PORT OF ALASKA MODERNIZATION PROGRAM

Cargo Terminals - Terminal 1 and Terminal 2 Report on Analyses of Marine Construction Alternatives

July 2022

Prepared for

Port of Alaska

Executive Summary

ES.1 Introduction

The Municipality of Anchorage owns and operates the Port of Alaska (POA). Redundancy is the first line of defense for most ports, but Alaska's population is too small to economically support enough redundant inbound marine cargo capacity to maintain the flow of goods into the POA if Anchorage is forced to shut down due to rapidly deteriorating conditions and seismic event vulnerability. Alaska warehouses very little food, and the state only has about a 1-week food supply if the POA is not operational (POA 2020).

Annually, the POA serves 90 percent (%) of the states' population, including some 75% of all inbound, non-fuel cargo, such as food, consumer goods, building materials, cars, cement, and other goods Alaskans need and use every day to live, work, and thrive. The POA also supports approximately 19,000 active-duty personnel and their dependents in Alaska, with most provisions consumed at Alaska's military bases passing through the port.

The Port of Alaska Modernization Program (PAMP) was developed to replace existing facilities at the POA and restore redundancy and security to Alaska's supply chain of food, fuel, and vital consumer goods. New Terminal 1 (T1) and new Terminal 2 (T2) are the primary components of Phase 2 of the PAMP. This report on Analyses of Marine Construction Alternatives for Cargo Terminals 1 and 2 documents the evaluation process and rationale used in selecting the recommended foundation systems and methods of construction.

ES.2 Project Objectives

The project includes construction of T1 and T2, planned new wharfs and trestles at the POA. The two new terminals will be located 140 feet seaward of the existing terminal structures. T1 will be accessed over two 35-foot-wide trestles, and T2 will be accessed by two 35-foot-wide trestles and one 55-foot-wide trestle.

The Port of Alaska Modernization Program (PAMP)'s primary goal is to deliver replacement terminals for the POA, and this report was prepared to evaluate preliminary engineering concepts and identify methods to construct the foundations and substructure systems in order to minimize adverse impacts to marine mammals, particularly the highly endangered Cook Inlet Beluga Whale.

ES.3 Alternative Analysis

The strategy for the alternative analysis implemented by the PAMP project team included multiple stages of development, evaluation, and narrowing of selected foundation alternatives by a multidisciplinary team.

At the initial level of development, non-pile driving alternatives were evaluated as potentially suitable foundation types in order to minimize hydroacoustic impacts to marine mammals. Gravity-based structures were previously analyzed in a 2013 report completed for the U.S. Army Corps of Engineers (CH2M 2013a). Its findings documented concerns with gravity-based structures and the extreme cost with providing soil stabilization techniques. This analysis is also applicable to other gravity wall systems, such as coffer dams or caissons. This led the team to evaluate an array of pile supported foundation types listed in this report along with the criteria for evaluating each alternative.

Alternatives were evaluated by considering the following five key metrics:

- Permanent piling
- Temporary piling
- Beluga takes
- Constructability
- Cost

Permanent and temporary piling considerations included diameter of piling and number of pilings. A key objective was to minimize the total number of piles in order to minimize adverse impacts to marine mammals. In addition, Environmental conditions at the POA in relation to seismic conditions and the requirement to be operational within 7–10 days after a seismic event drove the piling diameter size.

Beluga takes were considered by minimizing the number of piling required to be installed, pile driving duration, and construability.

Constructability was measured as high, medium, or low based on known construction techniques and the challenges that each alternative presents to construction, including length of construction schedules.

Costs were also considered in comparing alternatives, which is why gravity-based systems were not represented in the final comparison table.

The team considered the following five pile supported conceptual engineering alternatives:

- Alternative 1A: 48-inch-diameter Driven piles
- Alternative 1B: Composite Helical Piles
- Alternative 2A: 72-inch-diameter Driven Piles
- Alternative 2B: 72-inch-diameter Drilled Shafts
- Alternative 3: Prefabricated Jacketed System

Section 4.6 details Alternative 1B: Composite Helical Piles; however, this alternative is not carried through for comparison of costs and recommendations. Helical piles of the size required to withstand the environmental loading conditions of the POA are unproven at this scale and would represent significant risks to the program. Powerful specialized equipment would need to be developed for use with larger Helical piles, transported to Anchorage, and used to install the piling. Longer construction times would result, which would represent an increase in the potential for beluga whale takes and overall cost would increase. In addition, there are limited examples of industry practices, in using Helical piles of this size since the current maximum size is 24 inches, which if used an increase in piling would be required to support T1 and T2.

ES.4 Recommended Foundation System

Based on the application of the criteria, the team identified Alternative 2A: 72-inch-diameter Driven Piles as the preferred alternative. This system has less total piling than Alternative 1A: 48-inch-diameter driven and Alternative 2B: 72-inch-diameter drilled shafts. Fewer piles require shorter construction duration and fewer beluga takes.

Table ES-1. Alternatives Comparison Table

Alternative	Description	Perm. Piling (No.)	Temp. Piling (No.)	Beluga Takes (No.)	Construction Duration (years)	Constructability (High, Medium, or Low)	Cost
48-inch-diameter Driven	WH1a + TR1a: Wharf: 20-foot span with 48-inch-diameter driven pile Trestle: 20- to 40-foot span with 48-inch-diameter driven pile	752	560	1,171	7	**High** • Conventional installation methods proven successful on the PCT • Pile lengths can be driven with conventional equipment	$948,820,000
72-inch-diameter Driven	WH2a + TR2a: Wharf: 27- to 40-foot span with 72-inch-diameter driven pile Trestle: 60-foot span with 72-inch-diameter driven pile	281	560	969	5	**High** • Conventional installation methods proven successful on the PCT • Pile lengths can be driven with conventional equipment	$757,190,000
72-inch-diameter Drilled	WH2b + TR2b: Wharf: 27- to 40-foot span with 72-inch-diameter drilled shaft Trestle: 60-foot span with 72-inch-diameter drilled shaft	281	924	4,753	6	**Low** • Drilled shaft lengths required for T1 and T2 are beyond the limits of normal construction • Crane boom length may not be obtainable • Shaft installation is slower, leading to longer construction times • Requires significant additional temporary piling to support the drill rig	$830,900,000
Modular	WH3a + TR2a: Wharf: Prefabricated jacket with 60-inch-diameter driven pile Trestle: 60-foot span with 72-inch-diameter driven pile	171 x 60-inch + 73 x 72-inch for trestle approaches	353	711	4	**Medium** • Shortens duration of construction by placing large modules on the sea floor • Modules act as driving templates and work platforms • Requires specialized on-land fabrication facilities • Requires special equipment for module delivery and lifting into place • Not a conventional or common port foundation type • HLVs are required for construction and are only available internationally, which would require an unlikely waiver of the Jones Act	$1,315,010,000

HLV = heavy-lift vessel
No. = number
Perm. = permanent
PCT = Petroleum and Cement Terminal
Temp. = temporary

In evaluating these four alternatives in context of the five key evaluation metrics identified, the 72-inch driven pile alternative was determined to be the best structural foundation solution for T1 and T2 and is recommended to be advanced for more detailed design.

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Acronyms and Abbreviations

%	percent
AACE	AACE International
ABC	air bubble curtain
AdBm	AdBm Technologies, LLC
APE	American Pile Driving Equipment
ASCE	American Society of Civil Engineers
BBC	big bubble curtain
BCF	Bootlegger Cove Formation
Caltrans	California Department of Transportation
CH2M	CH2M HILL Engineers, Inc.
CIP	cast-in-place
CLE	contingency level earthquake
cSEL	cumulative sound exposure level
dB	decibel(s)
DE	design earthquake
EL.	elevation
ESA	Endangered Species Act
g	gravity
GAC	Geotechnical Advisory Commission
GFo	older glaciofluvial sand and gravel
H	horizontal
HLV	heavy-lift vessel
HSD	hydro-sound damper
Hz	hertz (frequency)
LO/LO	lift-on and lift-off
Malcolm	Malcolm Foundations
MCE	maximum considered earthquake
MLLW	mean lower low water
MMPA	Marine Mammal Protection Act
MT	metric ton(s)
NAS	noise attenuation system
NMFS	National Marine Fisheries Service
NMS	Noise Mitigation System
No.	number

o.c.	on center
OffNoise	OffNoise-Solutions GmbH
OLE	operational level earthquake
PAMP	Port of Alaska Modernization Program
PCT	Petroleum and Cement Terminal
PDA	pile dynamic analyzer
PGA	peak ground acceleration
PIEP	Port Intermodal Expansion Project
POA	Port of Alaska
POL	petroleum, oil, and lubricants
POLA	Port of Los Angeles
psf	pound(s) per square foot
psi	pound(s) per square inch
RO/RO	roll-on and roll-off
SC	silts and clays
SDM	Seismic Design Manual
SEL	sound exposure level
T1	Terminal 1
T2	Terminal 2
T3	Terminal 3
TOTE	Totem Ocean Trailer Express
TS	tidal silts and sands
USACE	U.S. Army Corps of Engineers
U.S.C.	United States Code
V	vertical
WSDOT	Washington State Department of Transportation

Section 1. Introduction

The Port of Alaska (POA), owned and operated by the Municipality of Anchorage, is modernizing its terminals. Modernization is needed to address age-related concerns with the existing facilities. These existing terminals were constructed in the 1960s, 1970s, and 1990s. In addition to terminal aging, understanding of the potential for earthquakes in southwest and interior Alaska has changed significantly since the existing structures were designed and constructed, leaving the current terminals vulnerable to a large seismic event (R&M 2014).

The POA serves 90 percent (%) of the states' population, including 75% of non-fuel cargo items such as food, consumer goods, building materials, cars, cement, and other goods critical for Alaskans every day requirements.

The POA also supports major troop deployments from Alaska bases via rail, road, and air connections, and most of the provisions consumed at Alaska's large military bases pass through the POA, supporting approximately 19,000 active-duty personnel and 26,000 dependents in Alaska. The POA provides high economic value to the military by supporting routine base operations and maintaining capability to support urgent, short-notice, troop and equipment deployments during times of crisis, saving the U.S. Department of Defense millions of dollars in avoided construction and maintenance for its own port facilities.

The POA serves as an essential import center to south central, interior, and western Alaska for most consumer goods delivery, including cement and petroleum products, and therefore the seismic vulnerability of the marine terminals is a critical regional and statewide consideration. Replacement of the Petroleum, Oil, and Lubricant Terminal 1 with the Petroleum and Cement Terminal (PCT) in 2018 to 2022 was the first step in improving the resiliency of the POA. The next step involves replacing the POA general-purpose cargo terminals with Terminal 1 (T1) and Terminal 2 (T2). The cargo terminal support not only the two container shipping operations based at POA, but also the military operations listed above and cruise vessels that call in Anchorage. This report documents the process and rationale for selection of the recommended foundation systems for T1 and T2. Sections 1.1 and Section 2 summarize conditions and considerations required for designing and constructing T1 and T2.

1.1 Development Plans for Terminals 1 and 2

Previous studies conducted by CH2M HILL Engineers, Inc. (CH2M) (CH2M 2021a) for the POA have identified the preferred configuration and location of the new terminals, as shown on Figure 1-1. The two new terminals are located 140 feet seaward of the existing terminal structures. This seaward location reduces sedimentation issues for the wharves, improves handling of berthing ships, and allows construction of the new terminals while the existing terminals remain in use. T1 will be a multi-use terminal with supporting military operations, cruise ships, and lift-on and lift-off (LO/LO) terminal capability, and T2 will be a roll-on and roll-off (RO/RO) terminal.

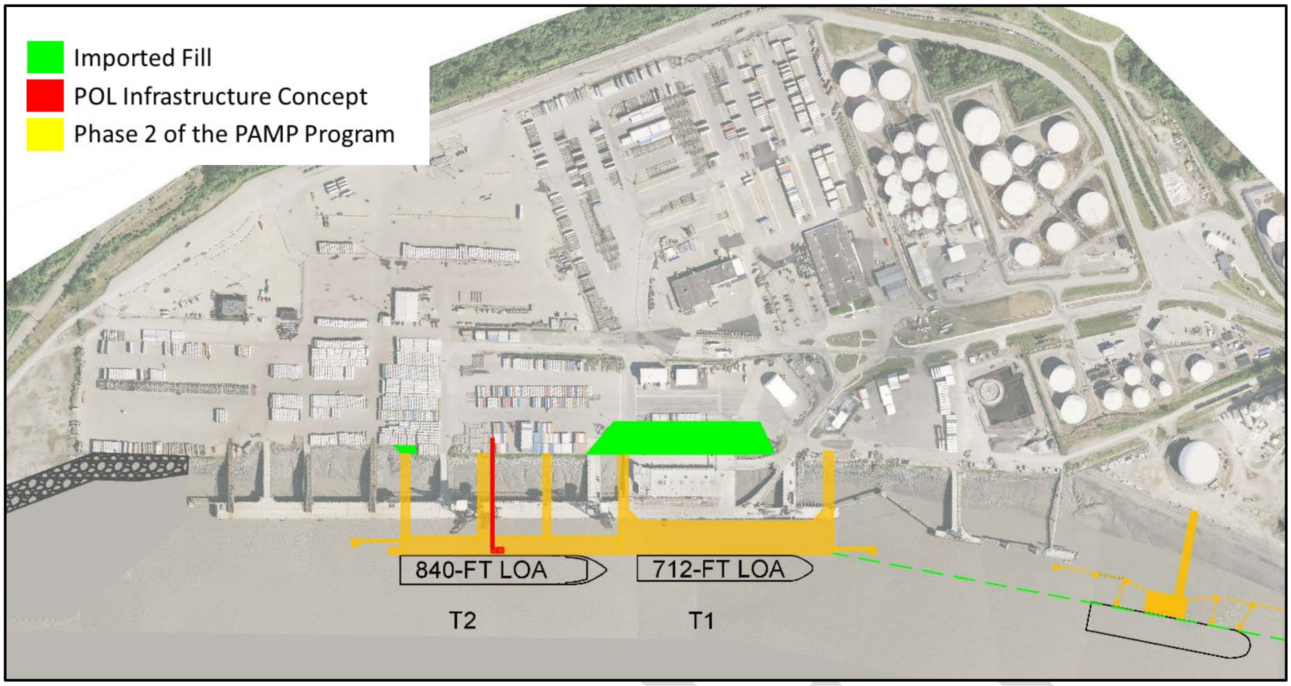

Figure 1-1. Overview of the Plan Concept for POA Terminals 1 and 2

Dimensions of the T1 LO/LO wharf will be 870 feet long and 129 feet wide. T1 will be accessed over two 35-foot-wide trestles. The T2 RO/RO facility will be 934 feet long by 69 feet wide. The T2 wharf will be accessed by two 35-foot-wide access trestles and one 55-foot-wide access trestle.

The T1 and T2 facilities are designated as seismic berths by the POA, following the Municipality of Anchorage's Geotechnical Advisory Commission (GAC) definition of a seismic berth (GAC 2014). This designation means that the terminals, including shoreline access, must be functional within 7 to 10 days of a design earthquake (DE). Section 2.4.1 provides further discussions of earthquake risks.

1.2 Project Objectives and Alternatives Analysis

The strategy for the alternative analysis implemented by the Port of Alaska Modernization Program (PAMP) team included multiple stages of development, evaluation, and narrowing of selected alternatives by a multidisciplinary team. While PAMP's primary goal is to deliver replacement terminals for the POA, this alternatives analysis was completed to identify methods to construct foundations and substructure systems that meet underwater (hydroacoustic) noise limits established by permitting agencies for protection of Cook Inlet Beluga Whales and other marine mammals traveling in proximity to the planned construction.

During previous studies, outlined in Section 3.1, it was determined the performing soil stabilization activities for gravity-based systems such as sheet pile, coffer dams or caissons was infeasible. Regardless of the gravity wall method chosen, the cost to stabilize the deep soils beneath the gravity wall structures make gravity wall concepts infeasible at the POA.

Alternatives were initially narrowed by considering permanent piling installed, temporary piling installed, beluga takes, construction constraints, and costs. The team considered the following five alternatives:

- Alternative 1A: 48-inch-diameter Driven piles
- Alternative 1B: Composite Helical Piles
- Alternative 2A: 72-inch-diameter Driven Piles
- Alternative 2B: 72-inch-diameter Drilled Shafts
- Alternative 3: Prefabricated Jacketed System

Section 2. Site Characteristics and Constraints

2.1 Tides, Winds and Tidal Currents

The POA site is characterized by relatively unique environmental conditions influenced by tides, currents, and winds. These conditions are important considerations during T1 and T2 construction activities and permanent operations throughout the design life.

- **Water Levels.** Tidal variations can be as much as 40 feet, with the PAMP Seismic Design Manual (SDM) (CH2M 2019) specifying the design basis for tidal variations using mean lower low water (MLLW) as the datum as:
  - Highest observed water: elevation (EL.) +34.6 feet
  - MLLW: EL. 0 feet
  - Lowest observed water: EL. -6.4 feet
- **Currents.** The design basis current has a maximum 3.0-knot current parallel to the shore for both the flood and ebb conditions, as specified in the SDM.
- **Winds.** Per the SDM, the design wind speeds for vessels at berth are as follows:
  - A wind speed of 45 miles per hour is the maximum normal operational wind speed. Ships are expected to carry out normal loading and offloading activities under this wind speed.
  - A wind speed of 75 miles per hour is the maximum wind speed allowed for ships to remain at berth. If wind exceeds this speed, ships will be expected to leave the berth.

2.2 Environmental Permit Requirements

Permit constraints specified to protect Cook Inlet Beluga Whales (*Delphinapterus leucas*) and other protected species exist for the POA site. These constraints will have a significant effect on methods of construction for the development of the T1 and T2 terminals. The most significant of the environmental permit constraints regarding the construction of T1 and T2 is the type, level, and duration of hydroacoustic sound generated by constructing foundations for the new T1 and T2 facilities. As the POA prepares for Phase 2 development, a range of engineering designs and construction methods are being considered to reduce impacts on marine mammals, especially the Cook Inlet Beluga Whale.

Since a primary goal of this report is to evaluate alternative options to reduce impacts to marine mammals, Appendix A was prepared and includes information to support that alternative analysis with a preliminary and rough order of magnitude estimation of potential beluga whale "takes", as a proxy for potential impacts to marine mammals that could be adversely affected by in-water pile driving construction work associated with T1 and T2. It is intended that these generalized beluga whale "take" estimates will provide an informative metric in comprehensively evaluating the various alternatives being evaluated.

The Cook Inlet Beluga Whale Distinct Population Segment and stock is protected under two federal laws: the Endangered Species Act (ESA) and the Marine Mammal Protection Act (MMPA). Knik Arm provides habitat for the federally endangered Cook Inlet Beluga Whales, and portions of Knik Arm are designated as critical habitat for the Distinct Population Segment. Section 7 of the ESA requires that federal agencies ensure that any action they authorize, fund, or carry out does not jeopardize the continued existence of any federally endangered or threatened species, and does not adversely modify its designated critical habitat. When a federal action agency authorizes, funds, or carries out an action, it must consult with the

National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service if the action may affect ESA-listed species that fall under their respective management authorities.

Beluga whales and other cetaceans and pinnipeds (except for walruses) fall under the management of NMFS. In-water work in Cook Inlet that has the potential to impact marine mammals, including beluga whales, is subject to regulation and requires consultation with NMFS. Consultation regarding previous work at the POA has provided multiple opportunities to engage with NMFS over the years. Thus, the POA has garnered much experience through these interactions, receiving numerous Letters of Concurrence and Biological Opinions under the ESA, and Incidental Harassment Authorizations under the MMPA for beluga whales and other marine mammals.

To construct additional terminals at the POA, engineering designs and construction methods must meet a "least practicable adverse impact" determination, which involves minimizing impacts on potentially affected species. To reduce impacts on Cook Inlet Beluga Whales, the design and construction strategy must consider attempts to reduce the total sound pressure levels entering the water column associated with terminal construction, primarily during pile installation. This can be accomplished through mitigation measures, design solutions, and construction methods, as presented in Sections 2 through 5 of this report. Appendix A provides an assessment of pile installation and potential impacts on marine mammals.

2.3 Soil Conditions

Several relatively unique soil and environmental loading conditions exist at the POA and must be considered during evaluation and selection of foundation types and substructure systems for the design of the new cargo terminals. The soil and environmental conditions will also affect the suitability of installation methods.

Soil conditions underneath the planned terminal locations have been investigated on multiple occasions beginning in the early 2000s (for example, Terracon 2004) and extending to the POA Test Pile Program (CH2M 2016b). These investigations have included drilling and sampling, cone penetrometer test soundings, and over-water geophysical surveys. Results of the past investigations show that the subsurface at the planned T1 and T2 facility locations include the following sequence of soil layers:

- Fills
- Tidal silts and sands (TS)
- Upper glaciofluvial sand and gravel
- Upper glaciolacustrine silts and clays (SC) – referred to locally as the Bootlegger Cove Formation (BCF) clay
- Older glaciofluvial sand and gravel (GFo)
- Lower glaciolacustrine SC
- Undifferentiated glacial drift

A typical section with soil layering and approximate depths of these layers is depicted on Figure 2-1. There are interlayers of silty sands and gravels ranging from 5 to 20 feet thick in the upper glaciolacustrine layer; artesian conditions were encountered 120 feet below the mudline in one layer during explorations for the PAMP Test Pile Program.

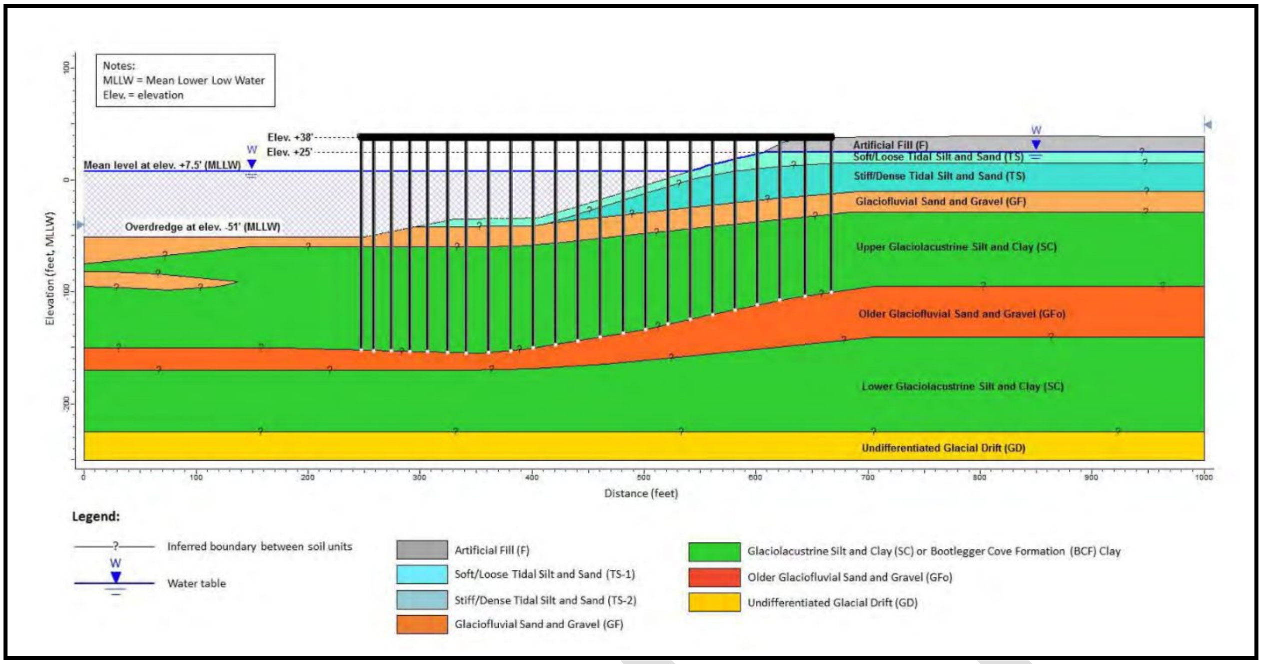

Figure 2-1. Typical Soil Cross Section at Terminal Wharf and Access Trestles
(Source: CH2M 2016a)

Upper BCF Layer. Piles used to support the new T1 and T2 facilities are expected to extend through the upper layers and be terminated in the GFo layer (dark orange), where high bearing resistance is assumed. The upper BCF clay layer (upper green) appears to be over-consolidated, with an estimated maximum past pre-consolidation pressure of 12,000 pounds per square foot (psf), resulting in over-consolidation ratios ranging from 5 to less than 2 at depth. Unconsolidated, undrained triaxial shear strength tests on intact BCF clay samples resulted in undrained strengths that varied from 2,000 to 3,000 psf (CH2M 2016a).

GFo Layer. The GFo layer located beneath the upper BCF clay is dense to very dense sand and gravel based on standard penetration test blow counts and cone penetrometer test end-bearing values. The GFo layer ranges from 150 to 200 feet below the mudline. Additional information about soil conditions at the POA is provided in reports prepared for the concept design evaluations for the modernization project (CH2M 2016a) and for the PAMP Test Pile Program (CH2M 2016b), as well as for the final design and construction of the PCT (COWI 2018).

TS Deposits. Results of previous geotechnical studies have found that the TS deposits just below the fills at the backshore are potentially liquefiable during an earthquake. These past studies have shown that the TS deposits could undergo lateral spreading during a significant magnitude DE, resulting in down slope mass wasting and lateral loads on piles in the path of the moving soil. These loads are expected to be significant for access trestle piles but minimal for wharf piles because of the distance between the wharf piles and shorelines. Because uplands areas at trestle access points are vulnerable to ground displacement from seismic response, they will require stabilization using ground improvement methods to maintain access to the trestles and wharves following a major seismic event.

2.4 Environmental Loading Considerations

The selection of alternative foundations and substructure systems for the T1 and T2 terminals will consider three primary types of environmental loading during design and construction evaluations. These include:

1. Seismic loading
2. Ice loading
3. Effects of winds tides and currents

Details regarding the form and extent of each type of loading are provided in the SDM (CH2M 2019), and other POA reports (CH2M 2016a).

2.4.1 Seismic Loading

The potential for seismic-induced ground shaking at the T1 and T2 terminals is significant (CH2M 2019). Piles supporting the deck structures must develop sufficient lateral reaction to the seismic effects below the mudline to remain stable.

According to the SDM, the T1 and T2 terminals will be designed for three levels of earthquake loading: the operational level earthquake (OLE), the contingency level earthquake (CLE), and the DEs. Return periods for the OLE and CLE are 72 years and 475 years, respectively. The maximum considered earthquake (MCE) has an average return period of 2,475 years, and the DE is defined as two-thirds of the MCE.

Peak ground acceleration (PGA) values for firm-ground conditions are identified in the SDM as 0.148g, 0.379g, and 0.758g (g is acceleration due to gravity) for the OLE, CLE, and MCE, respectively. These firm-ground conditions occur approximately 400 feet below the mudline at the T1 and T2 locations. As the ground motions propagate from firm-ground levels to the ground surface, the motions change due to the effects on local soil conditions. The SDM provides PGA values and response spectra at the ground surface associated with each of these return periods. The SDM also identifies terminal performance expectations for the three earthquake return periods to support performance-based structural design.

2.4.2 Ice Loading

There will be two types of ice load cases on the T1 and T2 marine terminals. The first is due to large, moving ice pans that form in Cook Inlet during the winter. These pans float on large tidal currents and can impact piles that support the T1 and T2 terminals. Ice pan loads must be considered for both short- and long-term lateral loading of piles. The second ice load case is due to an accumulation of ice around each pile when seawater freezes during daily tidal cycles, referred to as ice collars. The ice collars add mass to the piles, increasing loads during seismic events, and the buoyancy of the ice may create uplift forces on the piles at higher tides. The ice floe and ice collar loads must be considered for not only the permanent structures but additionally for the design of temporary work trestles or jack-up barges that must survive construction activities during the winter periods.

The design basis for ice loading, as stated in the SDM (CH2M 2019), is as follows:

- Ice live loads: The wharf will be designed for impact loads resulting from a slab of ice 24 inches in thickness crushing against the wharf. The crushing strength of the ice will be taken as 300 pounds per square inch (psi). The bending strength of the ice is assumed to be 25 to 40 psi. This ice loading applies to terminal piles. Piles supporting trestles will be somewhat protected from the full extent of ice pan loading because of the location of the trestles; therefore, they may be designed for a lesser loading, depending on location.
- Ice dead loads: The wharf and trestle piles will be designed for a mass of ice accretion equal to 3 feet of radial growth encircling and adhering to each pile. This loading applies to any structure that must survive the winter months at the port. Thus, ice dead load will be combined with earthquake loads.

2.4.3 Effects of Tides, Winds, and Currents

The POA site is also characterized by relatively unique environmental conditions from tides, and currents.

- Tidal fluctuation that can be as much as 40 feet (CH2M, 2013). This fluctuation is an important consideration for the evaluations of the static and seismic stability of embankment slopes during the design seismic events. Section 4.1.3 provides tidal levels that should be considered for seismic design of embankments.
- Wind and currents will not have a direct impact on the seismic design of the POA facilities; however, currents may cause scour at the mudline around piles. The resulting scour pits could extend one to two pile diameters beneath the existing mudline, resulting in an increase in the unsupported length of the piles. Section 4 provides guidance on methods for dealing with the effects of the scour pit on the lateral capacity of piles.

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Section 3. Previous Studies

3.1 Previous Foundation Studies

Prior to the PAMP, the POA was engaged in the Port Intermodal Expansion Project (PIEP) to construct 120 acres of in-water fill retained by a sheet pile wall system. This project was initiated in 2002 but was stopped in 2011 after a series of cost overruns and construction defects became apparent (CH2M 2013a).

In 2011, the U.S. Army Corps of Engineers (USACE) was contracted to lead a study with cooperation from the Municipality of Anchorage and the U.S. Maritime Administration to investigate whether the application of a sheet pile retaining wall and fill system was appropriate for the POA (CH2M 2013a).

USACE then contracted with Jacobs (formerly CH2M at time of initial contract) for a multidiscipline review of the PIEP. The culmination of this effort was the *Final Summary Report, Port of Anchorage Intermodal Expansion Project Suitability Study* (CH2M 2013a). Relevant studies in this report are discussed in this section and form the starting point for the alternatives studied later in this report.

3.1.1 Suitability Study Chapter 9 – Independent Design

This study was undertaken to assess the possibility of using ground improvements to stabilize the existing sheet pile wall. Figure 3-1 shows the cross section of the existing sheet pile wall and the addition of the ground improvement area below the sheet pile wall structure. The cross-sectional area of the ground improvements is approximately 224 feet wide by 109 feet deep, with the bottom of the soil improvement boundary about 190 feet from the ground surface. Because the depth to the stable soil below is 190 feet, the only viable option for improving the soil would be jet grouting. This method for ground improvement has been able to reach depths of 200 feet; however, it is the most expensive method.

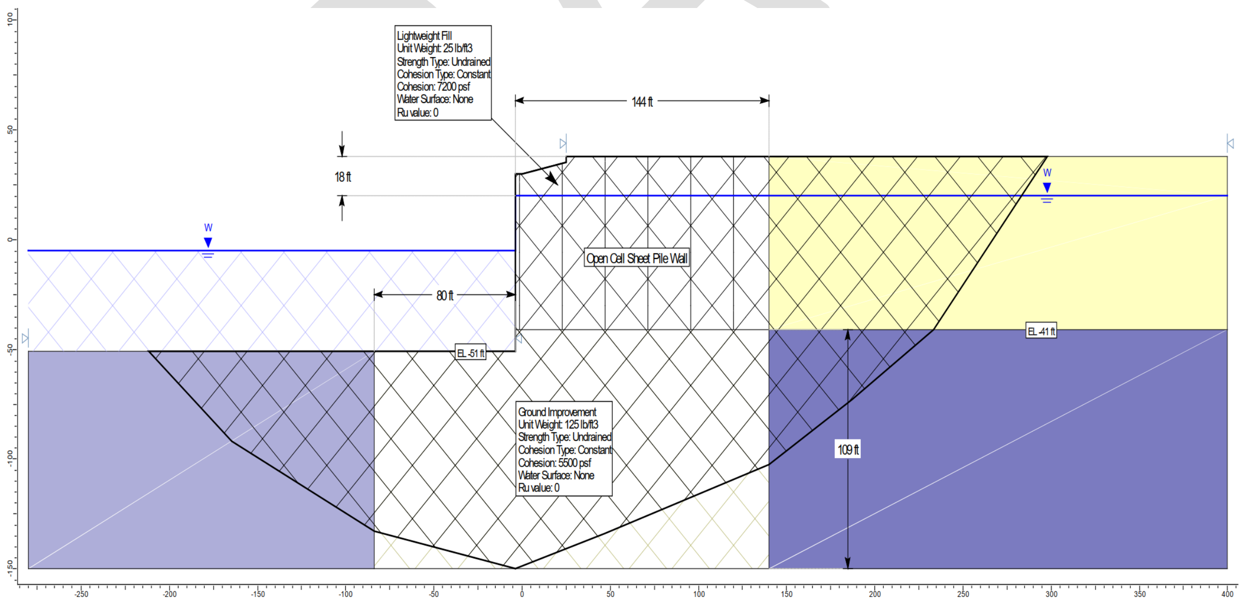


Figure 3-1. Ground Improvement Below Existing Sheet Pile Wall
(Source: CH2M 2013a)

During the 2013 study, approximately 2,000 linear feet of existing sheet pile and compacted fill had been constructed at POA at a cost of approximately $300 million (CH2M 2013a). Based on the cross section shown and the cost of soil improvements at $500 per cubic yard, the cost to stabilize the existing foundation is $900 million, or three times the cost to construct the sheet pile wall system.

Based on this analysis, the idea of stabilizing the soils beneath the existing sheet pile wall was deemed infeasible. This analysis is also applicable to other gravity wall systems, such as coffer dams or caissons. Regardless of the gravity wall method chosen, the cost to stabilize the deep soils beneath the gravity wall structures make gravity wall concepts infeasible at the POA.

3.1.2 Suitability Study Alternative Design Concepts

The *Final Report, Port of Anchorage Intermodal Expansion Project Study 15% Concept Plan* (CH2M 2013b) considered several wharf configurations and developed the preliminary pile foundations designs. In this pile design effort, both 24-inch- and 36-inch-diameter steel pipe piling were considered. The POA is located in a seismically active region, with a tidal range of nearly 40 feet, and is subject to additional weight from ice and impact loading to the structures; therefore, the POA requires a higher structure with additional demands than similar structures in the Lower 48, which means larger-diameter piles are required. Due to the extreme conditions at the POA, the 24-inch- and 36-inch-diameter piles did not have the necessary structural capacity. The analysis showed that 48-inch-diameter piles were the minimum size that would provide structural foundation support for the new wharves under consideration at POA.

3.2 Previous Hydroacoustic Monitoring Programs

Two pile installation projects with hydroacoustic noise monitoring programs during pile driving have been completed within the last 6 years at the POA. The first was the PAMP Test Pile Program (CH2M 2016b) and the second was construction of the PCT (I&R 2021, 2022). In both programs, 48-inch-diameter steel pipe piles were first vibrated approximately 50 feet into the ground to set the location of the piles. Once the piles reached this initial depth, they were driven with either a diesel or hydraulic impact hammer to the required termination depth.

3.2.1 Port of Alaska Modernization Program Test Pile Program

The 2016 PAMP Test Pile Program installed ten 48-inch-diameter, 200-foot-long test piles between the northern end of the current terminal facility and the planned location of the new PCT facility. Figure 3-2 shows the general locations of the test piles. The intent of the Test Pile Program was to evaluate pile drivability and the level of hydroacoustic sound generated during driving (CH2M 2016b).

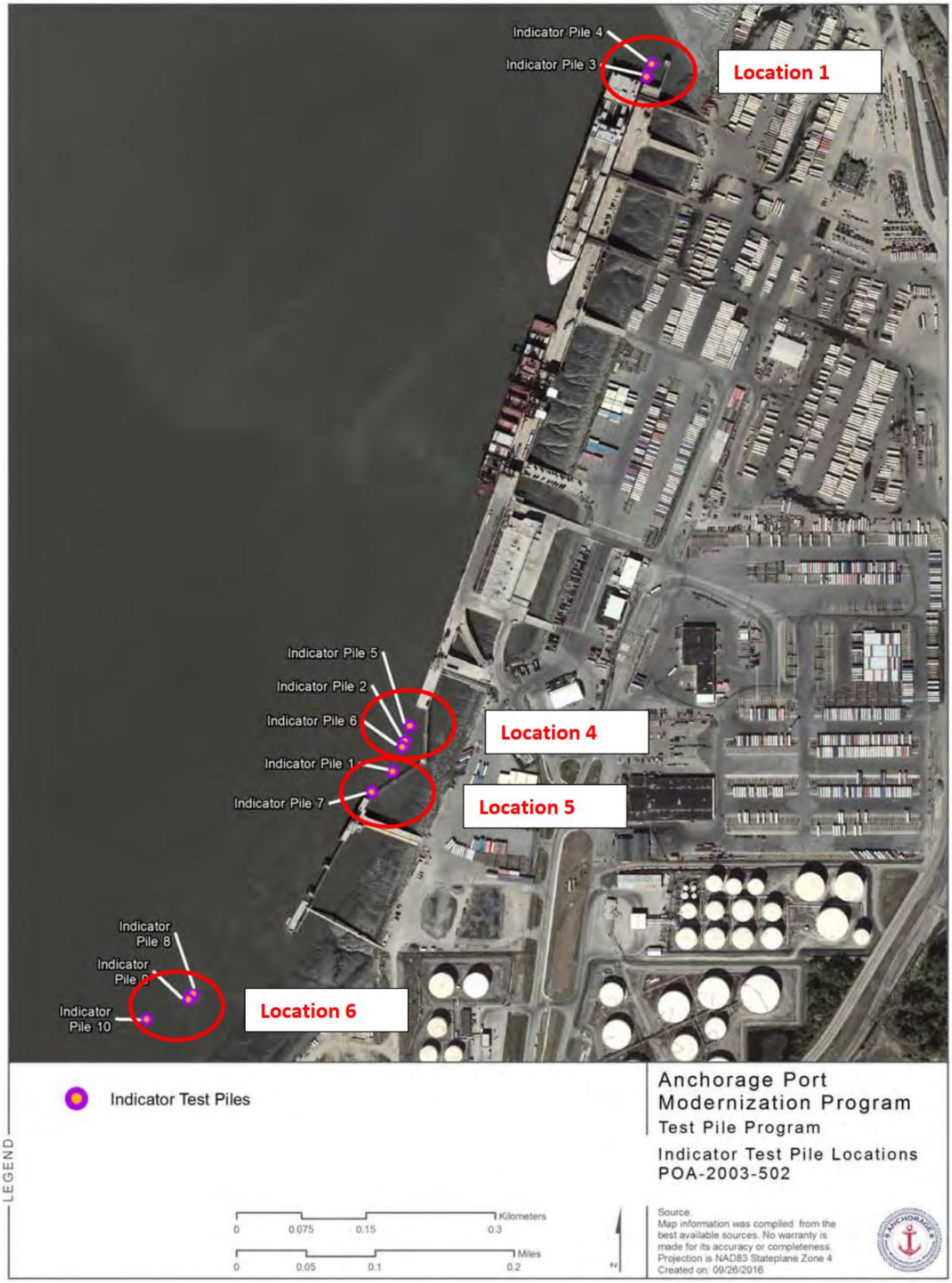


Figure 3-2. Locations of Test Piles Driven in the POA Test Pile Program
(Source: CH2M 2016b)

The hydroacoustic monitoring program included an evaluation of two types of noise attenuation systems (NASs) to determine whether either or both could reduce the level of hydroacoustic sound.

The two NASs adopted were a confined bubble curtain and a relatively new concept developed by AdBm Technologies, LLC (AdBm), called a Helmholtz resonator system. Details of the Test Pile Project, including results of hydroacoustic monitoring, are summarized in the Test Pile Program report (CH2M 2016b).

3.2.2 Petroleum and Cement Terminal Pile Installation

The POA Test Pile Program was followed by installation of piles to construct the PCT. Information from the POA Test Pile Program was used by the PCT contractor as a guide for limiting levels of hydroacoustic noise during production pile installation. Most of the PCT piles were 48-inch-diameter steel pipe piles driven with an American Pile Driving Equipment (APE) Delmag D180 diesel hammer. A confined bubble curtain, similar to the POA Test Pile Program, was used to limit levels of hydroacoustic noise on the wharf and trestle piles, and an unconfined bubble curtain was used on nine 144-inch-diameter monopiles and associated template piles.

More than a hundred 36-inch-diameter temporary steel piles were driven to support construction of work trestles and templates for the PCT. Additionally, nine 144-inch-diameter breasting and mooring dolphin piles were also driven using an IHC IQIP S-800 hydraulic impact hammer.

Section 4. Alternative Foundation Evaluations

4.1 Design Assumptions

The preliminary design of the structural alternatives is in accordance with SDM requirements (CH2M 2019). Section 3.2 highlights some of the main design assumptions using in the preliminary design concepts and states assumptions made for the alternative analysis process.

The approach to the preliminary designs has been simplified for this report, and consists of these steps:

1. Vertical loads (dead and live loads) were estimated based on the geometry of the structures, and the necessary superstructure member sizes for each alternative were iterated to determine mass of the structural elements.
2. Lateral loads on the alternatives were estimated based on seismic loads, as these were determined to be greater than other lateral loads on the structure such as berthing, mooring, and wind loads. No other lateral load cases were considered during the alternative analysis. The seismic loads are expected to control the foundation and substructure design.
3. Preliminary foundation designs were performed to confirm the required pile or drilled shaft size and length to support the structures.

4.1.1 Elevations

4.1.1.1 Structure Elevations

The top-of-deck elevation for both T1 and T2 wharves was determined to be +44 feet MLLW based on the modeled sea level rise for Anchorage Harbor over the 75-year design life (Figure 4-1). The top-of-trestle elevation was assumed to be sloping from +44 feet MLLW at the interface with wharf decks, down to +38 feet MLLW at the abutments (Figure 4-15).

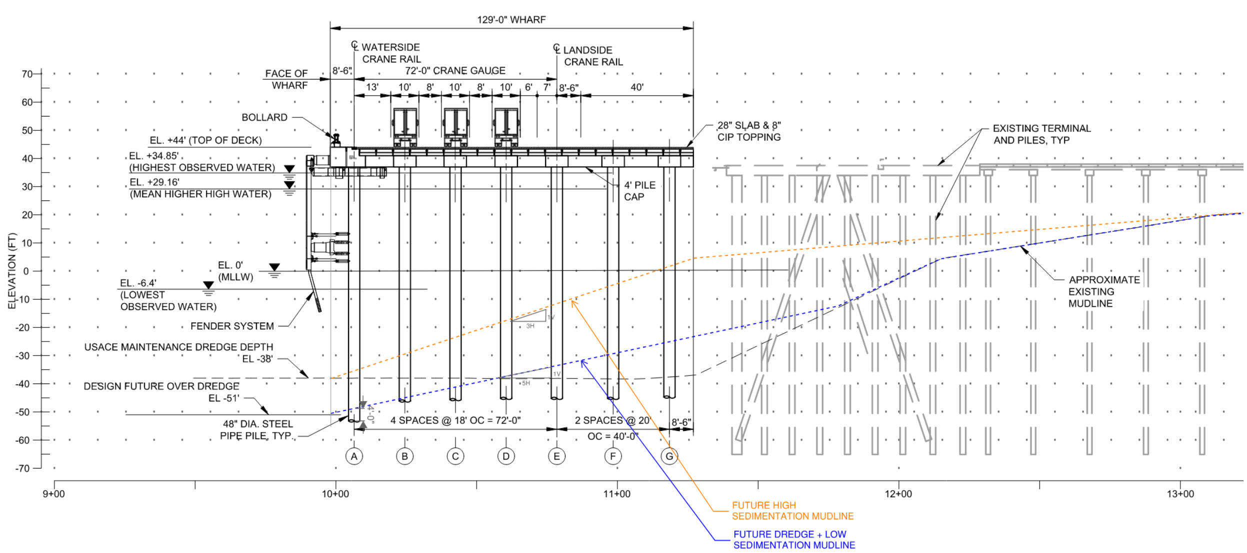


Figure 4-1. Mudline Assumptions

Notes: T1 shown; T2 similar.

4.1.1.2 Mudline Elevations

Mudline elevations at the project site could vary significantly during the design life of the structures. Mudline elevation assumptions have a significant impact on seismic analysis. Both a high and low mudline case are considered in the analysis to confirm the design can accommodate a wide range of mudline fluctuations (Figure 4-1).

The high mudline case assumes the harbor dredge depth remains at an overdredge depth of -38 feet MLLW at the new wharf face, matching the existing condition at the port (USACE 2018). The mudline is assumed to follow a 1V:3H slope (where V is vertical, and H is horizontal) from the wharf face toward the landside edge of the wharf. The mudline is then assumed to slope at 1V:10H until it joins with the existing mudline (Figure 4-1).

The low mudline case assumes the future harbor dredge depth of -45 feet MLLW at a new wharf face to accommodate bigger vessels. This case also includes an allowance of 6 feet for future overdredge, taking the mudline elevation at the new wharf face to -51 feet MLLW. The mudline is then assumed to follow a 1V:5H slope toward the landside, until it meets up with the existing mudline (Figure 4-1, blue line). This also considers a local scour depth equal to 1 times pile diameter.

4.1.2 Live Loads

These live loads are considered in the design analyses:

- **Uniform Live Load**: 1,000 psf.
- **Vehicular Load**: American Association of State Highway and Transportation Officials HS25 with impact factor of 1.33.
- **Container Gantry Crane (T1 wharf only)**: T1 wharf is designed to support the maximum loads from rail-mounted container gantry cranes provided in *Crane Load Estimates – Port of Anchorage Terminals 1 and 2* (Liftech 2016). The Liftech report only provided load magnitudes for 100-foot and 50-foot gauge gantry cranes. It is expected that the loads for 72-foot gauge cranes will be between that of 100-foot gauge and 50-foot gauge cranes. Because the load magnitudes for the 50-foot gauge crane are higher, they are conservatively used in the analysis (Figure 4-2).
- **RO/RO Ramp (T2 wharf and trestle only)**: T2 wharf and trestles are designed to withstand the loadings from the Totem Ocean Trailer Express (TOTE) RO/RO ramps. An impact factor of 1.1 is included in the analysis (Figure 4-3).
- **Mobile Cranes**: Wharves are designed to allow either a mobile harbor crane (Liebherr LHM550 or similar) or 275-foot-capacity truck crane and crawler crane to operate on specially strengthened heavy-lift areas. Access trestles are designed to carry the wheel or track loads of mobile harbor crane, track crane, and crawler crane in their respective traveling configurations.
- **Container Handler**: Container handler (Taylor TETCP-1100I or equivalent) loads are considered in the analysis per SDM requirements. An impact factor of 1.1 is included in the analysis (Figure 4-4).
- **Petroleum, oil, and lubricants (POL) Piping Live Load**: A 30-psf uniform live load is considered in the analysis at potential piping areas to account for the weight of fluids in the piping.

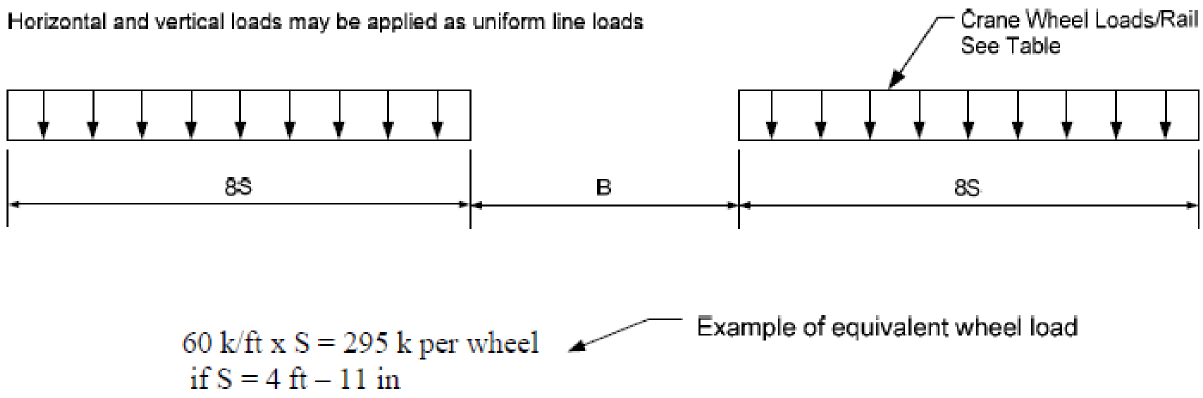


Figure 4-2. Gantry Crane Uniformly Distributed Wheel Loads
(Source: Liftech 2016)
ft = foot/feet, in = inch(es), k/ft = kip per foot/feet

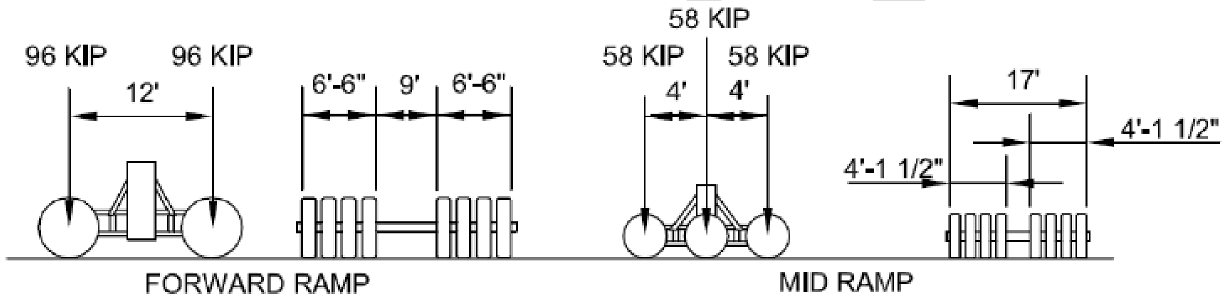


Figure 4-3. Roll-on and Roll-Off Ramp Axle Loads
(Source: CH2M 2019)

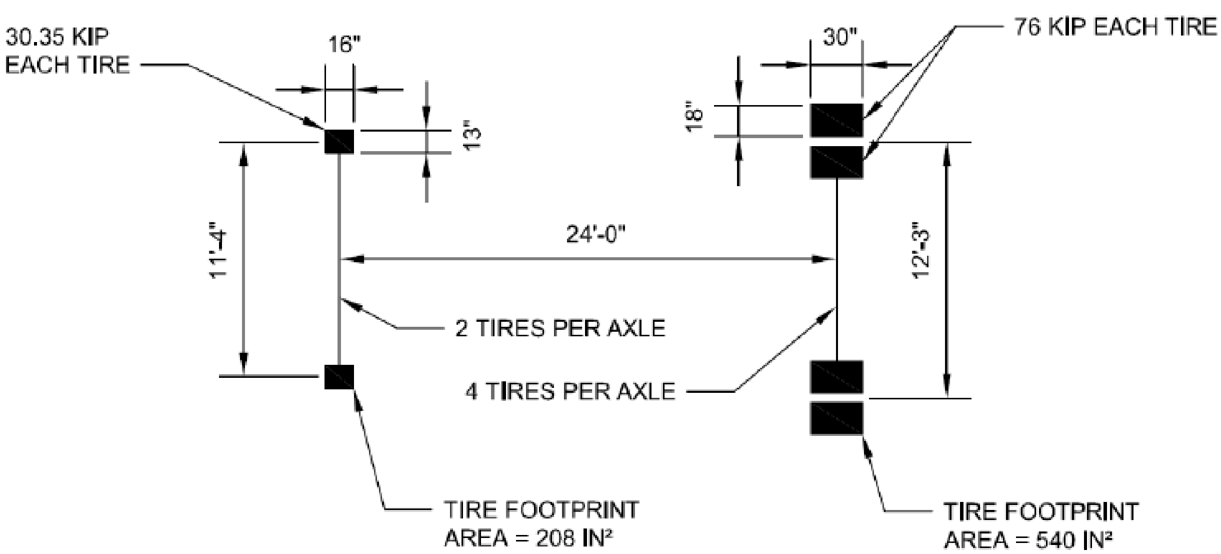


Figure 4-4. Typical Container Handler Wheel Loading
(Source: CH2M 2019)
IN^2 = square inch(es)

4.1.3 Seismic Loads

According to the revised PAMP project requirements, both T1 and T2 will need to meet the requirements of a seismic berth, specifically, structures for both terminals need to meet either the “minimal damage” performance level under the DE event or meet the “controlled and repairable damage” as defined in American Society of Civil Engineers (ASCE) 61 for performance level under the DE event, with provisions to repair the damage within 1 week of the event (ASCE 2014). To simplify the alternative analysis, it was decided to design all alternatives to meet the minimal damage performance level.

4.1.3.1 Design Response Spectra

The dominant load effect on the structure from a seismic event is the inertial load associated with ground shaking, represented by the design response spectra. The design response spectra used in the structure analysis are based on the *PAMP Geotechnical Engineering Report* (CH2M 2016a). As the target performance level is set to minimal damage for the DE event, only DE spectra are considered. Per *ASCE 7, Minimum Design Loads and Associated Criteria for Buildings and Other Structures* (ASCE 2022), the magnitude of the DE is defined as two-thirds of the MCE, which is a seismic event with a 2,475-year return period. The OLE and CLE are not expected to control substructure and foundation design and are not considered in the analysis. For geotechnical seismic hazard evaluation, such as soil liquefaction analysis, the response spectra associated with MCE are used, consistent with requirements of the SDM and ASCE 7.

To simplify the analysis, the envelope of T1 and T2 design spectra is used for both terminals. Due to different mudline elevations, one spectrum is used for the seismic analysis of the wharves, and another is used for the trestles. Figures 4-5 and 4-6 show the design spectra.

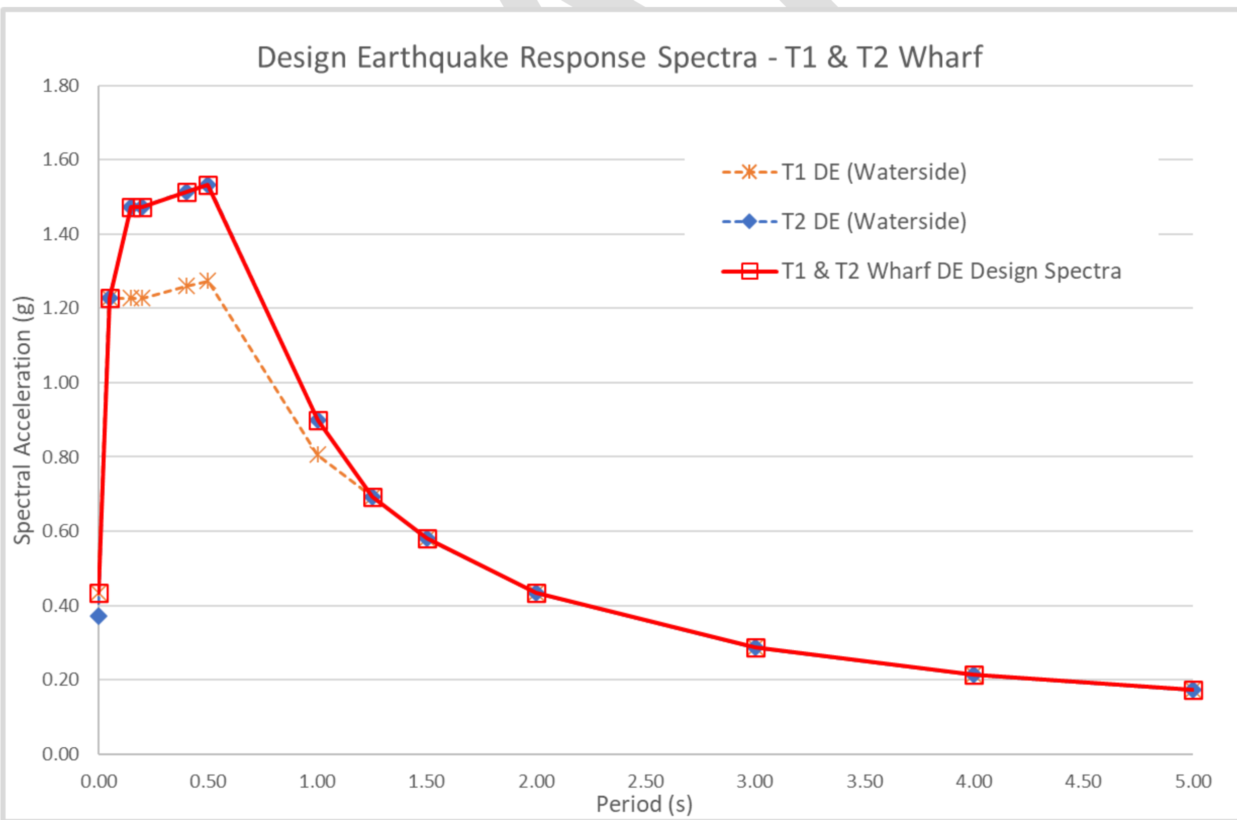


Figure 4-5. Design Response Spectra – Terminal 1 and Terminal 2 Wharves

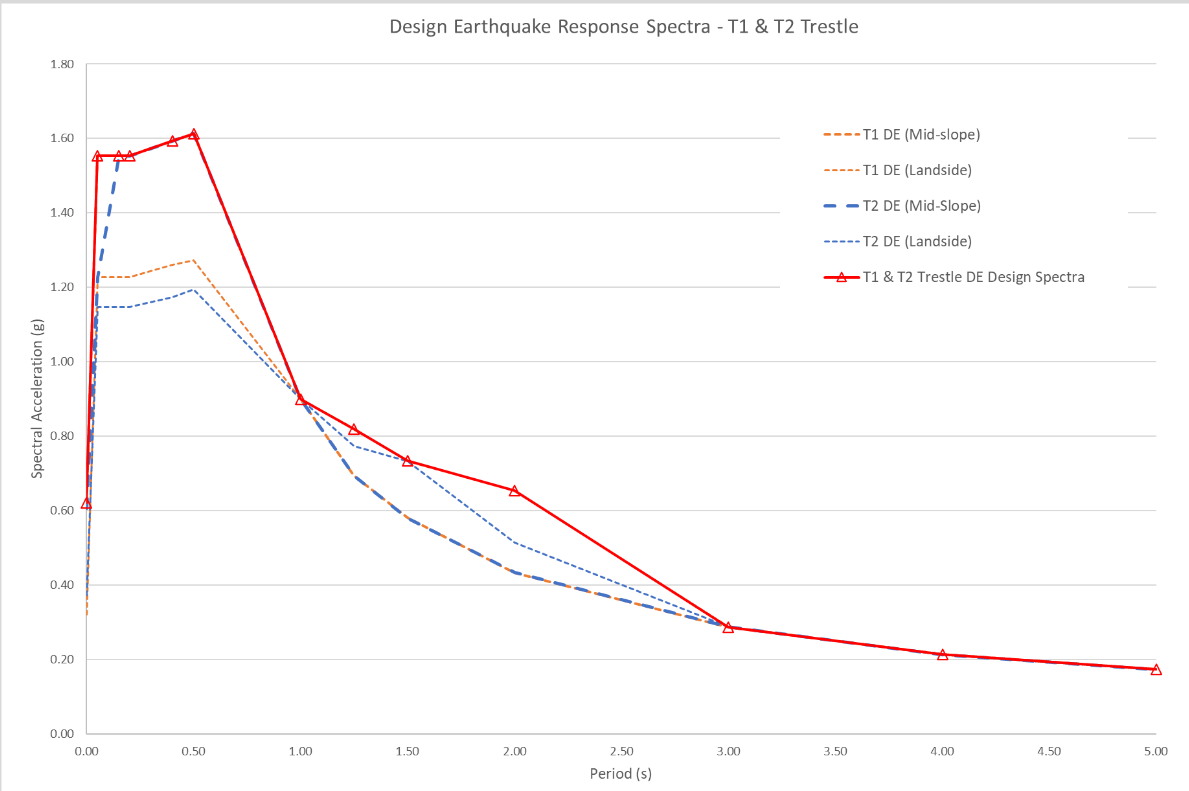


Figure 4-6. Design Response Spectra – Terminal 1 and Terminal 2 Trestles

4.1.3.2 Lateral Spreading Loads

Preliminary geotechnical analysis indicates the possibility of soil liquefaction under DE event at the project site. The resulting soil movement (commonly called "lateral spreading") will impart additional kinematic loads on foundation elements. These kinematic loads are represented by lateral soil pressures applied on the piles or shafts (Figure 4-7).

The timing of these kinematic loads generally differs from that of seismic inertial loads. The kinematic loads typically peak near the end of the seismic event, when ground shaking and inertial loads are significantly less than their peak. To reduce undue conservatism, the inertial and kinematic loads were combined in the structure analysis using these two cases:

100% inertial loads + 50% kinematic loads

and

50% inertial loads + 100% kinematic loads

Preliminary geotechnical analysis also suggested that ground improvement would be required near the shoreline to avoid global slope failure of the embankment. For the preliminary analysis, the ground improvement zone is assumed to extend 75 feet from the shoreline to both seaward and landward sides. No lateral spread load is expected for foundation elements within the ground improvement zone.

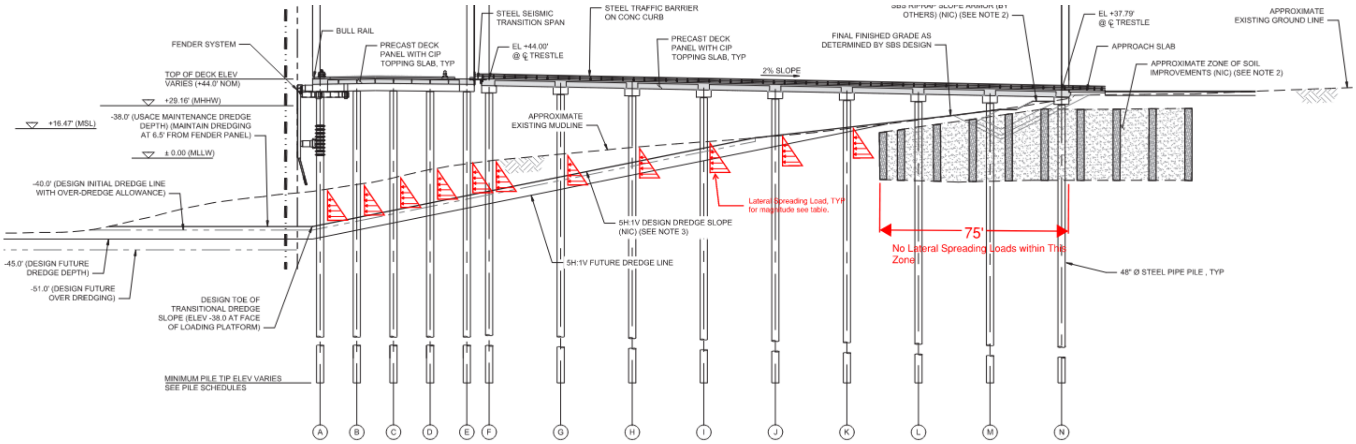


Figure 4-7. Typical Lateral Spreading Loads

4.1.3.3 Seismic Mass

Seismic mass considered in the analysis includes:

- Mass of structural components and permanent attachments
- 10% of Live Load: Uniform live load is assumed to be the controlling live load for seismic mass
- Ice Accretion: Assuming 3 feet of radial growth per the SDM, applied from MLLW to mean high water (+29.2 feet)
- Hydrodynamic Mass: Equal to the mass of displaced water, applied from mudline to mean sea level (+20.7 feet)

4.1.4 Load Combinations

Two main load combinations were considered in the alternative analysis:

$(1 + 0.5\ PGA)D + 0.1L + 1.0E$

and

$(1 - 0.5\ PGA)D + 1.0E$

Where:
PGA = peak ground acceleration
D = dead loads
L = live loads
E = horizontal earthquake load

4.1.5 Corrosion

It is assumed that a corrosion protection system that combines both pile coating and an impressed current cathodic protection system will be installed for all alternatives. It is expected that, when properly maintained, this corrosion protection system will limit the corrosion of main foundation and substructure elements over the life span of the structure. An 1/8-inch pile section corrosion loss allowance was considered in the analysis to provide an additional safety margin.

4.2 Base Design for Comparison

This section details the preliminary design solutions for the new T1 and T2 wharves and trestles using a 48-inch-diameter pile as a basis for the design. As discussed in Section 4.1, the 48-inch-diameter piles have the smallest diameter that will provide the structural foundation required for the new wharves. This was confirmed with the completion of final design and construction of the PCT using 48-inch-diameter driven piles.

Preliminary design alternatives for T1 and T2 wharves and trestles supported by 48-inch-diameter piles have been developed and are presented in this section. Two alternatives have been investigated, as follows:

- Alternative 1A: Wharves and trestles are designed to be supported by 48-inch-diameter steel pipe piles, installed by conventional impact pile driving. Noise mitigation technologies discussed in Section 5 can be used with this alternative to reduce pile driving noise. These strategies include the possibility of using 48-inch-diamater drilled shafts, discussed in Section 5.3. The 48-inch-drilled shafts would replace the 48-inch-diameter driven piles one-for-one. In addition the 48-inch drilled shafts would increase construction installation time line and, increase number of temporary piling and, increase the risk of beluga whale takes.
- Alternative 1B: Wharves and trestles are supported by composite 48-inch- and 24-inch-diameter helical piles. The concept is to install a conventional 48-inch-diameter pile through the water column and into the seabed to a nominal depth, and then install helical piles to the design toe depth. Helical pile construction through the harder materials is expected to generate lower noise levels than using conventional pile driving for the entire installation.

4.3 Terminal Layout

The layouts of the new T1 and T2 terminals are based on the revised Modified Concept, updated in December 2021. Figures 4-8 and 4-9 depict the overall dimensions and layouts of each terminal. The alternative designs focus on the main structural components of the terminals, namely the piled foundations of the wharves and access trestles. Other ancillary structures are not shown, such as mooring dolphins.

T1 comprises an 870-foot-long by 129-foot-wide wharf deck and two 287-foot-long by 35-foot-wide access trestles. The berth face of the new wharf is located approximately 140 feet seaward of existing terminal berthing line. T1 is planned and designed for the operations of 72-foot or 100-foot gauge container gantry cranes. For this report, the 72-foot gauge cranes are shown. If the 100-foot gauge cranes are ultimately chosen as the preferred alternative, this will not increase the size of the wharves or trestles, or the associated total number of piles installed.

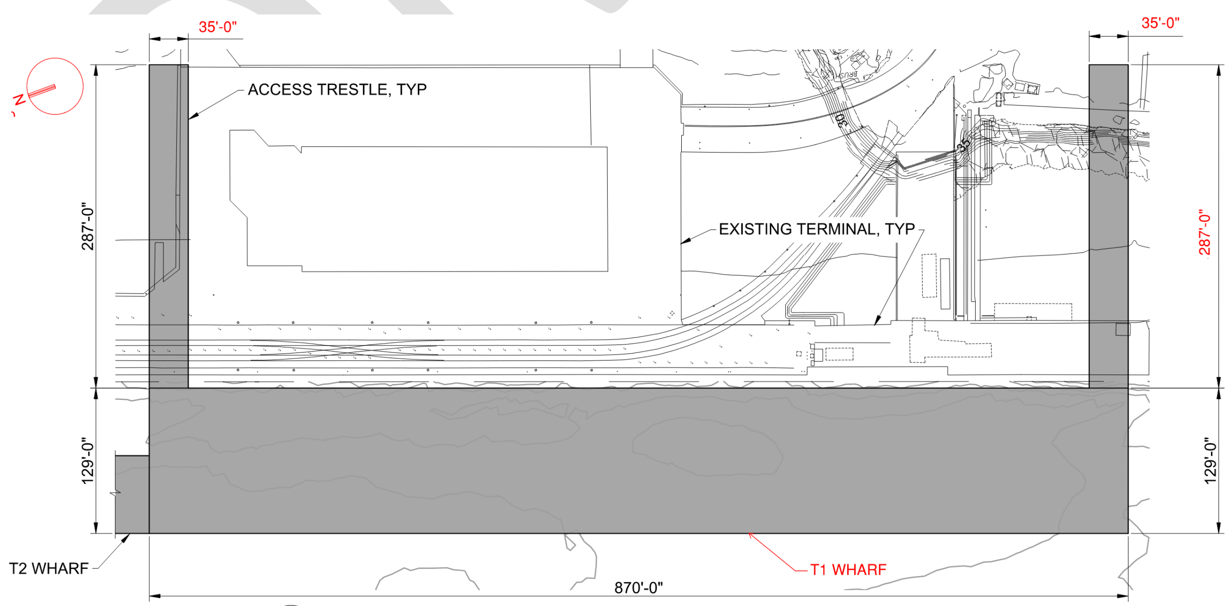


Figure 4-8. Terminal 1 (T1) Layout

T2 comprises a 934-foot-long by 69-foot-wide wharf deck and three access trestles. The southern and northern access trestles are approximately 334 feet long and 35 feet wide. The middle trestle is 334 feet long and 55 feet wide to accommodate an additional emergency vehicle access lane. T2 supports the RO/RO operation of TOTE and potentially POL loading and unloading operations. The middle trestle carries the potential POL piping on its southern side.

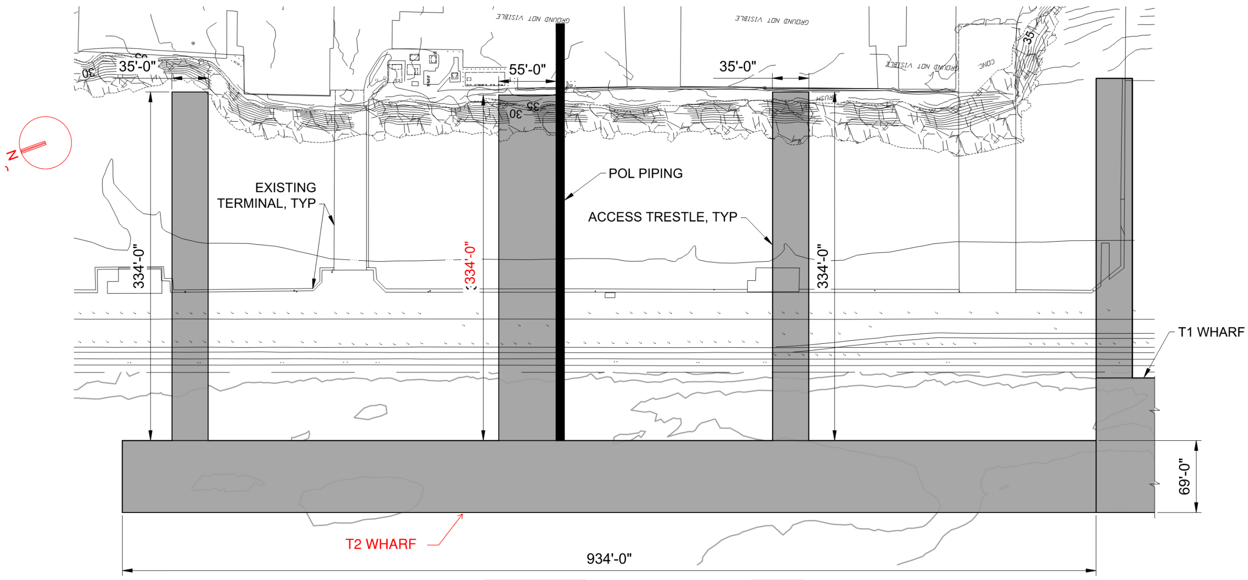


Figure 4-9. Terminal 2 (T2) Layout

4.4 Cofferdams, Caissons and Bulkheads

During previous studies, outlined in Section 3.1, the idea of non-pile driving alternatives such as stabilizing the soils beneath the existing sheet pile wall was deemed infeasible. This analysis is also applicable to other gravity wall systems, such as coffer dams or caissons. Regardless of the gravity wall method chosen, the cost to stabilize the deep soils beneath the gravity wall structures make gravity wall concepts infeasible at the POA.

4.5 Alternative 1A (48-inch-diameter Driven Piles)

For Alternative 1A, the wharves and access trestles are supported by 48-inch-diameter vertical steel pipe piles. Vertical steel pipe piles are preferred to support marine structures because they have a proven track record of constructability over water, demonstrate good seismic performance, and were installed successfully on the recently completed PCT. The existing terminals at the POA were constructed using mostly vertical steel pipe piles. The steel pipe piles on existing port structures have exhibited good ice load resistance, which is an important consideration in the seasonally cold climate of Alaska.

4.5.1 Description

4.5.1.1 Terminal 1 Wharf

Figure 4-10 displays the substructure and foundation layout for the T1 wharf for Alternative 1A (refer also to Appendix B). The overall size of the wharf is 870 feet long by 129 feet wide. The typical pile spacing for 48-inch-diameter piles is 20 feet on center (o.c.). For piles supporting the crane rail beams (rows A and E), the spacing is reduced to 10 feet o.c. due to the higher axial load imposed by the cranes. It is estimated that 394 of the 48-inch-diameter piles are required to support the T1 wharf for this alternative. The pile length is expected to be 200 feet for typical piles, and 220 feet for piles supporting the crane rails beams (rows A and E). The pile wall thickness is expected to be 1.5 inch.

Figure 4-11 shows the typical section of the wharf for T1. The total wharf width is 129 feet, with a 72-foot spacing between crane rail beams to accommodate 72-foot gauge cranes. Three 10-foot-wide truck lanes are provided between the crane rails (Figure 4-11). A 40-foot-wide hatch cover area is provided at the landside of the wharf for hatch cover storage. If the 100-foot gauge cranes are preferred, then the hatches would be stored either on the crane, on the ship, or between the crane legs.

The wharf superstructure comprises 28-inch-thick, solid, precast slabs with a composite 8-inch-thick cast-in-place (CIP) concrete topping. The precast slabs span 18 to 20 feet between pile bents and are supported by 4-foot-deep concrete pile caps. The pile caps are supported by 48-inch-diameter steel pipe piles. The steel pipe piles are connected to the pile caps via a concrete plug embedded in the top of the steel pipe pile and steel dowels extending into the pile cap.

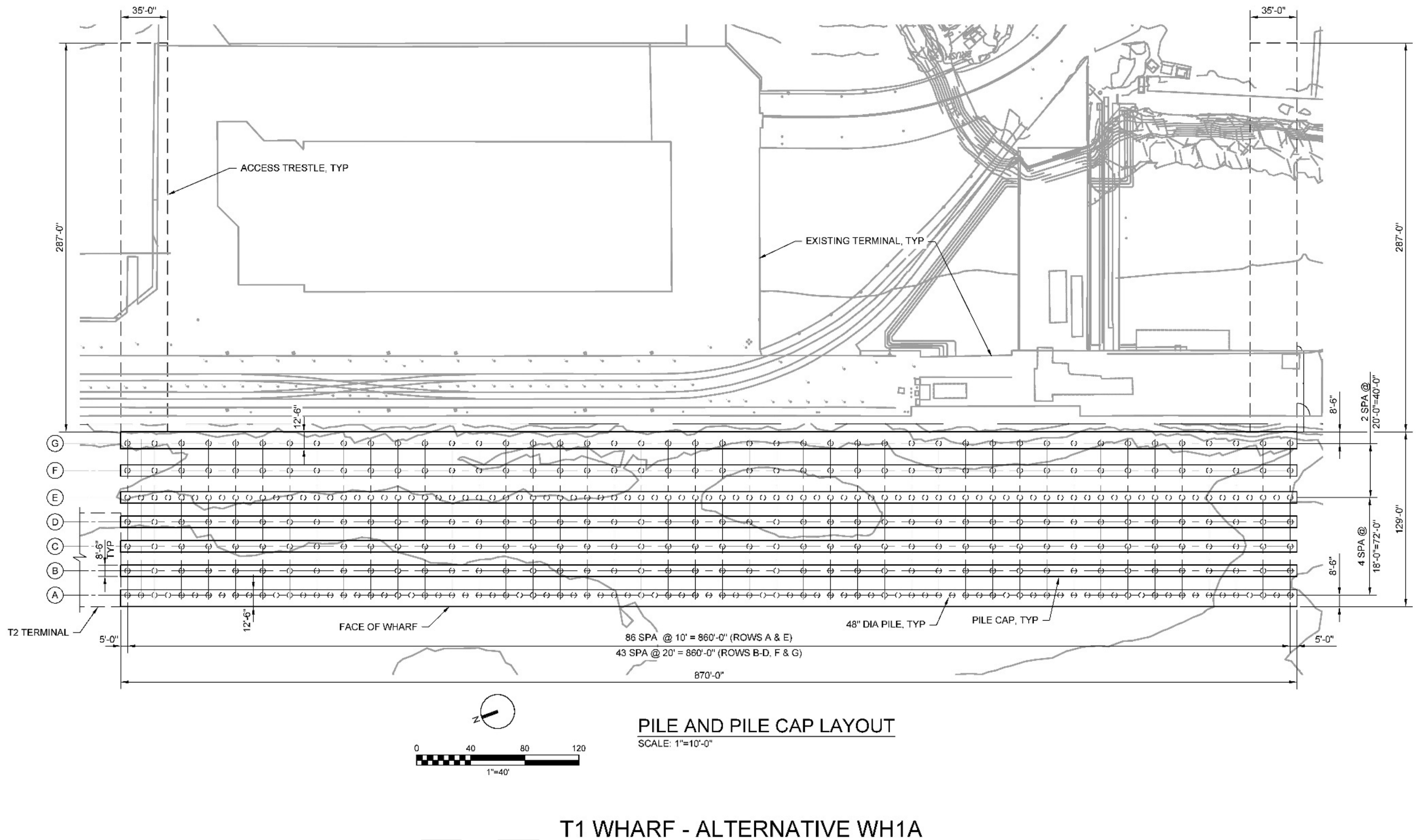


Figure 4-10. Wharf Pile Layout for Terminal 1: Alternative 1A with 48-inch-diameter Driven Piles

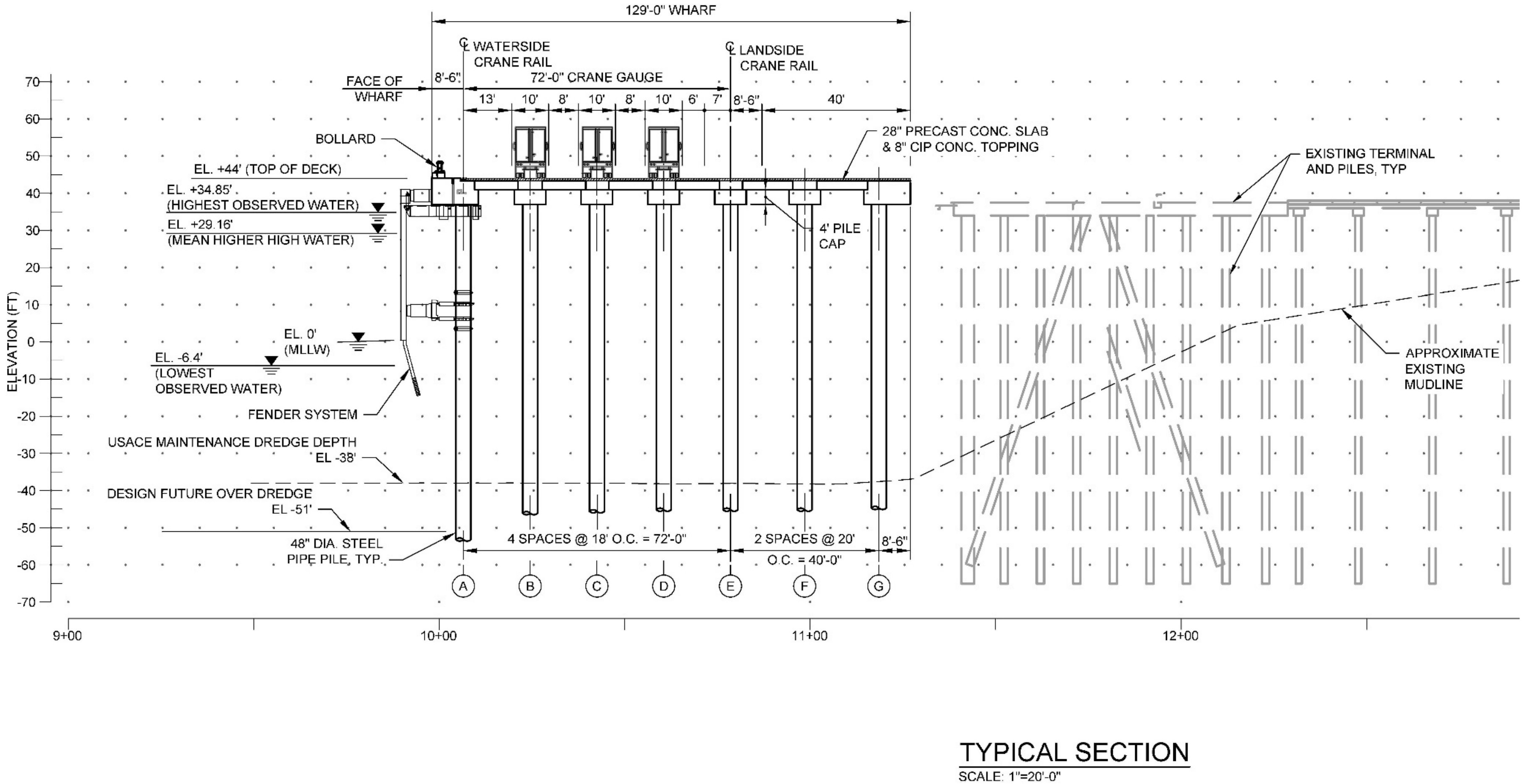


Figure 4-11. Typical Wharf Section for Terminal 1: Alternative 1A with 48-inch-diameter Driven Piles

4.5.1.2 Terminal 2 Wharf

Figure 4-12 depicts the substructure and foundation layout for this alternative's T2 wharf (refer also to Appendix B). The overall size of the wharf is 934 feet long by 69 feet wide. The typical pile spacing for 48-inch-diameter piles is 20 feet o.c. in the longitudinal direction and 18 feet o.c. in the transverse direction. A total of 188 of the 48-inch-diameter piles is required to support this T2 wharf. The pile length is expected to be 200 feet. The pile wall thickness is expected to be 1.5 inches.

Figure 4-13 shows the typical section of the wharf for T2 (refer also to Appendix B). The total wharf width is 69 feet. The T2 wharf will be separated from the T1 wharf by an expansion joint.

Similar to T1, the superstructure of the T2 wharf comprises 28-inch-thick, solid precast slabs with a composite 8-inch-thick CIP concrete topping. The precast slabs span approximately 18 feet and are supported by 4-foot-deep concrete pile caps. The pile caps are supported by 48-inch-diameter steel pipe piles. The steel pipe piles are connected to the pile caps via a concrete plug embedded in the top of the steel pipe pile and steel dowels extending into the pile cap.

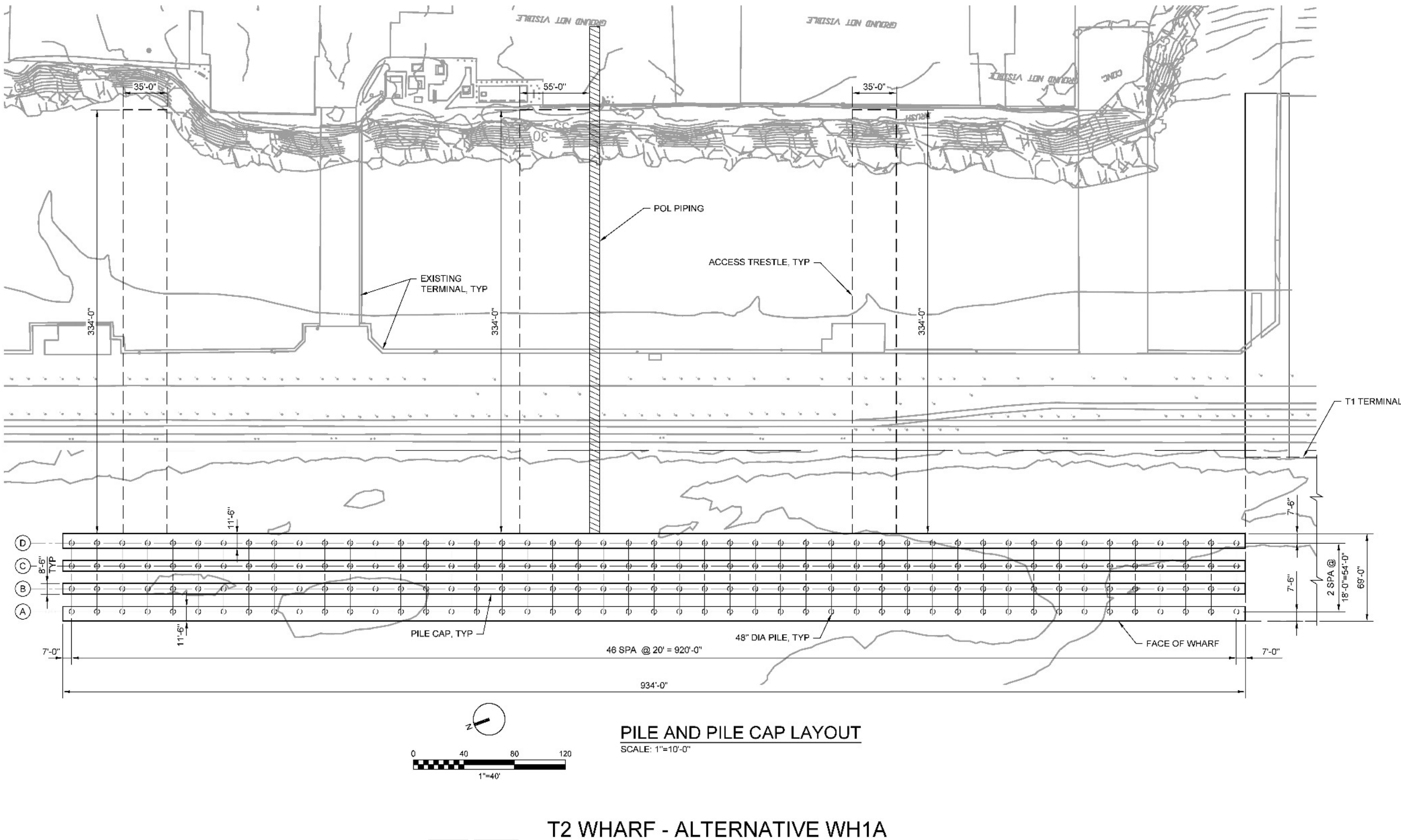


Figure 4-12. Wharf Pile Layout for Terminal 2: Alternative 1A with 48-inch-diameter Driven Piles

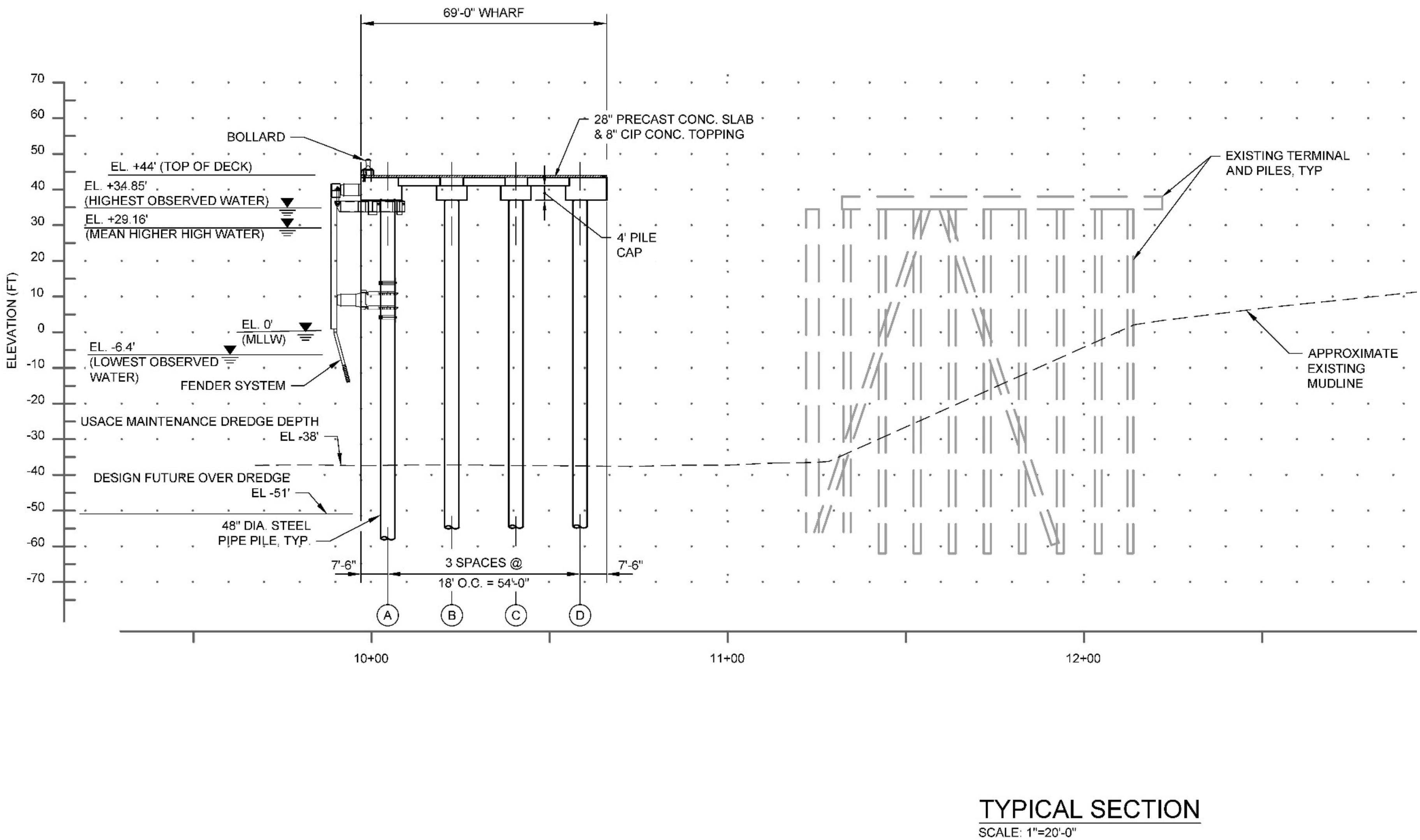


Figure 4-13. Typical Wharf Section for Terminal 2: Alternative 1A with 48-inch-diameter Driven Piles

4.5.1.3 Terminal 1 and Terminal 2 Access Trestles

Figures 4-14 through 4-17 show the substructure and foundation layout and the longitudinal elevation for typical access trestles for T1 and T2, respectively (refer also to Appendix C). Trestle lengths vary between approximately 287 feet for T1 to approximately 334 feet for T2. These trestle lengths are based on the assumed embankment location and presented for comparison between the alternatives.

Each trestle includes bents spaced at approximately 19.5 to 40 feet o.c. The pile cap at each bent is supported by three 48-inch-diameter piles spaced at 15 feet o.c. in the transverse direction. A total of 60 of the 48-inch-diameter piles are required to support the two access trestles for T1, and 110 of the 48-inch-diameter piles are required for the three access trestles for T2. The pile lengths vary and are expected to be no more than 180 feet. The pile wall thickness is expected to be 1.625 inches.

Figure 4-18 shows the typical sections of the access trestle (refer also to Appendix C). Except for the middle trestle at T2, all access trestles are approximately 35 feet wide. The middle trestle at T2 is approximately 55 feet wide because it includes a lane for emergency vehicle access. The trestle superstructure includes 30-inch-thick, voided, prestressed precast slabs with a composite 8-inch-thick CIP concrete topping (Figure 4-18). The precast slabs span approximately 40 feet and are supported by 4-foot-deep concrete pile caps. For the middle trestle at T2, the pile cap also has an overhang that extends south and supports the POL piping. The pile caps are supported by 48-inch-diameter steel pipe piles. The steel pipe piles are connected to the pile caps via a concrete plug embedded in the top of the steel pipe pile, and steel dowels extending into the pile cap.

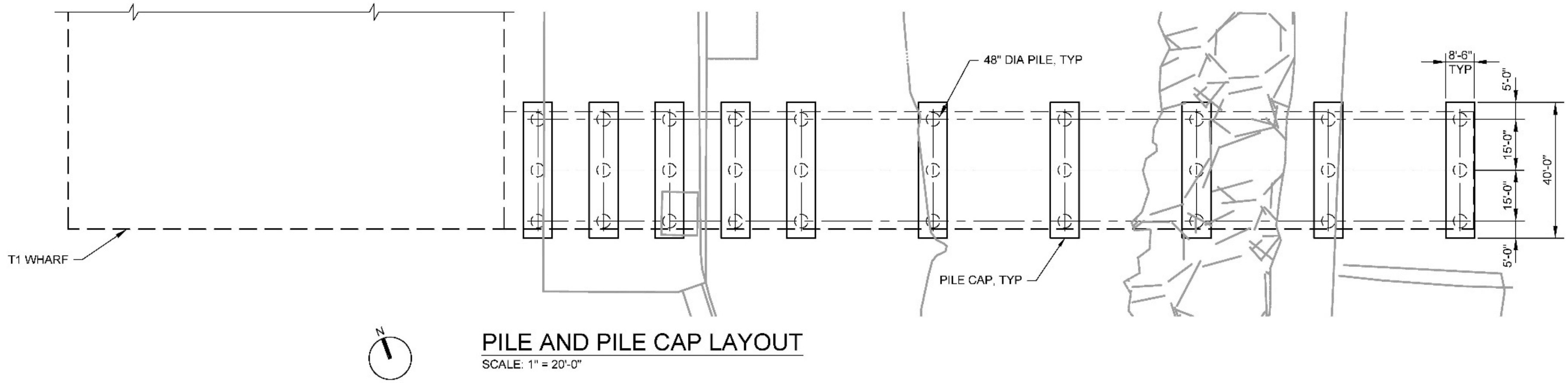


Figure 4-14. Pile Layout for Terminal 1 Access Trestle: Alternative 1A with 48-inch-diameter Driven Piles

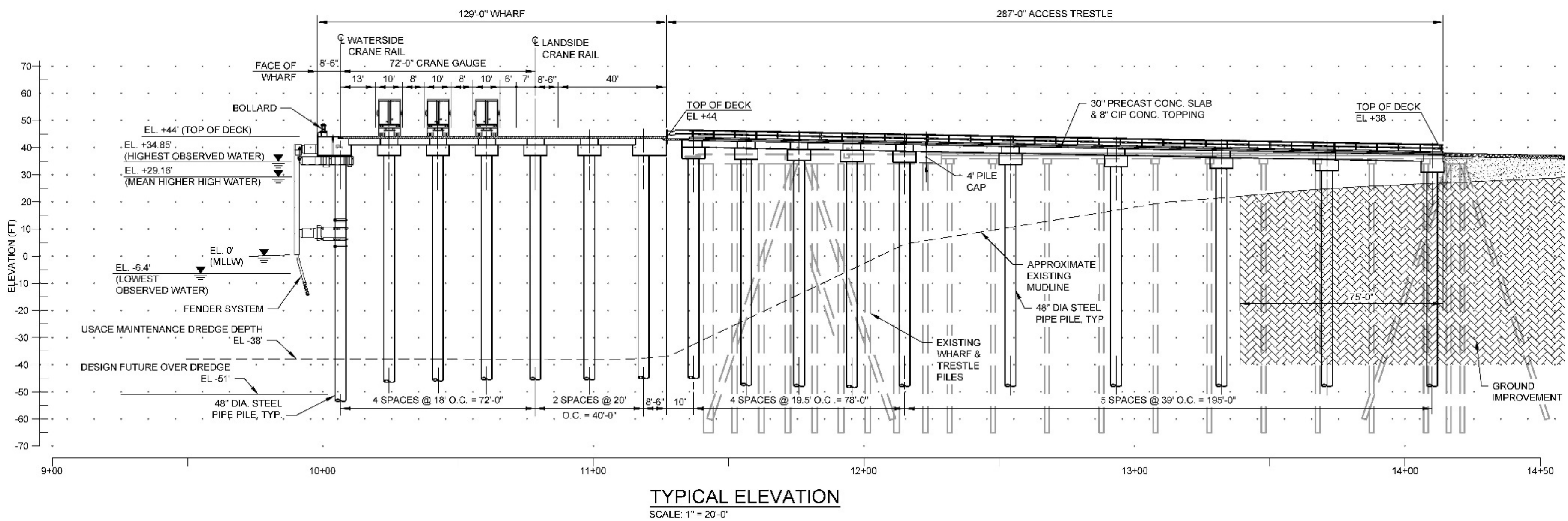


Figure 4-15. Longitudinal Elevation for Terminal 1 Access Trestle: Alternative 1A with 48-inch-diameter Driven Piles

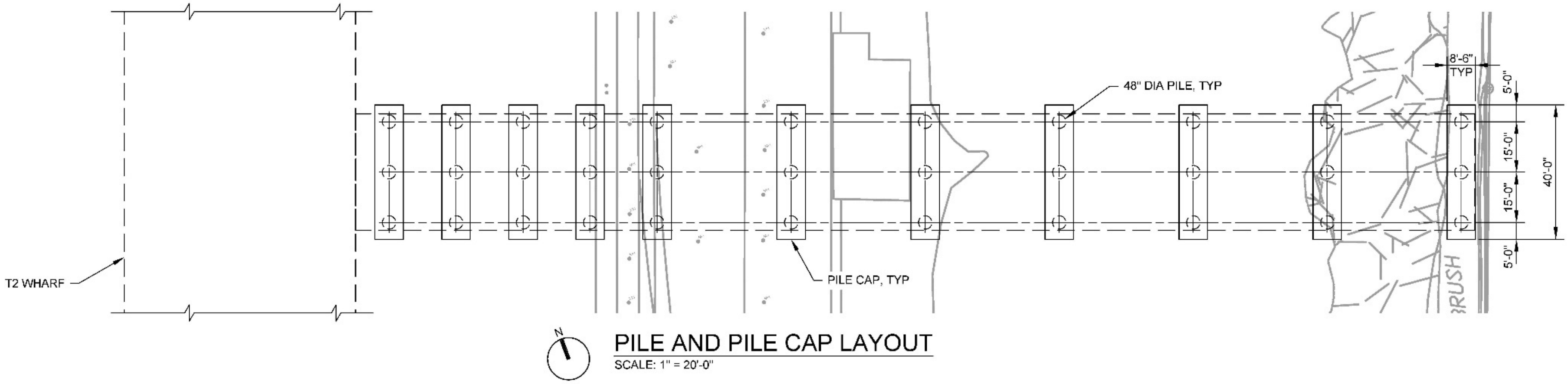


Figure 4-16. Pile Layout for Terminal 2 Access Trestle: Alternative 1A with 48-inch-diameter Driven Piles

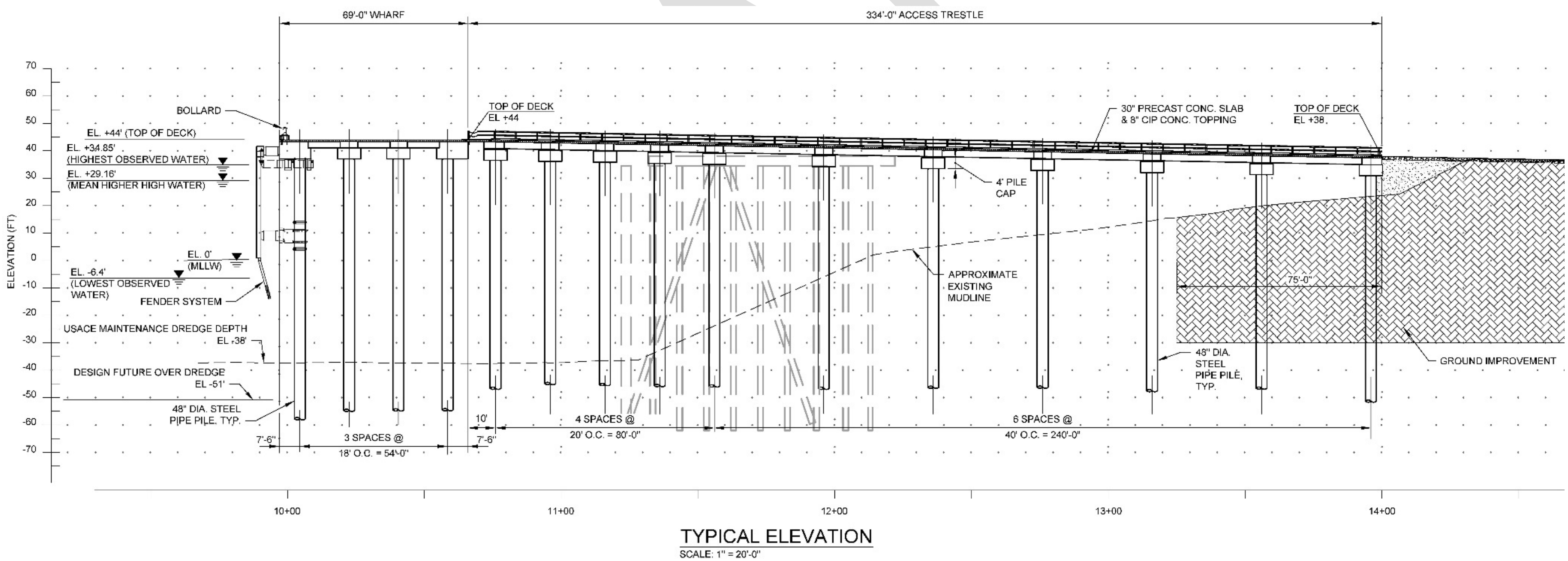


Figure 4-17. Longitudinal Elevation for Terminal 2 Access Trestle: Alternative 1A with 48-inch-diameter Driven Piles

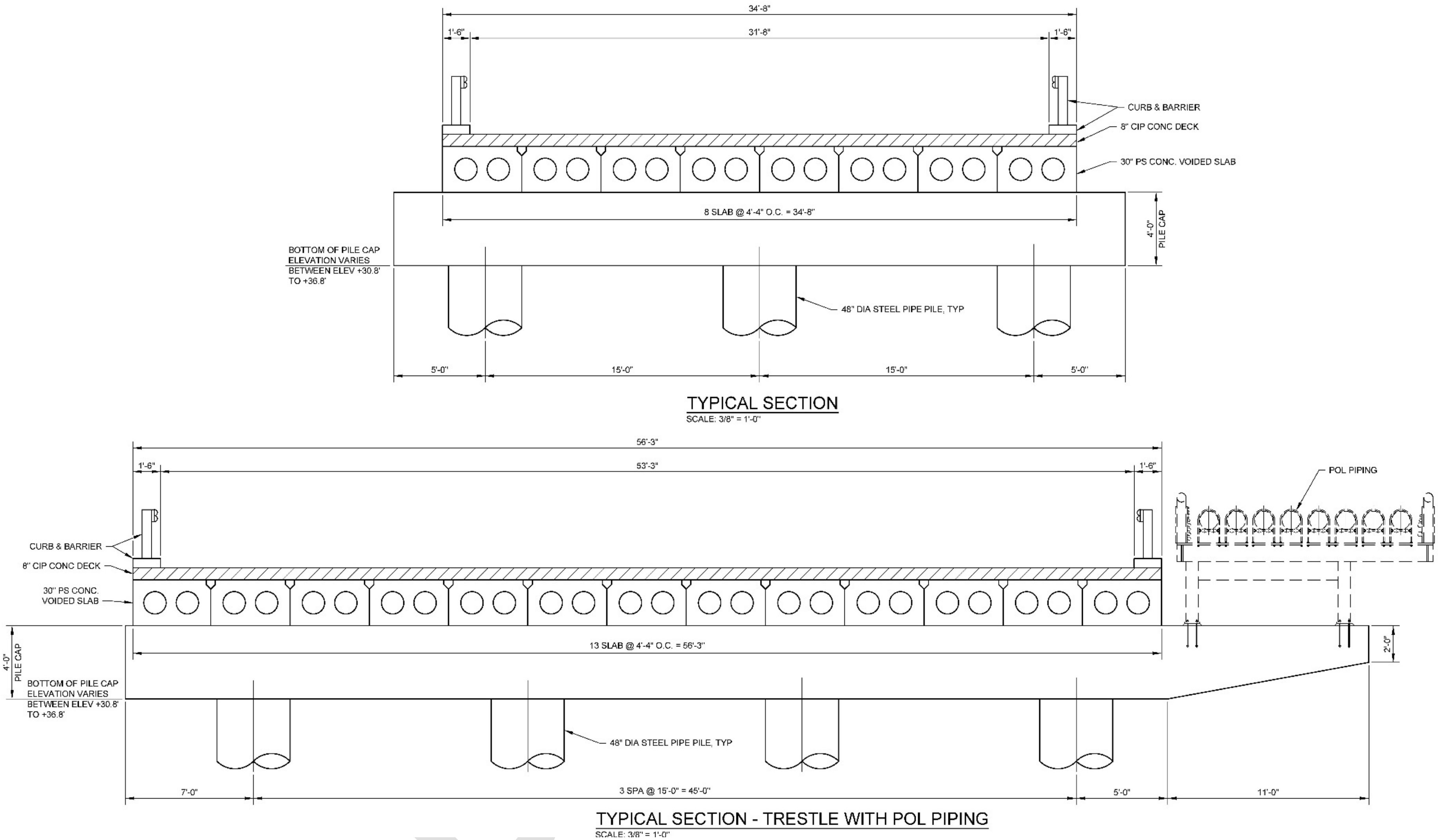


Figure 4-18. Typical Section for Typical and POL Access Trestles: Alternative 1A with 48-inch-diameter Driven Piles

4.5.2 Constructability and Noise Mitigation

4.5.2.1 Pile Driving

48-inch-diameter steel pipe piles installed with conventional impact driving or vibratory driving have been used successfully at the new PCT, which is close to completion. The piles installed at the PCT are of comparable size and length to the typical piles proposed for Alternative 1A, and the site geology is also similar. No significant pile driving issues with the 48-inch-diameter piles have been reported during PCT construction, although the piles were driven in a greenfield site. The new trestles at T1 and T2 will be partially constructed through the existing T1 and T2 pile fields. Therefore, the new piles for T1 and T2 will need to be positioned to avoid the existing piling, the pattern of which can be as close as 9 feet o.c. (CH2M 2021a).

Although installing new piles within the constraints of the existing pile field will have its challenges, there will also be some advantages. The existing T1 and T2 structures could be used for contractor's operations, staging, and temporary storage of materials for the installation of the new wharf structures constructed offshore of the existing berth line. By delaying the demolition of T1 and T2 to near the end of construction, the contractors will benefit from the large staging area on the existing wharves.

Additional axial capacity is required for the piles supporting the crane rail beams, due to the heavy load from the container gantry cranes. This additional capacity can be achieved in two ways:

1. Drive the pile open-ended to the underlying GFo layer, at approximate EL. -180 feet (MLLW). The high end-bearing capacity of the GFo layer is expected to provide the axial resistance required.
2. Drive the pile close-ended and terminate the pile in the upper SC (upper BCF clay) layer above the GFo layer. Due to the higher end-bearing capacity of close-ended pile, this option will also provide sufficient axial capacity. Drivability analyses of close-ended piles confirmed that 48-inch-diameter piles can be driven to the depth required to achieve the required end-bearing capacity.

4.5.2.2 Noise Mitigation

For Alternative 1A, it is expected that the noise and vibration associated with impact hammer pile driving can be high and may negatively affect marine mammals in the area. Pile driving noise can be reduced using the various noise mitigations discussed in Section 5.

4.5.2.3 Temporary Piles

Temporary piles are sometimes used to support temporary work platforms during marine structure construction to provide a fixed structure upon which the contractor can place equipment and materials to facilitate the construction of the permanent structure (Figure 4-19). Temporary piles are also sometimes used to support pile-driving templates or as temporary supports for formwork or precast pile caps. While constructing the new PCT, many temporary piles were installed to support the construction activities. Although the use of temporary piles effectively mitigates risk in the challenging marine environment, concerns were raised that the additional piling may increase noise impacts on marine mammals.

Figure 4-19. Typical Temporary Work Platform, Petroleum and Cement Terminal, Port of Alaska

Dependence on temporary piles can be reduced, or alternatively their noise impacts can be mitigated, in the following ways:

- **Cantilever Construction Method**: Sometimes referred to as the "cantitraveler" or "cantilevered bridge" method, this common method of constructing marine trestles has been used successfully around the world. The method uses a mobile work platform supported on permanent piles that have already been installed, thus eliminating the need for a temporary work platform and the associated piling. The pile guides and templates are cantilevered out from completed bents in the main work platform to facilitate pile installation work in the adjacent bent.

  A typical cantitraveler platform consists of a main carriage frame that supports a work deck for the crawler crane, equipment, and personnel. The carriage frame has steel wheels that ride on steel rail girders supported by the already finished bents. The rail girders are typically individual simple-span girders that can be picked up by the crane and repositioned as the construction progresses along the frame of the wharf deck. The main carriage frame is typically supported on a single span, and this allows completion of the superstructure behind the advancing pile rig.

  The cantilevered bridge construction method is a variation of the cantitraveler method, in which the work platform is supported on a steel through-truss that extends over multiple spans of the trestle. This method is typically more suitable for longer trestles and larger trestle spans, and not commonly used for marine construction.

  The basic construction cycle of the cantilevered method consists of these general steps:

  1. Install piles
  2. Install pile cap
  3. Install temporary bracing
  4. Transfer rail girders
  5. Move cantitraveler platform
  6. Install superstructure element on the back span

At the beginning of each cycle, after all the piles for a particular bent have been installed and cut off at the specified elevation, the precast pile cap is positioned and attached to the piles. A concrete plug will be cast into the pile with steel reinforcing dowels designed to extend vertically into preformed holes in the precast pile cap. The connection is made between the pile and pile cap by placing in the preformed holes in the pile cap, thus binding the piles to the pile cap. At least 7 days of curing time is typically required for the concrete to gain sufficient strength before any loads can be placed on the structure. This limits how fast the cantitraveler can be moved forward and begin constructing the next bent. By designing reusable steel frames, it may be possible to advance the piling rigs without waiting for the concrete to gain strength. To initiate this method of construction, typically two pile bents are installed using the crane located on land.

The trestle span length that can be achieved with the cantilever construction method is limited by the size of available cranes. For example, for Alternative 1A, the crane may need to lift a 75-ton pile and reach out to the next span. Span lengths of up to 60 feet can be achieved with cranes commonly available to contractors in Alaska.

The cantilevered construction method is most effective when used to construct long, linear types of trestles. To construct the five shorter trestles at T1 and T2, the cantitraveler would need to be broken down after finishing each trestle and moved to the next one. This process will incur additional time and cost.

- **Helical Piles as Temporary Piles**: As discussed in Section 5, the installation of helical piles benefits from low noise levels compared with conventional impact pile driving. If the selected construction method requires temporary work trestles supported by temporary piles, helical piles would be a good alternative to conventionally driven piles from a noise mitigation perspective.

  During a recent project in Seattle, Washington, 22-inch-diameter helical piles were successfully used to support temporary work trestles (Figure 4-20). This project is at a vibration-sensitive site, and impact or vibratory pile driving were prohibited. The use of helical piles proved successfully in limiting vibration impacts to adjacent occupied buildings.

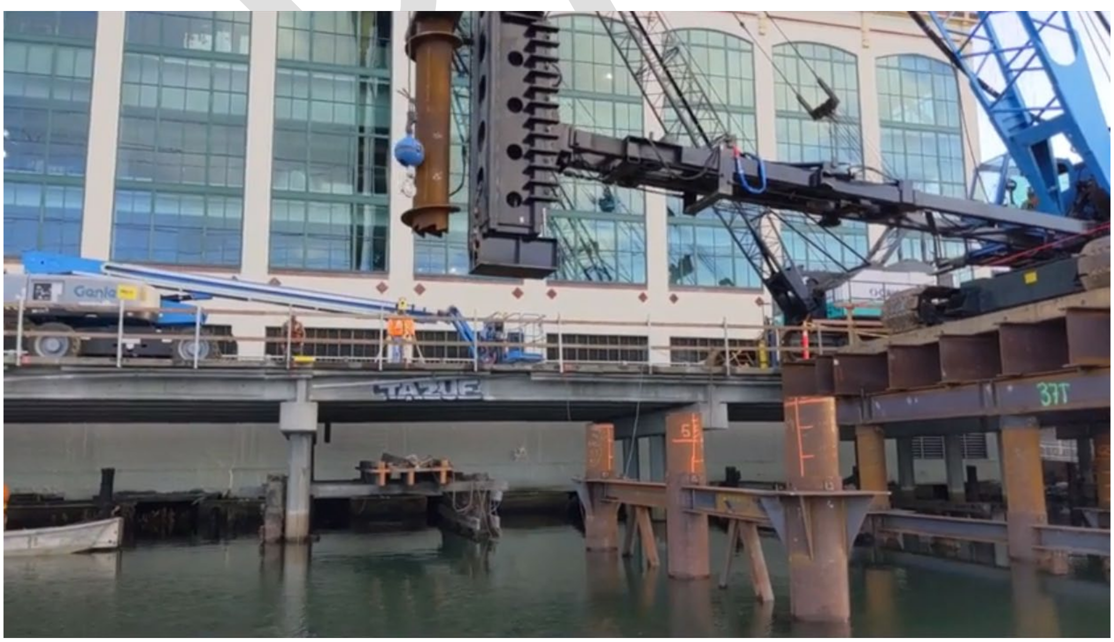


Figure 4-20. Example of Temporary Work Trestle Supported by Helical Piles: Fairview Avenue Bridge, South Lake Union, Seattle, Washington

(Source: Photograph taken by Jacobs and included with permission from Pileworks)

Note the helical pile suspended from the torquing apparatus in the crane rigging.

Preliminary calculations were carried out to confirm the suitability of helical piles as support for temporary work trestles at the POA site. Based on soil geology and expected loading, helical piles supporting temporary work trestles with a maximum span of 30 feet between pile bents is achievable at the port.

- **CIP Concrete Pile Cap**: Many temporary piles were used to support pile driving templates and temporary trestles during PCT construction. The temporary piles provide a stable platform to perform piling activities, which improves the accuracy of piling. It is important to install piles accurately, even in a marine environment, because precast pile caps are typically designed to accommodate a maximum of 6 inches of out of position tolerance. At locations with high current forces, this tolerance may be difficult to achieve without fixed pile driving templates.

  CIP pile caps can accommodate larger pile construction tolerances than precast pile caps by adjusting the dimensions during construction, although this practice should not be encouraged. The main disadvantage with CIP concrete pile caps in marine construction is that they would require the fabrication, support, bracing, and dismantling of the formwork for each pile cap, resulting in more labor-intensive and time-consuming over-water work.

4.6 Alternative 1B (Composite Helical Piles)

This alternative is a composite helical pile composed of an outer 48-inch-diameter pile installed to a nominal depth in the seabed to provide lateral stability and an inner 24-inch-diameter pile installed to the design toe depth to provide the required axial resistance and lateral resistance for the design. The annulus between the two piles will be filled with grout to provide composite action. As discussed in Section 5, helical piles have the unique benefit of low noise and vibration during installation when compared with conventional driven piles. Helical piles used in construction projects have been limited to 24 inches or smaller in diameter due to limitations of applying torque to the piles. Piles with such small diameter are expected to have stability issues in the water depths at the port.

The possibility of developing large-diameter helical piles specially for this project was also discussed with the supplier. However, it is unlikely that available equipment can install 48-inch-diameter helical piles to the depth required due to existing equipment being unable to apply the required torque. This concept is outlined via drawings in Appendix D.

While in principle this concept has potential, it has never been implemented on any other projects globally that Jacobs is aware of. Although innovation is what drives engineers to new and exciting solutions, it is noted that this concept is unproven and will carry significantly higher risks than the other alternatives discussed and will require extensive investigation, value engineering, and testing, adding to the cost and schedule of this alternative.

4.6.1 Description

4.6.1.1 Terminal 1 Wharf

The T1 foundation layout for Alternative 1B is the same as Alternative 1A (Figures 4-10 and 4-11). Structural analysis demonstrated that the global lateral response and resistance of the structure was not significantly affected by the use of composite helical piles.

It is estimated that a total of 394 composite helical piles are required to support the T1 wharf for Alternative 1B. The total lengths of the outer 48-inch-diameter pipe piles are expected to be approximately 150 feet. The lengths of the inner 24-inch-diameter helical piles are expected to be 220 feet to the design toe of the composite pile. The pile wall thickness of both pile types is expected to be 1.5 inches.

The wharf superstructure for Alternative 1B will be identical to that of Alternative 1A, comprising 28-inch-thick solid precast slabs with a composite 8-inch-thick CIP concrete topping. The precast slabs span approximately 18–20 feet and are supported by 4-foot-deep concrete pile caps. The pile caps are supported by 48-inch-diameter steel pipe piles extended by 24-inch-diameter helical piles at the toe.

4.6.1.2 Terminal 2 Wharf

The T2 wharf layout is essentially identical to Alternative 1A (Figure 4-12). A total of 188 of the 48-inch-diameter piles are required to support the T2 wharf for Alternative 1B. The length of the outer 48-inch-diameter pipe pile is expected to be approximately 150 feet. The length of the inner 24-inch-diameter pile is expected to be 220 feet. The pile wall thickness of both pile types is expected to be 1.5 inches.

The wharf superstructure for T2 adopting Alternative 1B is identical to that of Alternative 1A.

4.6.1.3 Terminal 1 and Terminal 2 Access Trestles

The access trestle layout for Alternative 1B is identical to that of the Alternative 1A (Figures 4-14 through 4-17). Each trestle includes a series of bents spaced at approximately 19.5 to 40 feet o.c. The pile cap at each bent is supported by three or four 48-inch-diameter composite piles spaced at 15 feet o.c. in the transverse direction. A total of 170 of the 48-inch-diameter composite piles is required to support the five access trestles. The length of the outer 48-inch-diameter pipe pile is expected to be approximately 150 feet. The length of the inner 24-inch-diameter helical pile is expected to be 220 feet. The pile wall thickness of both pile types is expected to be 1.625 inches.

4.6.2 Constructability

4.6.2.1 Pile Installation

Although Alternative 1B is expected to generate less noise than impact pile driving, it is unproven at this scale and would represent significant risks to the program (Appendix B provides more details). It would need more powerful specialized equipment to be developed, transported to Anchorage, and then used to drive piling. There are limited examples of industry practices and more piling would be required because the current maximum size is 24 inches.

4.7 Pile-supported Structure Alternatives with Larger-diameter Piles

This section investigates the potential of using larger-diameter (greater than 48-inch) piles to support the new T1 and T2 structures (refer also to Sections 4.8 and 4.9). There are several potential benefits in reducing the number of piles in the structures. The primary goal of using larger-diameter piles is to shorten the overall pile installation schedule, which has associated benefits of reducing the duration of hydroacoustic noise generated by piling and potentially also reducing overall cost. For the following analysis, 72-inch-diameter piles were selected for preliminary design, as they form a reasonable upper bound of pile diameter

For pile diameters greater than 72 inches to be economical and lead to a reduction in piles, the distance between the piles and the structural depth of the pile caps would both need to increase. The additional depth of the pile cap structural section would then push the bottom of the pile cap concrete formwork and pile cut off elevation into the high tide zone. This will make construction tide dependent, thus slower, less safe, and certainly more costly. Additionally, the decks spans would need to increase likely requiring precast concrete girders or steel girders. Changing from the planned precast deck slabs to deeper girders would further exacerbate the tidal construction problems noted above. And the steel girder option would be subject corrosion and likely would not meet the required 75-year design life.

Additionally, if the analysis shows 72-inch-diamter piles are a potential solution, 60-inch-diamter piling could be used as they are midway between 48-inch and 72-inch-diameter piling. While the 60-inch-diamter piling could be used, there would be more piling than the 72-inch-diameter piling, leading to additional pile driving, construction time, cost, and potential for beluga takes.

Sections 4.8 and 4.9 provide further details about the following alternatives:

- Alternative 2A: Wharves and trestles are designed to be supported by 72-inch-diameter steel pipe piles, installed by conventional impact hammer pile driving. Noise mitigation technologies discussed in Section 5 can be used with this alternative to reduce pile driving noise.
- Alternative 2B: Wharves and trestles are supported by 72-inch-diameter drilled shafts with permanent steel casing.

4.8 Alternative 2A (72-inch-diameter Driven Piles)

For Alternative 2A, the wharves and access trestle are supported by 72-inch-diameter vertical steel pipe piles. Steel pipe piles are commonly used to support marine structures and have a proven track record of constructability and good seismic performance.

4.8.1 Description

4.8.1.1 Terminal 1 Wharf

Figure 4-21 shows the substructure and foundation layout for the T1 wharf for Alternative 2A (refer also to Appendix E). The overall size of the wharf is 870 feet long by 129 feet wide. The typical pile spacing is about 39 feet o.c. in the longitudinal direction. For piles supporting the crane rail beams (rows A and C), the spacing is reduced to 19.5 feet o.c. due to the higher axial load imposed by the cranes. The typical transverse pile spacing is 36 feet. It is estimated that 136 of the 72-inch-diameter piles are required to support the T1 wharf for this alternative. The pile length is expected to be 200 feet maximum for typical piles, and 220 feet maximum for piles supporting the crane rails beams (rows A and C). The pile wall thickness is expected to be 1.75 inches maximum.

Figure 4-22 depicts the typical section of the wharf for T1 (refer also to Appendix E). The total wharf width is 129 feet, with a 72-foot spacing between crane rail beams to accommodate 72-foot gauge cranes. There are three 10-foot-wide truck lanes between the crane rails (Figure 4-22). A 40-foot-wide hatch cover area is located at the landside of the wharf for hatch cover storage.

The wharf superstructure includes 36-inch-thick solid precast slabs with a 10-inch-thick CIP concrete topping. The precast slabs span approximately 39 feet and are supported by 4-foot-deep concrete pile caps. The pile caps are supported by 72-inch-diameter steel pipe piles. The steel pipe piles are connected to the pile caps via a concrete plug embedded in the steel pipe pile with steel dowels extending into the pile cap.

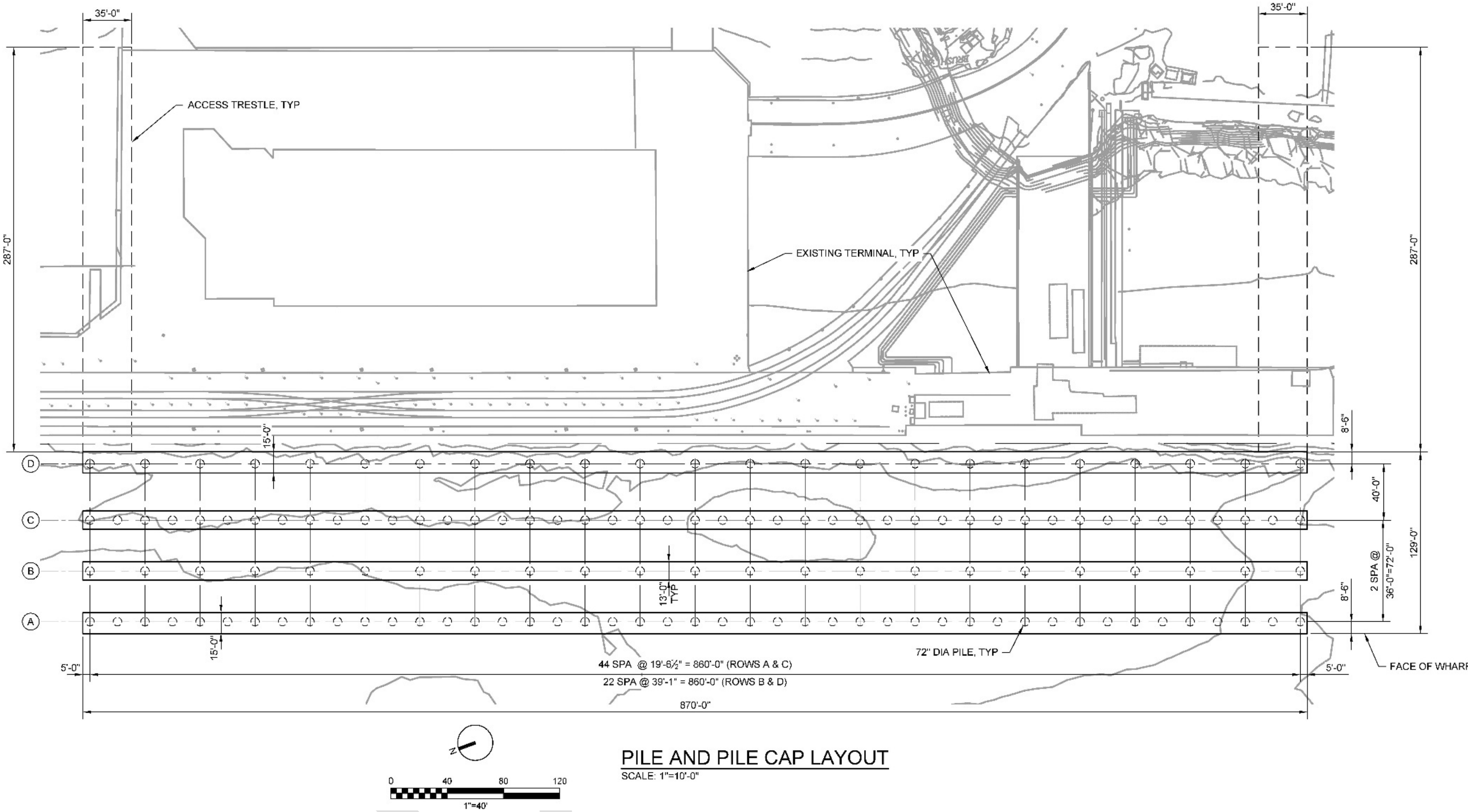


Figure 4-21. Wharf Pile Layout for Terminal 1: Alternative 2A with 72-inch-diameter Driven Piles

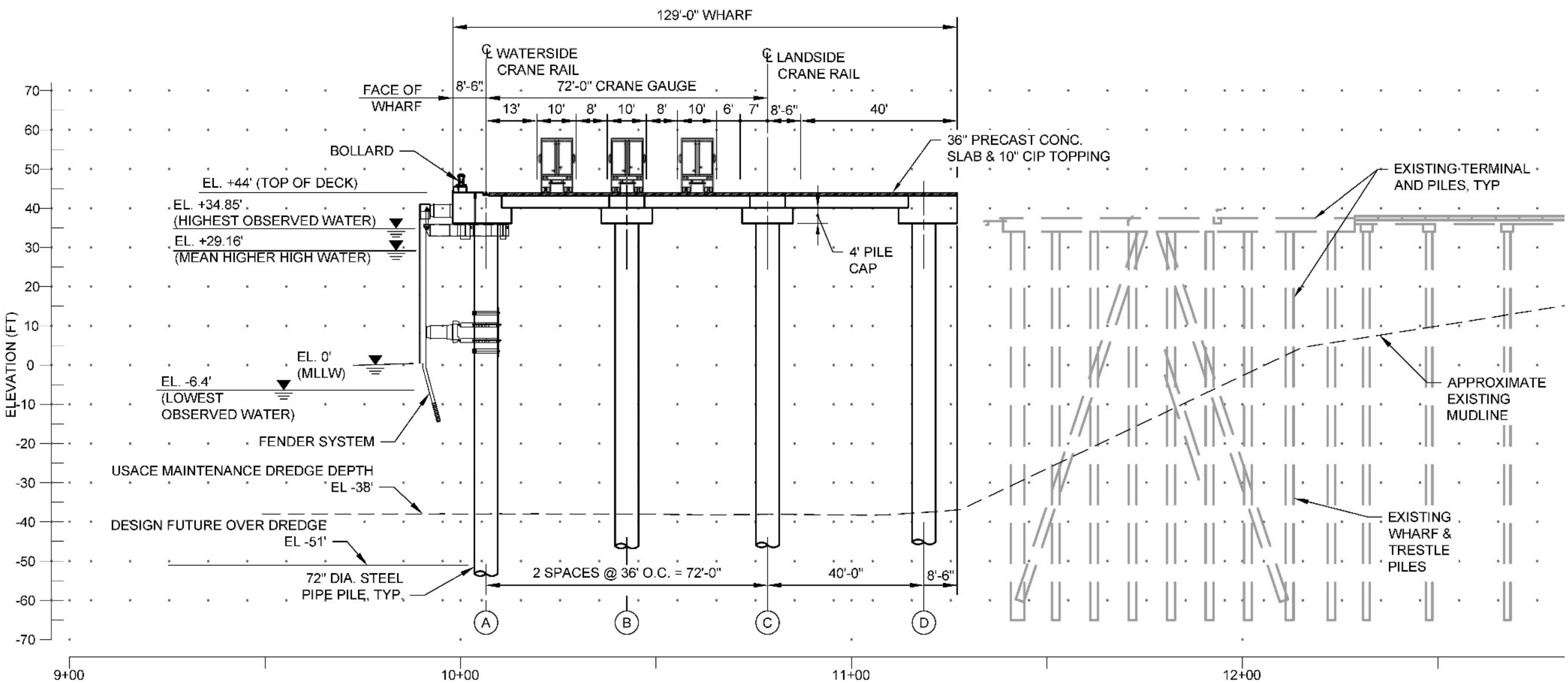


Figure 4-22. Typical Wharf Section for Terminal 1: Alternative 2A with 72-inch-diameter Driven Piles

4.8.1.2 Terminal 2 Wharf

Figure 4-23 displays the substructure and foundation layout for the T2 wharf for this alternative (refer also to Appendix E). The overall size of the wharf is 934 feet long by 69 feet wide. The typical pile spacing is 40 feet o.c. in the longitudinal direction and 27 feet o.c. in the transverse direction. Seventy-two 72-inch-diameter piles are required to support the T2 wharf for this alternative. The pile length is expected to be 220 feet. The pile wall thickness is expected to be 1.75 inches.

Figure 4-24 shows the typical section of the T2 wharf (refer also to Appendix E). The total wharf width is 69 feet. The T2 wharf will be separate from the T1 wharf by an expansion joint.

Similar to T1, the superstructure of the T2 wharf consists of 36-inch-thick solid precast slabs with a composite 10-inch-thick CIP concrete topping. The precast slabs span approximately 40 feet and are supported by 4-foot-deep concrete pile caps. The pile caps are supported by 72-inch-diameter steel pipe piles. The steel pipe piles are connected to the pile caps via a concrete plug embedded in the steel pipe pile and steel dowels extending into the pile cap.

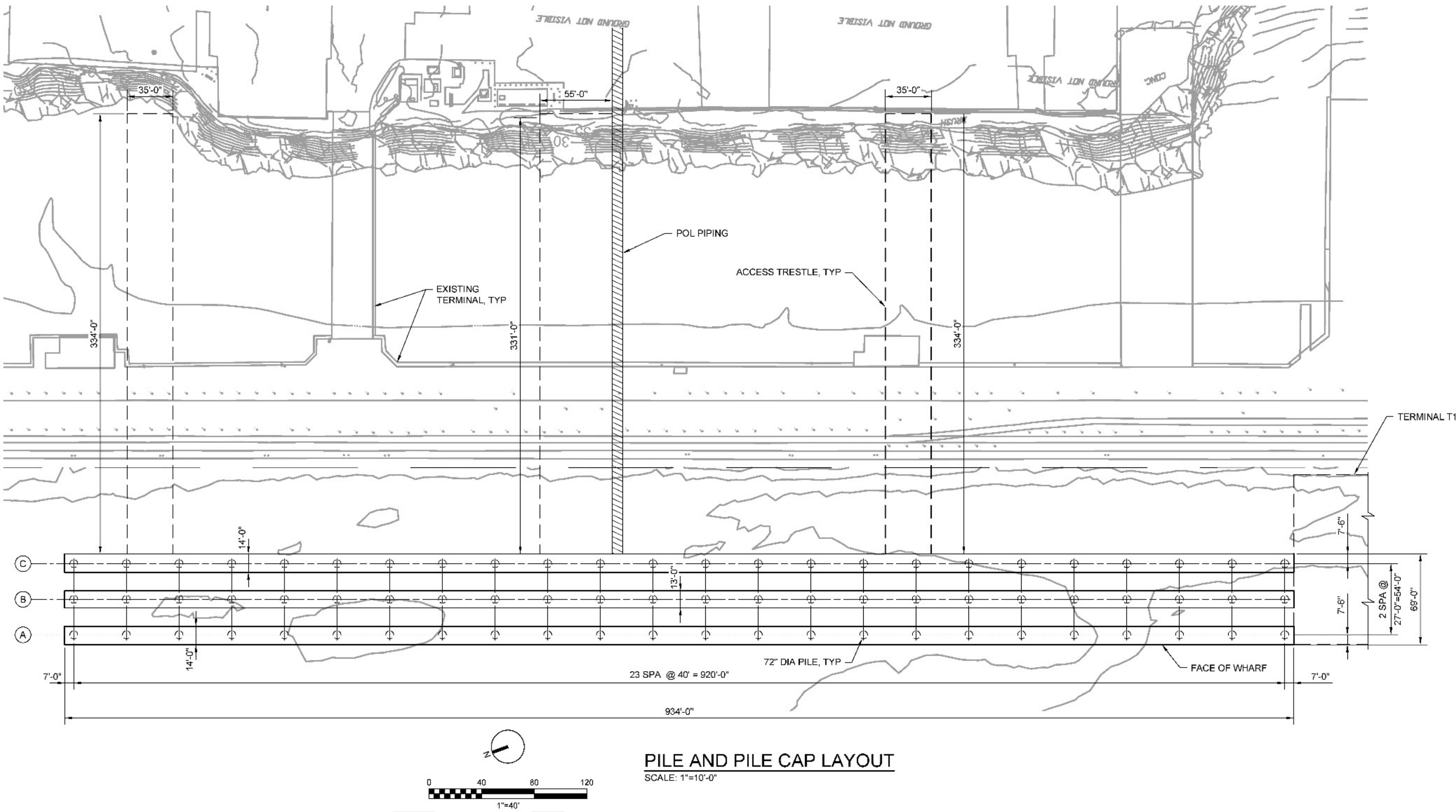


Figure 4-23. Wharf Pile Layout for Terminal 2: Alternative 2A with 72-inch-diameter Driven Piles

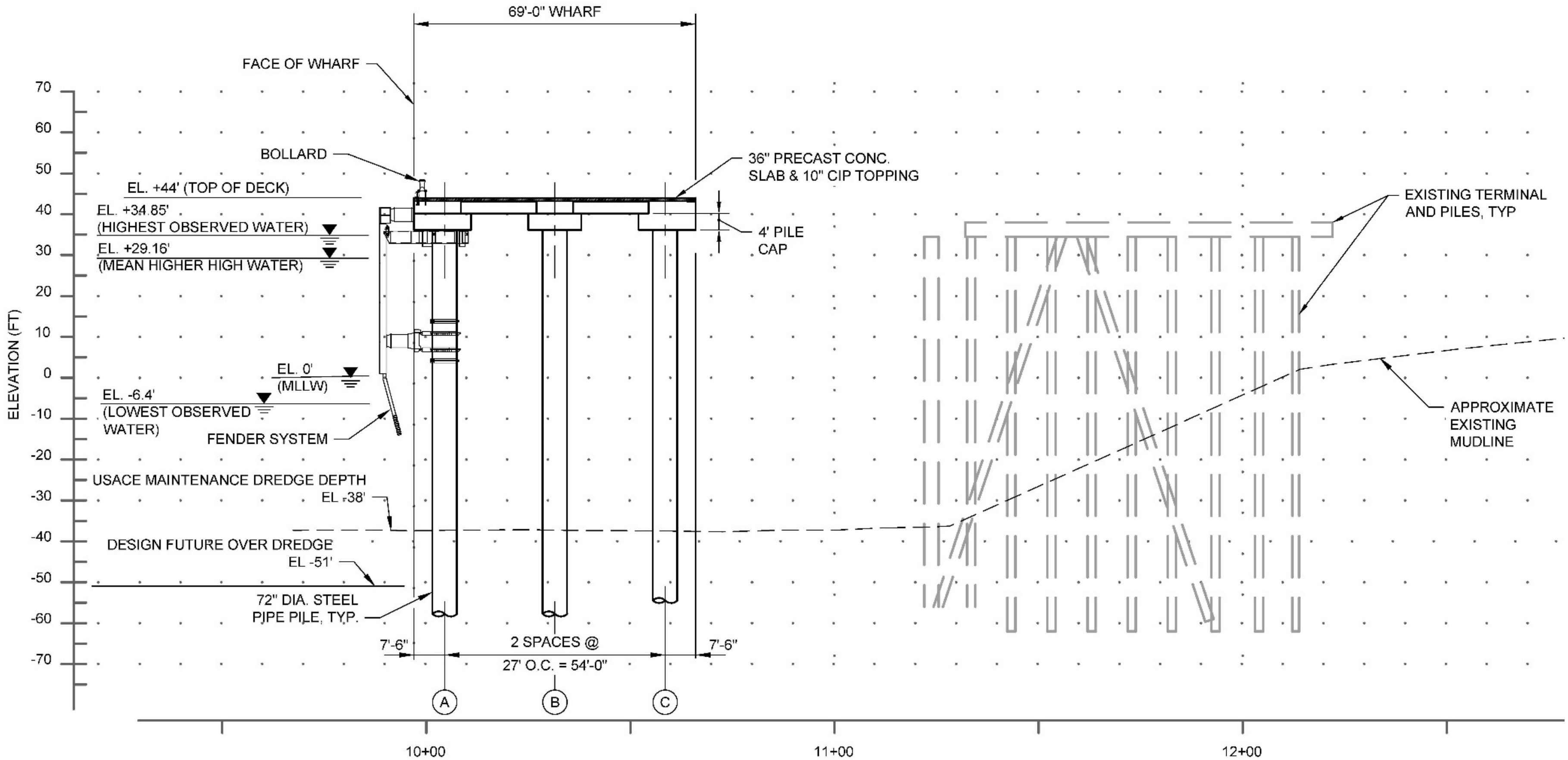


Figure 4-24. Typical Wharf Section for Terminal 2: Alternative 2A with 72-inch-diameter Driven Piles

4.8.1.3 Terminal 1 and Terminal 2 Access Trestles

Figures 4-25 through 4-28 show the substructure and foundation layout and the longitudinal elevation for T1 and T2 access trestles, respectively (refer also to Appendix F). Trestle length varies between approximately 287 feet for T1 to approximately 334 feet for T2. These trestle lengths are based on the assumed embankment location and are used for alternative comparison only. Each trestle consists of bents spaced typically at approximately 60 feet o.c. The pile cap at each bent is supported by two 72-inch-diameter piles spaced at 20 feet o.c. in the transverse direction. Seventy-three 72-inch-diameter piles are required to support the five access trestles. The pile length varies and is expected to reach 170 feet at the maximum. The pile wall thickness is expected to be 1.75 inches maximum.

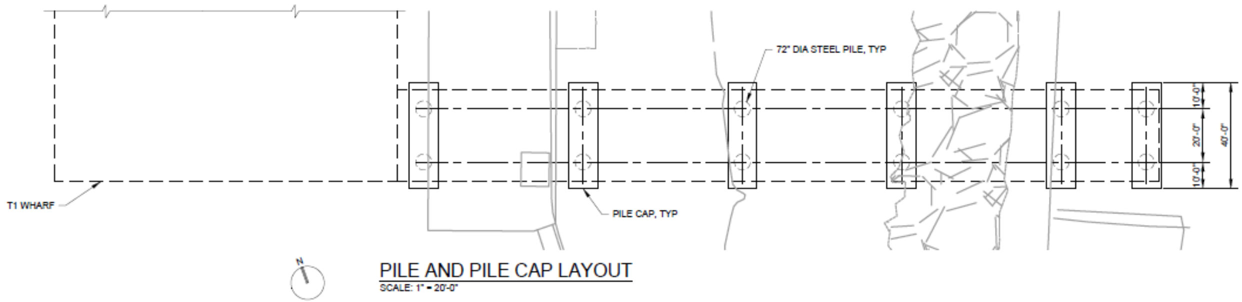


Figure 4-25. Pile Layout for T1 Access Trestles: Alternative 2A with 72-inch-diameter Driven Piles

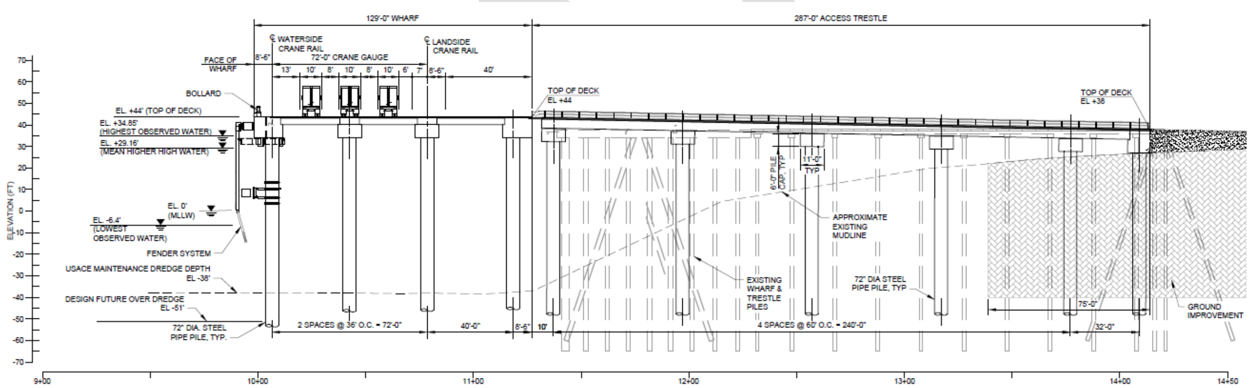


Figure 4-26. Longitudinal Elevation for T1 Access Trestles: Alternative 2A with 72-inch-diameter Driven Piles

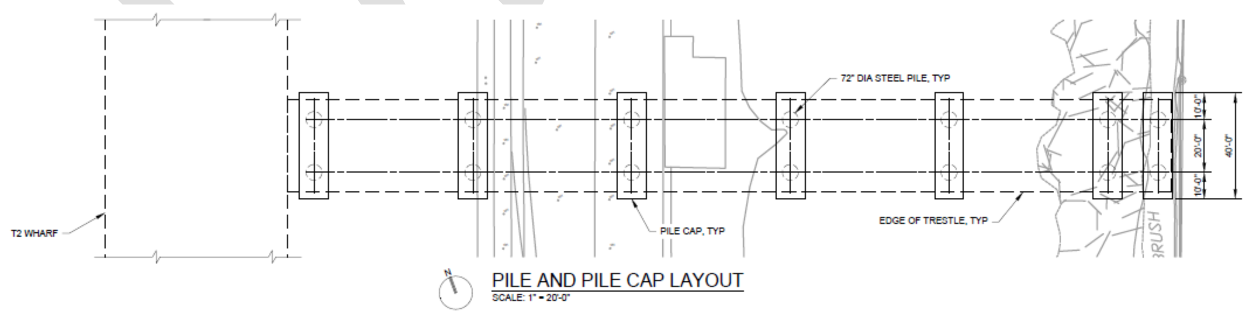


Figure 4-27. Pile Layout for T2 Access Trestles: Alternative 2A with 72-inch-diameter Driven Piles

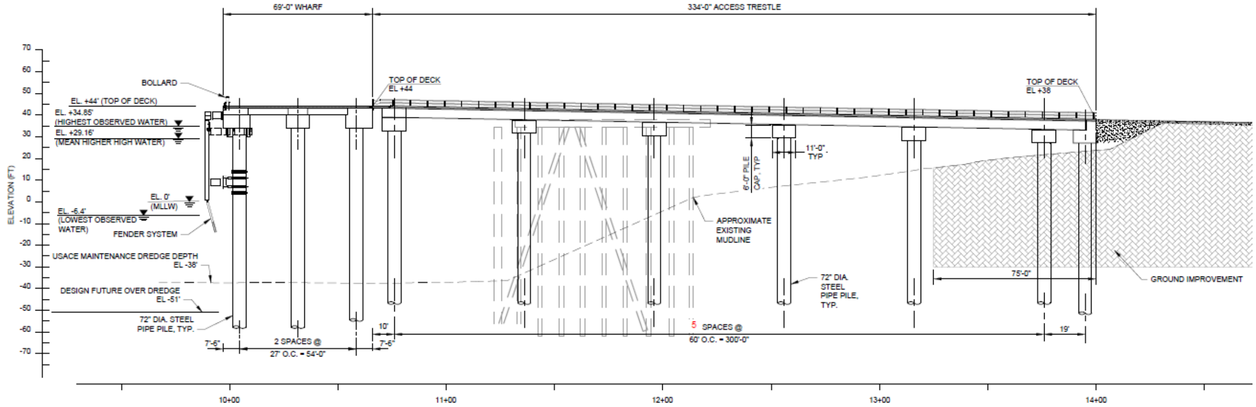


Figure 4-28. Longitudinal Elevation for T2 Access Trestles: Alternative 2A with 72-inch-diameter Driven Piles

Figure 4-29 depicts the typical sections of the access trestle (refer also to Appendix F). Except for the middle trestle at T2, all access trestles are approximately 35 feet in width. The middle trestle at T2 is approximately 56 feet wide. The trestle superstructure consists of 50-inch-deep, prestressed, precast concrete deck bulb-T girders with a 10-inch-thick CIP concrete topping (Figure 4-29). The precast girders span approximately 60 feet and are supported by 4-foot-deep concrete pile caps. For the middle trestle at T2, the pile cap also has an overhang that extends south and supports the POL piping. The pile caps are supported by 72-inch-diameter steel pipe piles. The steel pipe piles are connected to the pile caps via a concrete plug embedded in the steel pipe pile and steel dowels extending into the pile cap.

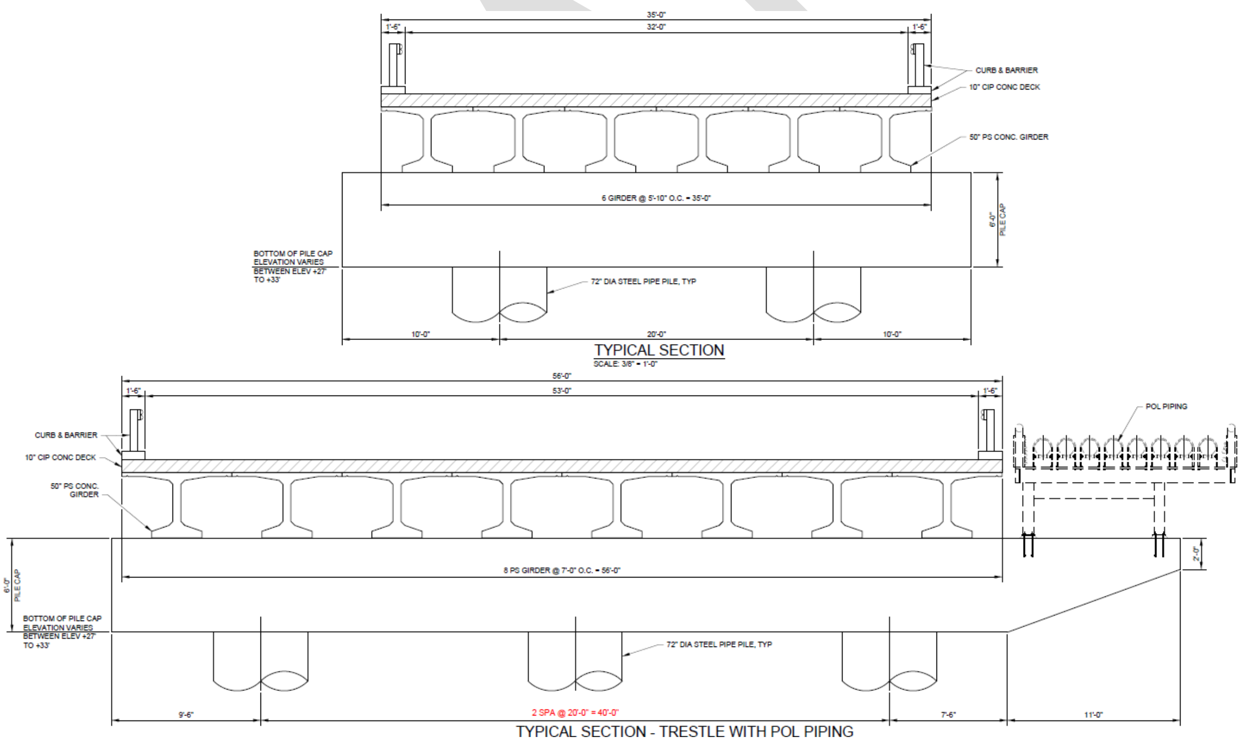


Figure 4-29. Typical Section for Typical and POL Access Trestles: Alternative 2A with 72-inch-diameter Driven Piles

4.8.2 Constructability

4.8.2.1 Pile Driving

It is expected 72-inch-diameter steel pipe piles can be installed with conventional impact driving or vibratory driving to the depth required for typical piles.

For the piles supporting the crane rail beams, additional axial capacity is required due to the heavy load from the container gantry cranes. This can be achieved via two options:

1. Drive the pile open-ended to the underlying GFo layer, located at approximately -180 feet (MLLW). The high end-bearing capacity of the GFo layer will provide the axial resistance needed.
2. Drive the pile closed-ended and terminate the pile in the upper glaciolacustrine SC (upper BCF clay) layer above the GFo layer. Due to the higher end-bearing capacity of closed-ended piles, this option will also provide sufficient axial capacity. Additional drivability analysis was performed to confirm that 72-inch-diameter pile can be driven closed-ended to the depth required. Appendix B provides the drivability analysis.

This alternative with larger-diameter piles reduces the number of piles to be driven and offers several constructability advantages and a few disadvantages. Because there are fewer piles, benefits to schedule and cost should be realized. Additionally, with the number of piles in the access trestles reduced, the distance between piles will increase, thus reducing pile driving conflicts in areas where the pile fields of existing wharves are located.

4.9 Alternative 2B (72-inch-diameter Drilled Shafts)

This alternative considers replacing the 72-inch-diameter driven piles with a drilled shaft system with a one-for-one replacement.

4.9.1 Description

4.9.1.1 Terminal 1 Wharf

Figure 4-30 shows the substructure and foundation layout for the T1 wharf for this alternative (refer also to Appendix G). The overall size of the wharf is 870 feet long by 129 feet wide. The typical shaft spacing in the longitudinal direction is about 39 feet o.c. The longitudinal spacing is reduced to 19.5 feet o.c. for the piles supporting the crane rail beams (rows A and C) due to the higher axial load. The typical transverse spacing is 36 feet with one span of 40 feet. It is estimated that 136 of the 72-inch-diameter shafts are required to support the T1 wharf for this alternative. The shaft lengths are expected to be 350 feet for typical shafts, and 390 feet for shafts supporting the crane rails beams (rows A and C). The permanent casing wall thickness is expected to be 1 inch.

Figure 4-31 displays the typical section of the wharf for T1 (refer also to Appendix G). The total wharf width is 129 feet, with 72-foot spacing between crane rail beams to accommodate 72-foot gauge cranes. Three 10-foot-wide truck lanes are provided between the crane rails. A 40-foot-wide hatch cover area is provided at the landside of the wharf for hatch cover storage.

The wharf superstructure consists of 36-inch-thick solid precast slabs with a 10-inch-thick CIP concrete topping. The precast slabs span approximately 36 feet and are supported by 4-foot-deep concrete pile caps. The pile caps are supported by 72-inch-diameter drilled shafts that are connected to the pile caps via steel dowels extending into the pile cap.

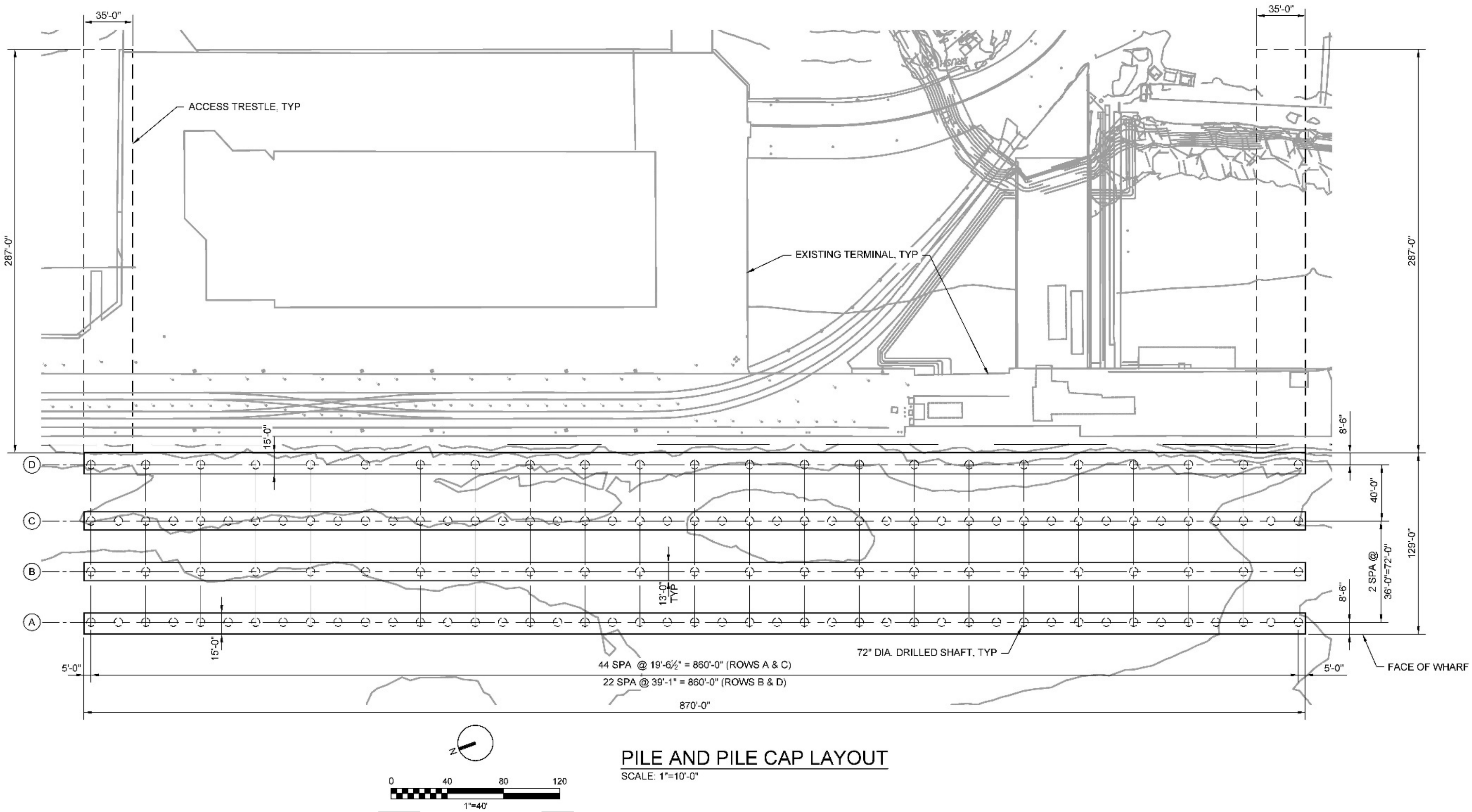


Figure 4-30. Wharf Pile Layout for Terminal 1: Alternative 2B with 72-inch-diameter Drilled Shafts

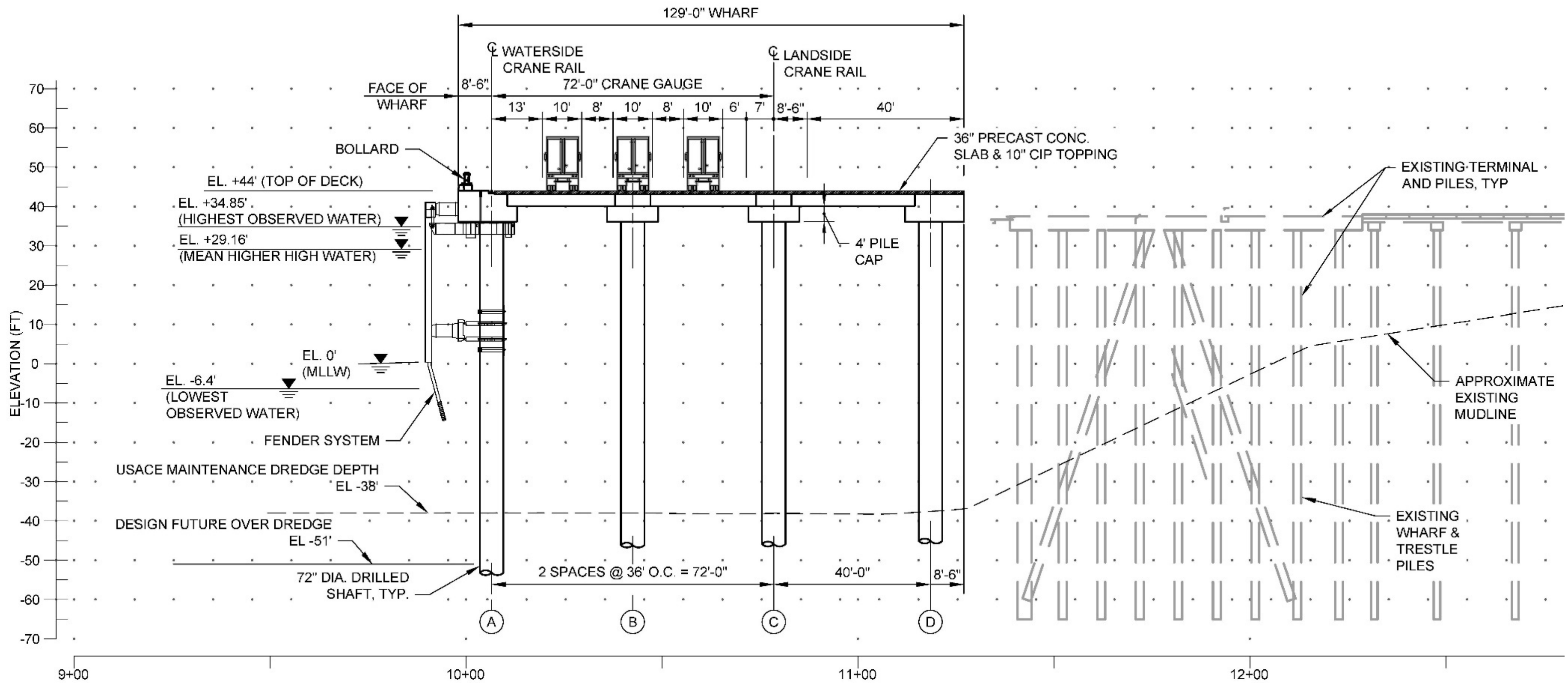


Figure 4-31. Typical Wharf Section for Terminal 1: Alternative 2B with 72-inch-diameter Drilled Shafts

4.9.1.2 Terminal 2 Wharf

Figure 4-32 depicts the substructure and foundation layout for the T2 wharf for this alternative (refer also to Appendix G). The overall size of the wharf is 934 feet long by 69 feet wide. The typical pile spacing is 40 feet o.c. in the longitudinal direction and 27 feet o.c. in the transverse direction. Seventy-two 72-inch-diameter drilled shafts are required to support the T2 wharf for this alternative. The shaft lengths are expected to be 390 feet and the permanent casing wall thickness is expected to be 1 inch.

Figure 4-33 shows the typical section of the wharf for T2 (refer also to Appendix G). The total wharf width is 69 feet. The T2 wharf will be separated from the T1 wharf by an expansion joint.

Like T1, the superstructure of the T2 wharf includes 36-in-thick solid precast slabs with a composite 10-inch-thick CIP concrete topping. The precast slabs span approximately 27 feet and are supported by 6-foot-deep concrete pile caps. The pile caps are supported by 72-inch-diameter drilled shafts. The drilled shafts are connected to the pile caps via steel dowels extending into the pile cap.

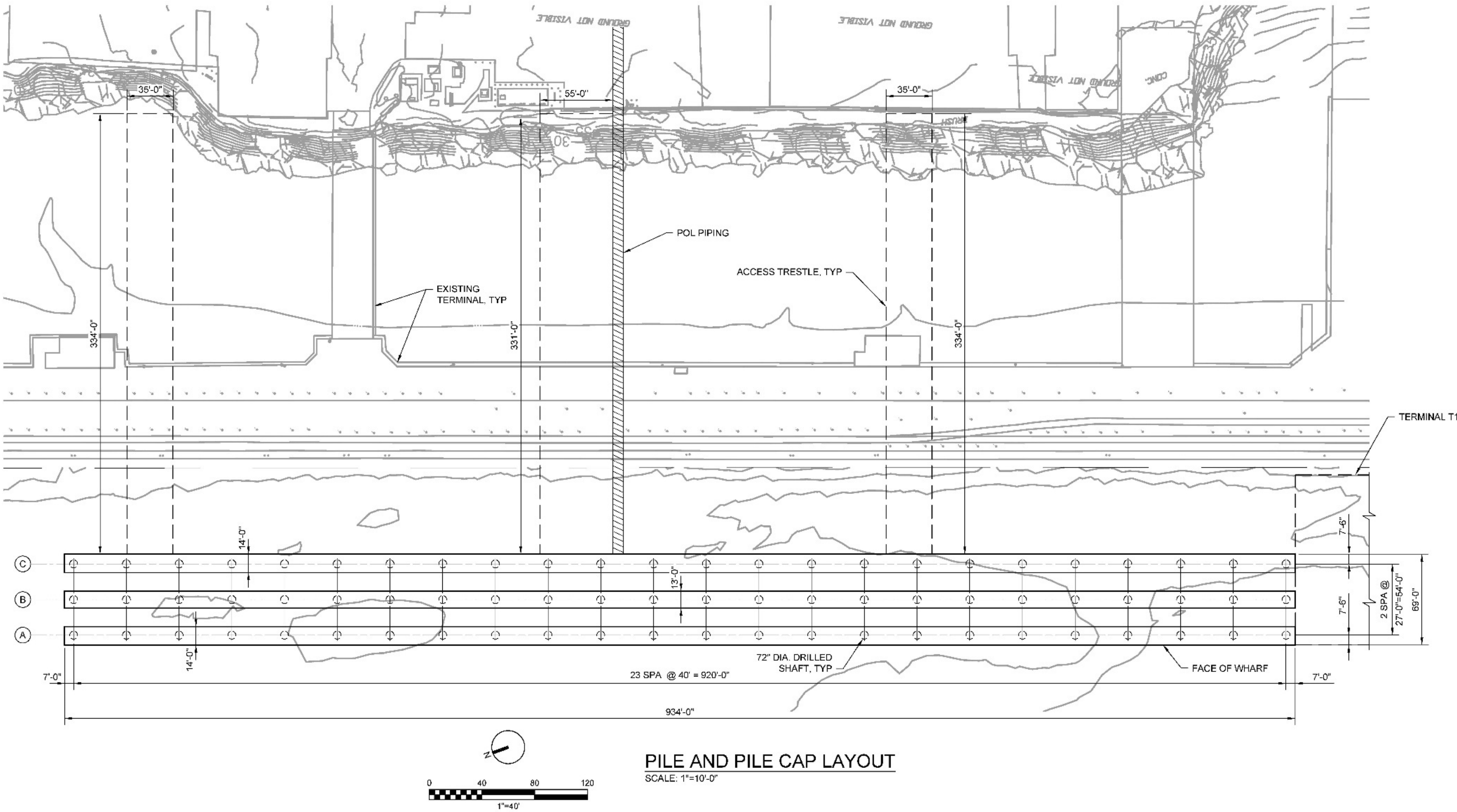


Figure 4-32. Wharf Pile Layout for Terminal 2: Alternative 2B with 72-inch-diameter Drilled Shafts

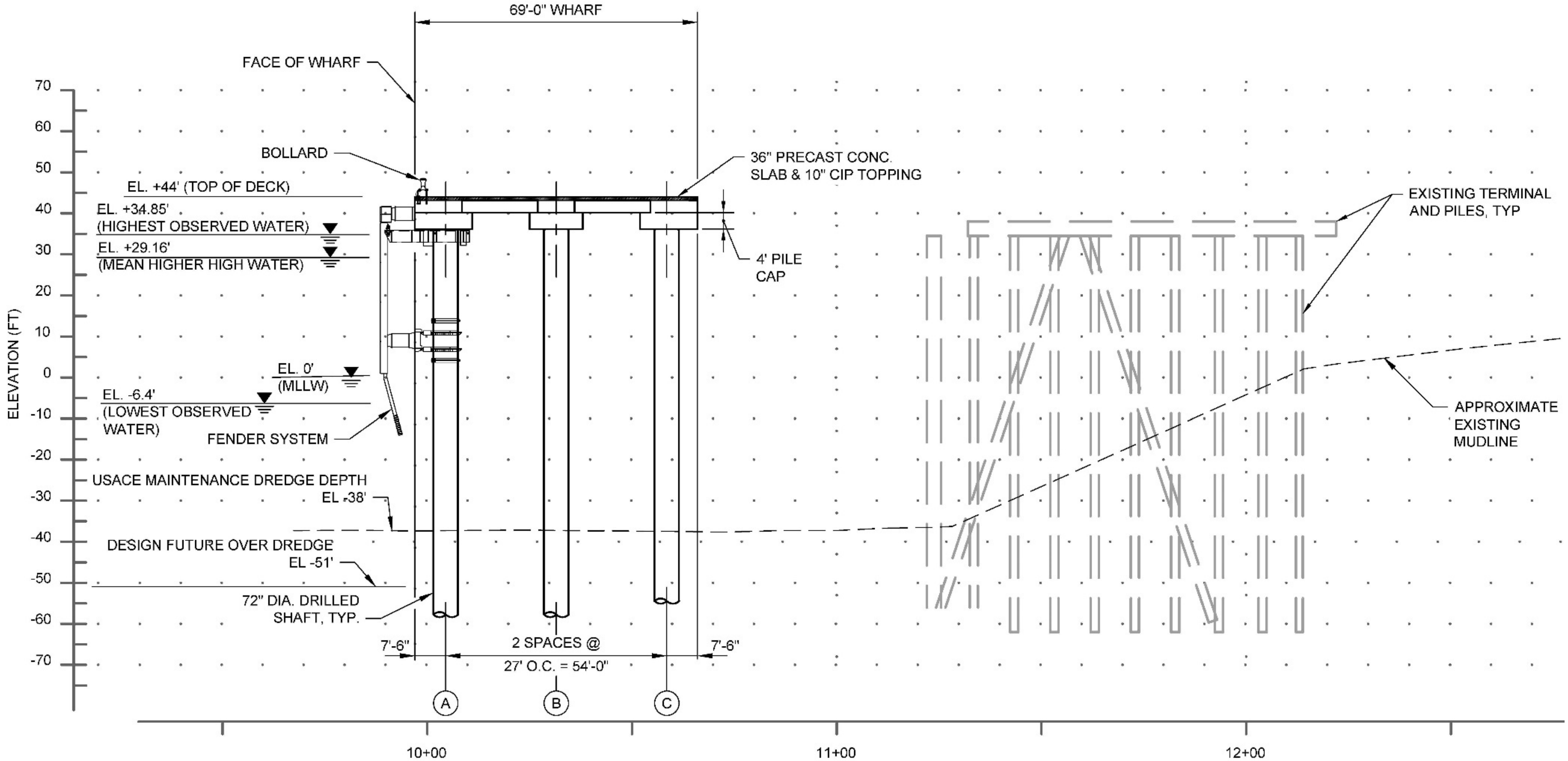


Figure 4-33. Typical Wharf Section for Terminal 2: Alternative 2B with 72-inch-diameter Drilled Shafts

4.9.1.3 Terminal 1 and Terminal 2 Access Trestles

Figures 4-34 through 4-37 show the substructure and foundation layout and the longitudinal elevation for the T1 and T2 access trestles, respectively (refer also to Appendix H). Trestle length varies between approximately 287 feet for T1 to approximately 334 feet for T2. Each trestle consists of typical bents spaced at approximately 60 feet o.c. The typical pile cap at each bent is supported by two 72-inch-diameter drilled shafts spaced at 20 feet o.c. in the transverse direction. Seventy-three 72-inch-diameter piles are required to support the five access trestles. The shaft length varies and is expected to reach 340 feet. The shaft casing wall thickness is expected to be 1 inch.

Figure 4-38 illustrates the typical sections of the access trestle (refer also to Appendix H). Except for the middle trestle at T2, all access trestles are approximately 35 feet wide; the middle trestle at T2 is approximately 56 feet wide. The trestle superstructure includes 50-inch-deep, prestressed, precast concrete deck bulb-T girders with a 10-in-thick CIP concrete topping. The precast girders span approximately 60 feet and are supported by 6-foot-deep concrete pile caps. For the middle trestle at T2, the pile cap also has an overhang that extends south and supports the POL piping. The pile caps are supported by 72-inch-diameter drilled shafts, which are connected to the pile caps via steel dowels extending into the pile cap.

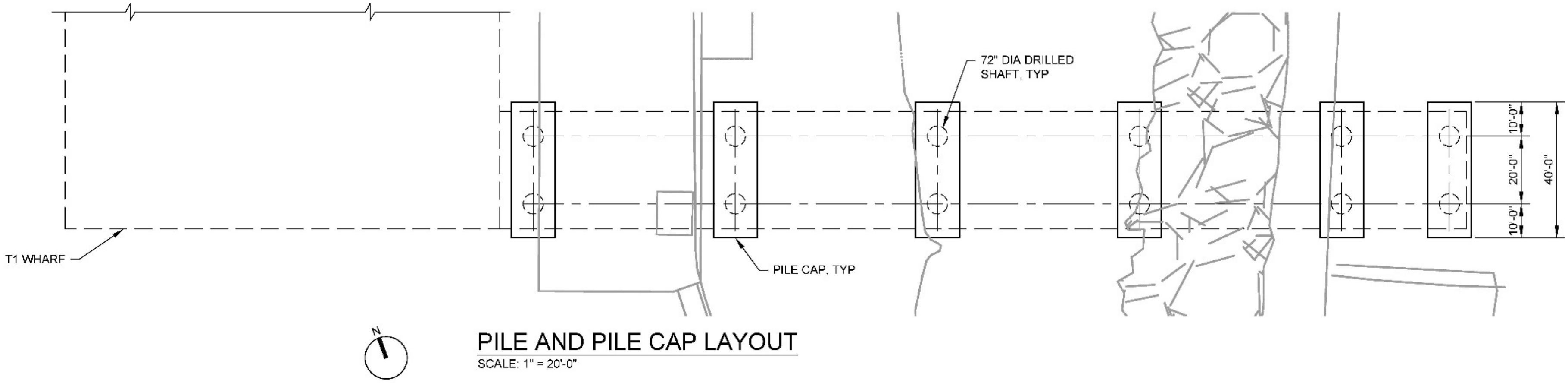


Figure 4-34. Pile Layout for T1 Access Trestles: Alternative 2B with 72-inch-diameter Drilled Shafts

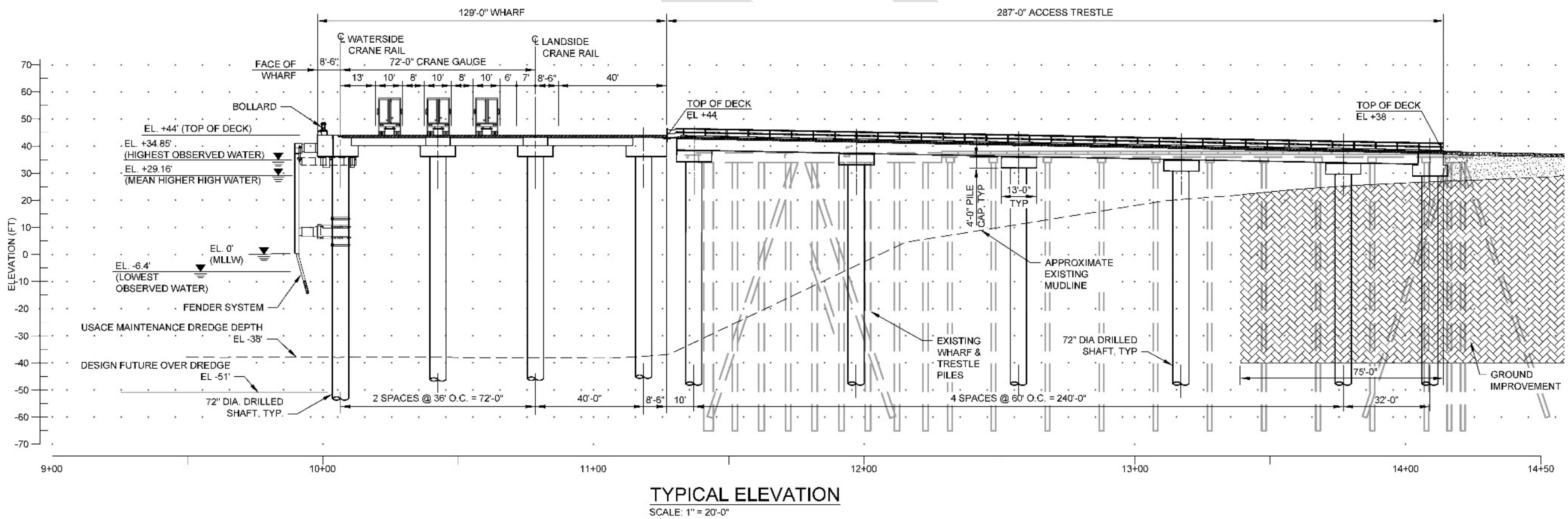


Figure 4-35. Longitudinal Elevation for T1 Access Trestles: Alternative 2B with 72-inch-diameter Drilled Shafts

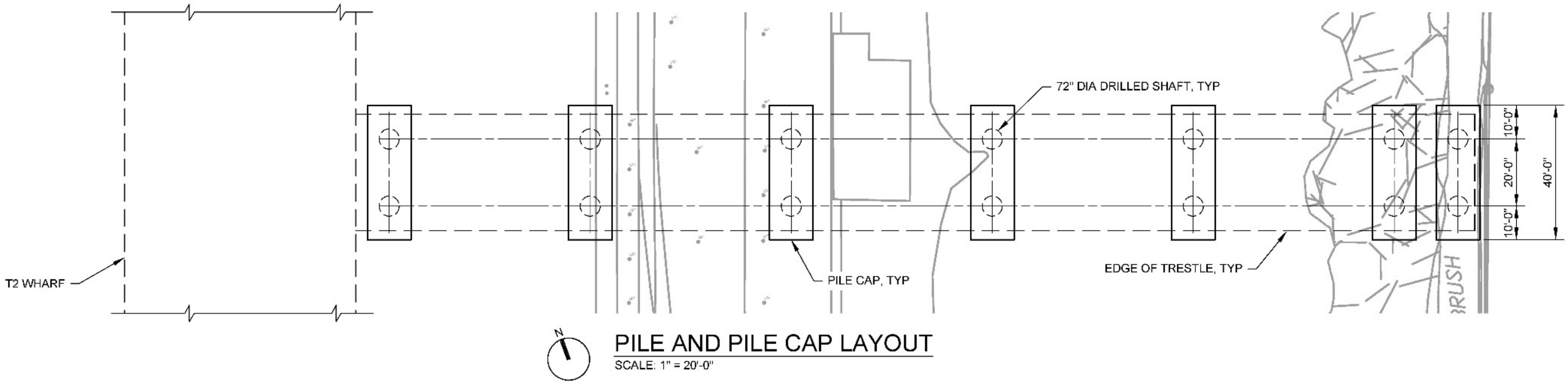


Figure 4-36. Pile Layout for T2 Access Trestles: Alternative 2B with 72-inch-diameter Drilled Shafts

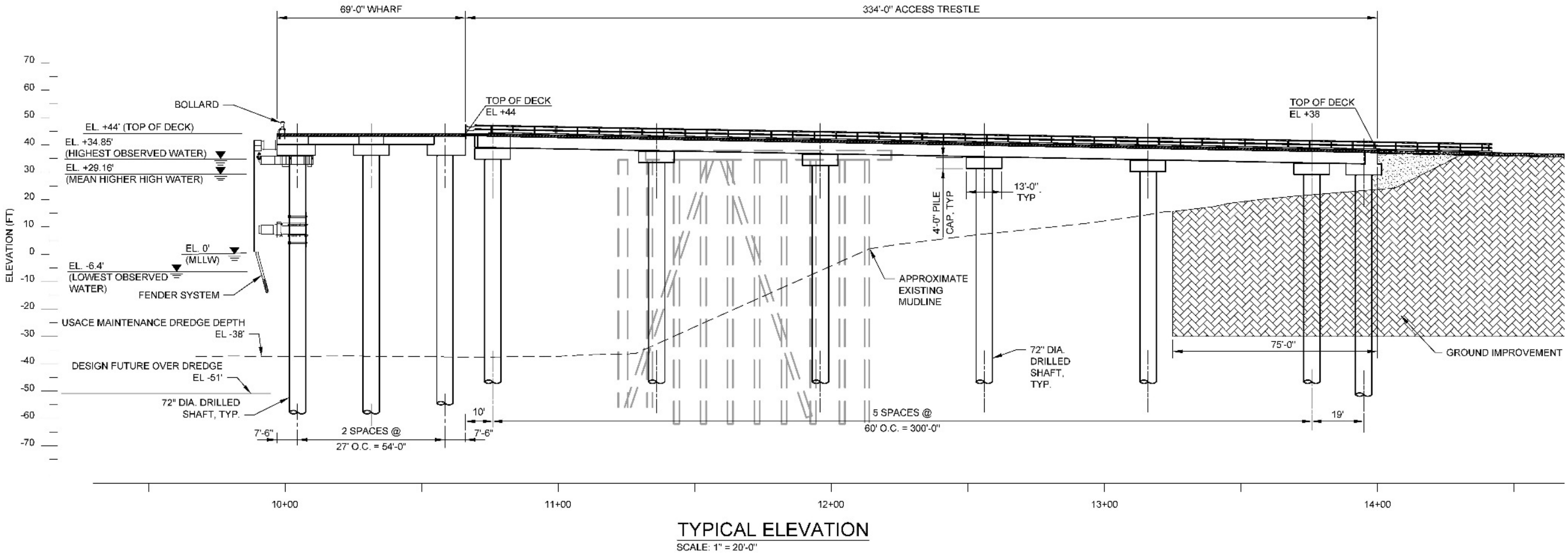
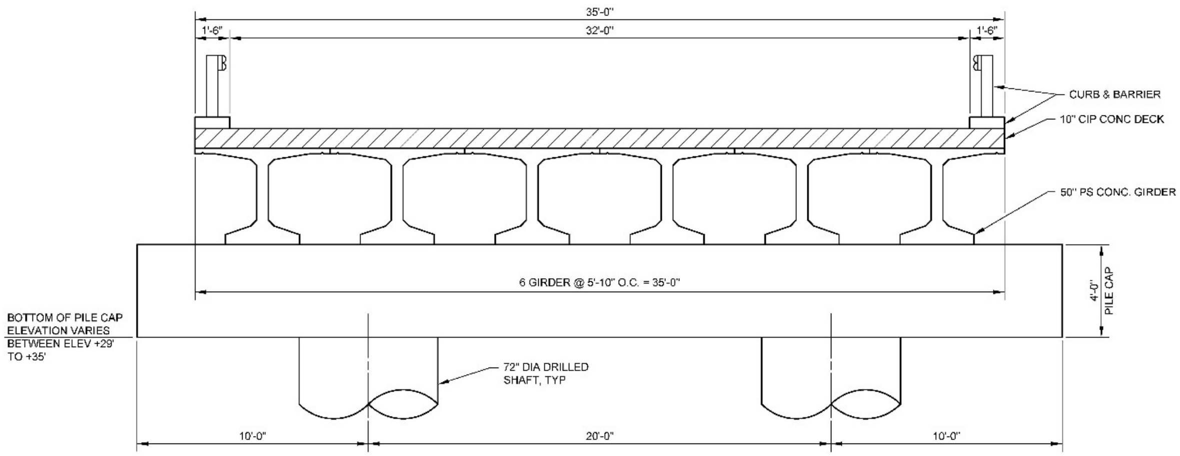
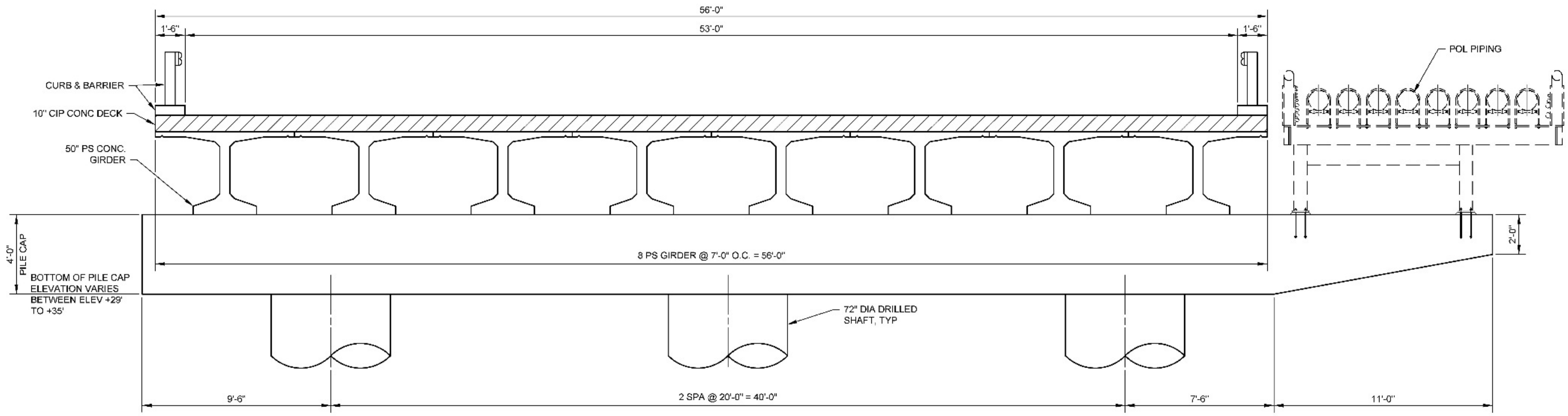


Figure 4-37. Longitudinal Elevation for T2 Access Trestles: Alternative 2B with 72-inch-diameter Drilled Shafts



TYPICAL SECTION

SCALE: 3/8" = 1'-0"



TYPICAL SECTION - TRESTLE WITH POL PIPING

SCALE: 3/8" = 1'-0"

Figure 4-38. Typical Section for Typical and POL Access Trestles: Alternative 2B with 72-inch-diameter Drilled Shafts

4.9.2 Constructability

4.9.2.1 Drilled Shaft Construction

The drilled shaft lengths (350 to 390 feet) required to support this structure are beyond the limits of normal drilled shaft construction and may not be constructable, especially over water. A drilled shaft requires a rebar cage be assembled horizontally on the ground and then picked up and dropped into the shaft. The crane boom length required may not be obtainable for that length of cage.

Additionally, as discussed in Section 5.3.3, the drilled shaft does not provide noise reduction benefits because of its longer installation duration, which requires additional temporary drill rig support structures and adds years to the construction schedule.

4.10 Alternative 3 Prefabricated Jacketed System Using 60-inch-diameter Driven Piles

This section summarizes the results of the investigation into conceptual modular construction using prefabricated jacketed substructures and large superstructure modules, specifically detailing how the jacket and modular approach differs from conventional construction techniques, and the potential advantages of the technique for this project.

4.10.1 Terminal 1 Alternative Description

4.10.1.1 General Arrangement Description

Figure 4-39 illustrates the T1 proposed jacketed modular wharf general arrangement plan (refer also to Appendix I).

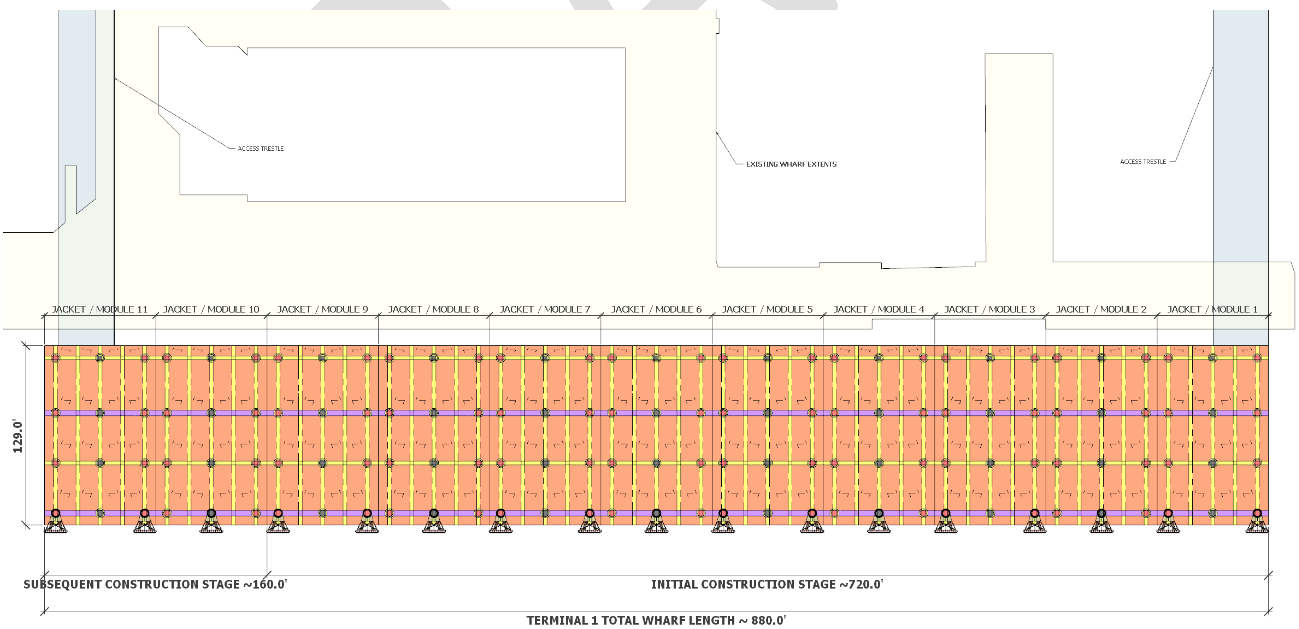


Figure 4-39. Terminal 1 General Arrangement

Figure 4-39 depicts an approximately 880-foot-long by approximately 129-foot-wide wharf deck accessed by two approach trestles.

The method of jacket and topside module installation is not suitable for the approach trestles; therefore, the trestle installation work is separated from the modular wharf construction.

4.10.1.2 Wharf Structure – Preliminary Details

The jacket modular wharf structure is divided into three primary components to enable transportation, lift, and construction:

1. **Jacketed substructure** is a three-dimensional, prefabricated braced frame placed on the seabed that forms the primary foundation structure for the wharf. The frame is designed to support the topside deck structure.
2. **Anchor piles** are conventional pipe piles installed through the legs of the jacketed substructure and into the seabed. These permanently pin the jacketed substructure in the correct position and are designed to resist vertical and lateral loads.
3. **Topside deck** is a slab structure designed to provide the working deck for container operations. This topside structure is supported on the anchored jacketed substructure.

These three primary components are typically fabricated offsite in specialist yards, and are designed to be as complete as possible, subject to constraints and limitations of shipping and handling. The fabrication is performed in a controlled environment, under expert supervision with strict quality control to provide accuracy and quality. The advantages of working remotely include safer labor conditions working on land and fewer delays due to poor weather.

Fittings and connections that can be included in the modules are:

- Bracing
- Bearing pads and bearings
- Handrails
- Fendering systems
- Mooring equipment
- The rail system (as practical)
- Support brackets for services
- Service systems (as practical)

In addition to fastening all permanent fittings on the modules, temporary and construction-facilitating fixtures can be attached. Such fittings include:

- Grout and bubble curtain tubes
- Lifting lugs
- Access platforms for welding and jacking works
- Pins and bumpers for placement alignment
- Survey guides and markers

The approach to fabricate, transport, and install the modules is described based on barge transportation due to limitations of the Jones Act. Heavy-lift vessels (HLVs) are available internationally, but the use of these would require a waiver of the Jones Act; therefore, references to HLV transportation are included for comparison should a waiver to the Jones Act be granted (Appendices J and K):

1. The modules are fabricated in a location remote from the POA in a facility specifically developed with the required equipment and experience to undertake the work.
2. The modules are then lifted onto a barge (or HLV) and secured on the deck for transport.
3. The modules are transported via barge (or HLV) to site and prepared for unloading.
4. The seabed identified for the final installation is prepared to receive the modules.
5. A large crane is mobilized to the POA site to unload the modules. The crane could be barge or vessel mounted (or use an HLV).

6. The modules are lifted from the barge (or HLV) and placed directly on the seabed.
7. Piles are driven through the tubular legs of the jacketed substructure, likely using a separate crane and piling rig. Additional piles are also proposed for the shoreward side of the T1 wharf to support the hatch cover laydown area.
8. The final position and level of the jacketed substructure is achieved by using jacks to adjust the positions of the legs.
9. Once the substructure is in position, it is secured to the piles by grouting the anulus between the jacket legs and the piles.
10. Steel caps are welded to the top of each of the tubular legs of the jacketed substructure.
11. The topside deck superstructure module is placed on top of the pile caps of the anchored substructure, and each element is then fixed in place with welded connections between the modules and the pile caps and connections between adjacent modules.
12. The final deck surface is placed using precast slabs and CIP concrete.

The actual methods of transporting and unloading modules may be limited by Buy America and Buy American acts, and the Jones Act for transportation.

The size of the modules is dependent on the availability of vessels to transport, handle, and place the components, and this limitation is currently unknown. At this stage of study, assumptions based on experience have been made to allow comparison of alternatives, but optimization of the preferred solution is recommended in the final detailed designs.

The following constraints have been selected for the preliminary design:

- **For transportation:** Deck dimensions and cargo capacities for a Crowley 455 series barge (400- by 405- by 25-foot draft), representing a typical large-capacity module barge used for similar operations within the United States.
- **For lifting onsite:** A standard crane barge (or HLV) with a single crane lift capacity of approximately 900 metric tons (MT) at a radius of 82 feet, comparable to Biglift's HLV Happy Star (which Jacobs has used on similar modular wharf construction projects in the past outside the United States).

The barges identified for transportation in this report are Jones Act compliant because the tug vessels are built in, documented under, and owned by persons who are citizens of the United States.

The jacket modules are sized for the transportation and lifting methodology as follows:

- The jackets have a maximum landing footprint in their shorter plan dimension (longitudinally along the wharf) of approximately 77 feet wide to suit the Crowley 455 barge deck width restrictions, with adequate width allowance for lashing and associated shipping restraint systems.
- The jackets have been sized in the lateral plan dimension to be 93 feet. This is considered the optimal reach of a crane to lift a 5-foot outer diameter pile capacity during pile driving operations.
- Based on preliminary structural design with these plan dimensions, the net lifted jacket mass (with preinstalled fender systems) is between 792 to 871 MT (depending on the number of fenders and fender panels detailed per jacket). These loads are within the crane lift capacity of the Biglift Happy Star vessel (Biglift 2014) and well within the lift capacity of a several crane barges available in USA.
- The jacket module size selected is compatible with the storage capacity of the Crowley 455 series barge. The latter barge has the capacity to store at least three jackets on the vessel, which is efficient for transportation and requires only three voyages to deliver the nine modules required for the first stage of construction.

The topside deck structure has been sized to fit the plan area of the jacket modules and could be lifted using the cranes on an HLV. While this is not the base case site cranage option, the superstructure module size is such that it provides greater flexibility.

A large crane (or HLV) will need to be mobilized to site to unload barges delivering the modules. The number of cranes available worldwide capable of lifting these magnitudes of loads is limited. Therefore, it may be necessary to consider alternatives that reduce the mass and size of the modules to broaden the availability of equipment for the construction. The disadvantage of reducing the size of the modules is more piles will be required to pin them to the seabed, which is counterproductive to the goal of reducing piling noise.

The size of modules discussed can be transported on HLVs, which are specifically designed for this type of operation. As mentioned, the issue with using HLVs is they are not American vessels and do not comply with the Jones Act. Appendices J and K provide further commentary, and Appendix L provides schematics for Biglift's HLV Happy Star stowage and lifting schematics.

HLVs could be used if the project is not funded by federal grants, thus removing the constraint of the Buy American Act. It is understood that federal funding is being pursued, so the use of HLVs seems improbable.

Further details on the jacketed substructure and topside modules are included in the next sections.

4.10.1.3 Jacketed Substructure – Preliminary Details

Appendix I includes schematics showing the jacketed wharf modular substructure design. Preliminary details are provided in this section for ease of reference.

The jackets are approximately 93 feet wide to form the lateral dimension of the wharf and approximately 77 feet long to form the longitudinal dimension of the wharf (Figures 4-40, 4-41, and 4-42). The 93-foot dimension is optimized to align the legs of the module to serve as sleeves for driving piles along the crane rail beams positioned for 72-foot gauge cranes. The 77-foot dimension is optimized to fit on the barges identified for the preliminary design. Each jacket has six 6-foot-diameter jacket sleeves (pink square feet on Figure 4-40), and 5-foot outer diameter piles are to be driven through these. The jacket also includes a central row of three vertical tubular members of 5-foot outer diameter, which provide additional support to the wharf superstructure without requiring additional piling.

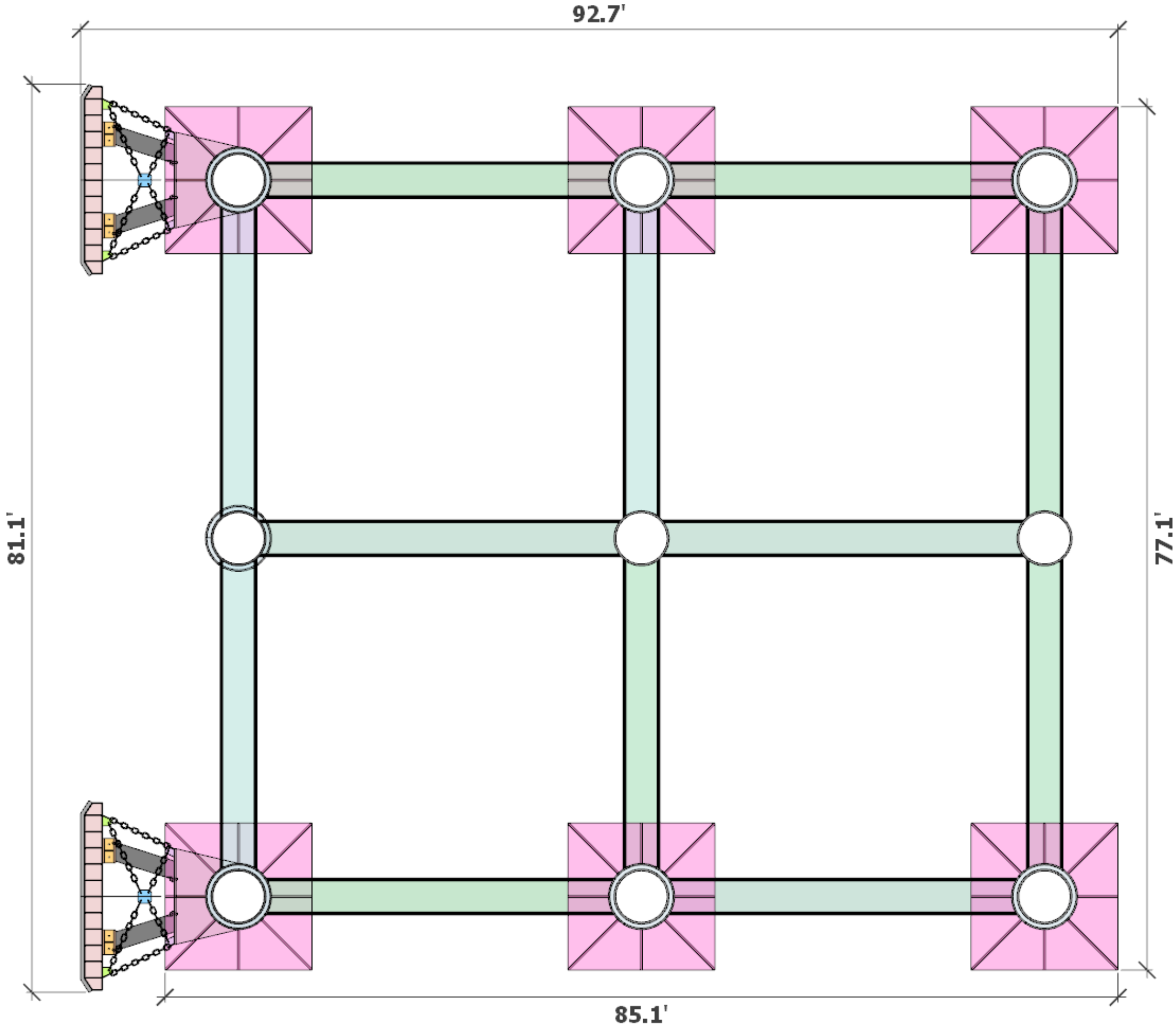


Figure 4-40. Terminal 1 Jacket Plan

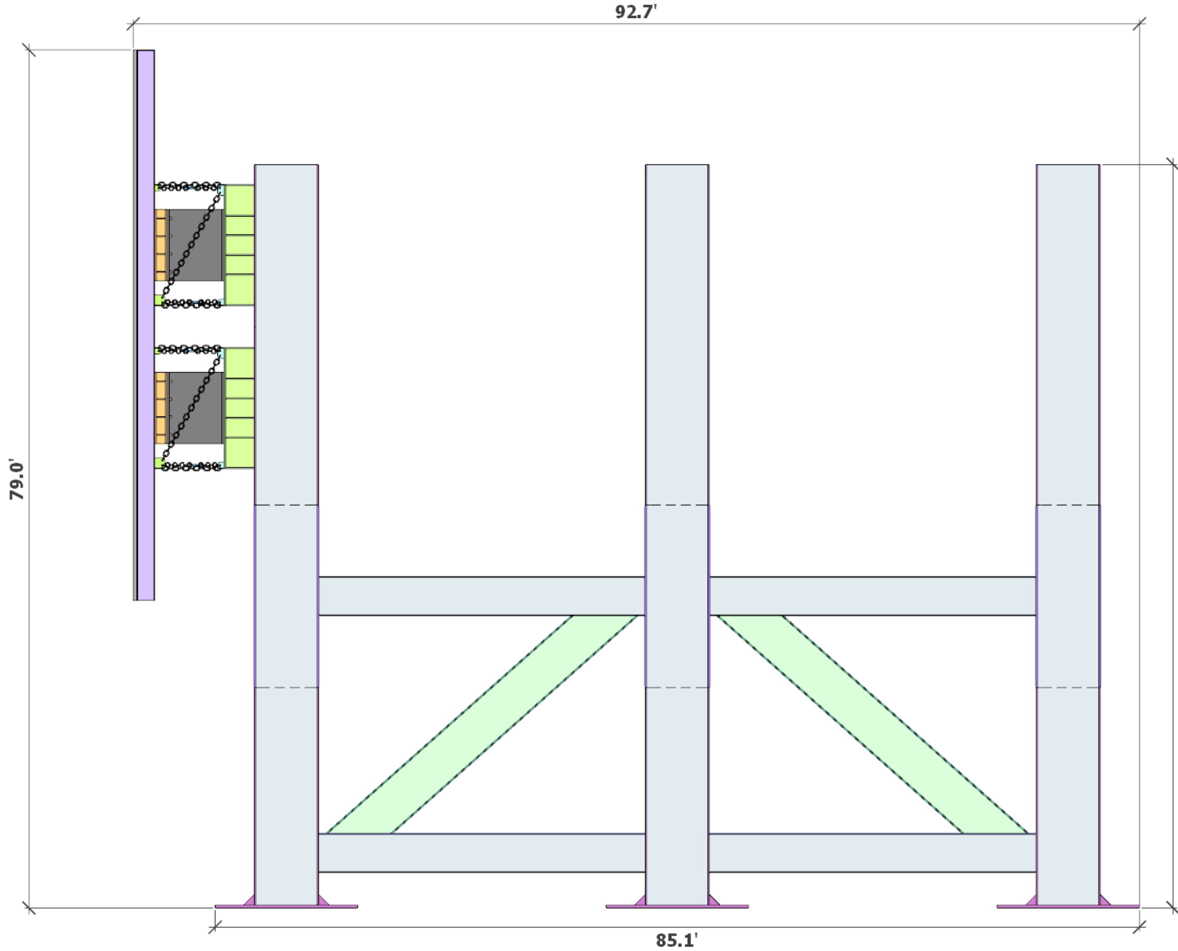


Figure 4-41. Terminal 1 Jacket Cross Section

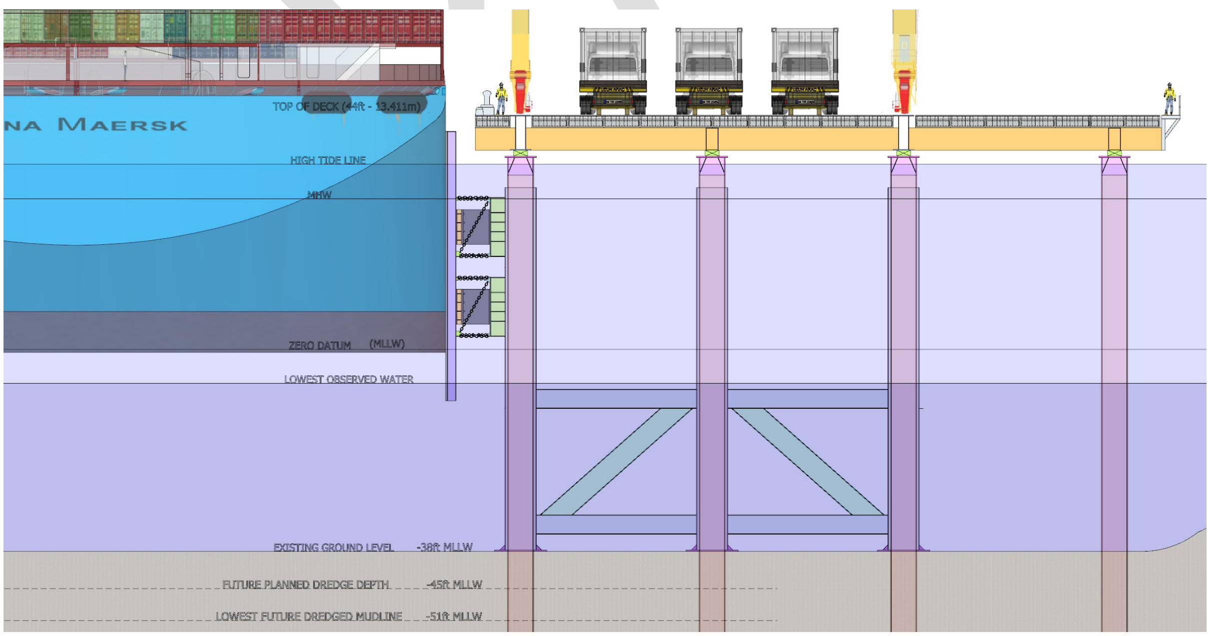


Figure 4-42. Terminal 1 Cross Section with Jacket, Wharf Deck Topside Module, and Landside Pile

The jacket substructure will be placed on the seabed at approximately EL. -38 feet MLLW, with the top upper edge of the jacket sleeves extending up to approximately EL. +33 feet MLLW. The top elevation has been determined to be above the tide range to suit pile cap welding construction activities. Thus, the jackets are nominally 93 feet long by 77 feet wide by 69 feet high, extending vertically a further approximately 10.5 feet if the prefitted fender panels are included.

The jackets are estimated to weigh approximately 712 MT, mainly composed of the steel substructure. To minimize work on site in the demanding marine conditions, preinstallation of the fenders and fender panel systems is recommended, but this increases the net lifted mass of the module between 795 to 871 MT (depending on the number of fenders per jacket).

The jacket substructure frames include steel tubular members similar to offshore jackets. Our experience shows this form of structure is:

- Cost-effective to produce (when manufactured in a facility with jacket experience and capability)
- The tubular members minimize the surface areas exposed to corrosion in the marine environment
- The jackets provide deck support with minimal surface area, thus reducing wave and current drag effects and reducing ice accumulations and associated hydrodynamic effects.

The tubular steel bracing of the jacket structure is positioned beneath the lowest observed water line. Above the bracing, a series of vertical tubular steel “sleeve” tubes extend above the water line, piles are driven through these sleeves, and the annulus are then grouted. In the center of the jacket, a series of vertical tubular steel members (the same size as the tubular steel piles) extend up, providing additional support for the deck.

The pile driving methodology, described in Section 4 and detailed in Appendix D, is independent of the jacket arrangement, reducing the number of piles required compared to conventional designs considered in the Sections 3 and 4 reference designs. The entire T1 wharf structure involves 99 tubular steel driven piles and 12 temporary piles (which could be removed in favor of a jacket landing guide system mounted in the existing T1). The permanent piles are approximately 60-inch outer diameter with 2.2 inches wall thickness. The piling shoe at the toe is thicker than the pile wall to improve drivability and to relieve internal skin friction.

The piles are estimated to require a final toe level of 225 feet beneath MLLW, which will be adequate to resist the imposed loading. The resulting permanent piles come in two pieces (total length 274 feet) and will be spliced together onsite after being lifted into the jacket sleeves. Alternatively, it may be possible to drive the piling close-ended to achieve bearing capacity with a shorter piling. Both alternatives are detailed in Appendix D.

The jacket is designed to be supported on the piles, with the grouted annulus locking the jacket and pile together. Before the grout is placed in the annulus, the jacket can be jacked and leveled, if necessary (within limitations), from either the permanent piles or temporary spuds.

The piles can be located with relative accuracy using the jacket as a template, but there is still some positional tolerance required to accurately connect the deck modules to the jacket. This will be achieved through surveying and cutting off the piles for vertical accuracy and then welding a prefabricated cap to the piles to provide for horizontal positional variability. The recommended pile cap is a stiffened welded steel cap called a “can and cone.”

An independent row of vertical tubular steel piles would be provided outside the jacket footprint on the landside to support the outer edge of the wharf deck while maintaining the substructure module size required for traditional HLV craneage and deck capacity (Appendix I provides more details).

4.10.1.4 Topside Module – Preliminary Details

Eleven topside deck modules with a steel framework form the deck of the wharf. The deck modules are supported by 11 jacketed substructure modules and a landside row of support piles as shown on Figure 4-42. Appendix I provides more detailed schematics.

The conceptual design includes 72-foot gauge rails on a 129-foot-wide deck, with the deck level at 44 feet above MLLW, matching the conventional wharf design. Unlike the substructure modules, the topside modules extend the full width of the wharf deck. Each topside module is 80 feet long by 129 feet wide and is supported on pot bearings connected to the pile caps fixed to the nine vertical supports. The pot bearings are positioned approximately 18 inches above the high tide line, avoiding the impacts of waves and ice accumulation.

The topside modules include an arrangement of steel box girders with bracing to provide support to the concrete deck, with two longitudinal steel box rail girders providing direct support to the container crane rails. The rail girders are estimated to be 6.5 feet deep to provide adequate fatigue strength, ultimate strength, and stiffness. The steel topside module provides uniform support for a composite deck formed with precast concrete panels and a CIP reinforced-concrete topping slab binding the deck together. The connection between the precast panels and the topside modules will be achieved via shear studs and CIP concrete. This approach optimizes prefabrication opportunities, further accelerating and minimizing the works required over water.

Most of the precast panels can be prefitted to the steel modules before delivery to site, thus further minimizing over-water works required onsite. The extent that preinstallation work can be achieved is limited only by the lifting capacity of onsite cranes. Jacobs has experience with lifting topside modules prefitted to near-final requirements, of very similar scale and weighing up to 1,450 MT.

4.10.1.5 Prefabricated Jacketed Seismic Considerations

The POA site is highly seismic; therefore, the seismic response of the wharf structure is an important design consideration. The jacketed substructure modules include a rigidly braced base, with flexible vertical tubular elements (some of which are grout filled) to provide support to the heavy wharf deck. This design provides a flexible structural system which is effective at resisting seismic forces.

The effective stiffness and mass distributions of the modular wharf system is comparable to a vertical pile wharf system. Seismic design analysis confirms that the modular structure has a natural frequency different to the peak seismic acceleration frequency, thus avoiding the risks of resonance.

The most important structural members in the jacket for seismic considerations are the vertical jacket sleeves immediately above the upper bracing level and the piles immediately below the lower bracing level and grout zone. The preliminary design of these elements is based on a steel strain limit for minimal damage performance level of 0.015 (0.015%) in the DE event. This approach provides for a force-based design analysis, with all main structural elements confirmed to operate within the elastic limits of the structure even in the DE event. The nonlinear structural performance of the vertical jacket sleeve, pile, and grout members will be a focus in the detailed design should this be the preferred alternative.

4.10.1.6 Prefabricated Jacketed Ice Considerations

Effects from ice accumulation, the force of ice on the structure, the associated abrasion and impacts of ice due to tidal movements and currents, and the associated maintenance requirements resulting from ice buildup are all important considerations for the project regardless of wharf design and construction approach. The modular jacket system differs from the traditional pile-supported deck system in several ways, including:

- The modules include fewer piles, which reduces the net area of structure exposed to ice within the intertidal zone.
- The jackets are braced at the base, avoiding accumulation of ice on the bracing due to the water depth. This also minimizes the risk of accelerated corrosion in the splash zone and tidal range.
- The fender system is mounted off the jacket sleeves allowing full installation of the system in the jacket fabrication yard.

4.10.2 Terminal 2 Alternative Description

4.10.2.1 Functional Requirements

The main function of T2 is to provide RO/RO berth functionality. Additionally, the terminal provides flexibility to accommodate heavy-lift mobile cranes, as discussed in Section 3.2.2.

The T2 wharf structure will support mobile crane operations (in two isolated strengthened locations), RO/RO ramps, and a general uniform live load of 1,000 psf. The wharf and approach trestles will have a reinforced-concrete deck suitable for vehicle traffic, similar to T1.

The T1 seismic and ice load design discussions in Sections 4.10.1.5 and 4.10.1.6 are applicable to T2.

4.10.2.2 Location and Staging

Similar to T1 (Section 4.10.1), the proposed new T2 wharf is constructed outward (marine side) of the existing T2. Therefore, during T2 wharf construction, the construction site can be accessed by:

- Approach from the marine side using barges and other vessels
- Approach from the existing T2 deck with general access (depending on load capacity and crane reach)

To allow ongoing cargo operations at the port, the full length of the T2 wharf will be constructed in stages:

1. The first stage of the T2 wharf will be built from the south and will include the majority of the T2 berth length, providing enough operating length to allow transfer of operations to T2. Access to and construction of the new structures will be facilitated using the existing T2 structures as a working platform. These works will be concurrent with the works of the adjacent northern end of T1. The works will be undertaken concurrent with port operations at the existing Terminal 3 (T3) and the partially completed length of T1.
2. During construction, access to the first stage of the T2 wharf will be available from the northern edge of the adjacent T1 wharf. Access may also be available from the existing T2 wharf via temporary bridging until such time that the existing T2 wharf structure is demolished. Following completion of the first stage of the new T2 wharf, permanent access will be provided from two approach trestles and the adjacent T1 wharf.
3. Operations at existing T3 will need to stop during construction of the far northern portion of T2. To enable port operations to continue with at least two berths during construction, a partial length of T2 is to be commissioned, enabling transfer of operations from the existing T3 to the partial length of T2 while the remainder of the T2 wharf is constructed.
4. The final stage of T2 will be completed via a jacket installed to connect the partial northern approach trestle of T2 constructed in the previous phase.

4.10.2.3 General Arrangement Description

The T2 proposed jacketed modular wharf general arrangement plan is very similar to that of T1, as described in Section 4.10.1.1, with modifications including:

- The T2 wharf deck (69 feet wide) is considerably narrower than T1’s deck (129 feet wide)
- T2 is not designed for container cranes and the associated crane rail system
- T2 provides for use of mobile cranes in two assigned and dedicated zones

4.10.2.4 Overall Structure – Preliminary Details

The jacket modular wharf structural system for T2 is very similar to that described for T1 in Section 4.10.1.2. The same approach to fabrication, transportation, and installation described for T1 is planned for T2.

4.10.2.5 Jacketed Substructure – Preliminary Details

Appendix M provides schematics showing T2's jacketed wharf modular substructure design, with figures supporting the text provided in this section.

The jackets are approximately 78 feet wide and approximately 81 feet long (Figures 4-43, 4-44, and 4-45). Similar to the concept for T1 described in Section 4.10.1, the jackets each have six 6-foot-diameter sleeves in similar positions, through which piles of 5-foot outer diameter are to be driven. The jackets include a central row of vertical support columns braced on the jacket for central support of the wharf deck. Due to the reduced wharf width, T2 does not require the additional rear row of vertical piles required behind the T1 jackets.

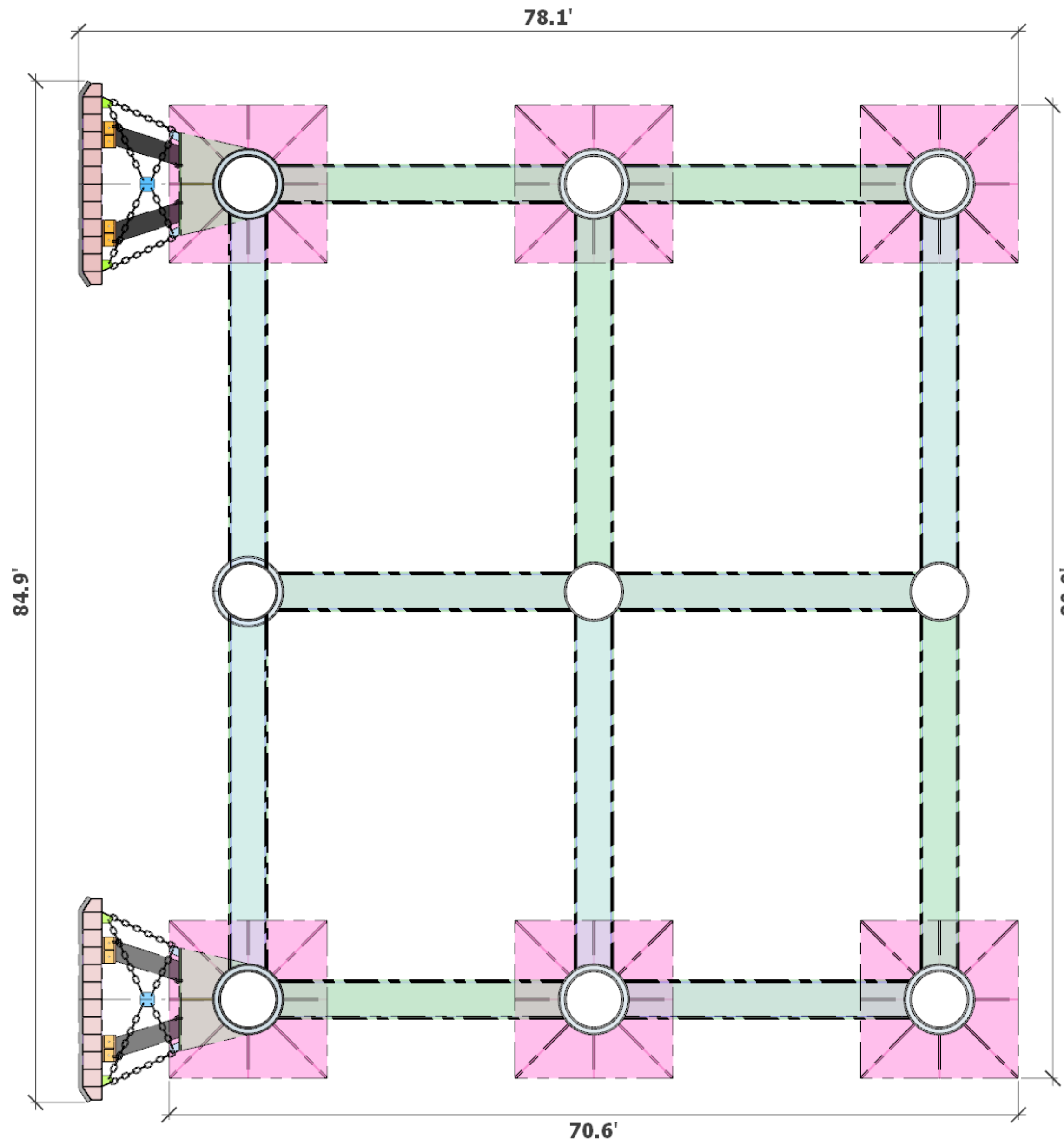


Figure 4-43. Terminal 2 – Jacket Plan

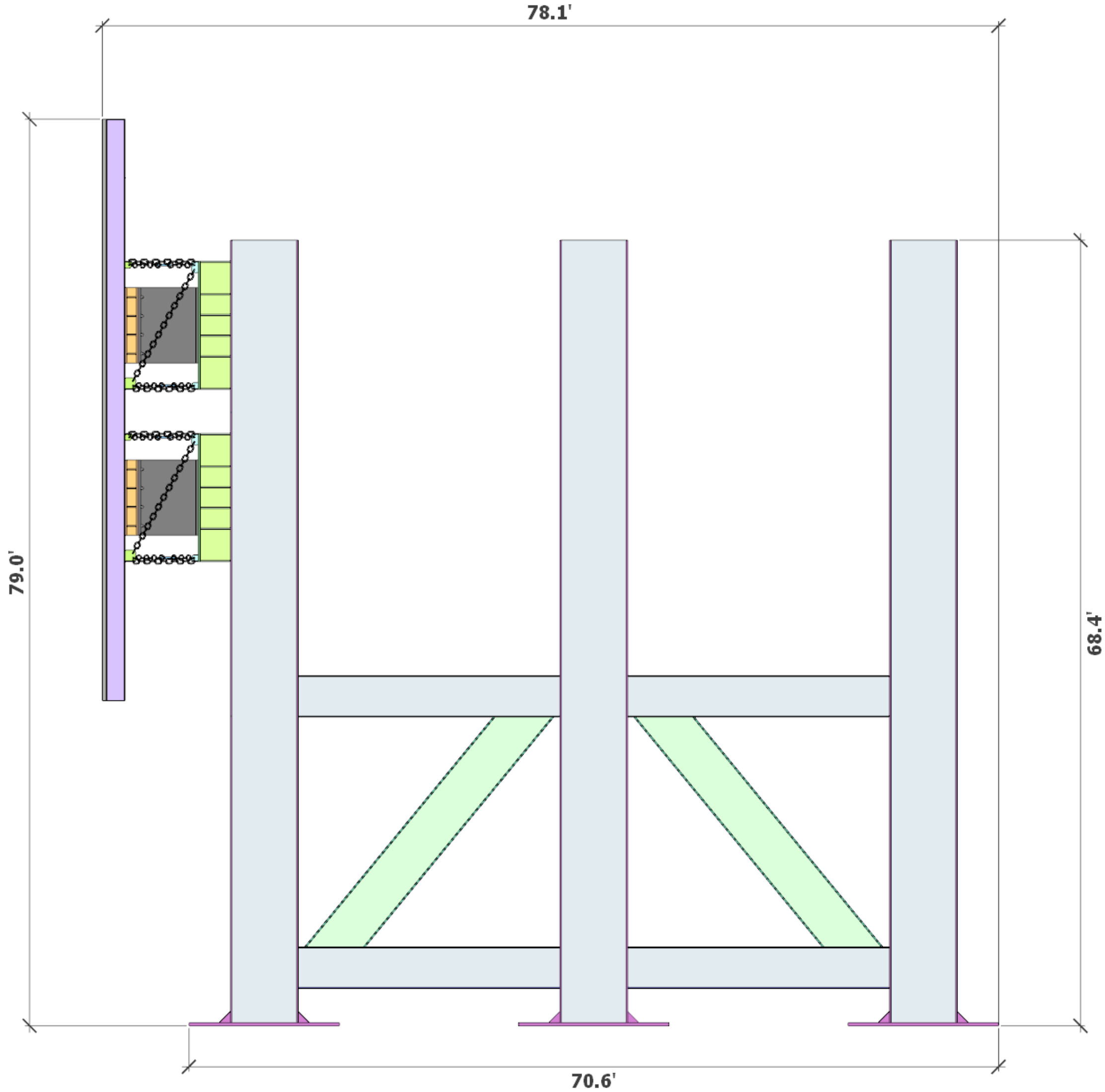


Figure 4-44. Terminal 2 – Jacket Cross Section

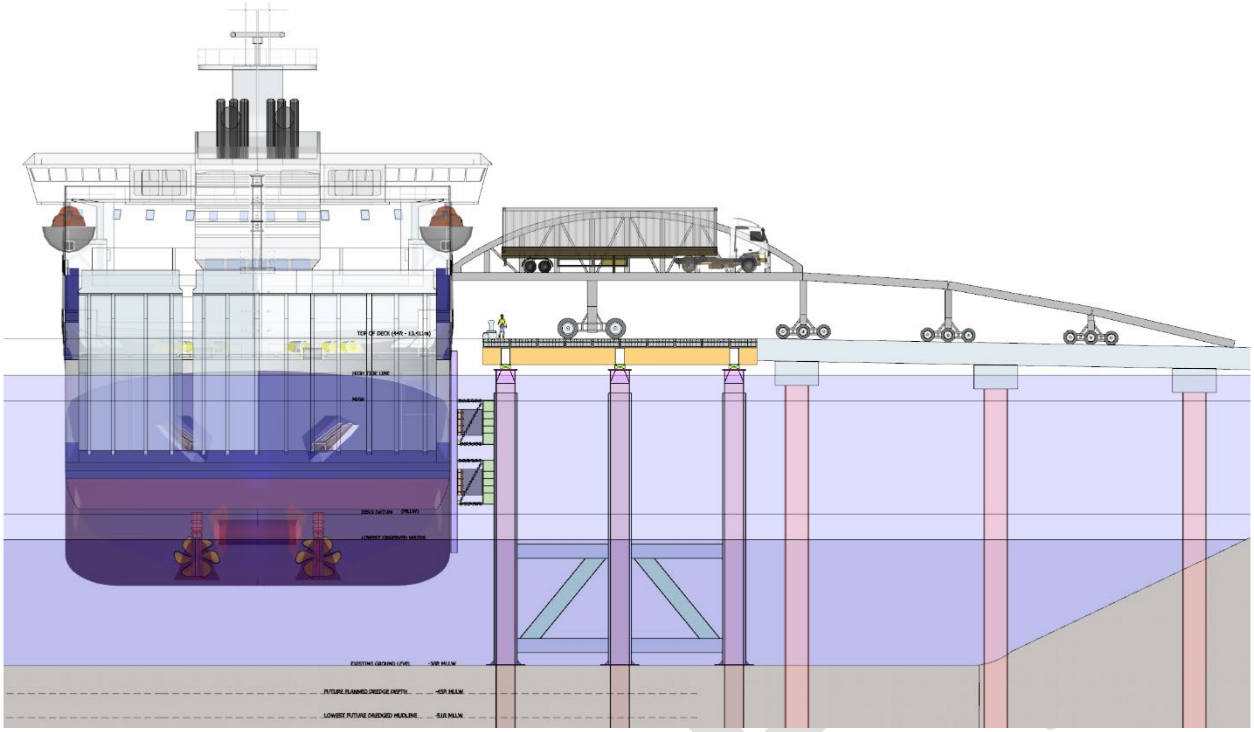


Figure 4-45. Terminal 2 – Cross Section with Jacket and Wharf Deck Topside Module and Trestle

The basic details and design approach for the jacket substructure for T2 is very similar to T1, with a few minor changes to accommodate the different sizing, as follows:

- The jackets are nominally 78 feet wide by 81 feet long by 69 feet high, extending vertically a further 10.5 feet when the prefitted fender panels are included.
- The jackets have an estimated steel weight with secondary steelwork and temporary construction access ways steelwork of approximately 666 MT. To further minimize onsite works, preinstallation of the fenders and fender panel systems is recommended, which results in a net lifted mass of approximately 764 to 863 MT (depending on the number of fenders per jacket).

4.10.2.6 Topside – Preliminary Details

Similar to T1, 11 topside deck modules form the steel support framework for the deck of the wharf, all supported by 11 jacketed substructure modules. Appendix M provides schematics for this terminal.

The basic details of the superstructure modules for T2 are very similar to T1, with a few minor changes to accommodate the different sizing and design requirements, as follows:

- Each topside module is generally 85 feet long by 72 feet and is supported on pot bearings connected to pile caps fixed to the top of the six support piles (driven within the jacket legs) and the three central vertical tubes integrated with the jacket substructure module.
- The wharf framing for T2 differs from T1 because there are no longitudinal crane girders and rails on the deck. The composite precast and CIP reinforced-concrete deck system covers the entire deck area.
- Two reinforced strong point modules are provided within the wharf deck to accommodate mobile harbor crane operations. Additional framing members are provided in the two reinforced topside modules to resist the large design loads from the outrigger system of the mobile cranes during lifting operations.

4.10.3 Constructability

The alternative modular construction includes prefabricated jacket substructures and a modular steel framed deck covered with precast concrete panels and CIP concrete topping slab. The jacket and modular elements have been successfully used elsewhere to minimize the number of piles required for the design and thus to minimize onsite construction activities. For the POA, the recognized advantages of modular construction could be beneficial to the construction of the T1 and T2 replacement structures.

The primary advantages that prefabricated steel jacket design offers compared to the other alternatives presented in Sections 3 and 4 are expected to include:

- Construction resourcing and schedule:
  - Reduced construction resources required onsite
  - Ability to engage competitively in market for offsite components
  - Reduced onsite construction duration because majority of the fabrication will be offsite
  - Extended use of existing structures due to offsite fabrication prior to onsite activities
  - The number of piles required to be installed is reduced, thus reducing associated driving noise
  - Port operations are impacted for less time due to using offsite fabrication works and quick onsite installation of the prefabricated modules
  - Reduced schedule risk associated with onsite construction and conditions, tidal constraints, and seasonal construction windows
- Quality:
  - High structure quality achieved because more of the structure is fabricated in a controlled facility
- Safety:
  - Fewer people working over water, and traversing stairs and walkways in a marine environment
  - Fewer crew transfers over water
  - Less manual handling
  - Reduced exposure to extreme weather and tides
- Noise abatement:
  - Reduced number of temporary and permanent piles
  - Piling-driving operations within the jacket sleeves are easier to attenuate and mitigate sound generated
  - Jacket bearing pad can include a sheath that continues a short distance into the seabed, further minimizing noise
  - The jacket tubes and bearing pad can be preinstalled with bubble tubes to further aid containment of noise

The disadvantages of a prefabricated steel jacket when compared to conventional designs are largely associated with fabrication and transport and are expected to include:

- Offsite fabrication is likely to be outside of Alaska (although local opportunities can be investigated).
- Offsite fabrication requires transportation to site using construction barges and access to very large cranes at site for the installation process.

- A preferred alternative transportation method using HLVs is expected to be difficult to implement due to Jones Act requirements. Due to the Jones Act requiring United States-compliant vessels to ship goods between U.S. ports, either of the following is required: (a) United States Defense waiver to the Jones Act, or (b) approval of offshore sourcing of jackets (HLV not shipping between United States ports).
- The concept of modular structures is not conventional or common and may limit the pool of capable construction contractors experienced in handling large modules, potentially reducing competition and increasing prices.

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Section 5. Noise Mitigation Options

This section evaluates various construction alternatives and noise mitigation measures to reduce the hydroacoustic noise from pile installation at T1 and T2 to a level that prevents harassment and injury to marine mammals within the vicinity of the construction. These alternatives are evaluated in terms of engineering and constructability and compatibility with environmental permits. Section 6 discusses relative costs.

5.1 Categories of Hydroacoustic Noise Reduction

Two general approaches are identified for reducing hydroacoustic noise generated by pile installation. The first approach attenuates the magnitude of sound as it propagates through the sea water away from the pile. The second approach uses pile installation methods that do not involve the use of impact hammers for pile driving. Approaches in each category are as follows:

1. NASs, including:
   - Air bubble curtains (ABCs)
   - Hydro-sound dampers (HSDs)
   - AdBm Noise Mitigation System (NMS)
   - Double-wall pile driving
2. Alternate installation methods include:
   - GIKEN SILENT PILER installation system
   - IQIP developed systems
   - Drilled or oscillated shafts
   - Helical piles
   - Jetting and jetting with grouting

Installation methods are identified in each category. Where documented in literature, magnitudes of underwater (hydroacoustic) noise are discussed.

5.2 Noise Attenuation Systems

There are four NASs identified for POA, and each is designed to reduce the level of hydroacoustic sound at the source of the sound by surrounding the pile with either an air-water mixture that absorbs the sound as it propagates outward or an air gap that limits sound propagation. The basis of the technology is that air forms a sound barrier because it is very compressible compared to water, so sound propagating through water is partially absorbed when it encounters the “spongy” air or air-water mixture.

The magnitude of sound from the impact of a diesel, hydraulic, or vibratory hammer on the head of the pile is not reduced by the systems, but the propagation of the sound is. Thus, by maintaining an air gap, or mixture of air and water around the pile, the magnitude of sound is attenuated before it propagates into the water beyond the curtain. The systems reviewed in this report have recorded levels of attenuation ranging from 10 to 30 decibels (dB), depending on the NAS. Further discussion is included in the following four subsections.

Due to the critical status of the existing cargo docks, expediting construction of the new terminals is of the highest priority. NAS technologies may have limited opportunity for consideration because of the following factors:

- Newly evolving and experimental technology
- Not tested in nearshore environments
- Not proven for high pile production rate circumstances
- Unknown performance success or applications in physical environments involving factors such as extremely high tidal currents or difficult geotechnical conditions
- Requires testing and proving performance at the POA to obtain and comply with required permits

5.2.1 Air Bubble Curtain

An ABC system comprises one or more perforated hoses or pipes placed in a ring around the noise source, namely the piles. Compressed air is supplied through the perforated hoses or pipes to produce an air bubble wall around the noise source (Figure 5-1). The hoses or pipes can be located at various elevations along the vertical length of the pile or in concentric horizontal rings on the seafloor. The air-water mixture forming the air bubble wall is very compressible compared to water and absorbs hydroacoustic energy as it radiates outward from the pile during driving (CH2M 2021b).

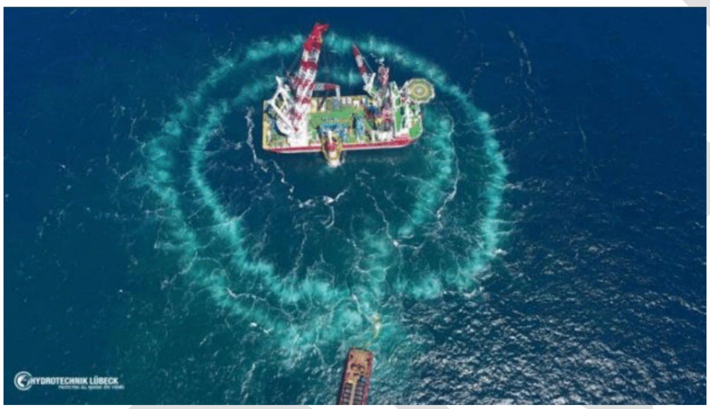

Figure 5-1. Double-bubble Curtain Around Offshore Pile Driving
(Source: Included with permission from Hydrotechnik 2022)

The diameter of the bubble curtain can range from a few feet larger than the diameter of the pile to a diameter greater than 500 feet beyond the pile. When the bubble curtain is located next to the pile wall, the ABC can be confined using confining casing (Figure 5-2). Typically, the confining casing consists of a plastic or steel pipe with a larger diameter than the pile being driven. The confined system is often used when strong currents could disperse unconfined air bubbles, reducing the effectiveness of the curtain. A confined ABC was used during the Test Pile Program conducted in 2016 (CH2M 2016b), and a confined and unconfined ABC were used during construction of the PCT between 2020-2021 (I&R 2021, 2022).

Figure 5-2. Confined System at the Benicia-Martinez Bridge
(Source: Caltrans 2015)

Use of the ABC method of sound attenuation has been documented in technical papers and project reports for various projects including:

- California Department of Transportation (Caltrans) has employed ABC systems at several bridge construction sites (Caltrans 2015):
  - San Francisco – Oakland Bay Bridge: This project included driving 8-foot-diameter steel pipe piles. Unconfined ABC systems provided a reduction of 0 to 2 dB due to the bubble size and the strong current conditions. In weak current conditions, a noise reduction of 5 to 15 dB was observed.
  - Richmond – San Rafael Bridge: This project included the installation of various diameters of steel pipe piles ranging from 14 to 150 inches in diameter. Unconfined ABC systems provided 5 to 15 dB of noise reduction under weak or zero current conditions when driving 30-inch-diameter steel pipe piles.
  - Benicia – Martinez Bridge: This project included the installation of 8-foot-diameter steel pipe piles. Due to the strong currents and deep-water conditions, nine bubble rings stacked vertically were used. The stacked ring system resulted in noise reductions of 15 to 30 dB. Also, a confined ABC system was tested using a steel confining casing (Figure 5-2). The confined system achieved 20 to 25 dB of noise reduction.
  - Humboldt Bay Bridge: Several confined and unconfined systems were evaluated. The best performing system provided 10 to 15 dB of noise reduction. The lower reduction compared to other locations was due to the noise being transmitted through the ground.

  Based on these findings, Caltrans (2015) concluded that noise reductions greater than 10 dB cannot be reliably predicted using confined or unconfined ABC systems.

- Washington State Department of Transportation (WSDOT) measured the performance of ABC systems during pile driving (pile diameters ranging from 18 to 72 inches) for 11 projects, including ferry terminal and transportation projects in the Puget Sound area (WSDOT 2020). The unconfined ABC system reduced the hydroacoustic noise by up to 32 dB and reductions up to 38 dB were achieved with a confined ABC system.
- A confined air bubble system was tested at POA in 2016 as a part of the Test Pile Program (CH2M 2016b). This project involved installation of 10 indicator piles. Each indicator pile was 48 inches in diameter and 200 feet long. Due to strong currents at the port, a 72-inch-diameter steel casing was used to confine air bubbles around the 48-inch-diameter test pile for eight of the piles (Figure 5-3). Tests were also conducted without the bubble curtain on two piles. Hydroacoustic sound

measurements were made as the indicator piles were installed using vibratory, diesel impact, and hydraulic impact hammers. When compared to unattenuated pile driving, the measured results with the ABC showed noise reductions of 7 to 10 dB at a distance of 33 feet from the pile and 4 to 8 dB at 3,280 feet from pile driving.

- Hydroacoustic noise measurements were made during the 2020 and 2021 PCT construction seasons at the POA (I&R 2021, 2022). These measurements were made driving 48-inch- and 144-inch-diameter steel piles. Piles were driven open-ended using either an APE D180 diesel hammer or an IHC S-800 hydraulic impact hammer. Confined bubble curtains were used during installation of the 48-inch-diameter piling, and unconfined curtains were used during installation of the 144-inch-diameter monopiles, with the following considerations:
  - Because there was no ABC on-and-off operation in either year, it was not possible to measure the effectiveness of the systems in reducing sound levels. Analysis of ABC performance in reducing sound was conducted by comparing measured sound levels against unattenuated levels predicted in the Incidental Harassment Authorization.
  - Measurements were made for impact driving with a confined bubble curtain of 11 permanent 48-inch-diameter piles. When compared with a single pile installed without a bubble curtain, it appears that ABC performance was variable and may reduce average near-source sound levels (that is, at 10 meters) by 2 to 8 dB. However, the measured transmission loss over larger distances was lower than expected.
  - Impact driving of two 144-inch-diameter piles with an unconfined bubble curtain system produced sound levels that were about 5 dB less than predicted unattenuated levels. Impact pile driving produced measurable sound well exceeding background over the frequency range of about 12.5 to 2,500 hertz (Hz) throughout all measurement positions out to 6 kilometers. Because the 144-inch-diameter pile sound levels were developed from theoretical data using sounds from other pile sizes, it is not possible to make an accurate comparison to unattenuated conditions.

Review of the documented reduction measurements shows that the performance of the ABC system is highly variable and dependent on system design and site conditions, such as current speed, water depths, and geology. Levels of hydroacoustic sound reduction reported for the different monitoring programs ranged between 0 to 38 dB. Nonetheless, it is apparent that the concept of using a bubble curtain to absorb sound energy is viable, and the variable results are probably site specific. For example, the ABC systems identified and described in this review did not appear to control sound that propagates from the ground into the water column. The efficiency of the ABC systems can be improved to further reduce sound energy transmitted through the seabed if concentric bubble curtains are installed on the sea floor at increasing distances beyond the pile installation, as shown on Figure 5-3.

The geometry of the ABC placement can be optimized for effectiveness by analyzing the geotechnical properties of the soils over the distance of sound energy propagation. Furthermore, the additional concentric curtains could be optimized to reduce sound propagation through the water.

The concept of combining a constrained ABC system with additional, unconstrained concentric rings may also be effective. However, physical constraints at the POA limit the ability to deploy multiple bubble curtain arrays due to the following factors:

- Water depths, strong tidal currents, and required anchoring systems
- Ongoing port vessel operations
- Interferences with the USACE maintenance dredging program
- Existing pile conflicts
- Construction vessel and anchoring system presence

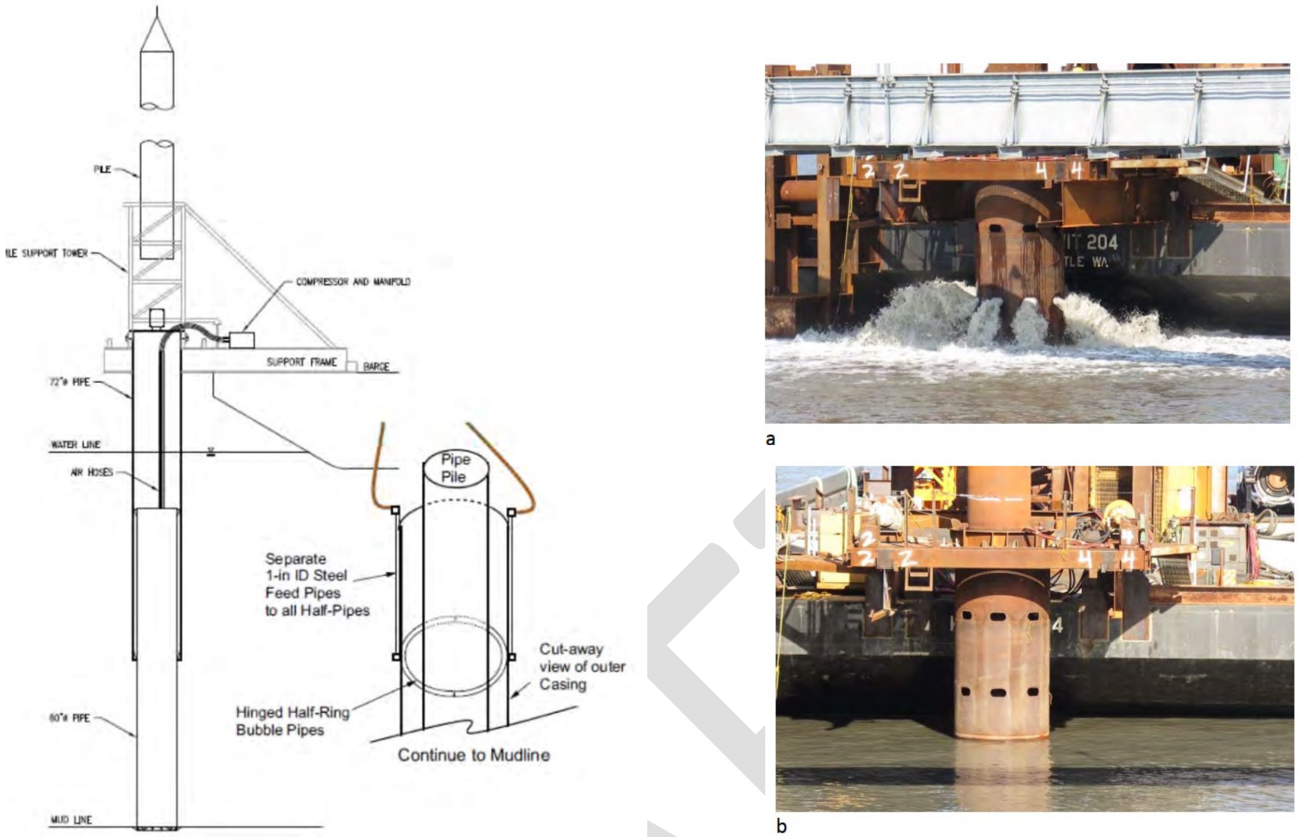

Figure 5-3. Design and Installation of Confined Bubble Curtain used for POA Test Pile Program

5.2.2 Hydro-sound Damper System

An HSD system is a net with elements such as air-filled elastic balloons and special polyethylene foam elements. The distribution and size of HSD elements are adjusted depending on the target frequency of underwater noise. The reported frequency range during installation has typically varied from 20 to 1,000 Hz. The HSD net encloses the entire length of piles above the sea floor, as shown on Figure 5-4.

Jacobs discussed the technology with OffNoise-Solutions GmbH (OffNoise) on October 13, 2021. OffNoise developed the HSD system for use in the North and Baltic Seas during wind farm construction programs, and the HSD system has been used successfully on five projects with pile diameters ranging from 9 feet up to 24 feet in diameter between 2012 and 2016. Typically, large hydraulic impact hammers were used during installation of the piles (Elmer et al. 2016).

The overall HSD system consists of the HSD net connected to a steel net basket and a winch frame to lower the basket to the sea floor (Figure 5-5). The steel net basket is attached at the bottom of the HSD net to compensate the buoyancy force from the HSD elements. Each net is expected to be used for at least 40 installations before it is replaced. The HSD system is often combined with a bubble curtain located at some distance (more than 650 feet) from the pile installation (similar to Figure 5-1). This bubble curtain is referred to on wind farm projects as a big bubble curtain (BBC). It is used to attenuate hydroacoustic noise initiated in the ground from pile installation, and attenuate high-frequency hydroacoustic sound.

Based on the measured noise data from North and Baltic Seas wind farm projects, the HSD system, combined with a BBC system, achieved hydroacoustic noise reductions between 14- and 25-dB single event sound exposure level (SEL) even in strong currents (up to 8 feet per second). Without the BBC system, the noise reduction was observed to be about 10 to 15 dB (SEL). Results from hydroacoustic noise monitoring (Elmer et al. 2016) found that the BBC provided good attenuation in the high-frequency range, while the HSD system showed better performance in the low-frequency range.

Figure 5-4. Hydro-sound Damper Net
(Source: Included with permission from OffNoise 2022)

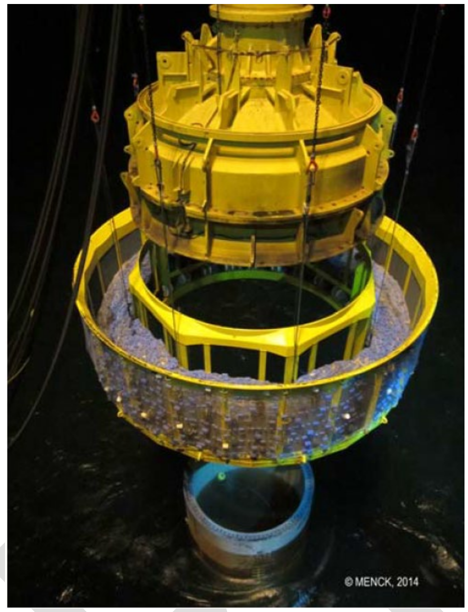

Figure 5-5. Hydro-sound Damper Net and Net Basket
(Source: Included with permission from OffNoise 2022)

The reported benefit of adding the BBC to the HSD system is similar to those reported when a BBC system was added to an ABC system, suggesting it may be worthwhile to investigate specifying the deployment of a BBC with either system.

The logistics of using an HSD at the port were discussed with OffNoise during the conference call (OffNoise 2021). One of the primary concerns was the ability of the HSD system to operate in such a large tidal fluctuation. As the tide recedes, the walls of the HSD system would relax and could touch the pile being driven. This contact would likely accelerate wear of the HSD system, requiring more frequent replacement, and reduce the effectiveness of the system. OffNoise also advised that it requires approximately 6 months to design and assemble a net in Germany, but once assembled, the HSD system would fit within a normal shipping container. OffNoise noted that a winch system would be required to lower the net over the pile, and this would be constructed by another firm under design guidance from OffNoise.

The HSD option is not recommended because of the following factors:

- Untested in nearshore applications
- Untested in high pile production rate circumstances
- Industry has expressed concerns for application in high tidal range conditions
- Requires frequent net replacement
- Requires testing and proof of performance at the POA to obtain and comply with required permits

5.2.3 AdBm Noise Mitigation System

The AdBm NMS is similar to the HSD net system but uses arrays of specially designed Helmholtz resonators tuned to specific frequencies. The Helmholtz resonators are small containers with open bottoms (Figure 5-6). Each container has trapped air inside when submerged. The resonators act as dampers as the underwater noise (or energy) travels through the AdBm NMS. The resonators are attached to the underside of horizontal slats configured to surround the pile as a ring. Multiple rings are attached to cabling spaced vertically at equal intervals, allowing the assembly to be raised and lowered in a manner similar to a venetian blind (Figure 5-7). A winch frame is required to deploy the AdBm NMS (AdBm 2021).

Based on the Demonstration Report prepared by AdBm (2019), the AdBm NMS has been tested on a full-scale monopile installation in the Belgian North Sea.

Figure 5-6. AdBm Helmholtz Resonators
(Source: Included with permission from AdBm 2020)

Figure 5-7. Winch Frame and AdBm System
(Source: Included with permission from AdBm 2020)

During the driving of the five test monopiles using a large hydraulic impact hammer, the hydroacoustic noise was measured. The piles were installed in water depths ranging between 60 and 90 feet and diameters varied between 23 and 26 feet. Three sizes of the Helmholtz resonators were used in the AdBm NMS.

Test results showed that the AdBm NMS, combined with a single BBC, achieved a maximum noise reduction of 15 dB (SEL) (Table 5-1). Without the BBC, the reduction was about 8 dB (SEL) (AdBm 2019). This indicates that the NMS is no more effective than the BBC.

Table 5-1. Results of Hydroacoustic Sound Measurements during AdBm NAS Testing

Noise Mitigation Configuration	Slat Spacing (meters)	Effective Noise Reduction of the SEL (dB)	Effective Noise Reduction of the $L_{p,pk}$ (dB)
AdBm	0.67	7 ≤ 7 ≤ 8	7 ≤ 7 ≤ 8
AdBm + BBC	0.67	14 ≤ 15 ≤ 15	18 ≤ 18 ≤ 20
BBC	0.67	10 ≤ 10 ≤ 11	12 ≤ 13 ≤ 15

Source: AdBm 2019

Notes:

Noise levels were measured at 750 meters from the source.

≤ = less than or equal to

$L_{p,pk}$ = maximum value reached by the sound pressure

It is noted that the AdBm NMS was tested independently during the Test Pile Program performed in 2016 at the POA (CH2M 2016b). The Test Pile Program showed that the AdBm NMS reduced the hydroacoustic noise from impact pile driving by 2 to 10 dB (SEL) at 32 feet from the pile installation. The AdBm NMS reduced the noise level at approximately 3,300 feet by 0 to 3 dB (SEL). These reductions were less effective compared to those reported on the North Sea wind farm projects. However, the Helmholtz resonators used during the PAMP Test Pile Program were all a single size, while three different sizes of resonators were used during the wind farm projects. The poorer performance at the port is thought to be due to mismatches between the predominant frequency of underwater sound propagation and the frequency response of the Helmholtz resonator.

Logistics were relatively simple when using the AdBm NMS during the Test Pile Program. The AdBm NMS was deployed from the construction barge (the DB General) during pile installation and accommodated the large tidal fluctuation by reducing the distance between layers of the Helmholtz resonators, similar to the function of Venetian blinds.

The AdBm NMS option is not recommended due to the following factors:

- Relatively poor and variable performance results experienced with the Test Pile Program
- Uncertainty whether broad-based noise can be fully mitigated through resonator modifications
- Requires testing and proof of performance at the POA to obtain and comply with required permits

5.2.4 Double-wall Pile Driving (Reinhall Piles)

The double-wall pile driving system consists of two sizes of steel pipe piles separated by an air-filled gap. The two piles forming the double-wall system are concentrically connected using a specially designed driving shoe. By having the gap between the two piles, noise generated by driving the inner pile is attenuated as it passes through the air gap (Marine Construction Technology 2021).

This double-wall system was developed by Professor Per Reinhall at the University of Washington with support from WSDOT. Professor Reinhall is Chair of Mechanical Engineering with expertise in dynamics, impact, and vibration analysis.

The system uses either a fixed double-wall pile or a reusable inner pile (mandrel-driven pile) to drive the outer pile. Impact to the inner pile drives the outer pile because they are connected through a specially designed and patented driving shoe, which provides a watertight connection between the inner pile and outer pile (Figures 5-8 and 5-9), enabling the gap between the two piles to remain dry while still transferring sufficient impact energy into the shoe to drive the outer pile.

The pile driving shoe includes a short section of pile that can be welded to the end of a full-length pile (Figures 5-8 and 5-9). The mandrel-driven pile shoe is welded to only the outer pile. The air gap between the inner and outer pile reduces the transmission of noise generated from driving the inner pile into the surrounding water along the entire pile length, including the portion of the pile driven below the sea floor. Pile spacers are attached to the inner pile so there is no pile-to-pile contact during driving.

Figure 5-8. Pile Shoe Assembly for Double-wall Pile System
(Source: WSDOT 2015)

Figure 5-9. Double-wall Pile
(Source: WSDOT 2015)

In 2014, a full-scale test of the double-wall pile driving system was conducted in Commencement Bay, in Puget Sound, Washington. During the test, three 30-inch-diameter by 80-foot-long steel pipe piles, with 24-inch-diameter inner piles, were driven with a diesel impact hammer (Delmag D46). The water depth was approximately 32 feet at the test pile locations (WSDOT 2015). The subsurface soil at the test location consisted of 26-foot-thick, very soft soils overlying very hard glacial till.

Table 5-2 summarizes the hydroacoustic noise reduction from the full-scale test. As summarized, a noise reduction of 17 to 18 dB (SEL) at a distance of 32 feet was observed.

Table 5-2. Results from Reinhall Test Pile Installation in Commencement Bay

Parameter	Double-walled Pile (dB)	Mandrel-driven Pile (dB)
Peak reduction	-21.2	-23.2
SEL reduction	-17.2	-18.0
Root mean square reduction	-19.1	-20.7

Source: WSDOT 2015

A second full-scale test was performed near Vashon Island in Puget Sound in 2015; the water depth at this location was approximately 41 feet and soils at the installation location included very hard glacial till. A Delmag D46 hammer was used during the test. As summarized in Table 5-3, the hydroacoustic noise reduction level ranged from 9 to 11 dB (SEL) at a distance of 64 feet (WSDOT 2017).

Table 5-3. Results from Reinhall Test Pile Installation at Vashon Island

Double Wall Test Pile	Peak reduction (dB)	RMS reduction (dB)	SEL reduction (dB)
range 20 m water depth 8.5 m hydrophone depth 5.0 m	12	10	9
range 120 m water depth 12.5 m hydrophone depths 1.25–9.25m	8.7–13.5	8.8–12.7	7–10.3
Mandrel Test Pile	**Peak reduction (dB)**	**RMS reduction (dB)**	**SEL reduction (dB)**
range 20 m water depth 8.5 m hydrophone depth 5.0 m,	12	11	11
range 120 m water depth 12.5m hydrophone depths 1.25–9.25m	11.4–14	10.8–12.6	9.3–11.1

Source: WSDOT 2017

m = meter

Based on discussions between Professor Reinhall and Jacobs staff on October 13, 2021, the maximum size of the special end piece could be expanded from the current maximum size of 30 inches to 48 or 60 inches with no loss in function. However, the largest size manufactured and used to date is 30 inches, and there are practical issues with crane capacities being able to lift 48-inch-, 60-inch-, or 72-inch-diameter double piles due to weight considerations.

The double-wall pile driving option is not recommended due to the following factors:

- Still experimental
- Untested in high pile production rate circumstances
- Untested for larger piles required for cargo dock construction
- High degree of uncertainty for pile installation associated with project-level geotechnical conditions and required pile depths

5.3 Low Noise Construction Methods

The noise reduction methods described in this section involve the reduction of hydroacoustic noise by using alternate pile installation methods as compared to the more conventional methods of vibratory and impact hammer pile installation. The alternate methods range from press-in pile, to boring methods, to jetting. While these methods are not noise free, they do not involve repetitive high-frequency impacts of a pile hammer striking a steel pile.

Due to the critical status of the existing cargo docks, expediting construction of the new terminals is of the highest priority. Alternative pile installation methods and technologies may have limited opportunity for consideration due to the following factors:

- Newly evolving and experimental
- Not tested in nearshore environments
- Not proven for high pile production rate circumstances
- Unknown performance success or applications in physical environments involving factors such as extremely high tidal currents or difficult geotechnical conditions
- Require testing and proving performance at the POA to obtain and comply with required permits

5.3.1 GIKEN Press-in Pile Installation System

The GIKEN press-in system installs piles with a uniform static force applied by a hydraulic ram. This method of pile installation was developed in 1967 by GIKEN Ltd., a large Japanese construction company. GIKEN has been installing piles in the United States for over 20 years (GIKEN 2021).

The installation method has been widely used for the installation of sheet piles. However, the method has been used to install pipe piles of up to 98 inches in diameter, although hydraulic systems for pushing piles at this diameter are currently only available in Southeast Asia. Manufacturing a system for installing large-diameter, 98-inch pipe piles in the United States could take 6 months or more based on discussions with GIKEN on October 1, 2021.

The GIKEN press-in installation method relies on a reaction system to resist the forces needed to jack a pile into place. The reaction for the press-in force is provided by either previously installed permanent piles or from a temporary deadweight reaction system. The maximum press-in force generated by GIKEN's system is approximately 320 kips. The system is proven to produce low construction noise and vibration compared to conventional impact hammers due to the steady force applied to the piles. Despite the reduced sound generated during installation of the piles, hydroacoustic noise is still expected from normal construction activities associated with lifting and placing pile sections. GIKEN did not provide any data regarding the level of hydroacoustic noise generated during installation of piles during a conference call between Jacobs and GIKEN's specialists (GIKEN 2021).

GIKEN's system is not as effective when attempting to drive piles into very dense soils or rock strata. To compensate, GIKEN provides various alternatives for drilling or softening the dense soil or rock. For soft rock or very dense granular soils, cutting teeth can be attached to the tip of the piles, and an oscillator can screw the pile into the ground. Alternatively, an auger can pre-drill through the soils to break up the soil before driving the pile. For softer soils, pipes and nozzles are attached inside the pile, and water jets loosen and soften the soil as the pile is advanced.

The GIKEN installation system was originally designed for driving sheet piles, thus enabling adjacent sheet piles already installed as the reaction point for progressing the wall. GIKEN has since adapted the system to install pipe piles by developing reaction from a nearby previously installed pipe pile using a special skip-lock system (Figure 5-10). The maximum pile spacing using this latter system is limited to 2.5 times the pile diameter. For example, 48-inch-diameter piles, such as used for PCT, would have a maximum spacing of 10 feet. In CH2M's experience, the optimal spacing of pile bents with 48-inch-diameter piles is about 20-feet, and so 10-foot spacing of piles would double the amount of piles to install, thus doubling the duration of construction noise. If a skip-lock system is used it will be designed for one pile size to allow reaction from adjacent piles, and therefore it is likely to be designed solely for this project.

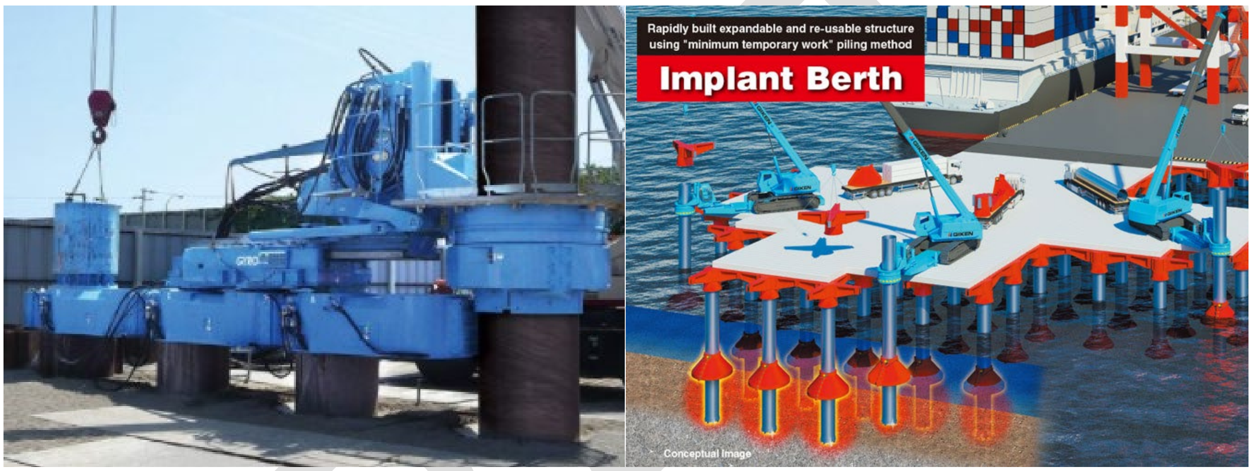

Figure 5-10. GIKEN System with Skip-lock
(Source: Included with permission from GIKEN)

Based on preliminary wharf configurations designed by Jacobs for T1 and T2 (CH2M 2016a and 2021a), 48-inch-diameter or larger pipe piles were designed to support the wharf deck. The ultimate shaft resistance required from a 48-inch-diameter pipe pile is estimated to be approximately 3,000 kips (unplugged) with 150 feet of penetration below the mudline (EL. -38 feet). As the maximum press-in force reported by GIKEN is 320 kips, the resistance from a pile during installation needs to be reduced significantly (approximately 10 percent [%] of the ultimate capacity).

This reduction of pile resistance would be difficult to achieve. Jacobs notes that even if resistances this low could be achieved using jetting, the reaction of the pile would be reduced for the permanent structure and other measures would be needed to achieve the design requirements. A case study in Japan used 32-inch-diameter pipe piles, which were installed to a toe depth of 190 feet using the GIKEN system augmented with water jetting. These piles achieved an ultimate capacity of approximately 1,400 kips (Takuma et al. 2020). The subsurface soils at the study location mostly consisted of loose to medium dense silt and sand.

The jacking capacity limitations associated with the GIKEN press-in system will be a major limitation for the T1 and T2. Very large reactions would have to be developed in the piles to support the wharf decks and crane unloading facilities, so additional piles would be required to reduce pile capacity demands. This results in the cost of pile purchase and installation increasing in proportion to the additional piles required.

Pile spacing limitations associated with the GIKEN system would also require doubling the number of piles to be installed, thus doubling the duration of construction activities and associated noise levels. GIKEN's system is not effective when attempting to drive piles into very dense soils or rock strata, such as at the port location. Improvements to GIKEN operations through augmentation with jetting creates additional significant issues, as discussed in Section 5.3.5. Realistically, this means the GIKEN system is not a feasible option for construction of the cargo docks.

5.3.2 IQIP Developed Systems

IQIP is a large offshore construction company based in the Netherlands with an office in Houston, Texas, developing low noise systems for the installation of offshore wind farm foundations. Their systems are the BLUE Piling System, ·the Integrated Monopile Installer, and the PULSE Noise Reduction System, which are detailed in this section.

BLUE Piling System (Figure 5-11). This technology uses a column of water to drive piles, unlike typical impact hammers that use a steel ram. Conventional impact hammers deliver an impulse of dynamic energy to piles over a very short period of 4 to 8 milliseconds, while the BLUE Piling hammer delivers the impulse over a period of 100 to 200 milliseconds. BLUE Piling's longer energy delivery time reduces the vibration and noise from pile driving. IQIP reports that the number of blows required to achieve the specified pile resistance will be reduced (IQIP 2021).

Figure 5-11. BLUE Piling Hammer
(Source: Included with permission from IQIP 2022a)

IQIP has been trialing the system, and one of their test programs using a 21-foot-diameter monopile IQIP (2021) recorded an underwater noise reduction during installation of approximately 20 dB (SEL) when compared to conventional impact hammers. The noise reduction level during the test program was measured at approximately 2,500 feet from the pile driving location. While the results of the BLUE Piling technology appear to be promising, this technology has not been used to drive actual production piles.

Integrated Monopile Installer (Figures 5-12 and 5-13). The integrated installer combines the hydraulic hammer and a shield system. No noise measurement data are available; however, the performance of the integrated system is expected to be similar to that of a confined bubble system with casing and a BBC system.

Figure 5-12. Integrated Monopile Installer, Close
(Source: Included with permission from IQIP 2022b)

Figure 5-13. Integrated Monopile Installer, Far
(Source: Included with permission from IQIP 2022b)

PULSE Noise Reduction System (Figures 5-14 and 5-15). The PULSE is still being developed by IQIP and Delft University. Its features appear to be similar to the BLUE Piling technology, as it uses a water column to reduce hydroacoustic noise. According to IQIP, the system is placed between a standard hammer and the pile and dampens the impact to the pile, thus reducing the noise. The IQIP website also states that:

> *"Due to its placement, PULSE can easily be combined with other underwater noise mitigating measures. One such is IQIP's Integrated Monopile Installer, which directly mitigates noise by shielding the pile with a double-walled steel tube into which a bubble curtain can be fed."*

Figure 5-14. PULSE Noise Reduction System
(Source: Included with permission from IQIP 2022b)

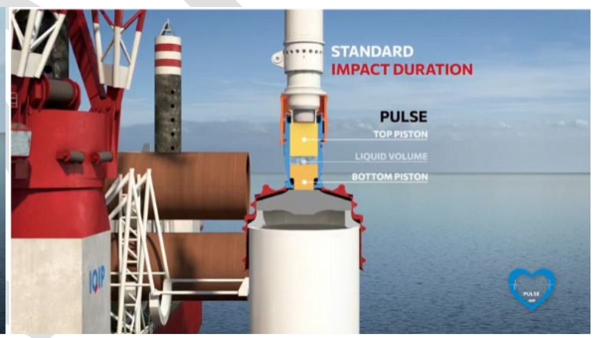

Figure 5-15. PULSE Noise Reduction System Features
(Source: Included with permission from IQIP 2022b)

These three systems under development by IQIP focus on hydroacoustic noise reduction for offshore wind farms. Each system is deployed from a large jack-up barge. While the methods, when tested and available, could be adapted to T1 and T2 construction, the costs may be significant, given the special equipment that would have to be mobilized from Europe for the work.

IQIP options 1 and 3 are not recommended because they are still in the developmental stages and are not on the market. Option 2, the hydraulic hammer, was successfully used to drive 144-inch-diameter monopiles at the POA on the PCT project. This type of hammer paired with a confined bubble curtain would be comparable to the shield system shown on Figures 5-12 and 5-13. The hydraulic hammer paired with a confined bubble curtain system is a feasible method for noise reduction at the POA.

5.3.3 Drilled Shaft

Drilled shafts do not use impact hammers; therefore, they have potential for quieter deep foundation construction. Drilled shaft foundations are deep foundations constructed by excavating a cylindrical hole in the ground, placing a steel reinforcement cage into the excavated hole, and then placing tremie concrete into the hole. Drilled shafts typically range in diameter from 2 to 12 feet or more (FHWA 2010).

Drilled shafts are commonly used on bridges and other transportation structures to depths of up to 200 feet (FHWA 2010). Jacobs' designs for the Honolulu Light Rail recently achieved depths greater than 300 feet using 12-foot-diameter shafts.

There are two common methods for excavating drilled shafts:

1. Oscillator Method: The oscillator rotates a steel casing with teeth at the toe into the ground while the soil inside the casing is simultaneously excavated using a clam or drop bucket (Figure 5-16). The casing supports the excavated shaft and allows the rebar cage and concrete to be placed. Once the concrete is placed, the casing is usually removed. For extremely soft soil conditions, the casing can be left in place to provide permanent support as the concrete cures. Casings are also left in place when the weight of the casing exceeds the lifting capacity of the drill rig. If the casing is left in place, adjustments have to be made to the side friction used in the drilled shaft capacity calculations to account for the reduced friction between steel and soil versus the friction between concrete and soil for a normal drilled shaft (FHWA 2010).
2. Auger Method: The second method uses an auger system to excavate the soil (Figure 5-17). The auger is used to cut a cylindrical hole in the ground; soil is removed by raising the auger and spinning the soil off and disposing of the soil at the surface. Hole stability is maintained by using a bentonite-water or polymer soil slurry, depending on the contractor's equipment and the soil being excavated. The diameter of the auger typically ranges from 2 to 10 feet. Shafts can be constructed using the auger method to depths of 200 feet, depending on the diameter of the auger and the type and consistency of the soil.

Figure 5-16. Oscillator Equipment for Drilled Shaft Construction, Far
(Source: FHWA 2010)

Figure 5-17. Auger Equipment for Drilled Shaft Construction, Close
(Source: FHWA 2010)

Information regarding hydroacoustic noise generation from drilled shaft construction is limited. Available data indicate that the hydroacoustic noise levels from drilled shaft construction are lower than levels from impact pile driving, as would be expected. A case study in California (Dazey et al. 2012) measured hydroacoustic noise from drilled shaft construction in Bechers Bay, Santa Rosa Island from November 2010 to July 2011. The data were measured at a distance of 154 to 637 feet from the source and the noise level was recorded from the drilled shaft construction between 120 to 185 dB, with an average level of 155 dB. The case study also included the noise levels from each phase of the drilled shaft construction. The maximum noise level during auger drilling was measured to be approximately 183 dB.

A bridge project in one of the mid-Atlantic states (Thalheimer et al. 2014) also measured underwater noise from drilled shaft construction and pile driving. The underwater noise measurements for cumulative sound exposure level (cSEL) were in the 20 Hz to 10,000 Hz range; measurements ranged from 143 to 171 dB cSEL for drilled shaft construction and from 174 to 209 dB cSEL for driven steel pile construction when no sound mitigation was applied in shallow water 1-2 meters (3-6 feet) deep at a distance of 10 meters (33 feet).

These case studies show that the hydroacoustic noise level during shaft construction can exceed 180 dB; however, average levels were around 160 dB for some of the caisson drilling methods. SEL levels for caisson drilling with a digger bucket are only slightly less than an auger. Because the rotation rate of augers and oscillators is relatively slow, the source of hydroacoustic noise is believed to result more from the contact of the auger or excavation bucket on the casing rather than noise caused by cutting of the soil. The clam or excavation bucket for the oscillator is also expected to be the source of noise as it is lowered into the casing to excavate soil.

Installation of drilled shaft foundations at the POA would require the following special considerations, due to the depths involved and the large tidal fluctuations:

- Temporary platforms: Based on discussions with Malcolm Foundations (Malcolm), a West Coast contractor specializing in drilled shaft construction, construction of the large-diameter shafts required for T1 and T2 is likely to require a temporary platform (or work trestle) supported with piles from which to conduct operations (Malcolm 2021). The work trestle is needed to provide a stable work platform for the drilling equipment because tidal fluctuations are too large to allow the use of a floating barge. Malcolm recommends using an auger and a polymer drilling mud rather than the oscillator because of the drilling depths expected to be required for the design.

  The maximum tide level (EL. + 34.6 feet) is over 72 feet above the planned mudline of EL. -38 feet; therefore, a steel casing will be required from the mudline to above the tidal height to contain the polymer drilling mud. The casing must be driven below the mudline to prevent the hydrostatic head of the drilling fluid to seep from the casing or cause hydro-facture or liquefaction of the soil. This casing will double as permanent formwork for the column and will need to be designed to permanently support the wharf structure. The use of a work trestle to support the drill equipment is conceptually similar to methodology used for construction of the PCT. Experience from PCT construction demonstrated that many piles were required to construct the work trestle, and the hydroacoustic noise from installation of these piles was significant, even when bubble curtains were used to mitigate sound propagation.

- Jack-up rig: The drilled shaft installation equipment could be stored and operated from a large jack-up barge (over 500-ton capacity). The jack-up rig would be similar to that shown on Figure 5-16 for the IQIP PULSE system. Drilled shafts could be installed from the jack-up barge using either a conventional on-land track-mounted drill rig and polymer drilling fluid without full-depth casings or an oscillator system. A casing would be installed for the full depth of water and driven into the seabed to sufficient toe depth, to confine the drilling fluid during shaft excavation, and to serve as a casing where reinforcing steel and concrete would be placed. Alternatively, the oscillator casing could be left behind. Based on Jacobs' engineering judgment, the jack-up barge potentially offers more flexibility for construction than the work trestle because it can be moved between locations relatively easily.

  However, a jack-up barge of this size does not exist currently in Alaska, and costs for mobilizing the jack-up barge to the port would be significant. Daily operating costs would also be high because of the special support staff and equipment needed to operate the equipment. A jack-up barge also creates noise in the raising and lowering of the legs.

As discussed, the noise generated from drilled shaft construction is less than the impact of driving steel piles, although few data are available to quantify the noise reductions. Nonetheless, drilled shaft installation is not silent, and noise is generated from several sources, including:

- Driving noise from vibratory installation of the casing below the mudline
- Contact between the auger and casing or between the drop bucket and oscillator casing as soil is excavated from the borehole creates loud impact noises exacerbated by the hollow casing
- Contact of the auger or oscillator with subsurface obstructions, such as erratic glacial formations during drilling
- Above-water noise from handling drill strings and casing
- Driving noise from temporary pilings needed to support drill rig, or noise from deploying and retracting the jack-up barge supports

In addition to the various sources of noise, when compared to a driven pile installation, which is typically less than 1 hour of impact driving, drilled shaft installation will take 2-3 days; the additional time for installation significantly increases the potential exposure to marine mammals and adds years to the construction schedule.

Based on these factors, the drilled shaft installation is not recommended. While drilled shafts offer a small reduction in noise intensity, this does not offset years of additional in-water work. Additionally, the temporary trestle pling to support the drill rig or installation and removal of jack-up barge legs will add significant impacts to marine mammals.

5.3.4 Helical Piles

Helical piles are a deep foundation system installed by rotating the shaft of a pile having one or more “helixes” welded to the pile, thus allowing the pile to be screwed into the ground. The helixes also increase the bearing surface for axial loading of the pile. While helical piles have been used for many years, APE has developed equipment that will allow helical piles with shafts that are up to 24 inches in diameter to be installed to depths of several hundred feet below ground surface (RMDT 2020).

Using the helical pile system, multiple lengths of piles can be connected using threaded or bolted couplers. Helical piles are typically installed using a hydraulic torque driver attached to a conventional excavator or a crane. Currently, the maximum torque from a driver is about 320 kips per foot, and the helical pile is manufactured for shaft diameters of up to 24 inches (helix diameter of up to 48 inches). Pressure grout can be applied during the installation of helical piles to achieve higher axial capacities.

Figures 5-18 and 5-19 depict helical piles prior to installation and during the installation process, respectively, during a project in Lake Union in Seattle, Washington. The helical piles were used to support a work trestle to construct the Eastlake Bridge. The work trestle was used to support an oscillator drilling system during construction of 8-foot-diameter drilled shafts.

Figure 5-18. Helical Piles
(Source: Included with permission from Pileworks)

Figure 5-19. Helical Pile Installation System (Crane, Driver, and Guide)
(Source: Included with permission from Pileworks)

Underwater noise level measurements from the helical pile installation were taken during bridge foundation construction, as summarized on Figure 5-20. The measured maximum noise level was as high as 153 dB (1-second interval).

	rmsSPL Results Measured During Helical Pile Advancement[1]		**Interim Criteria for Injury to Fish from Pile Driving Activities**[2]
	10 second interval	1 second interval	
Maximum rmsSPL, dB re: 1uPa	148	153	206 peak 187 accumulated 183 accumulated for fish < 2 grams
Median rmsSPL, dB re: 1 uPa	137	140	
Average rmsSPL, dB re: 1 uPa	136	140	
Standard Deviation of Average rms SPL value	5	5	

Figure 5-20. Hydroacoustic Noise Measurements during Helical Pile Installation
(Source: Included with permission from Pileworks [RMDT 2020])

< = less than

rmsSPL = root mean square of sound pressure level

uPa = ultrasound peak amplitude

Figure 5-21 plots the noise data at 33 feet from the noise source during the helical pile installation.

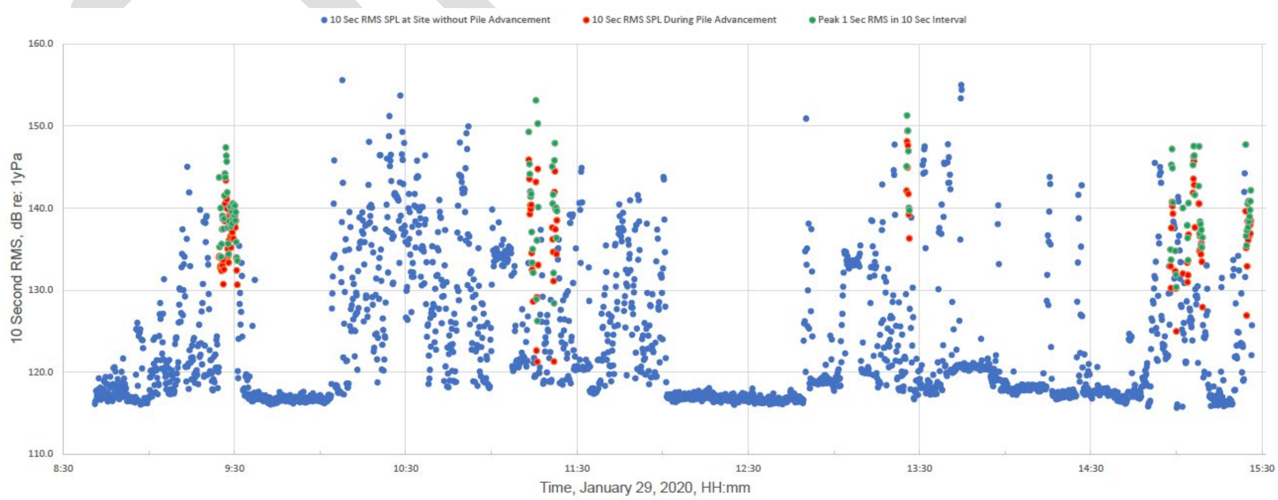

Figure 5-21. Measured Noise Levels at 33 feet from Helical Pile Installation
(Source: Included with permission from Pileworks [RMDT 2020])

Although the helical piles offer hydroacoustic noise reductions compared to impact piling, they are limited by the applied torque of available installation equipment. Thus, there is a limit to the diameter and length of helical piles that can be installed using existing technologies. The helical pile is best-suited to construct temporary work trestles and is not practical or recommended for cargo terminal construction. Temporary works do not have to be designed for seismic loads, allowing smaller pile diameters to be used and could be considered for limited applications during construction.

5.3.5 Jetting and Jetting with Grouting

Jetting is a method sometimes used to install piles during marine construction and involves the use of high-pressure water jets to assist in pile installation. The concentrated water flow from the jet loosens soils underneath the pile tip and along the pile wall, which reduces resistance during pile driving. The reason jetting is considered in this analysis is the idea that reducing the pile driving resistance will reduce the pile driving duration and pile driving noise.

This method of installation has been used at the Port of Los Angeles (POLA) (McNeilan et al. 2004), where thousands of 24-inch-diameter, prestressed, precast concrete piles have been installed aided by jetting through a center tube cast in the pile. The rate of jetting is controlled by varying the nozzle size at the toe of the pile and controlling the volume of water pumped to a connection at the head of the pile. A pumping rate of up to 300 gallons per minute was used during installation.

Under high flow rates, the pile penetrated the soil under the weight of the pile or with fewer hammer blows to the pile than impact pile driving without jetting. Typically, the flow rate and pressure influence the volume of soils affected by jetting. Excessive flow rate or pressure results in poor quality control, misalignment of piles, and reduction in pile axial and lateral capacity. Insufficient flow rate or pressure could make the jetting ineffective. Jetting is typically only effective where soils can be loosened by the water jet. Furthermore, the use of jetting counters the intent of developing blow count resistance at the pile toe as a reaction point for vertical loads due to the fact the soils have been loosened.

Two example installations using the jetting procedure are summarized as follows:

1. POLA P400 Test Program: During the construction of Pier 400 at the POLA, some indicator piles were driven aided by jetting, while other piles were driven without jetting. Pile dynamic analyzer (PDA) tests were conducted on the piles during and after installation. The PDA tests performed on the indicator piles after several weeks of setup showed that the shaft friction of the piles installed with jetting was about 30 to 40% less compared to piles installed without jetting. The PDA test results also indicated that the axial capacity gain over time was minimal for the piles installed with jetting. Additionally, the study showed that the jetting did not significantly reduce the time required to install piles when a properly sized hammer was used and increased the time to drive a pile because additional time was required to attach the jetting system to piles. Another finding from the study was that jetting adversely affected pile driving quality control and the control of pile location and inclination. Based on these findings, the study concluded that jetting should be avoided (McNeilan et al. 2004).
2. Cook Inlet Oil Platform: Jetting methods were used in the 1960s to install steel caissons to depths of 200 feet in Cook Inlet during construction of oil drilling platforms (Gerwick 1970). Jets were located on the inside of the casing with the jet nozzle located 2 to 6 inches above the tip of the casing. Spacing of the jets was 2 feet. According to Gerwick, this method of installation was used to install casings through “sands, gravels, cobbles, and glacial till” (Gerwick 1970). Installation was supplemented with driving; jetting was stopped about 2 feet above the planned base elevation after which the casing was driven without jetting.

As stated in the first example, the jetting did not decrease the pile driving time as expected, and because of the complexity of the operation, had an overall increase in installation time. Sound measurements were not taken during the pile installation to verify whether jetting was a quieter installation method. Additionally, at the end of the drive, the last few feet were driven without jetting to seat the piling and verify the bearing capacity. This final several feet of driving will have the same sound signature as a piling installed without jetting. Based on this discussion, there are no data supporting jetting as a means for quieter driving.

Additionally, jetting is not a recommended pile installation method because of the following factors:

- Significantly reduces pile bearing capacities due to the loosening of the soil (30–40% based on the example)
- Risk of adversely affecting control of the pile location and inclination
- Untested and uncertain performance for localized geotechnical conditions at the port
- Increases pile installation times
- Requires testing and proof of performance at the POA

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Section 6. Comparative Cost Estimate

6.1 Overview

This section describes the comparative cost estimates for the alternatives under consideration. The estimates help distinguish between alternatives based on the structural design. The costs presented are the comparative costs for T1 and T2, including trestles and ground improvements. Cost elements equal for all alternatives are not included in the estimates, such as:

- Gantry cranes and their power requirements
- Tug assist during construction
- Operations support
- Demolition of existing terminals
- Other similar items

This high-level cost exercise is intended to provide enough detail to aid in selecting the foundation substructure alternative for T1 and T2. Table 6-1 summarizes the cost estimate for each alternative, including contingency with an accuracy range of -20% to +30%, per AACE International (AACE) standard guidelines for a Class 3 estimate (AACE 2022). Appendix N provides supporting information.

Table 6-1. Cost Estimate Summary

Terminal	Low Range (-20%) ($)	Estimate Range ($)	High Range (+30%) ($)
48-inch-diameter Driven Piling			
T1	--	507,560,000	--
T2	--	441,260,000	--
Total	759,060,000	948,820,000	1,233,470,000
72-inch-diameter Driven Piling			
T1	--	421,950,000	--
T2	--	335,250,000	--
Total	605,760,000	757,190,000	984,350,000
72-in Diameter Drill Shaft Alternative			
T1	--	478,170,000	--
T2	--	352,730,000	--
Total	664,720,000	830,900,000	1,080,170,000
Jackets Conventional Alternative			
T1	--	722,000,000	--
T2	--	593,000,000	--
Total	1,052,010,000	1,315,010,000	1,709,520,000

Table 6-1 provides a simplified summary of the cost estimate alternatives. The first observation is that the driven 72-inch-diameter alternative is significantly less expensive than both the driven 48-inch-diameter alternative and the 72-inch drilled shaft option. It is less expensive than the 48-inch-diameter alternative because there are significantly fewer pilings to install, which reduces the construction duration and total material costs. It is less expensive than the drilled shaft option for essentially the same reasons. The drilled shaft installation will take days per shaft, whereas driven piling installation takes only hours per piling. Additionally, the drilled shafts require a separate equipment spread and temporary trestles or a jack-up barge to support the operation.

The other observation is that the modular jacket system, while offering speedy installation, high-quality workmanship, reduced acoustic impacts, and other advantages discussed in Section 4.10, is significantly more expensive than the other options. While there are advantages to potentially eliminate years from the project schedule and construction risks, it does not appear these advantages can be monetized toward closing the cost gap between the other alternatives.

6.2 Basis of Estimate

The cost estimate is based on working 6 days per week, 10 hours per day.

6.2.1 Markups and Allowances

Table 6-2 summarizes the typical contractor and owner's markups applied to the cost estimate.

Table 6-2. Typical Contractor and Owner's Markups

Item	Amount (%)
Contractor indirect cost	15
Profit markup	25
Subcontracts markup	25
Contractor's contingency	3
Project construction contingency	10

These markups and allowances represent the contractor's normal cost of doing business, including an amount to cover the uncertainties for the work. Definitions for each category are as follows:

- Contractor indirect cost: Indirect costs are also known as fixed costs. These costs are not directly related to a function or product. Indirect costs include taxes, administration, and personnel. Indirect costs are frequently referred to as general overhead expenses (for example, rent and utilities) of running a business, and general and administrative expenses (for example, officers' salaries, accounting and personnel department costs, maintenance of equipment, and support from the home office).
- Profit markup: This factor involves how much money the contractor wants to make. It is based on general market conditions, competition, risk involved, weather conditions, and logistic involved.
- Subcontracts markup: This markup is applied by the prime contractor to subcontractors who will provide special support.
- Contractor contingency: A contingency is applied to the overall project to account for uncertainties in completing the project. The percent of uncertainty is defined in general accordance with *ASTM E2516-11, Standard Classification for Cost Estimate Classification System* (ASTM 2019).

6.2.2 Escalation Rate

Because these estimates were created for comparison purposes only, escalation is not used.

6.2.3 Market Conditions

Costs are based on market conditions in the United States. The current market conditions are drastically affecting the construction market. This is based upon recent bids in the United States and comparisons with engineer's estimates. Bids can be erratic. Despite the estimator's best practices and adjustments, bids are being driven by current market conditions. In addition, this estimate is based upon a competitive bid contracting method with responsive bidders. Any single-source selection or reduced number of bidders will have an increased impact on the overall cost.

6.2.4 Estimate Classification

These cost estimates are considered to be at the Class 3 estimate level as defined by AACE. Their accuracy range is -20% to +30%. However, these estimates are not inclusive of all constructions costs and should be used for evaluation purposes only, not for program costs.

6.2.5 Estimate Methodology

This cost estimate is considered a cost-based estimate, with a portion of it being a historical bid-based estimate based on bids from the PCT. Historical bid-based methods are commonly used to develop engineer's estimates and are appropriate when a design has advanced to the point where the quantification of units of work is possible. These methods apply historical unit costs to counts or measures of work items to determine a total cost for the item or project. Techniques such as historical bid pricing, historical percentage, and cost-based estimating are also used to determine unit prices.

Cost-based estimate methods do not rely on historical bid data; rather, they are based on determining, for an item or set of items, the contractor's cost for labor, equipment, materials, and specialty subcontractor effort (if appropriate) needed to complete the work. A reasonable amount for contractor overhead and profit is then added. This method is preferable on unique projects or where geographical influences, market factors, and volatility of material prices can cause the use of historical bid-based methods to be unreliable. Also, because contractors generally use a cost-based estimating approach to prepare bids, this method can provide more accurate and defensible costs to support the decision for contract award or rejection, and to support future price negotiations with the contractor after contract award.

Jacobs performed a detailed quantity takeoff using the supplied set of drawings in Appendices C through I and Appendix M, productivity was assumed from typical experiences, and prices were quoted by specialty suppliers or taken from historical recent projects.

6.2.6 Cost Resources

The following is a list of the various cost resources used in the development of the cost estimate:

- Jacobs' historical data
- Root square means
- Estimator judgment
- Information from specialty vendors and suppliers

6.2.7 Labor Costs

Labor unit prices reflect a burdened rate, including:

- Worker's compensation
- Federal Insurance Contributions Act tax
- Unemployment taxes
- Fringe benefits

- Small tools and supplies
- Travel allowance

Labor rates are based upon local costs and per diem for specialty crafts when applicable.

6.2.8 Major Assumptions

This estimate should be evaluated for market changes after 90 days of the issue date. It is assumed that most of the materials will be purchased in the contiguous United States and shipped to Alaska. This estimate also assumes that all work will be executed by a local contractor under competitive bid conditions. Additional assumptions are as follows:

- Local sales taxes of 9.50% are applicable.
- There is a design and owner's risk of 10%.
- For most location repairs, a ready-mix concrete truck delivery was assumed as a short load of 3 cubic yards, applying the consequence of higher concrete costs.
- The contractor assumes work areas are allocated for work.
- Mobilization of a local contractor will take place from the United States Pacific Northwest.
- The contractor will always accommodate emergency egress from the work area and will have access to and control of the construction site during construction.
- POA will coordinate with the contractor and provide adequate notification when it is necessary to perform operations within the construction area.
- The contractor will accommodate owner access in the construction area in the event of an emergency.
- Specialty subcontractors will perform their own relocation and improvements.
- Site access for the contractor and contractor staging areas will be adequate for the contractor's needs.
- A builder's risk premium is applied for a ceiling value of $5 million.
- There is a payment and performance bond of 12/1,000.

6.2.9 Excluded Costs

The cost estimate excludes the following costs:

- Soft costs for legal fees
- Standby rate to cover nonoperational days in the event of an unplanned standby
- Material adjustment allowances beyond what are included at the time of the cost estimate

6.3 Reference Documents

Reference documents include the progress drawings prepared by Jacobs, dated February 2022, are included in the relevant appendix.

6.4 Disclaimer

Opinions pertaining to cost estimates, and any resulting conclusions on project financial or economic feasibility or funding requirements, have been prepared for guidance in project evaluation and implementation from the information available at the time the opinion was prepared. The final costs of the project and resulting feasibility will depend on the following factors:

- Actual labor and material costs
- Competitive market conditions
- Actual site conditions
- Final project scope
- Implementation schedule
- Continuity of personnel and engineering
- Other variable factors

The recent increases or decreases in material pricing may have a significant impact that is not predictable, and careful review or consideration must be used during evaluation of material prices. Thus, the final project costs will vary from the cost presented herein. Because of these factors, project feasibility, benefit to cost ratios, risks, and funding needs must be carefully reviewed prior to making specific financial decisions or establishing project budgets to help support proper project evaluation and adequate funding.

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Section 7. Summary and Recommendations

7.1 Summary

This report provides a multidisciplinary evaluation of alternatives for constructing new foundations for the modernization of T1 and T2 at the POA. Table 7-1 summarizes the alternatives based on the following factors:

- Permanent piling installed
- Temporary piling
- Beluga takes
- Constructability
- Cost

As mentioned previously, to support the alternative analysis a preliminary and rough order of magnitude estimation of potential beluga whale “takes” was prepared as a proxy for potential impacts to marine mammals that could be adversely affected by in-water pile driving construction work associated with T1 and T2. It is intended that these generalized beluga whale “take” estimates will provide an informative metric in comprehensively evaluating the various alternatives being evaluated. Note that preliminary beluga whale take estimates for each of the alternatives are reported for the full duration of construction and are not annual take estimates. Appendix A contains more detailed information on these preliminary take estimations and average annual rates.

Working with NMFS in the future to determine more accurate analytical methods, including determination of both reasonable sound propagation models for the different pile sizes and hammer types as well as marine mammal sighting rates, will be critical to accurately assessing potential impacts on beluga whales and other marine mammal species from this Project. Therefore, the calculations used for this analysis represent rough order of magnitude estimates only, useful for comparing among alternatives, but not reflective of final models or marine mammal take estimates.

Table 7-1. Alternatives Comparison Table

Alternative	Description	Perm. Piling (No.)	Temp. Piling (No.)	Beluga Takes (No.)	Construction Duration (years)	Constructability (High, Medium or Low)	Cost
48-inch-diameter Driven	WH1a + TR1a: Wharf: 20-foot span with 48-inch-diameter driven pile Trestle: 20- to 40-foot span with 48-inch-diameter driven pile	752	560	1,171	7	**High** • Conventional installation methods proven successful on the PCT • Pile lengths can be driven with conventional equipment	$948,820,000
72-inch-diameter Driven	WH2a + TR2a: Wharf: 27- to 40-foot span with 72-inch-diameter driven pile Trestle: 60-foot span with 72-inch-diameter driven pile	281	560	969	5	**High** • Conventional installation methods proven successful on the PCT • Pile lengths can be driven with conventional equipment	$757,190,000
72-inch-diameter Drilled	WH2b + TR2b: Wharf: 27- to 40-foot span with 72-inch-diameter drilled shaft Trestle: 60-foot span with 72-inch-diameter drilled shaft	281	924	4,753	6	**Low** • Drilled shaft lengths required for T1 and T2 are beyond the limits of normal construction • Crane boom length may not be obtainable • Shaft installation is slower, leading to longer construction times • Requires significant additional temporary piling to support the drill rig	$830,900,000
Modular	WH3a + TR2a: Wharf: Prefabricated jacket with 60-inch-diameter driven pile Trestle: 60-foot span with 72-inch-diameter driven pile	171 x 60-inch + 73 x 72-inch for trestle approaches	353	711	4	**Medium** • Shortens duration of construction by placing large modules on the sea floor • Modules act as driving templates and work platforms • Requires specialized on-land fabrication facilities • Requires special equipment for module delivery and lifting into place • Not a conventional or common port foundation type • HLVs are required for construction and are only available internationally, which would require an unlikely waiver of the Jones Act	$1,315,010,000

No. = number

Perm. = permanent

Temp. = temporary

7.2 Recommendations

Redundancy is the first line of defense for most ports, but Alaska's population is too small to economically support enough redundant inbound marine cargo capacity to maintain the flow of goods into Alaska if the Port of Alaska in Anchorage is forced to shut down. Alaska warehouses very little food, and the state only has about a 1-week food supply if the POA is not operational (POA 2020).

Constructability, Schedule, beluga takes, and cost are driving factors in constructing the POA, in time to provide food security in Alaska.

Non-pile driving alternatives were evaluated as potential structural foundation options for T1 and T2. As indicated in Section 3.1, and based on this analysis, provided by previous studies, the idea of stabilizing the soils beneath the existing sheet pile wall was deemed infeasible. This analysis is also applicable to other gravity wall systems, such as coffer dams or caissons. Regardless of the gravity wall method chosen, the cost to stabilize the deep soils beneath the gravity wall structures make gravity wall concepts impractical and cost-prohibitive at the POA.

Helical piles as discussed in Section 4.6 are unproven at this scale and would represent significant risks to the program (Appendix B provides more details). It would need more powerful specialized equipment to be developed, transported to Anchorage, and then used to drive piling. There are limited examples of industry practices and more piling would be required because the current maximum size is 24 inches. For these reasons, this method would only be feasible for the installation of the smallest temporary piles on the project, and may not be practical due to this limited applicability.

Four alternatives for the wharf structures were advanced for detailed evaluation in this report based on the analysis of alternative pile sizes, alternative pile installation methods and various conceptual design alternatives: 1) 48-inch-diameter driven piles, 2) 72-inch-diameter driven piles,3) 72-inch-diameter drilled piles, and 4) the modular design concept that requires 60-inch-diameter driven piles for the terminals and 72-inch driven piles for the access trestles.

In evaluating these four alternatives in context of the five key evaluation metrics identified above, the 72-inch driven pile alternative was determined to be the best structural foundation solution for T1 and T2 and is recommended to be advanced for more detailed design.

In consideration of conventional pile foundation options, the 72-inch driven pile alternative has the lowest cost of the alternatives by a substantial margin, has significantly fewer permanent and temporary piles, has the shortest construction duration, and has the lowest potential for adverse effect to the Cook Inlet Beluga Whale and other marine mammals based on a preliminary assessment of beluga whale take calculations.

In consideration of non-conventional foundation options, the modular alternative offers several distinct advantages, including the fewest number of permanent and temporary piles, prefabrication efficiency, shortest overall construction duration, which is a significant factor for the POA due to the rapidly deteriorating condition of the existing cargo terminals, and lower potential for adverse effect to beluga whales and other marine mammals. However, several distinct disadvantages contributed to the dismissal of advancing this foundation alternative. The high cost of the modular alternative is approximately 72% higher than the recommended 72-inch driven pile alternative. A Jones Act waiver to enable a contractor to deliver the prefabricated elements pile-jackets with larger vessels flagged outside the United States could help lower the cost of this option slightly, but such a waiver is highly unlikely to be granted. Additionally, though the modular system is a proven technology, it is not a common or conventional port foundation type for nearshore port facilities, and the number of contractors who have experience with technology is limited.

The next steps for advancing the analysis and conclusions contained in this report include sharing this information with regulatory and permitting agencies to obtain critical early input on the permitting aspects of the recommended 72-inch-diameter driven pile alternative, and to advance this recommended design concept to the preliminary engineering stage for more detailed evaluation. Key agencies involved in reviewing and permitting the T1 and T2 cargo terminals will include: USACE Civil Works Division, USACE Regulatory Division, and several offices of the NMFS for protection of marine mammals and marine fisheries under the MMPA, ESA, and Magnuson-Stevens Act. A pre-permit application meeting is currently scheduled for July 27, 2022, and agencies will be provided a copy of this report in advance of the meeting for their review to promote an informed discussion at the meeting.

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Appendix A
Port of Alaska Modernization Program
Assessment of Pile Installation for Potential Impacts on Marine Mammals

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PORT OF ALASKA MODERNIZATION PROGRAM

Appendix A: Assessment of Pile Installation for Potential Impacts on Marine Mammals

July 2022

Prepared for
Port of Alaska

Contents

Section Page

Tables

Acronyms and Abbreviations

$\mu N/m^2$	micronewton(s) per square meter
µPa	micropascal(s)
BiOp	Biological Opinion
CFR	Code of Federal Regulations
dB	decibel(s)
dB re 1 $\mu Pa^2/s$	decibel(s) root mean squared level referenced to a pressure of 1 square micropascal per second
dBA	A-weighted decibel(s)
DPS	Distinct Population Segment
DTH	down-the-hole
ESA	Endangered Species Act
FR	Federal Register
GIS	geographic information system
HF	high frequency
Hz	hertz
IHA	Incidental Harassment Authorization
ITS	Incidental Take Statement
kHz	kilohertz
km	kilometer(s)
km^2	square kilometer(s)
$L_{E,24h}$	sound exposure level, cumulative 24 hours
LF	low frequency
LOA	Letter of Authorization
LOC	Letter of Concurrence
L_{pk}	peak sound level
$L_{pk,flat}$	peak sound pressure level (unweighted)
m^2	square meter(s)
MF	mid-frequency
MMO	Marine Mammal Observer
MMPA	Marine Mammal Protection Act
N	newton(s)
NAS	noise attenuation system
NMFS	National Marine Fisheries Service

OW	otariid (sea lion) in water
Pa	pascal(s)
PAMP	Port of Alaska Modernization Program
PCT	Petroleum and Cement Terminal
POA	Port of Alaska
PTS	permanent threshold shift
PW	phocid (true seal) in water
rms	root mean square
SEL	sound exposure level
SEL_{cum}	cumulative sound exposure level
SFD	South Floating Dock
SPL	sound pressure level
SSL	sound source level
TL	transmission loss
TPP	Test Pile Program
U.S.	United States
U.S.C.	United States Code
USFWS	U.S. Fish and Wildlife Service

1. Introduction

1.1 Background

The Port of Alaska (POA) is located within the city of Anchorage along Knik Arm in upper Cook Inlet. The POA is in the midst of modernizing its marine terminals as part of the Port of Alaska Modernization Program (PAMP) and has successfully completed most of Phase 1, which included building a new Petroleum and Cement Terminal (PCT) as well as relocating the South Floating Dock (SFD). As the POA prepares for Phase 2, which will include the construction of two new marine terminals, Terminal 1 and Terminal 2, a range of engineering designs and construction methods are being considered to reduce impacts on marine mammals, especially the Cook Inlet beluga whale (*Delphinapterus leucas*).

The Cook Inlet beluga whale Distinct Population Segment (DPS) and stock are protected under two federal laws: the Endangered Species Act (ESA) and the Marine Mammal Protection Act (MMPA). Knik Arm provides habitat for the federally endangered Cook Inlet beluga whales, and portions of Knik Arm are designated as critical habitat for the DPS. Section 7 of the ESA requires that federal agencies ensure that any action they authorize, fund, or carry out does not jeopardize the continued existence of any federally endangered or threatened species and does not adversely modify its designated critical habitat. When a federal action agency authorizes, funds, or carries out an action, it must consult with the National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (USFWS) if the agency determines that the action may affect ESA-listed species that fall under their respective management authorities.

Beluga whales and other cetaceans and pinnipeds (except for walruses) fall under the management of NMFS. In-water work in Cook Inlet that has the potential to impact marine mammals, including beluga whales, is subject to regulation and requires consultation with NMFS. Consultation regarding previous work at the Port has provided multiple opportunities to engage with NMFS over the years. Thus, the POA has garnered much experience through these interactions, receiving numerous Letters of Concurrence (LOCs) and Biological Opinions (BiOps) under the ESA and Incidental Harassment Authorizations (IHAs) under the MMPA for beluga whales and other marine mammals.

Over time, as more information has become available on sound production and propagation, NMFS has increased the sizes of the harassment zones for pile installation and removal. During 2020 and previous years of construction, all Level B takes associated with pile driving were incurred while using a vibratory hammer, which produces a relatively large Level B zone. In 2021, there were two potential Level B exposures of beluga whales during impact pile driving of a 144-inch-diameter pile—the first time the POA has incurred potential Level B exposures during impact driving (61 North Environmental 2022). The 144-inch-diameter steel pipe piles are the largest ever installed at the POA and produced the largest impulsive Level B zone (I&R 2022).

To construct additional terminals at the Port, engineering designs and construction methods must meet a “least practicable adverse impact” determination, which involves minimizing impacts on potentially affected species. To reduce impacts on Cook Inlet beluga whales, the engineering designs for Phase 2 of the PAMP must reduce the total sound pressure levels (SPLs) entering the water column associated with the construction of the terminals, primarily during pile installation. This can be accomplished through design (reducing the required renumber of permanent and temporary piles), construction methods (various pile installation methods), and additional mitigation measures (Jacobs 2022) such as using a noise attenuation system (NAS).

The primary risk to the project is a “jeopardy” opinion issued from NMFS under the ESA or the inability to propose an activity that would meet the three MMPA requirements for findings of (1) small numbers, (2) negligible impact on the stock, and (3) not having an unmitigable adverse impact on subsistence.

Either of these determinations would be a risk for project construction. A jeopardy determination would result in permit denial, and an exceedance of the number of authorized incidental takes would require the project to shut down prior to completion of the work season, potentially adding additional work seasons onto the overall project schedule.

Since the primary goal of the base report is to evaluate alternative options to reduce impacts to marine mammals, the primary purpose of this assessment is to support that alternative analysis with a preliminary and rough order of magnitude estimation of potential beluga whale "takes" as a proxy for potential impacts on marine mammals that could be adversely affected by in-water pile driving construction work associated with Terminal 1 and Terminal 2. It is intended that these generalized beluga whale "take" estimates will provide an informative metric in comprehensively evaluating the various alternatives being evaluated.

1.2 Underwater Sound Descriptors

Sound is a physical phenomenon consisting of minute vibrations that travel through a medium such as air or water. Sound is generally characterized by several variables, including frequency and intensity. Frequency describes a sound's pitch and is measured in hertz (Hz), while intensity describes the sound's loudness and is measured in decibels (dB). Decibels are measured using a logarithmic scale.

The method commonly used to quantify in-air sounds for humans consists of evaluating all frequencies of a sound according to a weighting system that reflects that human hearing is less sensitive at low frequencies and extremely high frequencies than at mid-range frequencies. This is called A-weighting, and the decibel level measured is called the A-weighted sound level (dBA). A filtering method to reflect in-air hearing of marine mammals, such as hauled-out pinnipeds, has not been developed for regulatory purposes (NMFS 2018).

Underwater sounds are described by a number of terms that are commonly used and specific to this field of study (Table 1-1). Two common descriptors are the root-mean-square (rms) SPL (or dB rms) during the pulse or over a defined averaging period and the sound exposure level (SEL). The rms level is the square root of the energy divided by a defined time period and referenced to a pressure of 1 micropascal (dB re 1 µPa). Unless otherwise indicated, in-water sound levels throughout this report are presented in dB re 1 µPa (Ross 1987).

Spreading loss in marine waters is generally between 10 dB (cylindrical spreading) and 20 dB (spherical spreading), typically referred to as 10 log and 20 log, respectively. Cylindrical spreading occurs when sound energy spreads outward in a cylindrical fashion bounded by the bottom sediment and water surface, such as shallow water, resulting in a 3-dB reduction in noise level per doubling of distance. Spherical spreading occurs when the source encounters little to no refraction or reflection from boundaries (e.g., on the bottom, surface), such as in deep water, resulting in a 6-dB reduction in noise level per doubling of distance (Ross 1987).

Table 1-1. Definitions of Some Common Acoustical Terms

Term	Definition
Ambient Noise Level	The background sound level, which is a composite of noise from all sources, near and far. The normal or existing level of environmental noise at a given location.
Cumulative SEL (SEL_{cum})	Measure of the total energy received during pile installation and removal, defined here as occurring within a single day (24 hours).
Decibel (dB)	A unit describing the amplitude of sound, equal to 20 times the logarithm to the base 10 of the ratio of the pressure of the sound measured to the reference pressure. The reference pressure for water is 1 µPa and for air is 20 µPa (approximate threshold of human audibility).

Table 1-1. Definitions of Some Common Acoustical Terms

Term	Definition
Frequency (Hz)	Frequency is expressed in terms of oscillations, or cycles, per second. Cycles per second are commonly referred to as Hz. Typical human hearing ranges from 20 to 20,000 Hz.
rms, dB re 1 μPa	The rms level is the square root of the energy divided by a defined time period. For pulses, the rms has been defined as the average of the squared pressures over the time that comprises that portion of waveform containing 90% of the sound energy for one impact pile-driving impulse.
SEL, dB re 1 μPa^2-s	Proportionally equivalent to the time integral of the pressure squared in terms of dB re 1 μPa^2/s over the duration of the impulse. This is similar to the unweighted SEL standardized in in-air acoustics to study noise from single events.
SPL	Sound pressure is the force per unit area, usually expressed in μPa (or 20 $\mu N/m^2$), where 1 Pa is the pressure resulting from a force of 1 N exerted over an area of 1 m^2. The SPL is expressed in decibels as 20 times the logarithm to the base 10 of the ratio between the pressure exerted by the sound to a reference sound pressure. SPL is the quantity directly measured by a sound level meter.
TL	Underwater TL is the decrease in acoustic intensity as an acoustic pressure wave propagates out from a source. TL parameters vary with frequency, temperature, sea conditions, current, source and receiver depth, water chemistry, and bottom composition and topography.

Notes: $\mu N/m^2$ = micronewton(s) per square meter; dB re 1 μPa^2/s = db rms level referenced to a pressure of 1 square micropascal per second; m^2 = square meter(s); N = newton(s); Pa = pascal(s); TL = transmission loss

2. Federal Regulation of Marine Mammal Harassment

All marine mammals in Cook Inlet are protected by U.S. law under the MMPA. Additionally, species listed as endangered or threatened and their critical habitat, if designated, are protected under the ESA.

In 1972, Congress established the MMPA after finding marine mammals to be resources of great significance that should be protected due to their risk of extinction or depletion as a result of human activities (16 United States Code [U.S.C.] 1361 et seq.). The MMPA prohibits the "taking" (in Section 2.1) of marine mammals in U.S. waters, unless the take is by incidental harassment and is authorized by the designated U.S. regulatory authorities (50 Code of Federal Regulations [CFR] 216).

The ESA was enacted in 1973 to provide federal protection to wildlife species in danger of becoming extinct. Under the ESA, species may be listed as either endangered or threatened. "Endangered" means that a species is in danger of extinction, and "threatened" means that a species is likely to become endangered within the foreseeable future (16 U.S.C. 1531 et seq.). It is unlawful under the ESA to "take" a listed animal without an Incidental Take Statement (ITS).

NMFS has management authority for whales and dolphins (cetaceans) and pinnipeds (seals, sea lions) other than the walrus. Walruses, manatees, sea otters, dugongs, and polar bears are the marine mammal species under the management authority of the USFWS, which also manages terrestrial and aquatic ESA-listed species. Both agencies administer and enforce the ESA and MMPA for the species under their jurisdiction.

Only marine mammals managed by NMFS occur at the Port (Table 2-1), and marine mammals are the only ESA-listed species that occur at the Port; no ESA-listed terrestrial or aquatic species are known to occur near the Port, and none have required ESA Section 7 consultation with USFWS in the past. Therefore, NMFS is the federal agency the Port engages with for ESA Section 7 consultations and MMPA authorizations.

Table 2-1. Marine Mammals In or Near the Port of Alaska

Species or DPS	Abundance (Stock and/or DPS)	MMPA Designation	ESA Listing	Occurrence in Project Area
Harbor seal	28,411 (Cook Inlet/Shelikof Strait Stock)	None	None	Common
Western DPS Steller sea lion	52,932 (Western DPS and Stock)	Depleted and Strategic	Endangered	Rare
Harbor porpoise	31,046 (Gulf of Alaska Stock)	Strategic	None	Occasional
Killer whale (Orca)	2,347 (Eastern North Pacific Alaska Resident Stock)	None	None	Rare
	587 (Gulf of Alaska, Aleutian Islands, and Bering Sea Transient Stock)	None	None	
Cook Inlet beluga whale	279[a] (Cook Inlet DPS and Stock)	Depleted and Strategic	Endangered	Common

Table 2-1. Marine Mammals In or Near the Port of Alaska

Species or DPS	Abundance (Stock and/or DPS)		MMPA Designation	ESA Listing	Occurrence in Project Area
Humpback whale	10,103 (Central North Pacific Stock)	11,540 (Hawaii DPS)	Depleted and Strategic (stock)	None	Rare
		2,913 (Mexico DPS)	Depleted and Strategic (stock)	Threatened	
	1,107 (Western North Pacific Stock and DPS)		Depleted and Strategic (stock)	Endangered	Rare

Source: Humpback whale DPS population estimates: Wade 2021. All other population estimates: Muto et al. 2021, 2022.

Notes: DPS = Distinct Population Segment; ESA = Endangered Species Act; MMPA = Marine Mammal Protection Act

[a] N_{best} (Best Population Estimate) = 279. The 95% probability range is 250–317 whales (Shelden and Wade 2019).

2.1 Marine Mammal Protection Act

The MMPA defines *take* as "…to harass, hunt, capture, or kill, or attempt to harass, hunt, capture, or kill any marine mammal." (16 U.S.C. 1362). *Harassment* is defined as "…any act of pursuit, torment, or annoyance…" that either:

- "…has the potential to injure a marine mammal or marine mammal stock in the wild" (referred to as *Level A* harassment); or
- "…has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering…" (referred to as *Level B* harassment).

With submission of a detailed application, NMFS will authorize incidental takes of small numbers of marine mammals for specific activities in specific places under Sections 101(a)(5)(A) and (D) of the MMPA (16 U.S.C. 1361 et seq.).

There are two types of Incidental Take Authorizations: IHAs and Letters of Authorization (LOAs). An IHA authorizes Level A or Level B harassment, requires no rulemaking, and is valid for up to 1 year. One 30-day public comment period is required as part of the IHA process. An LOA is used to authorize Level A or Level B harassment and the potential for serious injury or death, and can be valid for up to 5 consecutive years. The process for issuing an LOA requires the promulgation of new regulations and two 30-day public comment periods. Both IHAs and LOAs require mitigation of potential harassment, monitoring of marine mammals and their behavior throughout construction, and reporting on the marine mammal monitoring program.

Most IHAs are issued for activities that produce underwater sound. NMFS uses defined acoustic thresholds to regulate and authorize, under the MMPA, the potential incidental harassment of marine mammals by sound-producing activities (NMFS 2018; Section 2.3.3). Pile installation and removal are commonly regulated by NMFS.

Other sound-producing marine construction activities that may be regulated include:

- Vessel movements
- Dredging
- Placement of fill and rock

- Pipe and sheet pile cutting

Both in-water and in-air marine construction activities are regulated for potential incidental harassment from noise and disturbance under the MMPA.

The NMFS Office of Protected Resources authorizes the incidental take of marine mammals under the MMPA if they determine that the taking would:

- Be of small numbers
- Have no more than a “negligible impact” on those marine mammal species or stocks
- Not have an “unmitigable adverse impact” on the availability of the species or stock for subsistence uses

2.2 Endangered Species Act

Section 7 of the ESA requires that federal agencies ensure that any action they authorize, fund, or carry out does not jeopardize the continued existence of any federally endangered or threatened species and does not adversely modify designated critical habitat of such species. When a federal agency authorizes, funds, or carries out an action, it must consult with NMFS or USFWS, or both, if the agency determines that the action may affect ESA-listed species that fall under their respective management authorities.

Under the ESA, *take* is defined as “…to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect or attempt to engage in any such conduct.” The ESA further defines *harass* as:

> *…an intentional or negligent act or omission which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering.*

Harm is defined as “…an act which actually kills or injures wildlife… by significantly impairing essential behavioral patterns, including breeding, feeding or sheltering” (50 CFR 402.02).

There are no defined acoustic thresholds at which harm or harassment (take) are considered to occur under the ESA itself or NMFS’ implementing regulations. Typically, however, the NMFS analysts implementing the MMPA and ESA converge their effects determinations and use the MMPA authorization process to determine potential effects that could result from exposure to elevated sound levels. Pile installation and removal are regulated by NMFS; other sound-producing construction activities that may be regulated include vessel movements, dredging, placement of fill and rock, and pipe and sheet pile cutting.

Both in-water and in-air activities are regulated under the ESA for potential harassment from noise and disturbance.

2.3 Implementation and Compliance

Different marine mammal species do not have equivalent hearing capabilities in terms of both absolute hearing sensitivity and the range of frequencies they hear best (Richardson et al. 1995; Southall et al. 2007; NMFS 2018). NMFS therefore separates marine mammals into five functional hearing groups for management and regulatory purposes: (1–3) low-frequency (LF), mid-frequency (MF), and high-frequency (HF) cetaceans; (4) phocids in water (PW; true seals); and (5) otariids in water (OW; sea lions; Table 2-2). Species from all five functional hearing groups occur at the Port (Table 2-2).

Table 2-2. Marine Mammal Functional Hearing Groups

	Functional Hearing Group	Representative Species Found at or Near the Port	Generalized Hearing Range
Cetaceans	LF	Humpback whales	7 Hz to 35 kHz
	MF	Beluga whales, killer whales	150 Hz to 160 kHz
	HF	Harbor porpoises	275 Hz to 160 kHz
Pinnipeds	PW	Harbor seals	50 Hz to 86 kHz
	OW	Steller sea lions	60 Hz to 39 kHz

Source: NMFS 2018

Notes: HF = high frequency; Hz = Hertz; kHz = kilohertz; LF = low frequency; MF = mid-frequency; OW = otariid in water; PW = phocid in water

2.3.1 Continuous versus Impulsive Sound

NMFS regulates impulsive and non-impulsive sounds differently because impulsive sound has physical characteristics near the source that make it potentially more injurious (brief, broadband, high-peak SPLs with rapid rise time and rapid decay) than non-impulsive sounds (broadband, narrowband, or tonal; brief or prolonged; continuous or intermittent) (NMFS 2018).

Because of this difference, NMFS uses a threshold of 160 dB rms for impulsive sound and 120 dB rms for continuous, intermittent, and non-impulsive sound for regulation of Level B harassment.

This means that, under identical environmental and substrate conditions, installation of a pile with an impact hammer will result in a smaller calculated Level B harassment zone than installation with a continuous sound source, unless installation of the same pile size and type with a continuous sound source is very quiet (that is, 40 dB quieter than the impact hammer installation it is being compared with). For example, sound from a vibratory hammer with a source level of 150 dB rms at 10 meters will reach the continuous noise threshold of 120 dB rms at 1,000 meters, and an impact hammer with a source level of 190 dB rms at 10 meters will reach the continuous noise threshold of 160 dB rms at 1,000 meters.

NMFS' method of regulating sound for Level B harassment can push projects toward use of an impact hammer instead of a continuous noise source simply because of the smaller Level B zone size based on the higher decibel threshold. For PAMP projects, which have been required to use the Level B zones as the shutdown zones for beluga whales, use of an impact hammer with a NAS could be optimal (as discussed in Section 2.3.4).

Conversely, for projects with extended durations of pile installation within a day, the SEL_{cum} Level A zones associated with hours of impact hammering can reach distances of several kilometers from the sound source, whereas Level A zones from vibratory hammering rarely exceed 100 meters. Level A zones are often treated as shutdown zones by NMFS, and NMFS analysts can be reluctant to authorize Level A exposure, especially for ESA-listed species. For projects that can obtain authorization for Level B exposure but not Level A exposure, vibratory pile installation may be preferred.

Down-the-hole (DTH) drilling or DTH pile installation is a special case because NMFS regulates the rapid pulses (strikes) as impulsive sound for Level A calculations. As the sound propagates away from the source, the individual pulses diminish in rise and become more spread out, eventually merging so that individual pulses can no longer be distinguished in sound recordings. Therefore, for Level B calculations, NMFS regulates DTH installation as continuous sound.

The pulse rate or frequency for DTH pile installation is generally negatively correlated with borehole diameter but varies by the equipment used. It is estimated that 60- and 42-inch-diameter boreholes are constructed by equipment operating at about 8–10 Hz or cycles per second, which is about 480–600 strikes per minute. For smaller boreholes up to 36 inches in diameter, equipment operates at about 15 Hz or cycles per second, which is equivalent to 900 strikes per minute (Reyff n.d.). For DTH pile installation, zones are generally large for both Level A and Level B harassment.

2.3.2 Ambient Noise

Ambient noise levels were measured at the POA during the PAMP 2016 Test Pile Program (TPP), when ambient noise recordings were made at two locations during a 3-day break in pile installation. Median ambient noise levels, measured at one location just offshore of the POA SFD and at a second location about 1 kilometer (km) offshore, were 117.0 and 122.2 dB re 1 µPa, respectively (Table 2-3) (Austin et al. 2016; POA 2016). The two IHAs for Phase 1 and Phase 2 of the 2020 PCT issued by NMFS in April 2020 (85 *Federal Register* [FR] 19294) used 122.2 dB as ambient noise, and the IHA for the SFD issued by NMFS in August 2021 (86 FR 50057) also used 122.2 dB as ambient noise. A recent sound source verification study conducted in 2020 at the PCT did not directly measure ambient noise but did not indicate that ambient noise levels were significantly different from 122.2 dB (Reyff, pers. comm., 26 August 2020).

Table 2-3. Measured Ambient Noise Levels at the Port of Alaska in 2016

Location	**SPL (dB re 1 µPa)**	
	Unweighted Media	**Unweighted Mean**
Dock	117.0	138.8
Offshore	122.2	136.0

Source: Austin et al. 2016

Note: dB re 1 µPa = decibels re 1 micropascal; SPL = sound pressure level

The site-specific ambient noise level is important because it is used by NMFS as the regulatory threshold for Level B exposure of marine mammals to continuous noise (that is, a marine mammal experiences Level B harassment when it is exposed to a continuous sound produced by anthropogenic activity that exceeds this sound level). NMFS typically uses 120 dB as the default threshold for Level B exposure to continuous noise. In cases where empirical data exist to justify a higher threshold, the site-specific value can be used instead. It is anticipated that 122.2 dB will continue to be used for PAMP projects; however, it is possible that NMFS could require use of 120 dB, the standard default value. Allowing use of the site- and project-specific value of 122.2 dB for the PAMP ambient noise level has been controversial and debated among NMFS analysts. Use of 122.2 dB for ambient noise results in smaller estimated harassment zone sizes.

2.3.3 Level A Harassment

NMFS has published Technical Guidance (NMFS 2018) that is currently used to assess the effects of exposure to underwater anthropogenic sound on the hearing of marine mammals. The Technical Guidance identifies the received levels, or thresholds, above which individual marine mammals are predicted to experience permanent changes (for example, a permanent threshold shift [PTS]) in their hearing sensitivity from incidental exposure to underwater anthropogenic sound sources. NMFS considers the Technical Guidance to represent the best available scientific information and, on this basis, suggests that these thresholds and weighting functions be used to assess the potential for onset of PTS in marine mammals, which equates to Level A harassment under the MMPA. The models used to derive the acoustic thresholds for onset of PTS incorporate marine mammal auditory weighting functions in recognition of the variability found among marine mammal species in their hearing sensitivity. The auditory weighting functions are specific to each of the five functional hearing groups defined in Table 2-2.

Additionally, the models used to derive the PTS onset acoustic thresholds incorporate a time component in the form of a cumulative sound exposure level (SEL_{cum}) for both impulsive and non-impulsive sound, and an SPL component by using peak sound level (L_{pk}) for impulsive sounds (NMFS 2018). The dual metrics of weighted SEL_{cum} and L_{pk} l for impulsive sounds, and weighted SEL_{cum} for non-impulsive sounds, are used by NMFS to predict the distances at which the onset of PTS could result from a specified duration of exposure to a specified noise level for each functional hearing group. The distances to theoretical PTS onset are implemented by NMFS as the distances to the Level A isopleths and used to determine take.

SEL_{cum} is incorporated into the model by a duration term that is based on minutes of activity for a vibratory hammer, drill, or other continuous sound source; and by the total number of strikes (or strike rate and duration) for an impact hammer. Typically, the duration component of the model is ignored by NMFS, and the calculated zones become the isopleths used to instantaneously assign a Level A take regardless of the duration of sound exposure experienced by marine mammals.

For example, if 5 hours of DTH pile installation of a 30-inch-diameter pile are predicted to take place in 1 day, the Level A zone for an LF cetacean is 2.26 km. NMFS will consider a humpback whale a Level A take the instant it crosses that isopleth, even if the marine mammal monitoring program can document that the individual was not present long enough to accumulate the requisite amount of sound exposure to meet the definition of PTS. This makes use of DTH pile installation particularly risky because of the long durations of installation typically required. The shorter durations of impact piling reduce this risk but do not negate it.

Table 2-4 summarizes the PTS onset for acoustic thresholds to assess Level A harassment and acoustic criteria to assess Level B harassment of marine mammals from exposure to noise from impulsive (pulsed) and non-impulsive (continuous) underwater sound sources.

Table 2-4. Permanent Threshold Shift Summary

Species Group	PTS Onset Acoustic Thresholds (Received Level)			
	Hearing Group	**Impulsive (Pulsed)**		**Non-impulsive (Continuous or Intermittent)**
Level A Harassment				
Cetaceans	LF	$L_{pk,flat}$	219 dB	$L_{E,\ LF,\ 24h}$: 199 dB
		$L_{E,\ LF,\ 24h}$	183 dB	
	MF	$L_{pk,flat}$	230 dB	$L_{E,\ MF,\ 24h}$: 198 dB
		$L_{E,\ MF,\ 24h}$	185 dB	
	HF	$L_{pk,flat}$	202 dB	$L_{E,\ HF,\ 24h}$: 173 dB
		$L_{E,\ HF,\ 24h}$	155 dB	
Pinnipeds	PW	$L_{pk,flat}$	218 dB	$L_{E,\ PW,\ 24h}$: 201 dB
		$L_{E,\ PW,\ 24h}$	185 dB	
	OW	$L_{pk,flat}$	232 dB	$L_{E,\ OW,\ 24h}$: 219 dB
		$L_{E,\ OW,\ 24h}$	203 dB	
Level B Harassment				
Cetaceans	LF	160 dB rms		120 dB rms or ambient level
	MF			
	HF			
Pinnipeds	PW			
	OW			

Source: NMFS 2018

Notes: dB = decibels; HF = high frequency; $L_{E,24h}$ = SEL, cumulative 24 hours; $L_{pk,flat}$ = peak SPLs (unweighted); LF = low frequency; MF = mid-frequency; OW = otariid in water; PTS = permanent threshold shift; PW = phocid in water; rms = root mean square

Uncommonly, the radius to the Level A zone for some species can exceed the radius to the Level B zone. This generally occurs for species with sensitive hearing in the LF and HF bands (that is, LF and HF cetaceans, such as humpback whales and harbor porpoises, respectively, near the Port) and occasionally occurs for impact pile driving when the pile and hammer are large and the number of strikes within a 24-hour period is high. It is most common for DTH pile installation. This situation is unlikely to occur at the Port given the data collected to date on impact installation and large, 144-inch-diameter piles. This situation is also unlikely to occur for beluga whales, which are MF cetaceans with limited hearing abilities at the higher and lower frequencies produced during impact pile installation. Therefore, the scenario of production of Level A zones that exceed Level B zones for beluga whales is not considered further in this analysis.

Level A take (exposure) of beluga whales was not authorized by NMFS in the BiOp and ITS, nor in the IHAs for the PAMP's 2016 TPP, the 2020 and 2021 PCT construction, or the SFD construction during 2022. It is highly unlikely that Level A take of beluga whales would be authorized for Phase 2 construction of the cargo docks or for any other POA construction. A small number of Level A takes was authorized for the other species that are more difficult to detect and could cause extended shutdowns (harbor seals and Steller sea lions), and it is anticipated that small numbers of Level A take will continue to be authorized for these species. Therefore, consideration of design and construction alternatives will focus on the potential for Level B take of beluga whales, avoidance of which, during PCT construction, caused shutdowns of 98.4 hours in 2020 and 97.0 hours in 2021 at significant cost to the POA (61 North Environmental 2021, 2022).

2.3.4 Level B Harassment

To assess Level B harassment levels, NMFS continues to use its interim criteria. Under the interim guidance, Level B harassment by impulsive sounds, such as impact pile installation, occurs with exposure to an SPL of 160 dB rms for all marine mammals. Level B harassment by non-impulsive sounds—such as vibratory pile installation and removal, drilling, and use of an oscillator—occurs with exposure to an SPL of 120 dB rms for all marine mammals unless empirical data exist to justify a higher threshold. For the PAMP, as discussed in Section 2.3.2, an ambient noise level and Level B threshold for continuous noise of 122.2 dB have been used (POA 2016).

The shutdown zone for PAMP projects (2016 TPP, 2020 and 2021 PCT construction, and SFD construction during 2022) has been the Level B zone for both impulsive and continuous sound, as defined for pile size and installation method. Shutdown once pile installation or removal is underway, or delay when the hammer and pile are set up for installation or removal, has contributed to schedule disruptions and cost overruns.

Level B take (exposure) occurs the instant an individual crosses the defined Level B isopleth; there is no duration term in Level B calculations. A Level B take occurs when the project is unable to shut down pile driving quickly enough to avoid take and a beluga whale enters the Level B zone while pile installation is occurring. Up through 2020 (ICRC 2009; Cornick and Seagers 2016; Kendall and Cornick 2016; 61 North Environmental 2021), all Level B potential takes of belugas whales occurred during vibratory installation or removal, and no takes occurred during impact installation alone.

On the single occasion in 2009 when impact hammer pile installation was taking place when beluga whales were taken, vibratory hammer pile installation was also taking place (ICRC 2009). In 2021, during impact installation of the 144-inch-diameter monopiles, up to three potential beluga whale Level B takes occurred (61 North Environmental 2022). Of these three takes, a single beluga whale was present near Ship Creek and sighted for approximately 3 minutes before being lost, and (possibly the same whale) then appeared an hour later just outside of Ship Creek within active impacting of a 144-inch-diameter monopile. A group of two beluga whales was spotted traveling toward the mouth of Knik Arm on the northern side of Cook Inlet 20 minutes after impact piling had ceased, but due to their location in the middle of the Level B zone, it was assumed that they were likely within the Level B zone during active piling, and they were marked as potential exposures. Additionally, there were 24 potential Level B takes of beluga whales during vibratory pile driving during the remainder of the 2021 season (61 North Environmental 2022).

These data indicate that the behavioral response of beluga whales may be different to impulsive sound at the 160-dB level than their response to continuous sound at the 120-dB level. Beluga whales in Knik Arm appear to avoid Level B zones calculated for impact pile installation, whereas they sometimes enter Level B zones calculated for vibratory pile installation and removal. Not only are the 120-dB Level B zones larger for vibratory pile installation based on the way the sound sources are regulated by NMFS, but this sound threshold appears to be low enough that beluga whales willingly swim into the zone. This may mean that use of a vibratory hammer could increase the risk of higher numbers of take that could approach or exceed authorized numbers.

Estimated sound source levels (SSL) and Level B isopleths for the pile sizes and installation methods anticipated for the four alternatives under consideration are summarized in Table 2-5. Figures depicting the extent of Level B isopleths for each alternative are included at the end of this document.

Table 2-5. Estimated Unweighted Source Levels, Distances to Level B Isopleths, and Ensonified Areas for Pile Installation without a NAS

Method and Pile Type	Size (in)	SSL (dB rms)	Measurement Distance (m)	TL	Distance to Level B Threshold (m)	Ensonified area (km²)	Literature Source for SSL
Impact Installation	48	200	10	15	4,642	26.44	POA Report of Findings 2016
	60	203		15	7,356	47.10	I&R unpublished data – curve fit and adjusted for Cook Inlet based on 48-inch data
	72	205		15	10,000	67.36	I&R unpublished data – curve fit and adjusted for Cook Inlet based on 48-inch data
	144	213		15	34,145	309.59	Caltrans 2015, I&R unpublished data – curve fit
Auger Drilled Shaft	72	168	1	15	1,131	2.02	Dazey et al. 2012
Vibratory Installation	36	166	10	16.5	4,514	25.43	I&R 2021; SSL from US Navy 2015; TL from Austin et al. 2016
	48	168		16.5	5,967	36.49	POA Report of Findings 2016
	60	170		16.5	7,888	50.80	I&R 2013 unpublished data – Richmond CA
	72	171		16.5	9,069	59.58	I&R 2013 unpublished data – Richmond CA
	144	178		16.5	10,000	67.36	Caltrans 2015, I&R unpublished data

Notes: Caltrans = California Department of Transportation; dB = decibels; I&R = Illingworth & Rodkin; in = inches; km² = square kilometers; m = meters; POA = Port of Alaska; rms = root mean square; SSL = sound source level; TL = transmission loss

2.3.5 Noise Attenuation Systems

NAS were identified and described by Jacobs (2022) that could be deployed by the POA for Phase 2 construction. All reduce the level of hydroacoustic sound at the source of the sound by surrounding the pile with either an air-water mixture that absorbs the sound as it propagates outward or an air gap that limits sound propagation. Data collected during the POA TPP and PCT construction indicate that a bubble curtain is more effective at close ranges (up to 500 meters from the sound source) and less effective at greater distances (beyond 500 meters), as evidenced by low TL rates calculated for near- and far-field data (POA 2016; I&R 2021, 2022).

Modification of the bubble curtain design could improve efficacy. It is also possible that greater success with an air bubble curtain system could be achieved if a second bubble curtain were installed on the sea floor at some distance beyond the pile installation (Jacobs 2022) as implemented by the offshore wind industry.

The use of a NAS, including an air bubble curtain system, can reduce noise levels from impact installation by 10 to 30 dB, depending on the specifics of the system, but a reduction of 10 dB or less is considered more reliable (see summary in Jacobs 2022). The current NAS designs use air and air bubbles in some way. Data indicate that efficacy of a specific NAS is similar for impact installations of different sizes of piles so that installation of larger piles is reduced by an amount similar to installation of smaller piles (I&R 2021, 2022).

Data collected during the POA TPP and PCT construction indicated that a bubble curtain was less effective in reducing sound levels associated with vibratory pile installation and removal, and more effective at reducing sound levels associated with impact pile installation (POA 2016; I&R 2021, 2022). Data on use of a NAS with helical piles or drilled shafts are not available.

2.4 Impacts on Marine Mammals

Two important parameters for assessing potential impacts of a project on marine mammals are (1) duration of pile installation and removal and (2) the area that is ensonified by these activities. Exposure to elevated sound levels and the duration of that exposure are both considered by NMFS and the scientific community to have negative impacts on beluga whales and other marine mammals. The duration of pile installation and removal and the area ensonified during those activities vary among the four alternatives considered (Table 2-6, Table 2-7, Table 2-8, and Table 2-9).

All alternative designs include two 144-inch monopiles, and potential impacts from those are anticipated to be identical among alternatives; therefore, the 144-inch piles and associated temporary piles are not included in the comparisons. All alternative designs include vibratory installation of 36-inch temporary piles, although the number of temporary piles varies, and those piles were included. Duration of pile installation and removal and the area that is ensonified for the four alternatives are summarized in Table 2-10. Note that the Modular Jacketed alternative has 60-inch wharf piles but will require 72-inch piles for the access trestles.

Table 2-6. Design and Construction Details for the 48-inch Driven Alternative

Pile Diameter and Type	Number of Piles	Impact Duration per Pile (minutes)	Impact Strikes per Pile	Vibratory Duration per Pile (minutes)	Total Duration of Activity per Pile (impact minutes + vibratory minutes)	Total Ensonified Area (km²)
Permanent Pile Installation						
48” Wharf	582	52	2,191	10	62	36,627
48” Trestle	170	52	2,191	10	62	10,699
Total Number of Permanent Installations	752	-	-	-	-	-
Temporary Pile Installation and Removal						
36" Installation	560	0	0	30	30	14,243
36" Removal	560	0	0	90	90	14,243
Total Number of Temporary Installations and Removals	**1,120**	-	-	-	-	-
Total	**1,872**	**39,104 (652 hours)**	**1,647,632**	**74,720 (1,245 hours)**	**113,824 (1,897 hours)**	**75,811**

Notes: km^2 = square kilometers

Table 2-7. Design and Construction Details for the 72-inch Driven Alternative

Pile Diameter and Type	Number of Piles	Impact Duration per Pile (minutes)	Impact Strikes per Pile	Vibratory Duration per Pile (minutes)	Total Duration of Activity per Pile (impact minutes + vibratory minutes)	Total Ensonified Area (km²)
Permanent Pile Installation						
72" Wharf	208	86	5,743	10	96	26,404
72" Trestle	73	86	5,743	10	96	9,267
Total Number of Permanent Installations	**281**	-	-	-	-	-
Temporary Pile Installation and Removal						
36" Installation	560	0	0	30	30	14,243
36" Removal	560	0	0	90	90	14,243
Total Number of Temporary Installations and Removals	**1,120**	-	-	-	-	-
Total	**1,401**	**24,166 (403 hours)**	**1,613,783**	**70,010 (1,167 hours)**	**94,176 (1,570 hours)**	**64,156**

Notes: km² = square kilometers

Table 2-8. Design and Construction Details for the 72-inch Drilled Shaft Alternative

Pile Diameter and Type	Number of Piles	Auger Duration per Pile (minutes)	Impact Duration per Pile (minutes)	Impact Strikes per Pile	Vibratory Duration per Pile (minutes)	Total Duration of Activity per Pile (impact minutes + vibratory minutes)	Total Ensonified Area (km²)
Permanent Pile Installation							
72" Wharf	208	1,240	0	0	10	1,250	12,812
72" Trestle	73	1,240	0	0	10	1,250	4,497
Total Number of Permanent Installations	**281**	-	-	-	-	-	-
Temporary Pile Installation and Removal							
36" Installation	924	0	0	0	30	30	23,500
36" Removal	924	0	0	0	90	90	23,500
Total Number of Temporary Installations and Removals	**1,848**	-	-	-	-	-	-
Total	**2,129**	**348,440 (5,807 hours)**	**0**	**0**	**113,690 (1,895 hours)**	**462,130 (7,702 hours)**	**64,309**

Notes: km² = square kilometers

Table 2-9. Design and Construction Details for the Modular Jacketed 60-inch Alternative

Pile Diameter and Type	Number of Piles	Impact Duration per Pile (minutes)	Impact Strikes per Pile	Vibratory Duration per Pile (minutes)	Total Duration of Activity per Pile (impact minutes + vibratory minutes)	Total Ensonified Area
Permanent Pile Installation						
60" Wharf	171	114	4,914	0	114	8,054
72" Trestle	73	86	3,686	10	96	9,267
Total Number of Permanent Installations	**244**	-	-	-	-	-
Temporary Pile Installation and Removal						
36" Installation	353	0	0	30	30	8,978
36" Removal	353	0	0	90	90	8,978
Total Number of Temporary Installations and Removals	**706**	-	-	-	-	-
Total	**950**	**26,772 (430 hours)**	**1,119,080**	**43,110 (719 hours)**	**69,130 (1,152 hours)**	**35,276**

Table 2-10. Summary of Design and Construction Details for the Four Alternatives

	48" Driven	72" Driven	72" Drilled Shafts	Modular Jacketed 60"
Total Installation and Removal Events	1,872	1,401	2,129	950
Average Production Rate, Piles per Day	1.7	1.7	1.5 temporary piles/0.5 shafts	1.7
Days of Installation or Removal per Year	135	135	135	135
Average Number of Piles per Year	219	211	134	200
Total Years of In-Water Pile Installation and Removal for this Alternative	7	5	6	4
Total Ensonified Area, km²	75,811	64,156	64,309	35,276
Total Duration of Active Pile Installation	**113,824 (1,897 hours)**	**94,176 (1,570 hours)**	**462,130 (7,702 hours)**	**69,130 (1,152 hours)**

Notes: km² = square kilometers

2.5 Take Estimation and Authorization

2.5.1.1 Density Methods

The only density data that have been collected for marine mammals in the area of Knik Arm are of Cook Inlet beluga whales. Goetz et al. (2012) used distribution and group size data collected during annual aerial surveys conducted primarily in June between 1994 and 2008 to develop a predictive habitat model for beluga whales. The model also included:

- Depth soundings
- Coastal substrate types
- An environmental sensitivity index
- An index of anthropogenic disturbance
- Information on anadromous fish streams

Three different beluga distribution maps were produced from the habitat model based on sightings of beluga whales during aerial surveys. First, the probability of beluga whale presence was mapped using a binomial (i.e., yes or no) distribution, and the results ranged from 0.00 to 0.01. Essentially, this means that there is no more than a 1 percent chance of a beluga whale being present in any portion of Cook Inlet at any time.

Second, the expected group size was mapped. Group size followed a Poisson distribution, which ranged from 1 to 231 individuals in a group.

Third, the product (that is, multiplication) of these predictive models produced an expected density model, with beluga whale densities ranging from 0 to 1.12 beluga whales per square kilometer (km^2). From this model, Goetz et al. (2012) developed a raster geographic information system (GIS) data set that provides a predicted density of beluga whales throughout Cook Inlet at a scale of 1 km^2. The model output is based on data collected primarily in June, which is a known period of low abundance in Knik Arm, but it is the best available density data for beluga whales in Upper Cook Inlet and has been the data set preferred by NMFS for use in beluga exposure estimates. In the *Recovery Plan for the Cook Inlet Beluga Whale*, NMFS (2016) stated that the distribution presented by Goetz et al. (2012) is "…largely representative of the distribution throughout the ice-free months."

This predictive model maps beluga whale density from zero to 1.12 whales per km^2 in Cook Inlet. The highest predicted densities of beluga whales are in Knik Arm, near the mouth of the Susitna River, and in Chickaloon Bay. The model suggests that the density of beluga whales at the mouth of Knik Arm, near the POA, ranges between approximately 0.013 and 0.062 whales per km^2. The distribution presented by Goetz et al. (2012) is generally consistent with beluga whale distribution documented in Upper Cook Inlet throughout ice-free months (NMFS 2016).

To calculate estimated take of marine mammals based on their density, it is assumed that each marine mammal is taken once per day. Take for each day is calculated by multiplying the area ensonified within the Level B isopleth in square kilometers by the density of marine mammals in number per square kilometer. The total take is the daily estimated take multiplied by the number of days of ensonification. These calculations do not consider how many hours of pile installation occur per day or overall; they are based on the number of days of in-water pile installation and removal. Therefore, a reduced number of days of pile installation and removal results in a lower estimate of take. There can be a long duration of pile installation and removal within each day. The area ensonified plays a large role in this method of calculating take, so a reduced area (smaller isopleth) results in a lower take estimate.

Although this method has been used in the past, it is anticipated that NMFS will prefer to use the sighting rate data collected in 2020, 2021, and 2022 (when those data are final) to calculate beluga whale take.

2.5.1.2 Sighting Rates

Current sighting rate data are available for marine mammals at the Port because of the robust marine mammal monitoring program implemented by Port in 2020 and 2021. Additionally, NMFS sponsored a supplemental monitoring program in 2021 during days when no construction was anticipated and no observations by the Port were planned, which has been used to supplement Port-collected data. The resulting combined data set includes from 87.9 to 574.2 hours of observations for each calendar month and spans April through October (61 North Environmental 2021, 2022; NMFS unpublished data; Table 2-11).

The monthly sighting rate method uses the total number of hours of marine mammal observation that were completed, and the total numbers of marine mammals of each species that were observed during that time, to calculate a number of individuals of each species sighted per hour for each month (Table 2-11).

Sighting rates as calculated in the PCT marine mammal monitoring reports (61 North Environmental 2021, 2022) are independent from the zone size because the marine mammal observers (MMOs) recorded all marine mammals as far as they could see. This outer boundary varied with each MMO, MMO location, weather, wind, and many other factors that affect visibility.

The beluga whale sightings represented in the data set vary in distance from the construction site. About 41 of 245 beluga whale groups (17 percent) observed in 2020 and 19 of 132 beluga whale groups (14 percent) observed in 2021 had a closest approach to the project site that was greater than 5 km; 13 sighted beluga whale groups (3 percent) had a closest approach that was greater than 7 km (61 North Environmental 2021, 2022). If the most-distant isopleth representing a regulated sound threshold is closer to the project site than some of the beluga sightings (if the beluga sightings are more distant than the regulated sound threshold), it may be appropriate to exclude those sightings from the analysis of potential exposures or takes.

If the radius to the regulated sound threshold is decreased through use of quiet technology or a NAS, then sighting rates should be recalculated using the anticipated zone size. Use of sighting rates from the PCT monitoring reports and as calculated here would include individuals that were seen, but may not accurately reflect the number of individuals that could swim closer to the POA and through an ensonified area smaller than those of the past. The locations of the marine mammals are known, and unique sighting rates could be calculated for each Level B or shutdown zone size. This is a feasible and logical GIS exercise that should be considered, and would result in a lower, more accurate estimate of take for a smaller Level B or shutdown zone size.

Additionally, for the PCT and SFD IHAs, the preclearance zone was based on the inbound and outbound lines, which were independent of zone size. The same preclearance zone was required regardless of pile size or hammer type. If the POA invests in the technology to reduce the sizes of the Level B and shutdown zones through design, installation methods, or use of a NAS, there should logically be a concomitant reduction in shutdown zone or preclearance zone sizes.

Working with NMFS in the future to determine more accurate analytical methods, including determination of both reasonable sound propagation models for the different pile sizes and hammer types as well as marine mammal sighting rates, will be critical to accurately assessing the project's potential impacts on beluga whales and other marine mammal species.

The calculations used for this analysis therefore represent rough order of magnitude estimates, useful for comparing among alternatives but not reflective of final models or marine mammal take estimates.

Table 2-11. Cook Inlet Beluga Whale Sighting Rate Summary for 2020 and 2021

Month	Total Observation Hours	Number of Belugas	Belugas per hour	Month	Total Observation Hours	Number of Belugas	Belugas per hour	Month	Total Observation Hours	Number of Belugas	Belugas per hour	
2020				***2021***				***Combined***				
April	40.5	33	0.81	April	47.4	29	0.61	April	87.9	62	0.71	
May	301.4	168	0.56	May	272.8	49	0.18	May	574.2	217	0.38	Cargo Dock Anticipated Construction Season
June	318.1	114	0.36	June	186.0	38	0.20	June	504.1	152	0.30	
July	192.5	25	0.13	July	54.4	7	0.13	July	246.9	32	0.13	
August	151.2	274	1.81	August	73.3	239	3.26	August	224.5	513	2.28	
September	85.6	276	3.22	September	240.6	450	1.87	September	326.2	726	2.23	
October	17.6	0	0.00	October	91.9	280	3.05	October	109.5	280	2.56	
November	132.0	97	0.73	November	N/A	N/A	N/A	November	132.0	97	0.73	

2.5.1.3 Take Estimation for Cook Inlet Beluga Whales

The sighting rates for beluga whales (beluga whales/hour) for each calendar month (Table 2-11) were multiplied by the anticipated number of hours of pile installation and removal each month to calculate potential beluga whale take for each month (Table 2-12).

Pile installation and removal for each alternative are anticipated to take place from May through October of each year, although the exact months are not known with certainty. It was assumed that the numbers of hours of pile installation and removal would be distributed evenly among the 6 months for each alternative. This yielded a total number of beluga whale takes for each alternative (Estimated Total Beluga Whale Take). The total number of beluga whale takes each year was also calculated by dividing the total take by the number of years of pile installation and removal (Estimated Annual Beluga Whale Take). For both metrics, the percentage of the Cook Inlet beluga whale population that would be taken was also calculated. Finally, a correction factor of 47 percent was used to adjust the number of calculated takes to account for the proportion of the calculated takes that would be avoided by shutting down. During the PCT Phase 1 construction season, only 47 percent of the authorized takes were realized, and it is anticipated that the marine monitoring program during construction of the cargo terminals will be similarly effective in avoiding take.

Table 2-12. Summary of Cook Inlet Beluga Whale Take Estimates for the Four Alternatives

	48" Driven	72" Driven	72" Drilled Shafts	Modular Jacketed 60”
Total Installation and Removal Events	1,872	1,401	2,129	950
Average Production Rate Piles per Day	1.7	1.7	1.5 temporary piles/ 0.5 shafts	1.7
Days of Installation or Removal per Year	135	135	135	135
Average Number of Piles per Year	267	280	355	238
Total Years of In-Water Pile Installation and Removal	7	5	6	4
Total Hours of Pile Installation or Removal	1,897	1,570	7,702	1,152
Average Hours Per Year	271	314	1,284	288
Average Hours Per Month (6 months/year)	45	52	214	48
Estimated Beluga Take in:				
May	17.1	19.8	80.9	18.1
June	13.6	15.8	64.5	14.5
July	5.9	6.8	27.7	6.2
August	103.2	119.5	488.9	109.7
September	100.5	116.5	476.2	106.9
October	115.5	133.8	547.2	122.8
Estimated Annual Beluga Take	355.8	412.1	1,685.3	378.2
47% of Calculated Take	167.2	193.7	792.1	177.7
Percentage of Population (Annual)	60%	69%	284%	64%
Estimated Total Beluga Take	2,490.6	2,060.7	10,111.9	1,512.6
47% of Calculated Take	1,170.6	968.5	4,752.6	710.9
Percentage of Population (Total)	420%	347%	1703%	255%

2.5.1.4 Ways to Reduce Estimated Marine Mammal Take

There are several methods that are potentially available to reduce the numbers of calculated marine mammal takes, especially for beluga whales. One primary method would be to develop a methodology for calculation of hourly sighting rates for beluga whales that is dependent on zone size, which would reduce the number of estimated takes as the Level B or shutdown zone size decreases (see Section 2.5.1.2 Sighting Rates).

Other potential methods include any combination of:

- Attempt to concentrate pile installation and removal in months when beluga whale abundance is low (April, May, June, and July).
- Use more powerful hammers to reduce installation and removal time.
- Use impact hammers instead of vibratory hammers to reduce harassment zone sizes.
- Use a NAS.
- Use more than one hammer per day to increase production rates and reduce hammer time in months of high beluga whale abundance.

3. POA Phase 2 Recommendations

3.1 Harassment Zone Sizes

Continuous noise installation methods are quieter than impact hammering but are regulated by NMFS at a threshold 40 dB rms less than the regulatory threshold for impact installation; therefore, impact installation yields smaller Level B zones than continuous noise methods, even if they are quiet. Additionally, NASs are designed to work on the frequency band and impulsive type of sound produced by an impact hammer; very few data exist on use of a NAS for other pile installation types. Given the 40-dB difference in regulatory thresholds, no known NAS can surmount that advantage and reduce a continuous noise source Level B isopleth enough to equal the Level B radius estimated using the NMFS regulatory standards for an impact hammer for the same size of pile.

Impact installation of larger piles produces higher SPLs and results in larger Level B isopleths (distances to Level B thresholds) than impact installation of smaller piles. An exception to this may be the 144-inch-diameter piles, which may reach a limit based on their high source level.

However, there is a trade-off between numbers of piles and sizes of piles. For example, in general, impact installation of fewer, larger piles ensonifies a smaller area overall than installation of a larger number of smaller piles. The calculation of the total ensonified area for each alternative (Table 2-10) supports this.

3.2 Cost

It is important to consider the costs and benefits to the project of investing in a terminal design and construction methods that reduce the sound energy entering surrounding waters. If the project invests in design and construction methods that decrease sound energy, on a per-pile or cumulative basis, and the associated harassment zones decrease in size, one would expect a concomitant reduction in shutdown zone sizes to be approved by NMFS. If the investment in project design and quieter technology would not result in reduced project risk in the form of reduced shutdown zone sizes, the costs of the various alternatives may need to be considered more carefully.

3.3 Permitting Timeline

As discussed in the base report, the alternative recommended for advancement to the preliminary engineering and permitting phase is the 72-inch driven pile alternative, with an estimated overall and in-water construction duration of 5 years starting in 2026.

3.3.1 Guidance

The NMFS website that provides guidance on applying for Incidental Take Authorizations under the MMPA (https://www.fisheries.noaa.gov/permit/incidental-take-authorizations-under-marine-mammal-protection-act) indicates that an applicant should apply for an IHA 5 to 8 months in advance and should apply for a rulemaking and LOA at least 9 months and preferably 15 months in advance of the intended project start date. However, the Port intends to submit an LOA application for the required 5 years of in-water construction work in the later part of 2022 due to current NEPA actions that are reliant upon approval of the LOA. The Incidental Take Authorization granted through the LOA is required in order for NMFS ESA Division to complete their BiOp, inclusive of the ITS, as part of the formal Section 7 consultation process. The BiOp is required to complete the NEPA process not just for the LOA, but also for other permitting and funding actions currently being pursued through USACE Civil Works Division, USACE Regulatory Division, and potential grant funding agencies such as the Maritime Administration.

Inability to obtain the BiOp with the ITS that is reliant upon the LOA would delay these other actions if the LOA was not authorized well in advance of the actual start date of construction. Although conditional ITSs under Section 7 that allow for issuance of a BiOp prior to the Incidental Take Authorization have recently been documented, the Port has been informed that this is not a desirable or valid option considering the highly endangered status of the Cook Inlet beluga whale. Therefore, the Port will be submitting the LOA in the later part of 2022 with the goal of obtaining authorization by 2024 in order to meet other permitting and grant requirements. The Port is currently accelerating the Terminal 1 and Terminal 2 delivery schedules, and it is possible that preparatory construction work, not including pile-driving activities, could occur as early as 2025, dependent on issuance of other permits.

3.3.2 Renewal

Although the preliminary estimate for construction duration is 5 years, several elements could extend this period of work due to unforeseen circumstances such as actual construction production and sequencing details, construction logistics, equipment breakdowns, materials supply delays, weather delays, and beluga whale and marine mammal construction shutdown requirements. The Port will need to coordinate with NMFS to roadmap the process to potentially extend the LOA beyond 5 years through LOA renewal or other process, should currently undetermined and unforeseen circumstances occur.

4. References

61 North Environmental. 2021. *2020 Petroleum and Cement Terminal Construction Marine Mammal Monitoring.* Prepared for Pacific Pile and Marine and the Port of Alaska. Final Report. February.

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Appendix B
Geotechnical Engineering Recommendations for Pile Foundations Technical Memorandum

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TECHNICAL MEMORANDUM

Geotechnical Engineering Recommendations for Pile Foundations

PROJECT:	Port of Alaska Modernization Program (PAMP)
PREPARED FOR:	Hong Guan, Doug Playter, and Chris Best, Jacobs
PREPARED BY:	Sean Shin and Nina Zabihi, Jacobs
DATE:	February 11, 2022
REVIEWED BY:	Don Anderson, Jacobs

This technical memorandum (TM) supplements geotechnical recommendations provided in the *Geotechnical Engineering Report* (CH2M 2016a) for the PAMP. The 2016 report was based on PAMP[1] preliminary design concepts being advanced at the time. This design concepts involved construction of two conventional wharf structures supported on 48-inch-diameter, driven steel pipe piles.

The supplemental geotechnical work described in this TM involves an evaluation of alternate methods of wharf foundation support for the PAMP to address permit issues associated with hydroacoustic (underwater) noise and the effects of this noise on beluga whales found in Cook Inlet. Limits on hydroacoustic noise have required consideration of alternate pile sizes and types from those evaluated during the 2016 geotechnical program, including drilled shafts and driven pipe piles greater than the 48-inch-diameter steel pipe piles originally considered.

These changes in pile size and type result in changes to the capacity charts were provided in 2016. The changes in pile sizes and types also involve different drivability requirements, larger downdrag forces, and lateral loading considerations.

These studies were carried out as part of Task Order 14, Change Order 1, Phase 2 Reprogramming of the contract between the Municipality of Anchorage and CH2M HILL Engineers, Inc. (CH2M, now Jacobs). This TM documents design methodologies used to evaluate capacities and other design considerations for the alternate foundation types, and provides the following recommendations for Terminal 1 (T1) and Terminal 2 (T2) trestle and wharf foundations:

- Axial capacities for driven piles of 5-foot, 6-foot, and 8-foot diameters
- Drivability of 5-foot and 8-foot diameter open- and closed-toe pipe piles
- Axial capacity and torque requirements for 2-foot-, 4-foot-, and composite 4-foot- and 2-foot-diameter helical piles
- Downdrag loading on piles from liquefaction-induced soil settlement of shallow silts and sands
- Lateral loading due to laterally spreading soils from liquefaction of shallow silts and sands during a design seismic event
- Upper- and lower-bound, load-adjustment factors (that is, p-multipliers) to account for interaction between adjacent piles during seismic loading

[1] Called the Anchorage Port Modernization Project (APMP) at the time of the 2016 geotechnical program.

Axial capacities of two other pile types, GIKEN SILENT PILER and jetted piles, were not considered in the capacity evaluations. Preliminary checks on the capacity of the GIKEN SILENT PILER (GIKEN 2021) concluded that the capacity of the GIKEN hydraulic pushing system was roughly 10% of the required capacity for steel pile piles. To install these piles, the GIKEN SILENT PILER would have to be drilled or jetted to the termination depth. This requirement was not considered practical for the Port of Alaska (POA) development.

Similarly, the idea of jetting piles to close to the termination depth was considered; however, information available (McNeilan et al. 2004) suggested that significant loss inside shear would occur from the jetting action. For the POA, this results in significant uncertainties about the ability of the pile to support lateral loads induced by ship mooring loads, wind and current action, ice loading, and seismic inertial loads from the wharf. These uncertainties are too significant, so jetting was not further considered in the capacity evaluations.

Driven Pile Axial Capacity

The ultimate axial resistance of driven pipe piles was computed using the same methodology developed by Fellenius (2015) and used in the 2016 geotechnical engineering evaluations (CH2M 2016a). Subsurface conditions used in these analyses were based on the soil profiles and engineering properties provided in Section 2 of CH2M's 2016 geotechnical report.

Separate pile capacity versus penetration design charts for side resistance and end bearing were produced for 60-inch-, 72-inch-, and 96-inch-diameter piles (Attachment 1). The following assumptions were made to estimate the ultimate axial capacity:

- Unit side resistance within the Bootlegger Cove Formation (BCF) clay unit is 1.2 kips per square feet (ksf). This unit side resistance includes the resistances from both inner and outer sides of the pile. The unit side resistance was determined by interpreting Pile Dynamics Inc.'s Pile Driving Analyzer (PDA) system results from a test pile program carried out in 1994 at the POA (CH2M 1994).
- Inner side resistance of the pile in other soil units is 50% of the outer side resistance.
- The side resistance from the uppermost 5 feet of soil is ignored to account for the disturbance during construction and localized scour.
- The nominal uplift resistance of the piles is assumed to be equal to the nominal side resistance.

The capacity charts in Attachment 1 show the capacities for both plugged and unplugged conditions. For the plugged condition, a flat plate or conical toe element must be welded to the end of the pile; while for the unplugged condition, the soil forming the plug is allowed to move upward within the pile as the pile is driven. For the POA Test Pile Project (CH2M 2016b), the plug was measured to be at or slightly below the mudline after driving 48-inch-diameter pipe piles. Similar response is expected if larger-diameter open-toe pipe piles are driven.

For load and resistance factor design (LRFD) design, the nominal resistances from the axial capacity chart must be multiplied by resistance factors based on the applicable loading limit state. Table 3-9 in the 2016 geotechnical report (CH2M 2016a) provides the resistance factors for Extreme, Strength, and Service Limit States.

The side, base, and uplift resistance factors for the Strength Limit State can be increased to 0.65, 0.65, and 0.5, respectively, if the following conditions are met (AASHTO 2020):

- Driving criteria are established based on dynamic testing.
- Quality control by dynamic testing occurs on at least 2% of production piles.

Group effects can be ignored when the center-to-center spacing between adjacent piles is greater than 5 pile diameters. The group efficiency factor should be taken as 1.0 and 0.65 for center-to-center spacings of 5 and 2.5 pile diameters, respectively. For intermediate pile spacing, the group reduction factor should be determined by linear interpolation.

If jetting is applied during pile installation, the axial resistance within the jetted zone should be reduced by 50% unless procedures, such as grouting, are implemented within the jetted zone. This reduction is based on observations from the Port of Los Angeles (POLA) construction (McNeilan et al. 2004). The test pile program performed as a part of the POLA construction in 2010 showed that the axial capacities of the piles installed with jetting were reduced by 30 to 50% compared to unjetted piles. The reduction in axial capacity resulted from loss in soil strength along the side of the pile caused by jetting, as well as loss in the bearing resistance at the toe of the pile.

Drivability of Steel Pipe Piles

The drivability of open-toe steel pipe piles at the T1 and T2 locations was evaluated based on observations from Petroleum/Cement Terminal (PCT) construction (Illingworth & Rodkin 2021). An American Piledriving Equipment (APE) D180-42 diesel hammer and an IHC (IQIP) S-800 Hydrohammer were used during construction to drive 48-inch- and 144-inch-diameter open-ended pipe piles, respectively. The pipe piles were driven to a dense glacial fluvial layer located at approximate elevation of -125 feet (mean lower low water [MLLW]) at the PCT site. The measured blow counts in the glacial fluvial layer ranged approximately from 40 to 60 blows per foot (bpf) and from 50 to 80 bpf for 48-inch- and 144-inch-diameter piles, respectively.

Based on these observations, open-toe pipe piles with a diameter of up to 144 inches could be driven through the glacial fluvial layer with a hammer with similar energy outputs as used during PCT construction.

The drivability of 5-foot- and 8-foot-diameter closed-toe steel pipe piles was evaluated using the software GRLWEAP (Pile Dynamics 2015). Based on the results from the GRLWEAP analyses, 5-foot-diameter closed-toe pipe piles could be driven several feet into the dense glacial fluvial layer with an IHC S-800 Hydrohammer (or other hammers with a similar energy output), while an IHC S-1800 or an equivalent Hydrohammer is required to drive 8-foot-diameter closed-toe piles into the glacial fluvial layer. The glacial fluvial layer was encountered at approximate elevations between -150 and -200 feet at the planned terminal locations.

Results of the drivability analyses indicate that 5-foot- and 8-foot-diameter closed-toe pipe piles cannot be driven more than several feet into the dense glacial fluvial layer. However, results of the axial capacity analyses show that the closed-toe piles driven several feet into the glacial fluvial layer would have enough capacity to support the planned terminal structures. Attachment 2 provides the GRLWEAP analyses outputs.

Helical Pile Axial Capacity and Torque Requirements

The nominal axial capacity of helical piles was estimated using the procedures provided in the *Helical Pile Foundation Design Guide* (Deep Foundation Institute 2019). Subsurface conditions used in these analyses were based on the soil profiles and engineering properties provided in Section 2 of CH2M's 2016 geotechnical report.

The following helical piles were considered:

- 24-inch shaft diameter (1.0-inch wall thickness) with a single 42-inch-diameter helix
- 48-inch shaft diameter (1.5-inch wall thickness) with a single 60-inch-diameter helix
- Composite of the 48-inch and 24-inch shaft diameters

Attachment 3 provides the axial capacity charts.

Installation data for helical piles with shaft diameters larger than 12 inches have not been widely shared within the industry. The existing empirical installation torque-to-axial resistance relationships are imprecise predictors of the torque required for pile installation. Currently available helical pile installation equipment (maximum torque of 375 kips per foot [kpf]) may advance helical piles to the depth required for the axial and lateral resistance, assuming skin friction during installation is much less than the ultimate. Temporary interruptions in pile advancement during installation could result in an increase in strength with time (that is, setup) that might prematurely stop pile penetration.

Also, it is unlikely that helical piles can be screwed to the depth needed for lateral resistance if a soil plug develops, and a soil plug should be removed unless it forms near the required depth. Therefore, the unplugged section plots in Attachment 3 should be used for preliminary design. The results from lateral analyses indicate that a 24-inch-diameter pile would not provide the required lateral resistance. A 48-inch-diameter pile should extend approximately 70 feet below the mudline to provide the required lateral resistance, and deeper than 70 feet to provide the required axial resistance. Although the currently available equipment may advance 48-inch-diameter piles to the required depths, there appears to be a high risk of developing the torque resistance beyond the equipment's capacity. Existing tools, such as used to predrill or drill through the pile to remove a soil plug, could be used as contingency measures to address potential premature setup and assist with helical pile installation.

Both APE and Eskridge are developing high-torque drive heads (maximum torque of 490 kpf) that should be available within a year or two based on discussions with APE and Eskridge. The high-torque equipment will decrease the risk of not reaching the required depth. Table 1 compares the estimated penetration depths with the currently available drive head and the one under development with the required depth for an ultimate resistance of 2,000 kips.

As an option to reduce the risk of not reaching the required depth, a composite pile consisting of 24-inch- and 48-inch-diameter piles may be used. The 48-inch-diameter pile extends through the upper 70 feet to provide the required lateral resistance. The 24-inch-diameter pile with a 42-inch-diameter single helix extends to the dense glacial fluvial layer to achieve the required axial capacity below the 48-inch-diameter pile. A 60-inch-diameter helix could be welded to the end of the 48-inch-diameter pile to help pull it into the ground and provide additional axial resistance.

Table 1. Comparison of Current Equipment Penetration Capability with Estimated Depth Required for Axial Resistance

Helical Pile Configuration	Estimated Maximum Penetration Depth Limited by Equipment Torque (feet)				Estimated Depth Required for Ultimate Resistance of 2,000 kips (feet)
	Drill Head Torque = 375 kpf (maximum torque currently available)		Drill Head Torque = 490 kpf (anticipated available within a year or two)		
	Without Setup	With Setup	Without Setup	With Setup	
24-inch x 42-inch single helix	140	100	140	120	140
48-inch x 60-inch single helix	115	75	135	90	135
Composite 70-foot-long 48-inch shaft with 24-inch lead section	140	100	140	120	140

To date 48-inch-diameter helical piles have not been installed. However, the axial capacity calculations for helical piles follow the same principals as for driven piles. Therefore, the estimates of axial capacity for helical piles, even of large diameters, are expected to be as accurate as those for driven piles.

If helical piles are selected as an option for the planned terminals, the constructability, drivability, and ultimate resistance must be verified through a test pile program.

Liquefaction-induced Downdrag Force on Pile Foundation

The downdrag forces due to liquefaction were estimated using the procedures discussed in the 2016 geotechnical engineering evaluations (CH2M 2016a). These forces develop as a result of liquefaction-induced settlement of silts and sands located close to the mudline after a design earthquake. The silts and sands are located to a depth of approximately 20 feet or less below the mudline at the access trestles; these thicknesses decrease to less than about 5 feet below the mudline at the terminal locations. The thickness of liquefiable layer was conservatively assumed to be 5 and 20 feet at the terminal and the access trestle location, respectively, to estimate downdrag force. The *Geotechnical Engineering Report* (CH2M 2016a) provides further information on the thickness of liquefiable layers. The additional thickness at the trestles results in more downdrag forces.

Table 2 summarizes the estimated downdrag forces on drilled shafts and driven piles.

Table 2. Downdrag Forces on Driven Piles

Structure		Downdrag Force per Pile (kips)		
		5-foot diameter	6-foot diameter	8-foot diameter
T1	Under wharf	15	18	24
	Under trestle	506	608	810
T2	Under wharf	15	18	24
	Under trestle	492	591	788

Lateral Loading on Piles due to Laterally Spreading Soils

Slope stability evaluations were carried out for the sloping shoreline at T1 and T2 during the 2016 geotechnical engineering program (CH2M 2016a). These evaluations involved use of limit-equilibrium analyses for gravity and seismic loading. The soft and loose tidal silt and sand deposit along the existing slope was predicted to liquefy during the design seismic event, and the loss of soil strength from liquefaction would result in a large amount of displacement (lateral spreading) during or after a design earthquake event.

An LPILE model (Ensoft 2021) was set up using the soil profiles and properties during the 2016 geotechnical evaluations (CH2M 2016a). Based on the soil profiles included in the 2016 geotechnical report, the thickness of the silt deposit varies from 5 to 15 feet along the existing slope from the mudline. In the LPILE model, the thickness of the silt deposit was conservatively assumed to be 15 feet from the ground surface. To simulate the laterally spreading silt deposit, a uniform soil displacement of 100 inches was applied within the top 15 feet of the soil profile in LPILE. Attachment 4 includes the LPILE analyses outputs.

Table 3 summarizes the estimated lateral spreading forces for different pile diameters from the LPILE analyses.

Table 3. Lateral Loading on Piles due to Laterally Spreading Soil at Terminals 1 and 2

Pile Diameter (ft)	Soil Pressure at the Bottom of Loose and Soft Silt Tidal Deposit	
	(lb/in)	**(kpf)**
4	250	3.0
5	330	4.0
6	410	4.9
8	560	6.7

ft = foot (feet)

lb/in = pound(s) per inch of depth

The lateral spreading forces should be applied only to the piles supporting the trestle structure, not the wharf structure, considering the much flatter slope conditions at the wharf location.

The distribution of the lateral loading in Table 3 should be applied in the top 15 feet of pile, as shown on Figure 1.

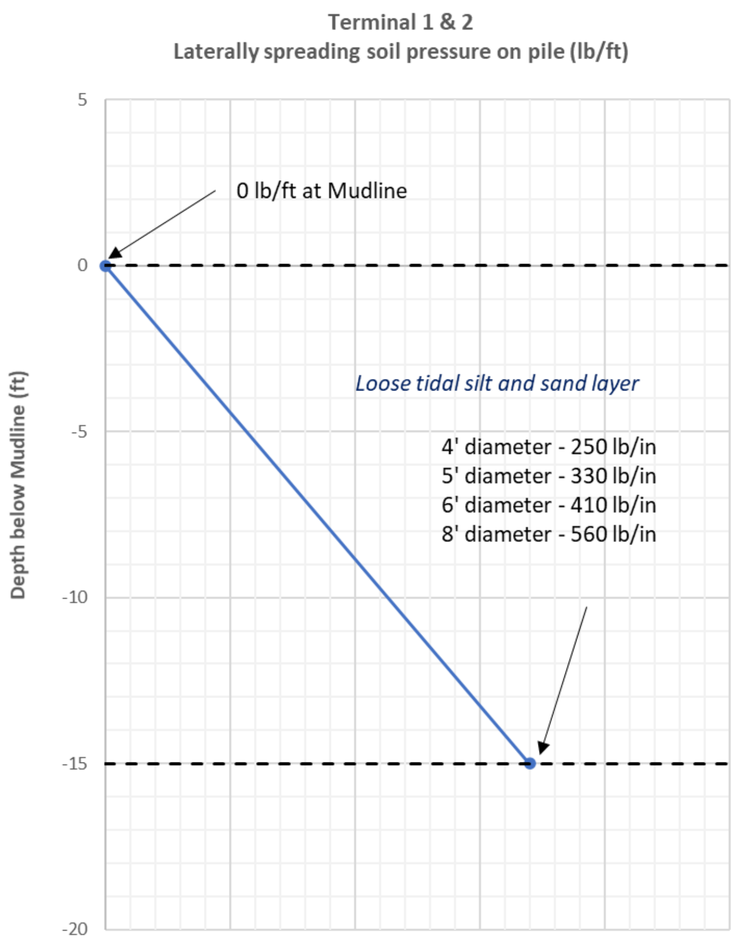

Figure 1. Distribution of Lateral Loading on Piles

Upper- and Lower-bound P-y Springs for Seismic Analysis of Trestle Piles

During seismic loading, piles supporting the access trestles potentially move upslope and downslope during seismic loading. This back-and-forth movement results in a soft soil response in the downslope direction and a stiffer response as the pile moves upslope. Due to the uncertainties associated with the soil lateral resistance, final slope conditions, and load distribution along piles, both upper- and lower-bound limits should be used to develop soil load-displacement (P-y) springs when evaluating the P-y response of access trestle piles. Wharf piles are located on a relatively flat sea bottom; therefore, they don't require consideration of the sloping ground P-y effects.

ASCE/COPRI 61-14, Seismic Design of Piers and Wharves (ASCE and COPRI 2014) suggests using P-multipliers of 0.3 and 2 for the lower- and upper-bound springs, respectively, for slopes on the order of 1.5H:1V (horizontal to vertical) to 1.75H to 1V based on the experience from other projects (POLA 2010; POLB 2012). The best-estimate P multiplier is 1.0. P-multipliers that are greater or less than the best-estimate are less likely occurrences, although they could occur based on the POLA and Port of Long Beach (POLB) guidelines. Considering that the slopes at the planned T1 and T2 locations are flatter than those at POLA or POLB, the lower- and upper-bound P-multipliers of 0.5 and 2 are recommended for T1 and T2.

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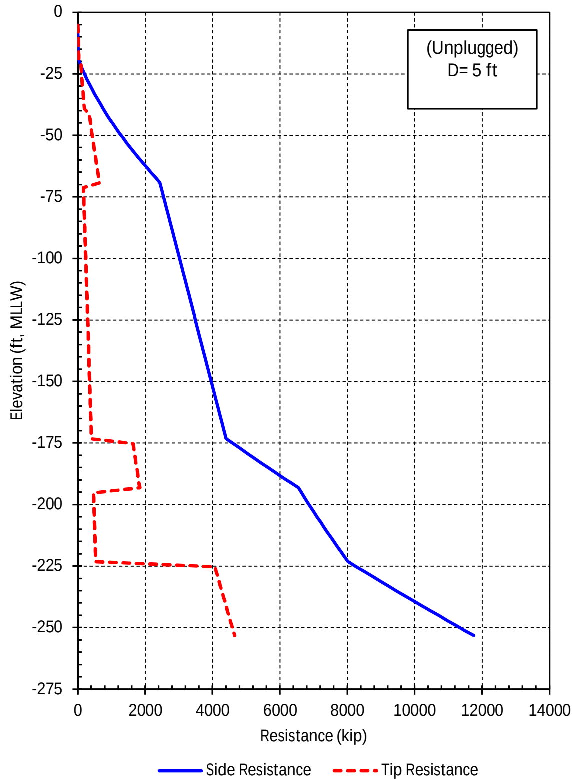
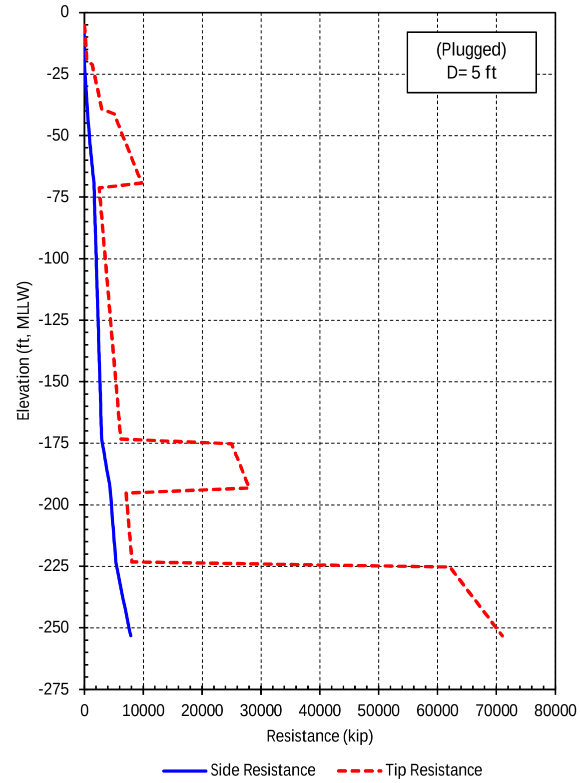
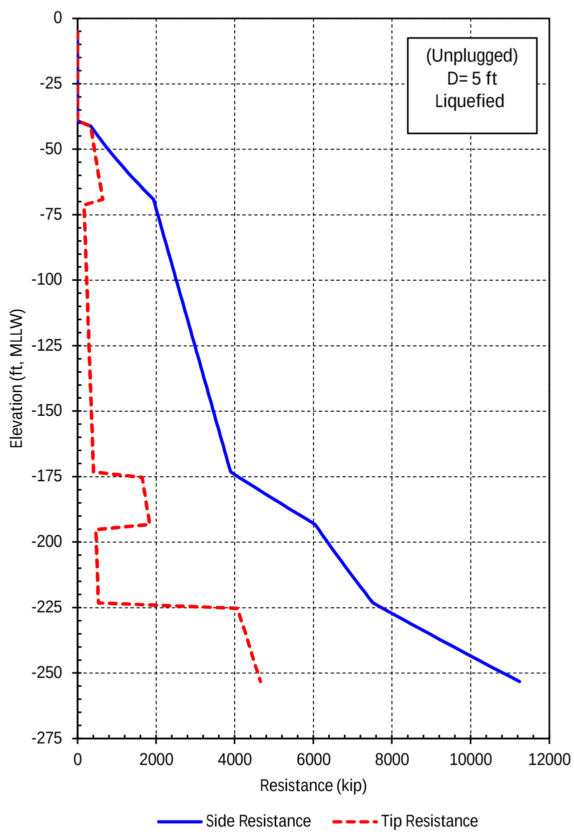
Attachment 1
Axial Capacity Charts – Driven Piles

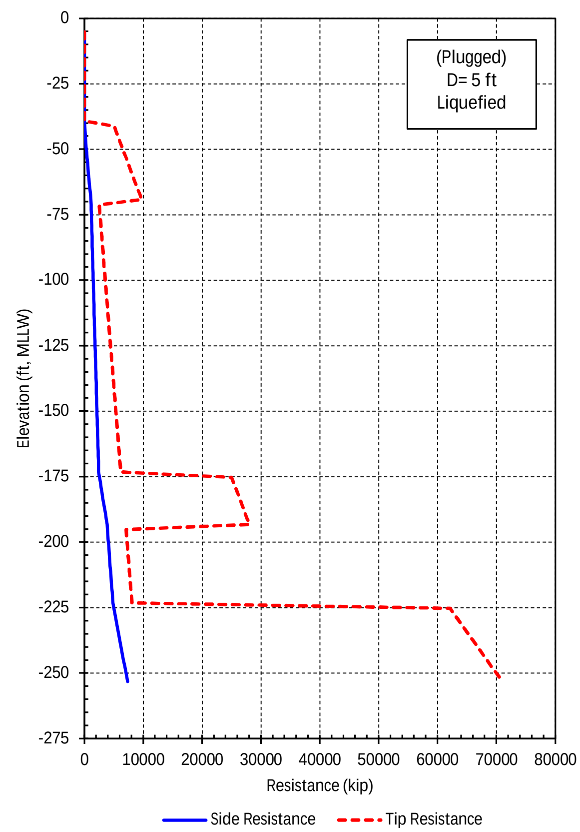
Anchorage Port Modernization Project

Nominal Resistance of 5-ft Pipepile at Terminal 1 (Trestle)



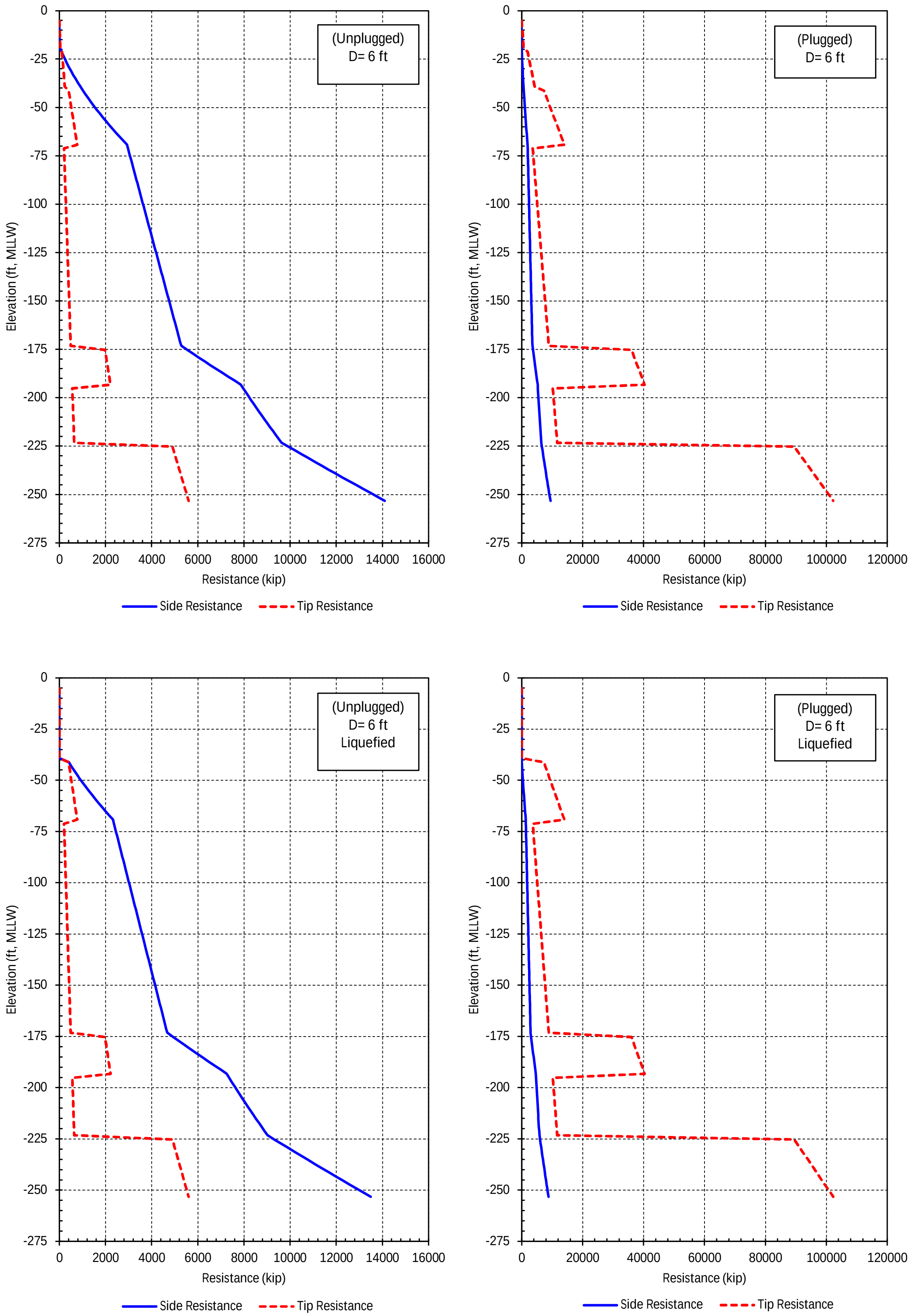






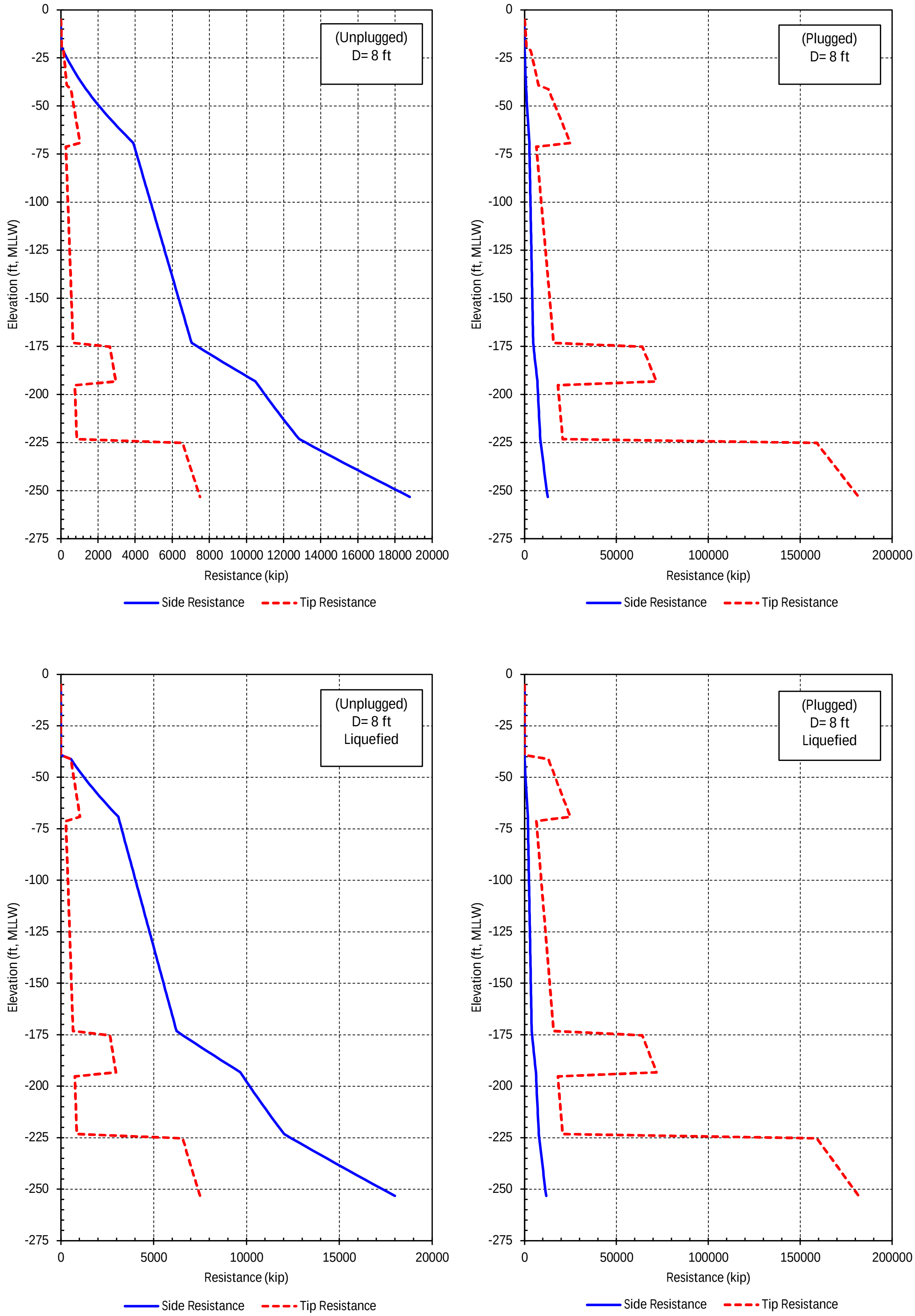
Anchorage Port Modernization Project

Nominal Resistance of 6-ft Pipepile at Terminal 1 (Under Trestle)



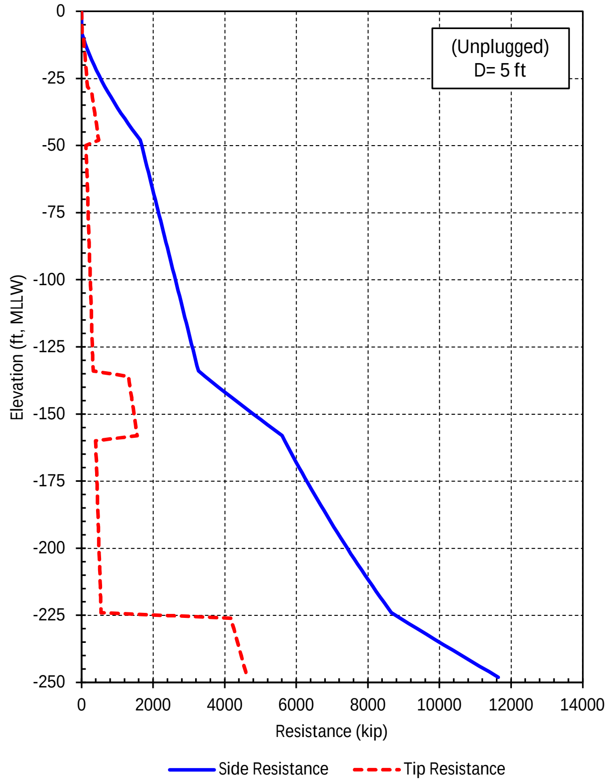
Anchorage Port Modernization Project

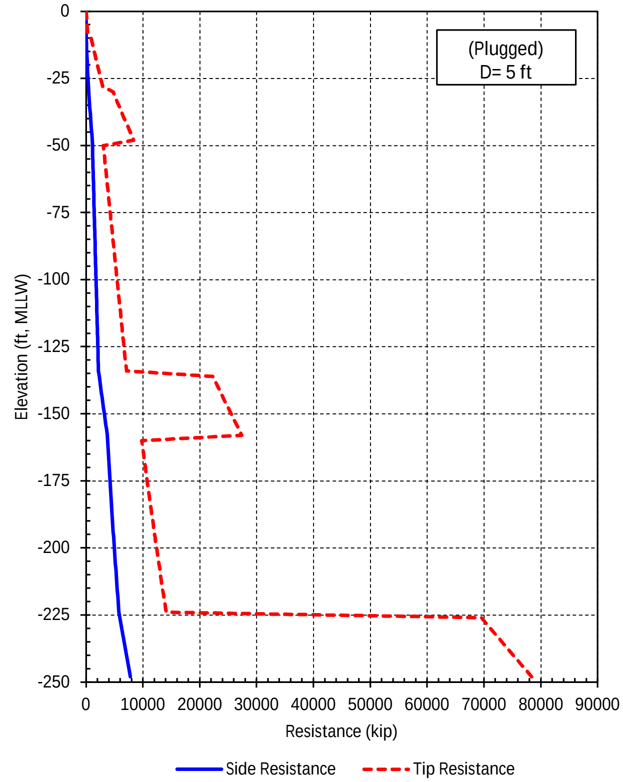
Nominal Resistance of 8-ft Pipepile at Terminal 1 (Under Trestle)

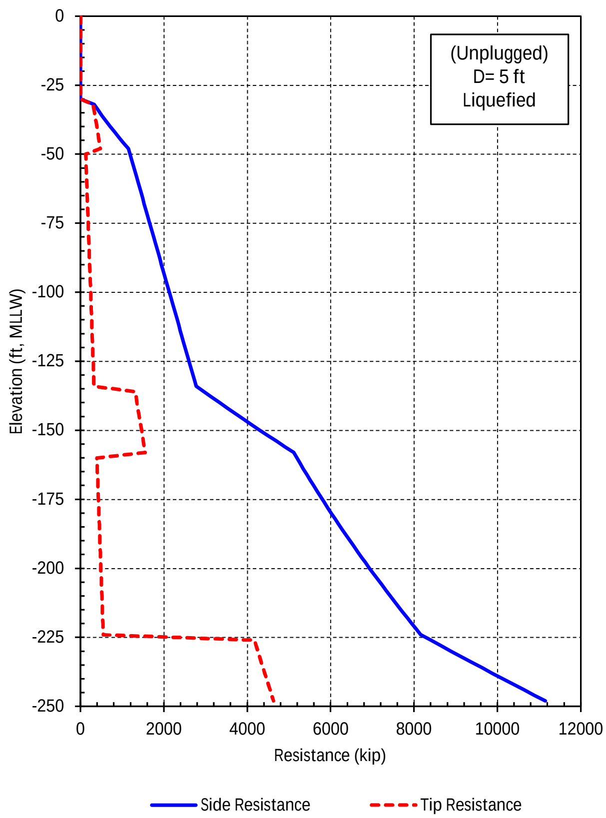


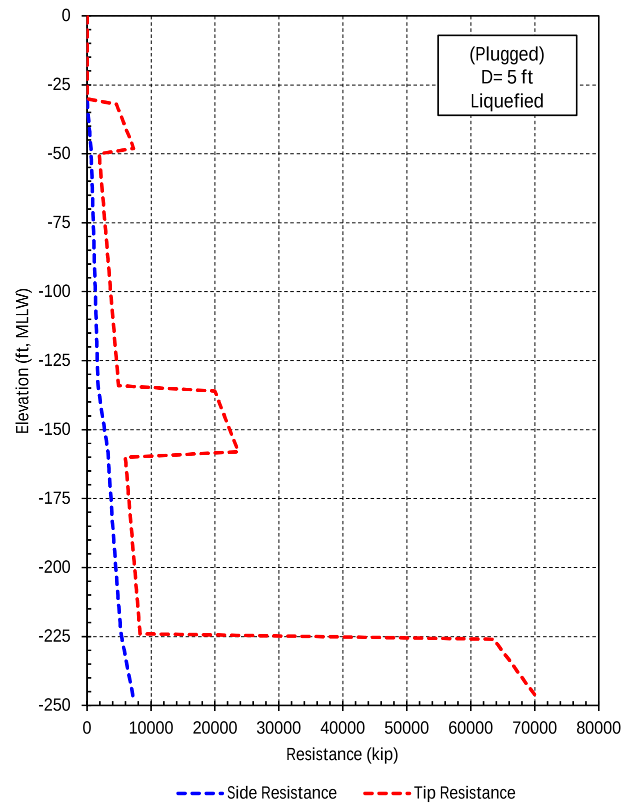
Anchorage Port Modernization Project

Nominal Resistance of 5-ft Pipepile at Terminal 2 (Trestle)



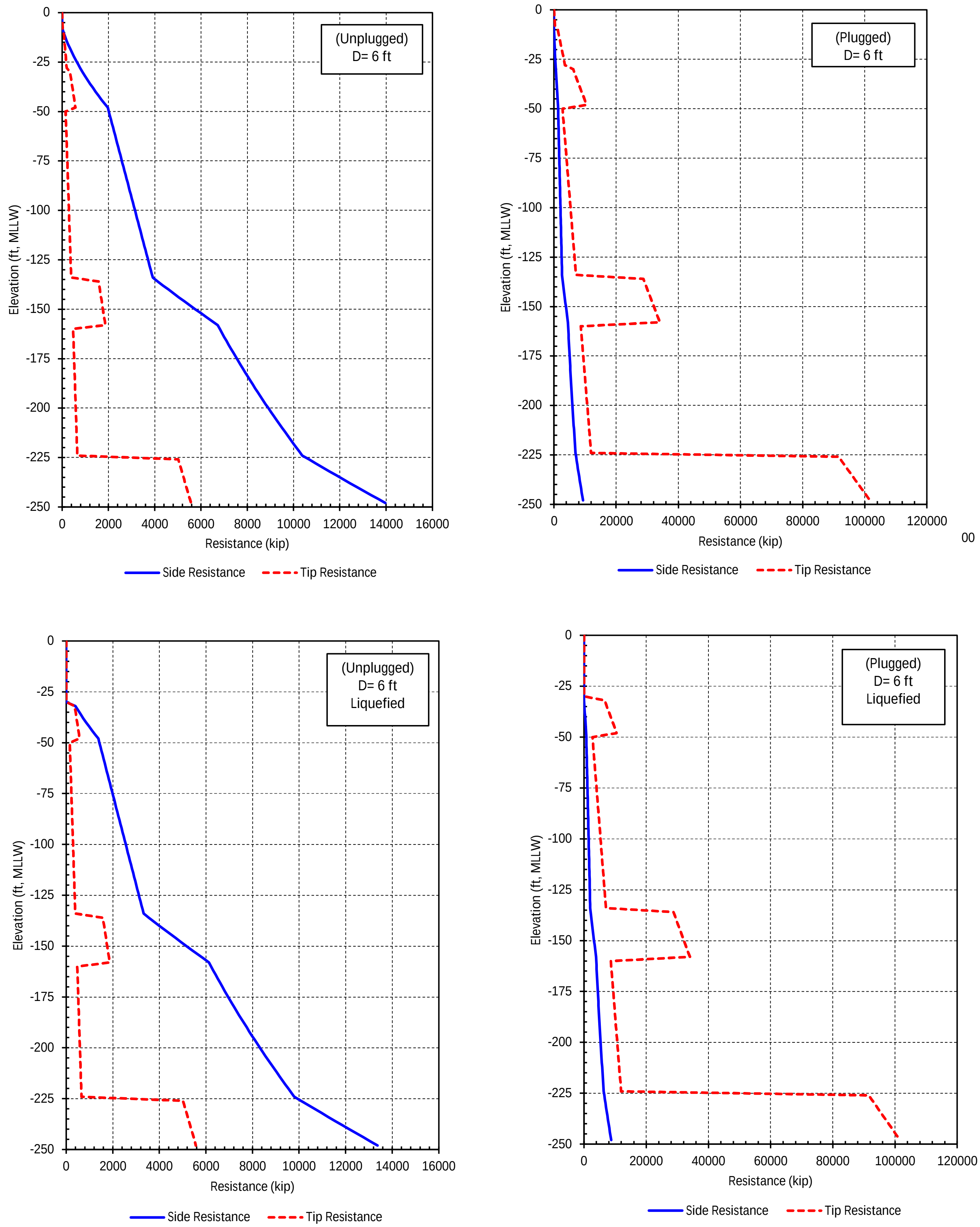






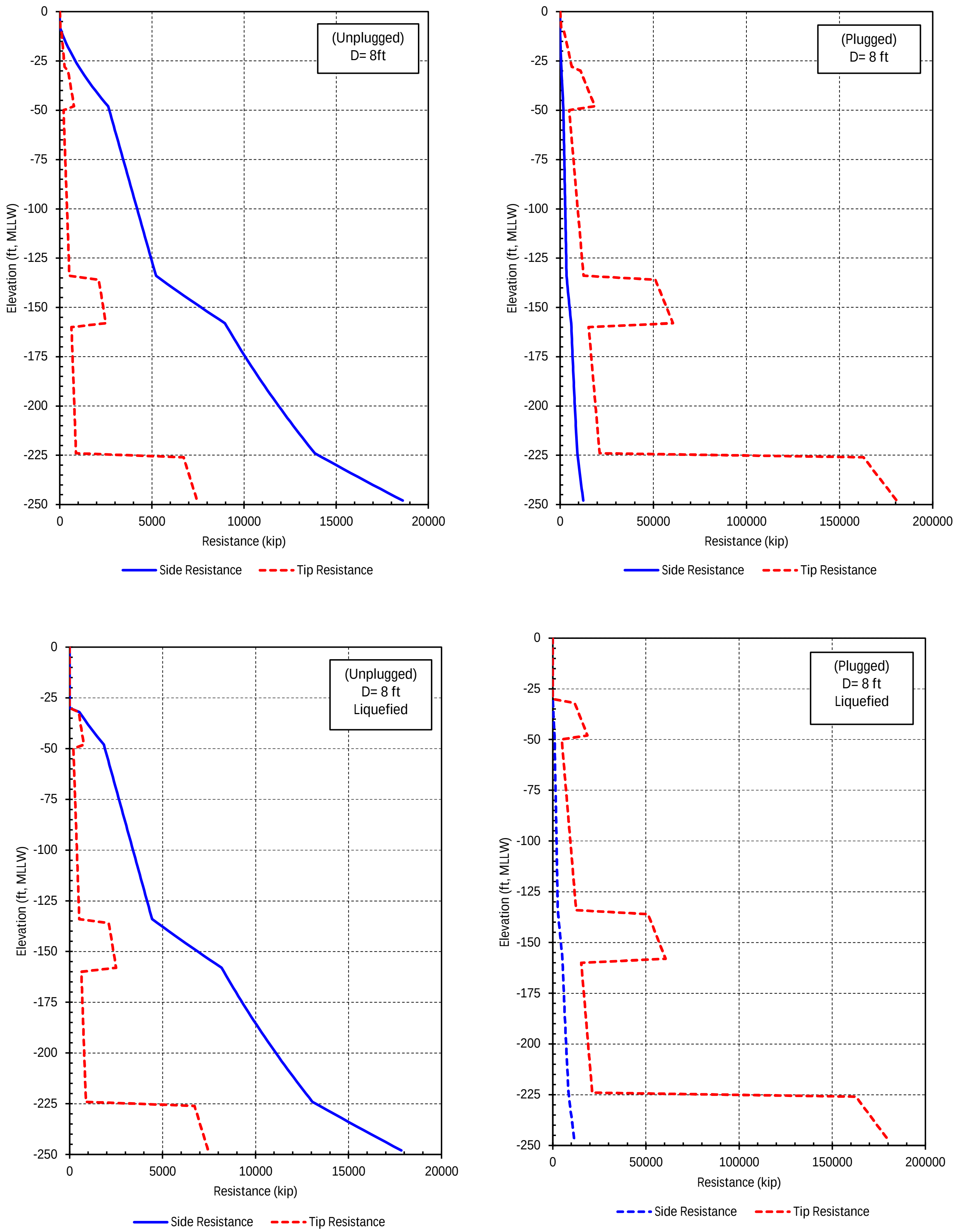
Anchorage Port Modernization Project

Nominal Resistance of 6-ft Pipepile at Terminal 2 (Trestle)



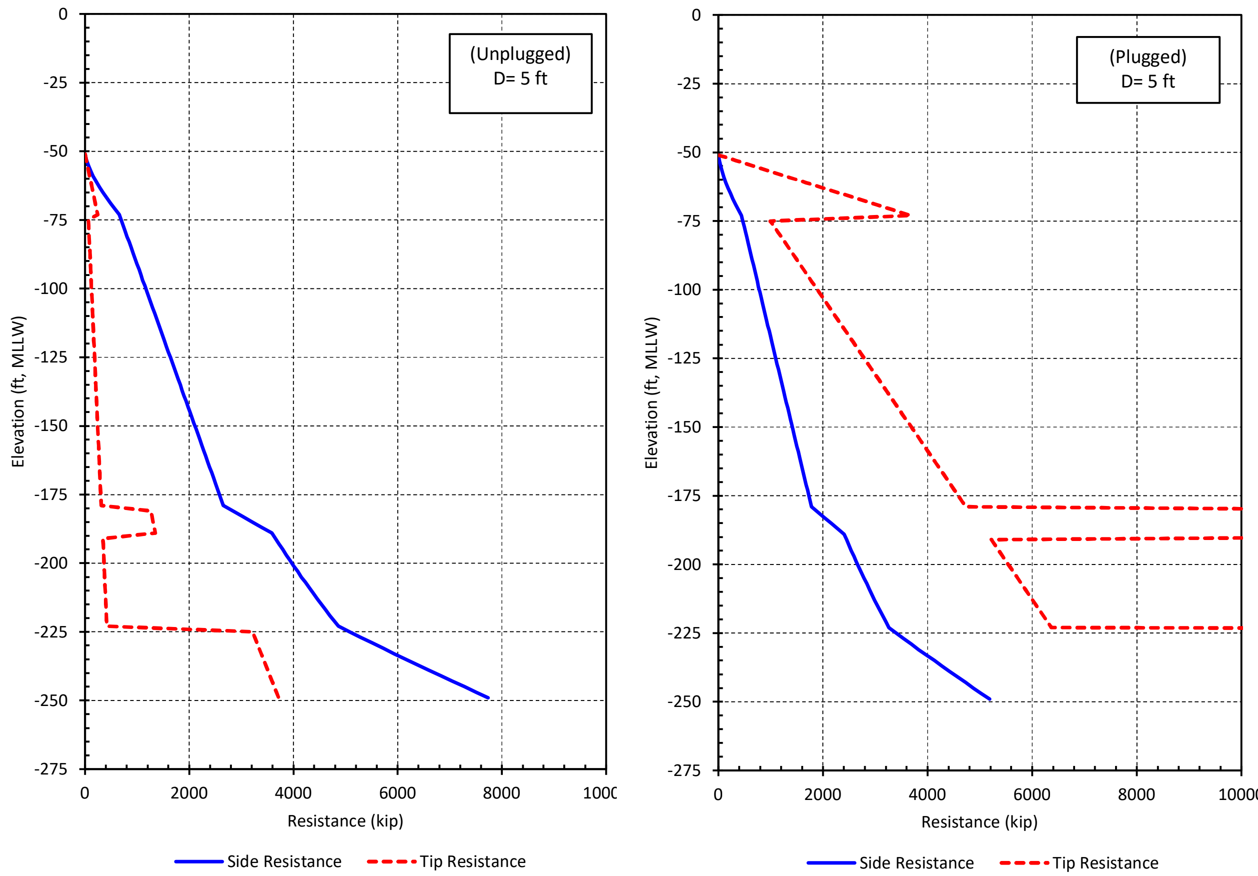
Anchorage Port Modernization Project

Nominal Resistance of 8-ft Pipepile at Terminal 2 (Trestle)



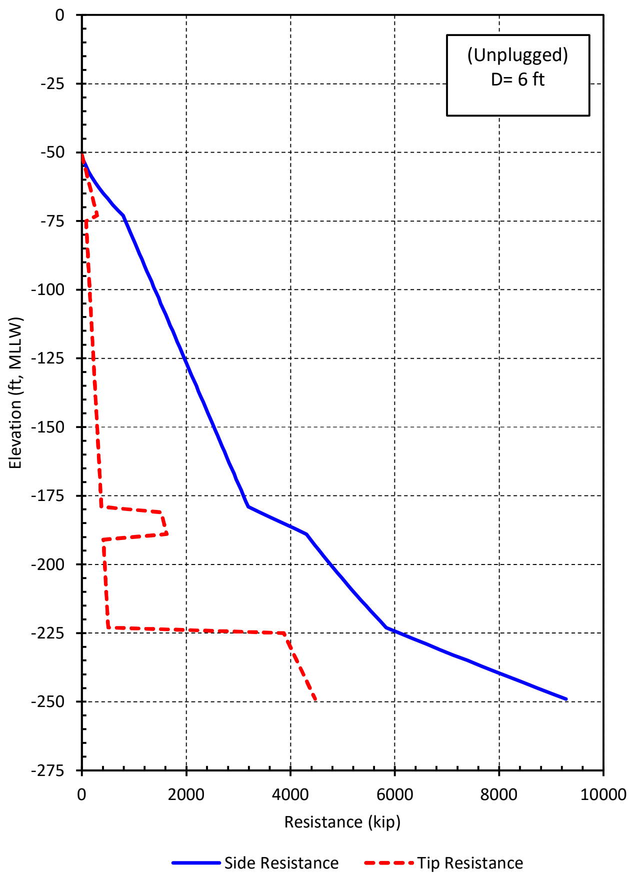
Anchorage Port Modernization Project

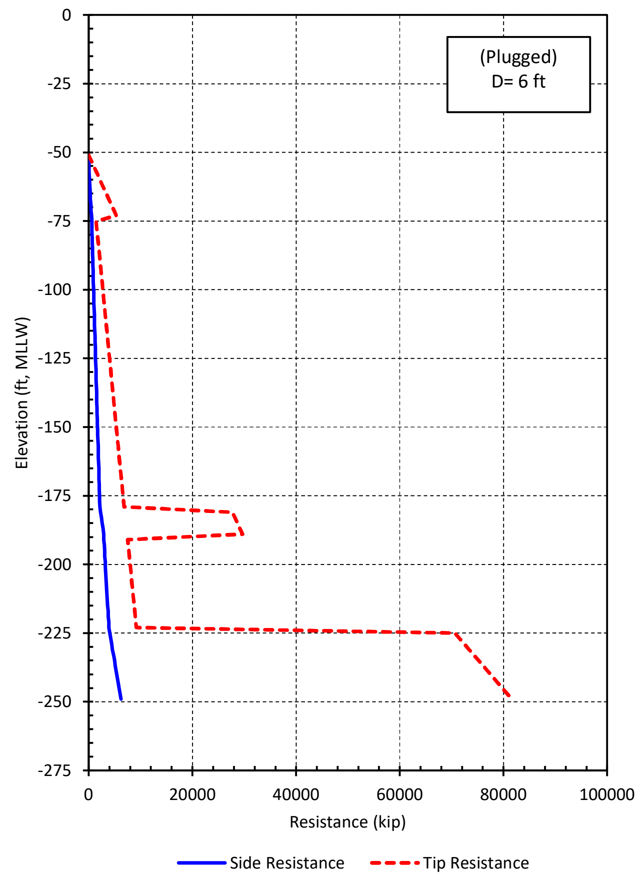
Nominal Resistance of 5-ft Pipepile at Terminal 1 (Under Wharf)



Anchorage Port Modernization Project

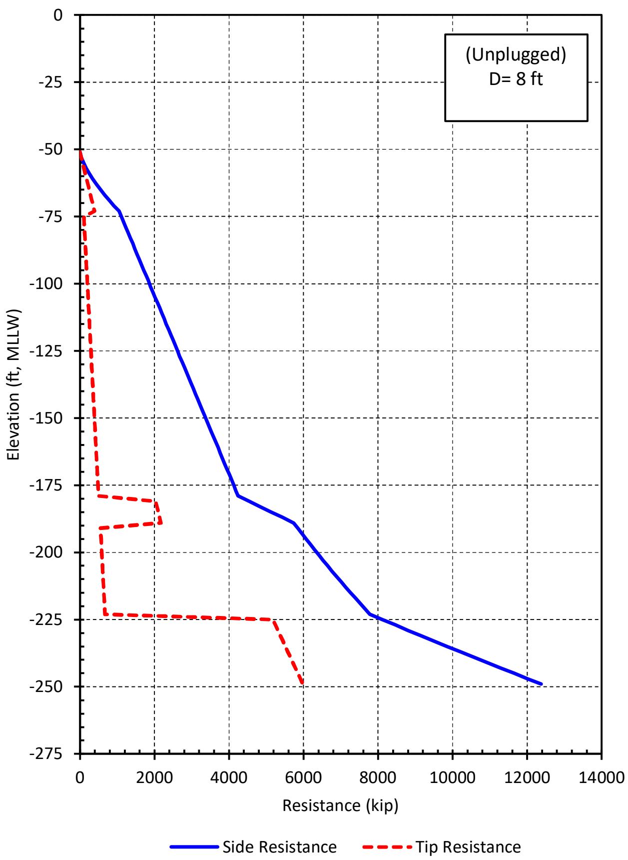
Nominal Resistance of 6-ft Pipepile at Terminal 1 (Under Wharf)

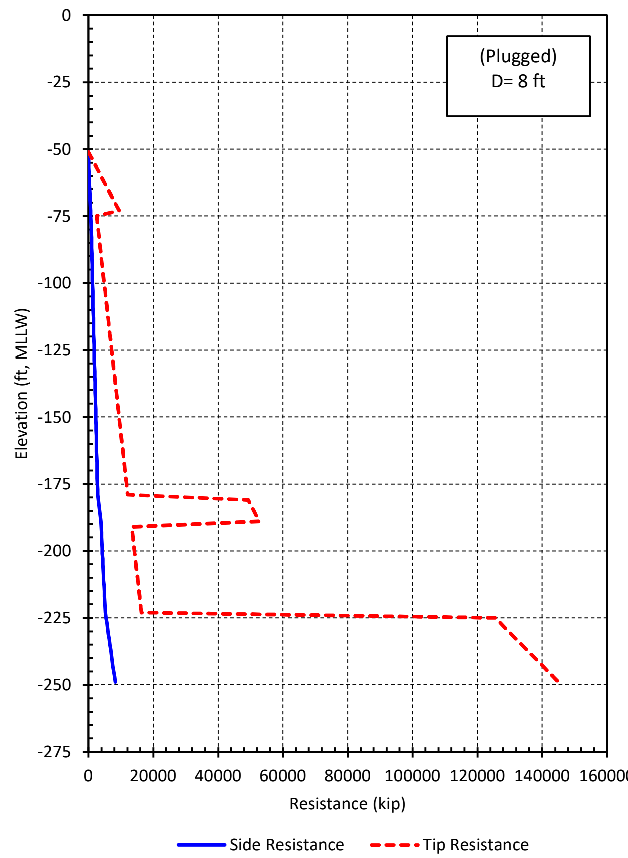




Anchorage Port Modernization Project

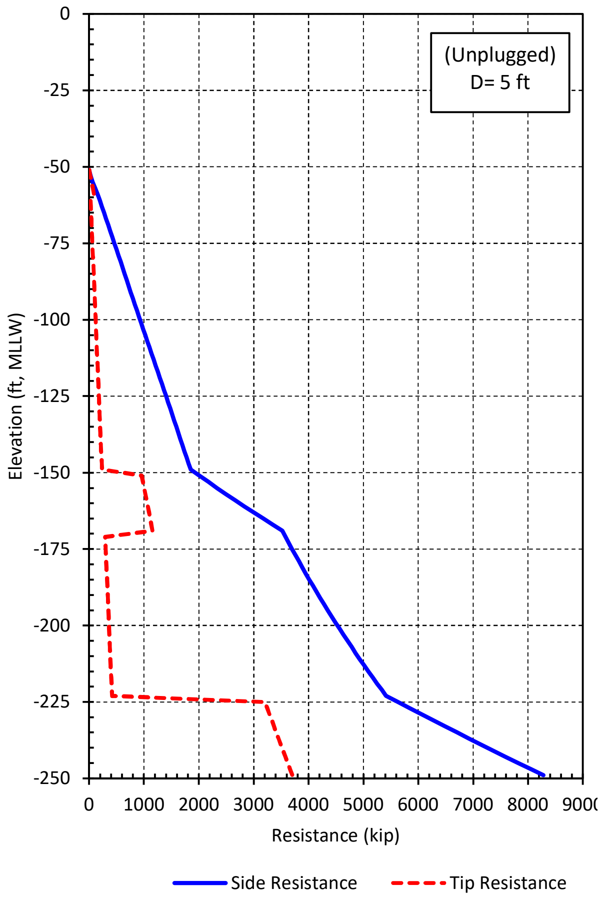
Nominal Resistance of 8-ft Pipepile at Terminal 1 (Under Wharf)

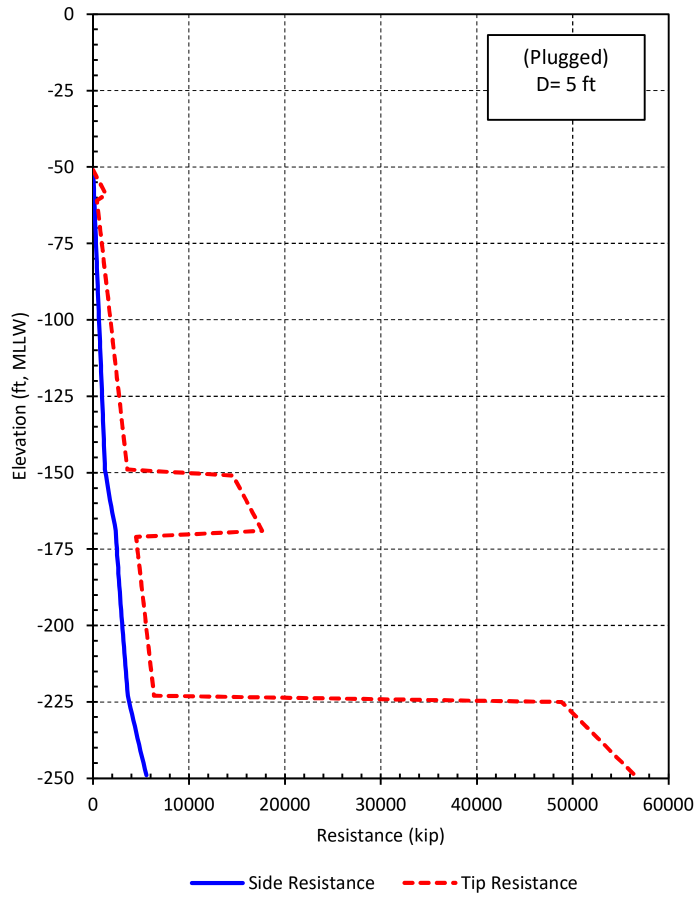




Anchorage Port Modernization Project

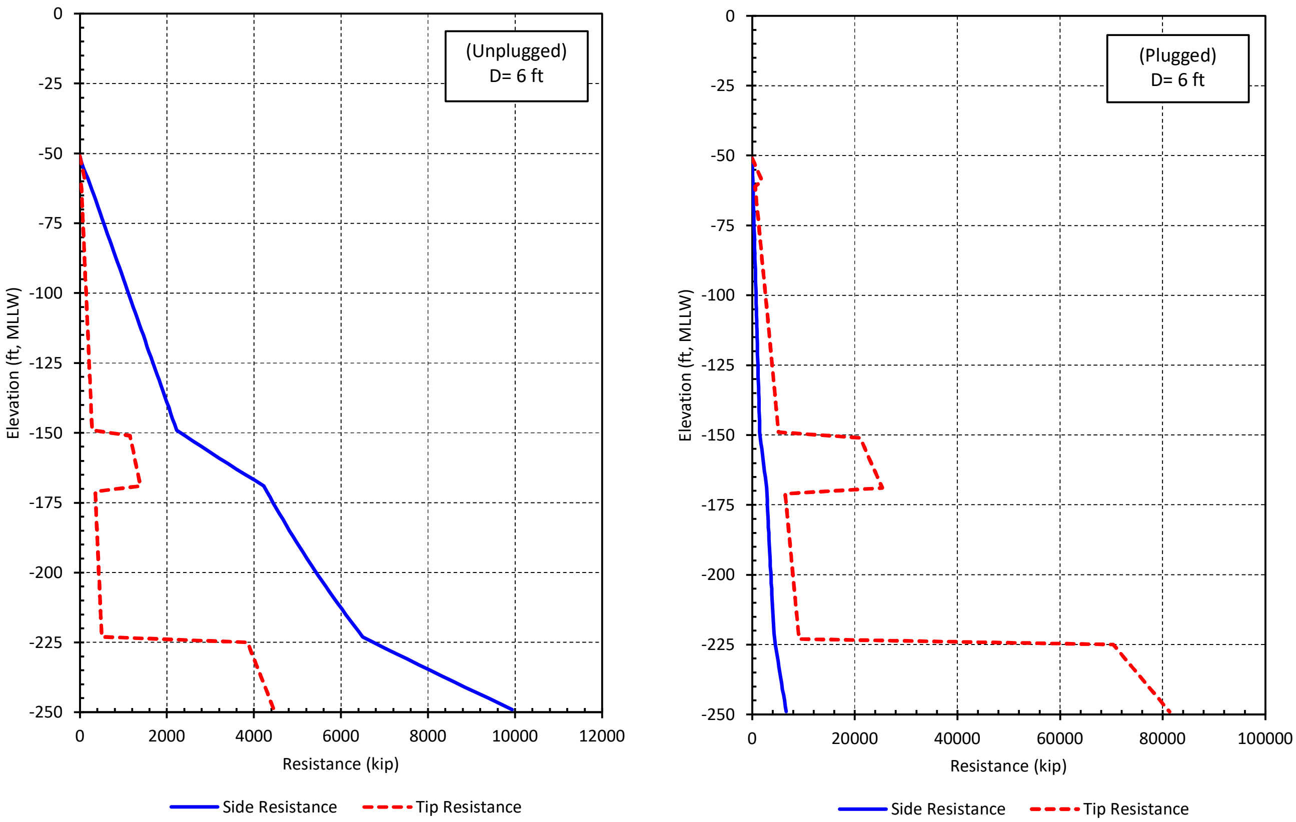
Nominal Resistance of 5-ft Pipepile at Terminal 2 (Wharf)





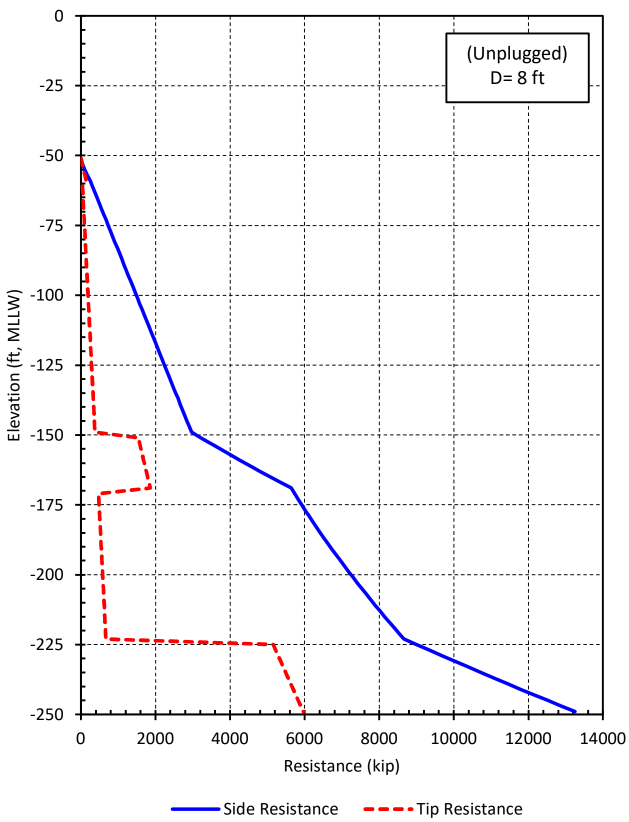
Anchorage Port Modernization Project

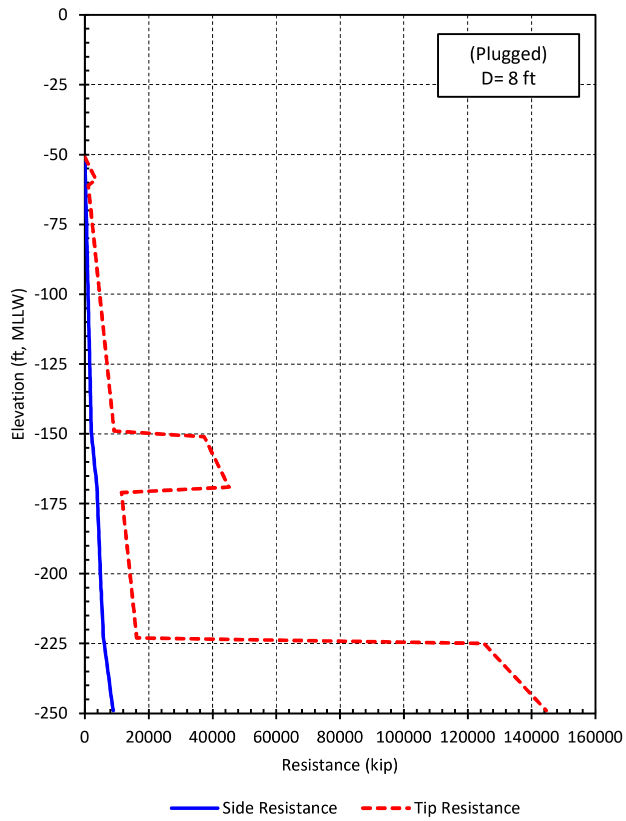
Nominal Resistance of 6-ft Pipepile at Terminal 2 (Wharf)



Anchorage Port Modernization Project

Nominal Resistance of 8-ft Pipepile at Terminal 2 (Wharf)





Attachment 2
Drivability Analysis Results – GRLWEP Outputs

5' diameter, close-end pile
APE D180-42 hammer

CH2M Hill
Enter Project Title Here

Jan 24 2022
GRLWEAP Version 2010

Gain/Loss 1 at Shaft and Toe 0.500 / 0.300

Depth ft	Ultimate Capacity kips	Friction kips	End Bearing kips	Blow Count blows/ft	Comp. Stress ksi	Tension Stress ksi	Stroke ft	ENTHRU kips-ft	
5.0	41.8	0.8	41.0	0.0	0.000	0.000	11.25	0.0	
10.0	85.2	3.1	82.1	0.0	0.000	0.000	11.25	0.0	
15.0	130.2	7.0	123.1	0.0	0.000	0.000	11.25	0.0	
20.0	579.8	58.3	521.5	5.6	25.562	-9.944	7.36	211.1	
25.0	758.6	115.8	642.8	9.3	26.385	-10.115	7.64	207.9	
30.0	943.7	179.6	764.1	13.2	27.323	-10.506	7.82	203.0	
35.0	1135.0	249.7	885.3	19.0	28.192	-10.354	8.08	203.8	
40.0	2079.8	328.7	1751.1	9999.0	30.267	-7.950	8.87	212.4	
45.0	2398.7	413.4	1985.3	9999.0	30.782	-7.456	9.03	213.5	
50.0	2723.3	503.8	2219.5	9999.0	31.157	-6.941	9.14	213.2	
55.0	3053.6	599.8	2453.7	9999.0	31.505	-6.478	9.23	213.1	
60.0	3389.5	701.5	2687.9	9999.0	31.770	-5.954	9.32	212.3	
65.0	3731.1	808.9	2922.1	9999.0	32.014	-5.426	9.39	211.3	
120.0	2489.8	1156.2	1333.6	9999.0	31.362	-8.305	9.17	193.8	BCF layer
169.0	3317.3	1465.7	1851.6	9999.0	32.212	-7.176	9.42	189.1	
175.0	9465.8	1676.7	7789.1	9999.0	33.867	-2.531	9.58	192.8	
180.0	9879.8	1855.5	8024.4	9999.0	33.820	-2.522	9.59	191.9	Glacial Fluvial layer
185.0	10296.6	2037.0	8259.6	9999.0	33.964	-2.517	9.60	191.2	

Refusal occurred; no driving time output possible

5' diameter, close-end pile
IHC S-800 hammer

CH2M Hill
Enter Project Title Here

Jan 24 2022
GRLWEAP Version 2010

Gain/Loss 1 at Shaft and Toe 0.500 / 0.300

Depth ft	Ultimate Capacity kips	Friction kips	End Bearing kips	Blow Count blows/ft	Comp. Stress ksi	Tension Stress ksi	Stroke ft	ENTHRU kips-ft	
5.0	41.8	0.8	41.0	0.0	0.000	0.000	6.69	0.0	
10.0	85.2	3.1	82.1	0.0	0.000	0.000	6.69	0.0	
15.0	130.2	7.0	123.1	0.0	0.000	0.000	6.69	0.0	
20.0	579.8	58.3	521.5	4.3	31.008	-20.816	6.69	550.5	
25.0	758.6	115.8	642.8	5.3	31.008	-20.450	6.69	550.4	
30.0	943.7	179.6	764.1	6.5	31.008	-20.229	6.69	550.4	
35.0	1135.0	249.7	885.3	7.9	31.008	-19.899	6.69	550.4	
40.0	2079.8	328.7	1751.1	22.7	31.008	-16.119	6.69	550.4	
45.0	2398.7	413.4	1985.3	31.2	31.008	-15.242	6.69	550.4	
50.0	2723.3	503.8	2219.5	38.3	31.008	-14.345	6.69	550.4	
55.0	3053.6	599.8	2453.7	47.9	31.059	-13.391	6.69	550.4	
60.0	3389.5	701.5	2687.9	59.1	31.008	-12.413	6.69	550.4	
65.0	3731.1	808.9	2922.1	74.7	31.102	-11.384	6.69	550.3	
120.0	2489.8	1156.2	1333.6	19.2	31.194	-12.924	6.69	549.5	BCF layer
169.0	3317.3	1465.7	1851.6	32.1	31.358	-10.939	6.69	547.9	
175.0	9465.8	1676.7	7789.1	9999.0	31.878	-4.734	6.69	547.5	
180.0	9879.8	1855.5	8024.4	9999.0	31.791	-4.471	6.69	547.3	Glacial Fluvial layer
185.0	10296.6	2037.0	8259.6	9999.0	31.818	-4.290	6.69	547.2	

Refusal occurred; no driving time output possible

8' diameter, close-end pile
IHC S-1400 hammer

CH2M Hill — Jan 24 2022

Enter Project Title Here — GRLWEAP Version 2010

Gain/Loss 1 at Shaft and Toe 0.500 / 0.300

Depth ft	Ultimate Capacity kips	Friction kips	End Bearing kips	Blow Count blows/ft	Comp. Stress ksi	Tension Stress ksi	Stroke ft	ENTHRU kips-ft	
5.0	106.3	1.2	105.1	0.0	0.000	0.000	6.99	0.0	
10.0	215.2	5.0	210.2	0.0	0.000	0.000	6.99	0.0	
15.0	326.5	11.2	315.3	0.0	0.000	0.000	6.99	0.0	
20.0	1428.4	93.3	1335.1	5.8	32.878	-19.319	6.99	965.4	
25.0	1830.9	185.3	1645.6	7.6	32.879	-18.690	6.99	965.4	
30.0	2243.4	287.4	1956.0	9.9	32.879	-18.212	6.99	965.4	
35.0	2666.0	399.5	2266.5	12.8	32.879	-17.440	6.99	965.3	
40.0	5008.8	525.9	4482.9	58.3	32.918	-13.009	6.99	965.2	
45.0	5743.9	661.4	5082.4	93.0	33.035	-12.170	6.99	965.4	
50.0	6488.0	806.0	5682.0	175.4	33.126	-11.306	6.99	965.4	
55.0	7241.2	959.7	6281.6	830.6	33.230	-10.421	6.99	965.2	
60.0	8003.6	1122.4	6881.1	9999.0	33.321	-9.489	6.99	965.3	
65.0	8775.0	1294.3	7480.7	9999.0	33.508	-8.530	6.99	965.3	
120.0	5263.9	1849.9	3413.9	31.9	33.114	-10.897	6.99	963.8	BCF layer
169.0	7085.1	2345.0	4740.1	83.8	33.373	-9.049	6.99	960.7	
175.0	22622.7	2682.6	19940.2	9999.0	33.976	-2.938	6.99	960.7	Glacial Fluvial layer
180.0	23511.0	2968.7	20542.4	9999.0	33.831	-2.756	6.99	960.5	
185.0	24403.7	3259.1	21144.6	9999.0	33.730	-2.789	6.99	960.4	

Refusal occurred; no driving time output possible

8' diameter, close-end pile
IHC S-1800 hammer

CH2M Hill
Enter Project Title Here

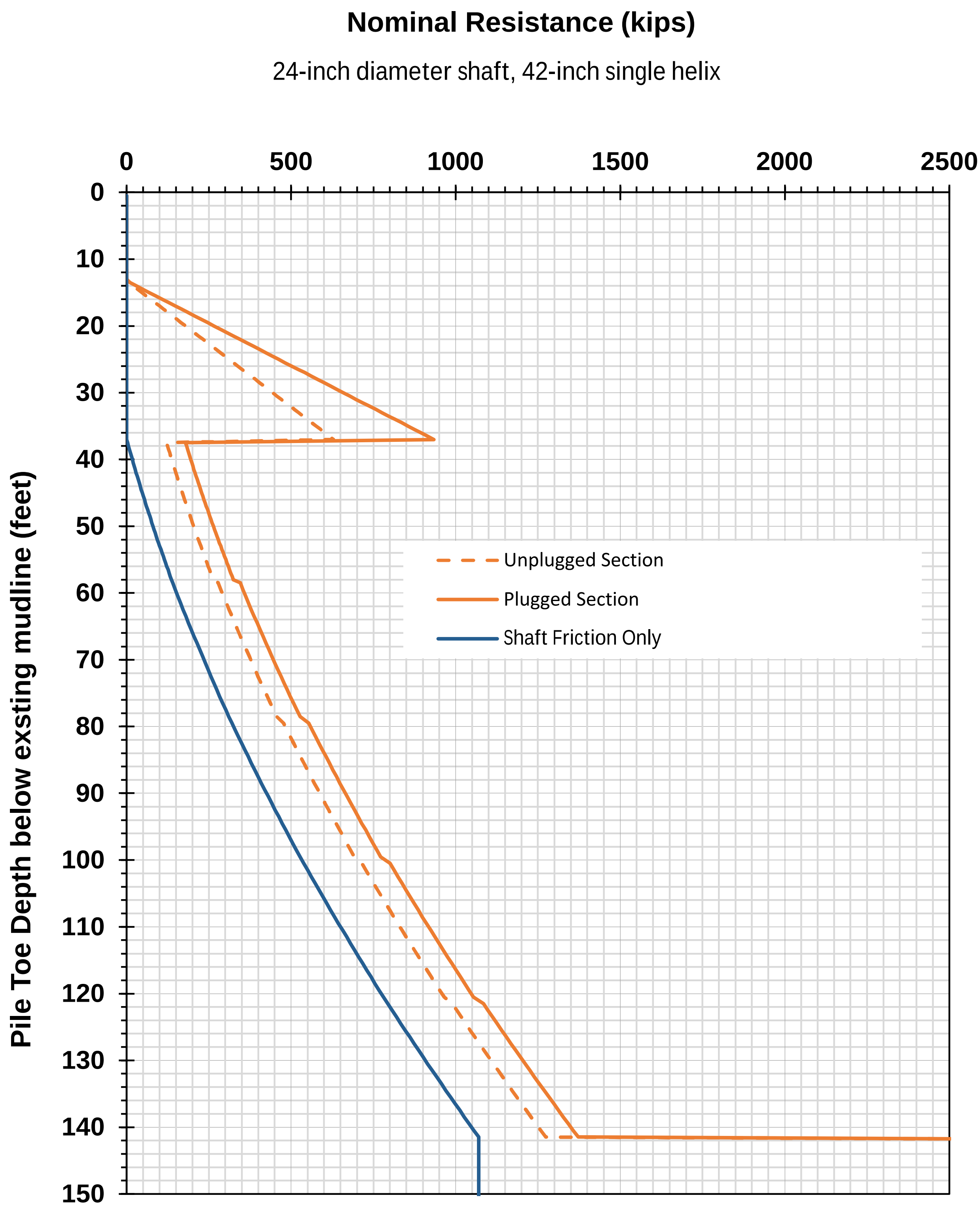
Jan 24 2022
GRLWEAP Version 2010

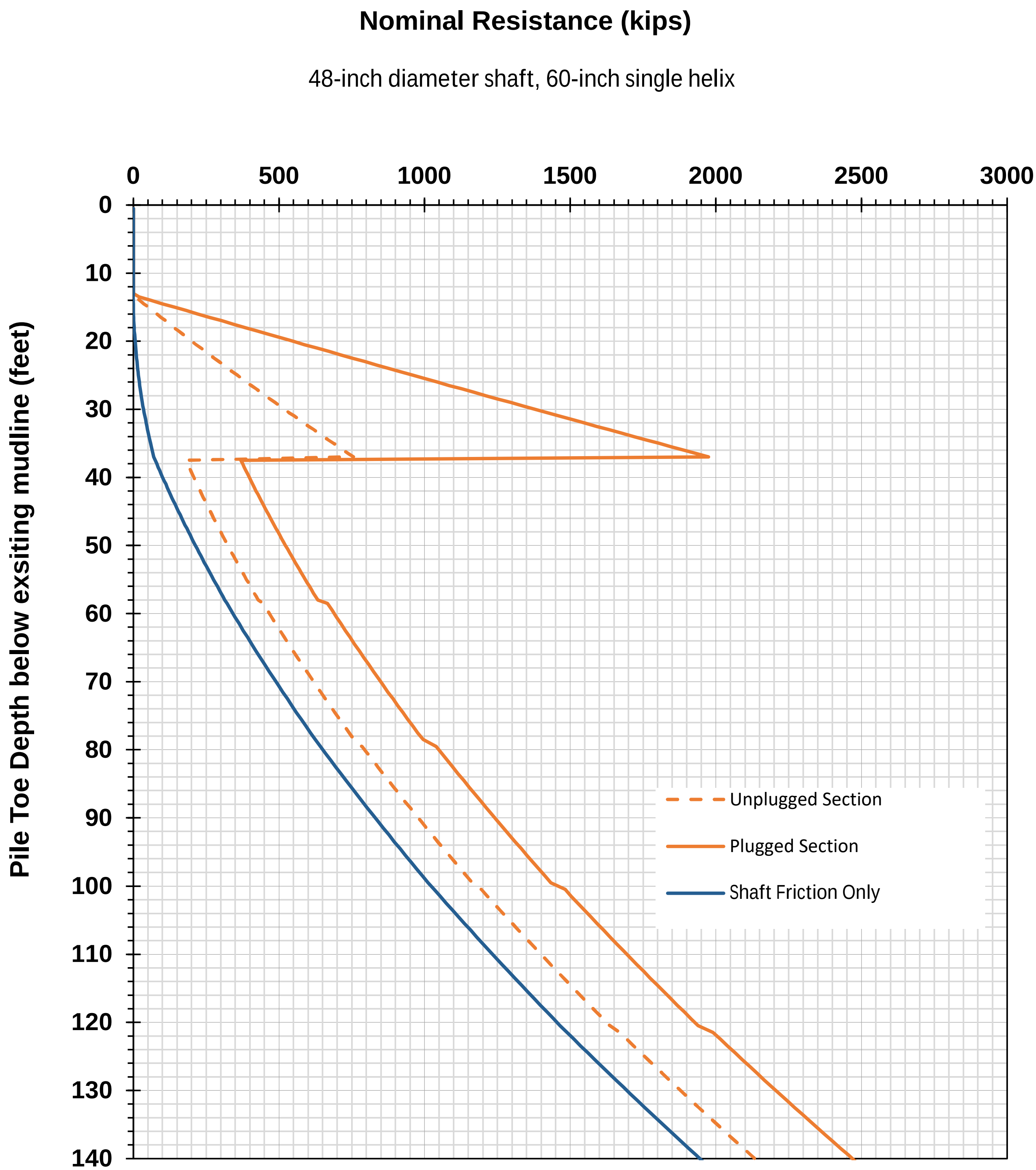
Gain/Loss 1 at Shaft and Toe 0.500 / 0.300

Depth ft	Ultimate Capacity kips	Friction kips	End Bearing kips	Blow Count blows/ft	Comp. Stress ksi	Tension Stress ksi	Stroke ft	ENTHRU kips-ft	
5.0	106.3	1.2	105.1	0.0	0.000	0.000	6.85	0.0	
10.0	215.2	5.0	210.2	0.0	0.000	0.000	6.85	0.0	
15.0	326.5	11.2	315.3	0.0	0.000	0.000	6.85	0.0	
20.0	1428.4	93.3	1335.1	4.2	34.007	-18.571	6.85	1252.8	
25.0	1830.9	185.3	1645.6	5.2	34.007	-17.946	6.85	1252.7	
30.0	2243.4	287.4	1956.0	6.6	34.007	-17.426	6.85	1252.6	
35.0	2666.0	399.5	2266.5	8.3	33.981	-17.056	6.85	1252.5	
40.0	5008.8	525.9	4482.9	26.8	34.284	-12.960	6.85	1253.1	
45.0	5743.9	661.4	5082.4	35.9	34.401	-12.002	6.85	1252.8	
50.0	6488.0	806.0	5682.0	49.2	34.668	-11.043	6.85	1253.0	
55.0	7241.2	959.7	6281.6	71.4	34.935	-10.048	6.85	1253.2	
60.0	8003.6	1122.4	6881.1	110.8	35.044	-9.038	6.85	1253.1	
65.0	8775.0	1294.3	7480.7	217.4	35.247	-8.005	6.85	1252.9	
120.0	5263.9	1849.9	3413.9	20.1	34.551	-10.123	6.85	1249.8	BCF layer
169.0	7085.1	2345.0	4740.1	39.7	34.763	-8.198	6.85	1247.5	
175.0	22622.7	2682.6	19940.2	9999.0	34.610	-2.344	6.85	1248.2	
180.0	23511.0	2968.7	20542.4	9999.0	34.606	-2.535	6.85	1248.4	Glacial Fluvial layer
185.0	24403.7	3259.1	21144.6	9999.0	34.759	-2.691	6.85	1248.5	

Refusal occurred; no driving time output possible

Attachment 3
Axial Capacity Charts – Helical Piles


Nominal Resistance (kips)
24-inch diameter shaft, 42-inch single helix
0
500
1000
1500
2000
2500
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
Pile Toe Depth below exsting mudline (feet)
Unplugged Section
Plugged Section
Shaft Friction Only



Nominal Resistance (kips)
48-inch diameter shaft, 60-inch single helix
0
500
1000
1500
2000
2500
3000
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
Pile Toe Depth below exsiting mudline (feet)
Unplugged Section
Plugged Section
Shaft Friction Only

Attachment 4
Lateral Spreading Load – LPILE Outputs

```
===============================================================================

                  LPile for Windows, Version 2019-11.009

              Analysis of Individual Piles and Drilled Shafts
             Subjected to Lateral Loading Using the p-y Method
                       © 1985-2019 by Ensoft, Inc.
                           All Rights Reserved

===============================================================================

This copy of LPile is being used by:

Jacobs
Bellevue

Serial Number of Security Device: 419704768

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-------------------------------------------------------------------------------
                           Files Used for Analysis
-------------------------------------------------------------------------------

Path to file locations:
\Users\shins2\OneDrive - Jacobs\Desktop\POA\Lateral spreading\

Name of input data file:
Term2_LS_SoilPressure.lp11d

Name of output report file:
Term2_LS_SoilPressure.lp11o

Name of plot output file:
Term2_LS_SoilPressure.lp11p

Name of runtime message file:
Term2_LS_SoilPressure.lp11r



-------------------------------------------------------------------------------
                          Date and Time of Analysis
-------------------------------------------------------------------------------
```

Date: January 13, 2022 Time: 13:15:17

Problem Title

Project Name:

Job Number:

Client:

Engineer:

Description:

Program Options and Settings

Computational Options:
- Conventional Analysis

Engineering Units Used for Data Input and Computations:
- US Customary System Units (pounds, feet, inches)

Analysis Control Options:
- Maximum number of iterations allowed = 500
- Deflection tolerance for convergence = 1.0000E-05 in
- Maximum allowable deflection = 100.0000 in
- Number of pile increments = 150

Loading Type and Number of Cycles of Loading:
- Static loading specified

- Analysis uses p-y modification factors for p-y curves
- Analysis uses layering correction (Method of Georgiadis)
- No distributed lateral loads are entered
- Analysis includes loading by one lateral soil movement profile acting on pile

```
 - Input of shear resistance at the pile tip not selected
 - Input of moment resistance at the pile tip not selected
 - Input of side resistance moment along pile not selected
 - Computation of pile-head foundation stiffness matrix not selected
 - Push-over analysis of pile not selected
 - Buckling analysis of pile not selected

Output Options:
 - Output files use decimal points to denote decimal symbols.
 - Values of pile-head deflection, bending moment, shear force, and
   soil reaction are printed for full length of pile.
 - Printing Increment (nodal spacing of output points) = 1
 - No p-y curves to be computed and reported for user-specified depths
 - Print using wide report formats




--------------------------------------------------------------------------------
                     Pile Structural Properties and Geometry
--------------------------------------------------------------------------------

Number of pile sections defined                         =            1
Total length of pile                                    =      150.000 ft
Depth of ground surface below top of pile               =       0.0000 ft

Pile diameters used for p-y curve computations are defined using 2 points.

p-y curves are computed using pile diameter values interpolated with depth over
the length of the pile. A summary of values of pile diameter vs. depth follows.

            Depth Below           Pile
Point        Pile Head          Diameter
 No.            feet             inches
-----      -------------     -------------
  1             0.000         144.0000
  2           150.000         144.0000


Input Structural Properties for Pile Sections:
----------------------------------------------

Pile Section No. 1:

   Section 1 is a steel pipe pile
   Length of section                                    =   150.000000 ft
   Pile diameter                                        =   144.000000 in
   Shear capacity of section                            =       0.0000 lbs
```

```
--------------------------------------------------------------------------------
                       Ground Slope and Pile Batter Angles
--------------------------------------------------------------------------------

Ground Slope Angle                                         =        0.000 degrees
                                                           =        0.000 radians

Pile Batter Angle                                          =        0.000 degrees
                                                           =        0.000 radians


--------------------------------------------------------------------------------
                       Soil and Rock Layering Information
--------------------------------------------------------------------------------

The soil profile is modelled using 7 layers

Layer 1 is sand, p-y criteria by Reese et al., 1974

   Distance from top of pile to top of layer               =       0.0000 ft
   Distance from top of pile to bottom of layer            =    15.000000 ft
   Effective unit weight at top of layer                   =    56.000000 pcf
   Effective unit weight at bottom of layer                =    56.000000 pcf
   Friction angle at top of layer                          =    30.000000 deg.
   Friction angle at bottom of layer                       =    30.000000 deg.
   Subgrade k at top of layer                              =       0.0000 pci
   Subgrade k at bottom of layer                           =       0.0000 pci

   NOTE: Default values for subgrade k will be computed for this layer.

Layer 2 is sand, p-y criteria by Reese et al., 1974

   Distance from top of pile to top of layer               =    15.000000 ft
   Distance from top of pile to bottom of layer            =    35.000000 ft
   Effective unit weight at top of layer                   =    61.000000 pcf
   Effective unit weight at bottom of layer                =    61.000000 pcf
   Friction angle at top of layer                          =    35.000000 deg.
   Friction angle at bottom of layer                       =    35.000000 deg.
   Subgrade k at top of layer                              =       0.0000 pci
   Subgrade k at bottom of layer                           =       0.0000 pci

   NOTE: Default values for subgrade k will be computed for this layer.

Layer 3 is sand, p-y criteria by Reese et al., 1974

   Distance from top of pile to top of layer               =    35.000000 ft
   Distance from top of pile to bottom of layer            =    65.000000 ft
   Effective unit weight at top of layer                   =    71.000000 pcf
```

```
   Effective unit weight at bottom of layer             =    71.000000 pcf
   Friction angle at top of layer                       =    38.000000 deg.
   Friction angle at bottom of layer                    =    38.000000 deg.
   Subgrade k at top of layer                           =       0.0000 pci
   Subgrade k at bottom of layer                        =       0.0000 pci

   NOTE: Default values for subgrade k will be computed for this layer.

Layer 4 is stiff clay with water-induced erosion

   Distance from top of pile to top of layer            =    65.000000 ft
   Distance from top of pile to bottom of layer         =   170.000000 ft
   Effective unit weight at top of layer                =    61.000000 pcf
   Effective unit weight at bottom of layer             =    61.000000 pcf
   Undrained cohesion at top of layer                   =        1500. psf
   Undrained cohesion at bottom of layer                =        2250. psf
   Epsilon-50 at top of layer                           =     0.006200
   Epsilon-50 at bottom of layer                        =     0.005500
   Subgrade k at top of layer                           =       0.0000 pci
   Subgrade k at bottom of layer                        =       0.0000 pci

   NOTE: Default values for subgrade k will be computed for this layer.

Layer 5 is sand, p-y criteria by Reese et al., 1974

   Distance from top of pile to top of layer            =   170.000000 ft
   Distance from top of pile to bottom of layer         =   190.000000 ft
   Effective unit weight at top of layer                =    71.000000 pcf
   Effective unit weight at bottom of layer             =    71.000000 pcf
   Friction angle at top of layer                       =    38.000000 deg.
   Friction angle at bottom of layer                    =    38.000000 deg.
   Subgrade k at top of layer                           =       0.0000 pci
   Subgrade k at bottom of layer                        =       0.0000 pci

   NOTE: Default values for subgrade k will be computed for this layer.

Layer 6 is stiff clay with water-induced erosion

   Distance from top of pile to top of layer            =   190.000000 ft
   Distance from top of pile to bottom of layer         =   220.000000 ft
   Effective unit weight at top of layer                =    61.000000 pcf
   Effective unit weight at bottom of layer             =    61.000000 pcf
   Undrained cohesion at top of layer                   =        2500. psf
   Undrained cohesion at bottom of layer                =        3100. psf
   Epsilon-50 at top of layer                           =     0.005300
   Epsilon-50 at bottom of layer                        =     0.004900
   Subgrade k at top of layer                           =       0.0000 pci
   Subgrade k at bottom of layer                        =       0.0000 pci

   NOTE: Default values for subgrade k will be computed for this layer.
```

Layer 7 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer = 220.000000 ft
Distance from top of pile to bottom of layer = 300.000000 ft
Effective unit weight at top of layer = 71.000000 pcf
Effective unit weight at bottom of layer = 71.000000 pcf
Friction angle at top of layer = 42.000000 deg.
Friction angle at bottom of layer = 42.000000 deg.
Subgrade k at top of layer = 0.0000 pci
Subgrade k at bottom of layer = 0.0000 pci

NOTE: Default values for subgrade k will be computed for this layer.

(Depth of the lowest soil layer extends 150.000 ft below the pile tip)

Summary of Input Soil Properties

Layer Num.	Soil Type Name (p-y Curve Type)	Layer Depth ft	Effective Unit Wt. pcf	Cohesion psf	Angle of Friction deg.	E50 or krm	kpy pci
1	Sand	0.00	56.0000	--	30.0000	--	default
	(Reese, et al.)	15.0000	56.0000	--	30.0000	--	default
2	Sand	15.0000	61.0000	--	35.0000	--	default
	(Reese, et al.)	35.0000	61.0000	--	35.0000	--	default
3	Sand	35.0000	71.0000	--	38.0000	--	default
	(Reese, et al.)	65.0000	71.0000	--	38.0000	--	default
4	Stiff Clay	65.0000	61.0000	1500.	--	0.00620	default
	with Free Water	170.0000	61.0000	2250.	--	0.00550	default
5	Sand	170.0000	71.0000	--	38.0000	--	default
	(Reese, et al.)	190.0000	71.0000	--	38.0000	--	default
6	Stiff Clay	190.0000	61.0000	2500.	--	0.00530	default
	with Free Water	220.0000	61.0000	3100.	--	0.00490	default
7	Sand	220.0000	71.0000	--	42.0000	--	default
	(Reese, et al.)	300.0000	71.0000	--	42.0000	--	default

---

p-y Modification Factors for Group Action

Distribution of p-y modifiers with depth defined using 2 points

Point No.	Depth X ft	p-mult	y-mult

```
-----     ----------     ----------     ----------
  1            0.000         0.1000         1.0000
  2           15.000         0.1000         1.0000




--------------------------------------------------------------------------------
                Lateral Soil Movements Applied to All Load Cases
--------------------------------------------------------------------------------

Profile of soil movement with depth defined using 2 points

Point       Depth X     Soil Movement
 No.           ft             in
-----     ----------    -------------
  1          0.00000      100.00000
  2         15.00000      100.00000




--------------------------------------------------------------------------------
                               Static Loading Type
--------------------------------------------------------------------------------

Static loading criteria were used when computing p-y curves for all analyses.



--------------------------------------------------------------------------------
                Pile-head Loading and Pile-head Fixity Conditions
--------------------------------------------------------------------------------

Number of loads specified = 1

Load    Load         Condition                Condition             Axial Thrust      Compute Top y     Run Analysis
 No.    Type             1                        2                  Force, lbs      vs. Pile Length
-----   ----   --------------------   -----------------------   ----------------   ---------------    ------------
   1     2     V =       0.0000 lbs   S =       0.0000 in/in          0.0000000          No                Yes

V = shear force applied normal to pile axis
M = bending moment applied to pile head
y = lateral deflection normal to pile axis
S = pile slope relative to original pile batter angle
R = rotational stiffness applied to pile head
Values of top y vs. pile lengths can be computed only for load types with
specified shear loading (Load Types 1, 2, and 3).
Thrust force is assumed to be acting axially for all pile batter angles.
```

```
-------------------------------------------------------------------------------
     Computations of Nominal Moment Capacity and Nonlinear Bending Stiffness
-------------------------------------------------------------------------------

Axial thrust force values were determined from pile-head loading conditions

Number of Pile Sections Analyzed = 1

Pile Section No. 1:
-------------------

Dimensions and Properties of Steel Pipe Pile:
---------------------------------------------

Length of Section                                      =   150.000000 ft
Outer Diameter of Pipe                                 =   144.000000 in
Pipe Wall Thickness                                    =     1.000000 in
Yield Stress of Pipe                                   =    36.000000 ksi
Elastic Modulus                                        =       29000. ksi
Cross-sectional Area                                   =   449.247749 sq. in.
Moment of Inertia                                      =     1148390. in^4
Elastic Bending Stiffness                              =   3.3303E+10 kip-in^2
Plastic Modulus, Z                                     =       20449.in^3
Plastic Moment Capacity = Fy Z                         =      736176.in-kip

Axial Structural Capacities:
----------------------------

Nom. Axial Structural Capacity = Fy As                 =    16172.919 kips
Nominal Axial Tensile Capacity                         =   -16172.919 kips




Number of Axial Thrust Force Values Determined from Pile-head Loadings = 1

   Number     Axial Thrust Force
                   kips
   ------     ------------------
      1               0.000

Definition of Run Messages:

   Y = part of pipe section has yielded.


Axial Thrust Force =      0.000 kips
```

Bending Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Max Total Stress ksi	Run Msg
3.66379E-07	12200.	3.32993E+10	72.0000000	0.7573500	
7.32759E-07	24400.	3.32993E+10	72.0000000	1.5147000	
0.00000110	36601.	3.32993E+10	72.0000000	2.2720500	
0.00000147	48801.	3.32993E+10	72.0000000	3.0294000	
0.00000183	61001.	3.32993E+10	72.0000000	3.7867500	
0.00000220	73201.	3.32993E+10	72.0000000	4.5441000	
0.00000256	85401.	3.32993E+10	72.0000000	5.3014500	
0.00000293	97602.	3.32993E+10	72.0000000	6.0588000	
0.00000330	109802.	3.32993E+10	72.0000000	6.8161500	
0.00000366	122002.	3.32993E+10	72.0000000	7.5735000	
0.00000403	134202.	3.32993E+10	72.0000000	8.3308500	
0.00000440	146402.	3.32993E+10	72.0000000	9.0882000	
0.00000476	158602.	3.32993E+10	72.0000000	9.8455500	
0.00000513	170803.	3.32993E+10	72.0000000	10.6029000	
0.00000550	183003.	3.32993E+10	72.0000000	11.3602500	
0.00000586	195203.	3.32993E+10	72.0000000	12.1176000	
0.00000623	207403.	3.32993E+10	72.0000000	12.8749500	
0.00000659	219603.	3.32993E+10	72.0000000	13.6323000	
0.00000696	231804.	3.32993E+10	72.0000000	14.3896500	
0.00000733	244004.	3.32993E+10	72.0000000	15.1470000	
0.00000769	256204.	3.32993E+10	72.0000000	15.9043500	
0.00000806	268404.	3.32993E+10	72.0000000	16.6617000	
0.00000843	280604.	3.32993E+10	72.0000000	17.4190500	
0.00000879	292805.	3.32993E+10	72.0000000	18.1764000	
0.00000916	305005.	3.32993E+10	72.0000000	18.9337500	
0.00000953	317205.	3.32993E+10	72.0000000	19.6911000	
0.00000989	329405.	3.32993E+10	72.0000000	20.4484500	
0.00001026	341605.	3.32993E+10	72.0000000	21.2058000	
0.00001063	353806.	3.32993E+10	72.0000000	21.9631500	
0.00001099	366006.	3.32993E+10	72.0000000	22.7205000	
0.00001136	378206.	3.32993E+10	72.0000000	23.4778500	
0.00001172	390406.	3.32993E+10	72.0000000	24.2352000	
0.00001209	402606.	3.32993E+10	72.0000000	24.9925500	
0.00001246	414807.	3.32993E+10	72.0000000	25.7499000	
0.00001282	427007.	3.32993E+10	72.0000000	26.5072500	
0.00001319	439207.	3.32993E+10	72.0000000	27.2646000	
0.00001356	451407.	3.32993E+10	72.0000000	28.0219500	
0.00001392	463607.	3.32993E+10	72.0000000	28.7793000	
0.00001429	475807.	3.32993E+10	72.0000000	29.5366500	
0.00001502	500208.	3.32993E+10	72.0000000	31.0513500	
0.00001575	524608.	3.32993E+10	72.0000000	32.5660500	
0.00001649	549009.	3.32993E+10	72.0000000	34.0807500	
0.00001722	573409.	3.32993E+10	72.0000000	35.5954500	
0.00001795	593475.	3.30579E+10	72.0000000	36.0000000	Y
0.00001869	608252.	3.25524E+10	72.0000000	36.0000000	Y
0.00001942	620322.	3.19455E+10	72.0000000	36.0000000	Y

0.00002015	630405.	3.12842E+10	72.0000000	36.0000000	Y
0.00002088	639097.	3.06028E+10	72.0000000	36.0000000	Y
0.00002162	646627.	2.99137E+10	72.0000000	36.0000000	Y
0.00002235	653294.	2.92313E+10	72.0000000	36.0000000	Y
0.00002308	659144.	2.85567E+10	72.0000000	36.0000000	Y
0.00002381	664351.	2.78967E+10	72.0000000	36.0000000	Y
0.00002455	669028.	2.72545E+10	72.0000000	36.0000000	Y
0.00002528	673244.	2.66313E+10	72.0000000	36.0000000	Y
0.00002601	677061.	2.60279E+10	72.0000000	36.0000000	Y
0.00002675	680532.	2.54445E+10	72.0000000	36.0000000	Y
0.00002748	683706.	2.48815E+10	72.0000000	36.0000000	Y
0.00002821	686603.	2.43380E+10	72.0000000	36.0000000	Y
0.00002894	689223.	2.38123E+10	72.0000000	36.0000000	Y
0.00002968	691652.	2.33062E+10	72.0000000	36.0000000	Y
0.00003041	693920.	2.28192E+10	72.0000000	36.0000000	Y
0.00003114	695992.	2.23488E+10	72.0000000	36.0000000	Y
0.00003188	697898.	2.18948E+10	72.0000000	36.0000000	Y
0.00003261	699717.	2.14586E+10	72.0000000	36.0000000	Y
0.00003334	701347.	2.10359E+10	72.0000000	36.0000000	Y
0.00003407	702908.	2.06293E+10	72.0000000	36.0000000	Y
0.00003481	704346.	2.02363E+10	72.0000000	36.0000000	Y
0.00003554	705700.	1.98572E+10	72.0000000	36.0000000	Y
0.00003627	706963.	1.94908E+10	72.0000000	36.0000000	Y
0.00003700	708157.	1.91371E+10	72.0000000	36.0000000	Y
0.00003774	709261.	1.87948E+10	72.0000000	36.0000000	Y
0.00003847	710334.	1.84647E+10	72.0000000	36.0000000	Y
0.00003920	711294.	1.81440E+10	72.0000000	36.0000000	Y
0.00003994	712253.	1.78352E+10	72.0000000	36.0000000	Y
0.00004067	713112.	1.75349E+10	72.0000000	36.0000000	Y
0.00004140	713941.	1.72446E+10	72.0000000	36.0000000	Y
0.00004213	714758.	1.69641E+10	72.0000000	36.0000000	Y
0.00004287	715470.	1.66907E+10	72.0000000	36.0000000	Y
0.00004360	716183.	1.64265E+10	72.0000000	36.0000000	Y
0.00004653	718700.	1.54459E+10	72.0000000	36.0000000	Y
0.00004946	720742.	1.45719E+10	72.0000000	36.0000000	Y
0.00005239	722451.	1.37893E+10	72.0000000	36.0000000	Y
0.00005532	723881.	1.30846E+10	72.0000000	36.0000000	Y
0.00005825	725081.	1.24468E+10	72.0000000	36.0000000	Y
0.00006119	726122.	1.18676E+10	72.0000000	36.0000000	Y
0.00006412	727056.	1.13396E+10	72.0000000	36.0000000	Y
0.00006705	727814.	1.08552E+10	72.0000000	36.0000000	Y
0.00006998	728516.	1.04106E+10	72.0000000	36.0000000	Y
0.00007291	729110.	1.00002E+10	72.0000000	36.0000000	Y
0.00007584	729663.	9621016156.	72.0000000	36.0000000	Y
0.00007877	730119.	9268817151.	72.0000000	36.0000000	Y
0.00008170	730575.	8941888030.	72.0000000	36.0000000	Y
0.00008463	730933.	8636434505.	72.0000000	36.0000000	Y
0.00008756	731274.	8351251617.	72.0000000	36.0000000	Y

Summary of Results for Nominal Moment Capacity for Section 1

Load No.	Axial Thrust kips	Nominal Moment Capacity in-kips
1	0.00000000	731274.

Note that the values in the above table are not factored by a strength reduction factor for LRFD.

The value of the strength reduction factor depends on the provisions of the LRFD code being followed.

The above values should be multiplied by the appropriate strength reduction factor to compute ultimate moment capacity according to the LRFD structural design standard being followed.

Layering Correction Equivalent Depths of Soil & Rock Layers

Layer No.	Top of Layer Below Pile Head ft	Equivalent Top Depth Below Grnd Surf ft	Same Layer Type As Layer Above	Layer is Rock or is Below Rock Layer	F0 Integral for Layer lbs	F1 Integral for Layer lbs
1	0.00	0.00	N.A.	No	0.00	700336.
2	15.0000	12.8945	Yes	No	700336.	4312467.
3	35.0000	29.2114	Yes	No	5012803.	1.74E+07
4	65.0000	1421.	No	No	2.24E+07	1774365.
5	170.0000	170.0000	No	No	2.42E+07	0.00
6	190.0000	190.0000	No	No	0.00	0.00
7	220.0000	220.0000	No	No	0.00	N.A.

Notes: The F0 integral of Layer n+1 equals the sum of the F0 and F1 integrals for Layer n. Layering correction equivalent depths are computed only for soil types with both shallow-depth and deep-depth expressions for peak lateral load transfer. These soil types are soft and stiff clays, non-liquefied sands, and cemented c-phi soil.

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 1

Pile-head conditions are Shear and Pile-head Rotation (Loading Type 2)

Shear force at pile head = 0.0 lbs
Rotation of pile head = 0.000E+00 radians
Axial load at pile head = 0.0 lbs

(Zero slope for this load indicates fixed-head conditions)

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness lb-in^2	Soil Res. p lb/inch	Soil Spr. Es*H lb/inch	Distrib. Lat. Load lb/inch
0.00	0.02203	-9718568.	-3.34E-08	0.00	609.3201	3.33E+13	0.00	0.00	0.00
1.0000	0.02201	-9718568.	263.1774	-3.50E-06	609.3201	3.33E+13	43.8629	5.2647	0.00
2.0000	0.02195	-9712251.	1071.	-7.00E-06	608.9241	3.33E+13	90.7208	10.8889	0.00
3.0000	0.02184	-9692871.	2457.	-1.05E-05	607.7091	3.33E+13	140.2614	16.8350	0.00
4.0000	0.02169	-9653294.	4451.	-1.40E-05	605.2277	3.33E+13	192.1725	23.0657	0.00
5.0000	0.02150	-9586043.	7081.	-1.75E-05	601.0113	3.33E+13	246.1419	29.5434	0.00
6.0000	0.02127	-9483348.	10369.	-2.09E-05	594.5727	3.33E+13	301.8573	36.2306	0.00
7.0000	0.02100	-9337186.	14331.	-2.43E-05	585.4088	3.33E+13	358.5122	43.0305	0.00
8.0000	0.02069	-9139397.	18979.	-2.76E-05	573.0082	3.33E+13	416.0999	49.9423	0.00
9.0000	0.02034	-8881691.	24321.	-3.09E-05	556.8509	3.33E+13	474.2903	56.9264	0.00
10.0000	0.01995	-8555687.	30364.	-3.40E-05	536.4116	3.33E+13	532.7532	63.9431	0.00
11.0000	0.01952	-8152966.	37107.	-3.70E-05	511.1624	3.33E+13	591.1586	70.9529	0.00
12.0000	0.01906	-7665118.	44549.	-3.99E-05	480.5760	3.33E+13	649.1764	77.9160	0.00
13.0000	0.01857	-7083789.	52690.	-4.25E-05	444.1287	3.33E+13	707.6262	84.9309	0.00
14.0000	0.01804	-6400562.	61527.	-4.49E-05	401.2928	3.33E+13	765.2883	91.8512	0.00
15.0000	0.01749	-5607133.	71097.	-4.71E-05	351.5476	3.33E+13	829.6335	99.5734	0.00
16.0000	0.01691	-4694237.	74407.	-4.90E-05	294.3122	3.33E+13	-278.0011	197260.	0.00
17.0000	0.01631	-3821373.	71029.	-5.05E-05	239.5867	3.33E+13	-284.9363	209589.	0.00
18.0000	0.01570	-2989540.	67577.	-5.17E-05	187.4337	3.33E+13	-290.3377	221917.	0.00
19.0000	0.01507	-2199516.	64070.	-5.27E-05	137.9019	3.33E+13	-294.2245	234246.	0.00
20.0000	0.01444	-1451860.	60525.	-5.33E-05	91.0265	3.33E+13	-296.6272	246575.	0.00
21.0000	0.01379	-746918.	56960.	-5.37E-05	46.8291	3.33E+13	-297.5861	258903.	0.00
22.0000	0.01315	-84829.	53391.	-5.39E-05	5.3185	3.33E+13	-297.1509	271232.	0.00
23.0000	0.01250	534471.	49836.	-5.38E-05	33.5095	3.33E+13	-295.3791	283561.	0.00
24.0000	0.01186	1111236.	46310.	-5.35E-05	69.6706	3.33E+13	-292.3358	295890.	0.00
25.0000	0.01122	1645905.	42827.	-5.30E-05	103.1924	3.33E+13	-288.0921	308218.	0.00
26.0000	0.01058	2139088.	39402.	-5.23E-05	134.1133	3.33E+13	-282.7245	320547.	0.00
27.0000	0.00996	2591559.	36048.	-5.15E-05	162.4817	3.33E+13	-276.3142	332876.	0.00
28.0000	0.00935	3004241.	32776.	-5.04E-05	188.3554	3.33E+13	-268.9460	345205.	0.00
29.0000	0.00875	3378194.	29599.	-4.93E-05	211.8009	3.33E+13	-260.7076	357533.	0.00
30.0000	0.00817	3714606.	26524.	-4.80E-05	232.8928	3.33E+13	-251.6888	369862.	0.00

31.0000	0.00760	4014775.	23562.	-4.66E-05	251.7123	3.33E+13	-241.9811	382191.	0.00
32.0000	0.00705	4280098.	20720.	-4.51E-05	268.3471	3.33E+13	-231.6766	394520.	0.00
33.0000	0.00651	4512060.	18005.	-4.35E-05	282.8903	3.33E+13	-220.8677	406848.	0.00
34.0000	0.00600	4712216.	15422.	-4.19E-05	295.4395	3.33E+13	-209.6466	419177.	0.00
35.0000	0.00551	4882184.	12745.	-4.02E-05	306.0958	3.33E+13	-236.5402	515226.	0.00
36.0000	0.00504	5018090.	9758.	-3.84E-05	314.6167	3.33E+13	-261.2305	622242.	0.00
37.0000	0.00459	5116379.	6724.	-3.65E-05	320.7790	3.33E+13	-244.5235	639527.	0.00
38.0000	0.00416	5179456.	3890.	-3.47E-05	324.7337	3.33E+13	-227.7322	656811.	0.00
39.0000	0.00376	5209740.	1258.	-3.28E-05	326.6324	3.33E+13	-210.9675	674096.	0.00
40.0000	0.00337	5209645.	-1174.	-3.09E-05	326.6265	3.33E+13	-194.3338	691380.	0.00
41.0000	0.00301	5181565.	-3408.	-2.91E-05	324.8660	3.33E+13	-177.9283	708665.	0.00
42.0000	0.00268	5127864.	-5446.	-2.72E-05	321.4991	3.33E+13	-161.8411	725949.	0.00
43.0000	0.00236	5050858.	-7294.	-2.54E-05	316.6711	3.33E+13	-146.1547	743234.	0.00
44.0000	0.00207	4952805.	-8957.	-2.36E-05	310.5235	3.33E+13	-130.9436	760518.	0.00
45.0000	0.00179	4835897.	-10440.	-2.18E-05	303.1938	3.33E+13	-116.2750	777803.	0.00
46.0000	0.00154	4702245.	-11751.	-2.01E-05	294.8143	3.33E+13	-102.2077	795087.	0.00
47.0000	0.00131	4553875.	-12897.	-1.84E-05	285.5120	3.33E+13	-88.7930	812372.	0.00
48.0000	0.00110	4392719.	-13886.	-1.68E-05	275.4081	3.33E+13	-76.0745	829656.	0.00
49.0000	9.08E-04	4220608.	-14727.	-1.53E-05	264.6173	3.33E+13	-64.0880	846941.	0.00
50.0000	7.34E-04	4039268.	-15429.	-1.38E-05	253.2480	3.33E+13	-52.8620	864225.	0.00
51.0000	5.77E-04	3850317.	-16000.	-1.24E-05	241.4014	3.33E+13	-42.4179	881510.	0.00
52.0000	4.38E-04	3655257.	-16452.	-1.10E-05	229.1718	3.33E+13	-32.7698	898794.	0.00
53.0000	3.13E-04	3455478.	-16792.	-9.72E-06	216.6464	3.33E+13	-23.9253	916079.	0.00
54.0000	2.04E-04	3252254.	-17031.	-8.51E-06	203.9049	3.33E+13	-15.8855	933363.	0.00
55.0000	1.09E-04	3046743.	-17178.	-7.38E-06	191.0201	3.33E+13	-8.6455	950648.	0.00
56.0000	2.72E-05	2839986.	-17243.	-6.32E-06	178.0572	3.33E+13	-2.1942	967932.	0.00
57.0000	-4.24E-05	2632914.	-17235.	-5.33E-06	165.0745	3.33E+13	3.4848	985217.	0.00
58.0000	-1.01E-04	2426344.	-17164.	-4.42E-06	152.1232	3.33E+13	8.4133	1002501.	0.00
59.0000	-1.48E-04	2220985.	-17038.	-3.58E-06	139.2479	3.33E+13	12.6179	1019786.	0.00
60.0000	-1.87E-04	2017443.	-16865.	-2.82E-06	126.4866	3.33E+13	16.1301	1037070.	0.00
61.0000	-2.16E-04	1816223.	-16654.	-2.13E-06	113.8708	3.33E+13	18.9857	1054355.	0.00
62.0000	-2.38E-04	1617738.	-16413.	-1.51E-06	101.4265	3.33E+13	21.2248	1071639.	0.00
63.0000	-2.52E-04	1422309.	-16148.	-9.60E-07	89.1738	3.33E+13	22.8911	1088924.	0.00
64.0000	-2.61E-04	1230176.	-15867.	-4.82E-07	77.1277	3.33E+13	24.0326	1106208.	0.00
65.0000	-2.64E-04	1041504.	-15105.	-7.24E-08	65.2987	3.33E+13	102.8909	4680000.	0.00
66.0000	-2.62E-04	867649.	-13864.	2.72E-07	54.3985	3.33E+13	103.9261	4752000.	0.00
67.0000	-2.57E-04	708758.	-12620.	5.56E-07	44.4367	3.33E+13	103.4364	4824000.	0.00
68.0000	-2.49E-04	564763.	-11390.	7.85E-07	35.4086	3.33E+13	101.6345	4896000.	0.00
69.0000	-2.38E-04	435403.	-10188.	9.65E-07	27.2982	3.33E+13	98.7231	4968000.	0.00
70.0000	-2.26E-04	320259.	-9026.	1.10E-06	20.0791	3.33E+13	94.8933	5040000.	0.00
71.0000	-2.12E-04	218779.	-7915.	1.20E-06	13.7167	3.33E+13	90.3231	5112000.	0.00
72.0000	-1.97E-04	130307.	-6862.	1.26E-06	8.1698	3.33E+13	85.1773	5184000.	0.00
73.0000	-1.82E-04	54099.	-5873.	1.29E-06	3.3918	3.33E+13	79.6064	5256000.	0.00
74.0000	-1.66E-04	-10645.	-4953.	1.30E-06	0.6674	3.33E+13	73.7466	5328000.	0.00
75.0000	-1.50E-04	-64769.	-4104.	1.29E-06	4.0608	3.33E+13	67.7197	5400000.	0.00
76.0000	-1.35E-04	-109142.	-3328.	1.26E-06	6.8428	3.33E+13	61.6332	5472000.	0.00
77.0000	-1.20E-04	-144640.	-2625.	1.21E-06	9.0684	3.33E+13	55.5808	5544000.	0.00
78.0000	-1.06E-04	-172134.	-1993.	1.15E-06	10.7922	3.33E+13	49.6429	5616000.	0.00
79.0000	-9.26E-05	-192479.	-1432.	1.09E-06	12.0678	3.33E+13	43.8870	5688000.	0.00
80.0000	-7.99E-05	-206505.	-938.5948	1.02E-06	12.9471	3.33E+13	38.3689	5760000.	0.00

81.0000	-6.82E-05	-215005.	-509.5842	9.41E-07	13.4801	3.33E+13	33.1329	5832000.	0.00
82.0000	-5.73E-05	-218735.	-141.5074	8.63E-07	13.7139	3.33E+13	28.2132	5904000.	0.00
83.0000	-4.75E-05	-218402.	169.5799	7.84E-07	13.6930	3.33E+13	23.6346	5976000.	0.00
84.0000	-3.85E-05	-214665.	427.8685	7.06E-07	13.4587	3.33E+13	19.4135	6048000.	0.00
85.0000	-3.05E-05	-208133.	637.6998	6.30E-07	13.0492	3.33E+13	15.5584	6120000.	0.00
86.0000	-2.34E-05	-199360.	803.4802	5.57E-07	12.4992	3.33E+13	12.0717	6192000.	0.00
87.0000	-1.71E-05	-188849.	929.6076	4.87E-07	11.8402	3.33E+13	8.9496	6264000.	0.00
88.0000	-1.17E-05	-177049.	1020.	4.21E-07	11.1004	3.33E+13	6.1837	6336000.	0.00
89.0000	-7.04E-06	-164359.	1080.	3.59E-07	10.3048	3.33E+13	3.7615	6408000.	0.00
90.0000	-3.09E-06	-151128.	1113.	3.03E-07	9.4752	3.33E+13	1.6670	6480000.	0.00
91.0000	2.16E-07	-137656.	1122.	2.50E-07	8.6305	3.33E+13	-0.1181	6552000.	0.00
92.0000	2.92E-06	-124201.	1112.	2.03E-07	7.7870	3.33E+13	-1.6142	6624000.	0.00
93.0000	5.10E-06	-110979.	1085.	1.61E-07	6.9580	3.33E+13	-2.8431	6696000.	0.00
94.0000	6.79E-06	-98166.	1045.	1.23E-07	6.1546	3.33E+13	-3.8274	6768000.	0.00
95.0000	8.05E-06	-85904.	994.2771	9.01E-08	5.3859	3.33E+13	-4.5901	6840000.	0.00
96.0000	8.95E-06	-74303.	935.8132	6.12E-08	4.6585	3.33E+13	-5.1539	6912000.	0.00
97.0000	9.52E-06	-63444.	871.6408	3.64E-08	3.9777	3.33E+13	-5.5415	6984000.	0.00
98.0000	9.82E-06	-53384.	803.7439	1.53E-08	3.3470	3.33E+13	-5.7746	7056000.	0.00
99.0000	9.89E-06	-44154.	733.8505	-2.25E-09	2.7683	3.33E+13	-5.8743	7128000.	0.00
100.0000	9.77E-06	-35771.	663.4442	-1.66E-08	2.2427	3.33E+13	-5.8601	7200000.	0.00
101.0000	9.49E-06	-28232.	593.7787	-2.82E-08	1.7700	3.33E+13	-5.7508	7272000.	0.00
102.0000	9.09E-06	-21521.	525.8935	-3.71E-08	1.3493	3.33E+13	-5.5634	7344000.	0.00
103.0000	8.60E-06	-15610.	460.6307	-4.38E-08	0.9787	3.33E+13	-5.3137	7416000.	0.00
104.0000	8.04E-06	-10465.	398.6524	-4.85E-08	0.6561	3.33E+13	-5.0160	7488000.	0.00
105.0000	7.43E-06	-6043.	340.4581	-5.15E-08	0.3789	3.33E+13	-4.6831	7560000.	0.00
106.0000	6.80E-06	-2294.	286.4024	-5.30E-08	0.1439	3.33E+13	-4.3262	7632000.	0.00
107.0000	6.16E-06	830.9355	236.7122	-5.33E-08	0.05210	3.33E+13	-3.9555	7704000.	0.00
108.0000	5.52E-06	3387.	191.5036	-5.25E-08	0.2123	3.33E+13	-3.5793	7776000.	0.00
109.0000	4.90E-06	5427.	150.7969	-5.09E-08	0.3403	3.33E+13	-3.2051	7848000.	0.00
110.0000	4.30E-06	7006.	114.5327	-4.87E-08	0.4392	3.33E+13	-2.8389	7920000.	0.00
111.0000	3.73E-06	8176.	82.5849	-4.60E-08	0.5126	3.33E+13	-2.4857	7992000.	0.00
112.0000	3.20E-06	8988.	54.7740	-4.29E-08	0.5635	3.33E+13	-2.1494	8064000.	0.00
113.0000	2.70E-06	9490.	30.8787	-3.95E-08	0.5950	3.33E+13	-1.8331	8136000.	0.00
114.0000	2.25E-06	9729.	10.6466	-3.61E-08	0.6100	3.33E+13	-1.5389	8208000.	0.00
115.0000	1.84E-06	9746.	-6.1966	-3.26E-08	0.6110	3.33E+13	-1.2683	8280000.	0.00
116.0000	1.47E-06	9580.	-19.9387	-2.91E-08	0.6006	3.33E+13	-1.0221	8352000.	0.00
117.0000	1.14E-06	9267.	-30.8742	-2.57E-08	0.5810	3.33E+13	-0.8005	8424000.	0.00
118.0000	8.52E-07	8839.	-39.2973	-2.24E-08	0.5542	3.33E+13	-0.6034	8496000.	0.00
119.0000	6.02E-07	8324.	-45.4977	-1.93E-08	0.5219	3.33E+13	-0.4301	8568000.	0.00
120.0000	3.88E-07	7747.	-49.7561	-1.64E-08	0.4857	3.33E+13	-0.2797	8640000.	0.00
121.0000	2.08E-07	7130.	-52.3403	-1.37E-08	0.4470	3.33E+13	-0.1510	8712000.	0.00
122.0000	5.85E-08	6491.	-53.5035	-1.13E-08	0.4070	3.33E+13	-0.04282	8784000.	0.00
123.0000	-6.30E-08	5846.	-53.4815	-9.07E-09	0.3665	3.33E+13	0.04648	8856000.	0.00
124.0000	-1.59E-07	5208.	-52.4920	-7.08E-09	0.3265	3.33E+13	0.1184	8928000.	0.00
125.0000	-2.33E-07	4586.	-50.7335	-5.31E-09	0.2875	3.33E+13	0.1746	9000000.	0.00
126.0000	-2.87E-07	3990.	-48.3850	-3.77E-09	0.2502	3.33E+13	0.2168	9072000.	0.00
127.0000	-3.23E-07	3425.	-45.6063	-2.43E-09	0.2147	3.33E+13	0.2464	9144000.	0.00
128.0000	-3.45E-07	2895.	-42.5380	-1.29E-09	0.1815	3.33E+13	0.2650	9216000.	0.00
129.0000	-3.54E-07	2404.	-39.3022	-3.39E-10	0.1507	3.33E+13	0.2743	9288000.	0.00
130.0000	-3.53E-07	1952.	-36.0036	4.46E-10	0.1224	3.33E+13	0.2755	9360000.	0.00

131.0000	-3.44E-07	1540.	-32.7299	1.08E-09	0.09655	3.33E+13	0.2701	9432000.	0.00
132.0000	-3.27E-07	1167.	-29.5535	1.56E-09	0.07314	3.33E+13	0.2593	9504000.	0.00
133.0000	-3.06E-07	830.6770	-26.5319	1.92E-09	0.05208	3.33E+13	0.2443	9576000.	0.00
134.0000	-2.81E-07	529.8826	-23.7095	2.17E-09	0.03322	3.33E+13	0.2261	9648000.	0.00
135.0000	-2.54E-07	261.6502	-19.8830	2.31E-09	0.01640	3.33E+13	0.4116	1.94E+07	0.00
136.0000	-2.26E-07	52.6909	-15.2023	2.37E-09	0.00330	3.33E+13	0.3685	1.96E+07	0.00
137.0000	-1.97E-07	-103.2062	-11.0456	2.36E-09	0.00647	3.33E+13	0.3243	1.97E+07	0.00
138.0000	-1.69E-07	-212.4034	-7.4187	2.30E-09	0.01332	3.33E+13	0.2802	1.99E+07	0.00
139.0000	-1.42E-07	-281.2554	-4.3162	2.21E-09	0.01763	3.33E+13	0.2369	2.00E+07	0.00
140.0000	-1.16E-07	-315.9932	-1.7247	2.10E-09	0.01981	3.33E+13	0.1950	2.02E+07	0.00
141.0000	-9.15E-08	-322.6477	0.3745	1.99E-09	0.02023	3.33E+13	0.1548	2.03E+07	0.00
142.0000	-6.83E-08	-307.0061	2.0021	1.88E-09	0.01925	3.33E+13	0.1164	2.04E+07	0.00
143.0000	-4.65E-08	-274.5984	3.1791	1.77E-09	0.01722	3.33E+13	0.07975	2.06E+07	0.00
144.0000	-2.58E-08	-230.7066	3.9252	1.68E-09	0.01446	3.33E+13	0.04460	2.07E+07	0.00
145.0000	-6.14E-09	-180.3929	4.2569	1.61E-09	0.01131	3.33E+13	0.01068	2.09E+07	0.00
146.0000	1.27E-08	-128.5407	4.1870	1.55E-09	0.00806	3.33E+13	-0.02233	2.10E+07	0.00
147.0000	3.11E-08	-79.9047	3.7240	1.51E-09	0.00501	3.33E+13	-0.05483	2.12E+07	0.00
148.0000	4.91E-08	-39.1636	2.8722	1.49E-09	0.00246	3.33E+13	-0.08714	2.13E+07	0.00
149.0000	6.69E-08	-10.9713	1.6318	1.48E-09	6.88E-04	3.33E+13	-0.1196	2.15E+07	0.00
150.0000	8.47E-08	0.00	0.00	1.48E-09	0.00	3.33E+13	-0.1524	1.08E+07	0.00

* This analysis computed pile response using nonlinear moment-curvature relationships. Values of total stress due to combined axial and bending stresses are computed only for elastic sections only and do not equal the actual stresses in concrete and steel. Stresses in concrete and steel may be interpolated from the output for nonlinear bending properties relative to the magnitude of bending moment developed in the pile.

Output Summary for Load Case No. 1:

```
Pile-head deflection             =     0.02202914 inches
Computed slope at pile head      =       0.000000 radians
Maximum bending moment           =      -9718568. inch-lbs
Maximum shear force              =         74407. lbs
Depth of maximum bending moment  =       0.000000 feet below pile head
Depth of maximum shear force     =    16.00000000 feet below pile head
Number of iterations             =              6
Number of zero deflection points =              4
```

Summary of Pile-head Responses for Conventional Analyses

Definitions of Pile-head Loading Conditions:

Load Type 1: Load 1 = Shear, V, lbs, and Load 2 = Moment, M, in-lbs
Load Type 2: Load 1 = Shear, V, lbs, and Load 2 = Slope, S, radians
Load Type 3: Load 1 = Shear, V, lbs, and Load 2 = Rot. Stiffness, R, in-lbs/rad.

Load Type 4: Load 1 = Top Deflection, y, inches, and Load 2 = Moment, M, in-lbs
Load Type 5: Load 1 = Top Deflection, y, inches, and Load 2 = Slope, S, radians

Load Case No.	Load Type 1	Pile-head Load 1	Load Type 2	Pile-head Load 2	Axial Loading lbs	Pile-head Deflection inches	Pile-head Rotation radians	Max Shear in Pile lbs	Max Moment in Pile in-lbs
1	V, lb	0.00	S, rad	0.00	0.00	0.02203	0.00	74407.	-9718568.

Maximum pile-head deflection = 0.0220291353 inches
Maximum pile-head rotation = -0.0000000000 radians = -0.000000 deg.

The analysis ended normally.

Appendix C
Alternative WH1A – Terminal 1 and Terminal 2 Wharves

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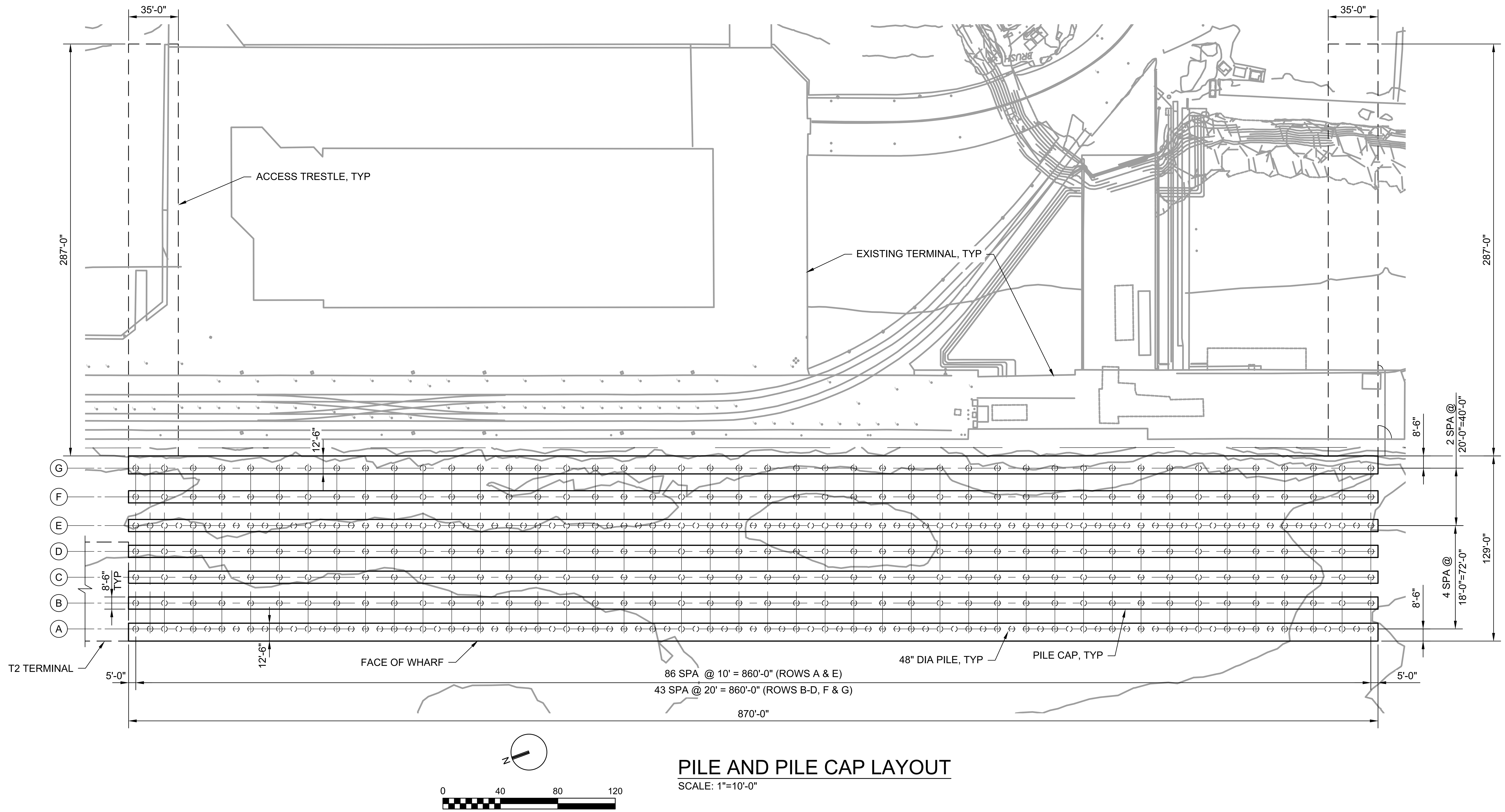

PILE AND PILE CAP LAYOUT

SCALE: 1"=10'-0"

T1 WHARF - ALTERNATIVE WH1A

CONCEPTUAL

VERIFY SCALES

BAR IS ONE INCH ON ORIGINAL DRAWING

0 1"

IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

REV	DATE	DESCRIPTION	BY	APVD

REVISIONS

Jacobs

DSGN	DR	CHK	APVD

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ALTERNATIVE FOUNDATION ANALYSIS

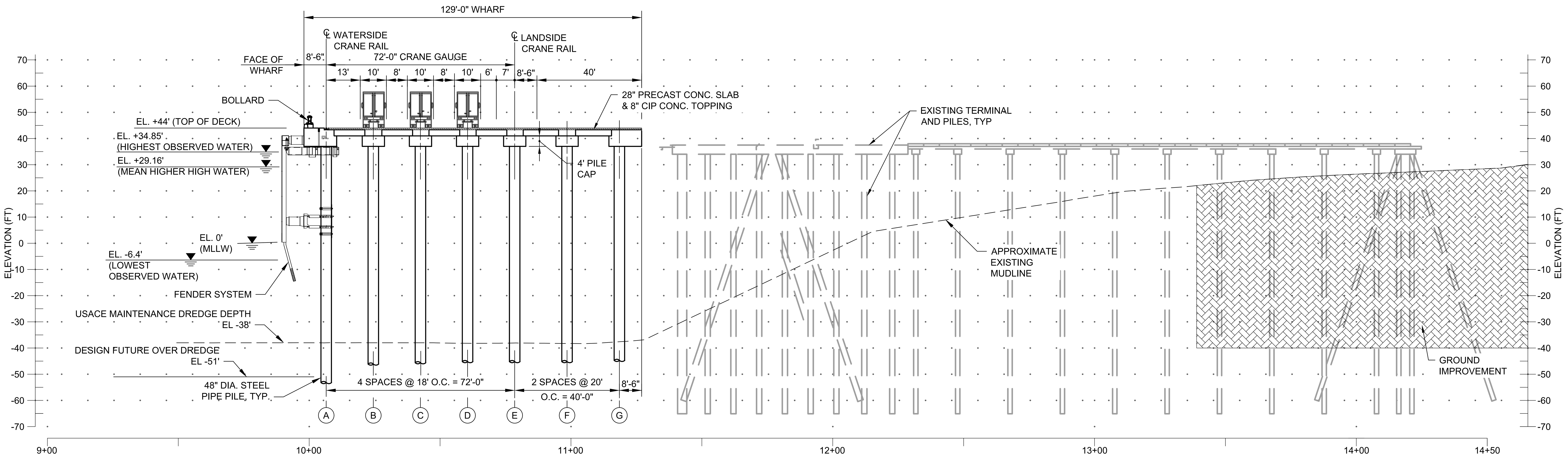
ANCHORAGE, ALASKA

HORIZ SCALE:
VERT SCALE:

DATE:
SHEET: OF

FILE NO.-

Drawing: T1-WHARF-1A_PLAN.DWG
Date: Feb 11, 2022 - 10:26am



TYPICAL SECTION

SCALE: 1"=20'-0"

T1 WHARF - ALTERNATIVE WH1A

CONCEPTUAL

Drawing: T1-WHARF-1A_SECTION.DWG
Date: Feb 14, 2022 - 12:30pm

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

REV	DATE	DESCRIPTION	BY	APVD

REVISIONS

Jacobs

DSGN	DR	CHK	APVD

CONSULTANT

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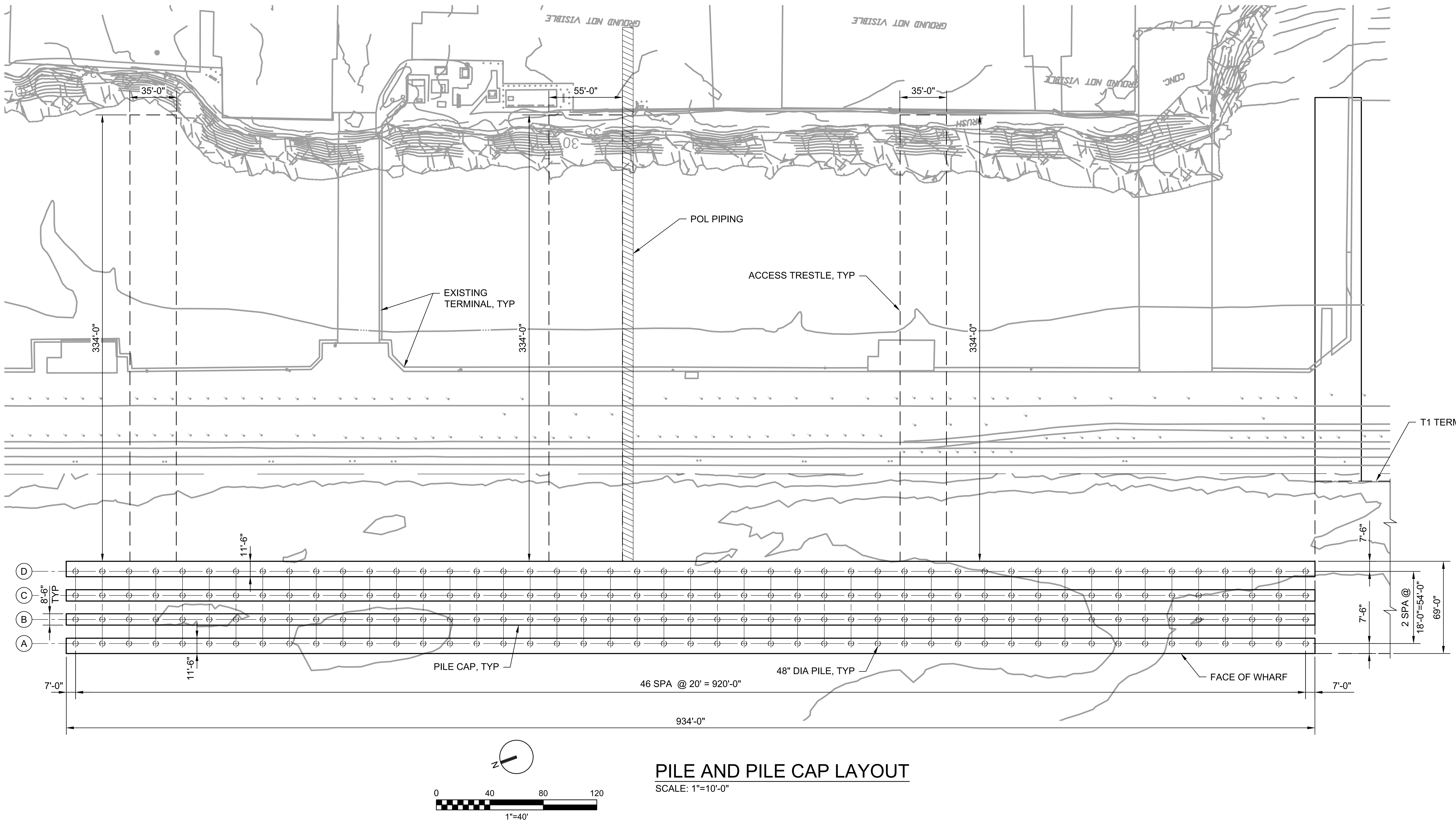
ALTERNATIVE FOUNDATION ANALYSIS
ANCHORAGE, ALASKA

HORIZ SCALE:
VERT SCALE:
DATE:
SHEET: OF

FILE NO.-



PILE AND PILE CAP LAYOUT

SCALE: 1"=10'-0"

T2 WHARF - ALTERNATIVE WH1A

CONCEPTUAL

REV	DATE	DESCRIPTION	BY	APVD
		REVISIONS		

VERIFY SCALES

BAR IS ONE INCH ON ORIGINAL DRAWING

0 1"

IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

Jacobs

DSGN | DR | CHK | APVD

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ANCHORAGE, ALASKA

HORIZ SCALE:
VERT SCALE:

DATE:
SHEET: OF

FILE NO.-

Drawing: T2-WHARF-1A_PLAN.DWG
Date: Feb 11, 2022 - 10:45am

TYPICAL SECTION

SCALE: 1"=20'-0"

T2 WHARF - ALTERNATIVE WH1A

CONCEPTUAL

VERIFY SCALES

BAR IS ONE INCH ON ORIGINAL DRAWING

0 1"

IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

REV	DATE	DESCRIPTION	BY	APVD

REVISIONS

Jacobs

DSGN	DR	CHK	APVD

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ANCHORAGE, ALASKA

HORIZ SCALE:
VERT SCALE:

DATE:
SHEET: OF

FILE NO.-

Drawing: T2-WHARF-1A_SECTION.DWG
Date: Feb 14, 2022 - 12:32pm

Appendix D
Alternative TR1A – Terminal 1 and Terminal 2 Trestles

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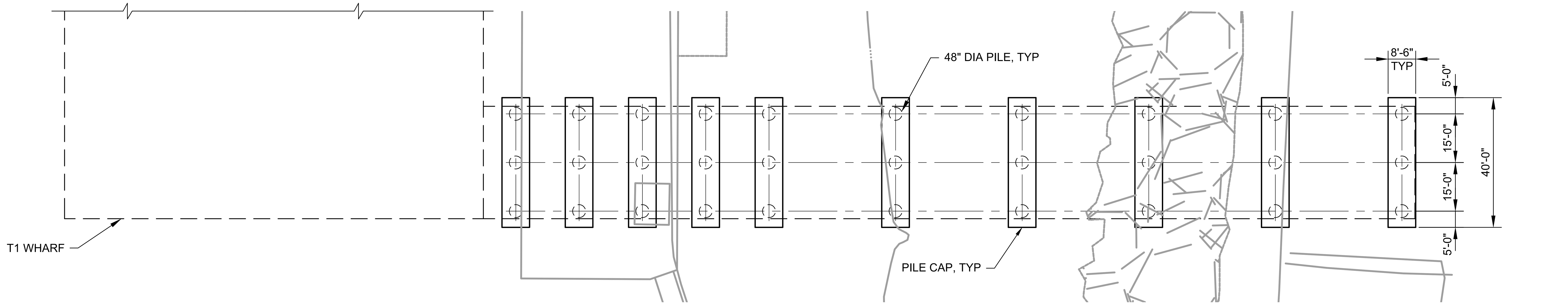
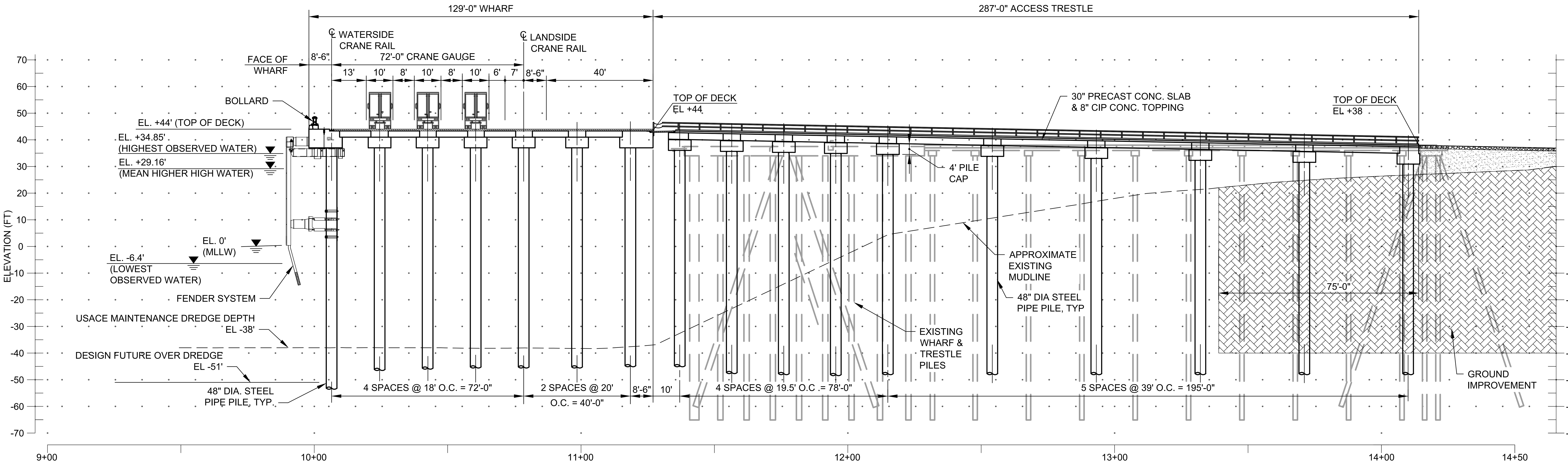


PILE AND PILE CAP LAYOUT
SCALE: 1" = 20'-0"



TYPICAL ELEVATION
SCALE: 1" = 20'-0"

T1 TRESTLE - ALTERNATIVE TR1A

CONCEPTUAL

REV	DATE	DESCRIPTION	BY	APVD

REVISIONS

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

Jacobs

DSGN | DR | CHK | APVD

CONSULTANT

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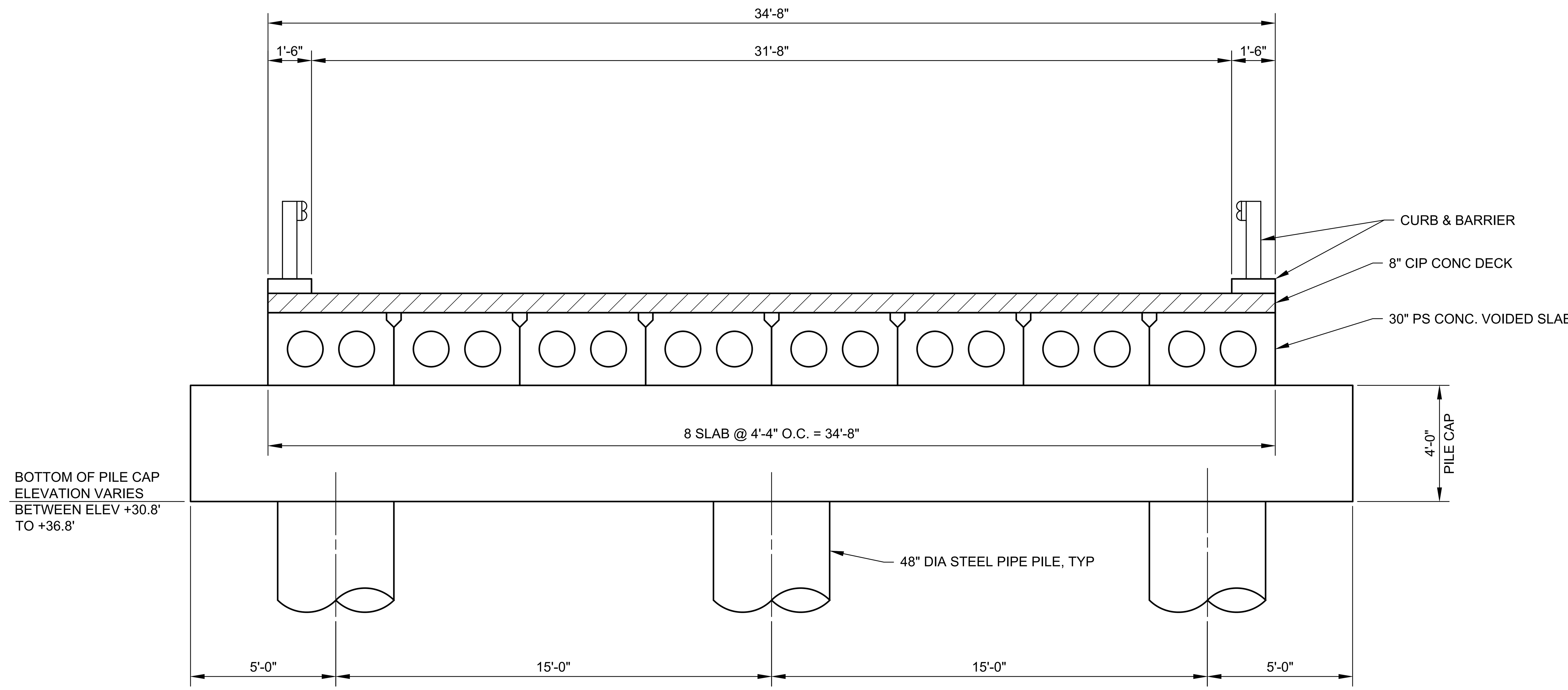
HORIZ SCALE: | DATE:
VERT SCALE: | SHEET: OF

FILE NO.-

Drawing: T1-TRESTLE-TR1A_P&E.DWG
Date: Feb 15, 2022 - 8:56am



TYPICAL SECTION

SCALE: 3/8" = 1'-0"

T1 TRESTLE - ALTERNATIVE TR1A

CONCEPTUAL

REV	DATE	DESCRIPTION	BY	APVD

REVISIONS

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

Jacobs

DSGN | DR | CHK | APVD

CONSULTANT

NOT FOR CONSTRUCTION

SEAL

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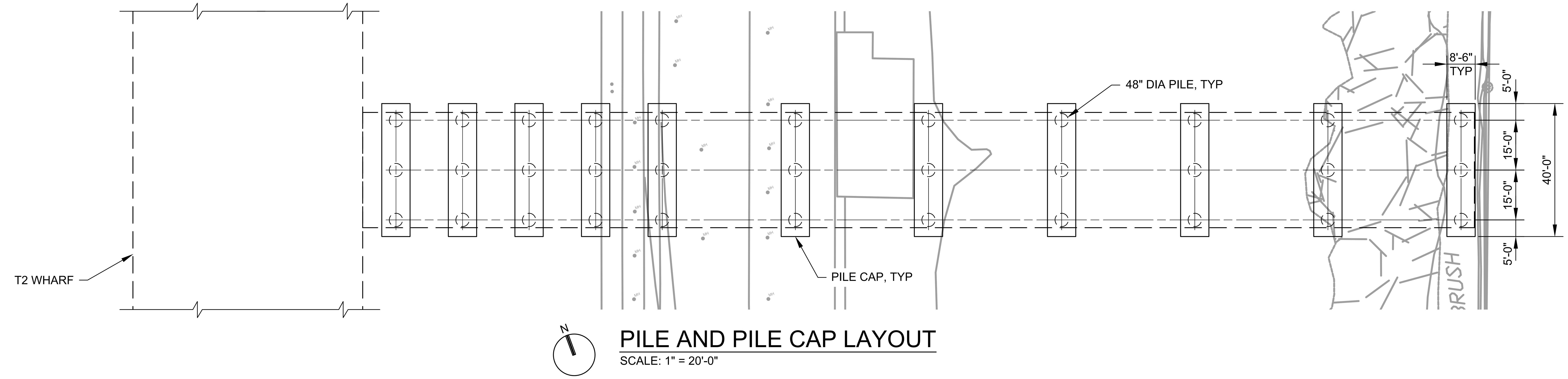
ANCHORAGE, ALASKA

HORIZ SCALE:
VERT SCALE:
DATE:
SHEET: OF

FILE NO.:

Drawing: T1-TRESTLE-TR1A_SECTION.DWG
Date: Feb 11, 2022 - 11:40am



PILE AND PILE CAP LAYOUT
SCALE: 1" = 20'-0"

TYPICAL ELEVATION
SCALE: 1" = 20'-0"

T2 TRESTLE - ALTERNATIVE TR1A

CONCEPTUAL

REV	DATE	DESCRIPTION	BY	APVD

REVISIONS

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

Jacobs

DSGN | DR | CHK | APVD

CONSULTANT

NOT FOR CONSTRUCTION

SEAL

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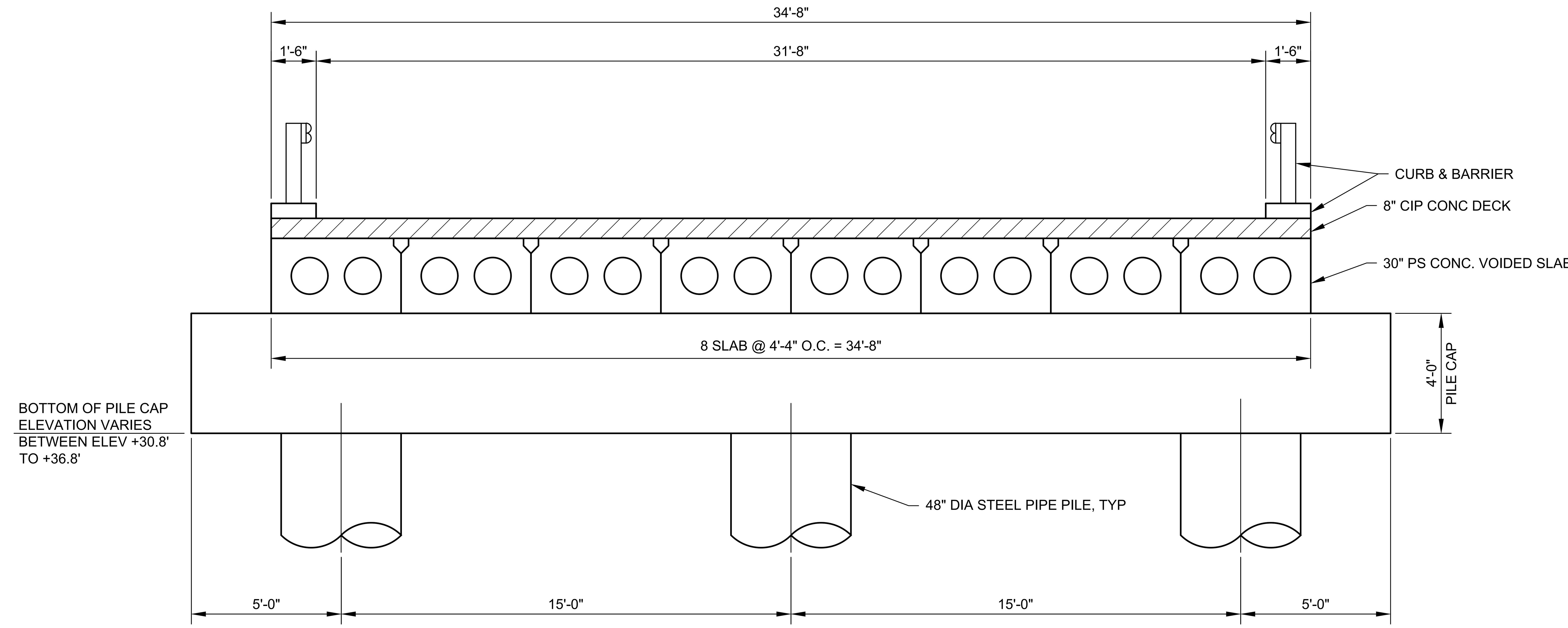
ANCHORAGE, ALASKA

HORIZ SCALE:
VERT SCALE:
DATE:
SHEET: OF

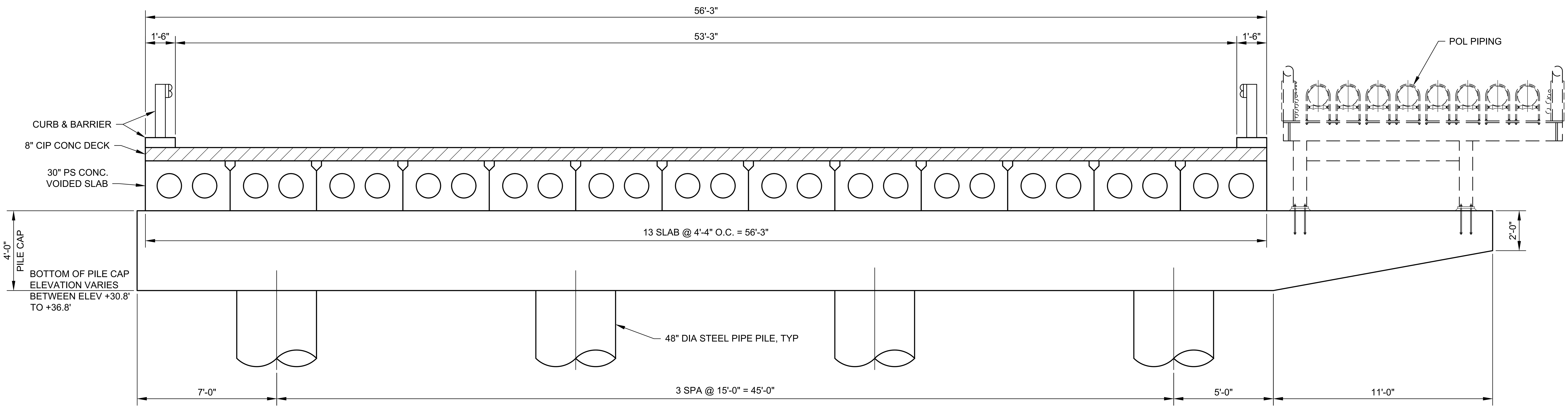
FILE NO.

Drawing: T2-TRESTLE-TR1A_P&E.DWG
Date: Feb 15, 2022 - 9:01am



TYPICAL SECTION

SCALE: 3/8" = 1'-0"



TYPICAL SECTION - TRESTLE WITH POL PIPING

SCALE: 3/8" = 1'-0"

T2 TRESTLE - ALTERNATIVE TR1A

CONCEPTUAL

Drawing: T2-TRESTLE-TR1A_SECTION.DWG
Date: Feb 11, 2022 - 11:38am

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

REV	DATE	DESCRIPTION	BY	APVD

REVISIONS

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PORT of ALASKA

PORT OF ALASKA MODERNIZATION PROGRAM

PORT OF ALASKA

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ALTERNATIVE FOUNDATION ANALYSIS
ANCHORAGE, ALASKA

HORIZ SCALE: | DATE:
VERT SCALE: | SHEET: OF

FILE NO.:

Appendix E
Alternative WH2A – Terminal 1 and Terminal 2 Wharves

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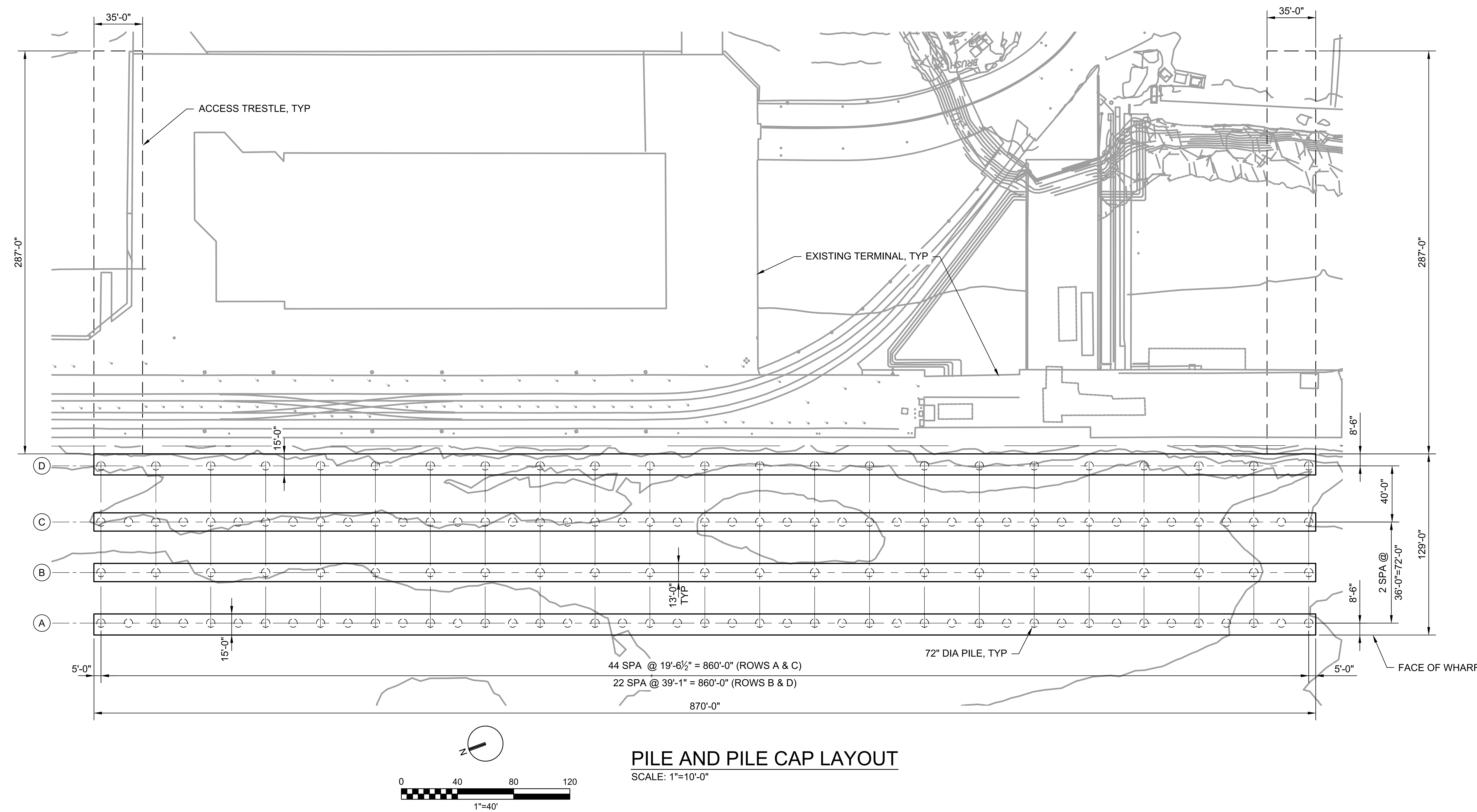

PILE AND PILE CAP LAYOUT

SCALE: 1"=10'-0"

T1 WHARF - ALTERNATIVE WH2A

CONCEPTUAL

VERIFY SCALES

BAR IS ONE INCH ON ORIGINAL DRAWING

0 1"

IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

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REVISIONS

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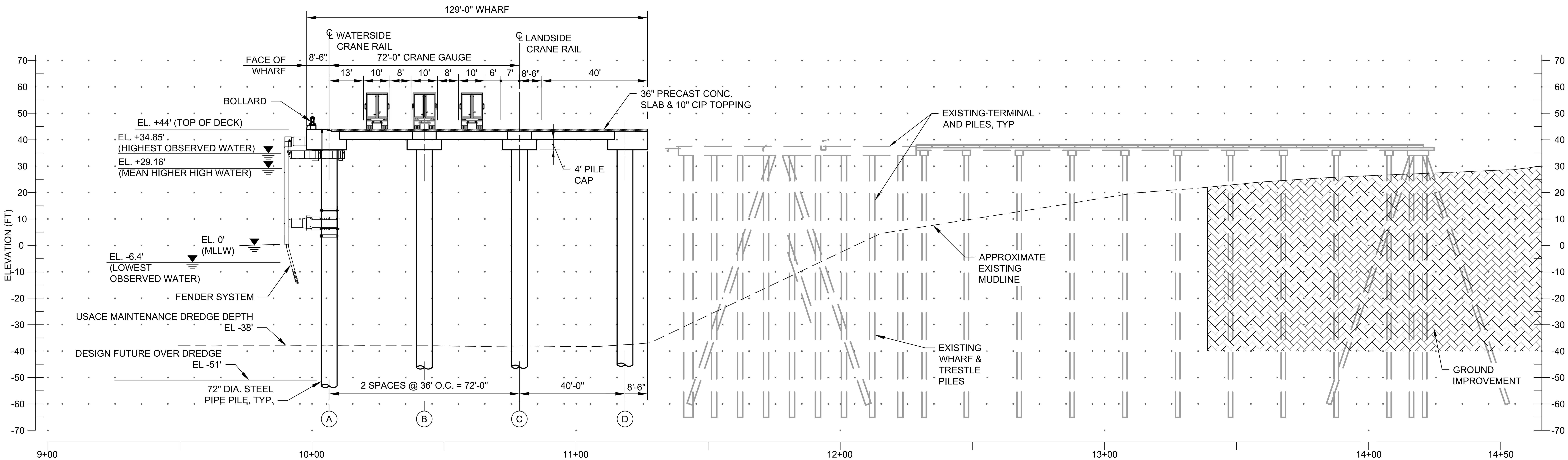
HORIZ SCALE: DATE:
VERT SCALE: SHEET: OF

FILE NO.-

Drawing: T1-WHARF-2A_PLAN.DWG
Date: Jun 02, 2022 - 3:54pm



TYPICAL SECTION

SCALE: 1"=20'-0"

T1 WHARF - ALTERNATIVE WH2A

CONCEPTUAL

REV	DATE	DESCRIPTION	BY	APVD
		REVISIONS		

VERIFY SCALES

BAR IS ONE INCH ON ORIGINAL DRAWING

0 1"

IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

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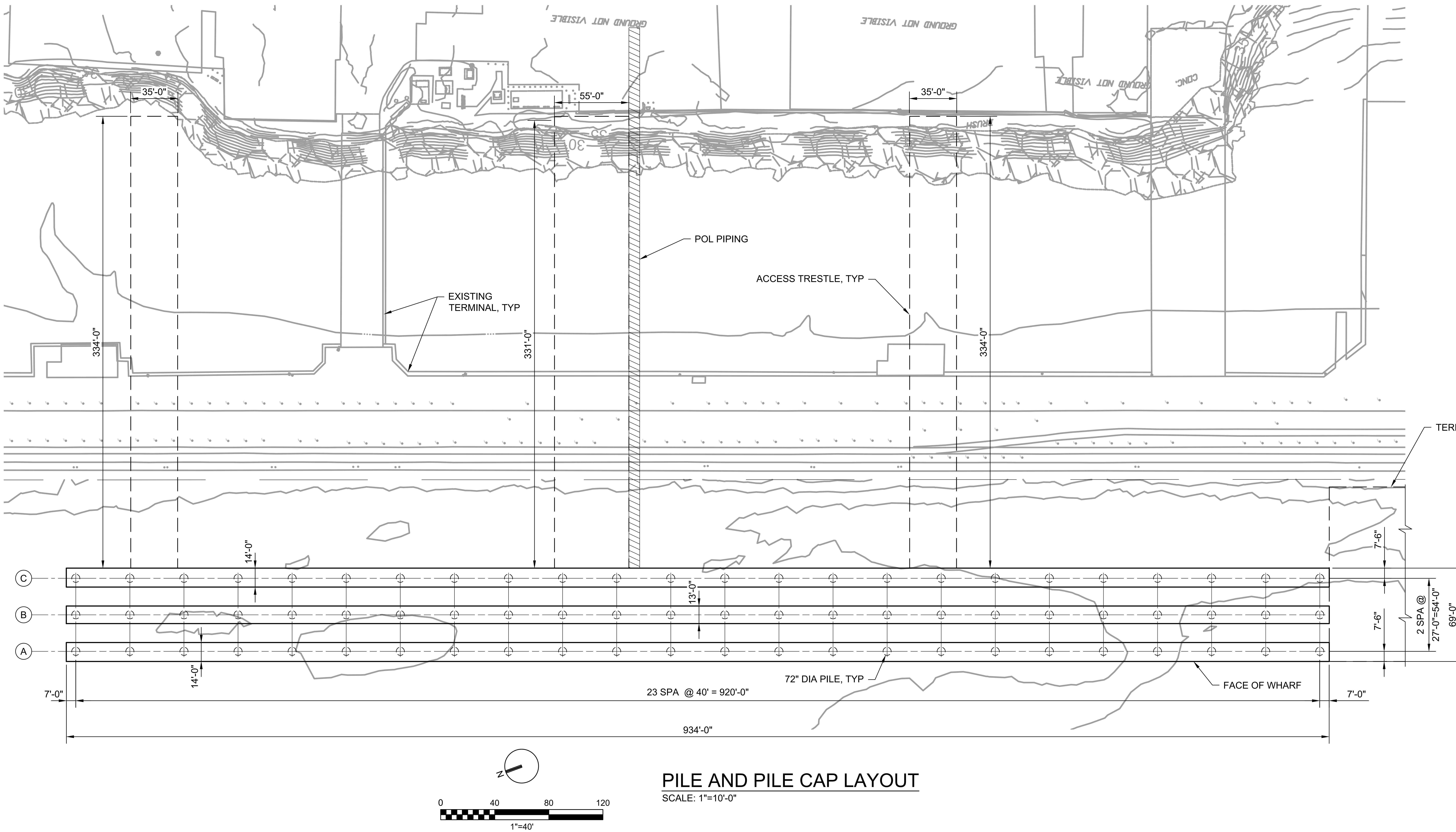
HORIZ SCALE:
VERT SCALE:
DATE:
SHEET: OF

FILE NO.:

Drawing: T1-WHARF-2A_SECTION.DWG
Date: Jun 02, 2022 - 3:55pm



PILE AND PILE CAP LAYOUT

SCALE: 1"=10'-0"

T2 WHARF - ALTERNATIVE WH2A

CONCEPTUAL

VERIFY SCALES	REV	DATE	DESCRIPTION	BY	APVD
BAR IS ONE INCH ON ORIGINAL DRAWING 0 1" IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.					

REVISIONS

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HORIZ SCALE:
VERT SCALE:
DATE:
SHEET: OF

FILE NO -

Drawing: T2-WHARF-2A_PLAN.DWG
Date: Jun 02, 2022 - 3:58pm

TYPICAL SECTION

SCALE: 1"=20'-0"

T2 WHARF - ALTERNATIVE WH2A

CONCEPTUAL

REV	DATE	DESCRIPTION	BY	APVD

REVISIONS

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
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HORIZ SCALE: DATE:
VERT SCALE: SHEET: OF

FILE NO.-

Drawing: T2-WHARF-2A_SECTION.DWG
Date: Jun 02, 2022 - 3:56pm

Appendix F
Alternative TR2A – Terminal 1 and Terminal 2 Trestles

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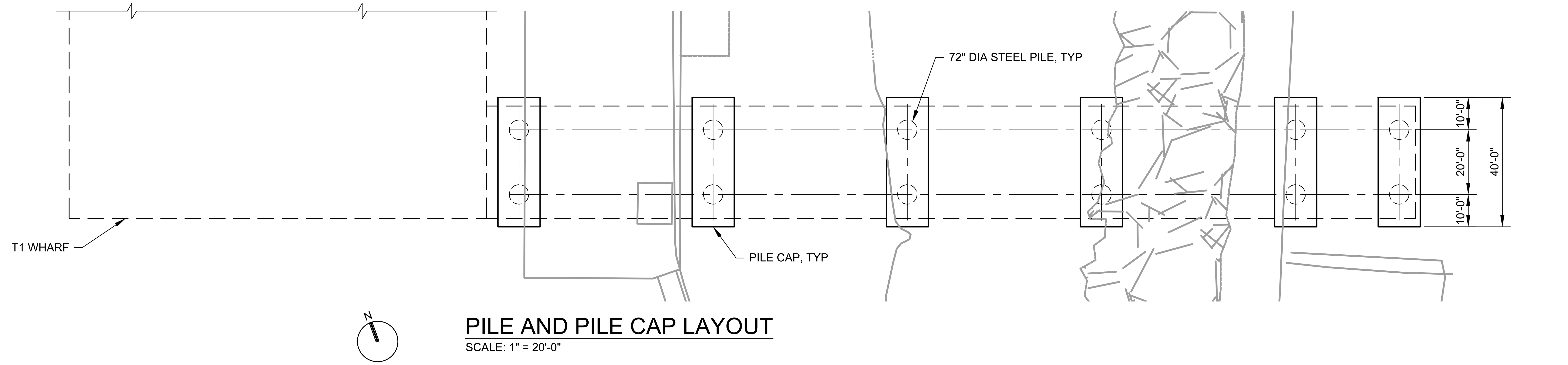
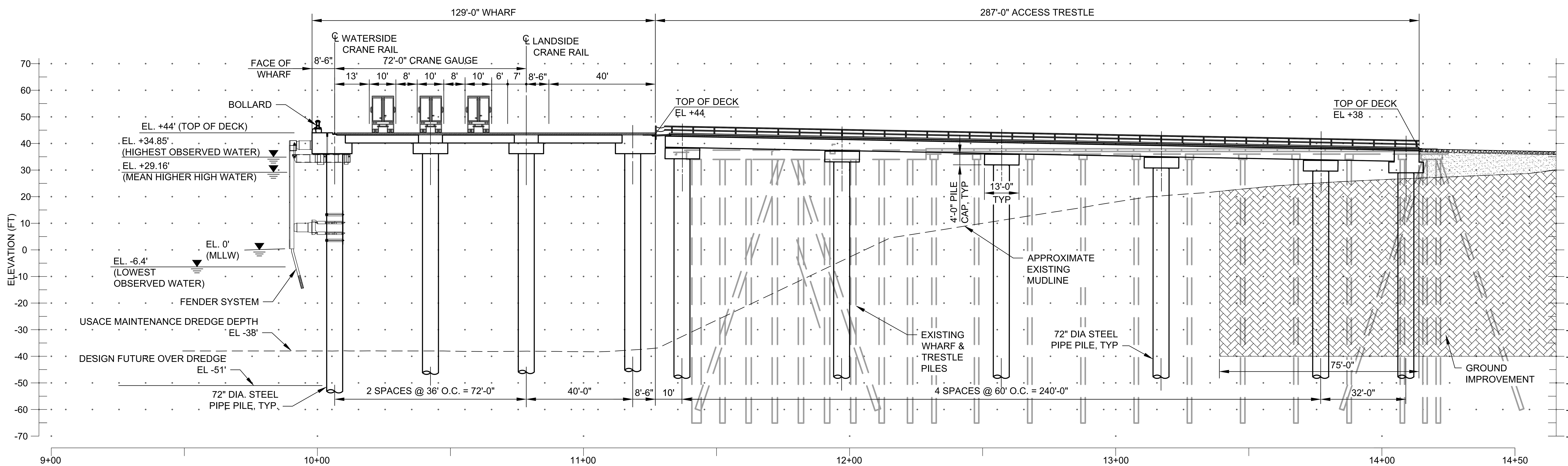


PILE AND PILE CAP LAYOUT

SCALE: 1" = 20'-0"



TYPICAL ELEVATION

SCALE: 1" = 20'-0"

T1 TRESTLE - ALTERNATIVE TR2A

CONCEPTUAL

Drawing: T1-TRESTLE-TR2A_P&E.DWG
Date: Jun 02, 2022 - 3:49pm

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
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REV	DATE	DESCRIPTION	BY	APVD

REVISIONS

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HORIZ SCALE:
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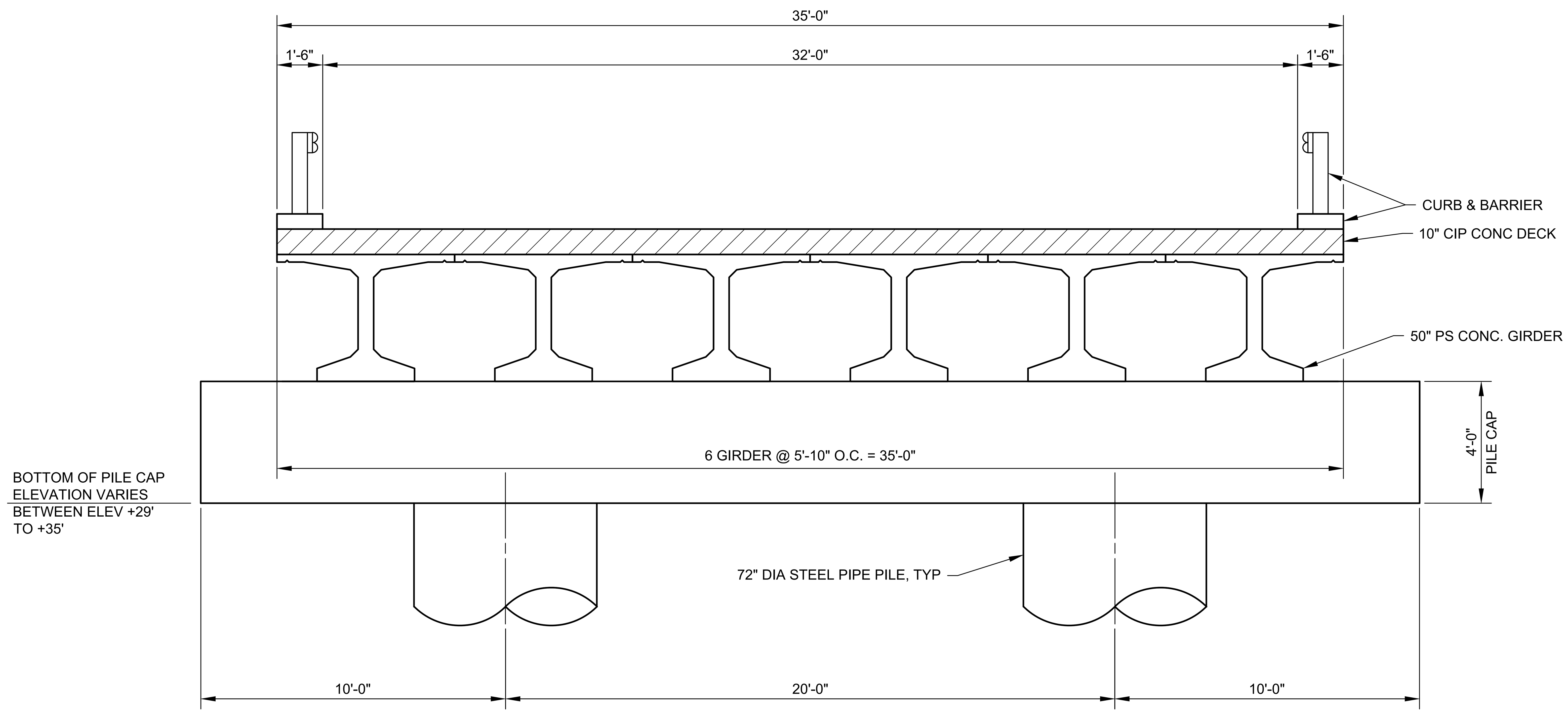
SHEET: OF

FILE NO.:



TYPICAL TRESTLE SECTION

SCALE: 3/8" = 1'-0"

T1 TRESTLE - ALTERNATIVE TR2A

CONCEPTUAL

Drawing: T1-TRESTLE-TR2A_SECTION.DWG
Date: Jun 02, 2022 - 3:51pm

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

REV	DATE	DESCRIPTION	BY	APVD

REVISIONS

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VERT SCALE:
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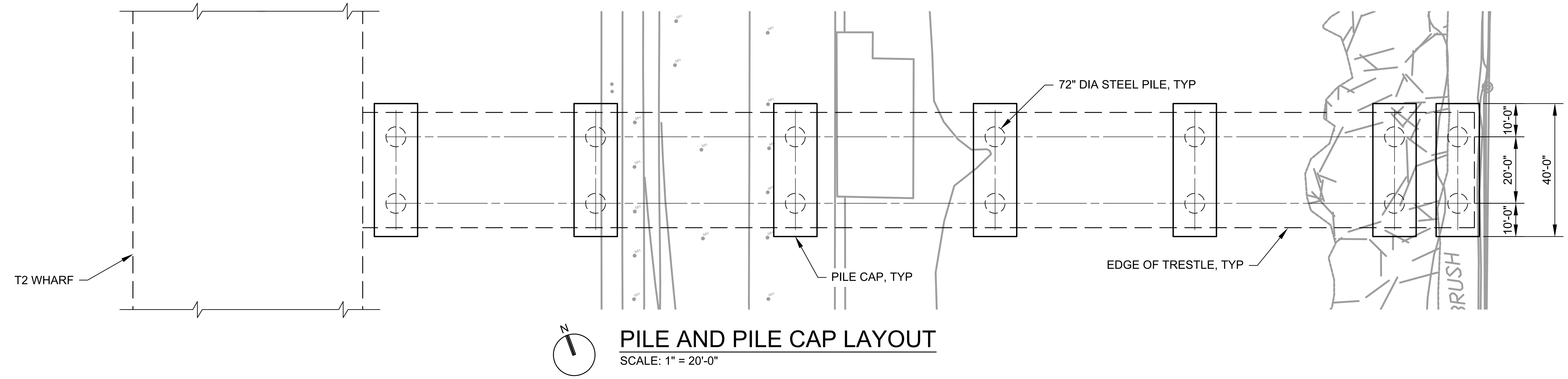
SHEET: OF

FILE NO.



PILE AND PILE CAP LAYOUT

SCALE: 1" = 20'-0"

TYPICAL ELEVATION

SCALE: 1" = 20'-0"

T2 TRESTLE - ALTERNATIVE TR2A

CONCEPTUAL

REV	DATE	DESCRIPTION	BY	APVD
		REVISIONS		

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
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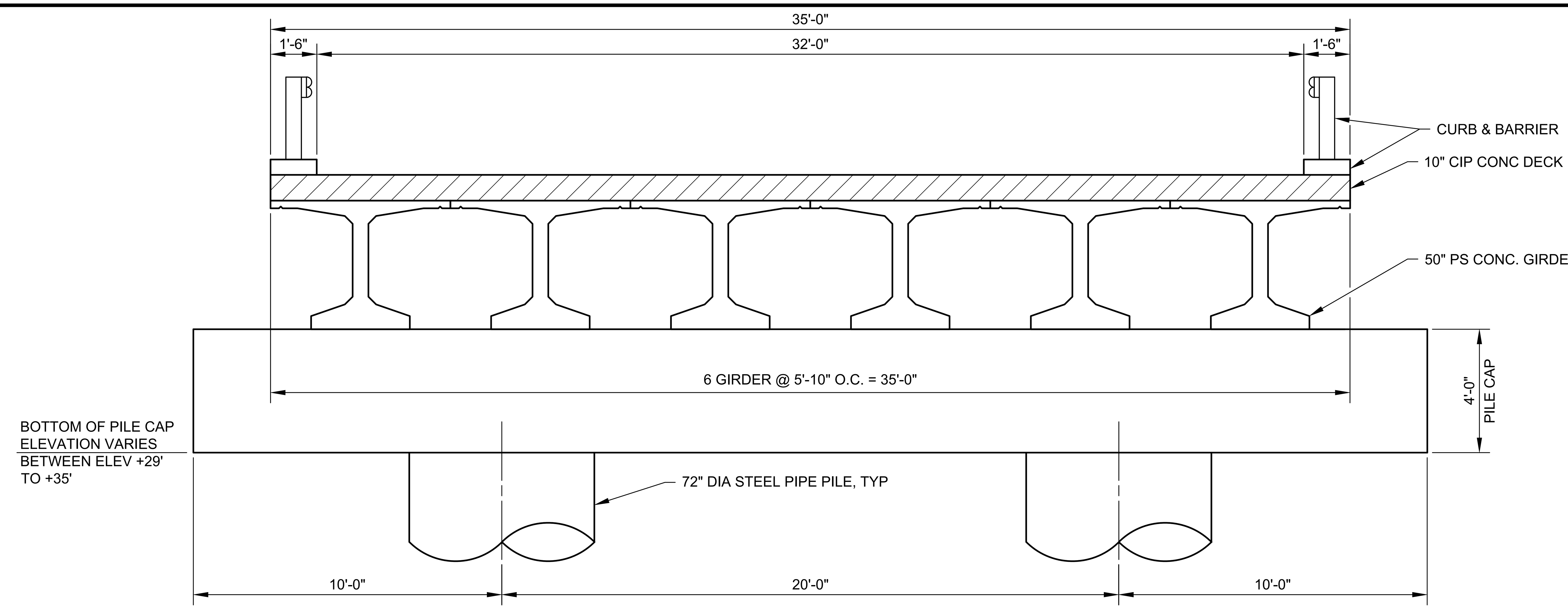
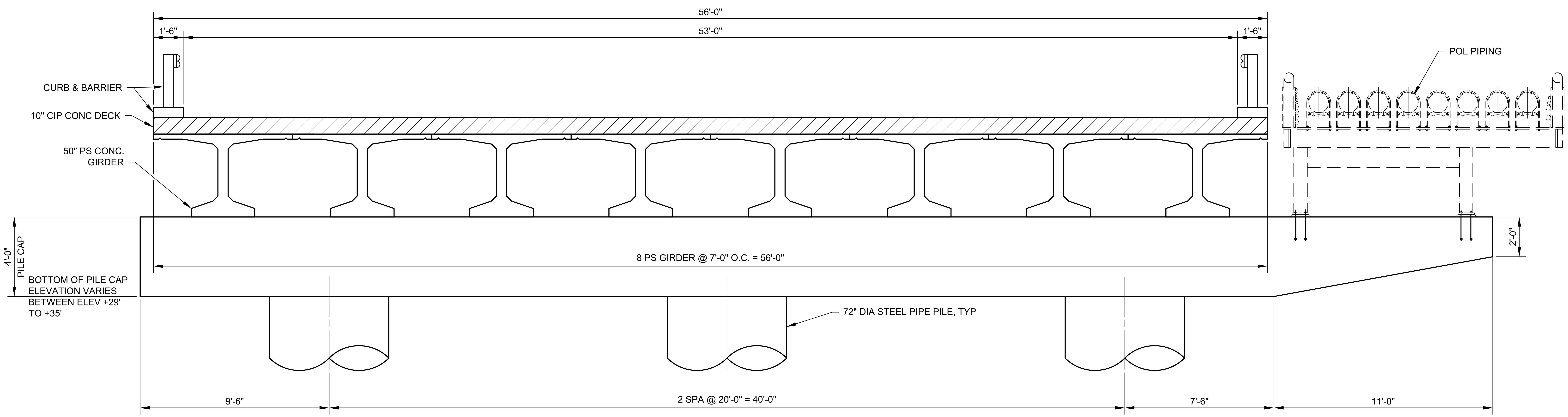
VERT SCALE:
DATE:
SHEET: OF

FILE NO.-

Drawing: T2-TRESTLE-TR2A_P&E.DWG
Date: Jun 02, 2022 - 1:37pm



TYPICAL SECTION
SCALE: 3/8" = 1'-0"



TYPICAL SECTION - TRESTLE WITH POL PIPING
SCALE: 3/8" = 1'-0"

T2 TRESTLE - ALTERNATIVE TR2A

CONCEPTUAL

REV	DATE	DESCRIPTION	BY	APVD

REVISIONS

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

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HORIZ SCALE:
VERT SCALE:
DATE:
SHEET: OF

FILE NO.-

Drawing: T2-TRESTLE-TR2A_SECTION.DWG
Date: Jun 02, 2022 - 1:42pm

Appendix G
Alternative WH2B – Terminal 1 and Terminal 2 Wharves

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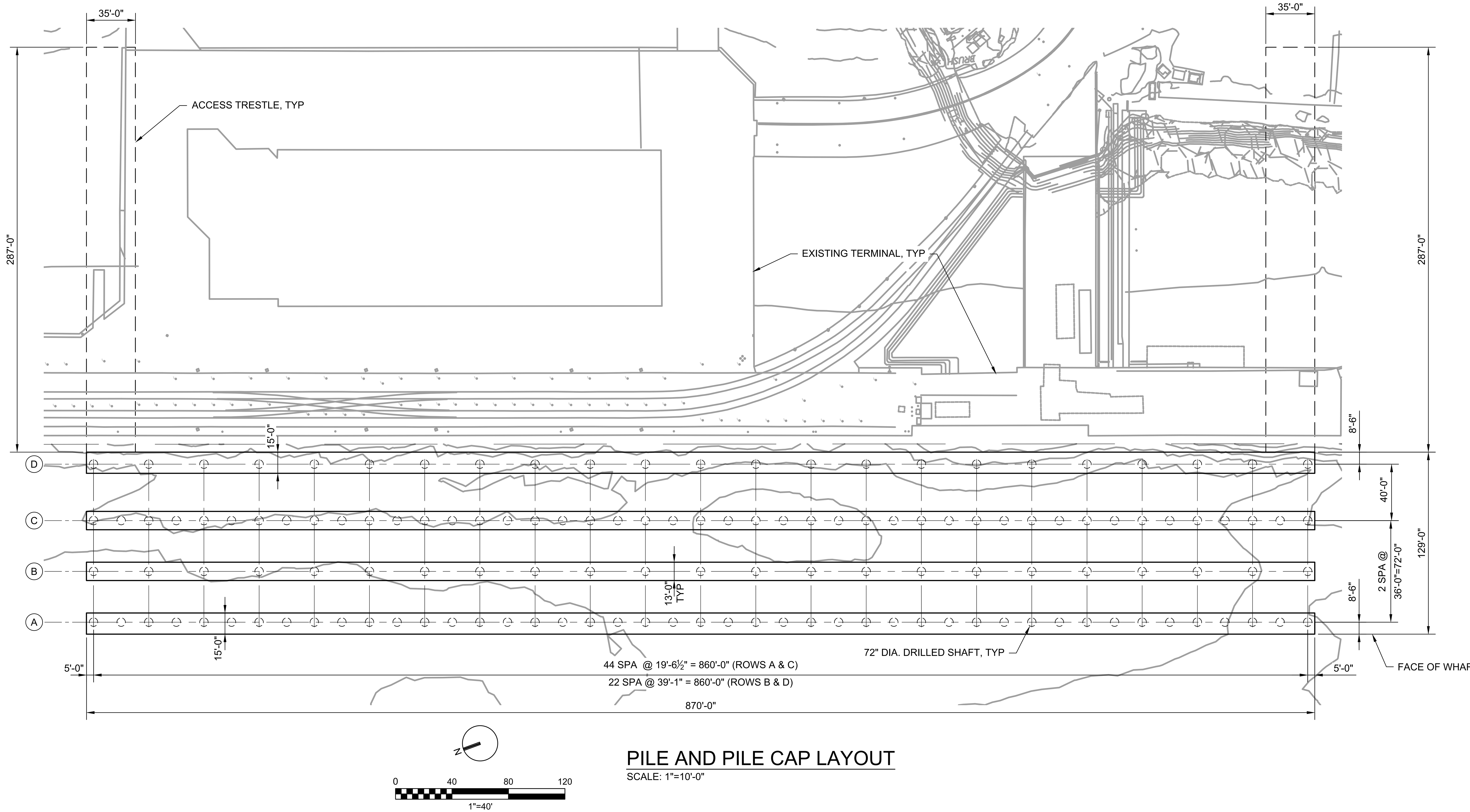

PILE AND PILE CAP LAYOUT

SCALE: 1"=10'-0"

T1 WHARF - ALTERNATIVE WH2B

CONCEPTUAL

VERIFY SCALES

BAR IS ONE INCH ON ORIGINAL DRAWING

0 1"

IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

REV	DATE	DESCRIPTION	BY	APVD

REVISIONS

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HORIZ SCALE:	DATE:
VERT SCALE:	SHEET: OF

FILE NO.-

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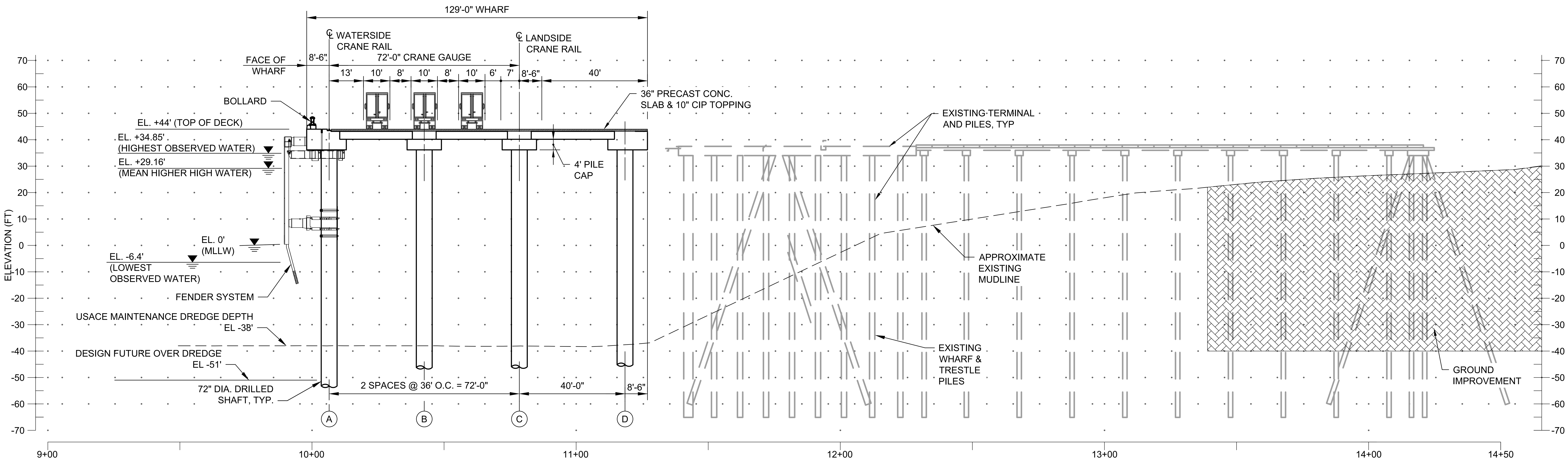

TYPICAL SECTION

SCALE: 1"=20'-0"

T1 WHARF - ALTERNATIVE WH2B

CONCEPTUAL

REV	DATE	DESCRIPTION	BY	APVD

REVISIONS

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

Jacobs

DSGN | DR | CHK | APVD

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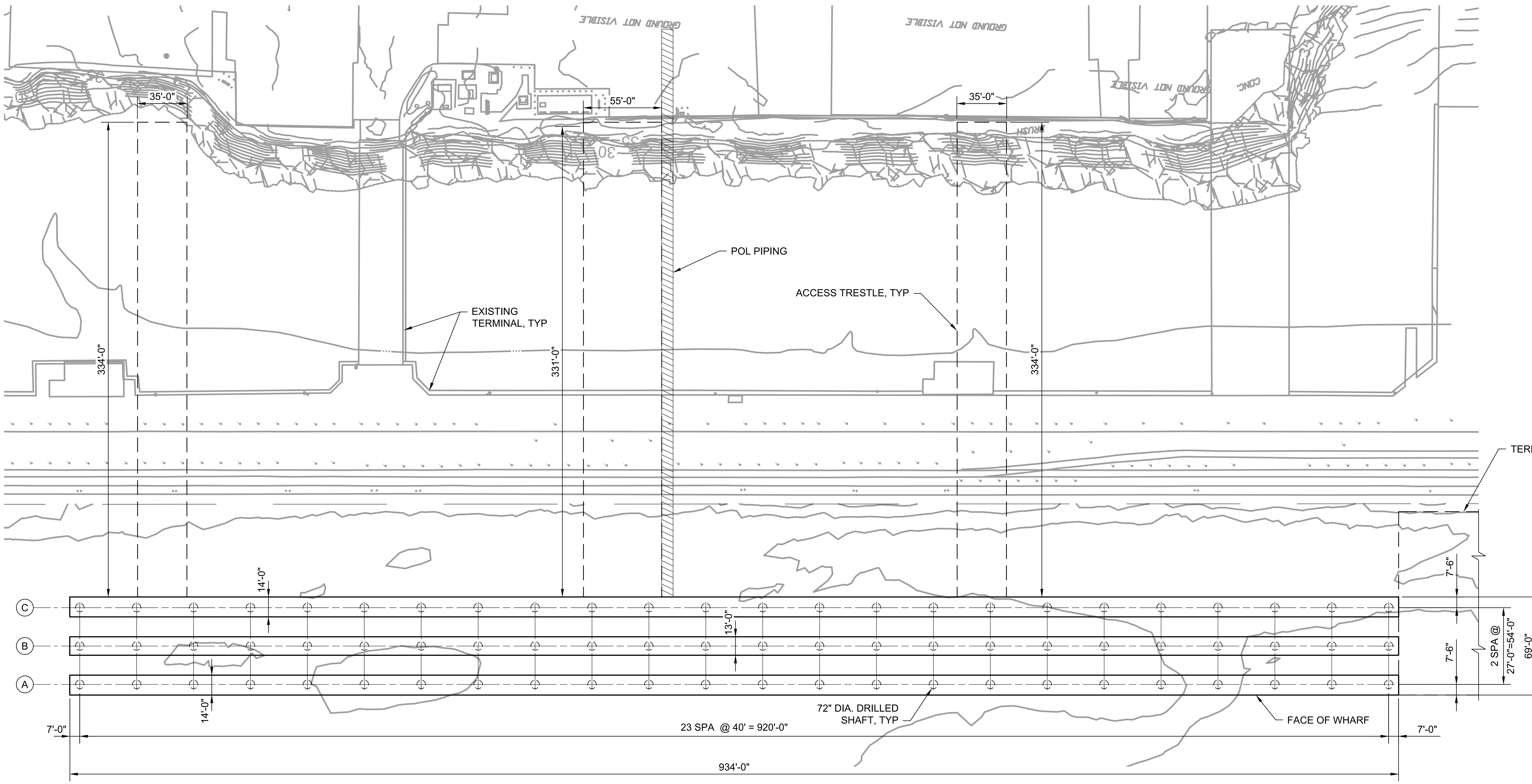
HORIZ SCALE: | DATE:
VERT SCALE: | SHEET: OF

FILE NO.-

Drawing: T1-WHARF-2B_SECTION.DWG
Date: Jun 02, 2022 - 11:55am



N

0 40 80 120

1"=40'

PILE AND PILE CAP LAYOUT

SCALE: 1"=10'-0"

T2 WHARF - ALTERNATIVE WH2B

CONCEPTUAL

REV	DATE	DESCRIPTION	BY	APVD
		REVISIONS		

VERIFY SCALES

BAR IS ONE INCH ON ORIGINAL DRAWING

0 1"

IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

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ALTERNATIVE FOUNDATION ANALYSIS

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HORIZ SCALE:
VERT SCALE:

DATE:
SHEET: OF

FILE NO.:

Drawing: T2-WHARF-2B_PLAN.DWG
Date: Jun 02, 2022 - 10:11am

TYPICAL SECTION

SCALE: 1"=20'-0"

T2 WHARF - ALTERNATIVE WH2B

CONCEPTUAL

VERIFY SCALES

BAR IS ONE INCH ON ORIGINAL DRAWING

0 1"

IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

REV	DATE	DESCRIPTION	BY	APVD

REVISIONS

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ALTERNATIVE FOUNDATION ANALYSIS

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HORIZ SCALE: DATE:
VERT SCALE: SHEET: OF

FILE NO.-

Drawing: T2-WHARF-2B_SECTION.DWG
Date: Jun 02, 2022 - 12:02pm

Appendix H
Alternative TR2B – Terminal 1 and Terminal 2 Trestles

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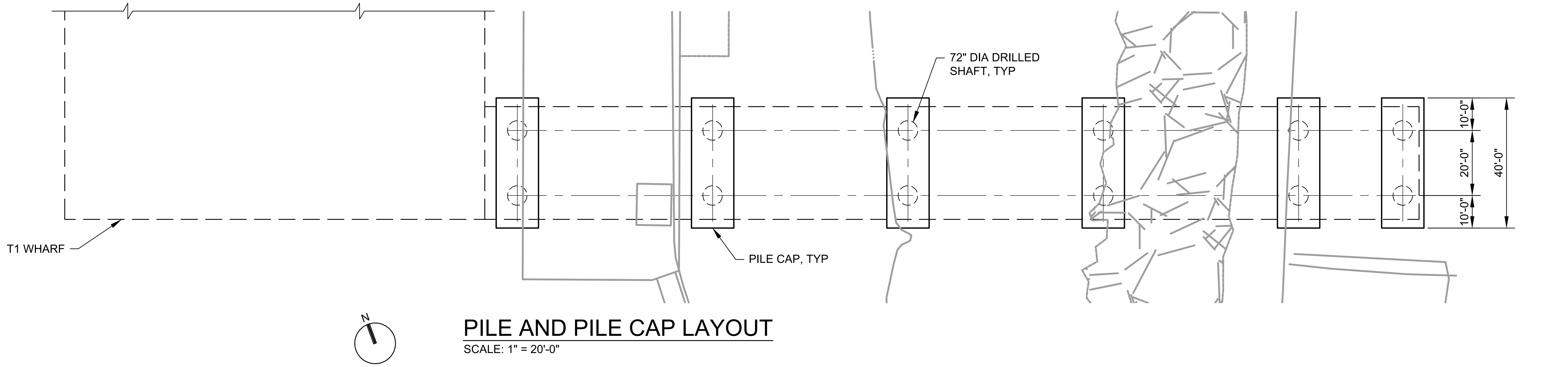
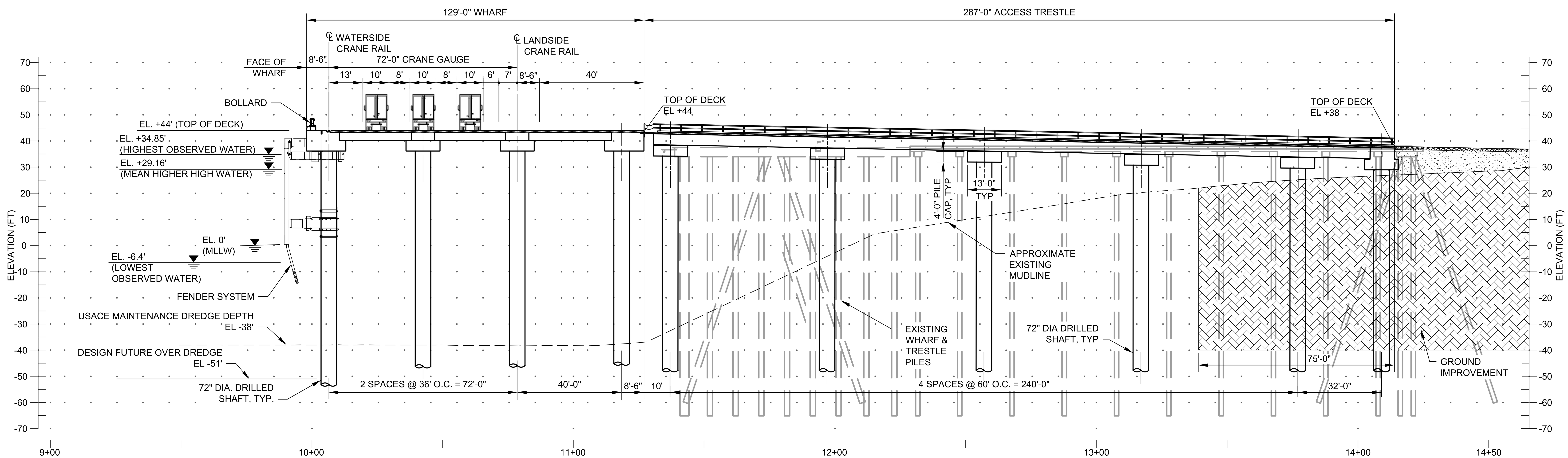


PILE AND PILE CAP LAYOUT

SCALE: 1" = 20'-0"



TYPICAL ELEVATION

SCALE: 1" = 20'-0"

T1 TRESTLE - ALTERNATIVE TR2B

CONCEPTUAL

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

REV	DATE	DESCRIPTION	BY	APVD
		REVISIONS		

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ANCHORAGE, ALASKA

HORIZ SCALE:
VERT SCALE:
DATE:
SHEET: OF

FILE NO -

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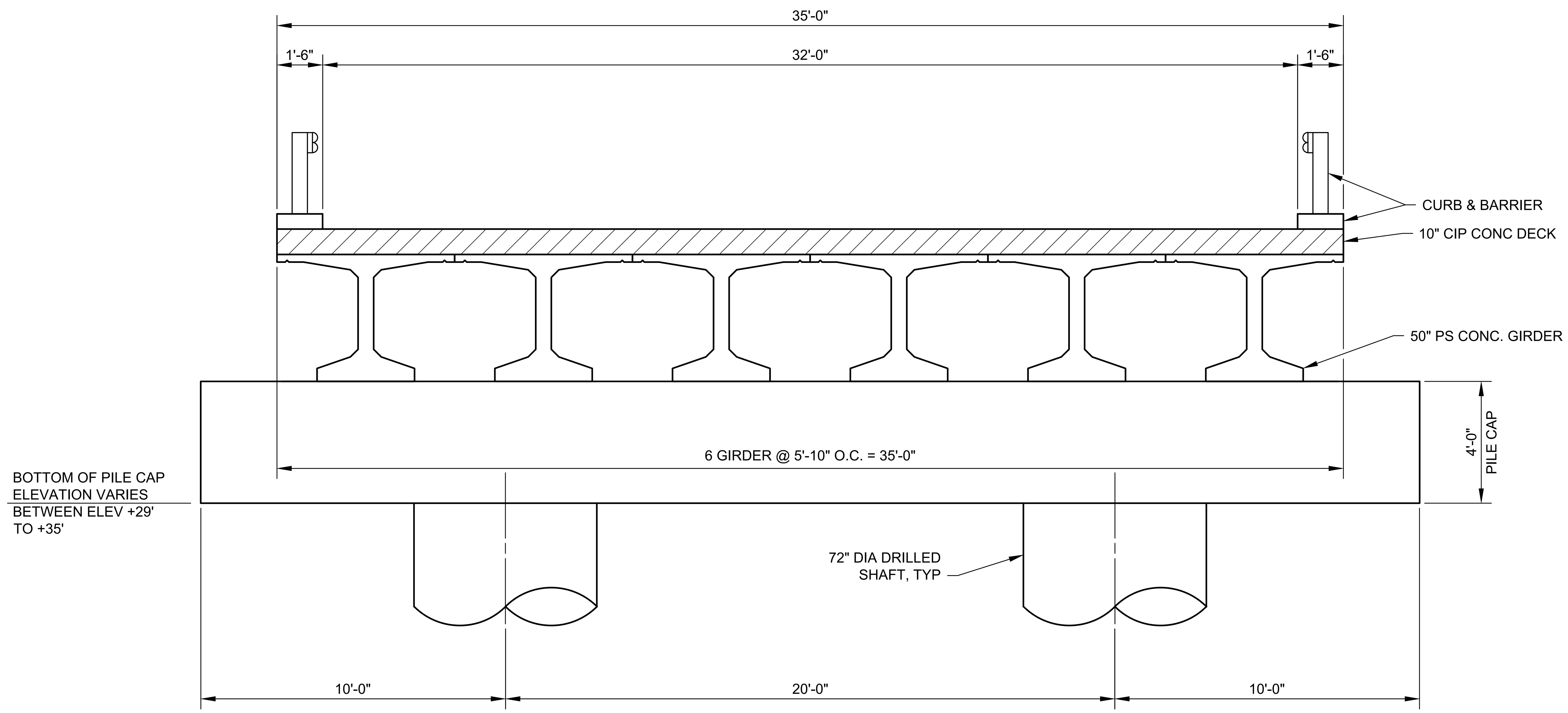

TYPICAL TRESTLE SECTION

SCALE: 3/8" = 1'-0"

T1 TRESTLE - ALTERNATIVE TR2B

CONCEPTUAL

REV	DATE	DESCRIPTION	BY	APVD

REVISIONS

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

Jacobs

DSGN DR CHK APVD

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HORIZ SCALE:
VERT SCALE:
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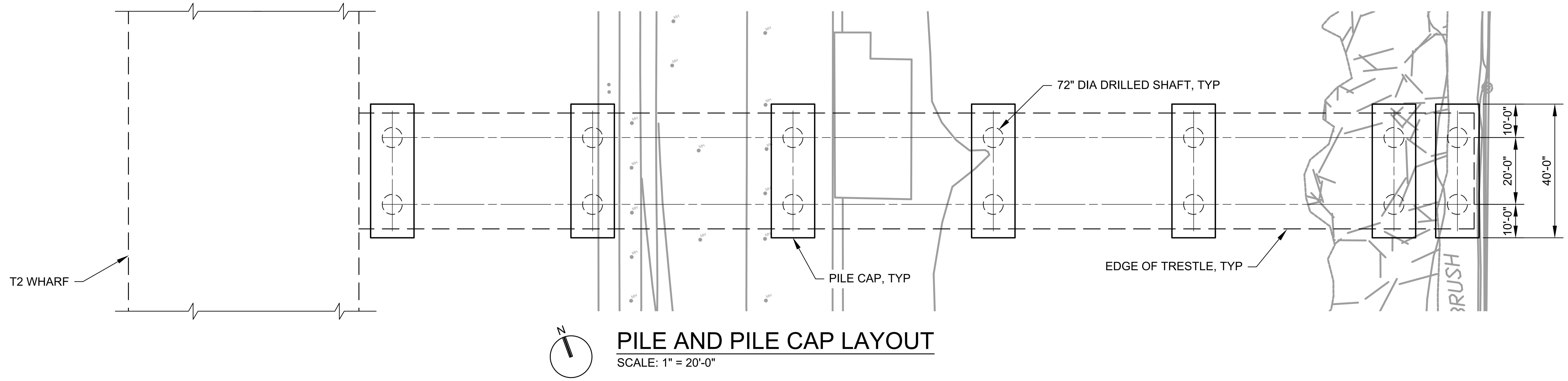
FILE NO -



PILE AND PILE CAP LAYOUT
SCALE: 1" = 20'-0"

TYPICAL ELEVATION
SCALE: 1" = 20'-0"

T2 TRESTLE - ALTERNATIVE TR2B

CONCEPTUAL

REV	DATE	DESCRIPTION	BY	APVD

REVISIONS

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

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HORIZ SCALE:
VERT SCALE:
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FILE NO.:

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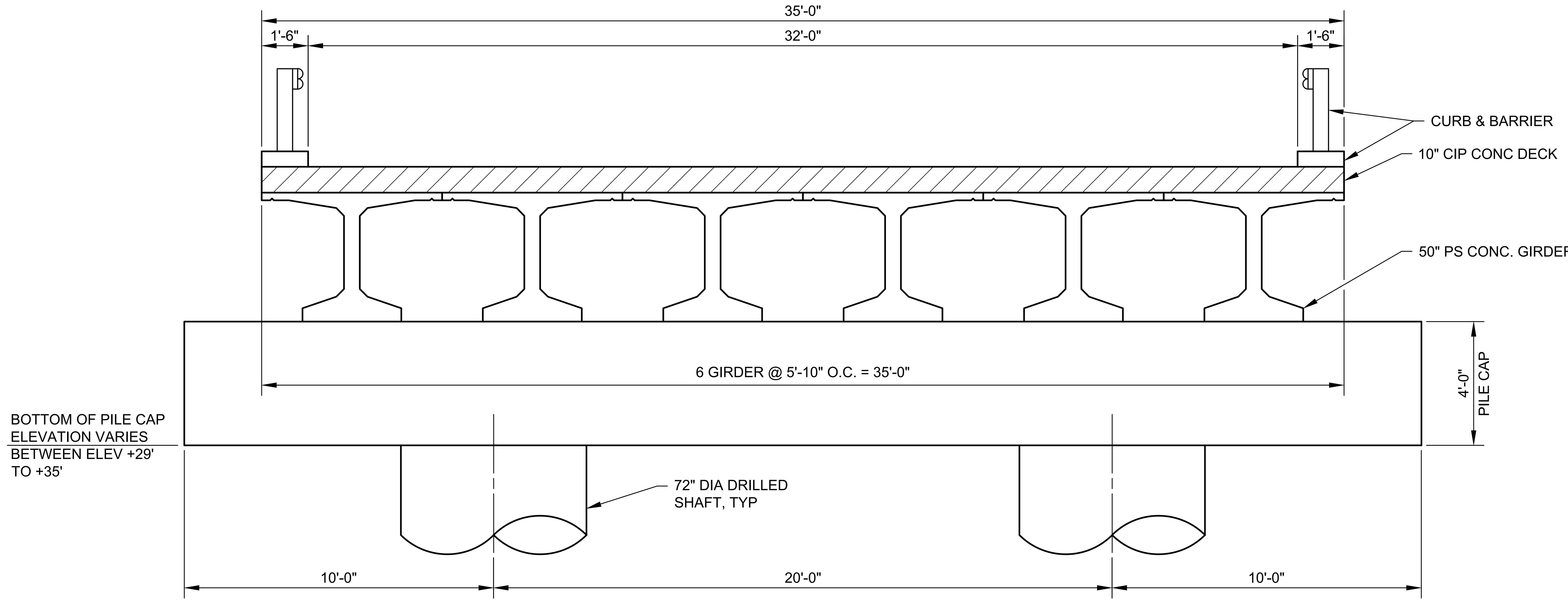
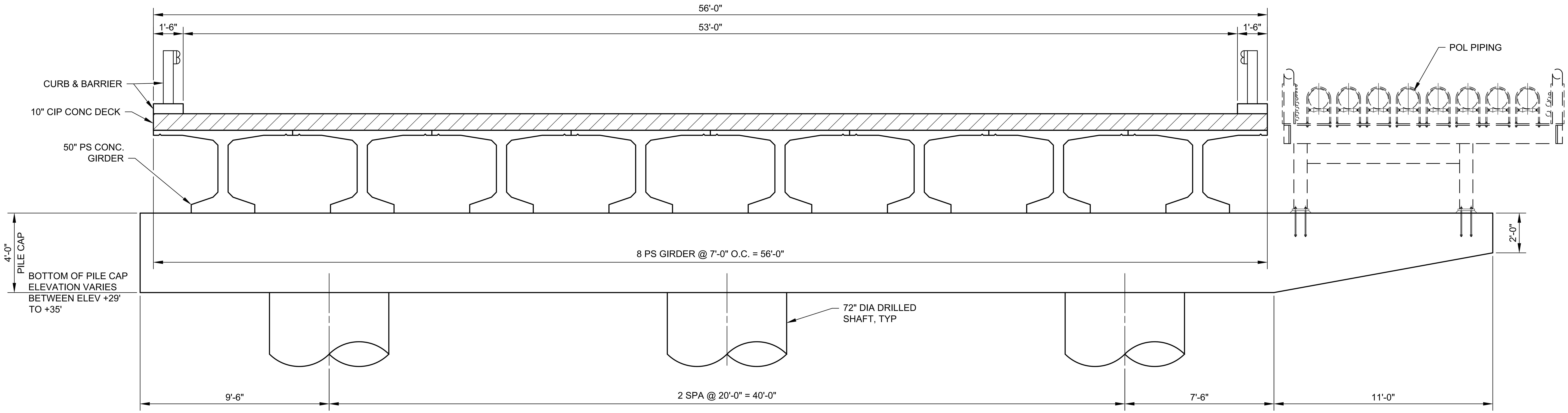
Date: Jun 02, 2022 - 12:36pm



TYPICAL SECTION

SCALE: 3/8" = 1'-0"



TYPICAL SECTION - TRESTLE WITH POL PIPING

SCALE: 3/8" = 1'-0"

T2 TRESTLE - ALTERNATIVE TR2B

CONCEPTUAL

REV	DATE	DESCRIPTION	BY	APVD

REVISIONS

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

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Drawing: T2-TRESTLE-TR2B_SECTION.DWG
Date: Jun 02, 2022 - 12:17pm

Appendix I
Terminal 1 Jacket Sketches

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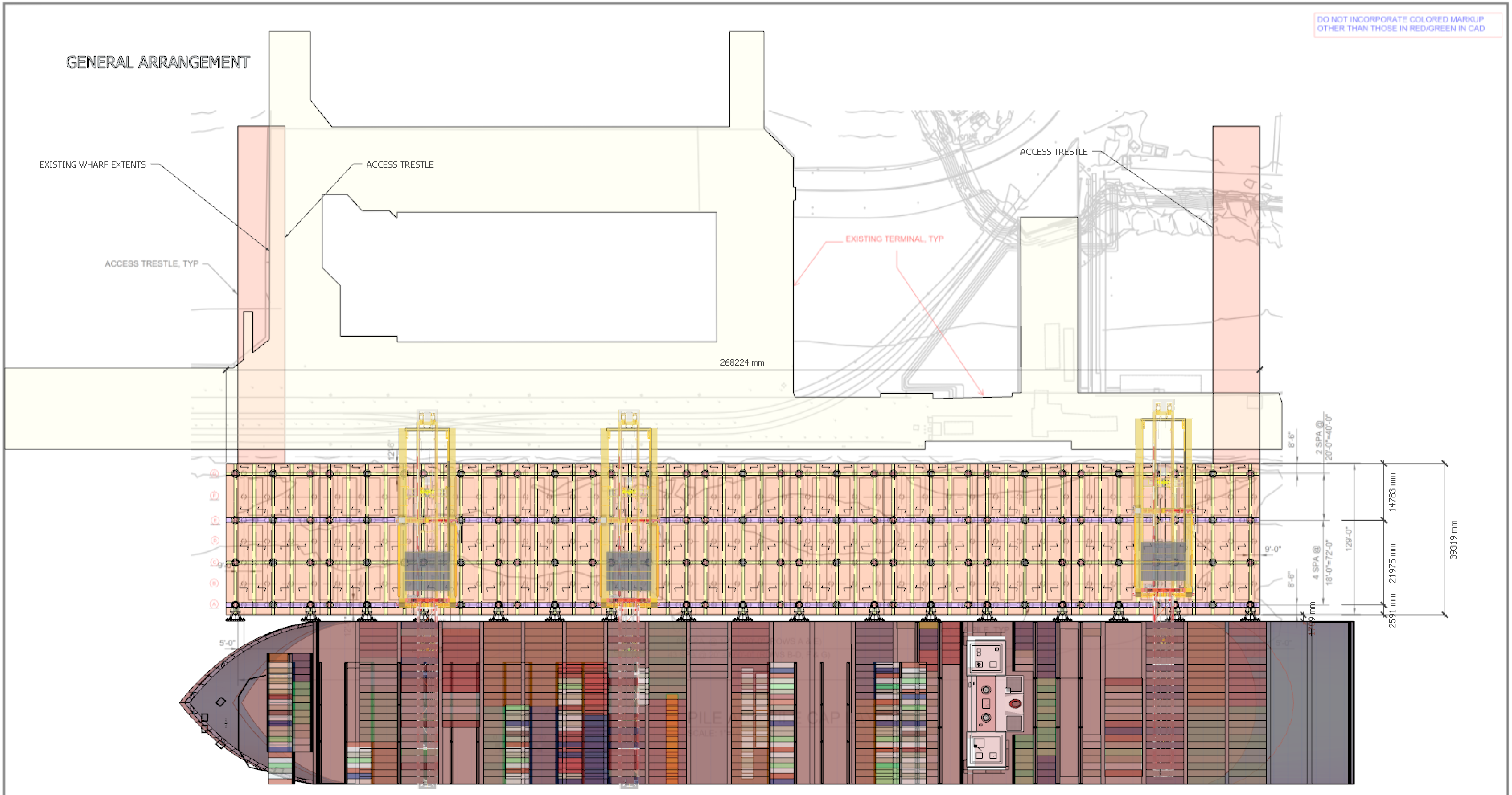
Jacobs Challenging today. Reinventing tomorrow.

TERMINAL 1 – Jacket Concept

Schematics 17 Dec 2021



T1 WHARF - ALTERNATIVE WH1A

CONCEPTUAL

REV	DATE	DESCRIPTION	BY	APVD

REVISIONS

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

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FILE NO

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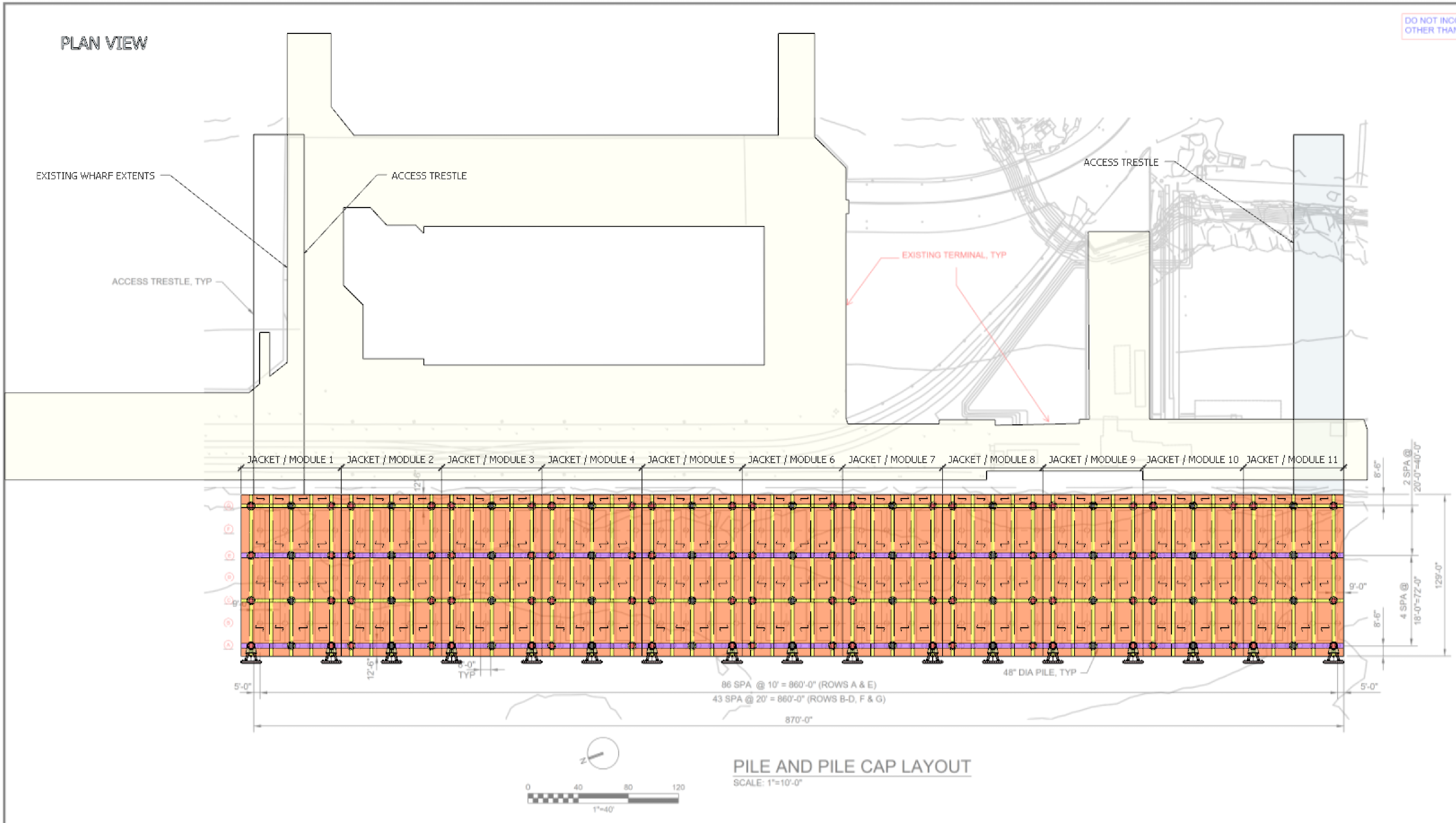

PILE AND PILE CAP LAYOUT

SCALE: 1"=10'-0"

T1 WHARF - ALTERNATIVE WH1A

CONCEPTUAL

DO NOT INCORPORATE COLORED MARKUP OTHER THAN THOSE IN RED/GREEN IN CAD

REV	DATE	DESCRIPTION	BY	APVD

REVISIONS

VERIFY SCALES

BAR IS ONE INCH ON ORIGINAL DRAWING

0 1"

IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

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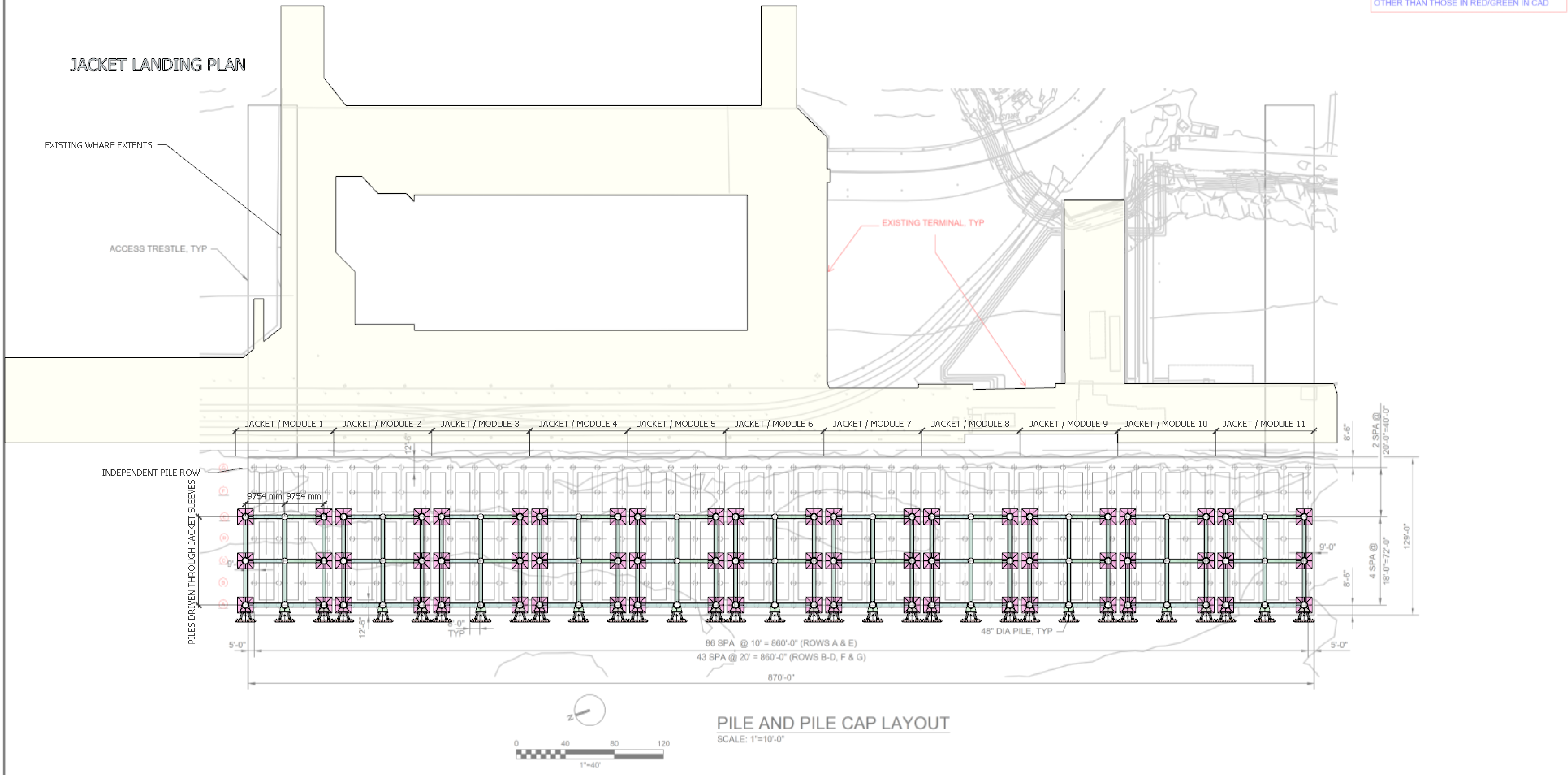
DO NOT INCORPORATE COLORED MARKUP OTHER THAN THOSE IN RED/GREEN IN CAD



T1 WHARF - ALTERNATIVE WH1A

CONCEPTUAL

REV	DATE	DESCRIPTION	BY	APVD

REVISIONS

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

Jacobs

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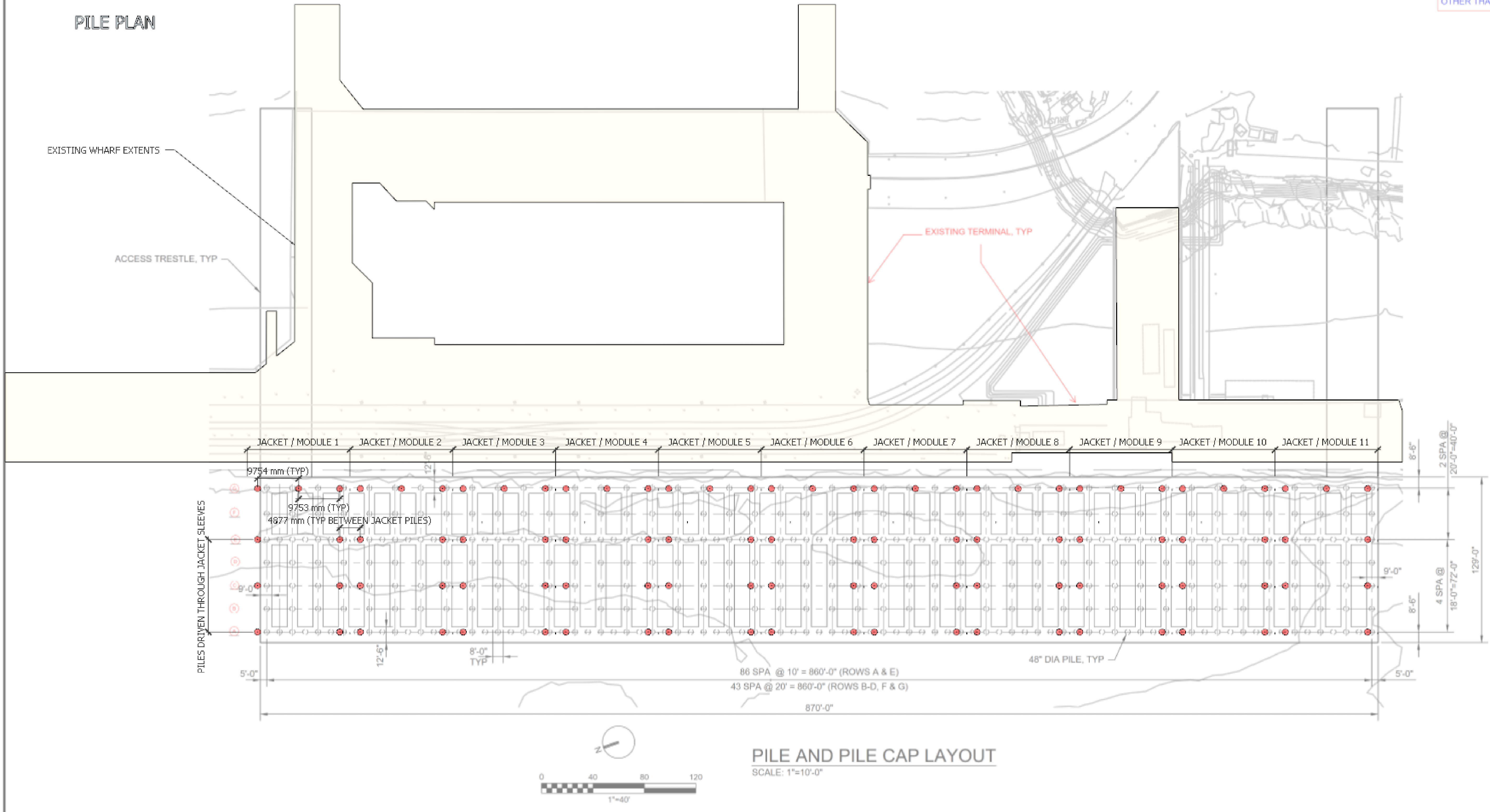
ALTERNATIVE FOUNDATION ANALYSIS
ANCHORAGE, ALASKA

HORIZ SCALE:
VERT SCALE:
DATE:
SHEET: OF

PILE PLAN



PILE AND PILE CAP LAYOUT

SCALE: 1"=10'-0"

T1 WHARF - ALTERNATIVE WH1A

CONCEPTUAL

DO NOT INCORPORATE COLORED MARKUP OTHER THAN THOSE IN RED/GREEN IN CAD

VERIFY SCALES

BAR IS ONE INCH ON ORIGINAL DRAWING

0 1"

IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

REV	DATE	DESCRIPTION	BY	APVD

REVISIONS

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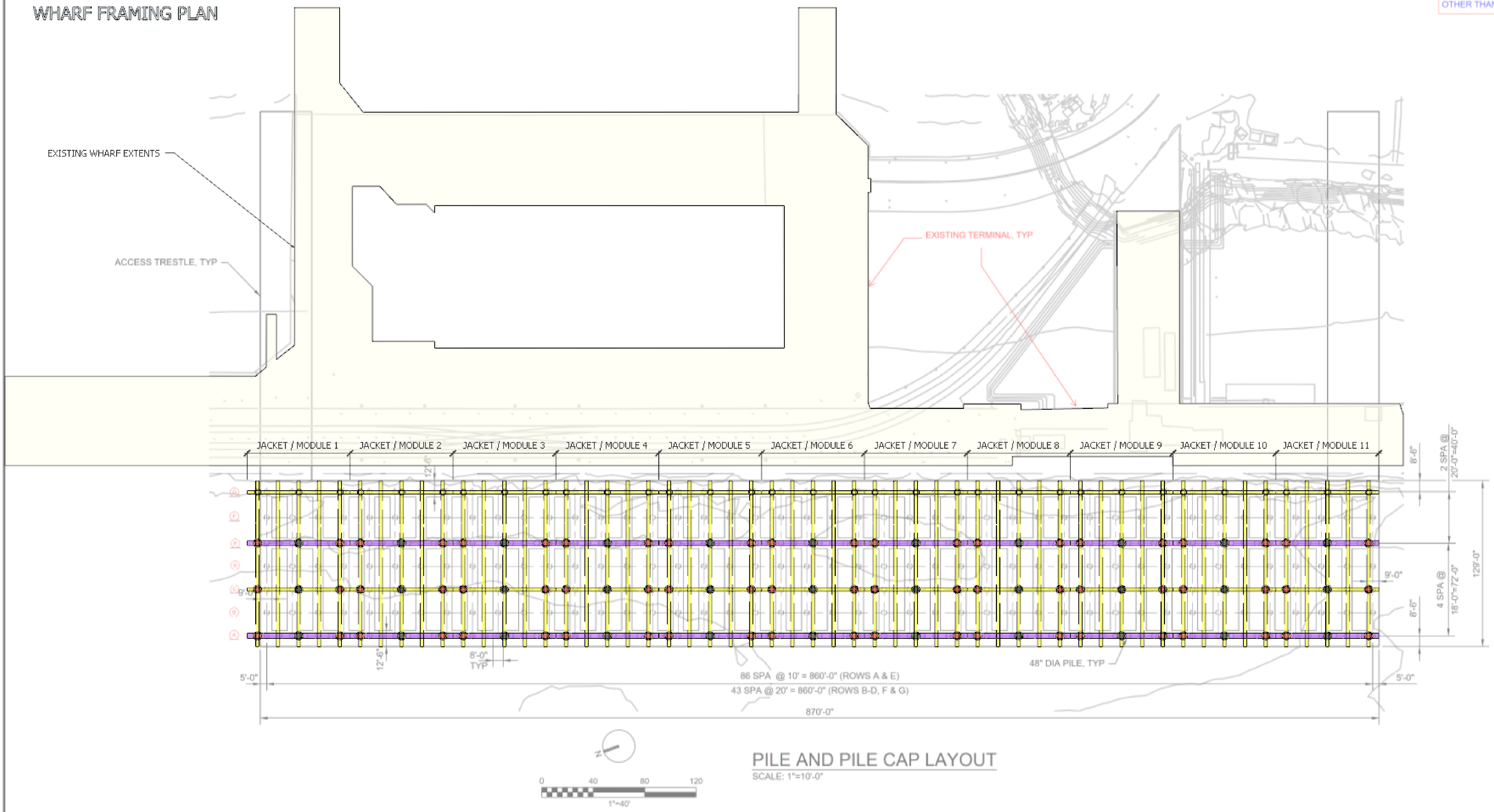
VERT SCALE:
DATE:
SHEET: OF

DO NOT INCORPORATE COLORED MARKUP OTHER THAN THOSE IN RED/GREEN IN CAD



PILE AND PILE CAP LAYOUT

SCALE: 1"=10'-0"

T1 WHARF - ALTERNATIVE WH1A

CONCEPTUAL

REV	DATE	DESCRIPTION	BY	APVD

REVISIONS

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

Jacobs

DSGN DR CHK APVD

CONSULTANT

NOT FOR CONSTRUCTION

SEAL

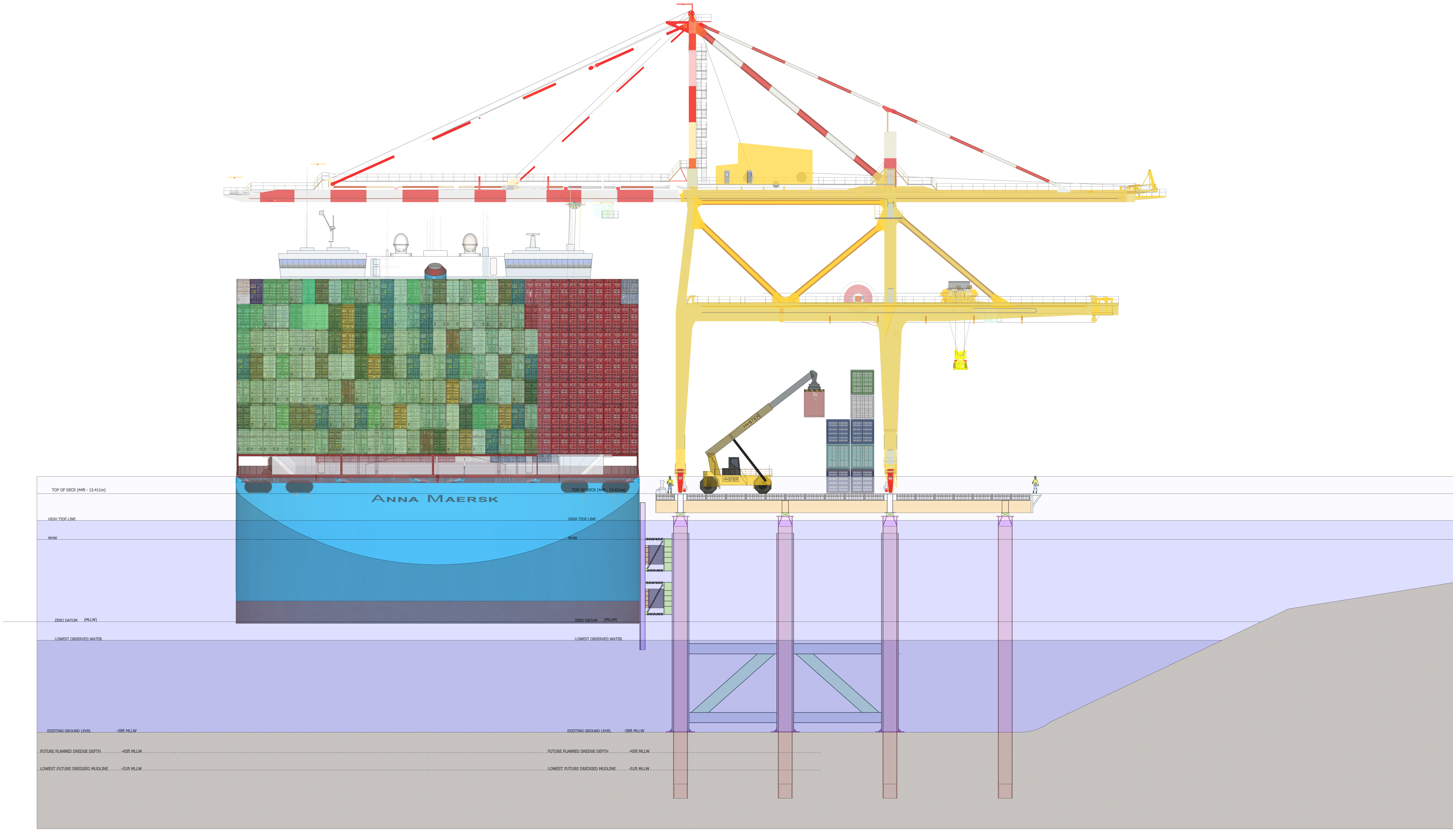
PORT of ALASKA

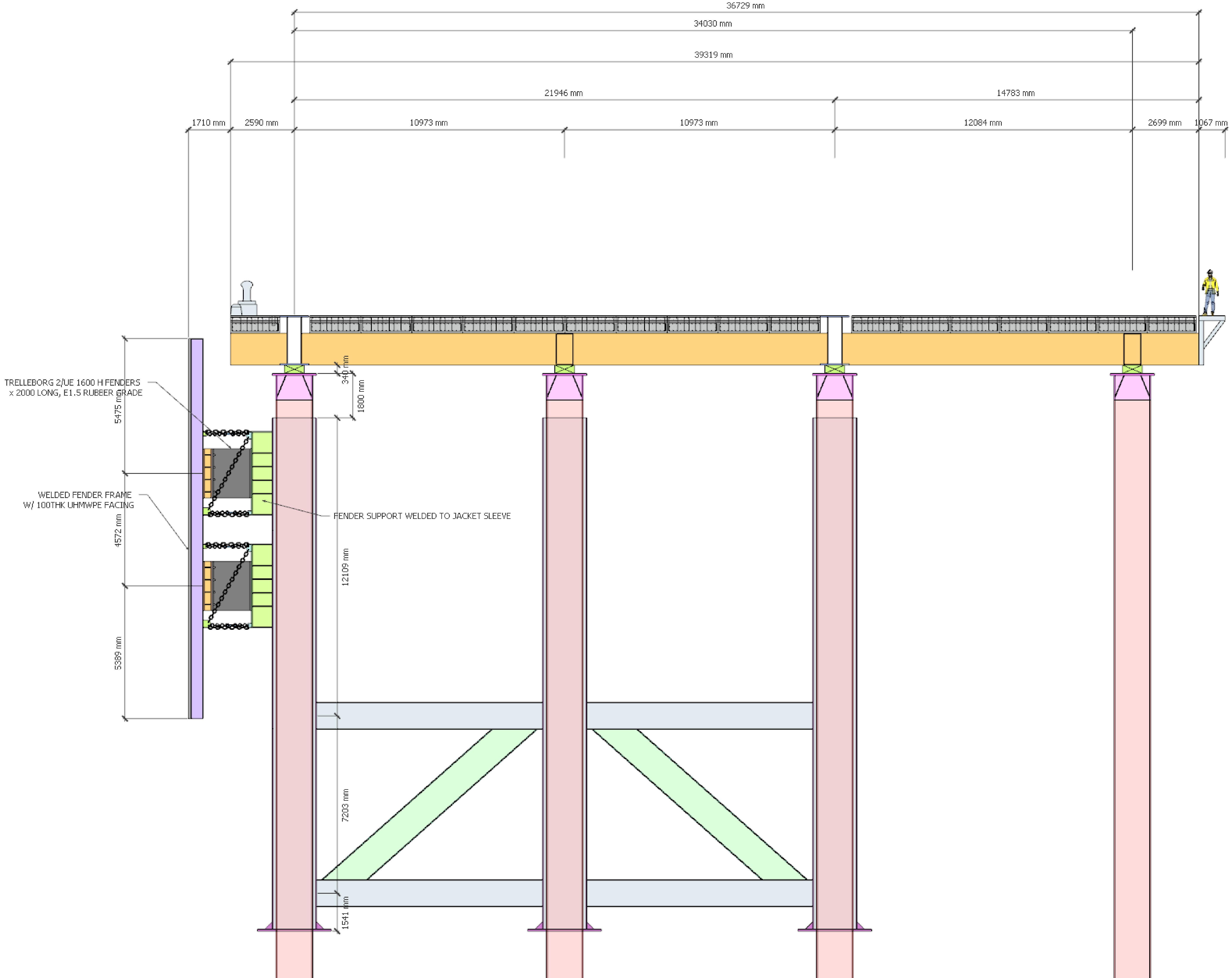
PORT OF ALASKA MODERNIZATION PROGRAM

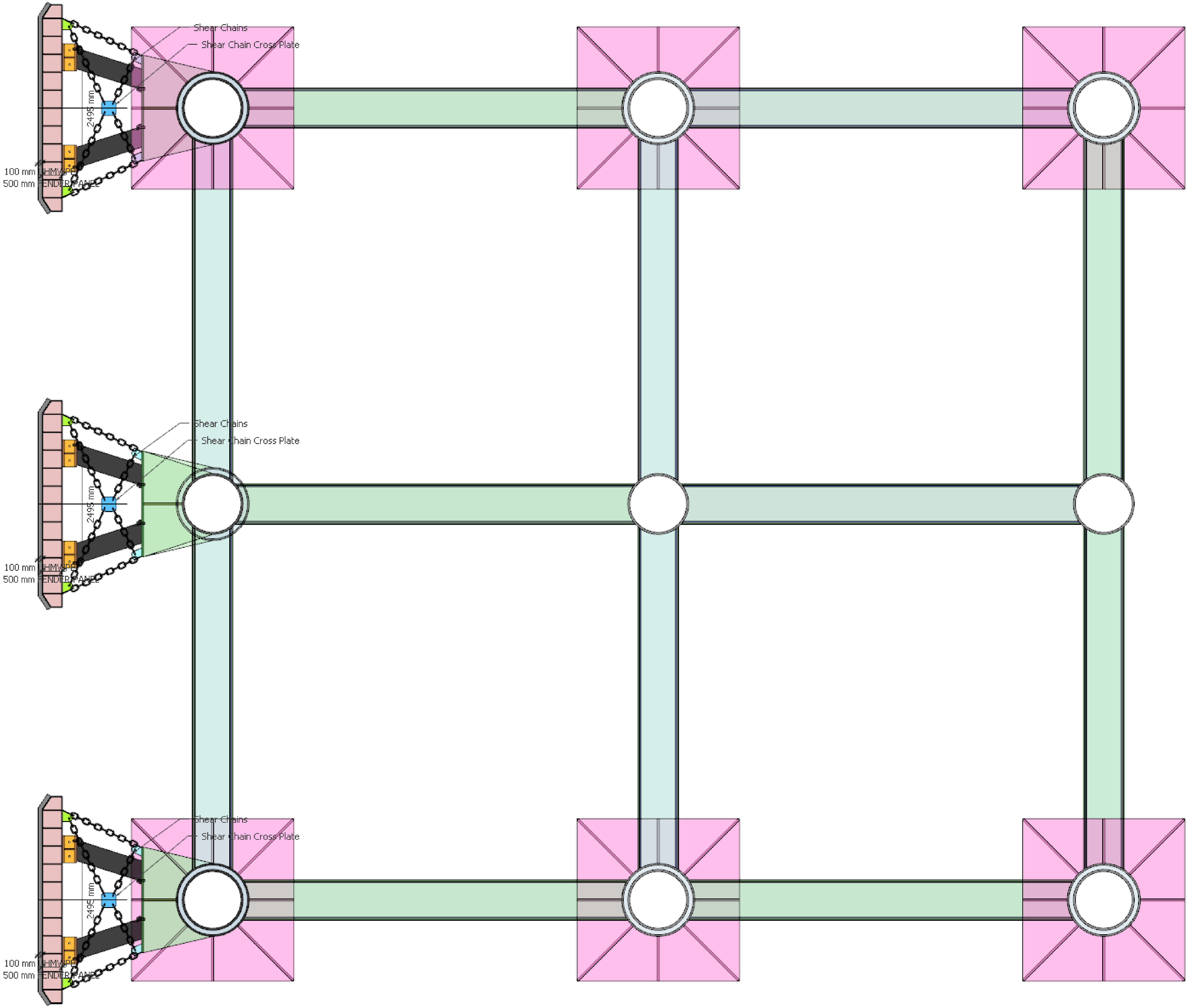
PORT OF ALASKA

PORT OF ALASKA MODERNIZATION PROGRAM
ALTERNATIVE FOUNDATION ANALYSIS
ANCHORAGE, ALASKA

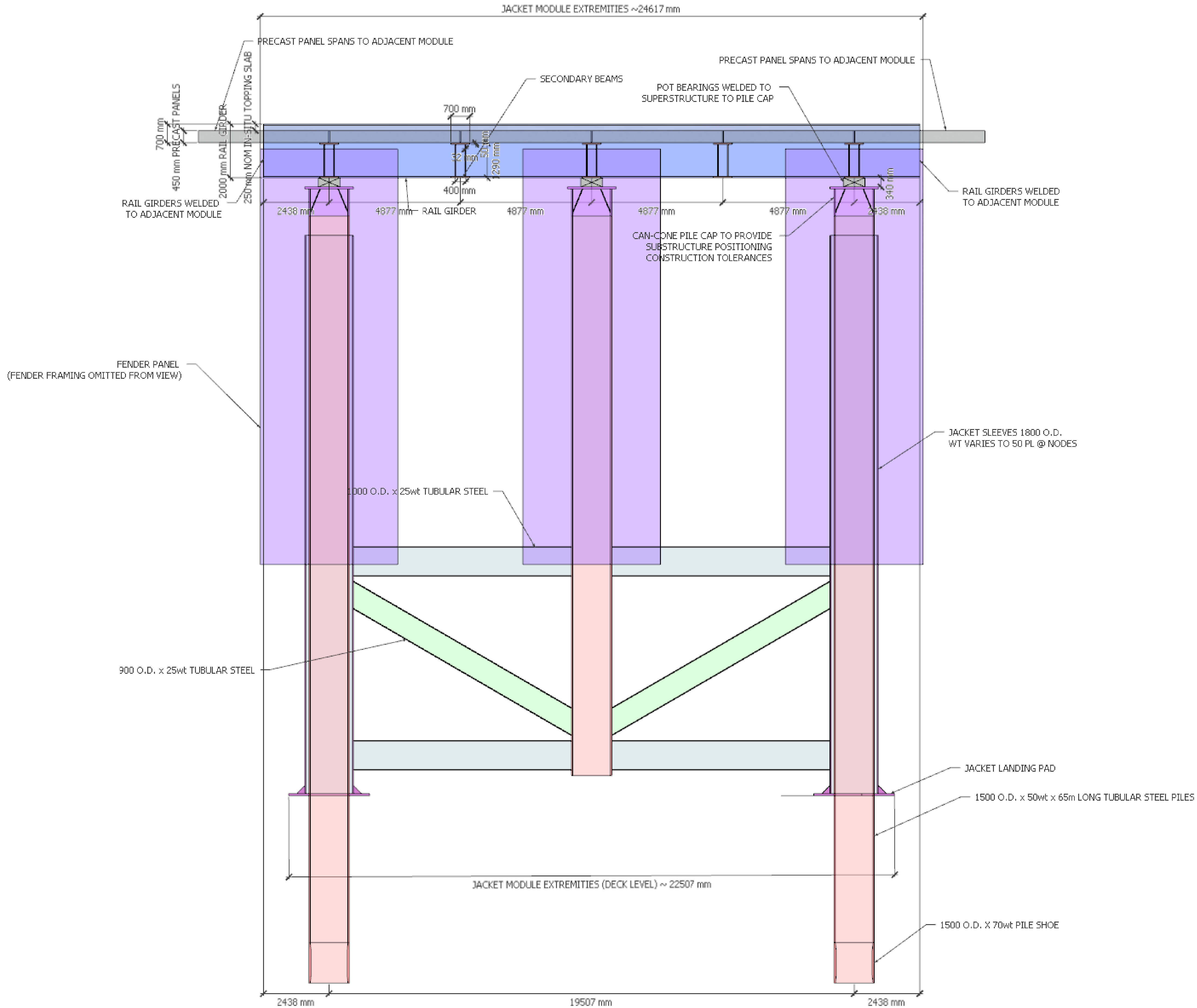
HORIZ SCALE:
VERT SCALE:
DATE:
SHEET: OF

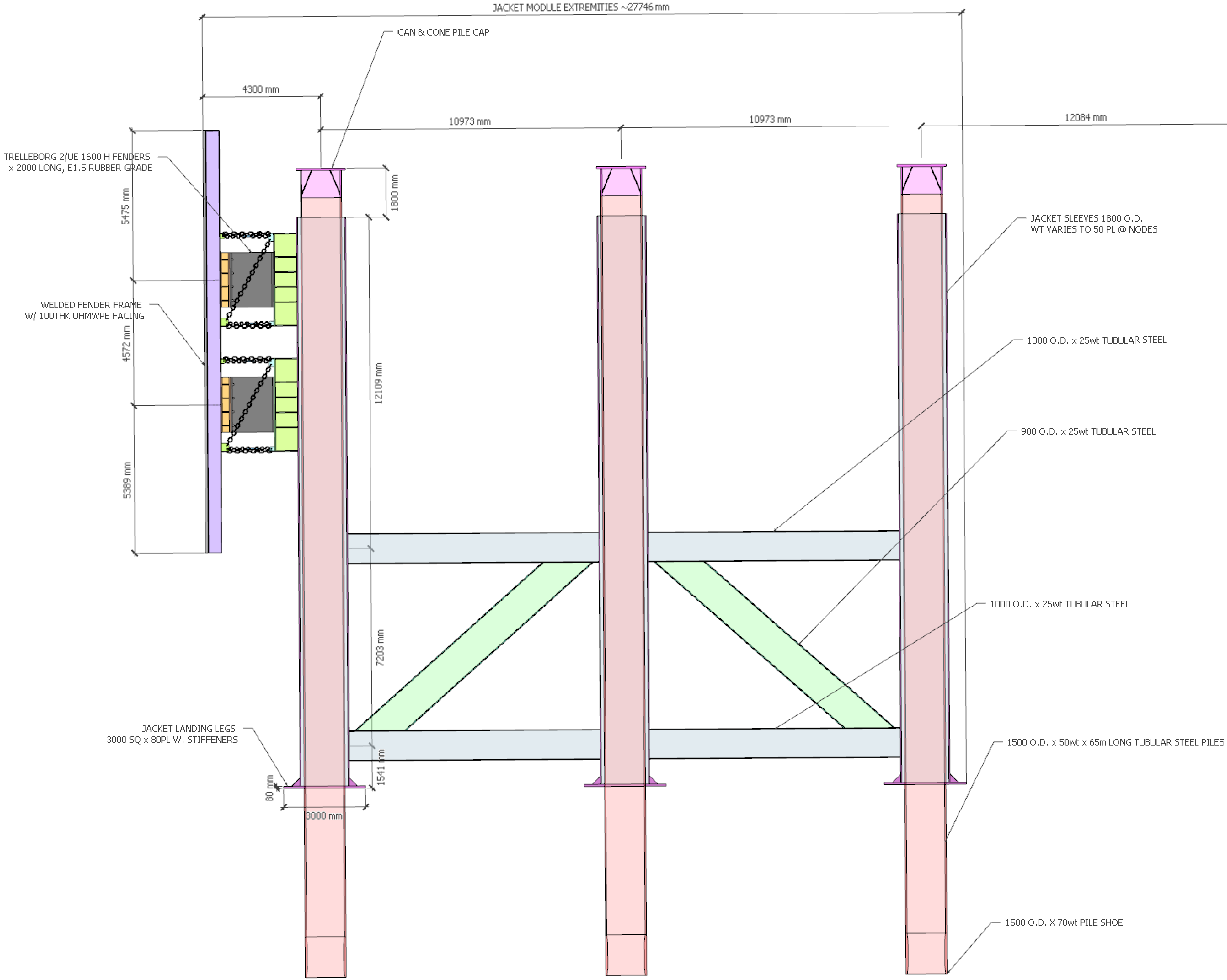

ANNA MAERSK
HYSTER
TOP OF DECK (44ft - 13.411m)
HIGH TIDE LINE
MHW
ZERO DATUM (MLLW)
LOWEST OBSERVED WATER
EXISTING GROUND LEVEL -38ft MLLW
FUTURE PLANNED DREDGE DEPTH -45ft MLLW
LOWEST FUTURE DREDGED MUDLINE -51ft MLLW

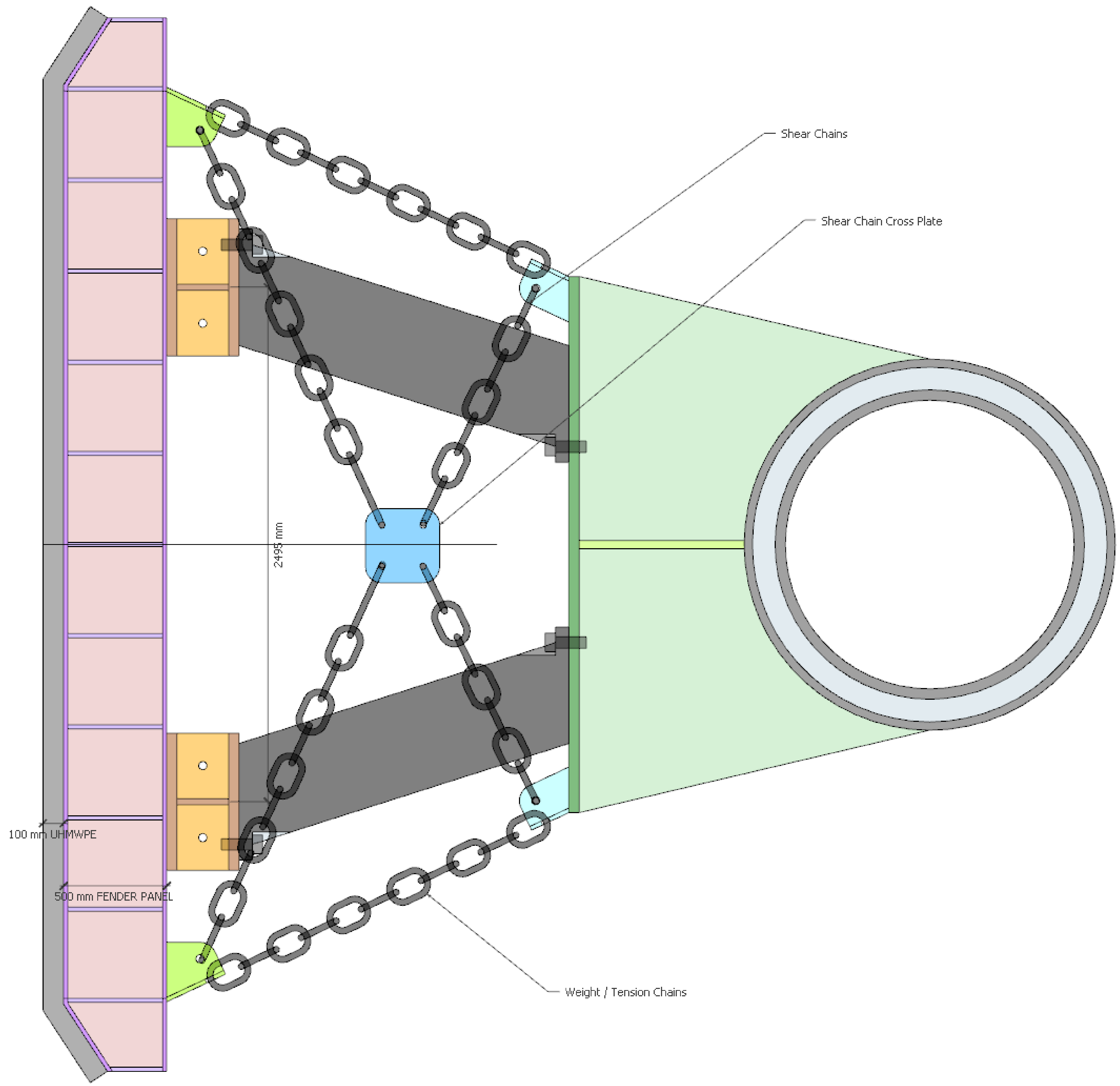

36729 mm
34030 mm
39319 mm
21946 mm
14783 mm
1710 mm
2590 mm
10973 mm
10973 mm
12084 mm
2699 mm
1067 mm
TRELLEBORG 2/UE 1600 H FENDERS
x 2000 LONG, E1.5 RUBEER GRADE
5475 mm
340 mm
1800 mm
WELDED FENDER FRAME
W/ 100THK UHMWPE FACING
FENDER SUPPORT WELDED TO JACKET SLEEVE
4572 mm
12109 mm
5389 mm
7203 mm
1541 mm

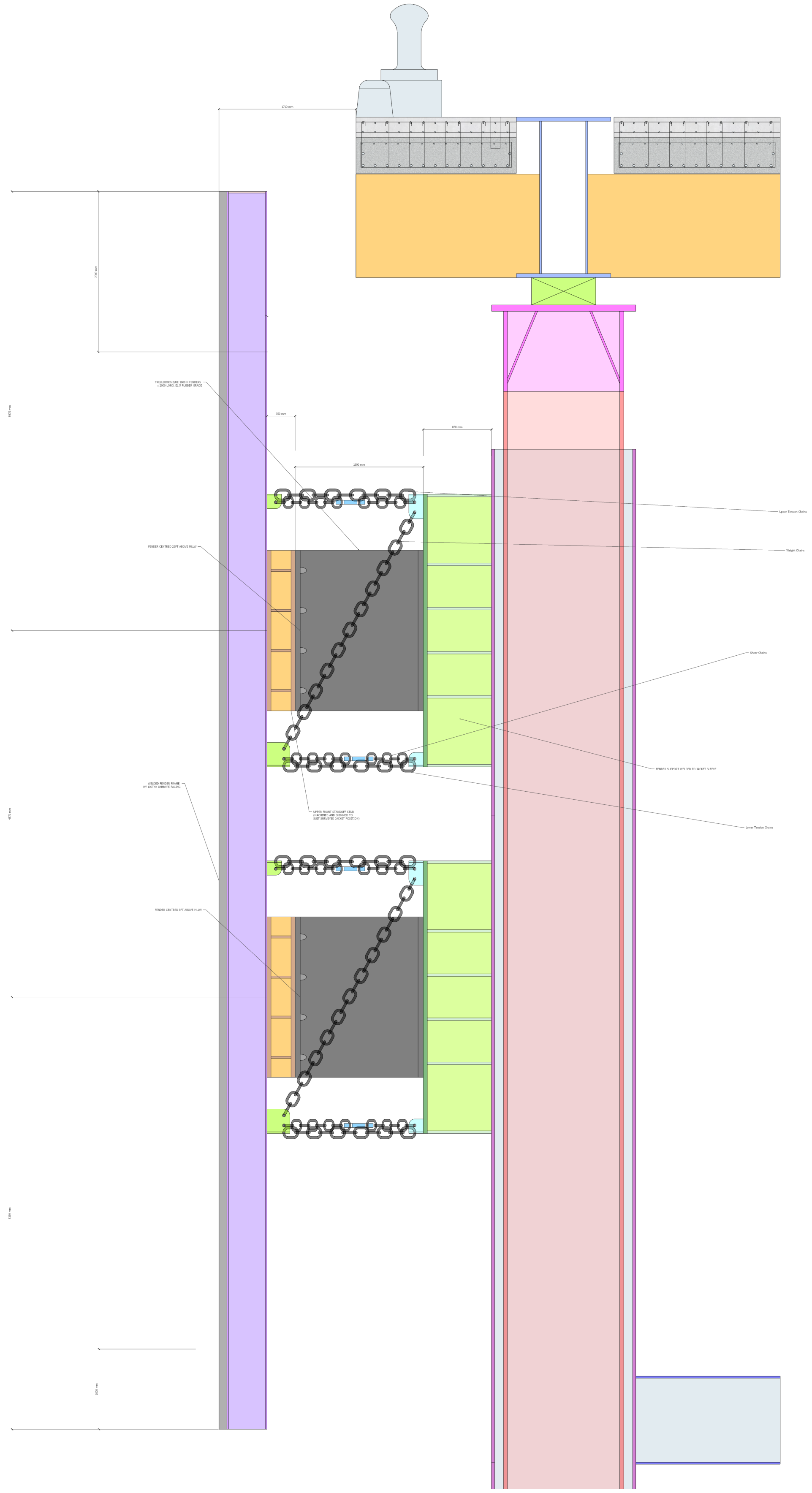


FENDERING SYSTEM VARIES IN POSITION BETWEEN JACKETS.


JACKET MODULE EXTREMITIES ~24617 mm
PRECAST PANEL SPANS TO ADJACENT MODULE
PRECAST PANEL SPANS TO ADJACENT MODULE
SECONDARY BEAMS
POT BEARINGS WELDED TO SUPERSTRUCTURE TO PILE CAP
700 mm
700 mm PRECAST PANELS
450 mm
2000 mm RAIL GIRDER
250 mm NOM IN-SITU TOPPING SLAB
32 mm
50 mm
290 mm
400 mm
340 mm
RAIL GIRDERS WELDED TO ADJACENT MODULE
RAIL GIRDERS WELDED TO ADJACENT MODULE
2438 mm
4877 mm
RAIL GIRDER
4877 mm
4877 mm
4877 mm
2438 mm
CAN-CONE PILE CAP TO PROVIDE SUBSTRUCTURE POSITIONING CONSTRUCTION TOLERANCES
FENDER PANEL (FENDER FRAMING OMITTED FROM VIEW)
JACKET SLEEVES 1800 O.D. WT VARIES TO 50 PL @ NODES
1000 O.D. x 25wt TUBULAR STEEL
900 O.D. x 25wt TUBULAR STEEL
JACKET LANDING PAD
1500 O.D. x 50wt x 65m LONG TUBULAR STEEL PILES
JACKET MODULE EXTREMITIES (DECK LEVEL) ~ 22507 mm
1500 O.D. X 70wt PILE SHOE
2438 mm
19507 mm
2438 mm

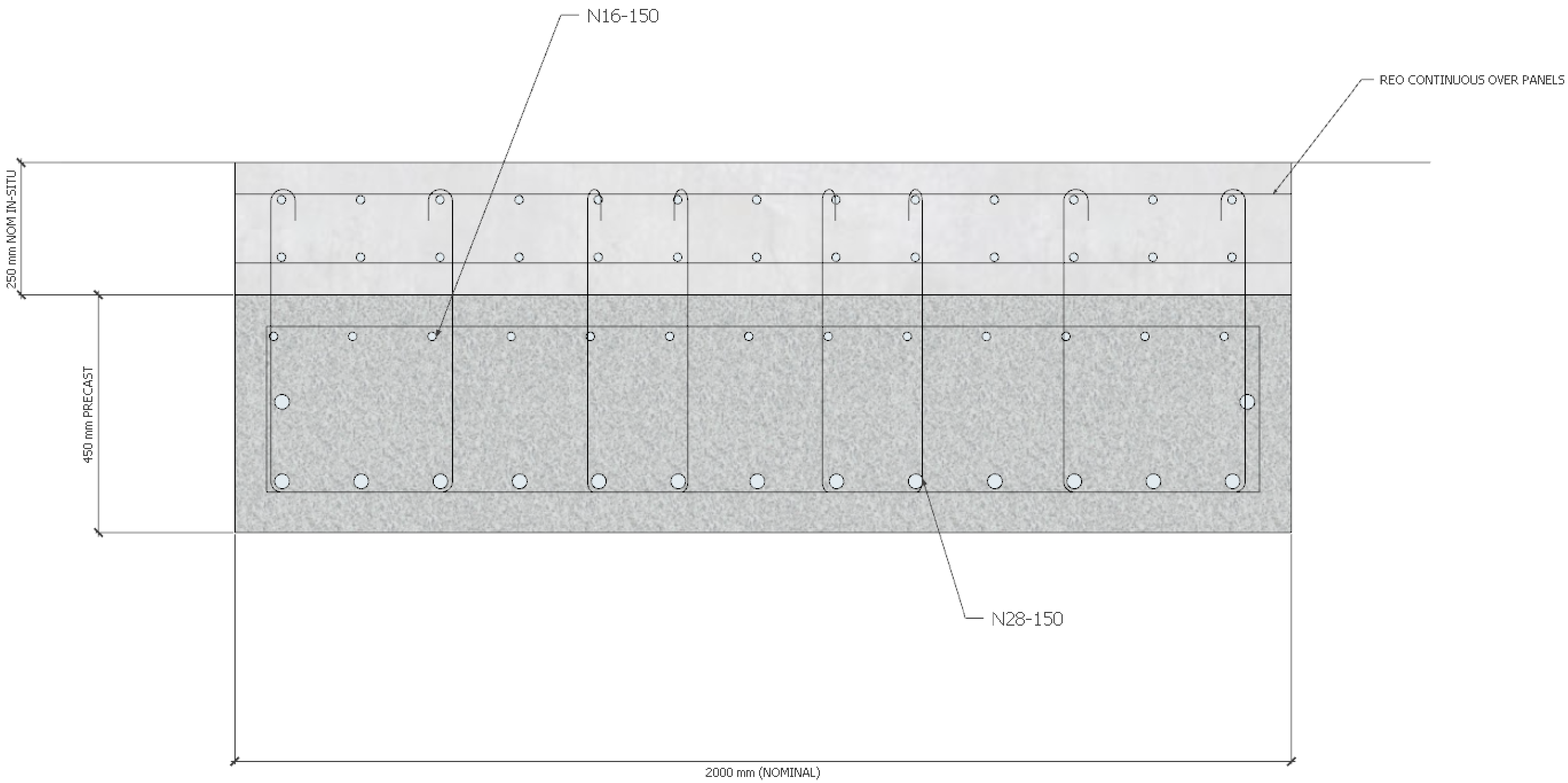

JACKET MODULE EXTREMITIES ~27746 mm
CAN & CONE PILE CAP
4300 mm
10973 mm
10973 mm
12084 mm
TRELLEBORG 2/UE 1600 H FENDERS
x 2000 LONG, E1.5 RUBBER GRADE
5475 mm
1800 mm
JACKET SLEEVES 1800 O.D.
WT VARIES TO 50 PL @ NODES
WELDED FENDER FRAME
W/ 100THK UHMWPE FACING
4572 mm
1000 O.D. x 25wt TUBULAR STEEL
12109 mm
900 O.D. x 25wt TUBULAR STEEL
5389 mm
1000 O.D. x 25wt TUBULAR STEEL
7203 mm
JACKET LANDING LEGS
3000 SQ x 80PL W. STIFFENERS
1500 O.D. x 50wt x 65m LONG TUBULAR STEEL PILES
80 mm
1541 mm
3000 mm
1500 O.D. X 70wt PILE SHOE


Shear Chains
Shear Chain Cross Plate
2495 mm
100 mm UHMWPE
500 mm FENDER PANEL
Weight / Tension Chains

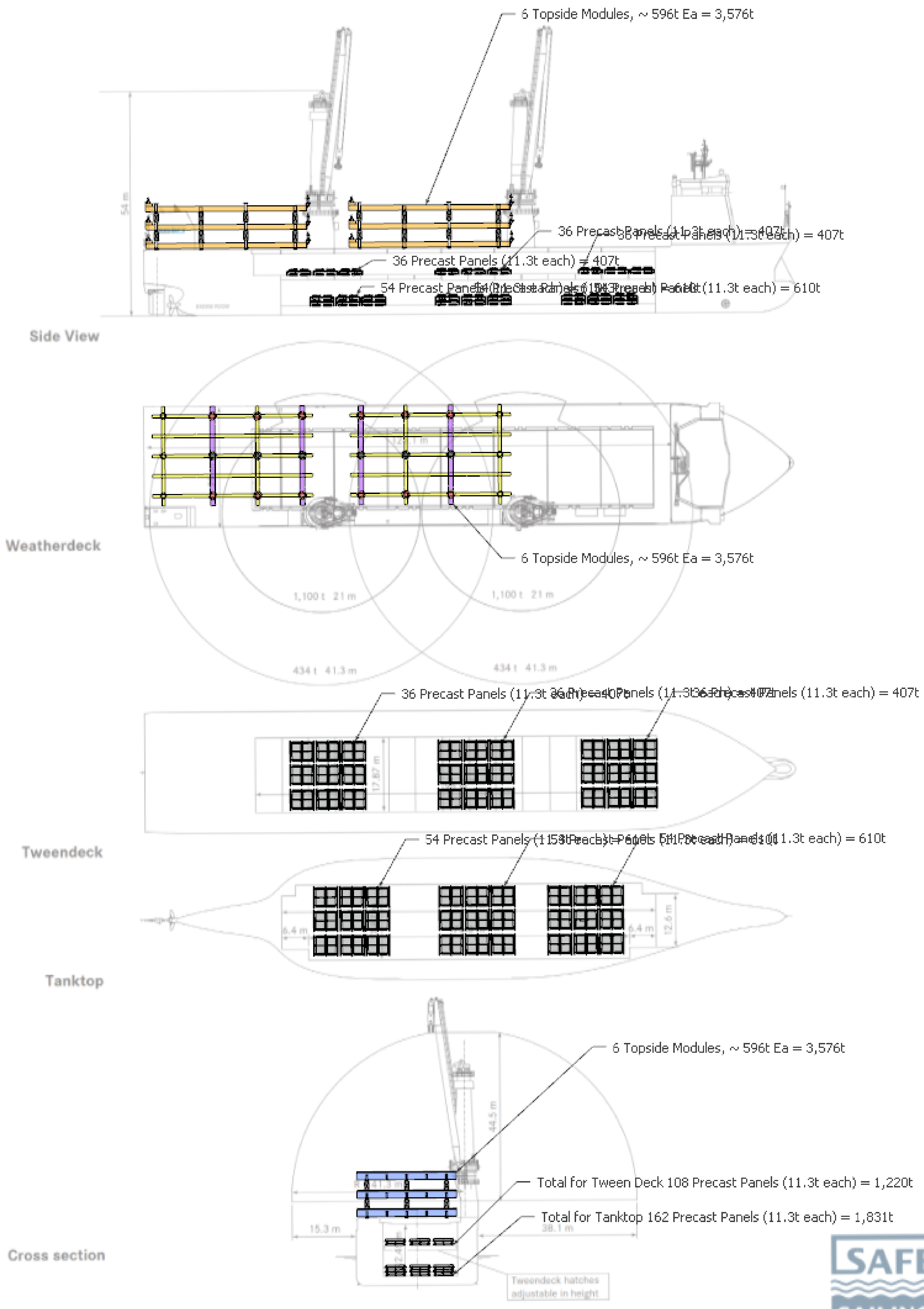


TRELLEBORG 2/UE 1600 H FENDERS
x 2000 LONG, E1.5 RUBBER GRADE
350 mm
1600 mm
FENDER CENTRED 23FT ABOVE MLLW
WELDED FENDER FRAME
W/ 100THK UHMWPE FACING
UPPER FRONT STANDOFF STUB
(MACHINED AND SHIMMED TO
SUIT SURVEYED JACKET POSITION)
FENDER CENTRED 8FT ABOVE MLLW
Upper Tension Chains
Weight Chains
Shear Chains
FENDER SUPPORT WELDED TO JACKET SLEEVE
Lower Tension Chains

PRECAST PLANK DETAILS



HAPPY STAR



SAFE SAILINGS

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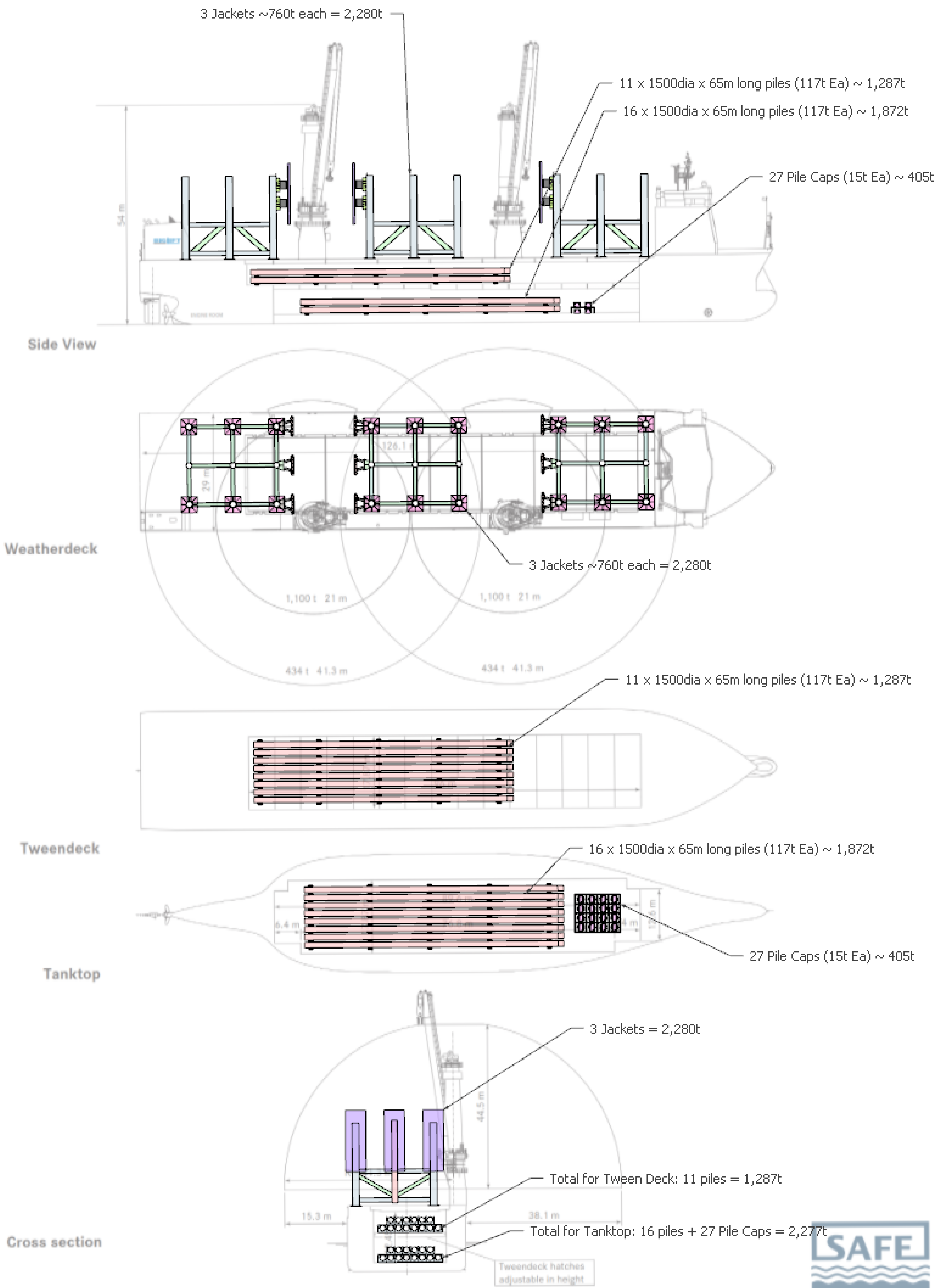
HAPPY STAR



3 Jackets ~760t each = 2,280t
11 x 1500dia x 65m long piles (117t Ea) ~ 1,287t
16 x 1500dia x 65m long piles (117t Ea) ~ 1,872t
27 Pile Caps (15t Ea) ~ 405t
54 m
Side View
29 m
126.1 m
3 Jackets ~760t each = 2,280t
1,100 t 21 m
1,100 t 21 m
434 t 41.3 m
434 t 41.3 m
Weatherdeck
11 x 1500dia x 65m long piles (117t Ea) ~ 1,287t
Tweendeck
16 x 1500dia x 65m long piles (117t Ea) ~ 1,872t
6.4 m
27 Pile Caps (15t Ea) ~ 405t
Tanktop
3 Jackets = 2,280t
44.5 m
Total for Tween Deck: 11 piles = 1,287t
15.3 m
38.1 m
Total for Tanktop: 16 piles + 27 Pile Caps = 2,277t
Tweendeck hatches adjustable in height
Cross section

Appendix J
Jones Act – Informed Compliance Publication – September 2020

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NOTICE:

This publication is intended to provide guidance and information to the trade community. It reflects the position on or interpretation of the applicable laws or regulations by U.S. Customs and Border Protection (CBP) as of the date of publication, which is shown on the front cover. It does not in any way replace or supersede those laws or regulations. Only the latest official version of the laws or regulations is authoritative.

Publication History

First Published January 2009
Revised September 2020

PRINTING NOTE:

This publication was designed for electronic distribution via the CBP website (https://www.cbp.gov) and is being distributed in a variety of formats. It was originally created in Microsoft Word97®. Pagination and margins in downloaded versions may vary depending upon the word processor or printer you use. If you wish to maintain the original settings, you may wish to download the PDF version, which can then be printed using the free Adobe Acrobat Reader®.

PREFACE

On December 8, 1993, Title VI of the North American Free Trade Agreement Implementation Act (Pub. L. 103-182, 107 Stat. 2057), also known as the Customs Modernization or "Mod" Act, became effective. These provisions amended many sections of the Tariff Act of 1930 and related laws.

Two new concepts that emerged from the Mod Act are ***"informed compliance"*** and ***"shared responsibility***," which are premised on the idea that in order to maximize voluntary compliance with laws and regulations of CBP, the trade community needs to be clearly and completely informed of its legal obligations. Accordingly, the Mod Act imposes a greater obligation for CBP to provide the public with improved information concerning the trade community's rights and responsibilities under CBP regulations and related laws. In addition, both the trade and CBP share responsibility for carrying out these requirements. For example, under Section 484 of the Tariff Act, as amended (19 U.S.C. § 1484), the importer of record is responsible for using reasonable care to enter, classify and determine the value of imported merchandise and to provide any other information necessary to enable CBP to properly assess duties, collect accurate statistics, and determine whether other applicable legal requirements, if any, have been met. CBP is then responsible for fixing the final classification and value of the merchandise. An importer of record's failure to exercise reasonable care could delay release of the merchandise and, in some cases, could result in the imposition of penalties or, in certain instances, referral for criminal enforcement.

The Office of Trade, Regulations and Rulings (RR) has been given a major role in meeting the informed compliance responsibilities of CBP. In order to provide information to the public, CBP has issued a series of informed compliance publications, on new or revised requirements, regulations or procedures, and a variety of classification and valuation issues.

This publication, prepared by the Border Security and Trade Compliance Division, Regulations and Rulings, is entitled "The Jones Act." It provides guidance regarding the procedures that control the coastwise transportation of merchandise between U.S. coastwise points. It is part of a series of informed compliance publications advising the public of CBP regulations and procedures. We sincerely hope that this material, together with seminars and increased access to rulings of CBP, will help the trade community to improve voluntary compliance with customs laws and to understand the relevant administrative processes.

The material in this publication is provided for general information purposes only. Because many complicated factors can be involved in customs issues, an importer may wish to obtain a ruling under the CBP Regulations, 19 C.F.R. Part 177, or to obtain advice from an expert who specializes in customs matters, for example, a licensed customs broker, attorney or a customs consultant.

Comments and suggestions are welcomed and should be addressed to the Executive Director, Regulations and Rulings, Office of Trade, U.S. Customs and Border Protection, 90 K Street, NE, 10th Floor, Washington, D.C. 20229-1177.

Alice A. Kipel
Executive Director, Regulations and Rulings
Office of Trade

INTRODUCTION

Purpose

U.S. Customs and Border Protection (CBP), previously the U.S. Customs Service, is responsible for enforcing and administering laws and regulations which set forth procedures to control and oversee vessels arriving in and departing from U.S. ports, and the coastwise transportation of merchandise between U.S. ports.

The purpose of this Informed Compliance Publication (ICP) is to identify the laws and regulations pertaining to the coastwise transportation of merchandise, such that the trade community is informed of its legal obligations, and in order to maximize voluntary compliance with laws and regulations enforced by CBP.

Background

Federal laws protecting U.S. shipping date back to the First Congress in 1789. American shipping in the U.S. coastwise[1] trade has been protected from foreign competition, in order to encourage the development of a U.S. merchant marine, for both national defense and commercial purposes. As a result, all vessels engaged in U.S. coastwise trade have been required to be U.S.-built and U.S.-owned.

The coastwise law governing the transportation of merchandise was first established by Section 27 of the Merchant Marine Act of 1920, sponsored by Senator Wesley L. Jones (hence its name, the "Jones Act"), which revamped several U.S. shipping laws, including those governing cabotage, shipping mortgages, and seamen's personal injury claims. That statute provided that "[N]o merchandise shall be transported by water, or by land and water, on penalty of forfeiture thereof, between points in the United States, including districts, territories, and possessions thereof embraced within the coastwise laws, either directly or via a foreign port, or for any part of the transportation, in any other vessel than a vessel built in and documented under the laws of the United States and owned by persons who are citizens of the United States."

The Coastwise Laws: Merchandise vs. Passengers

Generally, the coastwise laws prohibit the transportation of merchandise or passengers in points in the United States embraced within the coastwise laws in any vessel other than a vessel built in, documented under the laws of, and owned by citizens of the United States. The coastwise law pertaining to the transportation of merchandise is known as the Jones Act, codified at 46 U.S.C. § 55102. The coastwise law pertaining to the

[1] Customs (now CBP) has always enforced the coastwise laws, except for a 58-year period (1884-1942) when the responsibility resided with the former Bureau of Navigation, which operated both under the Department of the Treasury (between 1884 and 1903) and the Department of Commerce (between 1903 and 1942).

transportation of passengers is known as the Passenger Vessel Services Act (PVSA), codified at 46 U.S.C. § 55103. This document will cover the key laws, regulations, and concepts relating to the transportation of merchandise under the Jones Act. This document is not applicable to the transportation of passengers under the PVSA. Please refer to the Passenger Vessel Services Act Informed Compliance Publication for information about the PVSA.

Specifically, in this publication, CBP will summarize:

- U.S. Statutes and Regulations Enforced by CBP Pertaining to the Jones Act
- Key Elements of the Jones Act
- Statutory Exceptions to the Jones Act
- The Penalty for Violations of the Jones Act
- Jones Act Ruling Requests
- Waivers of the Navigation Laws

NOTE: CBP interpretive rulings are cited throughout this publication. You may access the rulings by clicking on the web link associated with the ruling number. Alternatively, you may visit the Customs Rulings Online Search System (CROSS) web link and enter the ruling number in the search bar.

APPLICABLE STATUTES

46 U.S.C. § 55101(a) and (b) - Application of Coastwise Laws

The coastwise laws apply to the United States, including U.S. island territories and possessions. The coastwise laws do not apply to American Samoa, the Northern Mariana Islands, and the U.S. Virgin Islands.

46 U.S.C. § 55102 – Transportation of Merchandise

The Jones Act provides that the transportation of merchandise between U.S. points is reserved for U.S.-built, U.S.-owned, and U.S.-documented vessels. Pursuant to section 55102, "a vessel may not provide any part of the transportation of merchandise by water, or by land and water, between points in the United States to which the coastwise laws apply, either directly or via a foreign port, unless the vessel— (1) is wholly owned by citizens of the United States for purposes of engaging in the coastwise trade; and (2) has been issued a certificate of documentation with a coastwise endorsement under chapter 121 of Title 46 or is exempt from documentation but would otherwise be eligible for such a certificate and endorsement."[2]

[2] Formerly codified at 46 U.S.C. App. § 883. Recodified by Public Law 109-304, 120 Stat. 1632 (Oct. 6, 2006).

46 U.S.C. § 12103 - General Eligibility Requirements

A certificate of documentation may be issued only to a vessel that is wholly owned by a U.S. citizen, the U.S. government, a state government, and/or an eligible entity, partnership, or corporation; is at least five net tons; and is not documented under the laws of a foreign country.

46 U.S.C. § 12112 - Coastwise Endorsement

A coastwise endorsement may be issued for a vessel that meets the criteria set forth in 46 U.S.C. § 12103, was built in the United States (or if not built in the United States, was captured in war by U.S. citizens and lawfully condemned as prize, was forfeited for a breach of U.S. laws, or qualifies as a wrecked vessel), and otherwise qualifies to engage in the coastwise trade. A vessel issued a coastwise endorsement may engage in the coastwise trade.

43 U.S.C. § 1333(a) – Laws and Regulations Governing Lands (the OCSLA)[3]

The laws of the United States extend to the subsoil and seabed of the Outer Continental Shelf, all artificial islands, installations, and other devices attached to the seabed "for the purpose of exploring, developing, or producing resources therefrom," and any installation or device (other than a ship or vessel) used for the transportation of those resources.[4]

46 U.S.C. § 501 - Waiver of Navigation and Vessel-Inspection Laws

Under 46 U.S.C. § 501(a), the Secretary of Defense may request that the Secretary of the Department of Homeland Security (DHS) waive the navigation laws to the extent the Secretary of Defense considers such a waiver *necessary in the interest of national defense*.

For all other waiver requests, under 46 U.S.C. § 501(b), the Secretary of DHS is authorized to grant the waiver request if the Secretary of DHS considers it *necessary in the interest of national defense* and if the Maritime Administrator determines there is no coastwise-qualified vessel capacity to conduct the transportation set forth in the request.

[3] The Outer Continental Shelf Lands Act (OCSLA) of Aug. 7, 1953, ch 345, 67 Stat. 462, amended at Pub. L. 95-372 (1978), appears generally as 43 USCS §§ 1331– 1356.
[4] *See*, *e.g.*, HQ H287418 (Jun. 19, 2017).

APPLICABLE REGULATIONS

19 C.F.R. § 4.80 - Vessels Entitled to Engage in Coastwise Trade

A vessel may not transport merchandise either directly or via a foreign port between coastwise points, including points within a harbor, unless the vessel has been issued a coastwise endorsement on its certificate of documentation by the U.S. Coast Guard or is exempt from documentation but otherwise eligible for a coastwise endorsement (also known as a "coastwise-qualified vessel"). The penalty imposed for the illegal transportation of merchandise between coastwise points is forfeiture of the merchandise or forfeiture of a monetary amount up to the value of the merchandise. A vessel qualified to engage in the coastwise trade will lose that right if it is "sold foreign"[5] or is placed under foreign registry (unless the vessel is 200 gross tons or less) or if it is rebuilt (unless the entire rebuilding was done in the United States).

19 C.F.R. § 4.80b - Coastwise Transportation of Merchandise

A coastwise transportation of merchandise takes place, within the meaning of the coastwise laws, when merchandise laden at a point embraced within the coastwise laws is unladen at another coastwise point, regardless of the origin or ultimate destination of the merchandise. Merchandise is not transported coastwise, however, if at an intermediate port or place other than a coastwise point (that is at a foreign port or place, or at a port or place in a territory or possession of the United States not subject to the coastwise laws), it is manufactured or processed into a new and different product, and the new and different product thereafter is transported to a coastwise point.

19 C.F.R. § 4.93 - Empty Cargo Containers, Stevedoring Equipment

U.S. vessels prohibited from engaging in coastwise trade as well as foreign-flag vessels of nations that grant reciprocal privileges to vessels of the United States may transport certain articles between coastwise points. These articles include empty cargo vans, empty lift vans, and empty shipping tanks and the equipment for use with said empty cargo vans, lift vans and shipping tanks; empty barges specifically designed to be carried aboard a vessel and equipment (excluding propulsion equipment) for use with such barges; and empty instruments of international traffic (IITs) if such articles are owned or leased by the owner or operator of the transporting vessel and are transported for the owner/operator's use in handling the cargo in foreign trade. Similarly, stevedoring equipment and material are also exempt, if they are owned or leased by the owner or operator of the transporting vessel, or owned or leased by the stevedoring company contracting for the lading or unlading of that vessel, and are transported without charge

[5] *See* 19 C.F.R. § 4.80(e)(1) ("No vessel which has acquired the lawful right to engage in the coastwise trade…will have the right to engage in such trade if it: (1) Thereafter has been sold foreign [(i.e., sold to a foreign citizen or entity)] in whole or in part or placed under a foreign registry….").

for use in the handling of cargo in foreign trade. The list of nations that extend reciprocal privileges to U.S. vessels is set forth at 19 C.F.R. § 4.93(b).

19 C.F.R. Part 177 – CBP Administrative Rulings

CBP issues prospective ruling letters regarding the Jones Act pursuant to 19 C.F.R. Part 177.

33 C.F.R. § 2.22 - Territorial Sea

The territorial sea of the United States means the waters, three nautical miles wide, adjacent to the U.S. coast and seaward of the territorial sea baseline.

COASTWISE TRANSPORTATION OF MERCHANDISE

As outlined above, the Jones Act (46 U.S.C. § 55102) provides that the transportation of merchandise between U.S. points, either directly or via a foreign port, is reserved for U.S.-built, owned, and documented vessels. Consequently, foreign-flag vessels are prohibited from engaging in any part of the coastwise trade—transporting merchandise between U.S. coastwise points. In addition, the same prohibitions apply to U.S.-flag vessels that do not have a coastwise endorsement on their documentation.

Key Elements

There are three key elements in determining whether a particular scenario constitutes coastwise transportation within the meaning of the Jones Act: (1) whether the transportation is between coastwise points, (2) whether the transportation is provided on a coastwise-qualified vessel, and (3) whether the material transported constitutes “merchandise” within the meaning of the Jones Act. This section discusses each of these considerations in turn by examining the definition of “transportation,” the geographic locations at which the Jones Act applies, the requirements for a vessel to be considered “coastwise-qualified,” and the characteristics of what constitutes “merchandise.”

What is Transportation?

The concept of “transportation” is fundamental to the application of the Jones Act and the coastwise laws. As outlined in 19 C.F.R. § 4.80b, a coastwise transportation of merchandise occurs when merchandise is laden at a point embraced within the coastwise laws (*i.e.*, a “coastwise point”) and unladen at another coastwise point, regardless of the origin or ultimate destination of the merchandise.

NOTE: As outlined in 46 U.S.C. § 55102, a non-coastwise-qualified vessel may not transport merchandise between coastwise points, either directly or via a foreign port.

EXAMPLE: Merchandise is laden onto a non-coastwise-qualified vessel in Maine and transported to St. John, Canada, where the merchandise is unladen and placed onto coastwise-qualified vessels for transportation to various ports on the East Coast of the United States. This scenario would violate the Jones Act because the non-coastwise-qualified vessel transported merchandise between coastwise points, albeit via a foreign port.[6]

NOTE: 46 U.S.C. § 55102 also provides that a non-coastwise-qualified vessel may not conduct "any part" of the transportation of merchandise between coastwise points.

EXAMPLE: A tugboat that is being built in Panama City, Florida, is laden on board a non-coastwise-qualified barge and transported into international waters where the barge submerges and the tug is launched into the water; a coastwise-qualified vessel then tows the tugboat back to Panama City, Florida. This scenario would violate the Jones Act because the non-coastwise-qualified barge took part in the transportation of merchandise (the tug boat) between two coastwise points.[7]

Situations in Which No Transportation Occurs

New and Different Products

As specified in 19 C.F.R. § 4.80b(a), merchandise is not transported coastwise if at an intermediate port or place (that is at a foreign port or place, or at a port or place in a U.S. territory or possession not subject to the coastwise laws), it is manufactured into a new and different product, and the new and different product is thereafter transported to a coastwise point.[8]

EXAMPLE: A non-coastwise-qualified vessel moves a shipment of cattle from Hawaii to Vancouver, British Columbia, Canada, where the cattle are slaughtered, dressed, packed, and then shipped onboard another non-coastwise-qualified vessel to Washington State. The cattle are manufactured to a new and different product; therefore, no "transportation" occurs.[9]

EXAMPLE: A non-coastwise-qualified vessel moves a shipment of iron ore pellets from Duluth, Minnesota, to Nanticoke, Ontario, Canada, where the pellets are sorted to separate large pellets from small pellets. The large pellets are fed into a blast furnace and the small pellets are then shipped onboard another non-coastwise-qualified vessel to Gary, Indiana. Merely sorting pellets by size does

[6] *See* HQ 111767 (Oct. 25, 1991).
[7] See HQ H173946 (Apr. 13, 2016).
[8] 19 C.F.R. § 4.80b(b) further specifies that interested parties may request an advisory ruling from CBP as to whether a specific action taken or to be taken with respect to merchandise at an intermediate foreign port or place will result in the creation of a new and different product. Such a request shall be filed in accordance with 19 C.F.R. § 177, as discussed below.
[9] HQ 112038 (Mar 3, 1992).

not constitute manufacture into a new and different product; this scenario therefore constitutes "transportation" under the Jones Act.[10]

Continuity of Transportation

Merchandise is transported if it is laden at one coastwise point and unladen at another point, regardless of the origin or ultimate destination of the merchandise.[11] However, when merchandise is transported in a non-coastwise-qualified vessel from one coastwise point to a foreign port and subsequently returned to the United States "without existing intent on the part of those responsible for the transportation that [the merchandise] shall be transshipped to an American port...[w]hether the subsequent transportation of such [merchandise] to an American port is a violation of [section 55102] must be determined by the existing facts in each case."[12]

EXAMPLE: Grain sold to buyers in Japan is transported on board a non-coastwise-qualified vessel from a U.S. port to Kagoshima, Japan, where it is denied entry by the Japanese government and returned to a U.S. port by a different non-coastwise-qualified vessel. The seller subsequently provides evidence establishing that it had intended to enter the merchandise into the commerce of Japan. As such, the continuity of transportation is broken and no violation of the Jones Act occurs.[13]

Lifting Operations

CBP has also interpreted the Jones Act and the underlying regulations such that certain lifting operations do not constitute transportation under the Jones Act. CBP has long held that the use of a non-coastwise-qualified crane vessel to load and unload cargo or to construct/dismantle a marine vessel is not coastwise transportation and does not violate the Jones Act provided that any movement of merchandise is effected exclusively by the crane and not by any movement of the vessel, except for necessary movement that is incidental to a lifting operation.

EXAMPLE: No Jones Act violation occurs when a non-coastwise-qualified crane barge lifts stones at one coastwise point, swivels its crane, and deposits the stones at another coastwise point. Although the barge remains anchored during the operation, it is jostled by wave action and the movement of its crane arm.[14] Such "movement" does not constitute transportation.

EXAMPLE: No Jones Act violation occurs when a non-coastwise-qualified lifting vessel lifts merchandise from one coastwise point, pivots 90 degrees on its axis

[10] HQ H261457 (May 7, 2015).
[11] 19 C.F.R. § 4.80b(a).
[12] HQ H117395 (Aug. 9, 2010) (citing HQ 100381 (Feb. 23, 1973)).
[13] HQ 116518 (Aug. 9, 2005).
[14] HQ 115212 (Nov. 16, 2002).

while the merchandise is suspended, and lowers the merchandise into place at another coastwise point.[15]

CBP has also clarified that certain lateral movements that are incidental to an offshore lifting operation do not constitute transportation pursuant to the Jones Act. The term "offshore lifting operations" includes the lifting by cranes, winches, lifting beams, or other similar activities or operations, from the time that the lifting activity begins when unlading from a vessel or removing offshore facilities or subsea infrastructure until the time that the lifting activities can be safely terminated. Such lifting operations may include any of the following:

(1) the initial vertical movement of an item from a lower position to a higher position, and any additional vertical or lateral movement effected by a vessel's lifting equipment or by the vessel itself that is necessary to safely place into position or to remove an item from the vicinity of an existing structure, facility or installation. This includes incidental movement of the vessel occurring while lifted items are temporarily placed on the deck of the lifting vessel as needed for the safety of the item, surface and subsea infrastructure, and the vessels and mariners involved;

(2) any lateral movement of the vessel or the item in the vicinity of the structure or facility where the item is being positioned or removed that is merely subordinate to and a direct consequence of the lifting operation; or

(3) any lateral movement in the lift operations area that is necessary for safety and practical concerns, including the physical demands of the lifting operations, the mitigation of risk to human life and health, and the avoidance of damage to the nearby surface and subsea infrastructure.[16]

Where Does the Jones Act Apply?

Points in the United States, Including its Island Territories and Possessions

The Jones Act prohibits the transportation of merchandise between points in the United States (including the island territories and possessions of the United States), even points within a harbor, either directly or via a foreign port, or for any part of the transportation, in any vessel other than one that is coastwise qualified.[17]

[15] HQ H242466 (July 3, 2013).
[16] *See* "Modification and Revocation of Ruling Letters Relating to CBP's Application of the Jones Act to the Transportation of Certain Merchandise and Equipment Between Coastwise Points," *Customs Bulletin*, Vol. 53, No. 45 (Dec. 11, 2019).
[17] 46 U.S.C. § 55101(a); 19 C.F.R. § 4.80(a).

EXAMPLE: A Jones Act violation occurs when merchandise is laden onboard a non-coastwise-qualified vessel in Sacramento and is transported to Seattle, where the merchandise is unladen.

EXAMPLE: A Jones Act violation occurs when merchandise is laden onboard a non-coastwise-qualified vessel in Baltimore harbor and it is transported to another berth in that same harbor, where the merchandise is unladen.

EXCEPTION: The Jones Act does not apply to American Samoa, the Commonwealth of the Northern Mariana Islands (CNMI), or the U.S. Virgin Islands.[18] Although CNMI is typically excluded from the Jones Act, this exclusion does not extend to the activities of the U.S. government and its contractors or to the transportation of U.S. government cargo.[19]

Points within the United States Three-Mile Territorial Sea

The Jones Act applies to the territorial sea, defined as the waters, three nautical miles wide, adjacent to the U.S. coast and seaward of the territorial sea baseline.[20] As such, the transportation of merchandise entirely between points within territorial waters is considered coastwise trade subject to the coastwise laws.

EXAMPLE: A Jones Act violation would occur when merchandise is laden onboard a non-coastwise-qualified vessel located within U.S. territorial waters (anchored or unanchored) and is then transported to a U.S. port where it is unladen.

Points within the United States Inland Waterways

The Jones Act applies to points located in internal waters, landward of the territorial sea baseline, including navigable waters.[21]

Points on the Outer Continental Shelf

The Jones Act also applies to points on the Outer Continental Shelf (OCS) under the Outer Continental Shelf Lands Act (OCSLA),[22] which extends the laws of the United States to:

- The subsoil and seabed of the OCS.
- All artificial islands, and all installations and other devices permanently or temporarily attached to the seabed, which may be erected thereon for the purpose of exploring for, developing, or producing resources therefrom to the

[18] 46 U.S.C. § 55101(b).
[19] HQ 112917 (Oct. 19, 1993).
[20] 33 C.F.R. § 2.22(a)(2).
[21] HQ 111275 (Nov. 13, 1990).
[22] 43 U.S.C. § 1333.

same extent as if the OCS were an area of exclusive federal jurisdiction within a state.

- Any such installation or other device (other than a ship or vessel) for the purpose of transporting such resources.[23]

EXAMPLE: Under the OCSLA, the Jones Act is extended to artificial islands and similar structures, as well as to mobile oil drilling rigs, drilling platforms, and other devices attached to the seabed of the OCS for the purpose of resource extraction and/or exploration operations. This includes drilling rigs located on the OCS, which are considered points or places in the United States for purposes of the Jones Act. Similarly, floating, anchored warehouse vessels, when anchored on the OCS to supply drilling rigs on the OCS, are also coastwise points.[24]

When is a Vessel Qualified to Engage in Coastwise Transportation (*i.e.*, coastwise-qualified)?

Although CBP determines whether the transportation activities are considered coastwise trade, whether the vessel itself is *qualified* to engage in coastwise trade is determined by the United States Coast Guard, National Vessel Documentation Center (NVDC). The NVDC determines vessel eligibility for coastwise endorsements and issues certificates of documentation.[25] This section discusses the general requirements that a vessel must meet in order to be considered "coastwise-qualified." If a vessel is coastwise-qualified, it may engage in the coastwise trade, including transporting merchandise between coastwise points. In general, a coastwise-qualified vessel must be U.S.-built, owned, and documented with a coastwise endorsement.

U.S.-Built

The vessel must be built in the United States.[26]

NOTE: A U.S.-built vessel will lose its eligibility to engage in the coastwise trade if it is sold foreign or placed under foreign registry (unless the vessel is 200 gross tons or less) or if it is rebuilt (unless the entire rebuilding is effected in the United States).[27] Rebuild determinations are made by the United States Coast Guard.

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[23] 19 C.F.R. § 4.80b(a). *See Demette v. Falcon Drilling*, 280 F.3d 492 (5th Cir. 2002).
[24] HQ 112387 (July 23, 1992).
[25] Questions regarding the eligibility of a vessel for documentation should be addressed to NVDC at the NVDC website.
[26] 46 U.S.C. § 12112.
[27] 19 C.F.R. § 4.80(e).

Owned by a U.S. Citizen

The vessel must be owned by a U.S. citizen, an entity (*e.g.*, partnership, corporation) owned and controlled by U.S. citizens and incorporated in the United States, or a federal or state government entity.[28]

Documented by the U.S. Coast Guard with a Coastwise Endorsement

In order to be issued a certificate of documentation, the vessel must be:

(1) Owned by a U.S. citizen or another eligible owner listed in 46 U.S.C. § 12103(b);
(2) At least five net tons; and
(3) Not documented under the laws of a foreign country.[29]

In addition, a coastwise-qualified vessel must have a coastwise endorsement on its certificate of documentation.[30]

EXCEPTIONS:

Vessels of less than five net tons will not be documented by the U.S. Coast Guard.[31] For those vessels to engage in coastwise transportation, they must, except for their tonnage, otherwise be entitled to be documented with a coastwise endorsement.[32]

In addition, a certificate of documentation and appropriate endorsement may be issued for a vessel that—(1) is owned by a Bowaters corporation; (2) was built in the United States; and (3) is self-propelled and less than 500 gross tons or is not self-propelled. The term "Bowaters corporation" relates to certain U.S. corporations primarily engaged in the manufacturing or mineral industries.[33]

NOTE: The U.S. Coast Guard's NVDC determines documentation and endorsement eligibility. Please contact the NVDC at the NVDC website.

What is Merchandise?

Vessels that are coastwise-qualified may transport ""merchandise" between coastwise points without violating the Jones Act. Non-coastwise-qualified vessels, however, are not permitted to transport "merchandise" between coastwise points.

[28] 46 U.S.C. § 12103(b).
[29] 46 U.S.C. § 12103.
[30] 46 U.S.C. § 12112.
[31] 46 U.S.C. § 12103.
[32] 19 C.F.R. § 4.80(a)(2).
[33] 46 U.S.C. § 12118.

Merchandise Defined

The text of the Jones Act, 46 U.S.C. § 55102, defines the term "merchandise" to include—(1) merchandise owned by the United States government, a State, or a subdivision of a State; and (2) valueless material. 19 U.S.C. § 1401(c) further defines "merchandise" to mean goods, wares, and chattels of every description, and includes merchandise the importation of which is prohibited, and monetary instruments.

Goods Not Considered Merchandise

Sea Stores and Vessel Equipment

Customs law recognizes that certain, limited categories of items do not constitute "merchandise" under the Jones Act. Sea stores (*i.e.*, supplies for the consumption, sustenance, and medical needs of the crew and passengers during the voyage) are not considered merchandise.[34]

Similarly, equipment of the transporting vessel (*i.e.*, "vessel equipment") is not considered merchandise, nor is the baggage or personal effects of crew or passengers. Vessel equipment includes "portable items necessary and appropriate for the navigation, operation or maintenance of a vessel and for the comfort and safety of the persons on board."[35]

The determination of whether an item constitutes "vessel equipment" is a highly particularized and fact-specific one. Items considered "necessary and appropriate for the operation of the vessel" are those items that are integral to the function of the vessel and are carried by the vessel. These items *may* include, for example, those items that aid in the installation, inspection, repair, maintenance, surveying, positioning, modification, construction, decommissioning, drilling, completion, workover, abandonment or other similar activities or operations of wells, seafloor or subsea infrastructure, flow lines, and surface production facilities. CBP also emphasizes that the fact that an item is returned to and departs with the vessel after an operation is completed, and is not left behind on the seabed, is a factor that weighs in favor of an item being classified as vessel equipment, but is not a sole determinative factor.[36]

STATUTORY EXCEPTIONS

Several narrow exceptions to the Jones Act are codified into law under Title 46 of the U.S. Code. These include the following:

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[34] *See* Treasury Decision (T.D.) 40934 (1925).
[35] *See* T.D. 49815(4) (1939).
[36] *See* "Modification and Revocation of Ruling Letters Relating to CBP's Application of the Jones Act to the Transportation of Certain Merchandise and Equipment Between Coastwise Points," *Customs Bulletin,* Vol. 53, No. 45 (Dec. 11, 2019).

46 U.S.C. § 55105(b) - Transportation of Hazardous Waste

Although the transportation of hazardous waste is deemed to be transportation pursuant to the Jones Act, this section provides narrow circumstances in which non-coastwise-qualified vessels may transport hazardous waste between coastwise points.

46 U.S.C. § 55106 – Merchandise Transferred Between Barges

Under specified circumstances, merchandise may be transferred between non-coastwise-qualified barges owned or leased by the same owner if reciprocal treatment is extended to U.S. vessels by the vessels' state of registry.

46 U.S.C. § 55107 – Empty Cargo Containers and Barges

In general, the Jones Act does not apply to the transportation of empty cargo vans, empty lift vans, or empty shipping tanks; equipment for use with cargo vans, lift vans, or shipping tanks; empty barges specifically designed for carriage aboard a vessel and equipment (except propulsion equipment) for use with those barges; empty instruments of international traffic (IIT); stevedoring equipment and material, if the government of the nation of the vessel's registry extends reciprocal privileges to vessels of the United States.

46 U.S.C. § 55108 – Platform Jackets

The Jones Act does not apply to the transportation of certain "platform jackets" in or on a non-coastwise-qualified launch barge between two coastwise points, at one of which there is an installation or other device within the meaning of the OCLSA.

46 U.S.C. § 55113 – Use of Foreign Documented Oil Spill Response Vessels

An oil spill response vessel documented under the laws of a foreign country may operate in waters of the United States on an emergency basis, for the purpose of recovering, transporting, and unloading in a U.S. port oil discharged as a result of an oil spill in or near those waters, if an adequate number and type of U.S. coastwise-qualified oil spill response vessels are unavailable and the foreign country extends reciprocal privileges to U.S. vessels.

46 U.S.C. § 55116 – Canadian Rail Lines

The Jones Act does not apply to the transportation of merchandise between points in the continental United States, including Alaska, over through routes in part over Canadian rail lines and connecting water facilities if the routes are recognized by the Surface Transportation Board and rate tariffs for the routes have been filed with the board.

46 U.S.C. § 55117 – Great Lakes Rail Route

Under certain circumstances, the Jones Act does not apply to the transportation of merchandise loaded on a railroad car or certain motor vehicles when the railroad car or vehicle is transported in a railroad car ferry operating between fixed terminals on the Great Lakes as part of a rail route.

46 U.S.C. § 55119 – Yukon River

The Jones Act does not apply to the transportation of merchandise on the Yukon River until the Alaska Railroad is completed and the Secretary of Transportation determines that facilities are available for transportation by U.S. citizens to properly handle the traffic.

46 U.S.C. § 55121 – Transportation of Merchandise and Passengers on Canadian Vessels

Until the Secretary of Transportation determines that suitable U.S. vessels are available, the Jones Act does not restrict the transportation on Canadian vessels of merchandise between Hyder, Alaska, and other points in southeastern Alaska or in the United States outside of Alaska.

46 U.S.C. § 55122 – Floating Dry Docks

The Jones Act does not apply to the movement of a floating dry dock if the dry dock is being used to launch or raise a vessel in connection with the construction, maintenance and repair of that vessel, and the dry dock is owned and operated by an "eligible owner" defined under 46 U.S.C. § 12103(b) (*i.e.*, certain U.S. persons or corporate entities) or an affiliate thereof, and was owned or contracted for purchase by such shipyard or affiliate prior to 2015.

PENALTY FOR JONES ACT VIOLATIONS

CBP may issue a penalty under the Jones Act against any person transporting the merchandise or causing the merchandise to be transported in violation of the Jones Act. Such parties may submit a petition for relief from these penalties at the port where the penalty was issued. The port may cancel or mitigate the penalty.

Penalty

- A monetary amount equal to the value of the merchandise or the actual cost of the transportation, whichever is greater.
- Issued to any person transporting the merchandise or causing the merchandise to be transported.

Petition

- Only the party against whom a penalty was issued or its legal representative/agent may petition for relief from a penalty issued for a Jones Act violation.
- Filed at the CBP Port from which the penalty was issued.
- Filed *after* the penalty has been issued.
- May contain a request that the penalty be canceled or that the monetary amount of the penalty be mitigated to a lower amount.
    - CBP may remit without payment any Jones Act penalty if there is satisfactory evidence that the violation occurred as a direct result of an arrival of the transporting vessel in distress.
    - Mitigation Requests: CBP has the sole authority to mitigate penalties at its discretion. Please review the Informed Compliance Publication on Mitigation Guidelines for additional information.

NOTE: IMPORTANT- MITIGATION IS NOT A WAIVER OF THE JONES ACT.

JONES ACT RULING REQUESTS

Jones Act ruling letters are binding guidance from CBP as to whether the transportation of material by a non-coastwise-qualified vessel would result in a violation of 46 U.S.C. § 55102. The requester or other entities with identical circumstances may rely on the ruling and the ruling will govern how CBP will treat the specific transaction outlined in the ruling letter. Jones Act ruling letters are **not mandatory**.

Who May Submit a Ruling Request

Jones Act rulings are binding only on the parties to the subject transaction and on CBP. CBP will accept Jones Act ruling requests from vessel owners and operators, the person or entity causing the merchandise to be carried (*e.g.*, the purchaser of the subject merchandise), the owner of the subject merchandise, or agents of such parties (*e.g.*, vessel agents, legal representatives, customs brokers).

When to Submit a Ruling Request

Requests must be submitted **prior to the date of the proposed transportation.**

Where to Submit a Ruling Request

Requests for Jones Act rulings may be submitted to the following address:

U.S. Customs and Border Protection

Chief, Cargo Security, Carriers and Restricted Merchandise Branch
Regulations and Rulings
Office of Trade
90 K Street, NE, 10th Floor
Washington, DC 20229

Ruling requests may also be submitted via email to the Branch Chief, Cargo Security, Carriers, and Restricted Merchandise Branch, Regulations and Rulings or via https://erulings.cbp.gov/s/.

What Information to Include in a Ruling Request

- Vessel name, place of build, and nationality of registration
- Requester name, position, and company
- Requester telephone and email address
- A detailed description of the material to be transported
- Location at which the subject material will be laden on board the vessel
- Location at which the subject material will be unladen
- Dates of lading and unlading
- A detailed description of the proposed voyage, including every port or point on the itinerary[37]

Processing and Issuance of Ruling Letters

All ruling requests, including requests involving the Jones Act, will be processed in the order they are received, regardless of the lading or transportation date. In order to receive a ruling response prior to the proposed transportation of laden merchandise, it is recommended that ruling requests be submitted far in advance of the voyage to allow time for processing. Ruling requests are not processed on weekends or when the federal government is closed. Requests that do not provide the required information will experience delays in processing. All ruling letters will issued to the requester by electronic mail and will be published weekly on the Customs Rulings Online Search System.

Effect of Ruling Letters

- **Rulings do not waive compliance with the Jones Act and are not "waivers."**
- Rulings remain in effect until the law changes or until CBP modifies or revokes the ruling.

[37] Before submitting a request for a ruling, individuals are encouraged to review 19 C.F.R. Part 177 as well as the CBP Rulings Program Informed Compliance Publication: *What Every Member of the Trade Community Should Know About: U.S. Customs & Border Protection Rulings Program*, *available at* https://www.cbp.gov/document/publications/us-customs-and-border-protection-rulings-program.

- Rulings may be relied upon by different entities other than the requester only so long as the facts and circumstances of the issue being decided are identical.

  EXAMPLE: Company X proposes to transport plastic pellets onboard the M/V FLYING DUTCHMAN from New York to Baltimore, with an intervening stop in Ireland where the pellets will be melted and pressed into widgets. Company X hopes that the processing in Ireland will create a "new and different product." Company X does a search on the Customs Rulings Online Search System and finds a ruling involving another vessel in which the owners of the M/V DAVEY JONES proposed processing plastic pellets into widgets at an intervening foreign port. Company X may rely on this ruling because even though the vessel names are different, the facts relating to the processing of plastic pellets at an intermediate port or place are identical.

Situations in Which No Ruling Will Be Issued

- The request is no longer prospective. The request was submitted after the merchandise has been laden and the subject transportation began.
- The request submitted is incomplete and the additional information requested by CBP was submitted after the voyage begins or in insufficient time to allow processing prior to the voyage's start date.
- The request is a duplicate of a request submitted by another interested party to the voyage/transaction. For example, the vessel operator submits a request for a particular voyage and the vessel agent at the port of embarkation submits a request for the same voyage.
- The person/entity has not established that it has the authority to request a ruling on behalf of the vessel owner/operator.
- The vessel owner/operator has already received a penalty notice for violating the Jones Act (*see* Penalty section above).

To determine whether CBP has previously ruled on a particular Jones Act issue, please visit the Customs Rulings Online Search System.

WAIVERS OF THE NAVIGATION LAWS

The navigation laws, including the Jones Act, can be waived by the Secretary of Homeland Security only if two requirements are met:

- The transportation requested must be "necessary in the **interest of national defense,"** and

- The Maritime Administration at the Department of Transportation has confirmed that there **are no coastwise-qualified vessels available** to conduct the transportation.[38]

CBP processes all requests to waive the Jones Act. To assist CBP with the processing of the request, the following information should be included in the request:

- Vessel name.
- Ports and dates of lading and unlading.
- A description of the merchandise to be transported onboard the vessel.
- An explanation why the transportation is necessary and in the interest of national defense.

NOTE: A request to waive the Jones Act should be submitted prior to the proposed transportation, i.e., lading and transportation of the subject merchandise. CBP strongly encourages potential requesters to contact the Maritime Administration prior to submitting a request to determine if there are any coastwise-qualified vessels available to conduct the transportation sought. Requests for a Jones Act waiver may be submitted to CBP's Jones Act waiver inbox at jonesactwaiverrequest@cbp.dhs.gov.

[38] 46 U.S.C. § 501(b). Waivers under 46 U.S.C. § 501(a) are within the jurisdiction of the Secretary of Defense.

WEBSITE APPENDIX

Passenger Vessel Services Act Informed Compliance Publication:
https://www.cbp.gov/sites/default/files/assets/documents/2019-Sep/PVSA-ICP.pdf

Mitigation Guidelines Informed Compliance Publication:
https://www.cbp.gov/trade/publications/informed-compliance-publication-mitigation-guidelines-fines-penalties-forfeitures-and

What Every Member of the Trade Community Should Know About: U.S. Customs and Border Protection Rulings Program:
https://www.cbp.gov/document/publications/us-customs-and-border-protection-rulings-program

Customs Rulings Online Search System (CROSS):
https://rulings.cbp.gov/home

CBP Headquarters Ruling HQ H287418 (Jun. 19, 2017):
https://rulings.cbp.gov/ruling/H287418

CBP Headquarters Ruling HQ H111767 (Oct. 25, 1991):
https://rulings.cbp.gov/ruling/111767

CBP Headquarters Ruling HQ H173946 (Apr. 13, 2016):
https://rulings.cbp.gov/ruling/H273946

CBP Headquarters Ruling HQ 112038 (Mar. 3, 1992):
https://rulings.cbp.gov/ruling/112038

CBP Headquarters Ruling HQ H261457 (May 7, 2015):
https://rulings.cbp.gov/ruling/H261457

CBP Headquarters Ruling HQ H117395 (Aug. 9, 2010):
https://rulings.cbp.gov/ruling/H117395

CBP Headquarters Ruling HQ 116518 (Aug. 9, 2005):
https://rulings.cbp.gov/ruling/116518

CBP Headquarters Ruling HQ 115212 (Nov. 16, 2002):
https://rulings.cbp.gov/ruling/115212

CBP Headquarters Ruling HQ H242466 (July 3, 2013):
https://rulings.cbp.gov/ruling/H242466

CBP Headquarters Ruling HQ 112917 (Oct. 19, 1993):
https://rulings.cbp.gov/ruling/112917

CBP Headquarters Ruling HQ 111275 (Nov. 13, 1990):
https://rulings.cbp.gov/ruling/111275

CBP Headquarters Ruling HQ 112387 (July 23, 1992):
https://rulings.cbp.gov/ruling/112387

Modification and Revocation of Ruling Letters Relating to CBP's Application of the Jones Act to the Transportation of Certain Merchandise and Equipment Between Coastwise Points, Customs Bulletin, Vol. 53, No. 45 (Dec. 11, 2019):
https://www.cbp.gov/sites/default/files/assets/documents/2019-Dec/Vol_53_No_45_Title.pdf

U.S. Coast Guard National Vessel Documentation Center (NVDC) Website:
https://www.dco.uscg.mil/Our-Organization/Deputy-for-Operations-Policy-and-Capabilities-DCO-D/National-Vessel-Documentation-Center/

ADDITIONAL INFORMATION

The Internet

The CBP homepage provides the trade community with current, relevant information regarding CBP operations and items of special interest. The site posts information—which includes proposed regulations, news releases, publications and notices, etc.—that can be searched, read online, printed or downloaded to your personal computer. The website was established as a trade-friendly mechanism to assist the importing and exporting community. The website also links to the homepages of many other agencies whose importing or exporting regulations CBP helps to enforce. The website also contains a wealth of information of interest to a broader public than the trade community. For instance, the "Know Before You Go" publication and traveler awareness campaign are designed to help educate international travelers.

The web address of U.S. Customs and Border Protection is http://www.cbp.gov.

CBP Regulations

The current edition of CBP Regulations is a loose-leaf, subscription publication available from the Superintendent of Documents, U.S. Government Printing Office, via the internet, phone, fax, postal mail, or email. Internet: http://bookstore.gpo.gov and https://www.ecfr.gov. Phone: DC Metro Area: (202) 512-1800, Toll-Free: (866) 512-1800, Monday through Friday, 8 a.m. – 4:30 p.m. EST, Fax: (202) 512-2104. Mail: U.S. Government Printing Office, P.O. Box 979050, St. Louis, MO 63197-9000. Email: ContactCenter@gpo.gov. A bound edition of Title 19, Code of Federal Regulations, is also available for sale from the same address. All proposed and final regulations are published in the Federal Register, which is published daily by the Office of the Federal Register, National Archives and Records Administration, and distributed by the Superintendent of Documents. Information about online access to the Federal Register may be obtained by calling (202) 512-1530 between 8 a.m. and 4:30 p.m. EST. The Federal Register is available online at https://www.federalregister.gov/. These notices are also published in the weekly Customs Bulletin described below.

Customs Bulletin

The Customs Bulletin and Decisions (Customs Bulletin) is a weekly publication that contains decisions, rulings, regulatory proposals, notices and other information of interest to the trade community. It also contains decisions issued by the U.S. Court of International Trade, as well as customs-related decisions of the U.S. Court of Appeals for the Federal Circuit. The Customs Bulletin is available online at https://www.cbp.gov/document/bulletins.

Importing Into the United States

This publication provides an overview of the importing process and contains general information about import requirements. The current edition of **Importing Into the United States** contains material explaining the requirements of the Mod Act. The Mod Act fundamentally altered the relationship between importers and CBP by shifting to the importer the legal responsibility for declaring the value, classification, and rate of duty applicable to entered merchandise.

The current edition contains a section entitled "Informed Compliance." A key component of informed compliance is the shared responsibility between CBP and the import community, wherein CBP communicates its requirements to the importer, and the importer, in turn, uses reasonable care to assure that CBP is provided accurate and timely data pertaining to the importation.

Single copies may be obtained from local offices of CBP, or from the Office of Public Affairs, U.S. Customs and Border Protection, 1300 Pennsylvania Avenue NW, Washington, DC 20229. An online version is available at the CBP website.

Informed Compliance Publications

CBP has prepared a number of Informed Compliance publications in the "*What Every Member of the Trade Community Should Know About:…"* series. Check the website https://www.cbp.gov/ for current publications.

Value Publications

Customs Valuation Encyclopedia (with updates) is comprised of relevant statutory provisions, CBP Regulations implementing the statute, portions of the Customs Valuation Code, judicial precedent, and administrative rulings involving application of valuation law. This publication may also be found online.

> The information provided in this publication is for general information purposes only. Recognizing that many complicated factors may be involved in customs issues, an importer may wish to obtain a ruling under CBP Regulations, 19 C.F.R. Part 177, or obtain advice from an expert (such as a licensed customs broker, an attorney or a customs consultant) who specializes in customs matters. Reliance solely on the general information in this pamphlet may not be considered reasonable care.

Additional information may also be obtained from CBP's ports of entry. Please consult the CBP website for an office near you. Contact information for ports of entry can also be found on the internet at https://www.cbp.gov/contact/ports.

"Your Comments are Important"

The Small Business and Regulatory Enforcement Ombudsman and 10 regional Fairness Boards were established to receive comments from small businesses about federal agency enforcement activities and rate each agency's responsiveness to small business. If you wish to comment on the enforcement actions of U.S. Customs and Border Protection, call 1-888-REG-FAIR (1-888-734-3247).

REPORT SMUGGLING: 1-800-BE-ALERT

Visit our website: http://www.cbp.gov

Appendix K
Jones Act – Logistics Inputs

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Jones Act – Logistics Inputs

Introduction

Logistics movement by ocean transport for the Port of Alaska (POA) project presents unique challenges with limited solutions. This appendix outlines both challenges and solutions to transport cargo from the Gulf Coat of the United States to the POA. For safety reasons, transportation from the Gulf Coast would pass through the Panama Canal. However, reviewing the construction capability of a West Coast option to avoid canal transport should be considered.

Jones Act

The first challenge is Jones Act compliance. The Jones Act is a federal law that regulates maritime commerce in the United States and requires goods shipped between United States ports to be transported on ships that are built, owned, and operated by United States citizens or permanent residents. Any non-United States vessel option would need to be granted a waiver by the U.S. Department of Homeland Security.

Vessels

Barge

Transporting the structures and cargo by barge offers a solution that more easily complies with Jones Act regulations and provides various United States-based options, but also presents unique challenges.

Benefits: Greater availability of United States-based fleet options in compliance with the Jones Act. Fleet operators, such as Foss Maritime, have experience handling similar projects in the Gulf and Alaska. Locally based operations allows in-person meetings with project teams to plan and coordinate for the project.

Concerns: Barges are not powered and are towed by tug. Separate crane gantry barges would need to be obtained and staged. For safety reasons, all transit would need to go through the Panama Canal, presenting concerns and challenges for non-powered vessels. Multiple barges likely would need to be used to complete transits.

Heavy-lift Vessel

Overview

Transporting the structures and cargo by vessels designed for the specific job offers a turnkey solution. Both Biglift Shipping (2022) and Jumbo Maritime (2022) provide options. Challenges are the lack of United States-flagged and -based fleet, which does not comply with Jones Act regulations.

Benefits: Offers powered vessels specifically designed to transit the cargo built for POA. Heavy-lift vessels (HLVs) incorporate gantry cranes on deck. They provide a dedicated sail from the chosen origin, POA, with powered transport through the Panama Canal. With HLVs, there is a better possibility to transport all cargo on single vessel.

Concerns: HLVs are not a Jones Act compliant fleet. Jacobs would need to secure a waiver to the Jones Act. HLVs would likely have to be repositioned from a possible foreign port empty and return to that origin port empty. Cost factors would be added to cover these transits. Lead time to secure vessels would need accurate planning with a foreign-based project team.

Jones Act Waiver

The U.S. Department of Transportation (DOT) Maritime Administration administers the Jones Act (DOT 2021). Jones Act exemptions are rare, as the only basis for an exemption is in the "interest of national defense."

There are two types of Jones Act waiver request processes: one for the Secretary of Defense and one for non-Defense entities. There are also other special exceptions allowed under Title 46 for non-United States flag allowances that could apply to obtain a waiver.

The process to apply for a waiver ruling should begin immediately and follow the guidance set forth by the Maritime Administration (DOT 2021).

Jacobs could make the case for a waiver under national defense or application of exceptions outlined in Title 46 of the United States Code (U.S.C.) 55105-55122. There could be a national defense (non-defense-related articles) justification to be made in that having to contract only non-powered ("tug pulled") Jones Act compliant barges, any incident involving a barge that could generate a loss of the cargo would directly affect POA operations and possibly shut down parts of the port. Transporting multiple tow-tugged barges through international waters compounds risks; whereas a single vessel transit under a waiver presents the best interests of national defense and security.

Jacobs could also look into the applicability of 46 U.S.C. 55108 and whether it were to apply to the jacket structures and related cargo under a Jones Act waiver. Planning on any waiver or use of an exception should be considered urgent and the process initiated immediately.

References

Biglift Shipping. 2022. "Encounter our versatile fleet." *Overview*. https://www.bigliftshipping.com/en/fleet/fleet-overview.

Jumbo Maritime. 2022. *Shipping Fleet*. https://www.jumbomaritime.nl/en/shipping/fleet/.

U.S. Department of Transportation (DOT). 2021. *Domestic Shipping*. Maritime Administration. August 10. https://www.maritime.dot.gov/ports/domestic-shipping/domestic-shipping.

Appendix L
Terminal 1 – Construction Approach Alternative – Heavy-lift Vessel Transportation and Installation Plans

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Terminal 1 – Construction Approach Alternative – Heavy-lift Vessel Transportation and Installation Plans

This appendix summarizes a construction approach using heavy-lift vessels (HLVs) for transportation and installation of the wharf substructure and superstructure modules. There are no Jones Act compliant HLVs available, so such an approach would require a waiver of the regulations to enable international vessels to transport cargo between two United States points.

This option could be viable should the module fabrication works be undertaken outside the United States, which would also need appropriate government and stakeholder acceptance. Regardless, this appendix summarizes transportation and lifting plans for the main construction modules.

It is estimated that the Terminal 1 (T1) construction works could be completed over seven voyages using the Biglift Happy Star for the 11 jacket substructure modules and 11 topside structure modules and all associated piles, pile caps, and precast panels.

Tables L-1 and L-2 summarize the voyage arrangements anticipated.

Table L-1. Terminal 1: Initial Construction Stage: 9 Substructure and 9 Superstructure Modules – 720-foot Wharf)

Construction Barge Voyage No.	Cargo	Cargo Stowage Plan
1	Three jacket substructure modules (J1, J2, J3) on the deck, and piles and pile caps beneath the deck	Refer to Figure L-1
2	Three jacket substructure modules (J4, J5, J6) on the deck, and piles and pile caps beneath the deck	Refer to Figure L-1
3	Three jacket substructure modules (J7, J8, J9) on the deck, and piles and pile caps beneath the deck	Refer to Figure L-1
4	Six wharf superstructure modules (W1, W2, W3, W4, W5, W6) on the deck, and precast concrete panels within the hold	Refer to Figure L-2
5	Three wharf superstructure modules (W7, W8, W9) on the deck, and precast concrete panels within the hold	Similar to Figure L-2

No. = number

Table L-2. Terminal 1: Final Construction Stage: 2 Substructure and 2 Superstructure Modules – Additional 160 ft of Wharf)

Construction Barge Voyage No.	Cargo	Cargo Stowage Plan
6	Two jacket substructure modules (J10, J11) on the deck, and piles and pile caps beneath the deck	Similar to Figure L-1
7	Two wharf superstructure modules (W10, W11) on the deck, and precast concrete panels within the hold	Similar to Figure L-2

Figures L-1 through L-5 demonstrate indicative stowage and lift plans.

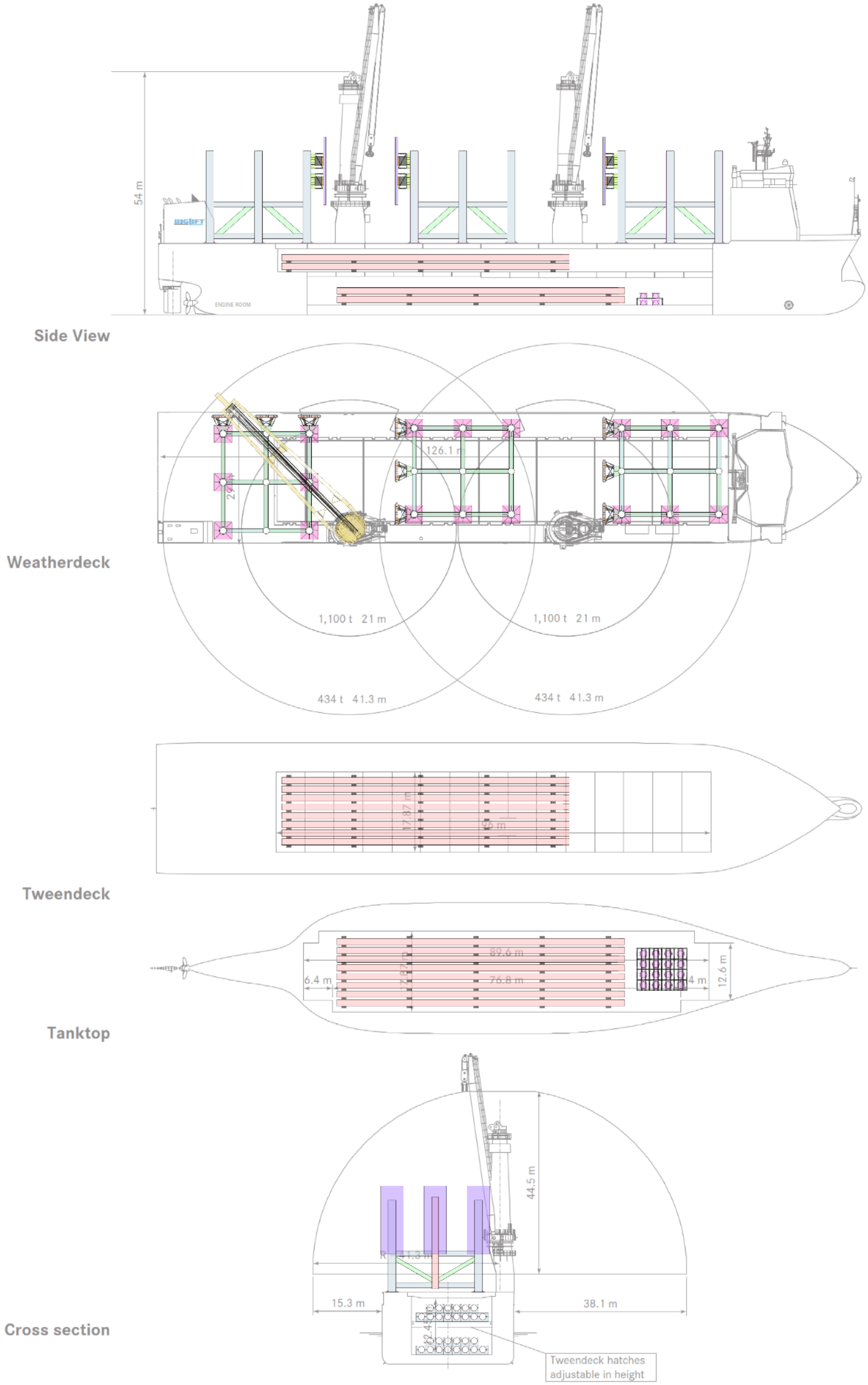

Figure L-1. Three Terminal 1 Jacket Substructure Modules and Pile Stowage Plan on HLV Happy Star

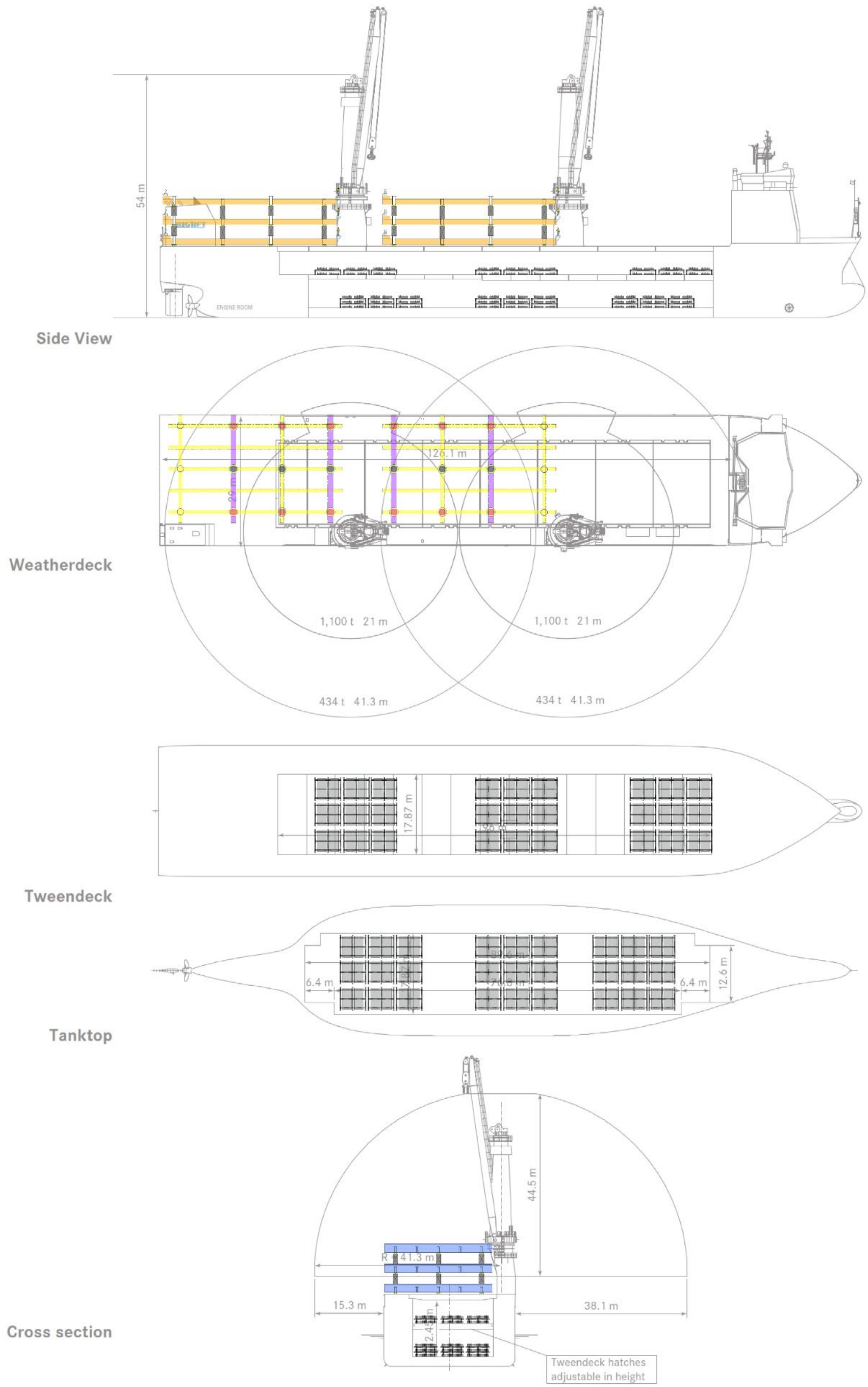

Figure L-2. Terminal 1 Wharf Superstructure Modules and Precast Panel Stowage Plan on HLV Happy Star

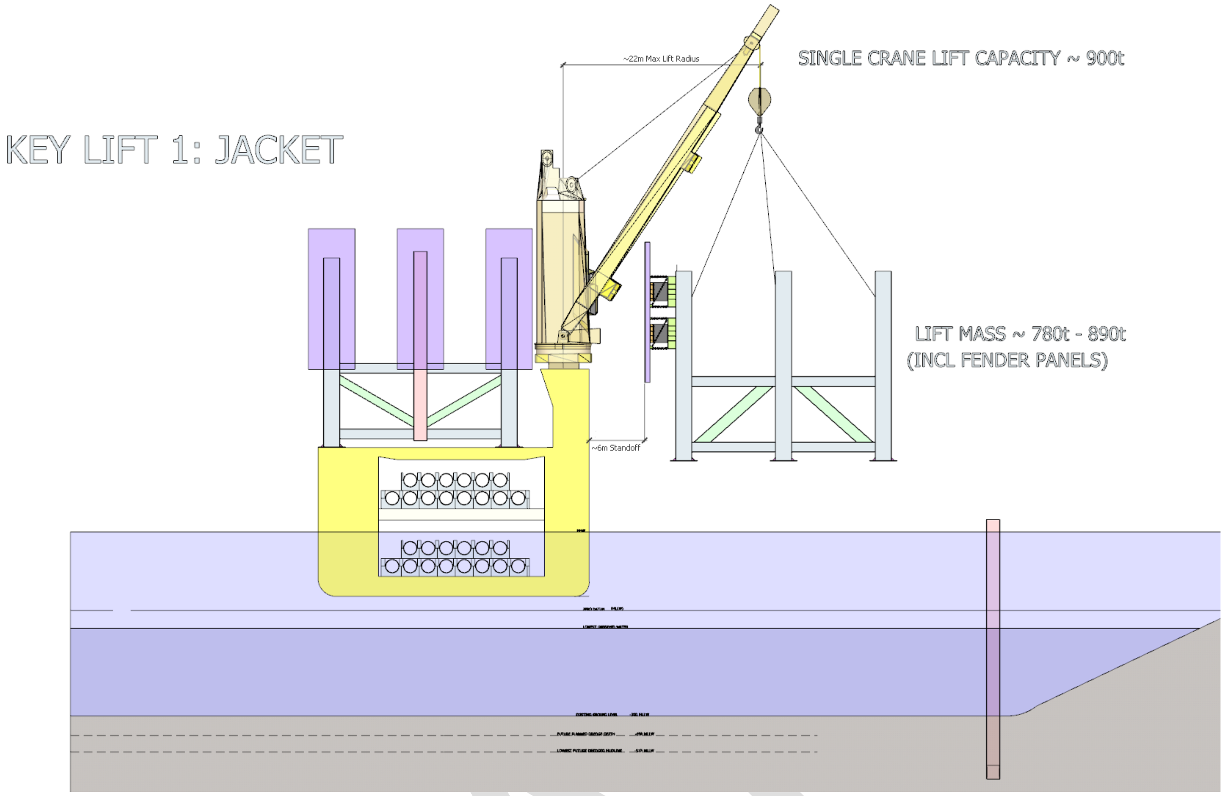

Figure L-3. Jacketed Substructure Module Installation Using HLV Happy Star

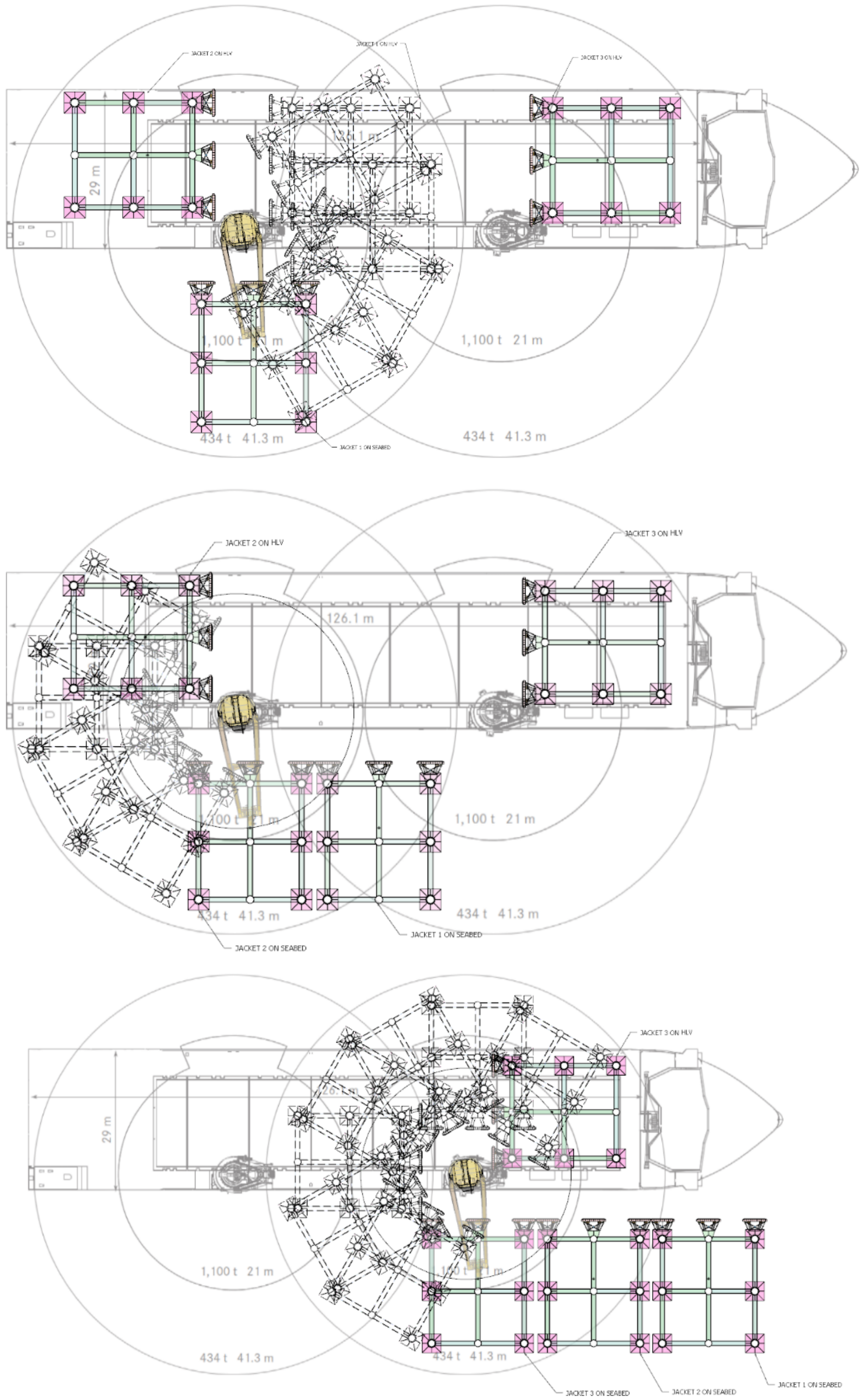

Figure L-4. Jacketed Substructure Module Installation Using HLV Happy Star – Voyage 1

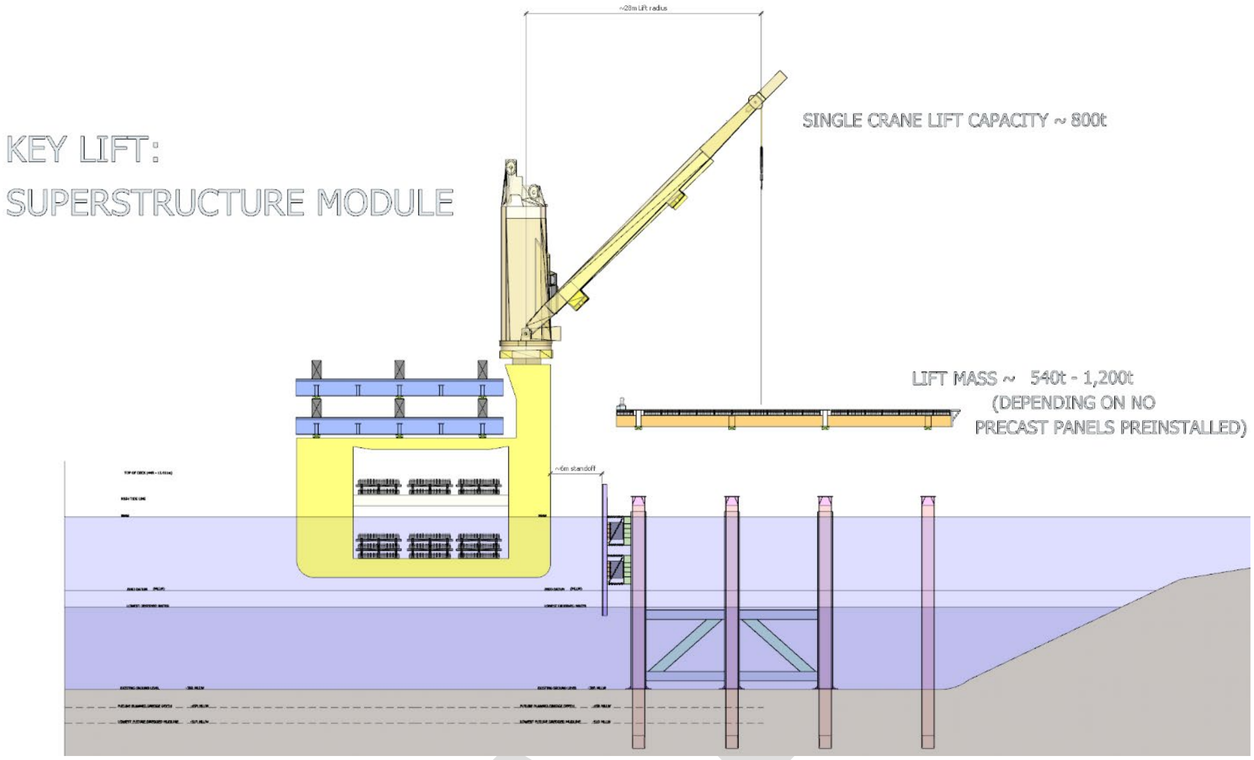

Figure L-5. Terminal 1 Superstructure Module Installation Using HLV Happy Star

Appendix M
Terminal 2 Jacket Sketches

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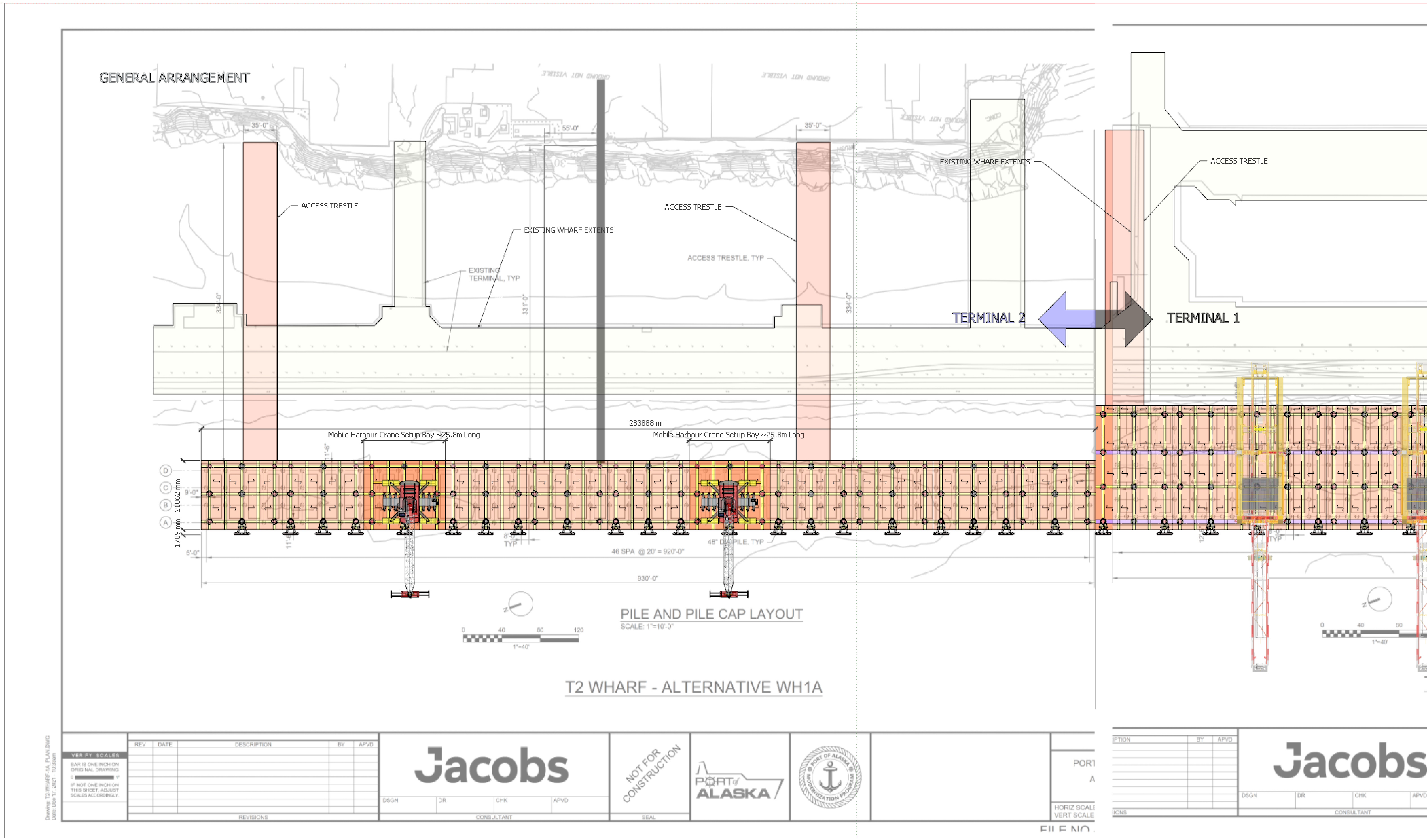
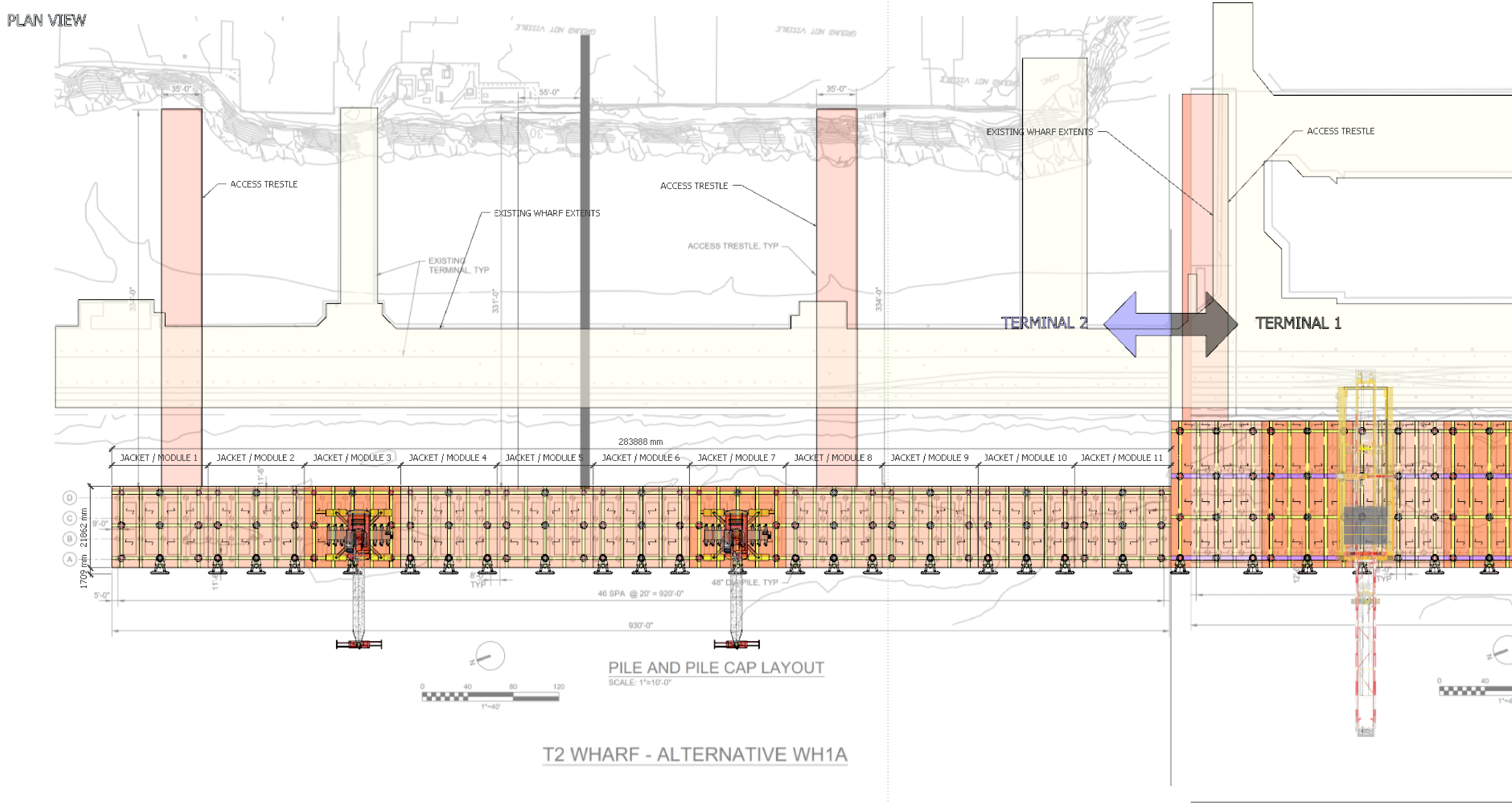
Challenging today.
Reinventing tomorrow.

TERMINAL 2 – Jacket Concept

Schematics 23 Dec 2021



GENERAL ARRANGEMENT
ACCESS TRESTLE
EXISTING WHARF EXTENTS
EXISTING TERMINAL, TYP
ACCESS TRESTLE, TYP
TERMINAL 2
TERMINAL 1
35'-0"
55'-0"
283888 mm
Mobile Harbour Crane Setup Bay ~25.8m Long
Mobile Harbour Crane Setup Bay ~25.8m Long
21862 mm
1703 mm
46 SPA @ 20' = 920'-0"
930'-0"
48" DIA PILE, TYP
PILE AND PILE CAP LAYOUT
SCALE: 1"=10'-0"
1"=40'
T2 WHARF - ALTERNATIVE WH1A
VERIFY SCALES
Jacobs
NOT FOR CONSTRUCTION
PORT of ALASKA



REV	DATE	DESCRIPTION	BY	APVD

REVISIONS

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

Jacobs

DSGN | DR | CHK | APVD

CONSULTANT

NOT FOR CONSTRUCTION

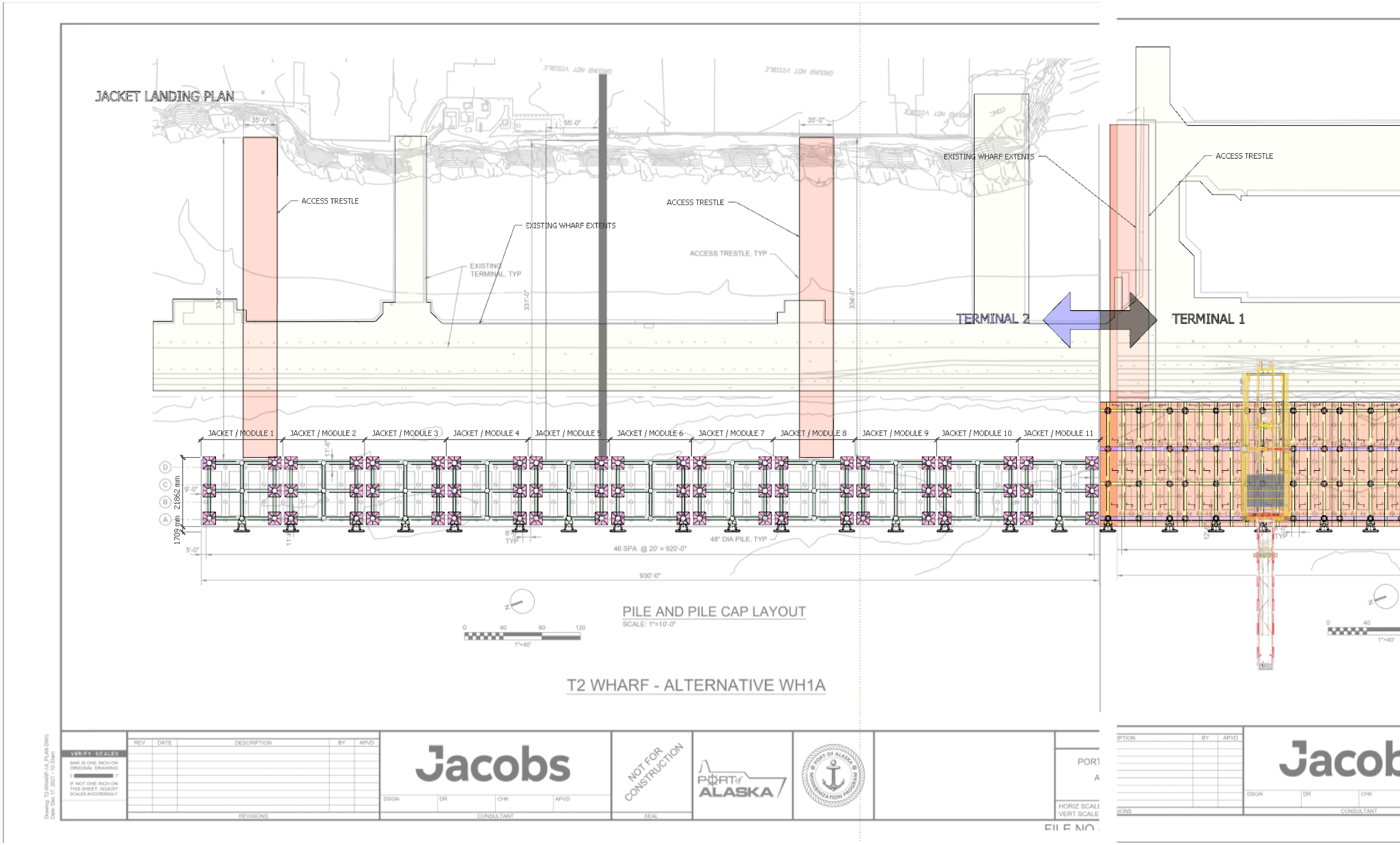
SEAL

PORT of ALASKA

PORT OF ALASKA MODERNIZATION PROGRAM

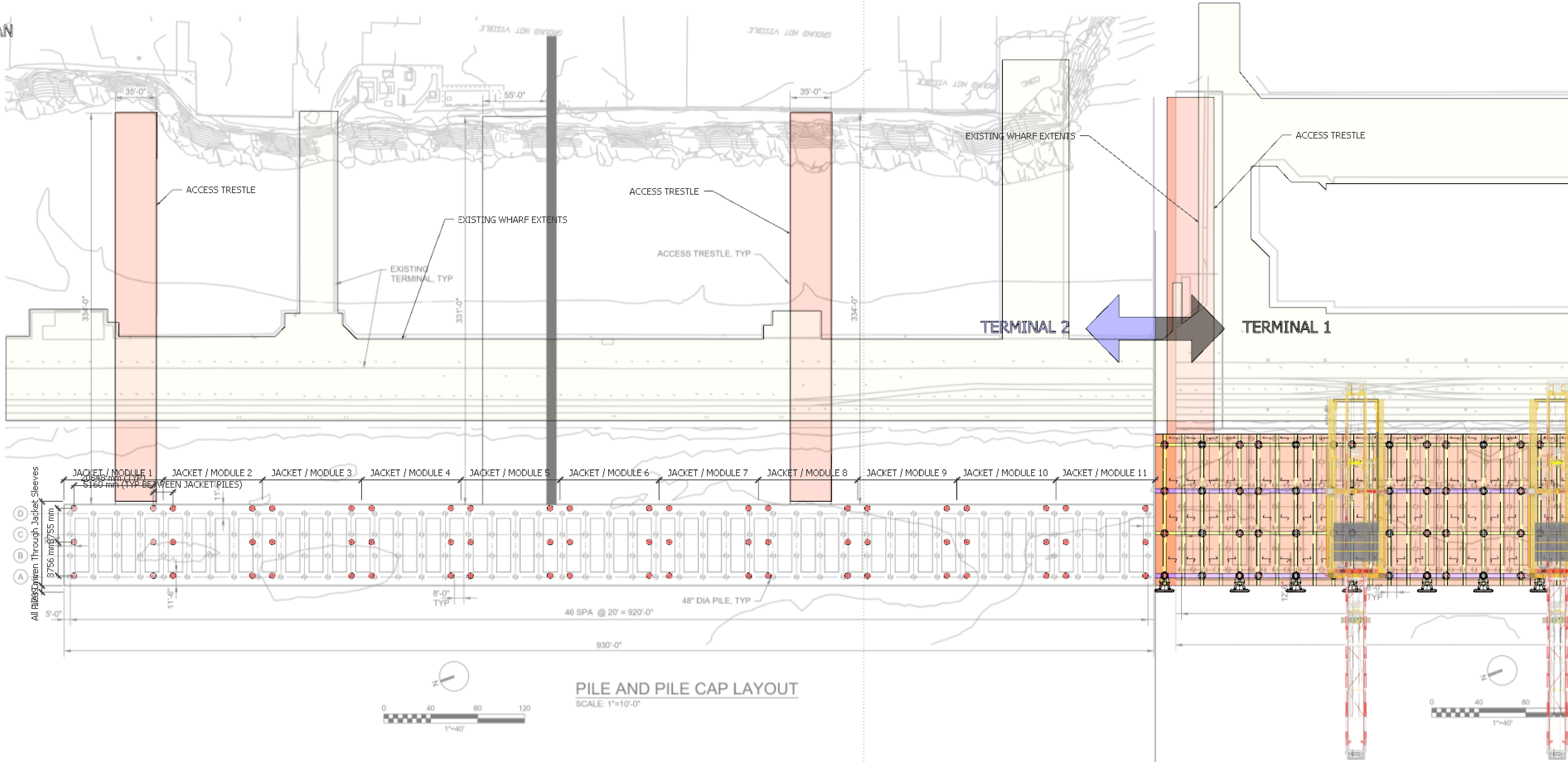
HORIZ SCALE
VERT SCALE
FILE NO.

Drawing: T2-WHARF-1A_PLAN.DWG
Date: Dec 17, 2021 - 10:33am



JACKET LANDING PLAN
35'-0"
55'-0"
ACCESS TRESTLE
EXISTING WHARF EXTENTS
EXISTING TERMINAL, TYP
ACCESS TRESTLE, TYP
334'-0"
331'-0"
TERMINAL 2
TERMINAL 1
JACKET / MODULE 1
JACKET / MODULE 2
JACKET / MODULE 3
JACKET / MODULE 4
JACKET / MODULE 5
JACKET / MODULE 6
JACKET / MODULE 7
JACKET / MODULE 8
JACKET / MODULE 9
JACKET / MODULE 10
JACKET / MODULE 11
21862 mm
1709 mm
9'-0"
5'-0"
8'-0" TYP
48" DIA PILE, TYP
46 SPA @ 20' = 920'-0"
930'-0"
PILE AND PILE CAP LAYOUT
SCALE: 1"=10'-0"
0 40 80 120
1"=40'
T2 WHARF - ALTERNATIVE WH1A
VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.
REV DATE DESCRIPTION BY APVD
REVISIONS
Jacobs
DSGN DR CHK APVD
CONSULTANT
NOT FOR CONSTRUCTION
SEAL
PORT of ALASKA
PORT OF ALASKA MODERNIZATION PROGRAM
HORIZ SCALE
VERT SCALE
FILE NO.
Drawing: T2-WHARF-1A_PLAN.DWG
Date: Dec 17, 2021 - 10:33am

PILE PLAN



PILE AND PILE CAP LAYOUT

SCALE: 1"=10'-0"

0 40 80 120
1"=40'

T2 WHARF - ALTERNATIVE WH1A

REV	DATE	DESCRIPTION	BY	APVD
		REVISIONS		

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
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SEAL

PORT of ALASKA

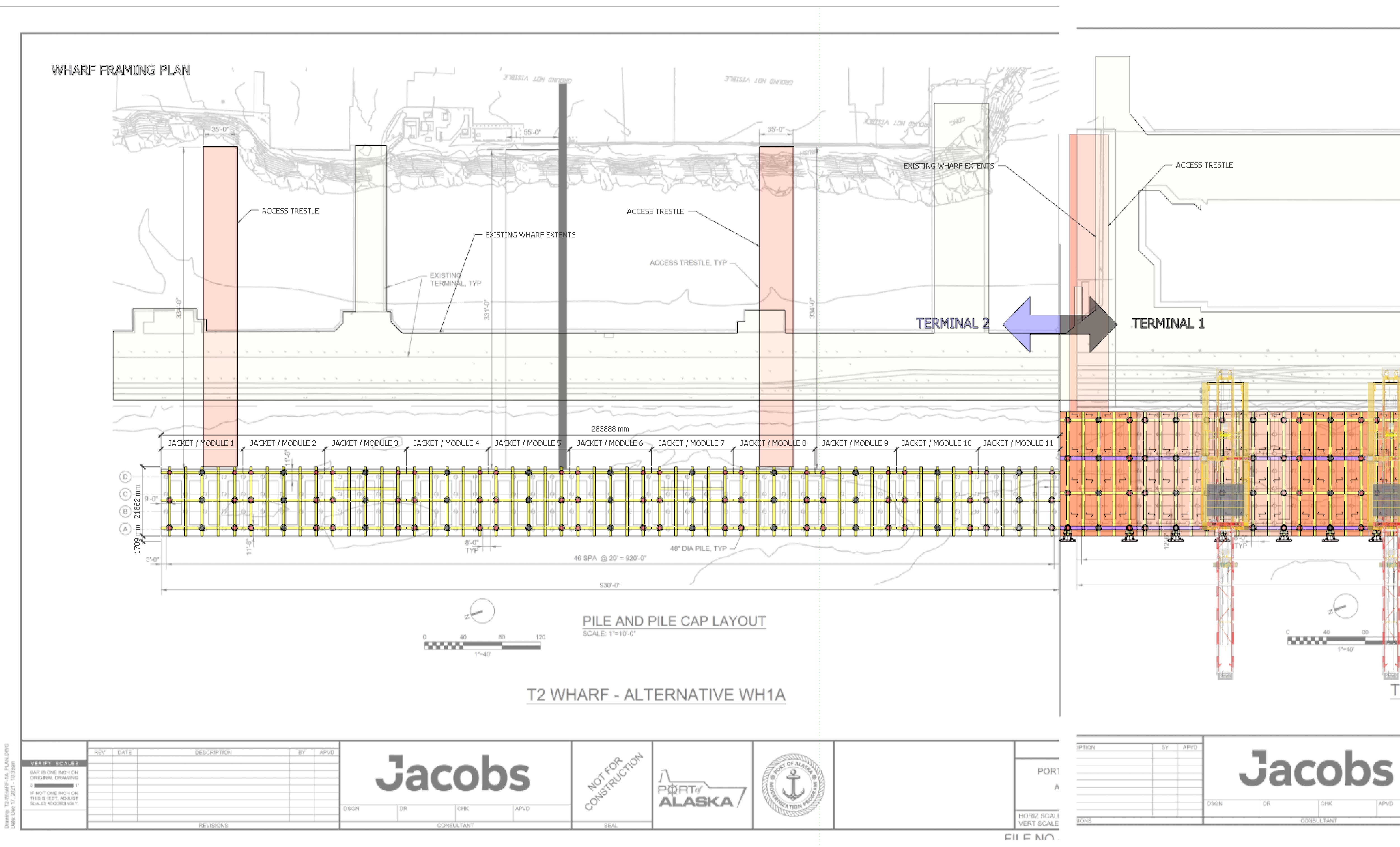
PORT OF ALASKA MODERNIZATION PROGRAM

HORIZ SCALE
VERT SCALE
FILE NO.

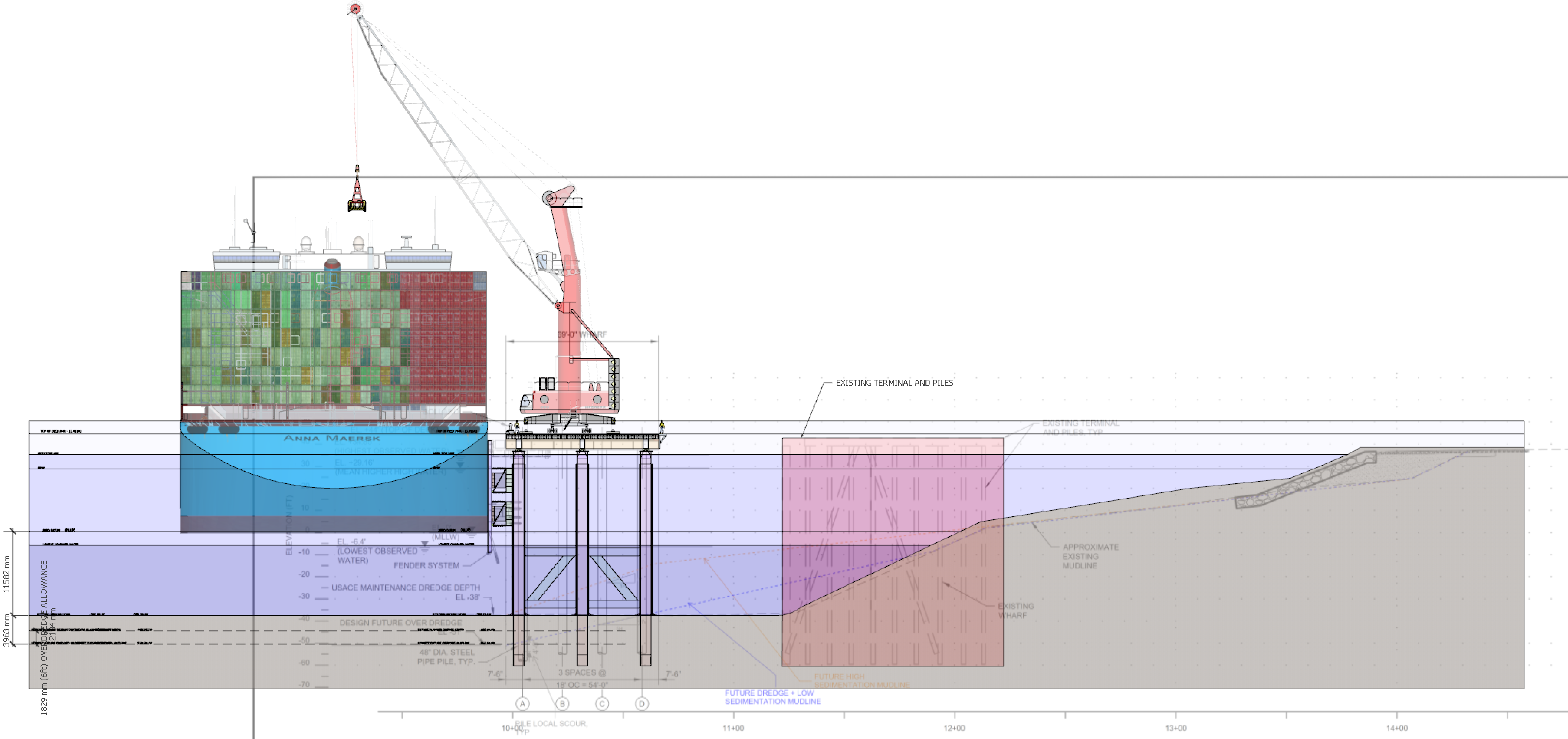
Drawing: T2-WHARF-1A_PLAN.DWG
Date: Dec 17, 2021 - 10:33am

Jacobs

DSGN | DR | CHK | APVD
CONSULTANT

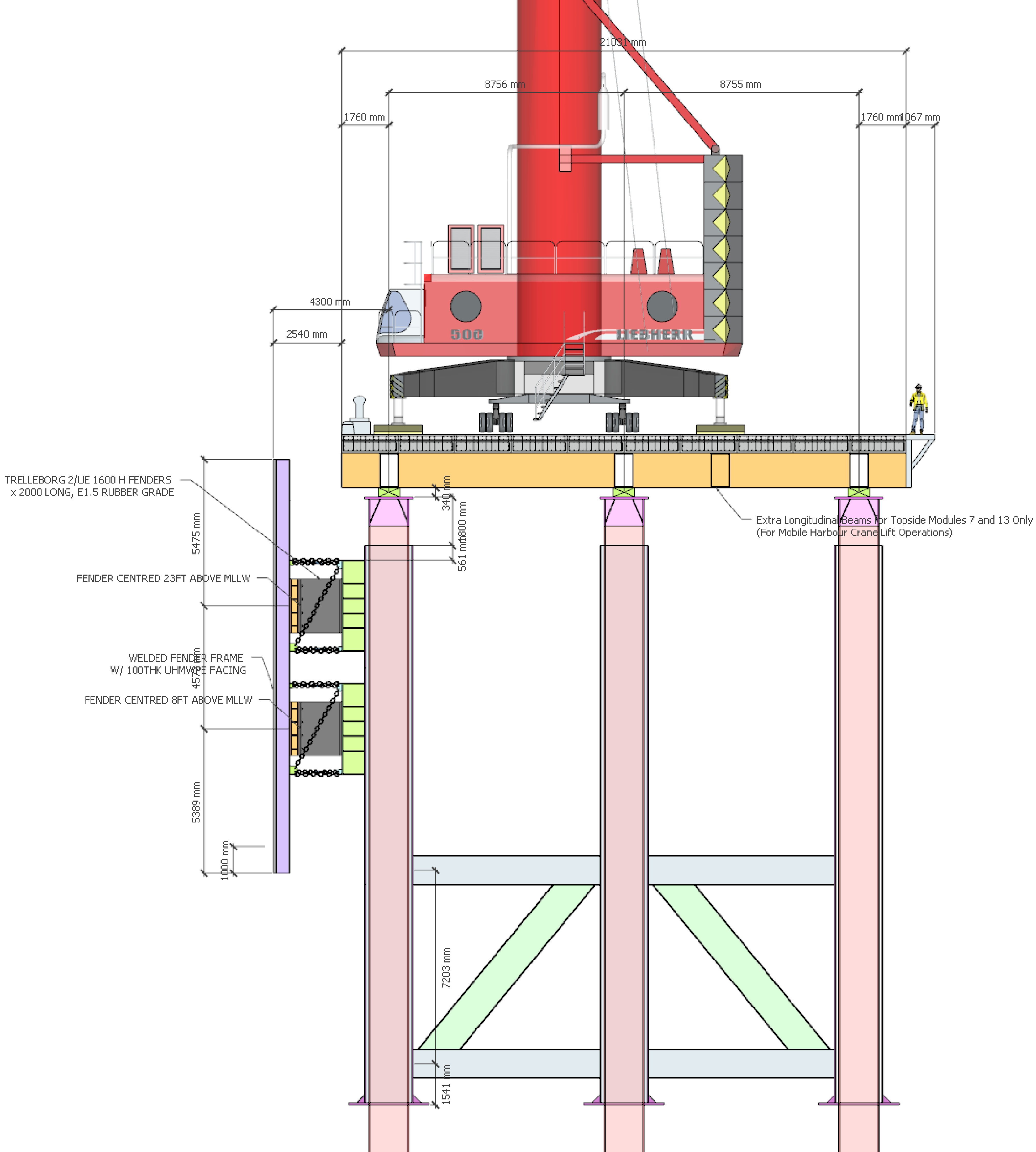


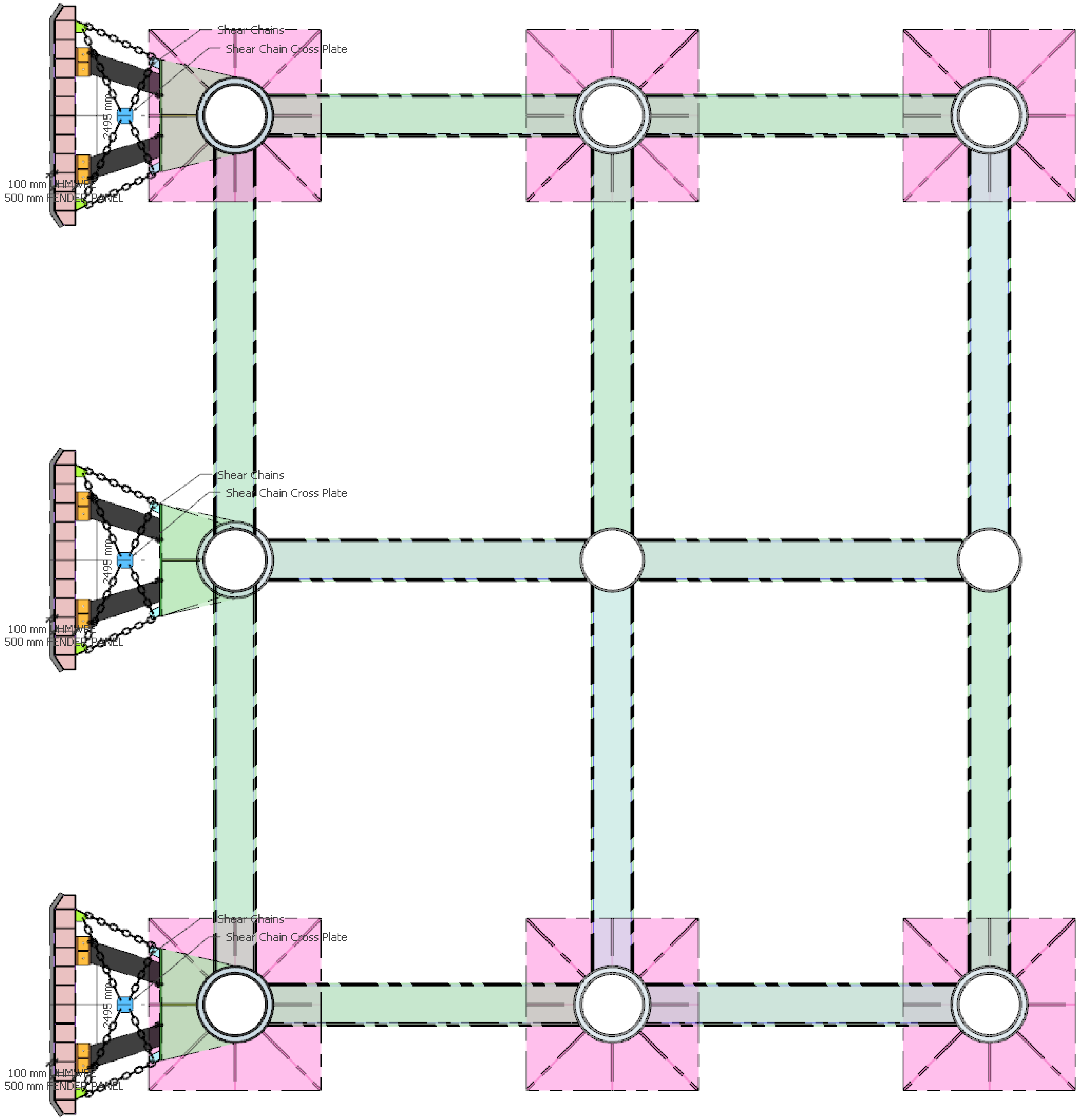
WHARF FRAMING PLAN
ACCESS TRESTLE
EXISTING WHARF EXTENTS
EXISTING TERMINAL, TYP
ACCESS TRESTLE, TYP
EXISTING WHARF EXTENTS
ACCESS TRESTLE
TERMINAL 2
TERMINAL 1
35'-0"
55'-0"
334'-0"
331'-0"
283888 mm
JACKET / MODULE 1
JACKET / MODULE 2
JACKET / MODULE 3
JACKET / MODULE 4
JACKET / MODULE 5
JACKET / MODULE 6
JACKET / MODULE 7
JACKET / MODULE 8
JACKET / MODULE 9
JACKET / MODULE 10
JACKET / MODULE 11
21862 mm
1709 mm
9'-0"
5'-0"
11'-6"
8'-0" TYP
48" DIA PILE, TYP
46 SPA @ 20' = 920'-0"
930'-0"
PILE AND PILE CAP LAYOUT
SCALE: 1"=10'-0"
1"=40'
T2 WHARF - ALTERNATIVE WH1A
VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY
REV DATE DESCRIPTION BY APVD
REVISIONS
Jacobs
DSGN DR CHK APVD
CONSULTANT
NOT FOR CONSTRUCTION
SEAL
PORT of ALASKA
PORT OF ALASKA MODERNIZATION PROGRAM
HORIZ SCALE
VERT SCALE
FILE NO.
Drawing: T2-WHARF-1A_PLAN.DWG
Date: Dec 17, 2021 - 10:33am



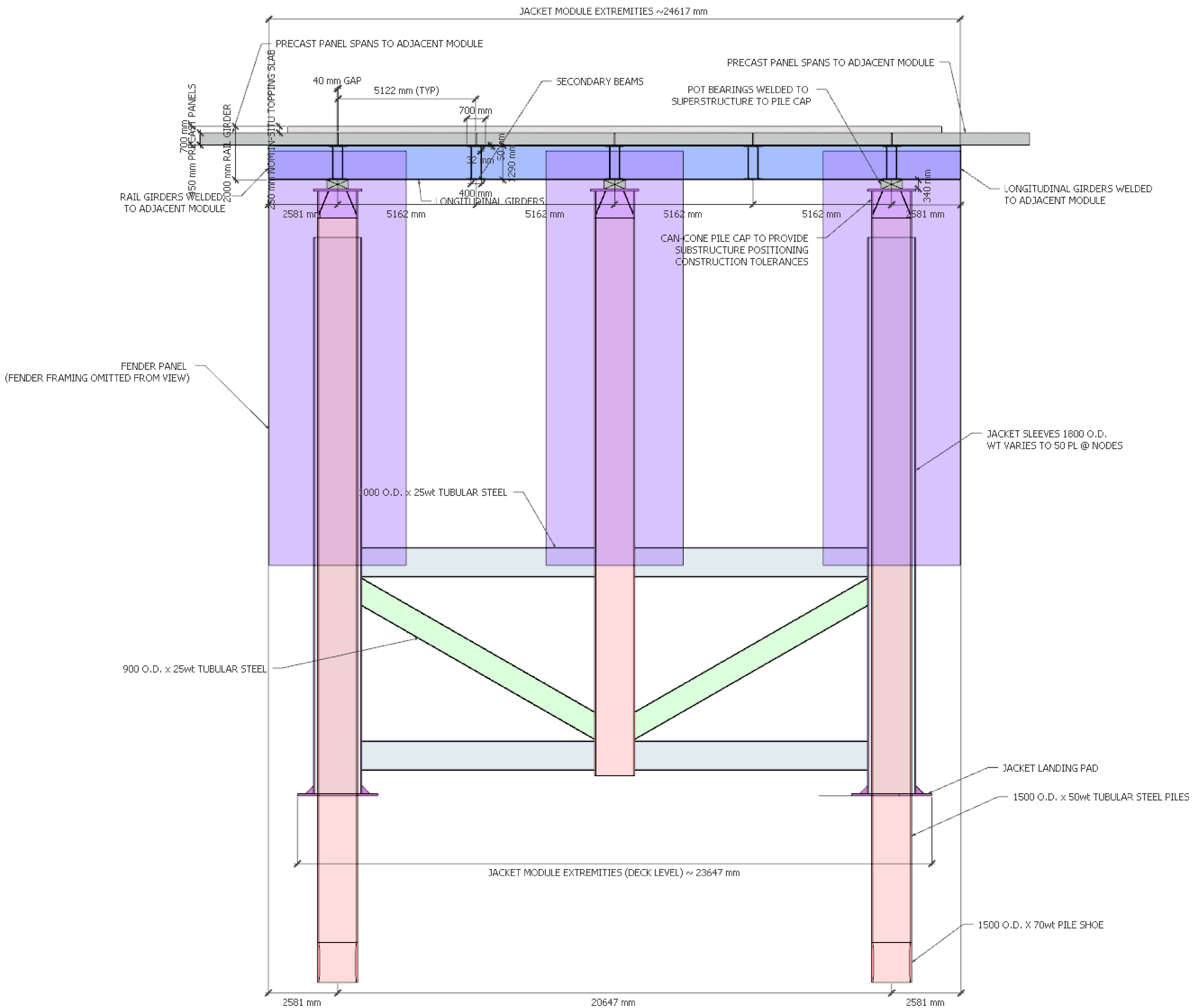
WHARF TYPICAL SECTION

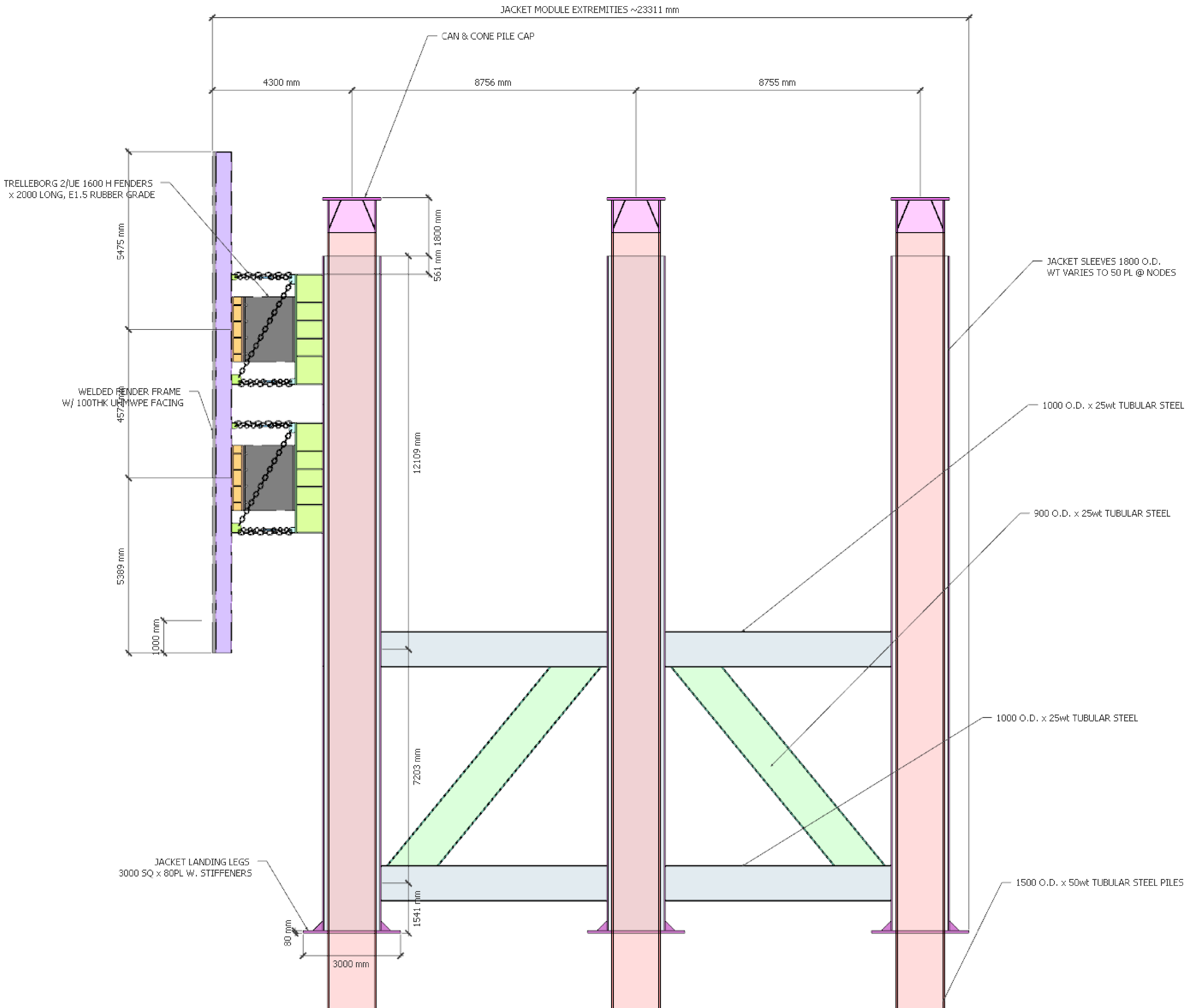
SCALE: 1"=20'-0"


21031 mm
8756 mm
8755 mm
1760 mm
1760 mm
1067 mm
4300 mm
2540 mm
TRELLEBORG 2/UE 1600 H FENDERS
x 2000 LONG, E1.5 RUBBER GRADE
5475 mm
340 mm
800 mm
561 mm
Extra Longitudinal Beams for Topside Modules 7 and 13 Only
(For Mobile Harbour Crane Lift Operations)
FENDER CENTRED 23FT ABOVE MLLW
WELDED FENDER FRAME
W/ 100THK UHMWPE FACING
FENDER CENTRED 8FT ABOVE MLLW
5389 mm
1000 mm
7203 mm
1541 mm



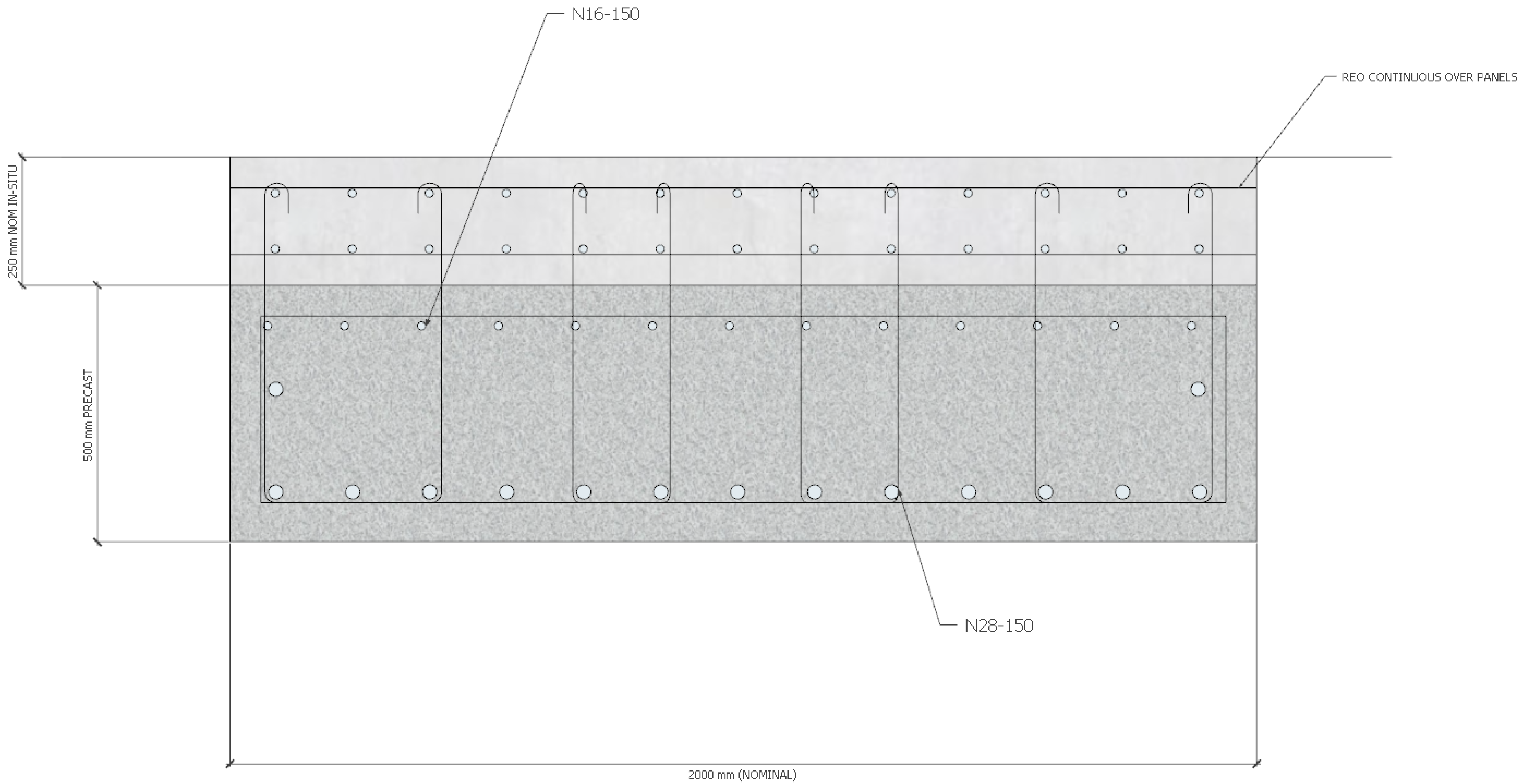
FENDERING SYSTEM VARIES IN POSITION BETWEEN JACKETS.


JACKET MODULE EXTREMITIES ~24617 mm
PRECAST PANEL SPANS TO ADJACENT MODULE
PRECAST PANEL SPANS TO ADJACENT MODULE
40 mm GAP
5122 mm (TYP)
700 mm
SECONDARY BEAMS
POT BEARINGS WELDED TO
SUPERSTRUCTURE TO PILE CAP
700 mm
150 mm PRECAST PANELS
2000 mm RAIL GIRDER
250 mm NOMIN-SITU TOPPING SLAB
32 mm
400 mm
1290 mm
340 mm
RAIL GIRDERS WELDED
TO ADJACENT MODULE
LONGITUDINAL GIRDERS
LONGITUDINAL GIRDERS WELDED
TO ADJACENT MODULE
2581 mm
5162 mm
5162 mm
5162 mm
5162 mm
2581 mm
CAN-CONE PILE CAP TO PROVIDE
SUBSTRUCTURE POSITIONING
CONSTRUCTION TOLERANCES
FENDER PANEL
(FENDER FRAMING OMITTED FROM VIEW)
JACKET SLEEVES 1800 O.D.
WT VARIES TO 50 PL @ NODES
1000 O.D. x 25wt TUBULAR STEEL
900 O.D. x 25wt TUBULAR STEEL
JACKET LANDING PAD
1500 O.D. x 50wt TUBULAR STEEL PILES
JACKET MODULE EXTREMITIES (DECK LEVEL) ~ 23647 mm
1500 O.D. X 70wt PILE SHOE
2581 mm
20647 mm
2581 mm



JACKET MODULE EXTREMITIES ~23311 mm
CAN & CONE PILE CAP
4300 mm
8756 mm
8755 mm
TRELLEBORG 2/UE 1600 H FENDERS
x 2000 LONG, E1.5 RUBBER GRADE
5475 mm
1800 mm
561 mm
JACKET SLEEVES 1800 O.D.
WT VARIES TO 50 PL @ NODES
WELDED FENDER FRAME
W/ 100THK UHMWPE FACING
4572 mm
1000 O.D. x 25wt TUBULAR STEEL
12109 mm
900 O.D. x 25wt TUBULAR STEEL
5389 mm
1000 mm
1000 O.D. x 25wt TUBULAR STEEL
7203 mm
JACKET LANDING LEGS
3000 SQ x 80PL W. STIFFENERS
1500 O.D. x 50wt TUBULAR STEEL PILES
1541 mm
80 mm
3000 mm

PRECAST PLANK DETAILS



Appendix N
Costs Basis of Estimate

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48" Conventional Alternative

BID PROPOSAL

Biditem	Description	Quantity	Units	Unit Price	Bid Total
	PORT ANCHORAGE MODERNIZATION				
	PRELIMINARY QUANTITY & ESTIMATE				
	WH1 CONVENTIONAL CONSTRUCTION 48" DIAM				
	CLASS 3 ESTIMATE				
	GENERAL CONDITIONS				
115	Mobilization & Demobilization Weld 2 POA Site	1.000	LS	834,781.15	834,781.15
120	Mobilization & Demobilization Marine Support Crew	1.000	LS	6,380,704.32	6,380,704.32
126	Sea Tow & Shipping from PNW	8.000	EA	3,124,162.52	24,993,300.16
127	Additional Voyage for Fendering	1.000	EA	3,124,162.51	3,124,162.51
130	Special Testing & Inspections	1.000	LS	4,184,906.29	4,184,906.29
140	Cargo Shipping Insurance ($157,000,000.00) @2%	1.000	LS	5,062,841.74	5,062,841.74
150	Environmental BMP	1.000	LS	1,221,182.73	1,221,182.73
160	Survey Services (12 days/mo)	144.000	DA	2,902.27	417,926.88
180	Marine Mammal Observation per Station	528.000	DA	1,366.38	721,448.64
280	Builder's Risk <5MM @1.2%	1.000	LS	96,742.20	96,742.20
290	Payment & Performance Bond	1.000	LS	6,090,766.73	6,090,766.73
	*****Subtotal**				**$53,128,763.35**
	WHARF PLATFORM T-1 - 48" DIAM				
	CONVENTIONAL CONSTRUCTION				
1100	48" Diam Pipe pile API 5L x65 supply	394.000	EA	452,510.84	178,289,270.96
1150	Pile driving installation	394.000	EA	144,165.19	56,801,084.86
1200	Pile concrete fill	2,870.000	CY	3,256.58	9,346,384.60
1250	P/C Concrete pile cap supply & installation	7,800.000	CY	1,795.10	14,001,780.00
1300	P/C deck slabs supply & installation (72,700 SF)	5,450.000	CY	1,545.38	8,422,321.00
1400	Secondary closure pour	3,430.000	CY	1,028.06	3,526,245.80
1420	CIP Deck crown topping	2,780.000	CY	929.88	2,585,066.40
1450	Concrete curb	62.000	CY	1,963.88	121,760.56
1500	100 Ton Bollards	18.000	EA	8,918.53	160,533.54
1550	Fenders	29.000	EA	1,759,915.03	51,037,535.87
1600	Quick release hooks	5.000	EA	234,894.93	1,174,474.65
	****TOTAL CONSTRUCTION WH1**				**$378,595,221.59**
	ACCESS TRESTLES CONVENTIONAL CONSTRUT (10 BENTS)				
351010	Trestle Conventional Constr (top/Down) 11,480sf/ea	2.000	EA	27,140,348.09	54,280,696.18

BID PROPOSAL

Biditem	Description	Quantity	Units	Unit Price	Bid Total
351020	Deep Soil Mixing (DSM)	2.000	EA	9,674,219.91	19,348,439.82
	*****Subtotal**				**$73,629,136.00**
	****TOTAL CONSTRUCTION WH1 & TRESTLES**				**$452,224,357.59**
	ANCILLARY WORKS & UTILITIES				
401010	Cathodic Protection- Jackets	394.000	PILE	3,432.69	1,352,479.86
401020	Fire Supression System- Entire Berth	1.000	LS	177,360.69	177,360.69
401030	Power & Lighting System- Entire Berth	1.000	LS	2,418,554.98	2,418,554.98
401040	Potable Water System- Entire Berth	1.000	LS	806,185.00	806,185.00
401050	CRANE RAILS- A100 Rail DIN 536 Supply & Install	1,740.000	FT	1,880.95	3,272,853.00
	*****Subtotal**				**$8,027,433.53**
	3 GANTRY CRANE ATTACHMENTS				
411010	Cable Trench & Panzer Belt System	870.000	FT	776.28	675,363.60
411020	Crane Tie-Down Points	12.000	EA	21,922.65	263,071.80
411030	Crane Stowage Sockets	12.000	EA	11,340.01	136,080.12
411040	Crane Stops	4.000	EA	21,892.35	87,569.40
	*****Subtotal**				**$1,162,084.92**
	****GRAND TOTAL****				**$461,413,876.04**
500100	Stakeholder's Project Contingency Approx. 10%	1.000	LS	46,150,000.00	46,150,000.00
	Bid Total				**$507,563,876.04**

BID PROPOSAL

Biditem	Description	Quantity	Units	Unit Price	Bid Total
	PORT ANCHORAGE MODERNIZATION				
	PRELIMINARY QUANTITY & ESTIMATE				
	WH2 CONVENTIONAL CONSTRUCTION 48" DIAM				
	CLASS 3 ESTIMATE				
	GENERAL CONDITIONS				
115	Mobilization & Demobilization Weld 2 POA Site	1.000	LS	815,337.03	815,337.03
120	Mobilization & Demobilization Marine Support Crew	1.000	LS	6,232,081.91	6,232,081.91
126	Sea Tow & Shipping from PNW	6.000	EA	3,051,393.04	18,308,358.24
130	Special Testing & Inspections	1.000	LS	4,087,429.46	4,087,429.46
140	Cargo Shipping Insurance ($95,000,000.00) @2%	1.000	LS	2,992,146.39	2,992,146.39
150	Environmental BMP	1.000	LS	1,192,738.36	1,192,738.36
160	Survey Services (12 days/mo)	144.000	DA	2,834.67	408,192.48
180	Marine Mammal Observation per Station	528.000	DA	1,334.55	704,642.40
280	Builder's Risk <5MM @1.2%	1.000	LS	94,488.84	94,488.84
290	Payment & Performance Bond	1.000	LS	5,295,123.06	5,295,123.06
	*****Subtotal**				**$40,130,538.17**
	WHARF PLATFORM T-2				
	CONVENTIONAL CONSTRUCTION				
1100	48" Diam Pipe pile API 5L x65 supply	188.000	EA	441,970.68	83,090,487.84
1150	Pile driving installation	188.000	EA	142,006.17	26,697,159.96
1200	Pile concrete fill	1,370.000	CY	3,180.74	4,357,613.80
1250	P/C Concrete pile cap supply & installation	5,100.000	CY	1,753.29	8,941,779.00
1300	P/C deck slabs supply & installation (40,200 SF)	2,825.000	CY	1,525.00	4,308,125.00
1400	Secondary closure pour	2,100.000	CY	1,004.09	2,108,589.00
1420	CIP Deck crown topping	1,600.000	CY	908.29	1,453,264.00
1450	Concrete curb	62.000	CY	1,918.13	118,924.06
1500	100 Ton Bollards	19.000	EA	8,710.77	165,504.63
1550	Fenders	32.000	EA	1,718,922.25	55,005,512.00
1600	Quick release hooks	5.000	EA	229,423.64	1,147,118.20
	****TOTAL CONSTRUCTION WH2**				**$227,524,615.66**
	ACCESS TRESTLES CONVENTIONAL CONSTRUT (10 BENTS)				
351010	Trestle Conventional Constr (top/Down)	3.000	EA	47,108,609.49	141,325,828.47
351020	Deep Soil Mixing (DSM)	3.000	EA	9,448,883.37	28,346,650.11

BID PROPOSAL

Biditem	Description	Quantity	Units	Unit Price	Bid Total
	***Subtotal				$169,672,478.58
	**TOTAL CONSTRUCTION WH2 & TRESTLES				$397,197,094.24
	ANCILLARY WORKS & UTILITIES				
401010	Cathodic Protection- Jackets	188.000	PILE	3,352.72	630,311.36
401020	Fire Supression System- Entire Berth	1.000	LS	173,229.53	173,229.53
401030	Power & Lighting System- Entire Berth	1.000	LS	2,362,220.84	2,362,220.84
401040	Potable Water System- Entire Berth	1.000	LS	787,406.94	787,406.94
	***Subtotal				$3,953,168.67
	GRAND TOTAL				$401,150,262.91
500100	Stakeholder's Project Contingency Approx. 10%	1.000	LS	40,110,000.00	40,110,000.00
	Bid Total				$441,260,262.91

72" Conventional Alternative

BID PROPOSAL

Biditem	Description	Quantity	Units	Unit Price	Bid Total
	PORT ANCHORAGE MODERNIZATION				
	PRELIMINARY QUANTITY & ESTIMATE				
	WH1 CONVENTIONAL CONSTRUCTION 72" DIAM x 2.2"wt				
	CLASS 3 ESTIMATE				
	GENERAL CONDITIONS				
115	Mobilization & Demobilization Weld 2 POA Site	1.000	LS	828,445.58	828,445.58
120	Mobilization & Demobilization Marine Support Crew	1.000	LS	6,332,278.06	6,332,278.06
126	Sea Tow & Shipping from PNW	8.000	EA	3,100,451.74	24,803,613.92
127	Additional Voyage for Fendering	1.000	EA	3,100,451.73	3,100,451.73
130	Special Testing & Inspections	1.000	LS	4,153,145.01	4,153,145.01
140	Cargo Shipping Insurance ($136,000,000.00) @2%	1.000	LS	4,352,361.56	4,352,361.56
150	Environmental BMP	1.000	LS	1,211,914.58	1,211,914.58
160	Survey Services (12 days/mo)	144.000	DA	2,880.24	414,754.56
180	Marine Mammal Observation per Station	528.000	DA	1,356.01	715,973.28
190	**Noise attenuation	1.000	LS	0.00	
280	Builder's Risk <5MM @1.2%	1.000	LS	96,007.98	96,007.98
290	Payment & Performance Bond	1.000	LS	5,678,477.58	5,678,477.58
	*****Subtotal**				**$51,687,423.84**
	WHARF PLATFORM WH-T1 x 72" DIAM				
	CONVENTIONAL CONSTRUCTION				
1100	72" Diam Pipe AWWA C200w/ A572 Gr65 supply	136.000	EA	1,137,676.16	154,723,957.76
1150	Pile driving installation	136.000	EA	246,129.48	33,473,609.28
1200	Pile concrete fill	2,940.000	CY	1,908.27	5,610,313.80
1250	P/C Concrete pile cap supply & installation	8,480.000	CY	1,790.37	15,182,337.60
1300	P/C deck slabs supply & installation (81,000 SF)	8,410.000	CY	1,552.04	13,052,656.40
1400	Secondary closure pour	3,480.000	CY	1,027.60	3,576,048.00
1420	CIP Deck crown topping	3,470.000	CY	922.83	3,202,220.10
1450	Concrete curb	62.000	CY	1,948.97	120,836.14
1500	100 Ton Bollards	18.000	EA	8,850.84	159,315.12
1550	Fenders	22.000	EA	1,746,558.18	38,424,279.96
1600	Quick release hooks	5.000	EA	233,112.20	1,165,561.00
1700	**Temporary 36" piles supply & shipping**	297.000	PILE	103,617.87	30,774,507.39
1800	**Temporary piles install & removal	263.000	EA	14,333.62	3,769,742.06

BID PROPOSAL

Biditem	Description	Quantity	Units	Unit Price	Bid Total
	****TOTAL CONSTRUCTION WH-T1 x 72" DIAM**				**$354,922,808.45**
	ACCESS TRESTLES CONVENTIONAL CONSTRUT (10 BENTS)				
351010	Trestle Convent Constr (top/Down) 11,480sf/ea 72"	2.000	EA	23,910,607.94	47,821,215.88
351020	Deep Soil Mixing (DSM)	2.000	EA	9,600,797.56	19,201,595.12
	*****Subtotal**				**$67,022,811.00**
	****TOTAL CONSTRUCTION WH1 & TRESTLES**				**$421,945,619.45**
	ANCILLARY WORKS & UTILITIES				
401010	Cathodic Protection- Jackets	136.000	PILE	3,406.63	463,301.68
401020	Fire Supression System- Entire Berth	1.000	LS	176,014.62	176,014.62
401030	Power & Lighting System- Entire Berth	1.000	LS	2,400,199.38	2,400,199.38
401040	Potable Water System- Entire Berth	1.000	LS	800,066.46	800,066.46
401050	CRANE RAILS- A100 Rail DIN 536 Supply & Install	1,740.000	FT	1,866.68	3,248,023.20
	*****Subtotal**				**$7,087,605.34**
	3 GANTRY CRANE ATTACHMENTS				
411010	Cable Trench & Panzer Belt System	870.000	FT	770.38	670,230.60
411020	Crane Tie-Down Points	12.000	EA	21,756.27	261,075.24
411030	Crane Stowage Sockets	12.000	EA	11,253.94	135,047.28
411040	Crane Stops	4.000	EA	21,726.20	86,904.80
	*****Subtotal**				**$1,153,257.92**
	****GRAND TOTAL****				**$430,186,482.71**
500100	Stakeholder's Project Contingency Approx. 10%	1.000	LS	43,020,000.00	43,020,000.00
500150	*Stand-By rate per day*	*1.000*	*DA*	*94,950.84*	*94,950.84*
	Bid Total				**$473,206,482.71**

** Items in italics are Non-Additive.

BID PROPOSAL

Biditem	Description	Quantity	Units	Unit Price	Bid Total
	PORT ANCHORAGE MODERNIZATION				
	PRELIMINARY QUANTITY & ESTIMATE				
	WH2 CONVENTIONAL CONSTRUCTION 72" DIAM x 2.2"wt				
	CLASS 3 ESTIMATE				
	GENERAL CONDITIONS				
115	Mobilization & Demobilization Weld 2 POA Site	1.000	LS	830,641.71	830,641.71
120	Mobilization & Demobilization Marine Support Crew	1.000	LS	6,349,064.23	6,349,064.23
126	Sea Tow & Shipping from PNW	6.000	EA	3,108,670.70	18,652,024.20
130	Special Testing & Inspections	1.000	LS	4,164,154.55	4,164,154.55
140	Cargo Shipping Insurance ($89,000,000.00) @2%	1.000	LS	2,855,786.97	2,855,786.97
150	Environmental BMP	1.000	LS	1,215,127.23	1,215,127.23
160	Survey Services (12 days/mo)	144.000	DA	2,887.87	415,853.28
180	Marine Mammal Observation per Station	528.000	DA	1,359.60	717,868.80
190	**Noise attenuation	1.000	LS	0.00	
280	Builder's Risk <5MM @1.2%	1.000	LS	96,262.48	96,262.48
290	Payment & Performance Bond	1.000	LS	4,473,234.40	4,473,234.40
	*****Subtotal**				**$39,770,017.85**
	WHARF PLATFORM WH-T2 x 72" DIAM				
	CONVENTIONAL CONSTRUCTION				
1100	72" Diam Pipe AWWA C200w/ A572 Gr65 supply	72.000	EA	1,204,476.48	86,722,306.56
1150	Pile driving installation	72.000	EA	245,687.53	17,689,502.16
1200	Pile concrete fill	1,560.000	CY	1,973.99	3,079,424.40
1250	P/C Concrete pile cap supply & installation	6,950.000	CY	1,782.38	12,387,541.00
1300	P/C deck slabs supply & installation (39,300 SF)	3,945.000	CY	1,561.36	6,159,565.20
1400	Secondary closure pour	2,810.000	CY	1,030.35	2,895,283.50
1420	CIP Deck crown topping	1,990.000	CY	925.32	1,841,386.80
1450	Concrete curb	62.000	CY	1,954.14	121,156.68
1500	100 Ton Bollards	19.000	EA	8,874.28	168,611.32
1550	Fenders	24.000	EA	1,751,188.12	42,028,514.88
1600	Quick release hooks	5.000	EA	233,730.15	1,168,650.75
1700	**Temp 36" piles supply** Re-use from WHT1	0.000	PILE	0.00	
1800	**Temporary piles install & removal	297.000	EA	14,371.80	4,268,424.60
	****TOTAL CONSTRUCTION WH-T2 x 72" DIAM**				**$218,300,385.70**

BID PROPOSAL

Biditem	Description	Quantity	Units	Unit Price	Bid Total
	ACCESS TRESTLES CONVENTIONAL CONSTRUT (10 BENTS)				
351010	Trestle Conventional Constr (top/Down) 72 inch Dia	3.000	EA	29,356,421.81	88,069,265.43
351020	Deep Soil Mixing (DSM)	3.000	EA	9,626,248.23	28,878,744.69
	*****Subtotal**				**$116,948,010.12**
	****TOTAL CONSTRUCTION WH2 & TRESTLES**				**$335,248,395.82**
	ANCILLARY WORKS & UTILITIES				
401010	Cathodic Protection- Jackets	72.000	PILE	3,415.65	245,926.80
401020	Fire Supression System- Entire Berth	1.000	LS	176,481.22	176,481.22
401030	Power & Lighting System- Entire Berth	1.000	LS	2,406,562.06	2,406,562.06
401040	Potable Water System- Entire Berth	1.000	LS	802,187.36	802,187.36
	*****Subtotal**				**$3,631,157.44**
	****GRAND TOTAL****				**$338,879,553.26**
500100	Stakeholder's Project Contingency Approx. 10%	1.000	LS	33,890,000.00	33,890,000.00
	Bid Total				**$372,769,553.26**

Drill Shaft Alternative

BID PROPOSAL

Biditem	Description	Quantity	Units	Unit Price	Bid Total
	PORT ANCHORAGE MODERNIZATION				
	PRELIMINARY QUANTITY & ESTIMATE				
	WH1 CONVENTIONAL CONSTR- DRILL SHAFT 71" OD CASING				
	CLASS 3 ESTIMATE				
	GENERAL CONDITIONS				
115	Mobilization & Demobilization Weld 2 POA Site	1.000	LS	843,565.79	843,565.79
120	Mobilization & Demobilization Marine Support Crew	1.000	LS	6,447,850.27	6,447,850.27
126	Sea Tow & Shipping from PNW 1,665 NM	8.000	EA	3,157,038.97	25,256,311.76
127	Additional Voyage for Fendering	1.000	EA	3,157,038.96	3,157,038.96
130	Special Testing & Inspections	1.000	LS	4,228,945.26	4,228,945.26
140	Cargo Shipping Insurance ($94,500,000.00) @2%	1.000	LS	3,079,447.72	3,079,447.72
150	Environmental BMP	1.000	LS	1,234,033.58	1,234,033.58
160	Survey Services (12 days/mo)	144.000	DA	2,932.81	422,324.64
180	Marine Mammal Observation per Station	528.000	DA	1,380.76	729,041.28
190	**Noise attenuation	1.000	LS	0.00	
280	Builder's Risk <5MM @1.2%	1.000	LS	97,760.25	97,760.25
290	Payment & Performance Bond	1.000	LS	6,422,528.52	6,422,528.52
	*****Subtotal**				**$51,918,848.03**
	WHARF PLATFORM WH-T1 x 71" DIAM CASING				
	DRILL SHAFT & CONVENTIONAL CONSTRUCTION				
1100	71" Diam Pipe AWWA C200w/ A572 Gr65 supply	136.000	EA	265,360.14	36,088,979.04
1150	Casing install & Drill shaft operation	136.000	EA	521,275.10	70,893,413.60
1200	Pile concrete fill- Casing & 79" Diam shaft	49,012.000	CY	2,346.41	115,002,246.92
1250	P/C Concrete pile cap supply & installation	8,480.000	CY	1,823.04	15,459,379.20
1300	P/C deck slabs supply & installation (81,000 SF)	8,410.000	CY	1,580.36	13,290,827.60
1400	Secondary closure pour	3,480.000	CY	1,046.36	3,641,332.80
1420	CIP Deck crown topping	3,470.000	CY	939.68	3,260,689.60
1450	Concrete curb	62.000	CY	1,984.54	123,041.48
1500	100 Ton Bollards	18.000	EA	9,012.38	162,222.84
1550	Fenders	22.000	EA	1,778,435.12	39,125,572.64
1600	Quick release hooks	5.000	EA	237,366.80	1,186,834.00
1700	**Temporary 36" diam piles**	500.000	PILE	107,507.82	53,753,910.00
1800	**Temporary piles install & removal	500.000	EA	13,940.86	6,970,430.00

BID PROPOSAL

Biditem	Description	Quantity	Units	Unit Price	Bid Total
	****TOTAL CONSTRUCTION WH-T1 x DRILL SHAFT**				**$410,877,727.75**
	ACCESS TRESTLES CONVENTIONAL CONSTRUT (10 BENTS)				
351010	Trestle Convent Constr (top/Down) 11,480sf/ea 72"	2.000	EA	23,869,753.49	47,739,506.98
351020	Deep Soil Mixing (DSM)	2.000	EA	9,776,024.47	19,552,048.94
	*****Subtotal**				**$67,291,555.92**
	****TOTAL CONSTRUCTION WH1 & TRESTLES**				**$478,169,283.67**
	ANCILLARY WORKS & UTILITIES				
401010	Cathodic Protection- Jackets	136.000	PILE	3,468.81	471,758.16
401020	Fire Supression System- Entire Berth	1.000	LS	179,227.12	179,227.12
401030	Power & Lighting System- Entire Berth	1.000	LS	2,444,006.12	2,444,006.12
401040	Potable Water System- Entire Berth	1.000	LS	814,668.71	814,668.71
401050	CRANE RAILS- A100 Rail DIN 536 Supply & Install	1,740.000	FT	1,900.75	3,307,305.00
	*****Subtotal**				**$7,216,965.11**
	3 GANTRY CRANE ATTACHMENTS				
411010	Cable Trench & Panzer Belt System	870.000	FT	784.45	682,471.50
411020	Crane Tie-Down Points	12.000	EA	22,153.35	265,840.20
411030	Crane Stowage Sockets	12.000	EA	11,459.34	137,512.08
411040	Crane Stops	4.000	EA	22,122.73	88,490.92
	*****Subtotal**				**$1,174,314.70**
	****GRAND TOTAL****				**$486,560,563.48**
500100	Stakeholder's Project Contingency Approx. 10%	1.000	LS	48,650,000.00	48,650,000.00
500150	*Stand-By rate per day*	*1.000*	*DA*	*100,482.42*	*100,482.42*
	Bid Total				**$535,210,563.48**

** Items in italics are Non-Additive.

BID PROPOSAL

Biditem	Description	Quantity	Units	Unit Price	Bid Total
	PORT ANCHORAGE MODERNIZATION				
	PRELIMINARY QUANTITY & ESTIMATE				
	WH2 CONVENTIONAL CONSTR- DRILL SHAFT 71" OD CASING				
	CLASS 3 ESTIMATE - REV2				
	GENERAL CONDITIONS				
115	Mobilization & Demobilization Weld 2 POA Site	1.000	LS	845,953.26	845,953.26
120	Mobilization & Demobilization Marine Support Crew	1.000	LS	6,466,099.06	6,466,099.06
126	Sea Tow & Shipping from PNW	6.000	EA	3,165,974.06	18,995,844.36
130	Special Testing & Inspections	1.000	LS	4,240,914.06	4,240,914.06
140	Cargo Shipping Insurance ($65,000,000.00) @2%	1.000	LS	2,124,133.41	2,124,133.41
150	Environmental BMP	1.000	LS	1,237,526.16	1,237,526.16
160	Survey Services (12 days/mo)	144.000	DA	2,941.11	423,519.84
180	Marine Mammal Observation per Station	528.000	DA	1,384.66	731,100.48
190	**Noise attenuation	1.000	LS	0.00	
280	Builder's Risk <5MM @1.2%	1.000	LS	98,036.93	98,036.93
290	Payment & Performance Bond	1.000	LS	4,704,962.81	4,704,962.81
	*****Subtotal**				**$39,868,090.37**
	WHARF PLATFORM WH-T2 x 7" DIAM CASING				
	CONVENTIONAL CONSTRUCTION				
1100	71" Diam Pipe AWWA C200w/ A572 Gr65 supply	72.000	EA	266,111.52	19,160,029.44
1150	Casing install & Drill shaft operation	72.000	EA	537,855.93	38,725,626.96
1200	Pile concrete fill- Casing & 79" Diam shaft	28,350.070	CY	2,228.80	63,186,636.02
1250	P/C Concrete pile cap supply & installation	6,950.000	CY	1,815.23	12,615,848.50
1300	P/C deck slabs supply & installation (39,300 SF)	3,945.000	CY	1,590.14	6,273,102.30
1400	Secondary closure pour	2,810.000	CY	1,049.35	2,948,673.50
1420	CIP Deck crown topping	1,990.000	CY	942.38	1,875,336.20
1450	Concrete curb	62.000	CY	1,990.16	123,389.92
1500	100 Ton Bollards	19.000	EA	9,037.86	171,719.34
1550	Fenders	24.000	EA	1,783,468.46	42,803,243.04
1600	Quick release hooks	5.000	EA	238,038.59	1,190,192.95
1700	**Temporary 36" diam piles** Re-use from WHT1	424.000	PILE	0.00	
1800	**Temporary piles install & removal	424.000	PILE	14,882.12	6,310,018.88
	****TOTAL CONSTRUCTION WH-T2 x DRILL SHAFT**				**$235,251,907.42**

BID PROPOSAL

Biditem	Description	Quantity	Units	Unit Price	Bid Total
	ACCESS TRESTLES CONVENTIONAL CONSTRUT (10 BENTS)				
351010	Trestle Conventional Constr (top/Down) 72 inch Dia	3.000	EA	29,356,418.82	88,069,256.46
351020	Deep Soil Mixing (DSM)	3.000	EA	9,803,692.68	29,411,078.04
	*****Subtotal**				**$117,480,334.50**
	****TOTAL CONSTRUCTION WH2 & TRESTLES**				**$352,732,241.92**
	ANCILLARY WORKS & UTILITIES				
401010	Cathodic Protection- Jackets	72.000	PILE	3,478.62	250,460.64
401020	Fire Supression System- Entire Berth	1.000	LS	179,734.36	179,734.36
401030	Power & Lighting System- Entire Berth	1.000	LS	2,450,923.17	2,450,923.17
401040	Potable Water System- Entire Berth	1.000	LS	816,974.39	816,974.39
	*****Subtotal**				**$3,698,092.56**
	****GRAND TOTAL****				**$356,430,334.48**
500100	Stakeholder's Project Contingency Approx. 10%	1.000	LS	35,650,000.00	35,650,000.00
	Bid Total				**$392,080,334.48**

Jackets Conventional Alternative

BID PROPOSAL

Biditem	Description	Quantity	Units	Unit Price	Bid Total
	PORT ANCHORAGE MODERNIZATION				
	PRELIMINARY QUANTITY & ESTIMATE				
	TERMINAL 1				
	JACKETS OPTION				
	CLASS 3 ESTIMATE				
	GENERAL CONDITIONS				
110	Mobilization & Demobilization Fabrication Yard	1.000	LS	5,312,148.60	5,312,148.60
115	Mobilization & Demobilization Weld 2 POA Site	1.000	LS	893,249.20	893,249.20
120	Mobilization & Demobilization Marine Support Crew	1.000	LS	6,827,608.73	6,827,608.73
125	*Sea Tow & Shipping from Gulf of Mexico (Non-Add)*	*9.000*	*EA*	*0.00*	
126	Sea Tow & Shipping from PNW	9.000	EA	3,261,143.95	29,350,295.55
130	Special Testing & Inspections	1.000	LS	4,478,017.06	4,478,017.06
140	Cargo Shipping Insurance ($298,500,000.00) @2%	1.000	LS	5,970,000.00	5,970,000.00
150	Environmental BMP	1.000	LS	1,306,714.35	1,306,714.35
160	Survey Services (12 days/mo)	144.000	DA	3,105.54	447,197.76
170	SPMT Services to Load Jackets	110.000	DA	22,072.78	2,428,005.80
180	Marine Mammal Observation per Station	528.000	DA	1,462.08	771,978.24
280	Builder's Risk <5MM @1.2%	1.000	LS	60,000.00	60,000.00
290	Payment & Performance Bond	1.000	LS	8,658,471.13	8,658,471.13
	*****Subtotal**				**$66,503,686.42**
	TERMINAL STAGE 1A				
	FABRICATED STEEL JACKET - SUBSTRUCTURE				
101010	JACKET MODULE-1 & 1-FENDER FRAMES	1.000	EA	17,972,171.57	17,972,171.57
101015	JACKET MODULE 1 Field Installation	1.000	EA	429,567.92	429,567.92
101020	JACKET MODULE-2 & 2-FENDER FRAMES	1.000	EA	20,391,400.18	20,391,400.18
101025	JACKET MODULE 2 Field Installation	1.000	EA	429,567.92	429,567.92
101030	JACKET MODULE-3 & 1-FENDER FRAMES	1.000	EA	17,972,171.57	17,972,171.57
101035	JACKET MODULE 3 Field Installation	1.000	EA	429,567.92	429,567.92
101040	JACKET MODULE-4 & 2-FENDER FRAMES	1.000	EA	20,391,400.18	20,391,400.18
101045	JACKET MODULE 4 Field Installation	1.000	EA	429,567.92	429,567.92
101050	JACKET MODULE-5 & 1-FENDER FRAMES	1.000	EA	17,972,171.57	17,972,171.57
101055	JACKET MODULE 5 Field Installation	1.000	EA	429,567.92	429,567.92
101060	JACKET MODULE-6 & 2-FENDER FRAMES	1.000	EA	20,391,400.18	20,391,400.18

BID PROPOSAL

Biditem	Description	Quantity	Units	Unit Price	Bid Total
101065	JACKET MODULE 6 Field Installation	1.000	EA	429,567.92	429,567.92
101070	JACKET MODULE-7 & 1-FENDER FRAMES	1.000	EA	17,972,171.57	17,972,171.57
101075	JACKET MODULE 7 Field Installation	1.000	EA	429,567.92	429,567.92
101080	JACKET MODULE-8 & 2-FENDER FRAMES	1.000	EA	20,391,400.18	20,391,400.18
101085	JACKET MODULE 8 Field Installation	1.000	EA	429,567.92	429,567.92
101090	JACKET MODULE-9 & 1-FENDER FRAMES	1.000	EA	17,972,171.57	17,972,171.57
101095	JACKET MODULE 9 Field Installation	1.000	EA	429,567.92	429,567.92
	*****Subtotal**				**$175,292,569.85**
	FABRICATED STEEL CYLINDER PILES - SUBSTRUCTURE				
102010	PILES SUPPLY (164,617 Kg/ea)	81.000	EA	1,105,194.46	89,520,751.26
102015	DRIVE PILES IN THE FIELD	81.000	EA	90,033.78	7,292,736.18
102020	Jacket Guide A-Frame Material_Supply	6.000	EA	73,911.32	443,467.92
102025	Temporary Work & Jacket Guides	9.000	EA	8,063.48	72,571.32
	*****Subtotal**				**$97,329,526.68**
103000	PILE CAPS (15,000 Kg/ea)_SUPPLY	108.000	EA	294,711.76	31,828,870.08
103010	PILE CAPS_INSTALL	108.000	EA	17,975.01	1,941,301.08
	*****Subtotal**				**$33,770,171.16**
	OTHER MISCELLANEOUS - SUBSTRUCTURE				
	FENDERING SYSTEM SUPPLY				
104110	FENDERS- Trelleborg - UE-1600 H x 2000mm long, E1.	52.000	EA	21,087.29	1,096,539.08
104120	FENDER CHAINS- Nom 52mm stud link chain	478.500	M	293.98	140,669.43
104130	FENDER PADS- UHMWPE Pads 100mm thk	1,025.000	M^2	1,052.29	1,078,597.25
	*****Subtotal**				**$2,315,805.76**
	SUPERSTRUCTURE				
	STEEL - SUPERSTRUCTURE (HEAVY FABRICATION)				
111010	TOPSIDE MODULE 1 FABRICATION	1.000	EA	10,550,234.26	10,550,234.26
111015	TOPSIDE MODULE 1_Field Installation	1.000	EA	433,684.84	433,684.84
111020	TOPSIDE MODULE 2 FABRICATION	1.000	EA	10,550,234.26	10,550,234.26
111025	TOPSIDE MODULE 2_Field Installation	1.000	EA	433,684.84	433,684.84
111030	TOPSIDE MODULE 3 FABRICATION	1.000	EA	10,550,234.26	10,550,234.26
111035	TOPSIDE MODULE 3_Field Installation	1.000	EA	433,684.84	433,684.84
111040	TOPSIDE MODULE 4 FABRICATION	1.000	EA	10,550,234.26	10,550,234.26
111045	TOPSIDE MODULE 4_Field Installation	1.000	EA	433,684.84	433,684.84
111050	TOPSIDE MODULE 5 FABRICATION	1.000	EA	10,550,234.26	10,550,234.26

BID PROPOSAL

Biditem	Description	Quantity	Units	Unit Price	Bid Total
111055	TOPSIDE MODULE 5_Field Installation	1.000	EA	433,684.84	433,684.84
111060	TOPSIDE MODULE 6 FABRICATION	1.000	EA	10,550,234.26	10,550,234.26
111065	TOPSIDE MODULE 6_Field Installation	1.000	EA	433,684.84	433,684.84
111070	TOPSIDE MODULE 7 FABRICATION	1.000	EA	10,550,234.26	10,550,234.26
111075	TOPSIDE MODULE 7_Field Installation	1.000	EA	433,684.84	433,684.84
111080	TOPSIDE MODULE 8 FABRICATION	1.000	EA	10,550,234.26	10,550,234.26
111085	TOPSIDE MODULE 8_Field Installation	1.000	EA	433,684.84	433,684.84
111090	TOPSIDE MODULE 9 FABRICATION	1.000	EA	10,550,234.26	10,550,234.26
111095	TOPSIDE MODULE 9_Field Installation	1.000	EA	433,684.84	433,684.84
	*****Subtotal**				**$98,855,271.90**
	STEEL - SUPERSTRUCTURE (MEDIUM FABRICATION)				
112010	SERVICE SUPPORTS- Service Support Framing (Light -	90,000.000	KG	1.37	123,300.00
112020	WALKWAY SUPPORT- Rear Walkway Support Framing (Med	66,570.000	KG	1.37	91,200.90
	*****Subtotal**				**$214,500.90**
	PRECAST CONCRETE PANELS SUPPLY & INSTALL				
113010	Precast Conc. Panels- 450tk Planks _Supply	810.000	EA	8,678.21	7,029,350.10
113015	Precast Conc. Panels- 450tk Plank_Install	810.000	EA	1,965.24	1,591,844.40
	*****Subtotal**				**$8,621,194.50**
	INSITU CONCRETE				
114010	TOPPING SLAB- Insitu Conc. - Average 250mm depth	1,975.185	M3	859.71	1,698,086.30
114020	KERBS- Nominal Allowance for kerbs etc.	140.452	M3	859.71	120,747.82
	*****Subtotal**				**$1,818,834.12**
	OTHER MISCELLANEOUS - SUPERSTRUCTURE				
115010	POT BEARINGS- Supply & Shop Install	108.000	EA	15,113.63	1,632,272.04
115020	BOLLARDS- 200t Double bit - Supply - Yard Install	13.000	EA	18,317.11	238,122.43
115030	WALKWAY SUPPORT- Grating - Nominal Webforge F325MP	300.000	M²	613.37	184,011.00
115040	CRANE RAILS- A100 Rail DIN 536 Supply & Install	429.000	M	6,056.39	2,598,191.31
115050	HANDRAILS- Nominal Length Supply - Yard Install	245.500	M	1,103.47	270,901.89
115060	GUARDRAILS Supply & Yard Install	245.500	M	1,054.25	258,818.38
115070	SHEAR STUDS Supply & Install	4,860.000	EA	120.80	587,088.00
	*****Subtotal**				**$5,769,405.05**
	TOTAL CONSTRUCTION TERMINAL 1A				**$490,490,966.34**

BID PROPOSAL

Biditem	Description	Quantity	Units	Unit Price	Bid Total
	TERMINAL STAGE 1B				
	GENERAL CONDITIONS				
	FABRICATED STEEL JACKET - SUBSTRUCTURE				
201010	JACKET MODULE-10 & 2-FENDER FRAMES	1.000	EA	20,391,400.18	20,391,400.18
201015	JACKET MODULE 10 Field Installation	1.000	EA	429,567.92	429,567.92
201020	JACKET MODULE-11 & 1-FENDER FRAMES	1.000	EA	17,972,171.57	17,972,171.57
201025	JACKET MODULE 11 Field Installation	1.000	EA	429,567.92	429,567.92
	*****Subtotal**				**$39,222,707.59**
	FABRICATED STEEL CYLINDER PILES - SUBSTRUCTURE				
202010	PILES SUPPLY (164,617 Kg/ea)	18.000	EA	1,105,195.21	19,893,513.78
202015	DRIVE PILES IN THE FIELD	18.000	EA	90,033.00	1,620,594.00
202025	Temporary Work & Jacket Guides	2.000	EA	8,063.50	16,127.00
	*****Subtotal**				**$21,530,234.78**
203000	PILE CAPS (15,000 Kg/ea)	24.000	EA	294,711.73	7,073,081.52
203010	PILE CAPS _INSTALL	24.000	EA	17,975.01	431,400.24
	*****Subtotal**				**$7,504,481.76**
	OTHER MISCELLANEOUS - SUBSTRUCTURE				
	FENDERING SYSTEM SUPPLY				
204110	FENDERS- Trelleborg - UE-1600 H x 2000mm long, E1.	12.000	EA	21,087.29	253,047.48
204120	FENDER CHAINS- Nom 52mm stud link chain	110.400	M	293.98	32,455.39
204130	FENDER PADS- UHMWPE Pads 100mm thk	236.634	M^2	1,052.27	249,002.75
	*****Subtotal**				**$534,505.62**
	SUPERSTRUCTURE				
	STEEL - SUPERSTRUCTURE (HEAVY FABRICATION)				
211010	TOPSIDE MODULE 10 FABRICATION	1.000	EA	10,550,234.26	10,550,234.26
211015	TOPSIDE MODULE 10_Field Installation	1.000	EA	433,684.84	433,684.84
211020	TOPSIDE MODULE 11 FABRICATION	1.000	EA	10,550,234.26	10,550,234.26
211025	TOPSIDE MODULE 11_Field Installation	1.000	EA	433,684.84	433,684.84
	*****Subtotal**				**$21,967,838.20**
212010	SERVICE SUPPORTS- Service Support Framing (Light -	20,000.000	KG	1.37	27,400.00
212020	WALKWAY SUPPORT- Rear Walkway Support Framing (Med	8,321.250	KG	1.38	11,483.33
	*****Subtotal**				**$38,883.33**
	PRECAST CONCRETE PANELS SUPPLY & INSTALL				
213010	Precast Conc. Panels- 450tk Planks_Supply	180.000	EA	8,678.25	1,562,085.00

BID PROPOSAL

Biditem	Description	Quantity	Units	Unit Price	Bid Total
213015	Precast Conc. Panels- 450tk Planks_Install	180.000	EA	1,965.24	353,743.20
	***Subtotal				$1,915,828.20
	INSITU CONCRETE				
214010	TOPPING SLAB- Insitu Concrete - Average 250mm dept	439.000	M3	859.72	377,417.08
214020	KERBS- Nominal Allowance for kerbs etc.	31.000	M3	859.77	26,652.87
	***Subtotal				$404,069.95
	OTHER MISCELLANEOUS - SUPERSTRUCTURE				
215010	POT BEARINGS- Supply & Shop Install	24.000	EA	15,113.63	362,727.12
215020	BOLLARDS- 200t Double bit - Supply - Yard Install	3.000	EA	18,314.72	54,944.16
215030	WALKWAY SUPPORT- Grating - Nominal Webforge F325MP	37.500	M²	613.38	23,001.75
215040	CRANE RAILS- A100 Rail DIN 536 Supply & Install	87.536	M	6,056.34	530,147.78
215050	HANDRAILS- Nominal Length Supply - Yard Install	54.546	M	1,103.47	60,189.32
215060	GUARDRAILS Supply & Yard Install	54.546	M	1,054.23	57,503.50
215070	SHEAR STUDS Supply & Install	1,080.000	EA	120.81	130,474.80
	***Subtotal				$1,218,988.43
	TOTAL CONSTRUCTION TERMINAL 1B				$94,337,537.86
	ACCESS TRESTLES CONVENTIONAL CONSTRUCT (10 BENTS)				
351010	Trestle Conventional Constr (top/Down) 11,480sf/ea	2.000	EA	27,140,348.09	54,280,696.18
351020	Deep Soil Mixing (DSM)	2.000	EA	6,000,000.00	12,000,000.00
	***Subtotal				$66,280,696.18
	TOTAL CONSTRUCTION TERMINAL 1A & 1B				$651,109,200.38
	ANCILLARY WORKS & UTILITIES				
401010	Cathodic Protection- Jackets	99.000	PILE	3,673.13	363,639.87
401020	Fire Supression System- Entire Berth	1.000	LS	189,783.03	189,783.03
401030	Power & Lighting System- Entire Berth	1.000	LS	2,587,950.53	2,587,950.53
401040	Potable Water System- Entire Berth	1.000	LS	862,650.18	862,650.18
	***Subtotal				$4,004,023.61
	3 GANTRY CRANE ATTACHMENTS				
411010	Cable Trench & Panzer Belt System	870.000	FT	830.65	722,665.50
411020	Crane Tie-Down Points	12.000	EA	23,458.12	281,497.44
411030	Crane Stowage Sockets	12.000	EA	12,134.26	145,611.12
411040	Crane Stops	4.000	EA	23,425.69	93,702.76

BID PROPOSAL

Biditem	Description	Quantity	Units	Unit Price	Bid Total
	*****Subtotal**				**$1,243,476.82**
	****GRAND TOTAL****				**$656,356,700.81**
500100	Stakeholder's Project Contingency Approx. 10%	1.000	LS	65,650,000.00	65,650,000.00
	*****Subtotal**				**$65,650,000.00**
	Bid Total				**$722,006,700.81**

** Items in italics are Non-Additive.

BID PROPOSAL

Biditem	Description	Quantity	Units	Unit Price	Bid Total
	PORT ANCHORAGE MODERNIZATION				
	PRELIMINARY QUANTITY & ESTIMATE				
	TERMINAL 2				
	JACKETS OPTION				
	CLASS 3 ESTIMATE				
	GENERAL CONDITIONS				
120	Mobilization & Demobilization Marine Support Crew	1.000	LS	6,860,566.02	6,860,566.02
125	*Sea Tow & Shipping from Gulf of Mexico (Non-Add)*	*9.000*	*EA*	*0.00*	
126	Sea Tow & Shipping from PNW	9.000	EA	3,261,143.95	29,350,295.55
130	Special Testing & Inspections	1.000	LS	4,499,632.73	4,499,632.73
140	Cargo Shipping Insurance ($203,000,000.00) @2%	1.000	LS	4,060,000.00	4,060,000.00
150	Environmental BMP	1.000	LS	1,313,021.93	1,313,021.93
160	Survey Services (12 days/mo)	144.000	DA	3,120.53	449,356.32
170	SPMT Services to Load Jackets	110.000	DA	22,179.32	2,439,725.20
180	Marine Mammal Observation per Station	528.000	DA	1,469.14	775,705.92
280	Builder's Risk <5MM @1.2%	1.000	LS	60,000.00	60,000.00
290	Payment & Performance Bond	1.000	LS	7,112,114.78	7,112,114.78
	*****Subtotal**				**$56,920,418.45**
	TERMINAL 2				
	FABRICATED STEEL JACKET - SUBSTRUCTURE				
101010	JACKET MODULE-1 & 1-FENDER FRAMES	1.000	EA	15,568,018.14	15,568,018.14
101015	JACKET MODULE 1 Field Installation	1.000	EA	431,641.47	431,641.47
101020	JACKET MODULE-2 & 2-FENDER FRAMES	1.000	EA	17,998,924.52	17,998,924.52
101025	JACKET MODULE 2 Field Installation	1.000	EA	431,641.47	431,641.47
101030	JACKET MODULE-3 & 1-FENDER FRAMES	1.000	EA	15,568,018.14	15,568,018.14
101035	JACKET MODULE 3 Field Installation	1.000	EA	431,641.47	431,641.47
101040	JACKET MODULE-4 & 2-FENDER FRAMES	1.000	EA	17,998,924.52	17,998,924.52
101045	JACKET MODULE 4 Field Installation	1.000	EA	431,641.47	431,641.47
101050	JACKET MODULE-5 & 1-FENDER FRAMES	1.000	EA	15,568,018.14	15,568,018.14
101055	JACKET MODULE 5 Field Installation	1.000	EA	431,641.47	431,641.47
101060	JACKET MODULE-6 & 2-FENDER FRAMES	1.000	EA	17,998,924.52	17,998,924.52
101065	JACKET MODULE 6 Field Installation	1.000	EA	431,641.47	431,641.47
101070	JACKET MODULE-7 & 1-FENDER FRAMES	1.000	EA	15,568,018.14	15,568,018.14

BID PROPOSAL

Biditem	Description	Quantity	Units	Unit Price	Bid Total
101075	JACKET MODULE 7 Field Installation	1.000	EA	431,641.47	431,641.47
101080	JACKET MODULE-8 & 2-FENDER FRAMES	1.000	EA	17,998,924.52	17,998,924.52
101085	JACKET MODULE 8 Field Installation	1.000	EA	431,641.47	431,641.47
101090	JACKET MODULE-9 & 1-FENDER FRAMES	1.000	EA	15,568,018.14	15,568,018.14
101095	JACKET MODULE 9 Field Installation	1.000	EA	431,641.47	431,641.47
101100	JACKET MODULE-10 & 2-FENDER FRAMES	1.000	EA	17,998,924.52	17,998,924.52
101105	JACKET MODULE 10 Field Installation	1.000	EA	431,641.47	431,641.47
101110	JACKET MODULE-11 & 1-FENDER FRAMES	1.000	EA	15,568,018.14	15,568,018.14
101115	JACKET MODULE 11 Field Installation	1.000	EA	431,641.47	431,641.47
	*****Subtotal**				**$188,150,787.61**
	FABRICATED STEEL CYLINDER PILES - SUBSTRUCTURE				
102010	PILES (124,748 Kg/ea)	66.000	EA	841,449.72	55,535,681.52
102015	DRIVE PILES IN THE FIELD	66.000	EA	90,465.95	5,970,752.70
102020	Jacket Guide A-Frame Material_Supply	6.000	EA	74,268.10	445,608.60
102025	Temporary Work & Jacket Guides	11.000	EA	8,102.41	89,126.51
	*****Subtotal**				**$62,041,169.33**
103000	PILE CAPS (15,000 Kg/ea)	66.000	EA	296,133.01	19,544,778.66
103010	PILE CAPS_INSTALL	66.000	EA	18,061.78	1,192,077.48
	*****Subtotal**				**$20,736,856.14**
	OTHER MISCELLANEOUS - SUBSTRUCTURE				
	FENDERING SYSTEM				
104110	FENDERS- Trelleborg - UE-1600 H x 2000mm long, E1.	64.000	EA	21,189.08	1,356,101.12
104120	FENDER CHAINS- Nom 52mm stud link chain	588.000	M	295.40	173,695.20
104130	FENDER PADS- UHMWPE Pads 100mm thk	1,262.000	M^2	1,057.37	1,334,400.94
	*****Subtotal**				**$2,864,197.26**
	SUPERSTRUCTURE				
	STEEL - SUPERSTRUCTURE (HEAVY FABRICATION)				
111010	TOPSIDE MODULE 1 FABRICATION	1.000	EA	6,247,400.20	6,247,400.20
111015	TOPSIDE MODULE 1_Field Installation	1.000	EA	435,778.25	435,778.25
111020	TOPSIDE MODULE 2 FABRICATION	1.000	EA	6,247,400.20	6,247,400.20
111025	TOPSIDE MODULE 2_Field Installation	1.000	EA	435,778.25	435,778.25
111030	TOPSIDE MODULE 3 FABRICATION	1.000	EA	6,831,931.25	6,831,931.25
111035	TOPSIDE MODULE 3_Field Installation	1.000	EA	435,778.25	435,778.25
111040	TOPSIDE MODULE 4 FABRICATION	1.000	EA	6,247,400.20	6,247,400.20

BID PROPOSAL

Biditem	Description	Quantity	Units	Unit Price	Bid Total
111045	TOPSIDE MODULE 4_Field Installation	1.000	EA	435,778.25	435,778.25
111050	TOPSIDE MODULE 5 FABRICATION	1.000	EA	6,247,400.20	6,247,400.20
111055	TOPSIDE MODULE 5_Field Installation	1.000	EA	435,778.25	435,778.25
111060	TOPSIDE MODULE 6 FABRICATION	1.000	EA	6,247,400.20	6,247,400.20
111065	TOPSIDE MODULE 6_Field Installation	1.000	EA	435,778.25	435,778.25
111070	TOPSIDE MODULE 7 FABRICATION	1.000	EA	6,831,931.25	6,831,931.25
111075	TOPSIDE MODULE 7_Field Installation	1.000	EA	435,778.25	435,778.25
111080	TOPSIDE MODULE 8 FABRICATION	1.000	EA	6,247,400.20	6,247,400.20
111085	TOPSIDE MODULE 8_Field Installation	1.000	EA	435,778.25	435,778.25
111090	TOPSIDE MODULE 9 FABRICATION	1.000	EA	6,247,400.20	6,247,400.20
111095	TOPSIDE MODULE 9_Field Installation	1.000	EA	435,778.25	435,778.25
111105	TOPSIDE MODULE 10 FABRICATION	1.000	EA	6,247,400.20	6,247,400.20
111110	TOPSIDE MODULE 10_Field Installation	1.000	EA	435,778.25	435,778.25
111115	TOPSIDE MODULE 11 FABRICATION	1.000	EA	6,247,400.20	6,247,400.20
111120	TOPSIDE MODULE 11_Field Installation	1.000	EA	435,778.25	435,778.25
	*****Subtotal**				**$74,684,025.05**
	STEEL - SUPERSTRUCTURE (MEDIUM FABRICATION)				
112010	SERVICE SUPPORTS- Service Support Framing (Light -	110,000.000	KG	1.38	151,800.00
112020	WALKWAY SUPPORT- Rear Walkway Support Framing (Med	77,591.000	KG	1.38	107,075.58
	*****Subtotal**				**$258,875.58**
	PRECAST CONCRETE PANELS				
113010	Precast Conc. Panels- 500tk Planks (5.162 M3/ea)	605.000	EA	10,191.08	6,165,603.40
113015	Precast Conc. Panels- 500tk Plank_Install	605.000	EA	1,982.89	1,199,648.45
	*****Subtotal**				**$7,365,251.85**
	INSITU CONCRETE				
114010	TOPPING SLAB- Insitu Conc. - Average 250mm depth	1,562.000	M3	863.86	1,349,349.32
114020	KERBS- Nominal Allowance for kerbs etc.	86.000	M3	863.86	74,291.96
	*****Subtotal**				**$1,423,641.28**
	OTHER MISCELLANEOUS - SUPERSTRUCTURE				
115010	POT BEARINGS	66.000	EA	15,186.59	1,002,314.94
115020	BOLLARDS- 200t Double bit bollards	16.000	EA	18,405.08	294,481.28
115030	WALKWAY SUPPORT- Grating - Nominal Webforge F325MP	338.000	M^2	616.33	208,319.54
115050	HANDRAILS- Nominal Handrail length	300.000	M	1,108.80	332,640.00
115060	GUARDRAILS	300.000	M	1,059.33	317,799.00

BID PROPOSAL

Biditem	Description	Quantity	Units	Unit Price	Bid Total
115070	SHEAR STUDS	3,630.000	EA	121.38	440,609.40
	*****Subtotal**				**$2,596,164.16**
	TOTAL CONSTRUCTION TERMINAL 2_JACKETS				**$417,041,386.71**
	ACCESS TRESTLES CONVENTIONAL CONSTRUCTION				
351010	Trestle Conventional Constr (top/Down)	3.000	EA	33,383,946.75	100,151,840.25
351020	Deep Soil Mixing (DSM)	3.000	EA	6,000,000.00	18,000,000.00
	*****Subtotal**				**$118,151,840.25**
	TOTAL CONSTRUCTION TERMINA 2_ JACKETS & TRESTLE				**$535,193,226.96**
	ANCILLARY WORKS & UTILITIES				
401010	Cathodic Protection- Jackets	66.000	PILE	3,690.91	243,600.06
401020	Fire Supression System- Entire Berth	1.000	LS	190,699.13	190,699.13
401030	Power & Lighting System- Entire Berth	1.000	LS	2,600,442.73	2,600,442.73
401040	Potable Water System- Entire Berth	1.000	LS	866,814.24	866,814.24
	*****Subtotal**				**$3,901,556.16**
	****GRAND TOTAL****				**$539,094,783.12**
500100	Stakeholder's Project Contingency Approx. 10%	1.000	LS	53,910,000.00	53,910,000.00
	*****Subtotal**				**$53,910,000.00**
	Bid Total				**$593,004,783.12**

** Items in italics are Non-Additive.