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First Annual Report: 2004 Pre-Construction Eelgrass Monitoring and Propagation for King County Outfall Mitigation

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March 2006

Prepared for
King County Department of Natural Resources and Parks
Wastewater Treatment Division, Brightwater Project
Under a Related Services Agreement
With the U.S. Department of Energy
Contract DE-AC05-76RL01830

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Pacific Northwest National Laboratory
Richland, Washington 99352

Executive Summary

King County proposes to build a new sewer outfall discharging to Puget Sound near Point Wells, Washington. Construction is scheduled for 2009. The Point Wells site was selected to minimize effects on the nearshore marine environment; however, unavoidable impacts to eelgrass (*Zostera marina*) beds are anticipated during construction. To mitigate for these impacts and prepare for post-construction restoration, King County began implementation of a multi-year eelgrass monitoring and restoration program in 2004, with the primary goal of returning intertidal and shallow subtidal habitat and eelgrass to pre-construction conditions. Major program elements are a) pre-construction monitoring (documenting initial eelgrass conditions and degree of fluctuation over 5 years prior to construction), b) eelgrass transplanting (harvesting, offsite propagating and stockpiling of local plant stock, and post-construction planting), and c) post-construction monitoring. The program is detailed in the *Final Eelgrass Restoration and Biological Resources Implementation Workplan* (King County 2005).

This report describes activities through calendar year 2004 on two major pre-construction eelgrass mitigation tasks. The first was a pre-construction eelgrass mapping survey by side-scan sonar and underwater videography, which covered the entire nearshore area from approximately 65 m (213.25 ft) north of the Marine Outfall Corridor to approximately 10 m (32.8 ft) south of the Eelgrass Reference Area, and offshore (west) to a depth of -25 ft mean lower low water (MLLW). A complementary dive survey of eelgrass density within the Marine Outfall Corridor and Eelgrass Reference Area was conducted and reported under separate cover by Grette Associates (Grette Associates 2005). Data from all three survey methods were used to compile the resulting eelgrass distribution maps. The second pre-construction eelgrass mitigation task involved harvesting of eelgrass shoots from the study area (marine outfall corridor) for propagation and stockpiling, which will occur over the 5-year pre-construction period, with the goal of providing a sufficient stock of local plants for post-construction site restoration. Experimental harvest plots in the outfall corridor area will be monitored to determine recovery rates relative to harvest rates, to determine an optimum harvest rate that allows for rapid recovery of donor eelgrass beds.

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1.0 Introduction

King County's Wastewater Treatment Division is planning to construct a new sewer outfall, the Brightwater outfall, which discharges into Puget Sound near the King-Snohomish County line just south of Point Wells, Washington. A lengthy siting process was conducted to determine an outfall site that would have the least impact to the nearshore marine environment. This particular site was chosen because the shallow nearshore zone is narrower and biological resources such as eelgrass are less abundant than at other potential sites. Because of the native eelgrass (*Zostera marina*) along the proposed outfall alignment, King County is implementing a mitigation program to monitor and restore eelgrass beds that will be unavoidably disturbed by construction.

This report is the first in a series of annual reports on pre-construction activities conducted by the Pacific Northwest National Laboratory (PNNL) for the King County Brightwater outfall eelgrass and biological resource mitigation program. Work related to this program is described in a *Draft Eelgrass Restoration and Monitoring Plan* (King County 2004), which was refined and further detailed in a *Final Eelgrass Restoration and Biological Resources Implementation Workplan* (King County 2005). PNNL tasks include pre-construction mapping and monitoring of eelgrass beds in the outfall survey area, and eelgrass stockpiling and propagation for post-construction restoration.

The Brightwater outfall survey area encompasses the Eelgrass (Outfall) Study Area, Marine Outfall Corridor, Eelgrass Reference Area, Eelgrass Reference Corridor, and Eelgrass Donor Site. These areas are defined below and depicted in Figure 1.

- *The Eelgrass (Outfall) Study Area* extends 64 m (210 ft) both north and south of the outfall pipeline alignment centerline, between 0 ft mean lower low water (MLLW) and -25 ft MLLW, which is the zone in which eelgrass and associated macroalgae grow.

- *The Marine Outfall Corridor*, a narrow zone (6.1 m; 20 ft wide) within the Eelgrass Study Area, is centered on the outfall pipeline alignment that includes 1.2 m (4 ft) on either side of the 3.7-m (12-ft) wide sheeted trench.

- *The Eelgrass Reference Area* is located directly south of the Eelgrass Study Area. Eelgrass densities in this area are similar to those in the southern portion of the Eelgrass Study Area. The Eelgrass Reference Area will be used to assess overall eelgrass trends and interannual variability.

- *The Eelgrass Reference Corridor*, a 6.1-m (20-ft) wide area in the center of the Eelgrass Reference Area and parallel to the Marine Outfall Corridor, was surveyed for eelgrass by divers in 2004 (Grette Associates 2005).

- *The Eelgrass Donor Site* is located south of the outfall pipeline alignment and extends south from the King-Snohomish County line. It is approximately 0.4 hectare (1 acre) of moderate to dense eelgrass beds that will provide the stock for transplanting as a contingency for failure of the planned pre-harvest and propagation strategy of using plants from the construction site (Marine Outfall Corridor).

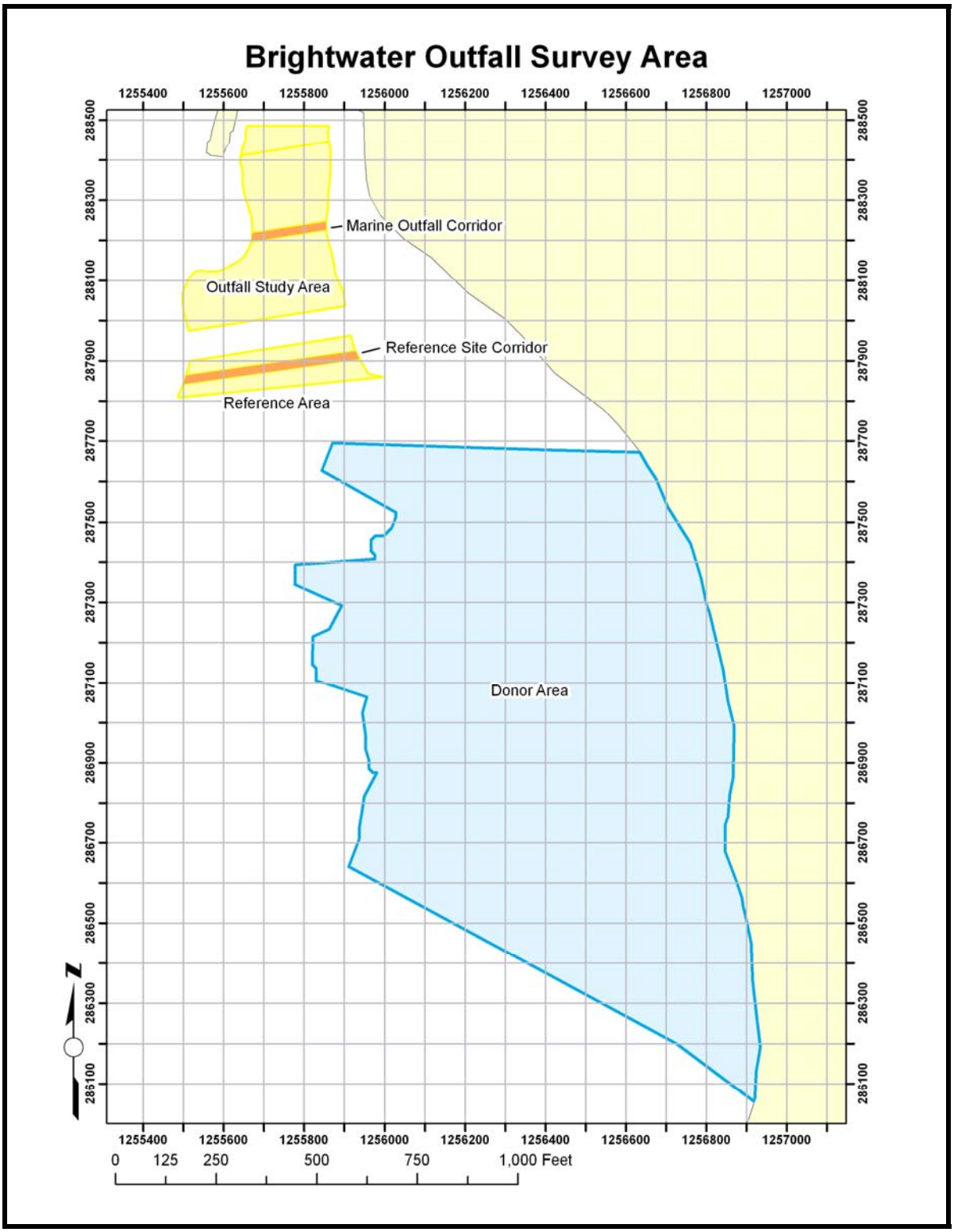

Figure 1. Brightwater Outfall Survey Area

In September 2004, following a dive survey by Grette Associates, LLC, during the summer of 2004 in the Marine Outfall and Reference Corridors, PNNL conducted side-scan sonar and underwater video surveys of all areas described above, analyzed the survey data for eelgrass extent and cover class, and prepared maps delineating eelgrass beds in the study and reference areas. These data and maps document the pre-construction condition of eelgrass beds and nearshore habitat in general, and will serve as the basis of comparison for the next 5 years of pre-construction monitoring. Eelgrass mapping activities and progress are detailed in Section 2 of this report.

It is assumed that the primary disturbance to the eelgrass in the Outfall Corridor will be from construction of the outfall. In anticipation of this occurring, PNNL harvested eelgrass shoots from the Marine Outfall Corridor to begin offsite propagation of plants for post-construction restoration. This approach to restoration eliminates the need to dig and transplant eelgrass meadows that would otherwise be disturbed, while ensuring that the resident population is restored at the site. In order to better understand eelgrass recovery rates within the potential donor bed and/or the Marine Outfall Corridor, an experimental approach was taken when harvesting the shoots for propagation. Approximately 300 shoots were harvested from the site and planted in tanks at the PNNL Marine Sciences Laboratory in Sequim, Washington, to begin propagation of plants for restoration. The propagation tanks will be supplemented with eelgrass seeds and additional shoots collected in the next 2 years. The experimental approach to eelgrass harvest and propagation activities are detailed in Section 3 of this report.

2.0 Eelgrass Mapping Using Side-Scan Sonar and Underwater Video

Between September 20 and 22, 2004, PNNL conducted a side-scan sonar and underwater video survey of the Brightwater outfall area (i.e., study area, reference area, donor area) (Figure 1). Eelgrass (*Z. marina*) boundaries and coverage classes were delineated in the study and reference areas. Side-scan sonar and underwater video data collected in the donor area were not post-processed; however, the imagery and data has been archived for future use if needed. This initial delineation in the study and reference areas, conducted 5 years prior to construction, will serve as the baseline condition upon which subsequent pre-construction surveys can be compared to evaluate natural variation in eelgrass distribution over time.

2.1 Eelgrass Mapping Methods

2.1.1 Side-Scan Sonar and Underwater Video Field Collection

Side-scan sonar and underwater video data were collected over the entire study and reference area, from approximately 65 m (213.25 ft) north of the Marine Outfall Corridor, to approximately 10 m (32.8 ft) south of the Eelgrass Reference Area, and offshore (west) to a depth of at least -25 ft (-7.6 m) MLLW. Methods are described in greater detail in the *Final Eelgrass Restoration and Biological Resources Implementation Work plan*, (King County 2005). A GeoAcoustics Ltd., side-scan system was towed behind PNNL's research vessel, *R/V Strait Science*, at high tide to ensure the fullest possible extent of nearshore coverage. Side-scan sonar data were collected along transects (tracklines) parallel to shore,

spaced approximately 60 m (196.85 ft) apart, which provided the best resolution of data with an approximate 50% overlap of swaths. Each transect provided a different signal return or "view angle" of the eelgrass. Multiple passes of each sonar transect were made; each pass providing a slightly different angle (upslope or downslope) of the eelgrass. An on-board differential global positioning system (dGPS) and computer imaging system provided real-time output of sonar images on a computer monitor. Each individual pass of the sonar was examined for signatures of eelgrass edges and patches; the information from the passes with the strongest eelgrass signal returns were merged, creating the final mosaic used to delineate the eelgrass polygons (Figure 2).

The planned locations of the underwater video transect are shown in Figure 3. Due to currents, wind and bottom depth, actual tracklines of the video location in the Outfall Study Area and Reference Area varied slightly: four parallel to shore throughout the entire study area, two to three perpendicular to shore in the Marine Outfall Corridor and Eelgrass Reference area (respectively), and two "zig-zag" passes through the entire study area (Figure 4). The underwater video system consists of a wide angle, color, underwater video camera mounted on a tow sled that is linked to a computer database and dGPS. The dGPS location and time are recorded and stored in a computer database and also burned directly on the video image as a permanent record. The position information is updated and recorded every 1 second. The camera was towed behind the PNNL vessel, *R/V Strait Science*, at an oblique angle approximately 1 m (3.28 ft) off the bottom. Video footage of the nearshore areas was also collected at high tide to ensure the fullest possible coverage. Copies of all video footage have been provided to King County.

2.1.2 Underwater Video Analysis

Video analysis was accomplished using custom software developed by PNNL (Figure 5). The software allows an operator to link a digital video stream to a GPS log file and thereby associate observed video features with a specific spatial position. The coordinated universal time (UTC) from the GPS is imprinted on each video frame in the field to enable accurate time calibration. The analyst has full control of video playback, including forward/reverse at any rate specified, and incremental frame stepping. Changes in eelgrass density, eelgrass cover type, and substrate type are recorded by clicking an appropriate button in the analysis software window. As the analyst plays back the video, each GPS point (logged once per second) is assigned a classification specified by the analyst. When a parameter is changed, subsequent points are assigned the new classification, continuing until the classification is changed again or the end of the transect is reached. Exact time changes are recorded (starting from time zero in the digital video file), so the new classification is assigned to the nearest whole-second GPS point. Percentage of eelgrass cover is designated from the lower half of the viewing screen only. A horizontal red line is used as the divider on the screen (Figure 5).

The video post-processing coverage designations for eelgrass were as follows:

- *None* – no eelgrass showing
- *Sparse* – 25% or less of the viewing area contained eelgrass
- *Moderate* – between 25% and 75% of the viewing area contained eelgrass
- *Dense* – >75% of the viewing area contained eelgrass.

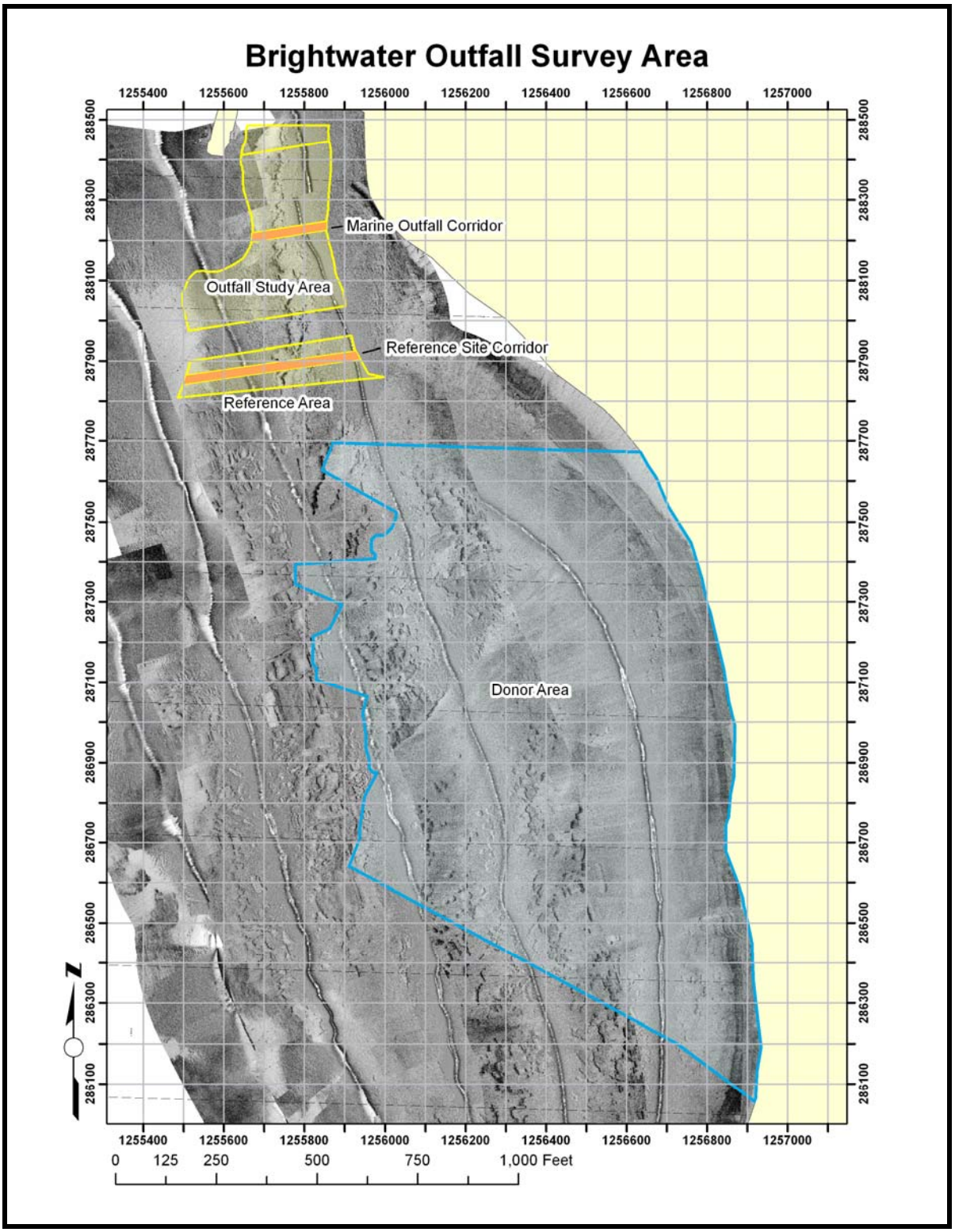

Figure 2. Final Side-Scan Sonar Mosaic Used to Delineate Eelgrass Polygons

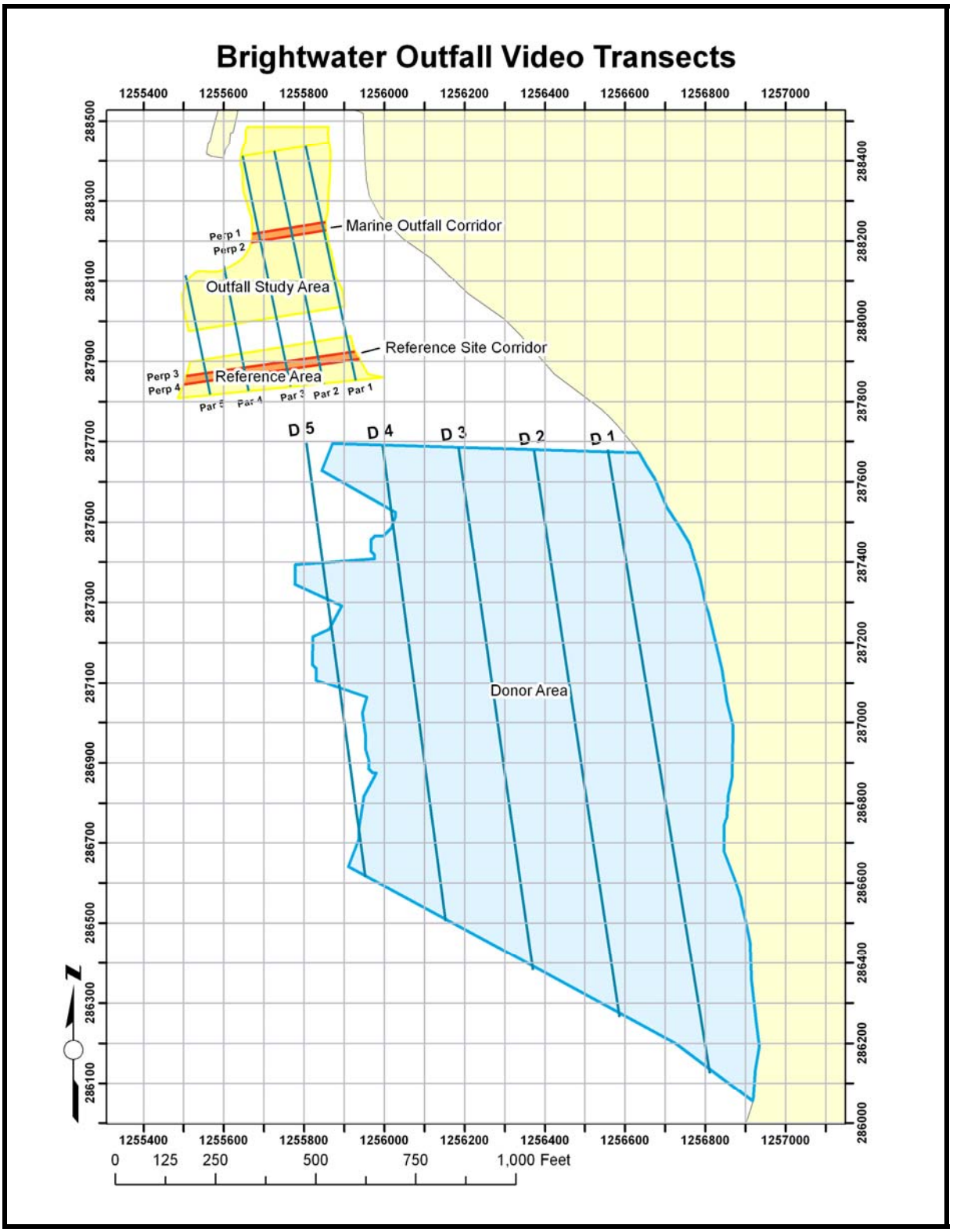

Figure 3. Proposed Video Transects in the Outfall Study Area, Reference Area, and Donor Area

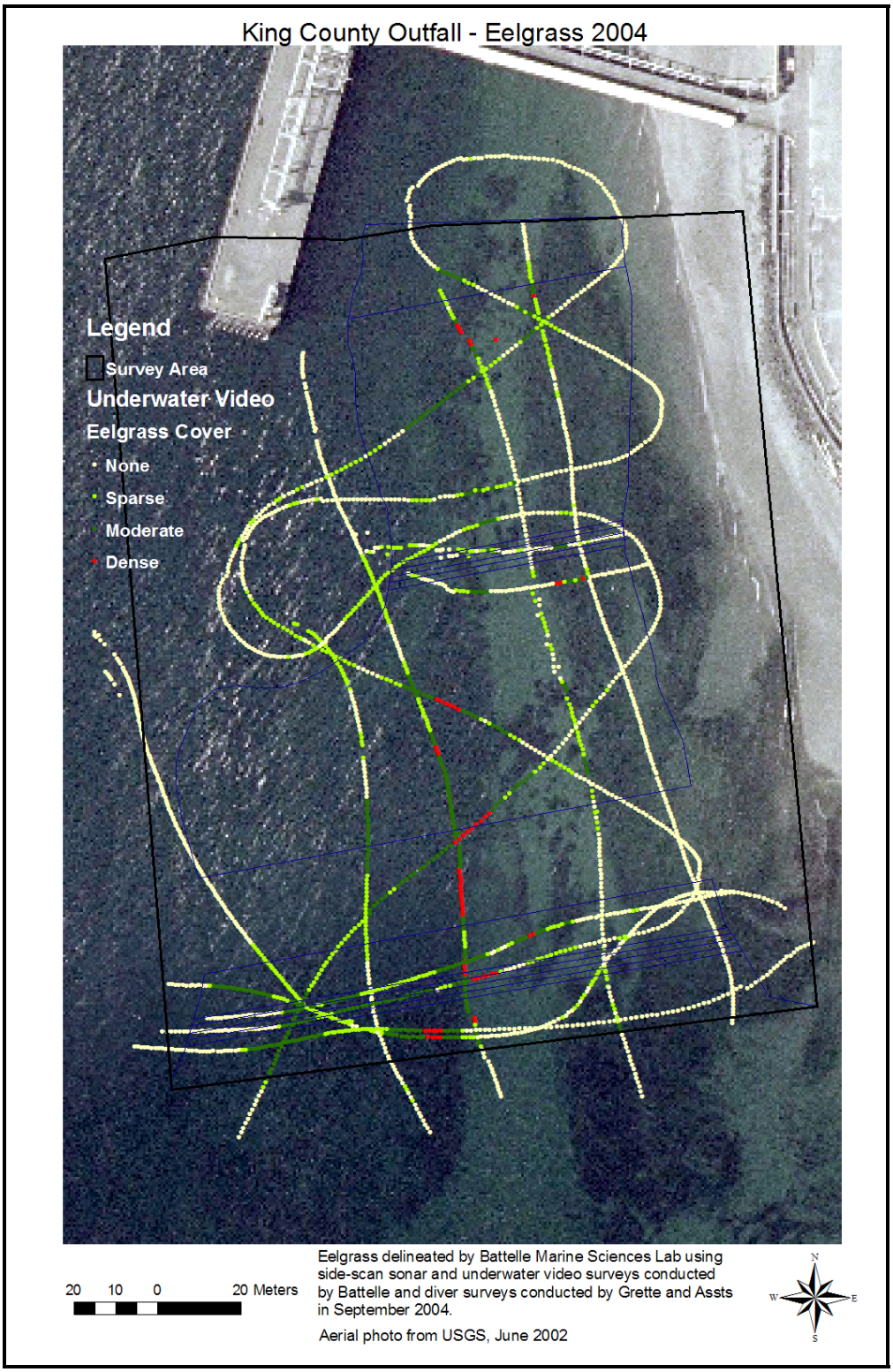

Figure 4. Georeferenced Underwater Video Location and Cover Class of Eelgrass Located in the Outfall Study Area and Reference Area. Video Collected on September 21, 2004.

Figure 5. Screen Capture of PNNL Video Analysis Software with King County Video Transect

2.1.3 Video Quality Assurance

Several levels of quality assurance (QA) checks were implemented to ensure consistent and repeatable estimates of eelgrass coverage. First, initial discussions were held to determine the most appropriate cover classes for this study site. Secondly, two individuals were trained to post-process the data and determine eelgrass coverage. The first individual conducted the entire "full playback" recording of the data. A second individual analyzed the video transects by recording the frame classification every 10 seconds. The two classification logs were then compared at coincident points to verify the classification accuracy of the original operator. A schematic of the processing steps is shown in Figure 6. A total of 266 records were compared; the results are summarized in Table 1.

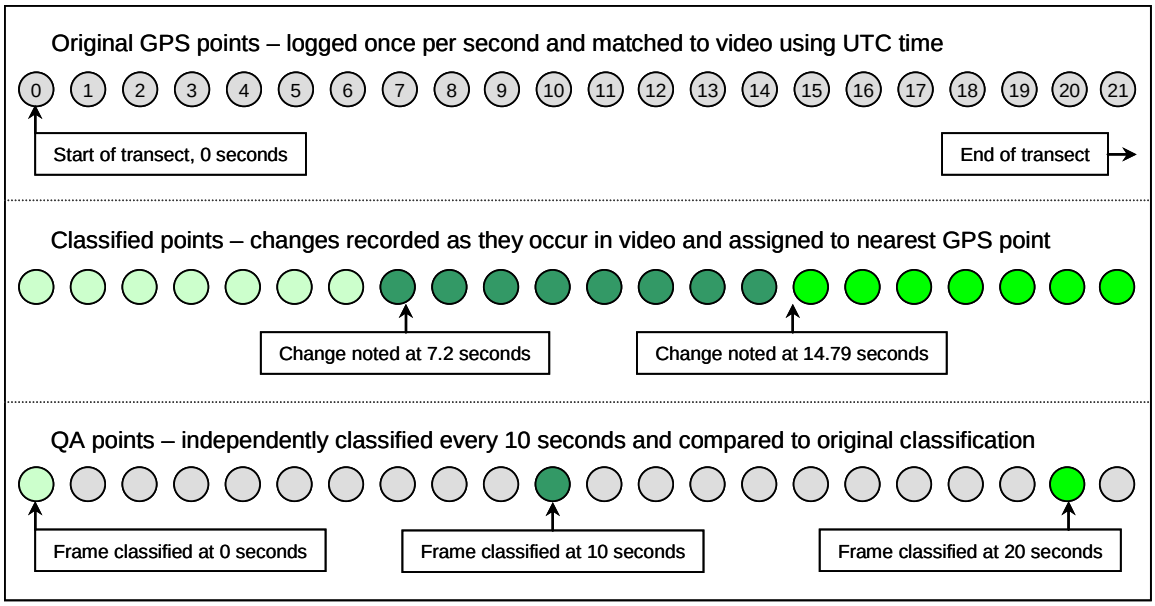

Figure 6. Diagram of Video Point Classification and Quality Assurance Process

Table 1. Summary of Quality Assurance Inconsistencies by Type between Original Classification and Independent Frame Classification Check Every 10 Seconds.

Transect	Type 1- Misidentification		Type 2 – Context Inconsistency		Type 3 – Subjective Discrepancy		Type 4 – QA Operator Discrepancy	
	# Video Frame Eval-uations	% of differences	# Video Frame Eval-uations	% of differences	# Video Frame Eval-uations	% of differences	# Video Frame Eval-uations	% of differences
SR PA 1	25	8%	25	0%	25	4%	25	0%
SR PA 2	21	5%	21	14%	21	0%	21	0%
SR PA 3	24	8%	24	0%	24	42%	24	0%
SR PA 4	14	7%	14	7%	14	43%	14	0%
SR PA 5	16	0%	16	0%	16	0%	16	0%
SR PE 1	9	11%	9	22%	9	0%	9	0%
SR PE 2	8	0%	8	38%	8	0%	8	0%
SR PE 3	20	5%	20	10%	20	0%	20	5%
SR PE 3A	16	0%	16	6%	16	6%	16	0%
SR PE 4	19	0%	19	5%	19	0%	19	0%
ZIG ZAG	94	1%	94	22%	94	4%	94	1%
Total	**266**	**3%**	**266**	**13%**	**266**	**8%**	**266**	**1%**

Finally, each point where the records were different was evaluated by a third independent party, and the types of errors were divided into four categories, as follows:

- Type 1 – classification discrepancy by the original operator (corrected)

- Type 2 – context inconsistency (not corrected)
- Type 3 – subjective discrepancy (not corrected)
- Type 4 – QA operator discrepancy (not corrected).

Type 1 errors occurred when the QA observer found conditions to be different from those identified by the original observer, and was the only type of error changed in the records.

Type 2 errors occurred when (1) a classification change was made within 1 second of when the coincident records were compared, resulting in two different classifications, and 2) when not enough information was available to the QA operator to make an accurate classification. Under the first scenario, when original data sheets (containing all data records, not only QA records) were compared, the original classification in question was found to be the same as the QA classification within 1 second. The second scenario occurred, when the QA operator made an classification based on a one frame, whereas the original viewer had the advantage of seeing the blades at various perspectives as the camera approached.

Type 3 errors (subjective) occurred for two primary reasons. First, the original observer would make a decision when to change a category call, and the QA observer would change the call a few seconds earlier or later. The other Type 3 errors occurred in cases in which the eelgrass cover classification was "borderline" and was subject to the opinion of the observer as to which classification was most appropriate. In these cases, the decision was made to not change the data, because the original observer had better context for assessing the subtle differences in cover of the bed, based on being able to view the continuous video rather than just a snapshot.

Type 4 error (QA operator error) occurred very rarely (0.75%) and was due to the QA observer incorrectly classifying the record.

Overall, the majority of errors occurred in the Type 2 and Type 3 categories, due to the nature of the QA process and to subjective assessments. The Type 1 error (misidentification) occurred very rarely, with a 3% error rate for all categories. These errors were primarily due to the extremely sparse and patchy nature of the eelgrass in the study area, resulting in quick and subtle changes occurring over a short span (i.e., seconds) on the video record.

2.1.4 Data Analysis and Map Production

Side-scan sonar and video imagery were post-processed and formatted in standard GIS software (ArcGIS 9) to create maps of eelgrass distribution. Eelgrass in the study area was delineated from a combination of side-scan sonar and underwater video transect data. In the Marine Outfall Corridor and Eelgrass Reference Area, the Grette Associates (2005) dive-survey information was also incorporated to provide higher resolution of eelgrass distribution within the Outfall and Reference corridors. The overall process involved an initial evaluation of the side-scan sonar to determine the spatial extent of the eelgrass (boundaries), then using the underwater video data to verify spatial cover and patchiness and to determine cover classes (Section 2.1.1).

The data from each sonar swath (Section 2.1.1) was evaluated separately to determine the location of eelgrass patch or bed edges. The edge visibility can vary depending on current flow direction, the angle

of the sonar, and the density of the eelgrass. In addition, the accuracy of the edge location depends on the accuracy of the GPS at the time of the data collection (depending on the number of satellites in range). Given these factors, it was deemed necessary to evaluate the overlapping swaths separately. The eelgrass edge from each of the sonar swaths was delineated individually; then the mapped location of each edge was determined based on the average location of the delineations from the multiple swaths (the difference in edge location was usually 0 m to 2 m).

After preliminary eelgrass polygons were defined from the sonar data, the underwater video data were overlaid on the mosaic of the side-scan sonar image. Additional polygons were delineated based on the cover-class information from the underwater video data. Finally, an additional, smaller polygon was identified in the corridors from the Grette Associates (2005) dive-survey data. Each polygon was assigned a cover class as shown in Table 2.

Final polygon delineation was based on a set of decision rules to guide the interpretation of the data. An eelgrass bed was considered a separate polygon if its dimension on any one side, based on a combination of the sonar and video data, was at least 3 m across. The only exception to this rule was within the Marine Outfall Corridor, where additional data sources at a finer scale were available (i.e., survey transects conducted by Grette Associates). In this area, a 1.5-m polygon was delineated. Eelgrass beds that did not meet the 3-m criterion but contained eelgrass recorded by the sonar or video were coded as sparse or patchy cover (Cover Class 1). It is possible that Cover Class 0 (none) may have contained single isolated eelgrass plants that were not captured by the sonar swath or were not within the video trackline field of view.

The spatial accuracy of this mapping method is determined by the equipment and the techniques used to collect the data. For example, the dGPS used with the side-scan sonar and underwater video data collection is accurate to ±2 meters in this kind of application. In addition, the location of the camera relative to the boat and GPS unit varies depending on the depth and the speed of the boat. Every attempt was made to account for and minimize the effects of these factors; however, they still must be considered. When the video data were analyzed using the GIS software, each transect was evaluated separately to determine the direction of the boat and the position of the camera relative to the recorded GPS point. The resulting eelgrass polygons were delineated accordingly. In areas where there were limited data, such as areas between video tracklines with sparse eelgrass, or areas of sonar swaths with sparse eelgrass and limited video coverage, best professional judgment was used to delineate the polygons. These areas occurred infrequently and were primarily located in the southwestern portion of the survey area.

Table 2. Eelgrass (*Zostera marina*) Polygon Cover Classification

Cover Class	***Z. marina* Coverage**	**Description**
0	0%	None
1	1-25%	Sparse or patchy cover
2	26-75%	Moderate cover
3	76 – 100%	Dense cover

2.2 Eelgrass Mapping Results

A summary of the spatial area of each eelgrass cover class is provided in Table 3. The distribution of eelgrass, *Z. marina*, in the Brightwater outfall study area, as delineated by side-scan sonar, underwater video, and dive surveys in 2004, is shown in Figure 7 (polygon overlays on side-scan mosaic) and Figure 8 (polygon overlays on aerial photograph). Cover-class categories for eelgrass polygons included none, sparse (1% to 25% cover), moderate (26% to 75% cover), and dense (>75% cover).

An additional category called "sparse/detritus?" was delineated in an area that merited further evaluation (Figure 7, Table 3). This area incorporated the deeper end of the Marine Outfall Corridor and an area that Grette Associates divers surveyed. Their survey indicated some eelgrass at the deeper end of the corridor (Grette Associates 2005). In addition, our video survey recorded a number of "single" eelgrass shoots in water deeper than -25 ft MLLW. From the video footage, we were unable to determine whether the eelgrass shoots were intact or recently uprooted amidst other detrital plant material at the lower limit of the eelgrass beds. A subsequent dive survey by PNNL divers confirmed that the eelgrass located in this area was all uprooted and mixed with drift macroalgae. The final eelgrass polygon coverage is shown in Figure 8, with the "sparse/detrital" category removed.

Table 3. Eelgrass (*Zostera marina*) Distribution in the Brightwater Outfall Survey Area

	Area (m^2)			
Survey Area	**Sparse**	**Moderate**	**Dense**	**Sparse/Detritus**
Outfall Study Area	1306	2125	201	329
Marine Outfall Corridor	38	25	--	26
Eelgrass Reference Area	856	952	102	--
Eelgrass Reference Corridor	77	304	31	--
Outside Defined Study Areas	622	536	136	702
Total	**2899**	**3942**	**470**	**1031**

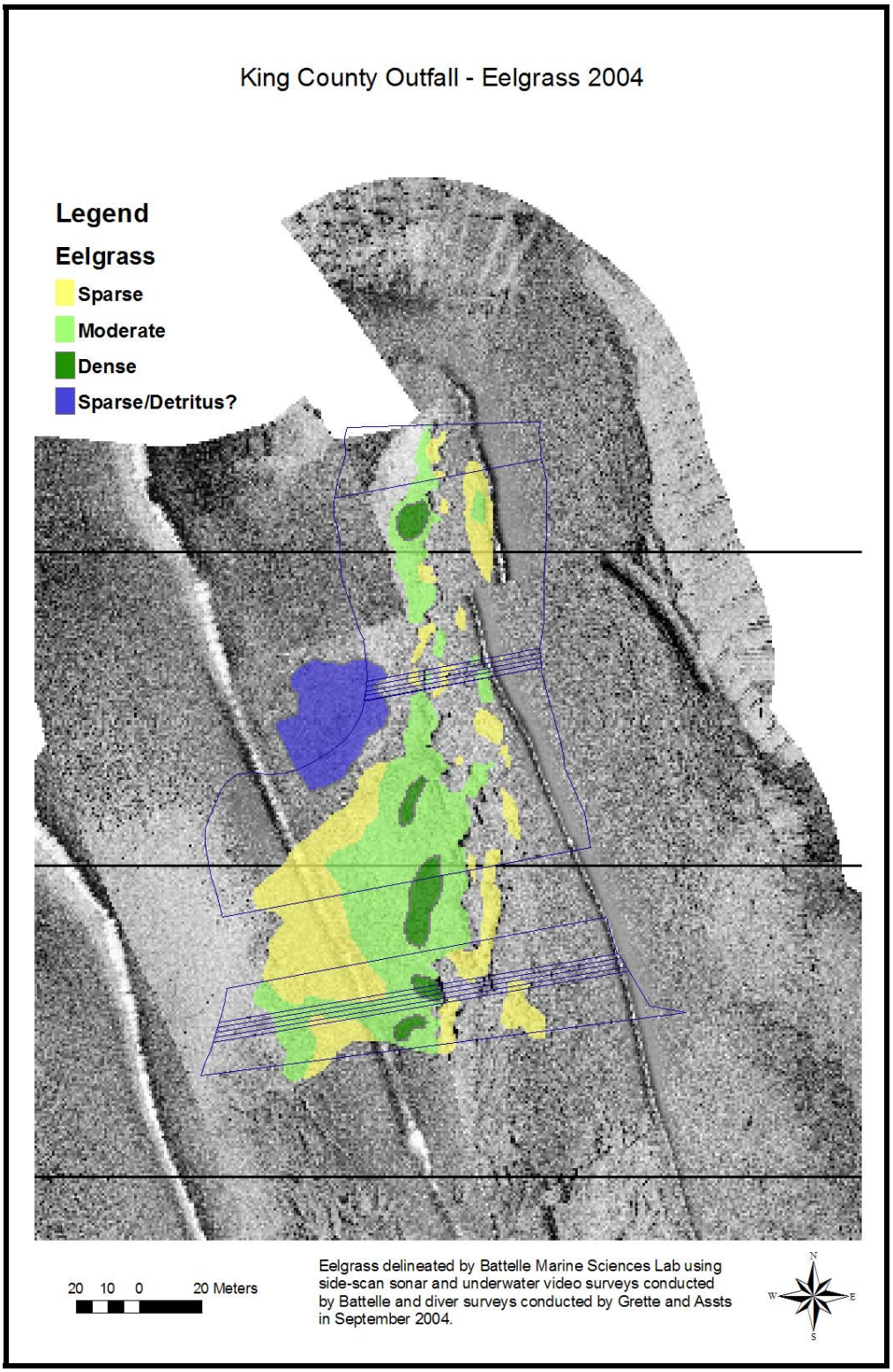

Figure 7. Preliminary Eelgrass Cover Class Polygon Overlays on Side-Scan Image Mosaic Showing Area of Possible Sparse/Detritus Coverage, September 2004

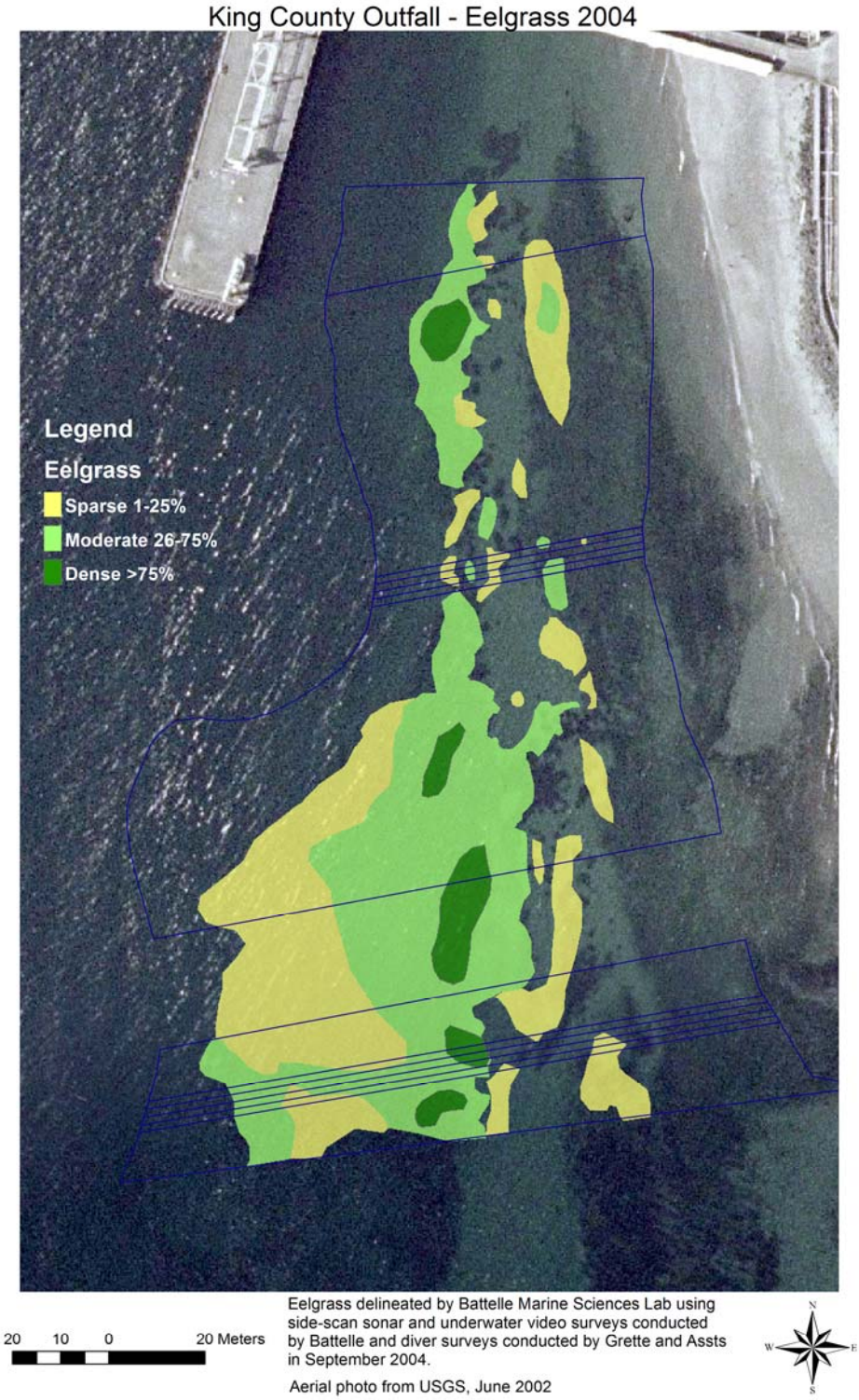

Figure 8. Final Eelgrass Cover Class Polygon Overlays (Data Collected September 2004) on June 2002 Aerial Photograph

3.0 Eelgrass Stockpile and Propagation

The purpose of the eelgrass stockpile and propagation task is to transplant a population of eelgrass from the construction site in advance, and use a variety of techniques to increase the population to the target number of plants needed for post-construction restoration planting. Propagation of plants from the site eliminates the need to disturb a natural eelgrass bed for the purpose of transplanting to another location; it also ensures that the same genetic population is restored to the site. Methods and results of 2004 eelgrass harvest and monitoring are described below.

3.1 Methods for Eelgrass Harvest for Propagation

The 2004 eelgrass harvest from the Marine Outfall Corridor was conducted by PNNL's scientific dive team in early October 2004. Divers selectively harvested thick rhizomes, about 4 to 6 inches long, with multiple shoots and long blades, rather than thinner rhizomes with single shoots or short blades. Eelgrass was harvested using a "bare-root method" in which divers used a gentle vibrating motion to loosen the substrate from around the rhizome and extract the rhizome with roots and blades attached. This method creates minimum disturbance to surrounding eelgrass and substrate in the donor beds. Bare-root shoots were transferred to a boat where biologists separated and counted the individual shoots into coolers of seawater. Coolers containing shoots were transported to the Marine Sciences Laboratory, where they were planted in tanks containing a medium-grained sand substrate.

A common uncertainty with many eelgrass restoration projects is the effect of removal of eelgrass from donor meadows. Harvest levels have typically been restricted to 10% or less of the total abundance to minimize deleterious effects; however, there are no published studies or quantitative data to support anecdotal observations that harvest has a small, short-term effect on eelgrass density. The *Eelgrass Restoration and Biological Resources Implementation Workplan* details a pre- and post-harvest monitoring plan to provide quantitative data on eelgrass recovery rates after shoot harvest. Prior to the 2004 eelgrass harvest, eelgrass shoot density was determined in the Marine Outfall Corridor, as described below.

The initial intent was to establish five semi-permanent 6-m^2 (2- by 3-m) rectangular plots, randomly located in moderate to dense eelgrass patches in the Marine Outfall Corridor, from which a goal number of 1000 shoots would be harvested. Each 6-m^2 plot was to be divided into six 1-m^2 treatment subplots. Four subplots would be subjected to harvest levels of 5%, 10%, 25%, and 50% of the shoots within the subplot, and two subplots would serve as controls where no shoots (0%) would be harvested. The arrangement of the harvest and control treatments within a plot would be randomly assigned. However, there was insufficient eelgrass present in early fall 2004 to establish the treatment plots as originally planned. Instead, they were established at one-fourth their planned size, as semi-permanent 1.5-m^2 (1- by 1.5-m) rectangular plots, still randomly located in the Marine Outfall Corridor. The harvest goal was also revised downward to 250 shoots (one-fourth of the original goal). Each 1.5-m^2 plot was then divided into six 0.25-m^2 treatment subplots, randomly assigned to one of four treatments (5%, 10%, 25%, and 50% harvest) or two control subplots (0% harvest). Because of the low density of eelgrass in the corridor and the reduced plot size, the harvest goal of 250 shoots was not attained after establishing and harvesting the

five plots as planned. Therefore, two additional 0.25-m^2 treatment subplots in which 100% of the shoots were removed were established adjacent to each existing plot. This resulted in a sufficient number of shoots to begin propagation, and establishment of a range of harvest rates, including the typical 10% harvest rate, to which recovery rates can be compared in subsequent monitoring years (2007, 2009).

3.2 Eelgrass Stockpile and Propagation Results

Five Marine Outfall Corridor harvest monitoring plots with a final area of 2 m^2 (1 m by 2 m) were established, monitored, and harvested as described above in October 2004. Plot locations and initial eelgrass density in each subplot are shown in Figure 9; harvest rates for each subplot are shown in Figure 10. The revised goal of harvesting at least 250 shoots for propagation at the Marine Sciences Laboratory was met, with a total of 305 shoots harvested. The harvested shoots were transported to the Marine Sciences Laboratory, where they were planted in outdoor tanks containing medium sand and supplied with continuously flowing raw seawater.

3.3 Eelgrass Stockpile and Propagation: Future Activity

The experimental harvest plots established in 2004 will be monitored for eelgrass shoot density (recovery) 1, 3, and 5 years after initial harvest (2005, 2007, and 2009), and concurrent with side-scan sonar and video mapping efforts planned in 2009. Maintenance and monitoring of the propagation tanks will continue, including occasional removal of excess macroalgae and invertebrates, and annual population counts to track progress toward the target adult plant population needed for post-construction restoration. To supplement the stock of eelgrass in propagation tanks, flowering shoots containing seeds will be collected from the construction area in the summers of 2005 and 2006. The seeds from the flowering shoots will be dispersed in the propagation tanks. In 2006, additional shoots will be harvested from the marine outfall corridor but outside the established plots, to provide additional stock for propagation and stockpiling. This phased approach to harvesting minimizes the loss of ecosystem function provided by eelgrass in the impact area and allows harvested areas to recover between harvest events.

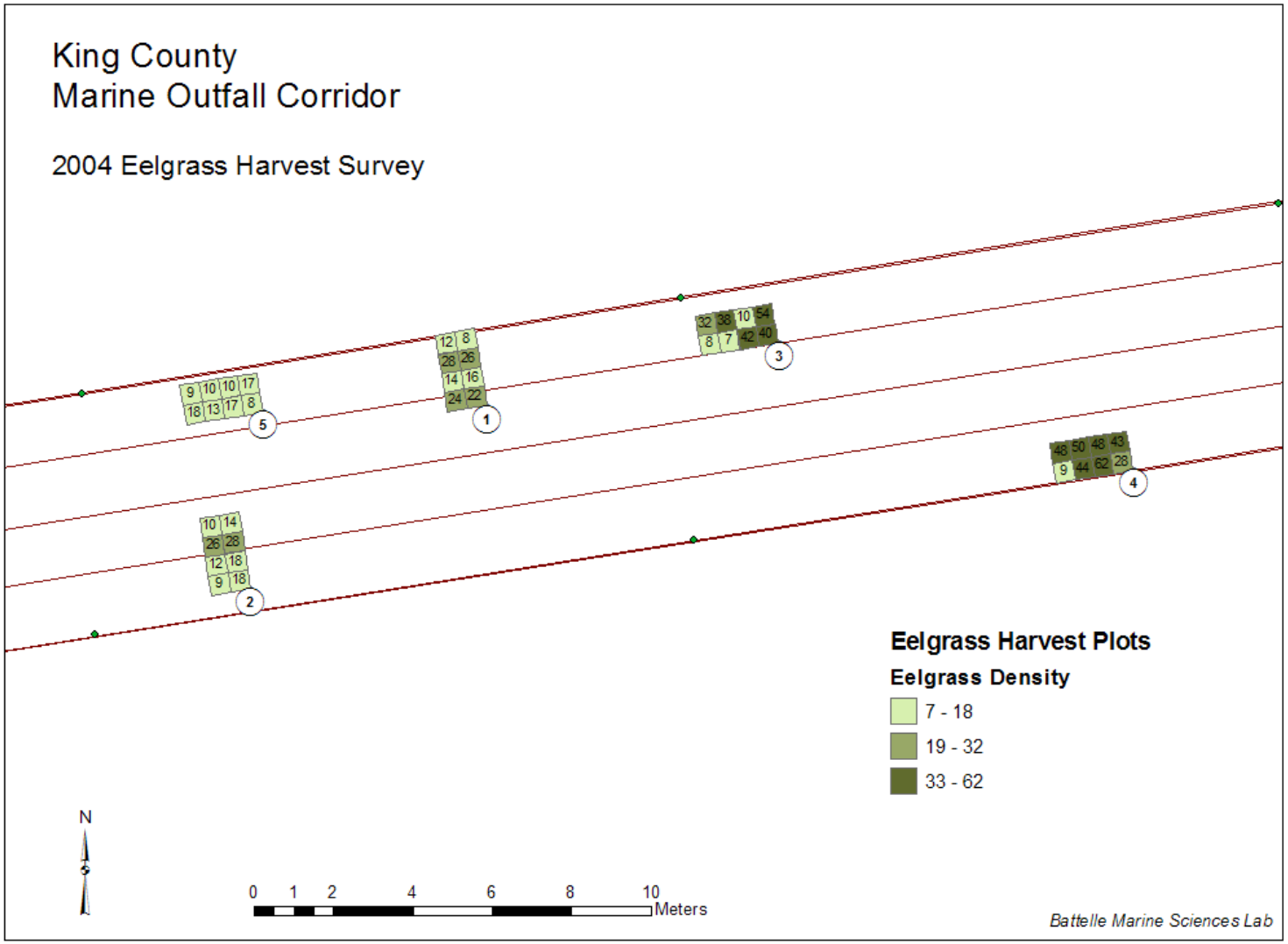

Figure 9. Initial Eelgrass Density (number of shoots) in Marine Outfall Corridor Harvest Plots

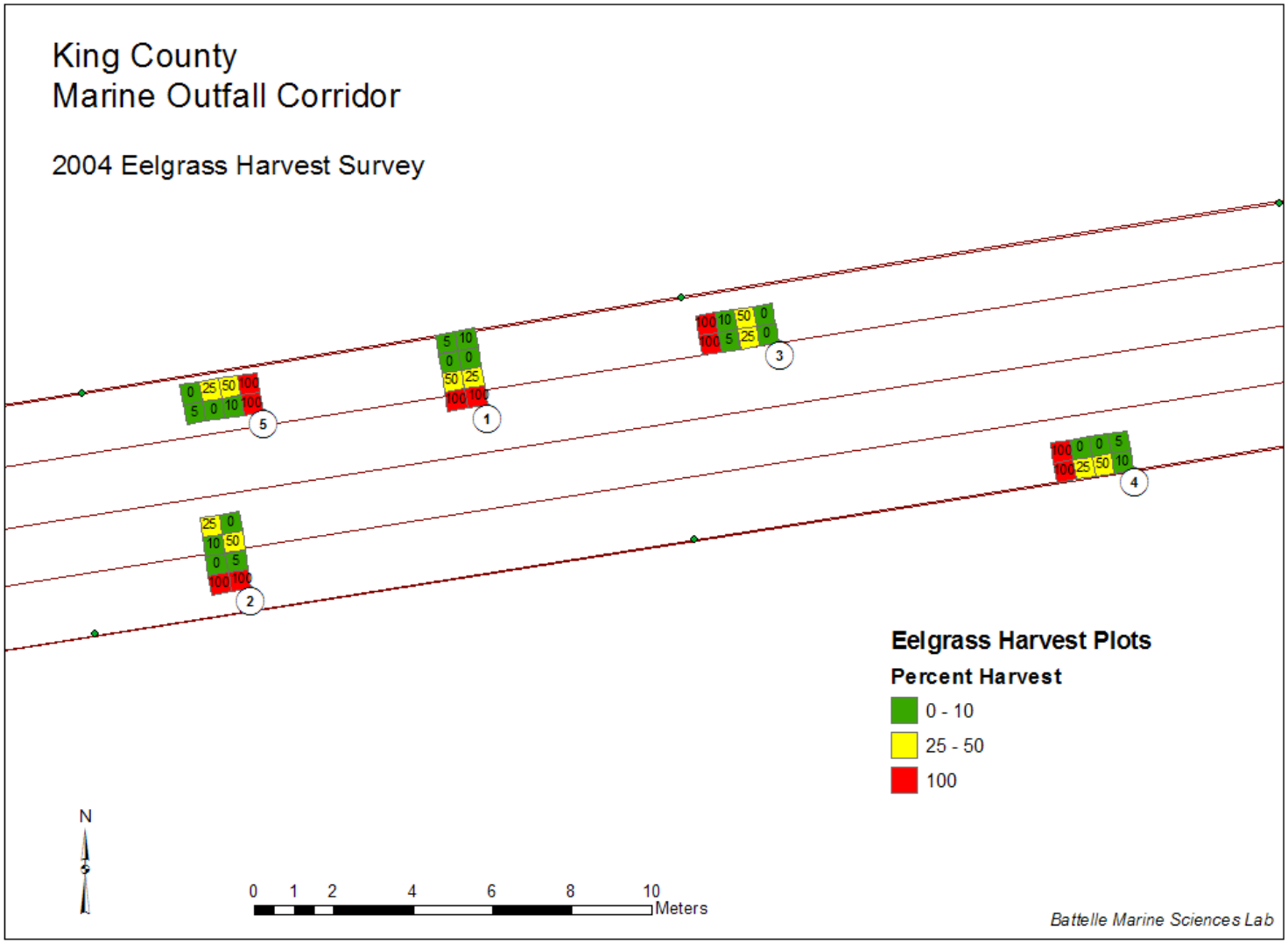

Figure 10. Experimental Harvest Rates (percent) in Marine Outfall Corridor Harvest Plots

4.0 References

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King County. 2004. *Draft Eelgrass Restoration and Monitoring Plan*. King County, Department of Natural Resources and Parks, Wastewater Treatment Division, Seattle, Washington.

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