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July 31, 2015

Via E-Mail

Sean Sheldrake
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Re: Supplemental RI/FS Work at the River Mile 11E Project Area
Portland Harbor Superfund Site (PHSS)
Transmittal of the Draft Implementability Study Report

Dear Mr. Sheldrake:

The Draft Implementability Study Report for the River Mile (RM) 11E Project Area is enclosed for your review. The report was prepared by Dalton, Olmsted & Fuglevand, Inc. (prime consultant), David Evans and Associates, Inc. (mapping subconsultant), Geotechnical Resources Inc. (geotechnical subconsultant), and KPFF Consulting Engineers (structural subconsultant) on behalf of Cargill, Inc.; CBS Corporation; City of Portland; DIL Trust; Glacier Northwest, Inc.; and PacifiCorp, collectively referred to as the RM11E Group. The Implementability Study Report identifies and assesses the site conditions that will need to be considered and addressed as part of the remedial design for the site. It also identifies remedial technologies for sediment remediation that can be adapted to those site conditions.

We are e-mailing you a copy of the main report with tables and figures merged into a single PDF. Due to the size of some of the appendices, we are transmitting those to you through a link to the **HIGHTAIL** File Delivery Service that also includes a pdf of the main report. Please let me know if you or any of your partners would like to receive a copy of the report on a CD. As provided for in the March 2013 Settlement Agreement, two hard copies of the report will be sent to the Oregon Department of Environmental Quality.

Please do not hesitate to contact me if you have any questions. The River Mile 11E Group looks forward to receiving and addressing comments on the draft report from EPA and your project partners.

Sincerely yours,

Jacqueline Thiell Wetzsteon
RM11E Project Coordinator

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Stephen Whittington, KPFF Consulting Engineers

Draft Implementability Study Report

Supplemental
Remedial Investigation/Feasibility Study

River Mile 11 East
Portland, Oregon

July 2015

Prepared for
RM11E GROUP

Prepared by
Dalton, Olmsted & Fuglevand, Inc.
With
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Appendix A - Digital Data Catalog

Appendix B – Waterfront Facilities Activities Questionnaire Responses

Appendix C – Shoreline References

Appendix D – Inclinometer Data

Appendix E – RM11E Project Area Boring Logs

Appendix F – GRI's April 7, 2015 Geotechnical Data Report

ABBREVIATIONS AND ACRONYMS

3D	three-dimensional
ACES	Automated Coastal Engineering System
AOPC	Area of Potential Concern
ARAR	applicable or relevant and appropriate requirement
BES	Bureau of Environmental Services (City of Portland)
BRKSTN	breakstone
Cargill	Cargill Inc., currently operated by Temco Inc.
CDF	confined disposal facility
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
City	City of Portland
CMP	corrugated metal pipe
CORS	Continuous Operating Reference Station
CRD	Columbia River Datum
CSP	corrugated steel pipe
CY	cubic yard
D_{50}	median particle size for soil/sediment gradation
dBA	decibels on the A-weighted scale
DEA	David Evans and Associates, Inc.
DEM	Digital Elevation Model
DOF	Dalton, Olmsted & Fuglevand, Inc.
DTM	digital terrain model
EMNR	enhanced monitored natural recovery
EPA	U.S. Environmental Protection Agency
FGIS	Federal Grain Inspection Service
FOIA	Freedom of Information Act
fps	feet per second
FS	feasibility study
ft	feet
Glacier NW	Glacier Northwest, Inc.
GPS	global positioning system

GRI	Geotechnical Resources, Inc.
GSI	GSI Water Solutions, Inc.
H:V	horizontal-to-vertical (ratio)
in	inches
Irving Terminal	Cargill grain elevator and terminal, currently operated by Temco Inc.
kHz	kilohertz
KPFF	KPFF Consulting Engineers
kV	kilovolt
LD	Louis Dreyfus
LiDAR	light detection and ranging
LWG	Lower Willamette Group
MNR	monitored natural recovery
NAD83	North American Datum of 1983, Oregon State Plane North (horizontal datum)
NAD83/96	North American Datum of 1983 (CORS96)
NAVD88	North American Vertical Datum of 1988
NOAA	National Oceanic and Atmospheric Administration
ODEQ	Oregon Department of Environmental Quality
ODFW	Oregon Department of Fish and Wildlife
ODOT	Oregon Department of Transportation
ODSL	Oregon Department of State Lands
OHW	ordinary high water
OLW	ordinary low water
pcf	pounds per cubic foot
PHSS	Portland Harbor Superfund Site
PHSS Draft FS	Portland Harbor Superfund Site draft Feasibility Study (Anchor QEA et al., 2012)
PM	project mile
psf	pounds per square foot
PVC	polyvinyl chloride
Questionnaire	Waterfront Facilities Activities Questionnaire
RAL	remedial action level
RAO	remedial action objective
RCP	reinforced concrete pipe

RI	remedial investigation
RI/FS	remedial investigation and feasibility study
RIS&G	Ross Island Sand and Gravel
RM	river mile
RM11E	River Mile 11 East (Project)
ROD	Record of Decision
S	qualitative indicator of displacement
Sakrete	Sakrete of Pacific Northwest
SOW	Statement of Work
Temco	Temco Inc., current operator of Cargill
tiff	tagged image file format
USACE	U.S. Army Corps of Engineers
USC&GS	U.S. Coast and Geodetic Survey
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VSP	vitrified (clay) sewer pipe
Work Plan	Final Supplemental RI/FS Work Plan for RM11E

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1. INTRODUCTION AND SITE SETTING

1.1 GENERAL

This Implementability Study Report for the River Mile 11 East (RM11E) Project Area of the Portland (Oregon) Harbor Superfund Site (PHSS) was prepared by Dalton, Olmsted & Fuglevand, Inc. (DOF) as prime consultant, with support from David Evans and Associates, Inc. (DEA) as mapping subconsultant, Geotechnical Resources, Inc. (GRI) as geotechnical subconsultant, and KPFF Consulting Engineers (KPFF) as structural subconsultant. The document was prepared on behalf of Cargill, Inc. (Cargill), CBS Corporation, City of Portland (City), DIL Trust, Glacier Northwest, Inc. (Glacier NW), and PacifiCorp, collectively referred to as the RM11E Group.

This report is part of the RM11E Supplemental Remedial Investigation and Feasibility Study (Supplemental RI/FS). The Final Supplemental RI/FS Work Plan (Work Plan) for RM11E (DOF/GSI, 2013) provides a detailed description of the work being conducted pursuant to the Statement of Work (SOW) contained within the Administrative Settlement Agreement and Order on Consent (U.S. Environmental Protection Agency [EPA] Region 10, Comprehensive Environmental Response, Compensation, and Liability Act [CERCLA] Docket No. 10-2013-0087). The RM11E investigation supplements the PHSS Draft Remedial Investigation (RI) Report (Integral et al., 2011) and the Draft Feasibility Study (PHSS Draft FS) Report (Anchor QEA et al., 2012) to inform selection and design of a final remedy at the RM11E Project Area. Portions of this Implementability Study Report use information presented in the PHSS Draft Final RI Report and Draft FS Report, which are currently under review by EPA. The findings of the Final PHSS RI/FS will be incorporated during remedial design for the RM11E Project Area.

The RM11E Project Area lies between approximately river mile (RM) 10.9 and RM 11.6 along the east bank of the Willamette River. It includes Area of Potential Concern (AOPC) 25 (from the PHSS Draft FS) and the shoreline[1] area to the top of the bank (Figure 1.1). The shoreline area includes numerous waterfront structures and public and private stormwater outfalls.

The Implementability Study Report assesses how the current site configuration, human activities (e.g., navigation, commerce), and river dynamics may impact the selection of a remedy. The Implementability Study Report identifies and assesses the site constraints that will need to be considered and addressed as part of the remedial design for the RM11E Project Area. It also identifies remedial technologies for sediment remediation that can be adapted to site constraints.

1.2 ENGINEERING ASSESSMENTS

This report is based on six engineering assessments of the RM11E Project Area:

- Mapping of bathymetry and of a PacifiCorp submarine cable crossing the Willamette River
- Waterfront activities and use assessment

[1] For purposes of this report and analysis, shoreline is defined as the slope from the relatively flat river bottom to the top of the bank.

- Debris survey
- Geotechnical assessment
- Structural assessment
- Hydrodynamic assessment

The engineering assessments address two broad categories of potential active remediation at the RM11E Project Area:

- Cap/Cover – placement of granular material on the riverbed over contaminated sediment
- Dredging – removal of contaminated sediment from the RM11E Project Area

The engineering assessments provide information that is also applicable to other remedy approaches such as monitored natural recovery (MNR), enhanced monitored natural recovery (EMNR), active capping, and in situ treatment as discussed in Section 9 of the report.

The scope of work for each of the six engineering assessments is summarized below with the findings detailed in separate sections of this report.

1.2.1 MAPPING ASSESSMENT

An array of topographic and bathymetric data for the RM11E Project Area is currently available from multiple sources and studies. The following tasks were completed for this report:

- Compiled existing bathymetric sonar data, airborne light detection and ranging (LiDAR) data, and vessel LiDAR data for the RM11E Project Area
- Constructed a detailed terrain model, including both upland topography and riverbed bathymetry for assessment of slope stability, containment options, constructability, and other key implementation factors
- Mapped the location of submarine power distribution cables that transect the RM11E Project Area to provide information on existing infrastructure.
- Mapped existing dock structures and supporting piles at Cargill and Glacier NW to support analysis of possible constraints on remedial alternatives
- Mapped locations of submerged debris to facilitate engineering assessment of possible constraints on remedial alternatives
- Compiled and modeled prior bathymetric surveys in PHSS conducted during an 8-year period by Lower Willamette Group (LWG) to facilitate engineering assessment of riverbed and slope stability

The results of the mapping assessment are presented in Section 2 of this report.

1.2.2 WATERFRONT ACTIVITIES AND USE ASSESSMENT

Current and projected in-water operations and utilities are summarized in Section 3, including loading and unloading activities, types of vessel traffic within the RM11E Project Area, and other activities associated with the various waterfront properties. Maintaining navigation access and minimizing disruption to ongoing shipping activities and utilities are important considerations for future remedial action. The analysis considers potential problems during implementation of

a remedy resulting from waterfront activities and the presence of utilities, including PacifiCorp's submarine cable crossing, as well as the implications of business disruption.

Projected maintenance dredging operations, including private dredging at the shoreside terminals and federal dredging of the navigation channel, are summarized, based on historical dredging at these locations and anticipated adjustments by the U.S. Army Corps of Engineers (USACE) and property owners. Changes to the shoreline alignment over time are also summarized, based on changes of the top of the bank and nearshore slopes revealed from bathymetric surveys (where available), aerial photographs, historical documents, and interviews of property owners (where possible).

1.2.3 DEBRIS SURVEY

A survey of in-water debris within the RM11E Project Area was conducted. The following tasks were completed for the debris survey; results are presented in Section 4:

- Mapped riverbed debris from multibeam sonar data
- Mapped former structures using information showing historical shoreline buildings, docks, and structures
- Interviewed local dredge operators and others familiar with the area

1.2.4 GEOTECHNICAL ASSESSMENT

Shoreline and upland soils were assessed to identify design and remedial action implementability concerns associated with shoreline slopes. The geotechnical characteristics of sediment were also evaluated for implementability purposes, including dredging setbacks from docks and in-water structures. The following tasks were completed for the geotechnical assessment; the results are presented in Section 5:

- Compiled existing geotechnical information and reports from RM11E shoreline property owners
- Completed geotechnical exploration borings, and installed inclinometers at three upland locations, and took inclinometer readings at installation and after 6 months
- Prepared geotechnical cross sections at three locations, performed preliminary assessment of slope stability along the shoreline, and provided initial geotechnical design guidance regarding slope stability
- Developed illustrative earth pressure diagrams for use in assessment of existing structures

1.2.5 STRUCTURAL ASSESSMENT

The configuration and integrity of existing infrastructure was generally evaluated to identify potential impacts to remedy selection and design elements. Where possible, the effort included coordination with property owners to review information regarding dock construction, condition, and history. The following tasks were completed for the structural assessment; results are presented in Section 6:

- Compiled existing drawings of the structures, where available from the property owners
- Compiled readily available information describing dock construction materials, foundations, other surface and subsurface components, repair history, condition, and design details

- Assessed the potential effects of dredging or capping at or beneath existing structures
- Developed preliminary guidance to mitigate adverse impacts on existing structures from dredging or capping

1.2.6 HYDRODYNAMIC ASSESSMENT

The potential for river dynamics (natural and anthropogenic) to impact remedial design has been assessed through the following tasks, the results of which are discussed in Section 7:

- Compiled and reviewed existing hydrodynamic data, studies, and assessments, including reports for the PHSS RI/FS and bathymetric data from LWG and USACE
- Made field observations of site conditions of wake generation, wave interactions with shoreline and structures, and evidence of large-scale eddy conditions
- Tabulated hydrodynamic factors and discussed potential impacts specific to RM11E dredging and capping from ship wakes, wind-generated waves, propeller wash, river currents, and potential eddies

1.3 SITE SETTING

The RM11E Project Area setting is detailed in Section 3 of the Work Plan for RM11E and is summarized below.

1.3.1 PHYSICAL SETTING AND SITE FEATURES

As in the rest of PHSS, the river within the RM11E reach was redirected, straightened, filled, and deepened during the last century to make it useable for navigation and commercial shipping operations. The hydrology of PHSS is controlled by a variety of natural and anthropogenic factors, including contributing flows from the Willamette River Basin, tidal fluctuation from the Columbia River Estuary, operation of dams on the Willamette and Columbia rivers, and channel modifications.

Physical features of the RM11E Project Area include remnant structures related to historical shoreline activities and structures associated with current and ongoing industrial and marine operations. Existing industrial facilities within the RM11E Project Area are depicted in Figure 1.2 and discussed below.

The RM11E Project Area contains several active docks associated with current operations at waterfront properties, including Cargill, Glacier NW, and Ross Island Sand & Gravel (RIS&G). Other exposed in-water structures include fields of remnant piles (e.g., behind the Cargill dock), and dolphins (e.g., along the shoreline near RM 11.1) placed in the river for navigational, operational, or engineering purposes. Submerged debris is abundant in the RM11E Project Area and consists of natural (e.g., logs), anthropogenic (piles and other structures), and unidentified objects.

The shoreline along RM11E is steep and has been locally reinforced for erosion control and stabilization of ongoing waterfront operations. Stabilization measures along the shoreline include a mix of armoring (e.g., riprap), shoreline bulkhead walls, and heavy vegetation (GSI, 2010; Black & Veatch, 2011). Several stormwater outfalls discharge along the shoreline to the RM11E Project Area. These include outfalls owned by the state, City, and waterfront industries.

PacifiCorp owns a submarine electric power cable crossing (seven-cable medium-voltage) that extends from the Albina Substation to the west side of the river. Providing power to a portion of downtown Portland, this element of infrastructure is referred to as the submarine cable crossing within the report.

1.3.2 PROPERTY OWNERSHIP AND OPERATIONS

The following is a description of the properties and their current operations in the immediate vicinity of the RM11E Project Area. Details of historical site ownership by tax lot are provided in the LWG compilation document (LWG, 2007; Section 3.3.1.1).

1.3.2.1 Upland Ownership and Operations

Most of the upland properties adjacent to the RM11E Project Area continue to be used for industrial purposes; however, since the mid-1980s some have been converted to commercial uses (e.g., artist studios). Ownership of the upland properties in the immediate vicinity of the RM11E Project Area is depicted in Figure 1.2. The following are brief descriptions of current property operations from upstream to downstream within the RM11E Project Area.

- *Cargill* — Cargill owns a grain elevator and terminal (Irving Terminal) that provides interim bulk storage for transfer of grain to and from trucks, rail cars, barges, and ships. Temco currently operates the terminal. Main features on the property are reinforced concrete grain silos, conveyor systems, enclosed grain processing, a rail grain dump station, a truck grain dump station, and shipping and unloading equipment (Black & Veatch, 2011).
- *Unkeles* – The River Street studios are a collection of artists' studios.
- *Glacier NW* – The Glacier NW property is a bulk cement distribution terminal and the regional headquarters for Glacier NW's Oregon and southwest Washington operations. No manufacturing or processing occurs at this property. Bulk cement is delivered by ship, pneumatically conveyed to the storage buildings (silos and dome), and then loaded into customer trucks and railcars for offsite delivery. The property includes 15 storage silos with capacities ranging from 1,000 to 6,500 tons and a cement storage dome with a capacity of 30,000 tons. The property also includes two covered truck loading and scale areas (ERM, 2011).
- *RIS&G* — RIS&G operates a concrete batch plant in the southwestern portion of its property and leases the remainder to KF Jacobsen & Co. (KF Jacobsen's operations are described below). The property includes a clamshell bucket crane and a barge dock that are used for delivering aggregate raw materials for use in both facilities. The crane unloads the aggregate from barges into hoppers that convey the materials to storage piles located at either property. The RIS&G property also accepts broken concrete pavement (construction debris), which is loaded onto barges at the dock and transported upstream to the Ross Island Lagoon for use as clean fill material. Operations include use of a river water pump to help make up the needed water for the concrete batch process (City, 2009).
- *KF Jacobsen & Co.* — KF Jacobsen leases a portion of the RIS&G property as well as the adjacent Oregon Department of Transportation (ODOT) property (under the Fremont Bridge) for its Albina Asphalt Plant. The plant is a "hot mix" asphalt plant using recycled asphalt, aggregate, hot asphalt, and sand to make asphalt paving. In addition to receiving aggregate from the barge dock it shares with RIS&G, the property receives recycled

asphalt by truck. The recycled asphalt is crushed onsite and conveyed to storage piles placed under the Fremont Bridge (City, 2009).

- *Stan Herman Warehouse* — According to a 2011 survey form submitted to the City, the warehouse is used for storage by Advanced M&D Sales (a tile and flooring company). No waterfront activities are known.
- *Sakrete of Pacific Northwest (Sakrete)* — Central Premix Concrete Products Co. combines Portland cement and aggregates to be bagged and resold at the Sakrete property. Aggregates and cement are received in bulk quantities via truck. Aggregate is unloaded on the ground into bunker areas, while the cement is pneumatically pumped into a closed silo vented to a baghouse (Central Premix, 2012). Based on aerial photos and observation, the property appears to include an inactive dock.
- *PacifiCorp Albina Substation* — The Albina Substation is an unmanned transmission and distribution substation where incoming 115 kilovolt (kV) transmission lines are stepped down to 11 kV for distribution to residential, commercial, and other customers. The substation is located on a three-square-block area between N. Lewis and N. Harding Avenues, and N. River and N. Randolph Streets. PacifiCorp owns a submarine cable crossing that extends from a cable vault on the Unkeles property to the west side of the river.
- *Tarr, Inc.* (Tarr) — The Tarr property is currently used to store and handle chlorinated and nonchlorinated solvents, lubrication oils, and fuels. Operations include three warehouses, a maintenance shop (leased to a third party for unrelated activities), a diesel and gasoline fuel dispenser, and three aboveground storage tank farms. Chlorinated solvents currently are handled only in prepackaged drums (Ash Creek, 2011).
- *City Outfall System* — The City operates and maintains the conveyance systems within Outfall Basins 43, 44, 44A, and 45. Two of these basins include a combined sewer system and a separated storm system, which serve the industrial area adjacent to the river. A portion of Outfall Basins 43 and 44A was diverted to the City's wastewater treatment plant in 2011.
- *ODOT Outfall System* — ODOT operates and maintains the Outfall WR-306 stormwater conveyance system that serves the Interstate-405 and Interstate-5 freeways.
- *Private Outfall Systems* – Most of the shoreline properties in the RM11E Project Area have private outfalls, which are described in Section 3.

1.3.2.2 Overwater and In-Water Operations

Offshore operations in the RM11E Project Area include ship transits, ship loading/unloading, other overwater activities for operations at the waterfront industrial properties, and in-water dredging as required to maintain usability of the docks, as summarized below and detailed in Section 3.

Active industrial docks are present offshore of the Cargill, Glacier NW, and RIS&G properties. Marine shipping activities at each property are summarized below.

- *Cargill* — Ships using the docks at the Irving Terminal are under the operation and control of the ship's captain or an independent river pilot and are typically foreign-flagged vessels. Tugboats provided to the ships by third parties assist the ships and barges that

dock at the property. Ships using the Irving Terminal dock may be as long as 765 feet and 106 feet wide ("Panamax" class vessels). Depth of draft of ships may be up to 40 feet. Ships dock at the Irving Terminal as often as five times a month, typically for a period of less than a week while loading grain primarily for international export. Much smaller shallower-draft barges use the separate barge dock at the south (upstream) end of the Cargill property (outside of but adjacent to the RM11E Project Area) to deliver grain to the Irving Terminal for transfer to export-bound ships. The barge dock is busy most days of the month, with up to 48 barges docking a month during the busy season.

- *Glacier NW* — The Glacier NW property has two docks. The main (upstream) dock consists of two sections used to offload cement from ships, with each section being about 100 feet long. The sections of this dock are connected by a gangway that allows for pedestrian and small equipment traffic. A smaller (downstream) dock is used only for short-term mooring by Tidewater Barge Lines.

  Ships delivering cement to Glacier NW's main dock are owned by third parties and are under the operation and control of the ship's captain or an independent river pilot. Third-party tugboats assist these ships when they arrive at and depart from Glacier NW's main dock. Vessels serving Glacier NW may be as long as 578 feet and 92 feet wide ("Handy" class vessels). Depth of draft of ships may be up to 20 feet when empty and 30 feet when loaded. Vessels arrive at Glacier NW's dock loaded and leave lightened or empty, drafting significantly less water when they depart than when they arrive. Ships may dock at the Glacier NW property 20 to 40 times per year; the number of ships varies with market demand for cement.

- *RIS&G* — The RIS&G property has one dock, which is used for loading and offloading construction debris and aggregate from barges. RIS&G has indicated that the facility loads and unloads sand and gravel barges daily, at an average rate of two barges per day.

The upland area east of the RM11E Project Area is referred to as the Historic Albina Riverlots Area and has been used for industrial purposes since the late 1800s. A summary of the known significant historical marine operations in the RM11E Project Area, as described in the LWG compilation document (LWG, 2007; Section 3.3.1.1) is provided below:

- *Albina Engine and Machine Works* —Before filling in the mid-1950s, a portion of the waterfront area was occupied by docks used by the Albina Engine and Machine Works, a shipyard active in shipbuilding at various times in various portions of the RM11E Project Area during World War I, World War II. Until 1973, ship repairs were undertaken at a repair dock located at the upstream end of their property; the remnants of a crane tramway from this former shipyard are visible along the shoreline near the downstream portion of the Cargill property.

- *Portland Fire Boat #2* — Before filling, a portion of the waterfront area, currently occupied by the Unkeles property, was occupied by the Portland Fire Boat #2 station between approximately 1923 and 1950.

1.4 PROJECT MILE BASELINE

A project baseline has been established for the purpose of referencing locations of various site features within this report. As shown on Figure 1.2, the project baseline runs roughly parallel to the shoreline and is positioned at or near the east edge of Willamette River navigation channel.

The stationing is identified as project mile (PM), with each 0.1 mile along the project baseline shown on Figure 1.2. More detailed figures within this report show the PM stationing every 0.01 or 0.02 mile (~53 or ~106 feet, respectively).

This project baseline (shown in blue on Figure 1.2) differs from the Willamette River navigation channel line located near the center of the river (shown in white on Figure 1.2) as established by the USACE. The stationing of the channel line is identified as RM and shown every 0.1 mile on Figure 1.2. The two stationing lines differ because the bends and angles of the project baseline make it longer than the straight navigation channel line.[2]

1.5 PROJECT DATUM

The horizontal datum is the reference system used to establish the mapping coordinates of the site and site features. The horizontal datum used in this report is Oregon State Plan North (North American Datum of 1983 [NAD83]).

The vertical datum is the reference system used to establish the elevations of the site and site features. Two vertical datums are used in this report:

- North American Vertical Datum of 1988 (NAVD88)
- Columbia River Datum (CRD)

The NAVD88 vertical datum is based on a leveling network on the North American continent that ranges from Alaska, through Canada, and across the United States, affixed to a single origin point on the continent (NOAA, 2014b). It is a fixed vertical datum that does not change along the length of the Willamette River.

The CRD is commonly used on the Willamette River, primarily for vessel navigation and associated dredging. CRD is a USACE nontidal gradient datum that changes with respect to NAVD88 along the length of the river to reflect the gradient of the river. CRD is an adopted low-water reference value based upon river gauge observations at distinct river miles, with linear interpolation applied between defined locations (NOAA, 2014a). CRD is defined at distinct river miles relative to NAVD88 above Columbia River RM 23. Figure 1.3 relates CRD and NAVD88 within the RM11E Project Area as of 2013.[3]

Within this report, elevations are identified as CRD or NAVD88. CRD is the primary vertical datum in discussions involving navigation or vessel traffic, and NAVD88 is the primary vertical datum for all other discussions.

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[2] The project baseline also differs by approximately 60 feet from the RM lines presented in the PHSS RI/FS reports and previous RM11E project documents.

[3] In the PHSS Draft FS, the difference between CRD and NAVD 88 is shown as 5.0 feet. As shown on Figure 1.3, the average value of this conversion for the RM 11 site is 5.3 feet based on 2013 data provided by DEA. The precise relationship between NAVD88 and CRD should be established again at time of design and time of construction as the conversion factor is dynamic and changes over time.

1.6 REPORT ORGANIZATION

The Implementability Study Report presents the information described in Section 9.3 of the Work Plan. The Work Plan identifies five report components (Introduction, Site Setting, Summary of Information, Implementability Considerations, Conclusions and Recommendations). Those components are incorporated into the following 10 sections of this report:

- Section 1 – Introduction and Site Setting
- Sections 2-7 – Summary of Information
  - Section 2 – Mapping (by DEA)
  - Section 3 – Waterfront Activities and Use Assessment
  - Section 4 – Debris Survey
  - Section 5 – Geotechnical Assessment (by GRI)
  - Section 6 – Structural Assessment (by KPFF)
  - Section 7 – Hydrodynamic Assessment
- Section 8 – Summary of Factors that Affect Implementability
- Section 9 – Implementability Considerations
- Section 10 – Conclusions and Recommendations

References cited in the text are listed in Section 11.

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1.7 SECTION 1 FIGURES

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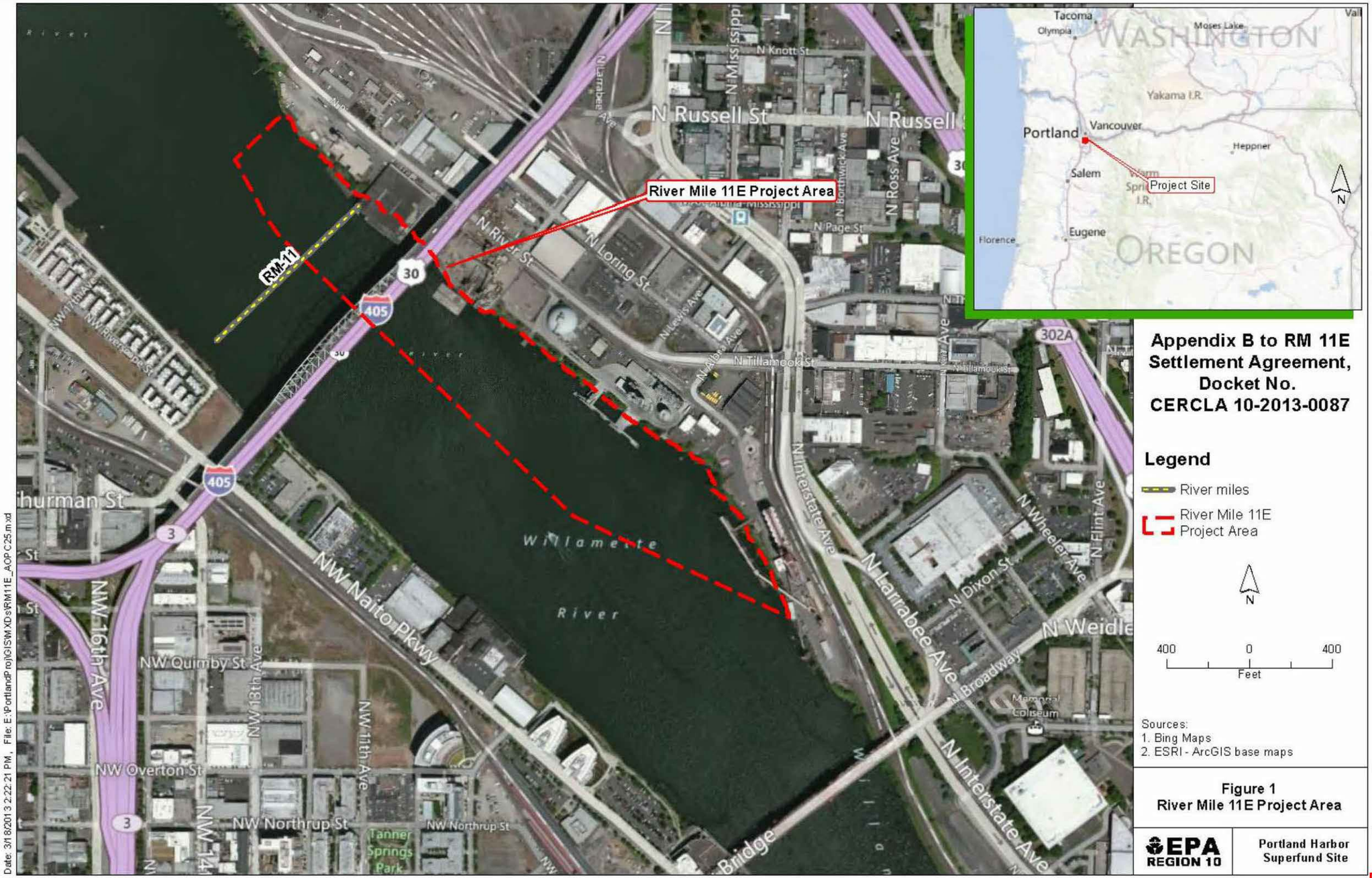

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Draft Implementability Study Report

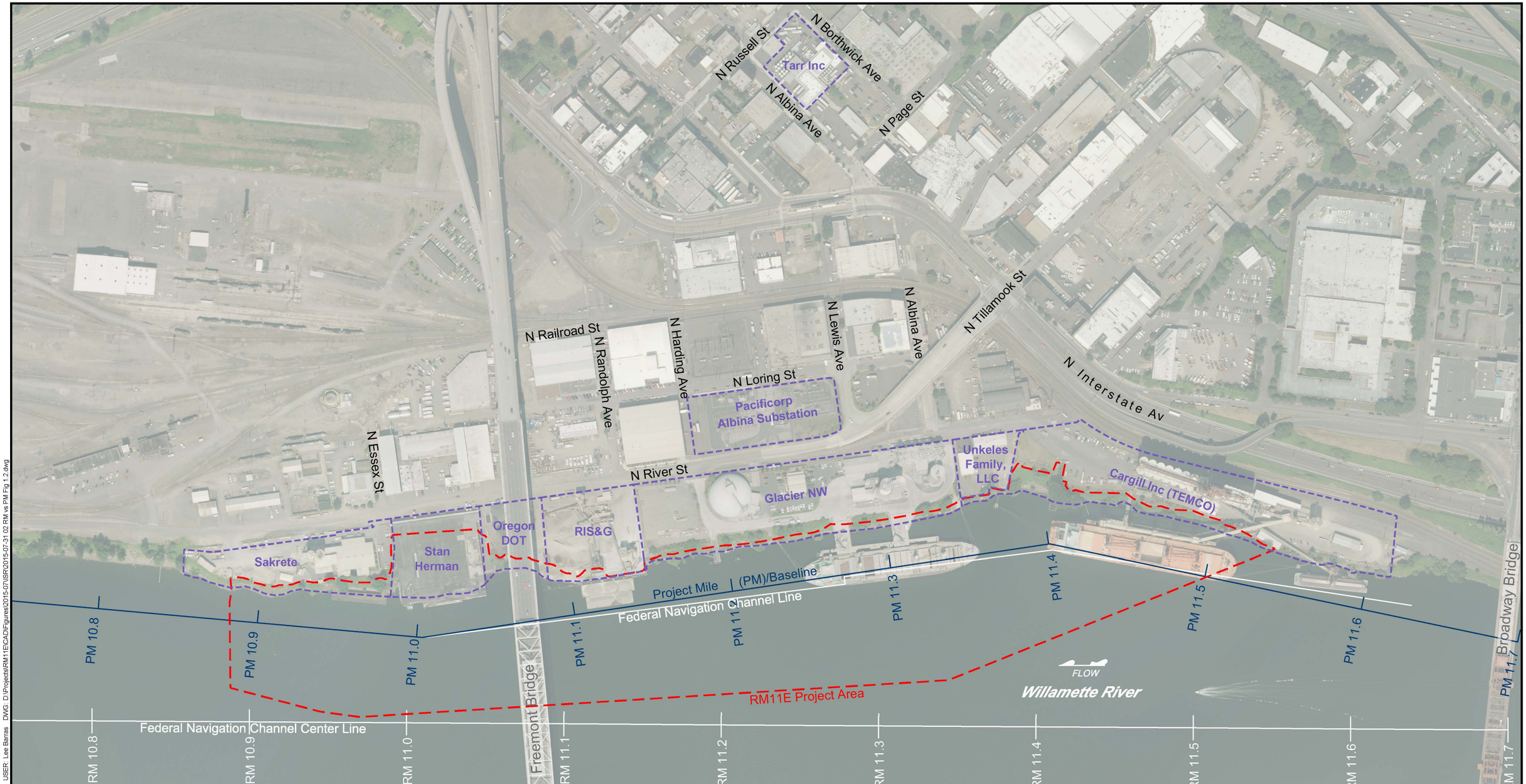
RM11E Project Area

DALTON OLMSTED FUGLEVAND

Figure 1.1

July 31, 2015

PLOT TIME: 7/31/2015 11:05 AM MOD TIME: 7/31/2015 10:42 AM USER: Lee Barras DWG: D:\Projects\RM11E\CAD\Figures\2015-07\NSR\2015-07-31 01 Project Area Fig 1.1.dwg



MAP NOTES

1. The locations of all features shown are approximate.
2. The Project Mile (PM) designation is a project baseline established by DOF for the purpose of referencing locations of various site feature within this report.
3. Horizontal datum is referenced to Oregon State Plane North NAD83 (international feet).
4. Tax lot boundary generated by METRO (Oct. 2013). Data layer acquired from GSI.
5. Background Image - METRO (Summer 2013).

LEGEND

Stationing Description

Federal Navigation Channel (USACE)

RM 11.2 River Mile (RM) Stationing

PM 11.2 Project Mile (PM) Stationing

Other Features

Tax Lot Boundary (Oct. 2013)

RM11E Project Area

0 300
Scale in Feet

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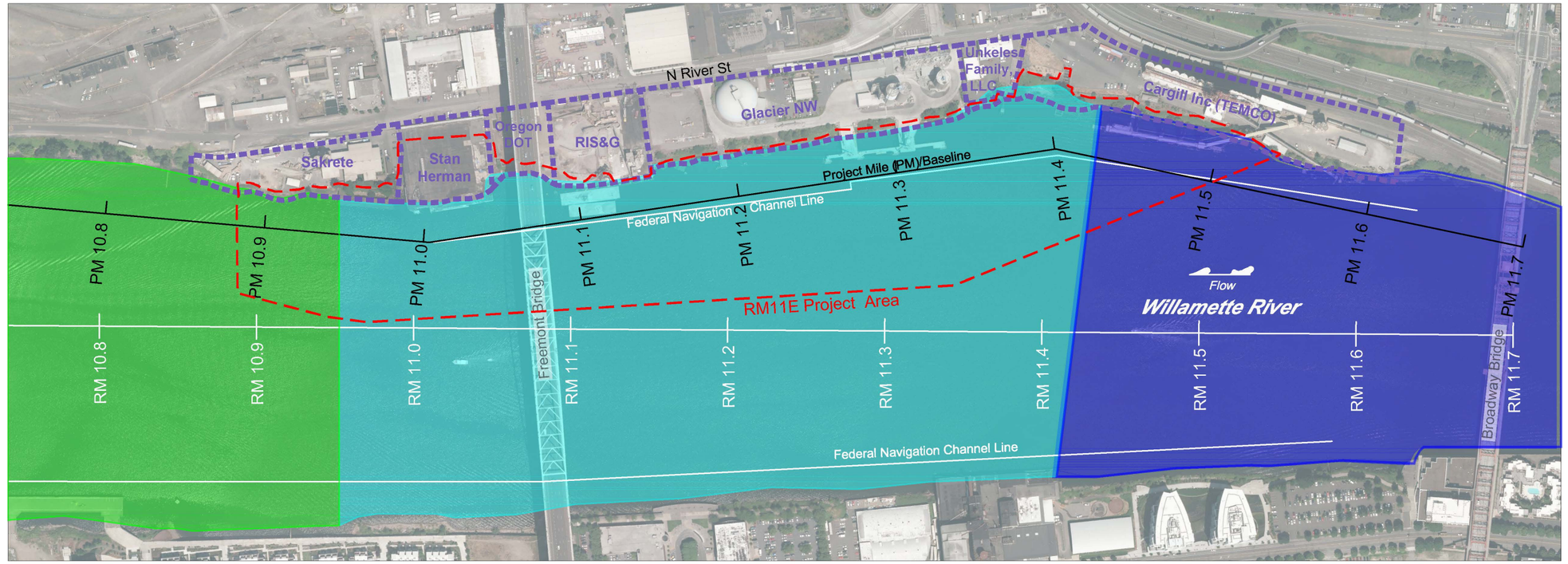
Project Mile (PM)
versus
USACE Navigation Channel Stationing (RM)

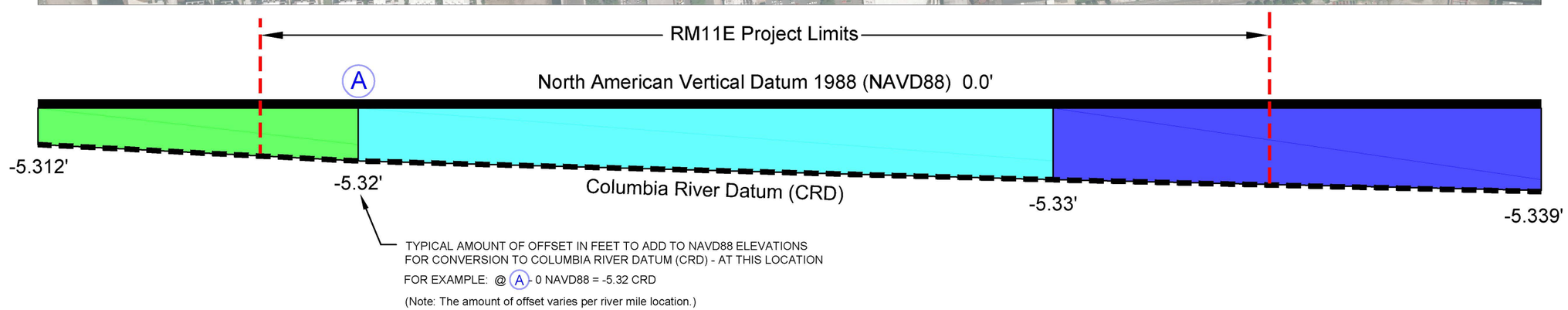
DALTON OLMSTED FUGLEVAND

Figure 1.2

July 31, 2015

PLOT TIME: 7/31/2015 11:05 AM MOD TIME: 7/31/2015 10:42 AM USER: Lee Barras DWG: D:\Projects\RM11E\CAD\Figures\2015-07\ISR\2015-07-31 02 RM vs PM Fig 1.2.dwg





MAP NOTES

1. The Columbia River Datum (CRD) is a gradient datum developed and maintained by the US Army Corps of Engineers, Portland District (CENWP), and is the Chart Datum extending from Harrington Point at Columbia River Mile 22 to Bonneville Dam at Columbia River Mile 145.5 continuing up the Willamette River from Willamette River Mile 0 to Willamette Falls at Willamette River Mile 26.6. CENWP lists Ordinary High Water as 14.8 feet above CRD at Willamette River Mile 11 (USACE, 2014).
2. In the Portland Harbor FS the difference between CRD and NAVD 88 is shown as 5.0'. The average value of this conversion for the RM11E site is 5.3' (USACE, 2014). Since this relationship can change over time, this relationship should be reviewed and updated again at time of design and time of construction.
3. The locations of all features shown are approximate.
4. Tax lot boundary generated by METRO (Oct. 2013). Data layer acquired from GSI.
5. Background Image - METRO (Summer 2012).

LEGEND

- RM11E Project Area
- RM 11.2 — River Mile Stationing (RM)
- PM 11.2 — Project Mile Stationing (PM)
- Federal Navigation Channel (USACE)
- Tax Lot Boundary (Oct. 2013)

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NAVD88 Datum versus CRD Datum

DALTON OLMSTED FUGLEVAND

Figure 1.3

July 31, 2015

PLOT TIME: 7/31/2015 11:05 AM MOD TIME: 7/31/2015 10:41 AM USER: Lee Barras DWG: D:\Projects\RM11E\CAD\Figures\2015-07\ISR\2015-07-31 03 CRD VS NAVD88 Fig 1.3.dwg

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2. MAPPING

2.1 OBJECTIVE

The primary objective of the mapping exercise was to compile existing geospatial data and collect supplemental data into digital mapping products to be used by the RM11E Group for an implementability study. The array of available topographic and bathymetric digital data compiled consisted of multibeam sonar bathymetric data, airborne topographic LiDAR, and vessel-based LiDAR. Final results include:

- A terrain model of existing conditions, which combines upland topography and riverbed bathymetry into a combined digital terrain model (DTM)
- Digital mapping products of existing dock structures and supporting piles at Cargill and Glacier NW
- Digital mapping products of significant debris and submerged piles on the riverbed in the RM11E Project Area
- Digital mapping products from a submerged utility cable survey
- Compilation of digital mapping products from prior bathymetric surveys and differences between LWG surveys conducted from 2002 to 2009 in Portland Harbor

A list of digital mapping products provided to the RM11E consultants, with file names, descriptions, applications, and delivery dates, may be found in Appendix A, Digital Data Catalog of this report.[4] In general, the bathymetric data and vessel-based and terrestrial LiDAR data are accurate to within 0.25 feet at a 95 percent confidence level. The project report from the Columbia River Treaty airborne LiDAR (used for upland topographic mapping at RM11E) lists a project accuracy of 13 cm (0.43 feet), root mean square error.

2.2 MAPPING TASK

The following outlines the tasks accomplished to support the stated mapping objectives.

2.2.1 TASK 1 – PROCESS EXISTING VESSEL LIDAR DATA

DEA acquired vessel-based LiDAR data at the RM11E Project Area under a contract with the Oregon Department of State Lands (ODSL).[5] After approval to utilize these data for the RM11E Group mapping efforts, the vessel-based LiDAR raw data were processed into point cloud data of dock structures, supporting piles, and other significant features detected above the water surface. In addition, shoreline LiDAR data were evaluated and processed to fill data gaps and assess accuracies of airborne topographic LiDAR data.[6] These data were used in the DTM of

[4] Detailed information about each data set (date, methodology, accuracy statement, etc.) is in the metadata provided with the electronic data files.

[5] The source of vessel-based LiDAR is a DEA survey for ODSL and the data cover only Cargill and Glacier NW properties.

[6] The source for airborne LiDAR is the Columbia River Treaty data set flown in 2009 by the USACE, Portland District, and the data cover all of the Willamette River in the Portland Harbor.

existing conditions and include the dock structures. A graphic example of how the data can be presented is shown in Figure 2.1.

Note: for illustration purposes only

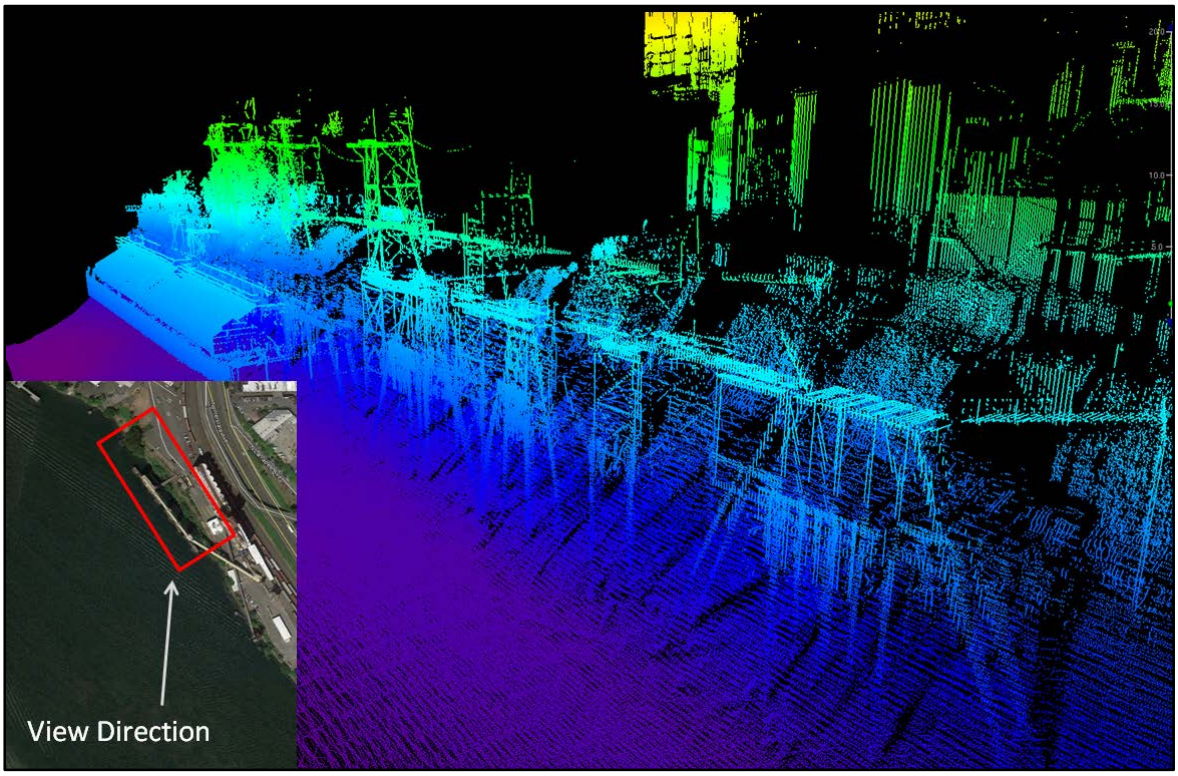

FIGURE 2.1 - GRAPHIC EXAMPLE OF POINT CLOUD OF VESSEL-BASED LIDAR DATA MERGED WITH MULTIBEAM SONAR DATA

2.2.2 TASK 2 – ACQUIRE SUPPLEMENTAL DATA

This task included the acquisition and processing of additional terrestrial data to supplement existing ODSL vessel LiDAR data on the dock structures and to fill data gaps in the terrain model. Existing airborne and vessel LiDAR data from the Cargill and Glacier NW sites were compiled and a data acquisition program was executed to supplement existing data and meet project objectives. The terrestrial survey program consisted of terrestrial high-definition stationary laser scanning with a Leica ScanStation P20 and conventional survey methods to acquire topographic data and the collection of upland bank cross-section data along four cross sections to provide an assessment of topographic LiDAR data.

A stationary high-definition laser scanner was placed at strategic locations on the dock structures, shoreline, and upland bank to acquire line-of-site high-resolution point cloud data. Horizontal and vertical control for the survey was established using a global positioning system (GPS) with a reference GPS station at DEA's Vancouver, Washington office. The control network was extended along the shoreline using terrestrial survey methods and an adjusted network was computed based on NAD83, Continuous Operating Reference Station (CORS) 1996 (NAD83/96), State Plane Coordinate System Oregon North Zone with units in international feet. Vertical control was based on NAVD88. A conversion to CRD relative to NAVD88 at RM11 was also

provided as a reference vertical datum (Figure 1.3). Use of these datums allowed supplemental data to be readily integrated with existing data for comprehensive mapping.

The high-definition stationary scanning was acquired during a period of lower river level to map remnant piles and acquire additional topographic data along exposed sections of the shoreline. Bank profile data were collected along four cross sections in areas with dense vegetation to verify the bank profile mapped with airborne LiDAR. The cross-sectional data were acquired by brushing lines and collecting ground elevations by conventional topographic methods using a land survey total station.

2.2.3 TASK 3 – COMPILE DATA: DOCK STRUCTURES AND PILING AT CARGILL AND GLACIER NW

This task included integrating existing vessel LiDAR and multibeam bathymetric data as well as newly acquired terrestrial high-definition laser scan point cloud data into a composite model of the Cargill and Glacier NW docks. Data representing structures above the dock surface were not processed, but remain in the raw data set if needed at a later date. Figure 2.2 depicts an example of an AutoCAD three-dimensional (3D) representation of the dock structures.

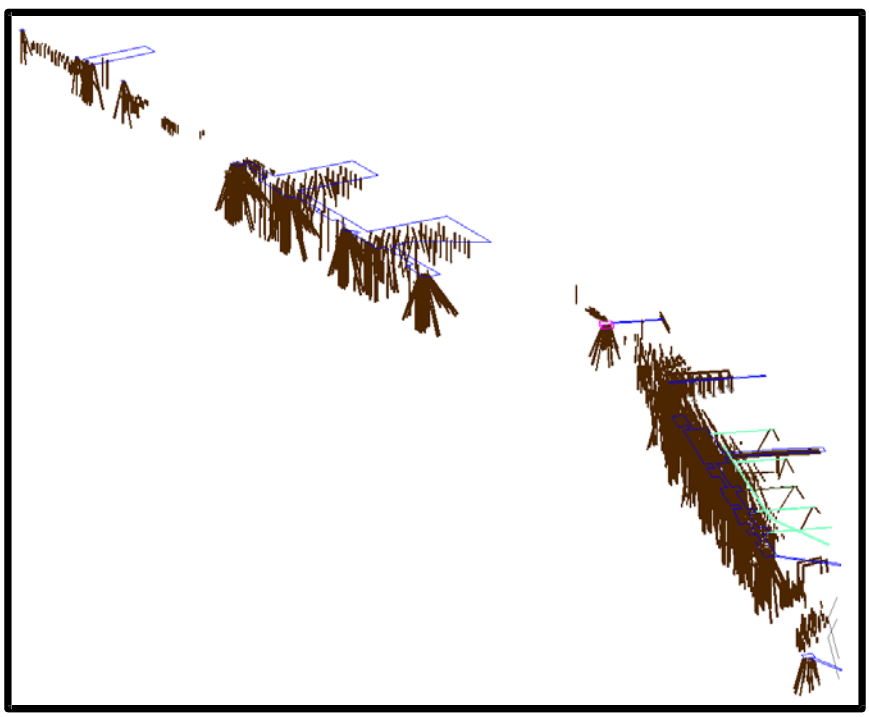

FIGURE 2.2 – SAMPLE OF DOCK STRUCTURES IN AUTOCAD

2.2.4 TASK 4 – MAP SUBMARINE CABLE CROSSING

This task included nonintrusive mapping methods to locate and map the submarine cable crossing across the river and through the submerged portion of the RM11E Project Area. The primary method for the detection of the cable crossing was the use of a radio detection system with a submersible antenna towed near the riverbed from the survey vessel. Prior to the survey, PacifiCorp, the owner of the medium-voltage cable crossing, marked the location of the cable

crossing on the upland area of the RM11E Project Area and facilitated radio detection by inducing a tone at a set frequency of 8 kilohertz (kHz) on one of the energized cables. DEA surveyors mapped the vaults on either side of the crossing and the marked cable alignment locations. The projection of the upland locations was used to refine the survey vessel operations.

The radio detection cable location method used for this task is identical to methods used for upland cable and pipe radio detection, except that a submersible marine antenna was used. DEA provided the tone-inducing equipment for placement on the cables by PacifiCorp's representative.

A signal generator was used to induce an 8 kHz signal on one of the cables since historical documents provided by PacifiCorp indicated that all of the cables were placed in the same trench. A Radio Detection model RD8000 with a submersible antenna and 40 feet of cable was deployed from the survey vessel using a hydraulic winch on the vessel A-frame. The submersible antenna was towed between 5 and 10 feet above the bottom at a dead slow speed such that the deployment remained approximately vertical. Accurate position data of the tow point was computed using heading and reference point position from the vessel GPS and inertial motion reference system to translate a position to the tow point. The cable locate signal and tow position were logged in Triton Isis data logging software. Data were digitally acquired along lines perpendicular to the crossing at discrete intervals, in an attempt to map the cable's horizontal position at peak signal strength during the cross section. Each cross section was run in opposing directions to validate the position of any signal detected. The plotted marine locate points on Figure 2.3 are estimated to be within ±5 feet of the 8 kHz-induced signal, recognizing that the other cables in the trench may be located over a wider distance.

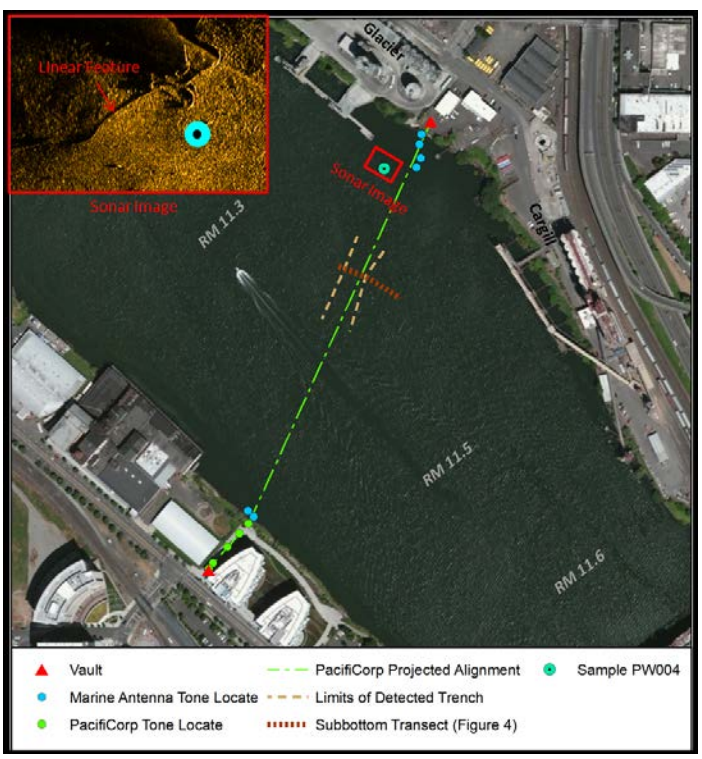

FIGURE 2.3 – RESULTS OF SUBMARINE CABLE LOCATE EFFORTS

This system was only marginally successful, as the tone could be detected only near shore, most likely due to burial of the cable and attenuation of the tone through water. PacifiCorp's representatives also lost tone on the cable as they approached the top of the bank from the vault with PacifiCorp tone-tracking equipment. At each shoreline, the handheld portion of the RD8000 was used in an attempt to locate the cable at the water's edge. A signal was detected at locations on either shoreline, one of which was a stronger signal. It is suspected that the tone transferred to one of the other cables because cables touched or because other conductive paths were present at the vault.

A secondary detection method included the use of an EdgeTech Chirp sub-bottom profiler consisting of a model 3100 portable topside unit and an SB-424 towfish sweeping between 4 and 16 kHz. The sub-bottom profiler was towed near the riverbed in an attempt to identify the cables in the sub-bottom profile data, and thereby identify the location and burial depth of the cables.

Although delineation of the cable from the sub-bottom data could not be achieved, a disturbed section of the riverbed was detected in one area and is suspected to be the remnants of the trench excavated for cable burial. Figure 2.4 is a sample sub-bottom profile record of what is interpreted as evidence of the trench location. The alignment of the profile depicted in Figure 2.4 is shown on a plan view of the results of the submarine cable location efforts in Figure 2.3.

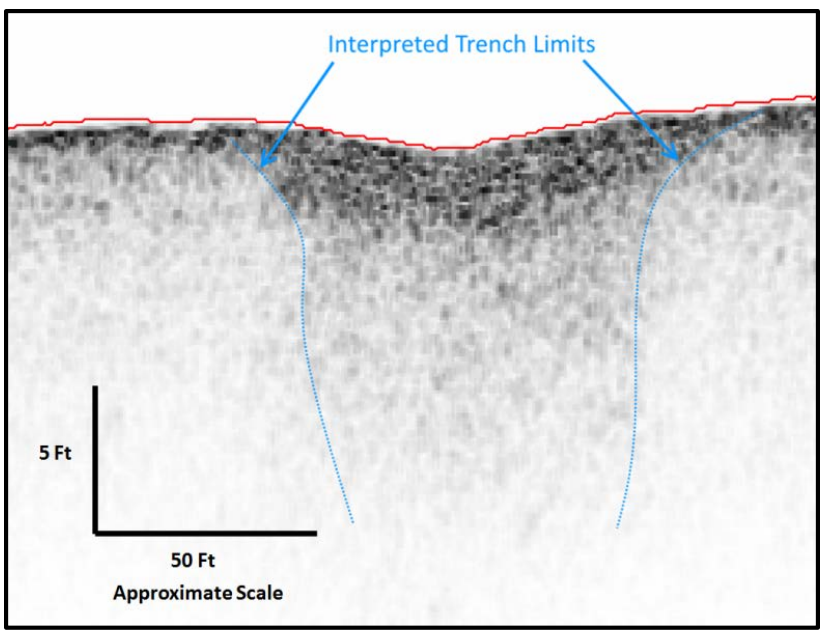

FIGURE 2.4 - SUSPECTED UTILITY TRENCH

In addition to sub-bottom profiling, sidescan sonar was deployed to image the riverbed in the search for surficial evidence of exposed cable or scars from trenching. No evidence of a submarine cable was located along the alignment. A linear feature that had bends and loops was identified off the bow of a moored ship at Glacier. This feature was also identified by divers during a porewater sampling effort at station RM11E PW004 as a possible cable on the riverbed. The location of sample RM11E PW0004, an outline of the sidescan sonar imagery, and the sonar

imagery of the linear feature are shown in Figure 2.3. Given the circuitous path of the feature, its location on the surface, and its distance from the reported location of the medium-voltage cables, it was determined that the feature was more likely a remnant of an earlier cable.

The success of these methods is dependent on several variables and the primary reason several methods were employed. Characteristics of the sediment in which the cable crossing is buried, burial depth, acoustic reflectance of anything exposed on the riverbed, and the ability of the cables to transmit an induced tone affect the results. All detected signals were mapped, along with the limits of the detected trench, and the projected alignment across the river from the east side vault location to the most riverward landside detection on the west side by PacifiCorp as shown on Figure 2.3. In areas where active remediation is required, additional studies will be required to locate each of the active cables more precisely across the RM11E Project Area.

2.2.5 TASK 5 – MAP SUBMERGED DEBRIS AND SUBMERGED AQUATIC VEGETATION

Multibeam sonar data collected by DEA under other data acquisition programs were evaluated for sonar contacts on debris, submerged piling, and submerged aquatic vegetation. No evidence of submerged aquatic vegetation was detected during this process. Several debris mounds, logs, and submerged piling were identified. To illustrate these features, logs on the riverbed were delineated as linear features, debris mounds were outlined with polygons, and submerged piles were mapped as point features. Figure 2.5 illustrates an example of the multibeam sonar returns on debris (detail on left) and the mapping product produced from the debris mapping effort (right). Vertical piles were not included in the Digital Terrain Model but were provided as a separate 3D features in AutoCAD as described in Section 2.3 of this report.

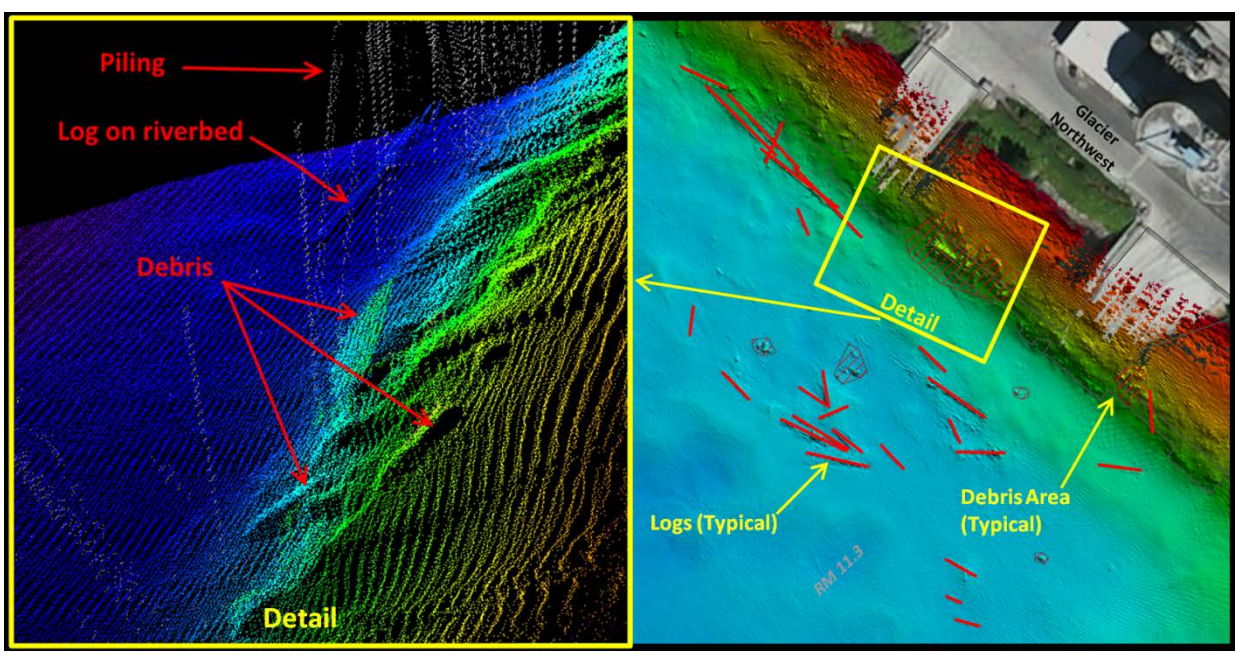

FIGURE 2.5 - EXAMPLE SONAR RETURNS ON DEBRIS (LEFT) AND EXAMPLE MAPPING OF DEBRIS (RIGHT)

2.2.6 TASK 6 – MODEL PRIOR LWG BATHYMETRIC SURVEYS IN AUTOCAD

During a comprehensive bathymetric mapping campaign of the PHSS for the LWG, DEA conducted periodic bathymetric surveys from 2002 to 2009, with the survey in 2009 performed under DEA's contract with the National Oceanic and Atmospheric Administration (NOAA) for nautical charting of the Willamette and Columbia rivers. Differences between results of the surveys were analyzed for the LWG, with images generated depicting color-coded gain or loss in bed elevation. The RM11E Group received permission from the LWG for use of these data and the resultant images. The raw XYZ data were modeled in AutoCAD and provided to the RM11E Group consultants for their use as part of the implementability study.

2.3 REPORTING AND DELIVERABLES

Reporting for the tasks listed above consists of this report and delivery of digital map products along with supporting metadata. The deliverables consist of digital files in ESRI ArcGIS and AutoCAD formats, geo-referenced tagged image file format (tiff) images, and associated metadata. Mapping products consist of the following:

- Composite surface terrain model with bounding polygons delineating disparate data sets, with text blocks defining metadata for each data set
- Contours at 1-foot intervals from composite surface
- Shapes of dock structures, supporting piles, and old submerged piles at Cargill and Glacier NW facilities
- Polygons delineating significant submerged debris
- Results of the submarine cable crossing survey
- Surface terrain models of prior LWG bathymetric surveys

Appendix A is a digital data catalog, which lists particulars of the digital mapping products delivered to the RM11E Group, including file name, description, application, and submittal date.

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3. WATERFRONT ACTIVITIES AND USES ASSESSMENT

3.1 OBJECTIVE

The SOW states that "maintaining navigation access and minimizing disruptions to ongoing shipping activities is an important consideration for future remedial action in this area." The objective of the waterfront activities and use study was to determine the extent to which shipping activities and vessel traffic, working dock and marine operations, existing and future navigational dredging, and other waterfront activities and conditions may impact the selection and long-term viability of remedial actions. Results of the study are summarized here. Waterfront activities and conditions include in-water work windows, dock operations and vessel calls, dock maintenance, outfalls, and utility crossings. Many of the figures mentioned in this and subsequent sections consist of four parts, each showing part of the RM11E Project Area. The key for these sets of figures is provided in Figure 3.1

3.2 EXISTING WATERFRONT FACILITIES

A RM11E Project Area site plan showing shoreline facilities and site bathymetry is provided as Figures 3.2a through 3.2d. Shoreline waterfront facilities and outfalls are discussed in Sections 3.2.1 and 3.5.3, respectively. The site plan bathymetry contours are based on a composite data set that consists of information from the NOAA 2009 multibeam survey, ODSL 2010 multibeam and laser survey, DEA's 2011 multibeam survey, and Anchor QEA's 2009 Sidescan Sonar Data Report prepared for the LWG (Anchor QEA, 2009).

A slope analysis was performed on the site plan data set to show the range of slopes within the RM11E Project Area. Figures 3.3a through 3.3d show the locations of the following six slope ranges:

- 0 to 20 percent (flat to 5H:1V[7])
- 20 to 33 percent (5H:1V to 3H:1V)
- 33 to 50 percent (3H:1V to 2H:1V)
- 50 to 67 percent (2H:1V to 1.5H:1V)
- 67 to 100 percent (1.5H:1V to 1H:1V)
- >100% (steeper than 1H:1V)

3.2.1 WATERFRONT FACILITIES

Existing waterfront facilities within the RM11E Project Area (Figure 1.2) include the following:

- Sakrete
- Stan Herman
- RIS&G

[7] Slope expressed as "H:V" refers to the ratio of horizontal to vertical.

- Glacier NW
- Unkeles
- Cargill (currently operated by Temco Inc.)
- PacifiCorp submarine cable crossing

Figures 3.4a through 3.4d show the locations and provide photographs of the existing waterfront facilities within the RM11E Project Area. Each waterfront facility is briefly identified below, moving from north to south along the river (i.e., upstream), and then described in greater detail in subsequent sections of the report.

3.2.1.1 Sakrete

Sakrete is located at ~PM 10.85 to 10.98, downstream of the Fremont Bridge, at 1402 N. River Street. Waterfront facilities include a dock (Photo 1, Figure 3.4a) approximately 185 feet long.

3.2.1.2 Stan Herman

The Stan Herman property is located at ~PM 10.98 to 11.05, downstream of the Fremont Bridge, at 1300 N. River Street. The facility is a warehouse-type structure (Photo 5, Figure 3.4a) that extends along the bank for approximately 300 feet. The structure is built on pilings and extends over the water.

3.2.1.3 RIS&G

The RIS&G facility is located at ~PM 11.09 to 11.15, just upstream of the Fremont Bridge, at 1208 N. River Street. Barges are moored to mooring dolphins; a shuttle system (Photo 6, Figure 3.4b) is used to move barges approximately 500 feet along the river frontage.

3.2.1.4 Glacier NW

Glacier NW is located at ~PM 11.15 to 11.35 (Photos 8, 11, and 12, Figure 3.4c) at 931 and 1050 N. River Street. Waterfront facilities include two docks. The upstream dock is approximately 400 feet long and is used by ocean-going vessels. On the infrequent occasions when it is used, the downstream dock is used for mooring barges.

3.2.1.5 Unkeles

The Unkeles property is located near PM 11.36, adjacent to and upstream of the Glacier NW site, at 820 and 822 N. River Street. The property has no riverfront access or activity; its river frontage rights are owned by Cargill (Unkeles, 2014). For this report, the waterfront area adjacent to the Unkeles property is addressed as part of the Cargill property.

3.2.1.6 Cargill

The Cargill property is located at ~PM 11.35 to 11.62 (Photos 14, 15, 17, 21, and 22, Figure 3.4d) at the upstream end of the RM11E Project Area at 800 N. River Street. Listed from downstream to upstream, the facility includes a mooring dolphin with a bridge to the bank located in front of the Unkeles property; a remnant structure approximately 100 feet downstream of the main dock; a main dock for ocean-going vessels; and a barge dock approximately 350 feet upstream of the main dock. Note that the barge dock is outside of the RM11E Project Area. The Cargill waterfront property abuts the Glacier NW property and includes retaining walls along portions of the shoreline. A steel retaining wall is located along the shoreline between the main dock and the barge facility dock.

3.2.1.7 PacifiCorp Submarine Cable Crossing

An electric power medium-voltage cable crossing owned by PacifiCorp and consisting of seven submarine cables extends from a cable vault on the Unkeles property to the west side of the river. The cable provides power to a portion of downtown Portland (DOF/GSI, 2013).

3.3 WATERFRONT USE INFORMATION SOURCES

Information about waterfront activities was compiled from waterfront facility owner responses to a Waterfront Facilities Activities Questionnaire (Questionnaire responses are included as Appendix B). Additional information was gathered from interviews with facility operators, tug captains, and Columbia River pilots. The following information was sought for each property (summarized in report locations shown in parentheses):

- Current and planned future waterfront operations (Tables 3.1 and 3.2)
- Frequency, duration, and variability of vessel calls by season (Tables 3.3 and 3.4, and Figures 3.6 and 3.7)
- Seasonality of waterfront operations (Table 3.4, Figures 3.6 and 3.7)
- Size (class) and draft of calling vessels (Table 3.3)
- Docking methods, with or without tug assist (Table 3.3)
- Potential upgrades to facility waterfront structures (Section 3.5.1)
- Historical records regarding dredging and description of possible future dredging (Section 3.6)
- Historical shorelines progression (Section 3.7, Figure 3.10, and Figures 3.11a through 3.11c)

3.4 EXISTING AND PLANNED FUTURE WATERFRONT OPERATIONS

This section, including the information in the following tables, summarizes information provided by respondents to the Questionnaire and related inquiries regarding the waterfront and over-water activities at the waterfront facilities. As the information comes from multiple sources, it does not necessarily represent the position of the RM11E Group. The Questionnaire responses are provided in Appendix B. Other commercial shipping and recreational vessel traffic using the Willamette River channel are not included in this summary, as the respondents did not identify them as users of the RM11E Project Area facilities. Therefore, these latter activities are not considered to be waterfront facility uses. Potential impacts of these vessels traversing through the area, including waves and wakes, are addressed in Section 7.

3.4.1 PACIFICORP SUBMARINE CABLE CROSSING

In 1968, General Construction Co. installed seven 15 kV armored submarine medium-voltage cables at the submarine cable crossing for PacifiCorp. This set of cables replaced three existing

power cables lying on the riverbed. A trench was dug to elevation -60.5 feet average low water[8] with a minimum bottom width of 6 feet. After cables were placed, the cable trench was backfilled to elevation between -42 and -45 feet average low water. The former cables are no longer in service and to the extent that they remain they will be dealt with as debris.

3.4.2 WATERFRONT OPERATIONS

The following tables include Questionnaire responses by waterfront property owners regarding their water operations. The vessel navigation areas, as well as berth areas for RM11E facilities, are shown in Figures 3.5a (CRD vertical datum) and 3.5b (NAVD88 vertical datum). Although vessels may move outside of these areas at times, the tug operators and Columbia River pilots when interviewed stated that this figure is representative of the areas typically used for arrival and departures of vessels.[9]

The following information was provided by Mr. Rich, Vice President of Marine Servicers, Shaver Transportation. He reported that tugs generally hook up with incoming vessels approximately 0.25 mile downstream of the destination dock and unhook from departing vessels approximately 100 yards downstream of the departure dock. When under tug assist, vessels need their engines running to help navigate. Vessels run their engines just above idle. For arrival, the ships use the propeller in forward while entering the berth, and shift the propeller into reverse to slow down as they approach the dock. Ocean-going vessels generally use two tugs of 3,000 to 4,000 hp to maneuver the vessel, while barges generally use one tug of 2,000 to 3,000 hp. Mr. Rich stated that due to the differences in draft and power, the scour potential for ocean-going vessels is greater than that for barges arriving and departing from the terminals. Mr. Rich reported that visible turbidity is created from propeller wash as the vessels arrive and depart (Shaver, 2015a,b). During docking, the vessels line up parallel to the docks in deeper water and the tugs push the vessel sideways toward the docks (Glacier NW, 2015a; Cargill, 2014b).

Tables 3.1 through 3.4 summarize information provided by the property owners on operational activities for the waterfront properties in the RM11E Project Area.

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[8] Average low water is the official term used above Willamette Falls and CRD is the official term below the Willamette Falls. The reference plane for the lower Willamette and Columbia rivers is called "low water" (Beeman, 1966). There is no readily available conversion between NAVD88 or CRD and average low water. Without such conversion the precise depth location for the cable installation cannot be determined.

[9] Tug operators and pilots verbally agreed during interviews (Pilots, 2015; Shaver, 2015a).

TABLE 3.1 – CURRENT WATERFRONT OPERATIONS

FACILITY	CURRENT WATERFRONT OPERATIONS
Sakrete	Sakrete stated it does not currently use or authorize the use of the dock associated with the property (Oldcastle, 2014).
Stan Herman	Mr. Herman indicated that the warehouse is used for storage by Advanced M&D Sales (a tile and flooring company, according to its website). There are no water-dependent activities at this site (DOF/GSI, 2013; Herman, 2014).
RIS&G	RIS&G stated that it operates a concrete batch plant in the southwestern portion of its site and leases the remainder of the site to KF Jacobsen & Co.[a] The site includes a clamshell bucket crane and barge docking equipment to unload aggregate raw materials for use in both facilities. The crane unloads the aggregate from barges into hoppers that convey the materials to storage piles located at each facility. The RIS&G facility also accepts broken concrete pavement (construction debris), which is loaded onto barges at the dock and transported to the upriver Ross Island Lagoon for use as fill material. Facility operations include use of a river water pump to help make up the needed water for the concrete batch process (DOF/GSI, 2013; RIS&G, 2014).
Glacier NW	Glacier NW indicated that the property is a bulk cement distribution terminal and the regional headquarters for Glacier NW's Oregon and southwest Washington operations. No manufacturing or processing occurs here. . Bulk cement is delivered by ship, pneumatically conveyed to the storage buildings (silos and dome), and then loaded into customer trucks and railcars for offsite delivery. The property includes 15 storage silos with capacities ranging from 1,000 to 6,500 tons and a cement storage dome with a capacity of 30,000 tons. The property also includes two covered truck loading and scale areas (ERM, 2011; DOF/GSI, 2013; Glacier NW, 2014a). Ocean-going vessels use the main upstream dock. No loading or unloading is performed at the downstream barge dock, which remains generally unused. Third-party barges are infrequently moored at the barge dock on a temporary basis (Glacier NW, 2014a).
Cargill	Cargill indicated that Temco operates the Irving Terminal on the Cargill property. The Irving Terminal provides interim bulk storage for transfer of grain to and from trucks, railcars, barges, and ships. The main features on the property are reinforced concrete grain silos, conveyor systems, enclosed grain handling facilities, a rail grain dump station, a truck grain dump station, and shipping and unloading equipment (DOF/GSI, 2013; Cargill, 2014a). Cargo loads contain only grain, primarily wheat, in ships and barges using the Irving Terminal (Cargill, 2014a). The Irving Terminal has a ship dock and a barge dock (Cargill, 2014a). The barge dock is upstream of the RM11E Project Area.

[a] R.B. Pamplin Corp. now leases the property leased by KF Jacobsen at the time that the reference document was written (RIS&G, 2014).

TABLE 3.2 – PLANNED FUTURE WATERFRONT OPERATIONS

FACILITY	PLANNED FUTURE WATERFRONT OPERATIONS
Sakrete	Sakrete indicated it has no plans to use the dock or waterfront area until at least 2018 or 2019 (Oldcastle, 2014).
Stan Herman	Mr. Herman indicated that no plans are in place for future waterfront operations (Herman, 2014).
RIS&G	RIS&G indicated that no changes or modifications are planned for the future, other than periodic maintenance of the facilities (RIS&G, 2014).
Glacier NW	Glacier NW indicated that no changes in shipping patterns are anticipated in future years (i.e., cement offloading will continue to be the focus of waterfront operations) (Glacier NW, 2014a).
Cargill	Cargill indicated that waterfront operations on the Cargill property will continue to be related only to grain storage and transfer. Cargill anticipates that shipping and operational patterns in coming years will remain consistent with past practices (Cargill, 2014a).

TABLE 3.3 –WATERFRONT OPERATIONS VESSEL INFORMATION

FACILITY	WATERFRONT OPERATIONS VESSEL INFORMATION
Sakrete	Sakrete stated that it has no waterfront operations (Oldcastle, 2014).
Stan Herman	Mr. Herman indicated that there are no water-dependent operations (Herman, 2014).
RIS&G – Barges	VESSEL TYPE OR CLASS RIS&G described barges using the facility as 175 to 215 feet long, with a 10-foot draft and 40-foot beam (RIS&G, 2014).
	VESSEL CALLS/DURATION RIS&G indicated that the facility loads and unloads sand and gravel barges daily, at average rates of two per day, 46 per month, and 552 per year (RIS&G, 2014).
	VESSEL DOCKING PROCEDURES RIS&G indicated that barges are tied to a steel cable shuttle system that moves them ±500 feet along river frontage for unloading by an upland crane. Barges approach and depart dock facilities from both upstream and downstream, depending on the position of the barge tied to the barge shuttle system. All barges are non-motorized and under the control of a tug when approaching and departing the dock facility (RIS&G, 2014).
Glacier NW – Barges	Glacier NW stated that third-party barges are infrequently moored at the barge dock on a temporary basis. Barges are tied off to two in-water dolphins, one each located north and south of the barge dock (Glacier NW, 2014a)

TABLE 3.3 –WATERFRONT OPERATIONS VESSEL INFORMATION (CONTINUED)

FACILITY	WATERFRONT OPERATIONS VESSEL INFORMATION
Glacier NW – Ships	VESSEL TYPE OR CLASS Glacier NW indicated that vessels serving Glacier NW may be as long as 578 feet and as wide as 92 feet ("Handy" class vessels). Incoming loaded vessels may draft up to 30 feet, but only up to 20 feet when empty upon departure (DOF/GSI, 2013; Glacier NW, 2014a)
	VESSEL CALLS/DURATION Glacier NW indicated that ocean-going vessels often remain moored at the facility for several days. The total number of ships at Glacier NW's dock may range from 20 to 40 per year. Occupied approximately 12 to 20 days each month, the main dock is open 5 to 10 days between vessel calls (Glacier NW, 2014a).
	VESSEL DOCKING PROCEDURES Glacier NW indicated that large vessels dock at Glacier NW's main dock to offload cement. Dock cleats that secure the vessel to the dock are located both north and south of the dock. One cleat is located in the greenway [a] slightly southwest of the cement storage dome, and the second cleat is located in the greenway at the southern end of the property (near the property boundary) (Glacier NW, 2014a). Vessels at the main dock always dock with the bow facing upstream (south) and the stern downstream (north). Vessels dock and embark under tug assistance. A vessel's thrusters may be used in the event of an emergency, but such a decision is at the discretion of the vessel's captain when working with the tugs (Glacier NW, 2014a).
Cargill - Ships	VESSEL TYPE OR CLASS Cargill indicated that ships using the Irving Terminal ship dock typically range from 500 to 765 feet long and up to 106 feet wide, and draft as much as 40 feet when full. These ships are typically "Handymax" or "Panamax" class vessels (DOF/GSI, 2013; Cargill, 2014a).
	VESSEL CALLS/DURATION Cargill indicated that ships dock at the Cargill ship dock at the Irving Terminal as often as four to five times per month, and typically for a period of less than a week each. However, individual ships may be docked at the ship dock up to 12 days during slower seasons, when limited commodity availability requires additional loading time (DOF/GSI, 2013; Cargill, 2014a). The average number of ships berthing at the Irving Terminal ship dock during Cargill's period of ownership (1995 to the present) is approximately 55 per year. Information for the past 3 years indicates the number of ships docking at the ship dock in any given month ranges between three and seven. In 2012, 33 ships docked at the Irving Terminal; in 2013, 49 ships; and in 2014, the approximate number of ships docking at the Irving Terminal as of September 25 was 44 (Cargill, 2014a).

[a] Greenway. Chapter 33.440 of the Portland Zoning Code includes the majority of the City of Portland Greenway regulations. The Greenway regulations are intended to protect, conserve, enhance, and maintain the natural, scenic, historical, economic, and recreational qualities of land along Portland's rivers (City, 2015c).

TABLE 3.3 –WATERFRONT OPERATIONS VESSEL INFORMATION (CONTINUED)

FACILITY	WATERFRONT OPERATIONS VESSEL INFORMATION
Cargill – Ships (continued)	VESSEL CALLS/DURATION The Irving Terminal ship dock is typically occupied for the majority of days in each month. The number of unoccupied days depends on several factors, including the number of vessels docking during the particular month and the amount of time necessary to load a ship to capacity, considering weather and commodity availability. For example, in months where only three ships are received, there may be up to seven unoccupied days at the ship dock, although the ship dock is very seldom unoccupied for that length of time. In contrast, in months where six or seven vessels are docked, there may be only one or two unoccupied hours at the ship dock. The Irving Terminal frequently operates around the clock, so open dock times may not occur during regular work weekdays or normal business hours (Cargill, 2014a). In the busiest months, there may be only 1 to 2 hours between ships. In slower months, the ship dock may remain open for 1 to 3 days at a time, but is seldom unoccupied more than a week at a time. (Cargill, 2014a)
	VESSEL DOCKING PROCEDURES Cargill reported that ships dock parallel to the designated docks, just offshore from the Irving facility, and tie up to the dock, nearby dolphins, or both (Cargill, 2014a). Cargill reported that ships typically approach the Irving Terminal ship dock from the northwest (moving against the current of the Willamette River). Ship departure typically proceeds downstream toward the confluence with the Columbia River and to the Pacific Ocean (Cargill, 2014a). Cargill reported that all vessels docking and embarking at the Irving Terminal use tug assistance. The tugs are contracted by the third-party vessel operators (Cargill, 2014a). Cargill reported that for ships using the ship dock, the process typically involves two tugs maneuvering the ships to and from the dock, one tug engaging the bow and one the stern of a ship. Cargill understands that the main propellers or thrusters of the ships are not engaged during the docking or embarking process and that the vessels are solely under tug power (Cargill, 2014a).
Cargill – Barges (Barge Dock is outside of RM11E Project Area) [b]	VESSEL TYPE OR CLASS Cargill indicated that barges using the barge dock at Irving Terminal are typically 280 feet long and 42 feet wide, and draft 14 feet when full (Cargill, 2014a).
	VESSEL CALLS/DURATION Cargill indicated that barges use the separate barge dock at the south end of the Irving Terminal (outside of RM11E Project Area) as often as 48 times per month to deliver grain for transfer to export-bound ships (DOF/GSI, 2013; Cargill, 2014a). The Irving Terminal barge dock is consistently occupied most days in a month. In a given month, the barge dock is likely occupied with a barge 27 of 30 days. Many times a tug will pull away an empty barge at the same time it brings in a full barge, so any unoccupied time between barges can be effectively nonexistent (Cargill, 2014a). Cargill indicated that in 2012, 257 barges docked at the Irving Terminal. In 2013, 409 barges docked at the Irving Terminal. In 2014, the approximate number of barges docking at the Irving Terminal as of September 25 was 489 (Cargill, 2014a).).

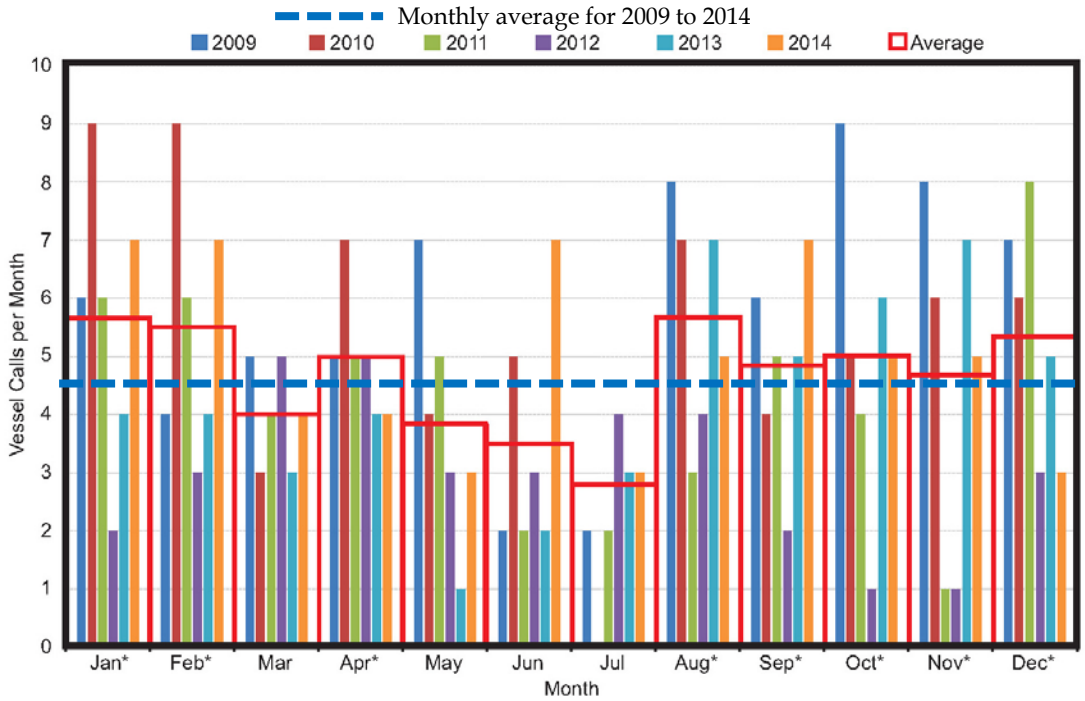
[b] Information on barge activity is included in the table, even though dock is outside of the RM11E Project Area because arrival and departure activities at the dock could be impacted by remedial activity.

TABLE 3.3 –WATERFRONT OPERATIONS VESSEL INFORMATION (CONTINUED)

FACILITY	WATERFRONT OPERATIONS VESSEL INFORMATION
Cargill – Barges (continued)	VESSEL DOCKING PROCEDURES Cargill stated that all vessels docking and embarking at the Irving Terminal barge docks use tug assistance. The tugs are contracted by the third-party vessel operators. Barges typically approach and depart from the Irving Terminal barge dock from downstream. Barges using the barge dock do not have propellers or thrusters and are typically maneuvered to and from the barge dock by one tug (Cargill, 2014a).

3.4.3 FREQUENCY AND SEASONALITY OF USE

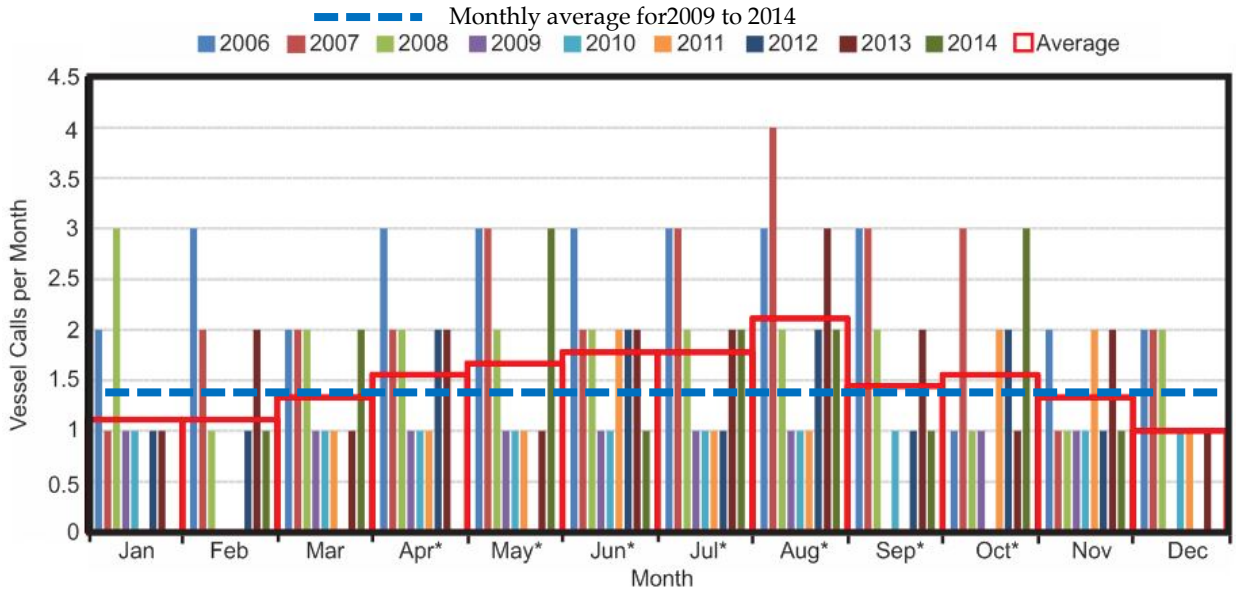
The Columbia River pilots provided data for vessel calls to the Cargill and Glacier NW ship docks for the period 2009 through 2014. This information excludes vessels that did not require Columbia River pilots to board, such as barges. Figure 3.6 summarizes this vessel-call data for Cargill. Figure 3.7 includes data received from Glacier NW for 2006 through 2008 in addition to the data received from the Columbia River pilots. The period of 2009 through 2014 includes a period of depressed economy for the cement industry (2009 to 2011). Therefore, additional Glacier NW vessel call data for the period 2006 through 2008 were added to the Columbia River pilots' data to generate a longer-term average. The following figures illustrate that Cargill (Temco) and Glacier NW have multiple ocean-going vessel calls each month.



[a] Source: Pilots, 2015

[b] The asterisks ("*") in Figure denotes months when the average number of vessel calls for that calendar month was greater than the monthly average indicated by the dashed blue line in the figures).

FIGURE 3.6 – CARGILL OCEAN-GOING VESSEL CALLS PER MONTH



[a] Source: Pilots, 2015, Glacier NW, 2014a

[b] The asterisks ("*") in Figure denotes months when the average number of vessel calls for that calendar month was greater than the monthly average indicated by the dashed blue line in the figures).

FIGURE 3.7 GLACIER NW OCEAN-GOING VESSEL CALLS PER MONTH ()

TABLE 3.4 –WATERFRONT OPERATIONS SEASONALITY

FACILITY	SEASONALITY OF WATERFRONT OPERATIONS
Sakrete	Sakrete reported it has no waterfront operations (Oldcastle, 2014).
Stan Herman	Mr. Herman indicated there are no water-dependent operations (Herman, 2014).
RIS&G	RIS&G reported that in May through October, barge calls can be as high as six per day, 162 per month. In November through April, barge calls can be as low as one every other day, 12 per month (RIS&G, 2014).
Glacier NW	Glacier NW reported that seasonal variations in the number of vessels are not expected to be significant. However, vessel calls are more consistent and slightly more frequent in July through September, and at times into October, due to a modest increase in the number of local construction projects during these warmer months. The interval between vessel calls can be shorter than 2 to 10 days during these months (Glacier NW, 2014a).

TABLE 3.4 –WATERFRONT OPERATIONS SEASONALITY (CONTINUED)

FACILITY	SEASONALITY OF WATERFRONT OPERATIONS
Cargill	Cargill reported that the number of ships docking at the Irving Terminal ship dock may be greater during or immediately following harvest season. The wheat harvest season in the United States is from mid-May to mid-September. For the past 3 years, vessel calls at the Irving Terminal have been fairly consistent throughout the year, with the fewest ships docked in May and June (Cargill, 2014a). Furthermore, despite any seasonal variation affecting the number of ships docking at the Irving Terminal, the amount of unoccupied time at the two docks is relatively consistent throughout the year. In slower seasons, gathering a full load of grain to fill a ship to capacity may take longer, and a ship may remain docked at the Irving Terminal ship dock for up to 12 days. Docked vessels may remain at the two docks longer in rainy weather than dry weather because of the open loading and unloading process for the grain and the need to keep the grain dry (Cargill, 2014a). Seasonal variation in the number of barges docking at the Irving Terminal is less than that for ships. Barges are consistently using the barge dock throughout the year. It can take 20 to 24 barges to fill a ship to capacity and 6 hours or more to unload the contents of a barge (Cargill, 2014a). Waterfront operations mirror ship and barge calls and remain fairly consistent throughout the year (Cargill, 2014a).

Figure 3.8 summarizes the busiest months for vessel calls at RIS&G, Glacier NW, and Cargill docks. For Glacier NW and Cargill, the busiest months were identified from Figures 3.6 and 3.7. For RIS&G, the business months were identified from RIS&G's Questionnaire response (RIS&G, 2014).

Condition	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Cargill	*				*	*	*	*	*	*	*	
Glacier NW	*	*	*	*	*	*	*					
RIS&G		*	*	*	*	*	*					

Period of Facility Activity

* Periods of Busiest Facility Activity

FIGURE 3.8 – BUSIEST MONTHS BY VESSEL CALLS

3.5 EXISTING AND PLANNED WATERFRONT STRUCTURES AND UTILITIES

3.5.1 STRUCTURES

The characteristics, design studies, drawings, and engineering assessments of waterfront structures are addressed separately in Section 6. The existing structures in the RM11E Project Area are shown in Figures 3.4a through 3.4d.

Possible changes in waterfront facility structures in the RM11E Project Area were identified through responses to the Questionnaire (Appendix B) as follows:

- Sakrete did not mention plans in its Questionnaire response (Oldcastle, 2014).
- Stan Herman did not mention plans in its Questionnaire response (Herman, 2014).
- RIS&G indicated it does not anticipate any construction, but will replace or repair any dolphins or piles damaged from barge landing accidents (RIS&G, 2014).
- Glacier NW indicated it intends to replace 16 piles in September 2015. The pile replacement will not modify the existing dock, shoreline, or waterfront facilities (Glacier NW, 2014b, 2015b).
- Cargill indicated it anticipates making dock repairs over the next 5 years. Permits for the dock repair work have been issued, but specific dates for this repair work have not been established (Cargill, 2014a).

3.5.2 PACIFICORP SUBMARINE CABLE CROSSING CAUTION ZONE

As part of the Section 2 work, nonintrusive methods were used in an attempt to locate the submarine cable crossing in the RM11E Project Area. As described in Section 2.2.4, the cable crossing was mapped using a radio detection system with a submersible antenna towed near the riverbed from a survey vessel. This system was only marginally successful as the tone could be detected only near shore because the cable is buried and the tone from the signal attenuates through water. The detected signals are mapped on Figures 2.3 and 3.4d.

A secondary detection method to locate the cable crossing included the use of a sub-bottom profiler. A disturbed section of the riverbed near the middle of the navigation channel was detected. The disturbance is suspected to be the remnants of the trench excavated for burial of the cables.

Based on the detected signals and the limits of the detected trench, DEA projected a cable crossing alignment that extends across the river from the east side vault location to the most riverward landside detection on the west side of the river (Figure 3.4d for the alignment in the RM11E Project Area). A submarine cable crossing caution zone was established around this alignment; the zone was projected 25 feet upstream of the most upstream detected signal and 25 feet downstream of the most downstream detected signal within the RM11E Project Area. If remedial action is required within the cable caution zone, then the location of the seven cables in the common trench will need to be further refined during remedial design.

3.5.3 SHORELINE OUTFALLS

Current shoreline outfall locations are shown on Figures 3.4a through 3.4d. Records from the City of Portland Bureau of Environmental Services (BES) were reviewed to identify outfall locations, including those of outfalls no longer in service, and known physical characteristics (e.g., size, type of pipe).

Photographs of selected outfalls appear on Figures 3.4a through 3.4d. Outfall data are summarized in Table 3.5. The outfalls are mapped on the figures with the center of the outfall symbol based on the BES database coordinates for the outfall. Field verification of outfall locations, invert elevations at the discharge point, size, and material type for specific outfalls that may be affected by the remedy will need to occur during future remedial design.

TABLE 3.5 – RM11E PROJECT AREA OUTFALL CHARACTERISTICS

OUTFALL ID	SIZE AND TYPE	X COORDINATE	Y COORDINATE	STATUS	APPROXIMATE LOCATION (PM)	COMMENTS
WR-283	15-in CMP	7642667.89	690690.87	I	10.93	Sakrete; Photo 2 on Figure 3.4a
WR-282	4-in PVC	7642775.37	690592.50	U	10.95	Sakrete; Photo 3 on Figure 3.4a
WR-291	8-in PVC	7642853.35	690526.60	A	10.97	Sakrete, Figure 3.4a
OF-45[a]	27-in CSP	7642879.65	690442.18	A	10.99	City of Portland; Photo 4 on Figure 3.4a
WR-306	48-in concrete	7643505.55	689914.45	A	11.15	ODOT; Photo 7 on Figure 3.4b
OF-44A	72-in RCP	7643534.78	689908.37	A	11.16	City of Portland; Photo 7 on Figure 3.4b
OF-44	12-in VSP	7643621.49	689747.44	A	11.19	City of Portland; Photo 9 on Figure 3.4c
WR-350	16-in plastic	7643696.33	689793.68	A	11.19	Glacier NW; Photo 10 on Figure 3.4c
WR-351	12-in PVC	7644094.98	689488.28	A	11.29	Glacier NW; Photo 13 on Figure 3.4c
WR-353	6-in metal	7644260.75	689362.85	A	11.33	Glacier NW; Figure 3.4c
WR-352	12-in PVC	7644299.58	689336.96	A	11.34	Glacier NW; Figure 3.4c
OF-43	56-in BRKSTN	7644507.49	689006.32	A	11.40	City of Portland; Photo 16 on Figure 3.4d
WR-401	Unknown	7644595.55	689192.05	I	11.40	Cargill; Figure 3.4d
WR-341	6-in PVC	7644754.07	688912.26	A	11.44	Cargill; Photo 18 on Figure 3.4d
WR-342	6-in PVC	7644865.78	688699.00	A	11.49	Cargill; Figure 3.4d
WR-343	6-in PVC	7644890.94	688648.36	A	11.50	Cargill; Photo 19 on Figure 3.4d
WR-344	6-in PVC	7644919.88	688506.30	A	11.52	Cargill; Photo 20 on Figure 3.4d

[a] An abandoned outfall (OF45) is located in the vicinity of the active OF45.

A = active
BRKSTN = breakstone
ODOT = Oregon Department of Transportation
PVC = polyvinyl chloride

CMP = corrugated metal pipe	RCP = reinforced concrete pipe
CSP = corrugated steel pipe	U = unknown
I = inactive	VSP = vitrified sewer pipe

3.6 HISTORICAL AND PLANNED DREDGING

Historical dredge projects provide insight into potential issues regarding the implementability of remedial alternatives. From the historical dredging elevations, the types of material that may be encountered during remedial removal can be inferred, such as loose infill in areas that have been dredged but have filled in naturally (via sedimentation), consolidated materials in areas that have never been dredged (native material), and debris in areas that have received anthropogenic fill.

3.6.1 HISTORICAL USACE DREDGING

USACE dredging records and hydrographic surveys from 1951 to 1997 in the RM11E Project Area were obtained from the USACE, Portland District (USACE, 2013). The RM11E Project Area is located at the upstream end of the federally maintained Columbia River and Lower Willamette navigation project. However, the dredging records obtained from the USACE did not identify any dredging activity in the RM11E Project Area during the time period covered by the records. The channel in the Willamette River is approximately twice as deep as the original river (Anchor QEA et al., 2012).[10] The Willamette River navigation channel has been dredged to the existing USACE project depth of -40 feet CRD.[11] Some areas may have been dredged to deeper depths for upland construction and fill projects.

3.6.2 HISTORICAL PRIVATE DREDGING

Private dredging records at the facilities were obtained through a review of documents made available by Glacier NW and Cargill, permit records obtained from the USACE through a Freedom of Information Act request, Questionnaire responses (Appendix B), personal contacts with waterfront facility operators, PHSS RI/FS reports and appendices, and personal contacts with marine contractors. Approximate locations of recent private dredging areas (1996 to 2009)[12] are shown in Figures 3.5a and 3.5b. Private dredging within the RM11E Project Area is summarized in Table 3.6 and discussed below.

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[10] The Columbia River and Lower Willamette River federal navigation channel was originally authorized by the Rivers and Harbors Act of 1878 and has been modified by subsequent Rivers and Harbors Acts.

[11] The USACE Chief of Engineers transmitted a favorable May 4, 1962 report to Congress to authorize deepening Columbia and Lower Willamette rivers to -40 feet CRD (Congress, 1962).

[12] No private dredging has been reported in the RM11E Project Area since 2009.

TABLE 3.6 – PRIVATE DREDGING (1996 – 2009) WITHIN RM11E PROJECT AREA

LOCATION	DISPOSAL	DREDGE DEPTH (FT CRD)	DATE	QUANTITY [a]
RIS&G barge dock (RIS&G, 2014) [b, c]	No dredging during this period			
Glacier NW (DOF/GSI, 2013; Glacier NW, 2014a)	Upland offload at RIS&G quarry (RM 14 to 15)	-40	1996	4,000 to 6,000 CY
Glacier NW (DOF/GSI, 2013; Glacier NW, 2014a)	Wasco County Landfill	-21 for barge dock; -36 for ship dock	2004	2,442 tons
Cargill main dock (Cargill, 2014a)	Wasco County Landfill	-40	2002 – July and September	5,000 CY
Cargill main dock (Cargill, 2014a)	Hickey Marine approved upland site in Vancouver, WA	-40	2006 - July	1,800 CY
Cargill main dock[d] (Cargill, 2014a)	Wasco County Landfill	-42	2009 - October	1,430[e] CY

Note: All dredging activity was performed by Hickey Marine Enterprises using a clamshell type of dredge.

[a] Quantity provided in the units as reported in the supporting documentation.

[b] The riverbed at or near the RIS&G facility was dredged during Port of Portland Terminal 2 reconstruction by the Port of Portland. The September 1981 issue of *Maritime Reporter and Engineering News* includes an article describing the planned Port of Portland Terminal 2 expansion, placing the dredging event in the early 1980s.

[c] The riverbed at or near the RIS&G facility was dredged during construction of the Fremont Bridge by ODOT. The Fremont Bridge was opened in November 1973, placing the dredging event in the early 1970s.

[d] A layer of sand at least 12 inches thick was placed over dredged area to cover potentially contaminated surfaces exposed by maintenance dredging.

[e] Includes dredging at both ship and barge docks.

3.6.2.1 RIS&G

RIS&G reported that it does not maintain any area of the riverbed, except where an aggregate spill during barge unloading may occur within the radius swing of its land-based clamshell crane (RIS&G, 2014).

3.6.2.2 Glacier NW

Glacier NW reported that the upstream dock is maintained at -36 feet CRD for ocean-going vessels and the downstream dock is maintained at -21 feet CRD for barges (depths allow for 1-foot overdredge, to -37 feet and -22 feet, respectively) (Glacier NW, 2014a). Glacier does not have an active maintenance dredging permit at this time (Glacier NW, 2015a).

3.6.2.3 Cargill

Cargill reported that its existing dredging permit (NWP-2001-00031) authorizes maintenance dredging until May 31, 2019, with maintenance of "adequate depths to accept ocean-going vessels at dockside and during grain loading operations: maintain a 40-foot draft at 0-foot CRD." This permit is for clamshell dredging to remove up to 8,000 cubic yards (CY) annually from the ship loading berth (1,400 feet long by 60 feet wide), with subsequent dewatering on a barge and trucking to an upland disposal facility. The last maintenance dredging event required post-

dredging placement of a sand cover to manage contamination remaining in the newly exposed surface material.

The main dock area is maintained at -40 feet CRD plus 1 foot overdredge (Cargill, 2014a), consistent with Willamette River navigational channel depths.

A 2008 sampling plan (GRI, 2008) describes maintenance dredging as typically removing 2,000 to 5,000 CY from along the 680-foot-long ship berth after spring runoff. The targeted materials are sand and silt infill.

3.6.3 ANECDOTAL WILLAMETTE RIVER DREDGING INFORMATION

The following information is anecdotal based upon the interviewee's recollections; supporting documentation was not available. This text is provided for informational purposes only. The interviewee's descriptive terms are as provided.

The following information from Mr. Steinwandle, RIS&G, is based upon his observations of Port of Portland dredging for fill for Swan Island, Port of Portland dredging for fill for Terminal 2, ODOT dredging for Fremont Bridge pier footings (Steinwandle, 2015):

- The riverbed material is largely small gravel and sand. The area has a reasonably compacted bottom with high silt content and some cementing of fine aggregate, which can be challenging for a cutter suction dredge.
- ODOT dredged pier footings for the Fremont Bridge to -60 feet CRD.
- If working too close to the shoreline, a cutter suction dredge can experience problems with riprap along the shoreline.

Mr. Jameson, Hickey Marine Construction, reported the following observations based upon his involvement in various maintenance and environmental dredging activities along the Willamette River, including the Cargill docks (Jameson, 2015):

- The RM11E Project Area is mostly consolidated material and cobbles with some wood debris.
- The riverbed in the RM11E Project Area has very little silty material.
- A hydraulic dredge would have difficulty because of the debris.

3.6.4 ANTICIPATED FUTURE DREDGING WITHIN RM11E PROJECT AREA

Navigation channel dredging in the vicinity of the RM11E Project Area has been infrequent in the past and is expected to remain infrequent in the future. If the Willamette River navigation channel is deepened from -40 feet CRD to -43 feet CRD,[13] then more frequent maintenance dredging may be required until the new project depth stabilizes. Since the Willamette River is

[13] The authorized Willamette River channel is -43 feet CRD, width varying, from the Columbia River to the Broadway Bridge (RM 11.6). Construction of the authorized channel has been deferred until after resolution of cleanup issues associated with the Willamette River being named to the National Priorities List by EPA under CERCLA (USACE, 2015)

authorized to -43 feet CRD and the Columbia River deepening has occurred to this elevation, future deepening of the Willamette River to this elevation can be expected.

Table 3.7 summarizes existing maintenance dredging metrics for facilities in the RM11E Project Area and anticipated future changes as reported by the facility operators in their response to the Questionnaire.

TABLE 3.7 –MAINTENANCE DREDGING METRICS IN THE RM11E PROJECT AREA

DREDGING LOCATION	MAINTAINED DEPTH	HISTORICAL DREDGED WIDTH	ANTICIPATED MAINTENANCE FREQUENCY	ANTICIPATED FUTURE CHANGES
Sakrete	No waterfront operations (Oldcastle, 2014)			
Stan Herman	No water-dependent operations (Herman, 2014)			
RIS&G (RIS&G, 2014)	-15 ft Hawthorne Bridge gauge[a]	Unknown	None	None
Glacier NW reported for barge dock (Glacier NW, 2014a)	-21 ft CRD plus 1 ft overdredge	Approximately 20 ft to 50 ft (from surveys)	8 to 15 years	None
Glacier NW reported for main dock (Glacier NW, 2014a)	-36 ft CRD plus 1 ft overdredge	Approximately 45 ft (from surveys)		None unless larger (deeper draft) vessels deliver cement to dock
Cargill reported for main dock(Cargill, 2014a)	-40 ft CRD plus 1 ft overdredge	Approximately 60 ft (from Questionnaire)	3 to 5 years	None unless Willamette River is deepened to -43 ft CRD
USACE	-40 ft CRD	Up to approximately 400 ft within RM11E Project Area[b]	Unknown	Unknown[c]

[a] Public information for Hawthorne Bridge gauge apparently not available. There is a Morrison Bridge gauge for which public information is available (~6 blocks immediately downstream of the Hawthorne Bridge). If the two gauges are consistent, then -15 ft Hawthorne Bridge gauge would be approximately -15.3 ft CRD (-9.9 ft NAVD88).

[b] Approximate longest distance from edge of navigation channel to RM11E Project Area limits.

[c] Deepening the Willamette River to -43 ft CRD has been authorized. It is unknown when the deepening will take place, as it is pending resolution of PHSS issues. If the Willamette River channel is deepened to -43 ft CRD consistent with the Columbia River depths, then maintained depths and frequency of maintenance dredging of the private berths could be affected.

Figures 3.5a (CRD vertical datum) and 3.5b (NAVD88 vertical datum) show the navigation areas within the RM11E Project Area, including the federal navigation channel limits and approximate access areas for private docks.[14] Although the full extents of the private navigation areas have apparently not been dredged in the past, dredging in these areas could occur if shoals were to develop.

[14] Private dock access areas were drawn on the basis of vessel arrival and departure descriptions in the Questionnaire responses and interviews with tug operators and Columbia River pilots.

3.7 HISTORICAL SITE CONDITIONS

Historical site conditions were evaluated for possible insight into the type of material present in the RM11E Project Area. Types of material present could impact implementation of remedial actions. For example, a removal action in a historical fill area could be expected to require removal of more debris than a removal action in an area of infilled river sediment.

3.7.1 VARIATIONS IN RECORDED BED ELEVATIONS

Available hydrographic public and private survey data were combined to present known variations of bottom elevations over time.

3.7.1.1 USACE Records

The Columbia and Lower Willamette River navigation project was authorized by Congress in 1878 (USACE, 1956). During the 1960s, the Willamette River navigation channel was deepened from -35 feet CRD to -40 feet CRD (USACE, 1960, 1970). The current authorization for the Willamette River is -43 feet CRD but this deepening has been deferred until issues associated with the PHSS are resolved. Representative cross sections of the various riverbed elevations shown in Figures 3.9a and 3.9b are based partly on USACE historical bathymetric survey data, which extends back to 1983.[15]

3.7.1.2 Other Survey Records

As part of the Section 2 mapping work, DEA compiled digital mapping data for the Lower Willamette River collected on behalf of the LWG from 2002 to 2009. Figures 3.9a and 3.9b show representative cross sections of the various riverbed elevations, developed from the LWG surveys, USACE records, and NWHydro surveys at Cargill.

3.7.2 HISTORICAL SHORELINE PROGRESSION (FILL AND EROSION)

The shoreline has been expanded riverward and steepened through the placement of artificial fill over much of the RM11E Project Area. As noted in Section 3.1.3 of the Work Plan (DOF/GSI, 2013), the artificial fill is known to contain building debris, abandoned steel, timber road ties, and concrete and woody debris in some areas, all of which could complicate implementation of future remedies. In addition to anthropogenic advances of the shoreline due to filling, localized deposition and scour have also likely helped shape the shoreline over time.

Changes in shoreline alignment over time were evaluated by mapping changes to the top-of-bank and nearshore slopes, where possible, from the following sources:

- Bathymetric surveys – The nearshore component of historical bathymetric surveys, with cross-sectional views generated at multiple points in time to provide an indication of historical filling or erosion along the shoreline
- Aerial photographs – Historical aerial photographs with the top-of-bank mapped over multiple years to provide an indication of historical filling or erosion along the shoreline

[15] No earlier survey data were available from the USACE to indicate the dates of initial Willamette River deepening.

- Interviews – Questionnaire responses from property owners regarding historical shoreline modifications and, if applicable, known shoreline instability

The following aerial photographs, charts, and Sanborn fire insurance maps were collected and reviewed to map and geo-register the historical RM11E shorelines for this study. The results were then combined to generate a composite summary of historical shoreline locations, as shown in Figure 3.10. Copies of information sources with double asterisks (**) were geo-registered and combined to create Figure 3.10 and are included in Appendix C. Copies of information sources with double hash tags (##) were also geo-registered but are not included in Figure 3.10, as they showed information similar to other geo-registered sources. These latter sources are also included in Appendix C for reference.

- U.S. Coast and Geodetic Survey (USC&GS) Willamette River map (**1888, ** 1908, ##1925)
- ODOT library photos (1959,## 1963, 1964, 1969,** 1970, 1974, 1979, 1986)
- U.S. Geological Survey (USGS) library photos (##1951, 1952, 1955, 1960, 1970, 1971, 1973, 1974, 1975, 1980, 1990, 1994, 2000, 2009, 2011)
- Sanborn maps (1887, 1889, ##1901, 1909, ##1924, **1950, 1969)
- NOAA charts (1880, 1947, 1948, 1949, 1974, 1976, 2000)
- USACE library photos[16] (## 1936, **1943, ##1948, 1952, **1957, **1963, 1969, ##1974, **1983, 1996)

The intent of many of these historical sources was not to show the shoreline location; stereo pairs of photos are not available for precise measurements, and in many areas the shoreline in the photos is obscured by structures. For example, in 1908 much of the shoreline in the RM11E Project Area is obscured by waterfront dock structures. However, the following can be concluded based upon the historical references in Appendix C:

- The current shoreline waterward of the shoreline in 1888 appears to be fill.
- In early 1920s, ship keyways and docks replaced overwater warehouses between PM 11.2 and PM 11.4 in the RM11E Project Area.
- In the 1950s, many of the shoreline warehouses and docks in the RM11E Project Area were removed.
- From the 1960s to the present, many areas have experienced shoreline fill.

DEA multibeam hydrographic surveys[17] and LiDAR upland surveys from 2002 through 2009 provide an 8-year snapshot of recent shoreline elevation changes, as shown in Figures 3.11a through 3.11c cross sections. The survey data are combined with the historical top-of-bank

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[16] Obtained from the USACE, Portland District library.

[17] There are many factors that contribute to the accuracy of multibeam survey data such as sound velocity, beam angle of reflectance, positioning, etc. When two multibeam surveys are compared, survey to survey, most of the data are within plus or minus 0.25 feet (DEA, 2015).

locations. With two exceptions, the cross sections generally show only minor changes in the shoreline slope over that 8-year time at most locations. PM 11.52 at the upstream end of the project (Figure 3.11c) is an exception in that a portion of the slope is now 14 feet lower than in 2002. The cross sections at both PM 11.18 (Figure 3.11 a) and PM 11.33 (Figure 3.11b) indicate that a portion of the slope is now on the order of 4 to 5 feet lower than in 2002.

Table 3.8 provides information from property owners regarding historical shoreline modifications.

TABLE 3.8 – PRIVATE SHORELINE MODIFICATIONS IN THE RM11E PROJECT AREA

WATERFRONT FACILITY	SHORELINE MODIFICATIONS
Sakrete	No information provided (Oldcastle, 2014)
Stan Herman	No shoreline issues and no modifications planned (Herman, 2014)
RIS&G	RIS&G stated that there is no history of shoreline stability problems at this facility. All structures that may "distress soil conditions" are placed on piles. The adjacent shoreline owned by ODOT has been riprapped (RIS&G, 2014).
Glacier NW	Glacier NW stated that a retaining wall has collapsed at the northern end of its property and that the bank behind the main dock was armored with riprap when the dock was replaced in 2001-2002. Vegetation was planted within the "greenway" to help stabilize the bank (Glacier NW, 2014a).
Cargill	Cargill stated that shoreline stabilization has occurred in three phases (Cargill, 2014a). The ODSL issued a General Authorization to Cargill for the bank reinforcement and stabilization in December 1998. Phase 1 work provided supplemental foundation support for an office building supported on piles. This phase also addressed approximately 300 feet of shoreline extending from about 30 feet upstream of the office building downstream to the dock walkway. Phase 2 addressed stabilization of another approximately 300 feet of shoreline just upstream of a recently constructed stabilization wall. Phase 3 work included stabilization through landscaping along the shoreline of the Cargill property.

3.8 REGULATORY WORK RESTRICTIONS

Work in or near the Willamette River is restricted by various regulations and policies. These restrictions are imposed by Oregon Department of Fish and Wildlife (ODFW), U.S. Fish and Wildlife Service (USFWS), ODSL, NOAA Fisheries (formerly National Marine Fisheries Service), and the City of Portland.[18] Four categories of regulatory restriction are addressed in this report:

- In-water work windows
- City noise ordinance
- City floodplain construction limitations

[18] Floodplain construction requirements are addressed in Section 3.8.3.

- City greenway regulations

3.8.1 IN-WATER WORK WINDOWS

In-water work windows are established to protect certain aquatic species. Work is generally not permitted outside of these windows, as summarized in Table 3.9.

TABLE 3.9 – IN-WATER WORK WINDOWS FOR RM11E PROJECT AREA

AGENCY	PREFERRED IN-WATER WORK WINDOW	SPECIES OF CONCERN
Oregon Department Fish and Wildlife(ODFW, 2008)	July 1 to October 31 (all depths) December 1 to January 31 (below -20 ft CRD [~-15 ft NAVD88])	Chinook salmon (fall, spring), coho salmon, steelhead (winter, summer), cutthroat trout (including sea run), and various warm water game fish
US Fish and Wildlife Service (USFWS, 2010)	July 1 to February 28	Pacific lamprey

The USACE and ODSL normally defer to ODFW, USFWS, and NOAA Fisheries for permitting in-water work windows. Figure 3.12 shows the agency-preferred in-water work windows.

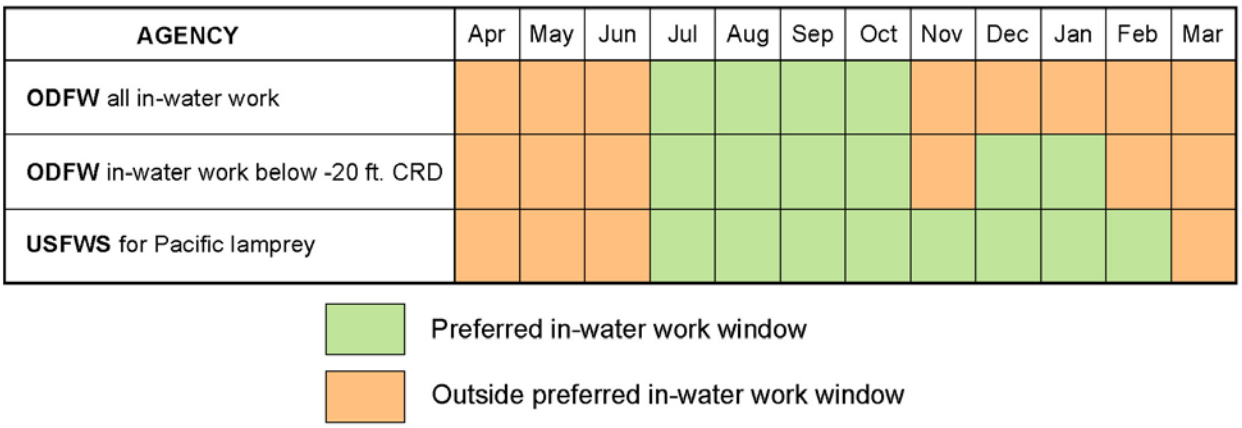

FIGURE 3.12 – AGENCY PREFERRED IN-WATER WORK WINDOWS

In some cases, project-specific exceptions to the standard in-water work windows (July 1 to October 31) have been considered in light of benefits to fisheries resources in the work area (Oregon Bridge Delivery Partners, 2014) (e.g., fewer effects to fish, less in-water activity during sensitive life stages, less turbidity, fewer construction seasons).

In-water work window restrictions may affect the implementability of remedial actions in the following ways:

- Prevent the remedial work from being completed within a single work season, resulting in a multiyear project
- Require stabilization or protection of partially remediated areas between work seasons

- Conflict with the busiest time of the year for waterfront operations at RIS&G, Glacier NW, and Cargill docks (Figure 3.8)

3.8.2 CITY OF PORTLAND NOISE RESTRICTIONS

The City of Portland establishes sound restrictions that vary based on zoning, activities, and time of day (Portland City Code 18.10.10). The City currently permits construction noise up to 85 decibels on the A-weighted scale (dBA) at 50 feet distance between 7 a.m. and 6 p.m. Monday through Saturday (Portland City Code 18.10.60). Outside of these hours, construction noise is limited to the baseline permitted dBA for the area in which the work is taking place unless a variance is issued by the City. In an industrial area, this baseline is 75 dBA. The ordinance requires all equipment to have sound control devices "no less effective than those provided on the original equipment, and no equipment shall have an unmuffled exhaust" (Portland City Code 18.10.060).

3.8.3 FLOODPLAIN, GREENWAY AND OTHER CONSTRUCTION REQUIREMENTS

The Portland Bureau of Development Services regulates grading and construction projects within the City limits. This oversight includes compliance with requirements of planning and zoning codes including Greenway Overlay Zones, floodplain management, grading, erosion control, and stormwater management. The City requires a balanced cut and fill in the floodway, such that for all fill placed at or below the base flood elevation, an equal amount of soil material is removed (City, 2015a). In addition, the City prohibits an encroachment into the floodway from increasing the base flood elevation (City, 2015b).

Greenway overlays protect, conserve, enhance and maintain the natural scenic, historical, economic, and recreational qualities of land along the Willamette River. The RM11E Project Area is within the Willamette Greenway Plan Boundary. Detailed analysis of specific remedial alternatives will be required during remedial design to address these requirements.

3.9 EVALUATION OF WATERFRONT ACTIVITIES AND SITE CONDITIONS

This section evaluates the effects of waterfront-related activities and site conditions on the physical, security, operational, and other constraints that may be imposed on the selection and long-term viability of potential remedial actions for contaminated sediment in the RM11E Project Area. These potential remedial actions include removal of sediment and placement of a cap or a cover over contaminated sediment. Consideration of the potential impacts to waterfront structures on the selection of potential remedial actions for the RM11E Project Area is addressed in Section 6.

Waterfront activities and site conditions in the RM11E Project Area were grouped into the following classes to evaluate impacts:

- Waterfront facility operations
- Navigation clearance criteria
- Construction access
- PacifiCorp submarine cable crossing
- Outfalls and shoreline utilities

The potential impacts are ranked as low, moderate, or high based upon the following general criteria:

- Low – no remedial management actions would be required prior to implementing remediation; potential for limited disruption to ongoing business operations
- Moderate – remedial management actions involving minor design, analysis, or modifications to standard remedial practices would be required prior to implementing remediation; potential for limited disruption to ongoing business operations
- High – remedial management actions involving complex design, analysis, or modifications to standard remedial practices would be required prior to implementing remediation; potential for significant disruption to ongoing business operations

The following sections describe issues, management actions, and rankings for each class of waterfront activity and site condition.

3.9.1 WATERFRONT FACILITY OPERATIONS

Waterfront facility operations include vessel traffic related to unloading of aggregate product from barges at RIS&G, vessel traffic related to the unloading of bulk cement from Handymax vessels at Glacier NW, and vessel traffic related to transfer of grains from barges and into Handymax and Panamax vessels at Cargill, as described in Section 3.4. Waterfront operations also include future maintenance dredging (Table 3.7) and potential future dock repairs (Section 3.5.1).

3.9.1.1 Waterfront Operations Issues

Extensive in-water work in the active dock areas along the RM11E waterfront is likely to disrupt ongoing business operations, affect remedial options, or both. With frequent ship activity at one or more docks in the RM11E Project Area, scheduling of extended in-water work may be difficult; careful coordination will be required with waterfront businesses to avoid or limit interruption of business operations. Any such shutdown would disrupt operations, impose economic hardship, and adversely impact these waterfront businesses. Any such shutdown could also impose Portland community costs including temporary or permanent loss of employment or ancillary businesses (e.g., commodity producers such as farmers, tug operators, stevedores,)

For in-water remedial action work areas farther away from the docks, the schedule will also need to accommodate vessel arrivals and departures. In addition to the ship traffic associated with facilities within the RM11E Project Area, ship traffic unrelated to those facilities traverses the navigation channel in the immediate area. Other unrelated boating (e.g., fishing, pleasure craft) also occurs within the RM11E Project Area. Furthermore, vessel traffic through a site where remedial action is still underway can disturb and damage the work.

The busiest periods at all three facilities coincide with the agency-preferred in-water work periods of July through October (Figure 3.8).

3.9.1.2 Waterfront Operations Management Actions

Potential waterfront operations management actions include coordinating scheduling of work at the multiple locations within the RM11E Project Area; As needed to accommodate facility operations, remedial equipment could be shifted from place to place to help limit down-time. Additional management actions include scheduled work pauses to accommodate vessel calls, and

close coordination with facility operators and remedial contractors (e.g., contractor daily meetings to update schedules). The ongoing and anticipated future commercial waterfront operations in RM11E Project Area present significant challenges for implementation of active remedies. The specific management actions to be developed must consider the conflicts between fish protection schedules, seasonal needs of the waterfront businesses, business interruption and community costs, and the effect of intermittent remedial action operations on the remedy constructability and cost.

3.9.1.3 Waterfront Operations Ranking

The potential impact of waterfront facility operations on remedial alternatives is ranked as high at RIS&G, Glacier NW, and Cargill both for removal and for cap or cover options. The prevention of disruption to ongoing business operations is expected to be challenging during the implementation of active remedial actions.

3.9.2 NAVIGATION CLEARANCE CRITERIA

In general, in-water remedial actions are to be completed in a manner that does not hinder future vessel navigation. This is particularly true for the federal navigation channel, berths at docks, and the navigational paths between the federal channel and those docks. Dredging will not affect navigation clearance. However, cap design and construction within the berths, navigational paths, and federal channel will need to be completed in a manner that does not adversely impact vessel operations. Consequently, expected navigable waterway depths and the potential for future maintenance dredging to impact caps must be considered when designing remedial alternatives involving capping.

The following bullets present post-remediation clearance criteria suggested for sediment confinement caps constructed in navigation areas, as documented in the PHSS Draft FS report (Anchor QEA et al., 2012), and shown on Figure 3.13:

- In navigation and maintenance dredging areas with depths less than -35 feet CRD (~-30 feet NAVD88), the top of any remedial cap should be 5 feet below the maintenance dredge elevation (3 feet for advance maintenance[19] plus allowable 2-foot overdredge operational buffer).
- In navigation and maintenance dredging areas with depths consistent with the (federal) navigation channel, the top of a remedial cap should be below -53 feet CRD (~-48 feet NAVD88) based upon authorized depth -43 feet CRD (~-38 feet NAVD88) plus 5 feet future deepening allowance, plus 3 feet for advance maintenance, plus allowable 2-foot overdepth operational buffer.

While these criteria do not represent the recommendations of the RM11E Group, they are indicative of the nature of navigation clearances to be considered during remedial design.

[19] Advance maintenance is dredging below the required, authorized, or previously permitted project elevation. This practice provides a temporarily deeper depth so as to prolong the useful life of the project and extend the time between maintenance dredging events.

Table 3.10 shows the post-remediation maximum top-of-cap or top-of-cover elevations that might apply if the FS clearance criteria were applied to the navigation areas shown in Figures 3.5a and 3.5b.

TABLE 3.10 – EXAMPLE POST-REMEDIATION MAXIMUM TOP-OF-CAP ELEVATION IN NAVIGATION AREAS PER THE FS CRITERIA

NAVIGATION AREAS	MAINTAINED DEPTH (WITHOUT OVERDEPTH)	POST-REMEDIATION MAXIMUM TOP-OF-CAP ELEVATION (PER FS CRITERIA)
RIS&G	-15 ft Hawthorne Bridge gauge	~-20 ft CRD
Glacier NW Barge	-21 ft CRD	-26 ft CRD
Glacier NW Ship	-36 ft CRD	-41 ft CRD
Cargill Ship	-40 ft CRD	-53 ft CRD
USACE	-40 ft CRD	-53 ft CRD

Applying the above FS criteria as an example, if a 5-foot-thick cap[20] was called for in a deep-draft vessel navigation/berthing area, then dredging would first have to remove material to elevation -46 feet CRD at the Glacier NW ship dock and to elevation -58 feet CRD at the Cargill ship dock and in the navigation channel; only then could a cap be constructed. However, the measured depths of impacted sediment in the navigation and maintenance dredging areas of the RM11E Project Area (GSI, 2009b) are consistently shallower than these elevations. Accordingly, full removal of the impacted material would likely be achieved before reaching the desired depth to initiate cap construction; the need for a cap would thus be negated.

3.9.2.1 Navigation Management Actions

For cap or cover remedial actions, two classes of management action are available to accommodate navigation requirements:

- Avoid construction of a cap or cover that encroaches into the post-remediation clearance for navigation
- Develop a remedial design to reduce cap or cover thickness where the required clearance cannot otherwise be achieved

3.9.2.2 Navigation Ranking

The potential impact of navigation requirements on remedial action involving a cap or cover is ranked as moderate to high for locations within navigation areas because of the need to accommodate 5 to 10 feet of post-remediation clearance[21] above the cap or cover and the need to accommodate erosive forces from vessel traffic. The potential impact of navigation requirements on remedial alternatives involving removal is ranked as low because the navigation clearance requirements do not constrain the removal alternative.

[20] Example cap thickness based on a 3-foot-thick large-rock armor layer and a 2-foot-thick cap layer.

[21] Post-remediation clearance is the distance from the authorized federal navigation channel elevation or the potential future maintenance dredge elevation to the top of the cap (armor) elevation.

3.9.3 CONSTRUCTION ACCESS

Physical features within the RM11E Project Area can impact the implementability of remedial technologies by constraining construction access to material targeted for remedial action. Construction access to target sediments within the RM11E Project Area can be limited by the following:

- In-water structures that block access by standard marine construction equipment
- Shallow water depths that cause grounding of standard marine construction equipment
- Upland structures that limit construction access along the shoreline

The nomenclature used to describe restricted access is defined below. Descriptors from the PHSS Draft FS are identified. Figures 3.14a through 3.14d illustrate RM11E Project Areas with restricted construction access.

- Access limited by overhead structures ("SS" in PHSS Draft FS) – Areas underneath or within 5 feet of robust structures are not accessible to conventional marine construction equipment. Locations with this restriction are shaded **green** on Figures 3.14a through 3.14d. This restriction applies to waterfront structures present along the Sakrete, Stan Herman, RIS&G, Glacier NW, and Cargill properties.
- Access limited by groups of vertical pile remnants – As discussed in Section 4, groups of vertical piles reduce available draft, and limit access by conventional floating marine construction equipment. Locations with this restriction are shaded **orange** on Figures 3.14c and 3.14d. This restriction applies along the Glacier NW and Cargill properties.
- Access constricted due to structures ("SL" in PHSS Draft FS) – For purposes of this analysis, the minimum width required to access remedial areas with conventional marine equipment is 100 feet (the width of a derrick and barge). Where horizontal distance between structures or obstructions is less than 100 feet, access by standard equipment will be impeded. Locations with this restriction are shaded **blue** on Figures 3.14c and 3.14d. This restriction applies along the Glacier NW and Cargill properties.
- Limited floating equipment draft, based on +4 feet to -4 feet NAVD88 – Standard floating equipment, typically used in unconstrained areas, requires a minimum 10-foot water depth (draft). During the in-water preferred work window (July through October) the surface of the Willamette River is between approximately 14 feet NAVD88 and 6 feet NAVD88, which limits access for 10-foot draft vessels during these months to between elevations 4 feet (14 feet minus 10 feet draft) NAVD88 and -4 feet (6 feet minus 10 feet draft) NAVD88. Locations with this restriction are shaded with a **blue dot pattern** on Figures 3.14a through 3.14d. This restriction applies to the waterfront along portions of the Sakrete, Stan Herman, RIS&G, Glacier NW, and Cargill properties.
- Inaccessible from water and upland ("SN" in PHSS Draft FS) – This condition occurs behind structures with no in-water access, in places surrounded by structures, nearshore features (such as groups of vertical piles), or upland conditions that prevent land-based removal (i.e., inaccessible from both shoreline and water). Locations with this restriction are shaded **yellow** on Figures 3.14a through 3.14d. This restriction applies along the Sakrete, Stan Herman, RIS&G, Glacier NW, and Cargill properties.

- Potentially accessible from upland ("SU" in PHSS Draft FS) – Behind structures with no in-water access but with possible shoreline access land-based equipment may be used for removal actions. Upland operations may prevent access by land-based equipment along portions of the shoreline. Locations accessible only by the upland are shaded with **red hatching** on Figures 3.14a and 3.14c. This restriction applies to areas along the Sakrete and Glacier NW shorelines.
- Submarine cable crossing caution zone –Dredging as well as the setting of anchors or spuds[22] to hold barges in place are restricted in the submarine cable crossing caution zone. Shaded **tan** on Figure 3.14d, the caution zone extends from the Unkeles property across the river.

3.9.3.1 Construction Access Issues

As shown on Figures 3.14a through 3.14d, much of the shoreline and areas beneath and behind structures are inaccessible to conventional marine construction equipment. The portions of the site offshore of the shallow shoreline or offshore of structures are generally accessible to conventional marine equipment.

3.9.3.2 Construction Access Management Actions

Active remedial action in locations of the RM11E Project Area that are not accessible from the water by conventional marine construction equipment, or from the upland, would likely require non-standard equipment and methods. Non-standard remedial approaches may include special remedial design accommodations, specialized equipment, and additional construction time. In-water approaches may include diver equipment, use of smaller float-mounted equipment, confinement of work activity to periods of low water for access beneath structures, confinement of work activity to periods of high water for access to locations closer to the shoreline, and double-handling of material with smaller barges in order to work between structures. Land-based equipment approaches may involve modification of existing banks, such as flattening slopes or cutting a bench on which to set equipment. In certain situations, lack of construction access may preclude active remediation of a portion of a management unit.

3.9.3.3 Construction Access Ranking

The potential impact of construction access constraints on remedial alternatives, whether removal or placement of a cap or cover, is ranked as high because of the complex remedial design and coordination that would likely be required to develop and implement non-standard remedial approaches for these shoreline and berth areas.

3.9.4 PACIFICORP SUBMARINE CABLE CROSSING

A submarine cable crossing runs from the upland at the Unkeles property and extends across the river to downtown Portland. The buried submarine cable crossing restricts dredging as well as the setting of anchors or spuds to hold barges in place. A caution zone for underwater cables is shaded **tan** on Figure 3.14d.

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[22] Spuds are steel columns used to hold a barge in place by extending through a spud well on the barge to the riverbed.

3.9.4.1 Submarine Cable Crossing Issues

The submarine cables supply power to a portion of downtown Portland. While a corridor for the cable crossing has been established, there remains uncertainty regarding the specific location and buried depth of the seven cables that cross the river. Disturbance of the cables would disrupt power to part of downtown Portland. Also, contact with the cables by marine construction equipment would pose a significant safety risk to marine construction workers.

3.9.4.2 Submarine Cable Crossing Management Actions

If active remediation is required in the submarine cable crossing area then management actions for the cable crossing will have to include additional site investigation during remedial design to further refine the location and depth of the buried cables, and to avoid dredging, anchoring, and placing spuds within the cable zone. Because the cables are submarine and have a very large capacity, relocation during sediment remediation is not a viable management option.

3.9.4.3 Submarine Cable Crossing Ranking

The potential impact of the cable crossing on remedial alternatives in the vicinity of the cable crossing, whether removal or placement of a cap or cover, is ranked as high because of uncertainty regarding the exact cable crossing location, the inability to dredge over the cables without better location information, and the lack of sufficient water depth in some areas for a cap or cover that would meet navigational clearance requirements without dredging.

3.9.5 OUTFALLS AND SHORELINE UTILITIES

Many elements of public and private infrastructure are located along the Willamette River within the RM11E Project Area, as discussed in Section 3.5.3.

3.9.5.1 Outfall Issues

Active outfalls and shoreline utilities are located on the upper shoreline of the RM11E Project Area. Dredging downslope of or around outfalls has the potential to destabilize the bank and damage outfalls. Cap or cover systems in the vicinity of outfalls must be designed to account for potential scour from the outfall discharges.

3.9.5.2 Outfall Management Actions

The primary management action for any outfall in a location slated for active remediation is to refine its position, elevation, and depth of cover. That information can then be used to evaluate the potential impact of specific remedial actions and to develop mitigating actions. Options may include modifying the cover configuration near the outfall, avoiding actions that could disturb or damage the structure, temporarily rerouting or permanently relocating an outfall to avoid a remedial action area, and repairing an outfall after completion of a remedial action.

3.9.5.3 Outfall Ranking

The potential impact of the outfalls and shoreline utilities on remedial alternatives, whether removal or placement of a cap or cover, is ranked as low to moderate because of the availability of common construction practices that could likely be deployed.

3.10 CONCLUSIONS

3.10.1 POTENTIAL TIMING IMPACTS ON REMEDIAL ALTERNATIVES

The implementation of remedial alternatives will be influenced by multiple schedule and timing constraints described in prior sections of this report:

- Waterfront operations, including frequency of vessel calls (Section 3.4)
- Regulatory work restrictions, including in-water work windows (Section 3.8)

A summary of potential timing impacts on remedial alternatives is shown in Figure 3.15.

Condition	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Cargill	*				*	*	*	*	*	*	*	
Glacier NW	*	*	*	*	*	*	*					
RIS&G		*	*	*	*	*	*					
Summary of agency preferred ODFW in-water work period				*	*	*	*					

Period of facility activity

* Periods of busiest facility activity

* Agency preferred in-water work window, all water depths

Agency preferred in-water work window in depths > -20' CRD

FIGURE 3.15 – SUMMARY OF POTENTIAL TIMING IMPACTS ON REMEDIAL ALTERNATIVES

3.10.2 POTENTIAL IMPACT CLASSIFICATION

Table 3.11 summarizes the potential impacts of waterfront activities and use in the RM11E Project Area on implementability of remedial actions, as detailed elsewhere in this report. The areas affected by different waterfront activity and use constraints are shown on Figures 3.16a through 3.16d.

TABLE 3.11 – WATERFRONT ACTIVITIES AND USE CATEGORIES VS POTENTIAL IMPACT CLASSIFICATION

CATEGORY	POTENTIAL IMPACT CLASSIFICATION	
	REMOVAL	CAP OR COVER PLACEMENT
Waterfront facility operations	High	High
Navigation clearance requirements	Low	Moderate to high
Construction access	High	High
Submarine cable crossing	High	High
Outfalls and shoreline utilities	Low to moderate	Low to moderate

Waterfront activities and uses classified as having moderate to high potential to impact remedial implementability will require additional effort to select and design the remedy, including identification of site-specific management actions tailored to the selected remedial action in areas where active remediation is required.

3.11 SECTION 3 FIGURES

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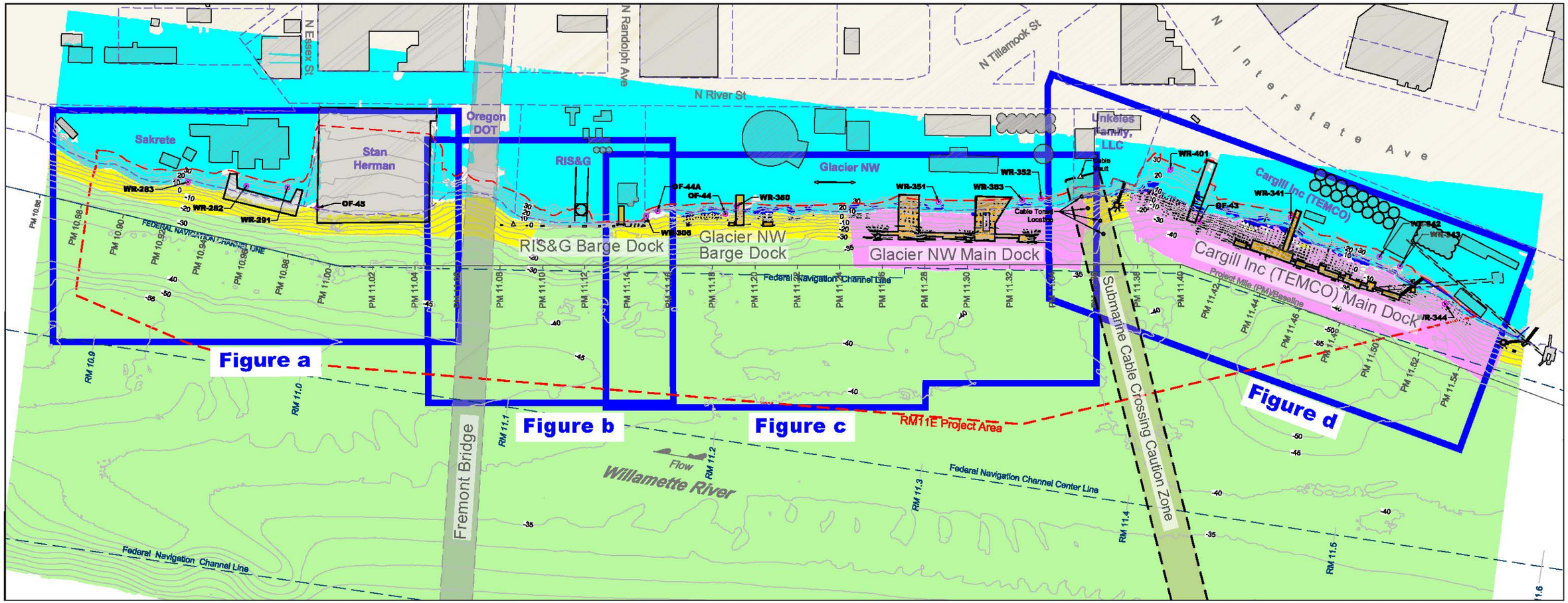

MAP NOTES

1. The locations of all features shown are approximate.
2. Contour lines and planimetric features are based on a composite data set which consists of the following: NOAA multibeam survey from 2009; ODSL multibeam and laser survey from 2010; USACE LiDAR survey from 2009; David Evans and Associates, Inc. multibeam survey from 2011 and terrestrial laser scan from 2013; and RLIS Metro GIS data. Digital elevation model (DEM) surface for bathymetric contours was modeled only in the immediate vicinity of the RM11E Project Area. It is not intended for litigation, construction, or navigation purposes .
3. Horizontal datum is based on Oregon State Plane North NAD83 (international feet). Vertical datum is referenced to NAVD88 (feet)
4. Outfall status and location from City of Portland - Bureau of Environmental Services (BES) GIS group in June 2013. Data layer acquired from GSI. Outfalls centered on coordinates from BES data layer..
5. Tax lot boundary generated by METRO (Oct. 2013). Data layer acquired from GSI.
6. Vertical pile remnants and submarine cable crossing location provided by David Evans and Associates, Inc. as described in the Draft Implementability Study Report, Section 2.

LEGEND

Figure Location

- Figure Location

Other Features

- Active Docks (2015)
- Existing Structures
- Submarine Cable Crossing Caution Zone
- Outfall - Active
- Outfall - Inactive or Status Unknown
- RM11E Project Area
- Tax Lot Boundary (Oct. 2013)
- RM 11.3 — River Mile Stationing (USACE)
- PM 11.32 — Project Mile Stationing
- Federal Navigation Channel (USACE)
- -40 — Bathymetric Contour - 5' Interval (NAVD88)

Survey Date (See Note 2)

- 2011 GSI Multibeam
- 2010 ODSL Multibeam
- 2009 USACE LIDAR
- 2009 NOAA Multibeam
- 2013 DEA Terrestrial Laser Scan

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Scale in Feet

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RM11E Project Area Map Key

DALTON OLMSTED FUGLEVAND

Figure 3.1

July 31, 2015

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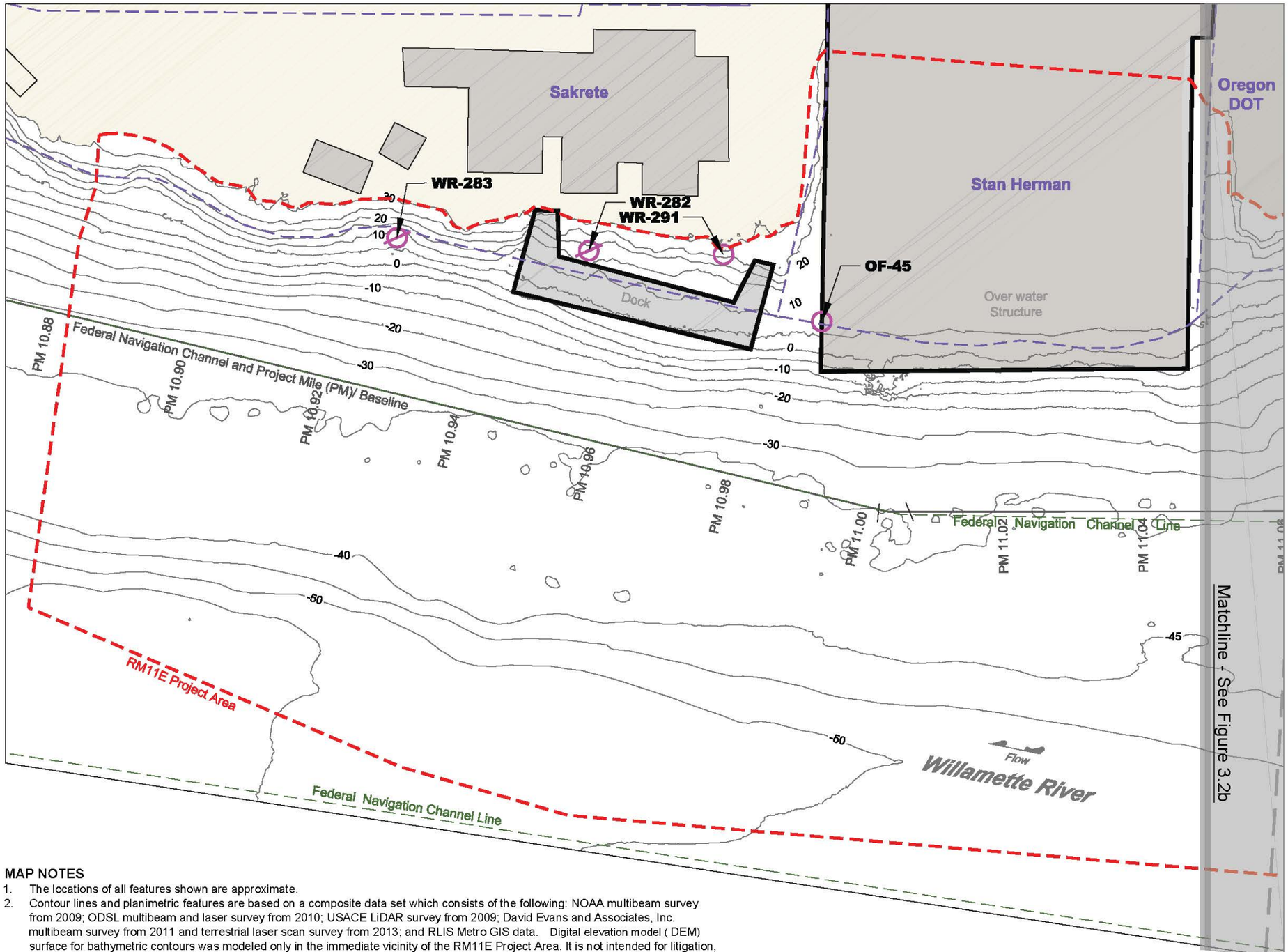

LEGEND

- Tax Lot Boundary (Oct. 2013)
- Existing Structures
- Outfall - Active
- Outfall - Inactive or Status Unknown
- RM11E Project Area
- PM 11.44 Project Mile Stationing
- Federal Navigation Channel (USACE)
- -40 Bathymetric Contour - 5' Interval (NAVD88)

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Scale in Feet

Figure Location Map

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Implementability Study Report

RM11E Project Area
Site Plan and Bathymetry
~PM 10.88 to ~PM 11.05

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Figure 3.2a

July 31, 2013

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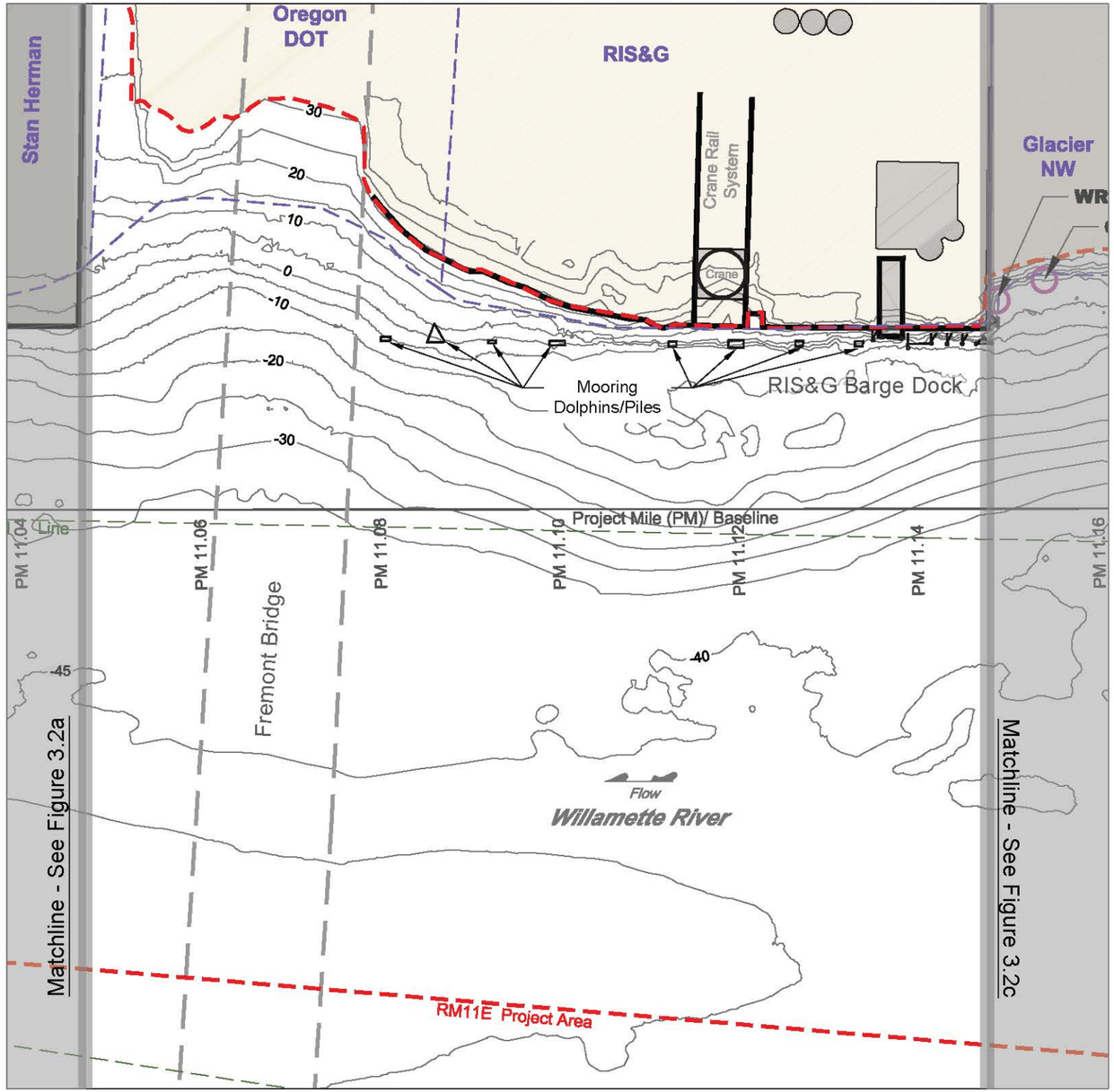

LEGEND

- Tax Lot Boundary (Oct. 2013)
- Existing Structures
- Outfall - Active
- RM11E Project Area
- PM 11.44 Project Mile Stationing
- Federal Navigation Channel (USACE)
- -40 Bathymetric Contour - 5' Interval (NAVD88)

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Scale in Feet

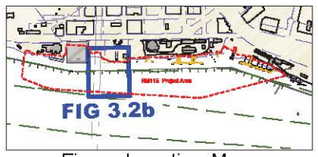

Figure Location Map

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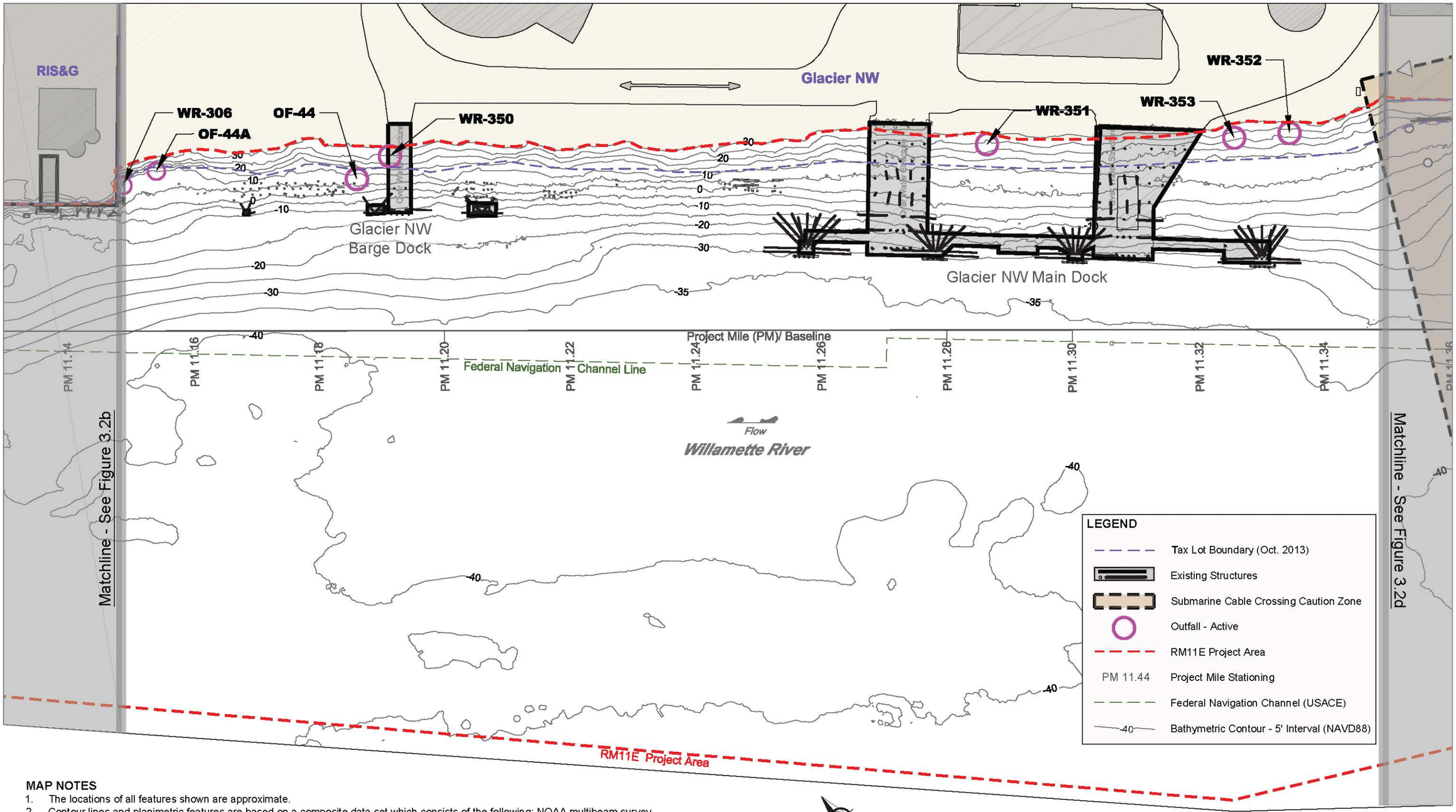
RM11E Project Area
Site Plan and Bathymetry
~PM 11.05 to ~PM 11.15

DALTON OLMSTED FUGLEVAND

Figure 3.2b
July 31, 2013

PLOT TIME: 7/31/2015 2:37 PM MOD TIME: 7/31/2015 2:15 PM USER: Lee Barras DWG: D:\Projects\RM11E\CAD\Figures\2015-07\SR\2015-07-31 05 Proj Site Plan and Bathy Fig 3.2abcd.dwg



MAP NOTES

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5. Tax lot boundary generated by METRO (Oct. 2013). Data layer acquired from GSI.
6. Vertical pile remnants and submarine cable crossing toned location provided by David Evans and Associates, Inc. as described in the Draft Implementability Study Report, Section 2.

0 80
Scale in Feet

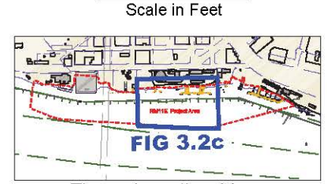

Figure Location Map

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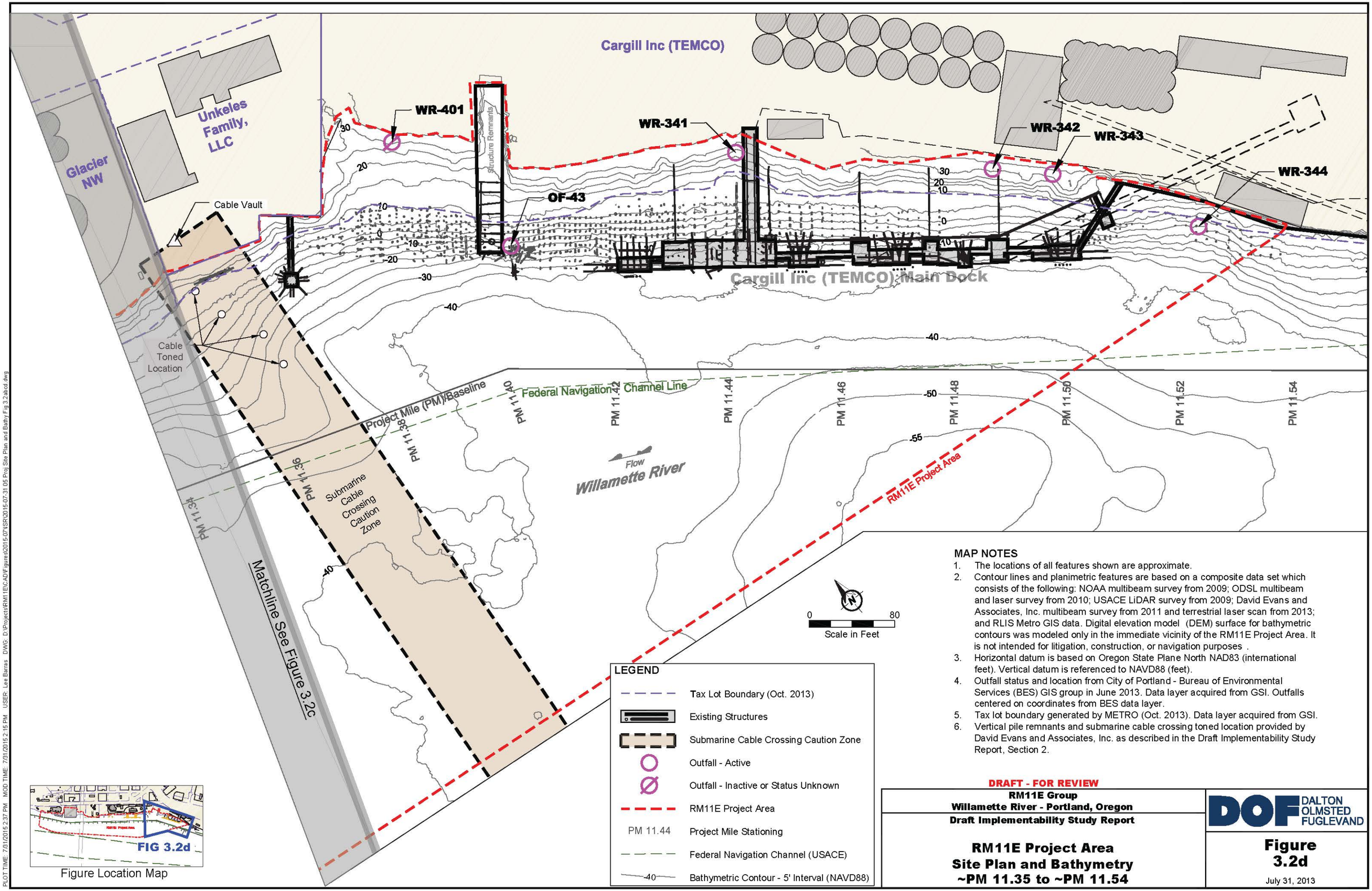
RM11E Group
Willamette River - Portland, Oregon
Draft Implementability Study Report

RM11E Project Area
Site Plan and Bathymetry
~PM 11.15 to ~PM 11.35

DALTON OLMSTED FUGLEVAND

Figure 3.2c
July 31, 2013

PLOT TIME: 7/31/2015 2:37 PM MOD TIME: 7/31/2015 2:15 PM USER: Lee Barras DWG: D:\Projects\RM11E\CAD\Figures\2015-07\SR\2015-07-31 05 Proj Site Plan and Bathy Fig 3.2abcd.dwg



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RM11E Group
Willamette River - Portland, Oregon
Draft Implementability Study Report

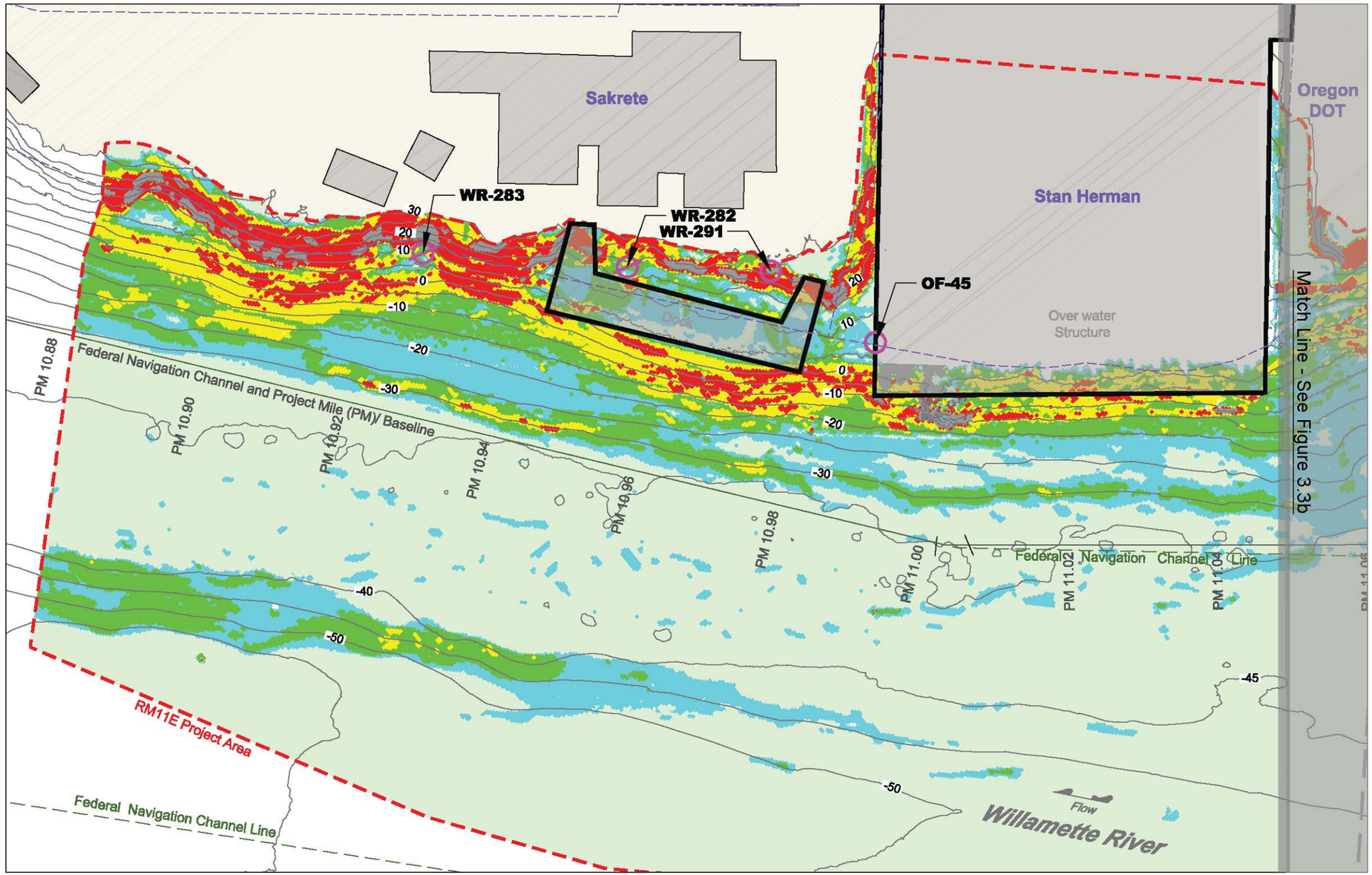
RM11E Project Area
Site Plan and Bathymetry
~PM 11.35 to ~PM 11.54

DALTON OLMSTED FUGLEVAND

Figure 3.2d

July 31, 2013

PLOT TIME: 7/31/2015 2:37 PM MOD TIME: 7/31/2015 2:15 PM USER: Lee Barras DWG: D:\Projects\RM11E\CAD\Figures\2015-07\SR\2015-07-31 05 Proj Site Plan and Bathy Fig 3.2abcd.dwg



LEGEND

Percent Slope Analysis

- 0% to 20% (flat to 5H:1V)
- 20% to 33% (5H:1V to 3H:1V)
- 33% to 50% (3H:1V to 2H:1V)
- 50% to 67% (2H:1V to 1.5H:1V)
- 67% to 100% (1.5H:1V to 1H:1V)
- > 100% (Steeper than 1H:1V)

Note: Slope analysis performed by GSI Water Solutions, Inc. - Sept. 2014 using ESRI ArcGIS to analyze the DEA Existing Grade composite project surface (DEM) for changes in slope.

Other Features

- Outfall - Active
- Outfall - Inactive or Status Unknown
- Existing Structures
- Tax Lot Boundary (Oct. 2013)
- RM11E Project Area
- PM 11.6 — Project Mile Stationing
- Federal Navigation Channel (USACE)
- -35 — Bathymetric Contour - 5' Interval (NAVD88)

0 80
Scale in Feet

Figure Location Map

MAP NOTES

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2. Contour lines and planimetric features are based on a composite data set which consists of the following: NOAA multibeam survey from 2009; ODSL multibeam and laser survey from 2010; USACE LiDAR survey from 2009; David Evans and Associates, Inc. multibeam survey from 2011 and terrestrial laser scan from 2013; and RLIS Metro GIS data. Digital elevation model (DEM) surface for bathymetric contours was modeled only in the immediate vicinity of the RM11E Project Area. It is not intended for litigation, construction, or navigation purposes.
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RM11E Group
Willamette River - Portland, Oregon
Draft Implementability Study Report

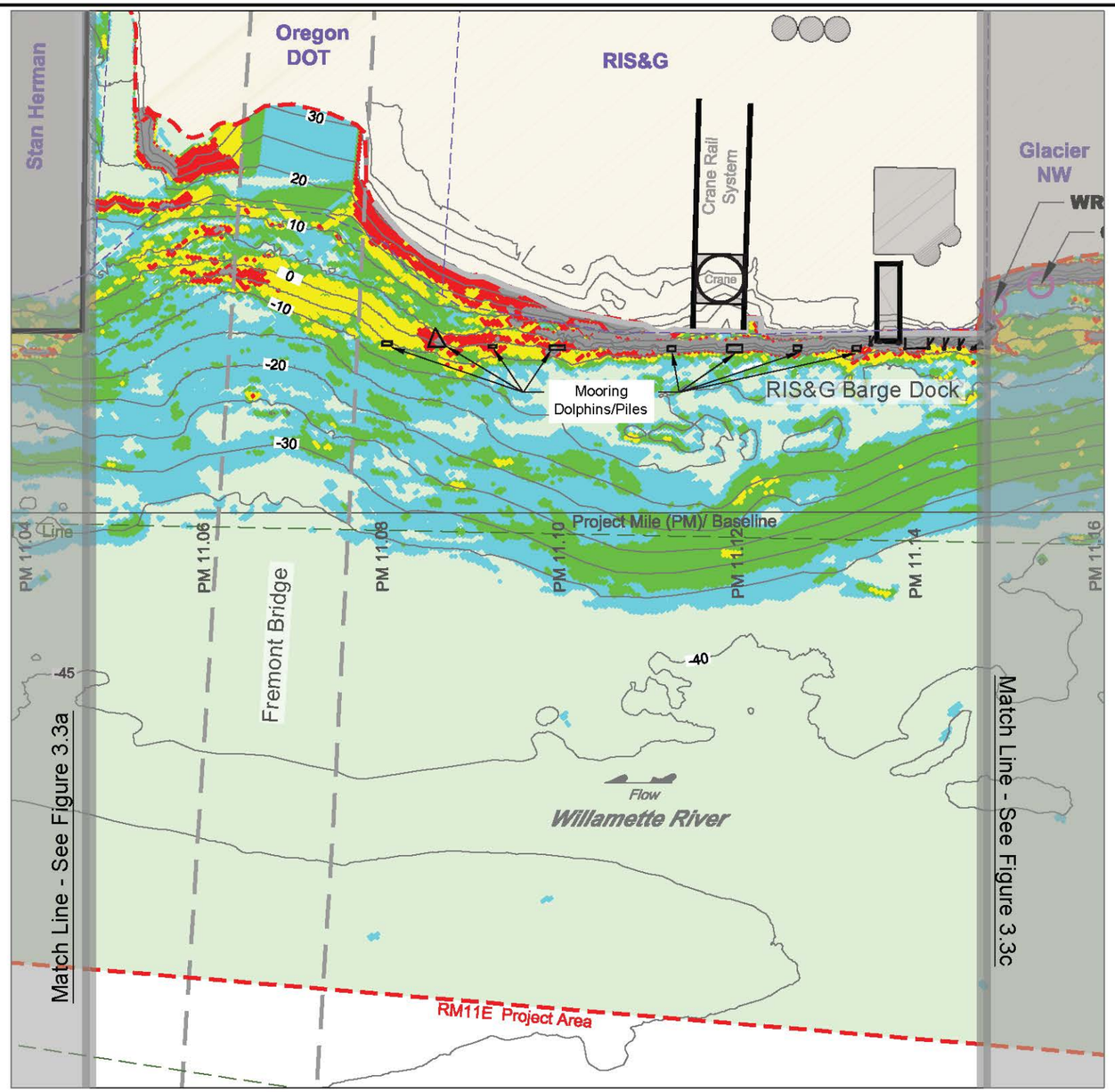
RM11E Project Area Slope Map
~PM 10.88 to ~PM 11.05

DALTON OLMSTED FUGLEVAND

FIGURE 3.3a

July 31, 2015

PLOT TIME: 7/31/2015 2:39 PM MOD TIME: 7/31/2015 2:23 PM USER: Lee Barrera DWG: D:\Projects\RM11E\CADFiguras\2015-07\SR\2015-07-31 06 Slope Map Fig 3.3abcd.dwg



LEGEND

Percent Slope Analysis

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- 20% to 33% (5H:1V to 3H:1V)
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- 50% to 67% (2H:1V to 1.5H:1V)
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Other Features

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- Existing Structures
- Tax Lot Boundary (Oct. 2013)
- RM11E Project Area
- PM 11.6 — Project Mile Stationing
- Federal Navigation Channel (USACE)
- -35 — Bathymetric Contour - 5' Interval (NAVD88)

0 80
Scale in Feet

Figure Location Map

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RM11E Group
Willamette River - Portland, Oregon
Draft Implementability Study Report

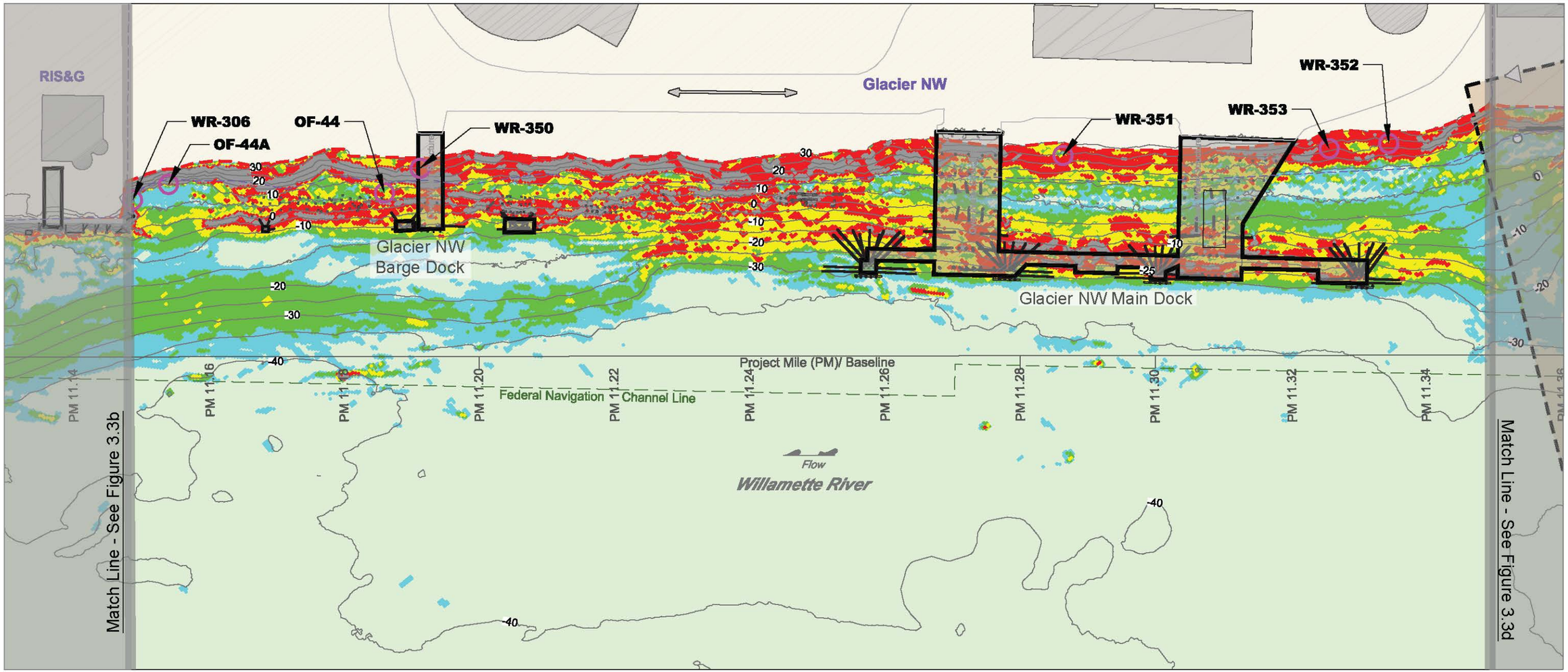
RM11E Project Area Slope Map
~PM 11.05 to ~PM 11.15

DOF DALTON OLMSTED FUGLEVAND

Figure 3.3b

July 31, 2015

PLOT TIME: 7/31/2015 2:40 PM MOD TIME: 7/31/2015 2:23 PM USER: Lee Barras DWG: D:\Projects\RM11E\CADFigures\2015-07\SR\2015-07-31 06 Slope Map Fig 3.3abcd.dwg



MAP NOTES

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LEGEND

Percent Slope Analysis

- 0% to 20% (flat to 5H:1V)
- 20% to 33% (5H:1V to 3H:1V)
- 33% to 50% (3H:1V to 2H:1V)
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Note: Slope analysis performed by GSI Water Solutions, Inc. - Sept. 2014 using ESRI ArcGIS to analyze the DEA Existing Grade composite project surface (DEM) for changes in slope.

Other Features

- Outfall - Active
- Existing Structures
- Submarine Cable Crossing Caution Zone
- Tax Lot Boundary (Oct. 2013)
- RM11E Project Area
- PM 11.6 — Project Mile Stationing
- Federal Navigation Channel (USACE)
- -35 — Bathymetric Contour - 5' Interval (NAVD88)

0 80
Scale in Feet

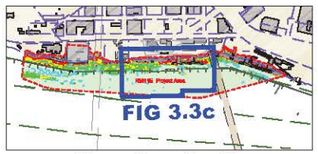

Figure Location Map

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RM11E Group
Willamette River - Portland, Oregon
Draft Implementability Study Report

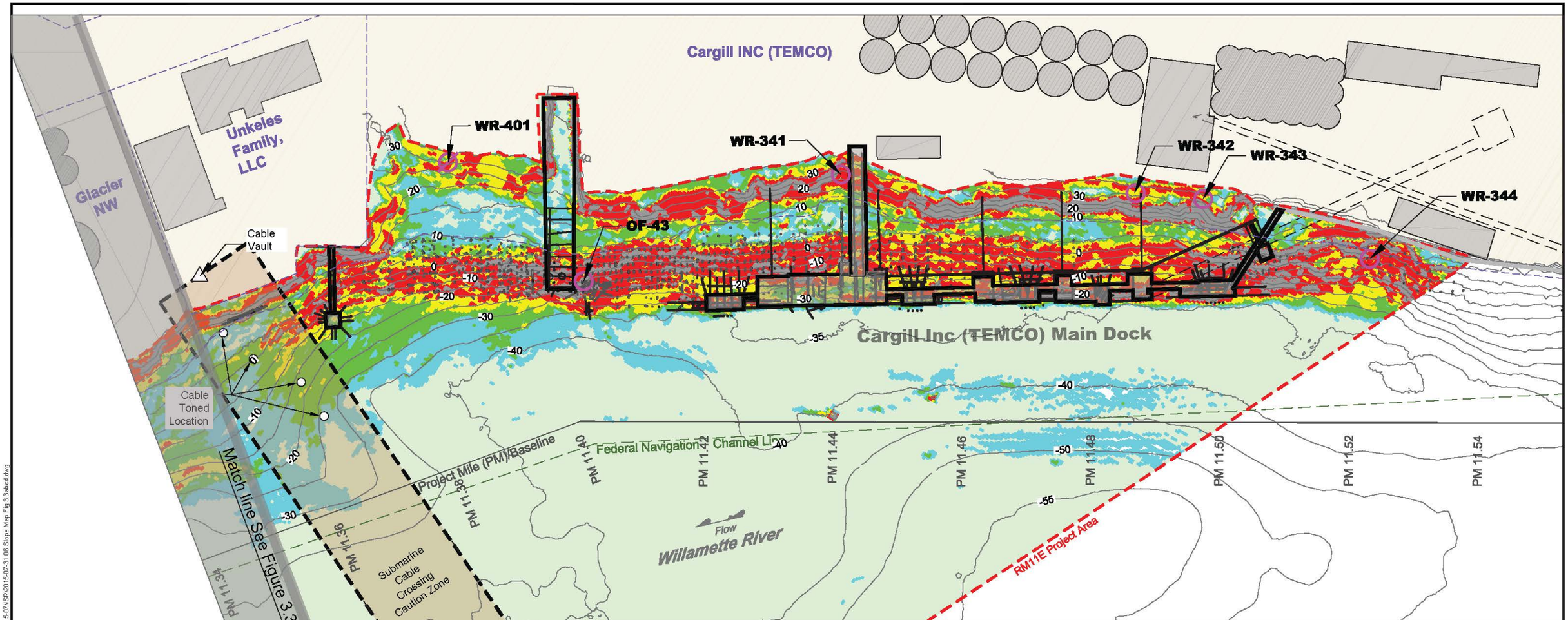
RM11E Project Area Slope Map
~PM 11.15 to ~PM 11.35

DALTON OLMSTED FUGLEVAND

Figure 3.3c

July 31, 2015

PLOT TIME: 7/31/2015 2:41 PM MOD TIME: 7/31/2015 2:23 PM USER: Lee Barras DWG: D:\Projects\RM11E\CADD\Figures\2015-07\SR\2015-07-31 06 Slope Map Fig 3.3abcd.dwg



LEGEND

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- Tax Lot Boundary (Oct. 2013)
- RM11E Project Area
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- Federal Navigation Channel (USACE)
- -35 — Bathymetric Contour - 5' Interval (NAVD88)

0 80
Scale in Feet

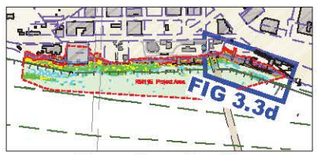

Figure Location Map

DRAFT - FOR REVIEW

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RM11E Group
Willamette River - Portland, Oregon
Draft Implementability Study Report

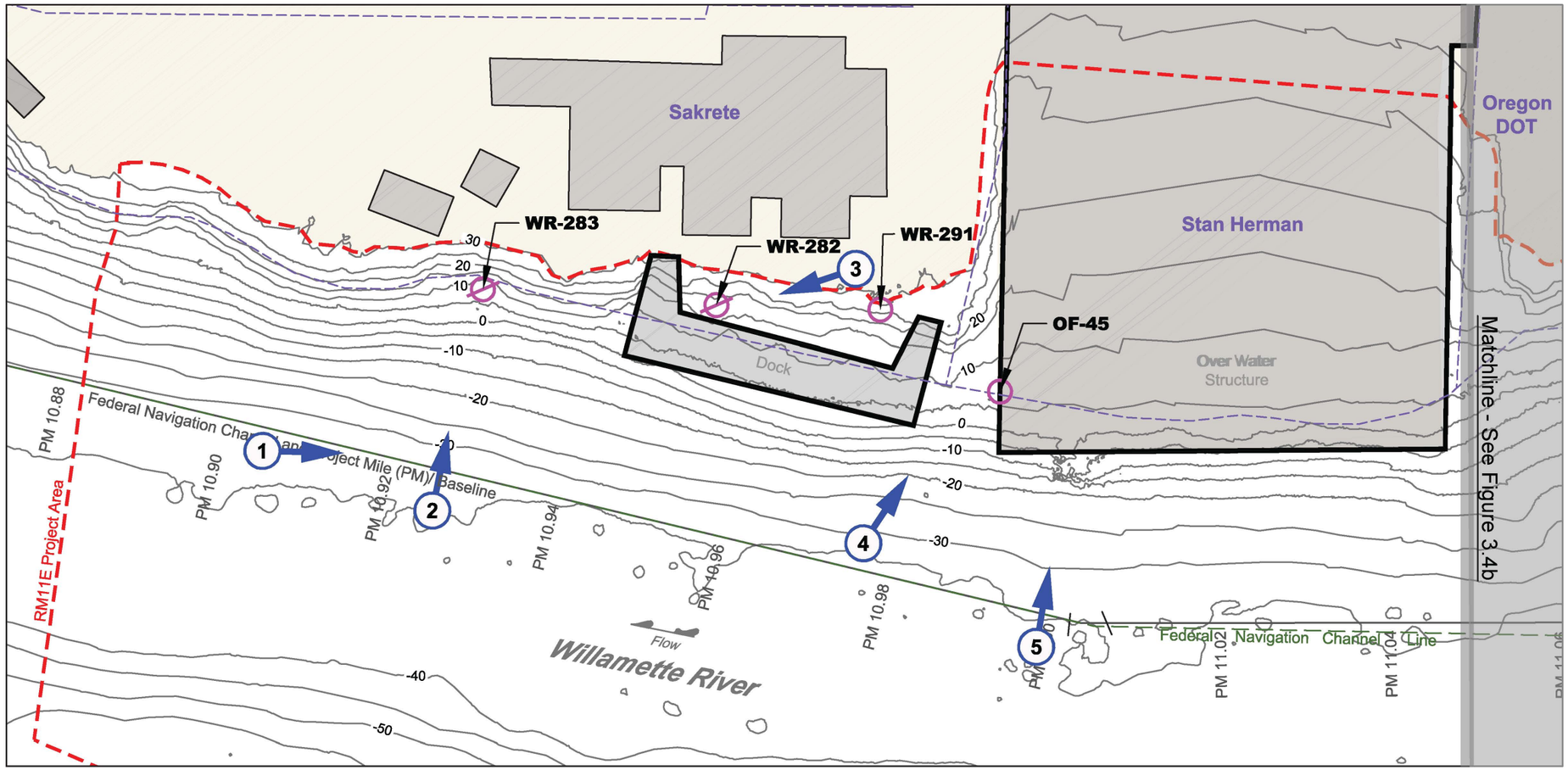
RM11E Project Area Slope Map
~PM 11.35 to ~PM 11.54

DALTON OLMSTED FUGLEVAND

Figure 3.3d

July 31, 2015

PLOT TIME: 7/31/2015 2:42 PM MOD TIME: 7/31/2015 2:23 PM USER: Lee Barnes DWG: D:\Projects\RM11E\CAD\Figures\2015-07\SR\2015-07-31 06 Slope Map Fig 3.3abcd.dwg



LEGEND

Photos

- Photo Orientation and ID

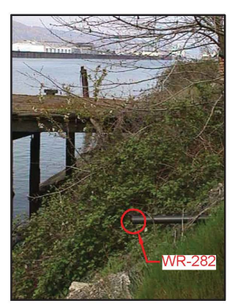
Other Features

- Tax Lot Boundary (Oct. 2013)
- Existing Structures
- Outfall - Active
- Outfall - Inactive or Status Unknown
- RM11E Project Area
- PM 11.44 Project Mile Stationing
- Federal Navigation Channel (USACE)
- -35 Bathymetric Contour - 5' Interval (NAVD88)

0 80
Scale in Feet

1. Sakrete Dock

2. Outfall - WR-283
(Source: City of Portland)



3. Outfall - WR282
(Source: City of Portland)

4. Outfalls - On the left OF45 - active
On the right OF45 - inactive

5. Stan Herman Property (May 2013)

Figure Location Map

MAP NOTES

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RM11E Group
Willamette River - Portland, Oregon
Draft Implementability Study Report

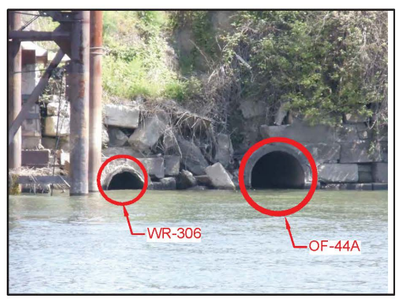
RM11E Project Area
Site Plan and Facility Photos
~PM 10.88 to ~PM 11.05

DOF DALTON OLMSTED FUGLEVAND

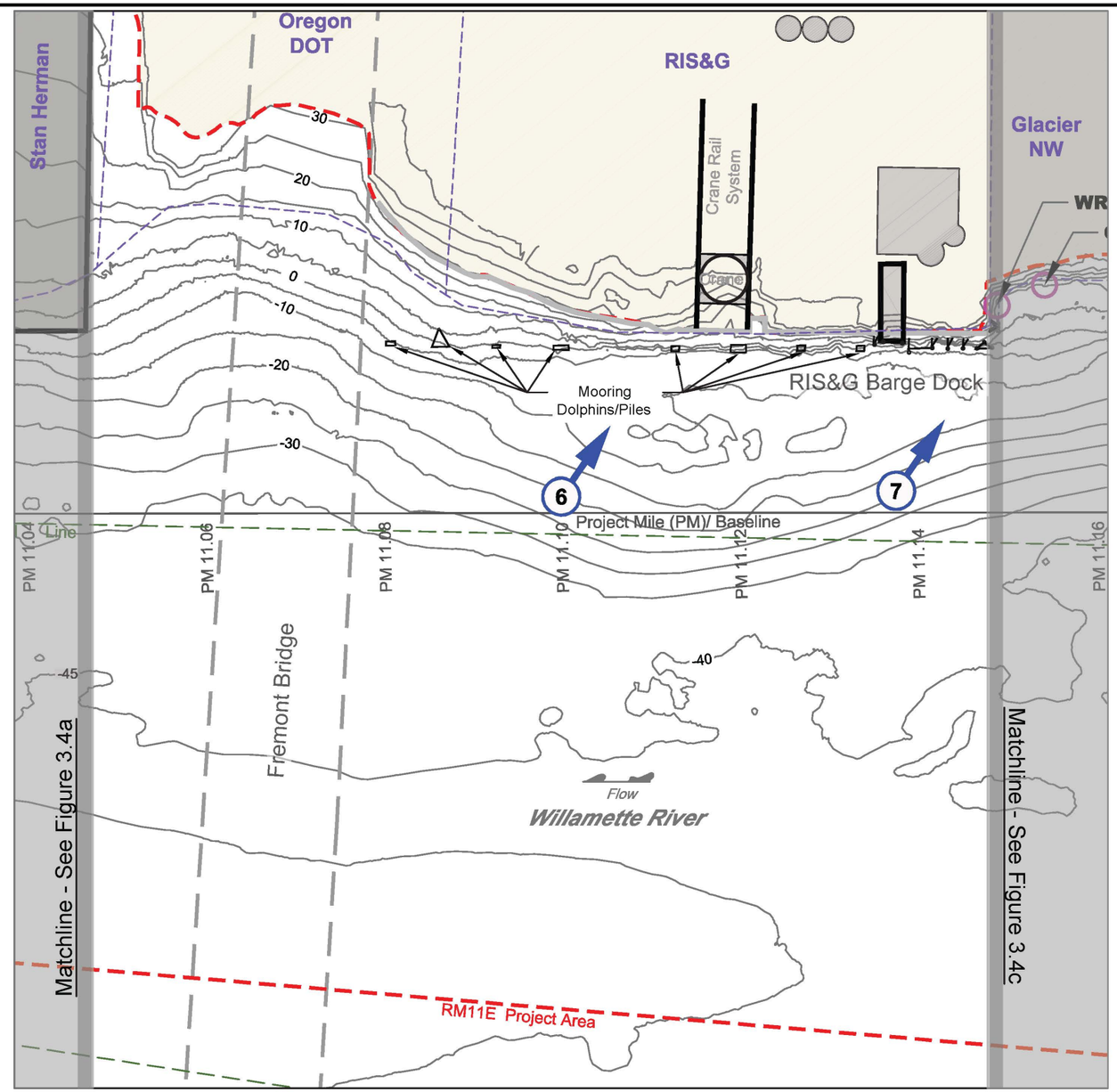
FIGURE 3.4a
July 31, 2015

PLOT TIME: 7/31/2015 11:31 AM MOD TIME: 7/31/2015 10:36 AM USER: Lee Barras DWG: D:\Projects\RM11E\CAD\Figures\2015-07\ISR\2015-07-31 07 Site Plan and Facility Photos Fig 3.4abcd.dwg

6. RIS&G Barge Mooring Dolphins



7. Outfalls WR-306 (left) and OF-44A (right)



LEGEND

Photos

- 6 Photo Orientation and ID

Other Features

- Tax Lot Boundary (Oct. 2013)
- Existing Structures
- Outfall - Active
- RM11E Project Area
- PM 11.44 Project Mile Stationing
- Federal Navigation Channel (USACE)
- -35 Bathymetric Contour - 5' Interval (NAVD88)

0 80
Scale in Feet

MAP NOTES

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Figure Location Map

DRAFT - FOR REVIEW

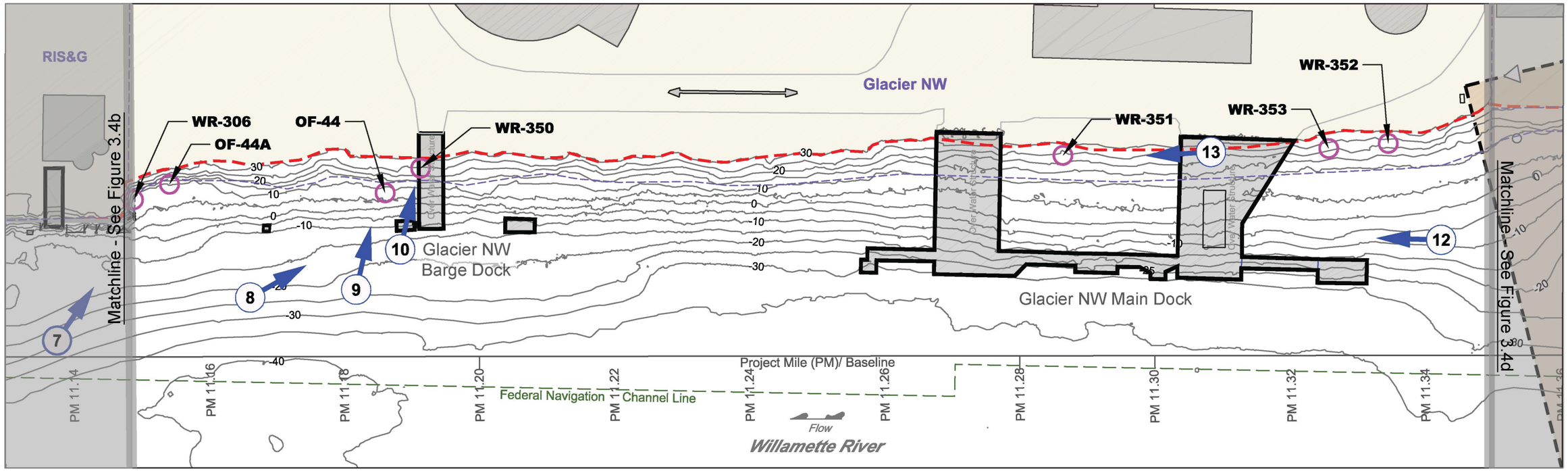
RM11E Group
Willamette River - Portland, Oregon
Draft Implementability Study Report

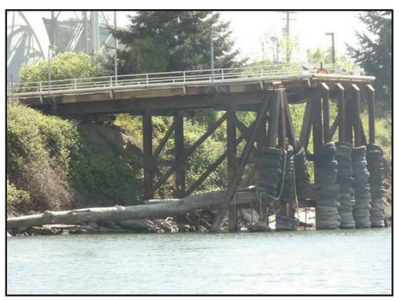
RM11E Project Area
Site Plan and Facility Photos
~PM 11.05 to ~PM 11.15

DOF DALTON OLMSTED FUGLEVAND

Figure 3.4b
July 31, 2015

PLOT TIME: 7/31/2015 11:31 AM MOD TIME: 7/31/2015 10:36 AM USER: Lee Barras DWG: D:\Projects\RM11E\CAD\Figures\2015-07\ISR\2015-07-31 07 Site Plan and Facility Photos Fig 3.4abcd.dwg

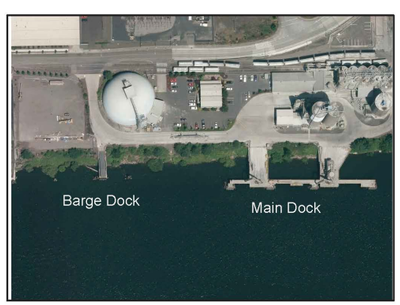




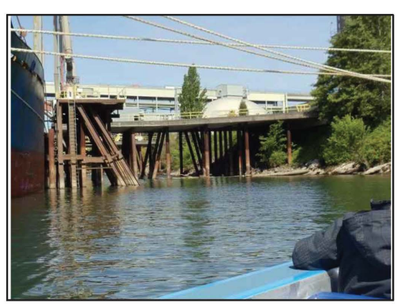
8. Glacier NW Barge Dock

9. Outfall OF-44
(Source: City of Portland)

10. Outfall WR-350
(Source: City of Portland)



11. Glacier NW Facilities
(Source: METRO 2012 Image)
(Note: No photo orientation arrow shown on plan view)



12. Glacier NW Main Dock
(View to the back side)

13. Outfall WR-351
(Source: City of Portland)

LEGEND

Photos

- Photo Orientation and ID

Other Features

- Tax Lot Boundary (Oct. 2013)
- Existing Structures
- Submarine Cable Crossing Caution Zone
- Outfall - Active
- RM11E Project Area
- PM 11.44 Project Mile Stationing
- Federal Navigation Channel (USACE)
- -35 Bathymetric Contour - 5' Interval (NAVD88)

0 80
Scale in Feet

MAP NOTES

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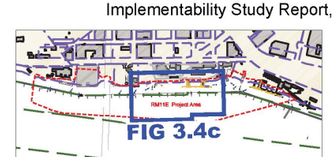

Figure Location Map

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RM11E Group
Willamette River - Portland, Oregon
Draft Implementability Study Report

RM11E Project Area
Site Plan and Facility Photos
~PM 11.15 to ~PM 11.35

DALTON OLMSTED FUGLEVAND

Figure 3.4c
July 31, 2015

PLOT TIME: 7/31/2015 11:31 AM MOD TIME: 7/31/2015 10:36 AM USER: Lee Barras DWG: D:\Projects\RM11E\CAD\Figures\2015-07\ISR\2015-07-31 07 Site Plan and Facility Photos Fig 3.4abcd.dwg

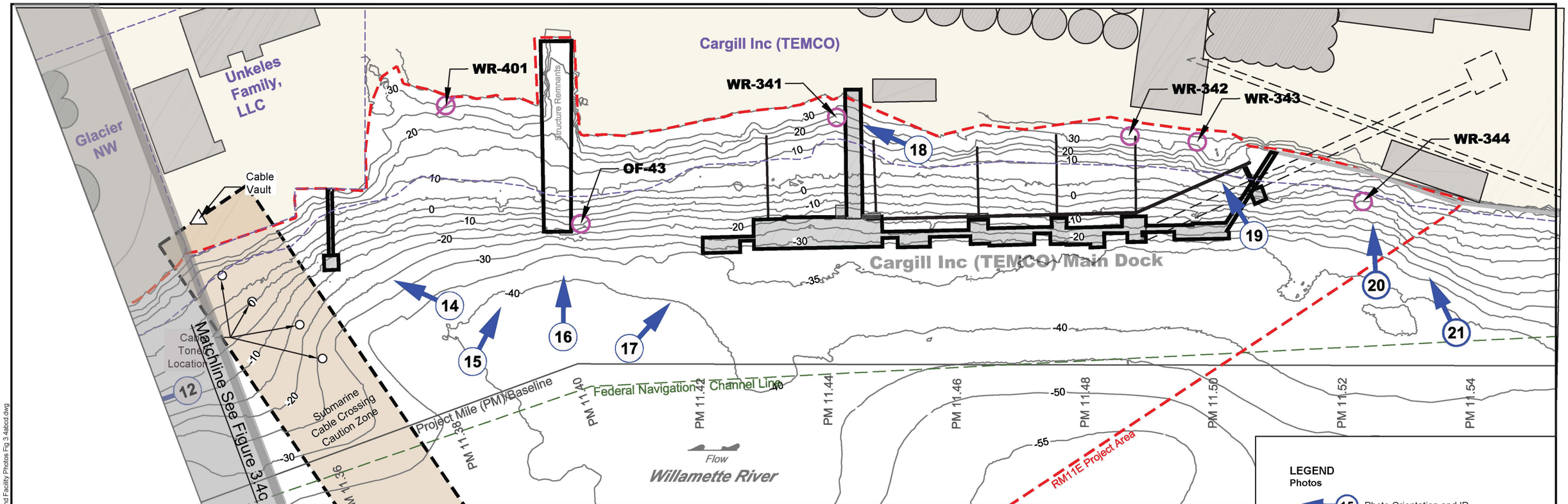


Figure Location Map

MAP NOTES

1. Photo source: DOF unless otherwise noted.
2. The locations of all features shown are approximate.
3. Contour lines and planimetric features are based on a composite data set which consists of the following: NOAA multibeam survey from 2009; ODSL multibeam and laser survey from 2010; USACE LiDAR survey from 2009; David Evans and Associates, Inc. multibeam survey from 2011 and terrestrial laser scan from 2013; and RLIS Metro GIS data. Digital elevation model (DEM) surface for bathymetric contours was modeled only in the immediate vicinity of the RM11E Project Area. It is not intended for litigation, construction, or navigation purposes.
4. Horizontal datum is referenced to Oregon State Plane North NAD83 (international feet). Vertical datum is referenced to NAVD88 (feet).
5. Outfall status and location from City of Portland - Bureau of Environmental Services (BES) GIS group in June 2013. Data layer acquired from GSI. Outfalls centered on coordinates from BES data layer.
6. Tax lot boundary generated by METRO (Oct. 2013). Data layer acquired from GSI.
7. Vertical pile remnants and submarine cable crossing toned location provided by David Evans and Associates, Inc. as described in the Draft Implementability Study Report, Section 2.

14. Cargill Inc (TEMCO) Dolphin in Front of Unkeles Family, LLC Property

15. Cargill Inc (TEMCO) Structure Approximately 100' Down Stream of Main Dock

16. Outfall OF-43 (Source: City of Portland)

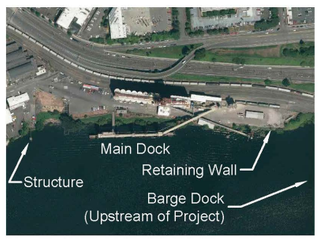
17. Cargill Inc (TEMCO) Main Dock

18. Outfall WR-341 (Source: City of Portland)

19. Outfall WR-343 (Source: City of Portland)

20. Outfall WR-344 (Source: City of Portland)

21. Cargill Inc (TEMCO) Retaining Wall



22. Cargill Inc (TEMCO) Facilities (Source: METRO 2012 Image) (Note: No photo orientation arrow shown on plan view)

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Willamette River - Portland, Oregon
Draft Implementability Study Report

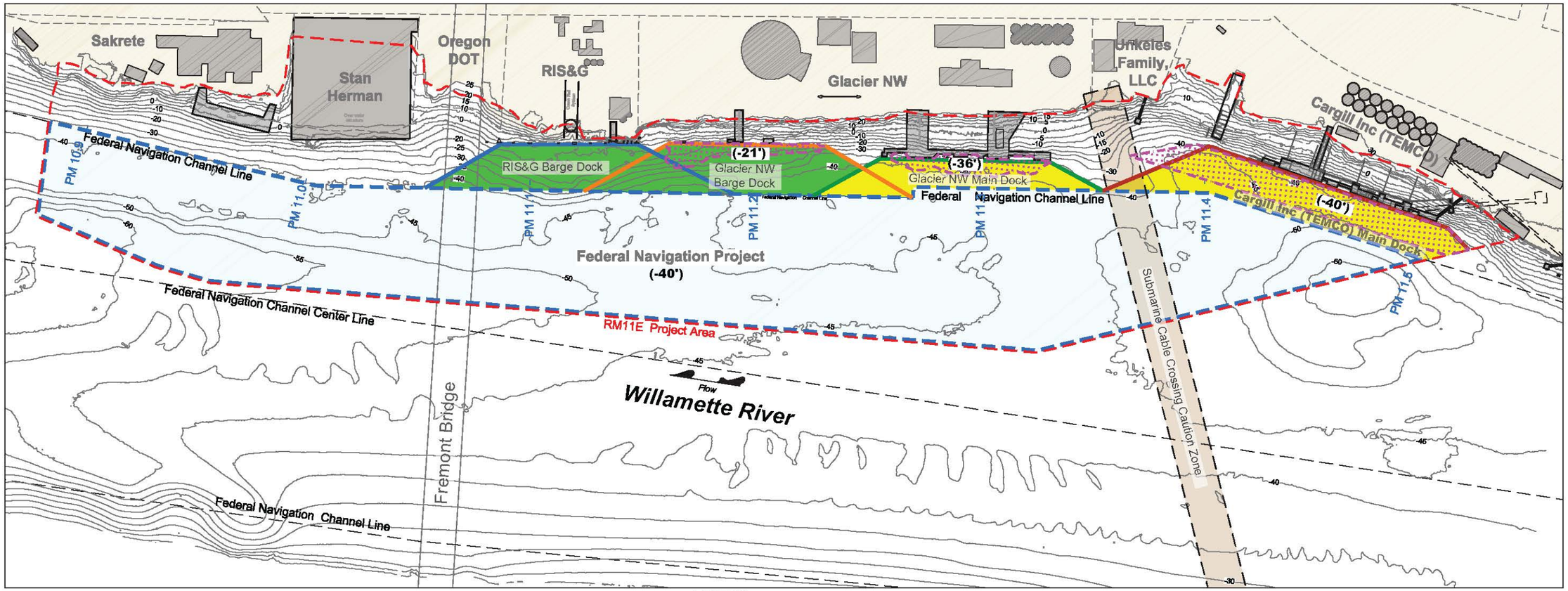
RM11E Project Area
Site Plan and Facility Photos
~PM 11.35 to ~PM 11.54

DALTON OLMSTED FUGLEVAND

Figure 3.4d

July 31, 2015

PLOT TIME: 7/31/2015 11:31 AM MOD TIME: 7/31/2015 10:36 AM USER: Lee Barras DWG: D:\Projects\RM11E\CAD\Figures\2015-07\ISR\2015-07-31 07 Site Plan and Facility Photos Fig 3.4abcd.dwg



LEGEND

Navigation and Private Maintenance Dredge Areas in RM11E Project Area (required elevation)

- Federal Navigation Project (-40' CRD) within RM11E Project Area
- Ross Island Sand & Gravel (RIS&G) Barge Navigation (-15' Hawthorne Bridge Gauge = Approx. -15.3' CRD)
- Glacier NW Barge Dock Navigation (-21' CRD)
- Glacier NW Main Dock Navigation (-36' CRD)
- Cargill Inc (TEMCO) Main Dock Navigation (-40' CRD)
- Recent Maintenance Dredge Areas
- Shallow Draft Berth
- Deep Draft Berth
- Deep Draft Navigation Channel
- (-44') Maintained Project Elevation (See Table 6.3) (Does not include overdepth)

Other Features

- Existing Structures and Beams/Piles
- Submarine Cable Crossing Caution Zone
- Tax Lot Boundary (Oct. 2013)
- RM11E Project Area
- PM 11.6 Project Mile Stationing
- Federal Navigation Channel (USACE)
- -35 Bathymetric Contour - 5' Interval (CRD)

0 250
Scale in Feet

MAP NOTES

1. The locations of all features shown are approximate.
2. Cargill Inc (TEMCO) recent maintenance dredge areas based on 2009 dredging; Glacier NW recent maintenance dredge areas based on 2004 dredging. Data layer acquired from GSI.
3. Contour lines and planimetric features are based on a composite data set which consists of the following: NOAA multibeam survey from 2009; ODSL multibeam and laser survey from 2010; USACE LiDAR survey from 2009; David Evans and Associates, Inc. multibeam survey from 2011 and terrestrial laser scan from 2013; and RLIS Metro GIS data. Digital elevation model (DEM) surface for bathymetric contours was modeled only in the immediate vicinity of the RM11E Project Area. It is not intended for litigation, construction, or navigation purposes.
4. Horizontal datum is referenced to Oregon State Plane North NAD83 (international feet). Vertical datum is referenced to CRD (feet).
5. Outfall status and location from City of Portland - Bureau of Environmental Services (BES) GIS group in June 2013. Data layer acquired from GSI. Outfalls centered on coordinates from BES data layer.
6. Tax lot boundary generated by METRO (Oct. 2013). Data layer acquired from GSI.
7. Vertical pile remnants and submarine cable crossing toned location provided by David Evans and Associates, Inc. as described in the Draft Implementability Study Report, Section 2.

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Navigation Areas (CRD Vertical Datum) and Private Dredging (1996 - 2009)

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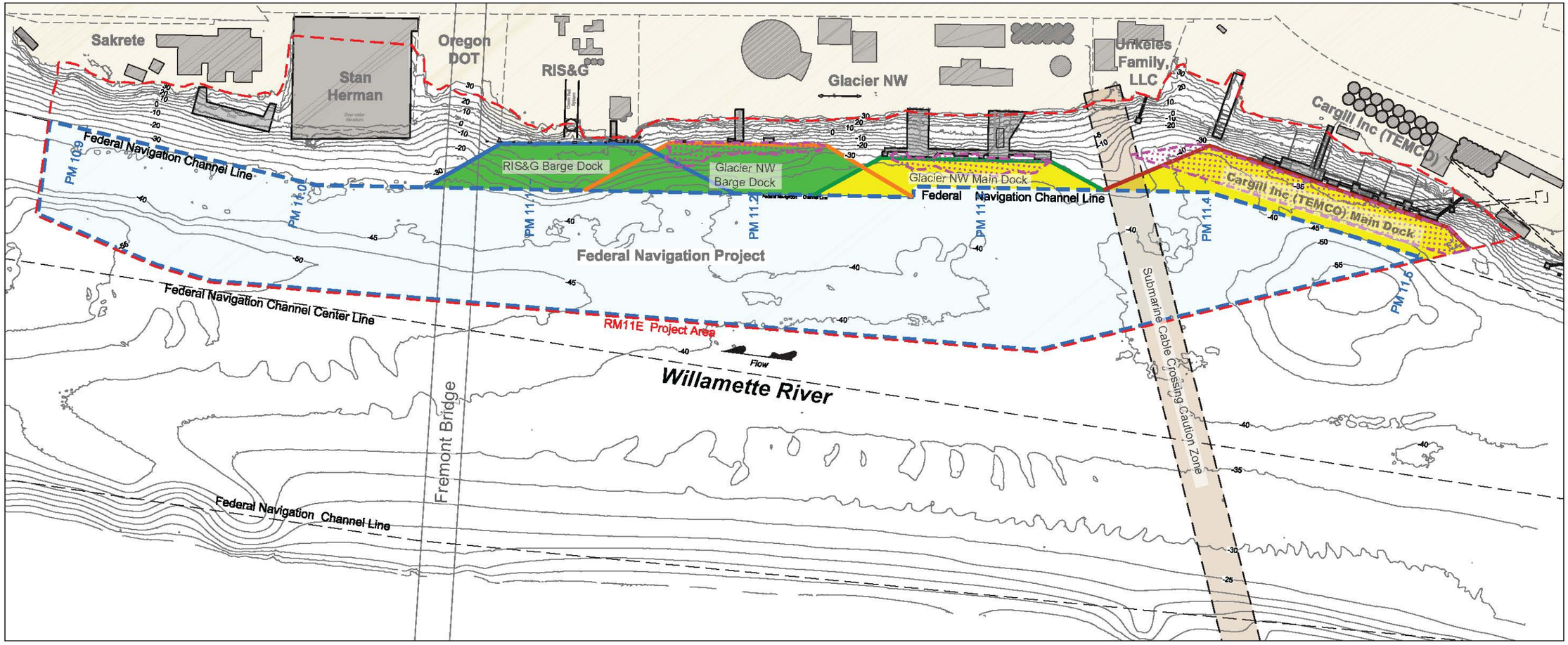
Figure 3.5a

July 31, 2015

PLOT TIME: 7/31/2015 2:42 PM MOD TIME: 7/31/2015 2:25 PM USER: Lee Barras DWG: D:\Projects\RM11E\CADFiguresb\2015-07\SR\2015-07-31 08 Nav Areas - Priv Dredge Fig 3.5ab.dwg



MAP NOTES

1. The locations of all features shown are approximate.
2. Cargill Inc (TEMCO) recent maintenance dredge areas based on 2009 dredging; Glacier NW recent maintenance dredge areas based on 2004 dredging. Data layer acquired from GSI.
3. Contour lines and planimetric features are based on a composite data set which consists of the following: NOAA multibeam survey from 2009; ODSL multibeam and laser survey from 2010; USACE LiDAR survey from 2009; David Evans and Associates, Inc. multibeam survey from 2011 and terrestrial laser scan from 2013; and RLIS Metro GIS data. Digital elevation model (DEM) surface for bathymetric contours was modeled only in the immediate vicinity of the RM11E Project Area. It is not intended for litigation, construction, or navigation purposes.
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6. Tax lot boundary generated by METRO (Oct. 2013). Data layer acquired from GSI.
7. Vertical pile remnants and submarine cable crossing toned location provided by David Evans and Associates, Inc. as described in the Draft Implementability Study Report, Section 2.

LEGEND

Navigation and Private Maintenance Dredge Areas in RM11E Project Area (required elevation)

- Federal Navigation Project within RM11E Project Area
- Ross Island Sand & Gravel (RIS&G) Barge Navigation
- Glacier NW Barge Dock Navigation
- Glacier NW Main Dock Navigation
- Cargill Inc (TEMCO) Main Dock Navigation
- Recent Maintenance Dredge Areas
- Shallow Draft Berth
- Deep Draft Berth
- Deep Draft Navigation Channel

Other Features

- Existing Structures and Beams/Piles
- Submarine Cable Crossing Caution Zone
- Tax Lot Boundary (Oct. 2013)
- RM11E Project Area
- PM 11.6 — Project Mile Stationing
- Federal Navigation Channel (USACE)
- -35 — Bathymetric Contour - 5' Interval

0 250
Scale in Feet

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Draft Implementability Study Report

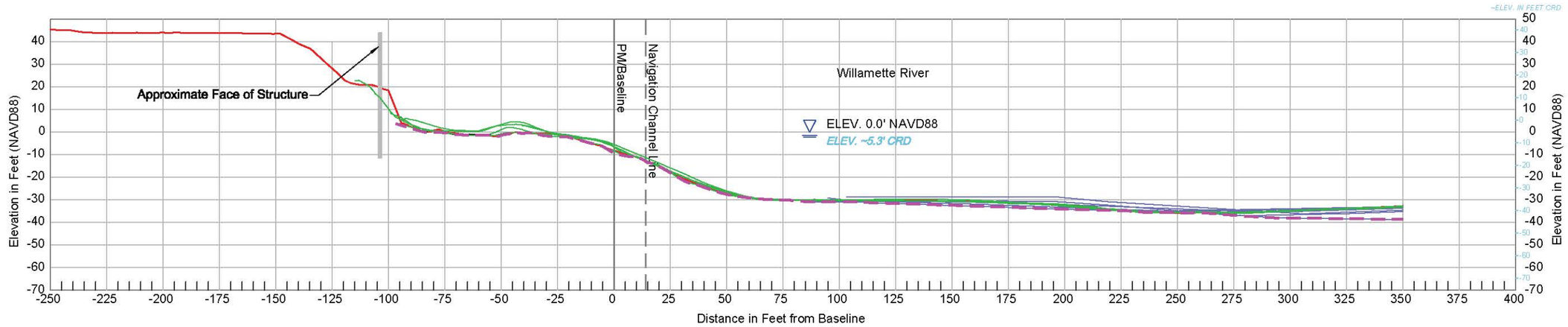
Navigation Areas (NAVD88 Vertical Datum) and Private Dredging (1996 - 2009)

DALTON OLMSTED FUGLEVAND

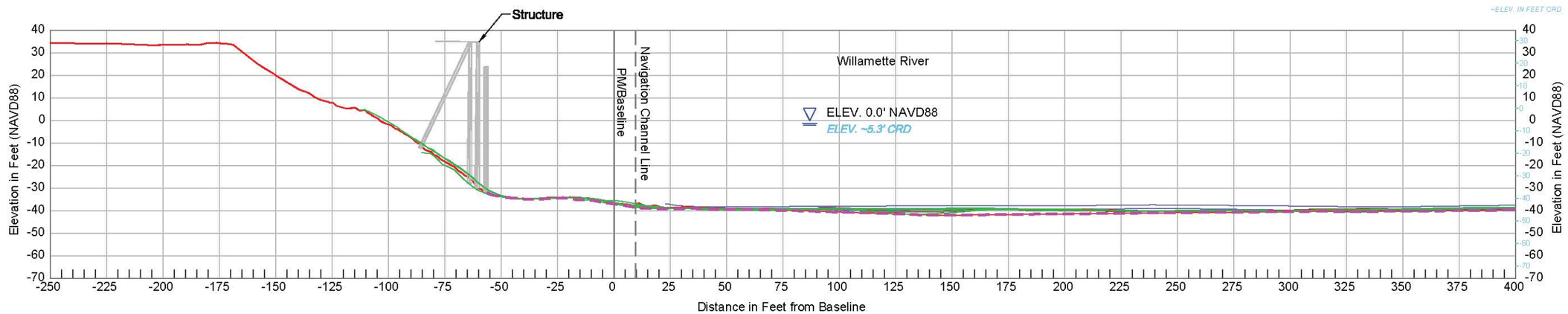
Figure 3.5b

July 31, 2015

PLOT TIME: 7/31/2015 2:42 PM MOD TIME: 7/31/2015 2:25 PM USER: Lee Barras DWG: D:\Projects\RM11E\CAD\Figures\2015-07\SR\2015-07-31 08 Nav Areas - Priv Dredge Fig 3.5ab.dwg

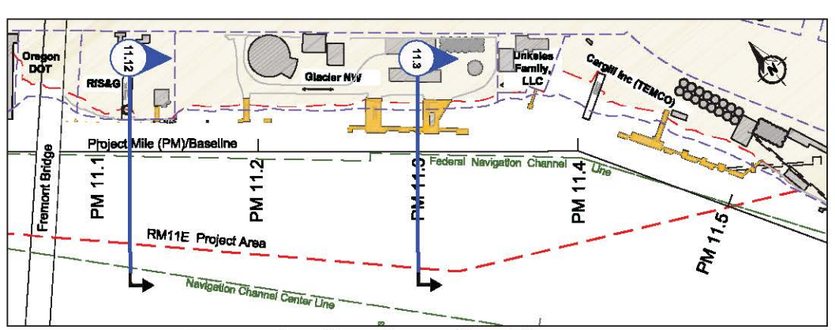


Section - PM 11.12
(RIS&G)



Section - PM 11.30
(Glacier NW - Main Dock)

0 50
Scale in Feet



Cross Section Location Map

LEGEND
Bed Elevations

- Line Representing Composite Deepest Bed Elevation Based on Available USACE, LWG, and Private Surveys.
- USACE Surveys (1985 through 2012)
- LWG Surveys by David Evans Assoc., Inc. (2002 through 2011)
- Current RM11E DEM (See Note 3)

MAP NOTES

1. Portrayal of section data is approximate and is based on available information regarding the vertical datum (NAVD88) at time of survey collection/processing which was then converted (if needed) to Columbia River Datum (CRD).
2. The locations of all features shown are approximate.
3. Cross sections and planimetric features are based on a composite data set which consists of the following: NOAA multibeam survey from 2009; ODSL multibeam and laser survey from 2010; USACE LiDAR survey from 2009; David Evans and Associates, Inc. multibeam survey from 2011 and terrestrial laser scan from 2013; and RLIS Metro GIS dat. Digital elevation model (DEM) surface for bathymetric contours was modeled only in the immediate vicinity of the RM11E Project Area. It is not intended for litigation, construction, or navigation purposes.

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Cross Sections: Variations in Recorded Bed Elevations in RM11E Project Area PM 11.12 and PM 11.30

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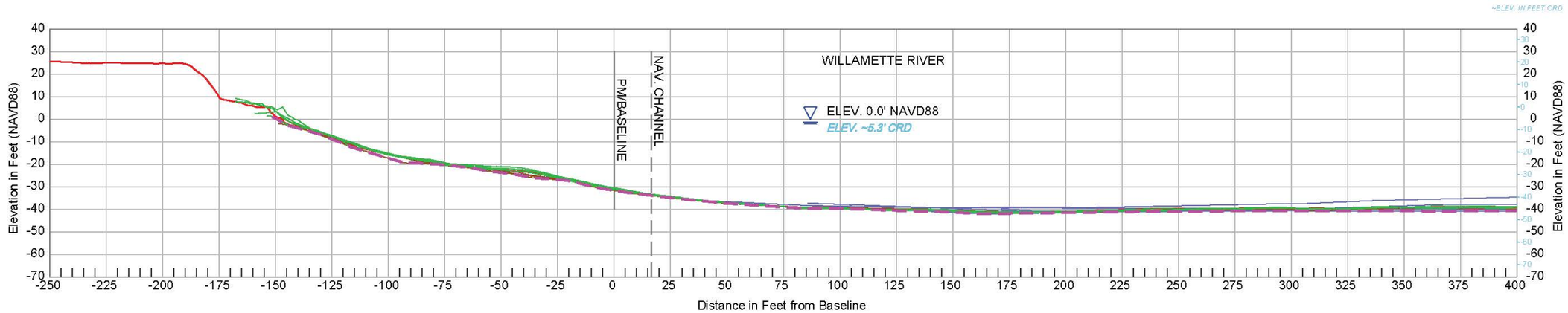
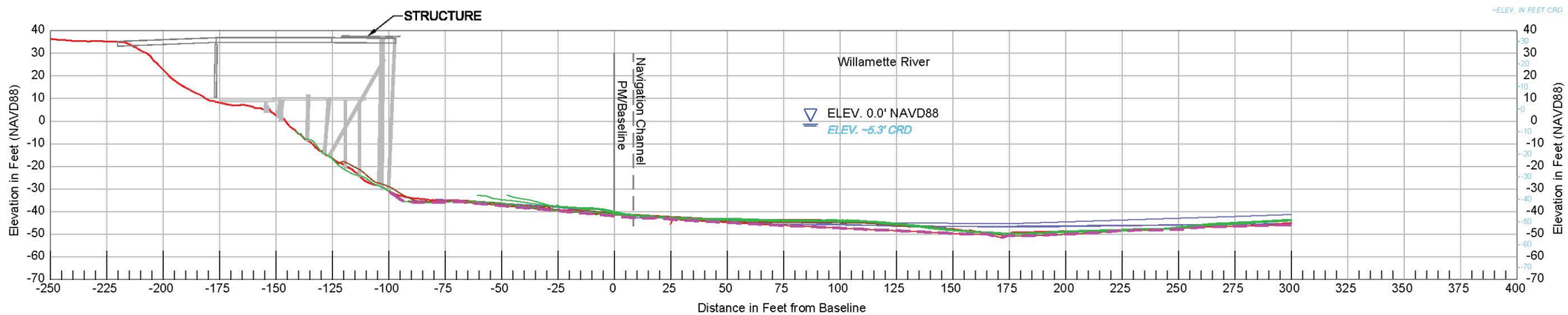
Figure 3.9a
July 31, 2015

PLOT TIME: 7/31/2015 11:31 AM MOD TIME: 7/31/2015 10:31 AM USER: Lee Barras DWG: D:\Projects\RM11E\CADV\Figures\2015-07\NSR2015-07-31 09 Xsect Variation in Bed Elevs Fig 3.9ab.dwg

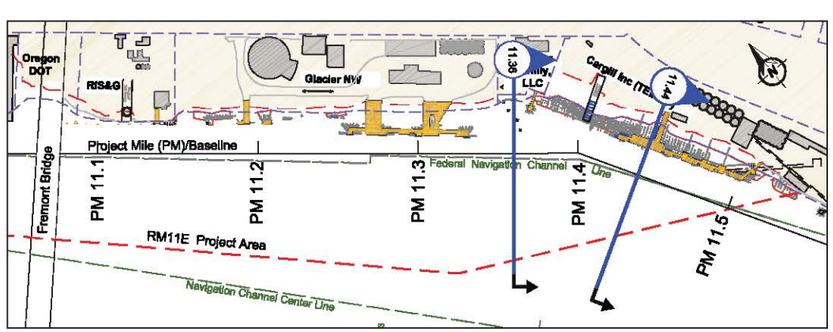


Section - PM 11.36
(Cargill Inc (TEMCO))



Section - PM 11.44
(Cargill Inc (TEMCO) - Main Dock)

0 50
Scale in Feet



CROSS SECTION LOCATION MAP

LEGEND
Bed Elevations

- Line Representing Composite Deepest Bed Elevation Based on Available USACE, LWG, and Private Surveys.
- USACE Surveys (1985 through 2012)
- LWG Surveys by David Evans Assoc., Inc. (2002 through 2011)
- Cargill Inc (TEMCO) Facility Surveys by NW Hydrographics (2009 and 2014)
- Current RM11E DEM (See Note 3)

MAP NOTES

1. Portrayal of section data is approximate and is based on available information regarding the vertical datum (NAVD88) at time of survey collection/processing which was then converted (if needed) to Columbia River Datum (CRD).
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Draft Implementability Study Report

Cross Sections: Variations in Recorded Bed Elevations in RM11E Project Area PM 11.36 and PM 11.44

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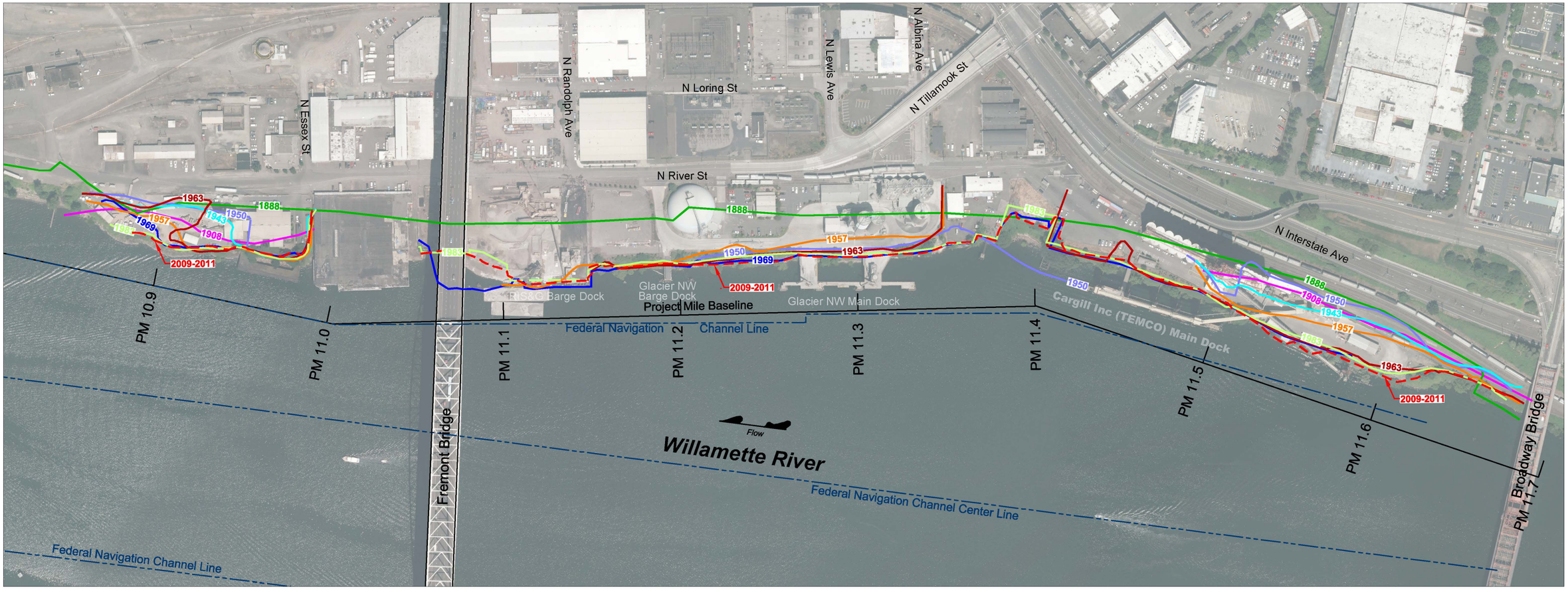
Figure 3.9b
July 31, 2015

PLOT TIME: 7/31/2015 11:32 AM MOD TIME: 7/31/2015 10:34 AM USER: Lee Barras DWG: D:\Projects\RM11E\CAD\Figures\2015-07\ISR2015-07-31 09 Xsect Variation in Bed Elevs Fig 3.9ab.dwg



MAP NOTES

1. The locations of all features shown are approximate.
2. 2009-2011 Shoreline based on a composite data set which consists of the following: NOAA multibeam survey from 2009; ODSL multibeam and laser survey from 2010; USACE LiDAR survey from 2009; David Evans and Associates, Inc. multibeam survey from 2011 and terrestrial laser scan from 2013; and RLIS Metro GIS data. Digital elevation model (DEM) surface for bathymetric contours was modeled only in the immediate vicinity of the RM11E Project Area. It is not intended for litigation, construction, or navigation purposes.
3. Background Image - METRO (Summer 2012).

LEGEND

Historical Shoreline (Approximate)

- 1888 Shoreline (USC&GS Chart)
- 1908 Shoreline (USC&GS Chart)
- 1943 Shoreline (Aerial Photograph)
- 1950 Shoreline (Sanborn Map)
- 1957 Shoreline (Aerial Photograph)
- 1963 Shoreline (Aerial Photograph)
- 1969 Shoreline (Aerial Photograph - ODOT)
- 1983 Shoreline (Aerial Photograph)
- 2009-2013 Composite Shoreline (See note 2)

Other Features

- Federal Navigation Channel (USACE)
- **PM 11.2** Project Mile (PM) Stationing

0 300
Scale in Feet

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Willamette River - Portland, Oregon
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Historical Shoreline Plan View

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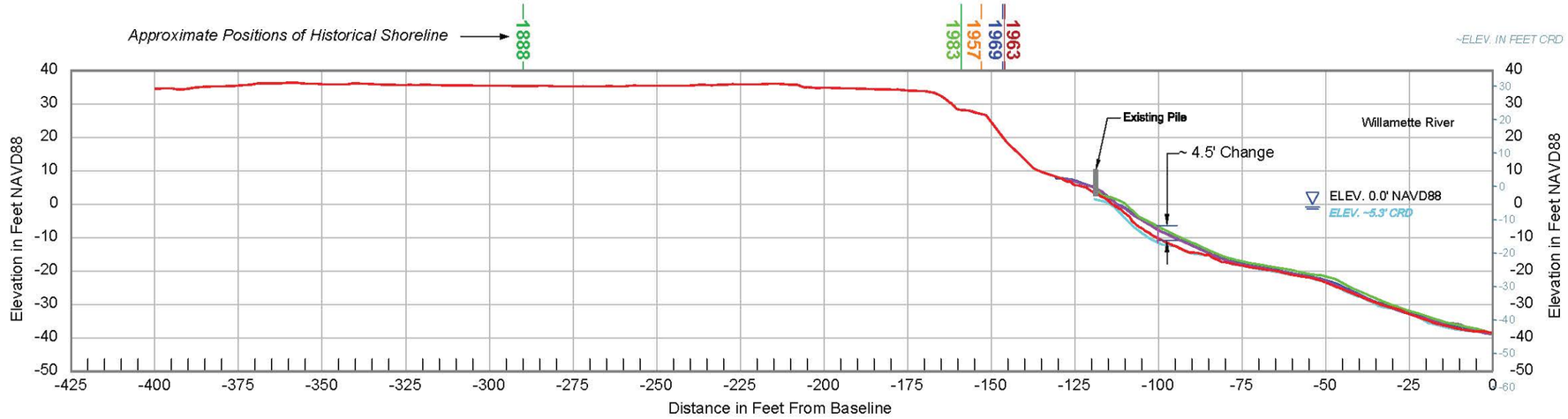
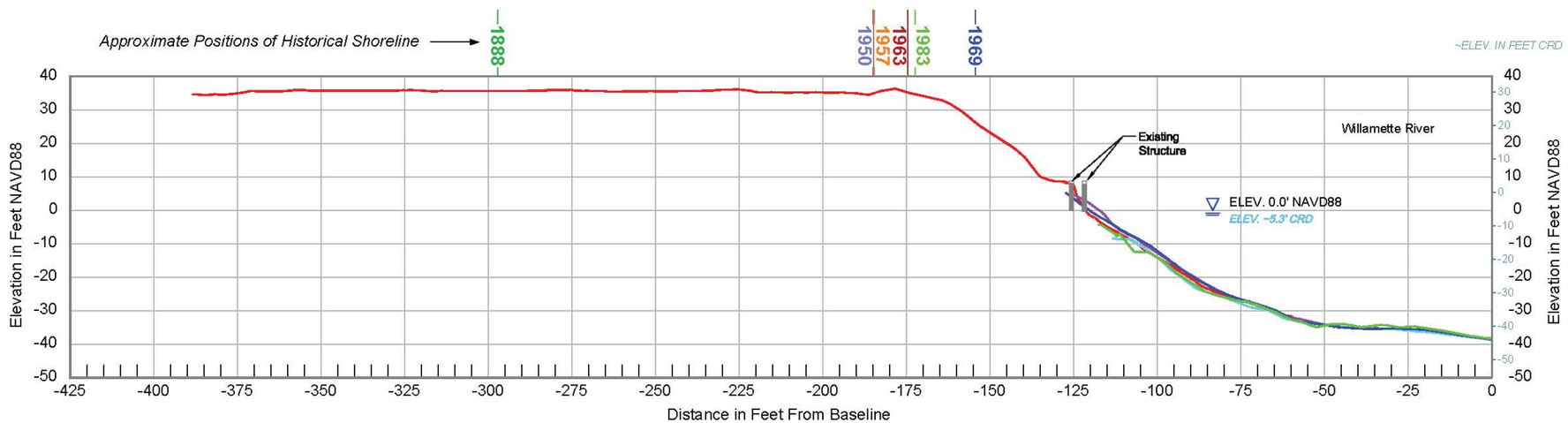
Figure 3.10

July 31, 2015

PLOT TIME: 7/31/2015 11:32 AM MOD TIME: 7/31/2015 10:43 AM USER: Lee Barras DWG: D:\Projects\RM11E\CAD\Figures\2015-07\ISR\2015-07-31 10 Historic Shoreline Fig 3.10.dwg

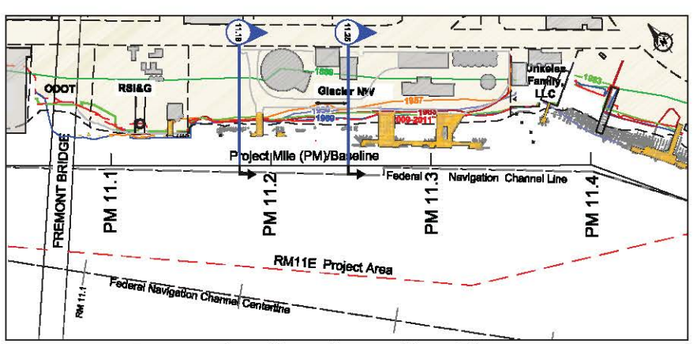


Cross Section - PM 11.18
(Glacier NW)



Cross Section - PM 11.25
(Glacier NW)

0 50
Scale in Feet



Cross Section Location Map

MAP NOTES

1. Portrayal of section data is approximate and is based on available information regarding the vertical datum (NAVD88) at time of survey collection/processing.
2. The locations of all features shown are approximate.
3. 2009-2013 DEA composite shoreline consists of the following: NOAA multibeam survey from 2009; ODSL multibeam and laser survey from 2010; USACE LiDAR survey from 2009; David Evans and Associates, Inc. multibeam survey from 2011 and terrestrial laser scan from 2013; and RLIS Metro GIS data. Digital elevation model (DEM) surface for bathymetric contours was modeled only in the immediate vicinity of the RM11E Project Area. It is not intended for litigation, construction, or navigation purposes.

LEGEND

Historical Shoreline Dates

- 2009-2013 Composite Shoreline (DEA) (See Note 3)
- 2009 (LWG)
- 2004 (LWG)
- 2003 (LWG)
- 2002 (LWG)

Other Features

- RM11E Project Area

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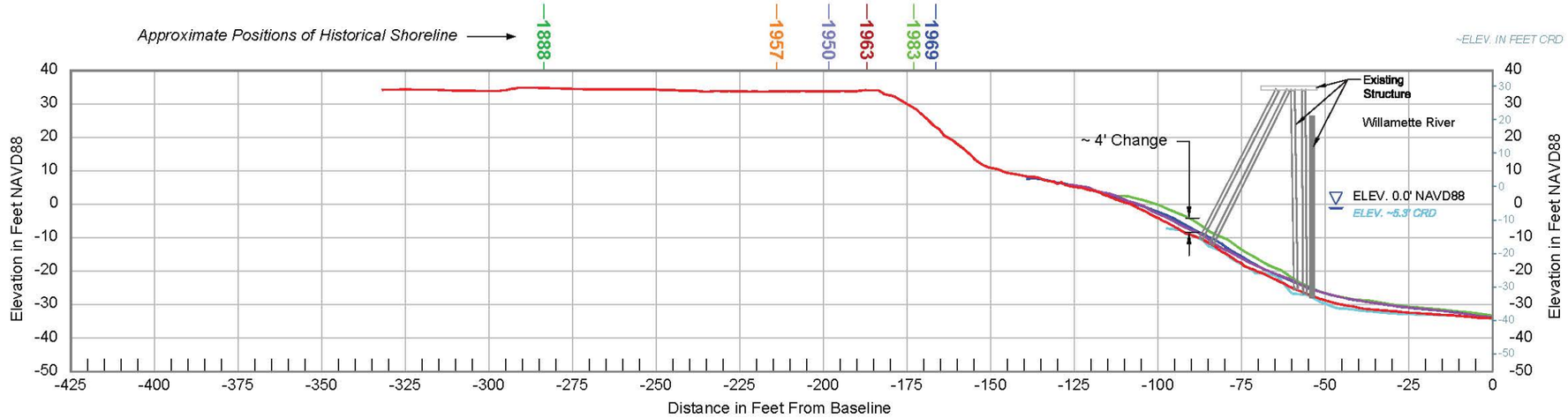
Willamette River - Portland, Oregon
Draft Implementability Study Report

Cross Sections:
RM11E Project Area Shoreline Changes:
PM 11.18 and PM 11.25

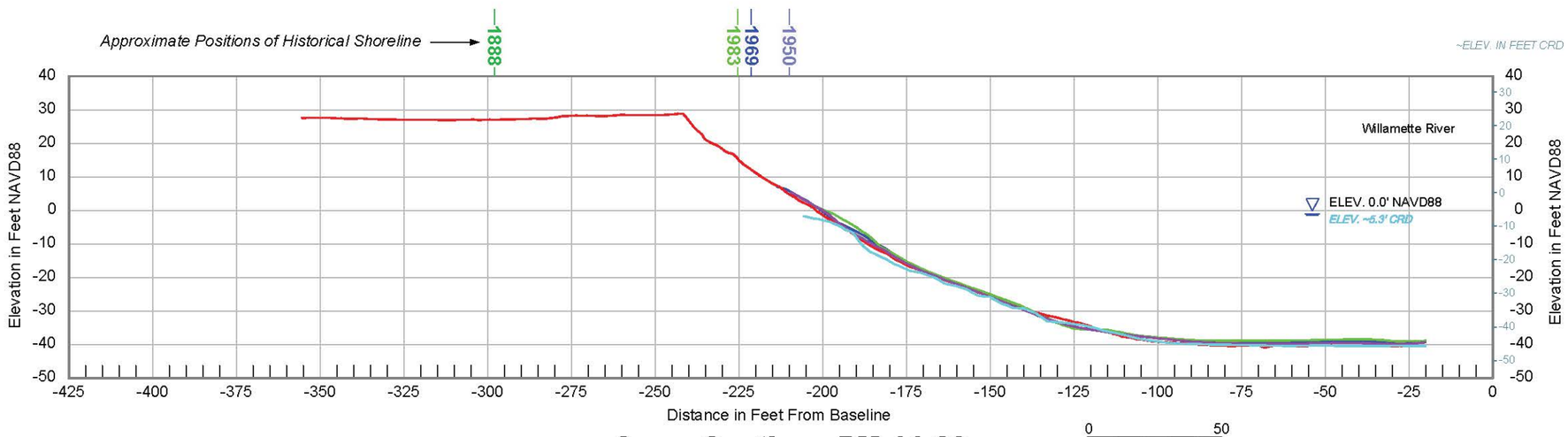
DALTON OLMSTED FUGLEVAND

Figure 3.11a
July 31, 2015

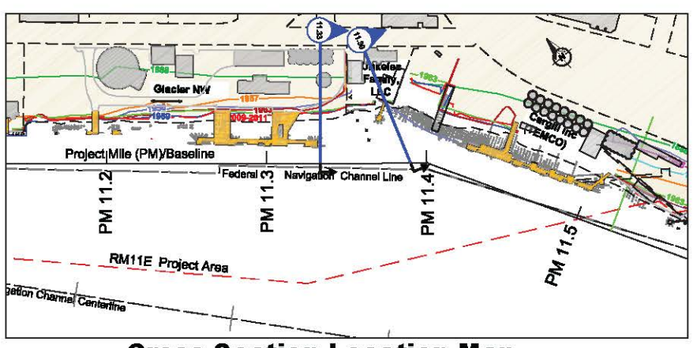
PLOT TIME: 7/31/2015 2:42 PM MOD TIME: 7/31/2015 2:29 PM USER: Lee Barras DWG: D:\Projects\RM11E\CADFigures\2015-07\SR\2015-07-31 11 X sect Shoreline Changes Fig 3.11abc.dwg



Cross Section - PM 11.33
(Glacier NW)



Cross Section - PM 11.39



Cross Section Location Map

MAP NOTES

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3. 2009-2013 DEA composite shoreline consists of the following: NOAA multibeam survey from 2009; ODSL multibeam and laser survey from 2010; USACE LiDAR survey from 2009; David Evans and Associates, Inc. multibeam survey from 2011 and terrestrial laser scan from 2013; and RLIS Metro GIS data. Digital elevation model (DEM) surface for bathymetric contours was modeled only in the immediate vicinity of the RM11E Project Area. It is not intended for litigation, construction, or navigation purposes.

LEGEND

Historical Shoreline Dates

- 2009-2013 Composite Shoreline (DEA) (See Note 3)
- 2009 (LWG)
- 2004 (LWG)
- 2003 (LWG)
- 2002 (LWG)

Other Features

- RM11E Project Area

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RM11E Group
Willamette River - Portland, Oregon
Draft Implementability Study Report

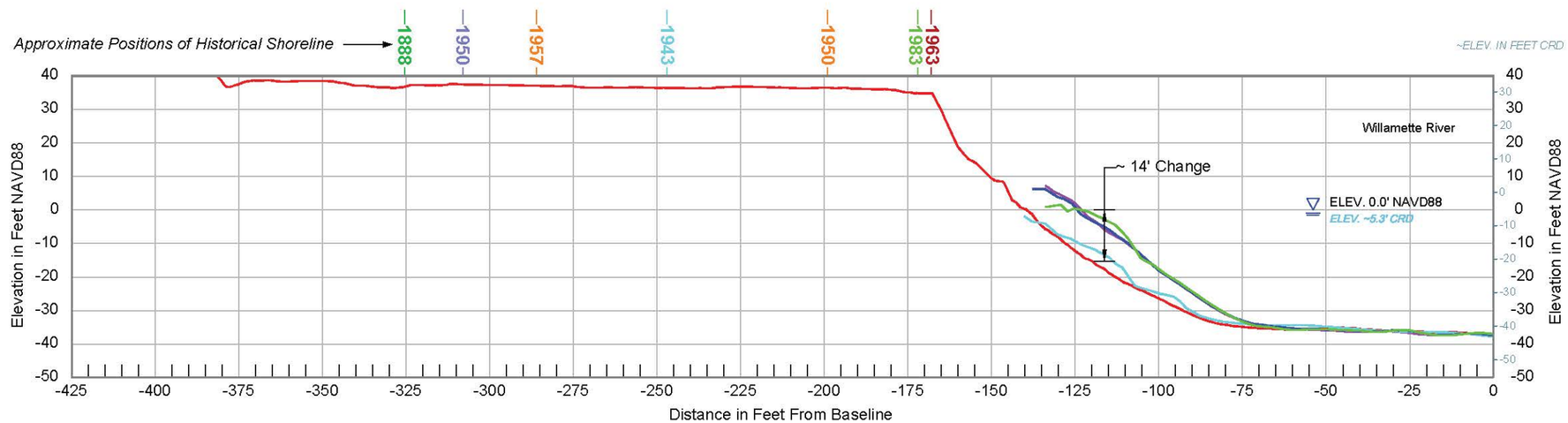
Cross Sections:
RM11E Project Area Shoreline Changes:
PM 11.33 and PM 11.39

DALTON OLMSTED FUGLEVAND

Figure 3.11b
July 31, 2015

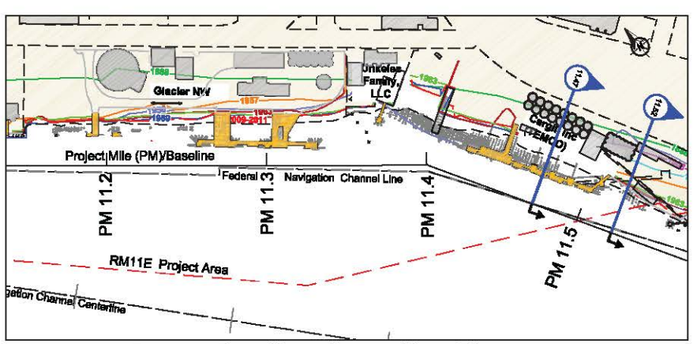
PLOT TIME: 7/31/2015 2:42 PM MOD TIME: 7/31/2015 2:29 PM USER: Lee Barras DWG: D:\Projects\RM11E\CAD\Figures\2015-07\SR\2015-07-31 11 Xsect Shoreline Changes Fig 3.11abc.dwg

Cross Section - 11.47
(Cargill Inc (TEMCO))



Cross Section - PM 11.52
(Cargill Inc (TEMCO))

0 50
Scale in Feet



Cross Section Location Map

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LEGEND

Historical Shoreline Dates

- 2009-2013 Composite Shoreline (DEA) (See Note 3)
- 2009 (LWG)
- 2004 (LWG)
- 2003 (LWG)
- 2002 (LWG)

Other Features

- RM11E Project Area

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Willamette River - Portland, Oregon
Draft Implementability Study Report

Cross Sections:
RM11E Project Area Shoreline Changes:
PM 11.47 and PM 11.52

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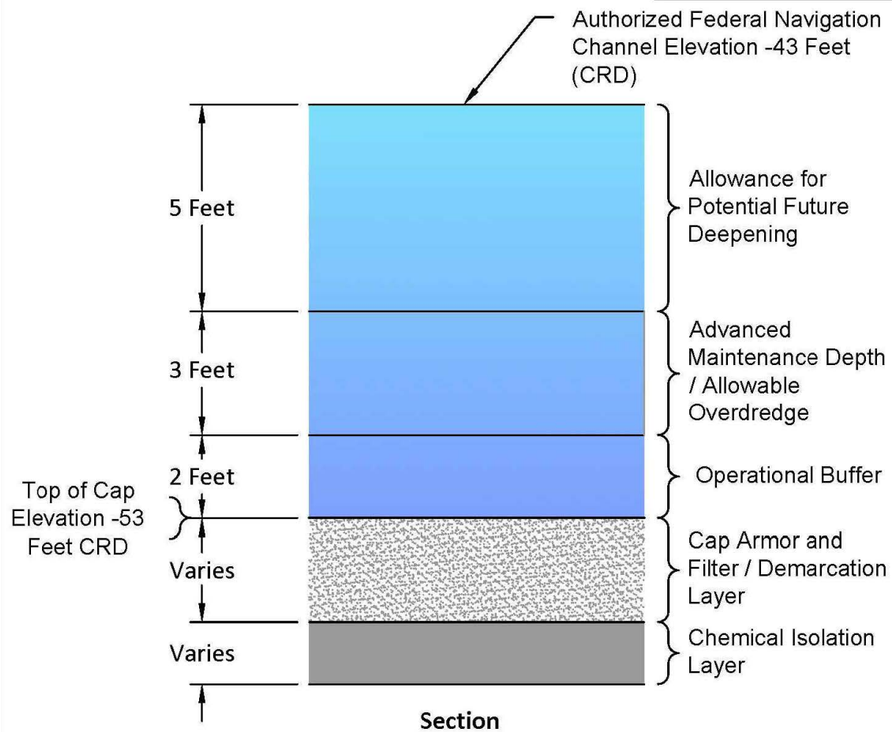
Figure 3.11c
July 31, 2015

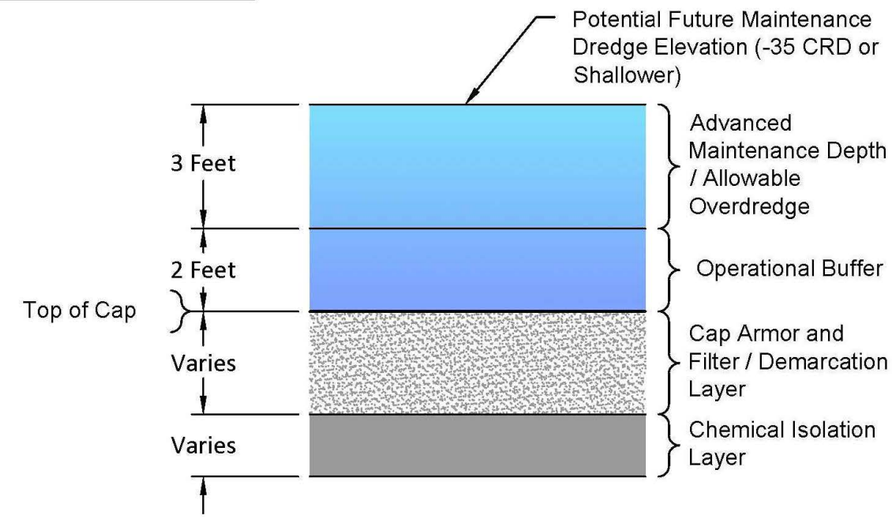
PLOT TIME: 7/31/2015 2:42 PM MOD TIME: 7/31/2015 2:29 PM USER: Lee Barras DWG: D:\Projects\RM11E\CADV\Figures\2015-07\SR\2015-07-31 11 X-sect Shoreline Changes Fig 3.11abc.dwg

This figure shows the water depths needed above a potential cap such that the cap would not be compromised by navigation and maintenance dredging activities.



Section
Not to Scale

In Situ Cap Offset Requirements in Navigation Channels and Future Maintenance Dredge Areas Currently Maintained Equal to Navigation Channel Depths



Section
Not to Scale

In Situ Cap Offset Requirements in Potential Future Maintenance Dredge Areas Currently Maintained at Depths of 35 Feet CRD or Shallower

ANCHOR QEA

LWG LOWER WILLAMETTE GROUP

DO NOT QUOTE OR CITE
This document is currently under review by US EPA and its federal, state, and tribal partners, and is subject to change in whole or in part

Figure 6.2-28
Portland Harbor RI/FS
Draft Feasibility Study
In Situ Cap Offset Requirements in Navigation Channels

Mar 16, 2012 9:24am heriksen K:\Jobs\010142-Lower_Williamette_Group\01014201\01014201-RP-LWG-039.dwg FIG 6_2-28 (LWG)

PLOT TIME: 7/31/2015 11:32 AM MOD TIME: 7/31/2015 10:45 AM USER: Lee Barnes DWG: D:\Projects\RM11E\CAD\Figures\2015-07\NSR\2015-07-31 12 PHSS Nav Clearance Criteria Fig 3.13.dwg

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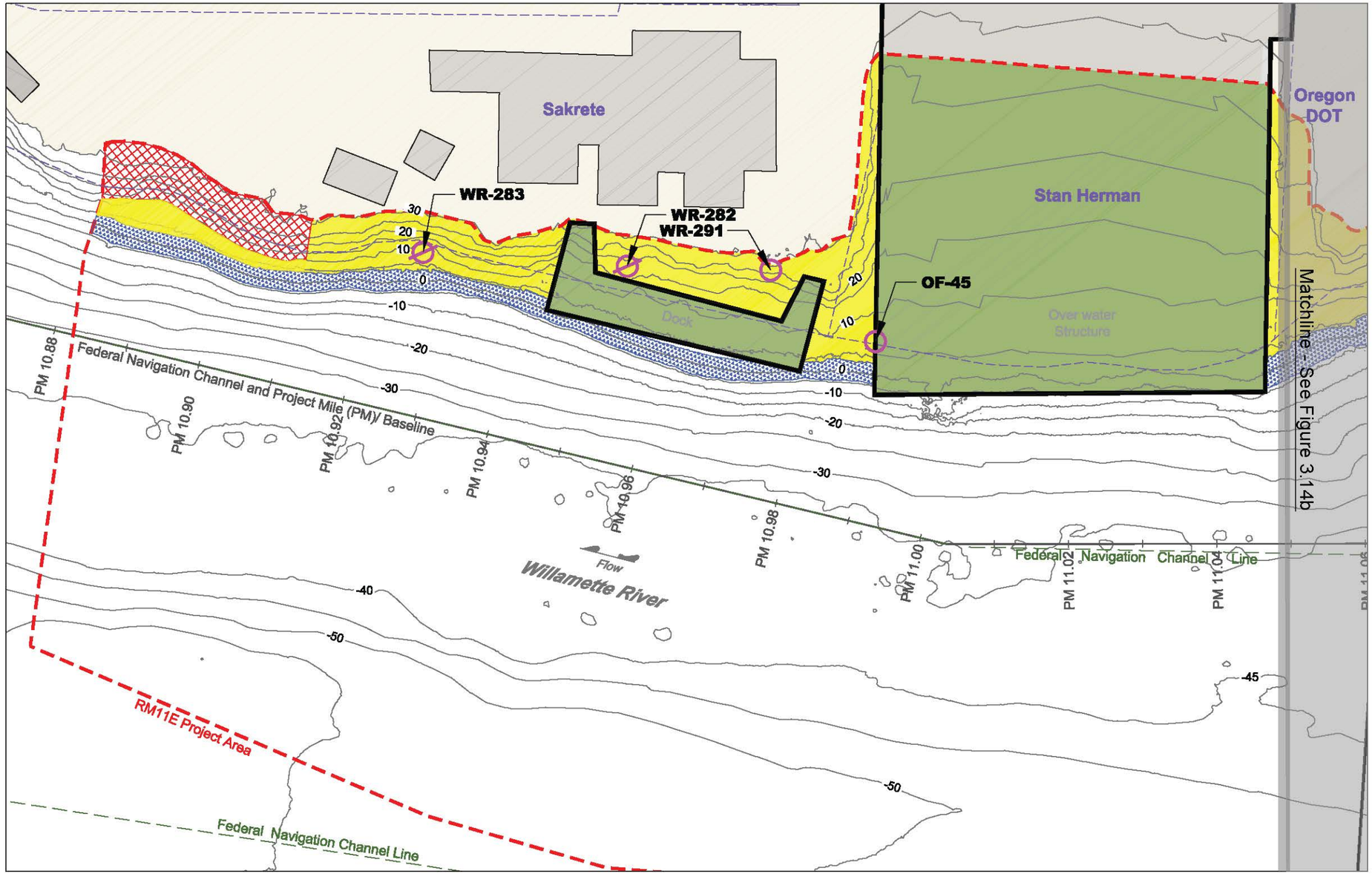
Willamette River - Portland, Oregon
Draft Implementability Study Report

PHSS Draft FS
Navigation Clearance Criteria

DALTON OLMSTED FUGLEVAND

Figure 3.13
July 31, 2015



LEGEND

Project Area Accessibility

- Potentially Accessible from Upland
- Limited Floating Equipment Draft (4' to -4' NAVD88)
- Access Limited by Overhead Structures
- Access Constricted Due to Structures
- Inaccessible from Water and Upland

Other Features

- Existing Structures
- Tax Lot Boundary (Oct. 2013)
- Outfall - Active
- Outfall - Inactive or Status Unknown
- RM11E Project Area
- PM 11.6 — Project Mile Stationing
- Federal Navigation Channel (USACE)
- -35 — Bathymetric Contour - 5' Interval (NAVD88)

0 80
Scale in Feet

MAP NOTES

1. Accessibility based upon standard marine construction equipment for open access remedial work.
2. Limited floating equipment draft based on Willamette River average stage during preferred in-water work window and 10' equipment draft.
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8. Vertical pile remnants and submarine cable crossing toned location provided by David Evans and Associates, Inc. as described in the Draft Implementability Study Report, Section 2.

Figure Location Map

DRAFT - FOR REVIEW

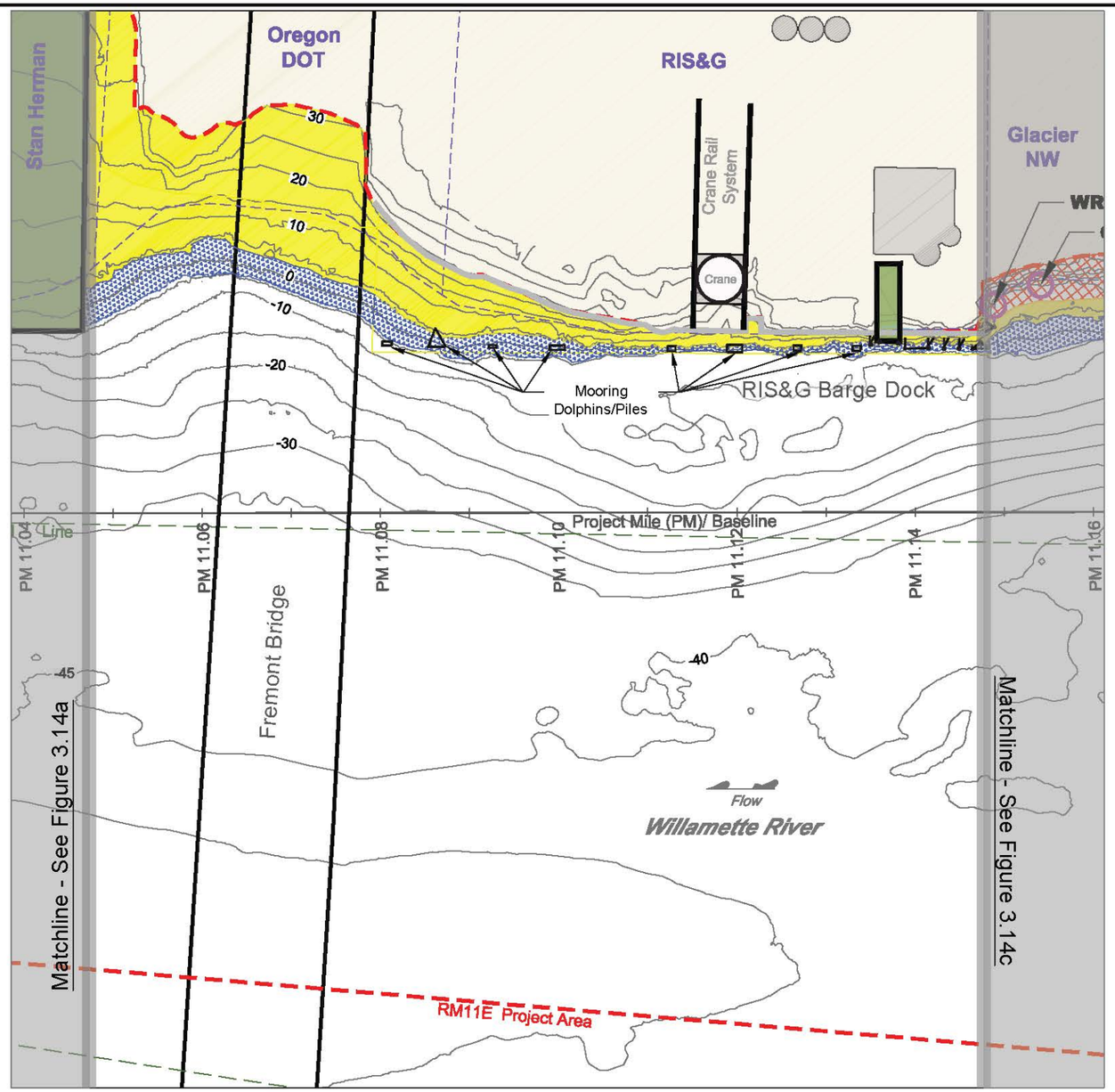
RM11E Group
Willamette River - Portland, Oregon
Draft Implementability Study Report

RM11E Project Area
Construction Access Site Plan
~PM 10.88 to ~PM 11.05

DALTON OLMSTED FUGLEVAND

Figure 3.14a
July 31, 2015

PLOT TIME: 7/31/2015 11:32 AM MOD TIME: 7/31/2015 10:46 AM USER: Lee Barras DWG: D:\Projects\RM11E\CAD\Figures\2015-07\NSR\2015-07-31 13 Proj Area Accessibility Figs 3.14a\bcd.dwg



LEGEND

Project Area Accessibility

- Potentially Accessible from Upland
- Limited Floating Equipment Draft (4' to -4' NAVD88)
- Access Limited by Overhead Structures
- Inaccessible from Water and Upland

Other Features

- Existing Structures
- Tax Lot Boundary (Oct. 2013)
- RM11E Project Area
- PM 11.6 — Project Mile Stationing
- Federal Navigation Channel (USACE)
- -35 — Bathymetric Contour - 5' Interval (NAVD88)

0 80
Scale in Feet

Figure Location Map

MAP NOTES

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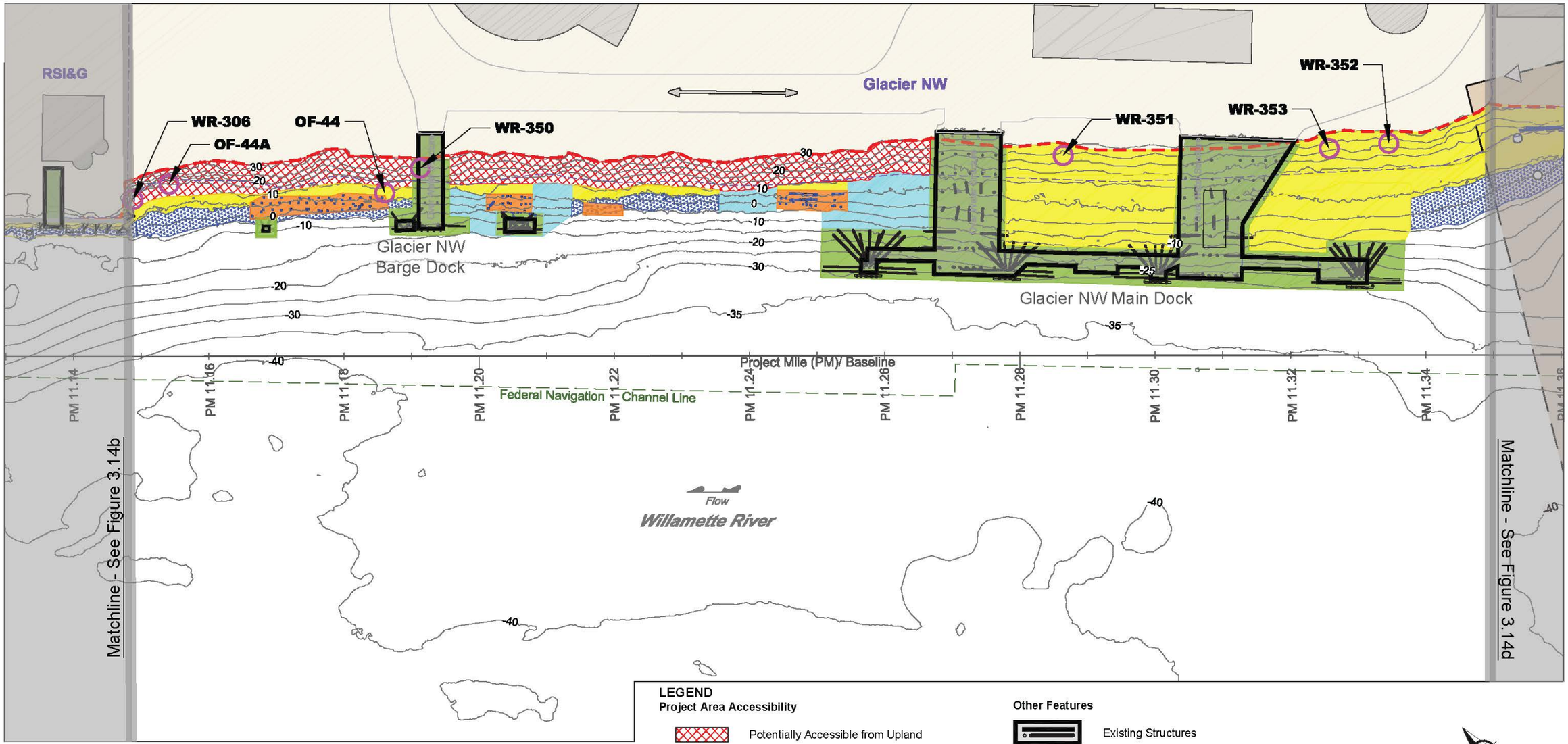
RM11E Group
Willamette River - Portland, Oregon
Draft Implementability Study Report

RM11E Project Area
Construction Access Site Plan
~PM 11.05 to ~PM 11.15

DALTON OLMSTED FUGLEVAND

Figure 3.14b
July 31, 2015

PLOT TIME: 7/31/2015 11:32 AM MOD TIME: 7/31/2015 10:46 AM USER: Lee Barras DWG: D:\Projects\RM11E\CAD\Figures\2015-07\NSR\2015-07-31 13 Proj Area Accessability Figs 3.14abcd.dwg



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LEGEND

Project Area Accessibility

- Potentially Accessible from Upland
- Limited Floating Equipment Draft Access (4' to -4' NAVD88)
- Limited Access by Overhead Structures
- Limited Access by Groups of Vertical Piles
- Access Constricted Due to Structures
- Inaccessible from Water and Upland
- Submarine Cable Crossing Caution Zone

Other Features

- Existing Structures
- Groups of Vertical Piles
- Tax Lot Boundary (Oct. 2013)
- Outfall - Active
- RM11E Project Area
- PM 11.6 — Project Mile Stationing
- Federal Navigation Channel (USACE)
- -35 — Bathymetric Contour - 5' Interval (NAVD88)

0 80
Scale in Feet

Figure Location Map

DRAFT - FOR REVIEW

RM11E Group
Willamette River - Portland, Oregon
Draft Implementability Study Report

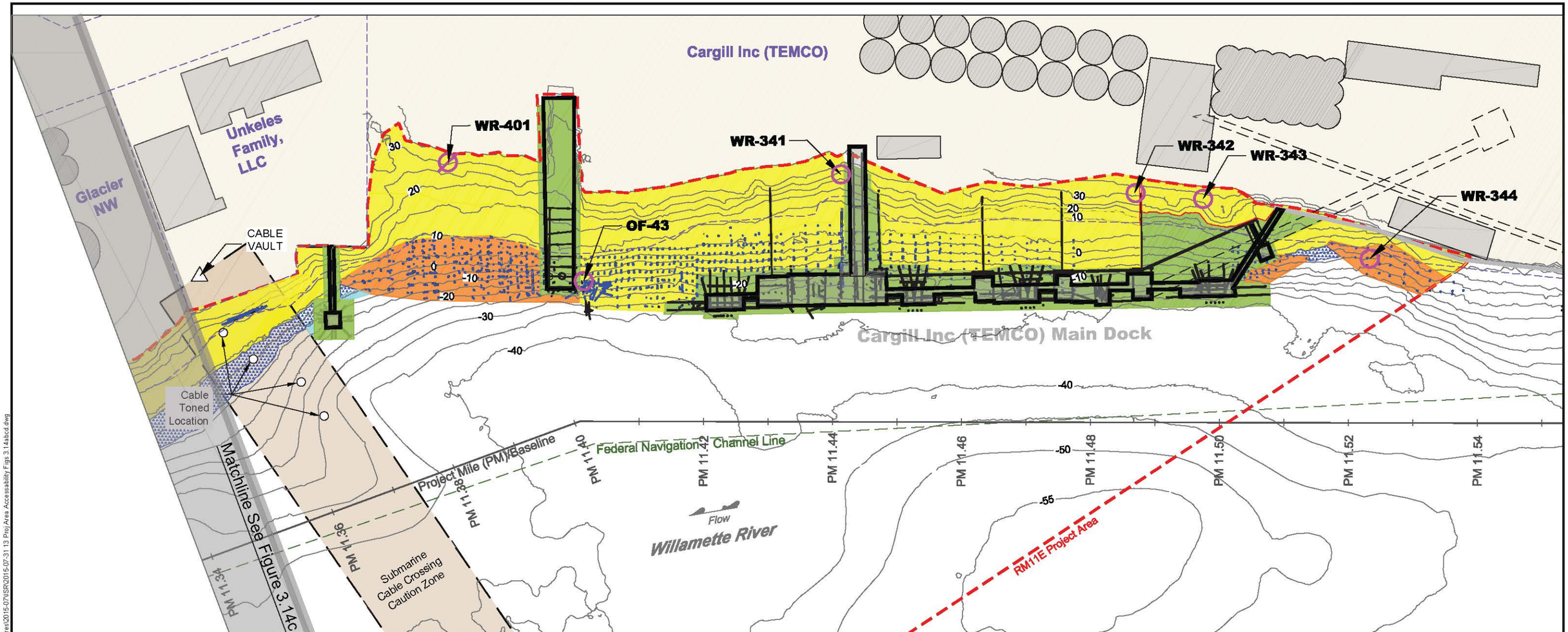
RM11E Project Area
Construction Access Site Plan
~PM 11.15 to ~PM 11.35

DALTON OLMSTED FUGLEVAND

Figure 3.14c

July 31, 2015

PLOT TIME: 7/31/2015 11:32 AM MOD TIME: 7/31/2015 10:46 AM USER: Lee Barras DWG: D:\Projects\RM11E\CAD\Figures\2015-07\NSR\2015-07-31 13 Proj Area Accessability Figs 3.14abcd.dwg



MAP NOTES

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LEGEND

Project Area Accessibility

- Limited Floating Equipment Draft (4' to -4' NAVD88)
- Access Limited by Overhead Structures
- Access Limited by Groups of Vertical Piles
- Access Constricted Due to Structures
- Inaccessible from Water and Upland
- Submarine Cable Crossing Caution Zone

Other Features

- Existing Structures
- Groups of Vertical Piles
- Tax Lot Boundary (Oct. 2013)
- Outfall - Active
- Outfall - Inactive or Status Unknown
- RM11E Project Area
- PM 11.6 — Project Mile Stationing
- Federal Navigation Channel (USACE)
- -35 — Bathymetric Contour - 5' Interval (NAVD88)

0 80
Scale in Feet

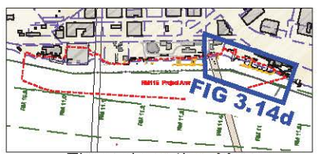

Figure Location Map

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RM11E Group
Willamette River - Portland, Oregon
Draft Implementability Study Report

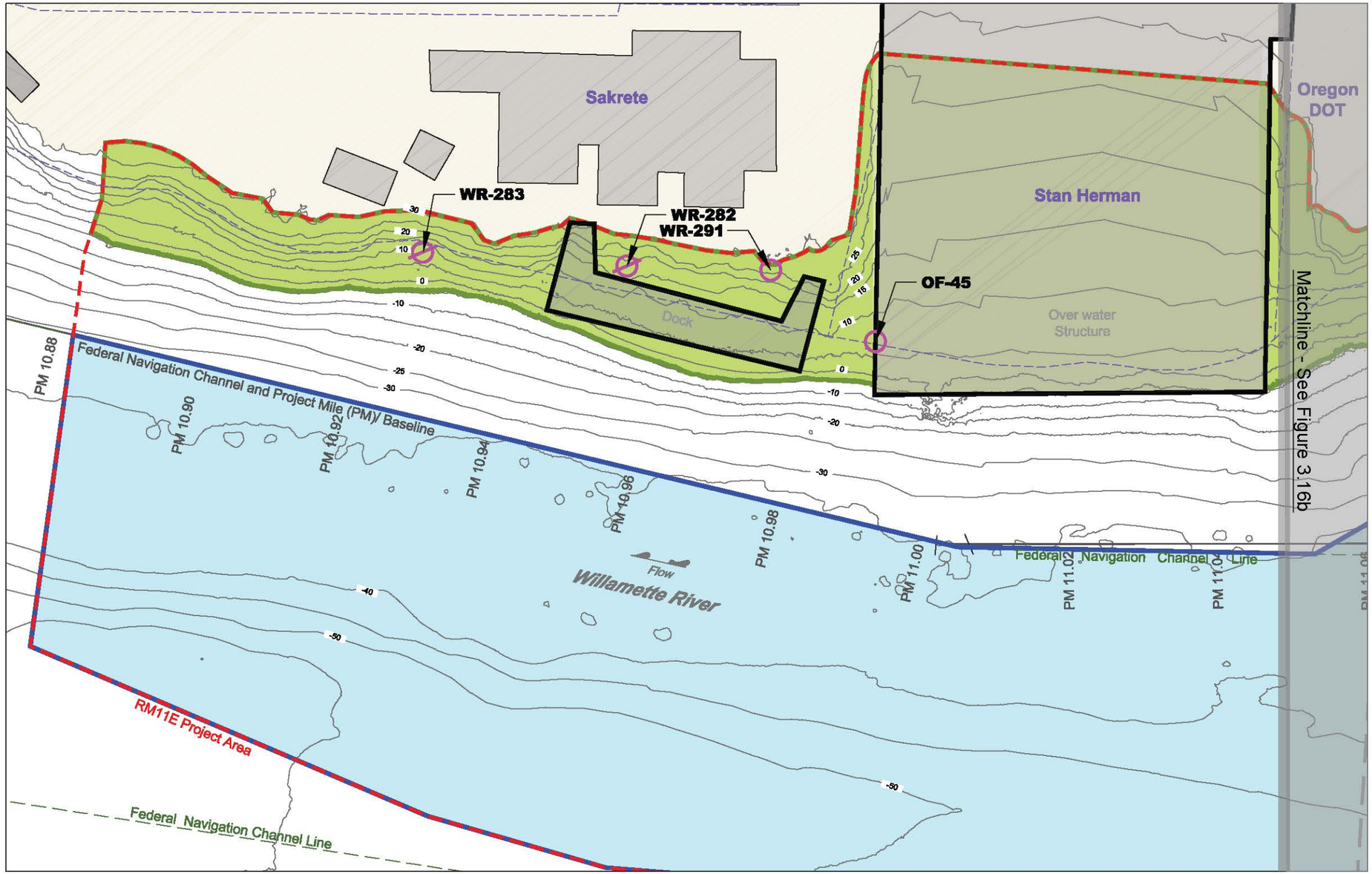
DALTON OLMSTED FUGLEVAND

RM11E Project Area
Construction Access Site Plan
~PM 11.35 to ~PM 11.54

Figure 3.14d

July 31, 2015

PLOT TIME: 7/31/2015 11:32 AM MOD TIME: 7/31/2015 10:46 AM USER: Lee Barras DWG: D:\Projects\RM11E\CAD\Figures\2015-07\NSR\2015-07-31 13 Proj Area Accessibility Figs 3.14abcd.dwg



LEGEND

Impact Ranking

- Construction Access: High-Impact
- Navigation Clearance/Facility Operations: Moderate- to High-Impact (Cap/Cover)
- Outfall - Active: Moderate- Impact
- Outfall - Inactive or Status Unknown: Moderate Impact

Other Features

- Existing Structures
- Tax Lot Boundary (Oct. 2013)
- RM11E Project Area
- PM 11.6 Project Mile Stationing
- Federal Navigation Channel (USACE)
- -35 Bathymetric Contour - 5' Interval (NAVD88)

0 80
Scale in Feet

MAP NOTES

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Figure Location Map

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RM11E Group
Willamette River - Portland, Oregon
Draft Implementability Study Report

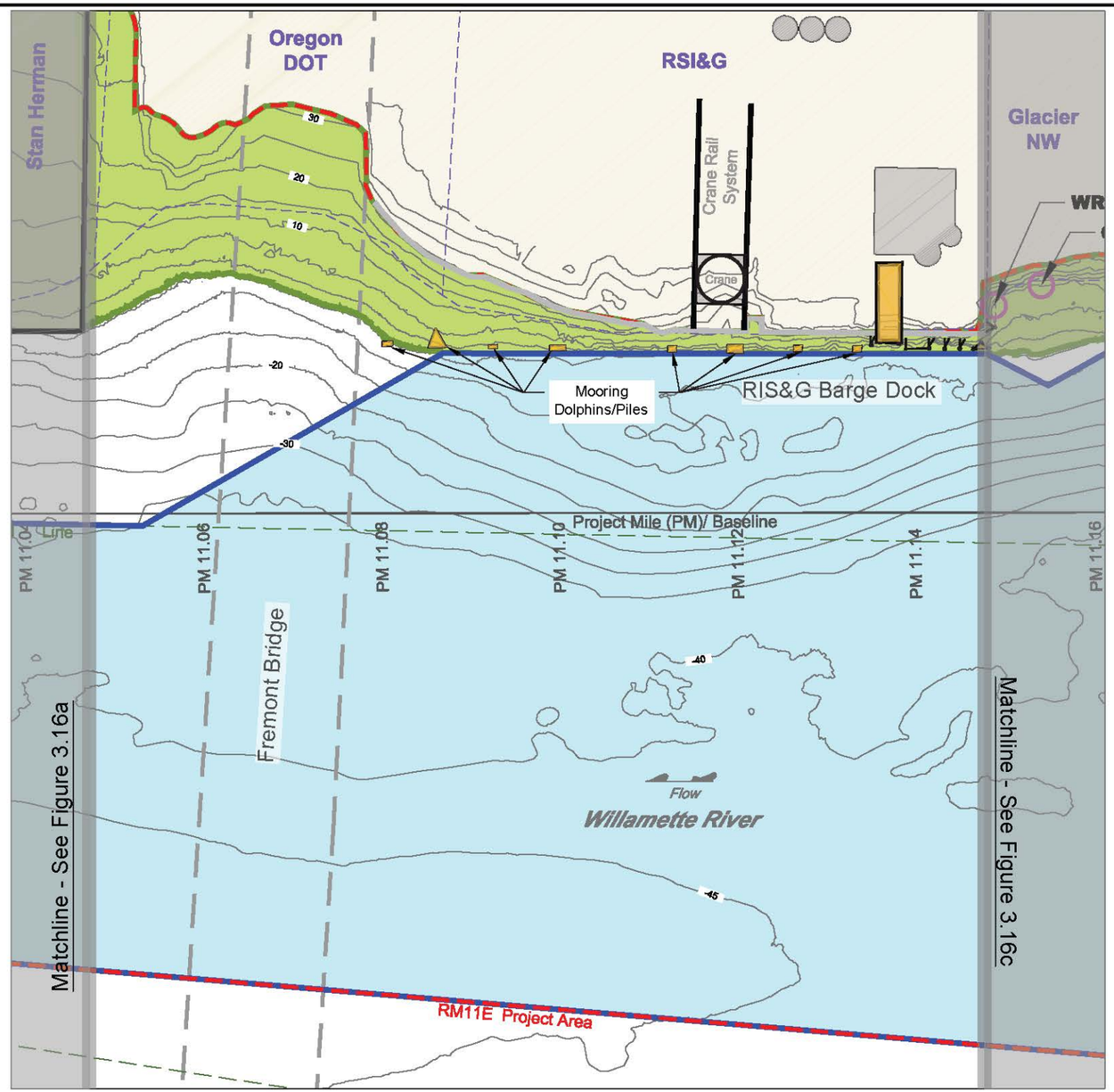
DALTON OLMSTED FUGLEVAND

Waterfront Activities and Use Impact Areas ~PM 10.88 to ~PM 11.05

FIGURE 3.16a

July 31, 2015

PLOT TIME: 7/31/2015 11:33 AM MOD TIME: 7/31/2015 11:22 AM USER: Lee Barras DWG: D:\Projects\RM11E\CAD\Figures\2015-07\NSR2015-07-31 14 Impact Ranking Figs 3.16abcd.dwg



LEGEND

Impact Ranking

- Construction Access: High-Impact
- Navigation Clearance/Facility Operations: Moderate- to High-Impact (Cap/Cover)
- Outfall - Active: Moderate-Impact

Other Features

- Active Docks (2015)
- Existing Structures
- Tax Lot Boundary (Oct. 2013)
- RM11E Project Area
- PM 11.6 Project Mile Stationing
- Federal Navigation Channel (USACE)
- -35 Bathymetric Contour - 5' Interval (NAVD88)

0 80
Scale in Feet

Figure Location Map

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5. Tax lot boundary generated by METRO (Oct. 2013). Data layer acquired from GSI.

DRAFT - FOR REVIEW

RM11E Group
Willamette River - Portland, Oregon
Draft Implementability Study Report

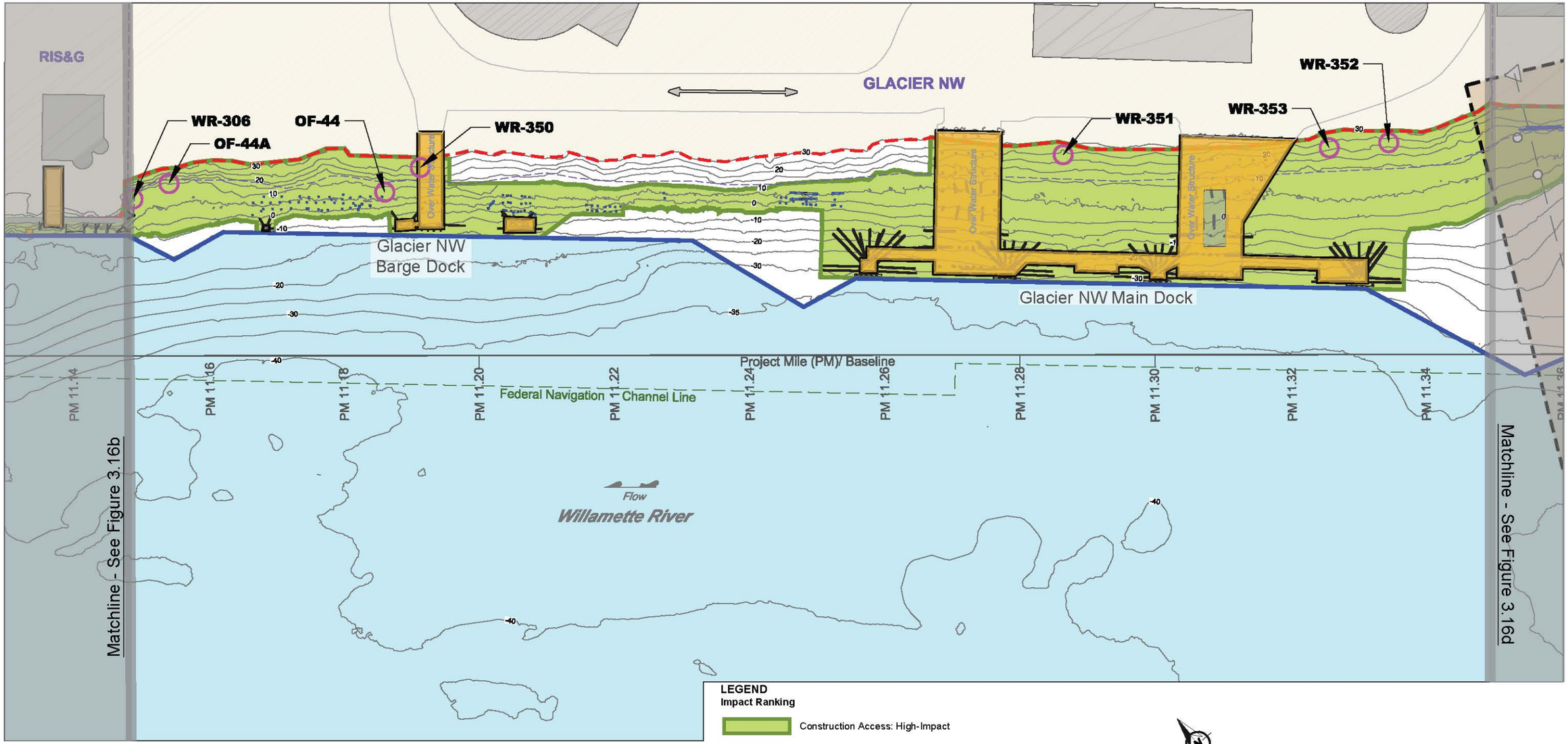
Waterfront Activities and Use Impact Areas ~PM 11.05 to ~PM 11.15

DALTON OLMSTED FUGLEVAND

Figure 3.16b

July 31, 2015

PLOT TIME: 7/31/2015 11:33 AM MOD TIME: 7/31/2015 11:22 AM USER: Lee Barras DWG: D:\Projects\RM11E\CAD\Figures\2015-07\SR\2015-07-31 14 Impact Ranking Figs 3.16a\c\d.dwg



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6. Submarine cable crossing location provided by David Evans and Associates, Inc. as described in Section 2.

LEGEND

Impact Ranking

- Construction Access: High-Impact
- Navigation Clearance/Facility Operations: Moderate- to High-Impact (Cap/Cover)
- Submarine Cable Crossing Caution Zone: High-Impact
- Outfall - Active: Moderate-Impact

Other Features

- Active Docks (2015)
- Existing Structures
- Tax Lot Boundary (Oct. 2013)
- RM11E Project Area
- PM 11.6 Project Mile Stationing
- Federal Navigation Channel (USACE)
- -35 Bathymetric Contour - 5' Interval (NAVD88)

0 80
Scale in Feet

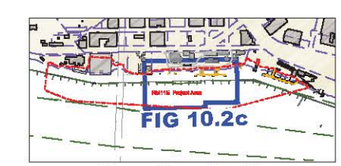


Figure Location Map

DRAFT - FOR REVIEW

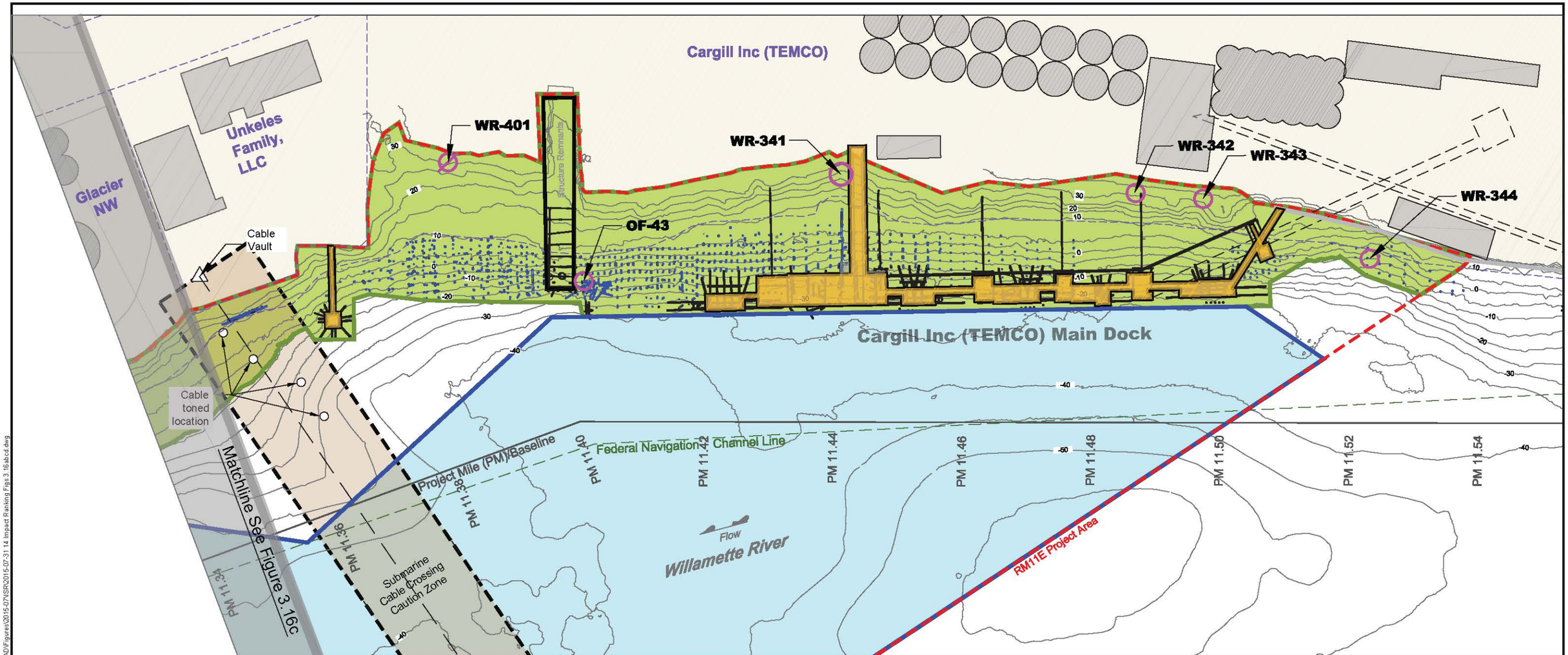
RM11E Group
Willamette River - Portland, Oregon
Draft Implementability Study Report

Waterfront Activities and Use Impact Areas ~PM 11.15 to ~PM 11.35

DALTON OLMSTED FUGLEVAND

Figure 3.16c
July 31, 2015

PLOT TIME: 7/31/2015 11:33 AM MOD TIME: 7/31/2015 11:22 AM USER: Lee Barras DWG: D:\Projects\RM11E\CAD\Figures\2015-07\SR\2015-07-31 14 Impact Ranking Figs 3.16abcd.dwg



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- Navigation Clearance/Facility Operations: Moderate- to High-Impact (Cap/Cover)
- Submarine Cable Crossing Caution Zone: High-Impact
- Outfall - Active: Moderate-Impact
- Outfall - Inactive or Status Unknown: Moderate-Impact

Other Features

- Active Docks (2015)
- Existing Structures
- Tax Lot Boundary (Oct. 2013)
- RM11E Project Area
- PM 11.6 — Project Mile Stationing
- Federal Navigation Channel (USACE)
- -35 — Bathymetric Contour - 5' Interval (NAVD88)

0 80
Scale in Feet

Figure Location Map

DRAFT - FOR REVIEW

RM11E Group
Willamette River - Portland, Oregon
Draft Implementability Study Report

Waterfront Activities and Use Impact Areas ~PM 11.35 to ~PM 11.54

DALTON OLMSTED FUGLEVAND

Figure 3.16d
July 31, 2015

PLOT TIME: 7/31/2015 11:33 AM MOD TIME: 7/31/2015 11:22 AM USER: Lee Barras DWG: D:\Projects\RM11E\CAD\Figures\2015-07\ISR\2015-07-31 14 Impact Ranking Figs 3.16abcd.dwg

4. DEBRIS SURVEY

4.1 OBJECTIVE

The objective of the debris study was to use the maps developed for Section 2 to estimate the type and volume of debris in the RM11E Project Area and to evaluate its potential effect on the implementability of remedial alternatives. Results of that study are summarized in this section.

4.2 DEBRIS MAPPING

The following is a summary of data sources and data collected, reviewed, and evaluated for this study. A summary of the approach for review of each data source is also included.

4.2.1 HISTORICAL AERIAL PHOTOGRAPHS AND CHARTS

Aerial photographs and charts were reviewed to map the locations of historical buildings along the RM11E Project Area shoreline as an indication of potential locations of debris, remnant piles, and buried foundations. Examples of aerial photographs are provided in Figure 4.1a (from 1943) and Figure 4.1b (from 1963). Individual historical structures were digitized from aerial photos, Sanborn fire insurance maps, and charts, and then geo-registered. Historical buildings identified and digitized from the various records were combined to generate a composite outline of the extent of historical shoreline structures, as shown on Figure 4.2. The historical locations of buildings along the RM11E shoreline indicate possible locations of physical elements that may have been abandoned, buried, or both. These physical elements include structures, foundations, demolition debris, and materials from past operations, whether protruding above or buried below the riverbed.

The following aerial photographs, charts, and Sanborn maps were collected and reviewed for this study. Those with double asterisks (**) are included in Appendix C and were used as the basis for Figure 4.2.

- USC&GS Willamette River maps (**1888 [Figure C-1], **1925 [Figure B-6])
- Map of the Willamette River, Sellwood to Linnton (**1908 [Figure C-4])
- ODOT photos (1959, 1963, 1964, 1969, 1970, 1974, 1979, 1986)
- USGS Earth Explorer photos (**1951 [Figure C-12], 1952, 1955, 1960, 1970, 1971, 1973, 1974, 1975, 1980, 1990, 1994, 2000, 2009, 2011)
- Sanborn fire insurance maps (1887, 1889, **1901 [Figure C-3], 1909, 1924, 1950, 1969)

4.2.2 BATHYMETRIC SURVEYS

Data from multibeam hydrographic surveys and LiDAR upland surveys from 2002 through 2009 were compiled and processed for the RM11E mapping work (Section 2). This effort produced computer-generated 3D images and hillshade views of the riverbed at RM11E. For the debris study, these images were evaluated to identify shape anomalies indicative of anthropogenic materials on the riverbed and shoreline. The results of these imaging efforts were combined with the sidescan sonar data from the PHSS Draft FS report to show the locations of mapped riverbed debris, as presented on Figures 4.3a through 4.3d. The figures also depict the approximate extent of historical shoreline structures, existing structures, and riverbed bathymetry. The nature of the

mapped debris is discussed and evaluated in Section 4.3. An example 3D image of the riverbed is included as Figure 4.4; it shows the southern end of the Cargill, Inc. shoreline.

4.2.3 ANECDOTAL INFORMATION

The Stan Herman building (Figure 4.3a) is built out over the shoreline north of the Fremont Bridge. As shown in Appendix C, Figure C-4, it was originally known as the Montgomery Dock. A historical photograph of Montgomery Dock is provided in Appendix C, Figure C-2. The building appears to have been constructed prior to 1908, with the southern portion of the Montgomery Dock demolished prior to or in conjunction with construction of the Fremont Bridge. A likely example of historical shoreline buildings in the area, it is supported on a grid of timber pilings. This building is observed to be in disrepair and portions of it have collapsed into the river, as further discussed in Section 6.4.2.

4.3 DEBRIS EVALUATION

Debris characteristics and their potential impacts on remedial actions involving removal of contaminated sediments or placement of a cap or cover over such sediments were evaluated using results of the debris mapping. As described below, three classes of debris were identified:

- Individual large debris
- Groups of vertical pile remnants (defined for this report as no fewer than four pile remnants in a group)
- Undifferentiated debris

The potential effects of each debris class on remedial operations are ranked as low-, moderate-, or high-impact based on the following general criteria:

- Low-impact – Limited quantities of smaller debris that may be left in place until remediation is implemented, with no specific management action required in advance. For example, smaller undifferentiated debris that can be left in place and capped or small quantities of debris that can be easily removed as part of an ongoing dredging program would be ranked as low impact.
- Moderate-impact – Debris that may require management action prior to remediation. For example, large objects on the riverbed (e.g., logs, isolated individual abandoned piles) that might require removal prior to dredging or the placement of a cap or cover would be ranked as moderate impact.
- High-impact – Debris that may make remediation difficult to implement or that is located in areas where management actions are limited or complex due to other site factors. For example, debris whose removal would increase slope instability, disrupt ongoing business operations, or potentially damage existing structures would be ranked as high impact.

The following subsections describe issues, management actions, and impact rankings for the three debris classes.

4.3.1 INDIVIDUAL LARGE DEBRIS

This debris class consists of individual pieces of large debris or clusters of large debris scattered on the riverbed. Examples include sunken logs, piling remnants lying horizontally on the riverbed, and isolated remnants of standing piles.[23] More than 100 items of large debris have been identified; they are distributed throughout the RM11E Project Area (Figures 4.3a through 4.3d).

A considerable amount of rock and broken concrete has been placed along the RM11E Project Area shoreline in the wave zone, likely as wave attenuation devices and shoreline armoring. Because this material appears to have been placed intentionally for the purpose of shoreline stabilization, it is not classified as debris for this report.[24] This anthropogenic armoring, however, can pose the same issues as individual large debris, and should be evaluated and incorporated into remedial actions once the extent of cleanup areas have been finalized.

4.3.1.1 Individual Large Debris Issues

For removal remedial actions, the following potential issues are associated with the presence of individual large debris:

- Debris that is too large to fit into the bucket of a mechanical dredge will block access to target sediment.
- Debris whose shape, weight, or texture (e.g., slick) impedes efficient pickup by the mechanical dredging bucket will slow the dredging process.
- Debris that prevents complete closure of the mechanical dredging bucket will result in loss of sediment during retrieval, and produce "generated residuals" on the riverbed.[25] The presence of significant debris is one of the most important site factors affecting volume of generated residuals (Bridges et al., 2008).
- Debris removal during dredging can increase resuspension of contaminated sediment and potential transport into non-impacted areas.
- Large debris will obstruct the swing path of a hydraulic cutter head and interfere with its effectiveness.
- If it is removed, large debris embedded in the slope could reduce slope stability.

For remedial actions involving placement of a cap or cover, the following potential issues are associated with the presence of individual large debris:

- Large debris can breach a cap or cover.

---

[23] Groups of vertical pile remnants are addressed in Section 4.3.2.

[24] Much of the armoring along the shoreline area appears to be rock and concrete that was placed on the bank, but not specifically as an engineered revetment structure designed for long-term bank stabilization.

[25] Residuals are defined as contaminated sediment found at the post-dredging surface profile, either within or adjacent to the dredging footprint, and broadly grouped into two categories: undisturbed residuals and generated residuals. Undisturbed residuals are contaminated sediments that have been uncovered by dredging but not fully removed. Generated residuals are contaminated post-dredging surface sediments dislodged or suspended by the dredging operation and subsequently redeposited on the bottom of the water body (Bridges et al., 2008)

- Depending upon the size of the debris and the design thickness of the cap or cover, material may slide off large debris, causing uneven or incomplete placement of the cap or cover.
- Depending on its shape, large debris protruding above the riverbed may act as a shield to areas of contaminated sediment, precluding placement of sufficient cap or cover material or requiring more extensive material placement activity to ensure the integrity of the cover.

4.3.1.2 Individual Large Debris Management Actions

Specifically designed pre-remediation debris removal actions can reduce impediments to dredging and facilitate more effective placement of a cap or cover. Such actions can help reduce resuspension of impacted sediment during dredging (Anchor QEA et al., 2012). Depending upon the depth of the debris, large objects can be removed by a mechanical dredge with a grab or grapple specifically suited for the purpose, such as an "orange peel" grapple that can pick up the individual large debris with limited additional sediment. In some instances, a thin blanket of sand can be placed over an area before recovering large debris to reduce (but not eliminate) resuspension of the soft, fine-grained contaminated sediment. Real-time riverbed viewing technologies such as Blueview[26] allow a crane operator to direct the bucket or grab to the identified large debris, limiting the extent of bed disturbance.

Isolated standing pile remnants can be removed using marine construction equipment, such as a vibratory hammer and a derrick. Use of a vibratory hammer to loosen and remove piling is generally more protective than use of a clamshell bucket or chain, which can strip, scrape, or squeeze creosote from the piling and distribute it on the riverbed. Removal of piling may result in some disturbance and resuspension of the surrounding sediment. Control measures such as placement of a blanket of sand around the pile can be implemented in advance to limit the disturbance of impacted sediment during removal and to partially fill the cavity left after the piling is removed. Piling extending above the bed can also be cut off near the mudline (e.g., by divers) to facilitate cap or cover placement.

Removal of individual large debris embedded below the riverbed on a slope or at the toe of a slope could undercut the adjacent bank, potentially cause slope failure, and affect adjacent structures and waterfront operations. Several management alternatives are available for working with embedded individual large debris; later site-specific remedial design work will be undertaken to evaluate their cost, effectiveness, and impacts to ongoing waterfront business operations.

Removal of individual large debris may require compliance with permitting conditions similar to those in pile removal/replacement permits. For example, Glacier NW's existing pile replacement permit requires control of erosion and sedimentation in disturbed upland and aquatic areas, control of floating debris, slow lifting of debris through the water column, and filling of any holes left by removal (Glacier NW, 2014b).

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[26] A technology that uses high-resolution, real-time multibeam sonar imaging equipment.

4.3.1.3 Individual Large Debris Impact Ranking

The potential impact of large debris is ranked as moderate for remedial alternatives involving removal and also for those involving placement of a cap or cover. Management actions, such as pre-remediation debris removal, are achievable with standard marine equipment and practices; complex remedial design analysis[27] may not be required for implementation. Individual large debris in the RM11E Project Area is identified on Figures 4.3a through 4.3d.

4.3.2 GROUPS OF VERTICAL PILE REMNANTS

Large areas of remnant timber piling exist in the RM11E Project Area, generally within the extents of the historical shoreline structures described in Section 4.2. These areas are shown as blue dots on Figures 4.3c and 4.3d, and as blue posts protruding above the riverbed on Figure 4.4. Most of the groups of vertical piles are located on or at the base of slopes steeper than 2H:1V, particularly near the existing Cargill docks (Figure 4.3d).

Remnant piles cover approximately 1.4 acres between PM 11.16 and PM 11.54, as shown on Figures 4.3c, 4.3d, and 4.4. Single piles, groups of two or three piles, or lines of single piling outside of the historical building extents are not included as groups of vertical piles, but rather are classified as individual large debris.

4.3.2.1 Groups of Vertical Piles Issues

For remedial actions involving sediment removal, groups of vertical piles present the following issues:

- Tall-standing piles can prevent floating remedial construction equipment from accessing the interior of the group of piles because of reduced draft above the tops of the standing piles and spacing that is too narrow for the equipment.
- Piles placed too closely to one another can interfere with placement of the mechanical bucket or hydraulic cutter head (e.g., deflecting the mechanical bucket during positioning or blocking access of the dredge head to the interior of the groups of vertical piles), thus limiting the effectiveness of the removal action.
- The presence of groups of vertical piles can cause incomplete removal around and between piling, which increases the area of post-remediation undisturbed residuals.

For remedial actions involving placement of a cap or cover, groups of vertical piles could limit access by the floating construction equipment needed for placement. Without additional precautions, groups of vertical piles could also penetrate the cover or cause inconsistent cover over targeted material.

4.3.2.2 Groups of Vertical Piles Management Actions

Several management alternatives are available for working with groups of vertical piles. A typical management action for remnant piling is to remove it prior to implementing a remedial action. Use of a vibratory hammer to loosen and remove piling is generally more protective than

[27] In general, removal of isolated individual piling will not contribute to slope instability or require special evaluation, in contrast to the removal of groups of vertical pile remnants, as discussed in Section 4.3.2.

use of a clamshell bucket or chain, which can strip, scrape, or squeeze creosote from the piling and distribute it on the riverbed. Sand placed at the site in advance of the extraction can limit disturbance of the surficial soft sediment around the pile and partially fill the cavity left after the piling is removed. In the RM11E Project Area, the viability of pile removal may be limited because doing so may reduce the stability of the steep slopes along the shoreline or the stability of in-water structures still in use (such as docks, sheet pile walls, outfalls).

Industrial divers can be employed to address some of the issues associated with remnant piling. The timber piling can be cut off near the riverbed to allow for vessel access and for more uniform placement of cover material. Typically, the remaining pile stub will extend 3 to 6 inches above the riverbed unless the diver first digs a large-diameter depression around the pile and cuts off the pile below the riverbed. Diver-operated hydraulic dredging can be implemented to remove sediment between and around piling. The viability of diver-implemented actions for groups of vertical piles may be limited by the combination of the large extent of groups of vertical piles in theRM11E Project Area, the low productivity of diver operations,[28] and the short in-water construction window.

4.3.2.3 Groups of Vertical Piles Impact Ranking

The potential impact of groups of vertical piles is ranked as high for removal remedial alternatives: the extent of groups of vertical piles at the site is large, the effectiveness of dredging is limited if the piles are left in place, and potential slope instability after piling removal is of concern.

The potential impact of groups of vertical piles on cap and cover alternatives is ranked only slightly lower than for dredging because a cap or cover option may only be viable after the piles are cut off near the riverbed. Groups of vertical piles are ranked as moderate to high for cap or cover: the extent of groups of vertical piles at the site is large, the effectiveness of a cap or cover may be limited if the piles are left in place, and the cap or cover remedial design would need to accommodate remaining pile stubs.

4.3.3 UNDIFFERENTIATED DEBRIS

For purposes of this analysis, undifferentiated debris is material on or buried below the riverbed that is too small to be detected in hydrographic surveys (unlike the individual large debris discussed in Section 4.3.1) or cannot be differentiated from natural bottom irregularities. Undifferentiated debris may be found anywhere in the RM11E Project Area, with buried undifferentiated debris likely present within the footprint and immediately downslope of historical buildings.

Undifferentiated debris can be comprised of domestic and industrial debris such as rubble, concrete, asphalt, cables, chains, stumps, and logs. According to local marine contractors, the

[28] Based on prior project experience, depending on site conditions, productivity of diver-operated hydraulic dredging is a few (~1 to 5) cubic yards per hour, and a diver-based program can cut off a few piles per hour (~2 to 10) depending on site conditions, dropping to a few piles per day if the piles are to be cut off below the riverbed.

majority of debris encountered in Willamette River dredging is associated with wood debris (Steinwandle, 2015;[29] Jameson, 2015[30]).

For this report, undifferentiated debris is categorized as minor or as large. Limited deposits of undifferentiated debris that may be encountered occasionally and that can be accommodated without significant impact by the equipment deployed to complete the remedial action are considered minor undifferentiated debris. Minor undifferentiated debris is commonly encountered in navigation dredging of urban rivers.

Large undifferentiated debris includes widespread deposits of buried debris, including items similar to individual large debris but not evident on the riverbed surface maps. Given the number of historical shoreline structures and corresponding demolitions associated with redevelopment, the potential for large undifferentiated debris is high at the site, particularly within the footprints of historical structures shown on Figure 4.2 and on the river's adjacent side slope.

4.3.3.1 Undifferentiated Debris Issues

For remedial actions that involve sediment removal, undifferentiated debris poses the following implementability issues:

- Debris that prevents complete closure of the mechanical dredging bucket will result in loss of sediment during retrieval, decreasing the dredging efficiency and increasing the production of generated residuals.
- Sediment disturbed or resuspended as the dredge removes debris embedded in the riverbed increases the production of generated residuals.
- Debris that interferes with hydraulic cutter head operation or plugs the hydraulic pipeline decreases efficiency and increases the production of generated residuals.
- Large undifferentiated debris encountered below the riverbed can result in the same general issues identified for individual large debris (e.g., cannot fit into or be picked up by a dredging bucket), increasing the production of generated residuals and potentially destabilizing slopes upon removal.

For remedial actions that involve placement of a cap or cover, undifferentiated debris is not expected to be a barrier to implementability, as it is generally buried or not large enough to significantly distort the cap or cover.

4.3.3.2 Undifferentiated Debris Management Actions

The limited deposits of minor undifferentiated debris (e.g., smaller material such as rubble, concrete, asphalt, wood, cables, or chains) can readily be captured in a dredge bucket. Pickup of undifferentiated debris in a mechanical dredging bucket is a normal aspect of dredging in urban areas.

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[29] Chuck Steinwandle, President of RIS&G, observed dredging by the Port of Portland for fill at Terminal 2 and dredging by ODOT for Fremont Bridge foundations. The majority of debris observed was large woody debris, including root stumps and trees.

[30] When dredging at Cargill, Inc., Darrell Jameson, Dredging Manager, Hickey Marine Enterprises, observed wood debris in dredge material.

Both minor and large undifferentiated debris can prevent a mechanical dredging bucket from closing completely, causing the bucket to leak sediment and water. One management action for this condition is to direct the operator to move the bucket rapidly across the water into the transport barge, thus limiting the amount of time the bucket is over the water and the volume of material that might be lost back into the river. When encountered on a limited basis, undifferentiated debris does not typically result in significant generated residuals.

Large undifferentiated debris may be of a size, nature, or extent that precludes proper handling with the equipment deployed for dredging, and specific management actions may be necessary. Examples of specific management actions that may be appropriate before continuing with dredging include but are not limited to the following:

- Mapping the exposed material via multibeam hydrographic survey, diver reconnaissance, or cores before proceeding further
- Utilizing recovery equipment specifically suited to encountered debris, such as a properly sized "orange peel" grapple
- Placing a thin sand cover over the debris prior to recovery to help limit the resuspension of soft sediment

Because the full nature and extent of undifferentiated debris will not likely be evident until uncovered by dredging, the incorporation of an adaptive management approach into the construction plans and specifications can facilitate flexibility in response to changing conditions. The plan would include numerous contingency actions and equipment that could be deployed as needed.

Undifferentiated debris can be more difficult to manage with hydraulic dredging equipment than with mechanical dredging equipment. Debris can foul the hydraulic dredge head and plug the pipeline, as well as block the swing path of the cutter head in the dredge cut. If the extent of debris can first be mapped and defined, the debris can be removed with a mechanical grab before hydraulic dredging begins

Undifferentiated debris of limited extent and size on the riverbed as well as buried debris can be capped or covered without additional pre-remediation management action, as long as large debris is removed from the area.

4.3.3.3 Undifferentiated Debris Impact Ranking

The potential impact of minor undifferentiated debris on remedial alternatives is ranked as low for both mechanical dredging removal and for cap and cover placement. The potential impact of minor undifferentiated debris for mechanical dredging is ranked as low because such debris is routinely removed and managed as part of urban dredging by mechanical techniques. The pickup of occasional debris that is straightforward for mechanical dredging in urban waterways can disrupt hydraulic dredging operations. Therefore, the potential impact of minor undifferentiated debris is ranked moderate for hydraulic dredging removal because the equipment can more readily be fouled by such debris, and might require special management action such as prior removal by mechanical dredging equipment.

The potential impact of large undifferentiated debris is ranked as moderate to high for remedial actions involving removal. Extensive debris fields could require additional equipment and time; resuspension of impacted sediment and production of generated residuals could be increased;

and the removal of large undifferentiated debris could destabilize slopes. The potential impact of large undifferentiated debris on remedial actions involving placement of a cap or cover is ranked as low because the cap or over could be installed without disturbing the debris.

4.4 CONCLUSION AND RECOMMENDATIONS

Table 4.1 identifies debris classes present in the RM11E Project Area and associated level of impact on the implementability of alternative remedial actions. Moderate impact areas for individual large debris are shown on Figures 4.5a through 4.5d and moderate- to high-impact areas for groups of vertical piles are shown on Figures 4.5c and 4.5d. Undifferentiated debris can be found anywhere in the RM11E Project Area, particularly within the footprint and immediately downslope of the combined extents of historical shoreline structures, which are ranked moderate to high for large undifferentiated debris.

TABLE 4.1 – DEBRIS CHARACTERISTICS AND POTENTIAL REMEDIATION IMPLEMENTABILITY IMPACTS

DEBRIS CLASS	POTENTIAL IMPACT ON IMPLEMENTABILITY	
	REMOVAL	CAP OR COVER
Individual large debris (e.g., sunken logs, piling remnants)	Moderate	Moderate
Groups of vertical piles	High	Moderate to high
Minor undifferentiated debris (e.g., rubble, rock, concrete, wire, rope, tires)	Low (for mechanical dredge) Moderate (for hydraulic dredge)	Low
Large undifferentiated debris	Moderate to high	Low

For debris classes whose potential impact on the implementability of remedial actions is moderate to high, additional effort will be required to select and design the remedy, including identification of site-specific management actions tailored to the selected remedial action in areas where active remediation is required.

Buried debris, such as historical building foundations, could be an issue for dredging. Once the extent of removal areas is established, supplementary investigations may be appropriate during remedial design to refine the understanding of the nature and extent of buried debris at the site. For cap or cover remedial alternatives, investigations to identify debris to date appear to be adequate. Further investigations to identify debris are not recommended at this time.

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4.5 SECTION 4 FIGURES

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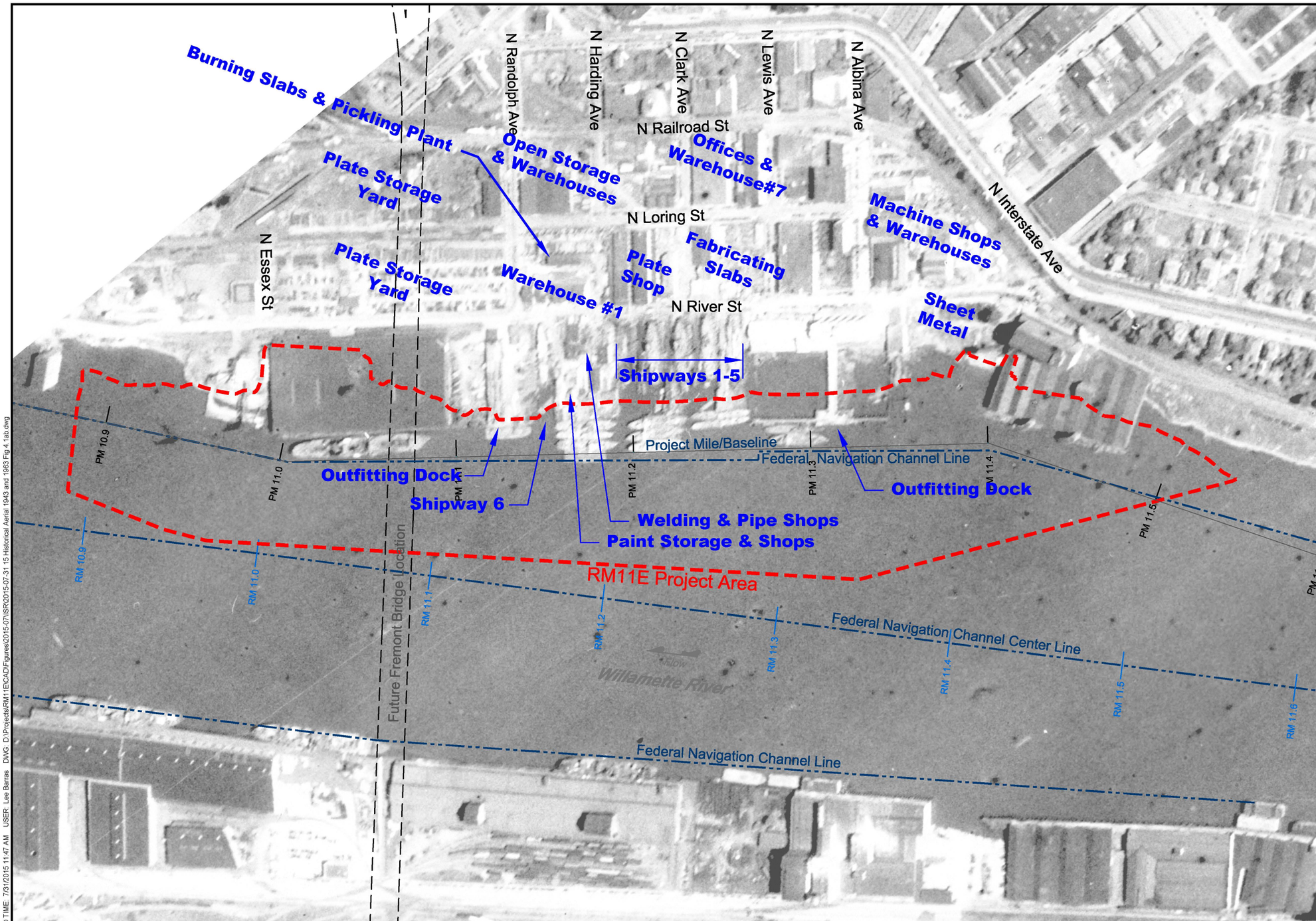

LEGEND

Feature	Historical Feature Name
RM 11.5	River Mile (RM) Stationing
PM 11.5	Project Mile (PM) Stationing
	Federal Navigation Channel (USACE)
	RM11E Project Area
	Future Fremont Bridge Location

N

0 300
Scale in Feet

MAP NOTES
1. The locations of all features shown are approximate.
2. Historical feature names are from GSI Figure 6-5 "Proposed Groundwater Monitoring Well Locations and Historic 1943 Air Photo" River Mile 11 East Supplemental RI/FS Work Plan - Map date of September 26, 2013.
3. The River Mile (RM) designations are based on USACE stationing along the centerline of the Lower Willamette River navigation channel and represent the distance in miles from the start of channel at the Columbia River (USACE Portland District Hydrosurvey file WR_2014_Channel.DXF). Project Mile Stationing is closely matched to USACE River Mile stationing and has been generated by DOF for the RM11E project and is to be used only by the RM11E Group in the context of this project.

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1943 Air Photo

DOF DALTON OLMSTED FUGLEVAND

Figure 4.1a

July 31, 2015

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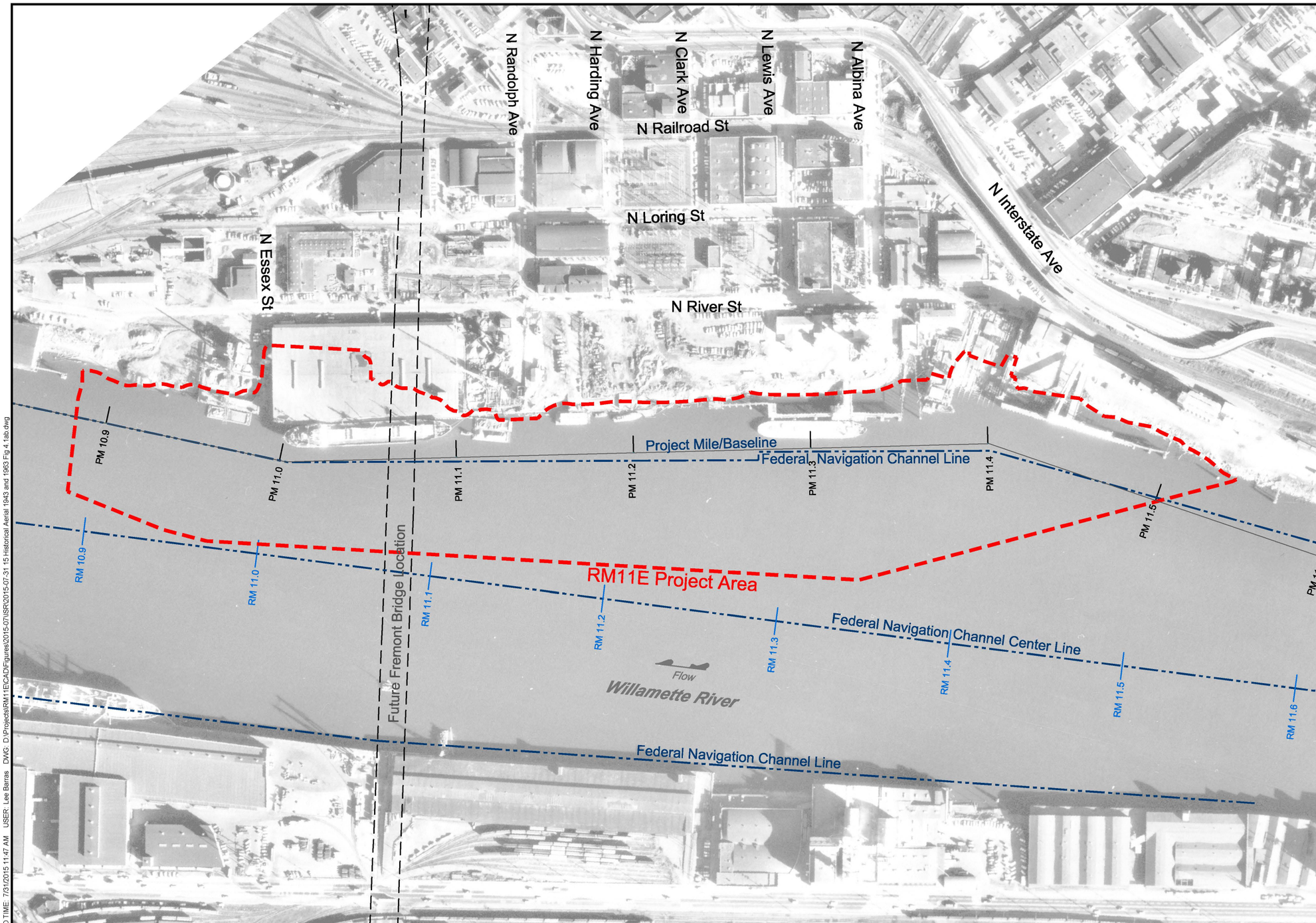

LEGEND

RM 11.5	River Mile (RM) Stationing
PM 11.5	Project Mile (PM) Stationing
	Federal Channel (USACE)
	RM11E Project Area
	Bridge (Future)

0 300
Scale in Feet

MAP NOTES

1. The locations of all features shown are approximate.
2. The River Mile (RM) designations are based on USACE stationing along the centerline of the Lower Willamette River navigation channel and represent the distance in miles from the start of channel at the Columbia River (USACE Portland District Hydrosurvey file WR_2014_Channel.DXF). Project Mile Stationing is closely matched to USACE River Mile stationing and has been generated by DOF for the RM11E project and is to be used only by the RM11E Group in the context of this project.

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1963 Air Photo

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Figure 4.1b

July 31, 2015

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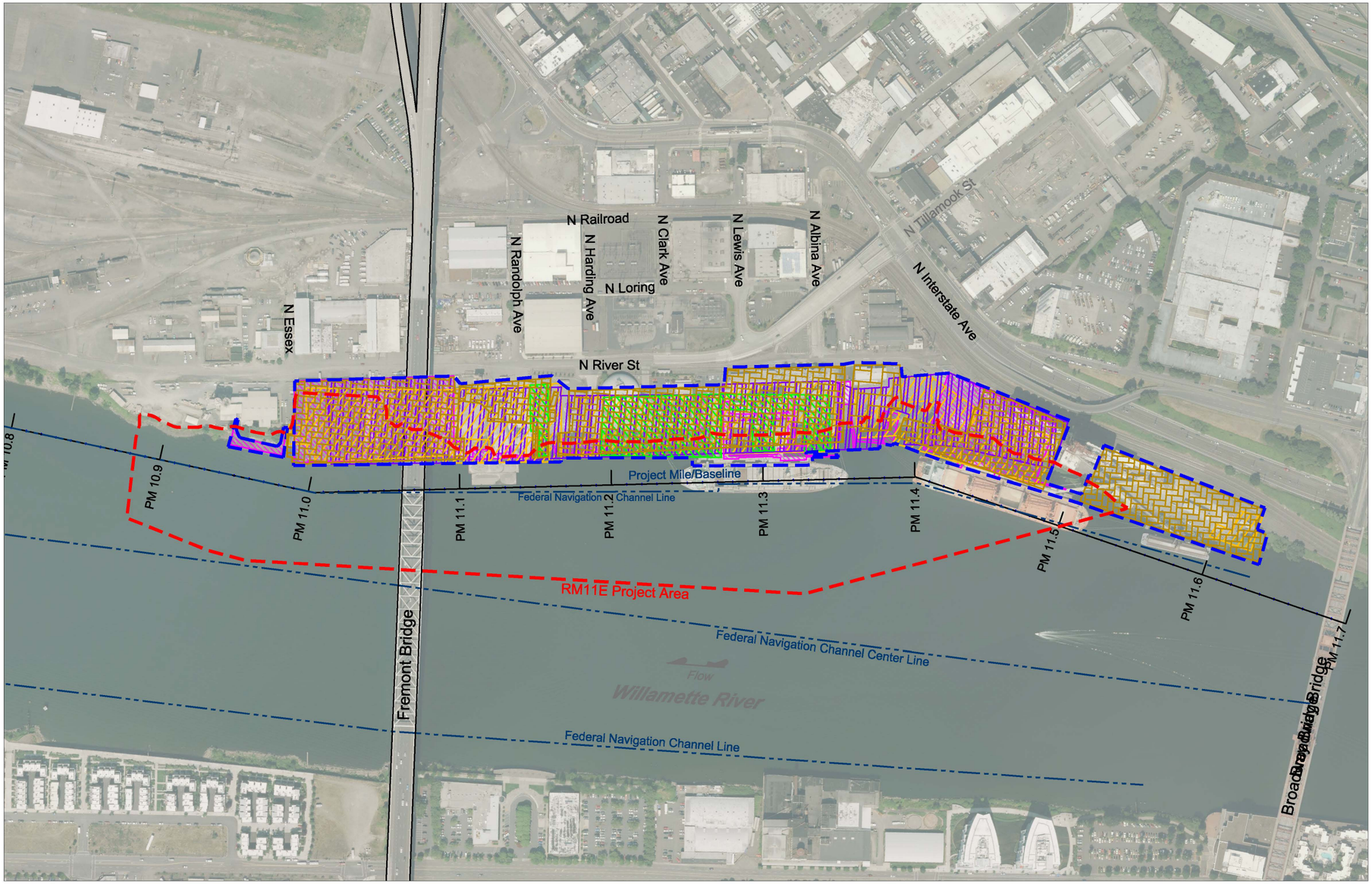

LEGEND

Historical Structure Extents

- Approximate Combined Extents of Historical Shoreline Structures
- Structure from 1888 USC&GS Willamette Navigation Chart
- Structure from 1901 Sanborn Map
- Structure from 1908 USC&GS Willamette Navigation Chart
- Structure from 1925 USC&GS Willamette Navigation Chart
- Structure from 1951 October 25 Aerial Photo (USGS)

Other Features

- Federal Channel (USACE)
- PM 11.6 — Project Mile (PM) Stationing
- RM11E Project Area

0 400
Scale in Feet

MAP NOTES

1. The locations of all features shown are approximate.
2. Combined extents of historical shoreline structures digitized from the following documents:
   - -1888 USCGS Willamette Navigation Chart - United States Coast and Geodetic Survey (USC&GS)
   - -1901 Sanborn Fire and Insurance Map - Environmental Data Resources, Inc. (EDR)
   - -1908 USCGS Willamette Navigation Chart - United States Coast and Geodetic Survey (USC&GS)
   - -1925 USCGS Willamette Navigation Chart - United States Coast and Geodetic Survey (USC&GS)
   - -1951 October 25 aerial photograph from U.S. Geological Survey (USGS)
3. Background aerial photograph: 2012 July from Metro RLIS GIS database.

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Historical Shoreline Structure Extents

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Figure 4.2

July 31, 2015

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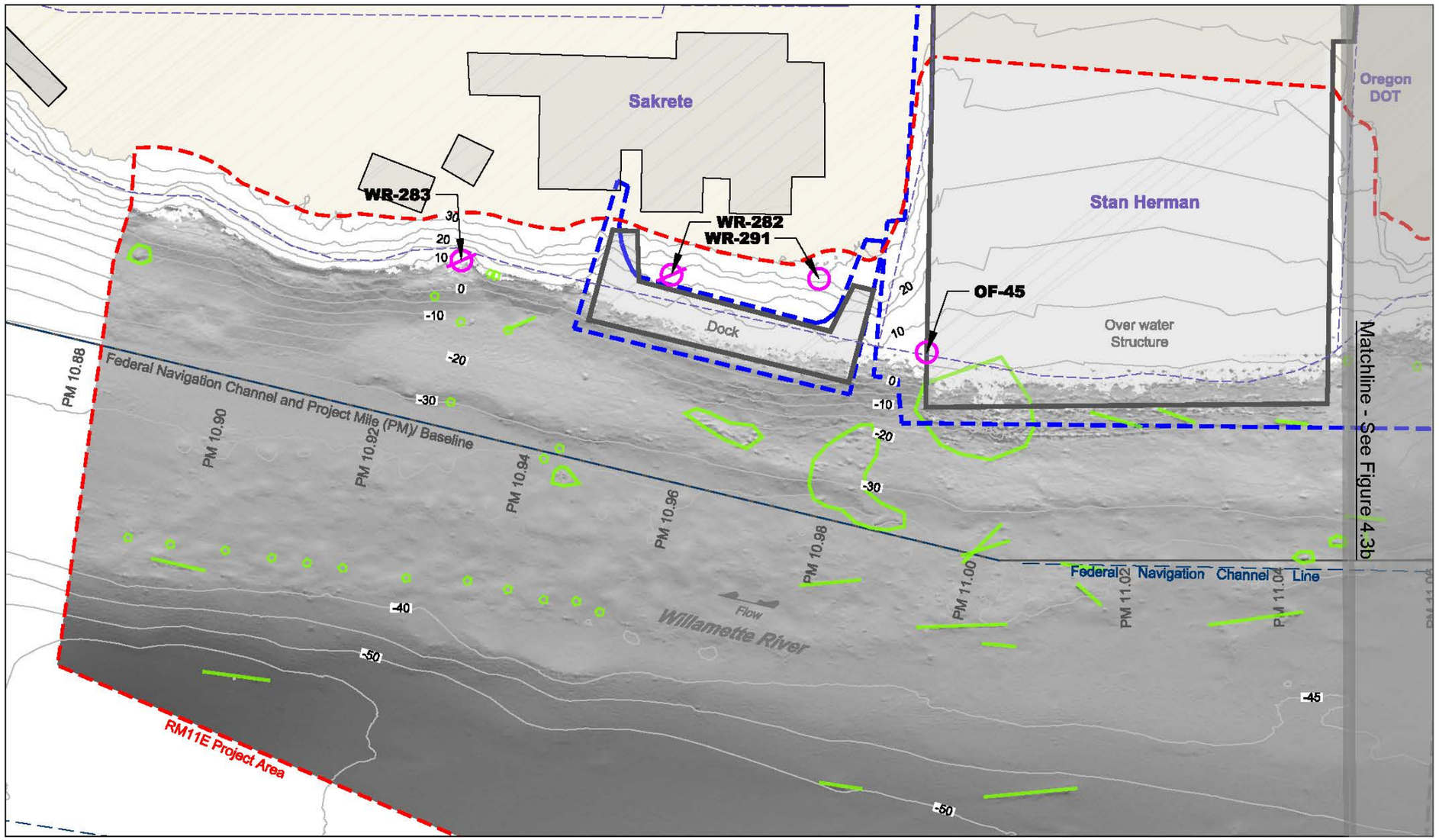

LEGEND

Debris Description

- Individual Large Debris / Debris Groupings

Other Features

- Approximate Combined Extents of Historical Shoreline Structures
- Existing Structures
- Tax Lot Boundary (Oct. 2013)
- Outfall - Active
- Outfall - Inactive or Status Unknown
- RM11E Project Area
- PM 11.6 Project Mile Stationing
- Federal Navigation Channel (USACE)
- -35 Bathymetric Contour - 5' Interval (NAVD88)

0 80
Scale in Feet

MAP NOTES

1. The locations of all features shown are approximate.
2. Contour lines and planimetric features are based on a composite data set which consists of the following: NOAA multibeam survey from 2009; ODSL multibeam and laser survey from 2010; USACE LiDAR survey from 2009; Anchor QEA 2009 Lower Willamette River Sidescan Sonar Data Report; David Evans and Associates, Inc. multibeam survey from 2011 and terrestrial laser scan from 2013; and RLIS Metro GIS data. Digital elevation model (DEM) surface for bathymetric contours was modeled only in the immediate vicinity of the RM11E Project Area. It is not intended for litigation, construction, or navigation purposes.
3. Background hillshade image generated by David Evans Associates, Inc. (DEA).
4. Horizontal datum is based on Oregon State Plane North NAD83 in units of international feet. Vertical datum is referenced to NAVD88 (feet).
5. Outfall status and location from City of Portland - Bureau of Environmental Services (BES) GIS group in June 2013. Data layer acquired from GSI. Outfalls centered on coordinates from BES data layer.
6. Tax lot boundary generated by METRO (Oct. 2013). Data layer acquired from GSI.

Figure Location Map

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RM11E Group
Willamette River - Portland, Oregon
Draft Implementability Study Report

Debris and Shoreline Structure Site Plan
~PM 10.88 to ~PM 11.05

DALTON OLMSTED FUGLEVAND

Figure 4.3a

July 31, 2015

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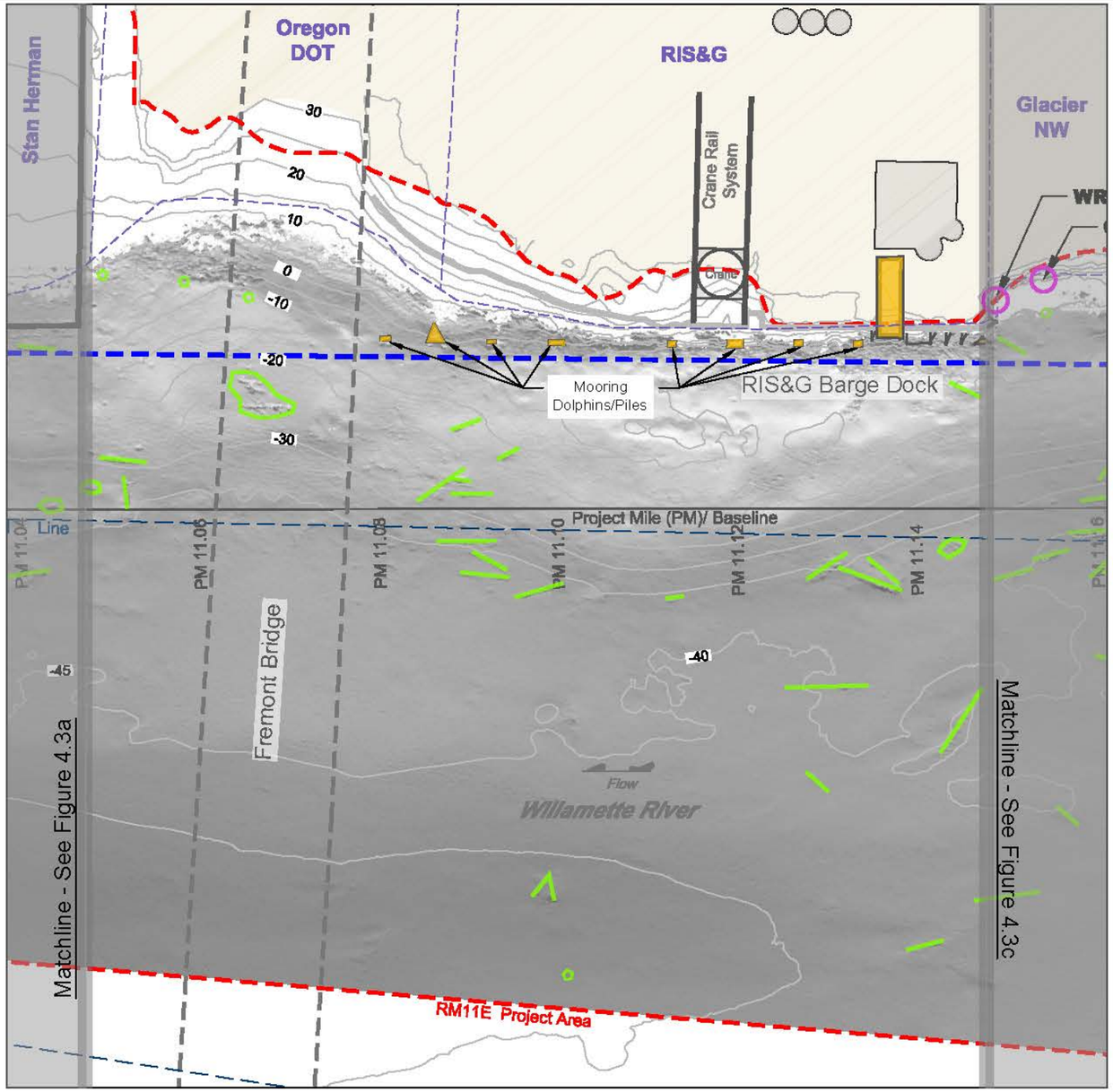

LEGEND

Debris Description

- Individual Large Debris / Debris Groupings

Other Features

- Approximate Combined Extents of Historical Shoreline Structures
- Active Docks (2015)
- Existing Structures
- Tax Lot Boundary (Oct. 2013)
- Outfall - Active
- RM11E Project Area
- PM 11.6 Project Mile Stationing
- Federal Navigation Channel (USACE)
- -35 Bathymetric Contour - 5' Interval (NAVD88)

0 80
Scale in Feet

MAP NOTES

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5. Outfall status and location from City of Portland - Bureau of Environmental Services (BES) GIS group in June 2013. Data layer acquired from GSI. Outfalls centered on coordinates from BES data layer.
6. Tax lot boundary generated by METRO (Oct. 2013). Data layer acquired from GSI.

Figure Location Map

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RM11E Group
Willamette River - Portland, Oregon
Draft Implementability Study Report

Debris and Shoreline Structure Site Plan ~PM 11.05 to ~PM 11.15

DALTON OLMSTED FUGLEVAND

Figure 4.3b

July 31, 2015

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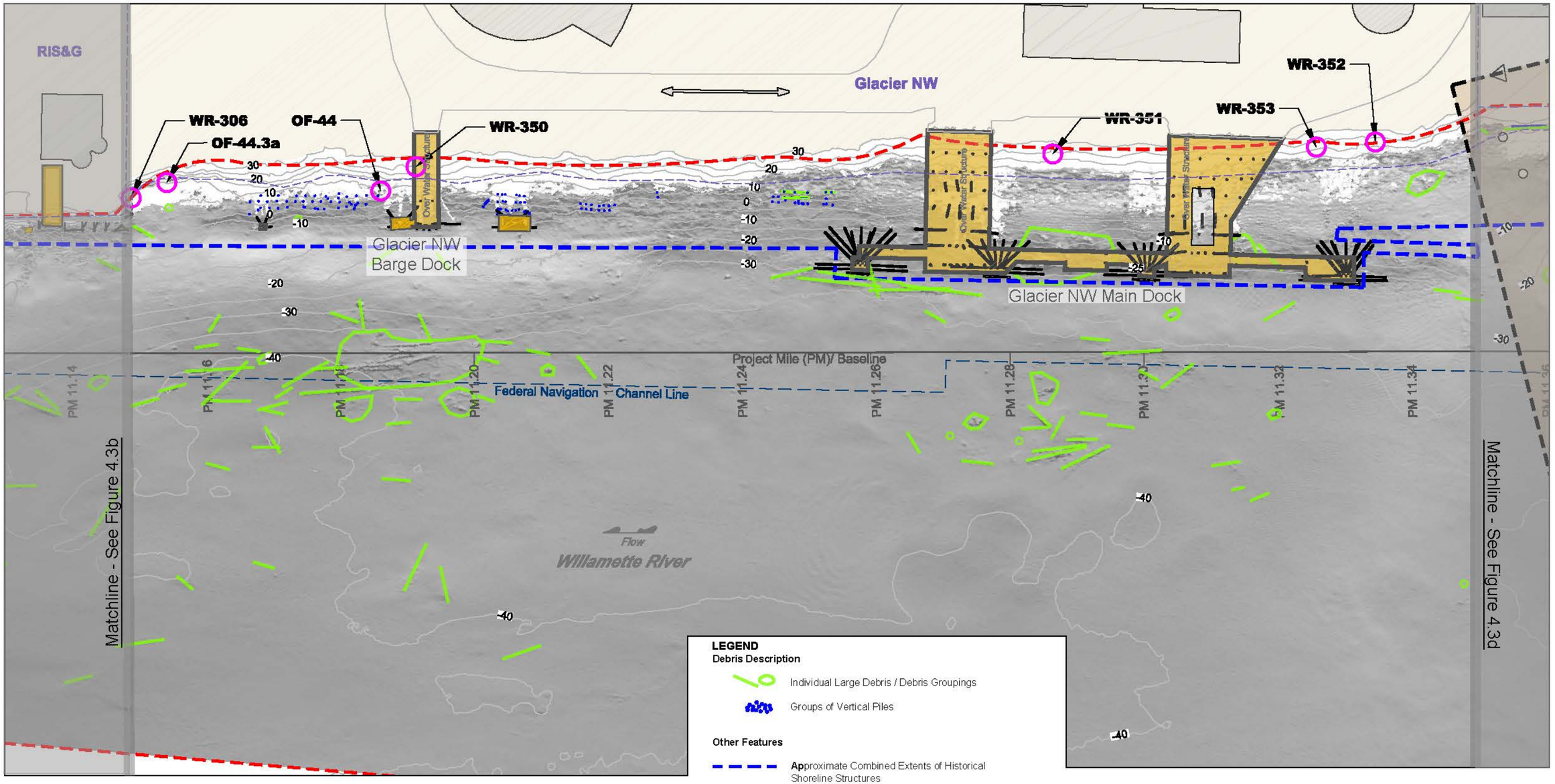

MAP NOTES

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6. Tax lot boundary generated by METRO (Oct. 2013). Data layer acquired from GSI.
8. Vertical pile remnants and submarine cable crossing toned location provided by David Evans and Associates, Inc. as described in the Draft Implementability Study Report, Section 2.

LEGEND

Debris Description

- Individual Large Debris / Debris Groupings
- Groups of Vertical Piles

Other Features

- Approximate Combined Extents of Historical Shoreline Structures
- Active Docks (2015)
- Existing Structures
- Submarine Cable Crossing Caution Zone
- Tax Lot Boundary (Oct. 2013)
- Outfall - Active
- RM11E Project Area
- PM 11.6 — Project Mile Stationing
- Federal Navigation Channel (USACE)
- -35 — Bathymetric Contour - 5' Interval (NAVD88)

0 80
Scale in Feet

Figure Location Map

DRAFT - FOR REVIEW

RM11E Group
Willamette River - Portland, Oregon
Draft Implementability Study Report

Debris and Shoreline Structure Site Plan
~PM 11.15 to ~PM 11.35

DALTON OLMSTED FUGLEVAND

Figure 4.3c

July 31, 2015

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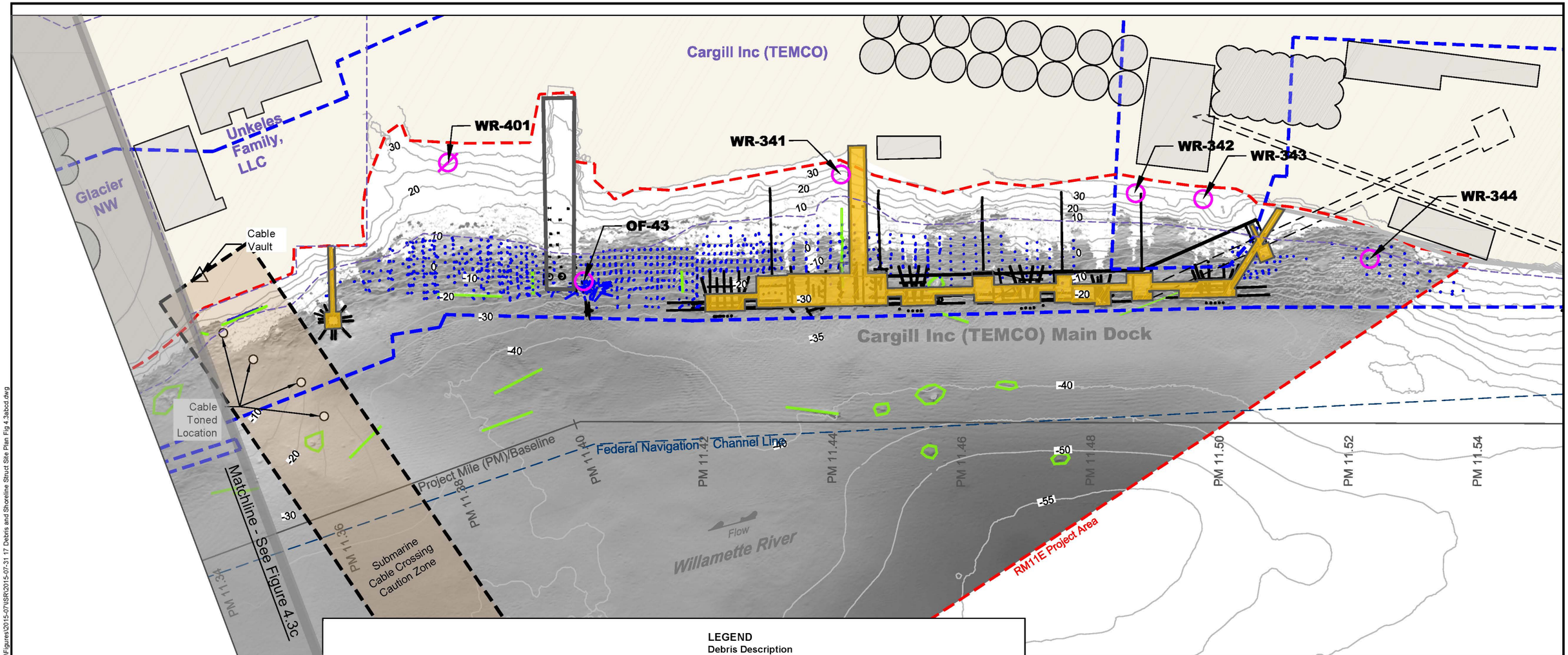

MAP NOTES

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3. Background hillshade image generated by David Evans Associates, Inc. (DEA).
4. Planimetric features (docks, overhead walkways, conveyors, walls, etc.) shown are a combination of features from RLIS Metro GIS data and features digitized by DOF from 2012 aerial photos. Data intended for planning and visual reference only. These features have not been field-verified and are not intended to be used for construction.
5. Horizontal datum is based on Oregon State Plane North NAD83 in units of international feet. Vertical datum is referenced to NAVD88 (feet).
6. Outfall status and location from City of Portland - Bureau of Environmental Services (BES) GIS group in June 2013. Data layer acquired from GSI. Outfalls centered on coordinates from BES data layer.
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LEGEND

Debris Description

- Individual Large Debris / Debris Groupings
- Groups of Vertical Piles

Other Features

- Approximate Combined Extents of Historical Shoreline Structures
- Active Docks (2015)
- Existing Structures
- Submarine Cable Crossing Caution Zone
- Tax Lot Boundary (Oct. 2013)
- Outfall - Active
- Outfall - Inactive or Status Unknown
- RM11E Project Area
- PM 11.6 Project Mile Stationing
- Federal Navigation Channel (USACE)
- -35 Bathymetric Contour - 5' Interval (NAVD88)

0 80
Scale in Feet

Figure Location Map

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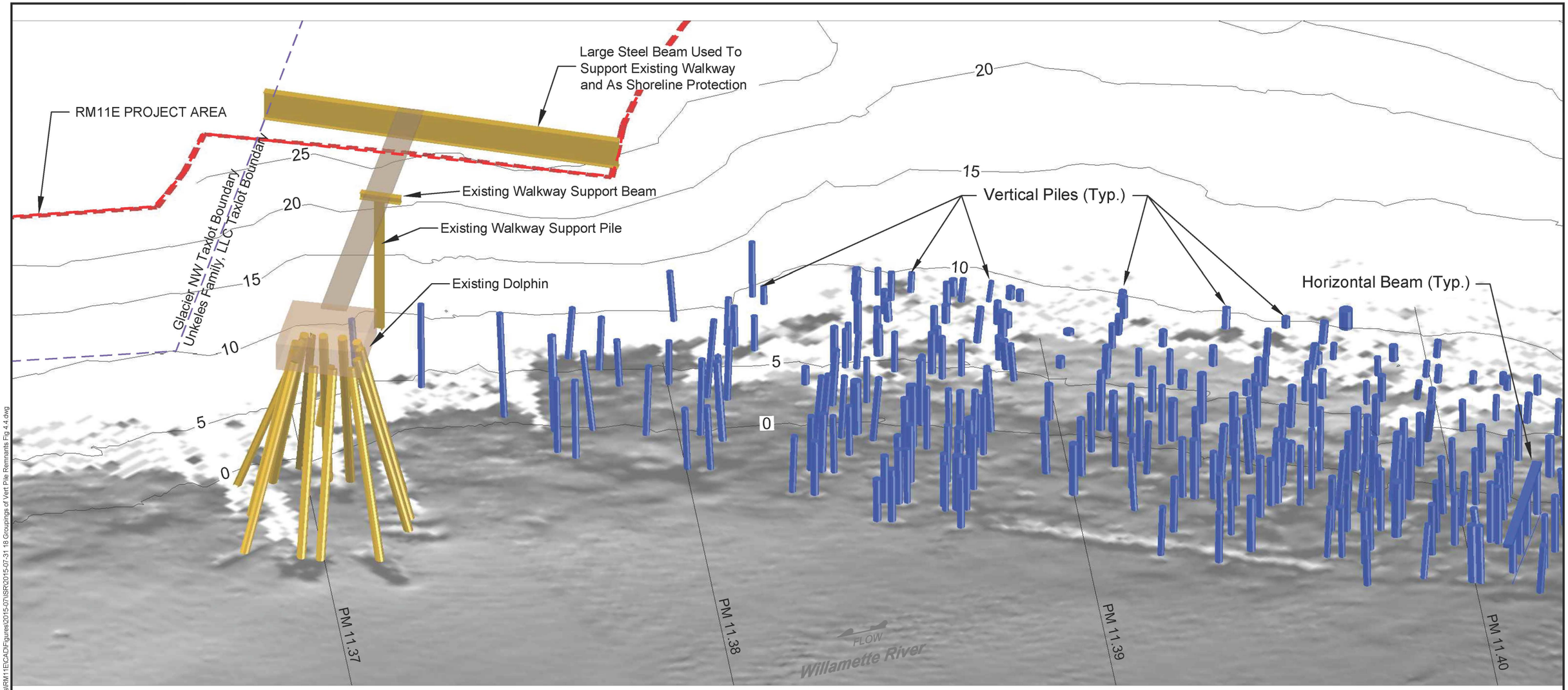
Debris and Shoreline Structure Site Plan ~PM 11.35 to ~PM 11.54

DALTON OLMSTED FUGLEVAND

Figure 4.3d

July 31, 2015

PLOT TIME: 7/31/2015 2:42 PM MOD TIME: 7/31/2015 2:33 PM USER: Lee Barras DWG: D:\Projects\RM11E\CAD\Figures\2015-07\NSR\2015-07-31 17 Debris and Shoreline Struct Site Plan Fig 4.3abcd.dwg



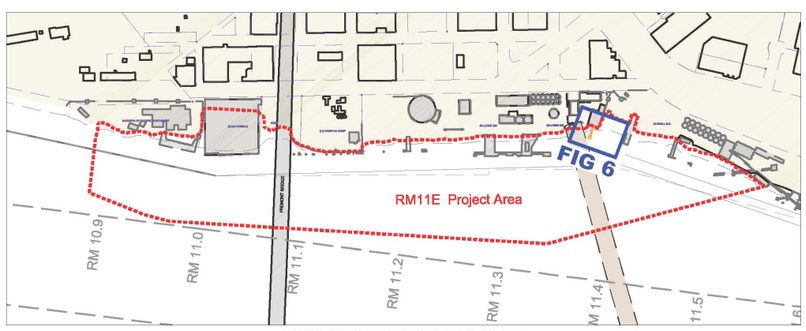


FIGURE LOCATION MAP

MAP NOTES

1. The locations of all features shown are approximate.
2. Contour lines and planimetric features are based on a composite data set which consists of the following: NOAA multibeam survey from 2009; ODSL multibeam and laser survey from 2010; USACE LiDAR survey from 2009; David Evans and Associates, Inc. multibeam survey from 2011 and terrestrial laser scan from 2013; and RLIS Metro GIS data. Digital elevation model (DEM) surface for bathymetric contours was modeled only in the immediate vicinity of the RM11E Project Area. It is not intended for litigation, construction, or navigation purposes.
3. Background hillshade image generated by David Evans Associates, Inc. (DEA).
4. Planimetric features (docks, overhead walkways, conveyors, walls, etc.) shown are a combination of features from RLIS Metro GIS data and features digitized by DOF from 2012 aerial photos. Data intended for planning and visual reference only. These features have not been field-verified and are not intended to be used for construction.
5. Horizontal datum is referenced to Oregon State Plane North NAD83 (international feet). Vertical datum is referenced to NAVD88 (feet).Outfall status and location from City of Portland - Bureau of Environmental Services (BES) GIS group in June 2013. Data layer acquired from GSI. Outfalls centered on coordinates from BES data layer. Vertical datum is referenced to NAVD88 (feet).
6. Tax lot boundary generated by METRO (Oct. 2013). Data layer acquired from GSI.

LEGEND

Main Feature Description

Vertical Piles

Existing Piles/Structural Member

Other Features

PM 11.6 Project Mile (PM) Stationing

RM11E Project Area

15 Bathymetric Contour - 5' Interval (NAVD88)

Tax Lot Boundary (Oct. 2013)

0 40
Scale in Feet

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Groups of Vertical Piles
3D Detail Example

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FIGURE 4.4

July 31, 2015

PLOT TIME: 7/31/2015 11:48 AM MOD TIME: 7/31/2015 10:53 AM USER: Lee Barras DWG: D:\Projects\RM11E\CAD\Figures\2015-07\NSR\2015-07-31 18 Groupings of Vert Pile Remnants Fig 4.4.dwg

LEGEND

Impact Ranking

- Large Undifferentiated Debris: Moderate- to High-Impact (Removal) (Expected within Extents of Historical Shoreline Structures Footprint)
- Individual Large Debris/Debris Groupings: Moderate-Impact (Removal)

Other Features

- Approximate Combined Extents of Historical Shoreline Structures
- Existing Structures
- Outfall - Active
- Outfall - Inactive or Status Unknown
- RM11E Project Area
- Tax Lot Boundary (Oct. 2013)
- PM 11.32 Project Mile Stationing
- Federal Navigation Channel (USACE)
- -40 Bathymetric Contour - 5' Interval (NAVD88)

0 80
Scale in Feet

MAP NOTES

1. While not mapped on this figure, minor undifferentiated debris is possible anywhere on site, and more likely within the footprint of historical buildings and immediately downslope of those buildings.
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3. Contour lines and planimetric features are based on a composite data set which consists of the following: NOAA multibeam survey from 2009; ODSL multibeam and laser survey from 2010; USACE LiDAR survey from 2009; David Evans and Associates, Inc. multibeam survey from 2011 and terrestrial laser scan from 2013; and RLIS Metro GIS data. Digital elevation model (DEM) surface for bathymetric contours was modeled only in the immediate vicinity of the RM11E Project Area. It is not intended for litigation, construction, or navigation purposes.
4. Horizontal datum is referenced to Oregon State Plane North NAD83 (international feet). Vertical datum is referenced to NAVD88 (feet).
5. Outfall status and location from City of Portland - Bureau of Environmental Services (BES) GIS group in June 2013. Data layer acquired from GSI. Outfalls centered on coordinates from BES data layer.
6. Tax lot boundary generated by METRO (Oct. 2013). Data layer acquired from GSI.

Figure Location Map

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Willamette River - Portland, Oregon
Draft Implementability Study Report

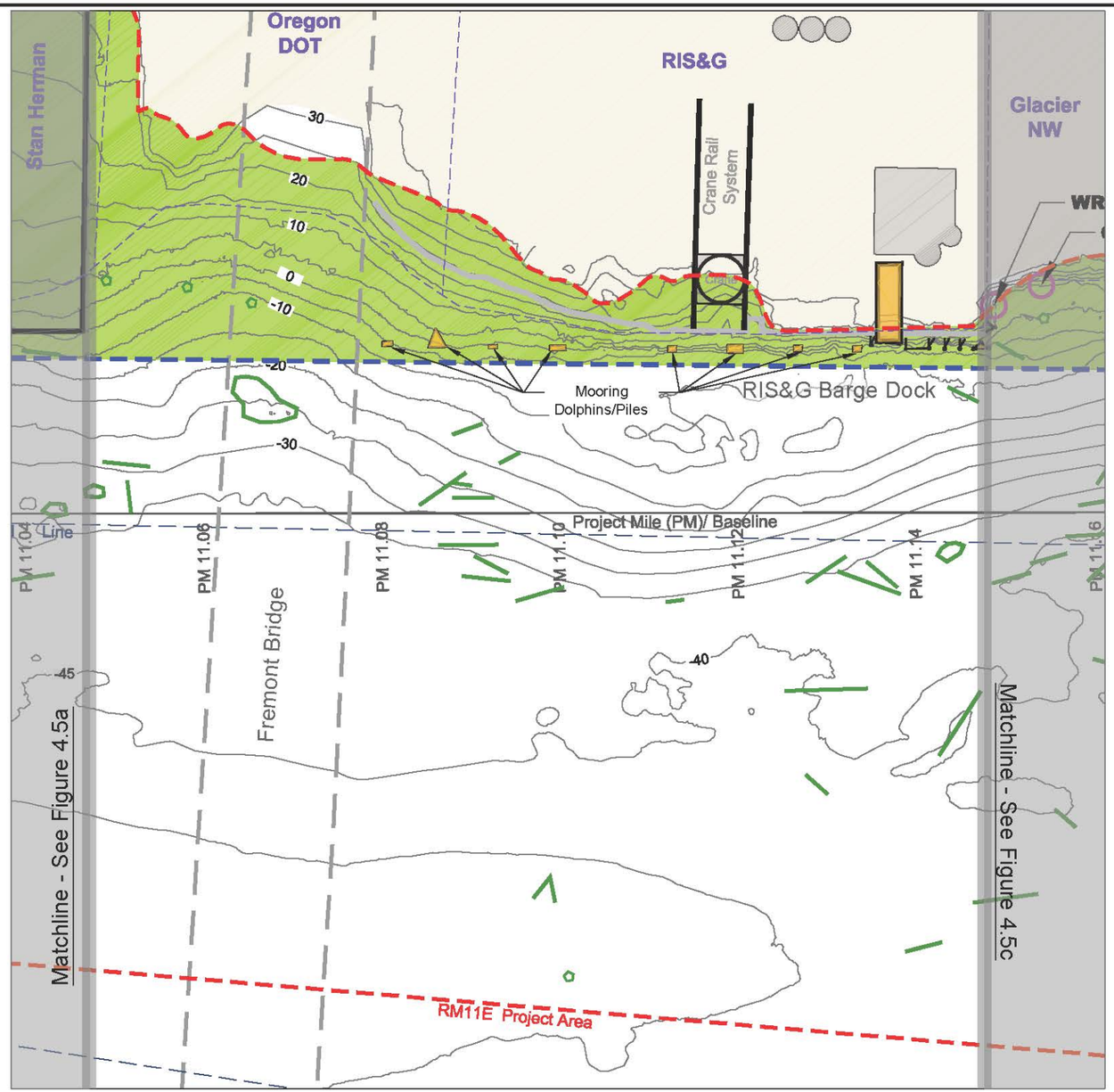
Debris Impact Areas
~PM 10.88 to ~PM 11.05

DALTON OLMSTED FUGLEVAND

Figure 4.5a

July 31, 2015

PLOT TIME: 7/31/2015 11:48 AM MOD TIME: 7/31/2015 11:40 AM USER: Lee Barras DWG: D:\Projects\RM11E\CAD\Figures\2015-07\NSR\2015-07-31 19 Debris Impact Ranking Fig 4.5abcd.dwg



LEGEND

Impact Ranking

- Large Undifferentiated Debris: Moderate- to High-Impact (Removal) (Expected within Extents of Historical Shoreline Structures Footprint)
- Individual Large Debris/Debris Groupings: Moderate-Impact (Removal)

Other Features

- Approximate Combined Extents of Historical Shoreline Structures
- Active Docks (2015)
- Existing Structures
- Tax Lot Boundary (Oct. 2013)
- Outfall - Active
- RM11E Project Area
- PM 11.6 Project Mile Stationing
- Federal Navigation Channel (USACE)
- -35 Bathymetric Contour - 5' Interval (NAVD88)

0 80
Scale in Feet

Figure Location Map

MAP NOTES

1. While not mapped on this figure, minor undifferentiated debris is possible anywhere on site, and more likely within the footprint of historical buildings and immediately downslope of those buildings.
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3. Contour lines and planimetric features are based on a composite data set which consists of the following: NOAA multibeam survey from 2009; ODSL multibeam and laser survey from 2010; USACE LiDAR survey from 2009; David Evans and Associates, Inc. multibeam survey from 2011 and terrestrial laser scan from 2013; and RLIS Metro GIS data. Digital elevation model (DEM) surface for bathymetric contours was modeled only in the immediate vicinity of the RM11E Project Area. It is not intended for litigation, construction, or navigation purposes.
4. Horizontal datum is referenced to Oregon State Plane North NAD83 (international feet). Vertical datum is referenced to NAVD88 (feet).
5. Outfall status and location from City of Portland - Bureau of Environmental Services (BES) GIS group in June 2013. Data layer acquired from GSI. Outfalls centered on coordinates from BES data layer.
6. Tax lot boundary generated by METRO (Oct. 2013). Data layer acquired from GSI.

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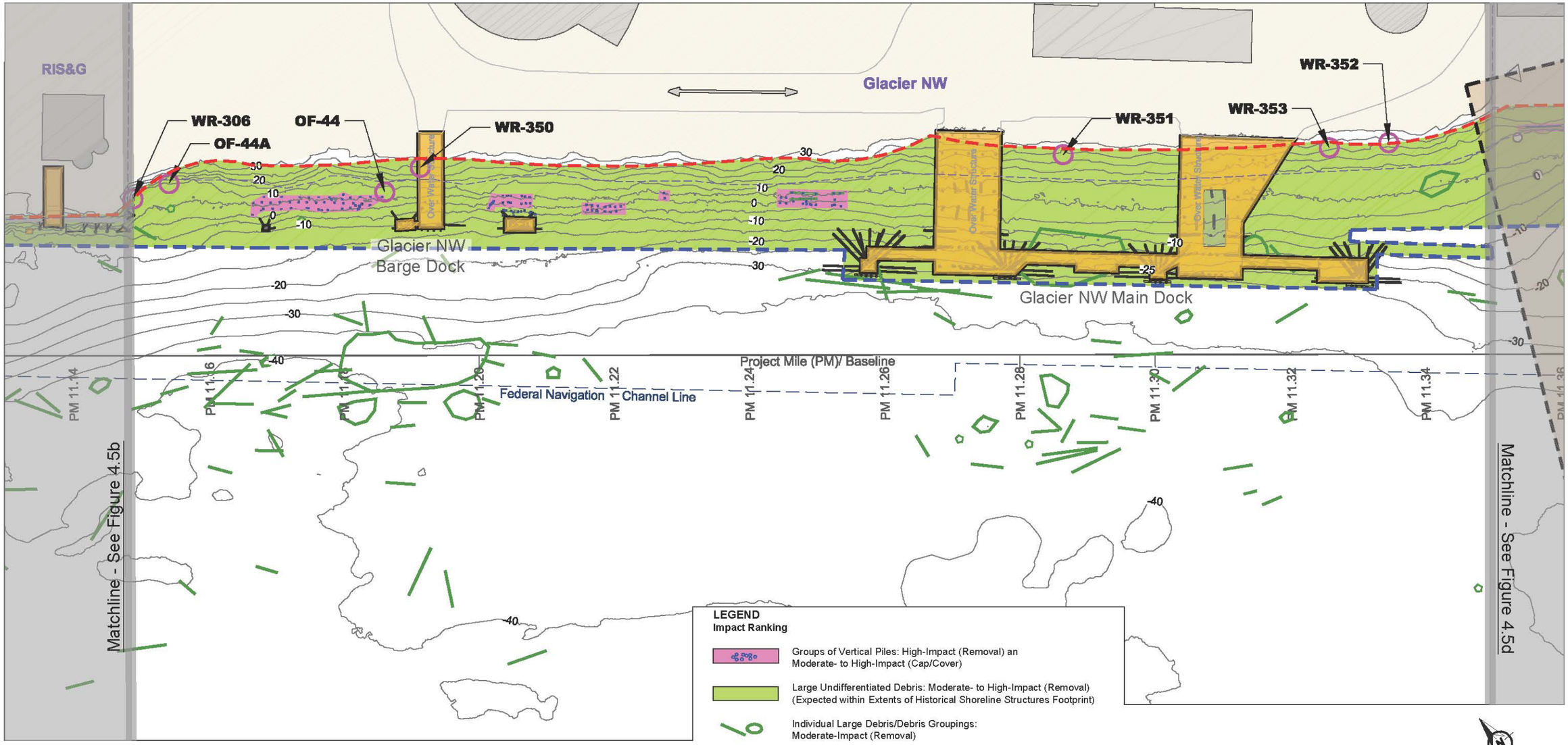
Debris Impact Areas
~PM 11.05 to ~PM 11.15

DALTON OLMSTED FUGLEVAND

Figure 4.5b

July 31, 2015

PLOT TIME: 7/31/2015 11:40 AM MOD TIME: 7/31/2015 11:40 AM USER: Lee Barras DWG: D:\Projects\RM11E\CAD\Figures\2015-07\NSR\2015-07-31 19 Debris Impact Ranking Fig 4.5abcd.dwg



LEGEND

Impact Ranking

- Groups of Vertical Piles: High-Impact (Removal) an Moderate- to High-Impact (Cap/Cover)
- Large Undifferentiated Debris: Moderate- to High-Impact (Removal) (Expected within Extents of Historical Shoreline Structures Footprint)
- Individual Large Debris/Debris Groupings: Moderate-Impact (Removal)

Other Features

- Approximate Combined Extents of Historical Shoreline Structures
- Active Docks (2015)
- Existing Structures
- Submarine Cable Crossing Caution Zone
- Outfall - Active
- Outfall - Inactive or Status Unknown
- RM11E Project Area
- Tax Lot Boundary (Oct. 2013)
- PM 11.32 Project Mile Stationing
- Federal Navigation Channel (USACE)
- -40 Bathymetric Contour - 5' Interval (NAVD88)

0 80
Scale in Feet

Figure Location Map

MAP NOTES

1. While not mapped on this figure, minor undifferentiated debris is possible anywhere on site, and more likely within the footprint of historical buildings and immediately downslope of those buildings.
2. The locations of all features shown are approximate.
3. Contour lines and planimetric features are based on a composite data set which consists of the following: NOAA multibeam survey from 2009; ODSL multibeam and laser survey from 2010; USACE LiDAR survey from 2009; David Evans and Associates, Inc. multibeam survey from 2011 and terrestrial laser scan from 2013; and RLIS Metro GIS data. Digital elevation model (DEM) surface for bathymetric contours was modeled only in the immediate vicinity of the RM11E Project Area. It is not intended for litigation, construction, or navigation purposes.
4. Horizontal datum is referenced to Oregon State Plane North NAD83 (international feet). Vertical datum is referenced to NAVD88 (feet).
5. Outfall status and location from City of Portland - Bureau of Environmental Services (BES) GIS group in June 2013. Data layer acquired from GSI. Outfalls centered on coordinates from BES data layer.
6. Tax lot boundary generated by METRO (Oct. 2013). Data layer acquired from GSI.
7. Submarine cable crossing location provided by David Evans and Associates, Inc. as described in Section 2.

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RM11E Group
Willamette River - Portland, Oregon
Draft Implementability Study Report

Debris Impact Areas
~PM 11.15 to ~PM 11.35

DALTON OLMSTED FUGLEVAND

Figure 4.5c

July 31, 2015

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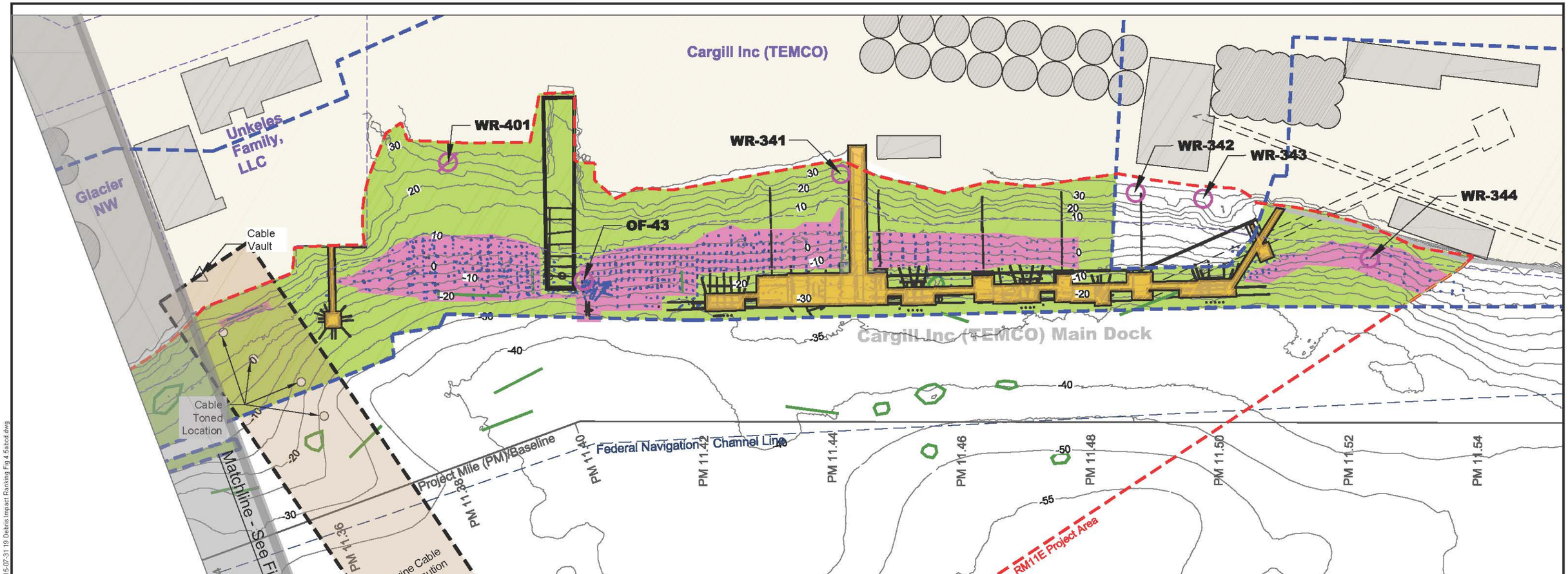

LEGEND

Impact Ranking

- Groups of Vertical Piles: High-Impact (Removal) and Moderate- to High-Impact (Cap/Cover)
- Large Undifferentiated Debris: Moderate- to High-Impact (Removal) (Expected within Extents of Historical Shoreline Structures Footprint)
- Individual Large Debris/Debris Groupings: Moderate-Impact (Removal)

Other Features

- Approximate Combined Extents of Historical Shoreline Structures
- Active Docks (2015)
- Existing Structures
- Submarine Cable Crossing Caution Zone
- Outfall - Active
- Outfall - Inactive or Status Unknown
- RM11E Project Area
- Tax Lot Boundary (Oct. 2013)
- PM 11.32 Project Mile Stationing
- Federal Navigation Channel (USACE)
- -40 Bathymetric Contour - 5' Interval (NAVD88)

0 80
Scale in Feet

Figure Location Map

MAP NOTES

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2. The locations of all features shown are approximate.
3. Contour lines and planimetric features are based on a composite data set which consists of the following: NOAA multibeam survey from 2009; ODSL multibeam and laser survey from 2010; USACE LiDAR survey from 2009; David Evans and Associates, Inc. multibeam survey from 2011 and terrestrial laser scan from 2013; and RLIS Metro GIS data. Digital elevation model (DEM) surface for bathymetric contours was modeled only in the immediate vicinity of the RM11E Project Area. It is not intended for litigation, construction, or navigation purposes.
4. Horizontal datum is referenced to Oregon State Plane North NAD83 (international feet). Vertical datum is referenced to NAVD88 (feet).
5. Outfall status and location from City of Portland - Bureau of Environmental Services (BES) GIS group in June 2013. Data layer acquired from GSI. Outfalls centered on coordinates from BES data layer.
6. Tax lot boundary generated by METRO (Oct. 2013). Data layer acquired from GSI.
7. Vertical pile remnants and submarine cable crossing toned location provided by David Evans and Associates, Inc. as described in the Draft Implementability Study Report, Section 2.

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RM11E Group
Willamette River - Portland, Oregon
Draft Implementability Study Report

Debris Impact Areas
~PM 11.35 to ~PM 11.54

DALTON OLMSTED FUGLEVAND

Figure 4.5d

July 31, 2015

PLOT TIME: 7/31/2015 11:48 AM MOD TIME: 7/31/2015 11:40 AM USER: Lee Barras DWG: D:\Projects\RM11E\CAD\Figures\2015-07\NSR\2015-07-31 19 Debris Impact Ranking Fig 4.5abcd.dwg

5. GEOTECHNICAL ASSESSEMENT

5.1 OBJECTIVE

The primary objective of the geotechnical study[31] summarized in this section was to support a preliminary assessment of geotechnical and slope stability considerations for potential remedial actions in the RM11E Project Area. To assist in this evaluation, existing conditions, topography, bathymetry, inclinometer data, and subsurface conditions along the length of the RM11E Project Area were reviewed. Inclinometers were installed in three additional borings to supplement existing data. This section summarizes geotechnical considerations for the RM11E Project Area that may influence the decision-making process during later selection of remedial alternatives. Additional explorations and design recommendations will be required as part of remedial design for areas where active remediation is required.

5.2 GEOTECHNICAL SITE DESCRIPTION

5.2.1 SLOPE INCLINATIONS, SLOPE ARMORING, AND WATERFRONT DEBRIS

Topography and bathymetry data collected for the project are included on Figures 3.2a through 3.2d and a summary of slope angles is presented on Figures 3.3a through 3.3d. This topographic information indicates the ground surface in the RM11E Project Area varies from approximately elevation 24 to 38 feet NAVD88 in upland areas to approximately elevation -40 to -55 feet NAVD88at the bottom of the river channel. The upper portion of the shoreline slope has been locally treated to control erosion and is protected with armoring consisting of a wide variety of materials, including riprap, construction debris, concrete, and heavy vegetation. In other locations, retaining walls, existing dock structures, and remnant piles from historical operations are also present. The armoring, retaining walls, remnant piles, and existing dock structures present in many locations result in slopes that are steeper than typical untreated shoreline slopes. Slope angles typically range from about 2H:1V to steeper than 1H:1V in these areas. The lower portion of the shoreline slope near the riverbed and away from waterfront structures or remnant piles is generally flatter, with slopes typically less than 2H:1V. Waterfront debris, presented in Section 4, also needs to be considered as part of the geotechnical site description.

5.2.2 SLOPE MOVEMENTS, RETAINING WALLS, AND EXISTING INCLINOMETER DATA

Much of the Cargill site has undergone creep and other slope movements as evidenced by cracking in pavements, cracks and visible offset of portions of the truck dumper and office building, and loss of ground underneath the maintenance building. On the basis of discussions with long-time employees at the Cargill site, this movement has been occurring at the site since at least the mid-1970s. Inclinometers were installed in five borings, designated B-1 through B-5, on the Cargill property in November 1996, as shown on Figure 5.1. In the 6-month period between March and September 1997, up to 0.5 inch of lateral deformation was measured in the

[31] This assessment has been prepared by GRI to aid the RM11E Group and Environmental Protection Agency in preliminary evaluation of subsurface materials and conditions in the RM11E Project Area, and is subject to the limitations stated in GRI's April 7, 2015 geotechnical data report, which is included as Appendix F to this report.

inclinometers. Slope movements during this time period were recorded to depths in excess of 25 feet in some locations. Inclinometer data for borings B-1, B-2, and B-5 are included on Figures D-1 through D-3 in Appendix D. The inclinometers from borings B-3 and B-4 have been damaged and are no longer functional, and their data are not included in this report.

To reduce the amount of long-term lateral deformation and to protect upslope buildings, anchored soldier pile retaining walls were constructed in two phases at the Cargill site in the late 1990s at the locations shown on Figure 5.1. Where the retaining walls have been installed at the Cargill site, slope movements are now typically negligible (less than about 0.25 inch of movement in inclinometer B-2 since the wall was installed in 1997). Based on inclinometer data from boring B-1, slope movements continue to occur downstream (north) of the wall limits to depths of about 30 feet below ground surface. About 1.25 inches of deformation has occurred in this area since late 1996. The inclinometer data for boring B-5, installed behind the retaining wall, indicate slope movements as deep as 90 to 100 feet in this area. The inclinometer in boring B-5 is situated upland of the location where about 14 feet of bathymetric deepening (i.e., drop in mudline elevation), as described in Section 3.7.2 of this report, was observed between 2002 and 2011. The monitoring indicates that movement in this area may coincide with the significant deepening observed in front of the wall.

A third, much smaller, cantilever soldier pile wall is located at the upstream end of the Cargill property. This wall is located just south of the anchored soldier pile retaining wall, outside of the RM11E Project Area boundary. The approximate location of the wall is provided on Figure 5.1. Construction records for this wall were not available.

A bulkhead wall is located near the southern boundary of the RIS&G property, as shown on Figure 5.2. Information in GRI files indicates the bulkhead wall consists of an upper mechanically stabilized earth wall supported by a lower anchored soldier pile wall.

Deep-seated slope movements have not been documented in the properties located north of the Cargill property; however, localized and surficial slope movements have been observed in some areas. Slope movements have been occurring at a minor retaining wall at the northern boundary of the Glacier NW property above outfalls OF-44A and WR-306. Based on observations during the course of the geotechnical study and discussions with Glacier NW, these slope movements appear to be relatively recent, ongoing, and related to the failure of the retaining wall. The failure has resulted in raveling, or surficial sloughing, of the oversteepened upper portion of the slope.

During a site visit for this project, the Unkeles property owner reported that localized and surficial slope movements near the top of the relatively steep shoreline had been observed near the southern portion of that site.

5.2.3 NEW INCLINOMETER DATA

Three inclinometers were installed for the geotechnical assessment: one each on the Glacier NW property (boring E-1), the Unkeles property (boring E-2), and downstream of the retaining walls at the Cargill property in an area where ground cracking was observed (boring E-3). The locations of these inclinometers are presented on Figure 5.2. At the time this report was prepared, movements at these locations had been monitored for approximately 1 year; total slope movements were less than 0.1 inch, which is less than the uncertainty of the equipment. Because of site access issues, the inclinometers in borings E-1 and E-2 were installed away from the surficial slope movement observed on the Glacier NW and Unkeles properties. The inclinometer data for these explorations are shown on Figures D-4 through D-6 in Appendix D.

5.2.4 SOURCES OF GEOTECHNICAL DATA

5.2.4.1 Historical Geotechnical Data

Historical geotechnical data were reviewed to evaluate subsurface materials and conditions within the RM11E Project Area. The approximate locations of geotechnical explorations reviewed as part of this study are presented on Figure 5.2 and summary boring logs are presented in Appendix E. Relevant geotechnical data were obtained from the following sources:

- *Soils Investigation, Proposed Willamette River Cable Crossing, Vicinity of North Albina Avenue, Portland, Oregon* (Dames & Moore, 1967)(in-river borings B-1 through B-4, B-4A, B-4B, B-5 through B-9, B-9A, B-10, B-10A, and B-10B, pages E-1 and E-2 of Appendix E)
- *Geotechnical Investigation Report, Proposed FGIS Building at the Temco Facility, 800 North River Street* (Earth Engineers, Inc., 2013) (Cargill-area upland borings B-1A, B-1B and B-2, pages E-3 through E-7 of Appendix E)
- *Geotechnical Investigation, Proposed Bulk Cement Storage Dome, Lone Star Marine Terminal, Portland, Oregon* (GRI, 1994) (Glacier NW-area upland borings B-1 and B-2, pages E-8 through E-11 of Appendix E)
- *Geotechnical Investigation, Riverbank Slope Instability at the Cargill Grain Irving Elevator Site, 800 N. River Street, Portland, Oregon* (GRI, 1997) (Cargill-area upland borings B-1 through B-5, pages E-12 through E-23 of Appendix E)
- *Phase II Geotechnical Investigation, Riverbank Slope Instability at the Cargill Grain Irving Elevator Site, 800 N. River Street, Portland, Oregon* (GRI, 1998) (Cargill-area upland borings B-8 and B-9, pages E-24 through E-29 of Appendix E)
- *Draft Summary Boring Logs B-4 and B-5* (GRI, 2014) (northern Cargill-area upland borings B-4 and B-5, pages E-30 through E-35 of Appendix E)
- *Draft Surface and Subsurface Sediment, Field and Data Report, River Mile 11 East Focused Sediment Characterization, Willamette River, Portland, Oregon* (GSI, 2009a (in-river C-series explorations, pages E-36 through E-44 of Appendix E)
- *Supplemental Remedial Investigation/Feasibility Study, Field Sampling and Data Report, Willamette River, Portland, Oregon* (GSI, 2014) (upland borings MW001 through MW005, pages E-45 through E-57 of Appendix E)
- *Geotechnical Baseline Report, East Side CSO Tunnel Project* (Parsons Brinckerhoff, 2006), and *Addendum for Diversion Pipeline for OF 44A* (Parsons Brinckerhoff, 2008) (upland ES-series borings, pages E-58 through E-118 of Appendix E)

5.2.4.2 New Geotechnical Data

As part of this investigation, three new borings (E-1 through E-3) were advanced to further characterize subsurface conditions and materials within the RM11E Project Area. The borings were advanced to depths of 80.2 to 101.5 feet at the locations shown on Figure 5.2 using mud-rotary and casing-advance drilling techniques. Details regarding the field exploration program, including summary boring logs and geotechnical laboratory test results, are included in GRI's April 7, 2015 geotechnical data report, which is included as Appendix F of this report.

5.2.5 SUBSURFACE SOIL CONDITIONS

Existing historical and new data related to subsurface conditions within the RM11E Project Area have been collected from a variety of sources, with exploration and analysis completed by several entities for multiple purposes. This has resulted in varying classifications of geologic units. For the purpose of this report, these materials are grouped and discussed in terms of soil units with similar engineering properties:

- Fill
- Silt/sand
- Gravel
- Lower sand

The following paragraphs provide a general description of the soil units encountered in the RM11E Project Area starting from the upland ground surface or mudline elevation down. As described below, four geologic cross sections have been prepared to illustrate the locations of the various soil units in the RM11E Project Area. The geologic cross sections are provided on Figures 5.2 through 5.5.

5.2.5.1 Fill

As discussed above, site grades in the RM11E Project Area were raised significantly with fill material from the beginning of the early 1900s through the 1970s. The materials used to establish the existing site grades generally consist of silty gravel to gravelly silt with a trace to some fine- to coarse-grained sand, but may also consist of silt or sand with little gravel content. Scattered cobbles, boulders, and construction debris such as concrete, brick, and wood are common within the fill. Fill depths vary across the RM11E Project Area, but generally extend to a depth of between 20 and 40 feet below the upland ground surface. Fill placement was not well documented and was generally not engineered, resulting in the variable composition and density evident in the historical and new geotechnical data.

The submerged side slopes of the shoreline are mantled with loose and soft materials consisting of silty clay with some sand, clayey or sandy silt, clean or silty sand, gravel, or a combination of these materials. Anthropogenic wood fragments and debris were observed in portions of this material, supporting the classification as fill. The fill material may have originated from upslope material that had sloughed downward and accumulated on the submerged side slopes of the shoreline. The thickness of the fill may be less than a foot to over 8 feet on the shoreline located southwest of the Unkeles property. In some areas, the fill may be interbedded with natural alluvial silts or sands or may be indistinguishable from the underlying alluvial silts and sands.

5.2.5.2 Silt/Sand

The fill is typically underlain by alluvial material composed of silt and sand. This material ranges from clayey silt with a trace of sand to silty sand with a trace of gravel. These materials are interbedded in some areas and are considered a single unit for the purposes of this study. Scattered organics are also common in the form of roots or woody debris such as logs. This unit is generally brown to gray. The consistency of the fine-grained portion of the unit is generally reported as soft to medium stiff, and the density of the coarse-grained portion of the unit in the upland area is generally reported as loose to medium dense. As illustrated on geologic cross

section A-A′, Figure 5.2, the silt/sand alluvium in the upland areas is typically around 15 feet thick on the northern half of the RM11E Project Area (Glacier NW property northward) and is up to 80 feet thick in the area of the Cargill property. The thickness of the alluvial silt and sand on the shoreline and in the navigation channel is typically thinner, varying in thickness from less than 1 foot to 5 feet or more.

5.2.5.3 GRAVEL

In the upland area, gravel is present below the silt and sand unit. Near the toe of the shoreline, and within the navigational channel, the gravel was generally encountered within several feet of the ground surface. This gravel ranges from relatively clean to sandy with some silt. Sand interbeds are commonly encountered within the gravel deposits. Portions of the gravel deposits may be cemented. The gravels are generally reported as dense, and drilling notes and construction experience indicate that boulders or cobbles may be present within the unit.

5.2.5.4 LOWER SAND

At the southern end of the site, several borings encountered a sand unit up to 30 feet thick, approximately 70 feet below the existing ground surface within the gravel unit. This sand unit is generally fine grained with a trace of silt and scattered gravel, and is generally denser than the upper sand observed in the silt and sand unit. This unit has been encountered only in borings located at the north end of the Cargill property onto the south end of the Glacier NW property as shown on geologic cross section A-A′ (Figure 5.2). As shown on the geologic cross sections B-B′ and C-C′ (Figures 5.3 and 5.4), this unit was generally encountered below the depth of the navigation channel and landward from the face of the existing shoreline slope.

5.2.6 GEOLOGIC CROSS SECTIONS

Four geologic cross sections have been developed from the available historical geotechnical information described in Section 5.2.6 and the subsurface information collected as part of this study. Geologic cross section A-A′ represents subsurface conditions parallel to the Willamette River near the top of the shoreline and is shown on Figure 5.2. Geologic cross sections B-B′, C-C′, and D-D′ represent subsurface conditions perpendicular to the Willamette River at three locations along the project alignment. These cross sections are presented on Figures 5.3, 5.4, and 5.5, and the locations are shown on Figure 5.2. The individual geologic sections are discussed briefly below.

Cross section A-A′ (Figure 5.2) was developed roughly parallel to the Willamette River along the RM11E Project Area. Compilation of the large amount of drilling data available for this area indicates that the subsurface conditions are highly variable along the length of the project, particularly near the Unkeles and Cargill properties.

Cross section B-B′, presented on Figure 5.3, was developed at the northern end of the Glacier NW property roughly perpendicular to the Willamette River. Explorations in this area indicate that the fill thickness increases near the water, the alluvial silt and sand unit is relatively thin, and the gravel is within several feet of the mudline in the waterway.

Cross section C-C′, presented on Figure 5.4, was developed through the Unkeles property roughly perpendicular to the Willamette River. At this location, the fill in the upland area is approximately 15 feet thick and the upland silts and sands are approximately 15 feet thick. The gravel layer unit underlies the silt and sand and a layer of the lower sand unit approximately 20 feet thick is present within the gravel layer. On the shoreline, about 5 to 10 feet of fill, native

silt and sand, or both overlie the gravel. Anthropogenic debris such as concrete or glass was encountered within these deposits to depths of up to 8 feet below the mudline.

Cross Section D-D′, as shown on Figure 5.5, was developed through the northern end of the Cargill property, roughly perpendicular to the Willamette River. Explorations in this area indicate that the fill thickness increases near the water, subsurface gravels slope steeply toward the river, and the silty alluvium unit is 60 feet thick, or more. The lower sand unit is present in the eastern portion of the property and is up to 30 feet thick in this area. Anthropogenic debris, such as nails, was encountered at depths of at least 5 feet below the mudline in the waterway. The alluvium continues at least 5 feet below this debris near the shore but is less than 2 feet thick near the center of the navigation channel.

5.2.7 GROUNDWATER

Based on review of RM11E Supplemental RI/FS monitoring well data, it is anticipated that the groundwater level in the upland portion of the site will closely mirror the water level in the Willamette River.

5.3 GEOTECHNICAL CONSIDERATIONS

Potential remediation options include removing (dredging) or capping the contaminated sediments, which will temporarily or permanently alter the existing shoreline slopes. The potential for remedial actions to activate slope movements should be considered during design. Depending on the specific subsurface soil conditions and proposed remediation methods, these slope movements may vary from gradual shallow movements over a long period of time to rapid, large block failures that may damage structures.

As background for evaluating potential remediation techniques, the following sections of this report provide a brief overview of the historical shoreline stability in the RM11E Project Area and discussion regarding potential dredging and capping measures. The sections include general considerations both for shoreline slopes and for areas adjacent to structures or other improvements. Also included are preliminary soil parameters for geotechnical evaluation, lateral earth pressure diagrams, and a brief discussion of seismic considerations. The discussion and recommendations in this section should be considered preliminary. Once the specific areas requiring active remediation and specific remediation options for a particular portion of the site are identified, additional geotechnical studies will need to be completed as part of remedial design.

5.3.1 HISTORICAL RIVERBANK STABILITY AND OVERSTEEPENED SLOPES

As shown on Figures 5.6a through 5.6d, the upper portion of much of the shoreline slope is inclined at slopes steeper than 2H:1V. This portion of the slope is armored with a wide variety of materials including riprap, construction debris, concrete blocks, concrete poured over the slope face at the southern end of the Glacier NW site and other locations, and heavy vegetation. In addition, remnant piling from historical operations is present throughout this area. The armoring and remnant piling has resulted in slope inclinations that are steeper than what would typically be considered to be stable based on geotechnical slope stability modeling for the soils present along the banks.

Along this stretch of the Willamette River, in areas not heavily armored or reinforced with a retaining wall, long-term slopes composed primarily of sand or silt are typically inclined at 2H:1V

or flatter, and long-term slopes composed primarily of gravel are typically inclined at 1.5H:1V or flatter. Waterfront slopes that are steeper than the inclinations noted above are considered to be oversteepened and have a low factor of safety. (These slope definitions exclude portions of the riverfront where engineered retaining walls have been constructed to stabilize oversteepened slopes.) In the long term, these slopes will generally erode or slough back to at least 2H:1V in sand, 2.5H:1V in silt, or 1.5H:1V in gravel. In the zone of predominant wind and vessel wave action (between about elevation 0 and 23 feet NAVD88), long-term unarmored slopes typically regress to the range of 5H:1V to 10H:1V unless properly armored. For the purpose of initial project planning, it is recommended that slopes steeper than indicated in Table 5.1 be considered oversteepened:

TABLE 5.1 – OVERSTEEPENED SLOPES BY SOIL TYPE

SOIL TYPE	OVERSTEEPENED CRITERION
Fill	Steeper than 2H:1V
Sand/silt	Steeper than 2H:1V to 2.5H:1V
Gravel	Steeper than 1.5H:1V

As discussed below, engineered slopes are commonly designed at flatter slope angles than presented above in order to achieve a higher factor of safety.

Figures 5.6a through 5.6d present the areas of the shoreline slopes that are considered oversteepened (incline steeper than 2H:1V) based on the above criteria and the slope mapping presented on Figures 3.3a through 3.3d. The potential impacts of remediation activities that occur within or adjacent to areas of oversteepened slopes will need to be thoroughly evaluated as part of remedial design.

5.3.2 DREDGING CONSIDERATIONS

Typical design slopes can vary significantly based on the consistency and density of the material. For preliminary planning purposes, the following permanent dredge slopes should be assumed: 2.5H:1V to 2H:1V in sand, 2.5H:1V to 3H:1V in silt, and 2H:1V in gravel.

Depending on a number of factors including the subsurface conditions, slope height, cut location, and the length of time the dredge cuts are left open, temporary oversteepening of slopes are often considered to minimize potential disruption to upland property uses. In the Portland area, temporary dredge slopes can be as steep as 1H:1V in sandy material and 1.5H:1V in silty material in areas below the wind or vessel wave zone. These temporary slopes have a very short standup time, and excavations in these materials could regress in a very short time period (i.e., hours or days). Temporary dredge slopes in gravel can be steeper and will typically have a longer standup time. Given the large variation in materials along the RM11E Project Area, it is recommended that at least one test excavation be completed in each area of interest during the design phase of the project to evaluate temporary standup times. Additional short-term slope considerations for box cut type methods are discussed further below.

As shown in Figures 5.6a through 5.6d, much of the RM11E Project Area includes oversteepened slopes. Dredging in oversteepened slopes could result in slope failures and the potential undermining of adjacent off- and nearshore structures. Consequently, dredging within or adjacent to oversteepened slopes could require special provisions, among which are the following:

- Complete the dredging in segments of limited width and partially backfill each segment prior to removing material from the adjacent segment. The width and depth of the dredging segment should be evaluated during construction by completing several test sections.
- Carefully evaluate the risks associated with box cut dredging methods, which include cutting a large excavation at the base of the slope and allowing the soil located uphill from the cut to slough into the excavation. Several large slope failures have occurred along the Willamette and Columbia rivers in areas where box cutting methods have been used. The risks associated with box cut methods vary with the type of soil, proposed dredge depth, and location of dredging, and should be carefully evaluated during remedial design.
- Place fill to reestablish site grades, if necessary, from the bottom of the excavation and at slopes flatter than about 2H:1V to 3H:1V, depending on material. Additional considerations regarding placement of capping materials are provided in Section 5.3.3.
- Remove material upslope of the contaminated sediments to limit the potential for bank failure above the cut. As shown on Figure 5.7, the zone of material removal is located above a 2H:1V to 3H:1V (depending on soil type) line extending upslope from the base of the planned cut into the upland area. Flatter upslope cuts may be needed in order to accommodate slope armoring. For this technique, it will likely be infeasible to reestablish pre-remediation upland site grades without an engineered wall.
- Support the upslope material with a temporary retaining wall prior to dredging. Backfill the excavation prior to removing the temporary wall, as shown on Figure 5.8.
- Closely monitor dredging in slopes approaching oversteepened values to achieve better control and to limit potential bank failure due to over-excavation.
- Consider the risk for propeller wash scour in areas of vessel traffic when establishing final dredge cut configurations and armoring.
- Consider the risk for erosion due to wave action when establishing final dredge cut configurations and armoring.

Given slope stability and other considerations, certain areas of the site may not be appropriate for dredging and will need to be further evaluated during remedial design.

5.3.3 CAPPING CONSIDERATIONS

As indicated by the survey data presented previously, much of the site is in an area of oversteepened slopes. Capping on oversteepened slopes, whether to contain contaminated sediments or to reestablish site grades after dredging, could result in an increased risk of slope movement or failure. Cap design considerations include the potential for capping or fill material to regress to a flatter slope in the long term and risk exposure of underlying contaminated sediments not removed as part of remedial activities, particularly after extreme high or low river level events. Consequently, placing material in this area would likely require special provisions that could, depending on site-specific conditions, include one or more of the following:

- Prior to installing the cap, lay back the slope either by removing material from the top of the slope or by placing material at the toe of the slope on the flatter riverbed.

- Construct a buttress at the toe of a slope to provide added stability for the slope cap, as shown on Figure 5.9. For stability considerations, the toe of the buttress may need to extend below the existing mudline elevation.
- Consider removing soft, fine-grained sediments, particularly on a significant slope, before constructing a toe buttress to support remediation caps; the low undrained shear strength of such sediments may not be suitable as foundation material. Partial or complete removal of the silt or clay to the underlying sand or gravel may be needed to support the buttress.
- Place capping material onto soft sediment in lifts, initially on the order of 6 inches thick, to reduce the risk of shallow bearing-capacity failures and subsequent cross-contamination of the capping material and the underlying sediment.
- Consider the effects on navigation and berthing depth of buttresses or caps placed at the toe of existing slopes. If located outboard of the pier head line, buttresses and caps may limit future dredging to deepen the draft of the adjacent berth or navigation channel. In these areas, a permanent retaining wall may be required, as shown on Figure 5.10.
- Consider use of a stepped retaining wall, as shown on Figure 5.11, in areas with large extents of contaminated sediments or very steep slopes.
- Angular rock, quarry spalls, or riprap fills used for capping are typically designed no steeper than 1.75H:1V or flatter in the long term and are more commonly designed at 2H:1V, particularly in the zone of wave action. Temporary excavations to place the slope protection, filter material, and bedding are common at slopes of 2.5H:1V or shallower.
- Sequence the capping material placement from the base of the slope toward the top of the slope.
- Consider the use of articulated concrete mats on slopes that are too steep for caps constructed of granular material. The articulated concrete mats could be anchored to the existing remnant piling or to new piling installed specifically for the project.
- Consider the risk of propeller wash scour in areas of vessel traffic when establishing final cap configurations and armoring.
- Consider the risk of erosion due to wave action when establishing final cap configurations and armoring.

Given slope stability and other considerations, certain locations within the RM11E Project Area may not be appropriate for capping and will need to be further evaluated during remedial design.

5.3.4 DEBRIS AND GRAVEL CONSIDERATIONS

Groups of vertical structural elements, such as the remnant piling from historical operations, provide additional shear resistance and locally improve the stability of slopes. While the presence of groups of vertical piles can make dredging and capping more difficult to implement, it is recommended that groups of remnant piles not be removed without further evaluation, as doing so could destabilize the shoreline slopes. To facilitate the remediation activities, it may be feasible to cut off the remnant piles at the existing or targeted mudline. The locations of the groups of vertical piles are presented on Figures 4.3a through 4.3d.

Numerous pieces of large debris are mapped on the bed of the river, as presented on Figures 4.3a through 4.3d. Armoring near the crest of the shoreline includes riprap, construction debris, and concrete. In addition, the fill present along much of the site is highly variable and may contain large buried debris. While the mapped debris on the riverbed can be removed prior to construction of stabilization measures, the presence of buried debris or logs in the alluvial sand and silt unit may limit the installation of structures such as sheet pile walls. Removal of large pieces of the existing slope armoring to facilitate new walls near the top of the slope could also result in localized instability due to propeller wash and wave-induced erosion.

As shown on the geologic cross sections (Figures 5.2 through 5.5), thick and continuous deposits of very dense or partially cemented gravels are located within several feet of the mudline, particularly in the downstream (northern) portion of the RM11E Project Area. These gravel deposits often contain significant quantities of cobble and boulder-sized material. In these soil conditions, sheet piles cannot typically be installed to adequate depths or may be severely damaged during driving. Additional subsurface investigations at any planned wall location will be needed during remedial design to address these considerations. Construction records of the nearshore structures, if available, could also be reviewed to assist in evaluating the feasibility of sheet pile installation as part of the remediation efforts.

5.3.5 EXISTING STRUCTURE CONSIDERATIONS

The general discussions related to dredging and capping earlier in this report are primarily based on considerations for undeveloped riverfront conditions. Numerous retaining walls, docks, and upland structures are located within, adjacent to, or above areas that may be targeted for remediation. These structures vary in their condition based on age and use. Selection and design of an appropriate remediation approach will need to consider the impacts of the remediation on the performance of these structures and will need to be evaluated on a case-by-case basis as remedial design progresses (Section 6). In areas where active remediation is required, it is recommended that the potential impacts of dredging or capping be evaluated for all existing retaining walls and dock structures located near all potential caps or dredge cuts. The impacts on all existing upland improvements located within about 100 feet from the crest of the shoreline slope should also be evaluated. The impacts of surcharge loading from structures should also be considered in the evaluation of the potential remediation measures. The soil parameters provided in Section 5.3.7.1 of this report may be used for these preliminary evaluations.

5.3.6 OBSERVATIONAL APPROACH

Regardless of the remediation method selected at a particular location, an observational approach is recommended to guide and refine the work as it progresses. In an observational approach, the performance of the slope in a small test section is evaluated prior to full-scale implementation. Ideally, the test section would be located away from critical structures but would have characteristics (e.g., soil type and slope inclination) similar to those of the area to be remediated. For example, a performance evaluation of the slope located immediately adjacent to an existing dock could guide the approach (e.g., standup time, size and length of time an area is left open, excavation side slopes, shoring types) used by the contractor in the portion of the slope located adjacent to that dock. As a general guide, it is best to complete the work in phases and, if needed to maintain stability of slopes or structures, to backfill dredged areas as soon as practical.

5.3.7 PRELIMINARY DESIGN CONSIDERATIONS

5.3.7.1 Preliminary Soil Parameters for Engineering Evaluation

The soil parameters provided in Table 5.2 are appropriate for preliminary evaluation of long-term stability of slopes and can also be used to evaluate the impacts of capping or dredging if the soil is predominantly non-plastic silt or coarse-grained sand or gravel. The soil parameters are based on correlation to standard penetration test (SPT) N-values, geotechnical laboratory testing completed by GRI and others on similar soils along the Willamette and Columbia rivers in the Portland area, and GRI's previous experience in the RM11E Project Area.

TABLE 5.2 – SOIL PARAMETERS FOR PRELIMINARY ENGINEERING EVALUATION OF LONG-TERM (DRAINED) CONDITIONS

SOIL TYPE	SOIL PARAMETERS			
	γ_M, PCF[a]	γ', PCF[b]	ϕ' [c]	C′, PSF [d]
Fill[e]	115	53	30°	0
Silt/sand[e]	115	53	32°	0
Gravel	125	63	38°	0
Lower sand	125	63	36°	0

[a] Moist unit weight, pounds per cubic foot

[b] Buoyant (submerged) unit weight, pounds per cubic foot

[c] Effective (drained) friction angle, degrees

[d] Effective (drained) cohesion, pounds per square foot

[e] See discussion below for additional strength considerations of fine grained fill or alluvium

Silt and clay soils may be encountered in the fill and silt/sand unit. If the soil is composed primarily of silt or clay, undrained strength parameters (i.e., S_u), will likely control the design of temporary excavation cuts and caps. Although site-specific testing has not been completed as part of this study, it is not unusual for these fine-grained sediments or fine-grained fill soils to have very low undrained shear strengths (on the order of 150 pounds per square foot). Fills placed on or cuts made into materials with low undrained shear strength may result in slope instability and this possibility should be considered during remedial design. The parameters for the gravel and lower sand units provided in Table 5.2 are still applicable for evaluation of temporary excavation cuts and caps.

Both drained and undrained shear strength parameters need to be further evaluated for areas where active remediation will be implemented as part of remedial design, especially where caps or cuts are considered in locations where significant fine-grained soils are encountered.

5.3.7.2 Lateral Earth Pressure Diagrams

As discussed previously, temporary or permanent retaining walls may be needed to accommodate potential remediation activities. Figures 5.12 and 5.13 present lateral earth pressure diagrams that can be used for this evaluation. Figure 5.12 presents a lateral earth pressure diagram for a completely submerged cantilever sheet pile wall constructed near the toe of the slope. The lateral earth pressure diagram presents equivalent fluid weights for active and passive pressures for backslope and frontslope inclinations up to 2H:1V. Figure 5.13 presents a lateral earth pressure diagram for new anchored soldier pile and lagging retaining walls

constructed at the top of the shoreline slope. The lateral earth pressure diagram assumes that the slope below the wall will regress to 2H:1V in the long term and that the lagging will extend to this depth. The tieback anchor bond zone will need to be located below the fill into the underlying unconsolidated deposits.

These lateral earth pressure diagrams should be considered preliminary and are intended for conceptual planning purposes only. They do not include seismic lateral earth pressure; the need to include seismic lateral earth pressures should be evaluated on a case-by-case basis as part of remedial design. During final design, additional geotechnical studies will need to be completed to refine the conceptual lateral earth pressure diagrams.

The design calculations, earth pressure diagrams, and tieback capacities developed during initial design of the existing walls at Cargill and RIS&G, if available, should be used to evaluate the impacts of any proposed remediation measures on these walls in lieu of the conceptual earth pressure diagrams presented on Figures 5.12 and 5.13.

5.3.7.3 Evaluation of Docks

Piles located within post-dredging oversteepened slopes will be subjected to additional temporary lateral forces. As shown on Figure 5.14, these lateral forces can be modeled on a preliminary basis using an equivalent fluid weight of 55 pounds per cubic foot. As the soils slough back to the maximum long-term slope inclination, horizontal loading on the piles will become negligible. Any dredging completed on or near the toe of a slope inclined at or steeper than its maximum long-term slope would likely result in significant loss of material extending upslope, which may undermine additional upslope improvements.

Dredging activities will reduce the amount of available soil to resist lateral loading and could potentially undermine the tips of relatively shallow piles. As-built records, if available, should also be reviewed and the effects of dredging on these structures should be considered when evaluating potential remediation measures.

5.3.7.4 Seismic Considerations

The loose or soft portions of the fill and sand/silt units are susceptible to liquefaction, which should be further evaluated as part of remedial design. Liquefaction is a process by which loose to medium dense sands or soft non-plastic to low-plasticity silts temporarily lose strength during and immediately after a seismic event. As strength is lost, there is an increased risk of lateral spreading deformations or slope instability. The lateral spreading deformations could be on the order of feet in the upland portion of the RM11E Project Area and more significant deformations (i.e., flow failures) could occur near the crest of oversteepened shoreline areas.

The discussions provided in this report are primarily limited to static slope stability considerations. If the contaminated sediments are capped and left in place, the selected remediation approach should consider the risk of seismically induced slope movements on contaminant containment and on existing structures. Structural or ground improvement may be an alternative to limit the risk of slope movements during seismic events; however, this will need to be evaluated as part of remedial design.

5.4 CONCLUSION AND RECCOMMENDATIONS

Oversteepened slopes in the RM11E Project Area are ranked as high-impact for both removal and cap/cover remedial actions. Areas with oversteepened slopes will require additional effort to

select and design the remedy, including identification of site-specific management actions tailored to the selected remedial action in areas where active remediation is required

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5.5 SECTION 5 FIGURES

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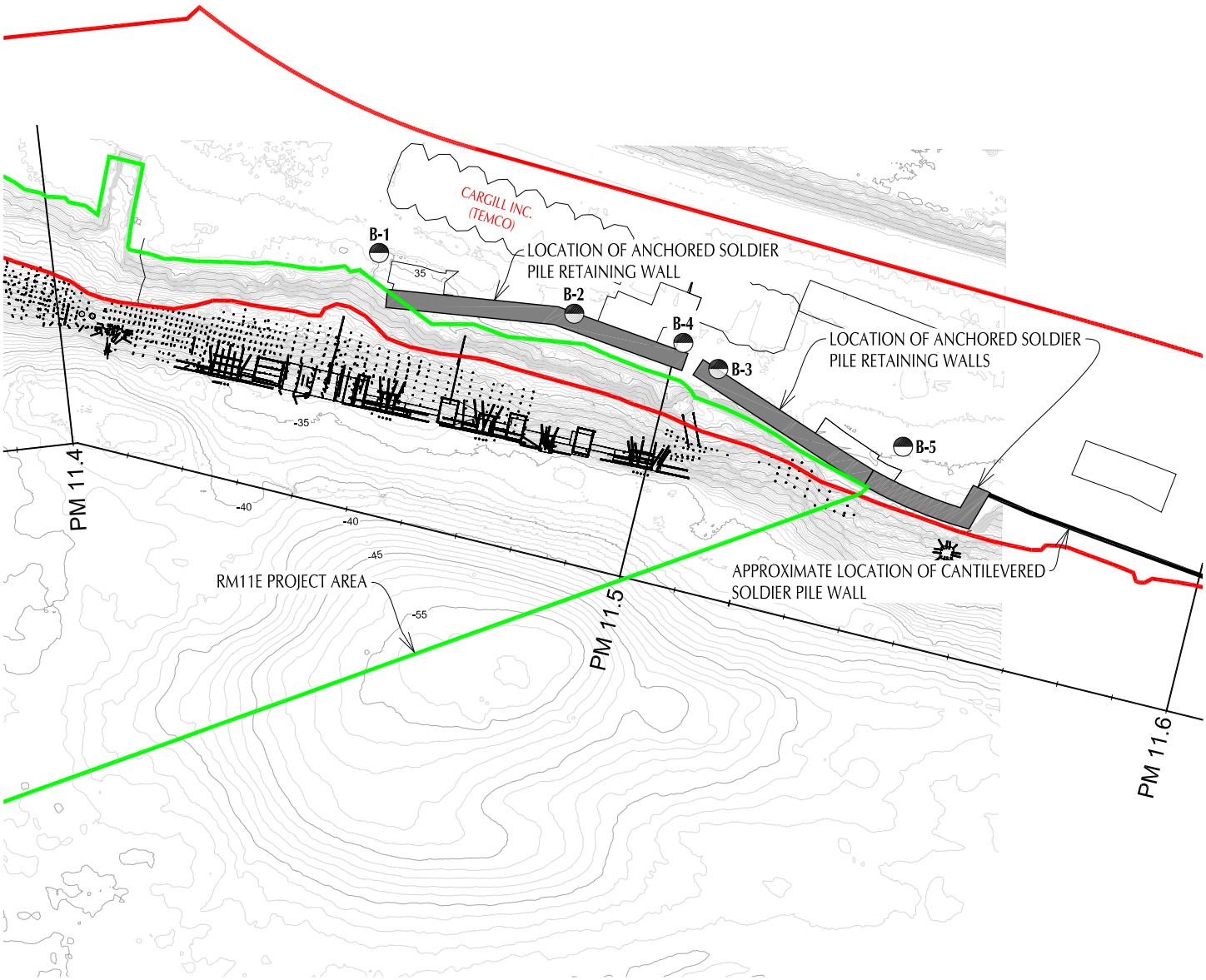

BORING AND INCLINOMETER BY GRI
(NOVEMBER 1996)

NOTE: WALL LOCATIONS ARE APPROXIMATE AND SHOULD BE SURVEYED, IF NECESSARY, AS PART OF REMEDIAL DESIGN.

SITE PLAN FROM DALTON, OLMSTED & FUGLEVAND, INC.

North

0 150 300 FT

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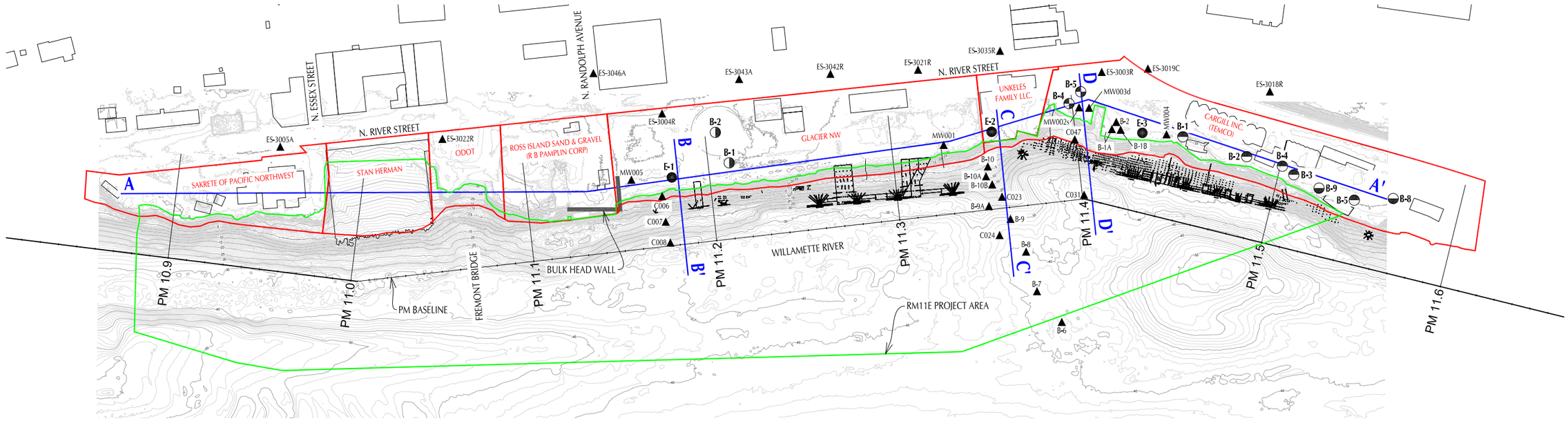
Site Plan
(Cargill)

GRI

Figure 5.1

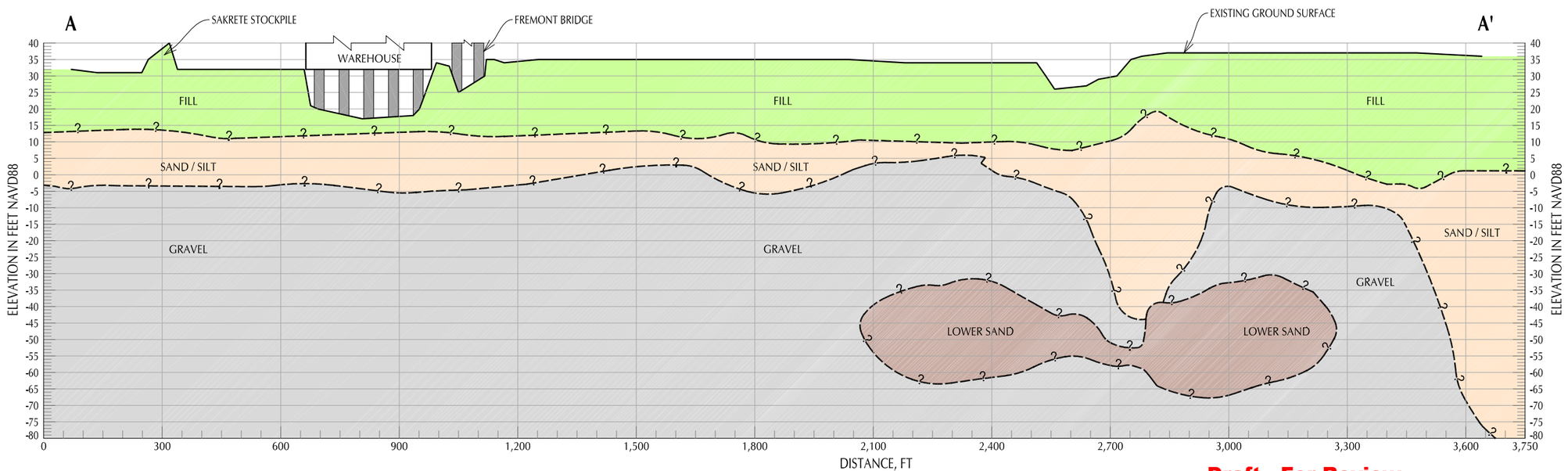
July 31, 2015

PLOT TIME: 7/29/2015 11:55 AM MOD TIME: 7/29/2015 11:55 AM USER: Lee DWG: P:\5401-5500\5445 River Mile 11 Consultation\Drafting\ISR REPORT\5445 CARGILL SITE PLAN (FIG 5.1).dwg



SITE PLAN

0 300 600 FT



CROSS SECTION

HORIZONTAL SCALE: 1 IN. = 300 FT
VERTICAL SCALE: 1 IN. = 36 FT

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SOIL LEGEND

- FILL
- GRAVEL
- SAND / SILT
- LOWER SAND

- BORING MADE BY GRI (MAY 2014)
- BORING AND INCLINOMETER BY GRI (NOVEMBER 2013)
- BORING MADE BY GRI (APRIL 1998)
- BORING AND INCLINOMETER BY GRI (NOVEMBER 1996)
- BORING MADE BY GRI (DECEMBER 1993)
- BORINGS BY OTHERS

LOCATIONS OF GEOLOGIC CROSS SECTIONS

SITE PLAN FROM DALTON, OLMSTED & FUGLEVAND, INC.

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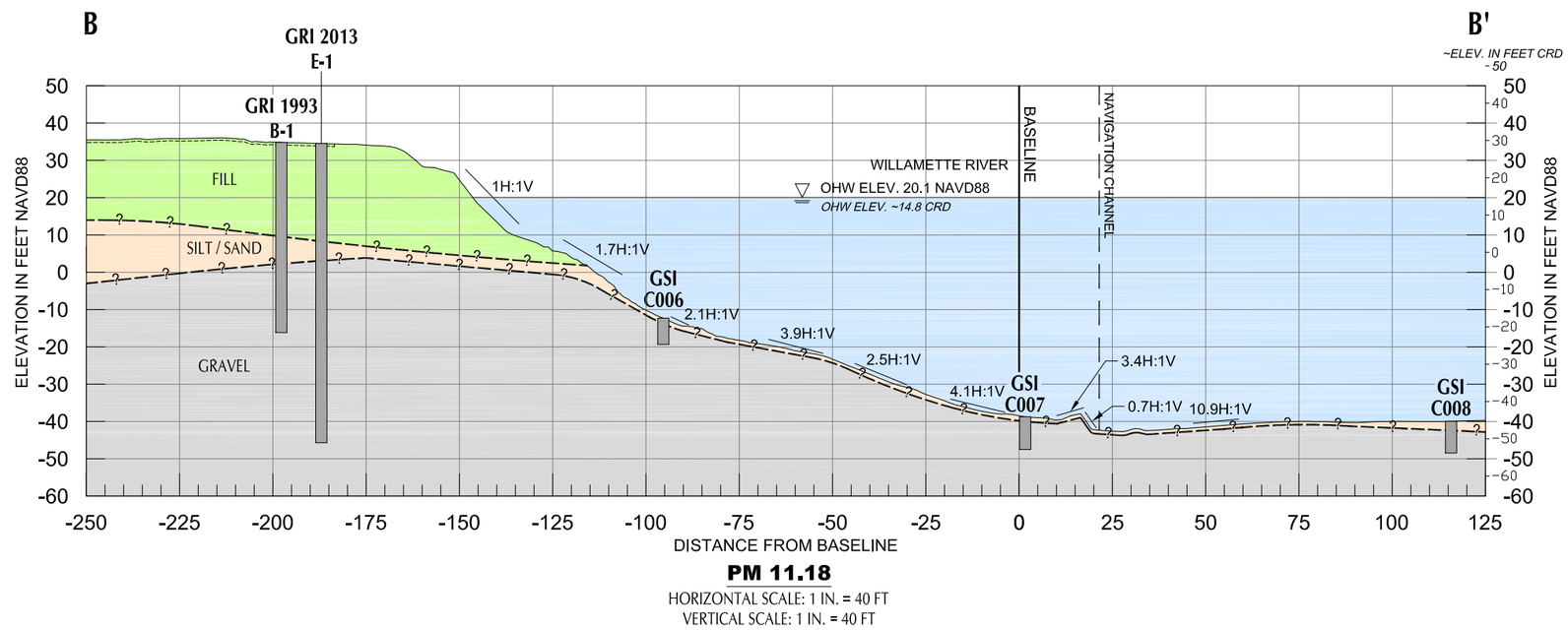
Site Plan & Geologic Cross Section A-A'

GRI

Figure 5.2

July 31, 2015

PLOT TIME: 7/29/2015 11:59 AM MOD TIME: 7/29/2015 11:58 AM USER: Lee DWG: P:\5401-5500\5445 River Mile 11 Consultation\Drafting\ISR REPORT\5445 SITE PLAN & PROFILE (FIG 5.2).dwg



PM 11.18

HORIZONTAL SCALE: 1 IN. = 40 FT
VERTICAL SCALE: 1 IN. = 40 FT

SOIL LEGEND

- FILL
- GRAVEL
- SILT / SAND

NOTE: BASE CROSS SECTION PROVIDED BY DALTON, OLMSTED & FUGLEVAND, INC.

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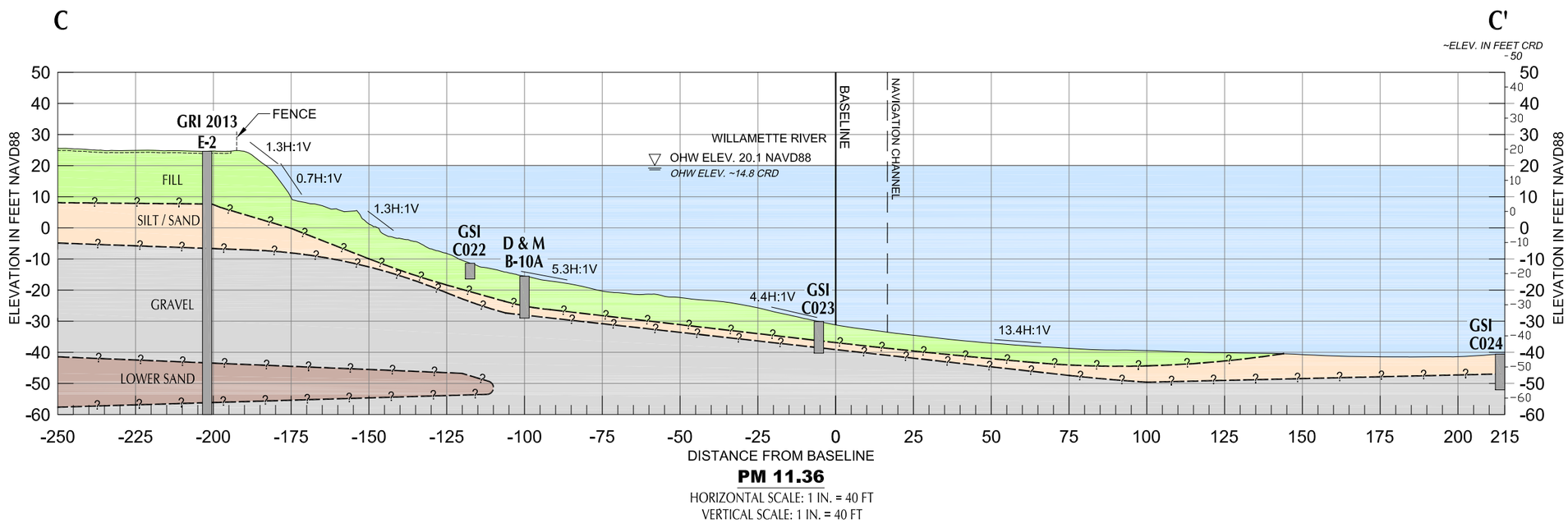
Geologic Cross Section B-B'
(PM 11.18)

GRI

Figure 5.3

July 31, 2015

PLOT TIME: 7/29/2015 12:03 PM MOD TIME: 7/29/2015 12:03 PM USER: Lee DWG: P:\5401-5500\5445 River Mile 11 Consultation\Drafting\ISR REPORT\5445 CROSS SECTIONS (FIG 5.3, 5.4 & 5.5).dwg



SOIL LEGEND

- FILL
- GRAVEL
- SILT / SAND
- LOWER SAND

NOTE: BASE CROSS SECTION PROVIDED BY DALTON, OLMSTED & FUGLEVAND, INC.

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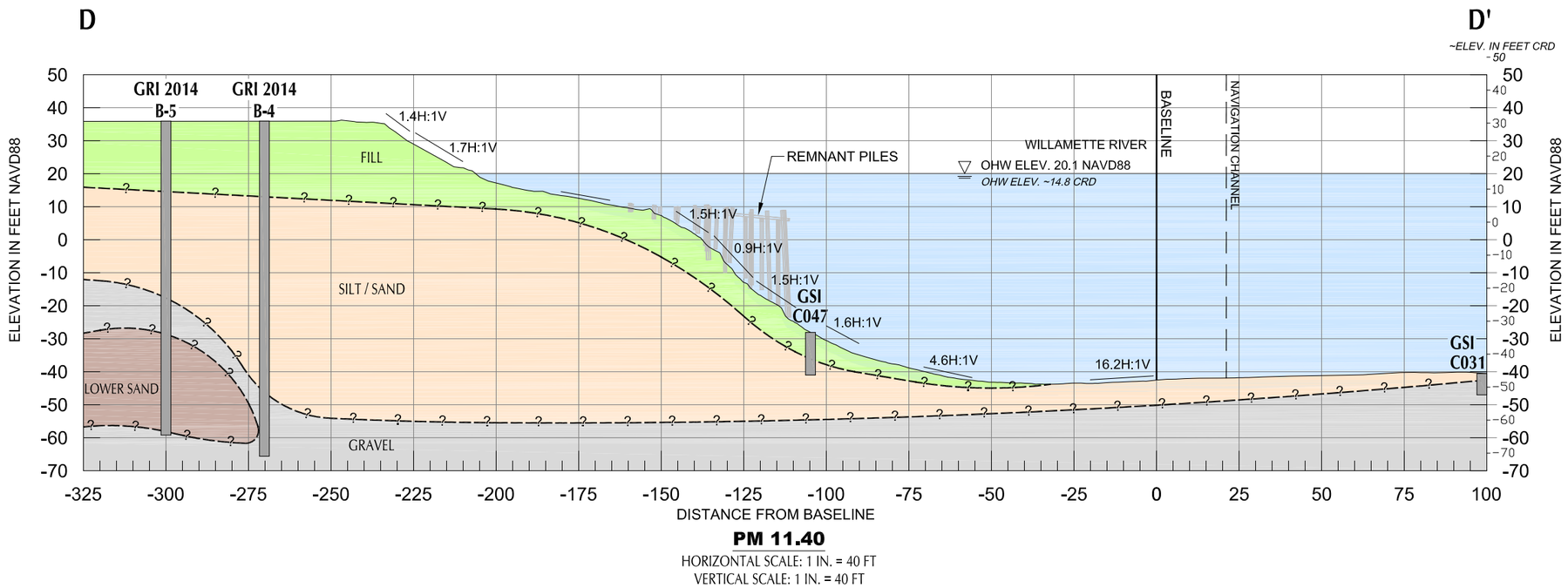
Geologic Cross Section C-C'
(PM 11.36)

GRI

Figure 5.4

July 31, 2015

PLOT TIME: 7/29/2015 12:04 PM MOD TIME: 7/29/2015 12:03 PM USER: Lee DWG:P:\5401-5500\5445 River Mile 11 Consultation\Drafting\ISR REPORT\5445 CROSS SECTIONS (FIG 5.3, 5.4 & 5.5).dwg



PM 11.40

HORIZONTAL SCALE: 1 IN. = 40 FT
VERTICAL SCALE: 1 IN. = 40 FT

SOIL LEGEND

- FILL
- GRAVEL
- SILT / SAND
- LOWER SAND

NOTE: BASE CROSS SECTION PROVIDED BY DALTON, OLMSTED & FUGLEVAND, INC.

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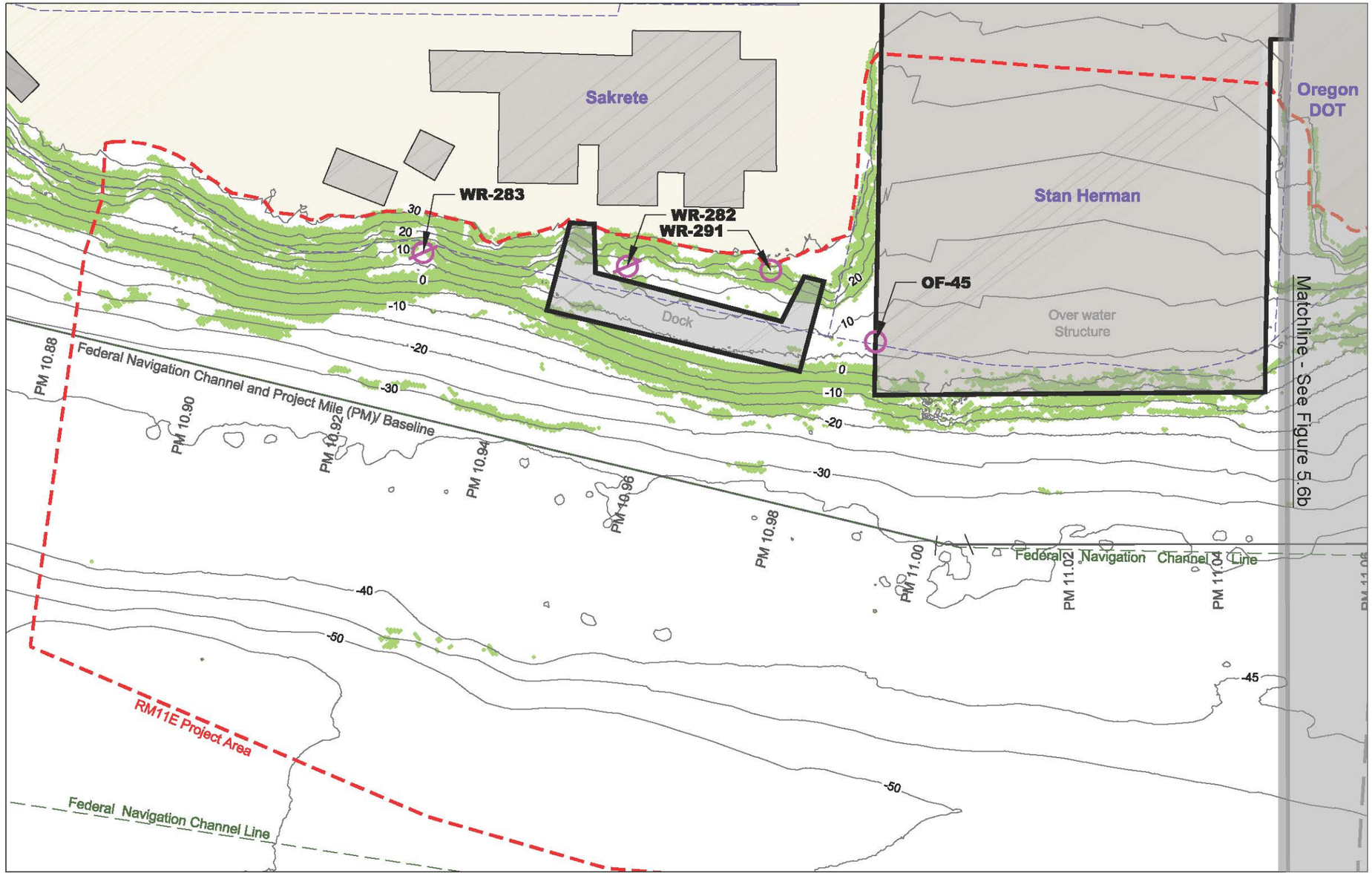
Geologic Cross Section D-D'
(PM 11.40)

GRI

Figure 5.5

July 31, 2015

PLOT TIME: 7/29/2015 12:05 PM MOD TIME: 7/29/2015 12:03 PM USER: Lee DWG: P:\5401-5500\5445 River Mile 11 Consultation\Drafting\ISR REPORT\5445 CROSS SECTIONS (FIG 5.3, 5.4 & 5.5).dwg



LEGEND

Impact Ranking

- Oversteepened Slopes (Steeper than 2H:1V): High-Impact

Other Features

- Existing Structures
- Outfall - Active
- Outfall - Inactive or Status Unknown
- RM11E Project Area
- Tax Lot Boundary (Oct. 2013)
- PM 11.32 Project Mile Stationing
- Federal Navigation Channel (USACE)
- 40 Bathymetric Contour - 5' Interval (NAVD88)

0 80
Scale in Feet

1. Slope analysis performed by GSI Water Solutions, Inc., September 2014, using ESRI ArcGIS to analyze the DEA Existing Grade composite project surface (DEM) for changes in slope.
2. The locations of all features shown are approximate.
3. Contour lines and planimetric features are based on a composite data set which consists of the following: NOAA multibeam survey from 2009; ODSL multibeam and laser survey from 2010; USACE LiDAR survey from 2009; David Evans and Associates, Inc. multibeam survey from 2011 and terrestrial laser scan from 2013; and RLIS Metro GIS data. Digital elevation model (DEM) surface for bathymetric contours was modeled only in the immediate vicinity of the RM11E Project Area. It is not intended for litigation, construction, or navigation purposes.
4. Horizontal datum is referenced to Oregon State Plane North NAD83 (international feet). Vertical datum is referenced to NAVD88 (feet).
5. Outfall status and location from City of Portland - Bureau of Environmental Services (BES) GIS group. Data layer acquired from GSI. Outfalls centered on coordinates from BES data layer.
6. Tax lot boundary generated by METRO (Oct. 2013). Data layer acquired from GSI.

Figure Location Map

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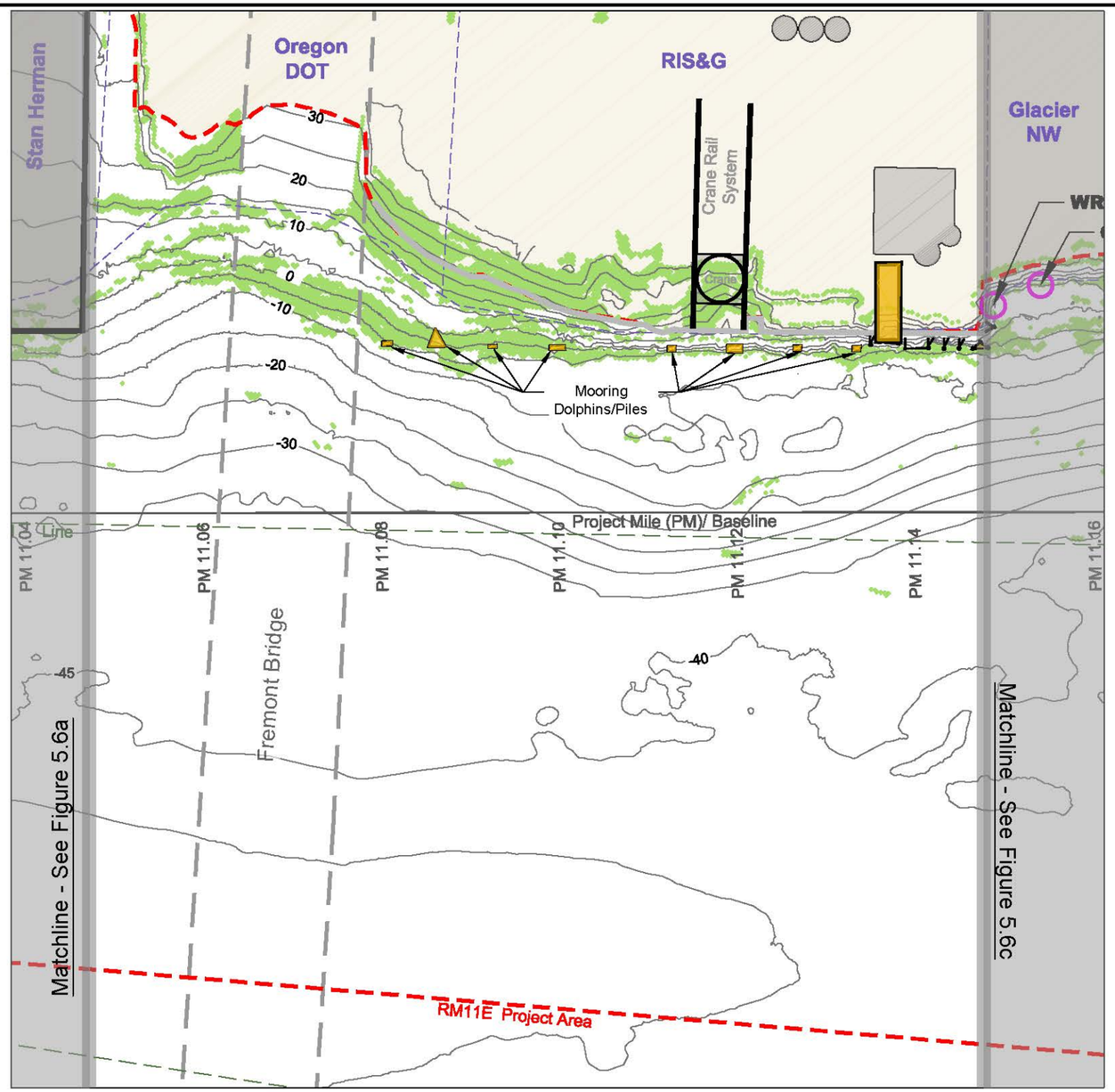
Geotechnical Impact Areas
~PM 10.88 to ~PM 11.05

DALTON OLMSTED FUGLEVAND

FIGURE 5.6a

July 31, 2015

PLOT TIME: 7/31/2015 11:53 AM MOD TIME: 7/31/2015 10:59 AM USER: Lee Barras DWG: D:\Projects\RM11E\CAD\Figures\2015-07\NSR\2015-07-31 20 Geotechnical High-Impact Areas Fig 5.6abcd.dwg



LEGEND

Impact Ranking

- Oversteepened Slopes (Steeper than 2H:1V): High-Impact

Other Features

- Active Docks (2015)
- Existing Structures
- Outfall - Active
- RM11E Project Area
- Tax Lot Boundary (Oct. 2013)
- PM 11.32 Project Mile Stationing
- Federal Navigation Channel (USACE)
- -40 Bathymetric Contour - 5' Interval (NAVD88)

0 80
Scale in Feet

1. Slope analysis performed by GSI Water Solutions, Inc., September 2014, using ESRI ArcGIS to analyze the DEA Existing Grade composite project surface (DEM) for changes in slope.
2. The locations of all features shown are approximate.
3. Contour lines and planimetric features are based on a composite data set which consists of the following: NOAA multibeam survey from 2009; ODSL multibeam and laser survey from 2010; USACE LiDAR survey from 2009; David Evans and Associates, Inc. multibeam survey from 2011 and terrestrial laser scan from 2013; and RLIS Metro GIS data. Digital elevation model (DEM) surface for bathymetric contours was modeled only in the immediate vicinity of the RM11E Project Area. It is not intended for litigation, construction, or navigation purposes.
4. Horizontal datum is referenced to Oregon State Plane North NAD83 (international feet). Vertical datum is referenced to NAVD88 (feet).
5. Outfall status and location from City of Portland - Bureau of Environmental Services (BES) GIS group. Data layer acquired from GSI. Outfalls centered on coordinates from BES data layer.
6. Tax lot boundary generated by METRO (Oct. 2013). Data layer acquired from GSI.

Figure Location Map

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Geotechnical Impact Areas
~PM 11.05 to ~PM 11.15

DALTON OLMSTED FUGLEVAND

Figure 5.6b

July 31, 2015

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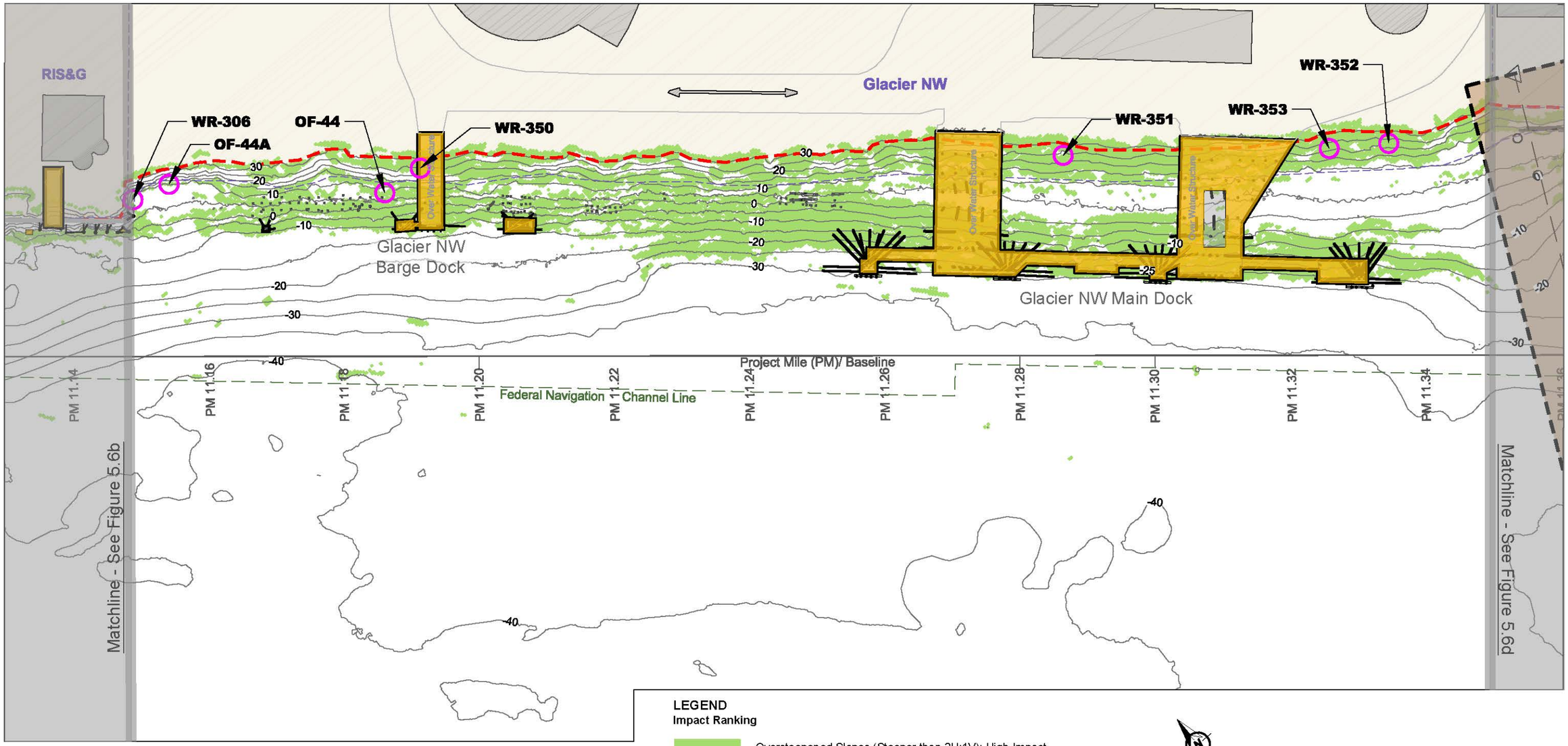

MAP NOTES

1. Slope analysis performed by GSI Water Solutions, Inc., September 2014, using ESRI ArcGIS to analyze the DEA Existing Grade composite project surface (DEM) for changes in slope.
2. The locations of all features shown are approximate.
3. Contour lines and planimetric features are based on a composite data set which consists of the following: NOAA multibeam survey from 2009; ODSL multibeam and laser survey from 2010; USACE LiDAR survey from 2009; David Evans and Associates, Inc. multibeam survey from 2011 and terrestrial laser scan from 2013; and RLIS Metro GIS data. Digital elevation model (DEM) surface for bathymetric contours was modeled only in the immediate vicinity of the RM11E Project Area. It is not intended for litigation, construction, or navigation purposes.
4. Horizontal datum is referenced to Oregon State Plane North NAD83 (international feet). Vertical datum is referenced to NAVD88 (feet).
5. Outfall status and location from City of Portland - Bureau of Environmental Services (BES) GIS group. Data layer acquired from GSI. Outfalls centered on coordinates from BES data layer.
6. Tax lot boundary generated by METRO (Oct. 2013). Data layer acquired from GSI.
7. Vertical pile remnants and submarine cable crossing toned location provided by David Evans and Associates, Inc. as described in the Draft Implementability Study Report, Section 2.

LEGEND

Impact Ranking

- Oversteepened Slopes (Steeper than 2H:1V): High-Impact

Other Features

- Active Docks (2015)
- Existing Structures
- Submarine Cable Crossing Caution Zone
- Outfall - Active
- RM11E Project Area
- Tax Lot Boundary (Oct. 2013)
- PM 11.32 Project Mile Stationing
- Federal Navigation Channel (USACE)
- 40 Bathymetric Contour - 5' Interval (NAVD88)

0 80
Scale in Feet

Figure Location Map

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RM11E Group
Willamette River - Portland, Oregon
Draft Implementability Study Report

Geotechnical Impact Areas
~PM 11.15 to ~PM 11.35

DALTON OLMSTED FUGLEVAND

Figure 5.6c

July 31, 2015

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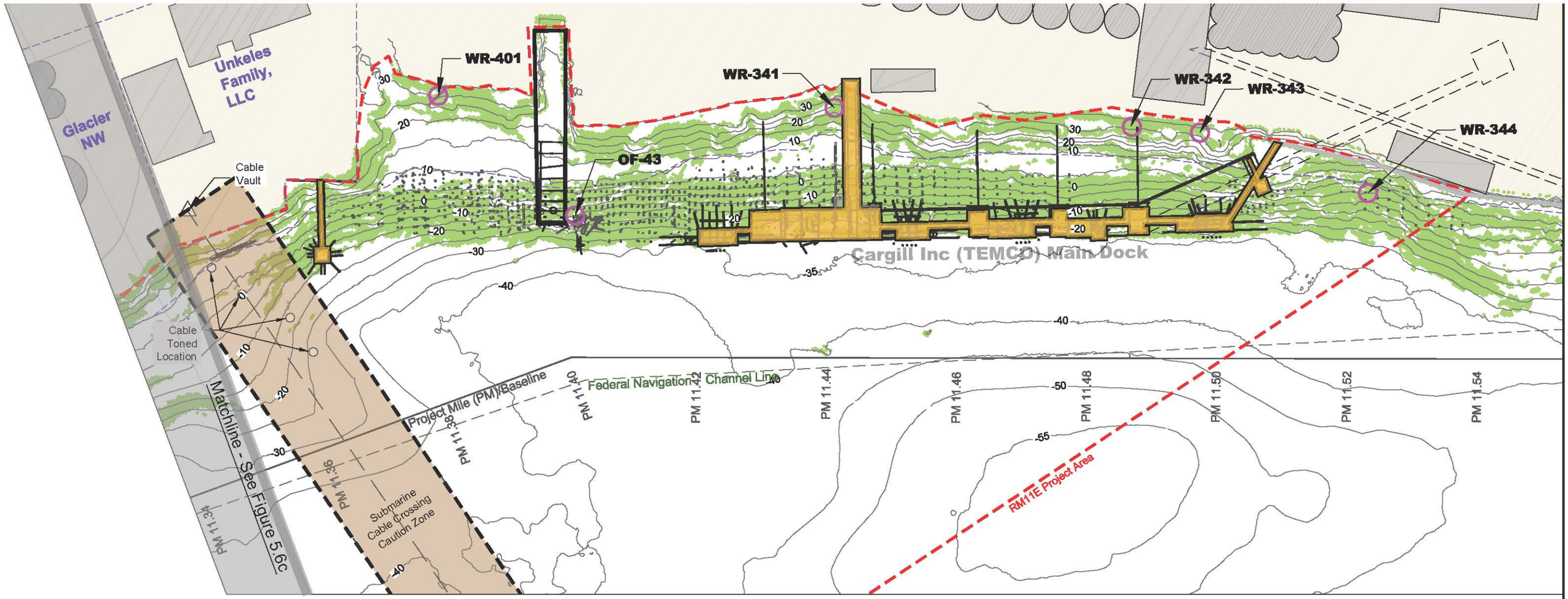

MAP NOTES

1. Slope analysis performed by GSI Water Solutions, Inc., September 2014, using ESRI ArcGIS to analyze the DEA Existing Grade composite project surface (DEM) for changes in slope.
2. The locations of all features shown are approximate.
3. Contour lines and planimetric features are based on a composite data set which consists of the following: NOAA multibeam survey from 2009; ODSL multibeam and laser survey from 2010; USACE LiDAR survey from 2009; David Evans and Associates, Inc. multibeam survey from 2011 and terrestrial laser scan from 2013; and RLIS Metro GIS data. Digital elevation model (DEM) surface for bathymetric contours was modeled only in the immediate vicinity of the RM11E Project Area. It is not intended for litigation, construction, or navigation purposes.
4. Horizontal datum is referenced to Oregon State Plane North NAD83 (international feet). Vertical datum is referenced to NAVD88 (feet).
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6. Tax lot boundary generated by METRO (Oct. 2013). Data layer acquired from GSI.
7. Vertical pile remnants and submarine cable crossing toned location provided by David Evans and Associates, Inc. as described in the Draft Implementability Study Report, Section 2.

LEGEND

Impact Ranking

- Oversteepened Slopes (Steeper than 2H:1V): High-Impact

Other Features

- Active Docks (2015)
- Existing Structures
- Submarine Cable Crossing Caution Zone
- Outfall - Active
- Outfall - Inactive or Status Unknown
- RM11E Project Area
- Tax Lot Boundary (Oct. 2013)
- PM 11.32 Project Mile Stationing
- Federal Navigation Channel (USACE)
- -40 Bathymetric Contour - 5' Interval (NAVD88)

0 80
Scale in Feet

Figure Location Map

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Willamette River - Portland, Oregon
Draft Implementability Study Report

Geotechnical Impact Areas
~PM 11.35 to ~11.54

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Figure 5.6d
July 31, 2015

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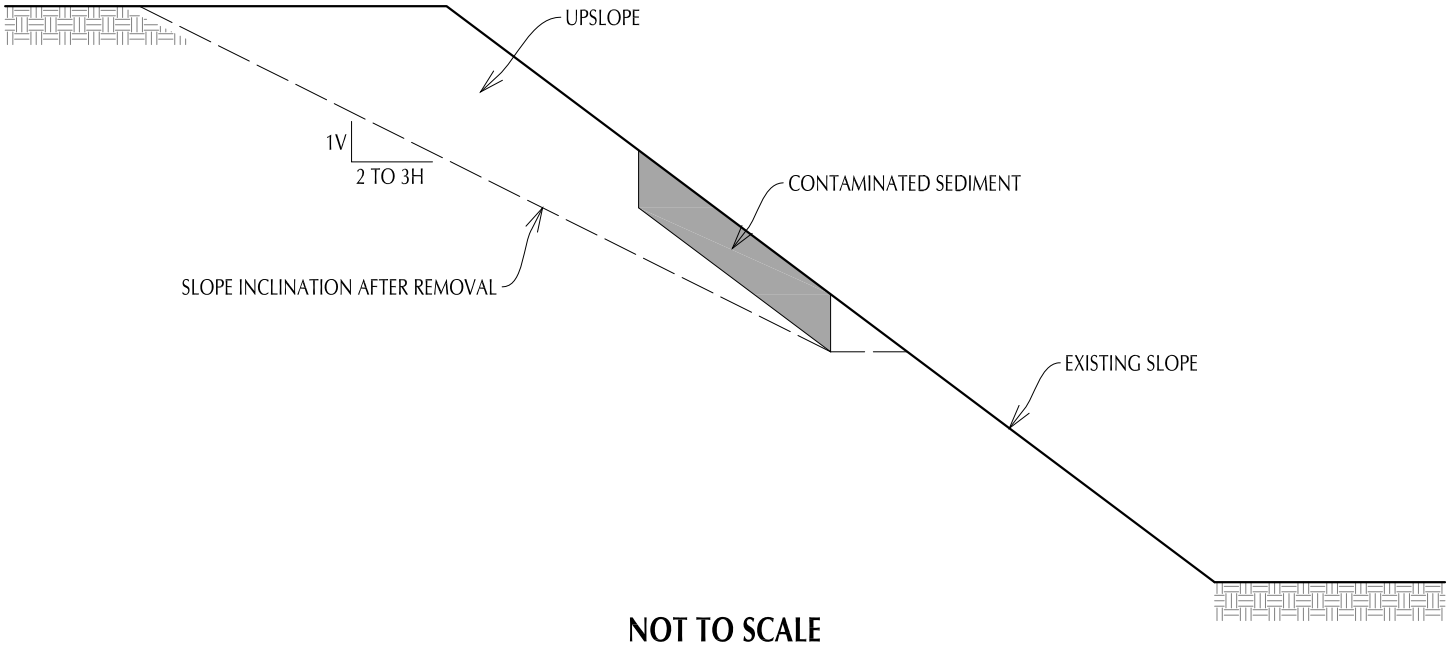

NOT TO SCALE

NOTES:

1. INCLINATION OF UPSLOPE MATERIAL REMOVAL IS DEPENDENT ON SUBSURFACE CONDITIONS AT LOCATION OF CUT AND OTHER FACTORS AND SHOULD BE EVALUATED AS PART OF FINAL DESIGN.
2. FLATTER CUTS MAY BE NEEDED TO ACCOMMODATE SLOPE ARMORING.
3. CONTAMINATED SEDIMENTS AND UPSLOPE MATERIAL SHOULD BE REMOVED BEGINNING AT TOP OF SLOPE AND WORKING DOWNWARD.

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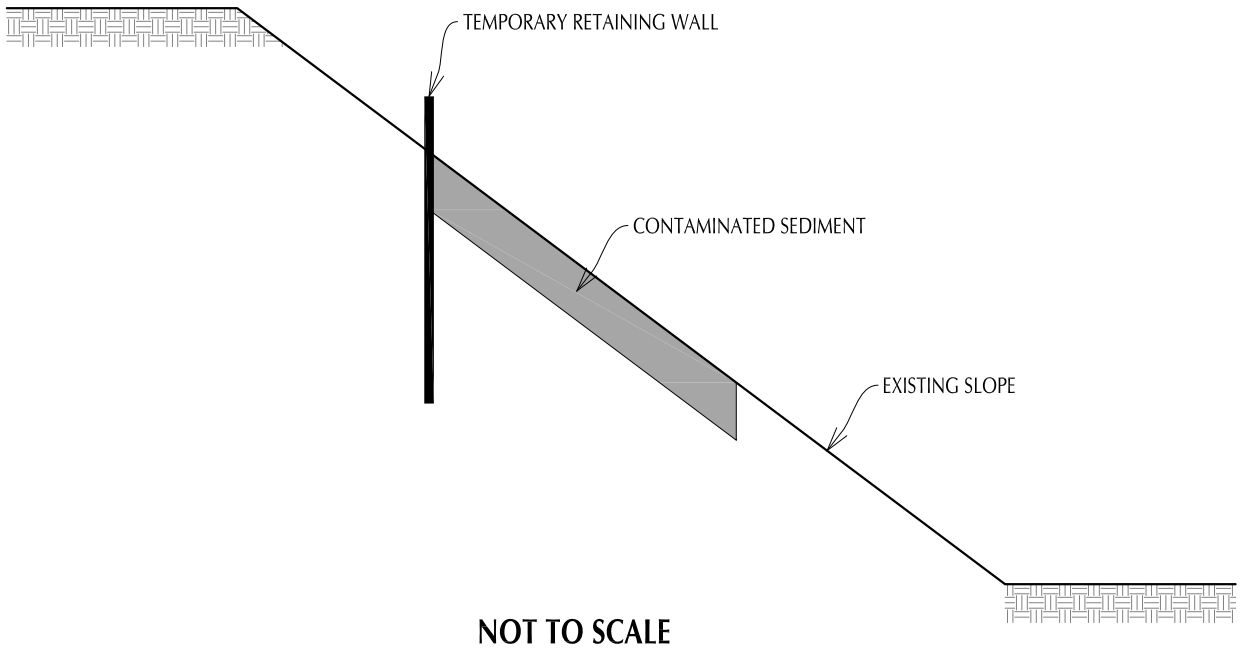
RM11E Group **Willamette River - Portland, Oregon**	GRI
Draft Implementability Study Report **Contaminated Sediment Removal**	**Figure 5.7** July 31, 2015

PLOT TIME: 7/29/2015 12:23 PM MOD TIME: 7/29/2015 12:23 PM USER: Lee DWG: P:\5401-5500\5445 River Mile 11 Consultation\Drafting\ISR REPORT\5445 DETAILS (FIGS 5.7 - 5.11).dwg



NOT TO SCALE

NOTES:

1. INSTALL TEMPORARY RETAINING WALL PRIOR TO DREDGING CONTAMINATED SEDIMENT. TEMPORARY RETAINING WALL DESIGN WILL BE EVALUATED AS PART OF THE FINAL DESIGN. SEE TEXT OF REPORT AND FIGURE 5.12 FOR CONCEPTUAL DESIGN RECOMMENDATIONS.

2. REMOVE CONTAMINATED SEDIMENT BEGINNING NEAR TOP OF SLOPE AND WORKING DOWNWARD. BACKFILL EXCAVATION FROM BASE OF SLOPE TOWARD TOP OF SLOPE.

3. REMOVE OR CUT OFF TEMPORARY RETAINING WALL AFTER ZONE OF CONTAMINATED SEDIMENT HAS BEEN COMPLETELY BACKFILLED.

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RM11E Group **Willamette River - Portland, Oregon** **Draft Implementability Study Report**	GRI
Temporary Retaining Wall For Dredging	**Figure 5.8** July 31, 2015

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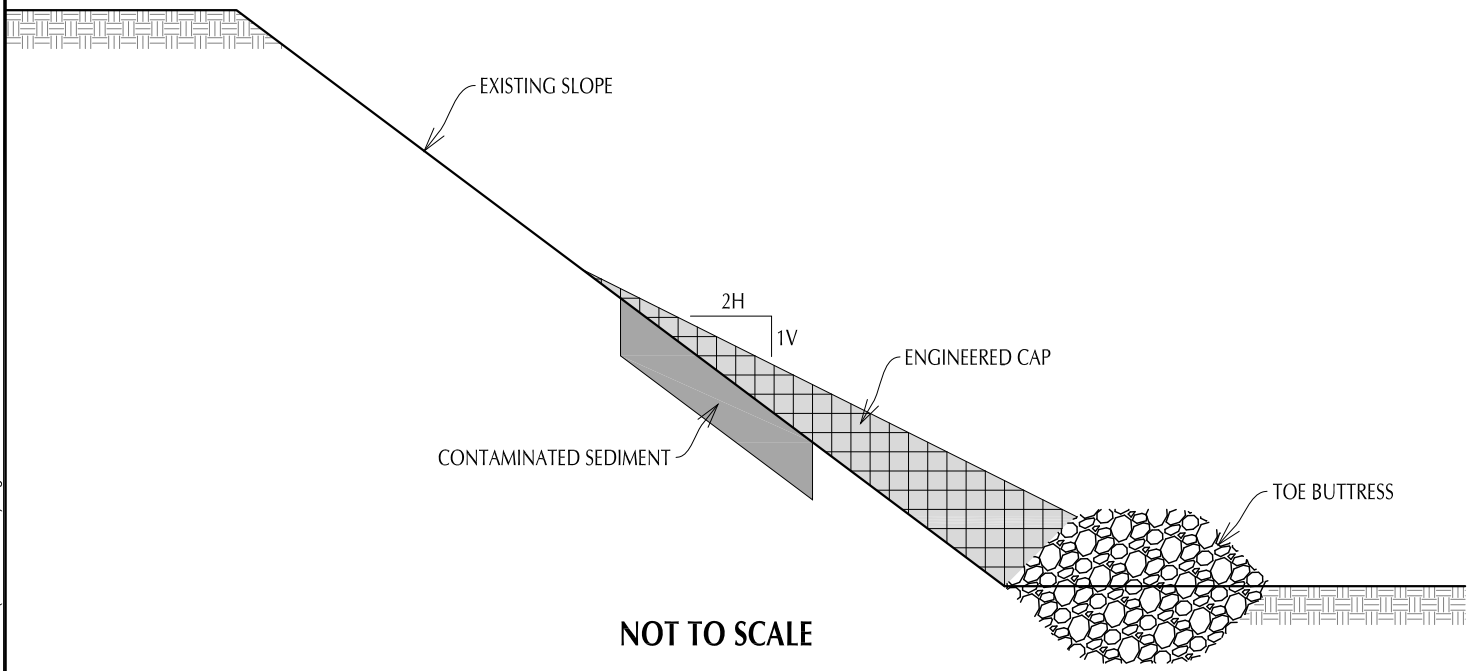

NOT TO SCALE

NOTES:

1. TOE BUTTRESS CONFIGURATION SHOULD BE EVALUATED AS PART OF FINAL DESIGN.
2. SOFT OR LOOSE SEDIMENTARY MATERIAL MAY NEED TO BE REMOVED PRIOR TO CONSTRUCTING BUTTRESS.
3. MAXIMUM INCLINATION OF CAPPING MATERIAL MAY NOT EXCEED 2H:1V.

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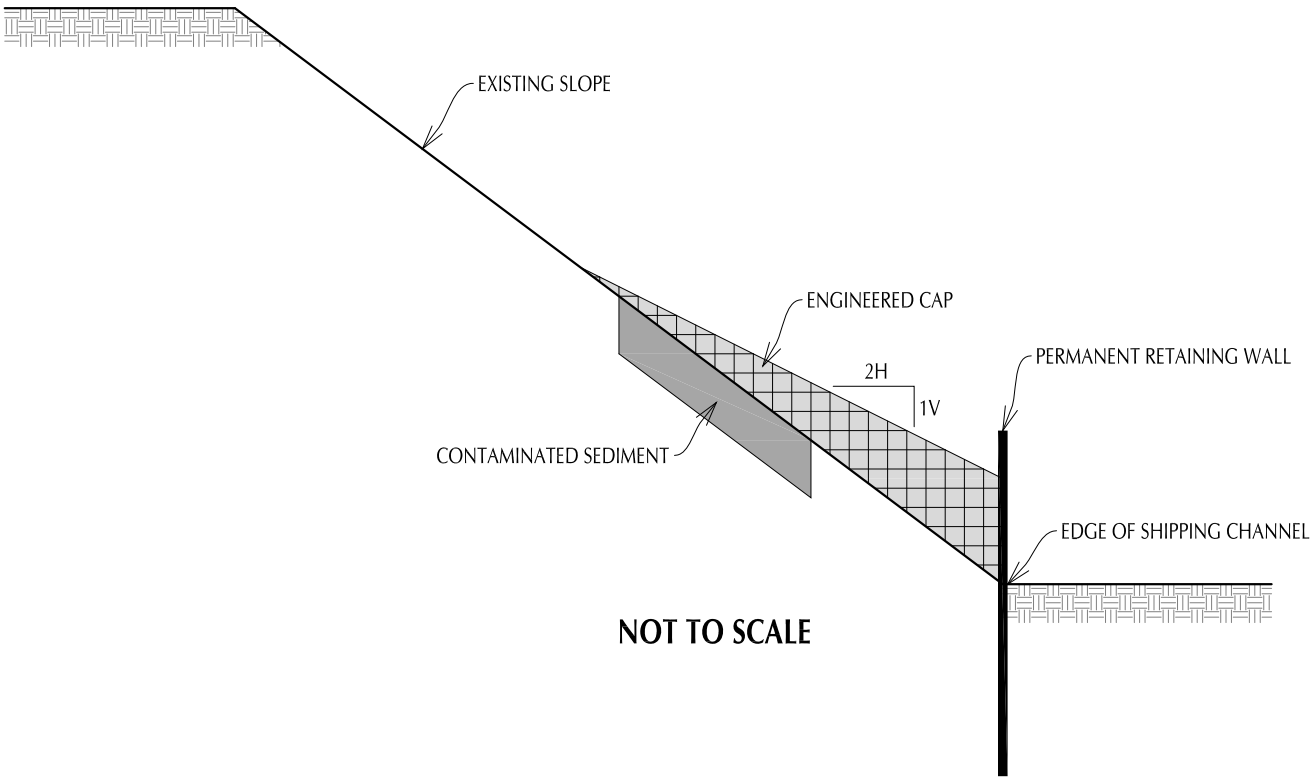
RM11E Group **Willamette River - Portland, Oregon** **Draft Implementability Study Report**	GRI
Toe Buttress With Engineered Cap	**Figure 5.9** July 31, 2015

PLOT TIME: 7/29/2015 12:24 PM MOD TIME: 7/29/2015 12:23 PM USER: Lee DWG: P:\5401-5500\5445 River Mile 11 Consultation\Drafting\ISR REPORT\5445 DETAILS (FIGS 5.7 - 5.11).dwg



NOTES:

1. RETAINING WALL DESIGN SHOULD BE EVALUATED AS PART OF THE FINAL DESIGN. SEE TEXT OF REPORT AND FIGURE 5.12 FOR CONCEPTUAL DESIGN RECOMMENDATIONS.

2. MAXIMUM INCLINATION OF CAPPING MATERIAL MAY NOT EXCEED 2H:1V.

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RM11E Group **Willamette River - Portland, Oregon**	GRI
Draft Implementability Study Report **Permanent Retaining Wall With Engineered Cap**	**Figure 5.10** July 31, 2015

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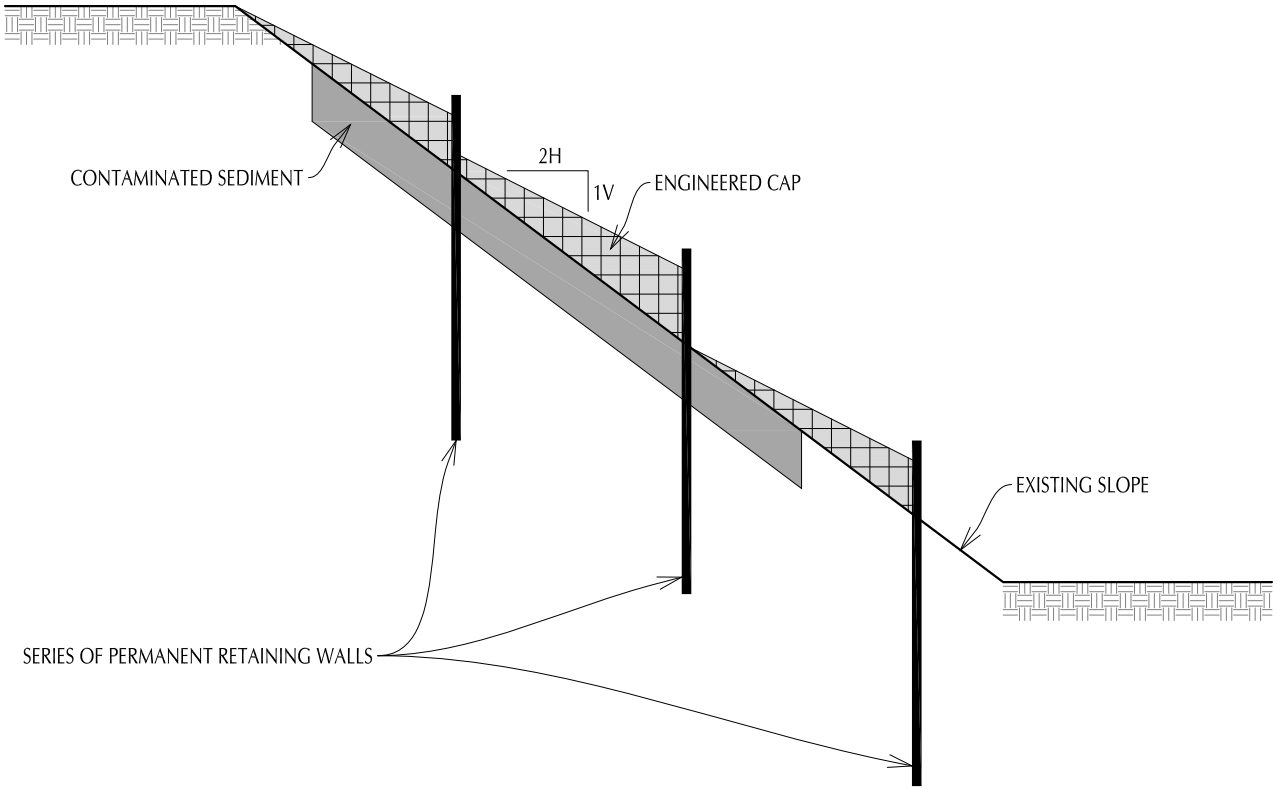

NOT TO SCALE

NOTES:

1. RETAINING WALL DESIGN SHOULD BE EVALUATED AS PART OF THE FINAL DESIGN. SEE TEXT OF REPORT AND FIGURE 5.12 FOR CONCEPTUAL DESIGN RECOMMENDATIONS.
2. SPACING OF PERMANENT RETAINING WALLS WILL DEPEND ON INCLINATION OF EXISTING SLOPES, EXTENT OF CONTAMINATED SEDIMENT, AND OTHER FACTORS.
3. MAXIMUM INCLINATION OF CAPPING MATERIAL MAY NOT EXCEED 2H:1V.

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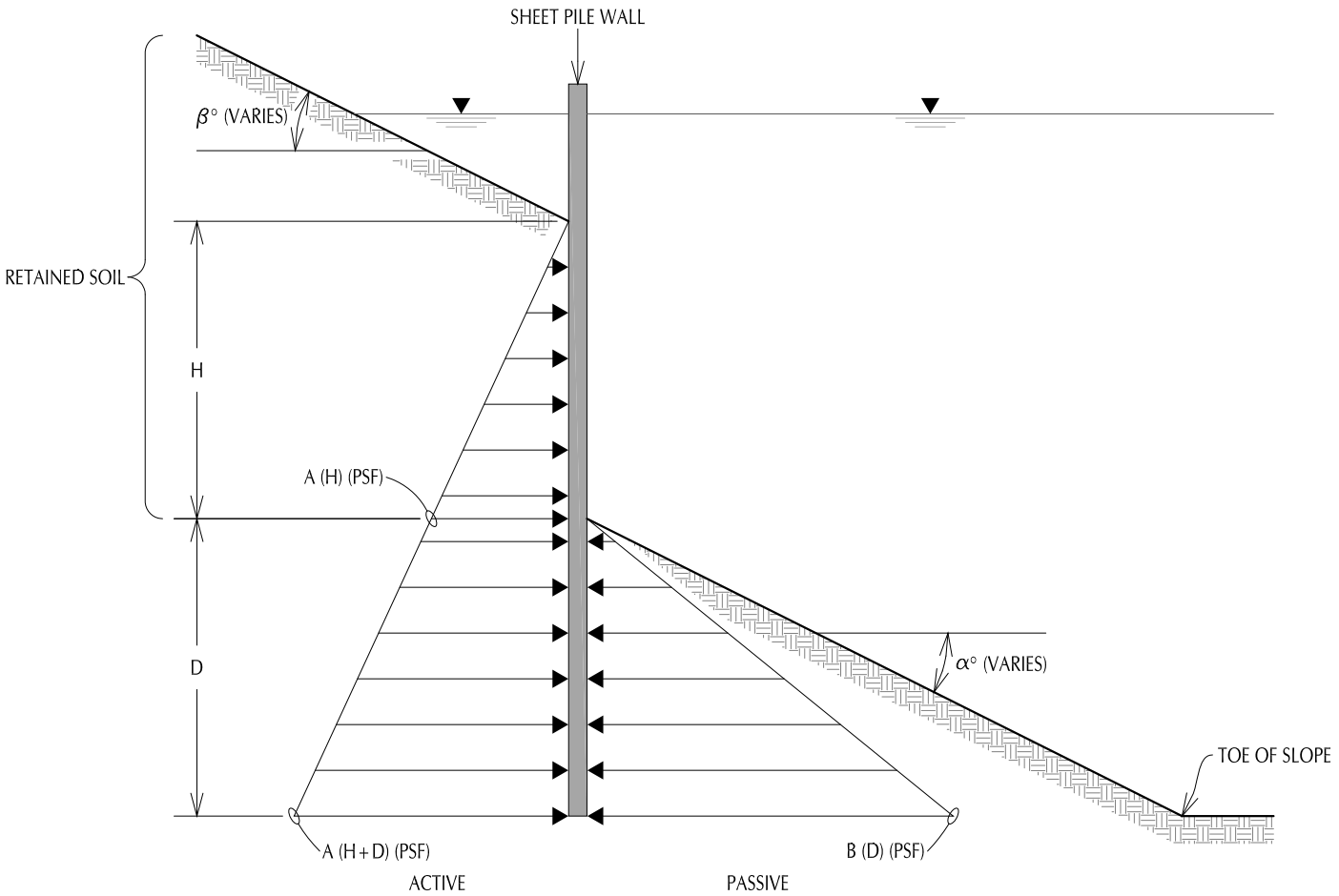
RM11E Group **Willamette River - Portland, Oregon**	GRI
Draft Implementability Study Report	
Series of Permanent Upslope Retaining Walls	**Figure 5.11** July 31, 2015

PLOT TIME: 7/29/2015 12:26 PM MOD TIME: 7/29/2015 12:23 PM USER: Lee DWG: P:\5401-5500\5445 River Mile 11 Consultation\Drafting\ISR REPORT\5445 DETAILS (FIGS 5.7 - 5.11).dwg



NOT TO SCALE

NOTES:

1. LATERAL EARTH PRESSURE DIAGRAM IS FOR A SHEET PILE WALL AND ASSUMES THE RETAINED SOIL IS COMPLETELY SUBMERGED AND CONSISTS OF NATIVE SAND AND GRAVEL OR IMPORTED CAPPING MATERIAL.
2. LATERAL EARTH PRESSURE DIAGRAMS ARE FOR CONCEPTUAL PLANNING PURPOSES ONLY AND SHOULD BE FURTHER EVALUATED AS PART OF FINAL DESIGN.
3. SURCHARGE EFFECTS FROM ADJACENT STRUCTURES SHOULD BE ADDED TO THE ABOVE CONCEPTUAL LATERAL EARTH PRESSURES AND FURTHER EVALUATED AS PART OF FINAL DESIGN.
4. SEISMIC EARTH PRESSURES SHOULD BE EVALUATED AS PART OF FINAL DESIGN.
5. THE EQUIVALENT FLUID WEIGHTS, A AND B, ARE DEPENDENT ON THE BACK SLOPE ANGLE, β, AND THE FRONT SLOPE ANGLE, α. SEE EMBEDDED TABLE FOR EQUIVALENT FLUID WEIGHTS CORRESPONDING TO BACK SLOPE AND FRONT SLOPE ANGLES OF 2H:1V (26.5°) OR FLATTER.
6. THE PASSIVE PRESSURE OF FRONT SLOPES STEEPER THAN 2H:1V SHOULD BE REDUCED TO ACCOUNT FOR POTENTIAL LONG-TERM INSTABILITY OF THESE OVERSTEEPENED SLOPES. FOR OVERSTEEPENED FRONT SLOPES, THE EMBEDMENT DEPTH, D, IS THE DISTANCE BETWEEN THE BOTTOM OF THE WALL AND A POINT EXTENDING ON AN IMAGINARY LINE INCLINED AT 2H:1V FROM THE TOE OF THE SLOPE.
7. PASSIVE PRESSURE HAS BEEN REDUCED BY A FACTOR OF SAFETY OF 1.5 TO LIMIT DEFORMATIONS TO LESS THAN 2 TO 3% OF THE EMBEDDED DEPTH, D.
8. FOR LONG-TERM STABILITY CONSIDERATIONS, THE BACK SLOPE BEHIND THE WALL MAY NOT EXCEED 2H:1V.

EQUIVALENT FLUID WEIGHT MULTIPLIER

SLOPE ANGLE, α, β	SLOPE	A (PCF)	B (PCF)
0°	LEVEL	16	143
14.0°	4H: 1V	18	79
18.4°	3H: 1V	20	60
21.8°	2.5H: 1V	21	48
26.6°	2H: 1V	22	35

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Draft Implementability Study Report

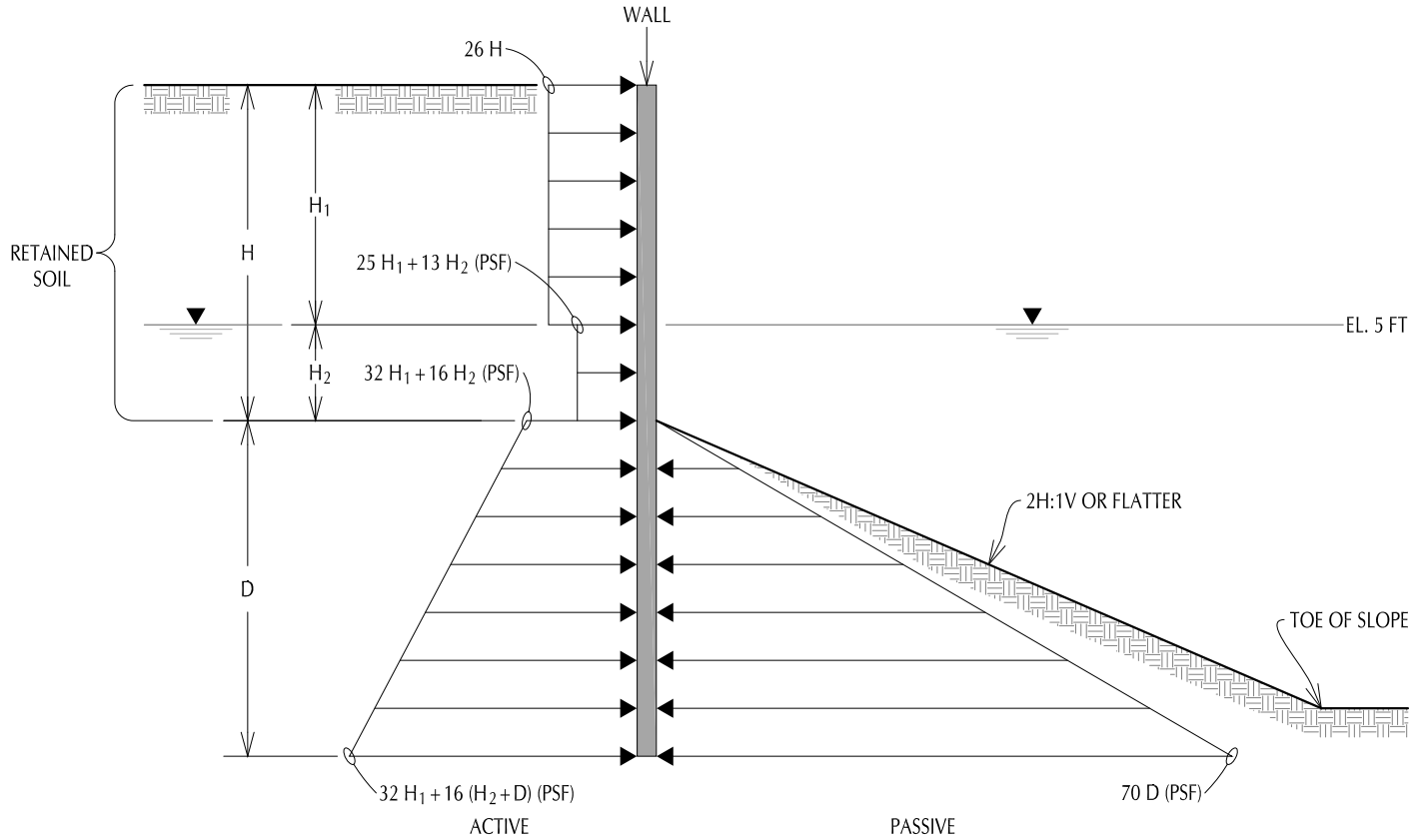
Lateral Earth Pressures (Cantilever Sheet Pile Toe Wall)

GRI

Figure 5.12

July 31, 2015

PLOT TIME: 7/29/2015 1:29 PM MOD TIME: 7/29/2015 1:29 PM USER: Lee DWG: P:\5401-5500\5445 River Mile 11 Consultation\Drafting\ISR REPORT\5445-LATERAL EARTH PRESSURE DIAGRAMS (FIGS 5.12 - 5.14).dwg



NOT TO SCALE

NOTES:

1. LATERAL EARTH PRESSURE DIAGRAM IS FOR A SOLDIER PILE AND LAGGING WALL WITH AT LEAST ONE ROW OF TIEBACKS AND LEVEL BACK SLOPE.
2. LATERAL EARTH PRESSURE DIAGRAM ASSUMES RETAINED SOIL CONSIST OF FILL, AND SOIL LOCATED WITHIN THE EMBEDDED DEPTH, D, IS NATIVE SAND AND GRAVEL.
3. LATERAL EARTH PRESSURE DIAGRAMS ARE FOR CONCEPTUAL PLANNING PURPOSES ONLY AND SHOULD BE FURTHER EVALUATED AS PART OF FINAL DESIGN.
4. SURCHARGE EFFECTS FROM ADJACENT STRUCTURES SHOULD BE ADDED TO THE ABOVE CONCEPTUAL LATERAL EARTH PRESSURES AND FURTHER EVALUATED AS PART OF FINAL DESIGN.
5. SEISMIC EARTH PRESSURES SHOULD BE EVALUATED AS PART OF FINAL DESIGN.
6. LAGGING SHOULD EXTEND AT LEAST TO THE POINT WHERE A 2H:1V PLANE EXTENDING FROM THE TOE OF THE SLOPE INTERSECTS THE WALL. PASSIVE RESISTANCE THAT DEVELOPS ABOVE AN EXTENDED 2H:1V SLOPE SHOULD BE NEGLECTED IN DESIGN.
7. PASSIVE PRESSURE HAS BEEN REDUCED BY A FACTOR OF SAFETY OF 1.5 TO LIMIT DEFORMATIONS TO LESS THAN 2 TO 3% OF THE EMBEDDED DEPTH, D. PASSIVE RESISTANCE SHOULD BE APPLIED OVER ONE PILE DIAMETER ASSUMING A MINIMUM SOLDIER PILE SPACING OF THREE DIAMETERS.
8. WITHIN ZONE OF LAGGING, ASSUME ACTIVE PRESSURE ACTS OVER CENTER-TO-CENTER PILE SPACING. BELOW LAGGING, ACTIVE PRESSURE ACTS OVER ONE PILE DIAMETER.

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RM11E Group **Willamette River - Portland, Oregon** **Draft Implementability Study Report**	GRI
Lateral Earth Pressures (Anchored Soldier Pile Wall)	**Figure 5.13** July 31, 2015

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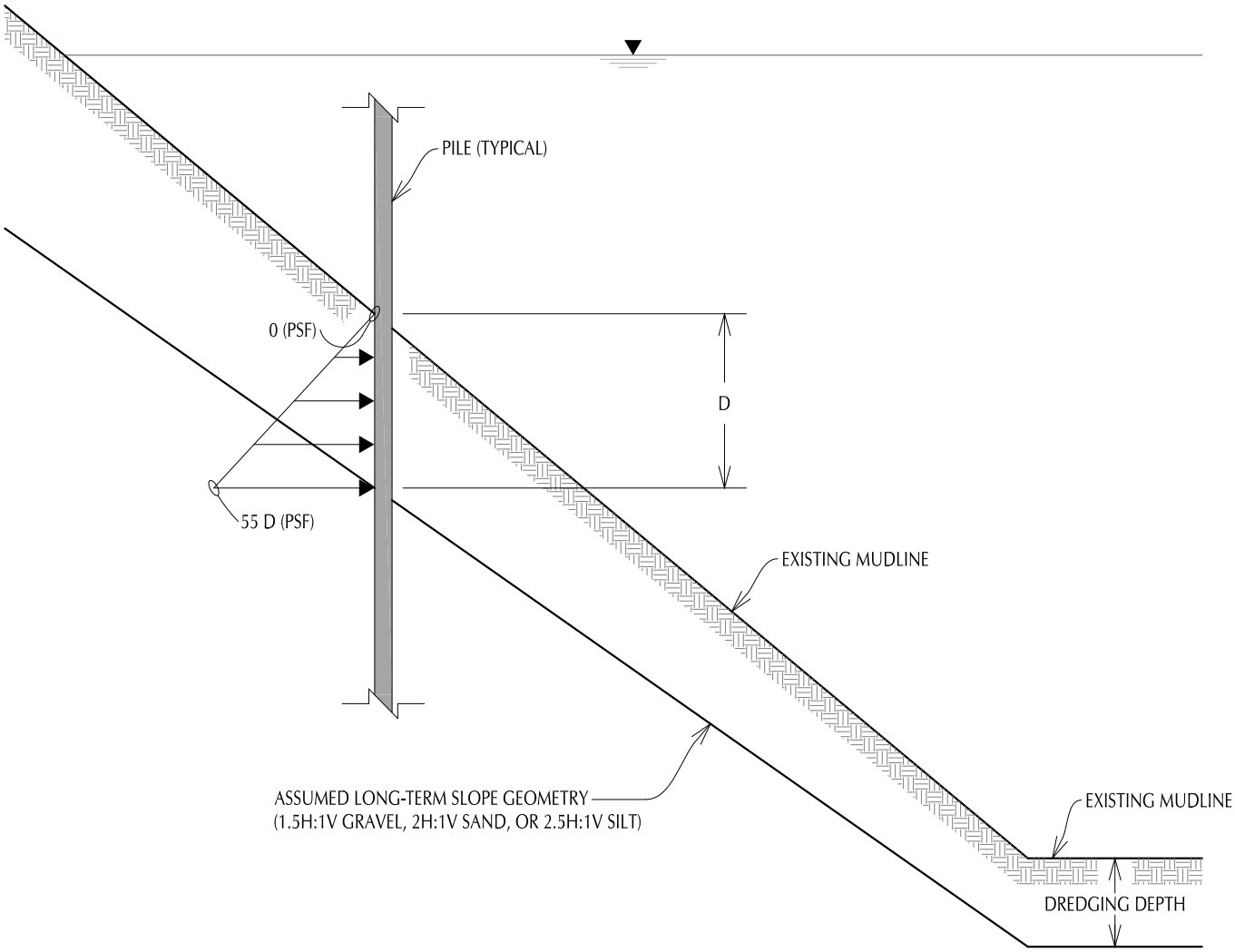

NOT TO SCALE

NOTES:

1. ASSUMES TYPICAL LONG-TERM MAXIMUM INCLINATION OF SLOPES COMPOSED PRIMARILY OF SILT IS 2.5H:1V, SAND IS 2H:1V, AND GRAVEL IS 1.5H:1V.
2. PORTION OF PILES LOCATED ABOVE TYPICAL MAXIMUM SLOPE INCLINATION ARE SUBJECT TO ADDITIONAL LATERAL LOAD DUE TO DOWNWARD SOIL MOVEMENT OF THE OVER STEEPENED SLOPE.
3. LATERAL LOAD ON PILE CAN BE ESTIMATED USING A TRIANGULAR PRESSURE DISTRIBUTION INCREASING FROM 0 PSF AT THE EXISTING MUDLINE ELEVATION TO 55D PSF AT THE EMBEDDED DEPTH, D, CORRESPONDING TO THE MAXIMUM LONG-TERM STABLE SLOPE. THIS LATERAL LOAD SHOULD BE APPLIED OVER ONE PILE DIAMETER.
4. LATERAL LOAD ON PILES IS FOR CONCEPTUAL PLANNING PURPOSES ONLY AND SHOULD BE FURTHER EVALUATED AS PART OF FINAL DESIGN.
5. SEISMIC EARTH PRESSURES SHOULD BE EVALUATED AS PART OF FINAL DESIGN.
6. LATERAL LOAD ASSUMES SUBMERGED SOIL CONDITIONS.

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RM11E Group **Willamette River - Portland, Oregon** **Draft Implementability Study Report**	GRI
Post-Dredging Lateral Loads on Piling	**Figure 5.14** July 31, 2015

PLOT TIME: 7/29/2015 12:19 PM MOD TIME: 7/29/2015 12:17 PM USER: Lee DWG: P:\5401-5500\5445 River Mile 11 Consultation\Drafting\ISR REPORT\5445-LATERAL EARTH PRESSURE DIAGRAMS (FIG'S 5.12 - 5.14).dwg

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6. STRUCTURAL ASSESSMENT

6.1 OBJECTIVE

The objective of this structural assessment is to evaluate the potential effects of dredging and capping alternatives on the existing waterfront and offshore structures (e.g., docks, dolphins, walls, buildings) and to summarize structural considerations for the RM11E Project Area that may influence the selection of remedial alternatives and remedial design.

The structural assessment is based upon drawings, reports, and other descriptive materials provided by the property owners for their existing facilities, when available, and upon visual observations. Where drawings were not available for a given structure, a narrative overview of potential impacts is provided. This assessment provides general condition assessments for the structures and describes likely risks to structures from potential remedial actions. This report does not develop as-built drawings or provide in-depth structural condition assessments, detailed structural engineering analysis, or designs for specific structures.

6.2 EXISTING STRUCTURAL DOCUMENTS USED AS THE BASIS OF THE STRUCTURAL ENGINEERING ANALYSIS

Requests for documents related to the significant existing waterfront and offshore structures present within the RM11E Project Area were sent to each waterfront facility in questionnaire format in late 2014. The questionnaire requested structural as-built drawings and repair or maintenance records as well as other non-structural data from each recipient. Documents received from respondents for each significant structure within the RM11E Project Area are listed in Table 6.1; these documents were used as the basis for the structural engineering assessment. Significant structures are defined as dolphins, piers, docks, walls over 4 feet tall supporting vertical loads or retaining soil, occupied buildings, and materials storage facilities such as silos. Table 6.1 also introduces a structure ID numbering system that is used throughout this assessment. Maps and photographs identifying these structures are shown in Figures 6.1 to 6.7.

Three waterfront facilities (Glacier NW, Cargill, and Stan Herman) responded to the questionnaire and produced structural documents, while five others either did not respond or did not have structural documents. As a result, this assessment lacks relevant structural information for numerous significant structures within or in the immediate vicinity of the RM11E Project Area. Additional efforts to acquire structure information should be undertaken as part of future remedial design in and near areas of planned active remediation. If the documentation describing existing structures is insufficient, then additional structural investigations and inspections may be needed as part of remedial design.

TABLE 6.1 – EXISTING STRUCTURAL DOCUMENTS USED AS THE BASIS OF STRUCTURAL ENGINEERING ANALYSES

FACILITY	STRUCTURE ID	STRUCTURE TYPE	STRUCTURAL DOCUMENTS RECEIVED[a]
Sakrete	S-1	Dock	None
	S-2	Building	None
Stan Herman	SH-1	Building	18
ODOT	BR-1	Bridge (Fremont)	None
RIS&G	R-1	Dolphins	None
	R-2	Silos	None
	R-3	Retaining wall	None
Glacier NW	G-1	Barge dock	1, 2, 3, 5
	G-1a-G-1c	Dolphins	None
	G-2	Main dock	9, 10, 11
	G-2a	North main dock	9, 10, 11
	G-2b	South main dock	9, 10, 11
	G-2c	Dolphin	7,8
	G-2d	Dolphin	7,8
	G-2e	Dolphin	9, 11
	G-2f	Dolphin	7,8
	G-2g	Dolphin	7,8
	G-2h	Walkway	9,10
	G-2i	Walkway	9,10
	G-2j	Walkway	9,10
	G-3	Cement storage dome	4
	G-4	Silos	None
Unkeles	U-1	Retaining wall	None
Cargill	C-1	Ocean vessel dock	
	C-1a	Main pier	15, 17
	C-1b(1) to C-1b(5)	Breasting dolphins	15,17
	C-1c(1) to C-1c(7)	Ship loader towers	15
	C-1d	Shore-to-dock walkway	15
	C-2	Most-downstream mooring dolphin (in front of Unkeles property, as viewed from the river)	None
	C-3	Abandoned pier	None
	C-4	Soldier pile wall	14,16
	C-5	Buried concrete shaft wall	13
	C-6	Silos	None
	C-7	Building (admin. and weighing)	None
	C-8	Building	None

[a] Referenced structural documents:

1. J. Cameron McKernan Company, *River Street Barge Pier Replacement,* Site Plan No. 0005-01C-1 Rev C – July 19, 2002
2. J. Cameron McKernan Company, *River Street Barge Pier Replacement Side and Front Elevations*, Site Plan No. 0005-03B-1 Rev B – July 19, 2002
3. J. Cameron McKernan Company, *River Street Barge Pier Replacement Bent Sections*, Site Plan No. 0005-04B-1 Rev B – January 19, 2002

4. Geotechnical Resources, Inc.,, Geotechnical Investigation, Proposed Bulk Cement Storage Dome, Lone Star Marine Terminal, revised June 22, 1994
5. J. Cameron McKernan Company, *Pile Driving Analysis and Driving Records*, May 22, 2003
6. Not used
7. Geotechnical Resources, Inc., *Marine Facility Upgrade*, Pile Strength Recommendations, July 6, 1993
8. Sundial, *Pile Driving Records – Dolphin1 1-4*, 1989 – 1992
9. Harris Group Inc., Marine Facilities Rehabilitation, structural drawings, July 22, 1993
10. Harris Group Inc., Marine Facilities Upgrade Portland Terminal Lone Star Northwest, Structural Calculations July 20, 1993
11. Harris Group Inc., *Lone Star Northwest Marine Facility Upgrade Section D, Pier Computer Run*, Structural Calculations, June 16, 1993
12. US Army Corps of Engineers, Portland District, *OSL0007237 USACE-DSL Joint Permit Application to Replace Pier (23383-NSP)*, November 11, 2000
13. Smith & Monroe & Gray Engineers Inc., *Cargill Grain Irving Elevator Site Slope and Stability Plans*, Rev 1 August 12, 1997
14. Smith & Monroe & Gray Engineers Inc., *Cargill Grain Irving Elevator Site Maintenance Shop Retaining Wall,* Rev F, April 6, 1998
15. Alpha Technical Group, Inc., *Irving Street Dock Inspection,* October 29, 2012
16. Geotechnical Resources, Inc., *Geotechnical Investigations, Phase 2 and 3, Riverbank Slope Stabilization at Cargill Grain's Irving Elevator,* June 12, 1998
17. Department of the Army Permit No. NWP-2001-31-2
18. Department of Environmental Quality, Warning Letter With Opportunity to Correct, July 2, 2014

6.3 EXISTING STRUCTURE DESCRIPTIONS AND APPARENT CONDITION

This section identifies structures within the RM11E Project Area that are relevant to this assessment and provides an overview of these structures' characteristics; locations are indicated on Figures 6.2 through 6.7. Relevant structures include all significant shoreline structures with foundations in the river or its eastern bank and significant upland structures located within approximately 100 feet from the top-of-bank. This section does not discuss outfalls or utilities, because they are included in descriptions in Section 3.5.3 and Table 3.5.

The structure descriptions and condition assessments that follow are generally presented in order from downstream to upstream. This section describes each waterfront facility's significant shoreline and upland structures based on the information sources cited in Table 6.1 and KPFF's limited visual observations. The observations were limited to conditions visible from a boat traveling dozens of feet away from the shoreline structures and conditions visible from walk-throughs at deck level along the docks.

6.3.1 SAKRETE PROPERTY

Sakrete's property is located at the downstream end of the RM11E Project Area approximately between PM 10.85 and PM 10.98. Nearby structures include a waterfront pile-supported timber dock (Dock S-1) (Photo 1, Figure 6.2) and an upland building (building S-2). No drawings or reports for the dock were available to review at the time of this assessment's preparation; however, the dock is estimated to be 180 feet long by 30 feet wide. No drawings or reports for the upland building structure were available to review at the time of this assessment's preparation; however, the nearest side of the building is estimated to be approximately 50 feet inland from the top of the bank. Apparent structural conditions are noted in Table 6.2.

TABLE 6.2 – SAKRETE: APPARENT STRUCTURAL CONDITION EVALUATION FOR SHORELINE STRUCTURES

SITE	STRUCTURE ID	STRUCTURE TYPE	APPARENT DECAY, DETERIORATION, OR DISTRESS?
Sakrete	S-1	Dock	No
	S-2	Building	Not evaluated

6.3.2 STAN HERMAN PROPERTY

The Stan Herman property is downstream of the Fremont Bridge approximately between PM 10.98 and PM 11.04. Waterfront structures consist of only a warehouse-type structure (building SH-1) extending over the water and supported on timber piles (Photos 2 and 3, Figure 6.2). No drawings for the building were available to review at the time of this assessment's preparation; however, the building is estimated to be approximately 250 feet long across the waterfront and extends approximately 90 feet riverward from the top-of-bank. Portions of the building have collapsed into the river (Photos 2 and 3 in Figure 6.2). (Apparent structural conditions are noted in Table 6.3.) Oregon Department of Environmental Quality (ODEQ) issued a warning letter to Stan Herman on July 2, 2014 noting that the site was inspected by ODEQ and that "building debris was present in the Willamette River at the northern end of the structure where the collapse had occurred, and additional portions of the building appeared to be in imminent danger of falling into the river." The ODSL sent a notice of default on the maintenance requirements of the property's waterway lease on June 18, 2014. Significant repair to the building since these letters has not been observed. The condition and potential implications of this derelict building will need to be considered in the remedial design if active remediation is required in this area.

TABLE 6.3 – STAN HERMAN: APPARENT STRUCTURAL CONDITION EVALUATION FOR SHORELINE STRUCTURES

SITE	STRUCTURE ID	STRUCTURE TYPE	APPARENT DECAY, DETERIORATION, OR DISTRESS?
Stan Herman	SH-1	Building	Yes

6.3.3 ODOT PROPERTY

The Fremont Bridge spans the Willamette River within the limits of the RM11E Project Area. A major bridge pier with deep foundations (Bridge BR-1) lies between the Stan Herman property and the RIS&G property approximately between PM 11.04 and PM 11.08 (Figure 6.2). Specific information on the bridge structure and foundations should be gathered and evaluated during remedial design if active remediation is planned in the bridge area. Apparent structural conditions are noted in Table 6.4.

TABLE 6.4 – ODOT: APPARENT STRUCTURAL CONDITION EVALUATION FOR SHORELINE STRUCTURES

SITE	STRUCTURE ID	STRUCTURE TYPE	APPARENT DECAY, DETERIORATION, OR DISTRESS?
ODOT	BR-1	Bridge	No

6.3.4 RIS&G PROPERTY

The RIS&G property is located upstream of the Fremont Bridge approximately between PM 11.08 and PM 11.15. Waterfront structures include a series of mooring dolphins (Photo 1, Figure 6.3) and an L-shaped (in plan) concrete bulkhead wall (Photos 2 and 3, Figure 6.3). There are storage silos and permanently located heavy lifting equipment near the top of the bank. The silos and heavy equipment would impart significant surcharge loads on the property's shoreline slopes unless founded on deep foundations. As-built drawings describing their foundation types were not available at the time this assessment was prepared.

Each dolphin consists of a cluster of battered and plumb steel piles aligned parallel to the harbor line. The bulkhead wall extends out beyond the natural shoreline and consists of stacked precast concrete blocks with steel frames riverward of the wall that serve as braces. There is visible evidence of repeated partial wall collapses in 2008 and 2009. Since these partial collapses, the wall has been repaired several times (Photos 2 – 7, Figure 6.3). Another steel bracing frame was added south of the south face of the wall since the last partial collapse at some time between September 2009 and October 2013. Given its height and location, the wall may have some type of tieback anchors; however, there was no visible evidence that tiebacks are present. The wall appears to extend down to the mudline near -10 feet NAVD88 and up to the top of the bank grade near +30 feet NAVD88. No drawings or reports for the dolphins, concrete wall, or silos present at the RIS&G Property were available to review at the time this report was prepared.

Apparent structural conditions are noted in Table 6.5.

TABLE 6.5 – RIS&G: APPARENT STRUCTURAL CONDITION EVALUATION FOR SHORELINE STRUCTURES

SITE	STRUCTURE ID	STRUCTURE TYPE	APPARENT DECAY, DETERIORATION, OR DISTRESS?
RIS&G	R-1	Dolphins	No
	R-2	Silos	Not evaluated
	R-3	Retaining wall	No[a]

[a] Historical photos indicate the wall has experienced partial failures in recent years.

6.3.5 GLACIER NW PROPERTY

6.3.5.1 General Arrangement

The Glacier NW property extends approximately from PM 11.15 to PM 11.35 and is between the downstream RIS&G property and the upstream Unkeles property. Waterfront structures include a barge dock, an ocean vessel dock (the main dock), dolphins, and elevated connecting walkways

(Figures 6.4 and 6.5). Upland structures include a cement dome, silos, and office buildings (Figures 6.4 and 6.5).

The following subsections describe general structural characteristics and the apparent condition of each significant waterfront structure on the Glacier NW property and how those structures may impact and be impacted by potential future remedial actions.

6.3.5.2 Barge Dock and Dolphins

The barge dock, structure G-1, is located near the downstream limits of Glacier NW's property. This structure was built circa 2002. Based on available drawings (McKernan, 2002a, 2002b, and 2002c) and structural calculations (McKernan, 2002d), the barge dock is 75 feet long by 20 feet wide. It consists of two flatbed railcars that span between pier bents and serve as the dock's deck. Pier bents consist of driven steel H-piles. KPFF observations confirmed that as-built conditions appear to be consistent with the pier descriptions noted above. According to the McKernan calculations, the piles were assumed to be fixed approximately 10 feet below mudline and were designed for a minimum 60-ton bearing capacity. Pile driving results from the dock's original construction were monitored and recorded by J. Cameron McKernan Co. in a May 2003 (McKernan, 2003). These records indicate that the most riverward row of piles was embedded approximately 10 feet and that the piles terminated approximately at.-27 feet CRD (-21.67 NAVD88). The records include tip elevation, embedment, and bearing capacity for each of the barge dock's piles. This information should be reviewed and evaluated as part of remedial design.

There are three mooring dolphins near the barge dock. Dolphin G-1c is upstream of the barge dock (G-1) and consists of five battered and plumb steel piles. Historical plans indicate the piles were embedded approximately 30 feet below mudline at the time of installation. The other two nearby dolphins, G-1a and G-1b, are downstream of the barge dock. Records indicate these two dolphins were constructed prior to the barge dock, circa 1993. No drawings or pile installation records for these two dolphins were available at the time of this assessment.

6.3.5.3 Main Dock and Dolphins

Glacier NW's main dock consists of north and south docks (G-2a and G-2b, respectively), four breasting dolphins (G-2c, G-2d, G-2f, G-2g), and one smaller dolphin (G-2e). Railcar walkways (G-2h, G-2i) run parallel to the harbor line spanning between dolphins and docks.

According to as-built drawings (Harris, 1993), the north dock structure, G-2a, is 112 feet long by 50 feet wide and consists of a two-way reinforced concrete deck slab supported on steel pipe piles. Battered steel pipe piles in combination with the concrete deck diaphragm provide lateral support to the north dock. The south dock structure, G-2b, is approximately 140 feet upstream of the north dock. The south dock is similar in structure to the north dock, except that the width of the south dock expands from 50 feet wide at the river end to 90 feet wide at the shore end. Existing drawings indicate piles for dock structures G-2a and G-2b were embedded at least 50 feet below mudline at the time of construction. Both docks were constructed circa 1993.

Each breasting dolphin consists of a cluster of plumb and battered steel H-piles. According to pile driving records, breasting dolphins G-2c, G-2d, and G-2f consist of 14 piles, breasting dolphin G-2e consists of 3 piles, and breasting dolphin G-2g consists of 22 piles. The dolphins were constructed between 1989 and 1993. Estimated pile embedments based on existing drawings and reports are as shown in Table 6.6.

TABLE 6.6 – ESTIMATED GLACIER NW PILE EMBEDMENTS

DOLPHIN	ESTIMATED EMBEDMENT (FT BELOW MUDLINE)	ESTIMATED MUDLINE AT FACE OF DOLPHINS AND SLOPE AT TIME OF INSTALL
G-2c	22 to 34	-35 ft CRD; 1.75H:1V
G-2d	22 to 34	-35 ft CRD; 1.75H:1V
G-2e	50	-35 ft CRD; 1.75H:1V
G-2f	32 to 54	-35 ft CRD; 1.75H:1V
G-2g	20 to 36	-35 ft CRD; 1.75H:1V

There are three elevated walkway structures along the harbor line of the north and south docks: north railcar walkway G-2h runs between the downstream dolphin and the north dock; middle railcar walkway G-2i runs between the north and south docks; and south railcar walkway G-2j runs between the south dock and the upstream dolphin. The walkways consist of flatbed railcars supported on intermediate steel pile bents or on dolphins or docks. The walkways were constructed along with the main docks circa 1993.

A large, high-capacity, mobile ship unloading device moves between the north and south docks (Photo 3, Figure 6.5). At the time of the structural observations, this equipment was being stored on the south dock.

6.3.5.4 Upland Structures

Several building structures at the Glacier NW Property lie within about 100 feet of the top of the bank and are therefore within the potential shoreline slope influence zone. A cement storage dome (building G-3) is upland of the barge dock (G-1). In addition, several tall storage silos (silos G-4) are located upstream of the cement dome.

The *Geotechnical Investigation, Proposed Bulk Cement Storage Dome, Lone Star Marine Terminal, Portland, Oregon* (GRI, 1994) suggests the cement dome could have been founded on continuous strip footings. According to personal recounts from a Glacier NW operator, the cement dome was founded on a continuous, steel-reinforced concrete "ring beam" and the edges of the dome were secured to the ring beam. The Glacier NW operator further recounts that a tunnel beneath the dome was constructed on top of existing buried piles, that the piles were cut to the elevation needed for the bottom of the tunnel, and that compacted gravel was placed around the existing (cut) piles. However, no as-builts were available to confirm either entity's assertions. If the cement dome is founded on spread footings, it would have a significant impact on bank stability. If the cement dome is founded on piles, the dome would likely have less impact on bank stability than spread footings.

The silos are likely founded on deep foundations and would thus have a lower impact on bank stability than if founded on shallow spread footings. However, silo as-built drawings confirming this assumption were not available at the time this assessment was prepared.

Apparent structural conditions of the shoreline and upland structures are noted in Table 6.7.

TABLE 6.7 – GLACIER NW: APPARENT STRUCTURAL CONDITION EVALUATION FOR SHORELINE STRUCTURES

SITE	STRUCTURE ID	STRUCTURE TYPE	APPARENT DECAY, DETERIORATION, OR DISTRESS?
Glacier NW	G-1	Barge dock	No
	G1-a, G1b, G1c	Dolphins	No
	G-2	Main dock	No
	G-2a	North main dock	No
	G-2b	South main dock	No
	G-2c	Dolphin	No
	G-2d	Dolphin	No
	G-2e	Dolphin	No
	G-2f	Dolphin	No
	G-2g	Dolphin	No
	G-2h	Walkway	No
	G-2i	Walkway	No
	G-2j	Walkway	No
	G-3	Cement storage dome	Not evaluated
	G-4	Silos	Not evaluated

6.3.6 UNKELES

Riverward of the Unkeles property is one retaining wall structure (wall U-1) that appears to consist of timber piles and timber lagging (Photo 8, Figure 6.6). No drawings or reports for the wall were available to review at the time this assessment was prepared. Apparent structural conditions of this wall are noted in Table 6.8.

TABLE 6.8 – UNKELES: APPARENT STRUCTURAL CONDITION EVALUATION FOR SHORELINE STRUCTURES

SITE	STRUCTURE ID	STRUCTURE TYPE	APPARENT DECAY, DETERIORATION, OR DISTRESS?
Unkeles	U-1	Retaining wall	No

6.3.7 CARGILL PROPERTY

6.3.7.1 General Arrangement

The Cargill, Inc. property extends approximately from PM 11.38 to PM 11.62 and is upstream of the Glacier NW and Unkeles properties. Waterfront structures include one timber dock, six dolphins, five ship loader support towers, tower-to-shore braces, elevated connecting walkways, and one barge dock (Figures 6.6 and 6.7). Although the barge dock is outside the defined limits of the RM11E Project Area, it could affect and be affected by remedial actions because of its close proximity. Upland structures include a steel soldier pile wall and several buildings and silos (Figures 6.6 and 6.7).

The following subsections describe the general structural characteristics and apparent condition of each significant waterfront structure on the Cargill property that may be impacted by potential future remedial actions.

6.3.7.2 Ocean Vessel Dock (also referred to as Main Dock)

The ocean vessel dock, also referred to as the main dock, consists of an array of structures (pier, dolphins, ship loader towers) linked together (Figure 6.7). The pier structure (C-1a) is 27 feet wide by 70 feet long and consists of a timber deck, timber framing, and 14-inch-diameter timber piles. The dock is located near the downstream end of the property. A concrete decked walkway structure (C-1d) supported on steel piles connects the shore to the ocean vessel dock. Original design drawings for the main dock or walkway back to shore were not available at the time of this assessment; pile embedments are thus unknown. An inspection report completed by Alpha Technical Group, Inc., dated October 29, 2012, provides general member sizes and dimensions for the main dock and rates each pile noting decay. On June 2, 2015, Temco received a proffered permit from the USACE to perform specified repairs of the main dock and ship and barge dolphins, including pile replacement.

Seven steel framed towers (towers C-1c1-7)) support the elevated ship loading device that runs the full length of the main dock. The towers consist of steel framing and steel H-piles. No as-built or design drawings for the tower frames were available. Each tower leg is braced back to the shore with a steel pipe member.

There are five breasting dolphins (dolphins C-1b (1-5)) along the face of the main dock. Each dolphin consists of a group of 18 battered and plumb steel H-piles with a steel cap plate and four steel pipe fender piles. Small gangways or walkways connect all five dolphins with the main dock and ship loading tower frames.

6.3.7.3 Retaining Walls

A tied-back, steel soldier pile wall (wall C-4) runs along the top of the bank beginning near the upstream end of the main dock and extends approximately 200 feet upstream. The wall was constructed circa 1998 and stabilizes the slope in front of an existing maintenance building. Original design drawings for the wall were prepared by Smith, Monroe, and Gray, dated April 6, 1998, and include revisions up to September 1, 1999 (Dwg. No. 96-142E-02). According to these drawings, the wall consists of driven W27 piles with steel plates serving as lagging between the piles. The top of the wall is at an elevation +33.0 feet (vertical datum not shown; see end of paragraph), while the bottom of the piles is shown at elevation -50 feet. A single waler and row of tieback anchors occurs near elevation +15.0 feet. The design drawings indicate riprap was placed in front of the wall up to elevation +8.0 feet. Wall lagging extends from the top of the wall down to 2 feet below the top of the riprap (at the time of construction). No vertical datum is shown on the drawings for the soldier pile wall; however drawings prepared by the same designer for the nearby wall structure (C-5) specify elevations based on the City of Portland Datum. Therefore, it is assumed the elevations cited for this soldier pile wall are based on the same vertical datum. City of Portland Datum is converted to NAVD88 by adding 2.10 feet.

Another tieback wall (wall C-5) is located near the top of the bank beginning at building C-7 and extending upstream for approximately 300 feet to building C-8. The wall was constructed circa 1997 and stabilizes the slope in front of these buildings. Original design drawings for the wall were prepared by Smith, Monroe, and Gray Engineers, dated June 16, 1997, and include as-built revisions up to April 7, 1998 (Dwg. Nos. 96-142D-01-07). According to these drawings, the wall

consists of 4-foot-diameter drilled concrete shafts spaced at 7 feet-0 inches on center and a continuous concrete cap cast across all shafts. The wall cap is tied back with strand anchors. The wall is buried with a top-of-cap beam near elevation +28 feet (City of Portland Datum) and a bottom of shaft located between elevations -32 feet and -37 feet (City of Portland Datum). City of Portland Datum is converted to NAVD88 by adding 2.10 feet.

6.3.7.4 Other Waterfront Structures

A barge mooring dolphin (dolphin C-2) is situated in front of the Unkeles property. The dolphin consists of a group of battered and plumb steel pipe piles and a concrete cap. A small elevated walkway connects the mooring dolphin to the shore. No drawings were available for this structure at the time this assessment was prepared.

There is an abandoned steel-pier-on-steel-pile structure (abandoned pier C-3) approximately 100 feet downstream of the main dock. The structure is not in use. No drawings were available for this structure at the time this assessment was prepared.

6.3.7.5 Upland Structures

Several structures have been built within approximately 100 feet of the top of the bank and thus are within the area where slope stability could potentially be affected by in-water remedial actions. These structures include a long row of concrete storage silos (silos C-6), a two-story truck dumper/office building (building C-7) in front of the silos, and a single-story maintenance building (building C-8) immediately behind the soldier pile wall. The silos may be founded on deep foundations; if so, they may have little impact on bank stability. However, a bank slope failure due to riverside remedial work could destabilize or pull the piles with the moving slope. The other two buildings (C-7 and C-8) are more likely founded on spread footings and would therefore impact bank stability. These structures also could be undermined if slope failure occurs. As-built drawings confirming these building and silo assumptions were not available at the time this assessment was prepared. Any existing additional available information concerning the stability of these structures should be acquired and reviewed during remedial design if active remediation is required in this area. If as-built drawings do not exist, then additional field inspections and testing of these upland structures and their foundations may need to be completed as part of remedial design.

Apparent structural conditions of the shoreline and upland structures are noted in Table 6.9.

TABLE 6.9 – CARGILL: APPARENT STRUCTURAL CONDITION EVALUATION FOR SHORELINE STRUCTURES

SITE	STRUCTURE ID	STRUCTURE TYPE	APPARENT DECAY, DETERIORATION, OR DISTRESS?
Cargill	C-1	Main dock/ocean vessel dock	Yes[a]
	C-1a	Main pier	Yes[a]
	C-1b(1-5)	Breasting dolphins	Yes[a]
	C-1c(1-7)	Ship loader towers	Yes[a]
	C-1d	Shore-to-dock walkway	No
	C-2	Most-downstream dolphin	No
	C-3	Abandoned pier	Yes
	C-4	Soldier pile wall	No
	C-5	Buried concrete shaft wall	Not evaluated
	C-6	Silos	Not evaluated
	C-7	Building	Not evaluated
	C-8	Building	Not evaluated
	C-9	Barge dock	Not evaluated

[a] Oct. 29, 2012 inspection report prepared by Alpha Technical Group, Inc. noted various levels of rot in structural timber elements and corrosion in structural steel elements

6.4 DATA AND APPROACH APPLIED TO STRUCTURAL ANALYSIS

6.4.1 GENERAL APPROACH TO ANALYSIS

Structural analyses in this assessment are conceptual only and site-specific or structure evaluations are limited. Further analysis for each individual significant structure will need to be completed during remedial design for areas where active remediation is required. The conceptual structural analyses in this assessment are based on conceptual geotechnical recommendations provided in Section 5; visual observations by KPFF and other members of the project team; available existing documents (as listed in Section 6.3); site photos; and KPFF's general structural experience analyzing and designing other waterfront structures. No design or detailed site-specific evaluation has been completed as part of this assessment.

The general data and approach applied to structural analyses in this assessment include:

- *Piling – axial capacity*: The ability of a pile to sustain or resist forces (or loads) parallel to its length.

  For piles that may depend on skin friction for axial capacity, the structural analyses considered a reduction of skin friction when material removal (i.e., dredging) is proposed as a potential remedial action. The structural analyses considered an increase in downdrag forces when a capping remedial option is proposed and potentially liquefiable soils underlie the capping materials. No increase in skin friction resistance is assumed due to capping.

- *Piling – lateral capacity*: The ability of a pile to sustain or resist forces (or loads) perpendicular its length.

  The structural analyses considered a reduction of lateral capacity against sliding from passive soil pressures when material removal is proposed as a potential remedial action. Similarly, depths to effective point of pile fixity[32] were considered to be lowered when material removal is proposed as a potential remedial action. The structural analyses considered similar, yet opposite, effects for a capping remedial option.

- *Retaining wall – global stability*: The ability of a wall to remain stable while resisting lateral and vertical pressures from the soil it is retaining.

  The structural analyses considered a reduced resistance to sliding, overturning, and bearing when material removal is proposed as a potential remedial action. The structural analyses considered similar, yet opposite effects for a capping remedial option.

Detailed structural condition assessments were not completed as part of this assessment. However, qualitative condition assessments for the relevant structures within the RM11E Project Area are provided in Section 6.4. Future remedial design should consider the structures' current conditions in those areas where capping or dredging remedies may be considered.

6.4.2 FUTURE REMEDIAL DESIGN CONSIDERATIONS

Remedial design will need to consider various factors affecting structural stability in and near areas where active remediation will be implemented. The most significant factors and considerations are materials, loading, and effects on structures.

6.4.2.1 Materials

The primary materials used for structural components are timber, steel, and concrete. The factors that affect their suitability include the following:

- *Timber* – Geometry, timber species, grade, section properties, condition (i.e., extent of decay, if applicable), bracing, and orientation to applied loads
- *Steel* – Member geometry, material grade, shape and section properties, condition (i.e., extent of corrosion), bracing, and orientation to applied loads
- *Concrete* – Member geometry, concrete compressive strength, steel reinforcing details, section properties, condition (i.e., extent of cracking, spalling, delaminations, reinforcing corrosion), bracing, and orientation to applied loads

6.4.2.2 Loading

The structural elements must be able to withstand expected loads, which occur as axial forces and as lateral forces.

- *Axial forces* – Structure self-weight, superimposed dead loads and vertical live loads, including from vessel mooring. Vertical piles are primarily designed for vertical axial

[32] Point of pile fixity is the depth to which the embedded pile is effectively fixed against rotation

forces. Resistance to vertical axial loads in piles is generated through pile-to-soil skin friction and pile-to-soil end bearing.

- *Lateral forces*: Mooring loads, breasting loads, current-driven debris loads, wind, and seismic loads. Lateral loads to dolphins are primarily resisted by battered piles that convert the lateral loads into axial components. Lateral loads in pier and dolphin piles may also be resisted through bending of the piles. Lateral loads to soldier pile walls are primarily resisted by bending in the piles, tension in soil tieback anchors, or both.

6.4.2.3 Potential Risks and Impacts to Structures from Remedial Actions

Potential risk to structures will vary by structure and potential failure mode. Some of the factors to be considered include the following:

- Remedial action being taken (e.g., dredging, capping)
- Existing slope condition
- Existing slope's soil materials
- Type of structure (i.e., dolphin, wall, building, or dock)
- Apparent condition of structure
- Design of structure (e.g., materials, pile embedment, original design factors of safety, and more)

Tables summarizing qualitative potential risks to each structure discussed in this study, and for each of three potential remedial actions, are provided in Section 6.5.

6.5 POTENTIAL IMPACTS ON STRUCTURES FROM PROPOSED REMEDIAL ALTERNATIVES (INCLUDING DREDGING AND CAPPING)

6.5.1 GENERAL

Existing structures within the RM11E Project Area that are interacting with the ground are sensitive to changes in the soil conditions around them. Changes to the soil loading conditions from dredging or capping activities can reduce the factors of safety for these structures across a range of potential failure mechanisms. The following is a list of potential failure mechanisms for which structures along the RM11E Project Area (dock and dolphin piles and retaining walls) will need to be evaluated during remedial design. Other failure modes may be possible for specific structures or conditions and will need to be analyzed during remedial design.

The potential impacts to the existing structures discussed in the following paragraphs and tables are conceptual effects. More detailed site- and structure-specific analyses in the locations where active remedies will be implemented should be completed as part of remedial design. The remedial design should consider both the change in soil loading conditions from the selected remedial method as well as the actual condition of the structures themselves. For example, a condition survey should be conducted to determine actual pile thicknesses (steel and timber), to assess the extent of corrosion for steel elements and of rot or decay for the timber elements, and to check for other damages.

6.5.2 POTENTIAL STRUCTURAL FAILURE MODES

6.5.2.1 Pile Kick-out

Pile kick-out (Figure 6.8) occurs when passive lateral soil resistance is less than the active lateral soil pressures being applied to the buried portion of the pile. This condition results in a loss of pile axial capacity and permanent deflections in the pile. For severe cases, the pile may lose all load carrying capacity, which could lead to partial or complete collapse of the supported structure. Pile kick-out could be a possible failure scenario associated with dredging on the downslope side (front side) of a pile or with capping on the upslope side (backside) of a pile. This failure could occur at a loaded dolphin or dock pile as well as at a soldier pile wall or sheet pile wall.

6.5.2.2 Pile Buckling or Pile Bending

Pile buckling (Figure 6.9) occurs when the axial load on the pile exceeds the pile's structural capacity. Pile bending occurs when lateral forces on the pile exceed its bending capacity. These conditions result in a loss of pile axial capacity and permanent deflections in the pile. For severe cases, the pile may lose all load carrying capacity, which could lead to partial or complete collapse of the supported structure. Pile buckling could be a possible failure scenario associated with dredging material from around a pile that then increases the pile's unbraced length. Placing capping materials on the upslope side or excavating from the downslope side of a pile would also increase the risk of pile bending.

6.5.2.3 Pile Shearing

Pile shearing (Figure 6.10) occurs when the shear capacity of the pile is less than the active lateral soil pressures being applied. This condition results in a sudden and permanent loss of pile axial and shear capacity. For severe cases, the pile may lose all load carrying capacity, which could lead to partial or complete collapse of the supported structure. Pile shear could be a possible failure scenario associated with unbalanced soil lateral pressures around a pile, such as with dredging on one side or capping on the opposite side.

6.5.2.4 Axial Soil Bearing Failure

Axial soil bearing failure (Figure 6.11) occurs when the axial compressive loads transmitted through the pile into the soil exceeds the soil's capacity to resist it. This condition results in permanent settlement of the pile. Soil bearing failure could occur when dredging material from around a pile reduces the skin friction component of the soil's axial capacity. Axial soil bearing failure could also occur from additional soil downdrag loads resulting from adding material around the pile (i.e., capping).

6.5.2.5 Pile Uplift

Pile uplift (Figure 6.12) occurs when the axial tension loads transmitted through the pile into the soil exceeds the soil's capacity to resist it. This condition results in permanent upward displacement of the pile. Pile uplift failure could occur when dredging material reduces the skin friction component of the soil's axial capacity. An example of this condition is when a berthing vessel applies lateral loads to a framework of piles, such as a mooring dolphin, that places certain piles into a state of tension.

6.5.2.6 Retaining Wall Sliding

Retaining wall sliding (Figure 6.13) occurs when the active (driving) soil pressures being applied to the wall exceed the wall's capacity against sliding through sliding friction between the wall and its underlying soil and soil passive pressure. This condition results in a permanent outward deflection of the wall. For severe cases, this condition could lead to partial or complete collapse of the wall. Retaining wall sliding could occur when soils from the front of a wall are removed by dredging or lost through slope failure.

6.5.2.7 Retaining Wall Overturning

Retaining wall overturning (Figure 6.14) occurs when the active (driving) soil pressures being applied to the wall exceed the wall's resistance against rotation. Passive soil pressure at the front face of a wall can be a contributing component to rotational resistance. This condition results in a permanent outward rotation of the wall. For severe cases, this condition could lead to partial or complete collapse of the wall. Wall overturning could occur when soils from the front of a wall that are contributing to passive lateral soil pressures are removed by dredging or slope failure.

6.5.2.8 Retaining Wall Bearing Failure

Retaining wall bearing failure (Figure 6.15) occurs when the vertical pressures exerted by the wall exceed the bearing capacity of the underlying soils. This condition may result in permanent vertical settlement, outward rotation, or both. For severe cases, this condition could also lead to partial or complete collapse of the wall and its retained earth. A retaining wall bearing failure could occur if backfill materials at the front of the wall are removed, thus weakening the soils below the wall. Loss of materials below the bottom of the wall (undermining) could also lead to a bearing failure. This failure mode is unlikely to occur for a soldier pile or sheet pile wall. However, block-type retaining walls, such as the RIS&G wall, are more vulnerable to this failure.

6.5.2.9 Retaining Wall Tieback Anchor Pullout

Retaining wall tieback anchor pullout (Figure 6.16) occurs when the active (driving) soil pressures being applied to the tied-back wall exceed the tieback anchor's tension capacity. This failure can occur as a structural failure of the anchor element or as a soil-structure interface failure between the anchor and the surrounding soil. This condition results in a permanent outward deflection of the wall. For severe cases, this condition could lead to partial or complete collapse of the wall. An example would be dredging soils from the front of a wall that are contributing to passive lateral soil pressures.

6.5.2.10 Building Structure Foundation and Slope Failures

Upland building structures could be impacted by any remedial action that reduces the global slope stability beneath and around the building structure. Buildings located on or near oversteepened slopes are particularly vulnerable to foundation or slope failures. Foundation and slope failures could occur when the global slope stability beneath the building and towards the river is reduced, resulting in block-like slope failures. Potential failures could include settlement of shallow foundations as well as deep foundations. For severe cases, this condition could also lead to partial or complete collapse of the building structure. In areas where active remediation will be required, geotechnical and structural analysis should be completed as part of remedial design for all structures within 100 feet of the top-of-bank, as noted in Section 5.3.5 (geotechnical considerations).

6.5.3 POTENTIAL REMEDIAL ALTERNATIVES

Three potential remedial alternatives are considered and discussed in the following sections.[33] These potential remedial actions have been selected to represent common remedial actions and to capture a broad range of potential impacts to structures. They have been grouped into three categories in order to simplify assessments and reporting:

- Dredging in front of structures to a depth of up to 5 feet.
- Dredging in front of structures to a depth between 5 feet and 10 feet
- Capping up to a uniform depth of 3 feet

Any alternative that steepens the slopes at an individual structure beyond the soil's natural angle of repose will result in relatively higher risks of failures than alternatives on slopes that remain at or flatter than their natural limits. The steepness of existing slopes has been factored into the qualitative structural risk assessments for each structure as presented in tables elsewhere in this section. Figures 5.6a through 5.6d depict locations of oversteep slopes across the RM11E Project Area.

6.5.3.1 Dredging in Front (Riverward) of Structures to a Depth of up to 5 Feet

Removing material riverward of a dock or dolphin piling may impact the stability and load carrying capacity of the piles. The loss of soil material may reduce the total passive lateral soil resistance acting on the pile and may also lower the pile's point of fixity elevation below mudline. The loss of soil material may also reduce the total skin friction resistance between the pile and soil, which would reduce the soil's capacity to resist the pile's vertical loads.

Removing up to 5 feet of material riverward of soldier pile-type and sheet pile-type retaining walls also may impact their stability and load carrying capacity. The loss of soil material riverward of the walls may reduce the total passive lateral soil resistance acting on the walls' piles and may also lower the walls' piling point of fixity elevation below mudline.

Similarly, removing up to 5 feet of material riverward of gravity-type retaining walls may also potentially impact their global stability. The loss of soil material riverward of the walls may reduce the total passive lateral soil resistance acting on the walls and could reduce the bearing resistance of the soils beneath the walls.

Areas with oversteepened slopes (Figures 5.6a through 5.6d) are particularly susceptible to slope failures from dredging. Refer to Section 5.3 for a discussion of geotechnical considerations associated with dredging.

Potential failure modes for each condition are outlined below.

- Reduced passive lateral soil resistance would lower the structures' factor of safety against:

[33] Other remedial alternatives such as addition of activated carbon, natural recovery, and no action are not specifically evaluated in this assessment because it is assumed their implementation would have no impact (MNR and no action) or would be similar in nature to, but much less severe than, the remedial alternatives that are specifically evaluated.

- Pile kick-out
- Pile buckling
- Soil bearing failure
- Pile shear
- Wall overturning
- Wall sliding
- Wall tieback anchor failure (for tied-back walls)

- Lowered point of pile fixity would lower the structures' factor of safety against:
  - Pile buckling
  - Pile bending (for soldier pile, sheet pile-type walls, and pier piling)
- Reduced soil vertical load resistance would lower the structures' factor of safety against:
  - Pile uplift
  - Pile bearing
  - Wall bearing

Qualitative structural risk assessments associated with dredging up to 5 feet deep riverward of each of the structures discussed in this assessment are provided in Table 6.10. Effects and risks to the structures for the failure modes listed would typically be less if soil was removed uniformly around the structures' piles, provided the dredging progressed from the top of the slope to the toe of the slope.

TABLE 6.10 – QUALITATIVE STRUCTURAL RISK ASSESSMENT FOR DREDGE DEPTHS LESS THAN 5 FEET

SITE	STRUCTURE ID	STRUCTURE TYPE	POTENTIAL FAILURE MODE[a]									
			PILE KICK-OUT	PILE BUCKLING/BENDING	PILE SHEAR	PILE SOIL BEARING	PILE UPLIFT	WALL SLIDING	WALL OVERTURNING	WALL BEARING	WALL ANCHOR PULL-OUT	BUILDING UNDERMINING
Sakrete	S-1	Dock	◐	◐	◐	◐	◐	-	-	-	-	-
	S-2	Building	-	-	-	-	-	-	-	-	-	◐
Stan Herman	SH-1	Building	◐	◐	◐	◐	○	-	-	-	-	◐
ODOT	BR-1	Bridge	-	-	-	-	-	-	-	-	-	◐
RIS&G	R-1	Dolphins	○	○	○	○	◐	-	-	-	-	-
	R-2	Silos	-	-	-	-	-	-	-	-	-	◐
	R-3	Retaining wall	-	-	-	-	-	●	●	●	◐	-
Glacier NW	G-1	Barge dock	◐	◐	○	◐	◐	-	-	-	-	-
	G1-a, G1b, G1c	Dolphins	○	○	○	○	◐	-	-	-	-	-
	G-2	Main dock										
	G-2a	North main dock	◐	◐	○	◐	◐	-	-	-	-	-
	G-2b	South main dock	◐	◐	○	◐	◐	-	-	-	-	-
	G-2c	Dolphins	○	○	○	○	◐	-	-	-	-	-
	G-2d	Dolphins	○	○	○	○	◐	-	-	-	-	-
	G-2e	Dolphins	○	○	○	○	◐	-	-	-	-	-
	G-2f	Dolphins	○	○	○	○	◐	-	-	-	-	-
	G-2g	Dolphins	○	○	○	○	◐	-	-	-	-	-
	G-2h	Walkway	◐	◐	○	◐	◐	-	-	-	-	-
	G-2i	Walkway	◐	◐	○	◐	◐	-	-	-	-	-
	G-2j	Walkway	◐	◐	○	◐	◐	-	-	-	-	-

[a] Legend:
● High Risk ◐ Moderate Risk ○ Low Risk - Not Applicable

TABLE 6.10 – QUALITATIVE STRUCTURAL RISK ASSESSMENT FOR DREDGE DEPTHS LESS THAN 5 FEET (CONTINUED)

SITE	STRUCTURE ID	STRUCTURE TYPE	POTENTIAL FAILURE MODE									
			PILE KICK-OUT	PILE BUCKLING/BENDING	PILE SHEAR	PILE SOIL BEARING	PILE UPLIFT	WALL SLIDING	WALL OVERTURNING	WALL BEARING	WALL ANCHOR PULL-OUT	BUILDING UNDERMINING
Glacier NW (continued)	G-3	Cement storage dome	-	-	-	-	-	-	-	-	-	●
	G-4	Silos	-	-	-	-	-	-	-	-	-	●
Unkeles	U-1	Retaining wall	●	●	●	○	○	●	●	○	●	-
Cargill	C-1	Ocean Vessel Dock Structures										
	C-1a	Main pier	●	●	●	●	●	-	-	-	-	-
	C-1b(1-5)	Breasting dolphins	○	○	○	○	●	-	-	-	-	-
	C-1c(1-7)	Ship loader towers	●	●	○	●	●	-	-	-	-	-
	C-1d	Shore-to-dock walkway	●	●	○	●	●	-	-	-	-	-
	C-2	Most-downstream dolphin	○	○	○	○	●	-	-	-	-	-
	C-3	Abandoned pier	●	●	○	●	●	-	-	-	-	-
	C-4	Soldier pile wall	●	●	●	○	○	●	●	●	●	-
	C-5	Buried concrete shaft wall	-	-	-	-	-	-	-	-	-	-
	C-6	Silos	-	-	-	-	-	-	-	-	-	●
	C-7	Building	-	-	-	-	-	-	-	-	-	●
	C-8	Building	-	-	-	-	-	-	-	-	-	●
	C-9	Barge dock	●	●	●	●	●	-	-	-	-	-

[a] Legend:
● High Risk ● Moderate Risk ○ Low Risk - Not Applicable

In order to avoid or minimize potential instability caused by dredging riverward of piles and walls, dredging activity would need to maintain a minimum safe setback away from the structures and provide stable slopes that would not lead to future raveling and loss of soil slope material. Representative cross sections depicting the likely minimum setbacks are provided in Figure 6.17 for oversteepened slopes and in Figure 6.18 for stable slopes. Setbacks are smaller for

less-steep conditions or when slopes consist of more stable soil materials, such as gravel. Monitored natural recovery or other engineered solutions, in combination with dredging (as more fully described in Section 6.7), are alternatives for mitigating instability effects due to dredging.

During remedial design, structures potentially impacted by dredging should be evaluated for all temporary conditions during construction as well as for the final long-term conditions.

6.5.3.2 Dredging in Front (Riverward) of Structures to a Depth between 5 Feet and 10 Feet

The effects from dredging deeper than 5 feet are similar to those of shallower dredging, with the following additional considerations:

- Higher chance of an abrupt failure of the piles or walls during temporary conditions created by the dredging process
- Longer duration of construction, which could leave the structures in less-stable temporary conditions for longer times
- Higher probability of completely undermining some of the shallower timber piles
- Higher chance of upslope material sloughing down in significantly greater volumes until stable conditions are reached, especially in oversteepened slope areas
- Higher chance of impacting global slope stabilities at upland structures, especially in oversteepened slope areas
- Larger scale and higher cost for potential mitigating methods

Qualitative structural risk assessments associated with dredging 5 feet to 10 feet deep riverward of each structure discussed in this assessment are provided in Table 6.11. Effects and risks to the structures for the failure modes listed would typically be less if soil was removed uniformly around the structures' piles, provided the dredging progressed from the top of the slope to the toe of the slope.

Areas with oversteepened slopes (Figures 5.6a through 5.6d; Section 5.3) are particularly susceptible to slope failures from dredging. .

TABLE 6.11 – QUALITATIVE STRUCTURAL RISK ASSESSMENT FOR DREDGE DEPTHS 5 FEET TO 10 FEET

SITE	STRUCTURE ID	STRUCTURE TYPE	POTENTIAL FAILURE MODE									
			Pile Kick-out	Pile Buckling/Bending	Pile Shear	Pile Soil Bearing	Pile Uplift	Wall Sliding	Wall Overturning	Wall Bearing	Wall Anchor Pull-Out	Building Undermining
Sakrete	S-1	Dock	●	●	●	●	●	-	-	-	-	-
	S-2	Building	-	-	-	-	-	-	-	-	-	●
Stan Herman	SH-1	Building	●	●	●	●	◐	-	-	-	-	●
ODOT	BR-1	Bridge	-	-	-	-	-	-	-	-	-	●
RIS&G	R-1	Dolphins	◐	◐	◐	◐	●	-	-	-	-	-
	R-2	Silos	-	-	-	-	-	-	-	-	-	●
	R-3	Retaining Wall	-	-	-	-	-	●	●	●	●	-
Glacier NW	G-1	Barge dock	●	●	◐	●	●	-	-	-	-	-
	G1-a, G1b, G1c	Dolphins	◐	◐	◐	◐	●	-	-	-	-	-
	G-2	Main dock										
	G-2a	North main dock	●	●	◐	●	●	-	-	-	-	-
	G-2b	South main dock	●	●	◐	●	●	-	-	-	-	-
	G-2c	Dolphins	◐	◐	◐	◐	●	-	-	-	-	-
	G-2d	Dolphins	◐	◐	◐	◐	●	-	-	-	-	-
	G-2e	Dolphins	◐	◐	◐	◐	●	-	-	-	-	-
	G-2f	Dolphins	◐	◐	◐	◐	●	-	-	-	-	-
	G-2g	Dolphins	◐	◐	◐	◐	●	-	-	-	-	-

[a] Legend:
● High Risk ◐ Moderate Risk ○ Low Risk - Not Applicable

TABLE 6.11 – QUALITATIVE STRUCTURAL RISK ASSESSMENT FOR DREDGE DEPTHS 5 FEET TO 10 FEET (CONTINUED)

SITE	STRUCTURE ID	STRUCTURE TYPE	POTENTIAL FAILURE MODE									
			PILE KICK-OUT	PILE BUCKLING/BENDING	PILE SHEAR	PILE SOIL BEARING	PILE UPLIFT	WALL SLIDING	WALL OVERTURNING	WALL BEARING	WALL ANCHOR PULL-OUT	BUILDING UNDERMINING
Glacier NW (continued)	G-2h	Walkway	●	●	◐	●	●	-	-	-	-	-
	G-2i	Walkway	●	●	◐	●	●	-	-	-	-	-
	G-2j	Walkway	●	●	◐	●	●	-	-	-	-	-
	G-3	Cement storage dome	-	-	-	-	-	-	-	-	-	●
	G-4	Silos	-	-	-	-	-	-	-	-	-	●
Unkeles	U-1	Retaining wall	●	●	●	○	○	●	●	◐	●	-
Cargill	C-1	Ocean Vessel Dock Structures										
	C-1a	Main pier	●	●	●	●	●	-	-	-	-	-
	C-1b(1-5)	Breasting dolphins	◐	◐	◐	◐	●	-	-	-	-	-
	C-1c(1-7)	Ship loader towers	●	●	◐	●	●	-	-	-	-	-
	C-1d	Shore-to-dock walkway	●	●	◐	●	●	-	-	-	-	-
	C-2	Most-downstream dolphin	◐	◐	◐	◐	●	-	-	-	-	-
	C-3	Abandoned pier	●	●	◐	●	●	-	-	-	-	-
	C-4	Soldier pile wall	●	●	●	◐	◐	●	●	●	●	-
	C-5	Buried concrete shaft wall	-	-	-	-	●	●	◐	●	-	-
	C-6	Silos	-	-	-	-	-	-	-	-	-	●
	C-7	Building	-	-	-	-	-	-	-	-	-	●
	C-8	Building	-	-	-	-	-	-	-	-	-	●
	C-9	Barge dock	●	●	●	●	●	-	-	-	-	-

[a] Legend:
● High Risk ◐ Moderate Risk ○ Low Risk - Not Applicable

6.5.3.3 Capping up to 3 Feet Deep Behind (Landward), Below, and in Front (Riverward) of Structures

Capping is another potential method for stabilizing contaminated sediments. Capping, or adding, materials above mudline typically provides structural benefits to the existing waterfront and nearshore structures, assuming global slope stability has not been negatively affected. An exception to this condition would occur where these additional materials increase downdrag loads to piling. Downdrag loads result from friction between piles and settling, or downward-moving soils. Higher downdrag would apply greater axial loads to the piles and could lead to a lower factor of safety against soil bearing failure and pile buckling. Downdrag loads could increase if underlying soils are susceptible to liquefaction or lateral spread, or may otherwise settle. Capping work would likely need to progress from the toe of the slope to the top of the slope to avoid temporarily overloading piles.

Qualitative structural risk assessments associated with capping the slopes uniformly around each structure discussed in this assessment are provided in Table 6.12. The assessments are primarily based on local effects to the piles and walls, rather than global slope instabilities and effects. The assessments also assume that capping progresses from the toe of the slope up to the top of the bank. (Building undermining failure mode is based primarily on slope stability conditions.) However, the risk of large slope failure increases significantly with capping, especially at locations with oversteepened slopes (Figures 5.6a through 5.6d; Section 5.3). Therefore, in situations where geotechnical (non-structural) slope failure may occur, all structures have a high failure risk. .

TABLE 6.12 – QUALITATIVE STRUCTURAL RISK ASSESSMENT FOR CAPPING SLOPES

SITE	STRUCTURE ID	STRUCTURE TYPE	POTENTIAL FAILURE MODE									
			PILE KICK-OUT	PILE BUCKLING/BENDING	PILE SHEAR	PILE SOIL BEARING	PILE UPLIFT	WALL SLIDING	WALL OVERTURNING	WALL BEARING	WALL ANCHOR PULL-OUT	BUILDING UNDERMINING
Sakrete	S-1	Dock	○	○	○	○	○	-	-	-	-	-
	S-2	Building	-	-	-	-	-	-	-	-	-	●
Stan Herman	SH-1	Building	●	●	●	●	●	-	-	-	-	●
ODOT	BR-1	Bridge	-	-	-	-	-	-	-	-	-	●
RIS&G	R-1	Dolphins	○	○	○	○	○	-	-	-	-	-
	R-2	Silos	-	-	-	-	-	-	-	-	-	●
	R-3	Retaining wall	-	-	-	-	-	○	○	○	○	-
Glacier NW	G-1	Barge dock	○	○	○	○	○	-	-	-	-	-
	G1-a, G1b, G1c	Dolphins	○	○	○	○	○	-	-	-	-	-
	G-2	Main dock	○	○	○	○	○	-	-	-	-	-
	G-2a	North main dock	○	○	○	○	○	-	-	-	-	-
	G-2b	South main dock	○	○	○	○	○	-	-	-	-	-
	G-2c	Dolphins	○	○	○	○	○	-	-	-	-	-
	G-2d	Dolphins	○	○	○	○	○	-	-	-	-	-
	G-2e	Dolphins	○	○	○	○	○	-	-	-	-	-
	G-2f	Dolphins	○	○	○	○	○	-	-	-	-	-
	G-2g	Dolphins	○	○	○	○	○	-	-	-	-	-
	G-2h	Walkway	○	○	○	○	○	-	-	-	-	-
	G-2i	Walkway	○	○	○	○	○	-	-	-	-	-
	G-2j	Walkway	○	○	○	○	○	-	-	-	-	-

[a] Legend:
● High Risk ● Moderate Risk ○ Low Risk - Not Applicable

TABLE 6.12 – QUALITATIVE STRUCTURAL RISK ASSESSMENT FOR CAPPING SLOPES (CONTINUED)

SITE	STRUCTURE ID	STRUCTURE TYPE	POTENTIAL FAILURE MODE									
			PILE KICK-OUT	PILE BUCKLING/BENDING	PILE SHEAR	PILE SOIL BEARING	PILE UPLIFT	WALL SLIDING	WALL OVERTURNING	WALL BEARING	WALL ANCHOR PULL-OUT	BUILDING UNDERMINING
Glacier NW (continued)	G-3	Cement storage dome	-	-	-	-	-	-	-	-	-	●
	G-4	Silos	-	-	-	-	-	-	-	-	-	●
Unkeles	U-1	Retaining wall	○	○	○	○	○	○	○	○	○	-
Cargill	C-1	Ocean Vessel Dock Structures										
	C-1a	Main pier	○	○	○	○	○	-	-	-	-	-
	C-1b(1-5)	Breasting dolphins	○	○	○	○	○	-	-	-	-	-
	C-1c(1-7)	Ship loader towers	○	○	○	○	○	-	-	-	-	-
	C-1d	Shore-to-dock walkway	○	○	○	○	○	-	-	-	-	-
	C-2	Most-downstream dolphin	○	○	○	○	○	-	-	-	-	-
	C-3	Abandoned pier	○	○	○	○	○	-	-	-	-	-
	C-4	Soldier pile wall	○	○	○	○	○	○	○	○	○	-
	C-5	Buried concrete shaft wall	-	-	-	-	-	◐	◐	◐	◐	-
	C-6	Silos	-	-	-	-	-	-	-	-	-	●
	C-7	Building	-	-	-	-	-	-	-	-	-	●
	C-8	Building	-	-	-	-	-	-	-	-	-	●
	C-9	Barge dock	○	○	○	○	○	-	-	-	-	-

[a] Legend:
● High Risk ◐ Moderate Risk ○ Low Risk - Not Applicable

6.6 PRELIMINARY GUIDANCE TO MITIGATE ADVERSE IMPACTS OF DREDGING AND CAPPING ON STRUCTURES

This section introduces and discusses potential options to mitigate adverse impacts to structures from potential future dredging and capping remedial actions. Options generally apply similarly to all facilities' docks, piers, dolphins, and walls.

Options to mitigate adverse effects and their key characteristics and considerations are listed below:

- Construct permanent toe walls in front of (i.e., on the downslope side of) affected piles and other existing retaining walls (Figure 6.19). Toe walls serve to support slopes behind (upslope from) the walls and thus maintain the local soil conditions and loads around the original piling or wall.
    - Construction staging would begin with removal of existing fendering systems and proceed to installation of the toe wall, after which dredging could proceed in front of wall.
    - Toe walls could be designed to resist loads from capping materials placed behind the wall.
    - Toe walls would likely need to be located near the pier or dock fender line to avoid extending past the harbor line and to avoid conflicts with existing pier decks during installation.
    - Feasible types of toe walls include continuous sheet pile walls and soldier pile walls with lagging.
    - Toe walls may be able to cantilever up from mudline if dredge depths are relatively shallow, such as dredging in front of structures to a depth of up to 5 feet (i.e., the first potential remedial alternative presented in Section 6.6.3); however, for dredging to depths greater than 5 feet to 10 feet (i.e., the second potential remedial alternative presented in Section 6.6.3) and where deep pile embedment may not be feasible (i.e., shallow gravels or large remnant debris), tieback anchors may be necessary.
    - Toe walls could be removed at a later stage of construction if dredged materials were replaced with acceptable fill and stable slopes were restored.
- Construct retaining walls behind (i.e., on the upslope side of) the existing structures (Figure 6.20).
    - For dredging, the construction sequence would be to install the new retaining wall and then dredge in front it.
    - For capping, the construction sequence would be to install the new retaining wall, or possibly a series of retaining walls up the slope, and then place capping materials behind the new retaining walls.
    - Feasible types of walls include continuous sheet pile walls and soldier pile walls with lagging.
    - Walls may be able to cantilever up from mudline if dredge depths are relatively shallow; however, for deeper dredging or thicker caps, and where deep pile embedment may not be feasible (i.e., shallow gravel and large remnant debris), tieback anchors may be necessary.
    - Walls could be removed at a later stage of construction if dredged materials were replaced with acceptable fill and stable slopes were restored.

- Maintain current slopes in the zone of influence around piling, and dredge and regrade only outside this zone (Figure 6.21).

a. The construction sequence would be to establish minimum safe distances away from piles or walls, dredge outside of the restricted zone, and then construct permanent stable slopes.

    - Dredging would begin at an engineered minimum setback distance away from the piles. The setback would be sufficient to prevent loss of soil resistance around the pile.
    - Dredged slopes would need to be constructed at angles that would remain stable for the temporary and permanent conditions.
    - Propeller wash and other potentially slope-eroding impacts would need to be considered during and reflected in remedial design.
    - Setbacks could be significant, which could make this option less feasible along the docks and piers where remedial dredging may need to occur close to piles.

- Strengthen existing structures. This option could include installing new supplemental piling or new lateral pile bracing (Figure 6.22).

    - For dock and pier piling, access holes may need to be cut through the existing decks to enable the installation of the new piles.
    - Additional pile lateral bracing could be installed to improve pile stability; however, the bracing would create more elements that could snag river debris.
    - For impacted soldier pile or sheet pile-type retaining walls, potential strengthening options include installing additional tieback anchors, welding stiffeners to the piles, or both.

6.7 CONSIDERATION OF TEMPORARY OR PERMANENT REMOVAL OF WATERFRONT OR OVERWATER STRUCTURES

6.7.1 GENERAL

Existing dock, dolphin and pier structures will influence many of the potential remedial actions. Temporarily or permanently removing these waterfront and overwater structures during the remedial work would offer certain advantages and disadvantages. The primary advantages are improved access to sediments and reduced temporary risks to the structures. Key disadvantages include potential decrease of slope stability, disturbance of contaminated sediments, substantial costs for structure removal and reconstruction, significant financial loss to waterfront business operations, and potential employment losses in ancillary business of the larger Portland community. These factors are discussed in the following subsections.

6.7.2 IMPROVED ACCESS

Equipment to drive piles for new toe walls and other retaining walls would require close access to the work and typically more headroom than is currently available below the footprints of the existing docks and piers. Thus, new sheet pile or soldier pile-type walls would likely need to be offset from the docks by approximately 3 feet or more, depending on the construction methods selected and equipment used. It may be possible to install drilled soldier piles with low-overhead equipment; however, construction costs would be significantly higher. Temporary removal of portions of the existing docks and fender systems would allow closer work access and facilitate new installations, yet would adversely impact associated waterfront businesses. Vertical

clearance is not expected to significantly inhibit most types of remedial work around dolphins and shoreline retaining walls.

Barge-based equipment may be used to drive new piles or to perform dredging and capping earthwork activities. However, the existing network of abandoned remnant timber piles (Figures 4.5c and 4.5d) and in-service piles may restrict barge access, thus leading to lower construction productivity, the need for more specialized equipment, longer construction durations, and higher costs than if the piles were not present. The temporary or permanent removal of selected groups of piles could facilitate barge access during construction, although the replacement of those piles would result in increased costs.

Dredging and capping remedial actions would require heavy earthwork equipment to maneuver in and around the existing network of abandoned remnant timber piles and in-service piles. These piles would make it more difficult to reach all of the areas of work. Construction crews would need to proceed carefully during excavation and cap placement to avoid damaging existing piles or structures. These factors would lead to decreased construction productivity, a need for more specialized equipment, longer construction durations, and higher costs than if the piles and structures were not present.

Installing new piles or walls may mitigate the adverse impacts of implementing certain remedial actions. However, the presence of existing piles in active use, as well as abandoned remnant timber piles, may interfere with installation of planned new piles and walls. These conditions could lead to more complications in the field during construction, further expanding the time needed for in-water work and increasing costs.

6.7.3 REDUCED RISKS TO EXISTING STRUCTURES

Existing structures may be at higher risk of damage or failure during remedial actions. For example:

- Heavy equipment used in close proximity to the existing structures is at risk of hitting them and causing minor to serious damage.
- Temporary earthwork conditions during various stages of the remedial actions may lead to local imbalance in soil pressures that, in overstressing the piles or walls, could result in damage or failure.
- Temporary earthwork conditions during various stages of the remedial actions may also lead to global slope instabilities that could jeopardize the existing structures and result in damage or failure.

If the structures are removed, these particular risks are eliminated.

6.7.4 IMPACTS TO SLOPE STABILITY

Existing piles (both in-service and remnant) for shoreline structures may be enhancing the stability of slopes in the RM11E Project Area, especially where slopes have been oversteepened. Removing piles in these areas could reduce slope stability and lead to slope failure, whether local or larger and more global. Cutting existing piles off at mudline, rather than extracting them, could be a mitigating option. Further analysis of selected pile removal should be considered during remedial design and prior to removing any piles.

6.7.5 DISTURBANCE OF CONTAMINATED SEDIMENTS

Removing piles (both in-service and remnant) from the RM11E Project Area may disturb contaminated sediments as piles are extracted from the riverbed. Reinstallation of piles into the structures as they are rebuilt may also disturb contaminated sediments. More costly efforts may be required to control and contain this transmission of contaminated materials. Cutting existing piles off at mudline, rather than extracting the piles, could be a mitigating option.

6.7.6 COST IMPACTS

While the direct costs of removing contaminated sediments would be lower in the absence of waterfront and overwater structures, removal of the structure would incur significant additional costs for the following elements:

- Demolition
- Design of replacement structures
- Permitting
- Construction of replacement structures

Furthermore, loss of business and income due to structure removal and replacement would be costly.

Table 1 of Appendix K of the PHSS Draft FS provides estimated remediation costs for each Area of Potential Concern, including the one relevant to the RM11E Project Area (AOPC 25), based on five alternatives (B, C, D, E, and F) with various remedial action levels (RALs for multiple compounds[34]) and combinations of remedial technologies, including monitored natural recovery, enhanced monitored natural recovery, in situ treatment, capping, active capping, and dredging. Removal-based alternatives, applicable to this discussion, are noted with "r", and those that are integrated-based are noted with "i." The top end of the reported cost estimates for removal-based options for AOPC 25 ranges from $12 million for alternative B-r (20,000 CY dredging max) to $34 million for alternative F-r (87,000 CY dredging max).

Table 7 of Appendix K of the PHSS Draft FS also provides cost estimates for remedial actions that involve demolishing existing structures, removing impacted sediment (removal-based approach), and replacing the structures. The top end of the reported cost estimates for the structural removal and replacement approach for AOPC 25 ranges from $52 million for alternative B-r to $54 million for alternative F-r. In other words, the temporary or permanent removal of existing waterfront and overwater structures would increase the cost of remediation by at least $20 million to $40 million, not including the lost business operation revenues or other financial hardships to waterfront business operations. The Appendix K costs also exclude costs to the Portland community that would arise from removal and replacement of structures which may include temporary or permanent loss of employment or ancillary businesses (e.g., commodity producers such as farmers, tug operators, stevedores).

In summary, the cost estimates in Appendix K of the PHSS Draft FS demonstrate that wholesale demolition and replacement of structures to facilitate sediment removal is neither cost-effective

[34] Polychlorinated biphenyl RAL (ppb) for each Alternative: B=1,000; C=750; D=500; E=200; F=75

nor practical. During remedial design, individual structures or components thereof may turn out to be candidates for cost-effective demolition and replacement.

6.8 CONCLUSIONS

Tables 6.10, 6.11, and 6.12 summarize the potential risks (high, moderate, low) of failure to existing structures at the RM11E Project Area due to dredging (0-5 ft. and 5-10 ft.) and/or placement of a cap (3 ft.). Structures having a high risk of failure on Tables 6.10, 6.11, or 6.12 are ranked as high-impact for remedial actions, and will require additional effort to select and design the remedy, including identification of site-specific management actions tailored to the selected remedial action in areas where active remediation is required

6.9 SECTION 6 FIGURES

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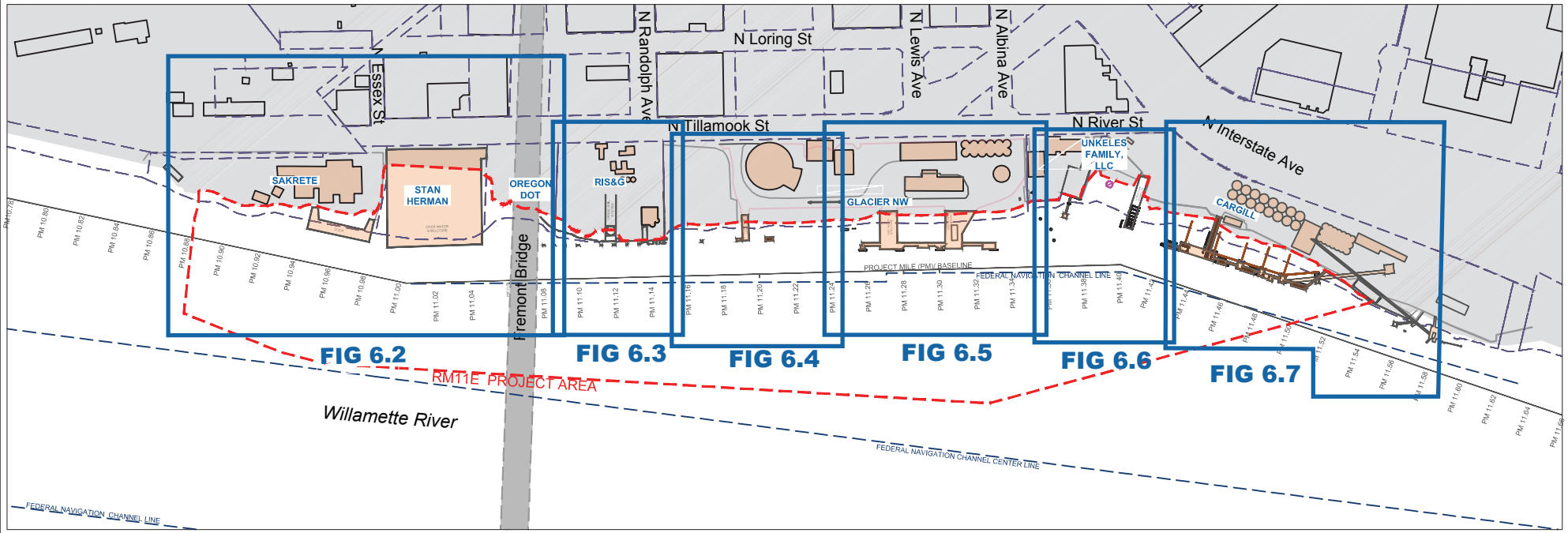


0 300
Scale in Feet

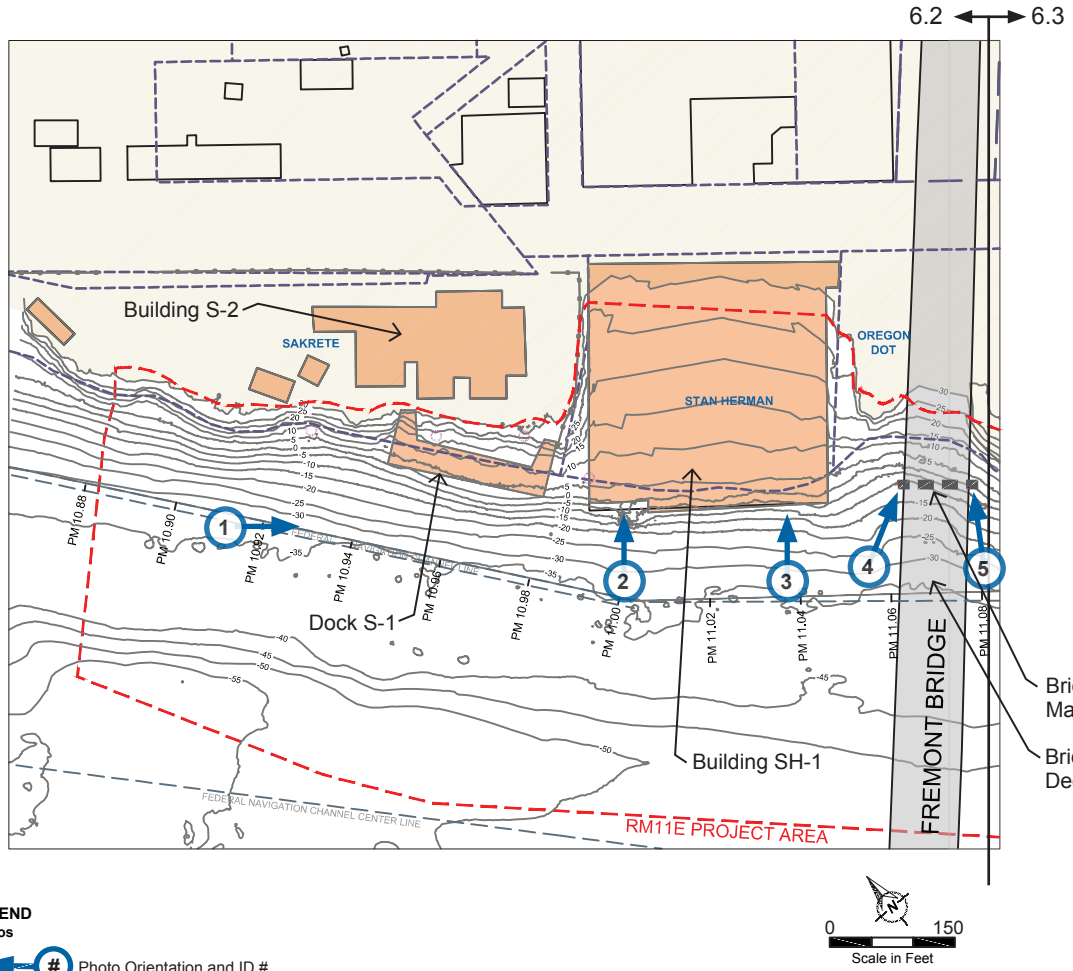
LEGEND

- Figure Location
- PM 11.5 Project Mile (PM) Stationing
- Federal Navigation Channel (USACE)
- RM11E Project Area
- Bridge
- Upland
- Building/Structure
- Tax Lot Boundary (Oct. 2013)

Site Plan from Dalton, Olmsted, & Fuglevand, Inc.

Draft - For Review

RM11E Group **Willamette River - Portland, Oregon** **Draft Implementability Study Report**	kpff
Structural Assesssment Key Map	**Figure 6.1** **Overview** June 30, 2015



1 – Sakrete Dock (May 2013)

2 – Downstream End of Stan Herman Property (May 2013)

3 – Upstream End of Stan Herman Property (May 2013)

4 – Fremont Bridge Main Span Substructure (May 2013)

5 – Fremont Bridge Main Span Substructure (May 2013)

Bridge BR-1, Main Pier

Bridge BR-1, Deck and Truss (above)

LEGEND

Photos

Photo Orientation and ID #

Other Features

- Tax Lot Boundary (Oct. 2013)
- Existing Structures
- Outfall - Active
- Outfall - Inactive
- RM11E Project Area
- PM 11.44 Project Mile Stationing
- Federal Navication Channel (USACE)
- Bathymetric Contour - 5' Interval (NAVD88)

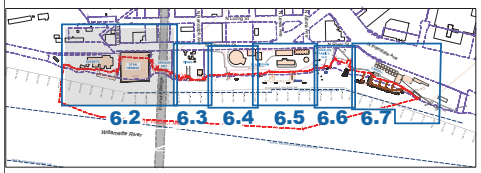


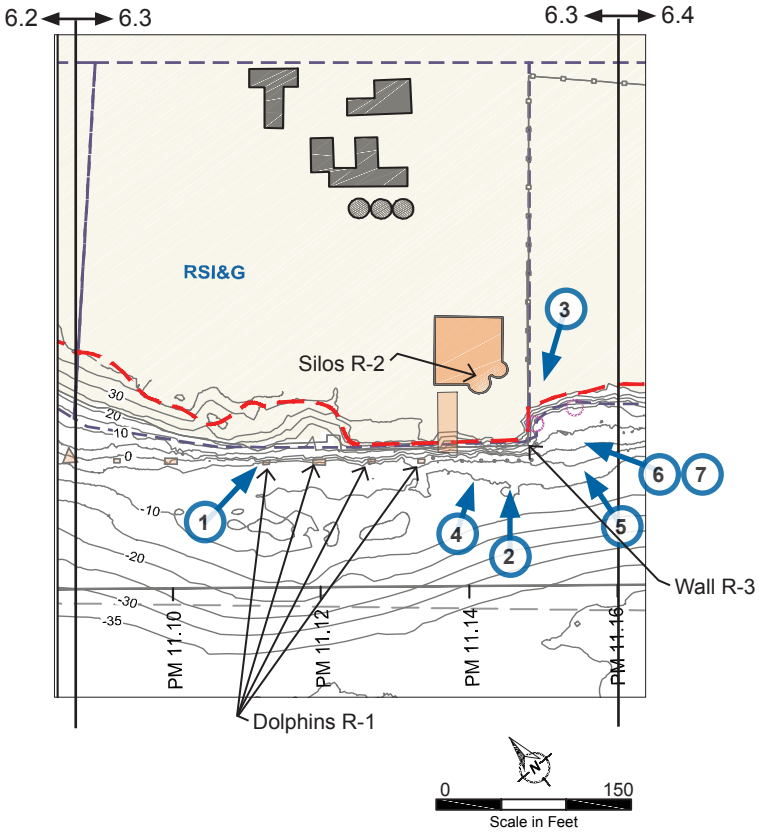
FIGURE LOCATION

MAP NOTES

1. The locations of all features shown are approximate.
2. Contour lines and planimetric features are based on a composite data set which consists of the following: NOAA multibeam survey from 2009; ODSL multibeam and laser survey from 2010; USACE LiDAR survey from 2009; David Evans and Associates, Inc. multibeam survey from 2011 and terrestrial laser scan from 2013; and RLIS Metro GIS data. Digital elevation model (DEM) surface for bathymetric contours was modeled only in the immediate vicinity of the RM11E Project Area. It is not intended for litigation, construction, or navigation purposes.
3. Horizontal datum is referenced to Oregon State Plane North NAD83 (international feet). Vertical datum is referenced to NAVD88 (feet).
4. Outfall status and location from City of Portland - Bureau of Environmental Services (BES) GIS group. Data layer acquired from GSI. Outfalls centered on coordinates from BES data layer.
5. Tax lot boundary generated by METRO (Oct. 2013). Data layer acquired from GSI.
6. Submarine cable crossing location provided by David Evans and Associates, Inc. as described in Section 2.
7. Photo source is DOF unless noted otherwise.

Draft - For Review

RM11E Group Willamette River - Portland, Oregon Draft Implementability Study Report	kpff
Partial Site Plan and Facility Photos Sakrete	Fig. 6.2 June 30, 2015



1 – RIS&G Barge Mooring Dolphins (May 2013)

2 – RIS&G Retaining Wall and Storage Silos (May 2013)

3 – RIS&G Retaining Wall (KPFF, May 2015)

4 – RIS&G Retaining Wall Partial Collapse of Western Portion of Wall (GSI, Sept. 2008)

5 – RIS&G Retaining Wall Partial Collapse of Southern Portion of Wall (GSI, June 2009)

6 – RIS&G Retaining Wall Partial Collapse of Southern Portion of Wall During Repairs (GSI, Sept. 2009)

7 – RIS&G Retaining Wall Partial Slope Failure near Southern Portion of Wall (GSI, Oct. 2013)

LEGEND

Photos

- # Photo Orientation and ID #

Other Features

- Tax Lot Boundary (Oct. 2013)
- Existing Structures
- Outfall - Active
- Outfall - Inactive
- RM11E Project Area
- PM 11.44 Project Mile Stationing
- Federal Navication Channel (USACE)
- -35 Bathymetric Contour - 5' Interval (NAVD88)

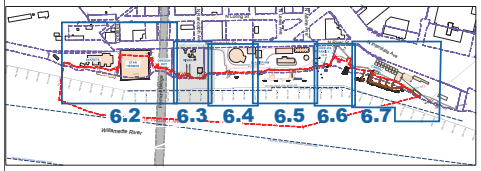
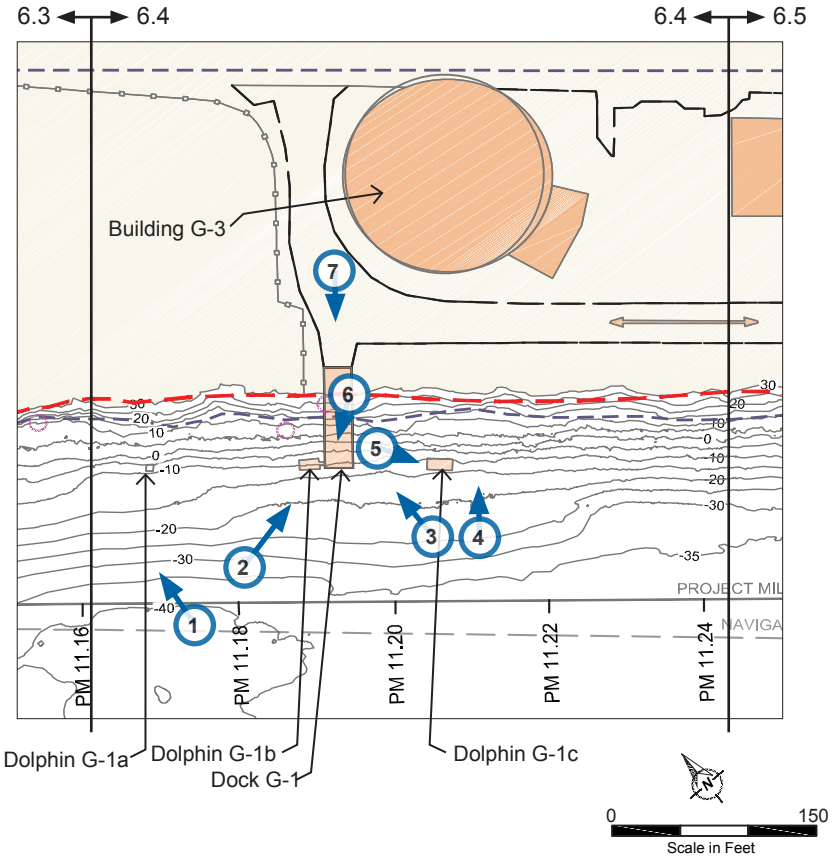


FIGURE LOCATION

Map Notes: Reference Figure 6.2

Draft - For Review

RM11E Group Willamette River - Portland, Oregon Draft Implementability Study Report	kpff
Partial Site Plan and Facility Photos RIS&G	Fig. 6.3 June 30, 2015



1 – Glacier NW Dolphin Downstream of Barge Dock (May 2013)

2 – Glacier NW Barge Dock and Dolphin; Cement Dome Structure (May 2013)

3 – Glacier NW Barge Dock and Dolphin (May 2013)

4 – Glacier NW Dolphin (May 2013)

5 – Glacier NW Dolphin (KPFF, May 2015)

6 – Glacier NW Dolphin (KPFF, May 2015)

7 – Glacier NW Barge Dock (KPFF, May 2015)

LEGEND

Photos

- Photo Orientation and ID #

Other Features

- Tax Lot Boundary (Oct. 2013)
- Existing Structures
- Outfall - Active
- Outfall - Inactive
- RM11E Project Area
- PM 11.44 Project Mile Stationing
- Federal Navication Channel (USACE)
- Bathymetric Contour - 5' Interval (NAVD88)

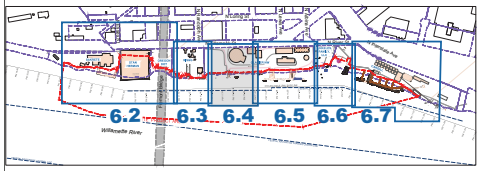
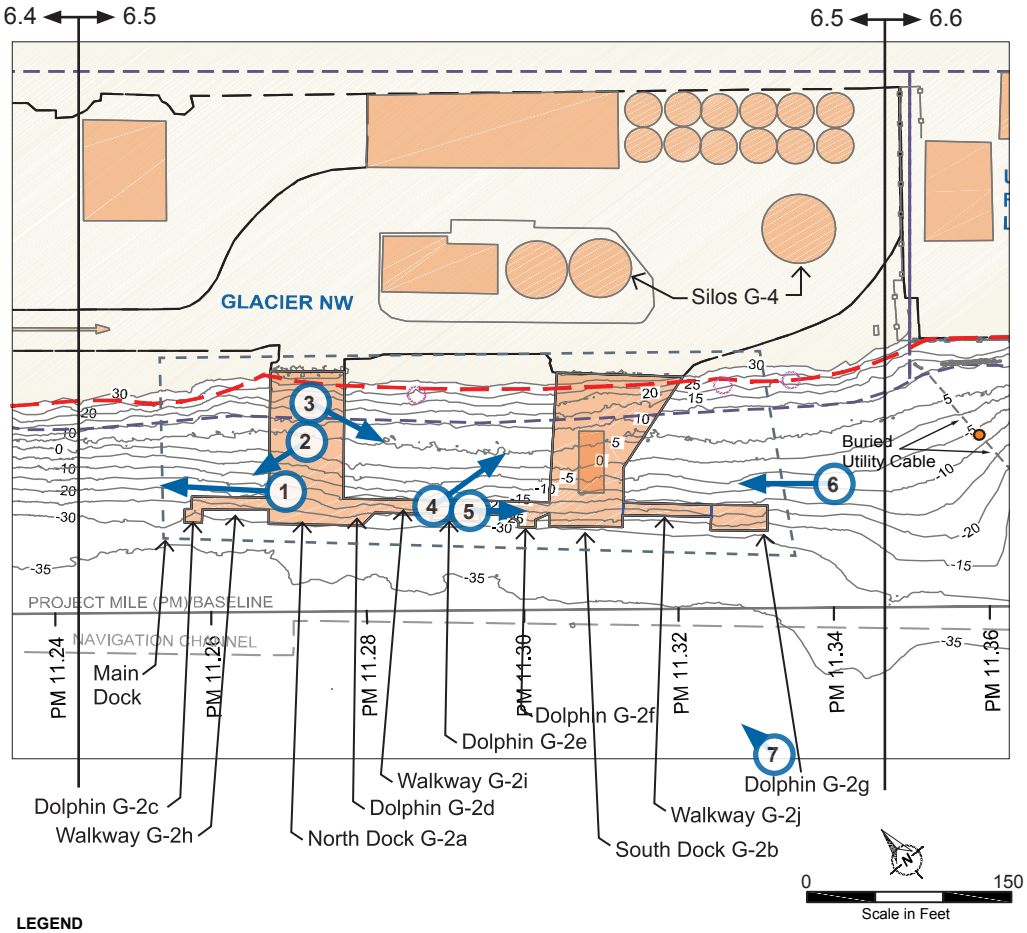


FIGURE LOCATION

Map Notes: Reference Figure 6.2

Draft - For Review

RM11E Group Willamette River - Portland, Oregon Draft Implementability Study Report	kpff
Partial Site Plan and Facility Photos Glacier NW (Downstream Portion)	**Fig. 6.4** June 30, 2015



LEGEND

Photos

Photo Orientation and ID #

Other Features

- Tax Lot Boundary (Oct. 2013)
- Existing Structures
- Outfall - Active
- Outfall - Inactive
- RM11E Project Area
- PM 11.44 Project Mile Stationing
- Federal Navication Channel (USACE)
- Bathymetric Contour - 5' Interval (NAVD88)

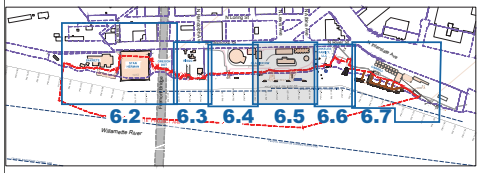


FIGURE LOCATION

Map Notes: Reference Figure 6.2

1 – Glacier NW Barge Dock (KPFF, May 2015)

2 – Glacier NW Breasting Dolphin at Main Dock (KPFF, May 2015)

3 – Glacier NW Main Dock with Shiploader Device in Background (KPFF, May 2015)

4 – Glacier NW Main Dock (KPFF, May 2015)

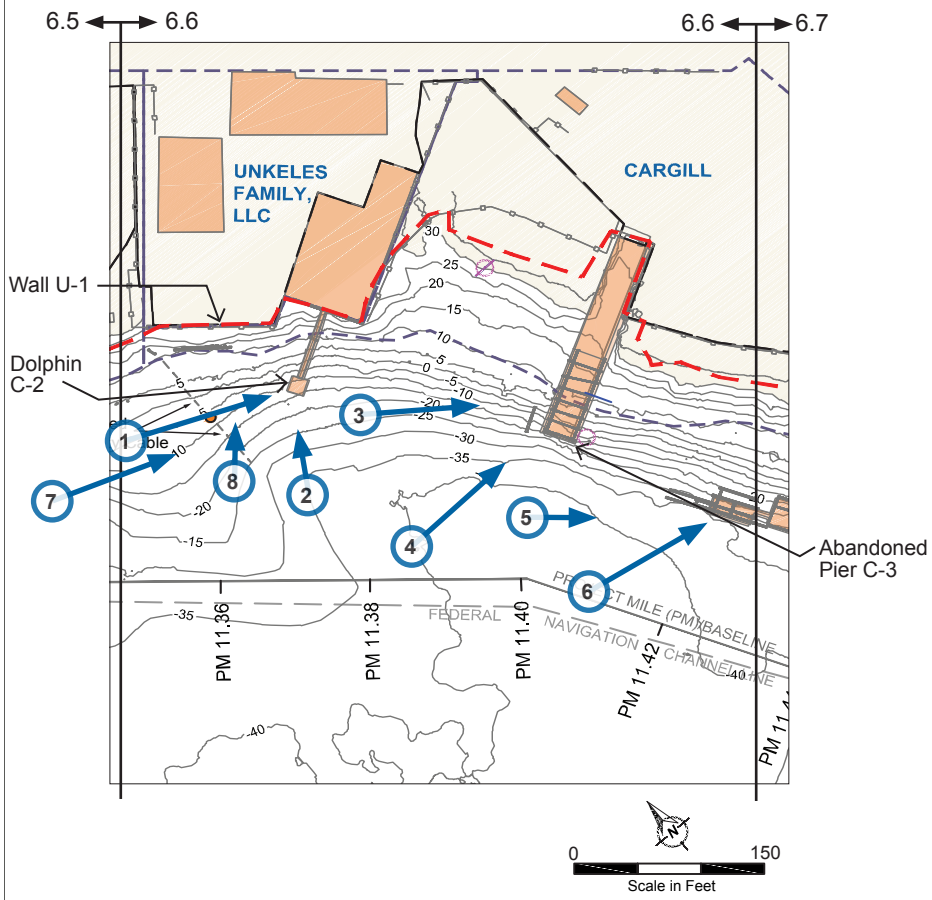
5 – Glacier NW Main Dock Walkway (KPFF, May 2015)

6 – Glacier NW Main Dock (May 2013)

7 – Glacier NW Property

Draft - For Review

RM11E Group Willamette River - Portland, Oregon Draft Implementability Study Report	kpff
Partial Site Plan and Facility Photos Glacier NW (Upstream Portion)	**Fig. 6.5** June 30, 2015



1 – Cargill Mooring Dolphin and Access Walkway (KPFF, May 2015)

2 – Cargill Mooring Dolphin and Access Walkway (May 2013)

3 – Cargill Abandoned Pier and Remnant Piling (KPFF, May 2015)

4 – Cargill Abandoned Pier (May 2013)

5 – Cargill Ocean Vessel Dock (KPFF, May 2015)

6 – Cargill Ocean Vessel Dock (KPFF, May 2013)

7 – Cargill Waterfront Facilities (KPFF, May 2015)

8 – Unkeles Shoreline Retaining Wall (GSI, May 2013)

LEGEND

Photos

Photo Orientation and ID #

Other Features

Tax Lot Boundary (Oct. 2013)

Existing Structures

Outfall - Active

Outfall - Inactive

RM11E Project Area

PM 11.44 Project Mile Stationing

Federal Navication Channel (USACE)

Bathymetric Contour - 5' Interval (NAVD88)

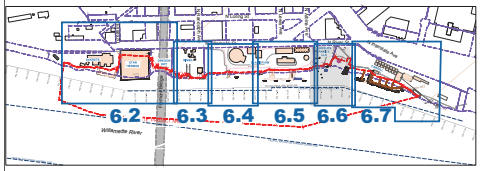
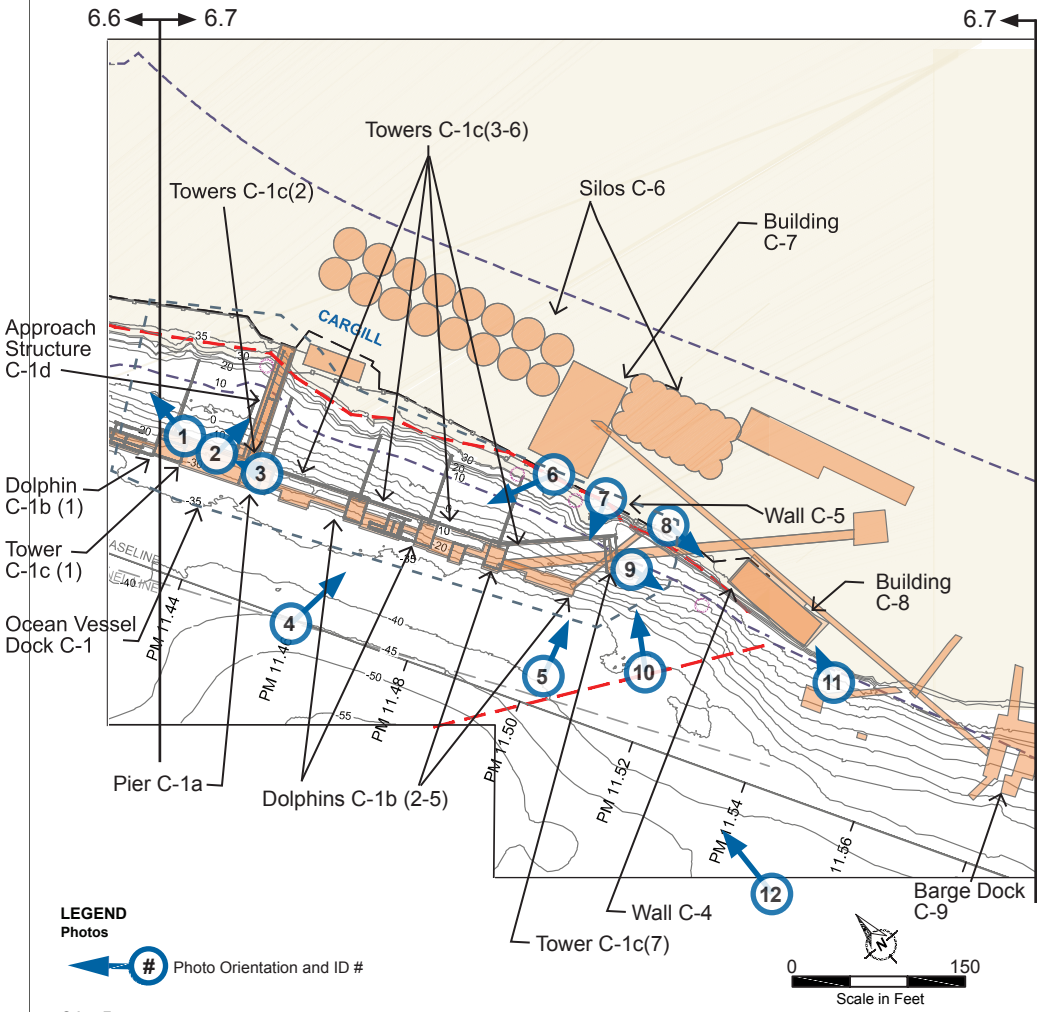


FIGURE LOCATION

Map Notes: Reference Figure 6.2

Draft - For Review

RM11E Group **Willamette River - Portland, Oregon** **Draft Implementability Study Report**	kpff
Partial Site Plan and Facility Photos Cargill (Temco) - (Downstream Portion)	**Fig. 6.6** June 30, 2015



LEGEND

Photos

Photo Orientation and ID #

Other Features

- Tax Lot Boundary (Oct. 2013)
- Existing Structures
- Outfall - Active
- Outfall - Inactive
- RM11E Project Area
- PM 11.44 Project Mile Stationing
- Federal Navication Channel (USACE)
- Bathymetric Contour - 5' Interval (NAVD88)

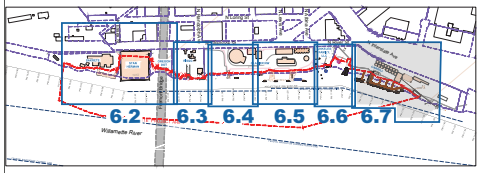


FIGURE LOCATION

Map Notes: Reference Figure 6.2

1 – Cargill Abandoned Pier and Remnant Piling (KPFF, May 2015)

2 – Cargill Shore-to-Dock Access Structure (KPFF, May 2015)

3 – Cargill Main Dock Below Deck Level (KPFF, May 2015)

4 – Cargill Dolphins and Ship Loader Tower (KPFF, May 2013)

5 – Cargill Dolphin (May 2013)

6 – Cargill Ocean Vessel Dock Including Ship Loader Towers and Bracing (KPFF, May 2015)

7 – Cargill Most-Upstream Breasting Dolphin

8 – Cargill Soldier Pile Wall

9 – Cargill Soldier Pile Wall with Barge Dock in Background (KPFF, May 2015)

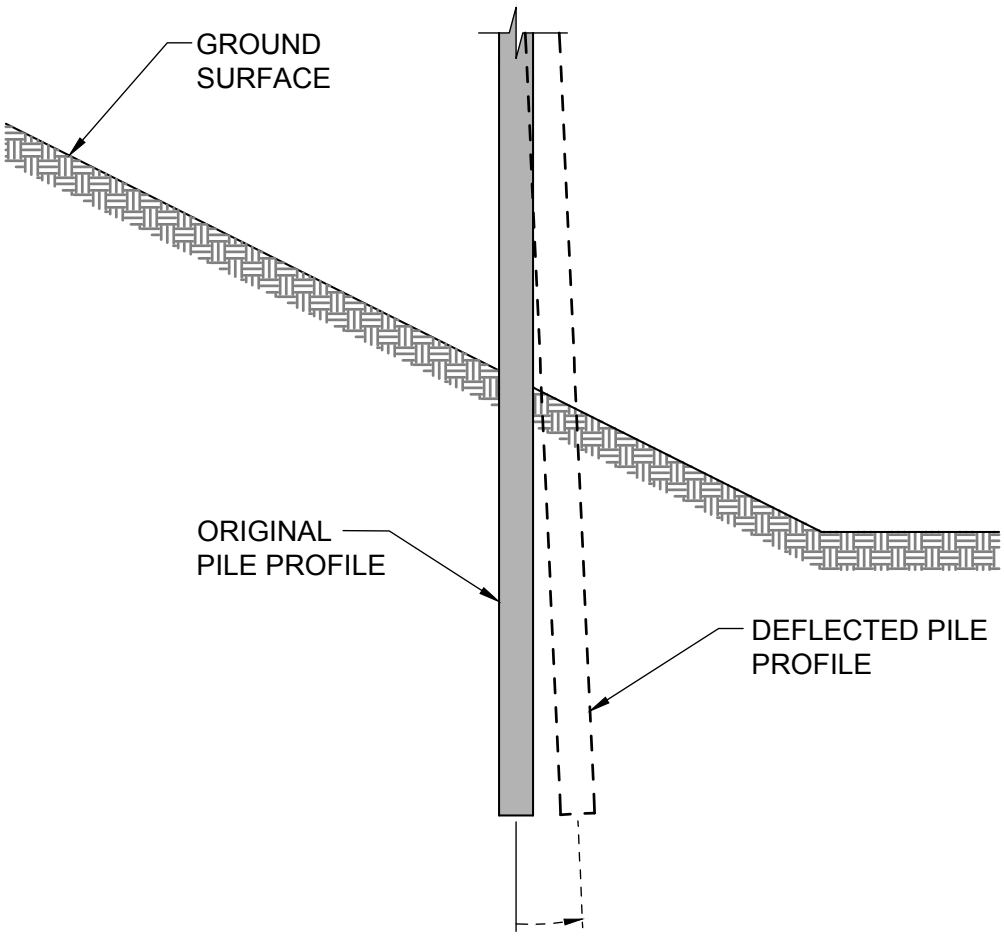
10 – Cargill Ship Loader Tower Support Frame (May 2013)

11 – Cargill Soldier Pile Return Wall (May 2013)

12 – Cargill Overall Facility Plan

Draft - For Review

RM11E Group **Willamette River - Portland, Oregon** **Draft Implementability Study Report**	kpff
Partial Site Plan and Facility Photos **Cargill (Temco) - (Upstream Portion)**	**Fig. 6.7** June 30, 2015

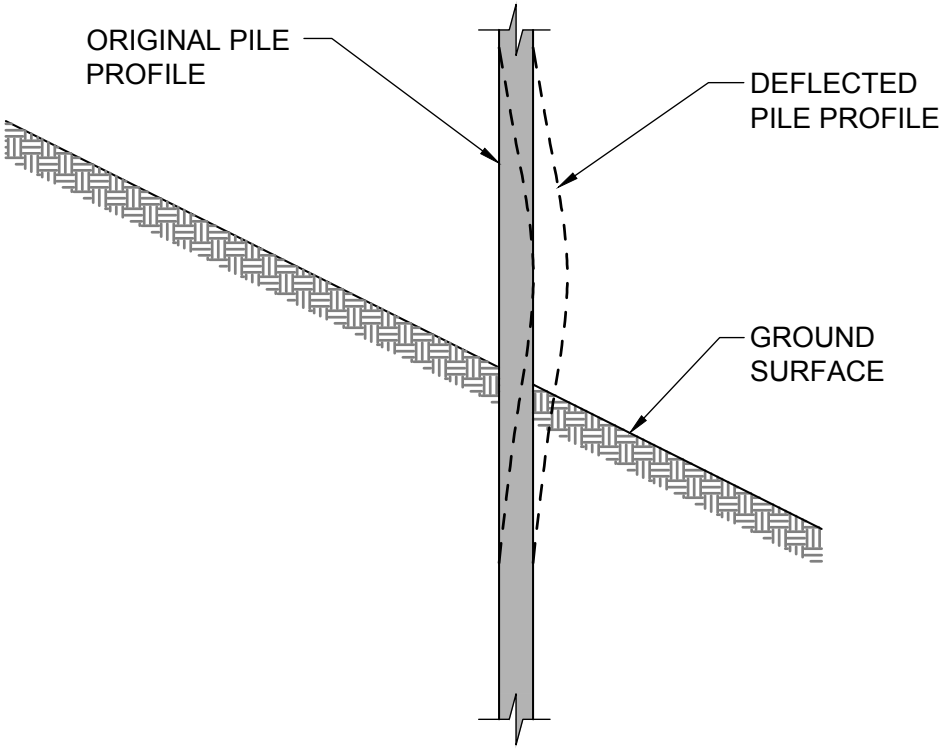


PILE FAILURE MODE - PILE KICK-OUT

NOT TO SCALE

Draft - For Review

RM11E Group **Willamette River - Portland, Oregon** **Draft Implementability Study Report**	kpff
Pile Failure Mode: Pile Kick-Out	**Fig. 6.8** June 30, 2015

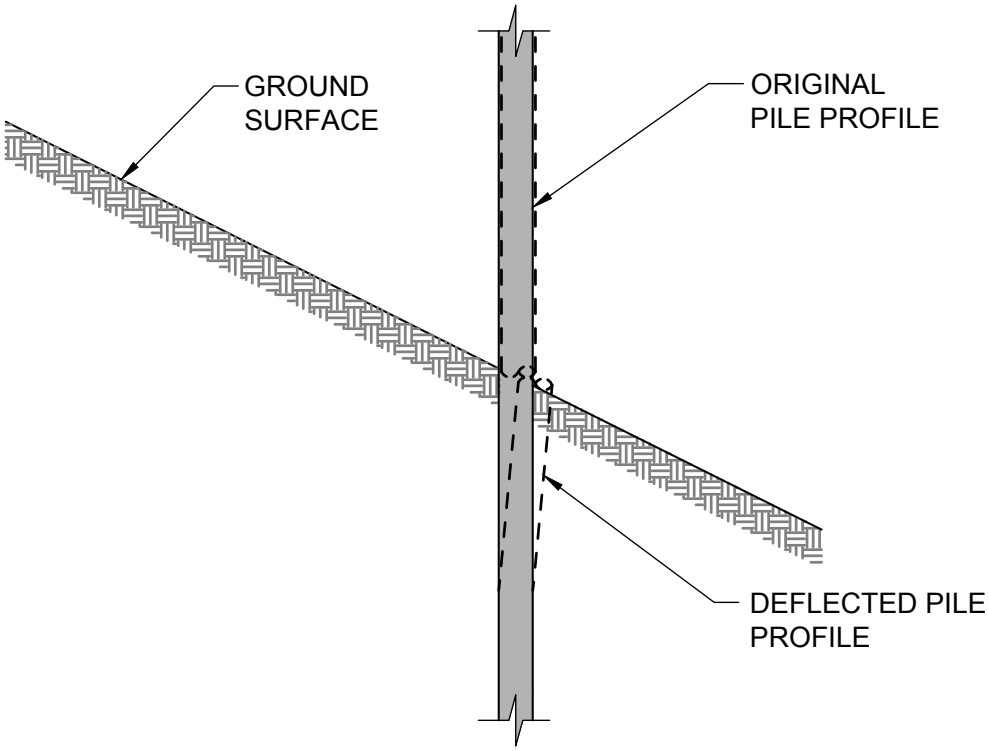


PILE FAILURE MODE - PILE BUCKLING

NOT TO SCALE

Draft - For Review

RM11E Group Willamette River - Portland, Oregon Draft Implementability Study Report	kpff
Pile Failure Mode: Pile Buckling	Fig. 6.9 June 30, 2015

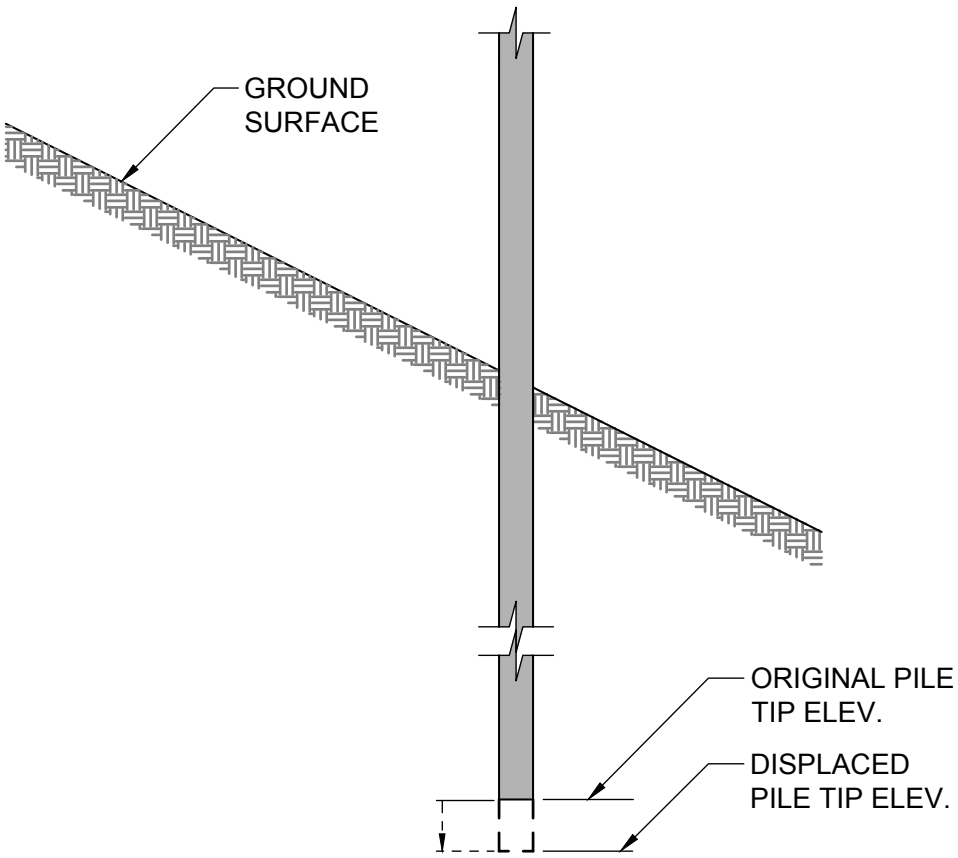


PILE FAILURE MODE - PILE SHEAR

NOT TO SCALE

Draft - For Review

RM11E Group Willamette River - Portland, Oregon Draft Implementability Study Report	kpff
Pile Failure Mode: Pile Shear	Fig. 6.10 June 30, 2015

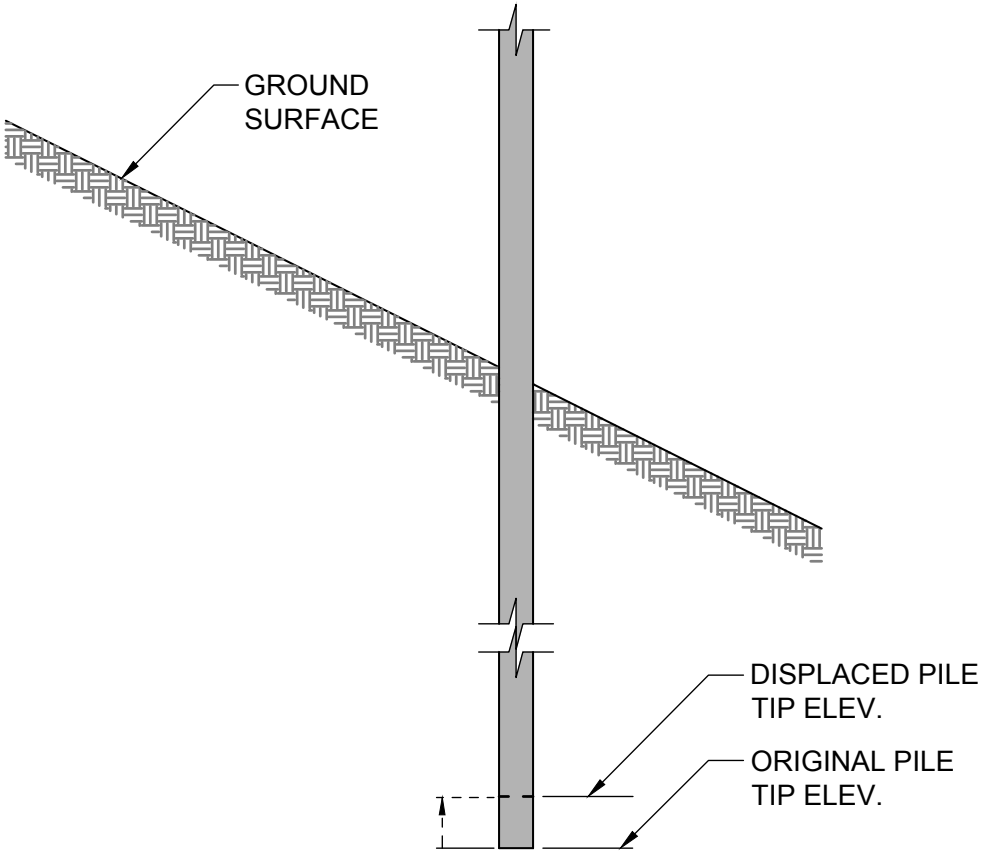


PILE FAILURE MODE - SOIL BEARING

NOT TO SCALE

Draft - For Review

RM11E Group Willamette River - Portland, Oregon Draft Implementability Study Report	kpff
Pile Failure Mode: Soil Bearing	Fig. 6.11 June 30, 2015

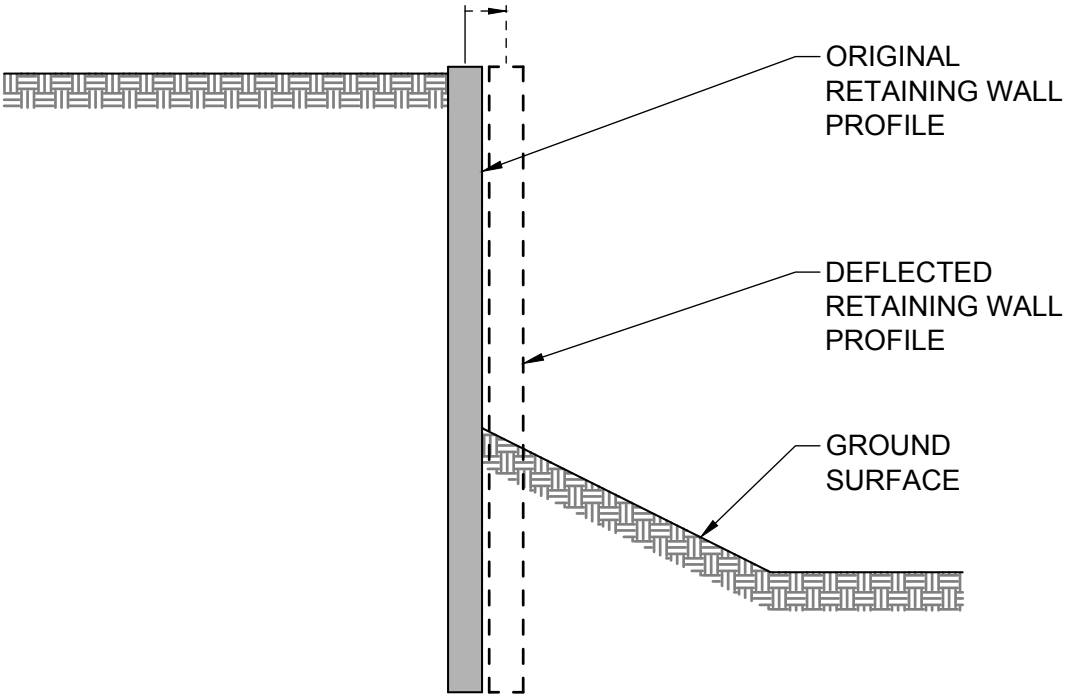


PILE FAILURE MODE - PILE UPLIFT

NOT TO SCALE

Draft - For Review

RM11E Group Willamette River - Portland, Oregon Draft Implementability Study Report	kpff
Pile Failure Mode: Pile Uplift	Fig. 6.12 June 30, 2015

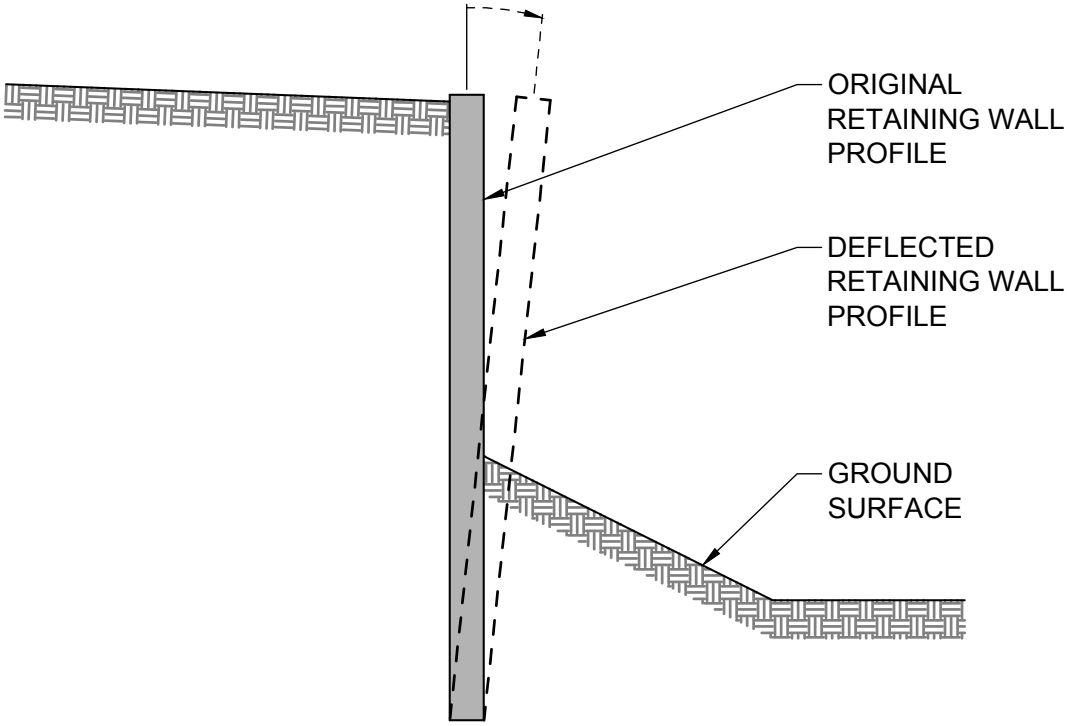


WALL FAILURE MODE - SLIDING

NOT TO SCALE

Draft - For Review

RM11E Group Willamette River - Portland, Oregon Draft Implementability Study Report	kpff
Pile Failure Mode: Sliding	Fig. 6.13 June 30, 2015

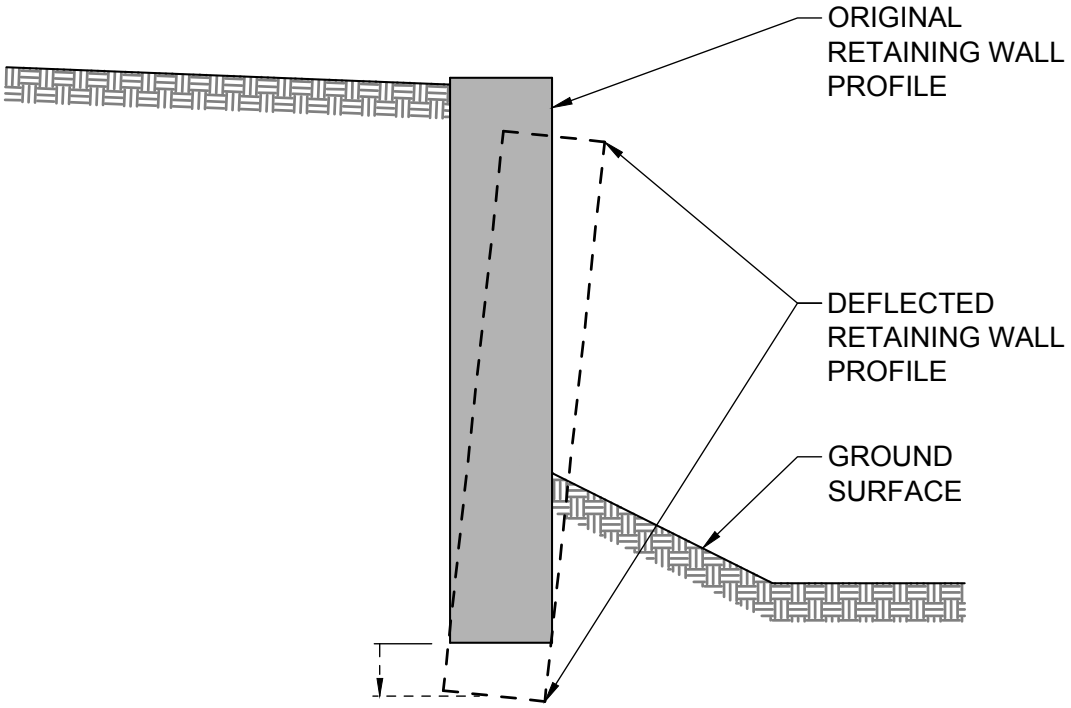


WALL FAILURE MODE - OVERTURNING

NOT TO SCALE

Draft - For Review

RM11E Group Willamette River - Portland, Oregon Draft Implementability Study Report	kpff
Pile Failure Mode: Overturning	Fig. 6.14 June 30, 2015

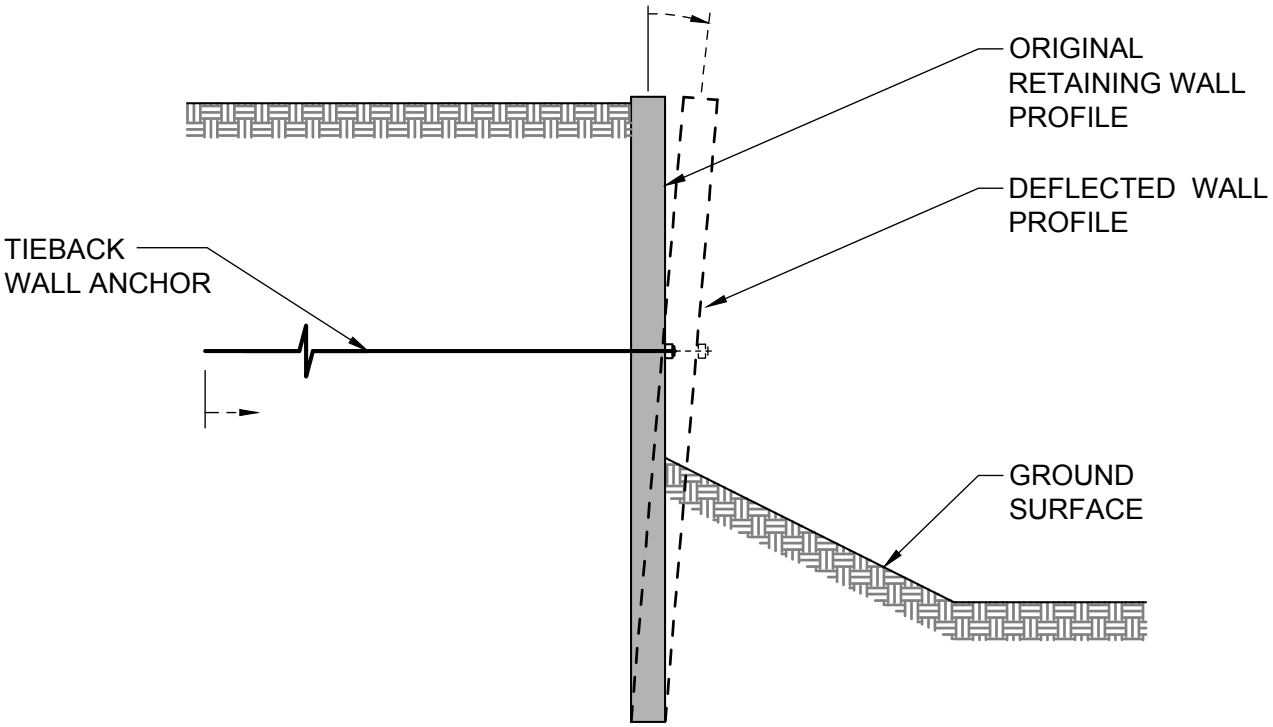


WALL FAILURE MODE - BEARING

NOT TO SCALE

Draft - For Review

RM11E Group Willamette River - Portland, Oregon Draft Implementability Study Report	kpff
Pile Failure Mode: Wall Bearing	Fig. 6.15 June 30, 2015

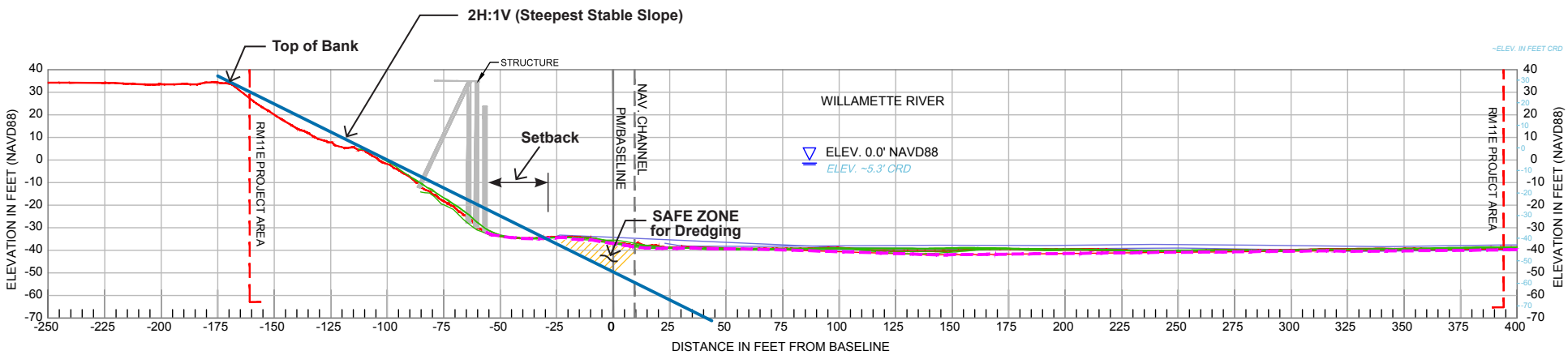


WALL FAILURE MODE - TIE-BACK ANCHOR PULLOUT

NOT TO SCALE

Draft - For Review

RM11E Group **Willamette River - Portland, Oregon** **Draft Implementability Study Report**	kpff
Pile Failure Mode: **Tie-Back Anchor Pullout**	**Fig. 6.16** June 30, 2015



TYPICAL SECTION – AT OVERSTEEPENED SLOPE

0 50
Scale in Feet

LEGEND

- Line Representing Composite Deepest Bed Elevation Based on Available USACE, LWG, and Private Surveys
- USACE Surveys (1985 through 2012)
- LWG Surveys by David Evans Assoc., Inc. (2002 through 2011)
- Current RM11E DEM (See Note 3)
- RM11E Project Area
- Assumed Steepest Stable Slope

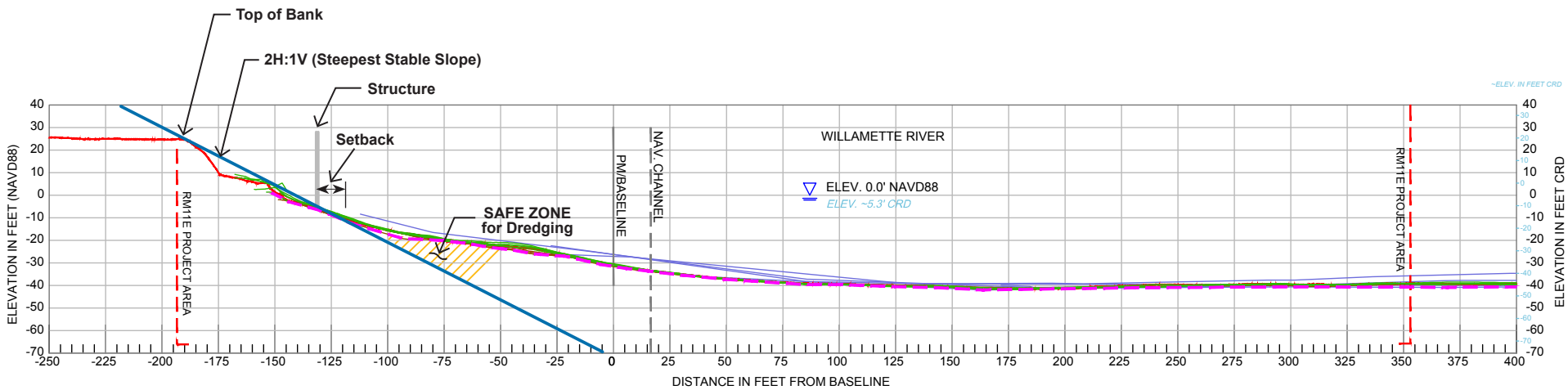
MAP NOTES

1. Portrayal of section data is approximate and is based on available information regarding the vertical datum at time of survey collection/processing which was then converted (if needed) to Columbia River Datum (CRD).
2. The locations of all features shown are approximate.
3. Contour lines and planimetric features are based on a composite data set which consists of the following: NOAA multibeam survey from 2009; ODSL multibeam and laser survey from 2010; USACE LiDAR survey from 2009; David Evans and Associates, Inc. multibeam survey from 2011 and terrestrial laser scan from 2013; and RLIS Metro GIS data. Digital elevation model (DEM) surface for bathymetric contours was modeled only in the immediate vicinity of the RM11E Project Area. It is not intended for litigation, construction, or navigation purposes.
4. The Columbia River Datum (CRD) is a gradient datum developed and maintained by the USACE, Portland District (CENWP), and is the Chart Datum extending from Harrington Point at Columbia River Mile 22 to Bonneville Dam at Columbia River Mile 145.5 continuing up the Willamette River from Willamette River Mile 0 to Willamette Falls at Willamette River Mile 26.6. CENWP lists Ordinary High Water as 14.8 feet above CRD at Willamette River Mile 11 as it applies to Section 10 of the Rivers and Harbors Act.
5. In the Portland Harbor FS the difference between CRD and NAVD 88 is shown as 5.0 feet. The average value of this conversion for the RM 11 site is 5.3 feet based on 2013 data provided by David Evans and Associates. This relationship between NAVD88 and CRD should be established again at time of design and time of construction as the conversion factor is dynamic and changes over time.

Draft - For Review

Notes: Figure based on information provided in DOF Figure 3.9a

RM11E Group Willamette River - Portland, Oregon	kpff
Draft Implementability Study Report	
Typical Section at Oversteepened Slope ~PM 11.3	Fig. 6.17 June 30, 2015



TYPICAL SECTION – AT STABLE SLOPE

0 50
Scale in Feet

LEGEND

- Line Representing Composite Deepest Bed Elevation Based on Available USACE, LWG, and Private Surveys.
- USACE Surveys (1985 through 2012)
- LWG Surveys by David Evans Assoc., Inc. (2002 through 2011)
- Current RM11E DEM (See Note 3)
- RM11E Project Area
- Assumed Steepest Stable Slope

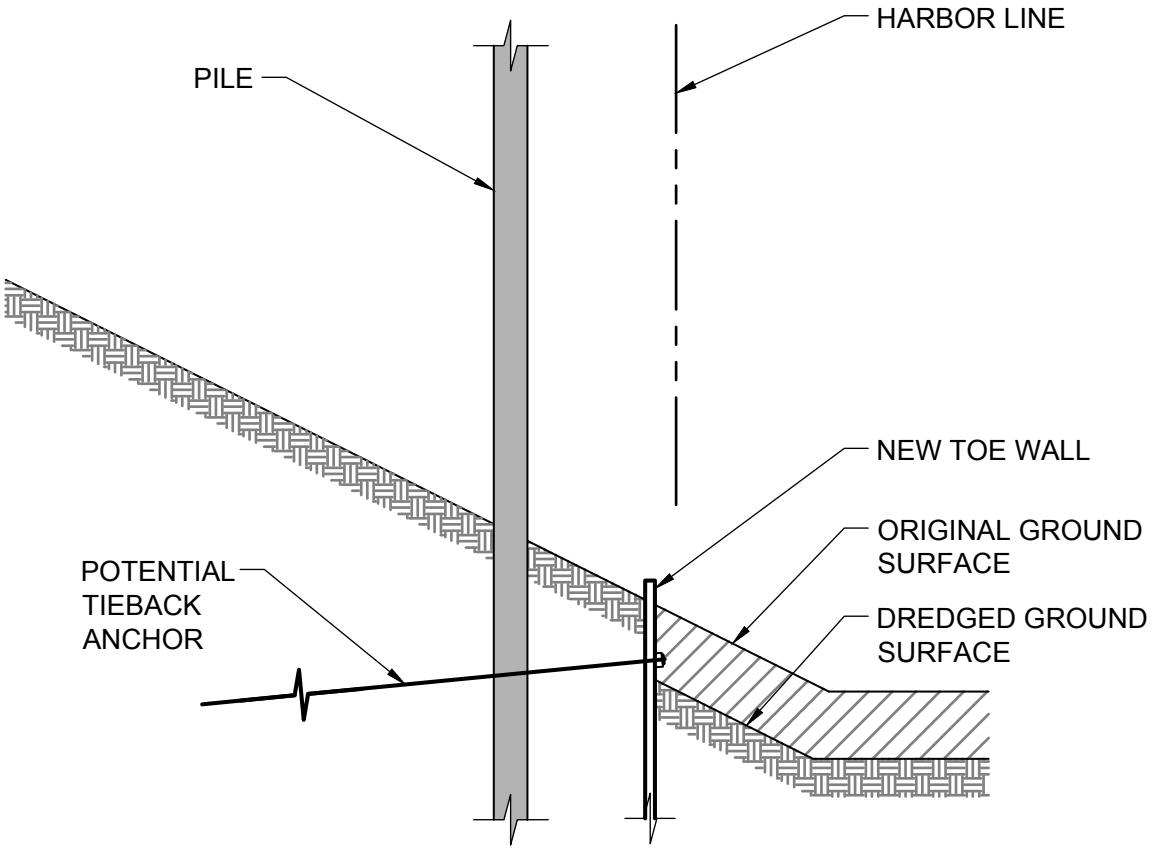
MAP NOTES

Reference Fig. 6.17.

Draft - For Review

Notes: Figure based on information provided in DOF Figure 3.9a

RM11E Group Willamette River - Portland, Oregon	kpff
Draft Implementability Study Report	
Typical Section at Stable Slope ~PM 11.36	Fig. 6.18 June 30, 2015

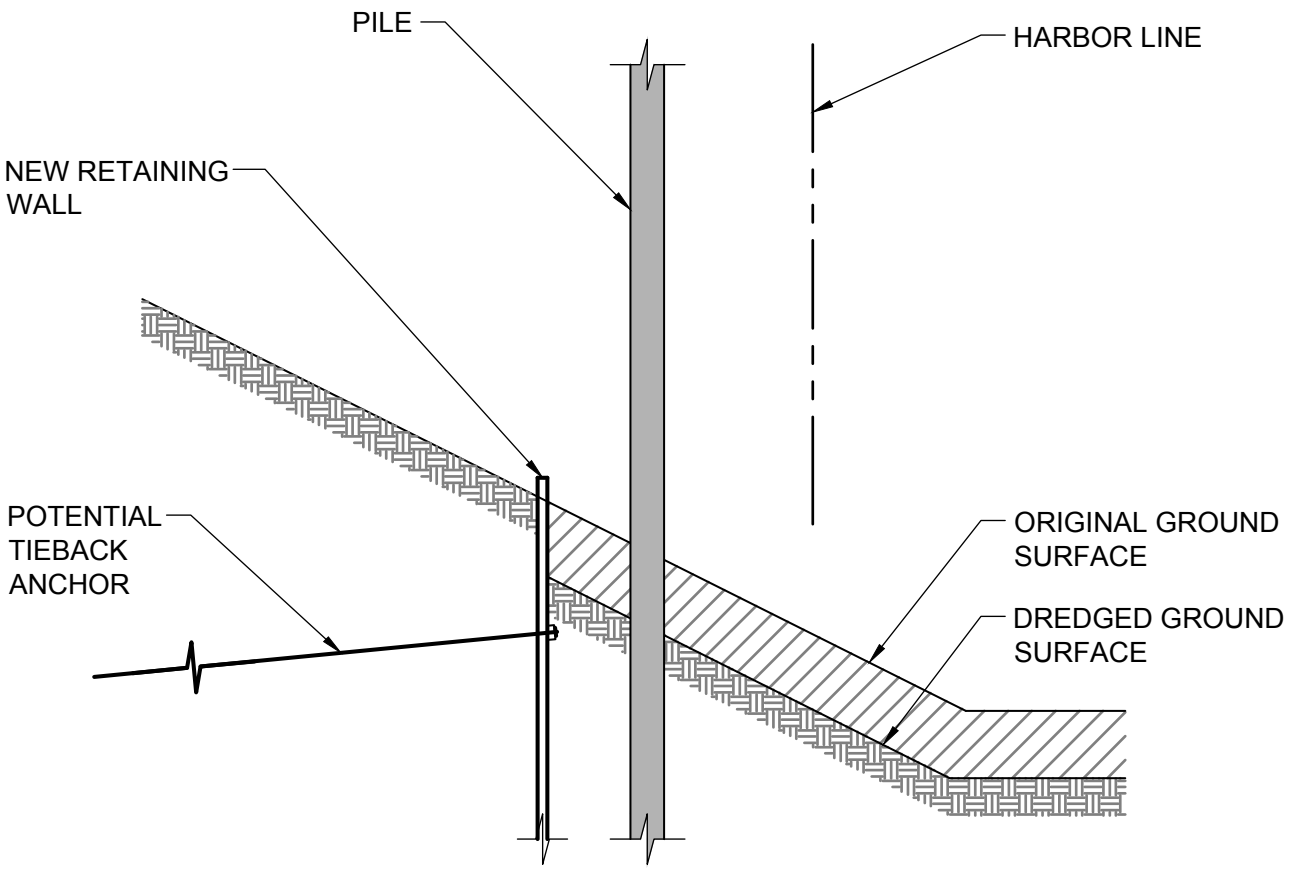


TOE WALL AT PILE

NOT TO SCALE

Draft - For Review

RM11E Group Willamette River - Portland, Oregon Draft Implementability Study Report	kpff
Toe Wall at Pile	Fig. 6.19 June 30, 2015

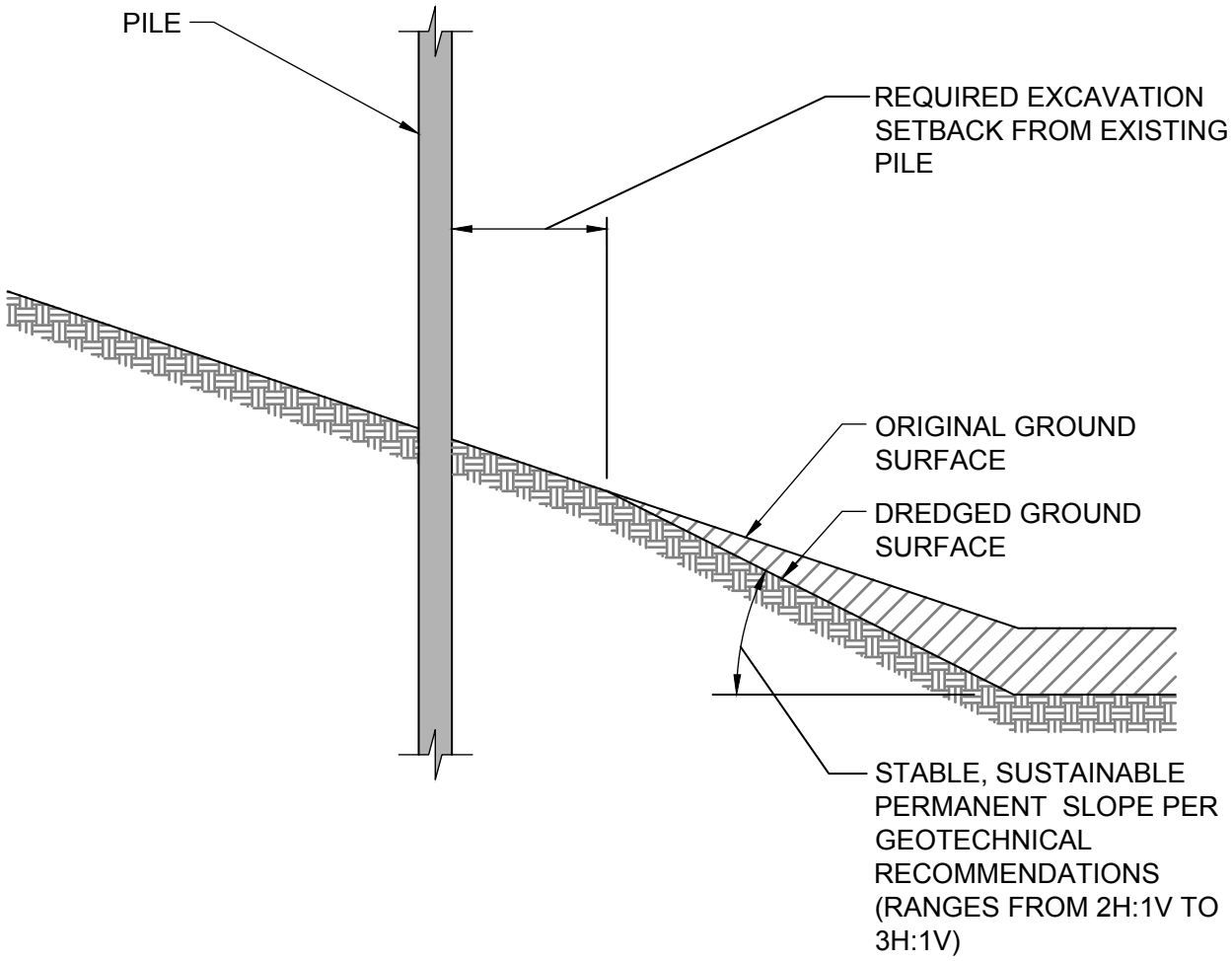


RETAINING WALL UPSLOPE OF PILE

NOT TO SCALE

Draft - For Review

RM11E Group Willamette River - Portland, Oregon Draft Implementability Study Report	kpff
Retaining Wall Upslope of Pile	Fig. 6.20 June 30, 2015

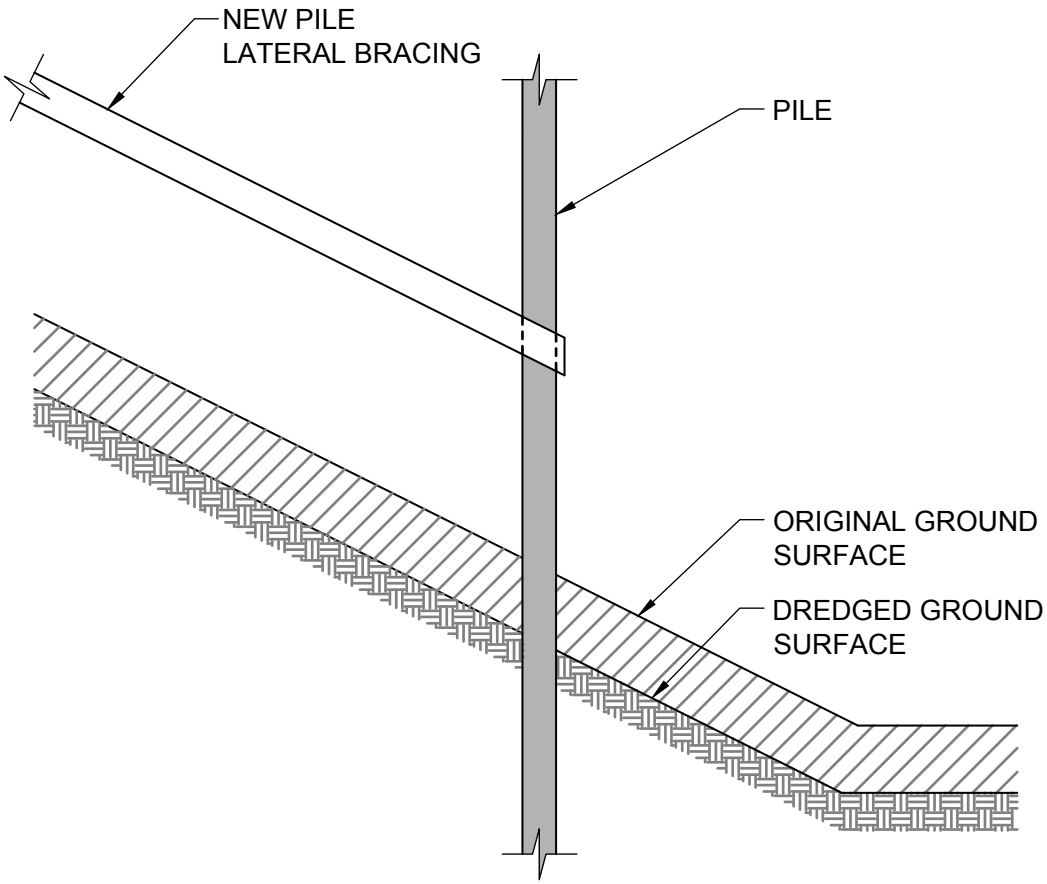


SLOPE REGRADING NEAR PILE

NOT TO SCALE

Draft - For Review

RM11E Group Willamette River - Portland, Oregon Draft Implementability Study Report	kpff
Slope Regrading	Fig. 6.21 June 30, 2015



PILE BRACING

NOT TO SCALE

Draft - For Review

RM11E Group Willamette River - Portland, Oregon Draft Implementability Study Report	kpff
Pile Bracing	Fig. 6.22 June 30, 2015

7. HYDRODYNAMIC ASSESSMENT

7.1 OBJECTIVE

The objective of this hydrodynamic evaluation is to identify how river dynamics related to river flows, wind-generated waves, vessel wakes, and propeller wash may affect future remedial design and remedial actions in the RM11E Project Area. A primary focus of the study was to identify the potential erosive forces on engineered caps or covers due to river dynamics and propeller wash as well as the size of armoring material (from sand to gravel to larger stone) needed to resist those erosive forces.

7.2 PRE-EXISTING HYDRODYNAMIC DATA SUMMARY

The PHSS Draft FS (Anchor QEA et al., 2012) includes hydrodynamic evaluations and modeling including its Appendix Hc, titled Capping Effectiveness and Stability Modeling, which served as a primary source of information for the hydrodynamics assessment of the RM11E Project Area. No new hydrodynamic modeling was completed for this study.

7.2.1 PHSS DRAFT FS APPENDIX HC

PHSS Draft F, Appendix Hc Section 4 provides a technical analysis describing potential erosive forces and armoring for PHSS. Although many of the evaluations were performed for the PHSS as a whole (RM 1.9 to RM 11.8), some were tailored for individual AOPCs, including AOPC 25, which is the RM11E Project Area. Except where otherwise stated, the findings listed in this section (7.2.1) are from Appendix Hc.

The Appendix Hc data and PHSS Draft FS level analysis are generally appropriate for the RM11E Project Area implementability assessment. However, evaluations and verifications during remedial design regarding the portions of the RM11E Project Area targeted for remedial action will refine the hydrodynamic site factors in relation to complex issues described in other sections of this report.

7.2.1.1 Typical Water Level Range – Tides and River Stages

7.2.1.1.1 Typical Water Level Range Assumptions

River stage and currents in the Lower Willamette River (including all PHSS sites) are influenced by hydrologic conditions in both the Willamette and Columbia rivers. Appendix Hc Section 4.1.1 provides the following design water level information:[35]

- The area is subjected to a tidally induced water level fluctuation averaging 2 feet across the entire length of PHSS.
- The ordinary high water mark (defined by USACE) of 19.8 feet NAVD88 (14.8 feet CRD) is used in the PHSS Draft FS. The ordinary high water elevation currently used

[35] Based on USGS maximum and minimum daily stage river data (USGS gage 14211720, Willamette River at Portland, Oregon), and the minimum and maximum extreme stage data from the USACE for 1973 to 2003

for the RM11E Project Area is 20.1 feet NAVD88 based upon more recent USACE analysis (USACE, 2014).

- The minimum extreme stage used in the PHSS Draft FS (i.e., the lowest anticipated river level) is 4.5 feet NAVD88 (-0.5 feet CRD).

7.2.1.1.2 Typical Water Level Range Assumptions: Applicability to RM11E Project Area

Figure 7.1 shows the average annual Willamette River water level at the Morrison Bridge Gauge Station (located approximately 2 miles upstream of the RM11E Project Area) from 2007 to 2012 and the actual water level from 2013.

Table 7.1 summarizes the extreme water levels used across the PHSS Draft FS in Appendix Hc.

TABLE 7.1 – WILLAMETTE RIVER STAGE EXTREMES

STAGE	APPENDIX HC	
	NAVD88	CRD[a]
High water[b]	19.8 ft	14.8 ft
Low water	4.5 ft	-0.5 ft

[a] See Section 1.5 of this report for additional information on CRD and NAVD88 conversions. PHSS Draft FS Table 2.1 uses NAVD88-to-CRD conversion of 5.0 feet.

[b] See Section 7.2.1.1.1 of this report for additional information on ordinary high water.

This range of extreme water levels (4.5 to 19.8 feet NAVD88, -0.5 to 14.8 feet CRD) is based on the period 1973 to 2003. During design, data from an alternative time period may be compared to the time period above to evaluate potential changes in river elevations. The effects of waves would extend the shoreline area influenced by hydrodynamic forces above and below this static water level range as discussed below.

The studies performed as part of Appendix Hc are limited to elevations below 13 feet NAVD88, as stated in Appendix Hc Section 4.1:

> *This study was limited to the river water levels between minimum extreme stage (4.5 feet NAVD88) and 13 feet NAVD88, which is the administrative boundary for the project. Sediment capping or shoreline stabilization above 13 feet NAVD88 is not included as part of this Draft FS; however, areas above 13 feet NAVD88 may require shoreline stabilization measures integrated with upland soils remedies as needed due to impacts from wind and vessel-generated waves.*

7.2.1.2 Waves and Wakes

This section discusses wind-generated waves and vessel wakes and their possible impacts on future remedial actions in the RM11E Project Area. Unless identified otherwise within this report, the PHSS-wide information is used as a reasonable approximation of conditions in RM11E. The impacts of waves and wakes will be refined during remedial design for areas of the RM11E Project Area requiring remedial action.

7.2.1.2.1 Wind-generated Waves – Methods and Analysis Assumptions

The height of wind-generated waves was estimated in the PHSS Draft FS using a hindcast model.[36] The hindcast is described in Appendix Hc Section 4.1.2, for each PHSS AOPC using the following assumptions and methods:

- Wind data for the Portland International Airport obtained from the National Climatic Data Center and the Meteorological Resource Center were compiled into a single set. Wind speeds were adjusted to 2-minute averages at 10 meters above ground elevation.
- A Rayleigh distribution curve was fitted to the annual maxima (from 1961 to 1964), and the 100-year return period wind speed was extrapolated for each of 12 wind direction zones.
- For each AOPC, fetch distances[37] were measured for each wind directional zone that could result in wind waves that impact the shoreline.
- For each AOPC, 100-year return wind periods for each relevant directional zone were calculated based on the fetch-limited, restricted-fetch wave growth formulation in the Automated Coastal Engineering System (ACES) developed by the USACE (1992).

7.2.1.2.2 Vessel-generated Waves – Methods and Analysis Assumptions

Vessel-induced wave heights were estimated in Appendix Hc Section 4.1.3 by evaluating ship traffic patterns and then calculating vessel wakes based on type of vessel, operational speed of vessel, and water depth using the following information and approach:

- Information on waterway traffic in the vicinity of the AOPC sites was obtained from the USACE website, Port of Portland documentation on vessel arrivals and departures, Lower Willamette Group property owner Site Use Survey, as well as other sources. Commercial vessel traffic between Port of Portland Terminals 2 and 4 was used to represent commercial vessel operations along the entire PHSS area.
- The Weggel-Sorensen model[38] was used to calculate the wave height generated at a vessel bow as a function of the vessel speed, distance from the sailing line, water depth, vessel displacement volume, and vessel hull geometry.
- A model developed by the Maritime Coastal Agency (2009) was used to estimate the height of waves generated by high-speed excursion boats (i.e., jet boats) traveling along

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[36] A wave hindcast predicts past wave conditions using observed wind fields (direction, frequency, velocity) to calculate potential wave heights based on wave growth and propagation equations.

[37] Fetch is the distance that wind can travel over a water body to create a wave. At the Portland Harbor site, the Willamette River's sinuosity (amount of curvature) limits the fetch relative to larger, more open water bodies. Wind waves can be fetch-limited or wind-(speed and duration) limited.

[38] The Weggel-Sorenson model is a vessel wave height prediction model developed in 1986 based on measured laboratory and field data.

the center line of the navigation channel, and for jet boats traveling halfway between the channel centerline and the bank.

7.2.1.2.3 Waves and Wakes – Applicability to RM11E Project Area

The wave heights presented in the PHSS Draft FS are the incident wave and wake heights at the shoreline. Additional effects such as wave reflection, refraction, shoaling, and wake and wave superposition (coincident waves) should be considered during design for both existing and potential future conditions. These factors should be addressed during remedial design based on the location and configuration of remedial actions.

For each AOPC, Tables 4-3 and 4-4 of Appendix Hc list the 100-year significant wind-generated wave height and period and associated 100-year wind speed. For the RM11E Project Area, the maximum wind-generated wave identified in Appendix Hc is 1.5[39] feet high, has a period of 2.1 seconds, and is caused by a 100-year wind speed of 59 mph[40] from a heading sector of 151 to 180 degrees north.

For commercial vessel traffic, the maximum wake (vessel-generated wave) for all PHSS is calculated in Appendix Hc to range from 2.0 to 2.8 feet with periods on the order of 3 to 4 seconds. Selection of an RM11E-specific preliminary design commercial vessel wake based upon anticipated future uses and vessel traffic will be part of design. An approximation for the RM11E Project Area, suitable for an FS and based on information in Appendix Hc, is a height of 2.8[41] feet and period of 3 to 4 seconds.

The height of wakes from excursion vessels was estimated in Appendix Hc at 2.5 feet for a jet boat traveling along the centerline of the navigation channel, and 3.3 feet for a jet boat traveling halfway between the channel centerline and the bank. Periods for jet boat wakes are not presented in Appendix Hc Table 4-7. These excursion jet boats are said to "travel through the project reach several times daily during the summer season (approximately April through September)." The frequency of these vessel trips can be expected to vary over time and could also include larger or faster vessels at some future time. For the purpose of this assessment, an RM11E excursion vessel wake height of 2.9 feet and a period of 4 seconds are appropriate based on information in Appendix Hc.

Appendix Hc Section 4.1.4 defines the shoreline wave zone (or surf zone[42]) as "the region in the Lower Willamette River extending from the location where the waves begin to break to the limit of wave run-up on the shoreline slope." The text goes on to state, "Within the surf zone, wave

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[39] Wind-generated waves were observed on January 14, 2015, with crest height visually estimated at less than 6 inches, with wind speeds estimated to be on the order of 15 mph. No wind-generated waves were observed January 20, 2015 with wind speeds estimated to be on the order of 5 mph (DOF, 2015).

[40] Note that a higher wind speed of 69 mph is used in Appendix Hc for winds from 181 degrees to 210 degrees but that the shorter available fetch along that heading limits wave growth to 1.4 feet.

[41] On January 20, 2014 a loaded vessel assisted by two tugs was observed during its departure from the Cargill dock. A wake less than 6 inches high observed at the starboard bow and at the stern of the ship during the maneuver appeared to have originated from the tugs (DOF, 2015).

[42] Wave zone in this section is interchangeable with surf zone used in Appendix Hc.

breaking is the dominant hydrodynamic process. Outside of the surf zone, the wave-induced horizontal orbital velocities are the dominant force." As stated in Appendix Hc Section 4.1.1, this "study was limited to the river water levels between minimum extreme stage (4.5 feet NAVD88) and 13 feet NAVD88, which is the administrative boundary for the project."

However, the wave zone can actually extend to approximately elevation 23 feet NAVD88 (ordinary high water [OHW] 20.1[43] feet NAVD88 plus a wave height of 2.9 feet), which is a consideration when determining shoreline armoring (Section 7.2.1.3). This wave zone (elevation 0 to 23 feet NAVD88) is shown in cross section for station PM 11.32 on Figure 7.2 (below) and in plan view on Figures 7.3a through 7.3d. Based on typical river stage frequencies, the shoreline elevations subject to the majority of wave force occurs between elevations 6 and 13 feet NAVD88 (Anchor et al., 2012). Many of the cross sections for the RM11E Project Area shoreline show a similar change in slope (flatter slope) through the wave zone elevations extending above elevation 0 feet NAVD88, as illustrated by Figure 7.2.

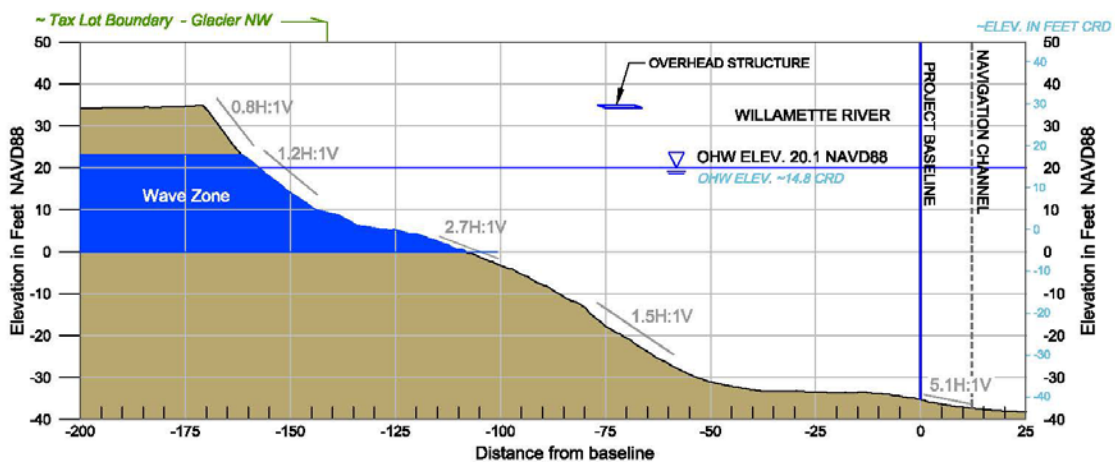

FIGURE 7.2 – TYPICAL RM11E PROJECT AREA WAVE ZONE CROSS SECTION

7.2.1.3 Shoreline Armoring Geometry

Armoring of the shoreline with material of sufficient gradation and thickness will protect the geometry and integrity of a sediment cap from site erosive forces, including wind- and vessel-generated waves, and river currents within the wave zone (above elevation 0 feet NAVD88). Shoreline armoring for the PHSS site was evaluated in the PHSS Draft FS, Appendix Hc Section 4.1.4. The remedial design for capping materials in any specific area should consider existing shoreline slopes, structures, and existing geotechnical stability.

[43] In the PHSS Draft FS, OHW is shown as 19.8 ft NAVD88. Current OHW for the RM11E Project Area is calculated as 20.1 ft NAVD88 based on USACE (2014) report. This elevation should be established again at time of design and time of construction as elevation is dynamic and changes over time.

7.2.1.3.1 Shoreline Armoring Geometry – Methods and Analysis Assumptions

Calculations in Appendix Hc Section 4.1 indicate that wave heights for vessel wakes are higher than those for wind-induced waves. The following wave heights were used for the Appendix Hc analysis, based on calculated averages for the entire PHSS (RM 1.9 to RM 11.8):

- Design wind-wave height – 1.0 to 1.6 feet
- Design wake height due to commercial vessels – 2.8 feet
- Design wake height due to jet boat excursion vessels – 2.9 feet

Other methods and assumptions used in Appendix Hc include the following:

- The sediment cap armor layer in the surf zone is modeled as a rubble mound revetment because of turbulence generated by breaking waves.
- As a screening-level analysis, the FS uses a single armor stone size for the entire shoreline, including all AOPCs.
- The selected largest design wave has a height of 2.9 feet and an assumed period of 4 seconds.
- In the PHSS-wide wave zone (along the shoreline where wave-breaking is the dominant hydrodynamic process), armor gradation required for the cap armor layer is based on the ACES "rubble-mound revetment design" module.
- Within the wave zone, the revetment is assumed to consist of an uppermost rock layer, an underlying filter area, and a chemical isolation layer immediately on top of the sediments. The revetment is assumed to be impermeable.
- Revetment geometries were calculated for two different displacement levels (S[44]=2 [associated with minor movement of armor units] and S=5 [associated with intermediate movement of the armor units]) and two different structure slopes (2H:1V and 5H:1V).

7.2.1.3.2 Shoreline Armoring Geometry – Applicability to RM11E Project Area

The shoreline armoring geometry analysis completed in Appendix Hc Section 4.1.5 is summarized in Table 7.2, which presents armor and filter layer sizing based on the median particle diameter (D_{50}). Figures 5.6a through 5.6d show that most shoreline slopes in the RM11E

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[44] S is a qualitative indicator of displacement. Revetments used for coastal protection projects are often designed with allowance for some maintenance of the armor layer. The revetment design methodology allows varying amounts of displacement (movement) of the armor layer. The amount of displacement considered can be categorized as the following:

- No displacement – No armor stone displacement (note that this does not account for settlement; displacement is a result of wave-induced forcings only)
- Minor displacement – Few armor stones displaced (less than 5 percent) and potentially redistributed within or in the near vicinity of the armor layer
- Intermediate displacement – Ranging from moderate to severe; armor stones are displaced without causing exposure of filter layer to direct wave attack

Allowable movement or rocking of armor stones (minor displacement) in the ACES revetment design methodology is based on steeper slopes (from 1.5 H:1V to 6H:1V) that are typically used for coastal revetments.

Project Area are steeper than 2H:1V (i.e., are oversteepened). Remedial design should integrate shoreline armoring design with stabilization of oversteepened slopes to achieve slope stability after remedial action.

TABLE 7.2 – APPENDIX HC POTENTIAL SHORELINE ARMOR STONE MEAN SIZE

SLOPE	DISPLACEMENT LEVEL (*S*)[a]	ARMOR LAYER STONE D_{50} (FT)	ARMOR LAYER THICKNESS (FT)	FILTER LAYER STONE D_{50} (FT)	FILTER LAYER THICKNESS (FT)
2H:1V	2	1.1	2.25	0.1	1
2H:1V	5	0.9	1.9	0.1	1
5H:1V	2	0.9	1.8	0.1	1
5H:1V	5	0.6	1.2	0.07	1

[a] Source: Appendix Hc Table 4-8

[b] Armor rock stability was evaluated for two different displacement levels: S=2 (associated with minor movement of armor units) and S=5 (associated with intermediate movement of armor units), consistent with experiments by Van der Meer (1988).

7.2.1.4 Stable Particle Size

7.2.1.4.1 Stable Particle Size Methods and Analysis Assumptions

The stable particle size is the size of the material (i.e., sand, gravel, rock) whose mass is sufficient to remain in place under a given shear stress or related water velocity below the wave zone (deeper than 0 feet NAVD88). As discussed in Appendix Hc Section 4.1.6, EPA's *Guidance for In-Situ Subaqueous Capping of Contaminated Sediment, Appendix A: Armor Layer Design* (Maynord, 1998) was used in the PHSS Draft FS to compute representative particle size (diameter) to resist wave-induced erosion for sediment caps that may be placed offshore at elevations below 0 feet NAVD88 (~-5 feet CRD).

7.2.1.4.2 Stable Particle Size Analysis: Applicability to RM11E Project Area

Stable sediment particle sizes predicted to resist 100-year wind-generated waves are summarized in Table 7.3 and Figures 7.3a through 7.3d. Generally, these particles are gravel and sand, with gravel-sized particles predicted in water depths ranging from approximately 10 feet to the wave zone. As with the shoreline geometry, these values are based on average parameters for the entire PHSS, and should be verified or refined during remedial design to determine stable particle sizes at specific depths.

TABLE 7.3 – SUMMARY OF APPENDIX HC SEDIMENT CAP OR COVER ARMOR LAYER FOR WAVES ANALYSIS

WATER DEPTH (FT)	ELEVATION (FT NAVD88)[a]	CAP OR COVER CHARACTERISTIC		
		D_{50} PARTICLE SIZE (IN)	SEDIMENT TYPE	MINIMUM THICKNESS (IN)
5 to 4.5	-1.5 to 0	1.14	Coarse gravel	6
6 to <5	-2.5 to -1.5	0.80	Coarse gravel	6
8 to <6	-3.5 to -2.5	0.63	Fine gravel	6
10 to <8	-5.5 to -3.5	0.42	Fine gravel	6
15 to <10	-14.5 to -5.5	0.29	Fine gravel	6
20 to <15	-19.5 to -14.5	0.13	Sand	6
30 to <20	-24.5 to -19.5	0.06	Sand	6

[a] Source: Appendix Hc Table 4-9.

[b] Elevations based upon minimum extreme stage (4.5 feet NAVD88, see Section 7.2.1.1.1.). This would be the lowest anticipated water stage and the resulting shallowest water depths requiring the largest D_{50} cover size.

7.2.1.4.3 100-Year Flood Analysis Methods and Analysis Assumptions

As discussed in Appendix Hc Section 4.3, a steady-state simulation of the 100-year flood[45] in the Lower Willamette River was performed for PHSS to evaluate the stable particle size associated with river currents during such a flood event. Representative particle sizes (diameters) to resist erosion associated with current velocities were computed to determine the approximate material size required to withstand the 100-year flow condition within each AOPC.

7.2.1.4.4 100 Year Flood Analysis: Applicability to RM11E Project Area

A summary of the reported results for the RM11E Project Area in Appendix Hc Table 4-12 is shown below, with minimum and maximum depth-averaged river current velocities (i.e., one velocity representing the full depth of the water column) and associated stable particle size. While the locations of the maximum and minimum model velocities are not identified in Appendix Hc, these values represent the range of velocities generated by the model within AOPC 25. Because of the large cell sizes used in the model[46] relative to the size of the RM11E Project Area, the model results may not accurately characterize the variation of currents within the RM11E Project Area. The potential impacts of a 100-year flood event will be refined during remedial design for areas of the RM11E Project Area requiring remedial action.

[45] The regulatory 100-year flood elevation is 31.6 feet NAVD at RM11 (FEMA, 2010) and the flow rate is 360,000 cubic feet per second per PHSS Draft FS Appendix La Table 2-1.

[46] As shown on Figure 2.1-4 of the PHSS Draft FS, the grid for the RM11E Project Area is approximately five cells long and five to seven cells wide, with gaps in the grid along the RM11E upper shoreline.

TABLE 7.4 – 100-YEAR FLOOD VELOCITY AND CORRESPONDING STABLE PARTICLE SIZE FOR RM11E PROJECT AREA

RANGE	FLOOD VELOCITY (FEET PER SECOND)	STABLE PARTICLE SIZE (IN)
Minimum	0.46	0.0032
Maximum	5.70	1.74

[a] Source: Appendix Hc, Table 4-12 for AOPC 25.

7.2.1.5 Propeller Wash Analysis

7.2.1.5.1 Propeller Wash Methods and Analysis Assumptions

The Appendix Hc Section 4.2 propeller wash analysis consisted of the following components:

- Obtaining information on the types of commercial and recreational vessels that operate in the PHSS area
- Obtaining the vessel characteristics, including draft and propeller type
- Selecting "representative reasonable conservative" vessels
- Defining operating assumptions for the "representative reasonable conservative" case vessels
- Defining a range of general site conditions across AOPCs for each model run
- Estimating the range of particle sizes necessary to withstand the erosive forces associated with propeller wash at various water depths

The standard predictive models for propeller-induced bottom velocities are based on jet flow for a stationary jet. Empirical relationships developed by Blaauw and van de Kaa (1978) were used for modeling. Although propeller wash is typically modeled as a stationary jet, this approach can be conservative, as the vessel's sailing speed, nominal though it may be, limits the duration of impact at a given location.

The propeller-induced bottom velocities and associated stable particle size required to resist the long-term, steady-state propeller wash from vessels were calculated in Appendix Hc for each AOPC in the PHSS, based on the following design assumptions:

- The propeller wash equations are based on maneuvering vessels with a sailing speed of zero.
- General vessel information is based on site-wide conditions augmented by field observations, offered by Integral Consulting (J. Moore) based on 4 years of experience conducting studies in and acquiring familiarity with operations in the area.
- The maximum operating horsepower is 30 percent of available horsepower for large ships and 80 percent for tugs.
- Water depth in the operational area of each vessel in each AOPC is the shallowest water depth measured in bathymetric surveys of February and March 2004 by David Evans and Associates.

7.2.1.5.2 Propeller Wash Analysis – Applicability to RM11E Project Area

The vessel data used in Appendix Hc Section 4.2, for the model inputs for the RM11E Project Area are summarized in the table below.

TABLE 7.5 – RM11E PROJECT AREA VESSEL DATA ESTIMATES

VESSEL CLASS	PROPELLER SHAFT DEPTH (FT)	PROPELLER DIAMETER (FT)	VESSEL HORSEPOWER (HP)	MAXIMUM REASONABLE HP APPLIED (%)
Small tug	9	6 (twin)	3,300	80
Large ocean-going vessel	30 to 31	18	20,000	30

[a] Source: Appendix Hc Table 4-10.

Results of the propeller wash analysis based upon the above assumptions for the RM11E Project Area, as presented in Appendix Hc Section 4.2.6, are summarized in Table 7.6.

TABLE 7.6 – APPENDIX HC STABLE SEDIMENT SIZE UNDER MAXIMUM VELOCITY SCENARIO FOR AOPC 25 PER FS ASSUMPTIONS

DESIGN VESSEL	MINIMUM WATER DEPTH IN AREAS OF OPERATION (FT)	C_3[a] (FREQUENCY COEFFICIENT)	MAX V_B[b] (FPS)	STABLE SEDIMENT SIZE D_{50} (IN)	SEDIMENT DESCRIPTION
Small tug	45	0.5	1.0	0.9	Coarse gravel
Large ocean-going vessel	50	0.6	5.4	18.1	Riprap

[a] Source: Appendix Hc Table 4-11.

[b] The C_3 parameter represents frequency of vessel operations: infrequent=0.7, moderate=0.6, and frequent=0.5.

[c] V_B is bottom velocity in feet per second.

The water depths (45 and 50 feet) assumed in the PHSS Draft FS are deeper than the minimum maintained depths in the RM11E Project Area: ~15 feet at RIS&G, 21 feet at Glacier barge dock, 36 feet at the Glacier NW main dock, and 40 feet at the Cargill ship dock; the difference between assumed and actual water depth may put a propeller closer to the riverbed than was assumed in the PHSS Draft FS. This means that near-bed velocity and stable particle sizes to be used for design may be larger at these docks than presented in Table 7.6. Additional evaluation of propeller wash effects will need to be included during remedial design should capping be planned in areas subject to propeller wash.

Potential propeller wash areas in the RM11E Project Area include the navigation channel, the private navigation berth areas, the surrounding shallow areas, and adjacent waterway banks. Propeller wash may create velocities capable of eroding sediment in areas impacted by the localized vessel routes. Since propeller wash can be repetitive, localized areas of impact may require additional consideration in the remedial design; navigation constraints, such as dolphins and groups of vertical pile remnants, also merit consideration. The private berth areas (Figures 3.5a and 3.5b) have been approximated from descriptions of in-water approach and departure paths in the facility Questionnaire responses, and interviews with tug operators and Columbia River pilots.

7.2.2 CALCULATED CHANGES IN RIVERBED AND BANK ELEVATION

The PHSS Draft FS states that the reach of the Willamette River between RM 10 and RM 11.8, which includes the RM11E Project Area, contains areas of localized net erosion interspersed with areas of net deposition.

In the PHSS Draft FS, apparent rates of sediment deposition and erosion were calculated by comparing the differences between bathymetric surveys of the riverbed between 2002 and 2009[47]. Because erosion and deposition are dynamic in a flowing river, the differences in bed elevation between two surveys does not necessarily represent a steady-state or constant rate condition, but rather just a single snapshot of the change. The riverbed at any particular location may be eroding during high river stage and flow, and gaining during low river stage and flow.

Figures 7.4a through 7.4d show the calculated changes in riverbed elevation within the RM11E Project Area between a January 2002 survey and a 2009/2013 composite[48] survey. Areas where the bed elevation is higher in the 2009/2013 composite than in January 2002 ("Increased Elevation") are indicated as apparent net deposition, while areas where the bed elevation is lower in the 2009/2013 composite than in 2002 ("Decreased Elevation") are indicated as apparent net scour. Changes in bed elevations year-to-year may not represent long-term trends, but rather could show dynamic equilibrium at two points in time.[49]

Figures 7.4a through 7.4d show areas of apparent decreased elevation (e.g., a localized areas around Cargill and downstream of Glacier NW), areas of apparent increased elevation (e.g., the navigation channel outboard of the Sakrete site, the downstream portion of RIS&G), and areas with no predominant change in elevation (the majority of the RM11E Project Area). During the time period evaluated (January 2002 to 2009/2011), maintenance dredging occurred at both the Cargill (July 2002, July 2006, October 2009) and Glacier NW facilities (2004) (see Section 3.6.2), which could have affected elevations in nearby riverbed and bank areas.

The multiple surveys between 2002 and 2009/2013 also provide a snapshot of recent shoreline and riverbed elevation changes, as shown in Figures 3.11a through -3.11c cross sections. The survey data are combined with the historical top-of-bank locations. At PM 11.52, at the upstream end of the RM11E Project Area, a portion of the shoreline was 14 feet lower in 2009 than in 2002. At other locations, shoreline elevations either did not change significantly, or changed on the order of up to 4.5 feet over this 8-year period. The cause of the elevation changes is not determinate from the available data, changes may be due to issues related to remnant pilings, dredging, shoreline instability or other natural processes.

7.2.3 TYPICAL CAP AND COVER SECTIONS

Appendix K in the PHSS Draft FS presents a figure depicting several typical cap and cover sections, including a base cap, filter layer, and armor layer with over placement allowances.

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[47] The period 2002 to 2009 was evaluated to look for significant changes in bathymetry. Year-to-year changes may not represent long-term trends.

[48] The 2009/2013 composite is a combination of bathymetric and terrestrial surveys completed between 2009 and 2013 to provide coverage of the RM11E Project Area, as described in Note 2 of Figure 34.1 and as shown on Figure 3.1.

[49] Many factors contribute to the accuracy of multibeam survey data, such as sound velocity, beam angle of reflectance, and positioning. When two multibeam surveys are compared survey-to-survey, most of the data are within plus or minus 0.25 feet (DEA, 2015).

These sections are reproduced in Figure 7.5. While RM11E Project Area-specific cap and cover sections would be determined during future remedial design, the sections presented in the PHSS Draft FS are reasonable for this hydrodynamics assessment.

The FS discusses and approximates potential cap thickness based on the stable sediment size (D_{50}, or median particle size) for maximum velocity conditions. To protect against ocean-going vessel propeller wash, the cap would presumptively need to be thicker (e.g., on the order of 5 to 6 feet thick) (see Armor Cap Class 700). In areas not subject to propeller wash or wave action, the resulting cap could be thinner. The thinnest cap evaluated in the PHSS Draft FS is typically 15 to 27 inches thick (see Armor Cap A and B). Cap configurations will be refined during remedial design based upon the localized conditions specific to the areas targeted for capping in the RM11E Project Area.

As an example, remediation recently occurred at the Zidell waterfront property site, located upstream and across the river from the RM11E Project Area (between RM 13.4 and RM 14.2). The cap armor designs developed for the Zidell site are based on hydrodynamic forces at the site, including waves, wakes, and propeller wash. These designs use Oregon Department of Transportation Class 100, 200, and 700 riprap[50] in thicknesses ranging from 1 to 3 feet in areas up to elevation +15 feet City of Portland datum (~+17.1 NAVD88).

7.3 VESSEL OPERATOR INTERVIEWS

Interviews with Shaver Transportation (which provides tug boat assistance in the area) and the Columbia River Pilots Association (which provides ship captains for ships traversing the area) are summarized below. The respondents provided anecdotes based on their personal observations, opinions, and experiences.

7.3.1 ROB RICH, SHAVER TRANSPORTATION

Rob Rich, the Vice President of Marine Services, Shaver[51] Transportation, was interviewed on January 9, 2015. The key points from the interview include the following (Shaver, 2015):

- The Glacier NW main dock receives vessels as large as the Handymax class; these vessels arrive loaded and can draft between 36 and 39 feet.
- The Cargill dock receives vessels typically between 550 and 738 feet long (Panamax class). Arriving empty and departing loaded, when these ships can draft between 39 and 40 feet.
- The vessels use their propellers to assist the tugs during arrival to and departure from the docks. The ship engines are generally just above idle, but can use higher power as conditions demand.
- Propeller wash creates visible turbidity during vessel arrival and departure.

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[50] Class of riprap refers to the maximum size (weight in pounds) of the rock in that class for riprap that is uniformly graded from 0 to 2 pounds to the maximum size. Class 100 maximum rock size=60 to 100 pounds, Class 200=140 to 200 pounds, and Class 700=500 to 700 pounds.

[51] Shaver Transportation provides tug services to Glacier NW and Cargill (Glacier NW, 2014; Cargill, 2014).

- Large vessels departing from Louis Dreyfus (LD) Commodities, LLC, just upstream of the RM11E Project Area, maneuver to the Broadway Bridge and then turn around in the RM11E Project Area. In the past, LD Commodities typically received 18 ships per year, but is now receiving 23 to 30 ships per year.

7.3.2 CAPTAIN RICK GILL, COLUMBIA RIVER PILOTS

Captain Rick Gill, the vice president of Columbia River Pilots, was interviewed on January 15, 2015. The key points from the interview are as follows (Gill, 2015):

- The vessels that arrive at and depart from the Cargill and Glacier NW docks always receive tug assist.
- The vessel engines always remain powered on during tug assist.

7.4 HYDRODYNAMICS EVALUATION

The following evaluation of potential hydrodynamic factors for RM11E Project Area and potential impacts on sediment remedial alternatives is based upon information from PHSS Draft FS Appendix Hc, other available information, site observations, and interviews with waterfront users. Three hydrodynamic factors are described in the following sections:

- Vessel wakes and wind-generated waves (wave action)
- Vessel propeller wash
- River flows (currents and potential eddies)

Within RM11E and the rest of PHSS, these factors have the potential to affect riverbed and bank erosion, and should therefore be considered when preparing remedial designs. Data presented in Section 7.2.2 and shown on Figures 7.4a through 7.4d indicate that changes in bank and bed elevation, both increases and decreases, occur at various places over time within portions of the RM11E Project Area, indicating that hydrodynamic forces capable of moving and depositing sediment are present, likely to varying degrees at different times based on many local conditions as discussed in the following section.

The potential effects of each hydrodynamic factor on remedial construction and operations are ranked as low, moderate, or high:

- Low – No management actions are required prior to remediation.
- Moderate – Some management actions may be required prior to or during remediation, such as minor design, analysis, or modifications of standard remedial practices.
- High – Significant management actions may be required prior to or during remediation, such as extensive design, analysis, or complex modifications to standard remedial practices.

The following sections describe considerations for remedial design, management actions, and rankings for hydrodynamic factors.

7.4.1 VESSEL WAKES AND WIND-GENERATED WAVES (WAVE ACTION)

As discussed in Section 7.2.1.2.3, the calculated maximum vessel wake height of 2.9 feet exceeds that of wind-generated wave height of 1.5 feet. In Appendix Hc Section 4.1.3.3, vessel-generated wakes were selected as the primary design wave condition for the RM11E Project Area. From Appendix Hc, the height of wind-generated waves is anticipated to be approximately one-half that of vessel-generated waves along the RM11E Project Area, due to short fetch distances and the local river sinuosity. Wave heights were calculated from a single phenomenon and coincident waves were not considered.

7.4.1.1 Wave Action Considerations for Remedial Design

For remedial actions, the following potential remedial design considerations are associated with vessel wakes and wind-generated waves:

- Wave action may cause shoreline erosion, potentially requiring protective armoring. The degree of erosion (and need for armoring) depends upon: the wave characteristics; the frequency of the wave events; the composition of the shoreline, cap, or cover material; and the exposure of the shoreline to waves.
- Wave action may impact remedial construction equipment by creating an unstable work platform, thereby causing operational delays.
- Wave action during removal operations can disturb materials within the shoreline.

7.4.1.2 Wave Action Management Actions

For remedial actions, the following actions should be considered during remedial design to mitigate vessel wakes and wind-generated waves:

- Armoring the shoreline, cap, or cover with rock of sufficient size to resist wave erosion (Figures 5.6a through 5.6d); oversteepened slopes (i.e., steeper than 2H:1V) within the RM11E Project Area may be more susceptible to erosion due to wave action than non-oversteepened areas.
- Placing a thin layer of initial backfill over dredged shoreline areas as soon as practicable to protect the area from wave-induced disturbance of loose sediment and to reduce the resuspension of any newly exposed surface material
- Building wave-dissipating structures along the shoreline to reduce the wave energy, (e.g., armoring, piling, a breakwater, or placement of rubble)
- Imposing institutional controls to reduce vessel wake, such as reduced vessel speed near remedial caps or covers

7.4.1.3 Wave Action Ranking

In areas exposed to wave action (i.e., upper shorelines between elevations 0 and +23 feet NAVD88), impacts are ranked as moderate to high for cap/cover remedial alternatives. Wave action is ranked as moderate for removal remedial alternatives. Wave action can create the potential for shoreline erosion, requiring proper design of shoreline armor or wave dissipation systems. Based on the analysis completed in Appendix Hc of the PHSS Draft FS as it applies to the RM11E Project Area, the potential impact of vessel wakes on potential remedies is more severe than the potential impact of wind-generated waves.

7.4.2 VESSEL PROPELLER WASH

The riverbed is subject to propeller wash in ship navigation areas, both in the navigation channel and the travel paths to and from the waterfront facilities, as well as the surrounding shallow areas and banks. The force and extents of the propeller wash in specific areas to be remediated will need to be evaluated during remedial design.

7.4.2.1 Vessel Propeller Wash Considerations for Remedial Design

Sediment resuspension or scour of the riverbed or adjacent shorelines can be caused by the currents generated by propellers or other drive systems on a vessel. This includes large vessels such as container ships as well as smaller vessels such as tug boats. Erosion of banks in the vicinity of berths may be created by propeller wash from the vessel's main propellers as well as bow thrusters. In general, the closer the propeller is to the riverbed or bank, the greater the potential for scour or erosion. Similarly, the larger the propeller and the higher the applied horsepower, the greater the potential for scour or erosion.

The following issues are associated with propeller wash from tugs, ships, and vessels with a propeller of sufficient size and power in sufficient proximity to the riverbed as shown in Figure 7.6 from Appendix Hc:

- Propeller wash has a potential to disturb sediment on the river bottom and adjacent slopes The nature and extent of propeller use are based on many factors, including vessel characteristics, pilot or captain preference, cargo (i.e., loaded or empty), wind, currents, water level, and other prevailing conditions.
- Propeller wash from larger vessels with deeper propellers and tugs in shallower berths can potentially disturb sediment on the river bottom and adjacent slopes depending upon propulsion type, horsepower, orientation, and other factors.
- Propeller wash from vessels during remedial construction has the potential to disturb native and newly exposed sediment on the river bottom.
- To meet potentially applicable PHSS Draft FS navigation clearance criteria in areas of potential propeller wash from vessels, as described in Section 3.9.2, the riverbed would first need to be excavated to sufficient depth to allow construction of a cap while maintaining post-remediation navigation clearance (Section 3.9.2). Thus for those locations where impacted sediment thicknesses are less than the required pre-excavation depth, cap placement would not be a viable alternative.

7.4.2.2 Vessel Propeller Wash Management Actions

To mitigate potential erosion from propeller wash in locations where contaminant concentrations exceed target cleanup levels, the following actions should be considered during remedial design:

- Evaluate current and potential future vessels that use waterfront facilities to refine selection of specific design vessels
- Evaluate current and future expected site bathymetry and shoreline configuration relative to vessel operating areas
- Select cap armoring material size to protect against vessel propeller wash

- Sequence removal operations to limit propeller wash-induced disturbance of exposed sediment[52]
- Place a thin layer of adequately sized initial backfill over dredged areas as soon as practicable to reduce propeller wash-induced disturbance or resuspension of newly exposed residual sediments

7.4.2.3 Vessel Propeller Wash Ranking

The potential impact of propeller wash in areas where cap/cover remedial alternatives are being considered is ranked as high, based on potential armor design considerations. The potential impact of propeller wash on removal remedial alternatives is ranked as moderate. As shown in Figures 7.7a through 7.7d, the areas likely affected by propeller wash include both navigation areas as well as the areas near berth access routes because of the potential effects of maneuvering vessels, tugs, and bow thrusters on these surrounding areas and slopes.

7.4.3 RIVER FLOWS (CURRENTS AND POTENTIAL EDDIES)

River currents have the potential to move sediment particles of increasing size as current velocities increase. The PHSS Draft FS (Appendix Hc, section 4.3) uses a steady-state simulation (2d2-d hydraulic model) of the 100-year flood along with the January 2002 DEA bathymetry data to evaluate the effect of river currents on the riverbed and estimate the stable particle size to resist those currents. The model also calculates velocity for each hydrodynamic model grid cell. As shown in Table 7.4, the minimum modeled velocity is up to 0.46 feet per second, and the maximum modeled velocity from the 100-year flood is 5.7 feet per second, requiring a D_{50} size of 1.74 inches to resist movement. This compares to the stable D_{50} particle size to resist large vessel propeller wash of 18 inches (Table 7.6). Accordingly, in areas of large vessel navigation, design of erosion protection will be controlled by propeller wash considerations, not river currents. In areas outside of large vessel navigation, river currents will be an erosion-control design factor.

The presence or impact from any eddies is not mentioned in the PHSS FS Appendices Ha (Fate and Transport Modeling), Hc (Capping Effectiveness and Stability Modeling), La (Sediment Transport Modeling), or Appendix Lb (HEC-RAS Hydrodynamic Model). During limited field observations on 2 days by DOF, only a few small eddies (of estimated 1- to 1.5-foot diameter) were observed, and on only 1 of the 2 days. For the hydrodynamic evaluation, the velocities associated with eddies are expected to be within the range of velocities indicated by the 100-year flood analysis and are thus unlikely to be a controlling design consideration for cap remedial design.

7.4.3.1 River Flow Considerations for Remedial Design

The following issues are associated with river flows:

- As river currents increase, they can cause increased erosion of the channel bottom, shoreline, or both.

[52] Sequencing could include setting up removal sequence to limit vessel traffic over areas where remediation has occurred and to work from upstream to downstream to limit transport of resuspended sediment into remediated area.

- Strong river currents may affect vessel movements in the RM11E Project Area, based upon discussions with facility personnel and their professional experiences. Extreme currents may cause operations to be suspended.
- Safe completion of docking maneuvers in strong river currents may require tug and vessel operators to use more propeller power, potentially exacerbating propeller wash impacts.
- Strong river currents may impact remedial construction by making it more difficult to hold work platforms in place, and more difficult to prevent erosion of newly exposed surfaces.

7.4.3.2 River Flow Management Actions

To mitigate impacts from river flows, the armoring material used for any cap or cover would be sized to resist erosive forces generated by river currents, as would cover material for initial backfill after removal actions.[53] Removal remedial actions can be timed to avoid the highest flow conditions, standing down during unsafe operating conditions.

7.4.3.3 River Flow Ranking

The potential impact of river flows on remedial alternatives is ranked as moderate for removal alternatives. The potential impact of river flows on remedial alternatives is ranked as moderate for cap/cover alternatives. The erosional force due to river currents will need to be taken into account when sizing the cap or cover material during remedial design.

7.5 CONCLUSION

This evaluation relies on readily available published data, including the PHSS Draft FS. When the remedial areas are identified, consideration should be given to the specific areas of possible hydrodynamic impacts and to options for addressing those impacts, including engineering controls. Other scenarios to be considered during remedial design include potential future site uses, the frequency and type of potential future vessels visits to and through the RM11E Project Area, and the potential effects of sea level rise.[54]

Table 7.8 identifies hydrodynamic factors in the RM11E Project Area and associated possible impact to the implementability of remedial alternatives. High-impact ranked areas are shown on Figures 7.7a through 7.7d.

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[53] Initial backfill would not require the same design effort as cap material, as the former is considered temporary.

[54] To be consistent with EPA 542-F-15-009 (Climate Change Adaptation Technical Fact Sheet: Contaminated Sediment Remedies).

TABLE 7.7 – HYDRODYNAMIC FACTORS VS POTENTIAL REMEDIATION IMPLEMENTABILITY IMPACTS

HYDRODYNAMIC FACTOR	POTENTIAL LEVEL OF HYDRODYNAMIC IMPACT[a] ON IMPLEMENTABILITY	
	REMOVAL	CAP OR COVER
Wave action	Moderate	Moderate to high
Vessel propeller wash	Moderate	High
River flows	Moderate	Moderate

[a] Potential level of remedial action implementability impact does not consider slope stability, waterfront usage, and debris, which are addressed in other sections of this report.

Hydrodynamic factors with high and moderate potential impacts on remedial action implementability will require additional effort to select and design the remedy, including identification of site-specific management actions tailored to the selected remedial action in areas where active remediation is required

7.6 SECTION 7 FIGURES

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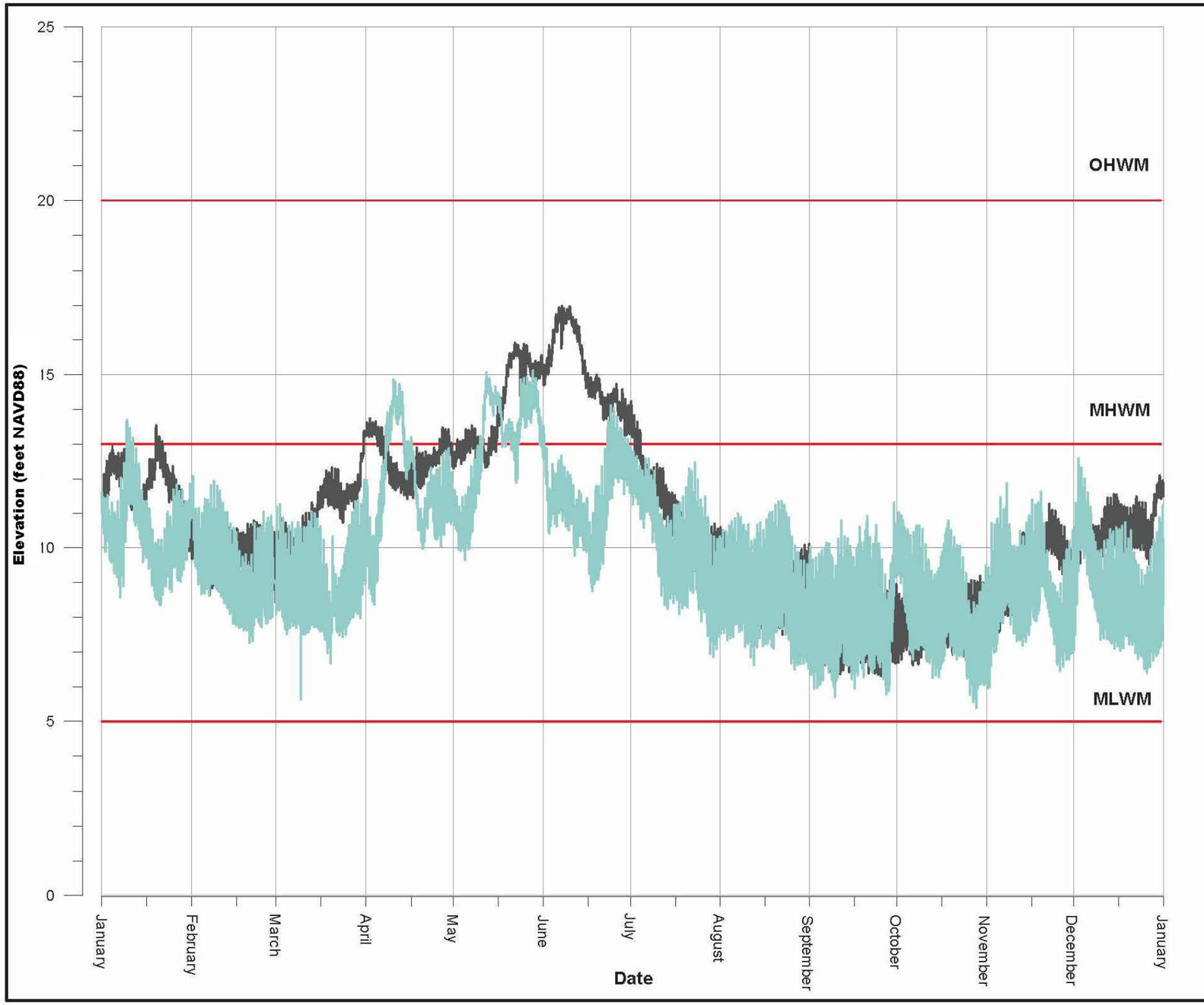

LEGEND

- 2013 Willamette River Stage
- Average Willamette River Stage (2007-2012)
- Portland Harbor Water Level Datums

NOTES

1. OHWM = Ordinary High Water Mark defines the elevation beyond which inundation by the river is limited to extreme flow events, which occur approximately every 5 years.
2. MHWM = Mean High Water Mark, refers to the elevation defining the shoreline boundary of the Portland Harbor Superfund Site and is based on ODEQ memorandum dated July 9, 2003 to EPA regarding the upland/in-water boundary for the Superfund Site (DEQ2003b).
3. MLWM = Mean Low Water Mark, refers to the approximate average low water height.
4. River stage data were recorded on a 30-minute basis from USGS station number 14211720. Station is located on the upstream side of the Morrison Bridge (RM 12.8). River stage elevation data reported by the USGS are corrected to NAVD88 at the Site by adding 5.05 feet to the USGS reading.
5. Precipitation data were obtained from the Astor Elementary School rain gage located approximately 4 miles from the RM11E Project Site. Daily totals were obtained from the City of Portland Hydro Network available on the USGS Web site.
6. Graph shown provided by GSI, Water Solutions, Inc.

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Willamette River Stage
Average 2007 to 2012 and Actual 2013

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Figure 7.1

July 31, 2015

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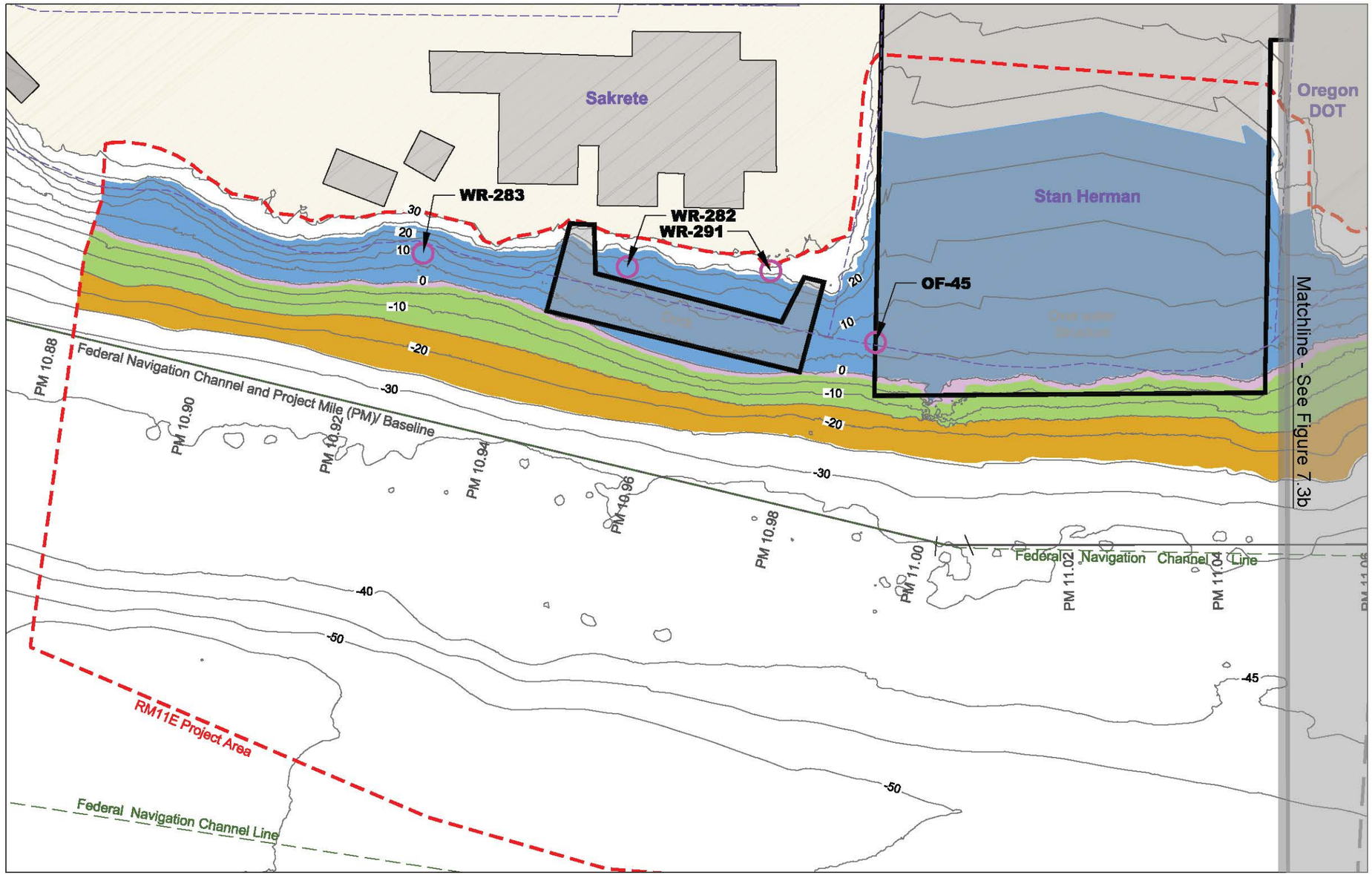

LEGEND

Zone

- Wave Zone: 0.0' to 23.0' (NAVD88)
- Coarse Gravel Zone: 0.0' to -2.4' (NAVD88)
- Fine Gravel Zone: -2.4' to -14.5' (NAVD88)
- Sand Zone: -14.5' to -24.5' (NAVD88)

Other Features

- Outfall - Active
- Submarine Cable Crossing Caution Zone
- Existing Structures
- Tax Lot Boundary (Oct. 2013)
- RM11E Project Area
- PM 11.6 — Project Mile Stationing
- Federal Navigation Channel (USACE)
- -35 — Bathymetric Contour - 5' Interval (NAVD88)

0 80
Scale in Feet

MAP NOTES

1. Zones reflect stable D_{50} particle size for 100-year wind-generated waves (Anchor QEA et. al., 2012).
2. Wave Zone defined in PHSS Draft FS (Anchor QEA et. al., 2012).
3. The locations of all features shown are approximate.
4. Contour lines and planimetric features are based on a composite data set which consists of the following: NOAA multibeam survey from 2009; ODSL multibeam and laser survey from 2010; USACE LiDAR survey from 2009; David Evans and Associates, Inc. multibeam survey from 2011 and terrestrial laser scan from 2013; and RLIS Metro GIS data Digital elevation model (DEM) surface for bathymetric contours was modeled only in the immediate vicinity of the RM11E Project Area. It is not intended for litigation, construction, or navigation purposes.
5. Horizontal datum is referenced to Oregon State Plane North NAD83 (international feet). Vertical datum is referenced to NAVD88 (feet).
6. Outfall status and location from City of Portland - Bureau of Environmental Services (BES) GIS group. Data layer acquired from GSI. Outfalls centered on coordinates from BES data layer.
7. Tax lot boundary generated by METRO (Oct. 2013). Data layer acquired from GSI.

Figure Location Map

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Wave Zone and RM11E Project Area
Stable Particle Sizes for Waves
~PM 10.88 to ~PM 11.05

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FIGURE 7.3a
July 31, 2015

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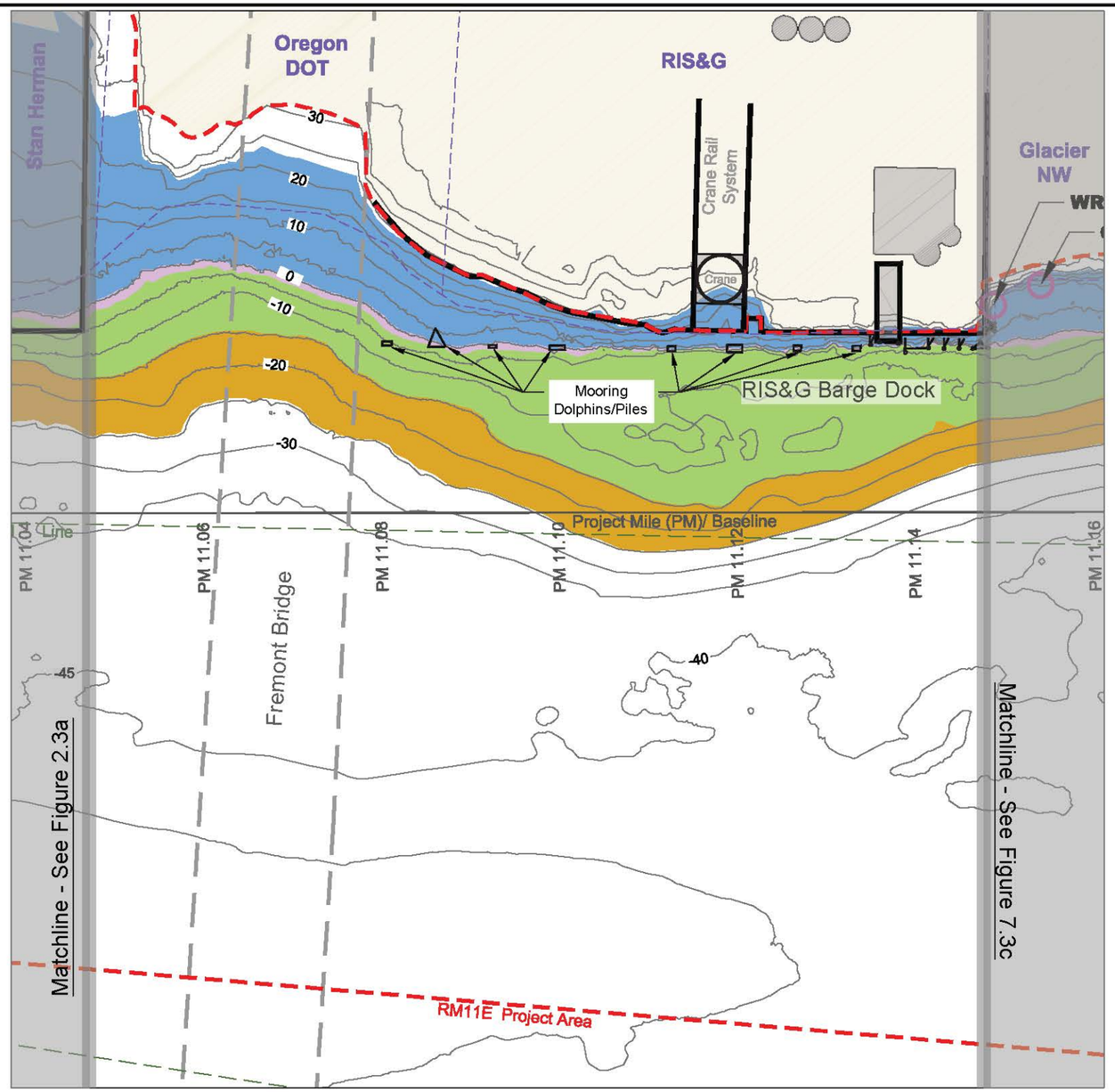

LEGEND

Zone

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- Coarse Gravel Zone: 0.0' to -2.4' (NAVD88)
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- Sand Zone: -14.5' to -24.5' (NAVD88)

Other Features

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- Existing Structures
- Tax Lot Boundary (Oct. 2013)
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- -35 — Bathymetric Contour - 5' Interval (NAVD88)

0 80
Scale in Feet

Figure Location Map

MAP NOTES

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7. Tax lot boundary generated by METRO (Oct. 2013). Data layer acquired from GSI.

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Wave Zone and RM11E Project Area Stable Particle Sizes for Waves ~PM 11.05 to PM ~11.15

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Figure 7.3b

July 31, 2015

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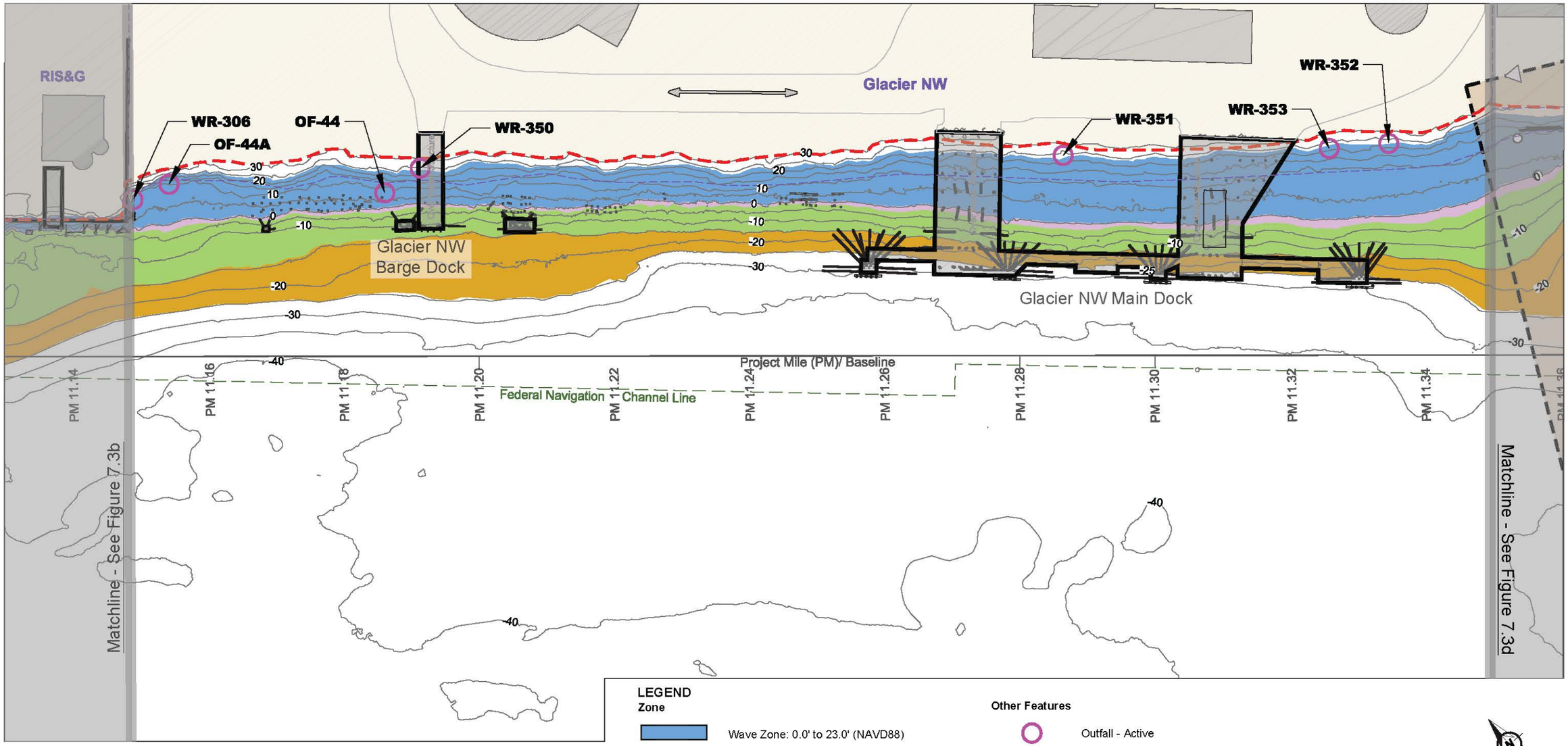

LEGEND

Zone

- Wave Zone: 0.0' to 23.0' (NAVD88)
- Coarse Gravel Zone: 0.0' to -2.4' (NAVD88)
- Fine Gravel Zone: -2.4' to -14.5' (NAVD88)
- Sand Zone: -14.5' to -24.5' (NAVD88)

Other Features

- Outfall - Active
- Submarine Cable Crossing Caution Zone
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- Tax Lot Boundary (Oct. 2013)
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- Federal Navigation Channel (USACE)
- -35 — Bathymetric Contour - 5' Interval (NAVD88)

0 80
Scale in Feet

Figure Location Map

DRAFT - FOR REVIEW

MAP NOTES

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6. Outfall status and location from City of Portland - Bureau of Environmental Services (BES) GIS group. Data layer acquired from GSI. Outfalls centered on coordinates from BES data layer.
7. Tax lot boundary generated by METRO (Oct. 2013). Data layer acquired from GSI.
8. Vertical pile remnants and submarine cable crossing toned location provided by David Evans and Associates, Inc. as described in the Draft Implementability Study Report, Section 2.

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Wave Zone and RM11E Project Area Stable Particle Sizes for Waves ~PM 11.15 to PM ~11.35

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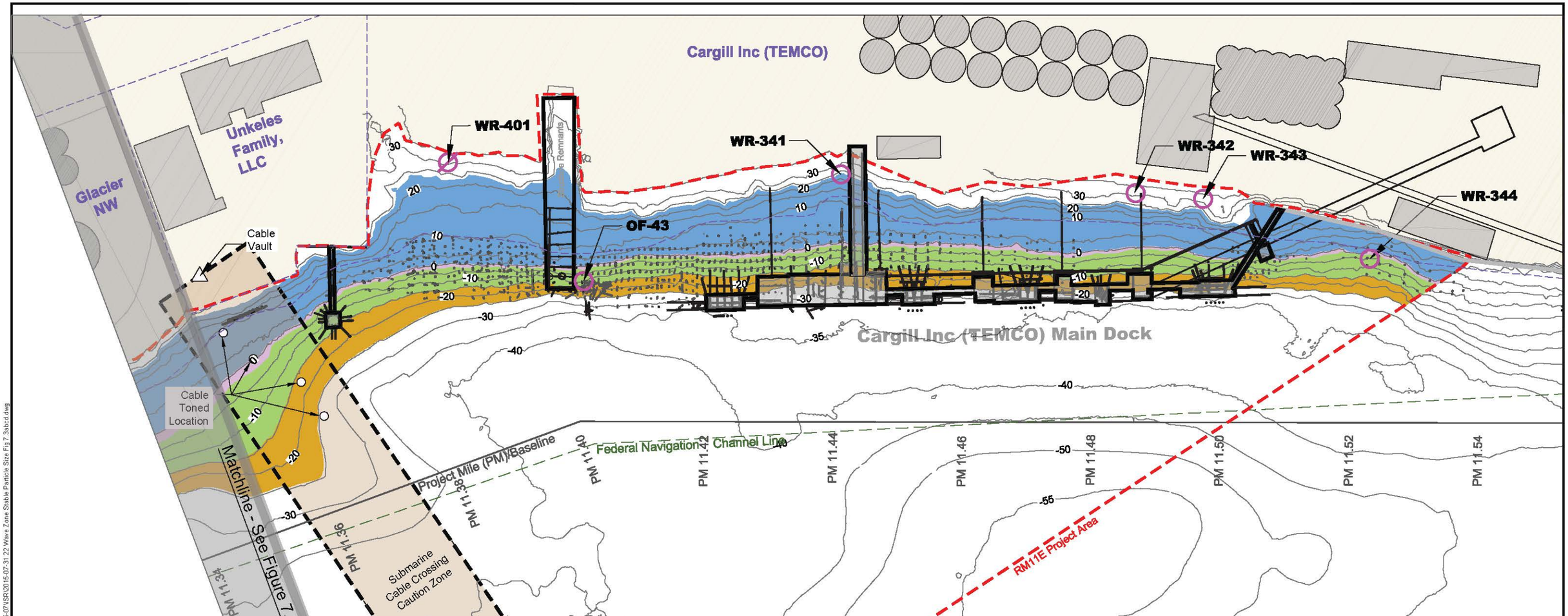
Figure 7.3c

July 31, 2015

PLOT TIME: 7/31/2015 2:43 PM MOD TIME: 7/31/2015 2:35 PM USER: Lee Barras DWG: D:\Projects\RM11E\CADV\Figures\2015-07\SR\2015-07-31 22 Wave Zone Stable Particle Size Fig 7.3abcd.dwg



MAP NOTES

1. Zones reflect stable D_{50} particle size for 100-year wind-generated waves (Anchor QEA et. al., 2012).
2. Wave Zone defined in PHSS Draft FS (Anchor QEA et. al., 2012).
3. The locations of all features shown are approximate.
4. Contour lines and planimetric features are based on a composite data set which consists of the following: NOAA multibeam survey from 2009; ODSL multibeam and laser survey from 2010; USACE LiDAR survey from 2009; David Evans and Associates, Inc. multibeam survey from 2011 and terrestrial laser scan from 2013; and RLIS Metro GIS data. Digital elevation model (DEM) surface for bathymetric contours was modeled only in the immediate vicinity of the RM11E Project Area. It is not intended for litigation, construction, or navigation purposes.
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6. Outfall status and location from City of Portland - Bureau of Environmental Services (BES) GIS group. Data layer acquired from GSI. Outfalls centered on coordinates from BES data layer.
7. Tax lot boundary generated by METRO (Oct. 2013). Data layer acquired from GSI.
8. Vertical pile remnants and submarine cable crossing toned location provided by David Evans and Associates, Inc. as described in the Draft Implementability Study Report, Section 2.

LEGEND

Zone

- Wave Zone: 0.0' to 23.0' (NAVD88)
- Coarse Gravel Zone: 0.0' to -2.4' (NAVD88)
- Fine Gravel Zone: -2.4' to -14.5' (NAVD88)
- Sand Zone: -14.5' to -24.5' (NAVD88)

Other Features

- Outfall - Active
- Outfall - Inactive or Status Unknown
- Submarine Cable Crossing Caution Zone
- Existing Structures
- Tax Lot Boundary (Oct. 2013)
- RM11E Project Area
- PM 11.6 — Project Mile Stationing
- Federal Navigation Channel (USACE)
- -35 — Bathymetric Contour - 5' Interval (NAVD88)

0 80
Scale in Feet

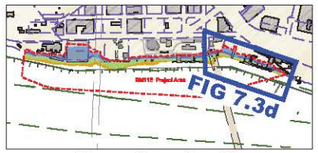

Figure Location Map

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RM11E Group
Willamette River - Portland, Oregon
Draft Implementability Study Report

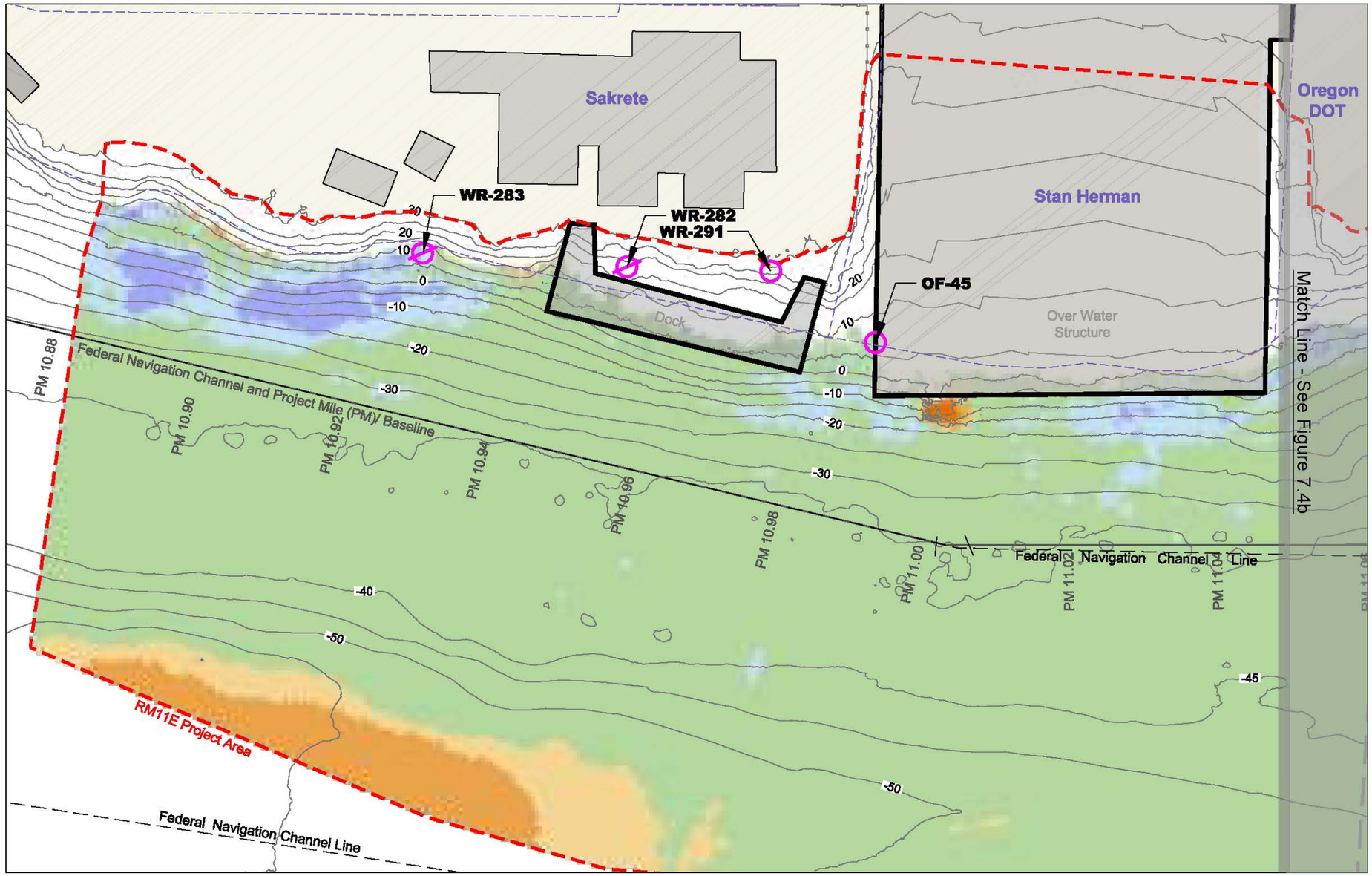
Wave Zone and RM11E Project Area
Stable Particle Sizes for Waves
~PM 11.35 to ~PM 11.54

DALTON OLMSTED FUGLEVAND

Figure 7.3d

July 31, 2015

PLOT TIME: 7/31/2015 2:43 PM MOD TIME: 7/31/2015 2:36 PM USER: Lee Barnes DWG: D:\Projects\RM11E\CAD\Figures\2015-07\SR\2015-07-31 22 Wave Zone Stable Particle Size Fig 7.3abcd.dwg



LEGEND

Change (ft) 2002 to 2009/2013 Composite

- 10 to 21.5
- 5 to 10
- 2 to 5
- 1 to 2

Increased Elevation

- -1 to 1
- -2 to -1
- -5 to -2
- -10 to -15
- -19.8 to -10

Decreased Elevation

- No 2002 Survey Data Available for Comparison

Other Features

- Outfall - Active
- Outfall - Inactive or Status Unknown
- Existing Structures
- Submarine Cable Crossing Caution Zone
- Tax Lot Boundary (Oct. 2013)
- RM11E Project Area
- PM 11.6 — Project Mile Stationing
- Federal Navigation Channel (USACE)
- -35 — Bathymetric Contour - 5' Interval (NAVD88)

0 80
Scale in Feet

MAP NOTES

1. Difference map compares the elevation change between two hydrographic survey surfaces generated by David Evans and Associates, Inc. The first surface is dated January 2002 (LWG LOA1) and the second is a composite surface generated from surveys dated between 2009 through 2013. See Figure 3.1 regarding individual survey coverage by date.
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6. Tax lot boundary generated by METRO (Oct. 2013). Data layer acquired from GSI.

Figure Location Map

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Willamette River - Portland, Oregon
Draft Implementability Study Report

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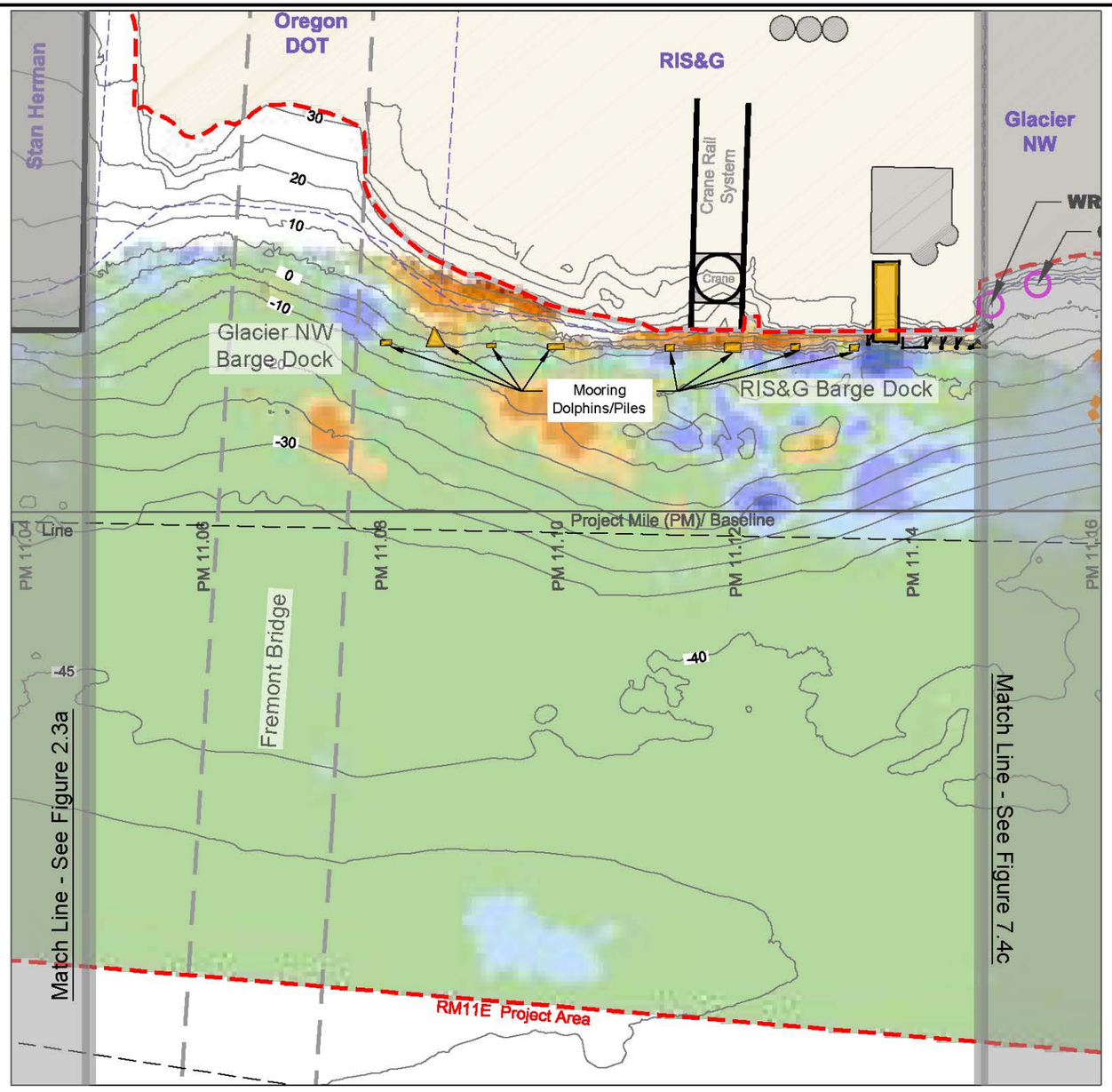
RM11E Project Area Change in Bed Elevation
January 2002 to 2009-2013 Composite
~PM 10.88 to ~PM 11.05

FIGURE 7.4a

July 31, 2015

PLOT TIME: 7/31/2015 1:15 PM MOD TIME: 7/31/2015 1:13 PM USER: Lee Barras DWG: D:\Projects\RM11E\CADF\figures\2015-07\SR\2015-07-31 23 Proj Area Change in Bed Elevations Fig 7.4abcd.dwg



LEGEND

Change (ft) 2002 to 2009/2013 Composite

- 10 to 21.5
- 5 to 10
- 2 to 5
- 1 to 2

Increased Elevation

- -1 to 1
- -2 to -1
- -5 to -2
- -10 to -15
- -19.8 to -10

Decreased Elevation

- No 2002 Survey Data Available for Comparison

Other Features

- Outfall - Active
- Recent Private Maintenance Dredge Areas
- Existing Structures
- Submarine Cable Crossing Caution Zone
- Tax Lot Boundary (Oct. 2013)
- RM11E Project Area
- PM 11.6 — Project Mile Stationing
- Federal Navigation Channel (USACE)
- -35 — Bathymetric Contour - 5' Interval (NAVD88)

0 80
Scale in Feet

Figure Location Map

MAP NOTES

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6. Tax lot boundary generated by METRO (Oct. 2013). Data layer acquired from GSI.

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RM11E Group
Willamette River - Portland, Oregon
Draft Implementability Study Report

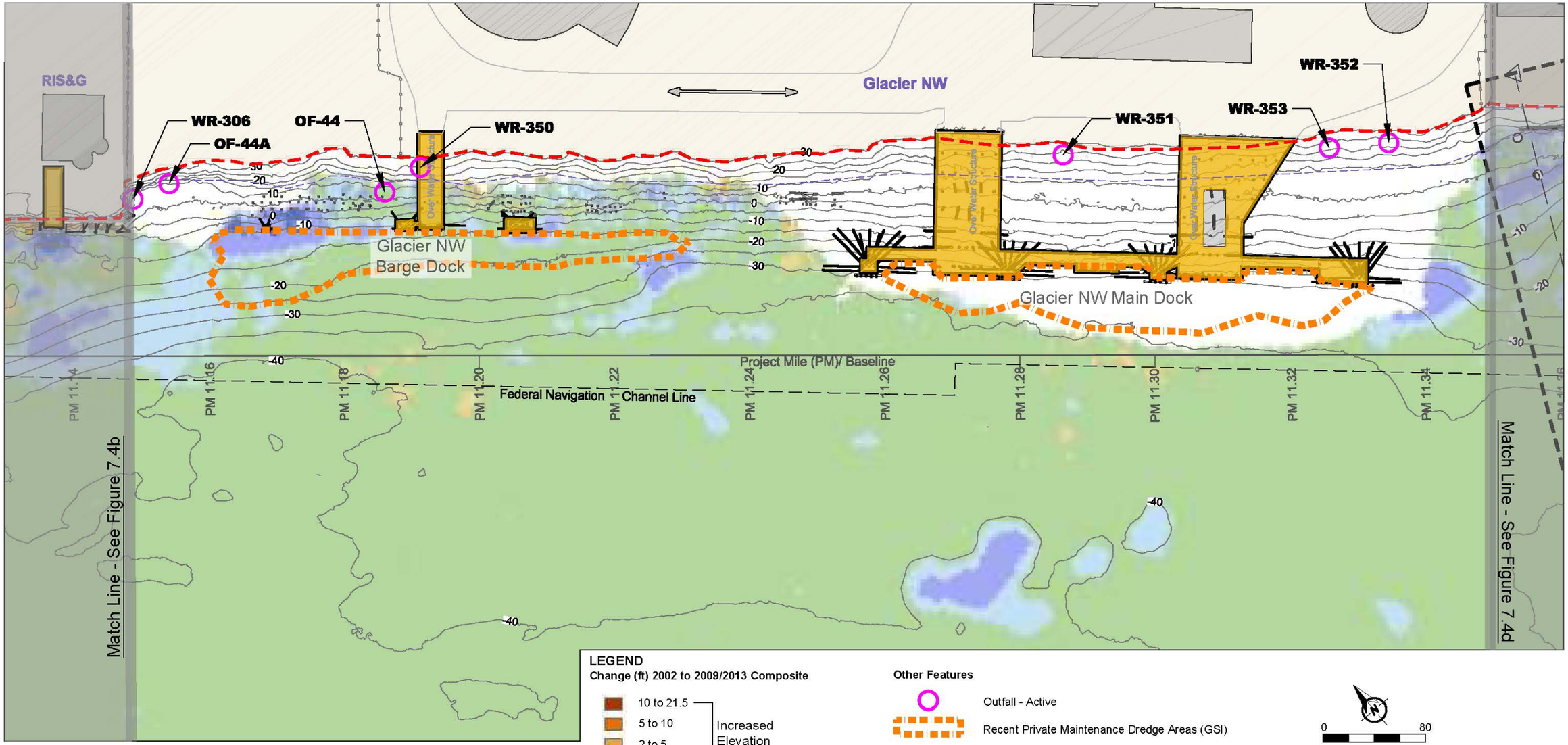
DALTON OLMSTED FUGLEVAND

RM11E Project Area Change in Bed Elevation
January 2002 to 2009-2013 Composite
~PM 11.05 to ~PM 11.15

Figure 7.4b

July 31, 2015

PLOT TIME: 7/31/2015 1:15 PM MOD TIME: 7/31/2015 1:13 PM USER: Lee Barras DWG: D:\Projects\RM11E\CADFiguresb\2015-07\GSR\2015-07-31 23 Proj Area Change in Bed Elevations Fig 7.4abcd.dwg



MAP NOTES

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6. Tax lot boundary generated by METRO (Oct. 2013). Data layer acquired from GSI.
7. Vertical pile remnants and submarine cable crossing toned location provided by David Evans and Associates, Inc. as described in the Draft Implementability Study Report, Section 2.

LEGEND

Change (ft) 2002 to 2009/2013 Composite

Increased Elevation:
- 10 to 21.5
- 5 to 10
- 2 to 5
- 1 to 2

- -1 to 1

Decreased Elevation:
- -2 to -1
- -5 to -2
- -10 to -15
- -19.8 to -10

- No 2002 Survey Data Available for Comparison

Other Features

- Outfall - Active
- Recent Private Maintenance Dredge Areas (GSI)
- Existing Structures
- Submarine Cable Crossing Caution Zone
- Tax Lot Boundary (Oct. 2013)
- RM11E Project Area
- PM 11.6 — Project Mile Stationing
- Federal Navigation Channel (USACE)
- -35 — Bathymetric Contour - 5' Interval (NAVD88)

0 80
Scale in Feet

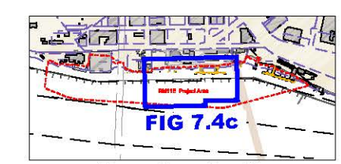

Figure Location Map

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RM11E Group
Willamette River - Portland, Oregon
DraImplementability Study Report

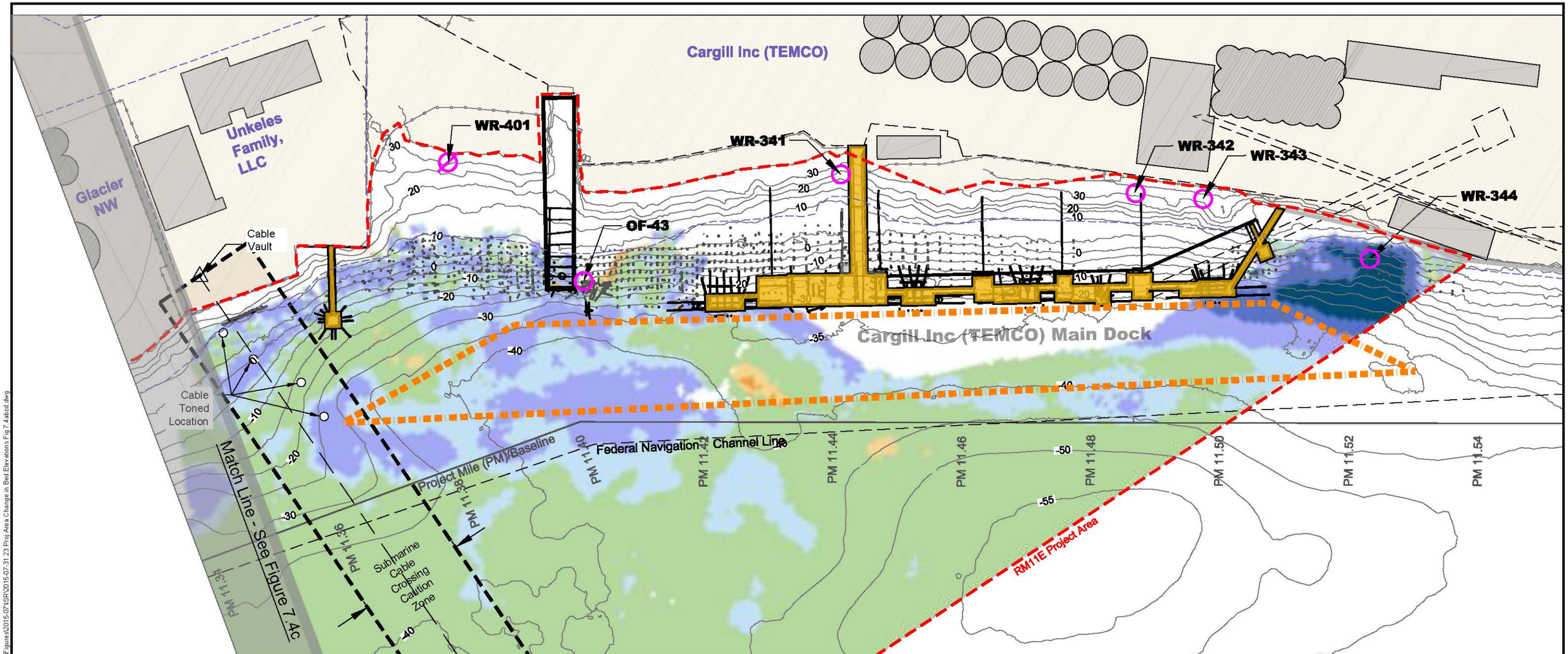
DALTON OLMSTED FUGLEVAND

RM11E Project Area Change in Bed Elevation
January 2002 to 2009-2013 Composite
~PM 11.15 to ~PM 11.35

Figure 7.4c

July 31, 2015

PLOT TIME: 7/31/2015 1:15 PM MOD TIME: 7/31/2015 1:13 PM USER: Lee Barras DWG: D:\Projects\RM11E\CAD\Figures\2015-07\SR\2015-07-31 23 Proj Area Change in Bed Elevations Fig 7.4abcd.dwg



MAP NOTES

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6. Tax lot boundary generated by METRO (Oct. 2013). Data layer acquired from GSI.
7. Vertical pile remnants and submarine cable crossing toned location provided by David Evans and Associates, Inc. as described in the Draft Implementability Study Report, Section 2.

LEGEND

Change (ft) 2002 to 2009/2013 Composite

- 10 to 21.5
- 5 to 10
- 2 to 5
- 1 to 2

Increased Elevation

- -1 to 1
- -2 to -1
- -5 to -2
- -10 to -15
- -19.8 to -10

Decreased Elevation

- No 2002 Survey Data Available for Comparison

Other Features

- Outfall - Active
- Outfall - Inactive or Status Unknown
- Recent Private Maintenance Dredge Areas (GSI)
- Existing Structures
- Submarine Cable Crossing Caution Zone
- Tax Lot Boundary (Oct. 2013)
- RM11E Project Area
- PM 11.6 — Project Mile Stationing
- Federal Navigation Channel (USACE)
- -35 — Bathymetric Contour - 5' Interval (NAVD88)

0 80
Scale in Feet

Figure Location Map

DRAFT - FOR REVIEW

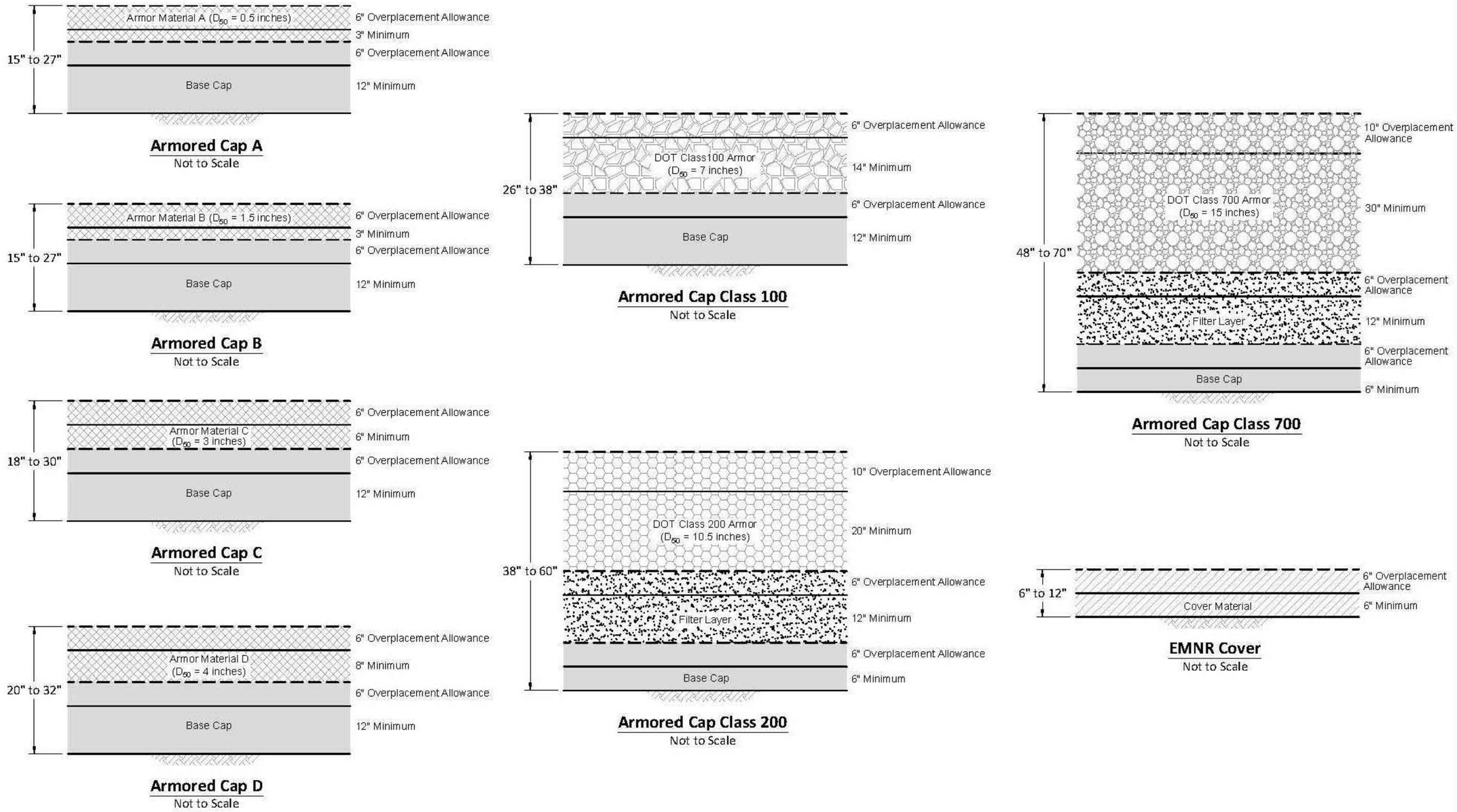
RM11E Group
Willamette River - Portland, Oregon
Draft Implementability Study Report

RM11E Project Area Change in Bed Elevation
January 2002 to 2009-2013 Composite
~PM 11.35 to ~PM 11.54

DALTON OLMSTED FUGLEVAND

Figure 7.4d
July 31, 2015

PLOT TIME: 7/31/2015 1:15 PM MOD TIME: 7/31/2015 1:13 PM USER: Lee Barras DWG: D:\Projects\RM11E\CAD\Figures\2015-07\SR\2015-07-31 23 Proj Area Change in Bed Elevations Fig 7.4abcd.dwg



ANCHOR QEA

LWG LOWER WILLAMETTE GROUP

DO NOT QUOTE OR CITE
This document is currently under review by US EPA
and its federal, state, and tribal partners, and is
subject to change in whole or in part

Figure 1
Portland Harbor RI/FS
Draft Feasibility Study
Typical Cap and Cover Sections used for Volume Calculations

Mar 13, 2012 1:58pm heriksen K:\Jobs\010142-Lower_Willamette_Group\01014201\D1014201-RP-LWG-032.dwg FIG 1 - CAP

PLOT TIME: 7/31/2015 1:15 PM MOD TIME: 7/31/2015 12:28 PM USER: Lee Barras DWG: D:\Projects\RM11EC-AD\Figures\2015-07\SR\2015-07-31 24 PHSS Typical Cap-Cover Sections Fig 7.5.dwg

RM11E Group
Willamette River - Portland, Oregon
Draft Implementability Study Report

PHSS Draft FS
Typical Cap/Cover Sections

DALTON OLMSTED FUGLEVAND

Figure 7.5
July 31, 2015

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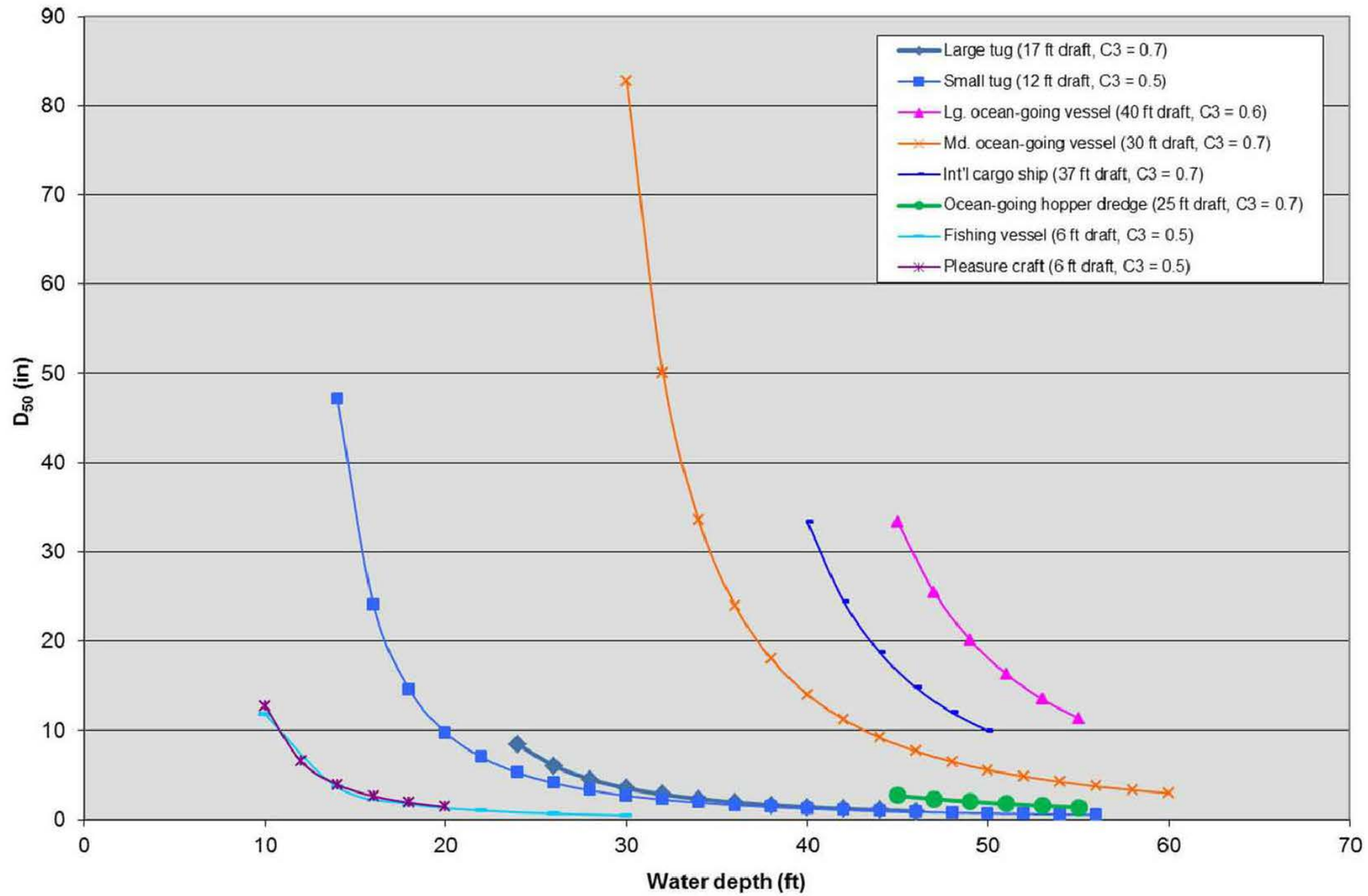


ANCHOR QEA

LWG
Lower Willamette Group

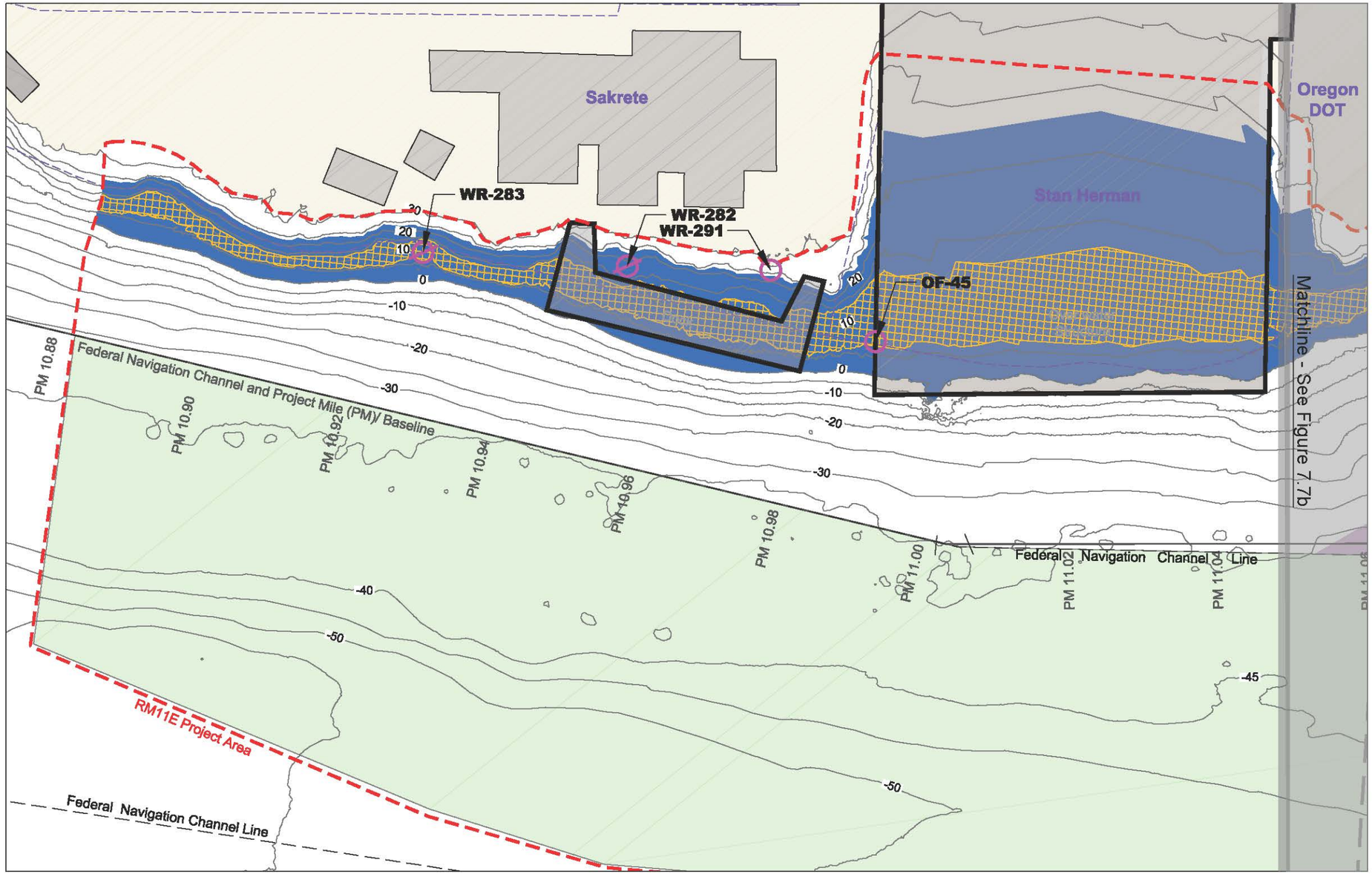
DO NOT QUOTE OR CITE
This document is currently under review by US EPA and its federal, state, and tribal partners, and is subject to change in whole or in part

Figure 4-3
Portland Harbor RI/FS
Draft Feasibility Study
Stable Sediment Size (D_{50}) versus Water Depth

DRAFT - FOR REVIEW

RM11E Group **Willamette River - Portland, Oregon** **Draft Implementability Study Report**	DALTON OLMSTED FUGLEVAND
Suitable Sediment Size versus Water Depth for Propeller Wash	**Figure 7.6** July 17, 2015

PLOT TIME: 7/31/2015 1:15 PM MOD TIME: 7/31/2015 12:29 PM USER: Lee Barras DWG: D:\Projects\RM11E\CAD\Figures\2015-07\ISR\2015-07-31 25 PHSS Stable Sediment Size Chart Fig 7.6.dwg



LEGEND

Impact Rating

- Wave Zone (0.0' to 23.3'): Moderate- to High-Impact (Cap/Cover)
- Majority of Wave Force (6.0' to 13.0'): High-Impact (Cap/Cover)
- Deep Draft Propeller Wash: Moderate- to High-Impact (Cap/Cover)

Other Features

- Existing Structures
- Outfall - Active
- Outfall - Inactive or Status Unknown
- Tax Lot Boundary (Oct. 2013)
- RM11E Project Area
- PM 11.6 Project Mile Stationing
- Federal Navigation Channel (USACE)
- -35 Bathymetric Contour - 5' Interval (NAVD88)

0 80
Scale in Feet

MAP NOTES

1. Majority of wave force 6' to 13' NAVD88 (Anchor QEA et. al., 2012).
2. The locations of all features shown are approximate.
3. Contour lines and planimetric features are based on a composite data set which consists of the following: NOAA multibeam survey from 2009; ODSL multibeam and laser survey from 2010; USACE LiDAR survey from 2009; David Evans and Associates, Inc. multibeam survey from 2011 and terrestrial laser scan from 2013; and RLIS Metro GIS data. Digital elevation model (DEM) surface for bathymetric contours was modeled only in the immediate vicinity of the RM11E Project Area. It is not intended for litigation, construction, or navigation purposes.
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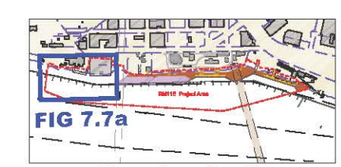

Figure Location Map

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RM11E Group
Willamette River - Portland, Oregon
Draft Implementability Study Report

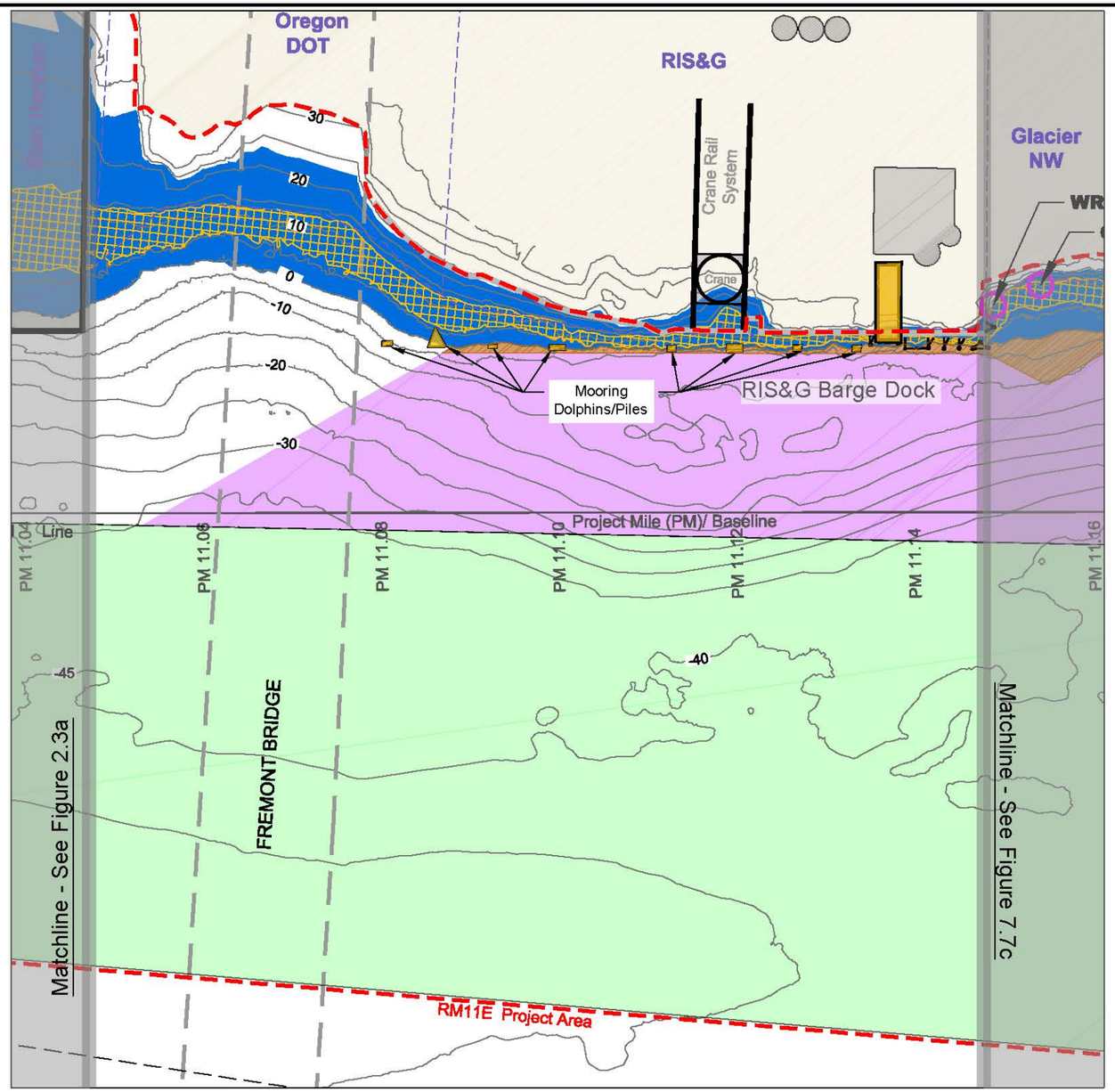
Hydrodynamics Impact Areas
~PM 10.88 to ~PM 11.05

DALTON OLMSTED FUGLEVAND

FIGURE 7.7a

July 31, 2015

PLOT TIME: 7/31/2015 1:24 PM MOD TIME: 7/31/2015 1:21 PM USER: Lee Barras DWG: D:\Projects\RM11E\CADFiguresi2015-07\SR\2015-07-31 26 Hydrodynamics Impact Ranking Fig 7.7 abcd.dwg



LEGEND

Impact Rating

- Wave Zone (0.0' to 23.3'): Moderate- to High-Impact (Cap/Cover)
- Majority of Wave Force (6.0' to 13.0'): High-Impact (Cap/Cover)
- Shallow Draft Propeller Wash: Moderate- to High-Impact (Cap/Cover)
- Deep Draft Propeller Wash: Moderate- to High-Impact (Cap/Cover)
- Adjacent Shoreline Propeller Wash: Moderate- to High-Impact (Cap/Cover)

Other Features

- Existing Structures
- Outfall - Active
- Outfall - Inactive or Status Unknown
- Tax Lot Boundary (Oct. 2013)
- RM11E Project Area
- PM 11.6 Project Mile Stationing
- Federal Navigation Channel (USACE)
- -35 Bathymetric Contour - 5' Interval (NAVD88)

0 80
Scale in Feet

MAP NOTES

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Figure Location Map

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RM11E Group
Willamette River - Portland, Oregon
Draft Implementability Study Report

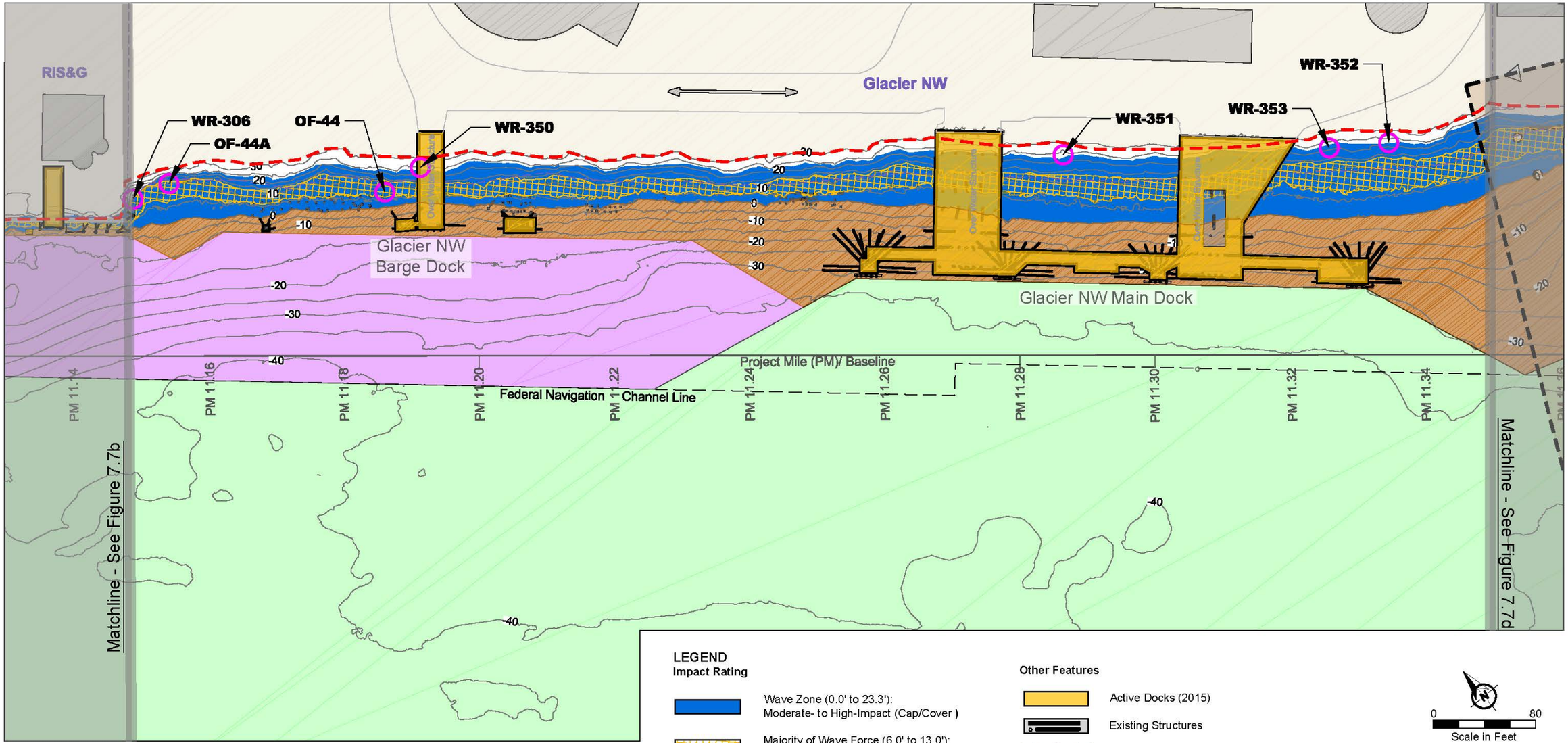
Hydrodynamics Impact Areas
~PM 11.05 to ~PM 11.15

DALTON OLMSTED FUGLEVAND

Figure 7.7b

July 31, 2015

PLOT TIME: 7/31/2015 1:24 PM MOD TIME: 7/31/2015 1:21 PM USER: Lee Barras DWG: D:\Projects\RM11E\QA\DF\figures\2015-07\SR\2015-07-31 26 Hydrodynamics Impact Ranking Fig 7.7 abcd.dwg



LEGEND

Impact Rating

- Wave Zone (0.0' to 23.3'): Moderate- to High-Impact (Cap/Cover)
- Majority of Wave Force (6.0' to 13.0'): High-Impact (Cap/Cover)
- Shallow Draft Propeller Wash: Moderate- to High-Impact (Cap/Cover)
- Deep Draft Propeller Wash: Moderate- to High-Impact (Cap/Cover)
- Adjacent Shoreline Propeller Wash: Moderate- to High-Impact (Cap/Cover)

Other Features

- Active Docks (2015)
- Existing Structures
- Submarine Cable Crossing Caution Zone
- Outfall - Active
- Tax Lot Boundary (Oct. 2013)
- RM11E Project Area
- PM 11.6 Project Mile Stationing
- Federal Navigation Channel (USACE)
- -35 Bathymetric Contour - 5' Interval (NAVD88)

0 80
Scale in Feet

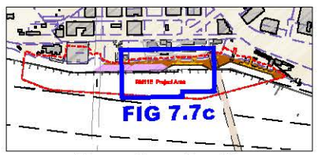


Figure Location Map

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RM11E Group
Willamette River - Portland, Oregon
Draft Implementability Study Report

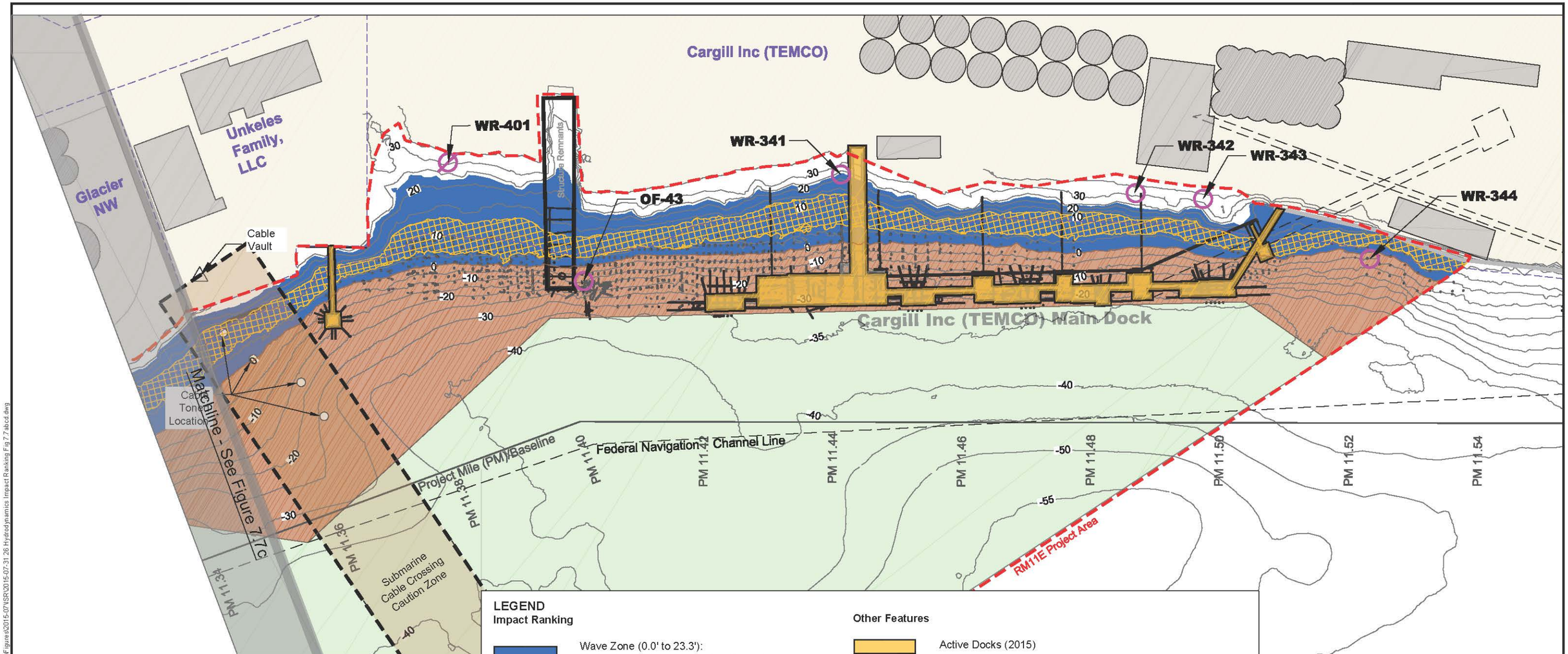
Hydrodynamics Impact Areas
~PM 11.15 to ~PM 11.35

DALTON OLMSTED FUGLEVAND

Figure 7.7c

July 31, 2015

PLOT TIME: 7/31/2015 1:24 PM MOD TIME: 7/31/2015 1:21 PM USER: Lee Barras DWG: D:\Projects\RM11E\GADF\figures\2015-07\GSR\2015-07-31 26 Hydrodynamics Impact Ranking Fig 7.7 abcd.dwg



LEGEND

Impact Ranking

- Wave Zone (0.0' to 23.3'): Moderate- to High-Impact (Cap/Cover)
- Majority of Wave Force (6.0' to 13.0'): High-Impact (Cap/Cover)
- Deep Draft Propeller Wash: Moderate- to High-Impact (Cap/Cover)
- Adjacent Shoreline Propeller Wash: Moderate- to High-Impact (Cap/Cover)

Other Features

- Active Docks (2015)
- Existing Structures
- Submarine Cable Crossing Caution Zone
- Outfall - Active
- Outfall - Inactive or Status Unknown
- Tax Lot Boundary (Oct. 2013)
- RM11E Project Area
- PM 11.6 — Project Mile Stationing
- Federal Navigation Channel (USACE)
- -35 — Bathymetric Contour - 5' Interval (NAVD88)

0 80
Scale in Feet

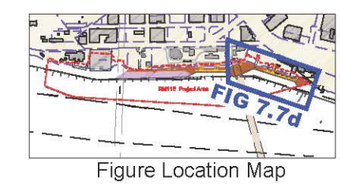


Figure Location Map

MAP NOTES

1. Majority of wave force 6' to 13' NAVD88 (Anchor QEA et. al., 2012).
2. The locations of all features shown are approximate.
3. Contour lines and planimetric features are based on a composite data set which consists of the following: NOAA multibeam survey from 2009; ODSL multibeam and laser survey from 2010; USACE LiDAR survey from 2009; David Evans and Associates, Inc. multibeam survey from 2011 and terrestrial laser scan from 2013; and RLIS Metro GIS data. Digital elevation model (DEM) surface for bathymetric contours was modeled only in the immediate vicinity of the RM11E Project Area. It is not intended for litigation, construction, or navigation purposes.
4. Horizontal datum is referenced to Oregon State Plane North NAD83 (international feet). Vertical datum is referenced to NAVD88 (feet).
5. Outfall status and location from City of Portland - Bureau of Environmental Services (BES) GIS group. Data layer acquired from GSI. Outfalls centered on coordinates from BES data layer.
6. Tax lot boundary generated by METRO (Oct. 2013). Data layer acquired from GSI.
7. Vertical pile remnants and submarine cable crossing toned location provided by David Evans and Associates, Inc. as described in the Draft Implementability Study Report, Section 2.

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RM11E Group
Willamette River - Portland, Oregon
Draft Draft Implementability Study Report

Hydrodynamics Impact Areas
~PM 11.35 to ~PM 11.54

DALTON OLMSTED FUGLEVAND

Figure 7.7d
July 31, 2015

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8. SUMMARY OF FACTORS THAT AFFECT IMPLEMENTABILITY

8.1 HIGH-RANKED SITE FACTORS

The engineering assessments presented in Sections 2 through 7 identify 10 physical conditions and site activities, referred to as "site factors," that have a high potential to impact remedial design and implementation. These 10 high-ranked site factors are listed below with cross-references to text descriptions and figures.

- Facility operations (Waterfront) – Section 3.9.1, Figure 3.15
- Navigation clearance (Waterfront) – Section 3.9.2, Figures 3.5a and 3.5b
- Construction access (Waterfront) – Section 3.9.3, Figures 3.14a through 3.14d
- Submarine cable crossing (Waterfront) –Section 3.9.4, Figure 3.4d
- Groups of vertical pile remnants (Debris) – Section 4.3.2, Figures 4.5a through 4.5d
- Large undifferentiated debris (Debris) – Section 4.3.3, Figures 4.5a through 4.5d
- Oversteepened slopes (Geotechnical) – Sections 5.3.1 and 5.32, Figures 5.6a through 5.6d
- Structure stability and capacity (Structures) – Section 6.6.3, Tables 6.10, 6.11, and 6.12
- Vessel propeller wash (Hydrodynamics) – Section 7.4.2, Figures 7.7a through 7.7d
- Wave action (Hydrodynamics) – Section 7.4.1, Figures 7.7a through 7.7d

As described below, these site factors are present in several locations and in many areas overlap.

8.2 SITE FACTOR PRESENCE

Table 8.1 indicates the current and anticipated presence of each site factor across the RM11E Project Area.[55] The RM11E Project Area was divided into eight project mile stations generally spaced at 0.1 PM intervals along the site and shown on Figure 8-1. Table 8-1 lists these eight stations, each with its associated upland property, and the presence or absence of each of the 10 site factors.

Table 8.1 is also presented in two parts:

- Table 8.1a addresses the shoreline and berth area – the portion of the site located between the navigation channel line and the upslope RM11E Project Area limit (top of the bank). This subarea accounts for approximately 45% of the RM11E Project Area.
- Table 8.1b addresses the federal navigation channel – the navigation channel portion of the site, located between the navigation channel line and the offshore RM11E Project Area limit. This subarea accounts for approximately 55% of the RM11E Project Area.

[55] The evaluation of the presence and ranking of site factors may be modified during remedial design based on the remedial action levels, remedial action objectives, and other conclusions in the Record of Decision.

TABLE 8.1A – SHORELINE AND BERTH AREAS WITH HIGH-IMPACT RANKED SITE FACTORS FOR CAPPING AND DREDGING REMEDIAL ACTIONS

Site Factor	Upland Property	Sakrete		Herman		RIS&G		Glacier NW				Cargill Inc. (Temco)						Total Stations	
	PM Station	10.9		11.0		11.1		11.2		11.3		11.36		11.4		11.5			
	Remedial Action	Cap	Drdg	Cap	Drdg	Cap	Drdg	Cap	Drdg	Cap	Drdg	Cap	Drdg	Cap	Drdg	Cap	Drdg	Cap	Drdg
Facility Operations (Waterfront)						X	X	X	X	X	X	X	X	X	X	X	X	6	6
Navigation Clearance (Waterfront)						X		X		X				X		X		5	0
Construction Access (Waterfront)		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	8	8
Submarine Cable Crossing (Waterfront)												X	X					1	1
Groups Vertical Pile Remnants (Debris)														X	X			1	1
Large Undifferentiated Debris					X		X		X		X		X		X		X	0	7
Oversteepened Slopes (Geotechnical)		X	X	X	X	X	X	X	X	X	X			X	X	X	X	7	7
Structures Stability and Capacity				X	X					X	X					X	X	3	3
Propeller Wash (Hydrodynamics)						X		X		X		X		X		X		6	0
Wave Action (Hydrodynamics)		X		X		X		X		X		X		X		X		8	0

Note: High-impact ranked refers to site factors classified as "high-impact" and as "moderate- to high-impact."

TABLE 8.1B – NAVIGATION CHANNEL AREAS WITH HIGH-IMPACT RANKED SITE FACTORS FOR CAPPING AND DREDGING REMEDIAL ACTIONS

Site Factor	Upland Property	Sakrete		Herman		RIS&G		Glacier NW				Cargill Inc. (Temco)						Total Stations	
	PM Station	10.9		11.0		11.1		11.2		11.3		11.36		11.4		11.5			
	Remedial Action	Cap	Drdg	Cap	Drdg	Cap	Drdg	Cap	Drdg	Cap	Drdg	Cap	Drdg	Cap	Drdg	Cap	Drdg	Cap	Drdg
Facility Operations (Waterfront)																		0	0
Navigation Clearance (Waterfront)		X		X		X		X		X		X		X		X		8	0
Construction Access (Waterfront)																		0	0
Submarine Cable Crossing (Waterfront)												X	X					1	1
Groups Vertical Pile Remnants (Debris)																		0	0
Large Undifferentiated Debris																		0	0
Oversteepened Slopes (Geotechnical)																		0	0
Structures Stability and Capacity																		0	0
Propeller Wash (Hydrodynamics)		X		X		X		X		X		X		X		X		8	0
Wave Action (Hydrodynamics)																		0	0

Note: High-impact ranked refers to site factors classified as "high-impact" and as "moderate- to high-impact."

As a means of demonstrating the relative presence of each site factor across the RM11E Project Area, the number of PM stations where each site factor is present is summed, as shown in the right hand column of Tables 8.1a and 8.1b. Because eight stations are addressed in Table 8.1, the highest possible score for site factors is 8.

8.3 SECTION 8 FIGURES

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LEGEND

Site Factor

- PM 11.50 — PM Stations for Site Factor Score Tabulation
- Shoreline and Berth Area
- Navigation Channel Area

Other Features

- Bridge
- Upland
- Building/Structure
- Submarine Cable Crossing Caution Zone
- Tax Lot Boundary (Oct. 2013)
- RM11E Project Area
- Federal Navigation Channel (USACE)
- PM 11.44 — Project Mile Stationing

0 300
Scale in Feet

MAP NOTES

1. The locations of all features shown are approximate.
2. Planimetric features (docks, overhead walkways, conveyors, walls, etc.) shown are a combination of features from RLIS Metro GIS data and features digitized by DOF from 2012 aerial photos. Data intended for planning and visual reference only.
3. Horizontal datum is based on Oregon State Plane North NAD83, international feet.
4. Tax lot boundary generated by METRO (Oct. 2013). Data layer acquired from GSI.
7. Submarine cable crossing toned location provided by David Evans and Associates, Inc. as described in the Draft Implementability Study Report, Section 2.

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RM11E Group
Willamette River - Portland, Oregon
Draft Implementability Study Report

Project Mile Stations for Site Factor Tabulation

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Figure 8.1

July 31, 2015

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9. IMPLEMENTABILITY CONSIDERATIONS

This section evaluates site factors identified in Sections 2 through 7 that are ranked as having a potential high-impact on remedy implementation within the RM11E Project Area. While the implementability studies address two broad categories of active remediation (i.e., capping and dredging), much of the information in Sections 2 through 7 also applies to other remedy approaches such as MNR, EMNR, in situ treatment and active capping in terms of the Site Factors. The selection of an integrated remedy using multiple available and developing technologies will likely be necessary and provide the most effective remedial program to address the complex site conditions found at the RM11E Project Area.

The remedial technologies potentially applicable to the RM11E Project Area are identified below, followed by a discussion of implementability and constructability constraints specific to the RM11E Project Area.

9.1 REMEDIAL TECHNOLOGIES

9.1.1 MONITORED NATURAL RECOVERY

MNR is based on natural physical, biological, and chemical processes that reduce the bioavailability or toxicity of contaminants over time. MNR includes a monitoring plan to track the progress of recovery. For a sediment site like PHSS, MNR is expected to be most effective in locations where deposition of uncontaminated sediment is ongoing. MNR may be effective in the RM11E Project Area, particularly in locations where access is limited by obstructions or where other factors limit other available remedial technologies.

9.1.2 ENHANCED MONITORED NATURAL RECOVERY

EMNR is similar to MNR but for sediment sites like PHSS, may include the placement of a thin layer of sand over the contaminated sediment to improve the rate of the natural recovery process. EMNR may be considered for areas that might otherwise be suitable for MNR but have a low natural sedimentation rate. EMNR would be most effective in RM11E Project Area at locations where the cover material could be expected to be mixed into and incorporated into the surface sediment over time, and in areas where access, instability, or other factors limit other available remedial technologies.

9.1.3 IN SITU TREATMENT

In situ sediment treatment is the direct placement of amendments such as activated carbon or other reagents into or onto the sediment to reduce the bioavailability of certain contaminants, including compounds found in the RM11E Project Area. The amendments can be introduced into the sediment by various means including placement on the surface, mechanical mixing into the sediment, and slurry injection; the selection of placement mechanism depends on site conditions.

In situ treatment would be effective in the RM11E Project Area at locations where the added material could be expected to be mixed into and incorporated into the surface sediment over time, and in areas where access, instability, or other factors limit other available remedial technologies.

9.1.4 ENGINEERED CAPPING

Engineered capping is the placement of a cover material over contaminated sediment in order to isolate contaminants from the surrounding environment. Figure 3.13, taken from the PHSS Draft

FS, shows a typical two-layer cap consisting of sand layer for chemical isolation placed directly on the contaminated sediment, and an overlying layer of gravel or armor rock to protect against erosion. Engineered capping would be effective in the RM11E Project Area where slopes are stable or have been stabilized and where it would not conflict with navigation. Various cap designs can be developed based upon the specific site conditions and uses.

9.1.5 ACTIVE CAPPING

Active capping for sediment sites like PHSS is a modification of engineered capping in which an amendment is added into or placed within the sand layer to reduce the flux of contaminants from underlying sediments to the water column, primarily through adsorption of contaminants into the amendment. It can be similar to in situ treatment that involves mixing amendments with sand and placing the blended material on the sediment surface, but differs by including an overlying layer of gravel or armor rock to protect the cap against erosion. Alternatively, the adsorptive media can be placed as a layer within the sand to increase the effective life expectancy of the adsorbent. Active capping would be effective in the RM11E Project Area at locations suitable for engineered capping.

9.1.6 DREDGING AND DISPOSAL

Dredging is the process of excavating material from underwater locations. It typically involves the following steps:

1. Dredging – physically excavating material from the riverbed or shoreline typically using mechanical or hydraulic methods
2. Conveyance – moving excavated material to a processing or offloading facility
3. Offloading – moving excavated material from the conveyance system to a processing facility
4. Processing – preparing excavated material for transport and disposal (such as dewatering, amending, and treating)
5. Transportation and disposal – moving excavated material to the final disposal location

Dredging would be effective in the RM11E Project Area at locations accessible to marine construction equipment, areas of stable or stabilized slopes, and where sediment removal would not adversely affect stability of structures.

Disposal is the placement of the excavated material in a final location that allows control of potential environmental impacts. Examples of currently available upland disposal facilities that could support a dredging project at RM11E include the Columbia Ridge Landfill (Oregon) and Roosevelt Regional Landfill (Washington), both of which can accept dredged material by rail and truck. In-water disposal options, such as confined aquatic disposal (CAD) and nearshore confined disposal facility (CDF), were evaluated in the PHSS Draft FS, but none have been constructed or made available at this time.

9.2 RM11E IMPLEMENTABILITY CONSIDERATIONS

The 10 site factors that received a high-impact rank are listed below along with the figure number showing the general extent of the specific site factor in the RM11E Project Area:

- Facility operations (Figure 9.1)
- Navigation clearance (Figure 9.2)

- Construction access (Figure 9.2)
- Submarine cable crossing (Figure 9.2)
- Groups of vertical pile remnants (Figure 9.3)
- Large undifferentiated debris (Figure 9.3)
- Oversteepened slopes (Figure 9.4)
- Structure stability and capacity
- Vessel propeller wash (Figure 9.5)
- Wave action (Figure 9.5)

The high-impact ranked site factors complicate, and in some cases will limit, certain remedial technologies in the RM11E Project Area. The following sections address the effects of these site factors on implementability from the following perspectives: general aspects that will be a challenge for any approach (Section 9.2.1); aspects that specifically affect capping (Section 9.2.2); aspects that specifically affect dredging (Section 9.2.3); aspects that relate to other remedial technologies (Section 9.2.4); and implementability considerations to limit potential adverse economic impacts and business interruptions (Section 9.2.5). For capping and dredging, the sections are further divided to separately consider the navigation channel area and the shoreline and berth area of the RM11E Project Area (Figure 8.1 and Table 8.1).

After cleanup levels are established in the ROD and areas requiring remediation are determined, site-specific investigations and evaluations will be required during remedial design to develop implementable and effective remedial actions to accommodate the multiple site factors in the RM11E Project Area. For example specific information on the Fremont Bridge structure and foundations would be gathered and evaluated during remedial design if active remediation was planned in the bridge area.

9.2.1 IMPLEMENTABILITY – GENERAL FACTORS FOR ALL REMEDIES

Three high-impact ranked site factors—construction access (Section 3.9.3), facility operations (Sections 3.4 and 3.9.1), and submarine cable crossing (Section 3.9.4)—present implementability challenges for all remedial technologies.

9.2.1.1 Construction Access

Efficient implementation of traditional remedies often requires the use of large equipment to either remove or place materials. Typical equipment used for sediment remediation includes excavators, cranes, barges, dump trucks and a range of conveyance systems. Many physical features of the shoreline and berth area, including structures, vertical pile remnants, the submarine cable crossing, and shallow draft areas, limit access for these types of conventional marine construction equipment (Section 3.9.3 and Figures 3.14a through 3.14d). The combined extent of constrained access by construction equipment, shown on Figure 9.2, occupies approximately 45% of the shoreline and berth area. Active remedial actions to be implemented underneath structures will likely require deployment of specialty construction equipment selected for the configuration of the specific structure (Sections 9.2.2.3 and 9.2.3.3). The availability and practicability of alternative application construction equipment and methods will need to be assessed in remedy selection and design.

9.2.1.2 Facility Operations

The docks at RIS&G, Glacier NW, and Cargill are used to transport aggregates, cement, and grain, respectively, to and from these waterfront businesses; active vessel traffic occurs at the respective docks (Figure 9.1) every month of the year. RIS&G unloads an average of two barges per day. The Glacier NW main dock receives 20 to 40 ships per year with the dock open 5 to 10 days between vessel calls. Three to seven ships berth at the Cargill main dock each month, typically for a period of less than a week each, but for up to 12 days at a time. Cargill's barge dock, while just outside of the RM11E Project Area, is visited by several hundred barges per year; the barges and accompanying tugs may transit the RM11E Project Area.

The busiest shipping time of the year for RIS&G is May through October, for Glacier NW it is April through October, and for Cargill it is April and August through February (Section 3.4.3 and Figure 3.8). These busy shipping times more or less coincide with the environmental windows during which in-water work is typically allowed (Section 3.8.1 and Figure 9.6). The ODFW construction window is July through October for all in-water work, with in-water work below elevation -20 feet CRD allowed in December and January. The USFWS window for in-water work is July through February (Section 3.8)

From a marine construction perspective, the more favorable time period for work within the RM11E Project Area is when there are no vessels at the docks. However, the RIS&G, Glacier NW, and Cargill docks are busy year-round. The next best option would be to schedule in-water remediation work when dock activity is slower, generally November through April for RIS&G, November through March for Glacier NW, as well as March and May through July for Cargill. However, these months generally correspond to the ODFW period when no in-water work above -20 feet CRD is typically allowed (November through June – Figure 9.6).

Condition	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Cargill	*				*	*	*	*	*	*	*	
Glacier NW	*	*	*	*	*	*	*					
RIS&G		*	*	*	*	*	*					
Summary of agency preferred ODFW in-water work period				*	*	*	*					

Period of facility activity

* Periods of busiest facility activity

* Agency preferred in-water work window, all water depths

Agency preferred in-water work window in depths > -20' CRD

FIGURE 9.6 – SUMMARY OF POTENTIAL TIMING IMPACTS ON REMEDIAL ALTERNATIVES

In short, regardless of the month of the year, remedial construction would conflict with either business operations, currently identified in-water work restrictions, or both. It may be possible to obtain agency approval for modified in-water work windows depending on the scope of work

and on benefits to fisheries resources in the work area. Possible options to limit the impacts on business operations are discussed in Section 9.2.5.

9.2.1.3 Submarine Cable Crossing

The PacifiCorp submarine cable crossing extends from a vault on the Unkeles property across the shoreline and berth area and proceeds across the river to downtown Portland. The specific location and burial depth of each cable are not known as they could not be determined using the methods employed for this study (Section 2.2.4). A caution zone for the underwater cables is shown on Figure 9.1.

Because the cables are buried and provide electricity to downtown Portland, relocation during sediment remediation is not a viable management option. Dredging or setting of anchors or spuds by marine construction equipment should not be conducted in the immediate vicinity of the cable so as not to damage the cables or risk injury to field personnel. Where remedial action within the caution zone of the submarine cables is necessary, either a large no-dig zone would be needed or additional studies would be required to refine the location and burial depth of the cables. If such detailed mapping is not viable or effective, then other non-removal measures such as capping or other passive technologies would be appropriate across the cable crossing caution zone. Conventional capping in navigation areas may not comply with the standard navigation clearance requirements described in Section 3.9.2, and other low-profile remedial technologies may be required.

9.2.2 IMPLEMENTABILITY – CAPPING

This discussion is divided into four subsections. Capping in the navigation channel area is addressed in Section 9.2.2.1 (also Sections 3.9.2 and 7.2.3). Capping in the shoreline and berth area is addressed in Section 9.2.2.2. Equipment considerations are addressed in Section 9.2.2.3. Finally, cap reliability, monitoring, and maintenance are addressed in Section 9.2.2.4.

9.2.2.1 Navigation Channel Area Capping

The three high-impact ranked navigation-related site factors for capping in the navigation channel area (Table 8.1b) are navigation clearance, vessel propeller wash (Figure 9.5), and the submarine cable crossing discussed in Section 9.2.1.3. As noted in Section 3.9.2, engineered caps are likely not suitable for the navigation channel because the top of an assumed 5-foot-thick cap (including armoring layers to protect against propeller wash) would have to remain lower than elevation -53 feet CRD. Construction of a heavily armored cap (see Armored Cap Class 700 on Figure 7.5, from PHSS Draft FS) would involve first dredging to -58 ft CRD. At that depth, the target contaminated sediment would likely have been fully removed, and a cap would no longer be necessary. If capping is employed in the navigation channel, caps would require armoring sufficient to resist the erosive forces of vessel propeller wash.

9.2.2.2 Shoreline and Berth Areas Capping

All of the high-impact ranked site factors, with the exception of large undifferentiated debris, affect capping in the shoreline and berth area of the RM11E Project Area. Those factors not already described in Section 9.2.1 are described below.

9.2.2.2.1 Dock Area Navigation Clearance and Propeller Wash (See Sections 3.9.2 and 7.4.2)

Navigation clearance in navigation areas (Figure 9.2) and propeller wash (Figure 9.5) affect capping in the shoreline and berth area. Figures 3.5a and 3.5b show the navigation areas between

the navigation channel and the four primary active dock areas. The two northern docks (RIS&G barge dock and Glacier NW barge dock) are for shallow-draft barges and the two southern docks (Glacier NW main dock and the Cargill main dock) are deep-draft for ocean-going ships.

As is the case for the navigation channel, engineered caps are unlikely to be considered practical in the navigation areas serving the deep-draft main docks at Glacier NW and Cargill; dredging followed by the construction of a heavily armored cap to protect against vessel propeller wash would most likely result in full removal of the target contaminated sediment and make a cap unnecessary.

Engineered caps may be viable outside of the deep-draft navigation areas of the RM11E Project Area. Engineered cap armoring layers and clearance requirements for navigation and future maintenance dredging that would be protective against vessel propeller wash would be established during remedial design. Once such design details are available, it would be possible to evaluate the constructability of engineered caps in shallow-draft navigation areas.

9.2.2.2.2 Oversteepened Slopes (See Sections 5.3.1, 5.3.3 and 5.3.4)

Oversteepened slopes (i.e., inclined steeper than 2H:1V) in the shoreline portion of the RM11E Project Area are shown in Figure 9.4. As detailed in the geotechnical assessment (Section 5), caps on oversteepened slopes require a detailed and site-specific evaluation of conditions during remedial design. From a constructability perspective, direct placement of capping material on oversteepened slopes is generally not possible without other management actions. Such actions may include laying back the overall slope; reinforcing the slope with a rock buttress at the toe of the slope (Figure 5.9); installing a retaining wall at the toe of the slope (Figure 5.10); using stepped retaining walls up the slope (Figure 5.11); and installing a structural cap (e.g., articulated concrete mat).

Driving piles or sheet-pile walls to construct retaining walls for capping (Section 5.3.4) may be difficult or impractical if large undifferentiated debris is present (Figure 9.3) or if very dense or partially cemented native gravel is present within several feet of the mudline (Figures 5.3 and 5.4). Site-specific investigations of the areas where active remedies are required will be needed during remedial design to assess this potential constructability issue.

9.2.2.2.3 Wave Action

The wave zone is the portion of the bank and upper shoreline that is subject to erosive vessel wakes and wind-generated waves. The wave zone (elevation 0 to 23 feet NAVD88) is mapped on Figure 9.5 and shown in cross section on Figure 7.2. Caps constructed in the wave zone will require armoring sufficient to resist these erosive forces (Section 7.2.1.3.2).

9.2.2.2.4 Groups of Vertical Pile Remnants (See Section 4.3.2)

Closely spaced remnant piles may make consistent placement of capping material difficult, resulting in possible non-uniform cover over targeted contaminated sediment. Groups of vertical pile remnants (Figure 9.3) are most prominent along the shoreline of the Cargill property. A three-dimensional example of groups of vertical pile remnants is shown on Figure 4.4. Remnant piles may also penetrate upward through the cap, providing a possible preferential pathway for movement of contaminants through the cap. The remnant piles could be cut off at or near the mudline to facilitate capping; however the remnant piles should not be removed without further evaluation, as doing so could destabilize the shoreline slopes (Section 5.3.4). Additional cover

material could be placed around the remnant piles to account for irregular placement around piles.

9.2.2.2.5 Structures (See Section 6.6.3)

The multiple in-river structures in the RM11E Project Area are listed in Table 6-1, mapped on Figures 6.2 through 6.7, and ranked on Tables 6.10 through6.12. While capping under docks is a viable remedial alternative, the presence of the structures within the shoreline and berth area will require additional consideration of material placement techniques that can be adapted for use under and around the structures. The structures are supported on vertical and battered piling, which may make consistent placement of capping material difficult. The piles supporting the structures will also penetrate through cap material placed under the structure, requiring additional assessment of the cap design to limit potential preferential pathways for movement of contaminants upward through the cap.

The need for slope stabilization to prevent added loads on structures may limit the areas that can be capped. Consideration must also be given to refinement of cap design to manage loads on piles that could otherwise lower the factor of safety against bearing failure.

Capping under structures will require facility-specific design and deployment of specialty equipment selected for the configuration of the structure (Section 9.2.2.3).

9.2.2.3 Capping Equipment Considerations

When compared to dredging, capping normally requires less infrastructure in terms of material handling, dewatering, transport, and disposal. Capping is potentially viable at locations shoreward of the navigation channel except for the deep-draft dock navigation areas (Figure 9.2); capping is better suited for locations along the sloping shoreline and beneath and behind structures, and potentially in shallow-draft navigation areas. Capping material can be placed with a wide assortment of equipment readily available in the Pacific Northwest. Clamshell buckets deployed from derrick barges and crane barges are the most common equipment used for placement of capping material in open-water accessible areas. Capping material may be placed in areas of limited access and under docks using telescoping conveyor belts deployed from the shoreline or from barges, and by slurry pipelines. The capping equipment best suited for a given location will depend on site-specific constraints and capping design parameters. Within the region, the availability of qualified personnel, equipment, and capping materials is likely sufficient to address the site conditions in the RM11E Project Area.

9.2.2.4 Cap Reliability, Monitoring, and Maintenance Considerations

9.2.2.4.1 Reliability – Short Term and Long Term

Where engineered capping can be designed and constructed to address the site factors identified above, it can quickly reduce exposure to contaminants with only limited resuspension of contaminants into the water column. In the long term, well-designed and well-constructed caps provide physical isolation of contaminated sediment, erosion protection of the sediment and cap, and chemical isolation to reduce exposure from transport of contaminants into the water column. Engineered caps have been shown to be reliable at providing physical and chemical isolation as well as erosion protection at multiple Superfund sites, including several in the Pacific Northwest, where caps were constructed over a decade ago.

Because contaminated sediment is left in the river with capping alternatives, a long-term potential exists for disturbance of the cap and the underlying contaminated sediment. Consequently,

institutional controls are frequently adopted to limit activities that could disturb the cap (Section 9.4.2). Monitoring plans are also an integral part of capping to assure that the cap functions as intended over the long term, as discussed below.

9.2.2.4.2 Monitoring – Short Term and Long Term

Initial short-term monitoring after cap construction includes collection of baseline data on the as-built configuration of the cap, including the thickness and extent of the cap layers, as well as the baseline chemical concentrations in the cap layers. PHSS Draft FS Appendix T (Long-Term Monitoring and Contingency Program Outline) describes the components of an assumed long-term (i.e., 30-year) cap monitoring program. The results of cap monitoring would be evaluated in accordance with a contingency plan consisting of additional actions, including further analysis of regularly scheduled monitoring data, additional data gathering, and additional remedial actions, based on the specific site conditions and design within the RM11E Project Area.

9.2.2.4.3 Maintenance – Long Term

A properly designed and constructed cap does not normally require periodic maintenance. However, investigation and possibly repair would be necessary if monitoring indicated unplanned disturbance of the cap that could reduce its effectiveness. The investigation would focus on determining the source of the damage, and consider other controls, such as modified institutional controls, to prevent similar disturbance in the future. Repair would normally be completed using the type of equipment and materials originally used to construct the cap.

9.2.3 IMPLEMENTABILITY – DREDGING

The discussion of implementability for dredging is divided into five subsections. Site factors that apply to the navigation channel area (Section 9.2.3.1) and to the shoreline and berth area of the RM11E Project Area (Section 9.2.3.2) are followed by a discussion of dredging equipment considerations (Section 9.2.3.3) and dredge material disposal considerations (Section 9.2.3.4). The final subsection addresses dredging reliability, monitoring, and maintenance (Section 9.2.3.5).

9.2.3.1 Navigation Channel Area Dredging

Only one high-impact ranked site factor—the submarine cable crossing caution zone (Figure 9.2)—is identified for dredging in the navigation channel area (Table 8.3; Section 3.9.4). Its impact on implementability is discussed in Section 9.2.1.3.

9.2.3.2 Shoreline and Berth Area Dredging

Seven high-impact ranked site factors affect dredging in the shoreline and berth area of the RM11E Project Area (Table 8.1a). Construction equipment access, facility operations, and the submarine cable crossing caution zone (Figures 9.1 and 9.2) are discussed in Section 9.2.1. Oversteepened slopes (Figure 9.4), debris (groups of vertical pile remnants and large undifferentiated debris) (Figure 9.3), and structures (Figure 9.1) are each discussed below.

9.2.3.2.1 Oversteepened Slopes (See Sections 5.3.1 and 5.3.2)

Oversteepened slopes (i.e., inclined steeper than 2H:1V) in the shoreline and berth area are shown in Figure 9.4. From a constructability perspective, proper engineering considerations will be needed when dredging on or adjacent to oversteepened slopes to help prevent bank instability, slope failures, or damage to adjacent and upland structures. Mitigating actions for dredging on oversteepened slopes could include first laying back the overall slope to remove material upslope

of the target dredging area (Figure 5.7), or installing a temporary retaining wall until the dredged area is backfilled and stabilized (Figure 5.8).

9.2.3.2.2 Groups of Vertical Pile Remnants (See Section 4.3.2)

Groups of vertical pile remnants, shown on Figure 9.3, are most prominent along the shoreline of the Cargill property; smaller groups are also present along the Glacier NW shoreline. A three-dimensional example of groups of vertical pile remnants is shown on Figure 4.4. Groups of vertical pile remnants may interfere with the placement of the dredge head or bucket, limiting complete removal of the target contaminated sediment, and resulting in the dredge's inability to fully recover residual contaminated sediment. Removing the remnant piles to facilitate dredging could destabilize slopes and should not be undertaken unless justified by remedial design evaluations (Section 5.3.4). Cutting the piles off near the mudline prior to dredging would not be expected to significantly improve dredging results, as the remaining portion of the piles would still interfere with placement of the dredge head.

9.2.3.2.3 Large Undifferentiated Debris (See Section 4.3.3)

Large undifferentiated debris, associated with the historical structures and shoreline stabilization along the RM11E Project Area shoreline, is mapped on Figure 9.3. Most of the historical structures have long been removed. During demolition, rubble may have fallen into the river. Given the number of historical shoreline structures and demolitions associated with redevelopment of the RM11E waterfront area, it is likely that large undifferentiated debris is buried below the mudline, particularly within the footprints of historical structures.

When encountered within a dredging footprint, large debris obstructs complete removal of the contaminated sediment and could prevent complete closure of a mechanical dredging bucket, resulting in loss of sediment to the water column. Large debris can also interfere with hydraulic cutter head operation or plug the hydraulic pipeline. When large debris is dislodged during dredging, contaminated sediment surrounding that item may be suspended into the water column.

Because the nature and extent of buried large undifferentiated debris will not be evident until uncovered by dredging, it may be appropriate to incorporate contingency actions into the remedial action work plan. Examples include multibeam hydrographic surveys or side-scan sonar during the course of dredging to map debris as it is exposed, use of customized debris recovery equipment to limit suspension of contaminated material, and placement of a thin sand cover over the debris prior to excavation and recovery to help limit suspension of contaminated sediment.

In the case of undifferentiated debris, application of a noninvasive method such as capping or other technology instead of dredging could limit the suspension of contaminated sediment into the water column.

9.2.3.2.4 Structures (See Section 6.3.3)

The multiple in-river structures in the RM11E Project Area are listed in Table 6-1, mapped on Figures 6.2 through 6.7 and ranked on Tables 6.10 through 6.12. Slopes will need to be evaluated and potentially stabilized before dredging adjacent to and beneath structures so as to limit the chance of damage to in-water or adjacent upland structures (Section 9.2.3.2.1). In addition, dredging near in-water structures with stable slopes can reduce passive lateral capacity of piles

and walls, lower the structure's factor of safety against pile bending and buckling, and lower pile-bearing capacities.

The need for management actions, such as stabilizing the slope with retaining walls in front of or behind the structure, strengthening the existing structure, or offsetting the dredging away from the structure, may limit the feasibility of dredging near structures.

Specialty equipment selected for the configuration of the specific structures might also be required (Section 9.2.3.3)

9.2.3.3 Dredging Equipment Considerations

Dredging equipment considerations are presented below for the navigation areas, open-access shoreline areas, and under-dock areas.

9.2.3.3.1 Dredging Equipment for Navigation Areas

The navigation areas for vessels servicing the docks within the RM11E Project Area are shown on Figure 9.2. Clamshell buckets deployed from derrick barges and crane barges are commonly used to dredge open-water navigation areas and are a likely candidate for remedial action dredging in such locations within the RM11E Project Area.

Large hydraulic pipeline dredges have been used for navigation dredging in the 50+ feet of water depth of the Willamette River. For example, the Port of Portland's Dredge Oregon incorporates a 30-inch-diameter hydraulic pipeline and a large steel frame (ladder) to lower the dredge cutterhead to the riverbed. However dredges of that size produce large volumes of slurry (thousands of cubic yards per hour) that would likely be impractical to manage for a sediment remediation project like RM11E. Mechanical dredging is expected to be the preferred technology in areas where sediment removal is required in the navigation areas at the RM11E Project Area.

9.2.3.3.2 Dredging Equipment for Open-access Shoreline Areas

Hydraulic dredging equipment is not likely to be used in shoreline areas of the RM11E Project Area because the considerable debris expected to be present could plug the pipeline, obstruct the swing of the dredge head through the sediment, or both. Groups of vertical pile remnants would also compromise the effectiveness of hydraulic dredging (Section 4.3). Dredging in the open-access shoreline areas of RM11E Project Area would most likely be completed by mechanical means.

The shoreline area has relatively steep slopes, much of it greater that 2H:1V (Figure 9.4). Conventional clamshell buckets deployed on a cable from a derrick barge or crane barge are difficult to place and control on sloping ground. The bucket tends to tip as it encounters the slope, displacing sediment on the slope and achieving poor recovery. A more controlled method for dredging on slopes is with a clamshell-type bucket deployed on the end of a rigid boom of an excavator, which can be held in place at a known location and elevation on the slope while the bucket is closed, thereby reducing disturbance of the sediment on the slope.

Shallow-draft sloping areas can also be dredged with conventional excavators configured on portable interlocking modular barge components to operate in a few feet of water.

Small and large excavator dredges have been used on multiple projects in the Pacific Northwest. The regional availability of qualified personnel and equipment is likely sufficient for dredging of the open-access shorelines and shallow-draft areas in the RM11E Project Area.

9.2.3.3.3 Dredging Equipment for Under-dock Areas

Dredging under docks is of limited viability in the RM11E Project Area because of access limitations. The deck of the dock would obstruct access to targeted sediment by conventional clamshell buckets deployed on a cable from a derrick barge or crane. Where the distance between dock piles and the clearance under the dock are sufficient, excavator dredges have been used to remove contaminated sediment from under the dock, working from the face of the dock.

Diver-guided hydraulic suction dredging has been employed under docks in situations like those found at RM11E, with production rates on the order of 1-5 cubic yards per hour. The production rates can be further reduced in the presence of debris or compact sediment

The viability of dredging under docks will be a function of the extent, location, and nature of the material to be removed as well as the configuration of the structure over the sediment. Within the Pacific Northwest, the availability of qualified industrial divers and equipment is likely sufficient for dredging under docks in suitable locations.

9.2.3.4 Dredged Material Disposal Considerations

Once contaminated sediment is removed from the riverbed and placed on a barge, it must undergo an integrated set of processes to reach final disposal. The dredged material has to be transported to a processing or offloading facility (conveyance); moved from the conveyance system (e.g., barges for mechanical dredging) to a land-based facility (offloading); prepared for transport by dewatering or stabilizing (processing); and then moved from the shore facility to the final disposal location (transportation and disposal).

Conveyance is not expected to be a significant constructability factor, as barges for sediment transport are generally in sufficient supply. Offloading, processing, and loading onto transport vehicles (truck or rail) for movement to the disposal facility such as a landfill is often a combined operation at a site configured specifically for that purpose. The availability and capacity of a suitable offloading facility can be limiting factors in dredge production rates. Establishment of such a facility would be a component of remedial design, with the size and throughput of the facility dependent on the scope of dredging planned for the project.

Dredged material generated at the RM11E Project Area could be placed at one of the existing upland commercial landfills discussed in Section 9.1.6.1. Trucking and rail transport options are available, with the latter offering better safety and efficiency.

Placement of dredged material from the RM11E Project Area into a nearshore CDF would be possible only if the facility were developed and ready to receive contaminated sediment at the time of dredging. If RM11E Project Area is among the first to implement PHSS remedial actions, a nearshore CDF may not be available at the time of dredging. In that case, dredging would have to be delayed until the facility was available, or dredged material could be disposed of at an upland commercial landfill without such a delay.

9.2.3.5 Dredging Reliability, Monitoring, and Maintenance Considerations

9.2.3.5.1 Reliability – Short Term and Long Term

The reliability of dredging in the RM11E Project Area will be dependent on the specific site factors in areas requiring dredging (such as presence of oversteepened slopes, debris, structures) as well as the RALs, remedial action objectives (RAOs), and other criteria set forth in the ROD. Where dredging successfully removes contaminated sediment from the river to meet RALs, it provides

for a long-term reliable remedy. However, dredging is less reliable where it results in residuals that exceed RALs. Since debris is a primary factor for the generation of dredging residuals, the extensive area of large undifferentiated debris along the RM11E Project Area shoreline is an indicator of decreased reliability of dredging in the local shoreline area. Also, in the short term, dredging can result in resuspension of contaminated sediment.

9.2.3.5.2 Monitoring – Short Term

The monitoring program during dredging will likely be developed to comply with Oregon's Clean Water Act Section 401 Water Quality Certification, based on Oregon's water quality regulations. The monitoring plan can include water quality parameters such as turbidity, dissolved oxygen, and contaminant concentration, along with contingency measures should water quality criteria be exceeded.

Monitoring programs can also include measurement of chemical concentrations in surface sediment that remains after dredging, and contingency measures should sediment quality criteria be exceeded. One contingency measure discussed in the PHSS Draft FS involves the placement of a layer of sand over dredged areas affected by residual contaminated sediment.

9.2.3.5.3 Maintenance – Long Term

Maintenance is not expected for dredged areas that achieve removal to the project criteria.

9.2.4 IMPLEMENTABILITY – OTHER REMEDIAL TECHNOLOGIES

Implementability for other remedial technologies is addressed as follows: active capping (Section 9.2.4.1), MNR (Section 9.2.4.2), EMNR (Section 9.2.4.3), and in situ treatment (Section 9.2.4.4). Site factors that affect implementability for these other technologies are not materially different from those discussed above for capping and dredging (e.g., facility operations, navigation clearance, construction access, submarine cable crossing , groups of vertical pile remnants, oversteepened slopes, structures, propeller wash, and wave action.).

9.2.4.1 Active Capping

Active capping refers to the addition of an amendment to the sand layer of an engineered cap prior to placement, or the placement of an amendment layer prior to placement of the conventional sand cap layer. Active capping can be completed with conventional equipment as part of the cap construction. The implementability of active capping is essentially the same as that for engineered capping (Section 9.2.2) and is influenced by navigation clearances, vessel propeller wash, waves and wakes, oversteepened slopes, groups of vertical pile remnants, structures, and the submarine cable crossing.

9.2.4.2 Monitored Natural Recovery

The effectiveness of MNR may be more complicated in specific areas of the RM11E Project Area because of wave action, propeller wash, or oversteepened slope site factors. However, even in such areas, MNR has the potential to improve the chemical quality of surface sediments over time. Thus, MNR should be considered for the RM11E Project Area during selection of remedial actions either as a stand-alone remedy for certain areas or in combination with other remedial strategies.

9.2.4.3 Enhanced Monitored Natural Recovery

EMNR is functionally similar to engineered capping from a constructability perspective, as both involve placing granular material on the riverbed. Both are influenced by facility operations, navigation clearance, construction access, groups of vertical pile remnants, oversteepened slopes, structures, propeller wash, and wave action.

The effectiveness of EMNR in the RM11E Project Area may be complicated due to wave action, propeller wash, or unstable slope site factors. However, even in such areas, EMNR has the potential to improve the chemical quality of surface sediments. Thus, EMNR should be considered for the RM11E Project Area during selection of remedial actions either as a stand-alone remedy for certain areas or in combination with other remedial strategies.

9.2.4.4 In Situ Treatment

In situ treatment is a potentially effective innovative technology for the RM11E Project Area that could improve the overall effectiveness of remedial actions, either alone or in combination with other technologies. For example, in situ treatment could be applied to dredge residuals where placement of a sand cover might be constrained by navigation clearances. In situ treatment in some locations might also improve surface sediment quality to the point that other remedial technologies such as capping or dredging would not be required or would be reduced in scope. Thus, in situ treatment should be considered for the RM11E Project Area during selection and design of remedial actions either as a stand-alone remedy for certain areas or in combination with other remedial strategies.

The implementability of in situ treatment will be influenced by facility operations, navigation clearance, construction access, submarine cable crossing, groups of vertical pile remnants, oversteepened slopes, structures, propeller wash, and wave action.

9.2.5 TECHNOLOGIES TO LIMIT POTENTIAL ADVERSE ECONOMIC IMPACTS AND INTERRUPTIONS ON WATERFRONT BUSINESSES

Active construction of remedial actions in the RM11E Project Area will likely require many months to complete, and may span multiple years to accommodate in-water work windows and waterfront operations. As discussed in Section 9.2.1.2, the typical ODFW in-water construction season coincides with the busiest shipping operations in the RM11E Project Area. Consequently, in-water work windows will limit the amount of work that can be accomplished each year unless ODFW and USFWS authorize work outside of the in-water construction windows. Examples of possible approaches to limit such potential adverse economic impacts on business operations are presented below; others may be identified and investigated during remedial design.

9.2.5.1 Subarea Projects

In lieu of a single major remedial action effort for the entire RM11E Project Area, work could proceed by subareas established for each waterfront operation (RIS&G, Glacier NW, and Cargill). This strategy offers scheduling flexibility to accommodate facility-specific periods of managed downtime and to help limit business interruptions. For example, remedial work could be coordinated with scheduled downtime for berth dredging or dock maintenance.

9.2.5.2 Sequencing of Remedy Implementation

The remedial design for the RM11E Project Area could be completed in phases, with the first phase focused on the high-concentration contaminated sediments of greatest concern while at the

same time further evaluating less-intrusive and more readily implemented technologies. For example, once high-concentration contaminated sediments have been remediated in the RM11E Project Area, MNR, EMNR, or in situ treatment may be more effective in reducing surface sediment concentrations to below the RAL in a reasonable time in lesser impacted areas away from the high concentration areas. If proven, the less-disruptive technologies could be applied to other portions of the site during subsequent phases of work.

9.2.5.3 Articulated Concrete Caps

Articulated concrete caps are made up of a grid pattern of individual concrete blocks held together by reinforcing cables. Cast-in-place or prefabricated articulated concrete mats have been applied in situations where a wear- and erosion-resistant cap was required but water depth was too shallow for a riprap cap, and under docks where both sediment confinement and erosion protection were desired but construction access was limited. In the RM11E Project Area, articulated concrete caps might work in areas of oversteepened slopes and under structures, possibly held in place by piling driven into deeper stable deposits.

Because of the potential for faster deployment relative to more conventional technologies, the articulated concrete caps may provide isolation of contaminated sediment, and erosion protection from vessel propeller wash, while being less disruptive to ongoing business operations. This technology should be considered further during remedial design.

9.2.6 TIME TO IMPLEMENT

Because of the multiple high-impact ranked site factors at the RM11E Project Area, the times required for remedial design and the remedial action itself are expected to be lengthy. After cleanup levels are established in the ROD and areas requiring remediation are specified, thorough environmental, structural, and geotechnical efforts must be completed to design implementable and effective remediation methods to accommodate all 10 of the site factors: facility operations, navigation clearance, construction access, submarine cable crossing, groups of vertical pile remnants, large undifferentiated debris, oversteepened slopes, structures, propeller wash, and wave action.

The site factor constraints will limit the use of conventional dredging or capping in many portions of the RM 11E Project Area. Accordingly, remedial construction in the RM11E Project Area will presumptively require location-specific sequencing and implementation of multi-component remedies. Progress may be constrained by difficult access, ongoing facility operations, and short in-water work windows. Remedial construction might best be completed as sequential subarea projects to effectively accommodate the site constraints.

9.2.7 COST CONSIDERATIONS

Until PHSS-wide cleanup action levels are selected in the ROD, and until design studies investigate and identify remedial technologies to address the multiple site factors, a realistic update on the cost estimates provided in Appendix K of the PHSS Draft FS is not practical. The specific site factors present in RM11E Project Area have not been accounted for in the PHSS Draft FS. For example, the cost estimates provided in Appendix K do not include slope stabilization components that may be required for oversteepened slopes.

9.3 REGULATORY FACTORS

9.3.1 APPROVALS AND PERMITS

The RM11E Project Area remedial action will likely be completed under an agreement with EPA that would allow agency approval without requiring local, state, or federal permits for actions conducted entirely within the PHSS. The selected remedy will presumptively have to comply with substantive requirements of the permits and RAOs established for the PHSS.

The remedial design will have to demonstrate that the planned remedial actions comply with all applicable or relevant and appropriate requirements (ARARs), unless such standards are waived. The federal and state ARARs listed on Table 3.4-1 of the PHSS Draft FS (are listed below. Compliance with applicable City of Portland codes will also be required.

- Federal ARARS
  - Clean Water Act, Sections 304, 401, 402, and 404
  - Safe Drinking Water Act
  - Resource Conservation and Recovery Act
  - Hazardous Materials Transportation Act
  - Fish and Wildlife Coordination Act
  - Magnuson-Stevens Fishery Conservation and Management Act
  - Federal Emergency Management Act
  - River and Harbors Act
  - Clean Air Act
  - Toxic Substances Control Act
  - Marine Mammal Protection Act
  - Migratory Bird Treaty Act
  - National Historic Preservation Act
  - Archeological and Historic Preservation Act
  - Native American Graves Protection and Reparation Act
  - Endangered Species Act
  - Executive Order for Wetlands Protection
  - Executive Order for Floodplain Management
  - National Flood Insurance Act and Flood Disaster Protection Act
- State ARARs
  - Oregon Environmental Cleanup Law
  - Hazardous Waste and Hazardous Materials
  - Solid Waste: General Provisions
  - Water Pollution Control Act
  - ODFW Fish Management Plans for the Willamette River
  - Oregon Air Pollution Control
  - Indian Graves and Protected Objects
  - Archeological Objects and Sites
  - Guidance for Assessing Bioaccumulative Chemicals of Concern in Sediment

Final ARAR determinations will be made by EPA in the ROD.

The process for EPA approval of the remedial design will include consultation with NOAA Fisheries for compliance with the Endangered Species Act, and with the State of Oregon for compliance with state water quality criteria under Section 401 of the Clean Water Act

Caps placed on property controlled by ODSL will require permission for land access, lease agreements, or both. Remedial actions affecting waterfront use of property or shorelines may require similar agreements with waterfront and shoreline facilities.

9.3.2 INSTITUTIONAL CONTROLS

Where the remedy will leave contaminants in place in the RM11E Project Area, institutional controls may be required. Institutional controls generally refer to non-engineering measures to protect the remedy and prevent or reduce exposure to hazardous substances. Various institutional controls, examples of which are listed below, can be evaluated for potential implementation to reduce exposure to contaminants, protect caps from damage, and prevent disturbance of subsurface contaminated sediment remaining in place after a remedy is implemented:

- RM11E Project Area use restrictions, such as prohibiting the anchoring of vessels, placing restrictions on maintenance dredging, and creating no-wake zones
- RM11E Project Area nearshore and shoreline use restrictions that restrict landowners and property operators from building retaining walls or docks, placing fill, or excavating along the shoreline
- Fish consumption advisories

Institutional controls may be established by regulation or directly with owners of both privately owned shoreline and state-owned submerged lands, and with state and local authorities. Typically, institutional controls would be put in place before or shortly after completion of a final remedial action. Institutional controls generally remain until the remediated site no longer needs protection or no longer poses a risk. Like any other remedial component, the costs of proposed institutional controls will be evaluated in the selection of remedial alternatives and the remedial design process.

9.4 SECTION 9 FIGURES

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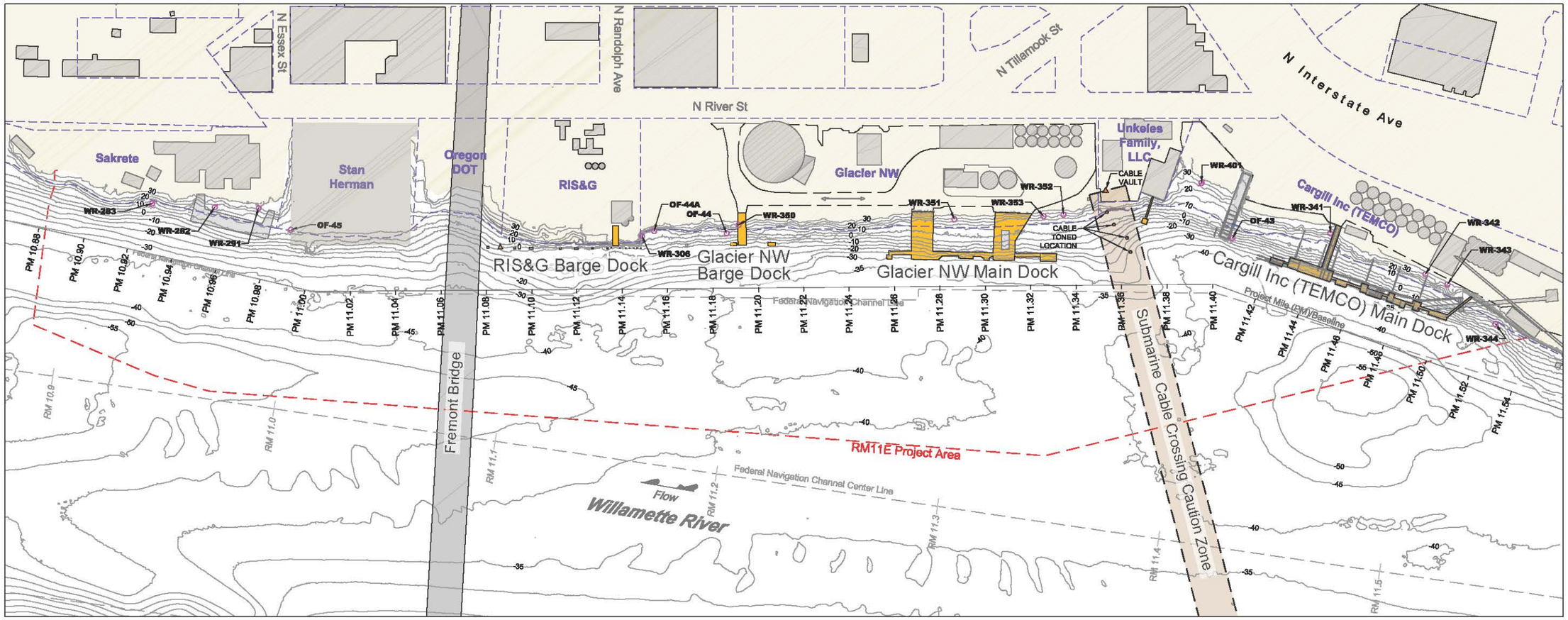

MAP NOTES

1. The locations of all features shown are approximate.
2. Contour lines and planimetric features are based on a composite data set which consists of the following: NOAA multibeam survey from 2009; ODSL multibeam and laser survey from 2010; USACE LiDAR survey from 2009; David Evans and Associates, Inc. multibeam survey from 2011 and terrestrial laser scan from 2013; and RLIS Metro GIS data. Digital elevation model (DEM) surface for bathymetric contours was modeled only in the immediate vicinity of the RM11E Project Area. It is not intended for litigation, construction, or navigation purposes.
3. Horizontal datum is based on Oregon State Plane North NAD83 (international feet). Vertical datum is referenced to NAVD88 (feet).
4. Outfall status and location from City of Portland - Bureau of Environmental Services (BES) GIS group in June 2013. Data layer acquired from GSI. Outfalls centered on coordinates from BES data layer.
5. Tax lot boundary generated by METRO (Oct. 2013). Data layer acquired from GSI.
6. Vertical pile remnants and submarine cable crossing toned location provided by David Evans and Associates, Inc. as described in the Draft Implementability Study Report, Section 2.

LEGEND

- Active Docks (2015)
- Existing Structures
- Submarine Cable Crossing Caution Zone
- Outfall - Active
- Outfall - Inactive or Status Unknown
- RM11E Project Area
- Tax Lot Boundary (Oct. 2013)
- RM 11.3 — River Mile Stationing (USACE)
- PM 11.32 — Project Mile Stationing
- Federal Navigation Channel (USACE)
- 40 — Bathymetric Contour - 5' Interval (NAVD88)

0 250
Scale in Feet

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RM11E Group
Willamette River - Portland, Oregon
Draft Implementability Study Report

Waterfront Facilities

DALTON OLMSTED FUGLEVAND

Figure 9.1

July 31, 2015

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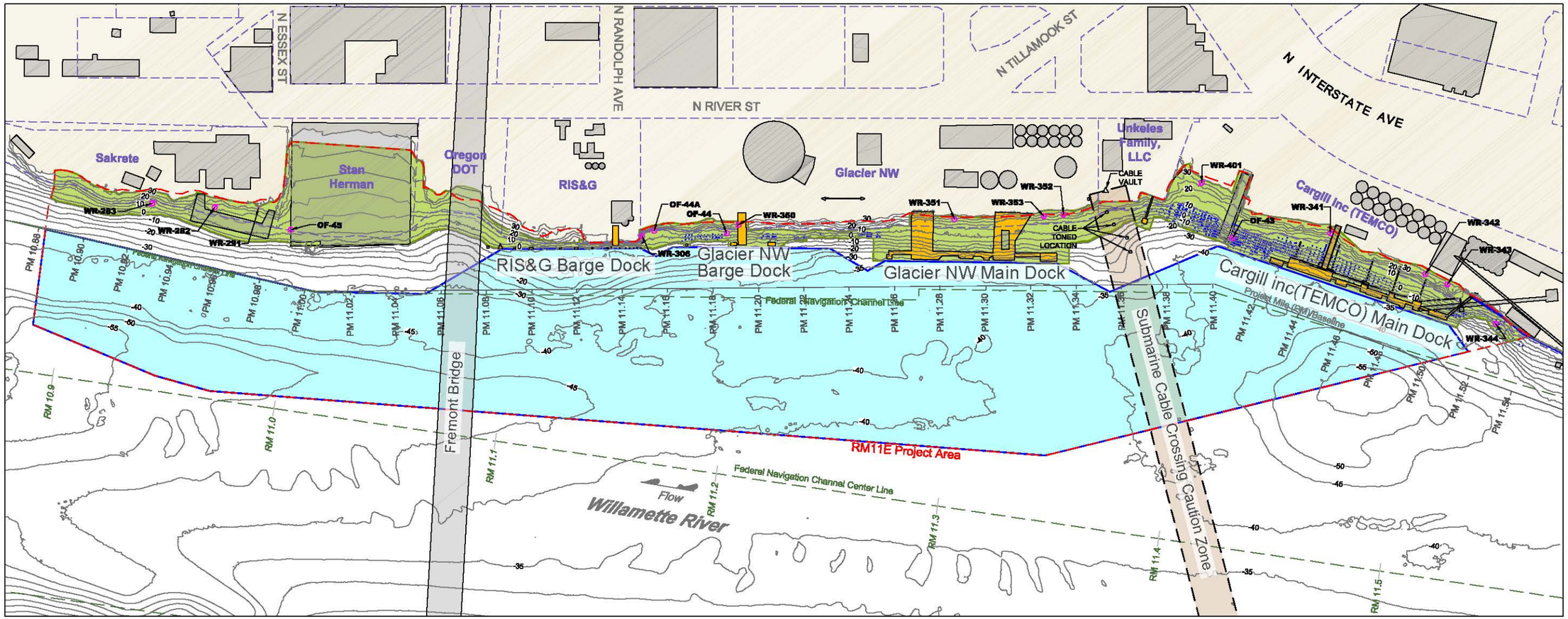

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5. Tax lot boundary generated by METRO (Oct. 2013). Data layer acquired from GSI.
6. Vertical pile remnants and submarine cable crossing toned location provided by David Evans and Associates, Inc. as described in the Draft Implementability Study Report, Section 2.

LEGEND

High-Impact Ranking

- Construction Access: High-Impact
- Navigation Clearance/Facility Operations: Moderate- to High-Impact (Cap/Cover)
- Submarine Cable Crossing Caution Zone: High-Impact
- Outfall - Active: Moderate-Impact
- Outfall - Inactive or Status Unknown: Moderate-Impact

Other Features

- Active Docks (2015)
- Existing Structures
- Submarine Cable Crossing Caution Zone
- RM11E Project Area
- Tax Lot Boundary (Oct. 2013)
- RM 11.3 — River Mile Stationing (USACE)
- PM 11.32 — Project Mile Stationing
- Federal Navigation Channel (USACE)
- 40 — Bathymetric Contour - 5' Interval (NAVD88)

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Scale in Feet

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Willamette River - Portland, Oregon
Draft Implementability Study Report

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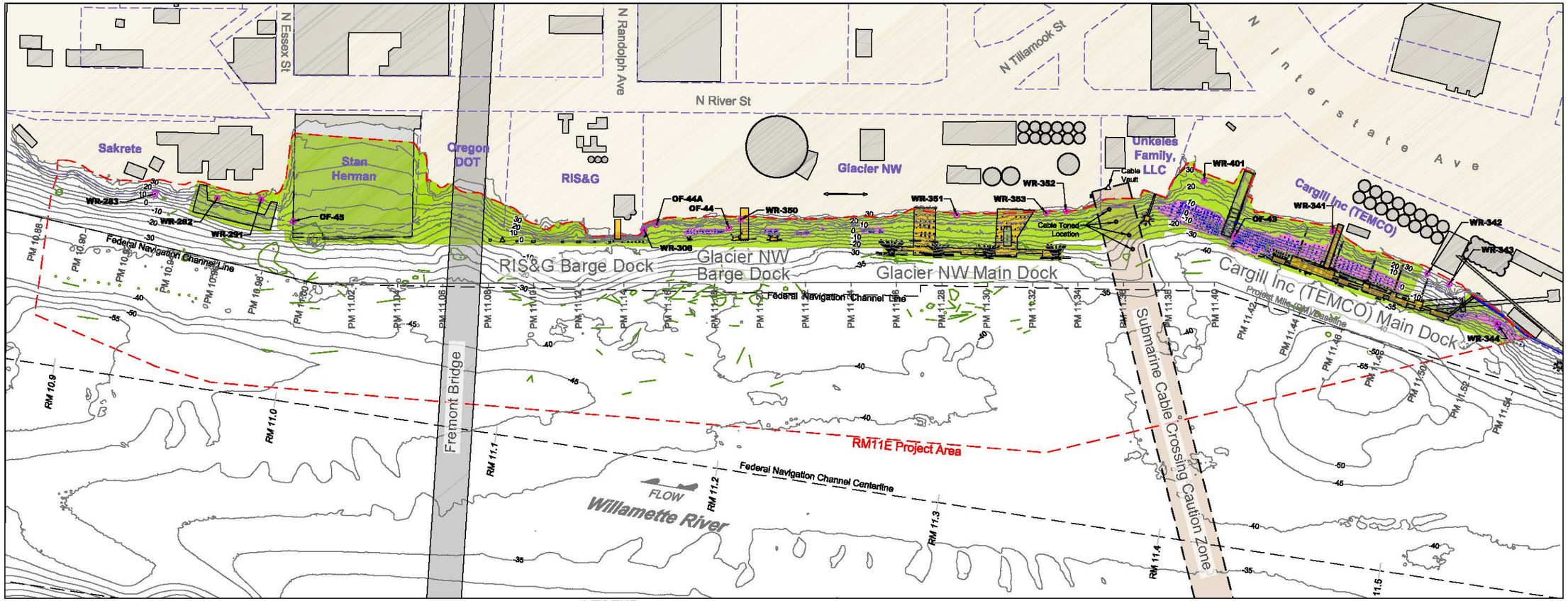
Waterfront Use High-Impact Ranked Areas

(See Figures 3.16a through 3.16d for details)

Figure 9.2

July 31, 2015

PLOT TIME: 7/31/2015 2:00 PM MOD TIME: 7/31/2015 1:57 PM USER: Lee Barras DWG: D:\Projects\RM11E\CADV\Figures\2015-07\SR\2015-07-31 29 Waterfront Use Impact Areas Fig 9.2.dwg



LEGEND

Impact Ranking

- Groups of Vertical Piles: High-Impact (Removal) and Moderate- to High-Impact (Cap/Cover)
- Large Undifferentiated Debris: Moderate- to High-Impact (Removal) (Expected within Extents of Historical Shoreline Structures Footprint)

Other Features

- Active Docks (2015)
- Individual Large Debris/Debris Groupings
- Existing Structures
- Submarine Cable Crossing Caution Zone
- Outfall - Active
- Outfall - Inactive or Status Unknown
- RM11E Project Area
- Tax Lot Boundary (Oct. 2013)
- RM 11.3 — River Mile Stationing (USACE)
- PM 11.32 — Project Mile Stationing
- Federal Navigation Channel (USACE)
- -40 — Bathymetric Contour - 5' Interval (NAVD88)

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Scale in Feet

MAP NOTES

1. While not mapped on this figure, minor undifferentiated debris is possible anywhere on site, and more likely within the footprint of historical buildings and immediately downslope of those buildings.
2. The locations of all features shown are approximate.
3. Contour lines and planimetric features are based on a composite data set which consists of the following: NOAA multibeam survey from 2009; ODSL multibeam and laser survey from 2010; USACE LiDAR survey from 2009; David Evans and Associates, Inc. multibeam survey from 2011 and terrestrial laser scan from 2013; and RLIS Metro GIS data. Digital elevation model (DEM) surface for bathymetric contours was modeled only in the immediate vicinity of the RM11E Project Area. It is not intended for litigation, construction, or navigation purposes.
4. Horizontal datum is referenced to Oregon State Plane North NAD83 (international feet). Vertical datum is referenced to NAVD88 (feet).
5. Outfall status and location from City of Portland - Bureau of Environmental Services (BES) GIS group in June 2013. Data layer acquired from GSI. Outfalls centered on coordinates from BES data layer.
6. Tax lot boundary generated by METRO (Oct. 2013). Data layer acquired from GSI.
7. Vertical pile remnants and submarine cable crossing toned location provided by David Evans and Associates, Inc. as described in the Draft Implementability Study Report, Section 2.

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Willamette River - Portland, Oregon
Draft Implementability Study Report

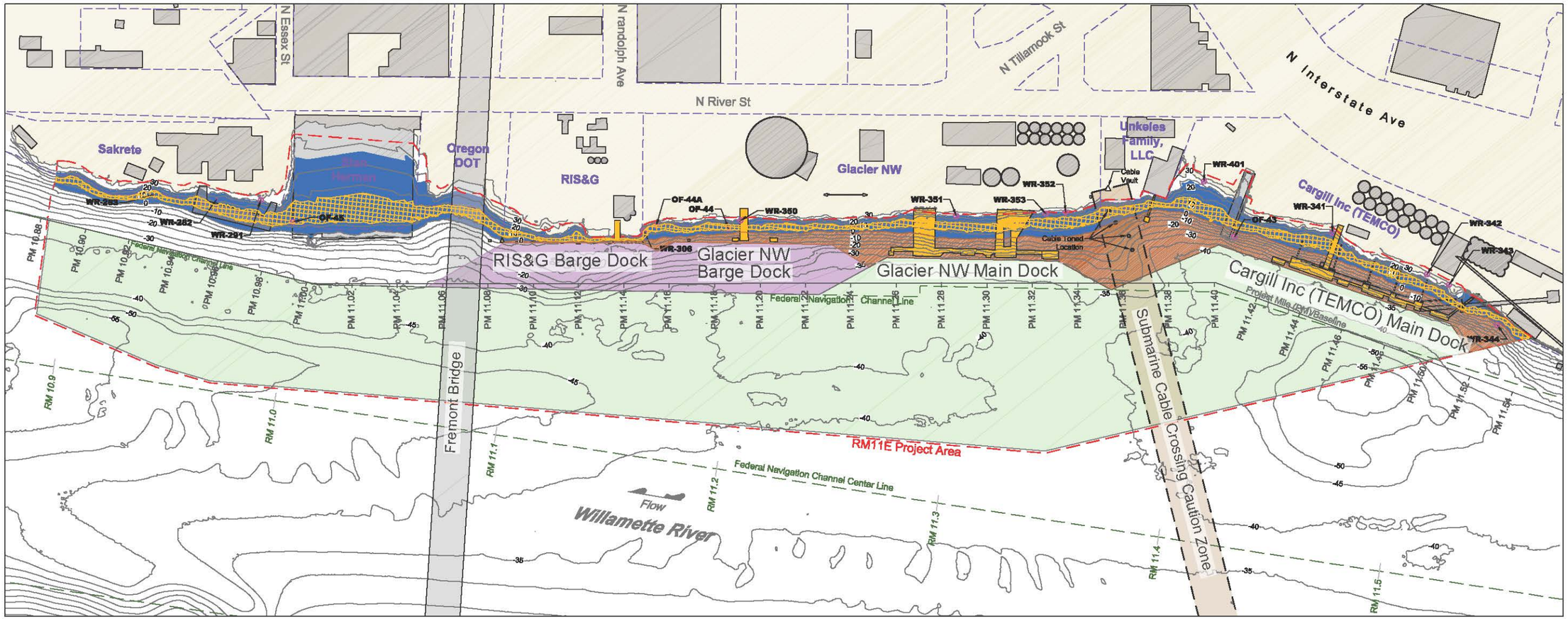
Debris High-Impact Ranked Areas

(See Figures 4.5a through 4.5d for details)

Figure 9.3

July 31, 2015

PLOT TIME: 7/31/2015 2:00 PM MOD TIME: 7/31/2015 1:57 PM USER: Lee Barras DWG: D:\Projects\RM11E\QAD\Figures\2015-07\ISR\2015-07-31 30 Debris Impact Areas Fig 9.3.dwg



MAP NOTES

1. Majority of wave force 6' to 13' NAVD88 (Anchor et. al., 2012).
2. The locations of all features shown are approximate.
3. Contour lines and planimetric features are based on a composite data set which consists of the following: NOAA multibeam survey from 2009; ODSL multibeam and laser survey from 2010; USACE LiDAR survey from 2009; David Evans and Associates, Inc. multibeam survey from 2011 and terrestrial laser scan from 2013; and RLIS Metro GIS data. Digital elevation model (DEM) surface for bathymetric contours was modeled only in the immediate vicinity of the RM11E Project Area. It is not intended for litigation, construction, or navigation purposes.
4. Horizontal datum is referenced to Oregon State Plane North NAD83 (international feet). Vertical datum is referenced to NAVD88 (feet).
5. Outfall status and location from City of Portland - Bureau of Environmental Services (BES) GIS group. Data layer acquired from GSI. Outfalls centered on coordinates from BES data layer.
6. Tax lot boundary generated by METRO (Oct. 2013). Data layer acquired from GSI.
7. Vertical pile remnants and submarine cable crossing toned location provided by David Evans and Associates, Inc. as described in the Draft Implementability Study Report, Section 2.

LEGEND

High-Impact Ranking

- Wave Zone (0.0' to 23.3'): Moderate- to High-Impact (Cap/Cover)
- Majority of Wave Force (6.0' to 13.0'): High-Impact (Cap/Cover)
- Shallow Draft Propeller Wash: Moderate- to High-Impact (Cap/Cover)
- Deep Draft Propeller Wash: Moderate- to High-Impact (Cap/Cover)
- Adjacent Shoreline Propeller Wash: Moderate- to High-Impact (Cap/Cover)

Other Features

- Active Docks (2015)
- Existing Structures
- Submarine Cable Crossing Caution Zone
- Outfall - Active
- Outfall - Inactive or Status Unknown
- RM11E Project Area
- Tax Lot Boundary (Oct. 2013)
- RM 11.3 — River Mile Stationing (USACE)
- PM 11.32 — Project Mile Stationing
- Federal Navigation Channel
- 40 — Bathymetric Contour - 5' Interval

0 250
Scale in Feet

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RM11E Working Group
Willamette River - Portland, Oregon
Implementability Study Report

Hydrodynamics High-Impact Ranked Areas

(See Figures 7.7a through 7.7d for details)

DALTON OLMSTED FUGLEVAND

Figure 9.5

July 15, 2015

PLOT TIME: 7/31/2015 2:00 PM MOD TIME: 7/31/2015 1:55 PM USER: Lee Barras DWG: D:\Projects\RM11E\CAD\Figures\2015-07\NSR\2015-07-31 32 Hydrodynamics Impact Areas Fig 9.5.dwg

MAP NOTES

1. Slope analysis performed by GSI Water Solutions, Inc., September 2014, using ESRI ArcGIS to analyze the DEA Existing Grade composite project surface (DEM) for changes in slope.
2. The locations of all features shown are approximate.
3. Contour lines and planimetric features are based on a composite data set which consists of the following: NOAA multibeam survey from 2009; ODSL multibeam and laser survey from 2010; USACE LiDAR survey from 2009; David Evans and Associates, Inc. multibeam survey from 2011 and terrestrial laser scan from 2013; and RLIS Metro GIS data. Digital elevation model (DEM) surface for bathymetric contours was modeled only in the immediate vicinity of the RM11E Project Area. It is not intended for litigation, construction, or navigation purposes.
4. Horizontal datum is referenced to Oregon State Plane North NAD83 (international feet). Vertical datum is referenced to NAVD88 (feet).
5. Outfall status and location from City of Portland - Bureau of Environmental Services (BES) GIS group. Data layer acquired from GSI. Outfalls centered on coordinates from BES data layer.
6. Tax lot boundary generated by METRO (Oct. 2013). Data layer acquired from GSI.
7. Vertical pile remnants and submarine cable crossing toned location provided by David Evans and Associates, Inc. as described in the Draft Implementability Study Report, Section 2.

LEGEND

High-Impact Ranking

- Oversteepened Slopes (Slopes Steeper than 2H:1V): High-Impact

Other Features

- Active Docks (2015)
- Existing Structures
- Submarine Cable Crossing Caution Zone
- Outfall - Active
- Outfall - Inactive or Status Unknown
- RM11E Project Area
- Tax Lot Boundary (Oct. 2013)
- RM 11.3 — River Mile Stationing (USACE)
- PM 11.32 — Project Mile Stationing
- Federal Navigation Channel (USACE)
- 40 — Bathymetric Contour - 5' Interval (NAVD88)

0 250
Scale in Feet

DRAFT - FOR REVIEW

RM11E Group
Willamette River - Portland, Oregon
Draft Implementability Study Report

Geotechnical High-Impact Ranked Areas

(See Figures 5.6a through 5.6d for details)

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Figure 9.4

July 31, 2015

PLOT TIME: 7/31/2015 2:00 PM MOD TIME: 7/31/2015 1:58 PM USER: Lee Barras DWG: D:\Projects\RM11E\CAD\Figures\2015-07\SR\2015-07-31 31 Geotechnical High-Impact Areas Fig 9.4.dwg

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10. CONCLUSIONS AND RECOMMENDATIONS

The conclusions and recommendations in this section are presented for EPA's consideration in its development of the Proposed Remedial Action Plan, presentation to the Remedy Review Board, and development of the ROD as they relate to the RM11E Project Area.

Once PHSS cleanup levels are established in the ROD, the remedial design process can commence to refine areas where remediation will be required and identify viable remedy combinations for the RM11E Project Area based on the engineering assessments conducted to date, the findings of this Implementability Study and post-ROD remedial design efforts.

10.1 REMEDIAL TECHNOLOGIES

As described in Section 9, the remedy for the RM11E Project Area will require combinations of the technologies listed below to provide an effective and implementable remedy across the RM11E Project Area compatible with the complexities posed by the 10 site factors reviewed in Section 9:

- Monitored natural recovery
- Enhanced monitored natural recovery
- In situ treatment
- Engineered capping
- Active capping
- Dredging

10.2 SITE FACTORS

As detailed in Chapters 2 through 9, six engineering assessments have significantly advanced the understanding of the RM11E Project Area and identified the primary site factors to be considered during remedy selection, remedial design, and remedial action. The primary site factors, the issues they pose to implementation, and recommended approaches to mitigate the constraints are summarized below.

The site factors are presented and discussed individually for clarity, but many areas within the RM11E Project Area that may require remediation have multiple site factors to consider. For example, some nearshore subareas will likely be subject to wave action, structural stability issues, oversteepened slopes, groups of vertical piling remnants, and large undifferentiated debris site factors, as well as construction access issues and facility operations issues. Remedial technologies will need to be tailored to accommodate the demands of each subarea.

10.2.1 FACILITY OPERATIONS (FIGURE 9.1)

Conclusions: The ODFW-allowed in-water construction season, which occurs when remediation would normally take place, coincides (and conflicts) with the busiest periods of shipping operations at the RM11E Project Area. Restricting remediation to the in-water work window will cause significant implementability challenges.

Recommendations: With agency authorization, expand the in-water work windows to continue or complete remedial actions outside the period of peak shipping activities. Consider sequentially

remediating portions of the RM11E Project Area using a phased or staged approach, so that remedial work can be coordinated with facility-specific operations.

10.2.2 NAVIGATION CLEARANCE (FIGURE 9.2)

Conclusions: Engineered capping in deep-draft navigation areas (i.e., the navigation channel, deep-draft berths at Glacier NW and Cargill, and associated approach areas) is not likely to be a viable option if the navigation clearances as noted in the PHSS Draft FS are required. Prior to constructing such a cap, it would be necessary to overdredge these areas to depths lower than the riverbed elevation to ensure that navigation clearance is maintained. This dredging would likely result in full removal of impacted material before the desired depth for cap construction is reached, thus negating the need for a cap.

Recommendations: Limit or avoid construction of thick engineering caps in deep-draft navigation areas where navigation clearance cannot be maintained. Revisit the navigation clearance and cap thickness requirements to determine where capping may be viable in navigation areas. In deep-draft navigation areas, consider low-profile remedial solutions, such as MNR, EMNR, in situ treatment, reduced thickness caps, and articulated concrete caps. Implement dredging as a remedial option where engineered capping or low-profile remedies are not viable.

10.2.3 CONSTRUCTION ACCESS (FIGURE 9.2)

Conclusions: Numerous areas within the shoreline and berth area of the RM11E Project Area are not accessible from the water by conventional marine construction equipment or from upland properties because of waterfront structures, groups of vertical pile remnants, shallow draft areas, and steep shorelines.

Recommendations: For caps in locations with limited access, deliver capping material via telescoping conveyor belts or slurry pipelines. For dredging in areas that cannot be accessed otherwise, use shallow-draft marine construction equipment (e.g., small excavator dredges on portable barges) and diver-guided hydraulic dredges Consider implementing remedial actions that require only limited use of marine construction equipment (e.g., MNR, EMNR, in situ treatment).

10.2.4 SUBMARINE CABLE CROSSING (FIGURE 9.2)

Conclusions: The presence of a submarine electrical power cable crossing through the RM11E Project Area precludes dredging as well as anchoring and spudding of marine construction equipment in the cable corridor.

Recommendations: If active remediation is required in the submarine cable crossing caution zone, conduct additional investigation to refine the location and burial depth of the energized cables, to the extent possible. Establish a no-dig zone in the area of the submarine cables. Incorporate remedial actions involving only limited disturbance of sediment (e.g., MNR, EMNR, in situ treatment) in the cable crossing caution zone as well as capping in areas outside of deep-draft navigation.

10.2.5 GROUPS OF VERTICAL PILE REMNANTS (FIGURE 9.3)

Conclusions: Large areas of remnant timber piles exist along the shoreline within the extents of historical shoreline structures, predominantly behind the Cargill main dock, and to a lesser extent north of the Glacier NW main dock. Removal of remnant piles near the shoreline may diminish slope stability and could result in slope failures. Groups of vertical pile remnants limit access for

marine construction equipment, prevent a dredge bucket from achieving complete removal of target sediment, and complicate the placement of a cap by limiting the achievement of a uniform cap thickness. If left in place, piles that extend through the cap could diminish the cap effectiveness.

Recommendations: For caps within groups of vertical pile remnants, consider cutting off piles near the riverbed and increasing cap thickness to account for irregular placement around pile remnants. For dredging within groups of vertical pile remnants, consider diver-operated hydraulic equipment to remove thin deposits of sediment in limited areas. Incorporate MNR, EMNR, and in situ treatment where appropriate.

10.2.6 LARGE UNDIFFERENTIATED DEBRIS (FIGURE 9.3)

Conclusions: Large undifferentiated debris is expected along the shoreline of the RM11E Project area, primarily within the extents of historical shoreline structures. The debris will complicate and diminish the effectiveness of dredging, its removal could potentially destabilize slopes.

Recommendations: In areas where large undifferentiated debris is expected, limit dredging in favor of non-removal technologies (e.g., MNR, EMNR, in situ treatment, engineered capping, and active capping). Where dredging is required, use mechanical dredging and include contingency plans to map debris fields as they are uncovered, and provide for the use of marine construction tools specific to debris recovery. Implement practices to manage turbidity generated during removal of large undifferentiated debris.

10.2.7 OVERSTEEPENED SLOPES (FIGURE 9.4)

Conclusions: Much of the shoreline of the RM11E Project Area is oversteepened and potentially susceptible to slope failure or movement. Dredging or capping could adversely affect slope stability.

Recommendations: Where practical, incorporate remedial technologies that will limit disturbance to the slope (e.g., MNR, EMNR, and in situ treatment). If necessary to cap or dredge in areas where active remediation is required, consider slope stabilization methods such as rock buttressing and retaining walls at the toe of the shoreline slope as well as intermediate retaining walls along the shoreline slope. Evaluate the use of articulated concrete caps in areas of oversteepened slopes, possibly held in place by piles that are driven into deeper stable deposits.

10.2.8 STRUCTURE STABILITY AND CAPACITY (FIGURE 9.1)

Conclusions: Numerous docks and structures in various structural conditions are present throughout the RM11E Project Area. Most are located along the shoreline in areas of oversteepened slopes. Changes to the soil loading conditions due to dredging or capping activities can reduce stability and capacity for these structures. Dredging to remove more than 5 feet of sediment at or near existing structures poses a higher risk to structure stability than does shallower dredging and cap placement.

Recommendations: Limit dredging around structures where possible through application of non-removal remedial technologies (e.g., MNR, EMNR, in situ treatment, engineered caps, and active caps). If necessary and practical, stabilize the slopes and structures to protect the integrity of a structure during and following remediation.

10.2.9 VESSEL PROPELLER WASH (FIGURE 9.5)

Conclusions: Disturbance of sediment and capping material is possible from vessel propeller wash in vessel navigation and berth areas.

Recommendations: Armor engineered caps and active caps in areas of potential propeller wash to protect against erosion. In areas of deep-draft vessel navigation, where navigation clearances render engineered and active capping impractical, consider dredging.

10.2.10 WAVE ACTION (FIGURE 9.5)

Conclusions: Sediment as well as caps placed in the wave zone (elevation 0 to +23 ft. NAVD88) of the RM11E Project Area are subject to erosion from vessel wakes and wind-generated waves.

Recommendations: Armor engineered caps and active caps in the wave zone to protect against erosion. Stabilize slopes where required for capping in areas of oversteepened slopes. Consider dredging in the wave zone.

10.3 SELECTION AND DESIGN OF REMEDIAL TECHNOLOGIES

Recommendations to guide the selection and design of the remedial action for the RM11E Project Area are as follows.

- Provide for the use of multiple combinations of remedial technologies, such as those listed in Section 10.1 to adapt to the many site factors present within the RM11E Project Area.
- As appropriate, conduct remedial actions as distinct subarea projects over a few construction seasons to limit the number of site factors being managed at any one time.
- Provide sufficient flexibility in the final PHSS FS, Proposed Plan, and ROD to allow for use of the RM11E Project Area-specific information for developing implementable and cost-effective designs after issuance of the ROD.

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APPENDIX A – DIGITAL DATA CATALOG

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Appendix A
Digital Data Catalog

Task 1 - Process Existing Vessel LiDAR Data			
File Name	**Description**	**Application**	**Submittal date**
RM11E_Model.dwg	AutoCAD Civil 3D composite surface model (CSM)	AutoCAD	January 17, 2014
RM11E_Composite_Jan2014.xml	LandXML composite surface model exported from CSM.	AutoCAD LMXL	January 17, 2014
RM11E_CompositeModel_20140117_ORN_NAD83_ift_NAVD88.txt	Gridded points used to generate CSM.	ASCII	January 17, 2014
RM11East_Rev1.gdb	ArcGIS 10.1 file based geodatabase housing multiple datasets.	ArcGIS Geodatabase	February 11, 2014
RM11E_Terrain_MappingExtent_20140117	ArcGIS Terrain of the CSM and points beyond its extent to expand area mapped.	ArcGIS Terrain	February 11, 2014
RM11E_Terrain_ModeledExtent_20140117	ArcGIS Terrain of the CSM.	ArcGIS Terrain	February 11, 2014
RM11E_Terrain_Map	ArcGIS 50cm GRID of the Mapping Extent ArcGIS Terrain	ArcGIS GRID	February 11, 2014
RM11E_Terrain_Model	ArcGIS 50cm GRID of the Modeled Extent ArcGIS Terrain	ArcGIS GRID	February 11, 2014
RM11E_3dModel_Sept2013_Rev1.dwg	AutoCAD Civil 3D model of structures in the project area. Revised from 1/17/2014.	AutoCAD	April 25, 2014
Task 2 - Acquire Supplemental Data			
File Name	**Description**	**Application**	**Submittal date**
RM11E_Model.dwg	AutoCAD 2012 Civil 3D CSM.	AutoCAD	January 17, 2014
RM11E_Composite_Jan2014.xml	LandXML composite surface model exported from CSM.	AutoCAD LMXL	January 17, 2014
RM11E_CompositeModel_20140117_ORN_NAD83_ift_NAVD88.txt	Gridded points used to generate CSM.	ASCII	January 17, 2014
RM11E_Sept2013XSec_Lines_ORN_NAD83_NAVD88_ift.dwg	AutoCAD profile lines used for independent checks of the CSM.	AutoCAD	January 17, 2014
RM11E_Sept2013XSec_ORN_NAD83_NAVD88_ift_xyz.txt	ASCII x,y,z, points used for independent checks of the CSM.	ASCII	January 17, 2014
RM11East_Rev1.gdb	ArcGIS 10.1 file based geodatabase housing multiple datasets.	ArcGIS Geodatabase	February 11, 2014
RM11E_Terrain_MappingExtent_20140117	ArcGIS Terrain of the CSM and points beyond its extent to expand area mapped.	ArcGIS Terrain	February 11, 2014
RM11E_Terrain_ModeledExtent_20140117	ArcGIS Terrain of the CSM.	ArcGIS Terrain	February 11, 2014
RM11E_Terrain_Map	ArcGIS 50cm GRID of the Mapping Extent ArcGIS Terrain	ArcGIS GRID	February 11, 2014
RM11E_Terrain_Model	ArcGIS 50cm GRID of the Modeled Extent ArcGIS Terrain	ArcGIS GRID	February 11, 2014
RM11E_3dModel_Sept2013_Rev1.dwg	AutoCAD 2013 Civil 3D model of structures in the project area. Revised from 1/17/2014.	AutoCAD	April 25, 2014
Task 3 - Dock Strutures and Piling and Cargill and Glacier			
File Name	**Description**	**Application**	**Submittal date**
RM11E_3dModel_Sept2013_Rev1.dwg	AutoCAD Civil 3D model of structures in the project area. Revised from 1/17/2014.	AutoCAD	April 25, 2014
RM11E_3DModel_Sept2013_2D.dwg	AutoCAD Civil 3D model of structures in the project area from 2D. Revised from 1/17/2014.	AutoCAD	January 30, 2014
Task 4 - Map Submerged Electrical Distribution Cable Crossing			
File Name	**Description**	**Application**	**Submittal date**
RM11E_Cable_Locate.mxd	ArcGIS map document containing the results of the survey.	ArcGIS map	September 5, 2014
RM11E_Cable_Locate.gdb	ArcGIS 10.2.2 file based geodatabase containing the results of the survey.	ArcGIS Geodatabase	September 5, 2014
Detected_Trench_Limits	Polyline defining the lateral extents of a trench detected with a sub-bottom profiler.	ArcGIS Feature Class	September 5, 2014
Marine_Tone_Locates	Points at the location of a tone detection during marine survey.	ArcGIS Feature Class	September 5, 2014
PacifiCorps_Projected_Tone_Locate	A projected line between PacifiCorp tone locates on both banks.	ArcGIS Feature Class	September 5, 2014
PacifiCorps_Tone_Locates	Points on land from PacifiCorps locates.	ArcGIS Feature Class	September 5, 2014
Vault	Points at the surveyed positions of a vault on either end of the alignment.	ArcGIS Feature Class	September 5, 2014

Appendix A
Digital Data Catalog

Task 5 - Map Submerged Debris and SAV			
File Name	**Description**	**Application**	**Submittal date**
DOFI0004_SP83OR-N_NAVD88_25cm_1x1_Interp_IntFt.tif	Hillshade image at 25cm resolution with vertical exaggeration of 5 to assist in detecting debris and SAV.	GeoTIFF	January 22, 2014
DOFI0004_SP83OR-N_NAVD88_25cm_1x1_Interp_wPiles_IntFt.tif	Hillshade image at 25cm resolution with vertical exaggeration of 5 to assist in detecting debris and SAV. Baring piles left in image.	GeoTIFF	January 22, 2014
RM11E_Logs_and_Debris_Linework.shp	Lines delineating debris digitized from the project CSM.	Shapefile	January 29, 2014
RM11E_Logs_and_Debris_Polygons.shp	Polygons delinating areas of debris digitized from the project CSM.	Shapefile	January 29, 2014
Task 6 - Model Prior LWG Bathymetric Surveys in AutoCAD			
File Name	**Description**	**Application**	**Submittal date**
GSIW_50cm_MBES_June2011.txt	ASCII x,y,z file depicting June 2011 survey.	ASCII	November 21, 2013
sh5_6_loa10_1m_xyz.txt	ASCII x,y,z file depicting January 2009 survey.	ASCII	November 21, 2013
sh5_6_loa4_1m_xyz.txt	ASCII x,y,z file depicting September 2002 survey.	ASCII	November 21, 2013
sh5_6_loa6_1m_xyz.txt	ASCII x,y,z file depicting May 2003 survey.	ASCII	November 21, 2013
sh5_6_loa7_1m_xyz.txt	ASCII x,y,z file depicting February 2004 survey.	ASCII	November 21, 2013
sh5_loa3_1m_xyz.txt	ASCII x,y,z file depicting July 2002 survey.	ASCII	November 21, 2013
sh6_loa1_1m_xyz.txt	ASCII x,y,z file depicting January 2002 survey.	ASCII	November 21, 2013
GSIW_June2011_50cm_dtmedge.dwg	DTM edge of the June 2011 survey.	AutoCAD	November 21, 2013
GSIW_June2011_50cm_hideboundary.dwg	No data areas of the June 2011 survey.	AutoCAD	November 21, 2013
sh5_6_loa10_1m_dtmedge.dwg	DTM edge of the January 2009 survey.	AutoCAD	November 21, 2013
sh5_6_loa4_1m_dtmedge.dwg	DTM edge of the September 2002 survey.	AutoCAD	November 21, 2013
sh5_6_loa6_1m_dtmedge.dwg	DTM edge of the May 2003 survey.	AutoCAD	November 21, 2013
sh5_6_loa7_1m_dtmedge.dwg	DTM edge of the February 2004 survey.	AutoCAD	November 21, 2013
sh5_loa3_1m_dtmedge.dwg	DTM edge of the July 2002 survey.	AutoCAD	November 21, 2013
sh6_loa1_1m_dtmedge.dwg	DTM edge of the January 2002 survey.	AutoCAD	November 21, 2013
Feb2004_LOA7.xml	LandXML surface model of the February 2004 survey.	AutoCAD LMXL	November 21, 2013
Jan2002_LOA1.xml	LandXML surface model of the January 2002 survey.	AutoCAD LMXL	November 21, 2013
Jan2009_LOA10.xml	LandXML surface model of the January 2009 survey.	AutoCAD LMXL	November 21, 2013
Jul2002_LOA3.xml	LandXML surface model of the July 2002 survey.	AutoCAD LMXL	November 21, 2013
Jun2011_GSI.xml	LandXML surface model of the June 2011 survey.	AutoCAD LMXL	November 21, 2013
May2003_LOA6.xml	LandXML surface model of the February 2004 survey.	AutoCAD LMXL	November 21, 2013
Sep2002_LOA4.xml	LandXML surface model of the February 2004 survey.	AutoCAD LMXL	November 21, 2013
diff5_10v1.tif	January 2009 to January 2002 difference image part 1 of 2.	GeoTIFF	November 21, 2013
diff5_3v1.tif	July 2002 to January 2002 difference image.	GeoTIFF	November 21, 2013
diff5_4v1.tif	September 2002 to January 2002 difference image part 1 of 2.	GeoTIFF	November 21, 2013
diff5_4v3.tif	September 2002 to July 2002 difference image.	GeoTIFF	November 21, 2013
diff5_7v1_1m.tif	February 2004 to January 2002 difference image part 1 of 2.	GeoTIFF	November 21, 2013
diff5_7v6_1m.tif	February 2004 to May 2003 difference image part 1 of 2.	GeoTIFF	November 21, 2013
diff6_10v1.tif	January 2009 to January 2002 difference image part 2 of 2.	GeoTIFF	November 21, 2013
diff6_4v1.tif	September 2002 to January 2002 difference image part 2 of 2.	GeoTIFF	November 21, 2013
diff6_7v1_1m.tif	February 2004 to January 2002 difference image part 2 of 2.	GeoTIFF	November 21, 2013
diff6_7v6_1m.tif	February 2004 to May 2003 difference image part 2 of 2.	GeoTIFF	November 21, 2013
striplin_colorbar.jpg	Legend for difference images.	Jpeg legend	November 21, 2013

APPENDIX B – WATERFRONT FACILITIES ACTIVITIES QUESTIONNAIRE RESPONSES

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Oldcastle®

DEBORAH L. MURPHEY
Attorney

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deborah.murphey@oldcastlelaw.com

November 26, 2014

Via e-mail to Nanci.Klinger@portlandoregon.gov

Ms. Nanci Klinger
Deputy City Attorney
City of Portland, Oregon

Re: Waterfront Questionnaire Portland Harbor Rivermile 11E

Dear Ms. Klinger:

Per your request received November 20, 2014 and in accordance with my voicemail of today, the following information is provided.

Oldcastle APG West, Inc. has received the Portland Harbor Superfund Site Waterfront Questionnaire relating to the property at 1402 N. River Street. We do not currently use or authorize the use of the dock associated with the property. We have not used the dock or waterfront area of the property since we acquired the property and have fenced off the dock access points. We have no plans to change this status or plans for the dock or waterfront area generally for at least 3 to 4 years. Should access to the property be needed, a summary of the nature, scope and duration of the access would be needed in advance as well as an acceptable access agreement.

Please let me know if you have questions or need additional information.

Cordially,

Deborah L. Murphey
Attorney for Oldcastle APG West, Inc.

Date: October 7, 2014

To: Mr. Stan Herman
5609 NE 60th Avenue
Vancouver, WA 98661

As you may know, the area along the east bank of the Willamette River from just downstream of the Broadway Bridge to just downstream of the Fremont Bridge is part of the Portland Harbor Superfund Site (PHSS). This area is known as the River Mile 11 East (RM11E) area (see Figure 1a attached). Under the direction and oversight of the US Environmental Protection Agency (EPA), the RM11E Group (consisting of Cargill, Inc., CBS Corporation, City of Portland, DIL Trust, Glacier Northwest, Inc., and PacifiCorp) is required to conduct supplemental investigation and analysis in support of EPA's selection and design of a response or cleanup plan for the RM11E area (known as the "remedial action").

This questionnaire was prepared by Dalton, Olmsted & Fuglevand, Inc. (DOF) on behalf of the RM11E Group as a component of the Supplemental Remedial Investigation and Feasibility Study (RI/FS) Work Plan (Work Plan) that the Group is conducting pursuant to an Administrative Settlement Agreement and Order on Consent with the EPA, CERCLA Docket No. 10-2013-0087. That Agreement provides that *"[m]aintaining navigation access and minimizing disruption to ongoing shipping activities is an important consideration for future remedial action in this area.*" This investigation is supplementary to the overall RI/FS for the entire Portland Harbor Superfund Site (PHSS) and is targeted to help facilitate selection and design of a final remedy at the RM11E Project Area.

This questionnaire is being used to gather information to evaluate the extent to which shipping activities, vessel traffic, working dock and marine operations, and other waterfront activities and conditions may impact the selection and long-term viability of remedial actions in the RM11E project area. The EPA-approved Work Plan requires the RM11 Group to collect the information in this questionnaire. By providing this information you will ensure that accurate information about your facility and its operations, including information on how to minimize impacts on your business, can be taken into account in the selection and design of the remedial action at RM11E.

Please insert your response onto the attached questionnaire. If you require additional room, attach additional pages with reference to the questionnaire number being addressed. If you would prefer to insert your response directly into the MS Word document, send an e-mail to ncase@dofnw.com to request the MS Word file. For some questions, information from the Supplemental RI/FS Work Plan and other data sources (as cited) has already been posted as Information Collected To Date in green font. Please review the questionnaire and respond, add detail, update, or make changes to the information as appropriate. Project figures are provided to mark up as part of your response.

Please email the completed Waterfront Use Questionnaire, marked up Figure 1b, and other supporting information to Nancy Case O'Bourke at ncase@dofnw.com **by November 30, 2014**. And please contact Nancy at that email address or at 425 827-4588 with questions.

QUESTIONNAIRE INSTRUCTIONS

1. Complete questionnaire by inserting response onto hardcopy of questionnaire or directly into MS Word file (e-mail ncase@dofnw.com to request MS Word file)
2. Mark Figure 1b as needed to illustrate responses
3. Scan and e-mail the completed questionnaire and marked-up map **within 30 days of receipt** to ncase@dofnw.com

1. **Respondent to Questionnaire**

a. **Waterfront facility name and address:**
1300 N. River Street

b. **Date of Response:** *10-30-2014*

2. Waterfront Operations

a. Describe the waterfront operations at your facility:

Information Collected to Date:
According to a 2011 survey form submitted to the City, the warehouse is used for storage by Advanced M&D Sales (a tile and flooring company)[1]. No overwater activities are known. (Supplemental RI/FS Work Plan Section 3.2.1)

Response:
Correct

b. **Describe future planned or likely changes to your waterfront operations, including modifications to docks, shoreline, and/or waterfront facilities. Please include projected dates of such future changes if known:** *Response*:
None

3. Vessel Calls on Facilities

Please provide information on expected future vessel calls at your facility. As an estimate of such future calls, your recent past activity may be indicative. Please provide:

a. Typical number of expected vessels each month, and per year: *Response*: *None*

[1] See http://www.amdsales.net/Pages/default.aspx

b. Seasonal variation in number of vessel calls, if any: *Response*: *None*

c. Typical range of vessel classes/sizes (smallest to largest): draft, length, beam: *Response*: *None*

d. Primary cargo, and indicate loading or unloading: *Response:* *None*

e. Do you expect past shipping patterns to change significantly in future years, and if so, how? *Response:*

No

If you prefer you can submit a tabulation of vessel calls at your facility or provide us with documents from which we can prepare a tabulation.

4. General information about dock usage

a. **Where do barges and large vessels tie up at your facility?** (show all locations on Figure 1b attached) *Response:*

None

b. **Please provide information on expected future dock usage at your facility. As an estimate of such future dock usage, your recent past usage may be indicative. Please provide:**

-Typical total number of days each dock is occupied each month and per year: *Response:* *None*

-Typical duration each dock is open between a pair of vessel calls: Response: *None*

c. **What are the seasonal variations, if any, in waterfront operations and dock usage for your facility?** *Response:* *None*

d. **Are there "critical operational" periods at your waterfront facility during which potential temporary limitations or access to your dock and/or waterfront operations would be most adverse? If so, please describe:** *Response:* *None*

e. **Do you expect these patterns to change significantly in future years, and if so, how?** *Response:*

No

5. Docking/departure procedures

a. **What is the typical direction of approach and departure for vessels using your docks or berths, both now and in the future?** (draw approximate approach and departure paths on Figure 1b, attached): *Response:* *None*

b. **When vessels dock and embark from your facility, is it done with or without tug assist? When vessels approach and depart from your facility, are their main ship propellers and/or thrusters engaged or are the vessels solely under tug control? Please explain:** *Response:* *None*

c. **If vessels use tug assist, what tug companies typically provide that service?** *Response:* *None*

6. Surveying information

a. **How does your facility monitor available berthing depth? Frequency?** *Response:* *No*

b. **If you conduct hydrographic surveying, how frequently do you do so?** *Response:* *None*

c. **Will you provide electronic versions (CADD or excel database x,y,z) of the surveys? This information will be used by us to assess where sedimentation is occurring.** *Response:* *N/A*

7. Private Dredging History and Future Plans

a. **What is the elevation of the river bed that you target to maintain for each dock / berth at your waterfront facility and on what vertical datum is this target based?** *Response:* *None*

b. **What areas of the river bed do you maintain for each dock / berth at your waterfront facility, including berthing areas and approach corridors?** (Draw approximate maintenance dredging areas on Figure 1b attached). *Response:* *None*

c. **How does your facility decide when it needs to dredge, and how often do you normally dredge at your docks?** *Response:* None

d. **Describe the historical dredging activities at your waterfront including: year, quantity, and specific area dredged. If you have not already done so, please provide historical dredging records (such as dredging permits, construction plans and specifications, dredging**

contractor, pre-dredge and post-dredge bathymetric surveys, chemical and physical properties of dredged material). *Response:* *None availbale*

e. **Regarding possible future dredging at your waterfront, how do you expect the frequency, depth, or extent of dredging to change in the foreseeable future?** *Response:* *None*

8. Repair and Maintenance

Describe current and anticipated waterfront maintenance and repair activities (other than dredging) at your dock or other waterfront facilities, such as bank armoring, work involving dolphins, piles, docks, etc. *Response:* *None*

9. Shoreline Stability

a. **Describe any relevant shoreline stability issues and/or history for your facility.** *Response:* *None*

b. **Describe any shoreline stability engineering / geotechnical studies for your facility.** *Response:*

Unkown

c. **Describe existing shoreline stabilization measures for your facility:** *Response:*

None

d. **Describe planned shoreline stabilization measures for your facility:** *Response:*

None planned

10. As-Built Drawings

Provide as-built drawings for waterfront structures and utilities for your facility. *Response:*

I have none

11. Upland Access
Describe any facility operations or other factors at your facility that could limit or prevent access from portions of your upland property to the river bank or near shore areas for implementing a remedial action, if needed. (Using the attached Figure 1b indicate areas of your shoreline where there is insufficient access for shore-based staging of equipment and personnel for in-river remediation due to existing operations, upland structures, steep slopes, etc.). *Response:* The only access of through the building
12. Other Information
Do you have any other observations about docks, waterfront facilities, operational activities, or the project area that we should know about for purposes of limiting impacts or disruption to ongoing shipping activities at your facility in the event future in-water remediation activities are performed? *Response:* *No*

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December 22, 2014

VIA ELECTRONIC TRANSMISSION

Nancy Case O'Bourke
Dalton Olmsted Fuglevand
10827 NE 68th Street, Suite B
Kirkland, WA 98033
ncase@dofnw.com

Re: Response to October 7, 2014, Waterfront Questionnaire From the River Mile 11 East Group ("RM11E Group")

Dear Ms. Case O'Bourke:

On behalf of my clients, Ross Island Sand & Gravel, Co. and its parent company, R.B. Pamplin Corp ("RIS&G"), I am submitting this response to the above-referenced questionnaire from the RM11E Group. The stated purpose of the questionnaire is to gather information from waterfront property owners at river mile 11 in order to assess potential conflicts with waterfront operations from the RM11E Group's implementation of its cleanup remedy in order to "minimize impacts" with such operations.

RIS&G is happy to provide the attached and trusts that the RM11E Group's use of this information will foremost be to avoid impacts, as opposed to merely minimizing them. To that end, please do not hesitate to contact me if you have any questions about RIS&G's operations at the site or to discuss potential access if the RM11E Group finds itself considering that as part of its remedy as RIS&G fully intends to be cooperative where practicable.

Additionally, RIS&G's provision of this information by no means equates to any admission of liability by the company for the remedial action being undertaken by the RM11E Group. As detailed in RIS&G's October 18, 2012, response to the federal Environmental Protection Agency's August 30, 2012, letter regarding the draft administrative settlement agreement and order on consent for removal action, RIS&G is not a responsible party under federal (or state) cleanup laws as there exists no evidence of any releases to the Willamette River from the RIS&G's property at river mile 11 nor as a result of RIS&G's operations thereon.

Alaska California Idaho
Minnesota Oregon Utah Washington
and Washington, D.C.

Again, please feel free to contact me if you have any questions or concerns.

Very truly yours,

Aaron C. Courtney

Attachments

River Mile 11 East - Waterfront Use Questionnaire

Supplemental Remedial Investigation and Feasibility Study
Portland Harbor Superfund Site

QUESTIONNAIRE INSTRUCTIONS

1. Complete questionnaire by inserting response onto hardcopy of questionnaire or directly into MS Word file (e-mail ncase@dofnw.com to request MS Word file)
2. Mark Figure 1b as needed to illustrate responses
3. Scan and e-mail the completed questionnaire and marked-up map **within 30 days of receipt** to ncase@dofnw.com

1. Respondent to Questionnaire

a. **Waterfront facility name and address:**
1300 N. River Street

b. **Date of Response:**
November 21, 2014

2. Waterfront Operations

a. **Describe the waterfront operations at your facility:**

Information Collected to Date:

KF Jacobsen[1] leases a portion of the RIS&G property as well as the adjacent ODOT property (under the Fremont Bridge) for its Albina Asphalt Plant. The plant is a "hot mix" asphalt plant using recycled asphalt, aggregate, hot asphalt, and sand to make asphalt paving. In addition to receiving aggregate from the barge dock it shares with RIS&G, the property receives recycled asphalt by truck. The recycled asphalt is crushed onsite and conveyed to storage piles placed under the Fremont Bridge (City, 2009b). (Supplemental RI/FS Work Plan Section 3.2.1)

Response:

b. **Describe future planned or likely changes to your waterfront operations, including modifications to docks, shoreline, and/or waterfront facilities. Please include projected dates of such future changes if known:** *Response:*

No changes or modification are planned for the future other than periodic maintenance of facilities.

3. Vessel Calls on Facilities

Please provide information on expected future vessel calls at your facility. As an estimate of such future calls, your recent past activity may be indicative. Please provide:

[1] R B Pamplin Corp. now leases the property leased by KF Jacobsen when the RI/FS was written.

a. Typical number of expected vessels each month, and per year: *Response*:

Average of 2 per day, 46 per month and 552 per year.

b. Seasonal variation in number of vessel calls, if any: *Response*:

May through October can be as high as 6 per day, 162 per month; November through April can be as low as: ½ per day, 12 per month.

c. Typical range of vessel classes/sizes (smallest to largest): draft, length, beam: *Response*:

Smallest: 10ft draft, 175ft length, 40ft beam; longest:10ft draft 215ft length, 40ft beam.

d. Primary cargo, and indicate loading or unloading: *Response:*

Unloading sand, gravel, crushed stone,drain or capping stoneand riprap.

e. Do you expect past shipping patterns to change significantly in future years, and if so, how? *Response:*

No changes are expected in future except as construction market in Portland Metro Area varies.

If you prefer you can submit a tabulation of vessel calls at your facility or provide us with documents from which we can prepare a tabulation.

4. General information about dock usage

a. **Where do barges and large vessels tie up at your facility?** (show all locations on Figure 1b attached) *Response:*

Barges are tied to "barge steel cable shuttle system" that moves barges ± 500ft along river frontage.

b. **Please provide information on expected future dock usage at your facility. As an estimate of such future dock usage, your recent past usage may be indicative. Please provide:**

-Typical total number of days each dock is occupied each month and per year: *Response:*

Deck is occupied every day of the month and year except when Willamette River is in freshet of +20ft (barges are removed from dock frontage for public safety concerns).

-Typical duration each dock is open between a pair of vessel calls: Response:

Typically there are no "open" periods at dock.

c. **What are the seasonal variations, if any, in waterfront operations and dock usage for your facility?** *Response:*

There are seasonal variations but never any "open dock" days.

d. **Are there "critical operational" periods at your waterfront facility during which potential temporary limitations or access to your dock and/or waterfront operations would be most adverse? If so, please describe:** *Response:*

Any time during the year.

e. **Do you expect these patterns to change significantly in future years, and if so, how?** *Response:*

No changes are expected in future years.

5. Docking/departure procedures

a. **What is the typical direction of approach and departure for vessels using your docks or berths, both now and in the future?** (draw approximate approach and departure paths on Figure 1b, attached): *Response:*

We approach and depart our dock facilities from both an up-stream or down-stream orientation depending on the position of the barges tied to "barge shuttle system".

b. **When vessels dock and embark from your facility, is it done with or without tug assist? When vessels approach and depart from your facility, are their main ship propellers and/or thrusters engaged or are the vessels solely under tug control? Please explain:** *Response:*

All barges are " non-motorized" and therefore are under the control of a tug when either approaching or departing dock facility.

c. **If vessels use tug assist, what tug companies typically provide that service?** *Response:*
Ross Island Sand & Gravel Co.

6. Surveying information

a. **How does your facility monitor available berthing depth? Frequency?** *Response:*
Bathymetric surveys done by Ross Island Sand & Gravel Co. usually done anually every July.

b. **If you conduct hydrographic surveying, how frequently do you do so?** *Response:*
Usually anually ever July.

c. **Will you provide electronic versions (CADD or excel database x,y,z) of the surveys? This information will be used by us to assess where sedimentation is occurring.** *Response:*
We keep no files electonically of our surveys.

7. Private Dredging History and Future Plans

a. **What is the elevation of the river bed that you target to maintain for each dock / berth at your waterfront facility and on what vertical datum is this target based?** *Response:*
Minus 15 ft based on Hawthorne Bridge guage.

b. **What areas of the river bed do you maintain for each dock / berth at your waterfront facility, including berthing areas and approach corridors?** (Draw approximate maintenance dredging areas on Figure 1b attached). *Response:*
We do not maintain any area of the river bed, except where spill may occur within the radius swing of our land based "clamshell bucket" crane.

c. **How does your facility decide when it needs to dredge, and how often do you normally dredge at your docks?** *Response:*
By bathymetric survey. Ross Island Sand & Gravel Co. has never dredged river bed.

d. **Describe the historical dredging activities at your waterfront including: year, quantity, and specific area dredged. If you have not already done so, please provide historical dredging records (such as dredging permits, construction plans and specifications, dredging contractor, pre-dredge and post-dredge bathymetric surveys, chemical and physical properties of dredged material).** *Response:*
River bed was dredged at or near dock facility during Terminal Two re-construction by Port of Portland and during construction (next pg.)

of Fremont Bridge by Oregon State Transportation Department. Not certain of the years of these activities and can not provide any records of these activities.

e. **Regarding possible future dredging at your waterfront, how do you expect the frequency, depth, or extent of dredging to change in the foreseeable future?** *Response:*

Ross Island Sand & Gravel Co. expects no future dredging activities.

8. Repair and Maintenance

Describe current and anticipated waterfront maintenance and repair activities (other than dredging) at your dock or other waterfront facilities, such as bank armoring, work involving dolphins, piles, docks, etc. *Response:*

Ross Island Sand & Gravel Co. does not anticipate any maintenance activities but will replace or repair any dolphins or piles damaged because of barge landing accidents.

9. Shoreline Stability

a. **Describe any relevant shoreline stability issues and/or history for your facility.** *Response:*

Ross Island Sand & Gravel Co. has no history of shoreline stability problems at this facility. But all structures which may distress soil condition are placed on piles. Shoreline owned by the Oregon State Transportation Dept. (Fremont Bridge) and adjacent RISG has been "ripraped.

b. **Describe any shoreline stability engineering / geotechnical studies for your facility.** *Response:*

None

c. **Describe existing shoreline stabilization measures for your facility:** *Response:*

Described in "A".

d. **Describe planned shoreline stabilization measures for your facility:** *Response:*

None.

10. As-Built Drawings

Provide as-built drawings for waterfront structures and utilities for your facility. *Response:*

No current "As Built" drawings have been generated nor needed. At this Writing no "record search" has been made covering more than one hundred years of property occupancy by Ross Island Sand & Gravel Co.

11. Upland Access

Describe any facility operations or other factors at your facility that could limit or prevent access from portions of your upland property to the river bank or near shore areas for implementing a remedial action, if needed. (Using the attached Figure 1b indicate areas of your shoreline where there is insufficient access for shore-based staging of equipment and personnel for in-river remediation due to existing operations, upland structures, steep slopes, etc.). *Response:*

Property can be accessed via North River Road or via the Union Pacific Railroad. The only factor that would limit access to upland property is the daily activities of the demands of our concrete and asphalt serving our customer base.

12. Other Information

Do you have any other observations about docks, waterfront facilities, operational activities, or the project area that we should know about for purposes of limiting impacts or disruption to ongoing shipping activities at your facility in the event future in-water remediation activities are performed? *Response:*

MacDonnald Dock Warehouse.

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River Mile 11 East - Waterfront Use Questionnaire

Supplemental Remedial Investigation and Feasibility Study
Portland Harbor Superfund Site

Date: October 7, 2014
To: Glacier

As you may know, the area along the east bank of the Willamette River from just downstream of the Broadway Bridge to just downstream of the Fremont Bridge is part of the Portland Harbor Superfund Site (PHSS). This area is known as the River Mile 11 East (RM11E) area (see Figure 1-1 attached). Under the direction and oversight of the US Environmental Protection Agency (EPA), the RM11E Group (consisting of Cargill, Inc., CBS Corporation, City of Portland, DIL Trust, Glacier Northwest, Inc., and PacifiCorp) is required to conduct supplemental investigation and analysis in support of EPA's selection and design of a response or cleanup plan for the RM11E area (known as the "remedial action").

This questionnaire was prepared by Dalton, Olmsted & Fuglevand, Inc. (DOF) on behalf of the RM11E Group as a component of the Supplemental Remedial Investigation and Feasibility Study (RI/FS) Work Plan (Work Plan) that the Group is conducting pursuant to an Administrative Settlement Agreement and Order on Consent with the EPA, CERCLA Docket No. 10-2013-0087. That Agreement provides that *"[m]aintaining navigation access and minimizing disruption to ongoing shipping activities is an important consideration for future remedial action in this area."* This investigation is supplementary to the overall RI/FS for the entire Portland Harbor Superfund Site (PHSS) and is targeted to help facilitate selection and design of a final remedy at the RM11E Project Area.

This questionnaire is being used to gather information to evaluate the extent to which shipping activities, vessel traffic, working dock and marine operations, and other waterfront activities and conditions may impact the selection and long-term viability of remedial actions in the RM11E project area. The EPA-approved Work Plan requires the RM11 Group to collect the information in this questionnaire. By providing this information you will ensure that accurate information about your facility and its operations, including information on how to minimize impacts on your business, can be taken into account in the selection and design of the remedial action at RM11E.

Please type your response for each question directly into this Word document, immediately following each question. For some questions, information from the Supplemental RI/FS Work Plan and other data sources (as cited) has already been posted as Information Collected to Date in green font. Please review the questionnaire and respond, add detail, update, or make changes to the information as appropriate. Project figures are provided to mark up as part of your response.

Please email the completed Waterfront Use Questionnaire, marked up Figure 1b, and other supporting information to Nancy Case O'Bourke at ncase@dofnw.com **within 30 days of receipt** of the questionnaire. And please contact Nancy at that email address or at 425 827-4588 with questions.

Attachments:

- Figure 1-1 showing project limits
- Figure 1b which is a larger scale site plan to mark up in response to questions
- Summary of documents reviewed

QUESTIONNAIRE INSTRUCTIONS

1. Complete questionnaire by inserting response into MS Word file
2. Mark Figure 1b as needed to illustrate responses
3. Scan and e-mail the completed questionnaire and marked-up map **within 30 days of receipt** to ncase@dofnw.com

1. **Respondent to Questionnaire**

a. **Waterfront facility name and address:**
Glacier Northwest, Inc.
1050 N River St. Portland 97227

b. **Date of Response:** November 18, 2014

2. Waterfront Operations

a. Describe the waterfront operations at your facility:

Information Collected to Date:

The Glacier NW property is a bulk cement distribution terminal. No manufacturing or processing occurs at this property. The property also serves as the regional headquarters for Glacier NW's Oregon and southwest Washington operations. Bulk cement is delivered by ship, pneumatically conveyed to the storage buildings (silos and dome), and then loaded into customer trucks and railcars for offsite delivery. The property includes 15 storage silos with capacities ranging from 1,000 to 6,500 tons and a cement storage dome with a capacity of 30,000 tons. The property also includes two covered truck loading and scale areas (ERM, 2011a). (Supplemental RI/FS Work Plan Section 3.2.1)

Ships delivering cement to Glacier NW's main (upstream) dock are owned by third parties and are under the operation and control of the ship's pilot or an independent river pilot. Third-party tugboats assist these ships when they arrive at and depart from Glacier NW's dock, thereby reducing or eliminating deep prop wash. Vessels arrive at Glacier NW's dock loaded and leave lightened or empty, drafting significantly less water when they depart than when they arrive. (Supplemental RI/FS Work Plan Section 3.2.2.1)

Response:
No additional information to provide for the main (upstream) cement offloading dock. Barges are infrequently and temporarily moored at Glacier NW's smaller (downstream) barge dock by third-parties on an as-needed basis. The barge dock is generally unused. No loading or unloading is performed at the barge dock.

b. **Describe future planned or likely changes to your waterfront operations, including modifications to docks, shoreline, and/or waterfront facilities. Please include projected dates of such future changes if known:**

Response:

Pile and fender replacement has been permitted and work will begin between July 1 and October 31,

2015 (in-water-work allowed by ODFW). Five to 15 piles will be replaced in 2015, 2016 and 2017. The replacement of these piles will not modify the current dock, shoreline or waterfront facilities.

3. Vessel Calls on Facilities

Please provide information on expected future vessel calls at your facility. As an estimate of such future calls, your recent past activity may be indicative. Please provide:

a. Typical number of expected vessels each month, and per year:

Information Collected to Date:
Ships may dock at the Glacier NW property once or twice a month; the number of ships is dependent on market demand for cement. (Supplemental RI/FS Work Plan Section 3.2.2.1)

Response:

The number of ships at Glacier's main dock may range from 20 to 40 per year.

b. Seasonal variation in number of vessel calls, if any: *Response*:

Seasonal variations in the number of vessels are not expected to be significant. However, vessel dockings are more consistent and slightly more frequent in July, August, September, and at times into October, due to a modest increase in the number of local construction projects during these warmer months.

c. Typical range of vessel classes/sizes (smallest to largest): draft, length, beam: *Response*:

Information Collected to Date:
Vessels serving Glacier NW may be as long as 578 feet and 92 feet wide ("Handy" class vessels). Depth of draft of ships may be up to 20 feet when empty and 30 feet when loaded. (Supplemental RI/FS Work Plan Section 3.2.2.1)

Response:

No additional information to provide.

d. Primary cargo, and indicate loading or unloading: *Response:*

Cement is the only cargo that arrives at Glacier's dock and is only offloaded from the vessel to upland storage silos. No loading occurs.

e. Do you expect past shipping patterns to change significantly in future years, and if so, how? *Response:*

No.

If you prefer you can submit a tabulation of vessel calls at your facility or provide us with documents from which we can prepare a tabulation.

4. General information about dock usage

a. **Where do barges and large vessels tie up at your facility?** (show all locations on Figure 1b attached) *Response:*

Large vessels dock at Glacier's main dock to offload cement. Dock cleats used for tying off the vessel to secure it to the main dock are located both north and south of the dock. One cleat is located in the 'greenway' slightly southwest of the cement storage dome, and the second cleat is in the 'greenway' at the southern end of the property (near the property boundary).

Barges are tied off to two in-water dolphins located north and south of the smaller barge dock.

b. **Please provide information on expected future dock usage at your facility. As an estimate of such future dock usage, your recent past usage may be indicative. Please provide:**

-Typical total number of days each dock is occupied each month and per year: *Response:*

The main dock is occupied approximately 12 to 20 days each month.

-Typical duration each dock is open between a pair of vessel calls: Response:

The main dock is open approximately 5 to 10 days between vessel calls (this duration can be shorter in July, August and September).

c. **What are the seasonal variations, if any, in waterfront operations and dock usage for your facility?** *Response:*

Vessel and dock usage is fairly consistent throughout the year with one to two vessels being unloaded per month. Vessel and dock usage increases based on demand for cement in the local market and tends to increase in warmer, summer months.

d. **Are there "critical operational" periods at your waterfront facility during which potential temporary limitations or access to your dock and/or waterfront operations would be most adverse? If so, please describe:** *Response:*

Vessels that dock at Glacier NW are allowed by contract to moor for a specified time period, typically seven days before demurrage charges apply. Therefore, any time a vessel is docked, this time becomes a 'critical operational' period. When no vessel is moored, in-water work can be performed without affecting upland distribution operations.

e. **Do you expect these patterns to change significantly in future years, and if so, how?** *Response:*

No.

5. Docking/departure procedures

a. **What is the typical direction of approach and departure for vessels using your docks or berths, both now and in the future?** (draw approximate approach and departure paths on Figure 1b, attached): *Response:*

Vessels always dock at the main dock with the bow facing upstream (south) and the stern downstream (north). Portside is always facing the dock.

b. **When vessels dock and embark from your facility, is it done with or without tug assist? When vessels approach and depart from your facility, are their main ship propellers and/or thrusters engaged or are the vessels solely under tug control? Please explain:** *Response:*

Vessels dock and embark under tug assistance. Each vessel is owned and operated by a third-party, and as a result, it is never under the control of Glacier NW. To Glacier NW's knowledge, the propellers are not engaged when the vessel is under tug assistance. A vessel's thrusters may be used in the event of an emergency, but such a decision is at the vessel Captain's discretion when working with the tugs.

c. **If vessels use tug assist, what tug companies typically provide that service?** *Response:*

Shaver Transportation typically provides this service for the third-party vessels that dock at Glacier NW.

6. Surveying information

a. **How does your facility monitor available berthing depth? Frequency?** *Response:*

Bathymetry surveys are taken approximately annually to determine depth.

b. **If you conduct hydrographic surveying, how frequently do you do so?** *Response:*

Hydrographic surveys are conducted approximately annually.

c. **Will you provide electronic versions (CADD or excel database x,y,z) of the surveys? This information will be used by us to assess where sedimentation is occurring.** *Response:*

Yes.

7. Private Dredging History and Future Plans

a. **What is the elevation of the river bed that you target to maintain for each dock / berth at your waterfront facility and on what vertical datum is this target based?**

Information Collected to Date:

-36 feet CRD depth at the main (upstream) dock and to -21 feet CRD depth in front of its barge (downstream) dock. These dredging depths included a 1-foot allowance for over-dredging. (Supplemental RI/FS Work Plan Section 3.2.2.3)

Response:

No additional information to provide.

b. **What areas of the river bed do you maintain for each dock / berth at your waterfront facility, including berthing areas and approach corridors?** (Draw approximate maintenance dredging areas on Figure 1b attached). *Response:*

Only the berthing areas in front of the main dock and barge dock are maintained. No dredging has occurred in the approach corridor.

c. **How does your facility decide when it needs to dredge, and how often do you normally dredge at your docks?** *Response:*

Dredging frequency is dependent on the rate of sedimentation by the river and vessel draft clearance needs. Dredging is generally infrequent (approximately every 8 to 15 years).

d. **Describe the historical dredging activities at your waterfront including: year, quantity, and specific area dredged. If you have not already done so, please provide historical dredging records (such as dredging permits, construction plans and specifications, dredging contractor, pre-dredge and post-dredge bathymetric surveys, chemical and physical properties of dredged material).**

Information Collected to Date:
Glacier NW has conducted only two maintenance dredging events (1996 and 2004) since acquiring the River Street Cement Terminal in 1991:

- In 1996, dredged approximately 4,000 to 6,000 cy of sediment from along its piers and riverfront to maintain a -40 feet CRD depth for deep draft vessels.
- In 2004, dredged 2,442 tons of sediment from along its main and barge docks to maintain a -36 feet CRD depth at the main (upstream) dock and to -21 feet CRD depth in front of its barge (downstream) dock. These dredging depths included a 1-foot allowance for over-dredging.

(Supplemental RI/FS Work Plan Section 3.2.2.3)

Response:

No additional information to provide.

e. **Regarding possible future dredging at your waterfront, how do you expect the frequency, depth, or extent of dredging to change in the foreseeable future?** *Response:*

Dredging frequency depends on deposition of sediment by the river and vessel draft clearance needs. Dredging is generally infrequent (approximately every 8 to 15 years). Dredging depth and extent will remain similar to previous dredge events unless deeper dredging is needed to allow larger vessels to deliver cement to the dock.

8. Repair and Maintenance

Describe current and anticipated waterfront maintenance and repair activities (other than dredging) at your dock or other waterfront facilities, such as bank armoring, work involving dolphins, piles, docks, etc. *Response:*

Pile replacement has been permitted for the main dock with in-water work anticipated to occur in 2015, 2016 and 2017. Five to 15 piles will be replaced each year.

9. Shoreline Stability

a. **Describe any relevant shoreline stability issues and/or history for your facility.** *Response:*

A retaining wall that lies within ODOT's and the City of Portland's easements in connection with outfalls WR-~~305~~ 306 and OF-44A has collapsed at the northern end of the property. Glacier NW has been working with ODOT and the City to ensure they comply with the terms and conditions of their respective easements and perform the requisite repairs.

b. **Describe any shoreline stability engineering / geotechnical studies for your facility.** *Response:*

No studies have been performed that have not been provided to date.

c. **Describe existing shoreline stabilization measures for your facility:** *Response:*

The entire bank behind the main dock was armored with riprap when the dock was replaced in 2001-2002. Vegetation planted within the 'greenway' also helps stabilize the bank.

d. **Describe planned shoreline stabilization measures for your facility:** *Response:*

N/A.

10. As-Built Drawings

Provide as-built drawings for waterfront structures and utilities for your facility. *Response:*

All such drawings have already been provided.

11. Upland Access

Describe any facility operations or other factors at your facility that could limit or prevent access from portions of your upland property to the river bank or near shore areas for implementing a remedial

action, if needed. (Using the attached Figure 1b indicate areas of your shoreline where there is insufficient access for shore-based staging of equipment and personnel for in-river remediation due to existing operations, upland structures, steep slopes, etc.). *Response:*

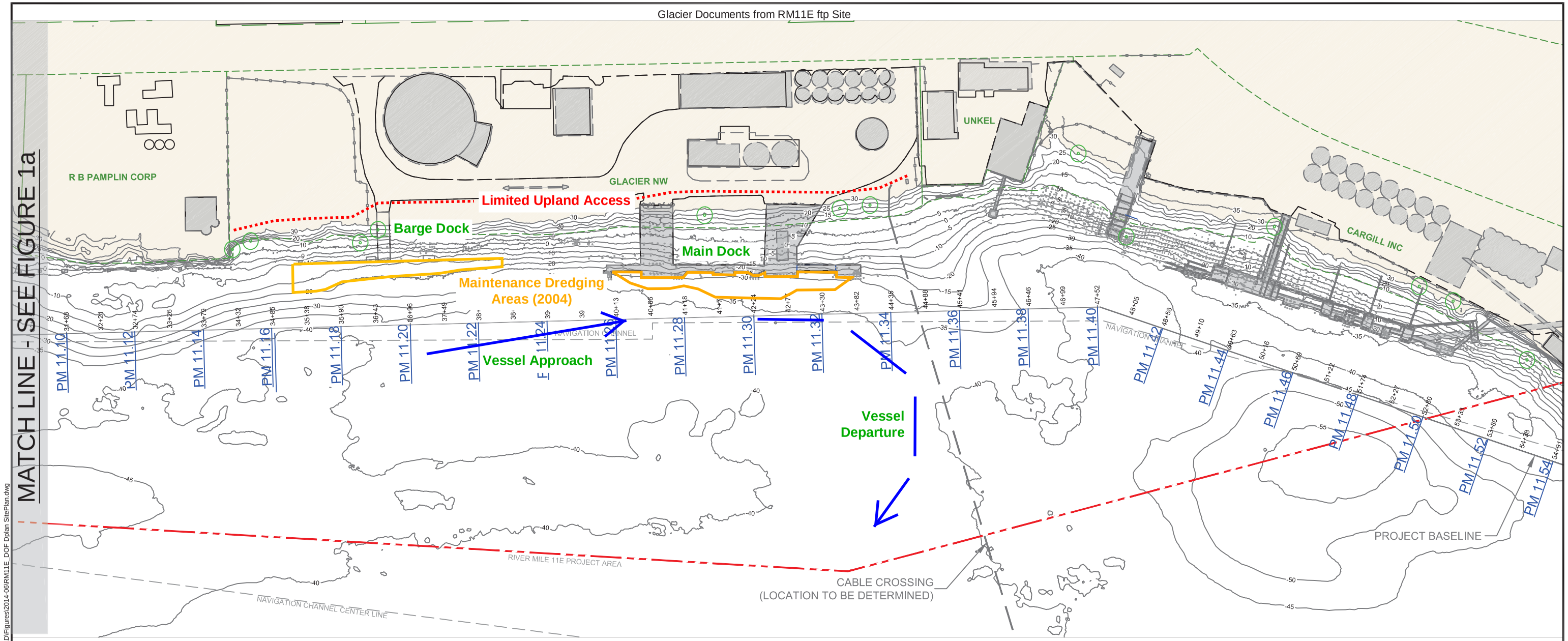
The river bank along the entire length of the property is steep and limits access to the river from upland. Work from the main dock and barge dock may be performed depending on the weight of the equipment and the duration of staging.

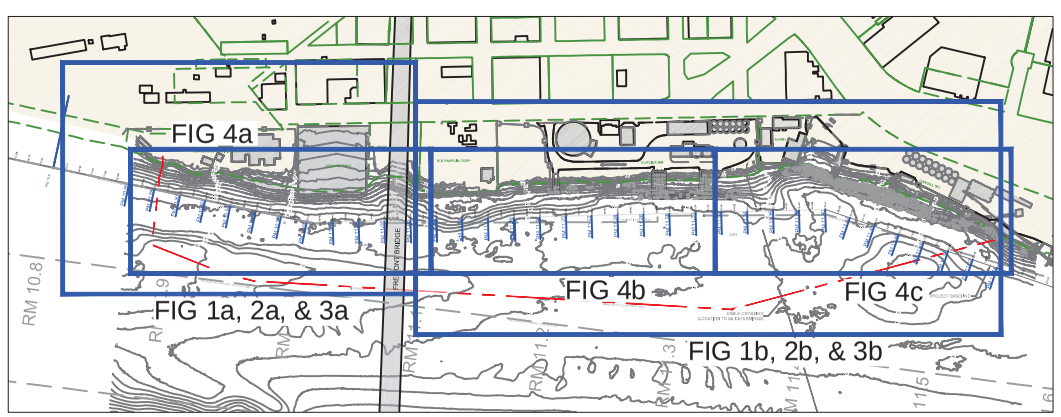
Truck traffic both entering and leaving the property is along one roadway upland of the greenway setback. This traffic lane is crucial to operations and cannot be blocked, especially during weekday hours.

12. Other Information

Do you have any other observations about docks, waterfront facilities, operational activities, or the project area that we should know about for purposes of limiting impacts or disruption to ongoing shipping activities at your facility in the event future in-water remediation activities are performed? *Response:*

None known.





KEY MAP

River Mile 11E Project Area

Outfall Locations

0 150
Scale in Feet

Notes:

1. Bathymetric contours generated from Digital Terrain Model (DTM) compiled by David Evans Associates (DEA) . The DTM was compiled to provide a muti-date single coverage surface across the entire project site which represents existing conditions at the time of the survey.
2. Planimetric features (docks, overhead walkways, conveyors, walls, etc.) shown were digitized from 2012 aerial photos and are shown for visual reference only. These features have not been field verified and are not to be used for construction.
3. Vertical Datum is based on NAVD88.
4. Outfall locations are approximate and were obtained from Metro GIS Database.

DRAFT - WORK IN PROGRESS

Privileged and Confidential, Attorney/Client Communication and/or Attorney Work Product

RM11E Working Group **Willamette River - Portland, Oregon**	DOF DALTON OLMSTED FUGLEVAND
RM11E Study Area **SITE PLAN** **Sheet 2**	**FIGURE** **1b** June 4, 2014

PLOT TIME: 6/4/2014 7:04 PM MOD TIME: 6/4/2014 3:33 PM USER: Steven Rasmussen DWG: D:\Projects\RM11E\CAD\Figures\2014-06\RM11E_DOF Dplan SitePlan.dwg

River Mile 11 East - Waterfront Use Questionnaire

Supplemental Remedial Investigation and Feasibility Study
Portland Harbor Superfund Site

Date: October 7, 2014

To: Mr. Kenneth Unkeles
Unkeles Family LLC
2211 NW Front Avenue
Portland, OR 97209

As you may know, the area along the east bank of the Willamette River from just downstream of the Broadway Bridge to just downstream of the Fremont Bridge is part of the Portland Harbor Superfund Site (PHSS). This area is known as the River Mile 11 East (RM11E) area (see Figure 1a attached). Under the direction and oversight of the US Environmental Protection Agency (EPA), the RM11E Group (consisting of Cargill, Inc., CBS Corporation, City of Portland, DIL Trust, Glacier Northwest, Inc., and PacifiCorp) is required to conduct supplemental investigation and analysis in support of EPA's selection and design of a response or cleanup plan for the RM11E area (known as the "remedial action").

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Please insert your response onto the attached questionnaire. If you require additional room, attach additional pages with reference to the questionnaire number being addressed. If you would prefer to insert your response directly into the MS Word document, send an e-mail to ncase@dofnw.com to request the MS Word file. For some questions, information from the Supplemental RI/FS Work Plan and other data sources (as cited) has already been posted as Information Collected To Date in green font. Please review the questionnaire and respond, add detail, update, or make changes to the information as appropriate. Project figures are provided to mark up as part of your response.

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River Mile 11 East - Waterfront Use Questionnaire
Supplemental Remedial Investigation and Feasibility Study
Portland Harbor Superfund Site

QUESTIONNAIRE INSTRUCTIONS

1. Complete questionnaire by inserting response onto hardcopy of questionnaire or directly into MS Word file (e-mail ncase@dofnw.com to request MS Word file)
2. Mark Figure 1b as needed to illustrate responses
3. Scan and e-mail the completed questionnaire and marked-up map **within 30 days of receipt** to ncase@dofnw.com

1. Respondent to Questionnaire

a. **Waterfront facility name and address:**
~~1300 N.~~ *River Street*
820 + 822 N River St

b. **Date of Response:** 10/14/14

2. Waterfront Operations

a. Describe the waterfront operations at your facility:

Information Collected to Date:
The River Street studios is a collection of artists' studios. (Supplemental RI/FS Work Plan Section 3.2.1)
+ professional offices

Response:

b. **Describe future planned or likely changes to your waterfront operations, including modifications to docks, shoreline, and/or waterfront facilities. Please include projected dates of such future changes if known:** *Response*:

Note: The Cargill property acquired the River Frontage rights in front of my site before I bought the property in the 1980s –

3. Vessel Calls on Facilities

Please provide information on expected future vessel calls at your facility. As an estimate of such future calls, your recent past activity may be indicative. Please provide:

a. Typical number of expected vessels each month, and per year: *Response*:

We have no Riverfront access or activity.

PRIVILEGED AND CONFIDENTIAL – ATTORNEY CLIENT COMMUNICATION – ATTORNEY WORK PRODUCT

River Mile 11 East - Waterfront Use Questionnaire

Supplemental Remedial Investigation and Feasibility Study
Portland Harbor Superfund Site

Date: October 7, 2014
To: Cargill

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- Figure 1b which is a larger scale site plan to mark up in response to questions
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1. Respondent to Questionnaire

a. Waterfront facility name and address:
Cargill
800 N River St. Portland 97227

b. Date of Response: *November 12, 2014*

2. Waterfront Operations

a. Describe the waterfront operations at your facility:
Response:
Cargill operates the Irving grain elevator and terminal (Irving Terminal) that provides interim bulk storage for transfer of grain to and from trucks, rail cars, barges, and ships. Main features on the property are reinforced concrete grain silos, conveyor systems, enclosed grain processing, a rail grain dump station, a truck grain dump station, and shipping and unloading equipment (Black & Veatch, 2011a). (Supplemental RI/FS Work Plan Section 3.2.1). The Irving Terminal also has a ship dock and a barge dock.

Ships using the ship dock at the Irving Terminal are typically foreign-flagged vessels and are under the operation and control of the ship's pilot or an independent river pilot. Tugboats provided to the ships by third parties assist ships and barges that dock at the property, reducing or eliminating deep prop wash. (Supplemental RI/FS Work Plan Section 3.2.2.1)

b. Describe future planned or likely changes to your waterfront operations, including modifications to docks, shoreline, and/or waterfront facilities. Please include projected dates of such future changes if known:
Response: *Cargill's waterfront operations will continue to be related only to grain storage and transfer. Cargill anticipates making dock repairs as described in the permit received for such repairs from the Oregon DEQ over the next 5 years. See Permit #56532-RF, issued 8/22/2014, provided to the RM11 group at CARGRM11_000866 to CARGRM11_000905. Cargill anticipates needing to periodically dredge the berths at the two docks as river conditions require. Such dredging has previously been required on average every 3 to 5 years.*

Cargill has investigated the option to build a multi-story office building on site for operational and Federal Grain Inspection Service ("FGIS") use as described in plans which have been circulated. See TEMCO, LLC FGIS Building Plans by Smith Monroe Gray. At this time, Cargill has not committed to pursue the FGIS building, However, within the next year, Cargill will likely remodel the existing warehouse and office space at the Irving Terminal. Cargill may also build a barge unloader at the Irving Terminal, and will pursue other capital development projects as necessary for operational needs.

3. Vessel Calls on Facilities

Please provide information on expected future vessel calls at your facility. As an estimate of such future calls, your recent past activity may be indicative. Please provide:

a. Typical number of expected vessels each month, and per year:

Response:

Ships dock at the Cargill ship dock at the Irving Terminal as often as 4 to 5 times a month, and typically individual ships are docked for a period of less than a week while loading grain primarily for international export. However, individual ships may be docked at the ship dock up to 12 days during slower seasons based on more limited commodity availability requiring additional loading time.

Much smaller shallower-draft barges use the separate barge dock at the south end of the Irving Terminal as often as 48 times per month to bring grain to the terminal for transfer to export-bound ships. (Supplemental RI/FS Work Plan Section 3.2.2.1)

The average number of ships berthing at the Irving Terminal ship dock during Cargill's period of ownership (1995 to the present) is approximately 55 per year. Information for the past three years indicates the number of ships docking at the ship dock in any given month may range between three and seven ships. In 2012, 33 ships and 257 barges docked at the Irving Terminal. In 2013, 49 ships and 409 barges docked at the Irving Terminal. In 2014, the approximate number of ships docking at the Irving Terminal as of September 25 was 44 ships and 489 barges.

b. Seasonal variation in number of vessel calls, if any:

Response**:**

The number of ships docking at the Irving Terminal ship dock may be greater during or immediately following harvest season. The wheat harvest season in the United States is from mid-May to mid-September. Analyzing vessel data over the past three years, vessel calls at the Irving Terminal have been fairly consistent throughout the year, although the months of May and June have consistently had the fewest ships docked for the past three years.

Further, despite any seasonal variation affecting the number of ships docking at the Irving Terminal, the amount of unoccupied time at the two docks is relatively consistent throughout the year. In slower seasons, gathering a full load of grain to fill a ship to capacity may take longer, and a ship may remain docked at the Irving Terminal ship dock for up to 12 days. Docked vessels may remain at the two docks longer in rainy weather than dry weather due to the open loading and unloading process for the grain and the need to keep the grain dry.

Barges docking at the Irving Terminal have less seasonal variation than ships. Barges are consistently using the barge dock throughout the year. It can take 20-24 barges to fill a ship to capacity and may take six hours or more to unload the contents of a barge.

-Typical range of vessel classes/sizes (smallest to largest): draft, length, beam:

Response:

Ships using the Irving Terminal ship dock typically range from 500 to 725 feet long and up to 106 feet wide. These ships are typically "Handymax" or "Panamax" class vessels. The depth of draft

of ships when full may be up to 40 feet. (Supplemental RI/FS Work Plan Section 3.2.2.1)

Barges using the barge dock at Irving Terminal are typically 280 feet long, 42 feet wide, and draft 14 feet when full.

c. Primary cargo, and indicate loading or unloading:
Response:
Cargo loads in ships and barges using the Irving Terminal contain only grain, primarily wheat.

d. Do you expect past shipping patterns to change significantly in future years, and if so, how?
Response:
No. Cargill anticipates the shipping patterns will remain consistent with past practices in coming years.

If you prefer you can submit a tabulation of vessel calls at your facility or provide us with documents from which we can prepare tabulation.

4. General information about dock usage

a. Where do barges and large vessels tie up at your facility? (show all locations on Figure 1b attached)
Response:
Ships and barges dock parallel to the designated docks, just offshore from the Irving facility, and tie up to the dock and/or dolphins located within the River near the dock. Ships dock at the ship dock and barges dock at the barge dock. See the attached Figure 1b.

b. Please provide information on expected future dock usage at your facility. As an estimate of such future dock usage, your recent past usage may be indicative. Please provide:

-Typical total number of days each dock is occupied each month and per year:
Response:
The Irving Terminal ship dock is typically occupied for the majority of days in each month. The number of unoccupied days depends on a number of factors, including the number of vessels docking during the particular month and the amount of time necessary to load a ship to capacity based on weather and commodity availability. For example, in months where only 3 ships are received, there may be up to 7 unoccupied days at the ship dock, although the ship dock is very seldom unoccupied for that length of time. In contrast, in months where 6 or 7 vessels are docked, there may be only 1 or 2 unoccupied hours at the ship dock. The Irving Terminal frequently operates 24 hours a day and 7 days per week, so open dock times may not be during regular work week days or normal business hours.

The Irving Terminal barge dock is also typically occupied the majority of days in each month. In a given month, the barge dock is likely occupied 27 of 30 days with a barge

The Irving Terminal ship dock and the Irving Terminal barge dock are not necessarily coordinated as to when they may be occupied by a ship or barge. In other words, the number of days when both the barge and ship docks are unoccupied is very few.

-Typical duration each dock is open between a pair of vessel calls:

Response:

In busiest months, there may be only 1 to 2 hours between ships. In slower months, the ship dock may remain open for one to three days at a time, but is seldom unoccupied more than a week at a time.

The barge dock is consistently occupied most days in a month. Many times a tug will pull away the previously unloaded/empty barge at the same time it brings in a full barge so any unoccupied time between barges can be effectively non-existent.

c. What are the seasonal variations, if any, in waterfront operations and dock usage for your facility?

Response:

Waterfront operations mirror ship and barge calls and remain fairly consistent throughout the year. Ship calls at Irving are fairly consistent throughout the year, although the months of May, and June have consistently had the fewest ships docked for the past three years. Barge calls are consistent throughout the year. Ships may remain docked at the ship dock for longer periods during slow seasons, and docked ships may require a longer load time in rainy weather than dry weather due to the open loading process of the grain.

d. Are there "critical operational" periods at your waterfront facility during which potential temporary limitations or access to your dock and/or waterfront operations would be most adverse? If so, please describe:

Response:

Any time a vessel is docked for loading or unloading at the Irving Terminal is a "critical operational" period where access to the docks will be limited by the presence of a vessel. As an export shipping terminal the facility is dependent on access to the docks and waterfront operations. Due to the uncertain nature of navigation and scheduling vessels, the presence or absence of ships or barges may occur on short notice, since the ships, tugs, and barges are operated by third parties.

e. Do you expect these patterns to change significantly in future years, and if so, how?

Response:

No. Cargill anticipates the operational patterns will remain consistent with past practices in coming years.

5. Docking/departure procedures

a. What is the typical direction of approach and departure for vessels using your docks or berths, both now and in the future? (draw approximate approach and departure paths on Figure 1b, attached):

Response:

Ships typically approach the Irving Terminal ship dock from the north west (moving against the current of the Willamette) and are maneuvered by two tugs to and from the ship dock at the Irving Terminal. Ship departure typically proceeds downstream toward the confluence with the Columbia River and to the Pacific Ocean.

Barges typically approach and depart from the Irving Terminal barge dock from the same directions as ships do to the ship dock. However, barges are typically maneuvered by one tug to dock and embark from the barge dock.

b. When vessels dock and embark from your facility, is it done with or without tug assist? When vessels approach and depart from your facility, are their main ship propellers and/or thrusters engaged or are the vessels solely under tug control? Please explain:

Response:
All vessels (ships and barges) docking and embarking at the Irving Terminal ship and barge docks use tug assistance. The tugs are contracted by the third party vessel operators. However, Cargill can provide a general description of the process, as it understands and periodically observes docking and embarking at the Irving facility.

Typically, for ships using the ship dock, the process involves two tugs maneuvering the ships to and from the dock, typically one tug engaging the bow and one the stern of a ship. Cargill understands that the main propellers or thrusters of the ships are not engaged during the docking or embarking process and the vessels are solely under tug power.

Barges using the barge dock do not have propellers or thrusters and are typically maneuvered to and from the barge dock by one tug.

c. If vessels use tug assist, what tug companies typically provide that service?

Response:
All ships docking at the Irving Terminal ship dock currently use Shaver Transportation for tug service.

All barges docking at the Irving Terminal currently use either Shaver Transportation or Tidewater Transportation & Terminals for tug service.

6. Surveying information

a. How does your facility monitor available berthing depth? Frequency?

Response: *Cargill performs bathymetric surveys as needed based on site conditions. These surveys typically occur every 6 months.*

b. If you conduct hydrographic surveying, how frequently do you do so?

Response: *Cargill performs bathymetric surveys as needed based on site conditions. These typically occur every 6 months.*

c. Will you provide electronic versions (CADD or excel database x,y,z) of the surveys? This information will be used by us to assess where sedimentation is occurring.

Response: *Cargill has already provided such information.*

7. Private Dredging History and Future Plans

a. What is the elevation of the river bed that you target to maintain for each dock / berth at your waterfront facility and on what vertical datum is this target based?

Response:

At the ship berth, the Irving Terminal is permitted to and does maintain a depth to -40 feet CRD plus 1-foot overdepth. There is potential that a change in the standard dredging depth of the navigational channel may occur, increasing the depth to 43 feet at some point in the future, at which time the Irving Terminal would presumably seek to maintain a 43 foot depth at its berth.

At the barge berth, the Irving Terminal is permitted to and does maintain a depth of -15 feet CRD plus 1-foot overdepth (Supplemental RI/FS Work Plan Section 3.2.2.3)

b. What areas of the river bed do you maintain for each dock / berth at your waterfront facility, including berthing areas and approach corridors? (Draw approximate maintenance dredging areas on Figure 1b attached).

Response:

Cargill maintains the areas depicted on Figure 1b at the depths specified above to a width of approximately 60 feet.

c. How does your facility decide when it needs to dredge, and how often do you normally dredge at your docks?

Response:

Based on bathymetric data, dredging is done periodically, as needed to maintain permitted River depth for Irving Terminal operations. Maintenance dredging has occurred most recently at the site in 2002, 2006, and 2009.

d. Describe the historical dredging activities at your waterfront including: year, quantity, and specific area dredged. If you have not already done so, please provide historical dredging records (such as dredging permits, construction plans and specifications, dredging contractor, pre-dredge and post-dredge bathymetric surveys, chemical and physical properties of dredged material).

Response:

Cargill has already provided the permits and specifications responsive to this question through the PCI Group Disclosure Questionnaire process. See CARG0004554-CARG0004555; CARG0005928-CARG0005931.

The Irving Terminal last performed maintenance dredging at two separate locations at the Irving Terminal in October 2009 to a depth of -42 feet (ship dock; RM 11.4 to RM 11.5) and -15 (upstream barge dock; RM 11.5 to RM 11.6) feet Columbia River Datum (CRD), and a 12-inch (or greater) sand cover was installed (HME, 2009), under permit NWP-2001-31 in the ship dock berth resulting in a -40 foot draft plus one foot overdepth. A total of approximately 1,430 cubic yards (cy) of sediment was dredged (Northern Resource, 2009), from the two areas (USACE, 2009):

CLD's USACE permit for the 2009 dredging contained a special condition recommended by the Project Review Group (USACE, EPA, National Marine Fisheries, Washington Department of Ecology, and Oregon DEQ) requiring CLD to "overdredge to 1 foot below the overdepth allowance (-42' CRD) and cover the dredged area with a 1-foot layer of sand." See August 31, 2009, Project Review Group Technical Memorandum for the Sediment Characterization Report for Regulatory Branch Project No. NWP-2001-31, CLD Pacific Grain, Irving Terminal, Willamette River, RM 11.4 (USACE, 2009). This sand cover was required in the permit to cover potentially contaminated surfaces exposed by the maintenance dredging. The specific cover thickness and composition were recommended by the Project Review Group and placed in the permit for the reason that "[s]ince tugboats assist the ships and barges that dock at the facility, deep prop wash is not an issue at this facility." CLD prepared a Completion Report for the dredging including a post-dredge and post-cover survey to confirm the cover thickness and extent. See CLD Pacific Grain, LLC Irving Terminal (R.M. 11.4) (Northern Resources, 2009). (Supplemental RI/FS Work Plan Section 3.2.2.3)

In 2006 maintenance dredging was performed at the Irving Terminal. See June 16, 2006 Notice to the U.S. Army Corps of Engineers of Dredging by CLD Pacific Grain. (CARG0005769). An estimated 1,800 cubic yards of material was disposed of at the Hickey Marine approved disposal site in Vancouver, Washington. The 2006 dredging was conducted pursuant to a U.S. Army Corps of Engineers permit to maintain necessary depth to facilitate ship docking at the Irving facility. See 2005 Hydrographic Survey of Irving (CARG0005770). CLD Pacific Grain contracted with Geotechnical Resources, Inc. to conduct a Sampling and Analysis of Material Dredged at Irving. See 2006 Sampling and Analysis of Material dredged at Irving. (CARG0005622 – CARG0005651). Sediment samples were analyzed for RCRA metals, VOCs, SVOCs, pesticides, herbicides, PCBs, percent solids and flash point. No contaminants were detected in the two samples taken. (CARG0005625).

Pursuant to a U.S. Army Corps of Engineers Section 404 permit, in 2002 CLD conducted maintenance dredging offshore of the Irving facility, and over 5,000 cubic yards of material were removed to a permitted depth of -40 CRD and disposed of at the WASCO County Landfill. See 2002 CLD Pacific Grain Oregon Department of State Lands Permit and Joint Application (CARG0005721 – CARG0005731); 2002 U.S. Army Corps of Engineers Notice of Approved Permit (CARG0005732); 2002 CLD Pacific Grain Notice to EPA of Dredging (CARG0005730); 2002 CLD Pacific Grain Notice to Oregon Department of State Lands of Dredging (CARG0005734); 2002 CLD Pacific Grain Notice to U.S. Army Corps of Engineers of Dredging and Sampling and Analysis of Dredged materials (CARG0005735 – CARG0005762); 2002 CLD Pacific Grain Special Waste Permit Application to WASCO (CARG0005763 – CARG0005768).

e. Regarding possible future dredging at your waterfront, how do you expect the frequency, depth, or extent of dredging to change in the foreseeable future?

Response:

Cargill expects that future dredging will be necessary at the Irving Terminal on average every 3 to 5 years as set forth above. Periodic permitted dredging of the ship and barge berths has been and will remain necessary for site operations.

8. Repair and Maintenance

Describe current and anticipated waterfront maintenance and repair activities (other than dredging) at your dock or other waterfront facilities, such as bank armoring, work involving dolphins, piles, docks, etc.

Response:

Dock repair at the Irving Terminal ship dock and dolphin, including particularly pile replacement, is anticipated to occur as permitted in the DEQ permit #56532-RF, issued 8/22/2014, which has been provided to the group. CARGRM11_000866 to CARGRM11_000905. *Schedule dates for this repair work have not yet been established.*

9. Shoreline Stability

a. Describe any relevant shoreline stability issues and/or history for your facility.

Response:

Cargill has previously provided substantial amounts of information regarding shoreline stability reinforcement work to the RM11E group. See generally CARGRM11_0000001 through CARGRM11_000771.

River bank stabilization has occurred in three phases. Phase 1 work addressed supplemental foundational support for an office building supported on piles and approximately 300 feet of riverbank, extending from about 30 feet upstream of the office building downstream to the dock walkway. CARGRM11_000459 to CARGRM11_000468, et seq.; See also CARGRM11_000668 (*providing map details of the project location*).

Phase 2 addressed stabilization of another approximately 300 feet of riverbank just upstream of a recently constructed stabilization wall. CARGRM11_000730. Phase 2 work extended approximately 130 feet upstream of the maintenance building. CARGRM11_000735. *See also* CARGRM11_000700- CARGRM11_000701 *(providing plans for the Phase 2 work) and* CARGRM11_000501-CARGRM11_000513 *(providing a map of the project location).*

Phase 3 work included stabilization through landscaping along the shoreline of the Irving Terminal property.

On December 3, 1998, the Oregon Division of State Lands issued a General Authorization to Cargill for the bank reinforcement and stabilization project, as detailed above. (CARG0004543).

b. Describe any shoreline stability engineering / geotechnical studies for your facility.

Response:

Engineering and geotechnical studies of the facility, which have been provided to the RM 11 E Group, were conducted to prepare plans for the above referenced shoreline stability project. The most recent geotechnical investigation was performed in March of 2013 and was related to the proposal to build a potential FGIS building.

c. Describe existing shoreline stabilization measures for your facility:

Response:

The response to part (a) provides the description of existing shoreline stabilization measures.

d. Describe planned shoreline stabilization measures for your facility:

Response:

No additional shoreline stabilization measures are currently planned for the Irving Terminal. However, to the extent that Cargill decides to pursue the proposal to build a new FGIS building, additional bank stabilization work may be a part of that project.

10. As-Built Drawings

Provide as-built drawings for waterfront structures and utilities for your facility.

Response:

Cargill has provided such documents. See the dock repair inspection and dock repair permit materials. CARGRM11_000866 to CARGRM11_000905.

11. Upland Access

Describe any facility operations or other factors at your facility that could limit or prevent access from portions of your upland property to the river bank or near shore areas for implementing a remedial action, if needed. (Using the attached Figure 1b indicate areas of your shoreline where there is insufficient access for shore-based staging of equipment and personnel for in-river remediation due to existing operations, upland structures, steep slopes, etc.).

Response:

Ongoing truck and rail traffic unloading grain at the facility, steep shorelines, and remnant pile fields, along with other operational factors will limit upland access from the Irving Terminal property.

12. Other Information

Do you have any other observations about docks, waterfront facilities, operational activities, or the project area that we should know about for purposes of limiting impacts or disruption to ongoing shipping activities at your facility in the event future in-water remediation activities are performed?

Response:

Due to the nature and variability of international shipping, arrival and departure dates for ships using the Irving Terminal may not be able to be accurately identified until less than a week before such arrival or departure dates. In addition, ships and barges using the Irving Terminal frequently get backed up, and will wait or stage at offsite locations so the vessel is available to occupy an Irving Terminal dock as soon as such dock is vacated by the prior vessel. Failure to timely accept an incoming vessel may result in substantial costs, as well as lost revenue, to the Irving Terminal.

NOTES:
1. Basemap from esri.com, courtesy of the Microsoft Corporation and its data suppliers.

Foth

N

0 80 160 Feet

This drawing is neither a legally recorded map nor a survey and is not intended to be used as one. This drawing is a compilation of records, information and data used for reference purposes only.

CARGILL, INC.

FIGURE 1B - SITE LAYOUT MAP

IRVING GRAIN ELEVATOR AND TERMINAL
800 N RIVER STREET
PORTLAND, OR 97227

Date: NOVEMBER 2014	Revision Date:	
Drawn By: BJW1	Checked By: BJS1	Scope: 13L003-01

Path: X:\GB\IE\2013\13L003-01\GIS\mxd\cargill_portlandOR_site_layout_map_a-size.mxd Date: 11/10/2014

APPENDIX C – SHORELINE REFERENCES

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1996 Aerial Photograph – USACE Library C-22

LEGEND

Historical Shoreline

Shoreline Digitized from 1888 USC&GS Willamette Navigation Chart

Other Features

Federal Navigation Channel (USACE)

PM 11.2 Project Mile (PM) Stationing

RM 11.0 River Mile (RM) Stationing

RM11E Project Area

MAP NOTES

1. The locations of all features shown are approximate.

0 500
Scale in Feet

RM11E Group
Willametter River, Portland, Oregon
Draft Implementability Study Report

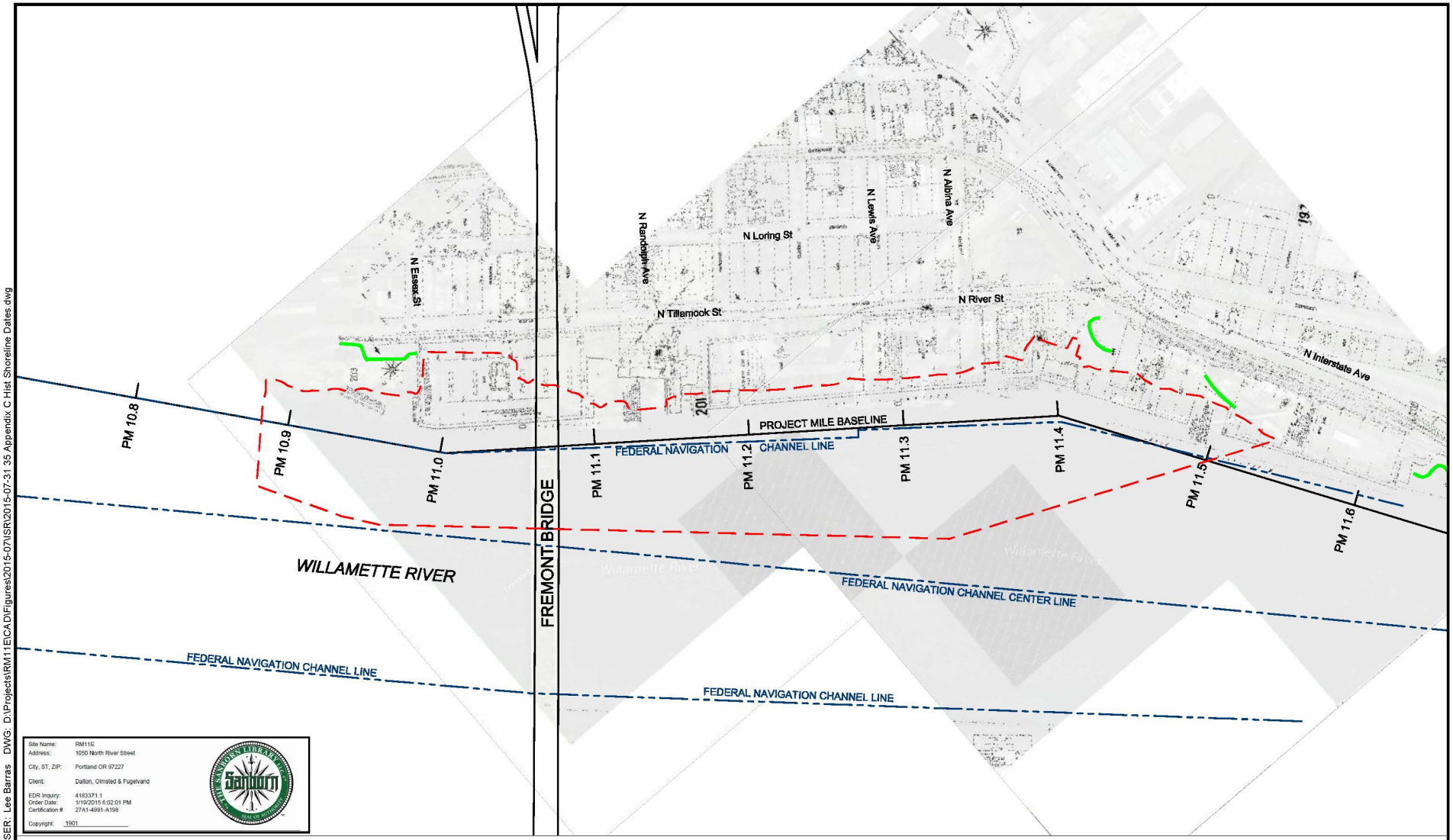
Appendix C
1888 USC&GS Willamette River Map

DALTON OLMSTED FUGLEVAND

Figure C-1

July 31, 2015

PLOT TIME: 7/30/2015 1:02 PM MOD TIME: 7/30/2015 1:01 PM USER: Lee Barras DWG: D:\Projects\RM11E\CAD\Figures\2015-07\ISR\2015-07-31 35 Appendix C Hist Shoreline Dates.dwg



LEGEND

Historical Shoreline

Shoreline Digitized from 1901 Sanborn Map

Other Features

Federal Navigation Channel (USACE)

PM 11.2 Project Mile (PM) Stationing

RM 11.0 River Mile (RM) Stationing

RM11E Project Area

MAP NOTES

1. The locations of all features shown are approximate.

0 500
Scale in Feet

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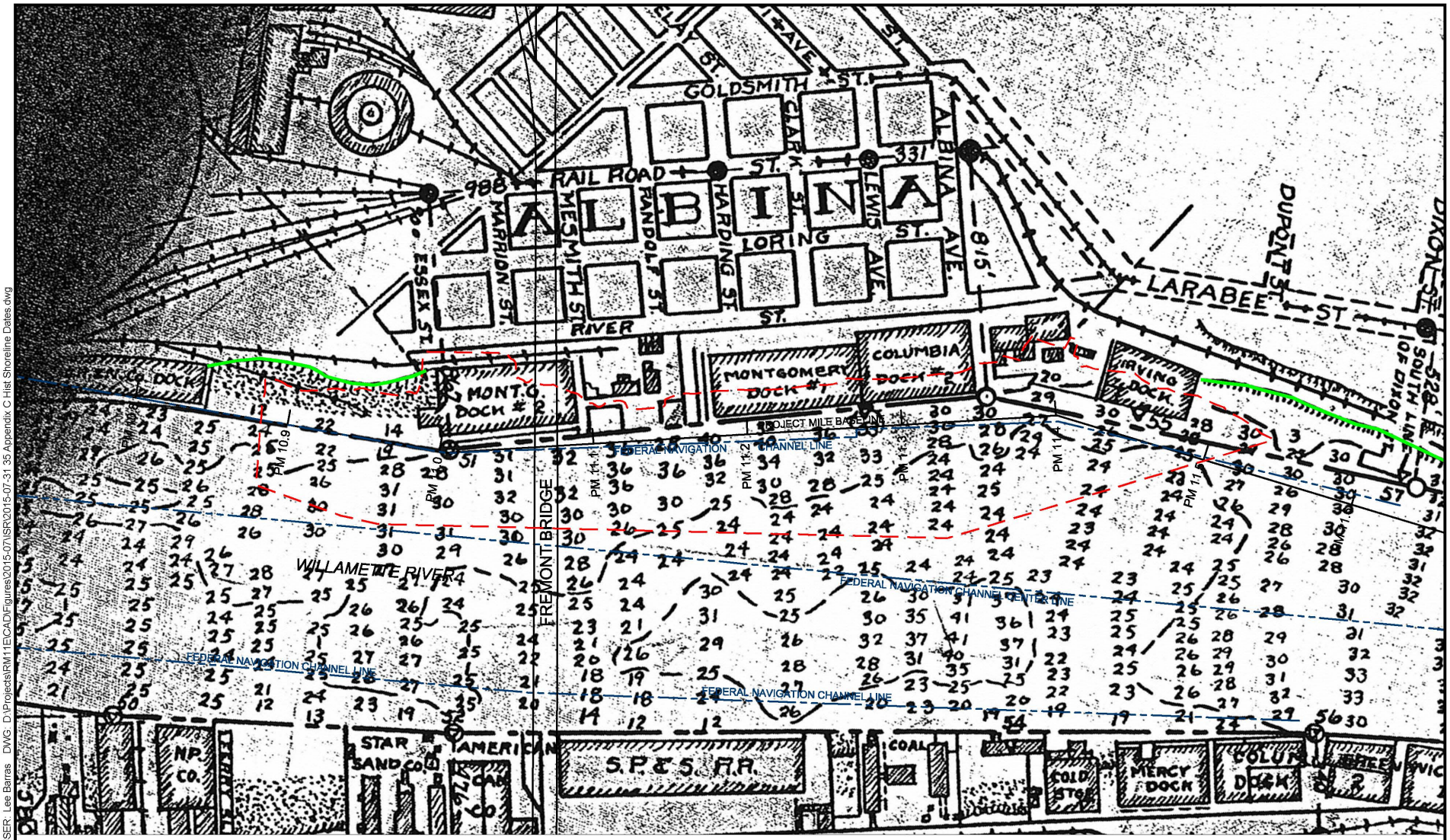
Appendix C
1901 Sanborn Map

DALTON OLMSTED FUGLEVAND

Figure C-2

July 31, 2015

PLOT TIME: 7/30/2015 1:02 PM MOD TIME: 7/30/2015 1:01 PM USER: Lee Barras DWG: D:\Projects\RM11E\CAD\Figures\2015-07\ISR\2015-07-31 35 Appendix C Hist Shoreline Dates.dwg



LEGEND

Historical Shoreline

Shoreline Digitized from 1908 USC&GS Willamette Navigation Chart

Other Features

Federal Navigation Channel (USACE)

PM 11.2 Project Mile (PM) Stationing

RM 11.0 River Mile (RM) Stationing

RM11E Project Area

MAP NOTES

1. The locations of all features shown are approximate.

0 500
Scale in Feet

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Appendix C
1908 USC&GS Willamette River Map

DALTON OLMSTED FUGLEVAND

Figure C-3

July 31, 2015

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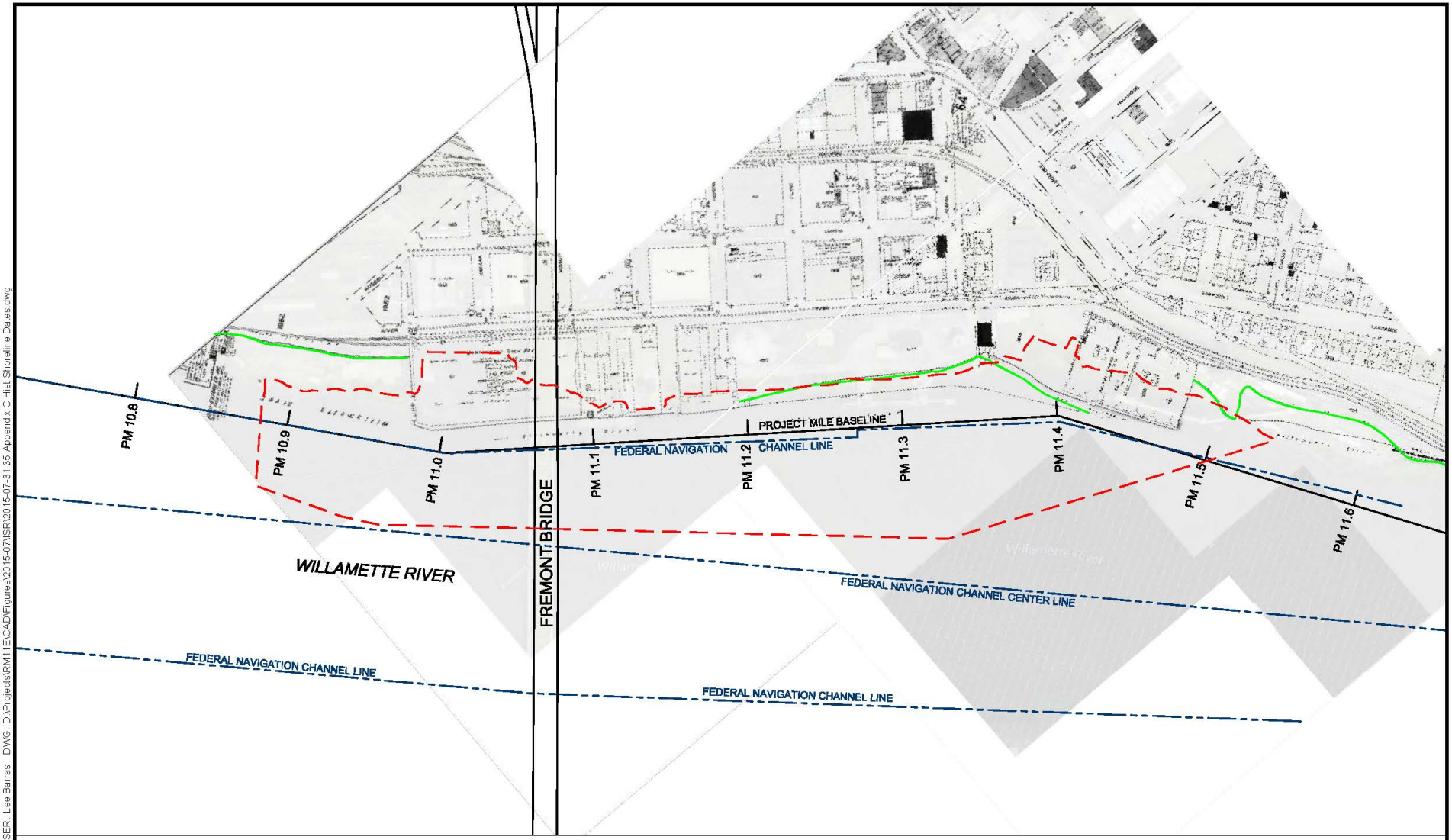

LEGEND

Historical Shoreline

Shoreline Digitized from 1924 Sanborn Map

Other Features

Federal Navigation Channel (USACE)

PM 11.2 Project Mile (PM) Stationing

RM 11.0 River Mile (RM) Stationing

RM11E Project Area

MAP NOTES

1. The locations of all features shown are approximate.

0 500
Scale in Feet

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Appendix C
1924 Sanborn Map

DALTON OLMSTED FUGLEVAND

Figure C-4

July 31, 2015

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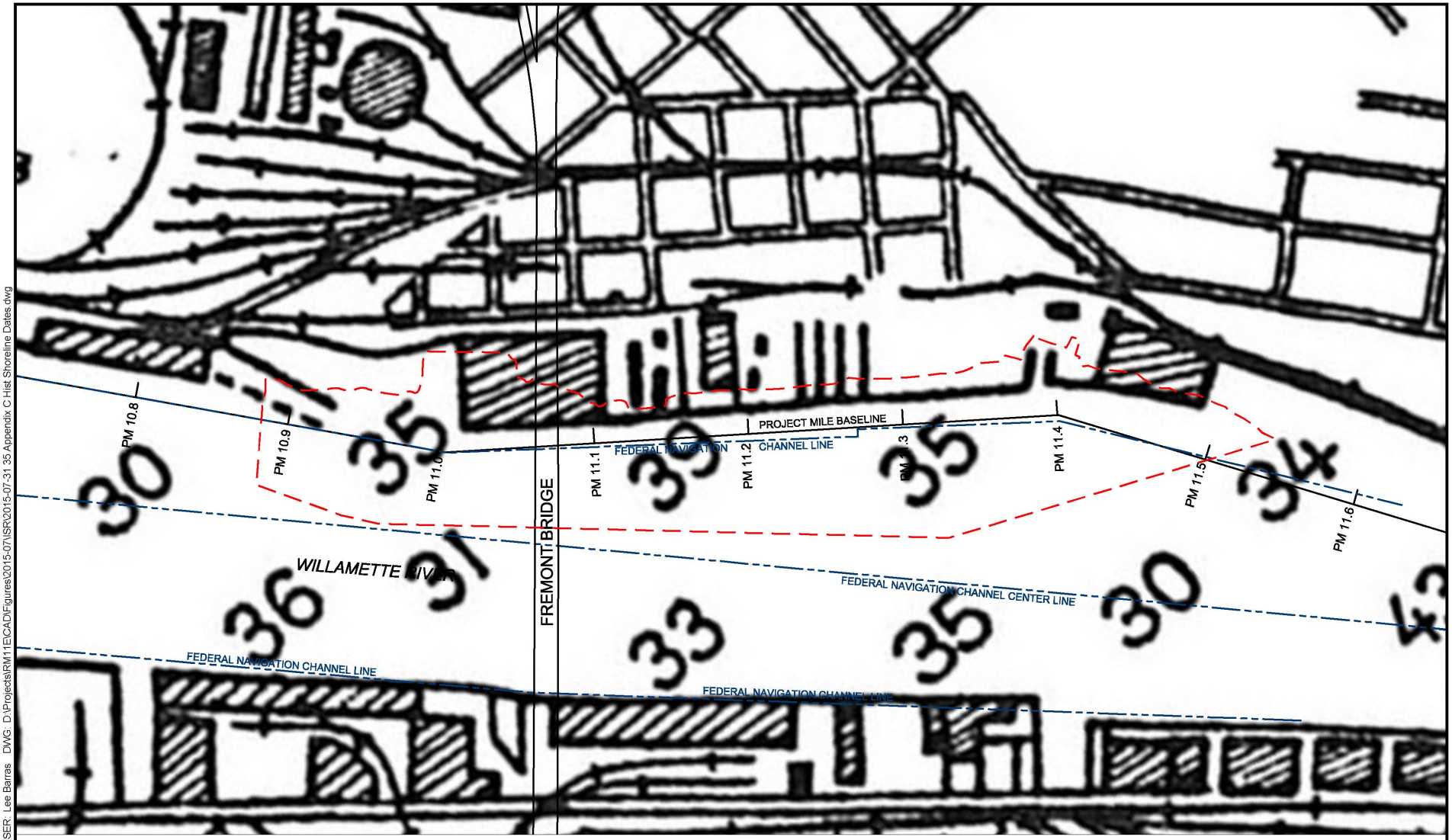

LEGEND

Historical Shoreline

N/A	Shoreline Not Digitized from 1925 USC&GS Willamette Navigation Chart

Other Features

— — —	Federal Navigation Channel (USACE)
PM 11.2	Project Mile (PM) Stationing
RM 11.0	River Mile (RM) Stationing
— — —	RM11E Project Area

MAP NOTES

1. The locations of all features shown are approximate.

0 500
Scale in Feet

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Appendix C
1925 USC&GS Willamette River Map

DALTON OLMSTED FUGLEVAND

Figure C-5

July 31, 2015

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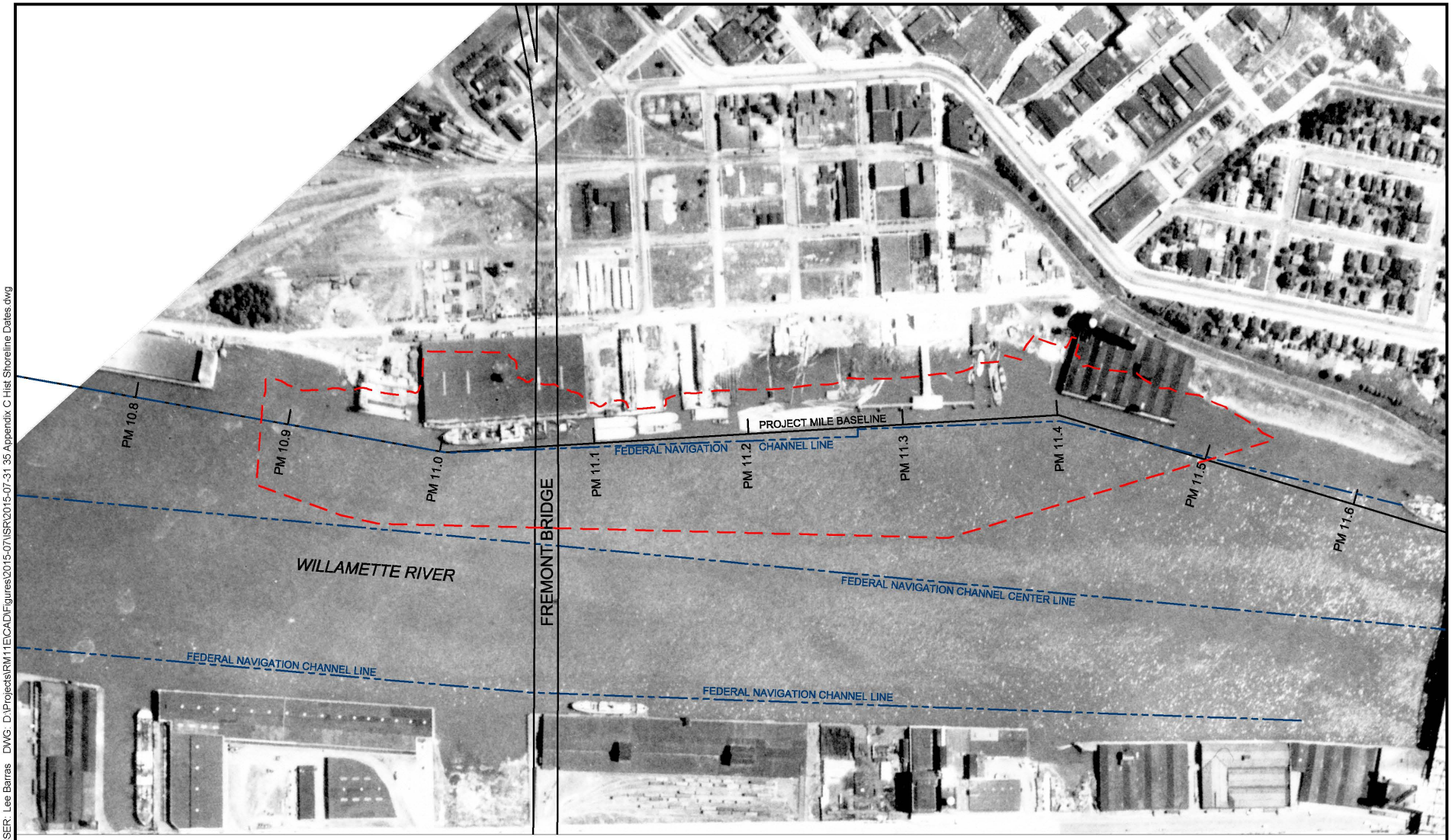

LEGEND

Historical Shoreline

N/A	Shoreline Not Digitized from 1936 Aerial Photograph (USACE Photo Library - Portland Branch)

Other Features

— - - —	Federal Navigation Channel (USACE)
PM 11.2	Project Mile (PM) Stationing
RM 11.0	River Mile (RM) Stationing
— — — —	RM11E Project Area

MAP NOTES

1. The locations of all features shown are approximate.

0 500
Scale in Feet

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Willametter River, Portland, Oregon
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Appendix C
1936 Aerial Photograph - USACE Library

DALTON OLMSTED FUGLEVAND

Figure C-6

July 31, 2015

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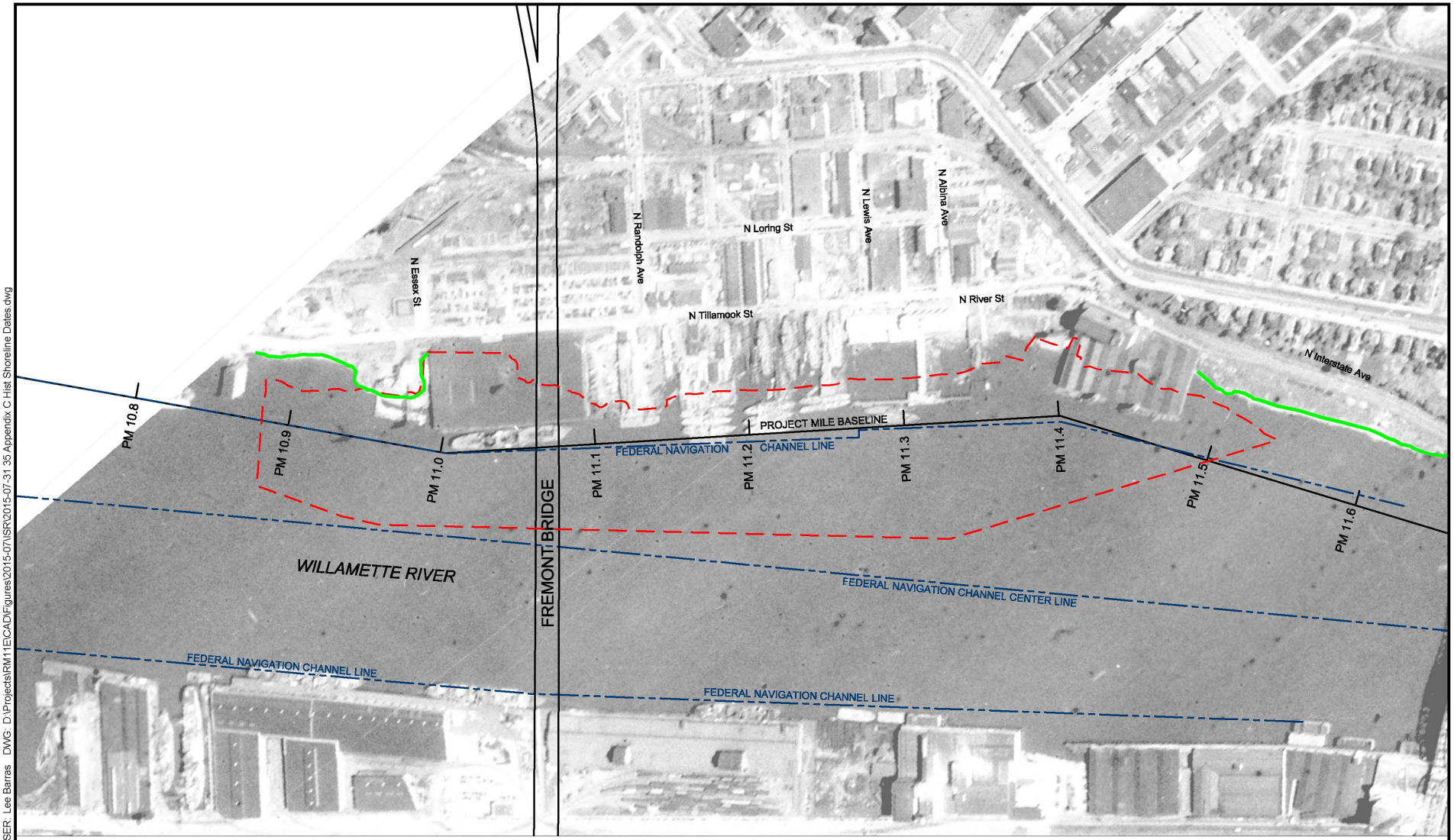

LEGEND

Historical Shoreline

Shoreline Digitized from 1943 Aerial Photograph (USACE Photo Library - Portland Branch)

Other Features

Federal Navigation Channel (USACE)

PM 11.2 Project Mile (PM) Stationing

RM 11.0 River Mile (RM) Stationing

RM11E Project Area

MAP NOTES

1. The locations of all features shown are approximate.

0 500
Scale in Feet

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Draft Implementability Study Report

Appendix C
1943 Aerial Photograph - USACE Library

DALTON OLMSTED FUGLEVAND

Figure C-7

July 31, 2015

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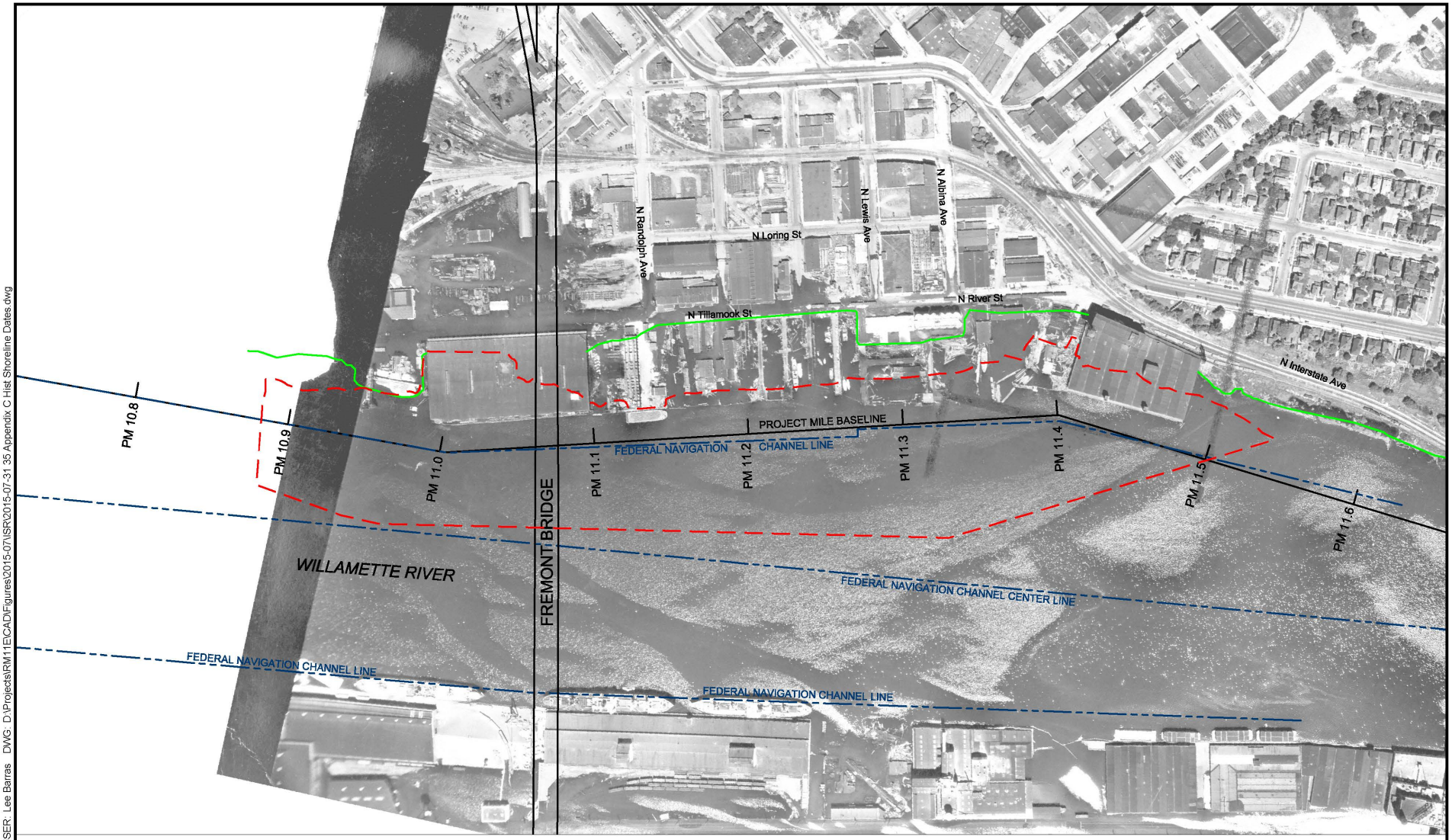

LEGEND

Historical Shoreline

Shoreline Digitized from 1948 Aerial Photograph (USACE Photo Library - Portland Branch)

Other Features

Federal Navigation Channel (USACE)

PM 11.2 Project Mile (PM) Stationing

RM 11.0 River Mile (RM) Stationing

RM11E Project Area

MAP NOTES

1. The locations of all features shown are approximate.

0 500
Scale in Feet

RM11E Group
Willamette River, Portland, Oregon
Draft Implementability Study Report

Appendix C
1948 Aerial Photograph - USACE Library

DALTON OLMSTED FUGLEVAND

Figure C-8

July 31, 2015

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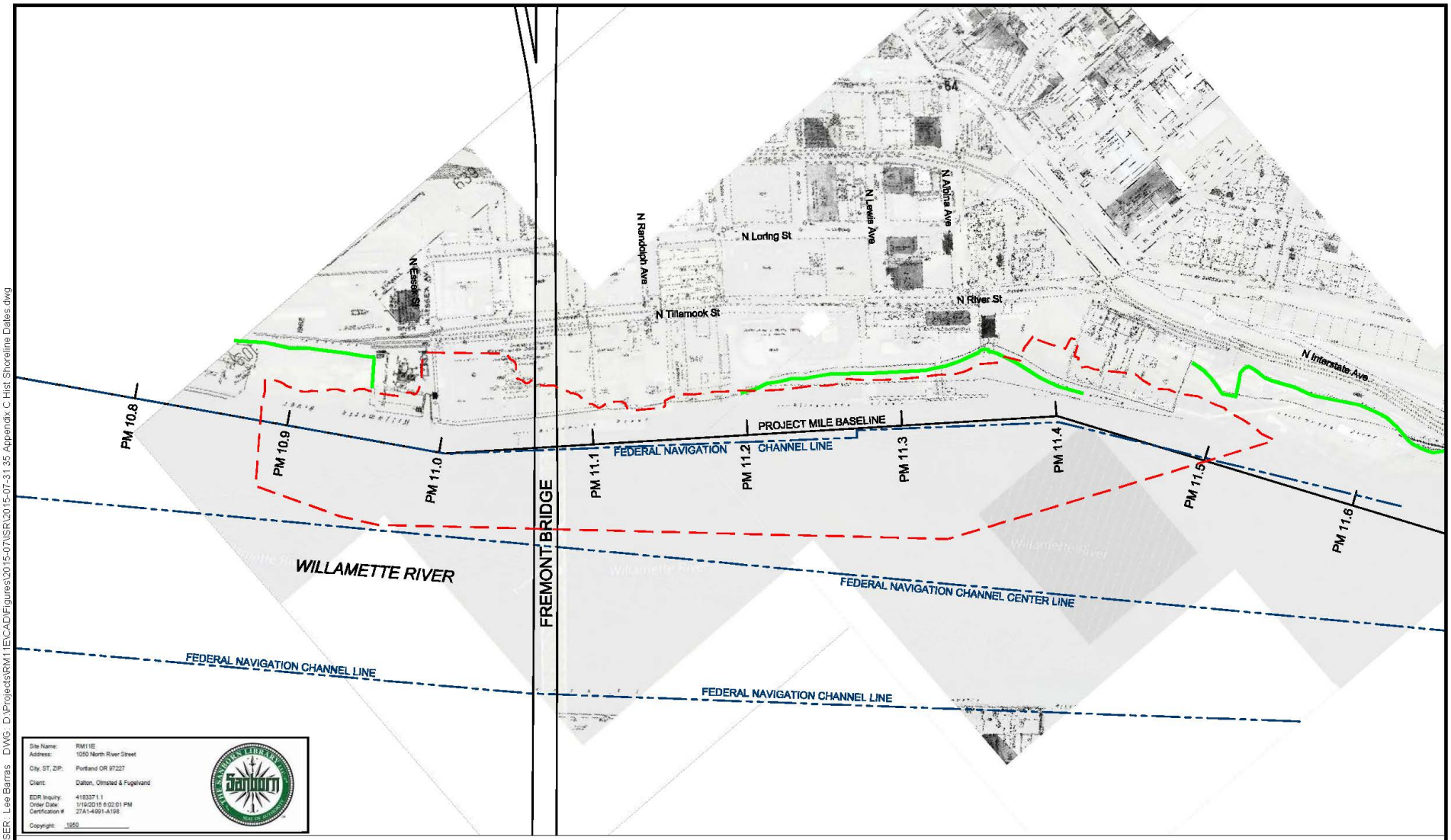

LEGEND

Historical Shoreline

Shoreline Digitized from 1950 Sanborn Map

Other Features

Federal Navigation Channel (USACE)

PM 11.2 Project Mile (PM) Stationing

RM 11.0 River Mile (RM) Stationing

RM11E Project Area

MAP NOTES

1. The locations of all features shown are approximate.

0 500
Scale in Feet

RM11E Group
Willamette River, Portland, Oregon
Draft Implementability Study Report

Appendix C
1950 Sanborn Map

DALTON OLMSTED FUGLEVAND

Figure C-9

July 31, 2015

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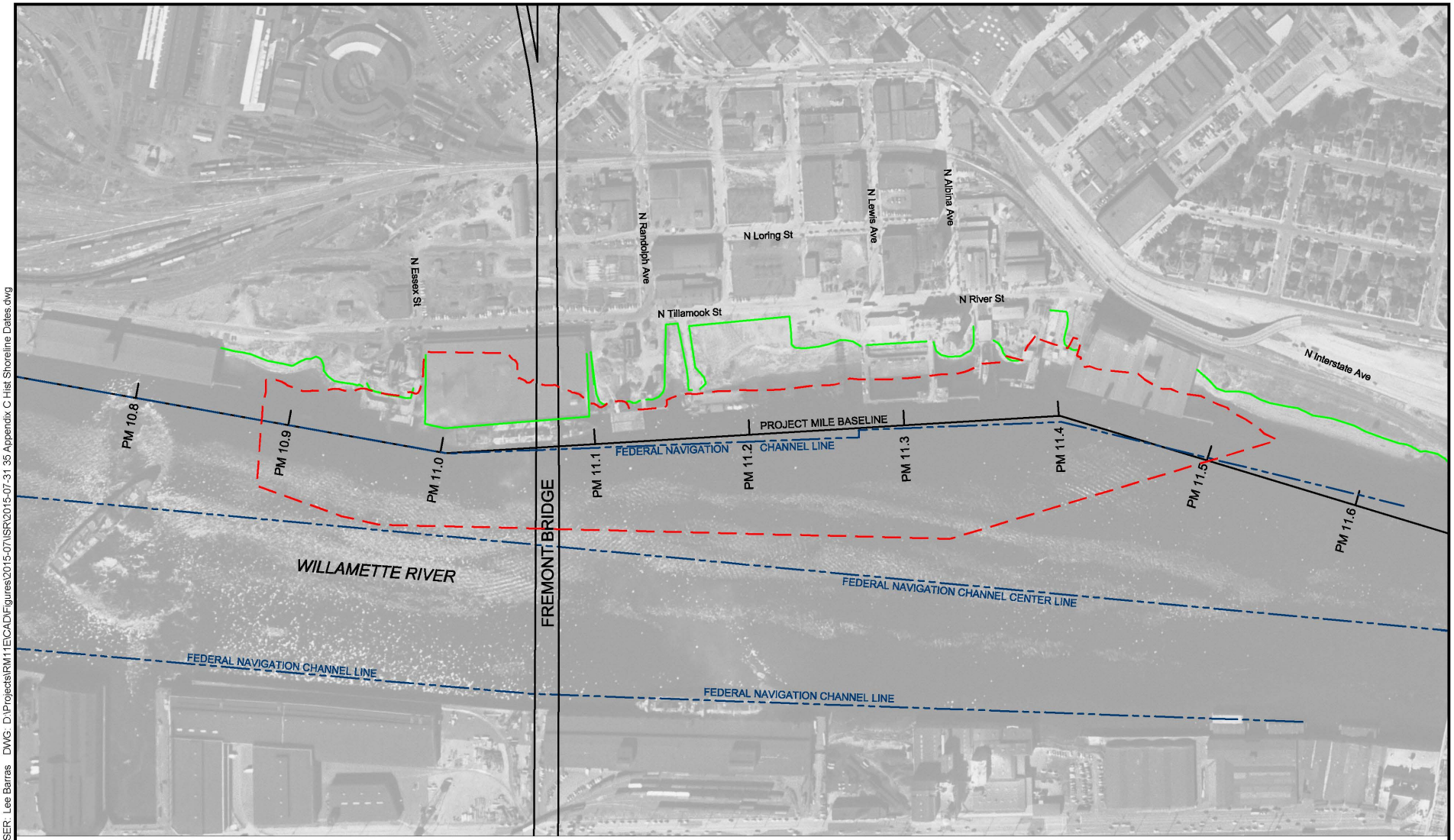

LEGEND

Historical Shoreline

N/A — Shoreline Not Digitized from 1948 Aerial Photograph (USGS Photo Library - EarthExplorer)

Other Features

Federal Navigation Channel (USACE)

PM 11.2 — Project Mile (PM) Stationing

RM 11.0 — River Mile (RM) Stationing

RM11E Project Area

MAP NOTES

1. The locations of all features shown are approximate.

0 500
Scale in Feet

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Draft Implementability Study Report

Appendix C
1951 Aerial Photograph - USGS Library

DALTON OLMSTED FUGLEVAND

Figure C-10

July 31, 2015

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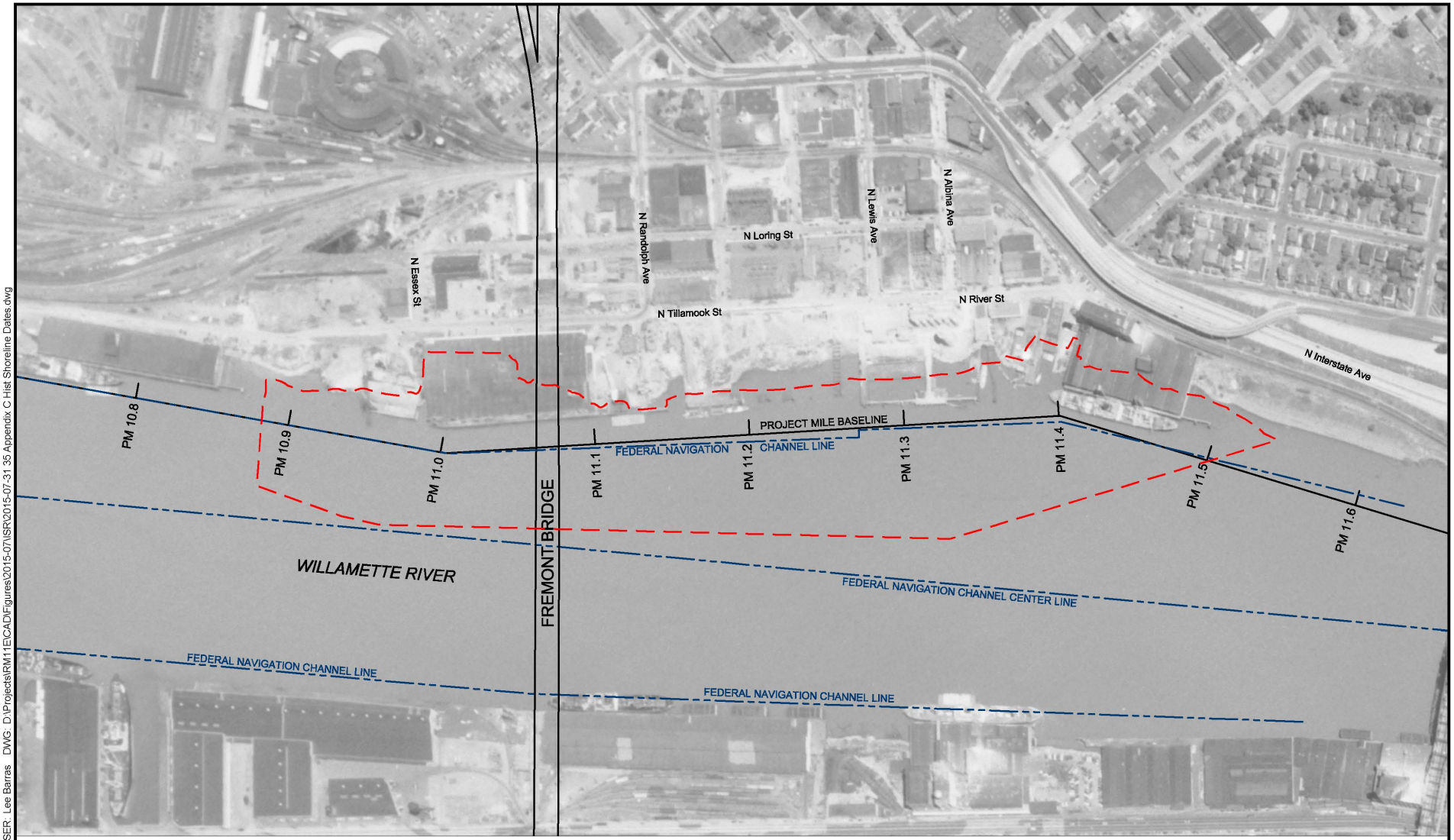


LEGEND

Historical Shoreline

N/A — Shoreline Not Digitized from 1948 Aerial Photograph (USGS Photo Library - EarthExplorer)

Other Features

Federal Navigation Channel (USACE)

PM 11.2 — Project Mile (PM) Stationing

RM 11.0 — River Mile (RM) Stationing

RM11E Project Area

MAP NOTES

1. The locations of all features shown are approximate.

0 500
Scale in Feet

RM11E Group
Willamette River, Portland, Oregon
Draft Implementability Study Report

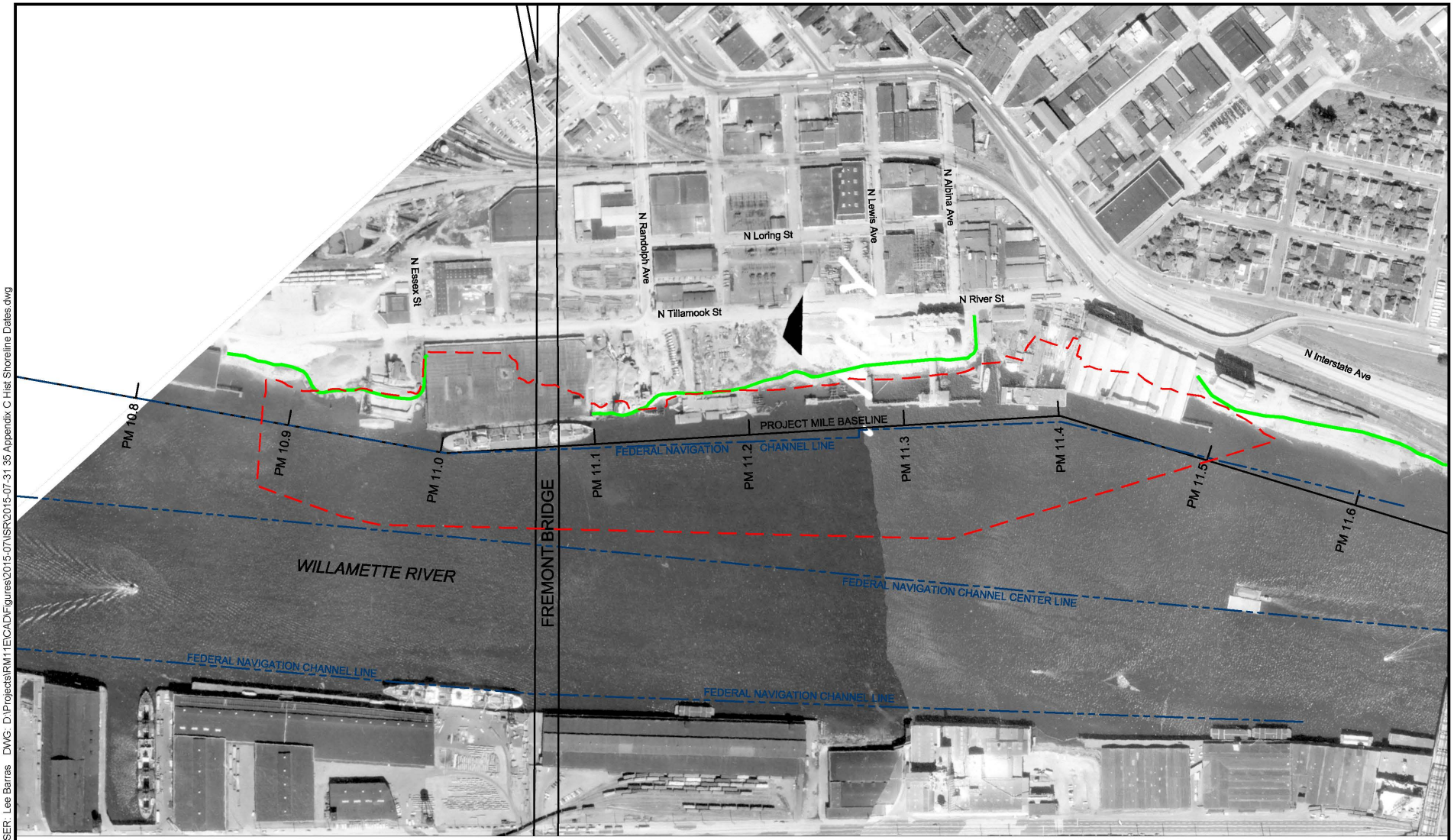
Appendix C
1952 Aerial Photograph - USGS Library

DALTON OLMSTED FUGLEVAND

Figure C-11

July 31, 2015

PLOT TIME: 7/30/2015 1:02 PM MOD TIME: 7/30/2015 1:01 PM USER: Lee Barras DWG: D:\Projects\RM11E\CAD\Figures\2015-07\ISR\2015-07-31 35 Appendix C Hist Shoreline Dates.dwg



LEGEND

Historical Shoreline

Shoreline Digitized from 1957 Aerial Photograph (USACE Photo Library - Portland Branch)

Other Features

Federal Navigation Channel (USACE)

PM 11.2 Project Mile (PM) Stationing

RM 11.0 River Mile (RM) Stationing

RM11E Project Area

MAP NOTES

1. The locations of all features shown are approximate.

0 500
Scale in Feet

RM11E Group
Willamette River, Portland, Oregon
Draft Implementability Study Report

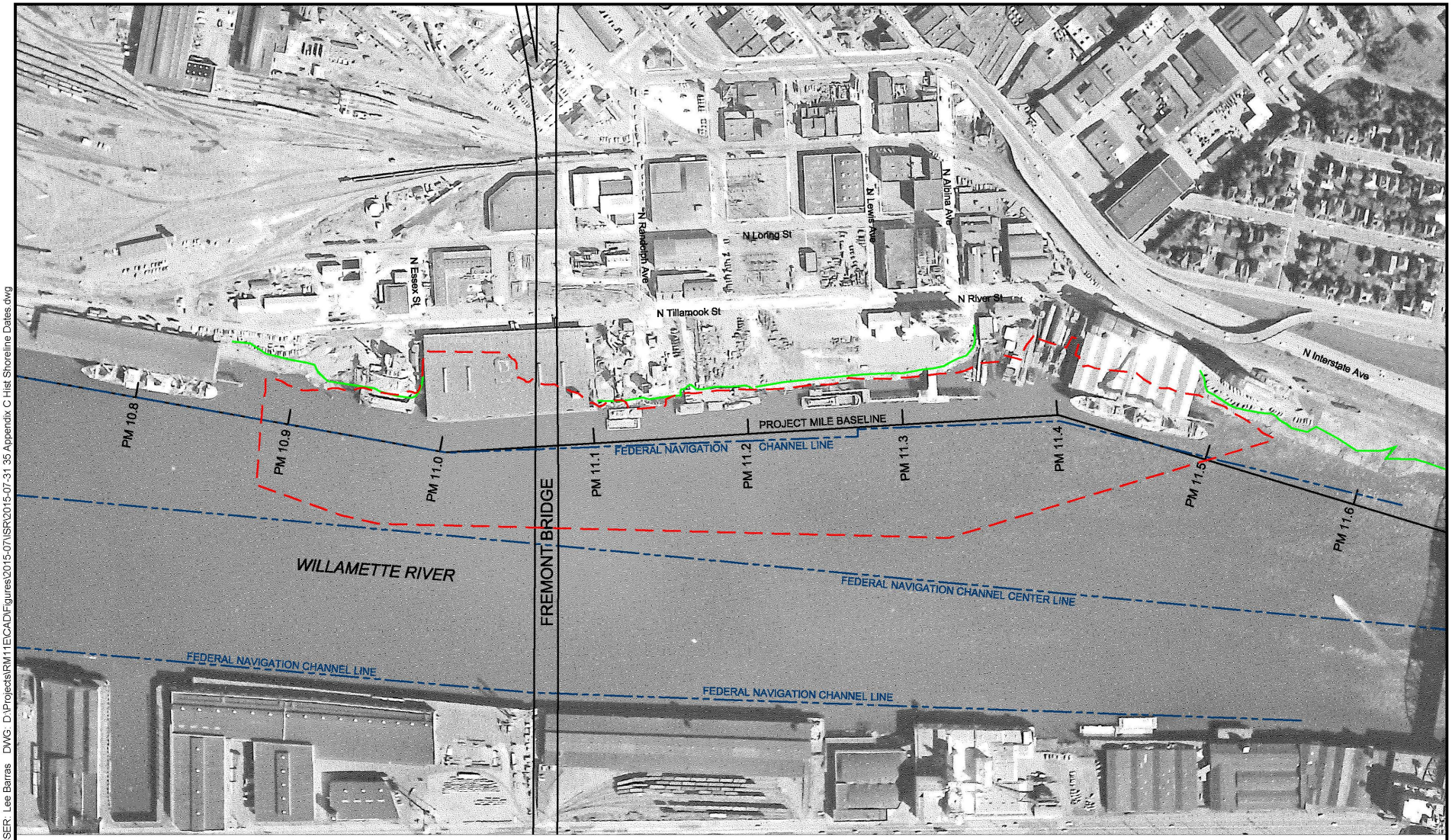
Appendix C
1957 Aerial Photograph - USACE Library

DALTON OLMSTED FUGLEVAND

Figure C-12

July 31, 2015

PLOT TIME: 7/30/2015 1:02 PM MOD TIME: 7/30/2015 1:01 PM USER: Lee Barras DWG: D:\Projects\RM11E\CAD\Figures\2015-07\ISR\2015-07-31 35 Appendix C Hist Shoreline Dates.dwg



LEGEND

Historical Shoreline

Shoreline Digitized from 1959 Aerial Photograph (ODOT Photo Library)

Other Features

Federal Navigation Channel (USACE)

PM 11.2 Project Mile (PM) Stationing

RM 11.0 River Mile (RM) Stationing

RM11E Project Area

MAP NOTES

1. The locations of all features shown are approximate.

0 500
Scale in Feet

RM11E Group
Willametter River, Portland, Oregon
Draft Implementability Study Report

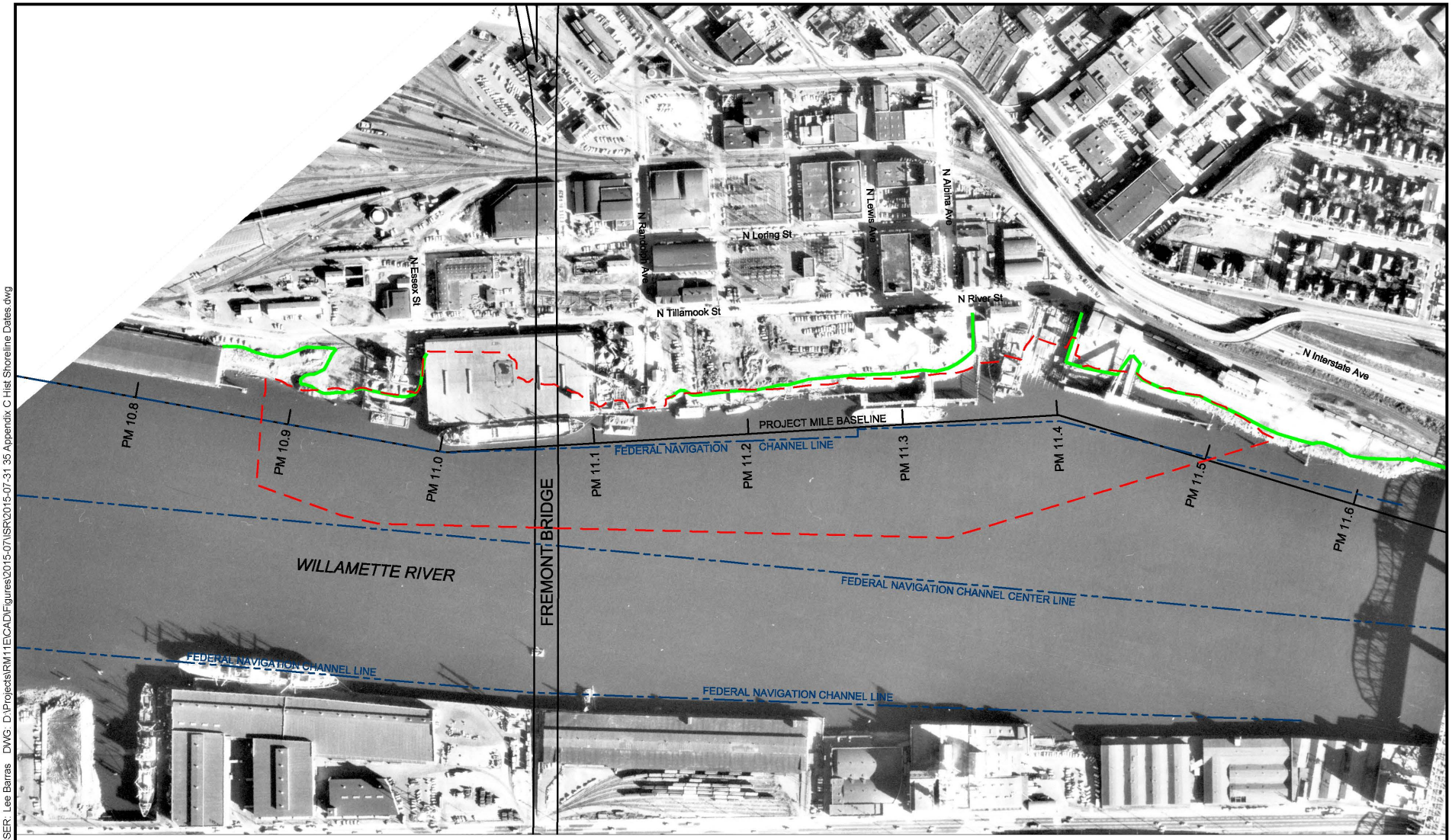
Appendix C
1959 Aerial Photograph - ODOT Library

DALTON OLMSTED FUGLEVAND

Figure C-13

July 31, 2015

PLOT TIME: 7/30/2015 1:02 PM MOD TIME: 7/30/2015 1:01 PM USER: Lee Barras DWG: D:\Projects\RM11E\CAD\Figures\2015-07\ISR\2015-07-31 35 Appendix C Hist Shoreline Dates.dwg



LEGEND

Historical Shoreline

Shoreline Digitized from 1963 Aerial Photograph (USACE Photo Library - Portland Branch)

Other **Features**

Federal Navigation Channel (USACE)

PM 11.2 Project Mile (PM) Stationing

RM 11.0 River Mile (RM) Stationing

RM11E Project Area

MAP NOTES

1. The locations of all features shown are approximate.

0 500

Scale in Feet

RM11E Group
Willametter River, Portland, Oregon
Draft Implementability Study Report

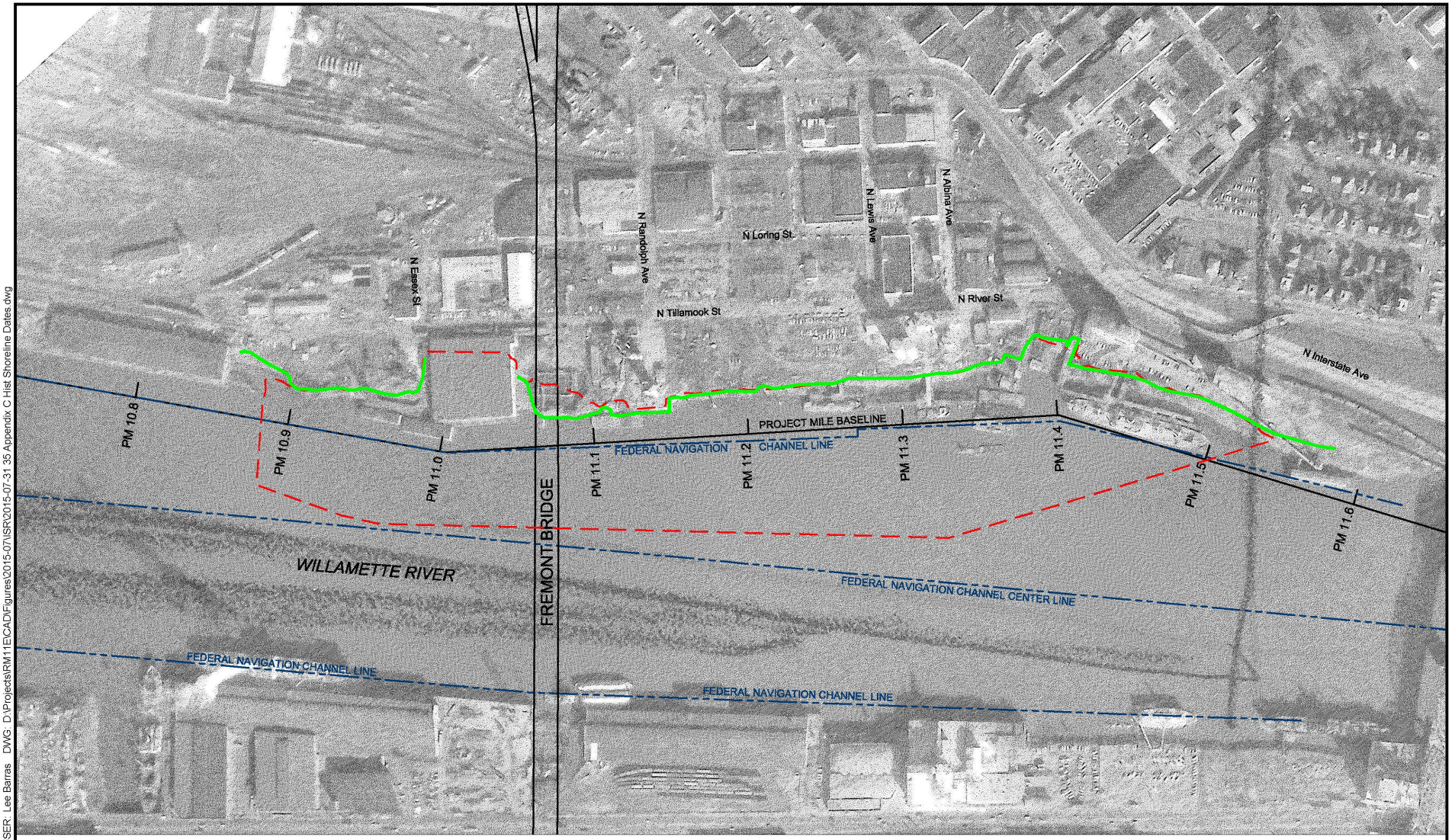
Appendix C
1963 Aerial Photograph - USACE Library

DALTON OLMSTED FUGLEVAND

Figure C-14

July 31, 2015

PLOT TIME: 7/30/2015 1:02 PM MOD TIME: 7/30/2015 1:01 PM USER: Lee Barras DWG: D:\Projects\RM11E\CAD\Figures\2015-07\ISR\2015-07-31 35 Appendix C Hist Shoreline Dates.dwg



LEGEND

Historical Shoreline

Shoreline Digitized from 1969 Aerial Photograph (ODOT Photo Library)

Other Features

Federal Navigation Channel (USACE)

PM 11.2 Project Mile (PM) Stationing

RM 11.0 River Mile (RM) Stationing

RM11E Project Area

MAP NOTES

1. The locations of all features shown are approximate.

0 500
Scale in Feet

RM11E Group
Willamette River, Portland, Oregon
Draft Implementability Study Report

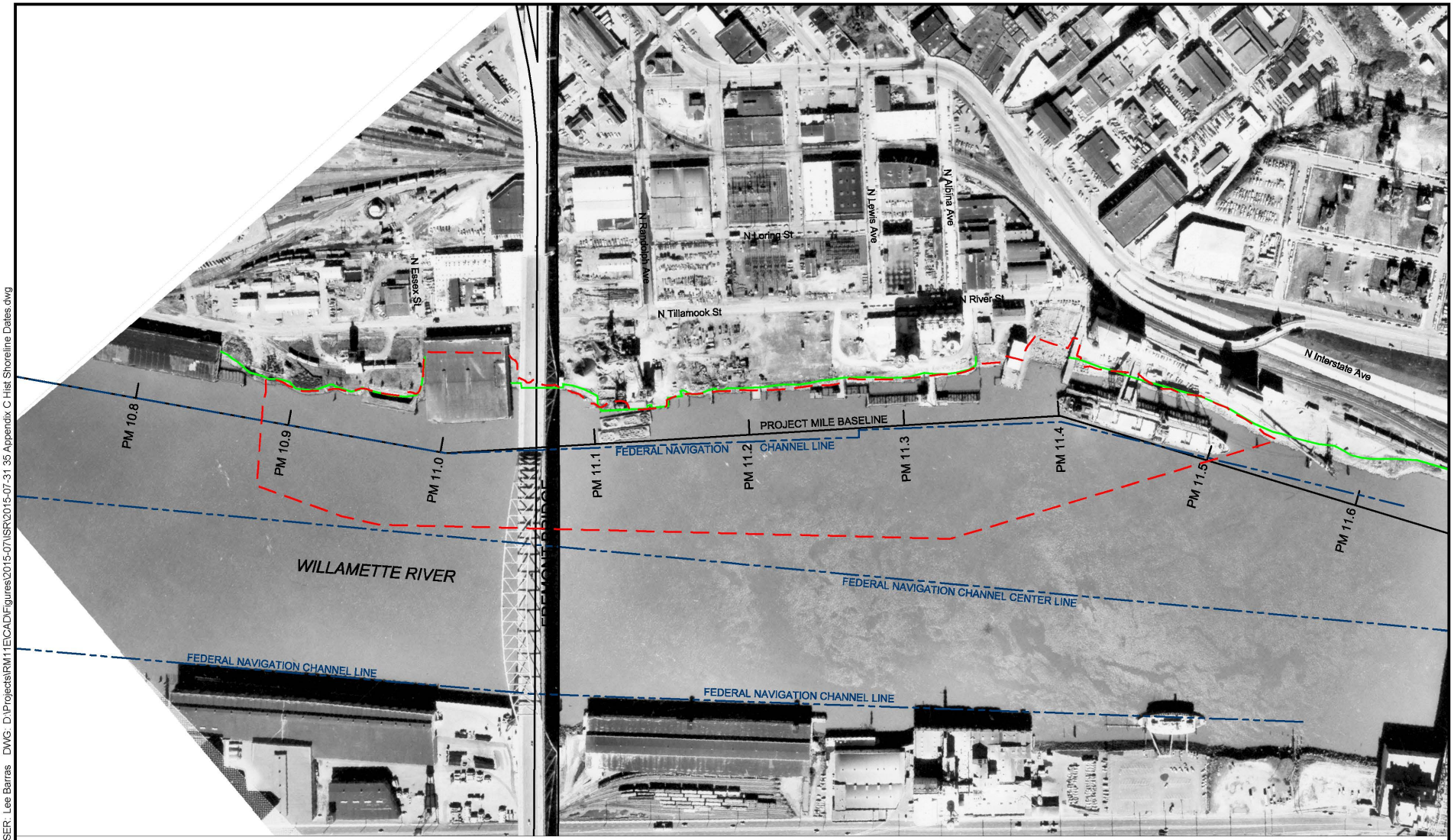
Appendix C
1969 Aerial Photograph - ODOT Library

DALTON OLMSTED FUGLEVAND

Figure C-15

July 31, 2015

PLOT TIME: 7/30/2015 1:02 PM MOD TIME: 7/30/2015 1:01 PM USER: Lee Barras DWG: D:\Projects\RM11E\CAD\Figures\2015-07\ISR\2015-07-31 35 Appendix C Hist Shoreline Dates.dwg



LEGEND

Historical Shoreline

Shoreline Digitized from 1974 Aerial Photograph (USACE Photo Library - Portland Branch)

Other Features

Federal Navigation Channel (USACE)

PM 11.2 Project Mile (PM) Stationing

RM 11.0 River Mile (RM) Stationing

RM11E Project Area

MAP NOTES

1. The locations of all features shown are approximate.

0 500
Scale in Feet

RM11E Group
Willametter River, Portland, Oregon
Draft Implementability Study Report

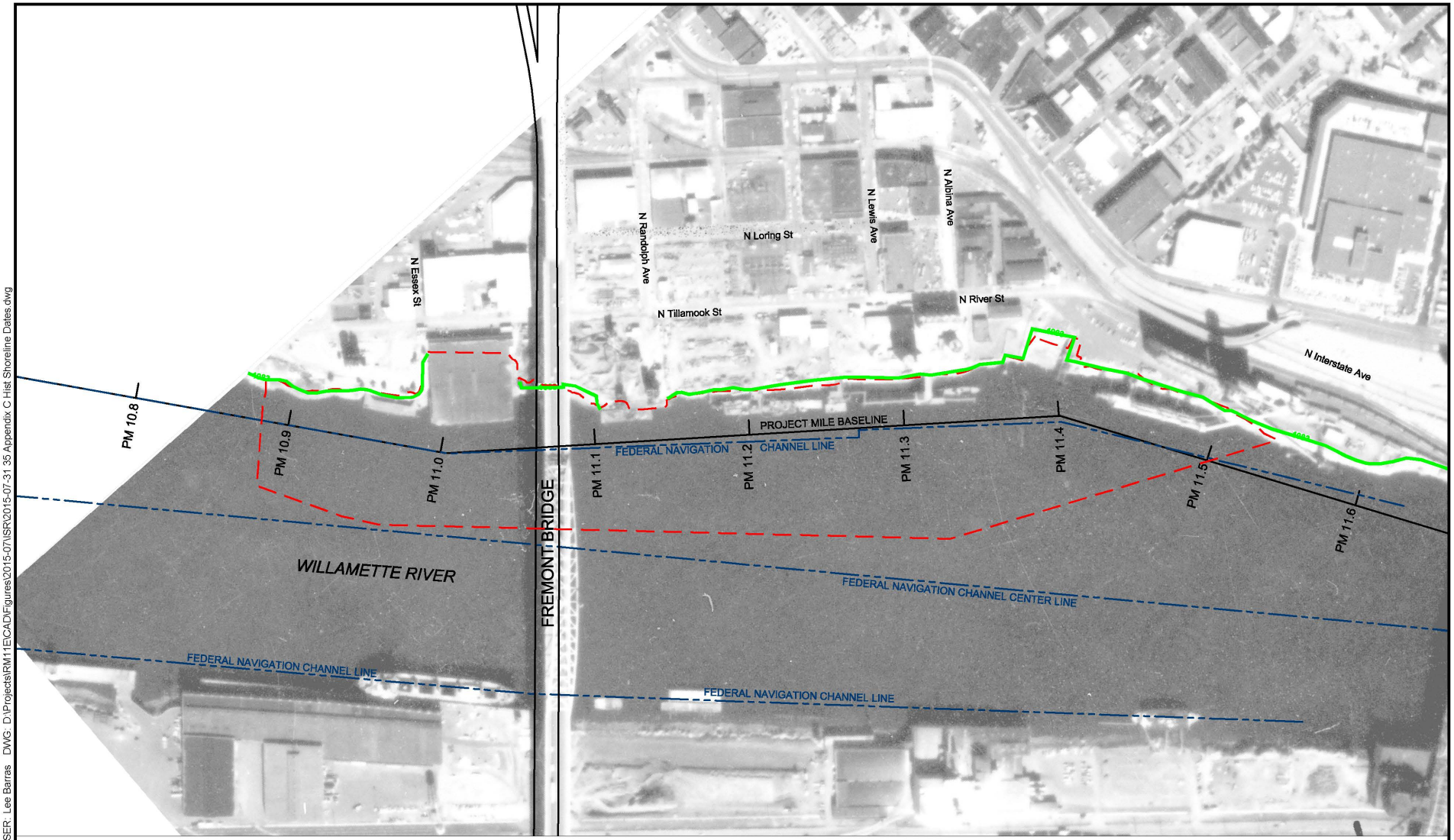
Appendix C
1974 Aerial Photograph - USACE Library

DALTON OLMSTED FUGLEVAND

Figure C-16

July 31, 2015

PLOT TIME: 7/30/2015 1:02 PM MOD TIME: 7/30/2015 1:01 PM USER: Lee Barras DWG: D:\Projects\RM11E\CAD\Figures\2015-07\ISR\2015-07-31 35 Appendix C Hist Shoreline Dates.dwg



LEGEND

Historical Shoreline

Shoreline Digitized from 1983 Aerial Photograph (USACE Photo Library - Portland Branch)

Other Features

Federal Navigation Channel (USACE)

PM 11.2 Project Mile (PM) Stationing

RM 11.0 River Mile (RM) Stationing

RM11E Project Area

MAP NOTES

1. The locations of all features shown are approximate.

0 500
Scale in Feet

RM11E Group
Willamette River, Portland, Oregon
Draft Implementability Study Report

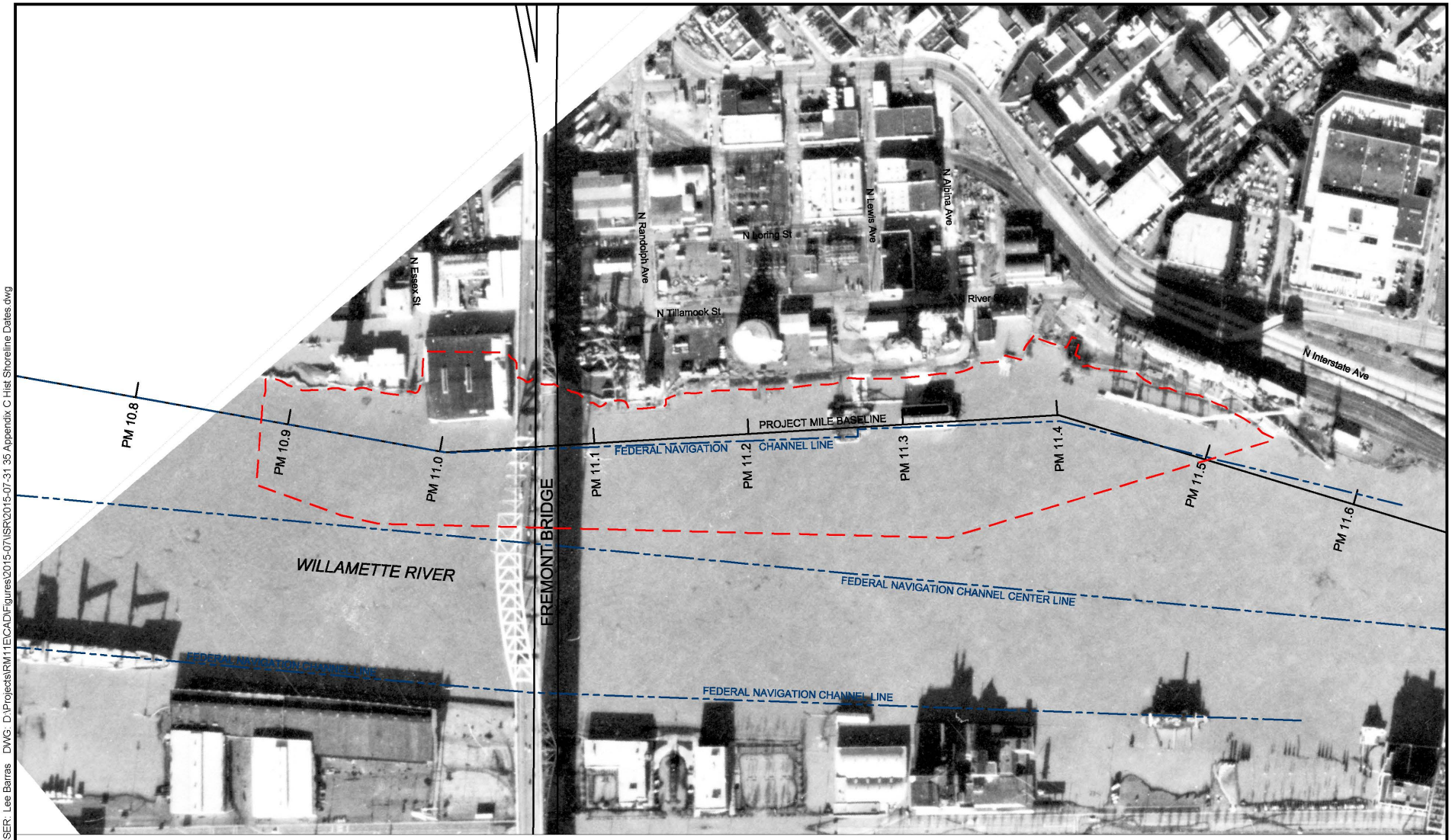
Appendix C
1983 Aerial Photograph - USACE Library

DALTON OLMSTED FUGLEVAND

Figure C-17

July 31, 2015

PLOT TIME: 7/30/2015 1:02 PM MOD TIME: 7/30/2015 1:01 PM USER: Lee Barras DWG: D:\Projects\RM11E\CAD\Figures\2015-07\ISR\2015-07-31 35 Appendix C Hist Shoreline Dates.dwg



LEGEND

Historical Shoreline

N/A — Shoreline Not Digitized from 1996 Aerial Photograph (USACE Photo Library - Portland Branch)

Other Features

Federal Navigation Channel (USACE)

PM 11.2 — Project Mile (PM) Stationing

RM 11.0 — River Mile (RM) Stationing

RM11E Project Area

MAP NOTES

1. The locations of all features shown are approximate.

0 500
Scale in Feet

RM11E Group
Willamette River, Portland, Oregon
Draft Implementability Study Report

Appendix C
1996 Aerial Photograph - USACE Library

DALTON OLMSTED FUGLEVAND

Figure C-18

July 31, 2015

PLOT TIME: 7/30/2015 1:02 PM MOD TIME: 7/30/2015 1:01 PM USER: Lee Barras DWG: D:\Projects\RM11E\CAD\Figures\2015-07\ISR\2015-07-31 35 Appendix C Hist Shoreline Dates.dwg

APPENDIX D – INCLINOMETER DATA

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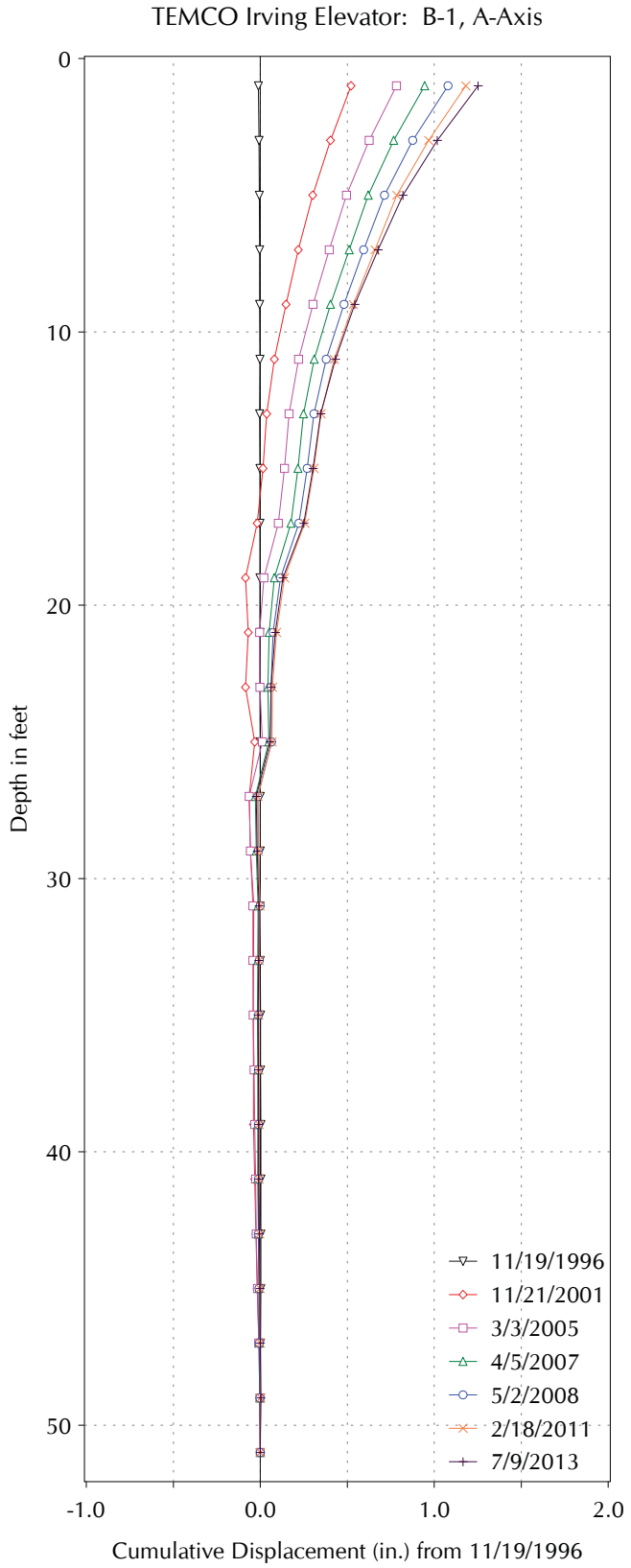
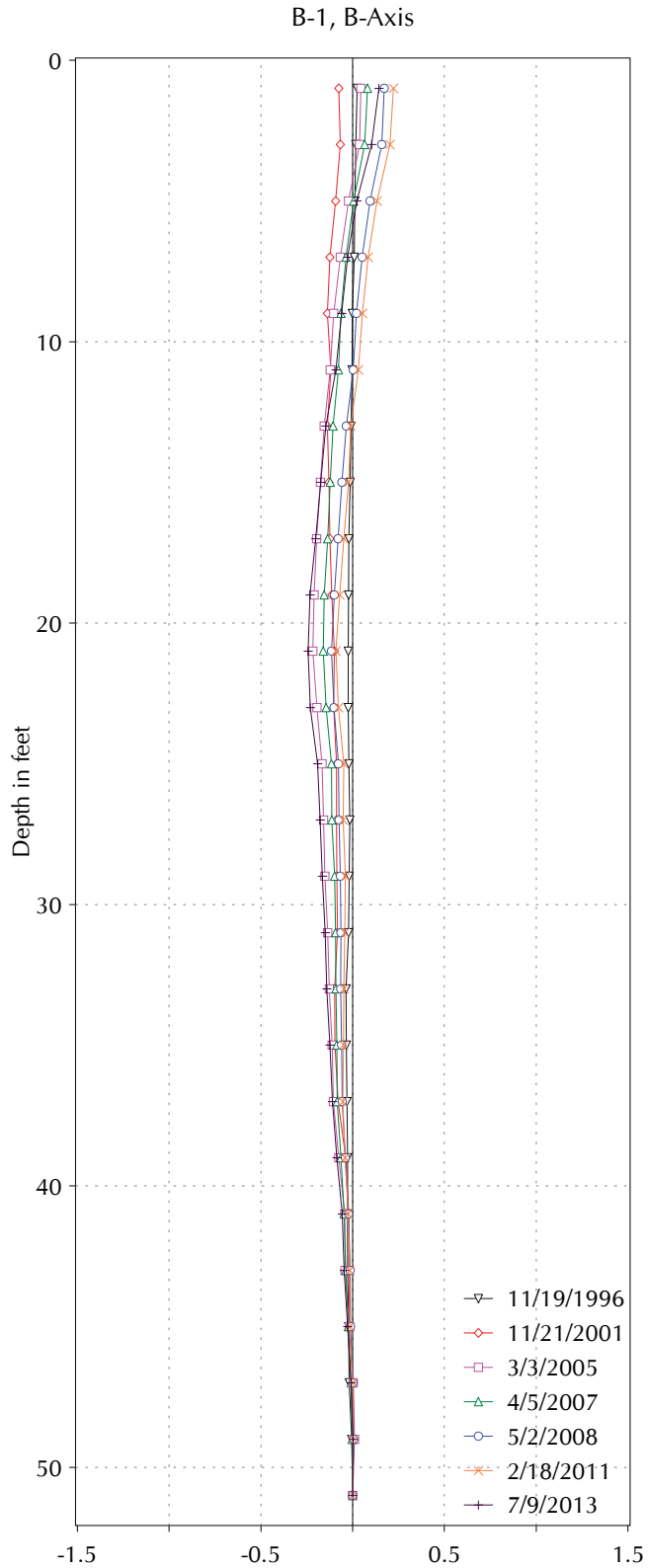


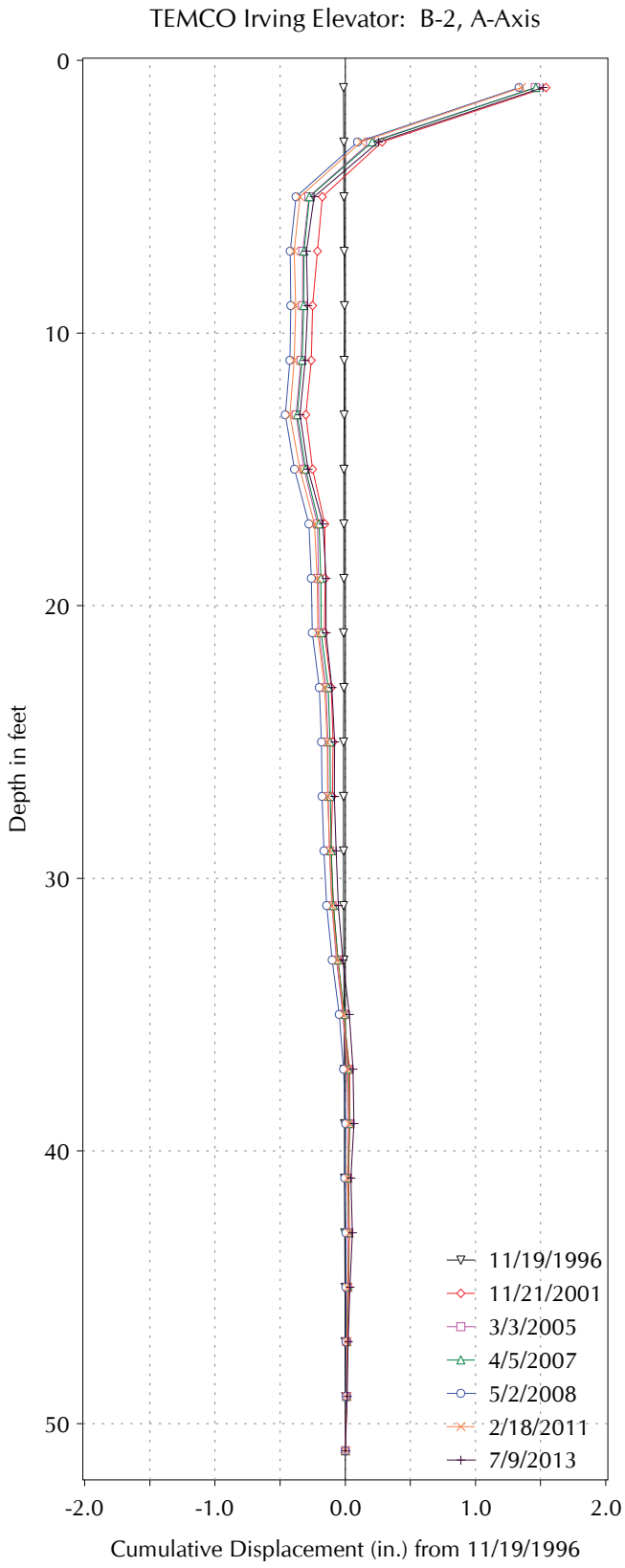


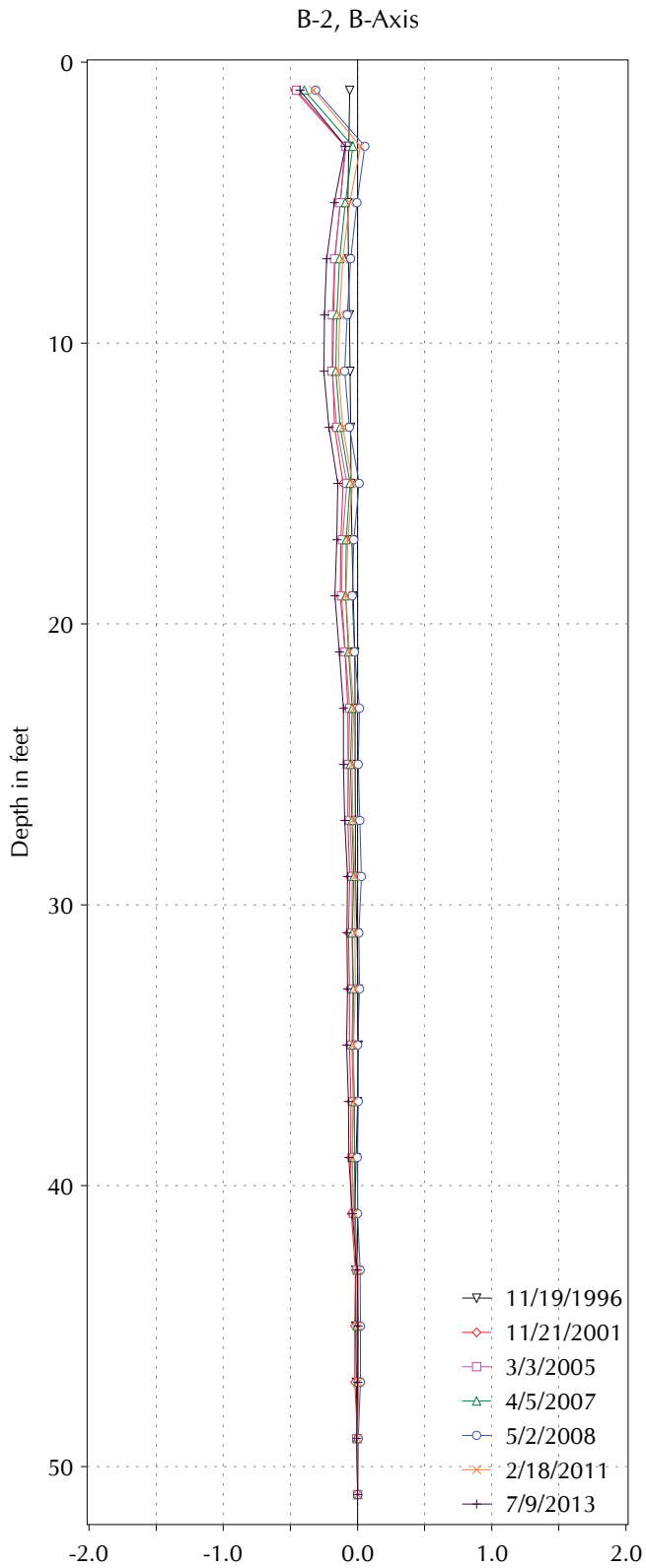
GRI

INCLINOMETER SUMMARY

(BORING B-1)

JULY 2015 JOB NO. 5445 FIG. D-1



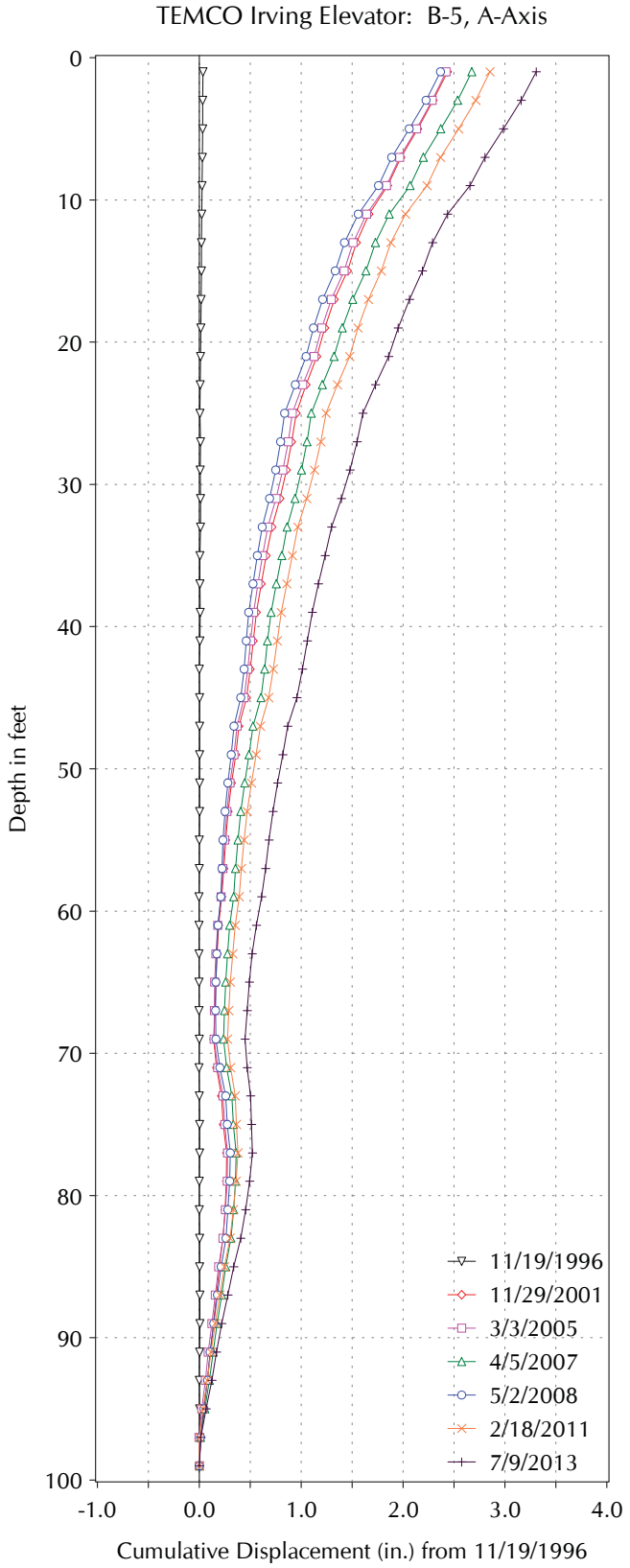


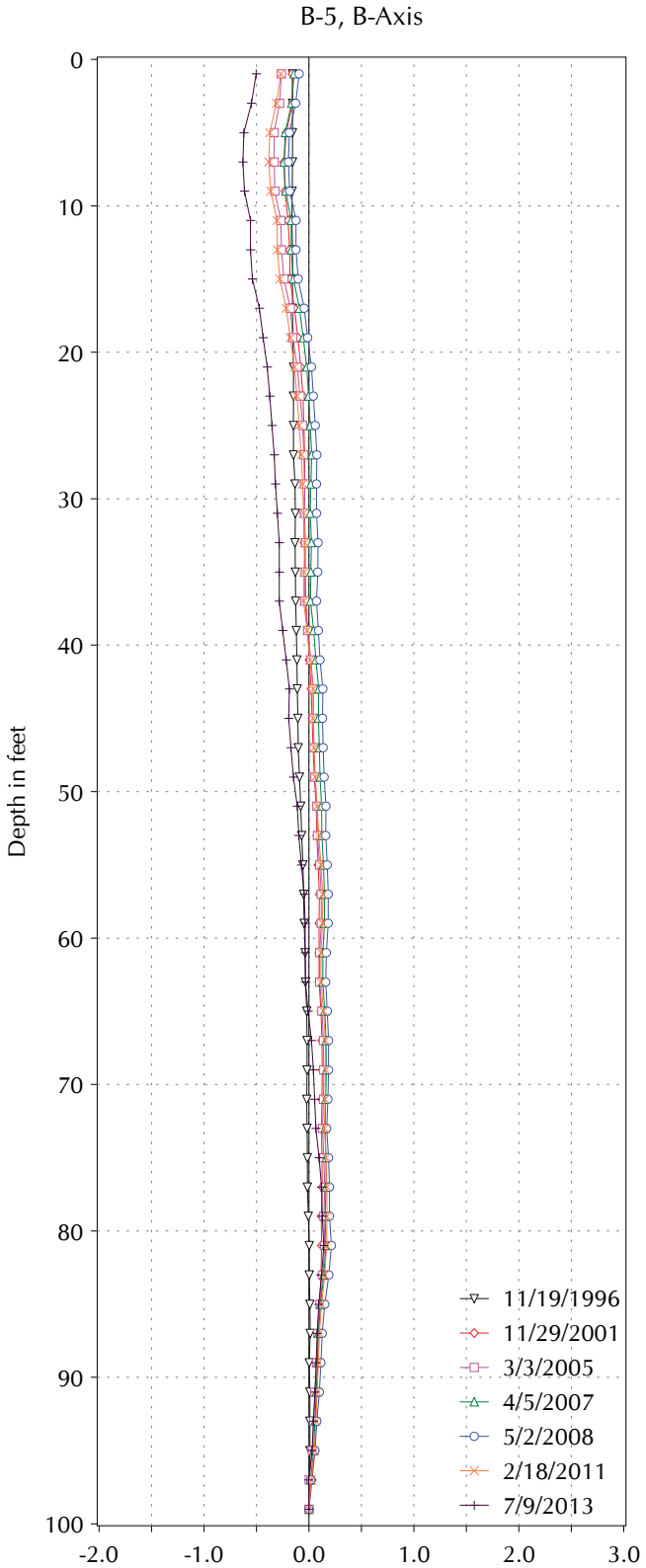
GRI

INCLINOMETER SUMMARY

(BORING B-2)

JULY 2015 JOB NO. 5445 FIG. D-2





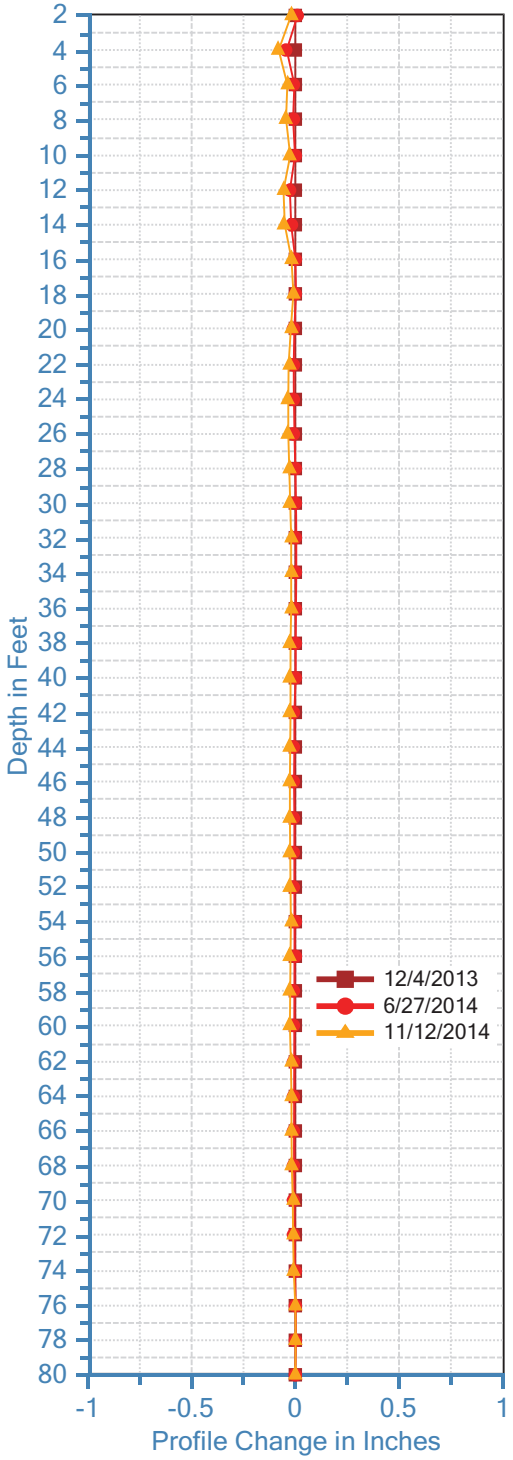
GRI

INCLINOMETER SUMMARY

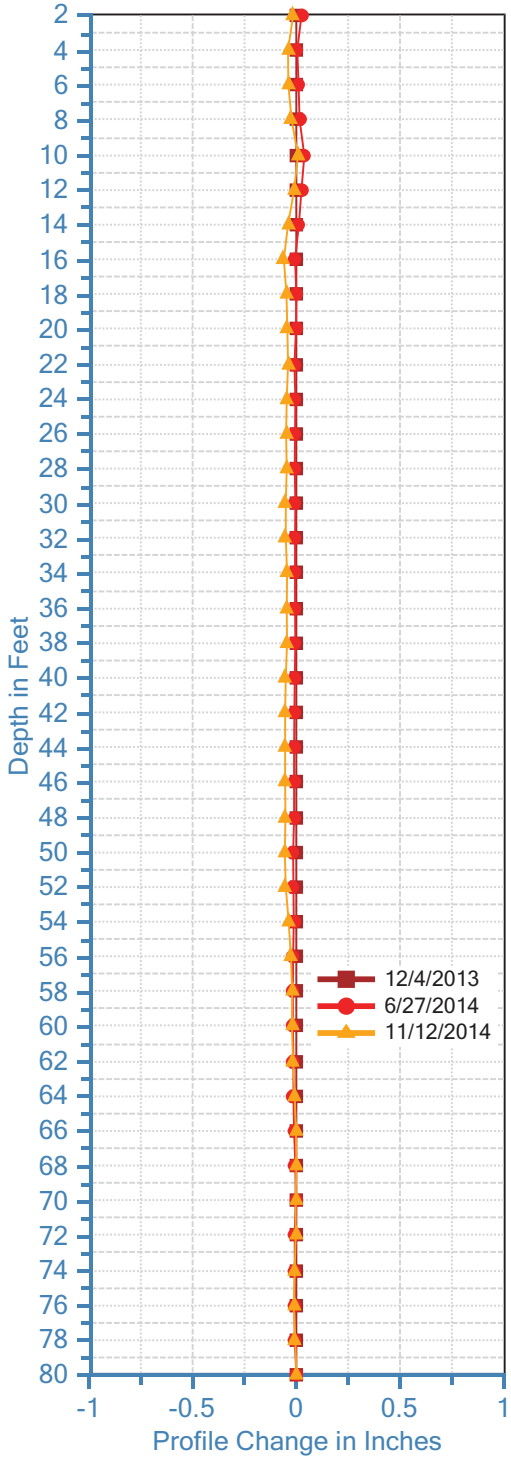
(BORING B-5)

JULY 2015 JOB NO. 5445 FIG. D-3

RiverMile 11 E-1 A



RiverMile 11 E-1 B



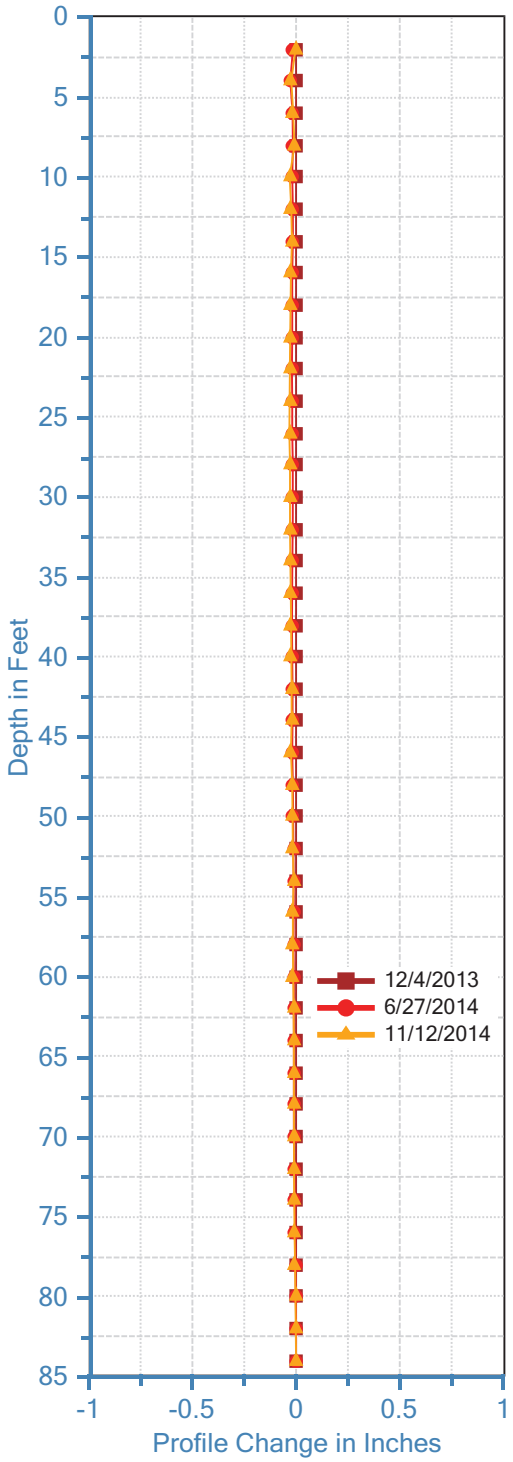
GRI

INCLINOMETER SUMMARY

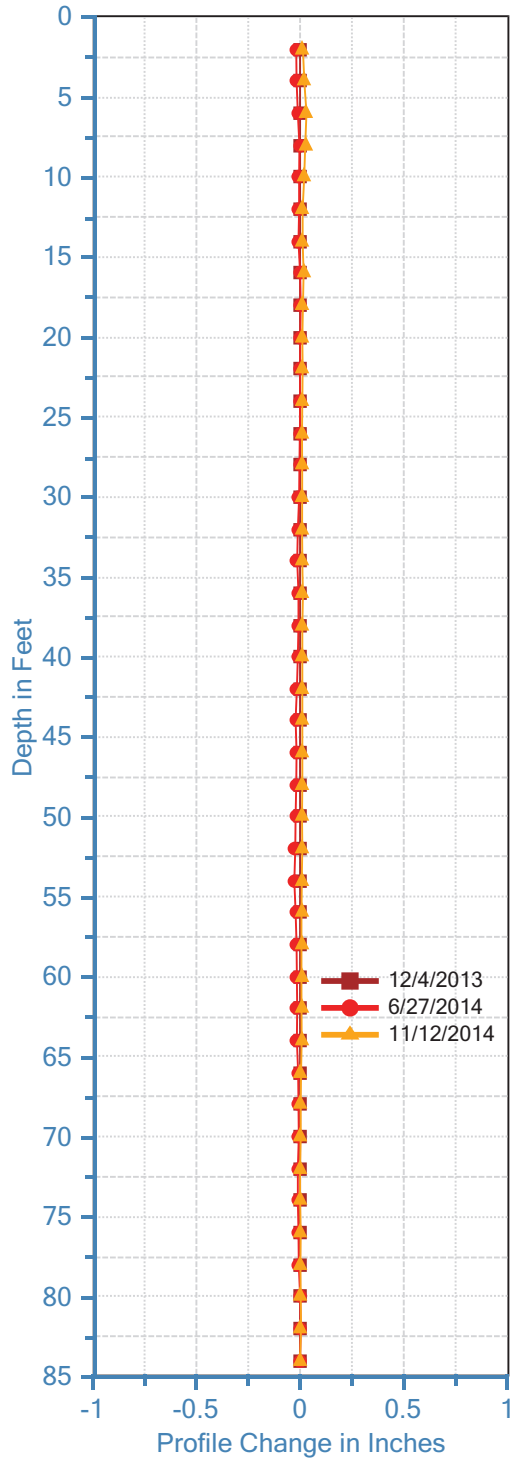
(BORING E-1)

JULY 2015 JOB NO. 5445 FIG. D-4

RiverMile 11 E-2 A



RiverMile 11 E-2 B



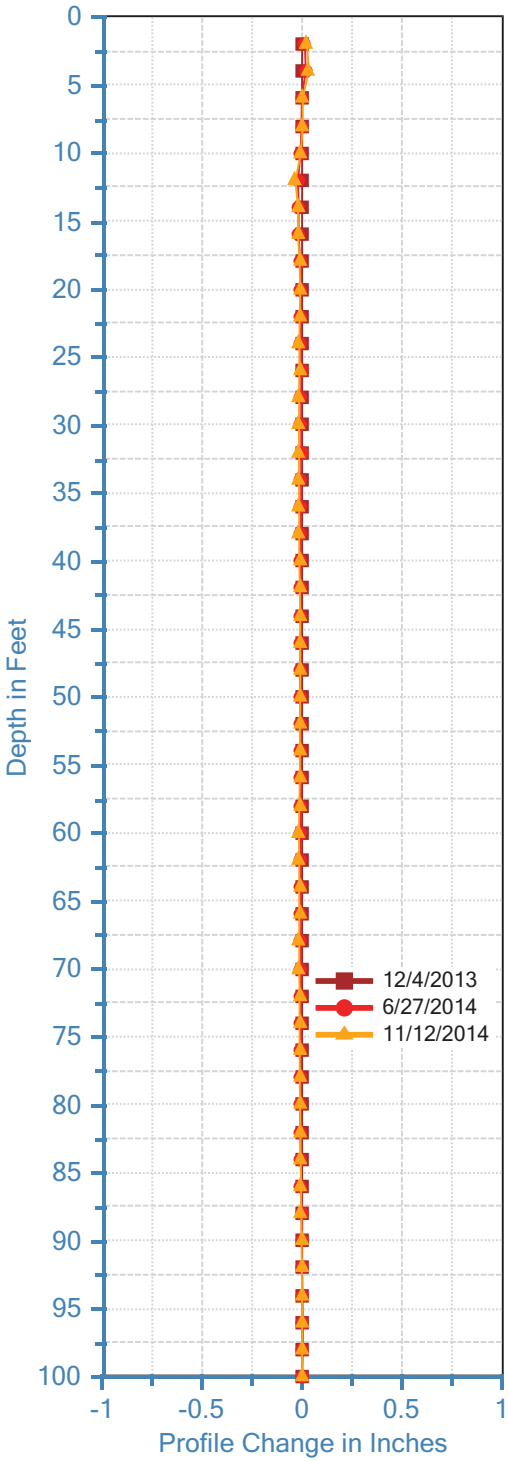
GRI

INCLINOMETER SUMMARY

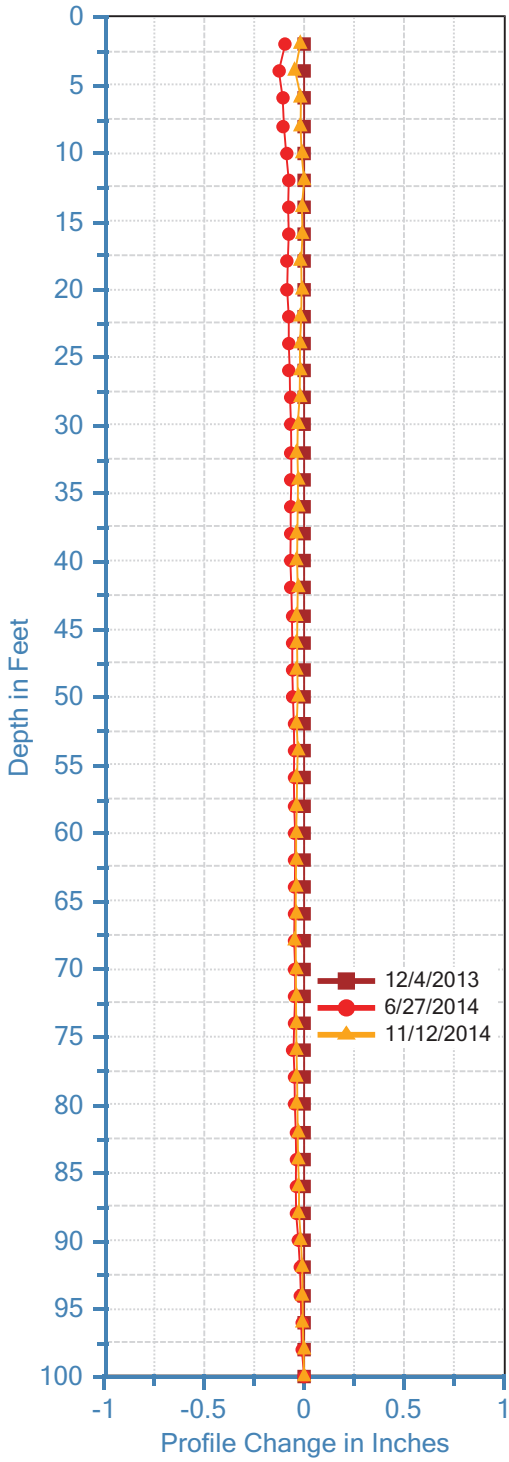
(BORING E-2)

JULY 2015 JOB NO. 5445 FIG. D-5

RiverMile 11 E-3 A



RiverMile 11 E-3 B



GRI

INCLINOMETER SUMMARY

(BORING E-3)

JULY 2015 JOB NO. 5445 FIG. D-6

APPENDIX E – RM11E PROJECT AREA BORING LOGS

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Boring Log ES-3046A (2007) E-117

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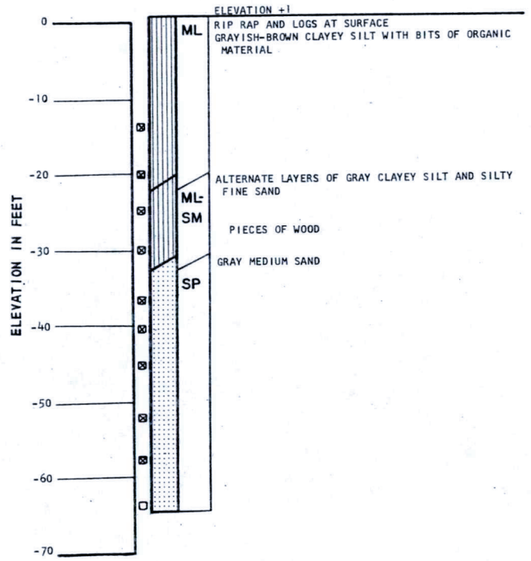
Oversized Page 1 of 2

BORING 1



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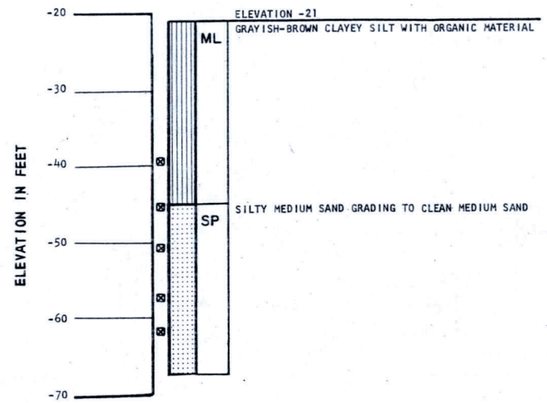

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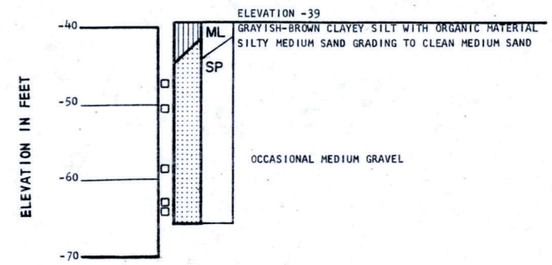

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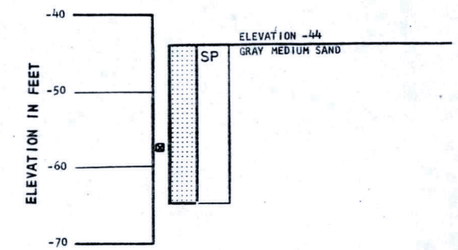

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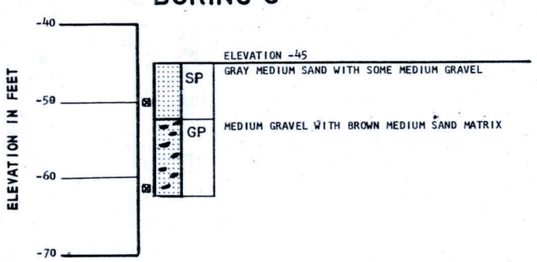

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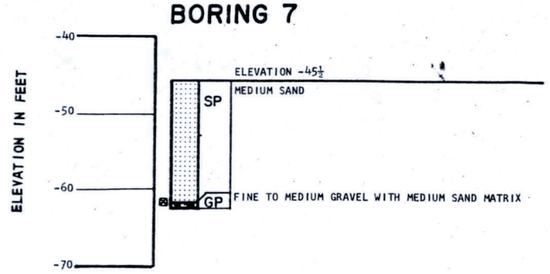

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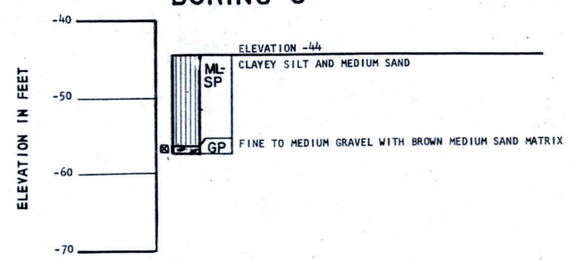

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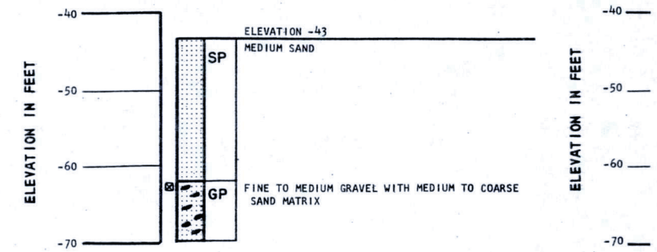


NOTE:
UNLESS OTHERWISE NOTED, TERMINATION OF THE BORINGS ABOVE ELEVATION -66 WAS DUE TO INSUFFICIENT JETTING ACTION RATHER THAN OCCURRENCE OF A HARD OR CEMENTED STRATUM.

ELEVATIONS REFER TO U.S.E.D. DATUM

REVISIONS
BY ____ DATE ____
BY ____ DATE ____
PLATE ____ OF ____

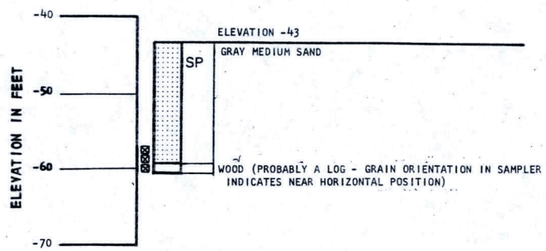
FILE 0623-012
BY S.D. DATE 6/25/80
CHECKED BY ____ DATE ____

466.11 (3-64)

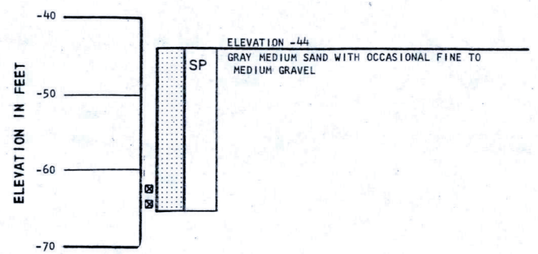
4

ION -44
EDIUM SAND

BORING 4 A



BORING 4 B



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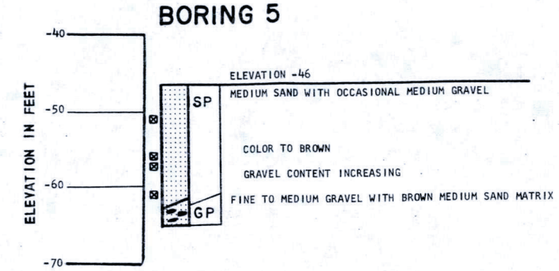
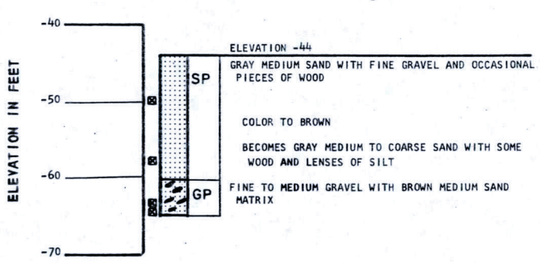
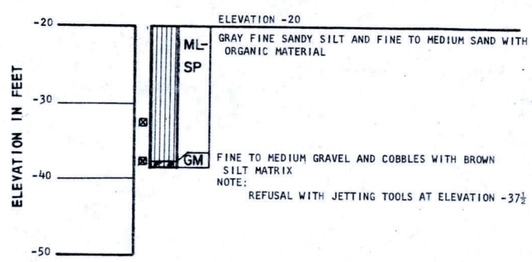


BORING 9A

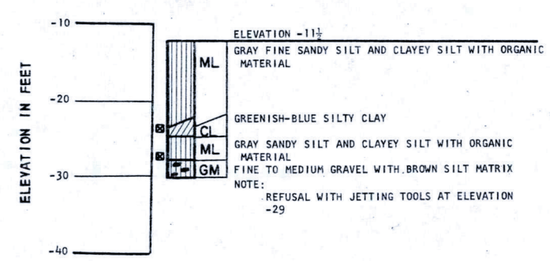
COARSE



BORING 10 B



BORING 10 A



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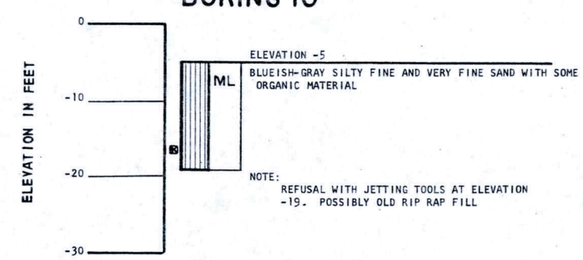

LOG OF BORINGS

DAMES & MOORE

PLATE A-1

APPENDIX C: BORING B-1A

CLIENT: Smith Monroe Gray Engineers, Inc.	PROJECT NO.: 13-007
PROJECT: FGIS Building Addition, TEMCO, 800 North River Street, Portland	BORING TYPE: Truck Mounted Diedrich D-50 with mud rotary & HSA
LOCATION: 34' north and 3 feet east of southwest building corner	ELEVATION: not available
DATE DRILLED: 1/24/2013	LOGGED BY: Troy Hull, P.E., G.E. & Eric Schellenger, E.I.T.

DEPTH (ft)	SAMPLE NO.	SAMPLE	SOIL DESCRIPTION	BLOWS PER 6 inches	Corrected N_{60}	% PASSING #200 SIEVE	LIQUID LIMIT	PLASTIC LIMIT	MOISTURE CONTENT (%)	REMARKS
			ASPHALT PAVEMENT - 3 inches thick							
	SPT-1	■	**FILL** - gravel base rock, wet	6 3						
		■	**SILTY GRAVEL WITH SAND** - brown, wet, medium dense (OLD FILL)	5	11					
		□		4						
	SPT-2	■		4 5	12					
5		□								
	SPT-3	■		5 4 5	12					Lost circulation at 5'. Rig bouncing at 6.5', switched to HSA.
		□								
			Boring terminated at 7 feet (practical drilling refusal). Groundwater not encountered. Boring backfilled with bentonite chips on 1/24/13. Automatic SPT hammer had a hammer energy ratio of 79% and a calibration factor of 1.32 (i.e. 79%/60%) per 8/1/12 report from Subsurface Technologies.							

EARTH ENGINEERS, Inc.

APPENDIX C: BORING B-1B

CLIENT: Smith Monroe Gray Engineers, Inc.	PROJECT NO.: 13-007
PROJECT: FGIS Building Addition, TEMCO, 800 North River Street, Portland	BORING TYPE: Truck Mounted Diedrich D-50 with HSA
LOCATION: 28' north and 3 feet east of southwest building corner	ELEVATION: not available
DATE DRILLED: 1/24/2013	LOGGED BY: Troy Hull, P.E., G.E. & Eric Schellenger, E.I.T.

DEPTH (ft)	SAMPLE NO.	SAMPLE	SOIL DESCRIPTION	BLOWS PER 6 inches	Corrected N_{60}	% PASSING #200 SIEVE	LIQUID LIMIT	PLASTIC LIMIT	MOISTURE CONTENT (%)	REMARKS
			ASPHALT PAVEMENT - 3 inches thick							
										Drilled to 7.5 without sampling.
5										Hard drilling at 4' on obstruction.
	SPT-1		**SILTY GRAVEL WITH SAND** - brown, wet, medium dense (OLD FILL)	9 2 17	25					No sample recovery.
10	SPT-2			12 6 8	18					2" of sample recovery. Rock in spoon tip.
			Boring terminated at 12 feet (practical drilling refusal). Groundwater not encountered. Boring backfilled with bentonite chips on 1/24/13. Automatic SPT hammer had a hammer energy ratio of 79% and a calibration factor of 1.32 (i.e. 79%/60%) per 8/1/12 report from Subsurface Technologies.							

EARTH ENGINEERS, Inc.

APPENDIX C: BORING B-2

CLIENT: Smith Monroe Gray Engineers, Inc.	PROJECT NO.: 13-007
PROJECT: FGIS Building Addition, TEMCO, 800 North River Street, Portland	BORING TYPE: Truck Mounted Diedrich D-50 with HSA & mud rotary
LOCATION: 37' north and 3 feet east of southeast building corner	ELEVATION: not available
DATE DRILLED: 1/24/2013	LOGGED BY: Troy Hull, P.E., G.E. & Eric Schellenger, E.I.T.

DEPTH (ft)	SAMPLE NO.	SAMPLE	SOIL DESCRIPTION	BLOWS PER 6 inches	Corrected N_{60}	% PASSING #200 SIEVE	LIQUID LIMIT	PLASTIC LIMIT	MOISTURE CONTENT (%)	REMARKS
			ASPHALT PAVEMENT - 3 inches thick							
	SPT-1	■	**SILTY GRAVEL WITH SAND** - brown, moist, dense (OLD FILL)	12 12 14	34	42			14	hollow stem auger drilling.
	SPT-2	■	gray, becomes very dense	8 23 24	62				6	
5										
				- - -						Void from 5' to 9'. Sampling rod dropped to 9' when attempting to sample at 5'.
				- - -						
10										
	SPT-3	■	**SILT** - brown, moist, very soft	0 0 0	0				24	
	SPT-4	■	mottled gray-orange-brown, wet	0 0 0	0	88			32	
15										
	SPT-5	■	light brown, becomes stiff	1 3 6	12	97			35	
20										
	SPT-6	■	brown, wet, medium stiff to stiff layered sands visible	2 4 3	9	94			29	Qp: 1 to 1.5 tsf
25										

13-007-1 (Appendix C, Boring Logs, FINAL).xls, B-2 (0-25')

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APPENDIX C: BORING B-2

CLIENT: Smith Monroe Gray Engineers, Inc.	PROJECT NO.: 13-007
PROJECT: FGIS Building Addition, TEMCO, 800 North River Street, Portland	BORING TYPE: Truck Mounted Diedrich D-50 with mud rotary & HSA
LOCATION: 34' north and 3 feet east of southwest building corner	ELEVATION: not available
DATE DRILLED: 1/24/2013	LOGGED BY: Troy Hull, P.E., G.E. & Eric Schellenger, E.I.T.

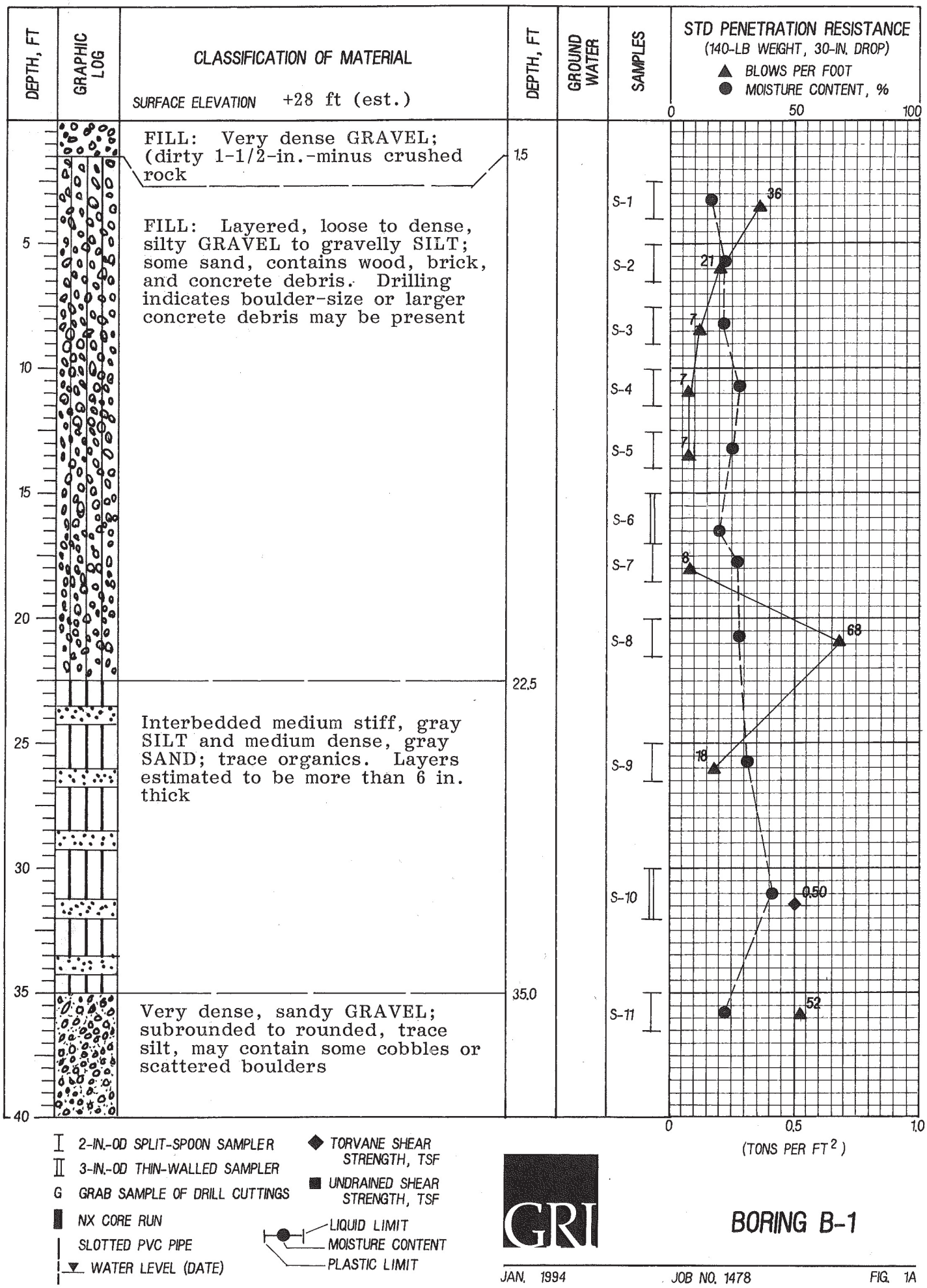
DEPTH (ft)	SAMPLE NO.	SAMPLE	SOIL DESCRIPTION	BLOWS PER 6 inches	Corrected N_{60}	% PASSING #200 SIEVE	LIQUID LIMIT	PLASTIC LIMIT	MOISTURE CONTENT (%)	REMARKS
	SPT-7	■	**SILT -** brown, wet, very soft to medium stiff	3 2 3	7	99			47	Qp: 0 to 0.5 tsf
30	SPT-8	■		2 3 4	9	98			42	
35	SPT-9	■		2 2 5	9	98			38	Qp: 0 to 0.75 tsf
										Drill rod was wet @ 38'.
40	SPT-10	■	mottled gray & red-brown	2 3 4	9	92			39	Switched to mud rotary.
45	SPT-11	■	**GRAVELLY, SANDY SILT -** wet, very dense	30 27 12	51	6			13	Driller felt gravelly material from 44-46'.
50										

APPENDIX C: BORING B-2

CLIENT: Smith Monroe Gray Engineers, Inc.	PROJECT NO.: 13-007
PROJECT: FGIS Building Addition, TEMCO, 800 North River Street, Portland	BORING TYPE: Truck Mounted Diedrich D-50 with mud rotary & HSA
LOCATION: 34' north and 3 feet east of southwest building corner	ELEVATION: not available
DATE DRILLED: 1/24/2013	LOGGED BY: Troy Hull, P.E., G.E. & Eric Schellenger, E.I.T.

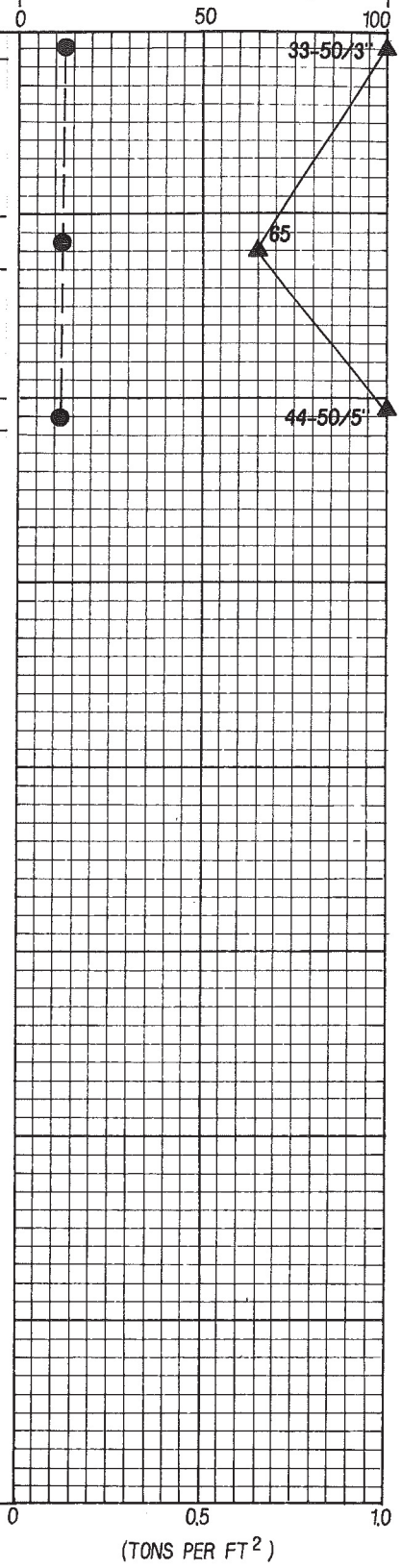
DEPTH (ft)	SAMPLE NO.	SAMPLE	SOIL DESCRIPTION	BLOWS PER 6 inches	Corrected N_{60}	% PASSING #200 SIEVE	LIQUID LIMIT	PLASTIC LIMIT	MOISTURE CONTENT (%)	REMARKS
	SPT-12	■	**SILT -** mottled brown-gray-orange, wet, very stiff	13 10 11	28	88			39	
55										
60	SPT-13	■	**GRAVEL WITH SAND -** wet, very dense	32 50/5"	66/5"	10			14	
			Boring terminated at approximately 61 feet. Groundwater encountered during drilling at 38 feet. Boring backfilled with bentonite chips on 1/24/13. Automatic SPT hammer had a hammer energy ratio of 79% and a calibration factor of 1.32 (i.e. 79%/60%) per 8/1/12 report from Subsurface Technologies.							

EARTH ENGINEERS, Inc.


DEPTH, FT
GRAPHIC LOG
CLASSIFICATION OF MATERIAL
SURFACE ELEVATION +28 ft (est.)
DEPTH, FT
GROUND WATER
SAMPLES
STD PENETRATION RESISTANCE
(140-LB WEIGHT, 30-IN. DROP)
BLOWS PER FOOT
MOISTURE CONTENT, %
0
50
100
FILL: Very dense GRAVEL; (dirty 1-1/2-in.-minus crushed rock
1.5
FILL: Layered, loose to dense, silty GRAVEL to gravelly SILT; some sand, contains wood, brick, and concrete debris. Drilling indicates boulder-size or larger concrete debris may be present
22.5
Interbedded medium stiff, gray SILT and medium dense, gray SAND; trace organics. Layers estimated to be more than 6 in. thick
35.0
Very dense, sandy GRAVEL; subrounded to rounded, trace silt, may contain some cobbles or scattered boulders
5
10
15
20
25
30
35
40
S-1
S-2
S-3
S-4
S-5
S-6
S-7
S-8
S-9
S-10
S-11
36
21
7
7
7
8
68
18
0.50
52
0
0.5
1.0
(TONS PER FT 2)
2-IN.-OD SPLIT-SPOON SAMPLER
3-IN.-OD THIN-WALLED SAMPLER
G GRAB SAMPLE OF DRILL CUTTINGS
NX CORE RUN
SLOTTED PVC PIPE
WATER LEVEL (DATE)
TORVANE SHEAR STRENGTH, TSF
UNDRAINED SHEAR STRENGTH, TSF
LIQUID LIMIT
MOISTURE CONTENT
PLASTIC LIMIT
GRI
BORING B-1
JAN. 1994
JOB NO. 1478
FIG. 1A

DEPTH, FT	GRAPHIC LOG	CLASSIFICATION OF MATERIAL SURFACE ELEVATION +28 ft (est.)	DEPTH, FT	GROUND WATER	SAMPLES
45 50		Very dense, sandy GRAVEL; subrounded to rounded, trace silt, may contain some cobbles or boulders			S-12 S-13 S-14
		(12/8/93)	51.0		
55					

STD PENETRATION RESISTANCE
(140-LB WEIGHT, 30-IN. DROP)
▲ BLOWS PER FOOT
● MOISTURE CONTENT, %



I 2-IN.-OD SPLIT-SPOON SAMPLER
II 3-IN.-OD THIN-WALLED SAMPLER
G GRAB SAMPLE OF DRILL CUTTINGS
NX CORE RUN
SLOTTED PVC PIPE
▼ WATER LEVEL (DATE)

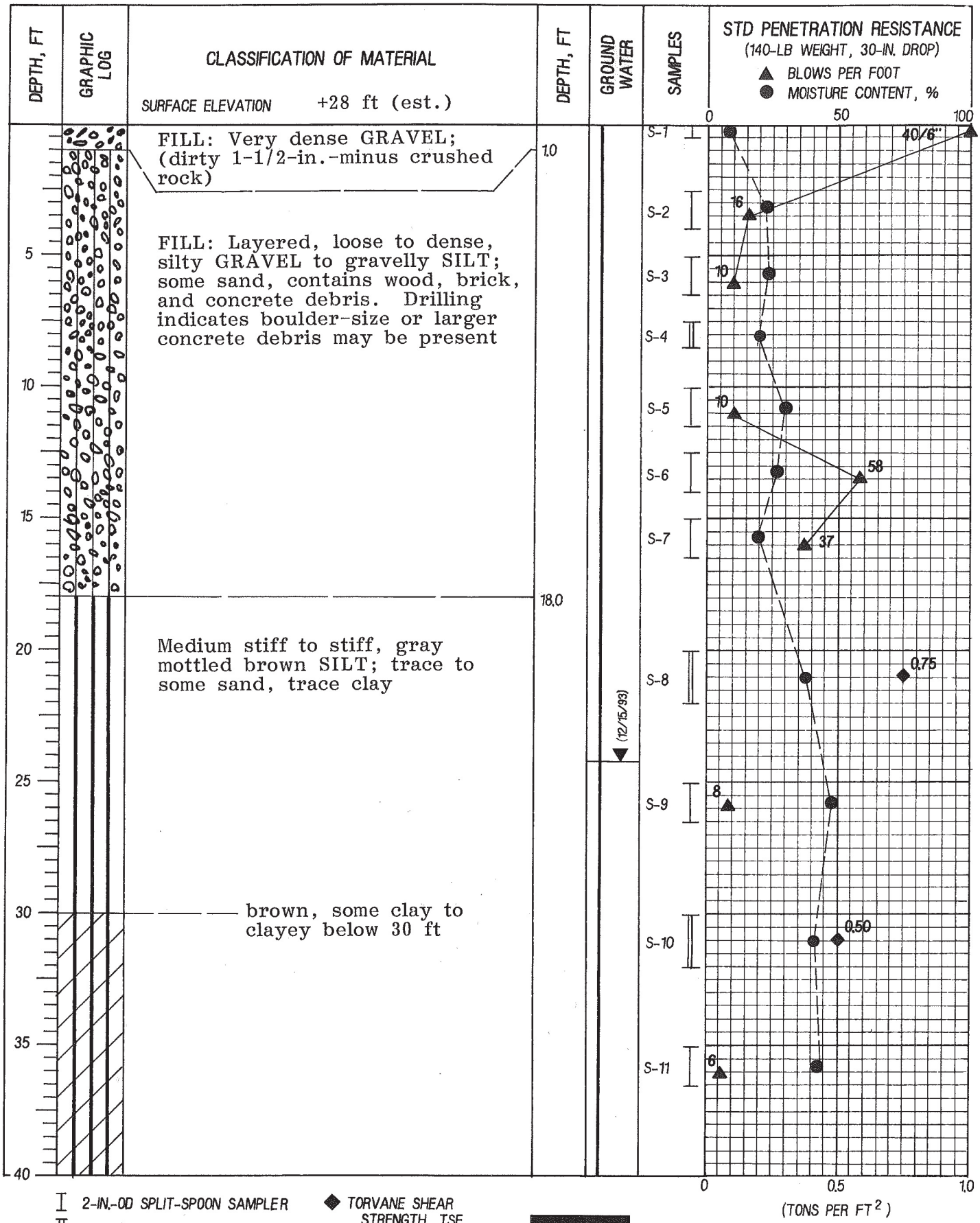
◆ TORVANE SHEAR STRENGTH, TSF
■ UNDRAINED SHEAR STRENGTH, TSF

LIQUID LIMIT
MOISTURE CONTENT
PLASTIC LIMIT

GRI

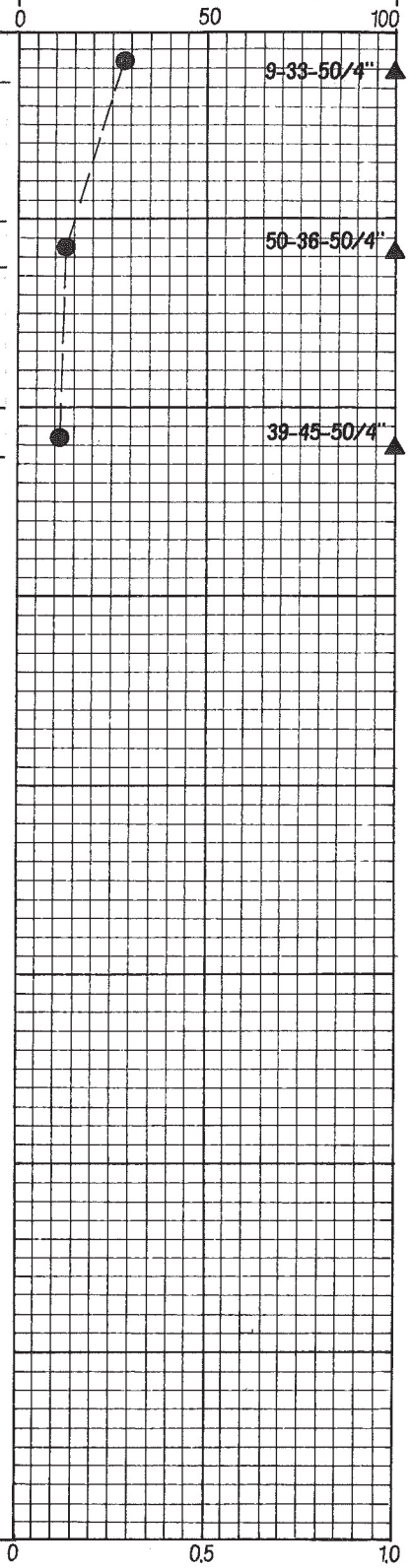
BORING B-1 (CONT.)

JAN. 1994 JOB NO. 1478 FIG. 1A


DEPTH, FT
GRAPHIC LOG
CLASSIFICATION OF MATERIAL
SURFACE ELEVATION +28 ft (est.)
DEPTH, FT
GROUND WATER
SAMPLES
STD PENETRATION RESISTANCE
(140-LB WEIGHT, 30-IN. DROP)
BLOWS PER FOOT
MOISTURE CONTENT, %
FILL: Very dense GRAVEL; (dirty 1-1/2-in.-minus crushed rock)
1.0
FILL: Layered, loose to dense, silty GRAVEL to gravelly SILT; some sand, contains wood, brick, and concrete debris. Drilling indicates boulder-size or larger concrete debris may be present
18.0
Medium stiff to stiff, gray mottled brown SILT; trace to some sand, trace clay
brown, some clay to clayey below 30 ft
(12/15/93)
S-1
S-2
S-3
S-4
S-5
S-6
S-7
S-8
S-9
S-10
S-11
40/6"
16
10
10
58
37
0.75
8
0.50
6
0
50
100
0
0.5
1.0
(TONS PER FT 2)
2-IN.-OD SPLIT-SPOON SAMPLER
3-IN.-OD THIN-WALLED SAMPLER
G GRAB SAMPLE OF DRILL CUTTINGS
NX CORE RUN
SLOTTED PVC PIPE
WATER LEVEL (DATE)
TORVANE SHEAR STRENGTH, TSF
UNDRAINED SHEAR STRENGTH, TSF
LIQUID LIMIT
MOISTURE CONTENT
PLASTIC LIMIT
GRI
BORING B-2
JAN. 1994
JOB NO. 1478
FIG. 2A

DEPTH, FT	GRAPHIC LOG	CLASSIFICATION OF MATERIAL SURFACE ELEVATION +28 ft (est.)	DEPTH, FT	GROUND WATER	SAMPLES
45 50		Very dense, sandy GRAVEL; subrounded to rounded, trace silt, may contain some cobbles or scattered boulders			S-12 S-13 S-14
55		(12/8/93)	51.5		

STD PENETRATION RESISTANCE
(140-LB WEIGHT, 30-IN. DROP)
▲ BLOWS PER FOOT
● MOISTURE CONTENT, %



I 2-IN.-OD SPLIT-SPOON SAMPLER
II 3-IN.-OD THIN-WALLED SAMPLER
G GRAB SAMPLE OF DRILL CUTTINGS
NX CORE RUN
SLOTTED PVC PIPE
▼ WATER LEVEL (DATE)

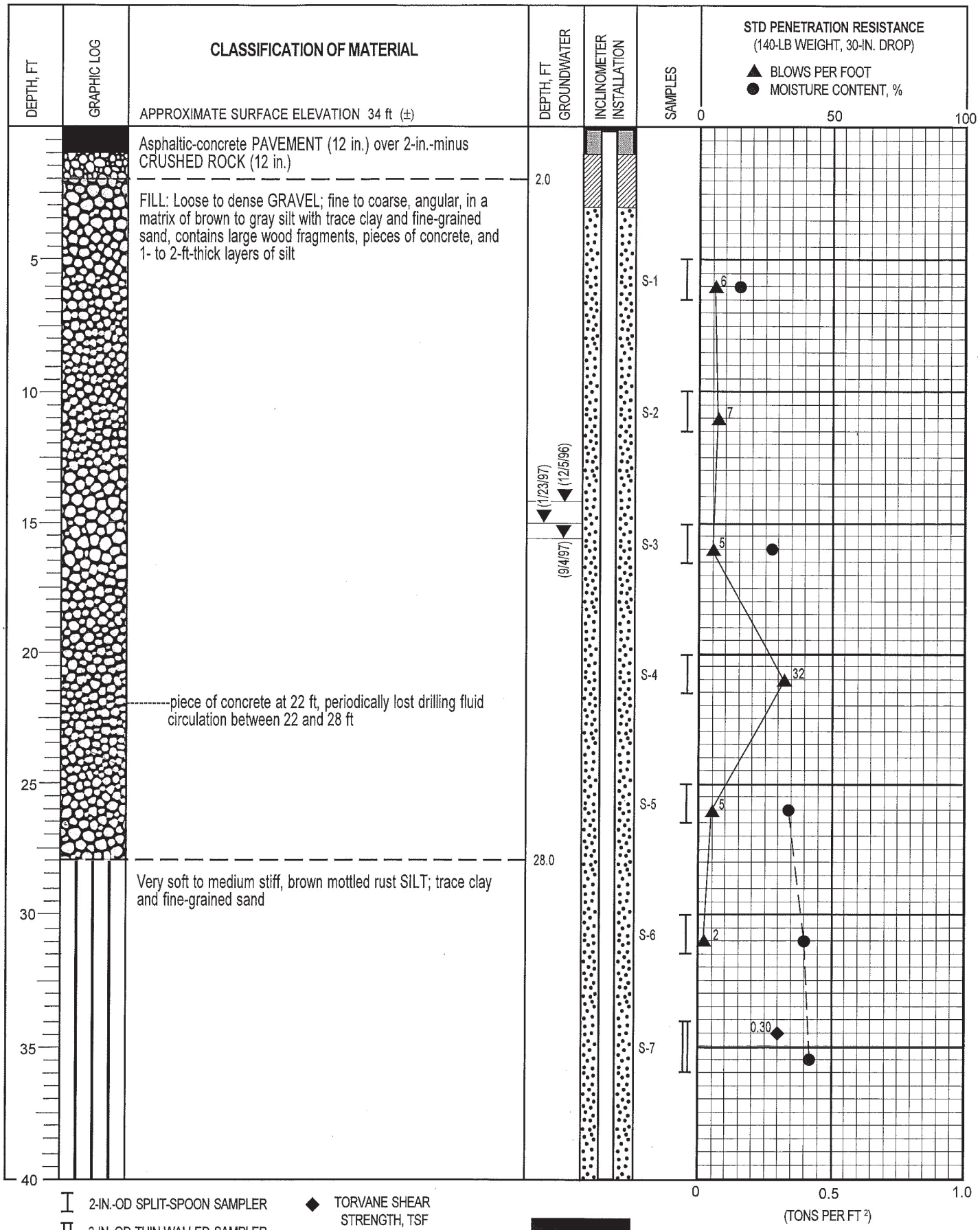
◆ TORVANE SHEAR STRENGTH, TSF
■ UNDRAINED SHEAR STRENGTH, TSF

LIQUID LIMIT
MOISTURE CONTENT
PLASTIC LIMIT

GRI

BORING B-2 (CONT.)

JAN. 1994 JOB NO. 1478 FIG. 2A



2-IN.-OD SPLIT-SPOON SAMPLER

3-IN.-OD THIN-WALLED SAMPLER

NX CORE RUN

INCLINOMETER CASING

Water Level (date)

TORVANE SHEAR STRENGTH, TSF

UNDRAINED SHEAR STRENGTH, TSF

NO RECOVERY

Liquid Limit

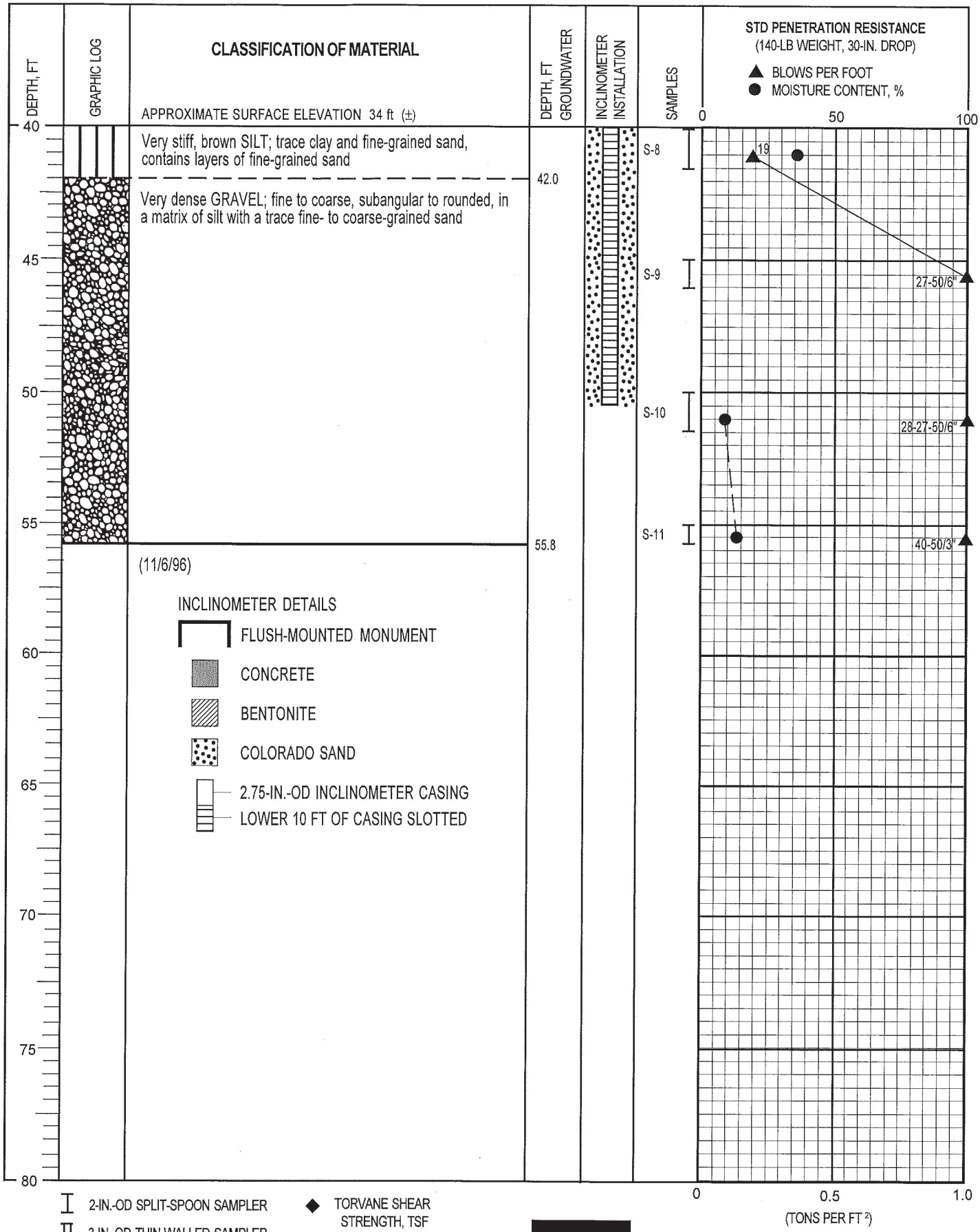
Moisture Content

Plastic Limit

GRI

BORING B-1

SEPT. 1997 JOB. NO. 2289 FIG. 1A



2-IN.-OD SPLIT-SPOON SAMPLER

3-IN.-OD THIN-WALLED SAMPLER

NX CORE RUN

INCLINOMETER CASING

Water Level (date)

TORVANE SHEAR STRENGTH, TSF

UNDRAINED SHEAR STRENGTH, TSF

NO RECOVERY

Liquid Limit

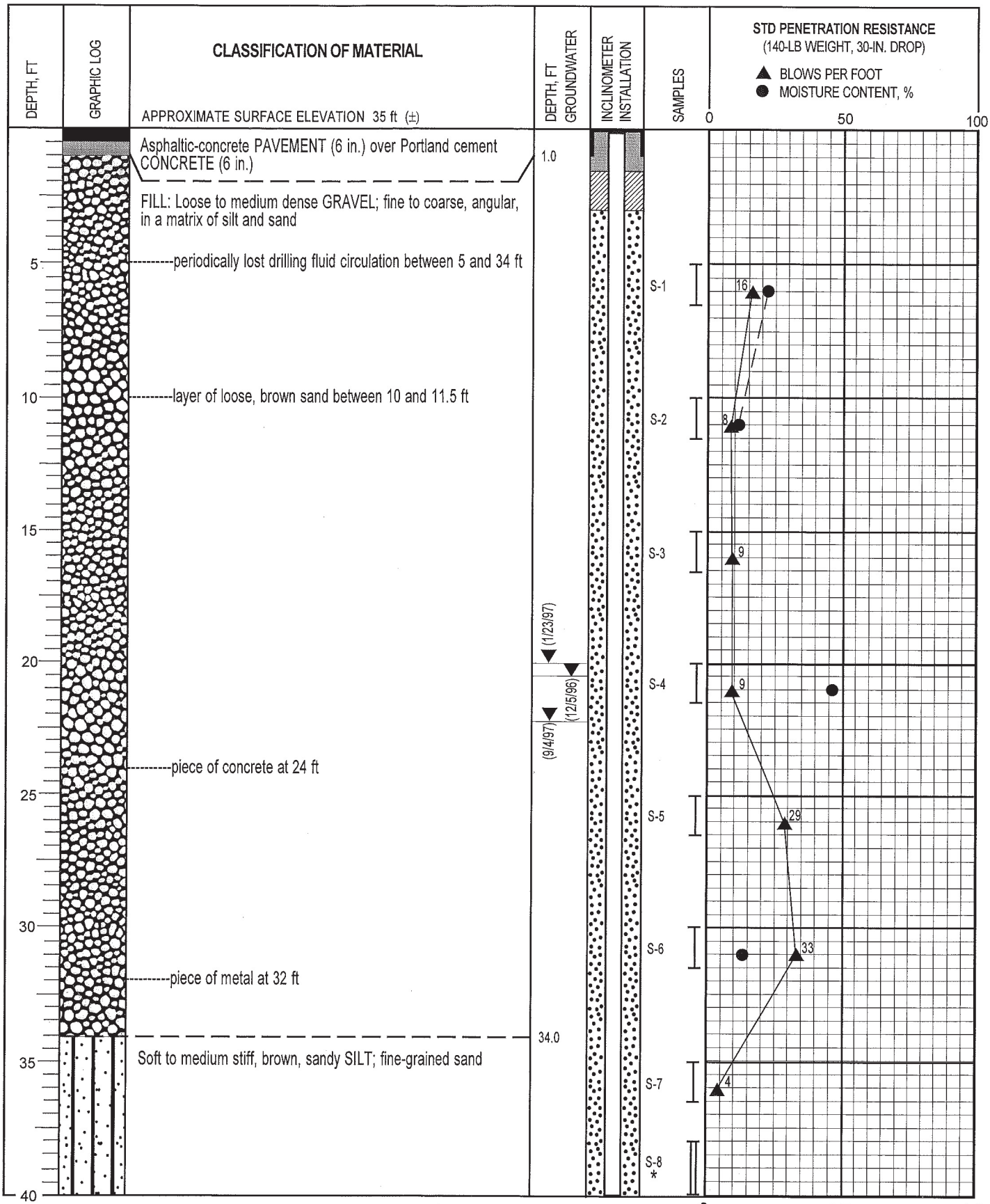
Moisture Content

Plastic Limit

GRI

BORING B-1 (cont.)

SEPT. 1997 JOB. NO. 2289 FIG. 1A



2-IN.-OD SPLIT-SPOON SAMPLER

3-IN.-OD THIN-WALLED SAMPLER

NX CORE RUN

INCLINOMETER CASING

Water Level (date)

TORVANE SHEAR STRENGTH, TSF

UNDRAINED SHEAR STRENGTH, TSF

* NO RECOVERY

Liquid Limit

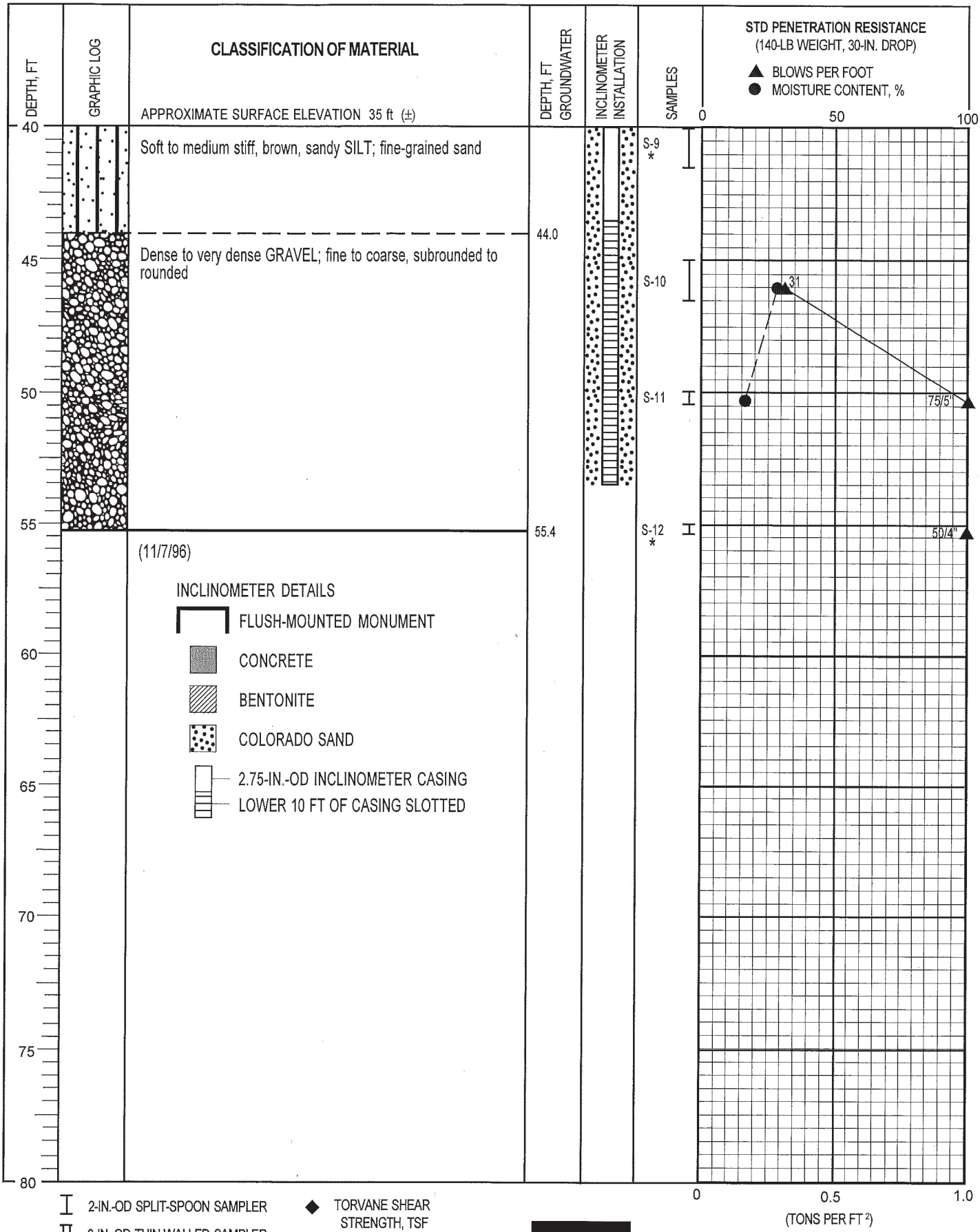
Moisture Content

Plastic Limit

GRI

BORING B-2

SEPT. 1997 JOB. NO. 2289 FIG. 2A



2-IN.-OD SPLIT-SPOON SAMPLER

3-IN.-OD THIN-WALLED SAMPLER

NX CORE RUN

INCLINOMETER CASING

Water Level (date)

TORVANE SHEAR STRENGTH, TSF

UNDRAINED SHEAR STRENGTH, TSF

* NO RECOVERY

Liquid Limit

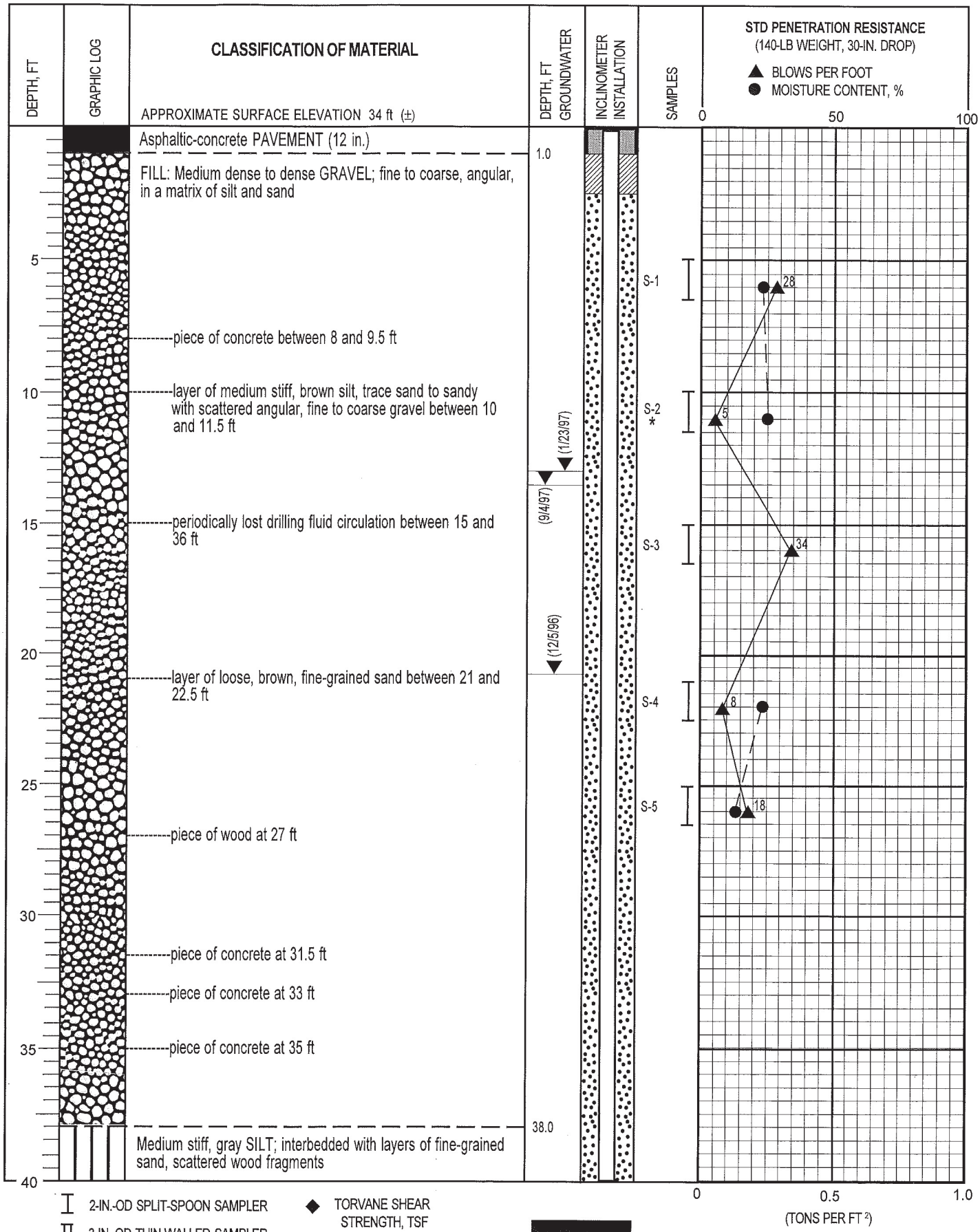
Moisture Content

Plastic Limit

GRI

BORING B-2 (cont.)

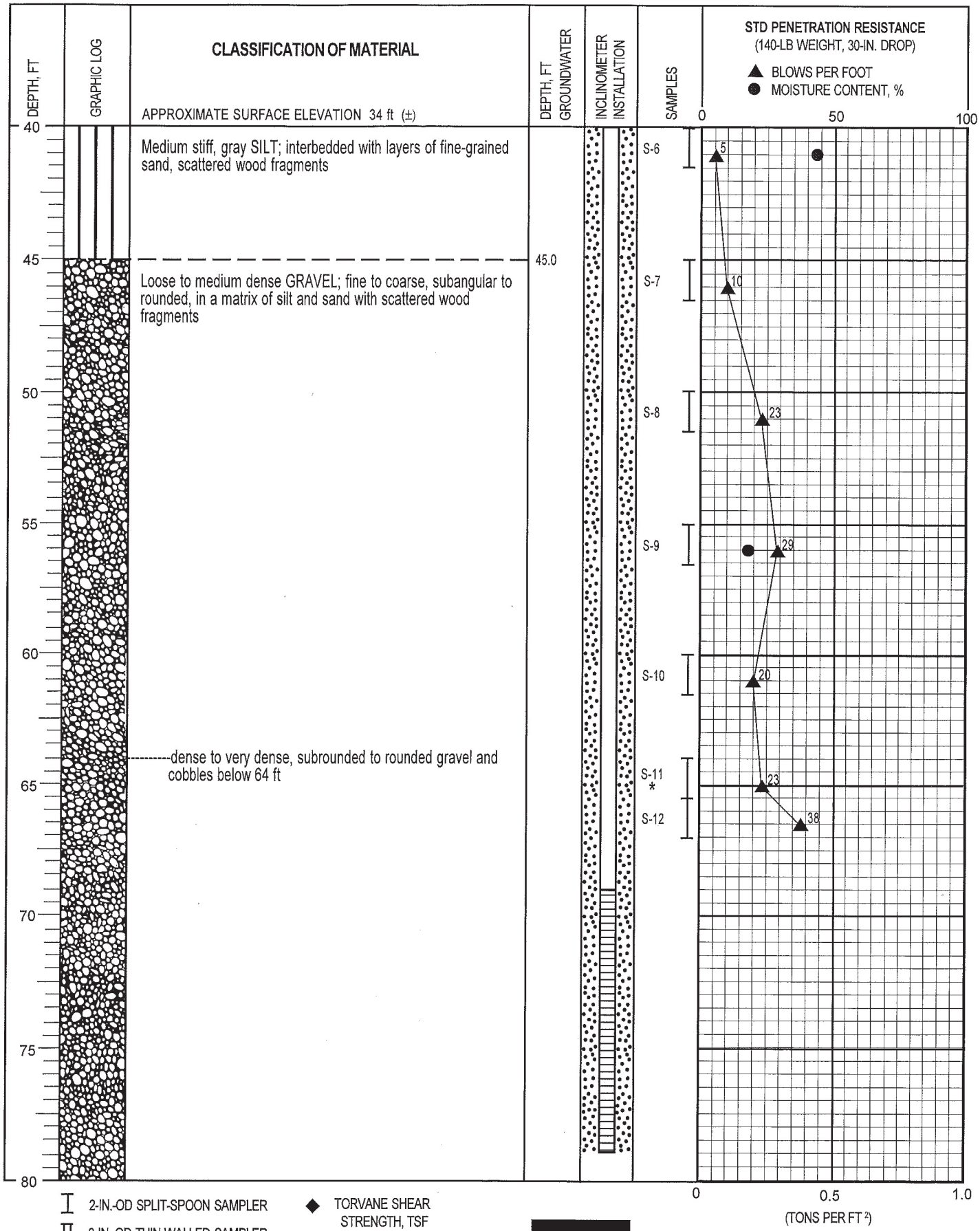
SEPT. 1997 JOB. NO. 2289 FIG. 2A



GRI

BORING B-3

SEPT. 1997 JOB. NO. 2289 FIG. 3A



2-IN.-OD SPLIT-SPOON SAMPLER

3-IN.-OD THIN-WALLED SAMPLER

NX CORE RUN

INCLINOMETER CASING

Water Level (date)

TORVANE SHEAR STRENGTH, TSF

UNDRAINED SHEAR STRENGTH, TSF

* NO RECOVERY

Liquid Limit

Moisture Content

Plastic Limit

GRI

BORING B-3 (cont.)

SEPT. 1997 JOB. NO. 2289 FIG. 3A

DEPTH, FT	GRAPHIC LOG	CLASSIFICATION OF MATERIAL	DEPTH, FT GROUNDWATER	INCLINOMETER INSTALLATION	SAMPLES	STD PENETRATION RESISTANCE (140-LB WEIGHT, 30-IN. DROP) ▲ BLOWS PER FOOT ● MOISTURE CONTENT, %
		APPROXIMATE SURFACE ELEVATION 34 ft (±)				
80		Dense to very dense GRAVEL and COBBLES; subrounded to rounded in a matrix of silt and sand				
			82.3		S-13	50/3"
		(11/14/96)				
85		INCLINOMETER DETAILS				
		FLUSH-MOUNTED MONUMENT				
		CONCRETE				
		BENTONITE				
90		COLORADO SAND				
		2.75-IN.-OD INCLINOMETER CASING				
		LOWER 10 FT OF CASING SLOTTED				

0 50 100

0 0.5 1.0
(TONS PER FT²)

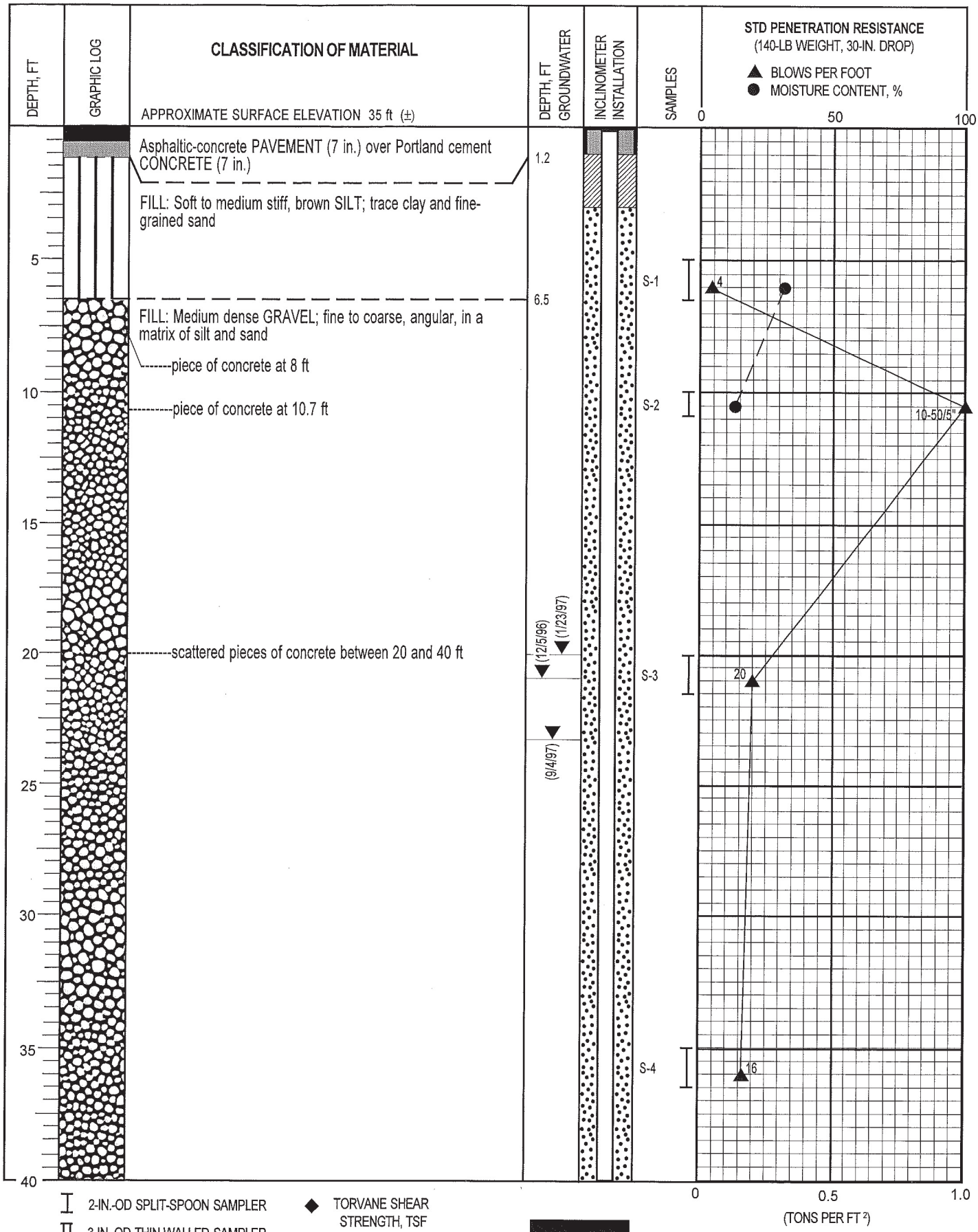
2-IN.-OD SPLIT-SPOON SAMPLER
3-IN.-OD THIN-WALLED SAMPLER
NX CORE RUN
INCLINOMETER CASING
Water Level (date)

TORVANE SHEAR STRENGTH, TSF
UNDRAINED SHEAR STRENGTH, TSF
NO RECOVERY
Liquid Limit
Moisture Content
Plastic Limit

GRI

BORING B-3 (cont.)

SEPT. 1997 JOB. NO. 2289 FIG. 3A



2-IN.-OD SPLIT-SPOON SAMPLER

3-IN.-OD THIN-WALLED SAMPLER

NX CORE RUN

INCLINOMETER CASING

Water Level (date)

TORVANE SHEAR STRENGTH, TSF

UNDRAINED SHEAR STRENGTH, TSF

NO RECOVERY

Liquid Limit

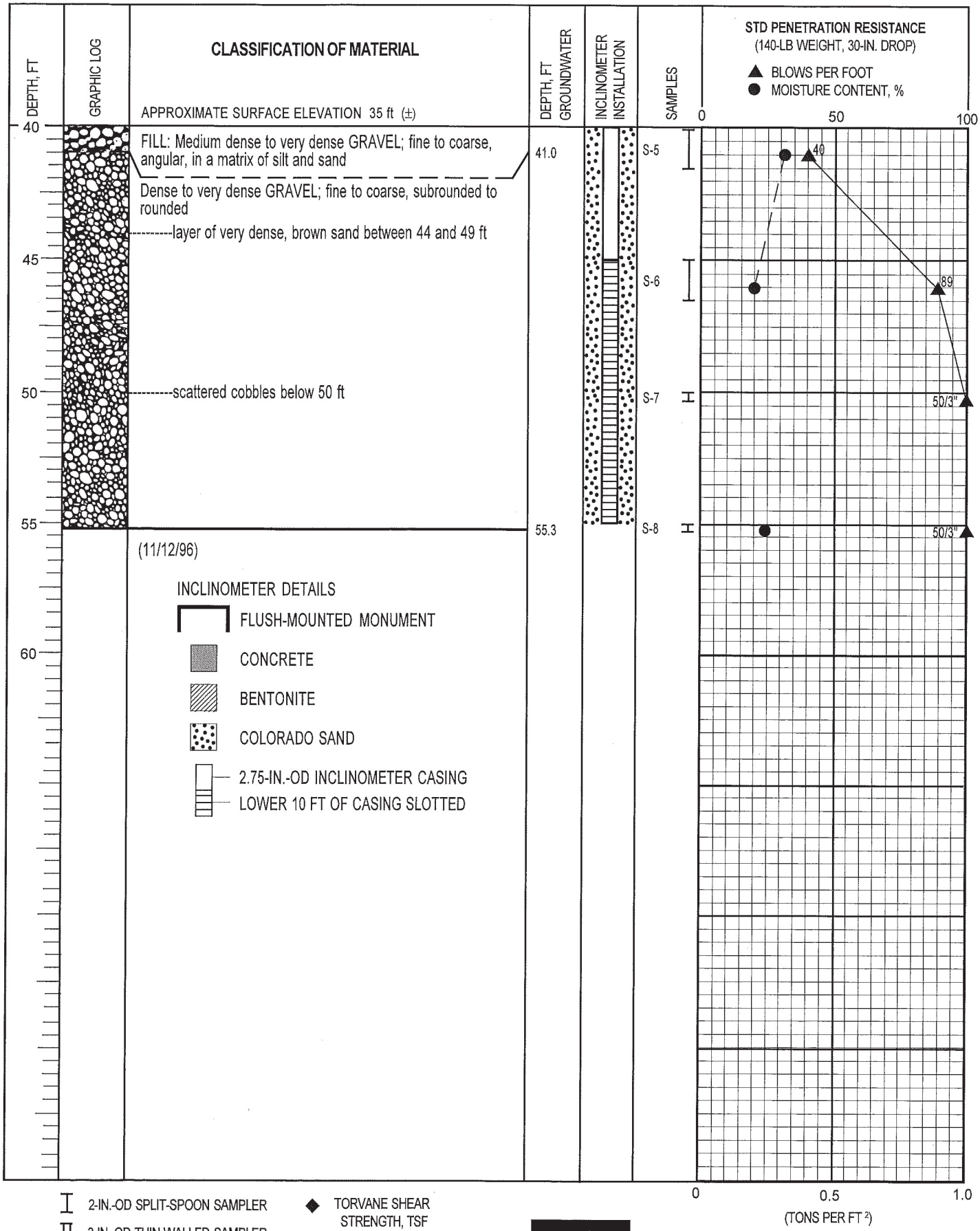
Moisture Content

Plastic Limit

GRI

BORING B-4

SEPT. 1997 JOB. NO. 2289 FIG. 4A



2-IN.-OD SPLIT-SPOON SAMPLER

3-IN.-OD THIN-WALLED SAMPLER

NX CORE RUN

INCLINOMETER CASING

Water Level (date)

TORVANE SHEAR STRENGTH, TSF

UNDRAINED SHEAR STRENGTH, TSF

NO RECOVERY

Liquid Limit

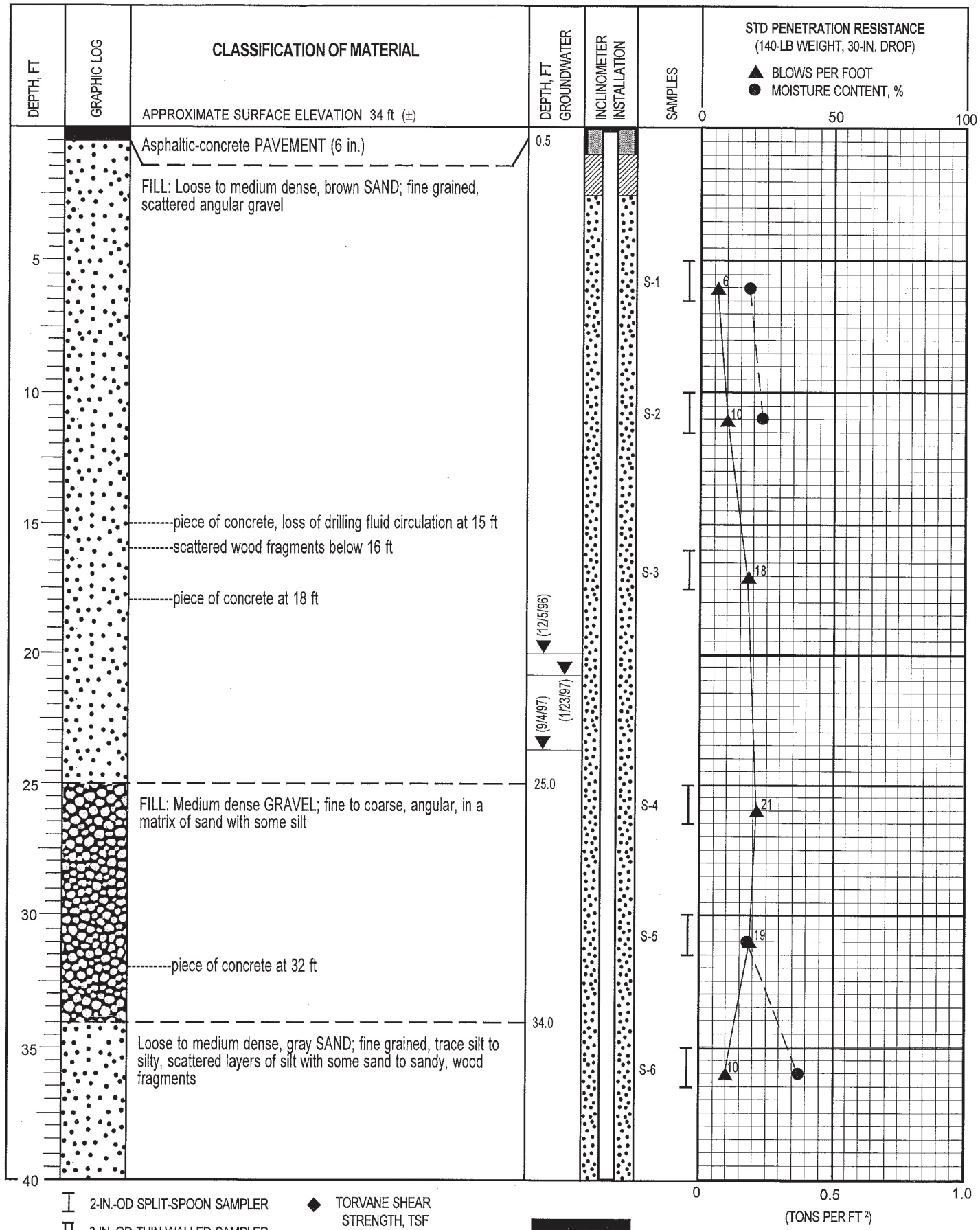
Moisture Content

Plastic Limit

GRI

BORING B-4 (cont.)

SEPT. 1997 JOB. NO. 2289 FIG. 4A



2-IN.-OD SPLIT-SPOON SAMPLER

3-IN.-OD THIN-WALLED SAMPLER

NX CORE RUN

INCLINOMETER CASING

Water Level (date)

TORVANE SHEAR STRENGTH, TSF

UNDRAINED SHEAR STRENGTH, TSF

NO RECOVERY

Liquid Limit

Moisture Content

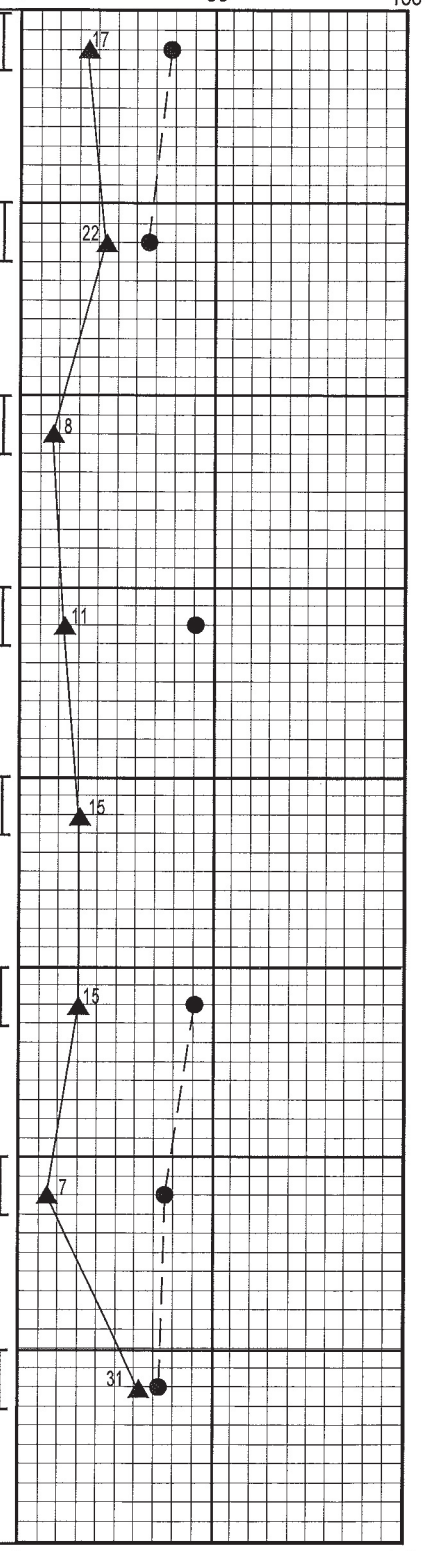
Plastic Limit

GRI

BORING B-5

SEPT. 1997 JOB. NO. 2289 FIG. 5A

DEPTH, FT	GRAPHIC LOG	CLASSIFICATION OF MATERIAL	DEPTH, FT GROUNDWATER	INCLINOMETER INSTALLATION	SAMPLES	STD PENETRATION RESISTANCE (140-LB WEIGHT, 30-IN. DROP) ▲ BLOWS PER FOOT ● MOISTURE CONTENT, %
		APPROXIMATE SURFACE ELEVATION 34 ft (±)				
40		Loose to medium dense, gray SAND; fine grained, trace silt to silty, scattered layers of silt with some sand to sandy, wood fragments			S-7	17
45		---------wood fragments at 46.5 ft			S-8	22
50					S-9 *	8
55					S-10	11
60					S-11 *	15
65					S-12	15
70					S-13	7
75					S-14	31
80						



2-IN.-OD SPLIT-SPOON SAMPLER

3-IN.-OD THIN-WALLED SAMPLER

NX CORE RUN

INCLINOMETER CASING

Water Level (date)

TORVANE SHEAR STRENGTH, TSF

UNDRAINED SHEAR STRENGTH, TSF

* NO RECOVERY

Liquid Limit

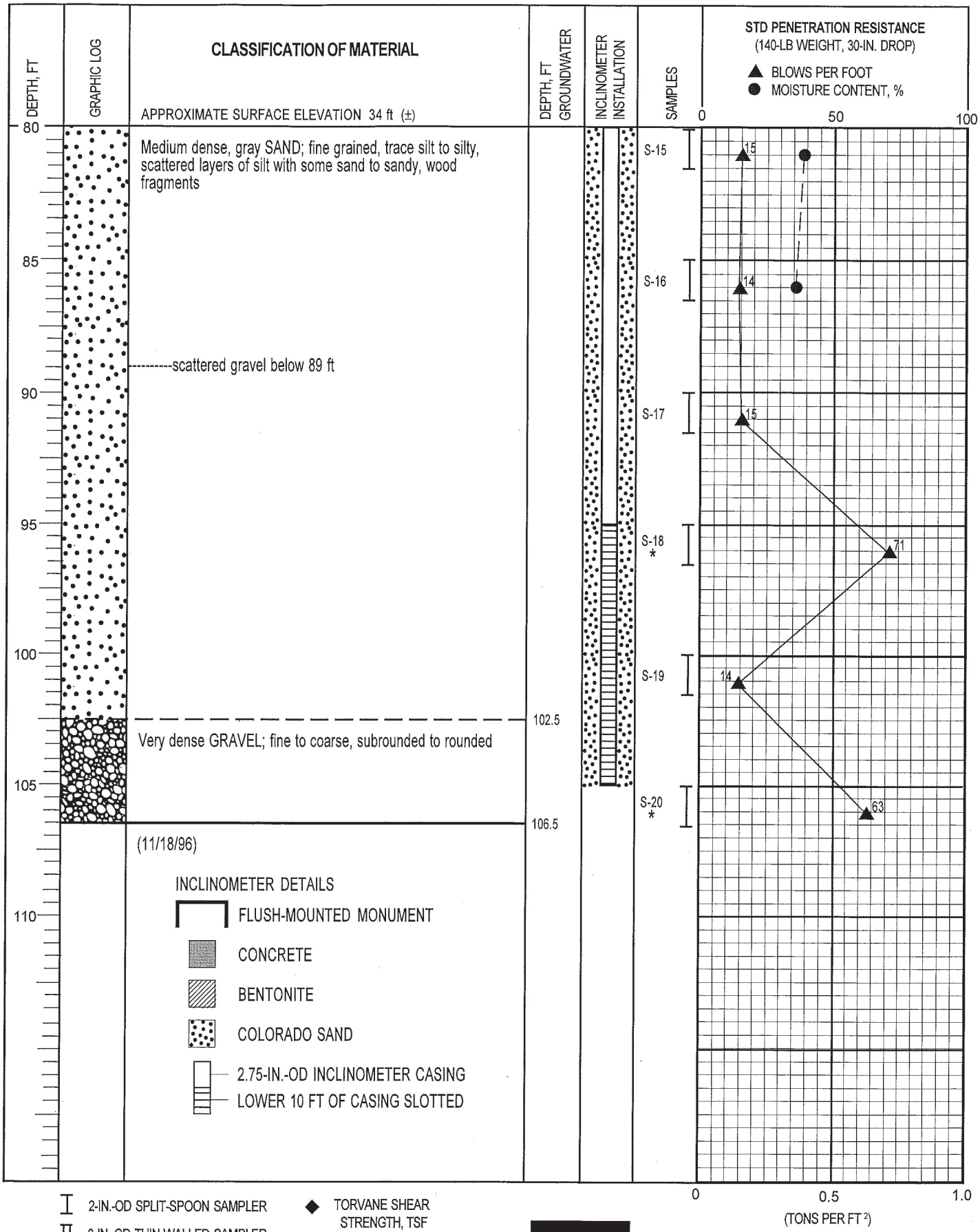
Moisture Content

Plastic Limit

GRI

BORING B-5 (cont.)

SEPT. 1997 JOB. NO. 2289 FIG. 5A



2-IN.-OD SPLIT-SPOON SAMPLER

3-IN.-OD THIN-WALLED SAMPLER

NX CORE RUN

INCLINOMETER CASING

Water Level (date)

TORVANE SHEAR STRENGTH, TSF

UNDRAINED SHEAR STRENGTH, TSF

* NO RECOVERY

Liquid Limit

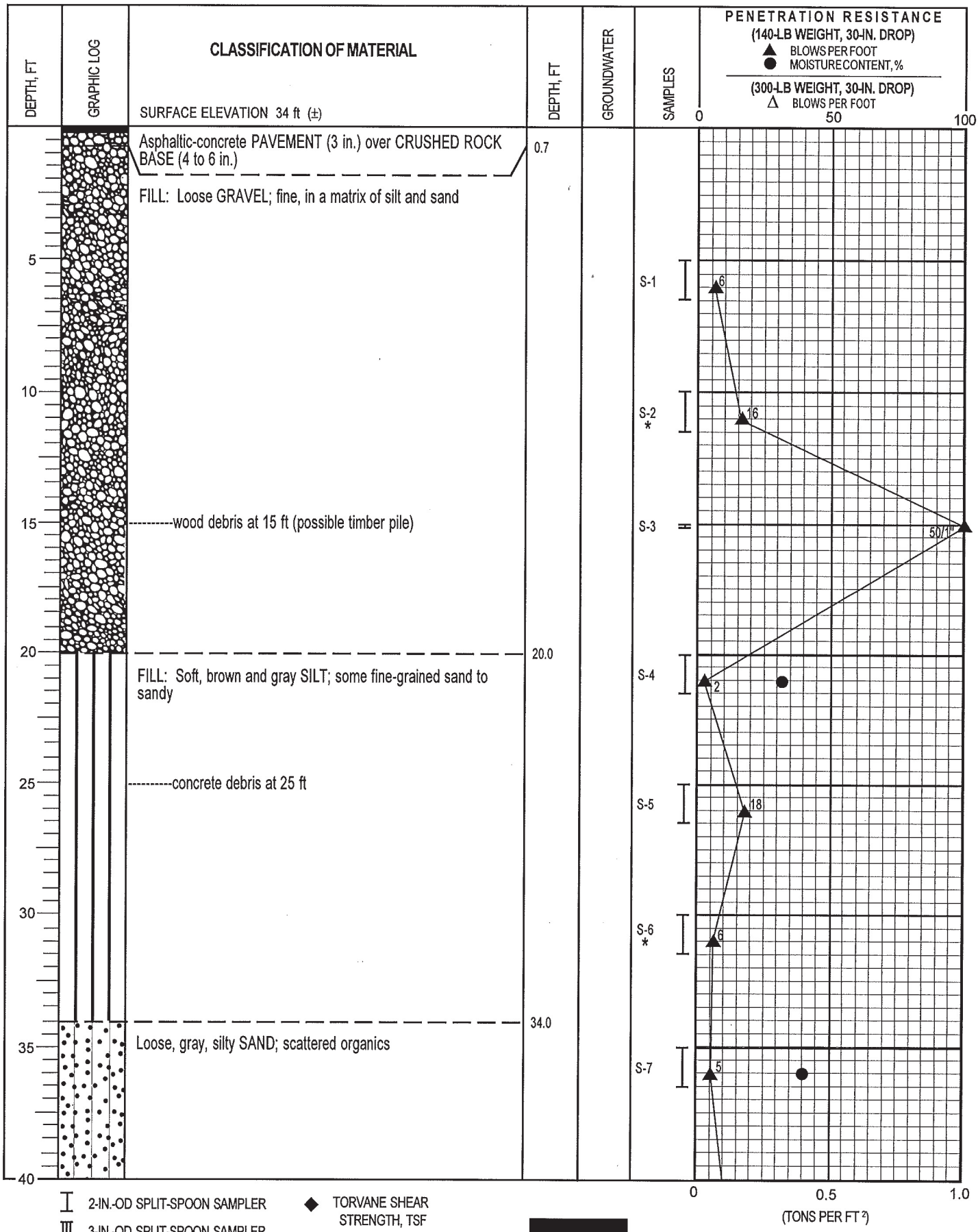
Moisture Content

Plastic Limit

GRI

BORING B-5 (cont.)

SEPT. 1997 JOB. NO. 2289 FIG. 5A



2-IN.-OD SPLIT-SPOON SAMPLER

3-IN.-OD SPLIT-SPOON SAMPLER

3-IN.-OD THIN-WALLED SAMPLER

G GRAB SAMPLE OF DRILL CUTTINGS

SLOTTED PVC PIPE

Water Level (date)

TORVANE SHEAR STRENGTH, TSF

UNDRAINED SHEAR STRENGTH, TSF

* NO RECOVERY

Liquid Limit

Moisture Content

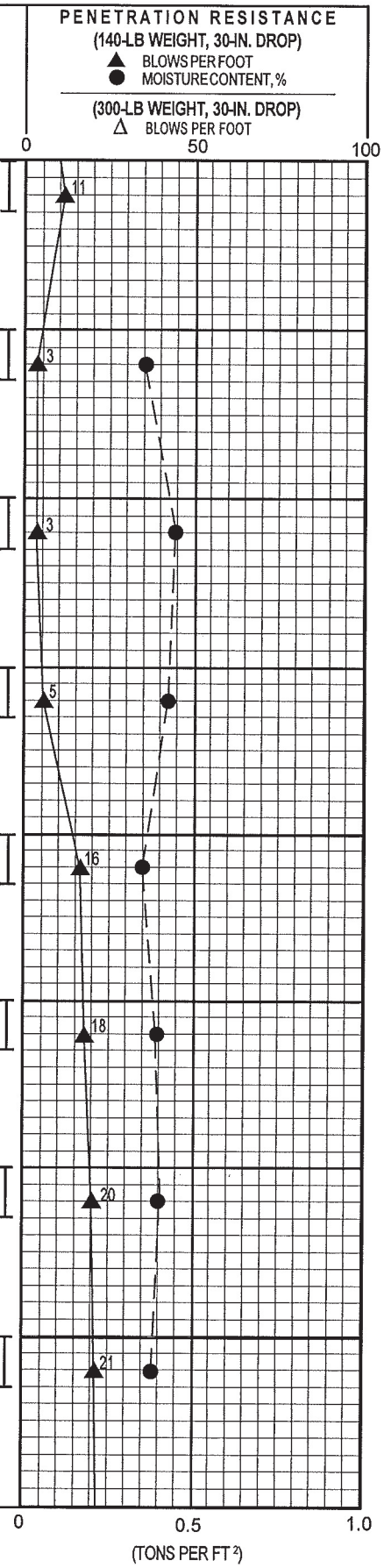
Plastic Limit

GRI

BORING B-8

JULY 1998 JOB. NO. 2730 FIG. 3A

DEPTH, FT	GRAPHIC LOG	CLASSIFICATION OF MATERIAL SURFACE ELEVATION 34 ft (±)	DEPTH, FT	GROUNDWATER	SAMPLES
40		Loose, gray, sandy SILT to silty SAND; fine to medium grained, scattered organics			S-8
45		--------some silt between 45 and 50 ft			S-9
50					S-10
55					S-11
60		---------medium dense below 60 ft			S-12
65					S-13
70					S-14
75					S-15
80					



2-IN.-OD SPLIT-SPOON SAMPLER
3-IN.-OD SPLIT-SPOON SAMPLER
3-IN.-OD THIN-WALLED SAMPLER
G GRAB SAMPLE OF DRILL CUTTINGS
SLOTTED PVC PIPE
Water Level (date)

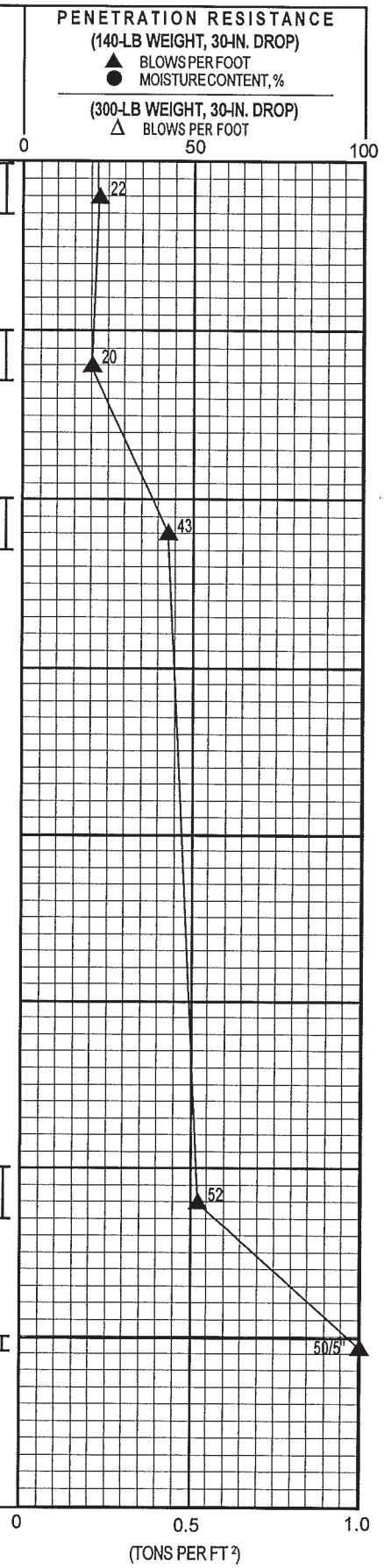
TORVANE SHEAR STRENGTH, TSF
UNDRAINED SHEAR STRENGTH, TSF
* NO RECOVERY
Liquid Limit
Moisture Content
Plastic Limit

GRI

BORING B-8 (cont.)

JULY 1998 JOB. NO. 2730 FIG. 3A

DEPTH, FT	GRAPHIC LOG	CLASSIFICATION OF MATERIAL SURFACE ELEVATION 34 ft (±)	DEPTH, FT	GROUNDWATER	SAMPLES
80		Medium dense, gray sandy SILT to silty SAND; fine to medium grained			S-16
85					S-17
90		---------dense below 90 ft			S-18
95					
100					
105					
110		---------very dense, brown below 110 ft			S-19
115		-------fragment of basalt cobble / boulder in sample S-20	115.5		S-20
		(4/23/98)			
120					



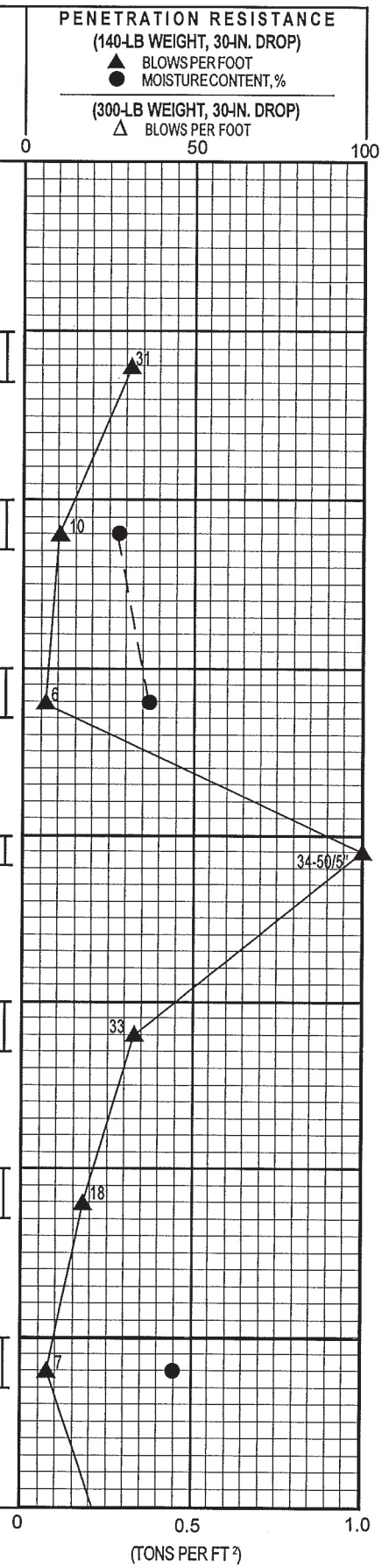
2-IN.-OD SPLIT-SPOON SAMPLER
3-IN.-OD SPLIT-SPOON SAMPLER
3-IN.-OD THIN-WALLED SAMPLER
G GRAB SAMPLE OF DRILL CUTTINGS
SLOTTED PVC PIPE
Water Level (date)
TORVANE SHEAR STRENGTH, TSF
UNDRAINED SHEAR STRENGTH, TSF
* NO RECOVERY
Liquid Limit
Moisture Content
Plastic Limit

GRI

BORING B-8 (cont.)

JULY 1998 JOB. NO. 2730 FIG. 3A

DEPTH, FT	GRAPHIC LOG	CLASSIFICATION OF MATERIAL SURFACE ELEVATION 35 ft (±)	DEPTH, FT	GROUNDWATER	SAMPLES
		Asphaltic-concrete PAVEMENT (9 in.) over 2-in.-minus CRUSHED ROCK BASE (12 in.)	1.8		
		FILL: Medium stiff to stiff, brown SILT; some sand to sandy, contains scattered pieces of brick, concrete, and angular fine to coarse gravel- and cobble-size rock fragments			
5					S-1 *
10					S-2
15					S-3
20					S-4
25					S-5 *
30					S-6
35		---------metal debris at 36 ft			S-7
40					



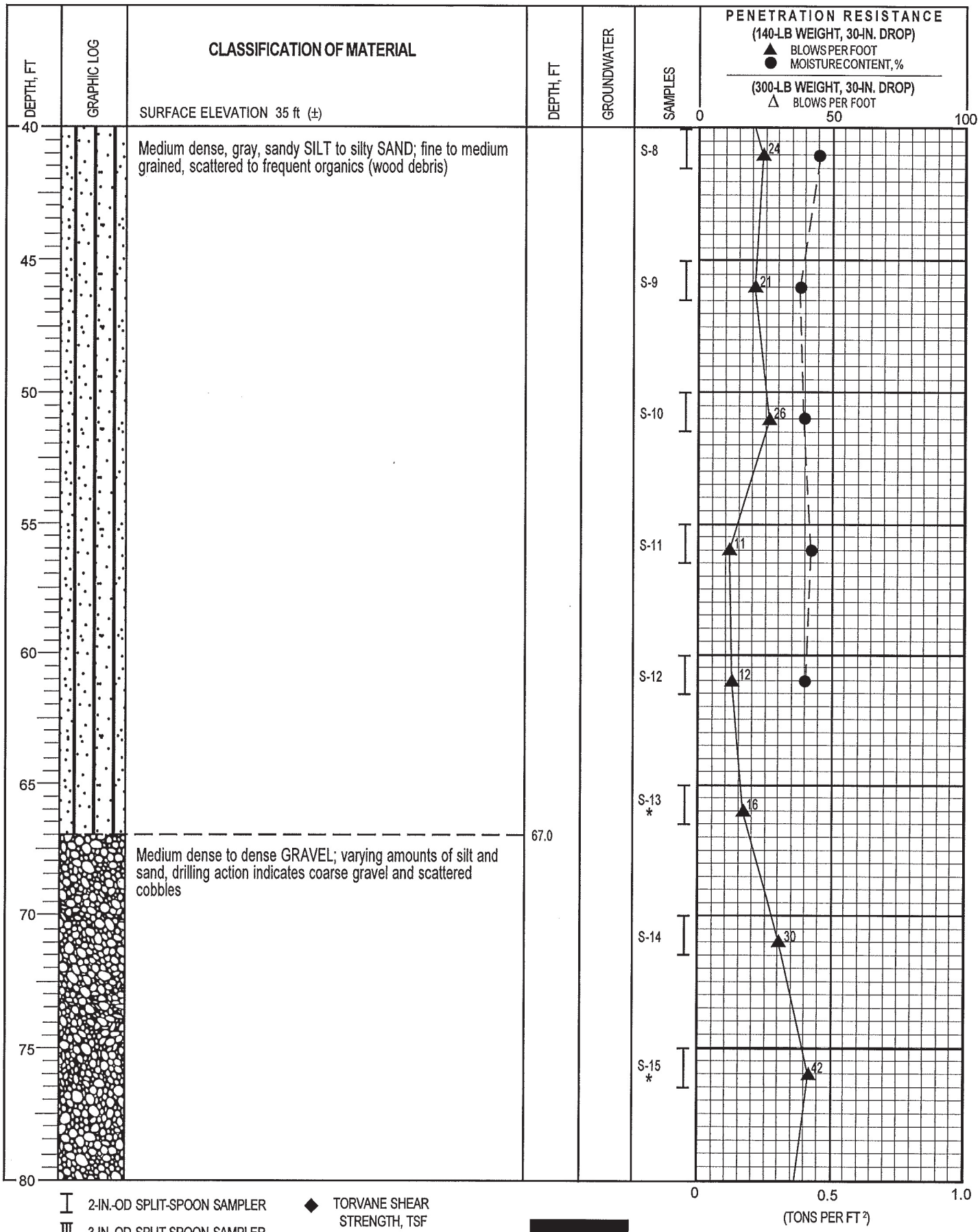
2-IN.-OD SPLIT-SPOON SAMPLER
3-IN.-OD SPLIT-SPOON SAMPLER
3-IN.-OD THIN-WALLED SAMPLER
G GRAB SAMPLE OF DRILL CUTTINGS
SLOTTED PVC PIPE
Water Level (date)

TORVANE SHEAR STRENGTH, TSF
UNDRAINED SHEAR STRENGTH, TSF
* NO RECOVERY
Liquid Limit
Moisture Content
Plastic Limit

GRI

BORING B-9

JULY 1998 JOB. NO. 2730 FIG. 4A



2-IN.-OD SPLIT-SPOON SAMPLER

3-IN.-OD SPLIT-SPOON SAMPLER

3-IN.-OD THIN-WALLED SAMPLER

G GRAB SAMPLE OF DRILL CUTTINGS

SLOTTED PVC PIPE

Water Level (date)

TORVANE SHEAR STRENGTH, TSF

UNDRAINED SHEAR STRENGTH, TSF

* NO RECOVERY

Liquid Limit

Moisture Content

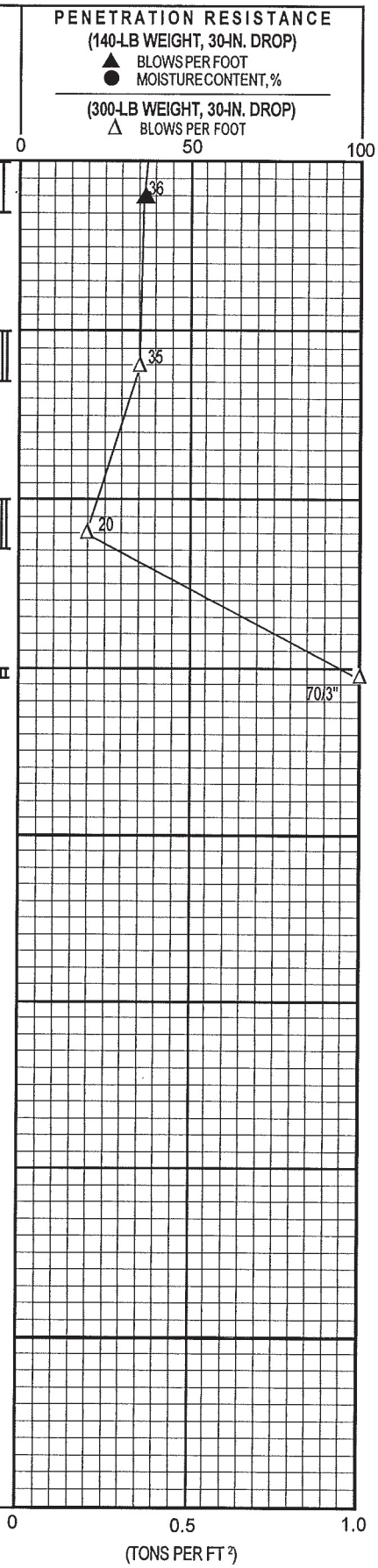
Plastic Limit

GRI

BORING B-9 (cont.)

JULY 1998 JOB. NO. 2730 FIG. 4A

DEPTH, FT	GRAPHIC LOG	CLASSIFICATION OF MATERIAL SURFACE ELEVATION 35 ft (±)	DEPTH, FT	GROUNDWATER	SAMPLES
80		Dense GRAVEL; drilling action indicates coarse gravel and scattered cobbles			S-16 *
85					S-17 *
90					S-18
95			95.3		S-19
		(4/24/98)			
100					



2-IN.-OD SPLIT-SPOON SAMPLER
3-IN.-OD SPLIT-SPOON SAMPLER
3-IN.-OD THIN-WALLED SAMPLER
G GRAB SAMPLE OF DRILL CUTTINGS
SLOTTED PVC PIPE
Water Level (date)

TORVANE SHEAR STRENGTH, TSF
UNDRAINED SHEAR STRENGTH, TSF
* NO RECOVERY

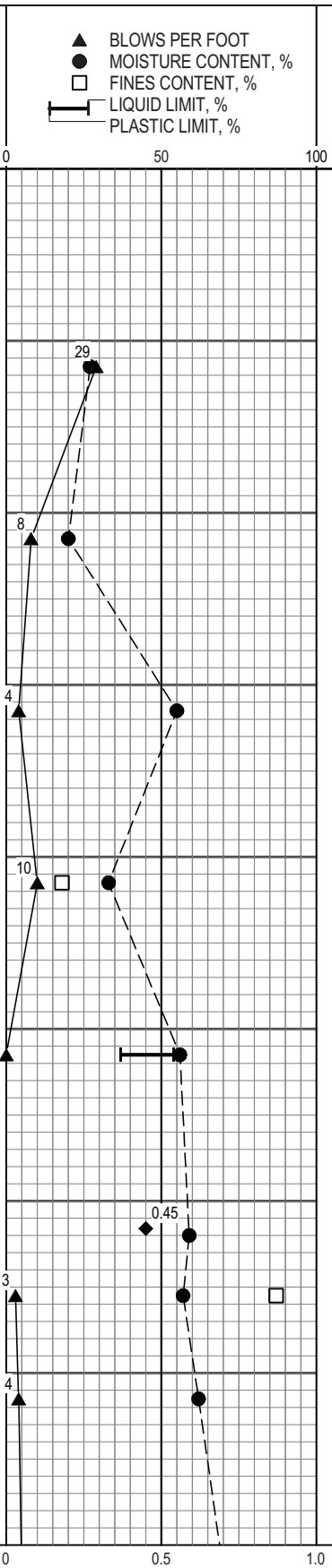
Liquid Limit
Moisture Content
Plastic Limit

GRI

BORING B-9 (cont.)

JULY 1998 JOB. NO. 2730 FIG. 4A

DEPTH, FT	GRAPHIC LOG	CLASSIFICATION OF MATERIAL **Surface Elevation:** Not Available	DEPTH, FT	INSTALLATION	SAMPLE NO.	SAMPLE TYPE	BLOW COUNT	COMMENTS AND ADDITIONAL TESTS
		FILL: Very stiff, brown, gravelly SILT; some fine- to coarse-grained sand, trace clay			S-1		5 12 17	
		FILL: Loose, black SAND; fine- to medium-grained, trace silt	8.0		S-2		2 2 6	
		FILL: Soft to medium stiff, brown SILT; some gravel and fine- to medium-grained sand, trace clay	13.0		S-3		1 2 2	
		FILL: Loose to medium dense, gray SAND; fine grained, some silt	18.0		S-4		6 5 5	
		Very soft, gray SILT; trace to some clay	24.0		S-5		0 0 0 0	
		---soft to medium stiff below 30 ft ---thin layer of wood debris at 30.3 ft ---trace to some fine-grained sand below 32 ft			S-6			Petroleum odor in sample S-6
					S-7		0 1 2	Dry Density = 66 pcf
					S-8		1 2 2	



5 10 15 20 25 30 35 40

GRI BORING LOG - NO ELEVATION GRI DATA TEMPLATE.GDT 5/22/14

(CONTINUED NEXT PAGE)

Logged By: T. Meskele	**Drilled by:** Hard Core Drilling, Inc.
Date Started: 5/1/14	**Coordinates:** Not Available
Drilling Method: Mud Rotary **Equipment:** CME 75 Truck-Mounted Drill Rig **Hole Diameter:** 4.875 in.	**Hammer Type:** Auto Hammer **Weight:** 140 lb **Drop:** 30 in. **Energy Ratio:** Not Available
Note: See Legend for Explanation of Symbols	

DRAFT

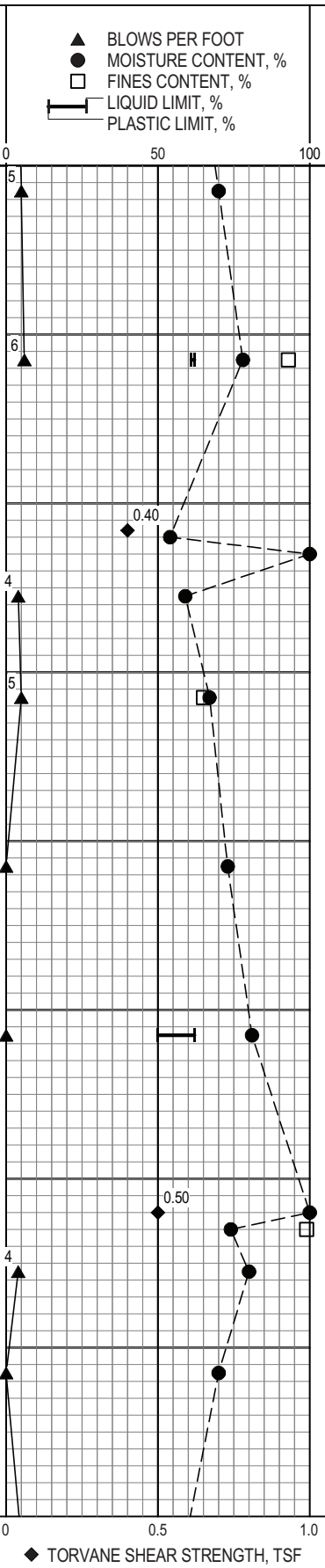
GRI

BORING B-4

MAY 2014 JOB NO. 5490-B FIG. 1A

JULY 2015 GRI JOB NO. 5445 FIG. E-30

DEPTH, FT	GRAPHIC LOG	CLASSIFICATION OF MATERIAL **Surface Elevation:** Not Available	DEPTH, FT	INSTALLATION	SAMPLE NO.	SAMPLE TYPE	BLOW COUNT	COMMENTS AND ADDITIONAL TESTS
		Medium stiff, gray SILT; trace to some fine-grained sand, trace clay and organics			S-9		0 2 3	
45					S-10		1 3 3	
50		---sandy, some wood debris below 51 ft			S-11			Dry Density = 52 pcf
					S-12		4 2 2	
55		---scattered organics below 55 ft			S-13		1 2 3	
60		---very soft, trace fine-grained sand below 60 ft			S-14		0 0 0	
		---trace to some clay between 63 and 68 ft						
65					S-15		0 0 0	
70					S-16			Dry Density = 56 pcf
					S-17		0 0 4	
75		---trace clay below 75 ft			S-18		0 0 0	
80								



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GRI BORING LOG - NO ELEVATION GRI DATA TEMPLATE.GDT 5/22/14

DRAFT

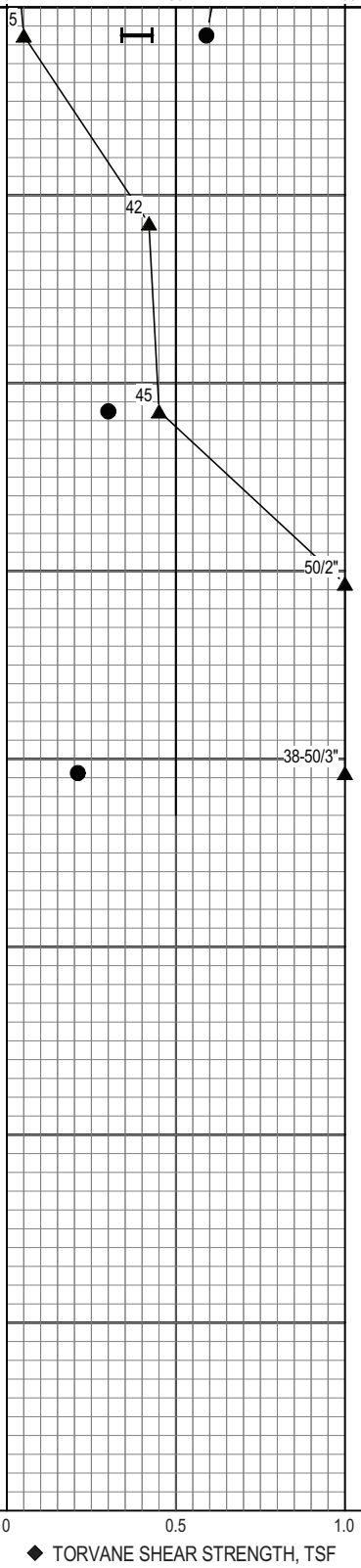
GRI

BORING B-4

MAY 2014 JOB NO. 5490-B FIG. 1A

JULY 2015 GRI JOB NO. 5445 FIG. E-31

DEPTH, FT	GRAPHIC LOG	CLASSIFICATION OF MATERIAL **Surface Elevation:** Not Available	DEPTH, FT	INSTALLATION	SAMPLE NO.	SAMPLE TYPE	BLOW COUNT	COMMENTS AND ADDITIONAL TESTS
		Medium stiff, gray SILT; some fine-grained sand, trace to some clay, scattered organics			S-19		2 2 3	
		Dense GRAVEL	82.0					
85					S-20		16 20 22	
90		Dense, gray SAND; fine grained, some silt, trace gravel	90.0		S-21		22 23 22	
95		Very dense, sandy GRAVEL; fine- to coarse-grained sand	95.0		S-22		50/2"	
100					S-23		38 50/3"	
		(5/1/2014)	101.5					
105								
110								
115								
120								



GRI BORING LOG - NO ELEVATION GRI DATA TEMPLATE.GDT 5/22/14

DRAFT

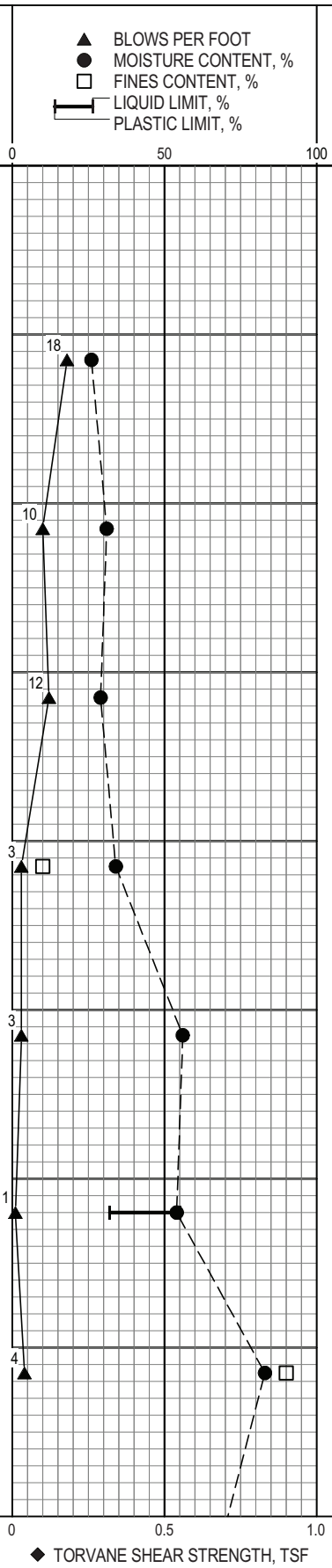
GRI

BORING B-4

MAY 2014 JOB NO. 5490-B FIG. 1A

JULY 2015 GRI JOB NO. 5445 FIG. E-32

DEPTH, FT	GRAPHIC LOG	CLASSIFICATION OF MATERIAL **Surface Elevation:** Not Available	DEPTH, FT	INSTALLATION	SAMPLE NO.	SAMPLE TYPE	BLOW COUNT	COMMENTS AND ADDITIONAL TESTS
		FILL: Dense, brown SAND; fine to medium grained						
5		---3-in.-thick layer of stiff, brown silt at 5 ft ---3-in.-thick layer of gravel, some concrete fragments at 5.3 ft			S-1		17 10 8	
10		---loose to medium dense, gravelly, some silt to silty below 10 ft			S-2		6 6 4	
15		---gravel absent below 15 ft ---5-in.-thick layer of stiff, brown silt, some clay and scattered gravel at 15.3 ft			S-3		4 6 6	
20		---very loose, trace to some silt, scattered wood debris below 20 ft			S-4		2 1 2	
25		Soft, gray, silty CLAY	25.0		S-5		0 1 2	
30		---very soft below 30 ft			S-6		0 0 1	
35		Soft to medium stiff, gray SILT; trace to some fine-grained sand, trace clay, scattered wood debris	35.0		S-7		0 2 2	
40								



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GRI BORING LOG - NO ELEVATION GRI DATA TEMPLATE.GDT 5/22/14

Logged By: T. Meskele	**Drilled by:** Hard Core Drilling, Inc.
Date Started: 5/2/14	**Coordinates:** Not Available
Drilling Method: Mud Rotary **Equipment:** CME 75 Truck-Mounted Drill Rig **Hole Diameter:** 4.875 in.	**Hammer Type:** Auto Hammer **Weight:** 140 lb **Drop:** 30 in. **Energy Ratio:** Not Available
Note: See Legend for Explanation of Symbols	

DRAFT

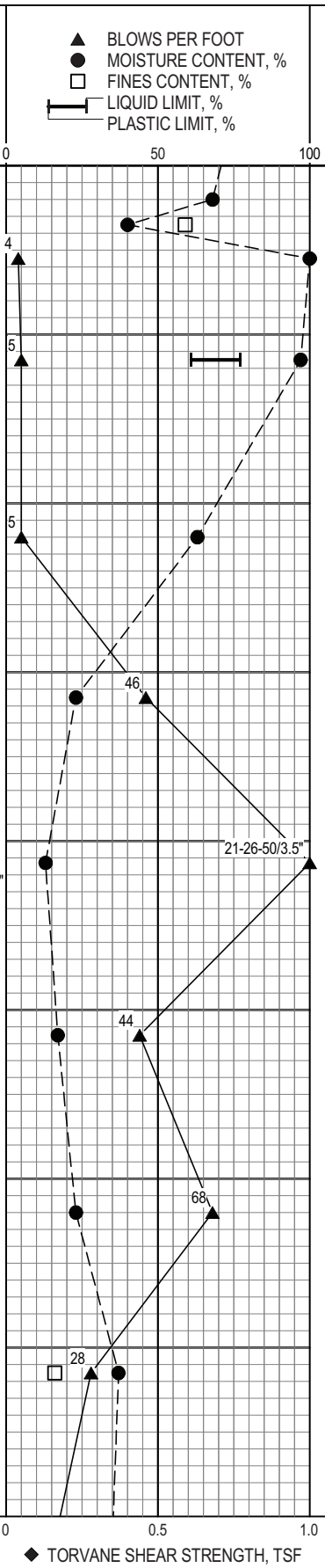
GRI

BORING B-5

MAY 2014 JOB NO. 5490-B FIG. 2A

JULY 2015 GRI JOB NO. 5445 FIG. E-33

DEPTH, FT	GRAPHIC LOG	CLASSIFICATION OF MATERIAL **Surface Elevation:** Not Available	DEPTH, FT	INSTALLATION	SAMPLE NO.	SAMPLE TYPE	BLOW COUNT	COMMENTS AND ADDITIONAL TESTS
		Soft to medium stiff, gray, sandy SILT; fine-grained sand, trace clay, scattered wood debris			S-8			Dry Density = 59 pcf Petroleum odor in sample S-8
					S-9		2 2 2	
45		---medium stiff, trace to some clay, trace wood debris below 45 ft			S-10		1 2 3	
50		---trace to some fine-grained sand, scattered wood debris below 50 ft			S-11		0 2 3	
		Dense, sandy GRAVEL; fine- to coarse-grained sand	53.0		S-12		6 8 38	
55								
60		---very dense below 60 ft			S-13		21 26 50/3.5"	
		Medium dense, gray SAND; fine to coarse grained, trace to some silt, trace gravel	63.0					
65		---4-in.-thick gravelly layer at 66 ft			S-14		40 23 21	
70					S-15		26 22 46	
75		---medium dense, brown, fine grained, gravel absent below 75 ft			S-16		19 14 14	
80								



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GRI BORING LOG - NO ELEVATION GRI DATA TEMPLATE.GDT 5/22/14

DRAFT

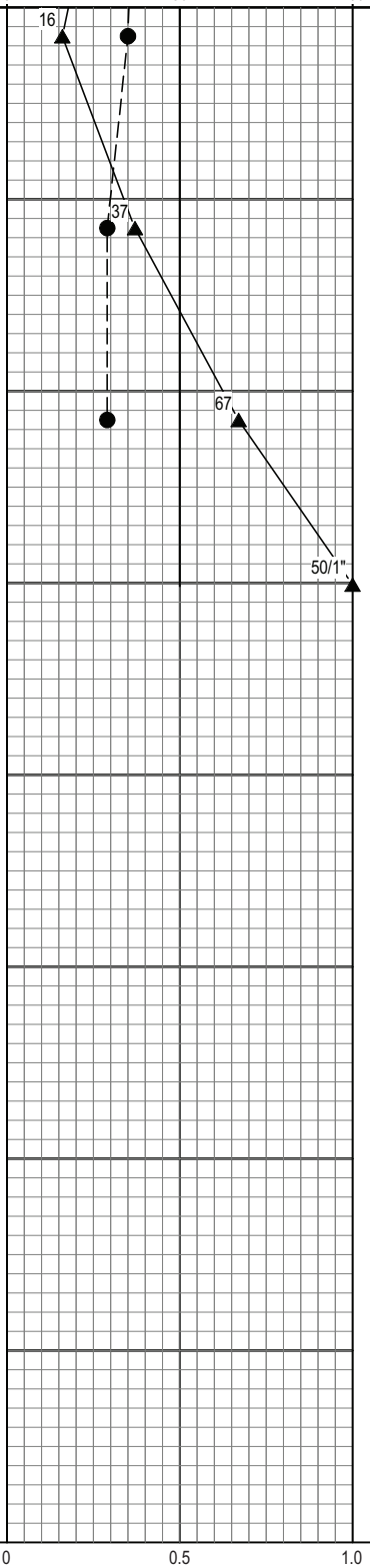
GRI

BORING B-5

MAY 2014 JOB NO. 5490-B FIG. 2A

JULY 2015 GRI JOB NO. 5445 FIG. E-34

DEPTH, FT	GRAPHIC LOG	CLASSIFICATION OF MATERIAL **Surface Elevation:** Not Available	DEPTH, FT	INSTALLATION	SAMPLE NO.	SAMPLE TYPE	BLOW COUNT	COMMENTS AND ADDITIONAL TESTS
		Dense, brown SAND; fine grained, trace to some silt			S-17		10 9 7	
85		---dense to very dense below 85 ft			S-18		17 21 16	
90					S-19		25 33 34	
		Very dense GRAVEL	93.5					
95		(5/2/2014)	95.1		S-20		50/1"	
100								
105								
110								
115								
120								



GRI BORING LOG - NO ELEVATION GRI DATA TEMPLATE.GDT 5/22/14

DRAFT

GRI

BORING B-5

MAY 2014 JOB NO. 5490-B FIG. 2A

JULY 2015 GRI JOB NO. 5445 FIG. E-35

SEDIMENT CORE

Core Collection Date/Time: 5-19-09 / 11:31
Core Processing Date/Time: 5-20-09 / 17:00
Cored By: Marine Sampling Systems
Coring Eq: vibracore **Core Type:** alum. 3.75"ID
Water Depth: 25.2 ft

Core ID: C006

Project: RM11E Sediment Characterization
Logged By: Dave Browning
Elevation: -21.4 ft **Datum:** NAD83/CRD
Easting: 7643594.084 **Northing:** 689809.063

Elev (ft)	Depth (ft/m)	Sym	Description/Classification of Materials (depth in units of centimeters)	Sample: Bulk Density	Sample: Sample ID (RM11E-)	Sample: Analyses
-21.4	ft 0 / m 0		Mudline			
-22.0	1		***0-24 SILTY GRAVELLY SAND*** 10YR 3/2, silty (15-20%) gravelly (10-20%) medium sand (60-75%), loose, wet, soft, partially sorted and normally graded, natural organic odor. decanted overlying water: 2.5Y 5/3, cloudy, floating wood fragments. 22-24: wood fragments that represent ~40% of interval.		C006-A	Archived
			24-32 SANDY SILT 10YR 3/3, fine sandy (25%) silt (60-70%) with trace of clay (5-10%) and trace organic vascular particles (1%), firm, moist, slightly plastic, no sheen with water application.			
-23.0	2		***32-90 GRAVEL*** 2.5Y 5/3, medium gravel (~90%) with trace of sand (5-10%) and clay (<5%), loose, wet, gravel is rounded and lithic, grain supported gravel, no odor, no sheen with application of water.	2396	C006-B	Full
-24.0	3		Bottom of Core Note: material at bottom of core was extruded from core catcher.			
-25.0	1					

Notes:
NAD83: North American Datum of 1983, State Plane Coord Sys, Oregon North Zone; CRD: Columbia River Datum; Elevation: top of core.
Sym: Geologic symbol representing classified unit; Color descriptions (e.g., 2.5Y 3/2) based on Munsell Color System.
Bulk Density: reported in kilograms per cubic meter.
Analyses: Full (Grain Size, Metals, PAHs & Alkylated PAHs, SVOCs, Heavy Range Diesel Compounds, Phenols, Butyltins, Dioxins/ Furans, Pesticides); Partial (PCB Aroclors, Total Organic Carbon, Total Solids); Physical Parameters (Atterburg Limits, Bulk Density, Specific Gravity, Gravimetric Water Content).

SEDIMENT CORE

Core Collection Date/Time: 5-22-09 / 12:34
Core Processing Date/Time: 5-26-09 / 09:47
Cored By: Marine Sampling Systems
Coring Eq: vibracore **Core Type:** alum. 3.75"ID
Water Depth: 54.7 ft

Core ID: C007

Project: RM11E Sediment Characterization
Logged By: Eric Collins
Elevation: -48.6 ft **Datum:** NAD83/CRD
Easting: 7643533.268 **Northing:** 689733.728

Elev (ft)	Depth (ft/m)	Sym	Description/Classification of Materials (depth in units of centimeters)	Sample: Bulk Density	Sample: Sample ID (RM11E-)	Sample: Analyses
-48.6	ft / m		Mudline			
-49.0	0 / 0		***0-3 SANDY SILT*** 2.5Y 4/3, fine sandy (25-50%) silt (50-75%) with trace of clay (<5%), saturated, very soft, no odor, no sheen with application of water.		C007-A	Archived
-50.0	1		***3-19 SAND*** 2.5Y 4/1, fine sand (>95%) with trace of fines (<5%), loose, moist, no odor, no sheen with application of water.			
-51.0	2		***19-36 GRAVEL*** 2.5Y 4/3, fine to coarse gravel (>95%) with trace of fines (<5%), dense, damp, gravel is subrounded, no odor, no sheen with application of water.	2470	C007-B	Partial
-52.0	3 / 1		***36-116 SANDY GRAVEL*** 2.5Y 4/3, fine to medium sandy (25-50%) fine to medium gravel (50-75%) with trace of fines (<5%), moist, well graded, very dense, gravel is subrounded, slight organic odor. 45: cobble (11cm). 90-116: decrease in medium sand and increase in fines, moist to wet.		C007-C	Partial
-53.0	4		***116-224 SILTY GRAVEL*** 2.5Y 4/3, silty (25-50%) fine to medium gravel (50-75%) with trace of sand (<5%), loose, wet, gravel is subrounded, no odor, no sheen.			
-54.0	5		116-130: 2.5Y 4/1, clayey silt layer, soft, no plasticity, wet, trace of gravel, no odor, no sheen with application of water.	2261		
-55.0	6 / 2		177-195: increase in coarse gravel. 195-206: 2.5Y 4/3, sandy gravel layer, mostly medium sand, moist, no odor, no sheen with application of water.		C007-D	Partial
-56.0	7			2209	C007-E	Archived
			Bottom of Core			

Notes:
NAD83: North American Datum of 1983, State Plane Coord Sys, Oregon North Zone; CRD: Columbia River Datum; Elevation: top of core.
Sym: Geologic symbol representing classified unit; Color descriptions (e.g., 2.5Y 3/2) based on Munsell Color System.
Bulk Density: reported in kilograms per cubic meter.
Analyses: Full (Grain Size, Metals, PAHs & Alkylated PAHs, SVOCs, Heavy Range Diesel Compounds, Phenols, Butyltins, Dioxins/ Furans, Pesticides); Partial (PCB Aroclors, Total Organic Carbon, Total Solids); Physical Parameters (Atterburg Limits, Bulk Density, Specific Gravity, Gravimetric Water Content).

SEDIMENT CORE

Core Collection Date/Time: 5-22-09 / 13:34
Core Processing Date/Time: 5-26-09 / 07:35
Cored By: Marine Sampling Systems
Coring Eq: vibracore **Core Type:** alum. 3.75"ID
Water Depth: 54.4 ft

Core ID: C008

Project: RM11E Sediment Characterization
Logged By: Eric Collins
Elevation: -48.4 ft **Datum:** NAD83/CRD
Easting: 7643471.408 **Northing:** 689637.076

Elev (ft)	Depth (ft/m)	Sym	Description/Classification of Materials (depth in units of centimeters)	Sample: Bulk Density	Sample: Sample ID (RM11E-)	Sample: Analyses
-48.4	ft 0 / m 0		Mudline			
-49.0	1		***0-10 SANDY SILT*** 2.5Y 3/2, fine sandy (25-50%) silt (50-75%) with organic debris (20%) mostly black wood chips, damp, loose, no plasticity, slight organic odor, no sheen with application of water.		C008-A	Archived
-50.0	2		***10-62 SAND*** 2.5Y 3/2, fine to medium sand (>95%), damp, loose, normally graded with increase in gravel with depth, no odor, no sheen with application of water. 18: brick fragment.	2097	C008-B	Partial, Phys Parameters
-51.0	3 / m 1		***62-116 SANDY GRAVEL*** 2.5Y 3/2, fine to coarse sandy (25-50%) fine gravel (50-75%), damp, moderately dense, well graded, gravel is subrounded to rounded, no fines observed, no odor, no sheen with application of water.		C008-C	Partial
-52.0	4		***116-270 GRAVELLY SAND*** 2.5Y 3/2, fine gravelly (25-50%) fine to coarse sand (50-75%) with trace of fines (<2%), damp, loose, well graded, gravel is <1cm, subrounded to rounded no odor, no sheen with application of water. 249: wood fragment.	2027		
-53.0	5					
-54.0	6				C008-D	Partial
-55.0	7 / m 2					
-56.0	8			2001	C008-E	Archived
-57.0	9		Bottom of Core			

Notes:
NAD83: North American Datum of 1983, State Plane Coord Sys, Oregon North Zone; CRD: Columbia River Datum; Elevation: top of core.
Sym: Geologic symbol representing classified unit; Color descriptions (e.g., 2.5Y 3/2) based on Munsell Color System.
Bulk Density: reported in kilograms per cubic meter.
Analyses: Full (Grain Size, Metals, PAHs & Alkylated PAHs, SVOCs, Heavy Range Diesel Compounds, Phenols, Butyltins, Dioxins/ Furans, Pesticides); Partial (PCB Aroclors, Total Organic Carbon, Total Solids); Physical Parameters (Atterburg Limits, Bulk Density, Specific Gravity, Gravimetric Water Content).

SEDIMENT CORE

Core Collection Date/Time: 5-18-09 / 10:27
Core Processing Date/Time: 5-20-09 / 11:45
Cored By: Marine Sampling Systems
Coring Eq: vibracore **Core Type:** alum. 3.75"ID
Water Depth: 13.6 ft

Core ID: C022

Project: RM11E Sediment Characterization
Logged By: Dave Browning
Elevation: -10.2 ft **Datum:** NAD83/CRD
Easting: 7644334.365 **Northing:** 689257.569

Elev (ft)	Depth (ft/m)	Sym	Description/Classification of Materials (depth in units of centimeters)	Sample: Bulk Density	Sample: Sample ID (RM11E-)	Sample: Analyses
-10.2	ft 0 / m 0		Mudline			
-11.0	1		***0-28 SILTY SAND*** 5Y 2.5/1, silty (40%) fine sand (60%), very soft, loose, wet, slight organic odor, no sheen with application of water. 9-28: silty (20-25%) fine to medium sand (75-80%), wet, soft, slightly consolidated. 10-19: large concrete fragment 10 x 12 cm.		C022-A	Archived
			28-44 SILTY CLAY silty (~25%) clay (60-70%) with trace of fine sand (~10%), firm, moist, plastic, no odor, 4 blebs of sheen with application of water.			
-12.0	2		***44-70 SANDY GRAVEL*** coarse sandy (40-50%) gravel (50-60%), wet, loose, mixed with ~8 x 6 cm clast of cohesive, plastic, wet, silty (20-35%) clay (75%), gravel is concrete and angular lithics. 46, 50, 65: concrete fragments (>8cm major axis).	2083	C022-B	Partial
-13.0	3 / 1		***70-140 SILTY CLAY*** 2.5Y, silty (~25%) clay (70-75%), soft, wet, plastic, slightly cohesive, moderate weathered petroleum odor. 130-140: metal threaded flange, moderate to strong petroleum odor, ropy sheen in sediment surrounding object with application of water.			
-14.0	4			1822	C022-C	Full
-15.0			Bottom of Core			

Notes:
NAD83: North American Datum of 1983, State Plane Coord Sys, Oregon North Zone; CRD: Columbia River Datum; Elevation: top of core.
Sym: Geologic symbol representing classified unit; Color descriptions (e.g., 2.5Y 3/2) based on Munsell Color System.
Bulk Density: reported in kilograms per cubic meter.
Analyses: Full (Grain Size, Metals, PAHs & Alkylated PAHs, SVOCs, Heavy Range Diesel Compounds, Phenols, Butyltins, Dioxins/ Furans, Pesticides); Partial (PCB Aroclors, Total Organic Carbon, Total Solids); Physical Parameters (Atterburg Limits, Bulk Density, Specific Gravity, Gravimetric Water Content).

SEDIMENT CORE

Core Collection Date/Time: 5-19-09 / 15:14
Core Processing Date/Time: 5-21-09 / 14:40
Cored By: Marine Sampling Systems
Coring Eq: vibracore **Core Type:** alum. 3.75"ID
Water Depth: 41.8 ft

Core ID: C023

Project: RM11E Sediment Characterization
Logged By: Dave Browning
Elevation: -37.7 ft **Datum:** NAD83/CRD
Easting: 7644265.515 **Northing:** 689165.162

Elev (ft)	Depth (ft/m)	Sym	Description/Classification of Materials (depth in units of centimeters)	Sample: Bulk Density	Sample: Sample ID (RM11E-)	Sample: Analyses
-37.7	ft 0 / m 0		Mudline			
-38.0	1		***0-96 SILTY SAND*** 2.5Y 3/2, interbedded fine sand (10-30%) clay (20-40%) and silt (40-70%), interbeds are 1-2cm thick and vary slightly in composition, moderate to strong tar-like odor in entire unit, sheen with application of water. 112-126: soft, wet, wood fragments. 153-175: iridescent sheen with application of water. 200: wood fragment. 160, 240-253: gravel stringers. 237-254: minerals blebs of NAPL with application of water. 261: light bulb with glass fragments. Entire unit is very similar and becomes only slightly less soft at depth, interbeds do not have sharp contacts and vary by changes in sand content, sandy interbeds always have at least 25% silt and are 1-5mm thick.	1979	C023-A	Archived
-39.0	2				C023-B	Partial, Phys Parameters
-40.0	3					
-41.0	4			1830	C023-C	Partial
-42.0	5					

Notes:
NAD83: North American Datum of 1983, State Plane Coord Sys, Oregon North Zone; CRD: Columbia River Datum; Elevation: top of core.
Sym: Geologic symbol representing classified unit; Color descriptions (e.g., 2.5Y 3/2) based on Munsell Color System.
Bulk Density: reported in kilograms per cubic meter.
Analyses: Full (Grain Size, Metals, PAHs & Alkylated PAHs, SVOCs, Heavy Range Diesel Compounds, Phenols, Butyltins, Dioxins/ Furans, Pesticides); Partial (PCB Aroclors, Total Organic Carbon, Total Solids); Physical Parameters (Atterburg Limits, Bulk Density, Specific Gravity, Gravimetric Water Content).

SEDIMENT CORE

Core Collection Date/Time: 5-19-09 / 15:14
Core Processing Date/Time: 5-21-09 / 14:40
Cored By: Marine Sampling Systems
Coring Eq: vibracore **Core Type:** alum. 3.75"ID
Water Depth: 41.8 ft

Core ID: C023

Project: RM11E Sediment Characterization
Logged By: Dave Browning
Elevation: -37.7 ft **Datum:** NAD83/CRD
Easting: 7644265.515 **Northing:** 689165.162

Elev (ft)	Depth (ft/m)	Sym	Description/Classification of Materials (depth in units of centimeters)	Sample: Bulk Density	Sample: Sample ID (RM11E-)	Sample: Analyses
-44.0	6		***96-275 INTERBEDDED CLAYEY SILT SAND*** 2.5Y 3/2, interbedded fine sand (10-30%) clay (20-40%) and silt (40-70%), interbeds are 1-2cm thick and very slushy in composition, moderate to strong tar-like odor in entire unit, sheen with application of water. 112-126: soft, wet, wood fragments. 153-175: iridescent sheen with application of water. 200: wood fragment. 160, 240-253: gravel stringers. 237-254: minor blebs of NAPL with application of water. 261: light bulb with glass fragments. Entire unit is very similar and becomes only slightly less soft at depth, interbeds do not have sharp contacts and vary by changes in sand content, sandy interbeds always have at least 25% silt and are 1-5mm thick.		C023-D	Partial
-45.0	7			1719	C023-E	Full
-46.0	8					
	3					
-47.0	9		***275-301 GRAVELLY SAND*** 10Y 6/6, gravelly (30-40%) medium sand (60-70%) with trace of clay (<5%), slightly soft, damp 284-268: 9 pieces of stick fragments. 281-283: 2cm x 2cm patch of darker sediment.	1871		
-48.0	10		Bottom of Core			

Notes:
NAD83: North American Datum of 1983, State Plane Coord Sys, Oregon North Zone; CRD: Columbia River Datum; Elevation: top of core.
Sym: Geologic symbol representing classified unit; Color descriptions (e.g., 2.5Y 3/2) based on Munsell Color System.
Bulk Density: reported in kilograms per cubic meter.
Analyses: Full (Grain Size, Metals, PAHs & Alkylated PAHs, SVOCs, Heavy Range Diesel Compounds, Phenols, Butyltins, Dioxins/ Furans, Pesticides); Partial (PCB Aroclors, Total Organic Carbon, Total Solids); Physical Parameters (Atterburg Limits, Bulk Density, Specific Gravity, Gravimetric Water Content).

SEDIMENT CORE

Core Collection Date/Time: 5-26-09 / 09:49
Core Processing Date/Time: 5-27-09 / 08:30
Cored By: Marine Sampling Systems
Coring Eq: vibracore **Core Type:** alum. 3.75"ID
Water Depth: 53.3 ft

Core ID: C024

Project: RM11E Sediment Characterization
Logged By: Dave Browning
Elevation: -46.2 ft **Datum:** NAD83/CRD
Easting: 7644169.518 **Northing:** 689065.852

Elev (ft)	Depth (ft/m)	Sym	Description/Classification of Materials (depth in units of centimeters)	Sample: Bulk Density	Sample: Sample ID (RM11E-)	Sample: Analyses
-46.2	ft 0 / m 0		Mudline			
-47.0	1		***0-182 SAND*** 10YR 4/2, medium sand (85%) with fine gravel (15%) and trace of fines (<1%), loose, damp, well sorted, weak normal grading, no odor, no sheen with application of water, becomes more gravelly (up to 25%) at lower unit, weak normal grading. 155: silty (40%) clay (60%) rip-up clasts (1-3cm x 1cm), no odor, no sheen with application of water.	1923	C024-A	Archived
-48.0	2				C024-B	Full
-49.0	3					
-50.0	4 (m 1)			1914	C024-C	Partial
-51.0	5					
-52.0	6				C024-D	Partial
-53.0	7 (m 2)		***182-324 SANDY GRAVEL*** 10YR 4/2, coarse sandy (25-35%) fine to medium gravel (65-75%) with trace of fines (<1%), loose, poorly sorted, normally graded, damp, gravel is 1-3cm, subrounded to rounded, lithic and volcanoclastic, no odor, no sheen with application of water. 186: silty clay rip-up clast (1cm x 3cm).	2106		
-54.0	8				C024-E	Archived
-55.0	9					
-56.0	10 (m 3)			2143		
					C024-F	Archived
-57.0	11		Bottom of Core			

Notes:
NAD83: North American Datum of 1983, State Plane Coord Sys, Oregon North Zone; CRD: Columbia River Datum; Elevation: top of core.
Sym: Geologic symbol representing classified unit; Color descriptions (e.g., 2.5Y 3/2) based on Munsell Color System.
Bulk Density: reported in kilograms per cubic meter.
Analyses: Full (Grain Size, Metals, PAHs & Alkylated PAHs, SVOCs, Heavy Range Diesel Compounds, Phenols, Butyltins, Dioxins/ Furans, Pesticides); Partial (PCB Aroclors, Total Organic Carbon, Total Solids); Physical Parameters (Atterburg Limits, Bulk Density, Specific Gravity, Gravimetric Water Content).

SEDIMENT CORE

Core Collection Date/Time: 5-21-09 / 16:26
Core Processing Date/Time: 5-23-09 / 08:30
Cored By: Marine Sampling Systems
Coring Eq: vibracore **Core Type:** alum. 3.75"ID
Water Depth: 54.8 ft

Core ID: C031

Project: RM11E Sediment Characterization
Logged By: Dave Browning
Elevation: -49.1 ft **Datum:** NAD83/CRD
Easting: 7644385.693 **Northing:** 688882.714

Elev (ft)	Depth (ft/m)	Sym	Description/Classification of Materials (depth in units of centimeters)	Sample: Bulk Density	Sample: Sample ID (RM11E-)	Sample: Analyses
-49.1	ft 0 / m 0		Mudline			
-50.0	1		***0-40 SAND*** 10YR 4/2, medium sand (>95%) with trace of coarse sand (<5%) and fines (<1%), well sorted, loose, soft, damp, fines are 7.5YR 5/6 with application of water, no odor, no sheen with application of water. 0: red nereid worm 3-4cm long, wood fragments 2-6cm long and 0.5cm diameter.		C031-A	Archived
-51.0	2		***40-217 SANDY GRAVEL*** 7YR 6/6, coarse sandy (30-35%) gravel (65-70%) with trace of fines, hard, damp, dense, ungraded, poorly sorted, gravel is seriate from 0.5-4cm, lithic, minor volcanoclastics, and subrounded, no odor, no sheen with application of water. 62-65: lens of coarse sand, sorted. 147-217: slight increase in fines but still less than 1%.	2081	C031-B	Partial
-52.0	3 / m 1				C031-C	Partial
-53.0	4			2276		
-54.0	5				C031-D	Partial
-55.0	6 / m 2			2375		
-56.0	7		Bottom of Core			

Notes:
NAD83: North American Datum of 1983, State Plane Coord Sys, Oregon North Zone; CRD: Columbia River Datum; Elevation: top of core.
Sym: Geologic symbol representing classified unit; Color descriptions (e.g., 2.5Y 3/2) based on Munsell Color System.
Bulk Density: reported in kilograms per cubic meter.
Analyses: Full (Grain Size, Metals, PAHs & Alkylated PAHs, SVOCs, Heavy Range Diesel Compounds, Phenols, Butyltins, Dioxins/ Furans, Pesticides); Partial (PCB Aroclors, Total Organic Carbon, Total Solids); Physical Parameters (Atterburg Limits, Bulk Density, Specific Gravity, Gravimetric Water Content).

SEDIMENT CORE

Core Collection Date/Time: 5-18-09 / 12:48
Core Processing Date/Time: 5-20-09 / 09:15
Cored By: Marine Sampling Systems
Coring Eq: vibracore **Core Type:** alum. 3.75"ID
Water Depth: 23.2 ft

Core ID: C041

Project: RM11E Sediment Characterization
Logged By: Dave Browning
Elevation: -16.1 ft **Datum:** NAD83/CRD
Easting: 7645040.385 **Northing:** 688203.454

Elev (ft)	Depth (ft/m)	Sym	Description/Classification of Materials (depth in units of centimeters)	Sample: Bulk Density	Sample: Sample ID (RM11E-)	Sample: Analyses
-16.1	ft 0 / m 0		Mudline			
			0-20 GRAVELLY CLAY 2.5y 4/1, gravelly (30%) clay (50-55%) with trace of sand (10-15%) and wood (5%), loose, wet, no grading, no sorting, slight road tar-like odor, blue and ropy sheen comes off of small weathered tarry fragments with application of water, sediments disturbed from coring. 10: brick fragments	2109	C041-A	Archived
-17.0	1		***20-41 SILTY CLAY*** 10YR 4/1, silty (20-30%) clay (70%) with trace of gravel (10%), soft, moist, plastic, gravel is subrounded and evenly distributed through clay, no odor, no sheen with application of water.			
-18.0	2		***41-64 CLAYEY GRAVEL*** 10YR 4/1, clayey (20%) gravel (70%) with trace of silt (10%), soft, wet, no odor, no sheen with application of water, sediment was removed from cone-catcher and not from sectional tube.		C041-B	Partial
			Bottom of Core			
-19.0	3					
	1					

Notes:
NAD83: North American Datum of 1983, State Plane Coord Sys, Oregon North Zone; CRD: Columbia River Datum; Elevation: top of core.
Sym: Geologic symbol representing classified unit; Color descriptions (e.g., 2.5Y 3/2) based on Munsell Color System.
Bulk Density: reported in kilograms per cubic meter.
Analyses: Full (Grain Size, Metals, PAHs & Alkylated PAHs, SVOCs, Heavy Range Diesel Compounds, Phenols, Butyltins, Dioxins/ Furans, Pesticides); Partial (PCB Aroclors, Total Organic Carbon, Total Solids); Physical Parameters (Atterburg Limits, Bulk Density, Specific Gravity, Gravimetric Water Content).

Well Number: RM11E-MW001

Client: Dalton Olmsted and Fuglevand
Project: River Mile 11 East (RM11E)
Location: Portland, Oregon
Project Number: 0487.002.004
TOC Elevation (NAVD88): 33.439'
Survey: 689361.119N--7644323.007E

Driller: Cascade Drilling, Clackamas, Oregon
Drilling Method: Sonic CS-500
Sampling Method: continuous plastic core sleeves
Logged by: Kenny Janssen-GSI
Start/Finish Date: 11-21/22-2013
ODWR Well Tag Number: L114004

Depth (ft)	Sample Info: Sample Type	Sample Info: Recovery	Soils and Formations	Soil Description Log	Elev/Depth
				Ground Surface	34.0
0	none	0%		0 to 5 feet: no recovery; borehole was airknifed to a depth of 5 feet on 11-18-13 to clear site for utilities	0.0 / 29.0
5	archive	90%		5 to 9 feet: soft, dark gray, moist, gravelly SILT (ML) with sand. Well-graded sand and gravel; gravel sub-rounded 3/4-inch minus; sands fine to medium. No odor (Fill)	5.0 / 25.0
				9 to 10 feet: soft, dark gray, moist to dry gravelly SAND (SM) with silt. Concrete construction debris, sub-rounded gravels 1-inch minus and well-graded fine to coarse sand. No odor (Fill)	9.0 / 24.0
10	archive	90%		10 to 12.5 feet: stiff, brown, gravelly SAND (ML)with sand. 3/4-inch gravels sub-rounded to sub-angular. Well-graded fine to medium gravel and well-graded fine to coarse sand. No odor (Fill)	10.0 / 21.5
				12.5 to 15 feet: same as above except gravel and sand fraction is decreasing with depth (Fill)	12.5 / 19.0
15	archive	90%		15 to 17.5 feet: stiff to very stiff, brown, moist, clayey SILT (ML-CL) with trace fine gravel. Concrete and woody debris present with concrete chuncks 3-inch minus. Some light brown to yellowish-orange mottles. No odor (Fill)	15.0 / 16.5
				17.5 to 20 feet: same as above (ML-CL) except increasing concrete and metal construction debris with depth (Fill)	17.5 / 14.0
20	archive	90%		**Analytical Sample: Unsaturated Fill (5' to 24')** 20 to 24 feet: Concrete throughout, no soil matrix (Fill)	20.0 / 10.0
25					24.0 / 9.0 / 25.0

Well Construction Notes and Field Observations

- 6-inch Diameter Borehole (0' to 40')
- Concrete (0' to 2')
- 0' to 5' interval--No PID/Gases
- 2-Inch Sch.40 PVC Well Casing (0.5' to 37')
- 3/8-inch Bentonite Chips (2' to 14.8')
- 5' to 10' interval: PID = 0.0 ppm LEL/CO/H2S = 0.0
- 10' to 15' interval: PID = 0.0 ppm LEL/CO/H2S = 0.0
- Stainless Steel Centralizer
- 15' to 20' interval: PID = 0.0 ppm LEL/CO/H2S = 0.0
- 2-Inch PVC 10-Slot Well Screen (17' to 32')
- 10/20 Silica Sand Filter Pack (14.8' to 33')
- 20' to 25' interval: PID = 0.0 ppm LEL/CO/H2S = 0.0
- Depth to Water: 23.50 on 11-25-13 (9.94' NAVD88)

Well Number: RM11E-MW001

Client: Dalton Olmsted and Fuglevand
Project: River Mile 11 East (RM11E)
Location: Portland, Oregon
Project Number: 0487.002.004
TOC Elevation (NAVD88): 33.439'
Survey: 689361.119N--7644323.007E

Driller: Cascade Drilling, Clackamas, Oregon
Drilling Method: Sonic CS-500
Sampling Method: continuous plastic core sleeves
Logged by: Kenny Janssen-GSI
Start/Finish Date: 11-21/22-2013
ODWR Well Tag Number: L114004

Depth (ft)	Sample Info: Sample Type	Sample Info: Recovery	Soils and Formations	Soil Description Log	Elev/Depth
	archive	60%		24 to 25 feet: loose, light brown grading to dark gray, moist SAND (SW-SM). Poorly graded fine sand trrending to dark gray silt (Silt-Sand Alluvium)	
				25 to 27.5 feet: loose, olive gray to dark gray, wet, clayey SAND (SC-SM) with silt. Poorly graded very fine to fine sand. No odor (Silt/Sand Alluvium)	6.5 27.5
30	archive	100%		**Analytical Sample: Upper 5' Native Alluvium (24' to 29')** 27.5 to 30 feet: same as above (SC-SM) except with some woody debris consisting of twigs and sticks (Silt/Sand Alluvium)	4.0 30.0
				30 to 31.5 feet: loose, olive gray to dark gray, moist, silty GRAVEL (GM) with fine sand. Well-graded cobbles 3-inch minus with some clay. Well-graded fine to medium gravel (Silt/Sand Alluvium)	2.5 31.5
35	none	100%		31.5 to 33.5 feet: loose, olive gray to dark gray, moist, silty SAND (SM). Poorly-graded fine sand. No odor (Sand/Silt Alluvium)	0.5 33.5
				33.5 to 35 feet: soft, light brown to yellowish-orange, wet, SILT (ML)coarsing downward to gravelly silt with some clay and chunks of weathered basalt. No odor (Sand/Silt Alluvium)	-1.0 35.0
40				35 to 40 feet: loose, light brown to brown, wet sandy GRAVEL (GM) with silt and cobbles. Well-graded fine to coarse gravels 2 1/2-inch minus; sub-rounded. Well-graded fine to coarse sand. Cobbles 3 1/4 to 4-inches. No odor (Gravel Alluvium)	-6.0 40.0
45				End of Log	
50					

Well Construction Notes and Field Observations

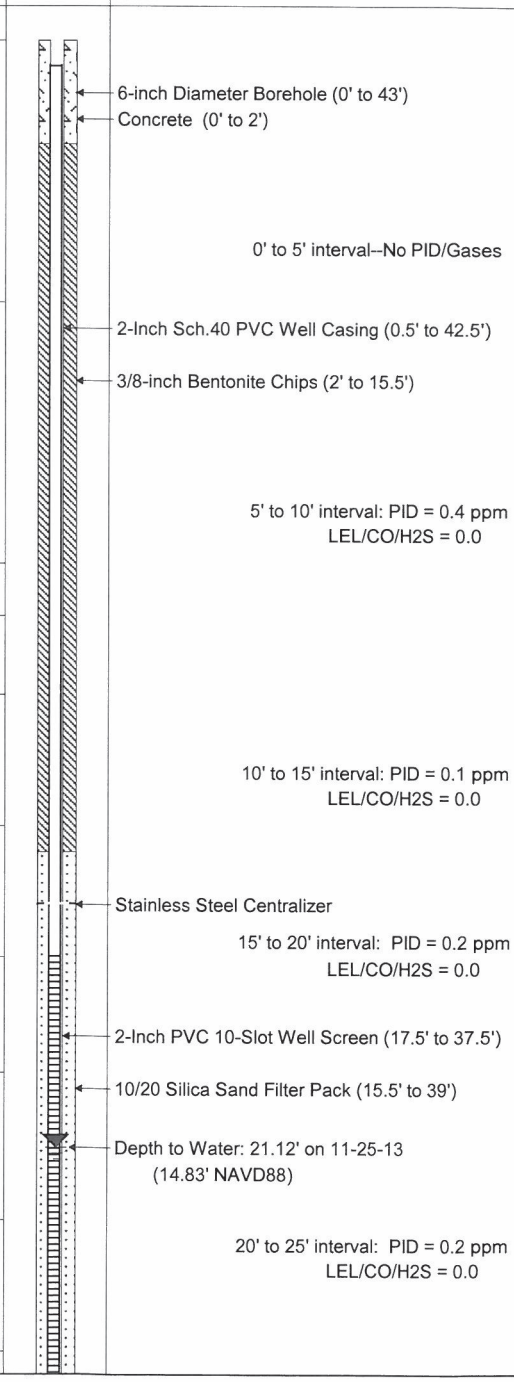
- 2-Inch PVC 10-Slot Well Screen (17' to 32')
- 10/20 Silica Sand Filter Pack (14.8 to 33')
- 25' to 30' interval: PID = 0.0 ppm LEL/CO/H2S = 0.0
- Stainless Steel Centralizer
- 30' to 35' interval: PID = 0.0 ppm LEL/CO/H2S = 0.0
- 5-foot Sch.40 PVC Well Sump (32' to 37')
- 35' to 40' interval: PID = 0.0 ppm LEL/CO/H2S = 0.0
- 3/8-inch Bentonite Chips (33' to 40')

Well Number: RM11E-MW002s

Client: Dalton, Olmsted, and Fuglevand
Project: River Mile 11 East (RM11E)
Location: Portland, Oregon
Project Number: 0487.002.004
TOC Elevation (NAVD88): 35.954
Survey: 689208.453N--7644646.99E

Driller: Cascade Drilling, Clackamas, Oregon
Drilling Method: Sonic CS-500
Sampling Method: continuous plastic core sleeves
Logged by: Kenny Janssen-GSI
Start/Finish Date: 11-20-2013
ODWR Well Tag Number: L114002

Depth (ft)	Sample Info: Sample Type	Sample Info: Recovery	Soils and Formations	Soil Description Log	Elev/Depth
				Ground Surface	36.3
0	none	0%		0 to 5 feet: no recovery; borehole was airknifed to a depth of 5 feet on 11-18-13 to clear site for utilities	0.0 / 31.3
5	archive	90%		5 to 10 feet: Soft, brown to dark brown gravelly SILT (ML) with sand and some clay. Some construction debris; bricks and concrete fragments. Some woody debris. No odor (Fill)	5.0 / 26.3
10	archive	85%		10 to 11 feet: no recovery	10.0 / 25.3
				11 to 12.5 feet: same as above (ML) but with a greater fraction of construction debris; large chunks of brick and concrete; moist (Fill)	11.0 / 23.8
				12.5 to 15 feet: soft, moist, light brown to yellowish-orange, sandy SILT (ML-MH) with some gravel and clay. Brick and concrete construction fragments and decomposed woody debris. Gravels sub-rounded 1-inch minus. (Fill)	12.5 / 21.3
15	archive	100%		15 to 17.5 feet: same as above (ML-MH) but with more brick debris and some dark gray sands from 15 feet to 15.5 feet (Fill)	15.0 / 18.8
				Composite Analytical Sample: Unsaturated Fill (5' to 20')	17.5
				17.5 to 19.7 feet: same as above but with slightly less brick debris. Some concrete debris (Fill). Transition to native formation at approximately 19.7 feet	16.6 / 19.7
20	archive	100%		19.7 to 22.5 feet: medium stiff to stiff, olive gray to dark gray, moist, SILT (ML-CL) with some clay and trace organics; fine roots (Silt/Sand Alluvium)	13.8
				Composite Analytical Sample: Upper 5' of native alluvium (20' to 25')	22.5
				22.5 to 25 feet: same as above (ML-CL) with light brown to yellowish-orange mottles from 23 feet to 25 feet; soft to medium stiff (S/S	11.3 / 25.0
25					



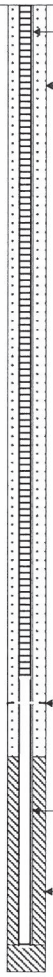
Well Number: RM11E-MW002s

Client: Dalton, Olmsted, and Fuglevand
Project: River Mile 11 East (RM11E)
Location: Portland, Oregon
Project Number: 0487.002.004
TOC Elevation (NAVD88): 35.954
Survey: 689208.453N--7644646.99E

Driller: Cascade Drilling, Clackamas, Oregon
Drilling Method: Sonic CS-500
Sampling Method: continuous plastic core sleeves
Logged by: Kenny Janssen-GSI
Start/Finish Date: 11-20-2013
ODWR Well Tag Number: L114002

Depth (ft)	Sample Info: Sample Type	Sample Info: Recovery	Soils and Formations	Soil Description Log	Elev/Depth
	archive	100%		25 to 27.5 feet: same as above (ML-CL) except with increased mottling with some light brown to yellowish-orange; some gray mottling.Soft, moist, some fine roots (Sand/Silt Alluvium)	8.8
				27.5 to 30 feet: same as above (ML-CL) except little to no mottling present (Silt/Sand Alluvium)	27.5 6.3
30	none	100%		30 to 32.5 feet: same as above (ML-CL) except soft to medium stiff. Some woody debris (Silt/Sand Alluvium)	30.0 3.8
				32.5 to 35 feet: same as above (ML-CL). Fine root hairs and woody debris at 34.6 feet (Sand/Silt Alluvium)	32.5 1.3
35	none	100%		35 to 37.5 feet: same as above (ML-CL) with large chunk of woody debris at 36.4 feet. Trace fine roots (Silt/Sand Alluvium)	35.0 -1.2
				37.5 to 43 feet: same as above (ML-CL) with trace woody debris and fine root hairs 40 to 43 feet (Silt/Sand Alluvium)	37.5
40	none	100%			
					-6.7
				End of Log	43.0
45					
50					

Well Construction



Well Construction Notes and Field Observations

2-Inch PVC 10-Slot Well Screen (17.5 to 37.5')

10/20 Silica Sand Filter Pack (15.5' to 39')

25' to 30' interval: PID = 0.1 ppm
LEL/CO/H2S = 0.0

30' to 35' interval: PID = 0.0 ppm
LEL/CO/H2S = 0.0

35' to 40' interval: PID = 0.0 ppm
LEL/CO/H2S = 0.0

Stainless Steel Centralizer

5-Foot Sch.40 PVC Well Sump (37.5' to 42.5')

3/8-inch Bentonite Chips (39' to 43')

40' to 43' interval: PID = 0.0 ppm
LEL/CO/H2S = 0.0

Well Number: RM11E-MW003d

Client: Dalton, Olmsted, and Fuglevand
Project: River Mile 11 East (RM11E)
Location: Portland, Oregon
Project Number: 0487.002.004
TOC Elevation (NAVD88): 35.63
Survey: 689217.885N--7644642.318E

Driller: Cascade Drilling, Clackamas, Oregon
Drilling Method: Sonic CS-500
Sampling Method: continuous plastic core sleeves
Logged by: Kenny Janssen/Erin Hughes-GSI
Start/Finish Date: 11-19/20-2013
ODWR Well Tag Number: L114001

Depth (ft)	Sample Info: Sample Type	Sample Info: Recovery	Soils and Formations	Soil Description Log	Elev/Depth	Well Construction	Well Construction Notes and Field Observations
				Ground Surface	36.1		
0	none	0%		0 to 5 feet: no recovery; borehole was airknifed to a depth of 5 feet on 11-18-13 to clear site for utilities	0.0		6-inch Diameter Borehole (0' to 106') Concrete (0' to 2') 0' to 5' interval--No PID/Gases
5	archive	50%		5 to 7.5 feet: poor recovery	31.1 5.0		2-Inch Sch.40 PVC Well Casing (0.5' to 105') 3/8-inch Bentonite Chips (2' to 31')
				7.5 to 9 feet: soft, dark brown, dry SILT (ML) with chunks of asphalt and angular brick fragments. No organics or odors (Fill)	28.6 7.5		5' to 10' interval: PID = 0.0 ppm LEL/CO/H2S = 0.0
				9 to 10 feet: solely construction debris with broken-up asphalt and concrete with dry powdered or pulverized cement (Fill)	27.1 9.0		
10	archive	90%		10.5 to 11.5 feet: medium stiff SILT (ML) with gravel and construction fragments (Fill)	26.1 10.0		
				11.5 to 13 feet: dry cement powder with suspended chunks of concrete (Fill)	24.6 11.5		
				13 to 18 feet: loose, gray, dry, concrete with gravel and sand. Gravels to 1-inch minus are coated with cement powder (Fill)	23.1 13.0		10' to 15' interval: PID = 0.0 ppm LEL/CO/H2S = 0.0
15	archive	100%		**Composite Analytical Sample: Unsaturated Fill (5' to 18.7') (Archive)**	21.1 15.0		
				18 to 18.7 feet: soft, light brown, moist, silty GRAVEL (GM) with some fine sand and clay. Gravels sub-rounded to 2-inch minus. Gravels compose up to 20% of the soil matrix (Fill-transition to native alluvium)	18.1 18.0		15' to 20' interval: PID = 0.0 ppm LEL/CO/H2S = 0.0
20	archive	70%		18.7 to 20 feet: soft to slightly firm, dark gray SILT (ML) with some clay. Trace woody debris (Silt/Sand Alluvium)	16.1 20.0		
				Composite Analytical Sample: Upper 5' of Native Alluvium (18.7' to 23.7') (Archive)			20' to 25' interval: PID = 0.0 ppm LEL/CO/H2S = 0.0
				20 to 23.5 feet: same as above with trace (~ 1%) gravel. Gravels sub-rounded to 1-inch minus (Silt/Sand Alluvium)	12.6 23.5		
25							

Well Number: RM11E-MW003d

Client: Dalton, Olmsted, and Fuglevand
Project: River Mile 11 East (RM11E)
Location: Portland, Oregon
Project Number: 0487.002.004
TOC Elevation (NAVD88): 35.63
Survey: 689217.885N--7644642.318E

Driller: Cascade Drilling, Clackamas, Oregon
Drilling Method: Sonic CS-500
Sampling Method: continuous plastic core sleeves
Logged by: Kenny Janssen/Erin Hughes-GSI
Start/Finish Date: 11-19/20-2013
ODWR Well Tag Number: L114001

Depth (ft)	Sample Info: Sample Type	Sample Info: Recovery	Soils and Formations	Soil Description Log	Elev/Depth	Well Construction	Well Construction Notes and Field Observations
	archive	100%		23.5 to 30 feet: soft, olive gray, moist SILT (ML) with trace clay. Light brown to yellowish orange mottles. Medium plasticity with no apparent structure. No odor (Silt/Sand Alluvium)			25' to 30' interval: PID = 0.0 ppm LEL/CO/H2S = 0.0
30					6.1		2-Inch Sch.40 PVC Well Casing (0.5' to 105')
	archive	100%		30 to 35 feet: soft to medium stiff, olive gray, moist SILT (ML-CL) with some clay. No mottling apparent. Woody and organic debris at 31.5'bgs and wood and leaves at 32.2' and 34.4'bgs (Silt/Sand Alluvium)	30.0		Top of Concrete Grout (31' to 84')
							30' to 35' interval: PID = 0.0 ppm LEL/CO/H2S = 0.0
35					1.1		
	none	100%		35 to 40 feet: same as above (ML-CL); organic debris at 36'bgs. No mottling or odor (Silt/Sand Alluvium)	35.0		35' to 40' interval: PID = 0.0 ppm LEL/CO/H2S = 0.0
40					-3.9		
	none	100%		40 to 45 feet: soft to medium stiff, olive gray, moist SILT (ML) with some clay and organics. Woody debris and trace fine sand. Moisture higher from 40' to 41'. Woody debris present at 41.4', 42.2', 42.5', 43.5', and 44'bgs. Diatom shell fragment at 44.5' (Silt/Sand Alluvium)	40.0		40' to 45' interval: PID = 0.0 ppm LEL/CO?H2S = 0.0
45					-8.9		
	none	100%		45 to 50 feet: same as above (ML) with woody debris at 45.6', 47.7', 48', 49.2', and 49.7'. No odor (Silt/Sand Alluvium)	45.0		45' to 50' interval: PID = 0.0 ppm LEL/CO/H2S = 0.0
							Stainless Steel Centralizer
50					-13.9		
					50.0		

Well Number: RM11E-MW003d

Client: Dalton, Olmsted, and Fuglevand
Project: River Mile 11 East (RM11E)
Location: Portland, Oregon
Project Number: 0487.002.004
TOC Elevation (NAVD88): 35.63
Survey: 689217.885N--7644642.318E

Driller: Cascade Drilling, Clackamas, Oregon
Drilling Method: Sonic CS-500
Sampling Method: continuous plastic core sleeves
Logged by: Kenny Janssen/Erin Hughes-GSI
Start/Finish Date: 11-19/20-2013
ODWR Well Tag Number: L114001

Depth (ft)	Sample Info: Sample Type	Sample Info: Recovery	Soils and Formations	Soil Description Log	Elev/Depth	Well Construction	Well Construction Notes and Field Observations
	none	100%		50 to 55 feet: soft to medium stiff, olive gray to greenish gray, moist SILT (ML-CL) with some clay and organics. Woody debris at 51.3', 51.9', 52.3', and 54'bgs. Density increasing with depth. No odor (Silt/Sand Alluvium)	-18.9		50' to 55' interval: PID = 0.0 ppm LEL/CO/H2S = 0.0
55	none	100%		55 to 60 feet: loose, olive gray, moist SILT (ML) with trace organics; fine root hairs. Cobble up to 3-inch minus at 57.8'. No odor (Silt/Sand Alluvium)	55.0 -23.9		2-Inch Sch.40 PVC Well Casing (0.5' to 105'); Concrete Grout (31' to 84'); 55' to 60' interval: PID = 0.0 ppm LEL/CO/H2S = 0.0
60	none	100%		60 to 65 feet: same as above (ML) (Silt/Sand Alluvium)	60.0 -28.9		60' to 65' interval: PID = 0.0 ppm LEL/CO/H2S = 0.0
65	none	90%		65 to 70 feet: soft to medium stiff, light gray to olive gray SILT (ML) with some clay and trace gravels up to 1/8-inch minus (Silt/Sand Alluvium)	65.0 -33.9		65' to 70' interval: PID = 0.0 ppm LEL/CO/H2S = 0.0
70	none	90%		70 to 73.5 feet: soft to medium stiff, light gray to olive gray SILT (ML) with some fine to medium sand and trace sub-rounded gravels to 3/4-inch minus (5 to 10%). Sand and gravel fraction increasing with depth. Loose, soft, and wet at 70' (Silt/Sand Alluvium)	70.0 -37.4		70' to 75' interval: PID = 0.0 ppm LEL/CO/H2S = 0.0
75				73.5 to 76 feet: very soft to soft, very soft, light to olive gray, wet SILT (ML) with some fine to coarse sand and sub-rounded gravel up to 3/4-inch minus (Silt/Sand Alluvium)	73.5		

Well Number: RM11E-MW003d

Client: Dalton, Olmsted, and Fuglevand
Project: River Mile 11 East (RM11E)
Location: Portland, Oregon
Project Number: 0487.002.004
TOC Elevation (NAVD88): 35.63
Survey: 689217.885N--7644642.318E

Driller: Cascade Drilling, Clackamas, Oregon
Drilling Method: Sonic CS-500
Sampling Method: continuous plastic core sleeves
Logged by: Kenny Janssen/Erin Hughes-GSI
Start/Finish Date: 11-19/20-2013
ODWR Well Tag Number: L114001

Depth (ft)	Sample Info: Sample Type	Sample Info: Recovery	Soils and Formations	Soil Description Log	Elev/Depth	Well Construction	Well Construction Notes and Field Observations
					-39.9 / 76.0		
	none	70%		76 to 86 feet: loose, dark gray, wet SAND (SP); poorly graded with trace sub-rounded gravels to 1-inch minus. Sands fine to medium with trace (~1%) cobbles 3-inch minus (Troutdale Formation Sands)			75' to 80' interval: PID = 0.0 ppm LEL/CO/H2S = 0.0
80							2-Inch Sch.40 PVC Well Casing (0.5' to 105')
	none	70%					80' to 85' interval: PID = 0.0 ppm LEL/CO/H2S = 0.0
							Bottom of Concrete Grout (31' to 84')
85					-49.9 / 86.0		3/8-inch Bentonite Chips (84' to 88')
	none	100%		86 to 96 feet: loose, dark gray, wet SAND (SP) with trace sub-rounded gravel to 3/4-inch minus. Poorly graded fine to medium sand. Mica flakes. No odor (Troutdale Formation Sands)			85' to 90' interval: PID = 0.0 ppm LEL/CO/H2S = 0.0
							Stainless Steel Centralizer
90							2-Inch PVC 10-Slot Well Screen (90' to 100')
							10/20 Silica Sand Filter Pack (88' to 101')
	none	100%					90' to 95' interval: PID = 0.0 ppm LEL/CO/H2S = 0.0
95					-59.9 / 96.0		
				96 to 101 feet: same as above (SP)			
	none	100%					95' to 100' interval: PID = 0.0 ppm LEL/CO/H2S = 0.0
100							

Well Number: RM11E-MW003d

Client: Dalton, Olmsted, and Fuglevand
Project: River Mile 11 East (RM11E)
Location: Portland, Oregon
Project Number: 0487.002.004
TOC Elevation (NAVD88): 35.63
Survey: 689217.885N--7644642.318E

Driller: Cascade Drilling, Clackamas, Oregon
Drilling Method: Sonic CS-500
Sampling Method: continuous plastic core sleeves
Logged by: Kenny Janssen/Erin Hughes-GSI
Start/Finish Date: 11-19/20-2013
ODWR Well Tag Number: L114001

Depth (ft)	Sample Info: Sample Type	Sample Info: Recovery	Soils and Formations	Soil Description Log	Elev/Depth	Well Construction	Well Construction Notes and Field Observations
	none	100%		101 to 103.5 feet: same as above (SP) except sand is increasingly coarse with depth. Gravels and soil density also increasing with depth (Troutdale Formation Sands)	-64.9 101.0		Stainless Steel Centralizer 5-Foot Sch.40 PVC Well Sump (100' to 105') Concrete/Bentonite Mix (101' to 106')
105				103.5 to 106 feet: medium dense to dense, olive gray to dark gray, moist GRAVEL (GM-GW) with silt and sand. Gravels are well graded and iron stained and cemented in a silt/sand matrix. Gravels well graded and rounded to sub-rounded to 2-inch minus. Well graded sand is fine to coarse. No odor (Troutdale Formation Gravels)	-67.4 103.5 -69.9 106.0		100' to 106' interval: PID = 0.0 ppm LEL/CO/H2S = 0.0
				End of Log			
110							
115							
120							
125							

Well Number: RM11E-MW004

Client: Dalton, Olmsted, and Fuglevand
Project: River Mile 11 East (RM11E)
Location: Portland, Oregon
Project Number: 0487.002.004
TOC Elevation (NAVD88): 35.911
Survey: 688981.017D--7644765.277E

Driller: Cascade Drilling, Clackamas, Oregon
Drilling Method: Sonic CS-500
Sampling Method: continuous plastic core sleeves
Logged by: Kenny Janssen-GSI
Start/Finish Date: 11-21-2013
ODWR Well Tag Number: L114003

Depth (ft)	Sample Info: Sample Type	Sample Info: Recovery	Soils and Formations	Soil Description Log	Elev/Depth
				Ground Surface	36.6
0	none	0%		0 to 5 feet: no recovery; borehole was airknifed to a depth of 5 feet on 11-18-13 to clear site for utilities	0.0 / 31.6
5	archive	100%		5 to 7.5 feet: stiff, light brown to brown, moist to dry SILT (ML-CL) with some clay and occasional gravel. Some brick, concrete, and woody construction debris. Gravels fine, sub-rounded to sub-angular (Fill)	5.0 / 29.1
				7.5 to 10 feet: stiff, light brown/brown to olive gray, moist SILT (ML-CL) with some clay and gravel. Gravel 3/4-inch minus, 5 to 10% sub-rounded. Increasing construction debris; highly-weathered brick, wood (Fill)	7.5 / 26.6
10	archive	100%		10 to 12.5 feet: same as above (ML-CL); gravel less abundant and 1-inch minus.Woody debris and vitrified glass(?).Color transitioning to olive/dark gray (Fill)	10.0 / 24.1
				12.5 to 15 feet: same as above (ML-CL) with trace chunks of wood and clinker (Fill)	12.5 / 21.6
15	archive	100%		15 to 20 feet: same as above (ML-CL). Increase in construction debris at 17.5 feet; chunks of 3-inch minus angular concrete (Fill)	15.0 / 16.6
20	archive	100%		20 to 22.5 feet: soft, dark gray, moist SILT (OL-OH) with lots of organics and some clay trace concrete and trace fine to medium sand (Fill)	20.0 / 14.1
				Composite Analytical Sample: Unsaturated Fill (5' to 24')	22.5 / 13.0
				22.5 to 23.6 feet: same as above (OL-OH) except no concrete debris apparent (Fill)	23.6 / 11.6
25					25.0

Well Construction

Well Construction Notes and Field Observations

- 6-inch Diameter Borehole (0' to 41')
- Concrete (0' to 2')
- 0' to 5' interval--No PID/Gases
- 2-Inch Sch.40 PVC Well Casing (0.5' to 40')
- 3/8-inch Bentonite Chips (2' to 18')
- 5' to 10' interval: PID = 0.0 ppm LEL/CO/H2S = 0.0
- 10' to 15' interval: PID = 0.0 ppm LEL/CO/H2S = 0.0
- 15' to 20' interval: PID = 0.1 ppm LEL/CO/H2S = 0.0
- Stainless Steel Centralizer
- 2-Inch PVC 10-Slot Well Screen (20' to 35")
- 10/20 Silica Sand Filter Pack (18' to 36')
- 20' to 25' interval: PID = 0.0 ppm LEL/CO/H2S = 0.0
- Depth to Water: 24.02' on 11-25-13 (11.89' NAVD88)

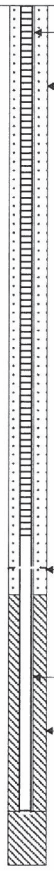
Well Number: RM11E-MW004

Client: Dalton, Olmsted, and Fuglevand
Project: River Mile 11 East (RM11E)
Location: Portland, Oregon
Project Number: 0487.002.004
TOC Elevation (NAVD88): 35.911
Survey: 688981.017D--7644765.277E

Driller: Cascade Drilling, Clackamas, Oregon
Drilling Method: Sonic CS-500
Sampling Method: continuous plastic core sleeves
Logged by: Kenny Janssen-GSI
Start/Finish Date: 11-21-2013
ODWR Well Tag Number: L114003

Depth (ft)	Sample Info: Sample Type	Sample Info: Recovery	Soils and Formations	Soil Description Log	Elev/Depth
	archive	100%		23.6 to 25 feet: very stiff, dark gray, moist SILT (ML) with some woody debris. Transition to native formation (Silt/Sand Alluvium) 25 to 27.5 feet: stiff, light brown to yellowish-orange SILT (ML) with trace orange mottles (Silt/Sand Alluvium)	9.1 27.5
				Composite Analytical Sample: Upper 5' of native alluvium (24' to 29') (Duplicate also collected) 27.5 to 30 feet: same as above (ML) except no mottling apparent. Moist to wet. No odor (Silt/Sand Alluvium)	6.6 30.0
30	archive	100%		30 to 32.5 feet: same as above (ML) except with increasing proportion of sand; fine to medium. No odor (Sand/Silt Alluvium)	4.1 32.5
				32.5 to 35 feet: loose, light brown to brown, moist to wet silty SAND (SM).Well-graded fine to very fine sand becoming fine to medium with depth (Silt/Sand Alluvium)	1.6 35.0
35	none	100%		35 to 37.5 feet: very loose to loose, light brown to brown, wet silty SAND (SM). Well-graded very fine to fine sand. No odor (Sand/Silt Alluvium)	-0.9 37.5
				37.5 to 41 feet: soft to very soft, light brown to brown, wet SILT (ML) with trace fine sand (Sand/Silt Alluvium)	-4.4 41.0
				End of Log	
40					
45					
50					

Well Construction Notes and Field Observations



- 2-Inch PVC 10-Slot Well Screen (20' to 35')
- 10/20 Silica Sand Filter Pack (18' to 36')
- 25' to 30' interval: PID = 0.0 ppm LEL/CO/H2S = 0.0
- 30' to 35' interval: PID = 0.0 ppm LEL/CO/H2S = 0.0
- Stainless Steel Centralizer
- 5-foot Sch.40 PVC Well Sump (35' to 40')
- 3/8-inch Bentonite Chips (36' to 41')
- 35' to 40' interval: PID = 0.0 ppm LEL/CO/H2S = 0.0

Well Number: RM11E-MW005

Client: Dalton, Olmsted, and Fuglevand
Project: River Mile 11 East (RM11E)
Location: Portland, Oregon
Project Number: 0487.002.004
TOC Elevation (NAVD88): 35.02
Survey: 689919.811N--7643614.754E

Driller: Cascade Drilling, Clackamas, Oregon
Drilling Method: Sonic CS-500
Sampling Method: continuous plastic core sleeves
Logged by: Kenny Janssen-GSI
Start/Finish Date: 11-22-2013
ODWR Well Tag Number: L114005

Depth (ft)	Sample Info: Sample Type	Sample Info: Recovery	Soils and Formations	Soil Description Log	Elev/Depth
				Ground Surface	35.5
0	none	0%		0 to 5 feet: no recovery; borehole was airknifed to a depth of 5 feet on 11-18-13 to clear site for utilities	0.0 / 30.5
5	archive	100%		5 to 9 feet: stiff to very stiff, dark gray, gravelly SILT (ML) with some sand. Some wood debris and construction materials; concrete, brick, metal, and rebar. Well-graded gravel; medium to coarse sand. No odor (Fill)	5.0 / 26.5
				9 to 10 feet: loose, dark gray, dry, sandy GRAVEL (GW-GM) with silt. Some construction debris; gravels sub-rounded 11/2-inch minus; medium to coarse sand. No odor (Fill)	9.0 / 25.5
10	archive	100%		10 to 12.5 feet: stiff to very stiff, olive gray to greenish gray, dry, clayey SILT (ML-CL) with trace light brown mottles. Trace glass with some wood and brick debris. No odor (Fill)	10.0 / 23.0
				12.5 to 15 feet: same as above (ML-CL) except no construction debris. Trace gravel (Fill)	12.5 / 20.5
15	archive	100%		15 to 19 feet: same as above (ML-CL). No odor (Fill)	15.0 / 16.5
				19 to 20.5 feet: same as above (ML-CL) except abundant construction debris; concrete and metal wire (Fill)	19.0 / 15.0
20	archive	100%		**Composite Analytical Sample: Unsaturated Fill (5' to 21')** 20.5 to 21 feet: same as above (ML-CL) with wood debris (Fill)	20.5 / 13.0
				Composite Analytical Sample: Upper 5 feet of native alluvium (21' to 26') 21 to 22.5 feet: soft, olive gray to greenish gray, moist, clayey SILT (ML-CL) with some woody debris. Transition to native formation	22.5 / 10.5
25					25.0

Well Construction

Well Construction Notes and Field Observations

- 6-inch Diameter Borehole (0' to 37')
- Concrete (0' to 2')
- 0' to 5' interval--No PID/Gases
- 2-Inch Sch.40 PVC Well Casing (0.5' to 36.5')
- 3/8-inch Bentonite Chips (2' to 14.5')
- 5' to 10' interval: PID = 0.0 ppm LEL/CO/H2S = 0.0
- 10' to 15' interval: PID = 0.0 ppm LEL/CO/H2S = 0.0
- Stainless Steel Centralizer
- 15' to 20' interval: PID = 0.1 ppm LEL/CO/H2S = 0.0
- 2-Inch PVC 10-Slot Well Screen (16.5' to 31.5')
- 10/20 Silica Sand Filter Pack (14.5' to 33')
- 20' to 25' interval: PID = 0.0 ppm LEL/CO/H2S = 0.0

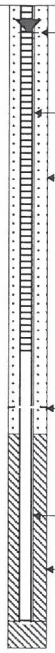
Well Number: RM11E-MW005

Client: Dalton, Olmsted, and Fuglevand
Project: River Mile 11 East (RM11E)
Location: Portland, Oregon
Project Number: 0487.002.004
TOC Elevation (NAVD88): 35.02
Survey: 689919.811N--7643614.754E

Driller: Cascade Drilling, Clackamas, Oregon
Drilling Method: Sonic CS-500
Sampling Method: continuous plastic core sleeves
Logged by: Kenny Janssen-GSI
Start/Finish Date: 11-22-2013
ODWR Well Tag Number: L114005

Depth (ft)	Sample Info: Sample Type	Sample Info: Recovery	Soils and Formations	Soil Description Log	Elev/Depth
	archive	60%		22.5 to 25 feet: loose, olive gray to dark gray, moist, silty fine SAND (SM) with some clay. Some woody debris. No odor (Silt/Sand Alluvium) 25 to 30 feet: same as above (SM) except silt and clay fines increasing with depth. Moist, no odor (Silt/Sand Alluvium)	5.5
30	archive	90%		30 to 33.5 feet: soft, dark gray, wet, sandy SILT (ML) with some sand and woody debris; sticks and roots. Sand is poorly graded fine to very fine and decreasing with depth and grading to silt. No odor (Silt/Sand Alluvium)	30.0 2.0
35				33.5 to 37 feet: loose, olive gray, wet, sandy GRAVEL (GM) with silt and cobbles. Well-graded fine to coarse sub-rounded gravel up to 3-inch minus; well-graded fine to coarse sand; cobbles to 41/2-inch minus. No odor (Gravel Alluvium)	33.5 -1.5
				End of Log	37.0
40					
45					
50					

Well Construction



Well Construction Notes and Field Observations

Depth to Water: 25.51' on 11-25-13 (9.51' NAVD88)

2-Inch PVC 10-Slot Well Screen (16.5' to 31.5')

10/20 Silica Sand Filter Pack (14.5' to 33')

25' to 30' interval: PID = 0.0 ppm
LEL/CO/H2S = 0.0

Stainless Steel Centralizer

30' to 35' interval: PID = 0.0 ppm
LEL/CO/H2S = 0.0

5-foot Sch.40 PVC Well Sump (31.5 to 36.5')

3/8-inch Bentonite Chips (33' to 37')

35' to 40' interval: PID = 0.0 ppm
LEL/CO/H2S = 0.0

PARSONS BRINCKERHOFF

BORING LOG
ES-3003R

PACRIM GEOTECHNICAL INC.
GEOTECHNICAL ENGINEERING AND APPLIED EARTH SCIENCES

PROJECT	East Side CSO - Final Design	SHEET 1 OF 9		INITIAL GW ELEV	9.6 ft (10/26/03)
CITY	Portland, Oregon	SURFACE ELEV. 35.1 ft	STA.	EQUIPMENT	Core Barrel and Casing
PROJECT NO.	5516	NORTHING 689,311.3	EASTING 7,645,406.5	DRILLING METHOD	Rotosonic
DATE DRILLED	10/25/03 to 10/27/03	LOCATION	N. River & Albina	LOGGED BY	KJL

SAMPLE TYPE: ☒ Ring (3.25" OD) ◧ Standard Penetration Test (2" OD) ■ Shelby Tube G Grab

Elevation (ft)	DEPTH (ft)	SAMPLE TYPE	SAMPLE NO.	PID	METHANE (ppm)	LAB TESTS	BOX NUMBER	PERCENT FINES (20 40 60 80) / PLASTIC M.C. LIQUID (20 40 60 80)	LITHOLOGY	SOIL DESCRIPTION	WELL
										ASPHALT; 4 inches thick.	
										Artificial Fill (Qaf) SILTY GRAVEL WITH SAND (GM); 45-50% gravel, fine to coarse, angular to subrounded; 25-30% sand, fine- to medium-grained; 15-20% silt; dark gray, dry.	
		G	1	0 0	0 0		1			SILTY SAND WITH GRAVEL (SM); 55-60% sand, fine- to medium-grained; 20-25% gravel, fine to coarse, subrounded to rounded; 15-20% silt; scattered debris (metal pipes, rubber), brown, dry to moist.	
30	5			0	0					**Sand/Silt Alluvium (Qal/Qff)** LEAN SILTY CLAY (CL); medium toughness, medium plasticity, no dilatancy, medium to high dry strength, brown, moist with occasional lenses of silt (ML). Water used in drilling method saturates outside of sample, overall moisture is "moist."	
		G	2	0	0		2	●		From 6 to 16 feet, recovered only upper one foot of sample during initial retrieval, resampled disturbed material.	
25	10			0	0					Lenses and layers of: SILT, low plasticity, slow to rapid dilatancy, low toughness, medium dry strength; SILTY SAND, fine-grained; and SAND, fine-grained.	
		G	3			AL	3	H●			
				0	0					SILT (ML)	
20	15				0					SILTY SAND/SANDY SILT (SM-ML); sand fine, silt non-plastic, rapid dilatancy when wetted, brown, moist.	
		G	4			FC	4	● △			
					0					POORLY GRADED SAND (SP); 100% fine sand, brown, moist, with occasional lenses of silt (ML).	
15	20				200					POORLY GRADED SAND WITH SILT (SP-SM); 90-95% sand, fine; 5-10% silt, non-plastic; brown, wet.	

JULY 2015 GRI JOB NO. 5445 FIG. E-58

PARSONS BRINCKERHOFF

BORING LOG
ES-3003R

PACRIM GEOTECHNICAL INC.
GEOTECHNICAL ENGINEERING AND APPLIED EARTH SCIENCES

PROJECT	East Side CSO - Final Design	SHEET 2 OF 9		INITIAL GW ELEV	9.6 ft (10/26/03)
CITY	Portland, Oregon	SURFACE ELEV. 35.1 ft	STA.	EQUIPMENT	Core Barrel and Casing
PROJECT NO.	5516	NORTHING 689,311.3	EASTING 7,645,406.5	DRILLING METHOD	Rotosonic
DATE DRILLED	10/25/03 to 10/27/03	LOCATION	N. River & Albina	LOGGED BY	KJL

SAMPLE TYPE: ☒ Ring (3.25" OD) ◧ Standard Penetration Test (2" OD) ■ Shelby Tube G Grab

Elevation (ft)	DEPTH (ft)	SAMPLE TYPE	SAMPLE NO.	PID	METHANE (ppm)	LAB TESTS	BOX NUMBER	PERCENT FINES (20 40 60 80) / PLASTIC M.C. LIQUID (20 40 60 80)	LITHOLOGY	SOIL DESCRIPTION	WELL
		G	5		400		5			**(Qal/Qff Cont'd)** POORLY GRADED SAND WITH SILT (SP-SM) Cont'd	
10	25				0					SILTY SAND (SM); sand fine, silt non-plastic, rapid dilatancy, brown, wet.	
		G	6		100	FC	6				
5	30				250					POORLY GRADED SAND (SP); 95-100% sand, fine; 0-5% silt, brown, wet. Occasional lenses of silty sand and sandy silt.	
		G	7		200	GSD	7				
0	35				150						
		G	8		450 250		8			**Gravel Alluvium (Qfc)** POORLY GRADED GRAVEL WITH SAND AND COBBLES (GP); 80-85% gravel, fine to coarse, with cobbles to 6 inches, subrounded to rounded, elongated, basalt; 15-20% sand, fine- to medium-grained.	
-5	40				600					Easy drilling.	
		G	9		750		9				

PARSONS BRINCKERHOFF

BORING LOG ES-3003R

PACRIM GEOTECHNICAL INC.
GEOTECHNICAL ENGINEERING AND APPLIED EARTH SCIENCES

PROJECT	East Side CSO - Final Design	SHEET 3 OF 9		INITIAL GW ELEV	9.6 ft (10/26/03)
CITY	Portland, Oregon	SURFACE ELEV. 35.1 ft	STA.	EQUIPMENT	Core Barrel and Casing
PROJECT NO.	5516	NORTHING 689,311.3	EASTING 7,645,406.5	DRILLING METHOD	Rotosonic
DATE DRILLED	10/25/03 to 10/27/03	LOCATION	N. River & Albina	LOGGED BY	KJL

SAMPLE TYPE: Ring (3.25" OD) | Standard Penetration Test (2" OD) | Shelby Tube | Grab

Elevation (ft)	DEPTH (ft)	SAMPLE TYPE	SAMPLE NO.	PID	METHANE (ppm)	LAB TESTS	BOX NUMBER	PERCENT FINES (20 40 60 80) / PLASTIC M.C. LIQUID (20 40 60 80)	LITHOLOGY	SOIL DESCRIPTION	WELL
										(Qfc Cont'd) POORLY GRADED GRAVEL WITH SAND AND COBBLES (GP) Cont'd	
					750						
					1900					46 TO 56: Poor recovery, only 5 feet due to large cobbles/gravel on bit and loose open gravel deposit; resampled after falling head test.	
		G	10			GSD	10				
					2300					POORLY GRADED GRAVEL WITH COBBLES (GP); 95-100% gravel, fine to coarse, with cobbles to 6 inches, subrounded to rounded, elongated, basalt, andesite and other lithics, open graded; 0-5% sand, fine- to coarse-grained, basalt and other lithics; gray, wet. Easy drilling.	
-15	50										
					0						
		G	11			FC	11			51 to 56 feet is material that sloughed into hole when casing pulled back to 45 feet - still representative of formation.	
					150						
-20	55										
					0						
		G	12				12			Grades to 70-75% gravel, fine to coarse with cobbles to 4 inches, elongated, basalt and other lithics; 25-30% sand, fine- to coarse-grained, subangular to subrounded, basalt and other lithics; gray to black, wet. No mica in sand. Easy drilling.	
					500						
-25	60									POORLY GRADED SAND (SP); 100% fine sand, mica, volcanic glass, basalt and lithics, light brown, wet.	
					150						
		G	13				13			POORLY GRADED GRAVEL WITH SAND (GP); 70-75% gravel, fine, subrounded, elongated; 25-30% sand, fine to medium, volcanic glass, basalt, and mica.	
					700					POORLY GRADED GRAVEL WITH COBBLES (GP); 95-100% gravel, fine to coarse, with cobbles to 5 inches, flat and elongated, basalt, andesite, and other lithics, generally open graded; 0-5% sand, fine- to coarse-grained, basalt and other lithics; gray, wet.	
-30	65										
					200					POORLY GRADED GRAVEL WITH SAND (GP); 75-80% gravel, fine to coarse, subrounded to rounded, elongated, basalt, other lithics; 20-25% sand, fine- to medium-grained, basalt and other lithics.	

PARSONS BRINCKERHOFF

BORING LOG
ES-3003R

PACRIM GEOTECHNICAL INC.
GEOTECHNICAL ENGINEERING AND APPLIED EARTH SCIENCES

PROJECT	East Side CSO - Final Design	SHEET 4 OF 9		INITIAL GW ELEV	9.6 ft (10/26/03)
CITY	Portland, Oregon	SURFACE ELEV. 35.1 ft	STA.	EQUIPMENT	Core Barrel and Casing
PROJECT NO.	5516	NORTHING 689,311.3	EASTING 7,645,406.5	DRILLING METHOD	Rotosonic
DATE DRILLED	10/25/03 to 10/27/03	LOCATION	N. River & Albina	LOGGED BY	KJL

SAMPLE TYPE: ☒ Ring (3.25" OD) ◨ Standard Penetration Test (2" OD) ■ Shelby Tube G Grab

Elevation (ft)	DEPTH (ft)	SAMPLE TYPE	SAMPLE NO.	PID	METHANE (ppm)	LAB TESTS	BOX NUMBER	△ PERCENT FINES △ 20 40 60 80 / PLASTIC M.C. LIQUID 20 40 60 80	LITHOLOGY	SOIL DESCRIPTION	WELL
		G	14		0		14			**(Qfc Cont'd)**	
										Troutdale Formation (Tt)	
										POORLY GRADED SAND WITH GRAVEL AND COBBLES (SP); 70-75% sand, fine- to medium-grained, with volcanic glass, lithics, and mica; 25-30% gravel, fine to coarse with cobbles to 6 inches; light brown.	
-35	70				0					POORLY GRADED SAND (SP); sand 100% fine to medium, subangular to subrounded, with volcanic glass, basalt, mica, lithics light brown, wet.	
		G	15		650		15				
-40	75				1350						
					0						
		G	16		0		16				
-45	80				1000						
		G	17			GSD	17	△ ●			
-50	85				2000						
					14%						
					0						
		G	18			FC	18	△ ●			
					350						

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GEOTECHNICAL ENGINEERING AND APPLIED EARTH SCIENCES

PROJECT	East Side CSO - Final Design	SHEET 5 OF 9		INITIAL GW ELEV	9.6 ft (10/26/03)
CITY	Portland, Oregon	SURFACE ELEV. 35.1 ft	STA.	EQUIPMENT	Core Barrel and Casing
PROJECT NO.	5516	NORTHING 689,311.3	EASTING 7,645,406.5	DRILLING METHOD	Rotosonic
DATE DRILLED	10/25/03 to 10/27/03	LOCATION	N. River & Albina	LOGGED BY	KJL

SAMPLE TYPE: Ring (3.25" OD) | Standard Penetration Test (2" OD) | Shelby Tube | Grab

Elevation (ft)	DEPTH (ft)	SAMPLE TYPE	SAMPLE NO.	PID	METHANE (ppm)	LAB TESTS	BOX NUMBER	PERCENT FINES (20 40 60 80) / PLASTIC M.C. LIQUID (20 40 60 80)	LITHOLOGY	SOIL DESCRIPTION	WELL
					700					**(Tt Cont'd)** SILTY SAND (SM); 70-80% sand, fine to medium, subangular to subrounded, with volcanic glass, basalt, mica, lithics; 20-30% silt; light brown, wet.	
		G	19			GSD	19			Change to hard drilling, gravel at 93 feet, grades to sand with gravel at 94.5 feet.	
					3850						
-60	95				1050					POORLY GRADED GRAVEL WITH COBBLES (GP); 95-100% gravel, fine to coarse with cobbles to 6 inches, flat and elongated, predominantly basalt; 0-5% sand, fine- to medium-grained.	
					450					POORLY GRADED GRAVEL WITH SAND AND COBBLES (GP); 60-85% gravel, fine to coarse, cobbles to 6 inches, subrounded to rounded, elongated, predominantly basalt; 15-40% sand, fine- to coarse-grained, predominantly basalt with other lithics. Easy drilling.	
		G	20			GSD	20			94 to 100 feet, open gravel.	
					700						
-65	100									POORLY GRADED GRAVEL WITH COBBLES (GP); 95-100% gravel, fine to coarse, with abundant cobbles to 6 inches, subrounded to rounded, elongated, predominantly basalt; 0-5% sand, fine- to medium-grained, basalt and other lithics; gray, wet. Core run from 96 to 106 retrieved only 5 feet of core: suspect large cobbles plugged up barrel preventing material from entering core barrel.	
		G	21				21				
					1150						
-70	105									POORLY GRADED GRAVEL WITH SAND AND COBBLES (GP); 75-80%, fine to coarse with cobbles to 6 inches, sand 20-25% fine to coarse, predominantly basalt. POORLY GRADED SAND (SP); 100% sand, fine- to medium-grained, predominantly basalt with other lithics, wet. Poor recovery from 106 to 116 feet. Drilled 10 feet, retrieved 8 feet.	
		G	22		400	GSD	22				
					2200						
-75	110									POORLY GRADED GRAVEL WITH SAND AND COBBLES (GP); 75-85% gravel, fine to coarse, with cobbles to 6 inches, subrounded to rounded, flat and elongated, predominantly basalt; 15-25% sand, fine- to medium-grained, subangular to subrounded, volcanic glass, basalt, mica, and other lithics.	
					1050						

JULY 2015 GRI JOB NO. 5445 FIG. E-62

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PROJECT	East Side CSO - Final Design	SHEET 6 OF 9		INITIAL GW ELEV	9.6 ft (10/26/03)
CITY	Portland, Oregon	SURFACE ELEV. 35.1 ft	STA.	EQUIPMENT	Core Barrel and Casing
PROJECT NO.	5516	NORTHING 689,311.3	EASTING 7,645,406.5	DRILLING METHOD	Rotosonic
DATE DRILLED	10/25/03 to 10/27/03	LOCATION	N. River & Albina	LOGGED BY	KJL

SAMPLE TYPE: Ring (3.25" OD) | Standard Penetration Test (2" OD) | Shelby Tube | Grab

Elevation (ft)	DEPTH (ft)	SAMPLE TYPE	SAMPLE NO.	PID	METHANE (ppm)	LAB TESTS	BOX NUMBER	PERCENT FINES (20 40 60 80) / PLASTIC M.C. LIQUID (20 40 60 80)	LITHOLOGY	SOIL DESCRIPTION	WELL
		G	23		700	GSD	23			(Tt Cont'd) POORLY GRADED SAND WITH GRAVEL AND COBBLES (SP); 50-60% sand, medium- to coarse-grained, subrounded, predominantly basalt, and other lithics; 40-50% gravel, fine to coarse, with cobbles to 6 inches, subrounded to rounded, flat and elongated, predominantly basalt; dark gray.	
-80	115	G	23A			GSD					
					800						
		G	24		250	GSD	24			POORLY GRADED GRAVEL WITH SAND (GP)	
-85	120										
					150					POORLY GRADED SAND WITH GRAVEL AND COBBLES (SP); 65-85% sand, fine- to medium-grained, volcanic glass, basalt and other lithics, subangular to subrounded; 15-35% gravel, fine to coarse, cobbles to 6 inches, subrounded, elongated, basalt and quartzite.	
		G	25			GSD	25				
					300					WELL GRADED GRAVEL WITH SAND AND COBBLES (GW); 60-65% gravel, fine to coarse, with cobbles to 5 inches, subrounded to rounded, elongated, basalt, quartzite, and other lithics; 35-40% sand, fine- to coarse-grained, subrounded to rounded, predominantly basalt; black-gray, wet.	
-90	125										
					250					NO RECOVERY	
		G	26		250	GSD	26			POORLY GRADED SAND WITH GRAVEL (SP); 80-85% sand, fine- to coarse-grained, subrounded to rounded, predominantly basalt; 15-20% gravel, fine, rounded, predominantly basalt; gray, wet.	
-95	130									POORLY GRADED GRAVEL WITH SAND (GP); 50-55% gravel, fine to coarse, subrounded to rounded, elongated, predominantly basalt, some quartzite; 45-50% sand, medium- to coarse-grained, trace fine, subrounded to rounded, predominantly basalt; gray, wet. Grades to increasing gravel at 131.5 feet; 65-70% gravel, 30-35% sand.	
					400						
		G	27			GSD	27				
					250					POORLY GRADED GRAVEL WITH COBBLES (GP); 95-100% gravel, fine to coarse with cobbles to 6 inches, subrounded to	

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GEOTECHNICAL ENGINEERING AND APPLIED EARTH SCIENCES

PROJECT	East Side CSO - Final Design	SHEET 7 OF 9		INITIAL GW ELEV	9.6 ft (10/26/03)
CITY	Portland, Oregon	SURFACE ELEV. 35.1 ft	STA.	EQUIPMENT	Core Barrel and Casing
PROJECT NO.	5516	NORTHING 689,311.3	EASTING 7,645,406.5	DRILLING METHOD	Rotosonic
DATE DRILLED	10/25/03 to 10/27/03	LOCATION	N. River & Albina	LOGGED BY	KJL

SAMPLE TYPE: ☒ Ring (3.25" OD) ◨ Standard Penetration Test (2" OD) ■ Shelby Tube G Grab

Elevation (ft)	DEPTH (ft)	SAMPLE TYPE	SAMPLE NO.	PID	METHANE (ppm)	LAB TESTS	BOX NUMBER	PERCENT FINES (20 40 60 80) / PLASTIC M.C. LIQUID (20 40 60 80)	LITHOLOGY	SOIL DESCRIPTION	WELL
					700					rounded, elongated, predominantly basalt, some quartzite; 0-5% sand, fine- to coarse-grained, predominantly basalt. Driller says easy, loose drilling.	
										(Tt Cont'd) POORLY GRADED GRAVEL WITH COBBLES (GP); 100% gravel, coarse, with cobbles >6 inches, subrounded to rounded, some elongated. Core run from 136 to 146 feet recovered only 2 feet of open gravel and cobbles greater than 6 inches, suspect larger cobbles rolling in and out of way. Had driller pull outer casing back to 136 feet and let material slough into hole in order to resample.	
		G	28		0	FC	28				
-105	140									POORLY GRADED GRAVEL WITH COBBLES (GP); 50-55% gravel, cobbles >6 inches comprise 45-50% of sample, subrounded to rounded, some elongated, predominantly basalt; <5% sand, fine- to medium-grained, volcanic glass, basalt, mica, light brown, wet. Loose cobbles rolling around in front of core barrel preventing recovery.	
		G	29		0	GSD	29			Pulled outer casing back to 136 and drilled core barrel from 136 to 146 three times to collect slough. Recovered 7 feet of GP with cobbles as described above. Some sand recovered, fine to medium, volcanic glass, predominantly basalt and lithics.	
-110	145				0					Core 146 to 156 - recovered 6 feet. Cobbles stuck on bit during extrusion. Segregated sample spread out in core box to equal 8 feet, bottom 1 foot missing. Cobbles stuck in barrel.	
		G	30		0		30				
-115	150				400					Grades to cobbles and boulders, very hard drilling.	
		G	31		350		31			POORLY GRADED GRAVEL WITH SAND AND COBBLES (GP); 70-75% gravel, coarse, with cobbles >6 inches, subrounded to rounded, elongated, predominantly basalt; 25-30% sand, fine- to medium-grained, subangular to subrounded, volcanic glass, basalt and other lithics; light brown, wet. Hard drilling again at 154 feet.	
-120	155				1000						
					1% LEL						

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PROJECT	East Side CSO - Final Design	SHEET 8 OF 9		INITIAL GW ELEV	9.6 ft (10/26/03)
CITY	Portland, Oregon	SURFACE ELEV. 35.1 ft	STA.	EQUIPMENT	Core Barrel and Casing
PROJECT NO.	5516	NORTHING 689,311.3	EASTING 7,645,406.5	DRILLING METHOD	Rotosonic
DATE DRILLED	10/25/03 to 10/27/03	LOCATION	N. River & Albina	LOGGED BY	KJL

SAMPLE TYPE: ☒ Ring (3.25" OD) ◧ Standard Penetration Test (2" OD) ■ Shelby Tube G Grab

Elevation (ft)	DEPTH (ft)	SAMPLE TYPE	SAMPLE NO.	PID	METHANE (ppm)	LAB TESTS	BOX NUMBER	PERCENT FINES (20 40 60 80) / PLASTIC M.C. LIQUID (20 40 60 80)	LITHOLOGY	SOIL DESCRIPTION	WELL
		G	32		600		32			**(Tt Cont'd)** POORLY GRADED GRAVEL WITH SAND AND COBBLES (GP) Cont'd	
-125	160				0					WELL GRADED GRAVEL WITH SAND AND COBBLES (GW); 65-70% gravel, fine to coarse with cobbles to 4 inches, subrounded, elongated, basalt, quartzite and other lithics; 30-35% sand, fine- to coarse-grained, subangular to subrounded, basalt, volcanic glass, other lithics; red-gray. Driller indicates easy to drill.	
		G	33		750	GSD	33 △●				
-130	165				0					SILTY GRAVEL (GM); 70-75% gravel, fine to coarse, subrounded to rounded, elongated, basalt and other lithics; 10-15% sand, fine- to medium-grained; 10-15% silt, non-plastic; olive gray, wet. NO RECOVERY; 166 to 168 may have been washed when outer casing driven to end of core barrel.	
		G	34		0		34				
		G	34		1050					POORLY GRADED GRAVEL WITH COBBLES (GP); 85-90% gravel, fine to coarse with cobbles to 6 inches, subrounded to rounded, flat and elongated; 10-15% sand fine- to medium-grained, subangular to subrounded, volcanic glass, mica, basalt and other lithics; light brown, wet. Easy to drill.	
-135	170				500					SILTY GRAVEL (GM); 70-75% gravel, fine to coarse, subrounded to rounded, elongated, basalt and other lithics; 10-15% sand, fine- to medium-grained; 10-15% silt, non-plastic; rusty brown, wet. POORLY GRADED GRAVEL WITH SAND AND COBBLES (GP); 70-75% gravel, fine to coarse with cobbles to 6 inches, subrounded to rounded, elongated, basalt, quartzite and other lithics; 25-30% sand, fine- to medium-grained, subangular to subrounded, volcanic glass, mica, basalt and other lithics; dark brown to olive gray, wet.	
		G	35		250		35				
-140	175				400						
		G	36				36				
					200						

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BORING LOG
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PACRIM GEOTECHNICAL INC.
GEOTECHNICAL ENGINEERING AND APPLIED EARTH SCIENCES

PROJECT	East Side CSO - Final Design	SHEET 9 OF 9		INITIAL GW ELEV	9.6 ft (10/26/03)
CITY	Portland, Oregon	SURFACE ELEV. 35.1 ft	STA.	EQUIPMENT	Core Barrel and Casing
PROJECT NO.	5516	NORTHING 689,311.3	EASTING 7,645,406.5	DRILLING METHOD	Rotosonic
DATE DRILLED	10/25/03 to 10/27/03	LOCATION	N. River & Albina	LOGGED BY	KJL

SAMPLE TYPE: ☒ Ring (3.25" OD) ◨ Standard Penetration Test (2" OD) ■ Shelby Tube G Grab

Elevation (ft)	DEPTH (ft)	SAMPLE TYPE	SAMPLE NO.	PID	METHANE (ppm)	LAB TESTS	BOX NUMBER	PERCENT FINES (20 40 60 80) / PLASTIC M.C. LIQUID (20 40 60 80)	LITHOLOGY	SOIL DESCRIPTION	WELL
					100					**(Tt Cont'd)**	
		G	37				37			POORLY GRADED GRAVEL WITH SAND AND COBBLES (GP) Cont'd	
					150						
-150	185									Boring completed to a depth of 185 ft on 10/27/03.	
-155	190										
-160	195										
-165	200										

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BORING LOG
ES-3004R

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PROJECT	East Side CSO - Final Design	SHEET 1 OF 7		INITIAL GW ELEV	12.8 ft (11/9/03)
CITY	Portland, Oregon	SURFACE ELEV. 32.1 ft	STA.	EQUIPMENT	Core Barrel and Casing
PROJECT NO.	5516	NORTHING 690,115.2	EASTING 7,644,401.8	DRILLING METHOD	Rotosonic
DATE DRILLED	11/8/03 to 11/10/03	LOCATION	N. River & Randolph	LOGGED BY	KJL

SAMPLE TYPE: Ring (3.25" OD) | Standard Penetration Test (2" OD) | Shelby Tube | Grab

Elevation (ft)	DEPTH (ft)	SAMPLE TYPE	SAMPLE NO.	PID	METHANE (ppm)	LAB TESTS	BOX NUMBER	PERCENT FINES (20 40 60 80) / PLASTIC M.C. LIQUID (20 40 60 80)	LITHOLOGY	SOIL DESCRIPTION	WELL
				0	0		1			ASPHALTIC CEMENT **Artificial Fill (Qaf)** POORLY GRADED GRAVEL WITH SILT AND SAND (GP-GM); 65-70% gravel, fine to coarse, subrounded to rounded, some elongated; 25-30% sand, fine- to medium-grained; 5-10% silt; brown, grading to black at 2.5 feet.	
30		G	1	3.2	1300					SILTY SAND (SM); 50-55% sand, fine- to medium-grained; 10-15% gravel, fine to coarse; 15-20% silt; scattered brick fragments and woody organics; moist, black. Slight petroleum odor at 3 feet. No odor at 5 feet.	
	5			--	400					SANDY SILT (ML); silt, nonplastic, no toughness, rapid dilatancy when wetted; sand, fine-grained; gray, moist.	
25		G	2	0	250		2			SAWDUST	
				0	2% LEL					WOODY DEBRIS IN SILT MATRIX; brown, wet.	
	10			0	0					**Sand/Silt Alluvium (Qal/Qff)** ELASTIC SILT (MH); low to medium plasticity, slow to no dilatancy, no toughness, medium dry strength, gray to brown, moist.	
20		G	3			AL	3			LEAN CLAY (CL); medium plasticity, medium toughness, no dilatancy, high dry strength, olive gray, moist.	
				0	0						
	15			0	0					FAT CLAY (CH); medium to high plasticity, high toughness, no dilatancy, high dry strength, olive gray, moist.	
15		G	4	0	0		4			LEAN CLAY (CL); low to medium plasticity, low to medium toughness, no dilatancy, medium to high dry strength, olive gray, moist.	
▼				0	0						
	20			0	0					SILT (ML); slow dilatancy, no plasticity, low toughness, medium dry strength, brown, wet, massive.	
10											

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BORING LOG ES-3004R

PACRIM GEOTECHNICAL INC.
GEOTECHNICAL ENGINEERING AND APPLIED EARTH SCIENCES

PROJECT	East Side CSO - Final Design	SHEET 2 OF 7		INITIAL GW ELEV	12.8 ft (11/9/03)
CITY	Portland, Oregon	SURFACE ELEV. 32.1 ft	STA.	EQUIPMENT	Core Barrel and Casing
PROJECT NO.	5516	NORTHING 690,115.2	EASTING 7,644,401.8	DRILLING METHOD	Rotosonic
DATE DRILLED	11/8/03 to 11/10/03	LOCATION	N. River & Randolph	LOGGED BY	KJL

SAMPLE TYPE: Ring (3.25" OD) | Standard Penetration Test (2" OD) | Shelby Tube | Grab

Elevation (ft)	DEPTH (ft)	SAMPLE TYPE	SAMPLE NO.	PID	METHANE (ppm)	LAB TESTS	BOX NUMBER	PERCENT FINES 20 40 60 80 / PLASTIC M.C. LIQUID 20 40 60 80	LITHOLOGY	SOIL DESCRIPTION	WELL
		G	5	0	0	HYD, AL	5			**(Qal/Qff Cont'd)** SILT (ML) Cont'd	
	25			0	0						
5		G	6	0	0	AL	6			SILT (ML); none to slow dilatancy, low to medium plasticity, medium to high dry strength, medium toughness, brown, moist.	
	30			-	0						
0		G	7	-	0		7			ELASTIC SILT (MH); slow dilatancy, low plasticity, low toughness, medium dry strength, brown, wet.	
	35			-	0					**Gravel Alluvium (Qfc)** SILTY GRAVEL WITH COBBLES (GM); 55-60% gravel, coarse, with cobbles to >5", subrounded to rounded, some elongated, basaltic; 40-45% silt, low plasticity, slow dilatancy, none to low toughness; brown, wet.	
-5		G	8	-	0		8			POORLY GRADED GRAVEL WITH SAND AND COBBLES (GP); 75-80% gravel, fine to coarse, with cobbles to >6 inches, subrounded to rounded, flat and elongated, basalt, quartzite and other lithics; 20-25% sand, fine- to coarse-grained, subangular to rounded, basalt and other lithics; red-brown, wet. Easy drilling. NO RECOVERY - large cobbles noted in drill action.	
	40			-	0						
-10		G	9	-	0	GSD	9			POORLY GRADED GRAVEL WITH SAND AND COBBLES (GP); 75-80% gravel, fine to coarse, with cobbles to >6 inches, subrounded to rounded, flat and elongated, basalt, quartzite and other lithics; 20-25% sand, fine- to coarse-grained, subangular to rounded, basalt and other lithics; red-brown, wet. Easy drilling.	
					7% LEL						

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PACRIM GEOTECHNICAL INC.
GEOTECHNICAL ENGINEERING AND APPLIED EARTH SCIENCES

PROJECT	East Side CSO - Final Design	SHEET 3 OF 7		INITIAL GW ELEV	12.8 ft (11/9/03)
CITY	Portland, Oregon	SURFACE ELEV. 32.1 ft	STA.	EQUIPMENT	Core Barrel and Casing
PROJECT NO.	5516	NORTHING 690,115.2	EASTING 7,644,401.8	DRILLING METHOD	Rotosonic
DATE DRILLED	11/8/03 to 11/10/03	LOCATION	N. River & Randolph	LOGGED BY	KJL

SAMPLE TYPE: Ring (3.25" OD) | Standard Penetration Test (2" OD) | Shelby Tube | Grab

Elevation (ft)	DEPTH (ft)	SAMPLE TYPE	SAMPLE NO.	PID	METHANE (ppm)	LAB TESTS	BOX NUMBER	PERCENT FINES 20 40 60 80 / PLASTIC M.C. LIQUID 20 40 60 80	LITHOLOGY	SOIL DESCRIPTION	WELL
-15		G	10		1% LEL, 0, 2% LEL		10			**(Qfc Cont'd)** POORLY GRADED GRAVEL WITH SAND AND COBBLES (GP) Cont'd	
	50				550		11			POORLY GRADED GRAVEL WITH COBBLES (GP); 95-100% gravel, fine to coarse, with cobbles to 5 inches, subrounded to rounded, flat and elongated, basalt, quartzite and other lithics; 0-5% sand, fine- to coarse-grained. Open gravel.	
-20		G	11		2% LEL					POORLY GRADED GRAVEL WITH SAND AND COBBLES (GP); 80-85% gravel, fine to coarse, with cobbles to >6 inches, subrounded to rounded, flat and elongated, basalt, quartzite and other lithics; 15-20% sand, fine- to coarse-grained, subangular to rounded; 0-5% silt; brown, wet. Easy drilling.	
	55				2% LEL, 0		12			POORLY GRADED GRAVEL WITH COBBLES (GP); 95-100% gravel, fine to coarse, with cobbles to >6 inches, subrounded to rounded, flat and elongated; 0-5% sand, fine- to coarse-grained. Open gravel.	
-25		G	12		0						
	60				850		13			**Troutdale Formation (Tt)** POORLY GRADED GRAVEL WITH SAND AND COBBLES (GP); 75-80% gravel, fine to coarse, with cobbles to 6 inches, subrounded to rounded, flat and elongated, basalt, quartzite and other lithics; 20-25% sand, fine- to coarse-grained, subangular to rounded, basalt and other lithics; 0-5% silt; brown, wet.	
-30		G	13		1000					POORLY GRADED GRAVEL WITH SAND AND COBBLES (GP); 50-55% gravel with cobbles to >6 inches, subrounded to rounded, flat and elongated; 45-50% sand, fine- to medium-grained, subangular to subrounded, volcanic glass, mica, basalt and other lithics; 0-5% silt; brown, wet.	
	65				750					POORLY GRADED SAND WITH GRAVEL (SP); brown, wet. POORLY GRADED SAND (SP); 95-100% sand, fine- to medium-grained, subangular to subrounded, volcanic glass, mica, basalt and other lithics; 0-5% gravel; light brown, wet.	
-35											

PARSONS BRINCKERHOFF

BORING LOG ES-3004R

PACRIM GEOTECHNICAL INC.
GEOTECHNICAL ENGINEERING AND APPLIED EARTH SCIENCES

PROJECT	East Side CSO - Final Design	SHEET 4 OF 7		INITIAL GW ELEV	12.8 ft (11/9/03)
CITY	Portland, Oregon	SURFACE ELEV. 32.1 ft	STA.	EQUIPMENT	Core Barrel and Casing
PROJECT NO.	5516	NORTHING 690,115.2	EASTING 7,644,401.8	DRILLING METHOD	Rotosonic
DATE DRILLED	11/8/03 to 11/10/03	LOCATION	N. River & Randolph	LOGGED BY	KJL

SAMPLE TYPE: Ring (3.25" OD) | Standard Penetration Test (2" OD) | Shelby Tube | Grab

Elevation (ft)	DEPTH (ft)	SAMPLE TYPE	SAMPLE NO.	PID	METHANE (ppm)	LAB TESTS	BOX NUMBER	PERCENT FINES 20 40 60 80 / PLASTIC M.C. LIQUID 20 40 60 80	LITHOLOGY	SOIL DESCRIPTION	WELL
		G	14		400		14			**(Tt Cont'd)** Hard drilling at 68 feet. POORLY GRADED GRAVEL WITH SAND AND COBBLES (GP); 70-75% gravel, fine to coarse, with cobbles to 6 inches, subrounded to rounded, flat and elongated, basalt and quartzite; 25-30% sand, fine to coarse, subangular to subrounded, volcanic glass, mica, basalt and other lithics; brown, wet. Gravels have spotty coatings of fine- to medium-grained sand cemented to surfaces.	
	70				550						
-40		G	15		25% LEL		15			POORLY GRADED GRAVEL WITH SILT, SAND AND COBBLES (GP-GM); 65-70% gravel, fine to coarse, with cobbles to >6 inches, subrounded to rounded, flat and elongated, basalt, quartzite and other lithics; 25-30% sand, fine- to medium-grained, subangular to subrounded, volcanic glass, mica, basalt and other lithics; 5-10% silt; red-brown to yellow-brown. Fines content increased by drilling action. Some gravels have spotty coatings of fine- to medium-grained sand cemented to surfaces. Very hard.	
	75				1% LEL						
-45					5%						
		G	16		400		16			POORLY GRADED GRAVEL WITH COBBLES (GP); 80-85% gravel, fine to coarse, with cobbles to 6 inches; 5-10% sand, fine- to coarse-grained; 0-5% silt.	
	80				13% LEL					POORLY GRADED GRAVEL WITH SILT, SAND, COBBLES, AND BOULDERS (GP-GM); 65-75% gravel, fine to coarse, with cobbles and boulders to >12 inches, subrounded to rounded, flat and elongated, basalt, quartzite and other lithics; 20-25% sand, fine- to medium-grained, subangular to subrounded, volcanic glass, mica, basalt and other lithics; 5-10% silt; yellow-brown with gray mottling, wet. Some gravel and cobbles have coatings of fine- to medium-grained sand cemented to surfaces. Fines content increased significantly by drilling action. Boulder at 80 feet.	
-50					4%						
		G	17		1% LEL	GSD	17				
	85				2% LEL						
-55		G	18		500		18			POORLY GRADED GRAVEL WITH SAND, COBBLES AND BOULDERS (GP); 80-85% gravel, fine to coarse, with cobbles to >8 inches, subrounded to rounded, flat and elongated, basalt, quartzite and other lithics; 15-20% sand, fine- to medium-grained; 0-5% silt; red-gray, wet. Fines content increased by drilling action. Some gravel and cobbles have spotty coatings of fine- to medium-grained sand cemented to surfaces. Very hard drilling. Grades to increasing sand.	

PARSONS BRINCKERHOFF

BORING LOG
ES-3004R

PACRIM GEOTECHNICAL INC.
GEOTECHNICAL ENGINEERING AND APPLIED EARTH SCIENCES

PROJECT	East Side CSO - Final Design	SHEET 5 OF 7		INITIAL GW ELEV	12.8 ft (11/9/03)
CITY	Portland, Oregon	SURFACE ELEV. 32.1 ft	STA.	EQUIPMENT	Core Barrel and Casing
PROJECT NO.	5516	NORTHING 690,115.2	EASTING 7,644,401.8	DRILLING METHOD	Rotosonic
DATE DRILLED	11/8/03 to 11/10/03	LOCATION	N. River & Randolph	LOGGED BY	KJL

SAMPLE TYPE: Ring (3.25" OD) | Standard Penetration Test (2" OD) | Shelby Tube | Grab

Elevation (ft)	DEPTH (ft)	SAMPLE TYPE	SAMPLE NO.	PID	METHANE (ppm)	LAB TESTS	BOX NUMBER	PERCENT FINES (20 40 60 80) / PLASTIC M.C. LIQUID (20 40 60 80)	LITHOLOGY	SOIL DESCRIPTION	WELL
										(Tt Cont'd)	
					10% LEL					POORLY GRADED GRAVEL WITH SAND, COBBLES AND BOULDERS (GP) Cont'd	
-60							19				
		G	19		250	GSD				POORLY GRADED GRAVEL WITH SAND AND COBBLES (GP); 75-80% gravel, fine to coarse, with cobbles to 6 inches, subrounded to rounded, flat and elongated, basalt, quartzite and other lithics; 20-25% sand, fine- to coarse-grained, volcanic glass, mica, basalt and other lithics; 0-5% silt; red-gray, wet. Some gravels have spotty coatings of fine- to medium-grained sand cemented to surfaces. Fines generated by drilling action.	
	95				5% LEL						
-65		G	20			GSD	20			POORLY GRADED GRAVEL WITH COBBLES (GP); 85-90% gravel, fine to coarse, with cobbles to >6 inches, subrounded to rounded, flat and elongated, basalt and quartzite; 10-15% sand, fine- to medium-grained, volcanic glass, mica, basalt and other lithics; 0-5% silt; mottled red-brown and gray, wet. Fines content increased by drilling action, creating 1/2-inch thick rind around sample.	
					27% LEL						
	100				11% LEL					POORLY GRADED GRAVEL WITH SILT, SAND AND COBBLES (GP-GM); 70-75% gravel, fine to coarse, with cobbles to >6 inches, subrounded to rounded, flat and elongated; 15-20% sand, fine- to medium-grained; 5-15% silt; red-brown to gray, wet. Fines content increased by drilling action.	
-70		G	21			GSD	21				
					14% LEL						
	105				400					Grades to dark gray.	
-75		G	22			FC	22				
					2% LEL						
	110										
										CLAYSTONE; weak to moderate induration; FAT CLAY (CH); high plasticity, high toughness, over-consolidated; gray, dry.	
-80					550						

JULY 2015 GRI JOB NO. 5445 FIG. E-71

PARSONS BRINCKERHOFF

BORING LOG ES-3004R

PACRIM GEOTECHNICAL INC.
GEOTECHNICAL ENGINEERING AND APPLIED EARTH SCIENCES

PROJECT	East Side CSO - Final Design	SHEET 6 OF 7		INITIAL GW ELEV	12.8 ft (11/9/03)
CITY	Portland, Oregon	SURFACE ELEV. 32.1 ft	STA.	EQUIPMENT	Core Barrel and Casing
PROJECT NO.	5516	NORTHING 690,115.2	EASTING 7,644,401.8	DRILLING METHOD	Rotosonic
DATE DRILLED	11/8/03 to 11/10/03	LOCATION	N. River & Randolph	LOGGED BY	KJL

SAMPLE TYPE: Ring (3.25" OD) | Standard Penetration Test (2" OD) | Shelby Tube | Grab

Elevation (ft)	DEPTH (ft)	SAMPLE TYPE	SAMPLE NO.	PID	METHANE (ppm)	LAB TESTS	BOX NUMBER	PERCENT FINES 20 40 60 80 / PLASTIC M.C. LIQUID 20 40 60 80	LITHOLOGY	SOIL DESCRIPTION	WELL
		G	23		2% LEL	GSD	23			**(Tt Cont'd)** POORLY GRADED SAND WITH GRAVEL (SP); 60-75% sand, fine- to medium-grained, volcanic glass, mica, basalt and other lithics; 25-35% gravel, fine to coarse, subrounded to rounded, flat and elongated, basalt, quartzite and other lithics; red-brown, wet. Cemented zone at 114 feet. Layer of siltstone at 115 feet.	
	115				2% LEL					POORLY GRADED GRAVEL WITH SAND (GP); 80-90% gravel, fine to coarse, grading to coarse with depth, subrounded to rounded, flat and elongated, basalt and quartzite; 10-20% sand; olive gray, wet. Layer of claystone at 117 feet.	
-85		G	24		150	GSD	24				
					200					POORLY GRADED GRAVEL WITH SAND AND COBBLES (GP); 85-90% gravel, fine to coarse, subrounded to rounded, flat and elongated, basalt, quartzite and other lithics; 15-20% sand, fine- to medium-grained; 0-5% silt; olive-gray, wet.	
	120				2% LEL					POORLY GRADED GRAVEL (GP); 95-100% gravel, fine to coarse, subrounded to rounded, elongated, predominantly basalt; 0-5% silt; olive gray, wet.	
-90		G	25				25			POORLY GRADED GRAVEL WITH SAND (GP); 75-80% gravel, fine to coarse; 15-20% sand. Occasional lenses of claystone or over-consolidated fat clay. Some gravels have thick coatings of fine- to medium-grained sand cemented to surfaces.	
					250					POORLY GRADED GRAVEL WITH SILT, SAND AND COBBLES (GP-GM); 65-70% gravel, fine to coarse, with cobbles to 4 inches, subrounded to rounded, flat and elongated, predominantly basalt; 25-30% sand, fine- to medium-grained, subangular to subrounded, volcanic glass, mica, basalt and other lithics; 5-10% silt; gray, wet. Some gravels have spotty coatings of fine- to medium-grained sand cemented to surfaces. Fines content increased by drilling action.	
	125				1% LEL					CLAYEY GRAVEL WITH SAND AND COBBLES (GC); 40-50% gravel, fine to coarse, with cobbles to 6 inches, subrounded to rounded, flat and elongated, predominantly basalt and quartzite; 20-30% sand, fine- to medium-grained; 25-35% clay, lean, medium plasticity, no dilatancy, medium toughness, high dry strength; dark gray, moist.	
-95		G	26		9% LEL	GSD	26				
	130				13% LEL					POORLY GRADED GRAVEL WITH CLAY AND SAND (GP-GC); 60-65% gravel, fine to coarse, subrounded to rounded, flat and elongated, basalt and quartzite; 15-20% sand, fine- to medium-grained, volcanic glass, mica, basalt and other lithics; 10-15% clay, lean, medium plasticity, medium toughness, no dilatancy, high dry strength; dark gray, moist.	
-100		G	27		16% LEL	FC	27				

PARSONS BRINCKERHOFF

BORING LOG
ES-3004R

PACRIM GEOTECHNICAL INC.
GEOTECHNICAL ENGINEERING AND APPLIED EARTH SCIENCES

PROJECT	East Side CSO - Final Design	SHEET 7 OF 7		INITIAL GW ELEV	12.8 ft (11/9/03)
CITY	Portland, Oregon	SURFACE ELEV. 32.1 ft	STA.	EQUIPMENT	Core Barrel and Casing
PROJECT NO.	5516	NORTHING 690,115.2	EASTING 7,644,401.8	DRILLING METHOD	Rotosonic
DATE DRILLED	11/8/03 to 11/10/03	LOCATION	N. River & Randolph	LOGGED BY	KJL

SAMPLE TYPE: Ring (3.25" OD) | Standard Penetration Test (2" OD) | Shelby Tube | Grab

Elevation (ft)	DEPTH (ft)	SAMPLE TYPE	SAMPLE NO.	PID	METHANE (ppm)	LAB TESTS	BOX NUMBER	PERCENT FINES (20 40 60 80) / PLASTIC M.C. LIQUID (20 40 60 80)	LITHOLOGY	SOIL DESCRIPTION	WELL
				--	16% LEL					**(Tt Cont'd)**	
				--	7%					POORLY GRADED GRAVEL WITH CLAY AND SAND (GP-GC) Cont'd	
105		G	28				28			CLAYEY GRAVEL WITH SAND AND COBBLES (GC); 50-55% gravel, fine to coarse, with cobbles to 6 inches, subrounded to rounded, flat and elongated; 15-20% sand, fine- to medium-grained; 20-25% clay, lean, medium plasticity, no dilatancy, medium toughness, high dry strength; gray, moist.	
				--	13% LEL						
	140										
				--	26% LEL						
110		G	29				29			Very hard drilling from 143 to 144 - cemented/over-consolidated.	
				--	15% LEL						
	145									Boring completed to a depth of 145 ft on 11/10/03.	
115											
	150										
120											
	155										
125											

PARSONS BRINCKERHOFF

BORING LOG ES-3005A

Foundation Engineering, Inc.

PROJECT East Side CSO - Final Design | SHEET 1 OF 4 | INITIAL GWL@ Not Available
CITY Portland, Oregon | SURF. EL. 28.1 ft | STA. | OFST. | EQUIPMENT CME 75
PROJECT NO. 2032011 | NORTHING 690791.6 | EASTING 7643611.5 | DRILLING METHOD Mud Rotary
DATE DRILLED 10/2/03 | LOGGED BY AR | LOCATION N River & Essex | HAMMER SYS. 140 + 300 lb. hammer, 30 inch drop

SAMPLE TYPE: Ring (3.25" OD) | Standard Penetration Test (2" OD) | Shelby Tube | Grab Sample

Elevation (ft)	DEPTH (ft)	SAMPLE TYPE	SAMPLE NO	FIELD BLOWS /6"	LAB TESTS	SOIL DESCRIPTION
						Pavement ASPHALTIC CONCRETE OVER BASE ROCK.
						Artificial Fill (Qaf) SILTY SAND (SM); loose.
25						POORLY GRADED GRAVEL WITH SAND (GP); medium dense. ±20 gallons of mud loss between 3 to 5 feet.
	5		1	6 4 5		POORLY GRADED SAND (SP); trace gravel, fine to medium sand, fine to coarse gravel, angular, yellow-brown, moist, loose.
20						LEAN CLAY (CL); trace sand, medium sand, low to medium plasticity, brown to light brown, moist, medium stiff.
	10		2	3 3 3	MC AL	
15						**Sand/Silt Alluvium (Qal)** SILT WITH SAND (ML); trace to some sand, fine sand, low plasticity, brown, moist to wet, soft.
	15		3			
10						
	20		4	9 3 3	MC	INTERBEDDED LAYERS OF SILTY SAND (SM) to SILT (ML); trace to mostly sand, fine sand, low plasticity to nonplastic, brown, wet, loose sand to medium stiff silt.
5						
	25		5	5 4 3	MC	
0			6		AL GSD HYD MD	Becomes SANDY SILT (ML).
	30		7	0 10 22	AL MC	
-5						**Gravel Alluvium (Qfc)** POORLY GRADED GRAVEL WITH SILT AND SAND; (GP-GM); trace to few silt, fine to coarse gravel, subrounded to rounded, gray-brown, wet, dense to very dense.
	35		8	20 24 35	FC	

Lab tests: PERCENT FINES (20 40 60 80); PLASTIC M.C. LIQUID (20 40 60 80)

LITHOLOGY

UNCORRECTED BLOW COUNTS (last 12") 20 40 60 80

WELL

ESCSO MUD 2005 2032011.GPJ 2042034-REV1.GPJ 6/6/05

Geotechnical Data Report

JULY 2015 GRI JOB NO. 5445 FIG. E-74

PARSONS BRINCKERHOFF

BORING LOG ES-3005A

Foundation Engineering, Inc.

PROJECT East Side CSO - Final Design | SHEET 2 OF 4 | INITIAL GWL@ Not Available
CITY Portland, Oregon | SURF. EL. 28.1 ft | STA. | OFST. | EQUIPMENT CME 75
PROJECT NO. 2032011 | NORTHING 690791.6 | EASTING 7643611.5 | DRILLING METHOD Mud Rotary
DATE DRILLED 10/2/03 | LOGGED BY AR | LOCATION N River & Essex | HAMMER SYS. 140 + 300 lb. hammer, 30 inch drop

SAMPLE TYPE: Ring (3.25" OD) | Standard Penetration Test (2" OD) | Shelby Tube | Grab Sample

Elevation (ft)	DEPTH (ft)	SAMPLE TYPE	SAMPLE NO	FIELD BLOWS /6"	LAB TESTS	PERCENT FINES (20 40 60 80) / PLASTIC M.C. LIQUID (20 40 60 80)	SOIL DESCRIPTION	LITHOLOGY	UNCORRECTED BLOW COUNTS (last 12") (20 40 60 80)	WELL
-10							**(Qfc Cont'd)** POORLY GRADED GRAVEL WITH SILT AND SAND; (GP-GM); trace to few silt, fine to coarse gravel, subrounded to rounded, gray-brown, wet, dense to very dense.			
	40		9	16 19 38	GSD					
-15										
	45		10	50					50/1"	
-20										
	50		11	50					50/4"	
-25							POORLY GRADED SAND (SP); trace silt, fine to coarse sand, gray-brown, wet, very dense.			
	55		12	50					50/3½"	
-30							WELL GRADED GRAVEL WITH SILT AND SAND (GW-GM); some sand, trace to few silt, fine to coarse gravel, subrounded to rounded, gray-brown, wet, very dense.			
	60		13	50	GSD				50/5"	
-35										
	65		14	50	GSD		Becomes WELL GRADED SAND WITH GRAVEL (SW).		50/2"	
-40							**Troutdale Formation (Tt)** POORLY GRADED GRAVEL WITH SILT AND SAND (GP-GM); some sand, few silt, fine to coarse gravel, subrounded to rounded, low to medium plasticity fines, orange-brown to gray, wet, very dense, some quartzite.			
	70		15	50					50/4"	
-45										

ESCSO MUD 2005 2032011.GPJ 2042034-REV1.GPJ 6/6/05

Geotechnical Data Report

JULY 2015 GRI JOB NO. 5445 FIG. E-75

PARSONS BRINCKERHOFF

BORING LOG ES-3005A

Foundation Engineering, Inc.

PROJECT East Side CSO - Final Design | SHEET 3 OF 4 | INITIAL GWL@ Not Available
CITY Portland, Oregon | SURF. EL. 28.1 ft | STA. | OFST. | EQUIPMENT CME 75
PROJECT NO. 2032011 | NORTHING 690791.6 | EASTING 7643611.5 | DRILLING METHOD Mud Rotary
DATE DRILLED 10/2/03 | LOGGED BY AR | LOCATION N River & Essex | HAMMER SYS. 140 + 300 lb. hammer, 30 inch drop

SAMPLE TYPE: Ring (3.25" OD) | Standard Penetration Test (2" OD) | Shelby Tube | Grab Sample

Elevation (ft)	DEPTH (ft)	SAMPLE NO	FIELD BLOWS /6"	LAB TESTS	SOIL DESCRIPTION	UNCORRECTED BLOW COUNTS (last 12")
		16	50		**(Tt Cont'd)** POORLY GRADED GRAVEL WITH SILT AND SAND (GP-GM); fine to coarse gravel, subrounded to rounded, low to medium plasticity fines, orange-brown to gray, wet, very dense.	50/2½"
-50						
	80	17	50			50/2½"
-55						
	85	18	50			50/2"
-60						
	90	19	50		Becomes olive-gray.	50/3"
-65						
	95	20	50			50/2½"
-70						
	100	21	50			50/3"
-75						
	105	22	50			50/3"
-80						
	110	23	50			50/2½"

PERCENT FINES 20 40 60 80; PLASTIC M.C. LIQUID 20 40 60 80

LITHOLOGY | WELL

ESCSO MUD 2005 2032011.GPJ 2042034-REV1.GPJ 6/6/05

PARSONS BRINCKERHOFF

BORING LOG ES-3005A

Foundation Engineering, Inc.

PROJECT East Side CSO - Final Design | SHEET 4 OF 4 | INITIAL GWL@ Not Available
CITY Portland, Oregon | SURF. EL. 28.1 ft | STA. | OFST. | EQUIPMENT CME 75
PROJECT NO. 2032011 | NORTHING 690791.6 | EASTING 7643611.5 | DRILLING METHOD Mud Rotary
DATE DRILLED 10/2/03 | LOGGED BY AR | LOCATION N River & Essex | HAMMER SYS. 140 + 300 lb. hammer, 30 inch drop

SAMPLE TYPE: Ring (3.25" OD) | Standard Penetration Test (2" OD) | Shelby Tube | Grab Sample

Elevation (ft)	DEPTH (ft)	SAMPLE TYPE	SAMPLE NO	FIELD BLOWS /6"	LAB TESTS	PERCENT FINES (20 40 60 80) / PLASTIC M.C. LIQUID (20 40 60 80)	SOIL DESCRIPTION	LITHOLOGY	UNCORRECTED BLOW COUNTS (last 12") (20 40 60 80)	WELL
-85							**(Tt Cont'd)** POORLY GRADED GRAVEL WITH SILT, SAND AND FEW COBBLES (GP-GM); fine to coarse gravel, subrounded to rounded, low to medium plasticity fines, olive-gray, wet, very dense.			
	115		24	50	GSD				50/2½"	
-90										
	120		25	50	GSD				50/3"	
-95										
	125		26	50					50/3"	
-100										
	130		27	50					50/2"	
-105										
	135		28	50	GSD				50/2½"	
-110										
	140		29	50			Bottom of boring at 140.2 ft.		50/2"	
-115										
	145									
-120										

ESCSO MUD 2005 2032011.GPJ 2042034-REV1.GPJ 6/6/05

PARSONS BRINCKERHOFF

BORING LOG
ES-3018R

PACRIM GEOTECHNICAL INC.
GEOTECHNICAL ENGINEERING AND APPLIED EARTH SCIENCES

PROJECT	East Side CSO - Final Design	SHEET 1 OF 9		INITIAL GW ELEV	8.5 ft (11/23/04)
CITY	Portland, Oregon	SURFACE ELEV. 79.7 ft	STA.	EQUIPMENT	Core Barrel and Casing
PROJECT NO.	5516	NORTHING 688,962.3	EASTING 7,645,783.0	DRILLING METHOD	Rotosonic
DATE DRILLED	11/18/04 to 11/24/04	LOCATION	Larabee Avenue at Hancock Ct	LOGGED BY	GS

SAMPLE TYPE: ☒ Ring (3.25" OD) ◨ Standard Penetration Test (2" OD) ■ Shelby Tube G Grab

Elevation (ft)	DEPTH (ft)	SAMPLE TYPE	SAMPLE NO.	PID	METHANE (ppm)	LAB TESTS	BOX NUMBER	PERCENT FINES (20 40 60 80) / PLASTIC M.C. LIQUID (20 40 60 80)	LITHOLOGY	SOIL DESCRIPTION	WELL
										Artificial Fill (Qaf) 3 to 4-inches dense roots/turf, grass. Trace brick at 6 and 14-inches. SILT (ML): Gravel (<5%), fine, rounded; Sand (10-20%), fine; Silt (75-85%), low plasticity; cement coating and staining, concrete fragments; brown to light-medium brown, moist.	
		G	1	0.5	420		1			**Sand/Silt Alluvium (Qal/Qff)** ELASTIC SILT (MH): Sand (5-10%), fine; concrete fragments, moist. SILT (ML): Sand (<5-10%); Silt (90-95%), low to medium plasticity; rapid dilatancy, iron staining, brown, moist.	
				2	260						
75	5			2	60		2				
		G	2	2	80	AL				At 7.4 to 8.1' - gray layer.	
70	10			10	60						
				12	400		3			SILTY SAND (SM) ranging to SANDY SILT (ML): Sand (40-70%), fine; Silt (30-60%), rapid dilatancy, low plasticity; light brown, moist.	
		G	3	4	220						
65	15			6	100					SILT (ML): Sand (10-15%), fine; Silt (85-90%), low plasticity; light brown, moist.	
							4				
		G	4	0	40	FC				SILTY SAND (SM): Sand (60-85%), fine; Silt (15-40%), rapid dilatancy, low plasticity to non-plastic; stratified, light brown, moist.	
60	20									SILTY SAND (SM) ranging to SANDY SILT (ML): Sand (45-85%), fine; Silt (15-55%), rapid dilatancy, low plasticity; stratified, light brown.	
				0	60						

JULY 2015 GRI JOB NO. 5445 FIG. E-78

PARSONS BRINCKERHOFF

BORING LOG
ES-3018R

PACRIM GEOTECHNICAL INC.
GEOTECHNICAL ENGINEERING AND APPLIED EARTH SCIENCES

PROJECT	East Side CSO - Final Design	SHEET 2 OF 9		INITIAL GW ELEV	8.5 ft (11/23/04)
CITY	Portland, Oregon	SURFACE ELEV. 79.7 ft	STA.	EQUIPMENT	Core Barrel and Casing
PROJECT NO.	5516	NORTHING 688,962.3	EASTING 7,645,783.0	DRILLING METHOD	Rotosonic
DATE DRILLED	11/18/04 to 11/24/04	LOCATION	Larabee Avenue at Hancock Ct	LOGGED BY	GS

SAMPLE TYPE: Ring (3.25" OD) | Standard Penetration Test (2" OD) | Shelby Tube | Grab

Elevation (ft)	DEPTH (ft)	SAMPLE TYPE	SAMPLE NO.	PID	METHANE (ppm)	LAB TESTS	BOX NUMBER	PERCENT FINES (20 40 60 80) / PLASTIC M.C. LIQUID (20 40 60 80)	LITHOLOGY	SOIL DESCRIPTION	WELL
		G	5	0	80		5			**(Qal/Qff Cont'd)**	
55	25									SANDY SILT (ML): Sand (40%), fine; Silt (60%), low plasticity.	
				0	40		6			**Troutdale Formation (Tt)** POORLY GRADED GRAVEL WITH SAND AND COBBLES (GP): Gravel (75-90%), fine to coarse, mostly < 2-inches, rounded to subrounded, basalt, metavolcanics; Sand (10-25%), fine to coarse; Silty matrix in upper 6 inches, grades coarser with depth; brown, weathered/reworked, moist.	
		G	6		330						
					2880						
50	30									At 29.7' - cobbles to 5-inches, flat and elongated. At 30' - Cobbles to 6-inches.	
					760		7			POORLY GRADED GRAVEL WITH CLAY AND SAND (GP-GC): Gravel (65-80%); Sand (10-25%), fine to coarse; Clay (10-15%), low plasticity; medium brown, moist.	
		G	7							POORLY GRADED GRAVEL WITH SAND (GP): Gravel (75-90%), fine to coarse; Sand (10-25%), fine to coarse.	
					140					CLAYEY GRAVEL WITH COBBLES (GC): Gravel (65-80%), 5-inch flat cobbles, metamorphic, elongated; Sand (5-10%); Clay (15-25%), low to medium plasticity; light brown, very moist.	
45	35									POORLY GRADED GRAVEL WITH SAND AND COBBLES (GP): Gravel (70-85%), fine to coarse, flat and elongated cobbles to 6 inches; Sand (10-25%), fine to coarse; Clay (<5%); brown to medium brown, moist to wet.	
					3120						
							8			POORLY GRADED SAND WITH GRAVEL (SP): Gravel (10-20%), fine to coarse, rounded; Sand (80-90%), fine; stratified.	
		G	8		6800					POORLY GRADED SAND WITH SILT (SP-SM): Sand (75-95%), fine to medium; Silt (5-25%), non-plastic; light to medium brown, blocky, weakly cemented, moist.	
40	40									SILTY SAND (SM): Sand (60-85%), fine to medium; Silt (15-40%), low plasticity to non-plastic; light brown, stratified (6 to 18-inch thick layers), weakly cemented, blocky.	
					5040		9				
		G	9		3540					At 44' - Brown, loose, weakly cemented, moist.	
35											

PARSONS BRINCKERHOFF

BORING LOG
ES-3018R

PACRIM GEOTECHNICAL INC.
GEOTECHNICAL ENGINEERING AND APPLIED EARTH SCIENCES

PROJECT	East Side CSO - Final Design	SHEET 3 OF 9		INITIAL GW ELEV	8.5 ft (11/23/04)
CITY	Portland, Oregon	SURFACE ELEV. 79.7 ft	STA.	EQUIPMENT	Core Barrel and Casing
PROJECT NO.	5516	NORTHING 688,962.3	EASTING 7,645,783.0	DRILLING METHOD	Rotosonic
DATE DRILLED	11/18/04 to 11/24/04	LOCATION	Larabee Avenue at Hancock Ct	LOGGED BY	GS

SAMPLE TYPE: ☒ Ring (3.25" OD) ◨ Standard Penetration Test (2" OD) ■ Shelby Tube G Grab

Elevation (ft)	DEPTH (ft)	SAMPLE TYPE	SAMPLE NO.	PID	METHANE (ppm)	LAB TESTS	BOX NUMBER	PERCENT FINES (20 40 60 80) / PLASTIC M.C. LIQUID (20 40 60 80)	LITHOLOGY	SOIL DESCRIPTION	WELL
					420					At 45' - Brown, blocky, friable, moist. **(Tt Cont'd)**	
					3200		10			POORLY GRADED SAND (SP): Sand (90-100%), fine to medium; Silt (0-10%); stratified beds (8 to 24-inches).	
		G	10		2420						
30	50				1000						
							11			POORLY GRADED SAND WITH SILT (SP-SM): Sand (80-95%), fine; Silt (5-20%); blocky.	
		G	11		3520						
25	55				2540					POORLY GRADED SAND (SP): Gravel (<5%), fine to coarse; Sand (85-100%); Silt (0-10%); brown, moist. At 56' - Gravel (5-15%), fine to coarse, to 3-inch elongated.	
							12			SILTY SAND (SM): Gravel (5%); Sand (65-80%); Silt (15-30%); blocky, friable, weakly cemented, dry.	
		G	12		1600					POORLY GRADED SAND WITH SILT (SP-SM): Gravel (5-10%), fine to coarse; Sand (80-95%), fine to medium; Silt (5-10%), non-plastic; brown, moist.	
					5300						
20	60				6400					At 60' - Decrease in Gravel (<5%).	
							13			POORLY GRADED GRAVEL WITH SAND AND COBBLES (GP): Gravel (80%), coarse, 8-inch elongated cobble, basalt gravel; Sand (20%).	
		G	13		4500					POORLY GRADED SAND WITH SILT (SP-SM): Gravel (<5%); Sand (90-95%), fine to medium; Silt (5-10%), non-plastic; brown, stratified, weakly cemented, blocky, friable, moist.	
					1740					SILTY SAND to SANDY SILT (SM/ML): Cemented siltstone/sandstone - Gravel (5%); Sand (30-70%), fine; Silt (30-70%), low to low plasticity; dry.	
15	65									POORLY GRADED SAND WITH SILT (SP-SM): Sand (90-100%), fine; Silt (0-10%), non-plastic; brown, weakly cemented, moist.	
					120					POORLY GRADED SAND (SP): Gravel (5-10%), fine to coarse, to 3-inches, flat, elongated; Sand (95-90%), fine to medium; brown, weakly cemented, moist.	

JULY 2015 GRI JOB NO. 5445 FIG. E-80

PARSONS BRINCKERHOFF

BORING LOG
ES-3018R

PACRIM GEOTECHNICAL INC.
GEOTECHNICAL ENGINEERING AND APPLIED EARTH SCIENCES

PROJECT	East Side CSO - Final Design	SHEET 4 OF 9		INITIAL GW ELEV	8.5 ft (11/23/04)
CITY	Portland, Oregon	SURFACE ELEV. 79.7 ft	STA.	EQUIPMENT	Core Barrel and Casing
PROJECT NO.	5516	NORTHING 688,962.3	EASTING 7,645,783.0	DRILLING METHOD	Rotosonic
DATE DRILLED	11/18/04 to 11/24/04	LOCATION	Larabee Avenue at Hancock Ct	LOGGED BY	GS

SAMPLE TYPE: ☒ Ring (3.25" OD) ◨ Standard Penetration Test (2" OD) ■ Shelby Tube G Grab

Elevation (ft)	DEPTH (ft)	SAMPLE TYPE	SAMPLE NO.	PID	METHANE (ppm)	LAB TESTS	BOX NUMBER	PERCENT FINES (20 40 60 80) / PLASTIC M.C. LIQUID (20 40 60 80)	LITHOLOGY	SOIL DESCRIPTION	WELL
		G	14		1400		14			**(Tt Cont'd)** SILT WITH SAND (ML): Sand (20%), fine; Silt (80%), low plasticity; light brown, cemented, friable/blocky, dry. POORLY GRADED SAND WITH COBBLES (SP) to POORLY GRADED SAND WITH SILT AND COBBLES (SP-SM): Sand (90-100%), fine to medium; Silt (0-10%); weakly cemented, brown, wet.	
10	70				540		15				
		G	15		760						
5	75				220		16			At 75' - Stratified.	
		G	16		180						
0	80				320		17			At 80' - Faintly stratified.	
		G	17		500						
-5	85				820		18				
		G	18		600	GSD				At 88' - Isolated elongated basalt cobbles to 5-inch.	
-10											

JULY 2015 GRI JOB NO. 5445 FIG. E-81

PARSONS BRINCKERHOFF

BORING LOG
ES-3018R

PACRIM GEOTECHNICAL INC.
GEOTECHNICAL ENGINEERING AND APPLIED EARTH SCIENCES

PROJECT	East Side CSO - Final Design	SHEET 5 OF 9		INITIAL GW ELEV	8.5 ft (11/23/04)
CITY	Portland, Oregon	SURFACE ELEV. 79.7 ft	STA.	EQUIPMENT	Core Barrel and Casing
PROJECT NO.	5516	NORTHING 688,962.3	EASTING 7,645,783.0	DRILLING METHOD	Rotosonic
DATE DRILLED	11/18/04 to 11/24/04	LOCATION	Larabee Avenue at Hancock Ct	LOGGED BY	GS

SAMPLE TYPE: ☒ Ring (3.25" OD) ◧ Standard Penetration Test (2" OD) ■ Shelby Tube G Grab

Elevation (ft)	DEPTH (ft)	SAMPLE TYPE	SAMPLE NO.	PID	METHANE (ppm)	LAB TESTS	BOX NUMBER	PERCENT FINES (20 40 60 80) / PLASTIC M.C. LIQUID (20 40 60 80)	LITHOLOGY	SOIL DESCRIPTION	WELL
					460		19			**(Tt Cont'd)**	
		G	19		960					POORLY GRADED SAND WITH SILT (SP-SM): Sand (90-95%), fine; Silt (5-10%), non-plastic; stratified, brown, moist to wet.	
-15	95				280		20			At 96' - Becomes weakly cemented.	
		G	20		360						
-20	100				480		21				
		G	21		380					SILTY SAND (SM): Sand (70-85%), fine; Silt (15-30%), low plasticity to non-plastic; brown, wet.	
-25	105				2920		22			POORLY GRADED SAND WITH SILT (SP-SM) to SILTY SAND (SM): Sand (80-95%), fine to medium; Silt (5-20%), non-plastic; stratified, weakly cemented, brown, wet.	
		G	22		760						
-30	110				3200						

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BORING LOG
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PACRIM GEOTECHNICAL INC.
GEOTECHNICAL ENGINEERING AND APPLIED EARTH SCIENCES

PROJECT	East Side CSO - Final Design	SHEET 6 OF 9		INITIAL GW ELEV	8.5 ft (11/23/04)
CITY	Portland, Oregon	SURFACE ELEV. 79.7 ft	STA.	EQUIPMENT	Core Barrel and Casing
PROJECT NO.	5516	NORTHING 688,962.3	EASTING 7,645,783.0	DRILLING METHOD	Rotosonic
DATE DRILLED	11/18/04 to 11/24/04	LOCATION	Larabee Avenue at Hancock Ct	LOGGED BY	GS

SAMPLE TYPE: Ring (3.25" OD) | Standard Penetration Test (2" OD) | Shelby Tube | Grab

Elevation (ft)	DEPTH (ft)	SAMPLE TYPE	SAMPLE NO.	PID	METHANE (ppm)	LAB TESTS	BOX NUMBER	PERCENT FINES (20 40 60 80) / PLASTIC M.C. LIQUID (20 40 60 80)	LITHOLOGY	SOIL DESCRIPTION	WELL
		G	23		1940		23			**(Tt Cont'd)**	
-35	115				200					SILTY SAND (SM): Sand (75-85%), fine to medium; Silt (15-25%), non-plastic; brown, moist to wet.	
		G	24		220	GSD	24	△●			
-40	120				620						
		G	25		1500	GSD	25	△●			
-45	125				1620						
		G	26		1240	FC	26	△●			
-50	130				5240						
		G	27		2980	GSD	27	△●			
-55											

PARSONS BRINCKERHOFF

BORING LOG
ES-3018R

PACRIM GEOTECHNICAL INC.
GEOTECHNICAL ENGINEERING AND APPLIED EARTH SCIENCES

PROJECT	East Side CSO - Final Design	SHEET 7 OF 9		INITIAL GW ELEV	8.5 ft (11/23/04)
CITY	Portland, Oregon	SURFACE ELEV. 79.7 ft	STA.	EQUIPMENT	Core Barrel and Casing
PROJECT NO.	5516	NORTHING 688,962.3	EASTING 7,645,783.0	DRILLING METHOD	Rotosonic
DATE DRILLED	11/18/04 to 11/24/04	LOCATION	Larabee Avenue at Hancock Ct	LOGGED BY	GS

SAMPLE TYPE: Ring (3.25" OD) | Standard Penetration Test (2" OD) | Shelby Tube | Grab

Elevation (ft)	DEPTH (ft)	SAMPLE TYPE	SAMPLE NO.	PID	METHANE (ppm)	LAB TESTS	BOX NUMBER	PERCENT FINES (20 40 60 80) / PLASTIC M.C. LIQUID (20 40 60 80)	LITHOLOGY	SOIL DESCRIPTION	WELL
										(Tt Cont'd)	
					2120					POORLY GRADED GRAVEL WITH COBBLES (GP): Gravel and Cobbles (85-95%), fine to coarse, basalt, metavolcanics, quartzite; Sand (5-15%), fine to coarse; gray, wet.	
		G	28		220	GSD	28			At 136' - Cobbles to 4-inches. At 137' - Cored 8-inch cobble. At 137.7' - 4-inch flat cobble.	
-60	140				300					At 140' - Increase in Sand (20-25%); brown and gray layers, stratified (1 to 2 ft layers). At 140.3' - 4-inch elongated cobble. At 141' - Cored 6-inch cobble. 4-inch flat cobble below. 6-inch and 4-inch elongated cobbles.	
		G	29		620	FC	29			At 143.5 - A few 5-inch cobbles.	
-65	145				1220					POORLY GRADED GRAVEL WITH COBBLES (GP): Gravel and Cobbles (100%), fine to coarse, several cobbles to 5-inches, flat and elongated, rounded to subrounded, basalt, metavolcanics; no matrix.	
		G	30		260		30			POORLY GRADED GRAVEL WITH COBBLES (GP): Gravel (85-90%), fine to coarse, cobbles to 10-inches, slightly flat and elongated, basalt, metavolcanics, quartzite; Sand (10-15%), fine to coarse; brown, wet.	
-70	150				180					At 150' - 4-inch cobbles.	
					400					At 151' - Elongated cobbles to 5-inch.	
										At 152.2' - Increase in Sand (20%).	
		G	31		520	FC	31			POORLY GRADED SAND WITH SILT AND COBBLES (SP-SM): Sand (80-95%); Silt (<5%-20%); stratified.	
										At 154.7' - 5-inch flat cobble.	
-75	155									POORLY GRADED GRAVEL WITH COBBLES (GP): Gravel (95-100%), cobbles to 4-inches, basalt, metavolcanics. At 155.2' - Cobbles to 6-inches, flat and elongated.	
										POORLY GRADED GRAVEL WITH COBBLES (GP): Gravel (95%),	

PARSONS BRINCKERHOFF

BORING LOG ES-3018R

PACRIM GEOTECHNICAL INC.
GEOTECHNICAL ENGINEERING AND APPLIED EARTH SCIENCES

PROJECT	East Side CSO - Final Design	SHEET 8 OF 9		INITIAL GW ELEV	8.5 ft (11/23/04)
CITY	Portland, Oregon	SURFACE ELEV. 79.7 ft	STA.	EQUIPMENT	Core Barrel and Casing
PROJECT NO.	5516	NORTHING 688,962.3	EASTING 7,645,783.0	DRILLING METHOD	Rotosonic
DATE DRILLED	11/18/04 to 11/24/04	LOCATION	Larabee Avenue at Hancock Ct	LOGGED BY	GS

SAMPLE TYPE: ☒ Ring (3.25" OD) ◧ Standard Penetration Test (2" OD) ■ Shelby Tube G Grab

Elevation (ft)	DEPTH (ft)	SAMPLE TYPE	SAMPLE NO.	PID	METHANE (ppm)	LAB TESTS	BOX NUMBER	PERCENT FINES (20 40 60 80) / PLASTIC M.C. LIQUID (20 40 60 80)	LITHOLOGY	SOIL DESCRIPTION	WELL
		G	32			GSD	32	△ ●		cobbles to 4-inches; Sand (5%), fine to coarse; gray. **(Tt Cont'd)** POORLY GRADED SAND WITH GRAVEL (SP): Gravel (15-30%), coarse, to 2.5-inch; Sand (70-85%), fine to medium; brown, moist. POORLY GRADED GRAVEL WITH SAND AND COBBLES (GP): Gravel (75-90%), fine to coarse, a few cobbles to 4-inch, flat, rounded to subrounded, basalt, metavolcanics, quartzite; Sand (10-25%), fine to medium; brown, moist to wet.	
-80	160									POORLY GRADED SAND WITH GRAVEL AND COBBLES (SP): Gravel (25-40%), coarse, rounded to subrounded, cobbles to 6-inch, basalt, metavolcanics, quartzite; Sand (60-75%), fine to medium; brown, coated, moist.	
					2780		33			POORLY GRADED GRAVEL WITH SAND AND COBBLES (GP): Gravel (70-80%), fine to coarse, cobbles to 5-inch, rounded, flat and elongated; Sand (20-30%), fine to coarse; brown to gray, wet.	
		G	33			GSD		△ ●		POORLY GRADED SAND WITH SILT (SP-SM): Gravel (5-15%), fine; Sand (85-95%), fine; Silt (5%); brown, wet.	
					760					POORLY GRADED GRAVEL WITH SAND AND COBBLES (GP): Gravel (80-90%), mostly < 1-inch, cobbles to 5-inch at base; Sand (10-20%), fine to coarse; brown, wet.	
-85	165									POORLY GRADED SAND WITH SILT (SP-SM): Sand (90-100%), fine; Silt (5-10%), non-plastic; brown, wet.	
					14% LEL					POORLY GRADED SAND (SP): Gravel (5%); Sand (90-95%), fine to medium; brown, wet.	
										POORLY GRADED GRAVEL WITH SAND (GP): Gravel (60%), to 3-inch elongated; Sand (40%), fine; Silt (5%); brown, wet.	
							34			POORLY GRADED SAND (SP): Gravel (5%); Sand (90-100%), fine; Silt (5%).	
		G	34		800	FC		●		POORLY GRADED GRAVEL WITH COBBLES (GP): Gravel and Cobbles (90-95%), Mostly 6 to 10-inch, basalt, metavolcanics, quartzite; Sand (5-10%), fine; Silt (<5%); brown, wet.	
										SILT (ML): light brown, strongly cemented, blocky/brittle, moist.	
-90	170									POORLY GRADED GRAVEL WITH COBBLES (GP): Gravel (80%), fine to coarse, cobbles to 5-inches; Sand/Silt matrix (20%). At 170' - Gravel (90-95%), 7-inch elongated cobble; Sand/Silt (5-10%).	
					49% LEL					POORLY GRADED SAND (SP): 6 to 8-inch layer, fine; brown, wet.	
							35			POORLY GRADED GRAVEL WITH CLAY, SAND AND COBBLES (GP-GC): Gravel (60-70%), fine to coarse, cobbles to 5-inches, basalt; Sand (25-30%), fine to coarse; Clay (5-10%), low plasticity; gray, wet.	
		G	35		50% LEL	GSD		●			
-95	175										
					560						
							36				
		G	36		620						
-100											

PARSONS BRINCKERHOFF

BORING LOG
ES-3018R

PACRIM GEOTECHNICAL INC.
GEOTECHNICAL ENGINEERING AND APPLIED EARTH SCIENCES

PROJECT	East Side CSO - Final Design	SHEET 9 OF 9		INITIAL GW ELEV	8.5 ft (11/23/04)
CITY	Portland, Oregon	SURFACE ELEV. 79.7 ft	STA.	EQUIPMENT	Core Barrel and Casing
PROJECT NO.	5516	NORTHING 688,962.3	EASTING 7,645,783.0	DRILLING METHOD	Rotosonic
DATE DRILLED	11/18/04 to 11/24/04	LOCATION	Larabee Avenue at Hancock Ct	LOGGED BY	GS

SAMPLE TYPE: Ring (3.25" OD) | Standard Penetration Test (2" OD) | Shelby Tube | Grab

Elevation (ft)	DEPTH (ft)	SAMPLE TYPE	SAMPLE NO.	PID	METHANE (ppm)	LAB TESTS	BOX NUMBER	PERCENT FINES (20 40 60 80) / PLASTIC M.C. LIQUID (20 40 60 80)	LITHOLOGY	SOIL DESCRIPTION	WELL
					2720					POORLY GRADED GRAVEL WITH CLAY AND COBBLES (GP-GC): Gravel (75-90%), fine to coarse, basalt; Sand (10-15%), fine to coarse; Clay (5-10%); gray, coated, staining, wet. **(Tt Cont'd)** At 180.8' - 7-inch elongated basalt cobble. POORLY GRADED GRAVEL WITH SAND (GP): Gravel (80-90%), fine to coarse, to 3-inch, flat and elongated, rounded to subrounded, some angular, basalt, metavolcanics, quartzite; Sand (10-20%), fine to coarse; Clay (<5%); stratified, brown, gray, wet.	
		G	37		1400		37				
-105	185						38				
					500					Boring completed to a depth of 186 ft on 11/24/04.	
-110	190										
-115	195										
-120	200										

PARSONS BRINCKERHOFF

BORING LOG ES-3019C

Foundation Engineering, Inc.

PROJECT East Side CSO - Final Design | SHEET 1 OF 4 | INITIAL GWL@ Not Available

CITY Portland, Oregon | SURF. EL. 73 ft | STA. | OFST. | EQUIPMENT Mobile B59

PROJECT NO. 2042034 | NORTHING 689209.7 | EASTING 7645558.6 | DRILLING METHOD Mud Rotary

DATE DRILLED 12/20/04 | LOGGED BY JMR | LOCATION Interstate Avenue Grade Seperation | HAMMER SYS. 140 lb. Hammer, 30 in. Drop

SAMPLE TYPE: Ring (3.25" OD) | Standard Penetration Test (2" OD) | Shelby Tube | Grab Sample

Elevation (ft)	DEPTH (ft)	SAMPLE TYPE	SAMPLE NO	FIELD BLOWS /6"	LAB TESTS	PERCENT FINES (20 40 60 80) / PLASTIC M.C. LIQUID (20 40 60 80)	SOIL DESCRIPTION	LITHOLOGY	UNCORRECTED BLOW COUNTS (last 12") (20 40 60 80)	WELL
							Boring drilled through bridge deck. Ground surface at depth of 21.6 feet below bridge deck.			
70	5									
65	10									
60	15									
55	20									
50							**Artificial Fill (Qaf)** CONCRETE COBBLE WITH SAND AND GRAVEL; moist, very dense.			
	25						SILT WITH SAND (ML); fine sand, nonplastic to low plasticity, no dilatancy, light brown, moist.			
45			1	5 3 6						
	30		2	4 4 5	MC AL		**Sand/Silt Alluvium(Qal)** LEAN CLAY WITH SAND (CL); fine sand, low to medium plasticity, no dilatancy, brown, wet.			
40							**Troutdale Formation (Tt)** SILTY SAND (SM); fine sand, nonplastic, no dilatancy, light brown, moist, very dense.			
	35		3	50/3"					50/3"	

ESCSO MUD 2005 2042034-.GPJ 2042034-REV1.GPJ 6/5/05

Geotechnical Data Report

JULY 2015 GRI JOB NO. 5445 FIG. E-87

PARSONS BRINCKERHOFF

BORING LOG ES-3019C

Foundation Engineering, Inc.

PROJECT East Side CSO - Final Design | SHEET 2 OF 4 | INITIAL GWL@ Not Available
CITY Portland, Oregon | SURF. EL. 73 ft | STA. | OFST. | EQUIPMENT Mobile B59
PROJECT NO. 2042034 | NORTHING 689209.7 | EASTING 7645558.6 | DRILLING METHOD Mud Rotary
DATE DRILLED 12/20/04 | LOGGED BY JMR | LOCATION Interstate Avenue Grade Seperation | HAMMER SYS. 140 lb. Hammer, 30 in. Drop

SAMPLE TYPE: Ring (3.25" OD) | Standard Penetration Test (2" OD) | Shelby Tube | Grab Sample

Elevation (ft)	DEPTH (ft)	SAMPLE TYPE	SAMPLE NO	FIELD BLOWS /6"	LAB TESTS	SOIL DESCRIPTION	UNCORRECTED BLOW COUNTS (last 12")	WELL
35						**(Tt Cont'd)** SILTY SAND (SM); fine sand, nonplastic, no dilatancy, light brown, moist, very dense.		
	40		4	50/3"	MC FC		50/3"	
30								
	45							
25								
	50		5	50/3"		Becomes wet.	50/3"	
20								
	55		6	50/4"			50/4"	
15								
	60		7	6 10 11	MC AL FC	Becomes medium dense.		
10								
	65		8	11 12 14				
5								
	70		9	8 10 9		Becomes with trace fine gravel.		
0								

PERCENT FINES: 20 40 60 80

PLASTIC M.C. LIQUID: 20 40 60 80

UNCORRECTED BLOW COUNTS (last 12"): 20 40 60 80

ESCSO MUD 2005 2042034-.GPJ 2042034-REV1.GPJ 6/5/05

PARSONS BRINCKERHOFF

BORING LOG ES-3019C

Foundation Engineering, Inc.

PROJECT East Side CSO - Final Design | SHEET 3 OF 4 | INITIAL GWL@ Not Available
CITY Portland, Oregon | SURF. EL. 73 ft | STA. | OFST. | EQUIPMENT Mobile B59
PROJECT NO. 2042034 | NORTHING 689209.7 | EASTING 7645558.6 | DRILLING METHOD Mud Rotary
DATE DRILLED 12/20/04 | LOGGED BY JMR | LOCATION Interstate Avenue Grade Seperation | HAMMER SYS. 140 lb. Hammer, 30 in. Drop

SAMPLE TYPE: Ring (3.25" OD) | Standard Penetration Test (2" OD) | Shelby Tube | Grab Sample

Elevation (ft)	DEPTH (ft)	SAMPLE TYPE	SAMPLE NO	FIELD BLOWS /6"	LAB TESTS	SOIL DESCRIPTION
			10	42 39 27	MD FC	**(Tt Cont'd)** SILTY GRAVEL WITH SAND AND COBBLES (GM); fine to coarse gravel, fine sand, subrounded to rounded, nonplastic fines, gray-brown, moist, very dense.
-5						
	80		11	32 27 25		
-10						
	85		12	50/4"		
-15						
	90		13	50/1"		
			14	13 11		Becomes medium dense.
-20						
	95		15	50/3"	MC FC	Becomes very dense.
-25			16	33 45 46	MD FC	POORLY GRADED SAND (SP); trace silt and gravel, fine to medium sand, fine gravel, nonplastic, no dilatancy, brown, moist, dense.
	100		17	12 13 20		Becomes wet, no gravel.
-30						
	105		18	30 36 39		
			19	7 13 16		Becomes medium dense.
-35						
	110		20	22 33 33		
			21	7 13		

PERCENT FINES 20 40 60 80; PLASTIC M.C. LIQUID 20 40 60 80

LITHOLOGY

UNCORRECTED BLOW COUNTS (last 12") 20 40 60 80

WELL

ESCSO MUD 2005 2042034-.GPJ 2042034-REV1.GPJ 6/5/05

JULY 2015 GRI JOB NO. 5445 FIG. E-89

PARSONS BRINCKERHOFF

BORING LOG ES-3019C

Foundation Engineering, Inc.

PROJECT East Side CSO - Final Design | SHEET 4 OF 4 | INITIAL GWL@ Not Available

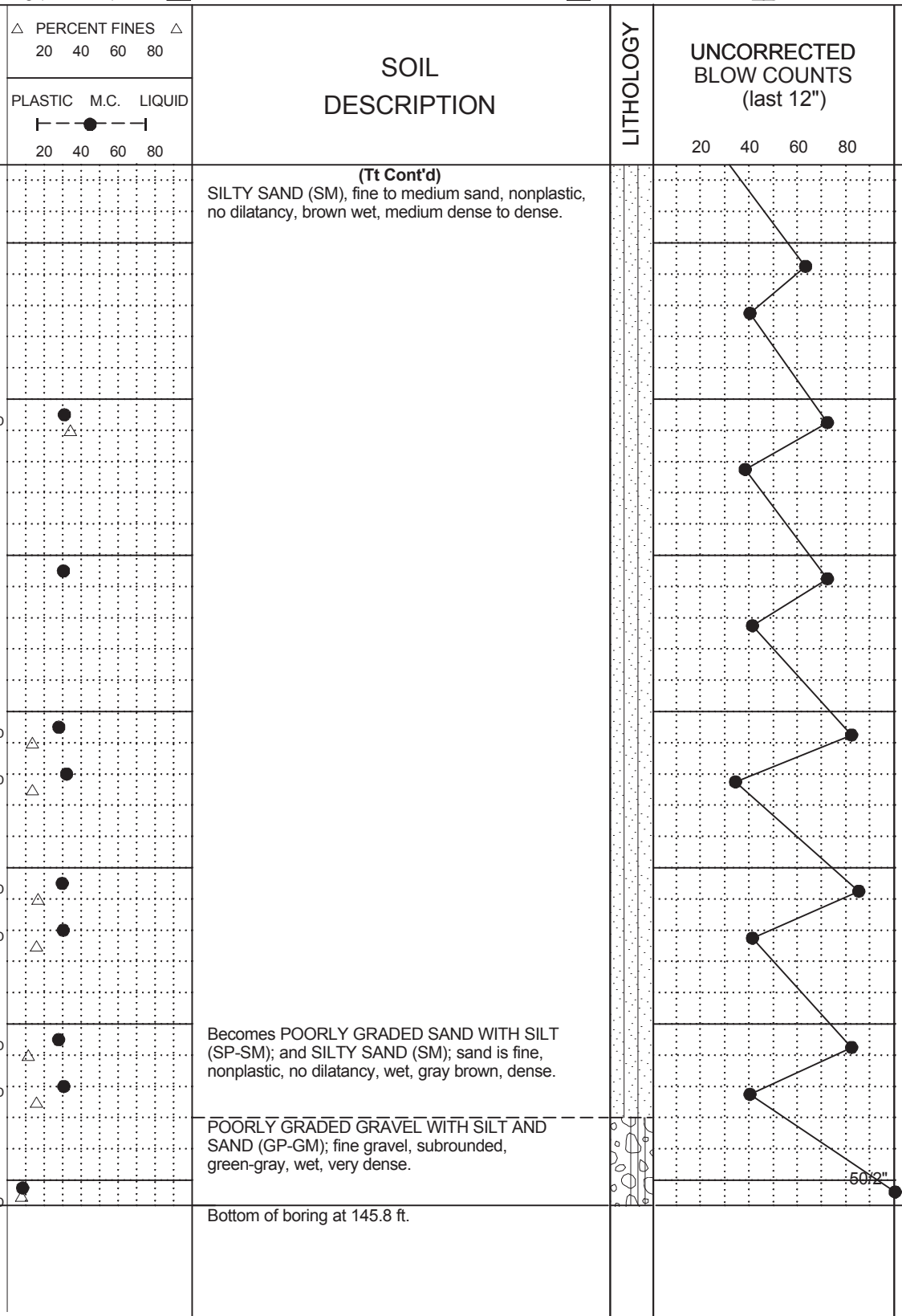
CITY Portland, Oregon | SURF. EL. 73 ft | STA. | OFST. | EQUIPMENT Mobile B59

PROJECT NO. 2042034 | NORTHING 689209.7 | EASTING 7645558.6 | DRILLING METHOD Mud Rotary

DATE DRILLED 12/20/04 | LOGGED BY JMR | LOCATION Interstate Avenue Grade Seperation | HAMMER SYS. 140 lb. Hammer, 30 in. Drop

SAMPLE TYPE: Ring (3.25" OD) | Standard Penetration Test (2" OD) | Shelby Tube | Grab Sample

Elevation (ft)	DEPTH (ft)	SAMPLE TYPE	SAMPLE NO	FIELD BLOWS /6"	LAB TESTS	SOIL DESCRIPTION
-40				16		**(Tt Cont'd)** SILTY SAND (SM), fine to medium sand, nonplastic, no dilatancy, brown wet, medium dense to dense.
	115	Ring	22	23 28 35		
		Shelby	23	12 18 22		
-45						
	120	Ring	24	24 34 38	MD GSD	
		Shelby	25	11 17 21		
-50						
	125	Ring	26	27 34 38	MC	
		Shelby	27	9 19 22		
-55						
	130	Ring	28	28 38 44	MD GSD	
		Shelby	29	6 15 19	MC GSD	
-60						
	135	Ring	30	29 41 44	MD GSD	
		Shelby	31	9 19 22	MC GSD	
-65						
	140	Ring	32	28 35 47	MD GSD	Becomes POORLY GRADED SAND WITH SILT (SP-SM); and SILTY SAND (SM); sand is fine, nonplastic, no dilatancy, wet, gray brown, dense.
		Shelby	33	9 18 22	MC GSD	
-70						POORLY GRADED GRAVEL WITH SILT AND SAND (GP-GM); fine gravel, subrounded, green-gray, wet, very dense.
	145	Ring	34	50/2"	MD GSD	
-75						Bottom of boring at 145.8 ft.



ESCSO MUD 2005 2042034-.GPJ 2042034-REV1.GPJ 6/5/05

Geotechnical Data Report

JULY 2015 GRI JOB NO. 5445 FIG. E-90

PARSONS BRINCKERHOFF

BORING LOG
ES-3021R

PACRIM GEOTECHNICAL INC.
GEOTECHNICAL ENGINEERING AND APPLIED EARTH SCIENCES

PROJECT	East Side CSO - Final Design	SHEET 1 OF 7		INITIAL GW ELEV	8.4 ft (9/21/04)
CITY	Portland, Oregon	SURFACE ELEV. 32.9 ft	STA.	EQUIPMENT	Core Barrel and Casing
PROJECT NO.	5516	NORTHING 689,674.9	EASTING 7,645,048.7	DRILLING METHOD	Rotosonic
DATE DRILLED	9/19/04 to 9/21/04	LOCATION	N. River Street at Albina Ave	LOGGED BY	GS

SAMPLE TYPE: ☒ Ring (3.25" OD) ◨ Standard Penetration Test (2" OD) ■ Shelby Tube G Grab

Elevation (ft)	DEPTH (ft)	SAMPLE TYPE	SAMPLE NO.	PID	METHANE (ppm)	LAB TESTS	BOX NUMBER	PERCENT FINES (20 40 60 80) / PLASTIC M.C. LIQUID (20 40 60 80)	LITHOLOGY	SOIL DESCRIPTION	WELL
										Asphaltic Concrete (3.5-4 inches thick).	
				0						**Artificial Fill (Qaf)** POORLY GRADED GRAVEL WITH SAND (GP): Gravel: 1"minus crushed rock, rounded to angular; Sand: fine to coarse, brown.	
										SILT (ML): low plasticity, brown.	
										White gypsum, trace silt (3-inch thick layer).	
							1			SILT (OL): low plasticity, organics including wood fibers (10-20%), brown with dark gray mottling, disturbed native topsoil.	
30		G	1	0	20					**Sand/Silt Alluvium (Qal/Qff)** SILTY SAND (SM): Sand (60-70%), fine; Silt (30-40%), nonplastic, brown, moist to wet.	
										ELASTIC SILT (MH): low to medium plasticity, low to medium toughness, brown, moist.	
	5									SILT to SANDY SILT (ML): low plasticity, low toughness, brown, moist to wet.	
				0			2				
25		G	2		20					SILT (ML): low to medium plasticity, low to medium toughness, brown, moist.	
	10			0							
										SILT WITH SAND (ML): Sand (20-30%), fine; Silt (70-80%), low plasticity, brown, moist to wet.	
				0			3			SILT (ML): low to medium plasticity, low to medium toughness, brown, moist.	
20		G	3		20	AL					
	15			0						SILT WITH SAND (ML): Sand (15-20%), fine; low plasticity, moist to wet, brown.	
				0						SILT (ML) interbedded with ELASTIC SILT (MH): Sand (<5%), fine; Silt, low to medium plasticity, slow to rapid dilatancy, low to medium toughness, brown, moist to wet.	
							4				
15		G	4		20						
	20										

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BORING LOG
ES-3021R

PACRIM GEOTECHNICAL INC.
GEOTECHNICAL ENGINEERING AND APPLIED EARTH SCIENCES

PROJECT	East Side CSO - Final Design	SHEET 2 OF 7		INITIAL GW ELEV	8.4 ft (9/21/04)
CITY	Portland, Oregon	SURFACE ELEV. 32.9 ft	STA.	EQUIPMENT	Core Barrel and Casing
PROJECT NO.	5516	NORTHING 689,674.9	EASTING 7,645,048.7	DRILLING METHOD	Rotosonic
DATE DRILLED	9/19/04 to 9/21/04	LOCATION	N. River Street at Albina Ave	LOGGED BY	GS

SAMPLE TYPE: Ring (3.25" OD) | Standard Penetration Test (2" OD) | Shelby Tube | Grab

Elevation (ft)	DEPTH (ft)	SAMPLE TYPE	SAMPLE NO.	PID	METHANE (ppm)	LAB TESTS	BOX NUMBER	PERCENT FINES (20 40 60 80) / PLASTIC M.C. LIQUID (20 40 60 80)	LITHOLOGY	SOIL DESCRIPTION	WELL
10		G	5		20		5			**(Qal/Qff cont'd)** SILT (ML) interbedded with ELASTIC SILT (MH): Sand (<5%), fine; Silt, low to medium plasticity, slow to rapid dilatancy, low to medium toughness, brown, moist to wet.	
▼	25				40		6				
5		G	6							SILTY GRAVEL (GM): Gravel (70-80%), fine to coarse; Silt (20-30%), low to medium plasticity matrix.	
										POORLY GRADED GRAVEL WITH SILT (GP-GM): Gravel (70-80%), fine to coarse, rounded to subrounded, some flat basalt and quartzite; Sand (10-15%); Silt (5-10%), wet, brown.	
	30									SILT WITH GRAVEL (ML): brown, wet, disturbed (dropped from core barrel and retrieved).	
							7				
0		G	7							POORLY GRADED SAND (SP); 100% fine to medium sand, dark gray, wet.	
	35				560					**Gravel Alluvium (Qfc)** POORLY GRADED GRAVEL WITH COBBLES (GP): Gravel (80-95%), fine to coarse, rounded to subrounded, some flat, elongated, basalt and quartzite; occasional cobbles to 4-inches; Sand (5-20%), fine to coarse, subangular to subrounded, brown, wet.	
							8				
-5		G	8								
	40										
					560		9			At 42' - increase in cobble content (20-35%) and size to 10-inches.	
-10		G	9		440						

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PACRIM GEOTECHNICAL INC.
GEOTECHNICAL ENGINEERING AND APPLIED EARTH SCIENCES

PROJECT	East Side CSO - Final Design	SHEET 3 OF 7		INITIAL GW ELEV	8.4 ft (9/21/04)
CITY	Portland, Oregon	SURFACE ELEV. 32.9 ft	STA.	EQUIPMENT	Core Barrel and Casing
PROJECT NO.	5516	NORTHING 689,674.9	EASTING 7,645,048.7	DRILLING METHOD	Rotosonic
DATE DRILLED	9/19/04 to 9/21/04	LOCATION	N. River Street at Albina Ave	LOGGED BY	GS

SAMPLE TYPE: ☒ Ring (3.25" OD) ◧ Standard Penetration Test (2" OD) ■ Shelby Tube G Grab

Elevation (ft)	DEPTH (ft)	SAMPLE TYPE	SAMPLE NO.	PID	METHANE (ppm)	LAB TESTS	BOX NUMBER	PERCENT FINES (20 40 60 80) / PLASTIC M.C. LIQUID (20 40 60 80)	LITHOLOGY	SOIL DESCRIPTION	WELL
					20					**(Qfc cont'd)** From 45' to 46' - increase in cobbles to 75%.	
										POORLY GRADED GRAVEL WITH SAND (GP): Gravel (75-80%), fine to coarse, rounded to flat, basalt and quartzite; Sand (20-25%), fine to coarse, subangular to subrounded.	
-15		G	10		500		10				
	50									POORLY GRADED GRAVEL WITH COBBLES (GP): Gravel and Cobbles (90-95%), cobbles to 6-inches; Sand (5-10%).	
					260		11				
-20		G	11							POORLY GRADED GRAVEL WITH SAND (GP): Gravel (60-80%), fine to coarse, rounded to subrounded, basalt and quartzite; Sand (20-40%), fine to coarse, subangular to rounded, brown, wet.	
					280						
	55									POORLY GRADED GRAVEL (GP): Gravel (85%) fine to coarse, Sand (15%).	
					180						
							12			POORLY GRADED GRAVEL WITH SAND (GP): Gravel (50-85%), fine to coarse; Sand (15-50%), fine to coarse, grayish brown, wet.	
-25		G	12		180	GSD					
										POORLY GRADED SAND WITH GRAVEL (SP): Gravel (40-50%), fine to coarse; Sand (50-60%).	
	60				600					SANDY SILT WITH GRAVEL (ML): low plasticity, brown.	
					980					POORLY GRADED GRAVEL WITH SAND (GP): Gravel (50-60%), fine to coarse, rounded to subrounded, some flat basalt, quartzite; Sand (40-50%), fine to coarse, subangular to subrounded, brown, wet.	
							13				
-30		G	13		460					At 63' - increase in gravel to 75-85%, decrease in sand to 15-25%.	
	65				140					POORLY GRADED GRAVEL (GP): Gravel (100%).	
					460					**Troutdale Formation (Tt)** POORLY GRADED SAND (SP): Sand (95-100%), fine to medium, massive, micaceous.	

JULY 2015 GRI JOB NO. 5445 FIG. E-93

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BORING LOG ES-3021R

PACRIM GEOTECHNICAL INC.
GEOTECHNICAL ENGINEERING AND APPLIED EARTH SCIENCES

PROJECT	East Side CSO - Final Design	SHEET 4 OF 7		INITIAL GW ELEV	8.4 ft (9/21/04)
CITY	Portland, Oregon	SURFACE ELEV. 32.9 ft	STA.	EQUIPMENT	Core Barrel and Casing
PROJECT NO.	5516	NORTHING 689,674.9	EASTING 7,645,048.7	DRILLING METHOD	Rotosonic
DATE DRILLED	9/19/04 to 9/21/04	LOCATION	N. River Street at Albina Ave	LOGGED BY	GS

SAMPLE TYPE: Ring (3.25" OD) | Standard Penetration Test (2" OD) | Shelby Tube | Grab

Elevation (ft)	DEPTH (ft)	SAMPLE TYPE	SAMPLE NO.	PID	METHANE (ppm)	LAB TESTS	BOX NUMBER	PERCENT FINES (20 40 60 80) / PLASTIC M.C. LIQUID (20 40 60 80)	LITHOLOGY	SOIL DESCRIPTION	WELL
-35		G	14		620		14			**(Tt cont'd)** POORLY GRADED SAND (SP): Sand (95-100%), fine to medium, massive, micaceous.	
	70				660		15				
-40		G	15		67% LEL					At 74' - 3-inch thick layer of SILTY SAND (SM): Sand (70%), Silt (30%), brown, wet.	
	75				200						
					40		16				
-45		G	16		2120					POORLY GRADED GRAVEL WITH COBBLES (GP): Gravel (85-95%), fine to coarse, rounded to subrounded, basalt; occasional cobbles to 5-inches; Sand (5-10%); Silt (<5%), gray, wet.	
	80									POORLY GRADED GRAVEL WITH COBBLES (GP): Gravel and Cobbles (85-95%), coarse, some fine, rounded to subrounded, basalt; Sand (5-10%), fine to coarse; Silt (<5%), gray, wet.	
					320		17			POORLY GRADED SAND (SP): Sand (95-100%), fine to medium; Silt (<5%), brown, wet.	
-50		G	17		360	GSD		△ ●			
	85				640						
					320		18				
-55		G	18		360	FC		△ ●		POORLY GRADED SAND WITH GRAVEL (SP): Gravel (10-20%), fine, rounded; Sand (80-90%).	
										POORLY GRADED GRAVEL WITH SAND AND COBBLES (GP): Gravel (60-80%), some elongated cobbles to 5 inches; Sand	

JULY 2015 GRI JOB NO. 5445 FIG. E-94

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PACRIM GEOTECHNICAL INC.
GEOTECHNICAL ENGINEERING AND APPLIED EARTH SCIENCES

PROJECT	East Side CSO - Final Design	SHEET 5 OF 7		INITIAL GW ELEV	8.4 ft (9/21/04)
CITY	Portland, Oregon	SURFACE ELEV. 32.9 ft	STA.	EQUIPMENT	Core Barrel and Casing
PROJECT NO.	5516	NORTHING 689,674.9	EASTING 7,645,048.7	DRILLING METHOD	Rotosonic
DATE DRILLED	9/19/04 to 9/21/04	LOCATION	N. River Street at Albina Ave	LOGGED BY	GS

SAMPLE TYPE: Ring (3.25" OD) | Standard Penetration Test (2" OD) | Shelby Tube | Grab

Elevation (ft)	DEPTH (ft)	SAMPLE TYPE	SAMPLE NO.	PID	METHANE (ppm)	LAB TESTS	BOX NUMBER	PERCENT FINES (20 40 60 80) / PLASTIC M.C. LIQUID (20 40 60 80)	LITHOLOGY	SOIL DESCRIPTION	WELL
					140					(20-40%).	
										(Tt cont'd)	
										POORLY GRADED SAND (SP): Sand (90-100%), fine; Gravel (<5%), coarse, rounded; Silt (<5%), brown, wet.	
					440		19				
-60		G	19			GSD					
					1540						
	95				1960						
										WELL GRADED GRAVEL WITH COBBLES (GW): fine to coarse, rounded and subrounded, some flat; some cobbles to approximately 10-inches.	
							20				
-65		G	20		0	GSD					
										POORLY GRADED SAND (SP): Sand (95-100%), fine; Silt (<5%), brown.	
	100				200					POORLY GRADED GRAVEL WITH COBBLES (GP): Gravel (85-95%), fine to coarse, rounded, flat; few cobbles to 4-inches; Sand (5-15%), fine to coarse, angular and subrounded.	
										POORLY GRADED GRAVEL WITH SILT, SAND AND COBBLES (GP-GM): Gravel (50-55%), fine to coarse, rounded to subangular; few cobbles to 5-inches; Sand (35-40%), fine; Silt (5-15%), brown and gray.	
							21				
-70		G	21			GSD				At 103.5' - increase in cobbles to 50%, increase in sand to 10%.	
	105									POORLY GRADED GRAVEL WITH SILT AND SAND (GP-GM): Gravel (50-65%), fine to coarse, subangular to subrounded; Sand (25-45%), fine to coarse; Silt (5-10%), low plasticity, gray, wet.	
					1200						
										POORLY GRADED GRAVEL WITH CLAY, SAND AND COBBLES (GP-GC): Gravel (70-75%), rounded to subrounded, some flat, some cobbles to 6-inches; Sand (15-20%), decreasing with depth, fine to coarse; Clay (5-10%), increasing with depth, low plasticity, gray.	
							22				
-75		G	22		42% LEL	GSD				At 109' - decrease in Gravel to 75-85%, increase in Sand to 10-15%, weakly cemented to 112'.	
	110										
					50% LEL					At 112' - increase in Gravel to 80-90%, decrease in Sand to 5-15%.	

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PACRIM GEOTECHNICAL INC.
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PROJECT	East Side CSO - Final Design	SHEET 6 OF 7		INITIAL GW ELEV	8.4 ft (9/21/04)
CITY	Portland, Oregon	SURFACE ELEV. 32.9 ft	STA.	EQUIPMENT	Core Barrel and Casing
PROJECT NO.	5516	NORTHING 689,674.9	EASTING 7,645,048.7	DRILLING METHOD	Rotosonic
DATE DRILLED	9/19/04 to 9/21/04	LOCATION	N. River Street at Albina Ave	LOGGED BY	GS

SAMPLE TYPE: ☒ Ring (3.25" OD) ◧ Standard Penetration Test (2" OD) ■ Shelby Tube G Grab

Elevation (ft)	DEPTH (ft)	SAMPLE TYPE	SAMPLE NO.	PID	METHANE (ppm)	LAB TESTS	BOX NUMBER	PERCENT FINES (20 40 60 80) / PLASTIC M.C. LIQUID (20 40 60 80)	LITHOLOGY	SOIL DESCRIPTION	WELL
-80		G	23		74% LEL	FC	23			**(Tt cont'd)** POORLY GRADED GRAVEL (GP): Gravel (80-90%), fine to coarse, rounded to subrounded, some flat; Sand (10-15%), fine to coarse; Clay (<5%), low plasticity, gray, wet.	
	115				64% LEL						
-85		G	24		34% LEL	GSD	24			POORLY GRADED GRAVEL WITH CLAY AND SAND (GP-GC): Gravel (50-55%), fine to coarse, rounded to subrounded, some flat, basalt; Sand (40-45%), fine to medium; Clay (5-10%), low plasticity, gray, wet.	
	120				200					POORLY GRADED GRAVEL WITH SILT AND COBBLES (GP-GM): Gravel (80-90%), fine some coarse; occasional cobbles to 5-inches; Sand (10-15%), fine to coarse; Silt (5-10%), yellowish brown, wet.	
										POORLY GRADED SAND (SP): Gravel (<5%); Sand (95-100%), fine to medium, yellow brown, wet.	
-90		G	25		120	GSD	25			POORLY GRADED GRAVEL WITH SAND (GP): Gravel (65-70%), fine to coarse, rounded to subrounded, some flat and elongated, basalt and quartzite; Sand (25-30%), fine to medium, yellow brown, wet.	
	125				440						
					440					At 126' - becomes olive gray.	
-95		G	26		1040	GSD	26				
	130				80						
					550		27				
-100		G	27		440					POORLY GRADED GRAVEL WITH CLAY (GP-GC): Gravel (75-85%), fine to coarse, rounded to subrounded, basalt; Sand (10-15%), fine to coarse; Clay (5-10%), olive gray, wet.	

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PACRIM GEOTECHNICAL INC.
GEOTECHNICAL ENGINEERING AND APPLIED EARTH SCIENCES

PROJECT	East Side CSO - Final Design	SHEET 7 OF 7		INITIAL GW ELEV	8.4 ft (9/21/04)
CITY	Portland, Oregon	SURFACE ELEV. 32.9 ft	STA.	EQUIPMENT	Core Barrel and Casing
PROJECT NO.	5516	NORTHING 689,674.9	EASTING 7,645,048.7	DRILLING METHOD	Rotosonic
DATE DRILLED	9/19/04 to 9/21/04	LOCATION	N. River Street at Albina Ave	LOGGED BY	GS

SAMPLE TYPE: Ring (3.25" OD) | Standard Penetration Test (2" OD) | Shelby Tube | Grab

Elevation (ft)	DEPTH (ft)	SAMPLE TYPE	SAMPLE NO.	PID	METHANE (ppm)	LAB TESTS	BOX NUMBER	PERCENT FINES (20 40 60 80) / PLASTIC M.C. LIQUID (20 40 60 80)	LITHOLOGY	SOIL DESCRIPTION	WELL
					1340					**(Tt cont'd)**	
							28			POORLY GRADED GRAVEL WITH CLAY AND COBBLES (GP-GC): Gravel (80-90%), fine to coarse, rounded to subrounded, some flat and elongated, basalt and occasional quartzite; occasional cobbles to 6-inches; Sand (5%), medium to coarse; Clay (5-15%), low to medium plasticity, weakly cemented.	
105		G	28								
	140				60						
							29			POORLY GRADED GRAVEL WITH COBBLES (GP): Gravel (85-90%), fine to coarse, rounded to subrounded; few cobbles to 9-inches, subrounded, elongated, basalt; Sand (10-15%), fine to coarse; Clay (<5%), olive gray, wet.	
110		G	29		400						
	145									Boring completed to a depth of 145 ft on 9/21/04.	
115											
	150										
120											
	155										

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PACRIM GEOTECHNICAL INC.
GEOTECHNICAL ENGINEERING AND APPLIED EARTH SCIENCES

PROJECT	East Side CSO - Final Design	SHEET 1 OF 7		INITIAL GW ELEV	8.0 ft (9/17/04)
CITY	Portland, Oregon	SURFACE ELEV. 30.0 ft	STA.	EQUIPMENT	Core Barrel and Casing
PROJECT NO.	5516	NORTHING 690,463.9	EASTING 7,643,974.4	DRILLING METHOD	Rotosonic
DATE DRILLED	9/16/04 to 9/18/04	LOCATION	River Street under Fremont Bridge	LOGGED BY	GS

SAMPLE TYPE: Ring (3.25" OD) | Standard Penetration Test (2" OD) | Shelby Tube | Grab

Elevation (ft)	DEPTH (ft)	SAMPLE TYPE	SAMPLE NO.	PID	METHANE (ppm)	LAB TESTS	BOX NUMBER	PERCENT FINES (20 40 60 80) / PLASTIC M.C. LIQUID (20 40 60 80)	LITHOLOGY	SOIL DESCRIPTION	WELL
										Asphaltic concrete pavement (2 ft. thick).	
		G	1	0	60		1			**Artificial Fill (Qaf)** SILT (ML): with trace fine sand, mottled gray, dry. SILTY SAND WITH GRAVEL (SM): Gravel (15-20%), fine, rounded; Sand (60-65%), fine to coarse; Silt (20-25%), dark gray, moist.	
				0	60					SILT WITH SAND (ML): Silt (75-80%), low plasticity; Sand (20-25%), fine to medium, brown, moist.	
25	5									ELASTIC SILT (MH): Low to medium plasticity, none to slow dilatancy, moist. Trace fine sand	
				0	0		2			Sawdust, shredded wood fibers, trace nonplastic silt and sand, brown, moist.	
		G	2	0	640					**Sand/Silt Alluvium (Qal/Qff)** SILTY SAND (SM): Sand (65-70%), fine; Silt (30-35%), none to low plasticity, gray, moist.	
20	10									At 11' - 8-inch thick layer of silty sand with gravel: Gravel (25-35%), fine, rounded.	
					320		3			SANDY SILT (ML): low to medium plasticity, gray, moist.	
		G	3	0	0	FC				SILTY SAND (SM): Sand (50-55%), fine; Silt (45-50%): none to low plasticity, gray, moist.	
15	15									At 15.5' - 6-inch thick layer of sandy silt to silty sand.	
					160		4			LEAN CLAY (CL): medium plasticity, high dry strength, no dilatancy, tough, gray with slight olive mottling, moist.	
		G	4		160						
10	20									ELASTIC SILT (MH): low to medium plasticity, slow dilatancy, gray, moist, slightly blocky.	
▼					20					At 22' - becomes mottled brown.	

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PACRIM GEOTECHNICAL INC.
GEOTECHNICAL ENGINEERING AND APPLIED EARTH SCIENCES

PROJECT	East Side CSO - Final Design	SHEET 2 OF 7		INITIAL GW ELEV	8.0 ft (9/17/04)
CITY	Portland, Oregon	SURFACE ELEV. 30.0 ft	STA.	EQUIPMENT	Core Barrel and Casing
PROJECT NO.	5516	NORTHING 690,463.9	EASTING 7,643,974.4	DRILLING METHOD	Rotosonic
DATE DRILLED	9/16/04 to 9/18/04	LOCATION	River Street under Fremont Bridge	LOGGED BY	GS

SAMPLE TYPE: Ring (3.25" OD) | Standard Penetration Test (2" OD) | Shelby Tube | Grab

Elevation (ft)	DEPTH (ft)	SAMPLE TYPE	SAMPLE NO.	PID	METHANE (ppm)	LAB TESTS	BOX NUMBER	PERCENT FINES (20 40 60 80) / PLASTIC M.C. LIQUID (20 40 60 80)	LITHOLOGY	SOIL DESCRIPTION	WELL
		G	5		0		5			**(Qal/Qff cont'd)** ELASTIC SILT (MH) ranging in places to SILT (ML): low to medium plasticity, medium to high dry strength, rapid dilatancy, gray mottled brown, moist, slightly blocky. At 24' - dilatancy increases to rapid, and becomes wet and softer.	
5	25				20						
					20		6				
		G	6		0	AL					
0	30									At 30' - low to medium plasticity, high to medium dry strength, no to slow dilatancy, medium to low toughness, moist.	
					20		7				
		G	7		0						
-5	35										
					20		8			**Gravel Alluvium (Qfc)** POORLY GRADED GRAVEL WITH SILT, SAND AND COBBLES (GP-GM): Gravel (75-80%), fine to coarse, occasional cobbles to 5-inches, rounded to subrounded, basalt and some quartzite; Sand: (15-20%), fine to coarse, subangular to subrounded; Silt (5-7%); brown, wet.	
		G	8		160	FC					
-10	40									At 40' - slight decrease in gravel content to 70-75%, increase in sand content to 20-25% .	
					540		9			POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM): Gravel (25-40%), fine to coarse, rounded to subrounded; Sand (55-70%), fine to medium, trace coarse; Silt (5-10%).	
		G	9		1000	GSD				POORLY GRADED GRAVEL WITH SAND AND COBBLES (GP): Gravel (75-85%), fine to coarse, scattered cobbles to 4-inches, rounded to subrounded, basalt, some quartzite; Sand (15-25%), fine to coarse, subangular to subrounded; trace silt (<5%) in places.	

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PACRIM GEOTECHNICAL INC.
GEOTECHNICAL ENGINEERING AND APPLIED EARTH SCIENCES

PROJECT	East Side CSO - Final Design	SHEET 3 OF 7		INITIAL GW ELEV	8.0 ft (9/17/04)
CITY	Portland, Oregon	SURFACE ELEV. 30.0 ft	STA.	EQUIPMENT	Core Barrel and Casing
PROJECT NO.	5516	NORTHING 690,463.9	EASTING 7,643,974.4	DRILLING METHOD	Rotosonic
DATE DRILLED	9/16/04 to 9/18/04	LOCATION	River Street under Fremont Bridge	LOGGED BY	GS

SAMPLE TYPE: ☒ Ring (3.25" OD) ◨ Standard Penetration Test (2" OD) ■ Shelby Tube G Grab

Elevation (ft)	DEPTH (ft)	SAMPLE TYPE	SAMPLE NO.	PID	METHANE (ppm)	LAB TESTS	BOX NUMBER	PERCENT FINES 20 40 60 80 / PLASTIC M.C. LIQUID 20 40 60 80	LITHOLOGY	SOIL DESCRIPTION	WELL
										(Qfc cont'd) POORLY GRADED GRAVEL WITH SAND AND COBBLES (GP)	
					1340		10			At 46' to 51' - hard drilling, scattered cobbles to 6-inches, slight decrease in sand.	
		G	10		1640						
-20	50										
					2160		11			At 52' to 56' - cobbles to 7-inches, mostly rounded to subrounded, some flat and elongated.	
		G	11		600						
-25	55										
					1720		12			WELL GRADED GRAVEL WITH SAND AND COBBLES (GW): Gravel (75-80%), fine to coarse, including up to 25% cobbles to 9-inches, rounded to subrounded, basalt, some quartzite; Sand (15-20%), fine to coarse, subangular to subrounded; Silt (0-3%).	
		G	12		400	GSD					
-30	60										
					1020		13				
		G	13		360						
-35	65										
					160					**Troutdale Formation (Tt)** POORLY GRADED GRAVEL WITH SILT, SAND AND COBBLES (GP-GM): Gravel (70-75%), fine to coarse, rounded to subrounded, basalt, quartzite; basalt cobbles to 9-inches; Sand (15-20%), fine to	

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PROJECT	East Side CSO - Final Design	SHEET 4 OF 7		INITIAL GW ELEV	8.0 ft (9/17/04)
CITY	Portland, Oregon	SURFACE ELEV. 30.0 ft	STA.	EQUIPMENT	Core Barrel and Casing
PROJECT NO.	5516	NORTHING 690,463.9	EASTING 7,643,974.4	DRILLING METHOD	Rotosonic
DATE DRILLED	9/16/04 to 9/18/04	LOCATION	River Street under Fremont Bridge	LOGGED BY	GS

SAMPLE TYPE: ☒ Ring (3.25" OD) ◧ Standard Penetration Test (2" OD) ■ Shelby Tube G Grab

Elevation (ft)	DEPTH (ft)	SAMPLE TYPE	SAMPLE NO.	PID	METHANE (ppm)	LAB TESTS	BOX NUMBER	PERCENT FINES (20 40 60 80) / PLASTIC M.C. LIQUID (20 40 60 80)	LITHOLOGY	SOIL DESCRIPTION	WELL
		G	14		3% LEL	GSD	14	● △		coarse, rounded to subrounded; Silt (5-7%); brown and gray, wet. **(Tt cont'd)**	
					20% LEL					POORLY GRADED GRAVEL WITH SAND AND COBBLES (GP): Gravel (75-80%), fine to coarse, rounded to subrounded, basalt, quartzite; basalt cobbles to 5-inches with some coated and weakly cemented; Sand (15-25%), fine to medium, rounded to subrounded, brown and gray, wet.	
-40	70				40						
		G	15		120		15				
-45	75										
					940					SILTY GRAVEL WITH SAND AND COBBLES (GM): Gravel (25-30%), fine to coarse, rounded to subrounded, basalt and quartzite; basalt cobbles to 5-inches, some flat; Sand (25-30%), fine; Silt (20-25%), low plasticity matrix, gray, moist to wet.	
		G	16			GSD	16	● △			
					3220					POORLY GRADED GRAVEL WITH SAND (GP): Gravel (80-85%), fine to coarse, rounded to subrounded; Sand (15-20%), fine to coarse, yellowish brown, wet. At 80' - becomes sandier (30-40%).	
-50	80										
					2300					WELL GRADED GRAVEL WITH SILT, SAND AND COBBLES (GW-GM): Gravel (50-60%), fine to coarse, rounded to subrounded, mostly basalt, with some coated; occasional cobbles to 6-inches and slightly flattened; Sand (30-35%), fine to coarse; Silt (10-15%).	
		G	17			GSD	17	● △		At 83' - layer of silty gravel, < 4-inches thick.	
					1560						
-55	85				4100						
					460					CLAYEY GRAVEL WITH COBBLES (GC): Gravel (75-85%), fine to coarse, rounded to subrounded, basalt; occasional cobbles to 9-inches; Sand (5-10%), fine to coarse; Clay (15-20%), low to medium plasticity matrix, gray with some brown, moist to wet.	
		G	18		45% LEL	FC	18	● △			

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BORING LOG ES-3022R

PACRIM GEOTECHNICAL INC.
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PROJECT	East Side CSO - Final Design	SHEET 5 OF 7		INITIAL GW ELEV	8.0 ft (9/17/04)
CITY	Portland, Oregon	SURFACE ELEV. 30.0 ft	STA.	EQUIPMENT	Core Barrel and Casing
PROJECT NO.	5516	NORTHING 690,463.9	EASTING 7,643,974.4	DRILLING METHOD	Rotosonic
DATE DRILLED	9/16/04 to 9/18/04	LOCATION	River Street under Fremont Bridge	LOGGED BY	GS

SAMPLE TYPE: ☒ Ring (3.25" OD) ◧ Standard Penetration Test (2" OD) ■ Shelby Tube G Grab

Elevation (ft)	DEPTH (ft)	SAMPLE TYPE	SAMPLE NO.	PID	METHANE (ppm)	LAB TESTS	BOX NUMBER	PERCENT FINES (20 40 60 80) / PLASTIC M.C. LIQUID (20 40 60 80)	LITHOLOGY	SOIL DESCRIPTION	WELL
										(Tt cont'd) At 90.5' - slight increase in sand to 10-15%, decrease in clay to 10-15%.	
		G	19		1760, 1580, 1060	GSD	19			POORLY GRADED GRAVEL WITH CLAY, SAND AND COBBLES (GP-GC): Gravel (60-70%), fine to coarse, rounded to subrounded; occasional cobbles to 5-inches; Sand (20-30%), fine to coarse; Clay (5-12%), low plasticity matrix, gray, wet, some sandy pockets.	
-65	95				420					CLAYEY GRAVEL WITH SAND AND COBBLES (GC): Gravel (45-65%), fine to coarse, rounded to subrounded; occasional cobbles to 5-inches; Sand (20-25%), fine to coarse; Clay (10-35%), low plasticity matrix, gray, wet, some sandy pockets.	
		G	20		60, 34% LEL	GSD	20			At 99' - some layers of more sandy material (25-30%).	
-70	100				440, 17% LEL		21				
		G	21		720	FC				POORLY GRADED GRAVEL WITH SAND (GP): Gravel (75-85%), fine to coarse, rounded to subrounded; Sand (15-20%), fine to coarse; Clay (<5%), grayish brown.	
-75	105									At 105.5' - absence of clay, increase in sand to 20-25%.	
					740		22			CLAYEY GRAVEL WITH SAND (GC): Gravel (60-65%); Sand (20-25%), Clay (10-15%), none to low plasticity matrix, mottled gray with olive and occasional red zones.	
		G	22		1360	GSD					
-80	110									CLAYEY GRAVEL WITH SAND AND COBBLES (GC): Gravel (55-65%), fine to coarse, rounded to subrounded, basalt, volcanics, quartzite; Sand (20-25%), fine to coarse; Clay (10-20%); brown, wet.	
					820					At 112' - flat 4-inch basalt cobble.	

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PROJECT	East Side CSO - Final Design	SHEET 6 OF 7		INITIAL GW ELEV	8.0 ft (9/17/04)
CITY	Portland, Oregon	SURFACE ELEV. 30.0 ft	STA.	EQUIPMENT	Core Barrel and Casing
PROJECT NO.	5516	NORTHING 690,463.9	EASTING 7,643,974.4	DRILLING METHOD	Rotosonic
DATE DRILLED	9/16/04 to 9/18/04	LOCATION	River Street under Fremont Bridge	LOGGED BY	GS

SAMPLE TYPE: Ring (3.25" OD) | Standard Penetration Test (2" OD) | Shelby Tube | Grab

Elevation (ft)	DEPTH (ft)	SAMPLE TYPE	SAMPLE NO.	PID	METHANE (ppm)	LAB TESTS	BOX NUMBER	PERCENT FINES (20 40 60 80) / PLASTIC M.C. LIQUID (20 40 60 80)	LITHOLOGY	SOIL DESCRIPTION	WELL
							23			**(Tt cont'd)** CLAYEY GRAVEL WITH SAND (GC): Gravel (55-65%), fine to coarse, rounded to subrounded, basalt, volcanics, quartzite; Sand (20-25%), fine to coarse; Clay (10-20%); brown, wet.	
		G	23		460	FC					
-85	115				140						
					600		24				
		G	24		140	GSD				At 118' - slight increase in sand and becomes gray.	
-90	120										
					60		25			POORLY GRADED GRAVEL WITH CLAY, SAND AND COBBLES (GP-GC): Gravel (65-70%), fine to coarse, rounded to subrounded, basalt, quartzite, occasional cobbles to 4 inches; Sand (15-20%), fine to coarse; Clay (10-15%); gray, wet.	
		G	25			FC					
					260						
-95	125										
					80		26				
		G	26		500						
-100	130										
					560						
					180		27				
		G	27		560						

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PROJECT	East Side CSO - Final Design	SHEET 7 OF 7		INITIAL GW ELEV	8.0 ft (9/17/04)
CITY	Portland, Oregon	SURFACE ELEV. 30.0 ft	STA.	EQUIPMENT	Core Barrel and Casing
PROJECT NO.	5516	NORTHING 690,463.9	EASTING 7,643,974.4	DRILLING METHOD	Rotosonic
DATE DRILLED	9/16/04 to 9/18/04	LOCATION	River Street under Fremont Bridge	LOGGED BY	GS

SAMPLE TYPE: ☒ Ring (3.25" OD) ◨ Standard Penetration Test (2" OD) ■ Shelby Tube G Grab

Elevation (ft)	DEPTH (ft)	SAMPLE TYPE	SAMPLE NO.	PID	METHANE (ppm)	LAB TESTS	BOX NUMBER	PERCENT FINES 20 40 60 80 / PLASTIC M.C. LIQUID 20 40 60 80	LITHOLOGY	SOIL DESCRIPTION	WELL
										(Tt cont'd)	
					120					POORLY GRADED GRAVEL WITH SILT AND COBBLES (GP-GM): Gravel (75-80%), fine to coarse, rounded to subrounded, some elongated basalt and quartzite; occasional cobbles to 5-inches; Sand (10-15%), fine to coarse; Silt (5-10%), low plasticity, gray, moist to wet.	
		G	28		1500		28			SILTY GRAVEL WITH SAND (GM): Gravel (50-60%), mostly fine; Sand (10-20%), fine to medium; Silt (15-25%).	
					45% LEL					POORLY GRADED GRAVEL WITH SILT (GP-GM): Gravel (75-85%), fine to coarse, rounded to subrounded, some flat, basalt and quartzite; Sand (10-15%), fine to coarse; Silt (5-10%), Clay (<5%), low plasticity matrix.	
-110	140	G	29							Very hard drilling	
					2100						
							29				
					120						
-115	145										
										Boring completed to a depth of 146 ft on 9/18/04.	
-120	150										
-125	155										

Geotechnical Data Report

JULY 2015 GRI JOB NO. 5445 FIG. E-104

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BORING LOG ES-3035R

PACRIM GEOTECHNICAL INC.
GEOTECHNICAL ENGINEERING AND APPLIED EARTH SCIENCES

PROJECT	East Side CSO - Final Design	SHEET 1 OF 7		INITIAL GW ELEV	11.0 ft (3/30/05)
CITY	Portland, Oregon	SURFACE ELEV. 33.0 ft	STA.	EQUIPMENT	Core Barrel and Casing
PROJECT NO.	5516	NORTHING 689,535.5	EASTING 7,645,229.6	DRILLING METHOD	Rotosonic
DATE DRILLED	3/30/05 to 3/31/05	LOCATION	N River Street at N Albina Ave	LOGGED BY	GS

SAMPLE TYPE: ☒ Ring (3.25" OD) ◨ Standard Penetration Test (2" OD) ■ Shelby Tube G Grab

Elevation (ft)	DEPTH (ft)	SAMPLE TYPE	SAMPLE NO.	PID	METHANE (ppm)	LAB TESTS	BOX NUMBER	PERCENT FINES (20 40 60 80) / PLASTIC M.C. LIQUID (20 40 60 80)	LITHOLOGY	SOIL DESCRIPTION	WELL
										Artificial Fill (Qaf) POORLY GRADED GRAVEL WITH SAND (GP): Gravel (65-80%), fine to coarse, 1.5-inch angular basalt, 2 to 3-inch concrete fragments; Sand (15-30%), fine to coarse; brown, moist.	
				1.5	0		1				
30		G	1							POORLY GRADED SAND (SP): Gravel (25-30%), fine to coarse, angular; Sand (60-65%), fine to coarse; Silt/Clay (<5%); sawdust (5%); brown.	
				0.8	40					SILT WITH SAND (ML) to SANDY SILT (ML): Gravel (5-15%), fine to coarse, angular; Sand (20-40%), fine to coarse; Silt (45-75%), low to medium plasticity; dark brown mottled orange. At 5' - Becomes brown.	
	5										
				1.8	80						
							2			SILTY GRAVEL WITH SAND (GM): Gravel (40-60%), 1.5-inch minus, angular; Sand (10-30%), fine to coarse; Silt (10-25%), low plasticity; dark brown, moist.	
25		G	2							SILTY SAND WITH GRAVEL (SM): Gravel (15-20%), 3-inch angular basalt; Sand (30-70%); Silt (30-50%).	
				5.2	720						
	10									SANDY SILT (ML): Gravel (5-15%), fine to coarse, angular; Sand (10-40%), fine to coarse; Silt (45-85%), low to medium plasticity; dark brown. At 10.5' - With orange mottling.	
				0.4	260						
							3			POORLY GRADED SAND WITH SILT (SP-SM): Gravel (5-10%); Sand (80-90%), fine to medium; Silt (5-10%), low-plasticity; brick fragments.	
20		G	3	14	100	FC				Layer of rotting wood and white powder with non-plastic silt. Ceramic debris and ashes.	
										SILTY SAND (SM): Sand (80-85%), fine to medium; Silt (15-20%); brown.	
	15			151	360					WOOD DEBRIS. Cored logs or lumber.	
										SILTY SAND (SM) to SANDY SILT (ML): Sand (40-60%); Silt (40-60%); brown, wet. Marble fragment.	
							4			WOOD DEBRIS. 8-inch thick cored piece.	
15		G	4	32	700						
										POORLY GRADED SAND WITH SILT (SP-SM): Sand (85-95%), fine to medium; Silt (5-15%); gray, wood fibers, wet. WOOD.	
	20									SILTY SAND (SM): Sand (80%), fine to coarse; Silt (20%), low to medium plasticity; gray, wood debris.	
										POORLY GRADED SAND WITH SILT (SP-SM): Sand (85-95%), fine; Silt (5-15%), non-plastic to low plasticity; gray, wet.	
										SILT (ML): Low to medium plasticity; brown, peaty organics (5-15%), wet.	
▼				3.6	2960					ELASTIC SILT (MH) ranging to SILT (ML): Low to medium plasticity; layered olive, gray and brown.	

JULY 2015 GRI JOB NO. 5445 FIG. E-105

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BORING LOG
ES-3035R

PACRIM GEOTECHNICAL INC.
GEOTECHNICAL ENGINEERING AND APPLIED EARTH SCIENCES

PROJECT	East Side CSO - Final Design	SHEET 2 OF 7		INITIAL GW ELEV	11.0 ft (3/30/05)
CITY	Portland, Oregon	SURFACE ELEV. 33.0 ft	STA.	EQUIPMENT	Core Barrel and Casing
PROJECT NO.	5516	NORTHING 689,535.5	EASTING 7,645,229.6	DRILLING METHOD	Rotosonic
DATE DRILLED	3/30/05 to 3/31/05	LOCATION	N River Street at N Albina Ave	LOGGED BY	GS

SAMPLE TYPE: Ring (3.25" OD) | Standard Penetration Test (2" OD) | Shelby Tube | Grab

Elevation (ft)	DEPTH (ft)	SAMPLE TYPE	SAMPLE NO.	PID	METHANE (ppm)	LAB TESTS	BOX NUMBER	PERCENT FINES (20 40 60 80) / PLASTIC M.C. LIQUID (20 40 60 80)	LITHOLOGY	SOIL DESCRIPTION	WELL
10		G	5	2.0	140	AL, FC	5			**Sand/Silt Alluvium (Qal/Qff)**	
										ORGANIC SILT (OL): Brown, peaty, wood chips, some carbonized. SILT (ML): Low to medium plasticity; brown to olive, wet to moist.	
	25									At 25' - Becomes blocky.	
				1.8	380		6				
5		G	6			FC				At 28.5' - Becomes olive-gray.	
				2.8	120						
	30										
				2.0	620					SILTY SAND (SM): Sand (50-70%), fine; Silt (30-50%); gray, olive, moist.	
							7			**Gravel Alluvium (Qfc)** POORLY GRADED GRAVEL WITH SAND AND COBBLES (GP): Gravel (80-90%), fine to coarse, to 3-inch, rounded to subrounded, flat and elongated, basalt, intrusives, quartzite; Sand (10-20%), fine to coarse; Silt (<5%); gray, stratified, no observed coating or cementation. At 33.6' - A few cobbles to 4-inches. At 34.2' - A few 4-inch cobbles.	
0		G	7								
				1.4	140						
	35										
				0.6	1140					At 36.5' - 6-inch cored cobble.	
							8			At 37.2' - 6-inch cored rounded cobble. A few elongated cobbles to 5 inches.	
-5		G	8		400						
	40									At 40' - A few 4-inch flat and elongated cobbles.	
					1980		9				
-10		G	9			GSD					
					600						

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PACRIM GEOTECHNICAL INC.
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PROJECT	East Side CSO - Final Design	SHEET 3 OF 7		INITIAL GW ELEV	11.0 ft (3/30/05)
CITY	Portland, Oregon	SURFACE ELEV. 33.0 ft	STA.	EQUIPMENT	Core Barrel and Casing
PROJECT NO.	5516	NORTHING 689,535.5	EASTING 7,645,229.6	DRILLING METHOD	Rotosonic
DATE DRILLED	3/30/05 to 3/31/05	LOCATION	N River Street at N Albina Ave	LOGGED BY	GS

SAMPLE TYPE: ☒ Ring (3.25" OD) ◨ Standard Penetration Test (2" OD) ■ Shelby Tube G Grab

Elevation (ft)	DEPTH (ft)	SAMPLE TYPE	SAMPLE NO.	PID	METHANE (ppm)	LAB TESTS	BOX NUMBER	PERCENT FINES (20 40 60 80) / PLASTIC M.C. LIQUID (20 40 60 80)	LITHOLOGY	SOIL DESCRIPTION	WELL
					860		10			**(Qfc Cont'd)** POORLY GRADED GRAVEL WITH COBBLES (GP): Gravel (85-95%), fine to coarse, 4-inch elongated quartzite cobble, rounded, basalt, intrusives, quartzite; Sand (5-15%), fine to coarse; Silt (<5%); gray, stratified/layered, no coating or cementation, wet. At 45.2' - 6-inch flat cobble. 5-inch rounded cobble below. At 46' - 8-inch flat cobble. A few flat and elongated cobbles to 4 inches. At 47.5' - 6-inch flat cobble. At 48' - 4-inch cobble.	
-15		G	10		1360					At 49.2' - 5-inch flat cobble. At 49.5' - 8-inch elongated cobble. At 50.4' - 6-inch rounded cobble.	
	50				1080					POORLY GRADED GRAVEL WITH COBBLES (GP): Gravel (80-95%), fine to coarse, a few cobbles to 4-inch; Sand (5-20%), fine to coarse; Silt (<5%); gray, wet.	
							11			No Recovery. At 53' - Possible cuttings, Sand to Gravel, fine, angular.	
-20					580						
	55	G	11		700					POORLY GRADED GRAVEL WITH SAND AND COBBLES (GP): Gravel (75-90%), fine to coarse, to 3-inch, rounded; basalt, quartzite, intrusives; Sand (10-25%), fine to coarse; Silt (<5%); gray, no coating or cement, wet. At 55' - Two 5-inch cobbles. At 56' - 4-inch flat and elongated cobbles. At 57' - 6-inch elongated cobble.	
							12			POORLY GRADED GRAVEL WITH SAND AND COBBLES (GP): Gravel (60-80%), mostly <1.5-inch, a few 2-inch, 6-inch rounded, cored cobble, basalt; Sand (20-40%), fine to medium; Silt (<5%); gray, wet.	
-25		G	12		280						
	60									At 60' - 4-inch elongated cobble.	
					60					POORLY GRADED SAND WITH SILT (SP-SM): Sand (85-95%), fine to medium; Silt (5-15%), non-plastic; gray, weak cementation, wet.	
							13			WELL GRADED GRAVEL WITH SILT, SAND AND COBBLES (GW-GM): Gravel (65-70%), fine to coarse, mostly to 3-inch, rounded; Sand (20-25%), fine to coarse; Silt (5-10%); gray, wet. At 63.5' - A few flat basalt cobbles to 5 inches.	
-30		G	13		700	GSD					
	65									At 64.8' - Trace cementation.	
					1180					**Troutdale Formation (Tt)** POORLY GRADED GRAVEL WITH SILT AND SAND (GP-GM): Gravel (75-85%); Sand (10-20%), fine; Silt (5-10%), low plasticity; brown, coated, weakly cemented.	

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PROJECT	East Side CSO - Final Design	SHEET 4 OF 7		INITIAL GW ELEV	11.0 ft (3/30/05)
CITY	Portland, Oregon	SURFACE ELEV. 33.0 ft	STA.	EQUIPMENT	Core Barrel and Casing
PROJECT NO.	5516	NORTHING 689,535.5	EASTING 7,645,229.6	DRILLING METHOD	Rotosonic
DATE DRILLED	3/30/05 to 3/31/05	LOCATION	N River Street at N Albina Ave	LOGGED BY	GS

SAMPLE TYPE: ☒ Ring (3.25" OD) ◧ Standard Penetration Test (2" OD) ■ Shelby Tube G Grab

Elevation (ft)	DEPTH (ft)	SAMPLE TYPE	SAMPLE NO.	PID	METHANE (ppm)	LAB TESTS	BOX NUMBER	PERCENT FINES (20 40 60 80) / PLASTIC M.C. LIQUID (20 40 60 80)	LITHOLOGY	SOIL DESCRIPTION	WELL
										(Tt Cont'd)	
-35		G	14		140		14			POORLY GRADED SAND WITH SILT (SP-SM) ranging to SILTY SAND (SM): Sand (80-90%), fine; Silt (10-20%), non-plastic; brown, wet.	
	70				700						
-40		G	15		300	FC	15	△ ●			
	75				220					At 75' - Becomes yellow, weakly cemented, moist to wet.	
-45		G	16		1540	GSD	16	△ ●			
	80				3180						
-50		G	17		940		17				
	85				2560						
-55		G	18		860	FC	18	△ ●		POORLY GRADED SAND WITH SILT (SP-SM): Sand (90-95%), fine to medium; Silt (5-10%), non-plastic; brown, wet.	

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BORING LOG ES-3035R

PACRIM GEOTECHNICAL INC.
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PROJECT	East Side CSO - Final Design	SHEET 5 OF 7		INITIAL GW ELEV	11.0 ft (3/30/05)
CITY	Portland, Oregon	SURFACE ELEV. 33.0 ft	STA.	EQUIPMENT	Core Barrel and Casing
PROJECT NO.	5516	NORTHING 689,535.5	EASTING 7,645,229.6	DRILLING METHOD	Rotosonic
DATE DRILLED	3/30/05 to 3/31/05	LOCATION	N River Street at N Albina Ave	LOGGED BY	GS

SAMPLE TYPE: Ring (3.25" OD) | Standard Penetration Test (2" OD) | Shelby Tube | Grab

Elevation (ft)	DEPTH (ft)	SAMPLE TYPE	SAMPLE NO.	PID	METHANE (ppm)	LAB TESTS	BOX NUMBER	PERCENT FINES (20 40 60 80) / PLASTIC M.C. LIQUID (20 40 60 80)	LITHOLOGY	SOIL DESCRIPTION	WELL
										(Tt Cont'd)	
					840					POORLY GRADED SAND WITH GRAVEL (SP): Gravel (30-50%), fine to coarse, to 1.5-inch, basalt, metavolcanics, quartzite; Sand (50-70%), fine to coarse; brown, weakly cemented, wet.	
							19			POORLY GRADED GRAVEL WITH SAND AND COBBLES (GP): Gravel (60-85%), fine to coarse, a few flat and elongated cobbles to 5 inches; Sand (15-40%), fine to coarse, mostly coarse; brown, wet.	
-60		G	19		660	GSD				WELL GRADED SAND WITH SILT, GRAVEL AND COBBLES (SW-SM): Gravel (30-35%), fine, to 2-inch, mostly <1-inch, rounded to subrounded, basalt, quartzite; Sand (55-65%), fine to coarse; Silt (5-10%), non-plastic; brown, wet. At 94.2' - 4-inch cobble. Reddish brown.	
	95									At 95' - A few 4-inch cobbles.	
					880					POORLY GRADED SAND (SP): Gravel (5-20%), fine; Sand (80-90%), fine to coarse; Silt (<5%).	
							20				
-65		G	20		1580					POORLY GRADED GRAVEL WITH COBBLES (GP): Gravel (85-95%), cobbles, fine to coarse, three flat elongated cobbles to 5 inches, basalt, quartzite; Sand (5-15%).	
		G	20b			FC				POORLY GRADED SAND WITH SILT (SP-SM): Sand (90-95%), fine; Silt (5-10%); brown, wet.	
	100									At 99' - Sand becomes fine to coarse.	
										POORLY GRADED GRAVEL WITH SAND (GP): Gravel (70-80%), fine, to 3-inch; Sand (20-30%), coarse, subrounded to subangular.	
										POORLY GRADED SAND WITH GRAVEL (SP): Gravel (20-30%), fine, basalt and quartzite; Sand (70-80%), medium to coarse.	
					2880					POORLY GRADED GRAVEL WITH SAND AND COBBLES (GP): Gravel (60-90%), to 3-inch.	
							21			At 102.8' - 5-inch rounded cobble.	
-70		G	21			GSD				POORLY GRADED SAND WITH GRAVEL AND COBBLES (SP): Gravel (10-30%), fine, rounded; Sand (65-85%), fine to coarse; Silt (<5%); brown, wet. At 103.7' - 4-inch rounded cobble.	
					1880						
	105									POORLY GRADED GRAVEL WITH SILT, SAND AND COBBLES (GP-GM): Gravel (55-65%), fine to coarse, mostly <2.5-inch, cobbles to 6-inch, rounded to subrounded, flat and elongated, basalt, intrusives, quartzite, metavolcanics; Sand (25-30%), fine to coarse, mostly fine; Silt (10-15%), non-plastic to low plasticity; yellow-brown, stratified, cemented, coated, stained, wet. At 106.3 - 4-inch cobble, rounded, flat.	
					1160						
							22				
-75		G	22			GSD					
					920						
	110									At 109.7 - 4-inch elongated cobble. At 110' - Increasing silt. Cobbles to 6 inches.	
					2440						
					1060					POORLY GRADED GRAVEL WITH CLAY AND SAND (GP-GC): Gravel (65-80%), fine to coarse, mostly <1.5-inch, rounded to subrounded, flat and elongated, basalt, quartzite; Sand (20-25%), fine to coarse; Clay (5-15%), low plasticity; coated, stained and	

JULY 2015 GRI JOB NO. 5445 FIG. E-109

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PACRIM GEOTECHNICAL INC.
GEOTECHNICAL ENGINEERING AND APPLIED EARTH SCIENCES

PROJECT	East Side CSO - Final Design	SHEET 6 OF 7		INITIAL GW ELEV	11.0 ft (3/30/05)
CITY	Portland, Oregon	SURFACE ELEV. 33.0 ft	STA.	EQUIPMENT	Core Barrel and Casing
PROJECT NO.	5516	NORTHING 689,535.5	EASTING 7,645,229.6	DRILLING METHOD	Rotosonic
DATE DRILLED	3/30/05 to 3/31/05	LOCATION	N River Street at N Albina Ave	LOGGED BY	GS

SAMPLE TYPE: ☒ Ring (3.25" OD) ◧ Standard Penetration Test (2" OD) ■ Shelby Tube G Grab

Elevation (ft)	DEPTH (ft)	SAMPLE TYPE	SAMPLE NO.	PID	METHANE (ppm)	LAB TESTS	BOX NUMBER	PERCENT FINES (20 40 60 80) / PLASTIC M.C. LIQUID (20 40 60 80)	LITHOLOGY	SOIL DESCRIPTION	WELL
-80		G	23		1180	GSD	23			cemented, brown, wet. **(Tt Cont'd)**	
										POORLY GRADED GRAVEL (GP): Gravel (80-90%), to 2-inch, basalt, metavolcanics, intrusives; Sand (10-15%), fine to coarse; Clay (<5%); stratified, coated and stained, and/or cemented, brown, wet.	
	115										
					720		24				
-85		G	24		540	FC				POORLY GRADED SAND WITH SILT (SP-SM) ranging to SILTY SAND (SM): Sand (80-95%), fine; Silt (5-20%), non-plastic; yellowish-brown, wet.	
	120									WELL GRADED GRAVEL WITH SILT, SAND AND COBBLES (GW-GM): Gravel (65-70%), fine to coarse, cobbles to 5-inch, rounded to subrounded, flat and elongated, basalt, intrusives, quartzite; Sand (20-25%) mostly fine; Silt (5-10%), non-plastic; coated and stained, weakly cemented, yellowish-brown, wet.	
					1300						
					4040		25				
-90		G	25		2620	GSD					
	125									At 125' - A few rounded cobbles to 4 inches.	
					2480		26			POORLY GRADED GRAVEL WITH COBBLES (GP): Gravel (75-90%), fine to coarse, mostly <2.5-inch, cobbles to 6-inch, rounded to subrounded, basalt, quartzite, intrusives, volcanics; Sand (10-20%), mostly fine; Silt (<5%); stratified, coated and stained, weakly cemented, yellowish brown, wet.	
-95		G	26		860					At 128.5' - 5-inch flat cobble, with 6-inch elongated below it. At 129' - A few 4-inch cobbles, flat.	
	130										
					960					WELL GRADED GRAVEL WITH SILT, SAND AND COBBLES (GW-GM): Gravel (65-75%), fine to coarse, cobbles to 5-inch, flat, basalt, quartzite, intrusives, rounded to subrounded, flat and elongated; Sand (20-25%), mostly fine; Silt (5-10%), non-plastic to low plasticity; stratified, coated and stained, weakly cemented, brown, wet.	
							27				
-100		G	27		1820	GSD					
					600						

PARSONS BRINCKERHOFF

BORING LOG
ES-3035R

PACRIM GEOTECHNICAL INC.
GEOTECHNICAL ENGINEERING AND APPLIED EARTH SCIENCES

PROJECT	East Side CSO - Final Design	SHEET 7 OF 7		INITIAL GW ELEV	11.0 ft (3/30/05)
CITY	Portland, Oregon	SURFACE ELEV. 33.0 ft	STA.	EQUIPMENT	Core Barrel and Casing
PROJECT NO.	5516	NORTHING 689,535.5	EASTING 7,645,229.6	DRILLING METHOD	Rotosonic
DATE DRILLED	3/30/05 to 3/31/05	LOCATION	N River Street at N Albina Ave	LOGGED BY	GS

SAMPLE TYPE: Ring (3.25" OD) | Standard Penetration Test (2" OD) | Shelby Tube | Grab

Elevation (ft)	DEPTH (ft)	SAMPLE TYPE	SAMPLE NO.	PID	METHANE (ppm)	LAB TESTS	BOX NUMBER	PERCENT FINES (20 40 60 80) / PLASTIC M.C. LIQUID (20 40 60 80)	LITHOLOGY	SOIL DESCRIPTION	WELL
					1040		28			**(Tt Cont'd)** POORLY GRADED GRAVEL WITH COBBLES (GP): Gravel (80-90%), fine to coarse, mostly <2-inch, cobbles to 4-inch, rounded to subrounded, basalt common, quartzite; Sand (10-20%), mostly fine; Silt (<5%); stained and coated, weakly cemented, stratified, brown, wet.	
105		G	28		3000						
	140				1180		29			POORLY GRADED GRAVEL (GP): Gravel (85-95%), fine to coarse, to 3-inch, mostly <1-inch; basalt, quartzite, intrusives, metavolcanics; Sand (5-15%), mostly fine; stratified, coated, stained and weakly cemented, brown, wet.	
110		G	29		1300					At 144.5' - Coarser gravel.	
	145									Boring completed to a depth of 145 ft on 3/31/2005.	
115											
	150										
120											
	155										

BORING LOG
ES-3042R

GEODESIGN INC
Geotechnical | Geological | Environmental

PROJECT	East Side CSO Tunnel	SHEET 1 OF 2		INITIAL GW ELEV.	27.27 ft (6/18/07)
CITY	Portland, OR	SURFACE ELEV.	37.80 ft	STA.	
EQUIPMENT	Core Barrel and Casing				
PROJECT NO.	BES 5516	NORTHING	689838.1	EASTING	7644827.9
DRILLING METHOD	Rotosonic				
DATE DRILLED	6/18/07 to 6/18/07	LOCATION	N. River St. & Lewis Ave.	LOGGED BY	GCS

SAMPLE TYPE: Ring (3.25" OD) | Standard Penetration Test (2" OD) | Shelby Tube | Undisturbed

ELEVATION (ft)	DEPTH (ft)	SAMPLE TYPE	SAMPLE NO	PID (ppm)	METHANE (ppm)	LAB TESTS	BOX NUMBER	PERCENT FINES (20 40 60 80) / PLASTIC M.C. LIQUID (20 40 60 80)	LITHOLOGY	SOIL DESCRIPTION	WELL
										Artificial Fill (Qaf) 13 inches portland cement concrete	
										6 inches base rock, ¾-inch minus, poorly graded, angular, dry to moist.	
				1	2					SILT (ML); Silt (90-95%); Sand (5-10%), fine; Gravel (5%), fine, rounded to subrounded, low to medium plasticity, rapid dilatancy; brown, moist.	
35		G	1								
	5			7	18					POORLY GRADED GRAVEL (GP); Gravel (90-95%), fine to coarse, rounded to angular; Sand (5%); Silt (5%); gray, dry.	
				6	420		1			At 5.5' - Grades to fine gravel; Sand (5-10%), fine to coarse; brown, moist.	
				6	3					POORLY GRADED GRAVEL WITH SILT (GP-GM) TO SILTY GRAVEL WITH COBBLES (GM); Gravel (60-90%), fine to coarse, with cobbles 4 inches maximum diameter; Silt (5-35%); Sand (5-15%), fine to coarse; low to medium plasticity, brown, moist.	
30		G	2			MC GSD					
				6	4					**Sand/Silt Alluvium (Qal/Qff)** SILT (ML); Silt (85-90%); Sand (10-15%), fine; low to medium plasticity, rapid dilatancy; orange and brown, moist.	
	10										
				2	4						
				0	560						
25		G	3			MC				At 12.5' - Grades to 5-10% sand, decrease in orange color grading to brown. Stratified layers from 13 to 16 feet.	
	15			4	54						
										At 16' - Grades to 10-15% sand with orange mottles, increase in plasticity.	
				1	2						
20		G	4			MC FC	2				
										At 19' - Grades to 10-20% sand, moist to wet.	
	20									At 20' - Grades to 5-10% sand, low to medium plasticity.	
				0	240					SANDY SILT (ML); Silt (40-70%), low plasticity, rapid dilatancy; Sand (30-60%), fine; gray-brown, moist to wet.	
		G	5			MC					

EAST SIDE CSO ROTOSONIC BORING (GDI) PBAMERICAS-1-02-ES_3039R_ES_3050R.GPJ PB AMERICAS.GDT 10/12/07

JULY 2015 GRI JOB NO. 5445 FIG. E-112

BORING LOG
ES-3042R

GEODESIGN INC
Geotechnical | Geological | Environmental

PROJECT	East Side CSO Tunnel	SHEET 2 OF 2		INITIAL GW ELEV.	27.27 ft (6/18/07)
CITY	Portland, OR	SURFACE ELEV.	37.80 ft	STA.	
EQUIPMENT	Core Barrel and Casing				
PROJECT NO.	BES 5516	NORTHING	689838.1	EASTING	7644827.9
DRILLING METHOD	Rotosonic				
DATE DRILLED	6/18/07 to 6/18/07	LOCATION	N. River St. & Lewis Ave.	LOGGED BY	GCS

SAMPLE TYPE: Ring (3.25" OD) | Standard Penetration Test (2" OD) | Shelby Tube | Undisturbed

ELEVATION (ft)	DEPTH (ft)	SAMPLE TYPE	SAMPLE NO	PID (ppm)	METHANE (ppm)	LAB TESTS	BOX NUMBER	PERCENT FINES (20 40 60 80) / PLASTIC M.C. LIQUID (20 40 60 80)	LITHOLOGY	SOIL DESCRIPTION	WELL
15				1	240					**(Qal/Qff Cont'd)** SILT (ML); Silt (90-95%); Sand (5-10%), fine; low to medium plasticity, brown.	
	25			0	320					At 25' - Grades to 20-35% sand, fine, low plasticity, moist to wet.	
				0	4						
10		G	6			MC AL				At 28' - Grades to 5-10% sand, low to medium plasticity.	
	30			0	340		3			At 35' - Grades 10-20% sand, fine	
										At 32' - Grades to 15-20% sand, low to medium plasticity.	
5		G	7	0	240	MC HYD				At 33' - Grades to 5-10% sand.	
										At 34' - Grades to 10-20% sand.	
	35			0	340					**Gravel Alluvium (Qfc)** POORLY GRADED GRAVEL WITH SILT, SAND AND COBBLES (GP-GM); Gravel (70-85%), fine to coarse, with cobbles 3 inches maximum diameter, rounded to subrounded, flat, elongated, basalt, volcanic glass; Sand (10-20%), fine to coarse; Silt (5-10%), nonplastic; brown, wet.	
0			8							Note: Lost sample and/or slough encountered in this zone. POORLY GRADED GRAVEL WITH COBBLES (GP); Gravel (85-95%), fine to coarse, with cobbles 5 inches maximum diameter, rounded to subrounded, basalt, volcanic glass, quartzite; Sand (5-15%); brown, wet.	
							4				
	40									Note: lost sample and/or slough encountered in this zone.	
		G	9		1	MC GSD				At 41' - No matrix recovery.	
-5										2-inch piezometer installed with bottom of 5-foot screen at 43 feet BGS. Boring completed to a depth of 43 ft on 6/18/07.	

EAST SIDE CSO ROTOSONIC BORING (GDI) PBAMERICAS-1-02-ES_3039R_ES_3050R.GPJ PB AMERICAS.GDT 10/12/07

PARSONS BRINCKERHOFF

BORING LOG ES-3043A

Foundation Engineering, Inc.

PROJECT East Side CSO - Outfall 44A | SHEET 1 OF 2 | INITIAL GWL@ Not Available

CITY Portland, Oregon | SURF. EL. 32.8 ft | STA. | OFST. | EQUIPMENT Mobile B-59

PROJECT NO. 2062029 | NORTHING 689977.3 | EASTING 7644641.3 | DRILLING METHOD Mud Rotary

DATE DRILLED 7/3/07 | LOGGED BY JPQ | LOCATION N. River Street | HAMMER WGT. Automatic

SAMPLE TYPE: Ring (3.25" OD) | Standard Penetration Test (2" OD) | Shelby Tube | Grab Sample

Elevation (ft)	DEPTH (ft)	SAMPLE TYPE	SAMPLE NO	FIELD BLOWS /6"	LAB TESTS	SOIL DESCRIPTION
						Pavement ASPHALTIC CONCRETE (4 inches) OVER BASE ROCK (5 inches).
						Artificial Fill (Qaf) POORLY GRADED SAND (SP); fine sand, gray, moist, medium dense, with wood fragments.
30	5		1	3 8 13	MC	
25						**Sand/Silt Alluvium (Qal)** SILT (ML); trace gravel, nonplastic to low plasticity, no dry strength, slow dilatancy, gray, moist, soft.
	10		2	1 2 2	MC	
20						
	15		3		MD	
15			4	1 2 3	MC FC	SILT WITH SAND (ML); fine sand, nonplastic, gray, moist, medium stiff.
	20		5	2 2 2	MC FC	SILT (ML); trace fine sand, trace clay, nonplastic, gray, wet, soft.
10			6	1 1 2	MC	More clay.
	25		7	1 1 1	MC GSD	
			8	1 2 2	MC	
5			9	1 3 3	MC GSD	More sand, gray-brown, medium stiff to stiff.
	30		10	1 2 9	MC	
0						**Gravel Alluvium (Qfc)** POORLY GRADED GRAVEL WITH SILT AND SAND (GP-GM); fine rounded gravel, fine sand, gray-brown, wet, very dense.
	35		13	29 25 30		Gravel becomes subangular.

Column headings: LITHOLOGY; UNCORRECTED BLOW COUNTS (last 12") 20 40 60 80; WELL

PERCENT FINES 20 40 60 80; PLASTIC M.C. LIQUID 20 40 60 80

ESCSO MUD 2005 2062029.GPJ 2042034-REV1.GPJ 10/10/07

JULY 2015 GRI JOB NO. 5445 FIG. E-114

PARSONS BRINCKERHOFF

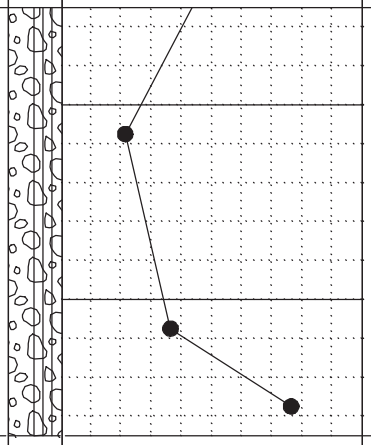
BORING LOG
ES-3043A

Foundation Engineering, Inc.

PROJECT East Side CSO - Outfall 44A | SHEET 2 OF 2 | INITIAL GWL@ Not Available
CITY Portland, Oregon | SURF. EL. 32.8 ft | STA. | OFST. | EQUIPMENT Mobile B-59
PROJECT NO. 2062029 | NORTHING 689977.3 | EASTING 7644641.3 | DRILLING METHOD Mud Rotary
DATE DRILLED 7/3/07 | LOGGED BY JPQ | LOCATION N. River Street | HAMMER WGT. Automatic

SAMPLE TYPE: Ring (3.25" OD) | Standard Penetration Test (2" OD) | Shelby Tube | Grab Sample

Elevation (ft)	DEPTH (ft)	SAMPLE TYPE	SAMPLE NO	FIELD BLOWS /6"	LAB TESTS	PERCENT FINES (20 40 60 80) / PLASTIC M.C. LIQUID (20 40 60 80)	SOIL DESCRIPTION	LITHOLOGY	UNCORRECTED BLOW COUNTS (last 12") (20 40 60 80)	WELL
-5							**Qfc Cont'd** POORLY GRADED GRAVEL WITH SILT AND SAND (GP-GM); fine rounded gravel, fine sand, gray-brown, wet, medium dense. ±30 gallons of drilling mud lost between 40 and 45 feet.			
	40		14	7 8 13						
-10										
	45		15	36 23 13			Sand becomes coarse.			
-15			16	39 40 36			Becomes very dense, subangular gravel.			
							Bottom of boring at 48.5 ft.			
	50									
-20										
	55									
-25										
	60									
-30										
	65									
-35										
	70									
-40										



ESCSO MUD 2005 2062029.GPJ 2042034-REV1.GPJ 10/10/07

JULY 2015 GRI JOB NO. 5445 FIG. E-115

PARSONS BRINCKERHOFF

BORING LOG
ES-3043B

Foundation Engineering, Inc.

PROJECT East Side CSO - Outfall 44A | SHEET 1 OF 1 | INITIAL GWL@ Not Available
CITY Portland, Oregon | SURF. EL. 32.8 ft | STA. | OFST. | EQUIPMENT Mobile B-59
PROJECT NO. 2062029 | NORTHING | EASTING | DRILLING METHOD Mud Rotary
DATE DRILLED 7/3/07 | LOGGED BY JPQ | LOCATION N. River Street | HAMMER WGT. Automatic

SAMPLE TYPE: Ring (3.25" OD) | Standard Penetration Test (2" OD) | Shelby Tube | Grab Sample

Elevation (ft)	DEPTH (ft)	SAMPLE TYPE	SAMPLE NO	FIELD BLOWS /6"	LAB TESTS	PERCENT FINES (20 40 60 80) / PLASTIC M.C. LIQUID (20 40 60 80)	SOIL DESCRIPTION	LITHOLOGY	UNCORRECTED BLOW COUNTS (last 12") (20 40 60 80)	WELL
							Note: Borehole ES-3043B located 5 feet north of ES-3043A and advanced to obtain Samples 11 and 12 missed during drilling and sampling of ES-3043A.			
30										
	5									
25										
	10									
20										
	15									
15										
	20									
10										
	25									
5										
	30									
0			11 12	13 34 14 31 34 38			**Gravel Alluvium (Qfc)** POORLY GRADED GRAVEL WITH SILT AND SAND (GP-GM); fine rounded gravel, fine sand, gray-brown, wet, dense to very dense.			
	35						Bottom of boring at 33.5 ft.			

ESCSO MUD 2005 2062029.GPJ 2042034-REV1.GPJ 10/10/07

PARSONS BRINCKERHOFF

BORING LOG
ES-3046A

Foundation Engineering, Inc.

PROJECT East Side CSO - Outfall 44A | SHEET 1 OF 2 | INITIAL GWL@ Not Available
CITY Portland, Oregon | SURF. EL. 32.2 ft | STA. | OFST. | EQUIPMENT CME 75
PROJECT NO. 2062029 | NORTHING 690290.8 | EASTING 7644330 | DRILLING METHOD Mud Rotary
DATE DRILLED 8/31/07 | LOGGED BY JPQ | LOCATION N. River Street | HAMMER WGT. Automatic

SAMPLE TYPE: Ring (3.25" OD) | Standard Penetration Test (2" OD) | Shelby Tube | Grab Sample

Elevation (ft)	DEPTH (ft)	SAMPLE TYPE	SAMPLE NO	FIELD BLOWS /6"	LAB TESTS	SOIL DESCRIPTION
						Pavement ASPHALTIC CONCRETE (8 inches) OVER BASE ROCK (12 inches).
						Artificial Fill (Qaf) SILT (ML); trace wood fibers, trace fine gravel, non-plastic, gray with some red brown iron staining, moist, soft.
30	5		1	1 2 2	MC	
25	10		2	1 1 2	MC	
20	15		3	2 2 3		Becomes medium stiff. No sample recovery at 15 feet.
15						**Sand Silt Alluvium (Qal)** SILT (ML); trace sand and fine gravel, nonplastic to low plasticity, gray and gray-black, moist to wet, soft, slight organic odor.
	20		4		MD FC	
10			5	1 1 2	MC	
	25		6	1 1 2 2 1 1	MC	
5			7		MC	
			8		MD FC	
	30		9	2 1 1 1 3 19 19 41 32	MC	
0			10		MC	
			11		MC	
	35					**Gravel Alluvium (Qfc)** POORLY GRADED GRAVEL WITH SILT AND SAND (GP-GM); fine rounded gravel, coarse sand, nonplastic fines, gray-brown, very dense.
-5						

PERCENT FINES: 20 40 60 80

PLASTIC M.C. LIQUID: 20 40 60 80

LITHOLOGY

UNCORRECTED BLOW COUNTS (last 12"): 20 40 60 80

WELL

ESCSO MUD 2005 2062029.GPJ 2042034-REV1.GPJ 10/10/07

JULY 2015 GRI JOB NO. 5445 FIG. E-117

PARSONS BRINCKERHOFF

BORING LOG
ES-3046A

Foundation Engineering, Inc.

PROJECT East Side CSO - Outfall 44A | SHEET 2 OF 2 | INITIAL GWL@ Not Available
CITY Portland, Oregon | SURF. EL. 32.2 ft | STA. | OFST. | EQUIPMENT CME 75
PROJECT NO. 2062029 | NORTHING 690290.8 | EASTING 7644330 | DRILLING METHOD Mud Rotary
DATE DRILLED 8/31/07 | LOGGED BY JPQ | LOCATION N. River Street | HAMMER WGT. Automatic

SAMPLE TYPE: Ring (3.25" OD) | Standard Penetration Test (2" OD) | Shelby Tube | Grab Sample

Elevation (ft)	DEPTH (ft)	SAMPLE TYPE	SAMPLE NO	FIELD BLOWS /6"	LAB TESTS	PERCENT FINES (20 40 60 80) / PLASTIC M.C. LIQUID (20 40 60 80)	SOIL DESCRIPTION	LITHOLOGY	UNCORRECTED BLOW COUNTS (last 12") (20 40 60 80)	WELL
							(Qfc Cont'd)			
	40		12	50/6"	MC				50/6"	
-10							±40 gallons of drilling mud lost at 43 feet. Driller reports borehole cave-in below 32 feet.			
	45		13	50/6"	MC				50/6"	
-15										
	50		14	22 33 38	MC					
-20							Bottom of boring at 51.5 ft.			
	55									
-25										
	60									
-30										
	65									
-35										
	70									
-40										

ESCSO MUD 2005 2062029.GPJ 2042034-REV1.GPJ 10/10/07

APPENDIX F – GRI'S APRIL 7, 2015 GEOTECHNICAL DATA REPORT

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9725 SW Beaverton-Hillsdale Hwy, Suite 140
Beaverton, OR 97005-3364
p| 503-641-3478 f| 503-644-8034

April 7, 2015

5445 GEOTECHNICAL DATA RPT

Dalton, Olmsted & Fuglevand, Inc.
10827 NE 68th Street, Suite B
Kirkland, WA 98033

Attention: Paul Fuglevand

SUBJECT: Geotechnical Data Report
River Mile 11E Implementability Study Plan: Geotechnical
Final Supplemental Remedial Investigation/Feasibility Study
East Bank Willamette River between Fremont and Broadway Bridges
Portland, Oregon

GRI has prepared this geotechnical data report for the Implementability Study Plan (ISP) phase of the River Mile 11 East (RM11E) project along the Willamette River in Portland, Oregon. This phase of work is being completed for Cargill, Inc.; CBS Corporation; City of Portland; DIL Trust; Glacier Northwest, Inc.; and PacifiCorp; collectively referred to as the RM11E Group. The ISP is a component of the Supplemental Remedial Investigation and Feasibility Study (RI/FS) Work Plan that provides a detailed description of the work being conducted pursuant to the Statement of Work (SOW) contained in the Administrative Settlement Agreement and Order on Consent (Settlement Agreement, U.S. Environmental Protection Agency [EPA] Region 10, CERCLA Docket No. 10- 2013-0087). This work is supplementary to the RI/FS for the Portland Harbor Superfund Site (PHSS) and is targeted to facilitate selection and design of a final remedy at the RM11E project area.

The primary objective of our work is to assess and address geotechnical and slope stability considerations for the shoreline and offshore areas associated with the remediation alternatives being considered for the RM11E project. Existing conditions, topography, bathymetry, and subsurface conditions vary along the length of the RM11E project area and are being evaluated as part of the study. An inclinometer has been installed in three borings at widely spaced locations to monitor slope movement. This geotechnical data report describes the subsurface conditions encountered in these borings.

SITE AND PROJECT DESCRIPTION

The RM11E project area lies between RM 10.9 and 11.6 along the eastern bank of the Willamette River and includes the Area of Potential Concern (AOPC) 25 (from the draft feasibility study for Portland Harbor) and the riverbank area to the top of the bank. The shoreline area includes numerous dock structures and public and private stormwater outfalls. The upstream end of the project is currently developed with the Cargill/TEMCO grain terminal, and the Sakrete property is located at the downstream end of the project. Available geotechnical information for the area indicates portions of the upland are mantled with up to about 40 ft of uncontrolled fill, including silt, sand, gravel, and construction debris.

Preliminary remediation concepts include a combination of dredging and capping to address contaminated sediments at the site. Constraints associated with active industrial sites, past slope instability, and proposed dredging at the toe of the slope are significant considerations for this project.

GEOLOGY AND TOPOGRAPHY

Available topographic information indicates the ground surface in the project area typically varies from approximately elevation 24 to 38 ft in upland areas and -35 to -60 ft on the bottom of the river channel (NAVD88). Site grades in much of the upland area have historically been raised using undocumented and uncontrolled fill. Below the fill, native soils consist of alluvial silt, sand, and gravel, which are in turn underlain by the Troutdale Formation.

SUBSURFACE CONDITIONS

General

Subsurface materials and conditions at the site were investigated between November 18 and 22, 2013, with three borings, designated E-1, E-2, and E-3. The borings were advanced to depths of 80.2 to 101.5 ft at the locations shown on Figure 2. Boring E-1 was completed in the gravel-covered fenced area on the northern end of the Glacier property. Boring E-2 was completed in a paved area on the Unkeles property, a non-RM 11 Group participant property, located between the Glacier and Cargill properties. Boring E-3 was completed north of the boat dock on the Cargill property. Logs of the borings and a discussion of the field exploration program conducted for this investigation are provided in Appendix A. The terms and symbols used to describe the soils are defined in Table 1A and the attached legend.

Soils

For the purpose of discussion, the materials encountered in the borings have been grouped into the following major units based on their physical characteristics and engineering properties.

1. **PAVEMENT**
2. **FILL**
3. **GRAVEL**
4. **SAND**
5. **SILT**

The following paragraphs provide a detailed description of the soil units and a discussion of the groundwater conditions at the site.

1. PAVEMENT. Asphaltic-concrete pavement was present at the ground surface in borings E-2 and E-3. This asphalt is approximately 2 in. thick.

2. FILL. The project area is occupied by industrial sites on the bank of the Willamette River. A substantial amount of fill has been placed on these sites over numerous years, resulting in highly variable and largely undocumented subsurface materials. These materials generally consist of silty gravel to gravelly silt with a trace to some fine- to coarse-grained sand. Scattered cobbles and construction rubble, such as concrete or bricks, are also common, as is large wood debris. Silt and sand fill with lesser gravel content were also encountered in the borings.

In boring E-1, fill extends from the ground surface to a depth of about 28 ft. Fill was encountered beneath the pavement in borings E-2 and E-3 and extends to depths of about 17.5 and 25.5 ft, respectively. Based on N-values of 0 blows/ft to refusal, i.e., more than 50 blows for 6 in. of sampler penetration, the relative consistency/density of the fill varies significantly across the site. The natural moisture content of the fine-grained fill materials ranges from about 22 to 41%. Atterberg limits testing of a representative sample of silt fill from boring E-3 indicates the soil has a liquid limit of 42% and plasticity index of 17%.

3. GRAVEL. Sandy gravel was encountered beneath the fill in boring E-1 at a depth of 28 ft and extends to the bottom of the boring at a depth of 80.2 ft; the gravel contains a 1-ft-thick layer of silty sand at a depth of about 33.5 ft. Gravel was encountered at a depth of 32 ft in boring E-2 and extends to a depth of 67.5 ft. A second layer of gravel was encountered in boring E-2 between a depth of 82 and 85.4 ft, where the boring was terminated. Gravel was encountered at a depth of 41 ft in boring E-3 and extends to a depth of 70.5 ft. The gravel is generally rounded, fine to coarse, and well graded. The gravel has a variable sand content, ranging from a trace of sand to sandy. Scattered cobbles and up to a trace of silt were also observed in the gravel. Based on N-values of 31 blows/ft to refusal, the relative density of the gravel ranges from dense to very dense and is generally very dense. Drilling observations indicate the gravel likely contains scattered boulders.

4. SAND. A 1-ft-thick layer of sand was encountered at a depth of 33.5 in the sandy gravel in boring E-1. Silty sand was encountered from a depth of 17.5 to 30 ft in boring E-2. The silty sand contains interbedded lenses of silt up to about 6 in. thick. The silty sand and lenses of silt contain scattered organics. A second layer of sand was encountered in boring E-2 between a depth of 67.5 and 82 ft. Sand was encountered at a depth of 70.5 ft in boring E-3 and extends to the bottom of the boring at 101.5 ft. The sand is generally brown to gray, fine grained, and has a silt content that varies from a trace of silt to silty. Based on N-values of 1 to 49 blows/ft, the relative density of the sand varies significantly across the sites, ranging from very loose to dense, and is generally medium dense. The natural moisture content of the sand ranges from about 24 to 41%.

5. SILT. The sand in boring E-2 contains interbedded lenses of silt up to about 6 in. thick between a depth of 17.5 and 30 ft, and a 2-ft-thick layer of clayey silt was encountered in the boring at a depth of about 30 ft. Silt was encountered at a depth of 25.5 ft in boring E-3 and extends to a depth of 41 ft. The silt is generally gray to brown and has a variable content of sand and clay that varies from a trace of sand to sandy and a trace of clay to clayey. Scattered organics are common in the silt unit. Based on N-values of 1 to 21 blows/ft, the relative consistency of the silt ranges from very soft to very stiff and is generally soft to medium stiff. The natural moisture content of the silt ranges from about 37 to 48%. Atterberg limits testing on two representative samples of silt fill from borings E-2 and E-3 indicates the soil has a liquid limit of 59 and 37% and plasticity index of 25 and 9%, respectively.

Groundwater

Groundwater was not directly measured during drilling. Based on our experience in the area, we anticipate groundwater is typically within about 15 to 30 ft of the ground surface and responds to the adjacent Willamette River elevations. In this regard, groundwater levels at the site are typically lowest during the late summer and early fall months.

LIMITATIONS

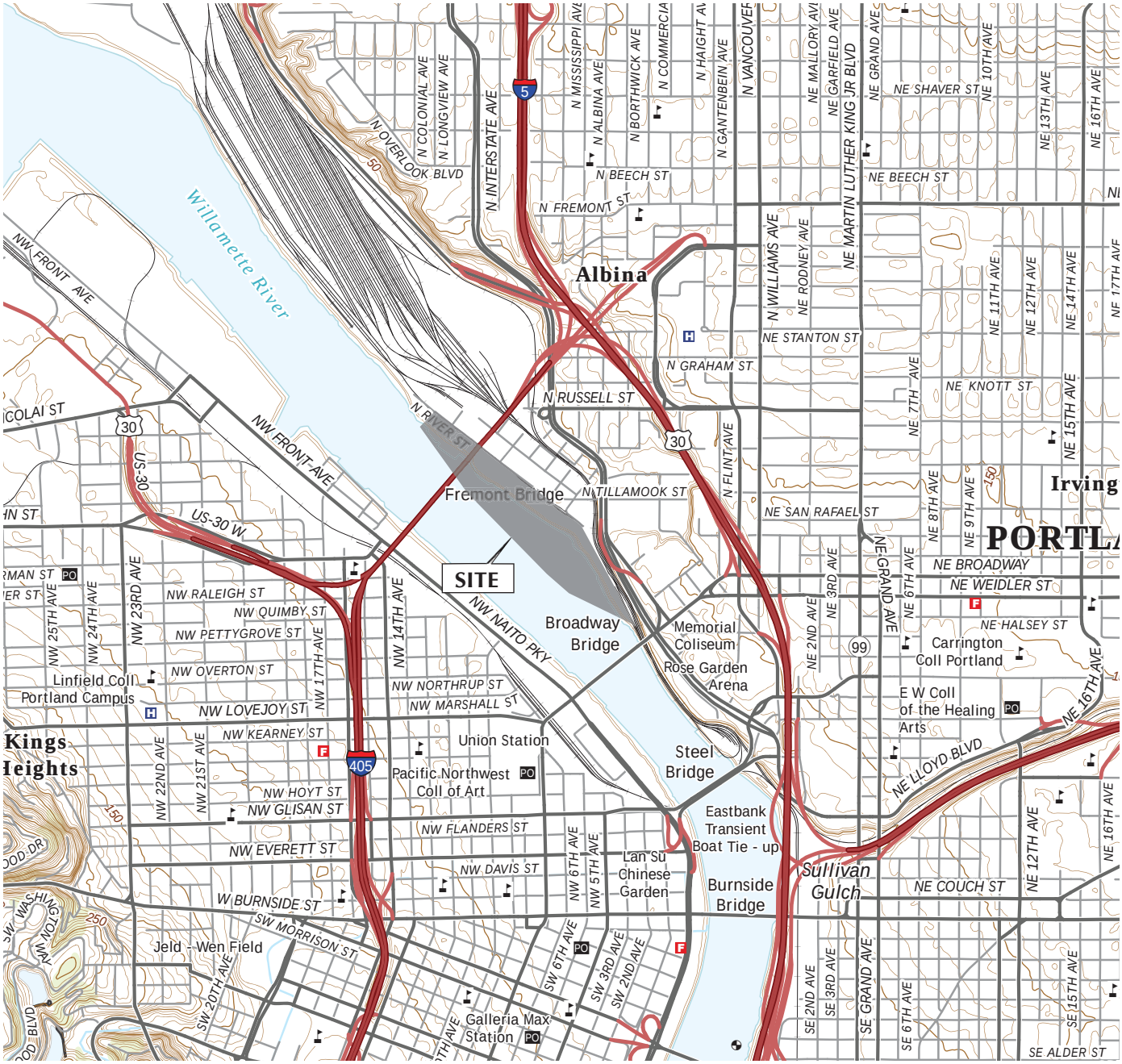
This data report has been prepared to aid the RM11E Group in the evaluation of subsurface materials and conditions in the project area. The scope is limited to the specific project and location described herein, and our description of the project represents our understanding of the significant aspects of the project relevant to the consideration of remediation alternatives.

The data provided in this report were obtained from the subsurface explorations made at the locations indicated on Figure 2 and from other sources of information discussed in this report. The locations of the explorations were coordinated with the RM11E Group. In the performance of subsurface investigations, specific information is obtained at specific locations at specific times. However, it is acknowledged that variations in soil conditions may exist between exploration locations. This report does not reflect any variations that may occur between these explorations.

Submitted for GRI,

Scott M. Schlechter, PE, GE
Principal

Melani M. Banks, PE
Staff Engineer



USGS TOPOGRAPHIC MAP
PORTLAND, OREG. (2014)

North

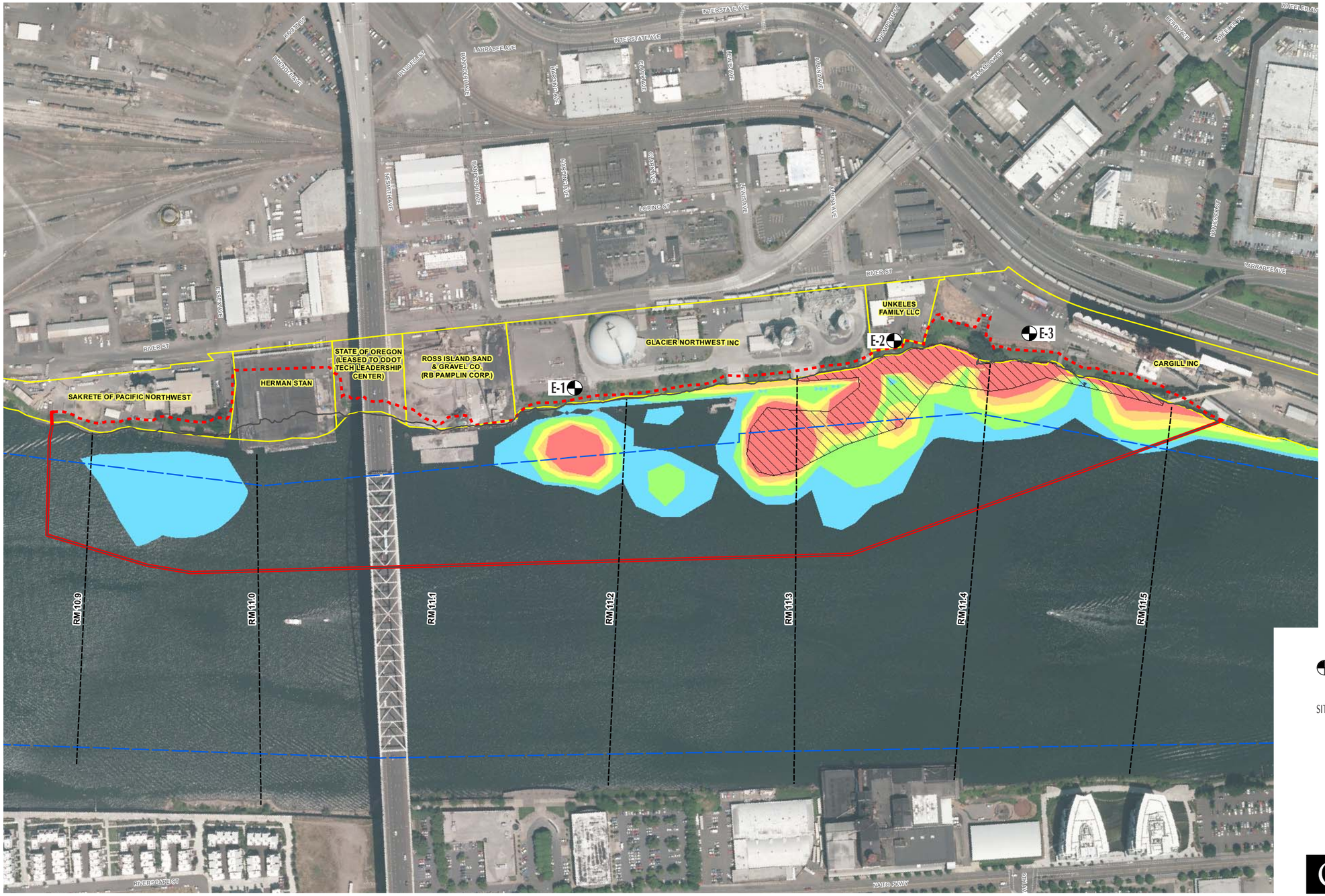
0 1/2 1 MILE

GRI

DALTON, OLMSTED & FUGLEVAND, INC.
RIVER MILE 11 E

VICINITY MAP

APR. 2015 JOB NO. 5445 FIG. 1



LEGEND

- Proposed Boring and Inclinometer

Total PCBs in Surface Sediment

- >1,000 ug/kg
- >750 - 1,000 ug/kg
- >500 - 750 ug/kg
- >200 - 500 ug/kg
- 75 - 200 ug/kg
- Comprehensive Benthic Risk Areas

All Other Features

- RM11E Project Area (dashed line indicates inferred top of bank)
- AOPC 25
- Properties of Interest
- U.S. Army Corps of Engineers Navigation Channel
- River Mile (RM) Tenth

BORING MADE BY GRI (NOVEMBER 19 - 22, 2013)

SITE PLAN FROM FILE BY GSI WATER SOLUTIONS, INC., DATED JUNE 24, 2013

North

0 300 600 FT

GRI DALTON, OLMSTED & FUGLEVAND, INC.
RIVER MILE 11 EAST

SITE PLAN

APR. 2015 JOB NO. 5445 FIG. 2

APPENDIX A

FIELD EXPLORATIONS AND LABORATORY TESTING

FIELD EXPLORATIONS

Subsurface conditions and materials at the site were investigated between November 18 and 22, 2013, with three borings, designated E-1, E-2, and E-3. Boring E-1 was completed in the gravel covered, fenced area on the northern end of the Glacier property. Boring E-2 was completed in a paved area on the Unkeles property, a non-RM 11 Group participant property, located between the Glacier and Cargill properties. Boring E-3 was completed north of the boat dock on the Cargill property. The borings were advanced to depths of 80.2 to 101.5 ft at the locations shown on Figure 2. The borings were drilled using mud-rotary and casing-advance drilling techniques with a truck-mounted drill rig provided and operated by Western States Soil Conservation of Hubbard, Oregon. The field exploration work was coordinated and documented by an experienced geotechnical engineer from GRI, who maintained a detailed log of the materials and conditions disclosed during the course of the work.

Disturbed samples were obtained from the borings at about 2.5- to 10-ft intervals of depth using a standard split-spoon sampler. At the time of sampling, the Standard Penetration Test was conducted. This test consists of driving a standard split-spoon sampler into the soil a distance of 18 in. using a 140-lb hammer dropped 30 in. The number of blows required to drive the sampler the last 12 in. is known as the standard penetration resistance, or N-value. The N-values provide a measure of the relative density of granular soils such as sand, and the relative consistency or stiffness of cohesive soils such as silt. The soil samples obtained in the split-spoon sampler were carefully examined in the field, and representative portions were saved in airtight jars for further examination and physical testing in our laboratory.

Logs of the borings are provided on Figures 1A through 3A. Each log presents a descriptive summary of the various types of material encountered and notes the depth where the materials and/or characteristics of the materials change. To the right of the descriptive summary, the numbers and types of samples taken during the drilling operation are indicated. Farther to the right, N-values are shown graphically, along with the natural moisture contents, percent passing the No. 200 sieve, and Atterberg limits values. The terms used to describe the soils are defined in Table 1A.

Inclinometer casing was installed in each of the borings to permit the measurement of slope movements over time. The annular space between the pipe and borehole was backfilled with a cement and quick gel mix from the bottom of the boring to about 18 in. below the ground surface, and a flush-mount monument was installed to mark and allow access to the pipe. Baseline measurements were obtained on December 4, 2013, and additional measurements were made June 27 and November 12, 2014.

LABORATORY TESTING

General

All samples obtained from the field exploration program were returned to our laboratory for examination and testing. The physical characteristics were noted, and the field classifications were modified where necessary. The laboratory program included determinations of natural moisture content, washed sieve analyses, and Atterberg limits. The following paragraphs describe the testing program in more detail.

Natural Moisture Content

Natural moisture content determinations were made in conformance with ASTM 2216. The results are shown on Figures 1A through 3A.

Grain Size Analysis (Washed Sieve)

Washed sieve analyses were performed on representative samples of the soils to assist in their classification. The test is performed by taking a sample of known dry weight and washing it over a No. 200 sieve. The material retained on the No. 200 sieve is oven-dried and re-weighed, and the percentage of material (by weight) that passed the No. 200 sieve is calculated. The test results are tabulated below and shown on Figures 1A through 3A.

SUMMARY OF GRAIN SIZE ANALYSIS (WASHED SIEVE)

Boring	Sample	Depth, ft	% Passing No. 200 Sieve	Classification
E-2	S-6	17.5	37	Silty SAND
	S-15	80.0	9	SAND; trace silt
E-3	S-10	30.0	90	SILT; trace clay and sand
	S-12	40.0	72	Sandy SILT
	S-18	80.0	17	SAND; some silt

Atterberg Limits

Atterberg limits tests were performed on three representative samples of the fine-grained soil in substantial conformance with ASTM D 4318. The test data are summarized on the Plasticity Chart, Figure 4A, and graphically on Figures 1A through 3A.

Table 1

GUIDELINES FOR CLASSIFICATION OF SOIL

Description of Relative Density for Granular Soil

Relative Density	Standard Penetration Resistance (N-values) blows per foot
very loose	0 - 4
loose	4 - 10
medium dense	10 - 30
dense	30 - 50
very dense	over 50

Description of Consistency for Fine-Grained (Cohesive) Soils

Consistency	Standard Penetration Resistance (N-values) blows per foot	Torvane Undrained Shear Strength, tsf
very soft	2	less than 0.125
soft	2 - 4	0.125 - 0.25
medium stiff	4 - 8	0.25 - 0.50
stiff	8 - 15	0.50 - 1.0
very stiff	15 - 30	1.0 - 2.0
hard	over 30	over 2.0

Sandy silt materials which exhibit general properties of granular soils are given relative density description.

Grain-Size Classification

Boulders
12 - 36 in.

Cobbles
3 - 12 in.

Gravel
1/4 - 3/4 in. (fine)
3/4 - 3 in. (coarse)

Sand
No. 200 - No. 40 sieve (fine)
No. 40 - No. 10 sieve (medium)
No. 10 - No. 4 sieve (coarse)

Silt/Clay - pass No. 200 sieve

Modifier for Subclassification

Adjective	Percentage of Other Material In Total Sample
clean	0 - 2
trace	2 - 10
some	10 - 30
sandy, silty, clayey, etc.	30 - 50

GRI

BORING AND TEST PIT LOG LEGEND

SOIL SYMBOLS

Symbol	Typical Description
	GRAVEL; clean to some silt, clay, and sand
	Sandy GRAVEL; clean to some silt and clay
	Silty GRAVEL; up to some clay and sand
	Clayey GRAVEL; up to some silt and sand
	SAND; clean to some silt, clay, and gravel
	Gravelly SAND; clean to some silt and clay
	Silty SAND; up to some clay and gravel
	Clayey SAND; up to some silt and gravel
	SILT; up to some clay, sand, and gravel
	Gravelly SILT; up to some clay and sand
	Sandy SILT; up to some clay and gravel
	Clayey SILT; up to some sand and gravel
	CLAY; up to some silt, sand, and gravel
	Gravelly CLAY; up to some silt and sand
	Sandy CLAY; up to some silt and gravel
	Silty CLAY; up to some sand and gravel
	PEAT

BEDROCK SYMBOLS

Symbol	Typical Description
	BASALT
	SILTSTONE
	SANDSTONE

SURFACE MATERIAL SYMBOLS

Symbol	Typical Description
	Asphaltic-concrete PAVEMENT
	Portland cement concrete PAVEMENT
	Crushed rock BASE COURSE

SAMPLER SYMBOLS

Symbol	Sampler Description
	2.0-in. O.D. split-spoon sampler and Standard Penetration Test with recovery (ASTM D1586)
	Shelby tube sampler with recovery (ASTM D1587)
	3.0-in. O.D. split-spoon sampler with recovery (ASTM D3550)
	Grab Sample
	Rock core sample interval

INSTALLATION SYMBOLS

Symbol	Symbol Description
	Flush-mount monument set in concrete
	Concrete, well casing shown where applicable
	Bentonite seal, well casing shown where applicable
	Filter pack, machine-slotted well casing shown where applicable
	Grout, vibrating-wire transducer cable shown where applicable
P	Vibrating-wire pressure transducer
	1-in.-diameter solid PVC
	1-in.-diameter hand-slotted PVC
	Grout, inclinometer casing shown where applicable

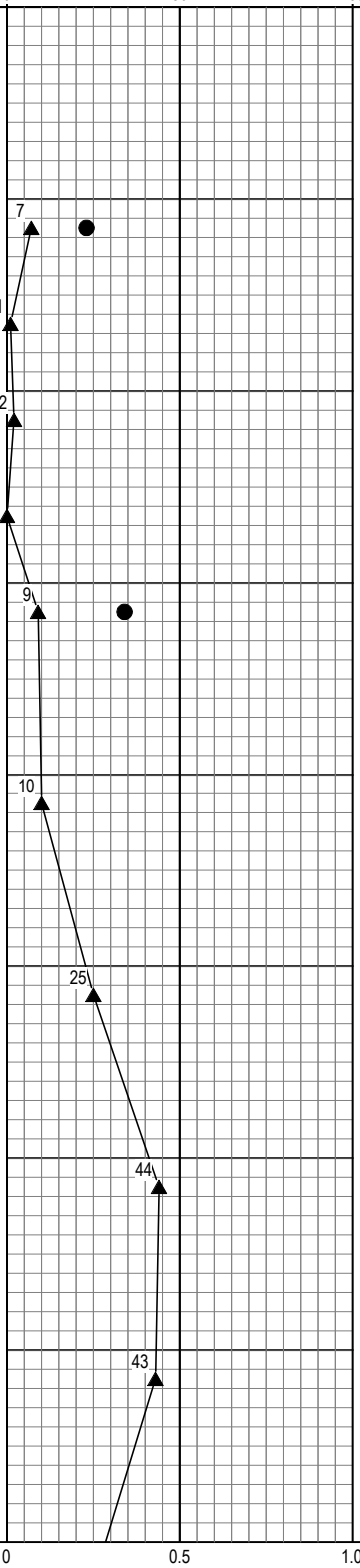
FIELD MEASUREMENTS

Symbol	Typical Description
▽	Groundwater level during drilling and date measured
▼	Groundwater level after drilling and date measured
	Rock core recovery
	Rock quality designation (RQD)

BORING AND TEST PIT LOG LEGEND 5515-APPENDIX A.GPJ GRI DATA TEMPLATE.GDT 12/18/13

GRI

DEPTH, FT	CLASSIFICATION OF MATERIAL **Surface Elevation:** 35.3 ft [±] (NAVD 88)	ELEVATION, FT / DEPTH, FT	SAMPLE NO.	SAMPLE TYPE	BLOW COUNT	COMMENTS AND ADDITIONAL TESTS
	Loose GRAVEL; fine to coarse, rounded to angular, trace silt and sand (gravel road surface)	34.9 / 0.4				
	FILL: Loose, silty GRAVEL; fine to coarse, rounded to angular, some fine- to medium-grained sand to sandy, scattered cobbles and concrete rubble					
5			S-1		4 5 2	
		27.8 / 7.5				Losing circulation
	FILL: Very soft, brown mottled rust and gray, gravelly SILT; some fine-grained sand to sandy, fine rounded gravel		S-2		0 0 1	
10			S-3		0 1 1	
						Mud loss continues
	---scattered gravel below 12.5 ft		S-4		0 0 0	
15	---stiff, trace to some sand below 15 ft		S-5		8 5 4	
						Drill rig chattering, wood in cuttings
20	---gray, contains wood debris below 20 ft		S-6		2 6 4	
25	---very stiff, gravelly below 25 ft		S-7		9 8 17	
						Losing circulation
	Dense, sandy GRAVEL; fine to coarse, rounded, fine- to coarse-grained sand, scattered cobbles	7.3 / 28.0				
30			S-8		20 23 21	
						Advance casings into gravel unit
	Loose to medium dense, brown, silty SAND; fine to coarse grained	1.8 / 33.5 / 0.8 / 34.5				Easy drilling, silty sand cuttings-no sample taken
35	Dense, sandy GRAVEL; fine to coarse, rounded, fine- to coarse-grained sand, scattered cobbles		S-9		23 22 21	
40						



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Logged By: M. Banks	**Drilled by:** Western States Soil Conservation, Inc.
Date Started: 11/21/13	**Coordinates:** Not Available
Drilling Method: Mud Rotary **Equipment:** **Hole Diameter:**	**Hammer Type:** Auto Hammer **Weight:** 140 lb **Drop:** 30 in. **Energy:**
Note: See Legend for Explanation of Symbols	

GRI

BORING E-1

APR. 2015 JOB NO. 5445 FIG. 1A

GRI BORING LOG 5445-APPENDIX A.GPJ GRI DATA TEMPLATE.GDT 1/2/14

DEPTH, FT	GRAPHIC LOG	CLASSIFICATION OF MATERIAL **Surface Elevation:** 35.3 ft [±] (NAVD 88)	ELEVATION, FT / DEPTH, FT	INSTALLATION	SAMPLE NO.	SAMPLE TYPE	BLOW COUNT	COMMENTS AND ADDITIONAL TESTS
		Dense, sandy GRAVEL; fine to coarse, rounded, fine- to coarse-grained sand, scattered cobbles ---medium dense, some sand below 40 ft			S-10		22 14 12	
45								
								Slight mud loss
50		---very dense below 50 ft			S-11		24 50/4"	
55								Full circulation return
60					S-12		50/3"	
65								
70					S-13		50/3"	
75								
80								

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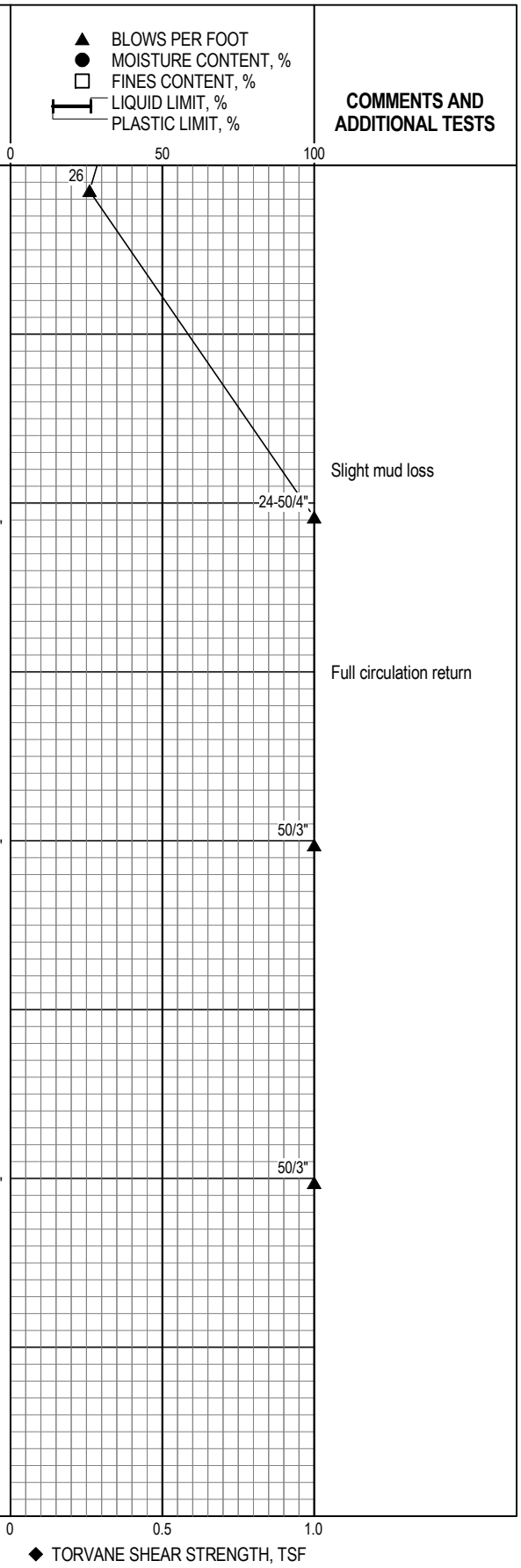


GRI BORING LOG 5445-APPENDIX A.GPJ GRI DATA TEMPLATE.GDT 1/2/14

GRI

BORING E-1

APR. 2015 JOB NO. 5445 FIG. 1A

DEPTH, FT	GRAPHIC LOG	CLASSIFICATION OF MATERIAL **Surface Elevation:** 35.3 ft [±] (NAVD 88)	ELEVATION, FT / DEPTH, FT	INSTALLATION	SAMPLE NO.	SAMPLE TYPE	BLOW COUNT	BLOWS PER FOOT / MOISTURE CONTENT, % / FINES CONTENT, % / LIQUID LIMIT, % / PLASTIC LIMIT, % (0 – 50 – 50/3" 00)	COMMENTS AND ADDITIONAL TESTS
		(11/22/2013)	-44.9 / 80.2		S-14		50/3"		
85									
90									
95									
100									
105									
110									
115									
120									

0 0.5 1.0

◆ TORVANE SHEAR STRENGTH, TSF

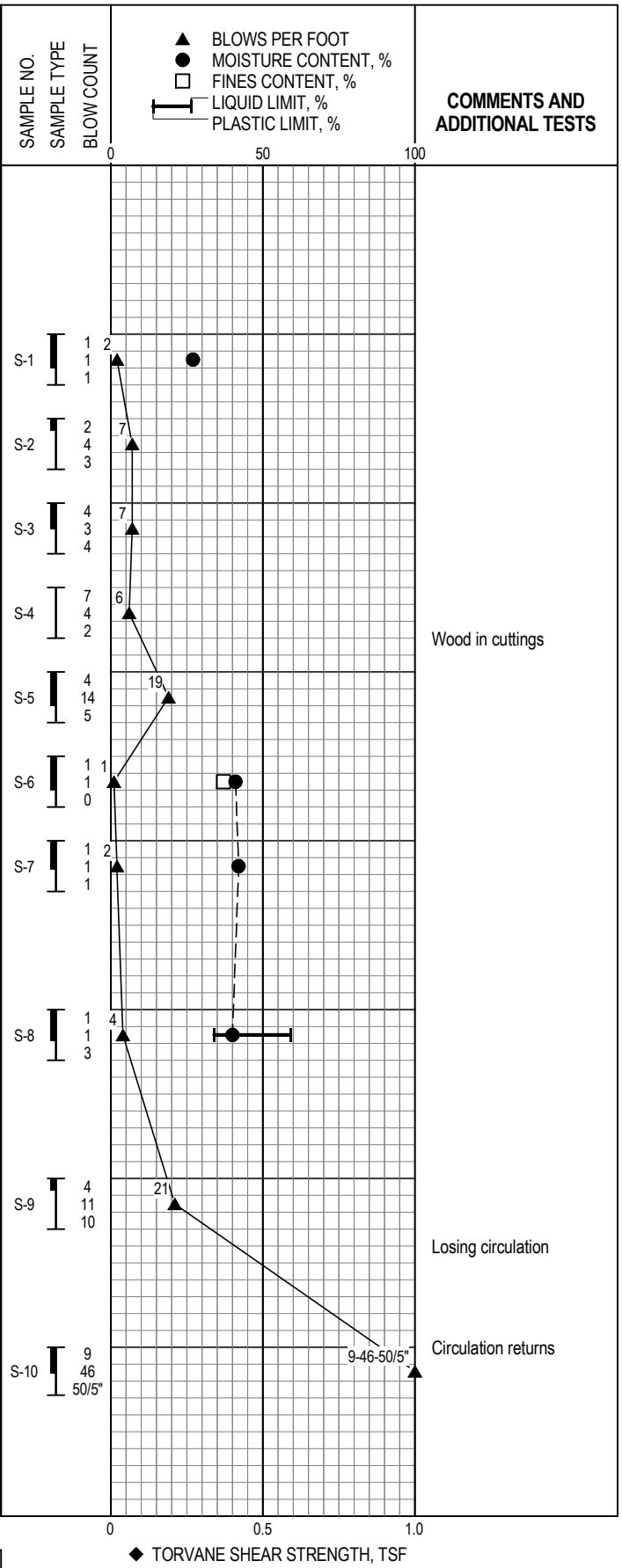
GRI BORING LOG 5445-APPENDIX A.GPJ GRI DATA TEMPLATE.GDT 1/2/14

GRI

BORING E-1

APR. 2015 JOB NO. 5445 FIG. 1A

DEPTH, FT	CLASSIFICATION OF MATERIAL **Surface Elevation:** 24.8 ft [±] (NAVD 88)	ELEVATION, FT / DEPTH, FT	INSTALLATION	SAMPLE NO.	SAMPLE TYPE	BLOW COUNT	COMMENTS AND ADDITIONAL TESTS
	Asphaltic-concrete PAVEMENT (2 in.)	24.6 / 0.2					
	FILL: Loose to medium dense, silty GRAVEL; fine to coarse, rounded to angular, some fine- to coarse-grained sand, scattered wood debris, cobbles, and construction rubble	20.3 / 4.5					
5	FILL: Soft, brown SILT; some fine- to coarse-grained sand, trace clay, scattered fine angular gravel	16.8 / 8.0		S-1		1 1 1	
	FILL: Loose, dark brown, silty GRAVEL; fine, rounded to subangular, some fine- to coarse-grained sand			S-2		2 4 3	
10				S-3		4 3 4	
				S-4		7 4 2	Wood in cuttings
15	---dark gray, contains wood debris below 15 ft	7.3 / 17.5		S-5		4 14 5	
	Very loose to loose, gray, silty SAND; fine grained, scattered organics, up to 6-in.-thick interbeds of soft, gray silt with trace to some fine-grained sand, trace clay, and scattered organics			S-6		1 1 0	
20	---scattered fine gravel at 20 ft, scattered wood debris below 20 ft			S-7		1 1 1	
25				S-8		1 1 3	
30	Very stiff, blue-gray, clayey SILT; scattered gravel and organics	-5.2 / 30.0		S-9		4 11 10	Losing circulation
	Very dense GRAVEL; fine to coarse, rounded, trace fine- to coarse-grained sand, scattered cobbles	-7.2 / 32.0					
35				S-10		9 46 50/5"	Circulation returns
40							



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Logged By: M. Banks	**Drilled by:** Western States Soil Conservation, Inc.
Date Started: 11/20/13	**Coordinates:** Not Available
Drilling Method: Mud Rotary **Equipment:** **Hole Diameter:**	**Hammer Type:** Auto Hammer **Weight:** 140 lb **Drop:** 30 in. **Energy:**
Note: See Legend for Explanation of Symbols	

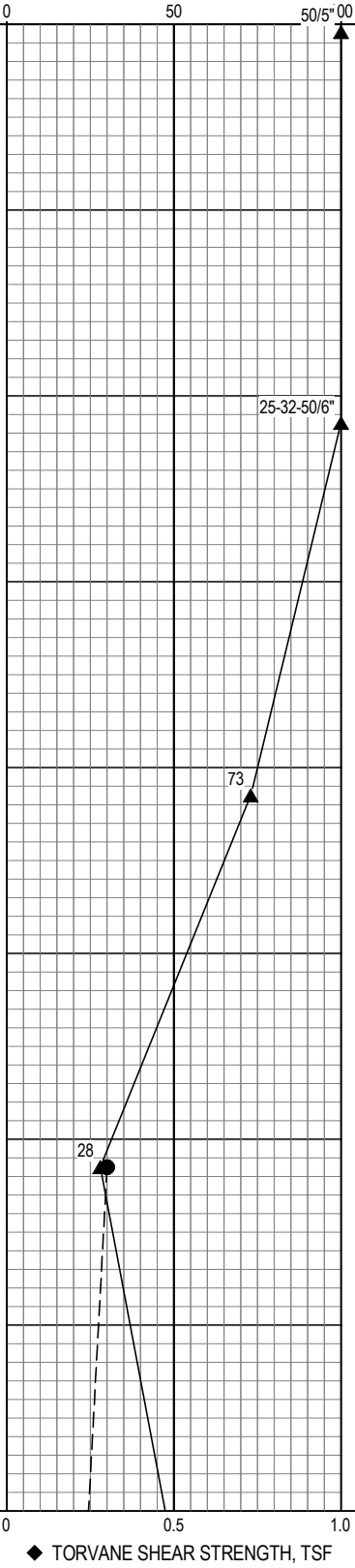
GRI

BORING E-2

APR. 2015 JOB NO. 5445 FIG. 2A

GRI BORING LOG 5445-APPENDIX A.GPJ GRI DATA TEMPLATE.GDT 1/2/14

DEPTH, FT	GRAPHIC LOG	CLASSIFICATION OF MATERIAL **Surface Elevation:** 24.8 ft [±] (NAVD 88)	ELEVATION, FT / DEPTH, FT	INSTALLATION	SAMPLE NO.	SAMPLE TYPE	BLOW COUNT	COMMENTS AND ADDITIONAL TESTS
		Very dense GRAVEL; fine to coarse, rounded, trace fine- to coarse-grained sand, scattered cobbles			S-11		50/5"	
45								
50					S-12		25 32 50/6"	
55								
60		---sandy below 60 ft			S-13		33 32 41	
65								Slight cementation below 65 ft
		Medium dense, brown SAND; fine grained, trace silt	-42.7 / 67.5					
70					S-14		13 14 14	
75								
80								



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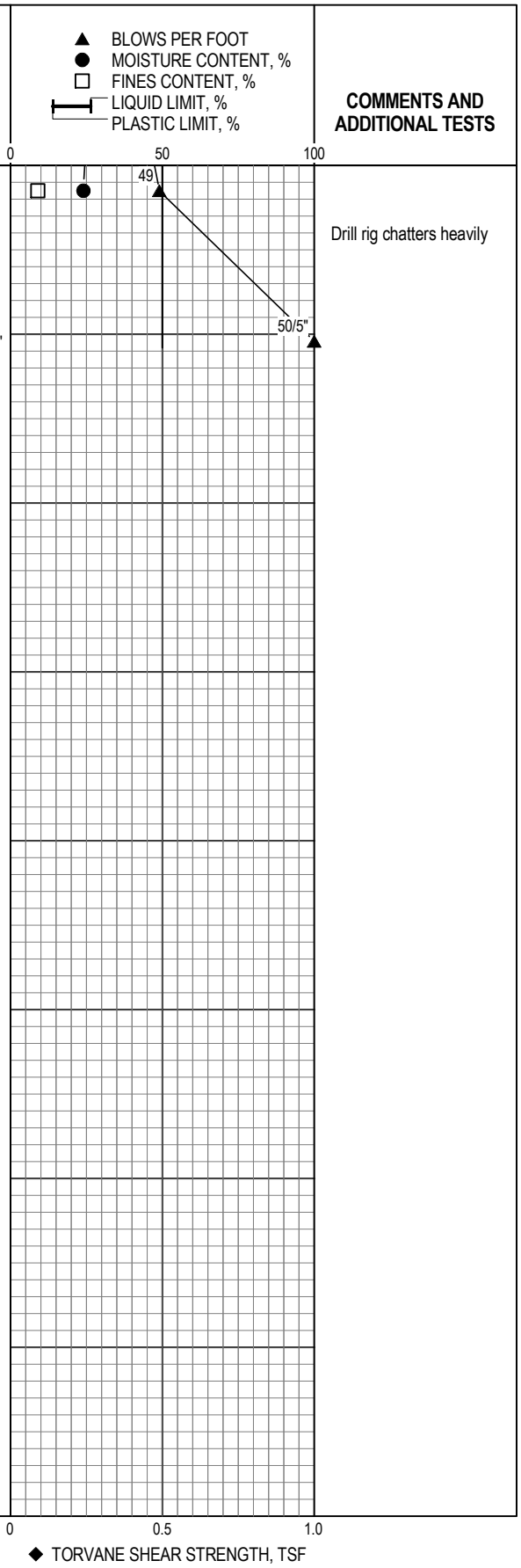
GRI BORING LOG 5445-APPENDIX A.GPJ GRI DATA TEMPLATE.GDT 1/2/14

GRI

BORING E-2

APR. 2015 JOB NO. 5445 FIG. 2A

DEPTH, FT	GRAPHIC LOG	CLASSIFICATION OF MATERIAL **Surface Elevation:** 24.8 ft [±] (NAVD 88)	ELEVATION, FT / DEPTH, FT	INSTALLATION	SAMPLE NO.	SAMPLE TYPE	BLOW COUNT	COMMENTS AND ADDITIONAL TESTS
		Medium dense, brown SAND; fine grained, trace silt ---dense, fine- to medium-grained, trace to some silt below 80 ft	-57.2 / 82.0		S-15		19 25 24	Drill rig chatters heavily
		Very dense GRAVEL; fine to coarse, rounded, some fine- to coarse-grained sand						
85		(11/21/2013)	-60.6 / 85.4		S-16		50/5"	
90								
95								
100								
105								
110								
115								
120								



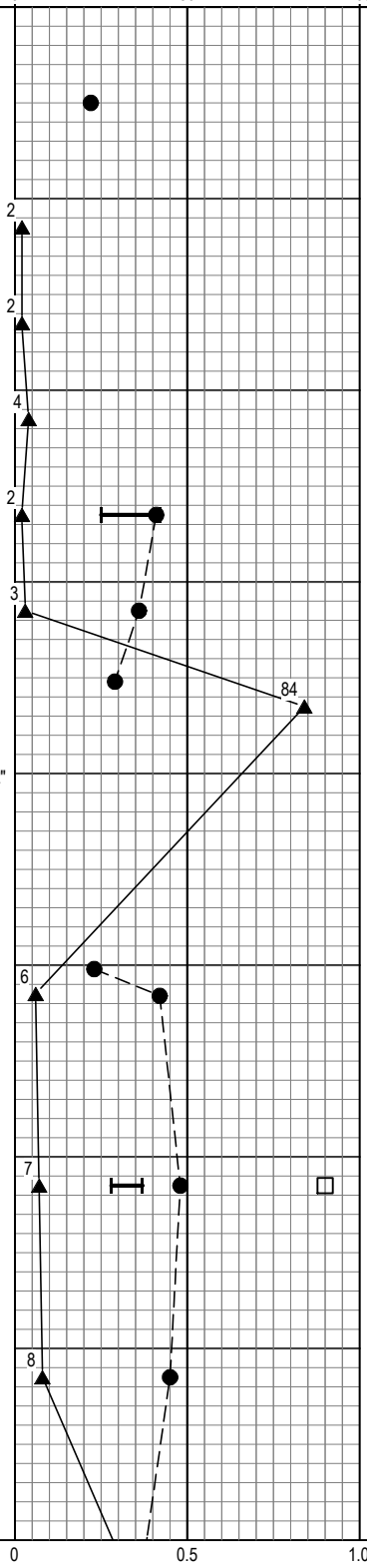
GRI BORING LOG 5445-APPENDIX A.GPJ GRI DATA TEMPLATE.GDT 1/2/14

GRI

BORING E-2

APR. 2015 JOB NO. 5445 FIG. 2A

DEPTH, FT	CLASSIFICATION OF MATERIAL **Surface Elevation:** 36.2 ft [±] (NAVD 88)	ELEVATION, FT / DEPTH, FT	SAMPLE NO.	SAMPLE TYPE	BLOW COUNT	COMMENTS AND ADDITIONAL TESTS
	Asphaltic-concrete PAVEMENT (2 in.)	36.0 / 0.2				
	FILL: Loose to medium dense, silty GRAVEL; fine to coarse, rounded to angular, some fine- to coarse-grained sand, scattered cobbles and construction rubble		S-1			
5	FILL: Soft, brown SILT; trace to some fine-grained sand and fine rounded gravel, trace clay	31.2 / 5.0	S-2		2 1 1	
			S-3		0 1 1	
10	---gray below 10 ft		S-4		12 2 2	Losing circulation
	---trace to some clay, scattered wood debris and construction rubble below 12.5 ft		S-5		0 1 1	
15			S-6		0 1 2	
	FILL: Very dense GRAVEL; fine, rounded, some fine-grained sand and silt	18.2 / 18.0	S-7		37 34 50	
20			S-8		50/2"	Full mud loss
	FILL: Medium dense, gray mottled brown SAND; fine to medium grained, trace to some silt, scattered wood debris and fine gravel	13.2 / 23.0				
25	Medium stiff, gray SILT; trace clay and fine-grained sand, scattered fine organics	10.7 / 25.5	S-9		5 2 4	
30			S-10		2 3 4	
35	---brown, some sand to sandy below 36 ft		S-11		2 4 4	
40						



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Logged By: M. Banks	**Drilled by:** Western States Soil Conservation, Inc.
Date Started: 11/18/13	**Coordinates:** Not Available
Drilling Method: Mud Rotary **Equipment:** **Hole Diameter:**	**Hammer Type:** Auto Hammer **Weight:** 140 lb **Drop:** 30 in. **Energy:**
Note: See Legend for Explanation of Symbols	

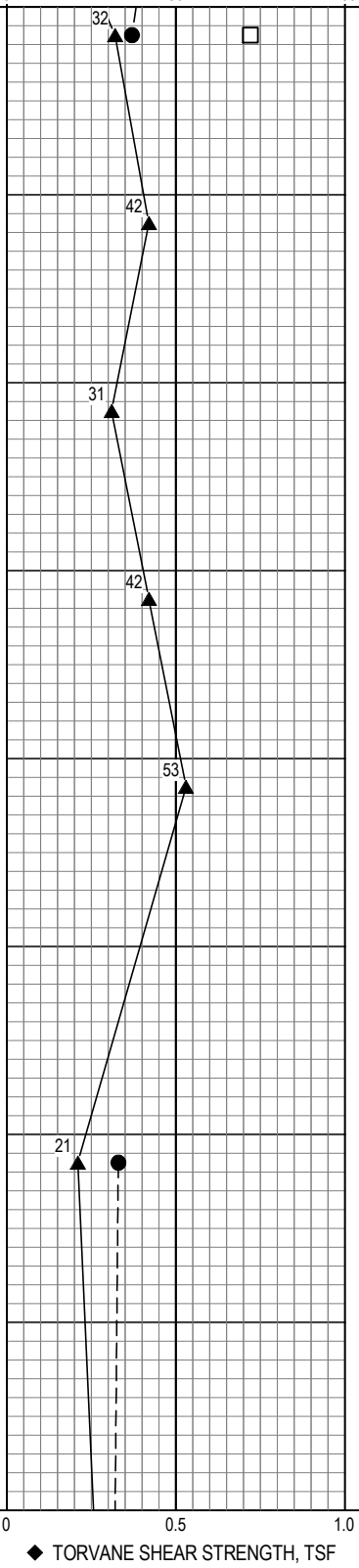
GRI

BORING E-3

APR. 2015 JOB NO. 5445 FIG. 3A

GRI BORING LOG 5445-APPENDIX A.GPJ GRI DATA TEMPLATE.GDT 1/2/14

DEPTH, FT	GRAPHIC LOG	CLASSIFICATION OF MATERIAL **Surface Elevation:** 36.2 ft [±] (NAVD 88)	ELEVATION, FT / DEPTH, FT	INSTALLATION	SAMPLE NO.	SAMPLE TYPE	BLOW COUNT	COMMENTS AND ADDITIONAL TESTS
		Dense GRAVEL; fine to coarse, rounded, some fine- to coarse-grained sand, trace silt, scattered cobbles	-4.8 / 41.0		S-12		2 6 26	Advance casings to 40 ft
45					S-13		18 17 25	
50					S-14		15 15 16	
55					S-15		22 18 24	
60					S-16		33 24 29	
65								
70		Medium dense, brown SAND; fine grained, trace to some silt	-34.3 / 70.5		S-17		16 10 11	
75								
80								



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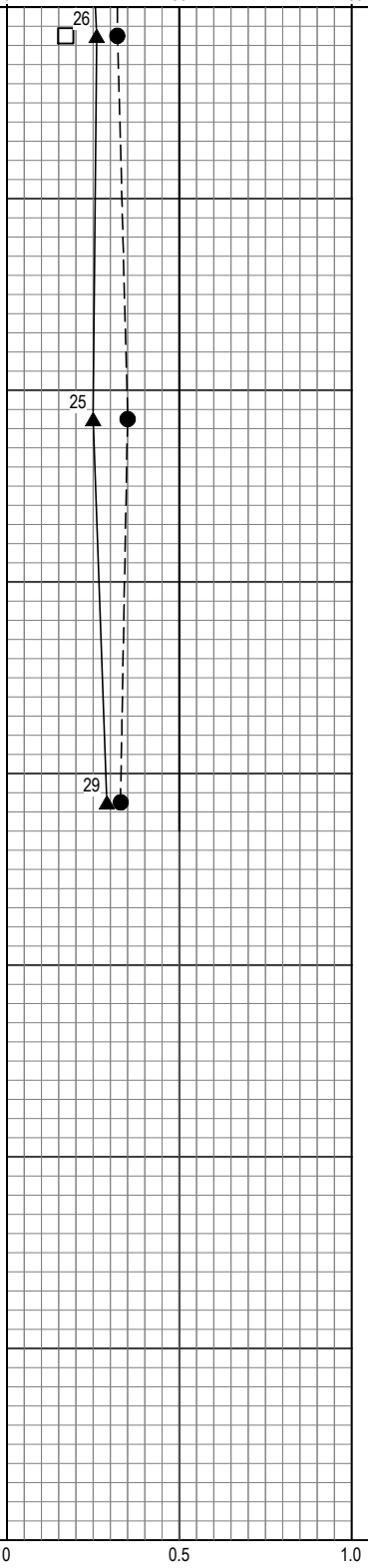
GRI BORING LOG 5445-APPENDIX A.GPJ GRI DATA TEMPLATE.GDT 1/2/14

GRI

BORING E-3

APR. 2015 JOB NO. 5445 FIG. 3A

DEPTH, FT	GRAPHIC LOG	CLASSIFICATION OF MATERIAL **Surface Elevation:** 36.2 ft [±] (NAVD 88)	ELEVATION, FT / DEPTH, FT	INSTALLATION	SAMPLE NO.	SAMPLE TYPE	BLOW COUNT	COMMENTS AND ADDITIONAL TESTS
		Medium dense, brown SAND; fine grained, trace to some silt			S-18		10 13 13	
85								
90					S-19		8 10 15	
95								
100			-65.3 / 101.5		S-20		13 13 16	
		(11/19/2013)						
105								
110								
115								
120								



GRI BORING LOG 5445-APPENDIX A.GPJ GRI DATA TEMPLATE.GDT 1/2/14

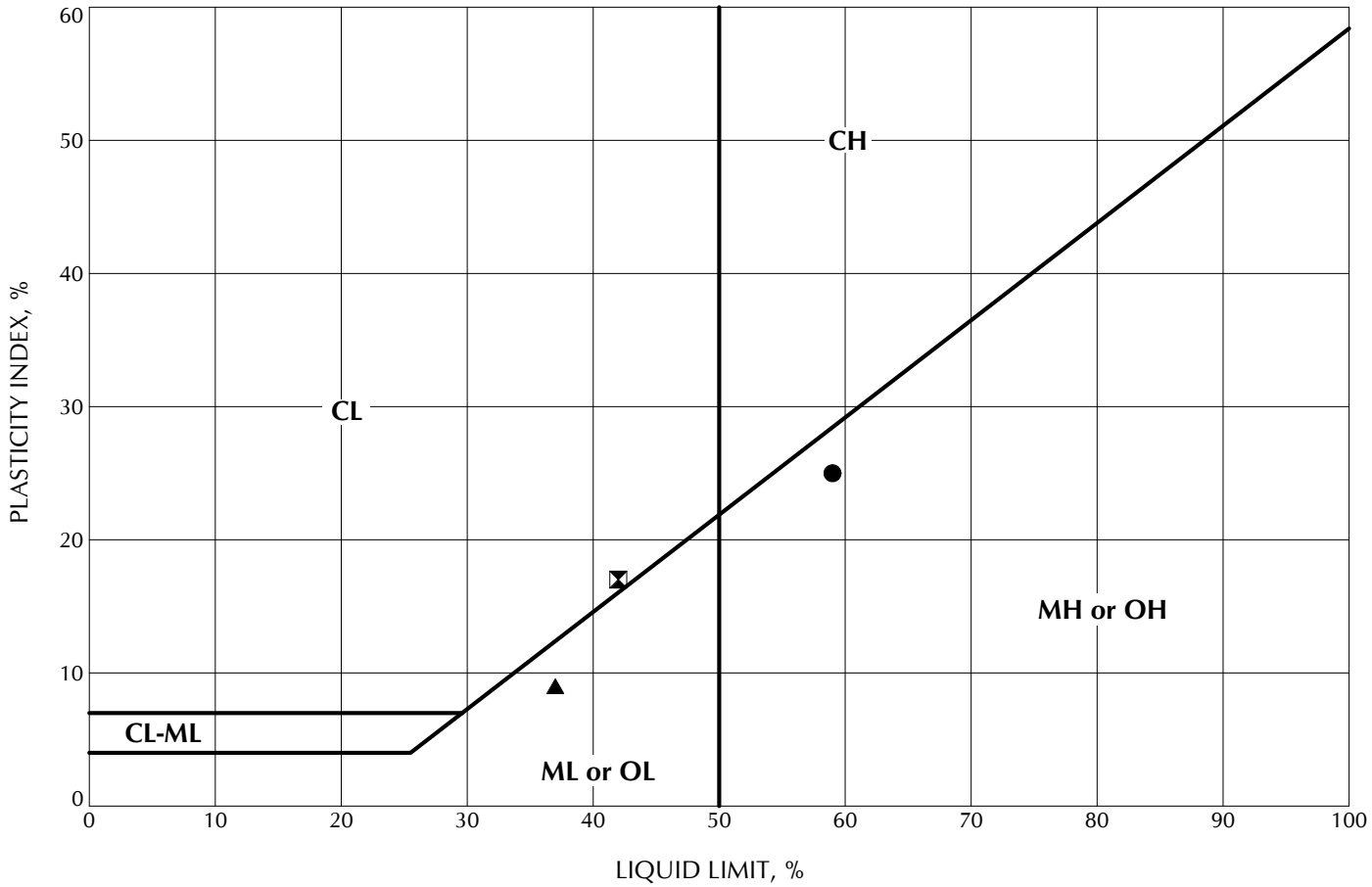
GRI

BORING E-3

APR. 2015 JOB NO. 5445 FIG. 3A

GROUP SYMBOL	UNIFIED SOIL CLASSIFICATION FINE-GRAINED SOIL GROUPS
OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
ML	INORGANIC CLAYEY SILTS TO VERY FINE SANDS OF SLIGHT PLASTICITY
CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY

GROUP SYMBOL	UNIFIED SOIL CLASSIFICATION FINE-GRAINED SOIL GROUPS
OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
MH	INORGANIC SILTS AND CLAYEY SILT
CH	INORGANIC CLAYS OF HIGH PLASTICITY



	Location	Sample	Depth, ft	Classification	LL	PL	PI	MC, %
●	E-2	S-8	25.0	Gray SILT; trace to some fine-grained sand, trace clay, scattered organics	59	34	25	40
⊠	E-3	S-5	12.5	FILL: Gray SILT; trace to some clay, trace fine-grained sand and fine gravel, scattered construction rubble and wood debris	42	25	17	41
▲	E-3	S-10	30.0	Gray SILT; trace fine-grained sand, scattered fine organics	37	28	9	48

ATTERBERG-PLASTICITY 3 PER PAGE 5445-APPENDIX A.GPJ GRI DATA TEMPLATE.GDT 1/2/14

GRI

PLASTICITY CHART

APR. 2015 JOB NO. 5445 FIG. 4A