Results of Dry Weather Water Quality Sampling around the Headwaters of Arboretum Creek in September, 2018:

FOAC Technical Memorandum #2[1]

— Dave Galvin 12/29/2018

SUMMARY:

Friends of Arboretum Creek (FOAC) sampled six sites in the current headwaters' area of Arboretum Creek at the end of Seattle's summer, 2018, to provide dry weather data regarding the water quality of various selected locations. All results support a hypothesis that the uphill/upstream springs that come off of the east side of Capitol Hill west of the Japanese Garden present clean water which currently flows into the combined sewer system and thus is lost to the creek. Nutrient levels in the Japanese Garden Koi Pond and also in the downstream headwaters' samples of Arboretum Creek were relatively high. Lube oil levels in the headwater sample might represent stormwater runoff contributions to the creek. More study is needed in order to fully understand the water quality as well as the water flows in the upper portions of today's Arboretum Creek.

BACKGROUND:

Friends of Arboretum Creek intends to document water quality and sediment quality issues related to Arboretum Creek as well as inputs to the creek and adjacent potential water sources, in order to better evaluate options for enhancing flows into Arboretum Creek in the future. With support from King County via a Waterworks grant, we have the capacity to collect and analyze a small number of samples so as to fill in gaps in current knowledge.

Earlier in 2018, we prepared a *Summary of Previous Water Quality Studies of Arboretum Creek: FOAC Technical Memorandum #1* (Galvin, 2018a)[2], a report that summarized existing data that we were able to locate related to the creek and its vicinity. We used this summary of existing data to fine-tune a sampling plan to look at the quality of the current headwaters of the creek as well nearby potential sources to the creek.

DRY-WEATHER SAMPLING:

We selected five sites in the "headwaters" area of today's Arboretum Creek in order to gain more

[1] This report can be cited as Galvin, Dave (2018b), *Results of Dry Weather Water Quality Sampling around the Headwaters of Arboretum Creek in September, 2018: FOAC Technical Memorandum #2*, available from galvind53@gmail.com .

[2] Galvin, Dave (2018a), *A Summary of Previous Water Quality Studies of Arboretum Creek: FOAC Technical Memorandum #1*. Last updated 8/13/2018. (Available from galvind53@gmail.com .)

understanding about existing conditions as well as the quality of potential new sources to the creek; we also took a grab of a sixth sample checking only for fluoride.

Figure 1 shows the locations of these six samples. Our reasons for choosing these sites are as follows:

#1. Arboretum Creek Headwaters. The outlet pipe on the east side of Lake Washington Blvd. across from the base of E. Interlaken Blvd. serves as the "headwaters" of the current creek. During much of the year (spring through fall), there appears to be no input to the creek from this pipe, other than occasional overflow from the Koi Pond in the Japanese Garden across the boulevard. During the winter shut-down of the Koi Pond's recirculating system (approximately mid-December through March), overflow from the pond crosses under the boulevard to serve as the major initial input to the creek.[3] We are still not sure of possible, additional, upstream sources to this point where the creek daylights, including possible stormwater sources from the boulevard. This spot is thus a key location to better understand.

#2. Alder Creek. To the west (uphill) of the Japanese Garden along the diagonal E. Prospect Street that connects 26th Ave. E and 28th Ave. E, a steady flow of water runs off Capitol Hill. It is known as Alder Creek. The "creek" flows down the southwest side of E. Prospect and disappears into a drain at the bottom of the hill. We have confirmed that this pipe flows east under the junction of E. Prospect and 28th E.; it then disappears downhill to the east. We have come to the conclusion that this unmapped pipe must be plumbed into the King County combined sewer at the base of the hill, probably joining the King County line at the south end of the Japanese Garden. No city or county maps show this pipe. This constant flow of fresh water coming off of Capitol Hill appears to contribute to the combined sewer; we believe it to be a potential, clean source of water to put back into Arboretum Creek. Thus there is a strong rationale for better understanding this flow.

#3. Arboretum Creek near North Curb Cut. Downstream of the current creek's "headwaters," there are various curb cuts along the east side of Lake Washington Blvd. that discharge stormwater from the boulevard into the creek during storm events. We need to better understand these runoff sources to the creek. We chose the north curb cut just north of the new parking area between E. Interlaken Blvd. and Boyer Ave. E. along Lake Washington Blvd. as a good location to document dry-weather flow and then to be able to compare to storm-related flow in the winter.

#4. "Alleyway Creek" midway between E. Aloha and E. Ward Streets on the west side of 28th Ave. E. A substantial flow of spring-water comes down the alley between E. Aloha and E. Ward Streets all year round. This flow appears to be nearly as robust as the Alder Creek flow that originates uphill in the E. Prospect Street right-of-way. Even in the driest periods of Seattle's summer, water pools on 28th Ave. E. in this area as a result of this constant spring flow. Currently, we believe that this flow enters the combined sewer at the base of E. Ward Street and flows into the King County combined sewer under the parking lot south of the Japanese Garden entrance. If this flow can be confirmed as clean, it will lend support to the idea of returning this flow to Arboretum Creek.

[3] While the overflow from the Koi Pond presents the major source of flow at the southern-most "headwaters" location of the current creek, it likely does not represent the major input of water into the creek overall. Downstream sources such as the tributary draining the Centennial Garden Pond, likely provide more volume as well as year-round flow to the creek. More assessment of water sources is needed.

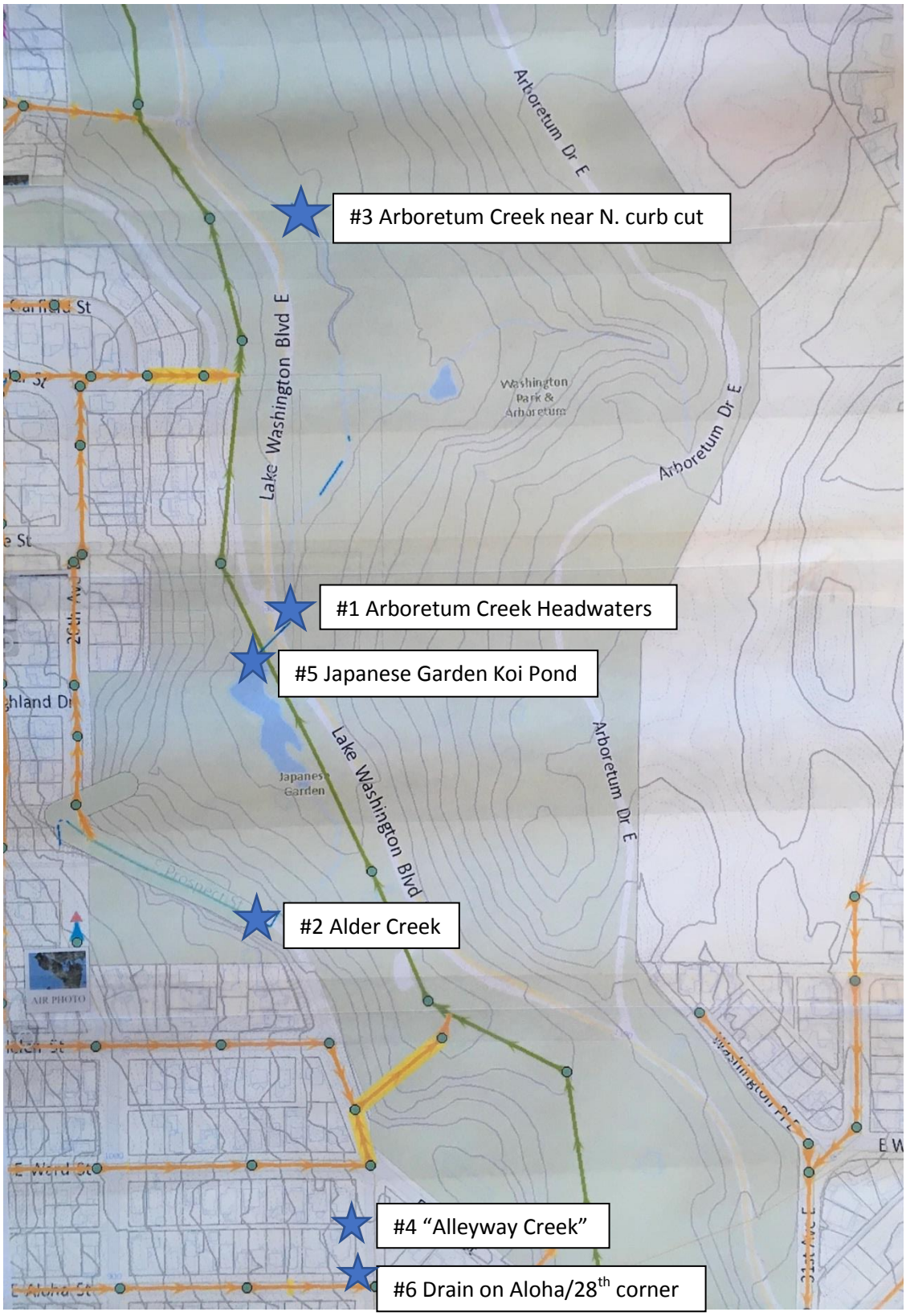

Figure 1. Map locating six sampling sites in the “headwaters” area of Arboretum Creek.

#5. Japanese Garden Koi Pond. We chose to sample the edge of the Koi Pond nearest its outlet in the Northeast corner of the pond. This is the major initial source of flow to Arboretum Creek in the winter, and a primary source of water during over-flow events in spring-summer-fall. It is thus important for us to better understand what is going on within the pond, its sources, including its sediments, and what might be done to both improve its quality while reducing dependence on city water supply to supplement the minimal rain and runoff sources to the pond.

#6. Spring flow at the corner of 28th Ave. E .and E. Aloha Street. This flow south of sample #4 was tested only for fluoride, in order to check for the possibility of leakage from drinking water pipes as a source to this flow that represents input to the major flow between E. Ward Street and E. Aloha Street on the west side of 28th Ave. E.

SAMPLING and ANALYSIS:

We contracted with King County's Environmental Lab (KCEL) to do the analyses of our samples. KCEL is one of the premier, certified labs in the region for trace-level environmental analyses. In addition, by using their services for these Waterworks-supported samples, the resulting data can move directly into King County's extensive database of environmental samples.

KCEL provided us with all of the sample bottles, plus coolers with ice, for collecting the samples. We followed all of the rigorous KCEL protocols for sample collection.

Sampling was done on **Tuesday, September 11, 2018**. This was at the very end of a dry Seattle summer. We had a few brief, very light, rainfall events in the week prior to sampling, but none of those events resulted in any runoff, so we feel confident that the samples we collected represent "dry weather" conditions.

Water samples were collected at each site into various bottles depending on the analyses to be done at the lab. All bottles were pre-labeled, and all were carefully stored on ice in the cooler until returned to KCEL at the end of the day.

Depending on the analytical protocol, some samples were then run within 24 hours, while others could wait for eventual analysis over the next few weeks.

We ran the first five samples for the following parameters:

- Total Suspended Solids. This is a filtration and weight-based analysis.
- Fluoride. We chose this analysis in order to detect possible sources of Seattle's drinking water supply to the flows we sampled. Fluoride above detection might indicate possible upstream breaks in distribution pipes.
- Total Nitrogen. An indicator of fertilizer or other sources of nutrients.
- Nitrite + Nitrate Nitrogen. A subset of Total N, to look for sources of nutrients from fertilizer.
- Total Phosphorus. An indicator of fertilize or other sources of nutrients.
- Ortho-phosphorus. The dissolved component of Total P, to look for sources of nutrients from fertilizer.

- Turbidity (in the field). We analyzed turbidity using a loaned field meter. This meter passes a light through the sample to check for suspended solids. Because this is an easy test to do in the field, we collected many additional turbidity data sites to the six described in this report.
- Fecal coliform bacteria. This protocol analyzes the sample for all fecal coliform bacteria, which include E. coli as well as many other flora. This is a traditional test for potential sources of sewage contamination. Low levels are common "background" in urban settings from pet waste, birds and other sources.
- *Escherichia coli*. This protocol is a more refined measure of fecal coliform, since *E. coli* is the dominant bacterium in animal guts. More environmental analyses are moving to E. coli from the more historical fecal coliform test. We opted to do both in order to compare results with previous environmental data.
- Oil-and-Grease. This is a traditional test going back many decades, particularly suited for wastewater samples that might be high in restaurant grease, for example, but also applied to environmental samples. It is a crude extraction of all organic substances. Results in environmental samples are often suspect due to low detections — the O&G protocol is focused more on organics routinely found in sewage.
- Diesel Range Organics. This newer test looks for carbon chains between 12 and 24 carbon atoms, thus focused more specifically on diesel-range fuels. This is used as an indicator for either spilled fuel or long-term stormwater runoff contributions.
- Lube Oil Range Organics. This newer test looks for carbon chains greater than 24 carbons in length, thus focused on heavier, lube-oil types of petroleum. This measure is used as a strong indicator of stormwater runoff contributions.

[See the discussion of these water quality parameters in *FOAC Technical Memo #1* (Galvin, 2018a) for more details.]

Sample #6 was run only for fluoride, since we were curious if this "spring" water flow at the base of E. Aloha Street might have any drinking water source.

FINDINGS:

Results from the sampling done on 9/11/2018, including tables for each sample containing the full analytical report from the King County Environmental Lab, are reported on the following pages. Within the data tables, note that there are certain qualifiers: "method detection limits" (MDLs), which usually reflect the minimum concentration that can reliably be reported for the analytical protocol used; "reporting detection limits" (RDLs), which indicate less precision (more variability) in the protocol at low quantification levels; method blank contamination issues; and flags where sample holding times were exceeded (which may or may not affect the resulting data).

The "Oil and Grease" analyses (noted as "Hem" in lab jargon) were suspect due to low levels at the MDL and contamination of method blanks; thus these reported values are likely not to be trusted. This protocol is an old measure primarily used for wastewater samples where levels are orders of magnitude higher than in typical environmental samples. So in hindsight this analysis did not produce reliable results for our samples. Fortunately, we also analyzed for the more accurate Diesel-range organics and Lube Oil-range organics, which we can review for potential influence of stormwater runoff.

Table 1: Results for Sample #1 at Arboretum Creek Headwaters.

Project: 421874-860
Locator: NONE
Sample: L70887-1
Matrix: LK FRESH WTR
ColDate: 9/11/18 11:00
ClientLoc: Arboretum Crk Headwaters (no flow)

WET Weight Basis

Parameters	Value	Qual	MDL	RDL	Units
CV SM2540-D					
Total Suspended Solids	165		6.7	13.3	mg/L
CV SM4110B FL					
Fluoride					
CV SM4500-N-C					
Total Nitrogen	4.89		0.1	0.2	mg/L
CV SM4500-NO3-F					
Nitrite + Nitrate Nitrogen	0.016	<RDL	0.01	0.04	mg/L
CV SM4500-P-B,F					
Total Phosphorus	0.867		0.01	0.02	mg/L
CV SM4500-P-F					
Orthophosphate Phosphorus	0.252		0.025	0.1	mg/L
ES NONE					
Turbidity, Field					
MC SM 9222D 20TH					
Fecal Coliform	100				CFU/100ml
MC SM9213D/3B					
Escherichia coli	14				CFU/100ml
OR EPA 1664B					
Hem (oil, total)	4.3	<RDL,B	1.5	5.3	mg/L
OR WDOE NWTPH-DX					
Diesel Range (>C12-C24)		<MDL	0.2	0.2	mg/L
Lube Oil Range (>C24)	0.649		0.2	0.2	mg/L

<MDL = less than the Method Detection Limit
(no value is reported)

B = method blank contamination
sample result may be biased

H = Analysis holding time exceeded

Table 2. Results for sample #2 at Alder Creek.

Project: 421874-860
Locator: NONE
Sample: L70887-2
Matrix: LK FRESH WTR
ColDate: 9/11/18 10:15
ClientLoc: Alder Crk (28th and Prospect)

WET Weight Basis

Parameters	Value	Qual	MDL	RDL	Units
CV SM2540-D					
Total Suspended Solids	14.8		0.5	1	mg/L
CV SM4110B FL					
Fluoride	0.183		0.02	0.04	mg/L
CV SM4500-N-C					
Total Nitrogen	1.87		0.05	0.1	mg/L
CV SM4500-NO3-F					
Nitrite + Nitrate Nitrogen	1.71		0.01	0.04	mg/L
CV SM4500-P-B,F					
Total Phosphorus	0.0598		0.005	0.01	mg/L
CV SM4500-P-F					
Orthophosphate Phosphorus	0.0392		0.0005	0.002	mg/L
ES NONE					
Turbidity, Field	6.8		0.5	2	NTU
MC SM 9222D 20TH					
Fecal Coliform	8				CFU/100ml
MC SM9213D/3B					
Escherichia coli	31				CFU/100ml
OR EPA 1664B					
Hem (oil, total)	6.5	B	1.5	5.3	mg/L
OR WDOE NWTPH-DX					
Diesel Range (>C12-C24)		<MDL	0.192	0.192	mg/L
Lube Oil Range (>C24)		<MDL	0.192	0.192	mg/L

<MDL = less than the Method Dete
(no value is reported)

B = method blank contamination
sample result may be biased

H = Analysis holding time exceeded

Table 3. Results for sample #3 from Arboretum Creek near north curb cut.

Project: 421874-860
Locator: NONE
Sample: L70887-3
Matrix: LK FRESH WTR
ColDate: 9/11/18 10:45
ClientLoc: Arboretum Crk near North Curb Cut

WET Weight Basis

Parameters	Value	Qual	MDL	RDL	Units
CV SM2540-D					
Total Suspended Solids	3.06	H	0.5	1	mg/L
CV SM4110B FL					
Fluoride					
CV SM4500-N-C					
Total Nitrogen	1.75		0.05	0.1	mg/L
CV SM4500-NO3-F					
Nitrite + Nitrate Nitrogen	1.31		0.01	0.04	mg/L
CV SM4500-P-B,F					
Total Phosphorus	0.0469		0.005	0.01	mg/L
CV SM4500-P-F					
Orthophosphate Phosphorus	0.0171		0.0005	0.002	mg/L
ES NONE					
Turbidity, Field	1.7	<RDL	0.5	2	NTU
MC SM 9222D 20TH					
Fecal Coliform	18				CFU/100ml
MC SM9213D/3B					
Escherichia coli	18				CFU/100ml
OR EPA 1664B					
Hem (oil, total)	3.6	<RDL,B	1.5	5.5	mg/L
OR WDOE NWTPH-DX					
Diesel Range (>C12-C24)		<MDL	0.194	0.194	mg/L
Lube Oil Range (>C24)		<MDL	0.194	0.194	mg/L

<MDL = less than the Method Dete
(no value is reported)

B = method blank contamination
sample result may be biased

H = Analysis holding time exceede

Table 4. Results for sample #4 from "Alleyway Creek" on 28th Ave. E.

Project: 421874-860
Locator: NONE
Sample: L70887-4
Matrix: LK FRESH WTR
ColDate: 9/11/18 10:00
ClientLoc: Midway between Aloha and Ward on 28

WET Weight Basis

Parameters	Value	Qual	MDL	RDL	Units
CV SM2540-D					
Total Suspended Solids	3.93	H	0.5	1	mg/L
CV SM4110B FL					
Fluoride	0.037	<RDL	0.02	0.04	mg/L
CV SM4500-N-C					
Total Nitrogen	2.24		0.05	0.1	mg/L
CV SM4500-NO3-F					
Nitrite + Nitrate Nitrogen	1.98		0.01	0.04	mg/L
CV SM4500-P-B,F					
Total Phosphorus	0.119		0.005	0.01	mg/L
CV SM4500-P-F					
Orthophosphate Phosphorus	0.0537		0.0005	0.002	mg/L
ES NONE					
Turbidity, Field	23.6		0.5	2	NTU
MC SM 9222D 20TH					
Fecal Coliform	26				CFU/100ml
MC SM9213D/3B					
Escherichia coli	36				CFU/100ml
OR EPA 1664B					
Hem (oil, total)	3.2	<RDL,B	1.5	5.3	mg/L
OR WDOE NWTPH-DX					
Diesel Range (>C12-C24)		<MDL	0.196	0.196	mg/L
Lube Oil Range (>C24)		<MDL	0.196	0.196	mg/L

<MDL = less than the Method Det
(no value is reported)

B = method blank contamination
sample result may be biased

H = Analysis holding time exceed

Table 5. Results for sample #5 from the Japanese Garden Koi Pond.

Project: 421874-860
Locator: NONE
Sample: L70887-5
Matrix: LK FRESH WTR
ColDate: 9/11/18 9:30
ClientLoc: Japanese Garden Pond

WET Weight Basis

Parameters	Value	Qual	MDL	RDL	Units
CV SM2540-D					
Total Suspended Solids	37.2	H	4.4	8.7	mg/L
CV SM4110B FL					
Fluoride					
CV SM4500-N-C					
Total Nitrogen	3.12		0.05	0.1	mg/L
CV SM4500-NO3-F					
Nitrite + Nitrate Nitrogen		<MDL	0.01	0.04	mg/L
CV SM4500-P-B,F					
Total Phosphorus	0.239		0.005	0.01	mg/L
CV SM4500-P-F					
Orthophosphate Phosphorus	0.00357		0.0005	0.002	mg/L
ES NONE					
Turbidity, Field	28.2		0.5	2	NTU
MC SM 9222D 20TH					
Fecal Coliform	17				CFU/100ml
MC SM9213D/3B					
Escherichia coli	24				CFU/100ml
OR EPA 1664B					
Hem (oil, total)	3.3	<RDL,B	1.6	5.7	mg/L
OR WDOE NWTPH-DX					
Diesel Range (>C12-C24)		<MDL	0.196	0.196	mg/L
Lube Oil Range (>C24)		<MDL	0.196	0.196	mg/L

<MDL = less than the Method Det (no value is reported)

B = method blank contamination sample result may be biased

H = Analysis holding time exceed

Table 6. Results for sample #6 from the corner of E. Aloha St. and 28th Ave. E.

Project: 421874-860
Locator: NONE
Sample: L70887-6
Matrix: LK FRESH WTR
ColDate: 9/11/18 10:30
ClientLoc: 28th Ave E. near Aloha (S of midpoint)

WET Weight Basis

Parameters	Value	Qual	MDL	RDL	Units
CV SM2540-D					
Total Suspended Solids					
CV SM4110B FL					
Fluoride	0.028	<RDL	0.02	0.04	mg/L
CV SM4500-N-C					
Total Nitrogen					
CV SM4500-NO3-F					
Nitrite + Nitrate Nitrogen					
CV SM4500-P-B,F					
Total Phosphorus					
CV SM4500-P-F					
Orthophosphate Phosphorus					
ES NONE					
Turbidity, Field					
MC SM 9222D 20TH					
Fecal Coliform					
MC SM9213D/3B					
Escherichia coli					
OR EPA 1664B					
Hem (oil, total)					
OR WDOE NWTPH-DX					
Diesel Range (>C12-C24)					
Lube Oil Range (>C24)					

<MDL = less than the Method Det (no value is reported)

B = method blank contamination sample result may be biased

H = Analysis holding time exceed

The following discussion provides a breakdown of our results from the sampling done on 9/11/2018. I explore these results first by site, then by parameter. I conclude with an overall summary.

A) FINDINGS BY SITE:

#1. Arboretum Creek Headwaters. Table 1 shows the results for site #1.

The headwaters turned out to be our most "contaminated" site, relatively speaking. The value for Total Suspended Solids was high due to sampling challenges — we kept having trouble stirring up the bottom silt while trying to collect a useful water sample because the water volume was very low — so I am not concerned about the reported value. Total Nitrogen level was relatively high, but still within the range found by O'Brien (2015) in the Stone Cottage samples he took to the south of this location. The Total N value is also consistent with the relative high nitrogen value found in the Japanese Garden Koi Pond, which makes sense given that the pond is the major input to the headwaters. Total Phosphorus was also slight elevated here and in the Koi Pond sample. I don't know what to make of the relatively high Orthophosphate result, as it does not correlate with the sample from the Koi Pond; more data will be needed to detect if there is any significance to this dissolved nutrient here. Bacteria levels were within expected urban samples — no sign of any unusual contamination there. Lube-oil-range organics were high here, which might signal stormwater runoff sources from the boulevard or accumulated background leaching from the sediments.

#2. Alder Creek. Table 2 shows the results for site #2.

All values reported show a very clean source of water coming out of Capital Hill in the vicinity of the E. Prospect Street right-of-way. Total Suspended Solids were slightly high, due to sampling challenges stirring up the bottom silt; I'm not concerned about this measure. While Fluoride was detected here, the value is quite low. It might signal a minor up-stream contribution from a leaking city water main or a residential lawn-watering system. Additional sampling could confirm this finding, yet the result does not otherwise influence potential uses of this flow downstream. All other results were low and indicate clean, uncontaminated water at this location.

#3. Arboretum Creek near north curb cut. Table 3 shows the results for site #3.

Everything in this sample, located a bit downstream of the headwaters, came back low. There were no issues with this water at this point in the creek.

#4. "Alleyway Creek" midway between E. Aloha and E. Ward Streets on the west side of 28th Ave. E. Table 4 shows the results for site #4.

All values were low and within normal expected ranges, showing very clean water flowing from this part of Capitol Hill. The turbidity result was caused by sampling conditions, where we couldn't get a "clean" water sample without stirring up some of the silt at the sampling location.

#5. Japanese Garden Koi Pond nearest outlet. Table 5 shows the results for site #5.

In the Koi Pond, Total Suspended Solids were high as a result of summer algae growth. Total Nitrogen and Total Phosphorus were also high, representing conditions within the pond that promote algae growth. These nutrients could be coming from fertilizers used within the Japanese Garden or from the limited areas of uphill runoff, or, more likely from recirculation from the accumulated bottom sediments. Turbidity measurements were also relatively high, given the levels of algae in the pond at the time of sampling. Background levels of bacteria could be simply from the ducks that inhabit the pond in summer months.

#6. Spring flow at the corner of 28th Ave. E and E Aloha Street.

The sample collected at this location was run only for fluoride and came back below the RDL. It is our conclusion that this source is likely from uphill groundwater springs rather than from uphill breaks or leaks in the city's drinking water pipes.

B) FINDINGS BY PARAMETER:

— Overall, our samples were pretty clean and did not have any unusually high values that would point to some significant contaminant problems. This is a good overall take-away.

— As noted earlier, the analytical protocol for "Total oil-and-grease" is designed for much higher values and is not reliable at its lower detection limits. We should ignore those values — and focus instead on the diesel and lube oil analyses (see below).

— Total Suspended Solids were high at the Arboretum Creek headwaters, in Alder Creek and in the Japanese Garden pond water. For the first two, I distinctly remember having challenges getting good water samples without slightly stirring up the bottom silt at those sampling spots, so I'm not concerned about these readings and think they reflect sampling variability from stirred up dirt. The Japanese Garden pond value also does not surprise me due to the level of algae in the pond when we took the samples.

— Fluoride came back undetected for the two samples we took on 28th. This reassures me that there is no potential drinking water contribution to those spring flows coming down the hill. However, fluoride was detected in the Alder Creek sample, albeit at levels lower than what would typically be in drinking water. This could indicate some up-hill pipe leakage, but not something that should affect our future recommendations. We should re-analyze for fluoride here when we do wet-weather sampling this winter.

— Total Nitrogen was high both at the Headwaters and in the Japanese Garden Pond. Since the latter feeds the former, these two high values make sense, but indicate some nutrient inputs either from fertilizers used within the Japanese Garden or seepage of accumulated nutrients from the bottom sediments within the pond. Clearly the pond has an algae challenge, which is supported by higher-than-normal nutrient levels. It is unsurprising then that's we would also see these levels at the headwaters. The low level seen in Alder Creek exactly matches Frodge's result there (see Frodge, 2018 or Galvin, 2018a). The level at 28th is slightly higher than Frodge's result, but still within normal variability there. Based on these results, I am not concerned about excess fertilizer running off the Capitol Hill slope.

— Nitrite+Nitrate Nitrogen levels were all low; no issues here at any of the samples.

— Total Phosphorus was similarly high in the Headwaters and Japanese Garden Pond samples, but low in the samples taken up on 28th. These results support the conclusion that we don't have fertilizer issues in the water coming off Capitol Hill.

— Orthophosphate (the dissolved P) was high only in the Headwaters sample. Interestingly, it was not high in the Japanese Garden Pond sample. A puzzle there, but not one I would spend much time dwelling on until we have additional data.

— Turbidity values were data we reported from the field meter. The Japanese Garden Pond was obviously turbid due to all the algae. We probably stirred up bottom silt in the 28th Ave. sample — I'm not concerned about that reading. Other ones at these sample sites were low. We were unable to record a value for the Headwaters in these reported results, but as we noted, we had difficulty collecting "clean" water samples there due to stirred up sediments.

— Bacteria levels (Total Coliforms and E. Coli) were all relatively low, within "urban background" levels. The one high reading was in the Headwaters sample, but still less than an urban background of around 200, so it doesn't indicate any significant contamination source. It probably just shows duck poop from the pond water or something like that, within a natural range for urban samples. The variability between samples and between TC and EC is probably just expected variability from sample to sample within the urban background levels. Clearly none of these levels were indicative of any problem sources such as sewage contamination.

— All analyses for Diesel-range hydrocarbons came back below detection limits, which is a good thing and indicates no stormwater or other contamination sources.

— Similarly, all but one of the Lube Oil-range hydrocarbons came back below detection, which is a good sign. The only high level was in the Headwaters sample, which might indicate accumulated background within the up-pipe sediments there from runoff from the boulevard, which would explain the slight oil sheen sometimes noted in this area and just a bit downstream of the Headwaters. Levels were below detection in the Japanese Garden Pond water, which is a good sign for that location. Future sediment samples there might tell a different story, but at least the dry-weather samples from the pond do not show any internal contamination from parking lot or road runoff.

CONCLUSIONS:

Our dry weather samples overall were quite clean by urban water standards. The two main springs uphill and west of the Japanese Garden appear to be clean groundwater, although a detection of fluoride in the Alder Creek sample might imply some input from uphill leakage in the city's drinking water pipes, but not a significant source of the observed flow. Both flows showed no contamination from sewage or fertilizer, thus providing at least preliminary support for their potential use as clean water sources into Arboretum Creek.

The Japanese Garden Koi Pond and the nearby headwaters of Arboretum Creek are a bit more complicated, primarily from high nutrient levels which promote algae growth, and, at the headwaters, a high lube-oil result pointing to possible stormwater runoff sources into the creek or from accumulated sediment contamination that could provide historical releases of petroleum hydrocarbons.

We plan to expand these results with wet weather sampling over the winter of 2018/2019 as well as focused sampling for specific parameters as appropriate in order to better understand the quality of the creek as well as the various existing and potential sources of water to the creek.

REFERENCES:

Frodge, Jonathan. 2018. *Technical Memo: Arboretum Creek Preliminary Water Quality Data*. Seattle Public Utilities: internal report.

Galvin, D. 2018a. *A summary of previous water quality studies of Arboretum Creek: FOAC Technical Memorandum #1*. Seattle, WA: Friends of Arboretum Creek. (Available from galvind53@gmail.com .)

O'Brien, K. 2015. *Technical Memo: Arboretum Water Quality Sampling and Analysis*. Seattle, WA: Seattle Parks and Recreation: internal report.