# Appendix H: Preliminary Marine Structures Assessment

# PORT OF WOODLAND, AUSTIN POINT MASTER PLAN PHASE I FEASIBILITY STUDY

## Preliminary Marine Structures Assessment

kpff
Engineering Opportunities.

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# ACRONYMS

| | |
|---|---|
| BGS | Below Ground Surface |
| CCC | Cowlitz County Code |
| City | City of Woodland |
| CLE | Contingency Level Earthquake |
| CRD | Columbia River Datum |
| CRP | Columbia River Pilots |
| DE | Design Earthquake |
| Ecology | Washington State Department of Ecology |
| ESA | Endangered Species Act |
| FNC | Federal Navigation Channel |
| NAVD88 | North American Vertical Datum of 1988 |

| | |
|---|---|
| OLE | Operating Level Earthquake |
| OWS | Over Water Shadowing |
| Port | Port of Woodland |
| RM | River Mile |
| SMP | Shoreline Master Program |
| UGA | Urban Growth Area |
| USACE | United States Army Corps of Engineers |
| WDFW | Washington State Department of Fish and Wildlife |

# 1.0 INTRODUCTION

The Port of Woodland (Port) owns approximately 338 acres of property in the Austin Point and Woodland Bottoms area. To better understand the full potential of the Austin Point site, the Port determined that a comprehensive master planning process should occur. The first step in the process was to perform a due diligence study to assess the feasibility to develop the Austin Point site into a marine shipping terminal.

As part of the study, the marine structures requirements were explored. This included a review of general pier types and locations based on bulk commodity uses, and the associated seismic design criteria for the area.

# 2.0 EXISTING CONDITIONS

The Austin Point site is approximately 132.7 acres located in unincorporated Cowlitz County. The site is bound to the west and south by the Columbia River and Lewis River, respectively, undeveloped forest to the north, and Dike Road to the east (see Exhibit 1 – Site Location Map). Dike Road is placed on a levee, which is part of the greater Cowlitz County flood control system, that runs along the eastern property boundary.

Upland ground surface elevations are referenced to the NAVD88 vertical datum for this project. The ground surface at the perimeter berm is generally level with an approximate average ground surface at elevation 25 feet NAVD88. West of the perimeter berm, grades typically slope gently towards the Columbia River. Bathymetry data indicates that the slope of the ground surface steepens to approximately 2H:1V (horizontal: vertical) beginning near elevation -5 (NAVD88), approximately 400 feet west of the perimeter berm.

The Columbia River shipping channel is adjacent to the site and is routinely dredged by the Army Corps of Engineers. The navigation dredge depth maintained by the United States Army Corps of Engineers (USACE) is -43 CRD (-47.23 NAVD88). Bathymetry elevations are typically referenced in Columbia River Datum (CRD) but were converted to NAVD88 to compare to upland elevations. For comparison between CRD and NAVD88 at Austin Point, the CRD is 4.23 feet above NAVD88. This conversion is specific to Austin Point because the CRD is not a level datum and is sloped with the Columbia River as it flows downriver.

The northern portion of the site contains three pile dikes located at River Mile 86.11, 85.93, and 85.75. The current proposed design does not include the removal of the pile dikes. The pile dikes at the project site likely act to direct river currents into the main channel and limit the ability of the river to migrate east. The St. Helens Range Front Light is located at RM 86.11 in front of the pile dike. This is associated with the bend in the Columbia River navigation channel and cannot be moved.

Based on previous site data and recent explorations, it is apparent the site is blanketed by surficial artificial fill soils largely composed of dredge sands underlain by thick deposits of alluvial soils. Bedrock was not positively identified but is expected to generally be present at depths more than 200 feet below ground surface. The saturated alluvial soils extending to depths of at least 150 to 200 feet below ground surface are subject to seismically induced liquefaction and strength loss. Settlement of liquefied soils could be greater than 1 foot.

# 3.0 MARINE STRUCTURES

Two separate marine structures are being considered to support the  current concept of a bulk grain export terminal. The vessel structure will serve a Panamax vessel and will be located upstream of the River Mile 86.11 pile dike. The barge structure will serve a grain barge and will be located downstream of the River Mile 86.11 pile dike.

Near shore marine structures can generally be classified into two types of structures: quay wall and pier/wharves. Quay wall structures are vertical wall structures where the top of the deck is supported by a vertical wall and earthen fill materials. These structures are normally constructed by driving steel sheet piles into the shoreline while the area on the waterside of the quay wall is dredged and the material is placed behind the quay wall as fill on the landside of the wall. The second type of near shore marine structures are pile supported structures known as piers or wharves. Piers and wharves are normally constructed using an elevated steel or concrete deck supported atop steel or precast concrete piles. The piers and wharves are constructed over water and allow the water to pass beneath the structure and minimize the dredging required to allow larger ships to access the piers and wharves. Piers and wharves are accessed from the land by use of a bridge structure known as a trestle. A trestle is built in a similar manner to the pier to which it provides access.

Pier structures, versus a quay wall, are being proposed at Austin Point for both the vessel and barge structures. This is based on many factors, including site specific characteristics involving the river geometry, navigational considerations, environmental consideration and impacts on the shoreline, structural requirements of the piers, dredging requirements, and geotechnical recommendations. The marine structures are anticipated to be constructed by the Port while commodity conveyance systems and ship loaders will be designed and constructed by the future tenants. All structures assume that pier design will be modified to accommodate individual projects and therefore, the basic geometry and loading of the marine structures as discussed here is focused on typical designs for similar bulk facility ship mooring and berthing, geometry, and footprint only.

## 3.1 LOCATION AND ORIENTATION

As part of the conceptual planning exercise, the marine structures were located based on a number of factors including clearance from the Federal Navigation Channel and existing elements, need for dredging, river bank slope stability and extent of ground improvements, passing vessel influence, and size of marine structures (e.g., trestle and pile length). For example, the further out into the water the structures are, the less dredging and ground improvements may be needed but the influence of passing vessels and the size and cost of the structure increases. Conversely, the closer to the shore the structures are placed, the more dredging and ground improvements may be needed but the influence of passing vessels and the size and cost of the structures decreases. Table 1 summarizes the general impacts of the location of the pierhead line.

**Table 1 - Waterfront Structures/Dredging Alternatives Considerations**

| Long Pier Alternative | Short Pier Alternative |
|---|---|
| Decreased Capital Dredging | Increased Capital Dredging |
| Decrease Maintenance Dredging | Increased Maintenance Dredging |
| Decreased Ground Improvements | Increased Ground Improvements |
| Increase Passing Vessel Influence | Decrease Passing Vessel Influence |
| Increase Capital Pier Structure | Decreased Capital Pier Structure |
| Increased Tenant Improvement Cost | Decreased Tenant Improvement Cost |

First, a potential pierhead line was set based on a minimum clearance from the Federal Navigation Channel line and existing the existing pile dikes and St. Helens Range Front Light. A pierhead line is the line where a vessel and a pier structure interface. Due to the curve in the Columbia River, the pierhead lines of the dry bulk pier and the barge pier are not aligned.

In discussion with the Columbia River Pilots, they stated that the outer edge of a berthed vessel should not be closer than 200 feet from the edge of the FNC. The proposed face of berth for this study was located to minimize the impacts of the dredge slope on the shoreline and pile dikes and places the study vessel within this 200-foot area. A Passing Vessel Study would be required to further understand the impact from a passing vessel on the design vessel moored up at the pier. A 100 foot clear distance was provided to the St. Helens Range Front Light. Additionally, the barge pier was located to eliminate the need for dredging. See Section 2.1 of the Dredging and Hydrodynamics report located in the Appendix F of the main report.

In future phases of work, further study of the river currents, winds, and passing vessel influence is required to determine the optimal pierhead line for each structure.

## 3.2 GEOMETRY OF PIERS

The marine structure geometry is based on generally accepted industry geometries for dry bulk piers. KPFF also compared these geometries to similar structures currently in use elsewhere on the Columbia River. The marine structures are assumed to be supported on open ended, steel pipe pile extending approximately 100 feet below the mudline. The typical pipe pile diameter is expected to be 24 inches. Larger diameter piles are expected for elements located on the riverbank slope or on upland areas to resist lateral forces acting on the piles.

Access to the piers is anticipated to be via a trestle. The trestle to the vessel pier is located such that its centerline is perpendicular to the berth. The constraints of the upland site and location of the barge pier, the basis of which is described above, results in the trestle being closer to a 45-degree angle to the centerline of the berth. The use of a trestle to access the pier was chosen based on several factors which include:

- The assumption that a pier structure would be utilized versus a quay wall structure
- Reducing the overwater shadow area by providing open grating in the near shore area
- Reduction of the number of supporting abutments and piles and associated environmental mitigation by reducing the impact area of the piles

Locating the top of pier deck elevation was based on historical river data for the 100-year and 500-year flood events which correspond to elevations 17.1 feet NAVD88 and 28.8 feet NAVD88, respectively, and then consideration of water level rise due to climate change. Preliminarily, the top of pier deck elevation was located above the 500-year event with an assumed one foot of freeboard which resulted in a pier deck elevation of +30 feet NAVD88. This was then compared to the range of anticipated water level increases reported in the Preliminary Resiliency Analysis located in Appendix G of the main report. In discussion with the Port, an additional 0.5 feet of elevation was added to the pier deck elevation resulting in a top of pier elevation of 30.5 feet NAVD88. In addition, similar facilities along the river use a similar approach to establish the top of pier elevation.

## 3.3 GRAVITY LOADING OF THE PIERS

Most of the gravity loading (vertical dead and live loads) on dry bulk piers is in the conveying system and the ship loaders, the foundations of which will be designed and constructed by the future tenants. The loading on the marine structures addressed in this report is limited to maintenance, service, and emergency vehicles (ambulances). Fire truck access will likely not need to be provided on the piers. Live loads on the pier deck are therefore assumed to be limited to a uniform load of approximately 150 pounds per square foot and vehicle loads of 10,000 to 20,000 pounds (H-5 to H-10 truck loading).

## 3.4 GEOTECHNICAL CONSIDERATIONS

The geotechnical traits of the river bank will affect the size, type and location of the pier structures. According to the preliminary geotechnical analysis (see Appendix E), nearly all of the saturated soils at the site extending to depths of at least 150 to 200 feet below ground surface are potentially subject to liquefaction forces on marine pile supported structures. As a result, localized in-water ground improvements will likely be required around the structures. Ground improvement techniques vary, but in general, they are geotechnical construction methods that stabilizes the soil for all construction taking place on the soil.

Global stability of the river bank and greater site during a seismic event is also a concern at Austin Point. Initial investigation shows the river bank and greater site is stable in a static condition, but is unstable in a seismic condition. A large-scale program of ground improvement will be required to stabilize the riverbank and mitigate lateral ground movements across the site during and after the design earthquake. See the Preliminary Geotechnical Site Assessment located in Appendix E of the main report for discussions on potential ground improvements.

The ground improvements and pier structures can be designed to withstand up to three different seismic design events. A structure designed to the Design Earthquake (DE) is a minimum life safety design that will sustain heavy damage during the design seismic event. The structure is designed not to collapse, but will likely be a total loss. A structure designed to the Contingency Level Earthquake (CLE) may be moderately damaged during the design seismic event but would require costly repairs to remain serviceable. A structure designed to the Operating Level Earthquake (OLE) may be minimally damaged during the design seismic event and may remain serviceable with minor repairs. For this study, it is assumed that ground improvements and structures will be designed to the OLE which is a conservative assumption.

## 3.5 ENVIRONMENTAL CONSIDERATIONS

There are several environmental concerns that may require mitigation or could influence the design of the pier structures. One of which is the requirement to limit Over Water Shading (OWS) of structures near the shore. The Columbia River is a sensitive salmon route for migrating species of salmon. To protect salmon, agencies of jurisdiction have requirements to reduce the shadow areas of near shore structures which ultimately reduces the habitat and numbers of predatory invasive species. Measures that may reduce the effects of the project on

Endangered Species Act (ESA)-listed fish species include configuring docks, piers, and wharves such that the OWS components are located in deep water, as well as using materials that allow for light transmission to reduce shading (e.g., grated decking for walkways or gangways) on near shore marine structures, like access trestles. In addition to structural design considerations, some manner of mitigation will likely be required for river bottom disturbance from pier structures and in-water ground improvements. See the Preliminary Environmental and Other Regulatory Considerations report located in Appendix D of the main report for more description on mitigation.

## 3.6 COLUMBIA RIVER PILOTS COORDINATION

KPFF met with a representative from the Columbia River Pilots (CRP) on July 20, 2022 to discuss possible concerns with marine structures at the Austin Point site. In general, the CRP representative had no concerns about the site or placement of pierhead lines that could not be addressed with proper planning and design. The representative stressed that the owner and operator of a pier be aware of passing ship effect on moored vessels. Significant forces can be imparted by a passing ship into vessels moored at piers. Moored vessels will be impacted greater by passing ships the closer the pierhead line is to the Federal Navigation Channel line. Passing ship effect, like wind and current force, is a known design consideration that will need to be fully investigated during future phases of work. Due to this concern, the CRP representative recommended a 200-foot setback from outer edge of moored vessel to edge of the federal navigation channel line until the passing vessel effect can be studied further. Currently, the structure and vessel are located within this 200-foot zone to minimize dredging impacts to the shoreline and existing pile dikes.

The representative also stated the need for a turning basin close to the proposed berth. See the Preliminary Dredging and Hydrodynamics Assessment report located in Appendix F of the main report for more description on the turning basin.

## 3.7 MARINE STRUCTURE DETAILS

Dry bulk and barge marine structures are typically comprised of several similar components. These include mooring dolphins, breasting dolphins, trestles, and interconnected walkways. This report will focus on the typical pier components that are to be provided by the Port and not the conveyor and ship loading components that are to be provided by the tenant. An example arrangement of a dry bulk structures is shown in Figure 1.

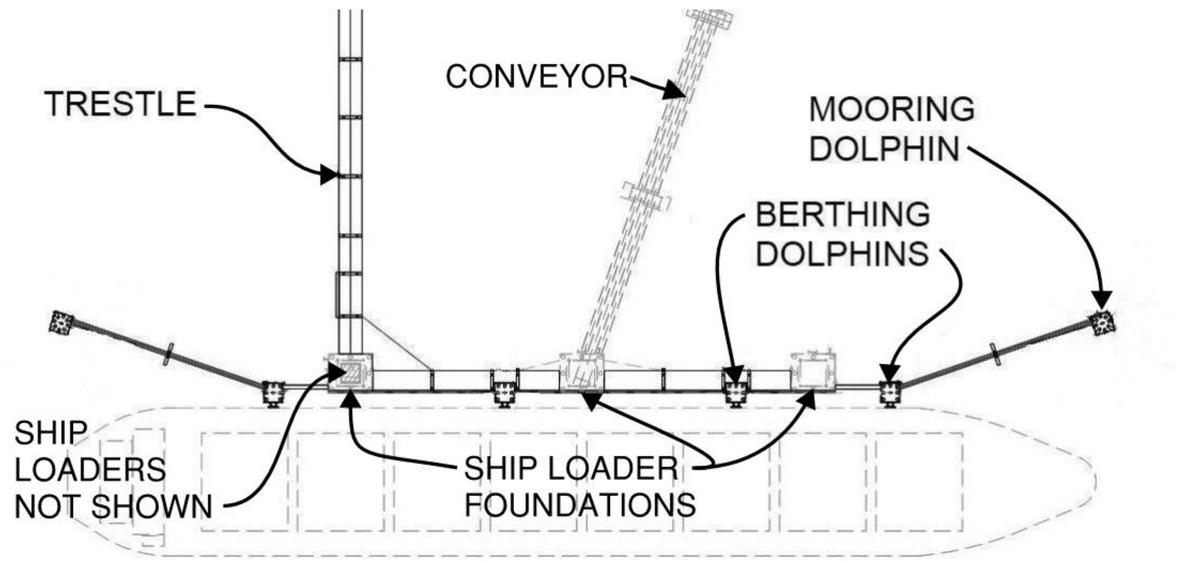


**Figure 1- Example Vessel Marine Structure**

Mooring Dolphins

Mooring dolphins are in-water structures that allow the ship to attach mooring lines to hold the ship in position against river current, wind, and waves. These structures hold the ship in place and are located foreword and aft of the ship. These structures are anticipated to be constructed of battered steel pipe piles and concrete pile caps. The battered steel piles (piles installed at an angle) are more efficient than plumb piles in their ability to resist the loading of the ship on the structure. These structures will be interconnected by use of pedestrian gangways at each end of the pier. The ship's mooring lines will be attached to a bollard located on the top of the mooring dolphins. Ideally, the design of the dry bulk pier will allow ships to be loaded without having to be moved along the structure. Under certain circumstances (e.g., out of commission loaders or loader type), ships may be periodically required to move along the face of the berth to facilitate loading. Ship movements can be accomplished in one of two ways. Tugs can be used to reposition the larger ships or mechanical winch capstans can be located on the mooring dolphins in order to facilitate ship movement along the pierhead line. The Panamax vessel structure shown in the alternatives has been sized assuming moving vessels along the pier is not required for loading.

Breasting Dolphins

Breasting dolphins are in-water structures that assist in berthing of vessels by absorbing berthing energy, keep the vessel from pressing against the pier structure, and serve as mooring points via the use of bollards to restrict the movement of the vessel. Fender panels located on the waterside of the dolphin are the main element which absorb the vessel berthing energy. The fenders are constructed of low friction, durable materials that allow the ship to move against the panel as the ballast of the ship changes or tidal changes occur. These structures are located along the side of the ship and are in line with each other and the side of the ship to provide a uniform hull pressure. These structures are anticipated to be constructed of vertical and battered steel pipe piles and concrete pile caps.

The breasting dolphin structures may be interconnected in one of three ways. If they are constructed prior to the ship loader foundations, pedestrian gangways will be located in between the breasting dolphins. If the dolphin structures are constructed at the same time but independent of the ship loader foundations, trestles will be located in between the dolphins and tower foundations which will allow for vehicular traffic. Another option if constructing the dolphins and ship loader foundations at the same time is fully integrating them into one structure, i.e., a continuous concrete pier. A one-structure approach may provide efficiency in both materials and construction time. A single, fully-integrated structure will distribute loads more uniformly, likely reducing the demands on both the piles and the pier structure.

Trestles

The main approach trestle (connecting the upland with the pier) will consist of pipe piles, steel pile caps, and longitudinal steel beams. Steel grating will span between the longitudinal beams. The trestle clear width is anticipated to be approximately 20 feet and pile caps will be spaced at approximately 70 feet. The trestles located at the breasting dolphins and ship loader foundations will likely consist of steel framing and grating and will span between the dolphins and foundations.

# 4.0 CONCLUSIONS

Marine structures at Austin Point are anticipated to be constructed using industry standard design with the structures likely being steel pile supported pier structures with piles extending to depths of at least 150 to 200 feet below ground surface.

No issues that could not be mitigated through thoughtful design were identified during this review. However, the following design considerations will need to be considered:

- Wind, wave, current, and passing ship analysis will need to be performed to further inform site design.
- Environmental mitigation measures associated with the pier construction will need to be considered including Over Water Shading and type and extent of in-water ground improvements.
- Localized in-water ground improvements around the marine structures will likely be required.
- In-water ground improvement of the riverbank and greater site to stabilize the river bank and mitigate lateral ground movements across the site during and after a seismic event will likely be required.

# 5.0 REFERENCES


- ASCE MREP No. 129, *Mooring of Ships to Piers and Wharves*, Mooring Analysis Task Committee, American Society of Civil Engineers (ASCE) – Coasts, Oceans, Ports, and Rivers Institute (COPRI), 2014.
- ASCE/COPRI 61-14. *Seismic Design of Piers and Wharves*, American Society of Civil Engineers (ASCE) – Coasts, Oceans, Ports, and Rivers Institute (COPRI), 2014.
- Gaythwaite, John W., *Design of Marine Facilities: Engineering for Port and Harbor Structures*, Third Edition
- PIANC MarCom WG 184, *Design Principles for Dry Bulk Marine Terminals*, The World Association for Waterborne Transport Infrastructure (PIANC) Coastal and Ocean Waterways Commission (MarCom), 2019