BRIGHTWATER POST-CONSTRUCTION

Eelgrass Program:
2009 Eelgrass Transplant Report

Task 400 – Eelgrass Transplanting

Subtask 470 - Reporting

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Rev 1

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Chapter 1 Introduction

King County's Wastewater Treatment Division constructed a marine outfall in late 2008 as part of the new Brightwater Treatment System. The purpose of the new outfall will be to discharge highly treated effluent into Puget Sound near the King-Snohomish County line, just south of Point Wells (Figure 1). This site was chosen because fewer biological resources, in particular the native eelgrass *Zostera marina,* were present compared to other potential locations. King County is implementing an eelgrass mitigation program to restore the areas populated by eelgrass that were disturbed by outfall construction. The program includes several elements: pre-construction monitoring, salvaging and propagation, transplanting, and post-construction monitoring.

The Brightwater outfall eelgrass survey area is comprised of the Study Area, the Marine Outfall Corridor (within the Study Area), and the Reference Area. A detailed description of each of these areas and the entire mitigation program are included in the Eelgrass Restoration and Biological Resources Implementation Work Plan (Work Plan) (King County 2005). Pre-construction monitoring of the Marine Outfall Corridor (Corridor) and Reference Area was performed by Grette Associates dive teams in 2004, 2006, and 2008. Pre-construction side-scan sonar and underwater video surveys of the Eelgrass Study Area were completed in 2004 and 2008 by Battelle Marine Science Laboratories (BMSL), and a post-construction survey in 2009 was completed by Global Remote Sensing (GRS). All reports, including the Work Plan, are available at http://green.kingcounty.gov/marine/Reports.aspx. Together, these studies have provided a robust baseline dataset concerning substrate condition, eelgrass spatial distribution and density in the Corridor and surrounding areas.

This report details the transplant efforts undertaken between May 13 – 29 2009, following construction of the Brightwater outfall, in addition to the side-scan sonar and underwater video surveys conducted on May 15 and May 21, 2009.

Chapter 2 Methods

2.1 Sonar and Underwater Video Survey

As stipulated by the Work Plan, Global Remote Sensing (GRS) performed side-scan sonar and underwater video surveys of the Eelgrass Study Area (an area of approximately 110,868 ft^2 in total) to determine the extent of eelgrass loss, if any, outside of the Outfall Corridor due to 2008 construction activities. Side-scan sonar imagery was collected on May 15, 2009, with towed underwater video completed about a week later on May 21 for ground verification. For details concerning survey methodology and results, see Appendix A.

Data from the 2009 surveys were compared to those from 2004 and 2008. Results of the post-construction surveys indicated no evidence of disturbance to eelgrass outside of the Corridor; therefore, transplant efforts (described below) occurred within the Corridor only.

2.2 Eelgrass Salvage

In April of 2008, prior to construction of the outfall, approximately 16,000 eelgrass shoots were harvested from within the Corridor. Most the eelgrass in the Corridor was manually cleared either from land during tidal exposure or by divers on SCUBA. For a detailed explanation of harvest methods used (the "bare-root" method), please see the Work Plan. Once harvested, the eelgrass shoots were transported to BMSL in Sequim, Washington, to be maintained until needed for transplant the following year. These shoots were added to the eelgrass that had been previously harvested from the Corridor in 2004, 2006, and 2007. Eelgrass was stockpiled and propagated in a medium-grained sand substrate inside two flow-through seawater tanks for just over one calendar year (April 2008 through May 2009). The 29-m^2 circular tanks were located outdoors, ensuring maintenance of ambient light and temperature conditions for the year.

2.3 Pre-construction Eelgrass Density

During the 2008 pre-construction survey, eelgrass was found within the Corridor between approximately -2 and -12 ft Mean Lower Low Water (MLLW) (King County 2008). Within this area, two "bands" of notable eelgrass density were observed: band A was located within the 0 to -5 ft MLLW contours (between 50 and 70 ft on the outfall transects); band B was located roughly within the -5 to -15 ft MLLW contours (between 100 and 140 ft on the outfall transects), as illustrated in Figure 2. (An explanation of Outfall transects and their orientation is described in Section 2.5 of this document.) Little to no eelgrass was observed between the two bands (King County 2008). The mean density of eelgrass in band A in 2008 was calculated to be 56 shoots/m^2; the mean density of band B was 74 shoots/m^2. A comparison of eelgrass shoot density observed during the 2004, 2006 and 2008 pre-construction surveys within these 2 specific bands is presented in Table 1.

Table 1. Eelgrass density of bands A and B within the Outfall Corridor in 2004, 2006 and 2008.

Location within Outfall Corridor	2004 density (shoots/m^2)	2006 density (shoots/m^2)	2008 density (shoots/m^2)	Percent increase 2004-2006	Percent increase 2006-2008	Percent increase 2004-2008 *(all 4 years)*
Band A	14	37	56	159%	50%	289%
Band B	15	39	74	164%	87%	394%

According to the Work Plan, the density of eelgrass to be transplanted post-construction in 2009 was to be calculated based on specific characteristics of pre-construction eelgrass abundance. The Work Plan states (p. 16) that *"Eelgrass shoots will be planted in approximately the same locations, and at the approximate densities, as they occurred prior to construction. The concept is to use the pre-construction distribution of plants to assist in determining where eelgrass will likely grow after construction."*

The Work Plan text (p. 23) also states the following: "*To account for the salvaging of eelgrass shoots prior to construction, the following method will be used to determine the number of shoots to be replanted following construction. The total number of eelgrass shoots to be planted within the Marine Outfall Corridor will be calculated as the greater of either the 2008 (Year -1) eelgrass abundance or the pre-harvest 2004 (Year -5) abundance, corrected for any trend observed in the Reference Area. Eelgrass abundance for the Marine Outfall Corridor is calculated as the mean eelgrass density (i.e. mean of all shoot counts including bare substrate counts within the Corridor) multiplied by the overall area (i.e. Marine Outfall Corridor)… The correction of the pre-harvest 2004 (Year -5) abundance for overall trends in eelgrass will be done by multiplying the pre-harvest abundance by the percent change in abundance in the Reference Area. The total number of shoots computed for replanting will be referred to as the "Baseline Abundance.""*

The Baseline Abundance to be planted in 2009 was therefore determined based on the mean shoot density values established by the 2004 and 2008 pre-construction surveys, as illustrated in Table 2.

Table 2. Eelgrass density in the Outfall Corridor and Reference Area for years 2004 and 2008.

Year	Location	Mean density (shoots/m^2)	Area (m^2)	Total shoots estimated by survey*	Percent increase
2004 data set	Outfall Corridor	6	395.3	~2,400	
	Reference Area	14	854.7	~12,000	
2008 data set	Outfall Corridor	26	395.3	~10,300	
	Reference Area	17	854.7	~14,500	
2004 to 2008	Reference Area	-	-	-	**~21%**

***** This value is calculated as the mean density (shoots/m^2) multiplied over the total area (m^2) for the Outfall Corridor and Reference Area. It is *not* a precise estimate of the total number of shoots found within either location, nor does it represent a density calculation method approved by WDFW.

Since an approximate 21% increase in density of the Reference Area was observed between 2004 and 2008, the adjusted eelgrass value for the Outfall Corridor for the same time span was determined from the following equation:

(Total Shoots x % change) + Total Shoots ≈ (2,400 x 0.21) + 2,400 ≈ *2,900 shoots*

Because ~2,900 shoots is less than the total number of shoots estimated by survey for the Outfall Corridor in 2008 (Table 2), it was determined that Baseline Abundance for the entire corridor should be calculated based upon the 2008 data set, rather than adjusted 2004 values. Based on the Work Plan guidelines and with verbal approval from resource agencies, eelgrass was planted in locations where it was observed during pre-construction and at densities equal to or greater than that observed during pre-construction, resulting in an adjusted shoot transplant total (Section 2.4).

2.4 Calculation of Minimum Density Needed for Eelgrass Transplant

As stated previously in Section 2.3, in 2008 the mean density of band A was calculated to be 56 shoots/m^2 (or 5.20 shoots/ft^2), and the mean density of band B was 74 shoots/m^2 (or 6.87 shoots/ft^2). The total number of shoots needed to replace pre-construction densities (at a minimum) for each band was therefore determined from the following equation:

Mean Density x Band Area = S

Where S = the total number of shoots needed per band. Band A required at least 2,081 shoots and band B required at least 5,500 shoots, for a total number of at least 7,581 shoots to be planted within the Corridor. Since each planting unit consists of at least 4 shoots (and often more than 4), the number of planting units needed for each band was determined from the following equation:

$S \div 4 \leq PU$

Where PU = the total number of planting units needed per band. Band A required at least 520 planting units, band B required at least 1,375 planting units. The number of planting units per foot needed for each band was determined from the following equation:

$PU \div \text{Band Area} \leq PU \text{ per ft}^2$

Band A required at least 1.30 planting units per ft^2 and band B required at least 1.72 planting units per ft^2. The inverse of the number of planting units per ft^2 was taken to determine the number of inches on center between each planting unit:

$1/(PU \text{ per ft}^2 \times 12) \leq \text{distance between PU}$

Band A required planting units to be at least 9.23 (rounded to 9) inches apart, band B required planting units to be at least 6.98 (rounded to 7) inches apart.

Based on the calculations above, which use the 2008 pre-construction data as the baseline, at least 7,581 total shoots were required for planting within the Corridor to meet the minimum density requirement. Section 4.1 of the Work Plan states "*In the event more shoots are propagated than are needed to return densities to pre-construction conditions, the decision may be made to replant sparse patches at higher densities than were present prior to construction*." Conservatively, 7,581 was determined to be the minimum number of plants needed to ensure more than enough shoots (since there are several eelgrass shoots per plant) to meet the restoration goals. Approximately 16,000 plants were obtained from Batelle (see Section 2.6), some unhealthy plants were discarded, and additional healthy plants were added as extras to some of the planting staples. The final number of plants actually placed into the Corridor was approximated to be between 10,000 and 16,000, which also met the estimated value of ~10,300 shoots within the Corridor noted in Table 2.

2.5 Transplant Preparation

Prior to the transplant effort, divers installed rebar stakes in the Corridor at the east and west endpoints of each of five, 200-ft long transects perpendicular to shore using dGPS coordinates provided by the County. Divers then marked the north and south boundaries (a 20 ft width) by running a transect tape between Transects 1 and 5 (T1 and T5, respectively) (Figure 2). Starting at the shoreward extent of the Corridor (0 ft MLLW), each of the five transects was marked with rebar stakes at 40-foot increments. This resulted in rebar stakes placed at 0, 40, 80, 120, 160, and 200 ft along each transect. Each stake was identified using a square, orange cap labeled with transect number and position (*e.g.,* at 120 ft, the caps were labeled 1-120, 2-120, 3-120, 4-120, 5-120). Photographs 1, 2a, 2b and Figure 2 illustrate rebar stake placement along the Corridor. After transplant efforts were complete, the rebar stakes were left at the site to facilitate underwater orientation during future post-construction monitoring efforts.

2.6 Transplant

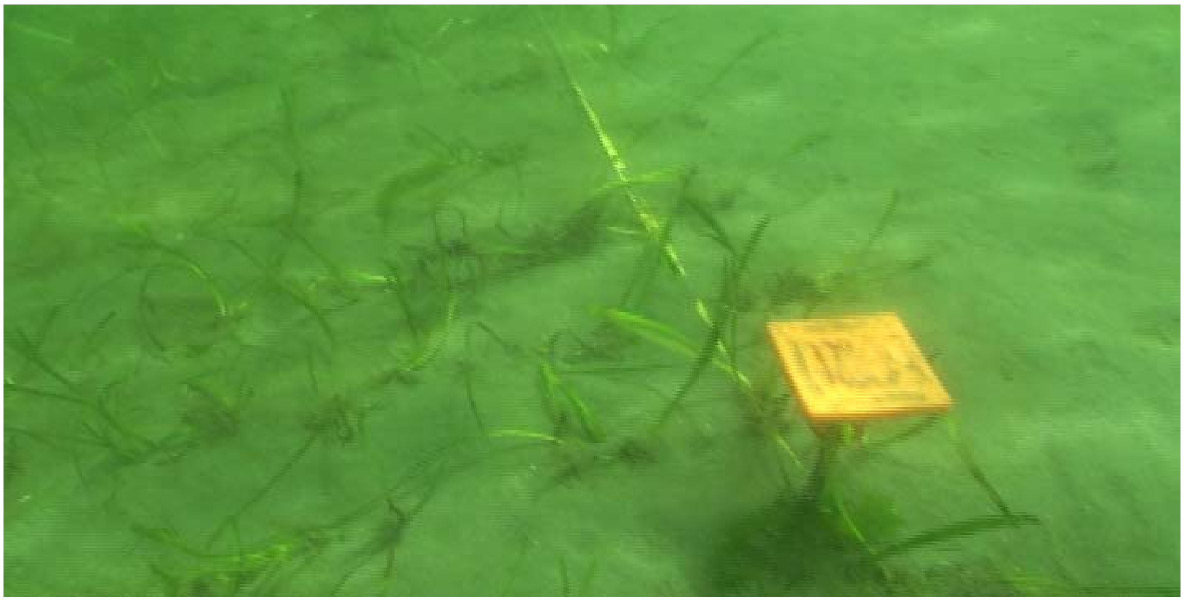
The eelgrass transplant effort was divided into two, week-long efforts. On the first day of each week, approximately 8,000 eelgrass plants were harvested from the BMSL tanks by BMSL staff using the bare-root method, for a total of ~16,000 plants (as noted previously, each eelgrass plant may consists of more than one eelgrass shoot). Eelgrass plants were then transported to the Brightwater site in coolers of seawater (refreshed every 8 hours) within a 24-hour period. On site, the shoots of each planting unit were cut to a length of approximately 30 cm (12 inches) to facilitate handling and planting (Merkel 2004). Bare-root material was then processed into planting units of at least 4 plants interlaced and attached directly to a landscape anchor (a 1-inch wide, 8-inch long turf staple) using paper-coated twist ties. During the course of handling, sorting, and preparation of planting units, some plants were either damaged or deemed unlikely to thrive after transplanting. These were either discarded or additional plants were placed on the staples to ensure a minimum of 4 healthy shoots per unit; this method often resulted in more than 4 eelgrass shoots per unit. Planting units were placed back into seawater-filled coolers and loaded onto a boat, which was anchored near the Outfall Corridor. Divers were supplied with planting units from the boat during the underwater planting effort.

In order to ensure that bands A and B were planted at densities at least as great as the calculated values in Section 2.4, a 20-ft scaled rope (the width of the Corridor) weighted on both ends was prepared for each band by marking at either 9-inch intervals (band A) or 7 inches (band B) with survey tape. Prior to planting each row, divers placed the appropriate rope across the width of the Corridor (since planted rows ran perpendicular to transects). At least one planting unit was then installed at each tape-mark along the rope. After a row was planted, the rope was moved 9 (band A) or 7 (band B) inches down each transect for the next row. Using this methodology, band A (400 ft^2) and band B (800 ft^2) were both transplanted (Photographs 3 and 4). Excess eelgrass stock was prepared into planting units which were then planted within the band boundaries after the rope method had been used to completion. In this way, Grette Associates biologists ensured that final planting density was at least as great as the pre-construction condition.

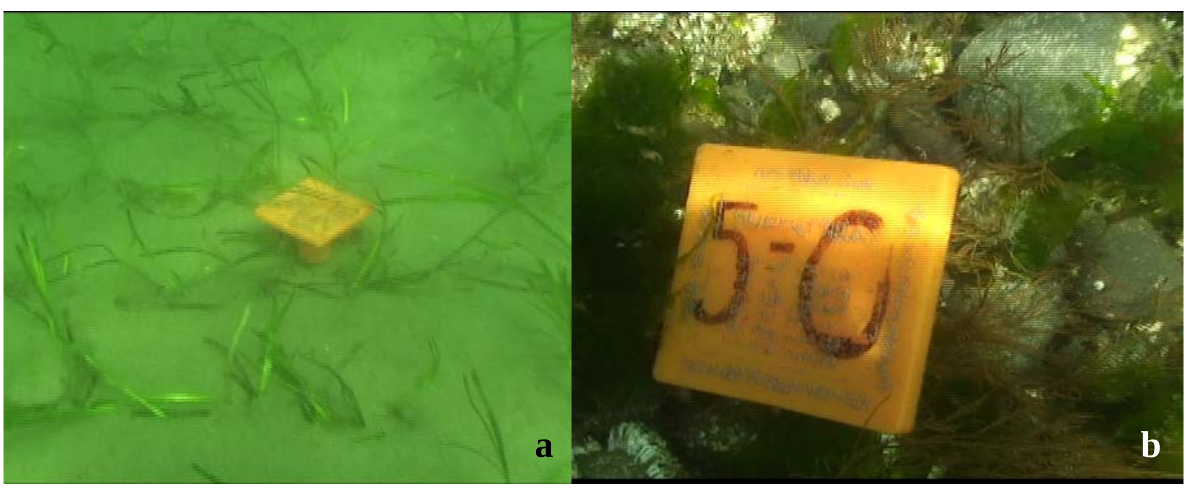
Chapter 3 Transplant Photographs

The following photographs, taken from stills of the underwater video, illustrate portions of the Corridor during and immediately after transplant. In total, over 10,000 eelgrass shoots were planted in two bands within the Outfall Corridor.

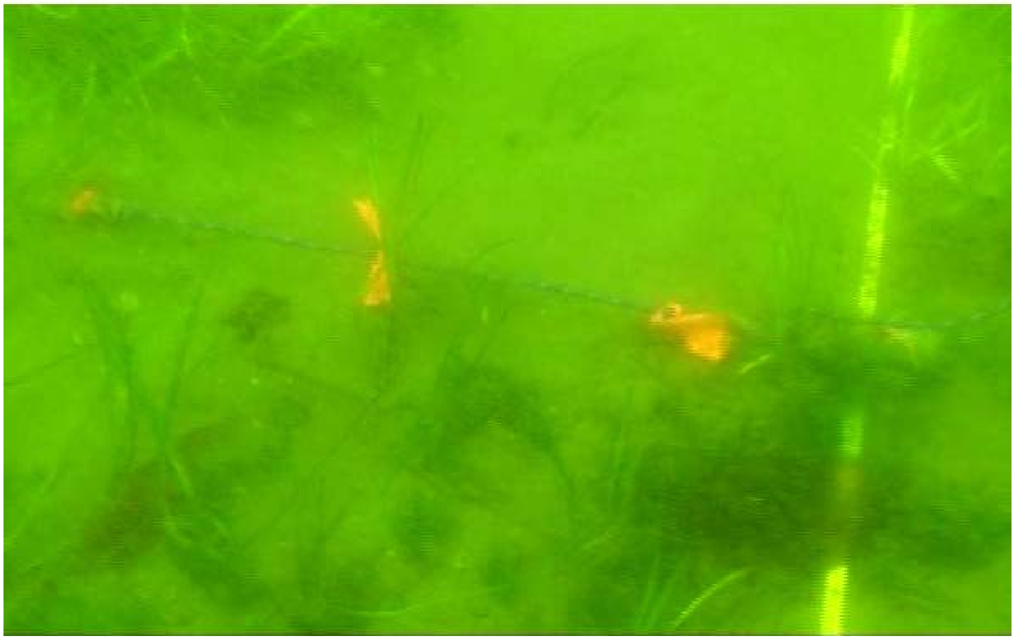
The first post-transplant monitoring will occur in the fall of 2009. This monitoring will include underwater video and diver surveys.



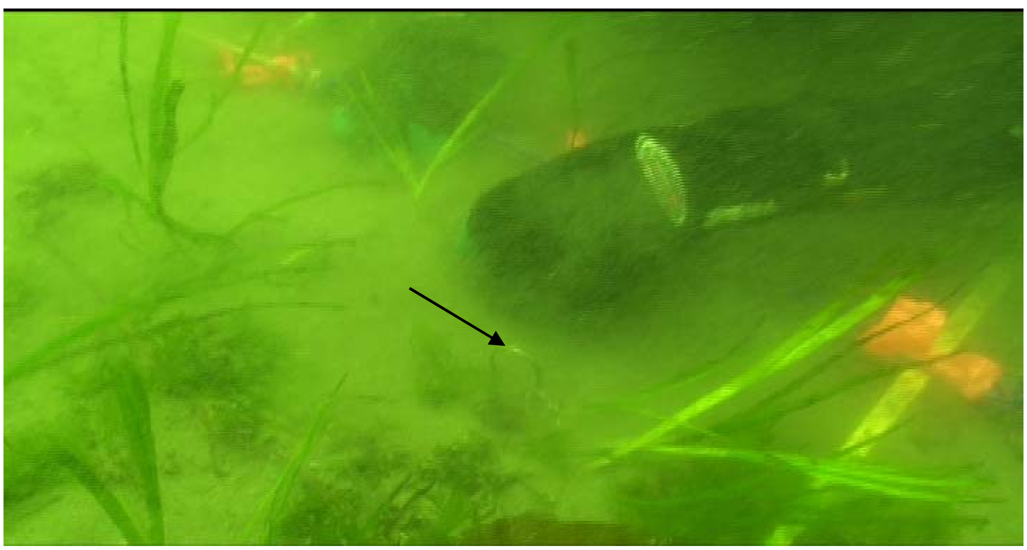
Photograph 1. Rebar at Transect 1, 120 feet waterward from the start of the transects (1-120; band B). This photograph was taken post-transplant.



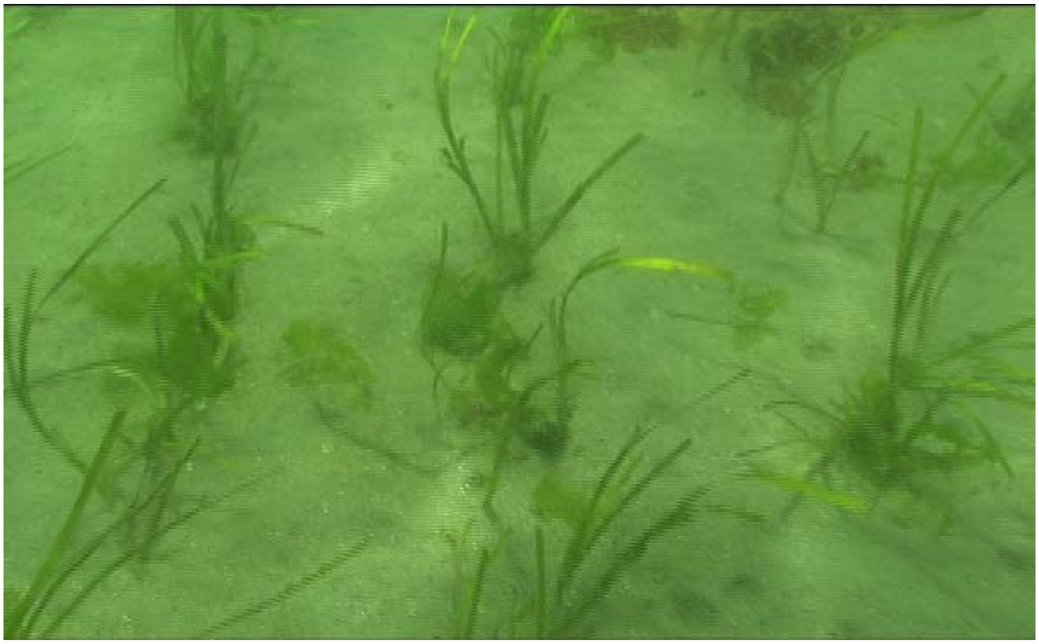
Photographs 2a and 2b. Rebars 2-120 (band B) and 5-0.



Photograph 3. Planting rope at band B. The rope, marked every 9 inches with orange survey tape, was laid out perpendicular to the transect tapes. An eelgrass planting unit was placed at each orange mark to achieve the correct density.



Photograph 4. Eelgrass planting in band A at Transect 1. The arrow denotes a landscape staple/anchor to which 4 eelgrass shoots were affixed (one planting unit). A furrow was manually created by the diver prior to anchor placement. After insertion the anchor, rhizomes and roots were covered with sediment and the blades pulled free.



Photograph 5. A portion of the Outfall Corridor post-transplant.

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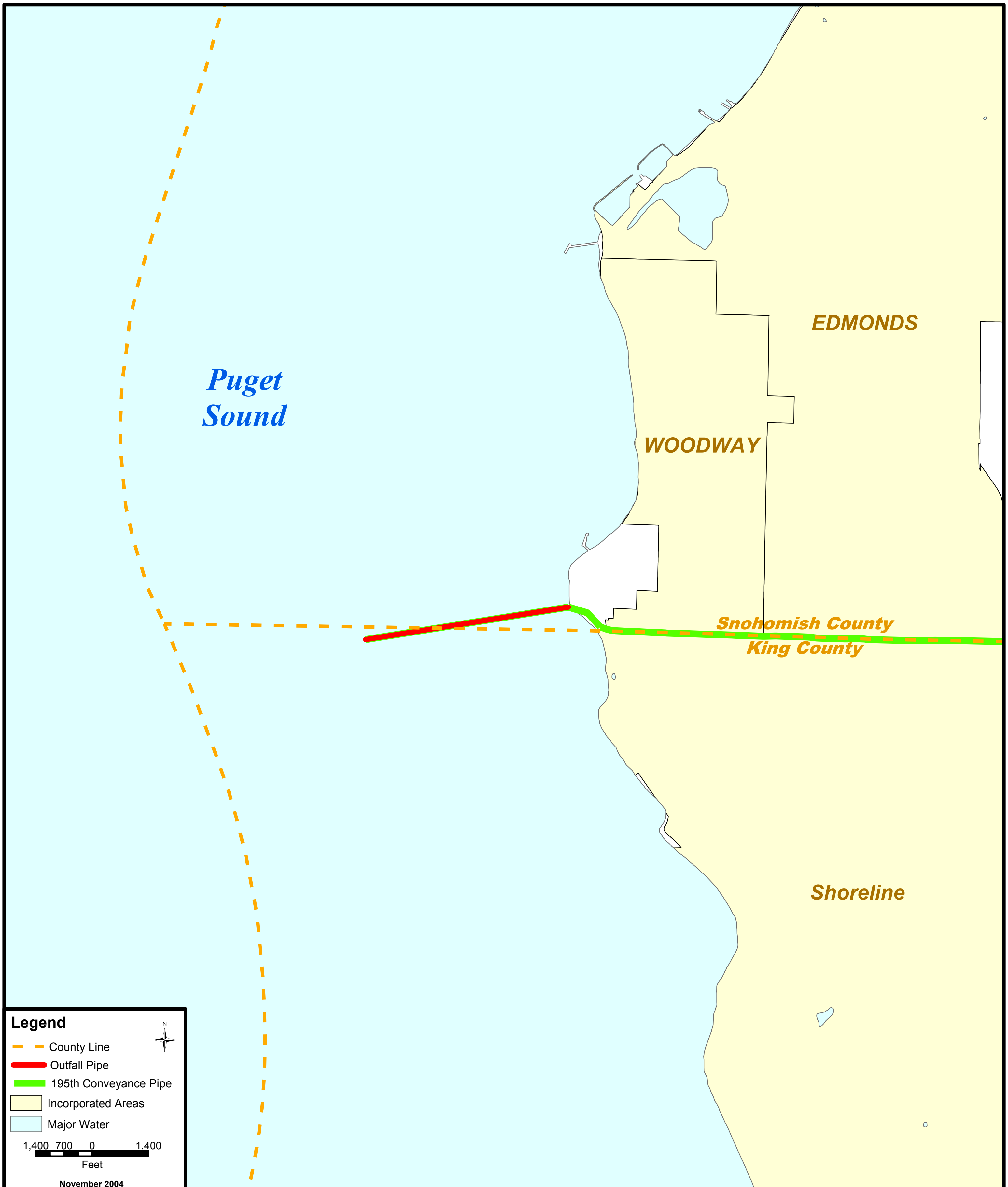

King County
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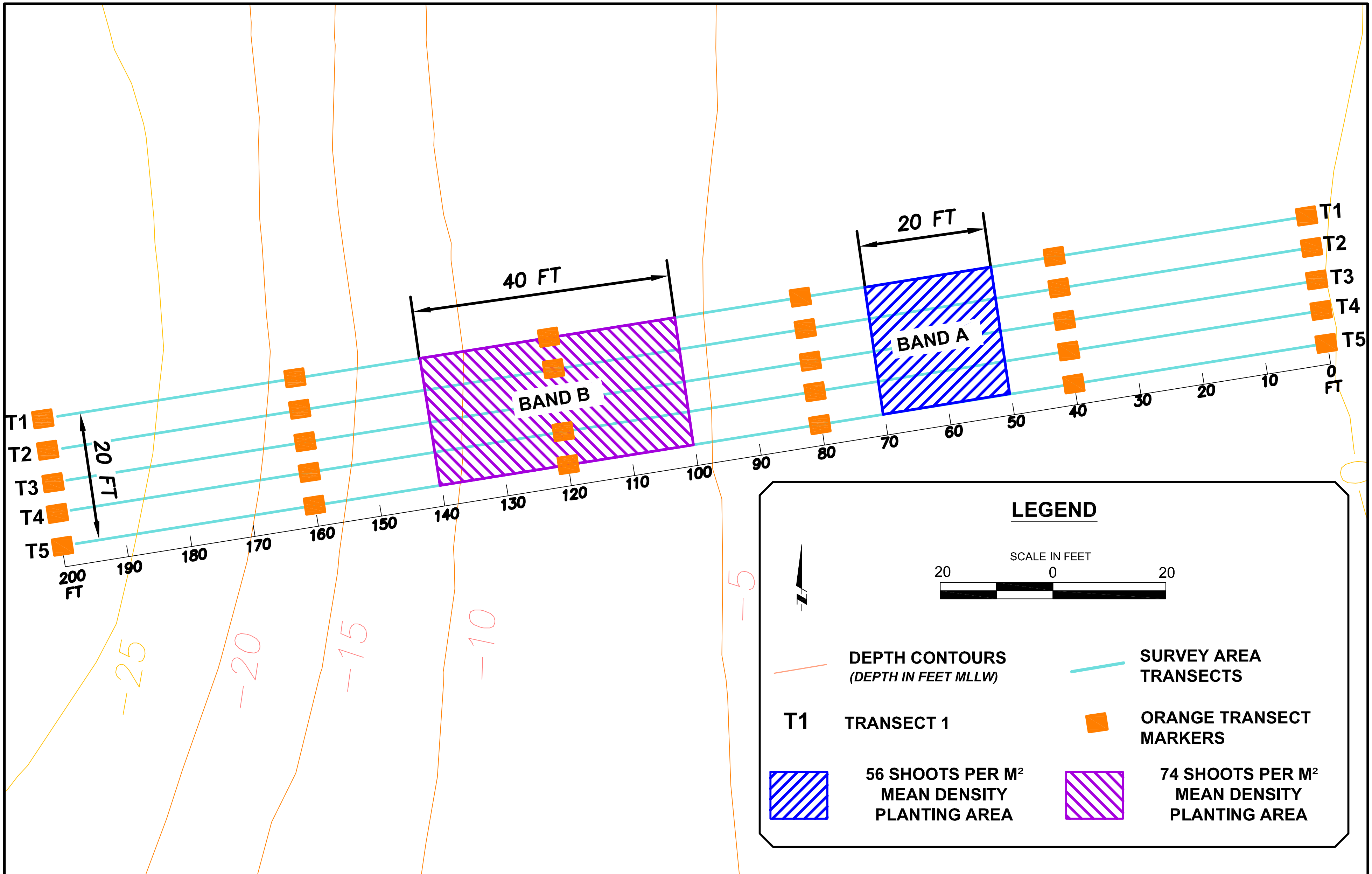
Figure 1

Marine Outfall Location

BRIGHTWATER REGIONAL WASTEWATER TREATMENT SYSTEM



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File Name: 312001100-3
Prepared By: Grette Associates, LLC

FIGURE 2

BRIGHTWATER MARINE OUTFALL CORRIDOR EELGRASS PLANTING ZONES

AUGUST 2009

Appendix A

2009 Brightwater Side-Scan Sonar and Underwater Video Survey

Report Title	**Side-Scan Sonar and Underwater Video Survey Brightwater Outfall Alignment, Puget Sound, Washington**
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Project Number	GRTA-0002
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Introduction

Global Remote Sensing, LLC (GRS) of Bothell, WA under contract to Grette Associates, LLC (Grette), Tacoma, WA, completed a comprehensive side-scan sonar and video survey of the inshore area of the Brightwater submarine outfall alignment. The site is located on the western shore of Edmonds, Washington immediately south of the Pt. Wells Fuel Pier.

Figure 1. Survey area overview map. Point Wells fuel pier region, Edmonds, Washington.

The scope of work developed by GRS will assist Grette in delineating eelgrass coverage following construction and determine where eelgrass losses occurred due to work activities. The survey objectives were to provide a full-coverage side-scan sonar map of the area, acquire video footage to groundtruth the side-scan imagery, and then use the two to delineate the eelgrass extents of the site using GIS. Data were to be collected within 64 meters on either side (both north and south) of the outfall centerline from 0 ft MLLW (Mean Lower Low Water) to the western limit of eelgrass in the survey area expected between -25 ft and -30 ft MLLW.

The side-scan sonar map will be used to monitor and detect eelgrass locations to assist in site restoration. This report summarizes the methods utilized to implement the side-scan and video survey and presents the results.

Survey Area	Systems	Survey Team
Brightwater Outfall Alignment, Edmonds, Washington.	Benthos SIS 1500 Side-scan sonar system and tow sled mounted, J W Fisher Model DV-2 Video Drop Camera	Darren Billard, Steve Budge and Bruce Titus

Table 1. Survey operational summary

Methods

The side-scan survey was conducted using a high-resolution Benthos SIS 1500 tow fish and the video survey was conducted using a J. W. Fisher Video Drop Camera housed in a protective tow sled. The survey including mobilization, calibration and demobilization was performed aboard the GRS-operated 27 foot R/V *Almar* on 15 May (side-scan sonar) and 21 May, 2009 (towed video). Figure 2 illustrates the positioning of the side-scan sonar and video towfish deployed from the vessel.

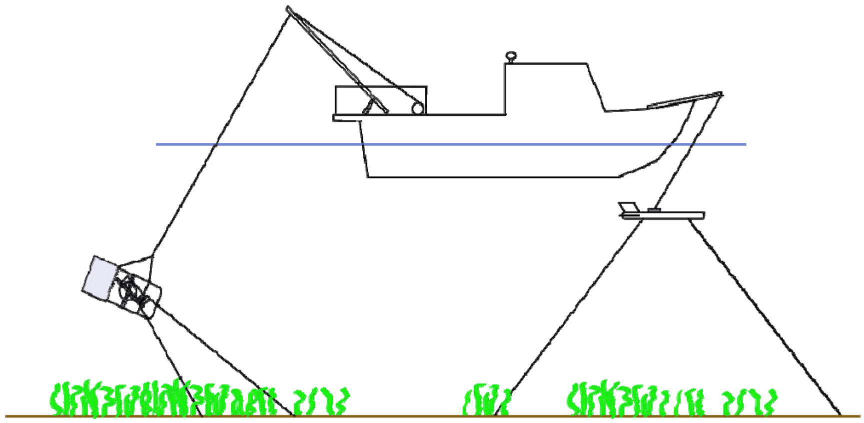


Figure 2. Survey vessel and video / sonar deployment techniques.

Tide height data for Edmonds, Washington was used to determine when tide level was optimal for data acquisition in the survey area to ensure maximum coverage for the delineation of the eelgrass extents. Tide level data was obtained from NOAA tide station located in Seattle, Washington.

Positioning

Primary horizontal position data was acquired using a Trimble DMS-232 DGPS system. The DGPS has a positional accuracy of +/- 0.25m RMS. DGPS data were sent to the Isis acquisition system and to Hypack navigation software. Hypack was used for line planning and vessel navigation along the survey lines. Horizontal and vertical offsets from the GPS Antenna to both the sonar towfish and the stern A-frame block on the vessel were measured and applied in post-processing, so timing and angular offsets of the sonar and video tow arrays could be calculated in order to accurately determine their correct positioning (Figure 3). Positional accuracy of the video tow array will vary up to +/- 5 meters due to varying drift from the centerline of the vessel track.

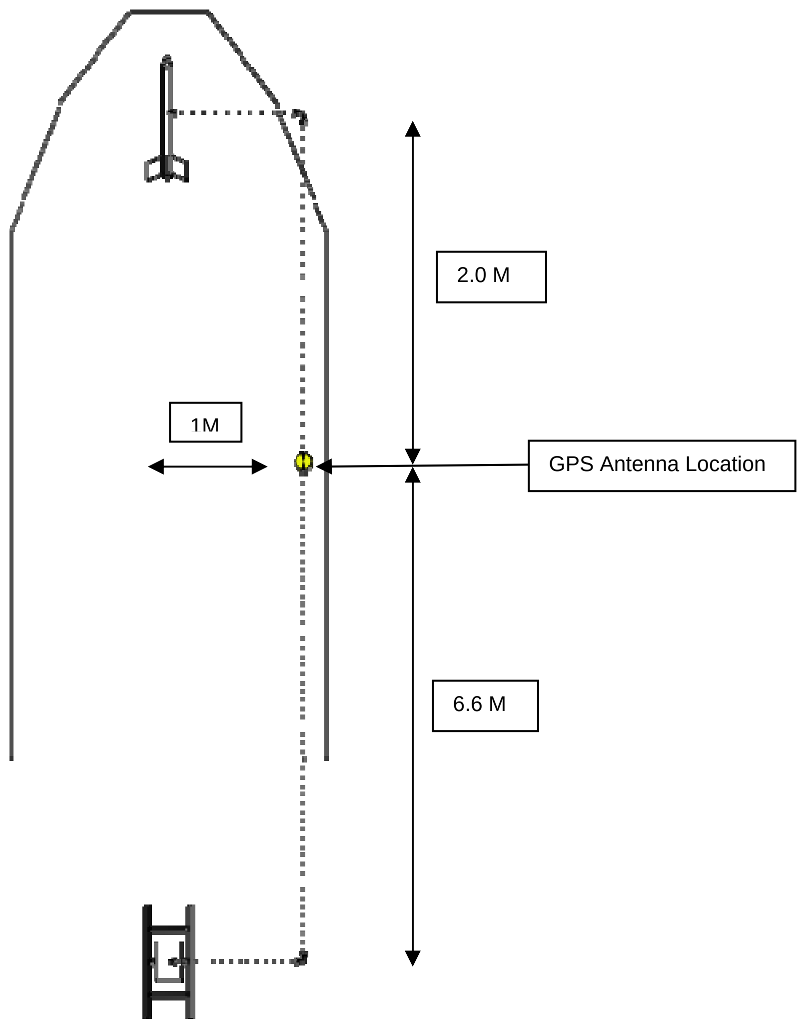


Figure 3. Vessel offset diagram of bow-mount side-scan sonar and towed video sled.

Sonar Survey

Side-scan Sonar

A Benthos SIS-1500 side-scan sonar system was installed aboard GRS's R/V *Almar* to collect seafloor high resolution sonar images. The SIS-1500 is a digital high resolution system consisting of the TTV-195 Tow fish, Sip-150 Sonar image processor and the Chirplink II digital multiplexer. The Chirplink II serves as a communications interface between the towfish electronics and the Sonar image processor, allowing the processor to send commands to the tow fish while simultaneously receiving sonar data. The TTY-195 Towfish operates in the 190 to 210 kHz band using two transducer line arrays that sonar sweep in opposite directions on each side of the towfish. The towfish speed is limited to less than 8 knots and has a maximum operating depth of 1000 m. The towfish used in the survey was suspended immediately below the bow, 1.5 meters below the water surface. Each survey transect was run using a maximum survey speed of 2 knots using a sonar ping range of 50 m that allows a 100 m swath coverage.

Sonar Acquisition System

The Triton Imaging Isis data acquisition system was used to acquire and store all side-scan sonar data. Isis software runs under Microsoft Windows 9x/NT/2000. Data from all ancillary sensors were sent directly to Isis and integrated within the data packet for each sonar ping. Real-time acquisition displays provided data quality control and assessments during surveys. A real-time digital image of seafloor characteristics was available during the survey to assure data quality and full bottom coverage. All data were stored in Triton Elics XTF format for post-processing, analysis, and archiving.

Data Processing

The side-scan sonar Isis .XTF files obtained for each survey line were processed using Chesapeake Technology, Inc. Sonar Wiz software. Data were individually examined for navigation and image quality and the clearest tracklines were selected for mosaic creation. Bottom-tracking, a crucial aspect to processing side-scan imagery, was verified and corrected where necessary. Towfish layback was applied to trackline navigation using coincident feature and edge-matching techniques. Towfish heading was corrected for magnetic declination. Acoustic gain corrections were then applied to the most complete and consistent tracklines to enhance the imagery across-swath. The final side-scan mosaic was constructed using image overlap (stacking) with the clearest trackline imagery on top. The mosaic was exported as a GeoTIFF into ArcGIS for digitization of eelgrass coverage.

Video Survey

Operations

A J.W. Fisher DV-2 drop video camera was mounted on a fabricated tow sled to obtain digital video images of the sea bottom during each transect run. The drop video camera shown in Figure 4 was mounted at a 30° down angle on the sled during the survey. The tow sled was lowered by the vessels hydraulic winch until the bottom was visually sighted on the video monitor. Survey lines were run at 25 m intervals across the study area. The digital output from the video camera and DGPS were linked to a video annotator which recorded video and positional information directly onto a laptop hard drive.

Figure 4 Underwater video camera mounted on a sled used to obtain seafloor video.

Analysis

Processing of towed video survey data consisted of recording time-based attribute information by observing the video footage and then assigning these observations to a time-based linear reference system using the navigation tracklines in ArcGIS. A spreadsheet was created to record the transitional bottom-type changes visible in video clips along each transect line. Categories were created to represent the eelgrass density distribution (sparse, medium, dense) and to separate the dominant bottom types (sand and rock/cobble). Density was relative, with “dense” filling up the video screen and “sparse” with plants appearing every meter or two. Because the focus was on mapping eelgrass distribution, marine algae (red, green, brown) along transects were not recorded.

To make the video observations spatial, navigation tracklines were converted to routes with time-based measures using linear referencing techniques. For each trackline, the video review spreadsheet was displayed in ArcGIS to guide the sidescan interpretation.

Results

The processed side-scan sonar mosaic (Figure 5) revealed very subtle variations in texture typical of very shallow, mixed-seafloor, environments. Specific variations in eelgrass plant density were not easily discernable due to geometric distortion typical in side-scan mosaics. Movement of plants due to tidal currents as well as plant shading of seafloor “uphill” of the sonar further complicated the acoustic image results. The eelgrass bed extents, however, were distinguishable from the surrounding sediment. An example of the acoustic texture signature of eelgrass is shown in Figure 6.

Sonar imagery and video trackline data were used together to delineate eelgrass bed extents within the survey area. ArcGIS was utilized for this purpose, resulting in a polygon shapefile that represents these extents. Other bottom types were not delineated. Density variations observed in video footage were not consistently represented in the sonar imagery.

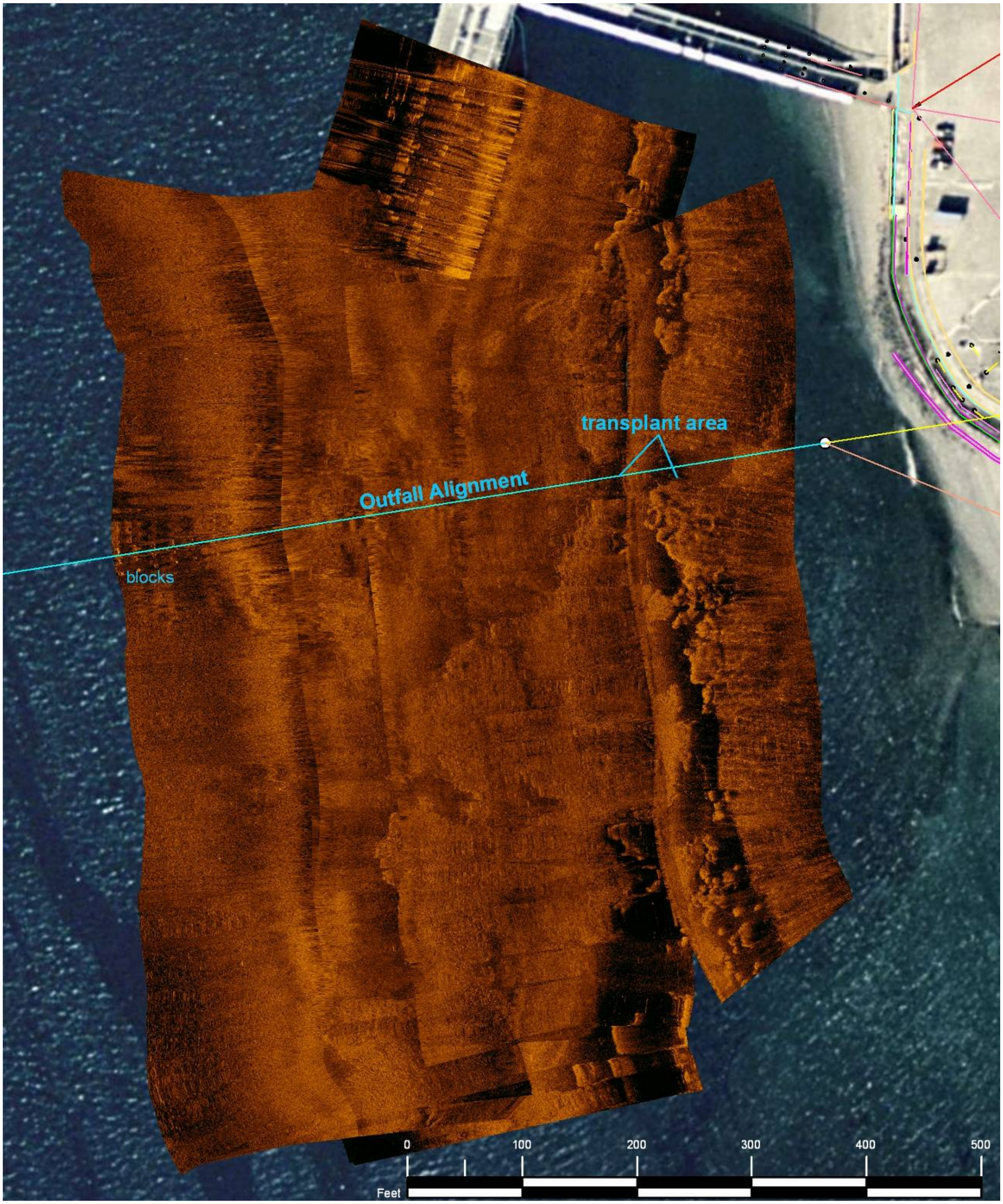


Figure 5. Side-scan sonar mosaic of survey area. Pipeline anchor blocks are visible on the western side of the image. The area to receive transplanted eelgrass is highlighted. Outfall alignment data provided to GRS by Triton Marine Construction for bathymetric surveys conducted during the pipeline lay.

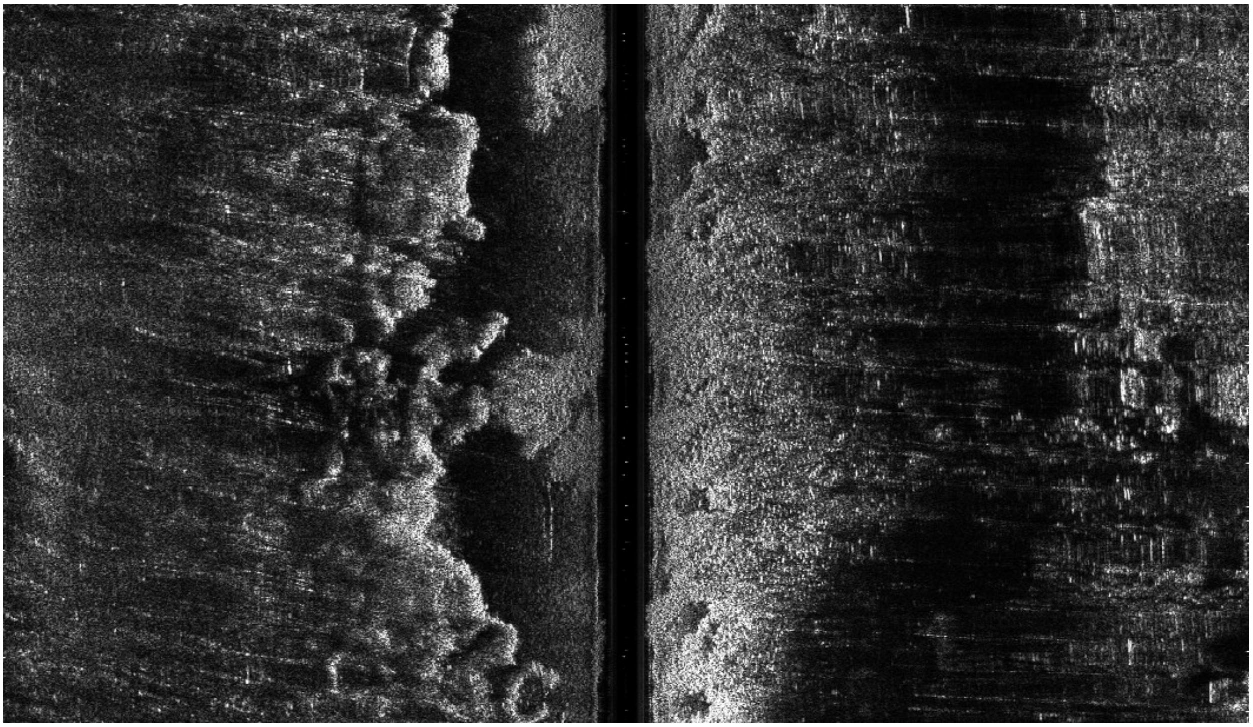


Figure 6. Side-scan waterfall view of eelgrass clumps (center-left) and mixed-density beds (center-right). Gap in the middle is the water column directly under the sonar towfish. The swath width is 100 m. The shoreward direction is to the left.

A large contiguous bed of eelgrass occurs to the south of the alignment, becoming more fragmented to the north and shoreward (Figure 7). The fragmentation (absence) of eelgrass to the north and south of the alignment appears to be naturally occurring, as it does not run precisely parallel to the sonar track. The seaward extent of eelgrass around the outfall alignment corridor coincides approximately with the -15 ft contour (Figure 8). The lack of eelgrass directly under the outfall alignment between 0 and -15 ft MLLW depths was expected due to the construction of the pipeline. There are two bright sonar textures in this region, which are likely cobble or turned up sediment following construction (A. Dubois, pers. comm.). There are no similar "gaps" in the eelgrass bed that appear to reflect the pipeline's location. There are no similar "gaps" of eelgrass coverage that occur along the pipeline alignment.

Pre-construction sidescan imagery from a 2004 survey by Batelle was provided to GRS for a comparison with the post-construction imagery presented in this report. Generally, the two sonar mosaics agreed, highlighting the largest eelgrass bed extents to the south of the alignment (Figure 9). Differences in polygon shape between 2004 and 2009 can be attributed to minor fluctuations in areal coverage by eelgrass over time. A few small areas adjacent to the Corridor where eelgrass was present in 2004 were absent of eelgrass in 2009. However, it was noted that these areas were not marked by obvious sediment or eelgrass disturbance when visually surveyed by divers in May or September of 2009. To confirm that construction of the alignment did not damage eelgrass, an ROV survey of the substrate adjacent to the Corridor will be undertaken during routine post-construction monitoring of the site in 2010.

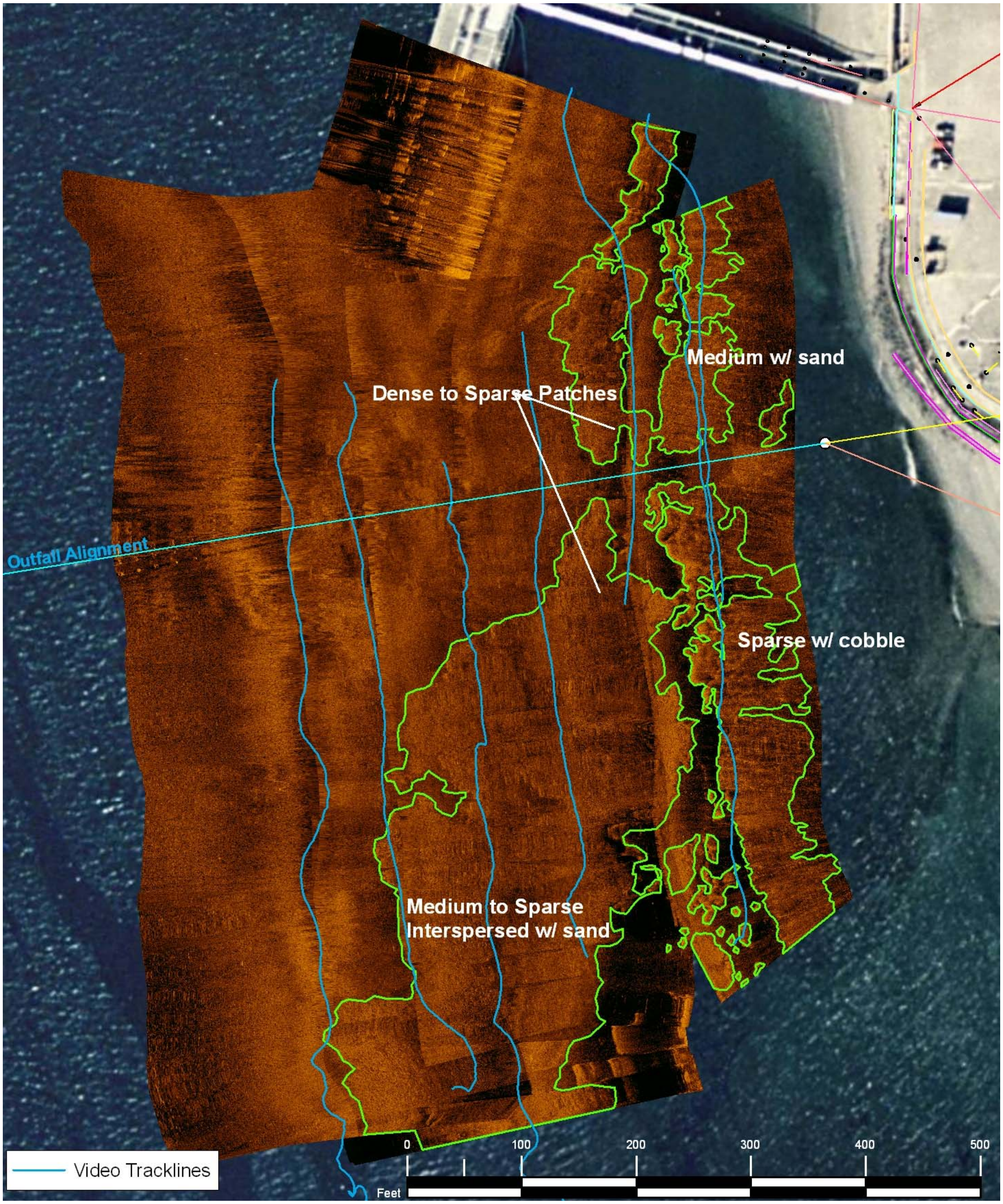


Figure 7. 2009 Eelgrass delineation based on groundtruth data and characteristic eelgrass texture signatures. Areas of qualitative density highlighted. The region seaward of the eelgrass area is sand, shoreward is mostly cobble.

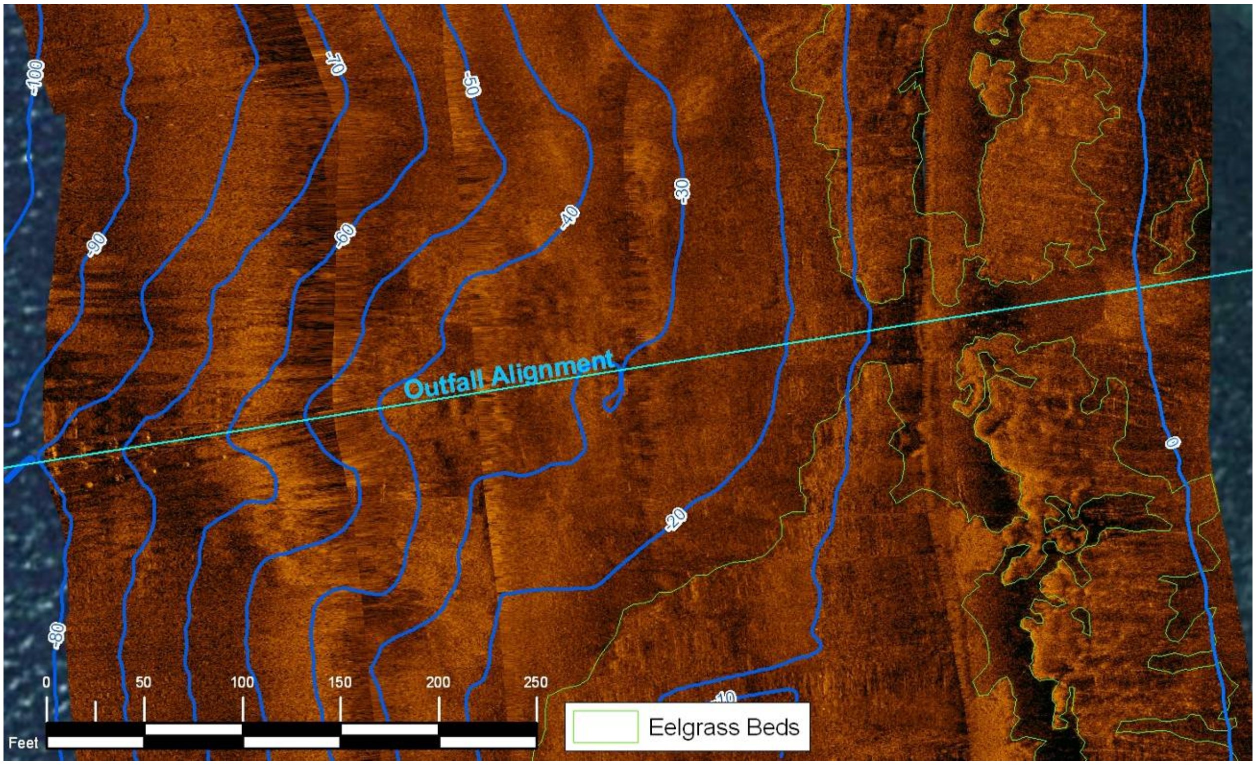
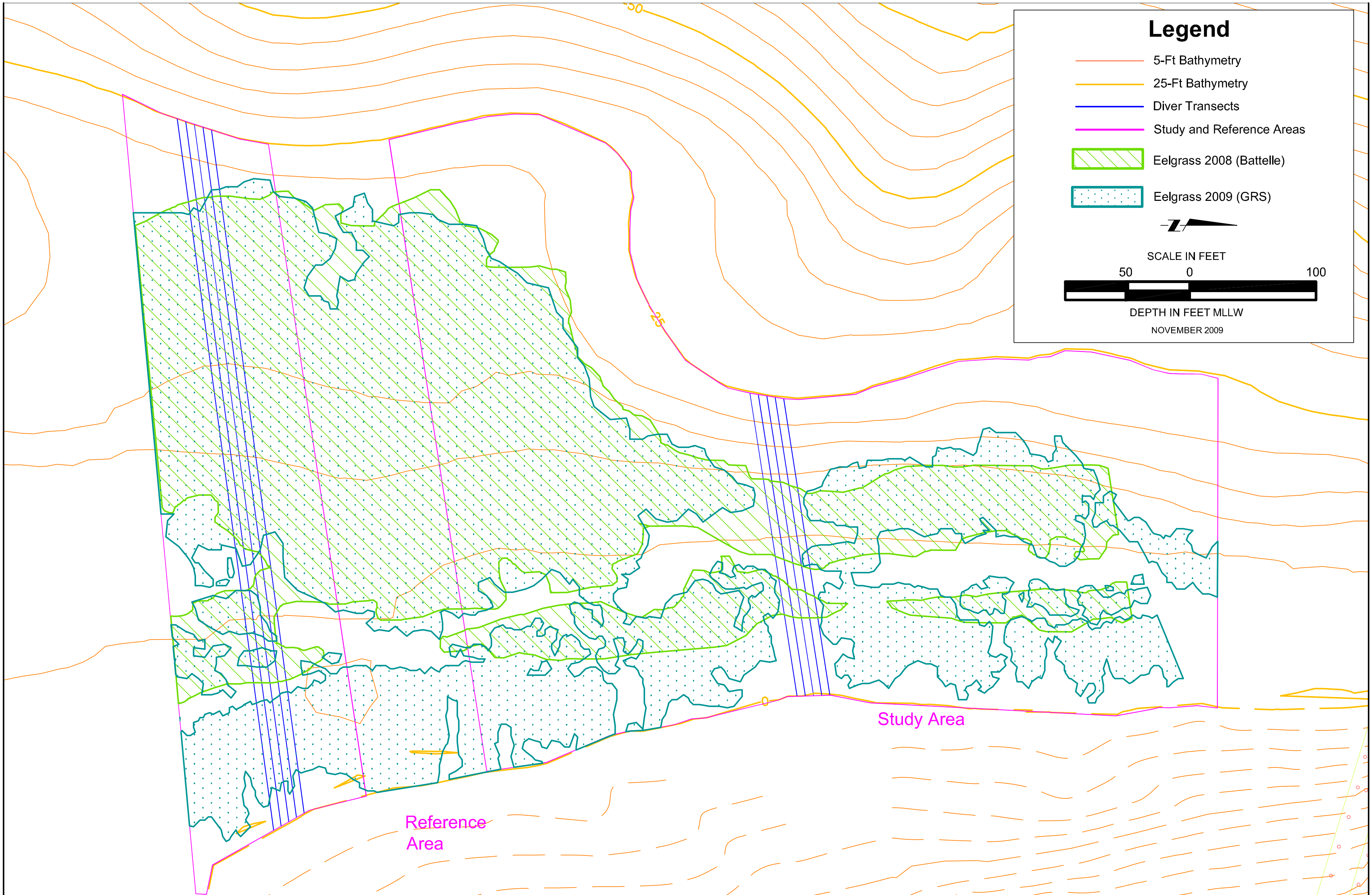


Figure 8. Close-up of outfall pipeline alignment section. Bathymetry from post-lay and pre-construction (0 ft MLLW contour only) single-beam echosounder surveys conducted by GRS for Triton Marine Construction. Depths in feet.

Summary

Side-scan sonar imagery was collected over the Brightwater Outfall pipeline alignment on 15 May, 2009. The sonar survey was followed by towed video on 21 May, 2009 for the purposes of groundtruthing sonar imagery. Eelgrass extents were delineated from the side-scan sonar image mosaic using ArcGIS and line-segment bottom type information observed in video footage. The eelgrass coverage generally was contained between the 0 and -15 ft MLLW depth contours. The absence of eelgrass immediately around the pipeline alignment was expected due to burial and no visible damage appeared outside of the outfall corridor. A comparison of eelgrass areal coverage between the 2004 pre-construction sonar survey and this 2009 post-construction survey did not reveal large spatial differences in mapping of eelgrass beds at the Marine Outfall Survey Area (Figure 9).



King County
Department of Natural Resources and Parks
Wastewater Treatment Division

File Name: 500-560-2
Prepared By: Grette Associates, LLC

FIGURE 9

Brightwater Marine Outfall Eelgrass Presence pre- and post-construction survey data