

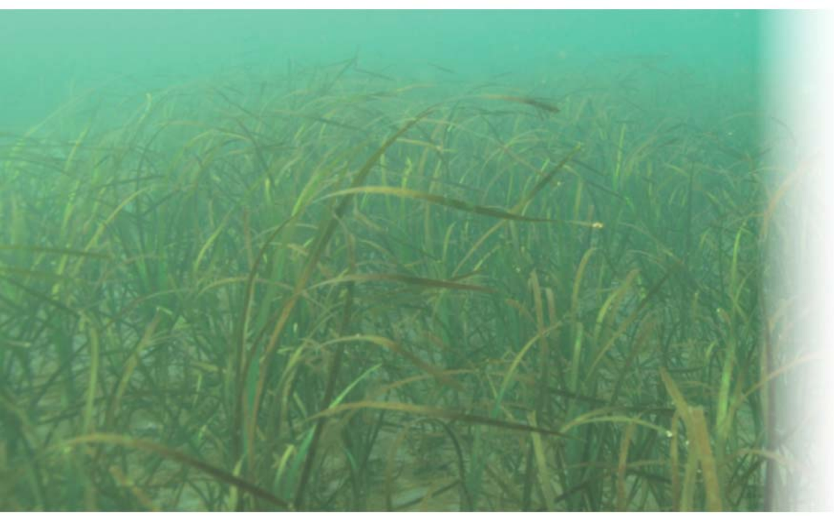
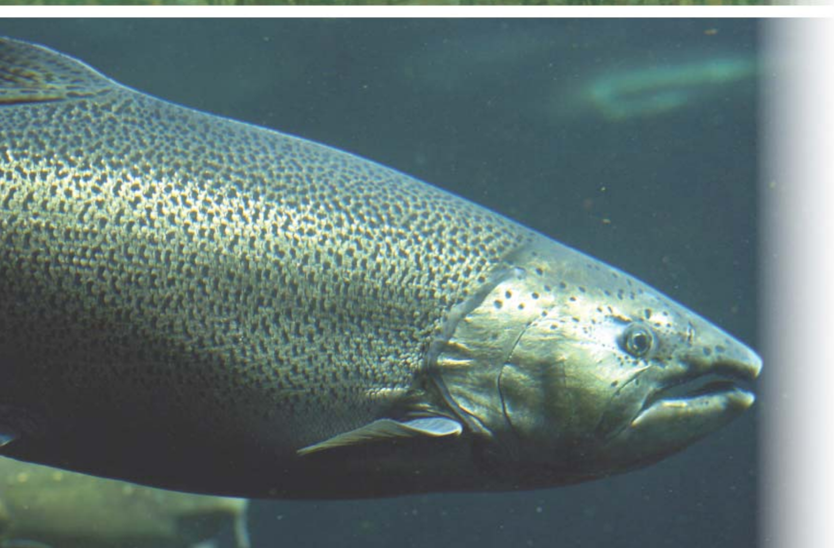

Draft
Thorndyke Resource
Biological Evaluation
Jefferson County, Washington

Prepared for
Thorndyke Resource

June 20, 2013
12674-04

HARTCROWSER

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THORNDYKE RESOURCE
BIOLOGICAL EVALUATION

1.0 INTRODUCTION

The Applicant proposes to construct and operate a conveyor system to transport sand and gravel from an upland processing site (a portion of the Thorndyke Area South located in Jefferson County, Washington) to a proposed pier that would be located approximately four miles south on the northwest shore of Hood Canal. The proposed Thorndyke Resource project has formerly been referred to as the Thorndyke Resource Operations Complex, Central Conveyor and Pier (T-ROC), and/or the Fred Hill Materials "Pit-to-Pier" Project.

Sand and gravel produced from the project will be primarily used as integral components of concrete and asphalt based on the historical demands for these resources by the regional, intrastate, and interstate construction industry. A multitude of environmental mitigation projects involving beach restoration also will be supplied by the sand and gravel from the project. As an alternative to trucking the sand and gravel to its markets, barges and ships would be loaded from the proposed pier connected to the upland Operations Hub by the Central Conveyor. The location for the pier was chosen based on a series of design criteria that considered distance from the sand and gravel resource; existing and proposed land uses in the project vicinity; and physical and environmental constraints including avoidance or minimization of impacts to environmentally sensitive areas.

The proposed project has the potential to affect Puget Sound/Hood Canal fish and wildlife species and their habitat. This biological evaluation (BE) has therefore been prepared to aid in evaluating this project's potential effects on fish and wildlife species listed as threatened or endangered under the Endangered Species Act (ESA).

Section 7 of the ESA requires that any action by a federal agency is "not likely to jeopardize the continued existence of any [listed] species or result in the destruction or adverse modification of habitat of such species...." Under ESA Section 7(c), the lead federal agency for this project, the US Army Corps of Engineers (USACE), must prepare a BE of the potential influence of its action (in this case, approval of the pier and Central Conveyor described in Section 2.2) on listed species or their critical habitat. Depending on the conclusion of the BE, USACE may be required to confer formally with NOAA Fisheries and the US Fish and Wildlife Service (USFWS) regarding the project.

Because this work will occur in nearshore subtidal areas of Hood Canal, the proposed project has the potential to impact 18 species listed as threatened or endangered under the ESA, or their respective critical habitats as of April 2013:

- Puget Sound Chinook salmon (*Oncorhynchus tshawytscha*);
- Hood Canal summer-run chum salmon (*Oncorhynchus keta*);
- Puget Sound steelhead trout (*Oncorhynchus mykiss*);
- Coastal-Puget Sound bull trout (*Salvelinus confluentus*);
- Bocaccio (*Sebastes paucispinis*);
- Canary rockfish (*Sebastes pinniger*);
- Yelloweye rockfish (*Sebastes ruberrimus*);
- Pacific eulachon (*Thaleichthys pacificus*);
- Green sturgeon (*Acipenser medirostris*);
- Marbled murrelet (*Brachyramphus marmoratus*);
- Northern spotted owl (*Strix occidentalis caurina*).
- Steller sea lion (*Eumetopias jubatus*);
- Southern resident killer whale (*Orcinus orca*);
- Humpback whale (*Megaptera novaeangliae*);
- Leatherback sea turtle (*Dermochelys coriacea*);
- Loggerhead sea turtle (*Caretta caretta*);
- Green sea turtle (*Chelonia mydas*); and
- Olive Ridley sea turtle (*Lepidochelys olivacea*).

The ESA status of each of these species is presented in Table 1, and agency correspondence regarding listed species can be found in Appendix A.

2.0 PROJECT DESCRIPTION

2.1 Location of Project and Action Area

The "project area" is the immediate area where construction and operations will take place. In this case, the 990-foot pier on the Hood Canal shoreline will deliver sand and gravel extracted from an approved 690-acre Mineral Resources Land (MLA), processed at an Operations Hub within the Shine Pit area, and transported via a 4-mile-long Central Conveyor. The project will extend through Thorndyke Area South, a privately owned commercial tree farm, including portions of the east halves of the following sections: Sections 6, 7, 8, 18, and 19, Township 27N, Range 1E, W.M., in Jefferson County, Washington (Appendix B, Sheets 1–16, C2.2, and C2.3). The 14.7-acre waterfront project site, controlled by the Applicant, is situated approximately 1.25 miles west of the community of South Point and approximately 2 miles southwest of the community of Shine (Appendix B, Sheet 1).

The "action area" includes all areas in and around the project that could be affected directly or indirectly by the project. In this case, the action area is broken down into two separate areas: the in-water action area and the upland action area. The upland action area includes the area within 2.1 miles on either side of the Central Conveyor from the Hood Canal shoreline to the Shine Pit and MLA (Figure 1). The in-water action area includes the waters and shorelines of Hood Canal extending approximately 11 miles to the south and 8 miles to the north of the project site. This area encompasses approximately 30.5 square miles (Figure 1).

2.2 Project Description

A detailed Project Description and Fact Sheet are provided in Appendix F.

The source of material for the conveyor is forestry land leased from Pope Resources, Inc., a Delaware Limited Liability Partnership. Olympic Resource Management manages the property. The current extraction site, the Shine Pit and MLA, is located south of State Route 104 on the Olympic Peninsula, approximately 5 miles south of Port Ludlow (Section 32, Township 28N, Range 1E; Appendix B, Sheet 1).

Fred Hill Materials, a former agent for Thorndyke Resource project applicants, was a separately owned company that operated the Shine Pit between 1979 and 2009 under Surface Mine Reclamation Permit No. 70-011936 issued by the Washington State Department of Natural Resources (WDNR) and Sand and Gravel General Permit No. WAG 50-1120 issued by the Washington State Department of Ecology (Ecology). Ecology regulates the treatment and control of stormwater at the 225-acre Shine Pit processing site. All stormwater on the site is contained and discharged to ground using infiltration techniques.

In 2009, Fred Hill Materials sold its truck-based Shine Pit mining operation to Miles Sand and Gravel (Miles). As part of the sale, Miles secured leased rights for truck-based mining in the Wahl Extraction Area while Thorndyke Resource project proponents preserved leased rights to extract within the Meridian Extraction Area (located southwest of Shine Pit). Mining will be conducted and reclaimed in sequential segments of 40 acres or less, dependent upon WDNR determination.

In 2010, Jefferson County approved Miles' application to move its processing hub to an 18-acre site just west of Wahl Lake. Subsequent to moving its operations, Miles will reclaim the Shine Pit area and no longer use forestry service road T-3100 for truck delivery of aggregates from Shine Pit to SR 104. A settlement agreement between the property owner and Washington State

Department of Transportation (WSDOT) clarified and limited access to SR 104 from Shine Pit, including prohibiting truck delivery of aggregate. It is therefore anticipated that the Shine Pit portable asphalt plant originally sub-leased by Ace Paving will move in the near future.

The proposed project would mine within the Meridian Extraction Area, move materials via the Wahl Conveyor to a reconfigured Operations Hub at the existing Shine Pit, and continue along the proposed Central Conveyor extending south to the west shore of Hood Canal where it would terminate at a new over-water pier and load-out facility. The shoreline parcels where the new pier and its approach structure would be located are owned by the Hood Canal Sand and Gravel Company, LLC and involve 14.7 acres in Section 19, Township 28N, Range 1E, W.M. (Appendix B, Sheets 8–16).

The proposed Central Conveyor uses conventional twin- and single-belt conveyors. Twin Conveyors (each belt measuring 60 inches wide, with a four-foot gap between them) will transport materials from the Shine Pit approximately 3.3 miles to a transfer point where the materials will load onto a Single Conveyor comprised of a 60-inch-wide belt. From this point, the Single Conveyor would extend approximately 0.7 miles and traverse a steep bluff approaching the pier before terminating at the load-out facility. The Central Conveyor (including the pier) would be covered or enclosed over its entire length. Existing forestry service roads, primarily used for access along the conveyor alignment, will be used or realigned to avoid wetlands and their associated buffers and to provide ongoing access for maintaining the conveyor system. Applicable stormwater management practices will be provided along the entire Central Conveyor.

Environmental conditions reports have been prepared for the proposed project. These reports include, but are not limited to, a Marine Resources Survey Report (Appendix C), a Habitat Management Plan for Marine Habitat and Bald Eagles (Appendix D), a Macrovegetation Survey Report (Appendix E), a Wetlands Delineations and Biological Inventory report (BGE 2008; Krazan 2002), a Preliminary Geotechnical Report (Shannon and Wilson 2001), a Preliminary Storm Drainage Report (Team 4 Engineering 2002), a Shorelines Impacts Study (Anchor 2002), a Preliminary Geotechnical Report (Shannon and Wilson 2003; see Appendix G), a Longshore Sediment Transport and Shoreline Process Report (Anchor 2003; see Appendix H), and a Noise Impact Study (Environalysis 2011; see Appendix I).

The primary project elements most relevant to this BE include the proposed Single Conveyor, as it crosses overhead at Thorndyke Road, and marine pier. Engineering drawings (project plans and profiles) for those elements are presented in Appendix B.

Construction details of the Central Conveyor (Appendix B, Sheets 9–16) and pier (Appendix B, Sheets 2–9, C2.2, and C2.3) are described in the following sections.

2.2.1 Central Conveyor

The Twin Conveyors will be approximately 3.3 miles in length and consist of two 5-foot-wide belts supported about 8 feet above the ground on steel frames spaced approximately 50 feet apart. A 2-foot-high ground clearance below the return belts, increasing to 4–6 feet every 300 feet, will allow for wildlife crossings. The conveyor belts will travel on self-lubricating rollers forming a U-shaped trough to carry the sand and gravel. Failsafe sensors on the conveyors will automatically shut down operation along the entire conveyor system in the event of a belt failure.

The Central Conveyor will contain six transfer points where sand and gravel will be transferred from one conveyor segment to the next. Each transfer point will be enclosed by a utility shed to contain fugitive dust and minimize noise. These 12-by-16-foot utility sheds would include a head pulley and electric motor, and an unpowered tail pulley. As the belts approach each tail pulley, they will rotate 180 degrees prior to returning to the head pulley. This will keep the "load side" of the belt facing upwards to limit escape of fugitive dust and sand during the belt's return to the head pulley.

Similar in construction and design to the Twin Conveyors, the Single Conveyor and pier will have a combined length of approximately 0.70 miles with one 60-inch-wide belt. The Single Conveyor will also be approximately 8 feet high, include wildlife crossings, and be supported by steel support frames spaced approximately 50 feet apart, except where the conveyor free-spans a steep slope and wetland area. Here the support spacing will be increased to 100 feet to avoid direct impacts to sensitive areas.

Metal roofs and sidings, and/or half-moon metal covers, will be installed over the Central Conveyor to keep out wind and rain, and to minimize fugitive dust or loss of sand and gravel. Pans or solid floors will be installed under the Central Conveyor return belts at all stream crossings as an additional measure to capture fugitive dust and minimize any potential spillage of sand and gravel into upland area water courses.

Approximately one acre (43,655 square feet [sf]) of new 14-foot-wide forestry service road will be constructed to provide access to the Central Conveyor. Since the Central Conveyor itself will occupy an additional 0.27 acre (11,750 sf), a total of approximately 1.27 acres (55,405 sf) of new impervious surface will be constructed along the conveyor corridor.

At approximately 700 feet from the shoreline, the Single Conveyor will angle down a hillside where a new cut will be excavated that is approximately 400 feet long, 50 feet wide, and 20 feet deep (Appendix B, Sheet C2.2). This cut will reduce the gradient the Single Conveyor travels down the slope. A temporary access from Thorndyke Road also may be required in order to conduct the excavation from the top of the slope. Near the base of the hillside, the Single Conveyor will be supported by the pier approach structure that will consist of a truss bridge designed to span (still at an angle) the steep slope and avoid direct impacts to Wetland B near the shoreline.

At the shoreline, the slope of the Single Conveyor will level out. From this point to the end of the pier, the conveyor will be fully enclosed as it extends across the beach and intertidal/subtidal marine waters. At about Station 228+00, a support consisting of four 18-inch-diameter steel piles will be installed near ordinary high water (OHW) where the pier structure begins.

2.2.2 Pier

The pier will be located approximately 5 miles southwest of the Hood Canal Bridge, extending approximately 1,000 feet from the Hood Canal shoreline at OHW to roughly –50 feet mean lower low water (MLLW; Appendix B, Sheet 3). The pier consists of the conveyor and a retractable load-out structure supported on pilings spaced at 100-foot intervals, support towers, eight dolphins (six breasting and two mooring dolphins), and an elevated, grated catwalk. The pier, with its covered conveyor, load-out structure, and grated catwalk, is the only project element that will be placed waterward of the OHW and above the water's surface. The pier structure has been designed with a profile that is as low to the water as possible yet capable of accommodating the proposed loading operations. To minimize shading effects, the pier maintenance walkway will have a grated decking along the conveyor.

For the first 500 feet (i.e., Station 228+00 to Station 233+00; Appendix B, Sheets C2.2 and C2.3), the conveyor will be supported on steel support frames (truss supports) that will be spaced approximately 100 feet apart. Based on the current pre-design, a total of 28 piles will be used to support seven trusses along this section of pier with each of the trusses supported by four 18-inch-diameter steel piles (Appendix B, Sheet 5). Each truss will be 13 feet wide in order to support both the conveyor and walkway. Over water, the top of the covered pier will be approximately 32 feet above MLLW (i.e., Station 228+00 to Station

233+00). The bottom (or invert elevation) of the conveyor will be approximately 22 feet above MLLW.

Beginning at Station 233+00, the conveyor will slope upward for a distance of 135 feet to a point where it will be supported by an open steel tower support approximately 91 feet above MLLW (Station 234+35; Appendix B, Sheet C2.3). A second tower support will be located approximately 240 feet from the first support structure. The second tower structure will support both the conveyor and a separate, enclosed load-out conveyor. The truss width between the first and second tower supports will be 18 feet. Each of the two open steel towers will include sixteen 30-inch steel piles, a total of 32 piles for both towers (Appendix B, Sheet 7).

At the second tower support, the conveyor will transfer materials onto the load-out conveyor that will discharge materials into the moored vessels (Appendix B, Sheet C2.3). The 165-foot-long load-out conveyor will pivot and retract to conform to various vessel-loading configurations. An enclosed control room with access stairways, storage area, and restroom with holding tank will be located within the second support structure. These facilities will not increase the area of overwater coverage. Currently, there are no provisions for stormwater collection along the pier.

The docking facilities at the end of the pier will consist of six pile-supported breasting dolphins and two pile-supported mooring dolphins located in water depths of –49 to –64 feet MLLW (Appendix B, Sheet C2.3). Each dolphin will be supported on twelve 30-inch steel piles capped with a 20-foot by 20-foot, 7-foot-thick concrete pilecap (Appendix B, Sheet 4). Construction of the breasting and mooring dolphins will require a total of 96 piles. The bottom of the pilecaps will be approximately 15 feet above MLLW. The pile-supported breasting and mooring dolphins will be connected by a grated, 5-foot-wide catwalk supported by 36 18-inch piles.

2.2.3 Lighting

Lighting of the conveyor and pier across marine habitats would be restricted to the minimum amount necessary to conform with applicable safety requirements (e.g., US Coast Guard, Occupational Safety & Health Administration, Washington Industrial Safety and Health Act, etc.). Direct lighting of the water surface would be minimized with shielding. During non-operation hours, lighting on the pier would be turned off except as required for maritime safety and navigation.

2.3 Construction

2.3.1 Project Timing

All in-water construction work (e.g., pile driving) will be restricted to the agency-approved work window to protect federally listed salmonids that may be present within the project and action areas. The work window is anticipated to extend from July 16 to February 15. The Washington Department of Fish and Wildlife (WDFW) Salmonscape database shows no historical or current documentation of forage fish spawning within approximately 1 mile of the proposed pier alignment; therefore, adherence to forage fish spawning windows is not anticipated. Assuming that in-water construction activities are allowed to proceed uninterrupted during this period, construction of the pier and associated structures is expected to take about 2 months.

2.3.2 Construction Methods

2.3.2.1 Upland

To provide continuous maintenance access along the conveyor alignment, segments of existing forestry service roads will be restored. In certain locations, a new gravel-surfaced service road will be constructed along the conveyor aligned in a manner that will avoid direct impacts to wetlands and their associated buffers. Construction of new segments of the maintenance access road will require some clearing of vegetation and, where necessary, grading. Small amounts of earth excavation and/or fill material will be required along the alignment to reduce local topographic variation and for installation of conveyor pile footings and/or foundations.

Preassembled sections of the conveyor will be brought to the site by truck for final installation. A small, truck-mounted crane will lift sections of the conveyor off flatbed trucks and lower them into place. If necessary, existing vegetation will be trimmed or removed in order to install the conveyor sections. Installation of elevated sections (e.g., over-road crossings, uneven terrain, streams, seeps, or steep slopes) will require drilling equipment and use of steel piles (up to 18 inches in diameter).

Use of preassembled components will minimize the need for on-site staging. In addition, staging activities will rely on areas that have been recently cleared during timber harvest activities in order to further minimize vegetation removal. Whenever possible, impacts to replanted areas will be avoided. Underground electrical and control wiring will be installed by trenching along the access road and/or conveyor alignment.

Stormwater will be managed during upland construction and operation along the entire conveyor alignment. Stormwater from all work areas will be distributed into surrounding forested areas for infiltration in accordance with Ecology's current stormwater manual (Ecology 2012). Once the conveyor system is constructed, stormwater facilities and practices will be maintained to ensure that runoff and hydrologic connectivity to local wetlands are effectively managed over the long-term. Anticipated stormwater facilities will include installation of properly sized culverts near existing swales that re-direct drainage from roadside ditches to historical watercourses. A comprehensive description of stormwater management plans is described in the preliminary storm drainage report (Team 4 Engineering 2002).

Approximately 700 feet from the Hood Canal shoreline, a cut will be made in the hillside and bluff to reduce the slope of the pier approach and conveyor before joining the elevated pier structure above the mean higher high water (MHHW) level. An area approximately 50 feet wide by 20 feet deep by 400 feet long will be cut using heavy excavation and grading machinery. A temporary access road also may be required in order to conduct the excavation from the top of the slope. Any surplus excavated material will be backhauled to an onsite upland disposal area. Construction best management practices (BMPs) will be installed prior to construction to avoid or minimize potential impacts to Wetland B, the surrounding slope, and beach.

A support structure for the pier approach located near the top of the steep bluff (approximately Station 226+00; Appendix B, Sheet C2.2) will be installed using either a steel pile bent (drilled) or a deeply founded spread footing. The specific type of support will be confirmed following final engineering and geotechnical evaluations. Either support type will be placed a sufficient distance from the top of the bluff to minimize the risk from possible bank erosion. Shannon and Wilson (2003) stated that, from a geologic hazard avoidance perspective, the alignment for the proposed pier approach that extends from the top of the bluff down to the beach is the preferred slope crossing among others investigated along the northwest shoreline of Hood Canal. In this report, Shannon and Wilson further stated that mitigation for landslide hazards on the top of the bluff along the conveyor alignment should reduce the frequency and magnitude of future landslide events that, in the past, tended to bury Wetland B at the toe of the bluff.

During construction and operation, erosion risks will be controlled using site-specific BMPs. These will include temporary measures such as silt fences, covering or mulching soils stockpiles, and scheduling select work activities during drier periods. Permanent control measures, such as geotextile and other fabrics, gravel-filled geocells, or erosion control vegetation, will be installed and maintained along the bluff face and elsewhere as specified during final design and construction. Measures also will be implemented to control potential landslides, erosion, and seismic hazards. These will include site-specific plans for foundations, retaining walls, debris catchment systems, and surface or subsurface drainage. Specific techniques and methods will be determined during the final design and construction phases of the project.

The large conveyor truss system will span the steep bluff and Wetland B at the toe of the slope. Design and construction details for installation of the truss system are described below.

2.3.2.2 Marine

The conveyor truss system will be constructed to support the pier approach that descends from the top of the bluff to the pier (Station 226+00 to approximately Station 228+00; Sheet C2.2). Construction will involve the use of heavy equipment along the upper beach as described below. The truss system will be installed by either lowering the structural components from the top of the bluff or by pulling them up from the toe of the slope. The sequence of work will include:

1. Installing permanent pilings to support the conveyor truss system for the pier approach and overwater structure.
2. Constructing temporary falsework and permanent support structures at the top of the bluff at Station 226+00 and on the conveyor bent pile at Station 228+00 simultaneously with Task 1.
3. Installing a temporary uphill cable-way hoist structure after completion of Task 2.
4. Installing a temporary downhill cable-way hoist structure.
5. Installing the cable-way hoist device.
6. Completing the pier approach by placing a prefabricated, 205-foot conveyor truss system with the cable-way.

The pile bents will support a temporary suspension cable and cable-way hoist/traveler system to support the conveyor when it is lowered from the top of the bluff or pulled up from the bottom, as described below. Suspension cable towers, jibs, pulleys, and other components will be temporarily attached to and supported by the piles and pile bents at the top of the bluff.

Lowering from Top of Slope. Under this option, the 205-foot conveyor truss for the pier approach will be delivered to the top of the slope in preassembled, 40- to 80-foot-long sections (length limited by highway regulations and permit fees). The truss will then be assembled along the prepared conveyor alignment at the top of the slope. The assembled conveyor will be supported on dollies and lowered down a ramp to Station 226+00 at the top of the bluff. The suspension cable-supported traveler would pick up the conveyor truss once the downhill end reaches the top of the bluff. This traveler would then roll down the suspension cable toward the pile bent at Station 228+00. The rate of downslope movement will be controlled by winches, cranes, or other equipment operating on the top of the slope, or by a barge-mounted crane with winch equipment that is tied to offshore dock dolphins.

Pulling Up from the Toe of the Slope. Under this option, the 205-foot-long preassembled truss will be brought to the site on a barge-mounted crane and hoisted up the slope on a suspension cable with a traveler similar to that described above. The truss will be lifted to the top-of-bent elevation with a crane or by travelers that are supported on the suspension cable system. The barge-mounted crane will control the travelers on the suspension cables and hoist the structure into position.

After completing the steps above, a barge with a crawler crane will be maneuvered alongside the newly placed pile supports near station 229+00 at a water depth of approximately +6 feet MLLW. Once the tide has receded, timber "mats" (about 20–28 feet long by 4–6 feet wide by 1 foot thick) will be lifted by the crawler crane and placed onto the beach. The temporary mats will be placed in a "leapfrog" manner to prevent the crawler crane from having direct contact with the beach. The 165-ton crawler crane will then move onto the mats where it will traverse the beach between elevations +6 and +12 feet MLLW so the pilings and prefabricated conveyor trusses in this section can be installed.

This process will be reversed during the flood tide, allowing the crane and mats to be moved back onto the barge until the next suitable low tide. Once the tide recedes again, the mats will be replaced on the beach so that work can resume until the pile installation is completed. The temporary disturbance to the beach is expected to be minimal and limited to the immediate areas where mats are placed and recovered. Once this element of work is completed, the beach will be restored to its original condition. The estimated time for piling placement at Stations 228+00 and 229+00 is 5 working days plus approximately 2 days for placing conveyor trusses into final position.

Placement of the remaining piles and assembly of the overwater pier will be completed from construction barges. The largest barge will be 155 feet by 50 feet and draw approximately 6 feet of water when fully loaded. All support and batter piles in the marine and shoreline areas will be installed using vibratory methods (site conditions permitting). It will likely be necessary to use an impact hammer to proof a small percentage (5–10 percent) of piles in order to verify their load-bearing capacity. Prefabricated overwater conveyor trusses will then be hoisted into position using barge-mounted cranes.

2.3.2.3 Best Management Practices

Upland Areas. BMPs will be implemented to control erosion and runoff at the project site, particularly areas involving earthwork and sloped topography. Stormwater controls will be implemented in accordance with Ecology's current stormwater manual (Ecology 2012) and in accordance with conditions of approval for required permits. Stormwater BMPs and related strategies, including those associated with new impervious surfaces, are described in the Preliminary Storm Drainage Report (Appendix L). A comprehensive description of BMPs will be included in the forthcoming Conservation Measures and Mitigation Plan (CMMP).

Marine. BMPs will be implemented in marine work areas to limit direct and indirect impacts to tidelands and beach areas and to control the release of debris during construction and operation of the pier. BMPs for construction and operation also will be implemented to control potential fuel spills and releases of other sources of contamination. Refueling will be conducted either off site or within contained areas on barges according to strict storage, handling, and safety procedures. An approved spill response plan, including provisions for on-site spill containment and recovery equipment, will be developed prior to initiation of construction activities. To minimize areas of disturbance, construction barges will be moved as little as possible while working near or over intertidal areas. In addition, extra care will be taken to minimize bed disturbance when working near eelgrass communities during construction. A comprehensive description of BMPs will be included in the forthcoming CMMP.

2.3.3 System Operation

2.3.3.1 Operating Schedule

Following construction, the conveyor is expected to operate on an intermittent basis. However, the operating lifespan of the project will ultimately depend on market conditions and available supplies of sand and gravel. Outside of scheduled intermittent shutdowns and any regulatory restrictions placed on conveyor or vessel operations, the conveyor's operating schedule will be driven by the demand for the materials. This will determine the capacities of transport vessels (described below) and their frequency (e.g., number of vessels per week or month). It is assumed that vessels would be loaded up to 300 days a year, up to 24 hours a day. This would allow 65 days annually for holidays, tribal fishing, inclement weather, and other periods of non-use. The different vessel sizes for which the facility has been designed and their expected loading times are described below.

2.3.3.2 Vessel Descriptions

Vessels of varying sizes/displacements will be used to transport sand and gravel materials. Initially, only barges will call at the pier. Typical barge capacity is 5,000 dead-weight US short tons (dwt), but barges may range in size from 2,500 dwt up to 20,000 dwt. Dimensions of the largest barges are 100 feet wide by 400 feet long, with a 25-foot draft. The dimensions of a typical barge are 60 feet wide by 240 feet long, with a 16-foot draft.

Ship capacities will range from 20,000 dwt to 65,000 dwt. Dimensions of the largest ships will be 110 feet wide by 745 feet long, with a 45-foot draft. It is anticipated that these ships (only US-flagged ships will be used) will become available in approximately 8 to 12 years after the pier's construction and will be used subject to market demand.

The smallest-capacity barge (2,500 dwt) will take approximately 1 hour to load, while the largest-capacity barge (20,000 dwt) will take up to 8 hours for loading. Loading times of the largest bulk carrier (65,000 dwt) will take up to 24 hours.

Depending on the vessels' sizes, it is anticipated that up to six vessels will be loaded at the facility each day.

During mooring operations, all vessels will be tug-assisted and will not maneuver under their own power. When mooring larger ships or multiple- barge tows, two tugs may be used. The assist tugs will not be stationed on site. The only vessel that will remain on site will be a small tender capable of operating a spill containment boom (also stored on site), along with other safety and maintenance equipment. When not in use, the tender will be stored off the water (on a lift) at the pier.

2.3.3.3 Annual Volumes Transported by Vessels

In Year 1 of pier operations, it is anticipated that the volume of sand and gravel transported by barge will be 2 million US 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 US-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.

2.3.3.4 Best Management Practices

The entire Central Conveyor (including the section on the pier) will be covered or enclosed to minimize the potential for spillage (see Appendix F, Central Conveyor and Pier Project Description and Fact Sheets). During conveyor operations, BMPs will be implemented in both the upland and marine operating areas. These BMPs are designed to minimize the risk of materials spills, including fuel spills and other potential sources of contamination. Refueling of equipment will be conducted off site whenever possible. On-site refueling activities will adhere to strict safety guidelines. An approved spill response plan including details regarding on-site spill containment equipment will be developed prior to conveyor operations. A comprehensive description of BMPs will be included in the forthcoming CMMP.

3.0 DEFINITION OF THE ACTION AREA

3.1 In-water Action Area

This BE uses in-water noise to define the in-water action area since it will provide a conservative (i.e., larger) area to evaluate for project effects to nearshore resources. Sound travels substantially farther underwater than through the air. Pile driving produces waterborne noises that may injure or cause behavioral disturbances to fish, marine mammals, and diving seabirds. Interim criteria have been developed by USFWS and NOAA/NMFS to protect marine species that use nearshore habitats. The interim criteria present conservative thresholds of underwater noise at which potential injury or disturbance may occur. These thresholds include:

- 206 decibels (dB) Peak for injury to fish (Fisheries Hydroacoustic Working Group 2008 in US Navy 2011; WSDOT 2013)
- 183 to 187 dB Sound Exposure Level (SEL) over time for injury to fish (Fisheries Hydroacoustic Working Group 2008 in US Navy 2011; WSDOT 2013)

- 190 and 180 dB RMS for injury to pinnipeds and cetaceans (respectively) (WSDOT 2013)
- 202 dB SEL for injury to diving marbled murrelet (SAIC 2011, WSDOT 2013)
- 160 dB RMS for disturbance to marine mammals from impact pile driving, and 120 dB RMS for disturbance to marine mammals from vibratory pile driving (WSDOT 2013)

These criteria also establish a methodology for estimating the distance from pile driving operations where injury or disturbances may occur. These methods were used to determine the in-water action area of the proposed action.

The proposed action will install 64 steel piles (18-inch) for the truss and catwalk structures and 128 steel piles (30-inch) for the tower support and dolphin structures. Although a majority of the pile installation will involve using a vibratory hammer, proofing with an impact hammer will be necessary to ensure load bearing capacity on a small percentage of piles (5 to 10 percent).

The action area was determined conservatively by using the noise analysis with the largest potential zone of disturbance, which was calculated using 30-inch piles installed (or proofed) with an impact hammer. Literature shows that sound levels for the use of an impact hammer on 30-inch steel piles equal 190 dB RMS at 10 meters from the pile (ICF Jones & Stokes et al. 2009). This value was then used in the NOAA Practical Spreading Loss Model to determine the isopleth for the marine mammal/cetacean continuous sound criteria of 120 dB RMS. Conservative calculations showed the in-water 120 dB RMS isopleth to attenuate out to 288 miles. This distance is reduced where intervening land masses would truncate the propagation of underwater pile driving sound. Therefore, the area encompassed by the isopleth (representing the in-water action area) is approximately 30.5 square miles around the project area (Figure 1).

3.2 Upland Action Area

To be consistent and conservative, this BE used airborne noise effects to determine the upland action area. Airborne noises from construction or material transport operations may also cause behavioral disturbances to nesting or roosting birds and other animals. The two most common types of noise based on attenuation dynamics are point source, such as construction noise at a site, and line source, such as those along a corridor that operates over a continuous period over the length of the conveyance. Natural factors such as topography, vegetation and temperature can reduce noise over distance from the source.

A hard site exists where sound travels from the source over a generally flat, hard surface such as water, concrete or hard-packed surface. When ground cover or normal unpacked earth is present between the source and receptor, the ground becomes absorptive to sound and is called a soft site. The type of site surrounding a source, whether hard or soft, can affect the rate of sound attenuation. Sounds emanating from soft sites attenuate more rapidly over distance relative to a hard site. According to the Washington Department of Transportation (WSDOT), point source noise attenuates from a soft site, which is present over terrestrial areas of the proposed conveyor, at a rate of 7.5 dB per doubling of distance. For line sources, which would be present during operations of the conveyor, the attenuation rate is 3 dB per doubling distance (WSDOT 2006). WSDOT uses these rates when calculating the potential noise from transportation projects on roads and ferry terminals in its Biological Assessments.

Documented point source noises for various types of construction activities and equipment that will be used at the pier and conveyor are presented below (noise measured at 100 feet from the source; MFG 2004):

- Clearing, 77 dB
- Grading, 69 to 82 dB
- Pile Driving (vibratory), 60 dB
- Bulldozer, 71–90 dB
- Dump Truck, 76–88 dB
- Scraper, 74–87 dB
- Crane 69–79 dB
- Generators, 65–76 dB
- Compressors, 68–75 dB

When multiple pieces of equipment are used at once, sound levels increase on a logarithmic scale with no added noise for activities more than 10 dB below the loudest activity (e.g., addition of 3 dB when two activities differ by 0 or 1 dB, 2 dB when two activities differ by 2 or 3 dB, and 1 dB when activities differ by 4 to 9 dB; WSDOT 2006). Assuming a conservative assumption that all of the above activities and equipment are operating at once, the maximum level of noise at the construction site would be approximately 5 dB above the highest level of noise (90 dB for a bulldozer) or 95 dB measured at 100 feet. Ambient pre-construction noise in the project area has been measured at 44.3 dB (MFG 2004). Assuming a noise attenuation rate of 7.5 dB per doubling of distance, construction noise would attenuate to ambient background levels in approximately 2.1 miles from the proposed pier alignment.

For line sources during conveyor operations, noise along the conveyance is estimated to be 49 dB measured at 100 feet (MFG 2004). Assuming an attenuation rate of 3 dB per doubling of distance, operational noise would attenuate to ambient background levels approximately 400 feet from the conveyor.

Noises would radiate spherically (for point source noise) or cylindrically (for line source noise) away from the site during construction or operational activities. Figure 1 shows the estimated terrestrial action area defined by the extent of airborne noise around the conveyor during the construction phase of the project. This area represents the most conservative approach to defining the upland action area.

4.0 DESCRIPTION OF THE SPECIES AND CRITICAL HABITAT

Eighteen ESA-listed species either occur or may occur in the action area. The status of each species and presence of critical habitat (if designated) in the action area are discussed below.

Of the 18 species considered in the BE, eight were considered not likely to be present in the project area as they have been only rarely observed in the past in Hood Canal or have not yet been documented. These eight species are listed below.

- Pacific eulachon (*Thaleichthys pacificus*);
- Green sturgeon (*Acipenser medirostris*);
- Southern resident killer whale (*Orcinus orca*);
- Humpback whale (*Megaptera novaeangliae*);
- Leatherback sea turtle (*Dermochelys coriacea*);
- Loggerhead sea turtle (*Caretta caretta*);
- Green sea turtle (*Chelonia mydas*); and
- Olive Ridley sea turtle (*Lepidochelys olivacea*)

Although their presence is uncertain, these eight species could occur at the project site since no barriers or obstructions exist that would restrict their distribution in Hood Canal.

Green sturgeon and Pacific eulachon were eliminated from further analysis because they are not likely to be present in Hood Canal (NMFS 2009; Longenbaugh 2010, personal communication). Further, four species of sea turtles are not known to be present; the humpback whale may have been present historically, but there have been no recent sightings; and the Southern Resident killer whale, also historically sighted, has not been recently observed and is considered rare (NMFS 2006; US Navy 2012). Southern Resident killer whales are present throughout much of Puget Sound and non-listed transient killer whales have been sighted in Hood Canal and often cannot be distinguished from southern residents (NMFS 2006). It is extremely unlikely, although possible, that these eight species occur in the action area; thus, they have been given a "no effect" determination in this BE. The analysis in this BE, therefore, focuses on the remaining ESA-listed species that are known to be present or are more likely to be present. These include:

- Puget Sound Chinook salmon (*Oncorhynchus tshawytscha*);
- Hood Canal summer-run chum salmon (*Oncorhynchus keta*);
- Puget Sound steelhead trout (*Oncorhynchus mykiss*);
- Coastal-Puget Sound bull trout (*Salvelinus confluentus*);
- Bocaccio (*Sebastes paucispinis*);
- Canary rockfish (*Sebastes pinniger*);
- Yelloweye rockfish (*Sebastes ruberrimus*);
- Marbled murrelet (*Brachyramphus marmoratus*);
- Northern spotted owl (*Strix occidentalis caurina*); and
- Steller sea lion (*Eumetopias jubatus*).

4.1 Chinook Salmon

4.1.1 Presence in Action Area

Identified stocks of Puget Sound Chinook salmon are found in four watersheds within Hood Canal—Skokomish, Hamma Hamma, Duckabush, and Dosewallips River basins. Chinook salmon prefer to spawn and rear in the mainstem of rivers and larger streams (Williams et al. 1975; Healey 1991). In Hood Canal, naturally reproducing Chinook exhibit primarily a summer/fall timing (WDFW and WWTIT 1994), spawning from mid-September to late October. Following incubation and subsequent emergence, the majority of Chinook fry rear in the system from 90 to 120 days before entering the estuary, with the major outmigration occurring between April and June (Williams et al. 1975).

Chinook smolts may spend a prolonged period (several days to several weeks) during their spring outmigration feeding in saltmarshes and distributary channels as they transition gradually into more marine waters (Simenstad et al. 1982). Chinook fry and subyearlings in saltmarsh and other shallow habitats predominantly prey on emergent insects and epibenthic crustaceans such as gammarid amphipods, mysids, and cumaceans. As Chinook mature and move to neritic habitat, they feed on small nekton (decapod larvae, larval and juvenile fish, and euphausiids) and neustonic drift insects (Simenstad et al. 1982; see also detailed life history review by Healey [1991]).

Spawn timing of Hood Canal stocks of Chinook salmon indicate a seasonal presence of adults within the canal between late July and mid-October. Adults are not often nearshore-oriented, and so would not be expected to commonly occur in the intertidal waters near the project area. However, juvenile Chinook have a prolonged presence in the nearshore and may occur within the project and action areas. Studies have shown the presence of juvenile Chinook on Hood Canal beaches as early as mid-February, extending into July. Very few have been detected in August or later (Duffy 2003; Weinheimer et al. 2011).

4.1.2 Stock Status

According to the Salmon and Steelhead Stock Inventory (SASSI), a salmonid stock database maintained by WDFW, the ESA status of Chinook has been designated as depressed in the Skokomish River (Table 2). Escapement goals for natural spawners have only been met in this basin three times since 1990. In the Hamma Hamma, Duckabush, and Dosewallips rivers, the ESA status has been designated as critical. The spawner escapement in each of these streams has been less than 100 fish per year in most years since 1990 (WDFW 2002).

4.1.3 Chinook Salmon Designated Critical Habitat

On September 2, 2005, NOAA Fisheries released the final rule designating critical habitat for Puget Sound Chinook salmon and other populations of federally protected salmon species in Washington, Oregon, and Idaho (70 FR 52630). All marine, estuarine, and river reaches accessible to Puget Sound Chinook salmon are designated as critical habitat, except for a number of watersheds, military lands, and tribal lands that have been excluded. Therefore, estuarine and marine areas in Hood Canal, including the action area, lie within the designated critical habitat for Puget Sound Chinook salmon (Figure 2).

4.2 Hood Canal Summer-Run Chum Salmon

4.2.1 Presence in Action Area

Two distinct runs of spawning chum salmon are found in Hood Canal. The earlier, ESA-listed summer run enters rivers in late August and September, while the later-run fall chum move upstream from October through November (Williams et al. 1975). Summer-run chum salmon have been found in seven Hood Canal drainages (Skokomish, Union, Lilliwaup Creek, Hamma Hamma, Duckabush, Dosewallips, and Big and Little Quilcene rivers).

Simenstad et al. (1982) summarized the diets of juvenile salmonids in 16 estuaries. Simenstad concluded that small (≤50- to 60-mm fork length) juvenile chum salmon feed primarily on such epibenthic crustaceans as harpacticoid copepods, gammarid amphipods, and isopods. Large juveniles (>60-mm fork length) in neritic habitats, on the other hand, feed on drift insects and on such plankton as calanoid copepods, larvaceans, and hyperiid amphipods.

Chum salmon spend more of their life history in marine waters than other Pacific salmonids. Chum salmon usually spawn in coastal streams and juveniles outmigrate to saltwater almost immediately after emerging from the gravel (Johnson et al. 1997). Adult summer-run chum salmon in Hood Canal also tend to spawn very low in streams, often within one mile of the mouth.

Estuarine residency is the most critical phase in the life history of juvenile chum. They remain close to the surface, rearing in shallow eelgrass beds, tidal creeks, sloughs, or other productive estuarine areas for several weeks between January and July (SSDC 2007). Therefore, Hood Canal summer-run chum likely occur in the project and action areas.

4.2.2 Stock Status

In Hood Canal streams, the continuous and cumulative reduction in habitat productivity and capacity has influenced summer-run chum salmon by lowering survival rates and population resiliency, and reducing potential population size. Net fisheries in Hood Canal, when combined with harvests in Puget Sound and the Strait of Juan de Fuca, began to catch a high percentage of returning summer-run chum salmon in 1980, contributing to low escapements through the 1980s. At the same time, oceanic climate changes influenced regional weather patterns, resulting in unfavorable stream flows during the winter egg incubation season. Fall spawning flows dropped substantially in 1986 (also likely climate related), contributing to the poor status of these stocks. The current low production of Hood Canal summer chum salmon appears to be the result of the combined effects of lower survivals caused by habitat degradation, climate change, and increases in harvest.

The stock status of summer-run chum salmon in the Union River is considered healthy, with mean annual runs of approximately 3,000 fish from 2001 to 2010 (WDFW 2013). However, the status of all other summer-run chum stocks in Hood Canal is considered depressed or worse. The stock status of summer-run chum salmon in the Hamma Hamma, Duckabush, Dosewallips, and Quilcene basins is considered depressed due to substantial declines occurring in all of the streams in the 1980s (Table 2). Annual run sizes of over 13,000 fish were observed in the Hamma Hamma and Duckabush Rivers, declining to less than 500 fish after 1992 (WDFW 2013). Natural production has increased in the last decade; however, it is largely due to supplementation by hatchery stocks. The stock status of summer-run chum in Lilliwaup Creek is considered critical; substantial declines occurred through the 1980s and 1990s (WDFW 2013). Hatchery supplementation since 1995 has supported natural production in this drainage.

In the Skokomish River, summer-run chum have declined steadily over the last three decades. Present numbers are not sufficient to be considered self-sustaining; the stock is considered extinct. Similarly, run sizes in Finch Creek averaged over 1,000 fish per year historically, but the last summer-run chum in this stream was observed in 1976 (WDFW 2013). Runs are considered extinct in several other streams including the Dewatto and Tahuya Rivers and Big Beef and Anderson Creeks (WDFW 2013).

4.2.3 Hood Canal Summer Chum Designated Critical Habitat

Critical habitat was designated for Hood Canal summer-run chum on September 2, 2005 (70 FR 52630). Critical habitat extends from extreme high tide to a depth of 30 m relative to MLLW; i.e., habitat typically within the photic zone that is important for rearing, migrating, and maturing salmon and their prey (primary constituent elements). Critical habitat for Hood Canal summer-run chum salmon occurs within the action area along portions of the shorelines in Hood Canal both north and south of the project site (Figure 3).

4.3 Puget Sound Steelhead

4.3.1 Presence in Action Area

Steelhead is the name commonly applied to the anadromous form of rainbow trout. The species exhibits perhaps the most complex suite of life-history traits of any of the Pacific salmon. Steelhead can be anadromous or freshwater residents, and in some circumstances yield offspring of the opposite life-history form. The anadromous form can spend up to seven years in fresh water prior to smoltification, although two years is most common, and then spend up to four years in salt water prior to first spawning. Unlike the Pacific salmon species, steelhead are iteroparous (individuals can spawn more than once).

Within Hood Canal and other Puget Sound basins, steelhead can be divided into two basic reproductive ecotypes, based on the state of sexual maturity at the time of river entry. The summer-run steelhead is a stream-maturing fish that enters fresh water in a sexually immature condition between May and October, and requires several months to mature and spawn. The winter-run steelhead is an ocean maturing fish that enters fresh water between November and April with well-developed gonads and spawns shortly after entrance. In basins with both summer and winter steelhead runs, the summer run generally occurs where habitat is not fully utilized by the winter run, or where an ephemeral hydrologic barrier separates them, such as a seasonal velocity barrier or at a waterfall. Summer-run steelhead usually spawn farther upstream than winter run. According to the WDFW Priority Habitat and Species (PHS) database, a winter run of steelhead has been documented in a small unnamed creek located approximately 1.2 miles north of the proposed conveyor project site. Winter runs of steelhead have also been documented in Thorndyke Creek and in another small unnamed creek, located 1.4 miles and 2 miles south of the proposed conveyor project site, respectively. It should be noted that Thorndyke Creek is located 500 feet or more to the west of mining activities associated with the proposed conveyor project.

Wild juveniles typically spend two full years or more in fresh water before outmigrating during the spring. Because of the larger size at outmigration, steelhead do not typically spend a large amount of time in the nearshore; instead, they tend to quickly outmigrate to open water (Hartt and Dell 1986). This is consistent with several juvenile salmonid studies conducted within the nearshore of Hood Canal where very few juvenile steelhead have been observed (Moore et al. 2010). Given the presence of both winter and summer-run fish, the occasional adult steelhead may be found in Hood Canal year round. Therefore, it is unlikely that juvenile steelhead would commonly occur in the project and action areas; however, adult steelhead may be present in the action area, albeit in small numbers.

4.3.2 Stock Status

Winter steelhead stocks within Hood Canal have been identified in the Skokomish, Hamma Hamma, Duckabush, Dosewallips, Big Quilcene and Little Quilcene River basins. The stock status of all of these stocks except for the Quilcene is considered depressed due to chronically low escapements (Table 2). In the Skokomish River, a long-term downward trend in escapement has been observed since 1980. Mean run size of wild winter fish decreased from a high of 1,444 in 1989 to 478 in 2011. A summer-run stock has also been identified based on run timing, but is believed to be small and very little is known about the stock.

The Hamma Hamma, Duckabush, and Dosewallips stocks have had chronically low escapements since the 1990s (Table 2). The run size in each of the streams is below 250 fish per year. Data are insufficient to determine the stock status in the Big and Little Quilcene Rivers. Annual observed run sizes have ranged from 6 to 76 fish from 1982 to 2006.

The stock status of winter steelhead within Thorndyke Creek and the two unnamed creeks in the vicinity of the proposed pier alignment is unknown, as these creeks are not continuously monitored for steelhead.

4.3.3 Steelhead Designated Critical Habitat

Critical habitat for Puget Sound steelhead was proposed on January 14, 2013 (78 FR 2726). All marine, estuarine, and river reaches accessible to Puget Sound steelhead are proposed as critical habitat, except for a number of watersheds, military lands, and tribal lands that have been excluded. Therefore, estuarine and marine areas in Hood Canal, including the action area, lie within proposed critical habitat for Puget Sound steelhead. In addition, Thorndyke Creek and the two small unnamed creeks in the vicinity of the proposed pier alignment contain proposed critical habitat for Puget Sound steelhead due to their documented presence (WDFW 2013).

4.4 Puget Sound Bull Trout

4.4.1 Presence in Action Area

Bull trout spawn in the fall in upper watershed tributaries containing clean gravel and cobble substrate and gentle slopes, with cold surface waters of 8° C or lower. The species requires long incubation periods (4 to 5 months) compared with other salmon and trout. Fry hatch in late winter or early spring and remain in the gravel for up to 3 weeks before emerging. A few weeks after emerging, most bull trout migrate downstream to mainstem and larger tributaries, while a portion stay in the streams where they hatched (USFWS 1998). Small bull trout eat terrestrial and aquatic insects. Large bull trout are primarily fish predators, eating whitefish, sculpins, and other trout (USFWS 1998). Bull trout are more sensitive to changes in temperature, poor water quality, and low-flow conditions in fresh water than many other salmon because of their life history requirements (USFWS 1998).

Little is known about the anadromous form of bull trout or their movements in estuarine waters of Puget Sound (KCDNR 2000) and virtually no studies of anadromous stocks have occurred in Hood Canal. However, the limited data that are available may be applicable to Hood Canal. Information from larger stocks, such as those present in the Snohomish and Skagit River Basins, indicate that bull trout have annual migrations to marine areas beginning in late winter and peaking in spring to mid-summer (e.g., Pentec 2002; Goetz et al. 2004). It is believed that larger subadult and adult bull trout migrate to marine areas occupying shallow nearshore habitats (adults are reproductively mature and subadults are immature fish that have migrated to salt water). Anecdotal information in central Puget Sound suggests that bull trout aggregations may be associated with surf smelt spawning beaches, presumably because bull trout feed on this forage species.

Most anadromous bull trout move back to fresh water by late summer, although not necessarily into the same systems from which they emigrated. Tagging data indicate that bull trout, similar to Dolly Varden in northern Alaska, do not always spawn and overwinter in the same systems (Goetz et al. 2004). Most mature adults migrate to upper watershed spawning grounds beginning in late May and continuing through mid-July. Subadults may remain in marine areas as late as September before migrating to lower-river freshwater habitats, where they reside during the winter months (Goetz et al. 2004).

Hood Canal bull trout are separated into three distinct stocks, based on geographical separation, and are all located within the Skokomish River basin (approximately 40 miles south of the project site). Of the three stocks, only the South Fork Skokomish stock is thought to contain anadromous forms that may use nearshore areas near the proposed pier alignment. Therefore, it is possible that bull trout from this system could be present in the project and action areas.

4.4.2 Stock Status

The status of the South Fork Skokomish bull trout stock is currently unknown and insufficient data have been collected to determine population trends (Table 2). However, populations are suspected to be small with redd counts from 2000 to 2010 ranging from 3 to 20 redds per year (Salmonscape GIS database).

4.4.3 Bull Trout Designated Critical Habitat

Critical habitat was designated for bull trout on September 26, 2005 (70 FR 56212). The geographic boundaries of this designation do not overlap with the action area. Therefore, there is no designated critical habitat in the action area. On October 18, 2010, the USFWS finalized the revised designation of critical habitat for bull trout (75 FR 63898). As part of this final revision additional nearshore areas of Hood Canal, south of the action area, were designated as critical habitat (75 FR 63976). However, there is no overlap between the action area and designated critical habitat for bull trout in Hood Canal (Figure 4).

4.5 Bocaccio

4.5.1 Presence in Action Area

Adult bocaccio inhabit waters from approximately 40–1,570 ft, but are most common at depths of 160–820 ft (i.e., greater than the project depth; 74 FR 18516). Although bocaccio are typically associated with hard substrate, they may wander into mud flats, and can be located as much as 98 ft off the bottom (Love et al. 2002). Bocaccio live up to about 54 years. Larval and pelagic juveniles inhabit surface waters (from approximately January to April) where they are occasionally associated with drifting kelp mats (74 FR 18516). Juveniles settle to shallow, algae covered rocky areas or to eelgrass and sand, then move to deeper rocky reefs as they grow (60–100 ft). Adult bocaccio are piscivorous, whereas juveniles consume smaller fishes and zooplankton.

Bocaccio range from Punta Blanca, Baja California, to the Gulf of Alaska, Alaska (Love et al. 2002). They are believed to have commonly occurred along steep walls in most of Puget Sound prior to fishery exploitations, although they are currently very rare in these Puget Sound habitats (Love et al. 2002). Little is known about the habitat requirements of most rockfishes despite the years of research already performed (Drake et al. 2010; Palsson et al. 2009). Much of the information presented below on bocaccio life history and habitat use is derived from other areas where bocaccio occur. DeLacy et al. (1972) and Miller and Borton (1980) compiled all available data on distribution and relative number of occurrences on Puget Sound fish species through the mid-1970s using literature, fish collections, unpublished log records, and other sources. Though bocaccio was recorded 110 times in these documents, most records were associated with sport catch from the 1970s in Tacoma Narrows and Appletree Cove (near Kingston). Only two records occurred for Hood Canal, both in the 1960s (DeLacy et al. 1972). Currently both sport and commercial fishing for rockfish in Hood Canal is prohibited, and no recent scientific surveys of these waters have occurred to document the recent prevalence of rockfish in these waters. Although there have been no confirmed observations of bocaccio in Puget Sound for approximately 7 years (74 FR 18516), Drake et al. (2010) concluded that it is likely that bocaccio occur in low abundances. As a result, bocaccio have a low potential to occur within the project and action areas (Figure 1).

4.5.2 Population Status

Very little is known of the population status of bocaccio in Hood Canal or Puget Sound (Drake et al. 2010; Palsson et al. 2009). The species has always been rare in northern Puget Sound. An approximate estimate of bocaccio abundance in

Puget Sound Proper (Whidbey Island and south, including the in-water action area) was only 100 individuals during the 1980s (NMFS 2009).

4.5.3 Critical Habitat in Action Area

Critical habitat has not been designated for bocaccio.

4.6 Canary Rockfish

4.6.1 Presence in Action Area

Canary rockfish range from Punta Blanca, Baja California, to the Shelikof Strait of Alaska, and are abundant from British Columbia to central California (74 FR 18516). Adult canary rockfish typically inhabit waters from 160–820 ft, but some may occur as deep as 1,400 ft (i.e., greater than the Project depth; 74 FR 18516). Larger fish tend to occur in deeper water. Although canary rockfish are sedentary, some have been reported to migrate 435 miles over several years (Love et al. 2002). Canary rockfish live up to approximately 84 years. Larvae inhabit the upper 330 ft of the water column. Juveniles generally inhabit intertidal areas (tide pools, rocky reefs, kelp beds, cobble areas), surface waters, but some have been found in much deeper waters. Juveniles may occupy rock-sand interfaces near 50–65 ft during the day, then move to sandy areas at night. Juveniles consume zooplankton, whereas larger canary rockfish consume both zooplankton and fishes (74 FR 18516).

Canary rockfish were once considered fairly common in the greater Puget Sound area (Holmberg et al. 1967; Kincaid 1919); however, little is known about their habitat requirements in these waters (Drake et al. 2010; Palsson et al. 2009). DeLacy et al. (1972) and Miller and Borton (1980) documented 114 records of canary rockfish prior to the mid-1970s, with most records attributed to sport catch from the 1960s to 1970s in Tacoma Narrows, Hood Canal, San Juan Islands, Bellingham, and Appletree Cove. Within Hood Canal 14 records occurred: 1 in the 1930s and 13 in the 1960s (Miller and Borton 1980). As mentioned for bocaccio, there is a moratorium on both sport and commercial fishing for rockfish in Hood Canal. With the absence of associated catch records, and no recent scientific surveys of these waters, the prevalence of rockfish in these waters remains unknown. Drake et al. (2010) concluded that canary rockfish occur in low and decreasing abundances in Puget Sound. Therefore, canary rockfish have a low potential to occur within the project and action areas (Figure 1).

4.6.2 Population Status

Very little is known of the population status of canary rockfish in Hood Canal or Puget Sound (Drake et al. 2010; Palsson et al. 2009). An approximate estimate of canary rockfish abundance in Puget Sound Proper was only 300 individuals during the 1980s (NMFS 2009).

4.6.3 Critical Habitat in Action Area

Critical habitat has not been designated for canary rockfish.

4.7 Yelloweye Rockfish

4.7.1 Presence in Action Area

Yelloweye rockfish are found from Ensenada, Baja California, to the Aleutian Islands in Alaska. Little is known about their habitat requirements or use in Puget Sound waters (Drake et al. 2010; Palsson et al. 2009) and much of the information presented below on yelloweye rockfish life history and habitat use is derived from research from other areas where the species is more abundant.

Yelloweye rockfish is a deep-water species that is relatively sedentary and found in association with high relief rocky habitats and often near steep slopes (Palsson et al. 2009). Larvae and juveniles remain pelagic for up to 2 months, settling to shallow, high relief zones, crevices, and sponge gardens (Love et al. 2002). Yelloweye larvae and juveniles are opportunistic feeders, preying upon fish larvae, copepods, amphipods, krill eggs, and larvae. Yelloweye rockfish move into deeper water as they grow into adults, continuing to associate with caves and crevices and spending large amounts of time lying on the substratum, sometimes at the base of rocky pinnacles and boulder fields (Love et al. 2002).

Adult yelloweye rockfish inhabit waters from 80–1,560 ft, but they are most common at depths of 300–590 ft (i.e., greater than the project depth). They are typically solitary but sometimes form aggregations near rocky substrate. Approximately 50 percent of the fish reach maturity at age 6 (approximately 16 inches). Their home range is relatively small, but adult rockfish have the potential to move long distances. Yelloweye rockfish live up to approximately 118 years. They are opportunistic feeders and adult diets consist of rockfishes, forage fish, flatfishes, shrimps, crabs, and lingcod eggs (Love et al. 2002).

Yelloweye rockfish are abundant from southeast Alaska to central California but are currently extremely rare in Puget Sound, Washington. DeLacy et al. (1972) and Miller and Borton (1980) discovered 113 documented yelloweye rockfish records from Puget Sound associated with sport catch. Of these records, 14 occurred in Hood Canal waters; 1 in the 1930s and 13 in the 1960s (Miller and Borton 1980). Palsson et al. (2009) investigated historic fish catch records and reported only 14 known instances of yelloweye captures in Hood Canal. Hood Canal had the greatest frequency of yelloweye rockfish observed in both trawl and scuba surveys conducted by WDFW (Palsson et al. 2009). Therefore, yelloweye rockfish have the potential to occur in the project and action areas.

4.7.2 Population Status

Very little is known of the population status of yelloweye rockfish in Hood Canal or Puget Sound (Drake et al. 2010; Palsson et al. 2009). Kincaid (1919) reported yelloweye rockfish used to be relatively common in the deep waters of Puget Sound. However, an approximate estimate of yelloweye rockfish abundance in Puget Sound was only 1,200 individuals during the 1980s (NMFS 2009). Due to the moratorium on both sport and commercial fishing for rockfish in Hood Canal, the absence of associated recent catch records, and the lack of recent scientific surveys of these waters, the current status of yelloweye rockfish in these waters remains unknown.

4.7.3 Critical Habitat in Action Area

Critical habitat has not been designated for yelloweye rockfish.

4.8 Marbled Murrelet

4.8.1 Presence in Action Area

The marbled murrelet, a small seabird that nests in the coastal, old-growth forests of the Pacific Northwest, inhabits the Pacific Coast of North America from the Bering Sea to central California. In contrast to many other seabirds, murrelets do not form dense colonies, and may fly 70 km or more inland to nest, generally in older coniferous forests. They are more commonly found inland during the summer breeding season, but make daily trips to the ocean to gather food, primarily fish and invertebrates, and have been detected in forests throughout the year. When not nesting, the birds live at sea, spending their days feeding and then moving several kilometers offshore at night (SEI 1999).

The breeding season of the marbled murrelet generally begins in April, with most egg laying occurring in late May and early June. Peak hatching occurs in July after a 27- to 30-day incubation. Chicks remain in the nest and are fed by both parents. By the end of August, chicks have fledged and dispersed from nesting areas (Marks and Bishop 1999). The marbled murrelet's primary nesting habitat is old-growth coniferous forest within 50 to 75 miles of the coast. The nest typically consists of a depression on a moss-covered branch where a single egg is laid. Marbled murrelets appear to exhibit high fidelity to their nesting areas, and have been observed in forest stands for up to 20 years (Marks and Bishop 1999).

Marbled murrelets are presumably long-lived species but are characterized by low fecundity (one egg per nest) and low nesting and fledging success. Fledging success has been estimated at 45 percent. Nest predation on both eggs and chicks appears to be higher for marbled murrelets than for other alcids, and may be cause for concern. Principal predators are birds, primarily corvids (jays, ravens, and crows; Marks and Bishop 1999).

At sea, foraging murrelets are usually found as widely spaced pairs. In some instances, murrelets form or join flocks that are often associated with river plumes and currents. These flocks may contain sizable portions of local populations (Ralph et al. 1995).

Low numbers of marbled murrelets have been observed in Hood Canal and in areas near the proposed pier alignment. Sharpe (2005) conducted marbled murrelet surveys between late February and mid-November at 6 stations between Thorndyke and Suquamish Bays, in the general vicinity of the proposed facility. A total of 34 marbled murrelets were observed during this period, 2 of these at a station adjacent to the proposed facility. Birds were observed from May 10 to September 22, during the breeding season. In addition, Hart Crowser, during bird and marine mammal monitoring within Hood Canal, observed up to 22 marbled murrelets in late October 2011, at the southern tip of the Toandos Peninsula (Hart Crowser and HDR 2012). Although relatively low numbers have been observed in Hood Canal, it is likely that marbled murrelets occur at least occasionally within the project and action areas.

4.8.2 Population Status

The total North American population of marbled murrelets is estimated to be 360,000 individuals. Approximately 85 percent of this population breeds along the coast of Alaska. Estimates for Washington from 2000 to 2011 ranged between 16,798 and 22,581 murrelets (Falxa, G., USFWS, personal communication, July 13, 2012). Monitoring results in 2011 showed the highest number of birds in the past 11 years. In British Columbia, the population was estimated at 45,000 birds in 1990 (Environment Canada 1999). In recent decades the murrelet population in Alaska and British Columbia has apparently suffered a marked decline, by as much as 50 percent. Between 1973 and 1989, the Prince William Sound, Alaska, murrelet population declined 67 percent.

Trends in Washington, Oregon, and California are also down, but the extent of the decrease is unknown. Current data suggest an annual decline of at least 3 to 6 percent throughout the species' range (Ralph et al. 1995). Population declines of approximately 7 percent are estimated for the populations in Washington (Teachout, E., USFWS, personal communication, September 1, 2011).

The most serious limiting factor for marbled murrelets is the loss of breeding habitat through the removal of old-growth forests and fragmentation of forests. Forest fragmentation may be making nests near forest edges vulnerable to predation by other birds such as jays, crows, ravens, and great-horned owls (USFWS 1996). Entanglement in fishing nets is also a limiting factor in coastal areas because the areas of salmon fishing and the breeding areas of marbled murrelets overlap. The marbled murrelet is especially vulnerable to oil pollution in both Alaska and British Columbia. In 1989, an estimated 8,400 marbled murrelets were killed as a result of the *Exxon Valdez* oil spill (Marks and Bishop 1999).

4.8.3 Marbled Murrelet Designated Critical Habitat

Critical habitat for marbled murrelet was designated in October 2011 for populations in Washington, Oregon, and California (76 FR 61599). Most critical habitat in Washington is associated with old-growth forest in foothills of the Cascade and Olympic Mountains. The nearest critical habitat to the proposed pier alignment is located in the foothills of the Quilcene Range west of Quilcene Bay, approximately 9 miles from the proposed facility. Critical habitat has not been designated in marine waters.

4.9 Northern Spotted Owl

4.9.1 Presence in Action Area

The northern spotted owl is believed to have historically inhabited most forests throughout southwestern British Columbia, western Washington and Oregon, and northwestern California as far south as the San Francisco Bay. Loss and adverse modification of nesting, roosting and foraging habitat due to timber harvesting, land conversions, natural disturbances such as fire and windstorms, and increased competition with barred owls; however, have led to a decline of northern spotted owls throughout much of their historic range. Today spotted owls are particularly rare in British Columbia, the Cascade mountains of northern Washington, the coast ranges of southwest Washington and northwest Oregon, and the Olympic Mountains. Estimates suggest that the amount of suitable habitat available to spotted owls has been reduced by over 60 percent in the last

190 years. Owl numbers appear to have declined annually since 1985 when many studies began.

Northern spotted owls in Washington generally live in forests characterized by dense canopy closure of mature and old-growth trees, abundant logs, standing snags, and live trees with broken tops. Although they are known to nest, roost, and feed in a wide variety of habitat types, owls in Washington prefer older forest stands with variety: multi-layered canopies of several tree species of varying size and age, both standing and fallen dead trees, and open space among the lower branches to allow flight under the canopy. Typically, forests do not attain these characteristics until they are at least 150 to 200 years old.

No such old growth habitats are present within the footprint of the proposed conveyer. According to the PHS database, spotted owl occurrences have been documented approximately 6.5 miles to the west of the proposed conveyor footprint, on the west shore of Quilcene Bay. The nearest nesting and roosting habitats to the proposed conveyor footprint are approximately 11 miles to the west, within the foothills of the Quilcene Range of the Olympic Mountains (Forsman and Giese 1997). WDFW has also established a spotted owl buffer zone that begins approximately 0.7 miles west of the proposed conveyor route; however, the proposed route will not intrude on this buffer. Therefore, it is unlikely for northern spotted owls to occur within the upland action area.

4.9.2 Population Status

A large and virtually isolated population of northern spotted owls persists on the Olympic Peninsula. Forsman and Giese (1997) identified 155 nests on the Peninsula, most in old growth forest along the eastern foothills of the Olympic Mountains. Additional clusters of nests were observed within the upper Quinault, Soleduck, and Bogachiel River basins.

4.9.3 Northern Spotted Owl Designated Critical Habitat

Critical habitat for northern spotted owl was designated on October 13, 2008, for populations in Washington, Oregon, and California (73 FR 47326). Most critical habitat in Washington is associated with old-growth forest in foothills of the Cascade and Olympic Mountains. The nearest critical habitat to the proposed facility is located in the foothills of the Quilcene Range west of Quilcene Bay, approximately 9 miles from the proposed pier alignment. Critical habitat has not been designated in marine waters.

4.10 Steller Sea Lion

4.10.1 Presence in Action Area

Steller sea lion habitat includes both marine and terrestrial areas that are used for a variety of purposes. Terrestrial areas (e.g., beaches) are used as rookeries for pupping and breeding. Rookeries usually occur on beaches with substrates that include sand, gravel, cobble, boulder, and bedrock (NMFS 1992). Sites used as rookeries may be used as haul-out areas during other times of the year. When Steller sea lions are not using rookery or haul-out areas, they occur in nearshore waters and out over the continental shelf. Some individuals may enter rivers in pursuit of prey (Jameson and Kenyon 1977).

Steller sea lions are opportunistic feeders and consume a variety of fish such as flatfish, cod, and rockfish, and invertebrates such as squid and octopus. Demersal and off-bottom schooling fishes dominate the diet of Steller sea lions (Jones 1981). Along the coasts of Oregon and California, Steller sea lions have eaten rockfish, hake, flatfish, cusk-eel, squid, and octopus (Fiscus and Baines 1966, Jones 1981, Treacy 1985). Rockfish and hake are considered to be consistently important prey items (NMFS 1992). Feeding on lamprey in estuaries and river mouths has also been documented at sites in Oregon and California (Jones 1981, Treacy 1985). Spalding (1964) and Otesiuk et al. (1990) have documented Steller sea lions feeding on salmon, but they are not considered to be a major prey item (Osborne 1988).

The breeding range of the Eastern distinct population segment (DPS) of Steller sea lions extends from southern California to the Bering Sea (Osborne 1988). Steller sea lions are born primarily at 13 major rookeries in southeastern Alaska, northern British Columbia, and southern Oregon (Pitcher et al. 2007). There are currently no known breeding colonies in Washington State (NMFS 1992), although three major haul-out areas exist on the Washington outer coast and one major haul-out area is located at the Columbia River south jetty (NMFS 1992, Jeffries et al. 2000; DFO 2003). Jagged Island and Spit Rock are used as summer haul-outs, and Umatilla Reef is used during the winter (National Marine Mammal Laboratory, unpublished data). Both sexes are found in Washington waters; these animals are most likely immature or non-breeding adults from rookeries located on the Oregon Coast and the British Columbia coast (NMFS 2008; Jeffries et al. 2000).

No haul-out areas have been documented in Hood Canal (WDNR 2000). However, during marine mammal monitoring in 2011, 6 to 7 Steller sea lions were observed in the water or hauled out on structures on the eastern shore of Hood Canal (HDR 2012). Animals were observed in October 2011, which is consistent with other sightings that found the species in the canal during the fall months. Although Steller sea lions are not common in Hood Canal, there presence has been documented in recent years. Therefore, it is possible that Steller sea lions may be present in the project and action areas.

4.10.2 Population Status

Steller sea lions are divided into the eastern and western DPS. The eastern DPS occupies the region from southeast Alaska to central California, including areas of Puget Sound. The western DPS occupy areas from the Gulf of Alaska, Aleutian Islands, as well as northern Asia. The eastern populations of Steller sea lions have continuously increased at an annual rate of 3 percent since the 1970s, with the current population ranging from 45,000 to 51,000 (NMFS 2008). During the period from 1978 to 2001, the highest breeding season Steller sea lion count at Washington haul-out sites was 847 individuals (Pitcher et al. 2007). Non-breeding season surveys of Washington haul-out sites reported as many as 1,458 individuals between 1980 and 2001 (NMFS 2008).

4.10.3 Steller Sea Lion Designated Critical Habitat

On August 27, 1993, the NMFS published a final rule designating critical habitat for the Steller sea lion (58 FR 45269). Steller sea lion critical habitat includes haul-out sites and rookeries within Alaska, California, and Oregon, and special aquatic foraging areas in Alaska (58 FR 45269). There is no Steller sea lion critical habitat in Washington State.

5.0 INVENTORIES AND SURVEYS

Information on existing habitat conditions in the action areas was largely obtained through field surveys conducted in conjunction with project planning and design as summarized below (Sections 6.1–6.11). Field surveys included three intertidal beach surveys, an underwater video survey, a diver survey, and reconnaissance of two previously delineated wetlands. Field surveys were conducted between August 17, 2001, and July 12, 2002, for the Marine Resources Survey Report (Appendix C). Field surveys were conducted again on August 28, 2007 and September 28, 2007, for the Macrovegetation Survey Report (Appendix E).

6.0 BASELINE CONDITIONS

The upland portions of the Central Conveyor will pass through a commercial timber forest owned by Pope Resources except for the last approximately 350 feet adjacent to the shoreline. This waterfront property (a 14.7-acre parcel) is owned by the Hood Canal Sand and Gravel Company, LLC. Portions of the upland area were recently logged and replanted; other sections will be logged sometime in the future. The Hood Canal Sand and Gravel Company property will not be commercially logged. In addition to timber stands and clearcuts, the upland action area includes wetlands and wetland buffers. These are identified in the project drawings (Appendix B).

The existing marine intertidal habitat and associated species are described in detail in the Marine Resources Survey Report (Appendix C).

6.1 Noise

6.1.1 Airborne Noise

Existing background sound levels in the upland action area are expected to be similar to other undeveloped forested areas along Hood Canal. The majority of the project site is located far from residential uses or other noise producers. Pre-project ambient sound levels in the upland action area were collected during the winter of 2004, with mean ranges from 43.1 to 45.4 dB (MFG 2004). Environalysis (2011) collected ambient sound levels in 2010 at three residential properties closest to the proposed project. Results showed mean ambient sound levels to be 39 dB to 45 dB. These two ranges falls within the few baseline data points collected from undisturbed forested areas in the Puget Sound area which ranged from 35 to 72 dB. Measured data in the upland action area are slightly higher, but similar to sound levels used by the Olympic National Forest programmatic biological assessment of 40 dB for undisturbed forested areas (USDI 2003).

Thorndyke Road is located several hundred feet inland from the shoreline in the immediate project area of the pier and Single Conveyor. This road is a major access road to residences and other properties. Sound levels in the vicinity of the road are greater than in undisturbed forest (45.4 dB; MFG 2004).

6.1.2 Underwater Noise

Both natural noise sources and mechanical or human generated noise contribute to the baseline ambient underwater noise conditions in the action area. Ambient sound levels in Puget Sound are typically around 130 dB (Laughlin 2005). Carlson et al. (2005) measured the underwater baseline for Hood Canal in the range of 115 to 135 dB. Illingworth and Rodkin (2012) measured underwater acoustics as part of the Test Pile Program located at Naval Base Kitsap at Bangor, Washington (located 4 miles south of the project site). Results showed typical ambient underwater sound levels to be 112 dB (mid-water column) and 114 dB (deep water column).

6.2 Water Quality

Very few direct measurements of water quality have been collected within the vicinity of the proposed project. Because this area has remained relatively undeveloped (e.g., no shoreline development or nearby industrial activity) and has no obvious sources of contaminants, marine water quality is expected to be good to excellent with respect to metals, oil and grease, and other pollutants. As a result of tidal fluctuations and strong nearshore currents, it is unlikely that water temperatures in the nearshore areas increase substantially in the summertime, with the exception of isolated tidepools.

However, the marine waters of Hood Canal have a long history of low dissolved oxygen (DO) concentrations during the late summer. Dissolved oxygen concentrations in Hood Canal exhibit seasonal variations. Typically, concentrations are highest in spring, drop to minimum levels by late summer, and then begin to rise throughout the fall and winter. Measurements taken over the past decade indicate that the spring highs are at lower concentrations, seasonal recovery is less, and the geographic extent of this condition is expanding from the head of the canal northward (Newton et al. 2002). Monitoring data have documented these worsening conditions over the last decade as measured by increasing persistence and spatial extent of low DO waters, the movement of mobile marine animals from their normal habitats, and periodic die-offs of fish and other marine animals. Some monitoring stations have experienced dissolved oxygen levels that rarely exceeds the 5 milligrams per liter (mg/L) "biological stress" level. Fish kills occurred in the spring and fall of 2002 and 2003 causing WDFW to close the canal to most recreational fishing. Dead or stressed fish have been reported periodically by divers in most years since then.

Dissolved oxygen levels in the canal are affected by both natural and anthropogenic influences. An underlying hypothesis is that nitrogen inputs stimulate overly abundant phytoplankton growth followed by their die-off and decomposition that consumes available oxygen. The long, narrow geography of the canal and low flushing rates exacerbates the problem. South winds during the summer and early fall push away surface waters containing high levels of DO, forcing low oxygen waters to rise from the bottom. Urbanization and its associated human activities, agricultural uses, forest practices, septic inputs from residential homes, nutrient inputs from anadromous salmon, and disposal of harvested carcasses in marine waters contribute to increased nutrient inputs to the canal. Recent loading calculations have found that nutrient inputs, principally nitrogen from sewage effluent, are the most significant anthropogenic sources of nitrogen to the canal.

Hart Crowser collected dissolved oxygen data within the vicinity of the proposed project in the summer of 2008. Continuous data were collected every 10 minutes from July 31 to August 18, 2008, and again from August 29 to August 31, 2008 (unpublished data). On all days, daily averages were above the 5 mg/L "biological stress" level. There were isolated incidences of low dissolved oxygen concentrations; however, this occurred only 0.4 percent of the time. Similarly, data collected by University of Washington scientists at 2 stations in the vicinity of the proposed project show only occasional instances of dissolved oxygen concentrations below 5 mg/L. The causes of low dissolved oxygen in Hood Canal are still not fully understood, but water quality in the vicinity of the proposed project appears to be much less affected by low DO conditions that in more southerly portions of the canal.

6.3 Sediment Quality

No quantitative sediment quality data are available for marine sediments in the vicinity of the proposed project. Because no industrial activity has historically occurred in the vicinity of the conveyor and pier, marine sediments in this area are likely to contain only very low concentrations of the contaminants that are associated with the industrial areas of Puget Sound (e.g., metals and organics). No sediment dredging is required for this project.

6.4 Access/Refugia

Juvenile salmonids, particularly juvenile Chinook and chum, outmigrate along the shoreline, using these nearshore areas for feeding and refuge from predation. Within intertidal habitats, juveniles require low-tide refuge and/or access to wetted habitat as the tide drops to avoid stranding or increased risk of predation. The low-gradient beach in the vicinity of the proposed pier alignment would be expected to provide excellent feeding and rearing opportunities for juvenile salmonids and may provide refuge from some predators. At lower tidal elevations, juvenile salmonids would be expected to make use of the eelgrass beds that lie between approximately +6 feet MLLW and 0 feet MLLW (*Z. japonica*) and between approximately –1 foot MLLW and –10 feet MLLW (primarily *Z. marina*; see Macrovegetation Survey report, Appendix E). Eelgrass (*Z. marina*) has been shown to be an important habitat type used by juvenile salmonids in their early marine life phase as they migrate through Puget Sound toward more marine rearing areas (Simenstad et al. 1982). In addition to providing feeding opportunities, the eelgrass beds provide refuge for small fish, including salmon, which can escape larger fish and avian predators by hiding among the blades.

6.5 Substrate

The upper beach is mostly sandy, with lenses of gravel visible at the beach face (Appendix C, Photo 2). A broad sand flat begins at about +6 feet MLLW and the sandy substrate continues outward into deep water well beyond the end of the proposed pier. Because of the limited area of disturbance, the proposed bluff modifications along the conveyor route should not affect site sediment supply source (Anchor 2003).

6.6 Slope

Below MHHW, the beach face is moderately steep and continues down to a sand flat that begins at about +6 feet MLLW. The sand flat extends out to subtidal depths (approximately –10 feet MLLW), where the slope increases considerably (Appendix B, Sheet C2.3).

Flatter slopes are considered to provide higher-quality habitat for juvenile salmonids than steeper slopes because of the typical interdependence of slope and substrate (e.g., steeper slopes usually have coarser materials and flatter slopes typically have more fines). Shallower slopes and finer materials tend to drain less quickly on falling tides and thus do not dry out as rapidly and can support more benthic life. Flatter slopes also provide small fish with shallow-water escape corridors from larger fish predators. However, flatter slopes also allow more efficient feeding by other predators (e.g., great blue heron).

6.7 Shoreline

The beach and backshore along the Central Conveyor is bordered on the northwest by a steep bluff that rises to about 100 feet above mean sea level (Appendix B, Sheet C2.2; Appendix C). A slope failure in the 1990s deposited a substantial quantity of sand and silt on the backshore, significantly altering a wetland formed by seepwater from sediment layers within the bluff. Along the high-tide drift line are scattered plants of saltbrush (*Atriplex patula*), jaumea (*Jaumea carnosa*), seaside plantain (*Plantago maritime*), meadow barley (*Hordeum brachyantherum*), Pacific silverweed (*Potentilla anserena*), and silver burweed (*Ambrosia chamissonis*; Appendix C). The beach face is composed of coarse sand overlain by small cobbles and pebbles, with woody debris (Anchor 2003). There is approximately 150 feet between the toe of the bluff and MHHW.

Most of the Toandos Peninsula shoreline is unarmored, including areas in the vicinity of the proposed pier alignment. Only 8.4 percent of the entire length of the peninsula has been modified by bulkheads. Predominantly natural vegetation on high and low bluffs account for 78 percent of the length of the peninsula. Diverse nearshore habitats in the area include a broad delta formation at the head of Thorndyke Bay, and a long sandy spit partially enclosing a large tidal lagoon. High, unstable bluffs to the east and north of Thorndyke Bay contribute large volumes of sediment as soils and vegetation slip off the top of clay banks, including areas within the vicinity of the proposed pier alignment. Some of this sediment is directed updrift to build and maintain the Thorndyke spit and other prominent shoreforms (Hirschi et al. 2003).

6.8 Flow/Current Patterns

Current patterns in the vicinity of the conveyor and pier result from tidal flows in Hood Canal. Given the relatively exposed shoreline and the geomorphology of northern Hood Canal, it is anticipated that localized currents near the proposed pier alignment are moderate in strength. Both on the upper beach and on the sand flat, low patches of unstable sand give evidence of a net drift from southwest to the northeast. A long drift cell originates just north of Hazel Point and extends for just over 12 miles along the Toandos Peninsula until terminating artificially at the jetty on the north of the Bridghaven Marina near Southpoint, located approximately 2 miles northeast of the proposed pier alignment (Hirschi et al. 2003; WDNR 2000; and Johannessen 1992).

Drift sediment within the drift cell 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 (Anchor 2003). Net sediment movement is northward and there are many sources of sediment outside the project location, even though the backshore serves also as a source of sediments (Anchor 2003).

6.9 Macrovegetation

Where the lower edge of the beach face transitions to the sand flat (approximately 0 feet MLLW), water emerges at low tide to create shallow pools of standing water and eventually forms a channel that meanders across the flat (Appendix C, Photo 4). At the time beach surveys were conducted in August /September of 2001, July 2002, and August 2007, patches of the annual green algae *Ulva* spp. (*U. intestinalis* and *U. linza*) were observed in these fresh or brackish seeps.

From about +6 feet MLLW to 0 feet MLLW the sand flat supports scattered and discrete patches of Japanese eelgrass (*Z. japonica*). Japanese eelgrass is an introduced species that is known to occur throughout northern Puget Sound, although its distribution has not been well documented (Thom and Hallum 1990). Because it is an annual, it is expected to be highly variable in space and time. This is especially true on beaches such as this one, where the advancing sand waves bury individual patches while new patches form in the wake of each sand wave. The summer 2001 beach surveys documented very high shoot density (approximately 1,100 turions per square meter [m^2]) and fertile fronds were present where patches occurred in shallow standing water ponds. In a brief, late-winter 2002 site visit, Japanese eelgrass was again noted in locations along the upper shore. During the beach survey conducted in July 2002 Japanese eelgrass appeared to be more scattered and less dense compared to the previous summer. It was also apparent that the upper beach and backshore in the vicinity of the pier had changed significantly from summer 2001 as a result of high tides and intense wave action over the winter. A sand/cobble berm that in 2001 existed near the top of the slope had shifted waterward by up to several meters (see photos, Appendix C). In contrast, the summer 2007 beach survey documented even higher shoot densities than in 2001 (approximate mean density of 1,400 shoots per square meter; Macrovegetation Survey Report, Appendix E). Compared to the 2001 survey data, the Japanese eelgrass population seemed to be increasing in density (27 percent increase) and possibly increasing in extent, as patch coverage was higher (nearly 40 percent) than the qualitative 25 percent reported in the 2001 survey.

Continuing waterward, the beach surface is somewhat firmer on the outer portion of the sand flat. Beginning at about –1 foot MLLW and extending down into the subtidal zone (approximately –10 feet MLLW), surveys have noted a band of patches of native eelgrass (*Z. marina*). Eelgrass was generally dense in the patches within this band, and the patches became larger and more continuous to the northeast of the pier. The diver survey in August 2001 indicated that most patches were smaller than 20 feet in diameter, with densities ranging from 20 to 428 shoots per m^2 (mean: 189 shoots per m^2) in quadrats containing eelgrass (i.e., within the patches shown on Sheet C2.3 [Appendix B]). In contrast, subtidal survey results in 2007 showed *Z. marina* to be declining relative to 2001 data, as the number of patches and in-patch root density had decreased between 50 and 90 percent, relative to 2001 data (Appendix E, Macrovegetation Survey Report).

Previous surveys within the 75-foot strip most prone to shading from the proposed pier (i.e., from 25 feet south to 50 feet northeast of the pier) documented that *Z. marina* was very sparse (Appendix C). Of the 32 observation points within this zone, only three contained any eelgrass. Overall density was 1.75 shoots per m^2, about 1 percent of the density in eelgrass patches southwest and northeast of the pier.

6.10 Fish and Invertebrates

6.10.1 Forage Fish Spawning Areas

Larval, juvenile, and adult Pacific herring (*Clupea pallasi*), surf smelt (*Hypomesus pretiosus*), and Pacific sand lance (*Ammodytes hexapterus*) are important forage fish for juvenile, subadult, and adult salmonids (Healey 1991). Alteration of spawning habitat for these species may directly affect the abundance of forage for a range of age groups of both juvenile and adult salmonids. The substrate along and below the high-tide line in the vicinity of the proposed pier appeared suitable for spawning by surf smelt and/or Pacific sand lance (Appendix C). According to the Salmonscape GIS database managed by WDFW, Pacific sand lance spawning areas have been documented within upper intertidal areas approximately 3,600 feet to the southwest and 1 mile to the northeast of the proposed pier site (WDFW 2013; Figure 5). Pacific sand lance spawn in clean intertidal beach substrates consisting of coarse sand to pea gravel at elevations between +6 feet and MHHW. Based on review of the Salmonscape database, no spawning areas have been documented at the proposed pier location or within at least 1 mile to the northeast and 1 mile to the southwest of the proposed pier site. The Salmonscape GIS database shows that Pacific herring (*Clupea pallasii*) spawning areas have been documented 4.5 miles to the north of the proposed pier location on the north shoreline of Squamish Harbor. Pacific herring spawning habitat was also documented 11.5 miles south of the proposed pier site along the Seabeck Bay shoreline. These Pacific herring spawning areas also were confirmed by Stick and Lindquist (2009). No herring spawning areas have been identified or documented at or near the proposed pier location.

6.10.2 Non-ESA-Listed Salmonids

According to the PHS database, the two small unnamed creeks and Thorndyke Creek (as mentioned in Section 4.3.1) contain small runs of sea-run cutthroat trout, fall chum salmon, and coho salmon, which use the creeks for spawning and rearing. Sea-run cutthroat typically conduct yearly outmigrations into the nearshore, feeding on small invertebrates and fish from mid-spring through early fall before migrating back to natal streams. Cutthroat trout may be found in the vicinity of the proposed pier location during their marine residence period. These creeks are far enough removed from the conveyor such that their riparian buffer zones will not be impacted by conveyor construction activities or operations. Furthermore, a minimum 200-foot buffer has been established from

Thorndyke Creek so that no mining operations associated with the proposed conveyor project will occur in that area (Appendix K).

Juvenile fall chum salmon outmigrate during the spring and can be found in the nearshore from April through June before migrating offshore. This species may also be present in the vicinity of the proposed pier, although excellent rearing habitat has been documented within a broad mud and sand flat estuary of Thorndyke Bay, which may limit the value of and time spent in habitats in the immediate vicinity of the proposed pier alignment. A long, sandy spit partially encloses a large tidal lagoon at this location (Hirschi et al. 2003). Adult chum may also occur near the project area, but likely stage closer to the stream mouths before their spawning runs in October through early December.

Coho salmon typically spend two years in freshwater before outmigrating at a larger size than other Pacific salmon species. This species is less dependent on nearshore environments during their juvenile marine residence period, but may be found in the vicinity of the proposed pier in May before migrating offshore.

6.10.3 EFH Species

The 1996 amendments to the Magnuson-Stevens Fishery Conservation and Management Act set forth the EFH provision to identify and protect important habitats of federally managed marine and anadromous fish species. Federal agencies, such as the USACE, which fund, permit, or undertake activities that may adversely affect EFH, are required to consult with NOAA Fisheries regarding the potential effects of their actions on EFH, and respond in writing to NOAA Fisheries' recommendations.

EFH is defined as those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity. "Waters" include aquatic areas and their associated physical, chemical, and biological properties that are used by fish, and may include aquatic areas historically used by fish where appropriate. "Substrate" includes sediment, hard bottom, structures underlying the waters, and associated biological communities (NMFS 1999).

Groundfish, coastal pelagic, and salmonid fish species that have designated EFH in Puget Sound are listed in Table 3. Some of these species may occur in the action area. The species most likely to be found in the action area include salmonids, cottids (sculpins), flat fish, and forage fish. Refer to the relevant EFH designations (Casillas et al. 1998, PFMC 1998a, 1998b, and 1999) for life history stages of these species that may occur in the action area. Assessment of the impacts to EFH for these species from the proposed project is based on this information.

6.10.4 Marine Invertebrates

According to the PHS database, numerous marine invertebrate species are found in the general vicinity of the proposed pier. Several species of hardshell clams have been documented in coarse sandy sediments in lower intertidal and shallow subtidal areas of the proposed pier. According to the WDFW Priority Habitat and Species maps, the proposed pier would cross approximately 150 feet of a low density, inactive, commercial geoduck tract. In addition, Dungeness crab are known to use subtidal areas of this portion of Hood Canal. The Hood Canal Sand and Gravel Company, LLC, recently leased portions of the intertidal and subtidal areas around the project site to a commercial geoduck/shellfish culture operation. Continual supplemental culture will help ensure productivity of geoduck and other shellfish in the vicinity of the proposed pier alignment.

No quantitative studies examining benthic and epibenthic biota have been conducted within the project and action areas, though the coarse sand and gravel of the upper beach likely supports a sparse epibenthic community of species common in Puget Sound, some of which are of importance to the diet of juvenile Chinook and chum salmon. The flatter, broad, middle-intertidal beach is composed mostly of coarse to medium sand and likely supports a more productive epibiota, as well as infauna such as polychaetes, bivalves, and crustaceans. Production of calanoids and other potential pelagic prey of salmonids are largely dependent on water-column processes in Puget Sound. Pelagic zooplankton productivity is dependent on the presence of adequate light and nutrients to stimulate phytoplankton, and is not influenced greatly by conditions along shorelines or in deeper waters in the vicinity of the proposed pier.

6.11 Wildlife

The PHS database has documented bald eagle nests approximately 1,400 feet northeast of the proposed pier along the shoreline. Inland, an osprey nest has been documented approximately 1.5 miles from the proposed conveyor route. WDFW has also established a spotted owl buffer zone that begins approximately 0.7 miles west of the proposed conveyor route; however, the proposed route will not intrude on this buffer. No spotted owl nests are present within 11 miles of the proposed conveyor, though occurrences have been documented 6.5 miles west on the western shore of Quilcene Bay. Waterfowl concentrations have been documented in several palustrine wetlands on either side of the conveyor; however, all freshwater wetlands in the vicinity of the conveyor will be avoided.

Sharpe (2005) found 34 species of land birds within the proposed conveyor route. Avian richness and abundance did not differ between plots located adjacent to the gravel mine and those located along the proposed route. The most important factor influencing avian communities appeared to be forestry practices. Forest management practices produced stands that were relatively small in size, structurally simple, and young in age. Sharpe (2005) also documented that bird diversity and abundance in existing active mining areas and vegetated reclamation zones was low, in part probably due to limited diversity in surrounding forest vegetation.

7.0 EFFECTS OF THE ACTION

The effects of construction and operation of the proposed conveyor and pier on listed salmonids and their habitat are described in this section in the context of a series of "pathways" and "indicators." Pathways represent groups of environmental attributes important to anadromous fish and their habitats. These pathways are further broken down into indicators, which are specific components of habitat quality that are relevant to the action area. The concept of pathways and indicators was developed by NMFS (now NOAA Fisheries) as a way to summarize important environmental parameters and associated levels of condition for ESA determinations of effect in fresh water at the watershed scale (NMFS 1999). The concept is used in this BE to frame discussions of how the project will contribute to improvement, maintenance, or degradation of each of the indicators of habitat quality. A list of pathways and indicators considered in this biological evaluation, and the net effect of the proposed project on each, is provided in Table 4.

Presented below is a discussion of direct and indirect effects of project activities on listed species potentially occurring in the action area. Only those pathways and their associated indicators that are likely to be affected by the project are described in detail below. These include indicators related to disturbance and noise, water quality, sediment quality, and disturbance to habitat, biota, and prey resources. The following section presents the analysis of potential project effects on these elements and how they relate to ESA-listed species in order to develop final effect determinations.

7.1 Disturbance and Noise

Direct effects related to in- and overwater construction of the pier and gantry are expected to occur over approximately 2 months. Construction activities waterward of the MHHW line will be conducted during the anticipated work window when few juvenile salmonids are expected to be present in the action area (between July 16 and February 15). Indirect effects will occur over time related to project operations.

7.1.1 Marine Environment

Short-term disturbance of salmonids, rockfish, marbled murrelets, and Steller sea lions may result from the direct effects of pile driving and work vessel activity during construction of the pier and gantry. In-water noise levels associated with pile installation and other aspects of the proposed action will temporarily elevate noise levels above existing background noise levels (112 dB to 114 dB).

To minimize the underwater noise during pile driving, a vibratory hammer would be used for the majority of pile installations. However, an impact hammer will be used to proof load the piles. Therefore, using the most conservative approach, noise exposure modeling used source level data for a single impact driving rig to predict the distances to injury thresholds. Underwater noise source levels used for the calculations were 203 dB Peak, 190 dB RMS, and 177 dB SEL at 10 meters based on unattenuated impacted driving of a 30-inch hollow steel pile (ICF Jones & Stokes et al. 2009). The distance to the injury criterion is dependent upon the number of strikes from the impact hammer during a 24-hour period. Assuming a worst-case scenario, a single impact hammer would be used to proof up to three piles in one day, with each pile requiring a maximum of 100 strikes. Therefore, the most conservative scenario would require up to 300 strikes per day. The NOAA Practical Spreading Loss Model was subsequently used to calculate the distances to the underwater injury and disturbance criterion.

7.1.1.1 Salmonids

There are currently no noise threshold criteria for fish behavior or injury as a result of vibratory pile installation. Noise levels produced by vibratory driving are expected to be in the range of 185 dB Peak and 175 dB SEL, which are below interim criteria for injury specifically from impact hammers (206 dB Peak and 183–187 dB SEL).

For impact pile driving, the isopleth for onset to physical injury to fish (206 dB peak) from a single unattenuated pile strike was calculated to be 6 meters from the pile. The 183 dB SEL injury zone for fish greater than or equal to 2 grams was 178 meters and the 187 dB SEL injury zone for fish less than 2 grams was 97 meters. Assuming the proper use of a bubble curtain or other sound attenuating device during impact pile driving, these distances may be significantly reduced (with a 10 dB noise reduction). For example, acoustic monitoring near the project site found the 183 dB SEL and 187 dB SEL injury zones for 100 pile strikes extended to only 62 and 36 meters, respectively, with a bubble curtain operating around 36-inch steel piles (Illingworth and Rodkin 2012). Although this study only monitored 100 pile strikes, the smaller injury zones detected could be applicable to the proposed project, especially when considering the project would be using smaller steel piles (30-inch) in combination with a sound attenuation device.

Salmonids in the vicinity of the proposed pier alignment may display a startled response upon the initial start-up of pile driving, and would likely avoid the immediate area during pile driving activities. However, a field study of salmonid behavior, near pile driving activities in Puget Sound, found no effects on feeding or any significant changes to size and behavior of schools with or without pile driving (Feist et al. 1996). The authors did report that fish appeared to be driven toward the acoustically isolated side of the site during pile driving, but were often observed about the pile-driving rigs.

More recent experience in Puget Sound and elsewhere, however, has documented more severe effects from use of an impact hammer to drive hollow, large-diameter steel piles. Impact driving of 24-inch steel piles in late 2002 at a ferry terminal in Puget Sound resulted in deaths of a number of pile perch (Embiotocidae); similar or larger piles, driven by impact hammer at the Port of Seattle, resulted in kills of Pacific herring (P. Erstad, WDFW, personal communications). However, impact driving of 24-inch piles at the Mukilteo Ferry dock in early 2003 did not result in documented fish kills; a bubble curtain was deployed at Mukilteo and shown to significantly reduce measured water-borne sound pressures (Hart Crowser, unpublished data). Similarly, no fish kills were documented despite both vibratory and impact hammer use on piles from 24 inch to 48 inch in diameter (Illingworth and Rodkin 2012).

This is consistent with studies examining the effects of pile driving on juvenile salmonids conducted in Puget Sound. Ruggerone et al. (2008) exposed juvenile coho salmon in live cages to over 1,600 strikes with an impact hammer of fourteen 20-inch diameter hollow steel pipe piles. Live cages were placed from 1.8 to 6.7 meters from the pile being driven. Measured sound pressures experienced were up to 208 dB Peak, and 194 dB rms. SEL reached 179 dB and cumulative SEL was approximately 207 dB over the 4.3-hour exposure period. No mortality and no visible sublethal effects were observed in fish held up to 19 days after the exposure. Necropsies found no gross external or internal injuries associated with pile driving. Exposed fish fed normally and only a minor startle response was seen in some fish upon initiation of driving a given pile.

Based on these studies, Puget Sound Chinook, Hood Canal summer-run chum, Puget Sound steelhead, and Coastal-Puget Sound bull trout may alter their normal behavior, including minor startle response and avoidance of the immediate project area as a result of project construction activities. However, it is unlikely that injury will occur to these four species of salmonids due to pile driving activities.

To further reduce potential impacts to listed salmonids, all pile driving activities would be conducted during the agency-approved work window anticipated to extend from July 16 to February 15, when few juvenile salmonids are expected to be present. A small number of federally-listed adult and juvenile salmonids may occur in the project area during construction. To help protect these fish, a soft-start approach using the vibratory and impact pile driving hammers will be utilized to encourage fish to move away from the area prior to initiation of pile driving.

Reduction in prey abundance and disruption of juvenile salmonid migratory behavior may occur as a result from the shadowing effects from large over-water structures built on nearshore habitats in the Puget Sound (Ono et al. 2010). Although the conveyor will be covered, shading effects will be minimized by constructing the pier primarily with open steel girders, and the walkway along the conveyor with grated decking material. In addition, due to the height of the pier (+22 feet MLLW) and its width (13 feet), its shade will move throughout each day, further minimizing shading impacts to prey resources and migratory behavior of juvenile salmonids.

It is unlikely that indirect effects related to noises generated during normal operations will alter salmonid behavior throughout the action area, as most of these activities will occur above water. It is unlikely that noise from marine traffic will adversely affect juvenile salmonids inhabiting shallow nearshore waters, because the pier operations and associated vessel traffic will be approximately 1,000 feet offshore in water generally greater than 40 feet deep. Also, due to its modern design (e.g., sealed bearings), combined with regular monitoring and maintenance, the conveyor itself is expected to generate relatively little noise. According to calculations presented in Section 3.2, operational noise would attenuate to ambient background levels (44.3 dB) approximately 400 feet from the conveyor.

7.1.1.2 Rockfish

Adult ESA-listed rockfish typically reside in waters deeper than 160 feet deep, which is at least 800 feet away from the closest pile driving activities associated with the project. Rockfish are therefore not expected to be affected by project activities due to the distance of the project and attenuation of sound. Although adult and juvenile rockfish are unlikely to be affected from vibratory pile driving, it is possible that small numbers of larval yelloweye rockfish, canary rockfish, and bocaccio could occur within the water column in the vicinity of the proposed pier alignment, and could be affected from noise generated from impact pile driving activities. However, the concentration of larval rockfish in the immediate vicinity of the proposed pier is expected to be extremely small due to currents within Hood Canal that readily disperse this stage of rockfish life history (NMFS 2003; US Navy 2011). Although the number of affected larval fish cannot be realistically estimated, the percentage will be so small that even if pile driving does have an impact to larval rockfish, it will not affect the abundance, productivity, or spatial structure of the Puget Sound/Georgia Basin DPSs of yelloweye rockfish, canary rockfish, or bocaccio (US Navy 2011).

7.1.1.3 Marbled Murrelet

Currently, no thresholds have been established by USFWS to assure protection of marbled murrelets from underwater noise generated by the vibratory installation of piles (FHA 2012). Despite this, a *guidance* threshold of 150 dB RMS has been established to minimize behavioral disturbance to marbled murrelets. It applies to both impact and vibratory pile driving and is considered a guidance measure, not a criterion, relative to foraging marbled murrelets (US Navy 2012). Although proposed pile driving activities within the action area will primarily involve use of vibratory methods, an impact hammer will be used to proof load the piles. Modeling indicates the peak injury threshold of 202 dB would not be exceeded during impact pile driving beyond a distance of 2 meters from the pile. Since it is unlikely that marbled murrelet would occupy waters within 2 meters of pile driving activities, no injury to this species is expected.

The established 150 dB RMS guidance threshold for minimizing behavioral disturbance to marbled murrelets extends over a distance of 1000 meters from the location where pile driving takes place. Therefore, short-term disturbance of foraging marbled murrelets may result when noise generated from pile driving and other construction activities approaches the guidance threshold within the 1000-meter disturbance zone. Marbled murrelet behavior considered characteristic of disturbance includes flushing, altered feeding attempts, or avoidance of the area. It is assumed, however, since low numbers of marbled murrelets have been observed in Hood Canal, within the action area and adjacent waters, that potential effects from project activities will be discountable relative to marbled murrelet population abundance, productivity, or spatial structure. Should they occur, such effects would be temporary, lasting only until project activities are completed.

A Marbled Murrelet Construction Monitoring Plan would be implemented to minimize potential construction effects to marbled murrelets. This plan would outline activities for monitoring the presence of marbled murrelets within designated disturbance and injury zones. If marbled murrelets are observed within either of these zones, pile driving would cease until the birds have left the respective areas. The size of the disturbance and injury zones would be determined in consultation with USFWS. Adherence to the Marbled Murrelet Construction Monitoring Plan will minimize the potential behavioral and injurious effects to marbled murrelet as a result of pile driving and construction activities.

7.1.1.4 Steller Sea Lion

For underwater noise, NMFS identified threshold criteria for determining injury exposure as 190 dB RMS for pinnipeds. Modeling showed the 190 dB RMS injury zone to be 10 meters without sound attenuating devices. Illingworth and Rodkin (2012) took acoustic measurements during impact driving near the proposed pier alignment and found the zone extended less than 10 meters from 36-inch piles (larger than for this project) with an air bubble curtain in operation. Therefore, it is likely that with a properly functioning sound attenuation device, that the 190 dB RMS injury zone would be less than 10 meters during impact driving activities for this proposed project.

Steller sea lions are unlikely to be injured by impact pile driving noise at this short of a distance (less than 10 meters) because the high level of human activity and vessel traffic would likely cause them to avoid the immediate construction area. Furthermore, the likelihood of Steller sea lions occurring near the proposed pier alignment is low, further reducing any potential injurious impacts to this species. Project monitoring of marine mammals during pile driving would also be an effective way to prevent construction from occurring when Steller sea lions are within 10 meters of any pile driving.

For pinnipeds, the behavioral disturbance threshold for impact pile driving is 160 dB RMS and the behavioral disturbance threshold for continuous noise such as vibratory pile driving is 120 dB RMS (US Navy 2012). The isopleth for 160 dB RMS is much smaller than for 120 dB RMS. Application of the 120 dB RMS threshold for continuous noise is therefore the more conservative approach to evaluating behavioral disturbance due to noise and will be utilized for this analysis. The 120 dB RMS marine mammal behavioral disturbance zone for vibratory diving was calculated to be 13 miles, which would spread through out much of upper Hood Canal, blocked only by topographic barriers (Figure 1). However, Illingworth and Rodkin (2012) took acoustic measurements during impact driving (36-inch piles, larger than for this project) and found that in some cases the zone extended only to 3 miles, with an air bubble curtain in operation. Therefore, it is likely that with a properly functioning sound attenuation device, that the 120 dB RMS disturbance zone could be approximately 3 miles during impact driving activities for this proposed project.

Although Steller sea lions have been documented in Hood Canal, the numbers are considered low; therefore, in-water noise generated from project activities are unlikely to adversely affect Steller sea lion. However, in the unlikely event that Steller sea lions enter the disturbance zone during the project, pile driving and removal activities may cause a behavioral disturbance (i.e., startle response or interruption of foraging) where project-related noise has not yet attenuated to the disturbance threshold. Any potential effects to Steller sea lions would discontinue once project activities are complete.

To further minimize potential effects to Steller sea lions, a Marine Mammal Construction Monitoring Plan would be implemented during construction. This plan would outline activities to monitor the presence of Steller sea lions within designated disturbance and injury zones. If Steller sea lions are spotted within the injury zones, pile driving would cease until the animals have left the respective zones. The size of disturbance and injury zones would be determined with consultation from NOAA/NMFS. Adherence to the Marine Mammal Construction Monitoring Plan will minimize the potential behavioral and injurious effects to Steller sea lions as the result of pile driving and construction activities.

7.1.2 Upland and Over-Water Areas

Following construction, the conveyor will operate on an intermittent basis. Other than scheduled maintenance shutdowns or restricted timelines for marine vessel berthings, the schedule for pier operations will be market driven. Depending on the size, capacity, and availability of marine transport vessels at the proposed pier, it is anticipated that one to six vessels will be loaded each day.

Noise associated with project operations will be periodically elevated above existing background levels in the upland action area. Routine noise-generating activities will include marine vessel operations and loading, conveyor operations, and maintenance activities. An analysis of anticipated noise-generating operations concluded that project operations would easily meet the nighttime noise criteria of 47 dBA and fall far below the allowable daytime sound level of 57 dBA (MFG 2004; Environalysis 2011). Although project-related noise would be audible much of the time, it would exceed the highest background levels only 2 to 3 hours per day (Environalysis 2011).

Measurements of operational sound levels have been documented for conveyor systems similar or identical to those planned for the proposed project (MFG 2004; Environalysis 2011). As a worst-case scenario, it was determined that sound pressure levels would attenuate to 69 dBA at 100 feet from a source that consisted of gravel being loading into steel ships. This level is well below the in-air disturbance guidance of 92 dBA for marbled murrelet (FHA 2012). All other operational noise associated with the proposed project would be lower than loading operations (i.e., conveyor belt sound level equaled 49 dBA). Furthermore, the conveyor will be covered, which provides additional noise reduction. As a result, in-air operational noise from the proposed conveyor and pier are not expected to disturb marbled murrelet behavior within the action area.

Marbled murrelet foraging is likely to occur in proximity to pier operations and marine vessel traffic. In such areas, seabirds may be temporarily disturbed to avoid encounters with vessel traffic. When approached by vessels, marbled murrelets, like most seabirds, will either swim or fly away from the vessel's path, or dive under water. As with the noise that would be generated by proposed over-water construction, noise from the conveyor and pier offloading activities could also result in minor disturbance to flight behavior between marine waters and upland areas. In the Puget Sound region, however, marbled murrelets have been observed in association with developed areas, suggesting a tolerance to noise sources and magnitudes characteristic of urban and industrial land uses. Should disturbance caused by the conveyor or marine vessel operations extend to upland areas, it would be localized and its frequency would be minimal since daily traffic movements would involve less than seven vessels, plus tugboats, per day. Furthermore, because the anticipated magnitude of sound levels generated from such operations would be well below the in-air disturbance threshold of 92 dBA (see Section 7.1.1.3), anticipated effects on marbled murrelet behavioral disturbance is expected to be discountable.

Upland construction and operations will not adversely affect nesting or roosting habitats for marbled murrelet or northern spotted owl. Analyses have determined that proposed construction noise will extend approximately 2 miles from the conveyor footprint before attenuating to background levels. Conveyor operational noise will attenuate to background levels within 400 feet from the conveyor route over terrestrial habitats. These distances are well removed from documented nesting and roosting sites for both species in the action area. The closest northern spotted owl nest, located in the foothills of the Olympic Mountains, is approximately 11 miles from the conveyor route. In addition, the closest documentation of northern spotted owl presence is over 6 miles from the conveyor route along the western shore of Quilcene Bay. Similarly, nesting and roosting habitats for marbled murrelet are approximately 9 miles from the proposed conveyor route. As a result, the effects of noise generated from construction and operational activities will be discountable relative to upland nesting or roosting habitats for marbled murrelets or northern spotted owl.

7.2 Water Quality

7.2.1 Direct Effects

7.2.1.1 Upland Areas

The proposed conveyor alignment does not cross any lakes, but would intersect with several small seasonal streams and natural drainage courses. The elevated conveyor would span local drainages and be equipped with pans under the return belt at specific locations where streams are crossed. This would effectively minimize potential spillage of sand and gravel into upland area water courses. The elevated conveyor will avoid several palustrine freshwater wetlands located along the proposed conveyer route. Because the conveyor will be fully covered or enclosed for its entire length, there is little risk of spillage into seasonal streams or natural drainage courses. BMPs designed to minimize erosion, particularly near slopes, will be put in place around all areas of earthwork, including construction of forestry service roads and excavation of the cut on the hillside above the shoreline. These BMPs include implementation of stormwater controls in accordance with Ecology's stormwater manual (Ecology 2012).

Previous studies and groundwater monitoring in the upland action area indicates that there are several aquifers in the region including the Vashon aquifer and the deeper pre-Vashon (Bridgehaven) aquifer (GeoResources 2013). The Vashon aquifer potentially discharges to Thorndyke Creek as seeps or springs. Mining operations will be limited to the aggregate resources encountered above the regional groundwater table with the mining depth limited to 10 feet above the Vashon aquifer (Appendix K). Therefore, no measureable change is expected to the water quality or quantity of the Vashon aquifer, and thus no adverse effects are anticipated to occur to Thorndyke Creek (GeoResources 2013). Furthermore, surface water in the upland action area will not be affected by mining operations since the lowest extent of excavation will be above the bed elevation of Thorndyke Creek and mining depth will not extend laterally to the creek channel (Appendix K). Mining operations are far enough removed from other unnamed creeks in the vicinity of the proposed project that no measurable adverse impacts to water quality or quantity are anticipated. GeoResources (2013) concluded that, based on results of site reconnaissance, subsurface explorations, groundwater monitoring, review of the available data, and professional experience, the mining operations involved with this proposed project will have no measureable adverse impacts, cumulative or otherwise, to the surface or groundwater systems in the area.

7.2.1.2 Marine Environment

Because of the relatively silt-free nature of sediments in the intertidal and shallow subtidal areas, relatively little material will be suspended in the water column during pile driving and other construction activities. However, turbidity may be increased above background levels within the immediate vicinity of construction activities and could exceed turbidity criteria for state water quality standards (WAC 173-2101A). Because of local currents and tidal action, any potential water quality exceedances are expected to be temporary and highly localized. The local currents will disperse suspended sediments from pile-driving operations at a moderate to rapid rate depending on tidal stage.

Juvenile salmon have been shown to avoid areas of unacceptably high turbidities (e.g., Servizi 1988), although they may seek out areas of moderate turbidity (10 to 80 nephelometric turbidity units [NTU]), presumably as cover against predation (Cyrus and Blaber 1987a and 1987b). Feeding efficiency of juveniles is also impaired by turbidities in excess of 70 NTU, well below sublethal stress levels (Bisson and Bilby 1982). Reduced preference by adult salmon homing to spawning areas has been demonstrated where turbidities exceed 30 NTU (20 mg/L suspended sediments). However, Chinook salmon exposed to 650 mg/L of suspended volcanic ash were still able to find their natal water (Whitman et al. 1982). Based on these data, it is unlikely that the locally elevated turbidities generated by the proposed action would directly affect juvenile or adult salmonids, or listed rockfish that may be present during pile driving activities. Furthermore, foraging by marbled murrelet or Steller sea lion would not be impacted by elevated turbidities as these events would be highly localized and temporary.

Minor increases in turbidity could result from propeller wash from tugboats conveying vessels to and from the pier. 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 in waters shallower than 50 feet (Anchor 2003). However, it is anticipated that tugs will generally operate over 150 feet offshore from the mooring dolphins in waters depths ranging from 90 to 110 feet. Furthermore, the propellers of tugs will generally be oriented parallel to or away from the shoreline during operations. Therefore, scouring impacts from propeller wash would be short-term and localized to the immediate area and should not have an impact on turbidity, shoreline processes, or beach stability (Anchor 2003). Because scouring impacts are likely to be minimal, resulting turbidity similarly will be minimal and subject to the composition of the substrate materials and tidal dispersion. Any potential turbidity increases resulting from these actions would be transient, highly localized, and not expected to yield acute or chronic exceedances of state turbidity criteria. Operational procedures for tug movements on site will be subject to the methods and procedures described in the forthcoming CMMP.

Minor increases in turbidity could also result from possible small spills of sand and gravel into Hood Canal while loading the vessels. However, strong tidal exchanges and currents in the project area will quickly dissipate any small increases in turbidity as a result of spillages. Furthermore, transported sand and gravel will be relatively free of fine materials, further minimizing any potential turbidity increases resulting from spillage. In addition, any potential small spills of sand and gravel would not introduce any foreign contaminants as these materials are clean and free of contaminants.

The potential for spillage from overwater sections of the proposed conveyor will be minimized because from the top of the marine bluff to the end of the pier, the conveyor system would be covered or structurally enclosed by a roof and siding. This containment feature also would include either a solid floor or a pan under the return belt of the conveyor. Where applicable, containment areas would be installed on the deck of transport vessels to manage risks of spillage of materials into marine waters. Similarly, containment areas would also be provided on construction barges to prevent spillage of materials into marine waters.

Fuel spillage during construction activities and operation of the conveyor is possible. However, as fueling of vessels will not occur on site, the quantity released from such an event will be limited to that contained within the vessel. Potential impacts to water quality from small spills or leaks are possible, but are unlikely to have a long-term impact.

Other BMPs will be implemented in the marine areas to minimize the risk of fuel spills and other potential sources of contamination. An agency-approved spill prevention and response plan including provisions for on-site containment equipment (including a boom) will be developed prior to any construction activities. Spill prevention and spill response procedures will be maintained throughout operation of the conveyor.

Sanitary facilities located at the end of the pier will be regularly pumped out and maintained. All sanitary waste will be contained and disposed of at an upland facility. There will be no discharge to the marine environment and BMPs will be implemented to avoid spills and leaks.

According to federal guidelines, vessels calling at the pier may release gray water within the confines of Hood Canal (EPA 40 C.F.R 122.3a). However, quantities released will be limited with releases intermittent in time and varied in location. Plumes of gray water are expected to disperse quickly in the substantial currents present in this portion of the canal, and no short-term acute or chronic effects on biota are likely. Discharge of gray water by vessels at the proposed project site are unlikely to impact levels of fecal coliform, nutrients, and organic matter in marine waters near the pier site due to the anticipated low frequency of these discharges (GeoEngineers 2008).

7.2.2 Indirect Effects

No significant indirect effects to freshwater or marine water quality are anticipated from project activities.

7.2.2.1 Upland Areas

The conveyor and associated forestry service roads do not represent a significant impervious area within the drainage basins and surrounding habitats consist of undisturbed land and native soils that will allow ready infiltration of stormwater. Based on the nature of the sand and gravel soils, the distance from the infiltration areas, and the direction of groundwater flow, no adverse impacts to Thorndyke Creek or any local creeks from increased runoff volumes from this project are expected (Appendix K).

7.2.2.2 Marine Environment

No indirect effects to water quality in the marine environment are anticipated as a result of project activities. From the top of the marine bluff to the end of the pier, the Central Conveyor will be enclosed by a roof and siding. The floor will consist of either a solid floor or a pan under the return belt of the conveyor with an adjacent grated walkway. Therefore, the risk of spillage of materials into marine waters will be minimized.

7.3 Sediment Quality

7.3.1 Direct Effects

Hollow steel piles will be used for construction of the pier and will not introduce or leach contaminants into the sediment surrounding the project site. Sediment quality in the vicinity of the proposed pier alignment is assumed to be good and relatively free of contaminants, so there will not be any resuspension of contaminants due to pile driving activities. Therefore, no direct effects to sediment quality are anticipated from pile driving and other construction activities, or from operation of the Central Conveyor in the action area.

7.3.2 Indirect Effects

All sand and gravel used during operations will be free of contaminants, so any potential small spills would not introduce any contaminants to the sediments surrounding the proposed pier alignment. Therefore, no indirect effects to sediment quality are anticipated from operation of the Central Conveyor in the action area.

7.4 Habitat and Biota

7.4.1 Direct Effects

7.4.1.1 Upland Areas

Construction of the proposed conveyor and forestry service road in upland areas will avoid bald eagle perch trees and will be sited to minimize the extent of vegetation that will be removed. The terrestrial action area is far removed from nesting and roosting areas for marbled murrelet and northern spotted owl. Therefore, the proposed project will have minimal effects to upland habitat and biota.

7.4.1.2 Marine Environment

Project construction will result in the destruction of isolated local areas of marine benthic habitat and species in the footprint of each pile (up to 30 inches in diameter). The pilings will occupy approximately 734 square feet of marine benthic habitat at depths between about +6 feet and –64 feet MLLW (Appendix D, Table D-1). The great majority of this area (about 613 square feet) would be below depths of –30 feet MLLW.

Short-term disturbance of fish fauna in the nearshore marine habitat will result from pile driving and other construction activities. These temporary disturbances, including increased sound levels and turbidity, are addressed in the previous sections. Grounding of work barges during construction of the overwater portions of the conveyor will disrupt substrate. This may result in a short-term compression of beach sediments that could alter the nature of benthic biota in these localized areas. As noted, the typical size of a construction barge is 155 feet by 50 feet (7,750 sf). A barge of this approximate size may be required to ground during low tide to offload the large crane required for installation of the pile bents and conveyor truss sections in the nearshore. This grounding is expected to occur above the elevation of the band of patchy *Z. japonica* (i.e., above +4 feet MLLW) in an area with little macro-infauna.

The preferred method of construction across the beach will be to drive piles during high tide to avoid grounding of barges. Nonetheless, barges will likely be required to drop spuds to hold position while working in a given area. There is a probability that some of these spuds will drop on patches of Japanese eelgrass.

The pier will likely bisect patches of Japanese eelgrass within a zone from about +4 feet MLLW to +1 foot MLLW (Appendix B, Sheet C2.3). Any piles driven through the patches will likely destroy or displace eelgrass immediately under pile footprints. Because of the dynamic nature of patches of this species on this beach, the extent of these disruptions can be difficult to predict. However, depending on the presence of *Z. japonica* at the time of construction (*Z. japonica* is seasonal and likely shifts in this area due to currents and wave action), the potential direct impact to eelgrass from pile driving is less than 6 sf (assuming that twelve 18-inch-diameter piles will be installed across the eelgrass zone and that the zone is 25 percent covered with eelgrass). However, the potential direct impact to Japanese eelgrass could increase to slightly more than 21 sf if all of these piles were placed in existing eelgrass patches.

Alignment and depth of the pier were chosen to directly avoid impacts to native eelgrass (*Z. marina*) through displacement or construction/operational effects (e.g. shading from vessel operations or scouring due to vessel movements). Therefore, no impacts to native eelgrass are anticipated. The applicant will work with regulatory agencies to determine measures that will ensure no long-term loss of nearshore productivity results from the project and provide compensatory mitigation for any temporal losses that may occur. A comprehensive description of BMPs, conservation and avoidance measures, and proposed mitigation will be included in the forthcoming CMMP.

7.4.2 Indirect Effects

7.4.2.1 Upland Environment

No indirect adverse effects to upland habitat are anticipated.

7.4.2.2 Marine Environment

As an offset to the direct loss of existing habitats and biota noted above, a substantially greater area of hard surface will be provided for attachment of epibenthic plants and animals. This new habitat, although different in nature, will nonetheless provide biological productivity that will greatly exceed impacts to benthic primary and secondary productivity in existing habitats. A total of over 11,000 square feet of epibenthic surface area will be created at depths between +6 feet and –10 feet MLLW (Appendix D, Table D-1). Plants and animals colonizing this surface area will contribute to the primary and secondary productivity of the water column passing the site. The offshore pilings, portions of which are permanently submerged, would likely attract pile-oriented fish such as shiner and pile perch (Embiotocidae). The shells of barnacles and mussels sloughed from the pilings would support a suite of organisms that is different from that now present in the predominantly sandy substrate of the project site.

The overwater portion of the conveyor will be fully enclosed out to the pier. However, some sand and gravel could be spilled at the discharge point. If any spillage occurred over the beach due to an unanticipated catastrophic system failure, it would add sand and gravel to a sand-and-gravel beach. Any effects are therefore expected to be minimal, localized, and quickly dispersed by wave action. In deeper water (e.g., deeper than –30 feet MLLW), any small amount of sand and gravel that may spill at the transfer point could alter the nature of the benthic fauna and epibiota in localized areas to favor an assemblage adapted to a coarser substratum. However, the steep slope of the seafloor at the transfer point will likely prevent any accumulation of sand and gravel resulting from potential spillage (Appendix B, Sheet C2.3). Therefore, rates of accumulation will not be great enough to adversely affect larger infauna, such as geoducks (e.g., Westley et al. 1975). Furthermore, any potential sand and gravel spillage at the discharge point would be unlikely to affect juvenile salmonids normally associated with shallow nearshore habitat, because the discharge point will be approximately 1000 feet offshore in water generally greater than 40 feet deep.

Over time, the presence of the conveyor will cast shadows on portions of the adjacent beach and subtidal bottom areas; however, shadowing effects to eelgrass beds are expected to be limited. During the major growth periods of spring and summer, shadows from the conveyor and pier (including vessels) are not expected to reach the large patch of the native eelgrass (*Z. marina*) north and east of the pier (Appendix B, Sheet C2.3) except in the early morning. However, due to the conveyor alignment and its proximity to patches of Japanese eelgrass, some shading of this species is likely to occur. The amount of shading and the amount of eelgrass potentially affected cannot be predicted with accuracy.

Given the height of the pier (22 ft above MLLW), width of the pier (13 feet), and average sun angle, it has been predicted that shading from the pier will traverse marine waters along the pier alignment throughout each day, and will remain over any specific area that may contain eelgrass patches for a maximum of one or two hours each day. *Z. japonica* occurs in isolated patches within a 250-foot-wide zone across which the shadow will traverse (Appendix B, Sheet C2.3). However, no one portion of *Z. japonica* will be shaded throughout the entire day. It is conservatively predicted that light availability may fall below thresholds necessary for optimal eelgrass production for periods of 1 to 2 hours per day in a zone of about 30 feet in width (three times the approximate effective diagonal dimension of the enclosed section of the conveyor, given the south half of the structure will consist of a grated walkway) over the *Z. japonica* band (Appendix D). This is an area of about 7,500 sf where some reduction in eelgrass growth may occur. This estimate is conservative because production of eelgrass at higher intertidal elevations is limited by desiccation, not by light levels. Thus, it is probable that there will be a negligible reduction in Japanese eelgrass productivity as a result of shadows cast by the conveyor.

Shading from the two open support platforms and from mooring dolphins will not reach areas of native eelgrass (*Z. marina*) during a majority of the day. The shadow from the northern mooring dolphin and from the outer support tower will reach adjacent eelgrass beds briefly during early morning, when the sun is very low in the eastern sky. Because of the low sun angle, light refraction off the water surface will be great under these circumstances, and the amount of photosynthetically active radiation reaching the bottom (and eelgrass) will likely be below the threshold for photosynthesis with or without the project structures (Appendix D). Thus, the effect of shading on native eelgrass (*Z. marina*) is expected to be minimal.

To reduce the potential for introductions of nonindigenous species, vessels calling at the pier will be subject to the US Coast Guard's ballast water management program rules set forth by Washington Administrative Code (WAC) 220-777-090 and 095, and Chapter 77.120 Revised Code of Washington (RCW). Among other restrictions, these rules require vessels involved in coastal trade to report and conduct ballast water exchange at least 50 miles offshore before they are allowed to discharge ballast into waters of the state. Therefore, the risk of introducing exotic species would be minimal.

7.5 Prey Resources

7.5.1 Direct Effects

7.5.1.1 Upland Areas

Construction of the conveyor through the upland areas will require some removal of vegetation along the Central Conveyor. A majority of the vegetation will be removed from upland areas with minimal removal of riparian vegetation.

Therefore, removal of riparian vegetation will have little to no impact on terrestrial prey resources for juvenile Chinook or chum salmon.

The conveyor route is well away from most local streams and freshwater wetlands. BMPs will be used to control site erosion reducing any potential turbidity effects. Therefore, construction activities are unlikely to adversely affect aquatic biota that may provide prey resources for listed upland species. Location of pilings and construction techniques have been chosen to avoid any impacts to the disturbed riparian wetland that occurs along the toe of the bluff (Appendix B, Sheet C2.2), effectively reducing any impacts to wetland prey resources (e.g., amphibians and insects) for listed upland species.

7.5.1.2 Marine Environment

Project construction will result in the destruction of non-mobile benthos in the footprint of each of the 18- or 30-inch-diameter piles. This will remove approximately 734 square feet of potential benthic and epibenthic prey resources for juvenile Chinook and chum salmon. However, as mentioned earlier, the addition of pilings will partially offset the loss of benthic habitat by creating a hard substratum habitat upon which invertebrate and algal colonization will occur and which, in subtidal areas, will likely introduce additional juvenile salmonid prey resources not previously present.

Barge movements over shallow intertidal areas could directly disturb or destroy portions of the shallower Japanese eelgrass (*Z. japonica*) beds on the low-gradient sandy bench. In addition, the pier will bisect patches of Japanese eelgrass within a zone from about +4 feet MLLW to +1 foot MLLW and any piles driven through the patches will likely destroy or displace eelgrass immediately under pile footprints. Disturbance or destruction of *Z. japonica* in these localized areas will effectively reduce production of epiphytic zooplankton, a potential prey resource for juvenile Chinook and chum salmon. However, the Applicant will work with regulatory agencies to determine measures to ensure no long-term loss of nearshore productivity results from the project, and to provide compensatory mitigation for any temporal losses that may occur. A comprehensive description of BMPs, conservation and avoidance measures, and proposed mitigation will be included in the forthcoming CMMP.

Forage fish are a prey resource for adult salmonids, marbled murrelets, and Steller sea lions. Pile driving and work barge activities during construction of the pier may disturb forage fish species in the action area (i.e., flight response and avoidance of the construction area). Should such disturbance occur, it would be short-term and localized.

No Pacific sand lance spawning areas have been documented in proximity of the proposed pier alignment. The WDFW-managed Salmonscape database currently documents Pacific sand lance spawning areas within upper intertidal shoreline approximately 3,600 feet to the southwest of the proposed pier alignment (WDFW 2013). Pacific sand lance spawning habitat was also documented 4,100 feet to the north along the intertidal shoreline surrounding Nordstrom Creek. As such, any temporary grounding of construction equipment on the upper intertidal beach is expected to result in negligible effects based on historic use of Pacific sand lance spawning habitat in the action area. Once constructed, operation of the pier is also expected to result in negligible effects on such habitat or on the spawning success of Pacific sand lance within the action area.

Should it be determined that Pacific sand lance spawn in the vicinity of the proposed pier alignment, the extent of effects would be limited to the location where the bluff stabilization and protection measures are installed. This would involve a shoreline distance of approximately 100 linear feet along the toe of the bluff. Anchor (2003) states that these measures will not impede the recruitment of sediments along the shoreline either north or south of this location. In addition, a negligible amount of riparian vegetation (along 50 feet of the shoreline) will be removed during construction. Proposed construction and operation, therefore, are expected to result in discountable effects relative to substrate composition and abundance along adjacent intertidal habitats and in upper beach spawning areas. Similarly, the effects of project construction and operations also would be discountable relative to Pacific herring or surf smelt and their related spawning habitats in the project action area.

7.5.2 Indirect Effects

7.5.2.1 Upland Areas

Construction and operation of the proposed project will have no indirect effects on prey resources for listed species in upland areas.

7.5.2.2 Marine Environment

The alignment of the proposed conveyor will result in shading of an area of approximately 7500 square feet. This will likely have a negligible effect on a portion of the Japanese eelgrass beds along the pier alignment as described in Section 7.4.2.2. Any potential shading could result in a limited reduction of eelgrass productivity and blade area available to support epiphytic zooplankton, a prey resource for juvenile Chinook and chum salmon. The Applicant will consult with regulatory agencies to confirm measures to be incorporated into the project to ensure long-term loss of nearshore productivity does not occur, and to provide compensatory mitigation for any anticipated temporal losses. A comprehensive description of BMPs, conservation and avoidance measures, and proposed mitigation will be included in the forthcoming CMMP.

7.6 Critical Habitat and Essential Fish Habitat

7.6.1 Chinook Salmon, Hood Canal Summer-Run Chum Salmon, and Puget Sound Steelhead

On September 2, 2005, NOAA Fisheries released the final rule designating critical habitat for Puget Sound Chinook, Hood Canal summer-run chum, and other populations of federally protected salmon species in Washington, Oregon, and Idaho. On January 14, 2013, NOAA Fisheries proposed critical habitat for Puget Sound steelhead. All marine, estuarine, and river reaches accessible to Puget Sound Chinook and Hood Canal summer-run chum salmon are designated as critical habitat, except for a number of watersheds, military lands, and tribal lands that have been excluded. Similarly, all marine, estuarine, and river reaches accessible to Puget Sound steelhead have been proposed as critical habitat, including similar exclusion areas. Critical habitat for listed Chinook, chum, and steelhead are known to overlap in many instances (78 FR 2726). Estuarine and marine areas of Hood Canal lie within the designated critical habitat for Puget Sound Chinook and Hood Canal summer-run chum salmon, as well within proposed critical habitat for Puget Sound steelhead. Critical habitat has been proposed for Puget Sound steelhead in Thorndyke Creek, as well as in two small unnamed creeks in the vicinity of the project site (78 FR 2726). There is no designated critical habitat for Puget Sound Chinook or Hood Canal summer-run chum in any of these creeks due to the lack of use by these listed species.

The project and action areas lie in critical habitat Unit 19, "Nearshore Marine Area" (70 FR 52630), as adopted for listed Chinook and chum salmon. These areas provide important rearing, feeding, and migration habitat for listed Chinook and chum as well as other salmonids. As a result of these biological functions, these areas are considered to be Primary Constituent Elements (PCE) essential to the conservation of the species. PCEs developed for listed Chinook and chum are the same as those proposed for Puget Sound steelhead (78 FR 2726). The relevant nearshore PCEs present within the project and action areas that are applicable to listed Chinook, summer-run chum, and steelhead are:

> "Nearshore marine areas free of obstruction with water quality and quantity conditions and forage, including aquatic invertebrates and fishes, supporting growth and maturation; and natural cover such as

submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels (70 FR 52665)."

Nearshore PCEs for listed Chinook, summer-run chum, and steelhead within the project and action areas include the following habitat attributes:

- Natural, low-gradient intertidal beach and littoral habitats free of obstructions.

- Water quality and quantity conditions that contain a natural epibenthic community for foraging juvenile salmonids and forage fish to support the growth of subadult and adult salmonids.

- Natural estuarine conditions with natural cover and protected sand flats in Thorndyke Bay. Vegetated bluff habitats with no armoring are present on the beach in the immediate vicinity of the proposed conveyor and pier.

The relevant freshwater PCEs present within the action area that are only applicable to listed steelhead are:

> "Freshwater spawning sites with water quantity and quality conditions and substrate supporting spawning, incubation and larval development (78 FR 2726)."
>
> "Freshwater rearing sites with water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility; water quality and forage supporting juvenile development; and natural cover such as shade, submerged and overhanging large wood, log jams and beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks (78 FR 2726)."
>
> "Freshwater migration corridors free of obstruction with water quantity and quality conditions and natural cover such as submerged and overhanging large wood, aquatic vegetation , large rocks and boulders, side channels, and undercut banks supporting juvenile and adult mobility and survival (78 FR 2726)."

These freshwater PCEs for listed steelhead are present within Thorndyke Creek and the two unnamed creeks in the action area. All of these creeks provide natural spawning and rearing opportunities with sufficient water quality and quantity to support larval and juvenile development. Migration corridors within these creeks are relatively free of obstructions, effectively supporting juvenile and adult steelhead mobility and survival.

7.6.2 Other Listed Species

Critical habitat for marbled murrelet and northern spotted owl are in mature and old growth forest habitats west of the upland action area. Such habitats are far removed from the project and action areas of Hood Canal. Accordingly, the upland action area is not included in the designated critical habitat for the two species. Similarly, the in-water action area does not include critical habitat for bull trout, southern resident killer whale, and Steller sea lion. No critical habitat has been designated for the three listed species of rockfish.

Critical habitat has not been designated within Puget Sound for humpback whale or the four species of sea turtles.

7.6.3 Critical Habitat Analysis

Direct effects to nearshore critical habitats are expected to be temporary, highly localized, and limited to the proposed pier footprint during the 2-month construction period. Indirect effects to critical habitat related to project operations also are anticipated. These include the following:

- Temporary avoidance of nearshore salmonid migratory corridors during construction. These effects will cease once construction is completed. Further, construction activities will take place during approved work windows outside of the juvenile salmon outmigration period. Minimal effects to nearshore migratory corridors due to shading will occur due to the height and design of the pier. Thus, project construction and operation will not degrade these existing PCEs within nearshore critical habitat for Chinook salmon, summer-run chum salmon, or steelhead.

- The invert elevation of the conveyor is +22 feet above MLLW. Piles will be driven at 100-foot intervals perpendicular to the shoreline within the intertidal and littoral zones. The end of the pier and barge docking areas will be 1,000 feet offshore from the MHHW mark in subtidal habitats (approximately –50 feet MLLW). These specifications were incorporated into the design to avoid interference with the natural littoral drift and natural processes affecting recruitment and productivity of benthic, epibenthic, and zooplankton communities along the Toandos Peninsula. As a result, project construction and operation will not affect the migratory corridors or create substantial impediments to intertidal and littoral movements of Chinook, summer-run chum, or steelhead. Therefore, the project will not impact the nearshore PCEs of these three species.

- Highly localized decreases in benthic and epibenthic productivity may temporarily reduce food abundance for juvenile salmon or steelhead. These temporary decreases will occur during approved work windows when few juvenile salmon or steelhead will be in the vicinity of the proposed pier alignment. Recovery of these communities is expected to occur quickly. Permanent loss of benthic and epibenthic habitats as the result of pile placement will be small and replaced with hard pile substrates that will be colonized by epibiota. Thus, pier operations are not expected to degrade food sources within nearshore critical habitat for Chinook, summer-run chum, or steelhead.

Direct effects to freshwater critical habitat for steelhead are not anticipated to occur. Mining operations associated with the proposed conveyor project will not occur within the local groundwater table, but remain a minimum of 10 feet above the seasonal high level. Furthermore, surface water in the upland action area will not be affected by mining operations, since the lower extent of excavation will be above the bed elevation of Thorndyke Creek, and mining depths will also not extend laterally to the creek channel (Appendix K). Therefore, mining operations are unlikely to adversely affect the water quality or quantity of Thorndyke Creek or the two unnamed creeks proposed as critical habitat for steelhead.

7.6.4 Summary of Potential Effects on Critical Habitat

Based on the analyses provided in this BE, the proposed project has the potential to affect only one of the 6 PCEs for Chinook and summer-run chum salmon—nearshore marine habitat. The proposed project also has the potential to affect to affect four of the 6 PCEs for steelhead—freshwater spawning habitat, freshwater rearing habitat, freshwater migration, and nearshore marine habitat.

The analyses provided above lead to the conclusion that the proposed project will result in no net degradation of any these PCEs for Chinook, summer-run chum, or steelhead. Pile installation will result in loss of 734 square feet of existing benthic habitats, and creation of 11,000 square feet of hard-bottom habitats on piles supporting the conveyor and pier. Thus, although the project would result in some habitat changes, it is not expected to significantly degrade or reduce nearshore critical habitat for Chinook salmon, Hood Canal summer-run chum salmon, or steelhead. Mining operations associated with the proposed conveyor project will not occur within the local groundwater table and established buffer zones and mining depths will reduce any potential surface water impacts. On-site stormwater control will further minimize any potential surface water impacts. Therefore, no adverse impacts are expected to the water quality or quantity of surface or groundwater systems in the area. Upland activities are not expected to degrade any of the freshwater PCEs for Puget Sound steelhead.

7.6.5 EFH Analysis

Proposed actions may have short-term, highly localized effects to the EFH of several federally managed species (Table 3) commonly found in nearshore littoral areas (e.g., English sole, rock sole, starry flounder). There is also the possibility that juvenile and subadult rockfish may be attracted to the proposed overwater structure. These species will likely be temporarily displaced from the pier footprint during the 2-month construction period, after which recolonization would occur. Food resources may be reduced until benthic and epibiota have the chance to recolonize. As reported, recolonization by invertebrates is expected to occur quickly. Permanent loss of benthic and epibenthic fauna will be small and limited to areas where piles are placed. No permanent alteration of existing EFH will occur outside of the 100-foot intervals of pile replacement in the littoral zone. This placement interval is not expected to interfere with the natural drift cell in the region along the Toandos Peninsula (Anchor 2003).

8.0 INTERDEPENDENT, INTERRELATED, AND CUMULATIVE EFFECTS

Interdependent effects are defined as actions with no independent utility apart from the proposed action. Interrelated effects include those that are a part of a larger action and depend on the larger action for justification.

The transport of sand and gravel from the Shine Pit and MLA will continue with or without this project. An environmental impact statement will address the potential impacts of transporting a similar quantity of materials by truck. Regardless of the method of delivery, only a permitted source of materials will be used.

If the proposed conveyor were constructed, up to six vessels each day (plus tugboats) will use the pier, depending upon specific demand for materials. The proposed action is not expected to affect other commercial marine traffic operating in the vicinity. Minor impacts to recreational fisheries may occur as a result of recreational boats avoiding both large vessels bound for the pier and small areas in the immediate vicinity of the proposed pier alignment. Also, the proposed action will not significantly increase the risk of oil spills or other environmental hazards associated with collisions between marine vessels. The US Coast Guard and American Waterways Operators investigated the prevalence and causes of bridge allisions involving barges and towing vessels, and developed recommendations to prevent allisions and mitigate their consequences (USCG and AWO 2003; see Appendix J). Incorporation of these recommendations into the operations of the proposed project may further reduce the potential for oil and fuel spills as a result of allisions with Hood Canal Bridge (which had only occurred one time during the 10-year study period; USCG and AWO 2003).

In the event that sand and gravel were spilled from a loaded vessel during transport from the proposed pier, the sand and gravel will pose negligible risk to marine biota, particularly in the nearshore environment. Vessels will normally travel in established shipping lanes located in deep water, where any sand and gravel spillage would likely dissipate.

The anticipated use of sands and gravels from the site for the restoration or re-nourishment of beaches around Puget Sound is an inter-related activity associated with the proposed project. The Applicant has pledged to make a large volume of source material from the site available for restoration actions subject to other separate environmental review and related permit approvals that would be required in the future. The proposed marine loading facility is essential to allowing efficient delivery of these materials to large-volume restoration sites on a long-term basis.

Cumulative effects are those effects of future state or private activities, not involving federal activities, that are reasonably certain to occur within the action area of the federal action subject to consultation. This definition applies only to Section 7 analyses and should not be confused with the broader use of this term under the National Environmental Policy Act or other environmental laws (50 CFR 402.02 Definitions).

No significant reasonably foreseeable future state or private activities have been identified in the action area of the proposed project. Future federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to Section 7 of the ESA. Although there is no requirement to evaluate cumulative effects from federal projects within this BE, the following summary briefly describes potential cumulative effects associated with a US Navy project involving construction of an Explosive Handling Wharf (EHW-2) near, but outside, the proposed project's action area (US Navy 2012).

In the Navy project, effects related to underwater noise and nearshore habitat displacement were two key issues described in the Final Environmental Impact Statement. No cumulative effects associated with underwater noise will result from construction of the EHW-2 as this action will occur outside the construction period for this proposed project. There also will be no cumulative effects to nearshore habitats because habitat displacement resulting from the EHW-2 project is outside the action area for the proposed project. Furthermore, the EIS for the EHW-2 project concluded that there would be no cumulative effects resulting from the proposed Thorndyke Resource project (US Navy 2012).

9.0 CONSERVATION MEASURES

The Thorndyke Resource Operations Complex Central Conveyor and Pier is proposed as an alternative that will avoid or minimize the overall impacts of transporting similar quantities of sand and gravel by trucks.

In addition to anticipated project construction windows, the proposed Central Conveyor and pier have been designed to avoid or minimize impacts to ESA-listed species and their critical habitat.

Timing Windows. A primary factor reducing the risk of impact to juvenile salmonids is the restriction of in-water construction to periods when few juveniles are present in the work area. Construction of the pier and gantry will occur within the approved agency work window for this area (anticipated to be July 16 to February 15).

Best Management Practices. A selection of routine and site-specific BMPs will be implemented during project construction and operation. Specific measures will be determined during the final design and construction phases of the project. Proposed measures will include those associated with grading, soil management, and erosion control; stormwater and wastewater management; spill prevention, control, and recovery; solid waste management; concrete use; dust control, and vegetation management including control of non-indigenous species. Anticipated measures will be similar to those developed by King County, Ecology, and the Washington State Department of Transportation (King County 2013; Ecology 2012; WSDOT 2004). The selected measures also will comply with requirements of Ecology's Section 401 Water Quality Certification issued for the project. A comprehensive description of proposed BMPs will be included in the forthcoming CMMP.

Design Features. Alignment and location of the pier were carefully chosen to avoid impacts to riparian marsh areas and to native eelgrass *Z. marina*; however, it was not possible to design a pier that does not cross a portion of non-native Japanese eelgrass. The conveyor support frame and pier will be constructed largely of open steel girders to minimize shading effects on this species.

Orientation, height above water, and narrowness of the structure also will minimize the potential for shading effects, which are considered to be unlikely.

However, timing windows and design features cannot fully eliminate the potential for adverse effects to these species or their habitats. To address these potential unavoidable effects, the Applicant will work with regulatory agencies to determine measures that will ensure no long-term loss of nearshore productivity results from the project, and to provide compensatory mitigation for any temporal losses that may occur. A comprehensive description of BMPs, conservation and avoidance measures, and proposed mitigation will be included in the forthcoming CMMP.

Construction Monitoring. To further minimize potential effects to Steller sea lions and marbled murrelets, a Construction Monitoring Plan will be developed for each species and would be implemented during construction. These plans would outline activities to monitor the presence of Steller sea lions (and other marine mammals, including harbor seals and California sea lions) and marbled murrelets within designated disturbance and injury zones. If these species are spotted within their respective injury zones, pile driving will would cease, until the animals/birds have left the zones. The size of the disturbance and injury zones would be determined consultation with USFS and NOAA/NMFS. Adherence to the Construction Monitoring Plans will minimize the potential behavioral and injurious effects to Steller sea lions and marbled murrelets as the result of pile driving and construction activities.

10.0 DETERMINATION OF EFFECT

NOAA Fisheries/USFWS guidelines for the preparation of biological evaluations state that a conclusion of “may affect, but is not likely to adversely affect” is the “...appropriate conclusion when the effects on the species or critical habitat are expected to be beneficial, discountable, or insignificant. Beneficial effects have contemporaneous positive effects without any adverse effects....” Insignificant effects, in the NOAA Fisheries/USFWS definition, “...relate to the size of the impacts and should never reach the size where take occurs...[One would not expect to]...be able to meaningfully measure, detect, or evaluate insignificant effects.” Based on the analyses in this biological evaluation, the expected nature and level of the impacts of the proposed project follow.

Although the conclusion of this BE regarding salmonids is focused on Chinook salmon and Hood Canal summer-run chum salmon, it is applicable to listed steelhead and bull trout as well. However, because of their lesser dependence on nearshore habitat and their briefer estuarine residency, these species will be less affected by both the negative and positive aspects of each project component. A summary of the effect determinations for each of the relevant ESA-listed species potentially occurring in the action area is presented below, followed by conclusions regarding the potential effects of the project on these species.

Puget Sound Chinook salmon – The project **may affect, but is not likely to adversely affect** this species or its critical habitat.

Hood Canal summer-run chum salmon – The project **may affect, but is not likely to adversely affect** this species or its critical habitat.

Puget Sound steelhead – The project **may affect, but is not likely to adversely affect** this species or its proposed critical habitat.

Coastal-Puget Sound bull trout – The project **may affect, but is not likely to adversely affect** this species.

Bocaccio – The project **may affect, but is not likely to adversely affect** this species.

Canary rockfish – The project **may affect, but is not likely to adversely affect** this species.

Yelloweye rockfish – The project **may affect, but is not likely to adversely affect** this species.

Marbled murrelet – The project **may affect, but is not likely to adversely affect** this species. The project will have **no effect** on marbled murrelet critical habitat.

Northern spotted owl – The project will have **no effect** on this species or its critical habitat.

Steller sea lion – The project **may affect, but is not likely to adversely affect** this species.

10.1 Salmonids

The net effect of the proposed actions in the action area will be to maintain the indicators for each of the pathways relative to their current conditions (Table 4). Short-term localized water quality degradation during construction will not impact habitat for juvenile salmonids because of the short-term nature of the effects on water quality and because of seasonal work restrictions; thus, current water quality conditions will be maintained in the long term. Noise generated from pile driving activities has the potential to disturb or displace salmonids, but injury is not anticipated given the methods of pile installation and the results of past studies on underwater sound levels and direct impacts to caged fish during pile driving in Puget Sound and Hood Canal. Potential noise impacts will be further reduced as construction will be conducted during the anticipated approved work windows when few juvenile salmonids are present in the nearshore (July 16 to February 15).

However, the proposed actions will result in long-term degradation of marine habitat through placement of overwater structures, including permanent loss of benthic habitat in the footprint of each pile, which will reduce potential food sources for salmonids. However, this loss will be offset by pilings providing a substantially greater area of hard surface for attachment of epibenthic plants and animals that will greatly exceed the lost benthic primary and secondary productivity. Resulting analysis in this BE concludes that the proposed project **may affect, but is not likely to adversely affect**, Puget Sound Chinook salmon, Hood Canal summer-run chum salmon, Puget Sound steelhead or Coastal-Puget Sound bull trout. Further, the proposed project **may affect, but is not likely to adversely affect** critical habitat for Puget Sound Chinook salmon or Hood Canal summer-run chum salmon. Finally, no adverse impacts to the surface or groundwater in the upland action area are anticipated; therefore, the proposed project **may affect, but is not likely to adversely affect** proposed critical habitat for Puget Sound steelhead.

10.2 Rockfish

Bocaccio, canary rockfish, and yelloweye rockfish, if present in Hood Canal, likely use offshore habitats removed from any nearshore water quality effects during construction. These disturbances will not impact habitat for these three species of rockfish because of the short-term nature of the effects on water quality; thus, there will be no long-term adverse effects on current water quality conditions. Adult ESA-listed rockfish reside in waters deeper than 120 feet; they are therefore not expected to be affected by project activities due to the distance of habitat at these depths from the project and attenuation of sound. Although noise generated from pile driving activities has the potential to injure or kill larval rockfish, concentrations of larval rockfish within the injury zone for fish will be so low (due to habitat characteristics of Hood Canal) that any potential adverse effects would be negligible. Thus, any injury or deaths of several larvae would not be expected to affect the viability of the three listed species of rockfish. Resulting analysis in this BE supports the conclusion that the proposed project **may affect, but is not likely to adversely affect** bocaccio, canary rockfish, and yelloweye rockfish.

10.3 Marbled Murrelet

Inland construction and operational disturbances are relatively low and will not reach nesting habitats in the Olympic Mountain foothills. Increases in vessel traffic will be limited to an additional 6 barges a day, which will have little effect on murrelet foraging patterns.

Noise generated from pile driving activities has the potential to disturb or displace marbled murrelet, but injury is not anticipated given the methods of installation, the small injury zone (2 meters), and measures designed to minimize the possibility of injury to marbled murrelet. Marbled murrelet presence has been documented in the action area, albeit in small numbers. Therefore, the likelihood of their presence near the vicinity of the proposed pier is low, further reducing any potential effects from the project.

Potential noise impacts will be further reduced as a construction monitoring plan will be implemented specifically to monitor for marbled murrelets occurring within disturbance and injury zones. Resulting analysis in the BE concludes that the proposed project **may affect, but is not likely to adversely affect** marbled murrelet. The proposed project will have **no effect** on marbled murrelet critical habitat as these areas are far removed from the project site.

10.4 Northern Spotted Owl

Inland construction and operational disturbances are relatively low and will not reach nesting habitats in the Olympic foothills or roosting habitats along Quilcene Bay. Project activities will not affect northern spotted owl habitat quality or prey base. Thus, the proposed project will have **no effect** on northern spotted owl or the species' critical habitat.

10.5 Steller Sea Lion

Noise generated from pile driving activities has the potential to disturb or displace Steller sea lions, but injury is not anticipated given the methods of installation and measures designed to minimize the possibility of injury to this species. Although Steller sea lions are not common in Hood Canal, their presence has been documented in recent years, albeit in small numbers. Therefore, the likelihood of their presence near the proposed pier is low, further reducing any potential effects from the project.

Construction activities may cause disturbance to forage fish near the proposed pier alignment, resulting in decreased foraging opportunities for Steller sea lion. However, any potential disturbances will be short-term and localized, and Steller sea lion will have ample opportunity to forage in other nearby areas. Resulting analysis in this BE concludes that the proposed project **may affect, but is not likely to adversely affect** Steller sea lion.

10.6 Essential Fish Habitat

Proposed actions may have short-term, highly localized effects to the EFH of several federally managed species (Table 3) commonly found in nearshore littoral areas (e.g., English sole, rock sole, starry flounder). No measureable net impacts to EFH are likely to occur as a result of highly localized and temporary impacts to water quality during construction. In addition, all work will be conducted during agency-approved work windows for listed Puget Sound Chinook salmon and Hood Canal summer-run chum salmon. Permanent loss of benthic and epibenthic fauna will be small and limited to areas where piles are placed. However, this loss will be offset by pilings providing a substantially greater area of hard surface for attachment of epibenthic plants and animals that will greatly exceed the lost benthic primary and secondary productivity. No permanent alteration of existing EFH will occur outside of the 100-foot intervals of pile replacement in the littoral zone. Therefore, the proposed project will have a more than minimal, but less than substantial, effect on EFH over the short term (construction period), and will have no long-term effects on EFH.

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TABLES

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Table 1 – ESA-Listed Species Documented Near the Project and Action Areas

Species	Listing Status	ESA Agency	Date of Listing	Critical Habitat in Action Area
Puget Sound Chinook salmon (*Oncorhynchus tshawytscha)*	Threatened	NOAA	March 24, 1999	Yes, designated September 2, 2005
Hood Canal Summer-run chum salmon (*O. keta*)	Threatened	NOAA	March 25, 1999	Yes, designated September 2, 2005
Puget Sound Steelhead Trout (*O. mykiss*)	Threatened	NOAA	May 11, 2007	Yes, proposed January 14, 2013
Southern resident Killer Whale (*Orcinus orca*)	Endangered	NOAA	November 18, 2005	No
Steller sea lion *(Eumetopias jubatus)*	Threatened	NOAA	April 5, 10090	No
Humpback whale *(Megaptera novaeangliae)*	Threatened	NOAA	June 2, 1970	No
Coastal-Puget Sound Bull trout (*Salvelinus confluentus*)	Threatened	USFWS	December 1, 1999	No
Marbled murrelet *(Brachyramphus marmoratus)*	Threatened	USFWS	October 1 1992	No
Northern spotted owl (*Strix occidentalis caurina)*	Threatened	USFWS	June 23, 1989	No
Leatherback turtle *(Dermochelys coriacea)*	Threatened	NOAA	June 2, 1970	No
Loggerhead sea turtle *(Caretta caretta)*	Threatened	NOAA	June 2, 1970	No
Green sea turtle *(Chelonia mydas)*	Threatened	NOAA	June 2, 1970	No
Olive Ridley sea turtle *(Lepidochelys olivacea)*	Threatened	NOAA	June 2, 1970	No
Bocaccio (*Sebastes paucispinis)*	Endangered	NOAA	April 28, 2010	No
Canary rockfish *(S. pinniger)*	Threatened	NOAA	April 28, 2009	No
Yelloweye rockfish *(S. ruberrimus)*	Threatened	NOAA	April 28, 2010	No
Pacific eulachon (*Thaleichthys pacificus*)	Threatened	NOAA	March 18, 2010	No
Green sturgeon –Southern DPS (*Acipenser medirostris*)	Threatened	NOAA	April 7, 2006	No

Table 2 – ESA-Listed Salmonid Stocks Within Hood Canal

Salmonid Stock	Spawn Timing	Stock Type	Status
Chinook			
Skokomish	mid Sept - late Oct	Hatchery/Native Composite	Depressed
Mid-Hood Canal	early to late Oct	Hatchery/Native Composite	Critical
Summer Chum			
Union	mid Sept - mid Oct	Hatchery/Native Composite	Healthy
Lilliwaup Creek	mid Sept - mid Oct	Hatchery/Native Composite	Critical
Hamma Hamma	mid Sept - mid Oct	Hatchery/Native Composite	Depressed
Duckabush	mid Sept - mid Oct	Hatchery/Native Composite	Depressed
Dosewallips	mid Sept - mid Oct	Hatchery/Native Composite	Depressed
Big/Little Quilcene	mid Sept - mid Oct	Hatchery/Native Composite	Depressed
Anderson Creek	mid Sept - mid Oct	Native	Extinct
Big Beef Creek	mid Sept - mid Oct	Native	Extinct
Tahuya	mid Sept - mid Oct	Native	Extinct
Dewatto	mid Sept - mid Oct	Native	Extinct
Skokomish	mid Sept - mid Oct	Native	Extinct
Finch Creek	mid Sept - mid Oct	Native	Extinct
Skokomish	mid Sept - mid Oct	Native	Extinct
Finch Creek	mid Sept - mid Oct	Native	Extinct
Big/Little Quilcene	mid Sept - mid Oct	Unknown	Unknown
Steelhead			
Dewatto	mid Feb - early June	Unknown	Depressed
Tahuya	early Mar - early June	Unknown	Depressed
Union	mid Feb - early June	Unknown	Unknown
Skokomish	early Feb - late April	Unknown	Depressed
Hamma Hamma	mid Feb - mid June	Native	Depressed
Bull Trout			
N. Fork Skokomish	mid-Oct - mid Nov	Native/Resident	Unknown
Lake Cushman	mid-Oct - mid Nov	Native/Adfluvial	Healthy
S. Fork Skokomish	mid-Oct - mid Nov	Native/Anadromous	Unknown

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Source: WDFW GIS database Salmonscape

Table 3 - Species of Fish with Designated Essential Fish Habitat in the Project Area

Groundfish Species
spiny dogfish, *Squalus acanthias*
big skate, *Raja binoculata*
California skate, *R. inornata*
longnose skate, *R. rhina*
spotted ratfish, *Hydrolagus colliei*
Pacific cod, *Gadus macrocephalus*
Pacific hake, *Merluccius productus*
black rockfish, *Sebastes melanops*
bocaccio, *S. paucispinis*
brown rockfish, *S. auriculatus*
canary rockfish, *S. pinniger*
China rockfish, *S. nebulosus*
copper rockfish, *S. caurinus*
darkblotched rockfish, *S. crameri*
greenstriped rockfish, *S. elongatus*
Pacific ocean perch, *S. alutus*
quillback rockfish, *S. maliger*
redbanded rockfish, *S. babcocki*
redstripe rockfish, *S. proriger*
rosethorn rockfish, *S. helvomaculatus*
rosy rockfish, *S. rosaceus*
rougheye rockfish, *S. aleutianus*
sharpchin rockfish, *S. zacentrus*
splitnose rockfish, *S. diploproa*
stripetail rockfish, *S. saxicola*
tiger rockfish, *S. nigrocinctus*
vermilion rockfish, *S. miniatus*
yelloweye rockfish, *S. ruberrimus*
yellowtail rockfish, *S. flavidus*
shortspine thornyhead, *Sebastolobus alascanus*
cabezon, *Scorpaenichthys marmoratus*
lingcod, *Ophiodon elongatus*
kelp greenling, *Hexagrammos decagrammus*
sablefish, *Anoplopoma fimbria*
jack mackerel, *Trachurus symmetricus*
Pacific sanddab, *Citharichthys sordidus*
butter sole, *Pleuronectes isolepis*
curlfin sole, *Pleuronichthys decurrens*
Dover sole, *Microstomus pacificus*
English sole, *Pleuronectes vetulus*
flathead sole, *Hippoglossoides elassodon*
petrale sole, *Eopsetta jordani*
rex sole, *Errex zachirus*
rock sole, *Pleuronectes bilineata*
sand sole, *Psettichthys melanostictus*
starry flounder, *Platichthys stellatus*
arrowtooth flounder, *Atheresthes stomias*
Coastal Pelagic Species
northern anchovy, *Engraulis mordax*
Pacific sardine, *Sardinops sagax*
chub mackerel, *Scomber japonicus*
market squid, *Loligo opalescens*
Salmonid Species
Chinook salmon, *Oncorhynchus tshawytscha*
coho salmon, *O. kisutch*
Puget Sound pink salmon, *O. gorbuscha*

Table 4 - Effects of Project Activities on Habitats used by Salmonids in the Project and Action Areas

Project Activities	Habitat Indicator	Effects of Action: Improve[1]	Maintain[2]	Degrade[3]
Construction Disturbances	Noise		X	
	Entrainment		X	
	Stranding		X	
Water Quality Disturbance	Turbidity		X	
	Chemical contamination/nutrients		X	
	Temperature		X	
	Dissolved oxygen		X	
Sediment Disturbance	Sedimentation sources/rates		X	
	Sediment quality		X	
Habitat Disturbance	Fish access/refugia		X	
	Depth		X	
	Substrate		X	
	Slope		X	
	Shoreline		X	
	Riparian conditions		X	
	Flow and hydrology/current patterns/ saltwater–freshwater mixing patterns		X	
	Overwater structures		X	
	Disturbance		X	
Biota Disturbance	Prey—epibenthic and pelagic zooplankton		X	
	Infauna		X	
	Prey—forage fish		X	
	Aquatic/wetland vegetation		X	
	Nonindigenous species		X	
	Ecological diversity		X	

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Notes:

1 Action will contribute to long-term improvement, over existing conditions, of the habitat indicator.

2 Action will maintain existing conditions.

3 Action will contribute to long-term degradation, over existing conditions, of the habitat indicator.

FIGURES

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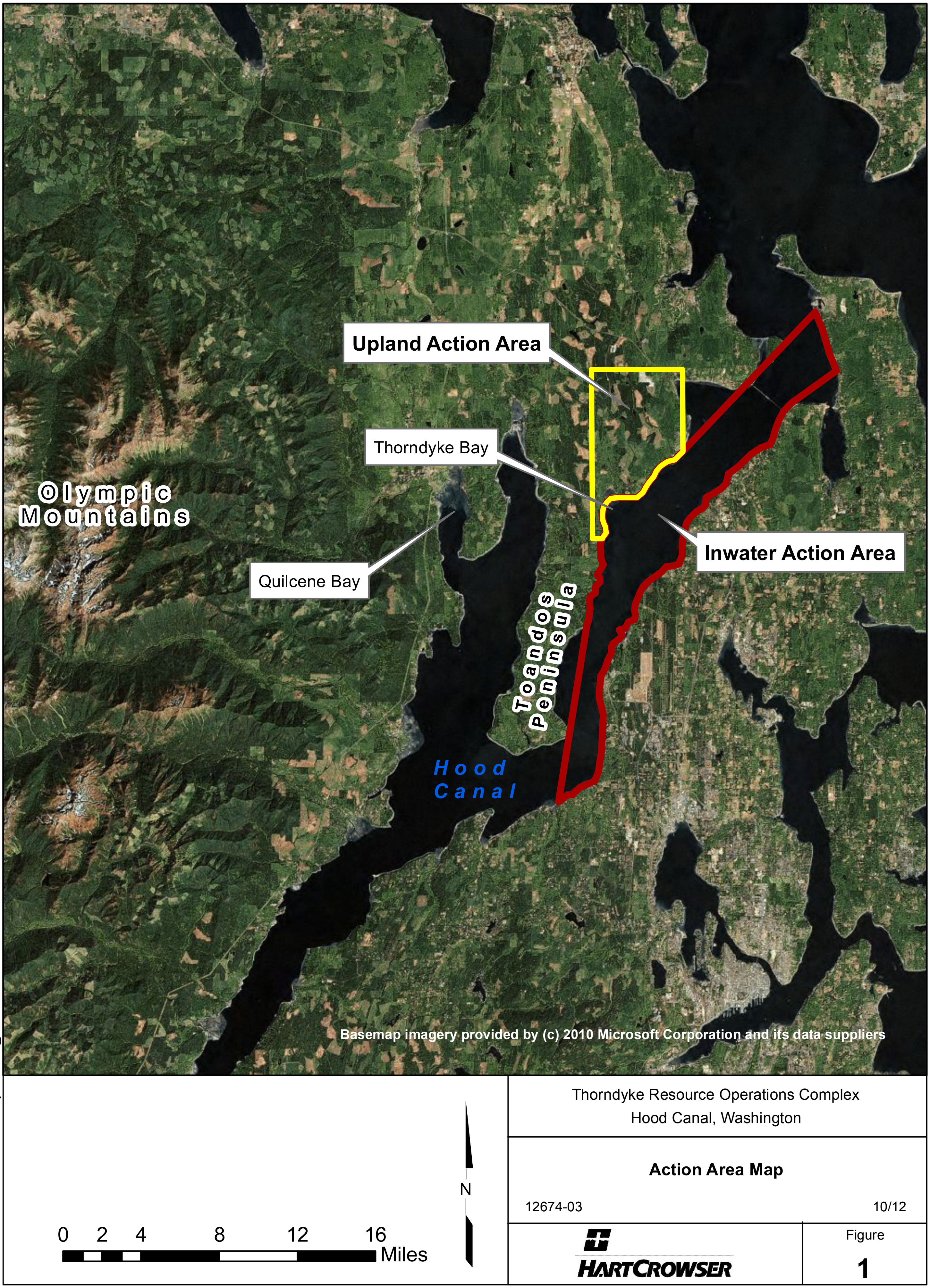

Thorndyke Resource Operations Complex
Hood Canal, Washington

Action Area Map

12674-03 10/12

HARTCROWSER

Figure 1

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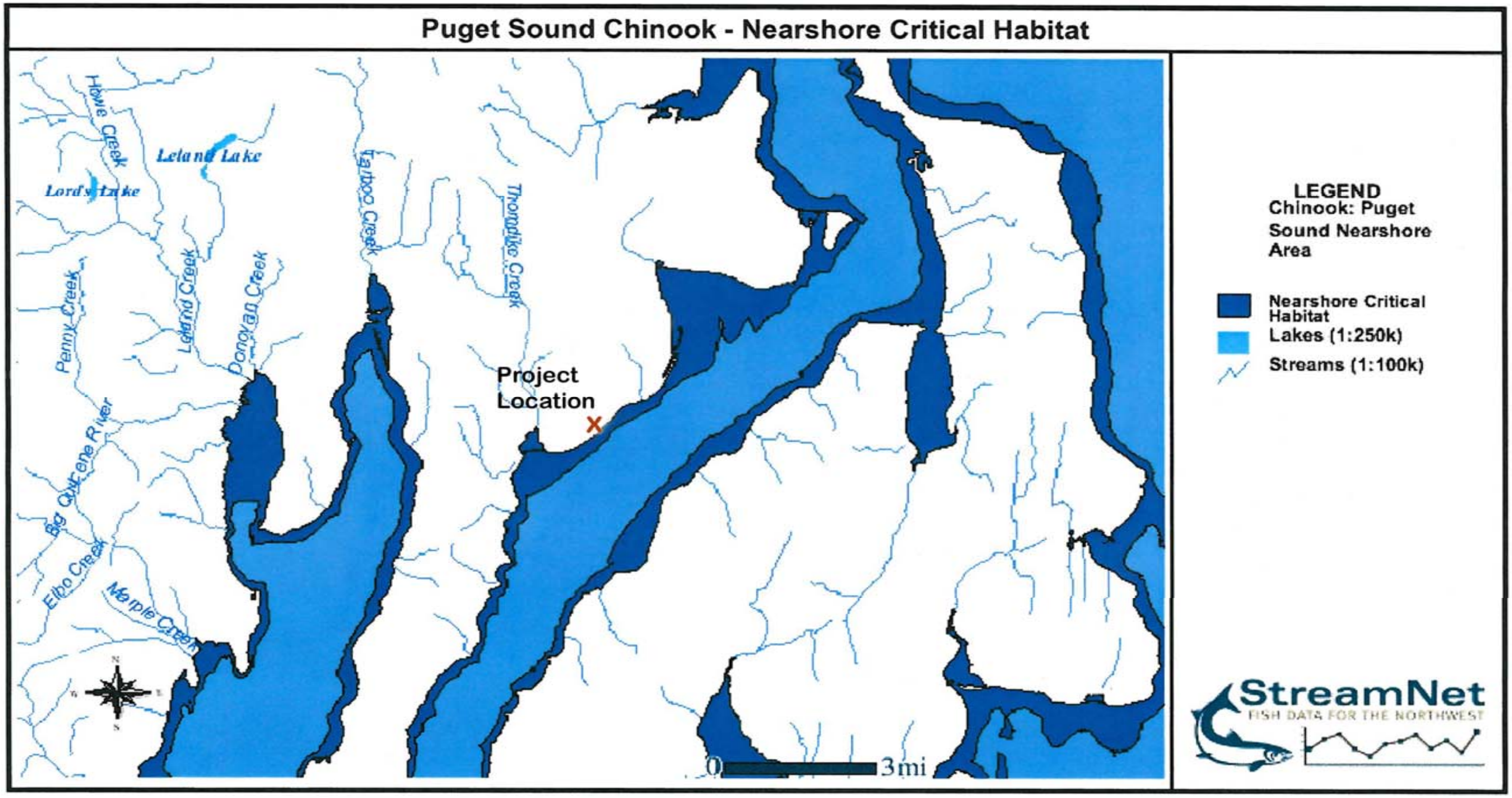

Thorndyke Resource
Hood Canal, Washington

Puget Sound Chinook Salmon
Nearshore Critical Habitat

12674-04 06/13

HARTCROWSER

Figure
2

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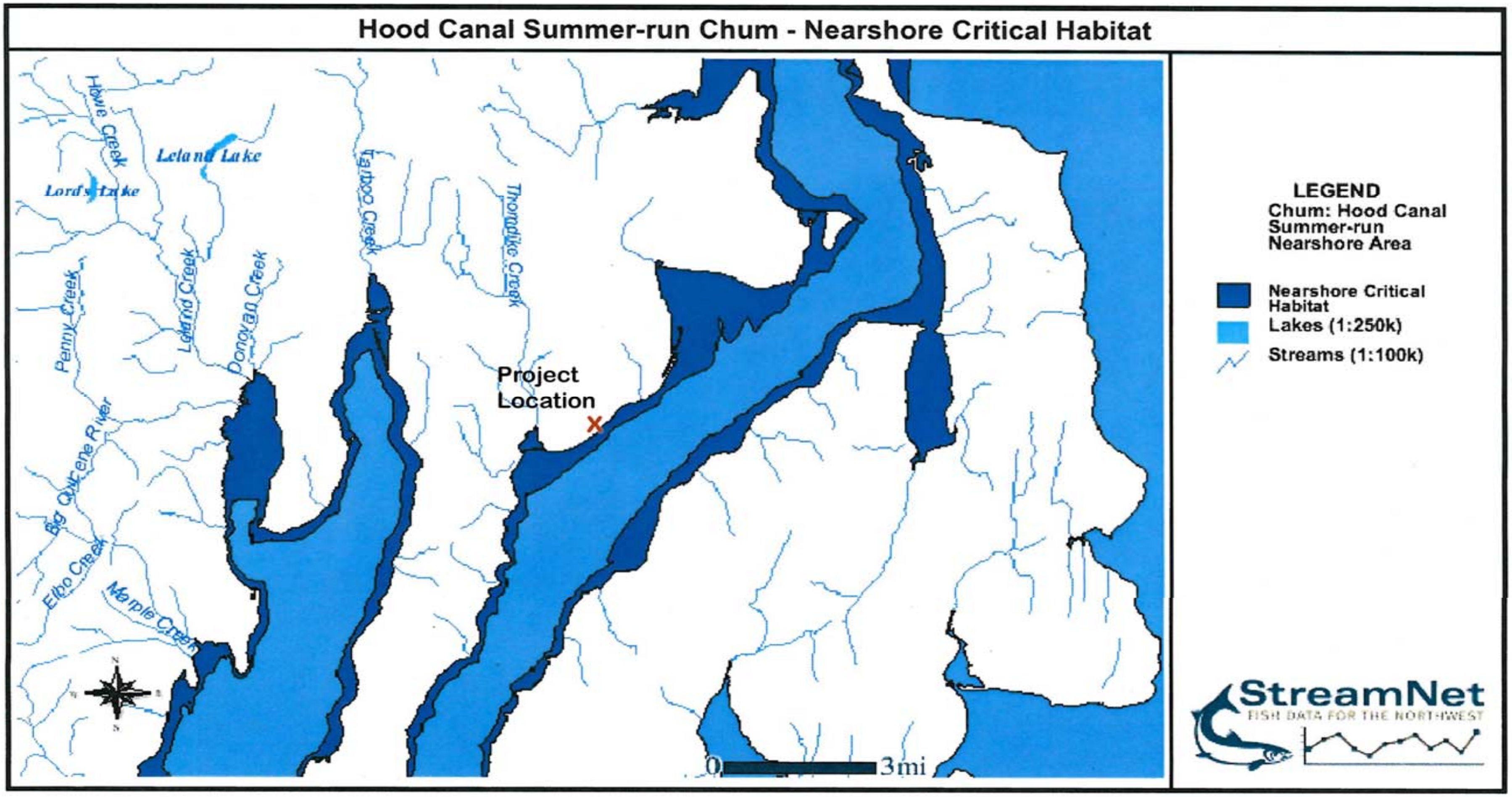

Thorndyke Resource
Hood Canal, Washington

Hood Canal Summer-run Chum Salmon
Nearshore Critical Habitat

12674-04 06/13

HARTCROWSER

Figure **3**

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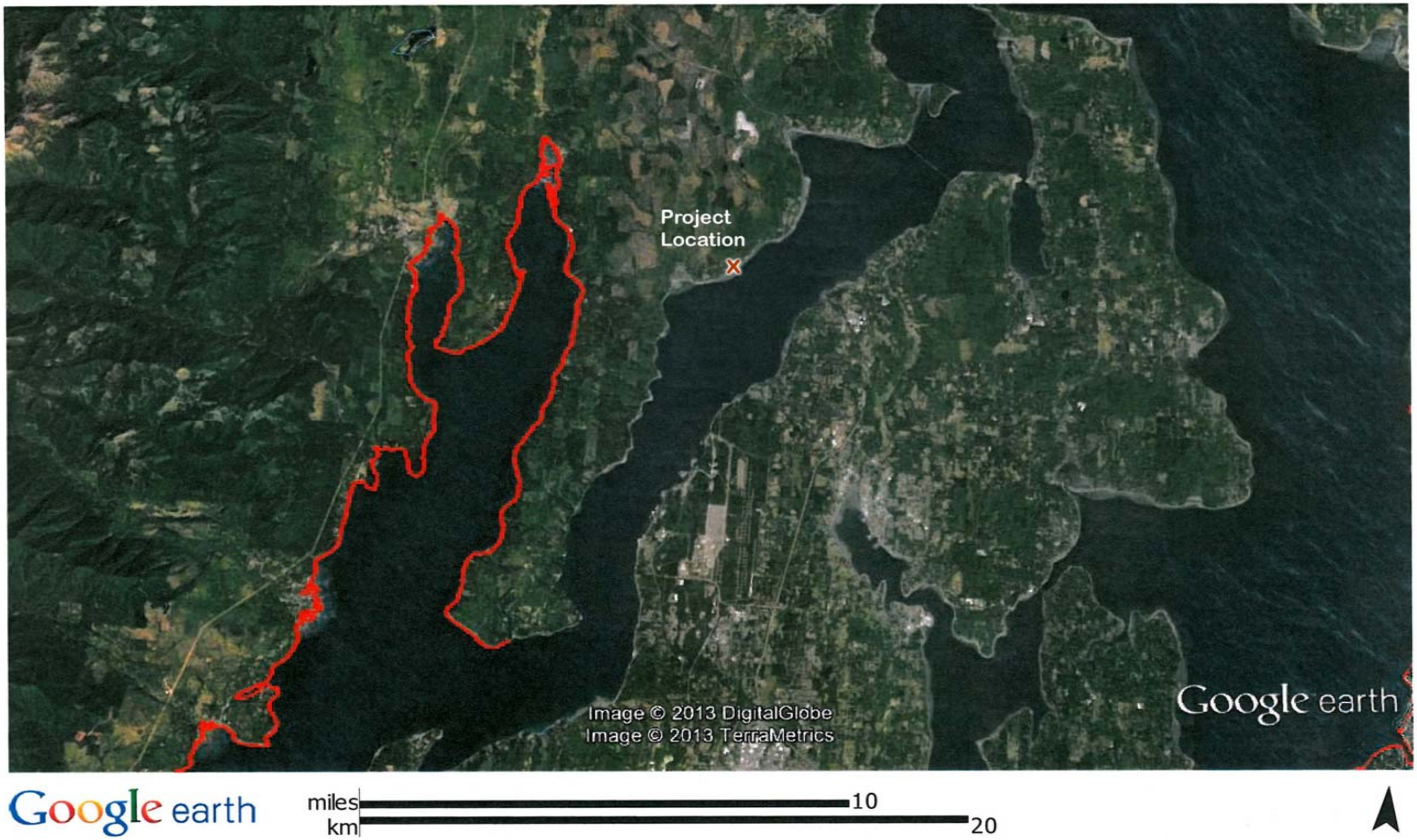

Thorndyke Resource
Hood Canal, Washington

Coastal-Puget Sound Bull Trout Nearshore Critical Habitat

12674-04

06/13

HARTCROWSER

Figure

4

W:\CLIENTS.WP\00674\004\Thorndyke BE 06-20-2013\New Figures\Figures 2-5.xls

The Department of Fish and Wildlife makes no guarantee concerning the data's content, accuracy, completeness, or the results obtained from queries or use of the data. WDFW makes no warranty of fitness for a particular purpose, no representation as to the quality of any data, and assumes no liability for the data represented here. These data do not represent exhaustive inventories, but are compilations of existing knowledge from field biologists that are updated periodically as knowledge improves. These data should be used cautiously because they are not exhaustive, and are subject to change. When conducting projects or planning for fish and wildlife, please consider using additional information gathered from field investigations and consultations with WDFW or other professional biologists.

The Department of
Fish and Wildlife
Olympia, Washington

Generated by SalmonScape Web Application - Wednesday, June 19, 2013 1:41:41 PM

Thorndyke Resource
Hood Canal, Washington

Sand Lance Spawning Locations

12674-04 06/13

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Figure

5

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APPENDIX A
AGENCY CORRESPONDENCE

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Endangered Species Act Status of West Coast Salmon & Steelhead

(Updated Aug. 11, 2011)

Species[1]			***Current Endangered Species Act Listing Status***[2]	***ESA Listing Actions Under Review***
Sockeye Salmon (*Oncorhynchus nerka*)	1	Snake River	***Endangered***	
	2	Ozette Lake	***Threatened***	
	3	Baker River	*Not Warranted*	
	4	Okanogan River	*Not Warranted*	
	5	Lake Wenatchee	*Not Warranted*	
	6	Quinalt Lake	*Not Warranted*	
	7	Lake Pleasant	*Not Warranted*	
Chinook Salmon (*O. tshawytscha*)	8	Sacramento River Winter-run	***Endangered***	
	9	Upper Columbia River Spring-run	***Endangered***	
	10	Snake River Spring/Summer-run	***Threatened***	
	11	Snake River Fall-run	***Threatened***	
	12	Puget Sound	***Threatened***	
	13	Lower Columbia River	***Threatened***	
	14	Upper Willamette River	***Threatened***	
	15	Central Valley Spring-run	***Threatened***	
	16	California Coastal	***Threatened***	
	17	Central Valley Fall and Late Fall-run	***Species of Concern***	
	18	Upper Klamath-Trinity Rivers	*Not Warranted*	
	19	Oregon Coast	*Not Warranted*	
	20	Washington Coast	*Not Warranted*	
	21	Middle Columbia River spring-run	*Not Warranted*	
	22	Upper Columbia River summer/fall-run	*Not Warranted*	
	23	Southern Oregon and Northern California Coast	*Not Warranted*	
	24	Deschutes River summer/fall-run	*Not Warranted*	
Coho Salmon (*O. kisutch*)	25	Central California Coast	***Endangered***	
	26	Southern Oregon/Northern California	***Threatened***	
	27	Lower Columbia River	***Threatened***	• Critical habitat
	28	Oregon Coast	***Threatened***	
	29	Southwest Washington	*Undetermined*	
	30	Puget Sound/Strait of Georgia	***Species of Concern***	
	31	Olympic Peninsula	*Not Warranted*	
Chum Salmon (*O. keta*)	32	Hood Canal Summer-run	***Threatened***	
	33	Columbia River	***Threatened***	
	34	Puget Sound/Strait of Georgia	*Not Warranted*	
	35	Pacific Coast	*Not Warranted*	
Steelhead (*O. mykiss*)	36	Southern California	***Endangered***	
	37	Upper Columbia River	***Threatened***	
	38	Central California Coast	***Threatened***	
	39	South Central California Coast	***Threatened***	
	40	Snake River Basin	***Threatened***	
	41	Lower Columbia River	***Threatened***	
	42	California Central Valley	***Threatened***	
	43	Upper Willamette River	***Threatened***	
	44	Middle Columbia River	***Threatened***	
	45	Northern California	***Threatened***	
	46	Oregon Coast	***Species of Concern***	
	47	Southwest Washington	*Not Warranted*	
	48	Olympic Peninsula	*Not Warranted*	
	49	Puget Sound	***Threatened***	• Critical habitat
	50	Klamath Mountains Province	*Not Warranted*	
Pink Salmon (*O. gorbuscha*)	51	Even-year	*Not Warranted*	
	52	Odd-year	*Not Warranted*	

1 The ESA defines a "species" to include any distinct population segment of any species of vertebrate fish or wildlife. For Pacific salmon, NOAA Fisheries Service considers an evolutionarily significant unit, or "ESU," a "species" under the ESA. For Pacific steelhead, NOAA Fisheries Service has delineated distinct population segments (DPSs) for consideration as "species" under the ESA.

ESA-Listed Marine Mammals

Under the jurisdiction of NOAA Fisheries that may occur:

off Washington & Oregon

- Southern Resident killer whale (*Orcinus orca*) (E); critical habitat
- humpback whale *(Megaptera novaeangliae)* (E)
- blue whale *(Balaenoptera musculus)* (E)
- fin whale (*Balaenoptera physalus)* (E)
- sei whale (*Balaenoptera borealis)* (E)
- sperm whale (*Physeter macrocephalus)* (E)
- Steller sea lion *(Eumetopias jubatus)* (T); critical habitat

in Puget Sound

- Southern Resident killer whale (*Orcinus orca*) (E); critical habitat
- humpback whale *(Megaptera novaeangliae)* (E)
- Steller sea lion *(Eumetopias jubatus)* (T); critical habitat

(E) = Endangered
(T) = Threatened

7600 Sand Point Way NE, Seattle, WA 98115-0070
Regional Receptionist: 206-526-6150
Email: Content Manager

Page last updated: August 24, 2012

Northwest Regional Office

NOAA's National Marine Fisheries Service

ESA Salmon Listings | ESA Regulations & Permits | Salmon Habitat | Salmon Harvest & Hatcheries | Marine Mammals
Salmon & Hydropower | Salmon Recovery Planning | Groundfish & Halibut | Permits & Other Marine Species

Home > Other Marine Species > ESA Other List

Search

Other ESA-Listed Species

Under the jurisdiction of NOAA Fisheries that may occur off Washington & Oregon:

- distinct population segment, or DPS, of bocaccio *(Sebastes paucispinis)* (E) in Puget Sound
- distinct population segment, or DPS, of canary rockfish *(Sebastes pinniger)* (T) in Puget Sound
- distinct population segment, or DPS, of yelloweye rockfish *(Sebastes ruberrimus)* (T) in Puget Sound
- southern distinct population segment, or DPS, of eulachon (Columbia River smelt) *(Thaleichthys pacificus)* (T)
- southern distinct population segment, or DPS, of north American green sturgeon *(Acipenser medirostris)* (T), listed in the NOAA Fisheries Southwest Region

(E) = Endangered
(T) = Threatened

Search NOAA Fisheries

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Publications

Biological Opinions

Public Consultation Tracking System (PCTS)

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Page last updated: August 24, 2012

ESA-Listed Marine Turtles

Under the jurisdiction of NOAA Fisheries that may occur off Washington & Oregon:

- leatherback sea turtle *(Dermochelys coriacea)* (E)
- green sea turtle (*Chelonia mydas)* (E)
- olive ridley sea turtle (*Lepidochelys olivacea)* (E)
- loggerhead sea turtle *(Caretta caretta)* (T)

Sightings and strandings of these animals are very rare, and there are no breeding beaches in the Northwest Region.

(E) = Endangered
(T) = Threatened

Jan. 20, 2012: NOAA designates additional critical habitat for leatherback sea turtles off West Coast

- News release *(PDF 218KB -- links to NOAA Fisheries Website)*
- Jan. 26, 2012, *Federal Register* notice *(PDF 4MB)*

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Page last updated: August 24, 2012

LISTED AND PROPOSED ENDANGERED AND THREATENED SPECIES AND CRITICAL HABITAT; CANDIDATE SPECIES; AND SPECIES OF CONCERN IN JEFFERSON COUNTY AS PREPARED BY THE U.S. FISH AND WILDLIFE SERVICE WASHINGTON FISH AND WILDLIFE OFFICE

(Revised March 15, 2012)

LISTED

Bull trout *(Salvelinus confluentus)*
Marbled murrelet *(Brachyramphus marmoratus)*
Northern spotted owl *(Strix occidentalis caurina)*
Short-tailed albatross *(Phoebastria albatrus)* [outer coast]

Major concerns that should be addressed in your Biological Assessment of project impacts to listed animal species include:

1. Level of use of the project area by listed species.

2. Effect of the project on listed species' primary food stocks, prey species, and foraging areas in all areas influenced by the project.

3. Impacts from project activities and implementation (e.g., increased noise levels, increased human activity and/or access, loss or degradation of habitat) that may result in disturbance to listed species and/or their avoidance of the project area.

DESIGNATED

Critical habitat for bull trout
Critical habitat for the marbled murrelet
Critical habitat for the northern spotted owl

PROPOSED

Dolly Varden *(Salvelinus malma)* due to similarity of appearance

CANDIDATE

Fisher *(Martes pennanti)* – West Coast DPS
Whitebark pine *(Pinus albicaulis)*

SPECIES OF CONCERN

Aleutian Canada goose *(Branta canadensis leucopareia)*
Bald eagle *(Haliaeetus leucocephalus)*
Brown pelican *(Pelecanus occidentalis)* [outer coast]
Cascades frog *(Rana cascadae)*

Cassin's auklet *(Ptychoramphus aleuticus)*
Coastal cutthroat trout *(Oncorhynchus clarki clarki)* [southwest Washington DPS]
Destruction Island shrew *(Sorex trowbridgii destructioni)*
Long-eared myotis *(Myotis evotis)*
Long-legged myotis *(Myotis volans)*
Northern goshawk *(Accipiter gentilis)*
Northern sea otter *(Enhydra lutris kenyoni)*
Olive-sided flycatcher *(Contopus cooperi)*
Olympic torrent salamander *(Rhyacotriton olympicus)*
Pacific lamprey *(Lampetra tridentata)*
Pacific Townsend's big-eared bat *(Corynorhinus townsendii townsendii)*
Peregrine falcon *(Falco peregrinus)*
River lamprey *(Lampetra ayresi)*
Tailed frog *(Ascaphus truei)*
Tufted puffin *(Fratercula cirrhata)*
Valley silverspot *(Speyeria zerene bremeri)*
Van Dyke's salamander *(Plethodon vandykei)*
Western toad *(Bufo boreas)*

State of Washington
DEPARTMENT OF FISH AND WILDLIFE
Mailing Address: 600 Capitol Way N • Olympia, WA 98501-1091 • (360) 902-2200, TDD (360) 902-2207
Main Office Location: Natural Resources Building • 1111 Washington Street SE • Olympia, WA

Date: FEB 12 2003

Dear Habitats and Species Requester:

Enclosed are the habitats and species products you requested from the Washington Department of Fish and Wildlife (WDFW). This package may also contain documentation to help you understand and use these products.

These products only include information that WDFW maintains in a computer database. They are not an attempt to provide you with an official agency response as to the impacts of your project on fish and wildlife, nor are they designed to provide you with guidance on interpreting this information and determining how to proceed in consideration of fish and wildlife. These products only document the location of important fish and wildlife resources to the best of our knowledge. It is important to note that habitats or species may occur on the ground in areas not currently known to WDFW biologists, or in areas for which comprehensive surveys have not been conducted. Site-specific surveys are frequently necessary to rule out the presence of priority habitats or species.

Your project may require further field inspection or you may need to contact our field biologists or others in WDFW to assist you in interpreting and applying this information. Generally, for assistance on a specific project, you should contact the WDFW Habitat Program Manager for your county and ask for the area habitat biologist for your project area. Refer to the enclosed directory for those contacts.

Please note that sections potentially impacted by spotted owl management concerns are displayed on the 1:24,000 scale standard map products. If specific details on spotted owl site centers are required they must be requested separately.

These products are designed for users external to the forest practice permit process and as such, does not reflect all the information pertinent to forest practice review. The Forest Practice Rules adopted August 22, 1997 by the Forest Practice Board and administered by the Washington Department of Natural Resources require forest practice applications to be screened against marbled murrelet detection areas and detection sections. Marbled murrelet detection locations are included in the standard priority habitats and species products, but the detection areas and detection sections are not included. If your project is affected by Forest Practice Regulations, you should specially request murrelet detection areas.

WDFW updates this information as additional data become available. Because fish and wildlife species are mobile and because habitats and species information changes, project reviews for fish and wildlife should not rest solely on mapped information. Instead, they should also consider new information gathered from current field investigations. Remember, habitats and species information can only show that a species or habitat type is present, they cannot show that a species or habitat type is not present. These products should not be used for future projects. Please obtain updates rather than use outdated information.

Because of the high volume of requests for information that WDFW receives, we need to charge for these products to recover some of our costs. Enclosed is an invoice itemizing the costs for your request and instructions for submitting payment.

Please note that sensitive information (e.g., threatened and/or endangered species) may be included in this request. These species are vulnerable to disturbances and harassment. In order to protect the viability of these species we request that you not disseminate the information as to their whereabouts. Please refer to these species presence in general terms. For example: "A Peregrine Falcon is located within two miles of the project area".

If your request required a Sensitive Fish and Wildlife Information Release Agreement and you or your organization has one on file, please refer to that document for conditions regarding release of this information.

For more information on WDFW you may visit our web site at http://www.wa.gov/wdfw or visit the Priority Habitats and Species site at http://www.wa.gov/wdfw/hab/phspage.htm.

For information on the state's endangered, threatened, and sensitive plants as well as high quality wetland and terrestrial ecosystems, please contact the Washington Department of Natural Resources, Natural Heritage Program at PO Box 47014, Olympia Washington 98504-7014, by phone (360) 902-1667 or visit the web site at http://www.wa.gov/dnr/htdocs/fr/nhp/wanhp.html.

If you have any questions or problems with the information you received please call me at (360) 902-2543 or fax (360) 902-2946.

Sincerely,

Lori Guggenmos

Lori Guggenmos, GIS Programmer
Priority Habitats and Species

Enclosures

WASHINGTON DEPARTMENT OF FISH AND WILDLIFE

SURF SMELT, SANDLANCE, ROCKSOLE AND HERRING INFORMATION IN THE VICINITY OF T27R01E SECTION 17

Map Scale – 1 : 24000
Coordinate System – State Plane South Zone 5626 (NAD27)
Production Date – February 11, 2003
Cartography by WDFW Habitat Program GIS

PLEASE NOTE

The spawning information for surf smelt are offset from the shoreline for display purposes only. The typical depths for herring spawning are +3 feet to -20 feet (MLLW).

DISCLAIMER

This map only includes information that Washington Department of Fish and Wildlife (WDFW) maintains in a central computer database. It is not an attempt to provide you with an official agency response as to the impacts of your project on fish and wildlife. This information only documents the location of fish and wildlife resources to the best of our knowledge. It is not a complete inventory and it is important to note that fish and wildlife resources may occur in areas not currently known to WDFW biologists, or in areas for which comprehensive surveys have not been conducted. Site specific surveys are frequently necessary to rule out the presence of priority resources.

This information is highly variable regarding source, some of it is based on field surveys while others are based on "best professional judgement" of the biologist involved. This information has been generalized for the release to the general public. To insure appropriate use or for more specific information, users are encouraged to consult with WDFW biologists.

MAIN DATA SOURCES

Marine Resource Data: WDFW Fish Program, Marine Resources Division.
Township/Section data: Wa. Dept. of Natural Resources.
7.5-minute quadrangle image: US Geological Survey.

MAP LEGEND

MARINE RESOURCE DATA

- Surf Smelt Spawning Area
- Sandlance Spawning Area
- Rocksole Spawning Area
- Herring Spawning Area
- Herring Holding Area

OTHER SYMBOLOGY

- Township Lines
- Section Lines

Washington Department of FISH and WILDLIFE

AREA LOCATION

0 0.5 1

MILES

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for double-sided printing.

APPENDIX B
PROJECT PLANS AND PROFILES

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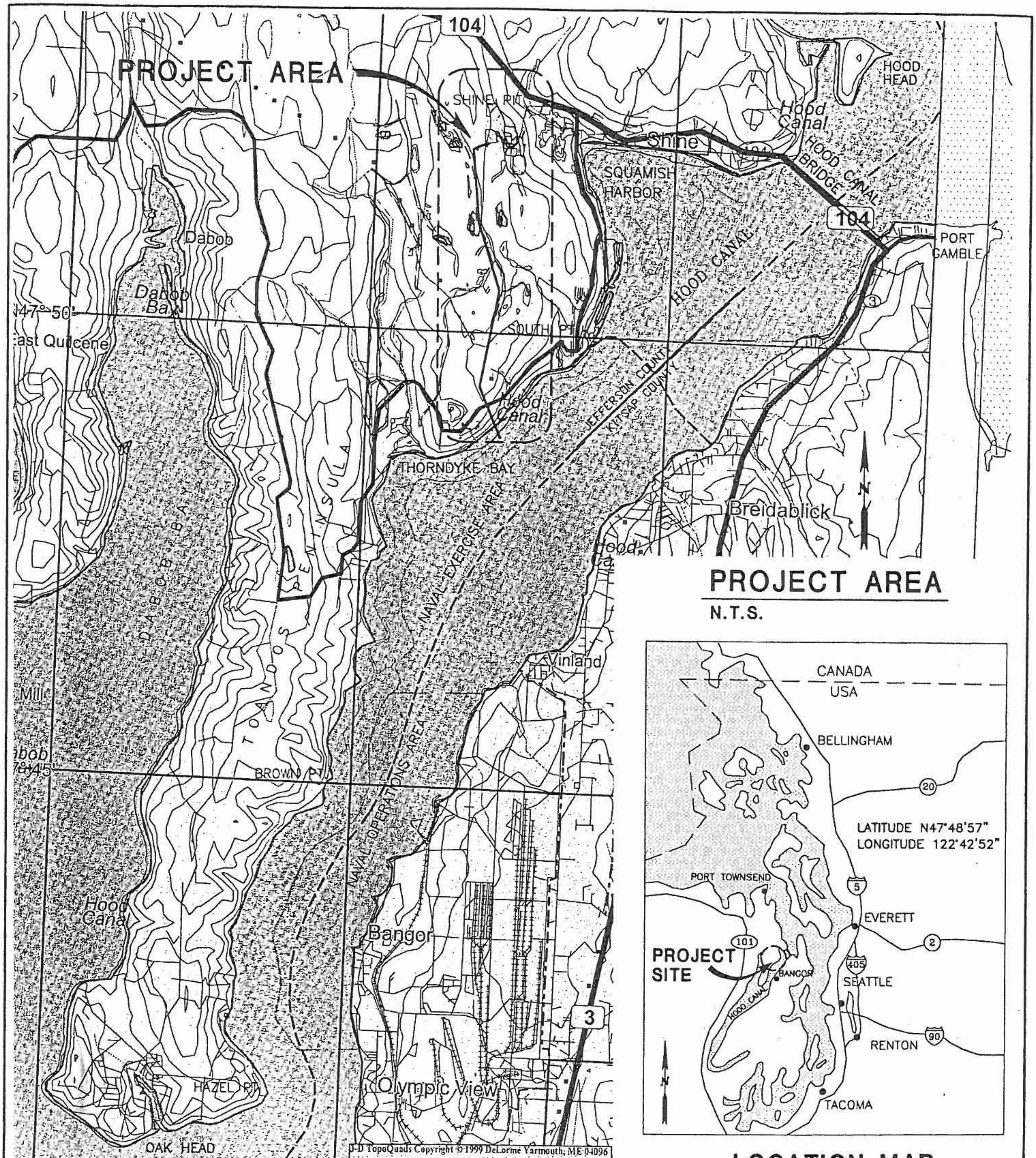


LOCATION MAP

10/16/2002 I:\24\01\012\ConceptDesign\COE-PERMIT 4112-VICINITY.dwg

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)

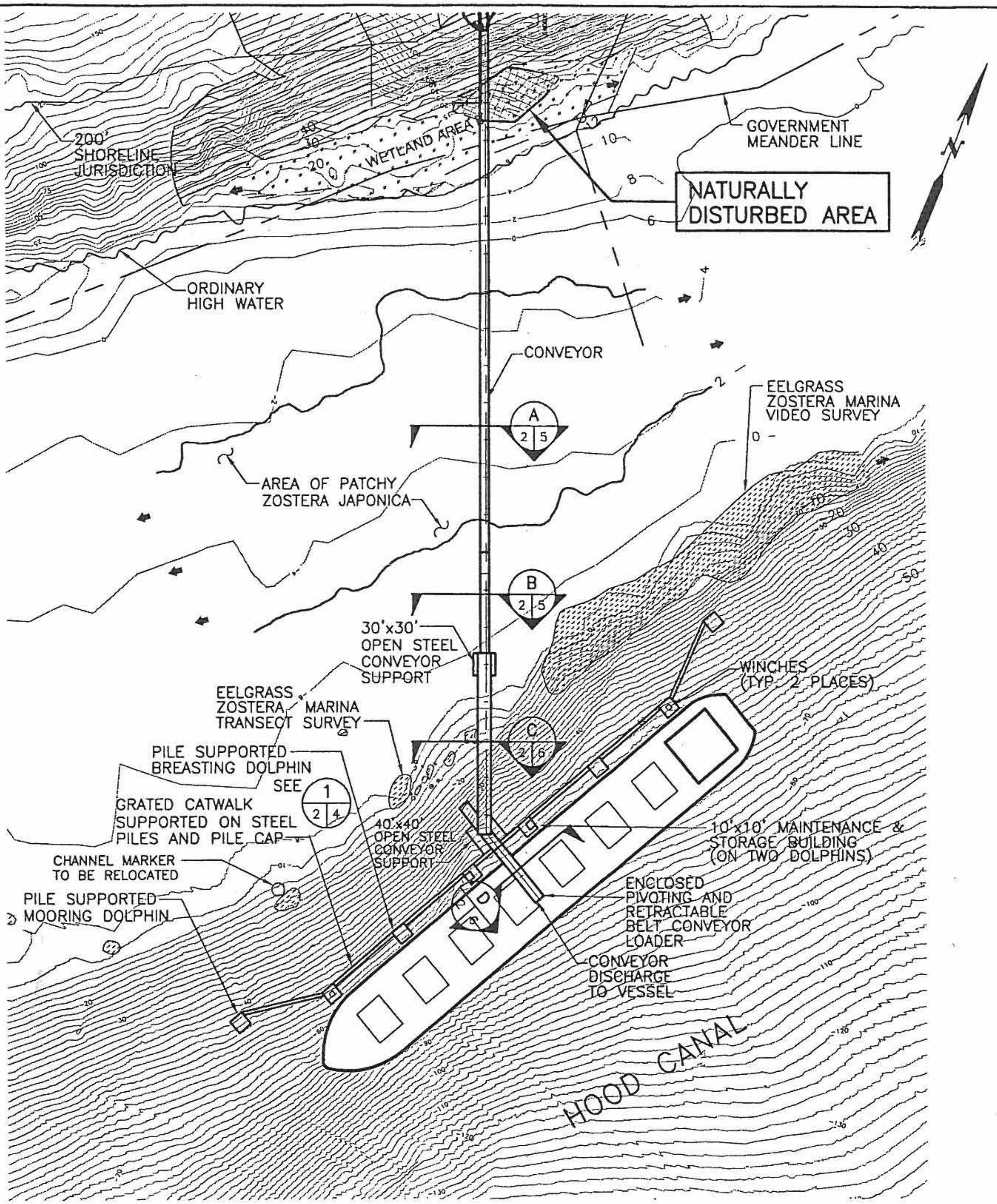
REGIONAL LOCATION MAP

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



PLAN

SCALE: 1" = 200'

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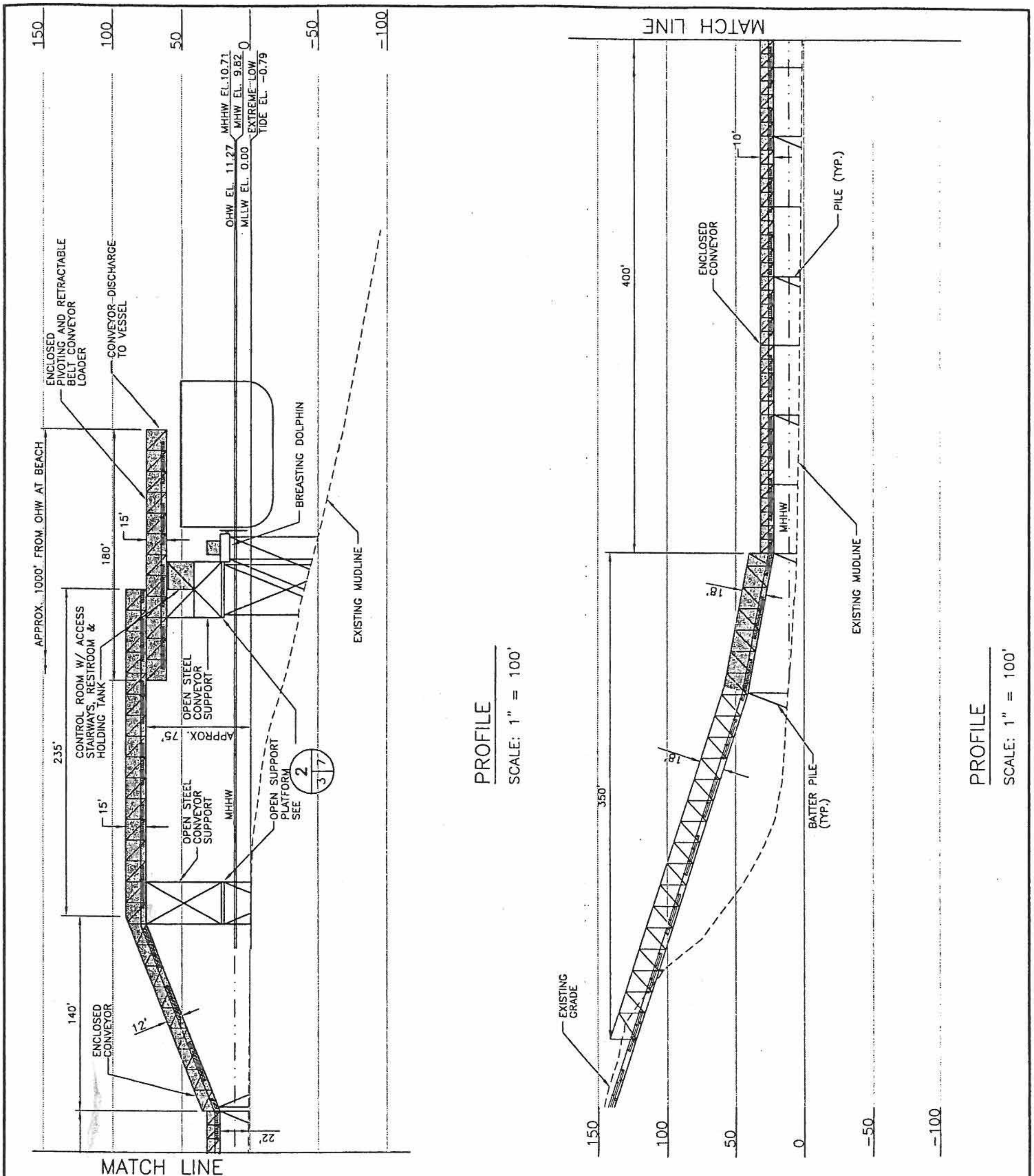
PURPOSE: CONSTRUCT CONVEYOR AND PIER FOR MARINE TRANSPORT OF SAND AND AGGREGATE MATERIALS VERTICAL DATUM: MLLW HORIZONTAL DATUM: NAD 1983/1991 ADJACENT PROPERTY OWNERS: (SEE ATTACHED LIST)	SINGLE CONVEYOR AND PIER SITE PLAN T-ROC CENTRAL CONVEYOR AND PIER ADDRESS: FRED HILL MATERIALS P.O. BOX 6 POULSBO, 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



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)

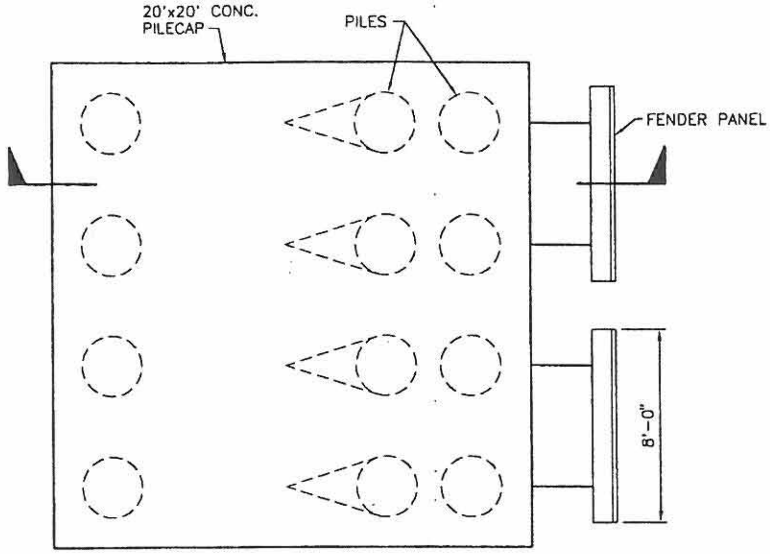
SINGLE CONVEYOR PROFILE

T-ROC CENTRAL CONVEYOR AND PIER

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

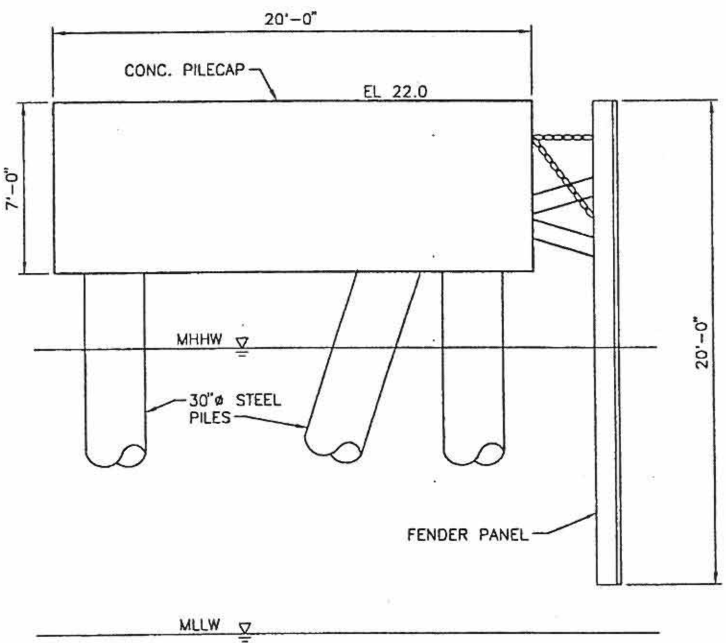
Reid Middleton
728 134th Street SW · Suite 200
Everett, Washington 98204
Ph: 425 741-3800

SEC. 19 T 27N. RGE. 1E
IN: HOOD CANAL
AT: THORNDYKE
COUNTY OF: JEFFERSON
APPLICATION BY: FRED HILL MATERIALS
SHEET 3 OF 16 DATE: 2-11-03



NOTE:
MOORING DOLPHIN SIMILAR BUT WITHOUT FENDER PANELS.

PLAN



SECTION

1 / 2 4 BREASTING DOLPHIN
SCALE: 1/8" = 1'-0"

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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)

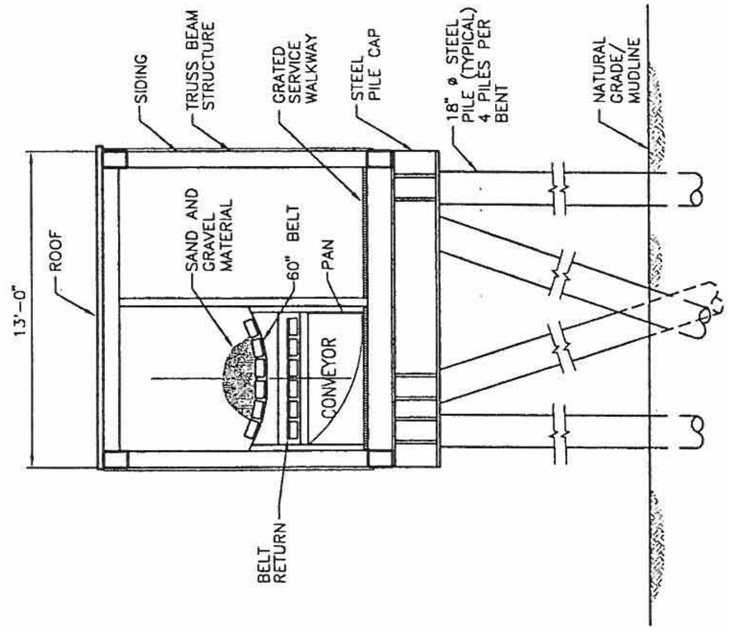
SINGLE CONVEYOR DETAIL

T-ROC CENTRAL CONVEYOR AND PIER

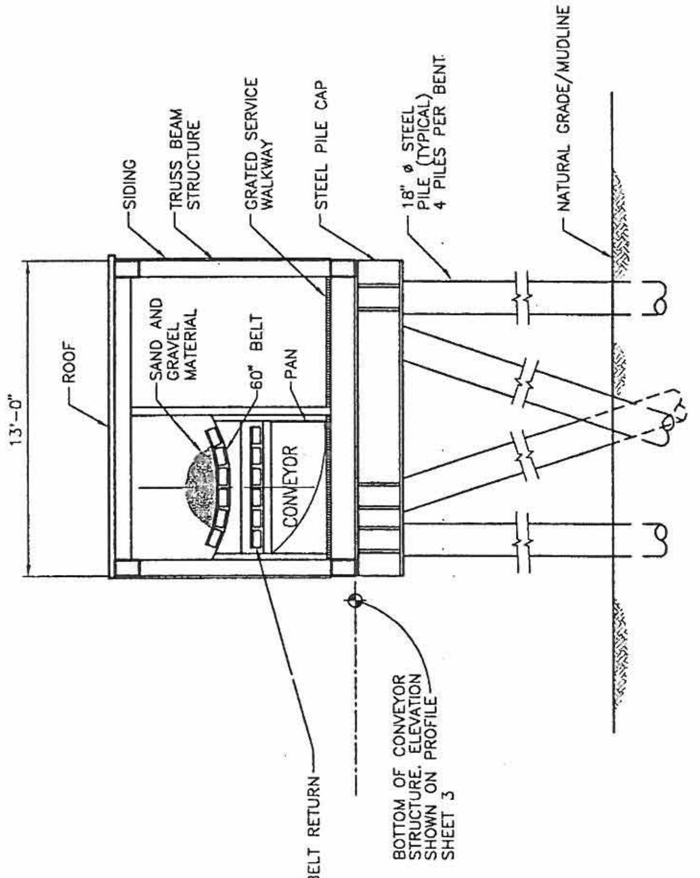
ADDRESS: FRED HILL MATERIALS
P.O. BOX 6
POULSBO, WA 98370

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 4 OF 16 DATE: 2-11-03



B 2|5 CONVEYOR SECTION
SCALE: 1/8" = 1'-0"



A 2|5 CONVEYOR SECTION
SCALE: 1/8" = 1'-0"

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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)

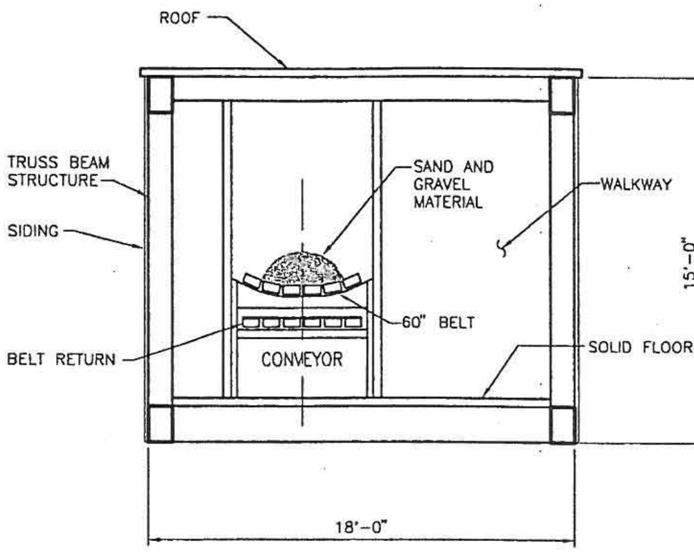
SINGLE CONVEYOR SECTIONS

T-ROC CENTRAL CONVEYOR AND PIER

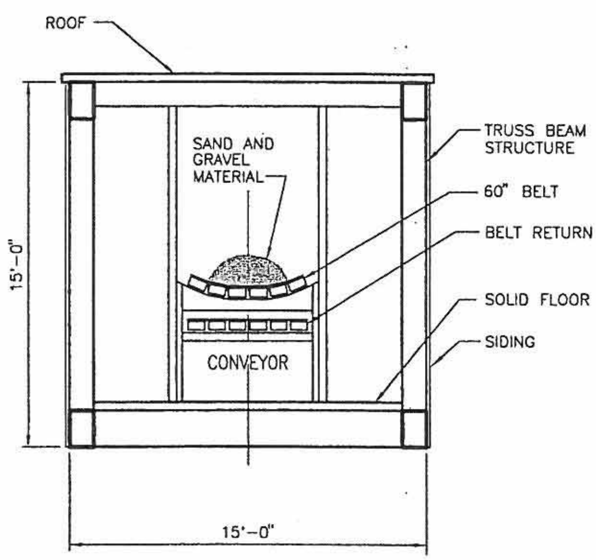
ADDRESS: FRED HILL MATERIALS
P.O. BOX 6
POULSBO, WA 98370

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 5 OF 16 DATE: 2-11-03



C 2 6 **CONVEYOR SECTION**
SCALE: 1/8" = 1'-0"



D 2 6 **CONVEYOR LOADER SECTION**
SCALE: 1/8" = 1'-0"

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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 SECTIONS

T-ROC CENTRAL CONVEYOR AND PIER

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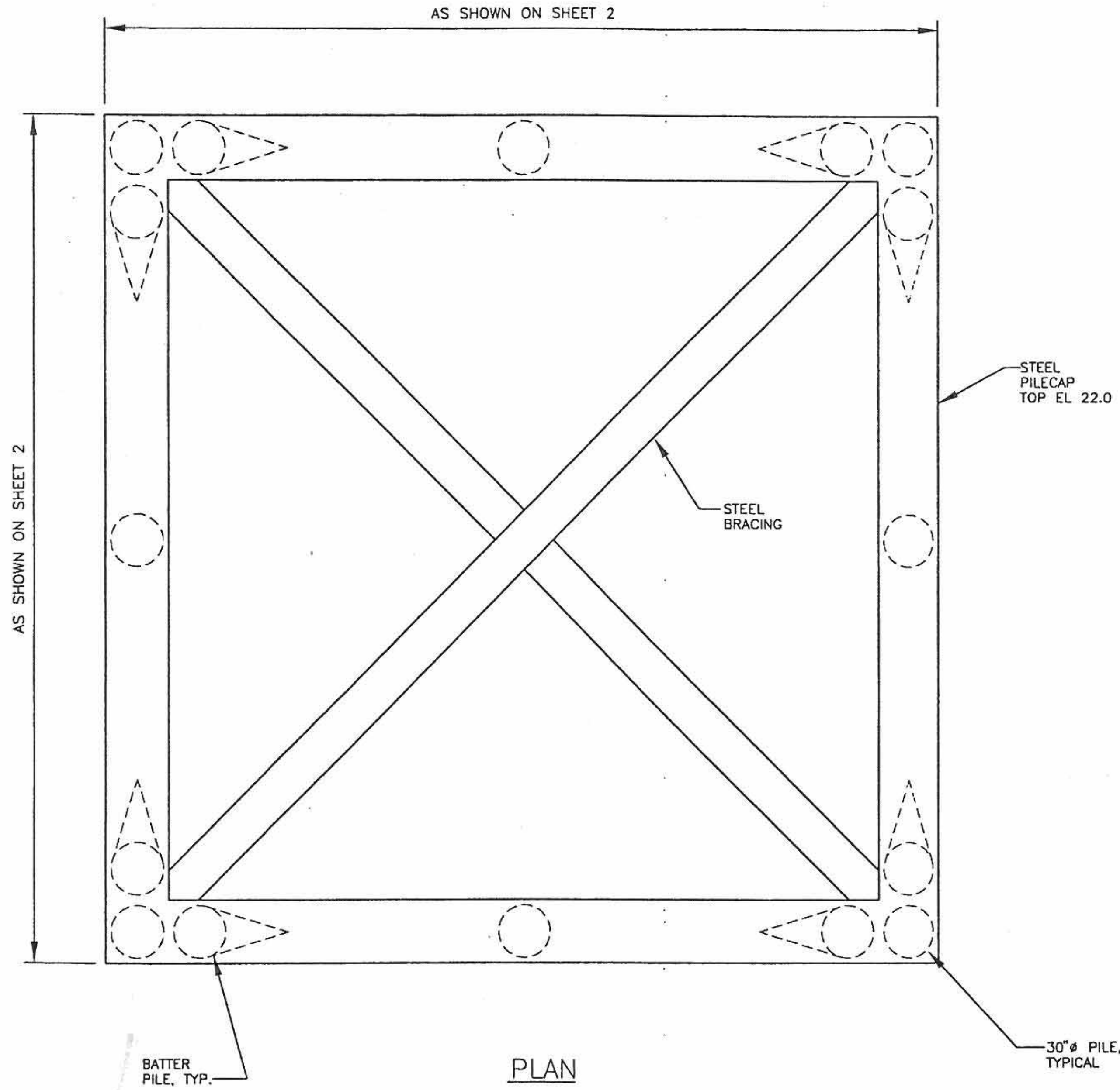
ReidMiddleton
728 134th Street SW · Suite 200
Everett, Washington 98204
Ph: 425 741-3800

SEC. 19 T 27N. RGE. 1E
IN: HOOD CANAL
AT: THORNDYKE
COUNTY OF: JEFFERSON
APPLICATION BY: FRED HILL MATERIALS
SHEET 6 OF 16 DATE: 2-11-03



PLAN

2 / 3 | 7 OPEN SUPPORT PLATFORM

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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 DETAIL

T-ROC CENTRAL CONVEYOR AND PIER

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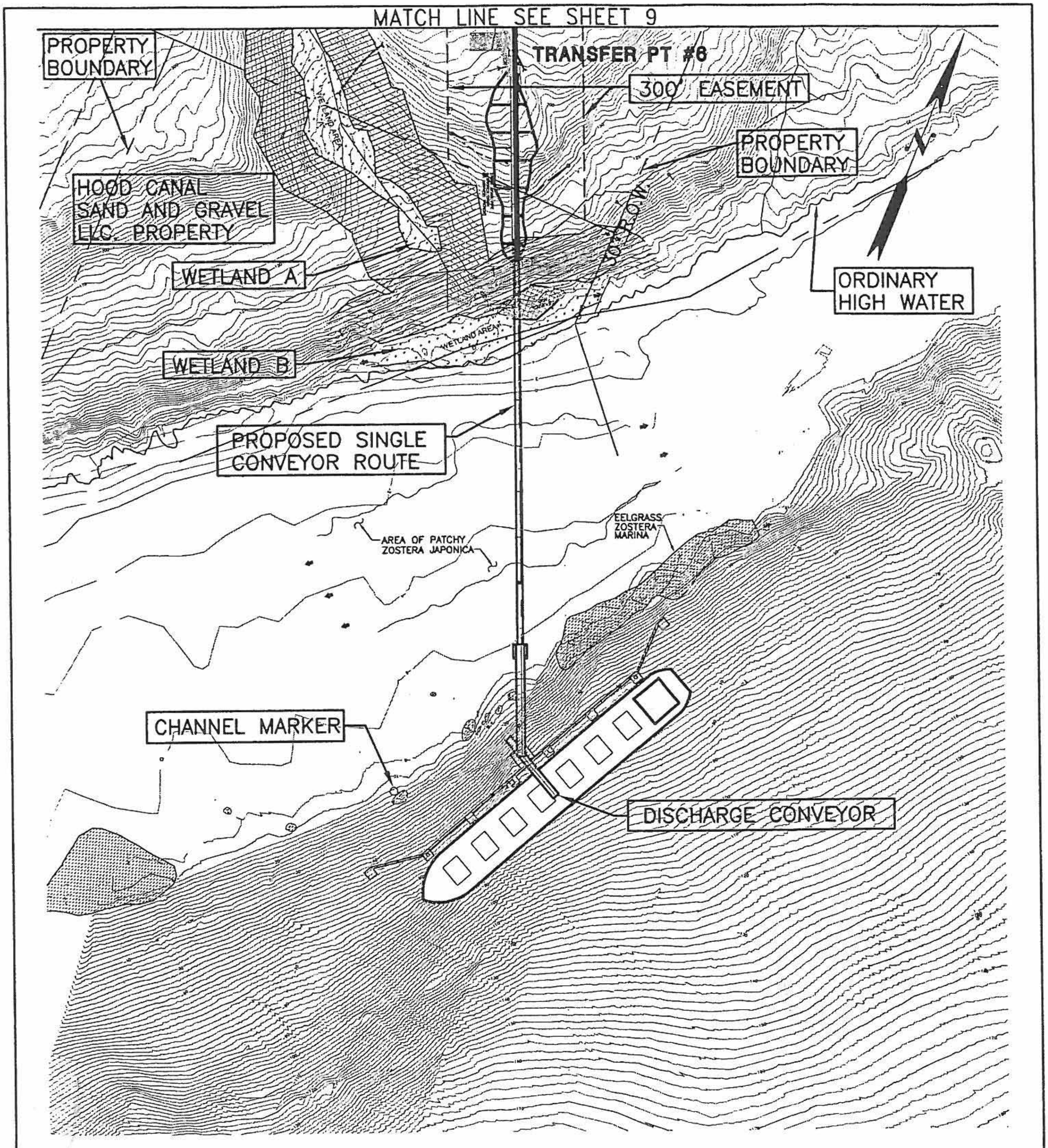
IN: HOOD CANAL
AT: THORNDYKE
COUNTY OF: JEFFERSON
APPLICATION BY: FRED HILL MATERIALS
SHEET 7 OF 16 DATE: 2-11-03



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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)

PROPOSED CONVEYOR ROUTE

T-ROC CENTRAL CONVEYOR AND PIER

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IN: HOOD CANAL
AT: THORNDYKE
COUNTY OF: JEFFERSON
APPLICATION BY: FRED HILL MATERIALS
SHEET 8 OF 16 DATE: 2-11-03

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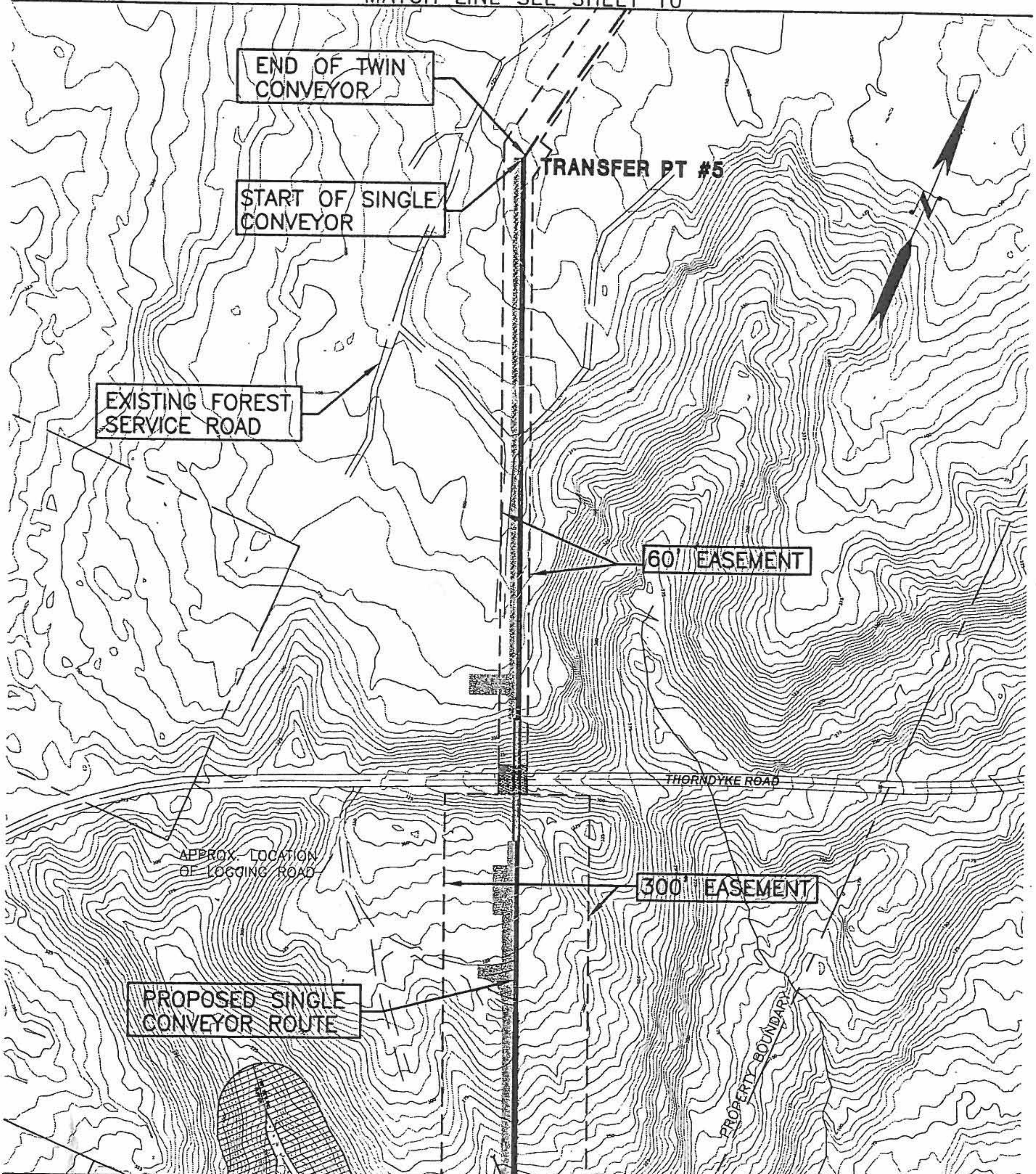

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PURPOSE: CONSTRUCT CONVEYOR AND PIER FOR MARINE TRANSPORT OF SAND AND AGGREGATE MATERIALS VERTICAL DATUM: NVDG 1929 HORIZONTAL DATUM: NAD 1983/1991 ADJACENT PROPERTY OWNERS: (SEE ATTACHED LIST)	PROPOSED CONVEYOR ROUTE T-ROC CENTRAL CONVEYOR AND PIER 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 9 OF 16 DATE: 2-11-03

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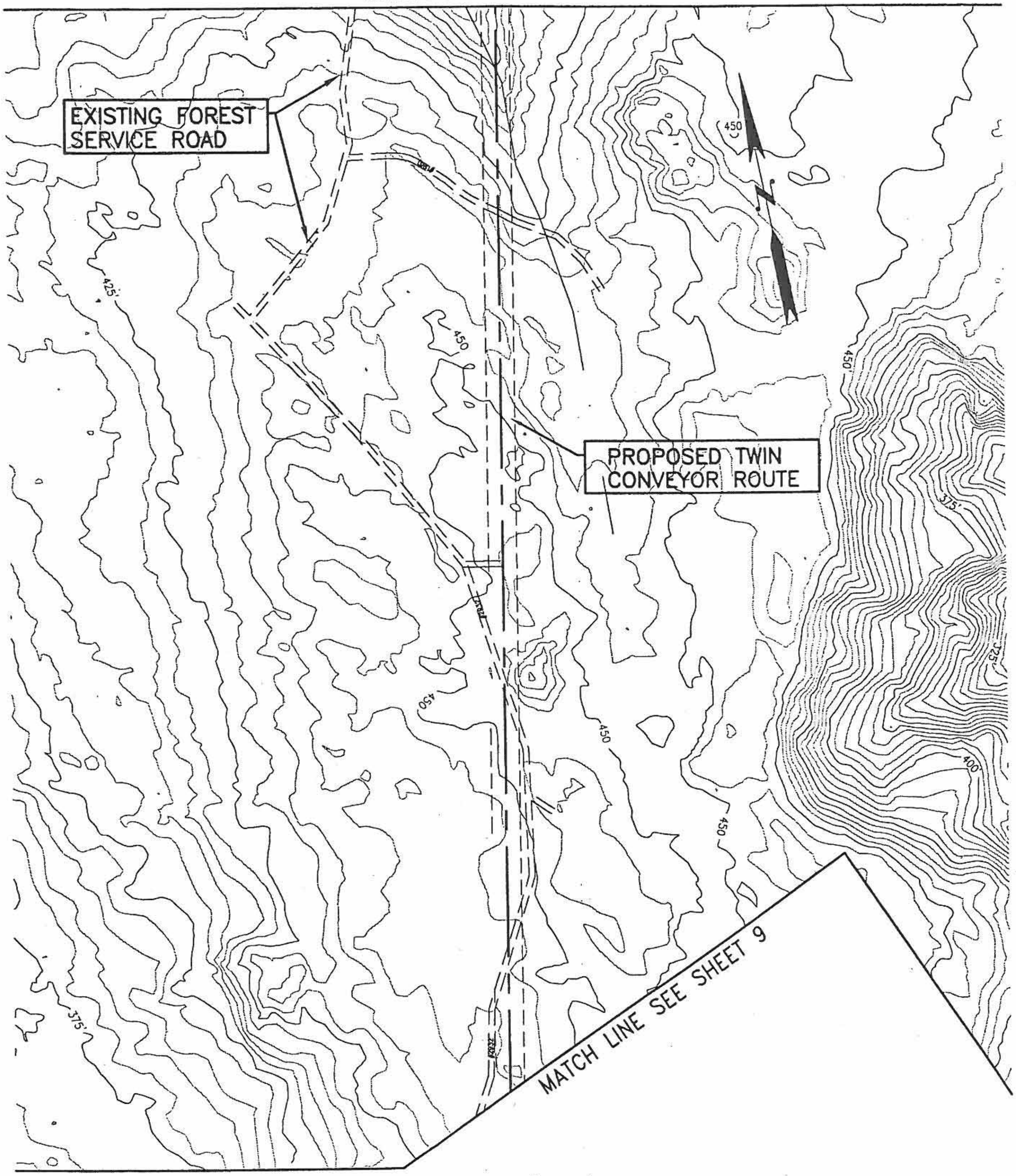

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PURPOSE: CONSTRUCT CONVEYOR AND PIER FOR MARINE TRANSPORT OF SAND AND AGGREGATE MATERIALS VERTICAL DATUM: NVDG 1929 HORIZONTAL DATUM: NAD 1983/1991 ADJACENT PROPERTY OWNERS: (SEE ATTACHED LIST)	PROPOSED CONVEYOR ROUTE T-ROC CENTRAL CONVEYOR AND PIER 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 10 OF 16 DATE: 2-11-03

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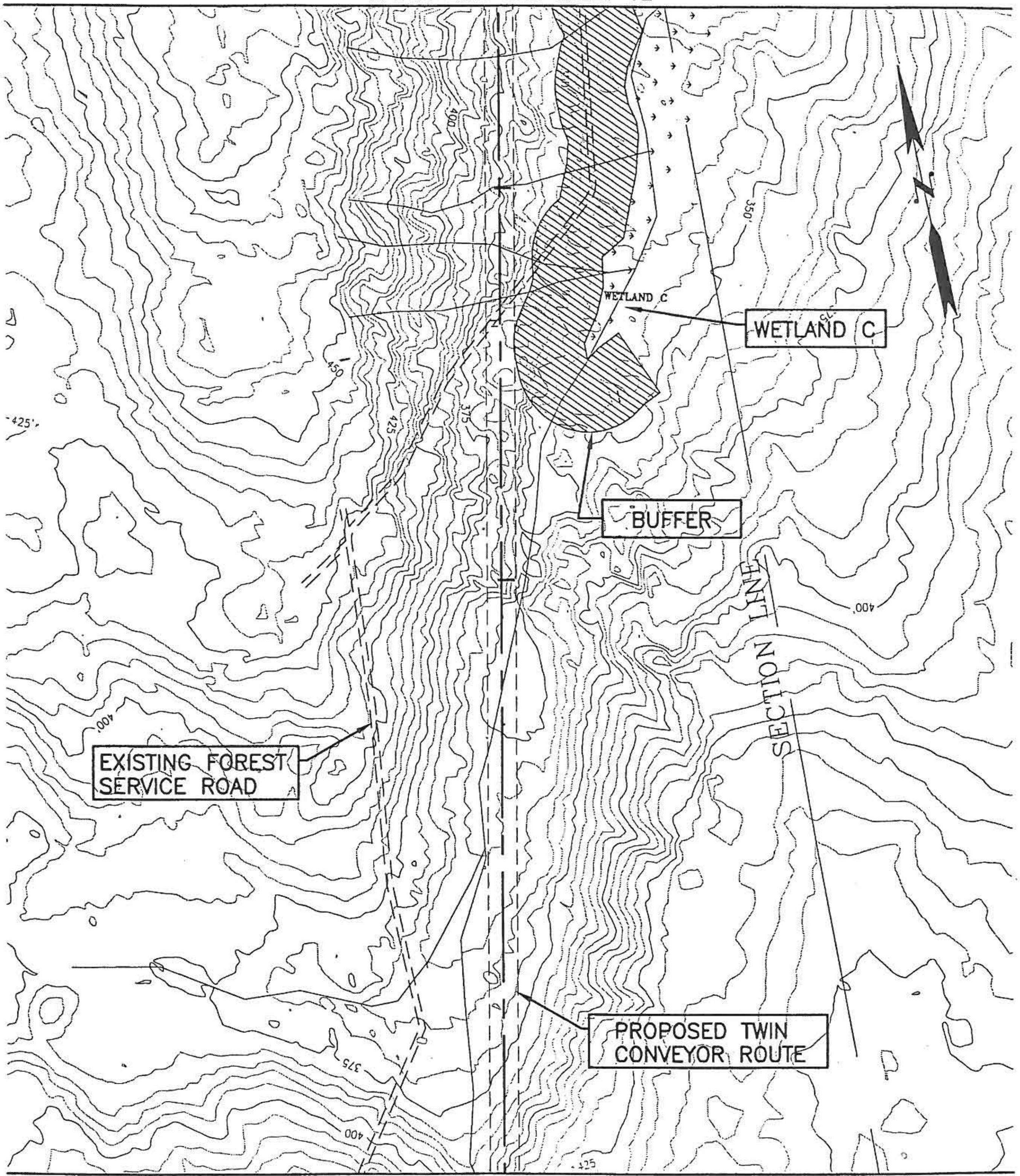

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PURPOSE: CONSTRUCT CONVEYOR AND PIER FOR MARINE TRANSPORT OF SAND AND AGGREGATE MATERIALS

VERTICAL DATUM: NVDG 1929
HORIZONTAL DATUM: NAD 1983/1991

ADJACENT PROPERTY OWNERS:
(SEE ATTACHED LIST)

PROPOSED CONVEYOR ROUTE

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AT: THORNDYKE
COUNTY OF: JEFFERSON
APPLICATION BY: FRED HILL MATERIALS
SHEET 11 OF 16 DATE: 2-11-03

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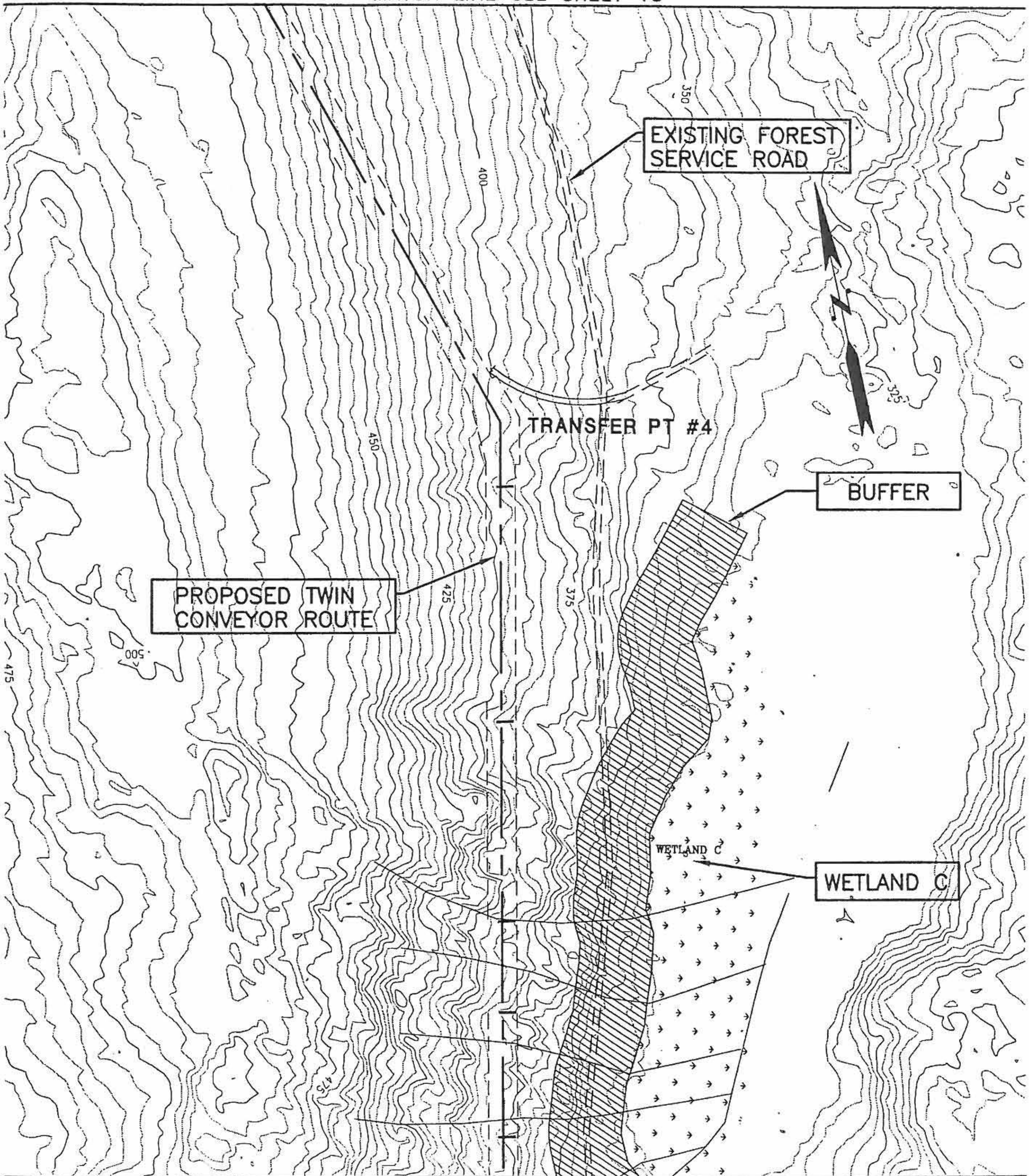

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PURPOSE: CONSTRUCT CONVEYOR AND PIER FOR MARINE TRANSPORT OF SAND AND AGGREGATE MATERIALS

VERTICAL DATUM: NVDG 1929
HORIZONTAL DATUM: NAD 1983/1991

ADJACENT PROPERTY OWNERS:
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PROPOSED CONVEYOR ROUTE

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IN: HOOD CANAL
AT: THORNDYKE
COUNTY OF: JEFFERSON
APPLICATION BY: FRED HILL MATERIALS
SHEET 12 OF 16 DATE: 2-11-03

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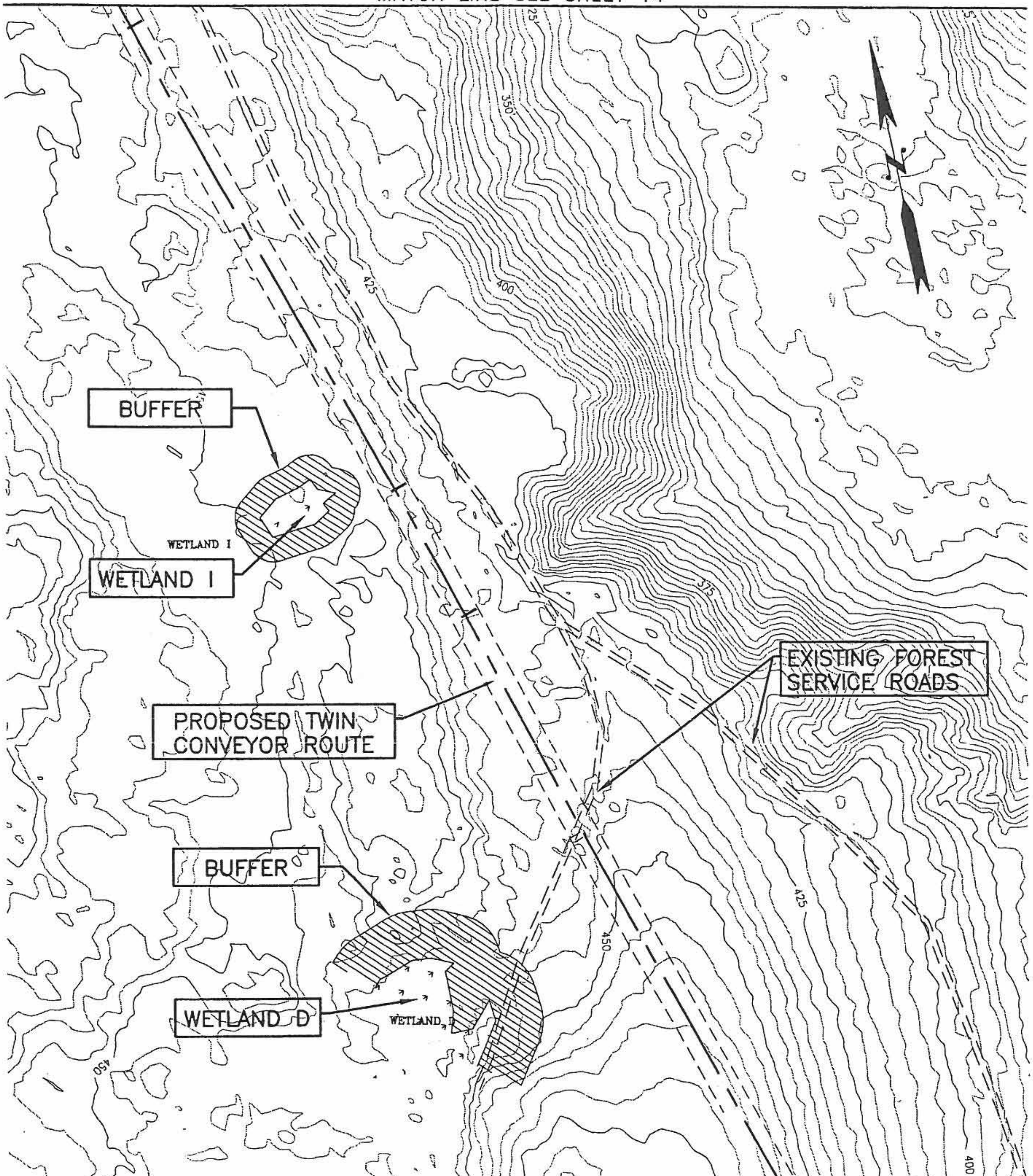

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VERTICAL DATUM: NVDG 1929
HORIZONTAL DATUM: NAD 1983/1991

ADJACENT PROPERTY OWNERS:
(SEE ATTACHED LIST)

PROPOSED CONVEYOR ROUTE

T-ROC CENTRAL CONVEYOR AND PIER

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IN: HOOD CANAL
AT: THORNDYKE
COUNTY OF: JEFFERSON
APPLICATION BY: FRED HILL MATERIALS

SHEET 13 OF 16 DATE: 2-11-03

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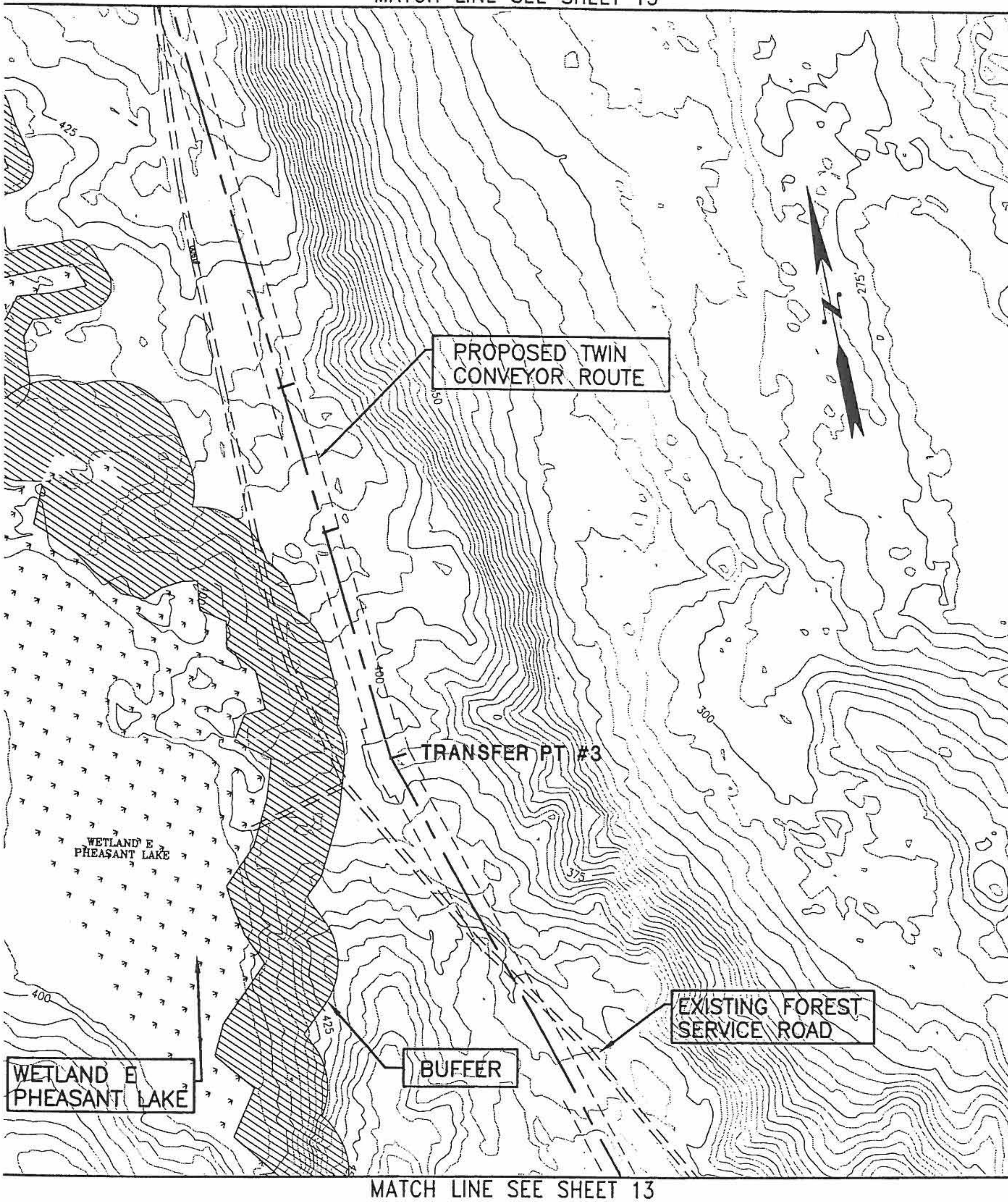

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PURPOSE: CONSTRUCT CONVEYOR AND PIER FOR MARINE TRANSPORT OF SAND AND AGGREGATE MATERIALS

VERTICAL DATUM: NVDG 1929
HORIZONTAL DATUM: NAD 1983/1991

ADJACENT PROPERTY OWNERS:
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IN: HOOD CANAL
AT: THORNDYKE
COUNTY OF: JEFFERSON
APPLICATION BY: FRED HILL MATERIALS
SHEET 14 OF 16 DATE: 2-11-03

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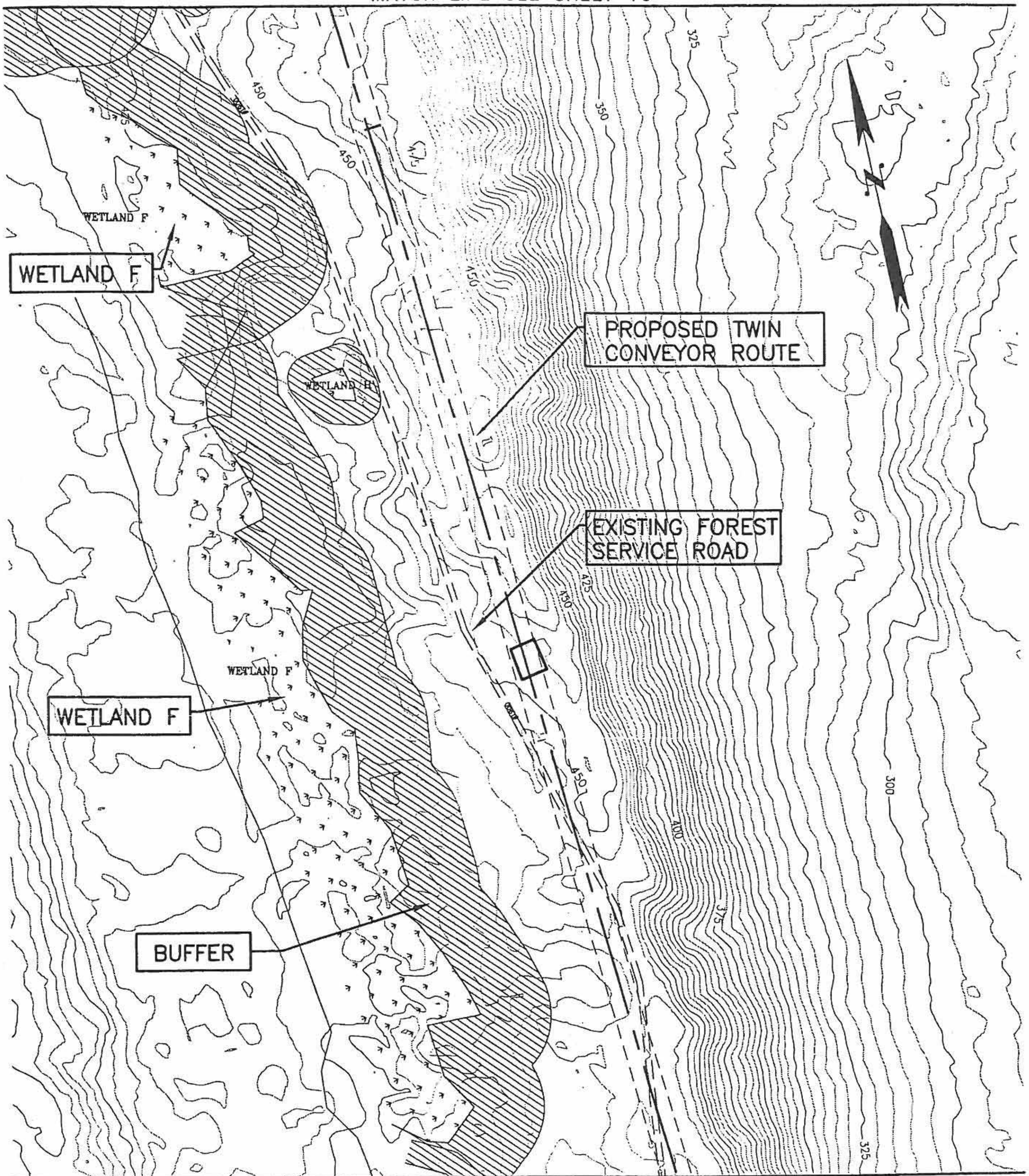

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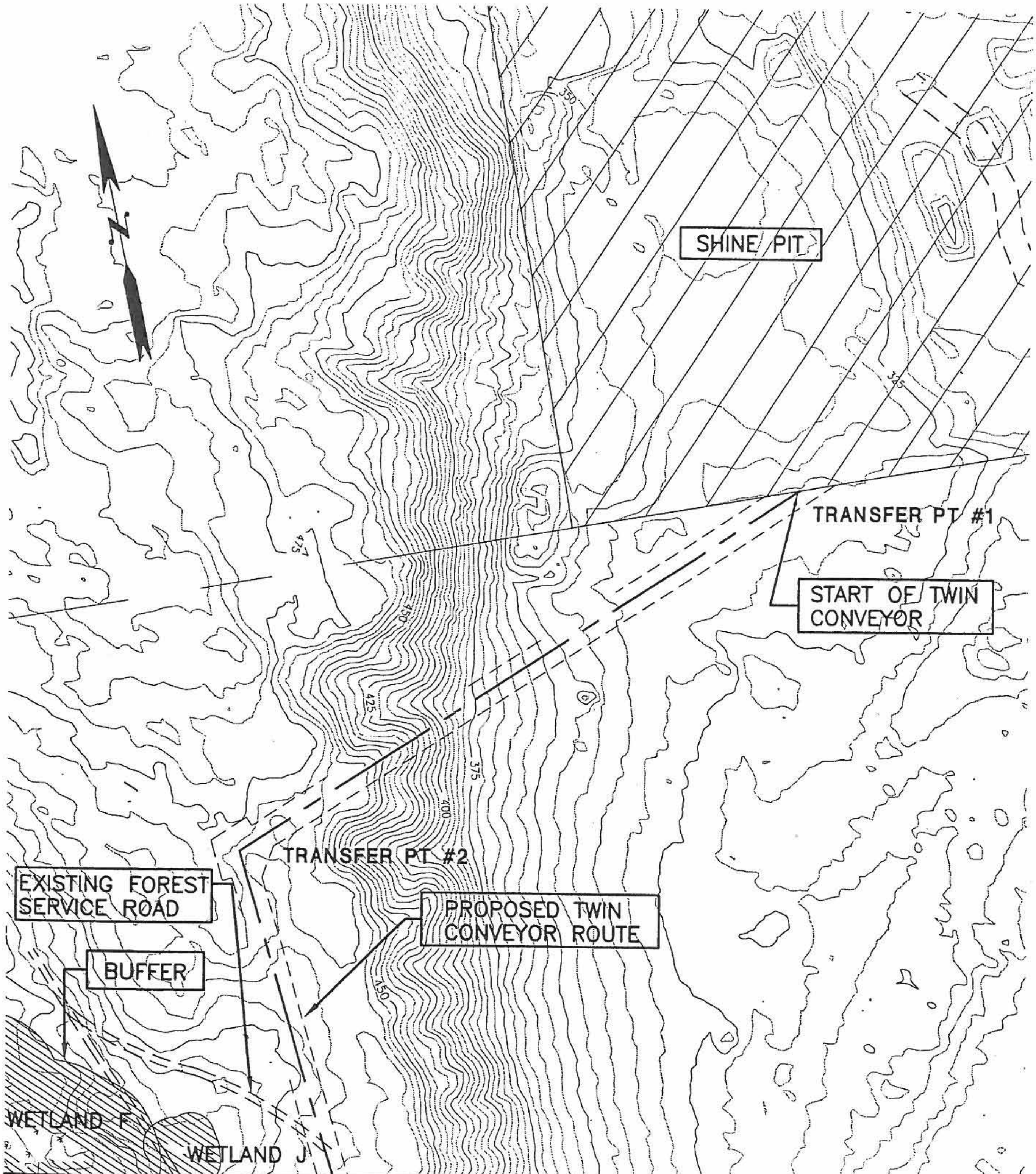
IN: HOOD CANAL

AT: THORNDYKE

COUNTY OF: JEFFERSON

APPLICATION BY: FRED HILL MATERIALS

SHEET 15 OF 16 DATE: 2-11-03



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

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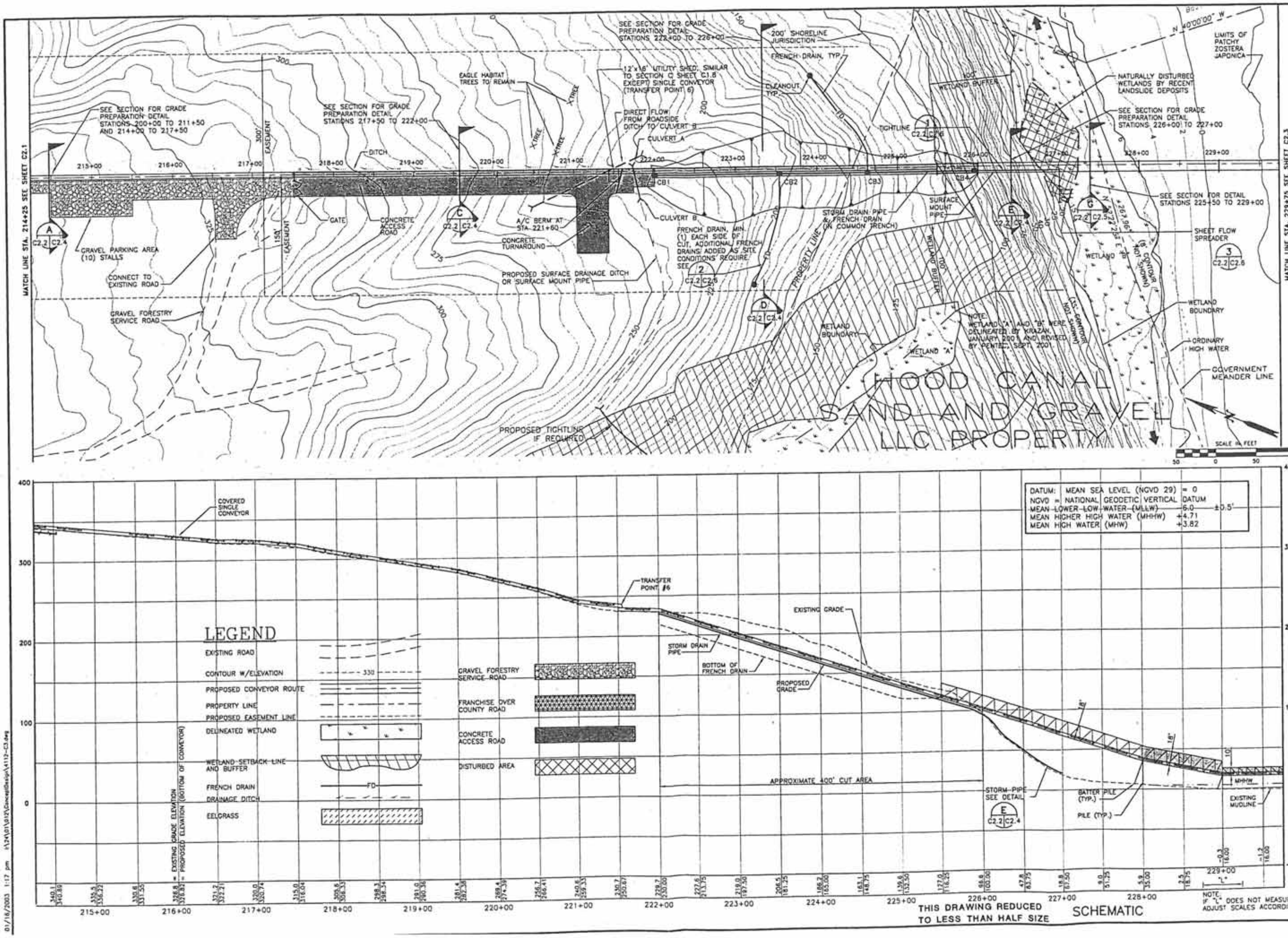
IN: HOOD CANAL
AT: THORNDYKE
COUNTY OF: JEFFERSON
APPLICATION BY: FRED HILL MATERIALS
SHEET 16 OF 16 DATE: 2-11-03



CLIENT:
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360-779-4431

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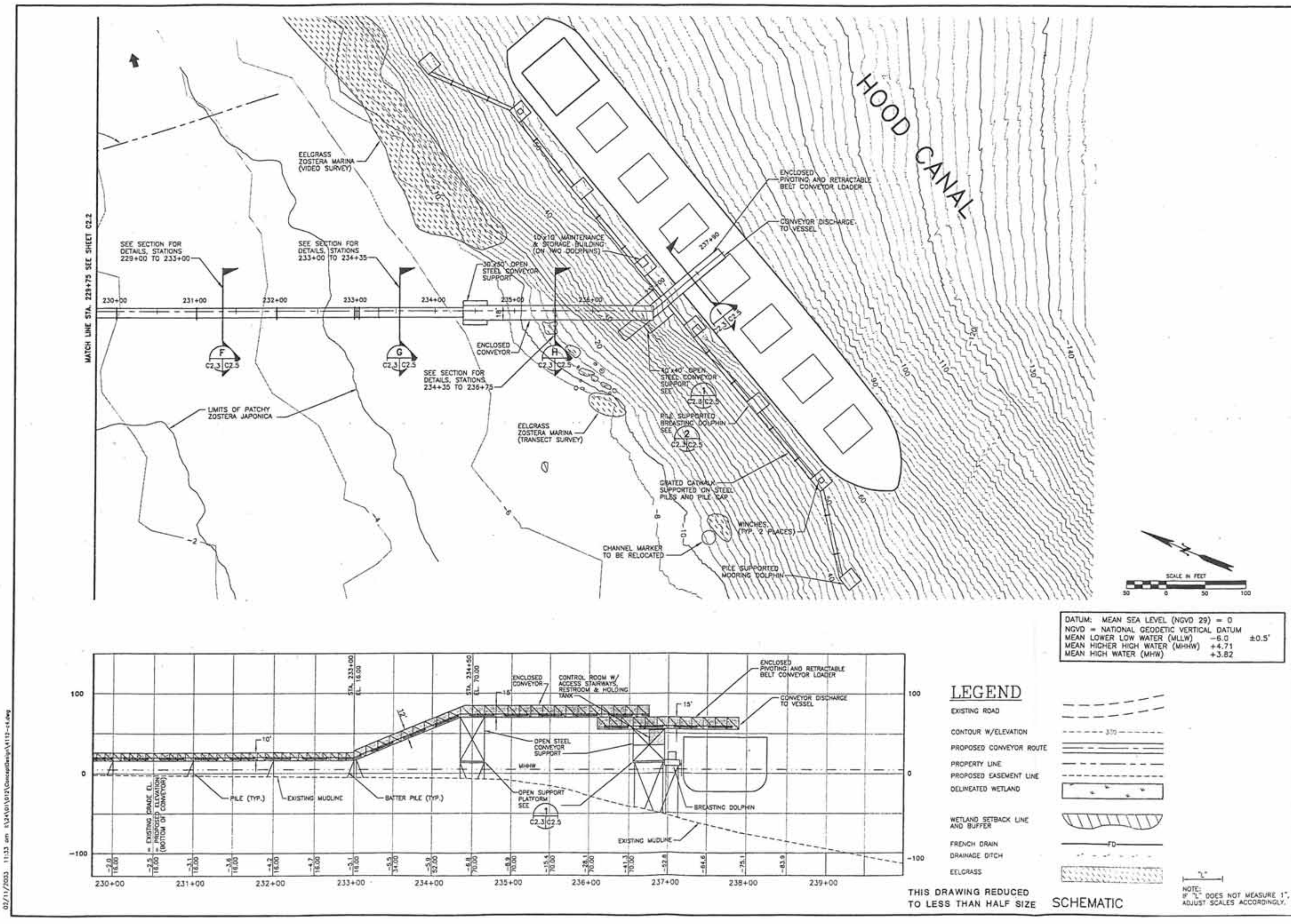
FRED HILL MATERIALS
T-ROC CENTRAL CONVEYOR
SINGLE CONVEYOR CORRIDOR
PLAN AND PROFILE

SCALE 1" = 50'
SHEET NO. C2.2
DATE 2/11/03
24-01-012



CLIENT:
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Everett, Washington 98204
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FRED HILL MATERIALS
T-ROC CENTRAL CONVEYOR
SINGLE CONVEYOR CORRIDOR
PLAN AND PROFILE

SCALE 1" = 50'
C2.3
DATE 2/11/03
24-01-012

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APPENDIX C
MARINE RESOURCES SURVEY REPORT

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October 19, 2012

DISCLAIMER FOR APPENDIX C – HABITAT MANAGEMENT PLAN FOR MARINE HABITAT AND BALD EAGLE

1. The Habitat Management Plan (HMP) was originally written in 2003 to address the design features of the proposed TROC Central Conveyor and Pier project that will help minimize potential impacts to bald eagles (*Haliaeetus leucocephalus*), marine habitat, and resources. In addition, the plan proposed an approach to ensure that compensation is provided for any adverse impacts to important marine resources (i.e., eelgrass) and those habitats which support ESA-listed salmonids. Changes affecting the project to the project design, analysis of impacts from the project, and status of ESA-listed species have occurred since this document was written. These changes have been appropriately addressed in the Biological Evaluation (BE) for this project. Best Management Practices and compensations for unavoidable impacts as they pertain to the most current regulations will be addressed in the Conservation Measures and Mitigation Plan.

2. In 2007, bald eagles were taken off the Federal List of Endangered and Threatened Wildlife and Plants (71 FR 37346). Bald eagles continue to be protected by the Bald and Eagle Protection Act and the Migratory Bird Treaty Act. Information in the HMP about presence of bald eagles near the project area and the potential impacts from the proposed project are outdated, and therefore the reader is encouraged to disregard this specific analysis for bald eagles.

3. The reader is encouraged to disregard the impact analysis for marine habitat in the HMP, as project details have changed as well as the resulting analyses. Please refer to the BE for a detailed analysis of project impacts.

4. The reader is encouraged to refer to the HMP specifically for descriptions of pre-project enhancement actions, monitoring of pre- and post-project impacts, compensatory mitigation, and opportunities for mitigation/enhancement.

JEFFREY C. BARRETT, PHD
Senior Ecologist/Regional Manager

PETER S. HELTZEL, MSC
Senior Fisheries Biologist

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for double-sided printing.

Thorndyke Resource Operations Complex Central Conveyor and Pier Marine Resources Survey Report

Jefferson County, Washington

Prepared for
Reid Middleton, Inc.

February 28, 2003
12007-47

Thorndyke Resource Operations Complex
Central Conveyor and Pier
Marine Resources Survey Report

Jefferson County, Washington

Prepared for
Reid Middleton, Inc.
728 – 134th Street SW, Suite 200
Everett, WA 98204

February 28, 2003
12007-47

Prepared by
Pentec Environmental

Jonathan P. Houghton, Ph.D.
Marine/Fisheries Biologist

J. Eric Hagen
Fisheries Biologist

Michael J. Muscari
Wetland Ecologist

CONTENTS

Page

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THORNDYKE RESOURCE OPERATIONS COMPLEX
CENTRAL CONVEYOR AND PIER
MARINE RESOURCES SURVEY REPORT

1.0 INTRODUCTION

1.1 General

This report describes existing marine resources and habitat conditions of the nearshore (i.e., shoreline, intertidal, and shallow subtidal) environment in the vicinity of the proposed Thorndyke Resource Operations Complex (T-ROC) Central Conveyor and Pier. The information provided herein was obtained through field surveys conducted at the project site and through review of the literature, including Priority Habitats and Species (PHS) data from the Washington Department of Fish and Wildlife (WDFW). Field surveys included three intertidal beach surveys, an underwater video survey, a diver survey, and reconnaissance of two previously delineated wetlands. All field surveys were conducted between August 17, 2001,and July 12, 2002.

1.2 Project Description

The proposed T-ROC project will include an approximately 4-mile conveyor to transport sand and gravel from an upland gravel mining operation (the Shine Pit) in Jefferson County to an offshore loading Pier located in Hood Canal approximately 5 miles southwest of the Hood Canal Bridge (Appendix B, Sheet 1). During operation, the conveyor system will transport up to 3,000 tons of materials per hour to vessels docked at the Pier.

A detailed T-ROC Central Conveyor and Pier project description and fact sheet are provided in Appendix F.

2.0 INTERTIDAL BEACH SURVEYS

2.1 General

Three separate marine habitat surveys were conducted at the proposed Pier location (anticipated Conveyor centerline). For each survey, two Pentec marine biologists were guided to the site by the project manager. The initial survey, in mid-August 2001, included general characterization of the beach habitat from the high-tide line to lower intertidal zone and measurements of native eelgrass (*Zostera marina*) distribution along the low-tide line (approximately −2 feet mean lower low water [MLLW]). The second beach survey, 6 weeks later, primarily focused on determining the extent (i.e., upper and lower boundaries) and density (via shoot counts) of the discontinuous patches of non-native Japanese eelgrass (*Z. japonica*) that were identified in the first beach survey, as well as during a subsequent underwater video survey. The third beach survey, conducted in mid-July 2002, primarily documented changes within the upper intertidal zone and along the upper beach face. Most of these changes occurred during the fall and winter months as a result of high tides and wave and current action. The survey also noted changes in the relative distribution and size of *Z. japonica*. The results of the three beach surveys are described below.

2.2 Intertidal Survey, August 17, 2001

The first intertidal survey was conducted during the morning of August 17, 2001. Low tide was –2.2 feet MLLW at 1001 hours. Weather was partly overcast early, with increasing sun by late morning. The upper beach and backshore are bordered on the northwest by a steep bluff that rises to about 100 feet above mean sea level (Photo 1 and Figure C-1). A slope failure in the 1990s deposited a substantial quantity of sand and silt on the backshore, significantly altering a wetland formed by seep water from sediment layers within the bluff. Vegetation of the riparian zone above the ordinary high water line is described in the beach wetland reconnaissance section herein. Along the high-tide drift line were scattered plants of saltbrush (*Atriplex patula*), jaumea (*Jaumea carnosa*), seaside plantain (*Plantago maritime*), meadow barley (*Hordeum branchyantherum*), pacific silverweed *(Potentilla ansirena*), and silver burweed (*Ambrosia chamissonis*) (Photo 2).

Below the high-tide line the beach face was moderately steep and sandy, with lenses of gravel; this beach face extending down to a broad sand flat that began at about +6 feet MLLW (Photo 2). Both on this upper beach and on the sandflat, low patches of unstable and shifting sand gave evidence of a net drift from southwest to northeast. Also prominent on the upper beach were lines of countless stranded and dead jellyfish (*Cyanea*), most on the order of 25 to 35 cm in diameter (Photo 3). The lowest line of drift from the previous high tide consisted of these jellyfish and dislodged eelgrass plants, and supported large numbers of beach hoppers (Hyalidae). No other macrobiota was evident on the beach face, but the substrate along and below the high-tide line appeared to be potentially suitable for spawning by surf smelt (*Hypomesus pretiosus*) and/or sand lance (*Ammodytes hexapterus*). According to the WDFW PHS, the nearest documented sand lance spawning occurs approximately one-third to one-half mile southwest of the proposed Conveyor alignment (Guggenmos, L., WDFW, personal communication, February 12, 2003; Appendix A). The PHS database does not contain any records of surf smelt nearer than at least 1 mile to the northeast and 1 mile to the southwest of the proposed pier.

Where the lower edge of the beach face transitioned to the sandflat, seep water emerged at low tide to create shallow pools of standing water (near flagged stake in Photo 4) and eventually formed a channel that meandered across the flat. Patches of the green algae *Ulva* spp., *Enteromorpha intestinalis*, and *E. linza* occurred in these fresh or brackish seeps. Burrows of ghost shrimp (*Neotrypaea californiensis*) were abundant on the middle and upper portions of the flat. Associated with the ghost shrimp were the commensal bivalve *Cryptomya californica* and the polychaete *Nephtys* sp.

From about +4 feet MLLW to +1 foot MLLW the sandflat supported scattered and discrete patches of *Z. japonica* (Photo 5). Within each patch, shoots were very dense (see shoot density data in Table C-1) and fertile fronds were present where patches occurred in shallow standing water ponds (Photo 6). Cumulatively, in this band of *Z. japonica* patches, total coverage of the beach surface by eelgrass patches was estimated at about 25 percent, and the band was approximately 75 m wide (250 feet wide) along the approximate pier alignment (Figure C-1). *Z. japonica* is an introduced species that is known to occur throughout northern Puget Sound, although its distribution has not been well documented (Thom and Hallum 1990). Because it is an annual, it is expected to be variable in space and time. This is especially true on beaches such as this one, where the advancing sand waves bury individual patches while new patches form in the wake of each wave.

Also noteworthy on the sandflat were very high-density patches of sand dollars (*Dendraster excentricus*), primarily in shallow tidewater ponds and drainage channels (Photo 7). Occasional cockles, *Clinorcardium nuttalli,* were also seen, and small holes of the burrowing polychaete *Nephtys* sp. were widespread.

The beach surface was somewhat firmer on the outer portion of the sand flat. Where slope steepened somewhat, ghost shrimp were less abundant, and *Z. japonica* was no longer abundant but was present as widely scattered shoots. Below about +1 foot MLLW, very widely scattered geoduck *(Panope abrupta*) siphons were seen. Patches of green algae (*Ulva, Ulvaria,* and *Enteromorpha* spp., including *E. procera*) were scattered over the outer beach, often attached to the tubes of an abundant parchment-tube polychaete (Chaetopteridae). Beginning at about –1.5 feet and extending down into the subtidal zone was a band of patches of *Z. marina* (Photo 8). At the upper edge of the *Z. marina* band were a few scattered smaller eelgrass plants that may have been *Z. japonica.* The green algae/chaetopterid association was dense along this upper edge of the eelgrass and is visible as the lighter green area along the upper margin of the eelgrass in Photos 8 and 9. Eelgrass was generally dense in the patches within this band, and the patches became larger and more continuous to the northeast of the proposed Pier centerline (Photo 9). Scattered tubular brown algae (*Scytosiphon lomentaria)* were present among the eelgrass, along with a small filamentous red alga (*Ceramium* sp.).

Scattered moon snail (*Polinices lewisii*) egg cases were found on this lower beach along with an occasional moon snail, usually well buried in the sand (Photo 10). Other animals seen in random excavations of the lower elevation sand (e.g., at –1.5 feet MLLW) included chaetopterid, oweniid, and capitellid polychaetes and another very deep-dwelling parchment-tube polychaete (possibly Onuphidae). The sand clam *Macoma secta* was common, and geoduck and cockles were increasingly abundant at lower tidal elevations. Another burrowing species was the anemone *Anthopleura artemisia*. In shallow water along the shoreline and in the runoff channels, a small cottid was very abundant; a few graceful crab (*Cancer gracilis*) were also present.

2.3 Intertidal Survey, September 28, 2001

The second intertidal beach survey was conducted during the morning of September 28, 2001. Low tide was +1.2 feet MLLW at 0907 hours. Weather was partly overcast with a light southerly breeze.

Beach conditions were generally similar to those observed during the first intertidal beach survey, although the overall abundance of green macroalgae (e.g., *Ulva* spp.) appeared to be less than that observed in mid-August. As was observed during the first survey, the upper beach contained lines of stranded/dead jellyfish (*Cyanea*), although in lower numbers.

The primary purpose of the second survey was to delineate the upper and lower boundaries of the *Z. japonica* patches that were identified during the initial beach survey and during the subsequent underwater video survey (see below), and also to measure shoot densities (as number of shoots per square meter [m^2]) within the eelgrass patches.

The upper and lower boundaries of the *Z. japonica* patches were delineated using a hand-held differential global positioning system (DGPS) unit. These boundaries are presented in Figure C-1, which also shows the general boundaries of eelgrass beds (both *Z. japonica* and *Z. marina*) identified in the video and diver surveys discussed in the following sections.

Shoot-count densities (based on the average of three individual counts) of *Z. japonica* within representative patches ranged from 677 to 1,483 shoots per m² (Table C-1). The mean density in all patches surveyed was 1,099 shoots per m². As was noted in the first beach survey, the patches of *Z. japonica* appeared to occupy about 25 percent of the total beach surface within the eelgrass band, which is a highly dynamic zone due to wave action and shifting of sand.

2.4 Intertidal Survey, July 12, 2002

A third intertidal beach survey was conducted on July 12, 2002. The primary purpose of this survey was to observe and document changes in the intertidal zone and backshore that had occurred since the beach surveys conducted in 2001. The low tide was –2.8 feet MLLW at 1300 hours. The weather was clear and there was a light breeze.

There were noticeable differences along the upper shoreline in the immediate vicinity of the Conveyor/Pier alignment. Above the extreme high-tide line the vegetation within the disturbed zone below the bluff had matured, particularly the young alders (*Aldus rubra*). Just below the upper tide line (driftwood line), a sand/cobble berm that in 2001 existed along the ordinary high water mark (Photographs 2 and 3) had shifted waterward by several meters (Photographs 11 and 12). Such dynamic changes in this upper tidal zone are likely to occur yearly as a result of abundant sediment sources, high tides, and intense wave action over the fall and winter months.

On the sandflat within the zone of *Z. japonica* (approximately +4 feet MLLW to +1 foot MLLW) there appeared to be differences in the relative distribution and size of *Z. japonica* between the 2001 and 2002 beach surveys. As previously noted, seasonal variability in this annual eelgrass is to be expected. In July 2002, the isolated patches of *Z. japonica,* particularly within the lower tidal range, appeared to be more scattered and generally less dense compared with the previous summer, although no eelgrass shoot counts were made during the latter survey (Photograph 13). In addition, the blades of *Z. japonica* appeared in general to be shorter and narrower than in summer 2001. We do not have any quantitative information to verify this observation, but it suggests the possibility of reduced seasonal growth in spring and early summer 2002.

Farther waterward, beginning about –1 foot MLLW, was the upper boundary of a band of *Z. marina* that was previously documented in 2001. In contrast to *Z. japonica*, boundaries of the *Z. marina* patches and densities of *Z. marina* within this band appeared to be relatively unchanged between August/September 2001 and July 2002, although no shoot densities were measured during the latter survey (Photographs 14, 15, and 16). It should be noted that some *Z. japonica* was also present within this band.

3.0 UNDERWATER VIDEO SURVEY

On August 28, 2001, Pentec mapped the extent of the *Z. marina* eelgrass beds using Pentec's proprietary ***Sea-All™*** video mapping system. On the day of the survey, the weather was calm and partly cloudy.

The ***Sea-All™*** consists of a high-resolution color underwater camera integrated with a DGPS unit. The camera was lowered to directly view the bottom habitat while the survey vessel slowly moved along a transect line. Video tracks run are shown on Figure C-2. Positioning information was superimposed onto the video image before recording onto Digital-8 videotape. The positioning information was also logged onto a computer. These data were then imported into AutoCAD® to create a map of the actual location of the eelgrass. Boundaries were drawn by hand around the areas where eelgrass was found during the survey (Figure C-3).

Z. marina was found to occur in a narrow band along the outer edge of the broad sandflat as described from the intertidal survey. This band of eelgrass lies between approximately –1 foot and –16 feet MLLW. The slope begins to increase significantly starting about –2 feet MLLW. The survey transects were aligned to be roughly parallel to the shoreline, to simplify keeping the camera a consistent distance off the bottom while surveying along this slope. Several transects were surveyed along 2,700 feet of shoreline at the project site (Figure C-2). The ***Sea-All™*** system logged the presence of eelgrass once per second, logging over 9,400 discrete data points during the survey. The spacing of these transects was usually less than 40 feet apart; however, in some places there were larger gaps. The eelgrass tended to occur in dense patches that were surrounded with bare sand. In general, the patches were larger and more continuous toward the northeastern portion of the study area (i.e., northeast of the proposed Pier centerline) (Figure C-3 and Photos 9 and 14). Only trace amounts of macroalgae were observed.

Just outside the southwestern boundary of the project area, several small cage-like structures were observed that were deployed in grid patterns on the bottom. The purpose of these objects is not known, but they most likely are some kind of an experiment.

Four additional transects were surveyed that extended from the shoreline out past the eelgrass beds. These transects were aligned to cover some possible alignment corridors for the Pier that were under consideration at the time of the survey. Bare sand predominated along these transects, with the exception of patches of *Z. japonica* that were observed. Insufficient video data were collected to accurately map the Z. *japonica* beds, which have been described above. The upper and lower boundaries of the zone containing these beds were mapped using a hand-held DGPS unit during the second beach survey and are shown on Figure C-1.

4.0 DIVER SURVEY

4.1 General

On September 27, 2001, Pentec divers conducted a concentrated eelgrass/ macroalgae/geoduck habitat survey along the anticipated alignment of the conveyor. The following sections outline the methods and observations of the diver survey.

The eelgrass/macroalgae survey generally conformed to WDFW "intermediate" protocols for macrovegetation surveys (WDFW 1996). Eleven parallel transects were surveyed and information recorded regarding the presence and quantity of eelgrass, the presence of macroalgae, and the nature of the substrate. Vertebrate and invertebrate species observed during the survey were noted.

4.2 Study Area

The 100- to 140-foot transects were spaced 20 feet apart, and observations were made every 20 feet along each transect. Transects were laid out along a 200-foot baseline crossing the anticipated Pier alignment and approximately parallel to the beach contours (Figure C-4). Based on the previous survey data, all eelgrass appeared to be inshore of the baseline. For verification, additional observations were made 20 feet waterward (south) of the baseline.

The slope of the study area was uniformly gradual (6 percent or less) from the inshore end of the transects to about –5 feet MLLW, where it increased to 20 percent. The steep slope continued beyond the lower boundary of eelgrass. Eelgrass was present in this area between 0 and –9.5 feet MLLW (Figure C-4). Eelgrass was more plentiful toward the southwest end of the study area, south and west of the Pier centerline. Of the 77 total observation points, 14 (18 percent) contained eelgrass, and 11 of those were southwest of the proposed alignment. Eelgrass was highly patchy throughout the study area, with most patches smaller than 20 feet in diameter and a mean density over the area surveyed of 22.9 shoots per m^2 (Table C-2). Eelgrass appeared to be healthy, with densities ranging from 20 to 428 shoots per m^2 (mean 189.1 shoots per m^2) in quadrats containing eelgrass; i.e., within the patches shown on Figure C-4. Higher densities were found toward the southwest end of the study area.

Within the 75-foot strip from 25 feet southwest of the proposed Conveyor centerline to 50 feet northeast of the centerline (the zone of maximum potential shading), eelgrass was very sparse. Of the 32 observation points within this zone, only three contained any eelgrass at all (Table C-2). Overall density was 1.75 shoots per m^2, about 1 percent of the density in eelgrass patches southwest and northeast of the centerline.

The substrate was fine sand over most of the study area. In dense patches of eelgrass, where the substrate is protected by the blades from current and wave action, silty sand was observed. No discarded debris was noted.

Diatoms and a slender chaetopterid tubeworm were observed over most of the study area. Other invertebrates seen included sunflower star *(Pycnopodia helianthoides),* coon-stripe shrimp *(Pandalus danae)*, and long-horned nudibranch *(Hermissenda crassicornis)*. An egg case from a moon snail was also observed. Crabs observed included Dungeness *(Cancer magister)*, graceful *(C. gracilis)*, and hermit crabs *(Pagurus* spp.*).* Fish included Pacific staghorn sculpin *(Leptocottus armatus)* and a cabezon *(Scorpaenychthys marmoratus).* No geoduck siphons were seen.

Macroalgae in the study area was limited to *Ulva* spp. and was most concentrated in and around patches of eelgrass. Coverage less than 20 percent was observed in areas with no eelgrass, whereas eelgrass beds showed coverage up to 90 percent. Average algal cover over the entire study area was 5.4 percent (Table C-2).

4.3 Reference Area

A single reference transect was surveyed in the near-continuous eelgrass bed that begins about 75 feet northeast of the proposed centerline (Figure C-4). Mean density of eelgrass in the four sample points that lay within the southwest portion of the bed was 169.3 shoots per m^2.

4.4 Summary

In general, eelgrass was very patchy in the diver survey-transect area, and more plentiful southwest of the alignment than immediately northeast of it. Shoot density was also generally higher toward the southwest. Average shoot density over the transect study area was 22.9 shoots per m^2 (compared with 169 shoots per m^2 in the continuous *Z. marina* band beginning farther to the northeast). The substrate was fine sand throughout, with areas of silty sand among dense patches of eelgrass. Associated fauna was typical for the area, and obvious macroalgae was limited to ulvoids.

5.0 WETLANDS RECONNAISSANCE

A Pentec wetlands scientist visited wetlands near the Hood Canal shoreline crossing point of the proposed site of the pier on September 12, 2001. The purpose of the visit was to review and provide comment on the delineation of two wetlands near the shoreline conducted by Krazan & Associates. The Pentec wetlands scientist was escorted to the wetlands by the project manager.

Pentec used the Routine Determinations wetland delineation method described in the *Washington State Wetlands Identification and Delineation Manual* (Ecology 1996) to evaluate the Krazan wetland delineations. According to the manual, an area is considered a jurisdictional wetland when hydrophytic (wetland) vegetation, hydric (wetland) soils, and wetland hydrology are present. With few exceptions, all three parameters are required for an area to be a jurisdictional wetland. Hydrophytic vegetation is considered to be present if more than 50 percent of the dominant plants in an area have wetland indicator statuses of facultative (FAC), facultative wetland (FACW), or obligate wetland (OBL), as defined by Reed (1988) and Reed et al. (1993).

Based on the survey map provided by Team 4 Engineering and site conditions on September 12, 2001, Pentec agreed with most of the wetland boundaries flagged on the project site. Pink “wetland boundary” flagging was clearly identifiable and was found to follow the jurisdictional wetland boundary of the wetland in the gully above the bluff (Wetland A). However, based on this review, the Wetland A boundary (and corresponding wetland buffer) was subsequently extended approximately 30 feet farther southeast down the steep portion of the gully (Appendix B, Sheet C2.2). Although the boundary was extended, the wetland did not appear to connect to Wetland B, adjacent to the beach (Appendix B, Sheet C2.2).

Pentec also disagreed with small portions of the boundary initially delineated on Wetland B, adjacent to the beach on the northeast end of the site. On the southwest end of the wetland, standing water, wetland plants, and hydric soil extended south and east from the flagged boundary. Dominant plants included toad rush (*Juncus bufonius*, FACW), and saltbush (*Atriplex patula*, FACW). Subsequently, the Wetland B boundary was extended to the edge of the vegetation and close to the ordinary high water mark.

In addition, Pentec determined the area just outside of the original northwest boundary of Wetland B had some wetland characteristics but was not definitively wetland throughout. This area included a portion of the bluff that had recently slumped off. Wetland plants were dominant here and hydric soils were seen in some places. Red alder (*Alnus rubra*, FAC) was the dominant plant and appeared to be 2 to 4 years old. Wetland hydrology was not seen at the time of the wetland review; however, evidence of wetland hydrology may be established if the site is visited during wetter months. It appears that a wetland was buried by the material that slid off the bluff, and that wetland conditions may be reestablishing on the slide area. Observations of conditions in and adjacent to Wetland B in the course of the intertidal surveys described above indicate that conditions of standing water and vegetation seem to vary considerably over seasons. Therefore, the Wetland B boundary was extended to the west to include this disturbed area, as shown in Appendix B, Sheet C2.2.

A third wetland was seen on the southwest end of the site. Most of the wetland is on the property to the southwest, but the wetland overlaps the property boundary by approximately 50 feet. Because this wetland is more than 200 feet from the project, it was not delineated.

Based on the Washington State Wetland Rating (Ecology 1996), Pentec would rate the wetland adjacent to the beach, Wetland B, as Category II. This rating is based on the facts that the wetland is less than 1 acre in size, the buffer is undisturbed, and features include woody debris, contiguous freshwater wetland, and high saltmarsh. The wetland in the gully, Wetland A, would also rate as Category II, primarily because of the undisturbed condition, good buffers, and connection to a stream. Jefferson County and the Washington State Department of Ecology should be consulted for a final wetland rating.

6.0 REFERENCES

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PHOTOS

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Photograph 1 – View from beach toward upper shoreline at approximate location of Conveyor crossing.

Photograph 2 – Upper beach and backshore, looking southwest.

Photograph 3 – Upper beach, looking northeast. Stranded/dead jellyfish (*Cyanae*) visible along high-tide line.

Photograph 4 – View looking southeast from upper beach across tideflat along Conveyor alignment.

Photograph 5 – View looking southwest. Scattered patches of *Zostera japonica* present on tideflat.

Photograph 6 – Dense stand of *Z. japonica* in tide pool.

Photograph 7 – Sand dollars (*Dendraster excentricus*) on tideflat.

Photograph 8 – View looking southwest at low tide (approximately -2 feet MLLW). Scattered patches of *Z. marina* beginning north of channel marker.

Photograph 9 – Eelgrass reference bed: low-tide (-2 feet MLLW) view looking northeast from north of proposed Conveyor alignment (lighter green on left is ulvoid algae).

Photograph 10 – Moon snail (*Polinices lewesii*) partially buried in sand.

Photograph 11 – View from upper beach looking southwest on July 12, 2002.

Photograph 12 – View from upper beach looking northeast on July 12, 2002.

Photograph 13 – View looking southwest across tideflat on July 12, 2002. Scattered patches of *Z. japonica*.

Photograph 14 – View looking northeast from north side of Pier alignment on July 12, 2002. Eelgrass (*Z. marina*) reference bed surveyed in 2001.

Photograph 15 – View looking southwest at low tide on August 17, 2001. Patches of *Z. marina* beginning north of channel marker.

Photograph 16 – View on July 12, 2002 from same location north of channel marker. Patches of *Z. marina* appear relatively unchanged.

TABLES

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Table C-1 - Japanese Eelgrass Density, September 28, 2001*

Patch No.	Rep.	Shoot Count (per 1/16 m^2)	Density (Shoots/m^2)	Average (Shoots/m^2)
1	a	66	1,056	
	b	58	928	
	c	77	1,232	1,072
2	a	55	880	
	b	71	1,136	
	c	52	832	949
3	a	82	1,312	
	b	89	1,424	
	c	96	1,536	1,424
4	a	29	464	
	b	57	912	
	c	41	656	677
5	a	48	768	
	b	65	1,040	
	c	68	1,088	
	d	66	1,056	988
6	a	91	1,456	
	b	94	1,504	
	c	93	1,488	1,483
	Average density within patches			1,099

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*Notes:
All counts taken within patches; data do not represent density over the entire beach.
Low Tide: 1.2 feet at 0700 hour

Table C-2 - Diver Quadrat Data and Observations, September 27, 2001*

						Eelgrass Shoot Counts			Macroalgae			
Transect	Distance	Tide	Depth	MLLW	Substrate	Quad 1	Quad 2	Quad 3	Quad 1	Quad 2	Quad 3	Comments
Reference	0	10.5	13	2.5	Sand	21	37	40	40	30	50	Grain-size sample
	10	10.5	14	3.5	Sand	47	50	66	20	30	20	
	30	10.5	14	3.5	Sand	54	47	39	20	20	30	
	55	10.5	15	4.5	Sand	56	20	31	20	10	20	
	75	10.5	19	8.5	Sand	0	0	0	0	0	0	No more grass
0	0	10.5	25	14.5	Sand	0	0	0	0	0	40	Hermit
	20	10.5	20	9.5	Sand	12	0	0	20	0	0	
	40	10.5	16	5.5	Sand	0	0	0	0	0	0	
	60	10.5	13	2.5	Sand	0	0	0	0	0	0	
	80	10.5	12	1.5	Sand	0	0	0	0	0	0	
	100	10.5	12	1.5	Sand	0	0	0	0	0	5	
20	-20	10	31	21	Sand	0	0	0	11	20	40	Worm tubes
	0	10	24	14	Sand	0	0	0	0	30	0	Worm tubes, diatoms
	20	10	20	10	Sand	0	0	0	0	5	5	Worm tubes, diatoms
	40	10	16	6	Sand	0	0	0	0	0	5	Worm tubes, diatoms
	60	10	14	4	Sand	0	0	0	0	5	15	No worm tubes, diatoms
	80	10	12	2	Sand	0	0	0	0	0	0	
	100	10	12	2	Sand	0	0	0	0	0	0	
	120	10	12	2	Sand	0	0	0	0	0	0	Moon snail egg case, diatoms
40	-20	9.5	27	17.5	Sand	0	0	0	0	30	10	Worm tubes, Dungeness crab
	0	10.5	24	13.5	Sand	0	0	0	0	0	0	Worm tubes, diatoms
	20	10.5	19	8.5	Sand	0	0	0	0	20	10	Worm tubes, diatoms
	40	10.5	15	4.5	Sand	0	0	0	0	0	0	Worm tubes, diatoms
	60	10.5	13	2.5	Sand	0	0	0	0	0	0	Worm tubes, diatoms
	80	10.5	13	2.5	Sand	0	0	0	0	20	0	Worm tubes, diatoms
	100	10.5	12	1.5	Sand	0	0	0	0	0	0	Diatoms
60	-20	10	28	18	Sand	0	0	0	0	10	0	Diatoms
	0	10	23	13	Sand	0	0	0	0	5	0	Diatoms
	20	10	19	9	Sand	0	0	0	0	5	10	Worm tubes, diatoms
	40	10	15	5	Sand	20	0	0	0	10	10	Worm tubes, diatoms
	60	10	12	2	Sand	0	0	0	0	5	5	Diatoms
	80	10	12	2	Sand	0	0	0	0	0	0	Diatoms
	100	10	11	1	Sand	0	0	0	0	0	0	Diatoms
	120	10	10	0	Sand	0	0	0	0	0	0	Hermit
80	-20	9.5	25	15.5	Sand	0	0	0	0	5	0	
	0	10	22	12	Sand	0	0	0	0	5	10	
	20	10	18	8	Sand	0	0	0	0	0	10	*Ulva*
	40	10	13	3	Sand	0	0	0	0	10	20	
	60	10.5	14	3.5	Sand	0	0	10	0	5	5	*Ulva*, hermit crab
	80	10.5	12	1.5	Sand	0	0	0	0	0	0	
	100	10.5	12	1.5	Sand	0	0	0	0	0	0	
	120	10.5	24	13.5	Sand	0	0	0	0	0	0	
100	0	9.5	21	11.5	Sand	0	0	0	0	5	0	
	20	9.5	28	18.5	Sand	0	0	0	0	5	5	Worm tubes, diatoms
	20	9.5	18	8.5	Sand	0	0	0	0	5	5	Worm tubes, diatoms
	40	9.5	14	4.5	Sand	0	0	0	0	5	0	Worm tubes, diatoms
	60	9.5	12	2.5	Sand	0	0	0	0	10	5	Worm tubes, diatoms
	80	9.5	11	1.5	Sand	0	0	0	0	0	0	Eelgrass nearby
	100	9.5	11	1.5	Sand	0	0	0	0	0	0	
	120	9.5	10	0.5	Sand	0	0	0	0	0	0	
120	0	10	22	12	Sand	0	0	0	0	5	0	
	20	10	19	9	Sand	0	0	0	5	0	0	
	40	10	16	6	Sand	0	0	0	10	20	10	
	60	10	13	3	Sand	94	80	78	10	10	10	Cabezon
	80	10	12	2	Sand	0	12	0	5	0	0	
	100	10	10	0	Sand	0	0	0	0	0	0	
140	0	7.5	18	10.5	Sand	0	0	0	0	65	0	Diatoms
	20	7.5	14	6.5	Sand	0	0	0	0	5	0	Worm tubes
	40	7.5	12	4.5	Sand	26	36	37	90	90	90	Sea star, Dungeness crab, shrimp
	60	7.5	11	3.5	Sand	0	0	25	0	5	80	
	80	7.5	10	2.5	Sand	0	0	0	0	0	0	
	100	7.5	10	2.5	Sand	0	0	0	0	0	5	
160	0	9.5	20	10.5	Sand	0	0	0	5	0	0	*Ulva*
	20	9.5	17	7.5	Sand	0	0	0	0	0	10	*Ulva*
	40	9.5	15	5.5	Sand	0	0	0	0	0	5	
	60	9.5	12	2.5	Sand	83	67	41	10	10	10	*Ulva*, kelp
	80	9.5	12	2.5	Sand	0	0	0	0	0	5	
	100	9.5	12	2.5	Sand	0	0	0	0	0	0	
180	0	7.5	17	9.5	Sand	0	0	0	0	0	0	Diatoms
	20	7.5	13	5.5	Sand	0	0	0	0	0	0	
	40	7.5	10	2.5	Sand	60	69	74	25	40	40	Dungeness crab
	60	7.5	10	2.5	Sand	0	0	0	0	0	0	Diatoms on sand
	80	7.5	9	1.5	Sand	28	0	0	10	0	0	Nudibranch
	100	7.5	9	1.5	Sand	0	0	0	0	0	0	
	120	7.5	9	1.5	Sand	0	0	0	0	0	0	*C. gracilis*
200	-20	9.5	21	11.5	Sand	0	0	0	5	5	5	*Ulva*
	0	9.5	16	6.5	Sand	0	0	0	5	10	5	*Ulva,* Dungeness crab (clasping)
	20	9.5	12	2.5	Sand	0	0	0	0	0	1	*Ulva*
	40	9.5	10	0.5	Sand	44	37	49	0	0	0	1-foot-wide eelgrass
	60	9.5	9	-0.5	Sand	107	105	39	0	0	0	*Ulva* - edge of bed
	80	9.5	10	0.5	Sand	5	20	25	10	20	20	*Ulva*
	100	9.5	10	0.5	Sand	0	41	0	0	0	0	

Average within entire study area **22.9 shoots/m²** **5.4 percent**

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* Shaded data are from the 32 quadrats within 25 feet south and 50 feet north of the Conveyor centerline.

FIGURES

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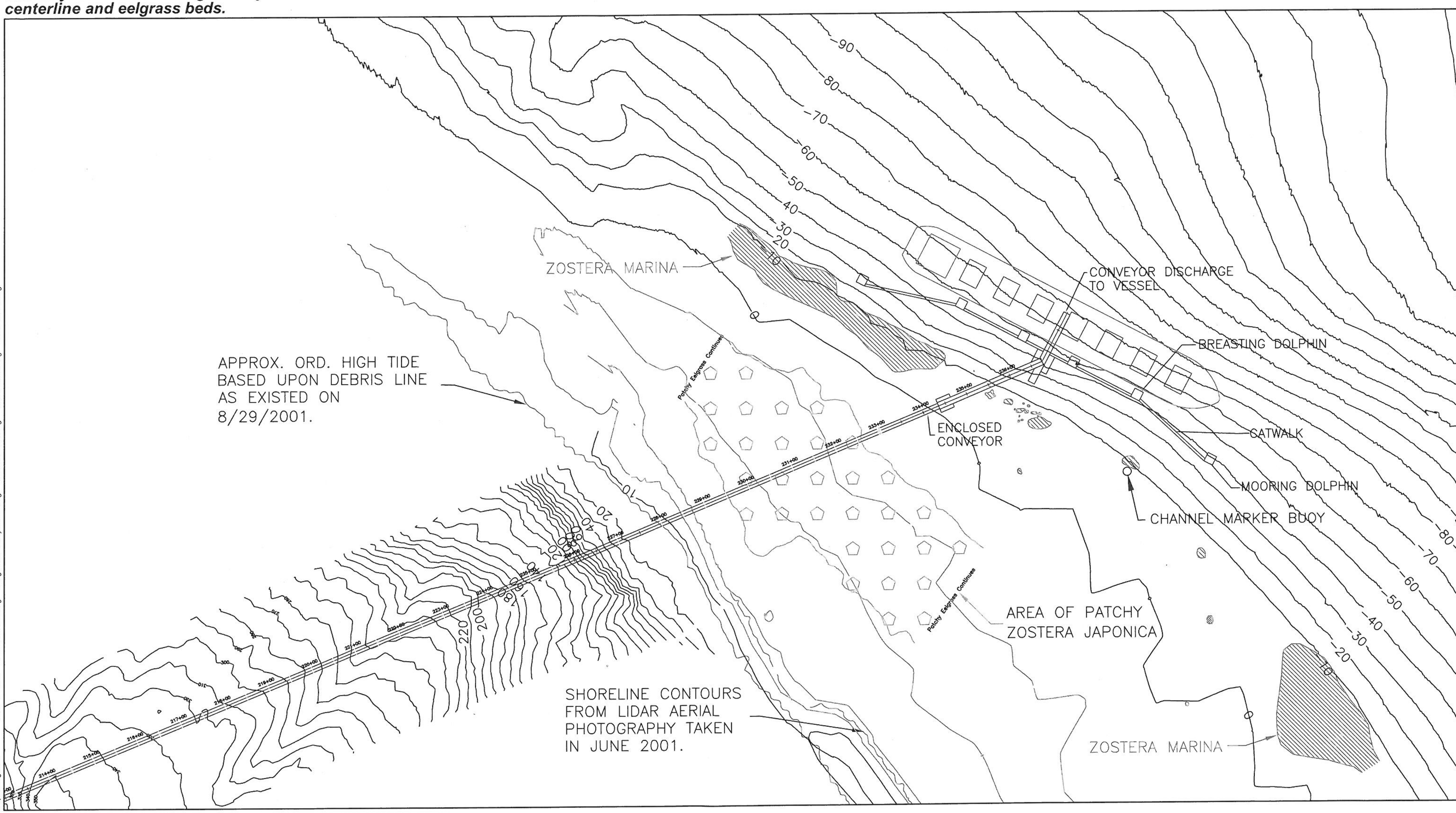
T-ROC CENTRAL CONVEYOR AND PIER
Thorndyke Beach showing conveyor centerline and eelgrass beds.



Report Figures MSL 1"=200' 4112-MLLWA.dwg Eelgrass Survey 2001.dwg 4112-SHT03.dwg vessel track.dwg 4112-Sht01.dwg

Elevations in Mean Lower Low Water (MLLW)

Patchy Eelgrass (Zostera japonica)

Eelgrass (Zostera marina)

APPROXIMATE SCALE IN FEET

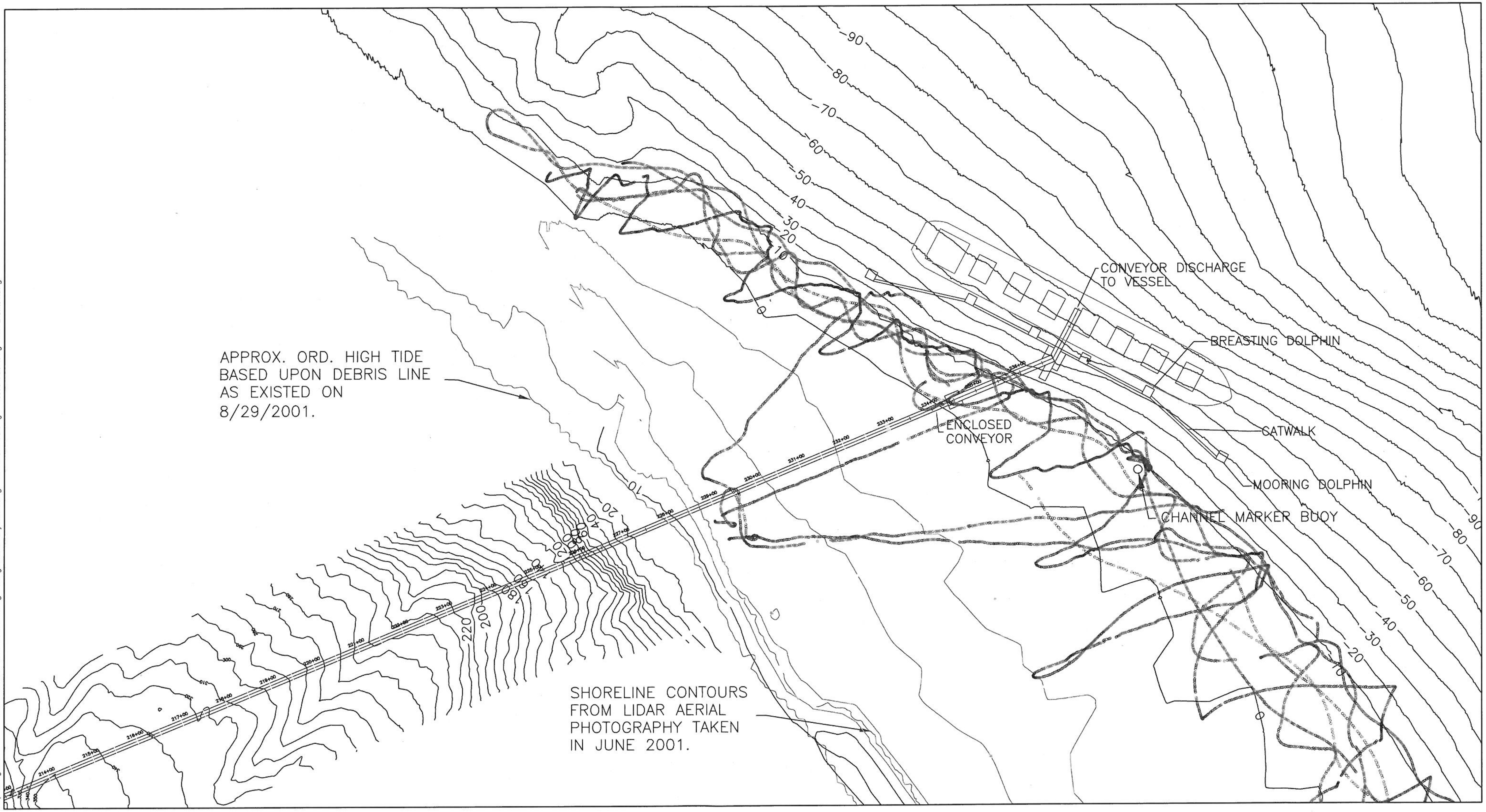
0 100 200 400

PENTEC ENVIRONMENTAL

12007-47 02/26/03

Figure C-1

T-ROC CENTRAL CONVEYOR AND PIER
Video survey vessel track.



Report Figures MSL 1"=200' 4112-MLLWA.dwg Eelgrass Survey 2001.dwg 4112-SHT03.dwg vessel track.dwg 4112-Sht01.dwg

Note: Video survey completed on 8/28/01.

Vessel Track

Elevations in Mean Lower Low Water (MLLW)

APPROXIMATE SCALE IN FEET

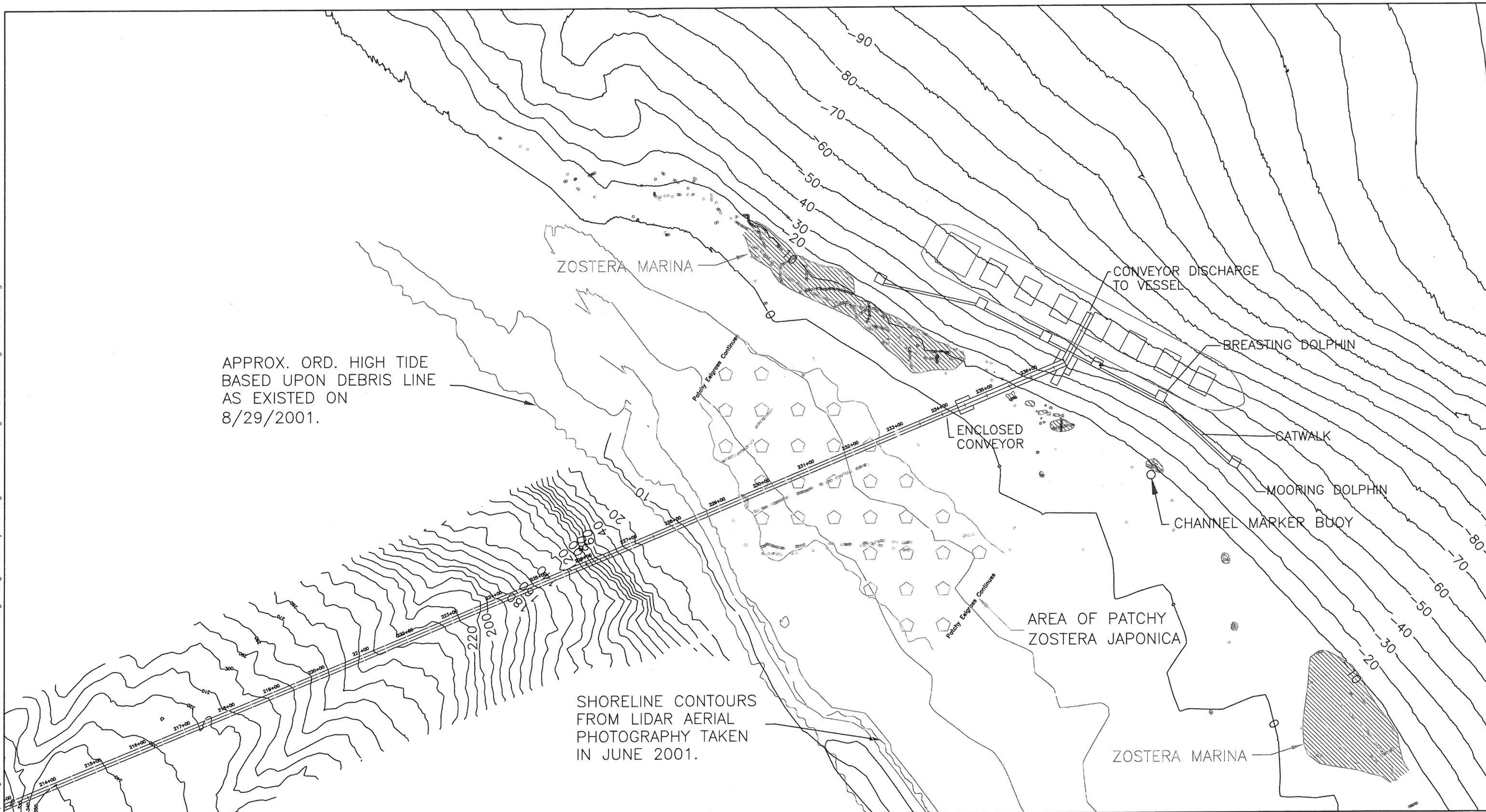
0 100 200 400

PENTEC ENVIRONMENTAL

12007-47 02/26/03

Figure C-2

T-ROC CENTRAL CONVEYOR AND PIER
Eelgrass documented in the video survey.



Report Figures MSL 1"=200' 4112-MLLWA.dwg Eelgrass Survey 2001.dwg 4112-SHT03.dwg vessel track.dwg 4112-Sht01.dwg

Note: Video survey completed on 8/28/01.

Patchy Eelgrass (Zostera japonica)

Eelgrass (SeaAll Survey)

Eelgrass (Zostera marina)

Elevations in Mean Lower Low Water (MLLW)

APPROXIMATE SCALE IN FEET

0 100 200 400

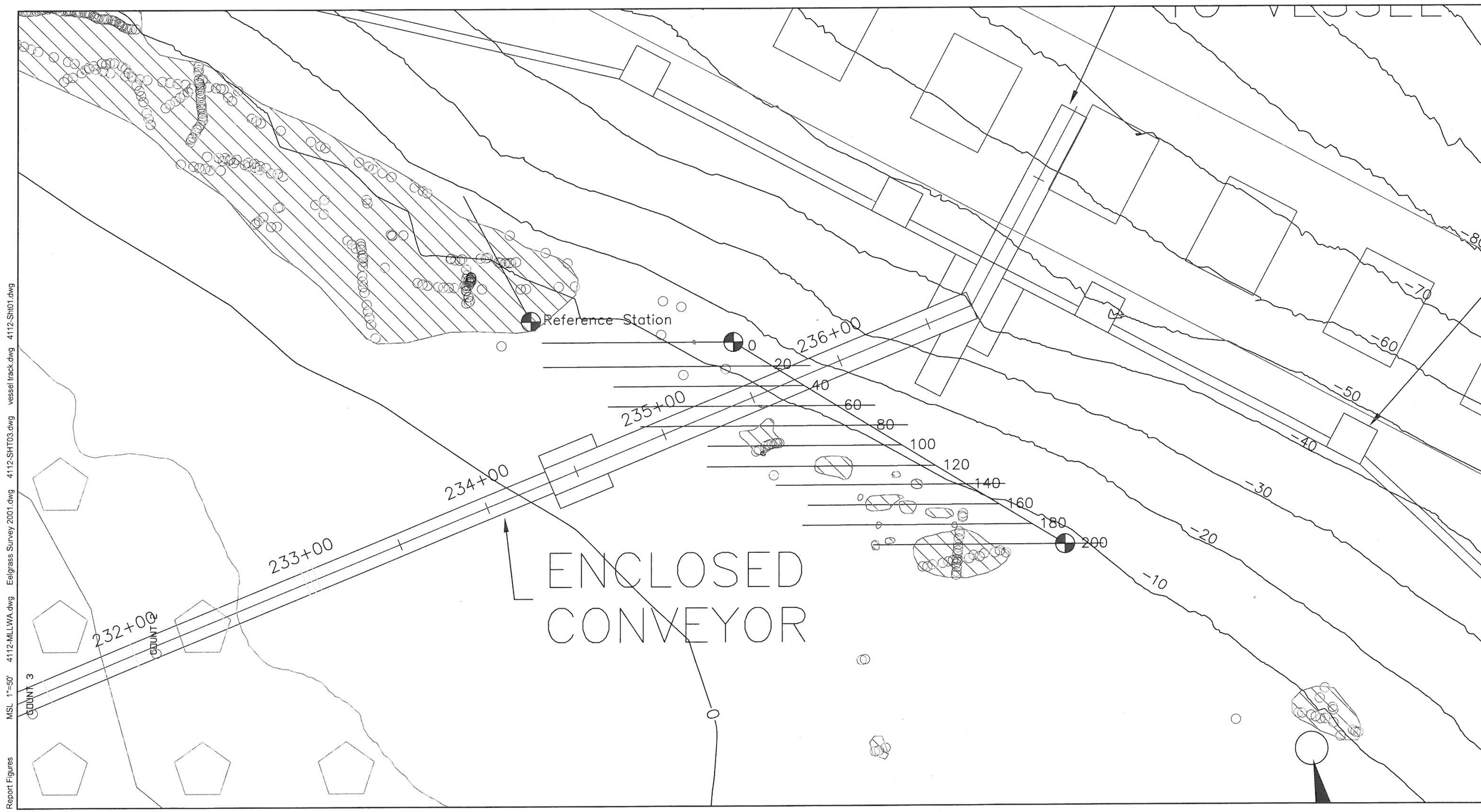
PENTEC ENVIRONMENTAL

12007-47 *02/26/03*

Figure C-3

T-ROC CENTRAL CONVEYOR AND PIER

Diver survey and eelgrass bed detail.



Note: Diver survey completed on 9/27/01.

Eelgrass (SeaAll Survey) — GPS Station

Eelgrass (Zostera marina) — Diver Survey Transect

APPROXIMATE SCALE IN FEET

0 25 50 100

PENTEC ENVIRONMENTAL

12007-47 02/26/03

Figure C-4

APPENDIX D
HABITAT MANAGEMENT PLAN
FOR MARINE HABITAT AND BALD EAGLES

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Thorndyke Resource Operations Complex
Central Conveyor and Pier
Habitat Management Plan
For Marine Habitat and Bald Eagles

Jefferson County, Washington

Prepared for
Reid Middleton, Inc.

February 28, 2003
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Central Conveyor and Pier
Habitat Management Plan
For Marine Habitat and Bald Eagles

Jefferson County, Washington

Prepared for
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February 28, 2003
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THORNDYKE RESOURCE OPERATIONS COMPLEX
CENTRAL CONVEYOR AND PIER HABITAT MANAGEMENT PLAN
FOR MARINE HABITAT AND BALD EAGLES

1.0 INTRODUCTION

This Habitat Management Plan (the plan) addresses the design features of the proposed Thorndyke Resource Operations Complex (T-ROC) Central Conveyor and Pier project to minimize potential impacts to bald eagles (*Haliaeetus leucocephalus*), marine habitat, and resources. In addition, the plan proposes an approach to ensure that compensation is provided for any adverse impacts to important marine resources, especially those comprising habitat for salmonids listed as threatened under the Endangered Species Act (ESA).

2.0 PROJECT DESCRIPTION

The proposed T-ROC Central Conveyor and Pier project will include an approximately 4-mile Conveyor to transport sand and gravel from an upland gravel mining operation (the Shine Pit) in Jefferson County to an offshore loading pier located in Hood Canal approximately 5 miles southwest of the Hood Canal Bridge (Appendix B, Sheet 1). During operation, the Conveyor system will transport up to 3,000 tons of materials per hour to vessels docked at the Pier. Depending on the vessels' sizes, it is anticipated that one to six vessels will be loaded at the facility each day. It is assumed vessels would be loaded up to 300 days a year, up to 24 hours a day.

The main elements of the proposal include the Central Conveyor, which is composed of the Twin Conveyors (approximately 3.3 miles in length) and the Single Conveyor (approximately 0.7 mile), and the Pier (approximately 1,000 feet). The Central Conveyor was designed to avoid impacts to environmentally sensitive areas. According to the technical studies prepared to date (i.e., wetlands and preliminary geotechnical reports), the Twin Conveyors will not impact any existing wetlands or steep slopes. In addition, the entire Conveyor (including the Pier) will be covered or enclosed to minimize the potential for spillage. Best management practices (BMPs) will be implemented during Conveyor operations in both the upland and marine operating areas. These BMPs are designed to minimize the risk of materials spills, including fuel spills and other potential sources of contamination. Refueling of equipment will be conducted off site whenever possible. On-site refueling activities will adhere to strict safety guidelines. An approved spill response plan including details regarding on-site spill containment equipment will be developed prior to Conveyor operations.

Lighting of portions of the Single Conveyor and Pier crossing marine habitats will be kept to a minimum, while still conforming to all applicable safety-related requirements of the regulatory agencies (i.e., U.S. Coast Guard, OSHA, WISHA, etc.). Lighting of the water surface will be minimized with shielding. During nonoperation hours, lights will be turned off, except as needed for maritime safety requirements.

A detailed T-ROC Central Conveyor and Pier project description and fact sheet are provided in Appendix F. Additional information regarding project construction and operation and potential impacts are presented in the main body of the biological evaluation (BE).

2.1 Plan Objectives

The objectives of this plan are as follows:

- To evaluate the nature of the marine and littoral habitat effects of the construction and operation of the proposed Central Conveyor and Pier with emphasis on habitat for bald eagles and salmonids listed or potentially listed as threatened under the ESA.

- To describe monitoring that will be conducted to document any adverse impacts on important species or habitats.

- To describe a preproject enhancement action that will be implemented with approval of project permits (i.e., in advance of project construction). The enhancement will offset a majority of the reasonable worst-case loss of marine habitat (eelgrass) function that might result from the project, should such impacts occur. If no, or lesser, impacts result from project shading, the preproject transplanting would simply provide an overall increase in habitat function in the area.

- To identify habitat enhancement actions that would be implemented to offset documented adverse impacts, should such impacts occur that exceed those mitigated in advance by the preproject enhancement action.

3.0 AVOIDANCE AND MINIMIZATION

The T-ROC Central Conveyor and Pier project is proposed as an alternative that would avoid or minimize the overall impacts of transporting similar quantities of sand and gravel by truck. An environmental impact statement (EIS) will analyze alternative transportation methods and the levels of impact associated with overland movement of different quantities of material.

Several aspects of the Conveyor are designed to avoid or minimize the potential for impacts to bald eagles, which utilize the forests and marine shorelines bordering Hood Canal, and to the nearshore marine environment, which provides critical habitat for ESA-listed salmonids, as well as other resources.

3.1 Marine Habitat

The Pier will terminate in deep water (>30 feet mean lower low water [MLLW]) to avoid impacts to macrovegetation from direct shading or from propeller scour. The Conveyor width will be minimized as it crosses the littoral zone (from ordinary high water [OHW] to –10 feet MLLW) and constructed with maximum use of open girders to reduce the extent of shading. The height of the Conveyor, particularly over the lower intertidal and subtidal areas, will further lessen the shadowing effect. The enclosed belt design will help contain dust, eliminate runoff of turbid water during rainy periods, and minimize the potential for spillage. The undersurface of the Conveyor will be light in color to minimize attenuation of reflected light.

The Conveyor will be supported across the intertidal and subtidal zone (i.e., <30 feet MLLW) with a minimum number of piles (spaced at 100-foot intervals). The footprint will be further minimized by the use of the smallest-diameter piles meeting the design requirements. Piles for the Pier and Conveyor support will be steel to eliminate any potential for hydrocarbon leaching that would result from use of wood piles.

The proposed Conveyor and Pier location was selected to avoid patches of native eelgrass (*Zostera marina*) found below approximately –1 foot MLLW and extending down into the subtidal depths, thus minimizing the overall area of eelgrass that may be affected. However, the Pier cannot be located to totally avoid eelgrass, because of the presence of non-native eelgrass, *Z. japonica*, as discussed below.

3.2 Bald Eagles

The Single Conveyor will pass approximately 0.5 mile south and west of a known bald eagle nesting site, as identified in the Washington Department of Fish and Wildlife (WDFW) Priority Habitats and Species (PHS) database (Guggenmos, L., WDFW, personal communication, February 12, 2003; Appendix A). Pope Resources previously developed a *Bald Eagle Management Plan* for this nesting site (identified as South Point Bald Eagle Nest #382) in preparation for a clearcut timber harvest on Pope property located immediately north of the Conveyor (Raedeke 1995). Under this previous *Bald Eagle Management Plan*, 24 trees were identified to be retained as current and future perch and nest trees. Three of these trees are located immediately (25 to 80 feet) north of the proposed Conveyor and will not be disturbed. No other large trees that currently exist within South Point Bald Eagle Territory #382 will be removed for construction of the Conveyor, and only minimal clearing of smaller trees will occur.

4.0 EXISTING CONDITIONS

4.1 Marine Habitat

The existing marine intertidal habitat and associated species are described in detail in the *Marine Resources Survey Report* (Appendix C). The upper beach is bordered on the northwest by a steep bluff. A previous slope failure deposited a substantial quantity of sand and silt on the backshore, significantly altering a wetland formed by seep water from sediment layers within the bluff. A variety of plants are found in this riparian zone and along the high-tide drift line.

Below the high-tide line, the beach face is moderately steep and sandy, with lenses of gravel; this beach face extends down to a broad sandflat that begins at about +6 feet MLLW. Both on this upper beach and on the sandflat, low patches of unstable sand give evidence of a net drift from southwest to northeast. The substrate along and below the high-tide line appears potentially suitable for spawning by surf smelt (*Hypomesus pretiosus*) and/or sand lance (*Ammodytes hexapterus*), although no documented spawning by either species occurs within at least one-third to one-half mile southwest of the proposed Central Conveyor and Pier (Guggenmos, L., WDFW, personal communication, February 12, 2003; Appendix A).

Where the lower edge of the beach face transitions to the sandflat, seep water emerges at low tide to create shallow pools of standing water, eventually forming a channel that meanders across the flat. Noteworthy biota on this flat is described in detail in Appendix C.

From about +4 feet MLLW to +1 foot MLLW the sandflat supports scattered and discrete patches of *Z. japonica*. *Z. japonica* is an introduced species known to occur throughout northern Puget Sound, although its distribution has not been well documented (Thom and Hallum 1990). Because it is an annual, it is expected to be highly variable in space and time. This is especially true on beaches such as this one, where the advancing sand waves bury individual patches while new patches form in the wake of each wave. Surveys in 2001 indicated shoots were very dense (approximately 1,100 turions per square meter [m^2]) and fertile fronds were present where patches occurred in shallow standing-water ponds. However, in July 2002, the isolated patches of *Z.*

japonica, particularly within the lower tidal range, appeared to be more scattered and generally less dense compared with the previous summer, although no eelgrass shoot counts were made during the latter survey (see Appendix C). In addition, the blades of *Z. japonica* appeared in general to be shorter and narrower than in summer 2001, suggesting there may have been reduced seasonal growth in spring and early summer 2002.

The beach surface is somewhat firmer on the outer portion of the sandflat. Below about +1 foot MLLW, very widely scattered geoduck *(Panope abrupta*) siphons were observed in August 2001. Beginning at about –1.5 feet MLLW and extending down into the subtidal zone (approximately –16 feet MLLW) is a band of patches of native eelgrass (*Z. marina*). In contrast to *Z. japonica*, boundaries of the *Z. marina* patches and densities of *Z. marina* within this band appeared to be relatively unchanged between August/September 2001and July 2002, although no shoot densities were measured during the latter survey. As reported in both the 2001 and 2002 surveys, eelgrass was generally dense in the patches within this band, and the patches became larger and more continuous to the northeast of the proposed Conveyor centerline. The diver survey in September 2001 indicated most patches were smaller than 20 feet in diameter, with densities ranging from 20 to 428 shoots per m^2 (mean 189 shoots per m^2) in quadrats containing eelgrass (i.e., within the patches shown on Appendix C, Figure C-4).

Z. marina is very sparse within the 75-foot strip from 25 feet southwest of the proposed Conveyor centerline to 50 feet northeast of the centerline (the zone of maximum potential shading). Of the 32 diver-survey observation points within this zone, only three contained any eelgrass at all. Overall density was calculated at 1.75 shoots per m^2, about 1 percent of the density in eelgrass patches southwest and northeast of the centerline.

No specific sampling of salmon use of the project site has been done; however, large numbers of adult pink salmon were observed in the shallows near the project site during a low-tide visit in August 2001. Several species of juvenile salmon, including threatened Puget Sound chinook salmon (*Oncorhynchus tshawytscha*) and Hood Canal summer-run chum salmon (*O. keta*), migrate past the project site during their spring outmigrations from streams to the south. The middle and lower intertidal sandflats are expected to provide moderate quantities of crustacean prey for juvenile salmonids, with greater abundance of prey produced in patches of eelgrass.

4.2 Bald Eagles

As described above, a bald eagle nest site (South Point Nest #382) exists about 0.5 mile northeast of the proposed Conveyor. Eagles have been observed on and near the site by other consultants working on this project, and foraging in shallow waters along the site and onsite beaches during low tides.

Most of the upland areas along the proposed Conveyor have been logged within the past 10 years and are in early stages of regeneration. Eagles may forage in these disturbed habitats, but level of use is expected to be less than in the marine shoreline areas. As noted above, known and potential perch trees were not cut during that logging, and additional large trees, especially Douglas fir and red alder, remain along the shoreline.

5.0 IMPACT ANALYSIS

5.1 Marine Habitat

Project construction will result in destruction of isolated local areas of marine benthic habitat and species in the footprint of each pile. Short-term disturbance of fish fauna will result from pile driving and work vessel activity during Conveyor construction. Noise levels associated with pile driving and other aspects of the proposed action will be temporarily elevated above existing background noise levels. Feist et al. (1996) investigated the impacts of driving concrete piles on juvenile pink and chum salmon behavior and distribution in Everett Harbor, Washington. The authors reported that there may have been changes in general behavior and school size, and that fish appeared to be driven toward the acoustically isolated side of the site during pile driving. However, the prevalence of fish schools did not change significantly with or without pile driving, and schools were often observed about the pile-driving rigs themselves. No impacts on feeding were reported. The study concluded that any effects of pile-driving noise on juvenile salmonid fitness would be very difficult to measure quantitatively.

More recent experience in Puget Sound and elsewhere, however, has documented more severe effects from use of an impact hammer to drive large-diameter hollow steel piles such as those that will be required for this project. Impact driving of 24-inch steel piles in late 2002 at a ferry terminal in Puget Sound resulted in deaths of a number of pile perch (Embiotocidae); similar or larger piles, driven by impact hammer at the Port of Seattle, resulted in kills of Pacific herring (Erstad, P., WDFW, personal communications). However, impact driving of 24-inch piles at the Mukilteo Ferry dock in early 2003 did not result in documented fish kills; a bubble curtain was deployed at Mukilteo and shown to significantly reduce measured water-borne sound pressures (J. Houghton, Pentec, personal observation).

For the proposed project, all support and batter piles in the marine and shoreline areas will be installed using a vibratory method (site conditions permitting), which produces much lower inwater noise levels than installation using an impact hammer like those that have had documented impacts to fish. Furthermore, the inwater construction activities will occur outside of periods when significant numbers of juvenile salmonids are expected to be present. Thus, no significant noise-related disturbances to salmonids are expected from these construction activities.

Pile driving may have temporary, short-term effects on other federally managed fish species that may occur in the project area, such as starry flounder (*Platichthys stellatus*), English sole (*Pleuronectes vetulus*), or sand sole (*Psettichthys melanostictus*). However, because these species lack swim bladders, no significant short-term, direct impacts to essential fish habitat are anticipated as a result of construction noise.

During project operation, additional short-term disturbance of fish fauna in deeper waters will result from movements of vessels to and from the Pier.

The Conveyor will cast shadows on portions of the adjacent beach and subtidal bottom areas; however, overall impacts (direct and indirect) to eelgrass beds are expected to be very limited. Shadows from the Conveyor and Pier (including vessels) are not expected to reach the large patch of *Z. marina* east of the Conveyor and north and east of the Pier (Appendix B, Sheet C2.3) during major growth periods (spring and summer). However, due to the Conveyor's proximity to patches of *Z. japonica*, some shading of *Z. japonica* is likely to occur. The amount of shading and the amount of eelgrass potentially affected cannot be determined. However, because of the height of the Conveyor, its shadow will move constantly throughout each day, falling on any given area that may contain eelgrass patches for a maximum of an hour or two each day. *Z. japonica* occurs in isolated patches within a 250-foot-wide zone over which the shadow will move. It is conservatively predicted that light availability may fall below thresholds necessary for optimal eelgrass production in a zone of about 30 feet in width (three times the approximate effective diagonal dimension of the enclosed section of the Conveyor, given the south half of the structure will consist of a grated walkway) over the *Z. japonica* band. This is an area of about 7,500 square feet (sf) within which *some reduction* in eelgrass growth *may* occur. This estimate is conservative because production of eelgrass at higher intertidal elevations is limited by desiccation, not by light levels. Thus, it is *probable* that there will be no reduction in *Z. japonica* productivity as a result of shadows cast by the Conveyor.

Shading from the two open support platforms and from mooring dolphins will not reach areas of eelgrass (*Z. marina*) during the great majority of the day. The shadow from the northern mooring dolphin and from the outer support tower will reach adjacent eelgrass beds briefly during early morning, when the sun is very low in the eastern sky. Because of the low sun angle, light refraction off the water surface will be great under these circumstances, and the amount of photosynthetically active radiation reaching the bottom (and eelgrass) will likely be below the threshold for photosynthesis with or without the project structures. Thus, the effect on eelgrass is expected to be minimal.

No long-term impact on potential forage fish spawning habitat will result from placement of pilings across the beach. The pilings will occupy approximately 734 sf of marine benthic habitat at depths between about +6 feet and –64 feet MLLW (Table D-1). The great majority of this area (about 613 sf) would be below depths of –30 feet MLLW. To offset this loss, a substantially greater area of hard surface will be provided for attachment of epibenthic plants and animals that will greatly exceed the lost benthic primary and secondary productivity. A total of over 11,000 sf of epibenthic surface area will be created at depths between +6 feet and –10 feet MLLW (Table D-1). Plants and animals colonizing this surface area will contribute to the primary and secondary productivity of the water column passing the site. The shells of barnacles and mussels sloughed from the pilings would support a suite of organisms that is different from that now present in the predominantly sandy substrate of the project site.

The overwater portion of the Conveyor will be fully enclosed out to the Pier. However, some sand and gravel could be spilled at the discharge point. If any spillage occurred over the beach due to an unanticipated catastrophic system failure, it will simply add sand and gravel to a sand-and-gravel beach. Any effects will be minimal, localized, and quickly dispersed by wave action. In deeper water (e.g., deeper than –30 feet MLLW), any small amount of sand and gravel that may spill at the transfer point could alter the nature of the benthic fauna and epibiota in localized areas to favor an assemblage adapted to a coarser substratum. Rates of accumulation will not be great enough to adversely affect larger infauna, such as geoducks (e.g., Westley et al. 1975).

5.2 Bald Eagles

Construction activities may result in short-term avoidance by bald eagles of the immediate project vicinity. Bald eagle breeding and nesting activity is not expected to be affected due to the distance from the Conveyor and Pier to known nesting territories identified by the WDFW PHS Database (Guggenmos, L., WDFW, personal communication, February 12, 2003; Appendix A). Increased noise levels may temporarily disrupt foraging behavior of bald eagles in the vicinity of the project area. The Washington State Department of Transportation (WSDOT) conducted monitoring studies to determine the potential impacts on wintering eagles associated with pile-driving activities at Orcas and Shaw islands in San Juan County, Washington, from December 15, 1986, through March 15, 1987 (Bottorff et al. 1987). Each of the monitoring areas was associated with a Washington State ferry terminal. Background noise sources included ferry whistles, boat motors, chain saws, aircraft, front-end loaders, cranes, generators, diesel trucks, hammers, and other general noise sources associated with construction. Noise readings were taken at the construction sites and various intermediate points out to about 6,000 feet from the construction sites.

Driving wood piles did not visibly disturb the eagles observed during the course of the study. A steel pile, which produces some of the loudest noises during pile-driving activities, may have disturbed a bald eagle at a distance of 4,000 feet. However, this same pair of eagles had been in the same location during the driving of two steel piles earlier in the day and exhibited no visible disturbance reaction. Even after more than 100 wood piles were driven (Bottorff et al. 1987), the eagle pair returned to their preferred perch with no further adverse reactions observed. Environmental factors such as wind and wave action, movement of tree branches and forest litter, barking dogs, bird noises, automobiles, airplanes, human voices, woodcutting, light construction activities, boats, and other unidentified noise sources create ambient noise levels similar to those produced by pile driving at distances of 0.25 to 0.5 mile away from the point source (Bottorff et al. 1987).

WSDOT also monitored noise levels during pile-driving activities at their Anacortes facility (Visconty, S., Washington State Ferries, personal communication, March 9, 2000). For comparison purposes, background noise levels were monitored at the Friday Harbor terminal. At the Friday Harbor terminal, ambient noise levels around the closest bald eagle nest (located near the terminal) ranged between 45 and 72 decibels (dB), 40 to 51 dB for local harbor traffic noise, and 69 to 74 dB from use of a 100-ton crane at the terminal.

Pile-driving noise at the Anacortes ferry facility ranged from 105 to 115 dB at 15 m (50 feet) from the noise source. Noise levels were highest when a pile was first driven and decreased near completion because of a reduction of exposed surface area and increased stiffness as the pile became more embedded (Visconty, S., Washington State Ferries, personal communication, March 9, 2000). Simultaneous readings taken at several distances to determine propagation loss at Anacortes indicated a 6-dB decrease in sound pressure for every doubling of distance. Given this information, at 560 m (1,850 feet) from the noise source at Anacortes, the sound was 70 dB, well within measured background ambient noise levels recorded at the Friday Harbor terminal (Visconty, S., Washington State Ferries, personal communication, March 3, 2000).

Again, the previously cited study included the use of an impact hammer to install piles. Because the proposed project will use a vibratory method (again, site conditions permitting), the increased ambient noise levels generated during construction activities will be lower, and therefore less likely to temporarily disturb bald eagles and marbled murrelets in the vicinity of the project area. Therefore, no significant short-term direct effects due to construction disturbances are anticipated for bald eagles.

Operation of the Conveyor is not expected to greatly affect bald eagles, which have been shown to adapt to relatively constant levels of noise and disturbance in urban areas. However, eagles may avoid foraging in the immediate vicinity of the Conveyor, or along the lower beach while vessels are moored at the Pier.

6.0 PROJECT AREA ENHANCEMENT

As noted above, some minimal reduction in *Z. japonica* productivity could occur in areas that receive repeated shading from the Conveyor. Given the expected variability in space and time of eelgrass on the site, this hypothesized reduction in productivity is not expected to be reasonably measurable. However, to ensure that no temporal loss of eelgrass productivity occurs, the Applicant proposes to conduct an eelgrass transplant in advance of incurring project impacts. This transplant will be conducted in the first spring following the issuance of project permits.

Two transplant areas will be identified during the preconstruction baseline survey, one for *Z. japonica* and one for *Z. marina*. Transplant areas will be within the appropriate depth range for each species of eelgrass in this area and will have the proper substrate for eelgrass (medium to fine sand), but will lack existing eelgrass beds. The donor sites will also be identified during the preconstruction baseline survey as areas with healthy and reasonably dense populations of eelgrass, at a depth similar to that at the respective transplant sites, and away from the area of potential project impact.

Biologists will harvest eelgrass shoots from the donor beds using a spading fork. Care will be taken to avoid damage to surrounding unharvested shoots and rhizomes. To avoid inducing erosion damage, harvest will avoid the edges of existing beds. A maximum of 10 to 20 percent of the shoots in the donor beds will be harvested. Experience has shown that remaining eelgrass plants quickly fill in the spaces left in the bed by harvesting, such that harvested areas are not identifiable after 1 year (Houghton, J., Pentec, personal observation).

Harvested shoots and associated rhizomes will be bundled into groups of three shoots and loosely tied with degradable twine. Blades will be clipped to a uniform length of about 9 inches. A Z-shaped ungalvanized wire, about 6 inches long, will be slipped inside the twine to serve as an anchor. Each three-shoot bundle is considered to be a planting unit (PU). All plant processing will be conducted with minimal exposure time, and plants will be stored only in a seawater bath.

PUs will be inserted into the sediment with the aid of a trowel. Using this technique, PU survival of 40 to 100 percent has been achieved in two recent transplants (Pentec, unpublished data). In one of these transplants, expansion and spreading of surviving PUs increased overall shoot density 100 times over the initial planting density within 2 years.

PUs will be transplanted using approximately a 0.5-m (1.64-foot) grid spacing over a cumulative area of approximately 232m^2 (2,500 sf; 117m^2 [1,250 sf] for each species). This area was selected to represent 33 percent of the area (697 m^2 or 7,500 sf) over which the impact analysis suggests that some reduction in eelgrass productivity could occur. Should this reduced productivity actually occur, the enhancement transplant will have concurrently replaced some or all of the lost productivity.

7.0 MONITORING OF PROJECT IMPACTS

This section describes a detailed eelgrass-monitoring program that will quantify the baseline eelgrass distribution and density on both sides of the Conveyor before construction begins. Monitoring following construction and during the early stages of operation will define actual losses of eelgrass attributable to the project, as well as the success of the preconstruction eelgrass enhancement project. Compensatory mitigation is then described that will offset any losses due to the project that exceed the gains provided by the preconstruction mitigation.

Monitoring will be stratified by species to cover both the areas of *Z. japonica* and *Z. marina* distribution. All sampling will be done between June 1 and September 30 in each sampling year.

7.1 Baseline Monitoring

A detailed video mapping of subtidal eelgrass distribution in the project vicinity was conducted in the summer of 2001 and will be repeated in the summer preceding construction. The subtidal *Z. marina* stratum will be surveyed with the Pentec ***Sea-All™*** video mapping system, providing a concurrent differential global positioning system (DGPS) georeferencing of resource distributions. The intertidal *Z. japonica* stratum will be mapped during low tides using a hand-held GPS. Both surveys will be tightly controlled to provide accurate positioning in relation to project structures and local bathymetry. Intensive mapping will be conducted in the subareas identified below. Monitoring will extend farther to the northeast, since that is the anticipated direction of any shading effects from the project and because the net sediment transport pathways are to the northeast. This design will maximize the potential for detection of any influence on eelgrass from any project changes in on longshore transport. An additional area, still farther to the northeast of the Conveyor, will be surveyed to locate a suitable reference site for quantitative sampling and areas where eelgrass beds could be expanded for the preproject enhancement, or, if compensation is needed, for project-related effects on eelgrass.

Eight subareas will be defined for quantitative monitoring of project effects on eelgrass and macrovegetation. Four of these will lie adjacent to the Conveyor as follows:

- *Z. japonica*–southwest (JS)—a rectangular area extending across the *Z. japonica* stratum on the southwest side of the Conveyor. Area JS will extend 30 feet southwest of the western edge of the Conveyor, thus representing approximately 7,500 sf (30 by 250 feet, assuming the stratum with eelgrass patches is 250 feet wide at this point).

- *Z. japonica*–northeast (JN)—a rectangular area extending across the *Z. japonica* band on the northeast side of the Conveyor. Area JN will extend 50 feet north from the western edge of the Conveyor, including the area directly under the Conveyor, thus representing approximately 12,500 sf (assuming the stratum with eelgrass patches is 250 feet wide at this point).

- *Z. marina*–southwest (MS)—an irregular area encompassing the scattered patches of *Z. marina* on the west side of the Conveyor. Area MS will follow the −1- and −10-foot contours southwest from the western edge of the Conveyor for approximately 150 feet. It will represent an area of approximately 7,500 sf (50 by 150 feet, assuming the *Z. marina* stratum is 50 feet wide in this area).

- *Z. marina*–northeast (MN)—an irregular area encompassing more or less continuous patches of *Z. marina* on the east side of the Conveyor. Area MN will follow the −1- and −10-foot contours northeast from the western edge of the Conveyor for approximately 400 feet.

Two subareas will be *Z. japonica* and *Z. marina* reference areas (JR and MR, respectively) located in the same strata at least 400 feet northeast of the Conveyor. Exact location of the reference areas will be determined by the baseline video mapping. Each of these areas will be 50 sf, selected to encompass eelgrass beds comparable to those in the potentially shaded areas nearer the Conveyor.

The final two subareas relate to the preconstruction eelgrass enhancement action and include the *Z. japonica* and *Z. marina* transplant sites (JT and MT, respectively). These locations will be identified following the preconstruction survey, shown on maps to be prepared and submitted to cognizant agencies prior to construction.

Video and visual mapping described above will be used to identify changes in the distribution and total coverage area of the two species of eelgrass in the project area. Quantitative monitoring (quadrat counts) will be used to document any changes in density of eelgrass within the mapped patches. Within each subarea, 25 randomly located replicate sample points will be established and permanently marked to allow relocation. During one or more surveys, it is expected that some of these points will fall in areas not supporting eelgrass. Where eelgrass is present, counts of shoot density will be made in accordance with WDFW protocols, which call for three 0.25-m^2 counts oriented 60 degrees apart at each sample point. Because of the high density of eelgrass within these patches (exceeding 1,000 shoots/m^2), subsampling with smaller quadrats may be used, where appropriate. Macroalgal cover will also be estimated. The mean of the three counts or cover estimates at each point will be used in statistical testing.

7.2 Postconstruction Monitoring

Postconstruction monitoring will be conducted in the first summer season following construction and will consist of mapping and quantification identical to those described above for the baseline survey.

Maps of the eelgrass distribution from pre- and postconstruction surveys will be compared to determine qualitatively if the degree of change in eelgrass distribution and boundaries at the Pier exceeds that at the reference subareas.

The proposed quantitative sampling design will allow statistical testing of several null hypotheses of the following forms:

H_o1 There is no difference between eelgrass density (shoots/m^2) northeast and southwest of the Pier within each stratum, tested pre- and postconstruction.

H_o2 There is no change in density (shoots/m^2) of eelgrass in any subarea from pre- to postconstruction (e.g., test subarea MN preconstruction vs. MN postconstruction).

H_o3 There is no difference in density (shoots/m^2) of eelgrass in either stratum from the east to the west side of the Conveyor (e.g., test subarea MN postconstruction vs. MS postconstruction).

All statistical testing will be stratified within the same depth stratum. If there is a significant preconstruction difference between the densities of eelgrass in the upper or lower stratum at the Pier and densities in the same stratum at the reference site, the ratio of density at the reference to that at the Conveyor site will be used to adjust densities determined in postconstruction monitoring before making tests for significant project impacts.

Operational monitoring will be conducted in the summer of years 1, 3, and 5 of project operation to determine if any reduction in eelgrass densities has occurred as a result of the project, and to assess the extent of any sand and gravel spillage that has occurred.

7.3 Enhancement and Mitigation Site Monitoring

The success of the eelgrass transplant will be qualitatively examined by comparison of the total number of shoots (density times area) of eelgrass in the transplanted area with the number of shoots of eelgrass transplanted (number per PU times number of PUs) to obtain percent survival of the transplant. Number of shoots in the transplanted area will also be compared against any loss of eelgrass shown to have occurred in the project operational monitoring.

The eelgrass transplant site will be monitored as described for the preconstruction monitoring to determine the total bed area and the density and number of eelgrass shoots provided.

8.0 COMPENSATORY MITIGATION

An intensive monitoring program has been described above to assess the degree to which the project actually impacts eelgrass. Compensatory mitigation in the form of replacement of area and numbers of eelgrass shoots will be required if the monitoring program demonstrates that a loss has occurred that exceeds the gains provided by the preconstruction transplant. A loss will be considered to have occurred if one or more of the following conditions is met:

- If postconstruction monitoring shows that eelgrass standing crop (density times area) at the upper or lower strata at the project site (subareas JN and JS or MN and MS) has declined significantly in relation to the upper or lower strata at the reference site (subareas JR or MR), and if those declines exceed increases in standing crop (density times area) at the transplant site.

- If operational mapping shows that the areas of eelgrass within northeastern (partially shaded) subareas at the project site have declined but no similar magnitude of decline has occurred at the southwestern (unshaded) subareas at the project site or at the reference subarea within the same stratum, and if such decline exceeds the increased bed area provided at the transplant site.

- If operational monitoring shows that eelgrass standing crop (density times area) at the upper or lower strata northeast of the Pier (subareas JN or MN) has declined significantly in relation to the upper or lower strata southwest of the Pier (subareas JS or MS), and if those declines exceed increases in standing crop (density times area) at the transplant site.

If any of these conditions are met (i.e., if the extent of loss [shoot density times area] exceeds any gains provided by the preconstruction transplant), compensatory mitigation will be required. Final selection of the mitigation action(s) will be made by mutual agreement between the Applicant and WDFW, the U.S. Army Corps of Engineers, NOAA Fisheries, and the U.S. Fish and Wildlife Service. The most probable mitigation action is likely to be additional transplanting of eelgrass from existing beds into areas within or adjacent to existing beds that currently lack eelgrass. The preconstruction survey will be used to identify such areas that may be suitable for additional eelgrass establishment in the event that mitigation is required. These locations will be displayed on maps to be prepared and submitted to cognizant agencies for review before transplanting begins.

The amount of mitigation required will be based on the degree of impact shown by the postconstruction or operational monitoring. Because mitigation for any effects that exceed the preproject enhancement will not occur in advance of the impact, the amount of mitigation required will be two times the amount of loss. Also, the size of the mitigation area may be increased by an additional factor to account for the fact that eelgrass transplanting may not be 100 percent effective. Final consideration of appropriate mitigation actions will be based on the experience gained from the proposed preconstruction eelgrass transplant.

9.0 HABITAT MITIGATION/ENHANCEMENT OPPORTUNITIES

As noted above, the need for and the amount of mitigation required will be determined by the monitoring program and the extent of documented impacts, and on the success of the preconstruction transplant. Also, the nature of compensatory mitigation actions will depend on the opportunities available. One of the objectives of the preconstruction survey will be to identify areas near the Conveyor site where eelgrass transplanting could be expected to be successful. Specifically, areas where eelgrass is not present within the depth ranges known to support each eelgrass species in the area will be identified. Factors limiting eelgrass in these areas also will be identified, if possible, so that the probability of achieving a successful transplant can be evaluated. A total area of up to 3,000 sf where successful eelgrass transplanting could be accomplished will be sought in each species stratum, and approximately 1,250 sf of this area will be used in the preconstruction enhancement transplants.

Additional eelgrass transplanting, if required for mitigation, will be accomplished in a manner similar to the preconstruction transplant, modified, as needed, to reflect the current state knowledge of factors contributing to the success of such transplants. Typical planting will be in a 0.5-m (1.64-foot)-grid pattern, but higher densities may be used if deemed more appropriate for meeting the mitigation objectives.

10.0 OBJECTIVES/PERFORMANCE STANDARDS

The overall objective of the habitat management plan is to avoid a net long-term loss of eelgrass density and area in the project vicinity. The primary means by which this objective will be met is that advanced enhancement will be provided that is expected to exceed project related losses. Subsequent compensation will be provided for any areas in the project vicinity with documented losses of eelgrass that exceed the amount provided by the advanced enhancement. This compensation will be provided by transplanting eelgrass to areas where it does not currently exist.

An additional performance standard is that any short-term loss that is documented (e.g., due to project shading) be compensated by a 200 percent replacement.

11.0 CONTINGENCY PLANS AND BONDING

If areas exist where off-site transplanting as mitigation for project losses do not meet the performance criteria stated above, additional transplantings will be accomplished in additional areas identified by the Applicant and approved by WDFW. Alternatively, a similar level of effort/cost will be expended by the Applicant to accomplish another type of mitigation action, approved by WDFW, which will provide similar benefits to the resources impacted by the project.

The Applicant will establish a $25,000 performance bond to be surrendered to WDFW in the event that the Applicant fails to meet the performance criteria described above or to take the contingency efforts described in this section. Upon surrender of this bond, the Applicant is released from all obligations under the mitigation plan described above.

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TABLE

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Table D-1 - Pile Area Calculations

Pile Type	Diameter (ft)	Number of Structures	Piles per Structure	Benthic Area (sf) Per Pile	Benthic Area (sf) Total	Assumed Ave. Depth (ft)	Epibenthic Area (sf) Per Wetted Foot of Pile	Epibenthic Area (sf) Total area (+6 to -10 ft)
Truss supports	1.5	7*	4	1.8	42.4	+3 ft	1.8	127.2
Catwalk supports	1.5	12	3	1.8	63.6	-40 ft	1.8	1,017.4
Support structures	2.5	2	16	4.9	157.0	-20 ft	4.9	2,512.0
Dolphins	2.5	8	12	4.9	471.0	-40 ft	4.9	7,536.0
Total					**734.0**			**11,192.5**
Ratio of littoral zone epibenthic area gained to infaunal area lost								**15.2**

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*Six truss supports below OHW

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APPENDIX E
THORNDYKE CONVEYOR MACROVEGETATION SURVEY

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Thorndyke Conveyor
Macrovegetation Survey
Port Orchard, Washington

Prepared for
Fred Hill Materials

February 4, 2008
12674-01

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Denver

Prepared for
Fred Hill Materials

Edmonds

February 4, 2008
12674-01

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THORNDYKE CONVEYOR
MACROVEGETATION SURVEY
PORT ORCHARD, WASHINGTON

INTRODUCTION

Fred Hill Materials (FHM) proposes to construct and operate a conveyor system to transport aggregate materials from an existing sand and gravel site (the Shine Pit) located in Jefferson County to a marine loadout facility on the northwest shore of Hood Canal, approximately 3 miles south of the Hood Canal Bridge (Figure 1). During operation, the conveyor system will transport up to 4,000 tons of materials per hour to transport vessels docked at the marine loadout facility.

Construction and operation of the proposed facility will likely impact local areas of marine benthic habitat and species within the project area, with specific concerns centered on the existing eelgrass habitat present in the area (both *Zostera japonica* and *Z. marina*).

To identify these areas of potential impact, permitting agencies, primarily the Washington Department of Fish and Wildlife (WDFW), require a macrovegetation survey to evaluate potential eelgrass that may be present in the project area and thus subject to unavoidable impacts that may require mitigation. Macrovegetation within the project area was surveyed by geo-referenced video on August 8, 2001 and by divers on September 27, 2001 (Pentec 2003) but was out of date with respect to the recent proposal and did not include detailed mapping of the upper intertidal population of *Z. japonica*. As a result, the immediate proposed project area required a re-investigation of the existing macrovegetation, concentrating on eelgrass distribution in both the intertidal and subtidal elevations. A survey team consisting of a Pentec Environmental representative and Research Support Services, Inc. Sea-All™ team conducted this survey of the potentially affected area.

METHODS

The macrovegetation survey was subdivided into two parts, a low tide visual survey of the intertidal eelgrass (*Z. japonica*) using a handheld sub-meter differential global positioning system (DGPS) and a geo-referenced video transect survey documenting subtidal eelgrass (*Z. marina*) using the Sea-All™ system previously used in the original survey.

On August 28, 2007, we conducted the intertidal portion of the macrovegetation survey of the proposed project area for the Thorndyke conveyor using a highly modified version of an intermediate macrovegetation survey. Instead of sampling in discrete transects, we collected discrete patch shapes and sampled within several of the patches to determine eelgrass density. This method quantifies through direct measurement all of the eelgrass coverage and estimates density giving a much more robust data set, free of the heterogeneity of the samples often associated with random or transect sampling. Approximately 11.2 acres of proposed affected intertidal area was surveyed (Figure 2) using this method. The survey encompassed the area from +6 mean low lower water (MLLW) to –2 MLLW and extended laterally several hundred feet from the proposed centerline of the proposed conveyor alignment. GPS parameters were configured for maximum precision and the survey was performed on a clear day encompassing a minus tide. Eelgrass (*Z. japonica*) densities were estimated using a 0.01-m^2 quadrat randomly tossed within surveyed patches.

On September 28, 2007, the subtidal survey was completed covering approximately 14.2 acres with 32 transects approximately perpendicular to shore with one long transect paralleling the shore line as the depth *Z. marina* was most likely to colonize (Figure 2). The survey was conducted using the Sea-All™ underwater video mapping system, to view and record habitat and benthic substrates from the lower depth contours of the project area to approximately the –3- or +1-foot MLLW contours, depending on the transect. This was done to provide complete coverage of potential subtidal eelgrass/macroalgae habitat not observable from by the naked eye at the water surface. The system uses a combination of digital video, DGPS, program-based habitat characterization, and allows for on-board audio annotation and direct transfer of data in to an AutoCAD™ map.

SURVEY SYNOPSIS

Intertidal Results

The intertidal survey was performed during a falling tide from about 9:00 a.m. on August 28, 2007 and extended from the late ebb, through low tide (at approximately 11:21 a.m.), into the early flood tide. Weather conditions were generally calm with sunny skies. The following descriptions are taken in part from, and supplement the Pentec surveys in 2001 and 2002 (Pentec 2003).

Benthos and Macrovegetation

Intertidal substrate at the survey is composed of sand and silt likely originating from the bluff system along several miles of shoreline in either direction (Photograph 1). Wetlands are present, formed by seep water from sediment layers within the bluff and constrained by a significant storm berm made of coarser more gravel-laden material (Photograph 2). Along the high-tide drift line were scattered plants of *Atriplex patula, Salicornia virginica, Jaumea carnosa, Plantago maritima, Hordeum branchyantherum, Potentilla anserina,* and *Ambrosia chamissonis* (Photograph 3).

Where the lower edge of the beach face transitions to the sand flat, at low-tide seep water emerges to create shallow pools of standing water and eventually forms a channel that meanders across the flat. Patches of the green algae *Ulva* spp., *Ulva intestinalis*, and *U. linza* occurred in these fresh or brackish seeps along with scattered loose drift segments within the *Z. japonica*.

From +6 feet MLLW to 0-foot MLLW the sand flat supported scattered and discrete patches of *Z. japonica* (Photograph 4). Within each patch, shoots were very dense (Photograph 5) and fertile fronds were noted in patches located at lower elevations. Shoot-count densities of *Z. japonica* within representative patches ranged from 700 to 2,400 shoots per m^2. The mean density in all patches surveyed was 1,400 shoots per m^2. The band of *Z. japonica* patches tended to occupy the portion of the sandflat above the 0 MLLW mark and did not overlap with the more subtidal *Z. marina* population (Figure 2). *Z. japonica* is an introduced species that is known to occur throughout northern Puget Sound, although its distribution has not been well documented (Thom and Hallum 1990). This species of seagrass is thought to be an annual in Puget Sound, it is expected to be highly variable in space and time. This is especially true within the project area, where the advancing sand waves bury individual patches while new patches form in the lee of each wave.

Invertebrate Fauna

The benthos supported a low diversity invertebrate assemblage with areas of high abundance. Burrows of ghost shrimp (*Neotrypaea californiensis*) were abundant on the middle and upper portions of the flat. Associated with the ghost shrimp were the commensal bivalve *Cryptomya californica* and the polychaete *Nephtys* sp.

At the lower elevations on the sand flat, very high-density patches of sand dollars (*Dendraster excentricus*) tests (non-living) were found, primarily in shallow tidewater ponds and drainage channels. This is in contrast to the 2001 survey, where high densities of live *D. excentricus* were documented. Occasional cockles, *Clinocardium nuttalli,* were also seen, and small holes of the burrowing polychaete *Nephtys* sp. were widespread. In shallow water along the shoreline and in the runoff channels, a few graceful crab (*Cancer gracilis*) were also present (Photograph 6).

Subtidal Results

The subtidal survey was conducted on September 28, 2007. Weather was mixed sun and clouds with variable wind gusts. The water column had an average visibility of 10 to 15 feet during the survey allowing full coverage to accurately document eelgrass and macroalgae in the project area.

Benthos and Macrovegetation

The subtidal substrate was primarily of sand with little silt. *Z. marina* was found to occur in a narrow band along the outer edge of the sandy beach as described from the intertidal survey. This band of eelgrass lay between –1-foot and –10 feet MLLW. The bottom along this depth contour had a moderate slope of approximately 3:1. The survey transects were aligned to be roughly perpendicular to the shoreline in order to cover as much of the depth gradient as possible during the survey. The eelgrass tended to occur in scattered sparse patches that were surrounded with large areas of bare sand. Densities could not be definitively calculated from video data, but estimates ranged from 2 to 25 shoots per m^2. In general, more patches and increased coverage were observed towards the northern portion of the study area (i.e., north of the proposed conveyor centerline; Figure 2), but much reduced from the original survey performed in 2001. In general, eelgrass health appeared poor with sparse densities and obvious stress due to macroalgal entanglement (see below).

Large amounts of drift macroalgae were recorded in the area. This drift algae was often noted as being entangled in the existing eelgrass to the point that a majority of the biomass in the seagrass patch was made up of the drift algae. Very little attached macroalgae was noted and was primarily *Ulva* spp., *Ulva intestinalis*, and *U. linza* that were noted in the intertidal survey. Diatoms mats were observed over most of the survey area.

Invertebrate Fauna

Large mobile invertebrates tended to be very sparse and often associated with the eelgrass patches. Invertebrates seen included the large pink sea star (*Pisaster brevispinus*), egg cases from a moon snail *(P. lewisii*), crabs represented by

Dungeness *(Cancer magister)*, graceful *(C. gracilis)*, and the kelp crab *(Pugettia producta*).

Vertebrate Fauna

Fish were observed at several subtidal locations throughout the survey area. The fish most often encountered during the survey were juvenile and sub-adult starry flounder (*Platichthyes stellatus*) and rock sole (*Pleuronectes bilineatus*) in the unvegetated areas between the *Z. japonica* and *Z. marina* patches. There were several small, unidentified sculpins associated with the *Z. marina* patches.

Anthropogenic Impacts

Minimal debris and anthropogenic impact was observed during the survey. The only obvious example was the presence miscellaneous plastic debris and containers in upper intertidal as well as the occasional Olympia oyster (*Ostrea conchaphila;* aka *O. lurida*) culture bag (Photograph 7) with attached ballast. This area is relatively undeveloped and reflects minimal direct human influence in the area.

CONCLUSIONS AND SUMMARY

We observed a fairly healthy population of *Z. japonica* in the intertidal and what appeared to be distressed population of *Z. marina* that is declining and in poor health.

We documented the extent of *Z. japonica* in the project area with sub-meter accuracy and shows typical patch dynamics for the species. Compared to the 2001 survey data, the population seems to be increasing in density (27 percent increase) and possibly increasing in extent, as patch coverage seemed much higher (nearly 40 percent) than the qualitative 25 percent reported in the previous survey.

In 2007, *Z. marina* seemed to be declining relative to 2001 survey data. The number of patches in the video transects had greatly declined and in-patch shoot density had decreased between 50 and 90 percent over the survey area relative to 2001 data (Pentec 2003). These results are consistent with Washington Department of Natural Resources (DNR) data for submerged aquatic vegetation for the area (DNR 2007 and DNR personal communication); DNR has recorded large-scale seagrass disappearance in the area and attributed those declines to non-point source impacts (DNR 2007) and the general susceptibility of *Z. marina* habitat to disturbance in Hood Canal (i.e., fringe habitat effects; Koch 2001).

If you have any questions regarding this report, please do not hesitate to call Jason Stutes at (425) 329-1163 or Jon Houghton at (425) 329-1150.

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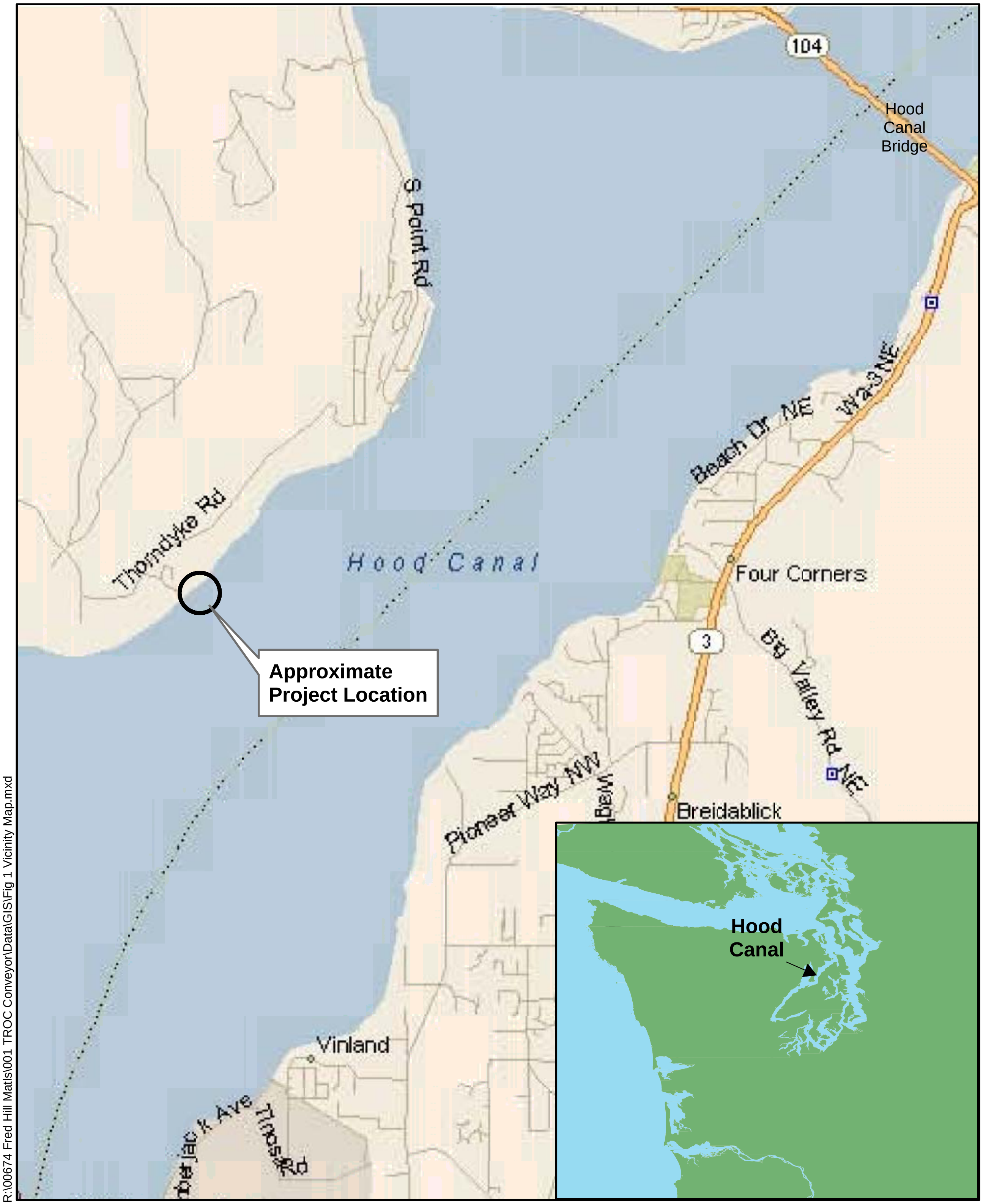
FIGURES

Thorndyke Bay Vicinity and Location Map



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Note: Map prepared from Microsoft Streets and Trips, 2007.

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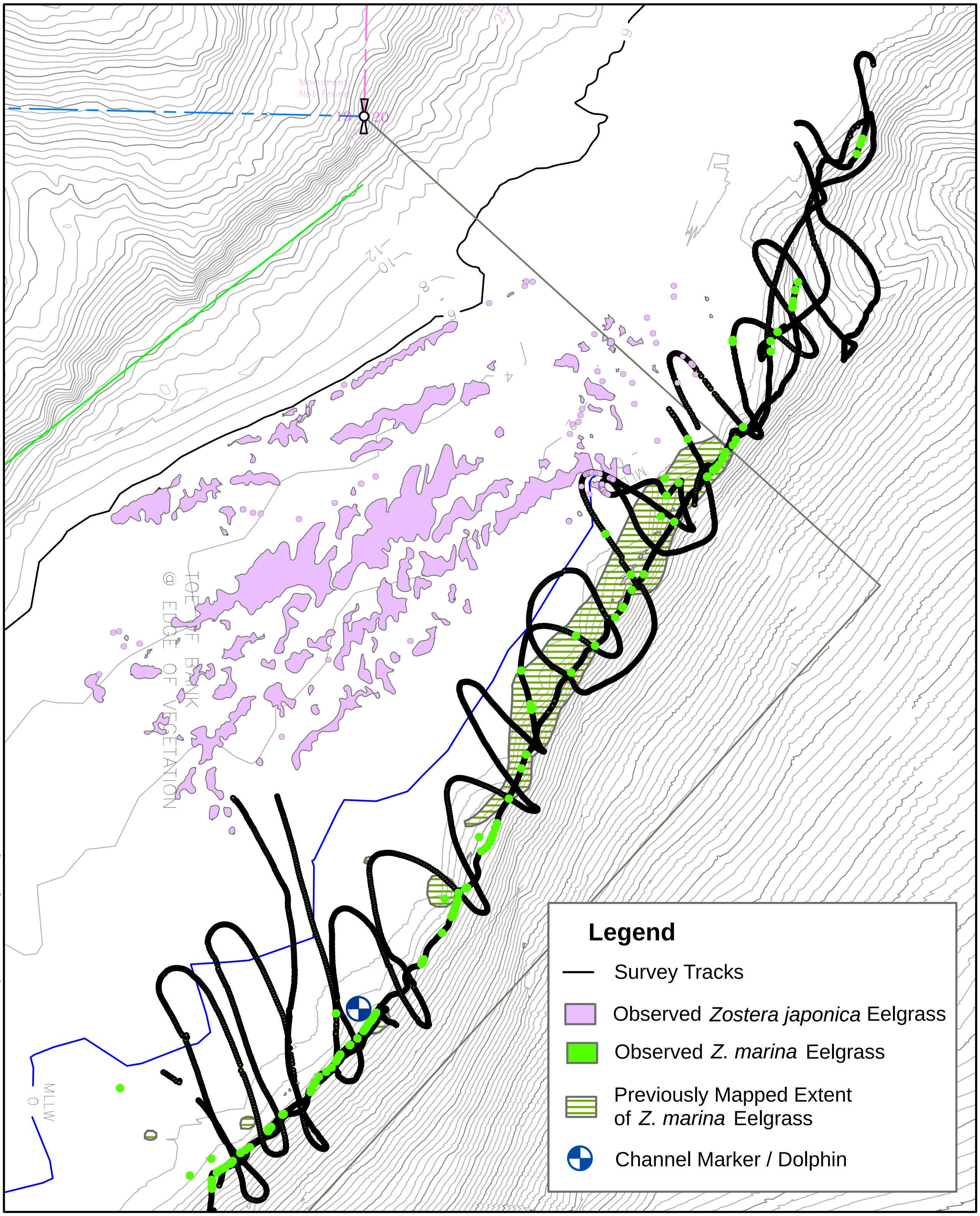
12674-01 **12/07**

Figure 1

Thorndyke Bay Eelgrass Survey



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Note: Background ACAD file provided by Reid Middleton, Inc.

0 125 250 500 Feet

N

PENTEC ENVIRONMENTAL

12674-01
Figure 2

12/07

APPENDIX A
PHOTOGRAPHS

Photograph 1 - Survey area with varied substrate originating from bluff system upshore.

Photograph 2 - Wetlands formed by seep water from sediment layers within the bluff and constrained by a significant storm berm made of coarser more gravel-laden material.

Photograph 3 - High-tide drift line composed of storm berm, large woody debris, and scattered plants (*Atriplex patula, Salicornia virginica, Jaumea carnosa, Plantago maritima, Hordeum branchyantherum, Potentilla ansirena,* and *Ambrosia chamissonis).*

Photograph 4 - Intertidal survey area with patchy *Z. japonica*.

Photograph 5 - *Z. japonica* patch density.

Photograph 6 - Graceful rock crab (*Cancer gracilis*) in the intertidal survey area.

Photograph 7 - Olympic Oyster (*Ostrea concaphila*) culture bag with attached ballast.

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APPENDIX F
CENTRAL CONVEYOR AND PIER PROJECT DESCRIPTION AND FACT SHEETS

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Project Description
Jan. 31, 2003

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.

Hood Canal Sand and Gravel's waterfront property, from which the Pier will originate, is 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) is being prepared and when completed will accompany and be incorporated into this Central Conveyor and Pier Application and applications for other proposals identified herein.

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 Fact 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
    - an access road 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 viewshed.

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 will initiate application for permission for processing concrete waste 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 an 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 FACT SHEET

Feb. 11, 2003

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 the Single Conveyor.

Twin Conveyors

Located at the northern portion of the Central Conveyor, originating at Shine Pit.

Location:	Station 25+23.69 to 200+00
Length:	3.3 miles long
Width (each conveyor)	5 feet wide
Gap between conveyors:	4 feet
Segments between transfer points:	4 of varying lengths
Stormwater:	Full dispersion

Single Conveyor

Located at the southern portion of Central Conveyor, originating at end of the Twin Conveyors and terminating at end of Pier.

Location:	Station 200+00 to 237+90
Length:	0.7 miles long
Width:	6 feet
Segments between transfer points:	2 of varying lengths
Color:	Natural color(s) to blend into existing environment
Stormwater:	Full dispersion

Belts

Central Conveyor belts travel on rollers forming a U-shaped trough that carries sand and gravel. Failsafe sensors on head pulley motor automatically shut down operation along the entire conveyor system in case of belt failure.

Power:	Electric motor at head pulley (tail pulley unpowered)
Rollers:	Self-lubricating
Materials:	Composite
Belt speed (approx):	6 miles per hour

Conveyor Assembly

Frame:	Steel channel, open box
Height (approx.)	5 feet
Vertical support:	20-foot spacing

Color(s): Natural to blend into existing environment

Cover

Installed over the Central Conveyor's belts to keep out rain and wind and to prevent fugitive dust, sand, or gravel from escaping.

Location:	Station 25+23.69 to 228+00 (beginning of Pier)
Material:	Metal
Height above belt:	2 feet 6 inches
Height above ground	7 to 8 feet

Pan

Installed under the Central Conveyor's return belt over all stream crossings and from top of the shoreline bluff to beginning of the Pier.

Locations:	Station 144+00 to 165+00 (stream crossings) Station 226+00 to 228+00 (bluff to Pier)
Clearance from ground:	Less than 2 feet

Enclosures

Enclosures can include a roof, siding, pan under return belt, and a grated walkway or solid floor.

Thorndyke

Road Location:	Station 211+50 to 214+00
Components:	Roof, siding, solid floor
Shoreline Location:	Station 228+00 to 234+35
Components:	Roof, siding, pan under return belt, and grated walkway
Pier Loadout Locations:	Station 234+35 to 237+90
Components:	Roof, siding, solid floor

Wildlife Crossings

Typical clearance:	2 feet below return belt
Large mammal crossings:	4-6 foot clearance below return belt
Spacing (approx.)	Every 300 feet
Electrical Power:	Underground
Control Lines:	Underground

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 roads in the Thorndyke Block. Abandoned roads will be re-graded and reforested. A turn-out/parking area for a maintenance vehicle will be provided at each transfer point. A parking area will be provided for employees working at the Pier. Stormwater generated by roads and parking surfaces will be managed via full dispersion.

Roads

Location:	Station 25+69 to 211+50, 214+00 to 217+50
Width:	14 feet
Surface:	Gravel
New surface area:	7.3 acres (includes road surfaces at transfer points, 10 employee parking stalls at Pier and concrete access road)
Abandoned roads:	6.3 acres
Net increase:	1.0 acres

Employee Parking for Pier

Location:	Station 214+50 to 215+50
Number of stalls:	10
Surface:	Gravel
Lighting:	Shielded

Turn-out/Parking at Transfer Points

Location:	Transfer Points 2, 3, 4, 5, & 6
Number of stalls:	One
Surface:	Gravel
Lighting:	None

Concrete Access Road

Location:	217+50 to 222+00
Width:	24 feet

TRANSFER POINTS

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 on to the next conveyor segment. A utility shed at each transfer point will enclose the conveyor and hopper to protect electrical equipment, contain fugitive dust, and minimize noise. The Central Conveyor shifts direction slightly at Transfer Points 2, 3, 4, and 5.

Locations:	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
At each transfer point, a small building will house a head pulley and electric motor, unpowered tail pulley, hopper, and return belt cleaning equipment.

Location:	Transfer Points 1, 2, 3, 4, 5, and 6
Size:	12 feet by 16 feet
Material:	Wood and metal
Lighting:	Interior only
Stormwater:	Downspout infiltration system or dispersion

PIER

The proposed Pier consists of a stationary and retractable load-out conveyor supported on pilings spaced at 100-foot intervals, support towers, and eight dolphins (six breasting and two mooring dolphins), with an elevated catwalk. The Pier is the only structure to be placed above the water's surface and will be as low profile as possible. The Pier will be painted to blend into the existing environment and constructed in a manner that will minimize visual intrusion and glare. To minimize shading effects, the Pier will be constructed largely of open steel girders.

Pier Location:	5 miles southwest of Hood Canal Bridge
Total Length (measured from the Ordinary High Water mark [OHW]):	990 feet
Stationary Conveyor:	Station 228+00 to 236+75
Length:	875 feet

Station 228+00 to 233+00
Station 228+00 is the location of the first pilings, marking the beginning of the Pier, and is located at approximately the Ordinary High Water 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 for Boats:	11 feet MHHW
Clearance from Beach (MSL):	19 or more feet above mudline/existing grade

Station 233+00 to 234+35
Station 233+00 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)
Bottom 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)
Bottom 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:	165 feet long
Overlap (Retractable Conveyor):	50 feet
Truss Height:	15 feet
Truss Width:	15 feet
Top Elevation:	76 feet above MLLW (70 feet MSL)
Bottom of Conveyor:	61 feet above MLLW (55 feet MSL)
Channel Elevation at end of pier:	-79 feet MLLW (-73 feet MSL)

Support structures
Two open steel structures will support the conveyor near the end of the pier. The first structure supports the conveyor. The second structure supports both the conveyor and the load-out conveyor. The Central Conveyor's second support structure will have an overall height of approximately 76 feet above MLLW (70 feet MSL). This is the minimum height necessary to be able to load sand and gravel on ships.

Support #1: Station 234+35 to 234+65

Dimensions:	30 feet by 30 feet
Top Elevation:	76 feet above MLLW (70 feet MSL)
Channel Elevation (measured at center of support):	13 feet MLLW (7 feet MSL)

Support #2: Station 236+55 to 236+95

Dimensions:	40 feet by 40 feet
Top Elevation:	61 feet MLLW (55 feet MSL)
Channel Elevation (measured at center of support):	-52 feet MLLW (-46 feet MSL)

Pilings

Pilings will be installed to support the Pier (truss supports), support structures, and breasting and mooring dolphins.

Material:	Steel
Diameter:	18-inch (Truss supports)
	18-inch (Catwalk supports)
	30-inch (Support structures)
	30-inch (Dolphins)
Spacing:	100-foot (Truss supports)
	50-foot (Catwalk supports)
Number:	4 each (Truss supports)
	16 each (Support structures)
	12 each (Dolphins)
	3 each (12 Catwalk Supports)

Control room

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.

Dimensions:	20’ x 40’ x 20’
Material:	Same siding as enclosures
Lighting:	Shielded

Maintenance walkway

The pile-supported breasting and mooring dolphins will be connected by a grated maintenance catwalk.

Material:	Galvanized or Aluminum steel
Width:	5 feet
Length:	710 feet
Railings:	36 – 42” high
Elevation:	22’ MLLW or 16’ MSL

Breasting and Mooring Dolphins
The end of the Pier will consist of six pile-supported breasting dolphins and two pile-supported mooring dolphins.

Water depth range:	-49 feet to -64 feet MLLW (-43 feet to –58 feet MSL)
Shallowest dolphin depth:	-37 feet MLLW (-31 feet MSL)
Pilecap Dimensions:	20-foot by 20-foot, 7-foot thick
Pilecap material:	Concrete
Pilecap invert elevation:	15 feet MLLW (9 feet MSL)

Maintenance and Storage Buildings
Two maintenance/storage buildings will be located on dolphins.

Dimensions:	10 feet by 10 feet
Material:	Same siding as enclosures

Lighting
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 the use of shielding and directional fixtures. During non-operation hours, lights will be turned off except as needed for maritime safety requirements.

VESSEL DESCRIPTION

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 eight to 12 years after the Pier's construction.

	Ship		**Barge**		**Typical Barge**
Maximum Length (LOA):	745'		400'		240'
Maximum Width (berth):	110'		100'		60'
Maximum Draft:	45'		25		16'
Volume Range (dead weight tons [dwt]):	20,000 to 65,000		2,500 to 20,000		5,000 to 7,000
Estimated Loading Time (hrs):	10-24		1-8		2-3

APPENDIX G
PRELIMINARY GEOTECHNICAL REPORT FOR THE T-ROC SINGLE CONVEYOR AND PIER

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Preliminary Geotechnical Report
Thorndyke Resource Operations Complex
Single Conveyor and Pier
Jefferson County, Washington

February 2003

SHANNON & WILSON, INC.

GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

At Shannon & Wilson, our mission is to be a progressive, well-managed professional consulting firm in the fields of engineering and applied earth sciences. Our goal is to perform our services with the highest degree of professionalism with due consideration to the best interests of the public, our clients, and our employees.

Submitted To:
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21-1-09475-001

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PRELIMINARY GEOTECHNICAL REPORT
THORNDYKE RESOURCE OPERATIONS COMPLEX
SINGLE CONVEYOR AND PIER
JEFFERSON COUNTY, WASHINGTON

1.0 INTRODUCTION

This report presents the results of our evaluation of the proposed Thorndyke Resource Operations Complex (T-ROC) Single Conveyor and Pier. *Note: This report is subject to modification as a result of the completion of the SEPA analysis (Environmental Impact Statement) being undertaken as a part of the governmental permitting process.*

The purpose of our work was to identify areas of potential slope instability and potential geologic and geotechnical issues related to the Single Conveyor and Pier (and zone of probable alignments) and the proposed construction. Our work for this task was limited to the area along the Single Conveyor and the proposed Pier to be constructed in Hood Canal.

Our scope of services consisted of:

1. Review of selected existing geologic, geotechnical, development, and environmental records related to the potentially affected properties and nearby properties.
2. Review of topographic, bathymetric, and other information available from the Client; U.S. Geological Survey (USGS) topographic and geologic maps; Washington State Department of Ecology (WSDOE) *Coastal Zone Atlas*; Critical Areas – Landslide Hazard map for Eastern Jefferson County; and information in our files for nearby properties.
3. Review of May 2001 aerial photograph stereo pairs of the proposed site and vicinity.
4. Reconnaissance of the slope and beach on property(ies) that the proposed Single Conveyor may cross performed by Mr. Ted Hopkins, an engineering geologist with Shannon & Wilson, Inc.
5. Observation of site conditions by Mr. Stan Boyle, Shannon & Wilson project manager and project geotechnical engineer.
6. Presentations of our findings at progress meetings.
7. Preparation of this report summarizing our opinions, conclusions, and recommendations.

No subsurface explorations were performed for this study. Our scope of services did not include reconnaissance along the proposed Twin Conveyors or the Shine Pit.

Our services were provided in general accordance with our August 28, 2001, proposal, as authorized by Ms. Lyn Keenan of Reid Middleton on August 28, 2001, via e-mail.

2.0 SITE AND PROJECT DESCRIPTION

A detailed T-ROC conveyor and pier project description and fact sheet are provided in Appendix A of this report. An abbreviated project description is presented below.

The proposed Single Conveyor and Pier site is located on the west side of Hood Canal approximately five miles southwest of the Hood Canal Bridge and approximately one mile northeast of Thorndyke Bay, as shown on the Vicinity Map, Figure 1. The site is near the edge of a broad upland plateau area that is dissected by valleys extending northwesterly from Hood Canal, Figure 2. The T-ROC sand and gravel transport system would consist of Twin Conveyors, a Single Conveyor, and Pier, which are proposed to be constructed along the approximate alignments and at the approximate locations indicated in Figures 1 and 2. The Twin Conveyors would consist of twin 48-inch conveyors originating at Shine Pit. Shine Pit is located approximately four miles south of Port Ludlow. These conveyors would transfer the sand and gravel to the Single Conveyor where the two conveyors meet (see Figure 1). The Single Conveyor would be 60 inches wide and convey the sand and gravel to the end of the Pier in Hood Canal where the materials would be loaded onto a vessel for transport.

The Single Conveyor would cross Thorndyke Road on a covered bridge, extend toward the beach across a narrow triangular-shaped point formed by two valleys that cut into the upland, and drop to the beach by crossing a steep, southeast-facing bluff (see Figure 2). The conveyor would be constructed through an approximately 400-foot-long cut proposed at the top of the bluff. The Single Conveyor would be about 3,800 feet long. Geologic and geotechnical review for design and construction of the Twin Conveyors was not part of our scope of services and is not discussed in this report.

The upland area slopes gently to moderately toward Hood Canal. At the edge of this upland area, the slopes become steep toward valleys located to the northeast and southwest of the proposed Single Conveyor and toward Hood Canal where the slope forms a bluff along the beach. This bluff is approximately 80 to 100 feet high. The combined height above Hood Canal of the bluff and steep slope above it is about 190 feet. The steep slopes are interrupted by a midslope bench along the east and southeast sides of the triangular upland area that this conveyor would cross. The upland area at the site and much of the adjacent valleys have been recently logged. Vegetation in these areas generally consists of fir trees less than about 6 feet high and thick understory brush. The base of the broad valley to the northeast and the lower portions of the valley to the southwest remain heavily wooded.

3.0 DOCUMENT REVIEW

As part of our study, we reviewed numerous documents relating to the geologic and geotechnical aspects of the subject property and vicinity. We reviewed published geologic maps, including the *Coastal Zone Atlas of Washington, Jefferson County* (WSDOE, 1979); *Geologic Map of East-Central Jefferson County*, Washington; (Birdseye, 1976a); and *Relative Slope Stability in East-Central Jefferson County*, Washington; (Birdseye, 1976b). We also reviewed the *Critical Areas Maps for Jefferson County* (Jefferson 1995) and Jefferson County's Resolution #37-83, Thorndyke Slide Area. Unpublished work we reviewed included several geotechnical reports that we previously prepared for nearby residential properties and two reports prepared by others (Krazan, 2001, and Golder, 2001) for the subject property and T-ROC project.

We analyzed May 2001 aerial photograph stereo pairs of the area. We also reviewed oblique aerial photographs of the site available on WSDOE and Jefferson County websites.

4.0 SITE CONDITIONS

Our description and analyses of the conditions at the site is based on a reconnaissance of the site and our review of published and unpublished documents. Reconnaissance of the site between the upland area near Single Conveyor Station 200+00 and the beach was performed on August 30, September 5, and October 9, 2001. During our reconnaissance, we noted features such as topography, soil exposures, springs, vegetational clues to geologic conditions and stability, and evidence of past landsliding.

4.1 Alignment Topography

Northwest of Thorndyke Road, the Single Conveyor crosses an upland plateau that generally slopes south and southwest at approximately 5 degrees. Between Stations 205+50 and 211+50, the conveyor skirts the top west edge of a ravine that has side slopes of about 35 degrees, although the slopes are steeper and flatter locally. Thorndyke Road lies in a 60- to 70-foot-deep cut where the conveyor crosses the road near Station 212+75. Just southeast of Thorndyke Road, the ground surface is between elevations 325 and 350 feet and slopes to the southeast, generally increasing in steepness as it approaches the beach. A ground surface and geologic profile along the Single Conveyor is presented in Figure 4.

At the southeast edge of the upland area, i.e., southeast of Station 221+00, there are two zones of relatively steep ground separated by a relatively gently sloped bench. The upper steep slope, from about Station 223+50 to Station 224+75, is between 50 and 75 feet high and slopes between 25 and 40 degrees. The bench is between about Station 224+75 and Station 225+60, is approximately 70 to 100 feet wide, and in the vicinity of the proposed conveyor lies between elevations 120 and 150 feet. The ground surface here has an approximate slope of 15 degrees. Between about Station 225+60 and Station 227+00, the conveyor spans an approximately 80 to 100 feet high bluff at the back of the beach. The uppermost portion of the bluff has a slope face inclination between approximately 60 and 70 degrees from the horizontal. The slope inclination decreases to approximately 40 to 45 degrees farther downslope and flattens more in the landslide debris that was observed along the toe of the slope, just above the beach. These areas are delineated in Figure 4.

4.2 Geology

Based on our observations of exposed soils and on reviewed geologic maps, the upland area is capped by a thin veneer of glacial till that overlies stratified outwash consisting of sand and gravelly sand with layers of sandy gravel. The outwash appears to extend down to the base of the bench (to approximately elevation 100 feet to 120 feet) near the face of the bluff. Both of these soil units were likely deposited during the last glacial advance into central Puget Sound.

Soils are well exposed along the bluff, where we observed layers of clayey silt and silt interbedded with layers of sand and gravelly sand. The uppermost layer of clayey silt outcrops near the top of the steepest portion of the bluff. This layer is likely perching water as we observed seepage near the top of this unit. The clayey silt appears to be lacustrine in origin and was likely deposited during the most recent glaciation. Below this layer, the soils are likely nonglacial sediments deposited during the interglacial period prior to the last glaciation. Thin or localized layers of silt in these soils may also perch water and are the likely cause of seepage that we observed on lower portions of the bluff face.

Although not observed, a low permeability layer is suspected to be present at an elevation of about 200 feet, approximately 800 feet northwest from the bluff face. Seepage and associated wetlands, likely indicating the presence of this perching layer, were observed in the valley west of the proposed Single Conveyor below an approximate elevation of 200 feet. Based on the log of a water well installed approximately 3,000 feet to the southwest, this layer could be continuous, with the uppermost layer of clayey silt exposed on the bluff. The log of this water well also indicates the presence of sandy or gravelly clay below an elevation of approximately 45 feet, extending downward to approximately 35 feet. This material is likely to be glaciomarine sediments deposited during the second to last glaciation. These sediments were not observed along the beach or in the bluff face but are indicated on geologic maps as being exposed just above beach level several thousand feet northeast of the site.

4.3 Landslide Mapping

The steep, southeast-facing slope along Hood Canal, including the site and areas southwest and northeast of the site, is mapped as "Unstable" in the *Coastal Zone Atlas of Washington* (WSDOE, 1979). During our reconnaissance, we observed numerous landslide scars and indicators of marginally stable and unstable slopes in the vicinity of the project and along the proposed conveyor. The landslides observed or inferred from aerial photographs and topography are shown in Figure 2. Although the proposed conveyor alignment does not cross and would not be affected by Landslide Areas A or B, we included these areas in our geologic review because doing so helps us to better understand the historical and ongoing geologic processes at and near the site. Review of these landslides also helps us to better understand and interpret geology below the conveyor alignment and Landslide Areas C and D.

Between Thorndyke Road and the beach, the proposed Single Conveyor crosses a narrow, triangular-shaped point formed by two valleys that cut into the upland. The upland area between the two valleys that define this point narrows from about 800 feet wide at Thorndyke Road to about 150 feet wide at proposed conveyor Station 224+00. This triangular point and the valleys that define its limits are located between two large, active landslide areas, portions of which are designated Landslide Areas A and B in Figures 2 and 3.

Landslide Area A, northeast of the site, is a bowl-shaped feature that appears to be a large, deep-seated, rotational landslide extending southeastward to about 500 feet northeast of the proposed conveyor alignment. Landslide Area A is about 1/2 to 3/4 mile long, parallel to the shore. This landslide appears to be relatively active; we observed offsets in Thorndyke Road where it crosses the slide and patched asphalt where Thorndyke Road crosses the landslide margins. We also observed blocks of clayey soils that appear to have been pushed upward through the landward edge of the beach. If these blocks have been pushed up, they would confirm our opinion that this is a deep-seated, rotational landslide. It is our understanding, based on previous work we performed in the area, that the most recent movement of this landslide occurred in the winter of 1999 or spring of 2000. This landslide area is mapped as "Unstable" in the *Coastal Zone Atlas of Washington* (WSDOE 1979). In our opinion, based on our observations of upturned beds on the beach and offsets and patching of Thorndyke Road, Landslide Area A would be better classified as an "Unstable Recent Slide" (Urs). According to the definition presented in the *Coastal Zone Atlas of Washington*: "Map symbol Urs identifies recent or historically active landslide areas." Landslide Area A includes areas designated "Risk Factor 1 and 2" on the *Critical Areas – Landslide Hazard, Eastern Jefferson County* map (Jefferson 1995). The Risk Factor ranges from 1 to 3, with 1 representing low potential for landsliding and 3 representing the highest risk for landsliding.

Landslide Area B, the area to the southwest of the site, is about one mile long parallel to the shore and appears to consist of a series of large rotational landslides and smaller translational landslides along the steep slope above the water. Large rotational landslides have developed in the thick section of sand and gravel above the interbedded clay, silt, and sand soils that are exposed in the bluff at the back of the beach. Much of this large landslide area is mapped as "Unstable Recent Slide" and is designated as a "Very Critical Area" in the *Coastal Zone Atlas of Washington*. Following landsliding in the winter of 1982/1983, Jefferson County passed Resolution No. 37-83, which designated this area as the "Thorndyke Bay Slide Area" and limited development within it. Extending northeasterly from the northeast side of Landslide Area B to the northeast side of the point upon which the conveyor alignment is to be located, the slopes are designated as "Critical Area" and are also included in the regulated "Thorndyke Bay Slide Area" (see Figures 2 and 3). Landslide Area B includes areas designated "Risk Factor 2 and 3" on the *Critical Areas – Landslide Hazard, Eastern Jefferson County* map (Jefferson 1995).

Landsliding has also occurred on the point that the Single Conveyor is proposed to cross. However, these instabilities are relatively small in comparison to those that occur in Landslide Areas A and B. These landslide areas, designated C and D in Figures 2 and 3, include the bench above the bluff, the upper steep slope just above the bench, and the extension of these two features around the point into the ravine southwest of the proposed conveyor. The instability expressed on the bench is indistinct but includes fallen and leaning trees, localized grabens and holes in the ground surface, and abrupt changes in the ground surface. The landslide activity is also represented by the accumulation of landslide debris at the base of the bluff (see Figures 3 and 4).

Slope movement in Landslide Areas C and D appears to occur as an episodic but progressive combination of rotational and translational failure in the areas of steeper ground upslope and south of the bench. Ground movement along the bench appears translational in nature. High water levels perched by the less permeable soils below likely cause both types of failure. High groundwater levels within the soils along the bench cause ground movement toward the bluff. As these soils move, support for the steeper slopes above is reduced. The reduction in support at the toe of the steeper slope combined with high groundwater levels within the steeper portion of the slope causes rotational failure of soil onto the bench.

In the area designated Landslide Area C, which the Single Conveyor is proposed to cross, the upper steep slope upslope of the bench represents the headscarp area of the broad zone of landsliding. Little of the landslide mass remains on this upper steep slope, having moved downslope to form and occupy the bench area. The thickness of the landslide mass that underlies the bench is unknown but may range from 10 to 50 feet (See Figure 4). A less advanced stage of landsliding was observed in Landslide Area D where the landslide mass still occupies steeper ground and has not completely failed. Ground instability in Landslide Areas C and D appears to be largely controlled by groundwater perched on the clayey silt layer that occurs at an elevation of about 100 feet.

Landslide Area D is on the northeast slope of the large ravine that bounds the southwest and south side of the proposed Single Conveyor. This landslide appears to move generally southwest toward the ravine. A relatively fresh set down with a near-vertical scarp as high as 12 feet exists at the top of the landslide area (see Figure 3.). Several benches, set downs, and setdown scarps were observed within this landslide area and jack-strawed trees exist along the lower portion of the landslide near its toe (above the bluff). At the mouth of the ravine, southwest of the proposed conveyor, the width of the bench diminishes and failure extends to the creek. In addition to instability caused by water pressures developed above a perching layer, stream erosion at the toe of the landslide mass removes support and reactivates landsliding or progression of landsliding upslope. The proposed Single Conveyor is located just northeast of the top of the Landslide Area D headscarp.

Besides the landsliding in Areas A through D discussed above, some indications of less significant instability were observed along the upland portion of the conveyor. Northwest of Thorndyke Road, the conveyor alignment lies close to the southwest edge of a deep ravine. We observed bowed 8- to 10-inch-diameter trees on the southwest slope of this ravine, which are indicative of soil creep. (This area is designated "area of creep" on Figure 2.) We did not observe evidence of active or past landsliding on this slope.

4.4 Faulting

The site is located along the west side of the Puget Lowland, which has several known and inferred west- to northwest-trending crustal faults. North- to northeast-trending faults are also known or inferred along the east and west margins of the Puget Lowland. One such fault is the Hood Canal Fault, approximately 4 miles west of the project site at its closest point (Figure 1). The Hood Canal Fault is inferred to trend northeasterly along Hood Canal in the southern half of Puget Sound and to diverge and extend northward along Dabob Bay west of Toandos Peninsula (Gower et al., 1985) (Johnson et al., 1994). No seismicity or Holocene activity (i.e., within the past 10,000 years) has been associated with this fault.

Based on recent seismic reflection work and on previous aeromagnetic studies, Brocher et al. (2001) infer an east-west-trending fault zone, informally named the Lofall fault zone, that is about one mile north of the proposed Pier at its closest point. The fault location was inferred from linear, steep, geophysical gradients; it is uncertain whether the structure is actually a fault, and no paleoseismic evidence attests to its earthquake history.

4.5 Geologic Hazardous Areas

In Landslide Areas C and D, Figure 3, the proposed Single Conveyor crosses several geologically hazardous areas regulated by Jefferson County Unified Development Code. Based on *Jefferson County Critical Areas* maps, designated erosion, seismic, and landslide hazard areas are present where the conveyor transitions from the upland plateau, crosses Landslide Area C, and extends down the bluff to the beach. Based on our discussions with the owners, our interpretation of the site geology, and our experience, the potential for and frequency of landsliding within Landslide Areas C and D near the proposed Single Conveyor can be reduced to a degree generally acceptable for protection and operation of facilities of this type, i.e., where the operators have control over maintenance and operation facilities and can make adjustments or suspend operations if necessary. Potential stability improvement measures are discussed below. Improving stability of the landslide zone above the bluff will also reduce the potential for landslide, seismic ground motion, and erosion hazards to contribute to burial or disturbance of wetland areas on the beach near the conveyor alignment.

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Slope Stability

5.1.1 General

Near the Single Conveyor alignment, the steep slopes along the margins of the upland plateau and the valleys and drainages dissecting the plateau are subject to landsliding. Many of these slopes show active landsliding or evidence of recent landsliding. To reach the beach from the upland plateau, the crossing of unstable slopes appears unavoidable. However, in our opinion, based on our observations and experience, the degree and significance of potential ground movement along the proposed Single Conveyor (Landslide Areas C and D) is significantly less than for the slopes northeast and southwest of the alignment (Landslide Areas A and B, respectively).

The proposed conveyor crosses an active landslide zone at the top of the bluff (Figures 3 and 4). The frequency and magnitude of landslide movement in this zone are unknown; however, movement appears to occur with relative frequency as tilted, downed, and jack-strawed trees were observed. Relatively fresh setdown scarps were also observed on the ravine slope southwest of conveyor Stations 222+00 to 226+00. Additionally, a portion of the wetland area at the toe of the bluff appears to have been recently impacted by deposition of landslide debris that likely originated from the bench at the top of the bluff.

Water is a major contributor to the occurrence and reactivation of landslides at this site. Instability of landslides observed at the site is likely associated with infiltration of rain, snowmelt, and runoff and with groundwater perched in sandy soils near the top of the bluff above less permeable soil layers. Based on our experience, reducing the quantity of water that infiltrates landslide-prone ground and draining groundwater from landslide-prone ground will reduce the frequency and magnitude of ground movement (see also, Turner and Schuster, 1996 and Abramson, et al, 1996). Recommendations for using drainage to improve stability of the landslide zone at the top of the bluff are presented below. In our opinion, based on our experience with the use of subsurface drainage systems to improve slope stability, implementation of the proposed drainage measures will reduce landslide, seismic, and erosion hazards to the natural environment and constructed facilities in the areas where the drainage measures are installed.

In our opinion, slope stability improvement measures more extensive than installation of surface and subsurface drainage are not required to improve stability of the slope to a level acceptable for conveyor operation. This opinion is based on (1) our observations at the site; (2) review of geologic information for the site; (3) our understanding that the proposed conveyor would be designed to tolerate occasional movement; (4) discussions with the owners regarding acceptable operations levels, maintenance, and ground movement; and (5) our experience. Other stability improvement alternatives, such as retaining walls and tiebacks, could be pursued should operational considerations so warrant.

5.1.2 Surface Drainage Improvements

We recommend that surface runoff be intercepted and directed away from Landslide Areas C and D to reduce infiltration in these areas. Decreasing infiltration into landslide-prone ground would improve stability of this ground. Runoff from upland areas should be intercepted and directed away from the proposed cut. In accordance with common practice, water that would not naturally flow onto adjacent property under the existing conditions should not be diverted onto adjacent property (unless authorized) or potentially unstable ground.

Interception and redirection of surface water may be accomplished using berms, diversion ditches, and storm drains. One proposed arrangement for surface drainage diversion berms, ditches, and catch basins is shown in Figure 5. Culverts should be installed where forestry service roads cross natural drainages. Storm drain pipes from the area above the bluff should be tightlined to the stream or beach, or discharged to an existing drainage swale or other location where the water would not increase the likelihood of a landslide or pose a hazard to the natural or developed environment. Water dispersion, energy dissipation, and erosion protection measures should be installed at tightline pipe outlets (see Figures 6 and 7). A schematic of a tightline pipe is presented in Figure 7.

5.1.3 Subsurface Drainage Improvements

Slope and landslide stability may be improved by removing water from and lowering the groundwater level in landslide-susceptible soils. Based on our preliminary geologic and geotechnical review of the site, site geometry, proposed conveyor alignment, and wetland locations, we recommend that trench drains be constructed near the Single Conveyor in Landslide Areas C and D to improve slope stability. A trench drain is used to intercept groundwater and is constructed by excavating a trench and backfilling the trench with drainage gravel. Trench drains are generally constructible to depths of 10 to 15 feet and have a maximum practical depth of about 25 feet. Drains proposed for this project would be about 5 to 15 feet deep near the top of the bluff and increase in depth with increasing distance from the bluff face. Perforated pipe may be buried in the gravel to collect and remove intercepted water (see Figures 7 and 8). Cleanouts should be provided for pipes installed in trench drains. Water collected in trench drains should be tightlined to the beach (see Figure 5). Water dispersion, energy dissipation, and erosion protection measures should be installed at tightline pipe outlets (see Figures 6 and 7).

Multiple trench drains are recommended for this project to improve ground stability along and to either side of the conveyor where it crosses Landslide Area C. Preliminary recommended trench drain locations are shown in Figure 5. Our preliminary recommendations include a central trench drain below the bottom of the cut along the conveyor and laterals that extend northeast and southwest from the central trench drain. Near the top of the bluff, at the south end of the cut (approximately Station 225+75), we propose that the trench drain system pipes discharge into a vault. The surface water collection system pipes could also discharge into this vault. A tightline drainpipe should be used to deliver water from the vault to the toe of the bluff. Energy dissipation and erosion protection measures should be installed at tightline pipe outlets. Depending on the ground conditions encountered in explorations that would be performed during the design phase of this project, additional trench drains or extension of the proposed trench drains (see Figure 5) may be appropriate to increase groundwater collection and sufficiently improve slope stability to protect the proposed facility. Trench drain depths and alignments would be determined after completion of explorations, during final design. If ground conditions encountered during trench drain installation differ from those interpreted from the design phase explorations, additional trench drains or extensions of the proposed trench drains may be necessary.

Other subsurface drainage measures may also be appropriate for this project. In our opinion, horizontal drains may be appropriate if it is determined through subsurface explorations and stability analyses that groundwater must be drained from a larger area or from depths unreachable by trench drains, or if less surface disruption is required. The need for and extent of alternative subsurface drainage systems would be determined during final design. Horizontal drains would be constructed by drilling 4-inch-diameter holes into the ground and installing a 1.5-inch-diameter slotted drainpipe in each hole. The holes would be drilled at a slight upward inclination so that water collected in the pipes will drain under the influence of gravity toward the pipe outlet. The drainpipes should connect to tightlines that discharge water at the beach. Energy dissipation and erosion protection measures should be installed at tightline pipe outlets.

5.2 Seismic Hazards

Two faults are inferred to be located within 4 miles of the project area: the Hood Canal Fault and the Lofall fault zone, respectively. The T-ROC conveyor system will cross the Lofall fault zone near the Twin Conveyor to Single Conveyor transfer location. Although these faults are not known to be active, the Puget Sound region is known to experience seismic events. Based on the *Seismic Zone Map of the United States* in the 1997 *Uniform Building Code*, the project is in Seismic Zone 3. The corresponding Seismic Zone Factor, Z, equals 0.30 (ICBO 1997). Soil explorations have not been conducted along the Single Conveyor alignment. However, based on our observations and experience, potentially liquefiable soils are likely present on the beach and below the waters of Hood Canal in the proposed Pier area. Liquefiable soils may also be present on the bench above the bluff, depending on the groundwater level and the effectiveness of proposed subsurface drainage measures on lowering the groundwater. The foundation systems for those portions of the facility that cross liquefiable soils should be designed to support the structures and resist forces associated with lateral spread of the ground should liquefaction occur. Candidate foundation systems are discussed below. Foundation design would be based on subsurface explorations and soil laboratory tests conducted during the project final design phase.

5.3 Foundation Systems

Preliminary geotechnical recommendations for foundation systems are presented below. These recommendations are based on our observations and review of geologic information and our understanding of the conveyor and pier design. Subsurface explorations have not been completed for this project; they would be performed prior to design of the conveyor and pier foundations.

5.3.1 Single Conveyor Station 200+00 to Station 224+75

Based on our understanding of the project, proposed conveyor construction, and foundation loads, it is likely that the conveyor could be supported on spread footings where it is constructed across the upland plateau from Station 200+00 to about Station 224+75, i.e., upland of Landslide Areas C and D. Spread footings or pile foundations would be appropriate for conveyor pier supports founded near the toe of the Thorndyke Road cut slopes. Spread footings that support the conveyor bridge over Thorndyke Road would be founded near or below the ditch elevation. Excavations into the existing roadway cut slopes would be necessary to construct spread footings. If spread footing construction is pursued, the slope should be reconstructed to its existing configuration after footing construction. Construction of drilled piers would not require significant excavation into the slope. Although the existing Thorndyke Road cut slopes are steep, in our opinion, conveyor foundations could be installed at the slope toes without causing slope instability.

5.3.2 Single Conveyor Station 224+75 to Station 225+60

Based on our understanding of the project, proposed conveyor construction, and foundation loads, it is likely that the conveyor could be supported on spread footings or piles where it passes through the proposed cut and crosses Landslide Area C between Station 224+75 and Station 225+60. In our opinion and based on our experience, the potential for and frequency and magnitude of landslide-associated ground movement would be decreased by installing the surface and subsurface drainage improvements described in Section 5.1. The potential for loose colluvium on the bench to liquefy during a seismic event would also be reduced through installation of these drainage improvements because the groundwater elevation would be lowered.

In our opinion, spread footing foundations and conveyor supports constructed on landslide-susceptible terrain could be designed to accommodate occasional ground movement from a few inches to a couple of feet without damaging the conveyor, provided the conveyor is also designed to accommodate these movements. Leveling, realigning, or other adjustments to the conveyor or footings could be made when ground movement exceeds some operational threshold.

Pile foundations could be used in lieu of footings where the conveyor crosses the landslide zone. Pile lengths would, in general, increase toward the center of the slide area. Piles could be required near the top of the bluff to support the conveyor where it extends over the top of the bluff and down the bluff face. Piles would pass through soils that have moved, or are likely to move, and would be embedded in stiff to hard or dense to very dense underlying soils. Piles could be designed to resist lateral forces associated with potential ground movement.

5.3.3 Single Conveyor Beach Area and Pier

We understand that the conveyor and pier would be supported across the beach and in Hood Canal by driven, steel pipe piles assembled in multiple-pile bents. Bent spacing would be selected based on foundation conditions, loads, and other factors. A preliminary bent spacing of 100 feet has been proposed for the conveyor in this area with the exception of a proposed 200- to 250-foot span where the conveyor extends from the top of the bluff to the beach. We understand that vertical and batter piles would be incorporated in each bent, as appropriate, to accommodate vertical and lateral loads, including conveyor, seismic, and docking loads. We understand that driven steel piles are also proposed for construction of breasting dolphins at the Pier. Based on our observations, review of geologic information for the site, and the proposed general facility plan, it is our opinion that the proposed driven pile foundation system would likely be appropriate for support of the conveyor, pier, and construction of breasting dolphins. Driven piles are commonly used for pier and dolphin applications and equipment to install piles of this type is locally available. Steel piles also have high vertical and lateral capacity and can be relatively easily increased in length to accommodate variations in bearing depth and channel bathymetry.

Drilled shafts may be applicable for bents constructed across the beach or in the landslide zone above the bluff. Drilled shafts would be appropriate if it is determined that steel piles could not be driven to adequate depth to obtain sufficient embedment for lateral loads and scour protection or if environmental or other considerations necessitated a particular foundation footprint. Small, mobile equipment is readily available and could be used to install drilled shafts on the bench above the bluff. Drilled shafts may be easier to install than driven piles in the bench area because small, mobile equipment could be used for their installation. Soil exploration, liquefaction potential analyses, and lateral load determination are recommended prior to final design and foundation type selection.

We understand that the conveyor will span from the top of the bluff (approximate Station 225+60) to the water side of Wetland Area B (approximate Station 228+00). The conveyor foundation near Station 225+60 can be designed as a spread footing, drilled shaft, or driven pile founded in stiff to dense, in situ native soil. Drilled shaft and driven pile foundations could be designed to directly resist lateral loads that might act on the top of bluff foundation or on the conveyor. Tiebacks could be installed through a spread footing located at the top of the bluff to resist lateral loads. In our opinion and based on our observation of soil deposits at the toe of the bluff, a bent located near Station 228+00 would be far enough from the bluff that it would be unlikely to be impacted by soil or other debris that might slide off the top of the bluff should ground movement continue. Erosion and scour protection may be necessary for structures on or near the beach or bluff toe and in Hood Canal.

5.4 Construction Considerations

In our opinion, conventional construction equipment, such as bulldozers, excavators, and dump trucks, could be used to excavate the proposed cut, and to construct surface and subsurface drainage systems, spread footing foundations, and forestry service roads for the proposed Single Conveyor and Pier. Blasting is not anticipated to be necessary. Track-mounted, pile-driving or shaft-drilling equipment would probably be applicable for pile installation above the bluff and on the beach. Pile-driving equipment working from a barge could be used to install offshore piles.

Erosion protection measures, including installation of silt fences, and scheduling of on land work during drier periods are recommended. A temporary erosion control plan is required. Permanent erosion control measures, such as surface drainage systems, application of erosion control mats, and seeding of disturbed areas, should also be installed upon completion of the conveyor and pier. Erosion control fabrics, gravel-filled geocells, erosion control vegetation, quarry spalls, or other erosion control system should be applied to the bluff face and slope at the base of the bluff to minimize erosion by rain, minor runoff that is not intercepted by upland catch basins, and water that drips from the conveyor.

Cut slopes should be constructed with maximum inclinations of 2H:1V (horizontal to vertical). Flatter slopes may be required depending on soil and groundwater conditions. Cut slopes and other areas disturbed by construction should be vegetated or otherwise protected from erosion.

5.5 Summary

The steep slopes along the northwest side of Hood Canal in the vicinity of the proposed project are generally unstable. From a geologic hazard avoidance perspective, in our opinion, the selected conveyor alignment and location where the Single Conveyor is proposed to descend from the upland plateau to the beach is a preferred location along Hood Canal in this area. Mitigation for landslide hazards to a risk level acceptable to the T-ROC operators is likely more manageable and less costly in Landslide Areas C and D than in Landslide Areas A and B. It is up to the Complex operators to determine the level of risk that they are willing to accept and to evaluate the cost tradeoffs associated with different risks.

The proposed Single Conveyor and Pier would cross or be constructed in areas classified as "Critical Areas," based on erosion, landslide, and seismic hazards. In our opinion, based on our observations and experience, the proposed facility could be constructed along the proposed alignment, and landslide, erosion, and seismic hazards that could affect the project could be mitigated to a risk level acceptable to the facility operators and regulatory agencies and with no increase in risk to adjacent properties above the current condition. These hazards could be reduced by construction of surface and subsurface drainage systems, appropriate foundation and facility designs, and construction of retaining walls or debris catchment systems. Mitigation for landslide hazards to protect the proposed facility would reduce the landslide, erosion, and seismic hazards below their existing condition. Erosion hazards associated with construction and operation of the facility could be addressed using best management practices.

The pattern of erosion on the beach may be modified by construction of the facility across the beach and in Hood Canal. In our opinion, mitigation for landslide hazards on the top of the bluff near the conveyor should reduce the frequency and magnitude of landslide events that bury wetlands at the bluff toe in this area, which have apparently occurred at this location in the past. Reducing the frequency and magnitude of landslides may also modify the bench environment by decreasing the volume of soil delivered to the beach. We understand that, if necessary, a study of these potential effects on the beach environment would be performed by others for this project.

6.0 LIMITATIONS

The analyses, conclusions, and preliminary recommendations presented in this report are based on the site and subsurface conditions as observed in the field and as represented in reviewed documents prepared by others. As for any site located on or near a slope, there is the potential for slope instability. Instability that could affect structures on or near a slope is a risk that owners must be prepared to accept. In addition to natural factors (heavy precipitation, steep topography, soil, and surface and groundwater conditions), other risks include water leaks, pipe breaks, improper or inappropriately directed drainage, lack of maintenance for drains or vegetative cover, filling or saturation at the top of the slope, excavating at the bottom of the slope, unwise acts by adjacent property owners, or similar events or unknown conditions which could cause slope instability.

The scope of our services did not include any subsurface explorations. Subsurface explorations should be completed prior to design or construction of the drainage improvements and foundation systems preliminarily recommended in this report. This report should not be used as a warranty of subsurface conditions. Unanticipated soil conditions commonly exist which may not be revealed by subsurface explorations or surface soil exposures.

The scope of our services did not include any environmental assessment or evaluation regarding the presence or absence of wetlands or hazardous or toxic materials in the soil, surface water, groundwater, or air at the project site. Shannon & Wilson has prepared the document, *Important Information About Your Geotechnical Report,* included in Appendix B, to assist you and others in understanding the use and limitations of our report.

SHANNON & WILSON, INC.

State of Washington Licensed Geologist — Engineering Geologist 362 — Theodor W. Hopkins — 2/24/03

Stanley R. Boyle — State of Washington — 35805 — Registered Professional Engineer — EXPIRES 12/30/03 — 2/24/03

Theodor W. Hopkins
Senior Principal Engineering Geologist

Stanley R. Boyle, Ph.D., P.E.
Associate

TWH:SRB/lkd

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8.0 GLOSSARY

bench A raised, narrow strip of relatively level earth. A small terrace or comparatively level area breaking the continuity of a sloping ground surface.

graben A block of earth, generally long compared to its width, which has been set down along faults or slide planes relative to earth on either side of it.

headscarp A steep slope that develops at the head (i.e., upland limit) of a landslide as a result of downward movement of the landslide mass.

interbedded Alternating or random thin layers of different soils lying in beds parallel to other soil beds. For example, interbedded layers of clay, silt, and sand, could create a unit consisting of layers of clay, silt, and/or sand that occur in any sequence in the overall soil unit created by the accumulation of the individual soil beds.

jack-strawed trees Trees tilted or leaning in multiple, seemingly arbitrary directions. This condition is often caused by non-uniform movement of ground after trees have grown on the ground.

lateral spread Lateral movement of ground resulting from seismically-induced soil shear-strength reduction or liquefaction and gravity-induced downslope movement of those soils and soils overlying them.

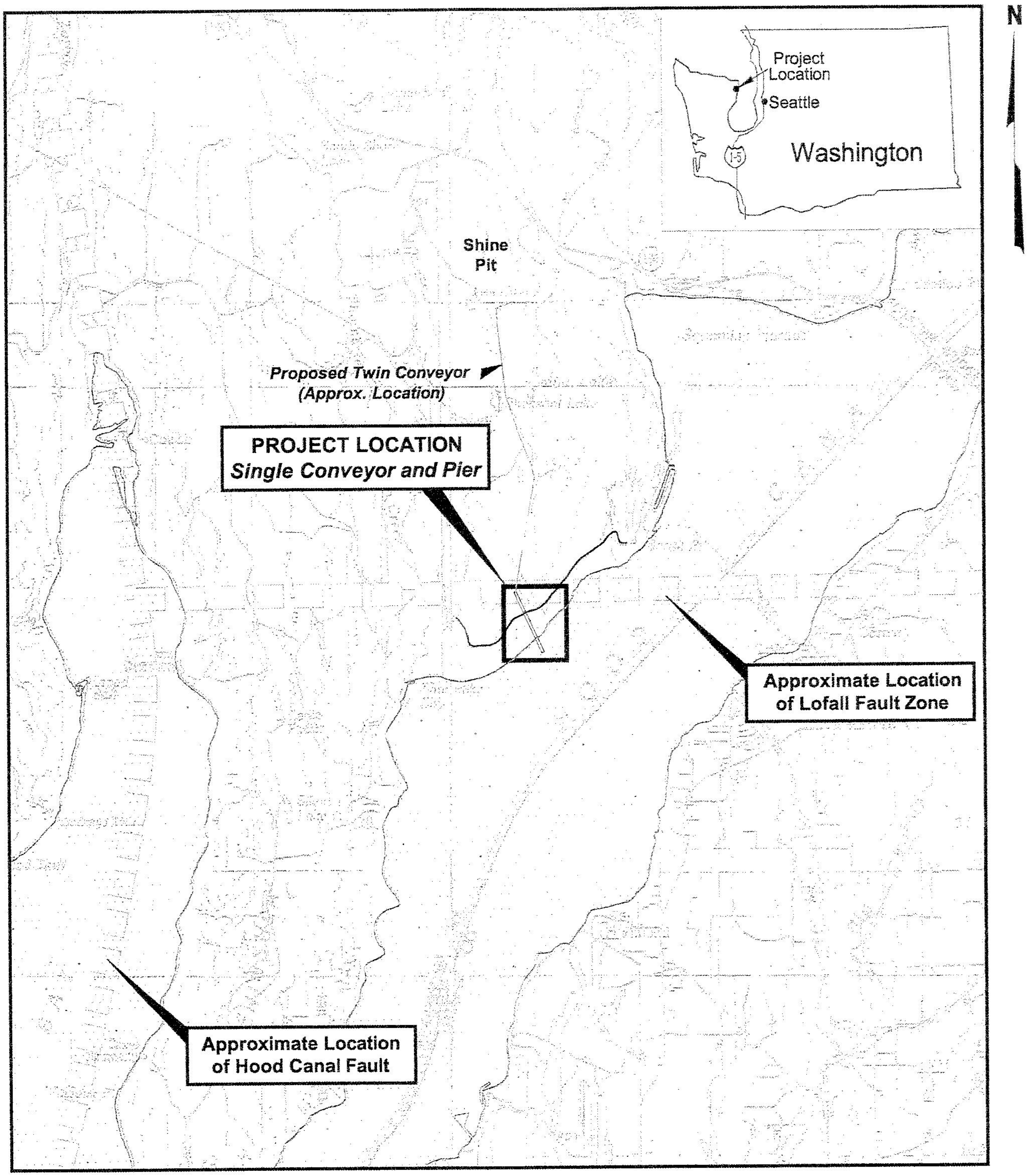
liquefaction The conversion of saturated loose, cohesionless soils (silts, sands, and gravels) to a liquid state as a result of seismic ground shaking and a resulting increase in porewater pressure (i.e., water pressure between the soil particles). Liquefaction reduces the shear strength and load resisting capacity of soil relative to its non-liquefied condition. Ground movement, settlement, and lateral spread commonly result following soil liquefaction.

perched groundwater Groundwater separated from an underlying body of groundwater by low permeability soil. This groundwater is said to be "perched" above the low permeability soil.

rotational failure / rotational ground movement / rotational landslide Ground movement along a generally circular surface as if the ground mass is rotating about an axis that is oriented parallel to a horizontal line crossing the ground mass. Rotational movement generally results in downward movement of the head (upslope end) of the ground mass and upward movement of the toe (downslope end) of the ground mass.

Seismic Zone Factor, Z (ICBO, 1997) A variable used to define the general level of ground shaking that structures to be constructed at a particular location are to be designed for, as specified in the Uniform Building Code, Chapter 16.

translational failure / translational ground movement / translational landslide Downslope ground movement along a generally planar surface, as if the ground mass is translating horizontally and downslope. Movement is generally parallel to the ground surface inclination.



0 2 4

Scale in Miles

NOTE

Map adapted from 1:100,000 USGS topographic map of Seattle, WA quadrangle, dated 1975.

Thorndyke Resource Operations Complex
Single Conveyor and Pier
Jefferson County, Washington

VICINITY AND FAULT LOCATION MAP

February 2003 21-1-09475-001

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FIG. 1

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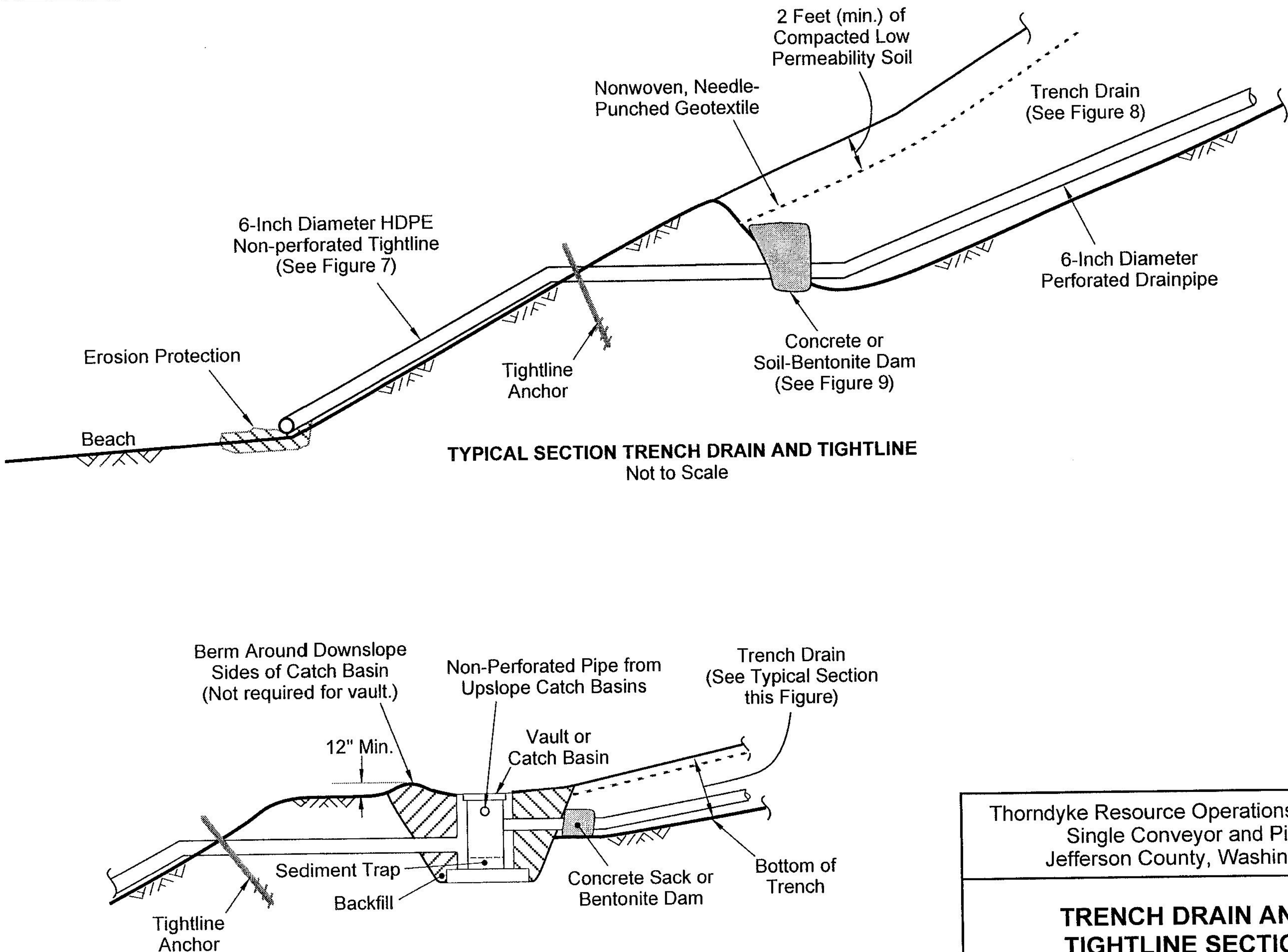

TYPICAL SECTION TRENCH DRAIN AND TIGHTLINE
Not to Scale

TYPICAL SECTION TRENCH DRAIN CONNECTION TO VAULT OR CATCH BASIN
Not to Scale

Thorndyke Resource Operations Complex
Single Conveyor and Pier
Jefferson County, Washington

TRENCH DRAIN AND TIGHTLINE SECTION

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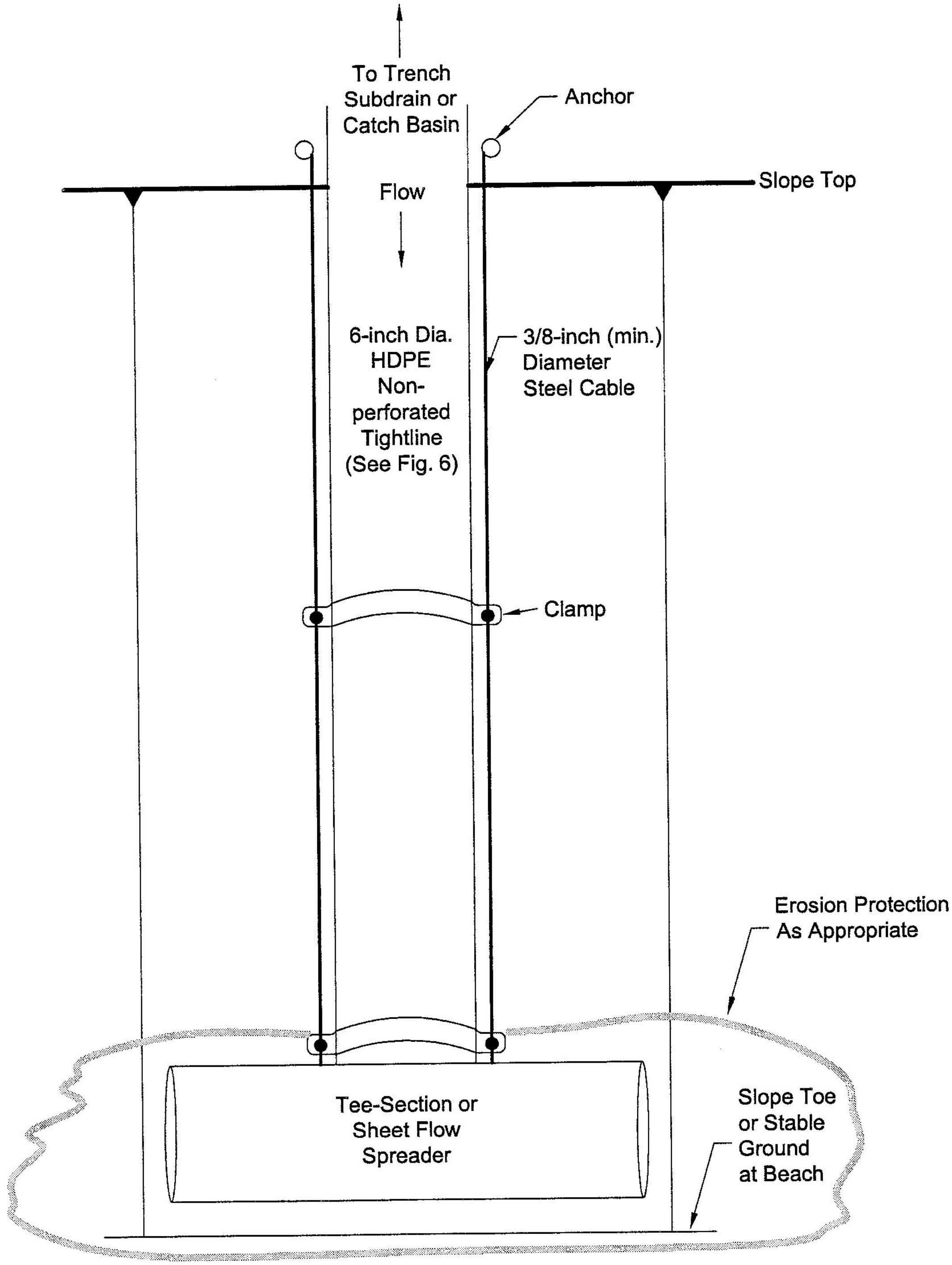
FIG. 6

FIG. 6



Not to Scale

Thorndyke Resource Operations Complex
Single Conveyor and Pier
Jefferson County, Washington

DRAINAGE TIGHTLINE DETAIL

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FIG. 7

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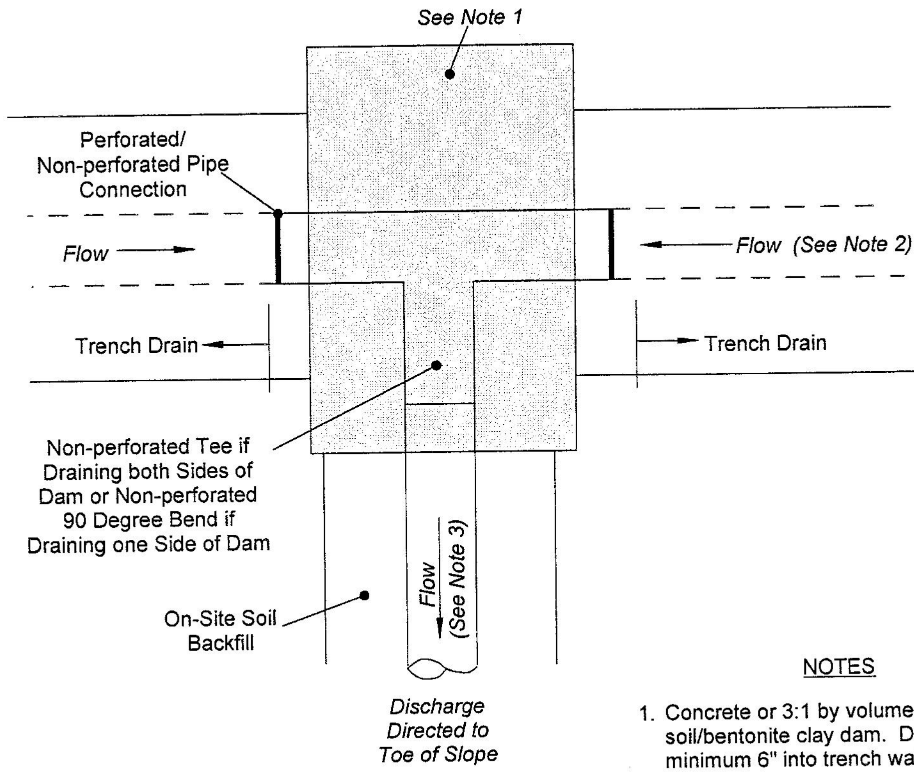
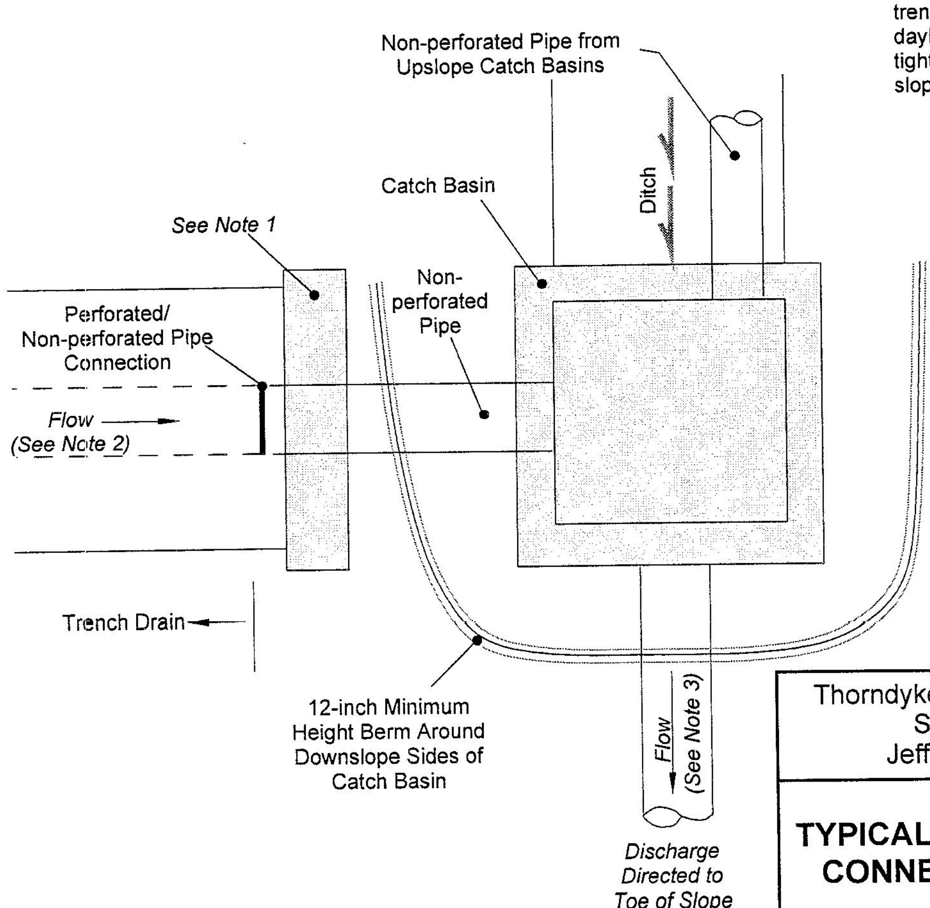


NOTES

1. Concrete or 3:1 by volume ratio soil/bentonite clay dam. Dam keyed minimum 6" into trench walls and invert.
2. 6" diameter flexible ADS perforated drain pipe, sloped at minimum 0.5 percent.
3. Non-perforated HDPE tightline pipe in trench sloped at minimum 0.5 percent; daylight pipe at break in slope; anchor tightline at slope top and extend down slope face (See Figure 7).



Not to Scale

Thorndyke Resource Operations Complex
Single Conveyor and Pier
Jefferson County, Washington

TYPICAL TRENCH DRAIN DAM AND CONNECTION TO CATCH BASIN

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FIG. 9

APPENDIX A

CENTRAL CONVEYOR AND PIER 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.

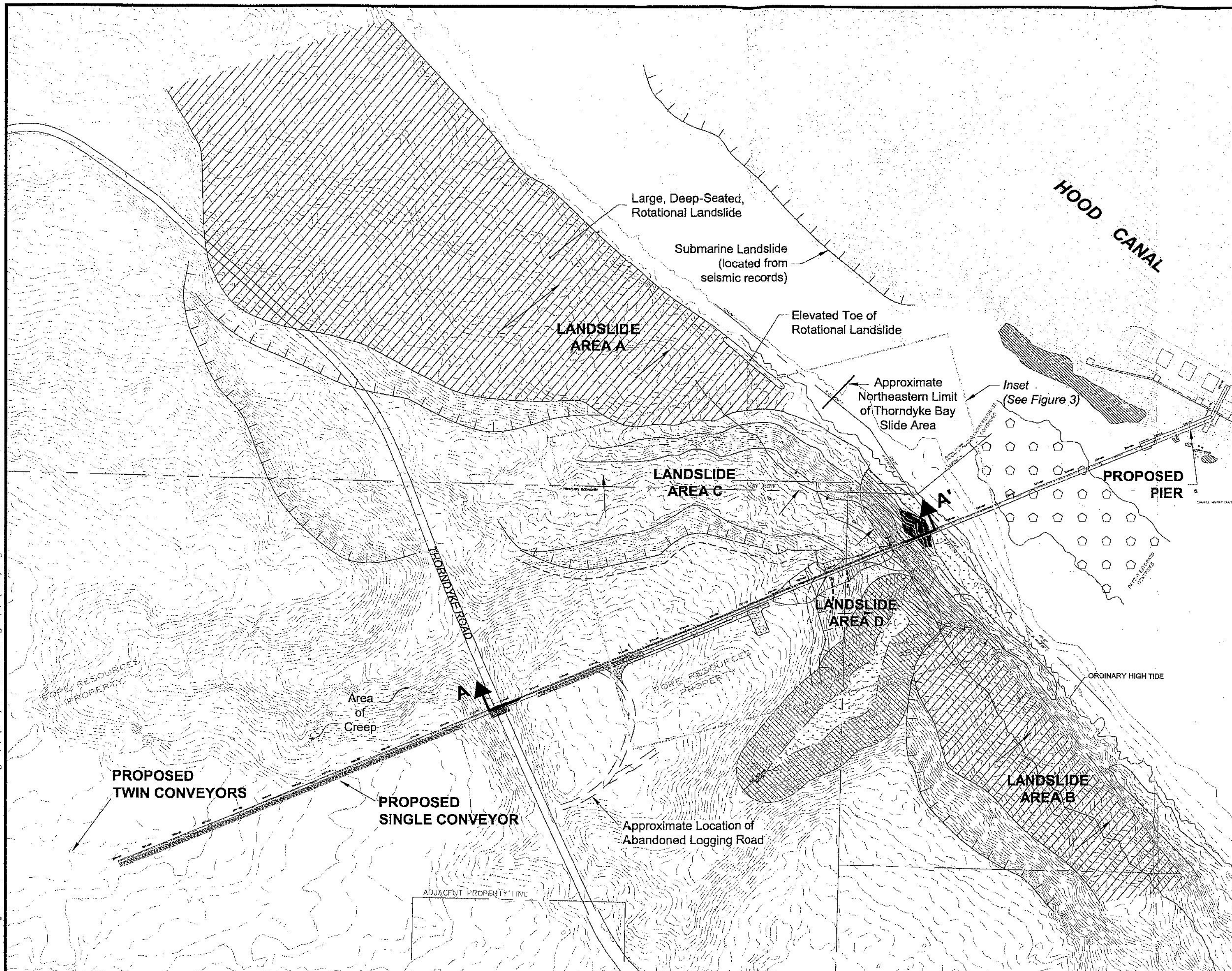
6.0 OPERATION

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

APPENDIX B

IMPORTANT INFORMATION ABOUT YOUR GEOTECHNICAL REPORT



N

0 300 600

Scale in Feet
Contour Interval = 5 Feet

LEGEND

- Headscarp of Landslide Area
- Ground Setdowns
- Approximate Boundary of Landslide Buffer
- Approximate Location of Seepage
- Approximate Direction of Slope Movement
- Approximate Area of Landslide Deposit
- Approximate Area of Deep-Seated, Rotational Landsliding
- Approximate Limits of Wetland Disturbed by Recent Landslide Deposits
- Wetland Area
- Wetland Buffer Area
- Eelgrass (Zoster Marina)
- Patchy Eelgrass
- A Generalized Subsurface Profile (See Figure 4)

NOTES

1. Figure adapted from plans provided by Reid Middleton, dated 11-13-01, 1-3-02, and 5-15-02.
2. Landslide features shown are located based on observations, stereo photographs, and topographic contours and should be considered approximate.

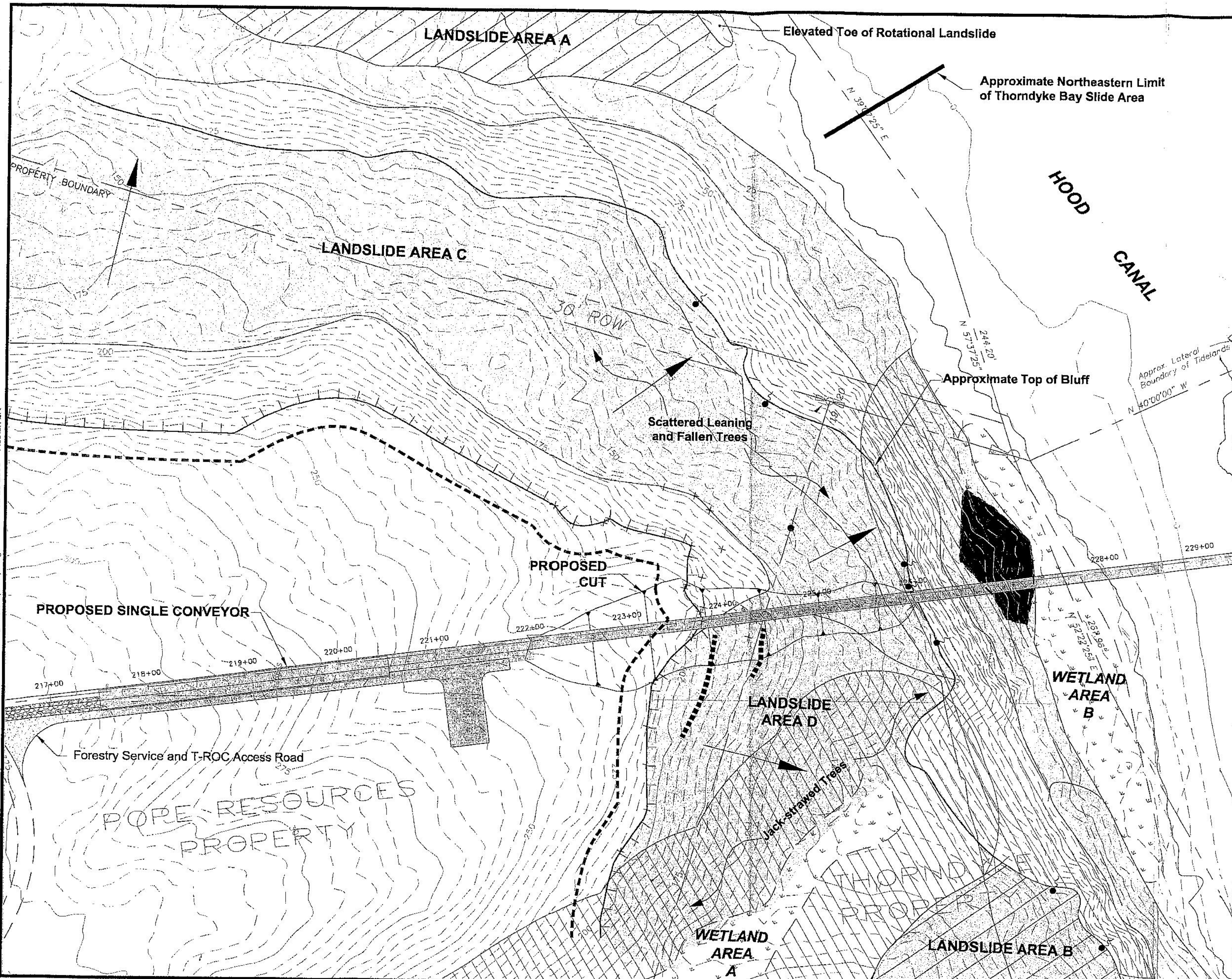
Thorndyke Resource Operations Complex
Single Conveyor and Pier
Jefferson County, Washington

SITE PLAN AND GEOLOGIC CRITICAL AREAS MAP

February 2003 21-1-09475-001

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. 2



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Scale in Feet
Contour Interval = 5 Feet

LEGEND

- Headscarp of Landslide Area
- Ground Setdowns
- Approximate Boundary of Landslide Buffer
- Approximate Location of Seepage
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- Approximate Limits of Wetland Disturbed by Recent Landslide Deposits
- Wetland Area
- Wetland Buffer Area

NOTES

1. Figure adapted from plans provided by Reid Middleton, dated 11-13-01, 1-3-02, and 5-15-02.
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Thorndyke Resource Operations Complex
Single Conveyor and Pier
Jefferson County, Washington

GEOLOGIC CRITICAL AREAS SINGLE CONVEYOR STATIONS 217+00 TO 230+00

February 2003 21-1-09475-001

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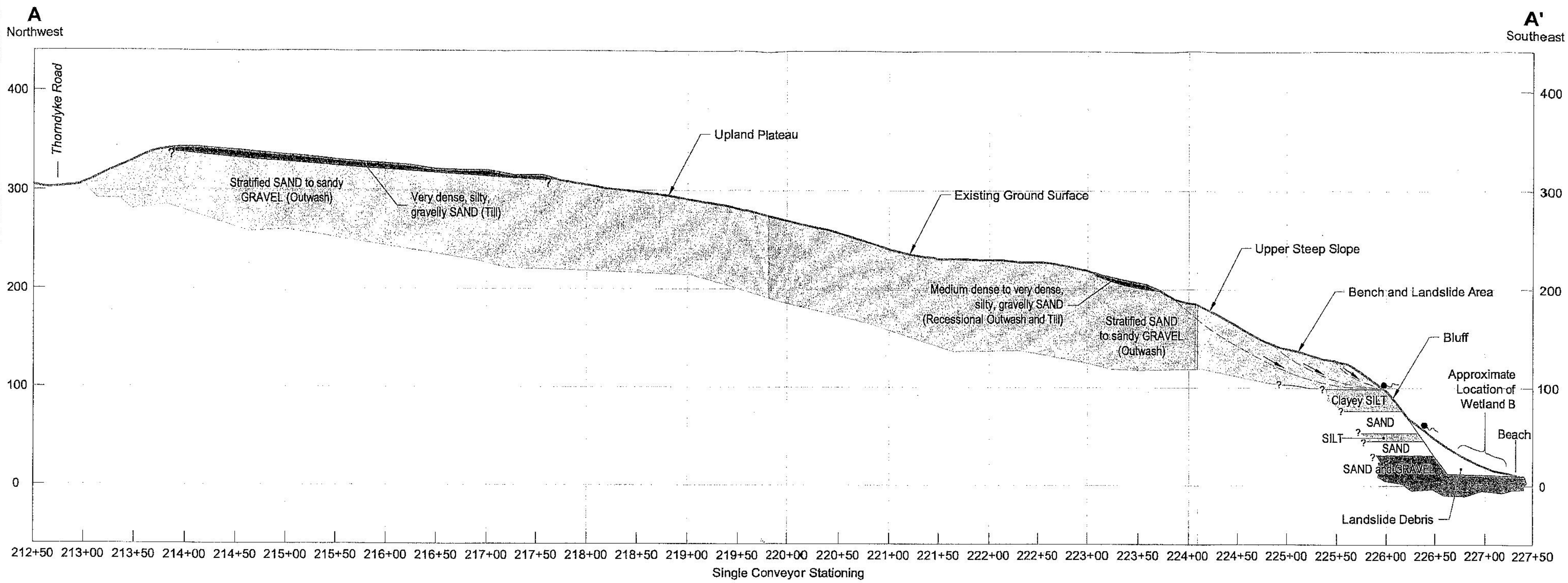
FIG. 3

File: I:\Drafting\21\1\09475-001\21-1-09475-001 Fig. 4 (7-02).dwg Date: 02-24-2003 Author: LR



NOTES

1. Profile provided by Reid Middleton and based on topographic plan, dated 11-13-01.

2. This subsurface profile is generalized from materials observed in soil exposures. Variations between the profile and actual conditions may exist.

LEGEND

●~ Approximate Location of Seepage

Thorndyke Resource Operations Complex
Single Conveyor and Pier
Jefferson County, Washington

GENERALIZED SUBSURFACE PROFILE A-A'

February 2003 21-1-09475-001

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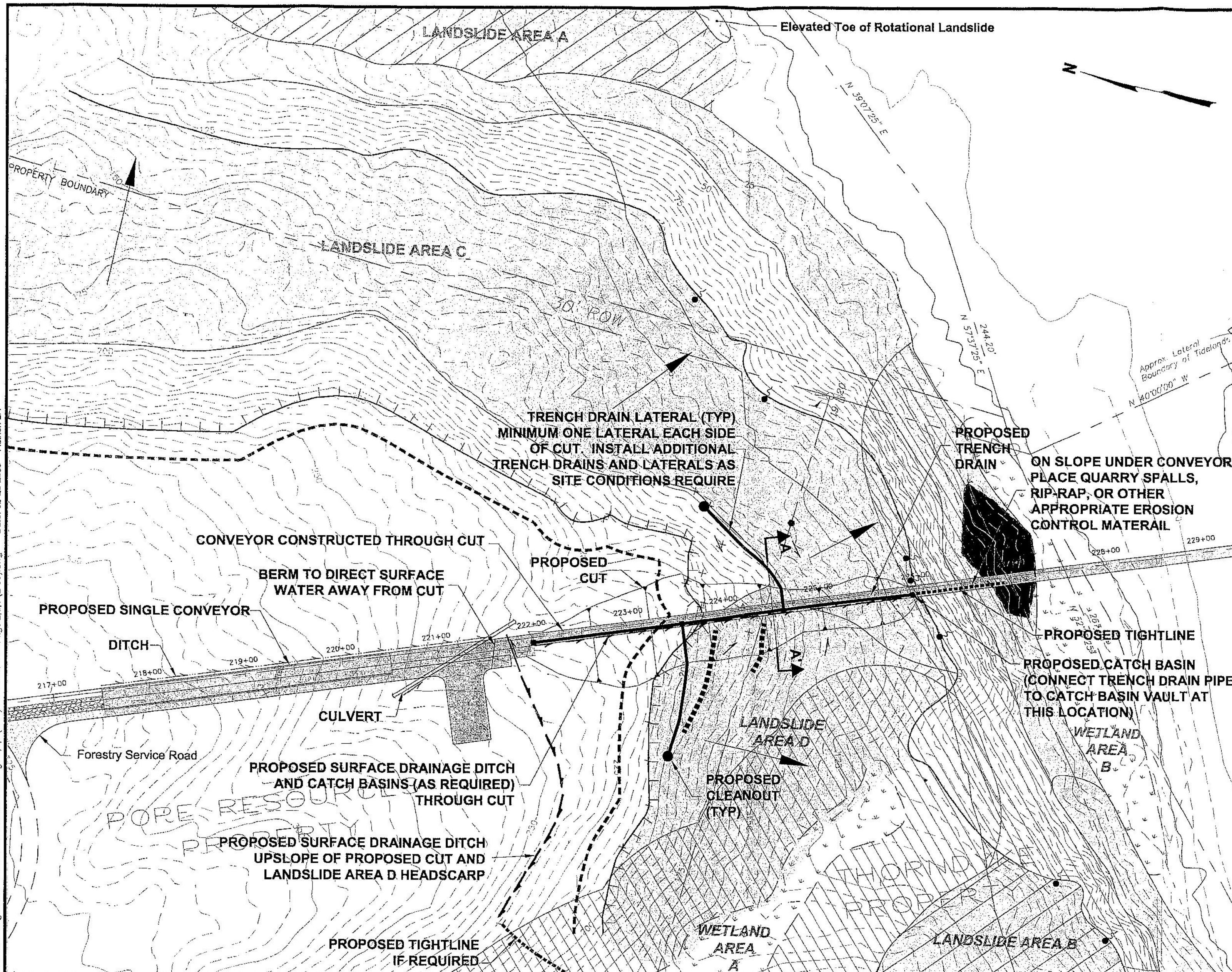
Geotechnical and Environmental Consultants

FIG. 4

File: I:\Drafting\211\09475-001\21-1-09475-001 Figs 2,3,5 (2-03)\21-1-09475-001 figs 2,3,5 (2-03).dwg Date: 02-25-2003 Author: LR



0 100 200
Scale in Feet
Contour Interval = 5 Feet

LEGEND

- Headscarp of Landslide Area
- Ground Setdowns
- Approximate Boundary of Landslide Buffer
- Approximate Location of Seepage
- Approximate Direction of Slope Movement
- Approximate Area of Landslide Deposit
- Approximate Area of Deep-Seated, Rotational Landsliding
- Approximate Limits of Wetland Disturbed by Recent Landslide Deposits
- Wetland Area
- Wetland Buffer Area
- Trench Drain and Direction of Flow
- Surface Ditch and Direction of Flow
- Tightline
- Cleanout
- A Trench Drain Section (See Figures 6 and 8)

NOTES

1. Figure adapted from plans provided by Reid Middleton, dated 11-13-01, 1-3-02, 5-15-02, and 10-4-02.
2. Landslide features shown are located based on observations, stereo photographs, and topographic contours and should be considered approximate.

Thorndyke Resource Operations Complex
Single Conveyor and Pier
Jefferson County, Washington

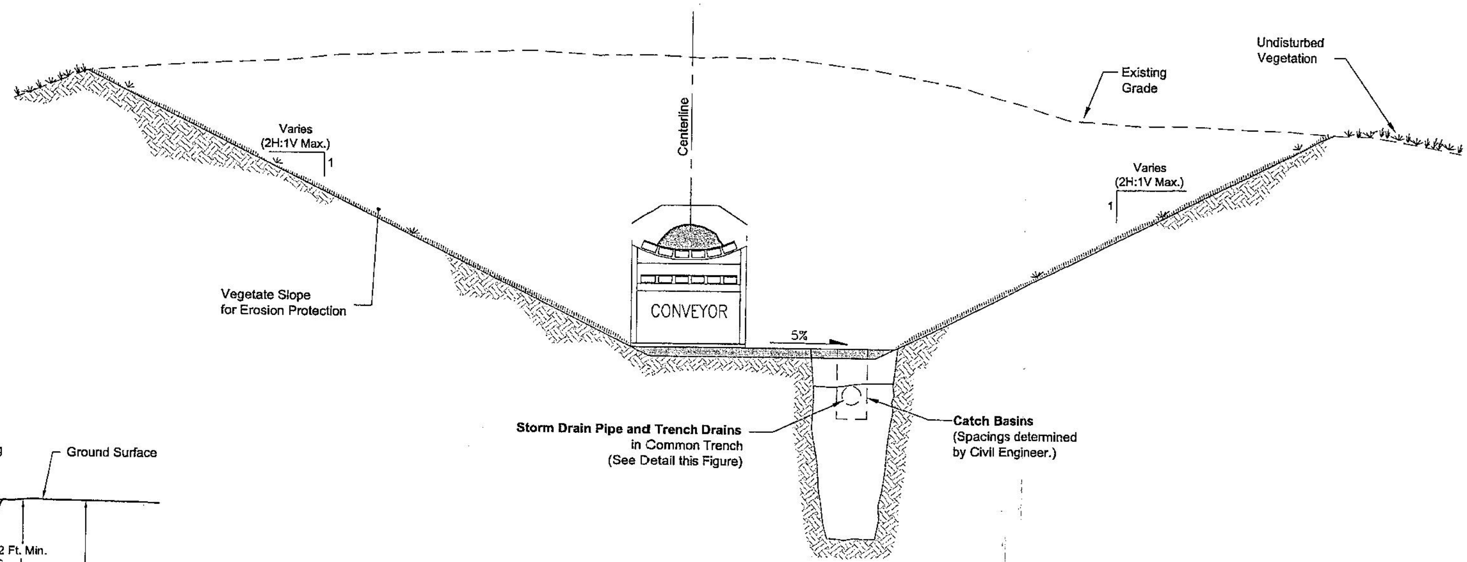
PROPOSED DRAINAGE IMPROVEMENTS SINGLE CONVEYOR STATIONS 217+00 TO 230+00

February 2003 21-1-09475-001

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

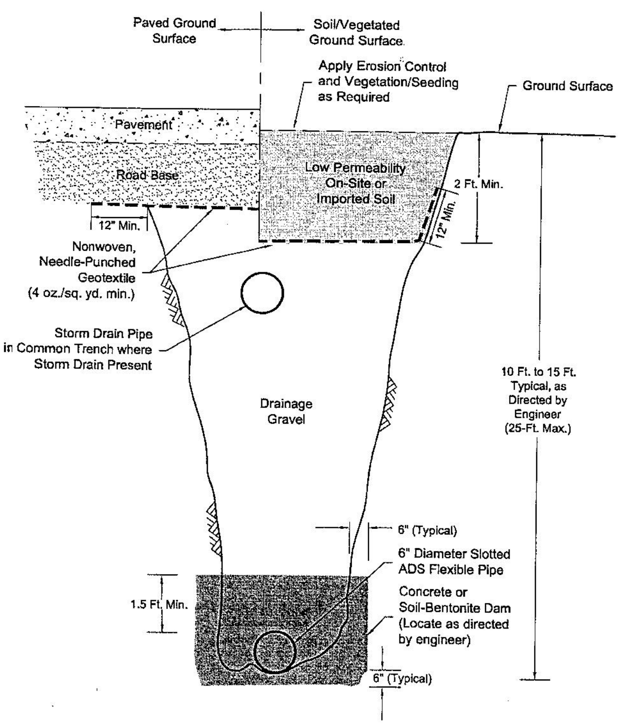
FIG. 5

File: I:\Drafting\211\09475-001\21-1-09475-001 Fig. 8 (7-02).dwg Date: 02-24-2003 Author: LR



SECTION A-A' - SUBSURFACE AND SURFACE DRAINAGE THROUGH CUT

Stations 222+00 to 226+00



DETAIL - TRENCH DRAIN

Not to Scale

Thorndyke Resource Operations Complex
Single Conveyor and Pier
Jefferson County, Washington

TRENCH DRAIN
SECTION A-A' AND DETAIL

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FIG. 8

APPENDIX H
POTENTIAL EFFECTS ON LONGSHORE SEDIMENT TRANSPORT AND SHORELINE PROCESSES – PRELIMINARY REPORT

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for double-sided printing.

PRELIMINARY REPORT

THORNDYKE RESOURCE OPERATIONS COMPLEX

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

Prepared for

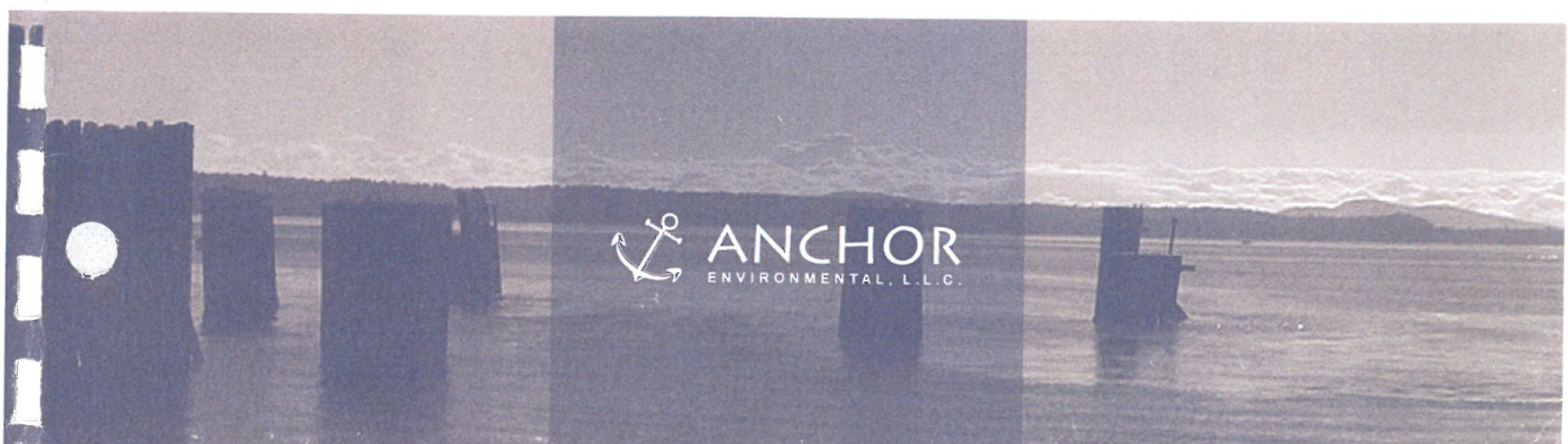
Reid Middleton
728 134th Street SW
Everett, Washington 98204

Prepared by

Anchor Environmental, L.L.C.
1411 4th Avenue, Suite 1210
Seattle, Washington 98101

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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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).

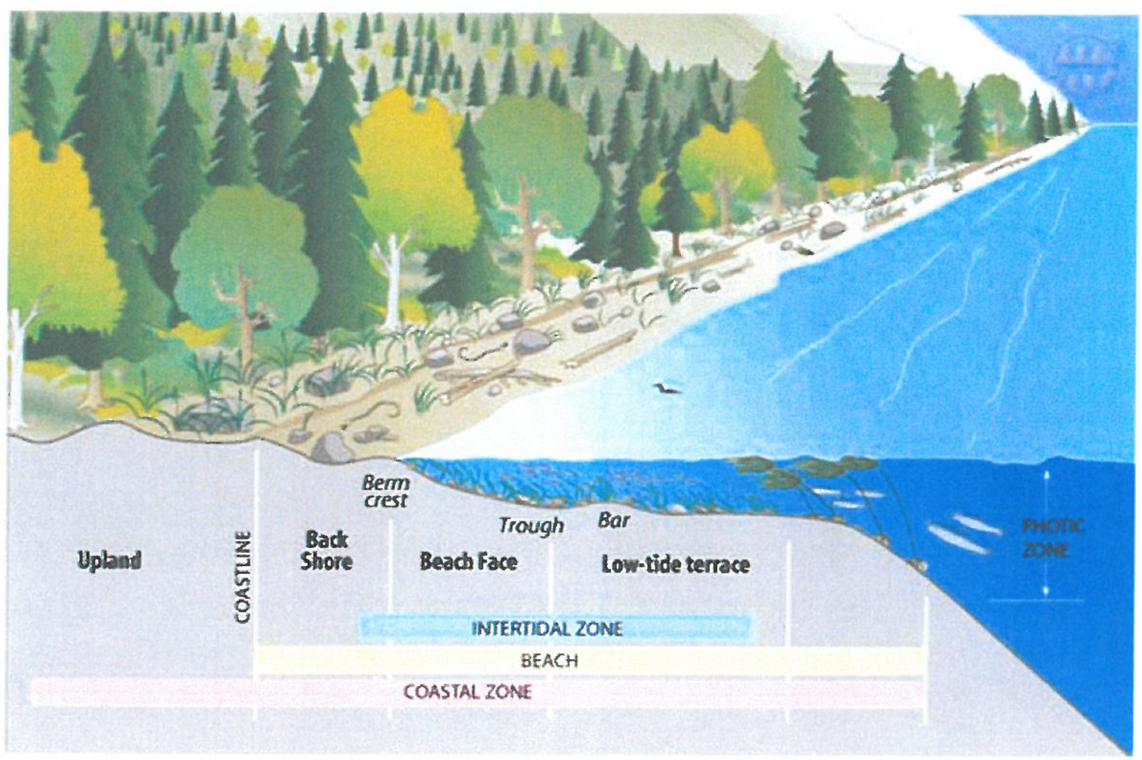

Figure 1
Nearshore Section Illustrating Typical Zonation
Source: Williams et al (2001)

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).

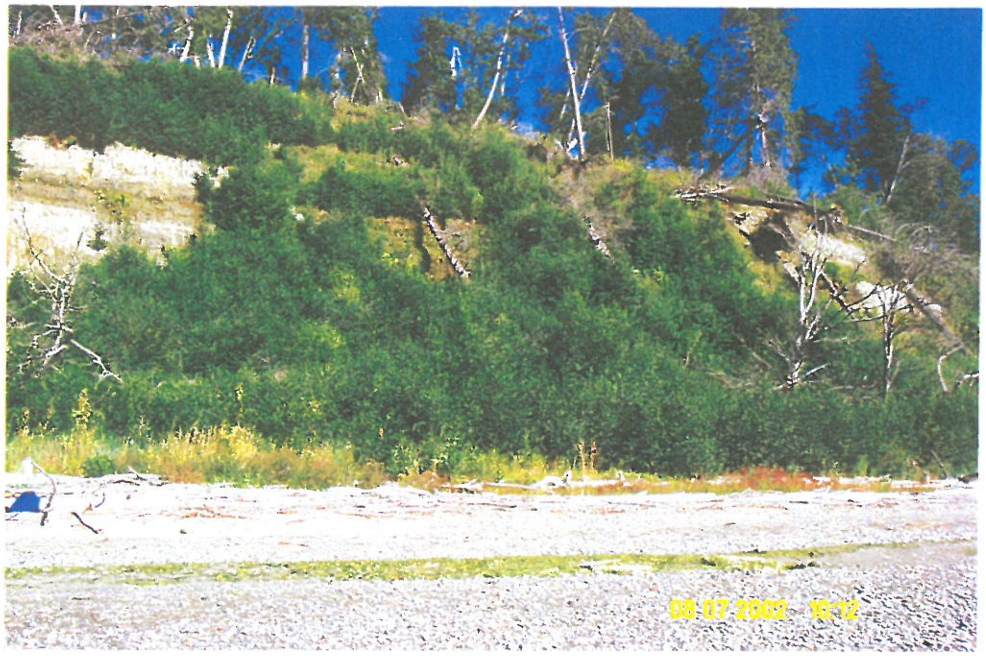

Figure 2
Backshore portion of the Hood Canal Sand and Gravel Company Property

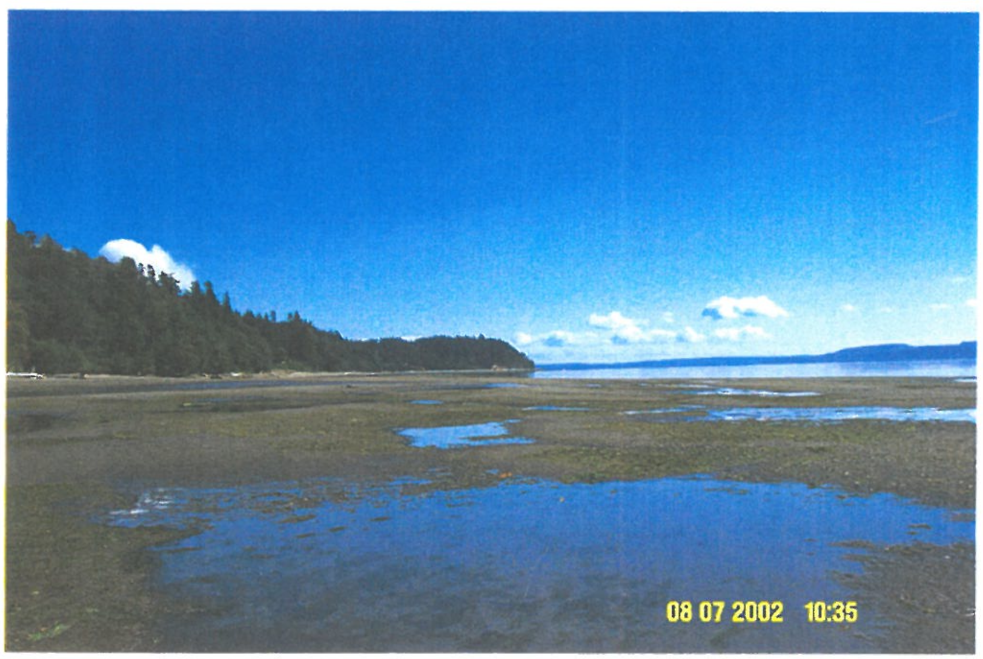

Figure 3
Low-tide terrace of the Hood Canal Sand and Gravel Company Property

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.

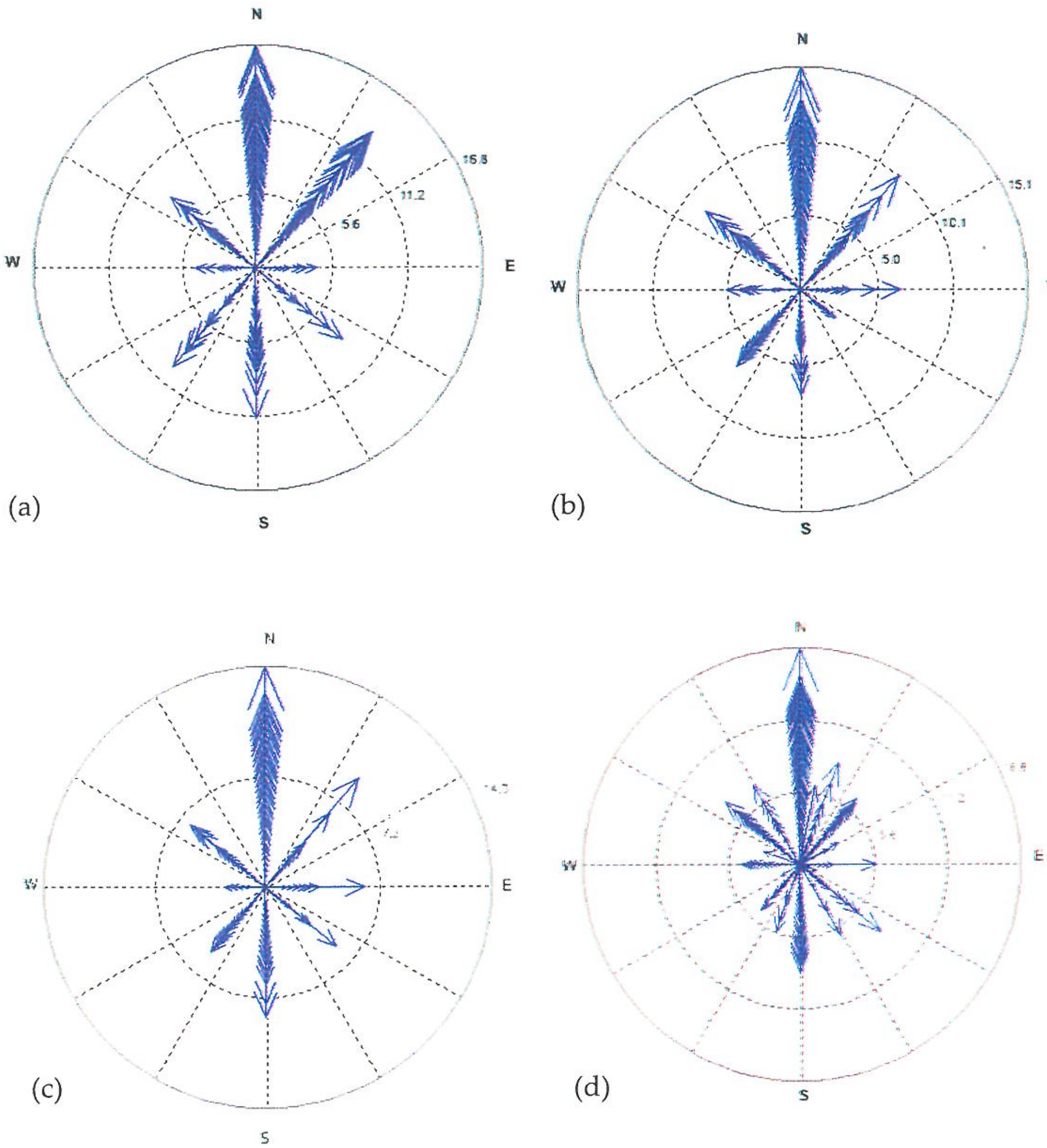

Figure 5
Wind vectors at Hood Canal Bridge (direction in degrees and velocity in m/s) for the years (a) 1998, (b) 1999, (c) 2000, and (d) 2001

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:

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

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

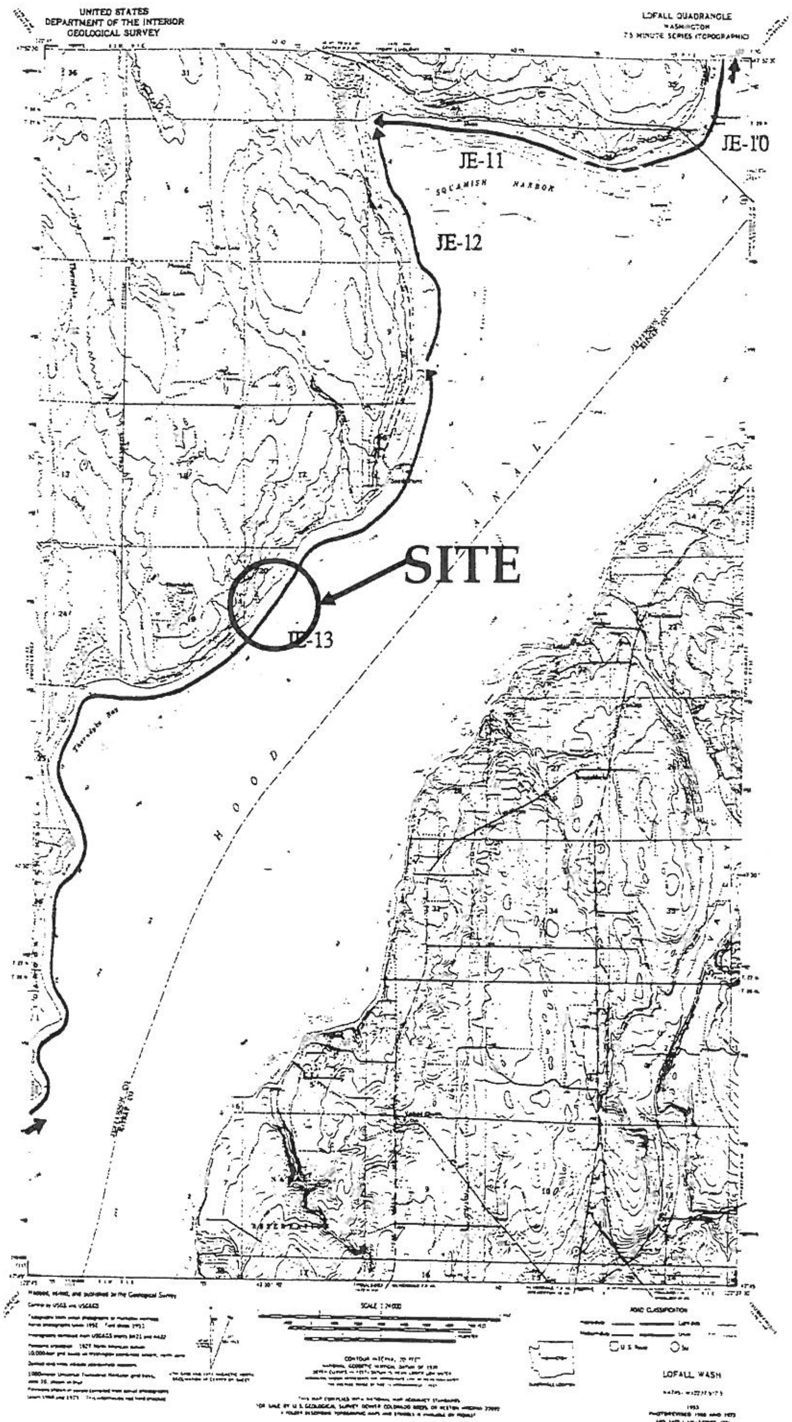

Figure 6
Drift cell JE-13 in Net-Shore Drift in Washington State (Johannessen 1992)

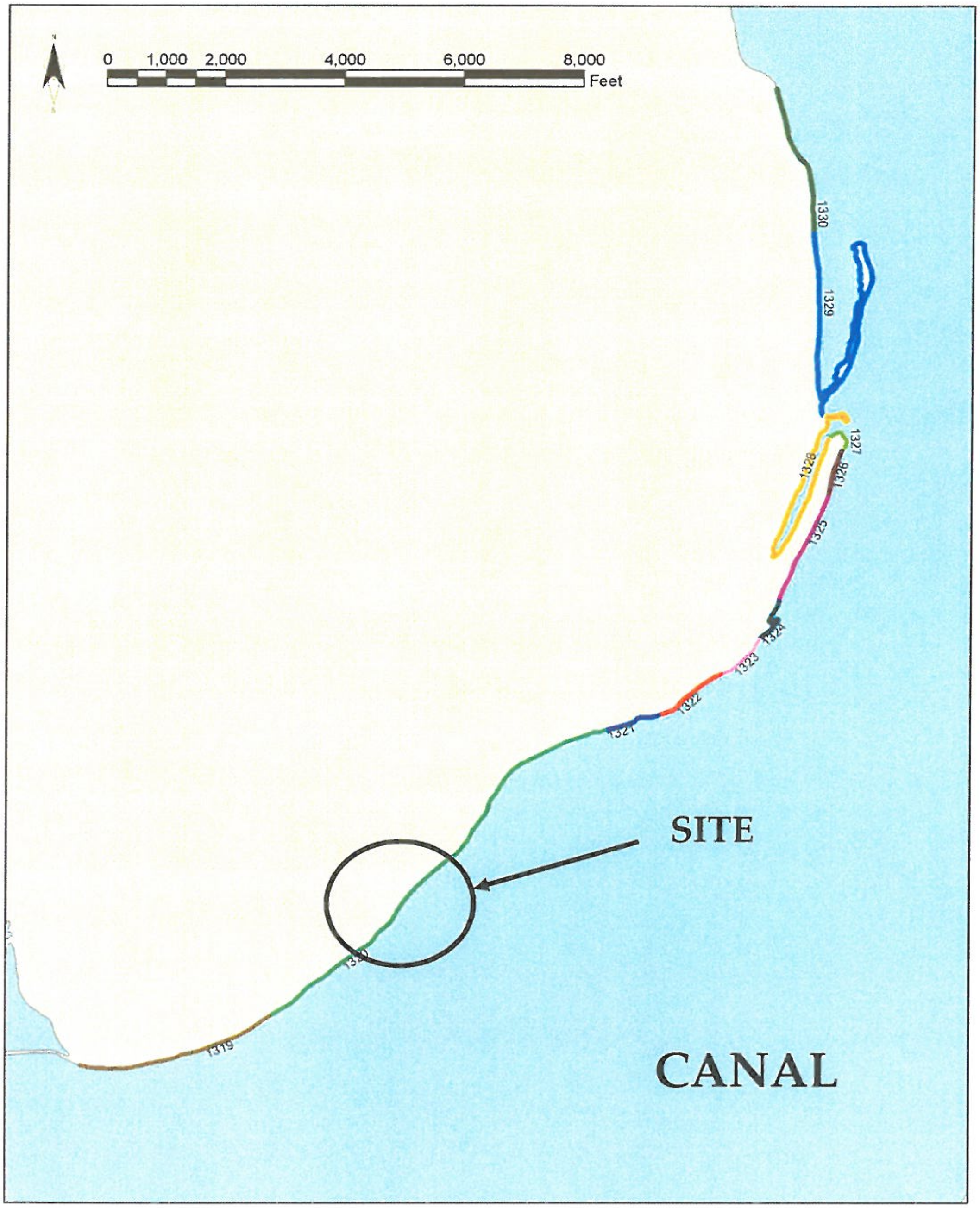

Figure 7
Drift cell 1320 in Shore Zone Inventory (WSDNR 2000)

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.

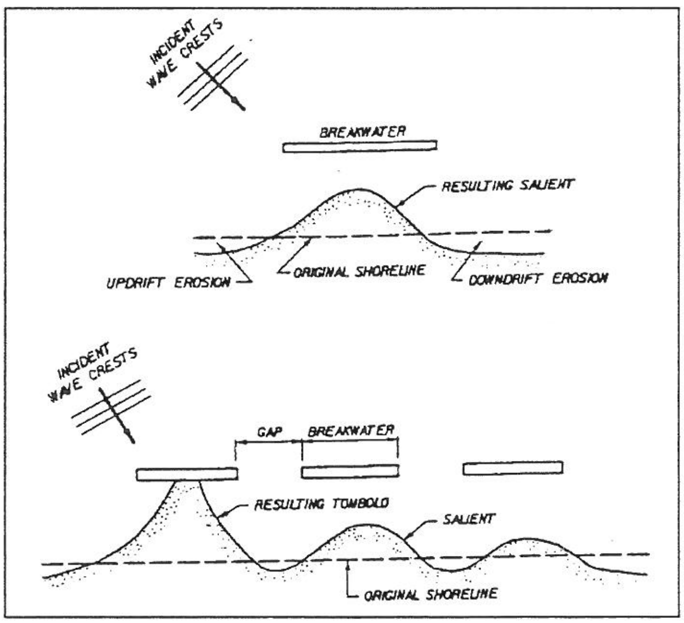

Figure 8
Types of shoreline changes associated with single and multiple breakwaters

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*

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

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

Under the project specifications, X ~ 900 feet (distance from beach to breasting dolphins), L_g = 100 feet, and L_s = 20 feet. With those numbers, X_s = 1.1e-12 ~ 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 $F = \dfrac{V_{x,z}}{(g\Delta d_{50})^{0.5}}$ is a jet Froude number

g = gravitational acceleration

$\Delta = \dfrac{\rho_s - \rho_w}{\rho_w}$ 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.

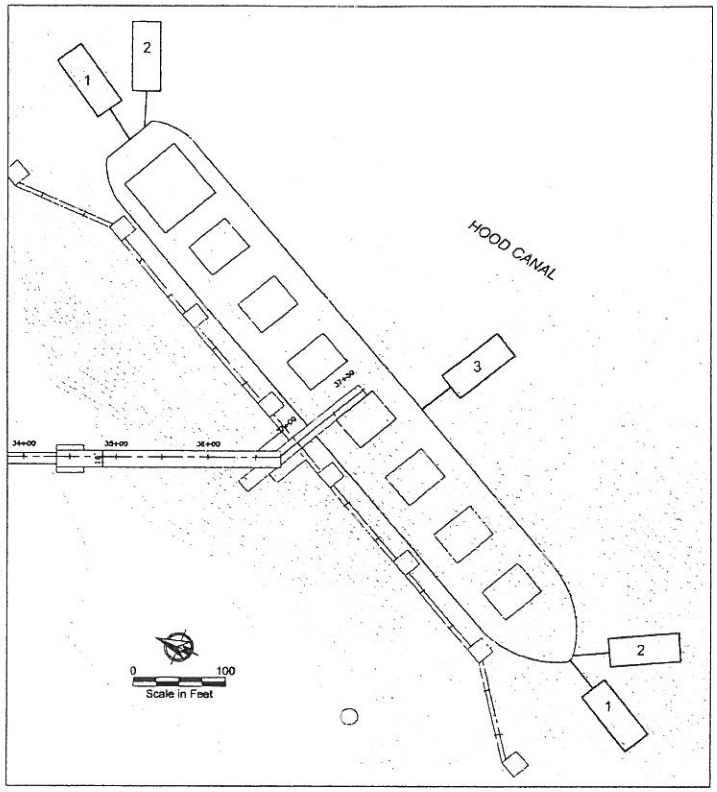

Figure 9
Different tugboat configurations for docking and undocking vessels

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.

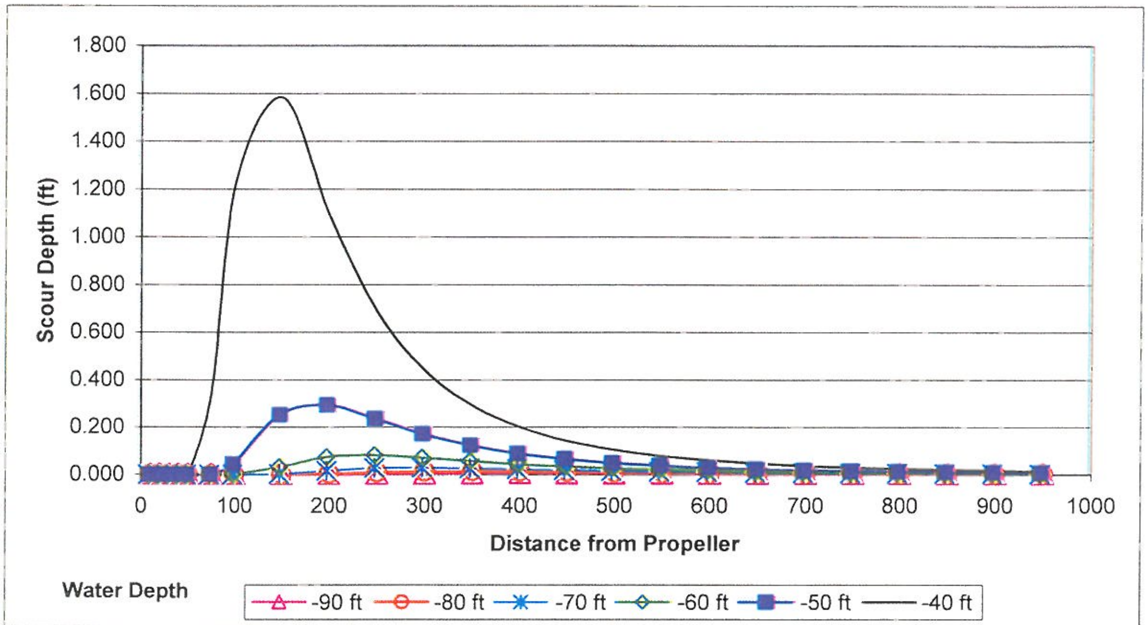

Figure 10
Scour depth as a function of distance from propeller for different water depths

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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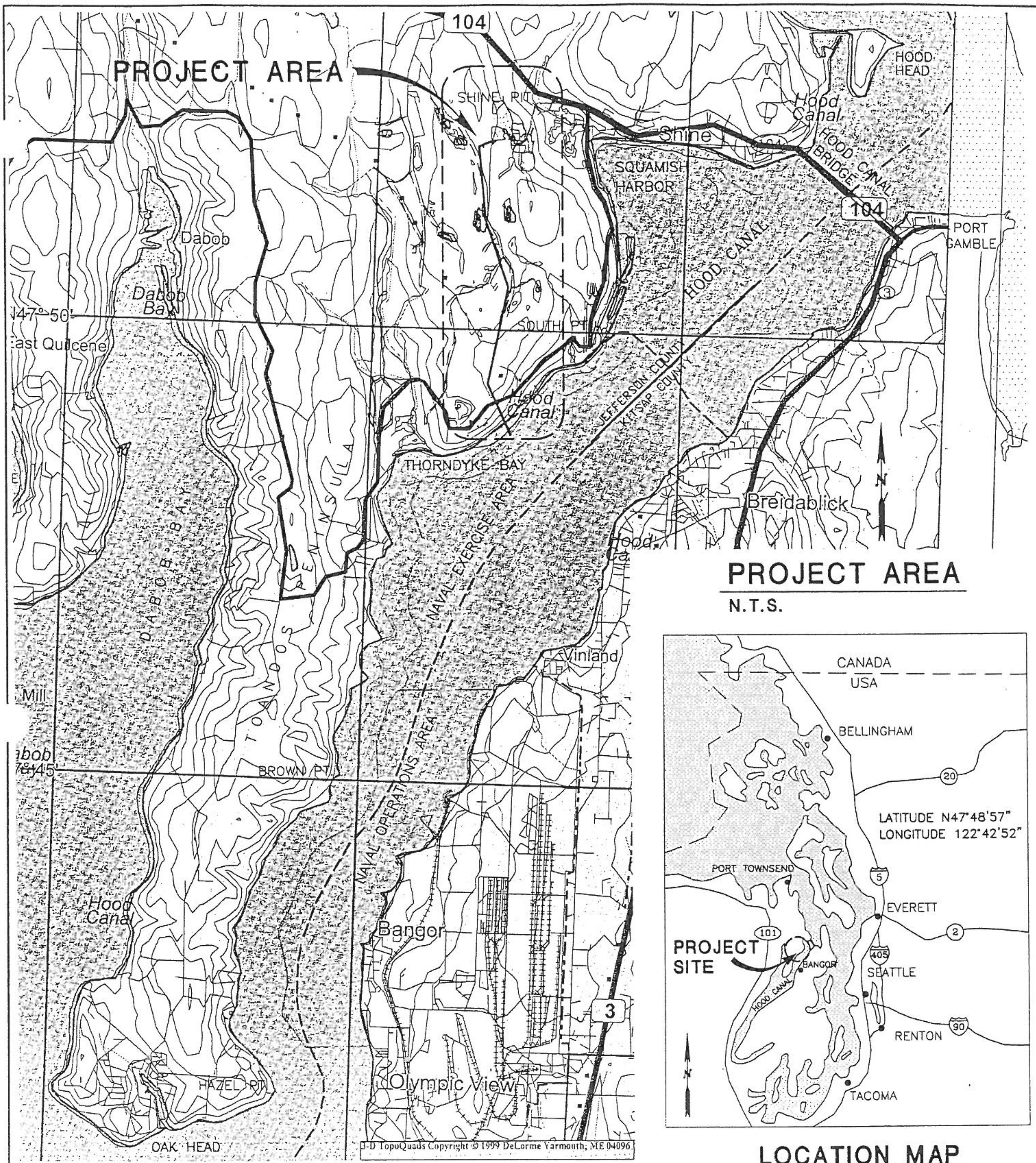
APPENDIX A

CONSTRUCTION DRAWINGS

(provided by Reid Middleton)



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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

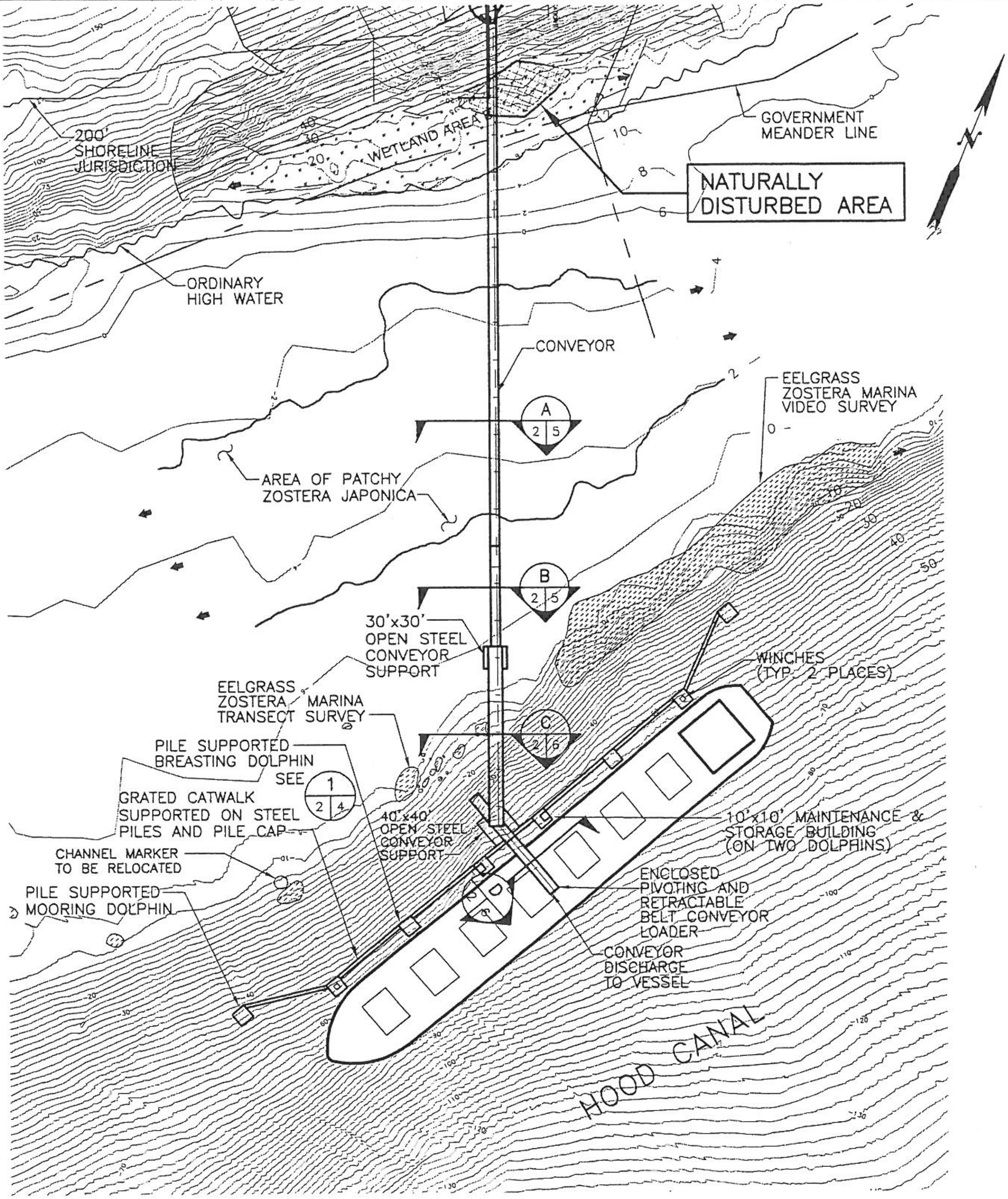
T-ROC CENTRAL CONVEYOR AND PIER

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

Reid Middleton
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
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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

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APPENDIX I
NOISE IMPACT ANALYSIS FOR THE
T-ROC CENTRAL CONVEYOR AND PIER PROJECT

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Noise Study for the Thorndyke Resources Operations Complex (T-ROC) Central Conveyor and Pier Project

Produced for Thorndyke Resources

Poulsbo, WA

Produced by Environalysis, LLC

Seattle, WA

September 1, 2011

Introduction

Thorndyke Resources requested that Environalysis examine the noise impacts of the Thorndyke Resources Operations Complex (T-ROC) Central Conveyor and Pier Project. Our examination included:

- Measuring existing noise levels simultaneously at four residential properties, three of them being the residences or residential property closest to the proposed operations.
- Measuring the sound pressure levels of a comparable gravel-loading facility and conveyor systems.
- Modeling the noise impacts of operating the 3.3-mile long conveyor and loading barges and ships from a 990-foot long pier.
- Determining the noise impacts of constructing the conveyor and pier.
- Comparing the project's noise impacts to the existing background sound environment and to the applicable Jefferson County noise codes.
- Recommending noise mitigation measures where necessary

Methodology

The noise monitoring task used Larson-Davis model 814 and 820 integrating Type 1 sound level meters to simultaneously measure existing sound levels on four residential properties. Noise monitoring was conducted for a continuous 48-hour period.

The modeling phase involved using the CadnaA noise prediction software to determine the project's noise impacts at the four monitoring sites and other noise sensitive locations. The project vicinity and the locations where the noise measurements were taken are shown in Figure 1.

In order to model the noise impacts of the T-ROC Central Conveyor and Pier noise data on each component was obtained from various sources as listed in Table 1.

Table 1. Sources of Sound Pressure Data

Component	Source of Data
T-ROC Operations	
Conveyor belt	Fred Hill Materials Central Hub
Pier loading System	Construction Aggregate Ltd. Sechelt, B.C.
Conveyor transfer point	Manke Operation at Johns Prairie
Ship Arrival & Departure	Orca Sand & Gravel Sound Assessment 2004
Construction of Central Conveyor & Pier	
Caterpillar D-9	Fred Hill Materials Central Hub
Vibratory Pile Driver	EPA
Impact Pile Driver	EPA
Cat Excavator	Fred Hill Materials Central Hub

The sound pressure levels measured from existing operating sources were used in the CadnaA noise model to determine the project's impacts. This program requires detailed (octave-band) noise measurements of all major machinery proposed for the T-ROC facility. Other inputs included topographical information imported from an AutoCAD project base map and the locations of the conveyor system obtained from the project's design drawings. The noise modeling assumed a 24-hour a day, 7-day a week work schedule. The source of the aggregate for the Central Conveyor will be the Meridian mining area with processing occurring at a new hub to be located east of the current Central Hub.

Figure 1. Project Vicinity- Noise Monitoring Locations

1.1 REGULATION OF NOISE

Local Regulations

The maximum permissible sound levels are cited in Jefferson County's ordinance (Section 18.30.190) are based on Washington State WAC 173-60. Section 18.30.190 states:
"

The intensity of sound emitted by any commercial or industrial activity shall not exceed levels established by the Washington State Department of Ecology under Chapter 173-60 WAC, and by Jefferson County under Resolution No. 67-85, "Establishment of Environmental Designations for Noise Abatement Areas for Jefferson County." [Ord. 11-00 § 6.19]"

The State's standards are shown in Table 1 and the one most applicable to the Proposal is shown in **bold.** The maximum permissible noise levels are the limits a project can generate at its boundary with other land uses-- they are not the sum of a project and the background non-project sound levels.

Table 1. Washington State Maximum Permissible Sound Levels in dBA

Land Use of Source:	Land Use of Receiving Property		
	Class A-Residential	**Class B-Commercial**	**Class C-Industrial**
A-Residential	55	57	60
B-Commercial	57	60	65
C-Industrial	60	65	70

Notes:
Between the hours of 10 p.m. and 7 a.m. on weekdays and 10 p.m. and 9 a.m. during weekends, the maximum limits for residential receivers are to be reduced by 10 dBA within residential receivers. For noises of short duration these limits can be exceeded by a maximum of 5 dBA for 15 minutes/hour, 10 dBA for 5 minutes/hour or 15 dBA for 1.5 minutes/hour.

Motor vehicle traffic traveling on public roads is exempt from the noise regulations summarized in Table 1.

Jefferson County has established standards in Section 18.25.100 (3) (f) of the County Code for noise sources located in areas designated as aquatic shorelines. The maximum noise level for sources within this designation is 50 dBA at a distance of 100 feet.

Existing Conditions

The results of onsite noise monitoring are summarized in Table 2 and shown graphically in Figures 2-5. The weather was dry with light winds during the 48-hour noise-monitoring period.

Table 2. Summary of Noise Monitoring

Noise Monitoring Site	Location	48-Hour LEQ	Range of Hourly LEQs	LMAX	LMIN	Notes
SLM-1	62 Soaring Eagle Road	43	26-52	86	23	Measured at edge of bluff at a quiet residential site
SLM-2	184 Groves Way	39	25-49	79	21	Measured at edge of bluff at one of residences closest to the pier
SLM-3	Near a Summer Cabin	45	30-53	68	28	Unoccupied at time of measurement
SLM-4	24559 Johnson St.	41	25-47	78	20	East side of Hood Canal

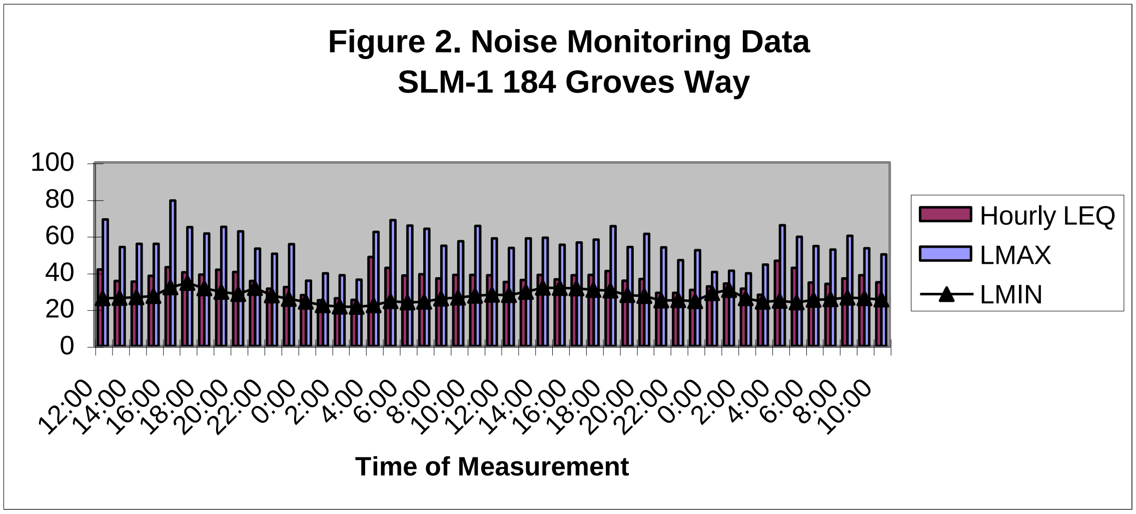


Figure 2. Noise Monitoring Data
SLM-1 184 Groves Way
100
80
60
40
20
0
12:00 14:00 16:00 18:00 20:00 22:00 0:00 2:00 4:00 6:00 8:00 10:00 12:00 14:00 16:00 18:00 20:00 22:00 0:00 2:00 4:00 6:00 8:00 10:00
Time of Measurement
Hourly LEQ
LMAX
LMIN

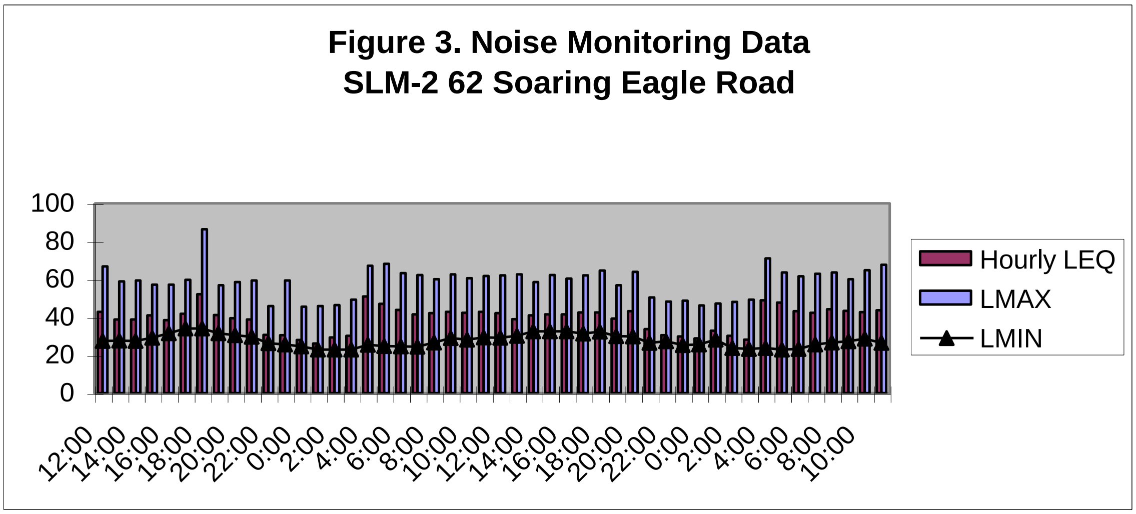


Figure 3. Noise Monitoring Data
SLM-2 62 Soaring Eagle Road
100
80
60
40
20
0
12:00 14:00 16:00 18:00 20:00 22:00 0:00 2:00 4:00 6:00 8:00 10:00 12:00 14:00 16:00 18:00 20:00 22:00 0:00 2:00 4:00 6:00 8:00 10:00
Hourly LEQ
LMAX
LMIN

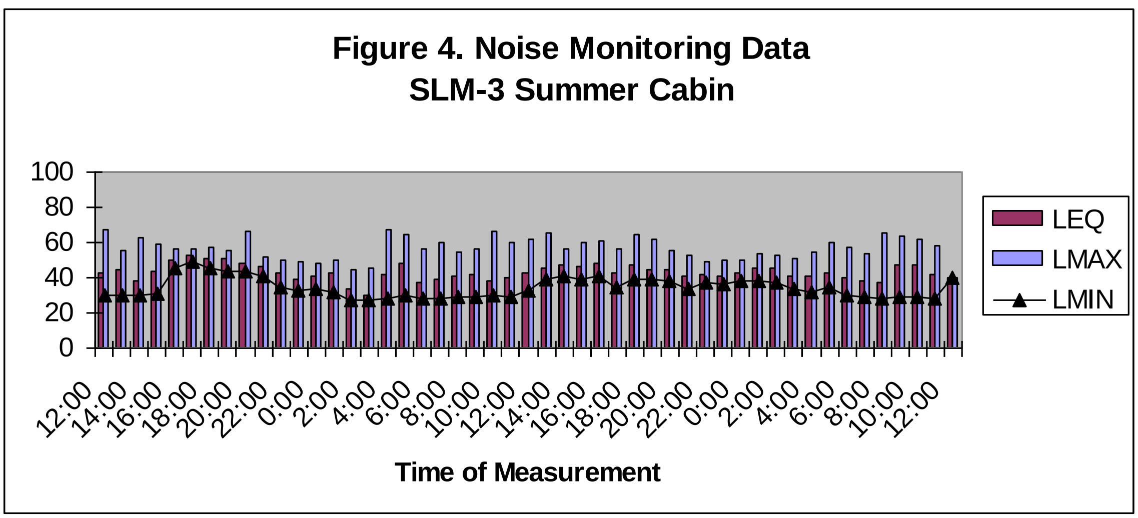
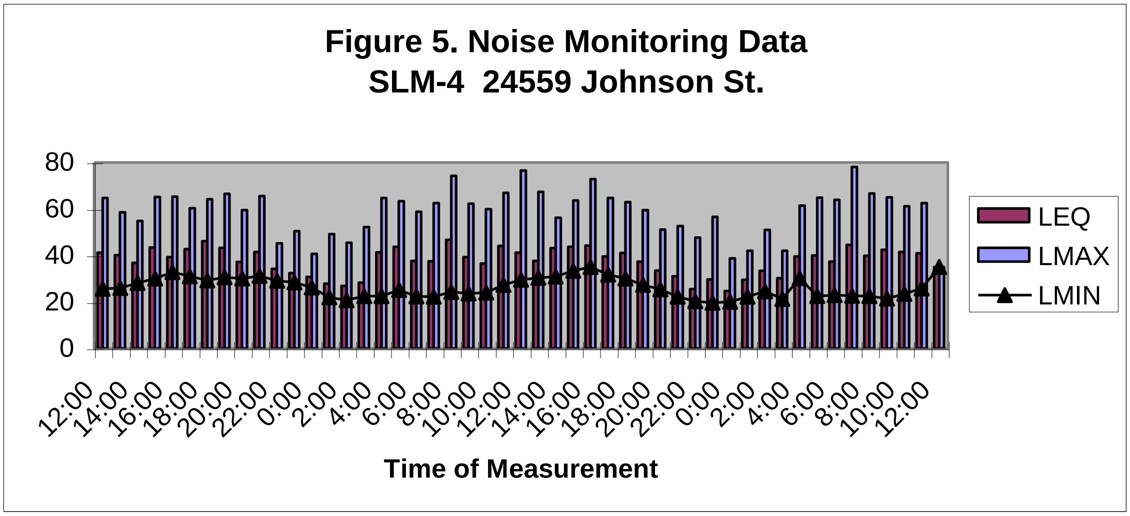


Figure 4. Noise Monitoring Data
SLM-3 Summer Cabin
100
80
60
40
20
0
12:00 14:00 16:00 18:00 20:00 22:00 0:00 2:00 4:00 6:00 8:00 10:00 12:00 14:00 16:00 18:00 20:00 22:00 0:00 2:00 4:00 6:00 8:00 10:00 12:00
Time of Measurement
LEQ
LMAX
LMIN



The information in Table 2 and Figures 2 to 5 illustrates how quiet the existing noise environment is on the average, with extremely low minimum noise levels.

Project Impacts

Measurements were made of construction machinery and conveyor systems similar or identical to what is being proposed. Measurements of the equipment, rounded to nearest whole decibel are shown in Table 3.

Table 3. Sound Levels of Machinery

Process and Equipment	Sound Pressure Level at 100' from Equipment
Facility Operations	
Conveyor belt	49
Conveyor transfer points	60
Gravel loading into steel ship	69
Ship Arrival/Departure with Tug Assisting	61
Pier Facility Construction	
Tug	61
Pile Driver (impact)	86-100
Pile Driver (vibratory)	60
Barge mounted cranes	69-79
Conveyor Construction	
D-8 Crawler Tractor	76-86
D9 Crawler Tractor	80
Cat 988 Frontend Loader	77
Cat 966 Frontend loader	79 (FHWA)
Grader	66-86 FHWA
631 Scraper	77-84
Crawler Crane	69-79
Mobile 50 ton crane	69-79
Dump trucks-10 yard	76-88
Boom trucks	76-88
Semi-trucks 40 foot	76-88
Welders	75-80
Crew Pickups	65-70

Table 4. Distance of Receivers from Construction Activity and Maximum Construction Noise

Construction of Pier		
Receiver	**Distance to Closest Part of Pier in Feet**	**Maximum Construction Noise**
SLM-1 Groves Way	1250	64-78
SLM-2 Soaring Eagle Drive	3950	54-68
SLM-3 Summer Cabin	1140	65-79
Construction of Conveyor		
Receiver	**Distance to Closest Part of Conveyor in Feet**	**Maximum Construction Noise**
SLM-1 Groves Way	1140	65-73
SLM-2 Soaring Eagle Drive	4020	54-62
SLM-3 Summer Cabin	840	68-76

Discussion of Table 4.

Table 4 presents a "worse-case" picture of potential construction noise as if all the equipment needed to build either the pier of the conveyor was operating at once and there were no attenuation due to inventing topography or vegetation. The actual noise impacts of construction will be substantially lower but will be audible at times on adjacent residential properties.

Operational Impacts

Modeling of Noise Impacts

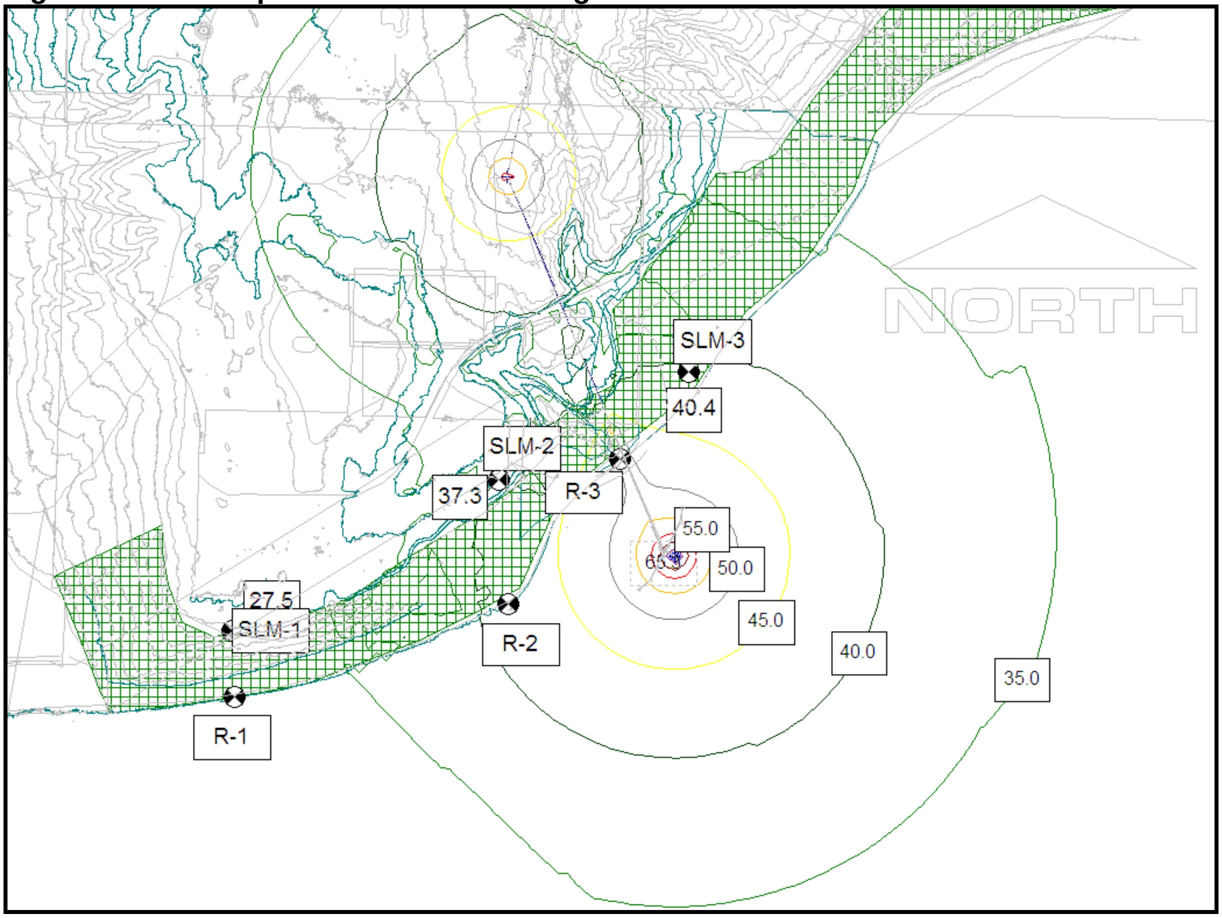
The CadnaA noise model was used for the analysis of potential noise impacts from the Central Conveyor and Pier project. The model inputs reflect the current thinking on the numbers and types of machinery that would be used. This analysis conservatively assumes that gravel loading could be a 7-day a week, 24-hours at day operation. The CadnaA model follows the methodology specified by the International Standards Organization (ISO 9613), which propagates noise as if there were a wind blowing from each source towards each receiver. Table 4 summarizes the results of the noise modeling and the results are shown graphically in Figure 6.

Table 4. Modeled Sound Pressure Levels $dBA_{HourlyLEQ}$

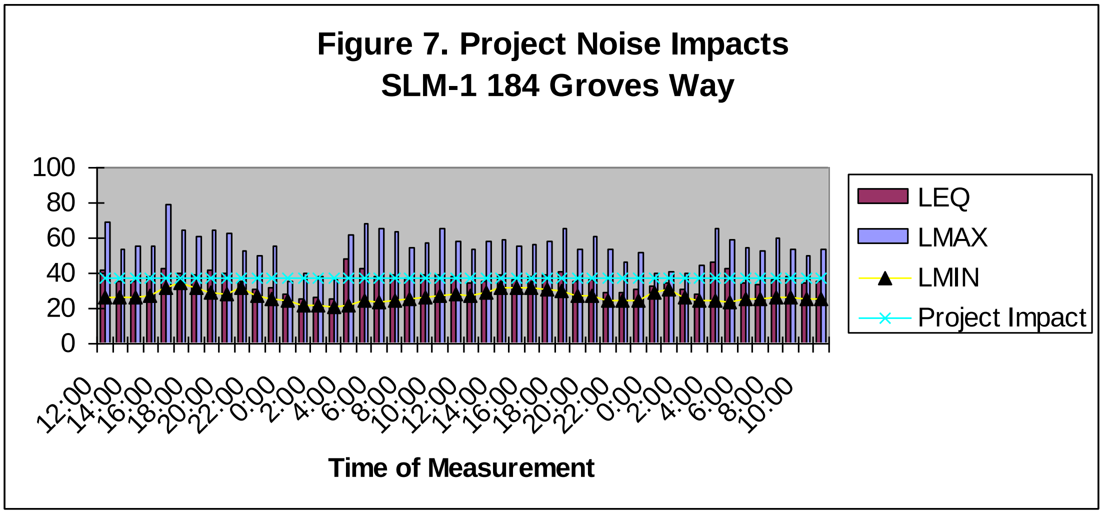
Receiver	Address of Receiver	Range of Background Noise Levels	Sound Levels Generated by Project	Cumulative Sound Levels Background + Project	Increase due to Project
SLM-1	62 Soaring Eagle Road	26-52	28	30-52	0-4
SLM-2	184 Groves Way	25-49	37	37-49	0-12
SLM-3	Near a Summer Cabin	30-53	40	40-53	0-10
SLM-4	24559 Johnson St.	25-47	0 (Too far from project)	25-47	0
R-1	Beach front at 62 Soaring Eagle Road	Assume 30-55	27	32-55	0-2
R-2	Beach front at 184 Groves Way	Assume 30-55	41	40-55	0-10
R-3	Portion of Aquatic Lands 100 Feet from Conveyor	Assume 30-55	49	49-56	1-19

Note: During periods of higher ambient noise the overall decibel level of the project is low enough that it would not be heard. The project will be clearly audible during moments of very low background noise. Also certain sounds from the project may be clearly audible because the project's decibel levels at those frequencies are greater than the background decibel level at the same frequencies.

Figure 6. Noise Impacts of Gravel Loading



The residential measurement site showing the highest project noise impacts is SLM-2 (184 Groves Way). Figure 7 overlays the project's modeled noise level of 37 dBA upon the hourly measurement data.



Summary of the Project's Impacts

The T-ROC Central Conveyor and Pier project meets the Jefferson County Noise Criteria of 57 dBA or 47 dBA nighttime. However for much of the time (38 hours out of the 48-hour measurement period) the project's noise could be audible (i.e. at least 3 dBA above hourly background levels). For 1-3 hours in the middle of the night the project would generate noise up to 10-12 decibels louder than the ambient sound environment. However only rarely would the project's noise exceed the highest background sound levels (2-3 hours per day). The CadnaA modeling likely overstates the project's impacts because the noise measurements of the ship loading system and conveyor belt are of older designs. For example the conveyor on the pier will be covered thus attenuating its noise emissions. In order to pinpoint the specific sources of project noise the contribution of each noise source to the project's total each at each receiver is `shown in Table 5.

Table 5. Noise Impacts from Each Component of the Project

Receiver	Address of Receiver	Conveyor Belt	Gravel Loading Nose	Belt Transfer Point
SLM-1	62 Soaring Eagle Road	12.1	26.7	18.8
SLM-2	184 Groves Way	23.4	36.9	23.5
SLM-3	Near a Summer Cabin	26.4	40.2	21.9
SLM-4	24559 Johnson St.	0	0	0
R-1	Beach front at 62 Soaring Eagle Road	11.6	26.4	16.2
R-2	Beach front at 184 Groves Way	29.7	40.7	19.7
R-3	Aquatic Shoreline 100 Feet from Pier	47.4	43.1	14.9

As can be seen from Table 5 the gravel-loading nose is the predominant source of the project's noise impacts, except at site R-3, which is only 100 feet from the conveyor.

Mitigation Measures

No mitigation measures would be required for the T-ROC Central Convey and Pier project in order to meet the County's noise standards, as no exceedances are predicted. However, the operations will be clearly audible when the background noise is low and complaints from neighbors may occur. The requirement that noise sources within aquatic shorelines generate less than 50 dBA when measured at a distance of 100 feet can be met under the assumptions used in the noise modeling. A variety of mitigation measures should be considered as summarized in Table 5.

Table 5. Noise Mitigation Measures

Type of Mitigation	Effectiveness	Cost/ Difficulty
Engineering Improvements		
Engineer a quieter gravel loading System, for example: Longer "nose" so gravel hits barge/ship hull with less force	Could significantly reduce noise impacts	Unknown
Use a quieter (covered) conveyor system	Could significantly reduce noise impacts	This is to be the design for the conveyor on the pier.
Insulate the buildings housing the belt transfer points	Could reduce noise impacts	Not difficult to do
Changes in operational Practices		
Line the bottom of ships with sand before loading gravel		Might be unacceptable to buyers of product
Other Changes		
Perform periodic noise monitoring	Could establish a baseline of normal ship loading noise levels	

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APPENDIX J
REPORT OF THE US COAST GUARD AMERICAN WATERWAYS OPERATORS: BRIDGE ALLISION WORK GROUP

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The United States Coast Guard | **The American Waterways Operators**

May 21, 2003

MEMORANDUM

TO: AWO Board of Directors
Designated Representatives, AWO Carrier Members

FROM: Tom Allegretti, The American Waterways Operators
RADM Paul Pluta, U.S. Coast Guard

RE: Coast Guard-AWO Bridge Allision Work Group Report

We are pleased to enclose the Report of the Coast Guard-AWO Bridge Allision Work Group, formed by the Coast Guard-AWO Safety Partnership in the wake of fatal barge-bridge accidents at South Padre Island, Texas, in September 2001 and Webbers Falls, Oklahoma, in May 2002. The Work Group was established by the Safety Partnership's National Quality Steering Committee and functioned as a Quality Action Team as provided for in the Coast Guard-AWO Partnership Agreement of 1995. The Work Group examined Coast Guard casualty data on bridge allisions involving barges and towing vessels and attempted to answer the questions, "How often do bridge accidents involving barges and towing vessels occur? What causes them? What do we need to do to prevent them and ensure that public safety is not placed at risk?" This report attempts to provide some answers to those questions, based on a study of towing vessel bridge allisions over the ten-year period 1992-2001, led by a group of Coast Guard and towing industry experts, including active and former towing vessel captains.

Because formal government investigations into the Texas and Oklahoma casualties are continuing, the Work Group did not attempt to draw conclusions about the causes of those particular incidents. This report is meant not to preempt the forthcoming accident investigation results, but to serve as context for them. Together, we expect that all of these inputs – the Work Group report **and** the Coast Guard and National Transportation Safety Board investigation results, combined with feedback from Congress and other federal agencies – will serve as the basis for well targeted and effective actions by industry and government to address the challenge of towing vessel/bridge accidents and ensure the safety of the traveling public. Copies of the report are also being shared with the Towing Safety Advisory Committee and the Navigation Safety Advisory Council for consideration.

Your feedback is an important part of this process. We hope that you will take the time to read the report carefully and offer your comments, questions, and suggestions for improvement. If you have any questions about the report, please feel free to contact Jennifer Carpenter, AWO Senior Vice President-Government Affairs and Policy Analysis, at jcarpenter@vesselalliance.com, or Captain Mike Karr, Chief, Office of Investigations and Analysis, U.S. Coast Guard, at mkarr@comdt.uscg.mil.

Tom Allegretti

Thomas A. Allegretti
President
The American Waterways Operators

Paul Pluta

RADM Paul Pluta
Assistant Commandant for Marine Safety, Security, and Environmental Protection
United States Coast Guard

Report of the

U.S. Coast Guard - American Waterways Operators Bridge Allision Work Group

Published May 2003

A Product of the Coast Guard - AWO Safety Partnership

Table of Contents

EXECUTIVE SUMMARY

Introduction

On May 26, 2002, a tow struck the I-40 highway bridge over the Arkansas River. The bridge collapsed, resulting in the tragic loss of the lives of 14 motorists. Under the auspices of the U.S. Coast Guard-American Waterways Operators (AWO) Safety Partnership, the Coast Guard and AWO convened a work group to investigate the prevalence and causes of bridge allisions involving barges and towing vessels and develop recommendations to prevent allisions and mitigate their consequences.[1] The group's work was **not** intended to address the I-40 accident itself, since that casualty is the subject of an ongoing investigation by the National Transportation Safety Board, which may result in additional recommendations for Coast Guard-industry action.

The Bridge Allision Work Group ("the Work Group," or "the Group") included members from both the Coast Guard and AWO member companies with expertise in towing operations and safety, including four active or former towing vessel captains. The Work Group also drew on subject-matter experts from the Coast Guard and the AWO staff. The Group used the principles of Risk-Based Decision Making (RBDM) to provide structure and discipline to its analysis.

Data Extract and Analysis

Data on all bridge allisions in which the primary event was either an allision or breakaway were extracted from the Coast Guard's databases. This resulted in a study database of 2,692 bridge allision cases involving towing vessels and barges in U.S. waters for the years 1992-2001. This number must be viewed in the context of the number of trips conducted by tugboats and towboats each year. Using data from the U.S. Army Corps of Engineers for the year 2000 (the most recent year for which published data is available) as a reference point, the Work Group calculated that bridge allisions occur at the rate of approximately 0.06%, or six allisions for every 10,000 towing vessel trips.

The Work Group divided the bridge allision cases into five severity classes. The table below gives the definitions of the classes and the number of cases in each:

Table 1: Severity Classes

Class	Definition	Count
0	Damage recorded as "None or Not Specified."	1,702
1	Damage between $1 and $25,000.	610
2	Damage between $25,001 and $100,000.	220
3	Damage between $100,001 and $500,000.	99
4	One or more of: damage > $500,000; loss of life > 0; injured > 0; missing > 0; oil spilled.	61

[1] An allision is a collision with a stationary object, such as a bridge or dock.

A statistical analysis of the entire study database was conducted. This provided the Work Group with information about the most frequently hit bridges, the bridges that sustained the most damage, and the bridges currently scheduled for alteration or removal under the Truman-Hobbs Act. Analyses of the allisions by vessel characteristics (e.g., length, horsepower, etc.), time of day of the accident, and occurrence of a pollution incident showed no correlations or patterns suggesting fruitful areas for further study.

To investigate the causal factors behind the bridge allisions, a subset of the cases was produced consisting of all the cases in severity classes 3 and 4, plus a random sample of cases from the other classes. The subset was sent to teams of industry experts, each chaired by a Work Group member. A computer-based tool was used by the experts to categorize and assign causal factors to each case. This exercise returned detailed data on 459 cases.

The information contained in the Coast Guard casualty reports posed a significant challenge to the Work Group. Current Coast Guard standards for gathering casualty facts and information, especially human factors information, were incompatible with the intent of the Work Group to conduct a detailed analysis. In many cases, the detail necessary to determine precisely the causal factors of an allision was not available. Work Group members were therefore forced to rely on their own operational experience, judgment, and knowledge of a particular waterway in interpreting the limited information in the Coast Guard casualty reports and classifying allisions by mishap type and causal factor. With this admittedly significant caveat, the Group concluded that 90% of the cases were related to human performance (78% to pilot error and 12% to other operational errors). Only 5% were related to mechanical problems, and for the remaining 5% there was insufficient information to assign a cause. The Group's analysis of the performance-based cases showed that the predominant causal factor in bridge allisions was decision making error on the part of the towing vessel operator, which surfaced as a causal factor in 68% of the 435 sampled cases in which a mishap category could be identified. Significantly, this pattern was the same for cases across the range of severity classes, meaning that both high- and low-consequence cases exhibited the same causal factors.

Development of Recommendations

Based on this information, the Work Group focused on improving decision making in the wheelhouse. Cognitive models of the decision making process were developed and used to construct a systems model of the factors involved. Development of the systems model showed clearly that reducing the number of bridge allisions is a complex issue; there are no "silver bullets" or quick fixes. The Work Group identified leverage points in the model where changes could be made to reduce the frequency of bridge allisions or mitigate the consequences of allisions and generated a list of potential recommendations. A cost-benefit analysis was applied to the list. Based on the results of the cost-benefit exercise, the Group developed this five-point action plan:

1) The Coast Guard and AWO should initiate a joint program to implement the six prevention recommendations with the highest efficiency scores resulting from the cost-benefit analysis. These are:

a) Identify vulnerable bridges where measures to prevent and/or mitigate allisions should be applied.

b) Develop navigation best practices for transiting bridges vulnerable to allision.
c) Train operators in the application of navigation best practices.
d) Require route familiarization, posting, or a check-ride before an operator is permitted to navigate under a vulnerable bridge alone.
e) Improve Coast Guard-industry information sharing on near misses.
f) Require the implementation of Crew Endurance Management Systems (CEMS) throughout the towing industry as a means of improving decision making fitness.

2) The Coast Guard and AWO should use this report to accelerate the removal and alteration of bridges under the authority and procedures of the Truman-Hobbs Act. More than 900 bridge allisions – 34% of all allisions between 1992-2001 – occurred at bridges under order to be altered or on the Truman-Hobbs backlog priority list.

3) The costs and benefits of requiring additional protection for bridge piers should be given further consideration in the process of identifying vulnerable bridges as proposed in Recommendation #1 above. Targeting improved bridge protection measures on those bridges identified as most vulnerable to allision or to severe consequences should an allision occur may be a meaningful and cost-effective addition to the prevention recommendations offered here and should be given further study.

4) The Coast Guard Research and Development Center should use this report as a basis to consider future studies to explore combinations of the potential recommendations that can generate greater benefits acting together than indicated by their individual cost-benefit scores (i.e., a study of the non-linear dynamics of the causes of bridge allisions).

5) The Coast Guard should implement a special investigative effort for certain bridge allision incidents, over a specified period of time (three to five years). As part of this effort, the Coast Guard would conduct a thorough investigation of each bridge allision for which the preliminary investigation showed human factors issues as possible causal factors. Coast Guard and AWO analysts would regularly evaluate the data from these completed investigations and report their findings to the National Quality Steering Committee (QSC) of the Coast Guard-AWO Safety Partnership. This effort would provide future analysts with more detailed information than was available in most of the cases reviewed by the Work Group.

<u>Conclusion</u>

The core findings of the Work Group are as follows:

1) The human element, in particular decision making errors, is the predominant factor in bridge allisions. This does not mean that towing vessel operators are poor decision makers. Indeed, the fact that the overwhelming majority of bridge transits take place without incident – and that most bridge allisions that do occur result in no damage to people, property, or the environment – testifies to the skill and professionalism of towing vessel operators who do a difficult job under challenging conditions, with very little margin for error.

2) A myriad of factors contribute to the human factor-based errors, thus there is no "silver bullet" or "quick fix" for reducing bridge allisions.

3) The recommendations advocated by the Work Group involve a mix of industry and government action to reduce the occurrence of bridge allisions. However, the risk of bridge allisions cannot be reduced to zero. Thus, additional actions by transportation authorities are needed to remove hazardous bridges and improve protection standards for bridges so that consequences from a bridge allision are minimized.

4) These findings should be distributed to industry, government, and related parties by as many channels as possible.

5) Additional research may develop other recommendations.

The Work Group is confident that it thoroughly explored the information it had available and that its findings and recommendations will provide a solid foundation for future work to reduce the frequency of bridge allisions and minimize the consequences of those that do occur.

BACKGROUND

In 2001 and 2002, two towboat/bridge allisions occurred that claimed a total of 22 lives. The first accident occurred on September 15, 2001, when the M/V BROWN WATER V, pushing four barges, struck the Queen Isabella Causeway Bridge that connects Port Isabel to South Padre Island, Texas. The accident severely damaged the bridge and resulted in the loss of eight lives. On May 26, 2002, the M/V ROBERT LOVE, pushing two empty asphalt barges, allided with the I-40 Bridge crossing the Arkansas River near Webbers Falls, Oklahoma. The allision collapsed two sections of the bridge and resulted in 14 deaths. Both accidents are the subject of ongoing governmental investigations, the conclusions of which may result in additional recommendations for Coast Guard-industry action.[2]

Shortly after the I-40 accident, the U.S. Coast Guard and The American Waterways Operators (AWO) convened a work group under the auspices of the Coast Guard-AWO Safety Partnership to investigate all bridge allisions involving towing vessels and barges over the past decade. The Work Group included Coast Guard personnel and AWO member company representatives and was supported by Coast Guard and AWO staff. Work Group members included the following:

Table 2: Work Group Members

Organization	Name	Office or Title
Coast Guard	CAPT Michael B. Karr	Chief, Office of Investigations and Analysis
Coast Guard	CAPT Dan Ryan	Chief, Marine Safety, 8th Coast Guard District
Coast Guard	CDR Lyle Rice	Chief, Compliance Analysis Division
Coast Guard	Ed LaRue LCDR Alan Blume	Waterways Management Directorate
Coast Guard	LCDR Luke Harden	Maritime Personnel Qualifications Division
Coast Guard	LCDR Martin Walker	Domestic Compliance Division
Coast Guard	LT Scott Calhoun LT Sam Stevens	Office of Design and Engineering Standards
American Commercial Barge Lines	Captain Mark Dougherty	Process Analyst
Kirby Corporation	Les Sutton	Manager, Governmental Affairs
Marathon Ashland Petroleum LLC	Bruce D. Tilton Captain David Smith	Manager, Marine Transportation Captain, M/V ASHLAND
MEMCO Barge Line	Mark Knoy Keith Darling	President Senior Vice President, Boat Operations
Moran Towing Corporation	Peter Nistad	Senior Vice President
Sause Bros.	Dale Sause	President
Western Kentucky Navigation	Captain Luke Moore	Captain, M/V ROY MECHLING
Western Towboat	Captain Jeff Slesinger	Director, Safety & Training

[2] The Queen Isabella Causeway accident is under investigation by the Coast Guard, and the I-40 accident is under investigation by the National Transportation Safety Board. Because the ongoing investigations are not complete, the causes of these two casualties are not addressed in this report.

The Coast Guard members provided expertise from a variety of disciplines aimed at tackling the problem of bridge allisions from both theoretical and operational perspectives. The AWO members were selected both for their expertise in towing operations (the group included four active or former towing vessel captains) and representation of the geographic and operational diversity of the industry. Staff support to the Work Group was provided by David Dickey, U.S. Coast Guard; Joseph Myers, U.S. Coast Guard; Jennifer Carpenter, AWO Senior Vice President-Government Affairs and Policy Analysis; Doug Scheffler, AWO Manager-Research and Data Analysis; and Amy Brandt, AWO Manager-Government Affairs.

The group met for the first time on July 14, 2002. At this meeting the Work Group agreed on a statement of the problem, established the goals of the group, and agreed on a process for analyzing the data.

Problem

The Work Group agreed on this problem statement:

> Allisions with bridges involving barges and towing vessels have occurred. These allisions have caused deaths, injuries, and property damage that are unacceptable.

Goals

The Work Group defined the following goals:

1) Develop a profile of bridge allisions involving barges and towing vessels (e.g., number, location, consequences, and trends).

2) Catalog measures already taken to reduce risks.

3) Minimize risk of bridge allisions by developing recommendations to:
   a) Prevent bridge allisions;
   b) Eliminate loss of life resulting from bridge allisions; and,
   c) Reduce the consequences of bridge allisions.

4) Effectively communicate findings and recommendations.

Goals #1 and #3 formed the heart of the Work Group's tasking and are the focus of this report. Goal #2 is addressed in Appendix 1, which catalogs measures taken by the Coast Guard and industry to reduce the risk of bridge allisions after the 1993 MAUVILLA casualty.[3] Goal #4 will be accomplished through an ongoing process beginning with the publication of this report.

Risk-Based Decision Making Methodology

To accomplish Goals #1 and #3, the Work Group decided to use Risk-Based Decision Making (RBDM). The RBDM process organizes information about the possibility of one or more

[3] On September 22, 1993, barges pushed by the towboat MAUVILLA struck and displaced the Big Bayou Canot railroad bridge near Mobile, Alabama, causing the derailment of the Amtrak Sunset Limited passenger train.

unwanted outcomes into a broad, orderly structure that helps decision makers make more informed management choices. RBDM provided the Work Group with a well-defined process for developing recommendations that would be reasonable, defendable, and reproducible.[4]

The Work Group pursued five general task areas, all of which are consistent with the RBDM process:

1) Collect and consolidate all available data and information about past bridge allisions.
2) Create a profile of allision casualties.
3) Use a national team of towing experts to review cases from the Coast Guard databases.
4) Analyze case reviews to determine most probable events and associated causal factors.
5) Develop recommendations and publish findings.

The Work Group executed the first four phases of its investigation from July-December 2002. This report completes the fifth task. Discussions, development of analysis tools, and review of results were conducted via e-mail, conference calls, and an additional in-person meeting on November 14, 2002.

The remainder of the report details the activities taken pursuant to each task. Since there were many review steps, and some activities were conducted simultaneously, a precise chronology of activities will not be referenced in the report. The subsequent sections of this report are organized as follows: data collection and allision profile, case review, causal factors analysis, and conclusion and recommendations.

DATA COLLECTION AND ALLISION PROFILE

Data Collection and Context

The data for this review were extracted from the U.S. Coast Guard Headquarters Marine Safety Management System (MSMS), which uses the Marine Safety Information System (MSIS) as its source. MSIS was the Coast Guard's repository of marine casualty data from March 19, 1990, through December 13, 2001.

The initial extract from the MSMS was vessel casualties with a primary event recorded as either ALLISION or BREAKAWAY**.** This generated a file of 3,121 allisions over the 10-year period from January 1, 1992, through December 31, 2001. These cases were screened to eliminate those that did not involve U.S.-flag towing vessels or bridges. **The Work Group's population data set thus contained 2,692 cases where a U.S.-flag towing vessel (with or without a tow) allided with a bridge.** The data set included 912 cases that were classified as CLOSED TO FILE.[5]

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[4] For more information on RBDM, go to www.uscg.mil/hq/g-m/risk/jobaids.html.

[5] Most of the cases CLOSED TO FILE occurred before a change in the marine casualty reporting requirements. These earlier cases were reported to the Coast Guard, but the damages were trivial and the cases were closed without further collection of information because the incident did not meet the definition of a marine casualty in effect at that time. Following the MAUVILLA casualty, 46 CFR Part 4 was revised to define any unintentional bridge allision as a marine casualty, even if the damage was less than $25,000. In the course of reviewing cases for this report, the Work Group did find that after 1994, some unintentional bridge allisions were incorrectly CLOSED TO FILE because the report noted no damage to the bridge or a vessel.

The number of allisions must be viewed in the context of the number of trips by tugboats and towboats. The Work Group used navigation data from the U.S. Army Corps of Engineers (Corps) to provide a snapshot comparison, focusing on the Mississippi River System to ensure an apples-to-apples comparison. According to the Corps, in 2000 (the most recent year for which published statistics are available) there were 274,978 trips by towing vessels on the Mississippi River System.[6] According to the Coast Guard's bridge allision data set, there were 153 towing vessel bridge allisions on the Mississippi River System in 2000. **These figures yield an allision rate of approximately 0.06%, or six allisions for every 10,000 towing vessel trips.**

<u>Severity Classes</u>

The Work Group sought to classify and distinguish the incidents of significance from the majority of bridge allisions involving little or no damage. After examining the data, the Group defined a significant case (Class 4) as one meeting one or more of the following criteria:

- Loss of life, injury, or missing person.
- Pollution incident.
- Bridge collapse or damage requiring removal from service for more than safety inspection.
- More than $500,000 in damages resulting from the allision.

The remaining cases involved only monetary damage and were divided into four classes (Classes 0-3). The table below shows the definitions of all the severity classes and the number of cases in each.

Table 3: Severity Classes

Class	Definition	Count
0	Damage recorded as "None or Not Specified."	1,702
1	Damage between $1 and $25,000.	610
2	Damage between $25,001 and $100,000.	220
3	Damage between $100,001 and $500,000.	99
4	One or more of: damage > $500,000; loss of life > 0; injured > 0; missing > 0; oil spilled.	61

Ninety-four (94) percent of all bridge allisions between 1992-2001 resulted in no injury, fatality, or environmental damage and less than $100,000 in damages reported to the Coast Guard. Three allisions during the study period resulted in fatalities: the 1993 CHRIS allision with the Judge Seeber Bridge, which caused one fatality; the 1993 MAUVILLA allision, which killed 47; and the 2001 BROWN WATER V at South Padre Island, which took eight lives.

[6] The Corps of Engineers defines a trip as follows: "A trip is a vessel movement. For self-propelled vessels, a trip is logged between every point of departure and every point of arrival." Thus, the number of bridges transited by a towing vessel in a single trip can range from none to many.

Trend Analysis

The table below presents the 2,692 bridge allisions by calendar year.

Table 4: Bridge Allisions by Year

Year	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Bridge Allisions	122	193	586	357	348	277	232	194	170	203

It is difficult to draw meaningful conclusions from this trend line because Coast Guard casualty reporting regulations were amended in 1994 as a result of a recommendation made following the 1993 MAUVILLA casualty. The revisions to 46 CFR Part 4 required reporting of any unintentional striking of a bridge, whether or not any damage occurred. As a result of this regulatory change, the trend line is discontinuous; that is, the data for 1992 and 1993 are not comparable to the data for 1994 and subsequent years. While the data appear to show a substantial decline in bridge allisions from the peak year of 1994, the Work Group believes that this result may have been significantly affected by the change in reporting requirements and evolving Coast Guard guidance on the reporting and investigation of bridge allisions that took place after 1994.

Other Analyses

AWO and Coast Guard staff conducted an exploratory data analysis to develop a profile of the cases and identify any issues or patterns that might warrant further study. Topics examined included bridges involved, geographical distribution of damages, circadian cycle, Truman-Hobbs bridges, type of vessel, and pollution incidents.

Details on these analyses are found in Appendix 2. Below is the summary of each topic and the Work Group's adjudication.

Bridges Involved

The table below lists the six bridges most frequently struck by barges or towing vessels and the number of allisions recorded at each.

Table 5: Most Frequently Struck Bridges

Bridge	Location	Allisions
EJE Railway Bridge	Morris, IL	170
CNW Railroad Bridge	Pekin, IL	95
Burlington Railroad Bridge	Burlington, IA	92
Galveston Causeway	Galveston, TX	76
Franklin Street Bridge	Peoria, IL	67
Naheola Bridge	Pennington, AL	67

The frequency with which these bridges have been hit is not a function of traffic volume; in other words, the bridges most frequently struck by towing vessels and barges are not the bridges that experience the heaviest volume of barge and towing vessel traffic. This suggests that characteristics of the bridges themselves, or their location on the waterways, may be a factor in the occurrence of allisions.

The complete list of bridges struck is included in Appendix 2. The Work Group reviewed the distribution and found it to be complete and consistent with the professional experience of operators familiar with the local geography and bridges in question. Appendix 2 also includes a map that aggregates the number of allisions by Coast Guard reporting unit.

Geographical Distribution of Damages

The Work Group thought that examining the distribution of bridge allisions by the amount of damage recorded might provide additional insight into the most important areas for future attention. The total damages were aggregated by Coast Guard reporting area. The area with the most damages was Charleston, SC. The Work Group concurred with the analysis of the Coast Guard/AWO data analysis team that this conclusion was a spurious result – most likely caused by a single allision with high dollar damages reported -- and does not warrant further examination. A map of the aggregated damages is included in Appendix 2.

Circadian Cycle

Medical literature documents the changes in human performance levels that occur throughout the day as a result of circadian cycles. (The relationship between circadian rhythms and human performance is thoroughly discussed in the Coast Guard's *Crew Endurance Management Guide*.) The AWO staff analyzed the data to see if there were large numbers of allisions that occurred during circadian "lows." No direct correlation could be established between the time of day and allisions; however, the group did not discount the possible effect of working at night and during expected circadian lows on a mariner's cognitive reasoning and decision making ability. These issues were further discussed in the development of prevention recommendations.

Truman-Hobbs Bridges

To maintain navigation safety and freedom of mobility, the Truman-Hobbs Act is administered by the Commandant to ensure that bridges provide sufficient clearance for the types of vessels that transit the bridge site. Bridges that are deemed to be unreasonable obstructions to navigation are placed on a list for removal or alteration.[7]

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[7] Information regarding the Coast Guard's Bridge Administration Program, including the bridge permitting process for approving the location and clearances of bridges, can be found at <http://www.uscg.mil/hq/g-o/g-opt/g-opt.htm>. The Coast Guard has no statutory authority or responsibility for the structural integrity of bridges across the navigable waters of the United States. This responsibility rests with the bridge owner, the Federal Highway Administration (FHWA), and the Federal Railroad Administration (FRA). Structural standards for the design of bridge piers and their appurtenant fendering systems to protect against collapse due to vessel hits can be found in the publications of The American Association of State Highway Officials (AASHTO) for highway bridges, and The American Railway Engineering and Maintenance Association (AREMA) for railroad bridges.

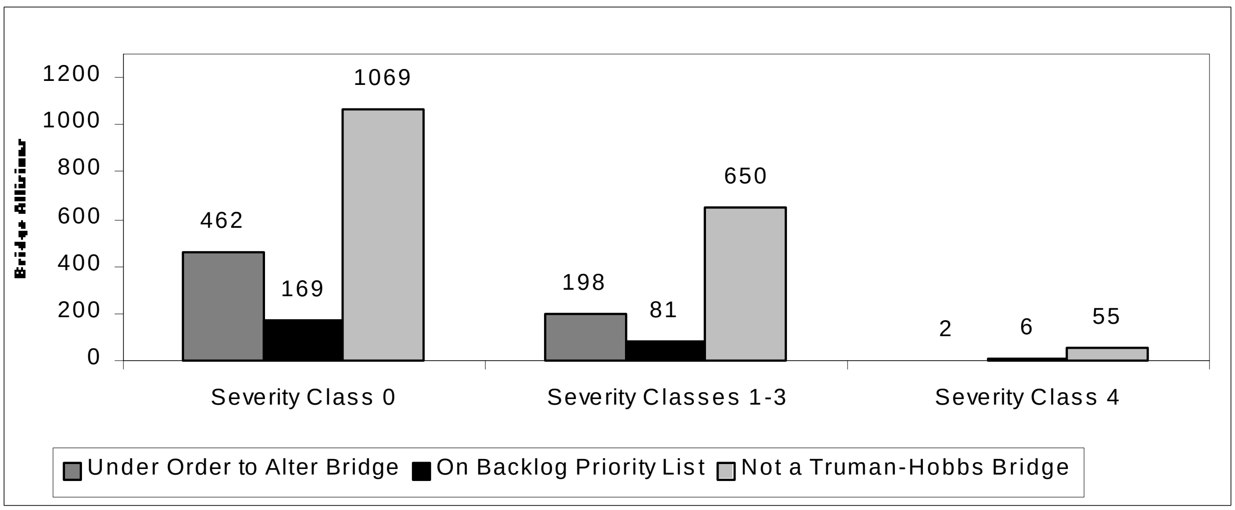
Table 6 shows the number of allisions by Truman-Hobbs classification.

Table 6: Allisions by Truman-Hobbs Classification

Classification of Bridge	Allisions	Percent
Not in program	1,774	66
Under order to alter bridge	662	25
On backlog priority list	256	9
Total	**2,692**	**100**

Figure 1 shows the number of allisions by Truman-Hobbs classification for each severity class.

Figure 1: Allisions by Severity Class and Truman-Hobbs Classification



Additional information on the Truman-Hobbs program can be found in Appendix 3.

Type of Vessel

The case database was linked to the Corps of Engineers' fleet data file (*Waterborne Transportation Lines of the U.S.*) by the common vessel identification code. Various tabulations and cross-tabulations of vessel characteristics, such as length, horsepower, and age, were generated. Unfortunately, the vessel characteristics are so diverse that there was no easy way to generate a classification scheme. Moreover, many cases did not have complete information on vessel characteristics, making it impossible to track patterns across the universe of all allision cases. The Work Group therefore concluded that there was little value in pursuing this area of inquiry further at this time.

Pollution Incidents

The data set contained 19 allisions that resulted in oil pollution over the 10-year study period. AWO and Coast Guard staff examined these cases from a number of perspectives and found no patterns.

Summary

In summary, the most important characteristics of the case universe were location and severity. These played an important role in defining the sample of cases to be individually reviewed.

CASE REVIEW

Sample

The Work Group determined that it did not have sufficient resources to read and analyze all 2,692 cases individually. Instead, the Group decided to generate a manageable subset by random sample based on the severity class. The Group directed that the sample include all of the cases from severity classes 3 and 4 and a random sample from the other severity classes. AWO staff generated a subset of 473 cases. Details of the sampling methodology are found in Appendix 4.

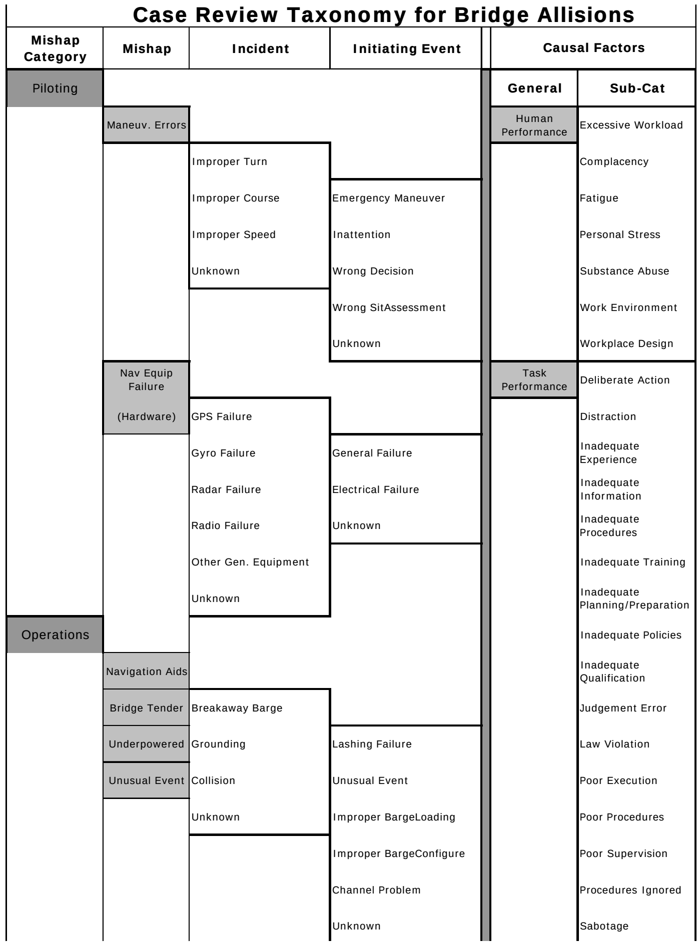
The casualty investigation reports for these 473 cases were distributed to teams of towing operations experts. The teams were organized by geography, and each was led by an AWO member of the Work Group. Each team consisted of active towing vessel captains and other experts with knowledge of conditions and operations in that area. The teams reviewed the cases from the specific region of the country with which they were most familiar (e.g., Upper Mississippi River, Lower Mississippi River/Gulf of Mexico, Ohio River, East Coast, West Coast). The cases were analyzed using an agreed upon-taxonomy and data collection tool described below.

Taxonomy

A fault tree was created and used to develop a taxonomy for reviewing the MSIS cases. The taxonomy was needed to ensure data consistency and prevent ambiguity in the case reviews. The taxonomy was particularly important because there were a large number of cases to review, there were many different reviewers with different backgrounds and experience, and the quality and detail of MSIS case information varied greatly from one case to another.

The taxonomy used was a hierarchical structure consisting of two tracks: mishaps and causal factors. The mishaps track includes four levels: mishap category, mishap, incident, and initiating event. The causal factors track is divided into general and sub-category. The structure for the first two mishap categories is shown below. The entire taxonomy is available in Appendix 5.

Figure 2: Case Review Taxonomy for Bridge Allisions



The teams were instructed to review each case using this taxonomy. After reviewing the case, each team used a data collection tool to populate a database with selections from the taxonomy.

CAUSAL FACTORS ANALYSIS

Of the 473 cases sent out for review, usable analyses on 459 were returned.[8] Data from the case reviews were compiled and a statistical analysis was performed to identify the most probable events and causes that led to bridge allisions during the study period.

The information contained in the Coast Guard casualty reports posed a significant challenge to the Work Group. Current Coast Guard standards for gathering casualty facts and information, especially human factors information, were incompatible with the intent of the Work Group to conduct a detailed analysis. In many cases, the detail necessary to determine the causal factors of an allision was not available; in 24 cases, it was impossible even to classify the mishap by type (piloting error, steering system failure, etc.) based on the information available. Work Group members were thus forced to rely on their own experience and judgment in interpreting the often limited information in the Coast Guard casualty reports and classifying allisions by

[8]Missing files or data entry problems were the reasons for the 14 unusable cases.

mishap type and causal factor, though the use of a standard taxonomy provided some consistency in the process. The results that follow must be read with the limitations of the Coast Guard casualty data in mind.

Using the taxonomy, the geographic expert teams categorized the incidents by the four mishap categories.

Mishap Categories

Table 7: Allisions by Mishap Category

Mishap Category	Cases	Percent
Piloting error	361	78
Operations error	54	12
Steering system	12	3
Propulsion system	8	2
Unknown/missing	24	5
Total	**459**	**100**

The 24 incidents in the unknown/missing category are cases that did not contain enough information for the group to make a reasonable decision as to the mishap category. The group was able to place 435 cases, or 95% of the total, into a mishap category.

Piloting error (an error in the wheelhouse affecting the movement of the vessel) and operations error (error by an individual other than the pilot, such as miscommunication by the deckhand on the head of the tow, tow configuration problem, etc.) combined for 90% of the cases, while mechanical failures accounted for only 5%. This first look at the data provided strong indications that a large majority of bridge allision cases result from human factors.

A drill-down analysis of the cases in the mishap category piloting error illustrates how the taxonomy and data collection tool were used by the expert teams to arrive at their conclusions about the leading causes of bridge allision casualties.

Piloting Error Drill-Down Analysis

The expert teams identified the following mishaps for the 361 cases in the mishap category piloting error.

Table 8: Mishap Category Piloting Error: Mishaps

Mishap	Cases	Percents
Maneuvering error	359	99.4
Navigation equipment failure	1	0.3
Missing information	1	0.3
Total	**361**	**100.0**

As the next step using the taxonomy, the teams then identified the following incidents for each of the maneuvering errors.

Table 9: Mishap Maneuvering Error: Incidents

Incident	Cases	Percent
Improper approach	263	73
Improper course	69	19
Improper speed	12	3
Improper turn	9	3
Unattended helm	3	1
Missing information	3	1
Total	**359**	**100**

Improper approach and improper course accounted for 92% of the maneuvering error incidents.

Next, the teams identified the initiating events for these two incident types. The results are shown below.

Table 10: Incident Improper Approach or Course: Initiating Events

Initiating Event	Cases	Percent
Wrong situational assessment	241	72.6
Wrong decision	64	19.3
Inattention	5	1.5
Emergency maneuver	4	1.2
Navigation aids	2	0.6
Chart problem	1	0.3
Incapacitation	1	0.3
Missing information	14	4.2
Total	**332**	**100.0**

Wrong situational assessment and wrong decision were combined into a decision making error group. This group accounted for 91.9% of improper approach/improper course incidents. Only 2.1% of the incidents were deemed the result of external factors (e.g., emergency maneuver, navigation aids, and chart problems).

In addition to the mishap category track, the taxonomy used by the expert teams also included a two-level analysis of causal factors. The first level is general causes. Table 11 shows the breakout by cause for the 305 cases in which the initiating event was a decision making error. Note that the data analysis tool provided the capability to assign up to three causes to each case. For this reason, the number of causes is greater than the number of cases examined.

Table 11: Decision Making Error Casualties: General Cause

General Cause	Count	Percent
Task performance	451	83
External event	56	12
Communications	18	3
Human performance	8	1
Equipment operations	2	0
Unknown	7	1
Total	**542**	**100**

The drill-down to the sub-categories for the task performance cause produced these results.

Table 12: Task Performance Errors: Sub-Category Cause

Sub-Category Cause	Count	Percent
Judgment error	248	55
Poor execution	90	20
Inadequate planning, preparation, or information	69	15
Others	39	9
Missing information	5	1
Total	**451**	**100**

Of the 305 decision-making error cases, 94% (287 cases) included judgment error or poor execution among their causes. Thus, the Work Group concluded that decision making errors were the predominant cause of bridge allisions classified as piloting error casualties.

<u>Operations Error Drill-Down Analysis</u>

Operations error was the second largest mishap category, with 54 cases or 12% of the total. A drill-down of the taxonomy, similar to the one described above for piloting error, was also conducted on these cases. The most common mishap in the operations error category was unusual event, with 36 cases or 66.7%. The incident breakout for the unusual event mishap included 14 cases of breakaway barge, 16 collisions, and one improper approach. With this nearly even split in incident type, the following distribution of initiating events was generated for all 36 unusual event cases.

Table 13: Mishap Category Operations Error: Initiating Events

Initiating Event	Count	Percent
Unusual event	21	58
Lashing failure	7	19
Improper barge loading	2	6
Inattention	1	3
Missing information	5	14
Total	**36**	**100**

For the initiating event of unusual event, the breakout by general causes showed that task performance and external event were each tallied nine times, or 32%. On a case basis, eight of the 21, or 38%, had task performance among their causes. External event was a general cause in eight cases. The number of cases was too small to facilitate a meaningful breakout by sub-category causes.

In summary, the operations error data show that external events and task performance are the two major causes. This is a different profile than piloting error, with its single predominant cause of decision making error.

Significant Consequence Cases

Appendix 6 contains an analysis of the 61 bridge allision incidents in Severity Class 4. This analysis generated results similar to the results for the entire universe of 459 incidents sampled by the Work Group. These data indicate that the significant consequence cases share the same causal pattern as bridge allisions across the range of severity classes. (See Appendix 7 for narrative summaries of selected allisions in Severity Class 4.)

Analysis of Findings

The piloting error and operations error mishap categories together account for 415 allisions, or 90% of the cases sampled. Drilling down to the general cause of allisions in both categories, judgment error and poor execution (the leading causes of piloting error casualties) can be combined with task performance (the leading cause of operations error casualties) to form a decision making cause. Applying the results of the preceding drill-down analyses shows that decision making errors were causal factors in 295 cases – that is, 68% of the 435 sampled cases with an identified mishap category.

The mishap categories relating to mechanical failure -- steering system and propulsion system -- account for 5% of the 435 cases with an identified mishap category. The drill-downs into the mishap and causal factor hierarchies show that the remaining causes are a mix of external events; other technical failures, such as navigation aids; and other human factors, such as improper planning, poor communication, and inattention. Thus, the data clearly demonstrate that human factors – in particular, decision making errors -- are the predominant cause of towing vessel bridge allisions.

DEVELOPMENT OF RECOMMENDATIONS

The finding that the significant consequence cases had the same causal pattern as bridge allisions in general led the Work Group to adopt the strategy of a broad-based attack on all bridge allisions. Reducing the frequency of bridge allisions overall, and mitigating the results of those allisions that do occur, should lead to a similar reduction in significant consequence allisions.

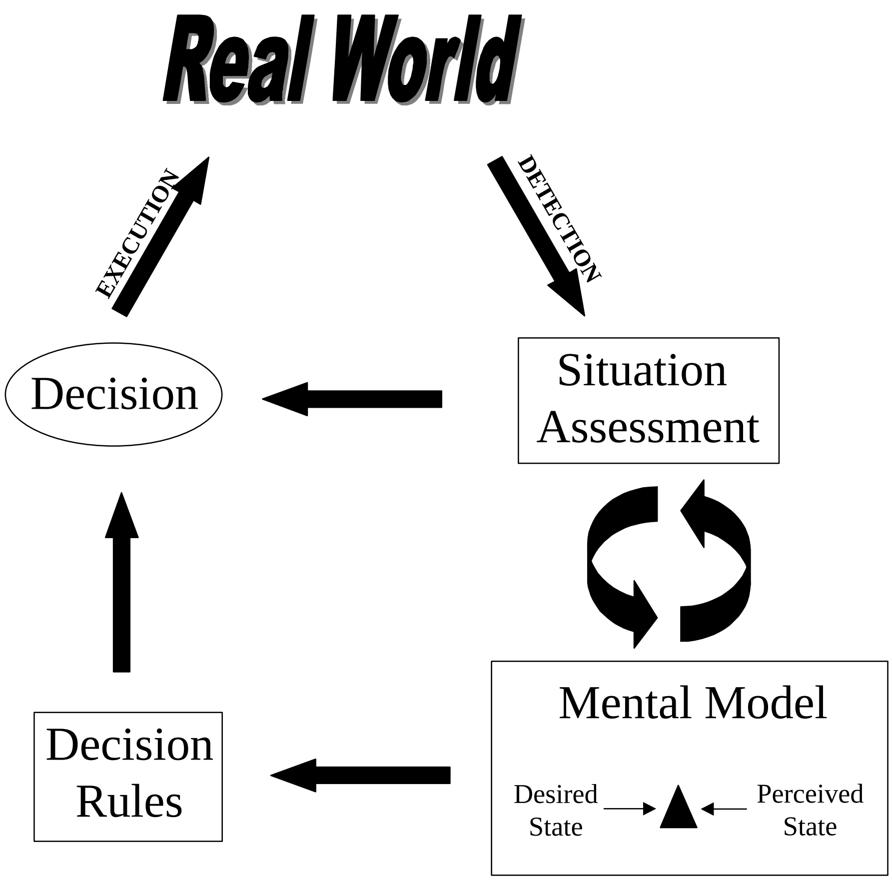
Based on its analysis of the data, the Work Group decided to target its recommendations on the human factors issue – decision making – that underlies the majority of towing vessel bridge allisions. The Group used a three-step process to develop its recommendations: developing an analytical framework, generating potential recommendations, and evaluating each recommendation for effectiveness and cost.

Analytical Framework

Cognitive Model

In order to develop its recommendations, the group first agreed upon a cognitive model that provided a reasonable representation of the decision making process. The model for this process is provided below:

Figure 3: Cognitive Model



Detailed descriptions of the components of this model are provided in Appendix 8.

The Work Group used this model to identify areas where the decision making process could be severely compromised or completely break down. Recommendations would then be developed to safeguard the decision making process.

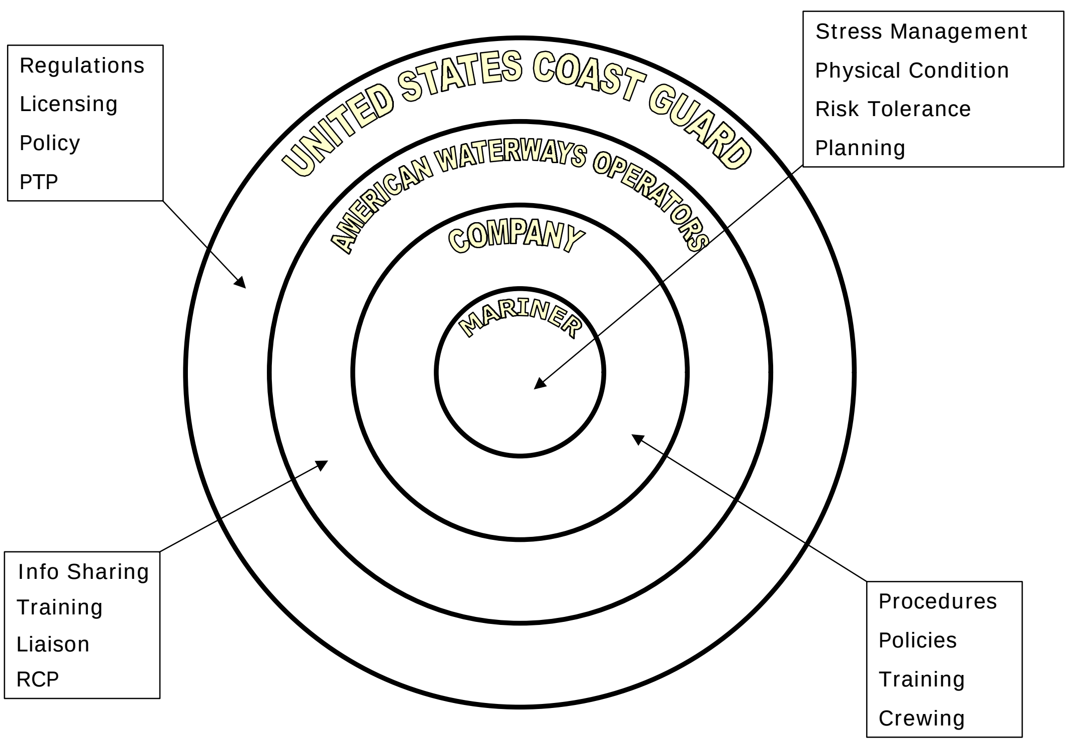
Systems Thinking

Although the Group focused on human factors, the cognitive model demonstrated that this is a complex issue. Applying the case review taxonomy to the cognitive model, the Group realized that there are many inputs to decision making by vessel operators, and their interactions are complex. Thus, there are no quick fixes or "silver bullets" that will prevent bridge allisions altogether.

To identify and address the interactions, the Group determined that it was necessary to think of safe navigation through bridges as a **system**. Appendix 9 provides more detail on the application of systems theory to vessel navigation.

The Work Group modeled safe navigation under bridges as a system, with mariner decision making at the center of the system. Other parties that affect the navigation process include the company, AWO, and the Coast Guard, each depicted by a separate layer of the model. Within each layer are shown examples of factors that bear on the decision making process that are within the control or subject to the influence of that party.

Figure 4: Safe Navigation Model



The first layer consists of factors influenced by the mariner. These include, but are not limited to, such things as voyage planning and the individual mariner's risk tolerance, physical condition, and ability to manage stress.

The second layer includes factors that companies control, such as policies and procedures, training, and crewing decisions.

The third layer includes factors influenced by the American Waterways Operators as the industry trade association, such as sharing of information, providing and encouraging certain training, acting as a liaison with the Coast Guard, and administering the AWO Responsible Carrier Program (RCP).[9]

The fourth layer is the Coast Guard, which controls regulations, licensing, agency policies, the Prevention through People (PTP) program, and other government-initiated activities relating to maritime safety.

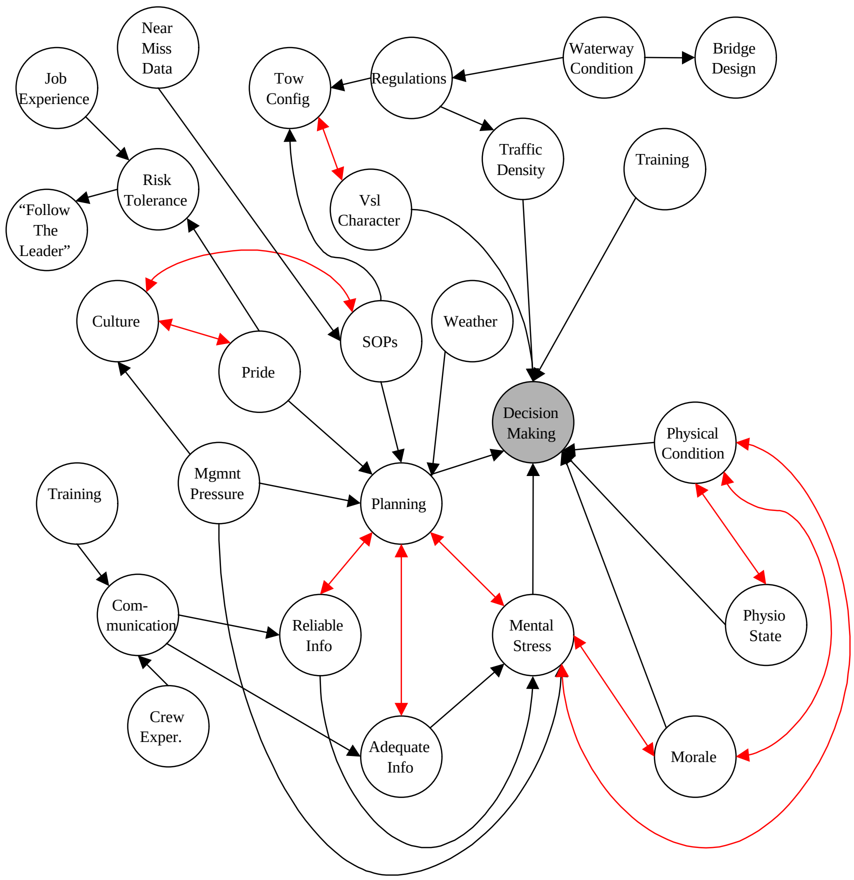
There are other layers affecting the navigation process, such as the Cabinet department in which the Coast Guard is operating,[10] other federal agencies, Congress, and the expectations of the American public. However, the Work Group chose to focus the model on the people and organizations represented by the Work Group members. This approach was intended to facilitate the development and timely implementation of recommendations to prevent and mitigate bridge allisions.

Safe Bridge Navigation Decision Making Systems Model

All of the layers shown in the model combine to form the system of elements that impact decision making in the process of safe bridge navigation. The Work Group created a systems model by identifying factors that influence decision making and safe navigation under a bridge. The structure of the systems model created by the Group is shown in Figure 5.

[9] The RCP, a third-party-audited safety management system, is a condition of membership in AWO. For more information on the RCP, see Appendix 1.
[10] When this study was begun, the Coast Guard was an operating agency of the Department of Transportation. On March 1, 2003, the Coast Guard was transferred to the newly created Department of Homeland Security.

Figure 5: Systems Model



This model was used to understand where leverage points exist in the decision making process where small investments may result in large returns. Clusters of mutually reinforcing feedback loops (double arrows) gave the Work Group insight into the leverage points within the system and helped the Group focus on the most promising issues to address in its recommendations.

The Work Group categorized the clusters into four areas: Human Performance, Planning and Information, Culture and Organization, and Training, Qualifications and Experience. Factors associated with each cluster that may influence the decision-making process and affect safe navigation include:

1) Human Performance
   a) Physiological and physical state
   b) Mental stress
   c) Health and well-being
   d) Morale

2) Planning and Information
   a) Adequate, reliable, and timely information
   b) Tow configuration
   c) Weather
   d) Waterway configuration
   e) Coast Guard investigations

3) Culture and Organization
   a) Management pressures
   b) Pride

4) Training, Qualifications, and Experience

Development of Potential Recommendations

Having identified these four clusters as potential high leverage points within the system, the Work Group used the systems model to develop a list of potential recommendations. In a brainstorming exercise, the Group considered the safeguards or processes that currently exist to address each influence factor. The Group identified areas in which current safeguards may not be adequate and brainstormed potential measures to supplement existing safeguards and improve the decision making process.

In the category of human performance, for example, the Group noted the importance of physical/physiological/mental condition to good decision making. The Group acknowledged that while many companies have programs to address crew health, wellness, and fitness for duty, such programs are not in place industry-wide. Hence, the Group identified implementation of the Crew Endurance Management System (CEMS), which provides a holistic approach to enhancing crewmember fitness for duty, as a potential recommendation targeted at the human performance leverage point.

In a similar fashion, the Work Group considered the other clusters and associated influence factors and brainstormed potential recommendations aimed at prevention (reducing the number of bridge allisions) and consequence management (preventing loss of life and reducing the consequences of bridge allisions), the dual focus of the group's Goal #3. Table 14 lists the potential recommendations developed by the Group to prevent bridge allisions; Table 15 lists the potential recommendations to mitigate the consequences of bridge allisions.

While the Group sought to identify measures it believed had a reasonable chance of reducing the number of bridge allisions or mitigating their consequences, the Group did not actively critique or evaluate the potential recommendations at this stage in the process.

Table 14: Potential Recommendations to Prevent Bridge Allisions

Number	Recommendation
1.	Continue or initiate navigation training.
2.	Continue real-life management training.
3.	Develop navigation best practices for particular transits.
4.	Develop wheelhouse/pilotage management training.
5.	Identify vulnerable bridges where measures to prevent and/or mitigate allisions should be applied.
6.	Improve accessibility of information in wheelhouse.
7.	Improve and revise agreements like the River Crisis Action Plans and cooperative agreements on vessel restrictions in certain areas.
8.	Improve communications training
9.	Improve dispatch policies by making dispatchers aware of factors like crew stressors and crew experience levels
10.	Improve tow configuration planning/develop standard operating procedures for tow configuration planning.
11.	Improve near miss reporting requirements so the Coast Guard collects better data.
12.	Improve Coast Guard/industry information sharing on near misses.
13.	Improve vessel information sharing (data links).
14.	Improve weather detection equipment.
15.	Improve the quality and distribution time of weather and other information (e.g., Notices to Mariners) to vessels.
16.	Initiate training for all levels in organization (e.g., support staff).
17.	Initiate wellness programs, if not already in place.
18.	Require annual physical exams.
19.	Require Crew Endurance Management System (CEMS) implementation throughout the towing industry.
20.	Require electronic chart systems on all vessels
21.	Require implementation of safety management systems like the International Safety Management (ISM) Code for the towing industry.
22.	Require implementation of the Responsible Carrier Program throughout the towing industry.
23.	Require route familiarization/posting/checkrides before an operator can conduct a particular transit alone.

Table 15: Potential Recommendations to Mitigate Consequences of Bridge Allisions

Number	Recommendation
1.	Identify vulnerable out-of-channel spans.
2.	Improve pollution prevention/product outflow prevention measures.
3.	Improve vessel protection measures (double-hulls, reinforced wheelhouses).
4.	Install proximity alarms to alert motorists, railroads of potential allision.
5.	Ensure adequate Truman-Hobbs Act funding.
6.	Reform bridge construction/protection guidelines to better withstand allisions.
7.	Review existing bridge design and construction standards.
8.	Review contingency planning for all relevant modal authorities.

Cost-Benefit Analysis

Having brainstormed these lists of potential recommendations to prevent and mitigate the consequences of bridge allisions, the Work Group next conducted a cost-benefit analysis to calculate the "efficiency" of each recommendation. **Benefit** was defined as the fraction of allisions that could be affected by a particular measure multiplied by its effectiveness in reducing risk. For example, a recommendation might address 25% of allision cases, and be 100% effective in those cases. This would result in a benefit score of .25 * 100, or .25. Another recommendation might address 50% of the allisions but be only 50% effective in those cases. This would result in the same benefit score (.50 * .50 = .25). **Cost** was defined as the industry-wide cost of implementing a recommendation over a 10-year period. **Efficiency** was calculated by dividing benefit by cost.

The complete list of potential recommendations was sent to each AWO member of the Work Group for cost-benefit scoring. Each member evaluated all of the recommendations. To provide some consistency in the process, the Work Group developed a four-level scale for calculating the three components of the efficiency equation.

Table 16: Cost-Benefit Scoring

Fraction of Allisions Addressed by Recommendation	
1	0% to 25%
2	25% to 50%
3	50% to 75%
4	75% to 100%
Effectiveness of Recommendation	
1	Reduce frequency of allisions by less than 10%
2	Reduce frequency of allisions 10% to 30%
3	Reduce frequency of allisions 30% to 60%
4	Reduce frequency of allisions by more than 60%
Cost of Recommendation	
1	Minimal
2	Low
3	Medium
4	High

Efficiency scores for each recommendation were then compiled by the Coast Guard. To produce a single score for each recommendation, the average of the scores from the six review teams was calculated and normalized to a 100-point scale. Tables 17 and 18 below show the average efficiency of each recommendation, along with its standard deviation (SD), median, minimum, and maximum, listed from highest efficiency to lowest:

Table 17: Potential Recommendations to Prevent Bridge Allisions: Efficiency Scores

Number	Recommendation	Average	SD[11]	Median[12]	Min.	Max.
1.	Develop navigation best practices for particular transits.	21.79	38.97	3.93	1.43	100.00
2.	Identify vulnerable bridges.	11.55	14.45	6.79	2.14	40.00
3.	Continue or initiate navigation training.	8.53	9.30	5.71	0.71	25.00
4.	Require route familiarization/posting/checkrides before the operator can conduct a particular transit alone.	7.70	8.88	4.05	0.71	23.81
5.	Improve Coast Guard/industry information sharing on near misses.	7.10	12.92	1.79	0.71	33.33

[11] SD: Standard Deviation, a measure of dispersion or spread of the data.
[12] Median: Midpoint of the sorted data. Fifty percent are above and 50% are below the median.

6.	Require Crew Endurance Management System (CEMS) implementation throughout the towing industry.	6.13	3.88	5.71	0.71	12.86
7.	Continue real-life management training.	5.52	9.17	1.07	0.71	23.81
8.	Develop wheelhouse/pilotage management training.	5.08	5.14	3.57	0.71	13.33
9.	Improve near miss reporting requirements so the Coast Guard collects better data.	4.76	6.88	1.79	0.71	18.57
10.	Require implementation of safety management systems like ISM for the towing industry.	4.32	4.73	3.45	0.36	10.00
11.	Improve dispatch policies by making dispatchers aware of factors like crew stressors and levels of crew experience.	4.10	4.57	1.43	0.48	11.43
12.	Require electronic chart systems on all vessels.	3.85	4.71	2.38	1.07	13.33
13.	Improve/revise agreements like the River Crisis Action Plans and cooperative agreements on vessel restrictions in certain areas.	3.33	3.43	1.43	0.71	9.29
14.	Require implementation of the RCP throughout the towing industry.	3.21	2.29	2.14	1.43	6.43
15.	Improve accessibility of information in wheelhouse.	3.13	2.26	2.62	0.71	5.71
16.	Improve communications training.	2.90	2.49	2.26	0.71	5.71
17.	Initiate training for all levels in organization (e.g., support staff).	2.88	4.23	1.25	0.48	11.43
18.	Improve vessel information sharing (data links).	2.88	4.63	0.71	0.36	12.14
19.	Improve tow configuration planning/develop standard operating procedures for tow configuration planning.	2.14	2.02	1.43	0.71	5.71
20.	Improve the quality and distribution time of weather and other information (e.g., Notices to Mariners) to vessels.	2.14	1.92	1.43	0.71	5.71
21.	Improve weather detection equipment.	1.63	1.19	1.43	0.48	3.81

22.	Initiate wellness programs, if not already in place.	1.03	0.51	0.71	0.71	1.90
23.	Require annual physical exams.	0.99	0.92	0.71	0.48	2.86

Table 18: Potential Recommendations to Mitigate Consequences of Bridge Allisions: Efficiency Scores

Number	Recommendation	Average	SD	Median	Min.	Max.
1.	Reform bridge construction/protection guidelines to better withstand allisions.	17.57	15.22	13.33	1.43	40.00
2.	Ensure adequate Truman-Hobbs Act funding.	15.29	16.38	6.07	3.57	42.86
3.	Review existing bridge design and construction standards.	5.71	7.30	3.57	0.71	18.57
4.	Review contingency planning for all relevant modal authorities.	2.74	4.86	0.71	0.36	11.43
5.	Identify vulnerable out-of-channel spans.	1.62	1.28	1.43	0.71	3.81
6.	Install proximity alarms to alert motorists, railroads of potential allision.	1.02	0.56	1.43	0.36	1.43
7.	Improve pollution prevention/product outflow prevention measures.	0.74	0.67	0.36	0.36	1.90
8.	Improve vessel protection measures (double-hulls, reinforced wheelhouses).	0.54	0.47	0.36	0.36	1.43

RECOMMENDATIONS

Based on the results of the cost-benefit analysis, the Work Group devised this five-point action plan:

1) The Coast Guard and AWO should undertake a joint program to implement the six prevention recommendations with the highest efficiency scores. These are:

a) Identify vulnerable bridges where measures to prevent and/or mitigate allisions should be applied.
b) Develop navigation best practices for transiting bridges vulnerable to allision.
c) Train operators in the application of navigation best practices.
d) Require route familiarization, posting, or a check-ride before an operator is permitted to navigate under a vulnerable bridge alone.
e) Improve Coast Guard-industry information sharing on near misses.
f) Require the implementation of Crew Endurance Management Systems (CEMS) throughout the towing industry as a means of improving decision making fitness.

2) The Coast Guard and AWO should use this report to accelerate the removal and alteration of bridges under the authority and procedures of the Truman-Hobbs Act. More than 900 bridge allisions – 34% of all allisions between 1992-2001 – occurred at bridges under order to be altered or on the Truman-Hobbs backlog priority list.

3) The costs and benefits of requiring additional protection for bridge piers should be given further consideration in the process of identifying vulnerable bridges as proposed in Recommendation #1 above. Targeting improved bridge protection measures on those bridges identified as most vulnerable to allision or to severe consequences should an allision occur may be a meaningful and cost-effective addition to the prevention recommendations offered here and should be given further study.

4) The Coast Guard Research and Development Center should use this report as a basis to consider future studies to explore combinations of the potential recommendations that can generate greater benefits acting together than indicated by their individual cost-benefit scores (i.e., a study of the non-linear dynamics of the causes of bridge allisions).

5) The Coast Guard should implement a special investigative effort for certain bridge allision incidents, over a specified period of time (three to five years). As part of this effort, the Coast Guard would conduct a thorough investigation of each bridge allision for which the preliminary investigation showed human factors issues as possible causal factors. Coast Guard and AWO analysts would regularly evaluate the data from these completed investigations and report their findings to the National Quality Steering Committee (QSC) of the Coast Guard-AWO Safety Partnership. This effort would provide future analysts with more detailed information than was available in most of the cases reviewed by the Work Group.

The marine environment for the towing vessel industry is a complex, highly interdependent system. It encompasses waterways, vessels, human operators, navigational aids and a supporting infrastructure for pilotage, vessel and port management, policy and regulation, and professional development. There is much interaction within the system. Because of this complex system of interaction and the infrequent number of accidents relative to the number of safe bridge transits, the Group could not identify any quick fixes or "silver bullets" that will prevent bridge allisions. The Group's conclusion that decision making error appears to be the predominant cause of bridge allisions underscores this result: the decision making process is complex and subject to multiple influences. There is no "one way" to ensure that an operator makes good decisions. However, the Work Group believes that the decision making process can be improved by a combination of process improvements based on the highest-rated safety strategies. These process improvements should be supplemented by additional measures to reduce the occurrence of bridge allisions and minimize their consequences.

CONCLUSION

The Work Group was guided by analysis of the data and expert judgment and employed structured methodologies in its deliberations. The methodologies facilitated the incorporation of both quantitative and qualitative inputs. The core findings of the Work Group are as follows:

1) The human element, in particular decision making errors, is the predominant factor in bridge allisions. This does not mean that towing vessel operators are poor decision makers. Indeed, the fact that the overwhelming majority of bridge transits take place without incident – and that most bridge allisions that do occur result in no damage to people, property, or the environment – testifies to the skill and professionalism of towing vessel operators who do a difficult job under challenging conditions, with very little margin for error.

2) A myriad of factors contribute to the human factor-based errors, thus there is no "silver bullet" or "quick fix" for reducing bridge allisions.

3) The recommendations advocated by the Work Group involve a mix of industry and government action to reduce the occurrence of bridge allisions. However, the risk of bridge allisions cannot be reduced to zero. Thus, additional actions by transportation authorities are needed to remove hazardous bridges and improve protection standards for bridges so that consequences from a bridge allision are minimized.

4) These findings should be distributed to industry, government, and related parties by as many channels as possible.

5) Additional research may develop other recommendations.

The Work Group is confident that it thoroughly explored the information it had available and that its findings and recommendations will provide a solid foundation for future work to reduce the frequency of bridge allisions and minimize the consequences of those that do occur.

APPENDIX 1
MEASURES TAKEN TO REDUCE BRIDGE ALLISIONS

Since the 1993 MAUVILLA accident on Bayou Canot, the Coast Guard and AWO have undertaken a wide variety of measures aimed at preventing the occurrence of bridge allisions and improving the safety of the tugboat, towboat, and barge industry overall. This appendix provides an overview of significant actions taken since that time.

<u>Review of Marine Safety Issues Related to Uninspected Towing Vessels</u>

In December 1993, the Coast Guard completed a comprehensive *Review of Marine Safety Issues Related to Uninspected Towing Vessels*. The review made 19 recommendations for changes to laws, regulations, or administrative practices governing towing vessel operations. These recommendations are summarized below, along with a description of the Coast Guard actions proposed and the results achieved.

Recommendation 1: The Operator of Uninspected Towing Vessel (OUTV) license should have levels of qualification. Restrictions for such levels of qualifications may include route, gross tonnage or horsepower of the towing vessel, type of towing configuration, etc. The basic three-year apprenticeship should qualify an applicant for a basic OUTV license only.

> **Commandant Action:** Commandant (G-MVP) will initiate rulemaking to propose the recommended regulatory changes.
>
> **Results:** In November 1999, the Coast Guard published regulations that replace the OUTV and Second Class OUTV licenses with a three-step licensing system. A mariner is eligible for an Apprentice Mate or Steersman license after 18 months of service and passage of a written exam. This license permits a mariner to stand watch in the wheelhouse of a towing vessel under the direct supervision of a Master, Mate, or Pilot of Towing Vessels. A mariner is eligible for a Mate or Pilot license after accruing an additional 12 months of service and either completing an approved training course or submitting a Towing Officer Assessment Record (TOAR) documenting a practical demonstration of skill before a Designated Examiner. A mariner is eligible for a Master of Towing Vessels license after an additional 18 months of service as Mate or Pilot of Towing Vessels. Minor modifications to the licensing rules were made in a revised interim rule issued in April 2001.

Recommendation 2: OUTVs holding a basic license should be able to increase the scope of the license after acquiring additional service. In addition to service, they should be required to attend a Coast Guard approved simulator course, pass a written or simulator examination, or some combination thereof.

> **Commandant Action:** Commandant (G-MVP) will initiate rulemaking to propose the recommended regulatory changes.

Results: The new Coast Guard regulations for licensing of towing vessel officers provide that in order to obtain an endorsement for a route superior to the route currently held, the mariner must spend 30 days of observation and training and pass a limited examination, as well as complete the Towing Officer Assessment Record (TOAR) for the route. The TOAR is a document to record demonstrations of proficiency. The mariner is given the option to conduct the demonstration of proficiency on a simulator; however, the use of simulators is not required.

Recommendation 3: OUTVs seeking to increase the scope of their license to the highest level should be required to attend a Coast Guard approved simulator course.

Commandant Action: Commandant (G-MVP) will initiate rulemaking to propose the recommended regulatory changes.

Results: During the rulemaking process, the Coast Guard determined not to require the use of simulators because of the relatively high cost and limited availability of simulator courses. The new regulations offer mariners the option of attending simulator courses; mariners are also allowed to complete their demonstrations of proficiency on actual towing vessels.

Recommendation 4: All OUTVs should be required to demonstrate their skills on a simulator when renewing their license.

Commandant Action: Commandant (G-MVP) will initiate rulemaking to propose the recommended regulatory changes.

Results: See response to Recommendation 3.

Recommendation 5: Regulations should be developed that limit a Second Class OUTV to service on smaller towing vessels. The operator for larger vessels should always be an OUTV.

Commandant Action: Commandant (G-MVP) will initiate rulemaking to propose the recommended regulatory changes.

Results: The new regulations have increased the service requirement for Mate or Pilot of Towing Vessels (the successor license to 2nd class OUTV), now requiring 30 months of service in order to obtain the license. Mariners are also required to demonstrate proficiency before obtaining a Mate or Pilot of Towing Vessels license.

Recommendation 6: Applicants desiring a Western Rivers route on their license must acquire operating experience on that route and pass an appropriate examination.

> **Commandant Action:** Commandant (G-MVP) will initiate rulemaking to propose the recommended regulatory changes.
>
> **Results:** The revised regulations require at least 90 days of training and observation on the Western Rivers and the completion of a TOAR for that route. No additional examination is required for mariners holding a towing officer license.

Recommendation 7: Regulations should be developed requiring a radar equipped towing vessel more than 26 feet in length to be operated by an OUTV qualified as a radar observer.

> **Commandant Action:** Commandant (G-MVP) will initiate rulemaking to propose the recommended regulatory changes.
>
> **Results:** This regulatory requirement became effective September 30, 1997.

Recommendation 8: The Coast Guard and the Maritime Administration (MARAD) should review the existing standard of the approved inland radar observer courses. The review should determine if the existing curriculum meets the operational and safety needs of the inland mariner. In addition, the review should develop the standards necessary to reflect current technology.

> **Commandant Action:** Commandant (G-MVP) will initiate the recommended review in cooperation with MARAD.
>
> **Results:** Completed.

Recommendation 9: The Coast Guard, with assistance from the Towing Safety Advisory Committee, should review the oceans (domestic trade) route authorized for an OUTV license and propose alternatives that conform to international standards.

> **Commandant Action:** Commandant (G-MVP) will initiate the recommended review and request assistance from the Towing Safety Advisory Committee.
>
> **Results:** The revised regulations restrict the Master of Towing Vessels license to vessels less than 200 GRT on domestic coastwise routes only. Mariners on towing vessels on international routes must obtain a license that meets international standards.

Recommendation 10: Regulations should be developed to specify the equivalency of licensed masters and mates of 500/1,600 GRT vessels to service as an OUTV. Licensed masters of vessels of 200 GRT or less should be limited to service as a second-class OUTV.

> **Commandant Action:** Commandant (G-MVP) will initiate rulemaking proposing the recommended license limitations.
>
> **Results:** The revised regulations require mariners who operate towing vessels to obtain a towing endorsement, which requires completion of 30 days of training and observation on towing vessels and completion of a TOAR, for the routes being sought. If an individual is seeking an endorsement for the Western Rivers, 90 days of training and observation is required. Masters and mates with authority on vessels less than 200 GRT must comply with the towing officer licensing regulations in effect since May 21, 2001, to obtain the Master of Towing Vessels license.

Recommendation 11: The Coast Guard should initiate a regulatory project to amend Title 46 CFR 4.05-01 to require that casualties be reported immediately after the resulting safety concerns have been addressed. In addition, all unintentional allisions (collisions of a vessel with a stationary object) with bridges or other structures should be reported.

> **Commandant Action:** Commandant (G-MMI) will initiate rulemaking proposing the recommended amendments to 46 CFR Part 4
>
> **Results:** Regulations now require the immediate reporting of marine casualties. Regulations have expanded the definition of a reportable marine casualty to include any unintentional striking of a bridge.

Recommendation 12: The Coast Guard should initiate a legislative proposal to amend 46 USC 6103 to increase the maximum civil penalty from $1,000 to $25,000 for failing to report a marine casualty as defined under 46 CFR 4.05-1.

> **Commandant Action:** Commandant (G-MMI) will initiate the recommended action through discussion regarding amendment of H.R. 3282 (see Recommendation 19) or as a separate legislative proposal, as appropriate.
>
> **Results:** 46 USC 6103 was amended, increasing the maximum civil penalty to $25,000 for failing to report a marine casualty.

Recommendation 13: The Coast Guard should initiate a regulatory project to amend 33 CFR 160.215 to clearly indicate that the required notice of a hazardous condition includes a condition caused by a vessel or its operation even when the hazard is not on board the vessel.

> **Commandant Action:** Commandant (G-MPS) will initiate the recommended regulatory action.
>
> **Results:** 33 CFR 160.215 has been amended to require the immediate notification of hazardous conditions caused by the vessel or its operations.

Recommendation 14: It is recommended that each Coast Guard district conduct a survey of all bridges under Coast Guard jurisdiction and make a case-by-case determination regarding the adequacy of existing systems, and the requirement for additional fendering systems, and the requirements, if any, for additional bridge lighting.

> **Commandant Action:** Commandant (G-NBR) will initiate the appropriate action.
>
> **Results:** Completed.

Recommendation 15: The Coast Guard should initiate rulemaking under authority of the Ports and Waterways Safety Act (33 USC 1231) to require that all uninspected towing vessels carry: 1) a marine radar system for surface navigation; 2) marine charts for the area to be transited; and 3) current or corrected publications. In addition, the rulemaking should seek to identify areas of operation where a compass and depth finder are necessary tools for safe navigation. This will result in carriage requirements wile navigating in specified areas.

> **Commandant Action:** Commandant (G-NSR) will initiate rulemaking under the authority of H.R. 3282, if enacted (see Recommendation 19), or 33 USC 1231, proposing the recommended action.
>
> **Results:** Regulations now require uninspected towing vessels to carry and properly use equipment including radars, compasses, and nautical charts and publications. During the rulemaking process, the Coast Guard determined that depth sounders were needed on ocean and coastal towing vessels. Towing vessels operating on the Western Rivers, because of the nature of their operations and the environment in which they operate, did not stand to gain any safety benefit from use of a depth sounder, so no such requirement was imposed on those vessels.

Recommendation 16: The Coast Guard should amend the Aids to Navigation Manual - Administration (COMDTINST M16500.7) to specifically address the need to consider approaches to bridges in the design for aids to navigation systems.

Commandant Action: Commandant (G-NSR) will make the recommended amendments to the Aids to Navigation Manual

Results: The Aids to Navigation Manual - Administration (COMDTINST M16500.7) now specifically addresses the need to consider approaches to bridges in the design for aids to navigation systems.

Recommendation 17: The Commander, Eighth Coast Guard District should initiate the improvements in the vicinity of Big Bayou Canot recommended in the WAMS Study Update for the Mobile River.

Commandant Action: Commander, Eighth Coast Guard District will initiate the recommended improvements in the vicinity of the Big Bayou Canot.

Results: Completed.

Recommendation 18: The Coast Guard should emphasize the responsibility of towing vessel owners to employ qualified, experienced personnel as operators in charge (or masters) of their vessels.

Commandant Action: Commandant (G-MVP) will initiate the recommended action.

Results: The Coast Guard was added at 46 CFR10.464 (f). The regulation reads: "Each company must maintain evidence that every vessel it operates is under the direction and control of a licensed mariner with appropriate experience, including 30 days of observation and training on the intended route other than Western Rivers." (Western Rivers routes require 90 days of observation and training.)

Recommendation 19: The Coast Guard should support H.R. 3282 and discuss with Congressional staff the inclusion of provisions for an increased maximum civil penalty for failure to report marine casualties and provisions to link the requirement for compasses and fathometers to the area of operation of a towing vessel.

Commandant Action: Commandant (G-CC) will coordinate support for H.R. 3282 and discussions with Congressional staff to include provisions for an increased maximum civil penalty and flexibility in the requirements compasses and fathometers on towing vessels.

Results: H.R. 3282 was not enacted. However, 46 USC 6104 was amended increasing the civil penalty to $25,000 for failing to report a marine casualty. In addition, the Coast Guard implemented towing vessel equipment carriage requirements through a rulemaking.

AWO Responsible Carrier Program (RCP)

In April 1994, the AWO Board of Directors commissioned a working group to "develop a series of recommended positions, practices, and standards aimed at enhancing the safety of the barge and towing industry." That effort produced the AWO Responsible Carrier Program (RCP), a comprehensive code of safety practices for tugboat, towboat, and barge operators that encompasses virtually every aspect of fleet operations, including company management and administration, vessel equipment and inspection, and human factors. The AWO Board of Directors adopted the Responsible Carrier Program as a code of practice for AWO member companies in December 1994.

Since that time, the RCP has continued to evolve. In 1998, the AWO membership voted to make compliance with the Responsible Carrier Program a condition of membership in the association. As of January 1, 2000, all AWO members were required to undergo a third-party audit as evidence of compliance with the Responsible Carrier Program. New members have two years from the date of joining the association to achieve audited compliance. Re-audits are required every three years.

The RCP is a living program that is regularly reviewed by the AWO Responsible Carrier Program Accreditation Board to identify recommended changes and additions based on lessons learned about safety improvements. Changes to the RCP are recommended by the Accreditation Board and approved by the AWO Board of Directors.

Coast Guard-AWO Safety Partnership

The Coast Guard-AWO Safety Partnership, established in November 1995, was the first of its kind to bring together Coast Guard and industry leaders in a cooperative effort to improve marine safety and environmental protection. The Partnership was founded on the belief that the Coast Guard and the tugboat, towboat, and barge industry share a common interest in improving marine safety and environmental protection, and that these goals are best served by a cooperative approach that emphasizes dialogue and non-regulatory action. Since its inception, the Partnership has launched more than 25 Quality Action Teams that have worked to improve safety in a number of areas critical to industry safety and environmental protection, including crew fatalities, oil spills, crew endurance, and bridge allisions.

Mississippi River Crisis Action Plan

The Mississippi River Crisis Action Plan provides the marine industry, U.S. Coast Guard, U.S. Army Corps of Engineers, states, and local governments with a plan for facilitating the safe and orderly movement of traffic during low and high water navigation crises on the Mississippi River. The River Crisis Action Plan is particularly helpful in reducing bridge allisions when high water causes faster river currents.

The River Industry Executive Task Force (RIETF), in conjunction with the Corps of Engineers and the Coast Guard, chartered the River Crisis Response Working Group in

September 1995. The group's goal was to draft a standard Crisis Action Plan for dealing with navigation crises on the Mississippi River system. Subsequently, floods in the Ohio valley in the spring of 1997 resulted in high water and excessive river flows in the lower Mississippi River from Vicksburg, Mississippi, to the mouth of the river. The Eighth Coast Guard District Commander then directed the Captain of the Port-New Orleans to convene a working group of stakeholders operating between Baton Rouge and Southwest Pass to modify the plan to include the entire Lower Mississippi River. These stakeholders included the Corps of Engineers, the four pilot associations, the Steamship Association of Louisiana, the American Waterways Operators, the Greater New Orleans Barge Fleeting Association, and Marine Navigation Safety Association. These and other stakeholders are to be consulted during high and/or low water situations.

A standing organization of senior Coast Guard, Corps of Engineers, and industry personnel has been established to administer the plan. This Waterway Management Committee (WMC) is a Unified Command (UC) that adheres to the nationally accepted Incident Command System (ICS) model. The UC promotes synergistic activity among all river stakeholders and ensures that joint evaluations and decisions are made that take all perspectives into account.

Chapters 1-5 of the plan detail the essential issues, authorities, and traffic management tools that enable government and industry to manage a river crisis. Particularly critical is the guidance for executing waterway management intervention actions. Responses are broken down into four phases: the Watch Phase, Implementation Phase, Emergency Phase, and Recovery Phase. Each phase triggers recommended actions for each phase of response. Actions to avert casualties are automatically triggered when certain river gauge levels are attained. The plan initiates Traffic Information Centers (TIC) to disseminate safety information and Traffic Control Centers (TCC) to temporarily perform active vessel traffic management.

The River Crisis Action Plan can be found at:
http://www.uscg.mil/d8/mso/nola/library/rcap/missrcap.pdf .

APPENDIX 2
PROFILE OF BRIDGE ALLISIONS

Coast Guard and AWO staff conducted a series of statistical analyses to provide a quantitative description of the bridge allisions and identify variables that could serve as indicators of incidents. The sections below recap the analyses of allision counts by bridge, geographic distribution of damages, circadian cycle, type of vessel, and pollution incidents. For more information, please contact Doug Scheffler, AWO Manager - Research and Data Analysis, by phone at (703) 841-9300 or by e-mail at dscheffler@vesselalliance.com.

Table 1: Bridge Allisions by Name of Bridge

Name of Bridge	Number of Allisions
E, J, & E Railway Bridge, MM-270.6, Illinois River, Morris, IL	170
Chicago & Northwestern Railroad Bridge, MM-151.2, Illinois River, Pekin, IL	95
Burlington Railroad Bridge, MM-403, Upper Mississippi River, Burlington, IA	92
Galveston Causeway (I-45) Bridge, MM-357, GICW, Galveston, TX	76
Franklin Street Bridge, MM-162, Illinois River, Peoria, IL	67
Naheola Bridge (Highway 114 Bridge), MM-173, Tombigbee River, Pennington, AL	67
East Main Street Bridge, MM-57, GICW, Houma, LA	50
Sabula Railroad Bridge, MM-535, Upper Mississippi River, Sabula, IA	48
South Quay (Highway 198) Bridge, Blackwater River, South Quay, VA	47
Camden Railroad Bridge, Pasquotank River, Camden, NC	46
Southern Pacific Railroad Bridge, MM-118, Atchafalaya River, Morgan City, LA	46
Clinton Railroad Bridge, MM-518, Upper Mississippi River, Clinton, IA	44
Bayou Dularge Bridge, MM-60, GICW, Houma, LA	42
CSX Railroad Bridge, MM-14, Mobile River, Mobile, AL	42
Crescent Railroad Bridge, MM-481.4, Upper Mississippi River, Davenport, IA	42
Illinois Central Railroad Bridge, MM-579.9, Upper Mississippi River, Dubuque, IA	33
McDonough Street Bridge, MM-287.3, Des Plaines River, Joliet, IL	29
Cairo Highway Bridge, MM-980.4, Ohio River, Cairo, IL	28
Cass Street Bridge, MM-288.1, Des Plaines River, Joliet, IL	26
Illinois Central Railroad Bridge, MM-977.8, Ohio River, Cairo, IL	26
Norfolk Southern Railroad Bridge, MM-90, Tombigbee River, Jackson, AL	26
Florence Highway Bridge, MM-56, Illinois River, Florence, IL	24
Burlington & Ohio Railroad Bridge, MM-254.1, Illinois River, Seneca, IL	23
Lacrosse Railroad Bridge, MM-700, Upper Mississippi River, Lacrosse, WI	23
Chickasaw Creek Railroad Bridge, MM-4, Mobile River, Prichard, AL	22
Louisiana Railroad Bridge, MM-282.1, Upper Mississippi River, Louisiana, MO	22
Fort Madison Railroad Bridge, MM-383.9, Upper Mississippi River, Fort Madison, IA	19
Victory Swing Bridge, Mouth Of Raritan River, Perth Amboy, NJ	17
Burlington Northern Railroad Bridge, Duwamish River, Seattle, WA	16
Jefferson Street Bridge, MM-287.9, Des Plaines River, Joliet, IL	16
Simmesport Railroad Bridge, MM-4.9, Atchafalaya River, Simmesport, LA	16
Bayou Blue Bridge, MM-49, GICW, Bourg, LA	15
Rigolets Pass Railroad Bridge, MM-34, GICW, Chalmette, LA	15

Name of Bridge	Number of Allisions
Chelsea Street Bridge, Chelsea River, Boston, MA	14
Highway 182 Bridge, MM-118, Atchafalaya River, Morgan City, LA	14
Black Bayou Bridge, MM-238, GICW, Lake Charles, LA	13
CSX Railroad Bridge, Back Bay Biloxi, Biloxi, MS	13
Chowan River (Highway 17) Bridge, Chowan River, Edenton, NC	13
DuPont Bridge, MM-295, GICW, Panama City, FL	13
Florida Avenue Bridge, Industrial Canal, New Orleans, LA	13
Highway 190 Bridge, MM-233.9, Lower Mississippi River, West Baton Rouge, LA	13
Highway 82 (Greenville Bridge) Bridge, MM-531, Lower Mississippi River, Greenville,	13
Norfolk & Western Railroad Bridge #5, East Branch, Elizabeth River, Chesapeake, VA	13
Walking Horse & Eastern RR Bridge, MM-185.2, Cumberland River, Nashville, TN	13
Melville Railroad Bridge, MM-30, Atchafalaya River, Melville, LA	12
Merchants Railroad Bridge, MM-183, Upper Mississippi River, St. Louis, MO	10
Pensacola Beach (Bob Sykes) Bridge, MM-189, GICW, Pensacola, FL	10
Spottsville Railroad Bridge, MM-8, Green River, Spottsville, KY	10
Thebes Railroad Bridge, MM-43.7, Upper Mississippi River, Thebes, IL	10
West Port Arthur Bridge, MM-289, GICW, Port Arthur, TX	10
B & O Railroad Bridge, MM-184.5, Ohio River, Parkersburg, WV	9
Berkeley (I-264) Bridge, Elizabeth River, Norfolk, VA	9
Caney Creek Bridge, MM-418, GICW, Freeport, TX	9
FEC Railroad Bridge, St. Lucie River, Stuart, FL	9
Grand Lake Pontoon Bridge, MM-232, GICW, Grand Lake, LA	9
Houma Navigation Canal Bridge, Houma Channel, Houma, LA	9
Ottawa Railroad Bridge, MM-239.4, Illinois River, Ottawa, IL	9
Bayou Sorrel Bridge, MM-38, Port Allen Route, Bayou Sorrel, LA	8
Bryan Beach Swing Bridge, MM-397, GICW, Freeport, TX	8
Eads Highway & Railroad Bridge, MM-180, Upper Mississippi River, St. Louis, MO	8
Humble Canal (Highway 55) Bridge, Humble Canal, Houma, LA	8
I-74 Bridge, MM-158, Illinois River, Peoria, IL	8
Illinois Central Railroad Bridge, MM-225.5, Illinois River, Lasalle, IL	8
Irvin Cobb (Highway 45) Highway Bridge, MM-937, Ohio River, Paducah, KY	8
Louisa Bridge, MM-134, GICW, Cypremort, LA	8
Popps Ferry Bridge, Back Bay Biloxi, Biloxi, MS	8
Venetian Causeway Bridge, AICW, Miami, FL	8
Bridge Of Lions, St. Johns River, St. Augustine, FL	7
Eltham Swing Bridge, Pamunkey River, West Point, VA	7
Henry R. Lawrence Memorial Bridge, MM-63.1, Cumberland River, Canton, KY	7
Highway 14 Bridge, MM-267.8, Black Warrior River, Eutaw, AL	7
Highway 49 Bridge, MM-662, Lower Mississippi River, Helena, AR	7
L & N Railroad Bridge, Industrial Canal, New Orleans, LA	7
New York Central Railroad Bridge, MM-265, Ohio River, Point Pleasant, WV	7
Pigs Eye Railroad Bridge, MM-836, Upper Mississippi River, St. Paul, MN	7
Railroad Bridge, Susquehanna River, Havre De Grace, MD	7
Rock Island Railroad Bridge, MM-288, Des Plaines River, Joliet, IL	7
2nd Avenue Bridge, Miami River, Miami, FL	6
Bayou Boeuf Southern Pacific Railroad Bridge, Amelia, LA	6
Blair Waterway Drawbridge, Tacoma, WA	6

Name of Bridge	Number of Allisions
Charenton Canal Railroad Bridge, Baldwin, LA	6
Dulac Swing Bridge, Houma Navigation Channel, Houma, LA	6
Gilmerton Highway Bridge, Elizabeth River, Chesapeake, VA	6
Hannibal Railroad Bridge, MM-309.9, Upper Mississippi River, Hannibal, MO	6
Highway 41 Dual Bridge, MM-786.8, Ohio River, Henderson, KY	6
Highway 80 Bridge, MM-435.8, Lower Mississippi River, Vicksburg, MS	6
Hylebos Waterway Bridge, Tacoma, WA	6
I-155 Highway Bridge, MM-838.9, Lower Mississippi River, Caruthersville, MO	6
Longboat Key Pass Bridge, GICW, Cortez, FL	6
P & I Railroad Bridge, MM-944.1, Ohio River, Metropolis, IL	6
West Larose Lift Bridge, MM-35, GICW, Larose, LA	6
B. B. Comer Highway Bridge, MM-385.9, Tennessee River, Scottsboro, AL	5
Belle Chasse Highway Bridge, MM-3.8, GICW, Belle Chasse, LA	5
Burlington Northern Railroad Bridge, Snohomish River, Everett, WA	5
Conrail Bridge #620, Rouge River, Dearborn MI	5
Decatur Highway Bridge, MM-305, Tennessee River, Decatur, TN	5
Eggners Ferry (Highway 68-80) Bridge, MM-41, Tennessee River, Aurora, KY	5
I-10 Highway Bridge, MM-60, Atchafalaya River	5
I-110 Highway Bridge, Back Bay Biloxi, Biloxi, MS	5
I-24 Highway Bridge, MM-940.8, Ohio River, Paducah, KY	5
I-5 Bridge, Columbia River, Vancouver, WA	5
Jackson Street Bridge, MM-288.4, Des Plaines River, Joliet, Il	5
L & N Railroad Bridge, MM-126.5, Cumberland River, Clarksville, TN	5
Navassa Railroad Bridge, Cape Fear River, Navassa, NC	5
Ocean City-Longport Bridge, AICW, Ocean City, NJ	5
Pelham Bay Parkway Bridge, Eastchester, NY	5
Pensacola Bay Bridge, GICW, Pensacola, FL	5
Sisters Creek Bridge (Highway 105), Sisters Creek, Jacksonville, FL	5
Southern Pacific Railroad Bridge, GICW, Amelia, LA	5
Southern Railroad Bridge, MM-647.3, Tennessee River, Knoxville, TN	5
Sunshine Bridge, MM-167.4, Lower Mississippi River, Union, LA	5
UPRR-SPRR Railroad Bridge, Martinez, CA	5
Union Pacific Railroad Bridge, MM-44, Atchafalaya River, Krotz Springs, LA	5
Wappoo Creek Bascule Bridge, Charleston, SC	5
Westlake Railroad Bridge, Calcasieu River, Westlake, LA	5
5th Street Bridge, Miami River, Miami, FL	4
B & M Railroad Bridge, Newport River, Morehead City, NC	4
Beardstown Highway Bridge, MM-88.1, Illinois River, Beardstown, IL	4
Burlington Northern Railroad Bridge, MM-105, Columbia River, Vancouver, WA	4
Chester Highway Bridge, MM-110, Ilinois River, Chester, IL	4
Dauphin Island (Highway 193) Bridge, MM-129, GICW, Dauphin Island, AL	4
East Park Avenue Bridge, MM-57, GICW, Houma, LA	4
Eureka Highway Bridge, MM-30, Cumberland River	4
Harahan Railroad Bridge, MM-734.8, Lower Mississippi River, Memphis, TN	4
Hood River Bridge (I-35), MM-169.8, Hood River, Hood River, OR	4
Huey P. Long Bridge, MM-106, Lower Mississippi River, New Orleans, LA	4
James River Bridge, James River, Newport News, VA	4

Name of Bridge	Number of Allisions
Keokuk Highway Bridge, MM-363.9, Upper Mississippi River, Keokuk, IA	4
L & N Railroad Bridge, MM-190.4, Cumberland River	4
Lansing Highway Bridge, MM-663.4, Upper Mississippi River, Lansing, IA	4
Leeville Lift Bridge, MM-13, Bayou Lafourche, Leeville, LA	4
Liberty Street Bridge, Saginaw River, Bay City, MI	4
Louisiana Highway 54 Bridge, MM-283, Upper Mississippi, Louisiana, MO	4
Mermentau River Railroad Bridge, Lake Arthur, LA	4
Middle Thoroughfare Bridge, Cape May Canal, Cape May, NJ	4
Natchez-Vidalia Highway Bridge, MM-363.3, Lower Mississippi River, Natchez, MS	4
Penn Central Railroad Bridge, MM-332, Calumet River, Chicago, IL	4
Sanibel Causeway Bridge, GICW, Fort Myers, FL	4
Tomlinson Bridge, Quinippiac River, New Haven, CT	4
Tule Lake Lift Bridge, Corpus Christi, TX	4
Bourdeaux Railroad Bridge, MM-190.5, Cumberland River	3
Burlington Northern Railroad Bridge, MM-328, Upper Mississippi River, Quincy, IL	3
Burlington Northern Railroad Bridge, Swinomish Channel, Anacortes, WA	3
CSX Railroad Bridge, MM-1, Big Sandy River, Kenova, WV	3
Campostella Bridge, Elizabeth River, Norfolk, VA	3
Casco Bay Bridge, Casco Bay, Portland, ME	3
Choctawhatchee Mid Bay Bridge, Destin, FL	3
Claiborne Avenue (Judge Seeber) Bridge, New Orleans	3
Dubuque Highway Bridge, MM-579.3, Upper Mississippi River, Dubuque, IA	3
FEC Railroad Bridge, St. Johns River, Jacksonville, FL	3
Gateway Western Railroad Bridge, MM-43.2, Illinois River	3
George P. Coleman Bridge, York River, Yorktown, VA	3
Great Bridge Highway Bridge, MM-12.6, AICW, Chesapeake, VA	3
Highway 84 Bridge, MM-41, Tensas River, Jonesville, LA	3
Highway 90 Bridge, Atchafalaya River, Morgan City, LA	3
Highway 90 Bridge, Back Bay Biloxi, Biloxi, MS	3
Hilton Railroad Bridge, Cape Fear River, Wilmington, NC	3
I-30 Highway Bridge, MM-118.5, Arkansas River, Little Rock, AR	3
I-55 Highway Bridge, MM-734.8, Lower Mississippi River, Memphis, TN	3
I-64 Highrise Bridge, Elizabeth River, Chesapeake, VA	3
Isabelle Stallings Holmes Bridge, Cape Fear River, Wilmington, NC	3
Jefferson Barracks (I-255) Bridge, MM-169.1, Upper Mississippi River, St. Louis, MO	3
K & I Railroad Bridge, MM-607, Ohio River, Louisville, KY	3
Kenova Railroad Bridge, MM-315, Ohio River, Kenova, WV	3
L & I Railroad Bridge, MM-605, Ohio River, Louisville, KY	3
Lake Pontchartrain Causeway Bridge, New Orleans, LA	3
Lexington Highway Bridge, MM-318, Missouri River, Lexington, MO	3
Louisiana Midland Railroad Bridge, MM-40.6, Ouachita River, Jonesville, LA	3
Mackay River Bridge, MM-674, AICW, St. Simons Island, GA	3
McArdle Street Bridge, Boston, MA	3
Omaha Railroad Bridge, MM-841, Upper Mississippi River, St. Paul, MN	3
P & LE Railroad Bridge, MM-8.6, Monongahela River, Pittsburgh, PA	3
Parkersburg Highway Bridge, MM-184.3, Ohio River, Parkersburg, WV	3
Peter P. Cobb Bridge, AICW, Fort Pierce, FL	3

Name of Bridge	Number of Allisions
Raritan River Railroad Bridge, South Amboy, NJ	3
Rock Island Railroad Bridge, MM-487, Upper Mississippi River, Rock Island, IL	3
Seabrook Railroad Bridge, Industrial Canal, New Orleans, LA	3
Shawneetown Highway Bridge, MM-858.2, Ohio River, Shawneetown, IL	3
Smithfield Street Bridge, MM-1, Monongahela River, Pittsburgh, PA	3
Southern Pacific Railroad Bridge, MM-227, Red River, Shreveport, LA	3
Southern Railroad Bridge, MM-472.5, Ohio River, Cincinnati, OH	3
Southern Railroad Bridge, MM-591.3, Tennessee River	3
Spuyten Duyvil Bridge, East River, Bronx, NY	3
Stono River Bridge, AICW, Charleston, SC	3
Wilkes Bridge, Back Bay Biloxi, Biloxi, MS	3
1st Avenue South Bridge, Duwamish River, Seattle, WA	2
3 Mile Slough Bridge, Sacramento River, Rio Vista, CA	2
92nd Street Bridge, Calumet River, Chicago, IL	2
AGS Railroad Bridge, MM-267.8, Black Warrior River	2
B. B. McCormick Bridge, MM-747, AICW, Jacksonville, FL	2
Baker Haulover Inlet Bridge, AICW, Miami, FL	2
Bayou Sallie Bridge, MM-113, GICW	2
Biggs-Maryhill Bridge, MM-208.1, Columbia River, Biggs, OR	2
Brightman Street Drawbridge, MM-1.8, Taunton River, Somerset, MA	2
Broadway Bridge, MM-12, Willamette River, Portland, OR	2
Buffalo Bluff Railroad Bridge, St. Johns River, Palatka, FL	2
Burlington Northern Railroad Bridge, MM-105.3, Alabama River, Pine Hill, AL	2
CSX Railroad Bridge, Pascagoula River, Pascagoula, MS	2
Cape Girardeau Highway Bridge, MM-53, Upper Mississippi, Cape Girardeau, MO	2
Chef Menteur (Highway 90) Bridge, New Orleans, LA	2
Cochran-Africatown Bridge, Mobile River, Mobile, AL	2
Congress Street Bridge, Fort Point Channel, Boston, MA	2
Conrail Bridge, Maumee River, Toledo, OH	2
Coronado Bridge, AICW, New Smyrna Beach, FL	2
Coronado Bridge, San Diego Bay, San Diego, CA	2
Crown Point Bridge (Highway 3134), GICW, Crown Point, LA	2
Douglas MacArthur Bridge, MM-179, Upper Mississippi River, St. Louis, MO	2
E, J, & E Railway Bridge, Indiana Harbor Ship Canal, East Chicago, IN	2
Grassy Sound Bridge (Route 147), Cape May, NJ	2
Grosse Ile Toll Bridge, Detroit River, Grosse Ile, MI	2
Grosse Tete Swing Bridge, MM-48, GICW, Port Allen Route	2
Gulf Beach (Highway 292) Bridge, MM-172, GICW, Gulf Beach, FL	2
Hackensack River Drawbridge, MM-5.4, Hackensack River, Hackensack, NJ	2
Hardin Drawbridge, MM-21.5, Illinois River, Hardin, IL	2
Henry Ford Lift Bridge, Cerritos Channel, Los Angeles, CA	2
Hickman-Lockhart Bridge, MM-100, Tennessee River	2
Highway 231 Bridge, MM-333, Tennessee River	2
Highway 302 Bridge, Barataria Waterway, Lafitte, LA	2
Highway 56 Bridge, Boudreaux Canal	2
Highway 80 Bridge, MM-166.5, Ouachita River, Monroe, LA	2
Highway 90 Bridge, Escambia River, Pensacola, FL	2

Name of Bridge	Number of Allisions
Hobucken Swing Bridge, Hobucken, NC	2
I-10 Highway Bridge, MM-229, Lower Mississippi River, Baton Rouge, LA	2
I-24 Highway Bridge, MM-429, Tennessee River, Chattanooga, TN	2
I-35 Bridge, Victoria Barge Canal, San Antonio Bay, Port Lavaca, TX	2
I-57 Bridge, MM-7.5, Upper Mississippi River, Cairo, IL	2
Indian Rocks Bridge, MM-128.2, GICW, Indian Rocks Beach, FL	2
Lewis & Clark Bridge, MM-13.5, Columbia River, Astoria, OR	2
Limehouse Swing Bridge, Stono River, Johns Island, Charleston, SC	2
Little River Swing Bridge, AICW, Little River, SC	2
Lockport Bridge, MM-291, DesPlaines River, Lockport, IL	2
McKinley Bridge, MM-182.2, Upper Mississippi River, St. Louis, MO	2
McWhorter Bridge, MM-66, Tennessee River	2
Mermentau River Railroad Bridge, Jennings, LA	2
Metro North Railroad Bridge, Norwalk River, Norwalk, CT	2
Monitor-Merrimac Causeway Bridge, James River, Newport News, VA	2
Navarre Beach (Highway 87) Highway Bridge, MM-207, GICW, Navarre Beach, FL	2
New Bridge Under Construction, MM-158, Cumberland River	2
Norfolk & Southern Railroad Bridge, Maumee River, Toledo, OH	2
Old Lyme Railroad Bridge, Old Saybrook, CT	2
Old River Bridge, Orwood, CA	2
Pekin Highway Bridge, MM-152.9, Illinois River, Pekin, IL	2
Pelham Bay Railroad Bridge, Eastchester, NY	2
Pelican Island Bridge, Galveston Channel, Galveston, TX	2
Poplar Street Bridge, MM-179.2, Upper Mississippi River, St. Louis, MO	2
Port Isabel Swing Bridge, GICW, Port Isabel, TX	2
Queen Isabella Causeway Bridge, GICW, Port Isabel, TX	2
Quincy Memorial Bridge, MM-327, Upper Mississippi River, Quincy, IL	2
Railroad Bridge, Ballard Locks, Seattle, WA	2
Railroad Bridge, MM-320, Chicago Sanitary & Ship Canal	2
Rankin Highway Bridge, MM-10.4, Monongahela River, Braddock, PA	2
Ravenswood Bridge, MM-221.3, Ohio River, Ravenswood, OH	2
Rockaway Railroad Bridge, AICW, Rockaway, NY	2
Roosevelt Railroad Bridge, AICW, Stuart, FL	2
Route 104 Steel Bridge, Elizabeth River, Chesapeake, VA	2
Route 313 Bridge, Nanticoke River, Sharptown, MD	2
Route 3A Bridge, Weymouth Fore River, Quincy, MA	2
Route 50 Bridge, Nanticoke River, Vienna, MD	2
Sidney Lanier Bridge, AICW, Brunswick, GA	2
Smallhouse Railroad Bridge, MM-79.7, Green River, South Carrollton, KY	2
Southern Railroad Bridge, MM-470.7, Tennessee River, Chattanooga, TN	2
Spokane Street Bridge, Duwamish River, Seattle, WA	2
Spokane Street Railroad Bridge, Duwamish River, Seattle, WA	2
State Highway Bridge, MM-725.8, Upper Mississippi River, Winona, MN	2
Steubenville Highway Bridge, MM-68, Ohio River, Steubenville, OH	2
Summer Street Bridge, Boston, MA	2
Sunset Beach Swing Bridge, AICW, Sunset Beach, NC	2
T, C & W Railroad Bridge, MM-14.3, Minnesota River, Savage, MN	2

Name of Bridge	Number of Allisions
Tucannon Railroad Bridge, MM-61.8, Snake River, Tucannon, WA	2
Union Pacific Railroad Bridge, Aberdeen, WA	2
Valentine Bridge, Bayou Lafourche, Valentine, LA	2
Victoria Island Bridge, Sacramento River, Antioch, CA	2
Vilano Beach Bridge, AICW, Vilano Beach, FL	2
Winfield Highway Bridge, MM-32, Kanawha River, Winfield, WV	2
100th Street Bridge, Calumet River, Chicago, IL	1
10th Street Bridge, Manitowoc River, Manitowoc, WI	1
16th Avenue Bridge, Duwamish River, Seattle, WA	1
17th Avenue Bridge, Miami River, Miami, FL	1
40th Street Bridge, MM-3, Allegheny River, Pittsburgh, PA	1
4th Street Bridge, MM-1, Licking River, Cincinnati, OH	1
4th Street Bridge, MM-135, Lower Mississippi River, New Orleans, LA	1
6th Street Bridge, Menomonee River, Milwaukee, WI	1
8th Street Bridge, Manitowoc River, Manitowoc, WI	1
A, T & SF Railroad Bridge, MM-181.9, Illinois River	1
ASB Railroad Bridge, MM-365.9, Missouri River, Kansas City, MO	1
Albany Railroad Swing Bridge, Hudson River, Troy, NY	1
Albany-Renssalaer Railroad Bridge, Hudson River, Albany, NY	1
Alford Street Bridge, MM-1.4, Mystic River, Boston, MA	1
Ambridge-Aliquippa Bridge, MM-15, Ohio River, Glenwillard, PA	1
Amelia Island-Kingsley Creek Bridge, AICW, Fernandina Beach, FL	1
Amtrak Bridge, Charles River, Boston, MA	1
Amtrak Railroad Bridge, MM-325, Chicago Sanitary & Ship Canal, Chicago, IL	1
Apalachicola Northern Railroad Bridge, MM-347, GICW, Apalachicola, FL	1
Apalachicola Railroad Bridge, Apalachicola, FL	1
Appomatox Railroad Bridge, Appomatox River, Petersburg, VA	1
Ashland Highway Bridge, MM-323, Ohio River, Ashland, KY	1
Astoria-Megler Bridge, MM-14.5, Columbia River, Astoria, OR	1
Atlantic Avenue Highrise Bridge, MM-744.7, AICW, Jacksonville, FL	1
Atlantic Beach Bridge, Long Island Sound, Long Island, NY	1
Atlantic Beach Causeway Bridge, AICW, Atlantic Beach, NC	1
B & O Railroad Bridge, Cuyahoga River, Cleveland, OH	1
B & O Railroad Bridge, MM-311, Chicago Sanitary & Ship Canal	1
Ballard Bridge, Lake Washington, Seattle, WA	1
Ballard Railroad Bridge, Ballard, WA	1
Bayou Blue (Highway 316) Bridge, GICW, Houma, LA	1
Bayou Pigeon Bridge, MM-41, GICW, Pigeon, LA	1
Bayou Portage Bridge, Pass Christian, MS	1
Beaufort High Rise Bridge, Newport River, Beaufort, NC	1
Betsy Ross Bridge, Delaware River, Port Richmond, PA	1
Beverly-Salem Bridge, Beverly Harbor, Salem, MA	1
Blackpoint Railroad Bridge, Petaluma River	1
Blynman Bridge, Annisquam River, Gloucester, MA	1
Bourg Lift Bridge, Bourg, LA	1
Brandon Road Bridge, MM-285.8, Des Plaines River, Joliet, IL	1
Brickell Avenue Bridge, Miami River, Miami, FL	1

Name of Bridge	Number of Allisions
Brielle Railroad Bridge, Manasquan Channel, Brielle, NJ	1
Broad Causeway Bridge, AICW, North Miami, FL	1
Broad River Bridge, Beaufort, SC	1
Broadway Bridge, AICW, Daytona, FL	1
Burham Railroad Bridge, Menomonee River, Milwaukee, WI	1
Burlington & Ohio Railroad Bridge, MM-312, Illinois River, Chicago, IL	1
Burlington Northern Railroad Bridge, Ballard Locks, Seattle, WA	1
Burlington Northern Railroad Bridge, MM-328, Columbia River, Pasco, WA	1
Burlington Northern Railroad Bridge, MM-89, Illinois River, Beardstown, IL	1
C & A Railroad Bridge, MM-14, AICW, Chesapeake, VA	1
CSX Railroad Bridge, AICW, Fernandina Beach, FL	1
CSX Railroad Bridge, Big Bayou Canot, Saraland, AL	1
CSX Railroad Bridge, MM-104.8, Apalachicola River	1
CSX Railroad Bridge, Maumee River, Toledo, OH	1
Calhoun-Rumsey Highway Bridge, MM-63.2, Green River, Calhoun, KY	1
Cathlamet Channel Bridge, MM-40, Columbia River, Cathlamet, WA	1
Cedar Street Bridge, MM-161, Illinois River, Peoria, IL	1
Celilo Railroad Bridge, MM-201.3, Columbia River, Wishram, WA	1
Center Street Bridge, Cuyahoga River, Cleveland, OH	1
Centerville Turnpike Bridge, AICW, Chesapeake, VA	1
Central Avenue Bridge, MM-1.3, Kansas River, Kansas City, KS	1
Central Ferry Bridge, MM-83.2, Snake River, Central Ferry, WA	1
Central Gulf Railroad Bridge, MM-167.1, Ouachita River, Monroe, LA	1
Chehalis River Highway Bridge, Aberdeen, WA	1
Chicago & Northwestern Railroad Bridge, MM-3.3, Fox River, Green Bay, WI	1
Chicago Avenue Bridge, North Branch, Chicago River, Chicago, IL	1
Cicero Avenue Bridge, MM-317, Chicago Sanitary & Ship Canal	1
Clark Bridge, MM-202.7, Upper Mississippi River, Alton, IL	1
Columbia Highway 62 Bridge, Chattahoochee River, Columbia, LA	1
Commodore Heim Bridge, Cerritos Channel, Los Angeles, CA	1
Conrail Bridge, Hackensack River, Hackensack, NJ	1
Conrail Bridge, MM-11.8, Monongahela River, Duquesne, PA	1
Conrail Bridge, Mantua Creek, Paulsboro, NJ	1
Conrail Railroad Bridge #308, Rouge River, River Rouge, MI	1
Conrail Railroad Bridge, Indiana Harbor Ship Canal, East Chicago, IN	1
Conrail Railroad Bridge, Indiana Harbor, Gary, IN	1
Conrail Railroad Bridge, MM-604.4, Ohio River, Louisville, KY	1
Cow Bayou Swing Bridge, Cow Bayou, Bridge City, TX	1
Dahoo River Bridge, AICW, Charleston, SC	1
Del Air Railroad Bridge, MM-90.5, Delaware River, Philadelphia, PA	1
Del Miller Bridge, GICW, Corpus Christi, TX	1
Demopolis Highway Bridge, MM-219, Black Warrior River, Demopolis, AL	1
Devalls Bluff Highway Bridge, MM-121.7, White River, Devalls Bluff, AR	1
Dodge Island Bridge, Miami, FL	1
Dow Canal Railroad Bridge, GICW, Freeport, TX	1
Dumbarton SPRR Railroad Bridge, San Francisco Bay, San Francisco, CA	1
E, J, & E Railroad Bridge, Calumet River, Chicago, IL	1

Name of Bridge	Number of Allisions
Ellender Bridge, GICW, Ellender, LA	1
Erie-Jacknife Railroad Bridge, MM-7.7, Hackensack River, Secaucus, NJ	1
Fairfax Dual Bridge, MM-372.6, Missouri River, Kansas City, MO	1
Fairfield Bridge #17, AICW, Belhaven, NC	1
Falgout Canal Bridge, Bayou Lafourche, LA	1
Figure 8 Island Bridge, Wilmington, NC	1
Flagler Beach Bridge, AICW, Flagler Beach, FL	1
Flagler Street Bridge, Miami River, Miami, FL	1
Fore River Bridge, Fore River, Portland, ME	1
Forked Island Bridge, MM-165.8, GICW, Forked Island, LA	1
Fort Madison Highway Bridge, MM-383, Upper Mississippi River, Fort Madison, IA	1
Fort Pierce Bridge, MM-965.8, AICW, Fort Pierce, FL	1
Fort Street Bridge, Rouge River, River Rouge, MI	1
Francis Scott Key Bridge, Patapsco River, Baltimore, MD	1
Fuller Warren (I-95) Bridge, St. Johns River, Jacksonville, FL	1
George Rogers Clark Memorial Bridge, MM-5.3, Tennessee River	1
Gibbstown Bridge, MM-220, GICW, Gibbstown, LA	1
Glasglow Bridge, MM-226.4, Missouri River	1
Golden Gate Bridge, San Francisco Bay, San Francisco, CA	1
Golden Meadow Lift Bridge, Bayou Lafourche, LA	1
Great Egg Inlet Bridge, AICW, Ocean City, NJ	1
Grosse Ile Toll Bridge, Trenton Channel, Riverview, MI	1
Harbor Island Reach Bridge, Duwamish River, Seattle, WA	1
Harris Saxon Bridge, AICW, New Smyrna, FL	1
Hastings Railroad Bridge, MM-813.7, Upper Mississippi River, Hastings, MN	1
Henley Street Bridge, MM-647, Tennessee River, Knoxville, TN	1
High Rise Bridge, AICW, Morehead City, NC	1
High Street Bridge, Alameda, CA	1
Highway 101 Bridge, Grays Harbor, Aberdeen, WA	1
Highway 159, MM-320, Black Warrior River	1
Highway 165 Bridge, MM-110, Ouachita River, Columbia, LA	1
Highway 165 Bridge, MM-88.6, Red River, Alexandria, LA	1
Highway 17 Bridge, Pasquotank River, Elizabeth City, NC	1
Highway 172 Bridge, AICW, Onslow Beach, NC	1
Highway 182 Bridge, GICW, Perdido Pass, Orange Beach, AL	1
Highway 23 Bridge, MM-354, Ohio River, Portsmouth, OH	1
Highway 27 Bridge, MM-469.9, Ohio River, Cincinnati, OH	1
Highway 278 Bridge, AICW, Hilton Head, SC	1
Highway 288 Bridge, MM-401, GICW, Freeport, TX	1
Highway 32 Bridge, Albemarle Sound, Edenton, NC	1
Highway 331 Bridge, Choctawhatchee Bay, Point Washington, FL	1
Highway 4 Bridge, Old River, Discovery Bay, CA	1
Highway 402 Bridge, AICW, Titusville, FL	1
Highway 453 Bridge, MM-25.2, Tennessee River	1
Highway 521 Bridge, San Bernard River, Freeport, TX	1
Highway 63 Bridge, MM-791, Upper Mississippi River, Red Wing, MN	1
Highway 70 Bridge, MM-90.4, Ohio River, Wheeling, WV	1

Name of Bridge	Number of Allisions
Highway 73 Causeway Bridge, Sabine River, Port Arthur, TX	1
Highway 80 Bridge, MM-3, Yahzoo River, Vicksburg, MS	1
Highway 82 Bridge, MM-94.8, Chattahoochee River, Eufala, AL	1
Highway 82 Bypass Bridge, MM-314.5, Black Warrior River, Tuscaloosa, AL	1
Highway 90 Bridge, Bayou Savage, New Orleans, LA	1
Highway 90 Draw Bridge, Gautier, MS	1
Highway Bridge, MM-228, Illinois River, LaSalle, IL	1
Hood Canal Bridge, Hood Canal, WA	1
Houma Twin Span Bridge, MM-58, GICW, Houma, LA	1
Hutchinson Parkway Bridge, Hutchinson River, Bronx, NY	1
I-10 Bridge, Neches River, Beaumont, TX	1
I-10 Bridge, San Jacinto River, Houston, TX	1
I-20 Highway Bridge, MM-435.8, Lower Mississippi River, Vicksburg, MS	1
I-24 Dual Bridges, MM-28, Cumberland River, Nashville, TN	1
I-24 Bridge, MM-21.1, Tennessee River	1
I-24 Highway Bridge, MM-940-8, Ohio River, Paducah, KY	1
I-275 Bridge, Hillsborough River, Tampa, FL	1
I-275 Highway Bridge, MM-491.5, Ohio River, Lawrenceburgh, IN	1
I-471 Bridge, MM-470, Ohio River, Cincinnati, OH	1
I-520 Floating Bridge, Lake Washington, Seattle, WA	1
I-58 Bypass Bridge, Blackwater River, Franklin, VA	1
I-64 (Sherman Minton) Bridge, MM-608.6, Ohio River, Louisville, KY	1
I-695 Bridge, Patapsco River, Baltimore, MD	1
I-77 Bridge, MM-63.5, Kanawha River, Charleston, WV	1
I-80 Highway Bridge, MM-495.4, Upper Mississippi River, Davenport, IA	1
I-90 Highway Bridge, MM-701, Upper Mississippi River, Lacrosse, WI	1
Illinois Central Railroad Bridge, MM-952, Lower Mississippi River	1
Isle Of Palms Connector Bridge, MM-458.9, AICW, Mount Pleasant, SC	1
JJ Railroad Bridge, AICW, Titusville, FL	1
James Island Bridge, Charleston Harbor, Charleston, SC	1
Joliet Railroad Bridge, MM-287.6, Des Plaines River, Joliet, IL	1
Judge Perez Bridge, Belle Chasse, LA	1
Kelley Memorial Drawbridge (Route 50), Chincoteague, VA	1
L & L Railroad Bridge, Lower Mississippi River, New Orleans, LA	1
Lacon Highway Bridge, MM-189, Illinois River, Lacon, IL	1
Lafayette Bridge, MM-838.7, Upper Mississippi River, St. Paul, MN	1
Lake State Railroad Bridge, Saginaw River, Detroit, MI	1
Lapalco Drawbridge, MM-98, GICW, Harvey, LA	1
Lockwood Street Bridge, Buffalo Bayou, Houston, TX	1
Loop Parkway Draw Bridge, Long Island Sound, Long Island, NY	1
Low Level Bridge, Chesapeake Bay Bridge Tunnel, Fishermans Island, VA	1
Lower Hackensack Bridge, Hackensack River, Hackensack, NJ	1
Lucy J. Lewis Memorial Bridge, MM-3, Cumberland River	1
Lyons Ferry Bridge, MM-58, Snake River, Snake River, WA	1
Madison Highway Bridge, MM-557.3, Ohio River, Madison, IN	1
Main Street Bridge, St. Johns River, Jacksonville, FL	1
Mansfield Highway Bridge, MM-16.6, Monongahela River, Dravosburg, PA	1

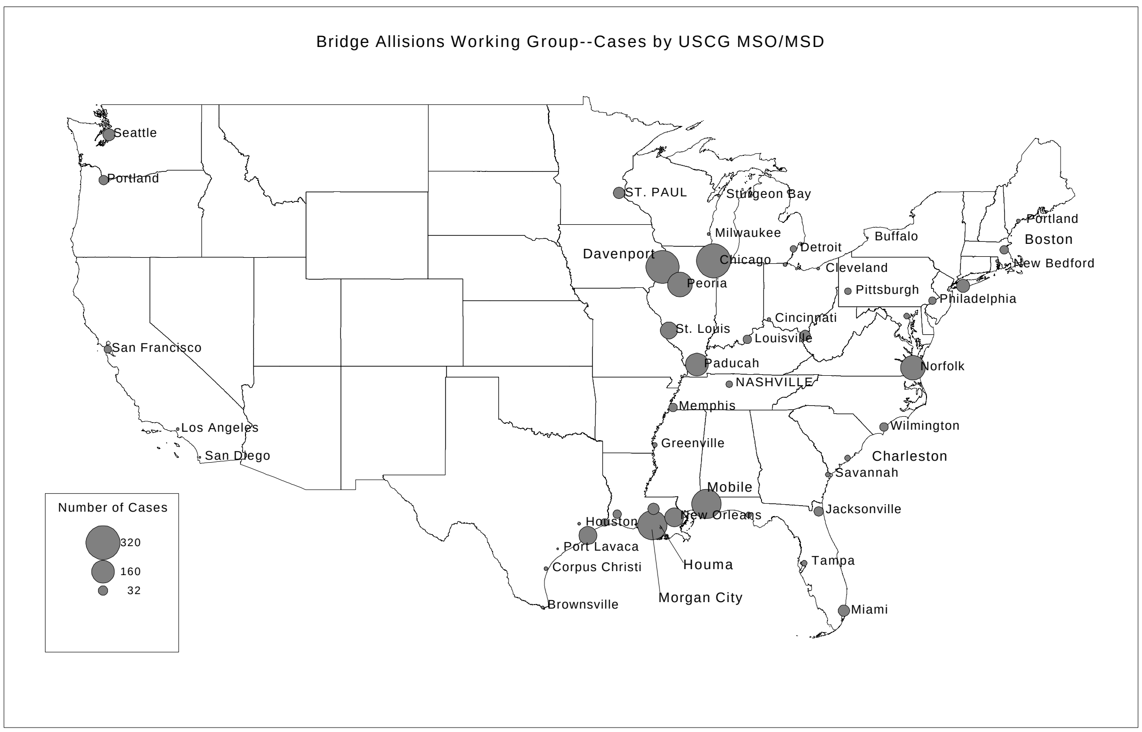
Name of Bridge	Number of Allisions
Margate Bridge, AICW, Margate City, NJ	1
Marietta-Williamston Highway Bridge, MM-171.8, Ohio River, Marietta, OH	1
Market Street Bridge, Christina River, Wilmington, DE	1
Marley Railroad Bridge, MM-57, Port Allen Route, Baton Rouge, LA	1
Martin Luther King Bridge, MM-180, Upper Mississippi River, St. Louis, MO	1
Martin Luther King Bridge, Sabine River, Port Arthur, TX	1
Matagorda Swing Pontoon Bridge, MM-440, GICW, Matagorda, TX	1
Maxine Mine Bridge, MM-397, Black Warrior River	1
McArthur Railroad Bridge, MM-179.3, Upper Mississippi River, St. Louis, MO	1
Meadowbrook Parkway Bridge, Jones Inlet, Long Island, NY	1
Memorial Bridge, MM-155, Ohio River, St. Marys, WV	1
Mermentau River Railroad Bridge, Mermentau, LA	1
Metro Rail Bridge, Miami River, Miami, FL	1
Million Dollar Bridge, Portland, ME	1
Milton Bridge, MM-32, Vermillion River, Milton, LA	1
Milwaukee Hoan Bridge, Milwaukee Inner Harbor, Milwaukee, WI	1
Missouri Railroad Bridge, MM-114.5, Ouachita River	1
Mokelumne Bridge, Sacramento River, Isleton, CA	1
Montauk Point Bridge, Hutchinson River, Bronx, NY	1
Montgomery Highway Bridge, MM-85.8, Kanawha River, Montgomery, WV	1
N & W Railroad Bridge, Maumee River, Toledo, OH	1
Nassau Sound Bridge, AICW, Nassau Sound, FL	1
Neponset River Railroad Bridge, Neponset River, Boston, MA	1
New Bedford-Fairhaven Bridge, New Bedford, MA	1
New Jamestown Bridge, Narragansett Bay, Jamestown, RI	1
Nitro-St. Albans Bridge, MM-43, Kanawha River, St. Albans, WV	1
Norfolk & Southern Railroad Bridge, MM-315, Ohio River, South Point, OH	1
Norfolk & Western Lift Bridge, Elizabeth River, Chesapeake, VA	1
Norfolk & Western Railroad Bridge #7, Elizabeth River, Chesapeake, VA	1
North Avenue Bridge, North Branch, Chicago River, Chicago, IL	1
North Landing Highway Bridge, AICW, Virginia Beach, VA	1
Northwestern Pacific Railroad Bridge, Petaluma River, Petaluma, CA	1
O'Neil Highway Bridge, MM-256.4, Tennessee River	1
Oakland Bay Bridge, B-C Span, Oakland, CA	1
Oakmont Highway Bridge, MM-12, Allegheny River, Oakmont, PA	1
Old River Railroad Bridge, Benicia, CA	1
Onslow Beach Swing Bridge, Onslow Beach, NC	1
Oregon Street Bridge, Oshkosh, WI	1
Orwood Santa Fe Railroad Bridge, Sacramento River, Rio Vista, CA	1
Outerbridge Crossing Bridge, Arthur Kill, Staten Island, NY	1
Passyunk Avenue Bridge, Schuykill River, Philadelphia, PA	1
Peace Bridge, Black Rock Canal, Buffalo, NY	1
Pierre Part Bridge, Bayou Maringouin, Pierre Part, LA	1
Prospect Avenue Bridge, MM-53.5, GICW, Houma, LA	1
Pungo Ferry Bridge, AICW, Virginia Beach, VA	1
Quarrier Street Bridge, MM-1, Elk River, Charleston, WV	1
R. V. Woods Bridge, Beaufort, SC	1

Name of Bridge	Number of Allisions
Railroad Bridge, Duwamish River, Seattle, WA	1
Railroad Bridge, MM-119, Arkansas River, Little Rock, AR	1
Railroad Bridge, MM-170, Ouachita River	1
Raritan River Bridge, Raritan River, Perth Amboy, NJ	1
Rice Creek Bridge, St. Johns River, Palatka, FL	1
Robert Michael Bridge, MM-162.1, Illinois River	1
Rock Island Railroad Bridge, MM-118.2, Arkansas River, Little Rock, AR	1
Route 136 Bridge, Norwalk River, Norwalk, CT	1
Route 836 Overpass Bridge, Miami River, Miami, FL	1
Ruby Street Bridge, MM-288.7, Des Plaines River, Joliet, IL	1
SL & SF Railroad Bridge, MM-220, Black Warrior River	1
San Jacinto River Railroad Bridge, San Jacinto River, Houston, TX	1
San Mateo-Hayward Bridge, San Francisco Bay, San Francisco, CA	1
Santa Fe Railroad Bridge, MM-315, Chicago Sanitary & Ship Canal	1
Sarah Long Bridge, Piscataqua River, Portsmouth, NH	1
Sawpit Creek Bridge, AICW, Nassau Sound, FL	1
Sea Island Bridge, St. Simons Island, GA	1
Shortcut Railroad Bridge, Rouge River, River Rouge, MI	1
Sidney C. Lewis Highway Bridge, MM-88.8, Tennessee River, Dover, TN	1
Simmesport Highway Bridge, MM-5, Atchafalaya River, Simmesport, LA	1
Skull Creek Bridge, Hilton Head, SC	1
Sloop Channel Bridge, Freeport, NY	1
South Park Bridge, MM-5.2, Buffalo River, Buffalo, NY	1
South Quay (Highway 189) Bridge, Blackwater River, South Quay, VA	1
Southern Pacific Railroad Bridge, Calcasieu River, Lake Charles, LA	1
Southern Pacific Railroad Bridge, Coos Bay, OR	1
Southern Pacific Railroad Bridge, Entrance To Buffalo Bayou, Houston, TX	1
Southern Railroad Bridge, MM-248.5, Tombigbee River	1
Southport Bridge, Boothbay Harbor, Southport, ME	1
St. Claude Avenue Bridge, Industrial Canal, New Orleans, LA	1
St. Georges Bridges, C & D Canal, St. Georges, DE	1
St. Lucie Railroad Bridge, AICW, St. Lucie, FL	1
Stephenville Pontoon Bridge, Bayou Milhomme, Stephenville, LA	1
Sterlington Bridge, MM-192, Ouachita River, Sterlington, LA	1
Summit Bridge, MM-313, Illinois River, Summit, IL	1
Sunrise Boulevard Bridge, AICW, Fort Lauderdale, FL	1
Surfside Bridge, GICW, Freeport, TX	1
TX-LA Causeway Bridge, Sabine River, Port Arthur, TX	1
Tacony-Palmyra Bridge, Delaware River, Philadelphia, PA	1
Tappan Zee Bridge, Hudson River, Tarrytown, NY	1
Tensas River Railroad Bridge, MM-20, Tensas River, Stockton, AL	1
Thomas Rhodes Highway Bridge, MM-27, Cape Fear River, Wilmington, NC	1
Townsend Inlet Bridge, AICW, Townsend Inlet, NJ	1
Union Pacific Railroad Bridge, MM-196.3, White River, New Augusta, AR	1
Union Pacific Railroad Bridge, MM-227, Red River, Shreveport, LA	1
Union Terminal Bridge, Cuyahoga River, Cleveland, OH	1
Veterans Memorial Bridge, MM-464.5, Tennessee River, Chattanooga, TN	1

Name of Bridge	Number of Allisions
Vincent Thomas Bridge, Los Angeles Harbor, Los Angeles, CA	1
Wallops Island Bridge, AICW, Wallops Island, VA	1
Walter Groves Bridge, AICW, Hilton Head, SC	1
Washington Street Bridge, Norwalk River, Norwalk, CT	1
Water Street Bridge, Milwaukee River, Milwaukee, WI	1
West Bay Bridge, Quantuck Canal, West Hampton Beach, NY	1
West End Bridge, MM-310.9, Ohio River, Huntington, WV	1
West Seattle High Rise Bridge, Seattle, WA	1
Western Electric Bridge, Passaic River, Passaic, NJ	1

The map below shows the bridge allisions aggregated by Coast Guard Marine Safety Office/Marine Safety Detachment. The size of the circle marking the unit's headquarters is proportional to the number of allisions.

Figure 1: Bridge Allisions by Coast Guard Marine Safety Office/Detachment



Bridge Allisions by Total Damage

AWO and Coast Guard staff hypothesized that the geographic distribution of damage amounts could provide an indicator of areas of interest. The map on the next page shows the monetary damages for each allision aggregated by Coast Guard Marine Safety Office/Marine Safety Detachment:

Figure 2: Bridge Allisions by Total Damage

Bridge Allision Working Group -- U.S.C.G. Data File

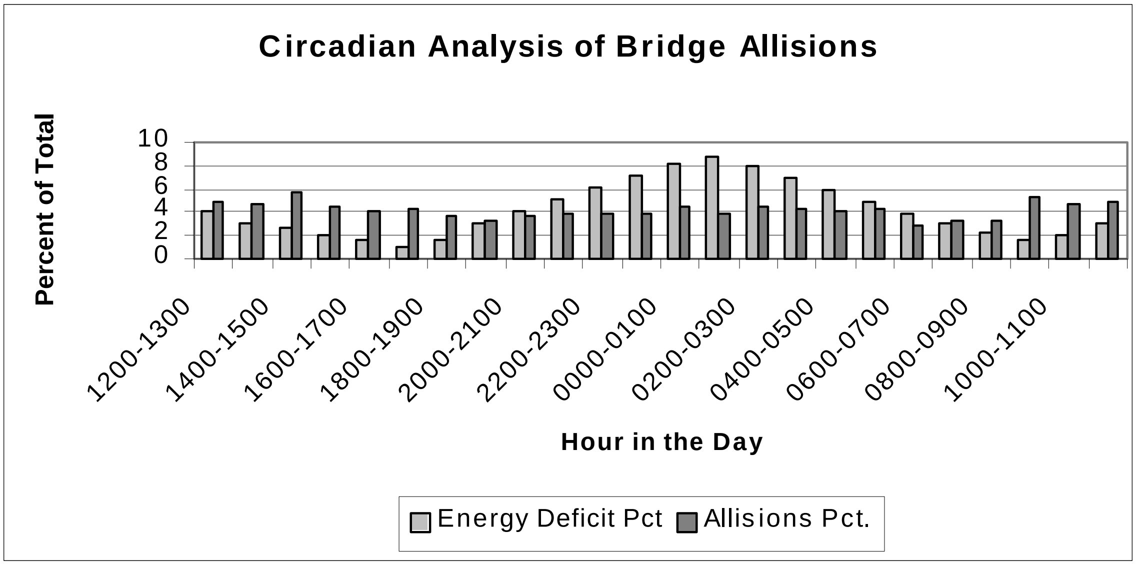
The map shows that the unit with the largest damage is Charleston, followed by New Orleans, Paducah, and Chicago. Examination of the data showed that one very costly incident, or a few incidents with significant damages, skewed the results. Coast Guard and AWO staff agreed that this analysis did not suggest useful areas for further research.

Circadian Cycle

Medical literature documents the changes in human performance levels that occur throughout the day as a result of circadian cycles. The Coast Guard and AWO staff hypothesized that if there was a circadian component in the causes of bridge allisions, then it could be tested as a correlation between circadian lows -- the times of the day with low energy levels -- and the times when the allisions occurred.

An “energy deficit” was derived for each hourly interval in the day and then that interval’s percent of the total deficit was calculated. The percentage of bridge allisions occurring in the same intervals was also calculated. This provided two similar rates that were input into a statistical correlation analysis. The results strongly indicated no correlation. The chart on the next page shows each percentage as separate bars. If there was a circadian effect, then the lengths of the bars would be approximately the same at each interval.

Figure 3: Circadian Analysis of Bridge Allisions



As the chart shows, for some intervals the allisions percentage is greater than the energy deficit, for others the energy deficit is greater, and rarely are the two close.

Similar analyses were run independently for each year. The results were inclusive for all years, except for one which showed a weak negative correlation -- the opposite of the hypothesis. Thus, this high-level analysis yielded no indication, in the aggregate, of a relationship between circadian rhythm and bridge allisions. This does not rule out the possibility of environmental factors or fatigue in particular circumstances or in a subset of the cases.

Type of Vessel

The case database was linked to the Corps of Engineers' fleet data file (*Waterborne Transportation Lines of the U.S.*) by the common vessel identification code. Various tabulations and cross-tabulations were generated for the characteristics of the towboats/tugboats involved. The tables below are the high-level distributions for registered gross tons, length, draft, horsepower, and age.

Table 1: Registered Gross Tons

Gross Tons	Number of Tow/Tugboats	Percent
Missing	59	2.0
1-250	1,649	57.2
251-500	428	14.9
501-750	559	19.4
751-1,000	152	5.3
1,001 +	36	1.2
Total	**2,883**	**100.0**

Table 2: Registered Length

Length in Feet	Number of Tow/Tugboats	Percent
Missing	58	2.0
1-100	1,703	59.1
101-150	856	29.7
151 +	266	9.2
Total	**2,883**	**100.0**

Table 3: Registered Draft

Draft in Feet	Number of Tow/Tugboats	Percent
Missing	60	2.1
1-9	1,361	47.2
9.1-10	848	29.4
10.1-11	296	10.3
11.1 +	318	11.0
Total	**2,883**	**100.0**

Table 4: Horsepower

Horsepower	Number of Tow/Tugboats	Percent
Missing	330	11.4
1-1,000	566	19.6
1,001-2,500	887	30.8
2,501-5,000	816	28.3
5,001 +	284	9.9
Total	**2,883**	**100.0**

Table 5: Age

Age	Number of Tow/Tugboats	Percent
Missing	327	11.3
40+	368	12.8
30-39	721	25.0
20-29	1,289	44.7
Under 20	178	6.2
Total	**2,883**	**100.0**

(1) Age is calculated from year built or year rebuilt.

As the above data indicate, the characteristics of the towing vessels involved in bridge allisions are as varied as those of the entire fleet. AWO and Coast Guard staff examined these and other tabulations and cross-tabulations and found nothing that indicated that a particular type of vessel was more likely to be involved in a bridge allision. More sophisticated statistical analyses could possibly discover some correlations, but the Work Group concluded that there were more important lines of analysis to pursue at this time.

APPENDIX 3
TRUMAN-HOBBS BRIDGES

Authority

Authority to order the alteration of unreasonably obstructive bridges to meet the reasonable needs of navigation pursuant to the Truman-Hobbs Act was transferred to the Secretary of Homeland Security by Section 1512(d) of the Homeland Security Act of 2002. This authority was subsequently delegated by the Secretary to the Commandant of the U.S. Coast Guard on February 28, 2003. The Commandant, represented by the Chief, Office of Bridge Administration (G-OPT), is responsible for overall management of the alteration program for unreasonably obstructive bridges, including planning, programming and budgeting; legal interpretations whenever such questions arise; and technical engineering assistance necessary in any portion of the program. The laws relating to unreasonably obstructive bridges across the navigable waters of the United States are contained in the following statutes:

1) The Rivers and Harbors Appropriations Act of 1899, Section 18 (30 Stat. 1153; 33 USC 502).

2) The Bridge Act of 1906, Sections 4 and 5 (34 Stat. 85; 33 USC 494-495).

3) The Act of June 21, 1940, as amended (Truman-Hobbs Act) (54 Stat. 497; 33 USC 511-523).

Policy

Coast Guard regulations pertaining to the administration of these statutes are found in Part 116 of Title 33, Code of Federal Regulations.

Coast Guard policy is to ensure that bridges that cross the navigable waters of the United States do not unreasonably obstruct the reasonable needs of waterway traffic. To maintain navigation safety and freedom of mobility, the Truman-Hobbs Act is administered by the Commandant to ensure that bridges provide sufficient clearances for the types of vessels that transit through the bridge site. In the implementation of this policy and in determining what action may be appropriate, the following general guidelines are used:

1) All bridges constructed across the navigable waters of the United States are considered obstructions to navigation tolerated only so long as they serve the needs of land transportation while still providing for the **reasonable** needs of navigation.

2) Only the location and vertical and horizontal navigation clearances of a bridge's navigational opening(s) affect its eligibility for alteration under the Truman-Hobbs Act. The structural integrity of a bridge or its adequacy for land transportation, while valid concerns of a bridge owner, have no bearing on the determination that a bridge unreasonably obstructs navigation.

3) The Truman-Hobbs Act applies only to actively used bridges. Bridges that have been abandoned or that are no longer being used for transportation purposes should be removed at the expense of the owner (33 CFR 116).

4) The Coast Guard may determine a bridge to be unreasonably obstructive to navigation if the navigational benefits that would accrue as a result of altering the bridge equal or exceed the cost of the bridge alteration.

5) Complaints by land transportation interests concerning delays or impediments to highway or rail traffic are not valid complaints under the provisions of the Truman-Hobbs Act, and may not be used as reasons to declare a bridge an unreasonable obstruction to navigation.

The Truman-Hobbs Team

On October 1, 1999, the Coast Guard program for conducting Truman-Hobbs investigations was centralized in the St. Louis, Missouri, Bridge Office (CGD8(obr)) to maximize the use of limited program resources. The CGD8(obr) Truman-Hobbs (T-H) Team is responsible for administering Truman-Hobbs investigations nationwide in conjunction with local district support and policy guidance from and oversight by the Commandant (G-OPT).

Investigation

The Commandant (G-OPT) solicits district bridge office input for a Truman-Hobbs Backlog Priority List that ranks bridges as potential candidates for investigation and alteration under the Truman-Hobbs Act by using an average point scoring system with the following criteria:

1) Complaints, i.e., type and number.

2) Allisions, i.e., number of hits, amount of monetary damages. In the absence of complaints, the district may use its discretion in determining whether a bridge's allision history warrants initiating a preliminary investigation.

3) Economic Value, i.e., vessel transit times and the cost, type, and tonnage of products or services that transit the bridge.

4) Clearance, i.e., adequacy of vertical and horizontal navigation clearances, angle of navigation span, bridge channel width, and pier locations.

5) Critical Waterway, i.e., significance of waterway's role in the national transportation infrastructure in terms of the economy, intermodal safety, and/or national security.

6) Water Flow, i.e., currents, tides, snowmelts.

7) Geographic Location, i.e., in relation to bends and/or nearby bridges and difficulty in transit lineups.

8) Vessels, i.e., specific types, numbers, and/or their size.

9) Cargo Type, i.e., types of cargo and their tonnage.

Overview of the Investigation Process

1) Upon receipt of complaints that a bridge is unreasonably obstructive or based on the bridge's allision history, the district will determine which bridges to recommend to Commandant (G-OPT) for further study under the Truman-Hobbs Act. The district's opinion as to whether or not the complaint warrants additional study will be formed through informal discussions with the complainant, users of the affected waterway, and other interested parties.

2) All decisions to conduct, or not conduct, a preliminary investigation shall be based on the criteria outlined above by the Commandant (G-OPT), which will add the bridge in question to a Truman-Hobbs Priority Backlog List. This priority list is used by the T-H Team for further investigation as available resources permit.

3) Before conducting a preliminary investigation, the T-H Team will notify the local District Commander and coordinate with the local district bridge office for assistance as needed. Upon completion of the preliminary investigation, the report will be signed by the preparer (Chief, T-H Team) and submitted by the district to the Commandant (G-OPT). If there is insufficient reason for pursuing a more detailed investigation, the Commandant (G-OPT) will inform the T-H Team and the concerned district, which will inform the complainant. The district will also make the complainant aware of the appeals process available.

4) The Commandant (G-OPT) will review the preliminary investigation report, with due consideration given to the district's recommendation, to determine whether there is sufficient reason for the T-H Team to pursue a more detailed investigation, including a public hearing. The local district bridge office will continue to assist the T-H Team as needed.

5) Upon completion of the detailed investigation, the report will be signed by the preparer (Chief, T-H Team) and submitted by the district to the Commandant (G-OPT). The Commandant (G-OPT) will analyze the detailed investigation report, with due consideration given to the district's recommendation, to determine whether the navigation benefit to be obtained from altering the bridge in question will support a benefit/cost ratio equal to or greater than 1.00:1.00. If so, the Commandant (G-OPT) will provide the bridge owner with written notification of a pending Order to Alter. The bridge owner will have 60 calendar days to provide the Commandant (G-OPT) with written reasons in opposition to an Order to Alter. If the bridge owner objects, Commandant (G-OPT) has 90 calendar days to reevaluate and make a decision based on additional information submitted by the bridge owner.

6) The Commandant signs the Order to Alter. The original document will be hand-delivered to the bridge owner by the T-H Team leader.

7) After the Order to Alter is served on the bridge owner, the Commandant (G-OPT) will provide the bridge owner with a letter of technical engineering instructions.

8) The Commandant (G-OPT) supervises the bridge alteration project through completion.

<u>Funding</u>

Apportionment of Cost

From 33 USC 516:

> At the time the Secretary of Homeland Security shall authorize the bridge owner to proceed with the project and after an opportunity to the bridge owner to be heard thereon, the Secretary shall determine and issue an order specifying the proportionate shares of the total cost of the project to be borne by the United States and by the bridge owner. Such apportionment shall be made on the following basis:
>
> The bridge owner shall bear such part of the cost as is attributable to the direct and special benefits which will accrue to the bridge owner as a result of the alteration, including the expectable savings in repair or maintenance costs; and that part of the cost attributable to the requirements of traffic by railroad or highway, or both, including any expenditure for increased carrying capacity of the bridge, and including such proportion of the actual capital cost of the old bridge or of such part of the old bridge as may be altered or changed or rebuilt, as the used service life of the whole or a part, as the case may be…The United States shall bear the balance of the cost, including that part attributable to the necessities of navigation…

Payment of Share of United States

From 33 USC 517:

> Following service of the order requiring alteration of the bridge, the Secretary of Homeland Security may make partial payments as the work progresses to the extent that funds have been appropriated. The total payments out of Federal funds shall not exceed the proportionate share of the United States of the total cost of the project paid or incurred by the bridge owner, and, if such total cost exceeds the cost guaranteed by the bridge owner, shall not exceed the proportionate share of the United States of such guaranteed cost, except that if the cost of the work exceeds the guaranteed cost by reason of emergencies, conditions beyond the control of the owner, or unforeseen or undetermined conditions. All payments to any bridge owner herein provided for shall be made by the Secretary of the Treasury through the Fiscal Service upon certifications of the Secretary of Homeland Security.

Current Status

Currently there are 14 bridge projects undergoing alteration, with a total funding liability of $516 million. Of this amount, the U.S. government share is estimate at $432 million. Thus far, $148 million has been appropriated. The entire $148 million has been obligated to specific projects. Future funding needs are placed at $284 million. The average annual amount that the Coast Guard received from 1991 to 2002 was $11.58 million. In 1995, the program received no funding; in 1997, the Coast Guard received $42.8 million, the largest amount received during this period.

APPENDIX 4
SAMPLING METHODOLOGY

The Work Group determined that it did not have sufficient resources to read and analyze all 2,692 bridge allisions cases individually. Instead, the Group decided to generate a manageable subset for review by teams of industry experts. The sampling process involved three steps: 1) defining the sampling criteria, 2) selecting the sample size, and 3) reviewing and refining the results.

In a September 20, 2002 teleconference, the Group decided to organize the cases by a cross-classification of severity class by region. The severity class is a measure of the impact of the accident. Table 1 lists the five severity classes, their definitions, and the number of allisions in each class.

Table 1: Severity Classes

Class	Definition	Count
0	Damage recorded as "None or Not Specified."	1,702
1	Damage between \$1 and \$25,000.	610
2	Damage between \$25,001 and \$100,000.	220
3	Damage between \$100,001 and \$500,000.	99
4	One or more of: damage > \$500,000; loss of life > 0; injured > 0; missing > 0; oil spilled.	61

A review of a few cases in Severity Class 0 showed that in some cases "None or Not Specified" was recorded as the damage because estimates from the state or local transportation agency were not available at the time the Coast Guard casualty report was filed. Addenda then provided damage amounts ranging up to \$87,000. Thus, Severity Class 0 is not homogenous and should not be interpreted as including only cases with trivial damages. As will be explained later, this finding had an impact on the sampling rate.

The Group designated six regions: Atlantic, Ohio Valley, Upper Mississippi, Lower Mississippi, Gulf, and Pacific. Table 2 lists the regions, their definitions, and the number of allisions in each region. The definitions are based on a review of the water body names in the source data file from the Coast Guard.

Table 2: Regions

Region	Definition	Count
Atlantic	All waters in ME, NH, MA, RI, CT, NY, NJ, MD, DE, VA, NC, SC, & GA; in PA, the Delaware & Schuylkill Rivers; and in FL ports and rivers from Jacksonville to Key West.	444
Gulf	All waters in TX; in LA all waters identified on the Gulf; in MS, all waters other than Mississippi and Yahzoo (sic) Rivers; in AL, other than Tennessee River; and in FL, all waters emptying into the Gulf.	596
Lower Miss.	All waters in AR & OK; in LA all non-Gulf; in TN, the Mississippi River.	299
Ohio Valley[1]	All waters in WV, IL, IN, KY; in TN other than Mississippi River.	814
Pacific	All waters in WA, OR, & CA.	113
Upper Miss.	All waters in WI, MN, MI, IA, KS, MO.	426
Total		**2,692**

The Group decided to review all of the 160 cases in Severity Classes 3 and 4. The next issue was to decide the sample size for each cross-classification of Severity Classes 0, 1, and 2 by region.

For populations with known characteristics, such as the U.S. population, the selection of a sample size is fairly straightforward. It is guided by factors such as cost, degree of precision required, time available, and variables of interest such as race, age, and gender. This case was more complicated because the Group was dealing with a population (the universe of bridge allisions) about which little was known. Three factors guided the selection of the sample size. The first was to get a sample of at least five cases in each cross-classification or cell. This would enable application of some statistical tests after the results were returned.

The second factor involved the aforementioned unreported damage amounts in Severity Class 0. To compensate for these problems, a sample rate was chosen that would enhance the probabilities of accurately representing the full range of damage in each cell.

Available time for the reviewers was the third factor. The Group decided that the reviews should be completed and returned in approximately six weeks to enable compilation and presentation of results at the November 14, 2002 meeting. Given the job responsibilities of the reviewers, the number of cases needed to be small enough that they could devote sufficient time to each one and yet large enough to yield meaningful results. As the cell sizes ranged from 11 to 668, a sample rate for each cell was chosen that would generate a representative sample for the cell **and**

[1] The Illinois River, Calumet River, Des Plaines River, and Indiana Harbor Ship Canal should have been assigned to the Upper Mississippi River (UMR) region. After the sample cases were selected, 52 cases from these waterways were transferred to the UMR region subgroup for review.

keep the total for the region at a manageable level. Table 3 presents the cross-classification table, each cell population, and the initial sample rate.

Table 3: Severity/Region Counts and Sample Rates

Class & Definition	Atlantic	Gulf	Lower Miss	Ohio Valley	Pacific	Upper Miss	**Total**
0: Non or Not Spec.	268 10%	386 10%	173 15%	563 5%	68 20%	244 10%	**1,702**
1: $1-$25,000	107 15%	132 15%	65 15%	151 15%	30 30%	125 15%	**610**
2: $25,001-$100,000	37 20%	47 20%	26 30%	62 20%	11 75%	37 20%	**220**
3: $100,001-$500,000	21 100%	21 100%	13 100%	28 100%	2 100%	14 100%	**99**
4: $500,001+, death, missing, injury, or poll.	11 100%	10 100%	17 100%	15 100%	2 100%	6 100%	**61**
Total	**444**	**596**	**294**	**819**	**113**	**426**	**2,692**

The sample cases were selected by a computer program that utilized a random number generator function. Each case in the universe was a record in the input file. A record/case was read and if the severity class was 3 or 4, then the record was output to the review file. For records/cases with severity classes 0, 1, or 2, the random number generator function was run, yielding a number from 0 to 1, with all numbers having equal chance of appearing. The number was compared to the selection percentage for the particular record's cell and if the random number was less than or equal to the selection percentage, then the record was output to the review file.

For example, consider a record in the Atlantic Region with Severity Class 0. This cell has a selection rate of 10%. Assume the random number generator produced 0.042. This is less than 0.10, so the record is output to the review file. Assume a second record with the same characteristics, but a random number of 0.683. The random number is greater than 0.10, so it would be discarded.

The use of the random number generator eliminates any human bias in the selection process, but the randomness introduces some imprecision in the control on the sample size. That is, a sampling rate of 10% probably will not yield a sample that is exactly 10% of the cell population.

After the initial round of selections, the sample was calibrated using the distribution of bridges within each region. If the sample was a representative sample, then the percentage of each bridge in the sample from a given region should be roughly the same as its corresponding percentage in the population for the region. The large number of bridges with only a few allisions introduces a range of imprecision in this comparison. For example, a bridge with only one allision may represent a small percentage of the region's population, possibly less than 1%. If by chance it is selected, it may represent 3% of the sample, a three-fold overweighting. This phenomenon is known to statisticians as "the tyranny of small numbers" and cannot be avoided in the case of bridge allisions, because a partial case does not exist.

The calibration review detected three bridges that were significantly under-represented. A second sample was executed on these three bridges, resulting in an additional nine cases. These were added to the original sample. The final sample file contained 473 cases. Table 4 is a copy of Table 3, with the inclusion of the number of selected cases in each cell.

Table 4: Severity-Class/Region Counts, Sampling Rate, and Sampled Cases

Class & Definition	Atlantic	Gulf	Lower Miss	Ohio Valley	Pacific	Upper Miss	**Total**
0: Non or Not Spec.	268 10% 23	386 10% 48	173 15% 27	563 5% 24	68 20% 11	244 10% 24	**1,702** **157**
1: $1-$25,000	107 15% 12	132 15% 28	65 15% 11	151 15% 21	30 30% 8	125 15% 24	**610** **104**
2: $25,001-$100,000	37 20% 10	47 20% 7	26 30% 9	62 20% 712	11 75% 7	37 20% 6	**220** **51**
3: $100,001-$500,000	21 100% 21	21 100% 21	13 100% 13	28 100% 28	2 100% 2	14 100% 14	**99** **99**
4: $500,001+, death, missing, injury, or poll.	11 100% 11	10 100% 10	17 100% 17	15 100% 15	2 100% 2	6 100% 12	**61** **61**
Total	**444** **77**	**596** **114**	**294** **77**	**819** **100**	**113** **30**	**426** **74**	**2,692** **472**

The resulting file of sampled cases was divided into separate files for each region and then distributed to the industry members of the Working Group.

APPENDIX 5
CASE REVIEW TAXONOMY FOR BRIDGE ALLISIONS

Case Review Taxonomy for Bridge Allisions

Mishap Category	Mishap	Incident	Initiating Event	Causal Factors	
Piloting				**General**	**Sub-Cat**
	Maneuv. Errors			Human Performance	Excessive Workload
		Improper Turn			Complacency
		Improper Course	Emergency Maneuver		Fatigue
		Improper Speed	Inattention		Personal Stress
		Unknown	Wrong Decision		Substance Abuse
			Wrong SitAssessment		Work Environment
			Unknown		Workplace Design
	Nav Equip Failure			Task Performance	Deliberate Action
	(Hardware)	GPS Failure			Distraction
		Gyro Failure	General Failure		Inadequate Experience
		Radar Failure	Electrical Failure		Inadequate Information
		Radio Failure	Unknown		Inadequate Procedures
		Other Gen. Equipment			Inadequate Training
		Unknown			Inadequate Planning/Preparation
Operations					Inadequate Policies
	Navigation Aids				Inadequate Qualification
	Bridge Tender	Breakaway Barge			Judgement Error
	Underpowered	Grounding	Lashing Failure		Law Violation
	Unusual Event	Collision	Unusual Event		Poor Execution
		Unknown	Improper BargeLoading		Poor Procedures
			Improper BargeConfigure		Poor Supervision
			Channel Problem		Procedures Ignored
			Unknown		Sabotage

Propulsion System

- Engine Failure
  - Control Failure
  - Cooling System Failure
  - Exhaust System Failure
  - Fuel System Failure
  - Lubrication Failure
  - Mechanical Failure
  - Unknown

  - Automation Failure
  - Collision
  - Debris
  - Electrical Failure
  - Filter Failure
  - Grounding
  - High Pressure
  - Line clog
  - Line Rupture
  - Fire
  - Flood
  - Low Pressure
  - Unknown

- Power Xmsn Failure
  - Propeller Failure
  - Shaft/Brng Failure
  - RedGear Failure
  - Control Failure
  - Unknown

  - Automation Failure
  - Collision
  - Fire
  - Flood

- Equipment Operation
  - Improper Installation
  - Improper Maintenance
  - Inadequate Design
  - Inadequate Maintenance
  - Misuse
  - Poor Design
- External Event
  - Debris
  - Natural Phenomena
  - Weather
  - Other
- Communication
  - Inadequate Communication
  - Misunderstood Communication
  - No Communication

APPENDIX 6
CAUSAL ANALYSIS OF SIGNIFICANT CONSEQUENCE CASES

Introduction: Definitions and Methodology

This Appendix examines the significant consequence cases.

Significant consequence cases are those that have one or more of these characteristics: one or more fatalities, one or more injuries, damage worth $500,001 or more, or pollution incident. There are 61 cases that fall into this category; usable analyses of 51 of these cases were returned by the industry review teams.[1]

The same "drill-down" analysis that was conducted on the dataset of all cases (hereafter referred to as the "master") was replicated for the subset of 51 significant cases. The results of the significant cases subset are remarkably similar to those from the master. The only difference of note is that "weather" appears as a causal factor in 6% of the significant cases subset, whereas it was trivial in the master.

Below are the results from the analyses of the significant cases subset and all cases. Note that the percentage total may not equal 100 due to independent rounding of the components.

Top-Level Analysis

The starting point for the analysis is the first level of accident type, Mishap Category.

Table 1: Mishap Category

	Significant Cases		All Cases	
Mishap Category	Number	Percent	Number	Percent
Piloting Error	35	69	361	78
Operations Error	8	16	54	12
Steering	0	0	12	3
Propulsion System	1	2	8	2
Unknown/Missing Data	7	14	24	5
Total	**51**	**101**	**459**	**100**

The two largest categories, piloting error and operations error, account for 85% of the significant cases and 90% of the master. The absence of steering in the subset is not noteworthy because it is a relatively small amount, 3%, in the master.

[1] Missing files or data entry problems were the reasons for the unusable cases.

Piloting Error Analysis

As piloting error is the largest mishap category in both datasets, the next step was to generate a breakout of the specific mishaps. As the table below shows, maneuvering error accounts for nearly all the mishaps in both the significant cases subset and the master.

Table 2: Piloting Error Mishaps

	Significant Cases		All Cases	
Mishap	Number	Percent	Number	Percent
Maneuvering Error	33	94	359	99
Navigation Equipment Failure	1	3	1	0
Missing	1	3	1	0
Total	**35**	**100**	**361**	**99**

The next level is the composition of the incidents for the piloting error/maneuvering error combination. The top two incidents, improper approach and improper course, account for about 90% of the incidents in both datasets.

Table 3: Piloting Error/Maneuvering Error Incidents

	Significant Cases		All Cases	
Mishap	Number	Percent	Number	Percent
Improper Approach	26	79	263	73
Improper Course	4	12	69	19
Improper Speed	2	6	12	3
Improper Turn	0	0	9	3
Unattended Helm	0	0	3	1
Missing Data	1	3	3	1
Total	**33**	**100**	**359**	**100**

The final level in the accident typology is initiating event. Improper approach and improper course account for 92% of the subset's incidents, so these served as the bases for the breakout for initiating events.

Table 4: Initiating Events for Mishap Category: Piloting Error, Mishap: Maneuvering Error, and Incident: Improper Approach or Improper Course

	Significant Cases		All Cases	
Mishap	Number	Percent	Number	Percent
Wrong Situation Assessment	22	73	241	73
Wrong Decision	7	23	64	19
Inattention	1	3	5	2
Others	0	0	7	2
Missing Data	0	0	14	4
Total	**30**	**99**	**331**	**100**

The review of the cases also included the identification of up to three causal factors for each case. The table below shows the general causal factors for 29 cases with initiating events "wrong situation assessment" or "wrong decision" from the previous table and corresponding cases from the master dataset.

Table 5: Piloting Error/Maneuvering Error/Improper Approach or Course

	Significant Cases		All Cases	
General Causal Factor	Number	Percent	Number	Percent
Task Performance	37	79	451	83
External Event	3	6	56	12
Communications	3	6	18	3
Human Performance	4	9	0	0
Equipment Operations	0	0	2	1
Unknown	0	0	7	1
Total	**47**	**100**	**534**	**100**

For the significant cases subset, the total of the task and human performance causes is 88%, which is reasonably close to the 83% for task performance from the master.

The final drill-down is a breakout of the sub-category causes of the task performance causes. As the table shows, on a percentage basis, the significant cases have an almost identical profile of sub-category causes to the master.

Table 6: Piloting Error/Maneuvering Error/Improper Approach or Course/ Task Performance General Cause

	Significant Cases		All Cases	
General Causal Factor	Number	Percent	Number	Percent
Judgment Error	20	54	248	55
Poor Execution	6	16	90	20
Inadequate Planning/ Prep/Info	5	14	69	15
Others	4	11	39	9
Missing	2	5	5	1
Total	**47**	**100**	**451**	**100**

Through every level of analysis, the piloting errors in the significant cases subset track the corresponding results from the master dataset.

<u>Operations Error Analysis</u>

The analysis of the operations error mishap category follows the same pattern as the one for piloting error. The first breakout is the specific mishaps. Despite the small total for the significant cases subset, the breakouts follow the same general pattern, with unusual event the predominant mishap in both.

Table 7: Operations Error Mishaps

	Significant Cases		All Cases	
Mishap	Number	Percent	Number	Percent
Unusual Event	5	62	36	67
Navigation Aids	2	25	5	9
Bridge Tender	1	13	9	17
Underpowered	0	0	4	7
Total	**10**	**100**	**361**	**100**

With only five cases for unusual event mishaps, this is too small make a meaningful comparison to its counterpart from the master dataset. For the record, the incidents were three breakaway barges and two collisions.

Reaching a dead-end at the accident typology, the next line of analysis is the causal factors. The table below shows the comparison of the general causes breakout.

Table 8: Operations Error/Unusual Event

	Significant Cases		All Cases	
General Causal Factor	Number	Percent	Number	Percent
Task Performance	3	38	9	32
External Event	2	25	9	32
Communications	1	12	2	7
Human Performance	1	12	2	7
Equipment Operations	1	12	2	7
Unknown	0	0	4	14
Total	**8**	**100**	**28**	**99**

Combining the top two causes, task performance and external events, they sum to 63% and 64% for the significant cases subset and master, respectively. The small number of cases in the significant cases subset renders meaningless any comparison of the sub-category breakout for the task performance and external event general causes.

As far as the data allow, the breakouts of the operations errors in the significant cases look very much like the ones from the master dataset.

Conclusion

In both the significant cases subset and the master dataset, the top two mishap categories are piloting error and operations error, with almost identical percentages. The analyses of both the accident typologies and the causal factors show very similar patterns at every level. The statistical evidence indicates that the significant cases have the same causal factors as the non-significant cases. Thus, an optimal strategy will be to reduce all bridge allisions and thereby reduce the number of allisions causing the most damage.

Concurrently, a deeper analysis of the causal factors could be executed to obtain information on the human, mechanical, and environmental factors not captured. Potential techniques include review of the Coast Guard reports; interviews with crew; interviews with shore side personnel; and capturing environmental data from other agencies such as the Corps of Engineers, the National Oceanic and Atmospheric Administration (NOAA), and state agencies.

APPENDIX 7
SEVERITY CLASS 4 BRIDGE ALLISION NARRATIVES

This appendix contains seven narrative summaries of the severity class four bridge allision incidents that occurred or had investigations completed in 2001.[1] These narratives are provided so a reader unfamiliar with operating a towing vessel will get an understanding for how a bridge transit may result in an allision with a bridge. The other 54 narratives for severity class four incidents may be found with this report on line at http://www.uscg.mil/hq/g-m/moa/marin.htm. Please note that the names of the vessels involved were changed to generic names.

Name of Towing Vessel: TOWBOAT1
Date of Casualty: 03 November 1999
Case Number: MC00014230
Number of Barges Involved: 1
Description of the Allision: The westbound loaded 236 ft diesel powered tug and tow allided with the CSX Railroad Bridge at MM 6.2 of ICW East Rigolets Pass. One minor injury, 5 gallons of ethylene glycol released, and minor damage to the barge resulted. The bridge sustained significant damage as a result of the allision. The crewmember was out on the barge when the barge made contact with the starboard side fendering system and struck his shoulder on one of the discharge pipelines as a result of the impact with the bridge. The resulting injury was a minor contusion. The impact also caused approximately 5 gallons of the cargo (ethylene glycol) to expel from a cargo vent. The product was contained on the deck of the barge and did not result in any pollution.
Cause of the Allision: Operator misjudged currents upon approach to the bridge.
Deaths: 0
Injuries: 1
Pollution Incident: None
Damage Amount: $110,000

Name of Towing Vessel: TUGBOAT 1
Date of Casualty: 03 February 2001
Case Number: MC01001713
Number of Barges Involved: No barges involved. Ship being towed.
Description of fhe Allision: Approximately 0040, 03 FEB 01, the TUGBOAT1 while being towed outbound the Miami River stern-first and deadship by the tugs TUGBOAT2 and TUGBOAT3 allided with the northeast corner of the NW 5th St. bridge abutment and the bridge's opened north span. The bridge sustained major damage to the pedestrian sidewalk, the north span's eastern-most girder, and its trunnion. The TUGBOAT1sustained damage to the upper starboard corner of the transom including a 5-inch hole in the side shell plating just below the weather deck, buckled bulwarks, and bent handrails. The TUGBOAT1 also sustained damage to a 2 feet wide by 1-foot deep section of deck, the deck-edge combing, and handrails on the starboard, after side of the boat deck. There were no injuries as a result of the incident.
Cause of the Allision: Unexpected currents and shoaling in vicinity of the bridge.
Deaths: 0
Injuries: 0
Pollution Incident: 0
Damage Amount: $2,000,000

[1] A severity class 4 bridge allision involves one or more of the following: lives lost > 0, injured > 0; missing > 0; damage > $500,000; oil spilled.

Name of Towing Vessel: TOWBOAT1
Date of Casualty: 12 February 2001
Case Number: MC01002574
Number of Barges Involved: 2
Description of the Allision: On 02/12/01 about 1700 CST the TOWBOAT1 was southbound on the Illinois River running 8 knots, when she became sideways in the channel above the Florence Highway Bridge at mile 56.0, resulting in an allision with one personnel injury. The pilot of the TOWBOAT1 stated that he had made his approach to the center span, but was turned by the high water from snow and ice melt off. The river current had increased substantially over the prior couple of days and had contributed to the vessel coming moving off line. The pilot had realized that the vessel was being set back and had made attempts to correct his position by backing down full with his engines, but the momentum of the tow had already reached a point of no return. The forward two barges, BARGE1 and BARGE2, both empty red flag gasoline barges, impacted the starboard descending bridge pier causing the TOWBOAT1's tow to break apart. There was no damage sustained to the bridge pier, but both barges sustained damage. BARGE1 had damage to the bow rake in the amount of $36,000. BARGE2 broke the timberhead on the port head and some of the deck plating was pulled up, at around $5000 in total damage costs. A tankerman aboard the TOWBOAT1 was injured in the allision.
Cause of the Allision: Operator lost situational awareness of the changing conditions in the river. The increased current and depth of water was not taken into consideration prior to making his approach to the bridge.
Deaths: 0
Injuries: 1
Pollution Incident: 0
Damage Amount: $41,000

Name of Towing Vessel: TOWBOAT1
Date of Casualty: 01 April 2001
Case Number: MC01004198
Number of Barges Involved: 2
Description of the Allision: On 01 April 2001, at approximately 0025, the southbound, twin screw, 1974 build, 65' towboat, 1360 hp, diesel powered, U.S. -flag tug TOWBOAT1 pushing ahead 02 loaded lube oil barges (12,000 tons in each) had an allision with the Jonesville Bridge at mile 40.9 of the Ouachita River. The vessel was transiting southbound under the Jonesville Bridge when the starboard beam of the vessel's pilothouse allided with the northern side of the opened Jonesville swing bridge. The allision with the bridge rolled the vessel on her port side, which caused uncontrolled flooding, followed by the vessel capsizing and sinking.
Cause of the Allision: The root cause of this casualty was human error in that the pilot misjudged the effect the river under the Jonesville Bridge would have on the vessel as he transited through the bridge opening.
Deaths: 0
Injuries: 0
Pollution Incident: Yes
Damage Amount: $500,000

Name of Towing Vessel: TOWBOAT 1
Date of Casualty: 17 May 2001
Case Number: MC01007108
Number of Barges Involved: 1
Description of the Allision: It was determined that the Operator of the TOWBOAT1 was illicitly using a prescription drug that severely impaired his ability to navigate and maneuver the vessel, causing him to negligently strike the Louisa Bridge. The Bridge Tender witnessed the TOWBOAT1 glance off the south bank three times as the TOWBOAT1 approached the Louisa Bridge just prior to the allision. The bridge tender stated that each time the TOWBOAT1 struck the bank she called the master of the TOWBOAT1 to inquire as to the problem. Each time the master replied that he was having steering problems. It was the opinion of the bridge tender that the master of the TOWBOAT1 was falling asleep because he sounded groggy on the radio. The TOWBOAT2 was approximately 500 yards astern of the TOWBOAT1 at the time of the allision. The master of TOWBOAT2 stated he heard the bridge tender's calls to the TOWBOAT1, confirming the bridge tender's statement. The Marine Surveyor inspected the TOWBOAT1's steering system, verified that the entire system was operating correctly and stated that the allision was not due to mechanical error. During the onboard investigation immediately after the allision, the operator appeared to fall asleep multiple times in the presence of the CG Investigator. On one of these instances, the Marine Surveyor also witnessed the operator appearing to fall asleep. The operator confessed to using Xanax without a prescription.
Cause of the Allision: Operator illegally used Xanax, causing him to fall asleep.
Deaths: 0
Injuries: 0
Pollution Incident: None
Damage Amount: $1,014,000

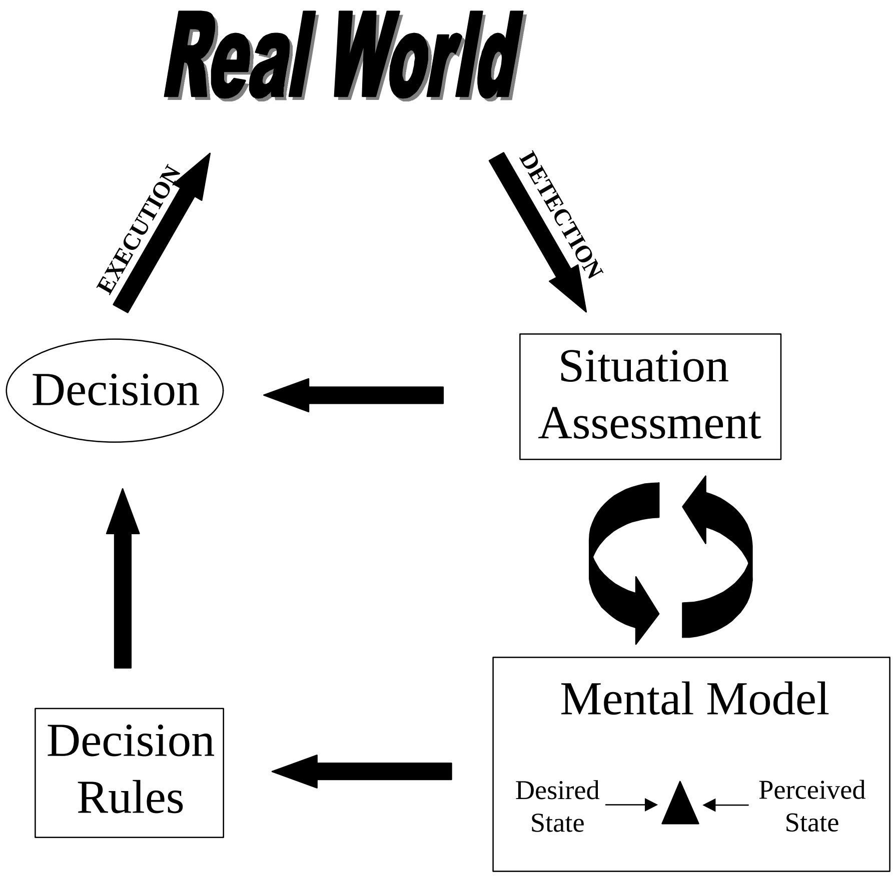
Name of Towing Vessel: TOWBOAT1
Date of Casualty: 19 July 2001
Case Number: MC01009280
Number of Barges Involved: 1
Description of the Allision: 1. Prior to 0221 the TOWBOAT1 was u/w west bound, pushing a T/B fully loaded with a cargo of PPM (propane-propylene mix), and pushed up on the North bank of the Gulf Intracoastal Waterway (GIWW) mile marker 132.5, 1.5 miles east of the Louisa Bridge awaiting the arrival of their relief pilot. 2. 0221 The TOWBOAT2 and the TOWBOAT3 pushing westbound and the TOWBOAT4 pushing eastbound asked for an opening, received permission and transited through the Louisa Bridge. 3. 0253 The Louisa Bridge closed. 4. 0320 The TOWBOAT5 pushing westbound, passed the TOWBOAT1, asked the Louisa Bridge Tender for an opening, received permission, the bridge opened and they transited the Louisa Bridge. 5. 0333 The Louisa Bridge closed. 6. 0330 The TOWBOAT6 was u/w pushing westbound and the TOWBOAT7 was light boat u/w west bound toward the Louisa Bridge. 7. 0350 (approximate) The TOWBOAT7 overtook the TOWBOAT6 and they both passed the TOWBOAT1 who was still pushed up on the bank. 8. 0410 (approximate) The TOWBOAT1's relief pilot arrived at and drove his vehicle across the Louisa Bridge to speak to the Bridge Tender. 9. 0413 The TOWBOAT7 and the TOWBOAT6 u/w westbound asked the Louisa Bridge Tender for an opening, received permission, the bridge opened and they transited through the Louisa Bridge. 10. 0415 (approximate) The Bridge Tender spoke to the pilot of the TOWBOAT1 on VHF, giving him info that the TOWBOAT 1's relief pilot was at the bridge and that the bridge was going to close to allow the relief to drive back across the bridge. 11. 0420 (approximate) The TOWBOAT1 got u/w without telling the Bridge Tender. 12. 0425 The Louisa Bridge closed and allowed the relief pilot to drive his vehicle to the north side of the channel to facilitate their relief process. The TOWBOAT7 continued westbound GIWW. The TOWBOAT6 pushed up against the bank mile to the west. 13. 0435 (approximate) The Bridge Tender began opening of the bridge for the TOWBOAT1. 14. The TOWBOAT1 struck the bridge with its barge while the bridge was only 50 percent open, breaking relief valves and cracking piping on the STBD Tank, allowing product to be released into the atmosphere.
Cause of the Allision: The pilot started his approach to the bridge despite having been told by the bridge tender that the bridge was closed. The pilot did not check in with the bridge tender after getting underway. The pilot was fatigued based upon the fatigue model worksheet, scoring a fatigue index of 53.67.
Deaths: 0
Injuries: 0
Pollution Incident: Air release
Damage Amount: $697,000

Name of Towing Vessel: TOWBOAT1
Date of Casualty: 15 September 2001
Case Number: MC01011939
Number of Barges Involved: 1
Description of the Allision: TOWBOAT1 allided with the Queen Isabella Causeway, South Padre Island TX, causing the bridge to collapse.
Cause of the allision: Cause of the allision is unknown as this case is still under investigation.
Deaths: 8
Injuries: Unknown
Pollution Incident: Yes
Damage Amount: Not specified.

APPENDIX 8
COGNITIVE MODEL FOR NAVIGATION DECISION MAKING

In order to develop its recommendations, the Work Group first agreed upon a cognitive model that provided a reasonable representation of the decision making process. The model for this process is provided below:

Figure 1: Cognitive Model



The Work Group used this model to identify areas where the process could be severely compromised or completely break down. Recommendations were intended to safeguard the process.

Each component of the model is described below:

<u>The Real World</u>

This is best described as what the operator sees "out the window." It is the primary source of stimulus and information for decision-making (for example, weather, vessel traffic, waterway conditions, etc.). The real world includes events and patterns of events. It is constantly changing and provides a continuous flow of input to the operator.

Situational Assessment

The operator collects this information through detection. Detection comes through the senses and through bridge equipment, such as radar and radio. This is the first place for the process to break down: the detection of information could be too slow or inadequate for the situation.

Situational assessment is based on the operator's evaluation, interpretation, and perception of the real world. It is the integration and computation of all the detected information. Situational assessment is affected by a host of things, such as experience, training, stress, workload, etc.

Mental Model

The mental model is essentially the operator's idea of "how the world works." A mental model is also understood to be a person's representation of reality. It can be used to understand and evaluate patterns. A person's mental model is the basis for all reasoning and has a number of important characteristics:

(1) Mental models are always incomplete and constantly changing and evolving.
(2) Mental models are not always accurate and usually contain errors and contradictions.
(3) Mental models are usually simplified representations of complex situations.
(4) Mental models are developed with uncertainty and are used even when they are incorrect.

Part of the use of the mental model in making decisions is evaluating the difference between the desired state and the perceived state. The desired state is the operator's decided-upon goal, such as turning to port five degrees or maintaining speed at five knots. The perceived state comes from the operator's situational assessment. The operator continuously makes comparisons of the desired state and perceived state. The amount of difference between the two determines the level of action that the operator will take to eliminate the difference.

Decision Rules

These are "If… then…" statements. These rules are personal to the individual and are formed by training, experience, education, etc. They also influence the final decision that gets made.

Decision

This is the part were the operator says, "I am going to take action." The final decision and determined course of action are influenced by the operator's application of his or her decision rules and situational assessment.

Execution

The execution is the actual carrying out of the determined course of action. This is one place where errors can occur. Also, the execution directly changes the "Real World" aspect of the process.

There are numerous opportunities for this process to be severely compromised or completely break down. When this happens, errors are highly likely to occur. For example, poor alertness affects the process in many ways: the entire process slows as a function of impaired cognitive ability, critical information can be missed, situational assessment may be skewed, and there can be errors in execution.

Another example is the influence of training and experience on the process. Inadequate training or lack of experience may prevent the operator for adequately interpreting the "Real World." He or she may not know what information to look for or may display poor pattern recognition, slower execution, or inappropriate application of the decision rules.

APPENDIX 9
SYSTEMS THINKING

Need for Systems Approach

Although the Work Group focused on human factors, the cognitive model demonstrated that this is a complex issue. Applying the case review taxonomy to the cognitive model, the Group realized that:

- There are a number of factors that impact decision-making, and their interactions are complex.
- There are no “quick fixes” or “silver bullets” that will prevent bridge allisions.
- The most effective approach to developing meaningful recommendations is to understand the whole, or rather, to understand safe bridge navigation as a **system.**

Certainly, the issue of bridge allisions could be broken into smaller, more manageable parts. This would make it easier to develop a thorough understanding of each piece. In theory, after each piece is solved, it should be possible to combine them to gain an understanding of the whole. However, this is a reductionist view and only works for simple linear problems.

The factors influencing safe bridge navigation are complex and exhibit non-linear behavior. Therefore, the only way to address the issue is with systems thinking concepts.

Explanation of Systems Thinking

Systems thinking is fundamentally different from “traditional” analysis:

- Traditional analysis typically focuses on separating the individual pieces from the whole and than solving each issue independently.
- **Systems thinking focuses on how the components interact with each other.**

Systems thinking is extremely important to the analysis of bridge allisions because the issues associated with preventing bridge allisions have components with interactions that are complex and have feedback. It is extremely important to understand that breaking apart a system of interdependent parts dissolves the system of its essential properties and of each of its parts.

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APPENDIX K
GEOLOGIC AND HYDROGEOLOGIC (CARA) REPORT

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May 19, 2003

Fred Hill Materials
P.O. Box 6
Poulsbo, Washington 98370

Attn: Mr. Alex Hill

Geologic and Hydrogeologic
(CARA) Report
Aggregate Resource Evaluation
The Wahl Extraction Area
Jefferson County, Washington
Job No.FredHill.01RR

INTRODUCTION AND HISTORY

Fred Hill Materials, Inc. (FHM) currently mines and processes aggregate resources at the existing Shine Pit site located south of SR 104 and west of the Hood Canal Bridge in Jefferson County, Washington. The existing Shine Pit and the proposed Wahl Extraction Area are situated within the Thorndyke Mineral Resource area, MLA-02-235, an approved Mineral Resource Land Overlay (MRL) designation for 690 acres. The Wahl Extraction area and MRL are located approximately one mile southwest of FHM's existing Shine Pit area. The Shine Pit, Wahl Extraction, and MRL area, all located within the Thorndyke Resource Operations Complex (T-ROC), are located within an approximate 21,000-acre Thorndyke Block, which is a portion of the Pope Resources 72,000-acre Hood Canal Tree Farm. These areas are located in Jefferson County on the Tornados Peninsula, which is south and west of the Hood Canal Bridge. This portion of the Peninsula is locally known as the Upper Coyle Peninsula. The general location of the site is shown on the Vicinity Map, Figure 1. The proposed Wahl Mine site layout is shown on the Site Plan, Figure 2.

The Shine processing area will function as the Operations Hub for the Wahl Extraction site. Material from the Wahl Extraction area will be transported to the Shine processing area by the Wahl Conveyor system. The Wahl Extraction area is located southwest of the existing Shine mine and processing area. The proposed 1.25-mile Wahl Conveyor originates at the southeast corner of the proposed Wahl Extraction Area, travels northeast through the Thorndyke Block (within an approximately 9-acre easement), and terminates at the southwest corner of the existing Shine Pit.

The Wahl Conveyor's route was specifically selected to avoid and/or minimize impacts to environmentally sensitive areas (steep slopes, wetlands, streams, and their associated buffers). SEPA documents are being prepared for the project. This report will be utilized as part of the submittal package.

The Thorndyke Block has been utilized for the production of forest products with logging as early as the 1900s. Currently, the area is managed as commercial forestland with periodic logging of acreage units and predominant replanting of Douglas fir. More than half of the proposed Wahl Extraction area and Conveyor route will be located in forestlands that have been logged within the past 10 years.

Mining of sand and gravel in the general area of the Shine site 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 the aggregate resources in the same vicinity and provided truck delivery of the processed materials. Mining has also occurred in the Thorndyke area since the 1930's for the construction and maintenance of logging roads and since the 1980's for Pope Resources plat development.

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 165-acre Wahl Extraction Area as an expansion of the existing Shine Pit mine area. 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 (Shine Pit). 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. As previously discussed, the Wahl Extraction Area is located within the approved MRL.

This report summarizes our site observations and subsurface exploration data and provides our conclusions and opinion with regard to the geologic conditions and aggregate resource present in the Wahl Extraction portion of the T-ROC area. Our evaluation and opinions are provided at your request.

GEOLOGIC CONDITIONS

Interpretation of the geologic conditions at the Wahl site are based on our site observations, soil exposures in the area, test pits and borings completed at the site, and our review of the available geologic literature. In general, the soils in the region consist of, from oldest to youngest, undifferentiated pre-Vashon glacial and interglacial sediments, overlain by Vashon advance outwash, glacial till (hardpan) and recessional outwash sediments. Locally ice marginal or ice contact deposits also occur along ridge and shoreline slopes. A generalized geologic map of the area is included as Figure 3.

The older glacial sediments are exposed along portions of the Puget Sound shoreline bluff located east of the site area. These soils typically consist of bedded sands and gravels and occasional till deposited by pre-Vashon glaciers. The interglacial deposits typically consist of bedded silt, sand and occasional clay. These older sediments are in a very dense or very hard condition where undisturbed.

The Wahl Extraction area is situated within a generally north-south trending Vashon glacial outwash area that is located west of the Hood Canal Bridge. During the Vashon glacial period, approximately 10,000 to 15,000 years ago, the pre-glacial geomorphic conditions of the Thorndyke area combined with the advancing and receding glacial ice conditions to deposit a thick deposit of high quality aggregate (sand and gravel) material within a confined area. These aggregate materials were generally deposited in front of the advancing glacial ice, and as the ice melted and receded. The geomorphology or topography of the area and the high energy of glacial melt waters resulted in the thick layers of clean sand and gravel material being concentrated in this geographic area.

Based on our site observations and data review, several large glacial outwash channels extended through the Thorndyke area in a general north-south direction. Within the outwash channel areas, the glacial till is absent, either not deposited or removed through erosion by the scouring melt water. Where this occurred, thick recessional sand and gravel deposits were deposited directly over the advance sand and gravel deposits, resulting in a thick or deep section of high quality aggregate material.

Thick deposits of clean high quality sand and gravel material, like those that occur in the Thorndyke area, are unique. Aggregate resource deposits of this nature are rare throughout the world. Although the Puget Sound area is blessed with several of these larger aggregate deposits, to date, none have been identified in the Kitsap or Olympic Peninsula areas. The Thorndyke MRL area is a valuable resource that will provide aggregate resource material to the region on a long-term basis. The location of the Thorndyke MRL in a remote area reduces the impacts to developed civic areas.

SUBSURFACE CONDITIONS

General

Subsurface conditions at the site were evaluated by excavating over 100 track-hoe test pits and completing nineteen borings in the Thorndyke MRL area. Observations wells were installed in the borings to monitor groundwater conditions in the site area. The approximate locations of the borings/observation wells is shown on the Outwash Channel Map, Figure 4. The test pits extended to depths of several feet to approximately 20 feet. Many of the test pits encountered sand and gravel to the full depth explored. The borings were completed with an air-rotary drilling rig to depths ranging from approximately 25 feet to 420 feet below the existing ground surface. Soil samples were collected on a 10-foot interval for further evaluation. Laboratory analyses (sieve tests) of select soil samples were completed from both the test pits and borings. Exploration and laboratory data for the MRL and Wahl Extraction areas will be maintained in our files and can be selectively provided based on approval from the owner and Fred Hill Materials.

Aggregate Quality

Based on our site observations throughout the region, excavation of the trackhoe test pits, and completion of the borings, the sand and gravel deposits located within the Wahl Extraction area consist of high quality commercial sand and gravel with cobbles and occasional boulders. The fines content (material passing the US. No. 200 Sieve) varies, but is typically less than 5 percent. This aggregate material is suitable to produce high quality commercial pit run and a variety of select commercial aggregate products. Any reject material that cannot be exported from the site will be utilized for reclamation of the site.

Adequate coarse gravel, cobbles and boulders occur in the aggregate material observed/encountered to produce commercial crushed products. Sufficient fine to medium sand occurs as lenses and at depth to provide for material binder and select concrete and commercial specialty sand products.

Aggregate Quantity

Based on the results of our subsurface explorations and data review, the aggregate resource quantity within the Wahl Extraction area is capable of supplying a variety of quality commercial aggregate products to the Kitsap and Olympic Peninsula region on a long-term basis, approximately 20 years. There are no other know aggregate resources of this quality or quantity in the Peninsula area.

HYDROGEOLOGIC CONDITIONS

Hydrogeologic conditions at the Wahl Extraction area were evaluated by reviewing available geologic literature and previous work in the area, our observations, and data from monitoring of over 100 test pits and nineteen borings at and near the site. The test pits ranged in depth from approximately 5 to 20 feet. The borings ranged in depth from approximately 2-5 feet to 420 feet (to Elevations 300 to 15 feet above sea level). Observation wells were installed in the borings and have been monitored on an intermittent basis. The locations of the borings/observation wells are shown on the Outwash Channel Map, Figure 4.

As previously discussed, the soils in the region consist of (from oldest to youngest): undifferentiated pre-Vashon glacial and interglacial sediments (Double Bluff and Whidbey Formations) that are overlain by Vashon advance outwash, glacial till (hardpan) and recessional outwash sediments. During the last 13,000 years, weathering of the soils has resulted in the accumulation of alluvial silts and organic debris in localized valley floor areas near the toe of slopes.

Surface water in the site area also occurs as perched near-surface water in localized wetland and lakes in and near the east portion of the site. The near surface water is perched above accumulated silt, clay and organic materials. These materials have a low permeability and perch surface water that accumulates in these low-lying areas. These wetlands and lakes are not in direct continuity with the underlying aquifer systems. Mining will be setback from these areas. A schematic section is included as Figure 5.

Within the Wahl Extraction and adjacent areas, surface water occurs seasonally within Thorndyke Creek. Thorndyke Creek is located west of the Wahl Extraction area. Mining will be setback from Thorndyke Creek several hundred feet. Based on the results of our explorations and review of mine plan, the lower mining limits will be above the nearby channel bottom elevations of Thorndyke Creek. This is illustrated in cross sections A, B and C, Figures 6a, 6b and 6c. Mining will not be conducted within this groundwater table, but remain a minimum of 10 feet above the seasonal high level.

Two aquifers were encountered in Wahl Extraction and MRL areas borings/observation wells and test pits. Water supply wells in the area typically produce water from the lower of the two aquifers encountered in the site area, or from even deeper pre-Vashon sediments, like those at the Squamish, Bridgehaven and Thorndyke community wells, located east and south of the site. The upper aquifer encountered over most of the site occurs within the Vashon outwash materials. Based on the water levels measured in the observation wells, the surface of the Vashon aquifer is at approximately Elevation 320, in the north sloping down to Elevation 150 in the south (T27N, R1W, Section 12). The seasonal groundwater fluctuation is approximately 10 feet. Wells completed in the south portion of the Wahl Extraction and MRL area did not encounter this aquifer. The groundwater flow of this aquifer is to the south. We expect that this aquifer provides spring flow along portions of Thorndyke Creek and the south shoreline of Hood Canal (approximately Elevation 100). The approximate extent of the Vashon aquifer and the estimated groundwater flow direction is shown on Figure 7.

The deeper pre-Vashon aquifer system encountered in the site area is overlain by a generally impermeable lacustrine silt/clay layer (aquitard) and is a confined aquifer. This is evidenced by water levels in Boring 14 (located near Wahl Lake) and the Fred Hill process area water well. The water levels in these wells rose to Elevations 83 and 93 respectively (artesian condition), after well completion. This aquifer was not encountered in a deep well completed in the southeast portion of the MRL, south of the Wahl Extraction area (Boring 18). This indicates that this aquifer is not continuous throughout the Thorndyke area. Groundwater levels in the wells are listed in Table 1, Wahl Extraction & MRL Area Groundwater Levels.

The Squamish, Bridgehaven and Thorndyke area wells are completed in an aquifer that is at approximately Elevation –50, an additional 100 feet or more below the pre-Vashon aquifer beneath the site. Based on our data review, the water-producing unit is the Double Bluff Formation and may or may not extend laterally through the region. This aquifer is overlain by the generally impervious Whidbey Formation, an aquitard that restricts the downward movement of the groundwater. The static water elevations of these wells range from approximately –10 to +30 and typically have head pressures of between 50 and 60 feet, a confined aquifer. Based on previous work completed in the area by Robinson & Noble, Inc., a 10 year horizontal capture zone for the Bridgehaven well, which is completed within this aquifer, would extend west-northwest approximately 7, 000 feet (Appendix A). This is east of the proposed Thorndyke area. The 10-year capture area for this well is shown on Figure 7. The capture zone does not include travel time for the vertical migration of the water from the ground surface to the aquifer (through the overlying soils and/or aquitards).

CONCLUSIONS

Based on the results of our site reconnaissance, subsurface explorations, groundwater monitoring, review of the available data and our experience, it is our opinion that the proposed mining activity at the Wahl Extraction area will have no adverse impact to the surface or groundwater systems in the area. Mining will be conducted in accordance with DNR and Jefferson County Regulations. Conventional 2 to 1 or flatter cut slopes will be utilized for the mining area. All structures can be founded on conventional foundations. Temporary and Permanent erosion control measures will be installed and maintained, as appropriate. In general, all stormwater runoff will be retained on-site.

EROSION AND SEDIMENTATION CONTROL

The erosion hazard for disturbed soils ranges from slight to moderate depending on the slope inclination. It is our opinion that the potential erosion hazards at the site are not a limiting factor for the proposed mining activity. Removal of natural vegetation at the site should be minimized and limited to the active mine area. Temporary and permanent erosion control measures should be installed and maintained during mining to limit the additional influx of water to exposed areas and protect storm ponds and potential receiving waters. Erosion control measures should include but not be limited to berms and swales with check dams to manage surface water run-off. Graded areas should be shaped to avoid concentrations of runoff water onto cut or fill slopes, natural slopes or other erosion-sensitive areas. In addition, ground cover/protection should be used in exposed or disturbed areas and silt fences where appropriate. Temporary ground cover/protection may include hydro-seeding, various mulches, jute matting, excelsior matting, wood chips or clear plastic sheeting. These temporary measures should be used until the permanent erosion protection is established.

EARTHWORK

Site Preparation

All areas to be graded/mined should be cleared of deleterious matter including existing debris and vegetation. The organic-laden strippings should be stockpiled on-site and later used for reclamation purposes

Prior to placement of any fill material, the exposed subgrade areas should then be compacted to a firm and unyielding surface. In fill areas, we recommend that trees be removed by overturning so that a majority of the roots are removed.

Any soft, loose or otherwise unsuitable areas should be recompacted, if practical, or overexcavated and replaced with structural fill.

Structural Fill

No significant fill material is expected at the site. The following is provided in the event that your plans change. All fill material used to achieve design grades within the structural areas should be placed as structural fill. The structural fill should be placed in horizontal lifts of appropriate thickness to allow adequate and uniform compaction of each lift. Structural fill should be compacted to at least 90 percent of MDD (maximum dry density as determined in accordance with ASTM D-1557). Where the fill will be used for structural support of structures or roadways, the upper 2 feet should be compacted to 95 percent MDD.

The appropriate lift thickness will depend on the fill characteristics and compaction equipment used. We recommend that the appropriate lift thickness be evaluated by our field representative during initial placement.

The suitability of material for use as structural fill will depend on the gradation and moisture content of the soil. As the amount of fines (material passing No. 200 sieve) increases, soil becomes increasingly sensitive to small changes in moisture content and adequate compaction becomes more difficult to achieve. During wet weather conditions, it may be necessary to stockpile the imported soils until appropriate moisture conditioning can take place. Material placed for structural fill should be free of debris, organic matter and trash. Particle sizes larger than 6 inches should be excluded from the top 1-foot of fill. The moisture content of the fill material should be adjusted as necessary for proper compaction.

CUT AND FILL SLOPES

Temporary cut slopes may be necessary during mining/grading operations. As a general guide, temporary slopes of 1 to 1 (horizontal to vertical) or flatter may be used for temporary cuts in the upper 3 to 5 feet of the recessional gravels or glacially consolidated soils that are weathered to a loose/medium dense condition. Temporary slopes of 1/2 to 1 or flatter may be used in the unweathered dense sand and gravel soils at the site. These guidelines assume that the temporary cut slopes will not exceed 30 feet in height (without appropriate benching), and that all surface loads are kept at a minimum distance of at least one half the depth of the cut away from the top of the slope. In addition, the slope inclination should be flattened where significant seepage occurs on the slope face.

We recommend a maximum of 2 to 1 for permanent cut and fill slopes, in accordance with DNR regulations. Where 2 to 1 slopes are not feasible, retaining structures should be considered.

Fill placed on slopes that are steeper than 5 to 1 should be "keyed" into the undisturbed native soils by cutting a series of horizontal benches. The benches should be 1½ times the width of equipment used for grading and a maximum of 3 feet in height. Subsurface drainage may be required in seepage areas. Surface drainage should be directed away from all slope faces. Some minor raveling may occur with time. All slopes should be planted as soon as practical to facilitate the development of a protective vegetative cover or otherwise protected.

SURFACE WATER - POENTIAL IMPACTS

Surface water in the project area will not be impacted by the proposed mining activity. The mining depth will not extend laterally to or below the nearby Thorndyke Creek channel. A minimum 200-foot buffer has been established from Thorndyke Creek so that no mining will occur in that area. Mining will remain a minimum of 10 feet above the Vashon water table that potentially discharges to Thorndyke Creek as seeps or springs.

Seasonal perched wetlands in the project area will not be affected by the proposed mining activity at the Wahl Extraction site. The localized wetlands in and east of the site area are perched on accumulated silt/clay and organic material. Setbacks from the wetland areas will preserve these perching layers, thereby protecting the wetland environments.

Lost Lake is also in a perched condition, but on glacial till (hardpan). Lost Lake is a classic kettle lake, formed in a depression in the surface of the glacial till. Kettle lakes are typically formed by a large block of glacial ice separated from the glacier during its retreat. Buffers and mining setbacks will adequately protect Lost Lake.

Mining will be incremental with segmental reclamation and replanting of the vegetation. Changes in surface water infiltration are expected to be similar to changes that have historically occurred during timber harvesting at the site. The BMPs' for aggregate resource sites are included in Appendix B.

GROUNDWATER – POTENTIAL IMPACTS

It is our opinion that there will be no adverse impacts on groundwater as a result of the proposed mining activity in the site area. The potential groundwater impacts for sites like this are related to the relationship between precipitation, surface water, shallow subsurface runoff, evapotranspiration, ground water recharge and the proposed site activities. Mining activity at the site will be conducted in accordance with the BMPs (Best Management Practices) for the gravel mining industry, and the regulations of Jefferson County and Washington State. The BMPs' for aggregate resource sites are included in Appendix B.

Groundwater in the site area will be protected from potential impacts from mining activity. Mining will remain a minimum of 10 feet above the underlying water table levels and will not extend into the aquifers below the site. The observation wells completed in the area will be utilized to monitor groundwater levels prior to and during mining operations. Mining will not extend into the groundwater table. A minimum 10 feet of undisturbed native sand and gravel will remain above the groundwater system at the site to act as a filter and protect the groundwater system. Therefore no significant changes in groundwater flow will occur. Monitoring wells were installed in the test borings at the site to allow for the monitoring of the groundwater systems in the site area. The wells have and will be monitored on a seasonal basis.

As the site is developed, a portion of the natural vegetative cover will be replaced with active mine surface and reclaimed (revegetated) areas. The replacement of the natural cover with revegetated reclamation area and mine will result in a slight, but temporary, decrease in evapotranspiration because of the localized temporary loss of vegetation. This temporary change in site conditions will result in a potential consequent increase in runoff and/or groundwater recharge in the active/unvegetated portions of the site. The permeable soils at the site will allow rapid infiltration of any runoff and/or precipitation. The net result of the proposed mine activity will essentially be a temporary minor increase in total groundwater recharge at the site. Therefore, relative to the shallower groundwater system, no significant impact is expected.

We do not expect any adverse affects on the recharge condition of the deep aquifers. As stated above, recharge to the deeper aquifers occurs by infiltration of rainfall through the overlying aquifers and aquitards. Because the recharge of the perched aquifer will not be significantly affected, the recharge of the deep aquifers will not be adversely affected. It should also be noted that the recharge area for the aquifers, in particular the deeper aquifers, essentially occurs over the entire east Peninsula area. This surface area of the site relative to the total recharge area is insignificant.

Relative to mining activity at the site, potential water quality impacts are generally related to equipment operation and stormwater runoff. No fuel or hazardous material storage is planned to occur at the Wahl Extraction site. Fuel for on-site equipment will be provided by service trucks. The on-site equipment and site activities will be closely monitored. The mine/process staff will be trained and spill prevention plans and kits will be kept on-site. The remaining undisturbed native soils, minimum of 10 feet, above the groundwater system at the site will provide a buffer against potential contamination from equipment/site activities. The deeper aquifers are protected from possible contamination by the filtering effect of the overlying sand and gravel and fine-grained silt and clay that occur below the site and surrounding area.

Storm runoff collected at the site will be directed to infiltration areas located at the site. Based on the results of the subsurface explorations, the soils in this area have adequate storage and permeability to infiltrate the stormwater runoff. This is discussed below in the **"Stormwater Control"** section of this report.

Typically, stormwater runoff from gravel mine sites is minimal. The granular nature of the soils allows for rapid infiltration of any precipitation that falls on them. The native soils disperse the infiltrated water over the site and recharges the shallow groundwater system similar to what is occurring at the site now. The only significant difference is the temporary reduction in the vegetative cover in the active mine areas. Once reclaimed, the new vegetation will closely match the effects of previous site vegetation.

Storm water infiltrated at the site will disperse into the underlying sand and gravel soils. The local direction of flow for the underlying groundwater system is generally to the south. Thorndyke creek is located approximately 200 feet or more south and west of the proposed mine site. The native soils will act to filter the infiltrated stormwater. Based on the nature of the sand and gravel soils, the distance from the infiltration areas and the direction of groundwater flow, no adverse impact to Thorndyke Creek is expected.

The deeper pre-Vashon aquifer within the Wahl Extraction site and adjacent area is separated from the Vashon aquifer and the overlying minable sand and gravel soils by a thick sequence of lacustrine silty fine sand, silt and clay materials. These soils form an aquitard that restricts the downward migration of the overlying groundwater and thereby protects the underlying pre-Vashon aquifer.

The still deeper aquifer that supplies water to the Squamish, Bridgehaven and Thorndyke area wells along the shoreline areas east and south of the site area is situated below an additional layer/thickness of impermeable silt and clay soils of the Whidbey Formation. This deeper aquifer is over two hundred feet below the proposed mining depth at the Wahl Extraction area. The Bridgehaven wells, which are the closest off-site wells to the site, are situated more than 1.5 miles east-southeast of the proposed Wahl Extraction mine site.

As previously discussed, in addition to the above geologic and hydrologic conditions that will preclude any significant adverse impact to the underlying aquifer systems, mining operations at the site will be conducted in accordance with BMPs (Best Management Practices) and current regulatory requirements. The active mining area will be limited in surface area. As new areas within the site are opened to mining, previously mined areas will be reclaimed and replanted in accordance with the required DNR Reclamation Permit. This is encouraged through the application of the reclamation bond, which is based on the amount of disturbed area, unreclaimed.

No adverse impacts to the groundwater systems have been identified since mining began at the Shine and Thorndyke sites, greater than 40 years ago. Mining and processing activity at the Shine and Wall Extraction sites is and will be monitored by a variety of State and Jefferson County regulatory agencies on an on-going basis. Monitoring of the existing observation wells will continue during mining activity at the site.

The aggregate resources identified and historically mined within the site area are high quality and of sufficient quantity to be considered a long-term commercial aggregate resource. The aggregate materials observed at the site are suitable for use in the production of a variety of select aggregate and crushed rock products.

SITE DRAINAGE

All ground surfaces should be sloped away from structures and erosion sensitive areas. Surface water runoff should be controlled by a system of berms, drainage swales, and or catch basins, and conveyed to an appropriate discharge point. Surface water should not be discharged into subdrains in fills and roadways, or near/on slopes. Drains should be provided behind all retaining walls.

Permanent drainage systems should be installed at the top and/or bottom of cut and fill slopes to intercept surface runoff and prevent it from flowing in an uncontrolled manner across the slopes. Surface water should not be discharged over the undisturbed slopes outside the grading areas.

In the event significant seepage is encountered in cut and/or fill slope areas, appropriate drainage control measures should be taken to collect and convey the water to an appropriate discharge point. Sub-drains in fills, where required, should be constructed as cut-off drains.

STORMWATER CONTROL

Based on our observations, a large portion of the precipitation on the site currently percolates into the surficial sand and gravel soil. Infiltration of the storm runoff at the site will closely match the existing conditions.

Soils in the mined area of the site will likely consist of permeable sand and gravels, which will extend to at least 10 feet below the surface and remain 10 feet above the high groundwater level. It is our opinion that infiltration of storm runoff water is feasible at the site where this condition occurs. Areas of soil with higher silt content may require special design considerations or rerouting to more permeable areas. Specific design criteria for infiltration systems will be provided, as appropriate.

In general, ground surface infiltration (percolation ponds) is preferred over percolation trenches because maintenance is easier and less costly. Where percolation trenches are used, the stormwater should be treated in accordance with current Jefferson County regulations.

♦ ♦ ♦

We have prepared this report for Fred Hill Materials and their representatives for use in evaluating the potential aggregate resources of the above-described area. Within the limitations of scope, schedule and budget, our services have been executed in accordance with generally accepted practices in this area at the time this report was prepared.

If you have any questions regarding this report or need additional information please call.

Yours Very Truly,
GeoResources, LLC

LSI/ADaPT, Inc.

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2228
Licensed Geologist
5/19
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Bradley P. Biggerstaff, LHG
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DocID:FredHill.01RR
Attachments

APPENDIX L
PRELIMINARY STORM DRAINAGE REPORT

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for double-sided printing.

RECEIVED
MAR 27 2003
JEFFERSON COUNTY
DEPT. OF COMMUNITY DEVELOPMENT

PRELIMINARY
STORM DRAINAGE REPORT

FOR:

FRED HILL MATERIALS
THORNDYKE RESOURCE OPERATIONS COMPLEX (T-ROC)
CENTRAL CONVEYOR AND PIER

LOCATED IN PORTIONS OF
SEC. 6, TWP. 27 N., RGE. 1 E., W.M.
SEC. 7, TWP. 27 N., RGE. 1 E., W.M.
SEC. 8, TWP. 27 N., RGE. 1 E., W.M.
SEC. 17, TWP. 27 N., RGE. 1 E., W.M.
SEC. 18, TWP. 27 N., RGE. 1 E., W.M.
SEC. 19, TWP. 27 N., RGE. 1 E., W.M.

JEFFERSON COUNTY, WASHINGTON

February 10, 2003

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.

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1.0 INTRODUCTION

1.1 Site Location

The project is located in eastern Jefferson County, Washington (See Figure 1 – Regional Location Map). The site is situate approximately 0.75 mile southwest of the community of Shine and approximately 5 miles south of Port Ludlow. The proposed development is located in portions of the east halves of all of the following Sections: Section 6, 7, 18 and 19, Township 27 North, Range 1 East, W.M., in Jefferson County, Washington. Also, some construction of forestry service roads will occur in a portion of the west halves of all of the following sections: Section 8 and 17, Township 27 North, Range 1 East, W.M. (See Figure 2 – Overall Site Map.)

1.2 Project Elements

The Central Conveyor and Pier, the proposed project discussed in this preliminary stormwater report, will provide a system to transport sand and gravel from an existing gravel pit operated by Fred Hill Materials (FHM), the Shine Pit, to a pier on the northwest shore of Hood Canal located approximately 1.3 miles south of the Hood Canal Bridge.

All stormwater generated by the proposed project is discussed in detail in this preliminary stormwater report. Both the Twin Conveyors, two 3.3-mile long conveyors, and the Single Conveyor, one 0.7-mile long conveyor, are included in this analysis. Although the conveyors are not located on the ground surface, they are close enough to shade the ground, affect rainfall paths, and consequently the ability of the ground to infiltrate stormwater. For the purposes of this report, they are considered impervious surfaces. The Twin Conveyors will create 174,763 square feet (4.0 acres) of new impervious surface. The Single Conveyor will generate 12,192 square feet (0.3 acre) of new impervious surface (measured to Mean Sea Level).

Transfer points are located along the length of the conveyors. A transfer point is located at a point where two straight-line segments of a conveyor meet. At this location, the route of the conveyor may change direction. A utility shed will house the transfer components: hopper, motor, electric controls, etc. Each utility shed will measure 12 feet by 16 feet. Overall, the project will require 6 utility sheds, for a new impervious area of 1,152 square feet (0.03 acre).

Existing forestry service roads provide access to the "Thorndyke Block," this region of commercial forest production under the ownership of Pope Resources. The existing roads located in the vicinity of the proposed conveyor route will be removed and replanted for tree plantation over an area of 275,105 square feet (6.3 acres). The new access road, located adjacent to the proposed conveyor, will provide access both to the conveyor and to the "Thorndyke Block" and will generate a new impervious surface of 316,936 square feet (7.3 acres). The net increase in impervious area generated by road surfaces will be 1.0 acre.

Additional disturbance of land may be required to grade the route for the conveyors and forestry service roads. Up to 89,000 square feet (2.0 acres) may require erosion and sediment control measures.

1.3 Project Description

A detailed T-ROC Central Conveyor and Pier project description and fact sheet are provided in Appendix A at the end of this document's appendices.

2.0 SOIL TYPES

2.1 Twin Conveyors

The soils on site along the Twin Conveyors are listed in the *Soil Survey of Jefferson County Area, Washington* (USDA 1975), as:

Alderwood gravelly sandy loam, 0 to 15 percent slopes (AlC)
Dabob very gravelly sandy loam, 0 to 15 percent slopes (DaC)
Dabob very gravelly sandy loam, 15 to 30 percent slopes (DaD)
Everett gravelly loamy sand, 0 to 15 percent slopes (EvC)
Everett gravelly loamy sand, 15 to 30 percent slopes (EvD)
Hoypus gravelly loamy sand, 0 to 15 percent slopes (HuC)
Sinclair gravelly sandy loam, 0 to 15 percent slopes (SnC)
Sinclair gravelly sandy loam, 15 to 30 percent slopes (SnD)

(See Figure 3A and 3B – Soils Map).

2.2 Single Conveyor

The soils on site along the Single Conveyor are listed in the *Soil Survey of Jefferson County Area, Washington* (USDA 1975), as:

Alderwood gravelly sandy loam, 0 to 15 percent slopes (AlC),
Cassolary sandy loam, 0 to 15 percent slopes (CfC)
Coastal Beaches (Co)
Kitsap silt loam, 0 to 15 percent slopes (KtC)
Rough Broken Land (Ro)

(See Figure 3B – Soils Map).

2.3 Hydrologic Groups

Each soil group is classified within one of four hydrologic groups (Ecology 2001). Each hydrologic group contains similar soils based on soil type (i.e. sand or loam), permeability, runoff, and hazard of erosion.

The Alderwood series Soil Group is listed as *Hydrologic Group C.*
The Cassolary series is listed as *Hydrologic Group C.*
Coastal Beaches are listed as *variable Hydrologic Soil Groups.*
The Dabob series Soil Group is listed as *Hydrologic Group C.*
The Everett series Soil Group is listed as *Hydrologic Group A.*
The Hoypus series Soil Group is listed as *Hydrologic Group A.*
The Kitsap series is listed as *Hydrologic Group C.*
The Sinclair series Soil Group is listed as *Hydrologic Group C.*

(See Exhibit 1 – Hydrologic Soil Series).

Rough Broken Land is not included in Table 2.2 – Hydrologic Soil Series for Selected Soils in Washington State (Ecology 2001).

3.0 PRE-DEVELOPMENT SITE CONDITIONS

The project area is located predominantly within Pope Resource's commercial forestlands. The only exception is the shoreline portion of the project, located within Tax Parcel number 721194002, owned by Hood Canal Sand and Gravel Company. The shoreline tax parcel is zoned *Rural Residential (1 Dwelling Unit per 5 acres)* and is currently undeveloped.

Heavy native underbrush and established second growth forest cover the shoreline property. The shoreline zone is regenerated with alder, wetland species, and invasive non-native vegetation.

Pope Resources land is currently used as a tree plantation harvested on an approximately 50-year rotation. Most areas have been logged and replanted within the last 10 years. Only one segment of the Twin Conveyors passes through a "mature forest," with timber stands as old as 1943 between stations 85+00 and 116+00. The subject property is zoned *Commercial Forest Lands (CF-80)*. Pope Resources continues to harvest and replant predominantly Douglas fir within the Thorndyke Block. Numerous forestry service roads provide access to the area (See Figure 4 - Downstream Map).

Stormwater is allowed to sheet flow into the adjacent native vegetation, an acceptable practice for forestry service roads and an acceptable practice under the new *Stormwater Management Manual* (Ecology 2001). In locations where ditches are required because of topography, such as adjacent to Wetland C, stormwater is concentrated to a series of ditches and culverts. Stormwater is then directed downstream, eventually discharging to a creek or wetland.

The southernmost portion of the project area, located adjacent to Hood Canal, is currently undeveloped.

4.0 UPSTREAM ANALYSIS

Predominantly, the project area runs north-south along a ridgeline. In some areas, offsite stormwater will cross the project area. In accordance with Best Management Practices (BMPs) in theWashington State Department of Ecology's current *Stormwater Management Manual for Western Washington* (Ecology 2001), BMP T5.30 Full Dispersion, offsite runoff will be allowed to sheet flow across the project area and into native vegetation. Where sheet flow is impractical, offsite runoff will be collected in ditches and piped under the project area in culverts. When it is necessary to concentrate runoff from upstream areas, stormwater in excess of existing concentrated flows will be incrementally discharged. Rock pads and/or dispersion trenches will be used to discharge flows.

5.0 DOWNSTREAM ANALYSIS

As discussed above, the project area is located predominantly on a north-south ridgeline. Sheet flow dispersion will be used for stormwater management for all new gravel forestry service roads. Stormwater discharges to the west along the northern portion of the ridge, the southernmost portion of the Twin Conveyors, and the Single Conveyor. Stormwater discharges to the east at the northernmost reach of the Twin Conveyors and along the middle portion of the Twin Conveyors, including the crossing of Shine Lookout (See Figure 4, Downstream Map).

5.1 Twin Conveyors

The northernmost portion of the project is located upstream and adjacent to the current mining activities at the Shine Pit, operated by Fred Hill Materials. Stormwater from upstream areas and within the mine permit area is currently captured and infiltrated under a Sand and Gravel Permit administered by the Department of Ecology (WAG 50-1120). Stormwater from the northernmost portion (Station 25+23.69 to 41+00) will continue to discharge to the Shine Pit and be infiltrated after development of the Twin Conveyors.

Stormwater will sheet flow to the west beginning near the start of the project, Station 41+00, and continuing to approximately Station 77+00. West of the project area, along the northern reach, is a series of wetlands that run from south to north in a localized valley and feed Twin Lakes. Overflow from this valley travels west and south and eventually discharges to Thorndyke Bay.

Stormwater will sheet flow to the east between Station 77+00 and 183+00. Stormwater travels overland easterly to drainages which ultimately discharge south to Hood Canal. Adjacent to the southerly crossing of Shine Lookout, stormwater travels southeasterly to an adjacent wetland, identified as Wetland C (See *Wetland Delineation and Biological Inventory, Fred Hill Materials, Jefferson County, Washington* [Krazan 2002]). Overflow from Wetland C travels northerly to a large scrub-shrub wetland, which also collects

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overflow from Mud Lake to the north. Overflow from this scrub-shrub wetland travels southeasterly and ultimately discharges to Hood Canal west of South Point.

The southernmost portion of the Twin Conveyors, Station 183+00 – 200+00, discharges stormwater overland southwesterly and ultimately drains to Thorndyke Lake.

5.2 Single Conveyor

The Single Conveyor continues along a ridge, which runs north-south until the Thorndyke Road Crossing. North of the road crossing, stormwater travels west to Thorndyke Lake, as discussed above. South of the Thorndyke Road, the topography aligns parallel with the shoreline of Hood Canal, in a northeast-southwest direction. Stormwater continues to discharge to the west along the Single Conveyor until approximately Station 217+50. Between Station 217+50 and 221+75, stormwater is collected in a ditch and discharged to Wetland A for wetland recharge. Between Station 221+75 and 225+95, stormwater is collected in catch basins and buried pipe and directly discharged to Hood Canal at the base of the bluff. At approximately Station 225+95, the conveyor begins a span over the bluff and existing stormwater patterns will not change. Overwater portions of the conveyor, supported by the pier, are not included in impervious calculations because a body of water is already modeled as impervious. A body of water can neither infiltrate stormwater nor generate stormwater runoff.

Ultimately all stormwater generated on this portion of the project area discharges to Hood Canal. The Single Conveyor travels along a localized ridge. Dispersed stormwater will be directed to the west side of this ridge. The Department of Natural Resources has mapped Type 5 streams in drainages on either side of the Single Conveyor.

6.0 OVERVIEW OF PROPOSED STORM WATER MANAGEMENT STRATEGIES

Fred Hill Materials Shine Pit is currently working under Department of Ecology (DOE) Sand and Gravel Permit No. WAG 50-1120. This permit has been kept up to date with a revised *Stormwater Pollution Prevention Plan* and *Erosion and Sediment Control Plan* (Fred Hill Materials Inc. 1999) and a revised *Storm Drainage Report* (Team4 Engineering 2001). The permit update was prepared in conjunction with an expansion to Fred Hill Materials' Department of Natural Resources (DNR) Reclamation Permit. The Reclamation Permit, No. 70-011936, was revised in July 2000 and approved by DNR in October 2000.

The stormwater analysis for the T-ROC Central Conveyor and Pier project will be submitted to the Washington State Department of Ecology as a revision to the existing Sand and Gravel Permit. All stormwater designs proposed in this preliminary report are designed to meet the requirements of the *Stormwater Management Manual for Western Washington* (Ecology 2001).

The stormwater management strategies selected for this project include the following elements:

- Sites that can fully infiltrate or fully disperse are not required to provide runoff treatment or flow control facilities (Sec. 5.3.4 *Stormwater Management Manual for Western Washington).*
- Stormwater generated within the Twin Conveyors corridor on new impervious surfaces (Station 25+23.69 to Station 200+00) will be discharged in accordance with BMP T5.30 - Full Dispersion. The project meets the requirements of being located within an area that is or will be more than 65% forested (or native vegetation cover) and less than 10% impervious (total). The roadway section will minimize the concentration of stormwater and allow sheet flow across the road whenever feasible. When stormwater is concentrated, either from the roadway or upstream areas, concentrated flows must be incrementally discharged at less than 0.5 cubic feet per second (cfs). Existing peak flows which enter the project site as a concentrated flow, may be discharged in addition to the allowable release of 0.5 cfs. Discharge points up to 0.2 cfs (100-year peak flow) will use rock pads or dispersion trenches to disperse flows. Discharge points between 0.2 and 0.5 cfs (100-year peak flow) shall use only dispersion trenches. Dispersion trench details are provided in full detail in BMP T5.30 of the *Stormwater Management Manual.* Flows from the project must traverse a minimum 100 feet of undisturbed native vegetation to meet the minimum requirements of this BMP. Flowpaths must not exceed 15% slopes. Ditch discharge points must be located at least 100 feet from steep slopes (steeper than 40%), wetlands, and streams.
- Each transfer point will have a utility shed and gravel parking/turn-out for the periodic maintenance of the conveyor components. Rooftop stormwater generated within five of the transfer points (#1-5) will be discharged to a downspout infiltration system as a first choice, and if impractical, will be discharged to a downspout dispersion system. The downspout infiltration system meets the design criteria of Vol. III, Sec. 3.1.1 of the *Stormwater Management Manual.* For preliminary design purposes, it is assumed that infiltration is practical at the transfer points. Final design will require the confirmation of suitable soils for infiltration. The gravel surface areas will continue to meet flow control criteria through Full Dispersion, discussed above. See Team4's Engineering Plan Set (2002) for specific locations.
- Upstream off-site areas will be allowed to sheet flow across the developed project area in accordance with BMP T5.30 – Full Dispersion. Where sheet flow is impractical, contributing stormwater will be collected in ditches and culverts, conveyed under the road, and dispersed in accordance with BMP T5.30.
- The project area located between the beginning of the Single Conveyor, Station 200+00, and approximately Station 217+50 will implement the Full Dispersion BMP.
- Between Station 217+50 and 221+75, stormwater will be collected in a roadside ditch and discharged to Wetland A, either by drainage ditch or surface mount pipe. Transfer Point #6 is located within this reach. Rooftop stormwater generated within Transfer Point #6 will be directed to the drainage ditch.

Concrete surfacing will be installed adjacent to and underneath the conveyor for permanent erosion control in this section. Although this portion of the project is surfaced with concrete and will be used for construction access, vehicular traffic during operation will be for emergencies only. Employees will park above this access and walk down to the pier. A gate will be installed at the top of this access to prevent vehicular traffic. This area is comparable to a pedestrian walkway, which does not require water quality treatment. Surface and subsurface flows are being diverted to the wetland to protect slope stability in the vicinity of the conveyor. The diversion of stormwater between Station 217+50 and 221+75 will provide recharge to Wetland A. Where appropriate, culverts will be placed in existing swales to allow the natural drainages to remain.

- Between Station 221+75 and 225+95, stormwater will be intercepted and conveyed in a series of catch basins and buried pipe to a surface-mount HDPE pipe traversing the bluff and directly discharging to the naturally disturbed area of Wetland B located at the base of the bluff. The impervious area beyond Station 222+00 has been minimized, decreasing from a 30.5-foot concrete section to a 12-foot concrete section adjacent to and underneath the conveyor. The 12-foot concrete section provides erosion control adjacent to the conveyor and is not used for vehicular access. This will decrease the total volume of stormwater that will contribute to the conveyance system. Trench drains will also discharge to this conveyance system. Prior to release, stormwater to the outfall will pass through an energy dissipater, a T-pipe formation with perforated top. For further details on this portion of the Stormwater Management Plan, see *Preliminary Geotechnical Report, Thorndyke Resource Operations Complex, Jefferson County, Washington* (Shannon & Wilson 2001) and Reid Middleton's *Single Conveyor Corridor* engineering plan set (RMI 2002).
- Overwater portions of the conveyor, supported by the pier, do not require stormwater management because there are no pollution-generating surfaces such as a road. The conveyor has a roof and sides along the length of the pier. Rooftop stormwater is considered "clean" and does not require water quality treatment.

7.0 TECHNICAL REQUIREMENTS/BEST MANAGEMENT PRACTICES (BMPs)

The Washington State Department of Ecology defines technical requirements for the Sand and Gravel General Permit, a National Pollutant Discharge Elimination System (NPDES) permit specifically for mining and related activities. Jefferson County will require a Stormwater Permit for the project.

The base level Operational BMPs to be implemented on the site include:

- Good Housekeeping,
- Preventive Maintenance,
- Spill Prevention & Emergency Cleanup,

- Inspections, and
- Employee Training.

Stormwater management includes the following parameters established in the Washington State Department of Ecology's *Stormwater Management Manual for Western Washington* (Ecology 2001):

- Source Control BMPs cover the continuing operation and maintenance of the conveyor belt and associated facilities. Source Control BMPs also cover associated operations such as dust control, fueling at utility sheds, and maintenance of the forestry service roads.

- Sites that can fully infiltrate or fully disperse are not required to provide stormwater runoff treatment or flow control facilities.

- Direct discharge is used for stormwater flow control over the last approximately 400 feet of the Single Conveyor (Station 221+75 to 225+95) prior to the top of the bluff. Stormwater will be collected in a stormwater conveyance system and discharged at the toe of the bluff.

- Rooftops at transfer points will fully infiltrate for stormwater control. Infiltration rates will be determined by site-specific inspections for final design. An infiltration rate for sandy loam soils has been used for preliminary design. Transfer Point #6 is an exception. Rooftop stormwater, which is considered "clean," will be directed to Wetland A for recharge.

8.0 HYDROLOGIC ANALYSIS

The soils listed on the site vary from a silt loam to a loamy sand. A sandy loam is used for analysis. The silt loam is located along the shoreline where no infiltration is proposed. The majority of soils listed are sandy loams, and designing to this soil type is a conservative measure because loamy sands would infiltrate stormwater twice as quickly as sandy loams. Sandy loam soils have a design infiltration rate of 0.25 inches/hour (Table 3.7, *Stormwater Management Manual for Western Washington).*

8.1 Stormwater Flow Control Design

8.1.1 Transfer Points

A utility shed will be constructed at each transfer point and will house motor controls. The transfer points are powered by electrical lines which will be buried adjacent to the conveyor along its length. The total building area used for design is 160 square feet.

Design criteria for infiltration trenches are listed in Vol. III, Sec. 3.1.1 of the *Stormwater Management Manual.* Sandy loam soils require 125 lineal feet of trench per 1,000 square feet of roof area. Typical trenches are 24 inches wide and 18 inches deep with a minimum cover of 6 inches.

8.1.2 Twin Conveyors

Full Dispersion provides Stormwater runoff control along the Twin Conveyors. This method of control does not require flow control or treatment as long as the BMP requirements are met.

8.1.3 Single Conveyor

The Single Conveyor will use the Full Dispersion BMP wherever possible. Stormwater from the last portion of the alignment will be collected and conveyed through a pipe directly to Hood Canal, commonly referred to as Direct Discharge. No detention or infiltration facility is proposed for this portion of the project. The geotechnical engineer has identified slide zones in the vicinity of the project (Shannon & Wilson 2002). It is not recommended that infiltration be used at this location because it may cause instability of the bluff and adjacent areas. Therefore, direct discharge is the preferred runoff control method.

8.2 Stormwater Runoff Treatment

Runoff treatment is not required where Full Dispersion is used. Runoff treatment is not required for roof downspout infiltration because stormwater generated on roofs is considered "clean."

9.0 EROSION AND SEDIMENTATION CONTROL

The *Erosion and Sedimentation Control Plan* includes the following features:

- Clearing Limits,
- Sediment Controls,
- Stabilization Practices,
- Pollutant Control, and
- BMP Maintenance.

Erosion and Sedimentation Control BMPs will be installed as the implementation of these features.

Offsite stormwater will be routed around portions of the project area during construction by interceptor swales. Any interceptor swale that slopes at greater than 6% will be riprapped to prevent erosion. A sediment pond with gravel filter cone will be used to prevent sedimentation offsite, if necessary.

Visual inspections of all Erosion and Sedimentation Control BMPs shall be conducted at least every seven days. BMPs shall also be inspected after any storm event which results in greater than 0.5 inch of rainfall within a 24-hour period.

10.0 OPERATION AND MAINTENANCE MANUAL

An Operation and Maintenance Manual will be provided after construction is complete.

REFERENCES

Fred Hill Materials, Inc., 1999. *Stormwater Pollution Prevention Plan and Erosion and Sediment Control Plan.*

Jefferson County Board of County Commissioners, March 7, 1989 with subsequent revisions. *Shoreline Management Master Program for Jefferson County and Port Townsend, Washington.*

Jefferson County Board of County Commissioners, August 28, 1998 with subsequent revisions. *Jefferson County Comprehensive Plan.*

Krazan & Associates, Inc., 2002. *Report of Geological Visual Site Reconnaissance, Thorndyke Resource Operations Complex, Twin Conveyors, Jefferson County, Washington.*

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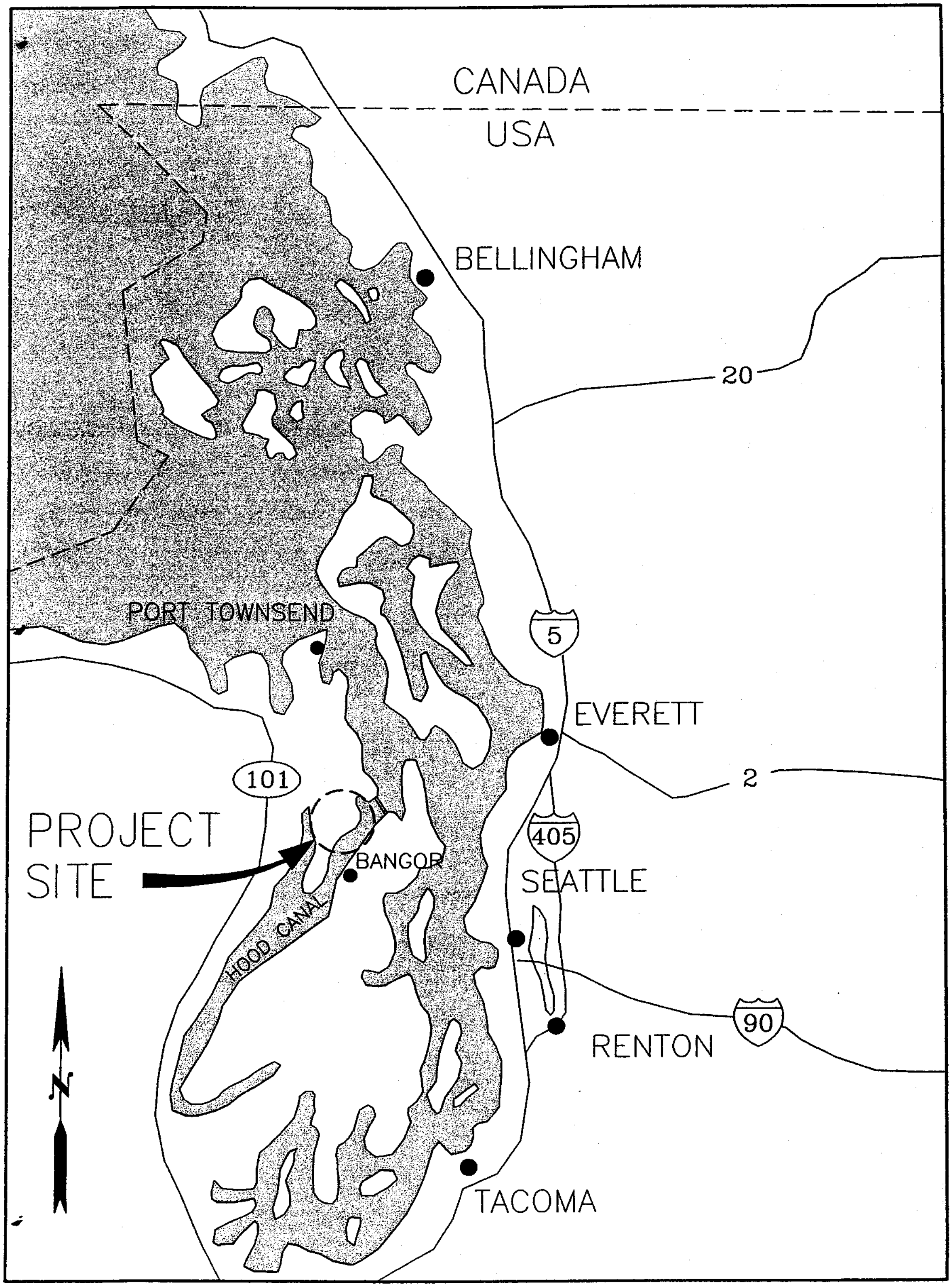

FIGURE 1

REGIONAL LOCATION MAP

NO SCALE

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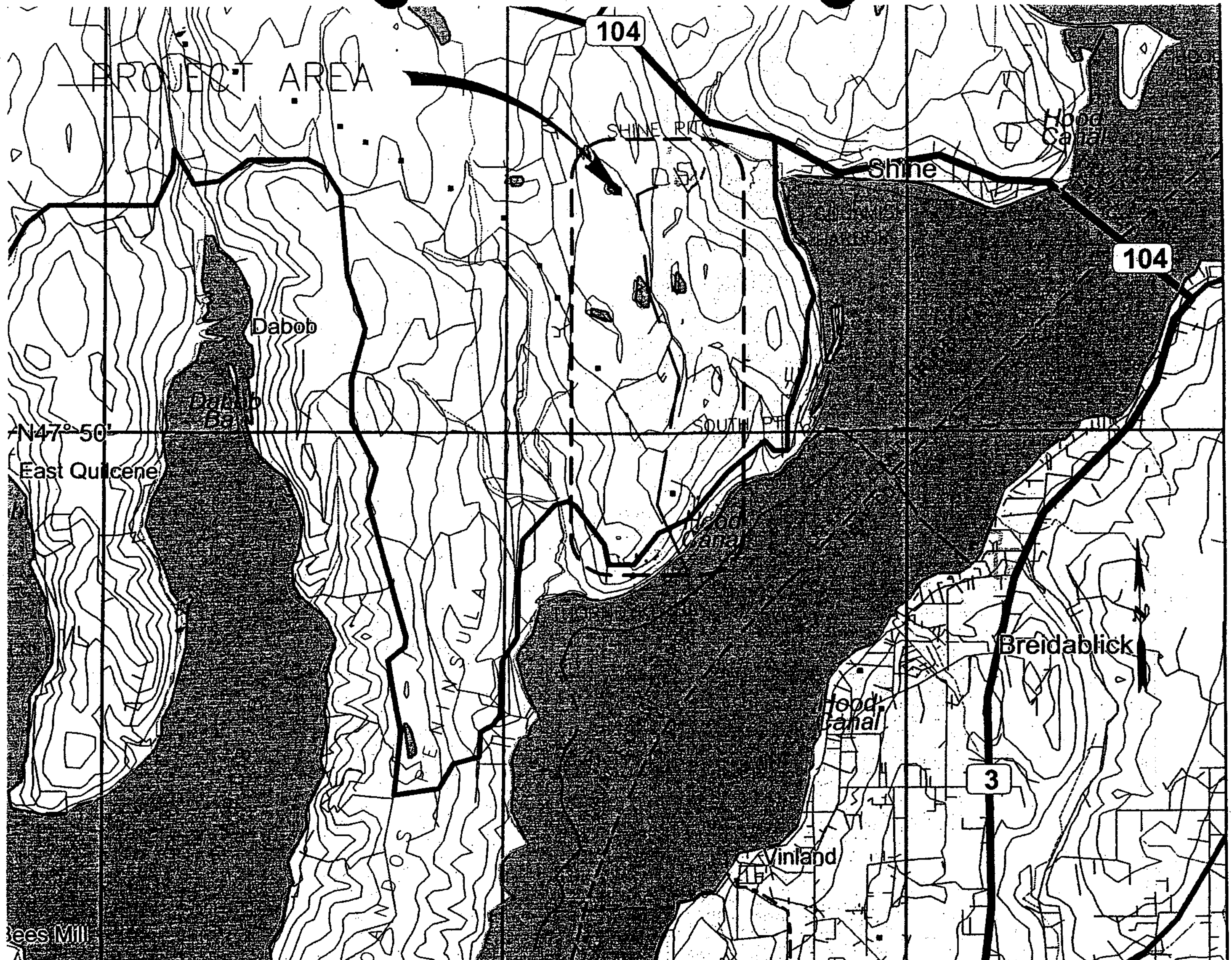

FIGURE 2

OVERALL SITE MAP

NO SCALE

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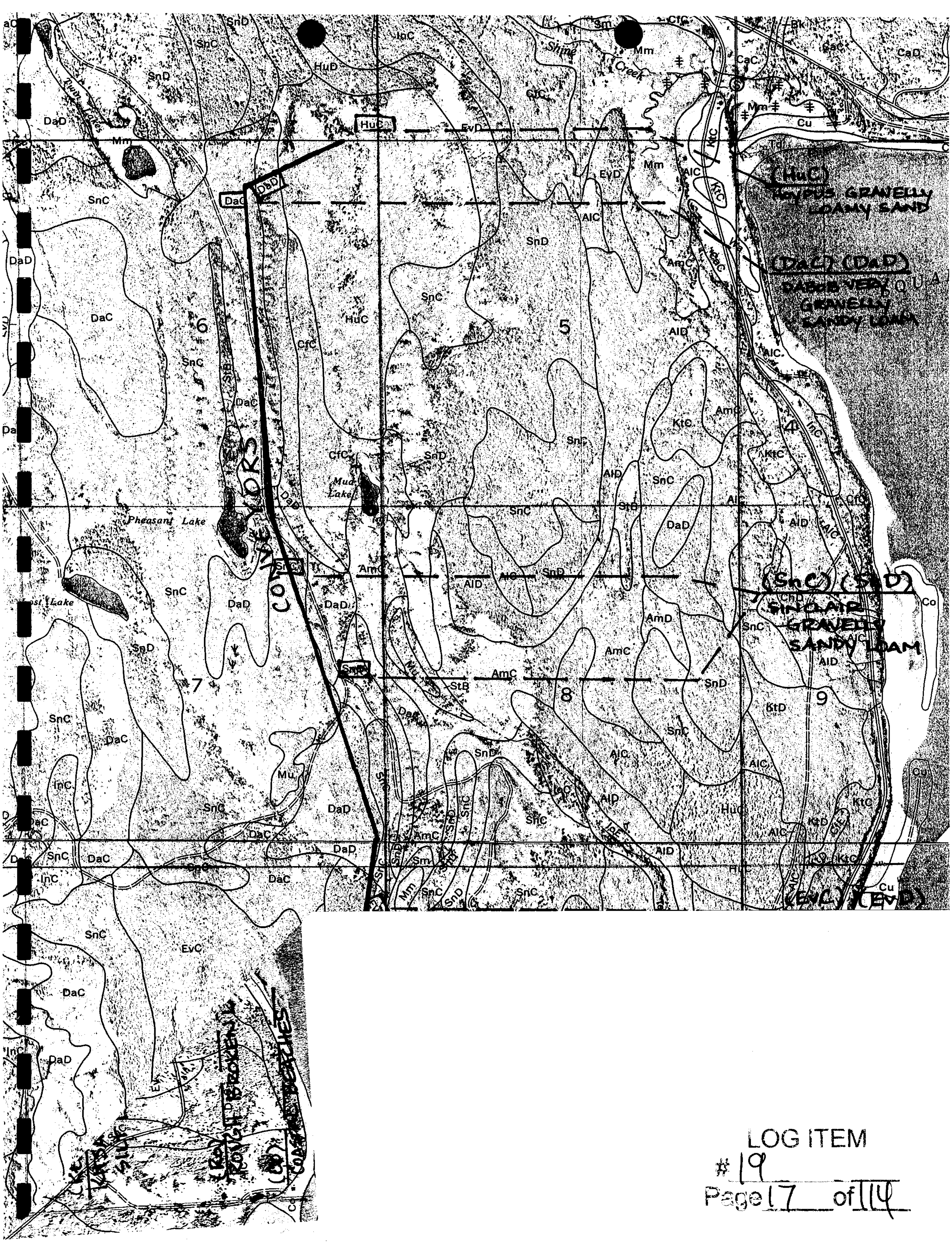

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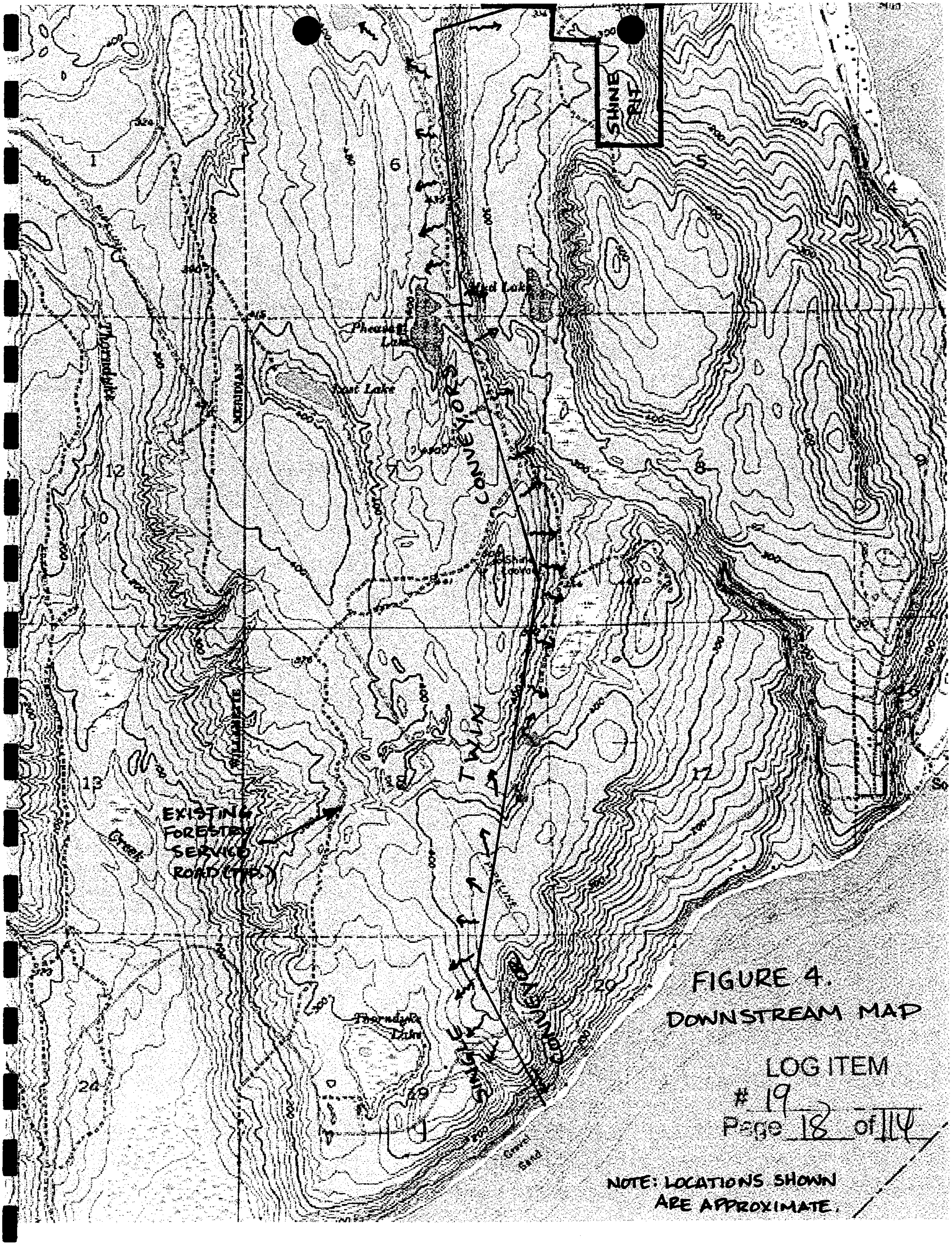

FIGURE 4.
DOWNSTREAM MAP

NOTE: LOCATIONS SHOWN ARE APPROXIMATE.

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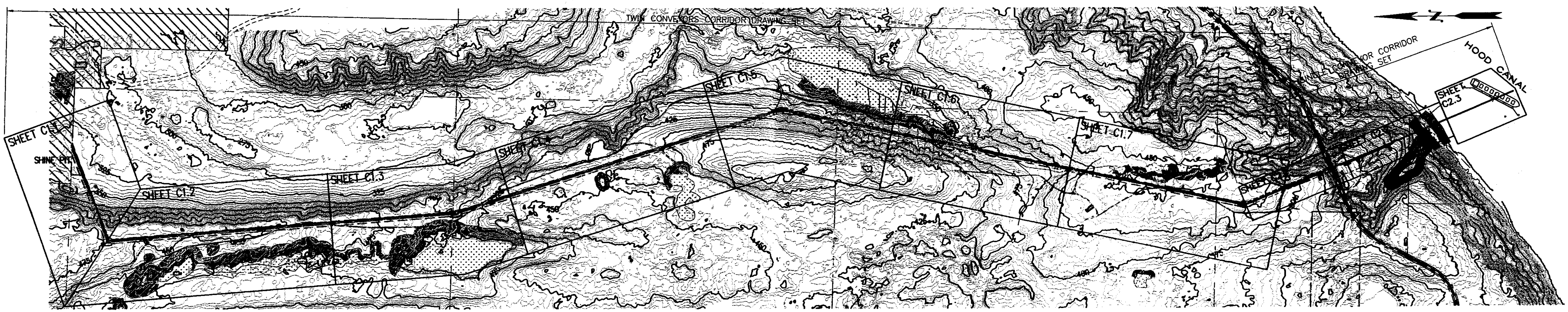

FIGURE 5

DEVELOPED CONDITIONS

NO SCALE

NOTE: SEE TEAM4 ENGINEERING AND REID MIDDLETON PLAN SETS FOR FURTHER DETAILS.

LEGEND

- WETLAND BUFFER
- PROPOSED EASEMENT
- LIDAR TOPOGRAPHY — 300
- PROPOSED TWIN CONVEYOR ROUTE
- SECTION LINE
- DELINEATED WETLANDS
- DNR-MAPPED STREAM
- PROPOSED GRAVEL FORESTRY SERVICE ROAD
- EX. ROAD

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Table 2.2 Hydrologic Soil Series for Selected Soils in Washington State

Soil Type	Hydrologic Soil Group	Soil Type	Hydrologic Soil Group
Agnew	C	Hoko	C
Ahl	B	Hoodsport	C
Aits	C	Hoogdal	C
Alderwood	C	Hoypus	A
Arents, Alderwood	B	Huel	A
Arents, Everett	B	Indianola	A
Ashoe	B	Jonas	B
Baldhill	B	Jumpe	B
Barneston	C	Kalaloch	C
Baumgard	B	Kapowsin	C/D
Beausite	B	Katula	C
Belfast	C	Kilchis	C
Bellingham	D	Kitsap	C
Bellingham variant	C	Klaus	C
Boistfort	B	Klone	B
Bow	D	Lates	C
Briscot	D	Lebam	B
Buckley	C	Lummi	D
Bunker	B	Lynnwood	A
Cagey	C	Lystair	B
Carlsborg	A	Mal	C
Casey	D	Manley	B
Cassolary	C	Mashel	B
Cathcart	B	Puget	D
Centralia	B	Puyallup	B
Chehalis	B	Queets	B
Chesaw	A	Quilcene	C
Cinebar	B	Ragnar	B
Clallam	C	Rainier	C
Clayton	B	Raught	B
Coastal beaches	variable	Reed	D
Colter	C	Reed, Drained or Protected	C
Custer	D	Renton	D
Custer, Drained	C	Republic	B
Dabob	C	Riverwash	variable
Delphi	D	Rober	C
Dick	A	Salal	C
Dimal	D	Salkum	B
Dupont	D	Sammamish	D
Earlmont	C	San Juan	A
Edgewick	C	Scamman	D
Eld	B	Schneider	B
Elwell	B	Seattle	D
Esquatzel	B	Sekiu	D
Everett	A	Semiahmoo	D
Everson	D	Shalcar	D
Galvin	D	Shano	B
Getchell	A	Shelton	C
Giles	B	Si	C
Godfrey	D	Sinclair	C
Greenwater	A	Skipopa	D
Grove	C	Skykomish	B
Harstine	C	Snahopish	B
Hartnit	C	Snohomish	D
Hoh	B	Solduc	B

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EXHIBIT 1 - HYDROLOGIC SOIL GROUPS

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Table 5-2 MODIFIED CURVE NUMBERS

SCS Western Washington Runoff Curve Numbers

Runoff curve numbers for selected agricultural, suburban, and urban land use for Type 1A rainfall distribution, 24-hour storm duration. (Published by SCS in 1982)

LAND USE DESCRIPTION		CURVE NUMBERS BY HYDROLOGIC SOIL GROUP A	B	C	D
Cultivated land [1]:	Winter condition	86	91	94	95
Mountain open areas:	Low growing brush & grassland	74	82	89	92
Meadow or pasture:		65	78	85	89
Wood or forest land:	Undisturbed	42	64	76	81
	Established second growth [4]	48	68	78	83
	Young second growth or brush	55	72	81	86
Orchard:	With cover crop	81	88	92	94
Open spaces, lawns, parks, golf courses, cemeteries, landscaping					
Good condition:	Grass cover on >= 75% of area	68	80	86	90
Fair condition:	Grass cover on 50-75% of area	77	85	90	92
Gravel roads & parking lots:		76	85	89	91
Dirt roads & parking lots:		72	82	87	89
Impervious surfaces, pavement, roofs, etc.		98	98	98	98
Open water bodies:	Lakes, wetlands, ponds, etc.	100	100	100	100
Single family residential [2]:		Separate curve number shall be selected for pervious and impervious portions of the site or basin.			
Dwelling unit/gross acre	% Impervious [3]				
1.0 DU/GA	15				
1.5 DU/GA	20				
2.0 DU/GA	25				
2.5 DU/GA	30				
3.0 DU/GA	34				
3.5 DU/GA	38				
4.0 DU/GA	42				
4.5 DU/GA	46				
5.0 DU/GA	48				
5.5 DU/GA	50				
6.0 DU/GA	52				
6.5 DU/GA	54				
7.0 DU/GA	56				
PUDs, condos, apartments, commercial businesses & industrial areas	% impervious must be computed				

[1] For a more detailed description of agricultural land use curve numbers, refer to National Engineering Handbook, Sec 4, Hydrology, Chapter 9, August 1972.

[2] Assumes roof and driveway runoff is directed into street/storm system.

[3] The remaining pervious areas (lawn) are considered to be in good condition for these curve numbers.

[4] Modified by KCPW, 1995.

EXHIBIT 2 - CURVE NUMBERS

MANNING'S COEFFICIENTS/"K" FACTORS

"n" AND "k" Values Used in Time Calculations for Hydrographs

"n_s" Sheet Flow Equation Manning's Values (for the initial 300 ft. of travel)	n_s
Smooth surfaces (concrete, asphalt, gravel, or bare hand packed soil)	0.011
Fallow fields or loose soil surface (no residue)	0.05
Cultivated soil with residue cover (s≤ 0.20 ft/ft)	0.06
Cultivated soil with residue cover (s > 0.20 ft/ft)	0.17
Short prairie grass and lawns	0.15
Dense grasses	0.24
Bermuda grass	0.41
Range (natural)	0.13
Woods or forest with light underbrush	0.40
Woods or forest with dense underbrush	0.80

*Manning values for sheet flow only, from Overton and Meadows 1976 (See TR-55, 1986)

"k" Values Used in Travel Time/Time of Concentration Calculations

	Shallow Concentrated Flow (After the initial 300 ft. of sheet flow, R = 0.1)	k_s
1.	Forest with heavy ground litter and meadows (n = 0.10)	3
2.	Brushy ground with some trees (n = 0.060)	5
3.	Fallow or minimum tillage cultivation (n = 0.040)	8
4.	High grass (n = 0.035)	9
5.	Short grass, pasture, and lawns (n = 0.030)	11
6.	Nearly bare ground (n = 0.025)	13
7.	Paved and gravel areas (n = 0.012)	27

	**Channel flow (intermittent) (At beginning of visible channels R = 0.2)	k_c
1.	Forested swale with heavy ground litter (n = 0.10)	5
2.	Forested drainage course/ravine with defined channel bed (n = 0.050)	10
3.	Rock-lined waterway (n = 0.035)	15
4.	Grassed waterway (n = 0.030)	17
5.	Earth-lined waterway (n = 0.025)	20
6.	CMP pipe (n = 0.024)	21
7.	Concrete pipe (0.012)	42
8.	Other waterways and pipe 0.508/n	

	Channel Flow (Continuous stream, R = 0.4)	k_c
9.	Meandering stream with some pools (n = 0.040)	20
10.	Rock-lined stream (n = 0.035)	23
11.	Grass-lined stream (n = 0.030)	27
12.	Other streams, man-made channels and pipe 0.807/n**	

**See Table 7-3 for additional Mannings "n" values for open channels.

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EXHIBIT 3 - MANNING'S COEFFICIENTS

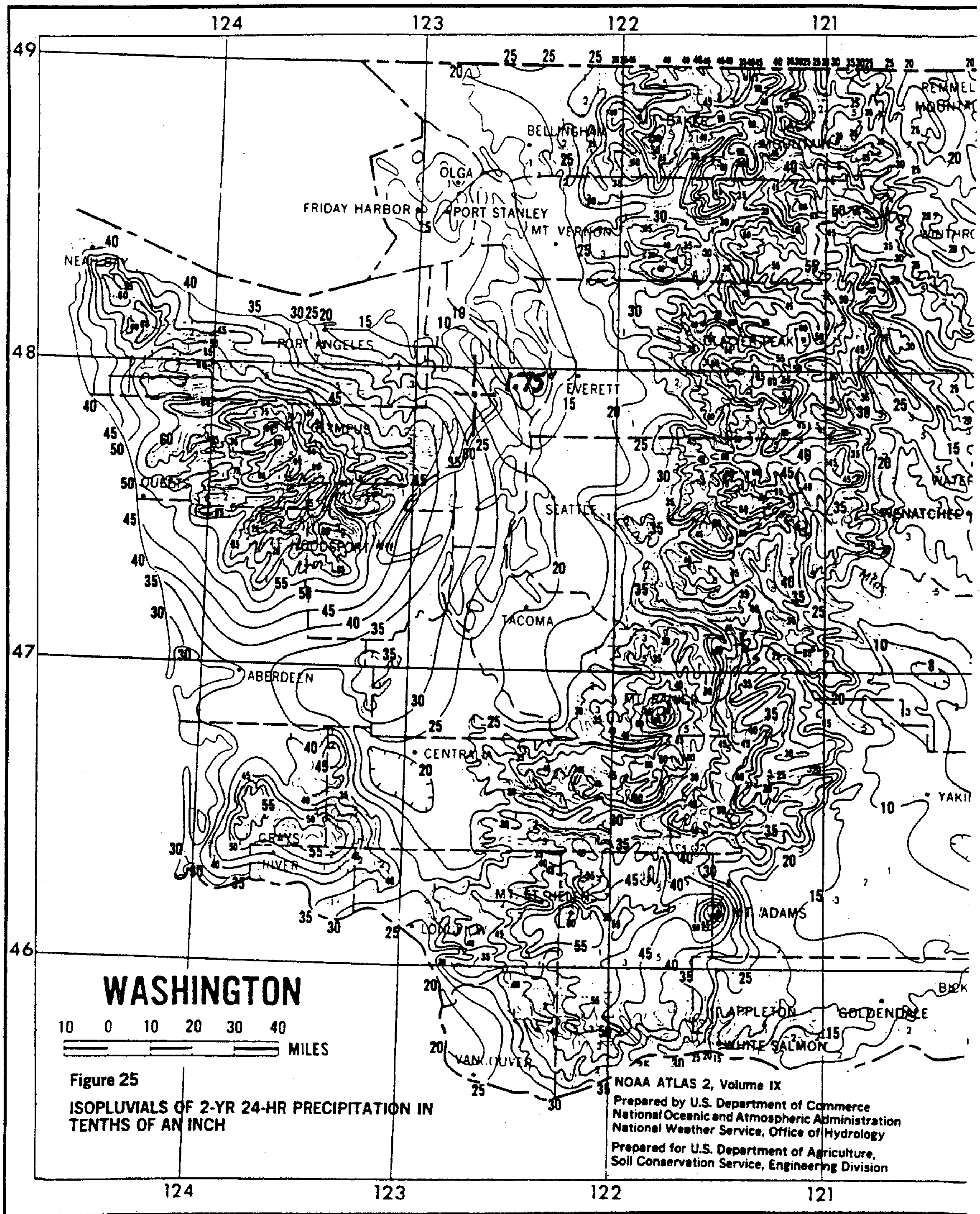

Figure 25

ISOPLUVIALS OF 2-YR 24-HR PRECIPITATION IN TENTHS OF AN INCH

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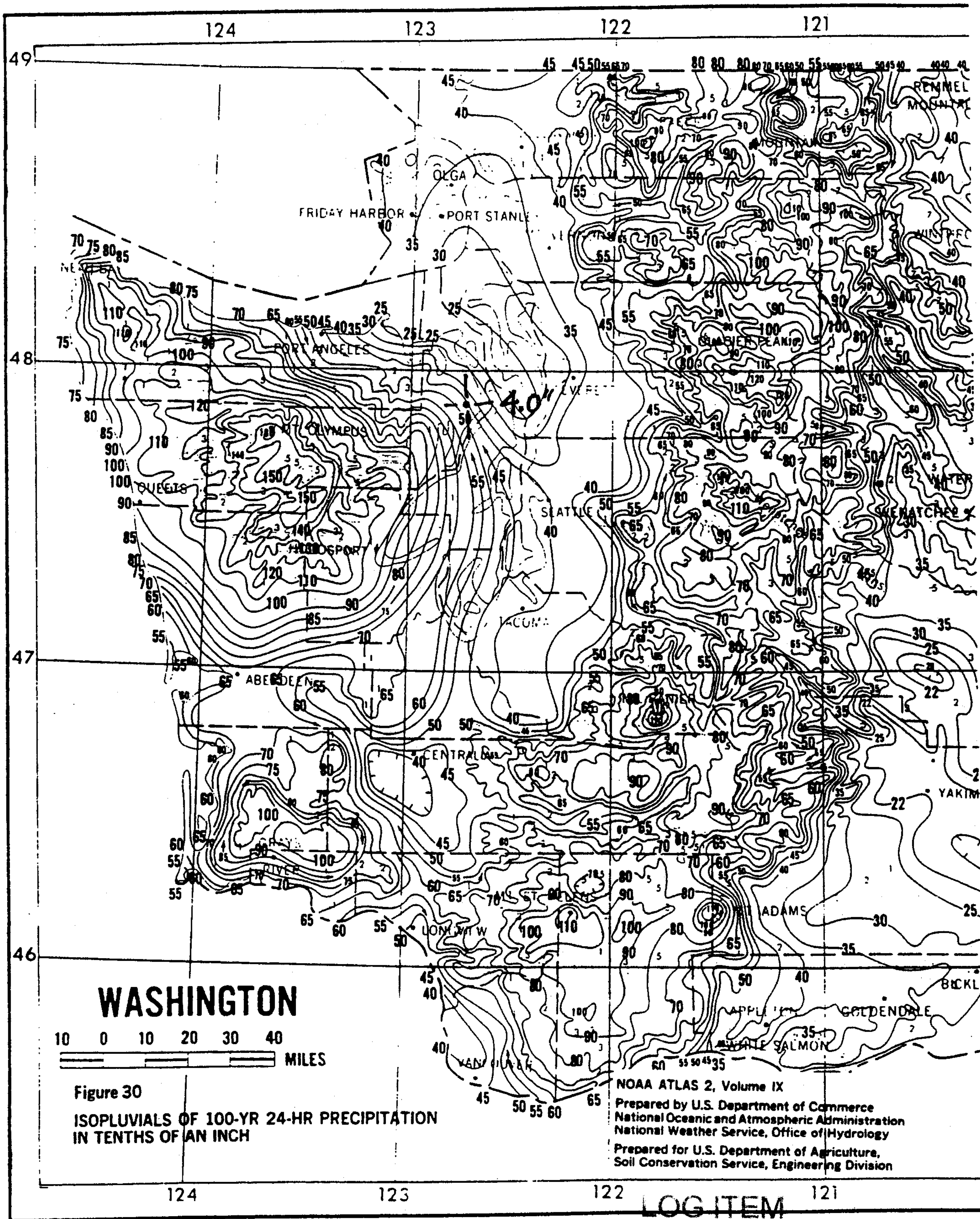

WASHINGTON

Figure 30

ISOPLUVIALS OF 100-YR 24-HR PRECIPITATION IN TENTHS OF AN INCH

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Appendix A:

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

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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

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	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)

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	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