KEYSTONE
FERRY TERMINAL

RELOCATION FEASIBILITY STUDY

August 2003

PREPARED BY:
CH2M HILL

Author: Douglas R. Playter, P.E.

TABLE OF CONTENTS

EXECUTIVE SUMMARY ..... **iv**

Purpose iv
Key Issues to Consider iv
Results iv
Estimated Costs v
Next Steps v

INTRODUCTION **1**

Study Objective 1
Route Statistics 1
Vessel Considerations 3

EXISTING CONDITIONS **5**

History 5
Vessel Operations 6

FEASIBILITY OF RELOCATING KEYSTONE FERRY TERMINAL **9**

Preliminary Investigation 9
Community Agency and Tribal Participation 9
Operability 9
Engineering 13
Environment 14
Cost 19

CONCLUSION **21**

Figures

1 Keystone Ferry Terminal Vicinity Map
2 2001 Keystone Cancellations
3 Pushing Back a Lake to Build Boat Haven
4 Operational Conditions
5 Grounded State Ferry
6 Wind, Waves, and Currents
7 Sailings Lost per Year
8 Study Area Affected Wetlands

Tables

1 Keystone Scheduled Sailings Per Year
2 Keystone Percentage of Time Inoperable and Number of Lost Sailings Per Year
3 Relative Impacts by Environmental Factor
4 Feasibility-Level Cost Estimate

Appendices

A Stakeholder Input and Agency Meetings
B Wind, Waves, and Currents
C Vessel Operability Analysis
D Offshore Geology
E Conceptual Terminal Designs
F Traffic Assessment
G Underwater Habitat Survey

EXECUTIVE SUMMARY

Purpose

The Keystone-Port Townsend ferry route is currently served with 76-year-old Steel Electric vessels that will be retired within the next 10 years. The replacement vessels will be designed similar to the existing Issaquah class vessels, which cannot navigate the shallow and narrow inlet to Keystone Harbor. Alternative vessels with the capacity to meet systemwide needs, and the physical characteristics necessary to navigate Keystone Harbor, will not meet Washington State Ferries' (WSF) goal of a standardized and interchangeable fleet. Therefore, WSF is evaluating the feasibility of relocating the Keystone ferry terminal to a location outside the existing harbor. Other potential benefits of a new location include a more reliable service schedule (Keystone ferry terminal has more canceled sailings than any other in the WSF system) and better access to and from State Route (SR) 20 and Engle Road.

The purpose of this feasibility study is to identify a range of potential new sites for a ferry terminal and to determine if there are fatal flaws associated with relocating the terminal outside the existing harbor. The final selection of the site will involve a thorough environmental review, which will include an examination of several potential alternative sites within the service area and analysis of potential environmental impacts.

Key Issues to Consider

Some of the key issues to consider regarding potential relocation of the ferry terminal include tribal treaty rights, recreational use of the spit, environmental impacts of relocation versus the impacts of widening and deepening the existing channel, general environmental impacts on the Keystone spit ecosystem, impacts on Crockett Lake, and traffic impacts on both Whidbey Island and Port Townsend.

Results

The results of this study have concluded that it is feasible to relocate the terminal outside the existing harbor, and that using a more maneuverable vessel such as the Issaquah class reduces the number of cancelled sailings due to tides and currents in Keystone Harbor from 95 per year (the 2001–2003 average) to 21 to 46 per year at a new location. The number of cancellations due to wind, waves and currents at a new location would depend on the location of the terminal and the slip orientation. An environmental review will be undertaken to identify and address the issues raised by the relocation.

Estimated Costs

Engineering costs and environmental factors were evaluated to assess the cost of a potential relocation. Relocation costs would range from $36 million to $62 million depending on the location selected and the number of slips constructed. At the low end, the $36 million estimate includes a single slip located on the east area of Keystone Spit; at the high end, the $62 million estimate includes a double slip located on the west area of the spit. There are other terminal locations and configurations that would result in cost estimates between these bounds.

Next Steps

During two public meetings and separate meetings with tribal representatives, many groups were concerned about potential impacts caused by relocation of the ferry terminal to Keystone Spit. The environmental review process will provide an effective forum to identify actual impacts, inform the public, address issues and potential mitigation, and decide on a final terminal location.

INTRODUCTION

Study Objective

Washington State Ferries (WSF) is investigating the feasibility of relocating the Keystone ferry terminal from its existing location to an unspecified location outside of the existing Keystone Harbor. The relocation is being considered to allow the use of larger standard-sized vessels. For this reason, a potential relocation would provide an opportunity for WSF to improve service on the Keystone-Port Townsend route.

For purposes of this feasibility study, the Keystone Spit area immediately east of Keystone Harbor was considered the study area (see Figure 1). This area is close to the existing terminal and has low bank access to SR 20. These attributes are appropriate for a comparison at this level of analysis; however, if the project moves forward to the environmental review process, then additional alternative locations would be considered. The additional alternatives could include no-build, modifications to the existing harbor, and evaluation of other locations that would meet the purpose and need for the project.

This feasibility study compares the effects of relocating the ferry terminal versus using the existing location in terms of performance, design feasibility, cost, natural and built environmental impact, impact on property, and potential mitigation. Overall, the purpose of this study is to answer the question—are there one or more sites outside the harbor that are feasible terminal locations from a technical, operational, environmental, and financial standpoint?

Route Statistics

The Keystone-Port Townsend ferry route provides the most direct link between Whidbey Island and the Olympic Peninsula. The route is more heavily used in the summer months for recreation because it provides a direct and scenic route for travelers between Jefferson and Clallam counties on the Olympic Peninsula and communities in Island, San Juan, Skagit, and Whatcom counties. Without this ferry route, the shortest distance between Port Townsend and Keystone would require driving approximately 70 miles and taking the Kingston-Edmonds and Mukilteo-Clinton ferries. The estimated time to make the trip around is over 3 hours, as opposed to the 30-minute sailing between Port Townsend and Keystone. Ridership on the route in 2002 was 798,291.

The Keystone-Port Townsend route is important for regional mobility and tourism; however, it has operability problems caused by severe low tides and associated currents that prevent the ferry from safely entering Keystone Harbor. For example, in 2001 there were 99 canceled sailings due to a combination of tides and currents at Keystone (see Figure 2). The 99 cancellations are roughly equivalent to 8 operating days based on an average of 12 sailings per day. Cancellations are frequent in the summer months when ridership is high. The canceled sailings represent lost revenue to the ferry system and, more importantly, are extremely frustrating to the traveling

167215.AD.04_T102002010SEA_Keystone Terminal Vicinity_10/22/02_dk

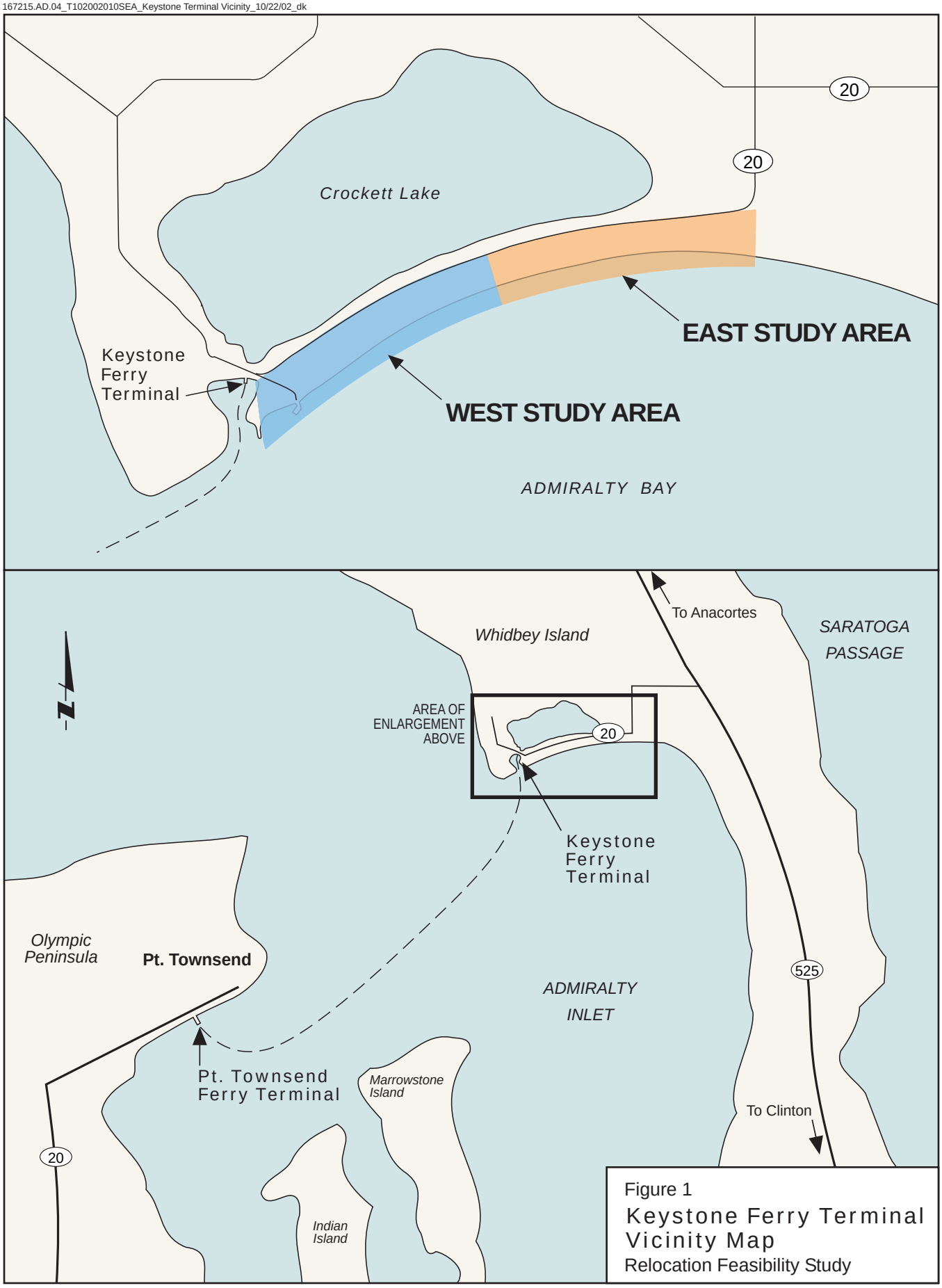


Figure 1

Keystone Ferry Terminal Vicinity Map

Relocation Feasibility Study

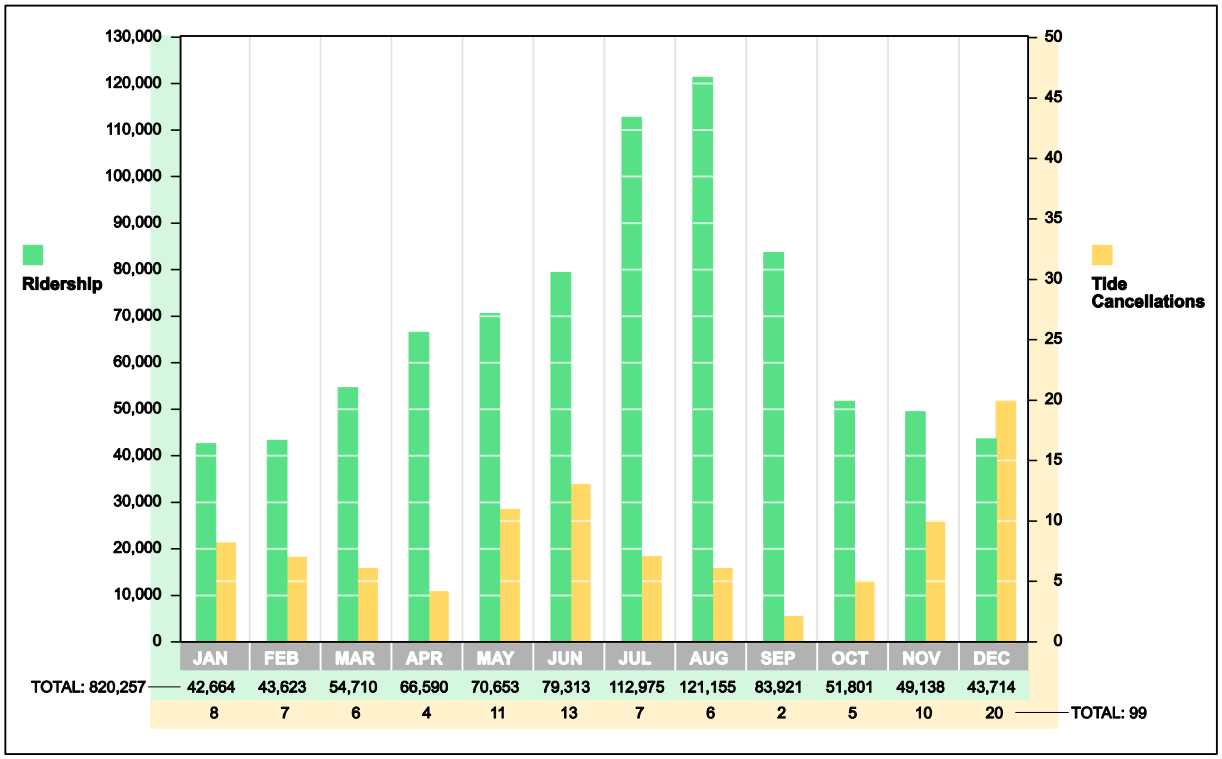


Figure 2
2001 Keystone Cancellations
Relocation Feasibility Study

public. Even though cancellations are predicted and a cancellation bulletin is published, tourists are not always aware of the cancellations, which leads to extremely long lines that affect traffic on the roads leading to the Port Townsend and Keystone terminals.

Vessel Considerations

Ferry service to Keystone is currently provided only by Steel Electric class vessels. This type of vessel was originally built in 1927 for service in San Francisco Bay. WSF operates four Steel Electric class vessels systemwide, with one or two working the Keystone-Port Townsend route, depending on the season. These vessels are 74 feet wide by 256 feet long and have a relatively shallow 12-foot-9-inch draft. The Steel Electric class vessels are the largest ferries operated by WSF that can reliably enter the channel into Keystone Harbor. Keeping these vessels in service would involve extensive renovation over the next decade. WSF thinks a better business decision is to replace them in the next decade with a more universally applicable class of vessel.

As part of WSF's strategic plan, new vessels will be designed for commonality with the existing fleet. The goal is to increase efficiency by working towards a fleet of interchangeable vessels. The current plan is to replace the Steel Electric vessels with a vessel similar to the Issaquah 130 class. The vessel is larger and has a deeper draft than the Steel Electric. A larger, deeper draft vessel would be more stable and have the ability to handle more vehicles. This vessel is highly

maneuverable, carries 130 vehicles, and is already in use within the ferry system. Constructing a new class of vessel similar to the Issaquah 130 will give the ferry system much more flexibility with vessel assignments that will benefit not only the Keystone-Port Townsend route, but also the entire system. For example, when a ferry requires replacement for maintenance, it can be replaced with a ferry of similar capacity rather than a smaller one. This capability provides WSF customers systemwide with a more reliable system.

EXISTING CONDITIONS

History

The Keystone-Port Townsend ferry route originated in the days of the Mosquito Fleet in the early 1900s. Prior to 1948, auto ferry operations took place at a terminal location approximately 1.5 miles east of the existing terminal, where SR 20 makes a 90-degree turn to due north (see Figure 1). The terminal operated seasonally in this location due to weather and lower traffic volumes in the winter.

In 1941, the United States Government through the Secretary of War authorized a new harbor to be constructed. The intent was to build an all-weather, year-round ferry terminal on the southwestern shore of Crockett Lake to increase regional mobility and, importantly at the time, to provide reliable ferry service for moving troops and supplies between Fort Worden and Fort Flagler on the Olympic Peninsula and Fort Casey on Whidbey Island. Construction of the jetty, the harbor, and the berm that separated Crockett Lake from Keystone Spit was completed in 1948 (see Figure 3). The original navigable channel was 150 feet wide, with the bottom of the channel at elevation –18′ mean lower low water (MLLW).

Figure 3
Pushing Back a Lake to Build Boat Haven
(source: Seattle Times, January 4, 1948)
Relocation Feasibility Study

Since 1948, vessels using Keystone Harbor have increased in size from the 165-foot by 48-foot, all-wood MV *Defiance* to the 256-foot by 74-foot MV *Quinault* and MV *Klickitat* in use today. In response to the increased size of vessels, the navigable channel was widened to 200 feet and deepened to –25′ MLLW.

Shortly after the harbor was constructed, Olympic Ferries, Ltd., of Port Townsend built the original Keystone Harbor terminal facilities. Olympic Ferries operated at the original site until 1973, when it became unprofitable. In 1974, WSF was directed by the Washington State Legislature to operate the route and, in 1979, built the existing terminal about 150 feet west of its previous location. Operations were switched to the existing location and have remained largely unchanged since that time.

Vessel Operations

While Keystone Harbor construction initially improved ferry service between Keystone and Port Townsend, the harbor does not ensure reliability for landings. The 99 sailings canceled at Keystone in 2001 represent 2.2 percent of the 4,410 annual scheduled sailings on that route. This percentage is more than four times the WSF systemwide average of 0.5 percent.

Cross-currents are the greatest challenge in landing a ferry at Keystone. Because of the several groundings at the entrance to the harbor over the years (see Figure 5), WSF has a set policy that ferries may not enter the harbor when crosscurrents exceed 3.5 knots, as determined at the nearest monitoring station.

To further illustrate how the crosscurrent affects the approach at Keystone Harbor, refer to Figure 4. As can be seen, the typical approach at other ferry terminals in the WSF system would have the vessel beginning to back down at 1/4 mile (1,320 feet) from the wingwalls, or about 1,100 feet from the outer dolphin. This is often not possible at Keystone because of the crosscurrents at the south end of the jetty. As the bow of the vessel crosses an imaginary east-west line at the south end of the jetty, the bow encounters slack water while the stern is being pushed strongly to the west by the current. To counteract the current force on the stern of the vessel, the captain must maintain propeller thrust on the rudder to steer. Often the current force exceeds the vessel's ability to compensate and this causes the vessel to veer from the preferred straight-in approach. The vessel captain must then correct course inside the south end of the breakwater prior to backing down for the final approach. As can be seen in Figure 4, the maximum theoretical backdown distance is only 720 feet from the wingwalls, or about 500 feet from the outer dolphin, which is less than half of typical. This condition is the cause of several groundings each year at Keystone Harbor.

FILE NAME: operational_conditions.dgn 07-AUG-2003 15:29:47

Washington State Ferries

CH2MHILL

FIGURE 4

OPERATIONAL CONDITIONS

KEYSTONE, WASHINGTON

Figure 5
Grounded State Ferry MV *Quinault* (source: Seattle Post-Intelligencer, August 23, 2002; photo credit: Meryl Schenker)
Relocation Feasibility Study

Intuitively, one can see that if the vessel were to increase in size, the available width within the channel to correct course and the backdown distance would decrease. For example, if the 328-foot by 79-foot Issaquah class vessel were used in the harbor, the backdown distance would be approximately 650 feet (less than half of typical), or about 430 feet to the outer dolphin, because the Issaquah class is 72 feet longer than the Steel Electric class. That, and the shallow depth of the harbor rule out the assignment of a larger vessel.

FEASIBILITY OF RELOCATING KEYSTONE FERRY TERMINAL

Preliminary Investigation

As previously discussed, the purpose of this study is to investigate the feasibility of relocating the Keystone ferry terminal outside of Keystone Harbor to allow a larger vessel on the run and to improve WSF system efficiency, reliability, and safety. For study purposes, the most comparable location appears to be the 1.5-mile-long Keystone Spit that lies east of the existing harbor. Any conclusions drawn from this study regarding Keystone Spit do not constitute a decision to move the terminal or the identification of an alternate site. This chapter provides overviews of the specific issues identified for Keystone Spit from operational, engineering, environmental and cost perspectives.

Community, Agency, and Tribal Participation

Public and tribal meetings were held as part of the feasibility study to elicit stakeholder input regarding the potential relocation of the Keystone ferry terminal. During the kickoff phase of the study, an open-forum public and agency meeting was held in Coupeville on July 30, 2002. Comments and questions raised by the attendees are included in Appendix A. These comments were important in shaping the study and developing recommendations. At a second meeting on November 30, 2002, the findings of the study were presented to the public and discussed in an open forum. Comments from the second meeting and attendees are included in Appendix A.

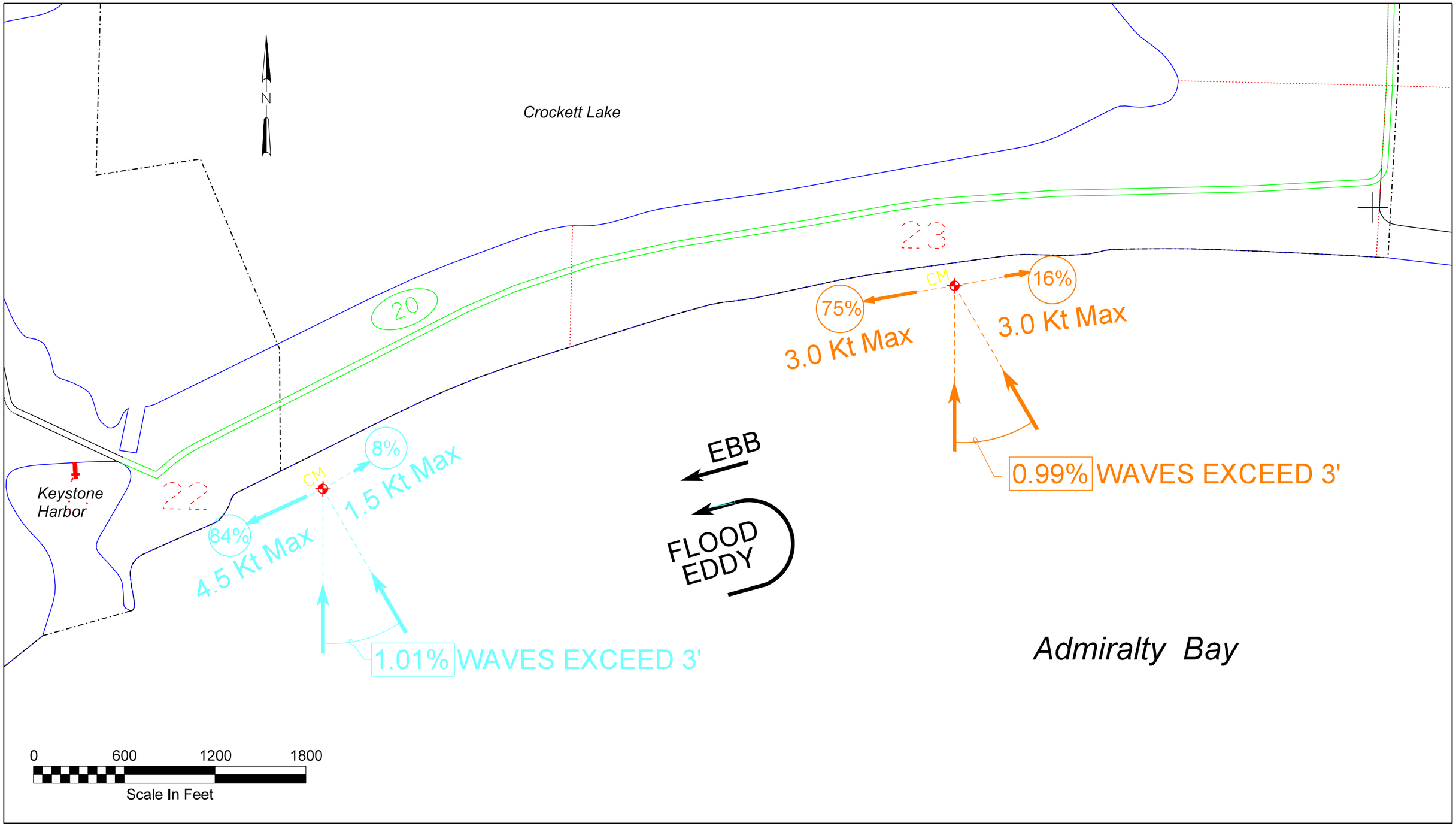
A series of meetings between WSF and potentially affected tribes also occurred over several dates in 2003. Summaries of these meetings and issues are also included in Appendix A.

Operability

Current Data

Current and wind data were gathered to evaluate the operability of the ferry outside of Keystone Harbor. Current meters were deployed at the locations shown on Figure 6 to identify the currents along Keystone Spit. The western meter was used to determine the effects along the west study area, including the jetty, and the eastern meter was used to provide general information about the east study area. The eastern portion of the spit was assumed to have generally consistent currents because there are no physical features that would cause a concentration of flow and associate high currents. Figure 6 shows that currents are predominantly east to west along the spit because, in addition to the ebb current, there is a counterclockwise eddy that occurs during a flood tide. Also as shown on the figure, the currents at the west current meter location run 84 percent of the time to the west at a maximum velocity

FILE NAME: windwavescurrents1a.dgn 07-AUG-2003 15:32:06



Washington State Ferries

CH2MHILL

LEGEND:

CM	CURRENT METER
(84%)	PERCENT OF TIME CURRENT FLOWS BY DIRECTION
[1.01%]	PERCENT OF TIME WAVES EXCEED 3' BY DIRECTION

FIGURE 6

WIND, WAVES, AND CURRENTS

KEYSTONE, WASHINGTON

of 4.5 knots; and the currents at the east current meter location run 75 percent of the time to the west at a maximum velocity of 3.0 knots. Appendix B contains the full report on currents and discusses the methods and means used to obtain and analyze the data.

Wind and Wave Data

Appendix B also describes the development of the wind and data record and subsequent wave generation method. Figure 6 summarizes relevant results of the wind and wave analysis. The 3-foot wave height is significant because it causes a 0.5-foot bow-heave when acting on the beam (or side) of the design vessel, which is the controlling criteria for in-slip vessel operations.

Vessel Operability

To evaluate the vessel's operability at a terminal outside of Keystone Harbor, a sophisticated vessel model and methodology was developed. The development of this model and the detailed analysis are contained in Appendix C. The vessel operability analysis considered both the dockside operability and the approach/departure operability. The results are presented in Figure 7 as the number of sailings that would be missed if the terminal were to be moved to the sites and orientations shown. These numbers were calculated by multiplying the "scheduled sailings per year" shown in Table 1 by the "percentage of time inoperable" calculated in Appendix C and shown in Table 2 (i.e., $1.05\% \times 4{,}410 = 46$). For comparison, the 2001–2002 average number of Keystone sailings missed (95) from the existing location (based on 99 cancellations in 2001 and 91 in 2002) is also shown in the figure.

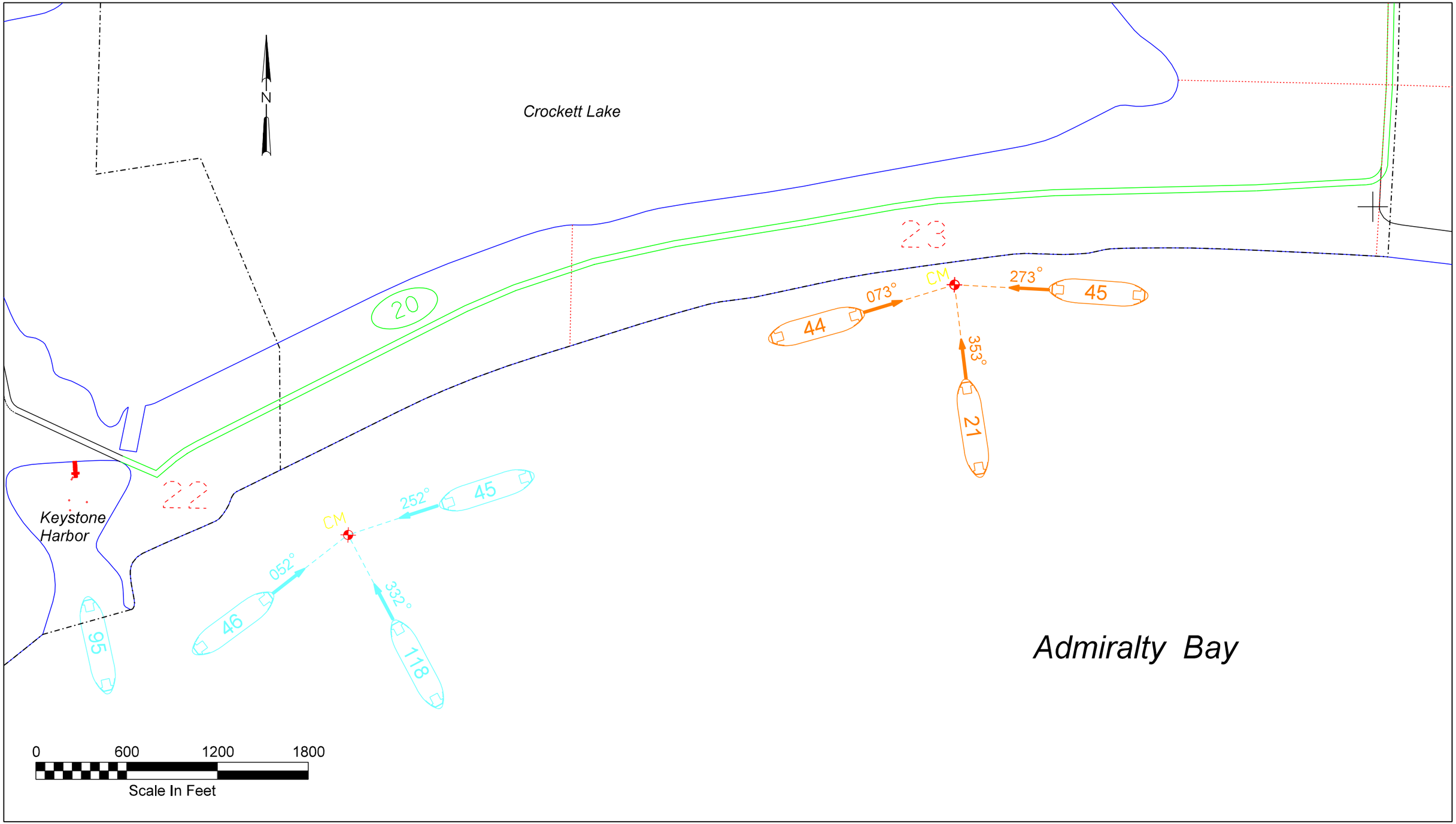
TABLE 1
Keystone Scheduled Sailings Per Year

	Scheduled Sailings/ Day	Scheduled Sailings/ Period
Mid-May to Mid-October	15	2,281
Mid-October to Mid-May	10	2,129
Total Per Year		4,410

TABLE 2
Keystone Percentage of Time Inoperable and Number of Lost Sailings Per Year

Site and Orientation	Waves (%)	Wind and Current (%)	Totals (%)	Sailings Lost Per Year
West				
052°	1.01	0.04	**1.05**	**46**
332°	0.34	2.34	**2.67**	**118**
252°	1.01	0.01	**1.02**	**45**
East				
073°	0.99	0.01	**1.00**	**44**
353°	0.17	0.30	**0.47**	**21**
273°	0.99	0.02	**1.01**	**45**

FILE NAME: lostsailings1a.dgn 07-AUG-2003 15:37:52



Washington State Ferries

CH2MHILL

LEGEND:

44 SAILINGS ARE LOST EACH YEAR DUE TO WINDS AT 073 (TRUE).

FIGURE 7

SAILINGS LOST PER YEAR

KEYSTONE, WASHINGTON

As shown in Figure 7, two of the three terminal orientations in the west study area would offer an improvement over the existing location inside Keystone Harbor. The two orientations that roughly parallel the shoreline are favored because the vessel is approaching either into or in the same direction as the current. In the non-favorable orientation (118 missed sailings), the vessel approaches through a crosscurrent in much the same way that it does today and is also exposed to wind and wave conditions outside of the harbor.

In looking at the forecasted missed sailings at the east study area, it can be seen that all orientations offer an advantage over the 95 missed sailings in Keystone Harbor. The east and west oriented approaches in the east study area are nearly identical to the west study area because they are primarily influenced by their orientation in line with the currents and the wind influence is the same. The generally north orientation has by far the best operability of the orientations studied. The reason it outperforms the others is a combination of two factors. First, the maximum crosscurrents are less than the similar orientation in the west study area. Second, the orientation places the stern of the vessel more directly into the wind and waves. The vessel has more ability to overcome the less severe crosscurrents and its orientation in-line with the wind induces less motion than if wind were on the vessel's beam.

In summary, five of the six orientations studied offer a sailing advantage over the existing location within Keystone Harbor.

Engineering

Uplands

From the practical engineering perspective, Keystone Spit is an ideal location for a ferry terminal. The uplands are generally flat and underlain with sand and gravel. Grading for the entry, toll plaza, and holding lanes would be relatively inexpensive. Little or no fill material would be needed and the resulting pavement structure would be durable. Other sites yet to be evaluated during further environmental review could offer similar attributes.

The utilities that are present are power and telephone. Water would require a well, and sewer would require a septic system.

Offshore

A bathymetric survey was completed by WSF Terminal Engineering staff and was used in this feasibility study (see Appendix D). The survey indicates the presence of a relatively steep beach slope (3:1) that continues falling until approximately –50′ MLLW, at which point it continues falling at a much flatter slope on the order of 30:1. This condition is ideal for constructing a cost-effective ferry terminal. The trestle area is minimized because deep water is so close to shore due to the steep slope. In addition, the cost of trestle and landing structure piling would be within normal ranges because as the bottom flattens out quickly, the piling lengths stay within typical ranges.

A reconnaissance-level subsurface sonar survey (Appendix D) was performed to verify the soil conditions for preliminary piling and foundation design. From the sea floor to –95′ to –115′ MLLW, the soil consists of sands and muds. Below this is glacial till, and below the glacial till

layer appears to be another less-dense layer. Pilings would not be expected to penetrate below the glacial till layer. Because of this, the pile-driving conditions are typical for ferry terminal construction and costly construction techniques such as rock anchors would not be required.

Terminal Layout

Conceptual terminal layouts were developed for the east and west study areas. The purpose of these layouts was to provide a basis for the environmental screening (see below) and to bracket the cost of the potential terminal relocation. In order to perform a preliminary design of conceptual terminal, a set of design criteria was developed (see Appendix E).

The conceptual terminal layouts are included in Appendix E for the west and east study areas as Figures E1 and E2, respectively. These layouts are essentially the same upland; however, they vary offshore. The most notable difference is the length of trestle and the two additional dolphins in the west study area layout. The western layout is nearly 500 feet longer than the eastern layout. The reason for this difference is that the vessel approach to the western layout must clear the Keystone Conservation Area, as shown previously in Figure 4. In the eastern layout, this constraint is eliminated, and the terminal can be placed much closer to shore.

The longer trestle of the western layout allows more vehicle holding over the water and less on land than the shorter trestle of the eastern layout. This accounts for the additional four holding lanes on shore in the eastern layout.

Traffic

A brief analysis of Keystone area traffic impacts was conducted to determine if the introduction of larger vessels and/or relocating the terminal anywhere on the spit would significantly impact traffic. The analysis showed the Level of Service (LOS) on SR 20 would change from Level A to Level B if the vessel capacity increased from 75 cars to 130 cars and if the vessel operated on the same schedule. The location of the terminal was inconsequential as traffic is consistent along SR 20 within the study area. Since both LOS A and LOS B are considered free-flow conditions, this change is below the impact threshold. Appendix F provides a more detailed description of the traffic analysis.

Environment

A preliminary screening of the terrestrial and aquatic environments along Keystone Spit was done to identify any environmental concerns that could prohibit locating a terminal. The following is a fatal-flaw analysis relative to aquatic and terrestrial habitat issues for the potential relocation of the Keystone ferry terminal.

Eelgrass

A submarine videographic survey was conducted in August 2002 (see Appendix G) along the entire shoreline of the study area. The survey located a small patch of eelgrass just east of the abandoned Army fort pier at a depth of about 11 to 15 feet. This eelgrass patch measured about 30 feet square (914 square feet). The remaining shoreline is too rocky and high energy to

support eelgrass. No eelgrass was found in Keystone Harbor. Neither an east area nor a west area relocation would impact the eelgrass bed.

Macroalgae

Macroalgaes were abundant throughout the study area. The dominant species were *Ulva*, a soft sheet-like green algae, and *Laminaria* sp., a large bladed brown algae. Keystone Harbor and the entire length of the spit had a patchwork of *Ulva*, *Laminaria* sp., and other macroalgaes. This was expected because the substrate throughout the study area is dominated by gravel and cobble. Relocating the terminal to either the east or west area would shade out macroalgae, as well as scour away some macroalgae as a result of prop wash. Both areas appeared to be equivalent for this resource. Moving the ferry operations from the harbor would compensate for the loss of macroalgae resources at either the east or west area. Shade-related compensation would be less than the new impacts, but prop wash-related impacts would likely be less at the east and west study areas. The reason for this is the approach to the existing terminal is shallow for a considerable distance, and is thus subject to prop wash scour. A new terminal at either study area would be in deeper water, with less exposure to prop wash and scour.

Keystone Conservation Area

The Keystone Conservation Area is part of Washington Department of Fish and Wildlife marine sanctuary park system. This marine park was created in May 2002 (WAC 220-16-760). The boundaries of the park extend from the jetty, east to the east side of the abandoned Army pier, extending offshore for 600 feet and then paralleling shore to a point straight off of the east side of the jetty (see Figure 4).

The marine park is used primarily as a SCUBA diving recreational site. The park also provides protection for reef-inhabiting fish and invertebrates such as rockfish, lingcod, wolf eels, cabezon, sea urchins, abalone, and octopus. The main dive destination is the jetty, but the abandoned Army pier is listed as an alternative dive destination in *Northwest Shore Dives* (Fischnaller 1990).

At the current time, there is a risk of divers straying into the channel and surfacing in front of an approaching ferry because of the patterns and intensity of the current at Keystone. The currents near the Keystone jetty can be very strong and do not move symmetrically with the tide. The current flows east during the early stage of one of the daily flood tides and flows strongly west during the latter stage of the flood tides and during both daily ebb tides. Divers can dive on either side of the jetty. At the end of the jetty, a moderate to very strong current moves west towards and across the ferry lane, which is very close by.

Relocating the terminal channel would place the ferry operations east of the eastern boundary of the marine park. Divers would more likely be swept west by the current toward the existing channel than they would east toward a new terminal because of the prevailing currents (see Figures 4 and 6**)**. A row of dolphins would be placed outside of the marine park boundary to prevent a ferry from accidentally straying into the park during inclement weather conditions or a power failure.

In conclusion, the terminal relocation could create a ferry approach and terminal that is sufficiently distant from the Keystone Conservation Area to enhance diver safety. Ferry operations also would not likely affect the marine ecosystem in the marine park.

Sport Fishing

Sport fishing opportunities for salmon from shore is rare in Puget Sound. There are only a small number of locations, perhaps eight to ten, where adult salmon migration patterns and shoreline morphology place the salmon within casting distance of shore. Admiralty Head and Keystone beach are two such locations. A few others are known to exist on Whidbey Island, most notably Bush Point.

The popularity of sport fishing at Keystone for salmon, especially coho, has grown rapidly in recent years. In 2001, in association with a record coho run into Puget Sound, thousands of anglers were reported to fish this shoreline. Their cars were reported to stretch 1.5 miles from the ferry terminal east to the 90-degree bend in SR 20. Fishing activity was apparently focused to the east near the ponds. Fishing intensity was reported to be "shoulder to shoulder" on some days during the run. On two days in late July and mid-August (see Appendix G), five to ten anglers were observed fishing in this area. These dates correspond to a period prior to the coho run, although one fish was observed to be caught during the mid-August visit.

Anecdotal evidence suggests that fishing intensity is seasonally higher at the east end of the spit than at the west end. As such, potential impacts on the fishery would be higher in the east study area. In either case, the effects of a ferry terminal on shore- (or boat-) based sport fishing are unknown and WSF could build a fishing pier as mitigation. Since salmon are rarely close enough to shore to catch and fishing piers would extend the salmon fishing opportunity into deeper water, a case could be made that it is likely that fishing opportunities would be improved with a fishing pier. This is more likely to be true near the west end of the spit than the east end based on the fact that fishing intensity seems to be higher on the east end. This would imply that salmon get closer to shore at the east end and are hence more catchable.

Boat Launch Safety

The Keystone Harbor boat launch is near the existing ferry approach and landing (see Figure 4). Boaters are at risk if they stray into the middle of the harbor at the wrong time, which could happen as a result of not paying attention or from motor failure. It is common for an outboard motor to stall soon after launching when the motor is cold. When the ferry is adjacent to the boat launch, it is committed to its line of approach to the terminal and there is no room to maneuver away. In addition, the ferry may be off course or trying to redirect steerage after negotiating the shear currents at the south end of the jetty. Moving the terminal outside of Keystone Harbor would alleviate this hazard.

Wetlands

Marine wetlands (intertidal habitats) extend along the entire shoreline of the study area. Upland wetlands are only present near the east end of the spit. Figure 8 shows the four wetland classifications that pertain to the study area. Two of the wetlands are ponds formed from an old gravel mine that operated between 1911 and 1914. Another nearby wetland appears on the National Wetland Inventory (NWI) maps as PEMC (a freshwater marsh) near the ponds. This

wetland is located north along the eastern shoreline of Crockett Lake, extending a short distance west of the ponds and shoreward of SR 20 for a very short distance. In all likelihood, however, this wetland stops at the upland side of the SR 20 road prism and the image that appears on the NWI maps is an artifact of poor GIS-laying resolution.

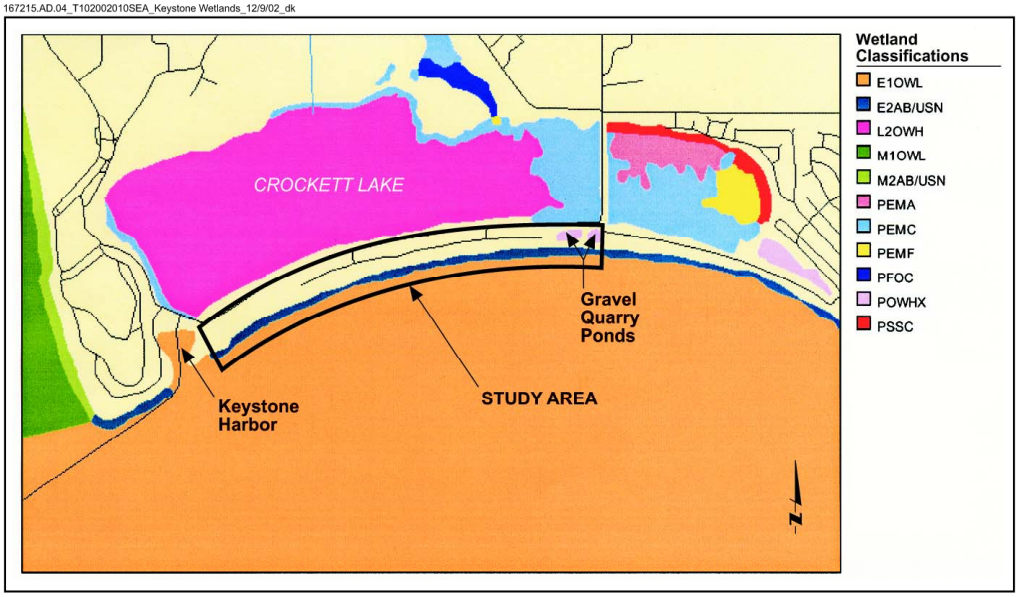


Figure 8
Study Area Affected Wetlands
Relocation Feasibility Study

Moving the ferry terminal to either the east end or the west end of the spit would miss the wetlands identified on the NWI maps; however, a field delineation would be necessary to verify this conclusion and satisfy permit regulations.

Upland Vegetation

Upland areas near the study area are disturbed due to past surface grading (mining, road construction, etc.). In addition, public amenities and utilities (roads, parking lot, beach access, electric converter station, etc.) limit native vegetation. The invasive vegetation species of tansy and Scot's broom dominate this area, along with native and introduced grasses (*Poa* spp., *Festuca* spp., etc.). Established native vegetation communities predominate in the wetland system described above. According to information issued from Washington Department of Fish and Wildlife's Priority Habitats Division and Washington Department of Natural Resource's Natural Heritage Program, sensitive upland vegetation species and/or communities likely do not exist on the spit in the study area.

Moving the ferry terminal to either the east or west area of the spit would not likely impact the native upland vegetation. In addition, if mitigation were required, the vacant terminal site could be restored with native upland and tidal marsh vegetation species, thus incrementally improving the vegetation on the spit.

Wildlife

Wildlife habitat and use are diverse near the study area. Marine-orientated fauna use nearshore habitat areas for staging, resting, and/or roosting. Gulls (*Larus* spp.), pigeon guillemot (*Cepphus columba*), and assorted waterfowl (sea ducks) appear to be the dominant marine fauna. Freshwater-type fauna that occur near the study area are predominantly duck and heron varieties of birds, with the occasional mammal (coyote, rabbit, vole, etc.) near Crockett Lake and the two ponds. Information provided by the Audubon Society and included in Appendix A indicate that over 200 species of birds have been identified in the area. Information from Washington Department of Fish and Wildlife's Priority Habitats Division reveals occasional sightings of bald eagles over Crockett Lake, the spit, and Admiralty Bay, but no resident or routine use is documented. In addition, marine mammals seldom occur near Admiralty Bay based upon information provided by wildlife resource agencies.

Moving the ferry terminal anywhere along the spit would not likely impact wildlife species as the existing ferry terminal is already in close proximity to the Keystone Spit-Crockett Lake area. Opportunities to enhance wildlife habitats, and thus wildlife use of the spit and nearshore areas, could be accomplished through mitigation or restoration plans identified in the *Wetland* and *Upland Vegetation* sections above.

Habitat Mitigation Potential

Moving the ferry terminal from the harbor to a location along Keystone Spit would provide many opportunities for mitigating aquatic, terrestrial, and recreation impacts. Restoration of the existing ferry terminal site with native vegetation would mitigate, for the most part, upland impacts. Loss of macroalgae habitat would be more than made up for by the cessation of ferry traffic in Keystone Harbor. Diver safety would improve due to greater separation and direction of the dominant water current near the Keystone Conservation Area. Moving the ferry terminal would add connectivity to the state park by turning the harbor into a park-only setting combining the camping area and boat launch with the harbor. Shore fishing impacts in the west study area of the spit would be more than offset by a fishing pier. Shore fishing impacts in the east study area would probably be offset by a fishing pier, but would need to be investigated further to evaluate the situation at this location.

The issue of connectivity between Crockett Lake and Admiralty Bay was raised by several stakeholders. Our preliminary investigation revealed the existing connection is via two 30-inch-diameter culverts and a tidal gate that connects the lake to Keystone Harbor. During the environmental process for the project, this connectivity would be studied and the existing flows would be maintained or improved as part of the project mitigation.

Summary of Analysis

Table 3 summarizes the relative impacts for each environmental factor.

TABLE 3
Relative Impacts by Environmental Factor

Factor	West Study Area		East Study Area	
	Impact Level	Fatal Flaw	Impact Level	Fatal Flaw
Eelgrass	None	No	None	No
Macroalgae	Minor	No	Minor	No
Keystone Conservation Area SCUBA Diver Safety	Less than existing	No	None	No
Keystone Conservation Area Ecosystem	None	No	None	No
Sport fishing	Low	No	Some	No
Boat Launch Safety	Less than existing	No	Less than existing	No
Wetlands	None	No	None	No
Upland Vegetation	Minor	No	Minor	No
Wildlife	None	No	Some	No

Note: Fatal flaw refers to an environmental impact that would prevent relocation of the ferry terminal.

Cost

Preliminary cost estimates for terminal sites at the east and west study areas (Table 4) were developed using conceptual level costs from similar terminals currently being designed by Terminal Engineering. The cost estimates include assumptions for mitigation and funding to cover the expense of environmental evaluation and studies. It is assumed that right-of-way could be leased from State Parks. The program estimates have been developed in a range that includes one or two slips for either terminal. For the east area, a single-slip and double-slip layout would vary from $36 million to $45 million, respectively. For the west area, the range would be from $53 million to $62 million for the single and double slip, respectively. The higher estimates for the west study area reflect longer trestle construction and two additional dolphins to protect the diving area east of the jetty.

It is important to note that approximately $10 million is allocated in the capital program for preserving the existing terminal in its current location over the next 10 years. If the terminal location project continues, much of this $10 million could be allocated toward constructing a new terminal, thus lowering the required additional capital monies to the range of $26 million to $52 million.

TABLE 4

Feasibility-Level Cost Estimate

			West Terminal w/Single Slip			2nd Slip	East Terminal w/Single Slip			2nd Slip
Item	**Unit**	**Unit Price**	**Quantity**	**Cost**	**Extension**		**Quantity**	**Cost**	**Extension**	
Upland Terminal					**$1,947,547**				**$1,965,073**	
Clearing and Grubbing	Acres	$11,000	3.0	$33,000			3.2	$35,200		
Overburden Excavation	CY	$7	4,840	$33,880			5,163	$36,139		
Terminal Pavement incl. Base	SY	$15	13,068	$196,020			13,939	$209,088		
Concrete Sidewalk	SY	$20	711	$14,222			711	$14,222		
Concrete Curb and Gutter	LF	$15	2,500	$37,500			2,500	$37,500		
Striping and Signing	LS	$20,000	1	$20,000			1	$20,000		
Storm Drainage	LS	$62,924	1	$62,924			1	$62,924		
Toll Booths	EA	$50,000	2	$100,000			2	$100,000		
Terminal Building	SF	$300	3,000	$900,000			3,000	$900,000		
Storage Building	SF	$100	500	$50,000			500	$50,000		
Mitigation	LS	$500,000	1	$500,000			1	$500,000		
Marine Terminal (2 Slips)					**$16,094,000**	**$5,150,000**			**$10,240,000**	**$5,150,000**
Pier Section	SF	$160	50,650	$8,104,000			21,888	$3,502,000		
Covered Walkway	SF	$90	6,000	$540,000			3,200	$288,000		
Bridge Seat	Ea	$200,000	1	$200,000		$200,000	1	$200,000		$200,000
Transfer Span	Ea	$550,000	1	$550,000		$550,000	1	$550,000		$550,000
Electrical and Mechanical Systems for Transfer Span	Ea	$800,000	1	$800,000		$800,000	1	$800,000		$800,000
Towers, Headframe & Foundations	Ea	$500,000	1	$500,000		$500,000	1	$500,000		$500,000
Wingwalls	Ea	$1,000,000	1	$1,000,000		$1,000,000	1	$1,000,000		$1,000,000
Inner Dolphins	Ea	$450,000	2	$900,000		$900,000	2	$900,000		$900,000
Outer Dolphins	Ea	$600,000	2	$1,200,000		$1,200,000	2	$1,200,000		$1,200,000
Protective Dolphins	Ea	$500,000	2	$1,000,000			-	$0		
Covered Waiting Area	SF	$150	2,000	$300,000			2,000	$300,000		
Mitigation	LS	$1,000,000	1	$1,000,000			1	$1,000,000		
Utilities					**$770,000**				**$770,000**	
Water Supply System	LS	$100,000	1	$100,000			1	$100,000		
Sanitary Sewer System	LS	$70,000	1	$70,000			1	$70,000		
Communication System	LS	$100,000	1	$100,000			1	$100,000		
Electrical Supply and Distributi	LS	$500,000	1	$500,000			1	$500,000		
SR 20 Improvements					**$550,000**				**$550,000**	
Center left turn lane	LS	$400,000	1	$400,000			1	$400,000		
Signal	LS	$150,000	1	$150,000			1	$150,000		
Subtotal Without Mobilization					$19,361,547	$5,150,000			$13,525,073	$5,150,000
Mobilization		10%			$1,936,155	$515,000			$1,352,507	$515,000
Subtotal With Mobilization					$21,297,701	$5,665,000			$14,877,581	$5,665,000
Design Contingency		30%			$6,389,310	$1,699,500			$4,463,274	$1,699,500
Subtotal with Contengency					$27,687,012	$7,364,500			$19,340,855	$7,364,500
Sales Tax		8.3%			$2,298,022	$611,254			$1,605,291	$611,254
Subtotal with Contengency					$29,985,034	$7,975,754			$20,946,146	$7,975,754
Construction Engineering		10%			$2,998,503	$797,575			$2,094,615	$797,575
Construction Contingency		5%			$1,499,252	$398,788			$1,047,307	$398,788
Subtotal					$34,482,789	$9,172,117			$24,088,068	$9,172,177
Environmental Impact Statement					$3,000,000				$3,000,000	
Design Engineering		15%			$4,153,052	$1,104,675			$2,901,128	$1,104,675
Project Totals (rounded)					$42,000,000	$10,000,000			$30,000,000	$10,000,000

	Total Cost	**Inflated to Biennium of Expenditure**			**Total Cost**
	2003 $$	**2003-2005**	**2005-2007**	**2007-2009**	**Inflated**
East Terminal Single Slip	$30,000,000	$3,000,000	$ 8,000,000	$ 25,000,000	**$36,000,000**
East Terminal Double Slip	$40,000,000	$4,000,000	$11,000,000	$ 33,000,000	**$48,000,000**
West Terminal Single Slip	$42,000,000	$4,000,000	$11,000,000	$ 35,000,000	**$50,000,000**
West Terminal Double Slip	$52,000,000	$5,000,000	$14,000,000	$ 43,000,000	**$62,000,000**

CONCLUSION

The potential relocation of the Keystone ferry terminal to a location outside of the existing harbor has been studied with respect to operational benefits, construction feasibility, environmental impacts, and cost. This initial relocation feasibility study has shown that the terminal could be relocated, pending a thorough environmental review, to accommodate new vessels and improve service on the Keystone-Port Townsend run. The relocation will also improve overall systemwide service and efficiency because incorporating more standard sized vessels in the fleet would improve reliability of the entire ferry system and ultimately increase customer satisfaction.

Appendix A
Stakeholder Input and Agency Meetings

Tribal Comments

DRAFT

Tribal Outreach Section of the Keystone Relocation Feasibility Study – Early Consultation With Area Tribes

In keeping with WSDOT's Centennial Accord agreement, WSF met with several area Tribes to identify tribal issues early on in the process. Meetings were held with staff members from the following Tribes: Jamestown S'Klallam, Lower Elwha Klallam, Port Gamble S'Klallam, Samish Indian Nation, Swinomish, Suquamish, and Tulalip. The tribal staff members represented various departments, including fisheries, governmental affairs, planning, cultural resources, and environmental.

The purpose of these meetings was to involve the Tribes early, rather than waiting until the environmental review process begins. These meetings were useful because they helped WSF staff identify areas for focus during the next phase of the project. Specifically, the meetings helped identify:

- Tribal fisheries in the area of the Keystone spit;
- Historic tribal use of the area;
- Potential areas to examine for possible mitigation;
- Contacts for detailed information on tribal fisheries, environmental, and cultural resource issues;
- Availability of archaeologist referrals.

Jamestown S'Klallam

We met with Annette Nesse, Director of Administration and Planning for the Tribe. Ms. Nesse confirmed that Admiralty Inlet in within the Tribe's Usual and Accustomed (U&A) area. The Natural Resources Department will have detailed information on tribal fisheries and will want to review and comment on the Draft EIS or whatever environmental review is done. That department may also have ideas regarding possible mitigation sites or projects. Improved ferry service to the peninsula would be beneficial for the economic development interests of the Tribe, especially regarding the casino.

Lower Elwha Klallam

We met with Doug Morrill, Finfish Manager for the Lower Elwha Klallam Tribe. He did not have details about fisheries in this area, although he did say that WDFW will be concerned about salmon migration along the banks. He said there probably had been fishing camps in this area and mentioned that there may already have been some cultural resource research done for the recent shellfish case. He said that removal of the creosote piling would be an overall environmental benefit and asked about what kind of additional dredging would need to be done for WSF to continue using the harbor.

Port Gamble S'Klallam

We met with Ted Labbe, Habitat Biologist for the Port Gamble S'Klallam Tribe. He explained that the Tribe has "shared U&A" with the Jamestown and Lower Elwha Tribes, and that they frequently work together on projects and issues. He said that the Tribe does have a shrimp fishery in Admiralty Inlet and referred us to the Natural Resources Director and Shellfish Biologist for more details. He also referred us to the Cultural Resources Director, Marie Hebert, who also sits on the Tribal Council and serves on the Olympic Peninsula Inter-Tribal Cultural Resources group.

Samish Indian Nation

We met with Christine Woodward, Environmental Director for the Samish Indian Nation. The Samish do not have U&A rights, so their primary interest in this project relates to cultural resources, tourism, and economic development. She referred us to the General Manager of the Environmental Department, who reviews and comments on environmental reports. She promised to forward the handouts from the meeting to the Tribe's Cultural Committee for their review.

Suquamish Tribe

We met with Rob Purser, Tom Ostrom, and Jay Zischke of the Suquamish Tribe's Fisheries Department. They explained that the Tribe has both shellfish and groundfish fisheries in the area of Keystone Spit. One area of concern for the Tribe is the potential for water traffic conflicts during fishing seasons. They added that a new terminal and larger boats—which would result in fewer trips—might be a positive development for tribal fishers. Other areas of concern for the Tribe include general environmental impacts and the protocol for handling the discovery of cultural resources. They think the discovery of Suquamish cultural resources is highly likely—especially close to Crockett Lake. It is possible that some tribal members may use the Port Townsend/Keystone ferry run during sockeye season in the San Juans.

The Tulalip Tribes

We met with Daryl Williams, Environmental Liaison for the Tulalip Tribes. He said that the Tribe may have shellfish fisheries in the area, such as crab, geoduck, and shrimp. He asked about the plans for Keystone Harbor assuming the ferry terminal is relocated. He suggested we examine the potential for possible tying together mitigation funding for the Keystone project with the fund for the Edmonds project. He also gave us the contact information for details on cultural resource issues.

Swinomish Tribe

We met with Larry Campbell, Intergovernmental Relations and Cultural Resources Planner, and Charlie O'Hara, Planning Director for the Suquamish Tribe. We were joined by Larry Wasserman, Environmental Services Director of the Skagit System

Cooperative (a natural resource management agency working on behalf of the Sauk-Suiattle, Upper Skagit and Swinomish Tribes).

They explained that the traditional use area of the Tribe includes the northern half of Whidbey Island and parts of Whatcom and Skagit counties. Larry Wasserman raised the issue of allowing adequate time to perform fish observations in planning for the environmental review. In some cases it is necessary to include more than one year's worth of data. He promised to provide information on Swinomish fisheries in the area, as well as shellfish resources and forage areas. He also had several questions about Crockett Lake and suggested that the lake may be an opportunity for mitigation, depending on its history. He specifically would like to know about historic fish utilization, chemistry, and historic connectivity between the lake and the inlet.

Larry Campbell wanted to find out whether any cultural resource work was done back in 1948. He also reminded us of the fact that 5,000 years ago the shorelines were out much farther, so if any pile driving is done, be aware that there may be archaeological sites in the tidal area. The archaeologist may want to do core sampling and testing in the tidal area. The archaeologist will also need to know where the dredge spoils were deposited from the original dredging in 1948. They provided archaeological contacts and urged us to include a provision in the RFP allowing a tribal trainee to work with the archaeologist.

Stakeholder Comments

Stakeholder Advisory Meeting
Keystone Ferry Terminal Relocation Feasibility Study
July 30, 2002

Name	Company	Address	Phone	E-mail Address
	National Parks			
	FHWA			
Applegate, Bill	IC Transportation TAC	2780 David Lane Oak Harbor, WA	360 / 679-1410	Applgate@whidbey.net
Bakke, Phil	Island County Planning and Community Development, Executive Director	PO Box 5000 Coupeville, WA 98239	360 / 679-7309	Phild@island.wa.us
Brennan-Dubbs, Nancy	US Fish & Wildlife	510 Desmond Drive SE, Suite 102 Lacey, WA b 98503-1273		
Brett, Phyllis	Island Transit	PO Box 1735 Coupeville, WA 98239	360 / 678-7771	Brett@islandtransit.org
Brewer-Rogstad, Traci	Washington State Ferries North Area Terminals Manager	2911 Second Avenue Seattle, WA 98121	206 / 583-2312	Brewert@wsdot.wa.gov
Buchanan, Kurt	Washington State Department of Fish and Wildlife	PO Box 1100 LaConner, WA 98257	360 / 466-4345	
Caldwell, Tim	Port Townsend Chamber of Commerce Ferry Advisory Committee Chair	2437 E. Sims Way Port Townsend, WA 98368	360 / 385-7869	Tim@ptchamber.org
Chan, Tom	Keystone FAC	3621 Shorewood Road Greenbank, WA 98253	360 / 678-5500	Fax 206-618-9306
Chapple, Bill	Washington State Ferries Keystone Captain TBD	Port Townsend		
Craig, Kelly	Department of Ecology Federal Permit Manager	300 Desmond Drive, Lacey, WA PO Box 47600 Olympia, WA 98504-7600	360 / 407-6056	Kcra461@ecy.wa.gov
Daniel, Roy	Island Transit	PO Box 1735 Coupeville, WA 98239	360 / 678-7771	Daniel@islandtransit.org

Name	Company	Address	Phone	E-mail Address
Deardorf, Ray	Washington State Ferries	2911 Second Avenue Seattle, WA 98121	206 / 515-3491 FAX - 206 / 515-3499	Deardorf@wsdot.wa.gov
East, Russ	Washington State Ferries	2911 Second Avenue Seattle, WA 98121	206 / 515-3701	Eastrus@wsdot.wa.gov
Hageman, Ken	Washington State Parks	1280 Engle Road Coupeville, WA 98239	360 / 678-4519	Fortcasey@whidbey.com
Harbour, Rob	Ebey's Landing National Historical Reserve	PO Box 774 908 NW Alexander St. Coupeville, WA 98239	360 / 678-6084 FAX - 360 / 678-2246	rob_harbour@partner.nps.gov
Hart, Sharon	Island County Executive Director Economic Development	PO Box 257 Coupeville, WA 98239	360 / 678-6889	IDEC@whidbey.net
Hodson, Julia	Keystone Ferry Advisory Committee	PO Box 99 Coupeville, WA 98239	360 / 678-7089	Julia1@whidbey.net
Hostetler, Tim	WSDOT - NW Region Mt. Baker Area Planning Office Assistant Transportation Planning Manager	1043 Goldenrod Road, Suite 101 Burlington, WA 98233	360 / 757-5981	Hostett@wsdot.wa.gov
Kind, Phyllis	MRC - Island County	1370 Seven Eagle Way Greenbank, WA 98253	360 / 331-6337	Phighawk@whidbey.com
Klacan, Julie	Washington State Department of Fish and Wildlife Region 4 Habitat Program	PO Box 1100 La Conner, WA 98257	360 / 466-4345, ext. 272	Klacajlk@dfw.wa.gov
Landino, Steve	National Marine & Fisheries Service	510 Desmond Drive SE, Suite 103 Lacey, WA b 98503-1273		
Malde, Jim	Washington State Ferries South Area Ports Captain	2911 Second Avenue Seattle, WA 98121	206 / 289-6411	Maldeja@wsdot.wa.gov
McFarland, Lee	Island County Parks	PO Box 5000 Coupeville, WA 98239	360/679-7373	
McKenzie, John	CH2M Hill, Inc.	777 - 108th Avenue Bellevue, WA 98004-5118 PO Box 91500 Bellevue, WA 98009-2050	425 / 233-3369	Jmckenzi@ch2m.com
Meehan, Don	Washington State Univ. Island County Marine Resources Committee	PO Box 5000 Coupeville, WA 98239	360 / 679-7327	Meehan@wsu.edu

Name	Company	Address	Phone	E-mail Address
Mills, Mary Lou	Washington State Department of Fish and Wildlife Marine Resources	600 Capital Way N. Olympia, WA 98501	360 / 902-2834 FAX - 360 / 902-2944	Millsmlm@dfw.wa.gov
Mitchell, Kelly	Washington State Ferries North Areas Port Captain	2911 Second Avenue Seattle, WA 98121	206 / 583-2311	Mitchek@wsdot.wa.gov
Morton, Mike	Island County Public Works	PO Box 5000 Coupeville, WA 98239	360 / 679-7331	
Mumford, Tom	WA State Dept of Natural Resources Division of Acquadic Resources	PO Box 47027 Olympia, WA 98504		
NEED NAME	WA. State Parks and Recreation Commission	PO Box 42650 Olympia, WA 98504-2669	360/902-8500	
Playter, Doug	CH2M Hill	777 - 108th Avenue Bellevue, WA 98004-5118 PO Box 91500 Bellevue, WA 98009-2050	425 / 453-5000	Dplayter@ch2m.com
Schisel, Alice	Washington Department of Ecology - NWRO	3190 - 160th Avenue SE Bellevue, WA 98008-5452	425 / 649-4309	Asch461@ecy.wa.gov
Schorr, Cecilia	Washington State Ferries Corp. Communications	2911 Second Avenue Seattle, WA 98121	206 / 515-3918	Schorrc@wsdot.wa.gov
Smith, Leonard	Washington State Ferries Operations	2911 Second Avenue Seattle, WA 98121	206 / 515-3695	Lsmith@wsdot.wa.gov
Smith, Ted	Washington State Parks	PO Box 487 Burlington, WA 98237	360 / 755-9231	Ted.smith@parks.wa.gov
Tribal Representation	NW Indian Fisheries Commission	North Sound Office 224 Stewart Road Mount Vernon, WA 98273		
Uhrich, Anne	Corps of Engineers - Seattle District	4735 E. Marginal Way S. Seattle, WA 98124-3755		Ann.R.Uhrich@NWS02.usace.army.mil
Velikanje, Joan	Washington Department of Ecology - NWRO	3190 - 160th Avenue SE Bellevue, WA 98008-5452	425 / 649-4253	Jvel461@ecy.wa.gov
Whitman, Randy	CH2M Hill, Inc.	777 - 108th Avenue Bellevue, WA 98004-5118 PO Box 91500 Bellevue, WA 98009-2050	425 / 453-5000	Rwhitman@ch2m.com

Keystone Stake Holder Meeting #1, Coupeville, WA – 7/30/02
Comments from Attendees

Corps of Engineers maintains the harbor and it was constructed in 1948.

From State Parks perspective the turn-around is too far away and there are too many illegal u-turns and driving over the speed limit to catch the ferry. Parking issues – people park at boat launch in middle of roadway. If terminal were moved there would be a large parking impact that must be addressed.

Plan must address road access. Locals/truck traffic now uses main street, which is a safety concern through Coupeville.

State Parks is undertaking a regional master planning effort that includes this area.

The Keystone Spit is a natural vegetation area and is home to shorebirds, waterfowl and wildlife and has some advocacy groups protecting it.

This area falls within the Ebey's Landing Natural Historic Preserve.

Ridership may increase without the tide cancellations.

Currently the inner harbor is sheltered from waves, if the terminal moves outside the harbor winter weather will be more of a factor.

For a time the ferry dock was on point, west of harbor

Washington Department of Fish and Wildlife the following comments:

> This is a prime fish and shellfish unit
>
> There is excellent salmon fishing from shore along the Keystone Spit
>
> Diving is popular within the marine sanctuary
>
> The marine sanctuary and the army pier are good rockfish habitat
>
> Look for kelp beds near the east end of the spit
>
> Tribal fishing concerns will need to be addressed

There are several state parks on Whidbey Island but this has the best boat launch.

State Parks owns the tidelands to ¼ mile offshore.

DOE: East side location is very popular designated natural area that does not have a lot of possible parking locations

DNR: This one of only 10 underwater parks in Washington.

Keystone Spit has Historical significance

The gravel from the ponds is reported to have been used for concrete for the Smith Tower in Seattle

The natural landscape has cultural value

1988 - 89 - Cost of Congress, State Legislature

It would be difficult of not impossible to transfer DNR recreational subtidal lease for the sanctuary to another state agency for "commercial" activity.

The man-made ponds at the east end the spit apparently are saltwater and contain steelhead and are for recreational fishing; swimming; Eagles perch in gravel piles to fish. Northshore school district sometimes uses ponds.

Other stakeholders:

- Island County Marine Resources Committee
- Seattle Pacific University
- Telacur Shores Development

Island County MRC looking at a beach feed study in the area and also finishing up eelgrass survey of all of Whidbey Island.

Sediment Sampling of the harbor should be done.

Historical maps of the shoreline should be reviewed

Historical photos of the old ferry dock in the east location are available

Questions from Attendees

If the ferry terminal was relocated, what would be the required amount of dredging to keep Keystone Harbor open for small craft.

What is the Long-term stability of existing harbor area. A beach analysis and coordination with Island County will be needed.

What will be the road access to the new terminal be from Coupeville?

Would the culvert connection to Crockett Lake be changed in any way?

What is the stability of the area regarding longshore drift.

Department of Ecology wanted to know what was the criteria for focusing on this shoreline?

What will be cost to taxpayers and passengers?

Timing in terms of replacing the Steel Electrics (assuming R51 passes) – can terminal move happen in time to utilize replacement ferries?

What is the source of funding?

DOE: Have you done O/D surveys? Why does terminal need to be located on this shore? Is that really where your traffic is coming from/going to?

Are possible improvements to existing facility an option? What are the alternatives for using the present site? – dredging, widening?

ECOLOGY: East side location is very popular, designated natural area, does not have a lot of possible parking locations

What kind of footprint will new terminal have? – size, location of dock

Could pay parking be used for Whidbey residents going to Pt. Townsend for the day.

Is it possible to build out to –35 MLLW at the present location?

What is the accident rate at this terminal vs. other terminals?

What are the overwater impacts at east location to meet depth that is planned? (

What will be done to encourage walk-ons and transit connections?

Who owns the shores of Crockett Lake? Parks service owns some conservation easements on lake. SPU owns also owns a portion of the lake.

Need to regulate levels on Crockett Lake (drainage District #6). Is there a relationship between the inlet and the terminal? ECOLOGY: Could this be looked at as possible mitigation?

DRAFT

Issues/Concerns Raised at 11/20/02 Meeting Regarding Keystone Relocation Feasibility Study

- Sand spit is a unique ecosystem. Plant community on the spit is rare. You have to view the spit May through September to see full spectrum. Admittedly, it would be nice to get rid of the exotic species.

- WSF should evaluate the cost to the local community vs. the advantages to WSF. What does the local community have to pay so that WSF can have an additional 20 sailings a year?

- WSF should look at correcting the problems at the current location, rather than automatically assuming you need to relocate in order to fix situation. Are there any feasible modifications that can be made at the existing location?

- How about filling in Keystone Harbor and building a dock there? This would not be a "no-action" alternative.

- Regarding WSF response that a variety of alternatives would be studied during an EIS: EISs are stacked in favor of a preferred alternative. The other options are just thrown in to fulfill NEPA requirements. We want to see a feasibility study on the feasibility of fixing the current location.

- Spoke to Matt Nichols. He said he could build a boat that could operate out of Keystone Harbor.

- What would the impact (of larger boats) be on Port Townsend? What would be the impact of more cars going through Port Townsend? (More parking needed?)

- How many times has Keystone Harbor been dredged? How much dredging and filling will be required in the future?

- There may be a need to relocate, but we should be presented with the pros and cons of what would be required to make present location an equal alternative. (Not with a pre-selected alternative.) Is there a fax at the current location and what would it cost?

- Re: urgency of replacing the Steel Electrics: parts have to be specially fabricated at Eagle Harbor because the boats are so old.

- RUSS: We will look at existing location as one alternative and will give it equal weight. What would it take and how much would it cost?

- Don't run this route during the winter – that is when the cancellations occur.

- WSF will need to look at the traffic impacts in Port Townsend as part of SEPA. (Russ?)

- The wrong question was asked in this study. Should have been 'What do I need to do at Keystone Terminal to improve safety and reliability?' Maybe also two versions – with and without new vessels.

- Why haven't we contacted Nichols?

- When WSF looks at other alternatives, should consider the option of (shaving?) one side of Keystone and of filling – not just no-action.

- Keep community updated on project. Wants to know timeline, plans for next steps.

Agency Comments

Brian E. Martin
1836 S. Fircrest Ave
Coupeville, WA 98239
360.678.5562
bemartin@earthlink.net

August 20, 2002

Ms. Patricia Patterson
Director of Corporate Relations and Communications
Washington State Ferries
2911 Second Avenue
Seattle, WA 98121-1012

Dear Ms. Patterson:

I am writing as a representative of the Whidbey Audubon Society to make you aware of why actions which impact the Keystone Spit-Crockett Lake ecosystem are of great concern to organizations dedicated to the protection of birds and their habitat.

The Keystone Spit-Crockett Lake area has been designated an important Bird Area by Washington State Audubon (see attached excerpt from Cullinan, T. 2001. Important Bird Areas of Washington, Audubon Washington, Olympia, WA, 170pp). In addition, the area and its near-shore waters are included as protected areas in the Puget Trough-Willamette Valley Ecoregional Conservation Plan under development by the Washington Department of Fish and Wildlife, The Nature Conservancy of Washington and their counterparts in British Columbia and Oregon. I have attached a list of the more than 200 species of birds that have been identified in the Keystone Spit-Crockett Lake area.

Whidbey Audubon Society believes it is essential that Washington State Ferries, their consultants and the Department of Transportation understand that protection and preservation of the Keystone Spit-Crockett Lake ecosystem is the highest priority. All agencies and organizations contributing to the feasibility study for relocating the Keystone Ferry Terminal need to carefully examine the potential impact on the Keystone Spit-Crockett Lake ecosystem of any relocation including future requirements for highway expansion and improvements in that area due to the use of larger capacity boats.

As representative of Whidbey Audubon, I look forward to actively participating in the process and appreciate your cooperation.

Sincerely,

Brian E Martin

Brian E. Martin
Vice President Whidbey Audubon

Attachments:
(1) Extract from Important Bird Areas of Washington
(2) Area bird list

Crockett Lake

48° 10′ N, 122° 39′ W

0-1.5 m/265 ha

Ownership	Private, state, county, federal
IBA Criteria	5c, 5d
Habitats	Estuarine, open water, marsh, grassland
Land Use	Open space, agriculture, low-density residential

Site Description

Crockett Lake is a shallow, brackish lake and a complex of salt and fresh water marshes five kilometers south of Coupeville on Whidbey Island. It is separated from Admiralty Inlet by a narrow gravel spit. Most of the area is open water under estuarine influence. Water levels are influenced by surface runoff and by a tidegate managed by the local drainage district. During periods of low water, extensive mudflats are exposed.

Birds and Habitat

Crocket Lake supports extraordinarily large numbers of shorebirds during autumn migration. The lake is a critically important migration staging area for 17 species of shorebirds, and for raptors such as Peregrine Falcon and Merlin that follow the migration south. The lake provides winter habitat for Bald Eagles and nine species of ducks. Whidbey Audubon Society has observed 213 species at the site. The largest concentration of Least Sandpipers ever recorded in Washington (5,000) occurred here in 1999. The lake also provides a rich foraging site for Great Blue Herons during the breeding season.

SPECIES OR GROUP	SEASON	AVERAGE	MAXIMUM
Great Blue Heron	B	37	63
shorebirds	SM	8,600	25,000
shorebirds	FM	162,400	222,700

Conservation Issues

The natural hydrology of the lake is has been altered by dikes, ditches, and the tidegate. The wetland may succeed to shrub communities if water levels are not carefully managed. The fresh water supply comes entirely from runoff in the surrounding 23-square-kilometer watershed, so pollution from agriculture and residential development is a threat. Disturbances from adjacent roads and increasing numbers of waterfowl hunters have been associated with a significant decrease in wintering waterfowl in recent years. The invasive, non-native Canada thistle has become established and is spreading.

Bird Species Sighted in the Vicinity of Crockett's Lake, Keystone Spit, Fort Casey and Near-shore Waters

(Revised Feb, 2002)

Key: (R)...Rare, (N)...Nesting, (P)...Possibly Nesting

Red-throated Loon
Pacific Loon
Common Loon
Yellow-billed Loon(R)

Pied-billed Grebe
Horned Grebe
Red-necked Grebe
Eared Grebe
Western Grebe

Double-crested Cormorant
Brandt's Cormorant
Pelagic Cormorant

American Bittern(N)
Great Blue Heron
Great Egret(R)
Green Heron(R)
Little Blue Heron(R)

Trumpeter Swan
Tundra Swan
Greater White-fronted Goose
Snow Goose
Brant
Canada Goose(N)

Wood Duck(R)
Green-winged Teal(N)
Mallard(N)
Northern Pintail
Blue-winged Teal
Cinnamon Teal
Northern Shoveler(P)
Gadwall(N)
Eurasian Wigeon
American Wigeon(N)
Canvassback
Ring-necked Duck
Greater Scaup
Lesser Scaup
Harlequin Duck
Long-tailed Duck
Black Scoter
Surf Scoter
White-winged Scoter
Common Goldeneye
Barrow's Goldeneye
Bufflehead
Hooded Merganser
Common Merganser
Red-breasted Merganser
Ruddy Duck

Turkey Vulture

Osprey

Bald Eagle(N)
Northern Harrier(N)
Sharp-shinned Hawk(P)
Cooper's HawkN)
Northern Goshawk(R)
Red-tailed Hawk(N)
Rough-legged Hawk
Golden Eagle(R)

American Kestrel(N)
Merlin(N)
Peregrine Falcon
Gyr Falcon(R)

Ring-neck. Pheasant(P)
California Quail(N)

Virginia Rail(P)
American Coot(P)

Black-bellied Plover
Pacific Golden Plover
Amer.Golden Plover
Semipalmated Plover
Killdeer(N)

Black Oystercatcher

American Avocet(P)
Greater Yellowlegs
Lesser Yellowlegs
Solitary Sandpiper
Willet
Spotted Sandpiper
Whimbrel
Long-billed Curlew
Hudsonian Godwit(R)
Ruddy Turnstone(R)
Black Turnstone
Red Knot(R)
Sanderling
Semipalm. Sandpiper
Western Sandpiper
Least Sandpiper
Rufous-necked Stint(R)
Baird's Sandpiper
Pectoral Sandpiper
Sharp-tailed Sandpiper(R)
Rock Sandpiper
Dunlin
Stilt Sandpiper
Ruff(R)
Short-billed Dowitcher
Long-billed Dowitcher
Common Snipe
Wilson's Phalarope
Red-necked Phalarope

Parasitic Jaeger
Bonaparte's Gull
Heermann's Gull
Mew Gull
Ring-billed Gull
California Gull
Herring Gull
Western Gull
Glaucous-winged Gull(N)
Glaucous Gull(R)
Blk-legged Kittiwake(R)

Bird Species Sighted in the Vicinity of Crockett's Lake, Keystone Spit, Fort Casey and Near-shore Waters

(Revised Feb, 2002)

Key: (R)...Rare, (N)...Nesting, (P)...Possibly Nesting

Sabine's Gull(R)
Caspian Tern
Elegant Tern(R)
Common Tern(R)
Arctic Tern(R)
Forster's Tern

Common Murre
Pigeon Guillemot(N)
Marbled Murrelet
Ancient Murrelet
Rhinoceros Auklet
Tufted Puffin(R)

Rock Dove
Band-tailed Pigeon
Mourning Dove

Barn Owl

Western Screech Owl
Great Horned Owl(N)
Snowy Owl(R)
Barred Owl(P)
Short-eared Owl

Vaux's Swift(R)

Rufous Hummingbird

Belted Kingfisher(N)

Downy Woodpecker(N)
Hairy Woodpecker(N)
Northern Flicker(N)
Pileated Woodpecker(N)

Olive-sided Flycatcher(P)
Western Wood-Pewee(P)
Willow Flycatcher(P)
Hammond's Flycatcher
Pacific Slope Flycatcher(P)

Northern Shrike

Hutton's Vireo(P)
Red-eyed Vireo(R)

Stellar's Jay(P)
American Crow(N)
Common Raven(P)

Hornrd Lark
Eurasian Skylark(R)

Tree Swallow(N)
Violet-green Swallow(N)
Rough-winged Swallow(N)
Bank Swallow(R)
Cliff Swallow(N)
Barn Swallow(N)

Black-capped Chickadee
Chestnut-backed Chickadee(N)

Bushtit(N)

Brown Creeper(N)

Red-breasted Nuthatch(N)
White-breasted Nuthatch(R)

Bewick's Wren(N)
House Wren(R)
Winter Wren(N)
Marsh Wren(N)

Golden-crowned Kinglet(P)
Ruby-crowned Kinglet

Swainson's Thrush(P)
Hermit Thrush(P)
Varied Thrush
American Robin(N)
White Wagtail(R)
Black-backed Wagtail(R)

European Starling(N)

American Pipit

Bohemian Waxwing(R)
Cedar Waxwing(N)

Orange-crowned Warbler(P)
Yellow Warbler(P)
Yellow-rumped Warbler(P)
Black-throated Gray Warbler(P)
Common Yellowthroat(N)
Wilson's Warbler(P)

Spotted Towhee(N)
Chipping Sparrow

Bird Species Sighted in the Vicinity of Crockett's Lake, Keystone Spit, Fort Casey and Near-shore Waters
(Revised Feb, 2002)

Key: (R)...Rare, (N)...Nesting, (P)...Possibly Nesting

Savannah Sparrow(N)
Fox Sparrow
Song Sparrow(N)
Lincoln's Sparrow
Golden-crowned Sparrow
White-crowned Sparrow(N)
Dark-eyed Junco(P)
Lapland Longspur
Snow Bunting

Black-headed Grosbeak

Western Meadowlark(P)
Red-winged Blackbird(N)
Brewer's Blackbird(P)
Brown-headed Cowbird(N)

Purple Finch(P)
House Finch(N)
Red Crossbill(P)
Pine Siskin(P)
American Goldfinch(P)
Evening Grosbeak(P)

House Sparrow(N)

This birdlist has been compiled from the records of the Whidbey Audubon Society, the WAS Nomination to DOE for Wetlands Acquisition, 10/29/88; Wetland Evaluation, Soil Conservation Service & Washington Dept of Game, 1979; Environmental Assessment, Island County Drainage Dist.#6 and T. Roehl, 7/6/87 and Notes of S. Ellis, N. Kenyon, R. Merrick and S. Mlodinow.

Washington State Department of Transportation

Douglas B. MacDonald
Secretary of Transportation

September 4, 2002

Brian Martin
Whidbey Audubon Society
1836 S. Fircrest Ave.
Coupeville, WA 98239

Dear Mr. Martin,

Thank you for your August 20 letter. I have shared the letter and attachments with our Planning Director Ray Deardorf, who is leading the relocation feasibility study and with Russ East, our Director of Terminal Engineering. I have also sent a copy of the letter and attachments to Doug Playter, who is working with us on the study.

As was explained at recent meetings in the community, this study is very preliminary, and is only intended to ascertain whether or not a relocation of the terminal might be possible. The study should be completed next month. If the study concludes that relocation is possible, then an Environmental Impact Statement (EIS) process would be undertaken. As part of that process, all potential impacts on habitat and wildlife would be analyzed and taken into account in deciding whether the terminal should be moved or should remain at its current site.

There is also a possibility of some environmental benefits if the terminal were to be moved out of Keystone Harbor. For example, WSF operations require that the harbor be dredged periodically. Moving ferry operations out of the harbor could allow the inlet to return to a more natural state. As part of any EIS process, all environmental impacts are studied, including the impacts of not taking any action (i.e., no relocation of the terminal).

We are planning two meetings with community members in the next couple of months, and will make sure you are on the list to receive notification once the dates and locations are set.

Once again, thank you for the information and for your interest in the study. We look forward to meeting you this fall.

Sincerely,

Patricia Patterson

Patricia Patterson
Director of Corporate Relations and Communications

cc: Ray Deardorf and Russ East, WSF
Doug Playter, CH2MHill

Washington State Ferries

WHIDBEY AUDUBON SOCIETY

"Protecting Whidbey's Wildlife"
Post Office Box 1012
Oak Harbor, WA 98277

June 2, 2003

Washington State Ferries
Colman Dock/Pier 52
801 Alaskan Way
Seattle, Washington 98104

To Mr. Michael Thorne, Director/CEO:

Washington State Ferries recently made a presentation of the findings of a study of relocation of the ferry dock at Whidbey Island's Keystone Spit area. The conclusions reached in the study were that the present dock and lagoon area is not suitable and need to be relocated.

Whidbey Audubon Society wants to advise you that the conclusions reached in your feasibility study for dock relocation and "allowing the naturalization of the harbor" cause us great concern over the effects such changes could have on the Crockett Watershed. Return of the entire system to its natural state is unlikely because that would also require the removal of the dam created by state highway #20 along the Keystone Spit.

The Crockett Watershed includes Crockett Lake, the surrounding uplands, marsh and wetlands. Allowing the Keystone Harbor to fill and return to its "natural state" would not, in the opinion of the Whidbey Audubon Society, return it to its true natural state, but would alter it and have a measurable effect on what is listed by the National Audubon Society as one of Washington's "Important Bird Areas." This area has been observed, studied and documented in the "Crockett Lake International Shorebird Survey" since 1997 with anecdotal information even prior to that.

The exchange of water is presently being artificially maintained by a manual tidegate at the southwestern corner of the lake, allowing water to flow south into Keystone Harbor. Since there is no longer a natural flow of water from Admiralty Bay into Crockett Lake and since most of the water that supplies Crockett Lake is surface water originating from the Crockett Watershed, there is no stream system.

The historical depth of the lake is not known. The present depth is shallow with the greatest depth occurring in drainage ditches. There is anecdotal information that a floatplane was forced to land on the Lake and the passengers actually walked to shore. Crockett Lake is shallow but will, on occasion, flood the state highway. In our opinion, allowing the Keystone Harbor to fill will harm the Crockett Watershed and the attributes that make it an "Important Bird Area".

Whidbey Audubon Society is intensely concerned about any activity that may affect the Crockett Watershed. We hope to be helpful to you in avoiding creation of harmful effects on sensitive natural resources in your efforts to improve transportation and the economy of Whidbey Island.

Thank you,

Whidbey Audubon Society, Officers and Members

Phyllis Kind	Diana Durden	Sarah Schmidt
Bob Merrick	Jan Martin	Sylvia Hollis
Steve Ellis	Don Knoke	Tom Campbell
Brian Martin	Gary Piazzon	Susan Bennett
Bill Bradkin	Judy Feldman	Cheryl Bradkin

Cc: Washington State Audubon Society
Seattle Pacific University
National Audubon Society
Pilchuck Audubon Society
Skagit Audubon Society
Washington Ornithological Society
Ducks Unlimited
Nature Conservancy
Island County Public Works-Watershed and Surface Drainage
Whidbey and Camano Land Trust
Washington State Department of Wildlife
Whidbey Sports Fishers
Washington State Parks
Ebey's Landing National Historical Preserve
Washington Conservation Voters
Whidbey Environmental Action Network
Senator Mary Margaret Haugen
Representative Barbara Bailey
Representative Barry Sehlin
Commissioner Mike Shelton
Commissioner Mac McDowell
Commissioner Bill Byrd

June 25, 2003

Officers and Members
Whidbey Audubon Society
P.O. Box 1012
Oak Harbor, WA. 98277

Ladies and Gentlemen:

Thank you for your letter of June 2, 2003. I assume you are referring to our last presentation to the community, which was held in Coupeville last November. As we explained at that time, the Relocation Feasibility study is only a preliminary first step in the process of deciding the future of the Keystone ferry terminal. We will go through a thorough environmental process as part of the project.

We are finalizing the report on the Feasibility Study, and I have forwarded your letter to our Planning Director and our Director of Terminal Engineering so that your concerns about the Crockett Watershed will be addressed during the environmental review process within the next few months.

Thank you for sharing this information with us. We welcome your comments on this project. If you should have any further questions or comments, please address them to Russ East, our Director of Terminal Engineering. He is responsible for the Keystone project. His business card is included.

Sincerely,

Michael Thorne
CEO/Director
Washington State Ferries

Appendix B
Wind, Waves, and Currents

KEYSTONE, WA
FERRY TERMINAL FEASIBILITY STUDY:
WINDS, WAVES, AND CURRENTS

Ken Lilly, Jr.
CH2M HILL

(27 August 2002)

Introduction

The two proposed ferry terminal locations, herein designated West Site and East Site, are located along the northern shoreline of Admiralty Bay. West Site is approximately 0.2 nautical mile (nm) NE of the existing breakwater at the entrance to Keystone Harbor, and East Site is approximately 1.2 nm ENE of the breakwater. As will be evident in the following sections, the East Site experiences less frequent storm waves and is subject to weaker currents than the West Site.

An analysis of the winds, waves, and currents was performed to determine long-term conditions and their frequency of occurrence at the 2 locations. In the following sections, summaries of the procedures used in the analysis are presented.

Winds

The wind climate for the north end of Admiralty Bay was determined using short-term wind data from Point Wilson in a comparative analysis with the long-term record from Smith Island (Figure A-1). Wind directions in Admiralty Inlet and Bay are modified considerably by the orientation of the terrain, so it was essential to use data from the wind reporting station closest to the proposed ferry terminals that was representative of the winds for the area. Point Wilson , located approximately 4 nm WSW of the West Site, is the closest location with an anemometer having a sufficient data set for use in a comparative study with a long-term wind station, namely, Smith Island. Wind directions for Point Wilson are reflective of the channeling of the wind due to terrain for the northern portion of Admiralty Inlet and Bay. Wind directions at Smith Island require adjustments to convert directions to those in Admiralty Inlet.

Annual winds recorded each hour for Smith Island were available for 1984 through 2001 from the National Oceanic and Atmospheric Administration (NOAA) National Data Buoy Center (NDBC). However, data for 2001 were omitted in the analysis due to too many corrupted values in the data set. For 1984-2000, the usable data ranged from 88.5 to 99.6 percent. Data for January through June 2002 were used in the comparative analysis of Point Wilson wind data, as described below.

Only wind speeds 15 knots and higher were used in the comparative analysis, as lower wind speeds are not important for wave analysis at the 2 proposed terminal sites, and directions for lower wind speeds are highly variable and not necessarily indicative of winds associated with strong pressure gradients affecting western Washington.

Data for Point Wilson are limited because the wind data reported each hour to the National Weather Service (NWS) by an automatic anemometer are not archived by the National Climatic Data Center or NWS. A 3-day running record of observations is available from the Weather Service Forecast Office-Seattle. Prior to the start of the Keystone project, CH2M HILL archived data for several major wind events in May and June 2002, both from the northerly and southerly quadrants at Point Wilson, to be used later in a wind climate analysis. Wind data were for each 10 °T of wind direction.

An additional set of all available archived Pt. Wilson wind data were made available to CH2M HILL through courtesy of the University of Washington Department of Atmospheric Science for the period October 2001 through June 2002. However, wind directions were only recorded in an 8-point compass rose (000, 045, 090, 135, ... 315 °T). A comparative analysis for simultaneous times between the 2 Point Wilson data sets using the wind events from May and June 2002 was performed to determine the frequency of occurrence of 10 °T wind directions within each 8-point compass direction.

A number of coincident wind events at Point Wilson and Smith Island for January-June 2002 were then used to determine the relationship between wind directions at Smith Island compared to those at Point Wilson. The frequencies of wind direction at Point Wilson were determined from the Smith Island directions and frequencies applicable to each 10-degrees of wind direction at Point Wilson.

Wind speeds at Smith Island were used for the wind speeds in the wind climate table for Point Wilson without adjustment. Smith Island wind speeds are based on an 8-minute averaging period versus a much shorter averaging period for Point Wilson.

Tables A-1, A-2, and A-3 show the estimated wind climate for Point Wilson applicable to the 2 proposed terminal sites. Table A-1 shows the hours of occurrence of wind speed in 5 knot speed ranges by direction for the entire 17 years of record (1984-2000) and was used to derive the frequency of occurrence in Table A-2 and the percent frequency of occurrence in Table A-3. These latter 2 tables may be used to estimate the fraction or percent of time that winds from a given direction and speed class will occur over a long period of time, such as a year. For example, using Table A-2, the frequency of occurrence of sustained winds (not momentary gusts) for wind speeds 15 knots and greater from 170 °T is 0.0399 or 0.0399 x 24 x 365 = 349.5 hours, on average, in a year. For wind speeds 30 knots and higher the frequency is 0.00257 + 0.00101 + 0.000270 + 0.0000443 = 0.0038943 or 34.1 hours per year, on average. It is pointed out that the statistics are based on long-term averages and that in an individual year, the frequencies of occurrence may be higher or lower than those in the tables.

Waves

Significant wave heights for the West Site and East Site were determined using the program "Windspeed Adjustment and Wave Growth" in the software package, CEDAS (Coastal Engineering Design and Analysis System), which contains a number of programs first developed by the U.S. Army Corps of Engineers and subsequently marketed by Veri-Tech, Inc. The mid-class wind speed was used for computing the waves for a given wind speed class and direction. For example, for the 15-19 knot wind speed class, 17 knots was used. Wind fetch lengths were adjusted, taking into account the channeling of winds as one

progresses southward from the 2 sites. Wind directions in Admiralty Inlet south of Bush Point are not the same as those north of Bush Point, which limits the length of fetches from the southerly quadrant that affect wave growth at the 2 proposed ferry terminal sites. The only directions of interest for wave development are 150 to 180 °T. The wind data indicate that winds 15 knots and higher do not occur from 080 to 140 °T, and if they did, would not be associated with waves of interest because of the proximity of land and the short fetch lengths. In addition, the wind data indicate an absence of strong winds from 190 to 270 °T. Winds from 280-360-070 °T do not produce waves of concern because Admiralty Head and Whidbey Island shelter the 2 sites from wave development.

However, in interviews CH2M HILL had with a ferry boat captain and first mate on the M/V QUINAULT on July 16, 2002, it was pointed out that very occasionally high waves of 8 to 10 feet can reach the mouth to the entrance of Keystone Harbor when storm winds are directly from the west in the Strait of Juan de Fuca. These waves refract around the southern tip of Admiralty Head and propagate toward Keystone Harbor. It is likely these waves could reach as far as the West Site, but would be considerably diminished by the time they reached the East Site. Analysis of refracted waves from the Strait of Juan de Fuca was not part of the detailed analysis performed here. It is judged that refracted waves from the Strait of Juan de Fuca that are high enough to adversely affect ferry boat operations at the West Site would be rare, and that several years could elapse between events.

Frequency of occurrence of significant wave heights and modal periods are shown in Table B-1 and Table B-2 for the West Site and East Site, respectively. Significant wave height is the average of the highest 33 percent of the waves in a wave record and is typically the wave height an experienced seaman would report as the wave height in a seaway. Modal period is the period of the waves with the highest energy in a wave train. Also included on each table is a summary table showing the percent frequency of waves 3.0 feet and higher. The analysis shows that waves 3.0 feet and higher are 1.005%/0.985% = 1.02 times as frequent at the West Site compared to the East Site. However, waves 4.0 feet and higher are 0.341%/0.166% = 2.05 times as frequent at the West Site compared to the East Site. This finding is supported by comments from the ferry boat captain and first mate that wave conditions are milder as one progresses eastward in Admiralty Bay.

Currents

CH2M HILL and Orders Research Associates, Inc. deployed 2 RD Instruments, Inc. Acoustic Doppler Current Profiler (ADCP) meters, one near each proposed terminal site from June 28 to July 15, 2002. Each instrument recorded the average speed and direction of the current over a 10-minute averaging period for each 1-meter thick water layer from the sea surface to the layer 1 meter above the top of the ADCP.

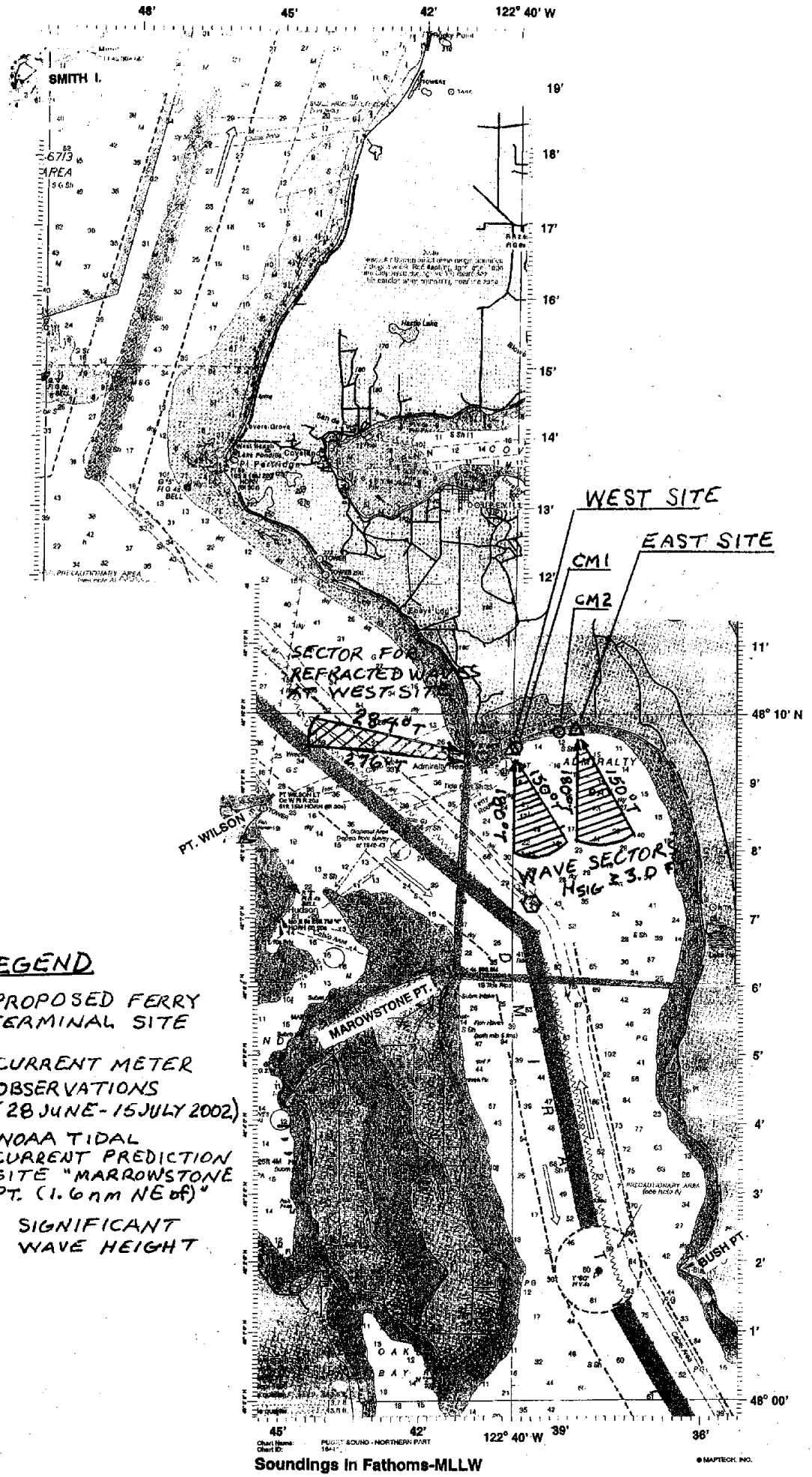
CM 1 (current meter 1) was deployed at seabed elevation –34.3 feet-Mean Lower Low Water (MLLW) datum approximately 240 feet NE of the West Site. CM2 was deployed at seabed elevation –36.2 feet-MLLW approximately 1,500 feet west of the East Site. Both ADCPs were mounted inside a Streamlined Underwater Buoyancy System (SUBS) to ensure that the vertical orientation of the ADCPs would remain within operational limits despite mooring tilt caused by strong current flows exceeding 2 knots. The sensor head of each ADCP was approximately 9.8 feet above the seabed. CM1 may be considered representative of the currents for the West Site, and CM2 currents representative of the East Site.

Each ADCP provided 100 percent of usable data over the 18 day deployment period. The data used in the analysis is for a depth of 8.25 feet below the sea surface, which is the mid-draft of an ISSAQUAH class ferry proposed to operate at the new terminal.

The number of events and the highest current speed recorded over the 18 day period are shown in Table C-1. In addition, a plot of the observed currents is shown in Figures C-1 through C- 6 for the two current meters. Shown also on the plots are the predicted currents for Marrowstone Point (1.6 nm NE of), hereinafter MAR, located in Admiralty Inlet approximately 2.3 nm south of CM1. MAR is the closest NOAA tidal current prediction station to CM1 or CM2. A comparison was made between the observed and predicted currents at MAR to develop a frequency of occurrence table for the West Site and East Site suitable for estimating currents for the long period, say one year or more.

Current directions prevail in a southwesterly ebb direction the majority of time at both the West and East sites regardless of whether the current is ebbing (flowing northward out of Admiralty Inlet) or flooding (flowing southward into Admiralty Inlet) at MAR. The West Site is located in a persistent counterclockwise rotating gyre that has only brief periods when the current reverses and flows in an easterly direction at much less speed than the persistent ebb flow. The East Site, however, has longer periods in which the persistent ebb flow reverses to become a flood current, sometimes nearly as strong as the persistent ebb flow. Figures C-1 through C-6 clearly show the flow reversals, as indicated by the abrupt change in direction on the graphs. Table C-1 also shows a much higher occurrence of flood currents at the East Site compared to the West Site.

In determining the long-term frequency current directions and speeds, the first step was to make a comparison between the maximum speed of ebb and flood at MAR and the corresponding maximum currents at CM1 and CM2 associated with the MAR events. A speed ratio function was determined for each current meter site so that the 10-minute predicted current speeds at MAR could be reduced to the speeds expected at CM1 and CM2. The frequency of adjusted MAR current speeds was then used with the frequency of occurrence by direction from the observed data to determine the long-term frequency for CM1 and CM2. Table C-2 and Table C-3 show the long-term current frequencies for the West Site and the East Site.



LEGEND

△ PROPOSED FERRY TERMINAL SITE

○ CURRENT METER OBSERVATIONS (28 JUNE - 15 JULY 2002)

⬡ NOAA TIDAL CURRENT PREDICTION SITE "MARROWSTONE PT. (1.6 nm NE of)"

H_{SIG} SIGNIFICANT WAVE HEIGHT

FIG. A-1
AREA MAP

PT WILSON, WA CONSTRUCTED WIND CLIMATE (1984-2000)
FREQUENCY OF OCCURRENCE OF WIND SPEED AND DIRECTION

Prepared by: Ken Lilly/CH2M HILL (16 JULY 2002) (REV 22 JULY 2002)

Note:
1. Smith I. wind directions 080, 090, 100, ... 360, 010T with speeds >= 15 kts produced Pt Wilson 150, 160, 170, 180T 280, 290, 300, 310, 320, 330, 340, 350, 360, 010, and 020T winds >= 15 kt. Smith I. 020,030, ... 070T winds did not produce any winds >=15 kts at Pt Wilson based on Pt Wilson data from 1 JAN 2002 - 30 June 2002

TABLE A-1
PT. WILSON CONSTRUCTED WIND CLIMATE (1984-2000)[1]
TOTAL HOURS OF WIND SPEED VERSUS DIRECTION

	WIND DIRECTION (°T)																				
Spd (kt)	10	20	30	40	50	60	70	150	160	170	180	280	290	300	310	320	330	340	350	360	TOTAL
15-19	308.0	308.0	79	57	52	48	47	229.9	1961.7	2942.5	2452.1	175.3	1227.0	1323.1	1512.1	2079.2	189.0	308.0	308.0	308.0	15915.1
20-24	155.5	155.5	49	25	4	4	6	116.1	990.4	1485.6	1238.0	88.5	619.5	668.0	763.4	1049.7	95.4	155.5	155.5	155.5	7980.1
25-29	80.8	80.8	28	9	2	1	0	60.3	514.3	771.4	642.8	46.0	321.7	346.9	396.4	545.1	49.6	80.8	80.8	80.8	4138.1
30-34	38.9	38.9	8	0	0	0	0	29.0	247.8	371.8	309.8	22.1	155.0	167.2	191.1	262.7	23.9	38.9	38.9	38.9	1983.1
35-39	15.2	15.2	2	0	0	0	0	11.4	97.0	145.5	121.3	8.7	60.7	65.5	74.8	102.9	9.4	15.2	15.2	15.2	775.1
40-44	4.1	4.1	1	0	0	0	0	3.0	26.0	39.0	32.5	2.3	16.3	17.5	20.1	27.6	2.5	4.1	4.1	4.1	208.1
45-49	0.7	0.7	0	0	0	0	0	0.5	4.3	6.4	5.3	0.4	2.7	2.9	3.3	4.6	0.4	0.7	0.7	0.7	34.1
50-54	0	0	0	0	0	0	0	0.03	0.3	0.4	0.3	0	0	0	0	0	0	0	0	0	1.0
TOT >=15 kt	603.3	603.3	167.0	91.0	58.0	53.0	53.0	450.2	3841.6	5762.4	4802.0	343.3	2402.9	2591.1	2961.3	4071.7	370.2	603.3	603.3	603.3	31035.0
																			NO. CALM		4459
																			NO.<15 kt		108914
																			TOTAL OBS		144408
																			TOTAL HRS		149040
																			% OBS		96.89%

NOTES:
[1]The table is based on comparison of wind observations made every hour at Smith I. and Pt. Wilson from 1 January 2002 -30 June 2002
Pt. Wilson wind data are not archived by the National Climatic Data Center or any other agency. The University of Washington Atmospheric Sciences Dept. furnished all of its archived hourly data on file for Pt. Wilson (Station K53S) for Jan.-June 2002 used to adjust Smith I. winds to Pt. Wilson winds.

TABLE A-2
PT. WILSON CONSTRUCTED WIND CLIMATE (1984-2000)
FREQUENCY OF OCCURRENCE (WIND SPEEDS >=15 kt)

	WIND DIRECTION (°T)																				
Spd (kt)	10	20	30	40	50	60	70	150	160	170	180	280	290	300	310	320	330	340	350	360	TOTAL
15-19	0.00213	0.00213	0.000547	0.000395	0.000360	0.000332	0.000325	0.00159	0.0136	0.0204	0.0170	0.00121	0.00850	0.00916	0.0105	0.014	0.00131	0.00213	0.00213	0.00213	0.110
20-24	0.00108	0.00108	0.000339	0.000173	0.0000277	0.0000277	0.0000415	0.000804	0.00686	0.0103	0.00857	0.000613	0.00429	0.00463	0.00529	0.0073	0.000661	0.00108	0.00108	0.00108	0.0553
25-29	0.000559	0.000559	0.000194	0.0000623	0.0000138	0.00000692	0	0.0004173	0.00356	0.00534	0.00445	0.000318	0.002228	0.00240	0.00275	0.0038	0.000343	0.000559	0.000559	0.000559	0.0287
30-34	0.000270	0.000270	0.0000554	0	0	0	0	0.000201	0.00172	0.00257	0.00215	0.000153	0.00107	0.00116	0.00132	0.0018	0.000165	0.000270	0.000270	0.000270	0.0137
35-39	0.000106	0.000106	0.0000138	0	0	0	0	0.0000787	0.000672	0.00101	0.000840	0.0000600	0.000420	0.000453	0.000518	0.00071	0.0000647	0.000106	0.000106	0.000106	0.00537
40-44	0.0000283	0.0000283	0.00000692	0	0	0	0	0.0000211	0.000180	0.000270	0.000225	0.0000161	0.000113	0.000121	0.000139	0.00019	0.0000174	0.0000283	0.0000283	0.0000283	0.00144
45-49	0.00000468	0.00000468	0	0	0	0	0	0.00000346	0.0000295	0.0000443	0.0000369	0.00000266	0.0000186	0.0000201	0.0000230	0.000032	0.00000287	0.00000468	0.00000468	0.00000468	0.000236
50-54	0	0	0	0	0	0	0	0.000000204	0.00000174	0.00000261	0.00000217	0	0	0	0	0	0	0	0	0	0.00000672
TOT >=15 kt	0.00418	0.00418	0.00116	0.000630	0.000402	0.000367	0.000367	0.00312	0.0266	0.0399	0.0333	0.00238	0.0166	0.0179	0.0205	0.0282	0.00256	0.00418	0.00418	0.00418	0.215
																		NO. CALM		4459	0.0309
																		0<NO.<15 kt		108914	0.754
																				SUM	1.000

TABLE A-3
PT. WILSON CONSTRUCTED WIND CLIMATE (1984-2000)
PERCENT FREQUENCY OF OCCURRENCE (WIND SPEEDS >=15 kt)

	WIND DIRECTION (oT)																				
Spd (kt)	10	20	30	40	50	60	70	150	160	170	180	280	290	300	310	320	330	340	350	360	TOTAL
15-19	0.213%	0.213%	0.0547%	0.0395%	0.0360%	0.0332%	0.0325%	0.159%	1.358%	2.038%	1.698%	0.121%	0.850%	0.916%	1.047%	1.440%	0.131%	0.213%	0.213%	0.213%	11.021%
20-24	0.108%	0.108%	0.0339%	0.0173%	0.00277%	0.00277%	0.00415%	0.0804%	0.686%	1.029%	0.857%	0.0613%	0.429%	0.463%	0.529%	0.727%	0.0661%	0.108%	0.108%	0.108%	5.526%
25-29	0.0559%	0.0559%	0.0194%	0.00623%	0.00138%	0.000692%	0%	0.0417%	0.356%	0.534%	0.445%	0.0318%	0.223%	0.240%	0.275%	0.377%	0.0343%	0.0559%	0.0559%	0.0559%	2.866%
30-34	0.0270%	0.0270%	0.00554%	0%	0%	0%	0%	0.0201%	0.172%	0.257%	0.215%	0.0153%	0.107%	0.116%	0.132%	0.182%	0.0165%	0.0270%	0.0270%	0.0270%	1.373%
35-39	0.0106%	0.0106%	0.00138%	0%	0%	0%	0%	0.00787%	0.0672%	0.101%	0.0840%	0.00600%	0.0420%	0.0453%	0.0518%	0.0712%	0.00647%	0.0106%	0.0106%	0.0106%	0.537%
40-44	0.00283%	0.00283%	0.000692%	0%	0%	0%	0%	0.00211%	0.0180%	0.0270%	0.0225%	0.00161%	0.0113%	0.0121%	0.0139%	0.0191%	0.00174%	0.00283%	0.00283%	0.00283%	0.144%
45-49	0.000468%	0.000468%	0%	0%	0%	0%	0%	0.000346%	0.00295%	0.00443%	0.00369%	0.00027%	0.00186%	0.00201%	0.00230%	0.00316%	0.000287%	0.000468%	0.000468%	0.000468%	0.0236%
50-54	0%	0%	0%	0%	0%	0%	0%	0.0000204%	0.000174%	0.000261%	0.000217%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0.000672%
TOT >=15 kt	0.418%	0.418%	0.116%	0.0630%	0.0402%	0.0367%	0.0367%	0.312%	2.660%	3.990%	3.325%	0.238%	1.664%	1.794%	2.051%	2.820%	0.256%	0.418%	0.418%	0.418%	21.491%
																		NO. CALM		4459	3.088%
																		0<NO.<15 kt		108914	75.421%
																				SUM	100.000%

KEYSTONE, WA - EAST SITE (1.2 NM ENE of Keystone Jetty)

SIGNIFICANT WAVE HEIGHT AND MODAL PERIOD DISTRIBUTION

Prepared by: Ken Lilly/CH2M HILL (22 JULY 2002)

Comments:

1. Tables are based on the wind climate for the northern part of Admiralty Inlet derived from the wind climate developed from wind observations taken every hour at Smith Island, WA (1984-2000). Smith Island wind directions were adjusted for changes in wind direction in Admiralty Inlet based on limited concurrent wind data (January- June 2002) available from Pt. Wilson in a comparative analysis with Smith Island data from the same 6-month period.
2. Reduced wind fetches used for wave analysis due to wind channeling south of Admiralty Bay.
3. Wind speeds used for determining wave heights and periods are the mid-value of the speed class (shown in parentheses in the table), except for 50-54 kts, in which 51 kts was used, as this was the highest wind speed observed 1984-2000.

TABLE B-1

EAST SITE FREQUENCY OF WAVE HEIGHTS AND PERIODS

WIND DIR: 150°T

Wind Spd	Hm_o (ft)		Hm_o (ft)		Hm_o (ft)		Hm_o (ft)		Hm_o (ft)		Hm_o (ft)		Hm_o (ft)		
(kts)	0-0.9	T_p (sec)	1.0-1.9	T_p (sec)	2.0-2.9	T_p (sec)	3.0-3.9	T_p (sec)	4.0-4.9	T_p (sec)	5.0-5.9	T_p (sec)	6.0-6.9	T_p (sec)	TOTAL
17 (15-19)			0.00159	2.4											0.00159
22 (20-24)			0.00080369	2.7											0.000804
27 (25-29)					0.000417	3.1									0.000417
32 (30-34)					0.000201125	3.4									0.000201
37 (35-39)							0.0000787	3.7							0.0000787
42 (40-44)									0.0000211	4.0					0.0000211
47 (45-49)									0.00000346	4.3					0.00000346
51* (50-54											0.000000204	4.3			0.000000204
TOTAL			0.00240		0.000618		0.0000787		0.0000245		0.000000204				0.00312
TOTAL %			0.240%		0.0618%		0.00787%		0.00245%		0.0000204%				

WIND DIR: 160°T

Wind Spd	Hm_o (ft)		Hm_o (ft)		Hm_o (ft)		Hm_o (ft)		Hm_o (ft)		Hm_o (ft)		Hm_o (ft)		
(kts)	0-0.9	T_p (sec)	1.0-1.9	T_p (sec)	2.0-2.9	T_p (sec)	3.0-3.9	T_p (sec)	4.0-4.9	T_p (sec)	5.0-5.9	T_p (sec)	6.0-6.9	T_p (sec)	TOTAL
17 (15-19)			0.0135	2.6											0.01358
22 (20-24)			0.00686	2.9											0.00686
27 (25-29)					0.00356	3.2									0.00356
32 (30-34)							0.00172	3.6							0.00172
37 (35-39)							0.000672	3.9							0.000672
42 (40-44)									0.000180	4.2					0.000180
47 (45-49)											0.0000295	4.5			0.0000295
51* (50-54											0.00000174	4.6			0.00000174
TOTAL			0.0204		0.00356		0.00239		0.000180		0.0000313				0.02660
TOTAL %			2.044%		0.356%		0.239%		0.0180%		0.00313%				

WIND DIR: 170°T

Wind Spd	Hm_o (ft)		Hm_o (ft)		Hm_o (ft)		Hm_o (ft)		Hm_o (ft)		Hm_o (ft)		Hm_o (ft)		
(kts)	0-0.9	T_p (sec)	1.0-1.9	T_p (sec)	2.0-2.9	T_p (sec)	3.0-3.9	T_p (sec)	4.0-4.9	T_p (sec)	5.0-5.9	T_p (sec)	6.0-6.9	T_p (sec)	TOTAL
17 (15-19)			0.0204	2.6											0.020376
22 (20-24)					0.0103	3.0									0.010287
27 (25-29)					0.00534	3.3									0.005342
32 (30-34)							0.00257	3.6							0.002574
37 (35-39)							0.00101	4.0							0.0010076
42 (40-44)									0.000270	4.2					0.0002698
47 (45-49)											0.0000443	4.5			0.00004432
51* (50-54											0.00000261	4.8			0.000002607
TOTAL			0.0204		0.0156		0.00358		0.000270		0.0000469				0.03990
TOTAL %			2.038%		1.563%		0.358%		0.027%		0.00469%				

WIND DIR: 180°T

Wind Spd	Hm_o (ft)		Hm_o (ft)		Hm_o (ft)		Hm_o (ft)		Hm_o (ft)		Hm_o (ft)		Hm_o (ft)		
(kts)	0-0.9	T_p (sec)	1.0-1.9	T_p (sec)	2.0-2.9	T_p (sec)	3.0-3.9	T_p (sec)	4.0-4.9	T_p (sec)	5.0-5.9	T_p (sec)	6.0-6.9	T_p (sec)	TOTAL
17 (15-19)			0.0170	2.7											0.016980
22 (20-24)					0.00857	3									0.008573
27 (25-29)					0.00445	3.4									0.004451
32 (30-34)							0.00215	3.7							0.002145
37 (35-39)									0.000840	4.1					0.0008397
42 (40-44)									0.000225	4.3					0.0002249
47 (45-49)											0.0000369	4.6			0.00003693
51* (50-54											0.00000217	4.8			0.000002172
TOTAL			0.0170		0.0130		0.00215		0.00106		0.0000391				0.0333
TOTAL %			1.698%		1.302%		0.215%		0.106%		0.00391%				

Notes:

*51 kt is max. observed wind (1984-2000)

PERCENT OF WAVES >= 3.0 ft.

	Significant Wave Height (ft)				
°T	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	TOTAL
150	0.0079%	0.00245%	0.0000204%	0%	0.010%
160	0.239%	0.0180%	0.0031%	0%	0.260%
170	0.358%	0.027%	0.00469%	0%	0.390%
180	0.215%	0.106%	0.00391%	0%	0.325%
TOTAL	0.819%	0.154%	0.0118%	0%	0.985%

KEYSTONE, WA - WEST SITE (0.2 NM NE of Keystone Jetty)
SIGNIFICANT WAVE HEIGHT AND MODAL PERIOD DISTRIBUTION

Prepared by: Ken Lilly/CH2M HILL (20 JULY 2002)

Comments:
1. Tables are based on the wind climate for the northern part of Admiralty Inlet derived from the wind climate developed from wind observations taken every hour at Smith Island, WA (1984-2000). Smith Island wind directions were adjusted for changes in wind direction in Admiralty Inlet based on limited concurrent wind data (January- June 2002) available from Pt. Wilson in a comparative analysis with Smith Island data from the same 6-month period.
2. Reduced wind fetches used for wave analysis due to wind channeling south of Admiralty Bay.
3. Wind speeds used for determining wave heights and periods are the mid-value of the speed class (shown in parentheses in the table), except for 50-54 kts. in which 51 kts was used, as this was the highest wind speed observed 1984-2000.

TABLE B-2
WEST SITE FREQUENCY OF WAVE HEIGHTS AND PERIODS

WIND DIR: 150°T

Wind Spd	Hm_o (ft)		Hm_o (ft)		Hm_o (ft)		Hm_o (ft)		Hm_o (ft)		Hm_o (ft)		Hm_o (ft)		
(kts)	0-0.9	T_p (sec)	1.0-1.9	T_p (sec)	2.0-2.9	T_p (sec)	3.0-3.9	T_p (sec)	4.0-4.9	T_p (sec)	5.0-5.9	T_p (sec)	6.0-6.9	T_p (sec)	TOTAL
17 (15-19)			0.00159	2.7											0.001592
22 (20-24)					0.000804	3.0									0.000804
27 (25-29)					0.000417	3.4									0.000417
32 (30-34)							0.000201	3.7							0.000201
37 (35-39)									0.0000787	4.1					0.0000787
42 (40-44)									0.0000211	4.3					0.0000211
47 (45-49)											0.00000345	4.6			0.00000345
51* (50-54											0.000000204	4.8			0.000000204
TOTAL			0.00159		0.00122		0.000201		0.000100		0.00000367				0.00312
TOTAL %			0.159%		0.122%		0.0201%		0.0100%		0.000367%				

WIND DIR: 160°T

Wind Spd	Hm_o (ft)		Hm_o (ft)		Hm_o (ft)		Hm_o (ft)		Hm_o (ft)		Hm_o (ft)		Hm_o (ft)		
(kts)	0-0.9	T_p (sec)	1.0-1.9	T_p (sec)	2.0-2.9	T_p (sec)	3.0-3.9	T_p (sec)	4.0-4.9	T_p (sec)	5.0-5.9	T_p (sec)	6.0-6.9	T_p (sec)	TOTAL
17 (15-19)			0.013584	2.7											0.013584
22 (20-24)					0.006858	3.1									0.006858
27 (25-29)					0.003561	3.4									0.003561
32 (30-34)							0.001716	3.7							0.001716
37 (35-39)									0.000672	4.2					0.0006717
42 (40-44)									0.000180	4.4					0.0001799
47 (45-49)											0.000030	4.6			0.00002955
51* (50-54													0.00000174	4.9	0.000001738
TOTAL			0.013584		0.010419		0.001716		0.000852		0.000030		0.00000174		0.02660
TOTAL %			1.358%		1.042%		0.172%		0.0852%		0.00295%		0.000174%		

WIND DIR: 170°T

Wind Spd	Hm_o (ft)		Hm_o (ft)		Hm_o (ft)		Hm_o (ft)		Hm_o (ft)		Hm_o (ft)		Hm_o (ft)		
(kts)	0-0.9	T_p (sec)	1.0-1.9	T_p (sec)	2.0-2.9	T_p (sec)	3.0-3.9	T_p (sec)	4.0-4.9	T_p (sec)	5.0-5.9	T_p (sec)	6.0-6.9	T_p (sec)	TOTAL
17 (15-19)			0.020376	2.7											0.020376
22 (20-24)					0.010287	3.1									0.010287
27 (25-29)					0.005342	3.4									0.005342
32 (30-34)							0.002574	3.8							0.002574
37 (35-39)									0.001008	4.1					0.0010076
42 (40-44)									0.000270	4.4					0.0002698
47 (45-49)											0.000044	4.7			0.00004432
51* (50-54													0.00000261	4.9	0.000002607
TOTAL			0.020376		0.015629		0.002574		0.00128		0.000044		0.00000261		0.03990
TOTAL %			2.038%		1.563%		0.257%		0.128%		0.00443%		0.000261%		

WIND DIR: 180°T

Wind Spd	Hm_o (ft)		Hm_o (ft)		Hm_o (ft)		Hm_o (ft)		Hm_o (ft)		Hm_o (ft)		Hm_o (ft)		
(kts)	0-0.9	T_p (sec)	1.0-1.9	T_p (sec)	2.0-2.9	T_p (sec)	3.0-3.9	T_p (sec)	4.0-4.9	T_p (sec)	5.0-5.9	T_p (sec)	6.0-6.9	T_p (sec)	TOTAL
17 (15-19)			0.016980	2.7											0.016980
22 (20-24)					0.008573	3.1									0.008573
27 (25-29)					0.004451	3.5									0.004451
32 (30-34)							0.002145	3.7							0.002145
37 (35-39)									0.000840	4.0					0.0008397
42 (40-44)									0.000225	4.3					0.0002249
47 (45-49)											0.000037	4.6			0.00003693
51* (50-54													0.00000217	4.9	0.000002172
TOTAL			0.016980		0.013024		0.002145		0.001065		0.0000369		0.00000217		0.03325
TOTAL %			1.698%		1.302%		0.215%		0.106%		0.00369%		0.000217%		

Notes:
*51 kt is max. observed wind (1984-2000)

PERCENT OF WAVES >= 3.0 ft.

	Significant Wave Height (ft)				
°T	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	TOTAL
150	0.0201%	0.00998%	0.000367%	0%	0.0305%
160	0.172%	0.0852%	0.00295%	0.000174%	0.260%
170	0.257%	0.128%	0.00443%	0.000261%	0.390%
180	0.215%	0.106%	0.00369%	0.000217%	0.325%
TOTAL	0.654%	0.329%	0.0114%	0.000652%	1.005%

KEYSTONE, WA

OBSERVED CURRENTS (28 JUNE-15 JULY 2002)

Prepared by: Ken Lilly/CH2M HILL (27 AUG 2002)

TABLE C-1

OBSERVED CURRENTS (28 JUNE-15 JULY 2002)

Current Direction (Deg. True)

	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240	250	260	270	280	290	300	310	320	330	340	350	360	TOTAL
CM1 (West Site)	6	8	10	18	126	114	30	12	5	1	3	0	0	1	3	1	2	2	4	3	9	12	25	1229	729	37	7	6	3	3	5	1	4	4	3	5	2431
CM2 (East Site)	1	2	6	7	12	22	67	386	79	22	16	6	5	6	7	3	2	2	6	6	3	9	11	28	57	432	1094	65	23	15	8	8	7	4	3	1	2431

OBSERVED MAXIMUM SPEED (KTS)

CM1 (West Site)	0.18	0.34	0.31	0.54	1.35	0.85	0.40	0.19	0.04	0.01	0.08	na	na	0.14	0.13	0.02	0.03	0.03	0.10	0.09	0.29	0.29	0.53	2.35	2.39	0.88	0.32	0.13	0.16	0.04	0.11	0.08	0.07	0.12	0.19	0.11	
CM2 (East Site)	0.12	0.08	0.15	0.47	0.58	0.60	0.81	1.67	0.85	0.28	0.15	0.08	0.09	0.08	0.10	0.05	0.04	0.03	0.08	0.09	0.06	0.11	0.13	0.24	0.53	1.14	1.75	0.77	0.37	0.22	0.36	0.14	0.15	0.17	0.16	0.03	

Note:

Number of cases are for the identical times of observation at both locations.

KEYSTONE, WA

WEST TERMINAL SITE TIDAL CURRENTS

Prepared by: Ken Lilly/CH2M HILL (2 AUG 2002)

NOTES:

1. West Terminal Site: 48° 09.502' N 122° 40.000' W (approx. 0.2 nm NE of Keystone Jetty)

2. The table is based on analysis of data from two sources: (1) an Acoustic Doppler Current Profiler (ADCP) meter deployed from 28 June 2002 - 15 July 2002 that recorded the average ambient current every 10-minutes, and (2) NOAA predicted tidal currents every 10 minutes for 2002-2006 for Marrowstone Pt. (1.6 nm NE of). This site is approximately 2.2 nm S of CM1and is in Admiralty Inlet. The current meter was deployed at 48° 09.538' W 122° 39.958' W.

3. Currents in Table C-2 are for 8.25 ft. below the sea surface (mid-draft of an Issaquah class ferry).

4. Current direction is the true direction toward which the current flows.

5. EBB currents prevail at the West Terminal Site regardless of the tidal flow in Admiralty Inlet. FLOOD currents at the West Terminal Site are weak and of short duration.

TABLE C-2 - WEST TERMINAL SITE
CURRENT DIRECTION AND SPEED FREQUENCY

Speed	CURRENT DIRECTION (°T)																																		No. Cases 2002-2006
(kt)	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240	250	260	270	280	290	300	310	320	330	340	350	360	TOTAL	(10-min Interval)
0-0.49	0.00203	0.00304	0.00338	0.00541	0.0301	0.0328	0.00981	0.00406	0.00169	0.00101	0.000338	NR	NR	0.000676	0.000676	0.000338	0.000676	0.000676	0.00169	0.000676	0.00304	0.00440	0.00913	0.0717	0.0463	0.00913	0.00237	0.00203	0.00101	0.00101	0.00169	0.000338	0.00135	0.00135	0.00101	0.00169	0.257	67497
0.50-0.99	0	0	0	0.000210	0.00693	0.00168	0	0	0	0	0	NR	NR	0	0	0	0	0	0	0	0	0	0.000420	0.145	0.0546	0.00105	0	0	0	0	0	0	0	0	0	0	0.209	55070
1.00-1.49	0	0	0	0	0.0100	0	0	0	0	0	0	NR	NR	0	0	0	0	0	0	0	0	0	0	0.262	0.112	0	0	0	0	0	0	0	0	0	0	0	0.383	100735
1.50-1.99	0	0	0	0	0	0	0	0	0	0	0	NR	NR	0	0	0	0	0	0	0	0	0	0	0.0912	0.0370	0	0	0	0	0	0	0	0	0	0	0	0.128	33714
2.00-2.49	0	0	0	0	0	0	0	0	0	0	0	NR	NR	0	0	0	0	0	0	0	0	0	0	0.0138	0.00302	0	0	0	0	0	0	0	0	0	0	0	0.017	4415
2.50-2.99	0	0	0	0	0	0	0	0	0	0	0	NR	NR	0	0	0	0	0	0	0	0	0	0	0.00329	0.000722	0	0	0	0	0	0	0	0	0	0	0	0.0040	1054
3.00-3.49	0	0	0	0	0	0	0	0	0	0	0	NR	NR	0	0	0	0	0	0	0	0	0	0	0.00103	0.000226	0	0	0	0	0	0	0	0	0	0	0	0.0013	330
3.50-3.99	0	0	0	0	0	0	0	0	0	0	0	NR	NR	0	0	0	0	0	0	0	0	0	0	0.000387	0.0000849	0	0	0	0	0	0	0	0	0	0	0	0.00047	124
4.00-4.49	0	0	0	0	0	0	0	0	0	0	0	NR	NR	0	0	0	0	0	0	0	0	0	0	0.0000156	0.00000342	0	0	0	0	0	0	0	0	0	0	0	0.000019	5
4.50-4.99	0	0	0	0	0	0	0	0	0	0	0	NR	NR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SUM	0.00203	0.00304	0.00338	0.00562	0.0470	0.03449	0.00981	0.00406	0.00169	0.00101	0.00034	NR	NR	0.00068	0.00068	0.00034	0.00068	0.00068	0.00169	0.00068	0.00304	0.00440	0.00955	0.587	0.254	0.0102	0.00237	0.00203	0.00101	0.00101	0.00169	0.000338	0.00135	0.00135	0.00101	0.00169	1.0000	262944

OBSERVED PEAK FLOWS AT CM1
(28 June 2002 - 15 July 2002)

Note: Speeds are arranged in descending order.

	PEAK EBB			PEAK EBB			PEAK EBB			PEAK FLOOD		
Date/Time	Direction	Speed	Date/Time	Direction	Speed	Date/Time	Direction	Speed	Date/Time	Direction	Speed
(PDT)	(°T)	(knots)	(PDT)	(°T)	(knots)	(PDT)	(°T)	(knots)	(PDT)	(°T)	(knots)
7/12/02 9:40	245	2.39	7/9/02 20:00	245	1.39	6/30/02 10:20	243	1.14	7/13/02 3:10	50	0.65
7/9/02 7:20	244	2.35	7/1/02 0:30	240	1.34	7/10/02 15:40	248	1.14	7/8/02 23:40	53	0.58
7/10/02 8:10	244	2.31	6/29/02 23:50	242	1.33	7/2/02 21:10	241	1.14	7/1/02 7:40	46	0.49
7/13/02 10:20	245	2.29	7/4/02 4:10	244	1.33	7/14/02 7:10	244	1.13	7/2/02 7:50	53	0.42
7/11/02 8:30	244	2.26	6/28/02 23:10	243	1.33	7/4/02 11:10	243	1.09	7/12/02 2:00	57	0.27
7/8/02 6:40	243	2.15	7/8/02 14:10	245	1.32	7/8/02 1:40	242	1.06			
7/14/02 11:10	245	2.11	7/14/02 17:50	245	1.29	7/12/02 17:00	247	1.06			
7/13/02 22:00	245	1.85	7/7/02 13:50	246	1.27	7/6/02 12:40	245	1.04			
7/7/02 7:00	246	1.75	7/5/02 17:40	245	1.25	7/5/02 12:10	242	1.03			
7/11/02 21:00	245	1.72	7/1/02 20:10	248	1.24	7/13/02 16:50	245	1.00			
7/14/02 23:00	244	1.62	7/3/02 0:40	245	1.24	7/11/02 15:20	244	0.99			
7/12/02 21:20	244	1.59	7/9/02 14:50	248	1.24	7/2/02 11:20	248	0.94			
7/2/02 0:50	244	1.53	7/15/02 9:30	246	1.24	7/4/02 23:20	245	0.91			
6/29/02 10:50	245	1.52	7/11/02 3:50	243	1.22	7/3/02 12:10	247	0.81			
7/5/02 5:30	244	1.48	7/7/02 18:50	243	1.21	7/4/02 15:50	244	0.64			
6/28/02 17:20	247	1.46	6/29/02 18:40	246	1.20	6/29/02 6:10	255	0.16			
7/6/02 5:10	243	1.46	7/1/02 11:00	246	1.19						
7/10/02 20:30	245	1.45	7/6/02 18:40	246	1.19						
6/30/02 19:00	245	1.43	7/10/02 3:30	244	1.17						
7/8/02 19:30	246	1.41	7/3/02 22:30	246	1.15						

SUMMARY	EBB	FLOOD
Mean Dir. (°T)	245	052
Mean Speed (kt)	1.37	0.48
Dir. Range	240-255	046-057
Speed Range	0.16-2.39	0.27-0.65

KEYSTONE, WA
EAST TERMINAL SITE TIDAL CURRENTS

Prepared by: Ken Lilly/CH2M HILL (22 AUG 2002)

NOTES:
1. East Terminal Site: 48° 09.790' N 122° 38.600' W (approx. 1.2 nm ENE of Keystone Jetty)

2. The table is based on analysis of data from two sources: (1) an Acoustic Doppler Current Profiler (ADCP) meter deployed from 28 June 2002 - 15 July 2002 that recorded the average ambient current every 10-minutes, and (2) NOAA predicted tidal currents every 10 minutes for 2002-2006 for Marrowstone Pt. (1.6 nm NE of). This site is approximately 2.5 nm S of CM2and is in Admiralty Inlet. Current meter CM2 was deployed at 48° 09.775' W 122° 38.940' W about 0.25 nm west of the proposed East Terminal Site.

3. Currents in Table C-3 are for 8.25 ft. below the sea surface (mid-draft of an Issaquah class ferry).

4. Current direction is the true direction toward which the current flows.

5. EBB currents prevail at the East Terminal Site regardless of the tidal flow in Admiralty Inlet. FLOOD currents (010 - 090 -180 °T) at the East Terminal Site occur approximately 20% of the time.

TABLE C-3 - EAST TERMINAL SITE
CURRENT DIRECTION AND SPEED FREQUENCY

Speed	CURRENT DIRECTION (°T)																																	No. Cases 2002-2006
(kt)	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240	250	260	270	280	290	300	310	320	330	340	350	360	TOTAL	(10-min Interval)
0-0.49	0.000178	0.000357	0.00107	0.00143	0.00178	0.00393	0.0102	0.0407	0.0114	0.00393	0.00268	0.00107	0.000892	0.00107	0.00125	0.000535	0.000357	0.000535	0.00107	0.000892	0.000714	0.00143	0.00214	0.00518	0.0107	0.0498	0.0496	0.00821	0.00393	0.00268	0.00143	0.00161	0.00107	0.000714	0.000535	0.000178	0.225	59217
0.50-0.99	0	0	0	0	0.000541	0.000541	0.00920	0.0704	0.00325	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00108	0.104	0.300	0.00649	0	0	0	0	0	0	0	0	0.496	130356
1.00-1.49	0	0	0	0	0	0	0	0.0255	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00851	0.227	0	0	0	0	0	0	0	0	0.261	68733
1.50-1.99	0	0	0	0	0	0	0	0.00303	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01177705	0	0	0	0	0	0	0	0	0.0148	3893
2.00-2.49	0	0	0	0	0	0	0	0.000551	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00214	0	0	0	0	0	0	0	0	0.00269	708
2.50-2.99	0	0	0	0	0	0	0	0.0000288	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000112	0	0	0	0	0	0	0	0	0.000141	37
3.00-3.49	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000	0
3.50-3.99	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000	0
4.00-4.49	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000	0
4.50-4.99	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000	0
SUM	0.000178	0.000357	0.001071	0.001428	0.002326	0.004467	0.019373	0.140185	0.014668	0.003926	0.002677	0.001071	0.000892	0.001071	0.001249	0.000535	0.000357	0.000535	0.001071	0.000892	0.000714	0.001428	0.002141	0.005175	0.011790	0.162754	0.590831	0.014703	0.003926	0.002677	0.001428	0.001606	0.001071	0.000714	0.000535	0.000178	1.000000	262944
																																				1.000		

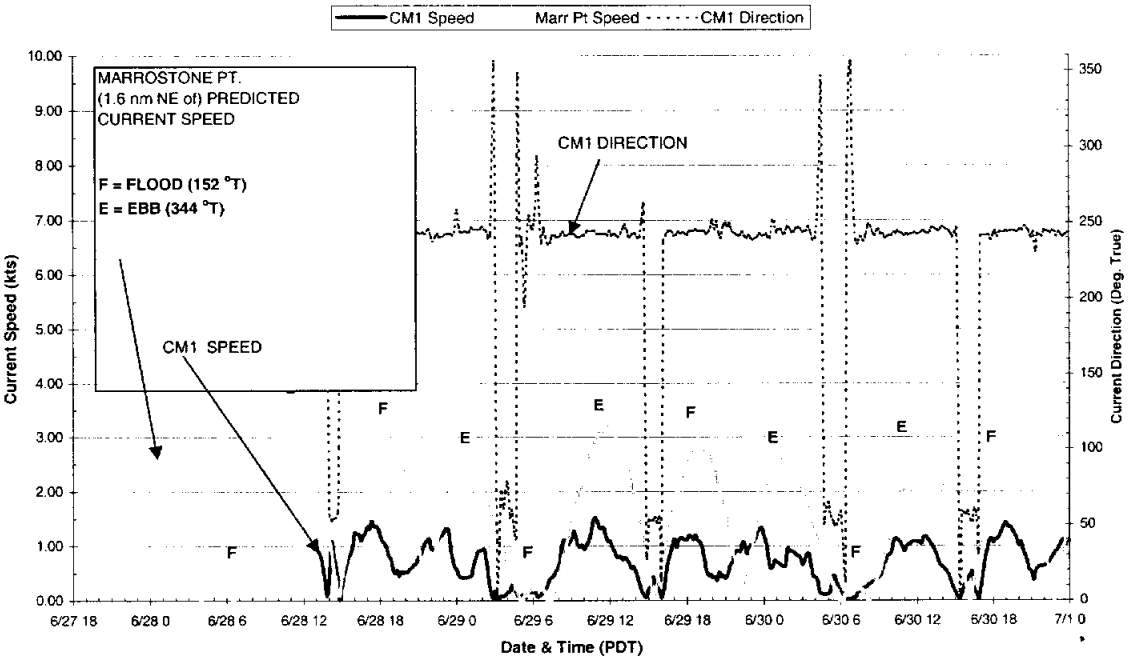
OBSERVED PEAK FLOWS AT CM2
(28 June 2002 - 15 July 2002)

Note: Speeds are arranged in descending order.

PEAK EBB			PEAK EBB			PEAK EBB			PEAK EBB			PEAK FLOOD			PEAK FLOOD		
Date/Time	Direction	Speed	Date/Time	Direction	Speed	Date/Time	Direction	Speed	Date/Time	Direction	Speed	Date/Time	Direction	Speed	Date/Time	Direction	Speed
(PDT)	(°T)	(knots)	(PDT)	(°T)	(knots)	(PDT)	(°T)	(knots)	7/7/02 2:40	271	0.58	(PDT)	(°T)	(knots)	(PDT)	(°T)	(knots)
7/9/02 7:10	268	1.72	7/3/02 22:20	271	1.23	7/15/02 1:40	273	0.84	7/4/02 15:40	268	0.41	7/14/02 15:10	77	1.67	6/30/02 16:40	78	0.65
7/8/02 6:10	267	1.68	7/14/02 17:30	267	1.18	7/10/02 20:00	264	0.84	6/29/02 2:00	274	0.37	7/12/02 13:40	79	1.66	7/6/02 10:10	76	0.65
7/12/02 9:20	268	1.68	7/5/02 5:40	268	1.18	7/9/02 19:40	266	0.83				7/13/02 14:20	80	1.65	7/2/02 17:30	76	0.63
7/11/02 8:10	268	1.64	7/11/02 20:30	269	1.15	7/3/02 0:20	270	0.83				7/9/02 11:30	78	1.59	7/3/02 7:30	81	0.62
7/13/02 10:00	269	1.63	6/29/02 18:30	269	1.13	7/8/02 19:10	271	0.83				7/11/02 12:40	80	1.54	6/29/02 4:10	72	0.58
7/10/02 8:40	267	1.54	7/12/02 21:00	267	1.10	7/3/02 3:40	266	0.80				7/10/02 12:20	79	1.50	7/6/02 23:50	81	0.54
6/28/02 17:30	268	1.49	7/13/02 17:30	269	1.09	7/6/02 18:30	269	0.80				7/8/02 11:00	82	1.38	7/12/02 2:20	79	0.52
7/8/02 14:00	268	1.47	7/6/02 12:10	271	1.06	7/5/02 12:20	265	0.78				7/7/02 10:30	77	1.17	7/1/02 6:30	76	0.46
7/9/02 14:30	268	1.47	7/14/02 22:50	266	1.01	7/12/02 5:30	268	0.77				6/28/02 14:50	77	0.99	6/29/02 15:10	78	0.46
7/7/02 6:50	268	1.47	6/29/02 8:30	268	0.99	7/1/02 0:20	265	0.77				7/11/02 1:00	83	0.92	6/30/02 6:50	75	0.46
7/14/02 11:00	270	1.46	7/1/02 20:30	267	0.95	6/29/02 23:20	260	0.75				7/1/02 16:50	77	0.90	7/2/02 9:00	79	0.36
7/13/02 21:50	274	1.37	7/1/02 3:30	271	0.93	7/4/02 12:30	269	0.72				7/9/02 0:20	76	0.89	7/5/02 20:40	82	0.35
7/7/02 13:20	269	1.36	7/15/02 9:40	271	0.92	7/2/02 11:30	268	0.72				7/10/02 0:30	77	0.88	7/4/02 8:00	81	0.32
7/10/02 15:10	268	1.35	6/30/02 2:40	269	0.92	7/6/02 1:00	271	0.68				7/15/02 4:20	77	0.83	6/28/02 23:50	98	0.28
7/6/02 6:30	269	1.33	7/2/02 0:40	270	0.90	7/7/02 18:30	260	0.66				7/7/02 22:20	77	0.79	7/4/02 20:40	80	0.25
6/30/02 19:30	269	1.28	7/4/02 23:20	268	0.89	7/2/02 3:40	266	0.66				7/14/02 4:30	73	0.75			
7/11/02 16:00	269	1.27	7/4/02 5:20	268	0.89	7/3/02 11:40	274	0.63				7/13/02 3:50	68	0.74			
7/2/02 20:50	268	1.26	7/1/02 10:10	269	0.89	7/6/02 15:40	269	0.63				7/3/02 19:50	77	0.72			
7/12/02 16:40	266	1.23	6/30/02 9:40	269	0.87	7/5/02 16:50	266	0.63				7/5/02 9:50	76	0.66			

SUMMARY		
	EBB	FLOOD
Mean Dir. (°T)	268	78
Mean Speed (kt)	1.04	0.84
Dir. Range (°T)	260-274	068-098
Speed Range (kt)	0.37-1.72	0.25-1.67

KEYSTONE, WA: CM1 (28-30 JUNE 2002)



KEYSTONE, WA: CM1 (1-3 JULY 2002)

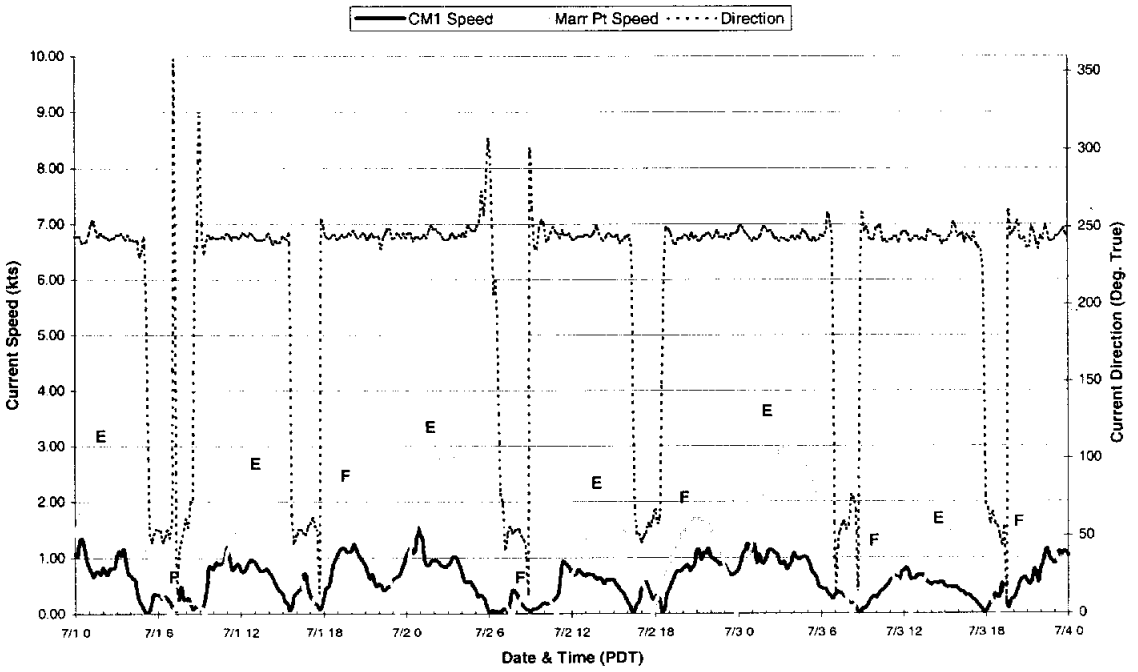
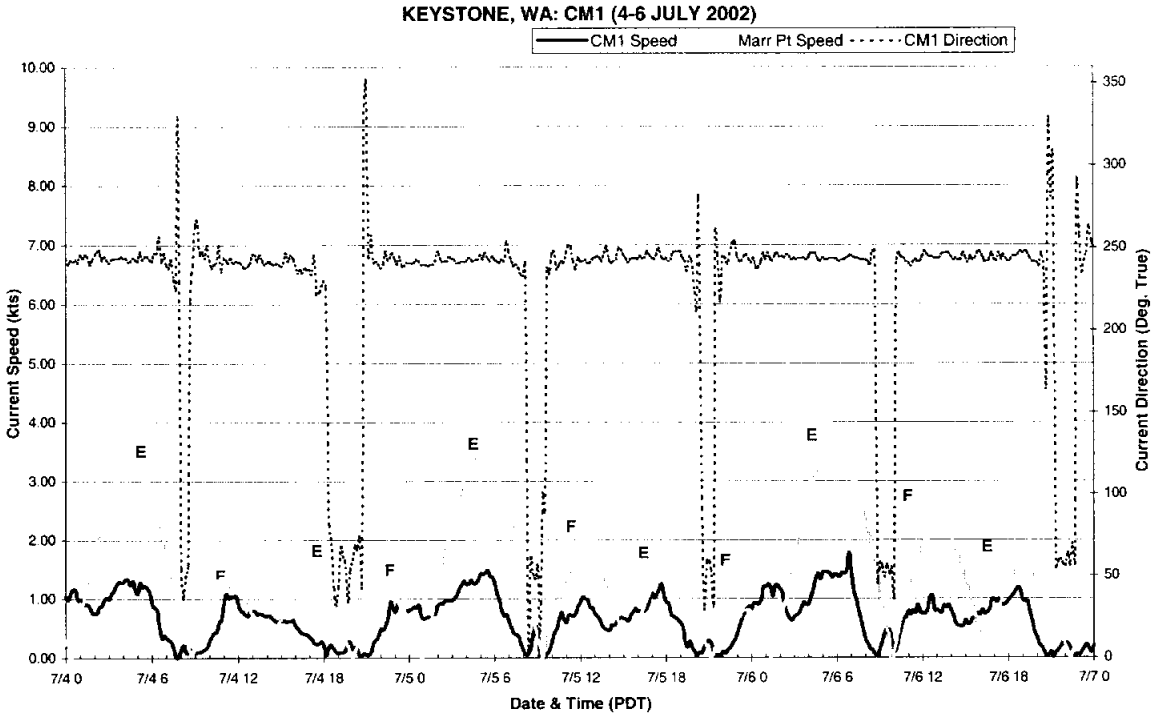


FIG. C-1
Observed currents at CM1 June 28-July 3, 2002.



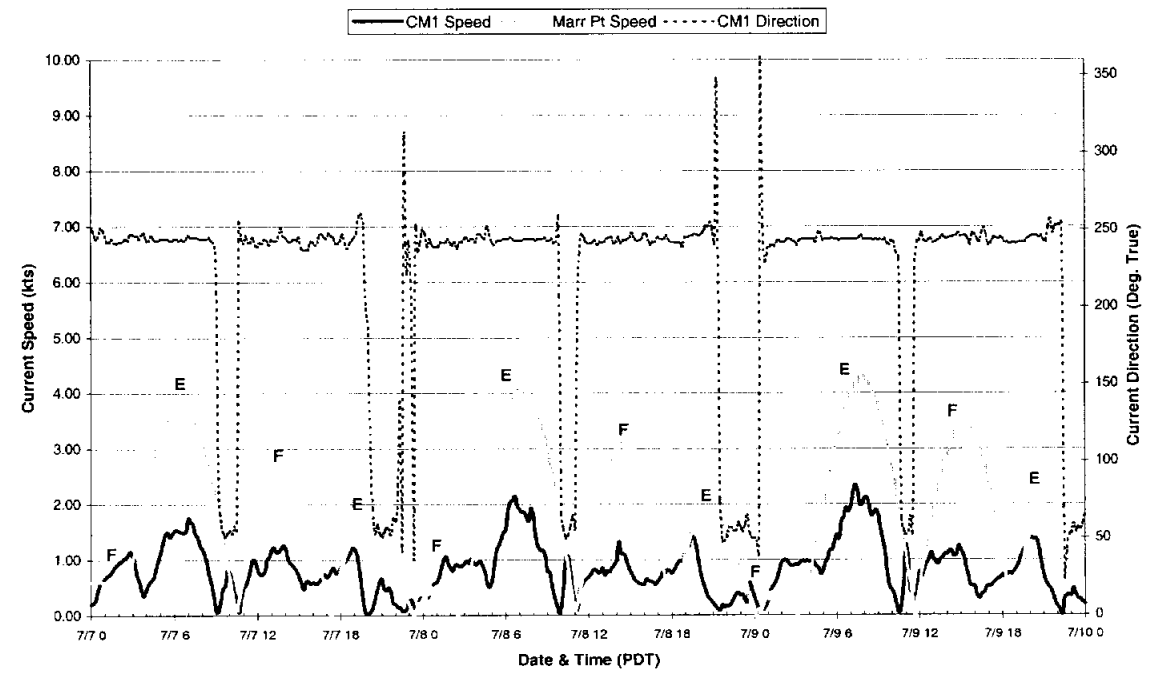
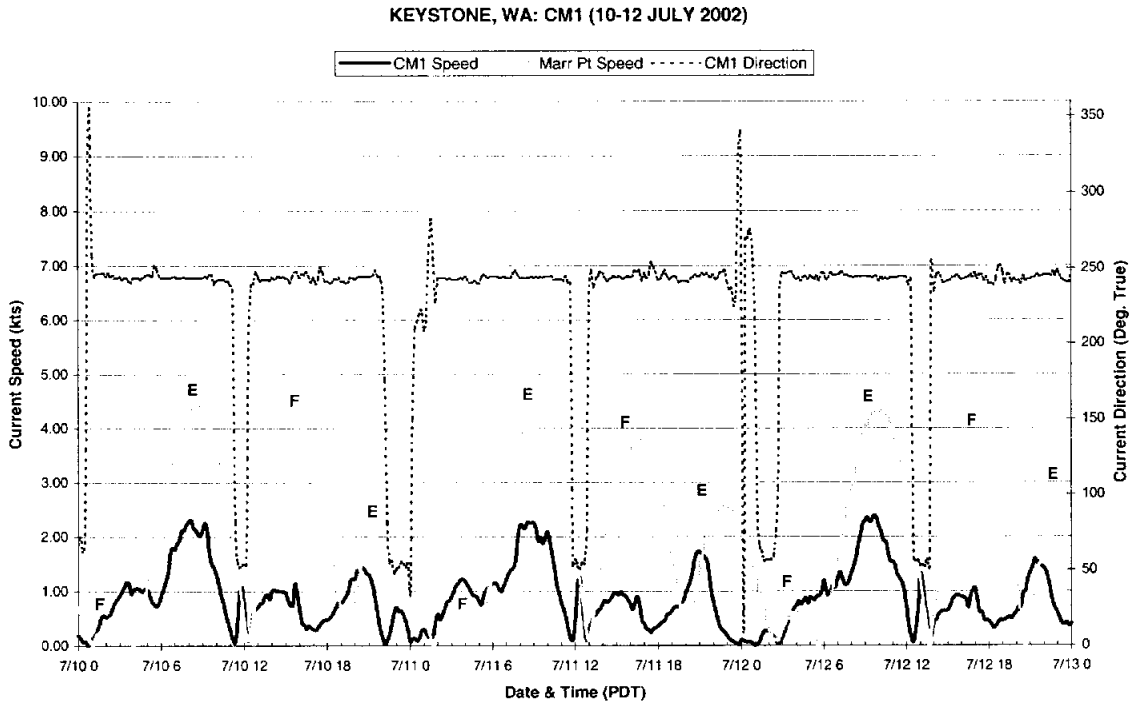


FIG. C-2
Observed currents at CM1
July 4-9, 2002.



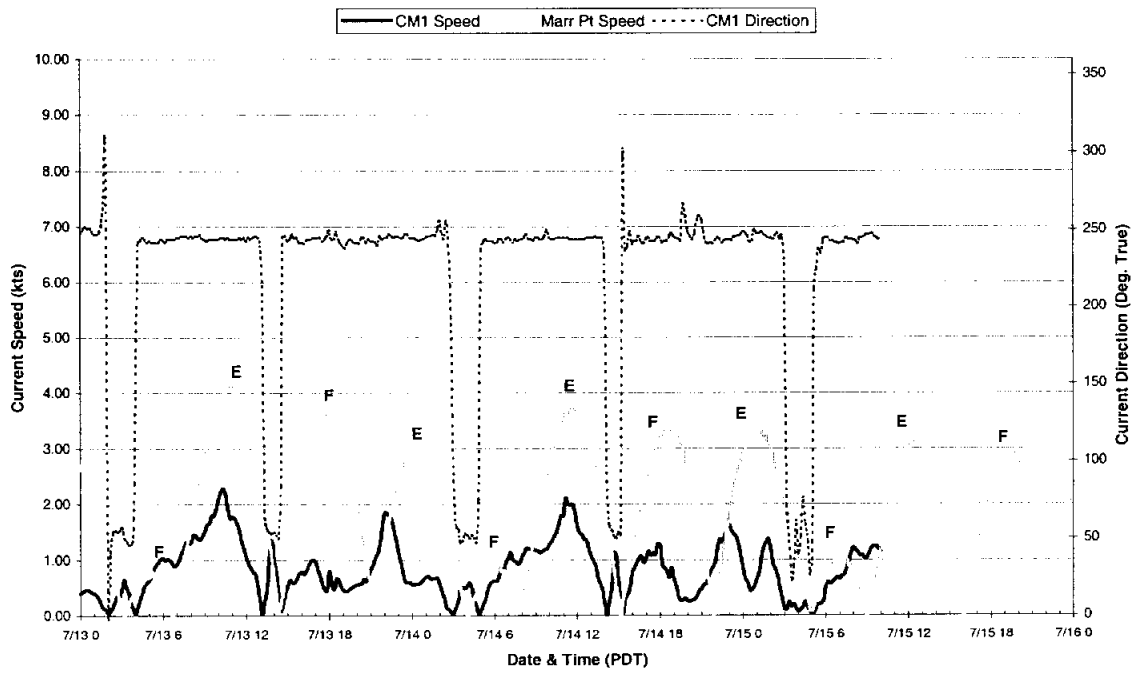
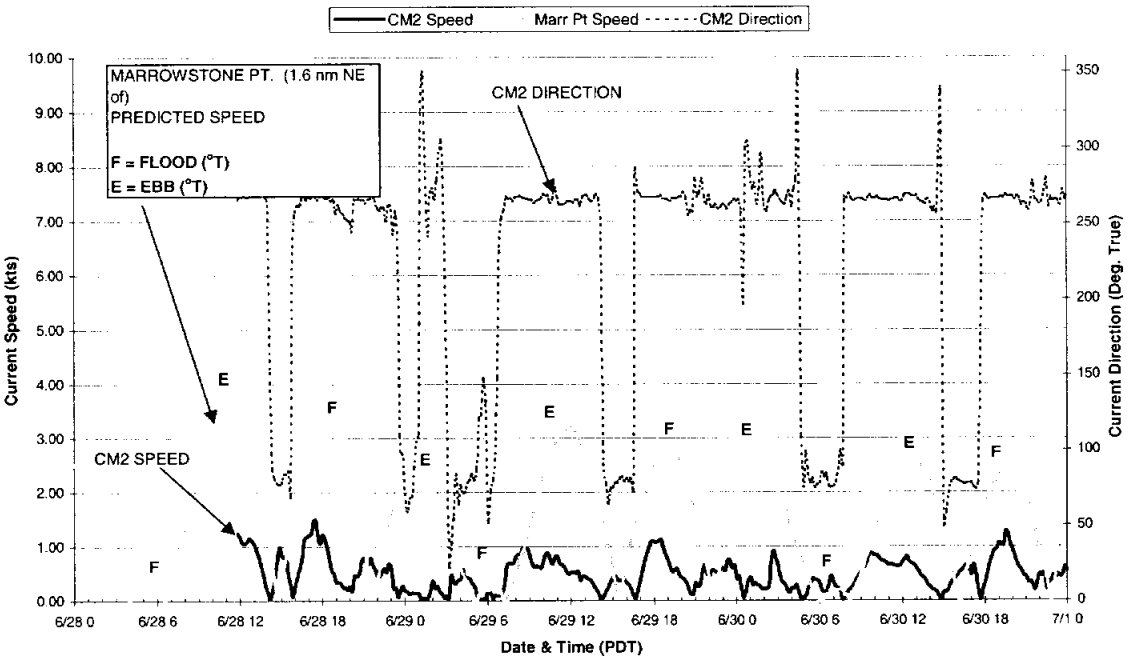


FIG. C-3
Observed currents at CM1
July 10-15, 2002.

KEYSTONE, WA: CM2 (28-30 JUNE 2002)



KEYSTONE, WA: CM2 (1-3 JULY 2002)

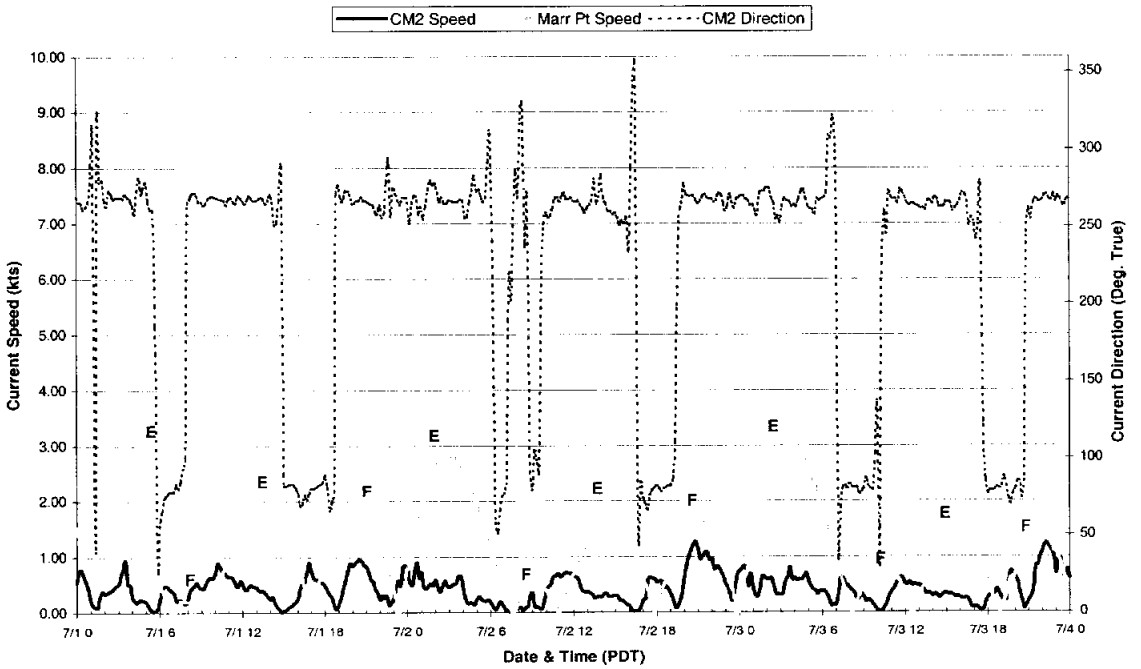
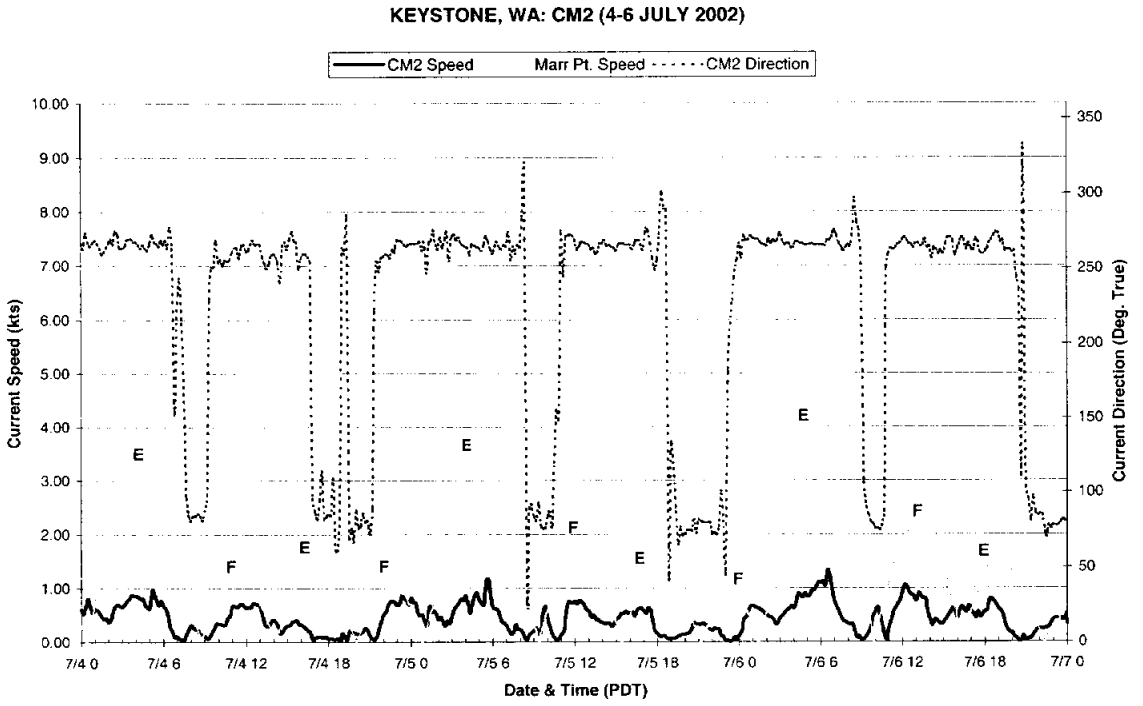


FIG. C-4
Observed currents at CM2
June 28-July 3, 2002.



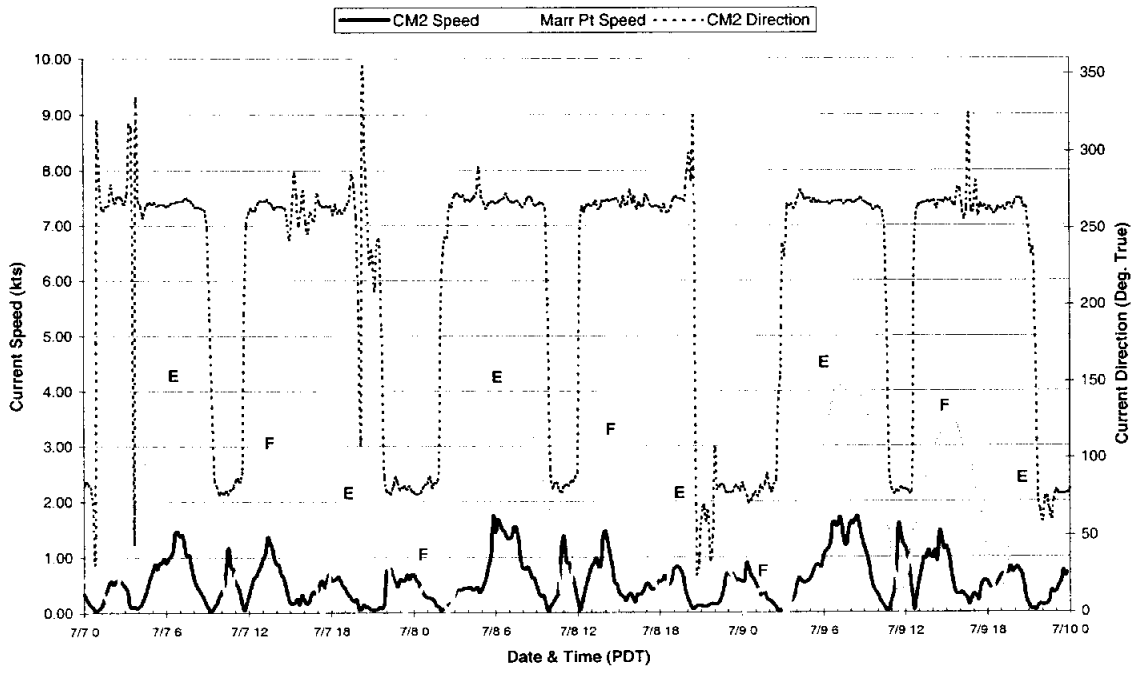
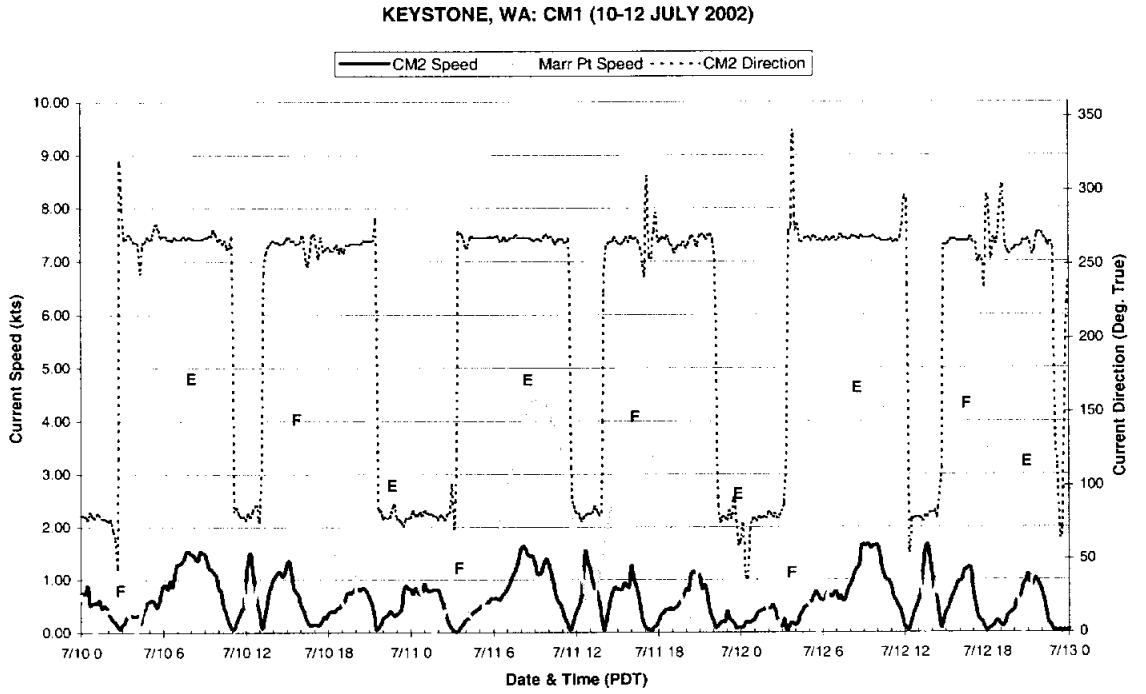


FIG. C-5
Observed currents at CM2
July 4-9, 2002.



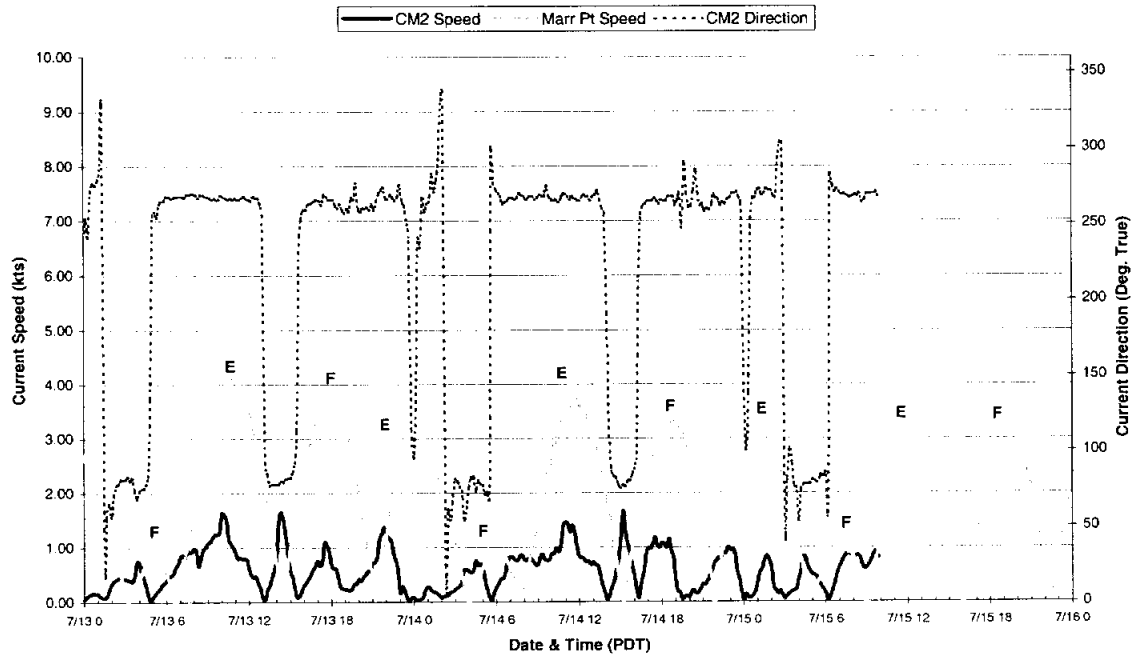


FIG. C-6
Observed currents at CM2
July 10-15, 2002.

Appendix C
Vessel Operability Analysis

WASHINGTON STATE FERRIES

KEYSTONE ALTERNATIVES STUDY

Vessel Operability Analysis

Prepared for

CH2M Hill
Bellevue, Washington

File No. 02078
31 October 2002

GLOSTEN
The Glosten Associates, Incorporated

Consulting Engineers Serving The Marine Community
600 Mutual Life Building • 605 First Avenue
Seattle Washington 98104-2224
Phone: (206) 624-7850 • Fax: (206) 682-9117
E-mail: email@glosten.com

WASHINGTON STATE FERRIES

KEYSTONE ALTERNATIVES STUDY

Vessel Operability Analysis

Prepared for

CH2M Hill
Bellevue, Washington

EXPIRES 5/16/ 2003

Benjamin B. Ackers, P.E.
Project Manager

Thomas Mathai, Ph.D.
Project Analyst

File No. 02078
31 October 2002

GLOSTEN
The Glosten Associates, Incorporated

Consulting Engineers Serving The Marine Community
600 Mutual Life Building • 605 First Avenue
Seattle Washington 98104-2224
Phone: (206) 624-7850 • Fax: (206) 682-9117
E-mail: email@glosten.com

TABLE OF CONTENTS

1. INTRODUCTION 2

2. SITE LAYOUT AND VESSEL DATA 2

3. DOCKSIDE OPERABILITY ANALYSIS 3

3.1 DEMAND 3
3.2 CAPABILITY 4
3.3 OPERABILITY 5

4. APPROACH AND DEPARTURE OPERABILITY ANALYSIS 5

4.1 DEMAND 6
4.2 CAPABILITY 6
4.3 OPERABILITY 9

5. RESULTS 9

6. CONCLUSIONS 10

REFERENCES

APPENDICES

A. WAVE-INDUCED SURGE FORCES AND BOW MOTIONS

B. CURRENT LOADS

C. WIND LOADS

D. STEADY WAVE FORCES

1. INTRODUCTION

In order to improve service reliability and vehicle capacity on Washington State Ferries' vehicle/passenger ferry service between Keystone and Port Townsend, the State is considering relocating the Keystone Terminal. This would also allow access by larger, more maneuverable vessels than those providing the current service into Keystone. The terminal is currently located in a sheltered inlet, not reliably accessible by vessels larger than the *Steel Electric Class*. To allow access by larger ferries without expanding access to the inlet, the terminal must be moved outside the inlet to Admiralty Bay.

Potential new terminal locations in Admiralty Bay are located in relatively unsheltered waters with high currents and exposure to rough sea conditions. Therefore, there is a need to understand how these environmental conditions will affect future operations, as well as a need to determine the terminal configuration least affected by environmental loads.

This study predicts vessel inoperability at two alternative site locations and three alternative dock orientations at each site. It accounts for the impact of motions due to waves while the vessel is offloading cars at the dock, and the impacts of current, wind, and waves on the vessels' capability to approach and depart from the dock.

2. SITE LAYOUT AND VESSEL DATA

The layout of the two proposed sites is shown in Figure 1, which also shows three possible dock orientations considered for each site. The climatology for the two sites has been developed and provided by CH2M Hill (Ref. 1).

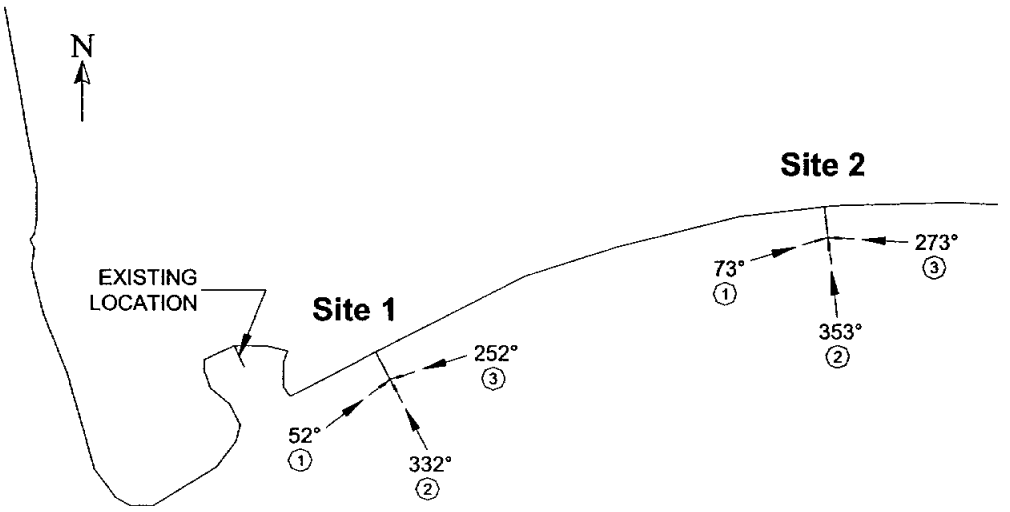


Figure 1. Site layout and vessel orientations

The *M/V Issaquah*, currently in service with Washington State Ferries, was used in this study as representative of the larger vessels that may use the proposed terminal. The principal parameters of the vessel are given in Table 1. The draft is selected as 14 feet for determining wind and wave effects. A 16 feet draft is selected for determining current effects. These choices are expected to yield conservative estimates of environmental loads.

Table 1. Principal Parameters of *M/V Issaquah*

Length, extreme	328.5 ft
Length on DLWL	317.5 ft
Breadth, extreme	78.7 ft
Breadth, MLD. @ 15.5 ft WL	63.2 ft
Depth, MLD. to passenger deck	41.8 ft
Draft @ DLWL	15.5 ft
Service Speed	16 knots

3. DOCKSIDE OPERABILITY ANALYSIS

As mentioned in Section 1, the operability analysis is divided into two areas. One is the dockside loading/unloading operability which is affected by the oscillatory motions and forces induced by waves. The other is the approach and departure operability which is governed by the capability of the vessel to keep station, subject to the steady forces of currents, winds and waves. In each case, the study uses a demand versus capability formulation. Demand is defined as the load or motion induced by the environment. Capability is the maximum load or motion that the vessel is capable of withstanding without adversely affecting normal operations. The demand capability pair is determined for each combination of environmental parameters with a non-zero probability of occurrence. Probabilities for which demand exceeds capability are then summed to get the total percentage of time that the vessel is inoperable. Details of this procedure for dockside operability are given in this section. The approach and departure operability is addressed in Section 4.

3.1 Demand

The demands under dockside operability are the vertical motion at the bow (at the point at which the vehicle ramp rests on the vehicle deck) and the longitudinal thrust required to hold the vessel against the dock. Both are assessed through a numerical model of the vessel-wave interaction problem. A linear radiation-diffraction panel program called WAMIT (Ref. 2) is used for this purpose. A panel representation of the underwater geometry corresponding to a 14 ft draft is developed for input to WAMIT (see Fig. 2). The vessel is allowed to oscillate freely in all six degrees of freedom

except for surge motion at the bow which is fully restrained. The response amplitude operators (RAOs) for the heave displacement at the bow and the longitudinal force to prevent surge are computed for a range of relative wave headings. They are then suitably integrated over a Bretschneider spectrum with a cosine-squared spreading function to determine their appropriate statistical measures in short-crested seas. The last step is repeated for every significant wave height and modal period combination with a non-zero probability of occurrence appearing in Reference 1.

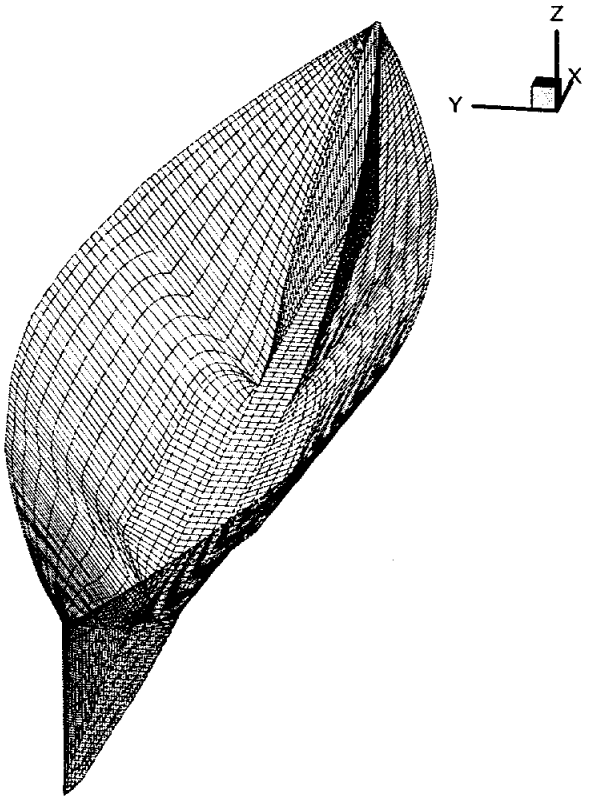


Fig. 2. Panel representation of wetted surface

The demand is represented separately for bow motion and surge force by appropriate statistical measures. For bow motion, this statistical measure is the significant amplitude of vertical displacement. The significant amplitude, in theory, corresponds to the average of the highest 1/3rd amplitudes and, in practice, is found to correlate well with the value reported by an observer. For surge force, the selected statistical level is the maximum in a 15 minute operation with only a 10% probability of being exceeded. Demand plots for different wave conditions are given in Appendix A.

3.2 Capability

The capability is defined separately for bow motion and surge force. For bow motion, the capability is defined as the maximum heave displacement the vessel can take without impeding normal loading/unloading operations. This value is taken to be 0.5 ft based on anecdotal evidence from vessel operators, terminal engineers and the

ramp designer. For surge force, the capability is defined as the longitudinal thrust that the vessel is capable of applying at all times while loading/unloading in order to hold itself against the dock. This value is taken to be 50 kips, corresponding to 70% of the maximum available thrust. These capabilities are superposed on the demand curves of Appendix A.

3.3 Operability

Based on the demands and capabilities developed in 3.1 and 3.2, and using the probability of occurrence of the significant wave height-modal period combinations in Ref. 1, the total percentage of time that the vessel is inoperable is determined. This is shown in the first row of Table 1 for each of three orientations at both Site 1 and Site 2. The rest of the rows in the table show similar results over a range of operability thresholds and serve to illustrate the sensitivity of the results to the choice of capability. It can be seen from Table 2 that the operability is more sensitive to variations in the allowable heave displacement than it is to variations in the longitudinal thrust.

Table 2. Dockside operability

Heave limit, ft	Longitudinal Thrust limit, kip	Percentage of time **IN-OPERABLE**					
		Site 1, Orient 1	Site 1, Orient 2	Site 1, Orient 3	Site 2, Orient 1	Site 2, Orient 2	Site 2, Orient 3
0.5	**50**	**1.01%**	**0.34%**	**1.01%**	**0.99%**	**0.17%**	**0.99%**
1.0	50	0.34	0.01	0.34	0.33	0.01	0.27
1.5	50	0.13	0	0.25	0.08	0	0.15
2.0	50	0.01	0	0.01	0.01	0	0.01
1.0	25	0.34	0.06	0.34	0.33	0.01	0.27
1.0	50	0.34	0.01	0.34	0.33	0.01	0.27
1.0	75	0.34	0.01	0.34	0.33	0.01	0.27
1.0	100	0.34	0.01	0.34	0.33	0.01	0.27

4. APPROACH AND DEPARTURE OPERABILITY ANALYSIS

The approach and departure operability is based on the capability of the vessel to withstand the steady environmental loads and still maneuver ahead or astern at slow speed.

4.1 Demand

The demands under approach and departure operability include the steady current loads, wind loads and wave drift forces.

The current loads and moments are determined based on Tsinker (Ref. 3) for a 16 ft draft condition. Sample plots are shown in Figures B1 to B3 of Appendix B. It is to be noted that separate site-specific probabilities (see Ref. 1) are used for current speeds and directions.

Wind loads and moments are determined based on the longitudinal and lateral windage areas for a 14 ft draft condition. The procedure follows Martin (Ref. 4). Sample results are shown in Appendix C.

Wave drift forces and moments in regular waves are available from the solution to the vessel-wave interaction problem in Section 3. By integrating these over a Bretschneider spectrum, the steady loads in long-crested seas are obtained. Plots of steady wave loads are shown in Appendix D.

4.2 Capability

The capability of the vessel to withstand steady forces and moments are developed from the propeller and rudder characteristics. It is described in the form of a closed surface in 3-dimensional space with the longitudinal thrust, transverse thrust and moment measured along the x, y and z axes respectively. Plan and elevation views of this capability envelope are shown in Figures 3a and 3b, respectively. A complete set of horizontal slices through this capability envelope used in the analysis is given in Figure 4.

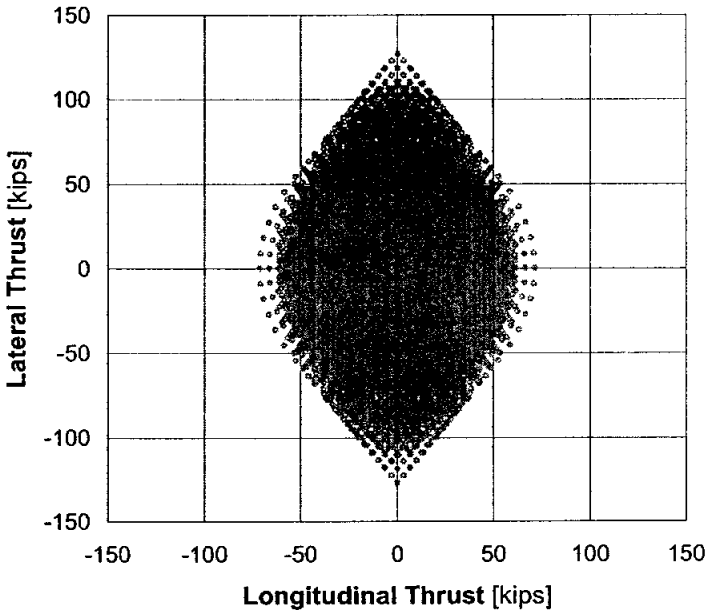


Figure 3a. Capability envelope viewed in the direction of the moment axis

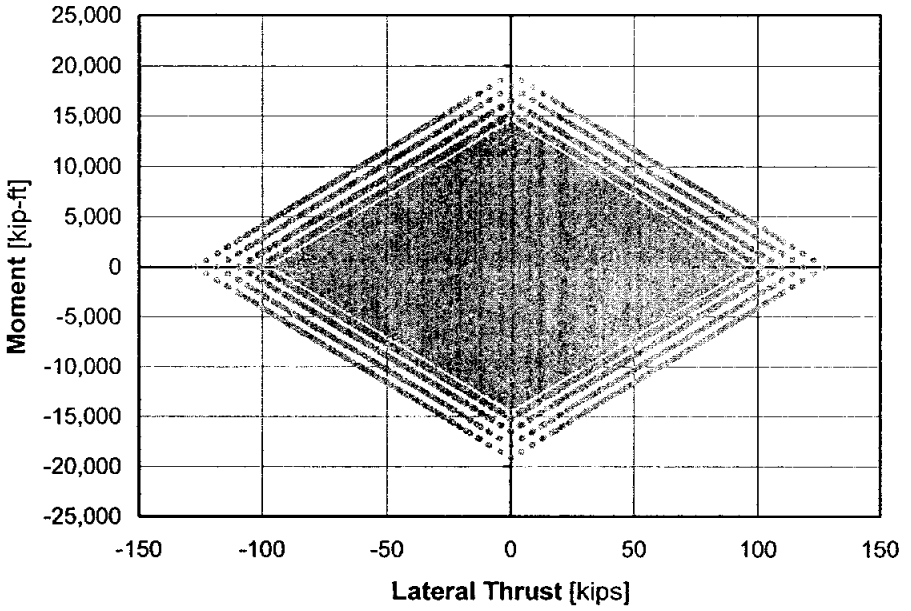
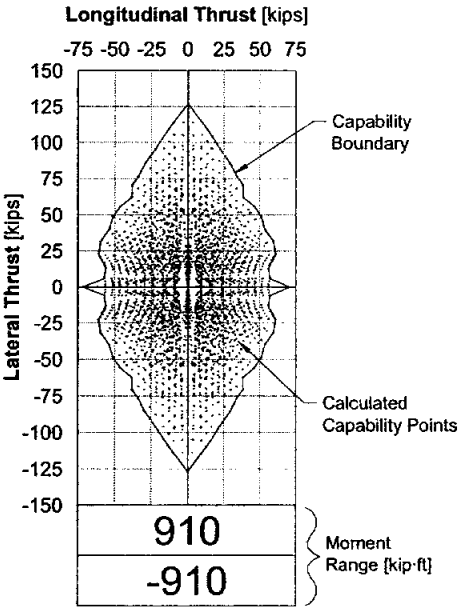


Figure 3b. Capability envelope viewed in the direction of the longitudinal thrust axis



Key to Figure 4. Horizontal slices through the capability envelope
(figure follows on next page)

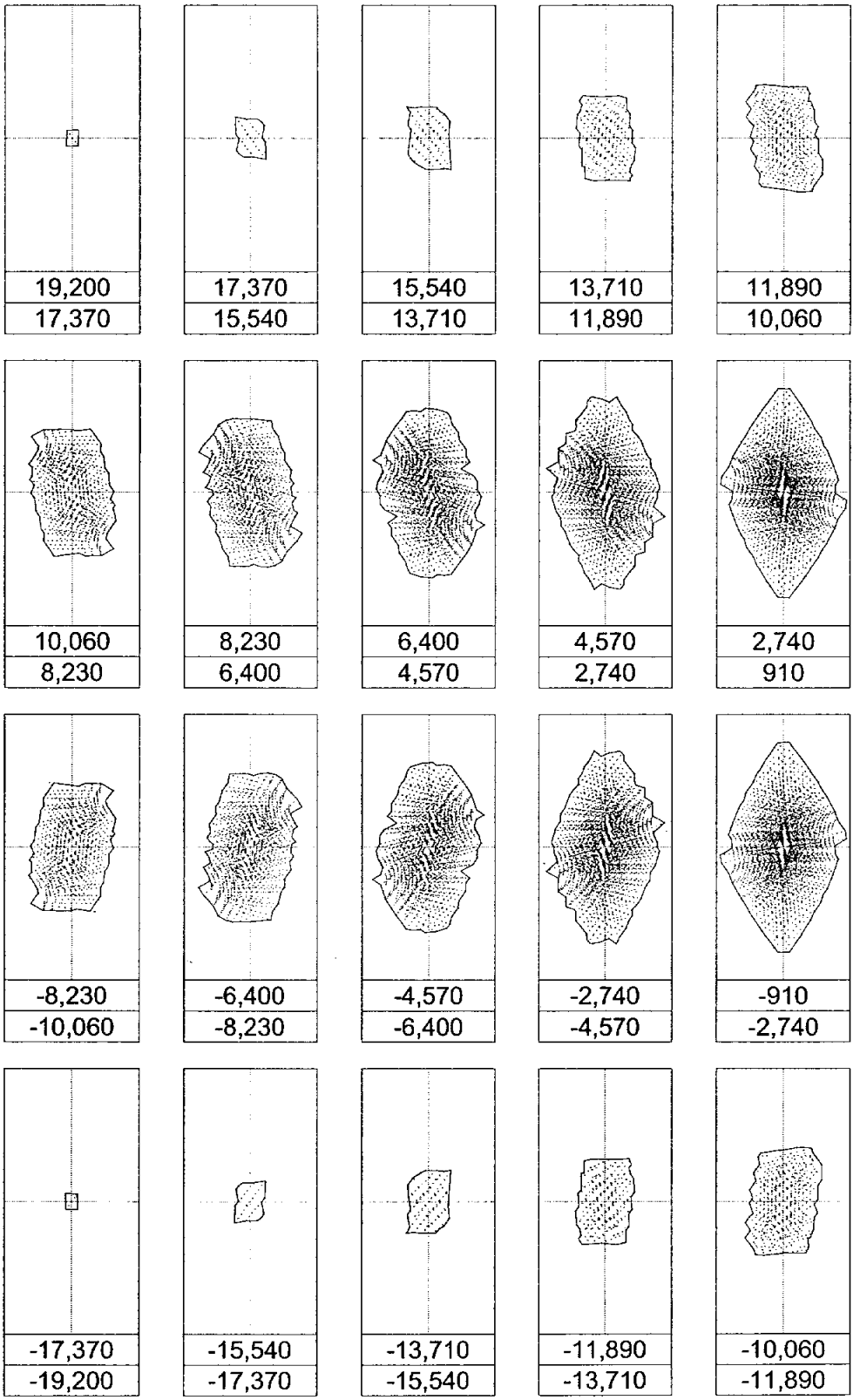


Figure 4. Horizontal slices through the capability envelope

4.3 Operability

The demands developed in Section 4.1 are augmented by a small reserve ahead/astern thrust of 13.5 kips to provide some additional maneuvering ahead/astern capability. Using these demands along with the capabilities from Section 4.2, and the probability of occurrence of currents and winds from Reference 1, the total percentage of time that the vessel is in-operable is determined. The results are shown in Table 3 for each of three orientations at both Site 1 and Site 2.

Table 3. Approach and departure operability

Percentage of time **INOPERABLE**					
Site 1, Orient 1	Site 1, Orient 2	Site 1, Orient 3	Site 2, Orient 1	Site 2, Orient 2	Site 2, Orient 3
0.04%	2.34%	0.01%	0.01%	0.30%	0.00%

5. RESULTS

Figure 5 presents the results of the annual inoperability analysis for each site and dock orientation. For each configuration three values are listed. The first, *inoperability due to waves*, refers to the dockside motions analysis and the ability to offload vehicles in the prevailing wave conditions. The second, *inoperability due to wind and current*, refers to the ability to successfully approach and depart the dock in the prevailing conditions, accounting for current, wind, and wave drift loads. The third operability value is the combined annual inoperability: the combination of the dockside operability, and the approach and departure operability, conservatively assuming that the two sets of environmental conditions are statistically uncorrelated.

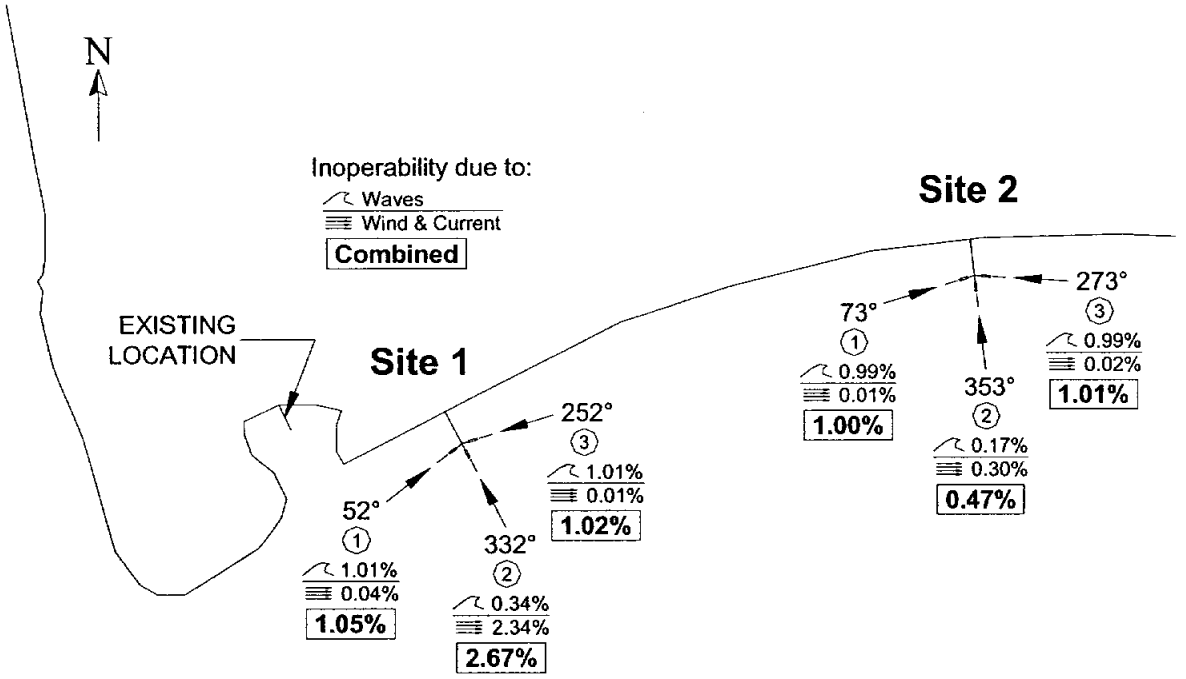


Figure 5. Inoperability Results

6. CONCLUSIONS

The inoperability analysis results indicate the following:

- Dockside operability, which is governed by prevailing wave conditions, is superior for dock Orientation 2. This results from the fact that the parallel orientations (1 and 3) generally expose the vessel to beam seas, which, for the site's wave characteristics, result in greater vessel motions than do the following seas seen in Orientation 2.

- Approach and departure operability, which is primarily governed by current loads, is superior for Orientations 1 and 3. This results from the fact that the current generally runs parallel to shore, making it easier to overcome when running directly into or against it than when running perpendicular to it, as is the case for Orientation 2.

- Site 2 has better operability than Site 1. Wind and wave operability is slightly better at Site 2. But, approach and departure operability is much better at Site 2, due to the lower current velocities at the western site.

- Site 2, Orientation 2, has the overall best operability of all alternatives studied in this analysis.

REFERENCES

1. Keystone (Washington) Ferry Terminal Feasibility Study: Winds, Waves and Currents, Ken Lilly, Jr., CH2M Hill, 27 August 2002.

2. WAMIT User Manual, Version 6.03, WAMIT, Inc.

3. Tsinker, G.P., Marine Structures Engineering, Chapman and Hall. New York, 1995.

4. Martin, L.L., "Ship Maneuvering and Control in Wind", SNAME Transactions, Vol. 88, 1980, pp. 257-281.

Appendix A

Wave induced surge forces and bow motions

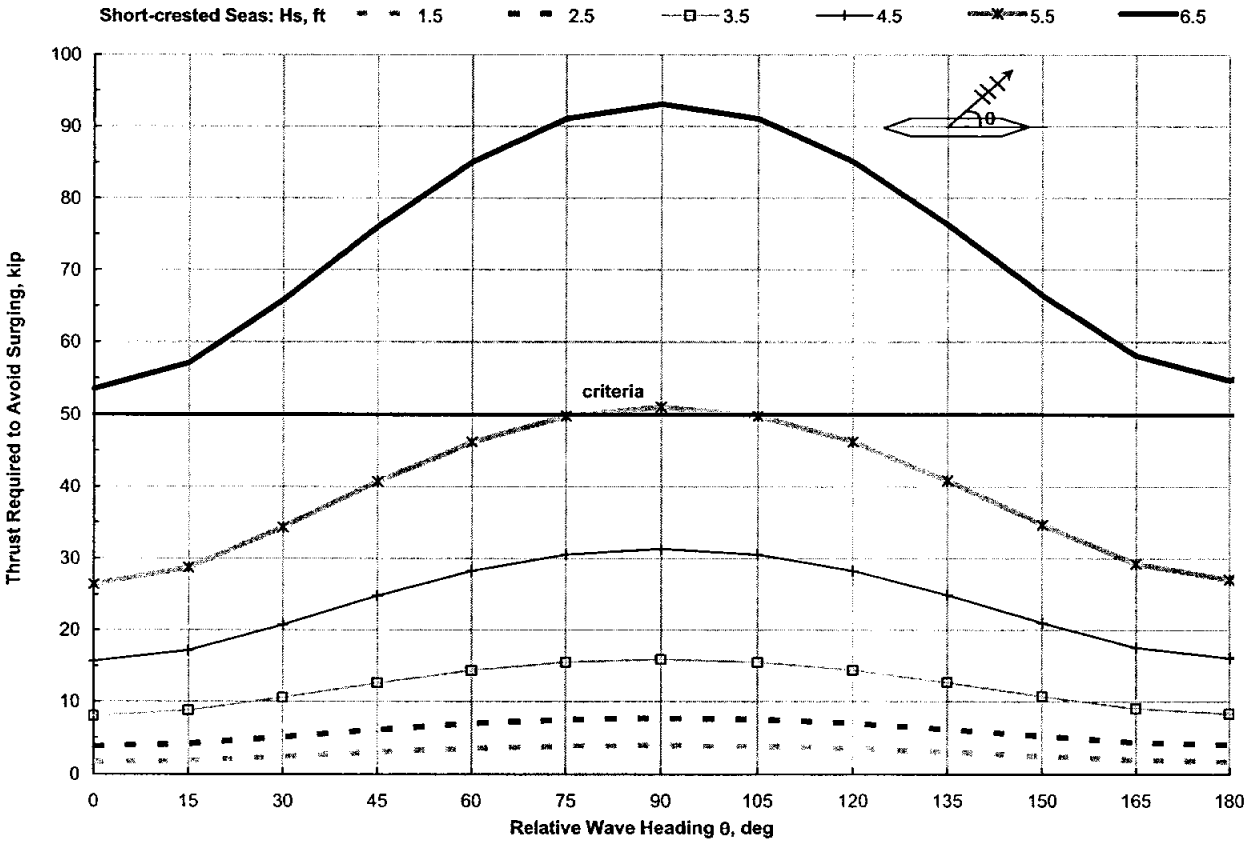


Fig. A1 Thrust to prevent surge in incident waves

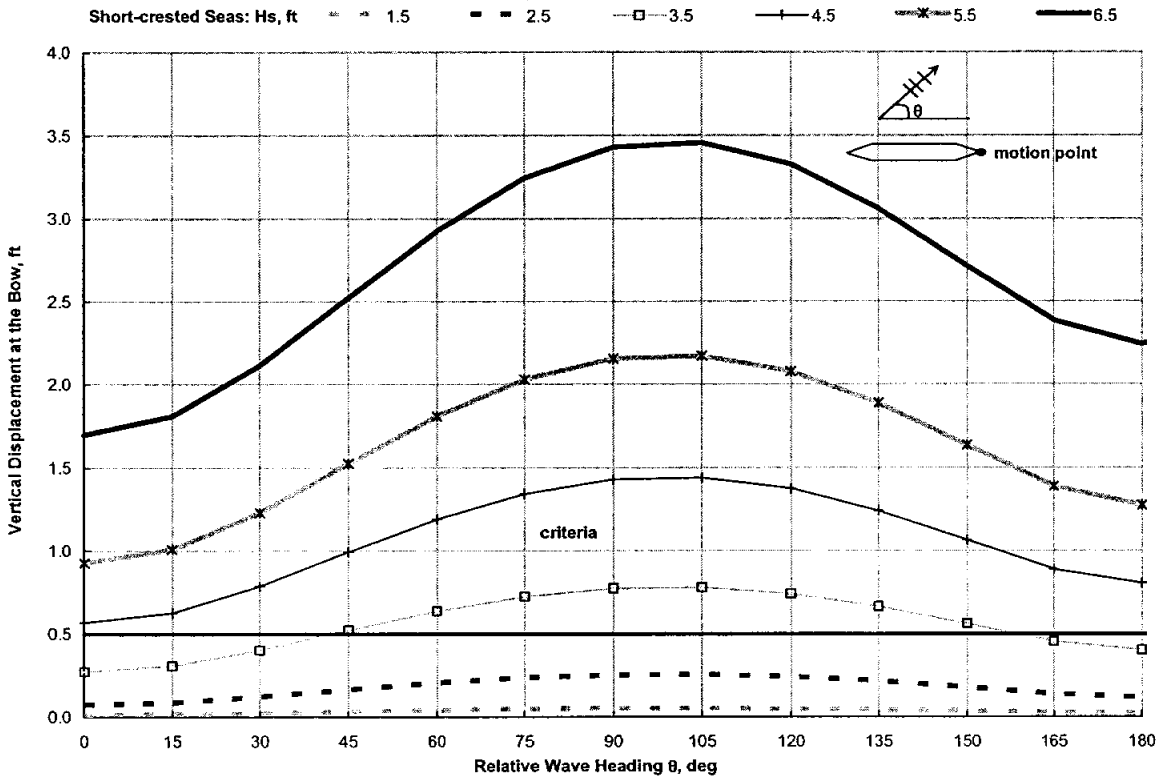


Fig. A2 Vertical displacement at the bow in incident waves

Appendix B
Current loads

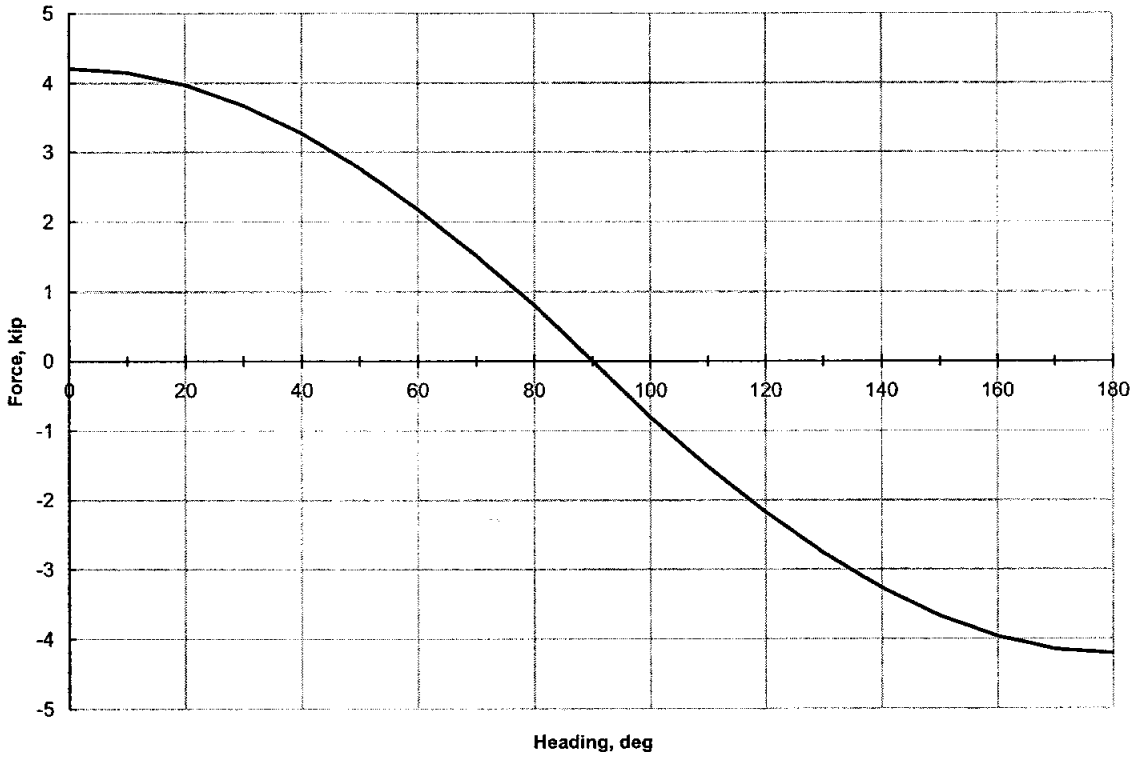


Fig. B1 Longitudinal force due to a 4 knot current

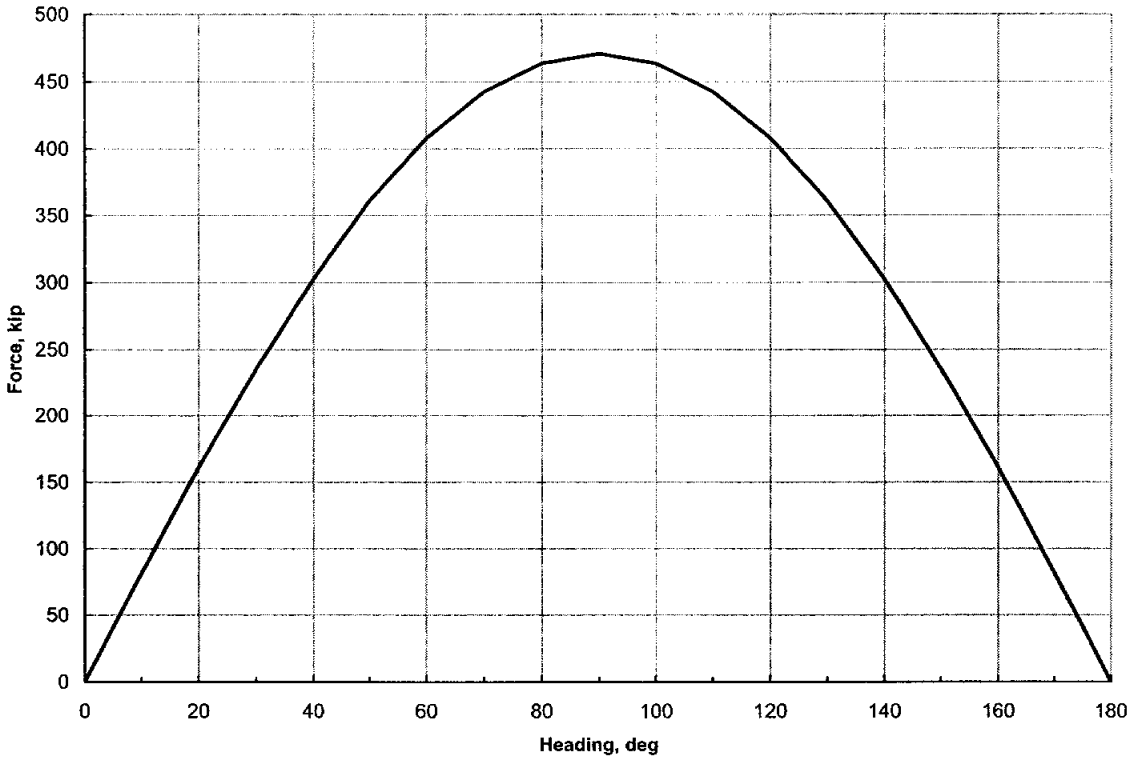


Fig. B2 Lateral force due to a 4 knot current

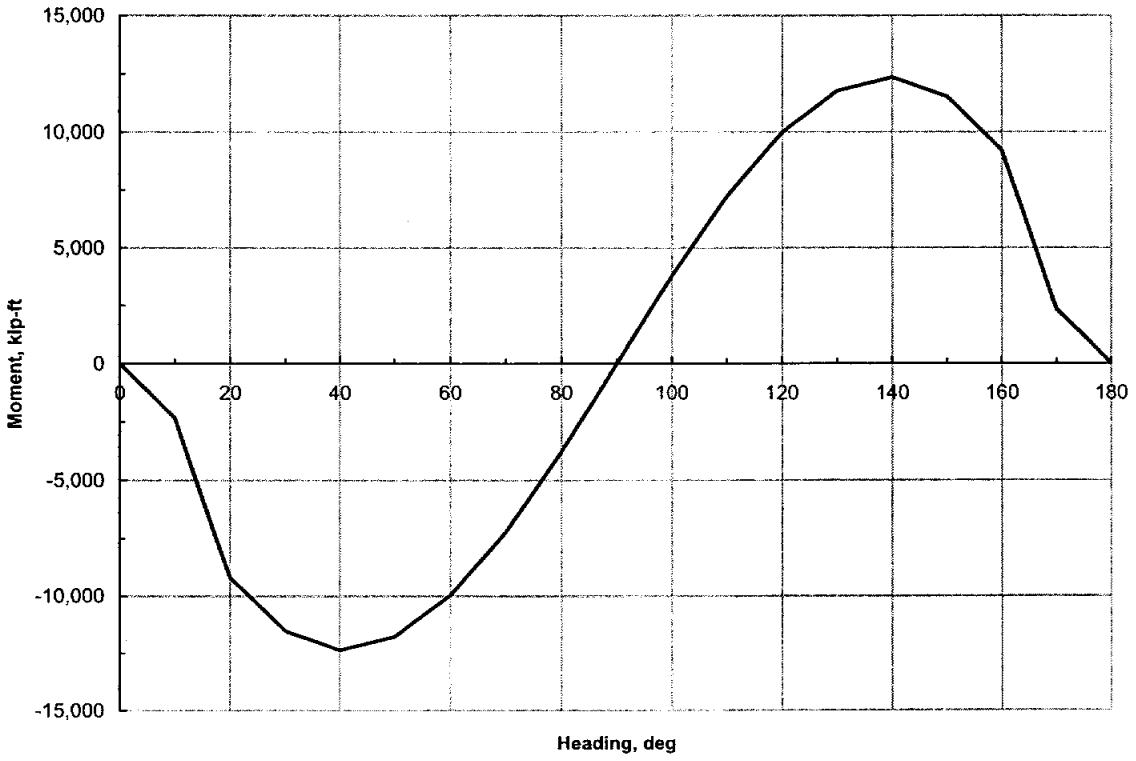


Fig. B3 Moment due to a 4 knot current

Appendix C

Wind loads

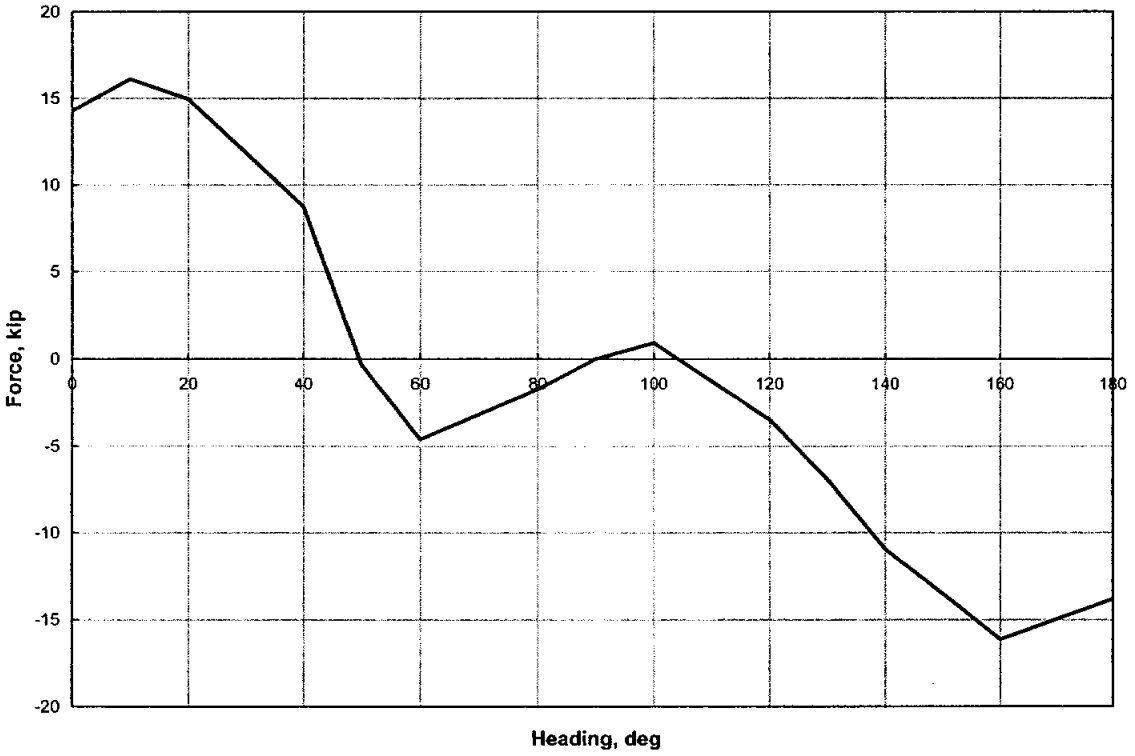


Fig. C1 Longitudinal load due to a 45 knot wind

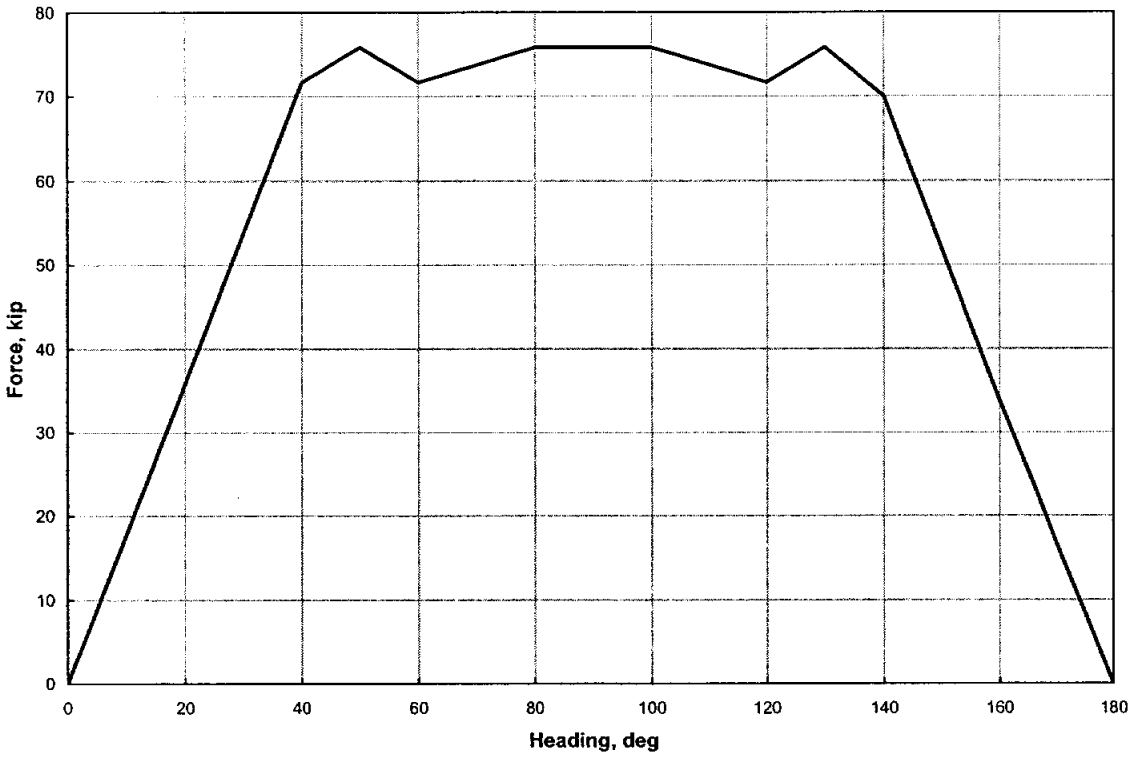


Fig. C2 Lateral load due to a 45 knot wind

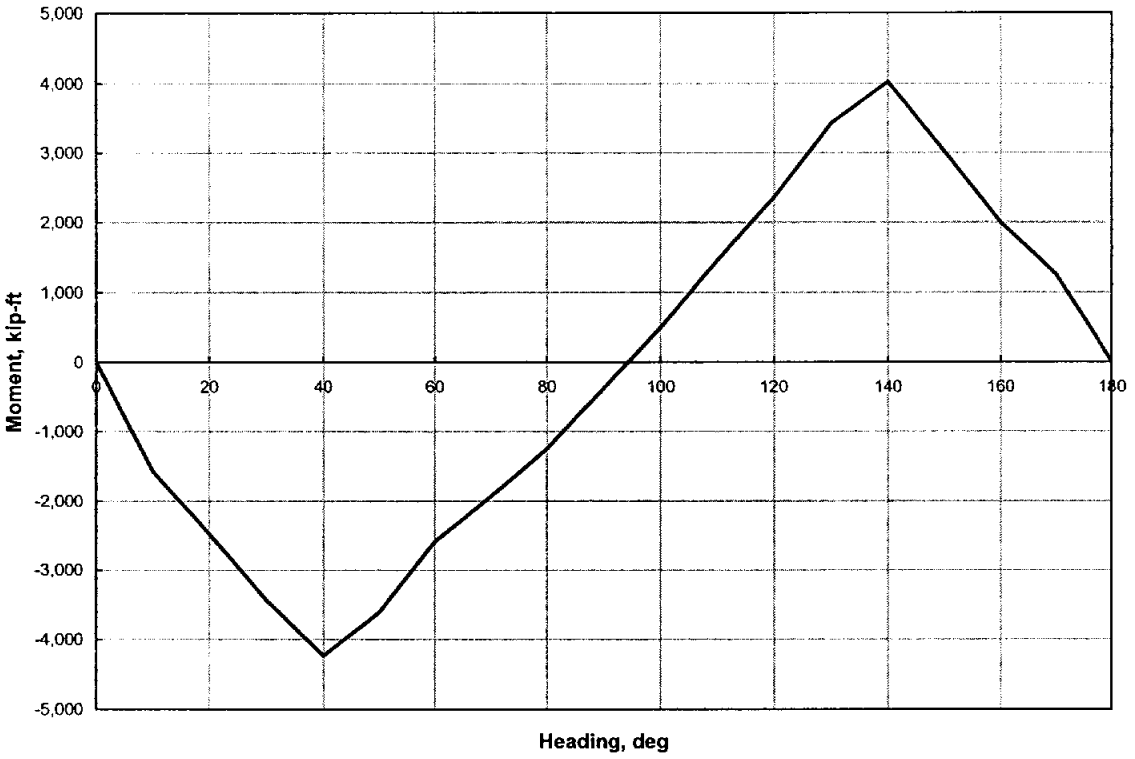


Fig. C3 Moment due to a 45 knot wind

Appendix D

Steady wave forces

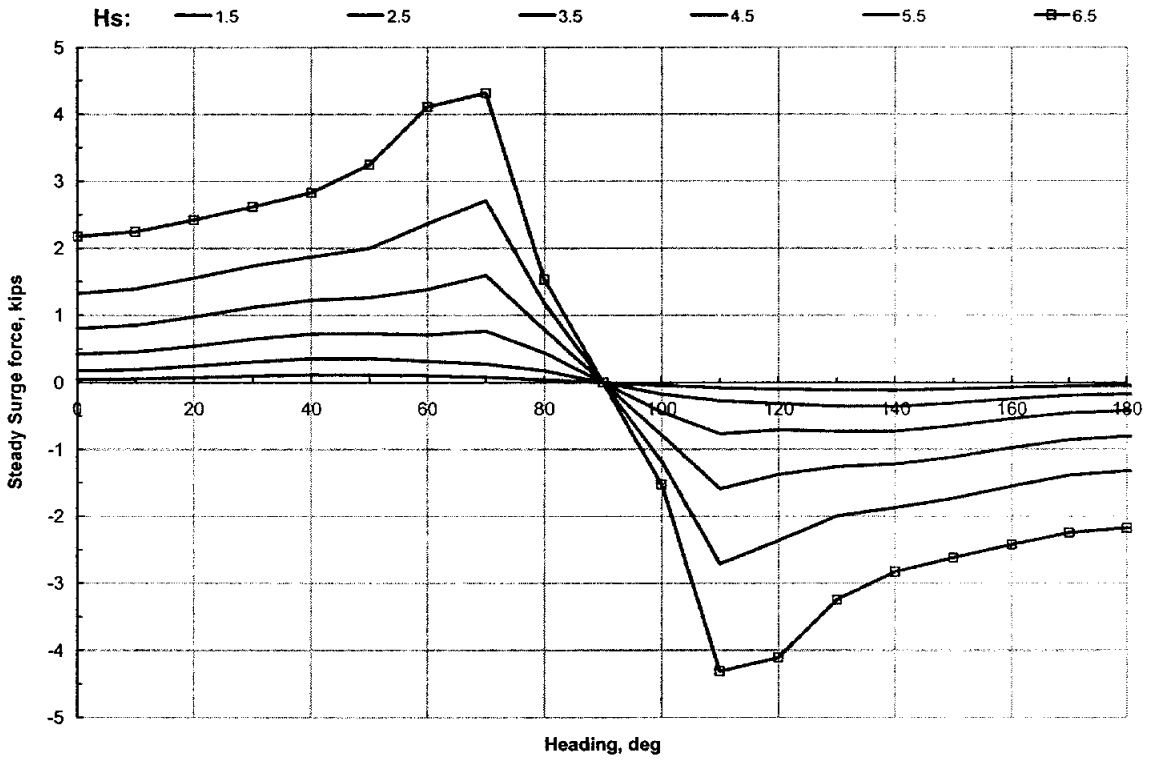


Fig. D1 Steady surge force due to incident waves

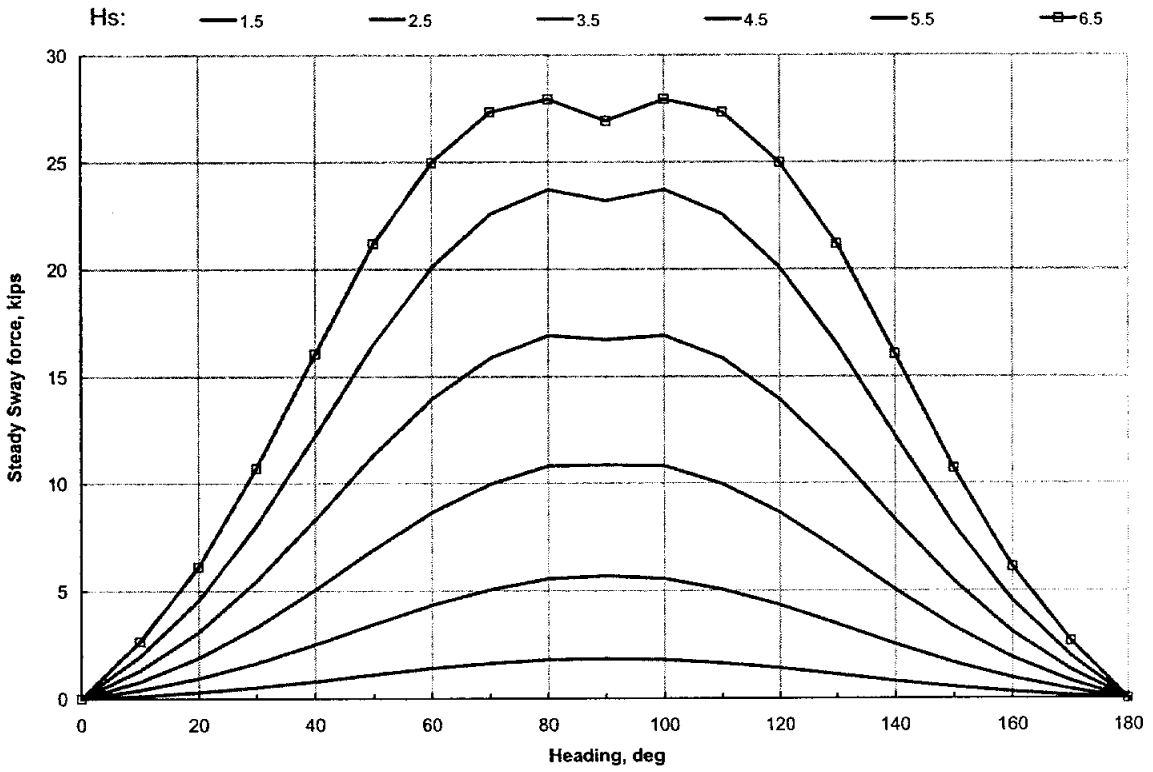


Fig. D2 Steady sway force due to incident waves

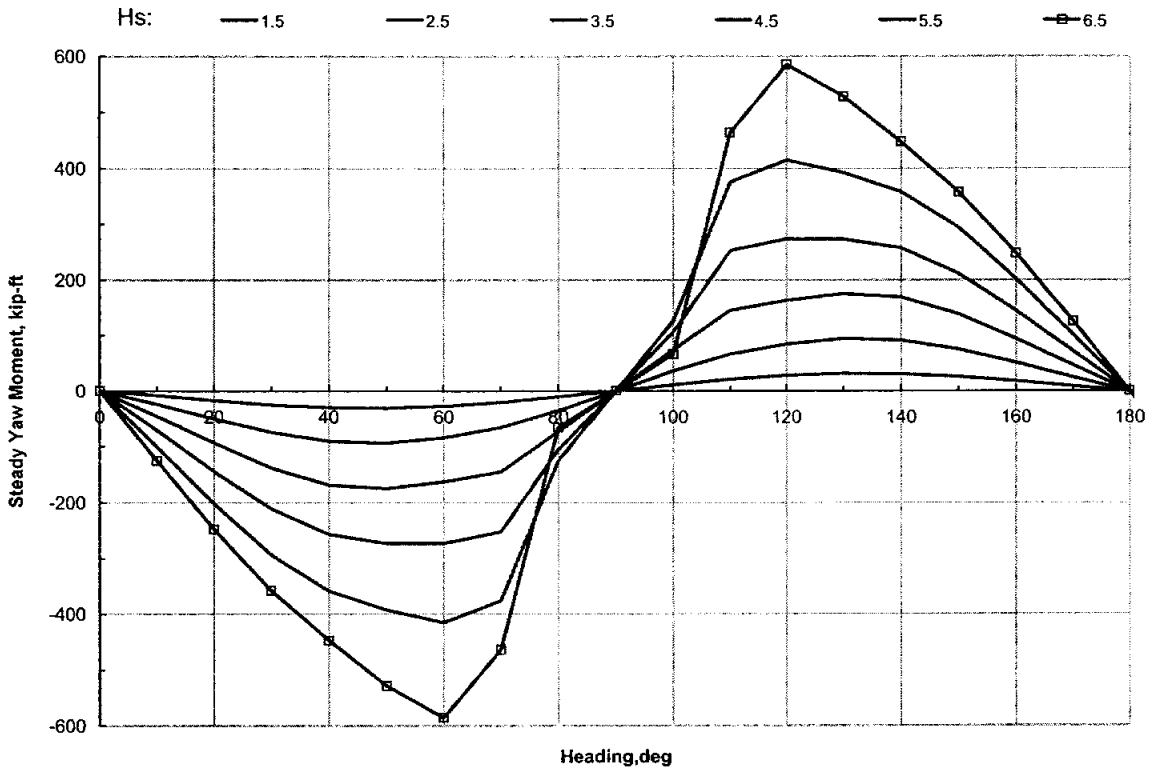


Fig. D3 Steady yaw moment due to incident waves

Appendix D
Offshore Geology

Keystone Ferry

Results of
Sub-Bottom Profile & Shallow Seismic
Survey

Prepared for:

Doug Playter
CH2M Hill
777 108th Avenue
Bellevue, WA 9898009-2050
425.233.3518

Submitted by:

Richard F. Graham
Geophysicist
Williamson & Associates
4200 23rd Ave. West
Seattle, WA 98199
206.285.8273

Summary

Williamson and Associates, Inc. is pleased to present the results of the geophysical investigation conducted October 23 and 24 for the Keystone Ferry project. The field data are for an approximate 1000-foot by 8000-foot area lying adjacent to and immediately to the east of Admiralty Head, Whidbey Island, Washington. The geophysical data consist of simultaneous acquired shallow seismic, sub bottom profiler and differential GPS positioning data.

Personnel

• Richard Graham	Geophysicist	Williamson & Associates
• Peter Jepsen	Navigator	Jepsen Technical Services
• Jim Muesey	Boat Operator	Evans Hamilton

Equipment

• *R/V Reflux*	25-foot Survey Vessel
• Honda Generator	2.5kW Electrical Generator
• Datasonics Bubble Pulser	400Hz Shallow Seismic Profiling System
• Datasonics SBP 1200	3.5kHz Sub Bottom Profiling System
• ISIS Sonar Processor	Sonar Data Acquisition & Processing
• EPC 1086	Thermal Graphic Recorder
• FieldWorks Laptop PC	Navigation Computer
• HyPack Max	Navigation Data Acquisition & Processing
• Trimble Ag132 dGPS	Differential Global Positioning System

Survey System

The *R/V Reflux*, a 25-foot converted gill-netter, is owned and operated by Evans-Hamilton Inc. of Seattle, WA. The *Reflux* powered by twin inboard outboard motors is highly maneuverable and features a large open fore deck and numerous modifications making it an ideal as a near-shore survey platform. System power to run all survey computers and electronics was supplied by a 2.5kW Honda generator.

The Datasonics 1200 sub-bottom profiler system, configured with a pair of Massa 3.5kHz transducers, was deployed from a pivoting overboarding pole on the port side amidships. Lines, fore and aft, secured the unit to the vessel and limited its movement in the water. The transducer face was 2 feet below the water surface.

The bubble pulser source, mounted on a 'surf board' arrangement, was towed starboard near the stern. The receiving array, an 8-foot single-channel, multi-element streamer, was towed starboard and forward of the acoustic source. The leading edge of the array was attached to a down rigging pole and the tail was supported by a small float; this arrangement held the array outside the bow wake and just below the water surface. The separation between the source transducer to the center of the array was 10 feet—the correction for the array-transducer separation is negligible at the working depths encountered.

The dGPS antenna was mounted to the roof of the wheelhouse along the centerline of the boat. This arrangement placed the placed the antenna three foot aft of both the 3.5kHz transducer and the acoustic center of the bubble pulser system. No navigation correction was applied to these offsets.

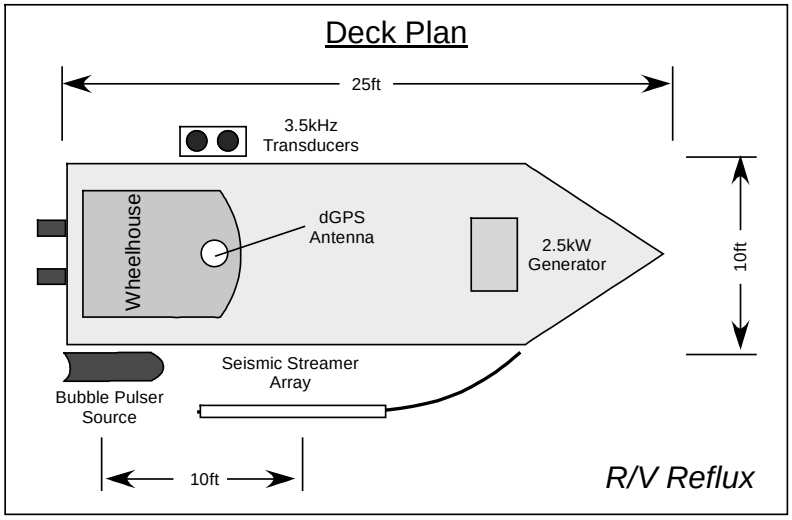


Figure 1. R/V Reflux Deck Plan.

Activities

The survey team arrived at the Admiralty Head State Park boat launch at 0745hr on the morning of October 23, 2002. Heavy fog blanketed the coast causing the Washington State Ferry system to suspend operations between Keystone and Pt. Townsend. The *R/V Reflux* was launched and survey mobilization immediately commenced; the geophysical and navigational hardware were installed, integrated, tuned and collecting test data by approximately 1300hr.

The fog had abated somewhat but visibility was still marginal (~500ft) as survey operations commenced. A minor error was soon apparent, the AutoCAD digital site map intended to serve as the background map for the HyPack navigation system, and to which the intended survey plan had been overlain, was discovered to contain negative grid values. HyPack could read the file but the locality plotted incorrectly. In an effort to provide orientation in the limited visibility environment, a survey line, parallel to the beach, was run at about 10ft depth contour. New survey lines were then charted using this line as a reference.

Shortly after completing the beach line, the fog returned reducing visibility to ~200ft. Compounding matters, a strong long-shore current was encountered a few hundred feet from shore making boat handling difficult. Four survey lines were successfully run though the trackline quality was marginal; and a fifth survey line was abandoned after five unsuccessful attempts. Survey operations were suspended at 1600hr due to the combined effects of fog, currents and gathering dark. The boat was partially de-mobilized, loaded on to the trailer while the survey crew stood down to spend the night in Coupeville.

Heavy fog the morning of October 24, had again reduced visibility to ~100ft. Prior to launching the boat, the navigation system was re-mobilized and ~8 minutes navigation data were collected as the boat was trailered west on Highway 20 for approximately 1 mile. These data were later analyzed and are found to be in very good agreement to the survey data provided in the AutoCAD drawings. The *R/V Reflux* was launched at 1000hr, fully remobilized and standing by for survey 1130hr. By 1200hr the fog had lifted to a point where operations could resume.

Currents again made boat handling difficult; however, at least until ~1500hr visibility was sufficient to keep reference landmarks in sight as the boat navigated into the current. Working from west to east, twenty-nine new data lines were shot including re-shooting the four lines from the previous day. Boat handling was considerably better with only four of the new data lines requiring re-shot.

The 'tie' line was last line in the sequence, and at its start, visibility had again decreased to ~100ft. Navigation was considerable aided by the ship's radar, which, despite the absence of navigable landmarks, permitted the boat to maintain a specified distance from shore. However, while maneuvering onto the second 'tie' line, the *R/V Reflux,* encountered boat traffic at a distance, which we considered too close for the weather conditions and survey operations were ceased without running the remaining two tie lines.

Data Collection

In total, twenty-nine ~1000-foot long survey lines, oriented normal to the 8000 feet of shoreline were collected--average line spacing was 300 feet. Survey speed was nominally 3 knots. All data reported herein were collected between 1200hr and 1630hr on October 24. One 'tie' line was also collected during this time. During this interval, the tide rose from 5.7ft to 6.8ft above MLLW (Figure 2).

For each line, two channels of high-resolution data were collected with both sources operating concurrently and timed from a single sync pulse. Initially, the data were collected at ping rate of 0.125s and a sampling rate of 2048 samples per ping, however, early on, it was noted that the bubble pulser was occasionally unable to maintain this cycle rate—likely the result of the transmitter capacitors being slightly underpowered by the deck generator. To avoid data dropouts, the ping rate was reduced to 0.250s and the sample rate increased to 4096 samples per ping. The net effect is that the vertical sample density remains the same, the duration of the record is twice as long, while the horizontal sample rate decreases by a factor of two (for any give survey speed). Nonetheless, the survey lines were typically ~1100ft long and the files contained ~900-1050 pings—approaching one ping per foot along track.

The acoustic data were collected digitally using an ISIS sonar data acquisition system and stored in the native ISIS .XTF format. An XTF file consists of a series of records, one for each ping, with each ping having its own header. In addition to tracking various system variables, the XTF header can accommodate navigation information.

During Keystone operations, real-time navigation data were provided by a Trimble Ag-132 dGPS unit with the data being collected and logged by the HyPack Max system.

Raw navigation data were fed from HyPack and stored in ISIS files as: GPS time, latitude and longitude. The ISIS data are standalone, however, a corresponding raw navigation file, containing more fully detailed information to aid in navigation diagnostics and post processing, are recorded by HyPack.

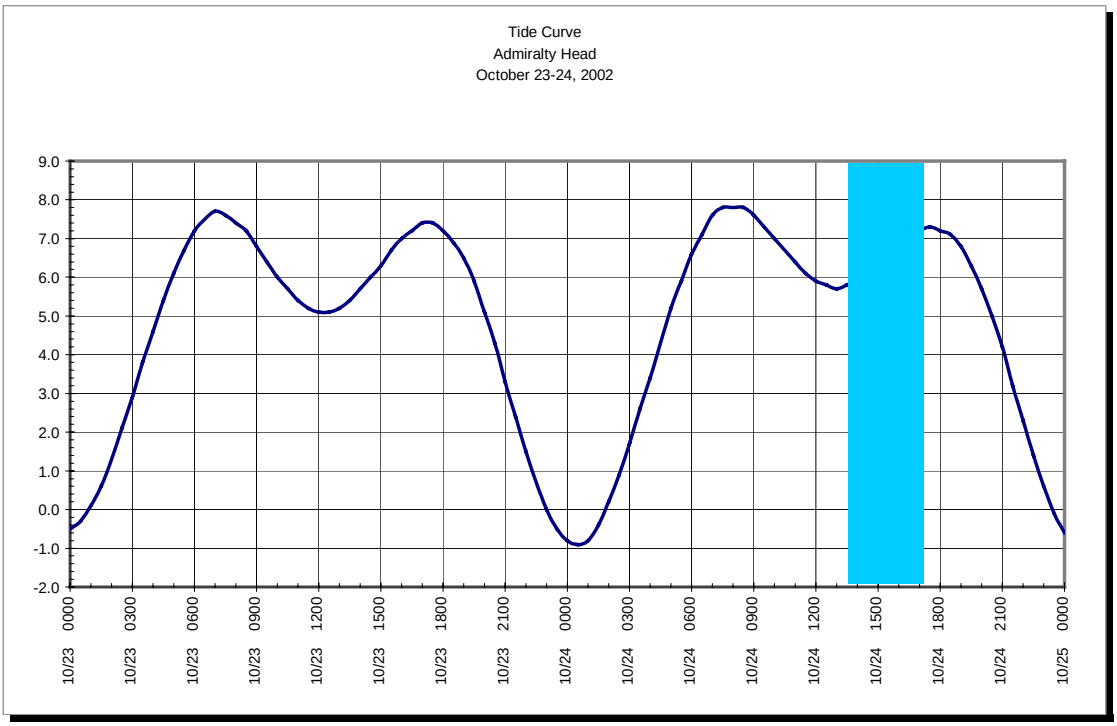


Figure 2 Tide curve for Admiralty Head, Whidbey Island. Shaded region is the interval in which the survey was conducted**.**

Geophysical Interpretation

Overall, the geophysical data quality is quite good; with the fog curtailing boating activity and with almost no wind to generate waves, the water proved to be acoustically very quite, and the effects of boat heave and roll were insignificant on the record. Likewise, the navigation data were very high quality; dGPS lock with the correction beacon was maintained throughout the survey operations. Minimal post-processing of the navigation data was required; the raw navigation data were converted to local grid coordinates (NAD 83, Washington State Plane, US survey Foot) and vertically tide-corrected to MLLW using the tide curve in Figure 2.

The 3.5kHz source achieved of ~15-20m of acoustic penetration and the bubble pulser (~400Hz) often exceeded 50m**.** Over the depth interval where they overlapped, the complementary data that these two sources provided significantly aided in the geophysical interpretation.

The bathymetric information was obtained tacking the first return in the 3.5kHz record using the automatic bottom-tracking feature of ISIS. The 3.5kHz data provided consistent bathymetry when compared to the bathymetric data supplied by Washington

Ferry System. The sub-bottom information was tracked manually using ISIS's sub-bottom picking utility.

This report informally recognizes two seismo-stratigraphic units, an upper and a lower unit. The upper unit is characterized by numerous sub-parallel, shallowly south-dipping reflectors. This unit is clearly stratified on the 400Hz record and is reflective but poorly stratified on the 3.5kHz record suggesting that is likely composed of coarse sands and gravels with inter-bedded muds. In the survey region, the base of the unit occurs between 90–115 feet below MLLW. The lower unit is reflective almost completely unstratified and is at least 25 feet thick suggesting that the material is a glacial till. Intermittently, the base of the lower unit can be seen on the record, and the material below has a similar acoustic character as the upper unit.

The present sea floor is an unconformity that clearly truncates the upper unit's sub-horizontal reflectors. As is the case of most the channels in Puget Sound, the cutting of this surface probable dates to sub-glacial channel formation during the Vashon Stade with relatively minor modification having occurred due to subsequent tidal activity.

The boundary between the upper and lower unit is less distinct, though the contact does appear to show ~15 feet of local topographic relief—suggesting that this surface too is an unconformity. Across the survey area, this surface is generally south dipping and occurs between ~85 and ~115 feet below MLLW.

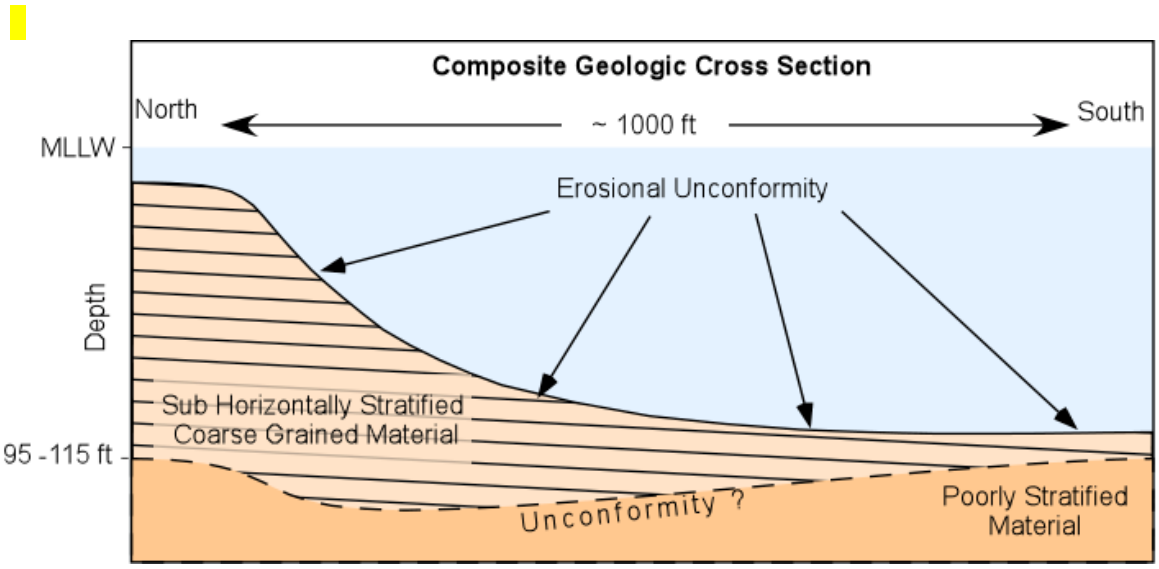


Figure 3 Composite geological cross section.

Appendix A
Line Log

	Date	SOF	EOF	Duration	Tide
KeyW15	10/24/02	12:28:22	12:31:34	0:03:12	5.8
KeyW14	10/24/02	12:32:08	12:41:45	0:09:38	5.8
KeyW13	10/24/02	12:43:41	12:48:21	0:04:40	5.8
KeyW12	10/24/02	12:50:05	12:54:07	0:04:01	5.8
KeyW11a	10/24/02	12:57:29	13:01:00	0:03:30	5.7
KeyW10	10/24/02	13:02:10	13:05:53	0:03:42	5.7
KeyW9	10/24/02	13:09:19	13:13:26	0:04:06	5.7
KeyW8a	10/24/02	13:18:51	13:22:31	0:03:40	5.8
KeyW7	10/24/02	13:24:29	13:24:29	0:00:00	5.8
KeyW6	10/24/02	13:30:57	13:35:43	0:04:46	5.8
KeyW5	10/24/02	13:37:30	13:43:02	0:05:32	5.8
KeyW4	10/24/02	13:44:20	13:48:44	0:04:25	5.9
KeyC11	10/24/02	13:54:04	13:54:59	0:00:55	5.9
KeyC10	10/24/02	13:56:07	14:00:30	0:04:24	5.9
KeyC9	10/24/02	14:02:00	14:06:49	0:04:49	5.9
KeyC8	10/24/02	14:07:40	14:11:51	0:04:11	5.9
KeyC7	10/24/02	14:13:12	14:17:53	0:04:41	6.0
KeyC6	10/24/02	14:18:45	14:22:41	0:03:56	6.0
KeyC5	10/24/02	14:23:55	14:28:09	0:04:14	6.1
KeyC4	10/24/02	14:29:21	14:33:06	0:03:45	6.1
KeyC3	10/24/02	14:34:47	14:39:10	0:04:24	6.1
KeyC2	10/24/02	14:40:07	14:44:03	0:03:56	6.2
KeyC1	10/24/02	14:45:29	14:49:58	0:04:29	6.2
KeyE	10/24/02	14:50:47	14:55:00	0:04:13	6.3
KeyE7	10/24/02	14:56:24	15:00:41	0:04:17	6.3
KeyE6	10/24/02	15:01:45	15:05:23	0:03:37	6.4
KeyE5	10/24/02	15:06:44	15:10:51	0:04:07	6.4
KeyE4	10/24/02	15:12:04	15:16:31	0:04:26	6.5
KeyE3	10/24/02	15:17:28	15:21:22	0:03:54	6.5
KeyE2	10/24/02	15:22:34	15:27:01	0:04:27	6.6
Tie2	10/24/02	15:34:14	16:07:10	0:32:56	6.7
KeyW15a	10/24/02	16:08:43	16:12:09	0:03:27	6.8

FILE NAME: bathymetry.dgn 07-AUG-2003 15:33:59

Washington State Ferries

CH2MHILL

BATHYMETRY

KEYSTONE, WASHINGTON

APPENDIX E

CONCEPTUAL TERMINAL DESIGNS

To adequately evaluate the feasibility of potential terminal sites it is necessary to have a complete understanding of the function of the new terminal. The purpose of this memo is to identify what the terminal area requirements will be so that a planning level concept design can be developed and evaluated. This memo will set criteria for terminal requirements such as number of slips, reliability of landings, holding area capacity, number of toll booths and similar requirements. This memo is not intended to set detailed design criteria such as seismic and structural codes, etc. Should the project move forward out of the planning arena, a detailed design report would then be prepared.

The following is an initial draft of the design criteria. This draft shall be circulated through WSF planning, operations, and terminal and vessel design for input. Once comments are received from these departments a final conceptual design criteria document will be issued.

Draft Ferry Terminal Design Criteria

A. Design Vessels in order of importance

Vessels	Length (ft)	Beam (ft)	Draft (ft)	Displacement (LT)	Passengers	Cars (20 ft)
Issaquah 130	328	78.8	16.5		1200	130
Evergreen State	310	73	15.6		1200	100

(The design vessel shall be the Issaquah 130 Class, with potential for the Issaquah 100 and Evergreen State Class vessels also

B. **Terminal Operational Criteria:** The terminal reliability shall be not less than the average existing conditions at the Keystone terminal. (The number of successful landings and vehicles transferred shall not decrease as a result of relocating the terminal.)

C. **Number and Type of Slips:** operational slip, with potential for a second slip if necessary for landing in certain weather conditions.

D. **Operation of Slips:** Assume one vessel loading and unloading at a time.

E. **Transfer Span:** Use standard transfer span for layout purposes. The transfer span is currently under redesign and changes will be incorporated into the layout as they become available.

F. **Staging Area Requirements:** The holding area size requirement is at minimum one 130 car ferries x 1.2 for sorting tall vehicles x 20 feet/vehicle = 3120 feet..

G. **Trestle Width:**

Pedestrian Walkway	8’
Loading Lanes	2 @ 10’/ea = 20’
Exit Lanes	2 @ 11’/ea = 22’
Barriers with shy distance	2 @ 5’/ea = 10’
Total Width	60 ft.

H. **Additional Parking:** 50 spaces – 20 short term/30 long term.

I. **Transit Pick Up/Drop Off Area**: Space for one 40-foot bus at terminal building (on land).

J. **Terminal Building:**

Office Space:	500 sq. ft.
Waiting Room:	750 sq. ft. (based on 250 people x 3 sq. ft. per person)
Mechanical Room:	200 sq. ft.
Restrooms:	150 sq. ft. men’s (three stalls minimum, as per UBC)
	150 sq. ft. women’s (three stalls minimum, as per UBC)
Storage:	200 sq. ft.
Employee Areas	400 sq. ft. for lockers, unisex restroom, small break area
Total Area	3,000 sq. ft.

K. **Toll collection facilities**: 130 cars every 45 minutes/2.6 vehicles per minute = 50 toll booth minutes so two toll booths required.

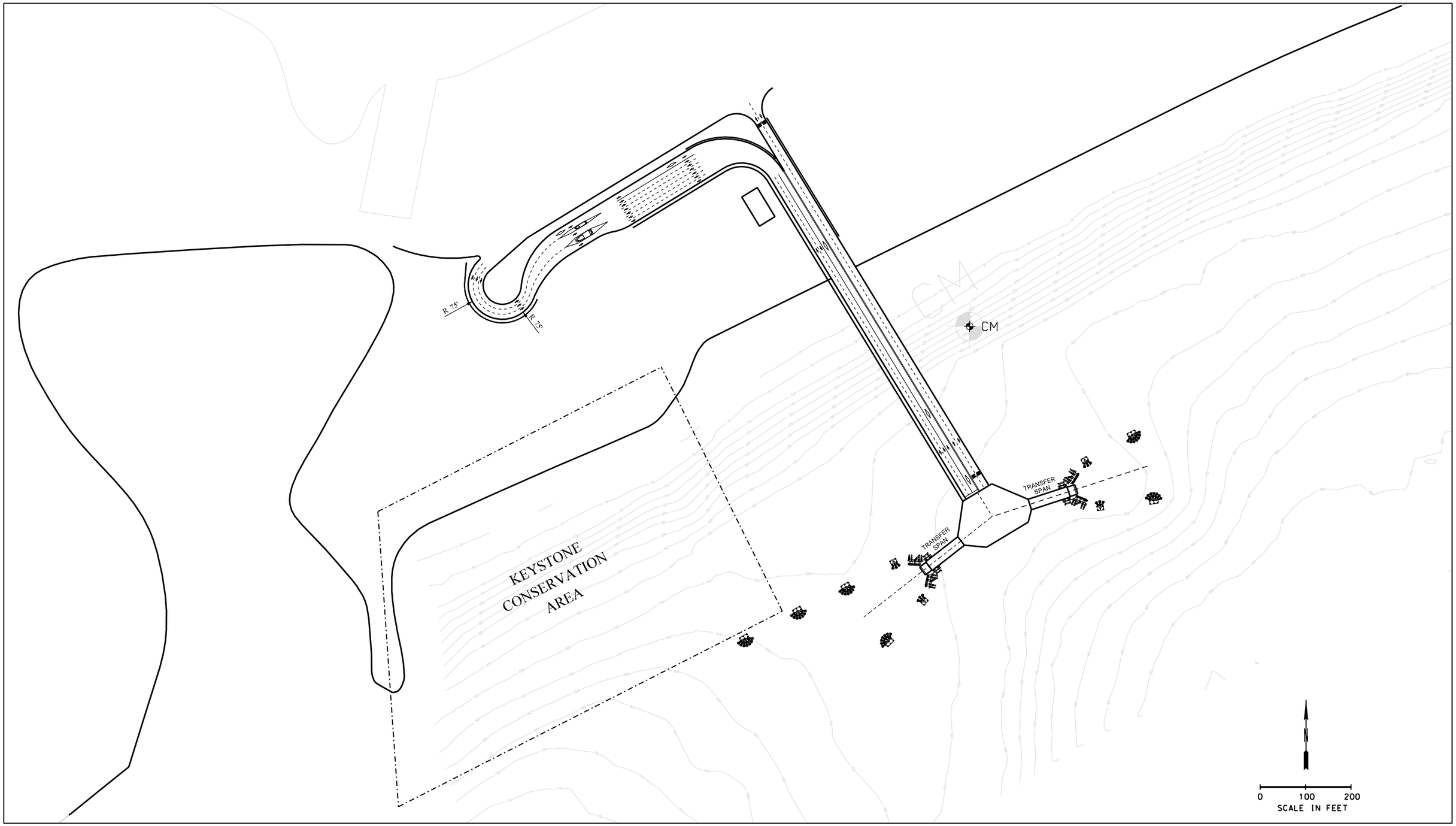
L. **Vehicle Access**: The terminal shall be accessed only from the east, off the SR 20 spur.

M. **Pedestrian Access:** There will be a 8-foot-wide sidewalk from the highway to the terminal building to the trestle.

N. **Utilities:** The terminal will need full utilities to include water, sewer, power, telephone

O. **Maintenance Building:** Assume no maintenance facilities. Allow 200 square feet on trestle for garbage and hazardous waste storage.

FILE NAME: site1.dgn 07-AUG-2003 15:24:49



Washington State Ferries

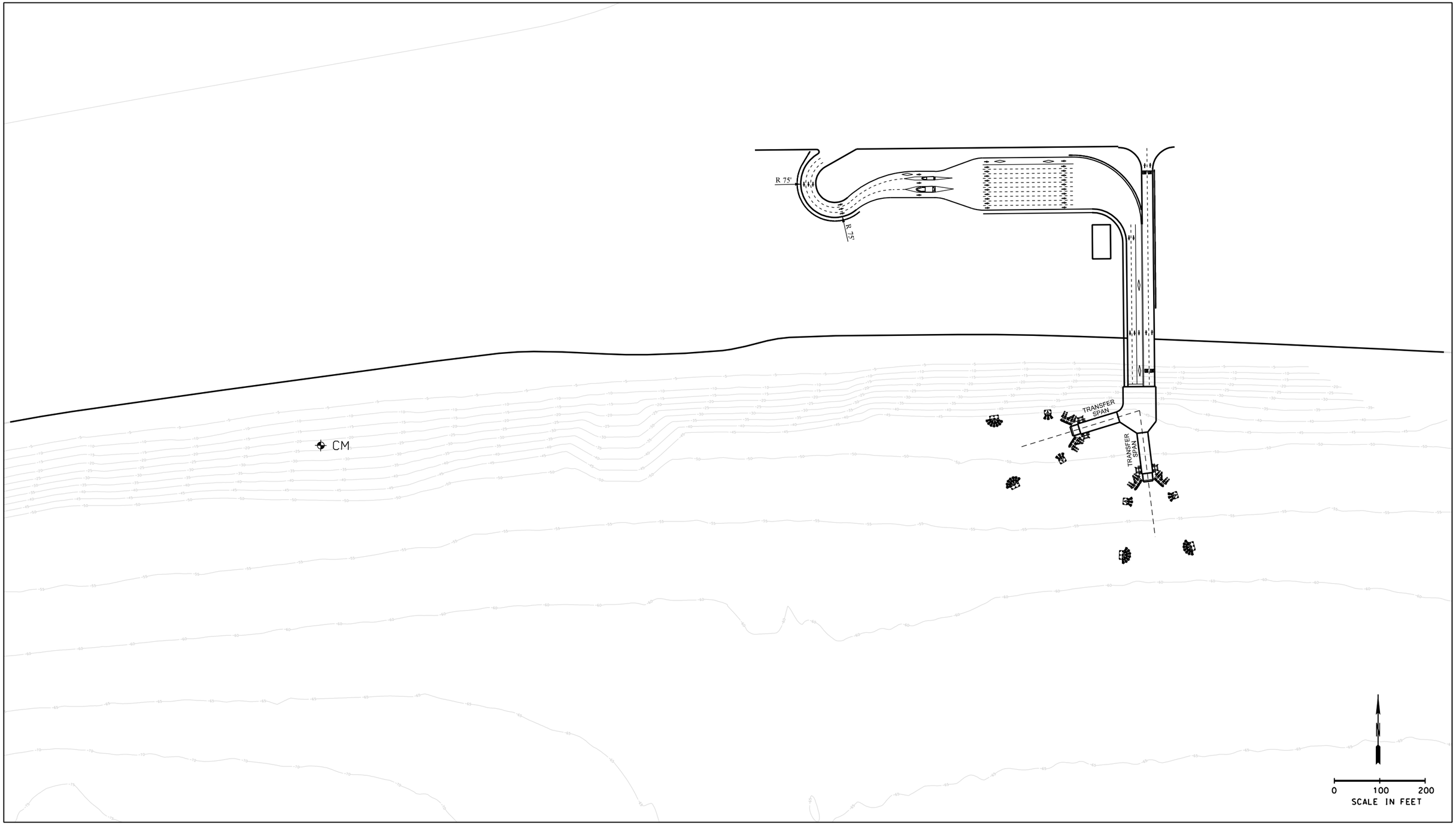
CH2MHILL

FIGURE E1

WEST AREA
CONCEPTUAL LAYOUT

KEYSTONE, WASHINGTON

FILE NAME: site2.dgn 07-AUG-2003 15:28:06



Washington State Ferries

CH2MHILL

FIGURE E2

EAST AREA
CONCEPTUAL LAYOUT

KEYSTONE, WASHINGTON

Appendix F
Traffic Assessment

APPENDIX F

TRAFFIC ASSESSMENT

Washington State Ferries (WSF) is investigating the possible relocation of the Keystone Ferry Terminal to a location east of the current dock on State Route (SR) 20. A relocation would allow a larger vessel to dock at the Keystone terminal. The potential locations are near the current site, therefore travel patterns are expected to remain the same.

Currently, the Steel Electric Class vessels serves the Port Townsend – Keystone route. This ferry provides capacity for 75 vehicles. If the terminal was relocated, a larger vessel that can accommodate 130 vehicles could be put into service for this route. WSF considers the PM peak period from 4 pm to 7 pm, but to quantify the traffic conditions for the most conservative hour within that period, 5 pm to 6 pm is selected. During the PM peak hour, the vessel currently departs twice at Keystone (5:15 pm and 6 pm) and arrives once (5:15 pm). This schedule is expected to remain the same if the terminal is relocated.

Assuming the ferry vessel departs and arrives at capacity, a total of 225 vehicles (75 vehicles for three boat loads) load and off-load at Keystone during the peak hour. To account for non-ferry traffic, such as ferry-related terminal activities, walk-on passengers and State Park drivers, an additional ten percent is assumed to travel on this portion of SR 20. Combining these two volumes, 245 vehicles currently travel along this segment of SR 20 in the PM peak hour. In addition, daily traffic data is available from WSDOT. Currently 1,000 vehicles travel on this segment of SR 20 each day.

Using the same assumptions described above, the potential terminal locations and vessel upgrade would increase the PM peak hour traffic volumes along SR 20 to 430 vehicles (130 vehicles for three boat loads with an additional 10 percent). Daily traffic volumes are also expected to increase. It is assumed the daily volume would increase similar to the PM peak hour increase, therefore approximately 1,900 vehicles would travel on this segment of SR 20 each day if the terminal was relocated. Table 1 displays the traffic volumes for each condition.

TABLE 1
SR 20-Keystone Ferry Terminal Traffic

Location/Condition	PM Peak Hour Volume	Daily Volume	PM Peak Hour V/C[1] Ratio	Daily V/C[1] Ratio	PM Peak Hour LOS[2]	Daily LOS[2]
SR 20 (@ Keystone Terminal) – Existing Terminal Condition	245	1,000	0.14	0.06	A	A
SR 20 (@ Keystone Terminal) – Relocated Terminal Condition	430	1,900	0.24	0.11	B	A

1 - V/C – volume to capacity ratio

2- LOS – Level of Service.

V/C to LOS Guidelines: LOS A < 0.15, LOS B < 0.27, LOS C < 0.43, LOS D < 0.64, LOS E < 1.0, LOS F > 1.0

A two-lane highway facility, such as this segment of SR 20, can accommodate approximately 18,000 vehicles per day[1] (both directions). During the peak hour, this facility could

[1] King County Planning Roadway Capacity Guidelines for a rural two-lane roadway.

accommodate up to 1,800 vehicles per hour (both directions). Assuming this capacity, SR 20 is currently at 14 percent of capacity in the PM peak hour. With larger vessels on the existing schedule, the v/c ratio is expected to increase to 0.24. Based on daily volumes, the v/c ratio is expected to increase from 0.06 to 0.11.

To establish a level of service (LOS) for the roadway, v/c ratio to LOS guidelines were developed based on the Highway Capacity Manual[2] (see Table 1 notes for the thresholds). Currently, this segment of SR 20 in the PM peak hour operates at LOS A and is predicted to operate at LOS B with larger vessels. Considering the daily volumes, SR 20 is predicted to operate at LOS A for both conditions. See Table 1 for v/c and LOS results. LOS A and B are considered at or near free-flow conditions with minimal traffic interruptions, therefore the potential ferry terminal relocation is predicted to not adversely impact SR 20.

[2] Highway Capacity Manual, 1997. The 2000 HCM does not state v/c ratio to LOS guidelines.

Appendix G
Underwater Habitat Survey

Keystone Ferry Terminal

Underwater Videographic Nearhsore Habitat Survey

August 19, 2002

by

James G. Norris and Ian E. Fraser

Submitted To:

CH2M Hill
777 108th Avenue NE
PO Box 91500
Bellevue, WA 98009-2050

October 10, 2002

Marine Resources Consultants

Marine Resources Consultants
PO Box 816
Port Townsend, WA 98368
(360) 385-4486
jnorris@olympus.net

Keystone Ferry Terminal
Underwater Videographic Nearhsore Habitat Survey
August 19, 2002

by

James G. Norris and Ian E. Fraser

Submitted To:

CH2M Hill
777 108th Avenue NE
PO Box 91500
Bellevue, WA 98009-2050

Oct 9, 2002
Date

James G. Norris
Signature

Table of Contents

Introduction 1
Methods 2
Personnel 2
Site Description and Sampling Plan 2
Underwater Videographic Survey Equipment and Methods 6
Field Sampling Procedures 7
Underwater Video Data Post-Processing 7
Tide Heights 8
Data Analysis 9
Results and Discussion 9
Appendix A: AutoCad Maps of the Entire Study Area
Appendix B: AutoCad Maps of the Existing Ferry Terminal Basin
Appendix C: AutoCad Maps of the West Relocation Option
Appendix D: AutoCad Maps of the East Relocation Option

List of Tables

Table 1. Personnel list. 2
Table 2. Survey equipment used onboard the *R/V Brendan D II* during this survey. 7
Table 3. Observed and predicted tides (ft) at the Port Townsend reference station during the time of the survey. 8
Table 4. Number of underwater videographic observations of each sediment type from a total of 6,793 observations. 10
Table 5. Number of underwater videographic observations of each seabed attribute from a total of 6,706 observations. 10

List of Figures

Figure 1. At right: aerial photograph of the Keystone Ferry Terminal taken on July 12, 1995 at a tide height of -2.7 ft (source: WSF archive photos). 1
Figure 2. West option for relocating the Keystone Ferry Terminal (source: Washington State Department of Ecology). 1
Figure 3. Eastern option for relocating the Keystone Ferry Terminal (source: Washington State Department of Ecology). 1
Figure 4. Site map showing east and west options for relocating the Keystone Ferry Terminal. 3
Figure 5. Aerial photos of the study site taken on May 5, 1993 at 11:05 pm at a tide height of –1.0 ft. 4
Figure 6. Vicinity bathymetry map (red lines show study area boundaries). 4
Figure 7. Map of underwater video transects. 5
Figure 8. Tidal prediction errors at the Port Townsend reference station during the time of the survey. 9

Introduction

The Washington State Ferry (WSF) system is exploring options to improve the Keystone Ferry Terminal (Fig. 1). Specifically, WSF would like a terminal that can accommodate larger vessels and is located where currents are less hazardous than those at the current location. WSF has contracted with CH2M Hill to examine options for locating a new terminal somewhere between the current location and a point approximately 1.5 nm to the east (where State Route 20 makes a sharp turn north away from the shoreline). The two preferred options at this time are: (1) just east of the old military dock located approximately 160 m east of the east jetty of the current landing basin (Fig. 2); and (2) approximately 150 m west of the point where State Route 20 makes a sharp turn north away from the shoreline (Fig. 3). A third area of biological interest is the inner basin at the current terminal because it may be useful as a mitigation site.

CH2M Hill contracted with Marine Resources Consultants to conduct an underwater videographic survey of the entire shoreline in the area of consideration, including the inner basin at the current terminal. The primary purpose of the survey was to identify any eelgrass (*Zostera marina*) beds and to provide a subjective characterization of the benthic community within the site.

Figure 1. At right: aerial photograph of the Keystone Ferry Terminal taken on July 12, 1995 at a tide height of -2.7 ft (source: WSF archive photos).

Figure 2. West option for relocating the Keystone Ferry Terminal (source: Washington State Department of Ecology).

Figure 3. East option for relocating the Keystone Ferry Terminal (source: Washington State Department of Ecology).

Methods

Personnel

Table 1 lists the personnel on board the vessel during the survey.

Table 1. Personnel list.

Date	Name	Position
August 19, 2002	Jim Norris	Skipper/Chief scientist
	Ian Fraser	Scientist

Site Description and Sampling Plan

The study area was defined to be the shoreline located west of the point where state highway 20 turns from a north-south orientation to an east-west orientation and east of the western edge of the existing ferry terminal basin (Fig. 4). This area corresponds to Washington State Department of Natural Resources "fringe" sites cps0801, cps0802, and cps0803 (1,000 m sections of shoreline, as measured by the –20 ft isobath). The upland is flat and devoid of trees (Fig. 5), but the bathymetry drops steeply to depths of 100 ft or more (Fig. 6). With the exception of the existing ferry terminal basin, the site is relatively undeveloped. The beach is coarse gravel and cobble, and the entire site is exposed to both strong currents and wave energy from southerly storms.

At the east and west preferred option locations, we conducted six and ten straight-line underwater video transects perpendicular to the shoreline, respectively. Transects were berthed 50 to 100 ft apart and extended to depths of –25 ft mean lower low water (MLLW). For the shoreline between these two options, we used zig-zag transects (i.e., from shallow to deep, then deep to shallow, and so on). Within the existing ferry terminal basin we conducted two east/west transects and three north/south transects. Figure 7 shows the location of all transects.

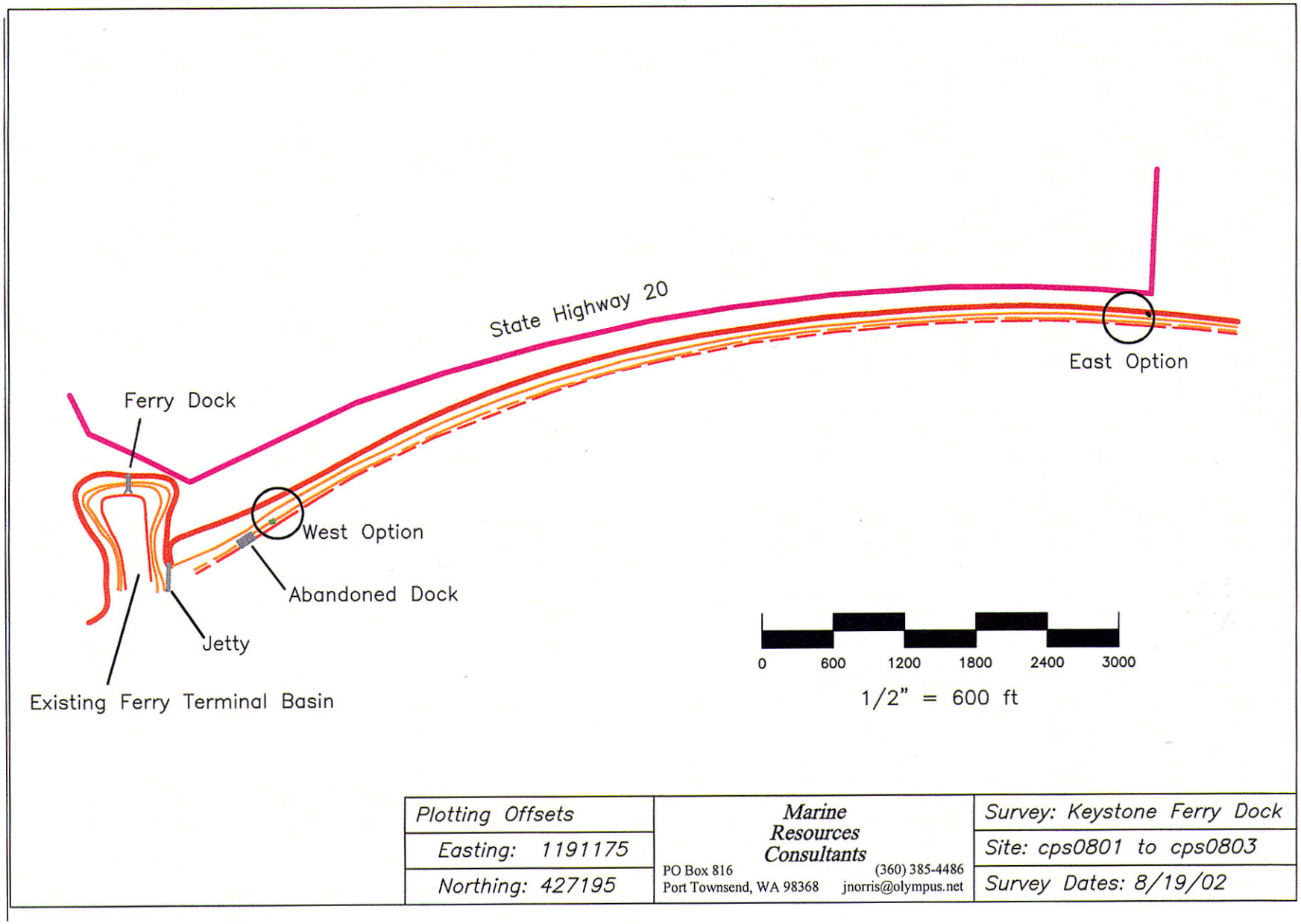


Figure 4. Site map showing east and west options for relocating the Keystone Ferry Terminal.

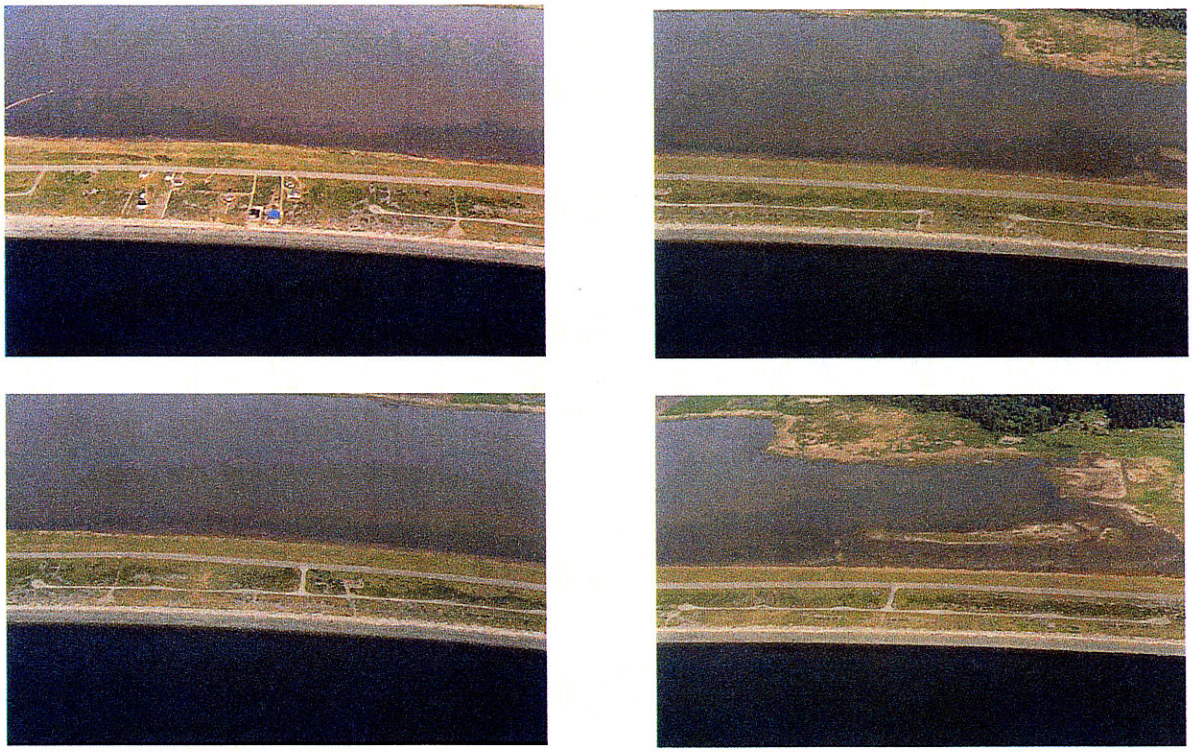


Figure 5. Aerial photos of the study area between the east and west relocation options taken on May 5, 1993 at 11:05 pm at a tide height of –1.0 ft (source: Washington State Department of Ecology).

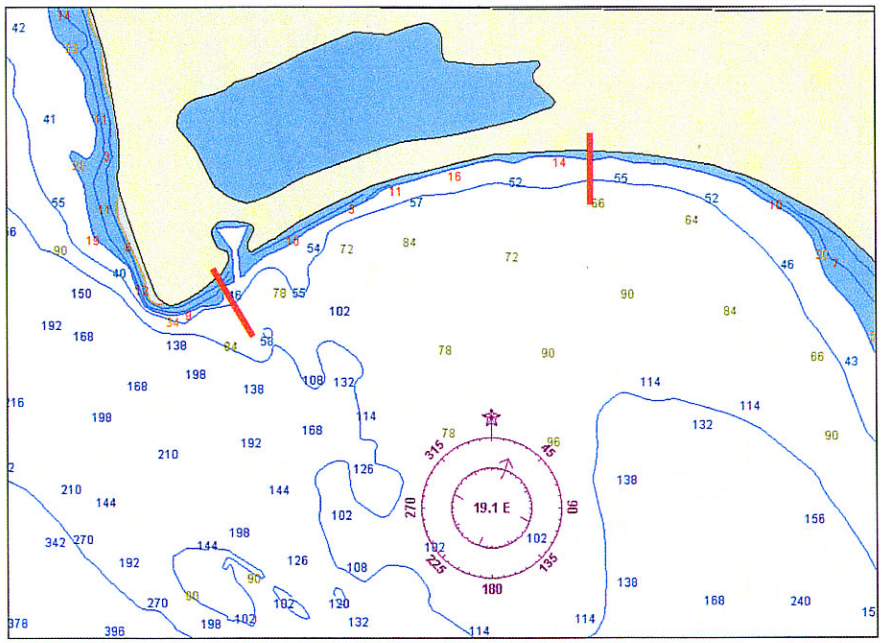


Figure 6. Vicinity bathymetry map (soundings in ft; red lines show study area boundaries).

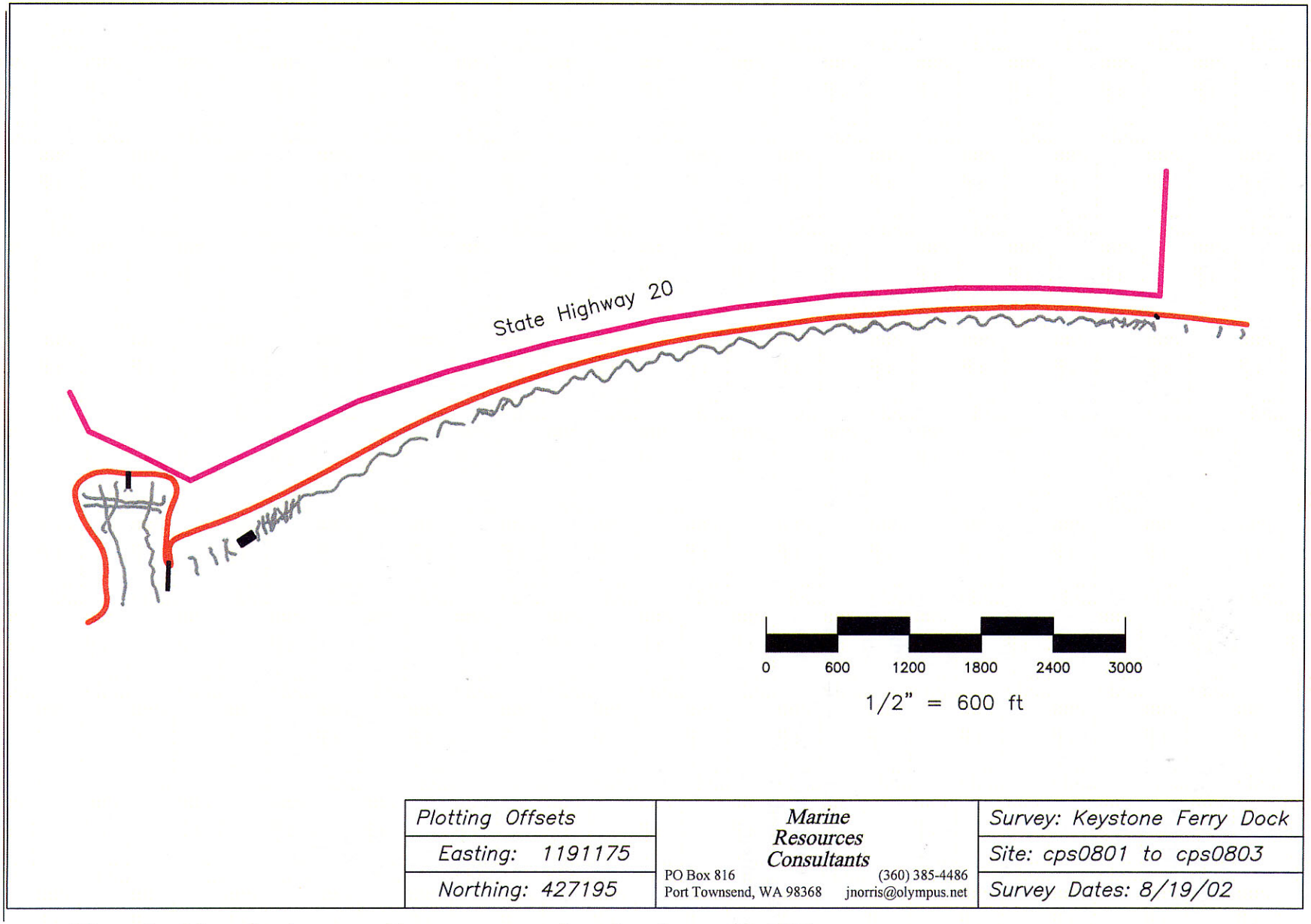


Figure 7. Map of underwater video transects conducted on August 19, 2002.

Underwater Videographic Survey Equipment and Methods

Table 2 lists the equipment used during this survey. Sampling was conducted aboard the 36-ft *R/V Brendan D II.* Position data were acquired using a Trimble Ag132 DGPS processor with the antenna located at the tip of the cargo boom used to deploy the camera. Differential corrections were received from the United States Coast Guard public DGPS network using the NAD 83 datum. Portable transducers mounted on both the starboard and port sides near the transom collected depth below transducer and bottom discrimination data (the American Pioneer and Garmin transducers were located on the starboard side; the BioSonics transducer was located on the port side). Underwater video images were obtained using an underwater camera mounted in a down-looking orientation on a heavy towfish. Two parallel red lasers mounted 10 cm apart created two red dots in the video images as a scaling reference. A 250 watt underwater light provided illumination when needed. The towfish was deployed directly off the stern of the vessel using the cargo boom and boom winch. The weight of the towfish kept the camera positioned directly beneath the DGPS antenna, thus ensuring that the position data accurately reflected the geographic location of the camera.

A laptop computer equipped with a video overlay controller and data logger software integrated DGPS data (date, time, latitude, longitude), user supplied transect information (transect number and site code), and the video signal. Video images were stored directly onto two VHS videotapes using two four head video cassette recorders and onto a Sony Digital8 videotape using a Sony DVR-TRV310 camcorder. Date, time, position, and transect information also were stored on a floppy disk at 1 s intervals. Television monitors located in both the pilothouse and the work deck assisted the helmsman and winch operator control the speed and vertical position of the towfish.

A real-time plotting system used a multiplexer to integrate National Marine Electronic Association 0132 standard sentences produced by the DPGS, two depth sounders (American Pioneer and Garmin), and a user-controlled toggle switch to indicate eelgrass presence/absence. At 1 to 4 s intervals, these data streams were forwarded to a laptop personal computer running a spreadsheet program with macro and plotting capabilities (Microsoft Excel 7.0). Data from the BioSonics depth sounder were recorded on a separate computer at 2 s intervals. A red cursor plotted the current position of the vessel. When the UV camera was down and observing the seabed, a thin black line on the plotter traced the camera's position. As the vessel moved along the track line, the chief scientist watched the TV monitor and clicked the eelgrass toggle switch on or off each time eelgrass appeared or disappeared from view. When the eelgrass toggle was on, the track line pattern changed to a thick green line and the eelgrass positions were stored on a separate worksheet. The result was a real-time plot of the area sampled and where eelgrass was observed.

Table 2. Survey equipment used onboard the *R/V Brendan D II* during this survey.

Item	Manufacturer/Model
Differential GPS	Trimble AgGPS 132 (sub-meter accuracy)
Depth Sounders	Garmin Fishfinder 240 (200 KHz transducer) American Pioneer Fishscope V (160 KHz transducer) BioSonics 2400 T system (including Dell laptop computer with Submerged Aquatic Vegetation software)
Sea Surface Temperature	Garmin Fishfinder 240 (w/temperature sensor)
Underwater Camera	Deep Sea Power & Light SeaCam 2000
Lasers	Deep Sea Power & Light
Underwater Light	Deep Sea Power & Light RiteLite (250 watt)
Real-time Plotting Computer	Sony VAIO laptop
Data Backup System	Sony CD-ROM
Color Printer	Hewlett-Packard HP DeskJet 842C
Video Overlay Computer	Toshiba 1200 Laptop
Video Overlay Controller	Discovery Bay Software
VCR#1 (master tapes)	General Electric VG4043 VHS 4-Head
VCR#2 (backup tapes)	Zenith TV/VCR Combo 4-Head
Digital VideoTape Recorder	Sony DVC310 Digital8 Camcorder

Field Sampling Procedures

At the start of each straight-line transect, the vessel was backed close to the shoreline and the camera was lowered to just above the bottom. Visual references were noted and the VCRs and data logger were started. As the vessel moved along the transect the winch operator raised and lowered the camera towfish to follow the seabed contour. The field of view changed with the height above the bottom. The vessel speed was held as constant as possible (about 1 m/sec). At the end of the transect, the VCRs were stopped, the camera was retrieved, and the vessel was moved to the next sampling position.

Underwater Video Data Post-Processing

Data stored on floppy disks were downloaded and organized into spreadsheet files including blank columns for "video code" and seabed attribute codes. NAD 83 position data were corrected to State Plane Washington North, US Survey Feet using the program CORPSCON (freeware from the US Army Corps of Engineers). Videotapes were reviewed in the laboratory to assign video codes (0 = cannot view the seabed; 1 = seabed in view) and attribute codes for eelgrass, *Laminaria* (sp), *Ulva* (sp), other macroalgae, fish, crabs, and seastars (0 = absent; 1 = present) to each position record. Sediment type codes were also assigned to each record (1 = sand; 2 = gravel; 3 = cobble; 4 = rock).

Tide Heights

The BioSonics and Garmin echosounders (located on each side of the transom) were used to gather bathymetry data. Raw depths collected from the echosounders measure the distance between the seabed and the transducer. To correct these depths to the mean lower low water (MLLW) vertical datum, three corrections were applied:

1. transducer offset (i.e., distance between the transducer and the surface);
2. predicted tidal height (i.e., predicted distance between the surface and MLLW);
3. tide prediction error (i.e., predicted tidal height minus the observed tidal height at a reference station).

Corrected depth equals depth below the transducer plus the transducer offset minus the predicted tidal height plus the tide prediction error. The transducer offsets were measured directly. We used the computer program Tides and Currents Pro 3.0 (Nobletec Corporation) to get predicted tide heights (at 6 min intervals) for the Port Townsend station (station ID 0995; 48 06.90 N; 122 45.00 W). We computed tide prediction errors by comparing the computer program predicted tide heights with actual observed tide heights published by the National Oceanic and Atmospheric Administration on their web site (http://www.co-ops.nos.noaa.gov/data_res.html). The observed and predicted tides and the prediction errors during the time of the survey ranged from –0.40 ft to +0.13 ft (Table 4; Fig. 7).

Table 3. Observed and predicted tides (ft) at the Port Townsend reference station during the time of the survey.

Time	Observed	Predicted	Error	Time	Observed	Predicted	Error
13:48	6.17	5.80	-0.37	16:12	8.37	8.50	0.13
13:54	6.34	6.00	-0.34	16:18	8.39	8.50	0.11
14:00	6.50	6.10	-0.40	16:24	8.40	8.50	0.10
14:06	6.64	6.30	-0.34	16:30	8.43	8.50	0.07
14:12	6.76	6.40	-0.36	16:36	8.43	8.50	0.07
14:18	6.89	6.60	-0.29	16:42	8.47	8.50	0.03
14:24	7.02	6.80	-0.22	16:48	8.49	8.50	0.01
14:30	7.13	6.90	-0.23	16:54	8.54	8.50	-0.04
14:36	7.26	7.00	-0.26	17:00	8.55	8.50	-0.05
14:42	7.37	7.20	-0.17	17:06	8.56	8.50	-0.06
14:48	7.49	7.30	-0.19	17:12	8.54	8.40	-0.14
14:54	7.57	7.40	-0.17	17:18	8.53	8.40	-0.13
15:00	7.67	7.60	-0.07	17:24	8.50	8.30	-0.20
15:06	7.75	7.70	-0.05	17:30	8.47	8.30	-0.17
15:12	7.84	7.80	-0.04	17:36	8.44	8.20	-0.24
15:18	7.91	7.90	-0.01	17:42	8.42	8.20	-0.22
15:24	7.99	8.00	0.01	17:48	8.40	8.10	-0.30
15:30	8.06	8.10	0.04	17:54	8.36	8.10	-0.26
15:36	8.12	8.10	-0.02	18:00	8.32	8.00	-0.32
15:42	8.16	8.20	0.04	18:06	8.25	7.90	-0.35
15:48	8.22	8.30	0.08	18:12	8.19	7.90	-0.29
15:54	8.27	8.30	0.03	18:18	8.09	7.80	-0.29
16:00	8.31	8.40	0.09	18:24	8.01	7.70	-0.31
16:06	8.35	8.40	0.05	18:30	7.93	7.70	-0.23

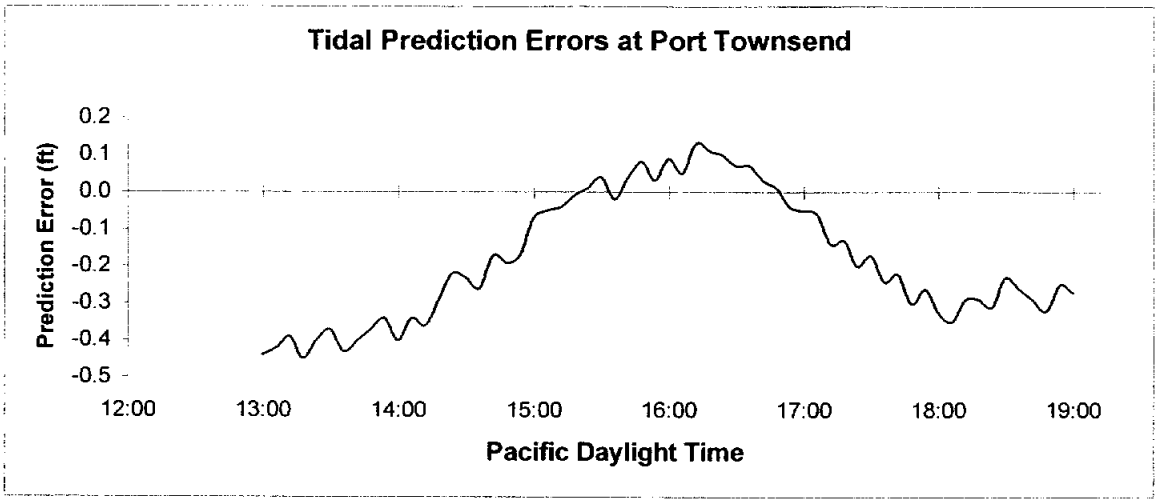


Figure 8. Tidal prediction errors at the Port Townsend reference station during the time of the survey.

Data Analysis

All data were merged (using time as the common field) into a single database file (tab delimited text file). Each data field was screened for gross errors (e.g., erroneous depth sounder readings caused by propeller turbulence at the start of a track). The Garmin and BioSonics corrected depths were averaged to determine the minimum and maximum eelgrass depths. We created maps in AutoCad to illustrate the locations of seabed attributes. The ferry dock, jetty at the east side of ferry terminal basin, the abandoned dock near the west option, shoreline and state highway 20 lines shown on the maps were drawn subjectively based on aerial photographs and the location of our underwater videographic tracks. Isobaths at MLLW, -10 ft, and –20 ft were drawn based on corrected depths from the Garmin and BioSonics depth sounders. A polygon was drawn around the eelgrass observations to define the one eelgrass bed observed. We used the AutoCad "inquiry" tool to determine the area of the eelgrass polygon.

Results and Discussion

Appendices A, B, C, and D contain AutoCad maps for the entire study area, the existing ferry terminal basin, the west relocation option, and the east relocation option, respectively. With the exception of the existing ferry terminal basin, the seabed throughout the study area had a relatively steep slope composed of gravel and cobble (Fig. A-1). The north margin of the existing ferry terminal basin had some rock, while the main body of the basin was composed of sand/mud (Fig. A-2). Table 4 lists the number of observations of each sediment type.

Table 4. Number of underwater videographic observations of each sediment type from a total of 6,793 observations.

Sediment Type	Number of Observations
Sand/Mud	1,035
Gravel	2,330
Cobble	3,201
Rock	68
Undetermined	169

One small patch of eelgrass (approximately 914 ft^2) was observed within the west option area, approximately 200 ft east of the abandoned dock (tracks 16, 17, and 30; Figs. C-1 to C-4). The minimum and maximum eelgrass depths were –10.4 ft and – 14.6 ft, respectively. *Ulva* was located throughout the study area (Fig. A-3). Along the exposed coastline it was located mostly between the MLLW to –10 ft isobaths (Figs. A-3, C-1, and D-1); within the existing ferry terminal basin it extended to the –20 ft isobath (Fig. B-1). *Laminaria* and other algae were located from MLLW to the maximum depths surveyed (about –25 ft MLLW; Figs. A-4, A-5, B-2, B-3, C-2, C-3, D-2, and D-3).

Fish were observed throughout the study area (Figs. A-6, B-4, C-4, and D-4). Although it was difficult to identify fish species, we noted the following taxa: tube snouts (*Aulorhynchus flavidus*), shiner perch (*Cymatogaster aggregata*), unidentified sculpins (family *cottidae*), and unidentified flatfish (families *bothidae* and *pleuronectidae*). In addition to fish observed with the underwater camera, we observed several jumping coho salmon (*Oncorhynchus kisutch*) and one beach angler capture a coho salmon. During the survey there were approximately 10 to 15 beach anglers fishing for coho salmon at the east end of the study area. A few crabs were observed, but again it was difficult to identify species. Most crabs were located within the existing ferry terminal basin (Figs. B4, C-4, and D-4). Sea stars were only observed within the existing ferry terminal basin (Fig. B-5). Table 5 summarizes the number of underwataer videographic observations of each attribute.

Table 5. Number of underwater videographic observations of each seabed attribute from a total of 6,706 observations.

Seabed Attribute	Number of Observations
Eelgrass (*Zostera marina*)	34
Laminaria (sp)	5,082
Ulva (sp)	3,786
Other macro algae	2,231
Fish	349
Crabs	40
Sea stars	43

APPENDIX A

AutoCad Maps of the Entire Study Area

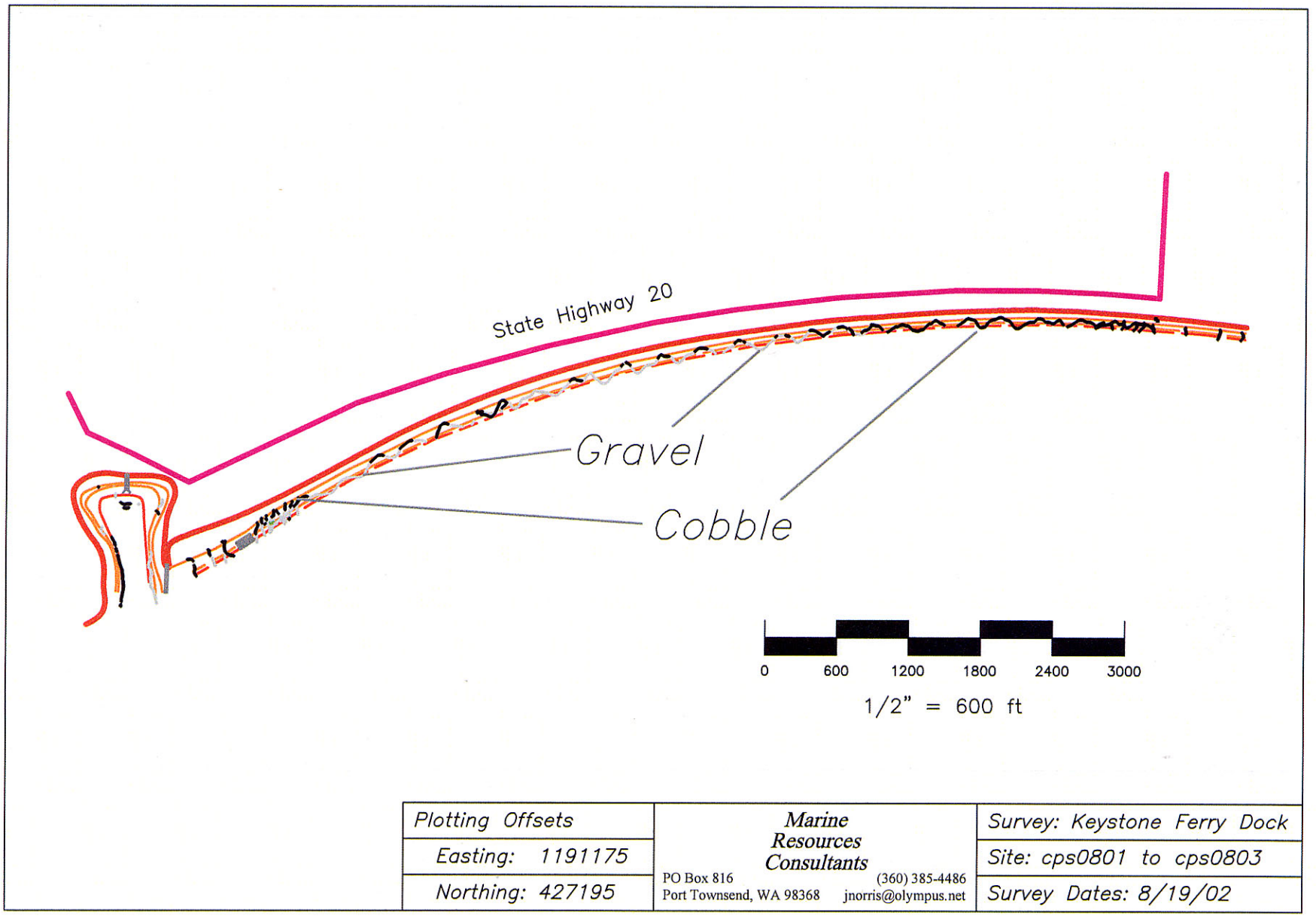


Figure A-1. Location of gravel (gray) and cobble (black) sediment type observations during the August 19, 2002 underwater videographic survey at the Keystone Ferry Terminal relocation study area.

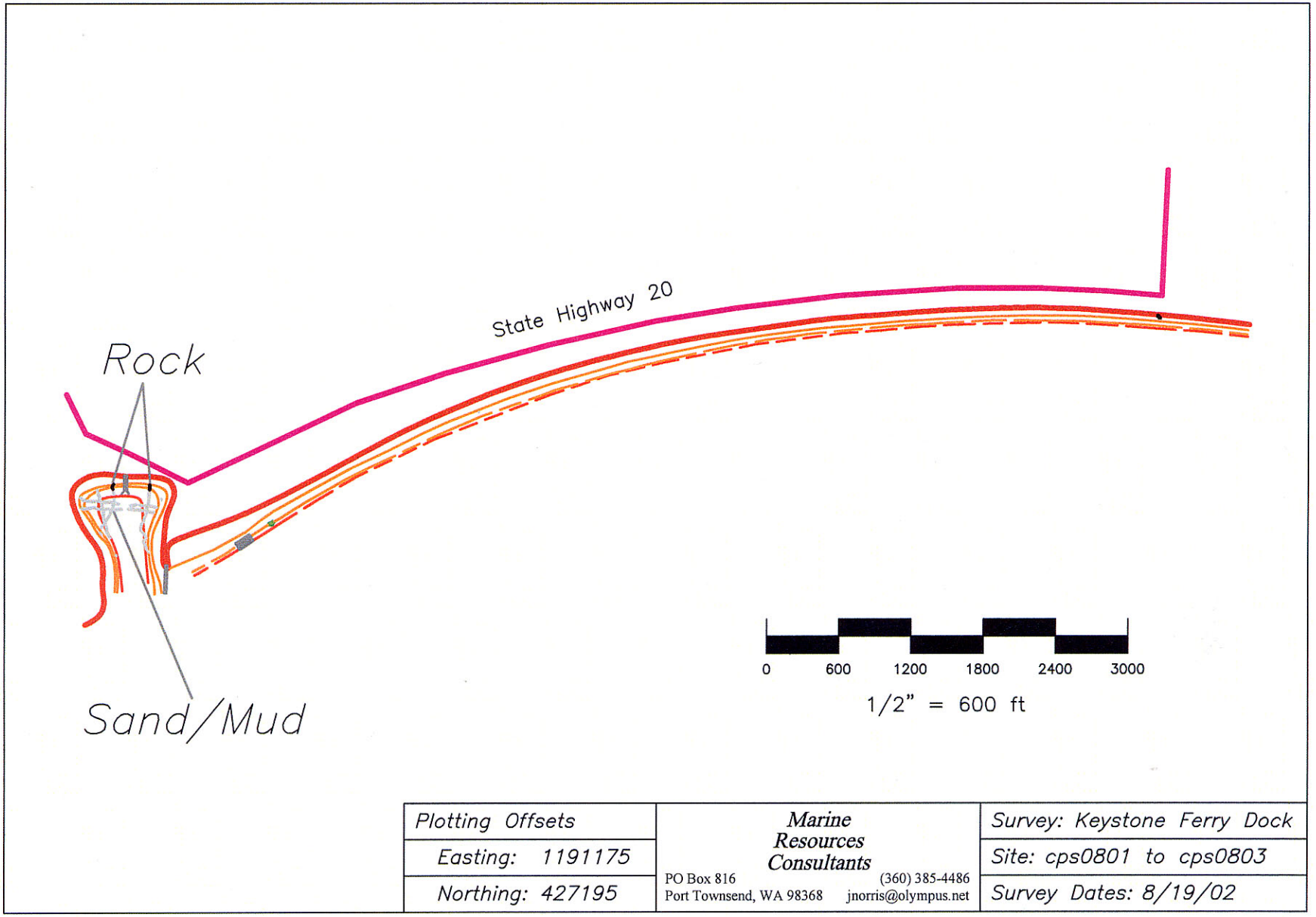


Figure A-2. Location of sand/mud (gray) and rock (black) sediment type observations during the August 19, 2002 underwater videographic survey at the Keystone Ferry Terminal relocation study area.

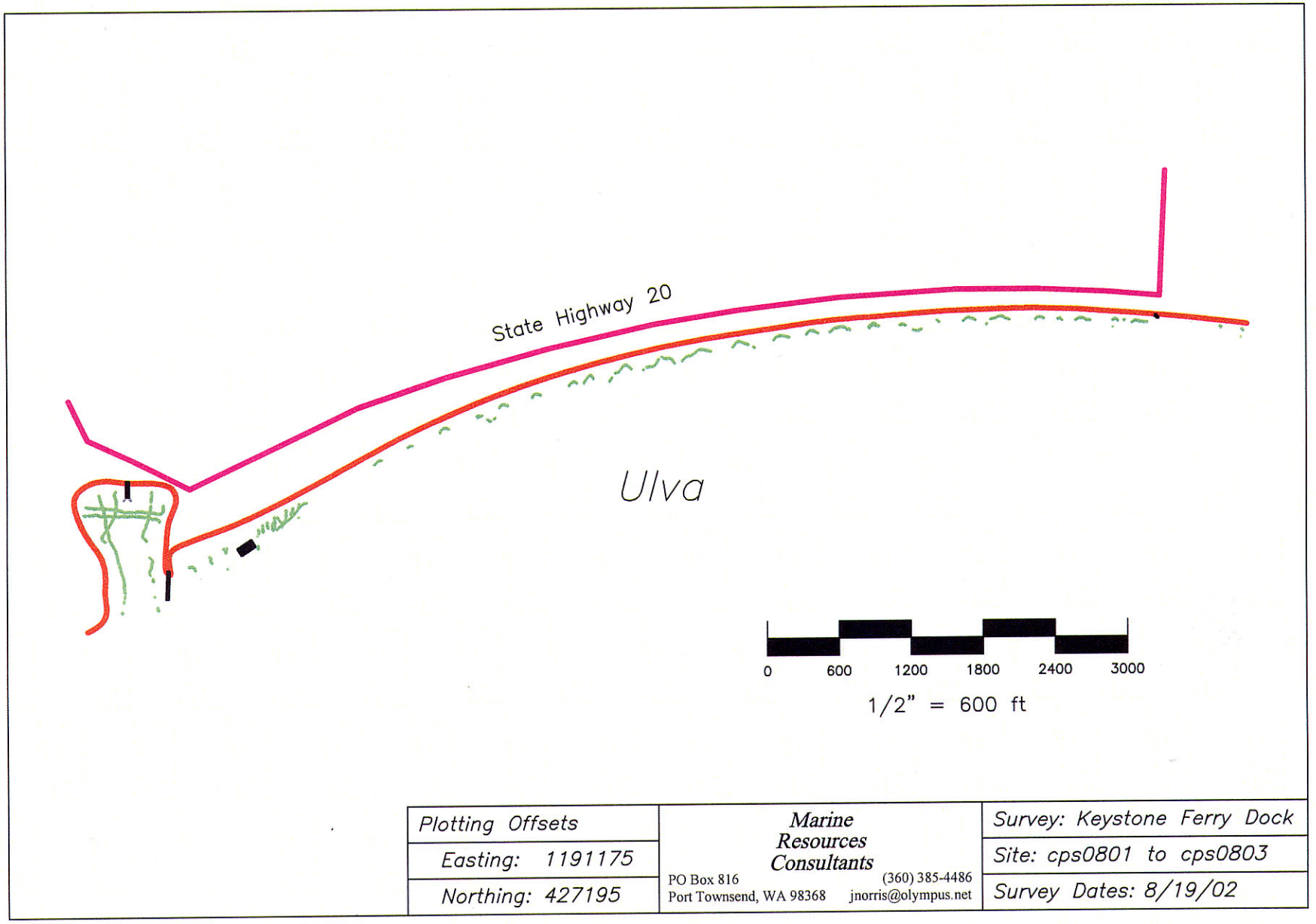


Figure A-3. Location of *Ulva* (light green) observations during the August 19, 2002 underwater videographic survey at the Keystone Ferry Terminal relocation study area.

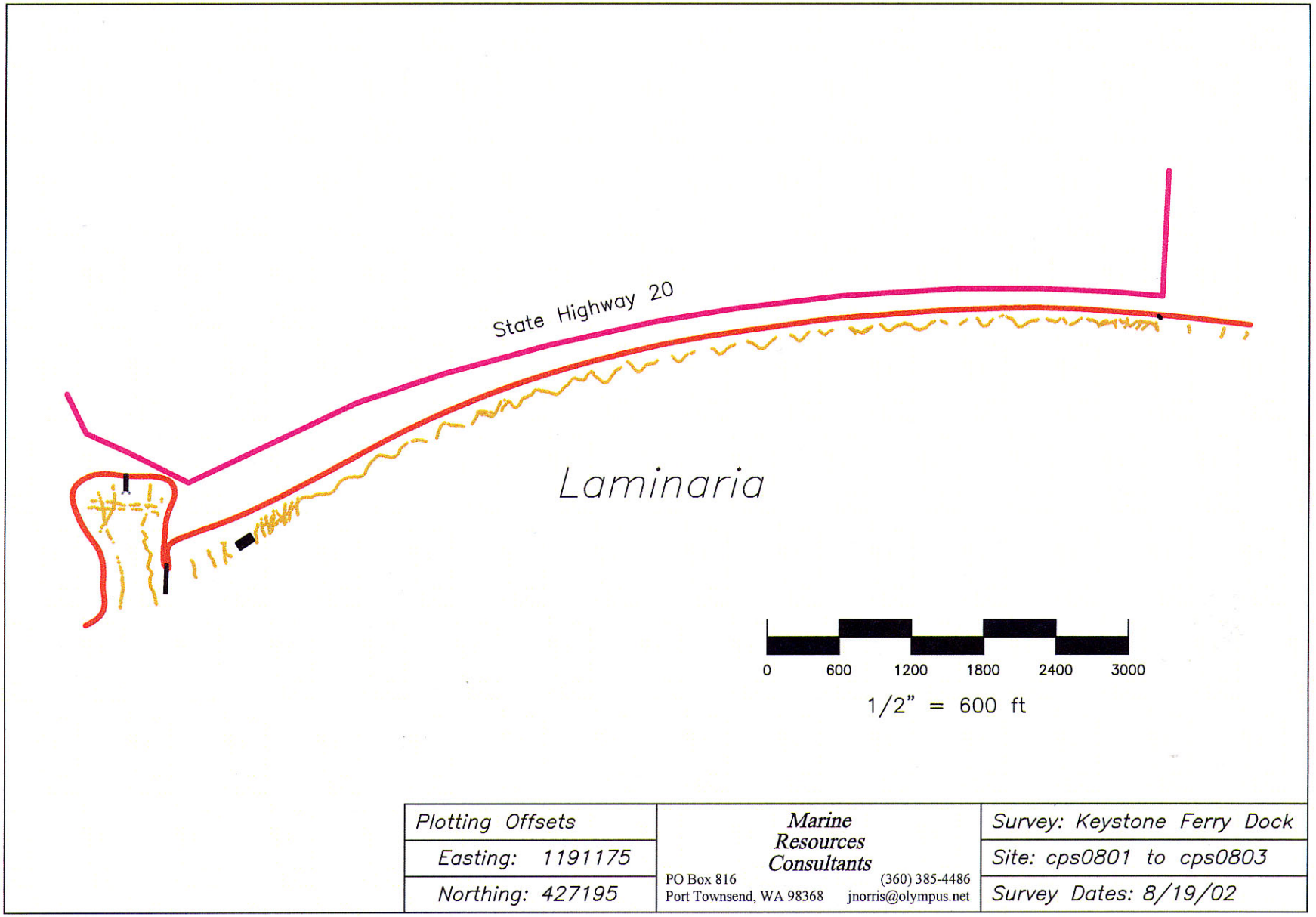


Figure A-4. Location of *Laminaria* (light brown) observations during the August 19, 2002 underwater videographic survey at the Keystone Ferry Terminal relocation study area.

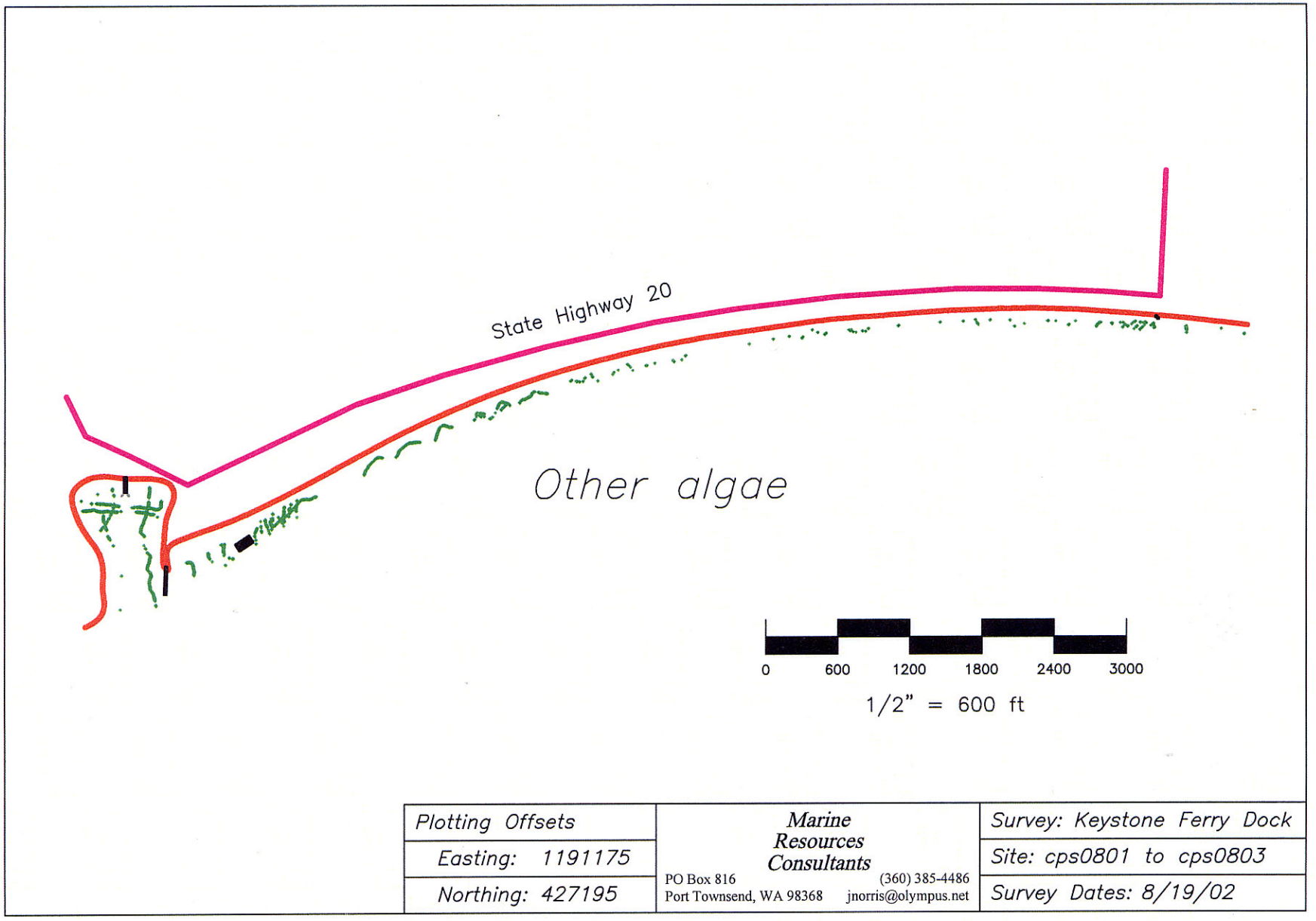


Figure A-5. Location of other macro algae observations during the August 19, 2002 underwater videographic survey at the Keystone Ferry Terminal relocation study area.

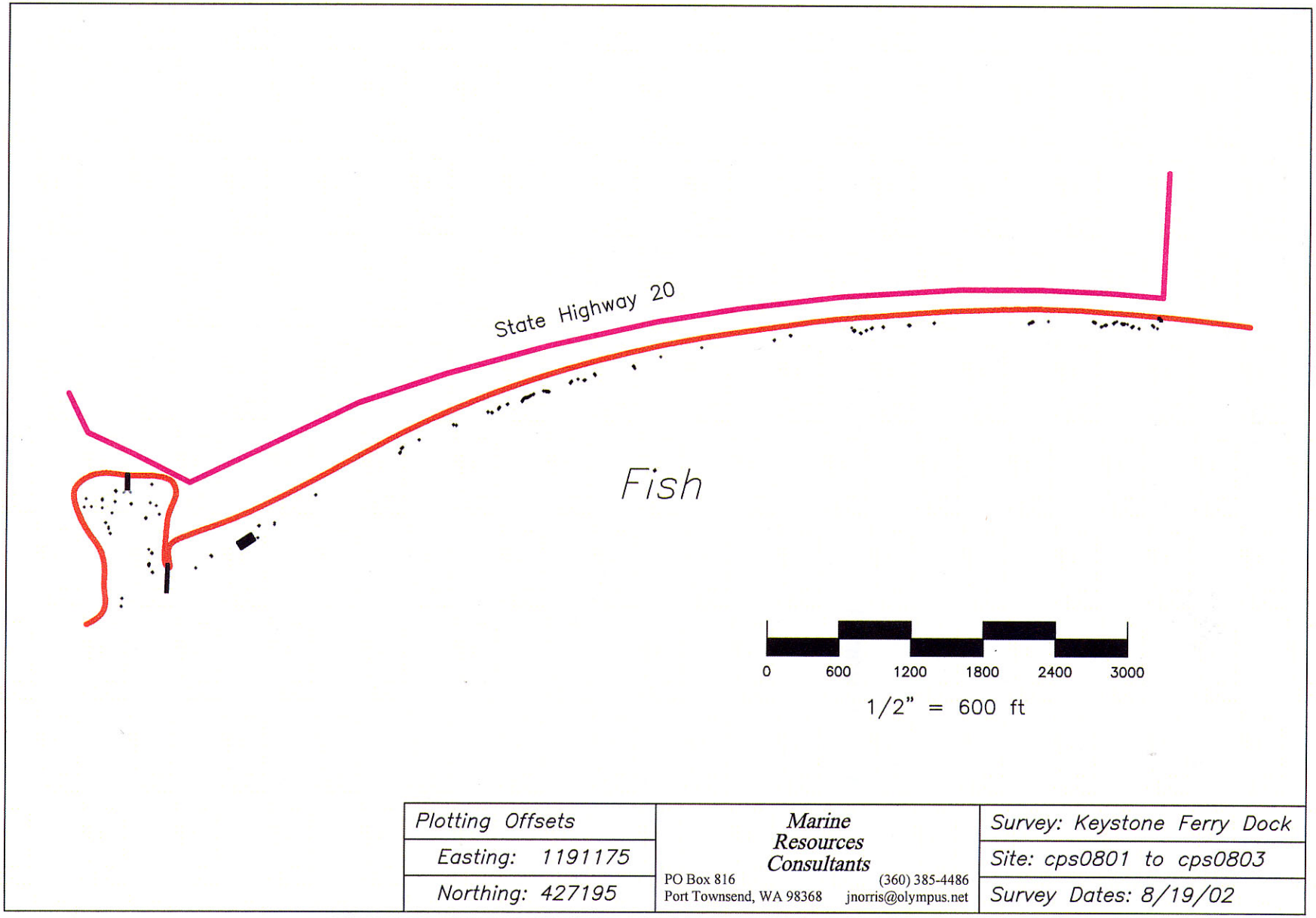


Figure A-6. Location of fish (dark blue) observations during the August 19, 2002 underwater videographic survey at the Keystone Ferry Terminal relocation study area.

APPENDIX B

AutoCad Maps of the Existing Ferry Terminal Basin

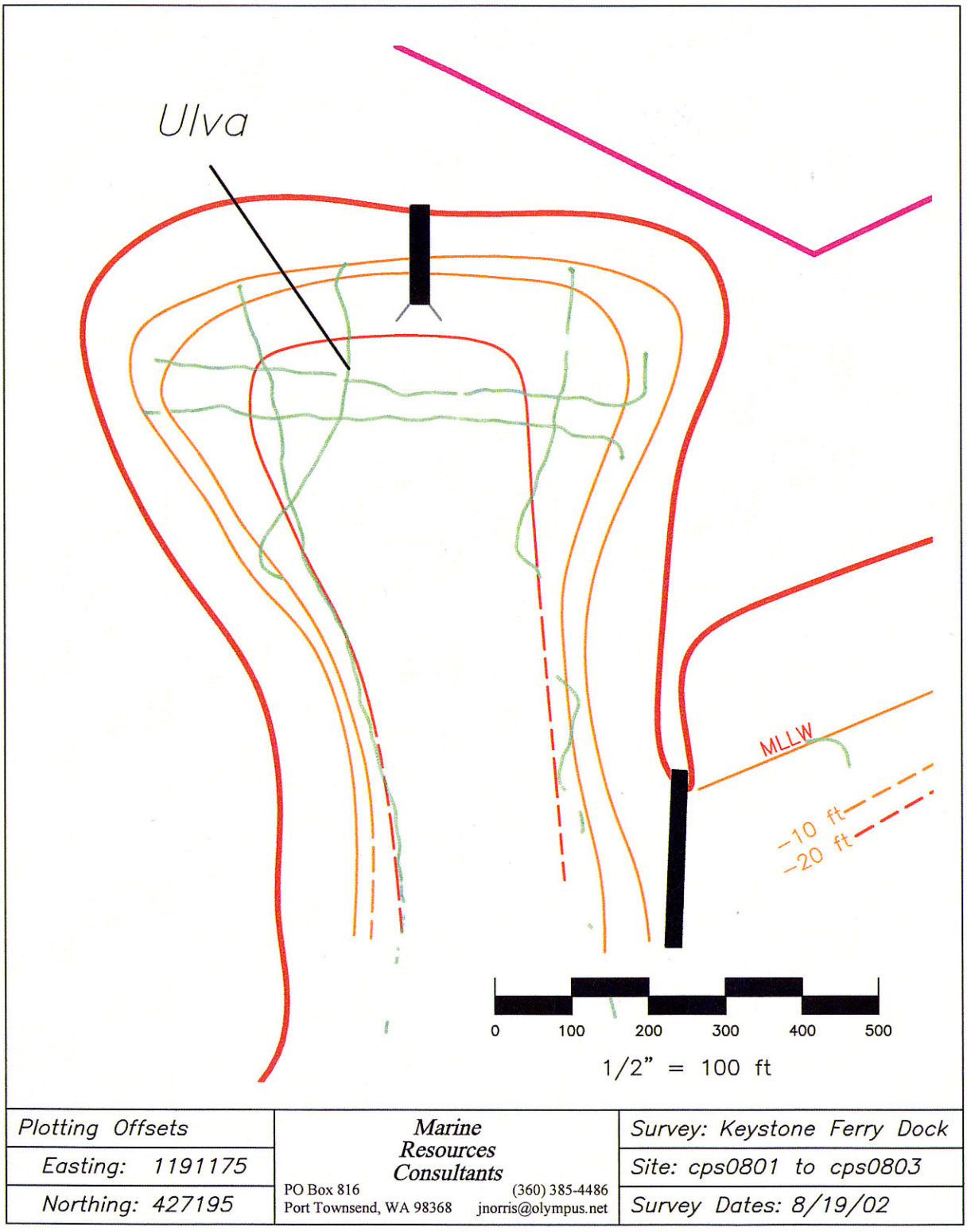


Figure B-1. Location of *Ulva* (sp) observations in the existing ferry terminal basin during the August 19, 2002 underwater videographic survey at the Keystone Ferry Terminal.

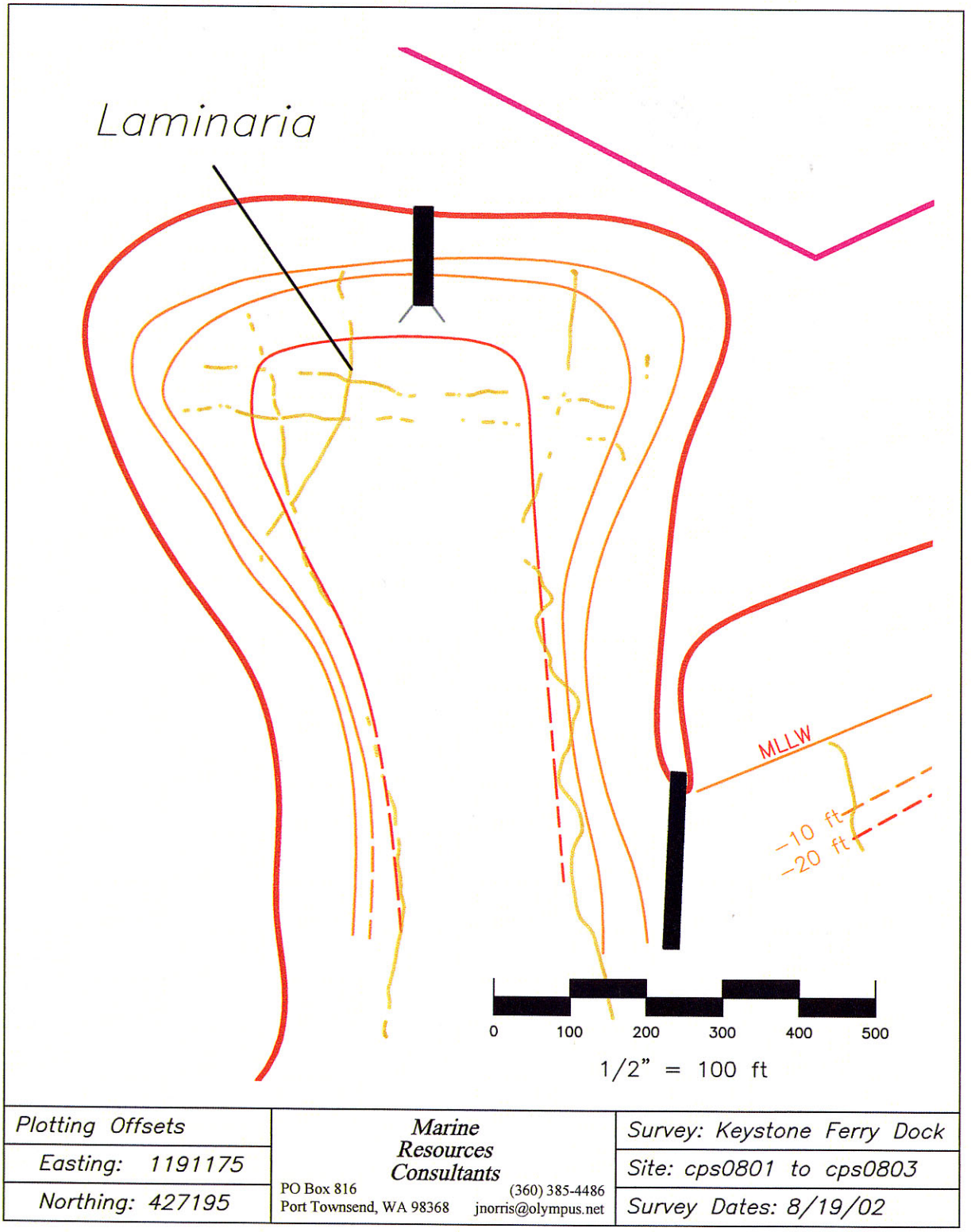


Figure B-2. Location of *Laminaria* (sp) observations in the existing ferry terminal basin during the August 19, 2002 underwater videographic survey at the Keystone Ferry Terminal.

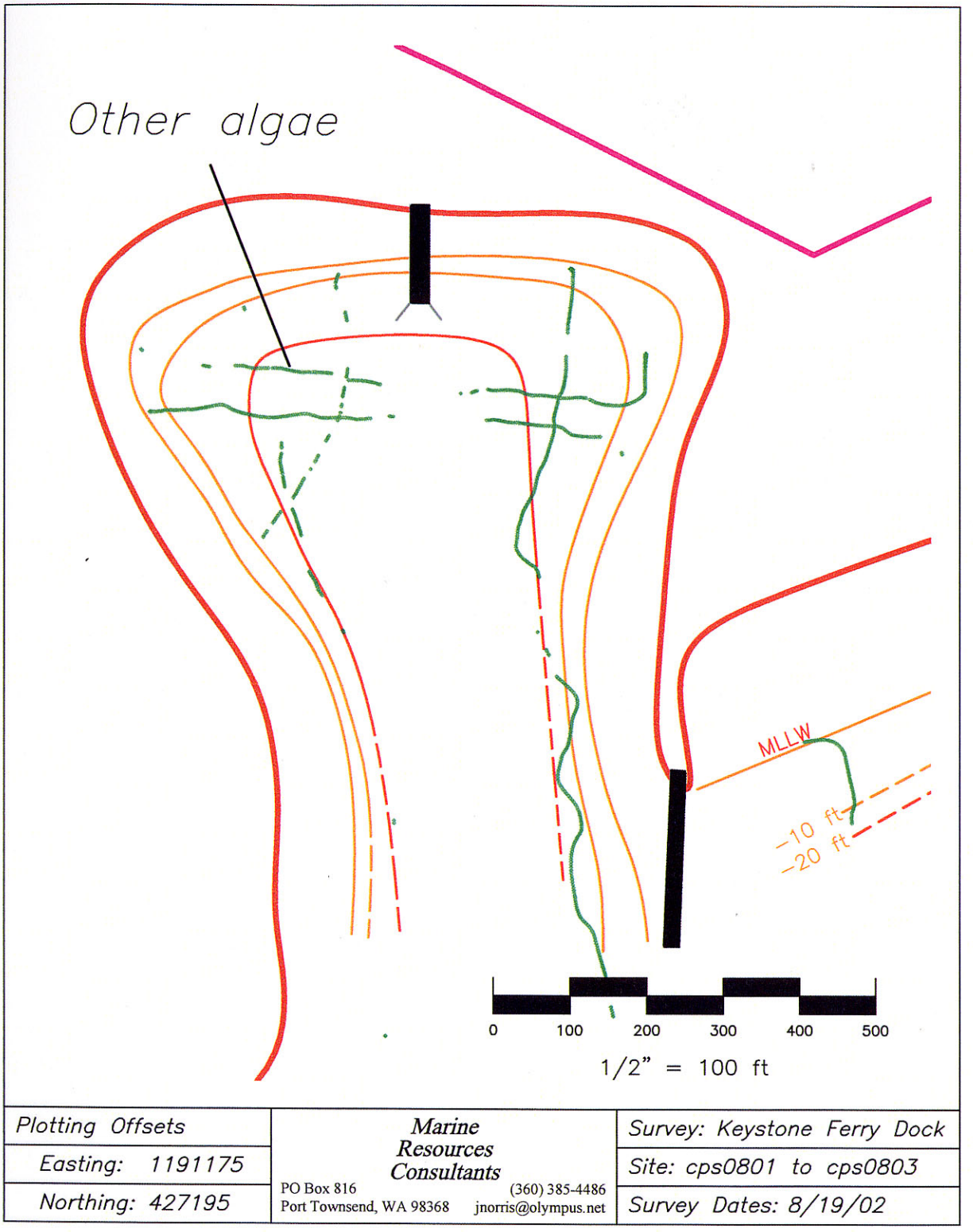


Figure B-3. Location of other macro algae observations in the existing ferry terminal basin during the August 19, 2002 underwater videographic survey at the Keystone Ferry Terminal.

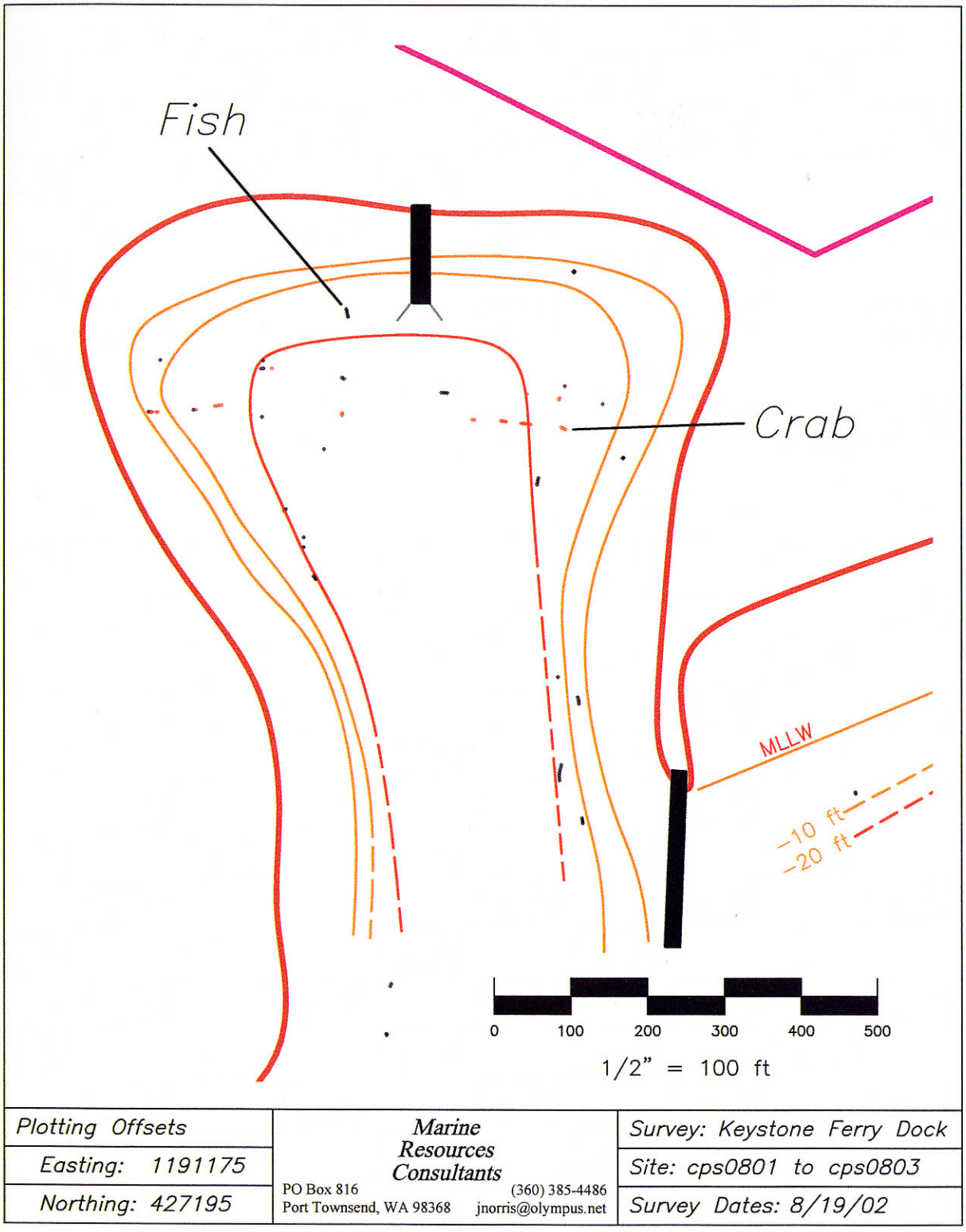


Figure B-4. Location of fish and crab observations in the existing ferry terminal basin during the August 19, 2002 underwater videographic survey at the Keystone Ferry Terminal.

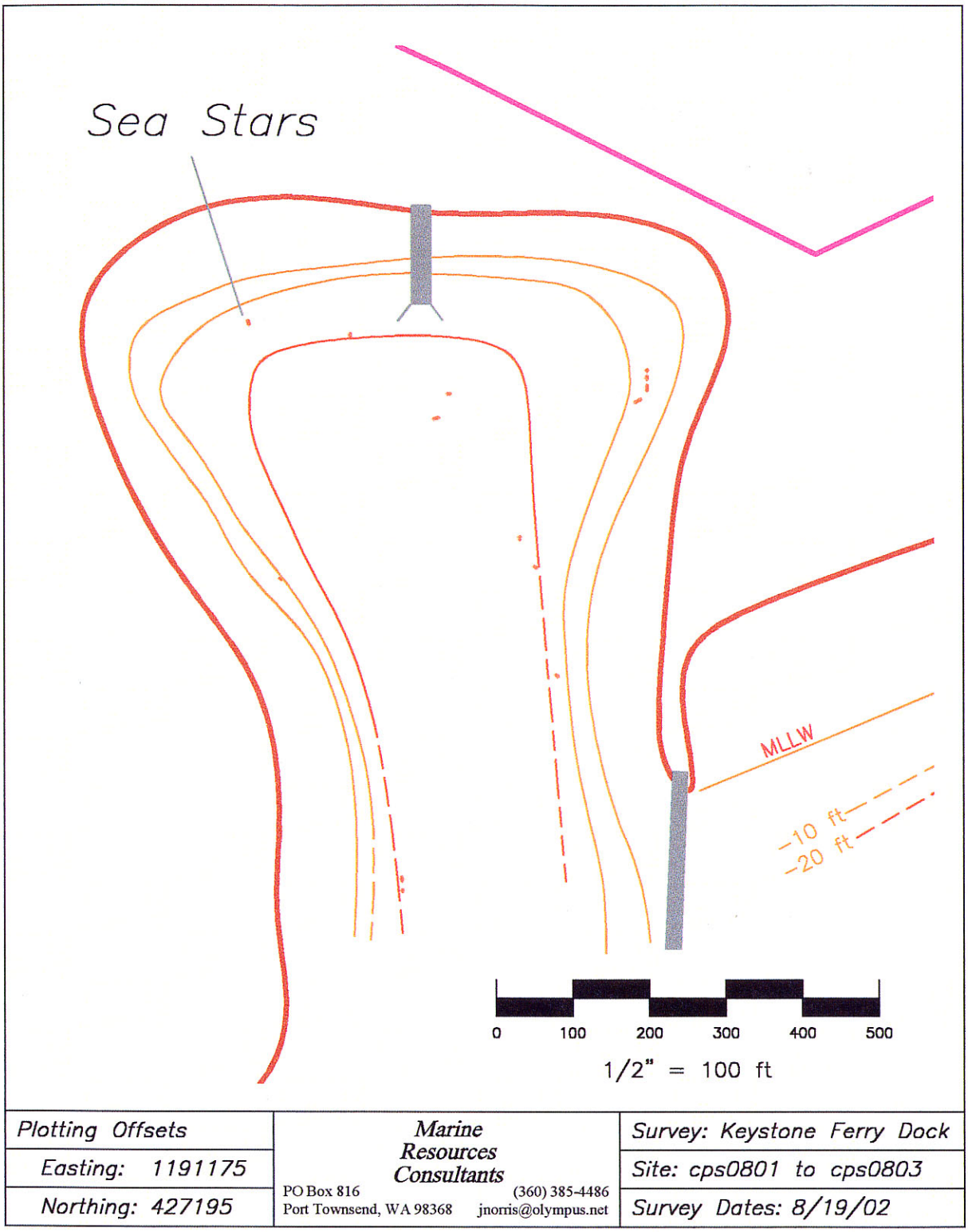
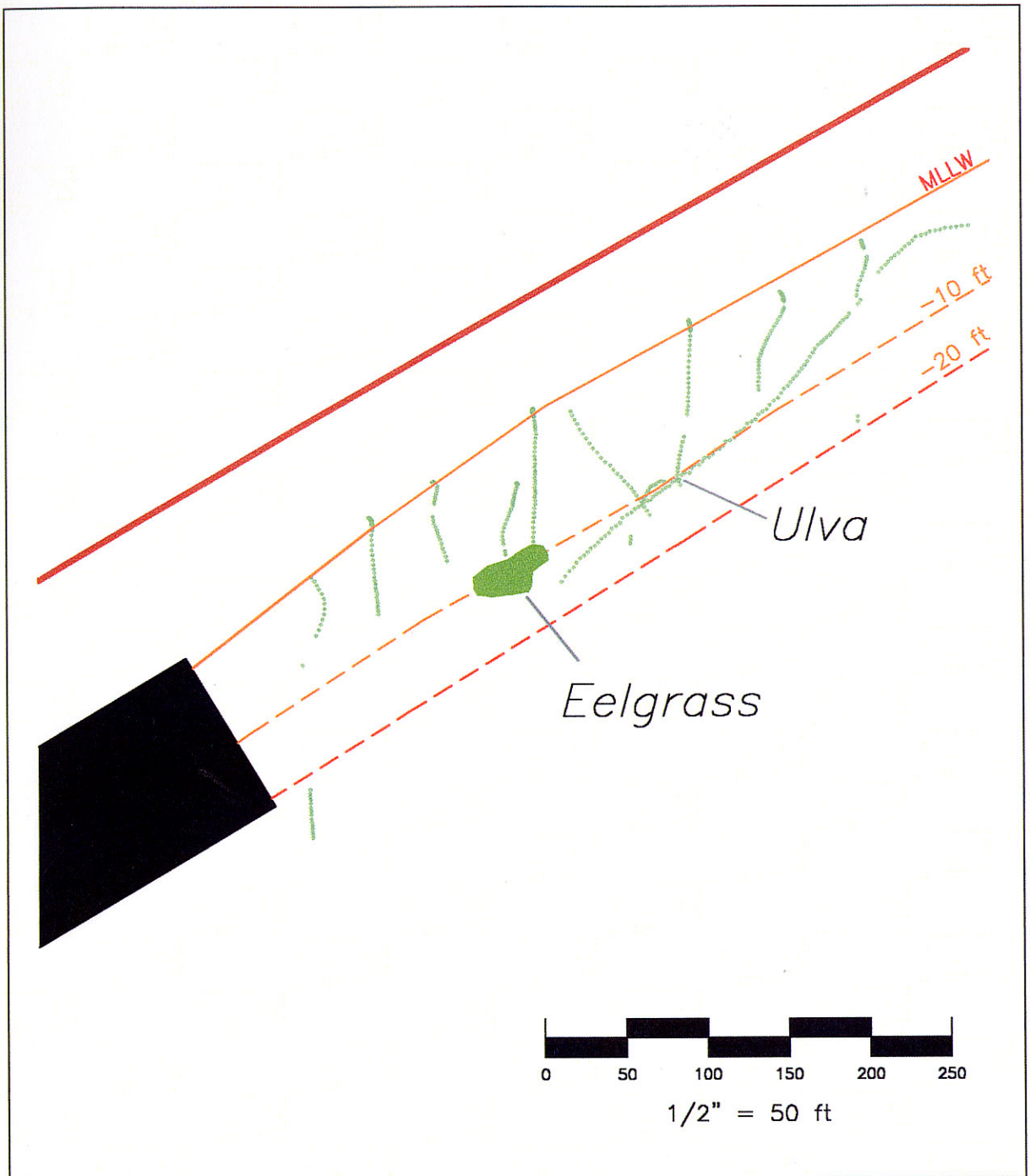


Figure B-5. Location of sea star observations in the existing ferry terminal basin during the August 19, 2002 underwater videographic survey at the Keystone Ferry Terminal.

APPENDIX C

AutoCad Maps of the West Relocation Option



Plotting Offsets	Marine Resources Consultants	Survey: Keystone Ferry Dock
Easting: 1191175		Site: cps0801 to cps0803
Northing: 427195	PO Box 816 (360) 385-4486 Port Townsend, WA 98368 jnorris@olympus.net	Survey Dates: 8/19/02

Figure C-1. Location of eelgrass and *Ulva* (sp) observations in the west relocation option during the August 19, 2002 underwater videographic survey at the Keystone Ferry Terminal.

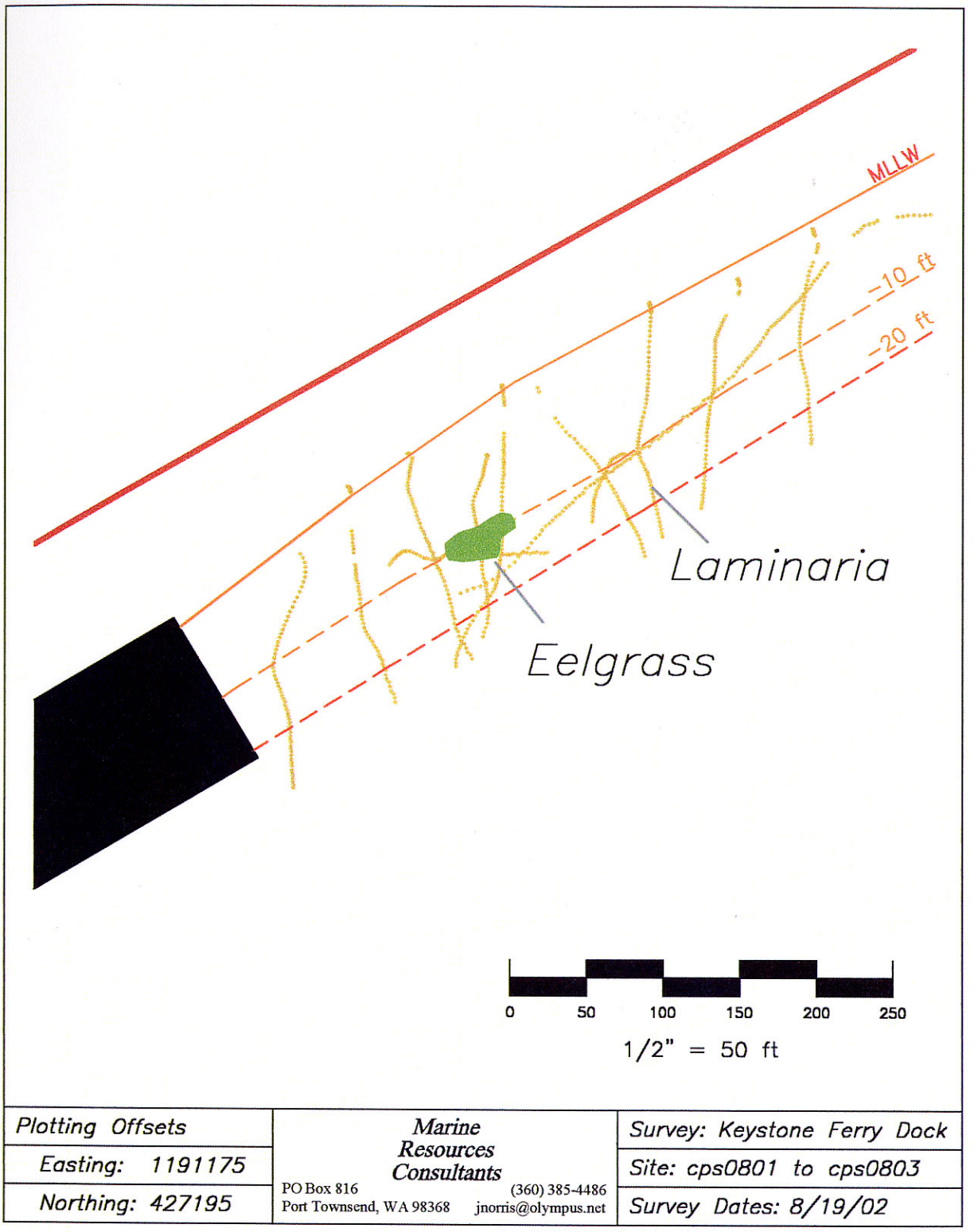


Figure C-2. Location of eelgrass and *Laminaria* (sp) observations in the west relocation option during the August 19, 2002 underwater videographic survey at the Keystone Ferry Terminal.

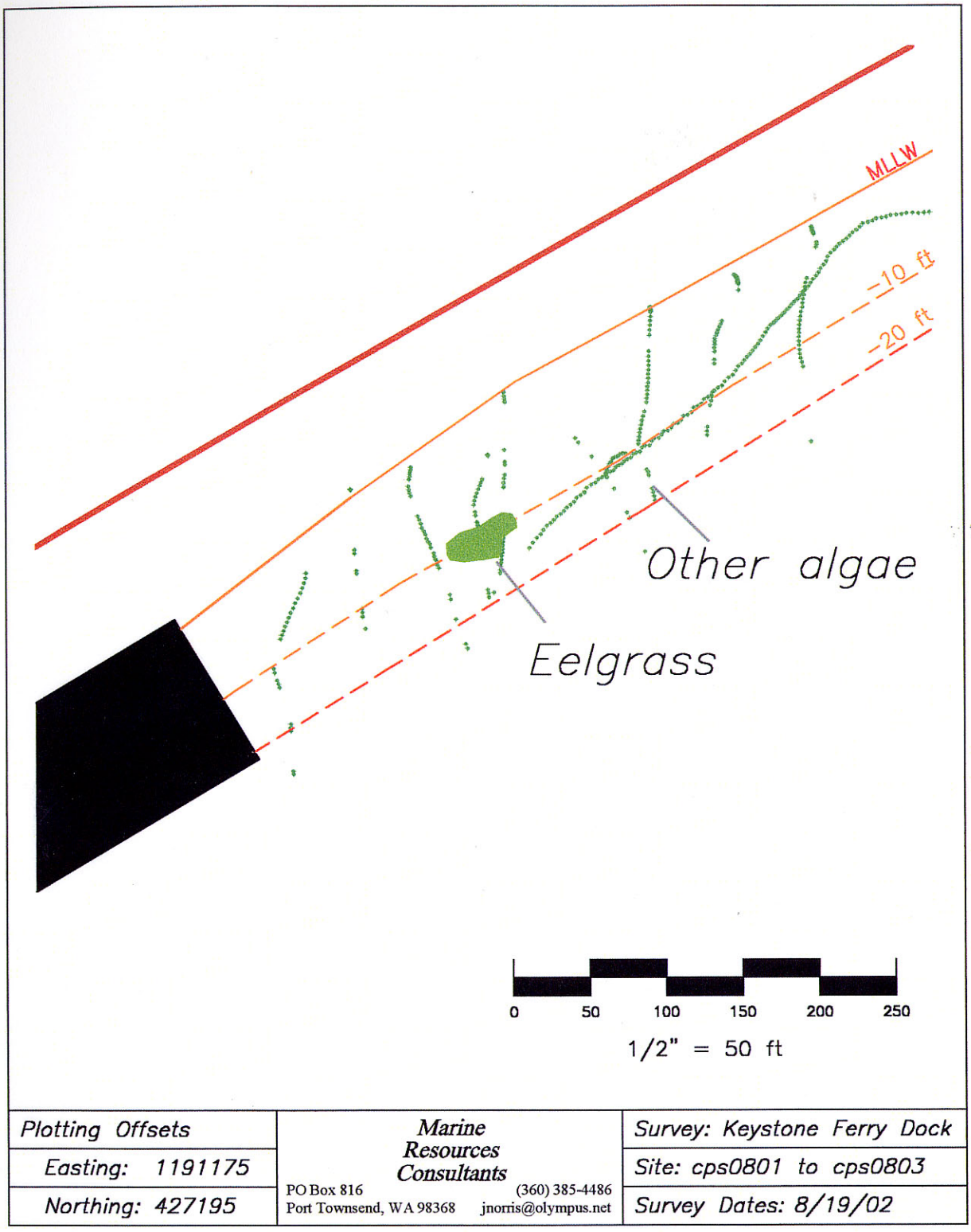


Figure C-3. Location of eelgrass and other macro algae observations in the west relocation option during the August 19, 2002 underwater videographic survey at the Keystone Ferry Terminal.

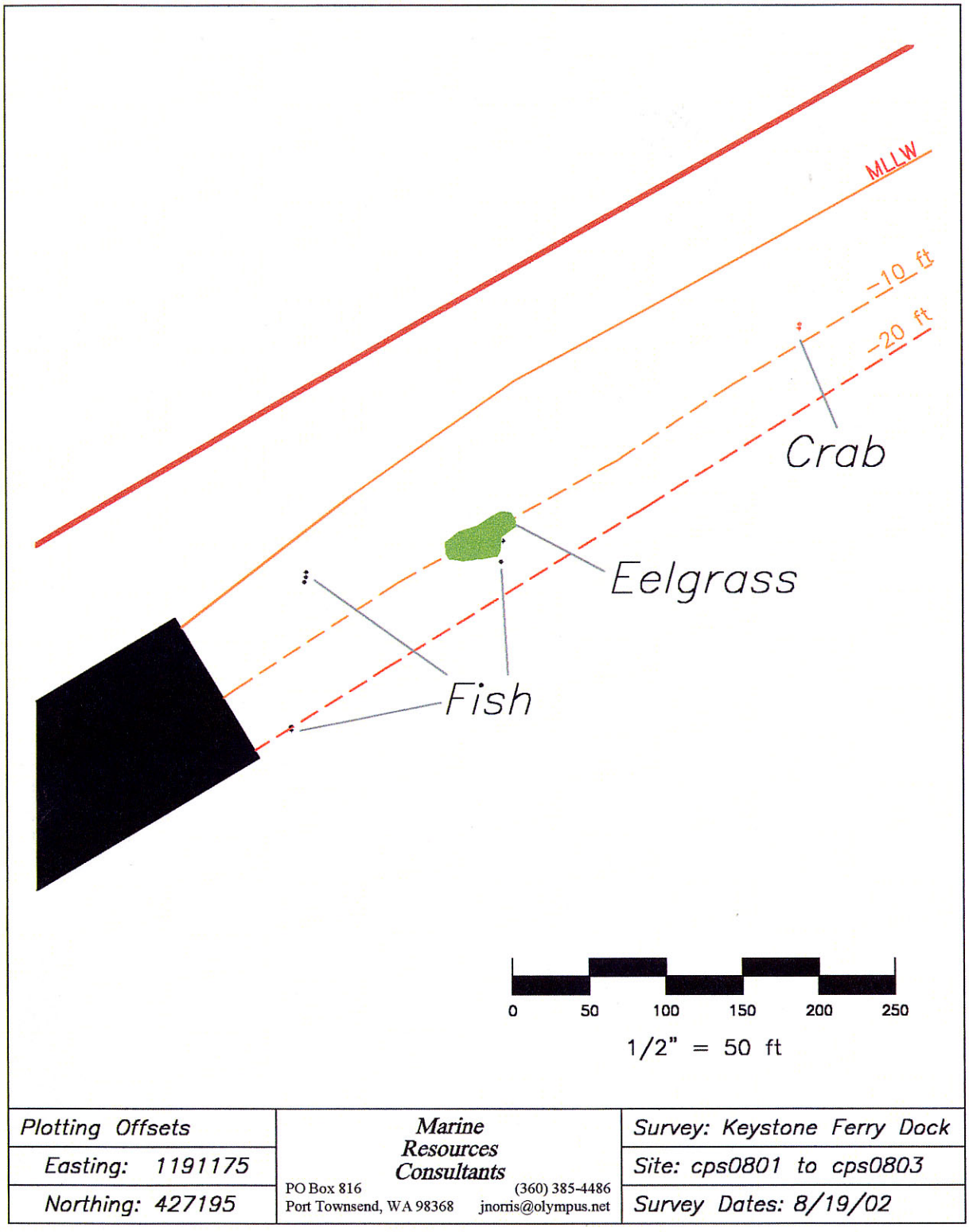


Figure C-4. Location of eelgrass and fish and crab observations in the west relocation option during the August 19, 2002 underwater videographic survey at the Keystone Ferry Terminal.

APPENDIX D

AutoCad Maps of the East Relocation Option

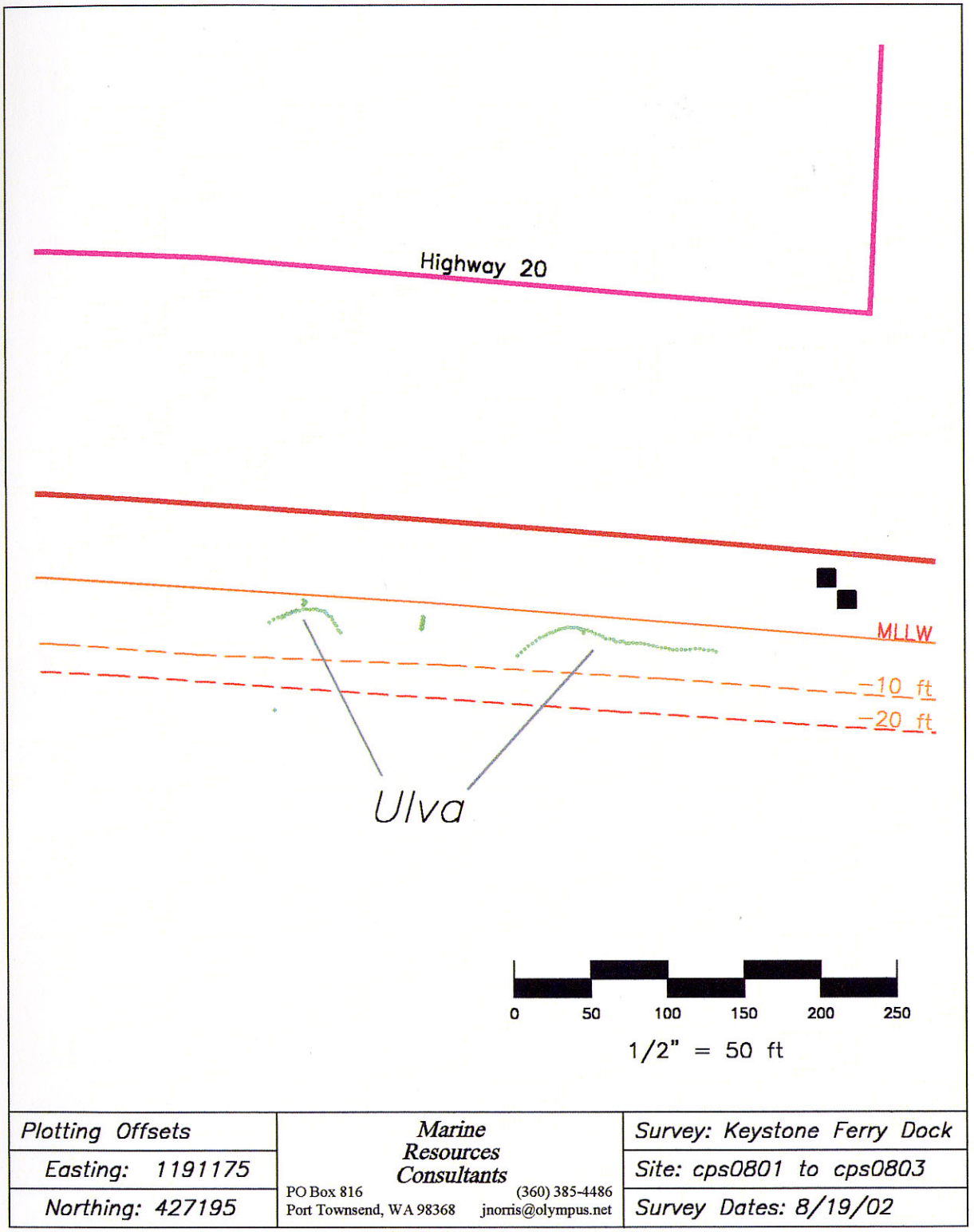
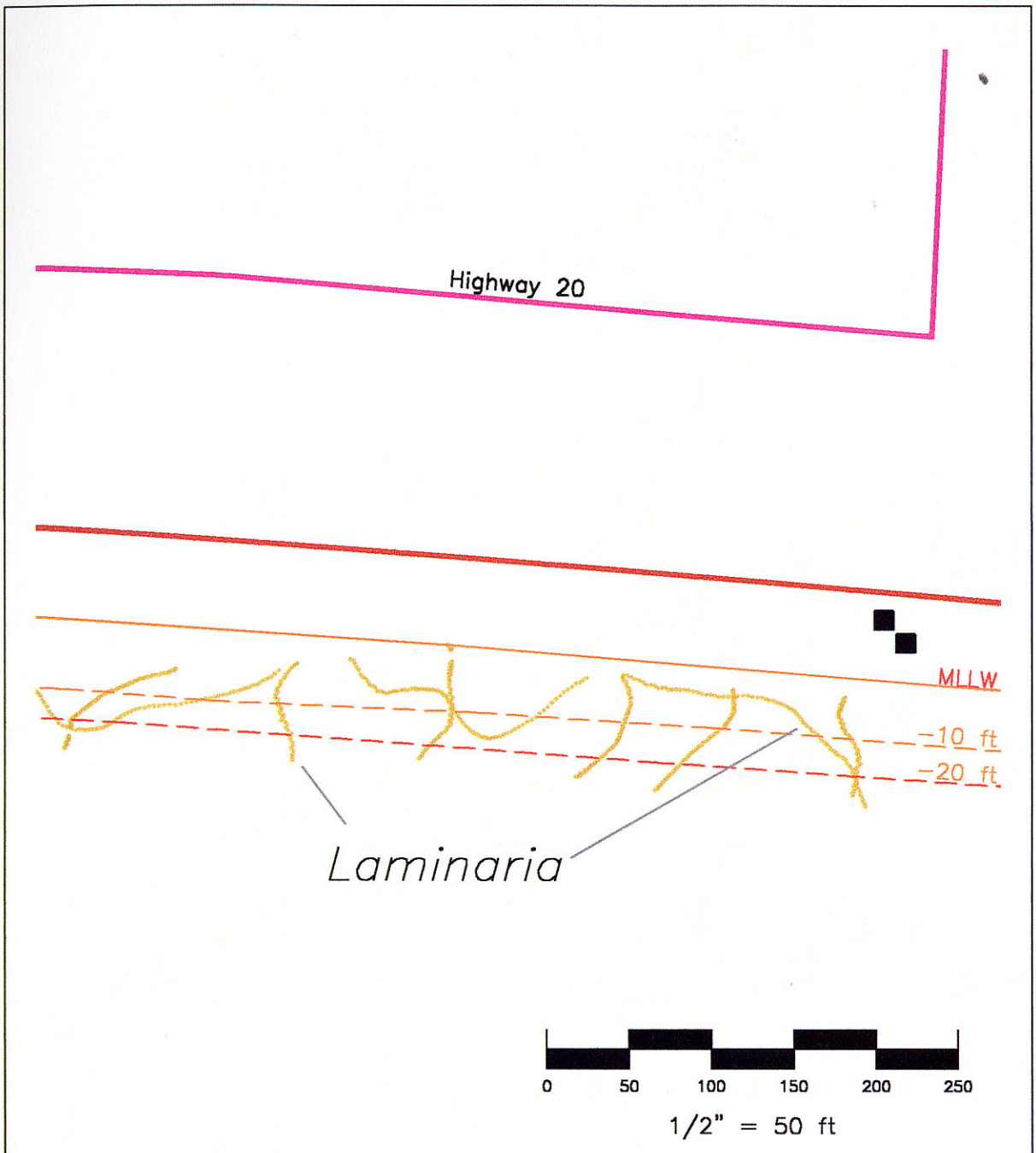


Figure D-1. Location of *Ulva* (sp) observations in the east relocation option during the August 19, 2002 underwater videographic survey at the Keystone Ferry Terminal.



Plotting Offsets	Marine Resources Consultants	Survey: Keystone Ferry Dock
Easting: 1191175		Site: cps0801 to cps0803
Northing: 427195	PO Box 816 (360) 385-4486 Port Townsend, WA 98368 jnorris@olympus.net	Survey Dates: 8/19/02

Figure D-2. Location of *Laminaria* (sp) observations in the east relocation option during the August 19, 2002 underwater videographic survey at the Keystone Ferry Terminal.

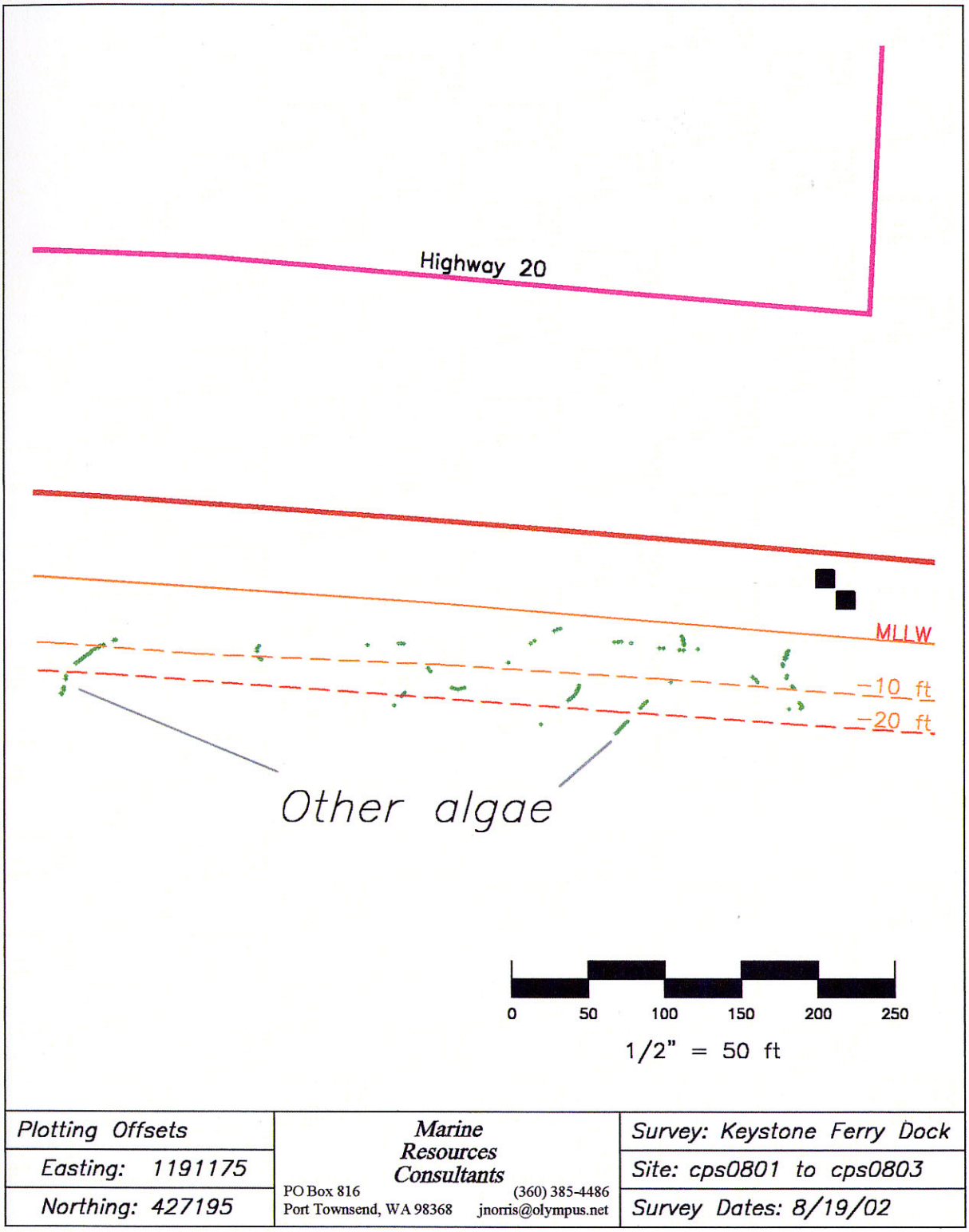
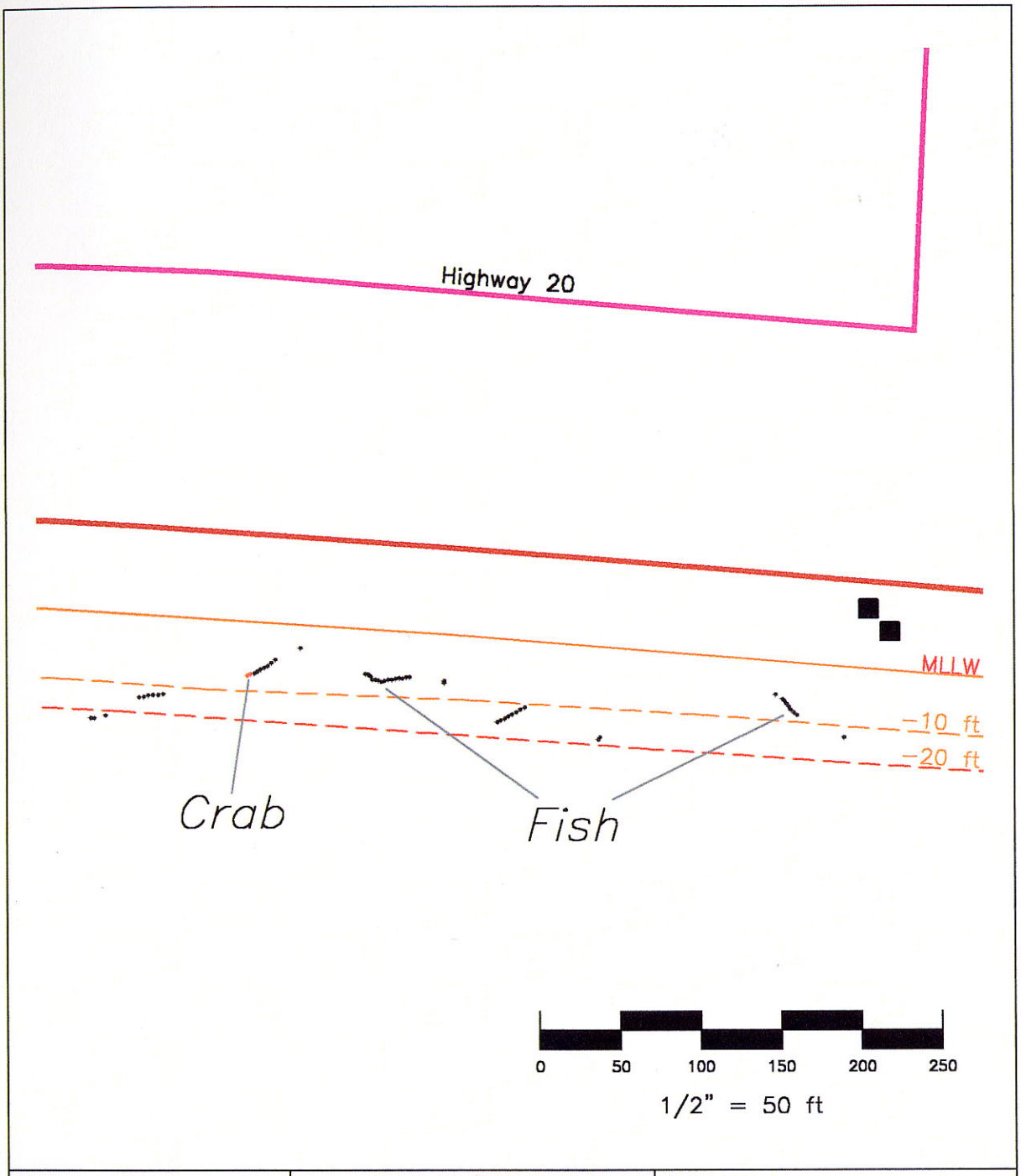


Figure D-3. Location of other macro algae observations in the east relocation option during the August 19, 2002 underwater videographic survey at the Keystone Ferry Terminal.



Plotting Offsets	Marine Resources Consultants	Survey: Keystone Ferry Dock
Easting: 1191175		Site: cps0801 to cps0803
Northing: 427195	PO Box 816 (360) 385-4486 Port Townsend, WA 98368 jnorris@olympus.net	Survey Dates: 8/19/02

Figure D-4. Location of fish (dark blue) and crab (red) observations in the east relocation option during the August 19, 2002 underwater videographic survey at the Keystone Ferry Terminal.