PRELIMINARY REPORT

THORNDYKE RESOURCE OPERATIONS COMPLEX

CENTRAL CONVEYOR AND PIER PROJECT
POTENTIAL EFFECTS ON LONGSHORE SEDIMENT TRANSPORT AND SHORELINE PROCESSES

Prepared for

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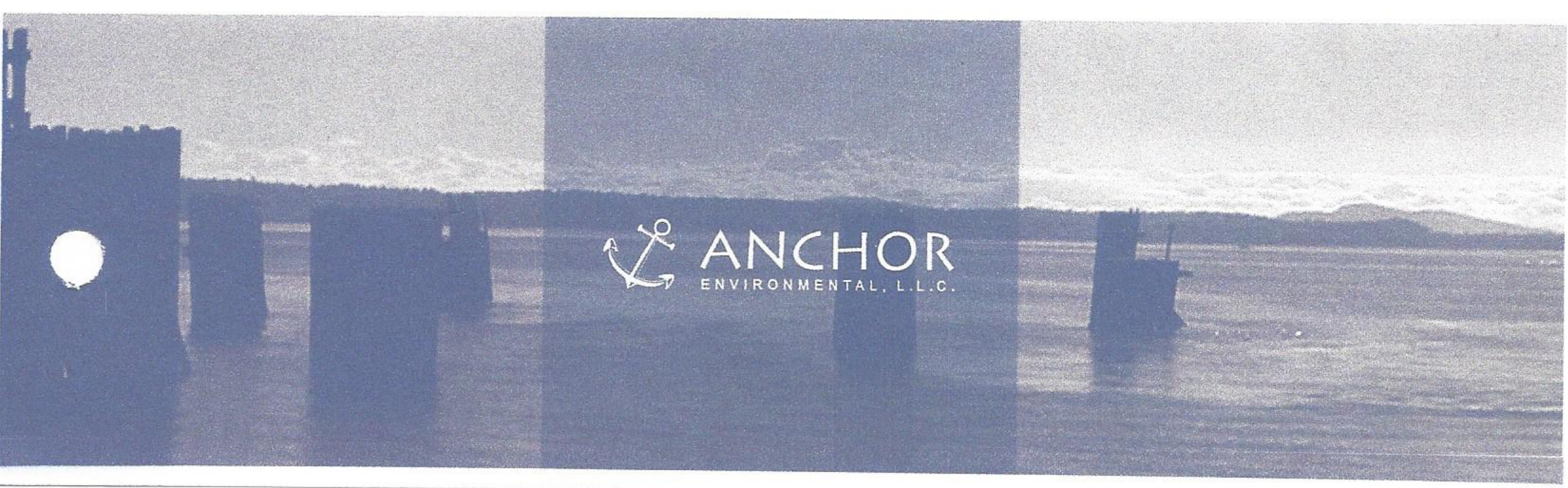
Note: This report is subject to modification as a result of the completion of the SEPA analysis (Environmental Impact Statement) being undertaken as part of the governmental permitting process.

February 2003



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EXECUTIVE SUMMARY

This report was written in conjunction with other studies in connection with the construction and implementation of a conveyor system, as part of the Thorndyke Resource Operations Complex (T-ROC) project. The purpose of this document was to evaluate the potential impacts on the nearshore environment by the construction and operation of the coastal element of the Central Conveyor and the proposed Pier.

Standard coastal engineering methodology was used, when applicable, to provide a quantitative or semi-quantitative basis for the conclusions. Four areas of potential impacts from the proposed construction were identified:

- Impacts on sediment sources due to modification of the backshore bluff;
- Impacts to longshore transport and general beach profile due to the presence of the Pier;
- Impacts to the wave climate and general beach profile due to the mooring of vessels at the Pier and the presence of the breasting dolphins;
- Impacts to the deep-water marine environment due to vessel propeller wash.

The conclusions are as follows:

- Because of the limited area of disturbance, the proposed bluff modifications along the conveyor route should not affect site sediment supply source.
- Although localized and short-term scour or accretion at the bases of the pilings that bear the support structures for the Pier may occur, because of their size and spacing, the pilings should not affect wave climate or create a rip current in the vicinity of the Pier.
- The breasting dolphins should not change wave climate or the rate and pattern of longshore sediment transport.
- Vessels moored along the Pier could potentially trigger the formation of a salient, but the shoreline should reach equilibrium and longshore sediment movement should not be stopped or perturbed. It is likely that any feature would be transitory.
- Scour of bed sediment due to vessel propeller wash is anticipated to occur only in the case where the propeller wash is directed toward the shoreline, or if the tug operates in water depth shallower than 50 feet. Scouring impacts would be short term and localized. Propeller wash should not have an impact on shoreline processes or beach stability.

1 INTRODUCTION

1.1 Presentation and Scope

The proposed Central Conveyor and Pier are components of the Thorndyke Resource Operations Complex (T-ROC). The Central Conveyor is approximately four miles long and is constructed to transport sand and gravel from the existing Shine Pit to a proposed Pier on Hood Canal. The Pier is located approximately five miles south of the Hood Canal Bridge on the western shore of Hood Canal (Appendix A, Figure A-1). At the Pier, sand and gravel will be transferred to barges and ships for delivery to customers for both construction and environmental mitigation projects (specifically beach restoration).

The purpose of this document is to evaluate potential short and long-term effects the southern end of the Central Conveyor and the proposed Pier may have on the geophysical and geological processes of the shoreline and nearshore environment at and near the proposed project site. The analysis will focus mainly on the over-water portion of the Central Conveyor and Pier.

Four potential impacts from the proposed construction were identified:

- Impacts on sediment sources due to modification of the backshore bluff;
- Impacts to longshore transport and general beach profile due to the presence of the Pier;
- Impacts to the wave climate and general beach profile due to the mooring of vessels at the Pier and the presence of the breasting dolphins;
- Impacts to the deep-water marine environment due to vessel propeller wash.

1.2 Evaluation Methodology

This report presents a discussion and a qualitative assessment of the degree the potential impacts the construction of the Pier will have on shoreline processes at and in the vicinity of the project site. Standard coastal engineering methodology was used, when applicable, to provide a quantitative or semi-quantitative basis for the conclusions. When standard methodology could not be used (due to either lack of key data or inapplicability of the evaluation method to the site conditions), best professional judgment was used in assessing potential impacts. National experts in shoreline processes were also consulted to provide quality control regarding the appropriate approach for assessing potential impacts.

The evaluation was performed using the following approach:

1. Locate and compile site-specific geographic, meteorological, and marine data;
2. Perform a literature search for similar projects in the United States and consult with technical experts on shoreline processes;
3. Conduct a site visit to identify sources of sediments, characterize sediment at the project location, and identify specific site features;
4. Identify aspects of the construction that could affect longshore sediment transport and shoreline processes;
5. Make a qualitative assessment of the potential impacts associated with the construction.

Information gathered during our investigation was considered sufficient to qualitatively evaluate potential impacts from construction of the Pier on shoreline processes. Site-specific information such as wind speed, direction, and duration, as well as water current velocities at the site and grain size information along the Pier path would be useful in verifying the assumptions used in this evaluation. This information would mostly have helped to refine our conclusions using simulations and other coastal engineering computer models.

The following individuals were consulted to discuss evaluation methodology and potential impacts, and as an internal quality control. These individuals were consulted as technical experts in the field of coastal engineering and shoreline processes:

- Dr. Billy Edge, Ph.D., P.E., Texas A&M University, College Station, TX;
- Dr. Daniel Cox, Ph.D., Texas A&M University; College Station, TX;
- Mr. W.A. Birkemeier, Hydraulic Engineer, CERC's Field Research Facility, Duck, NC;
- Dr. Lee Weisher, Ph.D., Woods Hole Group, Boston, MA.

1.3 Project Description

A detailed T-ROC Central Conveyor and Pier project description and fact sheet are provided in Appendix B of this document.

2 DEFINITION OF COASTAL TERMS

Several coastal engineering terms and concepts used to describe the nearshore environment are defined below. General concepts of sediment movement in the nearshore are also described.

2.1 Nearshore Environment

Figure 1 illustrates the nearshore environment, also referred to as the coastal zone. The nearshore environment begins at the coastal bluffs and extends offshore to the point where sediment movement is no longer affected by wave activity (Komar 1998). As illustrated in Figure 1, this environment consists of the nearshore upland, the backshore, the beach face (or surf zone), and the low-tide terrace.

The beach is the zone of unconsolidated material that extends landward from the low water line to the place where there is marked change in material or physiographic form, or to the line of permanent vegetation. The seaward limit of a beach, unless otherwise specified, is the mean low water line (CERC 1984).

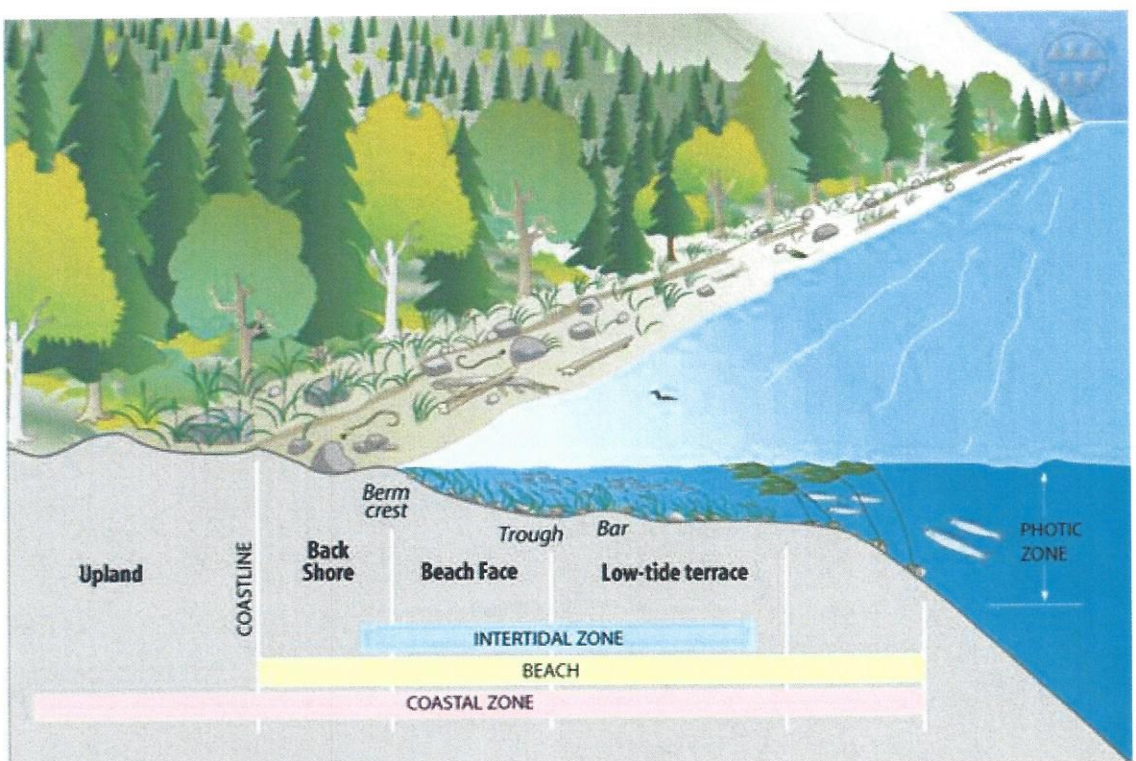

Figure 1
Nearshore Section Illustrating Typical Zonation
Source: Williams et al (2001)

2.2 Currents

Tides, wave action, and other phenomena generate currents in the nearshore that constantly move sediments. Currents in the Puget Sound are mainly generated by tides (Downing 1983), and the same holds for Hood Canal, which is a semi-enclosed basin. Even though tidal currents near the shore are not as swift as in deeper areas due to bottom friction, tidal currents tend to act along the length of a shoreline, and will vary in magnitude with respect to distance from the deepest part of a passage to the shore.

In addition to tidal currents, there are two wave-induced current systems in the nearshore that are typically the main causes of nearshore sediment movement:

- **Longshore Current:** Wave transformation in shallow water generates a movement of water called a longshore current that travels parallel to the shoreline. Waves breaking at an angle to the beach can also generate a longshore current that is largely confined to the nearshore area.
- **Rip Current:** A narrow intense current setting seaward through the surf zone. It removes the excess water brought to the zone by the small net mass transport of waves. It is fed by longshore currents. Rip currents usually occur at points, groins, jetties, etc., of irregular beaches, and at regular intervals along straight, uninterrupted beaches.

The different types of currents vary in velocity, depending on the tidal stage, wave climate, water depth, and the presence or absence of structures.

2.3 Sediment Source and Movement

The primary sediment source in the Hood Canal region is from coastal bluff abrasion, failure, and erosion. Once material is deposited within the beach zone, waves cause agitation in the water column and act to lift sediments into suspension. Currents then can transport the suspended sediments. This combined action of waves and currents on beach sediment is the main cause of shoreline change in the nearshore. There are two main directions for sediment movement:

- Longshore (parallel to the shoreline), mainly because of longshore currents.

- Cross-shore, or onshore/offshore (perpendicular to the shoreline), mainly because of wave swash and backwash (rush of water up and down on to the beach face following the breaking of a wave).

Most longshore movement of sediment is caused by wave-generated longshore currents. Tidal currents also play a role in sediment movement, but their contribution is less than wave generated currents. Sediment moves in both longshore directions (i.e., northeast and southwest for this project site) at different rates. However, there is typically a net movement of sediment in one of the directions caused by local geography and predominant wind direction. The rate of longshore sediment transport is a function of many different variables, and is usually difficult to predict.

Cross-shore sediment movement is mainly dependent on wave climate. The highest wave heights with shorter period waves experienced during the winter season tend to transport sediment offshore. In Hood Canal, the winter season is characterized by southerly winds and long waves that carry sediment loads longshore, mostly from south to north, and offshore. Longer period waves, typically experienced during the summer season, tend to transport sediment onshore. The summer season experiences northerly winds that induce a north to south movement of sediment. During the summer season, waves typically exert less energy on the beaches than during the winter.

3 SITE DESCRIPTION

This section describes the physical features of the study site, and summarizes the literature review for site-specific wind and wave information, and existing drift cell study results.

3.1 Physical Description

A field visit to the project site was conducted on the August 7, 2002, to identify site-specific characteristics that could affect the shoreline processes within the study area. During this site visit, which occurred during low tide, sediment classification along the beach was estimated, and potential backshore sources of sediment and location of shoreline stabilization structures were identified, as well as other site-specific features.

The backshore of the Hood Canal Sand and Gravel Company Property (Figure 2) is composed of an exposed steep cliff of moderate height (till) fronted by beach vegetation, medium size rocks, and woody debris of various sizes. The beach face is composed of coarse sand overlain by small cobbles and pebbles, with woody debris. There is approximately 150 feet between the bluff and the beach face.

The low-tide terrace extends approximately 650 feet offshore of the beach face, with longshore bars and troughs, and an approximate 1 vertical to 75 horizontal (1:75) slope. The low-tide terrace begins with a trough, approximately 15 feet wide, consisting of a mixture of sand, silt, and clay, with a high water content. Seaward of this trough, the low-tide terrace is composed almost exclusively of fine sand, with a predominant amount of quartz, to a thickness greater than 1.5 feet.

The low-tide terrace near the low-tide line is characterized by a succession of mounds that were approximately 100 feet wide and 2 feet high. The shape of these mounds is repeated periodically along the shoreline and extended farther south than north of the proposed project location. Where the low-tide terrace ends offshore, the bottom slope increases rapidly to a slope of 1:30 then 1:4. At approximately 900 feet from the coastal bluff, there is an existing dolphin that serves as a channel marker buoy (Figure 4).

Figure 2
Backshore portion of the Hood Canal Sand and Gravel Company Property

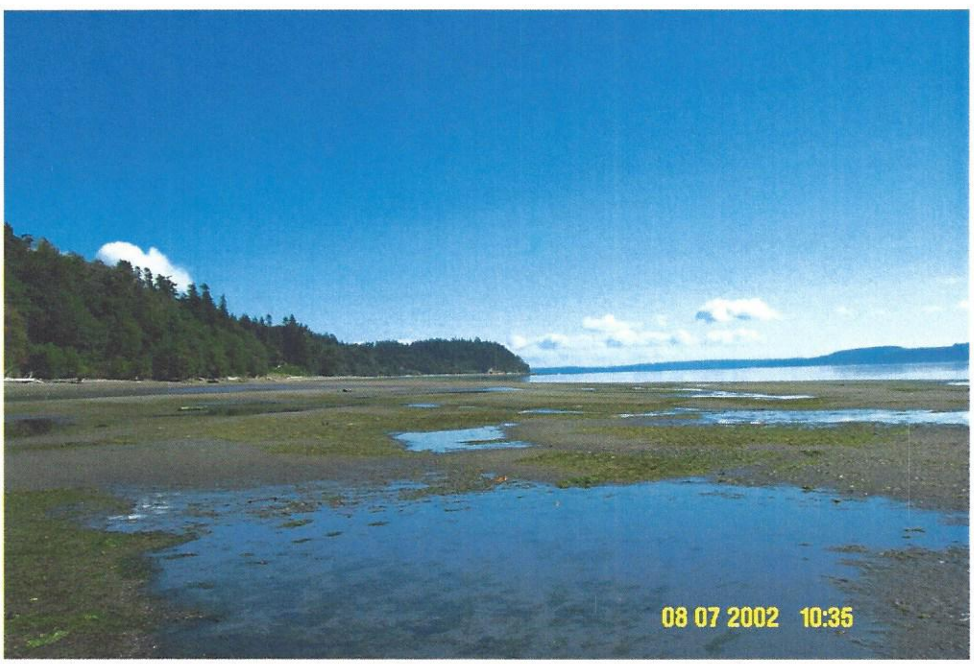

Figure 3
Low-tide terrace of the Hood Canal Sand and Gravel Company Property

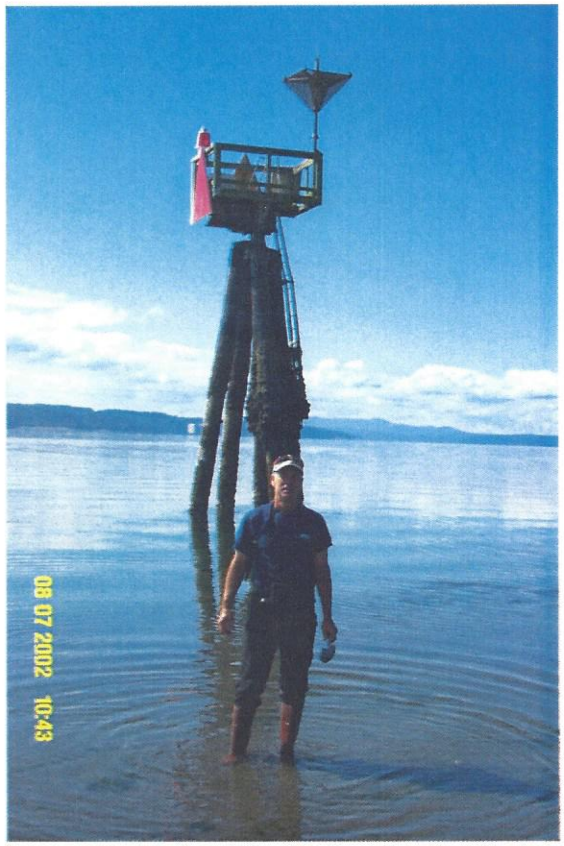

Figure 4
Channel marker dolphin located offshore of the Hood Canal Sand and Gravel Company Property

The beach morphology does not vary significantly south of the site but changes noticeably north of the site. Approximately 1,200 feet northwest of the dolphin, the beach becomes narrower, steeper, and the mounds are less apparent. The backshore is wider and consists of coarser material.

There are no existing shoreline protection structures in the immediate vicinity of the project site. At approximately 1,200 feet south of the dolphin, we noticed the presence of a 220 feet by 100 feet matrix of plastic mesh cylinders gridded approximately one foot apart. No information concerning the reason or date of the installation of those cylinders could be found. The cylinders are approximately 6 inches in diameter and 12 inches long (4 inches above sand and 8 inches below surface). Approximately 800 feet north of the dolphin, some property owners installed relatively short seawalls along their property.

3.2 Wave Climate

Waves are considered the primary force affecting the shoreline, and are characterized by a specific length, period, and height. In Hood Canal, wind-generated waves are the most common wave form and are created by winds blowing over a distance of open water. The main factors that affect the generation of waves are fetch (i.e., the distance that wind travels over an uninterrupted stretch of open water), duration of wind event, and sheltering of the surrounding terrain.

The *Washington State Shore Zone Inventory* (WSDNR 2000) classified the portion of shoreline at the project location as semi-protected to fetches (maximum fetch from 6 to 30 miles) and semi-protected to waves, on a scale consisting of very protected, protected, semi-protected, semi-exposed, and exposed. Based on a map of the project site, fetch from the north is approximately 5.3 miles, 9 miles from the south, and 2.3 miles from the east.

Figures 5a through 5d portray wind information collected on the Hood Canal Bridge for the years 1998, 1999, 2000, and 2001. On the figures, the arrows represent the wind vector (wind speed and direction in the direction toward which the wind blows). It appears that the predominant winds at the bridge are mainly from the south-southwest and from north-northeast. However, because the bridge is located at the entrance of the Canal, whereas the project site is located within the Canal, it can be assumed that winds that affect the project site are more closely aligned with the southwest-northeast direction of the Canal due to sheltering of winds from other directions. This feature of the wind pattern has been observed by many sources.

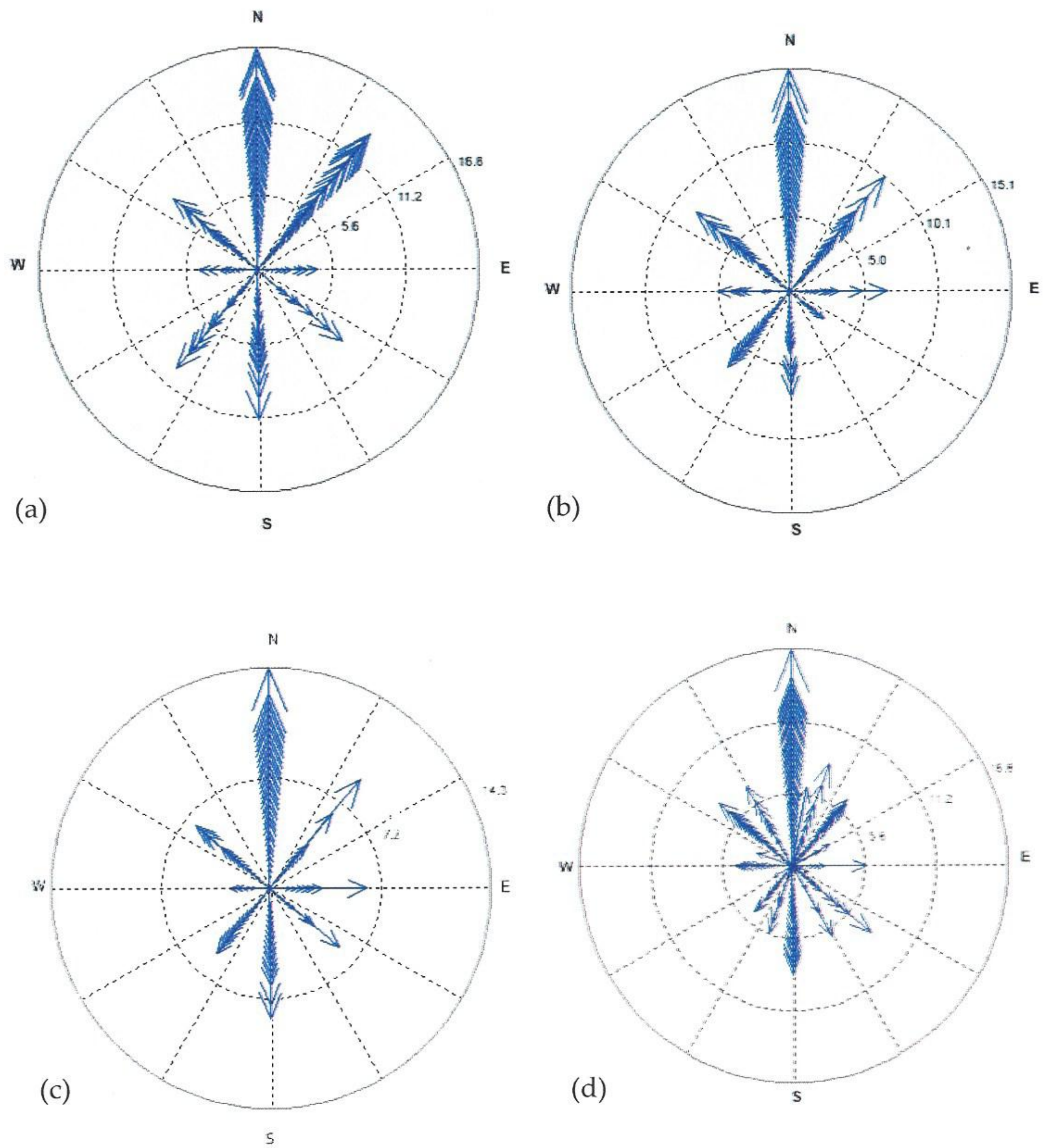

Figure 5
Wind vectors at Hood Canal Bridge (direction in degrees and velocity in m/s) for the years (a) 1998, (b) 1999, (c) 2000, and (d) 2001

Based on wind vectors observed at the project site, winds coming from the south-southwest and north-northeast quadrants were used to hindcast predicted wind wave heights and periods using the *Shore Protection Manual* (CERC 1984) methodology. The computed wave information is only an approximate representation of the wave environment at the project site, because wind duration data were unavailable.

Tables 1 and 2 present predicted significant wave height (H_s, which represents the average amplitude of the highest one-third of waves, and is the height of the waves perceptible by a human eye in a wave group), and period (T), for the years 1997 to 2001 during the winter and summer seasons. The winter season was defined as the months from November to April, and the summer season from May to October.

The significant wave heights and periods presented in the tables were computed using the average of all wind speeds in Hood Canal during those periods. Waves from the north were computed using the average wind speed from the northwest, north, and northeast. Waves from the south were computed using the average wind speeds from the southwest, south, and southeast. These tables serve as a basis for comparison between waves coming from the north versus the south, and waves that occur in the winter rather than the summer. Higher waves can be observed during storm events, which are frequent in the winter. For example, swells of 4 to 6 feet were observed in the Canal at the Bangor Station during storm events when winds ranged up to 60 knots (kts).

Table 1
Wave Information for the Winter Season

Year	North		South	
	H_s (ft)	T (seconds)	H_s (ft)	T (seconds)
1997	0.4	3	1.0	3.9
1998	0.5	3.1	1.4	4.7
1999	0.4	2.8	1.1	4.1
2000	0.4	2.7	1.0	4
2001	0.3	2.7	1.0	4.3

Table 2
Wave Information for the Summer Season

Year	North		South	
	H_s (ft)	T (seconds)	H_s (ft)	T (seconds)
1997	0.4	2.8	0.7	3.6
1998	0.5	2.7	0.9	3.9
1999	0.4	2.8	0.9	4.1
2000	0.4	2.8	0.8	4.2

From Tables 1 and 2, it appears that waves generated by southerly winds are higher than waves resulting from northerly winds, and are also higher during the winter than the summer season. This seasonal pattern of the wave climate results in a seasonal movement of sediment along the shoreline, in every direction, both longshore and cross-shore. However, because of the predominance of the southerly waves, the net sediment movement is oriented toward the north. The results of different drift cell studies presented in the next section confirm this information.

Beach morphology varies during time, both vertically and horizontally. Because pier construction might affect sediment movement at the proposed site location, it is relevant to compute the depth at which sediment movement is no longer affected by wave activity. This depth is known as the closure depth. For quartz-sand beaches (which is the case at our site, see Section 3.1), the closure depth, h_c, at which sediment transport becomes negligible, was found by (Komar 1998) to be approximately:

$$h_c = 2.28 H_e - 68.5\left(\frac{H_e^2}{gT_e^2}\right)$$

where H_e = nearshore storm-wave height that is exceeded only 12 hours per year

T_e = associated wave period.

Closure depth in the Hood Canal was computed using 50- and 100-year return period waves estimated with West Point (located in Discovery Park, six miles northwest of Seattle) wind data (Foster Wheeler personal communication, 2002), as presented in Table 3. Because wind speed duration was unavailable at the project site, it was not possible to do the same computation for the Hood Canal project site.

Table 3
Closure depth associated with 50- and 100-year waves

	Wave Height (ft)	Wave Period (s)	Closure Depth (ft)
North Quadrant			
50-year Return Period			
Lower 95% Confidence Bound	6.49	5.3	11.6
Median	8.69	6.0	15.4
Upper 95% Confidence Bound	10.99	6.6	19.2
100-year Return Period			
Lower 95% Confidence Bound	6.89	5.4	12.2
Median	9.51	6.2	16.7
Upper 95% Confidence Bound	12.40	7.0	21.6
South Quadrant			
50-year Return Period			
Lower 95% Confidence Bound	4.40	4.1	7.6
Median	5.12	4.4	8.8
Upper 95% Confidence Bound	5.90	4.6	10.0
100-year Return Period			
Lower 95% Confidence Bound	4.59	4.1	7.8
Median	5.54	4.5	9.4
Upper 95% Confidence Bound	6.59	4.9	11.2

According to Table 3, the deepest closure depth corresponds to the highest wave height, and is 21.6 feet. The –20 feet mean lower low water (MLLW) contour line lies approximately 780 feet offshore from the backshore and is shoreward of the proposed locations of the breasting dolphins. Hence, the sediments in the immediate vicinity of the breasting dolphins should not be affected by wave propagation and possible wave transformation at the site.

3.3 Drift Cell Study Results

A drift cell is a partially compartmentalized zone along the shoreline that acts as a closed system with respect to transport of beach sediments. A drift cell consists of segments of a shore that include the source of sediments, the area where they accumulate (a sink), and the connecting path between the two (Downing 1983).

The Washington Department of Ecology (Johannessen 1992) conducted a net shore drift study in San Juan County and parts of Jefferson, Island, and Snohomish counties. This study indicated that the project location is part of a drift cell that originates from a zone of divergence located 2.2 miles north of Hazel Point and has generally northeastward net-shore drift along the eastern shore of the Toandos Peninsula for approximately 10.6 miles to the eastern end of the spit that originates near South Point (located southwest of the site). Net northward shore-drift in this cell matches net northward and northeastward shore-drift in cell KS 2-1 on the Kitsap County shore of this portion of the Hood Canal (Taggart 1984). Drift sediment is initially derived from two stream deltas near the cell origin, exposed bluffs cut into sandy glacial drift, and from streams that are found intermittently along the cell.

Results from the *Shore Zone Inventory* (WSDNR 2000) classify the project site location as being in cell 1320, which is 1.5 miles long (Figure 7). This cell is described as a sand flat with open sandy beaches. The principal sediment source is the backshore, and general sediment movement is from the southwest to the northeast. Sediment in this cell is abundant, and the beach deposits are highly mobile. Because of this abundance and mobility, there are some accretional landforms in the vicinity, such as the spit. However, the *Shore Zone Inventory* (WSDNR 2000) mentions that the stretch of the shoreline in this cell might be currently eroding, but the reasons are not explained.

The results of both studies (WSDNR 2000; Johannessen 1992) indicate that the net sediment movement is northward and that there are many sources of sediment outside the project location, even though the backshore serves also as a source of sediments. The site however is subject to erosion due to a combination of factors that are yet to be determined.

Drift Cell Boundaries

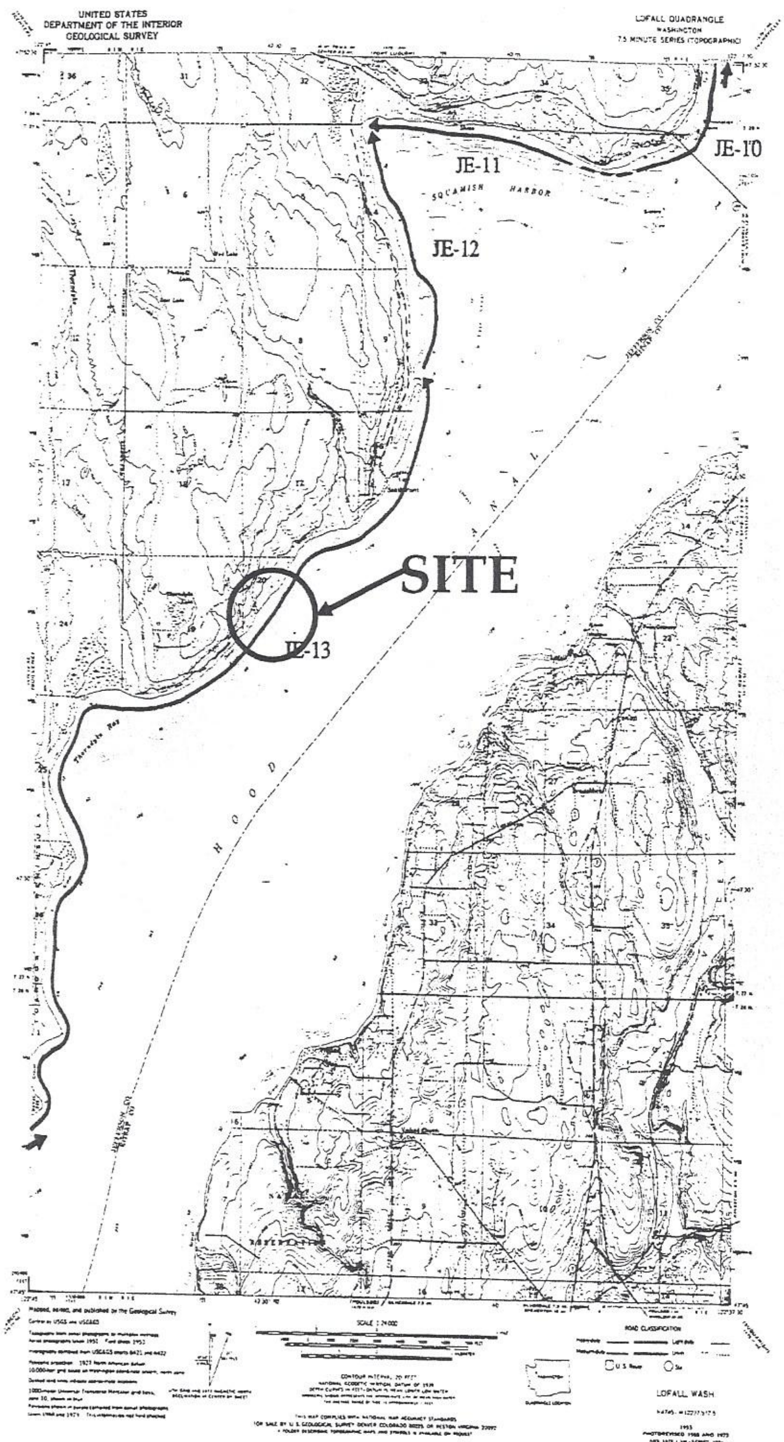

Figure 6
Drift cell JE-13 in Net-Shore Drift in Washington State (Johannessen 1992)

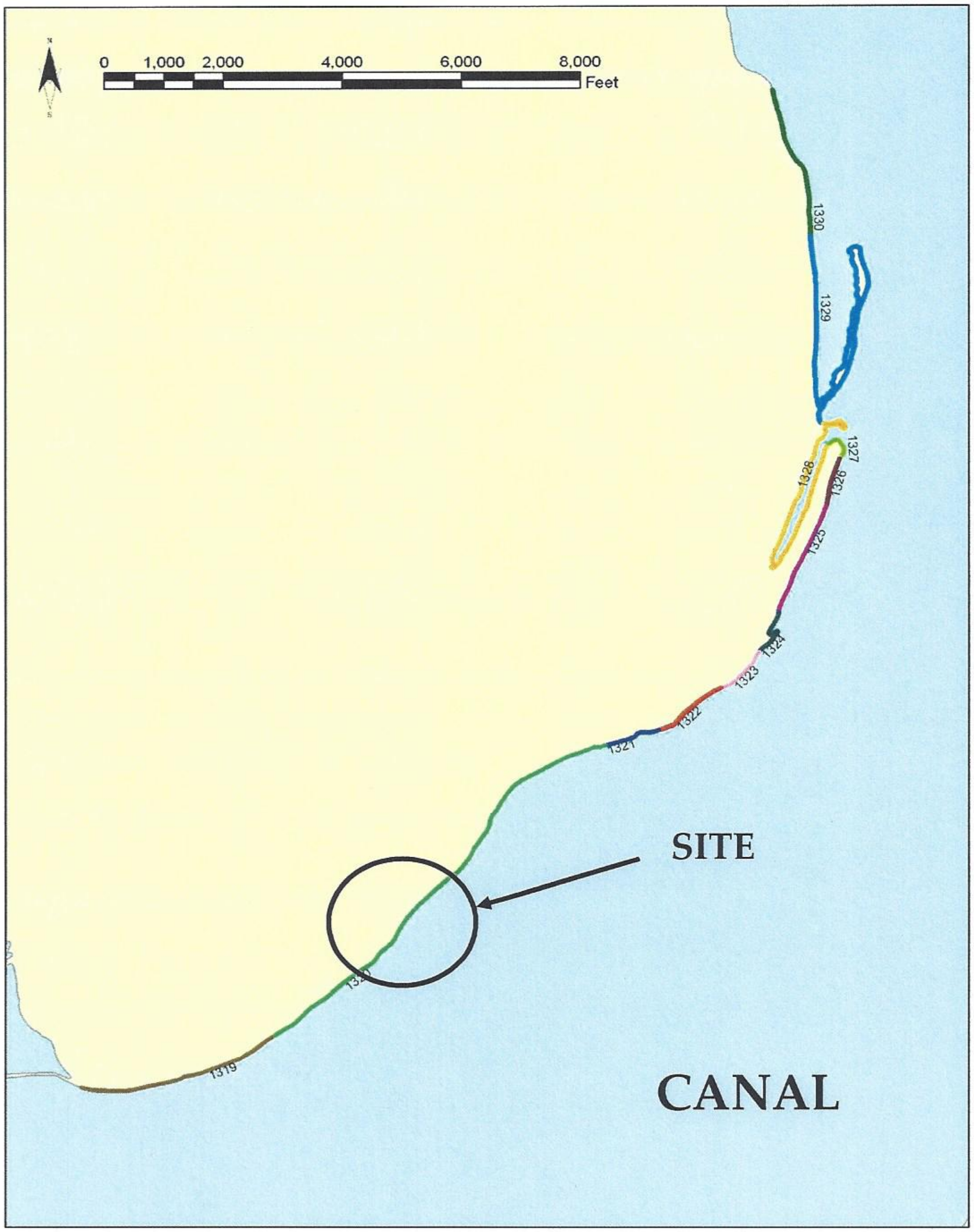

Figure 7
Drift cell 1320 in Shore Zone Inventory (WSDNR 2000)

4 SUMMARY OF PIER CONSTRUCTION AND OPERATION

The single conveyor, which will be approximately 0.70 mile long, begins at a point approximately 1300 feet north of Thorndyke Road and extends to the landward end of the proposed Pier. On land, approximately 200 feet from the Ordinary High Water (OHW) line, the single conveyor will angle down through a proposed cut in the hillside approximately 50 feet wide and 20 feet deep (Appendix A, Figure A-2).

The proposed Pier location is five miles south of the Hood Canal Bridge, extending approximately 1,000 feet from the OHW line at the Hood Canal Shoreline. It terminates in water 50 feet deep relative to MLLW. Over water, the Pier will be approximately 32 feet above MLLW for approximately the first 500 feet waterward of OHW (i.e., Station 228+00 to Station 233+00). The bottom (or invert elevation) of the conveyor will be approximately 22 feet above MLLW. The conveyor will then slope upward to a steel support structure approximately 91 feet above MLLW. The final support structure at the end of the Pier is located at an approximate height of 76 feet above MLLW. Each of these two open steel support structures will include sixteen 30-inch piles.

The Pier is designed to accommodate ships and barges of various sizes. During mooring operations, all vessels will be tug-assisted and will not maneuver under their own power. For mooring larger ships or multiple-barge tows, two tugboats may be used. Ships are not expected to call at the Pier until approximately 8 to 12 years after the Pier's construction.

Dimensions of the largest ships will be 110 feet wide and 745 feet long with a 45-foot draft. Ship capacities will range from 20,000 dead-weight tons (dwt) to 65,000 dwt. The largest-capacity ship will require approximately 24 hours to load.

Dimensions of the largest barges will be 100 feet wide and 400 feet long with a 25-foot draft. Barge capacities will range from 2,500 to 20,000 dwt, with a typical capacity of 5,000 dwt. A 2,500-dwt barge will take up to one hour to load, and a 20,000-dwt barge will take up to eight hours.

The Pier will be used up to 300 days per year. It is projected that ships would be loaded between 48 and 72 days a year, no more than one per day. Barges will be loaded the remainder of the 300 days, averaging three per day, but no more than six per day.

5 EVALUATION OF POTENTIAL IMPACTS

As previously mentioned, the four potential impacts from the proposed construction include:

- Impacts on sediment sources due to modification of backshore bluff;
- Impacts to longshore transport and general beach profile due to the presence of the Pier;
- Impacts to the wave climate and beach morphology due to the mooring of vessels at the Pier and the presence of the breasting dolphins;
- Impacts to the deep-water marine environment due to vessel propeller wash.

The evaluation of those impacts will be based on site visit observations, standard coastal engineering practice, and best professional judgment.

5.1 Potential Impacts to Shoreline Processes from Bluff Modifications

One potential impact from the proposed project is that construction on the bluff may affect the source of sediment that nourishes the beach. This type of impact can be seen in locations where substantial shoreline protection or slope stabilization efforts have interrupted the supply of sediment to the beach.

The proposed path of the conveyor will angle down a hillside through a cut that is approximately 50 feet wide and 20 feet deep. Stability of landslide zones at the top of the slope will be improved through subsurface drains, and surface drainage and erosion protection will be put on the bluff face below the conveyor. Also, up to 100 feet of riprap or other erosion protection may be installed along the face of the bluff.

The cut and stabilization measures may reduce the volume of soil present in the hillside only at its proposed location. However, the protection measures will affect only 100 feet of bluff, and drift cell study, *Shore Zone Inventory* (WSDNR 2000), and site observations demonstrated that sediment sources are abundant at the site. Hence, bluff modification will not impede continuous feeding of the shoreline either downdrift or updrift of its location. Since the impact of the project on the feeder bluff is very limited, it is not anticipated that the proposed construction will cause a significant decrease in the supply of sediment to the shoreline.

5.2 Potential Impacts of Pier Pilings on Nearshore Sediment Transport

The conveyor, located well above Mean Sea Level (MSL), is positioned high enough to never interact with waves and currents. Potential impacts to sediment movement in the nearshore would only be expected from the Pier pilings. According to the construction drawings (Appendix A, Figures A-3 and A-4), one structure located at the beach face will support the conveyor, and five others in the low-tide terrace will support the Pier. The support structures will be approximately 100 feet apart. Farther offshore in deep water, 150 feet away from the last support structure, two open steel support structures approximately 200 feet apart will support the Pier (Appendix A, Figure A-4). At the end of the Pier, vessels will berth along eight breasting dolphins, approximately 120 feet apart. Each dolphin will be composed of 12 closely arrayed piles 30 inches in diameter (Appendix A, Figure A-5).

The support structures and the first open steel structure located closest to the shore are considered to be sufficiently far apart that they will not alter longshore sediment movement or create a rip current in the nearshore. However, local scour at the bases of the five support structures' pilings in the nearshore can be expected, though the amount of scour is not anticipated to be significant.

5.2.1 General

Overwater structures, such as piers, placed within the nearshore zone can potentially affect the movement of sediments within local drift cells. The flow of water in the nearshore can be disrupted by the installation of pilings, which can affect the bathymetry of the substrate and change the water circulation patterns in the immediate vicinity of a pier (Nightingale and Simenstad 2001).

Sufficiently spaced piles typically do not cause erosion adjacent to a pier. Also, open pile structures like piers tend to interfere less with sediment transport than do closed structures such as groins (Nightingale and Simenstad 2001). Scour at the piling base can occur, but consequences on the nearshore environment are typically minimal. However, as the pile density increases in the intertidal environment, the pile field may effectively act like a groin, and impede the longshore drift. Groins are stiff, stand-alone structures usually placed perpendicular to the shoreline and sometimes impede longshore current, creating a rip current that scours the seabed at the base of one side of the groin and transports the material offshore. Piles placed in deep water, beyond the influence of sediment transport, would not have impacts on sediment movement.

5.2.2 Literature Review

Previous studies have investigated the effects of pile-supported structures on the transmission losses as waves pass through (Wiegel 1961; Macknight and Thomas 1973; Van Weele and Herbich 1972). Results of these studies indicated that for a given range of incident wave steepness, when pile spacing is greater than four times piles diameter, reflection and eddy losses are of minor importance, and the ratio of transmitted wave height to incident wave height approaches unity. This holds true for both transverse and longitudinal pile spacing. Also, it has been observed that piers do not significantly change the wave pattern in the nearshore; there is no difference in wave climate in the region under a pier and farther away (Miller, Birkemeier and DeWall 1982)

Noble (1978) inspected and reviewed historical aerial photographs to evaluate the impact on littoral sand transport of 20 different piers of different heights and lengths along the coast of California. Pile diameters ranged from 12 to 30 inches and the pile spacing within a row across the pier (bent) ranged from 4 to 28 feet. The 20 piers also exhibited a minimum bent spacing of 15 feet and a maximum of 60 feet. The study concluded that these piers have had a negligible effect on the adjacent shorelines. In two cases, where substantial accretion effects were observed, it was apparent that the presence of structures other than the pile-supported piers had been the cause (Noble 1978). Everts and DeWall (1975) also monitored many piers along the coast of California and North Carolina and did not find any significant effect on accretion or erosion along adjacent shorelines.

While the literature suggests that piers do not have a long-term effect on nearshore processes, short-term modifications of the shoreline and localized erosion along piers have been observed. Bowman and Dolan (1982), and Miller, Birkemeier and DeWall (1982) observed that the Field Research Facility (FRF) pier in North Carolina affected nearshore processes, especially the processes controlling erosion and deposition on the adjacent bottom and shoreline. They found that wave and current conditions contributed to the magnitude and shape of the observed scour areas. However, observation of aerial photographs revealed that modification of the shoreline morphology was seasonal, and the presence of the pier did not affect the long-term net sediment transport in the region.

The literature review, when applied to this project's site conditions, indicates that short-term modification of the shoreline may occur, but it should be mostly in the vicinity of the structure, and net longshore sediment transport should not be disrupted.

5.2.3 Impacts from Conveyor Support Structure

In the nearshore region shallower than the deepest closure depth, where most of sediment movement occurs, there will be six support structures (one on the beach face, and five others on the low-tide terrace) and two steel towers. In this section, the term "support structure" represents a group of pilings in the low-tide terrace.

In the low-tide terrace, the support structures will be 100 feet apart and each supported by four 18-inch diameter pilings. The steel tower nearest to land will be 150 feet offshore from the last support structure. It will be at approximately 0 feet MLLW and will include sixteen 30-inch steel piles. The second steel tower will be approximately 250 feet offshore of the first steel tower at -39 feet MLLW. Under the most severe conditions, closure depth will be located at approximately at –21 feet MLLW. Therefore, only the five support structures on the low-tide terrace and the steel tower nearest the shoreline will pose a potential influence on sediment movement.

In the low-tide terrace, the support structure's footprint (i.e., the addition of the four pilings diameter) is 6 feet. This represents 1/17 of the distance between two support structures. This spacing surpasses the criteria discussed above for which shoreline morphology is affected if the spacing of pilings is less than four times the diameter of the pilings. Hence, the spacing of the support structures is sufficient to prevent modification of the shoreline.

Each support structure is composed of four 18-inch piles. Based on the construction drawings (Appendix A, Figure A-5), the spacing of the pilings within each support structure is less than four times their diameter. Furthermore, the first steel tower is composed of sixteen 30-in piles. Based on the construction drawings (Appendix A, Figures A-3 and A-4) the steel towers are not wide enough so that the spacing between the sixteen piles is larger than their diameter. This reduced spacing within each support structure footprint may cause localized reflection and eddy losses. However, these individual groups of pilings are not anticipated to have an impact on the overall sediment movement, except for localized scour or accretion at the support structure footprint.

The second steel tower farther offshore and the piles composing the breasting dolphins are located in water deeper than the closure depth and wave-induced sediment movement. These pilings will not affect longshore sediment transport.

Based on the above assessment, the spacing of the pilings in the nearshore is anticipated to be large enough to prevent the Pier from behaving as a groin and significantly affecting longshore sediment movement or creating a rip current in the vicinity of the Pier. Scour or accretion can occur in the immediate vicinity of the bases of the pilings that compose the support structures.

5.3 Potential Impacts to Nearshore Sediment Transport from Breasting Dolphins

The potential for the breasting dolphins to behave as a series of offshore detached breakwaters was investigated. Detached breakwaters change the wave pattern in their lee (i.e., downwind side), and potentially change sediment movement and beach profile. Upon review, it is anticipated that the series of dolphins will not behave as a series of detached breakwaters, and should not significantly affect sediment transport in the nearshore.

5.3.1 General

Single or detached breakwaters are aligned parallel to the local shoreline and are built mainly to protect a long stretch of shoreline by providing a sheltered beach area between the breakwater and the shoreline. Breakwaters affect hydrological processes by reducing wave energy and changing current patterns (Williams and Thom 2001).

The reduction in wave height in the breakwater's lee and the redirection of wave crests around the breakwater's ends can trigger shoreline responses. There are three potential shoreline responses to a detached breakwater (Komar 1998, CERC 1984) that are illustrated in Figure 8:

- The development of a tombolo with attachment to the structure. A tombolo is a sand bar connecting an island, or breakwater in our case, to mainland or joining two islands;
- The formation of a salient in the lee of each breakwater, but without attachment to the structure. A salient is a coastal formation of beach material comprising of a bulge in the coastline towards an offshore island or breakwater, but not connected to it as in the case of a tombolo;
- Limited modification to the shoreline configuration.

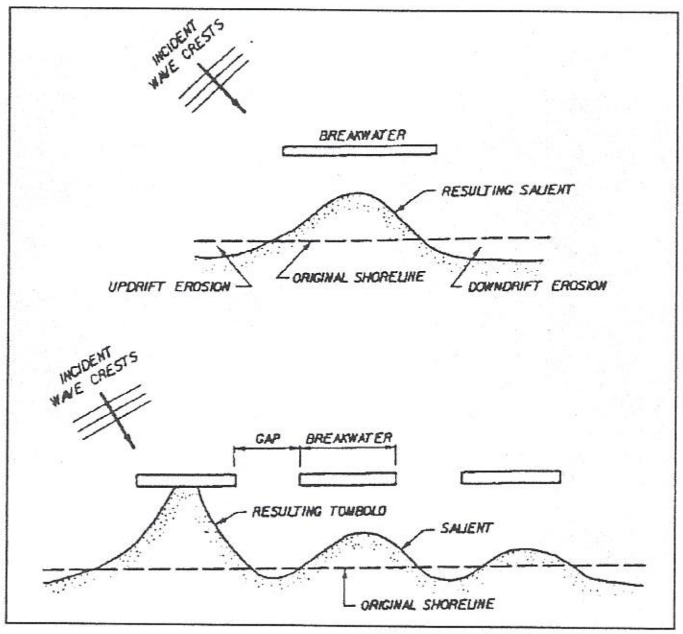

Figure 8
Types of shoreline changes associated with single and multiple breakwaters

The distance between breakwater segments is an important parameter in their design, together with their length and distance offshore. In principle, the sediment can pass longshore between the structure and the shoreline. However, the beach in the lee of the structure generally accretes because of the structure's sheltering effect that reduces the wave energy inshore (Komar 1998).

5.3.2 *Impact from the Succession of Breasting Dolphins*

Suh and Dalrymple (1987) developed the following relationship for the prediction of salient length, X_s, by combining movable-bed laboratory results with prototype data (Rosatti, 1990)

$$X_s = X(14.8)\frac{L_g X}{L_s^2} e^{\left(-2.83\sqrt{\frac{L_g X}{L_s^2}}\right)}$$

where X_s = salient/tombolo length in on-offshore direction measured from original shoreline

X = breakwater segment distance from original shoreline

L_g = gap distance between adjacent breakwater segments

L_s = breakwater segment length

Also, Seiji, Uda, and Tanaka (1987) derived a formula to predict the degree of retreat of shoreline to the lee of the gap from the initial shoreline position

$\frac{L_g}{X} < 0.8$ — *no erosion opposite gap*

$0.8 \leq \frac{L_g}{X} \leq 1.3$ — *possible erosion opposite gap*

$\frac{L_g}{X} \geq 1.3$ — *certain erosion opposite gap*

Under the project specifications, $X \sim 900$ feet (distance from beach to breasting dolphins), $L_g = 100$ feet, and $L_s = 20$ feet. With those numbers, $X_s = 1.1\text{e-}12 \sim 0$, and $L_g/X = 0.11$.

Therefore, breasting dolphins are sufficiently far away from the shoreline and are spaced and dimensioned so they will not act as a series of detached breakwaters. Their presence should not trigger the formation of a salient or tombolo, and the shoreline processes should not be affected by their presence.

Moreover, as mentioned earlier, waves in the Canal predominantly come from southwest and northeast, and propagate in the longshore direction offshore. In this configuration, the series of dolphins cannot be considered as a typical series of detached breakwaters because they are aligned with the direction of wave propagation and current flow.

Waves will hit the line of breasting dolphins on its southwestern and northeastern ends, and because the dolphins are only 20 feet wide and in deep water, they should not significantly affect wave propagation and energy. Parts of a wave will break on the structure, but because of the spacing between dolphins and the distance from the shoreline, the waves will transform without much perturbation and should not affect sediment transport on the nearshore.

5.4 Potential Impacts to Nearshore Sediment Transport from Vessels Moored along Pier

There is currently no standard methodology for evaluating the impact of ship mooring on shoreline processes. A possible approximation is to treat vessels as floating breakwaters. However, no fixed guidance on how to evaluate the impacts of such features on nearshore processes could be found. Thus, to estimate the impact of the vessels on the nearshore environment, we treated them as fixed breakwaters. This methodology is conservative for the project conditions, and can over predict the shoreline response.

Coastal Groins and Nearshore Breakwaters (USACE 1992) provides some criteria on how to evaluate the shoreline response to offshore breakwaters. The main factors that enter into account are breakwater length (L), and distance from the shoreline (y). Tables 4a-c present different conditions, based on the length to distance (L/y) ratio, for the formation of tombolos, salient, and minimal shoreline response. The conditions were developed from surveys of existing structures.

Table 4a
Condition for the Formation of Tombolo

Condition	Comments	Reference
L/y > 2.5	Periodic tombolo	Ahrens and Cox (1990)
L/y > 1.5 to 2.0	Tombolo	Dally and Pope (1986)
L/y > 2.0	Double Tombolo	Gourlay (1981)
L/y > 2.0	Tombolo	CERC (1984)
L/y > 1.0	Tombolo	Suh and Dalrymple (1987)

Table 4b
Conditions for the Formation of Salients

Condition	Comments	Reference
L/y < 1.5	Well-developed salient	Ahrens and Cox (1990)
L/y < 1.0	No tombolo	CERC (1984)
L/y < 1.0	No tombolo	Suh and Dalrymple (1987)
L/y < 0.8 to 1.5	Subdued salient	Ahrens and Cox (1990)
L/y = 0.5 to 0.67	Salient	Dally and Pope (1986)
L/y < 0.4 to 0.5	Salient	Gourlay (1981)

Table 4c
Conditions for Minimal Shoreline Response

Condition	Comments	Reference
L/y ≤ 0.5	No deposition	Nir (1982)
L/y ≤ 0.27	No sinuosity	Ahrens and Cox (1990)
L/y ≤ 0.17 to 0.33	No response	Inman and Frautschy (1978)
L/y ≤ 0.17	Minimal impact	Noble (1978)
L/y ≤ 0.125	Uniform protection	Dally and Pope (1986)

Using the project conditions, if a docked vessel is assumed to be a breakwater, the ratio L/y is 0.83 (with L = 745 feet and y ~ 900 feet, assuming the largest vessel). This indicates that the ratio is such that the conditions for minimal shoreline response are exceeded, and there is a potential to form a salient, but not a tombolo. The formation of a salient would represent a new beach profile equilibrium but would not necessarily mean that net sediment transport would be significantly impacted. Unless a tombolo was formed, sediment movement longshore would continue through the beach profile. Several conditions exist that make Tables 4a-c conservative. These conditions include the proposed orientation of the dock to the predominant wind direction and the temporary nature of the vessel moorages.

Waves in the nearshore undergo different transformations when they are in intermediate to shallow water, where they transfer progressively their energy to the environment. In deep water, they do not lose their energy as they propagate. One of the transformations waves undergo is refraction. Waves entering shallow waters tend to bend and align themselves parallel to the shoreline until they break. This process leads to the dissipation of most of the wave energy in the nearshore and the creation of currents.

Most of the waves in Hood Canal, because of their northwest-southeast propagation offshore, will typically not encounter the vessel on its broadside, where the vessel would act most as a breakwater, but rather on its bow or stern. Waves that propagate from the north or south would not encounter any obstructions in the distance between the vessel and the shoreline. Waves that approached the vessel from some angle less than perpendicular would have less effect than those approaching on the perpendicular because of reduction in the effective length of the "breakwater." For example, waves approaching at 45 degrees away from perpendicular would see an effective length of 527 feet, which would yield an L/y ratio of 0.59. A wave approaching the vessel at 60 degrees away from perpendicular would see an effective length of 375 feet, which would yield an L/y ratio of 0.41.

It is also important to note that vessels will not be permanently moored at the Pier, and when vessels are not present, natural shoreline processes may restore any short-term shoreline changes that occur. Based on discussions with Reid Middleton (Personal Communication, 2002), the loading time for the largest vessels (ocean-going bulk vessels of 65,000 dwt) will be up to 24 hours. The loading time for the smallest vessels (inland water vessels of 2,500 dwt) will be approximately one hour. Depending on the vessels' sizes, it is anticipated that one to four vessels may be loaded at the Pier each day. The largest vessels would be loaded at the maximum rate of one every other day. While loading operations are planned on a basis of 24 hours per day, seven days a week, there will be intervals between vessel arrival and departure and intervals when no vessels are present. During these intervals, no interruption of waves will occur, and the natural influence of waves on the shoreline will be unimpeded. Thus, the discussion above represents a worst-case scenario for the shadowing effects of vessels berthed at the Pier.

5.5 Potential Impacts from Vessel Propeller Wash on Nearshore Sediment Erosion

This section evaluates the potential for vessel propeller wash to scour Hood Canal bed sediment. Potential scour from vessel propeller wash would be considered a short-term impact, occurring only when vessels are docking or departing from the Pier. Significant scour may affect existing habitat or the Pier's structural stability. Scour from propeller wash would not have a significant impact on longshore sediment movement, because propeller wash would be of short duration and localized. Because vessels will not dock at or leave the Pier under their own power, but will be assisted by tugboats, the propeller wash analysis was conducted using operational characteristics of tugboats.

In the application of sediment resuspension models to sediment transport, it has been typical practice in Coastal Engineering to use the threshold criteria for sediment particle motion and resuspension developed for uniform steady state flow in the water above the sediments. Shields' threshold-type diagrams were empirically derived for uniform, steady flow conditions and are a typical method for evaluating the potential for sediment movement. However, propeller wash is neither steady nor uniform flow (i.e., the cross sectional area of the flow and the discharge vary with time and distance). Instead, it is a turbulent circular jet that expands outward from the propeller within a cone angle that has been measured between about 20 to 30 degrees (Blaauw and van de Kaa 1978; Hamill 1988; Verhey 1983; Fuehre, 1987).

Under most conditions, a propeller jet impinges on the sediments in a fully turbulent condition at a relatively shallow angle. The turbulent flow and shallow angle of the jet increase the actual shear stress on the sediments over what would be expected in uniform, steady flow conditions. In fact, empirical studies of coarse-grained sediments exposed to propeller jets have shown that particle motion begins at lower threshold velocities than Shields' criterion would indicate (Hamill 1988).

In order to evaluate the different conditions experienced under propeller wash, a PROPWASH model (developed by Blaauw and van de Kaa 1978; and Verhey 1983) was used to predict scour potential. The analysis showed that using conservative assumptions, scour might occur when the tugboat's propeller wash is directed toward the shoreline at water depths shallower than 50 feet. Propeller wash effects are mitigated if the propeller jet is directed against the surface of the vessel being tended or at some angle relative to directly onshore. Because of how vessel mooring operations are anticipated to be conducted, tugs are expected to operate in water depths of 60 to 70 feet or greater and at angles that would not allow an unobstructed propeller jet to be directed perpendicularly onshore.

5.5.1 Model Description

The PROPWASH model used for this analysis was developed with the equations developed by Blaauw and van de Kaa (1978), and Verhey (1983). This model was calibrated using results of scale model tests of the velocities produced by propeller jets, in uniform depth sandy bottoms. It assumes that the diffusion process is dynamically similar and that the maximum axial velocity occurs along the axis of the propeller jet. This model was tested at the Corps of Engineers' Waterways Engineer Station, and gave good agreement between measured and predicted bottom velocity distribution (Maynord 1990).

The propeller wash computation sequence includes calculation of propeller efflux velocity, axial velocity, radial velocity, and bottom velocity as a function of distance behind the propeller. The axial velocity and sediment characteristics are used to calculate a Froude number, which is a dimensionless ratio of inertial to gravitational forces. The Froude number, along with propeller height and diameter, is used to calculate the maximum depth of scour using empirical coefficients based on results of scour tests (Verhey 1983).

Propeller efflux velocity, V_0, or the initial axial velocity of the propeller jet at half a propeller diameter behind the plane of the propeller, is calculated according to the following equation:

$$V_0 = 1.6nD(K_t)^{0.5}$$

Where: n = propeller rotational speed,

D = propeller diameter,

K_t = propeller thrust coefficient (0.35±20% from Fuehrer et al. 1987).

The rest of the equations leading to the determination of scour depth appear in dimensionless form, which with consistent units, should allow scaling the results from model to prototype scales. The axial velocity $V_{x.0}$ any distance "x" behind the propeller is given by:

$$\frac{V_{x,0}}{V_0} = \left(\frac{D_0}{2cx}\right)^b$$

where D_0 = initial jet diameter,

= D for a ducted propeller,

= $D/(2)^{0.5}$ for a nonducted or open propeller,

c = empirical coefficient,

= 0.17 for a ducted propeller,

= 0.19 for a nonducted propeller, but the average 0.18 is recommended by Verhey (1983) and used herein,

x = axial distance behind the propeller,

b = empirical coefficient

= 1.0 for no rudder,

= 1.1 with a central rudder

= 0.7 with multiple rudders.

The radial velocity $V_{x,r}$ or velocity in the jet a distance "x" behind the propeller and a distance "r" from the propeller axis, is computed using the radial distance r in equation:

$$\frac{V_{x,r}}{V_{x,0}} = \exp\left(\frac{-r^2}{2c^2x^2}\right)$$

where r = radial distance from the propeller axis.

If the distance from the propeller axis to the bottom z is substituted for the radial distance, the scour velocity due to the propeller jet or the propeller wash $V_{x,z}$ is given by:

$$\frac{V_{x,z}}{V_0} = 2.78\left(\frac{D_0}{x}\right)\exp\left(\frac{-15.43z^2}{x^2}\right)$$

where z = depth from propeller axis to bottom,

=h-s

h = water depth

s = propeller shaft depth

The maximum scour depth S_{max} was derived empirically by Verhey (1983) and is given as:

$$\frac{S_{max}}{S} = 4x10^{-3}\left(\frac{FD_0}{z}\right)^{2.9}$$

where $F = \frac{V_{x,z}}{(g\Delta d_{50})^{0.5}}$ is a jet Froude number

g = gravitational acceleration

$\Delta = \frac{\rho_s - \rho_w}{\rho_w}$ is the relative density of the bottom sediments

d_{50} = median bottom grain size diameter

ρ_s = sediment density

ρ_w = water density

The only limitations stated in the literature were that for the above equations to be valid, the axial distance had to be twice the propeller distance ($x>2D$) and the depth had to be between 90 and 900 percent of the propeller diameter ($0.9<h/D<9$).

5.5.2 Model Results

To evaluate the potential for impact, the model was applied to the range of propeller wash conditions the site may potentially experience during vessel docking and departing. Operational characteristics of the tug were based on information provided by Reid Middleton (personal communications, 2002). Bed sediment characteristics were unknown, but assumed to be fine sand for modeling purposes. Water depths were determined from Figure 2, which is based on construction drawings. Datum on those drawings is Mean Sea Level, which is 6 ± 0.5 feet above MLLW. Hence, because of this small fluctuation and the water depth where the vessels will be, this analysis is valid for the entire tidal range.

Tugboats will assist vessels during berthing operations by maneuvering them to and away from the breasting dolphins. The largest tugboat expected at the facility has a horsepower of 5,000 HP, a single 12-feet diameter propeller, and a shaft depth of 15 to 16 feet below the waterline. The assumed tugboat and vessel configurations are depicted in

Figure 9. It is not expected that tugboats, when assisting vessels, will be closer to the breasting dolphins. Under these configurations, the tugs' propellers will be either aligned with the bathymetry lines, at –70 feet to –80 feet MSL (position 1), or directed offshore or toward the shoreline (positions 2 and 3), when they push or pull vessels.

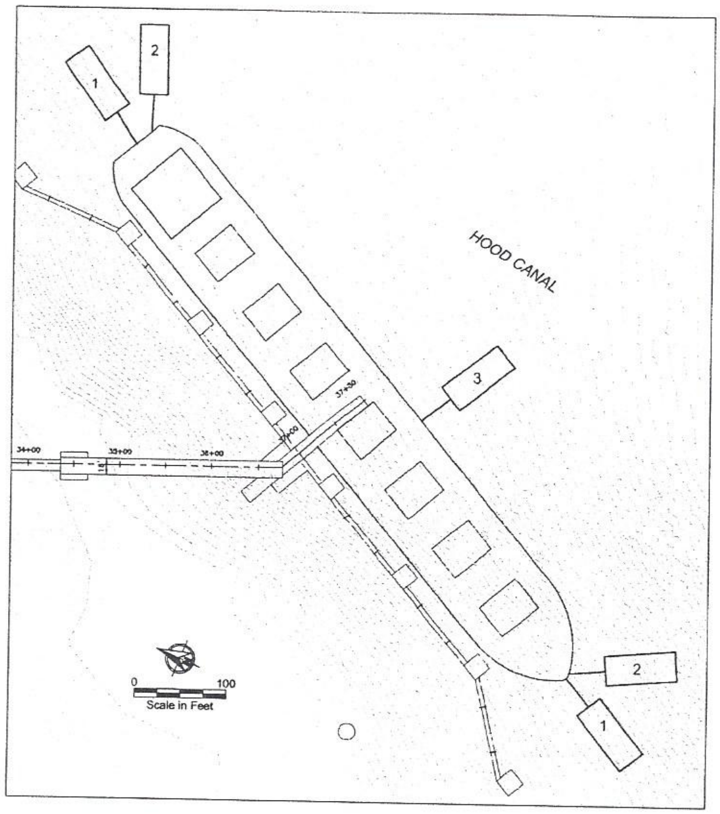

Figure 9
Different tugboat configurations for docking and undocking vessels

When the tugboat's propeller is directed away from the shoreline, the water depth increases, and the propeller wash has less effect than the model predicts when run at the depth where the tugboat is located. When the tugboat's propeller is directed toward the shoreline (assumed to potentially occur only when the vessel departs) the water depth decreases and the propeller wash reaches the bed sediment at a higher elevation than where the tugboat is located.

The model was run for water depths ranging from 90 feet to 40 feet, assuming fine sand as the bed sediment. Figure 10 presents the model results. The reader should bear in mind when looking at this figure that the model assumes that water depth is constant at any distance from the propeller.

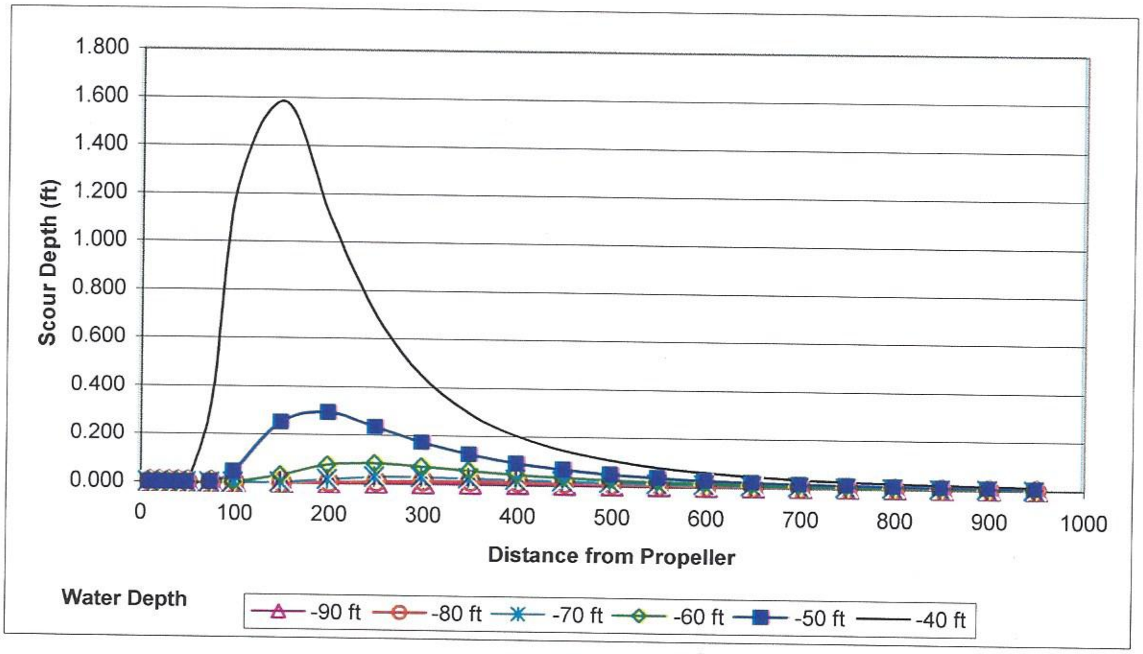

Figure 10
Scour depth as a function of distance from propeller for different water depths

This figure shows that potential scour depth increases as water depth decreases, reaches peak scour 150 feet away from the propeller, then decreases with increasing distance. For water depths greater than 50 feet, there is minimal predicted scour. Under most anticipated operating conditions, the tugs would operate in water depths equal to or greater than 70 feet. During certain times, the tugboat's propeller wash would be directed toward the shoreline and may potentially produce localized scour on a short-term basis. Because of the short duration of any potential impact and the localized nature of propeller wash, significant impact to longshore sediment transport processes is not expected.

6 CONCLUSIONS

The conclusions presented in this report are based on the available and existing information on site conditions, a field site visit, literature review, and discussions with shoreline process experts. The evaluation performed is mainly qualitative in nature and is based on standard coastal engineering methodology where applicable. The conclusions are as follows:

- Because of the limited area of disturbance, the proposed bluff modifications along the conveyor route should not affect site sediment supply source.
- Because of their size and spacing, the Pier pilings should not affect wave climate, or create a rip current in its vicinity. Although localized and short-term scour or accretion at the bases of the pilings that bear the support structures may occur, longshore and cross-shore sediment transport should not be significantly affected.
- The breasting dolphins should not have an impact on the wave climate due to their size, spacing, and distance from the shoreline. Since the breasting dolphins are located in deeper water than closure depth, they are not anticipated to affect sediment transport.
- Vessels moored along the Pier could potentially trigger the formation of a salient. Formation of a salient represents a new equilibrium in the beach profile. Potential impacts to sediment transport by wave sheltering from vessel moorage are considered more probable than from other causes discussed in this report. However, such a feature would not be expected to affect sediment transport in the nearshore environment. Shoreline morphology at the vicinity of the Pier might change, but this change should not change sediment budget in the nearshore environment or cause erosion southwest or northeast of the site.
- Scour of bed sediment due to vessel propeller wash is anticipated to occur only in the case where the propeller wash is directed toward the shoreline. Under most anticipated operating conditions, tugboats would operate in water depths equal to or greater than 70 feet. Scouring impacts would be short term and localized and should not have an impact on shoreline processes or beach stability.

7 LIMITATIONS

Coastal Engineering and shoreline processes are characterized by uncertainty. Professional judgments presented herein are based partly on our evaluation of the technical information gathered, partly on our understanding of the proposed construction, and partly on our general experience. Our engineering work and judgments rendered meet the current professional standards for the purposes of this evaluation. We do not guarantee the performance of the project in any respect.

The beach profile and shoreline configuration undergo seasonal changes, as well as long-term changes that can be caused by such natural factors as tidal elevation change over time or change in sediment supply source. There is a lack of site-specific information on key factors affecting shoreline processes (namely wind data, wind-generated wave data, and current velocities) that could be used to establish baseline conditions to better evaluate potential future changes. The results of the analysis presented in this report were based on recognized standard coastal engineering methods, and best engineering judgment and practice. It is anticipated that localized and transitory shoreline changes may occur, but a visual representation cannot be predicted given the limitations of the existing information.

8 GLOSSARY OF TERMS

This glossary of terms is a compilation of previous glossaries presented by several publications (Nightingale and Simenstad 2001, Komar 1998, CERC 1984). It is provided to assist the reader with interpretation of technical terms. Some of these terms may not appear in the text of the document. They are provided anyway for completeness.

ACCRETION - May be either natural or artificial. Natural accretion is the buildup of land, solely by the action of the forces of nature, on a beach by deposition of water- or airborne material. Artificial accretion is a similar buildup of land by reason of an act of man, such as the accretion formed by a groin, breakwater, or beach fill deposited by mechanical means.

ALONGSHORE - Parallel to and near the shoreline. (**LONGSHORE**)

BACKSHORE - Zone of beach lying between foreshore and coastline acted upon by waves only during severe storms.

BACKWASH – The seaward return of the water following the uprush of the waves.

BANK – A land surface above the ordinary high water line that adjoins a body of water

BAR - A submerged or emerged embankment of sand, gravel, or other unconsolidated material built on the sea floor in shallow water by waves and currents.

BATHYMETRY - The measurement of depths of water in oceans, seas, and lakes. Also, information derived from such measurements.

BEACH - The zone of unconsolidated material that extends landward from the **LOW WATER LINE** to the place where there is marked change in material or physiographic form, or to the line of permanent vegetation. The seaward limit of a beach – unless otherwise specified – is the mean low water line. A beach includes **FORESHORE** and **BACKSHORE**.

BEACH EQUILIBRIUM - Equilibrium is attained when the shore orients itself parallel to the predominant wave direction, and when the amount of sediment supplied is balanced with the amount of sediment carried away. When beach attains its equilibrium, it adapts its morphology and configuration to redistribute sediments equally along its shore and to minimize the impact of the waves and currents.

BEACH FACE - The sloping nearly planar section of the beach profile below the berm, which is normally exposed to the swash of waves

BEACH FEEDING - A process by which beach material is deposited at one or several locations in the updrift portion of a driftway. The material is then naturally transported by a wave's down drift to stabilize or restore eroding beaches or berms

BEACH GRADIENT - The angle of the beach down the beach profile, as it extends seaward.

BEACH NOURISHMENT - The process of replenishing a **BEACH** by artificial means; e.g., by the deposition of dredged materials, also called beach replenishment or beach feeding.

BEACH PROFILE - A vertical cross section of a beach measured perpendicular to the shoreline.

BEACH RESTORATION AND ENHANCEMENT - The alteration of terrestrial and tidal shorelines or submerged shorelines for the purposes of stabilization, recreational enhancement, or aquatic habitat creation or restoration.

BERM (BEACH BERM) - The nearly horizontal portion at the beach or backshore formed by the deposition of sediments by waves Some beaches have more than one berm at slightly different levels, separated by a scarp (not very frequent around Bainbridge Island).

BLUFF – A high, steep bank or cliff.

BREAKER - A wave that has become so steep that the crest of the wave topples forward, moving faster than the main body of the wave.

BREAKER ZONE - Zone of shoreline where waves break.

BREAKWATER - Structure protecting shore area, harbor, anchorage, or basin from waves. See **JETTY.**

COAST - A strip of land of indefinite length and width (may be tens of kilometers) that extends from the shoreline inland to the first major change in terrain features.

COASTAL PROCESSES - Collective term covering the action of natural forces on the shoreline, and the nearshore seabed.

COASTLINE - (1) Technically, the line that forms the boundary between the coast and the shore. (2) Commonly, the line that forms the boundary between land and the water. (3) The line where terrestrial processes give way to marine processes, tidal current, wind waves, etc.

COASTAL ZONE - Includes coastal waters and the adjacent shorelands designated by a State as being included within its approved coastal zone management program. The coastal zone may include open waters, estuaries, bays, inlets, lagoons, marshes, swamps, mangroves, beaches, dunes, bluffs, and coastal uplands. Coastal-zone uses can include housing, recreation, wildlife habitat, resource extraction, fishing, aquaculture, transportation, energy generation, commercial development, and waste disposal

CONSTRUCTIVE WAVES - Waves that move sediments up the **BEACH PROFILE** and help building the beach.

CREST - The seaward limit of a berm. Also, the highest part of a wave.

CROSS-SHORE – Movement in a direction perpendicular to the shoreline, up or down the **BEACH PROFILE.**

CUMULATIVE EFFECTS - The combined environmental impacts that accrue over time and space from a series of similar or related individual actions, contaminants, or projects. Although each action may seem to have a negligible effect, the combined effect can be significant.

CURRENT - A flow of water.

DEPOSITION - The deposit of sediment in an area through natural means such as wave action or currents; may also be done by man through mechanical means.

DESTRUCTIVE WAVES – Waves that move sediments from the upper **BEACH PROFILE** to deeper water and help eroding the beach.

DIFFRACTION – The phenomenon by which energy is transmitted laterally along a wave crest.

DOWNDRIFT - The direction of predominant movement of littoral materials.

DRAFT - The vertical distance on a vessel from the waterline to the bottom of the keel of a boat.

DRIFT CELL – See **DRIFT SECTOR**

DRIFT SECTOR - A segment of shoreline along which littoral, or longshore, sediment movement occurs at noticeable rates. It allows for an uninterrupted movement, or drift, of beach materials. Each drift sector includes: a feed source that supplied the sediment, a driftway along which the sediment can move, an accretion terminal where the drift material is deposited, and boundaries that delineate the end of the drift sector. (Also called a **DRIFT CELL** or **LITTORAL CELL**).

EBB CURRENT – The tidal current away from shore or down a tidal stream; usually associated with the decrease in height of the tide. See **FLOOD CURRENT**.

EROSION - The wearing away of land by natural forces. On a beach, the carrying away of beach material by wave action, tidal currents, littoral currents, or by deflation.

FEEDER BLUFF OR EROSIONAL BLUFF - Any bluff or cliff experiencing periodic erosion from waves, sliding or slumping that, through natural transportation, contributes eroded earth, sand or gravel material via a driftway to an accretion shoreform. These natural sources of beach material are limited and vital for the long-term stability of driftways and accretion shoreforms (e.g., spits, bars, and hooks).

FETCH - The distance over unobstructed open water on which waves are generated by a wind having a constant direction and speed.

FIXED PIER - A fixed structure supported by pilings

FLANKING - Wave action around the top or sides of a structure.

FLOOD CURRENT – The tidal current toward shore or up a tidal stream, usually associated with the increase in the height of the tide. See **EBB CURRENT**.

FORESHORE - Part of the shore lying between crest of seaward berm and ordinary low water mark.

GROIN - A rigid structure built at an angle (usually perpendicular) from the shore to protect it from erosion or to trap sand. A groin may be further defined as permeable or impermeable depending on whether or not it is designed to pass sand through it.

IMPACT - An action producing a significant causal effect of the whole or part of a given phenomenon.

INSHORE – The zone of the bench profile extending seaward from the foreshore to just beyond the breaker zone.

INTERTIDAL - The area between **MHHS** and **MLLW** tides, which is uncovered periodically.

LEE-SIDE - The side of a structure protected from wind or wave action.

LITTORAL - Of or pertaining to the shore

LITTORAL CELL – See **DRIFT SECTOR**.

LITTORAL SYSTEM – Defines a zone extending seaward from the shoreline to just beyond the breaker zone where the coastal processes take place.

LONGSHORE CURRENT – The littoral current in the breaker zone moving essentially parallel to the shore.

LONGSHORE BAR - An underwater ridge of sand running roughly parallel to the shore, sometimes continuous over large distances, at other times having roughly even breaks along its length. It may become exposed at low tide. Often there is a series of such ridges parallel to one another at different water depths, separated by longshore troughs.

LONGSHORE TRANSPORT – Transport of sedimentary material parallel to the shore.

LONGSHORE TROUGH - An elongated depression extending parallel to the shoreline and any longshore bars that are present often representing the low point in the profile between successive bars.

LOW TIDE TERRACE - - A flat zone of the **BEACH** near the low water level. Found along much of East Bainbridge Island, some of West Bainbridge Island, Restoration Point, and South Beach, Bainbridge Island.

LOW WATER LINE: The line where the established low water datum intersects the shore. The plane of reference that constitutes the low water datum differs in different regions.

MEAN HIGHER-HIGH WATER (MHHW) - The average of the measured higher-high water levels typically over a 19-yr period.

MEAN HIGH WATER (MHW) - The average of all measured high water levels, including both the higher-high and lower-high recorded levels, typically over a 19-yr period.

MEAN LOW WATER (MLW) - The average of all measured low water levels, including both the higher-low and lower-low recorded levels, typically over a 19-yr period.

MEAN LOWER-LOW WATER (MLLW) - The average height of the lower-low water levels, typically over a 19-yr period.

MEAN SEA LEVEL (MSL) - The average height of the surface of the sea for all stages of the tide over a 19-year period, usually determined from hourly height readings.

NEARSHORE or **NEARSHORE ZONE** - In beach terminology an indefinite zone extending seaward from the shoreline well beyond the breaker zone.

OFFSHORE – Term to describe the area seaward of the breaker zone, extending in a direction seaward from the shore.

ORDINARY HIGH WATER MARK (OHWM) - That mark that will be found by examining and ascertaining where the presence and action of waters are so common and usual, and so long continued in all ordinary years, as to mark upon the soil a character distinct from the abutting upland, in respect to vegetation as that condition exists on June 1, 1971, as it may naturally change. Thereafter, or as it may change thereafter in accordance with permits issued by a local government or the department [of ecology]: provided, that in any area where the ordinary high water mark cannot be found, the ordinarily high water mark adjoining salt water shall be the line of mean higher high tide (WAC 173-27).

OVERWATER STRUCTURES - Man-made structures that extend over all or part of the surface of a body of water, such as a pier.

OVERTOPPING - Passing of water over the top of a structure as a result of wave **RUNUP** or surge action.

PIER - A fixed, pile-supported structure secured to the shoreline .

PILE - Long, heavy timber or section of concrete or metal driven or jetted into earth or seabed for support or protection.

PILING - Group of piles.

REEF - An offshore chain or ridge of rock or ridge of sand at or near the surface of the water.

REFLECTIVE WAVE – That part of an incident wave that is returned seaward when a wave impinges on a steep beach, barrier, or other reflecting surface such as a bulkhead.

REFRACTION – The process by which the direction of a wave moving in shallow water at an angle to the contour is changed, causing the wave crest to bend toward alignment with the underwater contour.

RIP CURRENT - A narrow intense current setting seaward through the surf zone. It removes the excess water brought to the zone by the small net mass transport of waves. It is fed by **LONGSHORE CURRENTS**. Rip currents usually occur at points, groins, jetties, etc., of irregular beaches, and at regular intervals along straight, uninterrupted beaches. (Rip Currents are often miscalled Rip Tides.)

RUNUP - The rush of water up a structure or beach on the breaking of a wave.

SCOUR - The removal of underwater material by waves and currents, especially at the base or toe of a structure.

SEDIMENT - Material, such as sand, silt, or clay, suspended in or settled on the bottom of a water body. Sediment input to a body of water comes from natural sources, such as erosion of soils and weathering of rock, or as the result of anthropogenic activities, such as forest or agricultural practices, or construction activities. The term dredged material refers to material that has been dredged from a water body, while the term sediment refers to material in a water body prior to the dredging process.

SEDIMENT SINK - A point or area at which beach material is irretrievably lost from a **LITTORAL CELL**, such as an estuary, or a deep channel in the seabed.

SEDIMENT SOURCE - A point or area on a coast from which beach material arises, such as an eroding cliff, or river mouth.

SEMIDIURNAL TIDE – A tide with two high and two low waters in a tidal day with comparatively little diurnal inequality.

SHOALING - Gradual procession from a greater to a lesser depth of water.

SHORE – The narrow strip of land in immediate contact with the sea, including the zone between high and low water lines. A shore of unconsolidated material is usually called a beach.

SHORELINE - The intersection of a specified plane of water with the shore or beach.

SHORELINE DEVELOPMENT - As regulated by the Shoreline Management Act (Chapter 90.58 RCW) the construction over water or within a shoreline zone (generally 200 feet landward of the water) of structures such as buildings, piers, bulkheads, and breakwaters, including environmental alterations such as dredging and filling, or any project which interferes with public navigational rights on the surface waters.

STANDING WAVE – A type of wave in which the surface of the water oscillates vertically between fixed points without progression. Sometimes called Clapotis or Stationary Waves.

STORM WAVE – Wave generated by strong winds during a storm event that can attain height.

STRUCTURE – A permanent or temporary edifice or building, or any piece of work artificially built or composed of parts joined together in some definite manner on, above, or below the surface of the ground or water, except for vessels.

SURF ZONE - The area between the outermost breaker and the limit of wave uprush.

SWELL – Wind-generated waves that have traveled out of their generating area. Swell characteristically exhibits a more regular and longer period and has flatter crests than waves within their fetch.

TIDAL CHANNEL – A channel through which water drains and fills intertidal areas.

TIDAL CURRENT – The alternative horizontal movement of water associated with the rise and fall of the tide caused by the astronomical tide-producing forces.

TIDAL FLAT - The sea bottom, usually wide, flat, muddy, and unvegetated which is exposed at low tide; marshy or muddy area that is covered and uncovered by the rise and fall of the tide.

TIDAL RANGE – The difference in height between consecutive high and low water.

TOE - The lowest part of a bluff, bank, or shoreline structure, where a steeply sloping face meets the beach.

TOMBOLO - A causeway-like accretion spit connecting an offshore rock or island with the main shore

TRANSPORT - The movement of sediment along a current pathway.

UNDERTOW - A current below water surface flowing seaward; the receding water below the surface from waves breaking on a shelving beach.

UPDRIFT - The direction opposite that of the predominant movement of littoral materials.

UPLANDS - The land above a shoreline.

WATER COLUMN - The water in a lake, estuary, or ocean which extends from the bottom sediments to the water surface.

WAVE – A ridge, deformation, or undulation of the surface of a liquid.

WAVE CLIMATE - Annual and seasonal conditions that characterize the wave activity in a particular region.

WAVE ENERGY - Force exhibited by waves, which culminates in impact to an object or surface.

WAVE HEIGHT – The vertical distance between a crest and the preceding trough.

WAVE PERIOD – The time for two successive wave crests to pass a fixed point.

WAVE TRAIN – A series of waves from the same direction.

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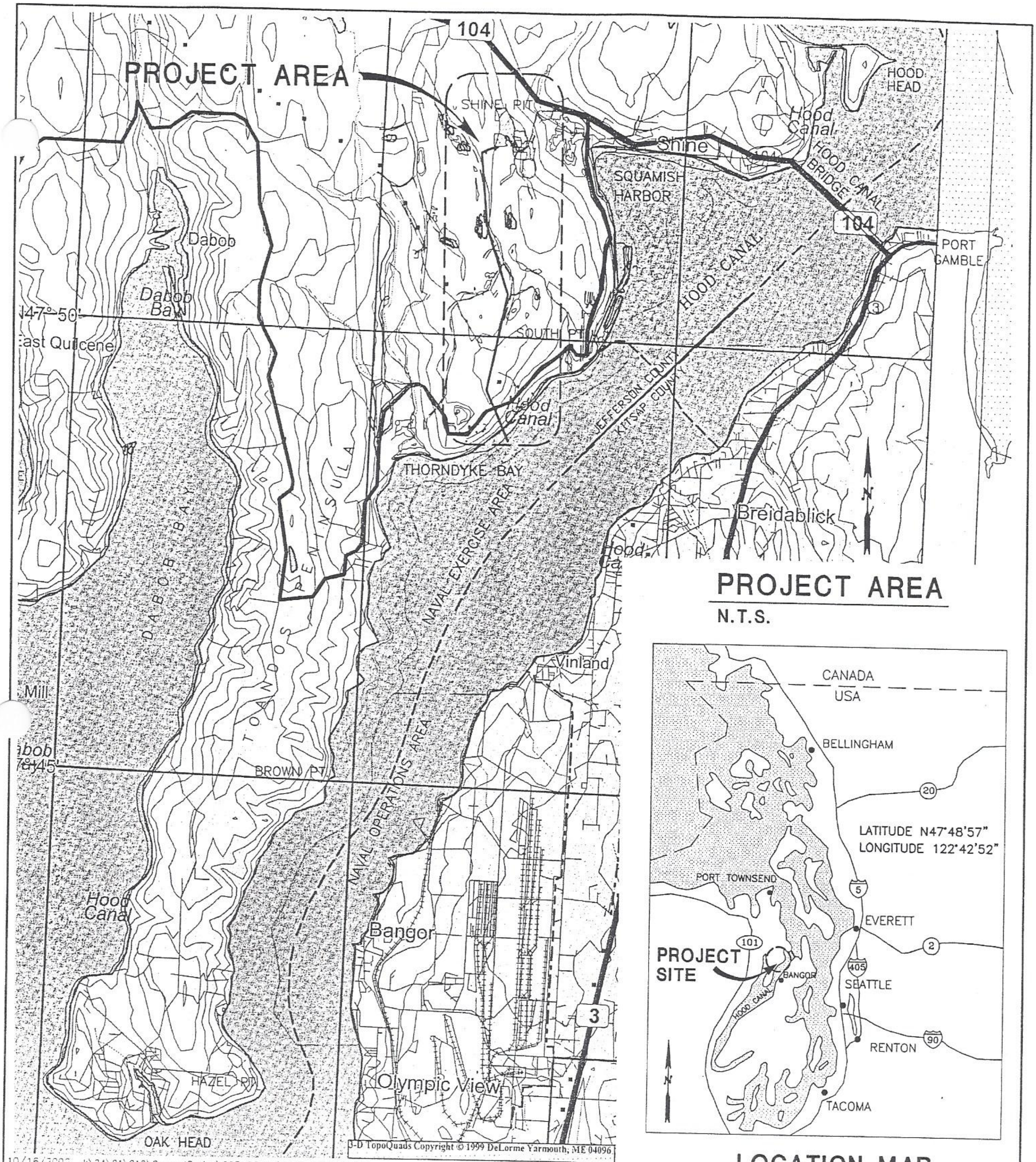
APPENDIX A

CONSTRUCTION DRAWINGS

(provided by Reid Middleton)



PURPOSE: CONSTRUCT CONVEYOR AND PIER FOR MARINE TRANSPORT OF SAND AND AGGREGATE MATERIALS

VERTICAL DATUM: NVDG 1929
HORIZONTAL DATUM: NAD 1983/1991
ADJACENT PROPERTY OWNERS:
(SEE ATTACHED LIST)

REGIONAL LOCATION MAP

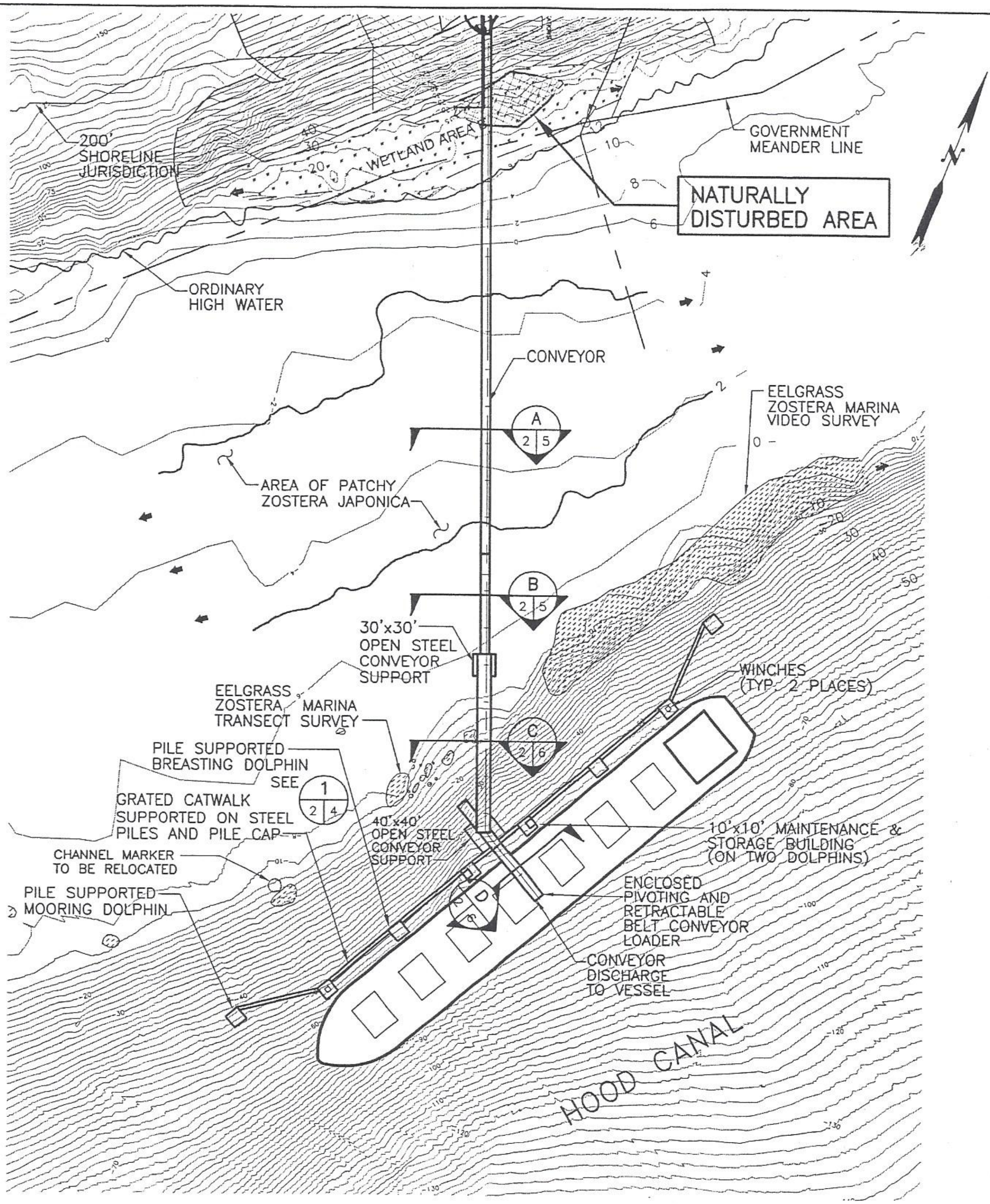
T-ROC CENTRAL CONVEYOR AND PIER

ADDRESS: FRED HILL MATERIALS
P.O. BOX 6
POULSBO, WA 98370

ReidMiddleton
728 134th Street SW · Suite 200
Everett, Washington 98204
Ph: 425 741-3800

SEC. 19 T 27N. RGE. 1E
IN: HOOD CANAL
AT: THORNDYKE
COUNTY OF: JEFFERSON
APPLICATION BY: FRED HILL MATERIALS
SHEET 1 OF 16 DATE: 2-11-03

Appendix A, Figure A-1



PLAN

SCALE: 1" = 200'

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PURPOSE: CONSTRUCT CONVEYOR AND PIER FOR MARINE TRANSPORT OF SAND AND AGGREGATE MATERIALS

VERTICAL DATUM: MLLW
HORIZONTAL DATUM: NAD 1983/1991
ADJACENT PROPERTY OWNERS: (SEE ATTACHED LIST)

SINGLE CONVEYOR AND PIER SITE PLAN

T-ROC CENTRAL CONVEYOR AND PIER

ADDRESS: FRED HILL MATERIALS
P.O. BOX 6
POULSBO, WA 98370

ReidMiddleton
728 134th Street SW · Suite 200
Everett, Washington 98204
Ph: 425 741-3800

SEC. 19 T 27N. RGE. 1E
IN: HOOD CANAL
AT: THORNDYKE
COUNTY OF: JEFFERSON
APPLICATION BY: FRED HILL MATERIALS
SHEET 2 OF 16 DATE: 2-11-03

Appendix A, Figure A-2

APPENDIX B

PROJECT DESCRIPTION AND FACT SHEET

CENTRAL CONVEYOR AND PIER
PROJECT DESCRIPTION

Purpose

This application is for a permit to build a Central Conveyor and Pier to move sand and gravel from the T-ROC Operations Hub to Hood Canal for marine transport by barges and ships.

Introduction

Fred Hill Materials, Inc. (FHM) conducts its primary sand and gravel mining and processing operations in Jefferson County at the existing Shine Pit, which is the Operations Hub for the Thorndyke Resource Operations Complex (T-ROC). T-ROC encompasses both existing and proposed expanded operations in and around the Shine Pit.

FHM has undertaken a planning and development process to identify and then pursue its business objectives into the mid-21st century. As a result of this planning process, including analysis of the geologic resources and critical environmental areas within the Thorndyke Management Area (Thorndyke Block), FHM has established a series of proposals, which, if approved, would result in:

- Continued growth of existing activities (Shine Pit), including opening of new extraction areas approximately one mile west and south of the Shine Pit (Wahl and Meridian)
- Development of a marine transportation system for the delivery of sand and gravel (Central Conveyor and Pier)

General Location

T-ROC is located within the approximately 21,000-acre Thorndyke Block, which is a portion of the Pope Resources 72,000-acre Hood Canal Tree Farm. The Thorndyke Block is located in Jefferson County on the Toandos Peninsula, which is south and west of the Hood Canal Bridge. The area is locally known as the Upper Coyle Peninsula.

General Description of Central Conveyor and Pier

The proposed four-mile Central Conveyor originates at the southwest corner of the Shine Pit, travels south through the Thorndyke Block (within an approximately 34-acre easement), bridges over Thorndyke Road (just south of mile post 3), crosses a 14.7-acre parcel of waterfront property (owned by Hood Canal Sand and Gravel, LLC) and terminates at the end of the proposed 1,000-foot Pier on Hood Canal.

The Pier will originate at Hood Canal Sand and Gravel's waterfront property approximately five miles southwest of the Hood Canal Bridge, one mile northeast of Thorndyke Bay, and 1.25 miles southwest of South Point.

The Central Conveyor's route was specifically selected to avoid and/or minimize impacts to environmentally sensitive areas (steep slopes, wetlands, streams, and their associated buffers). An Environmental Impact Statement (EIS) will be prepared that will examine any identifiable probable significant adverse environmental impacts of the proposal and, if required, will propose and evaluate possible mitigating measures that could become conditions of approval if accepted by Jefferson County.

The Pier is designed for ships and barges of various sizes and displacements to transport sand and gravel. Only ships will require opening of the Hood Canal Bridge. Only U.S. flagged ships will call at the Pier. At this time, the particular ships required for transport of sand and gravel at the proposed Pier are not available on the West Coast. It is anticipated that these ships will become available in approximately eight to 12 years after the Pier's construction and will be used subject to market demand.

Proposed Pier Operations

Initially, only barges will call at the Pier. Typical barge capacity is 5,000 dead-weight U.S. short tons (dwt).

In Year 1 of Pier operations, it is anticipated that the volume of sand and gravel transported by barge will be 2 million U.S. short tons (tons).

By Year 10, the volume of sand and gravel transported by barge is expected to reach 4 million tons annually.

In the first year that U.S. flagged ships become available (Year 8 to 12 of Pier operations), it is anticipated that 600,000 tons of sand and gravel will be transported by ship.

By Year 25, the volume of sand and gravel transported by ship is expected to reach 2.75 million tons annually.

By Year 25, it is anticipated that the combined volume of sand and gravel transported by ship and barge will reach 6.75 million tons annually (i.e. 4 million tons via barge and 2.75 million tons via ship), subject to market demand.

(For further details, see *Central Conveyor and Pier Facts Sheet.*)

History

The Thorndyke Block was logged in the early 1900s, with most of the logging having taken place in the 1930s. After a significant forest fire in 1939, much of the forest re-seeded naturally.

Currently, the area is managed as commercial forestland with periodic logging of small acreage units and predominant replanting of Douglas fir. Much of the commercial forestland crossed by the proposed Central Conveyor was logged within the past 10 years. Old tree stumps, small Douglas firs, forest brush, and shrubs dominate the landscape. In areas that were recently logged, second growth Douglas fir and stands of alder dominate.

Mining of sand and gravel in the general area of the Shine Pit began in 1959 to supply materials for the building of the Hood Canal Bridge revetment on the Jefferson County side. Since that time, various operators have mined sand and gravel in the same vicinity and provided truck delivery of materials.

In December 1979, FHM took over operation of the Shine Pit and obtained a Surface Mine Reclamation Permit (No. 70-011936) issued by the Washington State Department of Natural Resources (WSDNR). Since then, FHM has continuously operated the pit.

In addition to the WSDNR surface mining reclamation permit, FHM operates under a Washington State Department of Ecology (WSDOE) Sand and Gravel General Permit (No. WAG 50-1120), which regulates the treatment and control of stormwater. All stormwater that falls on the existing 144-acre Shine Pit is prevented from leaving the site through application of infiltration techniques.

In June 1999, Ace Paving obtained a Jefferson County Conditional Use Permit (No. ZON98-0041) to operate a portable asphalt batch plant located on five acres within the 144-acre Operations Hub/Shine Pit. Ace Paving operates under its own Washington State Department of Ecology (WSDOE) Sand and Gravel General Permit (No. WAG 50-1237). The stormwater that runs off the asphalt batch plant site goes directly into FHM's central stormwater treatment and control system.

In March 2001, to prepare for the impending depletion of sand and gravel supplies at the existing Shine Pit, FHM submitted to WSDNR a preliminary application for the 156-acre Wahl Extraction Area as an expansion of the existing Shine Pit

In April 2002, FHM submitted a Mineral Resource Lands Overlay (MRL) application to Jefferson County. The submission complied with the new requirements (effective January 2001) of the Jefferson County Unified Development Code (UDC).

In September 2002, WSDNR determined that the March 2001 FHM application for the Wahl Extraction Area would need to be resubmitted as a new permit, independent of the existing permit. In addition, Jefferson County UDC requirements will be applicable.

In December 2002, Jefferson County approved a modified application for MLA-02-235, a Mineral Resource Land Overlay (MRL) designation for 690 acres, located approximately a mile west and south of FHM's existing T-ROC Operations Hub. This MRL designation formally recognizes the existence of commercially viable deposits of sand and gravel; provides for appropriate notification of adjacent landowners regarding likely future mineral resource activities in this designated area; and allows FHM to apply for specific excavation permits greater than 10 acres in size under the requirements of the Jefferson County UDC. The MRL designation alone does not authorize specific mining activities within the MRL.

Existing T-ROC Operations

T-ROC *currently* consists of five major activity components at the existing 144-acre Shine Pit:

1. Sand and gravel extraction area
2. Operations Hub, including
    - portable crushing, washing, and sorting equipment for sand and gravel
    - portable equipment for recycling of concrete waste
    - stockpile areas
    - trucks and loaders
    - scale house, maintenance building, caretaker home, well, and outbuildings
    - Rock-To-Go access road (forestry service road T-3100) to Hwy. 104
3. Portable conveyors used to move sand and gravel from the extraction area to the Hub
4. Asphalt batch plant (operated by Ace Paving)
5. Mined acreage in various stages of reclamation

In 2003, it is anticipated that the volume of sand and gravel transported by truck will be 500,000 tons, including sand and gravel used in asphalt mix. In approximately 10-15 years, the annual volumes of sand and gravel transported by truck are projected to reach 750,000 tons and remain constant due to the saturation of the local market.

Current and future volumes of sand and gravel transported by truck will be supported by the existing configuration of the T-ROC Operations Hub.

Continued Growth of Existing Activities

Current truck-based operations are expected to deplete the sand and gravel extraction area at the existing Shine Pit by 2004, requiring the opening of a new extraction area.

The analysis of geological resources within the Thorndyke Block, combined with the public concern with the visual impacts of existing mining operations, led FHM to propose a new extraction area approximately a mile west and south of the existing Shine Pit. This new extraction area (Wahl) is outside the public's general view shed.

The proposed 156-acre Wahl Extraction Area is located west of Wahl Lake and is anticipated to have sufficient volumes of sand and gravel to supply truck-based operations for 20 years. After the Wahl Area is depleted, new permits would be sought to mine in the Meridian Extraction Area (a portion of MLA-02-0235).

Sand and gravel will be transported from the proposed Wahl and prospective Meridian Extraction Areas to the T-ROC Operations Hub via a 1.25-mile conveyor (located in an easement of approximately nine acres) referred to as the Wahl Conveyor. This conveyor will be built adjacent to an approved forestry service road. Much of the commercial forestland crossed by the proposed Wahl Conveyor has been logged within the past 10 years.

Since the extraction area located in the existing Shine Pit is nearing exhaustion, FHM reiterates that the proposed Wahl Extraction Area and Conveyor (a portion of MLA-02-235) are necessary to provide a continued supply for *existing* FHM truck-based operations.

Application for the Wahl Extraction Area and Wahl Conveyor has been initiated and will be considered in parallel to this application for the Central Conveyor and Pier.

In addition, FHM has initiated the process of gaining permission to accept concrete rubble from outside sources.

Development of Marine Transportation System

Should FHM receive necessary approvals for the proposed Central Conveyor and Pier, the extraction rates from the Wahl Extraction Area will accelerate due to the added marine delivery. This acceleration would advance the time frame for application for excavation permits in some or all of the remaining MRL area (Meridian Extraction Area).

The prospective 525-acre Meridian Extraction Area is located generally south of Wahl Lake, and contains the remainder of MLA-02-235. FHM expects that as excavation is completed in the Wahl Extraction Area, permits for expansion of mining into some or all of the Meridian Extraction Area will be submitted. The exact timing of a prospective application for the Meridian Extraction Area will be a function of numerous variables, including but not limited to future market demand and successful development of marine transport capabilities (i.e. the Central Conveyor and Pier).

Upon construction of the Central Conveyor and Pier, reconfiguration of the T-ROC Operations Hub will be needed to accommodate the processing of increased volumes of sand and gravel. The reconfigured Operations Hub will be located on a 100-acre area within the existing 144-acre Shine Pit.

Summary

Under currently planned proposals, if approved, T-ROC would include:

- a 100-acre **Operations Hub** located within the existing Shine Pit, where up to 7.5 million tons of sand, gravel and recycled concrete will be processed annually and transported by trucks (750,000 tons), barges (4 million tons), and ships (2.75 million tons)

- a proposed 156-acre extraction area **(Wahl Extraction Area)**, where sand and gravel would be mined to supply truck-based operations and initial years of marine operations

- a prospective 525-acre extraction area (**Meridian Extraction Area**), where up to 40 years of sand and gravel would be mined

- a proposed 1.25-mile conveyor (**Wahl Conveyor**) connecting the Wahl Extraction Area and subsequent Meridian Extraction Area to the Operations Hub

- a proposed 4-mile conveyor (**Central Conveyor**) connecting the Operations Hub to a 1,000-foot Pier located on Hood Canal, where ships and barges would be loaded up to 300 days a year, up to 24 hours a day

CENTRAL CONVEYOR AND PIER FACTS SHEET

1.0 CENTRAL CONVEYOR

The proposed Central Conveyor will move sand and gravel from the T-ROC Operations Hub (at the existing Shine Pit) to a Pier on Hood Canal for marine transport by barges and ships. The Central Conveyor will be approximately four miles long and is made up of the Twin Conveyors and Single Conveyor. The Twin Conveyors are located at the northern portion of the Central Conveyor originating at Shine Pit. The Single Conveyor is located at the southern portion of the Central Conveyor, originating at the end of the Twin Conveyors and terminating at the end of the Pier.

Central Conveyor belts travel on self-lubricating rollers forming a U-shaped trough that carries sand and gravel. Failsafe sensors on each head pulley motor automatically shut down operation along the entire conveyor system in case of belt failure. Covers are installed over the Central Conveyor's belts to keep out rain and wind, preventing fugitive dust, sand, or gravel from escaping. Pans are installed under the Central Conveyor's return belt over all stream crossings. Conveyor enclosures are at the Thorndyke Road crossing and from the shoreline to the end of the Pier. Enclosures include a roof, painted metal siding and solid floor (or a grated walkway with a pan under the return belt).

Each of the six segments of the Central Conveyor terminates at a transfer point, where sand and gravel on the incoming conveyor segment will drop into a hopper and funnel onto the next conveyor segment. The Central Conveyor shifts direction slightly at Transfer Points 2, 3, 4, and 5. A utility shed at each transfer point will enclose the conveyor and hopper to protect electrical equipment, contain fugitive dust, and minimize noise. This shed will include a head pulley and electric motor, unpowered tail pulley, hopper, and the return belt cleaning equipment.

Twin Conveyors		
	Location:	Station 25+23.69 to 200+00
	Easement:	60 feet
	Length:	3.3 miles long
	Width (each conveyor)	5 feet wide
	Gap between conveyors:	4 feet
	Segments between transfer pts:	4 of varying lengths
Single Conveyor		
	Location:	Station 200+00 to 237+90
	Easement:	60 feet north of Thorndyke Road; 300 feet south of Thorndyke Road
	Length:	0.7 miles long
	Width:	6 feet
	Segments between transfer points:	2 of varying lengths
Color	Scheme:	Natural to blend into environment

Belts	Power:	Electric motor at head pulley (tail pulley unpowered)
	Rollers:	Self-lubricating
	Material:	Composite
	Speed (approx):	6 miles per hour
Assembly	Frame:	Steel channel, open box
	Height (approx.):	5 feet
	Vertical support:	Pair of steel channel, open box legs at 20-foot intervals
	Color(s):	Natural to blend into existing environment
Cover	Material:	Light metal
	Shape:	Half-moon
	Height above belt:	2 feet 6 inches
	Height above ground:	7 to 8 feet
	Location:	Station 25+23.69 to 211+50 (to Thorndyke Road) Station 214+00 to 228+00 (beginning of Pier)
Pan	Location:	Station 144+00 to 165+00 (at stream crossings)
	Ground clearance:	Approximately 2 feet
	Location:	Station 226+00 to 228+00 (bluff to Pier)
	Ground clearance:	Approximately 5 to 60 feet
Enclosures	Location:	Thorndyke Road (Station 211+50 to 214+00)
	Components:	Metal roof/siding, solid floor
	Dimensions:	12 feet high by 13 feet wide
	Location:	Shoreline (Station 228+00 to 234+35)
	Components:	Metal roof/siding, pan under return belt, grated walkway
	Dimensions:	10-12 feet high by 13 feet wide
	Location:	Pier Loadout (Station 234+35 to 237+90)
	Components:	Metal roof/siding, solid floor
	Dimensions:	15 feet high by 15-18 feet wide
Transfer Point	Transfer Point 1:	Station 25+23.69
	Transfer Point 2:	Station 39+27.09
	Transfer Point 3:	Station 87+16.4
	Transfer Point 4:	Station 134+44.87
	Transfer Point 5:	Station 200+00
	Transfer Point 6:	Station 221+55
Utility Shed	Size:	12 feet by 16 feet
	Material:	Wood and metal
	Lighting:	Interior only
	Location:	Transfer Points 1, 2, 3, 4, 5, and 6
Wiring	Electrical Power:	Underground
	Control Lines:	Underground
Wildlife Crossings		
	Typical clearance:	2 feet below return belt
	Large mammal crossings:	4-6 feet clearance below return belt every 300 feet (approx.)

2.0 PIER

The proposed Pier consists of a stationary and retractable load-out conveyor supported on pilings spaced at 100-foot intervals and two support structures. Perpendicular to the Pier in deep water are eight dolphins (six breasting and two mooring dolphins) connected by a grated catwalk. The Pier will be painted to blend into the existing environment and constructed in a manner that will minimize visual intrusion and glare. While the conveyor supported by the Pier will be enclosed, the Pier will be constructed largely of open steel girders to minimize shading effects. The Pier begins at approximately the Ordinary High Water (OHW) mark. Pilings will support the trusses (and enclosed conveyor), support structures, and breasting and mooring dolphins.

Two open steel structures will support the conveyor near the end of the Pier. The first structure is located approximately 650 feet from the shoreline. It supports the conveyor and has an overall height of 91 feet above MLLW (85 feet MSL). The second structure supports both the conveyor and the retractable (load-out) conveyor. The load-out conveyor will have an overall height of 76 feet above MLLW (70 feet MSL).

Two maintenance/storage buildings will be located on dolphins. An enclosed control room with access stairways, storage area, restroom, and holding tank is located within the second support structure. These facilities will not increase the area of over-water coverage.

Lighting of the intertidal and subtidal portions of the Central Conveyor and Pier will be kept to the minimum required for safe operation. Lighting of the water surface will be minimized with location, color, shielded and/or directional fixtures. During non-operation hours, lights will be turned off except as needed for maritime safety requirements.

Pier	Location:	5 miles southwest of Hood Canal Bridge; 1 mile northeast of Thorndyke Bay; 2 miles southwest of the community of Shine; 1.25 miles southwest of Southpoint
	Total Length:	990 feet, measured at Ordinary High Water (OHW) mark
	Stationary Conveyor:	Station 228+00 to 236+75
	Length:	875 feet
Station 228+00 to 233+00		Station 228+00 is supported by pilings, marks the beginning of the Pier at approximately the OHW mark.
	Length:	500 feet
	Truss Height:	10 feet
	Truss Width:	13 feet
	Top Elevation:	32 feet above MLLW (26 feet MSL)
	Invert Elevation:	22 feet above MLLW (16 feet MSL)
	Clearance (Water):	11 feet MHHW (16 feet MSL)
	Clearance (Beach):	25 feet above MLLW (19+ feet MSL)
Station 233+00 to 234+35		Station 233+0 begins the incline toward the first support structure.
	Length:	135 feet
	Truss Height:	12 feet
	Truss Width:	13 feet

	Top Elevation:	Slopes from 32 feet MLLW to 91 feet MLLW (26 feet MSL to 85 feet MSL)
	Invert of Conveyor:	Slopes from 22 feet MLLW to 76 feet MLLW (16 feet MSL to 70 feet MSL)
Station 234+35 to 236+75		Station 234+35 is supported by the first steel support structure. Station 236+75 is supported by the second steel support structure.
	Length:	240 feet
	Truss Height:	15 feet
	Truss Width:	18 feet
	Top Elevation:	91 feet above MLLW (85 feet MSL)
	Invert of Conveyor:	76 feet above MLLW (70 feet MSL)
Station 236+75 to 237+90		This modular enclosed distribution (load-out) conveyor pivots and retracts to conform to various vessel loading configurations.
	Length:	180 feet (extended)
	Truss Height:	15 feet
	Truss Width:	15 feet
	Top Elevation:	76 feet above MLLW (70 feet MSL)
	Invert of Conveyor:	61 feet above MLLW (55 feet MSL)
	Channel Elevation at end of Pier:	-79 feet MLLW (-73 feet MSL)
Color	Scheme:	Blend into existing environment
Pilings	Material:	Hollow steel round
	Diameter:	18-inch (truss supports) 30-inch (support structures) 30-inch (dolphins) 18-inch (catwalk supports)
	Spacing:	100-foot (truss supports) 50 feet (catwalk supports)
	Number:	4 each (truss supports) 16 each (support structures) 12 each (dolphins) 3 each (catwalk supports)
Support Structures		
	Support No. 1:	Station 234+35 to 234+65 (approximately 650 feet from shoreline, as measured from center)
	Materials:	Steel
	Dimensions:	30 feet by 30 feet
	Top Elevation:	76 feet above MLLW (70 feet MSL)
	Overall Height (including conveyor):	91 feet above MLLW (85 feet MSL)
	Channel Elevation (measured at center of support):	-13 feet MLLW (-7 feet MSL)

	Support No. 2:	Station 236+55 to 236+95
	Materials:	Steel
	Dimensions:	40 feet by 40 feet
	Top Elevation:	61 feet MLLW (55 feet MSL)
	Overall Height	
	(at conveyor):	91 feet MLLW (85 feet MSL)
	(at load-out conveyor):	76 feet above MLLW (70 feet MSL)
	Channel Elevation (measured at center of support):	-52 feet MLLW (-46 feet MSL)
Control Room	Location:	Support Structure No. 2
	Dimensions:	20 feet by 40 feet by 20 feet
	Material:	Metal
Maintenance and Storage Buildings		
	Location:	Two innermost breasting dolphins
	Dimensions:	10 feet by 10 feet
	Material:	Metal roof/siding, solid floor
Breasting and Mooring Dolphins		
	Water depth range:	-37 feet to -64 feet MLLW (-43 feet to –58 feet MSL)
	Typical depth:	-50 feet MLLW (-42 feet MSL)
	Shallowest depth:	-37 feet MLLW (-31 feet MSL)
	Pilecap dimensions:	20 feet by 20 feet, 7-feet thick
	Pilecap material:	Concrete
	Pilecap invert elevation:	15 feet MLLW (9 feet MSL)
Maintenance Catwalk		
	Material:	Galvanized aluminum or steel
	Width:	5 feet
	Length:	710 feet
	Railings:	36 to 42 inches high
	Elevation:	22 feet MLLW (16 feet MSL)

3.0 ROADS AND PARKING

A gravel forestry service road will provide access for forest firefighting, logging, and Central Conveyor maintenance. It will parallel the Central Conveyor and connect to the network of existing forestry service roads in the Thorndyke Block. The majority of the route realigns an existing forestry service road; abandoned routes will be re-graded and reforested. A turnout/parking area for a maintenance vehicle will be provided at each transfer point.

Access to the Central Conveyor south of the Thorndyke Road will be via an existing gravel road that leads to a parking area for employees working at the Pier. The southernmost portion of the road/walkway will be constructed of concrete for greater erosion protection.

Gravel Road	Location:	Central Conveyor (Station 25+23.69 to 211+50, 214+00 to 217+50)
	Width:	14 feet
	Length:	3.6 miles
Concrete Road	Location:	Single Conveyor (Station 217+50 to 222+00)
	Width:	24 feet
	Length:	450 feet
Concrete Walkway	Location:	Single Conveyor (Station 222+00 to 226+00)
	Width:	12 feet
	Length:	400 feet
Parking	Location:	Employee Pier Parking (Station 214+50 to 215+50)
	Number of stalls:	10
	Surface:	Gravel
Parking/Turnout	Location:	Transfer Points 2, 3, 4, and 5
	Surface:	Gravel
	Location:	Transfer Point 6
	Surface:	Concrete
Roads, Walkways And Parking	New:	7.3 acres
	Abandoned roads:	6.3 acres
	Net increase:	1.0 acres

4.0 VESSEL DESCRIPTIONS

The Pier is designed for ships and barges of varying sizes and displacements to transport sand and gravel. Only ships will require opening of the Hood Canal Bridge. It is anticipated that the first ships will call at the Pier 8 to 12 years after the Pier's construction.

	Barge	Typical Barge	Ship
Maximum Length (feet)	400	240	745
Maximum Width (feet)	100	60	110
Maximum Draft (feet)	25	16	45
Volume Range (dwt's)	2,500 to 20,000	5,000 to 7,000	20,000 to 65,000
Estimated Loading Time (hrs.)	1 to 8	2 to 3	8 to 24

5.0 PROJECTED VOLUMES*

In U.S. Short Tons (tons)

Individual Year of Operation	Barge	Ship	Combined
Year 1 of Pier Operation	2,000,000	0	2,000,000
Year 10 of Pier Operation	4,000,000	**600,000	4,600,000
Year 25 of Pier Operation	4,000,000	2,750,000	6,750,000

* Subject to market demand.

** First year shipping volume. U.S. flagged ships are projected to become available in Years 8 to 12 of Pier operation and not specifically in Year 10.

6.0 OPERATION

The Pier will be used up to 300 days a year, which excludes 65 days annually for holidays, tribal fishing, inclement weather, and periods of non-use.

Frequencies	Barge	Ship
Avg. Berthings Per Day	3	---
Avg. Berthings Per Month	---	0 to 6
Max. Berthings Per Day (either/or)	6	1
Max. Number of Vessels Berthed		
At Any Given Time (either/or)	2	1