Appendix C:
Field Sampling Methods

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APPENDIX C - FIELD SAMPLING METHODS

This appendix provides an overview of the field sampling methods used in the study; greater detail is presented in the project QAPP (King County 2015). The sampling locations are described in Section C.1. Sections C.2 and C.3 summarize the sample collection and sample processing methods, respectively. Section C.4 describes the field sampling deviations from the QAPP. Photographs illustrating these sampling methods are included at the end of the appendix.

C.1 Sampling Locations

Stormwater samples were collected from the inlet and outlet of three BPB constructed in 2012, one BPB constructed in 2016, a Filterra constructed in 2012, and the DTS (Table C-1). These BPB and Filterra are located within the Echo Lake drainage basin and receive runoff from Aurora Ave N. (State Route 99) between N 185th St and N 200th St. Effluent from these treatment features is discharged back into the stormwater system. The DTS is located below ground at the Park and Ride on the corner of Aurora Ave N. and N 192nd St. This structure receives runoff from almost the entire drainage basin, including highway, residential, and commercial areas. Effluent from this structure discharges directly to Echo Lake. Figure A-1 identifies each sampled BPB, Filterra, and the inlet and outlet of the DTS. More detailed information about these structures is included in Appendix A and the project QAPP.

Table C-1. Echo Lake Stormwater Sampling Locations with Locator Names

Site Type	Locator Name*	Latitude	Longitude
Bioretention Planter Boxes (constructed in 2012)	ECHO-BP1-In	47.76749	-122.34573
	ECHO-BP1-Out	47.76760	-122.34573
	ECHO-BP2-In	47.76534	-122.34611
	ECHO-BP2-Out	47.76543	-122.34611
	ECHO-BP3-In	47.76685	-122.34572
	ECHO-BP3-Out	47.76695	-122.34572
Bioretention Planter Boxes (constructed in 2016)	ECHO-BP4-In	47.77263	-122.34580
	ECHO-BP4-Out	47.77271	-122.34580
Filterra (constructed in 2012)	ECHO-FLT1-In	47.76726	-122.34573
	ECHO-FLT1-Out	47.76727	-122.34572
Detention Tank System	ECHO-DTS-In	47.767697	-122.346477
	ECHO-DTS-Out	47.767634	-122.346277

*Locators are a unique name given to a sampling location and used in the KCEL database. Locators with the ending –In refer to the inlet of the treatment feature. Locators with the ending –Out refer to the outlet of the treatment feature.

C.2 Sample Collection

The QAPP provides a detailed description of sample collection procedures; however, there were several deviations from the QAPP, which are described in Section C.4. General procedures are summarized for the individual treatment features (BPB and Filterra) in Section C.2.1, and for the DTS in Section C.2.2.

C.2.1 General Procedures at the BPB and Filterra

As described in the QAPP, composite grab samples were collected at the inlet and outlet of each treatment feature using peristaltic pumps. Site-dedicated and pre-cleaned silicon tubing was used for each sampling event, and Teflon® tubing was pre-cleaned and site-dedicated. At each site, two-liter aliquots were generally collected every 20 to 30 minutes and composited in glass carboys. The QAPP specified up to 8.75 liters would be collected at each site over a period of at least two hours. In practice, up to 10 liters were collected at each site, usually over a period of 0.5 to 3 hours. These samples were not collected in relation to the hydrograph, but many composite sample collections spanned the entire effluent flow at the BPBs for a given storm event. Samples with less than the target volume were retained for analysis following the flow chart depicted in Figure 3 of the QAPP (King County 2015).

As specified in the QAPP, an additional 50 mL aliquot was filtered through a site-dedicated capsule filter (0.45µm) for each main sample aliquot collected. The QAPP specified that filtered aliquots would be composited at the KCEL, but in practice, field compositing was possible; therefore, filtered aliquots were composited into a 500 mL HDPE bottle as collected. Capsule filters were replaced when clogged, which occurred several times throughout a given sampling event. This filtered sample was collected for dissolved metals analysis, which requires filtering within 15 minutes of sample collection.

The QAPP specified that petroleum hydrocarbons samples would be collected directly into a dedicated container at the beginning of sampling. However, it was not possible to sample the effluent without the use of a peristaltic pump, due to the small opening of the clean out used to access the underdrain. Instead, grab samples were collected into a dedicated container using the peristaltic pump after the last aliquot was collected for the main composite sample. The project team anticipated that this procedure would prevent the loss of oils to equipment surfaces in two ways. One is by collecting this sample in a dedicated container, the splitting process is avoided, which would require the sample to pass through extra tubing while transferring containers. And second, by collecting the grab sample after all other sample aliquots have been collected, the tubing has already been coated with some oil, possibly preventing loss of oil from the final grab sample.

As described in the QAPP, field parameters were measured prior to each sampling event by collecting a volume of water in a pre-cleaned two-liter bucket using a peristaltic pump. Dissolved oxygen, temperature, pH and conductivity were measured using an EXO YSI Sonde, and turbidity will measured using a Hach 2100 Portable Turbidimeter.

C.2.2 Capturing Influent and Effluent at the BPB and Filterra

The QAPP specified general sample collection procedures; however, some details were honed during field visits after the QAPP was written. This section describes in detail how influent and effluent samples were collected at the BPB and Filterra over the course of this project.

Stormwater from the highway enters a catch basin system prior to reaching the BPBs (See Appendix A for layout). Influent samples were collected by holding the pump tubing at the surface of the water spilling from the catch basin into the BPB. While these samples likely contained a mixture of new stormwater and stormwater that had been sitting in the catch basin from previous storms, they were representative of the water entering the BPB.

There are no catch basins associated with the Filterra inlets. The QAPP directed that Filterra influent would be physically concentrated to sampling from the roadway; however, this was not necessary in practice. Instead, a small stainless-steel tray was placed on top of the mulch/media layer in the path of the sheet flow from the street. After several minutes of flushing, influent samples were collected from the surface of the water pooling in the stainless steel tray. Water continually overflowed from the tray into the media, so the Filterra continued functioning, but the walls of the tray prevented mulch debris from entering the sample line. This setup also allowed personnel to stay clear of the roadway.

Effluent samples for each BPB and the Filterra were collected from the underdrains, using overflows and/or clean outs for access (See Appendix B for details). The BPB underdrain was fairly deep, and so the pump tubing was secured within a PVC pole and lowered into the overflow or clean out until the tubing opening was submerged in the effluent flowing through the underdrain pipe. The Filterra underdrain was not visible, and so the pump tubing could not be placed using visual clues. Instead, with the pump running, the tubing was lowered into the clean out until effluent could be seen moving through the tubing. The tubing was held in place while the aliquot was collected.

C.2.3 General Procedures at the DTS

Flow meters were installed according to the procedures outlined in the QAPP, except for a number of deviations described in Section C.4. In the end, usable data were available for only a few months from the area velocity meter installed at the inlet.

Composite samples were collected using the GLS ISCO® autosamplers specified in the QAPP, but due to the flow monitoring issues, they could not be collected as flow-weighted samples. Instead time-weighted samples were collected using a visual level and start time to trigger sampling. Samples were collected over three to 11 hour timespans, depending on storm duration, with 250mL aliquots collected every 15 minutes. Otherwise, the procedures followed those described in the QAPP.

C.3 Sample Processing

Sample processing followed the procedures described in the QAPP. The samples were kept on ice and transported to KCEL where they were split into the appropriate sample containers, logged into the chain of custody, and stored at the appropriate storage temperatures until analysis. Samples for polychlorinated biphenyl (PCB) analysis were shipped to Pacific Rim Laboratories as described in the QAPP.

C.4 Additional deviations from the QAPP

- The QAPP specified that storms would qualify for sampling with at least 0.15 inches of rainfall during the storm event with an antecedent dry period of at least six hours with less than 0.04 inches of rainfall. In reality, these conditions did not sufficiently predict conditions that would generate effluent flow from the BPBs. Instead, the project team had to monitor the forecast for predicted rainfall greater than 0.03 inches per 15 minutes over at least two hours in order to target storms with the necessary intensity to produce effluent flow for sampling. This deviation was necessary to obtain samples for the study, but it resulted in sampling only high intensity storm conditions; however, this is still representative of treatment conditions at this site, because these are the only conditions under which effluent flow was observed at the BPBs.
- The QAPP specified that a second Filterra would be included in the study from the northern portion of the retrofit (completed in 2016). The design of this Filterra differed from the one sampled in the southern portion of the retrofit (completed in 2012) and the underdrain was much less accessible. The field crew could not access the effluent flow for sampling and so this site was dropped from the study.
- The QAPP specified that six to eight storms would be sampled at each BPB and Filterra. This sample goal was achieved at BPB1, BPB2, and BPB3. The Filterra developed drainage issues, and was not sampleable for the last two storms, meaning only five storms were sampled at this site. Only two storms were sampled at BPB4 due to insufficient effluent flow and delays in construction. The Filterra results were retained for analysis despite the small sample size, but only limited observations could be made with the BPB4 results.
- While the sample aliquots were generally collected at the BPBs between 20 and 30 minutes apart, as specified in the QAPP, there was one event where aliquots were collected a couple hours apart. This was because effluent from the BPB had stopped flowing during a period of lower intensity rain, and the project team had to wait until storm intensity increased and flow restarted. This event also had a timespan over 5 hours, because of this break midway through sampling. This deviation is not expected to affect data quality.
- One effluent sample at BPB2 (L64921-7) consisted of only one aliquot (i.e., single grab). This was because rainfall intensity diminished unexpectedly and effluent flows ceased before additional aliquots could be collected. Results for this sample were comparable to other effluent sample results, and retained for all data analysis.

- The filtered aliquots collected for dissolved metals were composited in the field instead of in the laboratory as specified in the QAPP. This did not affect the data quality.
- Sometimes sediment was present in the underdrains of BPB1 and BPB3. This sediment had likely built up during previous storms, and would not be representative of current conditions if captured in the sample. To prevent this, the underdrains were flushed with either reverse osmosis (RO) water from the laboratory or from rainwater collected in the field at least 30 minutes before samples were collected if sediment was present. This procedure was chosen to collect the most representative samples for each storm, but it does not provide information about the contaminants present in the sediment. While the water used to clear the sediment could potentially introduce contaminants into the outlet samples, the field crew minimized this risk by allowing the underdrains to flush with effluent for at least 10 minutes before sampling.
- The QAPP specified that flow would be monitored throughout the project with ISCO® 4230 air bubblers (level sensor-type flow meters) at both the inlet and outlet of the DTS. However, soon after the flow meters were installed, it became clear there were issues at both locations.
    - At the inlet, the pipe would often fill with water during storms, which is not a condition under which the air bubbler can correctly measure flow. The air bubble at the inlet was replaced with an ISCO 4250 area velocity meter on November 10, 2015, which can accurately measure flow in a full pipe.
    - At the outlet, an additional flow control structure intercepts the water before it proceeds to the outlet pipe where the flow meter was installed (Appendix A, page A-9). After recording questionable flow data during a couple storms, the field lead visited the site during a storm to assess the situation. The field lead observed water surging from the flow control structure into the outlet pipe. This non-uniform flow was causing the flow meter to record erroneous measurements. This issue was not resolved, and flow monitoring was discontinued at the DTS outlet site. This also necessitated modifying Study Objective #2 to exclude the evaluation of flow control effectiveness of the DTS. Additionally, since flow data was not recorded at the outlet, all samples collected at the DTS were time-weighted instead of flow-weighted as specified in the QAPP. Finally, due to technical errors, inlet flow data was not recorded during several months of the project. The collected flow data are available upon request.
- As mentioned in Section C.2.3, DTS samples timespans were shorter than those specified in the QAPP and they were time-weighted. Additionally, it is unclear what portion of the hydrograph was sampled, because the flow data was not reliable. Despite these deviations, the samples were successfully collected only during storm conditions and were retained for analysis unless additional data quality issues were expected (See Appendix G).

APPENDIX C REFERENCES

King County. 2015. Quality Assurance Project Plan For Monitoring Stormwater Retrofit in the Echo Lake Drainage Basin – RSMP Effectiveness Study. Prepared by Carly Greyell, Water and Land Resources Division. Seattle, Washington.

SAMPLING METHOD PHOTOGRAPHS

Figure C-1. Filterra with closed grate and Filterra with open grate, clean-out uncapped (June 2, 2015).

Figure C-2. Filterra inlet sampling, stainless steel tray collecting water from curb cut (October 26, 2016).

Figure C-3. BPB1 inlet sampling, peristaltic pump (December 8, 2015).

Figure C-4. BPB1 outlet sampling, PVC pole holds tubing along the bottom of underdrain (December 8, 2015).

Figure C-5. DTS inlet sampling, ISCO autosampler retrieval (October 13, 2015).

Figure C-6. DTS outlet sampling, ISCO autosampler retrieval, demonstrating weighted tubing (October 13, 2015).

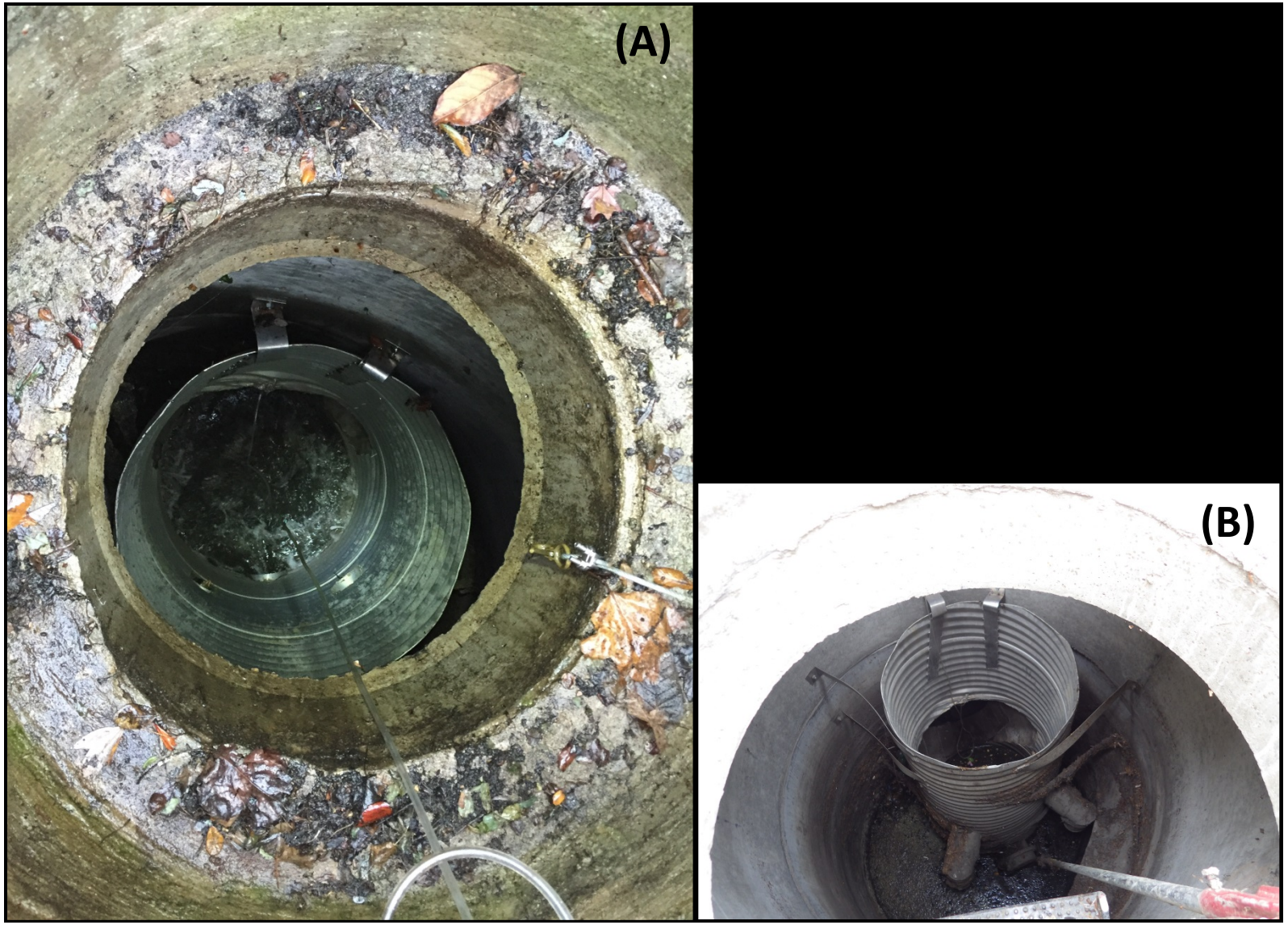

Figure C-7. View inside DTS outlet sampling location, flow control structure: (A) October 13, 2015, (B) June 2, 2015 (no storm).