1	2	3
Initial	Water Content, %	21.4	21.2	21.2
	Dry Density, pcf	103.3	102.3	102.7
	Saturation, %	91.6	88.4	89.4
	Void Ratio	0.6309	0.6474	0.6405
	Diameter, in.	2.390	2.389	2.388
	Height, in.	4.908	4.968	4.944
At Test	Water Content, %	24.3	23.7	23.3
	Dry Density, pcf	101.8	102.8	103.5
	Saturation, %	100.0	100.0	100.0
	Void Ratio	0.6561	0.6399	0.6291
	Diameter, in.	2.432	2.388	2.383
	Height, in.	4.815	4.948	4.929
Strain rate, in./min.		0.002	0.002	0.002
Eff. Cell Pressure, psf		504.0	1008.0	2016.0
Fail. Stress, psf		1837.5	1944.9	2681.9
Excess Pore Pr., psf		475.2	892.8	1483.2
Strain, %		4.7	1.1	2.5
Ult. Stress, psf				
Excess Pore Pr., psf				
Strain, %				
$\bar{\sigma}_1$ Failure, psf		1866.3	2060.1	3214.7
$\bar{\sigma}_3$ Failure, psf		28.8	115.2	532.8

Type of Test:
CU with Pore Pressures

Sample Type: 2.4" Remold

Description: Fat CLAY with SAND, dark grayish brown

LL= 51 **PL=** 13 **PI=** 38

Assumed Specific Gravity= 2.70

Remarks: Remolded to 97% of maximum dry density @ 2% over optimum per ASTM D698
Failure picked @ max principal stress ratio

Figure ________

Client: EIP

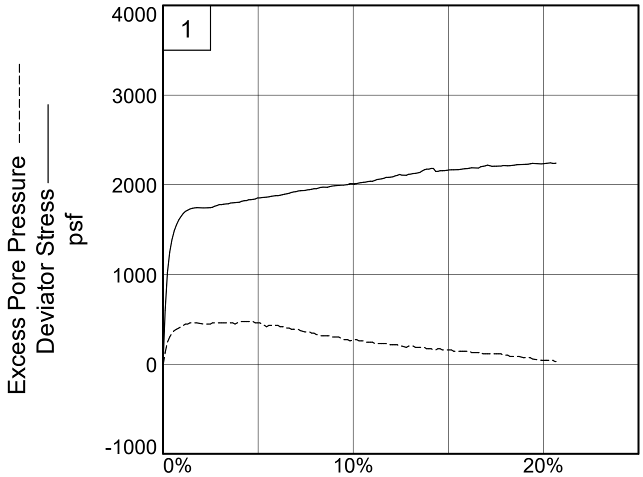
Project: Lookout Slough Restoration Project

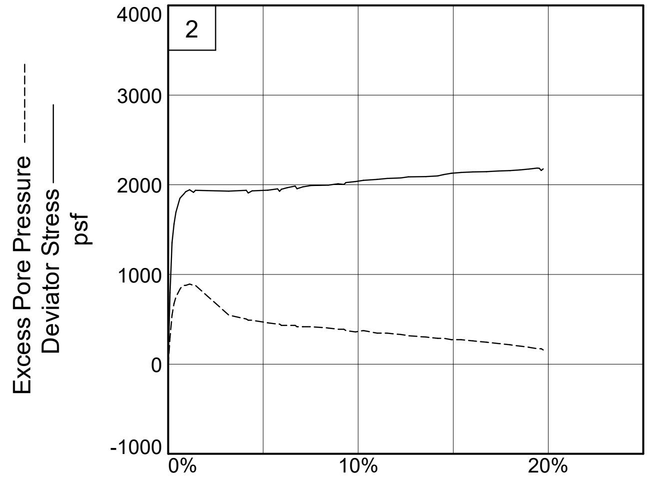
Source of Sample: TP6 **Depth:** 1.0-4.0'

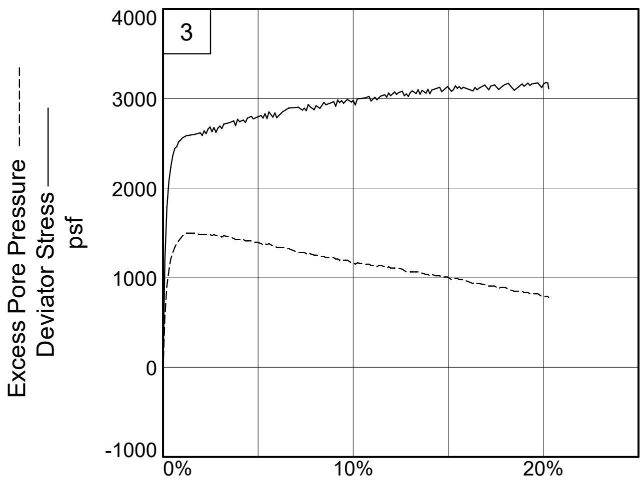
Sample Number: Bulks 1&2

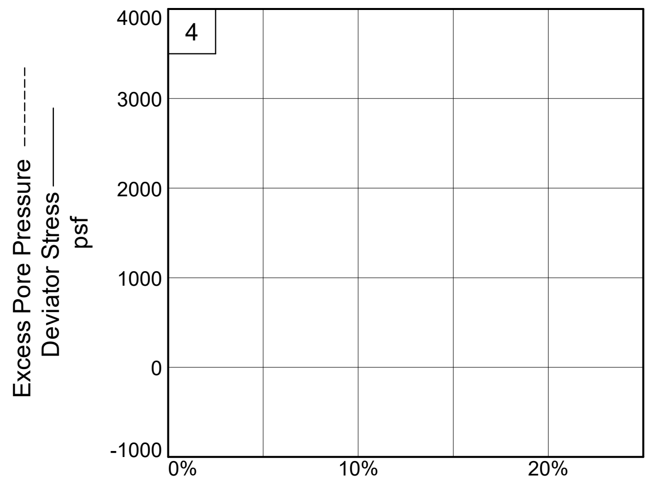
Proj. No.: 3195.P **Date Sampled:** 9/17

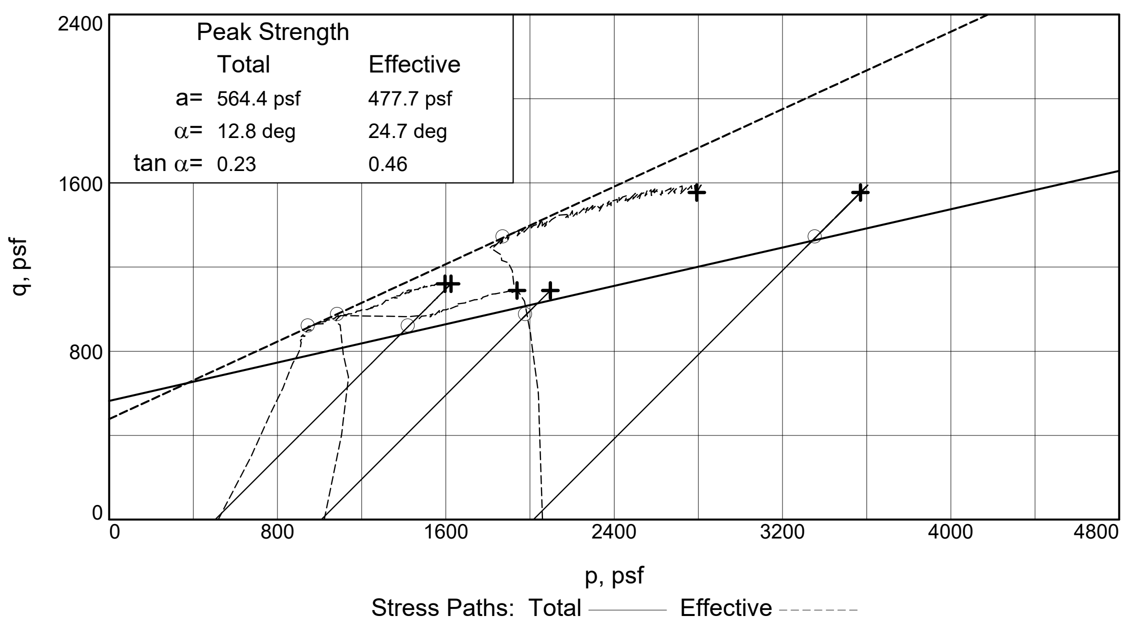
TRIAXIAL SHEAR TEST REPORT
Blackburn Consulting
W. Sacramento, CA











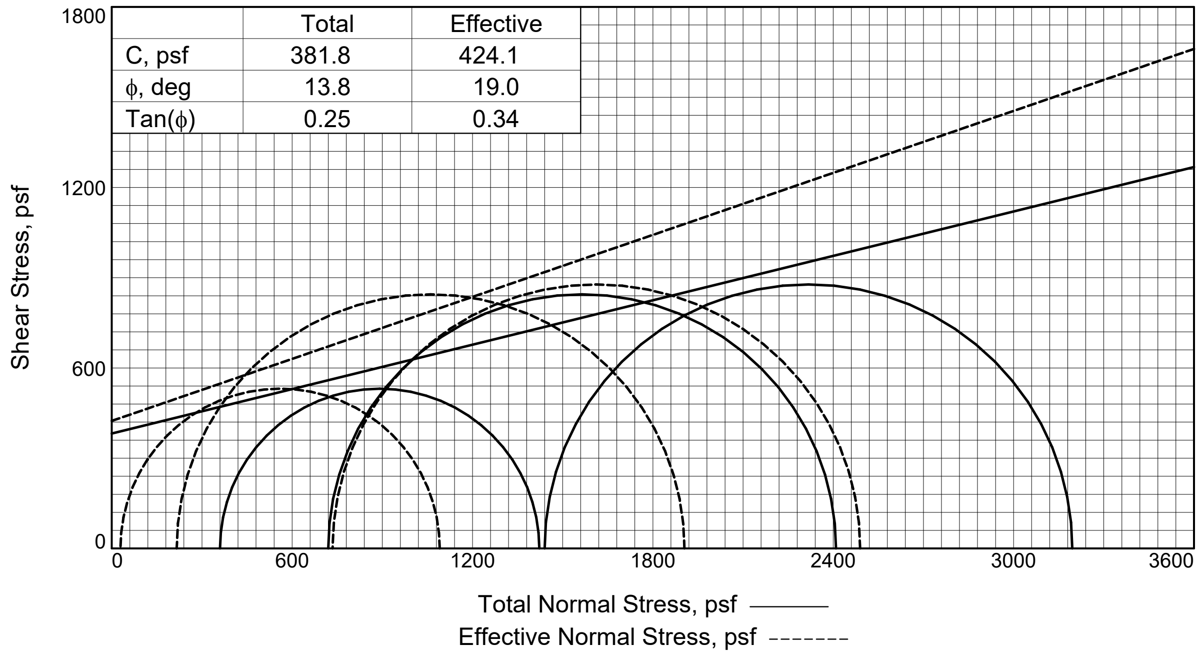
Client: EIP

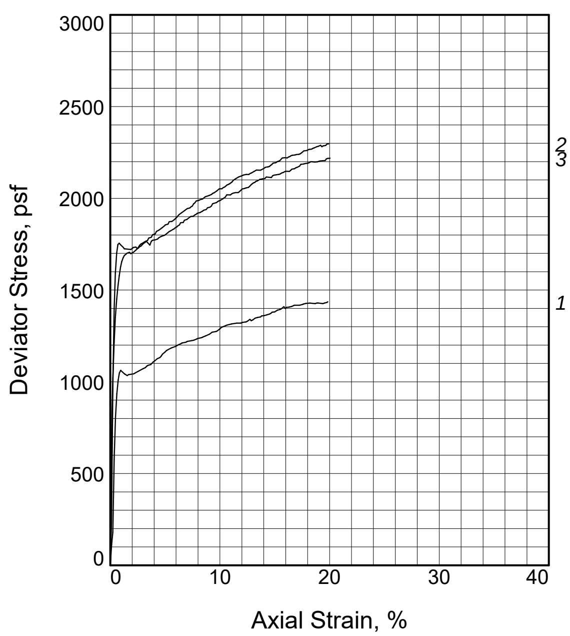
Project: Lookout Slough Restoration Project

Source of Sample: TP6 **Depth:** 1.0-4.0' **Sample Number:** Bulks 1&2

Project No.: 3195.P **Figure** ________

Blackburn Consulting





Sample No.		1	2	3
Initial	Water Content, %	22.1	22.1	22.1
	Dry Density, pcf	99.6	99.7	98.3
	Saturation, %	88.5	88.8	85.7
	Void Ratio	0.6616	0.6599	0.6835
	Diameter, in.	2.389	2.386	2.398
	Height, in.	4.748	4.851	4.878
At Test	Water Content, %	26.7	25.9	26.3
	Dry Density, pcf	96.9	98.1	97.5
	Saturation, %	100.0	100.0	100.0
	Void Ratio	0.7081	0.6867	0.6970
	Diameter, in.	2.411	2.399	2.404
	Height, in.	4.792	4.877	4.891
Strain rate, in./min.		0.002	0.002	0.002
Eff. Cell Pressure, psf		360.0	720.0	1440.0
Fail. Stress, psf		1062.2	1689.1	1755.3
Excess Pore Pr., psf		331.2	504.0	705.6
Strain, %		1.0	1.3	0.8
Ult. Stress, psf				
Excess Pore Pr., psf				
Strain, %				
$\bar{\sigma}_1$ Failure, psf		1091.0	1905.1	2489.7
$\bar{\sigma}_3$ Failure, psf		28.8	216.0	734.4

Type of Test:
CU with Pore Pressures

Sample Type: 2.4" remold

Description: Fat CLAY, olive brown

LL= 56 **PL=** 18 **PI=** 38

Assumed Specific Gravity= 2.65

Remarks: Remolded to 97% of max dry density @ 2% over optimum per ASTM D698

Figure ________

Client: EIP

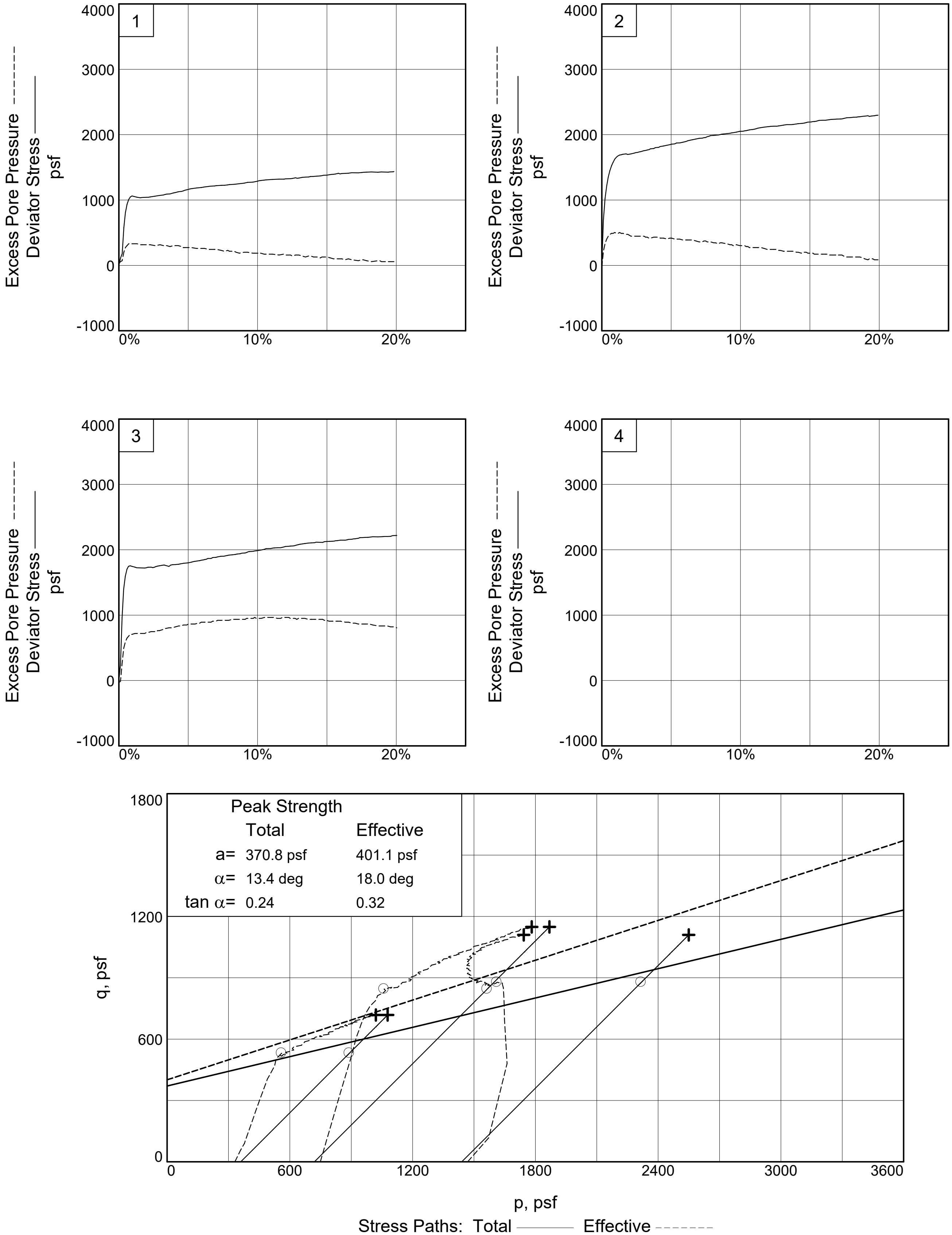
Project: Lookout Slough Restoration Project - Borrow Analysis

Source of Sample: BTP 24 **Depth:** 4-7'

Sample Number: B

Proj. No.: 3195.X **Date Sampled:**

TRIAXIAL SHEAR TEST REPORT
Blackburn Consulting
W. Sacramento, CA



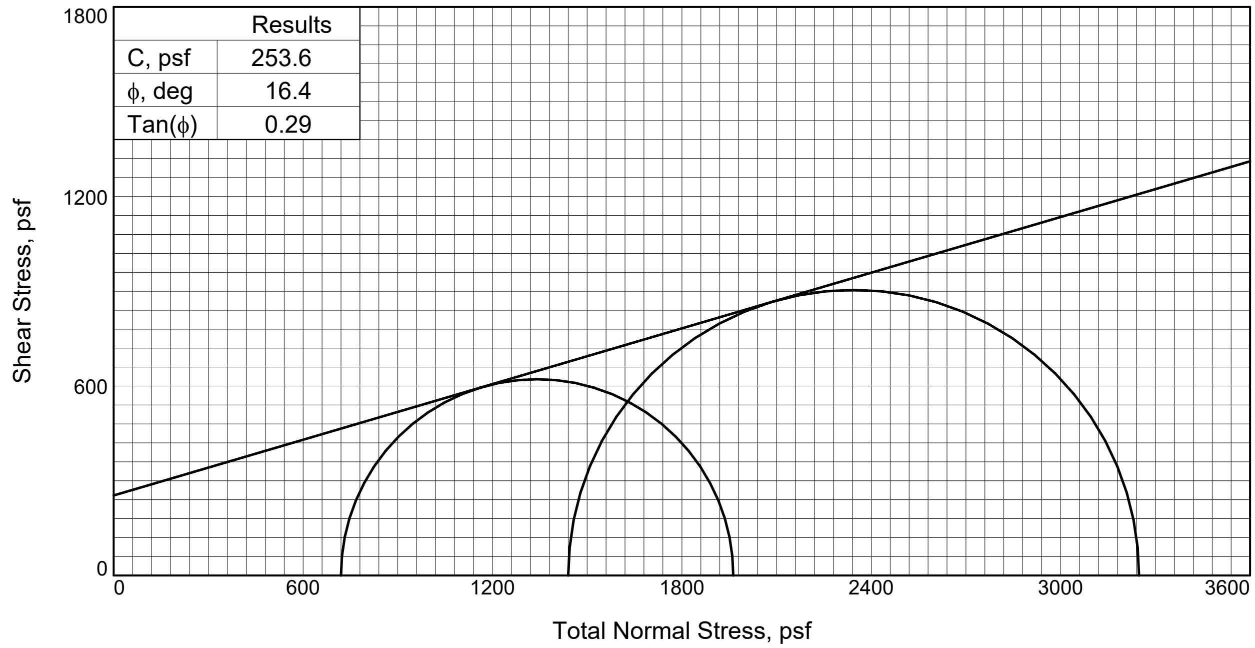
Client: EIP

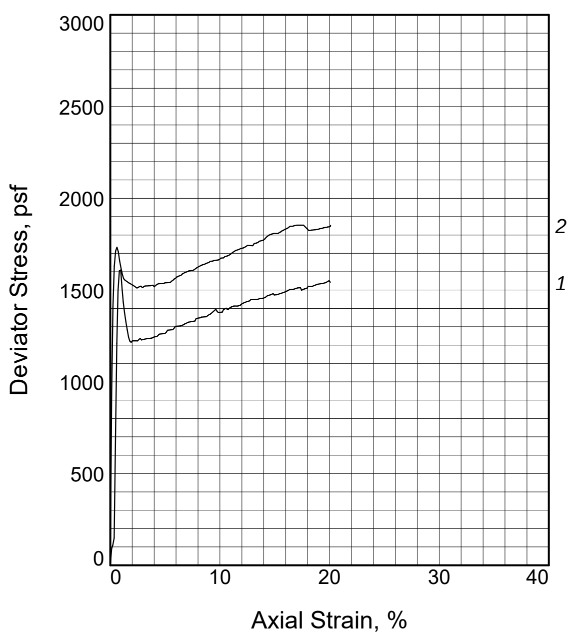
Project: Lookout Slough Restoration Project - Borrow Analysis

Source of Sample: BTP 24 **Depth:** 4-7' **Sample Number:** B

Project No.: 3195.X **Figure** ________

Blackburn Consulting





Sample No.		1	2
Initial	Water Content, %	20.9	20.6
	Dry Density, pcf	102.3	102.6
	Saturation, %	89.7	89.1
	Void Ratio	0.6176	0.6127
	Diameter, in.	2.412	2.386
	Height, in.	4.878	4.724
At Test	Water Content, %	20.6	22.0
	Dry Density, pcf	107.1	104.5
	Saturation, %	100.0	100.0
	Void Ratio	0.5447	0.5832
	Diameter, in.	2.375	2.371
	Height, in.	4.804	4.695
Strain rate, in./min.		0.002	0.002
Eff. Cell Pressure, psf		720.0	1440.0
Fail. Stress, psf		1242.9	1808.2
Excess Pore Pr., psf		417.6	1008.0
Strain, %		3.9	14.9
Ult. Stress, psf			
Excess Pore Pr., psf			
Strain, %			
$\bar{\sigma}_1$ Failure, psf		1545.3	2240.2
$\bar{\sigma}_3$ Failure, psf		302.4	432.0

Type of Test:
CU with Pore Pressures

Sample Type: 2.4" Remold

Description: Fat CLAY with SAND, dark yellowish brown

LL= 52 **PL=** 15 **PI=** 37

Assumed Specific Gravity= 2.65

Remarks: Samples remolded to 97% of maximum density per ASTM D698, peaks picked at max principle stress ratio.

Figure ________

Client: EIP

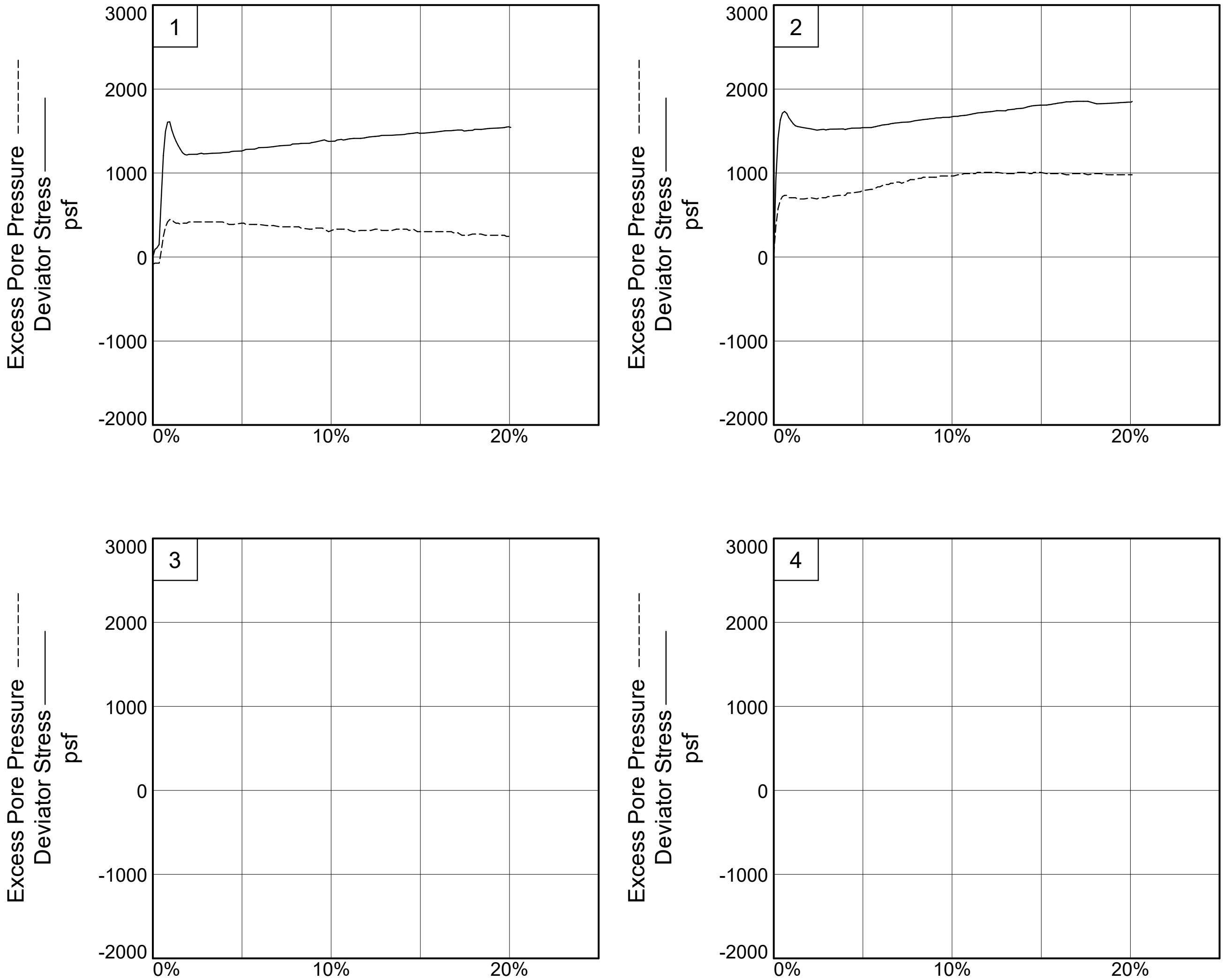
Project: Lookout Slough THRFP - Borrow Analysis

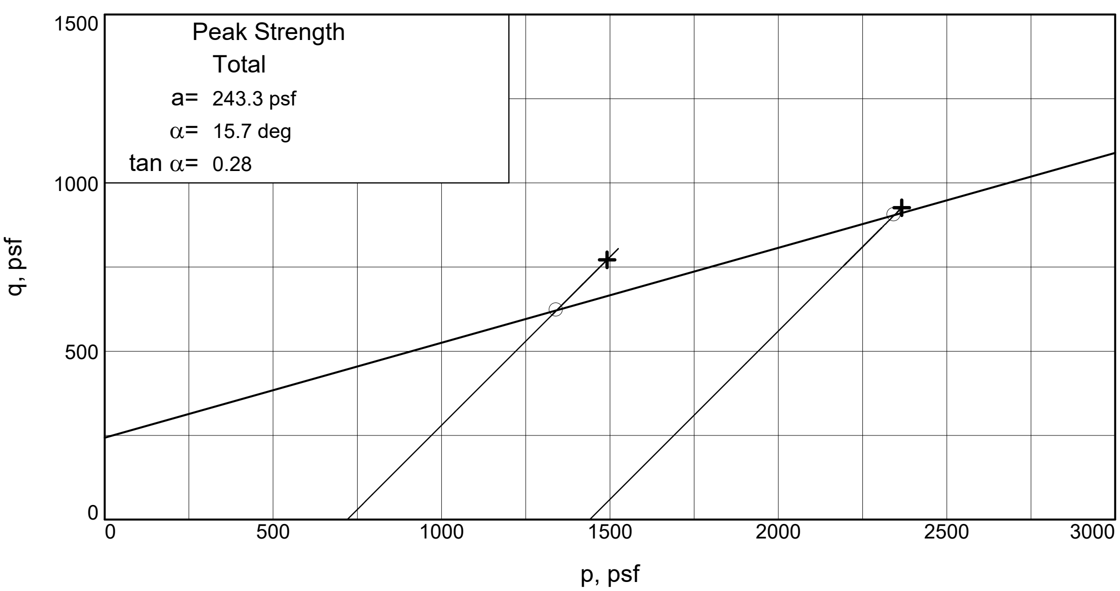
Source of Sample: BTP 34 **Depth:** 3-6'

Sample Number: B- Points 2&3 only

Proj. No.: 3195.X **Date Sampled:**

TRIAXIAL SHEAR TEST REPORT
Blackburn Consulting
W. Sacramento, CA





Stress Paths: o indicates peak + indicates end

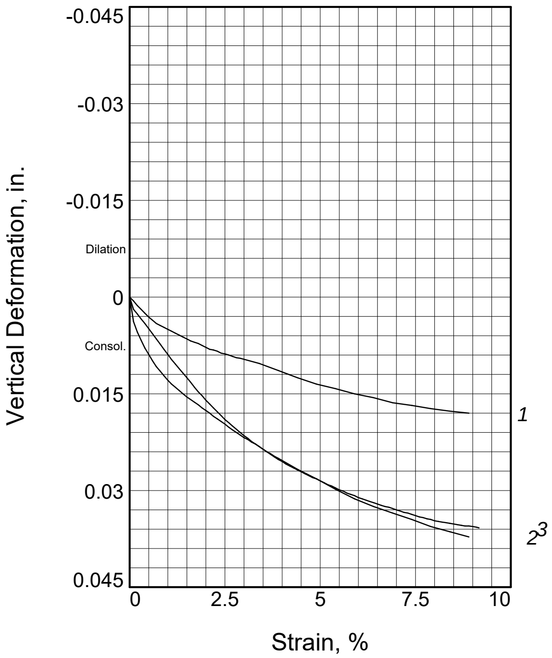
Client: EIP

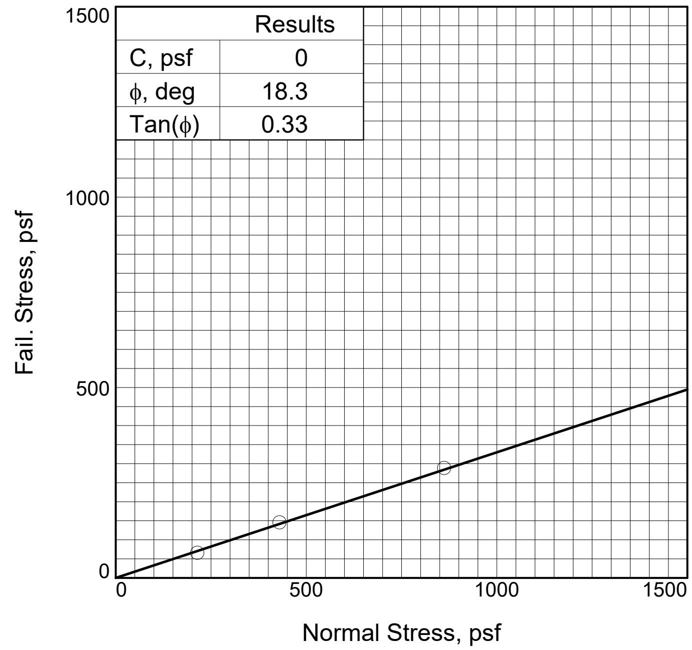
Project: Lookout Slough THRFP - Borrow Analysis

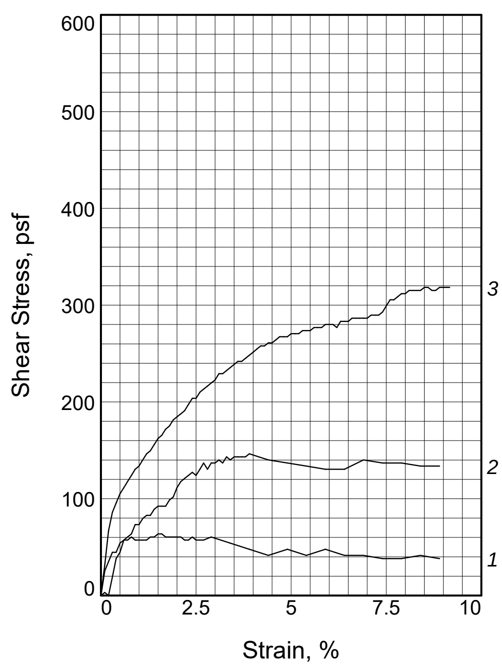
Source of Sample: BTP 34 **Depth:** 3-6' **Sample Number:** B- Points 2&3 only

Project No.: 3195.X **Figure** ________

Blackburn Consulting







	Sample No.	1	2	3
Initial	Water Content, %	60.1	60.1	60.1
	Dry Density, pcf	57.9	64.8	66.0
	Saturation, %	86.7	103.8	107.1
	Void Ratio	1.8039	1.5064	1.4597
	Diameter, in.	2.400	2.400	2.400
	Height, in.	1.240	1.240	1.240
At Test	Water Content, %	58.5	50.5	39.7
	Dry Density, pcf	58.4	70.1	79.8
	Saturation, %	85.6	99.9	100.0
	Void Ratio	1.7792	1.3152	1.0328
	Diameter, in.	2.400	2.400	2.400
	Height, in.	1.229	1.145	1.025
	Normal Stress, psf	216.0	432.0	864.0
	Fail. Stress, psf	63.7	143.2	286.5
	Strain, %	1.5	3.3	6.6
	Ult. Stress, psf			
	Strain, %			
	Strain rate, in./min.	0.000	0.000	0.000

Sample Type: 2.4" Fully Softened Shear
Description: Fat CLAY, brownish gray

LL= 57 **PL=** 18 **PI=** 39
Assumed Specific Gravity= 2.60
Remarks: Fully Softened Shear

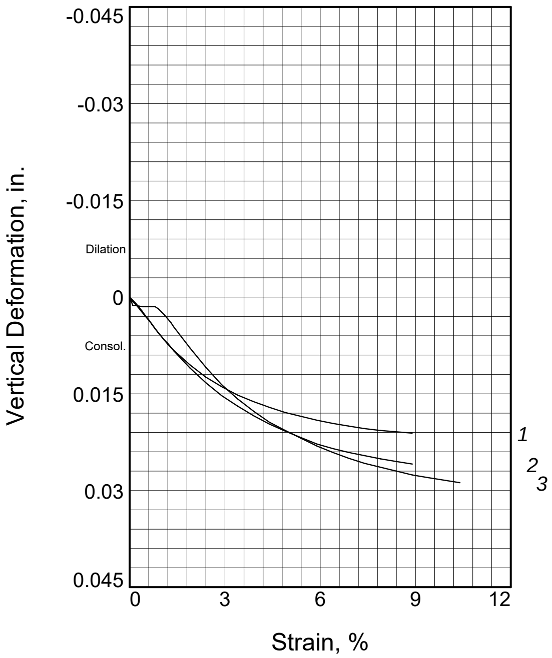
Figure ________

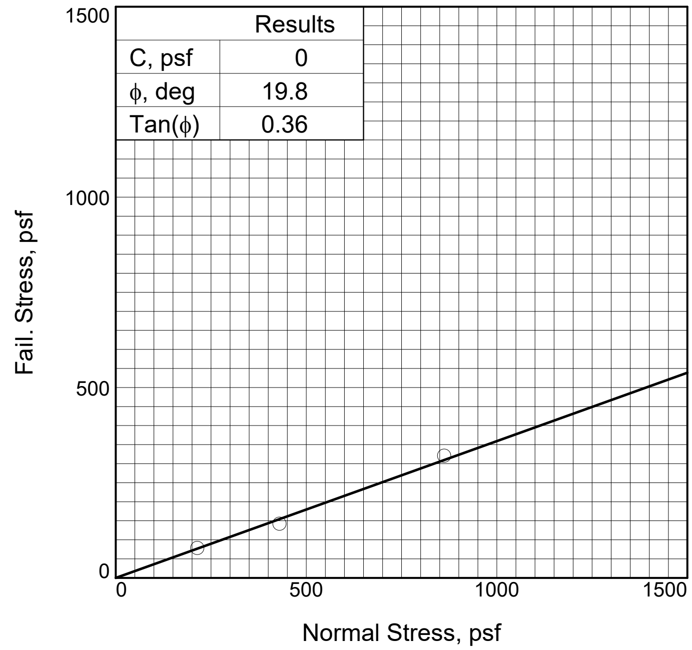
Client: EIP

Project: Lookout Slough Restoration Project - Borrow Analysis

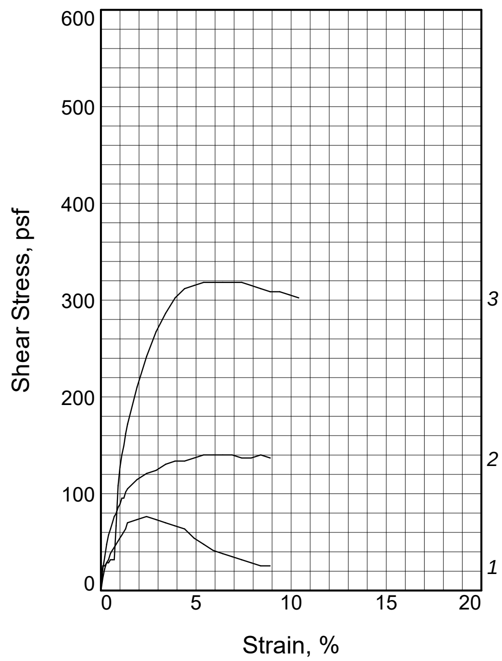
Source of Sample: BTP 4
Sample Number: Bulk A
Proj. No.: 3195.X **Date Sampled:**

DIRECT SHEAR TEST REPORT
Blackburn Consulting
W. Sacramento, CA





Results	
C, psf	0
ϕ, deg	19.8
Tan(ϕ)	0.36



	Sample No.	1	2	3
Initial	Water Content, %	68.9	68.9	68.9
	Dry Density, pcf	59.6	59.7	60.4
	Saturation, %	102.8	103.1	105.0
	Void Ratio	1.7748	1.7698	1.7374
	Diameter, in.	2.400	2.400	2.400
	Height, in.	1.069	0.936	0.996
At Test	Water Content, %	63.4	56.2	48.6
	Dry Density, pcf	62.1	67.0	73.0
	Saturation, %	101.1	101.3	101.6
	Void Ratio	1.6632	1.4701	1.2658
	Diameter, in.	2.400	2.400	2.400
	Height, in.	1.026	0.835	0.824
	Normal Stress, psf	216.0	432.0	864.0
	Fail. Stress, psf	76.4	140.1	318.3
	Strain, %	2.4	5.4	5.4
	Ult. Stress, psf			
	Strain, %			
	Strain rate, in./min.	0.000	0.000	0.000

Sample Type: Fully Softened Shear
Description: Fat CLAY, very dark gray

LL= 71 **PL=** 25 **PI=** 46
Assumed Specific Gravity= 2.65
Remarks: Fully Softened Shear

Figure ________

Client: EIP

Project: Lookout Slough Restoration Project - Borrow Analysis

Source of Sample: BTP 12 **Depth:** 1-3'
Sample Number: A
Proj. No.: 3195.X **Date Sampled:**

DIRECT SHEAR TEST REPORT
Blackburn Consulting
W. Sacramento, CA

Hydraulic Conductivity of Saturated Porous Material
ASTM D 5084 (Method C)

blackburn consulting

Project: Lookout Slough THRFIP
Project Number: 3195.x
Date: 2/26/2018

Sample Number: TP4 **Depth: 1'-3'**
Material Description: Fat CLAY, LL=59, PI=44
Sample Collection Date: 08/18/17

Sample Data:

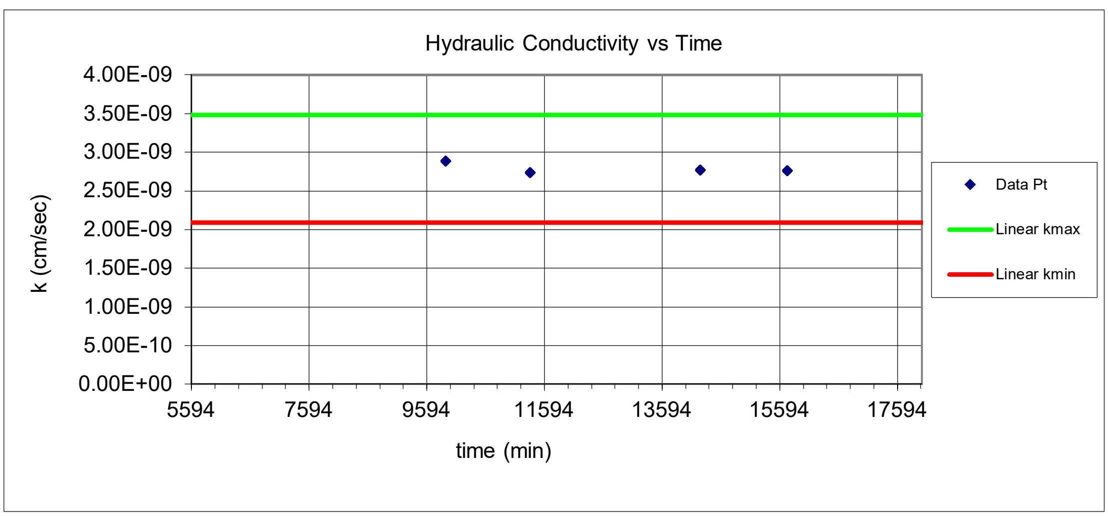
Type of Sample = 2.4" Remold

Initial Data:			**Final Data:**		
Sample Length =	12.7	cm	Sample Length =	12.7	cm
Sample Diameter =	6.10	cm	Sample Diameter =	6.10	cm
Area =	29.2	cm^2	Area =	29.2	cm^2
Volume =	371.0	cm^3	Volume =	371.3	cm^3
Wet Weight=	704.7	g	Wet Weight=	733.0	g
Moisture =	21.6	%	Moisture =	27.1	%
Dry Density =	1.56	g/cm^3	Dry Density =	1.55	g/cm^3
Dry Density =	97.5	pcf	Dry Density =	96.9	pcf
Saturation =	78.5	%	Saturation =	97.4	%
Specific Gravity =	2.74	(assumed)	Specific Gravity =	2.74	(assumed)

Testing Parameters:

B Value =		0.99				
Cell Pressure	P_C=	87	psi	Permeant:	Deaired Water	
Base Pressure	P_b=	85	psi	Aver. Temp=	69.5	°F
Top Pressure	P_T=	80	psi	Burette Area=	0.194	cm^2
Consolidation	=	7	psi	Initial Hydraulic Gradient=	31.41	
Confining Pressure	=	1008	psf	Final Hydraulic Gradient=	29.37	

Results: **Average k (cm/sec)= 2.78E-09 cm/sec**

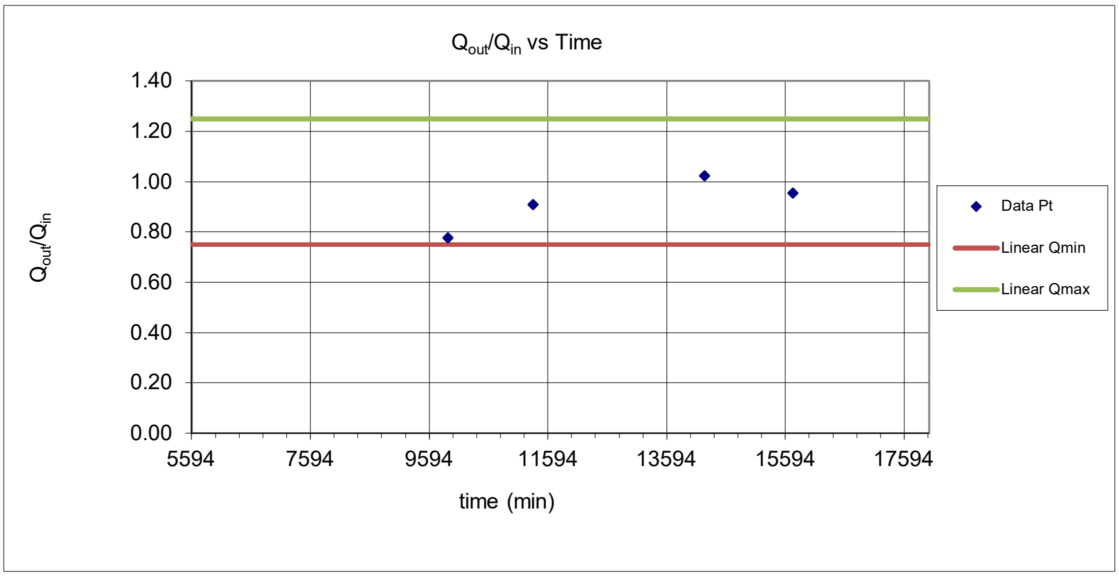


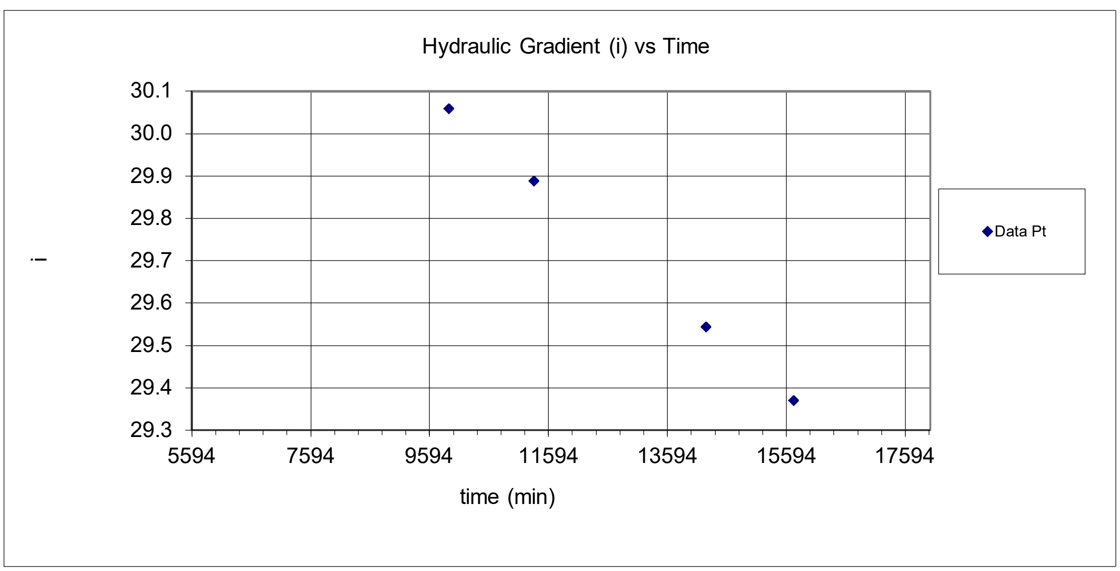
Hydraulic Conductivity of Saturated Porous Material
ASTM D 5084 (Method C)

Project: **Lookout Slough THRFIP**
Project Number: **3195.x**
Date: **2/26/2018**

Sample Number: **TP4** **Depth:** **1'-3'**
Material Description: **Fat CLAY, LL=59, PI=44**
Sample Collection Date: 08/18/17

Average k (cm/sec): 2.78E-09 cm/sec





Hydraulic Conductivity of Saturated Porous Material
ASTM D 5084 (Method C)

blackburn consulting

Project: **Lookout Slough THRFIP**
Project Number: **3195.x**
Date: **2/15/2019**

Sample Number: **BTP 15 B** **Depth:** **3 - 6'**
Material Description: **Fat CLAY, LL = 50, PI = 33**
Sample Collection Date: 07/19/18

Sample Data:

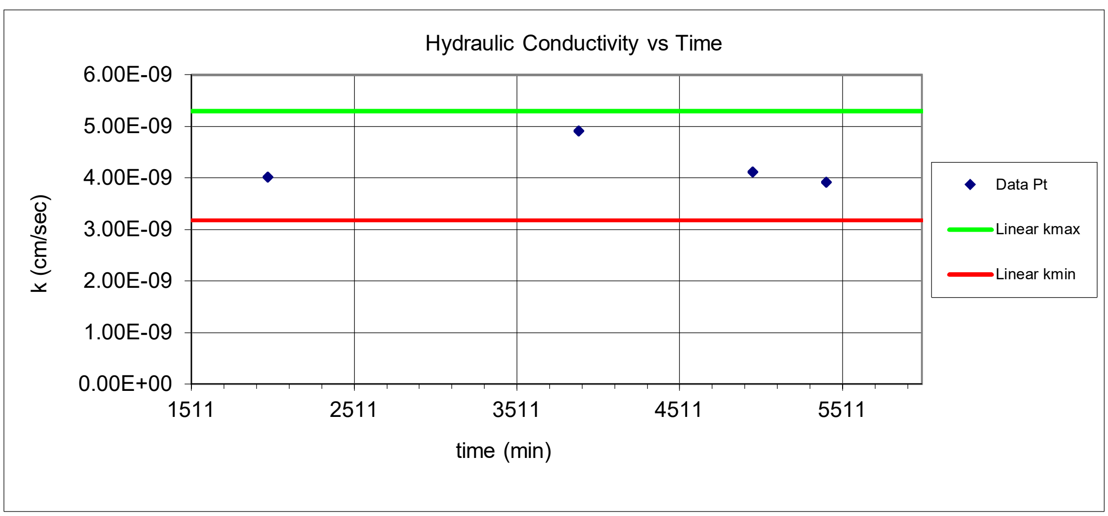
Type of Sample = 2.4" Remold

Initial Data:			**Final Data:**		
Sample Length =	7.1	cm	Sample Length =	7.1	cm
Sample Diameter =	6.08	cm	Sample Diameter =	6.09	cm
Area =	29.0	cm^2	Area =	29.2	cm^2
Volume =	205.9	cm^3	Volume =	207.5	cm^3
Wet Weight=	408.2	g	Wet Weight=	412.9	g
Moisture =	22.5	%	Moisture =	25.1	%
Dry Density =	1.62	g/cm^3	Dry Density =	1.59	g/cm^3
Dry Density =	101.0	pcf	Dry Density =	99.2	pcf
Saturation =	93.6	%	Saturation =	100.0	%
Specific Gravity =	2.65	(assumed)	Specific Gravity =	2.65	(assumed)

Testing Parameters:

B Value =		0.96				
Cell Pressure	P_C=	57	psi	Permeant:	Deaired Water	
Base Pressure	P_b=	56	psi	Aver. Temp=	68.6	°F
Top Pressure	P_T=	50	psi	Burette Area=	0.194	cm^2
Consolidation	=	7	psi	Initial Hydraulic Gradient=	66.33	
Confining Pressure	=	1008	psf	Final Hydraulic Gradient=	62.06	

Results: **Average k (cm/sec)= 4.24E-09 cm/sec**

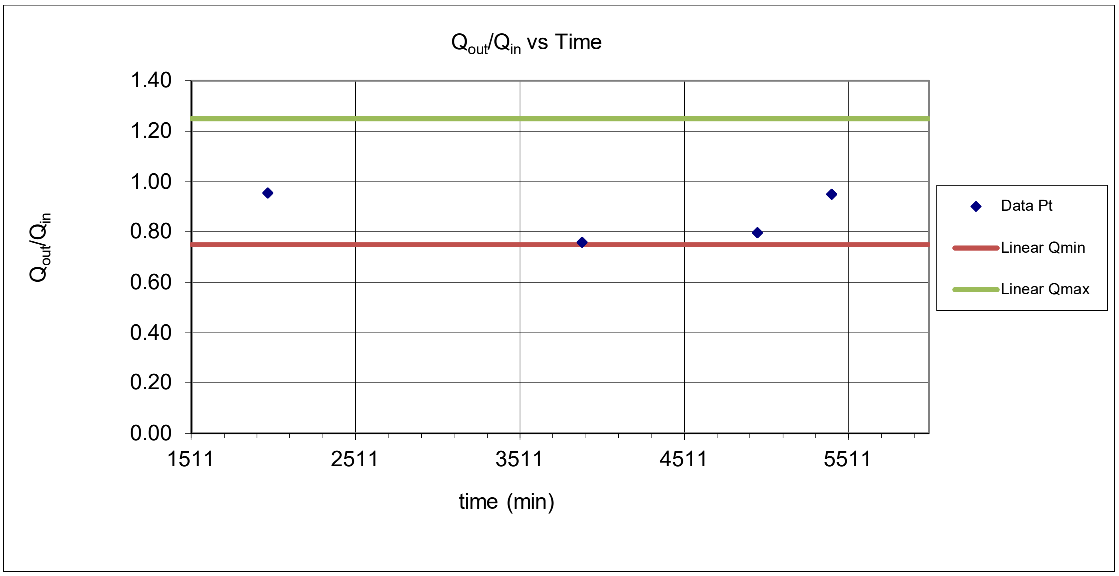


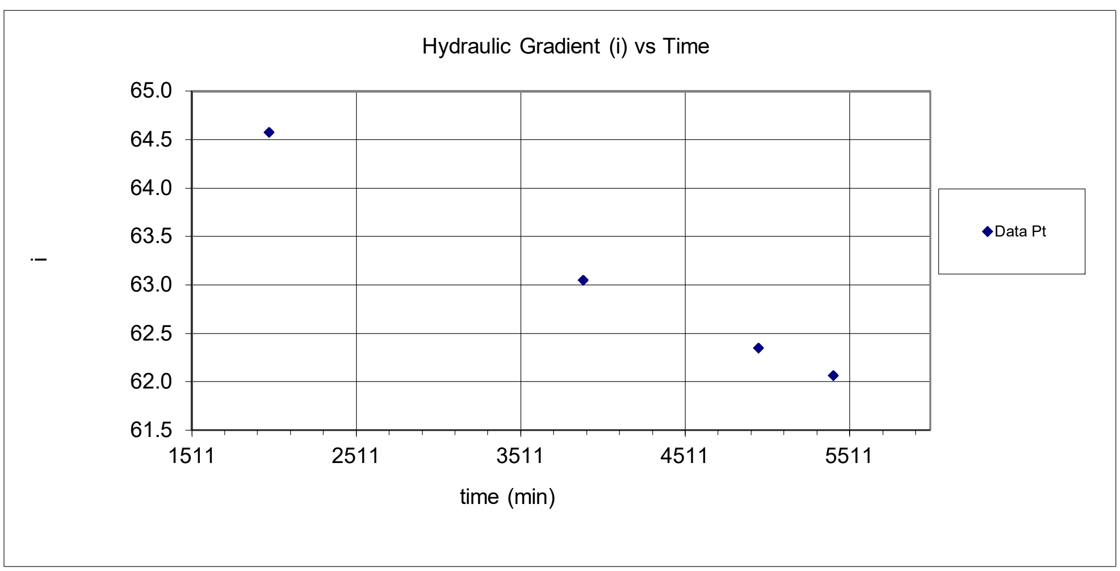
Hydraulic Conductivity of Saturated Porous Material
ASTM D 5084 (Method C)

Project: Lookout Slough THRFIP
Project Number: 3195.x
Date: 2/15/2019

Sample Number: BTP 15 B **Depth:** 3 - 6'
Material Description: Fat CLAY, LL = 50, PI = 33
Sample Collection Date: 07/19/18

Average k (cm/sec): 4.24E-09 **cm/sec**





Hydraulic Conductivity of Saturated Porous Material
ASTM D 5084 (Method C)

blackburn consulting

Project: Lookout Slough THRFIP
Project Number: 3195.x
Date: 2/15/2019

Sample Number: BTP-20 A **Depth: 1 - 3'**
Material Description: Lean CLAY,LL=43, PI=29
Sample Collection Date: 07/19/18

Sample Data:

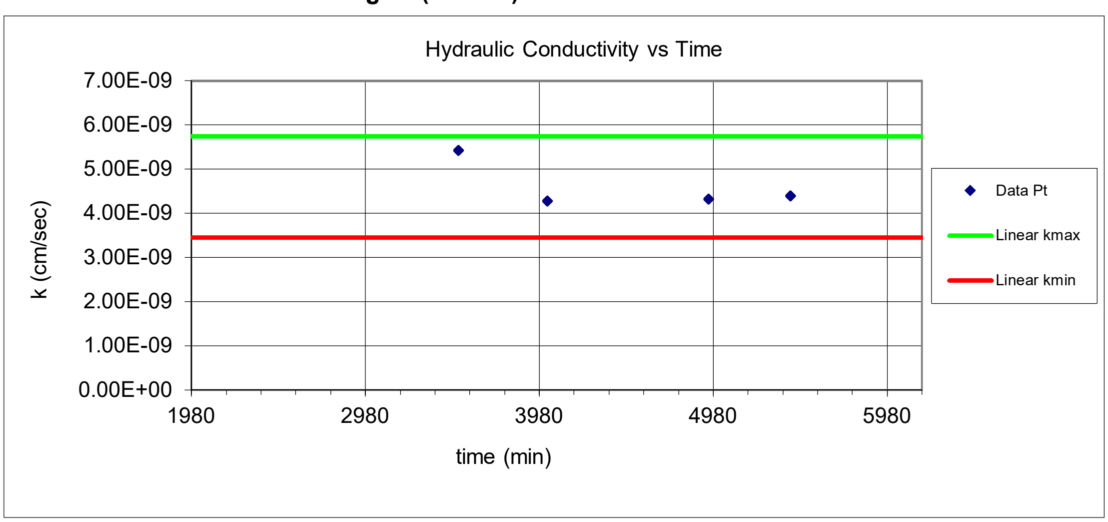
Type of Sample = 2.4" Remold

Initial Data:			Final Data:		
Sample Length =	7.5	cm	Sample Length =	7.4	cm
Sample Diameter =	6.10	cm	Sample Diameter =	6.07	cm
Area =	29.2	cm^2	Area =	28.9	cm^2
Volume =	218.0	cm^3	Volume =	214.3	cm^3
Wet Weight=	441.1	g	Wet Weight=	444.0	g
Moisture =	19.5	%	Moisture =	20.3	%
Dry Density =	1.69	g/cm^3	Dry Density =	1.72	g/cm^3
Dry Density =	105.7	pcf	Dry Density =	107.5	pcf
Saturation =	91.6	%	Saturation =	100.0	%
Specific Gravity =	2.65	(assumed)	Specific Gravity =	2.65	(assumed)

Testing Parameters:

B Value =		0.96				
Cell Pressure	P_C=	57	psi	Permeant:	Deaired Water	
Base Pressure	P_b=	56	psi	Aver. Temp=	68.6	°F
Top Pressure	P_T=	50	psi	Burette Area=	0.194	cm^2
Consolidation	=	7	psi	Initial Hydraulic Gradient=	64.47	
Confining Pressure	=	1008	psf	Final Hydraulic Gradient=	59.39	

Results: **Average k (cm/sec)= 4.60E-09 cm/sec**

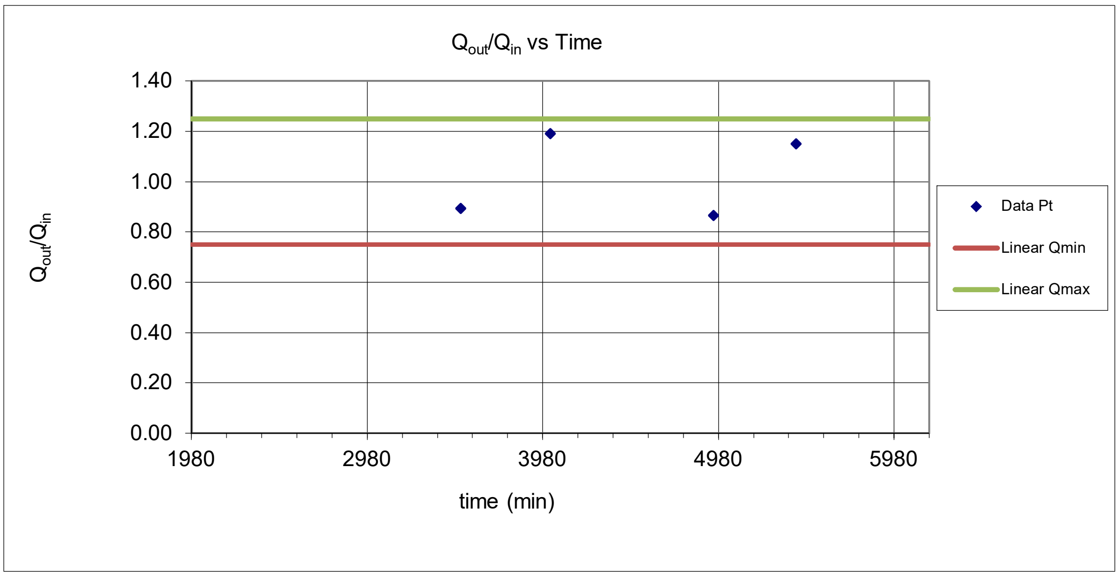


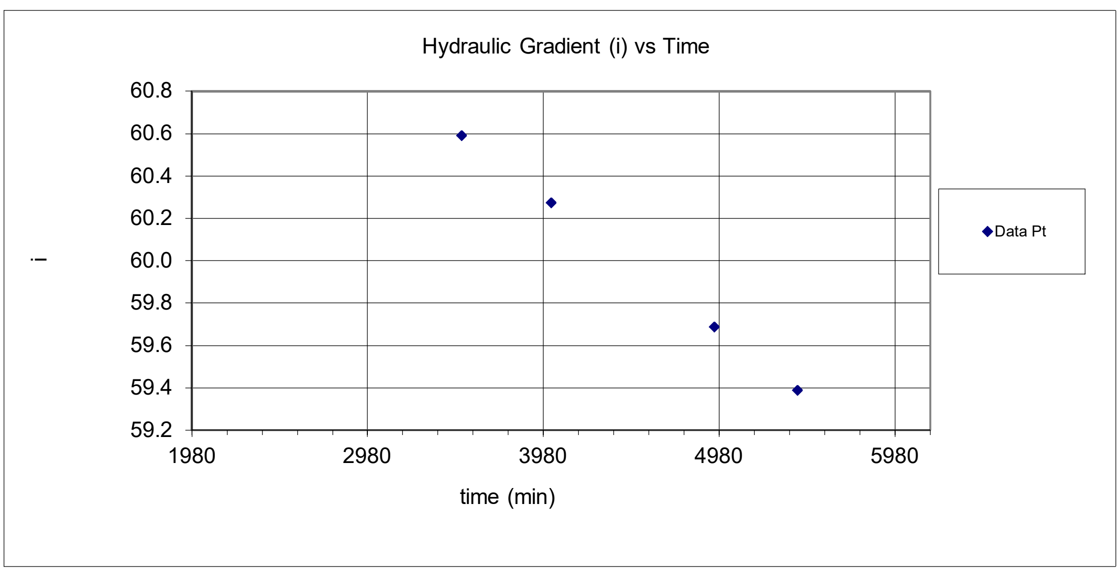
Hydraulic Conductivity of Saturated Porous Material
ASTM D 5084 (Method C)

Project: Lookout Slough THRFIP
Project Number: 3195.x
Date: 2/15/2019

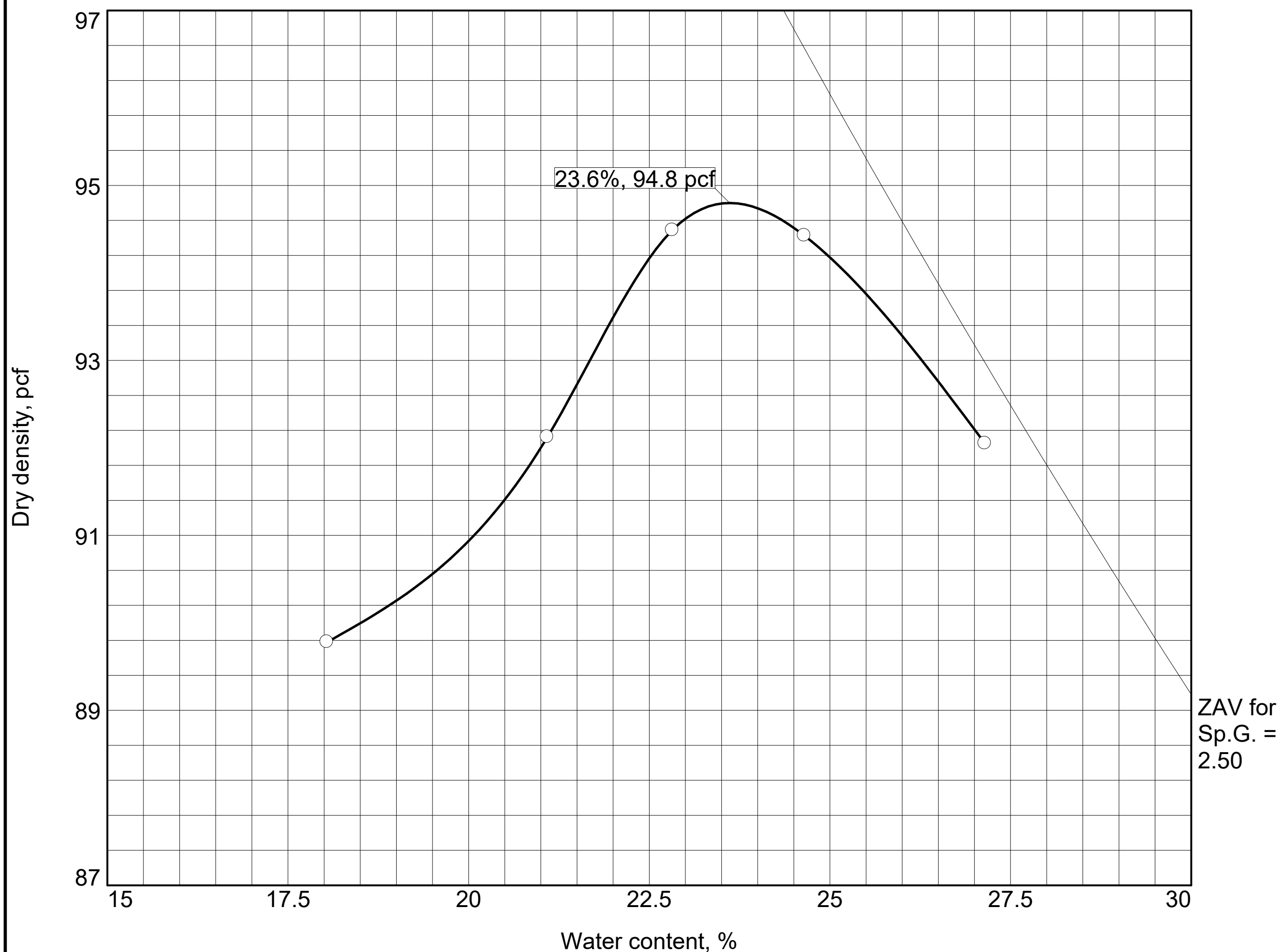
Sample Number: BTP-20 A **Depth:** 1 - 3'
Material Description: Lean CLAY,LL=43, PI=29
Sample Collection Date: 07/19/18

Average k (cm/sec): **4.60E-09** **cm/sec**





COMPACTION TEST REPORT



Test specification: ASTM D 698-12 Method A Standard, manual rammer, wet prep method

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > #4	% < No.200
	USCS	AASHTO						
1-3'				2.5 Assumed	68	49		93.2

TEST RESULTS	MATERIAL DESCRIPTION
Maximum dry density = 94.8 pcf Optimum moisture = 23.6 %	Fat CLAY, very dark grayish brown

Project No. 3195.X **Client:** EIP

Project: Lookout Slough Restoration Project - Borrow Analysis

Date:

Source of Sample: BTP 7 **Sample Number:** A

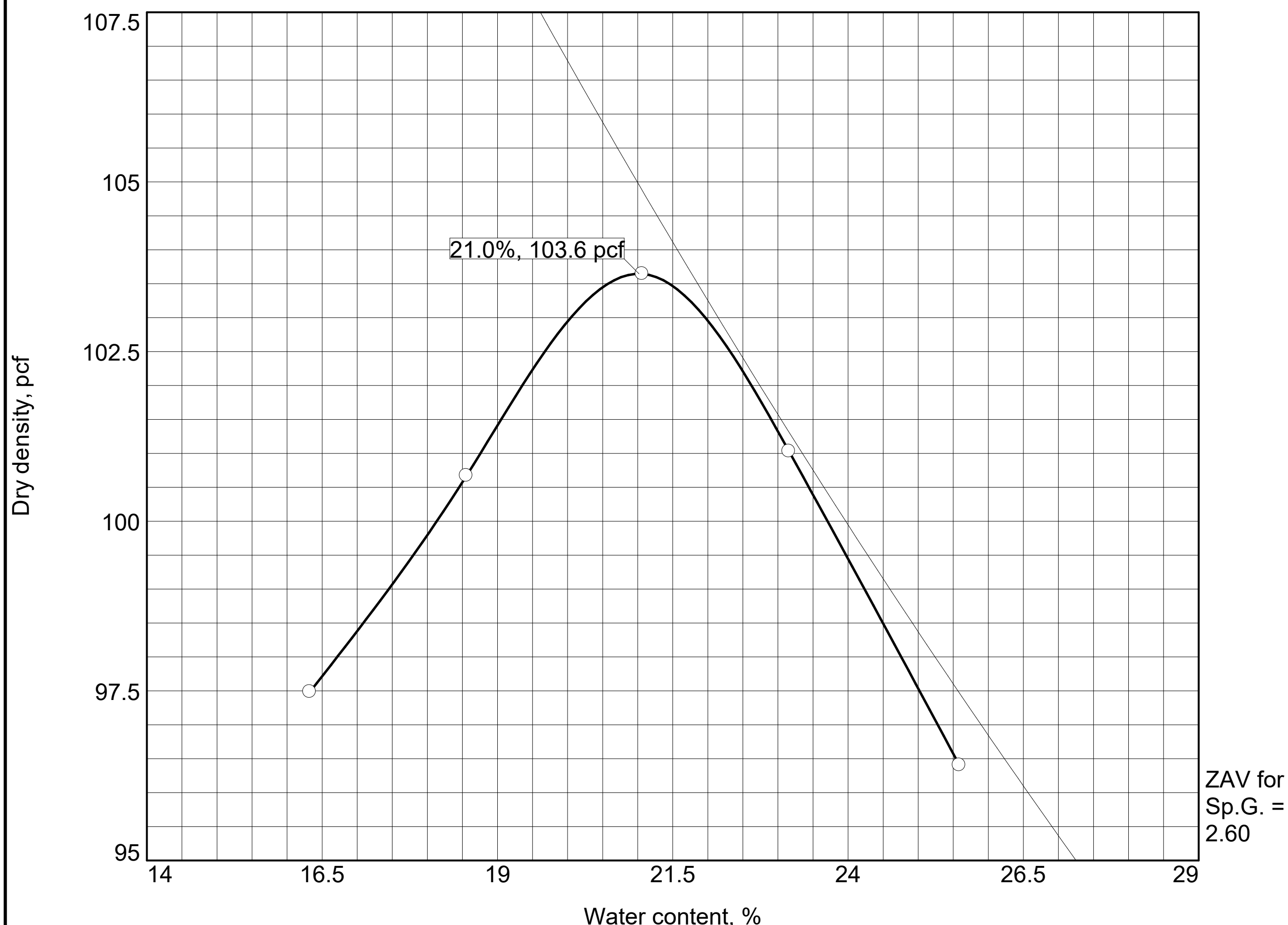
Blackburn Consulting

W. Sacramento, CA

Remarks:

Figure

COMPACTION TEST REPORT



Test specification: ASTM D 698-12 Method A Standard

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > #4	% < No.200
	USCS	AASHTO						
3-6'				2.6	50	33	0	80.2

TEST RESULTS	MATERIAL DESCRIPTION
Maximum dry density = 103.6 pcf Optimum moisture = 21.0 %	Fat CLAY with SAND, dark yellowish brown

Project No. 3195.X **Client:** EIP

Project: Lookout Slough Restoration Project - Borrow Analysis

Date:

○ **Source of Sample:** BTP 15 **Sample Number:** B

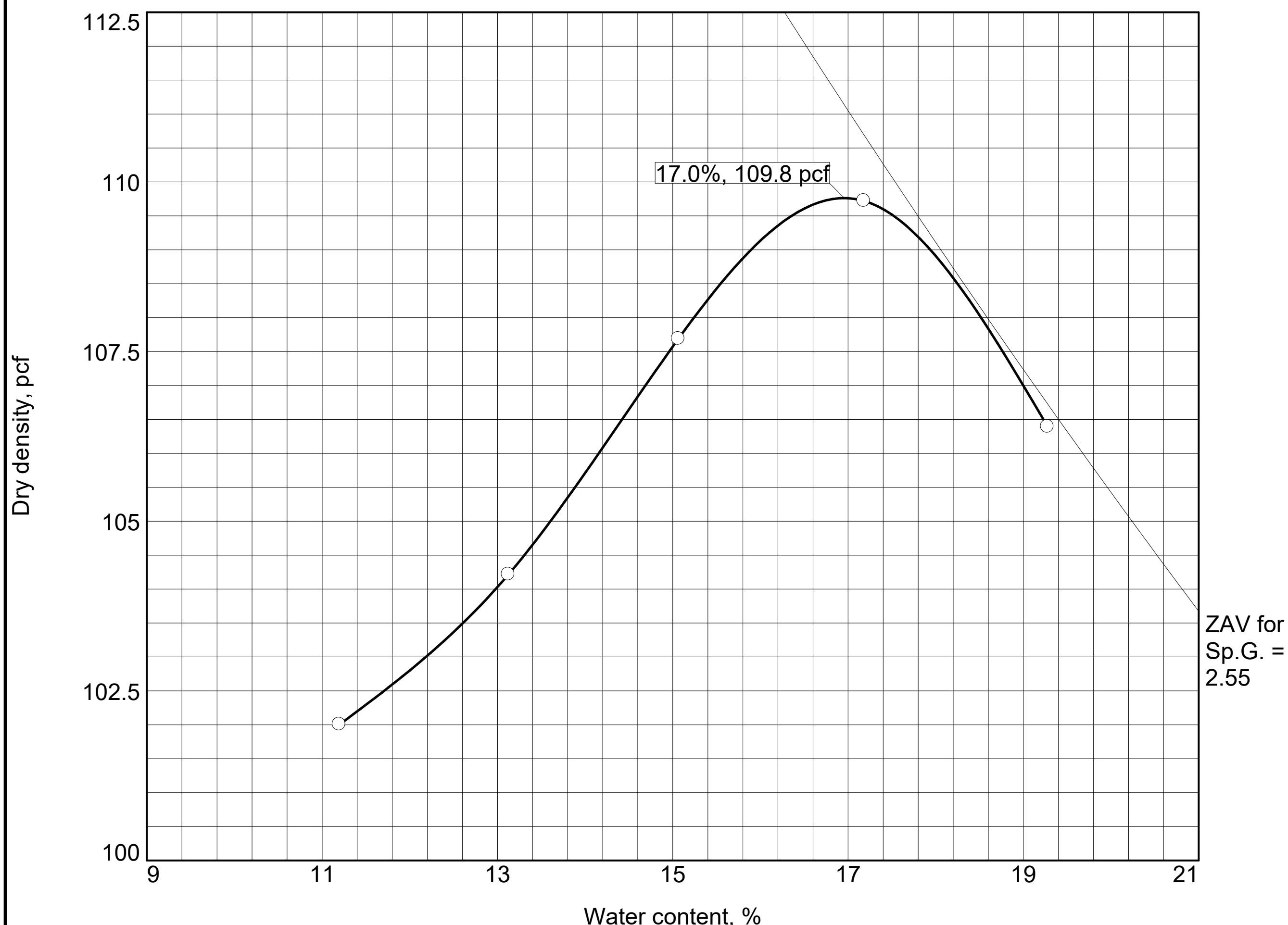
Blackburn Consulting

W. Sacramento, CA

Remarks:

Figure

COMPACTION TEST REPORT



Test specification: ASTM D 698-12 Method A Standard, manual rammer, dry prep method

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > #4	% < No.200
	USCS	AASHTO						
1-3'				2.55	43	29	0	68.4

TEST RESULTS	MATERIAL DESCRIPTION
Maximum dry density = 109.8 pcf Optimum moisture = 17.0 %	SANDY Lean CLAY, olive brown

Project No. 3195.X **Client:** EIP

Project: Lookout Slough Restoration Project - Borrow Analysis

Date:

Source of Sample: BTP 20 **Sample Number:** A

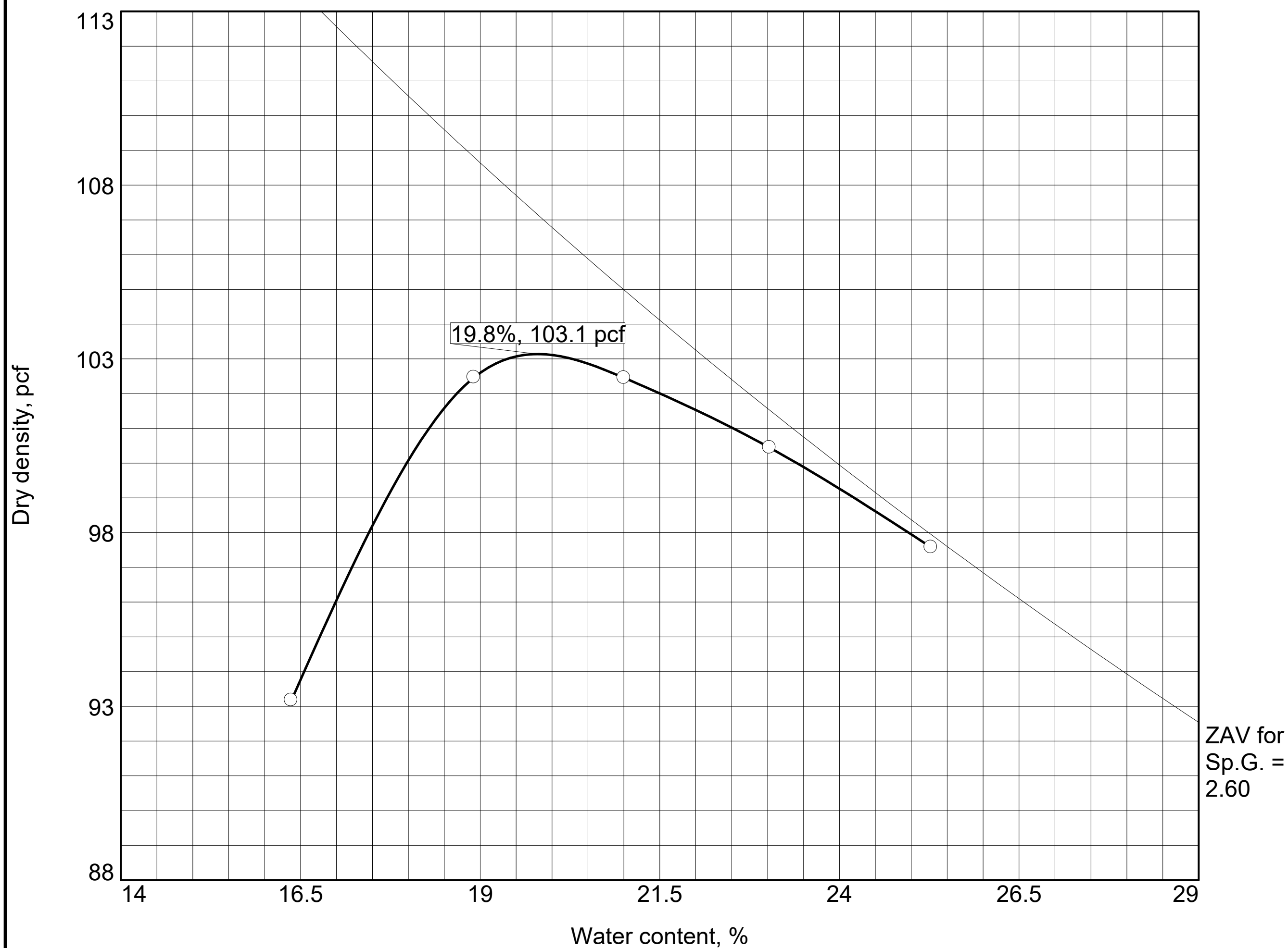
Remarks:

Blackburn Consulting

W. Sacramento, CA

Figure

COMPACTION TEST REPORT



Test specification: ASTM D 698-12 Method A Standard, manual rammer, dry prep method

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > #4	% < No.200
	USCS	AASHTO						
	CH			2.53	56	38	0	91.3

TEST RESULTS	MATERIAL DESCRIPTION
Maximum dry density = 103.1 pcf Optimum moisture = 19.8 %	Fat CLAY, olive brown

Project No. 3195.X **Client:** EIP
Project: Lookout Slough Restoration Project - Borrow Analysis
Date:
○ **Source of Sample:** BTP 24 **Sample Number:** B

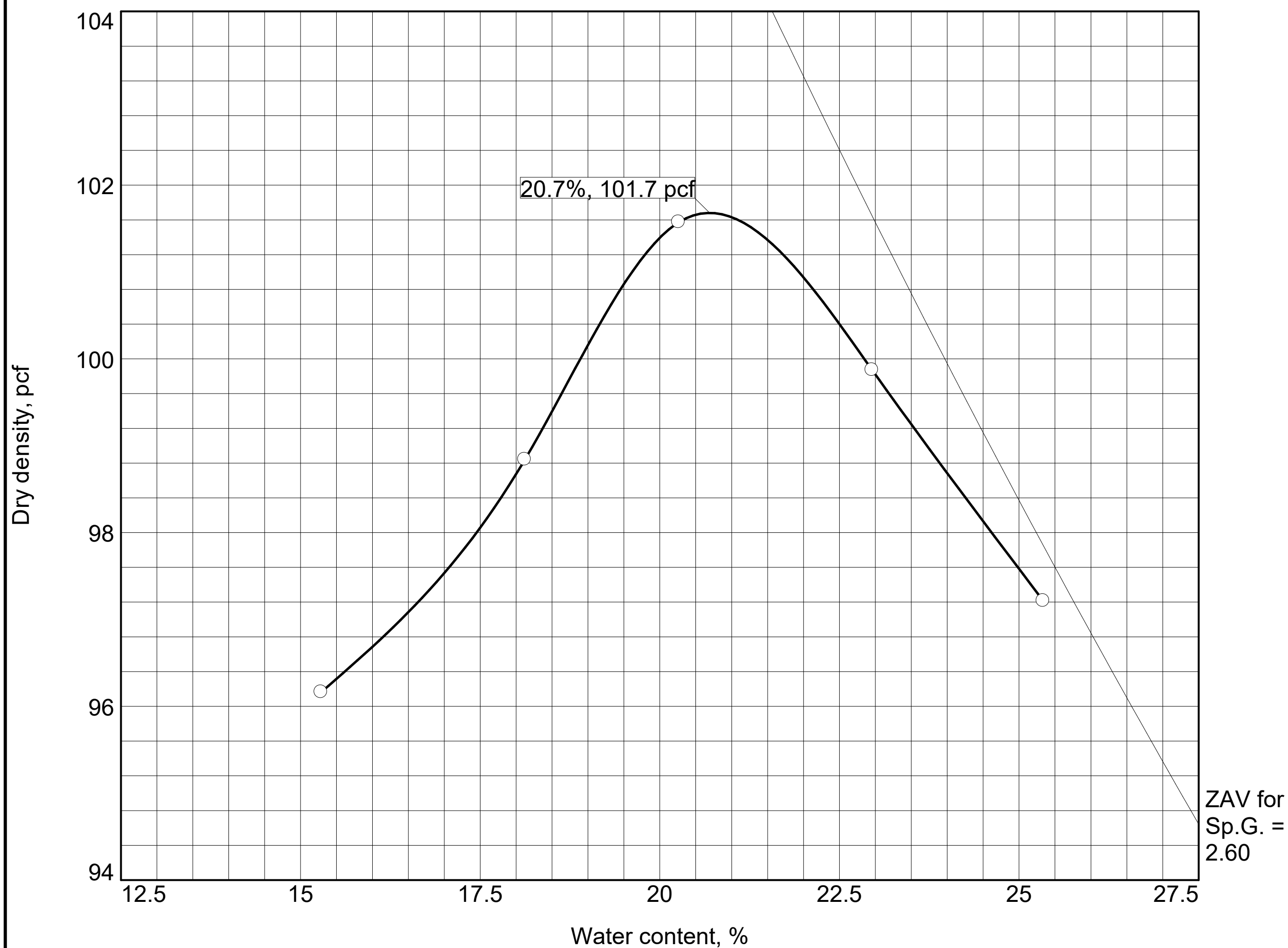
Blackburn Consulting

W. Sacramento, CA

Remarks:

Figure

COMPACTION TEST REPORT



Test specification: ASTM D 698-12 Method A Standard, manual rammer, wet prep method

Elev/ Depth	Classification USCS	Classification AASHTO	Nat. Moist.	Sp.G.	LL	PI	% > #4	% < No.200
4-7'	CL			2.6 Assumed	42	24	0	88.0

TEST RESULTS	MATERIAL DESCRIPTION
Maximum dry density = 101.7 pcf Optimum moisture = 20.7 %	Lean CLAY, dark yellowish brown

Project No. 3195.X **Client:** EIP

Project: Lookout Slough Restoration Project - Borrow Analysis

Date:

Source of Sample: BTP 26 **Sample Number:** B

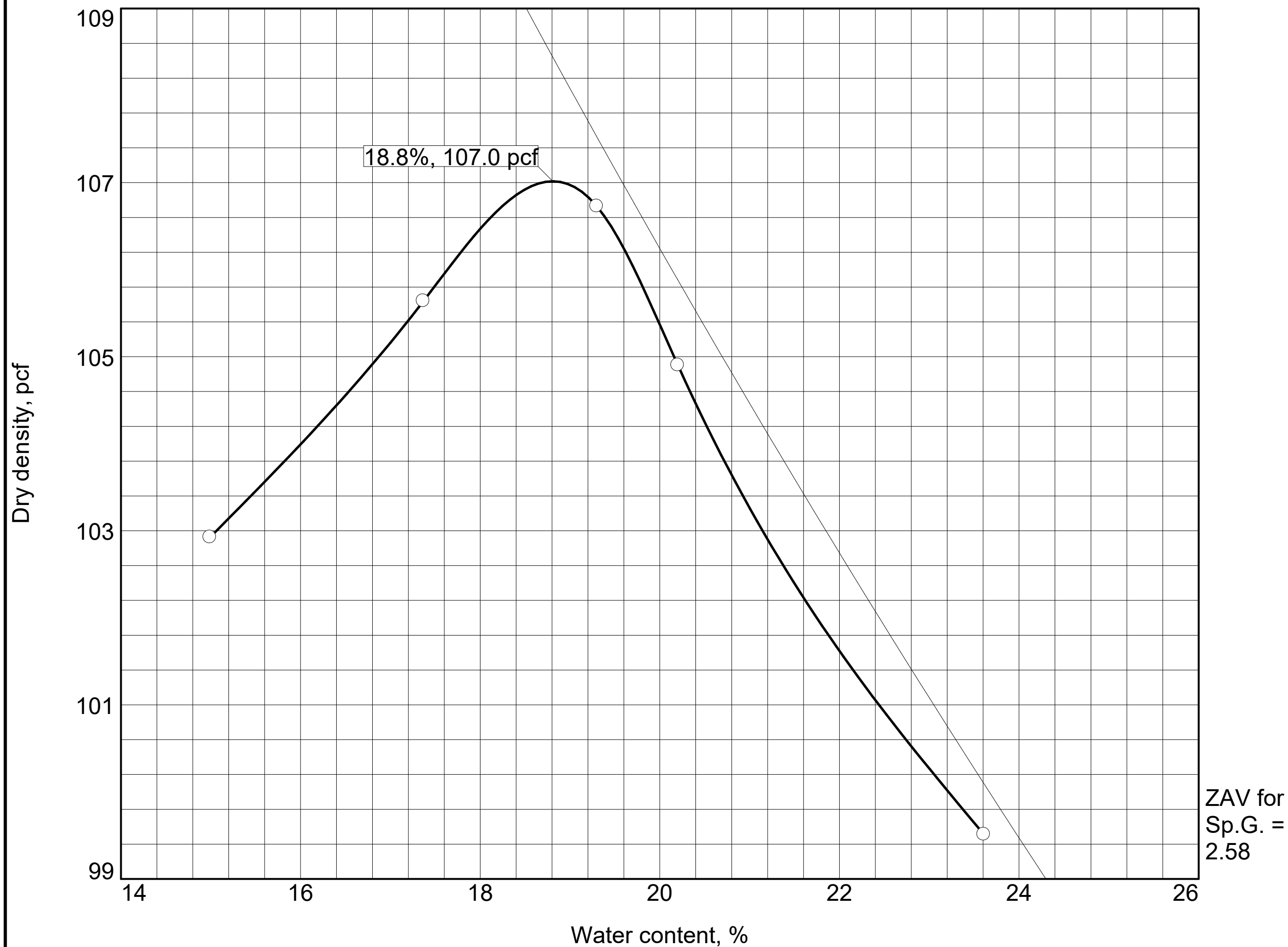
Remarks:

Blackburn Consulting

W. Sacramento, CA

Figure

COMPACTION TEST REPORT



Test specification: ASTM D 698-12 Method A Standard, manual rammer, dry prep method

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > #4	% < No.200
	USCS	AASHTO						
1-4'				2.58 Assumed	49	35	0	85.3

TEST RESULTS	MATERIAL DESCRIPTION
Maximum dry density = 107.0 pcf Optimum moisture = 18.8 %	very dark grayish brown

Project No. 3195.X **Client:** EIP
Project: Lookout Slough Restoration Project - Borrow Analysis
Date:
○ **Source of Sample:** BTP 29 **Sample Number:** A

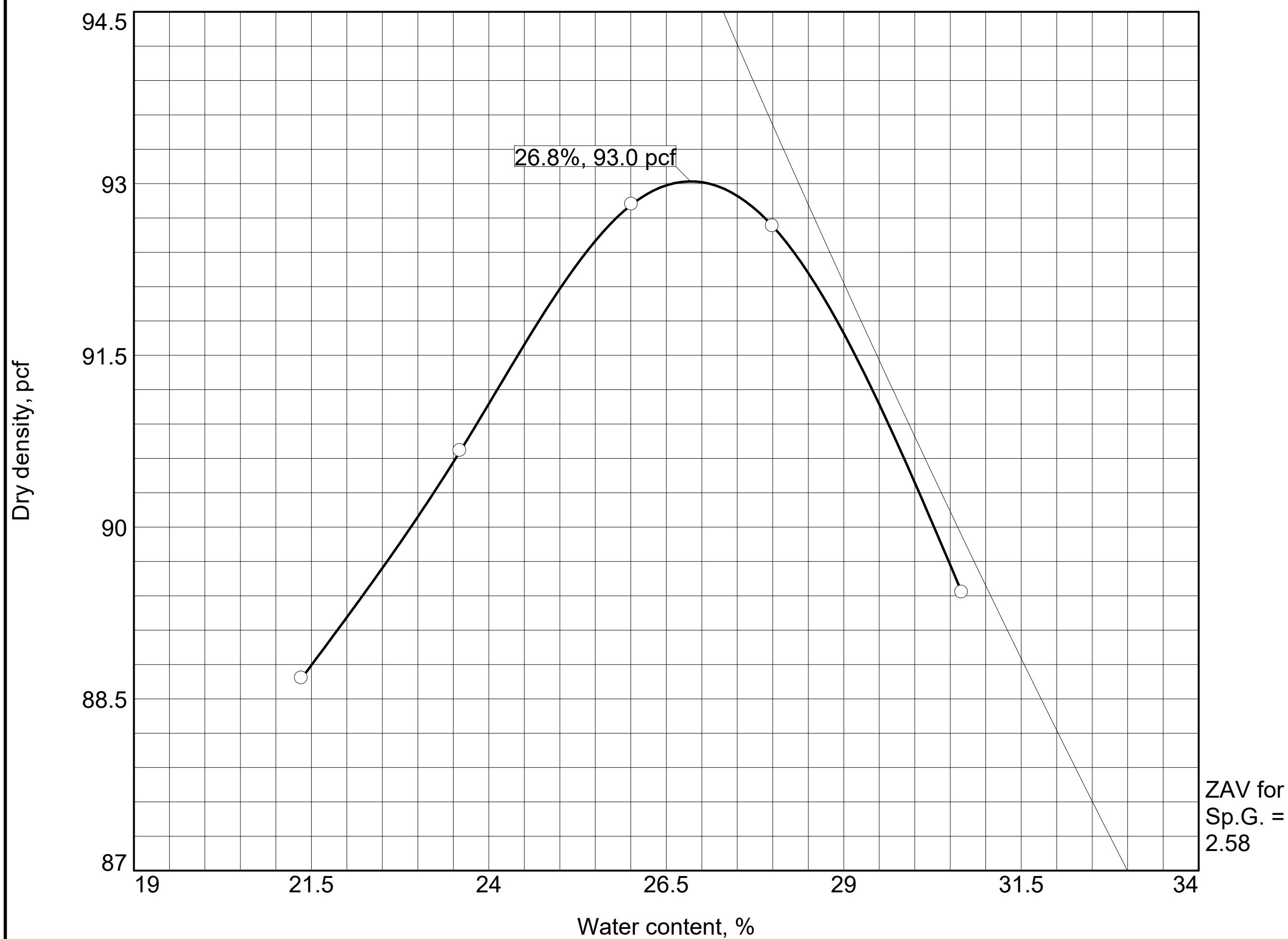
Remarks:

Blackburn Consulting

W. Sacramento, CA

Figure

COMPACTION TEST REPORT



Test specification: ASTM D 698-12 Method A Standard, manual rammer, dry prep method

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > #4	% < No.200
	USCS	AASHTO						
				2.58 Assumed	72	51	0	96.4

TEST RESULTS	MATERIAL DESCRIPTION
Maximum dry density = 93.0 pcf Optimum moisture = 26.8 %	Fat CLAY, Black

Project No. 3195.X **Client:** EIP

Project: Lookout Slough Restoration Project - Borrow Analysis

Date:

Source of Sample: BTP 32 **Sample Number:** A

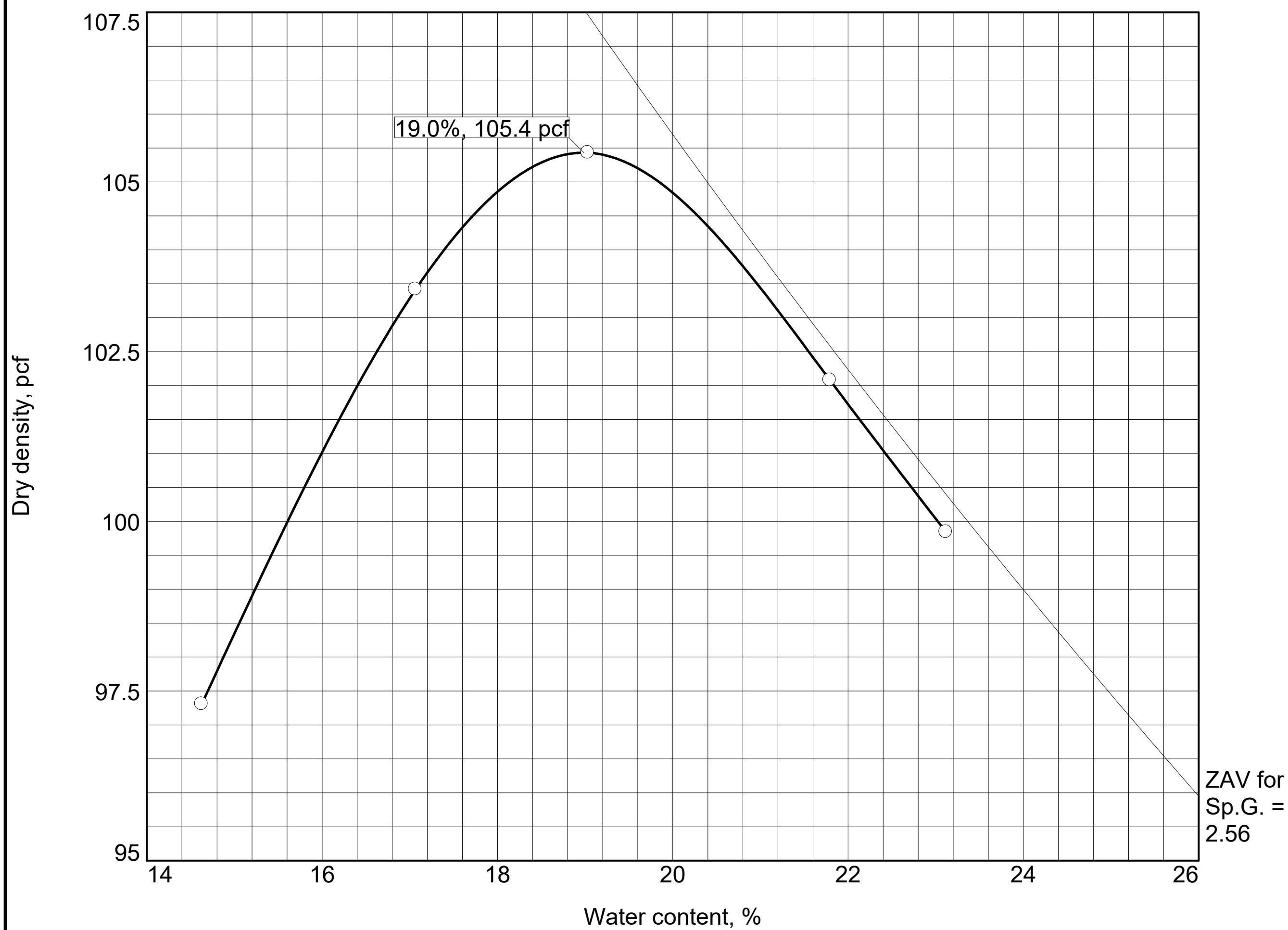
Remarks:

Blackburn Consulting

W. Sacramento, CA

Figure

COMPACTION TEST REPORT



Test specification: ASTM D 698-12 Method A Standard

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > #4	% < No.200
	USCS	AASHTO						
3-6'				2.56	52	37	0	82.8

TEST RESULTS	MATERIAL DESCRIPTION
Maximum dry density = 105.4 pcf Optimum moisture = 19.0 %	Fat CLAY with SAND, dark yellowish brown

Project No. 3195.X **Client:** EIP

Project: Lookout Slough Restoration Project - Borrow Analysis

Date:

○ **Source of Sample:** BTP 34 **Sample Number:** B

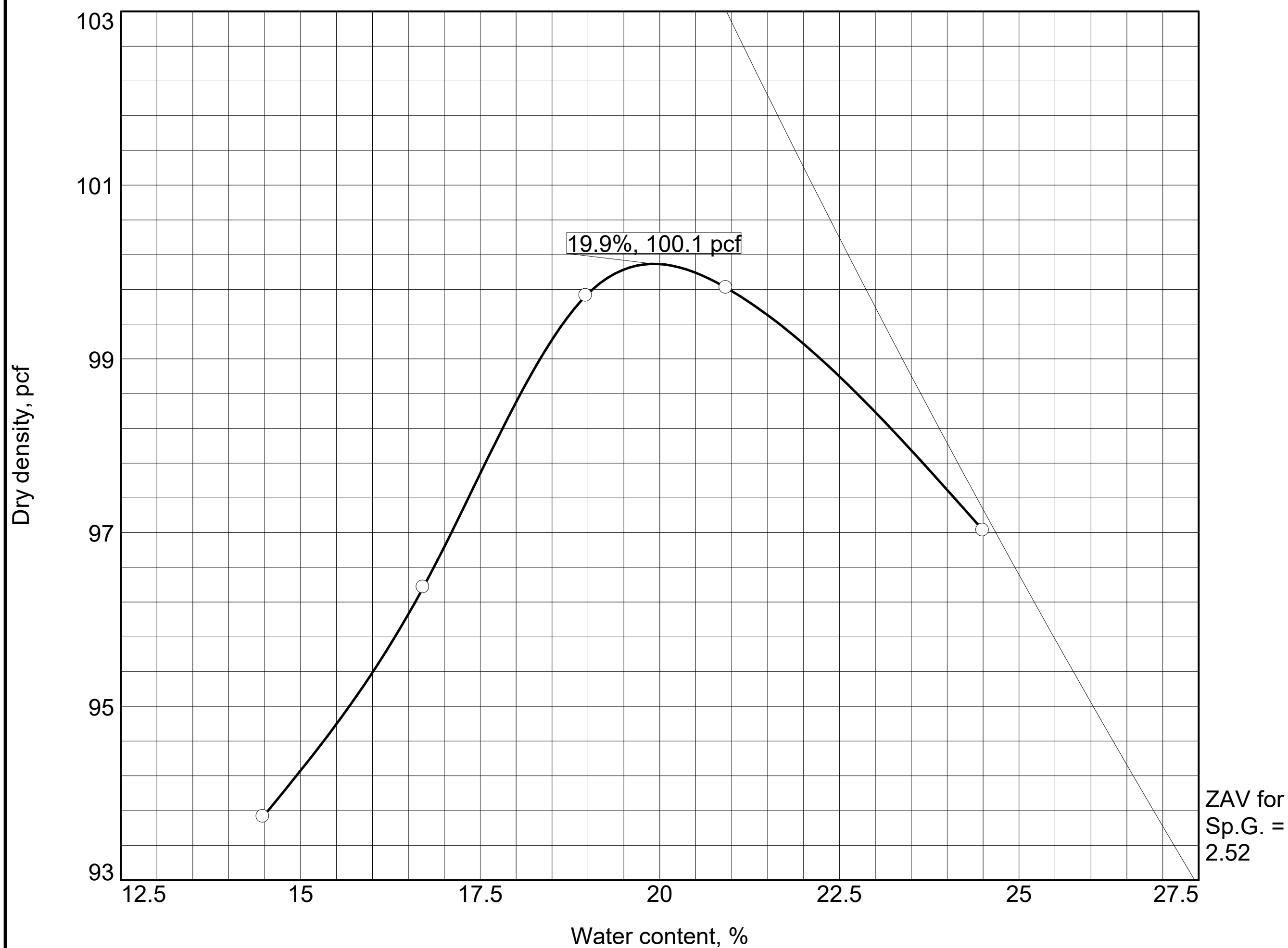
Blackburn Consulting

W. Sacramento, CA

Remarks:

Figure

COMPACTION TEST REPORT



Test specification: ASTM D 698-12 Method A Standard, manual rammer, dry prep method

Elev/ Depth	Classification USCS	Classification AASHTO	Nat. Moist.	Sp.G.	LL	PI	% > #4	% < No.200
1-3'				2.52	61	45	0	92.4

TEST RESULTS	MATERIAL DESCRIPTION
Maximum dry density = 100.1 pcf Optimum moisture = 19.9 %	Fat CLAY, very dark grayish brown

Project No. 3195.X **Client:** EIP

Project: Lookout Slough Restoration Project - Borrow Analysis

Date:

○ **Source of Sample:** BTP 37 **Sample Number:** A

Blackburn Consulting

W. Sacramento, CA

Remarks:

Figure

Appendix E – Cache/Hass Slough Levee Impact Assessement

DRAFT TECHNICAL MEMORANDUM

TO: Mr. David Urban, P.E., Ecosystem Investment Partners

FROM: Mr. Jesse J. Patchett, P.E., CFM
Ms. Nicole Hart, P.E.
Mr. Cody L. Milligan, P.E., CFM

DATE: November 15, 2019

SUBJECT: Cache/Hass Slough Levee Impact Assessment

INTRODUCTION

The Lookout Slough Tidal Habitat Restoration and Flood Improvement Project (Project) is initiated by Ecosystem Investment Partners (EIP) and the California Department of Water Resources (DWR) to evaluate restoration of tidal hydrology to more than 3,000 acres within the Sacramento-San Joaquin Delta (Delta) and to increase flood system resiliency.

As part of the Project, the west levee of the Yolo Bypass along Shag Slough will be breached in several locations. These breaches will hydraulically connect the Project to the Yolo Bypass. Therefore, the Project will introduce water on the current landside levee slopes for the Cache/Hass Slough East Levees, thereby bringing elevated water stages in the Yolo Bypass closer to the Cache/Hass Slough West Levees. During the 100-year flood event (i.e. 0.01 annual exceedance probability, AEP)[1], water levels on the Project are estimated to be approximately 0.7-feet higher than those inside of Cache/Hass Sloughs. This effectively changes the purpose of the Cache/Hass Slough East Levees from their current purpose of protecting the lands within RD 2098 from elevated water stages in Cache/Hass Sloughs to preventing Flood stages inside the Yolo Bypass within the Project from raising water surfaces in Cache/Hass Slough.

Neighboring reclamation districts have expressed concern that bringing elevated water stages in the Yolo Bypass closer to the Cache/Hass Slough West Levees could increase flood risk to properties protected by these levees. These concerns are understood to generally relate to:

- Potential increased flood risk associated with relying on the existing Cache/Hass Slough East Levees to prevent elevated water stages on the Project site from entering Cache/Hass Sloughs and impacting levees surrounding Hastings Island and Peters Pocket.
- Increased seepage potential and decreased landside slope stability potential for the Cache/Hass Slough West Levees.

In addition, the Department of Water Resources has expressed concern for additional operations and maintenance along the Cache/Hass Slough East Levees once the Project is completed. Project impacts which may result in additional operations and maintenance include:

- Hydraulically connecting the Project side of the Cache/Hass Slough East Levees to the Yolo Bypass.
- Crest erosion due to overtopping in the event that the maximum wind/wave will occur with the 0.01 AEP flood event.

[1] The 100-year water surface elevation differences are provided for reference. The design of the new setback levee is based on the USACE authorized 1957 Profile.

The purpose of this Technical Memorandum (TM) is to assess the With-Project impacts on the east and west levees of Cache/Hass Sloughs and to describe proposed improvements and Operations & Maintenance (O&M) actions that will mitigate some of these impacts.

DESCRIPTION OF THE EXISTING LEVEES AROUND THE PROJECT

There are several levees in the vicinity of the Project that could be potentially impacted as part of the Project. These include: the east and west levees along Hass Slough, the east and west levees along Cache Slough, and the Cross Levee. Numerous historical documents were reviewed in order to better understand and describe the condition of these levees (see References section of this TM for the acronyms associated with each reference). A graphical overview of these levees is shown on **Figure 1** (attached). **Figure 2** (attached) presents a Past Performance Map that outlines each Reported Levee Performance Event summarized in the 2011 NULE and the sites provided by DWR. A description of these existing levees and past performance issues are included below.

Hass Slough East Levee

The Hass Slough East Levee currently provides flood protection from elevated water stages in Hass Slough to Reclamation District 2098. According to 2011 NULE, this levee system was constructed in the early 1900s using dredge material from adjacent sloughs. The United States Army Corps of Engineers (USACE) later improved this levee system in the 1930s and 1960s using borrow from dredging operations in the Sacramento River Deep Water Ship Channel and borrow areas near Cache Slough.

Topographic mapping obtained for the Project indicates that landside slopes vary from 2H:1V to 5H:1V, with the majority being 2.5H:1V or flatter. Waterside slopes vary but are as steep as 1.5H:1V.

The USACE drilled three explorations in 1991: 2F-91-11,11A, and 2F-91-12, within this levee segment adjacent to the Project. The explorations indicate the levee and foundation material generally consists of lean to fat clay with some interbedded peat layers.

According to 2011 NULE, this levee section experienced waterside and landside sloughing at multiple locations during the 1997-1998 flood. Based on available information, slope instability and erosion have occurred along the levee alignment. No underseepage or through seepage problems have been documented.

Cache Slough East Levee

The Cache Slough East Levee currently provides flood protection from elevated water stages in Cache Slough to Reclamation District 2098. The Cache Slough East Levee was originally constructed in the early 1900s with soil most likely obtained from adjacent sloughs. Sometime between the 1930s and 1960s, the USACE improved this levee with borrow material generated from the Deep-Water Ship Channel and local borrow areas along Cache Slough.

Topographic mapping obtained for the Project indicates that the landside slopes vary from 2H:1V to 3.2H:1V. The waterside slopes vary from 1.3H:1V to 3H:1V.

The USACE drilled five explorations, 2F-91-13, 2F-91-14, 2F-91-15, 5F-62-7, and 5F-62-8, along this levee stretch in 1962 and 1991. The 1986 USACE (see references section) presents logs of 26 additional explorations along these levees and the Yolo Bypass West Levee. The explorations indicate the levee and foundation material generally consist of lean to fat clay with some interbedded peat layers.

The Cache Slough East Levee has a long history of distress from erosion and slope instability. Some of the landside slumps involved the entire landside slope and, at times, slumps extended into the levee crown. Based on available information, erosion and landside slumps and slips occurred regularly between 1974 and 1980, and again in 1993, 1997, 1998, 2003, 2006 and 2017. As slope instability has historically and continues to occur, it is reasonable to speculate that slope instability will continue to occur regardless if the Project is built or not built. There are no documented reports of underseepage or through seepage for this levee.

<u>*Hass Slough West Levee*</u>
The Hass Slough West Levee currently provides flood protection from elevated water stages in Hass Slough to Reclamation District 2104 (aka Peters Pocket). Construction of this levee is believed to have occurred after 1906, likely with dredge clay materials from the channels. The 2011 NULE indicated planned improvements included riverbank protection and a waterside berm, yet also indicated that no records were found to confirm work was performed.

Topographic mapping obtained for the Project indicates that landside slopes from 1.6H:1V to 5.5H:1V with the majority 2.5H:1V or flatter. Waterside slopes are approximately 3H:1V. There is an existing ditch running parallel to the Hass Slough West Levee within 50 feet of the landside levee toe in several sections.

One boring, 2F-91-8, drilled in 1991 for the Sacramento River Flood Control Evaluation Lower Sacramento Area indicates the levee and foundation soils consist of fat clay drilled to approximately 40 feet below the levee crest.

According to available information, there are no documented reports of slope stability, through seepage or underseepage issues within the area opposite the Project. Two reports of water leaking from the levee due to problems associated with penetrations occurred north of Duck Slough. The current hazards include lack of freeboard and insufficient levee prism along the entire levee segment.

<u>*Cache Slough West Levee*</u>
The Cache Slough West Levee currently provides flood protection from elevated water stages in the Yolo Bypass[2] and Cache Slough to Reclamation District 2060 (aka Hastings Tract). The Cache Slough West Levee was originally constructed in the early 1920s. The original levees were later improved, enlarged, setback and/or repaired by the USACE between 1938 and 1958. The 2011 NULE stated that the material used to improve the levees is believed to be high-plasticity fat clay fill. Multiple ditches (parallel and non-parallel) exist near the landside levee toe.

Topographic mapping obtained for the Project indicates that landside slopes range from 2H:1V to 5H:1V and waterside slopes range from 1.8H:1V to 4H:1V.

Geotechnical exploration information compiled by the Delta Risk Management Strategy project indicates that the foundation soils consist of about 15 to 20 feet of high-plasticity clay and lean clay along Cache Slough, and 20 to 25 feet of organic clay along the Yolo Bypass. The USACE drilled two explorations 2F-91-20 and 20A in 1992 within the levee segment. The explorations indicate that the levee and foundation material generally consist of fat clay with some interbedded peat layers.

According to available information, multiple erosion events occurred during the 1986, 1997 and 1998 flood seasons. Damage in 1986 resulted in multiple PL 84-99 erosion repairs, which subsequently failed

[2] The southern portion of the Cache Slough West Levee downstream of the Cross Levee is believed to protect RD 2060 from elevated water stages in the Yolo Bypass. It is unclear if USACE made the necessary modifications to this levee when the Cross Levee was constructed.

during 1997 and 1998 floods. The 2011 NULE document states that levee maintenance is classified as unacceptable. Only minor issues with seepage, slope instability and overtopping have been reported for this levee.

Cross Levee

The levees along the former southern end of Liberty Farms (Shag Slough and Cache Slough West Levee) experienced substantial subsidence and sloughing both during and after construction improvements in 1961. Through 1973, remedial repair and upgrade construction occurred annually. Repair continued until 1981 when the USACE decided to design a more permanent fix along this levee stretch.

The Cross Levee was constructed in 1989 in order to address these issues. The Cross Levee provides flood protection from elevated water stages in the Yolo Bypass and in Cache Slough to Reclamation District 2098. It appears that the initial USACE plan was to construct the Cross Levee to have 6-feet of freeboard above the 1957 water surface profile. However, due to cost considerations, the USACE ultimately constructed the Cross Levee to meet the Shag Slough crown elevation at the tie-in with Shag Slough and slope down to meet the elevation of the Cache Slough East Levee at that tie-in location. Underseepage and slope stability are categorized as Lacking Sufficient Data in the 2011 NULE, yet not expected to be elevated to a high hazard level with additional information based on the NULE classification system.

Explorations drilled for the Cross Levee indicate the foundation consists of clay to at least 30 feet below the ground surface.

WITH-PROJECT IMPACTS ON THE EXISTING LEVEES

Cache/Hass Slough East Levees

Hydraulic Impacts

During the 0.01 AEP flood event[3], water levels on the Project are estimated to be approximately 0.7-feet higher than the water levels inside of Cache/Hass Slough. This effectively changes the purpose of the Cache/Hass Slough East Levees from their current purpose of protecting the Project from elevated water stages in Cache/Hass Sloughs to preventing water on the Project from raising water surfaces in Cache/Hass Sloughs.

Since the Shag Slough Levee will not be maintained, long-term erosion could degrade the remnant Shag Slough embankment such that increased wind fetch lengths and the associated wave heights could impact the Cache/Hass Slough East Levees. Therefore, Wood Rodgers conducted a wind/wave analysis in order to assess the maximum probable wave heights that could impact the Cache/Hass Slough East Levees. It should be noted that the wind/wave analysis performed for the Project considered a 0.01 AEP flood event that is coincident with the maximum recorded wind speeds over the past 88 years from the directions that could generate waves on the Cache/Hass Slough East Levees. While this approach is conservative, the approach is consistent with the USACE EM 1110-2-1100, USACE EM 1110-2-1420, and the Shore Protection Manual (USACE 1984). The approach is also consistent with other levee setback projects undertaken in the Yolo Bypass (Lower Elkhorn Basin Levee Setback) Furthermore, since there are only 88 years' worth of data available, the wind speeds used are likely conservative. Details of the wind/wave analysis are discussed fully in Reference 9.

The results indicate wave heights of up to 3.4-feet could impact the Cache/Hass Slough East Levees if the Shag Slough levee was ultimately degraded due to erosive forces. This is expected to be unlikely to occur within the foreseeable future given that remnant levees from Liberty Island still exist, despite being breached and not maintained for more 20 years. However, since the ultimate degradation of the remnant Shag Slough embankments are a realistic possibility in the future, the design must take this into consideration.

The existing Cache/Hass Slough East Levees generally have between 1.9-feet and 5.4-feet (along the Cross Levee) of freeboard above the with-Project 0.01 AEP water surface elevation, but this freeboard is proposed to be reduced to 1-foot of freeboard above the 0.01 AEP. Therefore, overtopping of the existing Cache/Hass Slough East Levees could occur during a 0.01 AEP event if the Shag Slough embankments were to completely degrade and maximum wave heights occurred.

Geotechnical Impacts

Seepage (Underseepage and Nuisance Seepage)

The Project will result in water on both sides of the Cache/Hass Slough East Levees where these levees are adjacent to the Project. This will result in a lower head differential across these levees in the proposed condition as compared to the existing condition. Therefore, the proposed Project is not believed to have any underseepage impacts to the Cache/Hass Slough East Levees that would require mitigation.

Slope Stability

The introduction of water along the Project side, or former landside could trigger additional slumps. BCI does not believe that the Project will trigger additional waterside slope instability because the proposed project is slightly reducing the water level in the Cache and Hass Sloughs

[3] The 100-year water surface elevation differences are provided for reference. The design of the new setback levee is based on the USACE authorized 1957 Profile.

As slope instability has historically and continues to occur prior to Project construction, the design team expects slope instability to continue to occur regardless if the Project is built or not built.

Cache/Hass Slough West Levees

Hydraulic Impacts

The Project is estimated to decrease the 0.01 AEP water surface elevations in Cache/Hass Sloughs adjacent to the Project by approximately 0.02-feet. Additionally, the Cache/Hass Slough East Levees are proposed to be maintained as levees in accordance with the USACE Operation and Maintenance Manual for the Sacramento River Flood Control Project into the future, so fetch distances are expected to remain unchanged as part of the Project. Therefore, the proposed Project is expected to have a neutral or slightly beneficial hydraulic impact to the Cache/Hass Slough West Levees. Since wave overtopping is intermittent and isn't expected to occur along the entire length of this levee, the overtopping is not expected to have a significant impact on the water surface elevations in Cache/Hass Sloughs. For this reason, overtopping impacts and erosion are expected to be unchanged and do not require mitigation due to construction of the Project.

Geotechnical Impacts

Seepage (Underseepage and Localized Landside Ditch Seepage)

The Project will hydraulically connect the Project side of the Cache/Hass Slough East Levees to the Yolo Bypass, which could potentially influence the exit gradient at the Cache and Hass Slough West Levee's landside levee toe if an aquifer is present. Soil underlying the Cache/Hass Slough West Levees are expected to be similar to the subsurface soil conditions within the Project area near the landside levee toes based on geologic mapping in the area and existing subsurface explorations. This, along with historical explorations along the Cache/Hass Slough West Levees, indicate a clay blanket at least 25-feet thick. The relatively thick blanket and lack of documented reports of through seepage or underseepage indicate a low exit gradient is present at the Cache and Hass Slough West Levee's landside toe during high water events.

The 1986 USACE found that there was no true aquifer in the southern portion of the Project that could create uplift forces for elevated average exit gradients. The Seepage Section of the report states:

> *"Based on findings from field and laboratory investigations, seepage was determined not to require design consideration from either the standpoint of foundation underseepage or embankment seepage causing the development of excess hydrostatic pressures or piping. The existing levee embankment and foundation materials are highly impervious in nature. Some sandy lenses were encountered at depths in the foundation greater than 20 feet with the study area. However, they are generally composed of clayey sand materials that by nature are fairly impervious themselves and are at depths that make them of no consequence to design."*

The above indicates that With-Project-project underseepage is not expected to be a concern.

Several ditches exist along the landside toe of the Cache/Hass Slough West Levees that extend both longitudinal and transverse to the levee. Localized seepage may occur within these ditches if there are lenses of more permeable material within the thicker clay blanket. This condition would exist both Without- and With-Project.

Stability

As discussed above, the Project will introduce Yolo Bypass water levels closer to the Cache/Hass Slough West Levees that could influence the exit gradient at the landside levee toes. This effect could also affect the landside slope stability factor of safety for steady-state conditions. Historical information seems to indicate that the existing exit gradient may be low, which in turn would indicate the effect on slope stability would also be low. According to available information, there are no documented reports of landside slope stability issues for the Cache/Hass Slough West Levees across from the Project. Additional slope stability concerns are not anticipated from construction of the Project, and no mitigation is required to address these impacts.

However, multiple erosions sites have been identified in 1986, 1997 and 1998 along the Cache Slough West Levee and, as stated above, the 2011 NULE document states that levee maintenance is classified as unacceptable. In addition, the Levee Performance Curves indicated a high probability of failure with elevated water surface elevations lower than the 0.01 AEP flood event. Therefore, future waterside slope instabilities should be anticipated to occur on the Cache Slough West Levee regardless of whether the Project is constructed or not.

Cross Levee

Hydraulic Impacts

The with-Project hydraulic impacts on the Cross Levee are similar to those on the Cache/Hass Slough East Levees. During the 0.01 AEP flood event, water levels on the Project are estimated to be approximately 0.7-feet higher than the water levels on the current water side of the Cross Levee at the confluence of the Yolo Bypass and Cache Slough. This effectively changes the purpose of the Cross Levee from its current purpose of protecting the Project from elevated water stages in Cache Slough and the Yolo Bypass to preventing water on the Project from raising water surfaces in Cache Slough.

Given the orientation of the Cross Levee to the Yolo Bypass and the Project site, wind-generated waves for the Cross Levee are only expected to come from within the Project. The results of the wind/wave analysis for the Cross Levee indicate wave heights of approximately 6.4-feet. The existing Cross Levee generally has more than 5-feet of freeboard above the with-Project 0.01 AEP water surface elevation. Therefore, overtopping of the existing Cross Levee could occur if maximum wind speeds occurred concurrently with a 0.01 AEP event. However, since wave overtopping is intermittent and isn't expected to occur along the length of the Cross Levee, the over topping is not expected to have a significant impact on water surface elevations in Cache Slough or the Yolo Bypass.

Geotechnical Impacts

Seepage (Underseepage and Nuisance Seepage)

The Project will result in water on both sides of the Cross Levee. Therefore, the proposed Project is not believed to have any underseepage impacts to the Cross Levee, and these impacts do not require mitigation.

Stability

Slope stability is categorized as Lacking Sufficient Data in the 2011 NULE, yet not expected to be elevated to a higher hazard level with additional information. The introduction of water along the Project side, or former landside could trigger slumps. However, BCI expects slope instability may occur regardless if the Project is built or not built if the levee was constructed of fat clay with 3H:1V levee slopes.

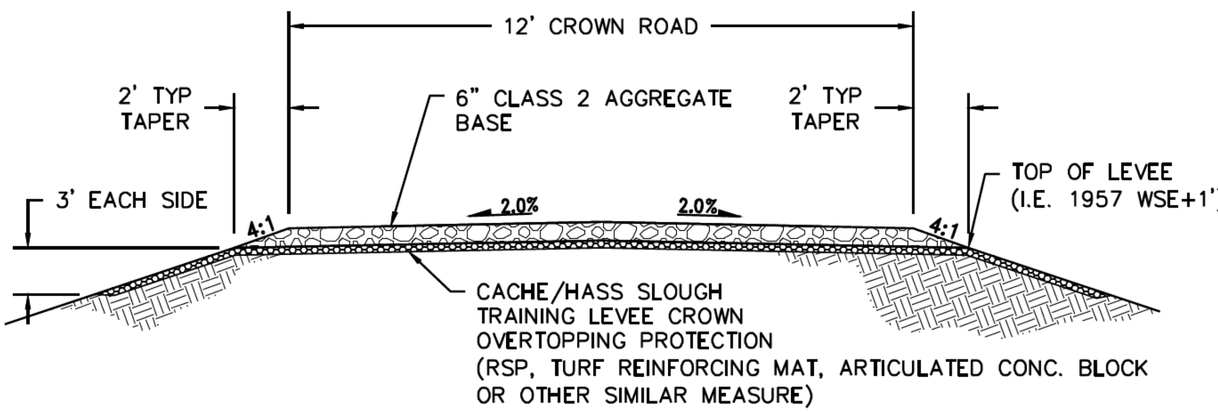
PROPOSED ACTIONS TO MITIGATE WITH-PROJECT IMPACTS

<u>*Cache/Hass Slough East Levees*</u>

Hydraulic Mitigation Measures

As previously discussed, the proposed 0.01 AEP water levels on the Project are estimated to be approximately 0.7-feet higher than the water levels inside of Cache/Hass Sloughs during infrequent, high-flow events in the Yolo Bypass. Additionally, if/when the remand Shag Slough embankments erode, the increased fetch lengths across the Yolo Bypass are expected to generate waves that are in excess of 3.4 feet above the water surface elevation. These waves could overtop the Cache/Hass Slough East Levees. Since wave overtopping is intermittent, the overtopping is not expected to have a significant impact on the water surface elevations in Cache/Hass Sloughs.

However, it is necessary to protect the remnant Cache/Hass Slough East Levee against overtopping. The *Lookout Slough Tidal Habitat Restoration and Flood Improvement Project: Wave Runup and Wind Setup Analysis* (Reference 9) recommended that the crown of the Cache/Hass Slough East Levee be protected against overtopping. Overtopping protection may consist of rock slope protection (RSP), articulated concrete block, a turf reinforcing mat, or other similar measure. The specific measure to provide armoring will be developed in coordination with USACE, DWR, and the design team as the design progresses. The extent of the overtopping protection will be the entire width of the crown and will extend down both slopes for three vertical feet. The exhibit below presents a typical cross-section for the crown of Cache/Hass Slough East Levee.



<u>Exhibit 1 – Typical Cache / Hass Slough East Levee Crown Detail</u>

Additionally, the Cache/Hass Slough East Levees adjacent to the Project site are proposed to be maintained in accordance with the USACE Operation and Maintenance Manual for the Sacramento River Flood Control Project into the future. These actions are expected to mitigate hydraulic impacts to the Cache/Hass Slough East Levees.

Therefore, armoring the landside slope and the levee crest, combined with regular O&M is proposed to mitigate hydraulic impacts along the Cache/Hass Slough East Levees.

Geotechnical Mitigation Measures

Proposed improvements to the Cache/Hass Slough East Levees were developed with the intent to minimize additional operations and maintenance along this levee once construction of the Project is complete.

As stated above, the introduction of Yolo Bypass water surface elevations along the Cache/Hass Slough East Levees project-side slopes may induce additional slope instability. The existing levees are fragile and the subsurface conditions are conducive to subsidence, particularly in the southern portion of the project area. In order to mitigate this instability, the project-side levee slopes of the Cache/Hass Slough East Levees will be flattened in order to reduce potential additional O&M.

The subsurface conditions under the site, particularly in the southern portion of the site, are soft and additional weight most likely will cause detrimental settlement. To allow for flatter slopes without additional subsidence concerns, proposed mitigation includes a 16-foot-wide crest (both Title 23 and EM 1110-2-1913 allow for a 12-foot-wide levee crest), freeboard of 1-foot over the 0.01 AEP WSE, flattening the over-steepened project-side slopes to 4(H):1(V), and creating a 12-foot-wide O&M corridor.

Therefore, along the Hass and Cache Slough East Levees, the mitigation measure includes degrading the levee to an elevation of 1-foot above the 0.01 AEP WSE (or 1-foot above the 1957 WSE, whichever is higher), creating a 16-foot -wide crest with the waterside hinge beginning along the existing waterside slope, flattening the project-side slope to 4H:1V to elevation 8 feet, then creating a 12-foot-wide O&M corridor, then slope down 4H:1V to the landside ground surface. The following exhibit presents a typical cross-section for this measure.

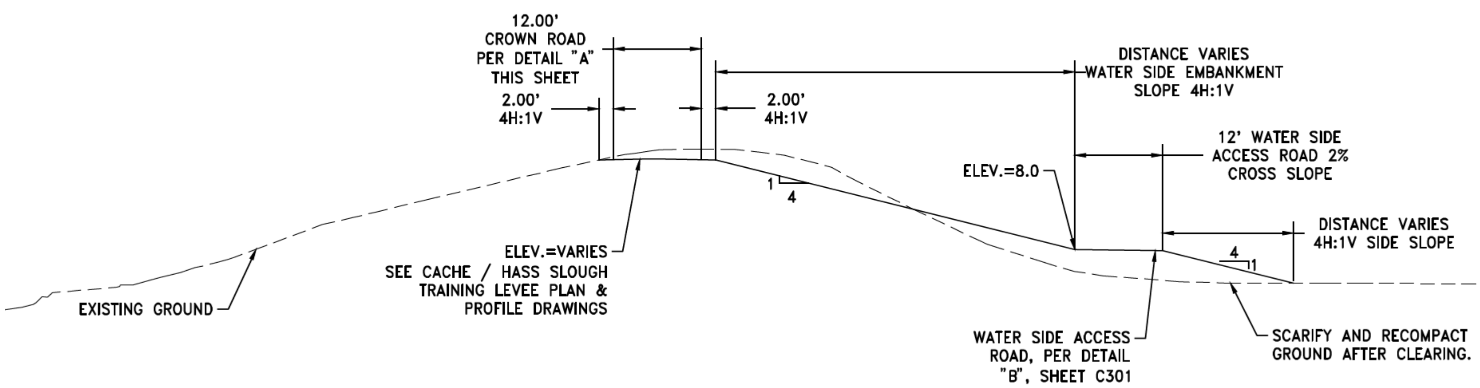


Exhibit 2 – Typical Cache / Hass East Levee Cross Section

Slope flattening along the current waterside slopes is not proposed since the Project is not expected to increase the already unstable slope conditions on these slopes.

It is understood that DWR would be responsible for maintaining the Cache/Hass Slough East Levees, and that project design would include access to the Cache/Hass Slough East Levees for operation and maintenance. As required in the past, future operations and maintenance may be required after heavy storm events to repair slumps on the Cache/Hass Slough East Levees. The amount of maintenance required will depend on the anticipated future purpose of the system. Based on information provided in the 2011 NULE, it does not appear that all instability events were mitigated and therefore it is difficult to state that each instability event moving forward must be mitigated. Progressive slumping and instability may however eventually erode a portion of the Cache/Hass Slough East Levees. Each future event will need to be individually evaluated.

Cache/Hass Slough West Levees

Hydraulic Mitigation Measures

The Project is estimated to decrease the 0.01 AEP water surface elevations in Cache/Hass Sloughs adjacent to the Project by approximately 0.02-feet. Additionally, the Cache/Hass Slough East Levees are proposed to be maintained as levees in accordance with the USACE Operation and Maintenance Manual for the Sacramento River Flood Control Project into the future, so fetch distances are expected to remain unchanged as part of the Project. Since wave overtopping is intermittent and isn't expected to occur along the entire length of this levee, the overtopping is not expected to have a significant impact on the water surface elevations in Cache/Hass Sloughs. Therefore, the proposed Project is expected to have a neutral or slightly beneficial hydraulic impact to the Cache/Hass Slough West Levees. For this reason, overtopping impacts and erosion are expected to be unchanged and do not require mitigation due to construction of the Project.

Geotechnical Mitigation Measures

According to available information, there are no documented reports of underseepage or landside slope instability for the Cache/Hass Slough West Levees across from the Project. If the subsurface soil conditions within this levee segment are similar to the subsurface conditions within the Project, additional underseepage or slope stability concerns are not anticipated from construction of the Project due to a relatively thick blanket and possible areas where no true aquifer exists that could create uplift forces for elevated average exit gradients.

No mitigation would therefore be necessary. However, multiple erosions sites have been identified in 1986, 1997 and 1998 along the Cache Slough West Levees and, as stated above, the 2011 NULE document states that levee maintenance is classified as unacceptable. Future waterside slope instabilities should be anticipated whether the Project is constructed or not.

Cross Levee

Hydraulic Mitigation Measures

The results of the wind/wave analysis for the Cross Levee indicate wave heights of approximately 6.4-feet. The existing Cross Levee generally has more than 5-feet of freeboard above the with-Project 0.01 AEP water surface elevation. Therefore, overtopping of the existing Cross Levee could occur if maximum wind speeds occurred concurrently with a 0.01 AEP event. However, since wave overtopping is intermittent and isn't expected to occur along the length of the Cross Levee, the over topping is not expected to have a significant impact on water surface elevations in Cache Slough or the Yolo Bypass.

Additionally, the Cross Levee is proposed to be maintained in accordance with the USACE Operation and Maintenance Manual for the Sacramento River Flood Control Project into the future. These actions are expected to mitigate any damage that could occur to the Cross Levee due to wave action.

Geotechnical Mitigation Measures

Due to the relatively recent construction of the Cross Levee by the USACE, geotechnical mitigation measures are not believed to be required at this time.

REFERENCES

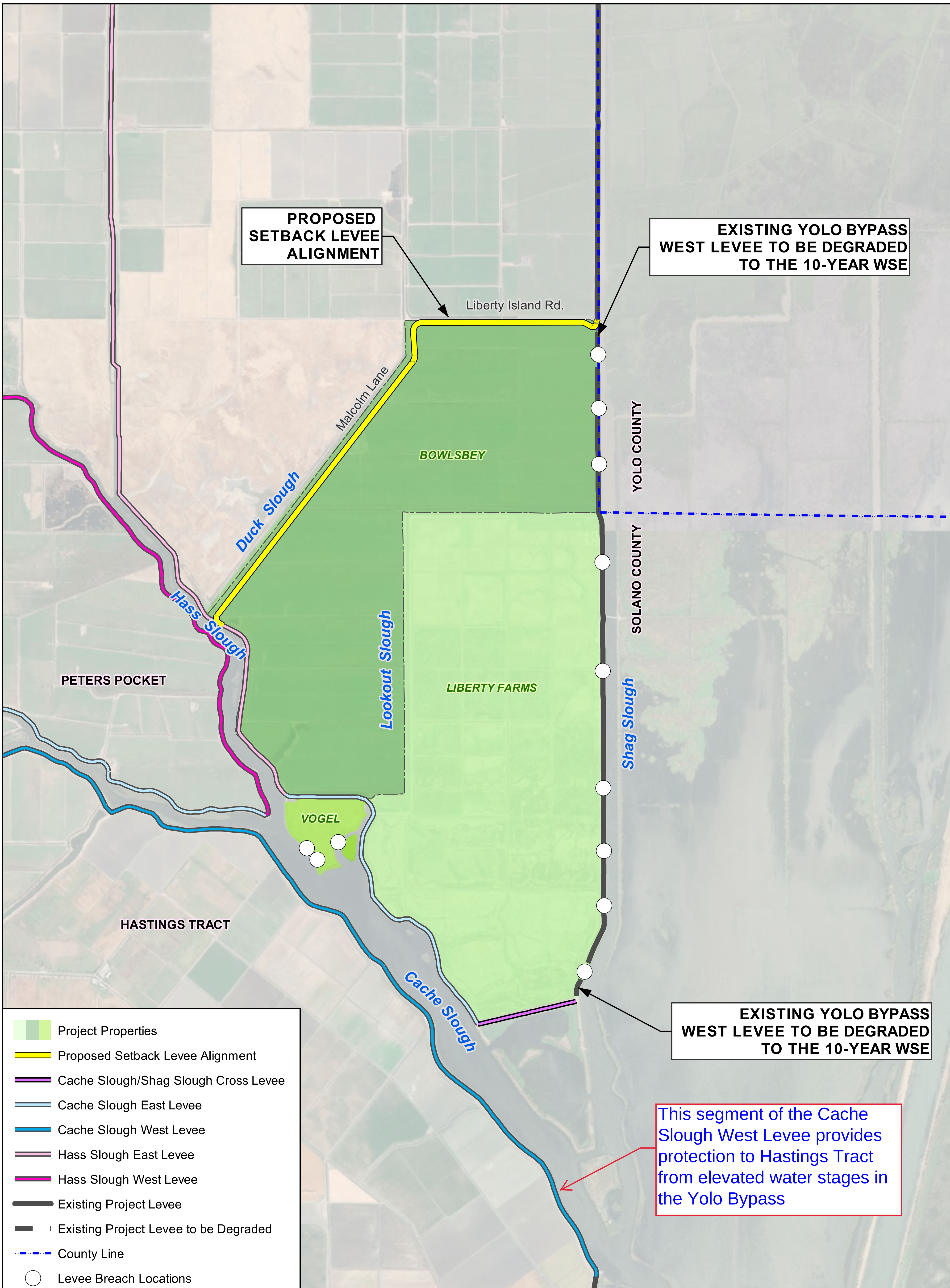
1. June 2012, 2012 Central Valley Flood Protection Plan, Attachment 8E: Levee Performance Curves (Attachment 8E), Department of Water Resources;
2. August 2011, *Remedial Alternatives and Cost Estimates Report (RACER), North NULE Study Area, Non-Urban Levee Evaluations Project, Contract 4600008101, Task Order U107,* (2011 RACER), URS;
3. April 2011 *Geotechnical Assessment Report, North NULE Project Study Area, Volume 1 of 6, Non-Urban Levee Evaluations Project Contract 4600008101, Task Order U104,* (2011 NULE), URS;
4. January 2011, *Final Geomorphology Technical Memoranda and Maps, North NULE Area Geomorphic Assessments, Non-Urban Levee Evaluations Project, Contract 4600008101,* (2011 Geomorphology TM), URS;
5. November 2007, *PL84-99 Levee Rehabilitation Repairs, CY2005 Site Inspection and Repair Alternatives, Reclamation District 2098, Solano County, California*, (2007 PL84-99), US Army Corps of Engineers, Sacramento District;
6. February 1993, *Attachment B Basis of Design Geotechnical Evaluation of Levees for Sacramento River Flood Control System Evaluation, Lower Sacramento River Area, Phase IV,* (1993 USACE BODR Attachment B), prepared by the USACE. Attachment B contains the Initial Appraisal Report – Lower Sacramento Area. BCI could not obtain a copy of the full 1993 USACE BODR;
7. November 1988, *Levee Construction Right Bank Yolo Bypass & Left Bank Cache Slough,* (1988 USACE), USACE;
8. May 1986, *Right Bank Yolo Bypass and Left Bank Cache Slough near Junction Yolo Bypass and Cache Slough, Levee Construction, General Design, Supplement No. 1 to Design Memorandum No. 13*, (1986 USACE), USACE.
9. November 2019, *Lookout Slough Tidal Habitat Restoration and Flood Improvement Project: Wave Runup and Wind Setup Analysis*, Wood Rodgers.

These documents provide historical information to the five levee segments discussed herein:

10. The Hass Slough West Levee (RD 2401 - the levee segment across Hass Slough from the Lookout Slough THRFIP)
11. The Hass Slough East Levee (RD 2098 – within the Lookout Slough THRFIP)
12. The Cache Slough West Levee (RD 2060 – the levee segment across Cache Slough from the Lookout Slough THRFIP)
13. The Cache Slough East Levee (RD 2098 – within the Lookout Slough THRFIP)
14. The Cross Levee (RD 2098 – within the Lookout Slough THRFIP)

Enclosures:
Figures

- Figure 1 – Overall Project Exhibit
- Figure 2 – Past Performance Map, RD 2098
- Figure 3 – Cache/Hass Slough East Levee Profiles



Overall Project Exhibit

N
W E
S

Ecosystem Investment Partners

0 0.25 0.5 1
Miles

Lookout Slough Tidal Habitat Restoration and Flood Improvement Project

Map Prepared Date: 7/25/2019
Map Prepared By: cmilligan
Base Source: Wood Rogers
Base Date: 10/24/17
Data Source(s):

Prepared by:
WOOD RODGERS

Path: J:\3000-s\3487_Ecosystem_Invest_Partners\3487002 Lookout Slough Prelim Hydraulic Analysis\GIS\Tasks\20190724_Project_Exhibit\Overall_Project_Exhibit_20190724.mxd

Figure 1

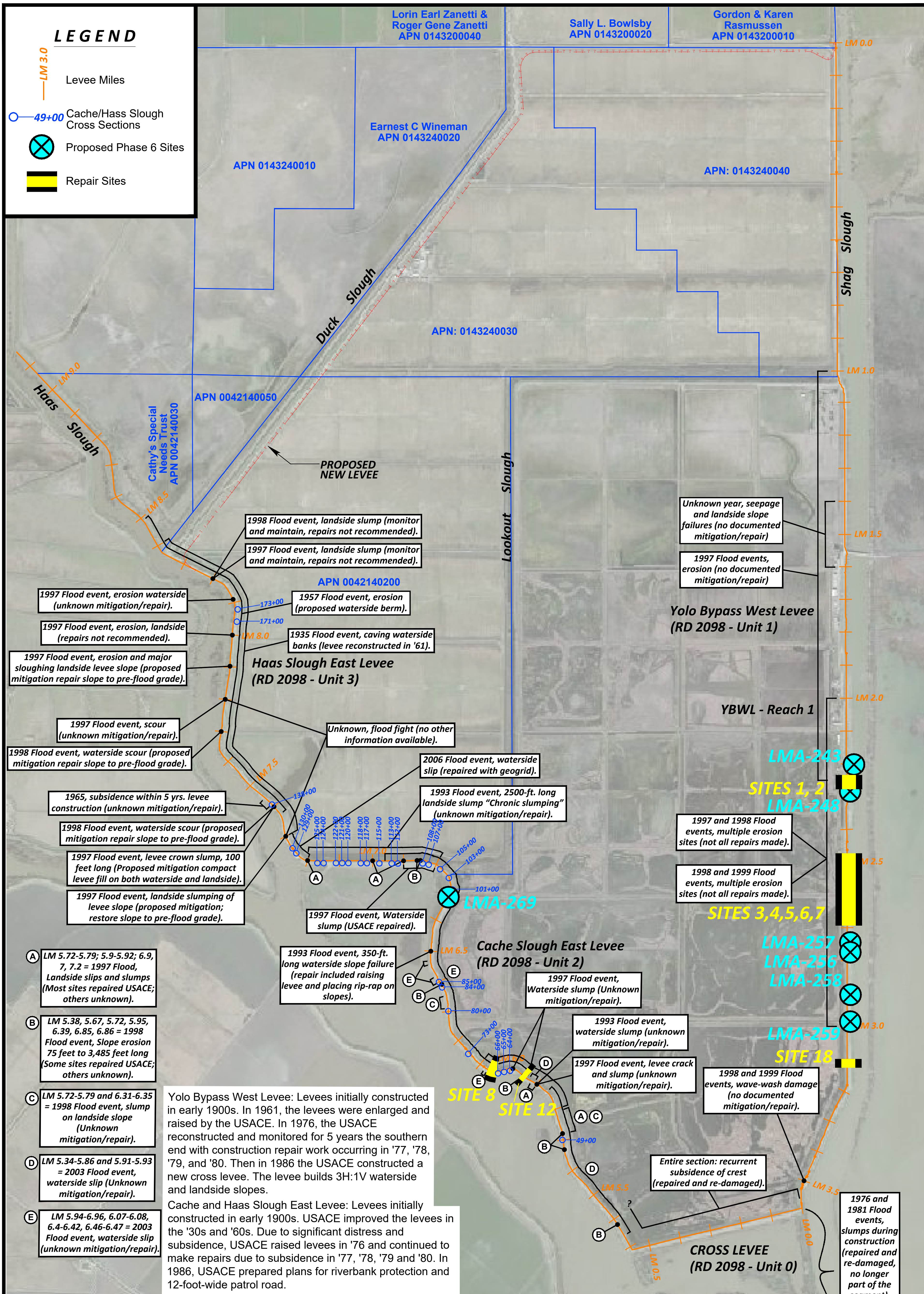


FIGURE 2a, PAST PERFORMANCE MAP RD 2098
August 2019

N
W E
S

Source: Geotechnical Assessment Report, North NULE Project Study Area, Volume 1 of 6, dated April 2011. Prepared by URS. Lookout Slough boundary lines and easements provided by Wood Rodgers, Inc., 12/08/2017. Proposed levee alignment and topography updated11/12/2018.

0 1500

SCALE: 1 " = 1500 '

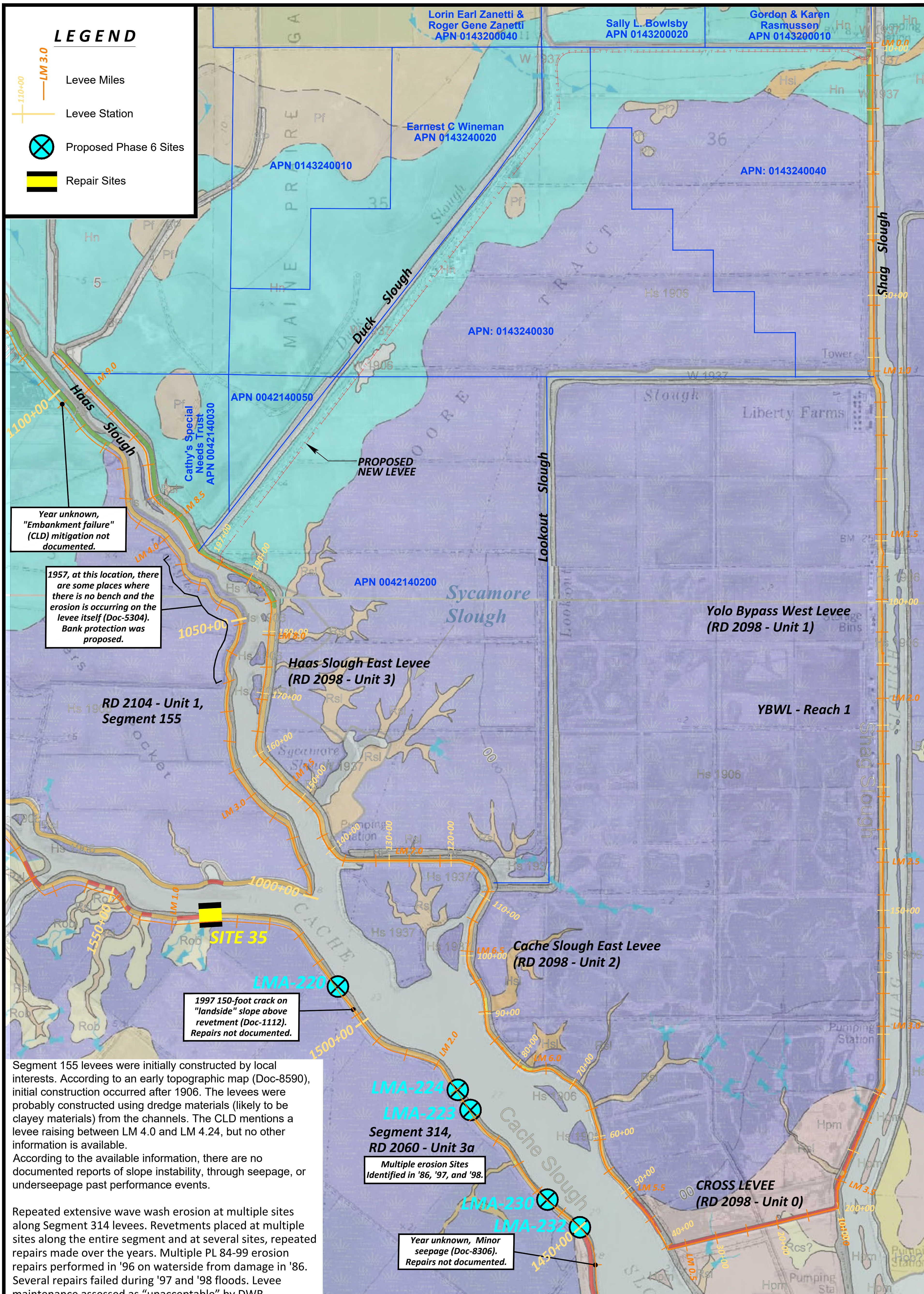
Lookout Slough Restoration Project

Ecosystem Investment Partners

Map Prepared Date: 07/08/19
Map Prepared By: M.D.R.
Checked By: N.C.H.
Job No.: 3195.x

Prepared by:
BLACKBURN CONSULTING

Path: \\FS-01\Common\Active Projects\3195.P DWR Lookout Slough Restoration Project\CAD\CACHE_HAAS SLOUGH TM FIGURES\3195.x Fig1A LSRP Past Performance Map.dwg



Segment 155 levees were initially constructed by local interests. According to an early topographic map (Doc-8590), initial construction occurred after 1906. The levees were probably constructed using dredge materials (likely to be clayey materials) from the channels. The CLD mentions a levee raising between LM 4.0 and LM 4.24, but no other information is available.
According to the available information, there are no documented reports of slope instability, through seepage, or underseepage past performance events.

Repeated extensive wave wash erosion at multiple sites along Segment 314 levees. Revetments placed at multiple sites along the entire segment and at several sites, repeated repairs made over the years. Multiple PL 84-99 erosion repairs performed in '96 on waterside from damage in '86. Several repairs failed during '97 and '98 floods. Levee maintenance assessed as “unacceptable” by DWR.

FIGURE 2b, PAST PERFORMANCE MAP
RD 2060 and RD 2104
August 2019

Source: Geotechnical Assessment Report, North NULE Non-Urban Levee Evaluation, RD 2060, Unit 3a, Segment 314 Summary, dated April 2011. Prepared by URS.
Lookout Slough boundary lines and easements provided by Wood Rodgers, Inc., 12/08/2017.
Proposed levee alignment and topography updated11/12/2018.

Ecosystem Investment Partners

Lookout Slough Restoration Project

Map Prepared Date: 04/24/19
Map Prepared By: M. D. Robertson
Checked By: N. C. Hart
Job No.: 3195.x

Prepared by:
blackburn consulting
2491 Boatman Avenue
West Sacramento, CA 95691
www.blackburnconsulting.com

Path: \\FS-01\Common\Active Projects\3195.P DWR Lookout Slough Restoration Project\CAD\CACHE_HAAS SLOUGH TM FIGURES\3195.x Fig1B LSRP Past Performance Map.dwg

This map shows surficial geologic deposits and levees as they existed in 1937. Map units and boundaries are drawn by interpretation of historical aerial photography supplemented by data from historical maps and surveys. For reference, the mapping is superimposed on modern U.S. Geological Survey 7.5' topographic base maps (individual maps referenced below).
Screened back semi-transparent mapping shown on this plate is from Deep Water Ship Channel study area, which is not assessed in this investigation. For clarity, only the surficial geologic map units of this study appear in the explanation.
See accompanying technical memorandum for complete descriptions of map units, process descriptions and methodology.
Adjacent polygons that have identical map unit symbols are employed to delineate sequences of sedimentation and landscape evolution.

Explanation

Underseepage Susceptibility Along Non-Urban Levee Alignment

Very High | High | Moderate | Low

— — -? ·········	Geologic contact; dashed where approximate, dotted where concealed, queried where uncertain. Solid contacts accurate to within 100' of line shown on map; dashed contacts accurate to within about 250' on either side of the line.
	Narrow channel, generally <100 ft in width. Dashed where approximate, dotted where concealed.
	Narrow, tidally influenced channel (<100 ft in width), commonly connected to a larger slough channel.
	Canal
	Levee; artificial fill prism, generally <70 ft in width.
	Borrow pit, generally <70 ft in width.
W 1937	Water; date indicates year of historical dataset.
BP	Borrow pit present in 1937.

Geologic Units

HISTORICAL	AF	Artificial fill, circa 1937.
	L	Levee (made of artificial fill), circa 1937.
	Rob	Overbank deposits; silt, sand, and lesser clay; deposited during high-stage water flow, overtopping channel banks.
	Rcs	Crevasse splay deposits; fine sand and silt with clay deposited from breaching of natural or artificial levees.
	Rch	Channel deposits; well sorted sand and trace fine gravel.
	Rsl	Slough deposits; silt, clay, and sand, fining upward facies, low-energy channel deposits.
	Ril 1906	Intermittent lake; seasonal lake shown on historical topographic maps. Date indicates source data set.
HOLOCENE	Hob	Overbank deposits; silt, sand, and clay; deposited during high-stage water flow, overtopping channel banks.
	Hcs	Crevasse splay deposits; fine sand and silt with clay deposited from breaching of natural levees.
	Hff	Fine-grained alluvial fan deposits; silt and clay with sand.
	Hch	Channel deposits; well sorted sand and trace fine gravel.
	Hsl	Slough deposits; silt, clay, and sand, fining upward facies, low-energy channel deposits.
	Ha	Alluvial deposits, undifferentiated; sand, silt, clay and minor lenses of gravel.
	Hpm	Peat and muck; interbedded peat and organic-rich silt and clay, former tidal marsh deposits, mostly now leveed, drained, and farmed.
	Hn	Basin deposits; fine sand, silt and clay.
	Hs 1937	Marsh deposits; silt and clay, possibly with organic-rich beds; perennially or seasonally submerged. Date indicates year of historical dataset used to map the marsh.
PLEISTOCENE	Pf	Alluvial fan deposits; semi-consolidated silt, sand, sandy clay and fine to coarse subrounded gravel.
	Pf (m)	Alluvial fan deposits of the Montezuma Hills; semi-consolidated sandy silt, sandy clayey silt, clay, sand and minor pebble gravel eroded from the early Pleistocene Montezuma Formation

Stratigraphic Correlation Chart

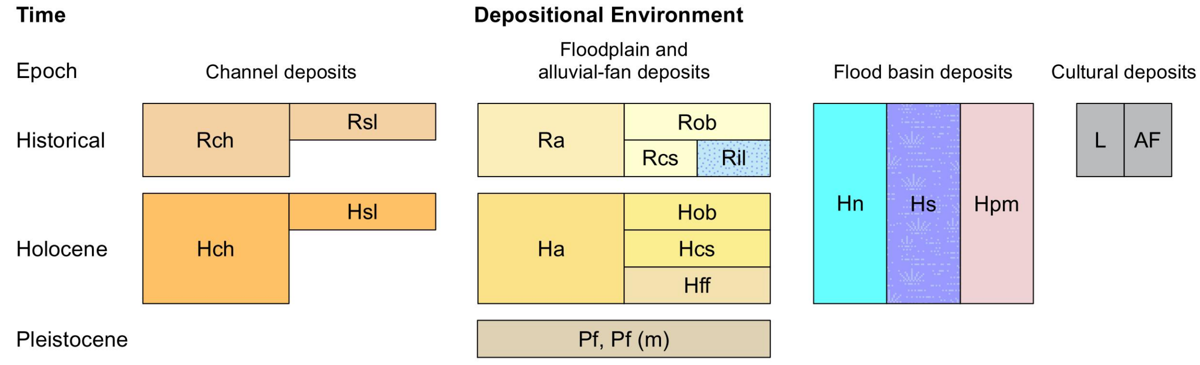


FIGURE 2c, GEOMORPHOLOGY MAP LEGEND
August 2019

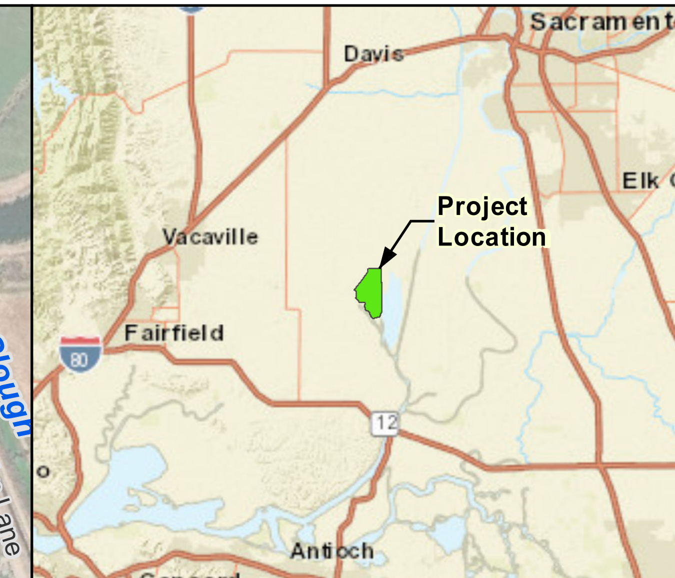
Source: Surficial Geologic Map of the West Delta Study Area, Plate 1 for the North Non-Urban Levee Evaluations. Produced by Department of Water Resources, Division of Flood Management, Levee Evaluations Branch in association with URS and Fugro, Scale is 1"=2000'.

Ecosystem Investment Partners

Map Prepared Date: 07/08/19
Map Prepared By: M.D.R.
Checked By: N.C.H.
Job No.: 3195.x

Prepared by:
BLACKBURN CONSULTING

Path: \\FS-01\Common\Active Projects\3195.P DWR Lookout Slough Restoration Project\CAD\CACHE_HAAS SLOUGH TM FIGURES\3195.x Fig1A LSRP Past Performance Map.dwg



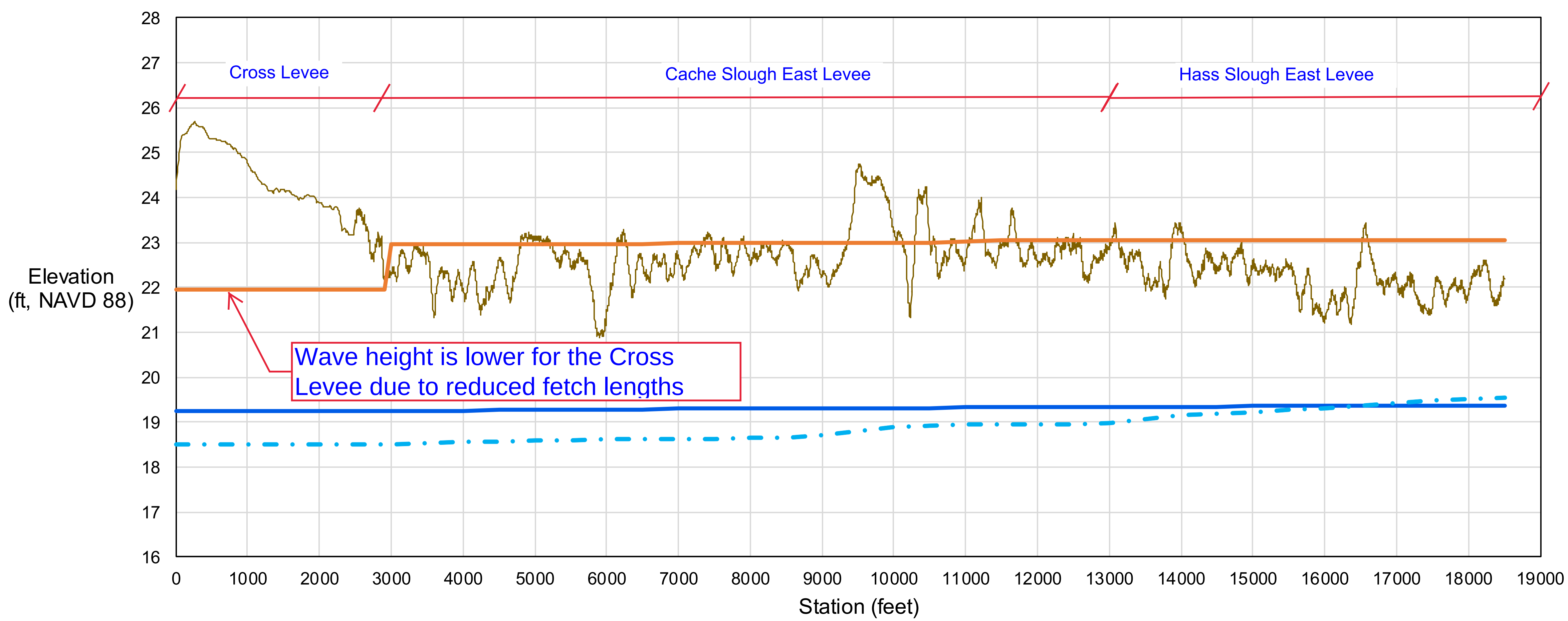
Ecosystem Investment Partners

CACHE/HASS SLOUGH EAST LEVEE PROFILES

SOLANO COUNTY, CALIFORNIA
JULY, 2019

NORTH

0 750 1,500 3,000
FEET



- Existing Cache Slough Levee Alignment
- Existing Top of Levee
- 1% AEP (100-year) Baseline Condition with-Project Water Surface Elevation
- 1957 Authorized Design Water Surface Profile
- Maximum Wave Hieght (3.7-Feet Above 1% AEP (100-year) Baseline Condition with-Project Water Surface Elevation)

PRELIMINARY

WOOD RODGERS

J:\3000-s\3487_Ecosystem_Invest_Partners\3487002 Lookout Slough Prelim Hydraulic Analysis\GIS\Tasks\20190724_100YR_WSEL_Wind_Wave_Exhibit_Cache_Slough\FXX_100YR_WSE_Wind_Wave_Exhibit_Cache_Slough.mxd 7/25/2019 3:53:33 PM cmilligan

FIGURE 3

This Page Intentionally Left Blank

Appendix F – 65% Progress Design Earthwork Estimates

This Page Intentionally Left Blank

Lookout Slough Tidal Habitat Restoration and Flood Control Improvement Project

65% Progress Design Earthwork Estimates

	Estimated Fill (CY)			Estimated Excavation		
	Structural Fill Needed (CY)	**Spoil / Misc Fill Needed**	**Total Fill**	**Excavated Material that is Suitable for Fill**	**Spoiled Excavation**	**Total Est. Excavation**
Lookout Slough Setback Levee						
4:1 Setback Levee Embankment & Landside Patrol Road	1,460,000	-	1,460,000			-
Levee Embankment Foundation Prep	126,560	-	126,560		113,000	113,000
Subtotal Lookout Slough Setback Levee	*1,586,560*		*1,586,560*		*113,000*	*113,000*
Cache Slough Levee Improvements						
Degrade and Slope Flattening Improvements	-	55,000	55,000		67,500	67,500
Flattening Foundation Prep.	-	61,600	61,600		55,000	55,000
Subtotal Cache Slough Levee Improvements		*116,600*	*116,600*		*122,500*	*122,500*
Other Items						
Fill Irrigation Canal on the east side of Duck Slough embankment	199,010		199,010		43,300	43,300
Muck Out / Overexcavate Duck Slough	-				56,296	56,296
Southern Shag Slough 1500' Degrade to 10-yr WSE	-				32,000	32,000
Northern Shag Slough 1500' Degrade to 10-yr WSE	-				36,500	36,500
Shag Degrade Spoil Berm/Redistribution onsite		68,500	68,500			
Lookout Slough Degrade and Fill		320,000	320,000		425,000	425,000
Muck Out / Overexcavate Lookout Slough					162,448	162,448
Misc. Site Berm, High Ground Degrade to Elev. 5.5+/-, and misc irrigation ditch fill		200,000	200,000		367,000	367,000
Shag Breach 1 (Northernmost Breach)	-				20,000	20,000
Shag Breach 2	-				24,000	24,000
Shag Breach 3	-				26,000	26,000
Shag Breach 4	-				28,000	28,000
Shag Breach 5	-				39,000	39,000
Shag Breach 6	-				34,000	34,000
Shag Breach 7	-				27,500	27,500
Shag Breach 8	-				29,000	29,000
Shag Breach 9 (Southernmost Breach)	-				33,750	33,750
Vogel Grading					25,600	25,600
Onsite Channels (725,000 CY to levee)	-			1,337,700	442,300	1,780,000
Spoil Areas (Current Volume is Estimated)		1,450,000	1,450,000			0
Setback Levee Borrow Pit / Habitat Grading Area Between PGE Roads	-			861,000	825,000	1,686,000
GGS Ponds	-				108,000	108,000
PG&E Access Roads & Ramps	107,000	120,500	227,500			-
PG&E Access Road Foundation Prep.	40,320		40,320		36,000	36,000
Subtotal Other Items	*346,330*	*2,159,000*	*2,505,330*	*2,198,700*	*2,820,694*	*5,019,394*
Estimated Total For All Items	**1,932,890**	**2,275,600**	**4,208,490**	**2,198,700**	**3,056,194**	**5,254,894**

This page intentionally left blank.