Pre-Remedial Design Investigation Project Plans – Habitat Survey

R.G. Haley Site
Bellingham, Washington

for

City of Bellingham

November 27, 2018

GeoEngineers
Earth Science + Technology

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Bellingham, Washington

File No. 0356-114-08

November 27, 2018

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Table of Contents

LIST OF FIGURES

APPENDICES

ABBREVIATIONS AND ACRONYMS

AO	Agreed Order
City	City of Bellingham
Ecology	Washington State Department of Ecology
GeoEngineers	GeoEngineers, Inc.
GIS	graphical information system
GPS	global positioning system
H/V	horizontal to vertical
Haley	R.G. Haley International Corp
HASP	Health and Safety Plan
JHA	Job Hazard Analysis
m^2	square meter
MLLW	mean lower low water
MTCA	Model Toxics Control Act
NAVD88	North American Vertical Datum of 1988
OHWM	ordinary high water mark
PRDI	Pre-Remedial Design Investigation
PVC	polyvinyl chloride
RCW	Revised Code of Washington
SCUBA	self-contained breathing apparatus
SSS	side-scan sonar
Site	R.G Haley Site
TEE	Terrestrial Ecological Evaluation
USACE	United States Army Corps of Engineers
WAC	Washington Administrative Code
WDFW	Washington Department of Fish and Wildlife

1.0 INTRODUCTION

A Pre-Remedial Design Investigation (PRDI) is planned at the R.G. Haley Site (Site) to obtain additional habitat survey data to support design and permitting of the Site cleanup action. The general location of the Site, south of the downtown business district in Bellingham, Washington, is shown on Figure 1. Wood products for commercial use were treated with pentachlorophenol between approximately 1948 and 1985. The Site is being cleaned up pursuant to requirements of the Washington State Model Toxics Control Act (MTCA), Chapter 70.105D of the Revised Code of Washington (RCW) and Chapter 173-340 of the Washington State Administrative Code (WAC). Site cleanup will be conducted under Agreed Order (AO) No. DE 15776, (Ecology 2018a) between the Washington State Department of Ecology (Ecology) and the City of Bellingham (City).

The AO for the Site requires developing PRDI Project Plans to obtain additional Site information as needed to address remaining data gaps and inform subsequent engineering analysis and design efforts. This document describes habitat surveys that will be completed to update and supplement prior assessments, and document current conditions to support design and permitting of site cleanup actions.

The planned habitat survey activities are summarized after discussions of Site background information (Section 2.0) and previous Site habitat surveys (Section 3.0). The survey plan is based on GeoEngineers experience with habitat surveys, discussions with Deborah Shafer and Randel Perry from the United States Army Corps of Engineers (USACE) and the current USACE requirements for eelgrass delineation and characterization reporting are presented in Appendix A.

2.0 GENERAL SITE DESCRIPTION

The R.G. Haley International Corp (Haley) wood treatment facility was formerly located at the foot of a steep bluff on the eastern shore of Bellingham Bay (Figure 1). The wood treatment facility operated in an upland, filled area adjacent to Bellingham Bay. The Site is subdivided into two units that are separated by the ordinary high water mark (OHWM). The Upland Unit boundary is based on existing Remedial Investigation data, although that data does not fully delineate the extent of all site contaminants. The Upland Unit boundary would be further evaluated in the future as a separate action. The upland portion of the Site (Upland Unit) is currently fenced and vacant. A vertical sheet pile barrier is present along a portion of the shoreline. The shoreline is covered with armoring, sparse vegetation, gravel and debris. Remnant timber pilings and debris associated with former overwater structures remain in the intertidal zone.

The offshore portion of the Site (Marine Unit) includes shoreline, intertidal, and deeper subtidal waters at distances up to about 1,000 feet westward into Bellingham Bay. The intertidal zone extends roughly 80 to 100 feet seaward from the shoreline into Bellingham Bay, from approximately elevation +10 feet to -4 feet (North American Vertical Datum of 1988 [NAVD88]). Below the shoreline bank, the intertidal zone generally slopes at 10 feet horizontal to 1 foot vertical (10H:1V) on the southern portion of the Site and 5H:1V on the northern portion of the Site. The subtidal zone extends from elevation -4 feet into deeper water below about -25 feet. The bathymetry of the shallow subtidal zone, from approximately elevation -4 feet to -15 feet is relatively steep and generally slopes from about 5H:1V to 6H:1V until reaching deeper water where the slope becomes less steep about 300 feet west of the shoreline bank.

Historical land uses at or near the Site included railroad activities, lumber mill operations, wood treatment and storage, disposal of municipal waste at the Cornwall Avenue Landfill, and pulp and paper mill activities.

Upland and in-water areas are impacted by contaminant releases from the former wood-treating operations. Fill beneath the Site includes wood waste from historical mill operations and construction debris.

3.0 2012 HABITAT SURVEY SUMMARIES

GeoEngineers, Inc. (GeoEngineers) completed habitat surveys at the Haley Site in 2012 to support previous phases of work. The marine habitat surveys were used to document existing conditions for permitting of supplemental sediment investigations at the Site and to avoid eelgrass and other valued habitats during sediment sampling. A terrestrial habitat survey was also performed in 2012 to develop a conceptual site model for the MTCA Site Terrestrial Ecological Evaluation (TEE). Results of these surveys were documented in the Remedial Investigation.

3.1. Eelgrass/Macroalgae Habitat Survey

GeoEngineers biologists conducted a benthic habitat survey of eelgrass and macroalgae at the Site in September 2012. The primary goal of the survey was to identify the locations and extent of eelgrass at the Site. The survey was conducted using side-scan sonar (SSS) and divers using self-contained underwater breathing apparatus (SCUBA) equipment. Visual observations of eelgrass locations and densities were made both during the SCUBA dive survey and from shore during low tide.

The 2012 survey identified multiple patches of eelgrass at the Site, with eelgrass distributed in shallow subtidal areas between approximate Elevations -2 to -12 feet NAVD88. Eelgrass density ranged between 60 and 120 turions per square meter. The survey identified the eelgrass distribution extending generally parallel to the eastern shoreline of the site and present as patches along approximately 50 percent of the shoreline. The SSS and SCUBA dive surveys conducted by GeoEngineers biologists identified multiple patches of eelgrass within the subtidal zone totaling an estimated 11,665 square feet (0.27 acres) with moderate to high densities.

3.2. Shoreline/Intertidal Habitat Survey

A GeoEngineers biologist conducted a shoreline and intertidal habitat survey during low tides in June 2012 along 10 transects extending from approximately Elevations +10 to -2 feet NAVD88. Along each transect, data were collected regarding the presence/absence and cover of substrate, macroalgae, invertebrates and other habitat features.

3.3. Marine Shoreline Riparian/Terrestrial Survey

The terrestrial survey involved visually evaluating upland areas for soils/impervious groundcover, vegetation, wildlife and signs of wildlife use (e.g., nests, scat, tracks, tree rubbings or scratches, droppings, food remains, feathers, carcasses), in order to develop a conceptual site model for the TEE.

4.0 METHODS FOR UPDATED HABITAT SURVEYS

These described methods are the current applicable approach based on recent input from USACE. These proposed methods were transmitted to Randel Perry and Deborah Shafer, both with USACE, for preliminary review in a memorandum (GeoEngineers 2018). We received a response on November 13, 2018 from Randel Perry via email stating that "the plan is acceptable for our purposes." (Perry 2018).

4.1. Eelgrass/Macroalgae Survey

The updated eelgrass and macroalgae habitat survey will utilize some of the established methodology presented in the latest methods specified in the USACE Technical Guidance “Components of a Complete Eelgrass Delineation Report” (USACE 2018; Appendix A). Survey methods described below will be a combination of USACE Tier 1 surveys, intended for identifying the boundaries and spatial distribution of the eelgrass beds (USACE 2018), and previously published technical guidance and procedures (Tier 2 surveys) intended to provide a high level of quantitative data on eelgrass bed distribution and density within the area of potential impact (USACE 2016). Survey methods will also conform with the substantive requirements of the Washington Department of Fish and Wildlife (WDFW) Eelgrass/Macroalgae Habitat Interim Survey Guidelines (WDFW 2008). The location of the survey and proposed transects, as described below, are shown on Figure 2.

The survey will be conducted using a combination of SSS and divers. Underwater video may also be used for additional documentation depending on visibility at the time of survey. The SSS survey will be conducted within the side-scan sonar assessment area shown on Figure 2. Eelgrass bed boundary locations, eelgrass shoot densities, and species determinations will be made by divers via SCUBA dive survey and from shore during low tide. Preliminary eelgrass bed boundaries and extent of eelgrass beds will be estimated via SSS and divers will identify the boundary and collect density and eelgrass/macroalgae species information.

4.2. Preliminary Determination of Eelgrass Bed Boundaries and Extent (Side-Scan Sonar)

The SSS is an in-water imaging system that uses an acoustic oblique image similar to an aerial photograph. The SSS in conjunction with a global positioning system (GPS) and data reduction software produces a georeferenced image that is built up of objects on the sea floor. Using SSS results in a high-resolution image of bottom texture that allows for the interpretation of vegetated bottom areas and speciation can then be verified visually by divers.

4.2.1. Equipment

Equipment necessary to acquire the SSS imagery:

- Vessel
- Independent Trimble PRO XH with NIMA string out at 9600 baud GPS
- EdgeTec 4125: Ultra High-Resolution duel frequency sidescan sonar imaging unit (towfish)
- EdgeTech’s Discover acquisition software loaded on a Lenovo laptop computer
- Leraand Engineering Inc. Sonar TRX data reduction software

4.2.2. Proposed Track Lines

Track lines are planned vessel paths across a site. The area imaged on either side of the track line is called a swath. The width of a swath is determined by the angle of the sonar within the towfish, the depth that the towfish is towed, and the bottom depth. Track lines are designed so that there is approximately 50 percent overlap of associated swaths. This high percentage of overlap is required to image the narrow area directly below the towfish (nadir), which the towfish does not have the ability to “see”.

4.2.3. Calibration

Calibration of the SSS will be done by performing a patch test. The patch test consisted of running the SSS over a known submerged target twice in opposite directions. The data from the Patch Test will then be compared for positional accuracy and image calibration. The patch test will also allow for fine tuning of the swath width of the towfish. Positional accuracy for the purposes of this survey will be approximately +/- 1 foot between the patch test swaths. Towfish frequency, swath width, and ping rate (rate of sonar pulse transmission in "pings per second") used in the survey will be 400 and 900 kHz with a swath width of 30 meters and a ping rate of 20 pings per second. This combination yields a sonar resolution of 0.3 feet (3.3 pings per foot).

4.2.4. Planning

The number of swaths necessary for 100 percent coverage of the project area with greater than 50 percent of overlap will be determined following the patch test at the time of survey. We anticipate that swaths 40 feet apart will produce the needed overlap in the imaging similar to GeoEngineers' first eelgrass survey in 2012 that utilized the SSS technology.

4.2.5. Data Processing and Interpretation

The process of combining all sonar files into a composite image is known as 'mosaicing' and is performed by specialized software. Distortions of data induced by fluctuations in vessel speed and tow depth are corrected at this time. Mosaics can be considered as images and are dereferenced raster image formats satiable for use within a graphical information system (GIS) format. Classification and interpretation of the images will be done by GeoEngineers using an image truthing methodology. Areas of potential eelgrass identified during the survey will be visually observed from the surface vessel at low tide and by divers during density counts.

4.3. Eelgrass Boundary Delineation, Density Counts and Eelgrass/Macroalgae Species Information

We have separated the study area into three distinct areas for transect surveys. The three areas have different sizes, shapes and distributions of beds, based on previously collected macrovegetation survey data in this area (Hart Crowser 2016; GeoEngineers 2015; Landau 2015; Anchor QEA 2010). Maps of previous eelgrass surveys conducted in the vicinity are included in Attachment B. The three distinct areas for transect surveys are shown on Figure 2.

In addition to the dive survey methods described below, a low tide beach survey will be conducted to delineate the upper edge of the bed. This will increase our accuracy and calibration and add another level of detail regarding the boundaries for assessment of areal coverage within the project area.

Below is a summary of proposed transects within anticipated areas of eelgrass based on an eelgrass survey conducted at the site by GeoEngineers in 2012 (GeoEngineers 2015) and other eelgrass surveys completed in the vicinity (Hart Crowser 2016; Landau 2015; Anchor QEA 2010). Final transect locations and numbers will be determined after reviewing results of the SSS survey. All patchy areas of eelgrass will be surveyed by divers along transects 16 feet on center and perpendicular to shore, while large and consistent patches of eelgrass will be surveyed by divers along transects 30 feet on center and perpendicular to shore (Figure 2).

If, during the SSS survey, eelgrass beds are identified outside of the anticipated areas of eelgrass, transects will be extended or more transects will be added to conduct boundary delineations, density counts and species assessments within those beds. Transects will cover the full extent of the eelgrass beds during the time of survey.

4.3.1. Area 1

This narrow bed is located at the southern end of the project area along the eastern shoreline. This bed was included in the 2012 GeoEngineers survey and the shape of the eelgrass bed mapped in 2012 matches current aerial imagery. Based on these available data, the bed seems to be relatively unchanged over a period of many years.

Method for determining shoot density within this area includes:

- Shoot density will be assessed along perpendicular transects within the bed. These transects will be spaced 30-feet apart. Since the bed is approximately 700-feet long, approximately 25 transects are proposed within Area 1. The final location and number of transect(s) within Area 1 will be determined after the SSS survey results are reviewed, in case areas of eelgrass have expanded or shifted since prior surveys.
- To guide the divers, a tape will be installed parallel to shore within the center of the bed. This tape will allow the divers to identify each transect as they swim the 30-foot spaced perpendicular transects. Additional tapes may be installed along some of the perpendicular transects if visibility is poor or conditions make navigation difficult. Along each perpendicular transect, the pair of divers will collect shoot density via a 0.25 square meter (m^2) polyvinyl chloride (PVC) quadrat.
- We propose a total of 50 shoot density counts within Area 1, which is approximately 2 shoot density counts per transect, or a shoot count every 30 feet.
- For each quadrat sample location, native eelgrass (*Z. marina*) shoot density (number of native eelgrass shoots present in the quadrat sampling frame) will be recorded. The 0.25m^2 sample quadrats density counts will be converted to numbers of shoots per square meter during post-processing of the data.
- For non-native eelgrass (*Z. japonica*) or macroalgae, estimates of percent cover (0; 1 to 10; 11 to 25; 26 to 50; and greater than 50 percent cover) may be recorded in lieu of shoot density for each quadrat sample.
- The field form for each transect will be reviewed upon completion of the transect to verify that all field observations have been recorded and documented in the field form and/or associated notes prior to completion of this survey area.

4.3.2. Area 2

This area is located waterward of the pocket beach which is a depositional area for fine grain material. This area was identified as patchy habitat during the 2012 eelgrass survey. Additional surveys done by Anchor QEA (2009) also map eelgrass in this area. Current aerial imagery indicates that the eelgrass in this area is patchy. Due to the patchy nature of this eelgrass habitat, this area will require a fine level of review since eelgrass in this area seems to be dynamic and changing overtime.

An initial assessment of this bed will be done via SSS to identify extent of this patchy habitat and verify the location of transects. Our proposed method for boundary delineations, density counts and species assessments in this area will be through diver-based transects running perpendicular to shore. The proposed spacing for these transects is 16 feet apart and covering the extent of the anticipated patchy eelgrass area (Figure 2) resulting in approximately 21 transects, ranging from approximately 75 to 250 feet long. A pair of divers will swim transects and count densities every 30 feet with a $0.25m^2$ PVC quad, with a shoot density for each patch. This will result in approximately 112 density quad counts within Area 2. Actual location and number of transects within Area 2 will be determined after the SSS survey results are reviewed.

4.3.3. Area 3

This area was not included in the 2012 GeoEngineers eelgrass survey, but was assessed by Anchor QEA (2009) and Hart Crowser (2016) as part of eelgrass surveys for other projects in this vicinity. These surveys found a consistent and approximately 100-foot wide bed of eelgrass along the shore. Since this area has not been recently surveyed, we are suggesting a combination of divers and SSS/video to determine density and boundaries. Boundary delineations, density counts and species assessments will be conducted by a pair of divers along perpendicular transects 30-feet apart. A tape will be installed within the center of the bed prior to the density assessment to help guide the divers on the location of their 30-foot spaced transects. Based on the approximate extent of the eelgrass within this area, we assume 14 transects within Area 3. These transects are shown on Figure 2.

The location of these proposed transects are based on the recent aerial imagery of the eelgrass bed and past eelgrass surveys within the vicinity. We propose 42 shoot density counts within Area 3, which is approximately 3 density counts per transect, or one every 40 feet of dive transect. Similar to the other areas, density will be assessed using a $0.25m^2$ PVC quadrat. Actual location and number of transects within Area 3 will be determined after the SSS survey results are reviewed.

4.4. Shoreline and Intertidal Habitat Survey Methods

The intertidal and terrestrial/marine riparian habitat assessments will be updated for the PRDI using the same methods as used in 2012 to document Site changes since that time. For the survey update, the 10 upper intertidal transects from 2012 will be resurveyed by foot at low tide. The updated data will be compared to 2012 to understand changes at the site and characterize current habitat conditions and types within these areas.

4.5. Marine Shoreline Riparian/Terrestrial Survey

The updated marine shoreline riparian/terrestrial survey will involve visually evaluating upland areas for soils/impervious groundcover, vegetation, wildlife and signs of wildlife use. General habitats/vegetation communities will be mapped to document baseline habitat conditions.

5.0 HEALTH AND SAFETY

Health and safety requirements will be described in a Dive-Specific Health and Safety Plan (HASP) and Job Hazard Analysis (JHA) documents to be prepared prior to the field work. An additional JHA will be developed for the nearshore and upland portion of the habitat surveys.

6.0 REPORTING

The eelgrass/macroalgae habitat survey data will be compiled to develop eelgrass habitat distribution maps using the SSS data and the shoot density counts taken in the field. The map will show the following:

- Boundaries of the project area and project footprint; and north arrow
- Depth contours (datum NAVD88, mean lower low water [MLLW] = -0.48 feet) at intervals of 1 foot, based on bathymetric survey by Wilson Engineering, LLC in August of 2015
- Scale and measures of distance along the axis of the transects
- Locations of all sample transects and sampling stations
- Locations of the boundaries of *Z. marina* and *Z. japonica* (if present) eelgrass beds, including tidal elevations
- Maps of each eelgrass survey area depicting locations of density count sampling stations and results of density counts

In addition to the maps of eelgrass habitat distribution within the project area described above, the report will also include the scanned data sheets with the information collected on each transect, and a summary of the tidal elevation ranges within which the eelgrass beds were observed to occur, based on the information collected on the survey transects.

This eelgrass/macroalgae habitat summary, along with the shoreline and intertidal habitat and shoreline riparian/terrestrial survey results and associated field records, will be packaged for inclusion as appendices to the Engineering Design Report, and as needed for preparing permit applications.

7.0 SCHEDULE

The intertidal and eelgrass/macroalgae surveys will be performed during low tides between June 1 and October 1, 2019, to capture the most current Site conditions to support development of permit applications anticipated for subsequent submittal and noting that eelgrass surveys are valid for one year. The terrestrial/marine shoreline riparian habitat survey is planned to be conducted between June 15 and July 31, 2019.

8.0 REFERENCES

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Washington Department of Fish and Wildlife (WDFW) (2008). Eelgrass/Macroalgae Habitat Interim Survey Guidelines. Olympia, Washington. Revised June 16, 2008.

FIGURES

N
Project North
W E
S

2,000 0 2,000
Feet

Reference: Whatcom County GIS, City of Bellingham GIS, Aerial from Esri, 2017.

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. can not guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.
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Projection: NAD 1983 UTM Zone 10N

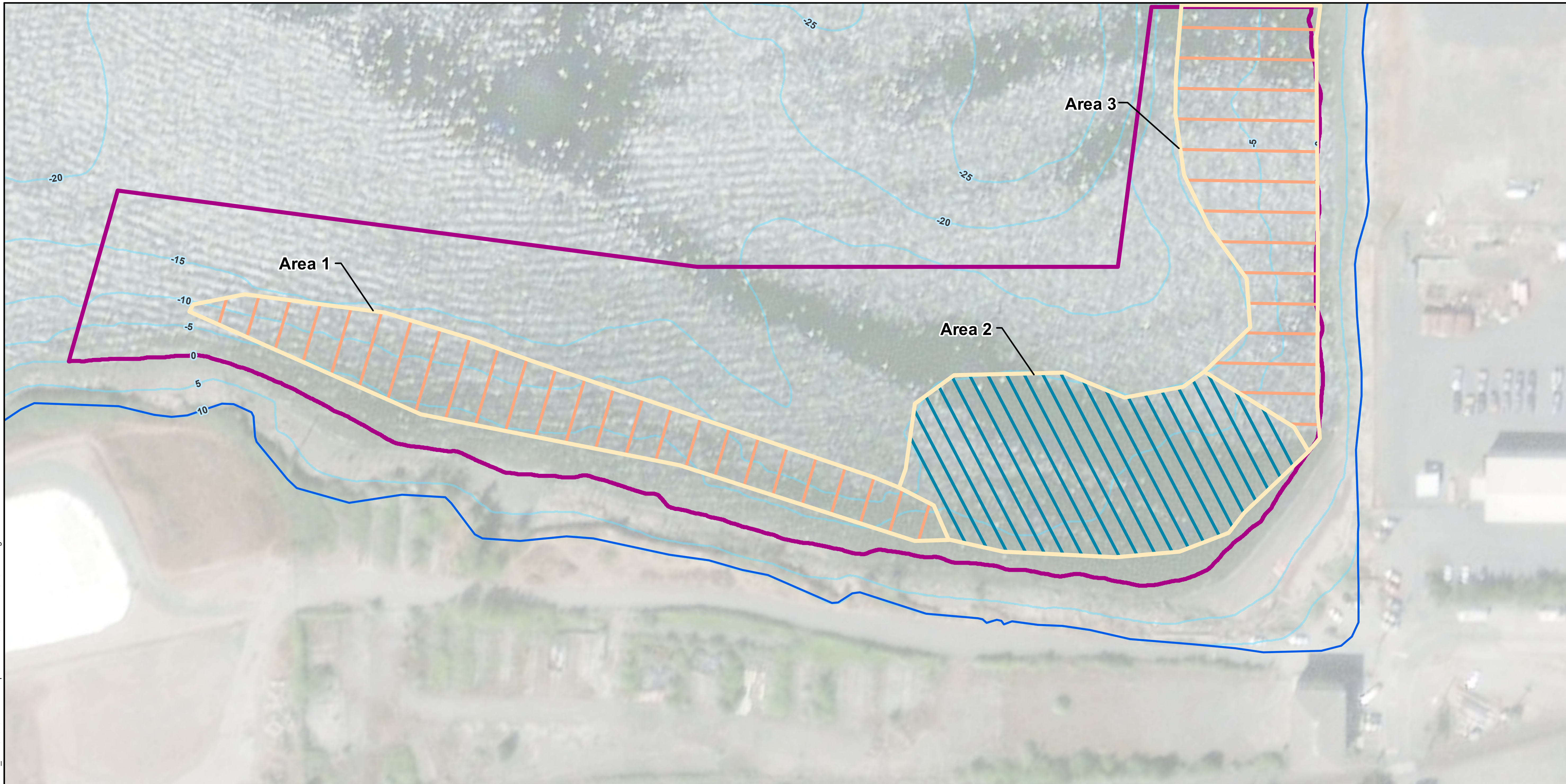
Vicinity Map

R.G. Haley Site
Bellingham, Washington

GeoEngineers

Figure 1

Path: P:\0\0356114\GIS\MXDs\Fig_1-1_VicinityMap.mxd Map Revised: 19 November 2018 maugust



True North
Project North
0 50 100
Feet

Bathymetric Contour (5-ft interval)
Proposed Dive Transect, 16-feet apart
Proposed Dive Transect, 30-feet apart
Side-scan Sonar Assessment Area
Anticipated Areas of Eelgrass (from 2012 GeoEngineers eelgrass survey)
OHWM

Reference: Aerial from Google Earth, August 2011.
Contour elevation displayed is referenced to
NAVD88 vertical datum.

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.
3. If eelgrass beds are identified outside of the anticipated areas of eelgrass, transects will be extended or more transects will be added to conduct density and species assessments within those beds.

Proposed Eelgrass and Macroalgae Survey Transects

R.G. Haley Site
Bellingham, Washington

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Figure 2

Path: P:\0\0356114\GIS\MXDs\035611406_Fig02_Macrovegetation_rev102018.mxd Map Revised: 26 October 2018 maugust

APPENDICES

APPENDIX A

Components of a Complete Eelgrass Delineation Report, U.S. Army Corps of Engineers, 2018

COMPONENTS OF A COMPLETE EELGRASS DELINEATION REPORT

January 9, 2018

CONTENTS

PREFACE

This document was developed by Dr. Deborah Shafer Nelson, U.S. Army Engineer Research and Development Center at the request of the Seattle District and Headquarters, U.S. Army Corps of Engineers, with funding provided through the Wetlands Regulatory Assistance Program.

Dr. Nelson is presently a biologist with Seattle District.

PURPOSE

This document provides technical guidelines and procedures for identifying and delineating eelgrass beds (*Zostera* spp.), which are a type of special aquatic site under Section 404 of the Clean Water Act (33 U.S.C. 1344). Eelgrass beds may also be affected by activities requiring permits under Section 10 of the Rivers and Harbors Act of 1899 (33 U.S.C. 403). It has been developed to assist applicants and/or their consultants within the geographic area covered by the Seattle District U. S. Army Corps of Engineers when a delineation of an eelgrass bed is requested to evaluate proposed work within marine and estuarine waters. Note: This document was developed for eelgrass; however, we encourage the user to document other marine plant species, such as kelp, as that information may be required for the overall characterization of the project site. Also, although these guidelines are specifically for eelgrass, they may be applicable for other types of seagrasses that occur in Washington, such as surfgrasses (*Phyllospadix* spp.).

QUALIFICATIONS

Eelgrass bed delineations should be performed by someone who has demonstrated the ability to identify eelgrass species present within the project area, and conduct ecological surveys.

TIMING

Eelgrass delineations should be conducted during periods when above-ground leaves and shoots are present in sufficient quantities to be readily observable: June 1 through October 1.

Within eelgrass habitat, eelgrass is normally expected to fluctuate in density and patch extent; eelgrass can expand, contract, disappear, and re-colonize areas within suitable environments based on prevailing environmental factors (e.g., turbidity, freshwater flows, wave and current energy, bioturbation, temperature, etc.). Eelgrass bed boundaries on the Pacific coast can expand by an average of 5 meters (m) and contract by an average of 4 m annually (Washington Department of Natural Resources 2012).

Because of the potential for substantial interannual changes in the locations of the eelgrass bed boundaries, delineation results should be submitted with a permit application within one year of the delineation having been conducted. If it has been more than 1 year but less than 3 years since the delineation was performed, we recommend the mapped boundaries of the eelgrass beds be re-verified prior to submitting your permit application to ensure they have not changed. If more than 3 years have elapsed since the last eelgrass bed delineation, a new complete eelgrass delineation survey should be conducted prior to submitting the permit application.

OVERVIEW OF EELGRASS SURVEY TYPES

This document describes the procedures for the Preliminary Eelgrass Survey and Tier 1 Eelgrass Delineation Survey. In areas where there is a reasonable expectation for suitable eelgrass habitat (e.g. appropriate depth and substrate) to occur in the project vicinity, a Preliminary Survey may be used to support a statement regarding the absence of eelgrass at the project site. For those projects that intend to avoid work in eelgrass beds, a Tier 1 Delineation Survey may be used to identify the boundaries and spatial distribution of the eelgrass beds, in relationship to tidal elevation(s), and the proposed project footprint.

PRELIMINARY SURVEY

A non-quantitative Preliminary Survey may be used to support a statement regarding the absence of eelgrass at the site. This method should be used when there is reasonable expectation for eelgrass habitat to occur in the project vicinity. These areas could include waterbodies where eelgrass is present in the vicinity, the appropriate substrate is present, there was a historical presence, etc. The Preliminary Survey involves using an organized, systematic method to document the absence of eelgrass across the entire project area using a series of photographic images.

An acceptable methodology would be a series of photographs of the substrate taken while walking or wading at low tide. Transects or grid sampling patterns are commonly used to ensure complete coverage of the site, but other sample patterns (e.g., random) may be considered.

Sample points for the photographic documentation should be selected to be representative of the entire project area so as to clearly show the absence of eelgrass. Particular emphasis should be placed on any areas that appear to be occupied by submerged aquatic vegetation of any type, because it is often not possible to reliably distinguish between various species of seagrass and macroalgae from a photograph. Photos of the ground showing the substrate(s) present are the most helpful, since eelgrass typically grows only in certain substrates. Landscape type photos are generally not sufficient.

A Preliminary Survey report should include a figure or map of the project area showing the locations of each of the individual photographic sample points labeled with a GPS coordinate along with individual photos of the ground taken at each sample point.

There could be some situations where the absence of eelgrass could be documented without walking or wading the site. Low altitude, high resolution aerial imagery collected by unmanned aerial vehicle (UAV) is becoming more commonly available. This is an acceptable methodology for collecting photographs. If the aerial photographs reveal the presence of any areas that appear to be occupied by submerged aquatic vegetation of any type (i.e. green in color), on-ground photographs should be collected to verify the identification of the vegetation.

If eelgrass is known to be present within the project area, or if a Preliminary Survey reveals the presence of eelgrass beds, follow the procedures outlined below to conduct an eelgrass delineation.

DEFINING AND DELINEATING EELGRASS BED BOUNDARIES

The uppermost boundaries of seagrass growth are controlled by desiccation and temperature stress (Boese et al. 2005), but can also be locally influenced by activities such as shellfish harvest and reflective energy from shoreline armoring (Short and Wyllie-Echeverria 1996). The lower boundary, or maximum depth of seagrass growth, can be directly related to the submarine light environment (Duarte 1991). Within these limits, seagrass bed patterns range from continuous or semi-continuous over hundreds of meters to patchy distributions with patches ranging in size from a meter to tens of meters in the longest dimension (Fonseca and Bell 1998).

Potential native eelgrass (*Zostera marina*) habitat in the Pacific Northwest may be classified as either fringe or flats based on its geomorphic setting (Berry et al. 2003). Fringe *Z. marina* habitats are areas with relatively linear shorelines where potential *Z. marina* habitat is limited to a narrow band by water depth. Identification of eelgrass bed boundaries in fringe sites is relatively straightforward. Flats *Z. marina* sites are shallow embayments with extensive broad shallows that have little slope within the vegetated zones. Eelgrass beds in flats sites can be highly fragmented and very dynamic on both spatial and temporal scales. Bed patchiness increases with increasing wave exposure and tidal current speed. For more information on the influence of landscape setting and physical exposure on eelgrass bed configuration, see Appendix A.

If the eelgrass bed is composed of many individual patches, which each meet the definition of an eelgrass bed, and the distance between adjacent patches is 16 feet (5 meters) or less, then it is not necessary to delineate each individual patch. Considerable time savings can be achieved by mapping the outer limits or boundaries of patchy eelgrass habitat and describing them as a patchy bed rather than attempting to delineate and map each individual patch. In the context of this document, patchy eelgrass habitat area includes the cumulative area of the individual patches, including any areas between patches that are less than 16 feet (5 meters) apart. See examples in Appendix B.

In areas where there are too few eelgrass shoots to meet the bed thresholds described below, the survey map should indicate that there are a few isolated eelgrass shoots present, with no discernable beds.

Use one of the two following methods to identify eelgrass habitat and delineate native eelgrass (*Z. marina*) bed boundaries[1]. Although the two methods are slightly different, in practice the results of eelgrass bed delineations done with either method were found to be similar.

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[1] Some in-water activities require an un-vegetated buffer around existing eelgrass beds (e.g. programmatic Endangered Species Act consultations, or a proposed mitigation plan). In these cases, the appropriate buffer should be included in maps/drawings. See Figure B1 in Appendix B for example. Once the bed edge is identified using either Method A or B, an un-vegetated buffer zone around the edge of each bed should be included on plan views or maps. Un-vegetated areas within this buffer zone may have eelgrass shoots a distance greater than 1 meter from another shoot and therefore not meet the definition of an eelgrass bed. The width of the un-vegetated buffer may vary by project type. Applicants should also be aware of local and state requirements for eelgrass surveys, as these may differ from the guidance presented here. Contact the District for more information.

Eelgrass Delineation Method A: An eelgrass bed is defined as a minimum of 3 shoots per 0.25 m^2 (1/4 square meter) within 1 meter of any adjacent shoots. To identify the bed boundary, proceed in a linear direction and find the last shoot that is within 1 meter of an adjacent shoot along that transect. The bed boundary (edge) is defined as the point 0.5 meter past that last shoot, in recognition of the average length of the roots and rhizomes extending from an individual shoot (Washington Dept. of Natural Resources (WADNR) 2012).

Eelgrass Delineation Method B: *The California Eelgrass Mitigation Policy and Implementing Guidelines* (NOAA Fisheries 2014) identify eelgrass bed edge as follows: any eelgrass within one square meter quadrat and within 1 meter of another shoot.

TIER 1 DELINEATION SURVEYS

The goal of a Tier 1 Delineation Survey is to identify the boundaries and spatial distribution of the eelgrass beds, in relationship to tidal elevation(s), and the proposed project footprint, in order to assist in avoidance of eelgrass beds.

Data Collection Methods

Sample intertidal sites by walking or wading during low tides. Divers may be needed to collect information at subtidal sites.

For very large sites, remote sensing methods such as aerial photography, underwater photography, or hydroacoustic surveys may be used instead of walking or wading the entire site to survey the boundaries of eelgrass beds. For more information on these methods, see the section on Eelgrass Survey and Mapping Methods. However, if remote sensing methods are used to prepare maps of eelgrass beds, select or limited ground-truth data should also be collected using walking, wading or diver surveys to verify the remotely sensed data. For ground-truth data collection, emphasis should be placed on data collection within those areas that appear to have submerged aquatic vegetation of any type, but the sampling effort should also include some areas that appear un-vegetated to verify whether eelgrass beds are absent.

Transect Layout

For linear projects (e. g. pipelines), establish a single transect aligned along the centerline of the proposed project footprint. Otherwise, establish a series of sample transects perpendicular to shore. In most cases, transects oriented perpendicular to shore are preferred over shore parallel transects because perpendicular transects are better suited to detecting and mapping the boundaries of submerged aquatic vegetation beds. However, if the boundary of the eelgrass bed is clearly visible, it may be more efficient to walk the boundary of the eelgrass bed in a shore parallel orientation, recording GPS coordinates of the bed boundary at intervals equivalent to the suggested transect spacing below (5-40 feet). For projects that are not adjacent to the shoreline (e.g., mooring buoys), orient transects relative to another physical reference, such as a channel boundary or depth gradient. Transects must also be referenced to a permanent feature at the site to ensure repeatability.

At sites where the eelgrass beds are smaller, with patchy or discontinuous distributions, sample transects should be closely spaced (5 to 15 feet). For sites containing relatively contiguous eelgrass beds, or for projects involving very large areas, transects spaced at intervals of 15 to 40 feet apart are appropriate. To start, at least one transect should be aligned along the proposed centerline of the project. Transects are then spaced at intervals starting from the centerline transect and continuing through the proposed project footprint. Locate additional transects 10 or 25 feet beyond the outer edges of the proposed project footprint. Transects should either extend to the deepest edge of the eelgrass bed, or at least 25 feet waterward beyond the project footprint, whichever is less.

There may be more than one eelgrass species present along each transect (e.g. an upper intertidal zone of continuous or patchy non-native dwarf eelgrass (*Zostera japonica*), a mid-intertidal bed of *Z. japonica* mixed with native eelgrass (*Z. marina*), a patchy or sparse *Z. marina* bed, and a dense or continuous *Z. marina* bed in the lower intertidal/subtidal zone) (see Appendix B for examples). Both eelgrass species may not be present at each site. Identification of the *Z. japonica* along each transect is necessary because of the potential for confusion and misidentification between the two *Zostera* species. For further information on how to distinguish *Z. marina* and *Z. japonica*, see Appendix C.

Along each transect, identify the locations of the upper and lower boundaries of the eelgrass beds or patches according to the instructions for either Method A or B. Because the bed edge is defined as the presence of eelgrass shoots within 1 meter of another eelgrass shoot, each transect should be roughly equivalent to a 2-meter wide belt transect (1 meter on each side of the centerline). Record the GPS coordinates, elevation (relative to mean lower low water (MLLW)), and distance along the transect for the upper and lower boundaries of each eelgrass bed as described above, if present.

Field Data Collection and Reporting
The following data should be recorded in the field and included in the survey report:

- Site name, sample date and time of day (start and finish); the name(s) of the person(s) conducting the survey; and whether Method A or Method B was used to delineate the eelgrass bed(s).

Preparation of Eelgrass Bed Maps
Prepare an eelgrass habitat distribution map using the GPS coordinates taken from the survey data. The map should include the following information:

- Boundaries of the project area and project footprint; and north arrow;
- Accurate depth contours (datum MLLW = 0.00 ft.) at intervals of 1 foot;
- Scale and measures of distance along the axis of the transects;
- Locations of all sample transects and sampling stations;
- Locations of the boundaries of *Z. marina* and *Z. japonica* (if present) eelgrass beds, including tidal elevations, and, if a buffer is proposed, the boundaries of the proposed buffer around bed edges.

If the individual patches of eelgrass are spaced less than 16 feet (5 meters) apart, it is not necessary to delineate each individual patch. Considerable time savings can be achieved by mapping the outer limits or boundaries of patchy eelgrass habitat and describing them as a patchy bed rather than attempting to delineate and map each individual patch. In the context of this document, patchy eelgrass habitat area includes the cumulative area of the individual patches, including any areas between patches that are less than 16 feet (5 meters) apart.

Reporting
In addition to the maps of eelgrass bed distribution within the project area described above, the report should also include the data sheets showing the information collected on each transect, and a summary of the tidal elevation ranges within which the eelgrass beds were observed to occur, based on the information collected on the survey transects.

For example:

+1-0' MLLW	Beds of mixed native (*Z. marina*) and non-native (*Z. japonica*) eelgrass species
+1-1' MLLW	Patchy beds of *Z. marina*
-1-5' MLLW	Continuous beds of *Z. marina*

EELGRASS DELINEATION AND MAPPING METHODS

Method 1: Walking or Wading
This method should be used if the site is intertidal. The shallow, or inshore, edge of the bed is usually clearly visible at low tide. At each site, establish a series of transect lines according to the guidelines provided in the previous sections. An observer with a handheld Geographic Positioning System (GPS) unit walks or wades along each transect and records the locations of boundaries of eelgrass beds, using either Method A or B for delineating the boundaries of the eelgrass beds. If the water is clear, the deep or offshore edge of the eelgrass bed may be visible with the naked eye from the boat or with the use of a bathyscope (underwater viewing box). GPS coordinates and water depth can be taken to track the deep edge of the bed.

Method 2: Snorkelers or Divers
If the water, even at low tide, does not allow observation of the bottom with the naked eye or a bathyscope from the boat, then use snorkelers or divers to identify the boundaries of eelgrass beds. Safety issues such as the potential for strong tidal currents in some areas should also be considered before using snorkelers or divers.

A series of buoys can be used to mark the deep edges of the eelgrass bed(s) to identify their locations. The scope, or length, of the line on the buoy needs to be minimized to the greatest extent possible to avoid inaccuracies due to buoys drifting away from their anchorage points. Having a large amount of scope on the line can lead to significant under/overestimate of actual eelgrass extent. Once the boundaries are marked with buoys, then a vessel can be maneuvered from buoy to buoy recording GPS coordinates.

Method 3: Underwater Photography
Underwater videography can be particularly useful for detecting and mapping the presence of eelgrass over large study areas that may be difficult to sample using more intensive methods

such as diver transects. At each site, establish a series of transect lines running perpendicular to the shoreline that begin just outside the boundaries of the proposed project area, making sure the transects cover the entire project area. Record underwater imagery along each transect and identify the locations of all visible eelgrass beds or patches. However, it may not always be possible to distinguish among Pacific Northwest seagrasses (e.g. *Z. marina*, *Z. japonica* and *Phyllospadix* spp.) (Berry et al. 2003). Where multiple seagrass species occur, perform the verification using Methods 1 or 2 above to verify species identification.

Method 4: Hydroacoustic Mapping
If the site is very large, hydroacoustic surveys may be considered as an alternative to the methods outlined above. Because detection and mapping of eelgrass using hydroacoustic equipment is not limited by water clarity, this method is particularly suitable for turbid water conditions; however, this method does have certain limitations[2]. Depending on the heterogeneity of the eelgrass beds, the size of the area, and the desired degree of survey resolution, transect spacing may vary from as little as 25 feet to more than 100 feet. However, ground-truthing using wading, divers, or underwater photography must be performed to verify the hydroacoustic mapping classifications. It should also be noted that this method is likely to underestimate the extent of the eelgrass beds, because the eelgrass bed boundaries as defined herein may be below the minimum detection thresholds of the hydroacoustic system.

Method 5: Aerial Photography
If the site is extremely large, aerial photography obtained from the state or other sources may be used to provide background information on the likely presence or absence of eelgrass at that site. Unmanned aerial vehicles (UAVs) are an emerging technology that has the capability of providing low altitude, high-resolution aerial imagery that could be useful to document the potential presence or absence of submerged aquatic vegetation for large sites. However, aerial imagery should not be used as the only source of information. When using aerial imagery, it is not possible to reliably distinguish between eelgrass and macroalgae, or between different species of eelgrass or other seagrasses. Aerial photography is also likely to underestimate eelgrass coverage because eelgrass occurring in deeper waters can appear dark and may not be detected. Ground-truthing using any of Methods 1 or 2 above should be performed to verify the mapping of eelgrass bed boundaries determined from aerial photography.

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[2] Limitations: Hydroacoustic surveys are not suitable for very shallow waters (less than 0.75 m) where access by small boats is limited. The hydroacoustic survey system is not currently capable of reliably distinguishing between underwater vascular plants (e.g. eelgrass) and macroalgae (e.g., kelp). In tidal waters, the information on canopy height is unreliable unless the surveys were conducted at slack tide.

APPENDIX A: THE INFLUENCE OF LANDSCAPE SETTING ON EELGRASS BED CONFIGURATION

Shallow eelgrass populations form characteristic landscapes with a configuration that is highly related to the level of physical exposure. Seagrass bed patterns range from continuous or semi-continuous over hundreds of meters to patchy distributions ranging from a meter to tens of meters in the longest dimension (Fonseca and Bell 1998). Bed fragmentation generally increases with increasing wave exposure and tidal current speed (Fonseca and Bell 1998). Therefore, the geomorphic setting and hydrodynamics of the nearshore zone have a strong influence on seagrass distribution and bed structure. Potential *Z. marina* habitat in the Pacific Northwest may be classified as either fringe (Figure A1) or flats (Figure A2) based on its geomorphic setting (Berry et al. 2003).

Fringe Eelgrass Habitats

Fringe *Z. marina* habitats are areas with relatively linear shorelines where potential *Z. marina* habitat is limited to a narrow band by water depth. Fringe eelgrass beds may be contiguous or nearly contiguous over long sections of linear shorelines (Figure A1). The fringe category is further classified into narrow fringe and wide fringe based on a 305 m (1000 ft) threshold width separating mean high water and the –20 ft depth contour at mean lower low water (Berry et al. 2003) (Figure A1).

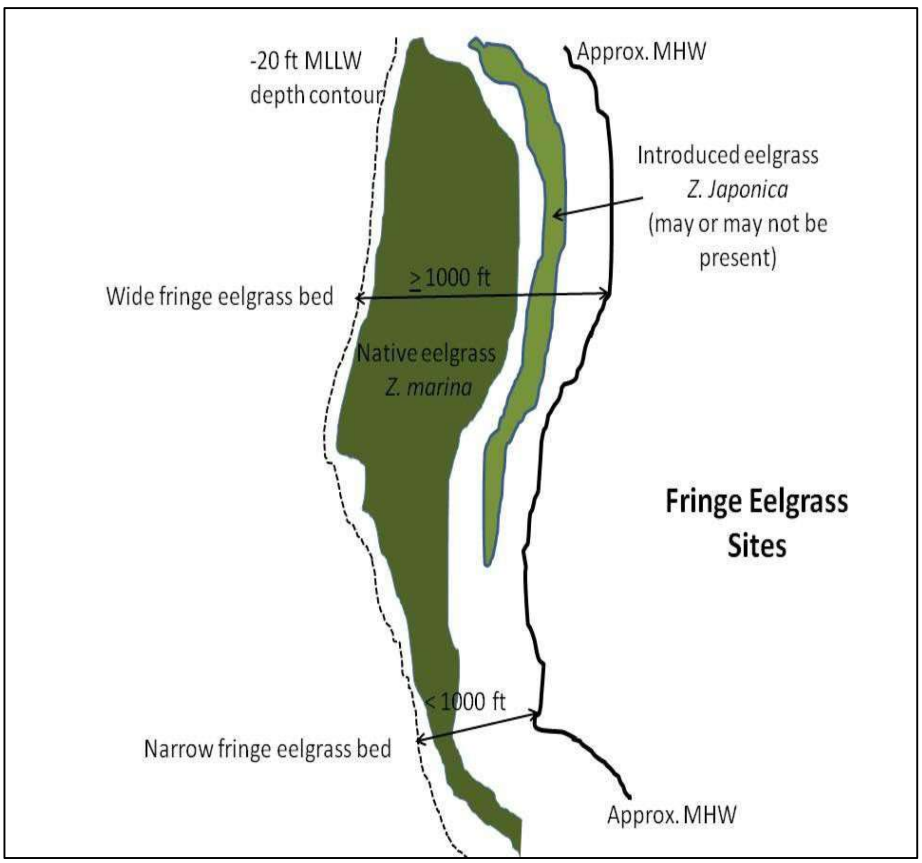


Figure A1. Illustration of fringe geomorphic classifications of eelgrass sites (modified from Berry et al. 2003).

Flats Eelgrass Habitats

Flats *Z. marina* sites are shallow embayments with extensive broad shallows that appear to have little slope within the vegetated zones. Slightly more than half of the total area of *Z. marina* habitat in Puget Sound is characterized as flats; one large embayment, Padilla Bay, contains approximately 20% of the *Z. marina* in Puget Sound (Berry et al. 2003). Flats sites may be further sub-classified into river-influenced flats such as river deltas, and tide-influenced flats (pocket beaches and other sites that lack a significant source of freshwater and associated sediment input) (Figure A2). Periodic pulses of sediment in river- influenced flats sites may generate shallow shoal complexes that can be highly dynamic over timeframes of months to years, leading to a continually changing mosaic of eelgrass patches interspersed with unvegetated shoals (Marbà et al. 1994).

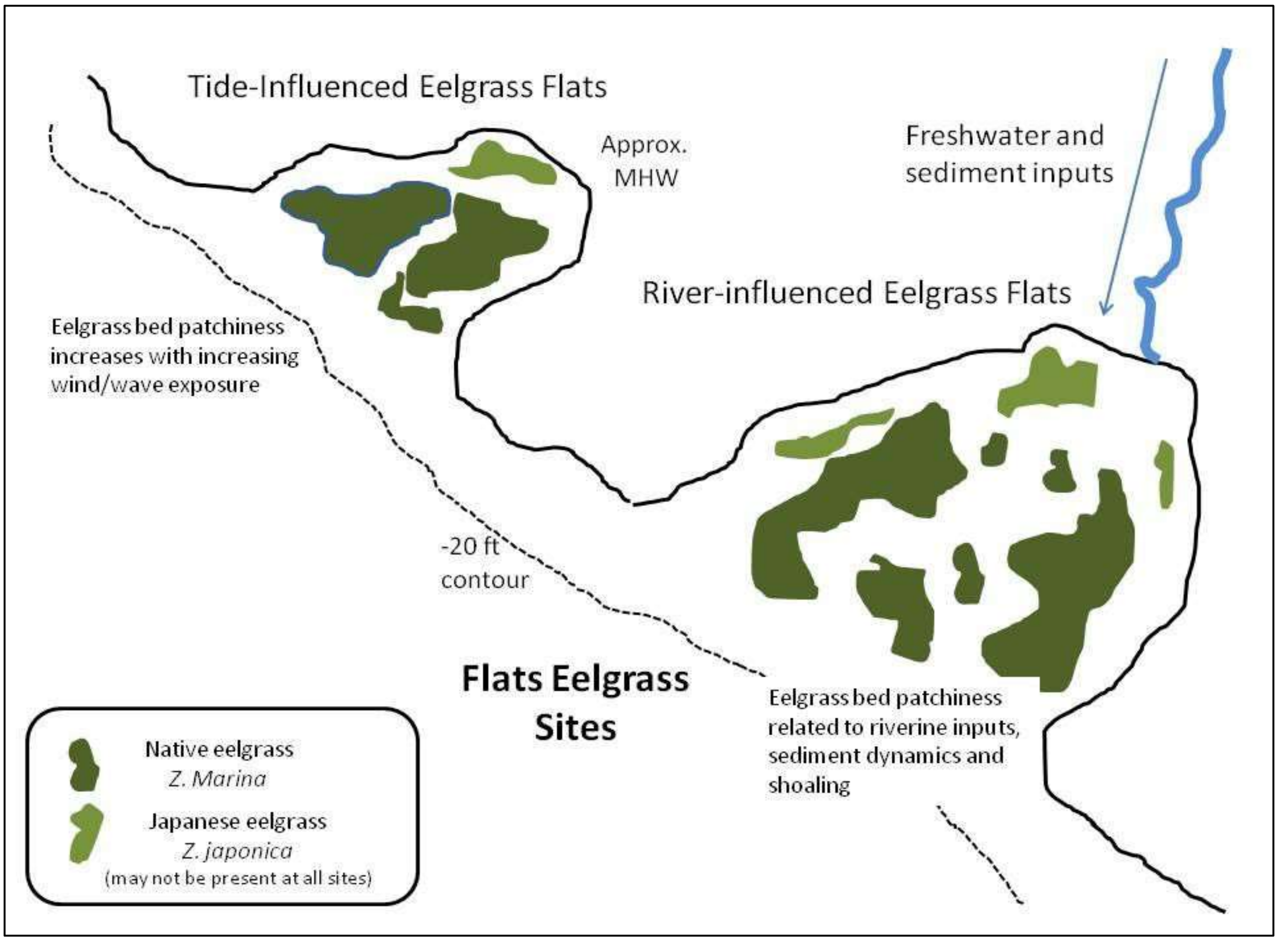


Figure A2. Illustration of flats geomorphic classifications of *Z. marina* habitats (modified from Berry et al. 2003).

Spatial and Temporal Variation in Eelgrass Bed Location

Within eelgrass habitat, eelgrass is expected to fluctuate in density and patch extent and can expand, contract, disappear, and re-colonize areas within suitable environments based on prevailing environmental factors (e.g., turbidity, freshwater flows, wave and current energy, bioturbation, temperature, etc.). Because the maximum depth of seagrass colonization is controlled by light availability, tracking the deep edge of growth can provide information on the quality of the estuarine light environment over time relative to local and regional water quality standards. Upslope movements (deep → shallow) in the location of the deep bed edge have been used as an indicator of some type of chronic disturbance, either natural or anthropogenic, that results in increased turbidity and reduced light availability for seagrasses.

Eelgrass meadows in Puget Sound are characterized by substantial interannual variability that appear to be related to the occurrence of El Niño climate events, emphasizing the importance of multi-year surveys to adequately characterize seagrass abundance and distribution in a particular area (Nelson 1997). On average, vegetated eelgrass areas on the Pacific coast can expand by 5 meters (m) per year and contract by 4 m per year (Washington Dept of Natural Resources 2012). To account for these normal fluctuations, Fonseca et al. (1998) recommends that seagrass habitat include the vegetated areas as well as presently unvegetated spaces between seagrass patches.

Patterns in eelgrass bed 'patchiness' or fragmentation are related to the degree of exposure to disturbance from wind, waves and tidal currents. Wind-generated wave dynamics and tidal currents create sediment movement, which may either bury plants, expose roots and rhizomes or during heavy storms even uproot entire plants (Kirkman and Kuo 1990). Plant burial was found to be an important mechanism of gap formation in a seagrass system in Tampa Bay, USA (Bell et al. 1999); the patch dynamics of *Zostera marina* vegetation in Rhode Island, USA was likewise thought to be controlled by sediment movement (Harlin and Thorne-Miller 1982).

Eelgrass patches may be constantly moving even during periods when a relatively constant total eelgrass area suggests stable conditions in the population. For example, although the total area of eelgrass was quite stable in the 1980s in Amager, Denmark, where a complex system of alternating eelgrass belts and sandbars is found, about 55 % of the eelgrass changed between two consecutive mappings (Frederiksen et al. 2004). The mechanism is probably that extrinsic disturbance factors constantly change growth conditions in the exposed areas and keep the eelgrass populations in a state of continuous re-colonization. The maps showed that the eelgrass belts migrated in a northeasterly direction and the sandbars migrated in the same direction. Outer sandbars feed the inner sandbars with sediment and substantial transportation of sand thus occurs along the sandbars (Frederiksen et al. 2004). This sediment movement most likely led to either burial or erosion on the western edges of the eelgrass patches and new growth mainly occurred in the eastern parts. Similar patterns have been observed in the eelgrass beds associated with a flood tide delta in Rhode Island, USA (Harlin and Thorne-Miller 1982), and in Tillamook Bay, OR. Comparison of historic eelgrass maps and aerial imagery in Tillamook Bay suggests that eelgrass associated with shallow sandy shoals may have become buried or eroded over time, then became re-established in different locations as the shoals shifted in response to current or sediment pulses (Figure A3). Other areas in the Pacific Northwest that exhibit this pattern include eelgrass beds near the mouth of the Dungeness River in northern Washington.

Figure A3. Historic maps of eelgrass distribution on river-influenced flats in Tillamook Bay, OR (shown as light green polygons) superimposed on more recent aerial photography, showing apparent changes in the location of the eelgrass beds over time in an area with dynamic sediment movement and shoaling.

APPENDIX B: EXAMPLE EELGRASS HABITAT MAPS FOR TIER 1 DELINEATION SURVEYS

This section includes several examples of eelgrass habitat maps prepared using the results of the delineation process described in this document. In these examples, an un-vegetated buffer around existing eelgrass beds is shown. The buffer may be required for some, but not all, in-water activities. Situations where an eelgrass buffer may be required include programmatic Endangered Species Act consultations, or a proposed mitigation plan. In these cases, the appropriate buffer should be included in maps/drawings, as shown in these examples. Consult your local Corps representative for more information.

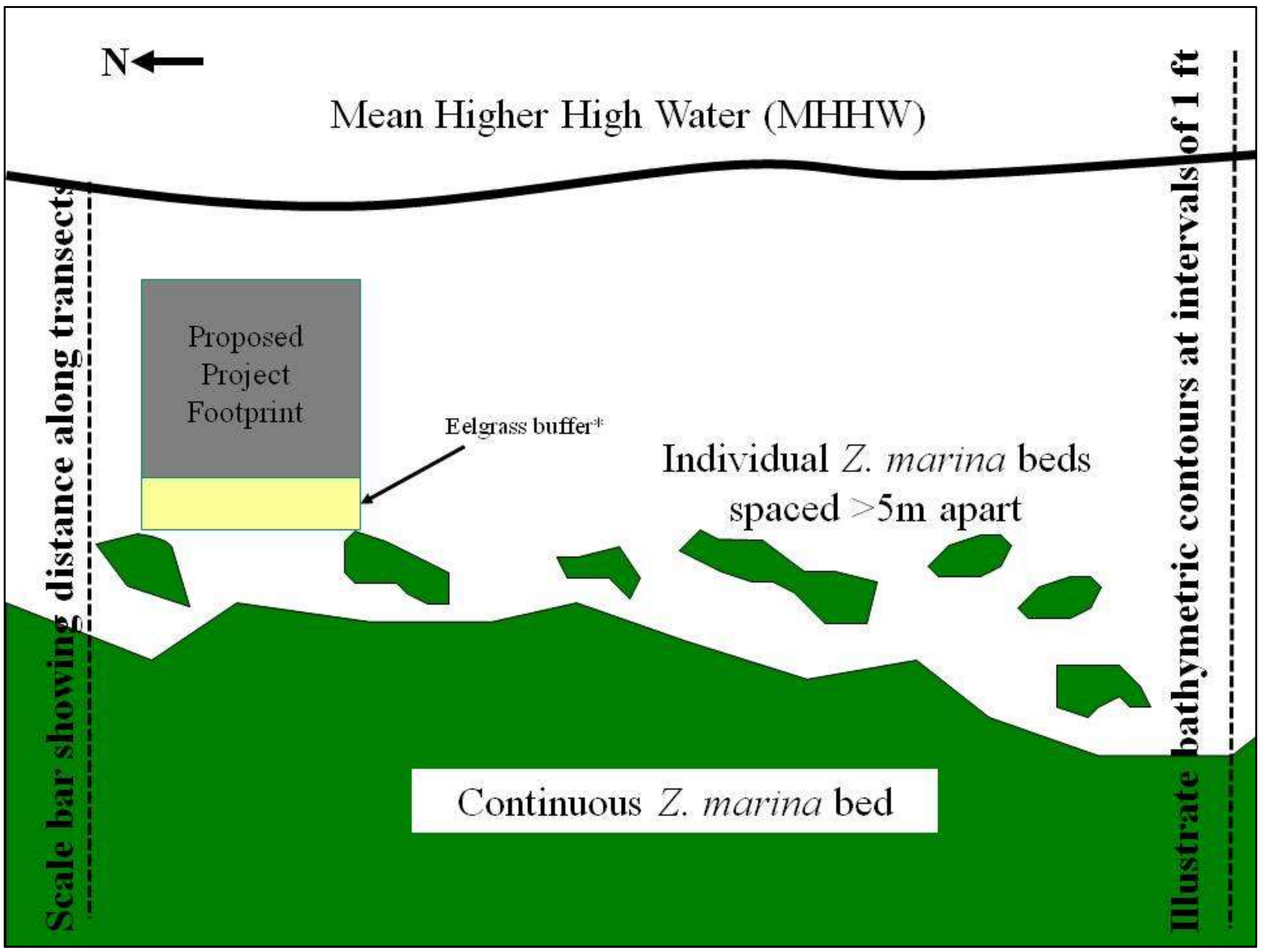


Figure B1. This example illustrates numerous individual beds of native eelgrass (Z. marina) in the mid-intertidal zone and a continuous bed of native eelgrass in the lower intertidal zone. In this illustration, the individual beds of eelgrass each meet the definition of a bed and are more than 5 meters apart. In this case it is appropriate to delineate and map each individual bed of native eelgrass as shown here.

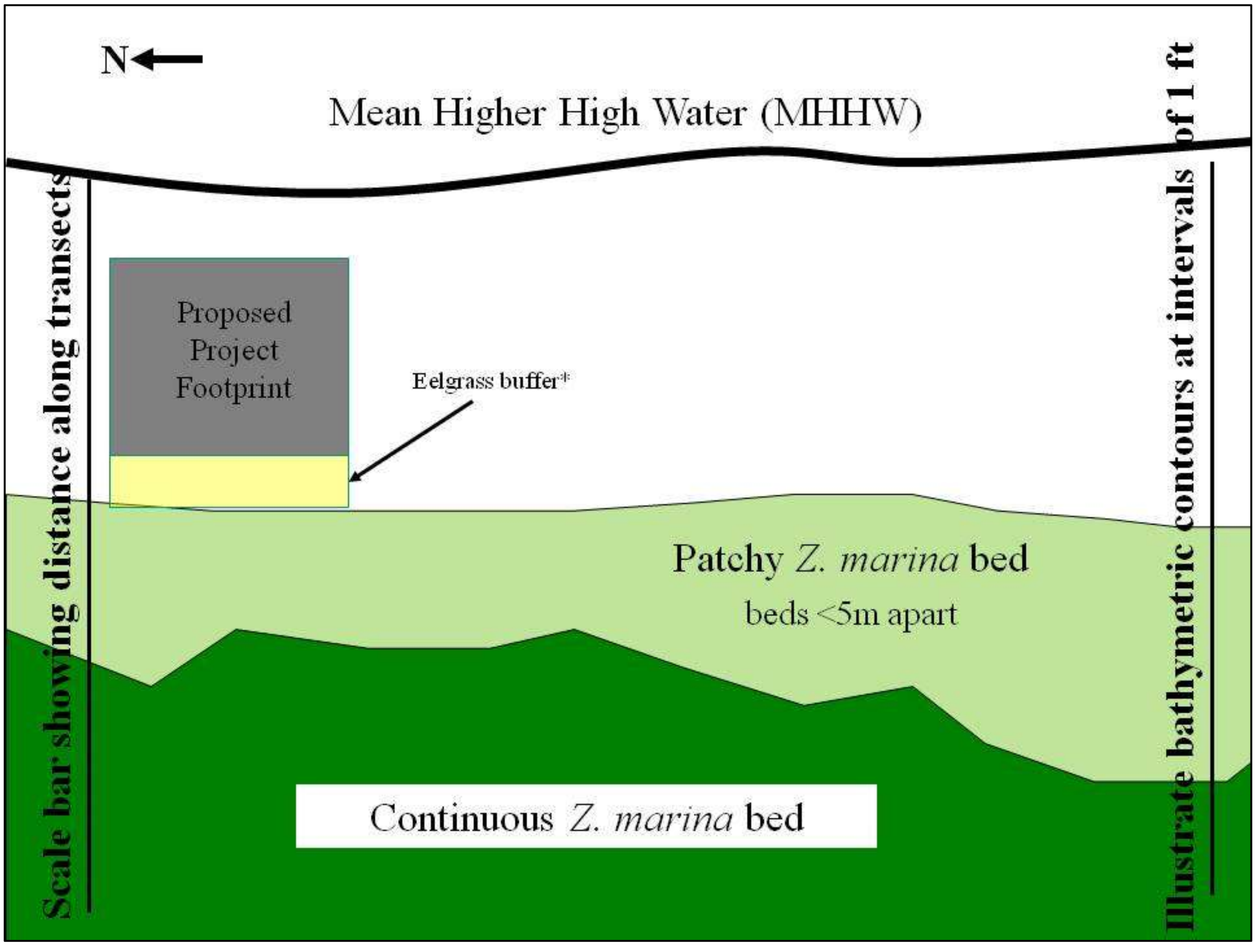


Figure B2. This example illustrates a bed of patchy native eelgrass in the mid-intertidal zone and a continuous bed of native eelgrass in the lower intertidal zone. In this illustration, there are multiple individual beds of eelgrass in the patchy bed, each meeting the definition of a bed. However, in this example, the individual beds are less than 5 meters apart. In this case, we recommend that only the upper and lower boundaries of the patchy eelgrass be mapped, without the need to delineate each individual patch.

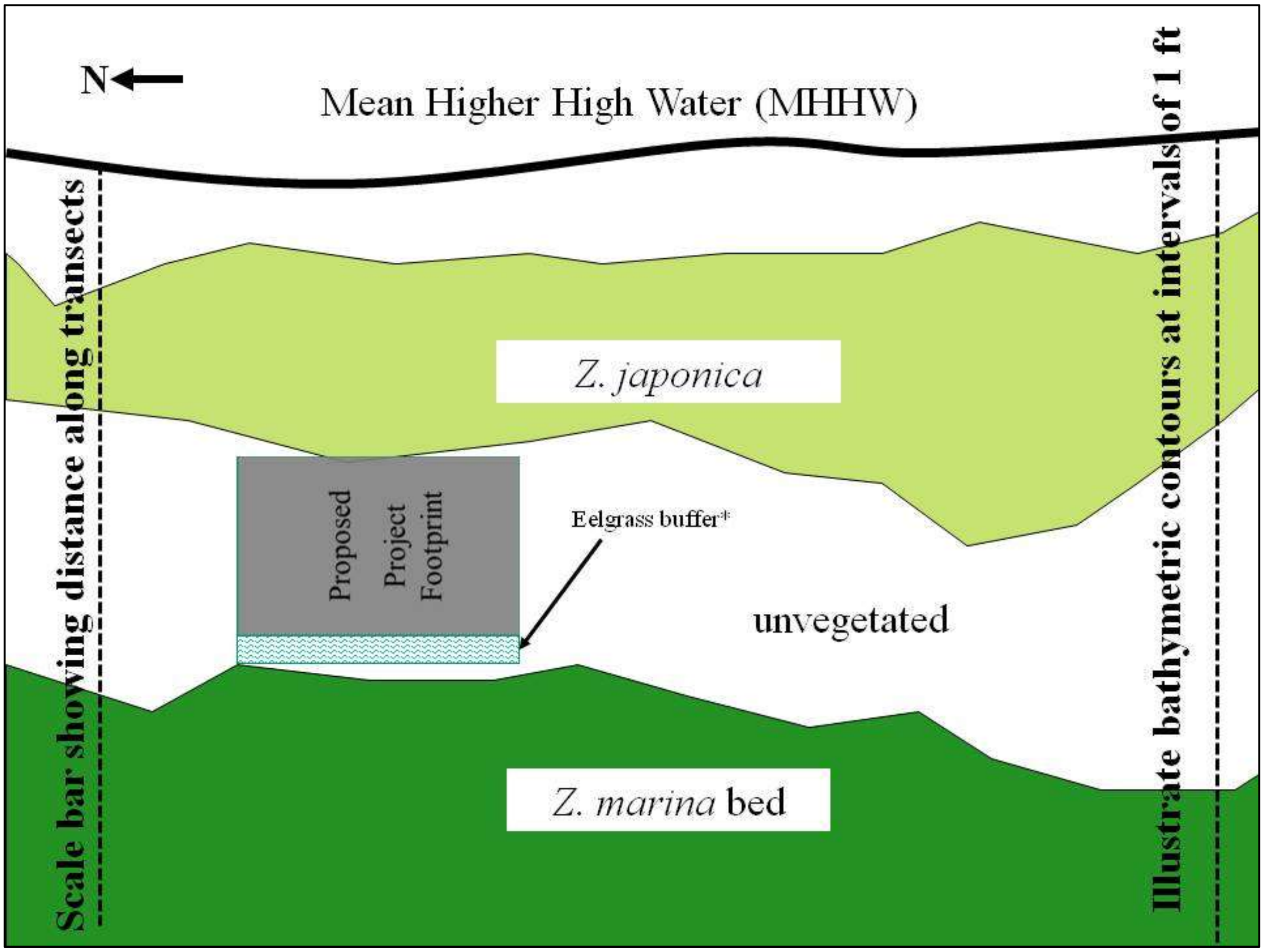


Figure B3. Example of eelgrass delineation where both eelgrass species (Z. marina and Z. japonica) are present. The non-native Z. japonica typically occupies a slightly higher position in the intertidal zone, with the native eelgrass (Z. marina) occurring in deeper waters. In some cases, there may be a variable width of un-vegetated substrate separating the two eelgrass species, as shown in this example. The presence of non-native eelgrass should be shown because of the potential for confusion and mis-identification between the two species. However, the criteria for bed thresholds apply only to the native eelgrass Z. marina.

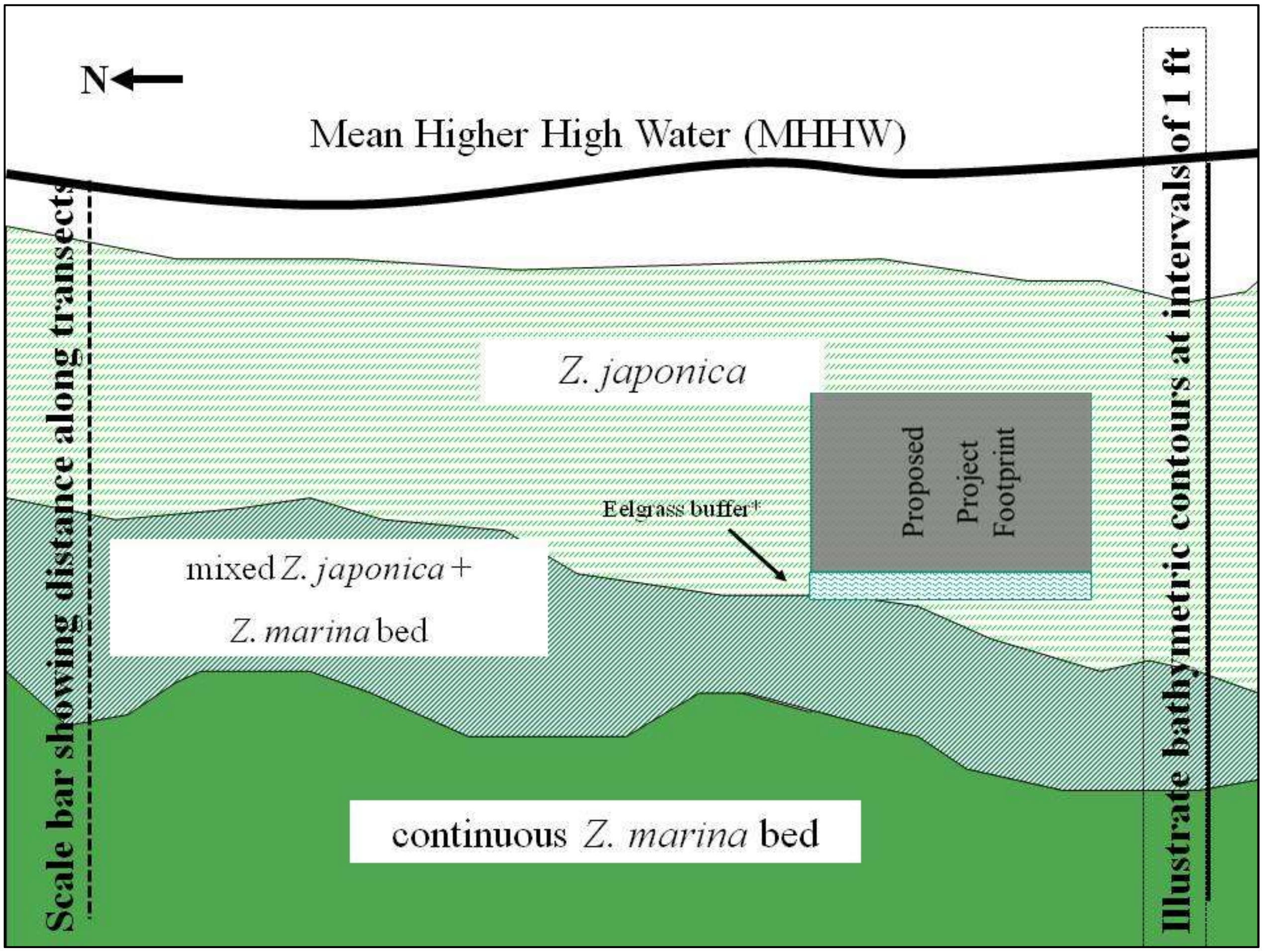


Figure B4. Another example of eelgrass delineation where both eelgrass species (Z. marina and Z. japonica) are present. The non-native Z. japonica typically occupies a slightly higher position in the intertidal zone, with the native eelgrass (Z. marina) occurring in deeper waters. In this example, there is a mixed zone where both species grow intermingled. In these situations, the mixed beds should be carefully examined to determine where there is sufficient native eelgrass present to meet the bed definitions. However, the criteria for bed thresholds apply only to the native eelgrass Z. marina.

APPENDIX C: IDENTIFICATION OF *ZOSTERA MARINA* AND *ZOSTERA JAPONICA*

Zostera marina (eelgrass) Status: Native

Zostera marina is the most widely distributed seagrass in the world. Its range spans the area from Alaska to Baja California on the West Coast of North America; it is also found on the North American East Coast, Europe, Asia, and the Middle East. Common in low intertidal and subtidal zones to a depth of 20-30 feet along sheltered areas with sandy or muddy beaches. Leaf blades are usually about ½ inch (8-10 mm) wide but may be narrower. The blades reach a length of 10 ft (3 m) and are flat. This species blooms from June through August. The inflorescence (flower clusters) grow on the tips of long shoots separate from the leaf blades.

Habitat: marine to brackish waters, lower intertidal and shallow subtidal; sandy to muddy sediments.

Ecology: Eelgrass habitats play an important role as foraging habitat for juvenile salmonids, particularly chum and Chinook. Pacific eelgrass stands also provide habitat for other important fishes and shellfish, including Dungeness crab and starry flounder. Spawning Pacific herring utilize eelgrass as a substrate to deposit eggs. Pacific eelgrass beds also harbor a diversity of infaunal and epifaunal species, including polychaetes, gastropods, bivalves, amphipods, echinoderms, and other crustaceans that are known prey of many commercially valuable fish and invertebrates. Eelgrass meadows are also important foraging habitats for many species of migratory geese, ducks, and swans. Pacific Black Brant feed almost exclusively on eelgrass (both native and non-native), and their populations can be affected by declines in eelgrass abundance. Eelgrass leaves, roots, and rhizomes attenuate wave energy and provide shoreline stabilization. Eelgrass beds also sequester carbon and may play a role in minimizing the effects of ocean acidification, thus helping to mitigate the effects of global climate change.

Zostera japonica (dwarf eelgrass) **Status: Introduced**

Z. japonica forms dense stands in shallow, sheltered bays and estuaries. In its native range, it occurs from Korea and Japan northward to the Kamchatka Peninsula in Russia. In North America, this species ranges from southern British Columbia to Humboldt Bay, California, and is expected to continue expanding its range. In the northern part of its range in North America (British Columbia), Z. japonica lives as an annual, overwintering as buried seeds. Towards the southern part of its established range in North America, it occurs as a short-lived perennial. It is listed as a Class C noxious weed in California and Washington, but is not listed on the federal invasive species list. It reproduces vegetatively through rhizomatous cloning and sexually through seed production. The habitat structure provided by this species may perform similar functions as native eelgrass; in particular, additional research is needed to verify its role in fisheries species utilization. This species is known to be an important food source for many species of migratory waterfowl, especially Pacific Black Brant. The dispersal of the seeds, both within and between estuaries, may be aided by waterfowl species.

Habitat: marine to brackish waters, lower intertidal and shallow subtidal; sandy to muddy sediments. It typically occupies the upper to mid-intertidal zone at a higher elevation than the native eelgrass, Z. marina.

Distinguishing Native and Introduced Eelgrass

Zostera marina

Native Eelgrass

(typical)

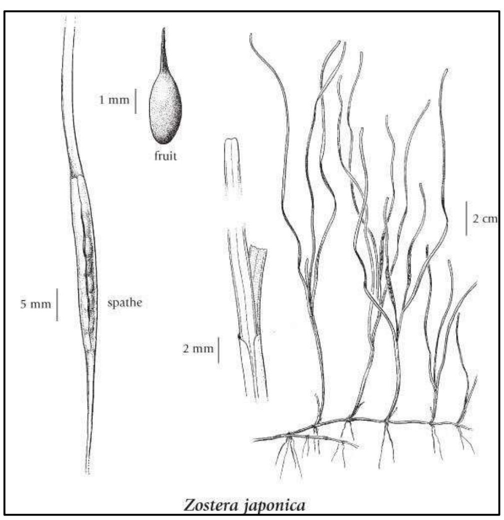
Zostera japonica

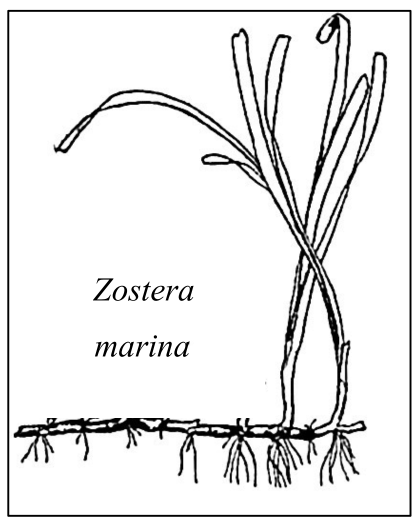
Japanese eelgrass

Introduced

IMPORTANT:

Leaf size is NOT a reliable indicator. *Z. marina* can sometimes look very similar to *Z. japonica*





DISTINGUISHING CHARACTERISTIC

***Z. japonica* has roots in pairs at each rhizome node.**

***Z. marina* has roots in bundles (>2) at each rhizome node.**

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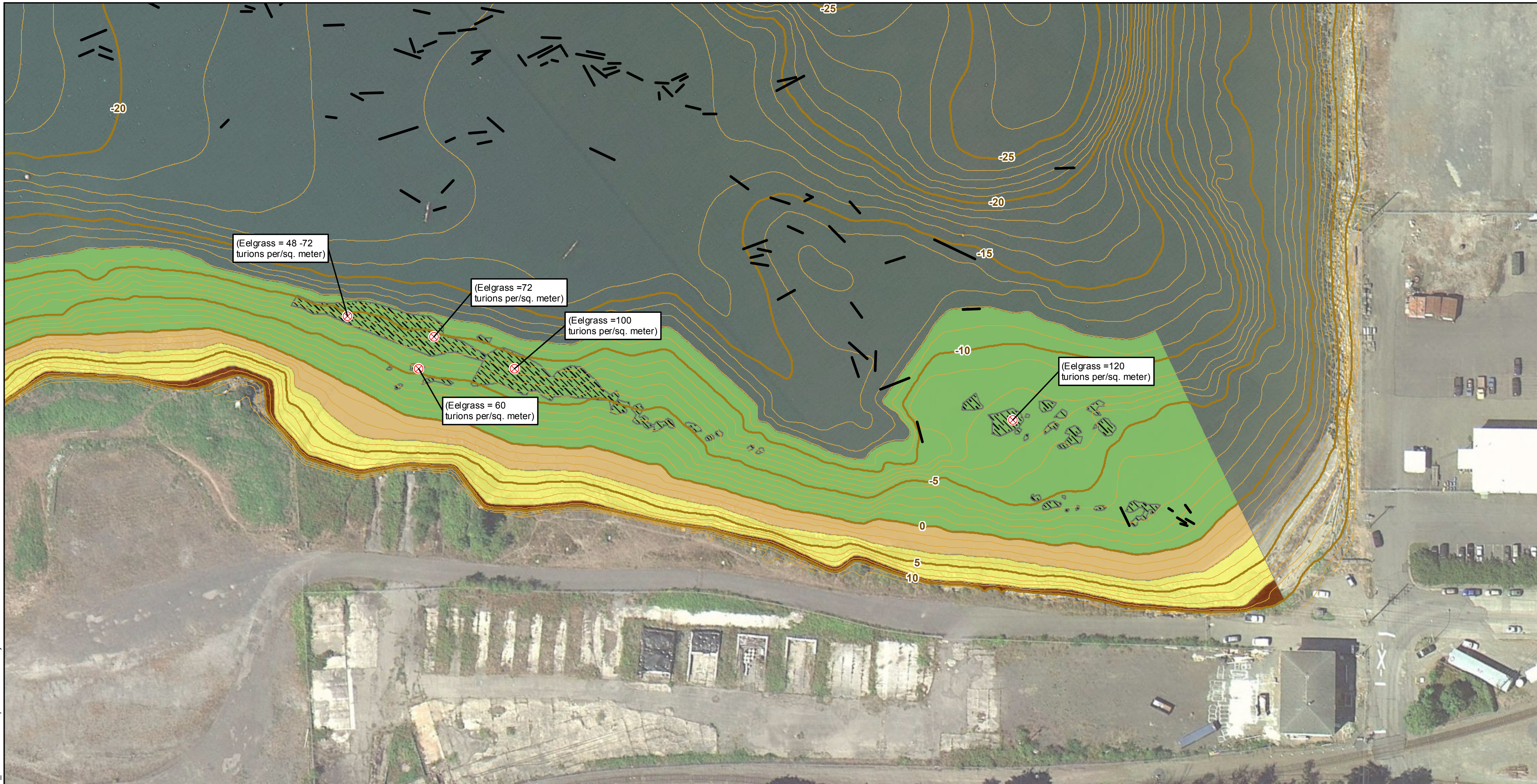
APPENDIX B
Maps of Previous Eelgrass Surveys Conducted in the Project Vicinity



True North
Project North
0 50 100
Feet

Reference: Aerial from Google Earth, August 2011.

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Legend

Upper Tidal Zone (10 to 8 ft)
Primarily consists of filamentous algae and sparse patches of lichen with occasional barnacles on hard substrates.

Fucus Zone (8 to 3 ft)
Primarily consists of Rockweed (*Fucus* spp.) with some Sea Lettuce (*Ulva* spp.). Also present is a green macro algae (*Enteromorpha* spp.) with barnacles on hard substrates, mussels, limpets, snails and some rock crabs.

Ulva Zone (3 to 0 ft)
Primarily consists of Sea Lettuce (*Ulva* spp.). Also present is some Rockweed (*Fucus* spp.) with limpets, snails, and rock crabs.

Eelgrass Zone (0 to -12 ft)
Primary Eelgrass (*Zostera marina* spp.) area. Also present is some Sea Lettuce (*Ulva* spp.) with sea stars, clams, crabs, sea cucumber, and snails.

Eelgrass (one clump = 1 turion)
Debris (Logs, etc.)
Contour (5 ft interval; NAVD88)
Contour (1 ft interval; NAVD88)

Biotic Zones and Eelgrass Locations

R.G. Haley Site
Bellingham, Washington

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Figure 4-19

Path: \\sea\projects\0\0356114\GIS\HabitatSurvey\0356114_Biotic.mxd Map Revised: 31 July 2013 tward

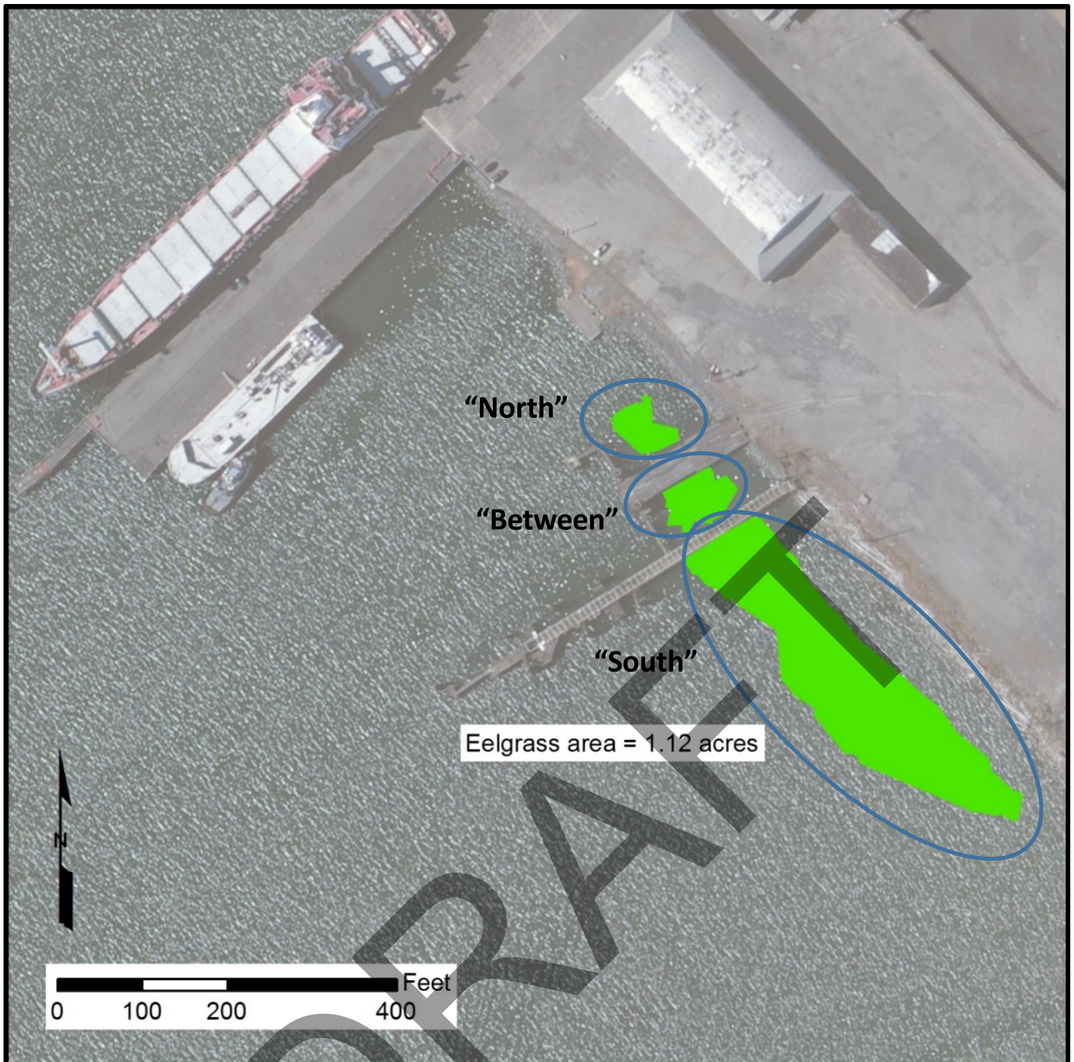
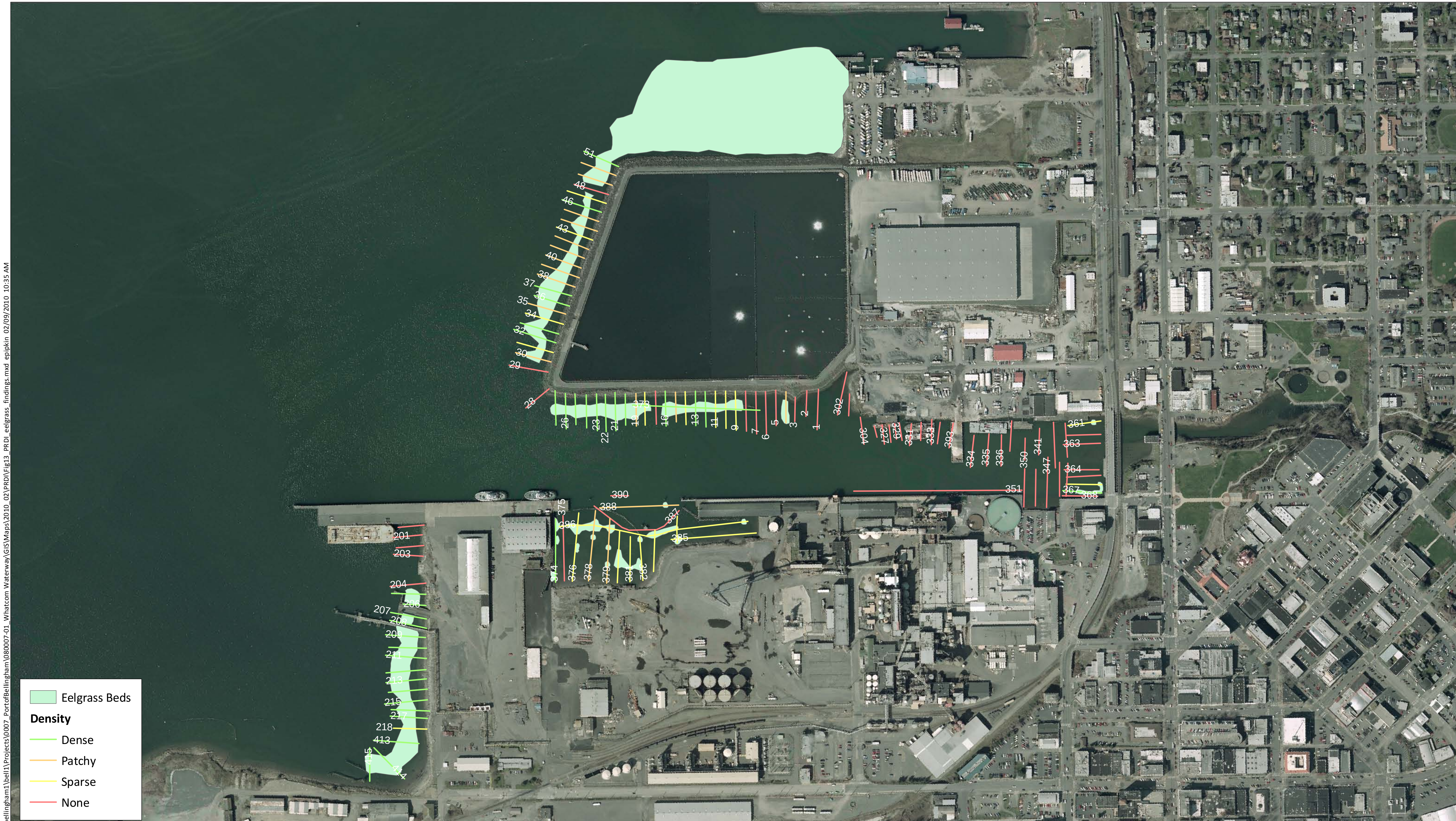


Figure 3 – Eelgrass bed in project area

Invertebrate Fauna

Large mobile invertebrates were numerous and associated with various substrates and macrovegetation in the area. These mobile invertebrates included crab species such as the Dungeness crab (*Metacarcinus magister*, Photograph 8, adult and juveniles) and red rock crab (*Cancer productus*, Photograph 9), were noted in a variety of sizes and habitats from the intertidal to subtidal zones. A few mottled sea stars (*Evasterias troschelii,* Photograph 10) and ochre sea stars (*Pisaster ochraceus*, Photograph 11).



\\bellingham1\bell1\Projects\0007_PortofBellingham\080007-01_Whatcom Waterway\GIS\Maps\2010_02\PRDI\Fig13_PRDI_eelgrass_findings.mxd epipkin 02/09/2010 10:35 AM

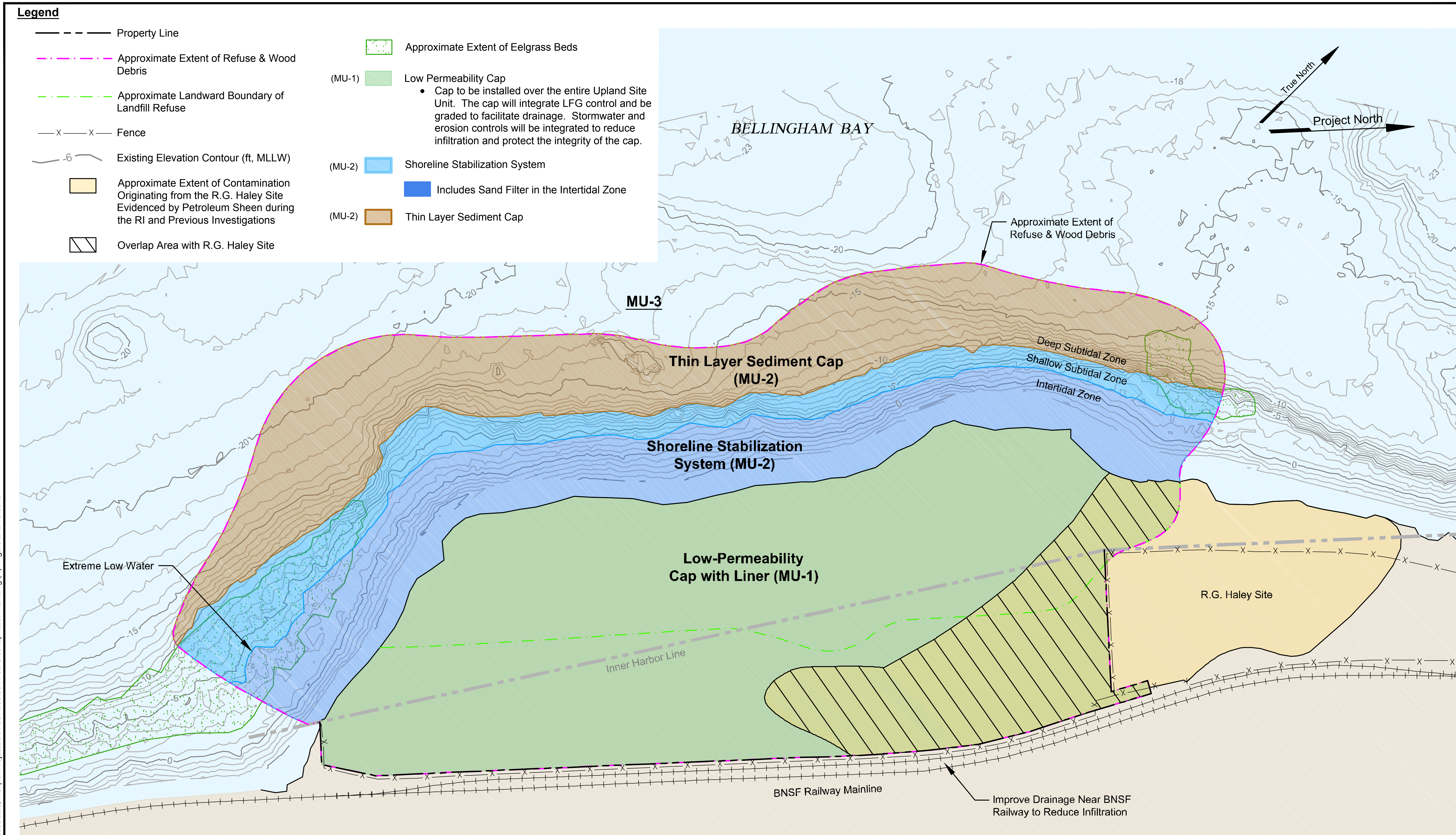
ANCHOR QEA

NOTES:

1. Source: Anchor QEA. *Draft Underwater Video and Dive Survey of Eelgrass and Macroalgae Report*. March 2009.
2. Horizontal datum: Washington State Plane North, NAD 27/98.
3. Vertical datum: Mean Lower Low Water (MLLW).
4. Transect 351 is a combination of transects 352 and 353 per this figure.
5. Sector A includes transects 029-051.
6. Sector B includes transects 001-028, 302-304, 325, 327-338, 341-343, 361-363, 373, and 392-393.
7. Sector C includes transects 200-218, 344-345, 347, 349, 350, 364-368, 374-376, 378-388, 390, and 413-415.

Feet
0 220 440 660 880

Figure 13
Eelgrass Survey Findings
Whatcom Waterway PRDI Data Report



Basemap source: Port of Bellingham 1996, Anchor Environmental 2008, Wilson Engineering LLC 2015

0 150 300
Scale in Feet

Landau Associates, Inc. | G:\Projects\001\037\030\031\F02 CleanupActionPlan.dwg (A) "Figure 2" 2/13/2015

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Pre-Design Work Plan
Cornwall Avenue Landfill
Bellingham, Washington

Site Cleanup Action

Figure
2

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