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Semi-Annual Progress Report for Effectiveness Monitoring of the South 356th Street Retrofit and Expansion Project, Federal Way, WA (Deliverable D2.3)

Submitted to Brandi Lubliner, Ecology – RSMP Coordinator
Submitted by Kate Macneale, King County
Submitted on August 30, 2016 (revised)

Summary of Activities

In the first half of 2016, King County continued to monitor the effectiveness of stormwater controls at the South 356th Street Retrofit and Expansion Project in Federal Way, WA. The objectives for this period were to 1) continue collecting flow data at the seven sampling locations, 2) develop precipitation and flow relationships for each of the sampling locations so that autosamplers can be programmed to collected flow-weighted samples appropriately, and 3) collect water samples for chemical analyses and toxicity tests for up to ten storm events.

This deliverable includes a summary of the activities and analyses that were conducted between January 1, 2016 and June 30, 2016. This includes a log of site visits and sampling events (Table 1), preliminary summaries of flows at sampling locations and precipitation during sampling events (Table 2), preliminary data from chemical analysis (Table 3) and toxicity tests (see attached report), and some photos from site visits.

Summary of Progress

We were able to monitor flows from all locations during this period, although we are still working to verify the reliability and accuracy of the measurements at one location. With the flow data from 2015 and early 2016, we were able to develop the relationships between precipitation and flow at each of the sampling locations. These relationships are critical for setting the pacing of the autosamplers and ensuring sampling events meet the sampling criteria (e.g., sampled >50% of the flow from a storm, the peak of the hydrograph was captured among samples, sufficient volumes were collected). The developed relationships worked very well, and most of the samples met the criteria during the two storms (Table 2). Most of the preliminary chemistry data are available from the two storm samples (Table 3 and toxicity report); PCB data are not yet available.

Remaining Challenges

At the outlet of the west bioretention facility (WBO), flow measurements appear to be affected by water backing up from the catch basin that the outlet drains into. We suspect that this resulted in untreated runoff from the road contaminating the water sample collected at WBO during the first storm. The preliminary chemistry data from this location also suggests the sample was contaminated from untreated runoff into the catch basin. Because of this, a grab sample was

collected at WBO during storm 2 instead of a flow-weighted sample. To remedy the problem, the field team installed a weir in the pipe in May, and we continue to evaluate whether this will improve flow measurements. If we cannot resolve this, we may have to collect grab samples at this site during times we are certain there is no back-flow from the catch basin.

An additional challenge will be meeting our target number of storms. We plan to sample as many storms as possible through the next wet season, but due to the initial delay in the start of sampling and the storm criteria it will be difficult to reach our target number of twenty storms by the end of 2017. We will continue to discuss our progress with Ecology and Federal Way, and will revise our target and/or timeline depending on the progress and the results of the chemistry analyses.
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Table 1. The following activities and site visits were logged by Jeff Droker, Houston Flores and Kate Macneale.

Date	KC staff	Changed battery at one or more sites	checked flow; downloaded data	Trouble-shooting flow measurements	Collected samples	Notes
1/7/16	HF, JD	x	x	x		Checked on locations of two small inlet pipe to upper pond
1/11/16	JD, DH		x	x		Check new pipes (trickle)
1/14/16	HF	x	x			
1/19/16	KM		x			Downloaded depth data
1/25/16	HF	x	x	x		Check new pipes (dry)
1/27/16-1/28/16	HF, JD		x		Test run	Trial run at EBI and EBO
2/3/16	HF	x	x	x		
2/11/16	HF, JD	x	x			
2/16/16	KM		x			Downloaded depth data
2/22/16	HF		x			Downloaded data from office via modem
2/25/16	JD, HF	x	x	x		Met Skyler, tech from Federal Way, at site
3/2/16	JD, HF	x	x			Set up for predicted storm
3/3/16	JD, HF	x	x			Storm smaller than predicted, did not meet criteria; equipment cleaned, tubing replaced
3/8/16	JD, HF	x	x			Set up for predicted storm
3/9/16	HF		x			Start of Storm 1
3/10/16	JD, HF		x	x	x	
3/16/16	JD, HF	x	x	x		
3/23/16	HF, CB	x				Set up for predicted storm

Date	KC staff	Changed battery at one or more sites	checked flow; downloaded data	Trouble-shooting flow measurements	Collected samples	Notes
3/24/16	HF, CB, KM	x	x	x	x	
3/31/16	HF, DH, CB	x	x			Installed weather station
4/4/16	JD		x			
4/14/16	JD, HF	x	x	x		
4/19/16	JD, HF	x	x			Replaced YSI probes
5/10/16	JD, HF	x	x	x		Installed weirs in WBO and EBO
6/2/16	CB, SH, HF	x	x	x		
6/7/16	JD	x				Dealt with ants and wasps at site
6/13/16	JD	x				Dealt with ants and wasps at site

Table 2. Summary of storm precipitation and flow at each location during the two sampling events. See following sheets for site specific flow and sample collection information.

Storm Number	Storm 1	Storm 1	Storm 1	Storm 1	Storm 1	Storm 1	Storm 1	Storm 2	Storm 2	Storm 2	Storm 2	Storm 2	Storm 2	Storm 2
Storm Date	3/9/2016	3/9/2016	3/9/2016	3/9/2016	3/9/2016	3/9/2016	3/9/2016	3/23/2016	3/23/2016	3/23/2016	3/23/2016	3/23/2016	3/23/2016	3/23/2016
location	EBI	EBO	WBI	WBO	WCI	WCEBO	NWH	EBI	EBO	WBI	WBO	WCI	WCEBO	NWH
Precipitation Information														
Dry antecedent period (hours)	12	12	12	12	12	12	12	39	39	39	39	39	39	39
Rainfall in previous 24 hours (before first measured rain during storm) (inches)	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0	0	0	0	0	0	0
Rainfall in previous 6 hours (before first measured rain during storm) (inches)	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0	0	0	0	0	0	0
Total rainfall that occurred by the time the last sample was collected (inches)	0.67	0.86	0.86	0.86	0.86	0.86	0.86	0.28	0.29	0.28	0.29	0.29	0.29	0.29
Total rainfall that occurred during the storm (inches)	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.29	0.29	0.29	0.29	0.29	0.29	0.29
Sampling Information														
Runoff volume during first 24 hours of event (starting at time of first sample) (cubic feet)	40484	12600	18658	5753	222909	238255	272265	867	2458	259	**	51647	69661	62412
Runoff volume sampled (cubic feet)	23170	5978	14546	4987	200755	197620	210972	737	1280	225	0	44309	38007	32398
% of runoff volume sampled	57.23	47.44	77.96	86.69	90.06	82.94	77.49	85.01	52.07	86.87	0.00	85.79	54.56	51.91
average flow rate during the interval that was sampled (cfs)	0.608	0.127	0.322	0.075	3.27	2.737	3.261	0.017	0.033	0.013	n/a	0.727	0.79	0.765
Peak of hydrograph captured (yes/no)	unclear	unclear	yes	yes	yes	yes	yes	yes	yes	yes	no	yes	yes	yes
Number of aliquots collected	36	36	36	36	36	32	26	36	36	6	0	21	19	13
Time from start of sampling to tail (when rate of change in cfs is less than 2%) (hours)	20.5	47	20	*	15	46	44	14.25	19	7.5	**	14.6	26.5	30***
Volume of runoff from first sample to tail (cubic feet)	38540	19056	18255	*	195206	394742	407077	867	2193	259	**	41210	75146	72359***

*Due to very low and slow flow at this site, there is no discernable tail.

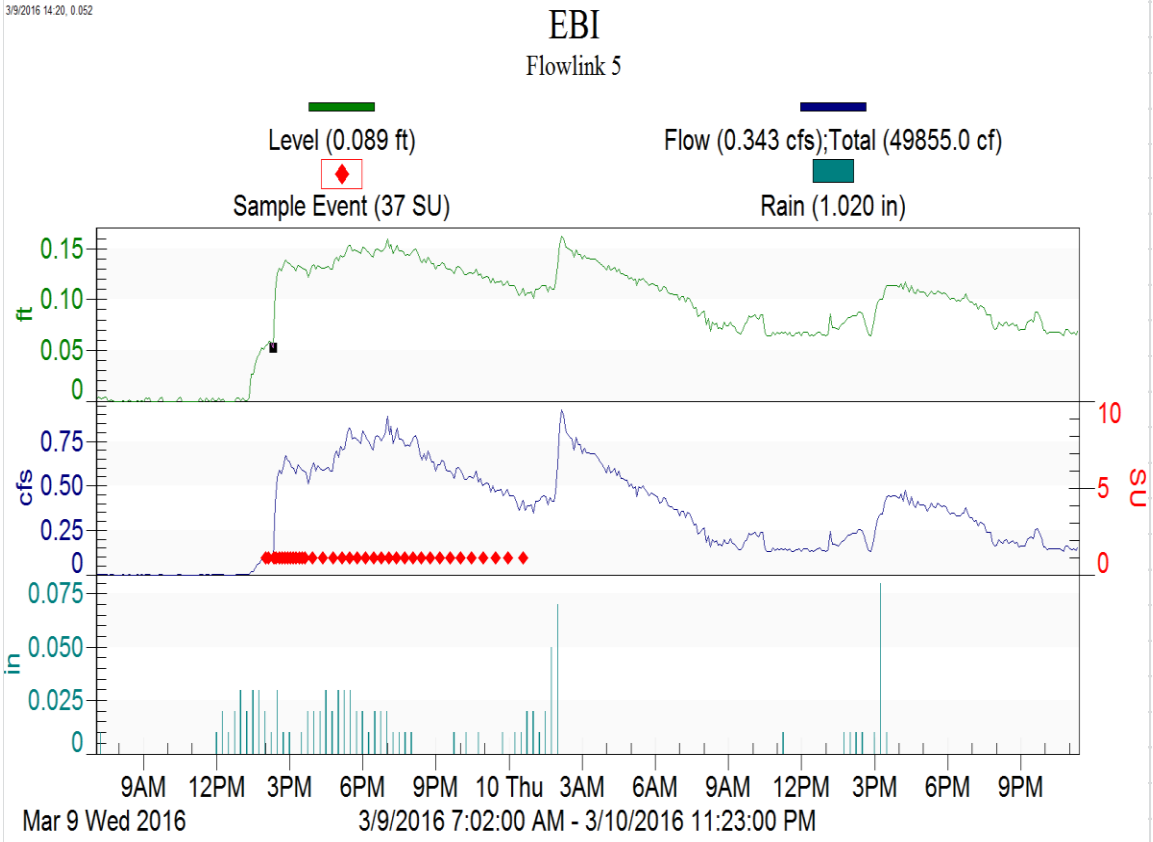
*Spikes in flow level were due to backflow caused by high flow in adjacent pipe.

**no samples taken

***rate of change was never more than 2% at this site, this is the time interval from start of sampling to when the tail neared zero percent.

Federal Way Regional Detention Facility

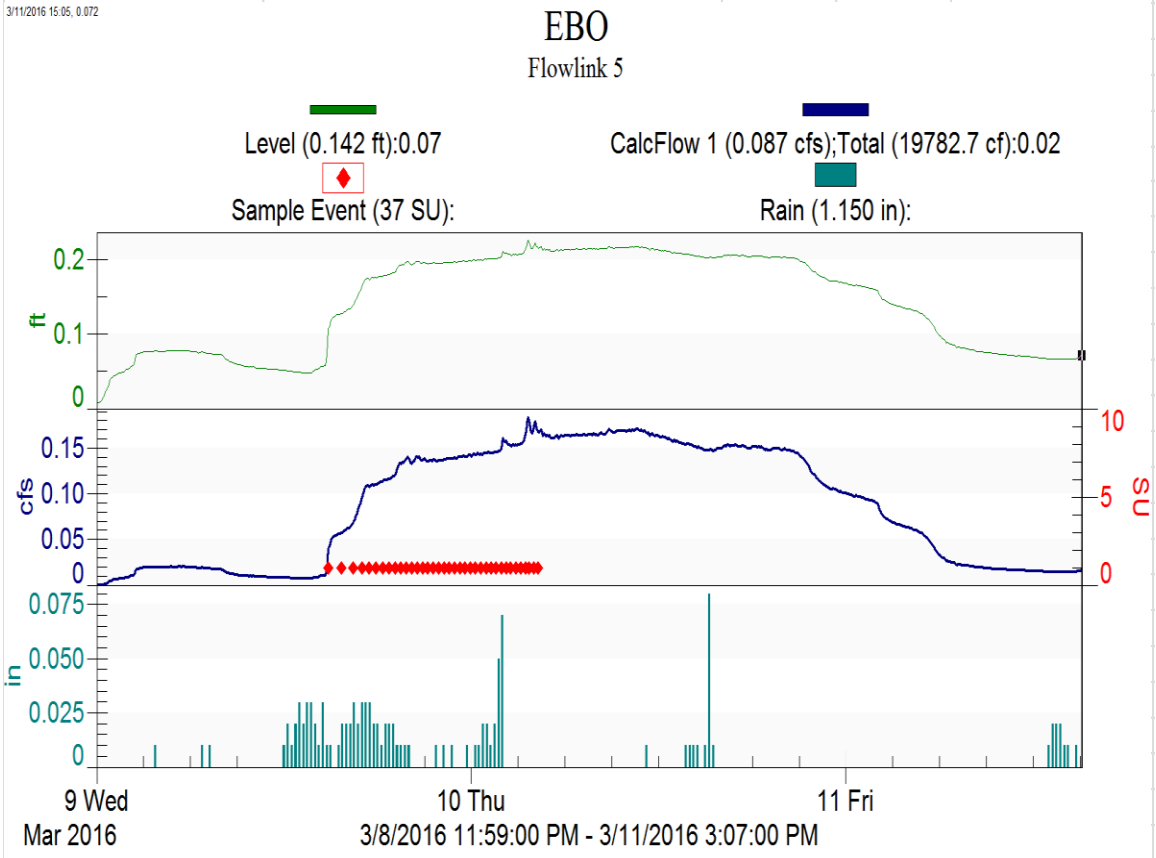
Location:	EBI
Storm Date:	3/9/2016
Flow Measurement:	Manning Equation
Monitoring Equipment:	Isco 730 Bubbler Module and 6712 Autosampler
Raingage:	King County 24v East Fork Hylebos



Precipitation Information	
Dry antecedent period (hours)	12
Rainfall in previous 24 hours (before first measured rain during storm) (inches)	0.25
Rainfall in previous 6 hours (before first measured rain during storm) (inches)	0.02
Total rainfall that occurred by the time the last sample was collected (inches)	0.67
Total rainfall that occurred during the storm (inches)	0.86
Sampling Information	
Runoff volume during first 24 hours of event (starting at time of first sample) (cubic fe	40484
Runoff volume sampled (cubic feet)	23170
% of runoff volume sampled	57.23
average flow rate during the interval that was sampled (cfs)	0.608
Peak of hydrograph captured (yes/no)	unclear
Number of aliquots collected	36
Time from start of sampling to tail (when rate of change in cfs is less than 2%) (hours)	20.5
Volume of runoff from first sample to tail	38540

Federal Way Regional Detention Facility

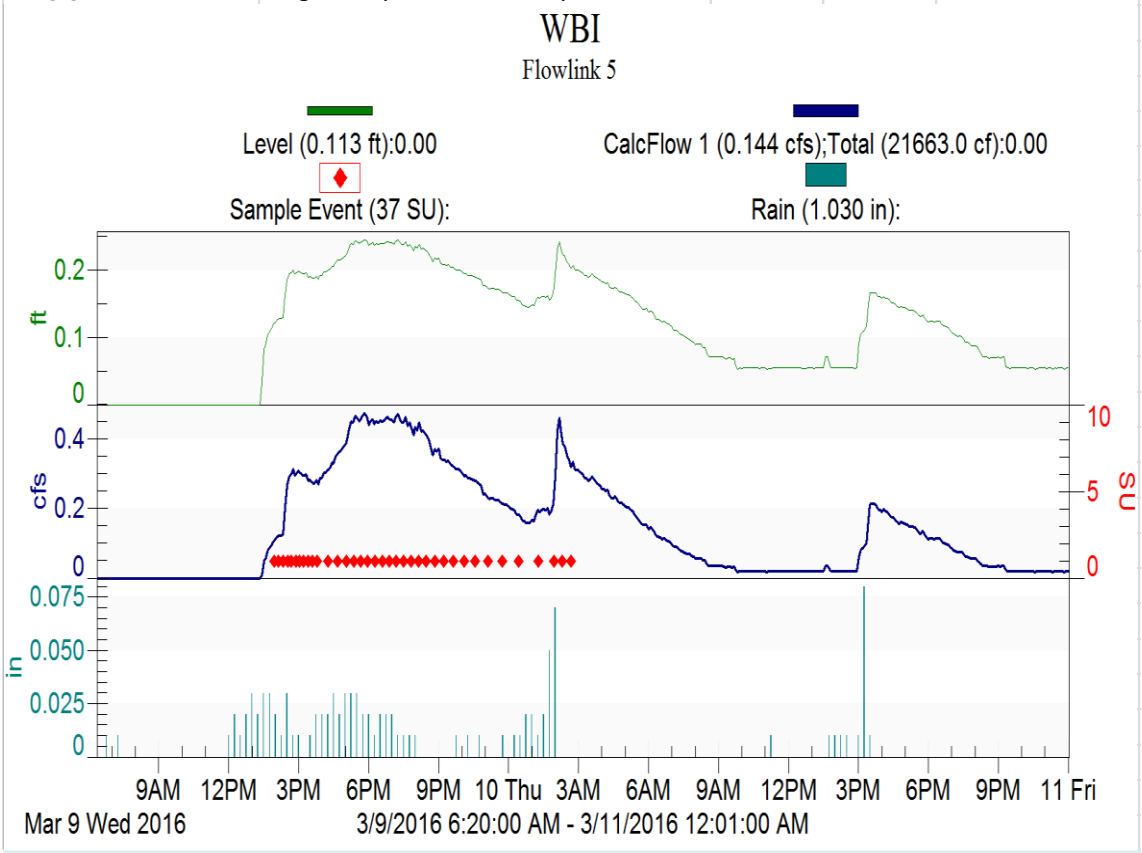
Location:	EBO
Storm Date:	3/9/2016
Flow Measurement:	Manning Equation
Monitoring Equipment:	Isco 750 Area Velocity Module and 6712 Autosampler
Raingage:	King County 24v East Fork Hylebos



Precipitation Information	
Dry antecedent period (hours)	12
Rainfall in previous 24 hours (before first measured rain during storm) (inches)	0.25
Rainfall in previous 6 hours (before first measured rain during storm) (inches)	0.02
Total rainfall that occurred by the time the last sample was collected (inches)	0.86
Total rainfall that occurred during the storm (inches)	0.86
Sampling Information	
Runoff volume during first 24 hours of event (starting at time of first sample) (cubic fe	12600
Runoff volume sampled (cubic feet)	5978
% of runoff volume sampled	47.44
average flow rate during the interval that was sampled (cfs)	0.127
Peak of hydrograph captured (yes/no)	unclear
Number of aliquots collected	36
Time from start of sampling to tail (when rate of change in cfs is less than 2%) (hours)	47
Volume of runoff from first sample to tail	19056

Federal Way Regional Detention Facility

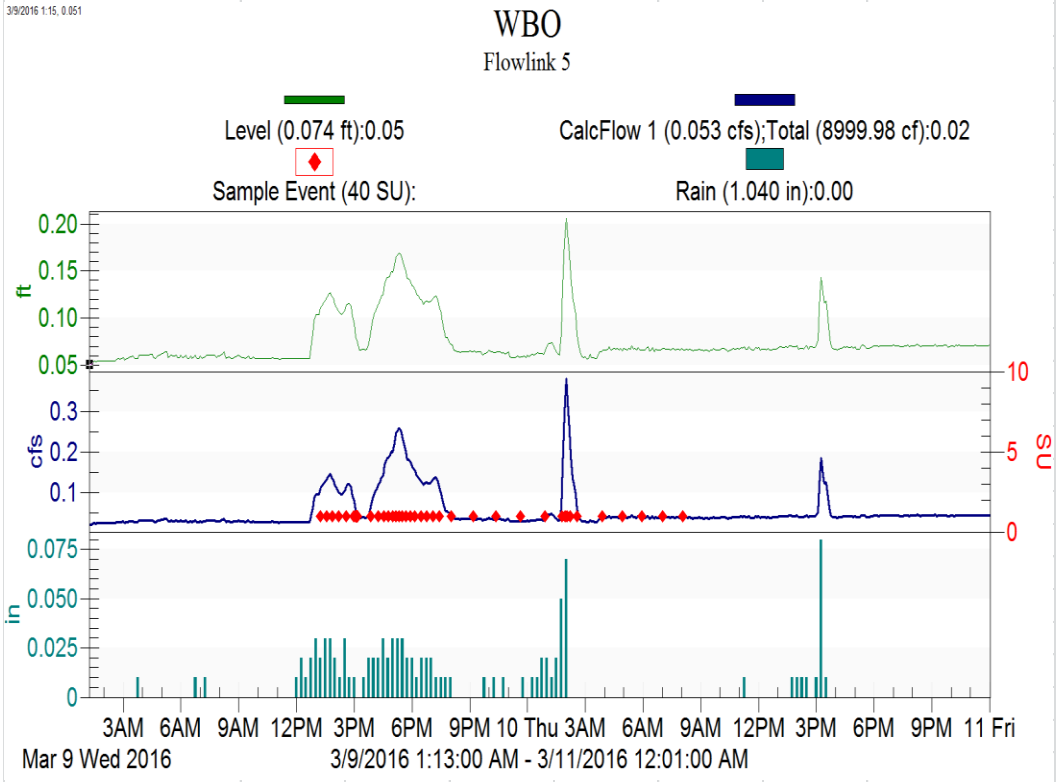
Location:	WBI
Storm Date:	3/9/2016
Flow Measurement:	Manning Equation
Monitoring Equipment:	Isco 730 Bubbler Module and 6712 Autosampler
Raingage:	King County 24v East Fork Hylebos



Precipitation Information	
Dry antecedent period (hours)	12
Rainfall in previous 24 hours (before first measured rain during storm) (inches)	0.25
Rainfall in previous 6 hours (before first measured rain during storm) (inches)	0.02
Total rainfall that occurred by the time the last sample was collected (inches)	0.86
Total rainfall that occurred during the storm (inches)	0.86
Sampling Information	
Runoff volume during first 24 hours of event (starting at time of first sample) (cubic fe	18658
Runoff volume sampled (cubic feet)	14546
% of runoff volume sampled	77.96
average flow rate during the interval that was sampled (cfs)	0.322
Peak of hydrograph captured (yes/no)	yes
Number of aliquots collected	36
Time from start of sampling to tail (when rate of change in cfs is less than 2%) (hours)	20
Volume of runoff from first sample to tail	18255

Federal Way Regional Detention Facility

Location:	WBO
Storm Date:	3/9/2016
Flow Measurement:	Manning Equation
Monitoring Equipment:	Isco 730 Bubbler Module and 6712 Autosampler
Raingage:	King County 24v East Fork Hylebos



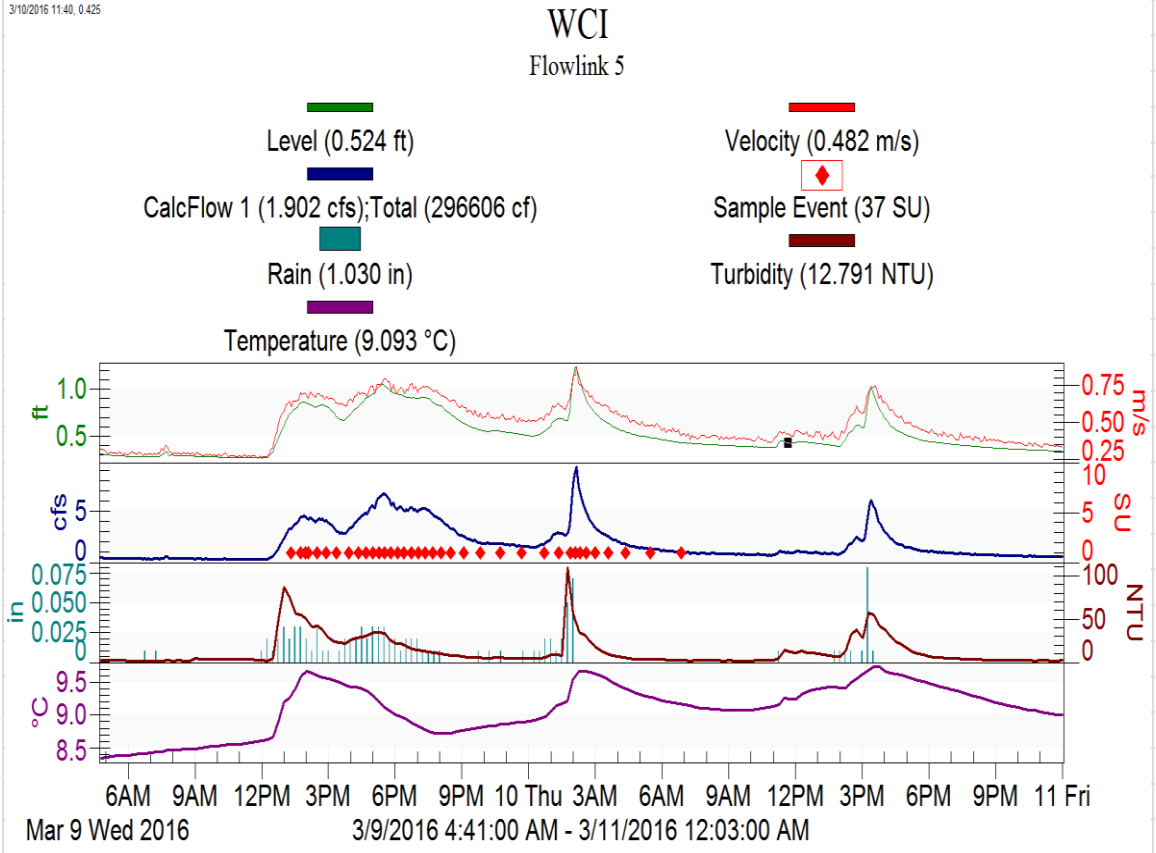
Precipitation Information	
Dry antecedent period (hours)	12
Rainfall in previous 24 hours (before first measured rain during storm) (inches)	0.25
Rainfall in previous 6 hours (before first measured rain during storm) (inches)	0.02
Total rainfall that occurred by the time the last sample was collected (inches)	0.86
Total rainfall that occurred during the storm (inches)	0.86
Sampling Information	
Runoff volume during first 24 hours of event (starting at time of first sample) (cubic fe	5753
Runoff volume sampled (cubic feet)	4987
% of runoff volume sampled	86.69
average flow rate during the interval that was sampled (cfs)	0.075
Peak of hydrograph captured (yes/no)	yes
Number of aliquots collected	36
Time from start of sampling to tail (when rate of change in cfs is less than 2%) (hours)	*
Volume of runoff from first sample to tail	*

*Due to very low and slow flow at this site, there is no discernable tail.

*Spikes in flow level were due to backflow caused by high flow in adjacent pipe.

Federal Way Regional Detention Facility

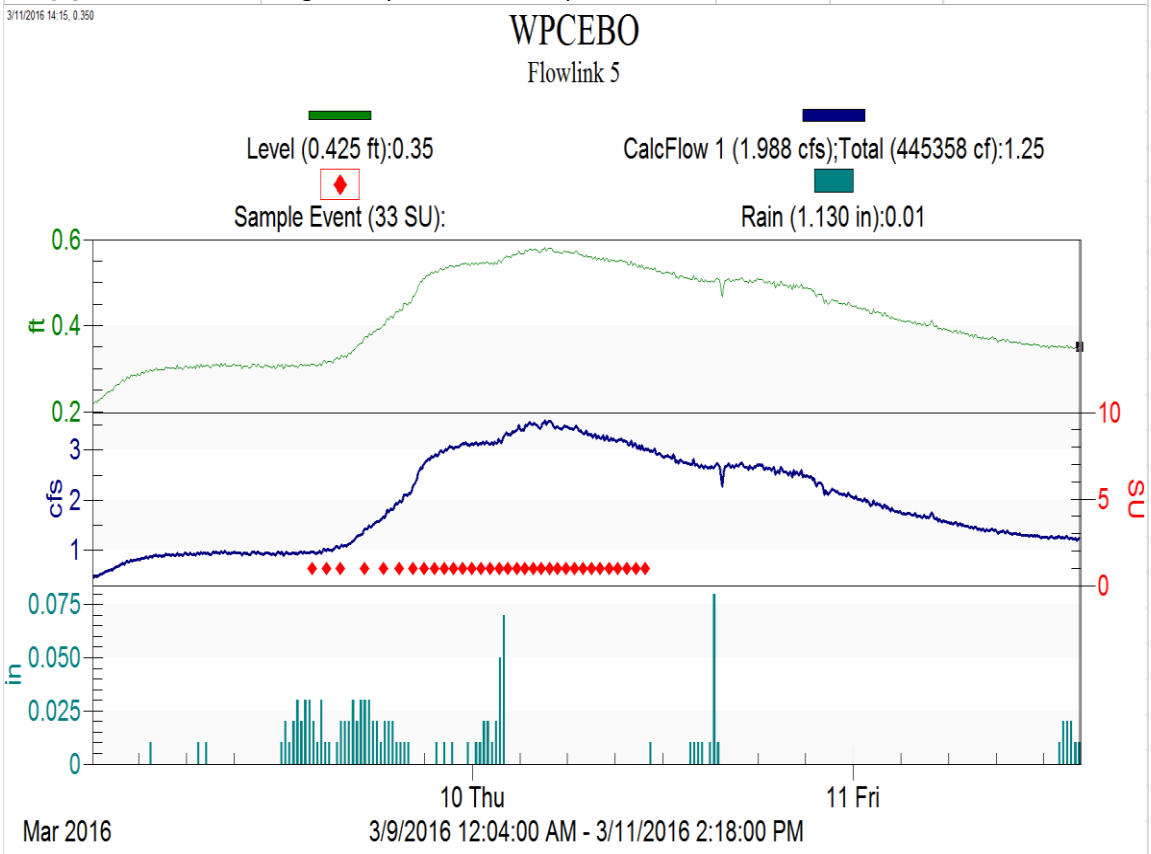
Location:	WCI
Storm Date:	3/9/2016
Flow Measurement:	Area * Velocity
Monitoring Equipment:	Isco 750 Area Velocity Module/6712 Autosampler and YSI 6920 Sonde
Raingage:	King County 24v East Fork Hylebos



Precipitation Information	
Dry antecedent period (hours)	12
Rainfall in previous 24 hours (before first measured rain during storm) (inches)	0.25
Rainfall in previous 6 hours (before first measured rain during storm) (inches)	0.02
Total rainfall that occurred by the time the last sample was collected (inches)	0.86
Total rainfall that occurred during the storm (inches)	0.86
Sampling Information	
Runoff volume during first 24 hours of event (starting at time of first sample) (cubic fe	222909
Runoff volume sampled (cubic feet)	200755
% of runoff volume sampled	90.06
average flow rate during the interval that was sampled (cfs)	3.27
Peak of hydrograph captured (yes/no)	yes
Number of aliquots collected	36
Time from start of sampling to tail (when rate of change in cfs is less than 2%) (hours)	15
Volume of runoff from first sample to tail	195206

Federal Way Regional Detention Facility

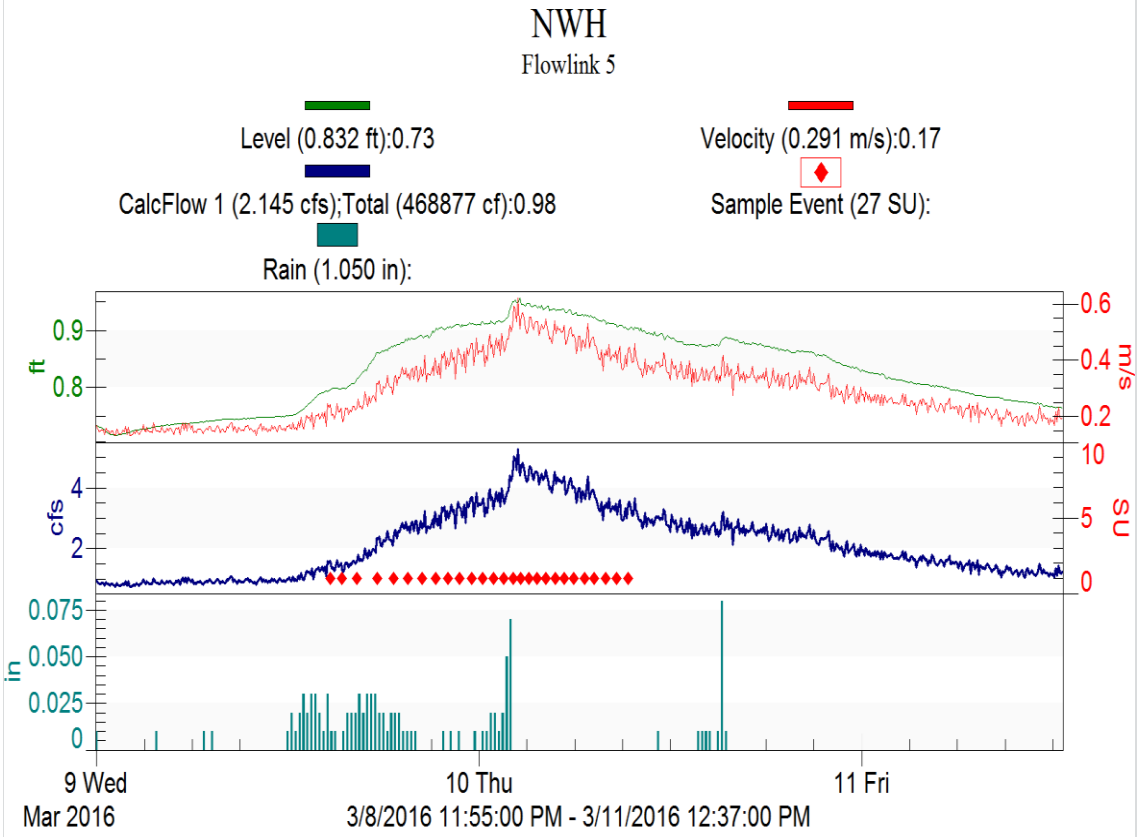
Location:	WCEBO
Storm Date:	3/9/2016
Flow Measurement:	Manning Equation
Monitoring Equipment:	Isco 730 Bubbler Module and 6712 Autosampler
Raingage:	King County 24v East Fork Hylebos



Precipitation Information	
Dry antecedent period (hours)	12
Rainfall in previous 24 hours (before first measured rain during storm) (inches)	0.25
Rainfall in previous 6 hours (before first measured rain during storm) (inches)	0.02
Total rainfall that occurred by the time the last sample was collected (inches)	0.86
Total rainfall that occurred during the storm (inches)	0.86
Sampling Information	
Runoff volume during first 24 hours of event (starting at time of first sample) (cubic fe	238255
Runoff volume sampled (cubic feet)	197620
% of runoff volume sampled	82.94
average flow rate during the interval that was sampled (cfs)	2.737
Peak of hydrograph captured (yes/no)	yes
Number of aliquots collected	32
Time from start of sampling to tail (when rate of change in cfs is less than 2%) (hours)	46
Volume of runoff from first sample to tail	394742

Federal Way Regional Detention Facility

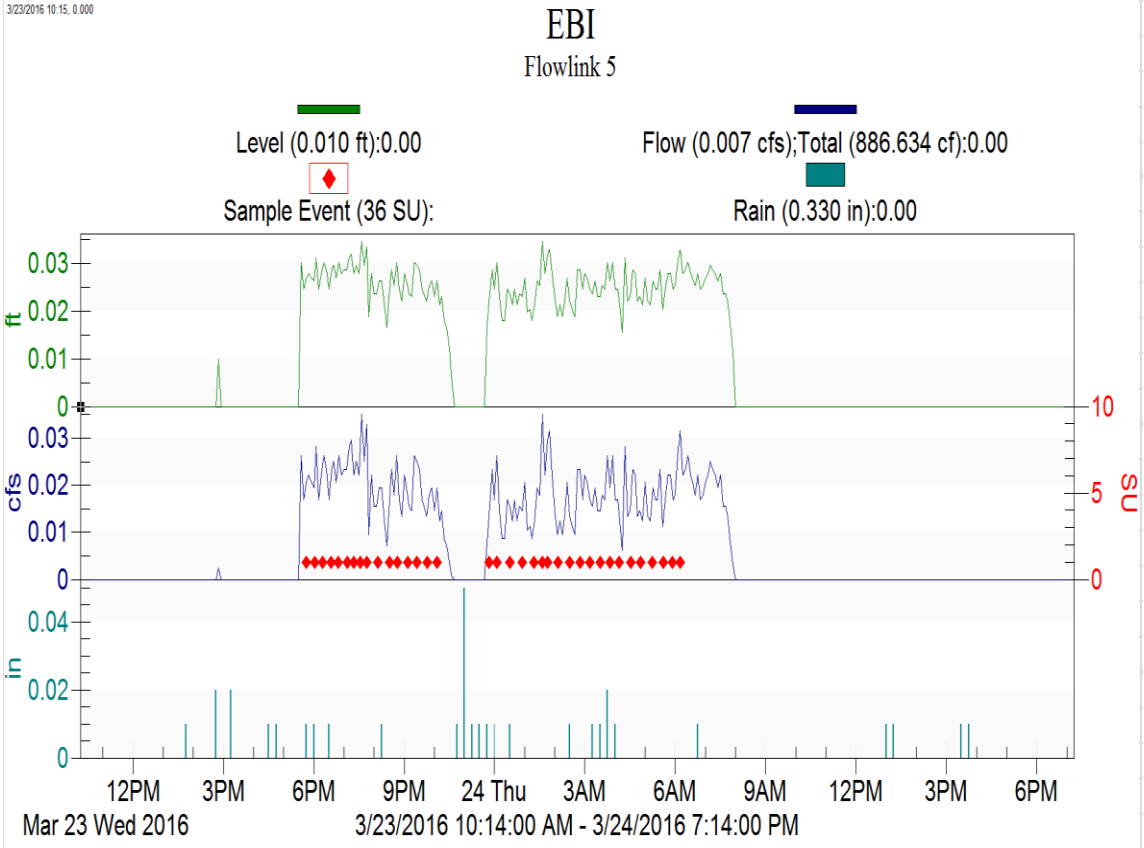
Location:	NWH
Storm Date:	3/9/2016
Flow Measurement:	Area * Velocity
Monitoring Equipment:	Isco 750 Area Velocity Module and 6712 Autosampler
Raingage:	King County 24v East Fork Hylebos



Precipitation Information	
Dry antecedent period (hours)	12
Rainfall in previous 24 hours (before first measured rain during storm) (inches)	0.25
Rainfall in previous 6 hours (before first measured rain during storm) (inches)	0.02
Total rainfall that occurred by the time the last sample was collected (inches)	0.86
Total rainfall that occurred during the storm (inches)	0.86
Sampling Information	
Runoff volume during first 24 hours of event (starting at time of first sample) (cubic fe	272265
Runoff volume sampled (cubic feet)	210972
% of runoff volume sampled	77.49
average flow rate during the interval that was sampled (cfs)	3.261
Peak of hydrograph captured (yes/no)	yes
Number of aliquots collected	26
Time from start of sampling to tail (when rate of change in cfs is less than 2%) (hours)	44
Volume of runoff from first sample to tail	407077

Federal Way Regional Detention Facility

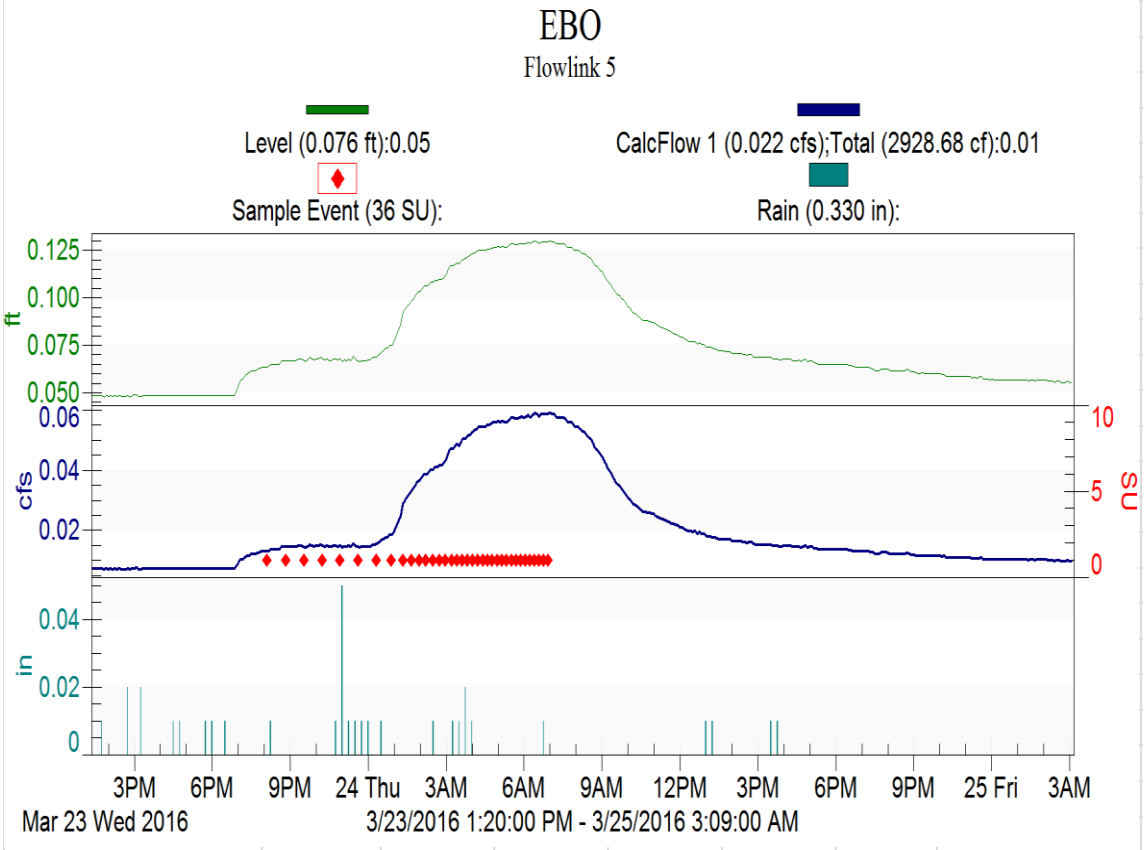
Location:	EBI
Storm Date:	3/23/2016
Flow Measurement:	Manning Equation
Monitoring Equipment:	Isco 730 Bubbler Module/6712 Autosampler
Raingage:	King County 24v East Fork Hylebos



Precipitation Information	
Dry antecedent period (hours)	39
Rainfall in previous 24 hours (before first measured rain during storm) (inches)	0
Rainfall in previous 6 hours (before first measured rain during storm) (inches)	0
Total rainfall that occurred by the time the last sample was collected (inches)	0.28
Total rainfall that occurred during the storm (inches)	0.29
Sampling Information	
Runoff volume during first 24 hours of event (starting at time of first sample) (cubic fe	867
Runoff volume sampled (cubic feet)	737
% of runoff volume sampled	85.01
average flow rate during the interval that was sampled (cfs)	0.017
Peak of hydrograph captured (yes/no)	yes
Number of aliquots collected	36
Time from start of sampling to tail (when rate of change in cfs is less than 2%) (hours)	14.25
Volume of runoff from first sample to tail	867

Federal Way Regional Detention Facility

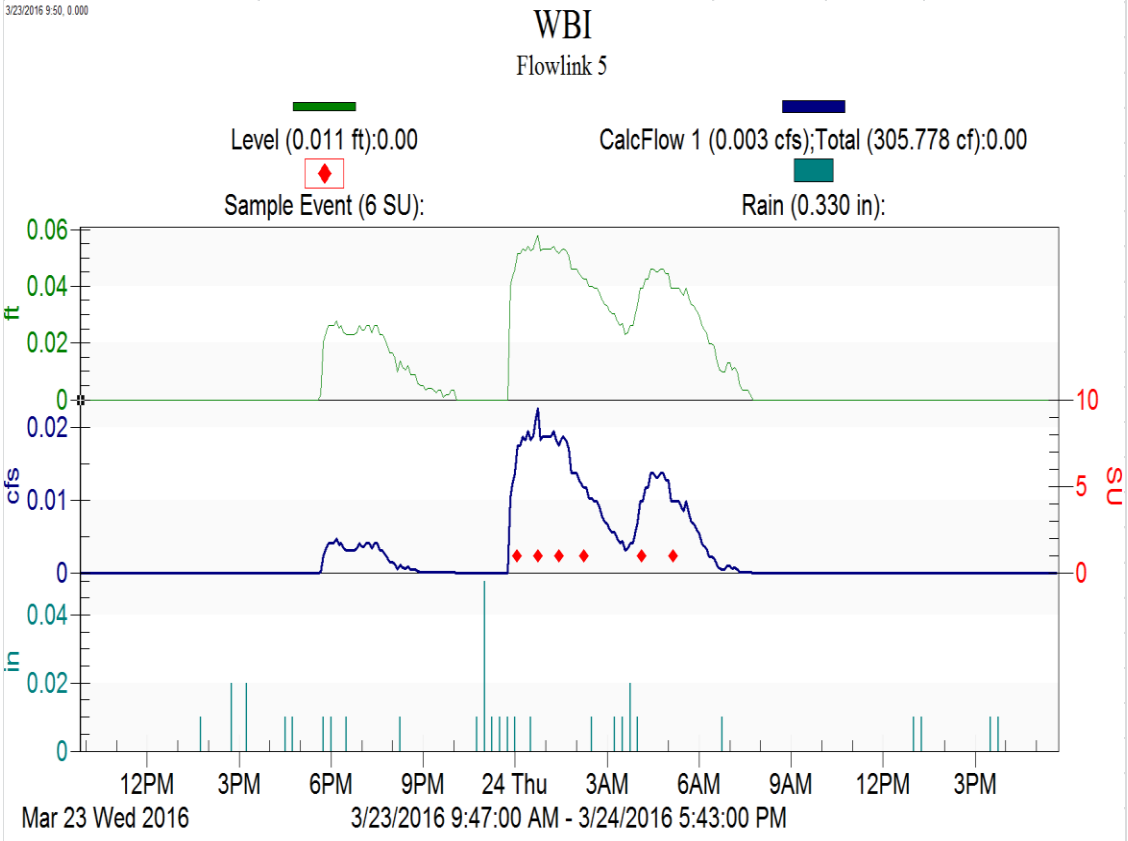
Location:	EBO
Storm Date:	3/23/2016
Flow Measurement:	Manning Equation
Monitoring Equipment:	Isco 750 Area Velocity Module/6712 Autosampler
Raingage:	King County 24v East Fork Hylebos



Precipitation Information	
Dry antecedent period (hours)	39
Rainfall in previous 24 hours (before first measured rain during storm) (inches)	0
Rainfall in previous 6 hours (before first measured rain during storm) (inches)	0
Total rainfall that occurred by the time the last sample was collected (inches)	0.29
Total rainfall that occurred during the storm (inches)	0.29
Sampling Information	
Runoff volume during first 24 hours of event (starting at time of first sample) (cubic fe	2458
Runoff volume sampled (cubic feet)	1280
% of runoff volume sampled	52.07
average flow rate during the interval that was sampled (cfs)	0.033
Peak of hydrograph captured (yes/no)	yes
Number of aliquots collected	36
Time from start of sampling to tail (when rate of change in cfs is less than 2%) (hours)	19
Volume of runoff from first sample to tail	2193

Federal Way Regional Detention Facility

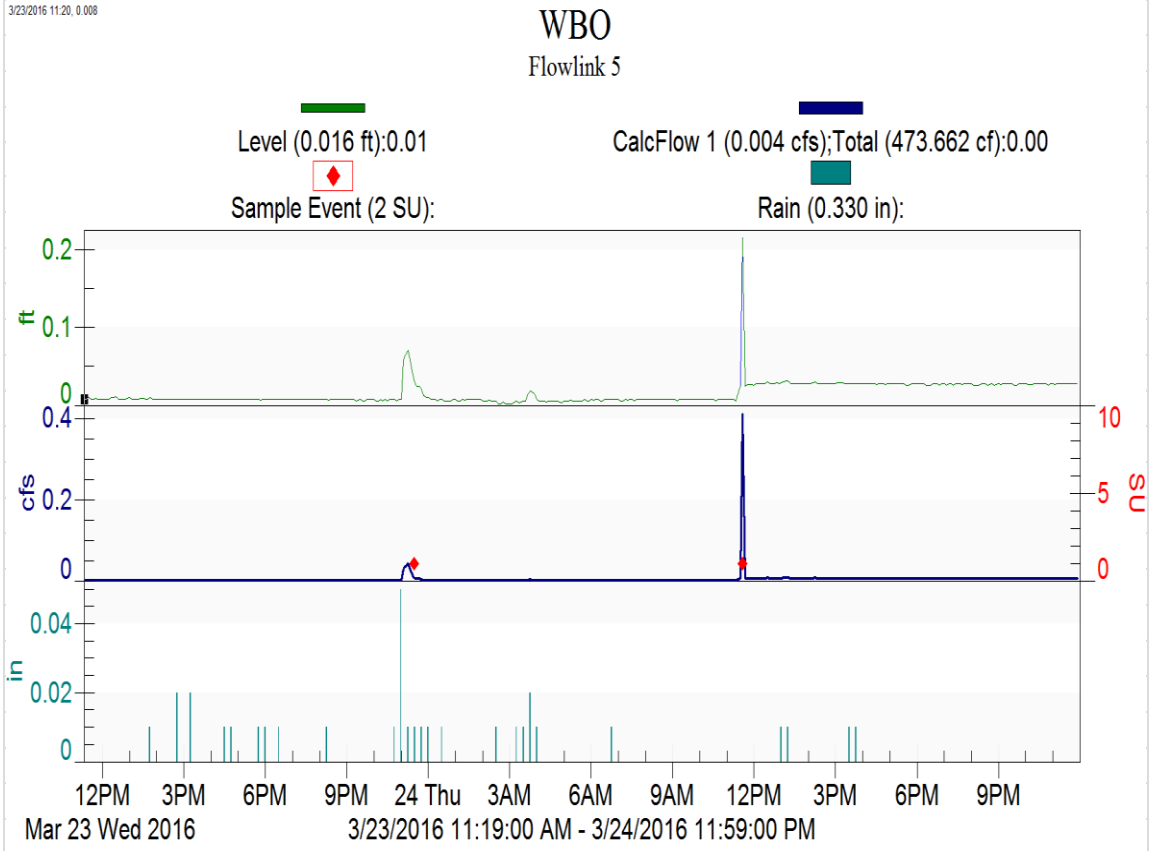
Location:	WBI
Storm Date:	3/23/2016
Flow Measurement:	Manning Equation
Monitoring Equipment:	Isco 730 Bubbler Module/6712 Autosampler
Raingage:	King County 24v East Fork Hylebos



Precipitation Information	
Dry antecedent period (hours)	39
Rainfall in previous 24 hours (before first measured rain during storm) (inches)	0
Rainfall in previous 6 hours (before first measured rain during storm) (inches)	0
Total rainfall that occurred by the time the last sample was collected (inches)	0.28
Total rainfall that occurred during the storm (inches)	0.29
Sampling Information	
Runoff volume during first 24 hours of event (starting at time of first sample) (cubic fe	259
Runoff volume sampled (cubic feet)	225
% of runoff volume sampled	86.87
average flow rate during the interval that was sampled (cfs)	0.013
Peak of hydrograph captured (yes/no)	yes
Number of aliquots collected	6
Time from start of sampling to tail (when rate of change in cfs is less than 2%) (hours)	7.5
Volume of runoff from first sample to tail	259

Federal Way Regional Detention Facility

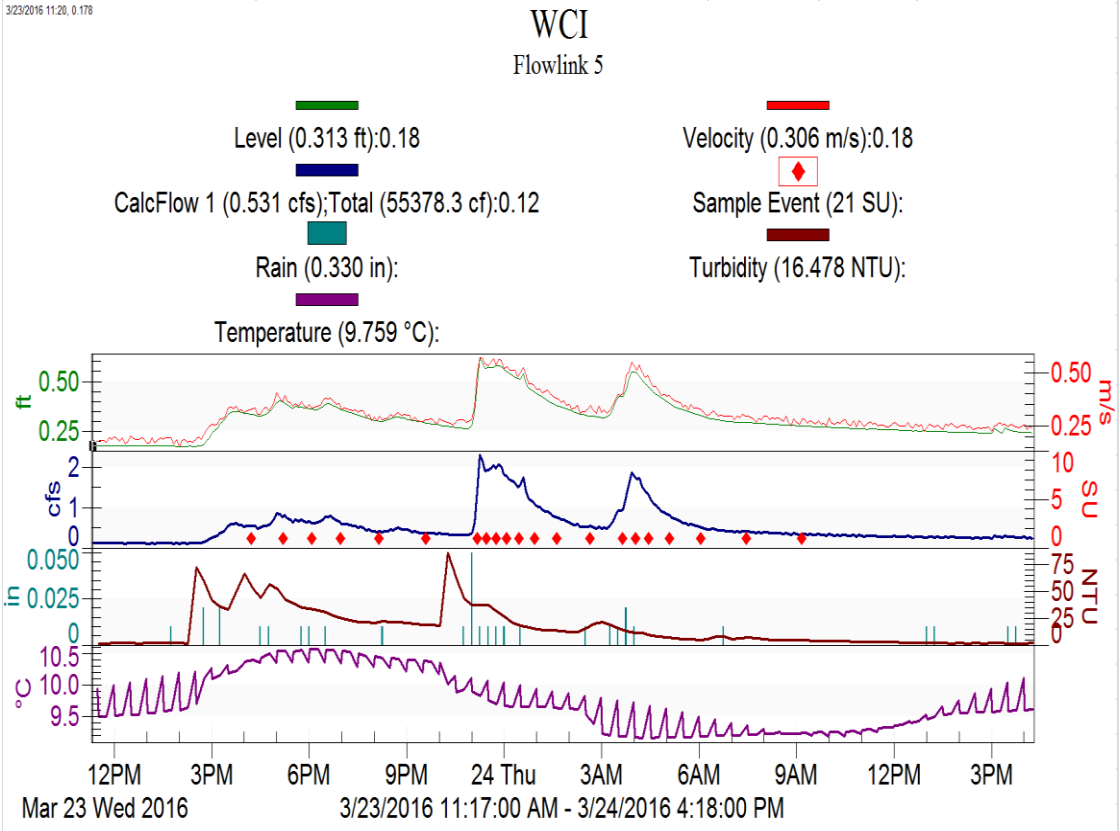
Location:	WBO
Storm Date:	3/23/2016
Flow Measurement:	Manning Equation
Monitoring Equipment:	Isco 730 Bubbler Module/6712 Autosampler
Raingage:	King County 24v East Fork Hylebos



Precipitation Information	
Dry antecedent period (hours)	39
Rainfall in previous 24 hours (before first measured rain during storm) (inches)	0
Rainfall in previous 6 hours (before first measured rain during storm) (inches)	0
Total rainfall that occurred by the time the last sample was collected (inches)	0.29
Total rainfall that occurred during the storm (inches)	0.29
Sampling Information	
Runoff volume during first 24 hours of event (starting at time of first sample) (cubic fe	**
Runoff volume sampled (cubic feet)	0
% of runoff volume sampled	0.00
average flow rate during the interval that was sampled (cfs)	n/a
Peak of hydrograph captured (yes/no)	no
Number of aliquots collected	0
Time from start of sampling to tail (when rate of change in cfs is less than 2%) (hours)	**
Volume of runoff from first sample to tail	**
**Autosampler did not collect any samples. A 4L grab sample was obtained at 11:50 on 3/24.	

Federal Way Regional Detention Facility

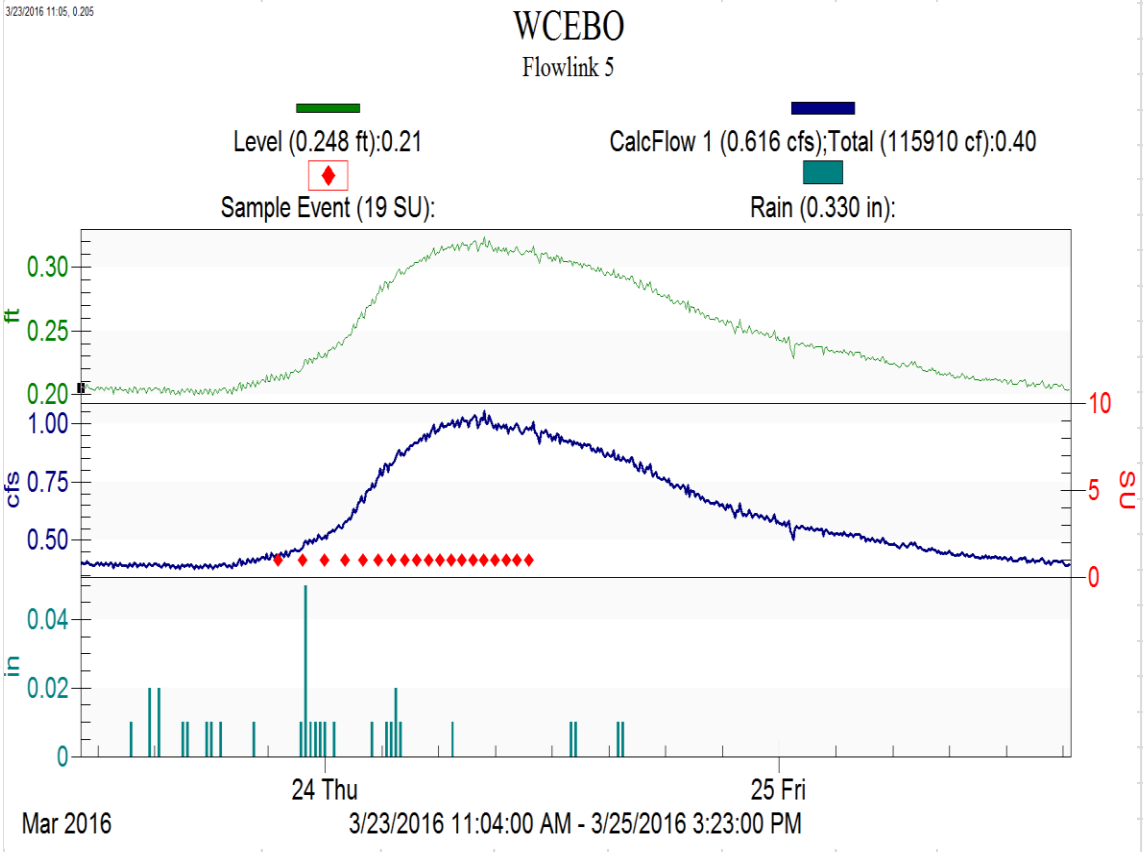
Location:	WCI
Storm Date:	3/23/2016
Flow Measurement:	Area * Velocity
Monitoring Equipment:	Isco 750 Area Velocity Module/6712 Autosampler and YSI 6920 Sonde
Raingage:	King County 24v East Fork Hylebos



Precipitation Information	
Dry antecedent period (hours)	39
Rainfall in previous 24 hours (before first measured rain during storm) (inches)	0
Rainfall in previous 6 hours (before first measured rain during storm) (inches)	0
Total rainfall that occurred by the time the last sample was collected (inches)	0.29
Total rainfall that occurred during the storm (inches)	0.29
Sampling Information	
Runoff volume during first 24 hours of event (starting at time of first sample) (cubic fe	51647
Runoff volume sampled (cubic feet)	44309
% of runoff volume sampled	85.79
average flow rate during the interval that was sampled (cfs)	0.727
Peak of hydrograph captured (yes/no)	yes
Number of aliquots collected	21
Time from start of sampling to tail (when rate of change in cfs is less than 2%) (hours)	14.6
Volume of runoff from first sample to tail	41210

Federal Way Regional Detention Facility

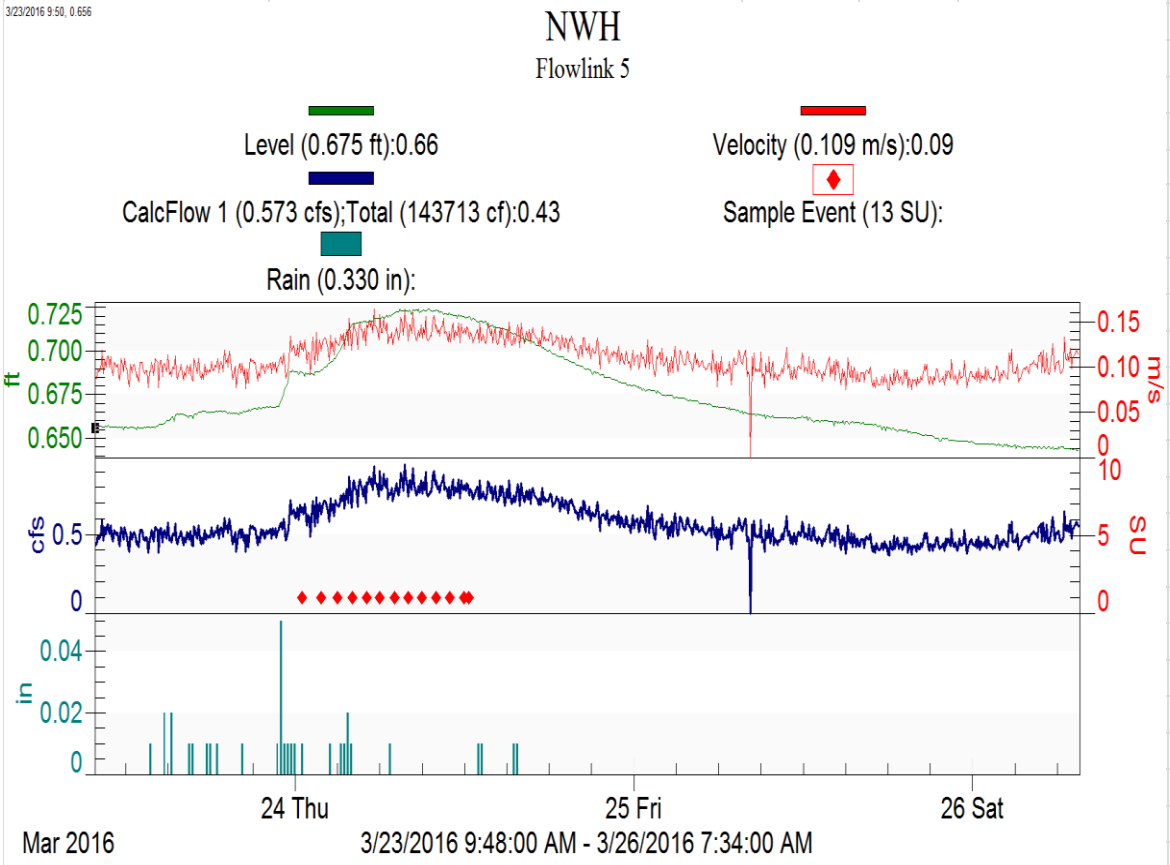
Location:	WCEBO
Storm Date:	3/23/2016
Flow Measurement:	Manning Equation
Monitoring Equipment:	Isco 730 Bubbler Module/6712 Autosampler
Raingage:	King County 24v East Fork Hylebos



Precipitation Information	
Dry antecedent period (hours)	39
Rainfall in previous 24 hours (before first measured rain during storm) (inches)	0
Rainfall in previous 6 hours (before first measured rain during storm) (inches)	0
Total rainfall that occurred by the time the last sample was collected (inches)	0.29
Total rainfall that occurred during the storm (inches)	0.29
Sampling Information	
Runoff volume during first 24 hours of event (starting at time of first sample) (cubic fe	69661
Runoff volume sampled (cubic feet)	38007
% of runoff volume sampled	54.56
average flow rate during the interval that was sampled (cfs)	0.79
Peak of hydrograph captured (yes/no)	yes
Number of aliquots collected	19
Time from start of sampling to tail (when rate of change in cfs is less than 2%) (hours)	26.5
Volume of runoff from first sample to tail	75146

Federal Way Regional Detention Facility

Location:	NWH
Storm Date:	3/23/2016
Flow Measurement:	Area * Velocity
Monitoring Equipment:	Isco 750 Area Velocity Module/6712 Autosampler
Raingage:	King County 24v East Fork Hylebos



Precipitation Information	
Dry antecedent period (hours)	39
Rainfall in previous 24 hours (before first measured rain during storm) (inches)	0
Rainfall in previous 6 hours (before first measured rain during storm) (inches)	0
Total rainfall that occurred by the time the last sample was collected (inches)	0.29
Total rainfall that occurred during the storm (inches)	0.29
Sampling Information	
Runoff volume during first 24 hours of event (starting at time of first sample) (cubic f	62412
Runoff volume sampled (cubic feet)	32398
% of runoff volume sampled	51.91
average flow rate during the interval that was sampled (cfs)	0.765
Peak of hydrograph captured (yes/no)	yes
Number of aliquots collected	13
Time from start of sampling to tail (when rate of change in cfs is less than 2%) (hours)	30*
Volume of runoff from first sample to tail	72359

*rate of change was never more than 2% at this site, this is the time interval from start of sampling to when the tail neared zero percent.

Table 3. **Preliminary** chemistry data for conventionals, nutrients, microbiology (for storm 1 only), metals, and organics and PAHs for two storms. Do not cite.

PRELIMINARY DATA - DO NOT CITE	**method detection limit (MDL)**	**reporting detection limit (RDL)**	**Storm 1**	**Storm 1**	**Storm 1**	**Storm 1**	**Storm 1**	**Storm 1**	**Storm 1**	**Storm 1**
storm date			**3/9/2016**	**3/9/2016**	**3/9/2016**	**3/9/2016**	**3/9/2016**	**3/9/2016**	**3/9/2016**	**3/9/2016**
location			**EBI**	**EBO**	**WBI**	**WBO**	**WCI**	**WCEBO**	**NWH**	**WBI_field rep**
Conventionals										
Total Suspended Solids (mg/L)	0.5	1	5.4	2.47	6.8	4.53	38.4	7.7	19.4	6.5
Turbidity (NTU)	0.2	0.5	7.53	4.59	7.42	7.63	21.4	12.6	16.6	6.51
Conductivity (umhos/cm)	1	5	20.9	37.7	20.75	125	27.5	37.5	89.6	20.8
pH	NA	NA	6.73, H	6.68, H	6.89, H	6.75, H	6.94, H	6.87, H	7.3, H	6.95, H
Dissolved organic carbon (mg/L)	0.5	1	1.05	1.18	1.77	12.6	1.91	1.86	4.6	1.35
Total organic carbon (mg/L)	0.5	1	1.62	2.67	1.88	12.3	5.15	2.58	6.43	1.71
Total alkalinity as CaCO3 (mg/L)	1	5	6.95	13.4	6.84	46.6	9.02	12.4	35.2	6.82
Hardness as CaCO3 (mg/L)	0.331	0.331	6.47	10.3	6.18	33.4	10.7	12.6	34.5	6.23
Nutrients										
Nitrite + Nitrate Nitrogen (mg/L)	0.01	0.04	0.0714	0.123	0.0719	0.747	0.0909	0.0889	0.253	0.0687
Ammonia Nitrogen (mg/L)	0.002	0.01	0.0109	0.0436	0.0125	0.24	0.0668	0.0338	0.0164	0.0109
Total Phosphorus (mg/L)	0.005	0.01	0.0246	0.407	0.0272	3.32	0.0566	0.0439	0.0619	0.0255
Orthophosphate Phosphorus (mg/L	0.0005	0.002	0.00429	0.324	0.00445	2.76	0.00389	0.0134	0.0129	0.00429
Microbiology										
Fecal coliforms (cfu/100mL)	1	1, 1E6 max	830	25	1000	25	520	10	50	not measured
Metals										
Cadmium, Dissolved (ug/L)	0.05	0.25	H	H	H	H	H	H	H	H
Cadmium, Total (ug/L)	0.05	0.25		0.12			0.08		0.052	
Copper, Dissolved (ug/L)	0.4	2	1.8, H	1.6, H	1.9, H	3.26, H	3.02, H	2.71, H	2.96, H	1.8, H
Copper, Total (ug/L)	0.4	2	2.94	1.8	2.9	3.86	10.5	4.73	4.05	2.58
Lead, Dissolved (ug/L)	0.1	0.5	H	0.11, H	H	0.524, H	H	0.13, H	0.2, H	H
Lead, Total (ug/L)	0.1	0.5	0.727	0.3	0.724	0.856	4.3	1.24	2.12	0.695
Zinc, Dissolved (ug/L)	0.5	2.5	18.2, H	3.44, H	17.7, H	6.29, H	24.9, H	30.5, H	15.1, H	17.9, H
Zinc, Total (ug/L)	2.5	2.5	26.8	4.63	25.8	7.17	73	44	34.7	25.2
Organics										
PAHs										
Acenaphthene (ug/L)	0.0047	0.0236								
Acenaphthylene (ug/L)	0.0047	0.0236								
Anthracene (ug/L)	0.0094	0.0472								
Benzo(a)anthracene (ug/L)	0.0094	0.0472					0.015			
Benzo(a)pyrene (ug/L)	0.0094	0.0472					0.015			
Benzo(b,j,k)fluoranthene (ug/L)	0.0094	0.0472					0.0493			
Benzo(g,h,i)perylene (ug/L)	0.0094	0.0472					0.015			
Benzo(k)fluoranthene (ug/L)	0.0094	0.0472								
Chrysene (ug/L)	0.0094	0.0472					0.036			
Dibenzo(a,h)anthracene (ug/L)	0.0094	0.0472								
Fluoranthene (ug/L)	0.0094	0.0472					0.047	0.0096		
Fluorene (ug/L)	0.0094	0.0472								
Indeno(1,2,3-Cd)Pyrene (ug/L)	0.0094	0.0472								
1-Methylnaphthalene (ug/L)	0.0094	0.0472								
2-Methylnaphthalene (ug/L)	0.0047	0.0236		0.0089		0.0089	0.011	0.0078	0.017	
Naphthalene (ug/L)	0.0047	0.0236	0.0072, B	0.0058, B	0.0078, B	B	0.0099, B	0.0057, B	0.0058, B	0.0071, B
Phenanthrene (ug/L)	0.0094	0.0472					0.022			
Pyrene (ug/L)	0.0094	0.0472	0.011		0.011		0.0827	0.016		0.01

NA, not applicable

Blank cells, or cells with no value reported, indicate analyte not detected above MDL

Values reported with "H" indicate the holding time was exceeded for that analyte.

Values reported with "B" indicate blank contamination was observed.

PRELIMINARY DATA - DO NOT CITE	method detection limit (MDL)	reporting detection limit (RDL)	Storm 2	Storm 2	Storm 2	Storm 2	Storm 2	Storm 2	Storm 2
storm date			3/23/2016	3/23/2016	3/23/2016	3/23/2016	3/23/2016	3/23/2016	3/23/2016
location			EBI	EBO	WBI	WBO	WCI	WCEBO	NWH
Conventionals									
Total Suspended Solids (mg/L)	0.5	1	3.4	1.88	-	0.9	24.9	2.8	4.1
Turbidity (NTU)	0.2	0.5	5.97	4.05	-	2.55	21.7	4.55	4.72
Conductivity (umhos/cm)	1	5	28.3	89	-	133	45.4	70.2	157
pH	NA	NA	7.01	6.76	-	7.16	7.12	7.2	7.7
Dissolved organic carbon (mg/L)	0.5	1	1.92	5.11	2.65	12.8	4.05	3.74	4.89
Total organic carbon (mg/L)	0.5	1	2.26	5.91	3.16	13.5	7.4	3.7	5.39
Total alkalinity as CaCO3 (mg/L)	1	5	10.3	37.5	-	55.9	14.4	23	63.8
Hardness as CaCO3 (mg/L)	0.331	0.331	9.68	31.1	10.1	43.2	16.1	21.1	70.1
Nutrients									
Nitrite + Nitrate Nitrogen (mg/L)	0.01	0.04	0.136	0.54	0.146	0.531	0.26	0.04	0.321
Ammonia Nitrogen (mg/L)	0.002	0.01	0.0347	0.22	0.0406	0.436	0.123	0.0134	0.0057
Total Phosphorus (mg/L)	0.005	0.01	0.0332	0.878	-	3.2	0.0572	0.0433	0.0364
Orthophosphate Phosphorus (mg/L)	0.0005	0.002	0.0105	0.775	0.0122	3.13	0.00492	0.0245	0.0146
Metals									
Cadmium, Dissolved (ug/L)	0.05	0.25	H	H	H	H	H	H	H
Cadmium, Total (ug/L)	0.05	0.25					0.05		
Copper, Dissolved (ug/L)	0.4	2	3.16, H	2.63, H	4.8, H	3.43, H	5.36, H	5.24, H	2.8, H
Copper, Total (ug/L)	0.4	2	4.01	3.04	6.55	3.41	11.4	6.36	3.55
Lead, Dissolved (ug/L)	0.1	0.5	H	0.17, H	H	0.791, H	0.21, H	0.17, H	0.13, H
Lead, Total (ug/L)	0.1	0.5	0.49	0.32	0.695	0.859	2.82	0.44	0.557
Zinc, Dissolved (ug/L)	0.5	2.5	23.1, H	2.81, H	24.3, H	5.69, H	33.8, H	33.5, H	12.4, H
Zinc, Total (ug/L)	2.5	2.5	29.2	4.02	32.4	6.08	66.8	39.1	17
Organics									
PAHs									
Acenaphthene (ug/L)	0.0047	0.0236			-				
Acenaphthylene (ug/L)	0.0047	0.0236			-				
Anthracene (ug/L)	0.0094	0.0472			-				
Benzo(a)anthracene (ug/L)	0.0094	0.0472			-				
Benzo(a)pyrene (ug/L)	0.0094	0.0472			-				
Benzo(b,j,k)fluoranthene (ug/L)	0.0094	0.0472			-		0.028		
Benzo(g,h,i)perylene (ug/L)	0.0094	0.0472			-		0.018		
Benzo(k)fluoranthene (ug/L)	0.0094	0.0472			-				
Chrysene (ug/L)	0.0094	0.0472			-				
Dibenzo(a,h)anthracene (ug/L)	0.0094	0.0472			-				
Fluoranthene (ug/L)	0.0094	0.0472			-		0.036		
Fluorene (ug/L)	0.0094	0.0472			-				
Indeno(1,2,3-Cd)Pyrene (ug/L)	0.0094	0.0472			-				
1-Methylnaphthalene (ug/L)	0.0094	0.0472			-				
2-Methylnaphthalene (ug/L)	0.0047	0.0236	0.005	0.007, JG	-	0.0059	0.019	0.014	0.0382
Naphthalene (ug/L)	0.0047	0.0236	0.0054		-		0.011	0.0051	0.0089
Phenanthrene (ug/L)	0.0094	0.0472			-		0.019		
Pyrene (ug/L)	0.0094	0.0472			-		0.0629		

NA, not applicable

Blank cells, or cells with no value reported, indicate analyte not detected above MDL

"–", analyte not analyzed

Values reported with "H" indicate the holding time was exceeded for that analyte.

Values reported with "B" indicate blank contamination was observed.

Values reported with "JG" indicate value is estimated with a probable low bias.

Toxicity Report

July 20, 2016

Kate Macneale
King County Department of Natural Resources & Parks
Water and Land Resources Division/ Scientific and Technical Support
Watershed and Ecological Assessment Team
King Street Center
201 S. Jackson Street, Room 600
Seattle, WA 98104-3855

Dear Kate:

A summary of 48-hour acute (*Daphnia*) and 7-day chronic (*Ceriodaphnia*) tests conducted with storm water samples collected from Federal Way Bioretention sites on March 9, 2016 is listed in the following table. The tests were initiated on March 11, 2016. Detailed findings and method descriptions are in the "RESULTS" and "Methods" sections of the attached report.

			Daphnia	*Ceriodaphnia*	
		Test #/ Date →	7898/ 3-11-16	7897/ 3-11-16	
Sample #↓	Station	Site	Mean % Surv	Mean Surv	Mean Reprod
Control	---	WW (*D.p.*); LWW (*C.d*)	100	100	17.4
L65007-1	FW-EBI	East Bioretention Facility- Inlet	90	100	22.7$^{\phi}$
-2	FW-EBO	East Bioretention Facility- Outlet	100	100	22.6
-3	FW-WBI	West Bioretention Facility- Inlet	100	100	20.2$^{\phi}$
-4	FW-WBO	West Bioretention Facility- Outlet	100	80	28.4 (n = 9)
-5	FW-WPCI	Wet Pond Complex- Inlet	75*$^{\phi}$	100	25.1^{+}
-6	FW-WPCEPO	Wet Pond Complex & East Bioretention- Outlet	95	100	20.2$^{\phi+}$
-7	FW-NFWHC	N. Fork West Hylebos Creek (Receiving Water)	100	100	24.9

*Significantly different from the control $^{\phi}$ from receiving water $^{+}$Outlet and Inlet sample differ significantly
($p < 0.05$; 2-sample 1-tailed t-Test; Wilcoxon Rank-Sum test; Tukey's Pairwise Comparison as appropriate)

If you would like additional information, please contact me at 477-7118 or Francis Sweeney at 477-7117.

Sincerely,

Julie Alaimo
King County Dept. of Natural Resources and Parks
Water and Land Resources Division
Environmental Laboratory Section
322 West Ewing St.
Seattle, WA 98119

BIOLOGICAL MONITORING REPORT FOR THE

Federal Way Bioretention Pond Storm Water Tests
March 2016

Program #421879-240

KING COUNTY DEPARTMENT OF NATURAL RESOURCES AND PARKS
WATER AND LAND RESOURCES DIVISION
ENVIRONMENTAL LABORATORY SECTION
322 WEST EWING STREET
SEATTLE, WASHINGTON 98119

Test #/Date:	**7898 *Daphnia* Acute**	**3/11/2016**
	7897 *Ceriodaphnia* Chronic	**3/11/2016**

Report Date: **July 20, 2016**

METHODS

SAMPLES

Seven storm water samples were collected at Federal Way Bioretention Pond sites on March 10, 2016. Approximately 3 to 4 L of each sample was delivered to the King County Environmental Laboratory (KCEL) in 4-L glass flasks with minimal headspace and tested as received. The samples were stored in the dark at 4 ± 2°C and used to initiate the *Daphnia pulex* acute and the *Ceriodaphnia dubia* chronic toxicity tests, as well as for *C. dubia* test renewals.

Collection information and chemical characteristics of the test samples are listed in the table below.

Site:	East Bioretention Facility (Inlet)	East Bioretention Facility (Outlet)	West Bioretention Facility (Inlet)	West Bioretention Facility (Outlet)	Wet Pond Complex (Inlet)	Wet Pond Complex + East Bioretention (Outlet)	N. Fork Hylebos Creek (Receiving Water)
Station:	FW-EBI	FW-EBO	FW-WBI	FW-WBO	FW-WPCI	FW-WPCEPO	FW-NFWHC
KCEL Sample #:	L65007-1	L65007-2	L65007-3	L65007-4	L65007-5	L65007-6	L65007-7
Collect Date/Time	3-10-16/ 1100h	3-10-16/ 1125h	3-10-16/ 1100h	3-10-16/ 1130h	3-10-16/ 1030h	3-10-16/ 1115h	3-10-16/ 1145h
Rec'd Date/Time	3-10-16/ 1620h	3-10-16/ 1620h	3-10-16/ 1620h	3-10-16/ 1620h	3-10-16/ 1620h	3-10-16/ 1620h	3-10-16/ 1620h
Volume (L)	3.4	3.5	3.5	3.6	3.5	3.5	3.5
Temp (°C)	13.4	14.1	12.5	13.0	13.0	11.9	9.9
pH	7.10	6.80	7.02	6.76	7.07	6.99	7.43
D.O. (mg/L)	9.9	9.5	10.1	8.8	9.9	10.0	10.2
Tot. Alk (mg/L as $CaCO_3$)	7.0	13	6.8	47	9.0	12	35
Tot. Hard (mg/L as $CaCO_3$)	6.5	10	6.2	33	11	13	35
Cond (µmhos/cm)	23	38	21	127	28	38	90
Turbidity (NTU)	7.53	4.59	7.42	7.63	21.4	12.6	16.6
Tot. Susp. Solids (mg/L)	5.4	2.47	7.1	4.53	38.4	7.7	19.4
Ortho-P (mg/L)	0.00429	0.324	0.00445	2.76	0.00389	0.0134	0.0129
$NO_2 + NO_3$ (mg/L)	0.0714	0.123	0.0719	0.747	0.0909	0.889	0.253
Tot N (mg/L)	0.219	0.445	0.226	2.49	0.439	0.306	0.637
Tot P (mg/L)	0.0246	0.407	0.0272	3.32	0.0556	0.0439	0.0619
Tot NH_3 (mg/L)	0.0109	0.0436	0.0125	0.240	0.0668	0.0338	0.0164

CONTROL WATER

The control water for tests with *Daphnia pulex* is fresh water obtained from a 95 ft. deep well located at the KCEL and filtered to 60 µm with Nitex screen before use. *D. pulex* are routinely maintained in static-renewal cultures of well water (WW) at 20 ± 1°C.

Water used for testing and culturing with *Ceriodaphnia* is fresh water obtained monthly from Lake Washington at a site midway between the I-90 and 520 bridges and filtered through 60 µm Nitex screen before use.

Metals by ICP are measured monthly (last analysis: 5-2016); metals by ICP/MS or CVAA and organic compounds are measured annually (last analyses: 02 & 03-2016). Hardness, alkalinity, conductivity and pH are measured at the beginning of each test.

Physical-chemical characteristics of the WW and LWW are listed in the following table:

Parameter	WW 1-18-16	LWW 2-29-16	Units
Temperature	16.9	NA	°C, adjusted as necessary
Conductivity	160	98.2	µmhos/cm
pH	7.90	7.71	
Total Hardness (calc.)	62	39	mg/L as $CaCO_3$
Total Alkalinity	54	37	mg/L as $CaCO_3$
Total Cd	< 2	< 2	µg/L
Total Cr	< 3	< 3	µg/L
Total Cu	< 4	< 4	µg/L
Total Ni	< 5	< 5	µg/L
Total Pb	< 20	< 20	µg/L
Total Zn	< 5	< 5	µg/L
Total Mercury	< 0.05	< 0.05	µg/L
Volatile Organics	*	+	
Organic Analysis (BNA'S):	**	++	
Bis(2-Ethylhexyl)Phthalate	7.1	0.56 < RDL	µg/L
Di-N-Butyl Phthalate	< MDL	< MDL	µg/L
Pesticides & PCB's:	***	+++	

* 45 cmpds not detectable
** 68 cmpds not detectable
*** 28 cmpds not detected

\+ 45 cmpds not detectable
++ 68 cmpds not detectable
+++ 28 cmpds not detected

ACUTE TOXICITY TEST

Water Flea - *Daphnia pulex* – 48-Hour Static Acute Test

The *Daphnia* acute toxicity test followed the methods of US EPA (2002a). Test animals were neonates (< 24-hours old) taken from an overnight brood board; parent animals were adults isolated from in-house mass cultures. Samples were tested as received at one undiluted (100%) concentration along with a WW-only control. Test chambers were 30-mL beakers containing 25 mL of test solution. Individual broods were blocked across treatments such that each replicate contained representatives of five separate broods, with four replicates per treatment. Test chambers were randomized at the start of the test. The test was incubated at 20.0 ± 1.0°C for 48 hours on a 16:8 hour light:dark cycle. Survival and water quality measurements were recorded every 24 hours. Temperature was measured daily by digital thermometer in replicate blanks at six positions of the test tray (4 outer corner + 2 center). In addition,

incubator temperature was measured at 15-minute intervals using an Onset Tidbit data logger. Temperature, pH and dissolved oxygen (D.O.) values can be found on the attached photocopied pages from the laboratory notebook in the "Storm Water Tests" section of this report.

Test #	LIMS Sample #	Start Date/ Time	End Date/ Time	Sample Concentrations (%)	Daphnid Age	# Reps/ Trtmt	# Orgs/ Rep
7898	L65007-1 to -7	3-11-16/ 1255h	3-13-16/ 1300h	0 (WW control), 100%	< 24 hr	4	5

CHRONIC TOXICITY TEST

Water Flea - *Ceriodaphnia dubia* - 7-Day Chronic Static Renewal Test

The *Ceriodaphnia dubia* 7-day static renewal chronic toxicity test was conducted as outlined in US EPA (2002b). Samples were tested as received at one undiluted (100%) concentration. Ten replicates containing one animal each were tested at each treatment, including the control. Test organisms were 3rd or 4th-brood neonates (< 24 hours old) taken from an in-house individual brood board of adults started from mass culture. Individual broods were blocked across treatments, and each replicate represented a different brood. The test was incubated at 25 ± 1.0°C for 7 days on a 16:8 h light:dark cycle. All test solutions were renewed daily. Reproduction, survival, temperature and water quality measurements were recorded every 24 hours. Temperature was measured daily in six test board temperature blanks (4 outer corner + 2 center) and at 15-minute intervals using an Onset "Tidbit" data logger placed in a beaker of water in the incubator. The pH and D.O. values measured during testing can be found on the attached photocopied pages from the laboratory notebook in the "Storm Water Tests" section of this report.

Test #	LIMS Sample #	Start Date/ Time	End Date/ Time	Sample Concentrations (%)	Daphnid Age	# Reps/ Trtmt	# Orgs/ Rep
7897	L65007-1 to -7	3-11-16/ 1120h	3-18-16/ 1130h	0 (LWW control), 100%	< 24 hr	10	1

QUALITY CONTROL

Reference toxicant control results are summarized in the following table.

	Daphnia	*Ceriodaphnia*
Test #:	7905	7904
Control Survival (%)	100	100
Criteria	≥ 90	≥ 80
Acceptable?	**Yes**	**Yes**
Survival LC50 (g/L)	3.17	
Lab Control Limits	2.43 – 4.36	
Acceptable?	**Yes**	

Control Reprod (# neos/adult)		36.8
Criteria		≥ 15
Acceptable?		**Yes**
PMSD for Reproduction (%)*		24.4
Criteria		13 - 47
Acceptable?		**Yes**
Reproduction IC25 (µg/L)		6.71
Lab Control Limits		0 – 6.07
Acceptable?		**No**

*Percent Minimum Significant Difference; determined by Dunnett's Multiple Comparison test (Steels Many-One Rank Test for unequal variance); ($\alpha = 0.05$)

NaCl was used as a reference toxicant in the acute test with *Daphnia*. Temperature, pH and dissolved oxygen measurements remained within acceptable limits throughout the reference toxicant test for *Daphnia* (#7905) (US EPA 2002a). The acute positive control test met acceptability criteria regarding control survival, and the survival LC50 endpoint was within the control limits of the mean ± 2SD (US EPA, 2002a).

Cadmium nitrate was used as a reference toxicant in the chronic toxicity test with *Ceriodaphnia*. Temperature, pH and dissolved oxygen measurements remained within acceptable limits throughout the reference toxicant test for *Ceriodaphnia* (#7904) (US EPA 2002b). In addition, the chronic test met acceptability criteria regarding control survival and mean control reproduction (US EPA 2002b). The reproduction IC25 for #7904 slightly exceeded the upper control limit. Because it met all other QC criteria, the test was retained. Reference toxicant tests with *Ceriodaphnia* were re-started in 2015 following a three-year hiatus. It is possible that a change in diet or culture health may have affected the response to the toxicant.

The precision tables located at the end of this report are constructed to monitor the sensitivity of the organisms to the reference toxicant and thereby provide an indication of their overall sensitivity to other compounds.

WATER QUALITY MONITORING

Methods and method numbers for water quality tests are listed in the following table:

Parameter	Method
Water Quality Tests	APHA (1992); US EPA (1991).
Temperature	Standard Mercury Thermometer (calibrated with a certified thermometer traceable to NBS records) and Onset, Tidbit (v2) UTBI-001 Temperature Logger (KCEL #436v1).
Dissolved Oxygen	YSI membrane electrode method (Method #4500-0 G; KCEL #434).
pH	Beckman 690 meter with automatic temperature compensation and Ross combination electrode (Method #4500-H; APHA 1992; KCEL #433).
Total Alkalinity	Potentiometric Method (Method #2320 B; KCEL #319v4).
Total Hardness	By calculation (Method #2340 B; KCEL #612v4).
Conductivity	Orion Model #122 Meter with 012210 conductivity cell (Method 2510B; KCEL #435).
Total Ammonia	Phenate Method (Standard Methods SM 4500 - NH_3-G; KCEL #330v4).
Unionized Ammonia	Calculated from total ammonia, pH and ionization constants (APHA Method #417 G).
Pesticides and PCB's	Continuous liquid extraction method (EPA Method #608; KCEL #733).
Organic Analysis	Continuous liquid extraction method for BNA's (EPA Method #625; KCEL #731).
Volatile Organics	Purge and trap method (EPA Method #624; KCEL #732).

Total Metals	ICP for Cd, Cr, Cu, Ni, Pb and Zn (EPA Method #200.7; KCEL #612v4); for Hg analysis (KCEL #604v5, 601v4, 605v0).

RESULTS

ACUTE TOXICITY TESTS

Water Flea - *Daphnia pulex* – 48-Hour Static Acute Test

Survival results for the 48-hour *Daphnia* acute test #7898 with storm water samples are listed in the table below.

Sample #	Station/ Site	% Sample	Percent Survival at 48 Hours					# *Daphnia* Tested
			% Survival in each rep. (n=5 *Daphnia*/rep)					
			Rep 1	Rep 2	Rep 3	Rep 4	Mean	
----	Well Water Control	0	100	100	100	100	**100**	20
L65007-1	FW-EBI East Bioretention Facility (Inlet)	100	80	100	100	80	**90**	20
L65007-2	FW-EBO East Bioretention Facility (Outlet)	100	100	100	100	100	**100**	20
L65007-3	FW-WBI West Bioretention Facility (Inlet)	100	100	100	100	100	**100**	20
L65007-4	FW-WBO West Bioretention Facility (Outlet)	100	100	100	100	100	**100**	20
L65007-5	FW-WPCI Wet Pond Complex (Inlet)	100	80	60	60	100	**75*ϕ**	20
L65007-6	FW-WPCEPO Wet Pond Complex + East Bioretention Facility (Outlet)	100	80	100	100	100	**95**	20
L65007-7	FW-NFWHC Hylebos Creek (Receiving Water)	100	100	100	100	100	**100**	20

*Significantly different from WW control ($p < 0.05$; homoscedastic 2-sample 1-tailed t-Test)

ϕSignificantly different from receiving water ($p < 0.05$; homoscedastic 2-sample 1-tailed t-Test)

Survival was 100 % in the well water-only control, the East Bioretention Outlet, the West Bioretention Outlet and the Hylebos Creek receiving water samples. Survival was 90% in the East Bioretention Inlet,

95% in the Wet Pond Complex Outlet and 75% in the Wet Pond Complex Inlet samples. Survival in the East Bioretention Inlet and Wet Pond Complex/East Facility Outlet samples was not significantly reduced from the control ($p > 0.05$; 1-tailed homoscedastic t-Test or Wilcoxon Rank Sum test, respectively). In the Wet Pond Complex Inlet sample, survival was significantly reduced from both the control and the receiving water ($p < 0.05$; 1-tailed homoscedastic t-Test).

Survival between Inlet and Outlet samples did not differ significantly in East Bioretention and Wet Pond Complex samples (1-tailed homoscedastic t-Test and Tukey's Pairwise Comparison, respectively). Survival was the same for the West Bioretention Inlet and Outlet samples.

The maximum un-ionized ammonia levels in the 100% storm samples during the 48-hour test are listed in the table below.

Site:	East Bioretention Facility (Inlet)	E. Bioretention Facility (Outlet)	West Bioretention Facility (Inlet)	West Bioretention Facility (Outlet)	Wet Pond Complex (Inlet)	Wet Pond Complex + East Bioretention (Outlet)	N. Fork Hylebos Creek (Receiving Water)
Station:	FW-EBI	FW-EBO	FW-WBI	FW-WBO	FW-WPCI	FW-WPCEPO	FW-NFWHC
KCEL Sample #:	L65007-1	L65007-2	L65007-3	L65007-4	L65007-5	L65007-6	L65007-7
NH_3-N (mg/L)	< 0.001	0.001	< 0.001	0.008	0.001	0.001	< 0.001

Water Flea - *Ceriodaphnia dubia* - 7-Day Chronic Static Renewal Test

Reproduction and survival results over the 7-day chronic *Ceriodaphnia* test #7897 with 100% bioretention pond storm water samples are shown in the table below.

Sample #	Station	% Sample	Reproduction (Mean #Neonates/Adult in 7 Days)										Mean Reprod	Mean % Surv
			1	2	3	4	5	6	7	8	9	10		
---	LWW Control	0	19	16	20	17	20	18	18	9	19	18	**17.4**	100
L65007-1	FW-EBI	100	23	25	22	22	23	21	22	24	23	22	**22.7**$^{\phi}$	100
L65007-2	FW-EBO	100	24	25	23	23	23	25	23	26	12	22	**22.6**	100
L65007-3	FW-WBI	100	25	17	16	10	22	23	21	22	21	25	**20.2**$^{\phi}$	100
L65007-4	FW-WBO	100	34	30	30	30	23	0 Ω	30	21	29	29	**28.4** (n = 9)	80
L65007-5	FW-WPCI	100	28	25	33	21	25	22	24	22	26	25	**25.1**$^{+}$	100
L65007-6	FW-WPCEPO	100	15	22	30	25	24	11	9	21	26	19	**20.2**$^{\phi+}$	100
L65007-7	FW-NFWHC	100	2	2	2	2	2	2	2	2	2	2	**24.9**	100

ϕSignificantly different from receiving water ($p < 0.05$; equal (for -1, -3) or unequal (for -6) variance 1-tailed t-Test)
+Outlet differs significantly from Inlet sample ($p < 0.05$; homoscedastic 1-tailed t-Test) ΩOutlier omitted from reproduction analysis

As shown in the table above, survival was 100% in the LWW-only control and all samples except for the West Bioretention Outlet, where survival was 80%. Survival in the West Bioretention sample was not significantly less than in the control ($p > 0.05$; Fisher Exact Test).

Reproduction was not decreased relative to the LWW-only control in any sample. For samples L65007-1, -3 and -6, reproduction was significantly reduced from the Hylebos Creek receiving water ($p < 0.05$; equal (for -1, -3) or unequal (for -6) variance 1-tailed t-Test). Reproduction in both East Bioretention Inlet and Outlet samples was not significantly reduced from the Hylebos Creek receiving water ($p > 0.05$; homoscedastic t-tailed t-Tests). Reproduction in the Wet Pond Complex Outlet sample was significantly reduced from the corresponding Inlet sample ($p < 0.05$; homoscedastic 1-tailed t-Test). Reproduction did not differ significantly between corresponding Inlet and Outlet samples for East Bioretention and West Bioretention samples ($p > 0.05$; 1-tailed t-Tests).

The maximum un-ionized ammonia levels reached in the 100% storm samples during the 7-day chronic test are listed in the table below.

Site:	East Bioretention Facility (Inlet)	E. Bioretention Facility (Outlet)	West Bioretention Facility (Inlet)	West Bioretention Facility (Outlet)	Wet Pond Complex (Inlet)	Wet Pond Complex + East Bioretention (Outlet)	N. Fork Hylebos Creek (Receiving Water)
Station:	FW-EBI	FW-EBO	FW-WBI	FW-WBO	FW-WPCI	FW-WPCEPO	FW-NFWHC
KCEL Sample #:	L65007-1	L65007-2	L65007-3	L65007-4	L65007-5	L65007-6	L65007-7
NH_3-N (mg/L)	< 0.001	0.001	< 0.001	0.013	0.002	0.001	0.001

QUALITY CONTROL

Storm water sample and control performance results are summarized in the following table:

Test Organism:	*Ceriodaphnia*	*Daphnia*
Test #:	7897	7898
Control Survival (%)	100	100
Criteria	≥ 80	≥ 90
Acceptable?	**Yes**	**Yes**
Control Reproduction (# neos/adult)	17.4	
Criteria	≥ 15	
Acceptable?	**Yes**	
PMSD for	17.3 (IN)	

Reproduction (%)*		
Criteria	13-47	
Acceptable?	**Yes**	

*Percent Minimum Significant Difference; determined by Dunnett's Multiple Comparison test ($\alpha = 0.05$)

As shown in the table above, both the acute and chronic effluent tests met acceptability criteria regarding control
performance and test variability, including survival, reproduction and PMSD (US EPA, 2002a & 2002b).

Dissolved oxygen, pH, temperature and/or salinity remained within acceptable limits throughout both the acute and chronic tests (US EPA, 2002a & 2002b). Water quality data recorded during testing is shown on the photocopied pages from the laboratory notebook in the "Effluent Tests" section of this report.

Tested By:

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REFERENCES

APHA. 1992. Standard Methods for the Examination of Water and Wastewater, 18th Edition. American Public Health Association, American Waterworks Association, Water Pollution Control Association, Washington D.C.

US EPA. 2002a. Methods for measuring the acute toxicity of effluents and receiving waters to freshwater and marine organisms. 5th edition. EPA-821-02-012, October, 2002. US Environmental Protection Agency, Office of Water (4303T), Washington, DC.

US EPA. 2002b. Short-Term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to
Freshwater Organisms. 4th Edition (EPA-821-R-02-013).

US EPA. 1991. Code of Federal Regulations, 40CFR, Appendix A, July 1991. U.S. Environmental Protection Agency, Office of Federal Registry, Washington, D.C.

Storm Water Tests:

Bench Sheets, Calculations, and Statistics

UNIONIZED AMMONIA IN 100% STORM SAMPLES

Acute Test #7898- *Daphnia pulex*

Sample #/ Station	pH (Max)	Sample Age	T* (ºC)	T (ºK)	pKa	Tot Amm (mg/L)	pKa – pH	$1 + 10^{(pKa-pH)}$	NH_3N (mg/L) ** Calc	Reported
L65007-1 FW-EBI	7.464	48h	19.7	292.9	9.4097	0.0109	1.9457	89.247	0.0001	< **0.001**
L65007-2 FW-EBO	7.595	48h	19.7	292.9	9.4097	0.0436	1.8147	66.268	0.001	**0.001**
L65007-3 FW-WBI	7.438	48h	19.7	292.9	9.4097	0.0125	1.9717	94.691	0.0001	< **0.001**
L65007-4 FW-WBO	7.965	48h	19.7	292.9	9.4097	0.240	1.4447	28.842	0.008	**0.008**
L65007-5 FW-WPCI	7.543	48h	19.7	292.9	9.4097	0.0668	1.8667	74.570	0.0009	**0.001**
L65007-6 FW-WPCEPO	7.631	48h	19.7	292.9	9.4097	0.0338	1.7787	61.076	0.0006	**0.001**
L65007-7 FW-NFWHC	7.891	48h	19.7	292.9	9.4097	0.0164	1.5187	34.014	0.0005	< **0.001**

Chronic Test #7897 – *Ceriodaphnia dubia*

Sample #/ Station	pH (Max)	Sample Age	T* (ºC)	T (ºK)	pKa	Tot Amm (mg/L)	pKa – pH	$1 + 10^{(pKa-pH)}$	NH_3N (mg/L) ** Calc	Reported
L65007-1 FW-EBI	7.512	4d	25.1	298.3	9.241	0.0109	1.729	54.580	.0002	< **0.001**
L65007-2 FW-EBO	7.694	1d	23.6	296.8	9.287	0.0436	1.593	40.174	0.001	**0.001**
L65007-3 FW-WBI	7.555	1d	23.6	296.8	9.287	0.0125	1.732	54.951	0.0002	< **0.001**
L65007-4 FW-WBO	8.030	1d	23.6	296.8	9.287	0.240	1.257	19.072	0.013	**0.013**
L65007-5 FW-WPCI	7.625	3d	25.2	298.4	9.238	0.0668	1.613	42.020	0.002	**0.002**
L65007-6 FW-WPCEPO	7.671	3d	25.2	298.4	9.238	0.0338	1.567	37.898	0.0009	**0.001**
L65007-7 FW-NFWHC	7.981	2d	23.9	297.1	9.278	0.0164	1.297	20.815	0.0008	**0.001**

***** Highest temperature measured in the temperature cups placed in the test tray

** Unionized ammonia calculation in non-saline samples (APHA Method #417 G):

$$NH_3\text{-}N = \frac{\text{Total Ammonia}}{1 + 10^{(pKa - pH)}}$$

where $pKa = 0.09018 + (2729.69/T)$

and $T\ (^oK) = \text{Temp.}\ (^oC) + 273.2$

King County

Reference Toxicant Tests:

Bench Sheets
and
Precision Tables

Supporting Water Quality Chemistry

Photos of select field activities

Black PVC pipe protects tubing running to new EBO location. 19Jan2016.

East bioretention facility with some standing water on February 16th, 2016.

West bioretention facility with no standing water in west end on February 16th, 2016. There was standing water in east end.

Water samples from EBI and EBO, retrieved March 24, 2016.

Measuring depth of water in WBO on March 24, 2016, in effort to verify depth and flow estimates.

Taking a grab sample at WBO on March 24, 2016.