Sampling and Analysis Plan for HDPE Biological and Structural Integrity Assessment at the Brightwater Marine Outfall
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Prepared by

Kimberle Stark and Jeff Lundt
King County Dept. of Nat. Resources & Parks

For more information:
Brightwater Project
201 South Jackson Street, Suite 503
Seattle, WA 98104-3855
206-684-6799 or toll free 1-888-707-8571

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1.0 Introduction

King County's new wastewater treatment plant, the Brightwater Treatment System, includes a marine outfall that will discharge highly treated effluent to Puget Sound. The outfall is located over a mile offshore near Point Wells and terminates at the -600 foot (ft) water depth referenced to mean lower low water (MLLW) approximately 5,000 ft from the shoreline. The outfall consists of twin, 63-inch diameter pipes each with a 250 ft long diffuser on the end of each pipe (Figure 1). The diffusers are staggered for an overall length of 500 feet. The outfall pipes are composed of high-density polyethylene (HDPE) and the buoyant pipes are anchored to the seafloor by concrete collars. Outfall construction was completed in late 2008, however, effluent was not discharged from the outfall until November 2012.

Underwater video of the outfall pipes was collected in 2010, 2011, 2012, and 2013 during eelgrass monitoring surveys at depths between approximately -80 to -130 ft MLLW. Additional outfall video was collected at about -300 ft MLLW. Video shows that the pipes in shallower water (i.e., the -80 to -130 ft MLLW depths) were first colonized by barnacles about one year after placement, followed by other organisms. Several other sessile species, such as anemones, calcareous tubeworms, and hydroids, have also attached to the pipes. In addition, motile species such as shrimps, squat lobsters, sea stars, and fishes, have been observed utilizing the space around the pipes and anchors as habitat. The most recent 2013 video shows that the pipes and concrete collars are almost entirely covered with marine organisms at the shallower depths and mostly covered at the deeper depth. Colonization was slower at the deeper depths, as would be expected. Epibenthic crustaceans, such as shrimp and squat lobsters, are more abundant at the -300 ft MLLW depth and are utilizing crevices provided by the concrete collars.

The purpose of this project is to determine if marine organisms attached to the pipe may affect the structural integrity of the HDPE over time. As the material durability directly impacts structural performance, it is important to accurately determine any long-term implications on the pipe's service life. A secondary purpose is to document the presence and abundance of marine organisms on the pipes and concrete collars over time. A goal of this project is to obtain sufficient and quality data to aid state natural resource agencies in assessing the effectiveness and amount of habitat artificial structures provide to various marine organisms.

Figure 1. Brightwater marine outfall location at Point Wells

2.0 Site Description

The Brightwater Treatment System marine outfall leaves the shoreline in the southwest corner of unincorporated Snohomish County at Point Wells. Running just south of due west (about 260°) the 5,000 ft long pipes discharge south of the County line in King County. Point Wells is composed of a natural point of land that was reinforced with a rubble seawall by the railroad more than 100 years ago. The site borders are Puget Sound to the west, the terminal dock for the Paramount Asphalt and Petroleum Storage Facility to the north, and the Burlington Northern Santa Fe railroad to the east. Other land uses within a 0.25-mile of radius of the outer perimeter of the site include single-family residences to the southeast, and a forested terrace and ravine to the east and northeast.

The marine outfall pipes are buried beneath the seafloor landward to a water depth of -80 ft MLLW. From -80 ft MLLW to where the pipes terminate at -600 ft MLLW, the pipes lie on the seafloor. For the day-lighted portion of the outfall, the pipe lengths are approximately 4,255 ft for the north pipe and 4,505 ft for the south pipe.

Sediment at the outfall terminus consists primarily of fine-grained (silt and clay) material, with total fines ranging from 50 to 60% (King County, 2008). The particle size distribution at the outfall terminus is characteristic of a silty, depositional environment. Sediment at the shallower outfall depths where the pipes daylight consists primarily of sand with only a small amount of fines. Percent sand at depths between 80 to 93 ft ranged from 95 to 98% and contained less than 2% fines (King County, 2009).

3.0 Sampling Design and Methods

HDPE pipe meeting the specified tests for structural integrity (see specific tests below) were placed near the seafloor in September 2012 at three locations in close proximity to the south marine outfall. The pipe material will be allowed to remain in place for pre-defined time intervals: 2, 5, and 10 years. Twenty-seven approximately 2-ft^2 (1-ft by 2-ft) portions of the pipe were placed by a remotely-operated vehicle (ROV) at the -100 ft, -300 ft, and -600 ft MLLW depths adjacent to the south outfall pipe (Figure 2). Three replicates were placed at each depth and for each time interval, for a total of nine pipe segments at each depth. Replicates are included due to inherent biological variability and to mitigate this variability to the extent feasible. As the pipe material is buoyant, each portion was bolted to a solid concrete block in order for the pipe material to be contained within the water column and not resting directly on the seafloor, thereby replicating to the extent practical the pipe/weight configuration. Each block was placed within a frame to remain upright in the correct orientation and placed no further than 15 ft south of the outfall pipe. Figure 3 shows the configuration of the nine pipe segments placed at each depth.

Although it is not expected that effluent will have an effect on biota colonization of the pipe material at the -600 ft MLLW depth or the other two depths further away from the diffusers, a reference site is included in this study. Effluent dilutions within 80 ft of the discharge are expected to be between 377 to 950:1 dependent on various conditions and not expected to have a measurable effect on ambient salinity. Effluent dilutions beyond 800 ft from the discharge ports are expected to be between 400 to 6000:1. The -300 ft MLLW and -100 ft MLLW sites are over 3,400 ft and 4,400 ft east of the end of the outfall, respectively. As only the -600 ft MLLW depth is located near a diffuser, nine 2-ft^2 portions of the pipe material were placed along the same -600 ft MLLW bathymetric contour 300 ft south of the outfall pipe. As with the other three sites, three replicates were placed at the reference site for each time interval, for a total of eighteen pipe portions at -600 ft MLLW. No reference sites will be used for the shallow depths as they are located far from the diffusers.

Sample Retrieval

At each time interval, an ROV deployed from a vessel will be used to retrieve three replicates at each site. The ROV will be equipped with a video camera and the video recorded.

Immediately following retrieval of the 12 samples for each time interval (4 sites, 3 replicates each), the samples will be placed in tubs/containers filled with seawater onboard the vessel. Each site will have its own tub so as not to cross-contaminate samples in the event organisms become detached. Each 2-ft^2 portion will be assessed for total percent cover by placing a flexible mesh grid over the sample and estimating the biota coverage in each grid cell. The mesh grid will contain 21 cells, each 3.94 inches x 3.54 inches (10cm x 9 cm). Macroscopic biota will be identified and enumerated in each grid cell and recorded on field sheets. Whenever possible, organisms will be identified down to the species level, however, all organisms will identified

down to the class level at a minimum. Taxonomic references will include Kozloff (1996), Blake et al. (1997), and Lamb and Hanby (2005).

Digital photographs will be taken in .jpg format of each sample at a minimum of 3 megapixel (MP) resolution. At least one photograph will be taken of the entire plate and multiple photos will be taken zoomed in on each grid cell(s). Site (depth), plate, and grid cell identifiers will be placed in either the lower left or right corner prior to each photograph. Preferably, a circular polarizing filter will be placed over the camera lens to minimize glare. For species that cannot readily be identified down to species level, efforts will be made to take macro photographs

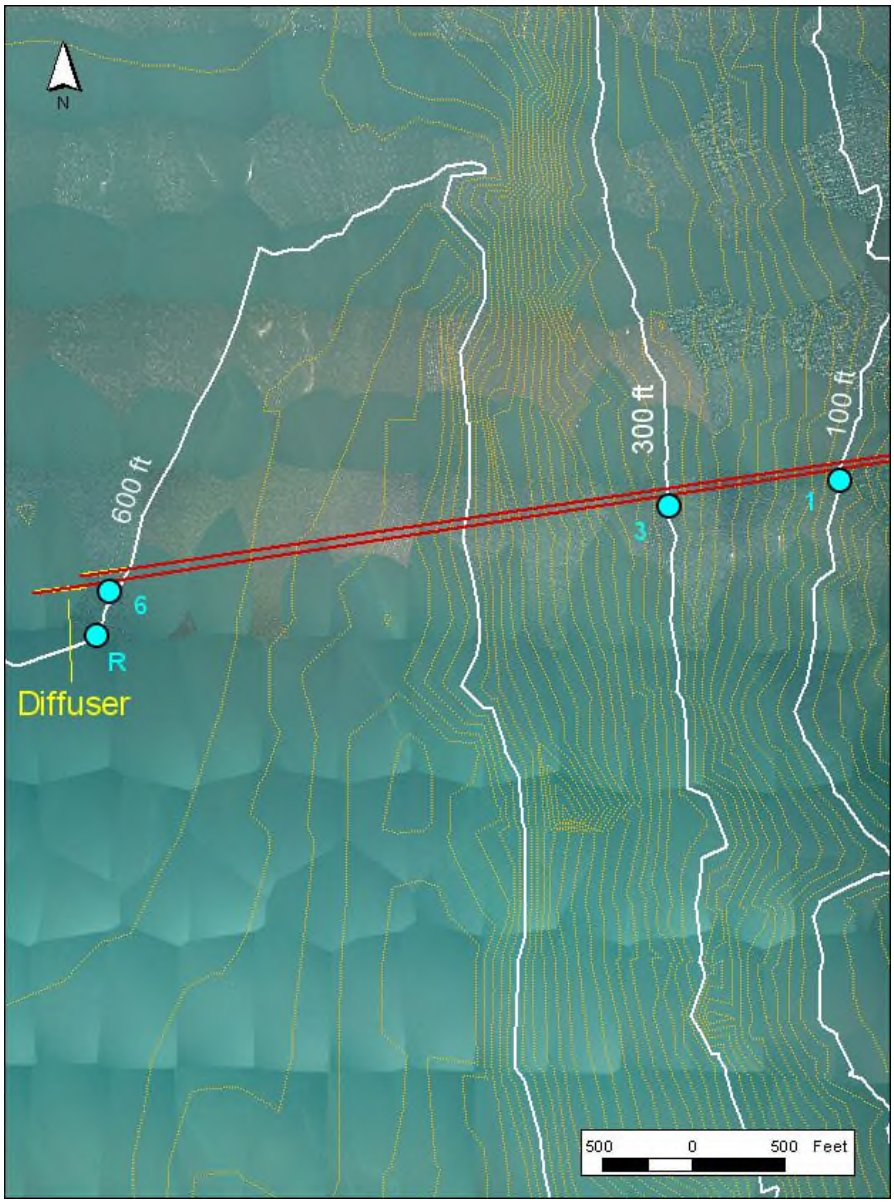

Figure 2. Sample locations as indicated by blue circles ('R' indicates reference site)

Figure 3. Configuration and orientation of the pipe segments

to enable identification at a later date. All image files will be copied from the memory cards onto a network server following completion of the field work.

Upon completion of organism identification and enumeration, any relatively large biota such as anemones and hydroids will be gently detached and returned to the water. The pipe samples will then be transported to the King County Environmental Laboratory and allowed to dry. As much organic material as possible will be removed before shipping to the pipe manufacturer (KWH) for the structural integrity tests described below. Metal scrapers and a pressure washer will not be used to remove the organic material in order not to damage the pipe segments for the structural integrity tests.

Structural integrity tests will be conducted following the appropriate ASTM testing protocols: F894, D3350, F714, D3350, and F894 (ASTM, 2007, 2009, 2011). Tests will include:

- assessment of scratches and/or gouges on the outside surface and, if present, determination of the scratch/gouge depth as a percentage of the total wall thickness;
- tensile strength test; and
- stress-crack resistance.

4.0 Project Organization and Schedule

The tasks involved for this project and the primary personnel responsible for those tasks are shown below.

--**Jeff Lundt** *King County Department of Natural Resources and Parks.* Project management, coordination of pipe placement and retrieval, report preparation and review.
--**KWH** Provision of pipe and structural integrity testing. Preparation of data report.
--**Kimberle Stark & Wendy Eash-Loucks** *King County Department of Natural Resources and Parks.* Biota identification and data report preparation.
--**Laura Arber** *Washington State Department of Fish and Wildlife.* Review and approval of Sampling and Analysis Plan.
--**Cindy Rathbone** *Washington State Department of Natural Resources.* Review and approval of Sampling and Analysis Plan.

All 36 pipe portions were placed in September 2012 and effluent began discharging from the marine outfall in November 2012. The first 12 pipe samples will be retrieved in September of 2014, the second 12 portions retrieved in the fall of 2017, and the last 12 portions retrieved in the fall of 2022. At least two months prior to each sample retrieval event, Laura Arber and Cindy Rathbone will be contacted. If any changes to the sampling protocol or schedule are anticipated, Laura Arber and Cindy Rathbone will be contacted.

5.0 Sample Documentation

Sampling information and sample metadata will be documented using the methods described below.

Field sheets printed on Rite in the Rain® paper for biota sampling generated by King County will include the following information:

1. unique site and replicate identifier
2. date and time
3. sampling personnel
4. species type and either count or percent cover
5. estimated total percent cover

Figure 4 provides an example of the biota sampling field sheet. Table 1 shows the unique identifier assigned to each grid cell for each site and replicate to aid digital photograph identification. Figure 5 shows how grid cell numbers were assigned for each pipe segment.

Digital photographs will be arranged in folders by sites so there will be a total of four primary folders. Photographs from each of the three replicates at each site will be arranged in subfolders by year. Each digital photograph of the individual grid cells will be renamed to include the unique grid cell number listed in Table 1 and the date. The file will then be placed in the correct replicate subfolder. An example of the organizational structure is provided below for the 100ft site.

```
--100 ft depth
        --2014
            --replicate 1
                --date 1-1-1.jpg
            --replicate 2
                --date 1-2-1.jpg
            --replicate 3
                --date 1-3-1.jpg
        --2017
```

Laboratory sheets for structural integrity testing generated by an outside contractor will include the following information:

1. unique site and replicate identifier
2. date and time
3. testing personnel
4. testing methods
5. testing results for each parameter

Date:_____ Time:_____ **Staff:_____**

	100 ft (A)	100 ft (B)	100 ft (C)
CRUSTACEANS (count)			
Barnacles (% cover)			
Shrimps			
True crabs			
Squat lobster			
Hermit crabs			
Lithode crabs			
Other			
ANEMONES (count & % cover)			
Urticina spp.			
Metridium spp.			
Other			
HARD CORALS (% cover)			
HYDROIDS (% cover)			
SPONGES (% cover)			
Calcareous sponge			
Siliceous sponge			
Demosponges			
CALCAREOUS TUBEWORMS			
SEA STARS (count)			
BRITTLE STARS (count)			
BRYOZOA (% cover)			
MOLLUSCS (count OR % cover)			
Chitons			
Limpets			
Nudibranchs			
Other			
TUNICATES (% cover)			

Figure 4. Example of field sheet for biota samples

	100 ft (A)	100 ft (B)	100 ft (C)
MISCELLANEOUS			
Plate size (cm)			
Photo documentation notes			
Comments			

Figure 4 (cont.). Example of Field Sheet for Biota Samples

Table 1. Unique identifiers assigned to each grid cell

	Location and Plate Identification											
	100 ft depth			300 ft depth			600 ft depth			Reference 600 ft depth		
Grid Cell #	Replicate 1	Replicate 2	Replicate 3	Replicate 1	Replicate 2	Replicate 3	Replicate 1	Replicate 2	Replicate 3	Replicate 1	Replicate 2	Replicate 3
1	1-1-1	1-2-1	1-3-1	3-1-1	3-2-1	3-3-1	6-1-1	6-2-1	6-3-1	R-1-1	R-2-1	R-3-1
2	1-1-2	1-2-2	1-3-2	3-1-2	3-2-2	3-3-2	6-1-2	6-2-2	6-3-2	R-1-2	R-2-2	R-3-2
3	1-1-3	1-2-3	1-3-3	3-1-3	3-2-3	3-3-3	6-1-3	6-2-3	6-3-3	R-1-3	R-2-3	R-3-3
4	1-1-4	1-2-4	1-3-4	3-1-4	3-2-4	3-3-4	6-1-4	6-2-4	6-3-4	R-1-4	R-2-4	R-3-4
5	1-1-5	1-2-5	1-3-5	3-1-5	3-2-5	3-3-5	6-1-5	6-2-5	6-3-5	R-1-5	R-2-5	R-3-5
6	1-1-6	1-2-6	1-3-6	3-1-6	3-2-6	3-3-6	6-1-6	6-2-6	6-3-6	R-1-6	R-2-6	R-3-6
7	1-1-7	1-2-7	1-3-7	3-1-7	3-2-7	3-3-7	6-1-7	6-2-7	6-3-7	R-1-7	R-2-7	R-3-7
8	1-1-8	1-2-8	1-3-8	3-1-8	3-2-8	3-3-8	6-1-8	6-2-8	6-3-8	R-1-8	R-2-8	R-3-8
9	1-1-9	1-2-9	1-3-9	3-1-9	3-2-9	3-3-9	6-1-9	6-2-9	6-3-9	R-1-9	R-2-9	R-3-9
10	1-1-10	1-2-10	1-3-10	3-1-10	3-2-10	3-3-10	6-1-10	6-2-10	6-3-10	R-1-10	R-2-10	R-3-10
11	1-1-11	1-2-11	1-3-11	3-1-11	3-2-11	3-3-11	6-1-11	6-2-11	6-3-11	R-1-11	R-2-11	R-3-11
12	1-1-12	1-2-12	1-3-12	3-1-12	3-2-12	3-3-12	6-1-12	6-2-12	6-3-12	R-1-12	R-2-12	R-3-12
13	1-1-13	1-2-13	1-3-13	3-1-13	3-2-13	3-3-13	6-1-13	6-2-13	6-3-13	R-1-13	R-2-13	R-3-13
14	1-1-14	1-2-14	1-3-14	3-1-14	3-2-14	3-3-14	6-1-14	6-2-14	6-3-14	R-1-14	R-2-14	R-3-14
15	1-1-15	1-2-15	1-3-15	3-1-15	3-2-15	3-3-15	6-1-15	6-2-15	6-3-15	R-1-15	R-2-15	R-3-15
16	1-1-16	1-2-16	1-3-16	3-1-16	3-2-16	3-3-16	6-1-16	6-2-16	6-3-16	R-1-16	R-2-16	R-3-16
17	1-1-17	1-2-17	1-3-17	3-1-17	3-2-17	3-3-17	6-1-17	6-2-17	6-3-17	R-1-17	R-2-17	R-3-17
18	1-1-18	1-2-18	1-3-18	3-1-18	3-2-18	3-3-18	6-1-18	6-2-18	6-3-18	R-1-18	R-2-18	R-3-18
19	1-1-19	1-2-19	1-3-19	3-1-19	3-2-19	3-3-19	6-1-19	6-2-19	6-3-19	R-1-19	R-2-19	R-3-19
20	1-1-20	1-2-20	1-3-20	3-1-20	3-2-20	3-3-20	6-1-20	6-2-20	6-3-20	R-1-20	R-2-20	R-3-20
21	1-1-21	1-2-21	1-3-21	3-1-21	3-2-21	3-3-21	6-1-21	6-2-21	6-3-21	R-1-21	R-2-21	R-3-21

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21

Figure 5. Grid cell numbering scheme for each 2ft x 1 ft pipe segment

6.0 Data Analysis and Reporting

6.1 Data Analysis

Biota: If identification and enumeration of all biota cannot be completed in the field, the digital photographs of each plate will be assessed at a later date. It is anticipated that upon retrieval, organisms such as colonial hydroids and anemones will close up/retract once out of the water, making identification down to the species level difficult. It is possible that once the plates are submerged in the seawater tubs on the vessel, the organisms will re-open, making identification down to the species or genus level feasible. However, if organisms remain closed/retracted the photographs may not contain sufficient detail of key features to enable identification to a low taxonomic level.

Image J®, an image processing software created by the National Institutes of Health may be used to process the photographs. The software may be used to determine percent cover of the target species and/or taxonomic group by calculating area and pixel value statistics. The feasibility of using Image J® will be determined once the amount of biota contained on the pipe segments and quality of the photographs are assessed.

Data from the three replicates at each site will be averaged. Multivariate statistical analyses of the species composition will be conducted, including relative abundances and diversity at each site. After the second and third collection events, additional analyses and how the biota shifts over time (e.g., 2-yr vs. 5-yr) will be conducted. It is expected that some individual species and/or organism groups will be sufficiently abundant in the samples to conduct univariate analyses of their changes in abundance with time. In addition, species richness and relative abundances from the -600 ft MLLW samples will be compared to the nearby reference samples.

Structural integrity: Results from the three replicates at each site will be averaged. Results for each time interval will be compared to initial testing results prior to placement. Univariate statistical analysis of the results at each time interval (i.e., 2, 5, and 10 years) and comparison of results between the various depths for each year will be conducted.

6.2 Reporting

All biological data will be entered into an Excel spreadsheet maintained by King County's Department of Natural Resources and Parks (DNRP) Marine and Sediment Assessment Group. Structural integrity data will be sent to Jeff Lundt (DNRP, Wastewater Treatment Division) by the testing facility and maintained in Excel and/or pdf files.

A summary report will be prepared for each survey year. The summary report will include tables listing number of each species identified at each site and pertinent information regarding data collection (survey dates, survey personnel, coordinates, and maps). Electronic versions of the species tables will be generated following each survey. The summary report will also include

results from the structural integrity tests. A final survey report will be completed after the last sampling event and following completion of the final structural integrity tests. The final report will include:

- results from statistical analyses of the biota community and structural integrity over time;
- any observed biota differences with respect to water depth;
- any observed structural integrity differences with respect to water depth;
- tables listing all the species observed throughout the entire project; and
- tables listing results from all structural integrity tests.

Project reports will be distributed to Washington Department of Natural Resources and Washington Department of Fish & Wildlife. The reports will also be available on the Marine and Sediment Assessment Group's publications webpage at http://green.kingcounty.gov/marine/.

7.0 References

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