DEPARTMENT OF ECOLOGY
State of Washington

Puyallup River Tributaries Effectiveness Monitoring Quarterly Report

July – September 2019

November 2019

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Data for this project are available in Ecology's EIM Database.
Study ID: EFF_PRT

All data presented in this report are provisional and subject to change.

Cover photo: Boise Creek site Boise_I5 (near 284th Ave SE), taken by Allison Brownlee on 6/25/19.

Project Overview

In 2011, the Department of Ecology wrote a Total Maximum Daily Load (TMDL) for fecal coliform bacteria in the Puyallup River Watershed (Mathieu and James, 2011, Ecology report 11-10-040). The TMDL identified Boise Creek as a high priority for cleanup. A subsequent study of nearby Pussyfoot and Second Creeks (Dickes, 2015, Ecology report 15-10-048) also suggested focused cleanup efforts due to fecal coliform exceedances. Ecology's nonpoint staff and partners are currently working together to address bacteria pollution sources in these three watersheds. It is the goal of the implementation work plan that efforts to reduce sources of bacteria will simultaneously improve water quality overall including other parameters of concern (temperature, dissolved oxygen, pH). This effectiveness monitoring study has the following objectives:

- Track general water quality trends in each of the tributaries.
- Provide the information feedback needed for adaptive management purposes.
- Trace sources of pollution and identify likely causes.

To meet these objectives, this long-term (10 year) study was initiated in July 2019 and includes monthly sampling with more extensive sampling efforts in years 1, 5, and 10. Details on site locations, sample frequency, methods, etc. are described in the project's Quality Assurance Project Plan (Brownlee, 2019, Ecology report 19-10-040).

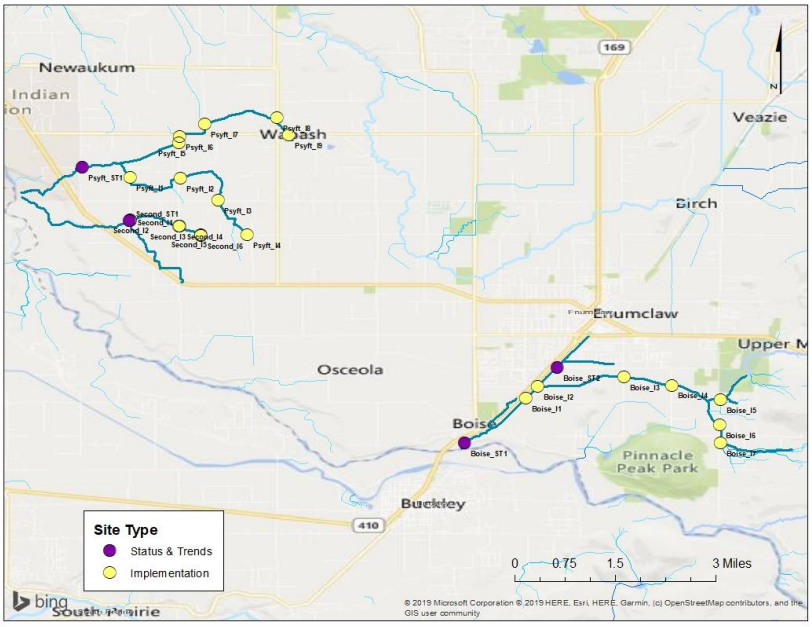

Figure 1. Map of 26 core sites along Boise Creek, Pussyfoot Creek, and Second Creek. Status and trends sites are monitored for bacteria, nutrients and in-situ field parameters, while implementation sites are monitored for bacteria and in-situ field parameters only.

Narrative Summary

- For all sample events between July and September 2019, sites on Pussyfoot Creek and Second Creek were either dry or stagnant and no data were collected. All sites on Boise Creek were sampled twice a month on the following days:
    - July 8, 22
    - August 5, 26
    - September 9, 23

Precipitation and Discharge

- From July 01-September 30, total precipitation recorded at King County's Enumclaw Rain Gauge (44u) was 9.72 inches (data is provisional, https://green2.kingcounty.gov/hydrology/DataDownload.aspx).
    - Jul = 1.79 inches
    - Aug = 2.74 inches
    - Sep = 5.19 inches
- From July 01-September 30, mean discharge at USGS station 12099600 (Boise Creek River Mile 0.1) was 9.88 cfs (data is provisional, https://waterdata.usgs.gov/wa/nwis/uv/?site_no=12099600&PARAmeter_cd=00060,00065).
    - Jul = 9.77 cfs
    - Aug = 7.66 cfs
    - Sep = 12.28 cfs

Bacteria

- All sites on Boise Creek except Boise_I6 exceeded the WA Administration Code Chapter 173-201A geometric mean water quality standard for fecal coliform bacteria and *E. coli* (100 cfu per 100 mL).
    - Boise_I6 did not pass the secondary criterion for either fecal coliform or *E. coli* (200 and 320 cfu per 100 mL, respectively) due to the single sample (as less than 10 sample points exist) collected on September 9.
- The two sites with the highest discrete fecal coliform results were Boise_I7 and Boise_ST2 (2300 and 2200 cfu/100mL, respectively). Boise_I7 also had the highest *E. coli* result at 2300 cfu/100mL.

Nutrients

- All forms of nitrogen sampled (ammonia, nitrate-nitrite, and total persulfate nitrogen) were each below 0.6 mg/L.
- The maximum ortho-phosphate result was 0.09 mg/L and the maximum total phosphorus result was 0.12 mg/L, both from Boise_ST2.

Field Parameters

- The following sites did not meet state water quality standards for in-situ collected data during all sample events (n = 6):
    - Boise_ST2: Temperature* and dissolved oxygen
    - Boise_I6: Dissolved oxygen and September temperature*
    - Boise_I7: Dissolved oxygen and September temperature*

*Discrete temperature results are not directly comparable to the 7-DADMax water quality criteria, however more than one result above the standard suggests a possible exceedance (Table 5, Water Quality Program, 2018)

Investigative Sampling

- Samples were collected at three sites upstream of Boise_I7 on 8/27, 9/09, and 9/23. Results suggest that future efforts should focus on properties upstream of Boise_B2. Although concentrations were similar between Boise_B2 and Boise_I7, higher flow rates were observed at Boise_I7 during all three sample events, thus it is likely there are additional sources between the two locations.

Boise Creek: Bacteria

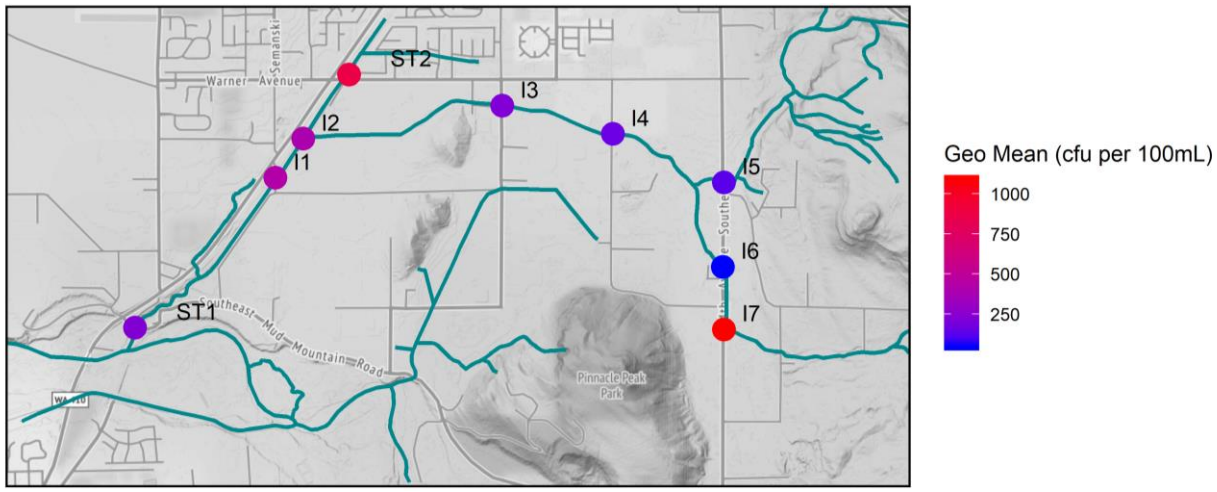

Figure 2. Map of fecal coliform geometric means at sites along Boise Creek (n = 6).

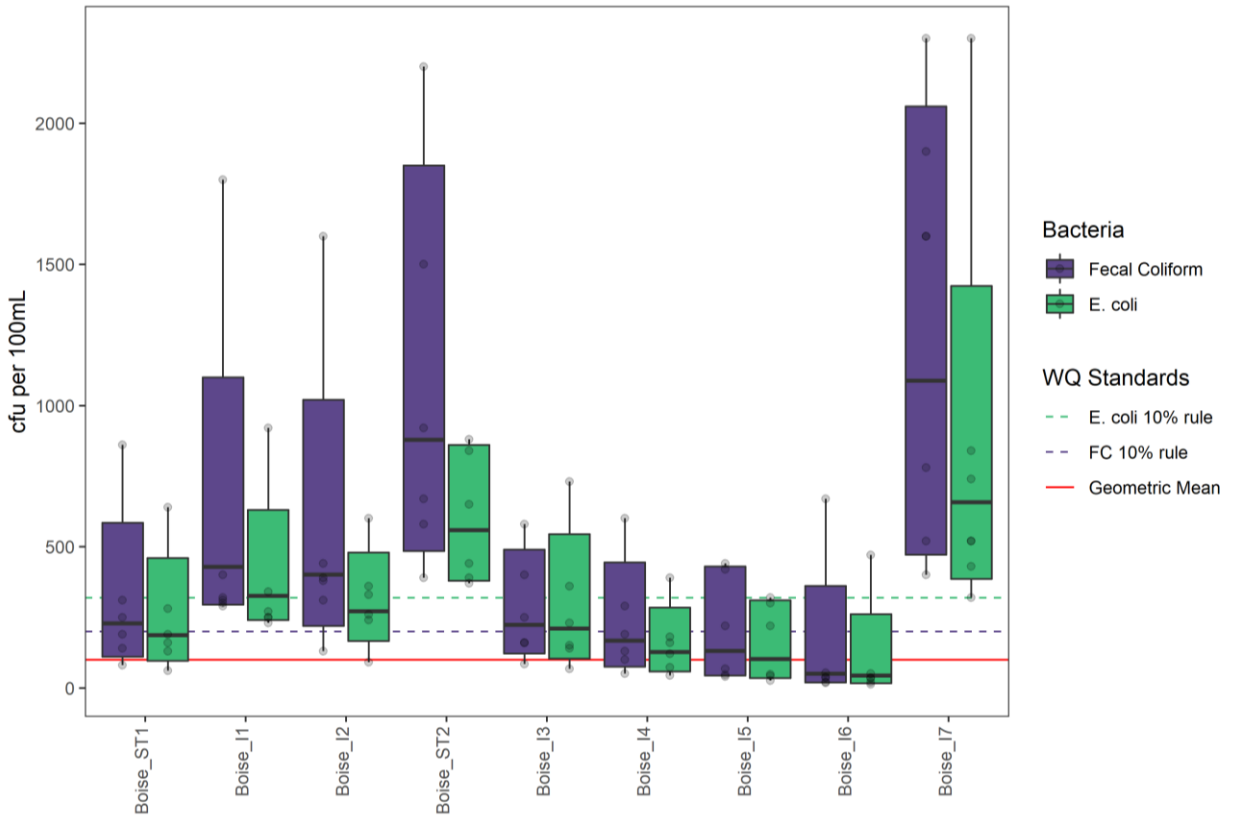

Figure 3. Boxplot of bacteria results at Boise Creek sites with the sold black bars as the geometric mean, the boxes representing the 10th and 90th percentiles, and the whiskers being the maximum and minimum values. All individual data points are grey points in the background. Data are compared to Washington State water quality standards: the geometric mean for both fecal coliforms and *E. coli* must not exceed 100 cfu/100mL (solid red line), with not more than 10 percent of all samples (or any single sample when less than ten sample points exist) exceeding 200 cfu/100mL for fecal coliforms (dashed purple line) and 320 cfu/100mL for *E. coli* (dashed green line).

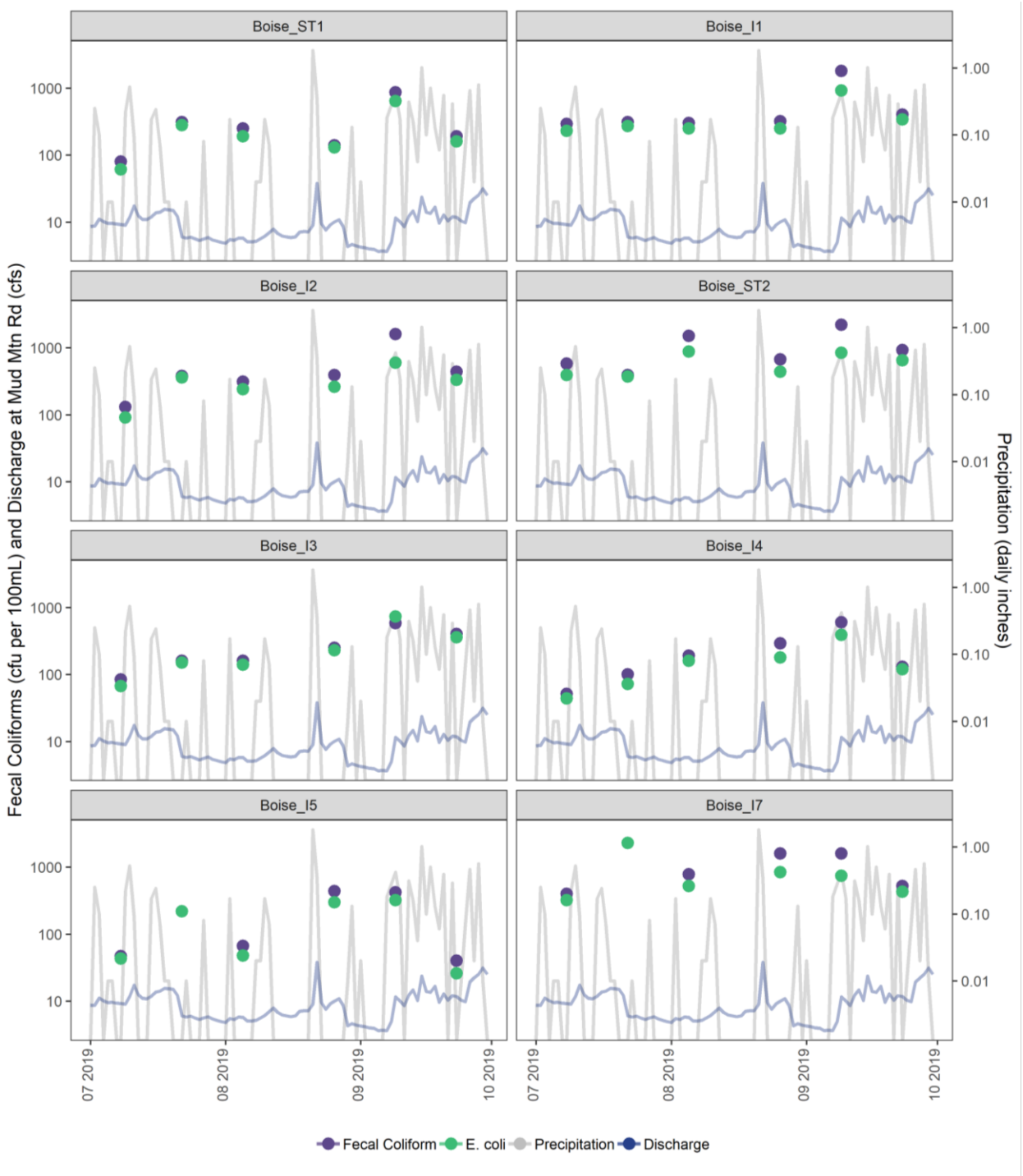

Figure 4. Time series plots for the sites that exceeded the Washington state geometric mean water quality standard (see Figure 3). Also plotted are daily precipitation (provisional, King County station 44u) and daily stream flow at Mud Mountain Rd (provisional, USGS station 12099600 at river mile 0.1).

Boise Creek: Nutrients

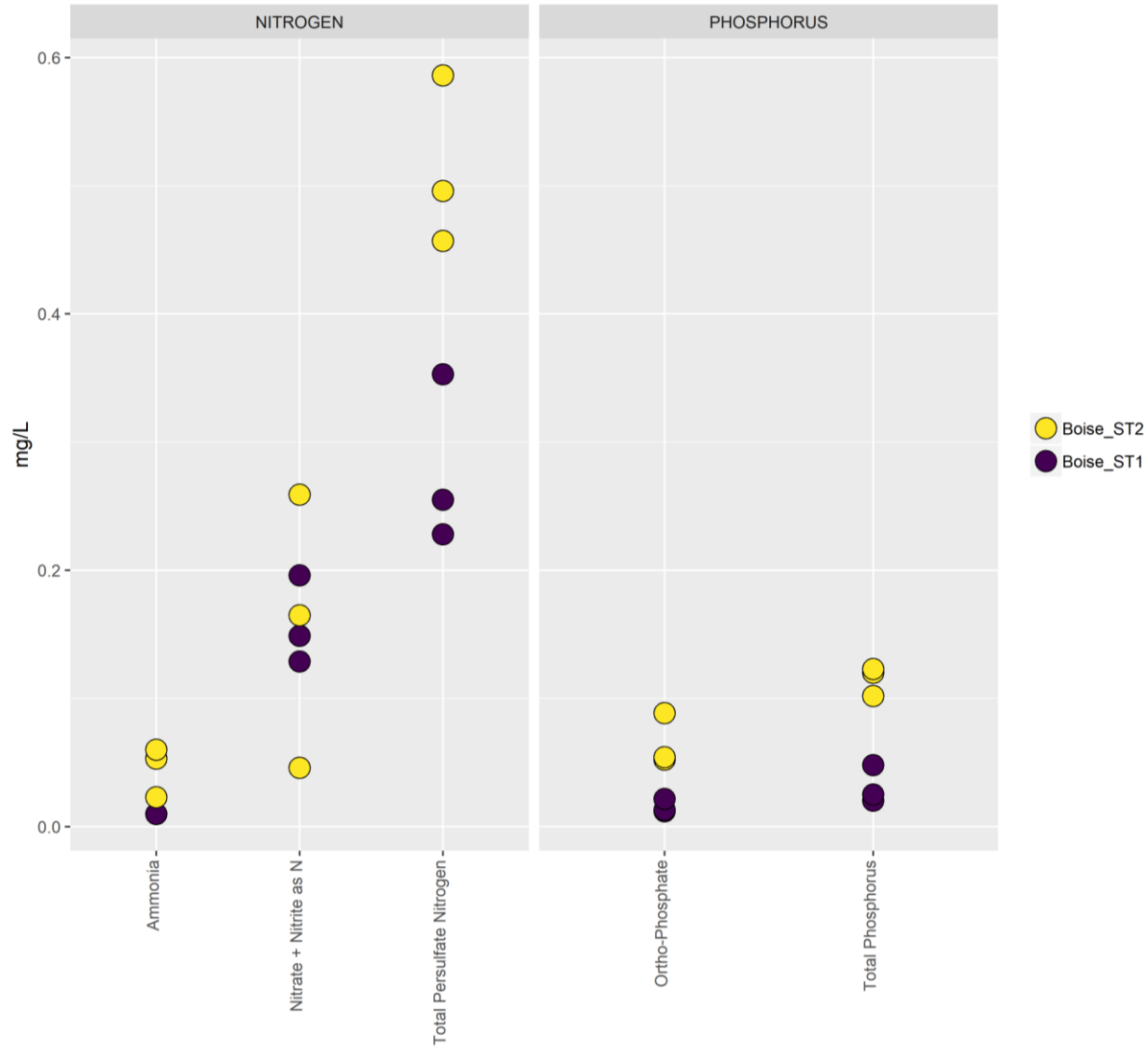

Figure 5. Nutrient results at the two Boise status and trends sites: Boise_ST1 and Boise_ST2.

Boise Creek: Field Parameters

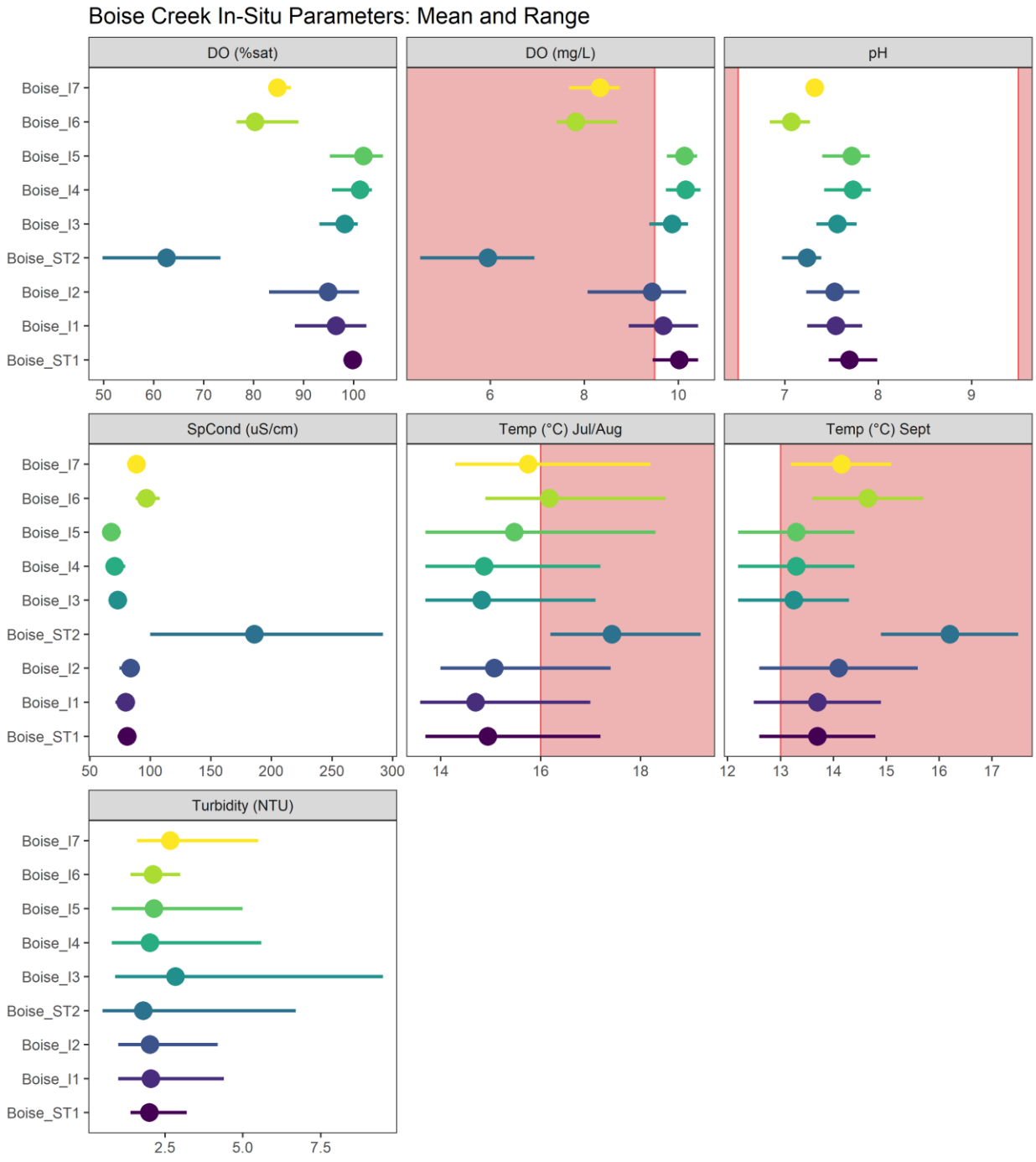

Figure 6. Mean (dots) and range (lines) of field parameters collected in-situ at Boise Creek sites. Red shaded areas are values that are outside of Washington state water quality standards. Temperature for Boise Creek has two seasonal standards: maximum of 16°C from July 2 to August 31 and maximum of 13°C from September 1 to July 1. Although discrete temperature measurements are not directly comparable to the 7-DADMax, more than one result over the red line suggests a possible exceedance (Table 5, Water Quality Program, 2018).

Boise Creek: Investigative Sampling

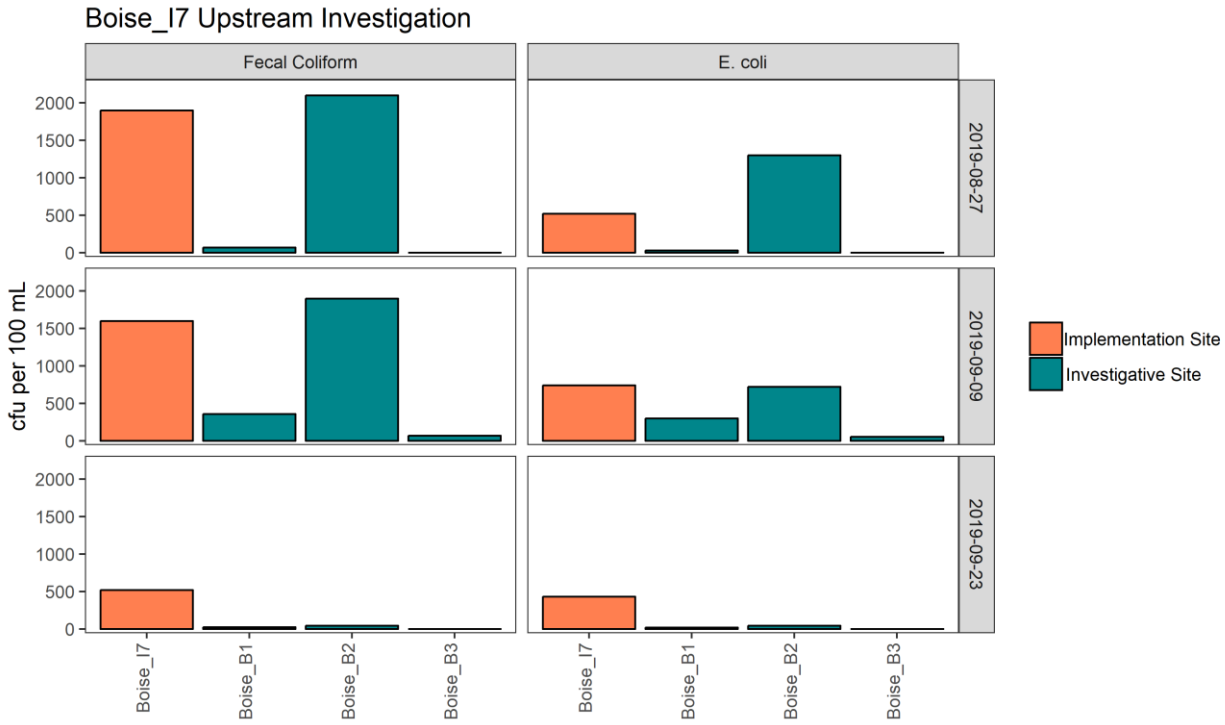

Figure 7. Samples collected at Boise_I7 (implementation site) in conjunction with samples collected at three upstream investigative sites on 8/27, 9/09, and 9/23.

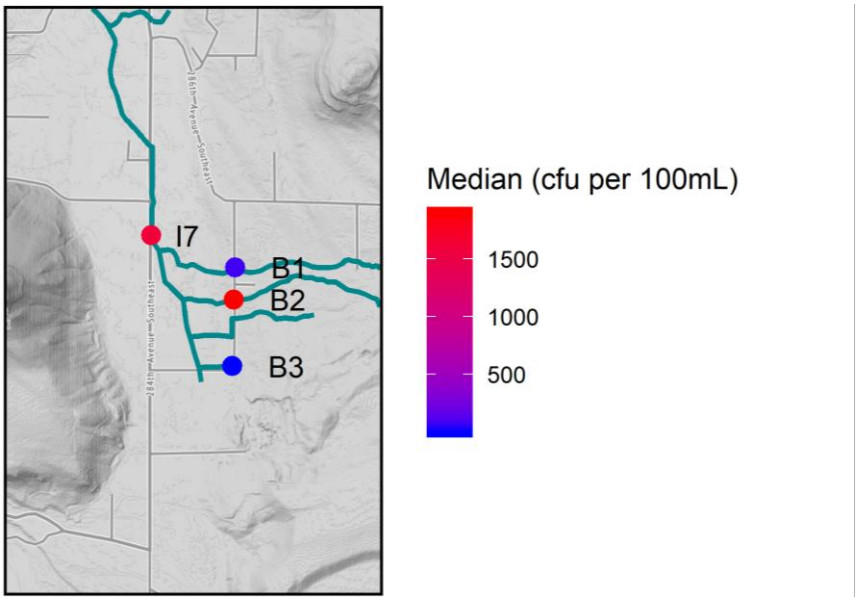

Figure 8. Map of investigative samples collected upstream of Boise_I7. Color compares median of fecal coliform bacteria at the three sample events. The small tributary with no site marked was dry or stagnant on all three visits.

References

Brownlee, A. 2019. Quality Assurance Project Plan: Puyallup River Tributaries Effectiveness Monitoring. Ecology publication 19-10-040.

Dickes, B. 2015. Pussyfoot Creek and Second Creek Fecal Coliform Characterization Monitoring: Two Tributaries to the White River. Washington State Department of Ecology, Olympia, WA. Publication No. 15-10-048. https://testfortress.wa.gov/ecy/publications/SummaryPages/1510048.html

Kahle, D and H. Wickham. ggmap: Spatial Visualization with ggplot2. The R Journal, 5(1), 144-161. URL http://journal.r-project.org/archive/2013-1/kahle-wickham.pdf

Mathieu, N. and James, C. 2011. Puyallup River Watershed: Fecal Coliform Total Maximum Daily Load – Water Quality Improvement Report and Implementation Plan. Washington State Department of Ecology, Olympia, WA. Publication No. 11-10-040. https://test-fortress.wa.gov/ecy/publications/SummaryPages/1110040.html

Water Quality Program, 2018. Water Quality Program Policy 1-11: Washington's Water Quality Assessment Listing Methodology to Meet Clean Water Act Requirements. Ecology publication 18-10-035. https://fortress.wa.gov/ecy/publications/SummaryPages/1810035.html

Water Quality Standards for Surface Waters of the State of Washington Section 173-201A. https://apps.leg.wa.gov/WAC/default.aspx?cite=173-201A

Appendices

Appendix 1. Precipitation on dates with greater than 0.1 inches of rainfall (data is provisional, King County gauge station 44u, https://green2.kingcounty.gov/hydrology/DataDownload.aspx).

Date	Daily Precipitation (inches)	Date	Daily Precipitation (inches)
7/2/2019	0.25	9/9/2019	0.42
7/9/2019	0.22	9/10/2019	0.17
7/10/2019	0.52	9/12/2019	0.31
7/15/2019	0.17	9/13/2019	0.16
7/16/2019	0.24	9/15/2019	1.01
8/2/2019	0.17	9/17/2019	0.5
8/10/2019	0.17	9/18/2019	0.13
8/21/2019	1.81	9/20/2019	0.39
8/22/2019	0.34	9/22/2019	0.29
8/30/2019	0.13	9/26/2019	0.46
9/7/2019	0.18	9/28/2019	0.56

Appendix 2. Dates and corresponding number of sites sampled for each type of data collected. Values include all status and trends, implementation, and investigative sites.

Date	Bacteria	Nutrients	Field/ In-situ	Dry Sites Visited
7/8/2019	8	2	8	0
7/9/2019	1	0	1	17
7/22/2019	9	0	9	0
7/23/2019	0	0	0	17
8/5/2019	9	2	9	0
8/6/2019	0	0	0	17
8/26/2019	9	0	9	0
8/27/2019	4	0	0	17
9/9/2019	12	2	9	0
9/10/2019	0	0	0	17
9/23/2019	12	0	0	0
9/24/2019	0	0	0	17

Appendix 3. Raw data collected at sites on Boise Creek.

Site	Date	Fecal Coliform (cfu/100mL)	*E. coli* (cfu/100mL)	Ammonia (mg/L)	Nitrate + Nitrite as N (mg/L)	Total Persulfate Nitrogen (mg/L)	Ortho-Phosphate (mg/L)	Total Phosphorus (mg/L)	Temperature (°C)	Barometric pressure (in/Hg)	Specific Conductivity (µS/cm)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (% saturation)	pH	Turbidity (NTU)
Boise_ST1	7/8/2019	80	61	0.0	0.1	0.3	0.0	0.0	13.7	29.4	80.8	10.3	101.1	8.0	1.4
Boise_ST1	7/22/2019	310	280	-	-	-	-	-	14.9	29.4	75.6	10.0	100.5	7.6	1.6
Boise_ST1	8/5/2019	250	190	0.0	0.1	0.2	0.0	0.0	17.2	29.5	82.0	9.5	99.9	7.8	1.6
Boise_ST1	8/26/2019	140	130	-	-	-	-	-	14.0	29.6	88.6	10.2	99.5	7.8	1.6
Boise_ST1	9/9/2019	860	640	0.0	0.2	0.4	0.0	0.0	14.8	29.3	85.0	9.8	98.7	7.5	2.6
Boise_ST1	9/23/2019	190	160	-	-	-	-	-	12.6	29.6	73.2	10.4	99.2	7.5	3.2
Boise_I1	7/8/2019	290	230	-	-	-	-	-	13.7	29.3	81.2	10.4	102.6	7.8	1.2
Boise_I1	7/22/2019	310	270	-	-	-	-	-	14.5	29.3	74.2	9.9	99.4	7.6	1.0
Boise_I1	8/5/2019	300	250	-	-	-	-	-	17.0	29.3	80.1	9.5	100.6	7.7	1.1
Boise_I1	8/26/2019	320	250	-	-	-	-	-	13.6	29.5	84.5	10.0	97.3	7.6	1.4
Boise_I1	9/9/2019	1800	920	-	-	-	-	-	14.9	29.2	86.8	9.0	90.8	7.3	4.4
Boise_I1	9/23/2019	400	340	-	-	-	-	-	12.5	29.5	71.3	9.3	88.3	7.2	3.2
Boise_I2	7/9/2019	130	91	-	-	-	-	-	14.0	29.3	91.6	10.2	100.9	7.8	1.0
Boise_I2	7/22/2019	380	360	-	-	-	-	-	14.9	29.4	76.2	10.0	100.5	7.6	1.0
Boise_I2	8/5/2019	310	240	-	-	-	-	-	17.4	29.4	86.7	9.5	101.1	7.7	1.1
Boise_I2	8/26/2019	390	260	-	-	-	-	-	14.0	29.5	91.6	9.8	96.7	7.6	1.1
Boise_I2	9/9/2019	1600	600	-	-	-	-	-	15.6	29.2	82.4	8.1	83.1	7.2	4.2
Boise_I2	9/23/2019	440	330	-	-	-	-	-	12.6	29.5	74.6	9.2	87.2	7.3	3.7
Boise_ST2	7/8/2019	580	390	0.0	0.2	0.5	0.1	0.1	17.0	29.3	194.5	6.9	73.4	7.4	0.7
Boise_ST2	7/22/2019	390	370	-	-	-	-	-	17.3	29.4	194.1	6.2	65.3	7.3	0.5
Boise_ST2	8/5/2019	1500	880	0.1	0.0	0.5	0.1	0.1	19.2	29.3	292.1	4.5	49.8	7.4	1.4
Boise_ST2	8/26/2019	670	440	-	-	-	-	-	16.2	29.5	171.8	5.8	59.7	7.2	0.6
Boise_ST2	9/9/2019	2200	840	0.1	0.3	0.6	0.1	0.1	17.5	29.2	99.9	5.9	62.7	7.0	6.7
Boise_ST2	9/23/2019	920	650	-	-	-	-	-	14.9	29.5	163.0	6.5	64.7	7.2	0.9
Boise_I3	7/8/2019	84	67	-	-	-	-	-	13.8	29.3	73.6	10.2	100.9	7.8	1.1
Boise_I3	7/22/2019	160	150	-	-	-	-	-	14.7	29.3	69.5	10.0	100.0	7.6	1.0
Boise_I3	8/5/2019	160	140	-	-	-	-	-	17.1	29.3	77.9	9.4	99.4	7.6	0.9
Boise_I3	8/26/2019	250	230	-	-	-	-	-	13.7	29.5	80.6	10.0	97.6	7.6	1.1
Boise_I3	9/9/2019	580	730	-	-	-	-	-	14.3	29.2	70.9	9.8	98.2	7.5	9.5
Boise_I3	9/23/2019	400	360	-	-	-	-	-	12.2	29.5	66.8	9.9	93.2	7.3	3.4
Boise_I4	7/8/2019	51	44	-	-	-	-	-	13.9	29.3	71.5	10.5	103.7	7.9	0.9
Boise_I4	7/22/2019	100	72	-	-	-	-	-	14.7	29.3	69.6	10.2	102.8	7.8	1.0
Boise_I4	8/5/2019	190	160	-	-	-	-	-	17.2	29.3	73.2	9.7	103.3	7.8	0.8
Boise_I4	8/26/2019	290	180	-	-	-	-	-	13.7	29.5	79.5	10.4	101.7	7.8	0.8
Boise_I4	9/9/2019	600	390	-	-	-	-	-	14.4	29.2	63.9	10.0	100.6	7.7	5.6
Boise_I4	9/23/2019	130	120	-	-	-	-	-	12.2	29.5	66.0	10.1	95.7	7.4	3.0
Boise_I5	7/8/2019	47	43	-	-	-	-	-	13.7	29.3	68.3	10.4	102.7	7.9	1.0
Boise_I5	7/22/2019	220	220	-	-	-	-	-	15.5	29.3	67.9	10.2	104.6	7.9	1.1
Boise_I5	8/5/2019	67	48	-	-	-	-	-	18.3	29.3	71.7	9.8	105.9	7.8	0.8
Boise_I5	8/26/2019	440	300	-	-	-	-	-	14.4	29.5	76.0	10.3	102.7	7.8	0.8
Boise_I5	9/9/2019	420	320	-	-	-	-	-	14.4	29.1	60.7	10.0	100.6	7.6	5.0
Boise_I5	9/23/2019	40	26	-	-	-	-	-	12.2	29.5	62.1	10.1	95.3	7.4	4.2
Boise_I6	7/8/2019	20	20	-	-	-	-	-	15.3	29.2	88.0	8.7	89.0	7.3	1.4

Site	Date	Fecal Coliform (cfu/100mL)	*E. coli* (cfu/100mL)	Ammonia (mg/L)	Nitrate + Nitrite as N (mg/L)	Total Persulfate Nitrogen (mg/L)	Ortho-Phosphate (mg/L)	Total Phosphorus (mg/L)	Temperature (°C)	Barometric pressure (in/Hg)	Specific Conductivity (µS/cm)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (% saturation)	pH	Turbidity (NTU)
Boise_I6	7/22/2019	36	33	-	-	-	-	-	16.0	29.3	93.9	7.5	78.0	7.1	1.9
Boise_I6	8/5/2019	18	13	-	-	-	-	-	18.5	29.3	91.2	7.6	83.3	7.2	1.8
Boise_I6	8/26/2019	37	36	-	-	-	-	-	14.9	29.4	101.3	7.7	77.4	7.1	2.0
Boise_I6	9/9/2019	670	470	-	-	-	-	-	15.7	29.1	98.4	7.4	76.6	6.9	3.0
Boise_I6	9/23/2019	53	51	-	-	-	-	-	13.6	29.5	107.8	7.9	77.3	6.8	2.6
Boise_I7	7/8/2019	400	320	-	-	-	-	-	14.3	29.2	83.6	8.8	87.5	7.3	1.8
Boise_I7	7/22/2019	2300	2300	-	-	-	-	-	15.9	29.3	89.6	8.2	84.3	7.4	2.2
Boise_I7	8/5/2019	780	520	-	-	-	-	-	18.2	29.3	89.3	7.7	83.2	7.4	1.6
Boise_I7	8/26/2019	1600	840	-	-	-	-	-	14.6	29.4	90.8	8.5	85.3	7.4	2.7
Boise_I7	8/27/2019	1900	520	-	-	-	-	-	-	-	-	-	-	-	-
Boise_I7	9/9/2019	1600	740	-	-	-	-	-	15.1	29.1	85.7	8.3	84.6	7.3	5.5
Boise_I7	9/23/2019	520	430	-	-	-	-	-	13.2	29.5	93.0	8.7	83.7	7.2	2.2
Boise_B1	8/27/2019	68	29	-	-	-	-	-	-	-	-	-	-	-	-
Boise_B1	9/9/2019	360	300	-	-	-	-	-	-	-	-	-	-	-	-
Boise_B1	9/23/2019	22	21	-	-	-	-	-	-	-	-	-	-	-	-
Boise_B2	8/27/2019	2100	1300	-	-	-	-	-	-	-	-	-	-	-	-
Boise_B2	9/9/2019	1900	720	-	-	-	-	-	-	-	-	-	-	-	-
Boise_B2	9/23/2019	45	44	-	-	-	-	-	-	-	-	-	-	-	-
Boise_B3	8/27/2019	2	2	-	-	-	-	-	-	-	-	-	-	-	-
Boise_B3	9/9/2019	69	52	-	-	-	-	-	-	-	-	-	-	-	-
Boise_B3	9/23/2019	1	1	-	-	-	-	-	-	-	-	-	-	-	-